Petrology of selected Ultramafic Layers in the Reed Lake Pluton, Flin Flon–Snow Lake Greenstone Belt, Manitoba

by

JEFFREY YOUNG

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A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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ABSTRACT

The early Proterozoic, Reed Lake Pluton is a steeply dipping, mafic-ultramafic, subvolcanic pluton that is 4 km thick and at least 10 km long; the pluton is west facing. In cross-section, the pluton has a rectangular appearance. The pluton comprises a 100 to 300 m thick Lower Mafic Group, 335 to 700 m thick Mafic-Ultramafic Group and 3200 m thick Upper Mafic Group. Original minerals are largely replaced, but in the Mafic-Ultramafic Group, clinopyroxene is commonly relict, as are some oxides and rare olivine.

In the Mafic-Ultramafic Group 15 cycles were identified, each of which consists of a lower ultramafic zone and an upper mafic zone; two country rock septa occur within the group. The 15 ultramafic zones comprise about 20% of the group and range in thickness from 1.3 to 16.3 m. Ultramafic zones consist largely of olivine clinopyroxenite, olivine websterite, olivine-bearing clinopyroxenite, olivine-bearing websterite and clinopyroxenite, with lesser abundances of lherzolite, wehrlite, websterite and several gabbroic lithologies. In each zone there are 1 to 6 layers that range in thickness from 30 cm to 10.2 m. Crystallization in layers followed the following orders: (1) olivine, clinopyroxene, orthopyroxene, plagioclase; or (2) orthopyroxene, clinopyroxene, plagioclase. Clinopyroxene probably crystallized at about the same time as olivine. The crystallization sequence was controlled by phase equilibria and crystallization kinetics. Magmas probably crystallized near or at cotectic boundaries, saturated in either olivine or clinopyroxene.

Variations in mineral abundances, chemistry and texture occur at both layer and zone scale. Most layers are ungraded or normally graded with respect to olivine, but some layers have complex olivine/clinopyroxene variations; most layer contacts are sharp. In most graded layers, maximum olivine abundance occurs slightly above to well above the base. Olivine/clinopyroxene trends in most zones varies from ungraded to normally graded to symmetrically graded; in some zones olivine is absent. Two zones, which are reversely graded, have no olivine in

the lower part. Clinopyroxene ranges in composition from $Wo_{43.8}En_{48.2}Fs_{8.0}$ to $Wo_{42.3}En_{43.8}Fs_{13.9}$. Correlation between mineral variations and clinopyroxene is poor and En/Fs in many layers is similar across layer boundaries.

Layers crystallized *in situ* in a boundary layer at the magma-crystal interface. Small currents probably swept across the floor locally and slower, large scale convection occurred during development of zones. Some crystal settling may have occurred locally. Ungraded layers formed at a constant rate of accumulation during *in situ* crystallization with efficient removal of elements across the boundary layer. Some ungraded layers represent magma that was more evolved than other layers. Normally graded layers and complexly graded layers probably formed by similar processes. The height above the base of graded layers at which olivine abundance is highest, may be a function of compositional variations and gradients, fluctuations in temperature and crystallization kinetics. Above the magma-crystal interface a new pulse of nucleation occurred forming the next layer. Crystallization in some layers was probably halted by the onset of nucleation in overlying layers. Migration of varying abundances of intercumulus magma caused re-equilibration of mineral compositions and local deformation at a few zone contacts.

Cycles formed by repeated influx of fractionated tholeiitic magma that mixed, to varying degrees, with residual magma or incorporated crystals or other material that had solidified from underlying zones; three zones formed from at least 2 batches of magma. Fractionation within zones is dependent on the size of each batch of magma, time between replenishment of magma batches and the degree of mixing and convection.

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CHAPTER 1
INTRODUCTION

Mafic-ultramafic plutons comprise a relatively small, but important, part of greenstone belts, and vary in abundance, habit and age relative to volcanism and deformation. In the Proterozoic Flin Flon - Snow Lake greenstone belt the ultramafic to mafic plutons have been subdivided into four tectonic groups: a) subvolcanic sills, stocks and plugs that appear to be an integral part of an emerging mafic volcano; b) high level sills within metasedimentary and felsic to intermediate metavolcanic sequences that overlie thick mafic metavolcanic sequences; c) syntectonic stocks and zones that are spatially associated with, and probably early phases of, large granitoid complexes; and, d) late tectonic stocks and sheets that are less deformed and metamorphosed than the surrounding country rocks (Ayres and Young, 1989). These groups appear to represent a progressive evolution in the generation and upward movement of basaltic magma in response to crustal thickening and changes in crust-mantle conditions. The habit, internal structure and crystallization history of the plutons, in part, reflect these changing conditions.

The Reed Lake Pluton, the subject of the present study, is a 10 km long and 4 km thick, mafic-ultramafic pluton that has a rectangular appearance in plan view. The originally horizontal pluton has been tilted to a near vertical orientation and faces westward. The pluton has been classified as a subvolcanic pluton (Young and Ayres, 1985; Ayres and Young, 1989). Subvolcanic plutons probably acted as feeder chambers to volcanism. There were periods of magma withdrawal, during eruptions, and of replenishment as magma ascended and ponded en route from the mantle. The continuous process of emplacement and withdrawal of magma batches would have facilitated fluid dynamic stratification of the magma and rapid changes in pressure and temperature conditions. Many plutons preserve the dynamic relationship of magma emplacement and withdrawal in their cyclical repetition of lithologic types and layers (Brown, 1956; Irvine and Smith, 1967; Jackson, 1970; Raedeke and McCallum, 1984). The age of a volcano though, is relatively short compared to the time necessary for crystallization and solidifi-

cation of a large layered magma chamber. After cessation of volcanism, crystal fractionation probably continued under relatively stable conditions.

In the lower part of the Reed Lake Pluton, 15 distinct ultramafic zones, commonly separated by thicker gabbro zones, have been identified in a single stratigraphic section; there are probably additional ultramafic zones higher in the pluton. In this thesis the vertical variations of the 15 ultramafic zones are documented. Changes in mineralogy, texture, and chemistry within and between layers that make up zones lead to a better understanding of the crystallization history of individual zones. Comparison is made between the various zones to model the evolution of this part of the pluton and to suggest possible models for the crystallization and emplacement of the whole pluton. Preliminary work has been done on some of the secondary products developed during recrystallization and alteration of the pluton.

1.1 Present study

The present study was initiated as part of the Manitoba-Canada Mineral Development Agreement 1984-1989. Twelve mafic-ultramafic plutons were examined in the Flin Flon-Snow Lake greenstone belt. After a reconnaissance study of the Reed Lake Pluton it was chosen for more detailed study because

a) the pluton is one of only three that have well developed layering and a section of ultramafic rocks;
b) clinopyroxene in the ultramafic rocks is preserved making the pluton attractive for petrologic work;
c) a relatively complete section of ultramafic rocks is well exposed; and
d) recently the pluton has been examined as a possible host for platinum group elements.

1.1.1 Method of study

A general stratigraphic section of the Reed Lake Pluton was measured during several days of reconnaissance mapping in 1984. Traverses were done across the center of the pluton by using aerial photographs at a scale of 1:15 840. Several days were also spent cleaning and examining a section of outcrop that exposes an interlayered sequence of mafic and ultramafic layers in the lower part of the

pluton.

In 1987, L.D. Ayres measured a detailed section through ultramafic and interlayered mafic units in the lower part of the pluton. Over 500 samples were collected of which about 350 were examined petrographically for the present study. Modal analyses were completed on 102 samples, with emphasis on samples that were processed for geochemistry and samples from better exposed, internally layered ultramafic zones. Whole rock geochemistry was done on 34 samples selected from the center of most ultramafic layers in the sequence. Microprobe mineral analyses were obtained on primary clinopyroxene from 100 samples. Primary oxide grains were analyzed from 16 samples. Random microprobe analyses were also made of secondary amphibole, chlorite and serpentine to examine the degree of metamorphism and any compositional correlation between primary phases and their metamorphic products.

1.1.3 Location and access

The Reed Lake Pluton is about 37 km southwest of the town of Snow Lake on the west side of Reed Lake (Figure 1). The lower parts of the pluton are accessible by boat from the Reed Lake Provincial Campground on the north side of Provincial Trunk Route 39 that connects Provincial Highways 10 and 6. Access to the upper part of the pluton is more difficult, although some areas are accessible by canoe from the Grass River. Long traverses by foot are necessary to reach the northern part of the pluton.

1.2 Terminology

Mineralogy, textures and structures in layered intrusions provide information about the changing relationship between the magma and crystals during solidification. Early work on the Skaergaard Intrusion by Wager and Deer (1939) led to the development of cumulus terminology and the hypothesis that cumulus crystals accumulated by the process of crystal settling (Wager et al., 1960). More recent evidence, however, has suggested that crystal settling was not the controlling factor in crystallization of Skaergaard and other intrusions and that other

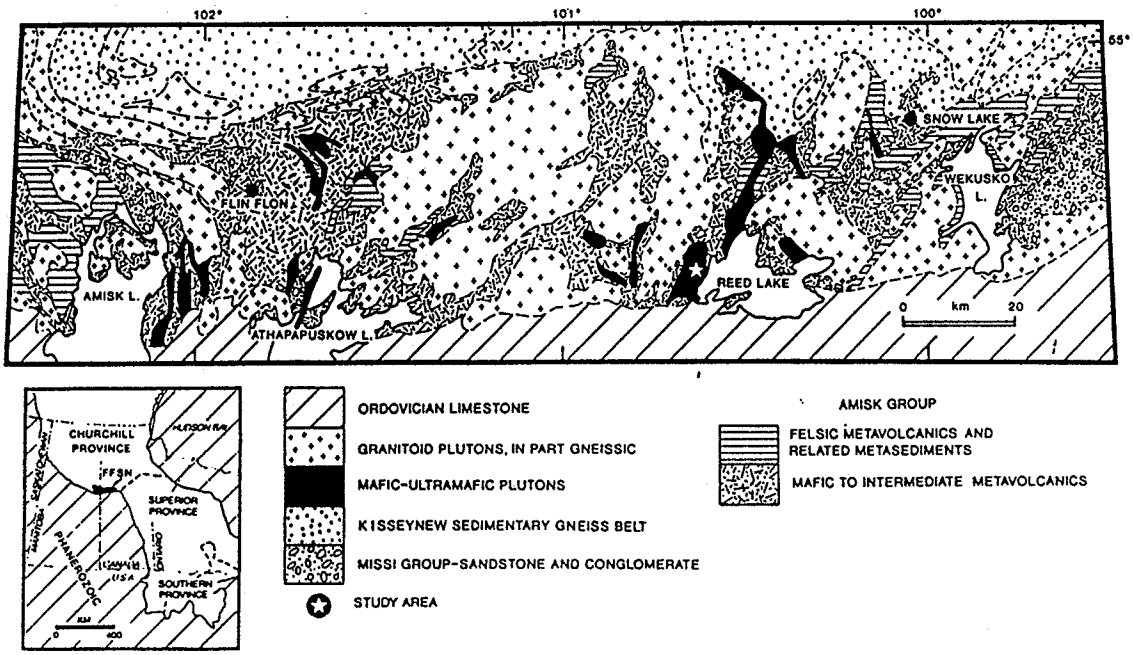


Figure 1. Geology of the Flin Flon-Snow Lake Greenstone Belt (FFSN) and location of the study area. (modified after Bailes, 1971)

processes may be important in development of layering and zoning. Possible other process include:

a. fluid dynamics and convection (Wager and Brown, 1967; Huppert and Sparks, 1984; McBirney et al., 1985; Morse, 1986b; Turner and Campbell, 1986; Marsh, 1989);

b. crystal transport and deposition (Wager and Brown, 1967; Irvine, 1974; Brandeis and Jaupart, 1986; Morse, 1986b);

c. heat flux in the magma chamber (Irvine, 1970; Marsh, 1989);

d. *in situ* crystallization adjacent to a lower temperature interface (McBirney and Noyes, 1979) or in a relatively stagnant supercooled boundary layer (Jackson, 1961; Campbell, 1977; Jaupart and Brandeis, 1986);

e. multiple magma injection, magma displacement and mixing (Brown, 1956; Irvine and Smith, 1967; Campbell, 1977; Irvine et al., 1983; Raedeke and

McCallum, 1984; Wilson, 1982); and

f. changes in pressure (Cameron, 1980).

In order to adequately reflect the changing concepts of crystallization and still accommodate the widespread use of cumulus terminology, Irvine (1982, 1987b) modified cumulus terminology so that the mechanism of crystal accummulation is no longer part of the definition. This modified terminology, with certain changes to be discussed later, is used in this thesis.

CHAPTER 2
GENERAL GEOLOGY

As exposed, the early Proterozoic, east-trending Flin Flon-Snow Lake greenstone belt is about 250 km long and at least 32 km wide; the south part of the belt is covered by Paleozoic rocks (Figure 1). The belt is bounded on the north by the Kisseynew Metasedimentary Gneiss Belt. The greenstone belt consists of subaqueous to subaerial, ultramafic to felsic volcanic rocks and associated sedimentary rocks of the Amisk Group all of which are unconformably overlain by terrestrial, fluvial-alluvial sedimentary rocks of the Missi Group. The Missi Group also includes subaerial and subaqueous volcanic rocks in the Snow Lake area (Gordon and Gall, 1982). These rocks were subsequently intruded by a series of synvolcanic to post-tectonic ultramafic to mafic plutons and syntectonic to post-tectonic felsic plutons.

Metamorphism and structure vary in the degree of development across the belt. In general, metamorphic grade increases northward, across the belt, although the regional metamorphic pattern is complicated by metamorphic aureoles associated with large plutons. The lowest metamorphic grade rocks, subgreenschist facies, have been identified south of Flin Flon (Bailes and Syme, 1983), whereas amphibolite facies occur at the north edge of the belt, adjacent to the Kisseynew Gneiss Belt.

Up to 5 stages of folding have been identified in the Flin Flon area (Bailes and Syme, 1989), including one stage of pre-Missi folding, but only 2 major folding episodes have been recognized in the Snow Lake area (Bailes et al., 1987, Froese and Moore, 1980). The main metamorphic event is associated with the fourth stage of folding in the Flin Flon area and the second stage in the Snow Lake area. Block faulting occurred throughout the belt, generally during the later stages of metamorphism and folding. These late faults hamper stratigraphic correlation: in the Flin Flon area the volcanic stratigraphy cannot be correlated across these faults.

2.1 Geology of the Reed Lake area

That part of the greenstone belt adjacent to the Reed Lake Pluton is a se-

quence of mafic to intermediate metavolcanic rocks assigned to the Amisk Group (Figure 2). Felsic plutonic rocks that locally contain 20 to 80% metavolcanic xenoliths are common northwest of the pluton (Figure 2). Ordovician dolomitic limestone overlies the Precambrian rocks to the south.

2.1.1 Metavolcanic and Associated Metasedimentary Rocks

The metavolcanic rocks comprise an interlayered sequence of mafic to intermediate, massive to locally pillowed flows and intermediate tuff and tuff-breccia (Rousell, 1970). The intermediate fragmental metavolcanic rocks are restricted to several islands in Reed Lake. Thin greywacke, argillite, and iron formation units are locally intercalated with the metavolcanic sequence (Rousell, 1970). Several metavolcanic septa occur in the Reed Lake Sill (Rousell, 1970; Ayres and Young, 1989)

2.1.2 Mafic Intrusive Rocks

The Reed Lake Pluton is the most southerly exposed pluton in a belt of mafic plutons that extends from the Paleozoic cover in the south to the Kisseynew Metasedimentary Gneiss Belt in the north (Figure 1). This belt of mafic intrusions may extend under the Ordovician dolomitic limestone to the south (Hosain, 1985). Although occurring in a linear zone, these mafic intrusions may not all be genetically related. The Josland Lake Gabbros at the north end of the zone are high level plutons that are interpreted to be related to Missi volcanism (Bailes, 1980), whereas the Reed Lake Pluton is interpreted to be related to Amisk volcanism.

The Reed Lake Pluton is a north-trending, subvertical intrusion that youngs to the west. The pluton is largely conformable as suggested by pillow elongation directions (Figure 2) and bedding in tuffaceous rocks adjacent to the pluton (Young and Ayres, 1985). The pluton is characterized by three north-trending

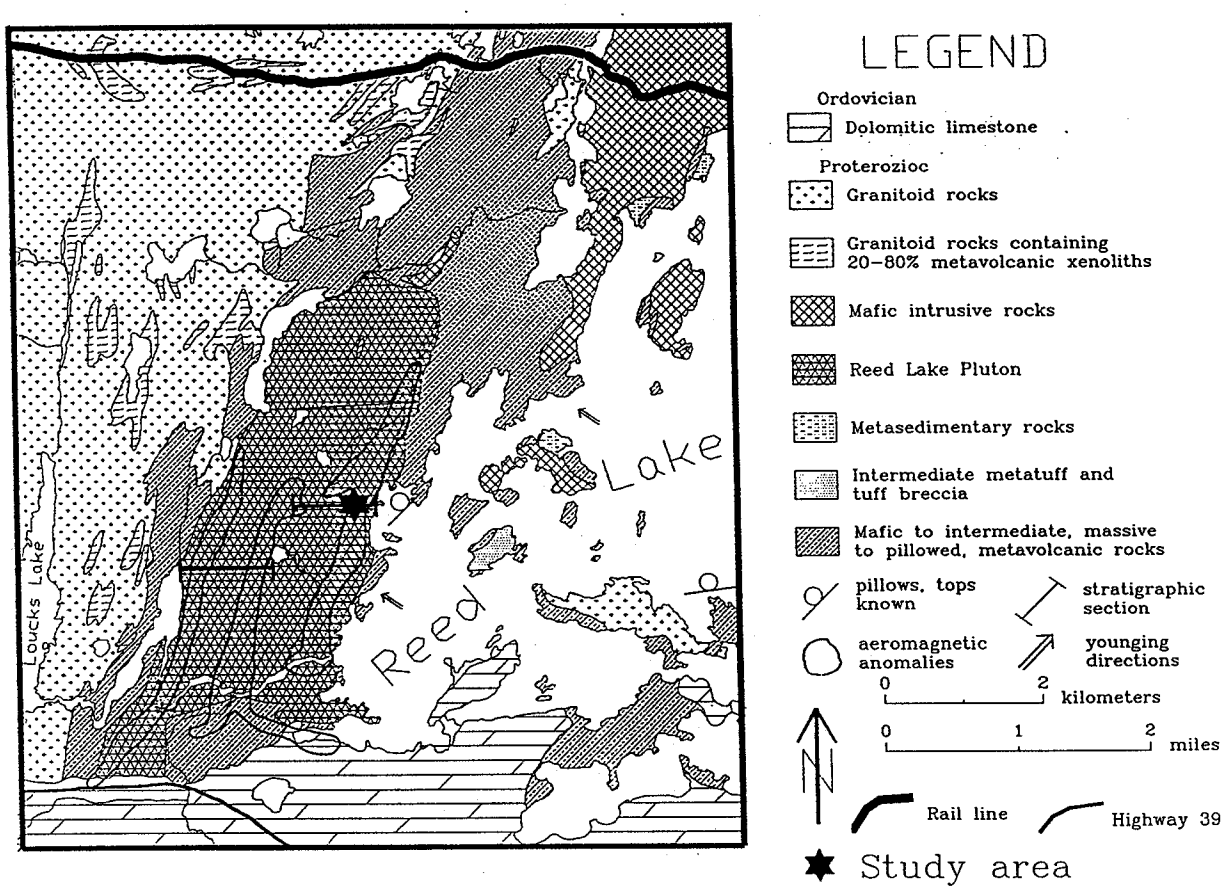


Figure 2 Geology adjacent to the Reed Lake Pluton (modified from Rousell, 1970) including the location of the stratigraphic section from Young and Ayres (1985) and anomalously high aeromagnetic zones (GSC, 1983).

aeromagnetic anomalies (Figure 2; GSC, 1983) produced by areas of increased magnetite abundances; the eastern anomaly corresponds to a sequence of ultramafic units within a dominantly mafic sequence.

2.1.3 Granitoid and Related Rocks

Tonalite and granodiorite, the marginal phases of a large batholith, occur northwest and west of the Reed Lake Pluton. The granitoid rocks are massive to well foliated and contain numerous xenolith-rich zones containing between 20 and 80% mafic metavolcanic xenoliths. The granitoid batholith is generally separated from the Reed Lake pluton by a 1.5 km thick sequence of mafic metavolcanic rocks that widens to about 2.8 km along the northwest part of the pluton contact; locally granitoid rocks are in contact with the pluton (Figure 2).

Younger granitoid and mafic dykes crosscut layering in the Reed Lake Pluton. These dykes are too small to be shown on Figure 2.

2.1.4 Metamorphism

The mafic to intermediate metavolcanic rocks, the metasedimentary rocks and the mafic plutonic rocks in the Reed Lake area have been metamorphosed to greenschist facies (Rousell, 1970), metamorphic grade increases to almandine-amphibolite facies towards the granitoid batholith in the northwest. No data are available on possible metamorphic effects of the Reed Lake Pluton on the surrounding country rocks.

2.1.5 Structure

Units in the area shown on Figure 2 are largely subvertical and Rousell (1970) suggested that the metavolcanic rocks have been isoclinally folded and are steeply plunging. Rousell (1970) identified at least one shallow north-plunging open synform in the granitoid rocks northwest of the Reed Lake pluton.

The trend of the metavolcanic-metasedimentary sequence changes across the

area, from north-trending to east-trending. Immediately east of the pluton, country rocks trend northeasterly and young northwesterly. Farther east, however, near the edge of the area shown in Figure 2, units have an easterly trend and young northward.

The country rocks have a pronounced foliation that largely parallels, but locally crosscuts, primary layering; foliation dips are steep. The mafic plutonic rocks, including the Reed Lake Pluton, display no evidence of this regional foliation. Topographic lineaments are common in the area and Rousell (1970) identified two major north-trending lineaments that are close to, and largely parallel the trend of the pluton; these may be faults. In the Reed Lake Pluton, faults both parallel and crosscut layering and complicate the stratigraphy.

CHAPTER 3

GEOLOGY OF THE REED LAKE PLUTON

The Reed Lake pluton is a steeply dipping, north-trending, high aspect ratio, apparently conformable, mafic-ultramafic intrusion that is about 4 km thick and at least 10 km long; the pluton is west-facing. Based on mapping by Rousell (1970), the pluton has a rectangular shape in plan view, but at the south end the pluton thins abruptly with only part of the pluton extending under Paleozoic cover (Figure 2). Where the pluton thins, a segment of the pluton extends to the east under Reed Lake. Where examined, the lower contact is covered by overburden or Reed Lake, but the upper contact is exposed in places and is marked by a 15 to 20 cm thick chilled zone.

Young and Ayres (1985) subdivided the pluton into three groups: Lower Mafic Group, Mafic-Ultramafic Group and Upper Mafic Group (Table 1). Although the internal stratigraphy of the Mafic-Ultramafic Group is well documented in the area of this study, further work is needed to refine the stratigraphy of the other groups, and to define lateral continuity of the stratigraphy in all groups.

Four mafic to intermediate septa, of probable volcanic origin, two in the Mafic-Ultramafic Group and two in the Upper Mafic Group, have been identified (Rousell, 1970; Ayres and Young, 1989). Considering the reconnaissance nature of much of the stratigraphy, there are probably other unidentified septa. The septa range in thickness from 30 cm to 150 m (Rousell, 1970; Figure 2); locally septa bifurcate into two parts separated by ultramafic units. Contacts between the septa and pluton phases are sharp but irregular, and some irregular ultramafic patches are randomly distributed in one septum. Two of the septa occur in, and extend beyond, the thesis area; their maximum extents are unknown.

3.1 Lower Mafic Group

The Lower Mafic Group is a 100 to 300 m thick, layered sequence of gabbroic rocks with rare pegmatoid phases and local pyroxenitic layers (Table 1). Layers

GROUP	THICKNESS (m)	LITHOLOGY	STRUCTURE
UPPER MAFIC	3200	Fine- to coarse-grained melagabbro, gabbro and quartz diorite; minor anorthosite, and magnetite-bearing or olivine-bearing varieties; local megacrystic gabbro.	Zones, 100 to 700 m thick, consist of layers that have uniform modal abundances or are modally graded; layers are 1 mm to > 1 m thick; in many places layering is obscured by lichen.
MAFIC - ULTRAMAFIC	335 - 700	Olivine pyroxenite and pyroxenite, some peridotite, local melagabbro to anorthosite in ultramafic zones; ultramafic rocks typically medium-grained to coarse-grained; melagabbro to anorthosite and local pyroxenite in mafic zones; mafic rocks are largely fine-grained to medium-grained to local pegmatitic varieties.	Complexly layered sequence of at least 15 cycles, many of which change in composition upwards from olivine pyroxenites to pyroxenites to gabbros and leucogabbros; ultramafic zones, which are up to 15.4 m thick, are commonly internally layered and overlain by mafic zones, which are up to 82 m thick; contacts between layers are straight, sharp and locally scoured; contacts between zones are wavy to irregular.
LOWER MAFIC	100 - 300	Leucogabbro to melagabbro, local pyroxenite; medium-grained to rare concordant pegmatoid phases.	Numerous layers 5 mm to >21 m thick defined by small differences in modal abundance or grain size; in many places layering is obscured by lichen.

Table 1. Stratigraphy of the Reed Lake Sill (from Young and Ayres, 1985).

dip vertically or steeply to the east. Gabbroic layers range from 5 mm to at least 21 m thick and are defined by differences in grain size and mafic mineral content. Most layers are uniform, but some layers have normal modal grading with pyroxene-rich bases up to 7 cm thick; rare layers have reverse modal grading. Layers are locally discontinuous. Layer contacts are sharp, but vary from straight to irregular.

Medium-grained pyroxenite and feldspathic pyroxenite laminae and layers, which range in thickness from 1 to 60 cm, appear to increase in abundance upwards. Layer contacts between pyroxenitic laminae and layers and adjacent gabbroic layers are sharp and straight, but locally appear to be slightly irregular and some layers may bifurcate. Locally, pyroxenite forms discordant dykes, up to 1.1 m wide, that change trend along strike to become semi-concordant with layering. Rare pyroxenite xenoliths occur in gabbro near the top of the group.

Clinopyroxene generally ranges in abundance from 0 to 80%, except in pyroxenitic layers where abundance is 90 to 100%, and varies in grain size from 1 to 3 mm; in pyroxenite layers grain size is about 4 mm. Clinopyroxene is largely pseudomorphed by actinolite, but there are local cores of relict clinopyroxene. In most gabbro layers the only other minerals are plagioclase, which is largely replaced by single crystal albite and clinozoisite, and Fe-Ti oxides. Several layers

contain 2 to 10 mm rusty weathering spots that are probably orthopyroxene.

3.2 Mafic-Ultramafic Group

The Mafic-Ultramafic Group is 335 to 700 m thick; the variations in thickness of this group and the Lower Mafic Group are due to difficulties in measurement that are further complicated by post-solidification faults parallel and oblique to layering. Fifteen ultramafic to mafic cycles were defined in a 340 m thick measured section that is about 75% well exposed outcrop (Figure 3; Table 2). Cycles range from about 3 to 89 m thick; lower ultramafic zones comprise 7.9 to 100% of cycles with the remainder being upper mafic zones (Figure 3). Additional ultramafic zones, that are part of the Mafic-Ultramafic Group, occur above the measured section on more widely separated outcrops (pers. comm. L.D. Ayres, 1991), but are not considered in the present thesis. The ultramafic zones are 1.6 to 16.1 m thick and consist largely of pyroxenites and olivine pyroxenites (Table 2). Orthopyroxene-bearing pyroxenites and peridotites, and plagioclase-bearing pyroxenites and gabbros occur locally with plagioclase-bearing varieties largely restricted to the tops of zones. Most zones comprise several layers defined by modal and textural differences (Table 2). Layers dip 70±10° to the west, and an igneous lamination is present in some layers. Some ultramafic zones have thin layers of melagabbro, gabbro or leucogabbro.

The mafic zones range in thickness from 0.7 to 82 m (Figure 3) and consist of melagabbro, gabbro and leucogabbro with minor pyroxenite, which is generally restricted to thin layers, and rare anorthosite (Table 2); there is no mafic zone in cycle 9. Some pyroxenite occurs as fragments. The zones are uniform to well layered. Layers and laminae, which are wispy to discrete, are defined by modal and/or grain size differences, and they have sharp to gradational contacts; some layers are modally graded (Table 2).

The base of the group is defined by the first thick ultramafic unit comprising the ultramafic zone of cycle 1. Contacts between the mafic and ultramafic zones of a cycle are typically irregular to undulating or less commonly are sharp and

Figure 3. Stratigraphy of the Mafic-Ultramafic Group subdivided according to cycles and zones. Thin ultramafic layers in the mafic zones of the Mafic-Ultramafic Group are not shown. The upper part of the Lower Mafic Group is also included, but thin ultramafic layes that occur in this group are not shown.

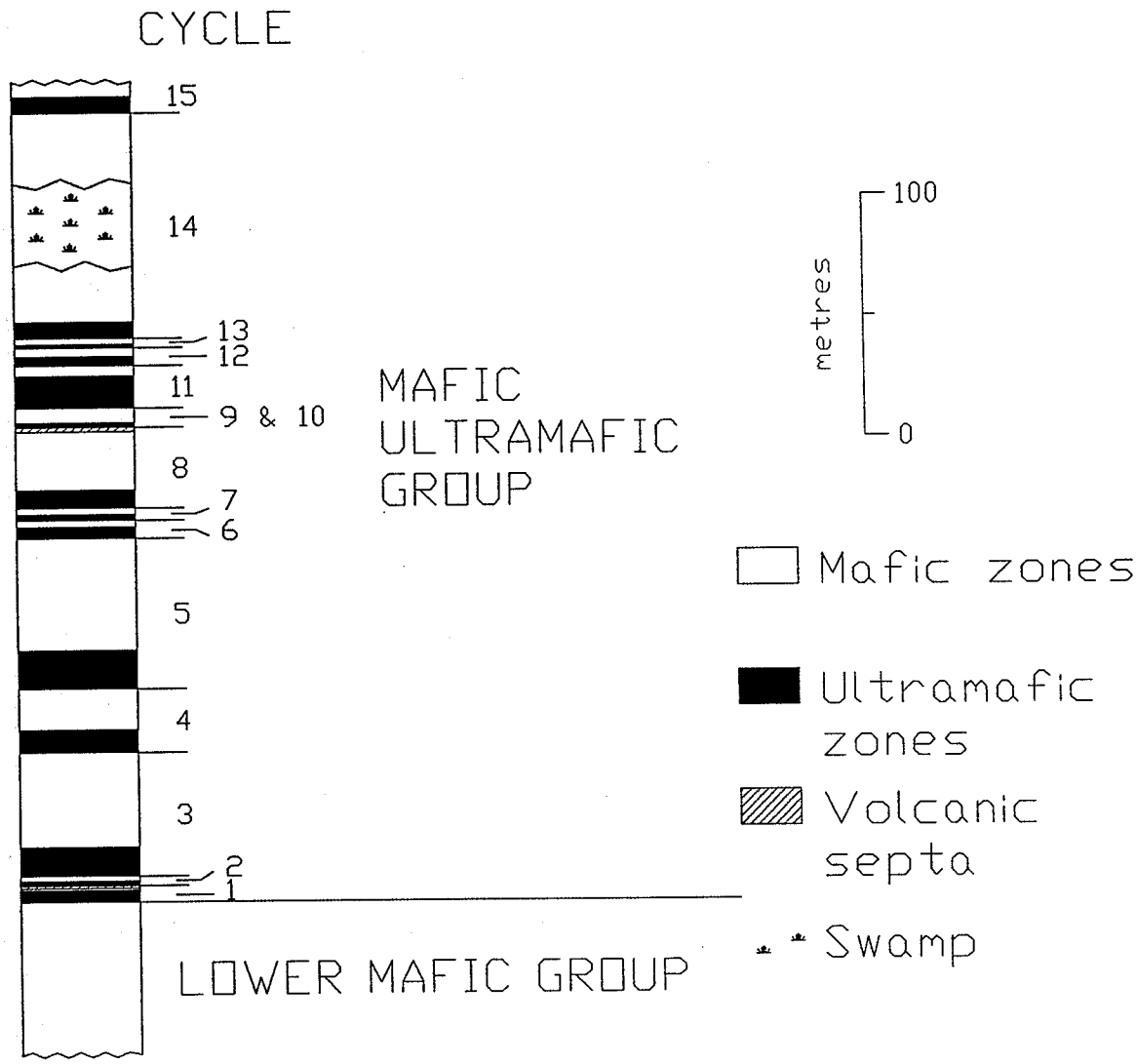


Table 2. Stratigraphic description of the cycles in the Mafic-Ultramafic Group. All thicknesses are in metres unless otherwise stated. Lithologies are listed in order of decreasing abundance and named according to Streckeisen (1976).

CYCLE	THICKNESS	ULTRAMAFIC ZONE THICKNESS	ULTRAMAFIC ZONE LITHOLOGY	ULTRAMAFIC ZONE STRUCTURE	MAFIC ZONE THICKNESS	MAFIC ZONE LITHOLOGY	MAFIC ZONE STRUCTURE
15	>17.3	7.0	Olivine clinopyroxenite, olivine-bearing clinopyroxenite, clinopyroxenite, olivine websterite, websterite, orthopyroxene- and olivine-bearing clinopyroxenite; medium- to coarse-grained	Zone comprises 3 layers that are uniform or reversely graded; from the base to the top layers are 1.6, 1.6 and 3.8 m thick; oikocrysts are most common in the middle layer; local fine-grained gabbro patches near base of lowest layer; some areas have moderately developed mineral alignment; thin, internal discontinuous layers of websterite that have sharp contacts; layer contacts are sharp and straight; lower contact of zone is sharp and irregular and upper contact is sharp and straight.	>10.3	Gabbro, leucogabbro, and rare anorthosite; fine- to medium-grained	Zone consists of a uniform layer with local intermittent wispy anorthosite and leucogabbro laminae: the top of the zone is not exposed; no mineral alignment.
14	89	5.5 to 7	Olivine websterite, orthopyroxene-bearing olivine clinopyroxenite, olivine clinopyroxenite, lherzolite, orthopyroxene-bearing wehrlite, and gabbronorite; medium- to coarse-grained	Zone comprises 2 modally graded layers; the lower layer is 2.0 m thick, but the upper layer varies in thickness from 3.5 to 5 m; oikocrysts occur in both layers; local mineral alignment; discontinuous gabbro layer up to 20 cm thick occurs at the top of the zone; layer contact is gradational; lower and upper contacts of zone are sharp and straight.	82	Gabbro, gabbronorite, melagabbro, leucogabbro, feldspathic pyroxenite, anorthosite; local plagioclase-phyric varieties; fine-grained to, less commonly, medium-grained.	Zone comprises 9 modal layers that are mostly uniform, although some are modally graded and one is modally layered; layer contacts are sharp: normal and rare reverse modal grading; intermittent layers and laminae of leucogabbro, melagabbro and anorthosite in uniform and modally graded layers: pyroxenite and feldspathic pyroxenite xenoliths in 2 layers; no mineral alignment.
13	3.9	1.6	Olivine clinopyroxenite: medium- to coarse-grained; locally pegmatitic	Zone comprises one modally graded layer; grain size increases upwards and there is pegmatitic olivine clinopyroxenite in upper 30 cm; lower contact of zone is sharp and straight and upper contact is sharp and irregular; no mineral alignment.	2.3	Melagabbro, leucogabbro, pyroxenite; medium- to coarse-grained.	Zone consists of a uniform melagabbro overlain by normal, modally graded leucogabbro; separated by a 30 cm thick coarse-grained pyroxenite layer; contacts sharp; in the lower 60 cm of the zone there are intermittent discontinuous leucogabbro laminae and irregular pyroxenite patches; magnetic mafic clots in upper part of zone: no mineral alignment.
12	7.5	3.9	Olivine clinopyroxenite, olivine-bearing clinopyroxenite, websterite and melagabbro; medium- to coarse-grained	Zone comprises 3 layers that are uniform or modally graded; from the base to the top layers are 0.4, 2.3 and 1.3 m thick; layer contacts are sharp; local continuous and discontinuous internal layers, 4 to 30 cm thick, defined by grain size variations; gabbroic phases occur at the top of the middle layer; lower contact is relatively sharp, but the upper contact is covered: no mineral alignment.	3.6	Melagabbro, leucogabbro, pyroxenite, and peridotite; fine-grained.	Zone is a relatively uniform fine-grained layer with intermittent discontinuous leucogabbro laminae; modal pyroxene increases upwards near the top of the zone: local pyroxenite and peridotite layers up to 30 cm thick in upper part of zone; no mineral alignment.
11	17.5	13.5	Olivine clinopyroxenite, clinopyroxenite, olivine-bearing clinopyroxenite, olivine websterite, wehrlite, orthopyroxene-bearing clinopyroxenite, plagioclase-bearing websterite, gabbro, gabbronorite, leucogabbro and olivine gabbro; medium- to coarse-grained, locally pegmatitic	Zone comprises 6 layers of which 1 is uniform and 5 are modally graded; layers range in thickness from 0.3 to 4.7 m: grain size grading occurs in 3 layers and the lower 2 layers contain oikocrysts: some layers thin slightly along strike; layer contacts are sharp: internal layers of discontinuous websterite occur locally at the base of one layer: gabbro occurs at the top of three layers; lower contact of zone is sharp, wavy and scalloped and upper contact is sharp, but highly irregular: no mineral alignment.	4	Gabbro, leucogabbro, anorthosite, feldspathic pyroxenite and pyroxenite; fine-grained.	Zone is largely uniform except for a modally layered interval at the base; modally layered interval changes upwards from pyroxenite to leucogabbro and local anorthosite: discontinuous intermittent gabbro laminae up to 1 cm thick occur in center of zone: internal layer contacts sharp: no mineral alignment.
10	8	2 to 7	Olivine websterite, olivine clinopyroxenite, plagioclase-bearing websterite, olivine-bearing clinopyroxenite; medium- to coarse-grained	Zone comprises 2 modally graded layers: variable thickness of zone from about 2 to 7 m: the lower layer has a thickness that varies from 35 cm to 2 m and the upper layer has a thickness of 1.65 to 5 m: gradational contact between layers; xenoliths of feldspathic pyroxenite occur at base of upper layer and locally crosscut layer contact; plagioclase-bearing phases occur at the base of the zone: lower and upper contacts of zone are sharp and straight; no mineral alignment.	6	Gabbro and gabbronorite; medium-grained.	Uniform layer with local, 5 to 30 cm thick, intermittent gabbro layers defined by modal or grain size changes; some areas of mineral alignment; zone thins laterally.
9	3+	3+	Websterite, orthopyroxene-bearing clinopyroxenite; medium-grained	Zone comprises 2 uniform layers; layer contact is sharp; zone pinches and swells and one or both layers are locally absent; lower contact of zone is sharp and slightly irregular adjacent to volcanic septum; upper contact of zone is sharp, but truncated by overlying ultramafic zone; no mineral alignment.	Absent		
			Upper		**Septum**		
8	31.8	7.8	Olivine-bearing clinopyroxenite, olivine clinopyroxenite, clinopyroxenite, orthopyroxene-bearing clinopyroxenite, olivine websterite, websterite, olivine-bearing leucogabbro, orthopyroxene-bearing melagabbro, feldspathic clinopyroxenite; medium- to coarse-grained	Zone comprises 5 layers that are uniform or modally graded; layers range in thickness from 0.7 to 3.1 m; layer contacts are sharp and locally undulatory; gabbro or plagioclase-bearing phases occur at the top of 4 layers; internal layers (4 to 30 cm thick) defined by modal differences: xenoliths of gabbro occur at or near the base of lower layers and rapidly decrease in abundance upwards; lower contact of zone is sharp and straight and upper contact is sharp and irregular; no mineral alignment.	24	Gabbro, melagabbro, leucogabbro, and feldspathic pyroxenite; medium-grained.	Layered zone comprising 10 layers that are defined by variations in modal abundance and grain size: layers are modally layered, modally or grain size graded or uniform; contacts are sharp and locally wavy; layers, which are themselves modally layered, comprise internal layers that are mostly normally graded and less commonly reversely graded: intermittent discontinuous to continuous gabbro, melagabbro and leucogabbro laminae and layers occur in uniform or graded layers; intermittent gabbro and melagabbro layers are more common in lower layers and leucogabbro layers are more common in upper layers: local pyroxenite lenses in upper layer. contacts between intermittent layers and the adjacent rock are sharp to locally gradational; 5 layers have local to common mineral alignment;

Table 2 continued

CYCLE	THICKNESS	ULTRAMAFIC ZONE THICKNESS	LITHOLOGY	STRUCTURE	MAFIC ZONE THICKNESS	LITHOLOGY	STRUCTURE
7	5	2.4	Wehrlite, melagabbronorite, lherzolite, gabbro, olivine gabbro and olivine melagabbro; medium- to coarse-grained	Zone comprises 3 modally graded layers that from base to top of zone are 0.5, 1.5 and 0.4 m thick; locally inequigranular with up to 10% coarser grained pyroxene in clinopyroxene matrix; layer contacts are sharp, but one is slightly irregular; local magnetic intervals; plagioclase-bearing phases occur in lower half of zone and the top of the upper layer; lower contact of zone is sharp and irregular and upper contact is sharp and straight; no mineral alignment.	2.6	Melagabbro, gabbro, pyroxenite; medium-grained with local coarse-grained patches.	Zone consists of a lower uniform layer and an upper modally and grain size graded layer in which pyroxene grain size and plagioclase abundance increases upwards; local patchy coarser-grained areas; thin discontinuous pyroxenite at top of zone; well developed mineral alignment.
6	7.5	4.8	Olivine websterite, olivine clinopyroxenite, lherzolite, clinopyroxenite, olivine melagabbro; medium-grained.	Zone comprises 2 modally graded layers; the lower layer is 2.8 m and the upper layer 2.0 m thick; grain size is relatively uniform, but there are coarser grained areas that have a patchy distribution or occur as discontinous layers; local finer grained, irregularly shaped, rusty weathering patches; most of lower layer is magnetic; layer contact is sharp and straight; internal layers defined by changes in grain size and distribution of oikocrysts; internal layer contacts are relatively sharp; where not internally layered oikocrysts have a patchy distribution; lower contact of zone is not exposed, but upper contact is sharp and straight; no mineral alignment.	2.7	Gabbro and pyroxenite; medium-grained.	Uniform layer that contains two pyroxenite layers in lower half; plagioclase-phyric in upper 50 cm; intermittent layers have sharp to gradational contacts; pyroxene grain size increases upwards in upper part of zone; well developed mineral alignment.
5	62.7	16.1	Olivine clinopyroxenite, olivine-bearing clinopyroxenite, olivine websterite, orthopyroxene-bearing clinopyroxenite, feldspathic clinopyroxenite; medium- to coarse-grained with locally pegmatitic patches	Zone comprises 5 layers that are uniform or modally graded; layer thickness ranges from 0.5 to 10.2 m; a grain size graded layer occurs at top of zone and is locally pegmatitic at the top; layer contacts are sharp; slight mineral alignment in some layers; plagioclase-bearing phases occur at top of zone; local, slightly discordant, finer grained ultramafic patches, which are 5 to 20 cm thick and up to 40 cm long, occur in lower layers; local gabbro xenoliths; lower contact of zone is straight to wavy to scalloped and upper contact is sharp, but irregular.	46.6	Gabbro, melagabbro, leucogabbro, pyroxenite, anorthosite; largely medium-grained, but some layers are fine-grained; rare coarse-grained layers and local coarse-grained patches.	11 layers that are modally graded or, more commonly, modally layered; layer contacts are sharp; modal layers comprise uniform to modally graded to some grain size graded internal layers and lamina that are continuous to discontinuous; modal and grain size grading is both normal and reverse, but modal layers increase in plagioclase content from lowest internal layer to highest internal layer; internal layer contacts are sharp to gradational, but commonly oblique to layer contacts; patchy, irregular to elongate, textural and modal variations occur in some layers; intermittent melagabbro lamina and layers increase in abundance in upper layer; local mineral alignment in some layers.
4	26.8	9.6	Olivine websterite, olivine clinopyroxenite, olivine-bearing clinopyroxenite, clinopyroxenite, olivine-bearing websterite, orthopyroxene-bearing clinopyroxenite, melagabbro, gabbro, leucogabbro; medium- to coarse-grained	Zone comprises 3 layers that are uniform or modally graded; from base to top of the zone layers are 5.2, 2.9, and 1.5 m thick, respectively; layer contacts are sharp; internal layers, 3 to 20 cm thick, defined by variations in grain size, oikocrysts, and modal proportions; internal gabbro layers occur in middle of lowest layer; contacts between internal layers are sharp; lower contact is not exposed and upper contact is sharp; no mineral alignment.	17.2	Gabbro and gabbronorite; medium-grained.	Modal and grain size layered; contacts are sharp to gradational; textural layers occur locally and contain oikocrysts or patchy textural variations; layers are commonly discontinuous and discordant; local moderately well developed mineral alignment; local, angular, 5 to 10 cm, pyroxenite xenoliths near base of zone.
3	51.3	12.3	Clinopyroxenite, gabbro, melagabbro, feldspathic clinopyroxenite, orthopyroxene-bearing clinopyroxenite; medium- to coarse-grained.	Zone comprises 3 uniform layers that vary in grain size; from base to top of the zone layers are 5.7, 3.7, and 3.9 m thick; gabbro, ranging from 0 to 60%, occurs as equant to cylindrical clots up to 60 cm long or as discontinuous internal layers; clots occur in patches or are distributed relatively randomly in two layers; layer contacts are sharp; lower contact of zone is sharp and straight and the upper contact is sharp and irregular; no mineral alignment.	39.0	Gabbro and melagabbro; medium-grained.	Uniform zone that contains several melagabbro and leucogabbro layers; layer contacts are sharp to locally gradational; no mineral alignment.
2	4.1	2.15	Orthopyroxene-bearing clinopyroxenite, websterite, feldspathic websterite; medium- to coarse-grained.	Zone comprises 1 layer that is uniform; zone contacts are sharp, but lower contact is straight and upper contact is irregular; no mineral alignment	1.95	Melagabbro, leucogabbro and anorthosite; medium-grained.	Modally layered zone comprising several uniform layers; local pyroxenite and melagabbro xenoliths near base of zone; anorthosite clots occur in top layer; no mineral alignment.
			Lower		Septum		
1	5.5	4.8	Websterite, orthopyroxene-bearing clinopyroxenite, melagabbro; medium- to coarse-grained; except for melagabbro which is fine-grained.	Zone comprises a lower uniform layer and an upper modally graded layer; layers are 3.4 and 1.4 m thick; gabbro occurs at the top of the lower layer; lower contact is covered, but the upper contact is sharp and possibly slightly irregular; no mineral alignment.	0.7	Melagabbro; fine- to medium-grained.	Uniform layer; no mineral alignment.

relatively straight. Irregular zone contacts typically have an appearance of mafic blocks enclosed by ultramafic material. Cycle contacts are largely straight to locally undulatory.

3.3 Upper Mafic Group

The Upper Mafic Group comprises the bulk of the pluton. Based on reconnaissance work, Young and Ayres (1985) subdivided the group into 12 zones that range in thickness from 100 to 700 m (Table 1). The zones were defined by differences in texture, mineralogy, and structure. Lithologically, the zones consist of leucogabbro, gabbro, melagabbro and minor anorthosite; olivine-bearing gabbro and magnetite-rich gabbro, which has 1 to 10% magnetite, occur locally. The gabbro varies from megacrystic with up to 15%, 6-9 mm pyroxene megacrysts to equigranular with grain size from 1 to 3 mm. Plagioclase-phyric varieties occur locally.

Internal layering was only observed in one zone where lichen was burned off the outcrop, but heavy lichen cover may have obscured layering in other zones. Where observed, layers range from 1 mm to more than 1 m thick and vary modally from anorthosite to melagabbro; anorthosite layers are up to 6 cm thick. Internally, layers are uniform to modally graded and contacts are sharp.

Metamorphic grade increases upward with increasing proximity to the granitoid batholith. The original pyroxene is replaced by actinolite in the lower 1.5 km of the group and by hornblende at higher levels. Occurring with actinolite that has replaced pyroxene are single crystal albite pseudomorphs after plagioclase or rare relict bytownite-labradorite grains. The single crystal albite is partly to completely recrystallized to clinozoisite. Where hornblende replaces pyroxene at higher levels, the plagioclase is replaced by mosaic plagioclase and clinozoisite.

CHAPTER 4
MINERALOGY

Primary minerals in the Mafic-Ultramafic Group, in order of decreasing abundance, include clinopyroxene, olivine, orthopyroxene, plagioclase and oxides. Primary minerals have undergone minor to complete recrystallization (Table 3), but clinopyroxene, the oxides and rare olivine are preserved. Primary textures are generally well preserved by primary minerals and pseudomorphs, except in areas of more intense recrystallization. Minerals that have been completely recrystallized have been identified from pseudomorphs, but, in many places, identification of individual precursor minerals from pseudomorphs is dependent on the abundance of the original mineral and its texture. The degree of recrystallization increases towards metavolcanic septa.

4.1 Clinopyroxene

Clinopyroxene occurs as colourless to light green, anhedral to less commonly subhedral, equant to tabular, cumulus grains with postcumulus overgrowths. Postcumulus overgrowths are recognized by grain boundary irregularities and complex interdigitations. In the ultramafic zones of the Mafic-Ultramafic Group, clinopyroxene ranges in abundance from 2 to 100% and has a grain size of 0.06 mm to 8.0 cm; original grains are largely preserved. Clinopyroxene has a relatively restricted composition within the limits $Wo_{46.1-41.5}$, $En_{48.2-43.8}$, and $Fs_{13.9-7.5}$ (Figure 4; Table 7). Optically and chemically, most clinopyroxene grains are unzoned, although mineral chemical analyses indicate that rare, optically unzoned grains have lower $Mg/(Mg+Fe^{2+})$ in the margins than the core; Cr_2O_3 is unzoned across these grains (Figure 5).

There is a large variation in $Mg/(Mg+Fe^{2+})$ in some clinopyroxene, both within and between layers; this appears to be a function of variable Fe_2O_3 values (Table 7). The anomalously high values of ferric iron lead to anomalously high calculated $Mg/(Mg+Fe^{2+})$ values. The high values of ferric iron are considered to be anomalous because there are wide variations within, and between, layers. These variations could be caused by very fine-grained incipient alteration that was not observed optically. Changes in $Mg/(Mg+Fe^{2+})$ are greater than variations

Table 3. Secondary products from recrystallization of primary minerals.

MINERAL	PRODUCTS OF RECRYSTALLIZATION
Clinopyroxene	Largely preserved in the ultramafic rocks, but partly replaced, to varying degrees, by actinolite ± Fe-Ti oxides ± chlorite ± carbonate ± serpentine ± sphene, and in rare places quartz, clinozoisite, biotite and smectite; rare magnesio-hornblende occurs in samples that lack olivine, and tremolite occurs in samples containing abundant olivine. Actinolite occurs as light green to colourless, optically continuous rims that corrode inward (Figs. 7 and 11), especially along cleavages and fractures; very fine-grained Fe-Ti oxides are evenly to patchily disseminated in actinolite (Fig. 11) and are locally concentrated along cleavages and fractures (Fig. 11). Less commonly actinolite forms slightly greener multicrystal aggregates of randomly oriented, subhedral to euhedral, equant to bladed grains with sutured ends and common crosscutting habit (Fig. 14). Optically continuous actinolite is locally recrystallized to disseminated fine-grained actinolite that is concentrated along fractures, cleavages and, less commonly, along grain margins; in some places coarse-grained actinolite porphyroblasts crosscut optically continuous actinolite. Single-crystal and multicrystal actinolite have disaggregated and/or undulatory extinction in more deformed samples. The degree of recrystallization of chadacrysts in oikocrystic orthopyroxene and of clinopyroxene outside of the oikocrysts is similar, but matrix clinopyroxene has a more intense recrystallization near chlorite-clinozoisite pseudomorphs after orthopyroxene than enclosed chadacrysts. Recrystallization is more intense near metavolcanic septa. Chlorite is highly variable in abundance ranging from 0 to 80% of any one clinopyroxene grain and is most abundant near chlorite-clinozoisite pseudomorphs. Carbonate occurs mostly in samples with crosscutting fractures that also contain carbonate.
Olivine	Olivine is completely recrystallized except for rare relict cores in serpentine aggregates (Fig. 13); in samples with relict olivine a yellowish-brown cryptocrystalline aggregate of unidentified minerals partly replaces olivine. Olivine is generally replaced by one of two mineral aggregates that are dominated by either serpentine or tremolite; generally, serpentine-rich pseudomorphs weather reddish and tremolite-rich pseudomorphs weather white. The occurrence and abundance of serpentine or tremolite is generally proportional to the abundance of the original olivine: with increasing olivine the abundance of serpentine increases. Both types have similar internal structure generally consisting of a monomineralic rim of varying width and a core that consists of a fine-grained aggregate of several minerals (Figs 15, 16 and 17); both types are locally monomineralic. The serpentine-rich pseudomorphs consist of a rim of radiating light green serpentine that is cored by interpenetrating serpentine or a multicrystal mat of fine-grained acicular tremolite, serpentine, carbonate and Fe-Ti oxides (Figs. 15 and 16). Original olivine grains are outlined by a mesh-like network of fine sutures that are enhanced by concentrations of Fe-Ti oxides and/or carbonate (Figs. 13 and 15); the pseudomorphic outline of olivine is destroyed with increasing serpentinization (Fig. 14). Serpentine along the rim is crosscut by a finer grained serpentine or locally by euhedral to subhedral porphyroblastic tremolite and lesser abundances of carbonate ± Fe-Ti oxides. Tremolite-rich pseudomorphs consist of optically continuous, colourless to light green tremolite that varies from thin, partial to complete, margins surrounding cores of multicrystal aggregates to complete replacement of the original olivine; olivine that is completely replaced by tremolite occurs where olivine is enclosed by clinopyroxene. Tremolite extends out from the margin between clinopyroxene and olivine, but is commonly in optical continuity with the actinolite that is replacing clinopyroxene. Where optically continuous tremolite is only marginally developed, the core is a multicrystal aggregate that includes one or more of the following: (a) chlorite as aggregates of fine-grained randomly oriented grains or rare optically continuous plates; (b) fine-grained tremolite aggregates in which grains are either randomly oriented or parallel (Fig. 17); (c) radiating aggregates of serpentine. Fine-grained tremolite aggregates are commonly associated with chlorite or serpentine aggregates in the core, but only in rare samples do chlorite and serpentine aggregates after olivine occur together. In serpentine aggregates, fine-grained tremolite occurs as randomly oriented multicrystal mats where individual grains are commonly difficult to differentiate (Fig. 15), but in chlorite aggregates fine-grained tremolite grains are much better defined. Chlorite is more abundant near or adjacent to pseudomorphs after oikocrystic orthopyroxene or cumulus orthopyroxene, both of which are replaced by chlorite; fine-grained aggregates of diopside occur locally (Fig. 19). Lesser abundances of carbonate and Fe-Ti oxides form patches or disseminations in these aggregate types.

Table 3. continued . . .

Orthopyroxene	Orthopyroxene is completely replaced by multicrystal aggregates composed of one of: (1) actinolite + chlorite ± carbonate ± Fe-Ti oxides ± serpentine ± diopside; (2) chlorite ± clinozoisite ± carbonate ± Fe-Ti oxides ± diopside ± actinolite ± sphene; (3) actinolite ± Fe-Ti oxides ± carbonate; (4) serpentine ± actinolite ± carbonate; and (5) talc ± Fe-Ti oxides ± carbonate; aggregate 1 occurs after cumulus grains, aggregates 2 and 4 occur after oikocrysts, and aggregates 3 and 5 occur after discrete postcumulus orthopyroxene. In aggregate 1 chlorite is more abundant than actinolite, which in some samples, occurs only in trace abundances. Actinolite occurs as single crystals (Fig. 20), incipiently recrystallized to multicrystal aggregates of mostly actinolite, chlorite and carbonate; in oikocrysts actinolite occurs mostly as optically continuous margins that replaces adjacent clinopyroxene and extends into orthopyroxene. Single crystal actinolite is colourless to light green and has a common mottled extinction; some extinction patterns suggest multicrystal habit of parallel grains with diffuse to sharp mutual boundaries. Optically continuous actinolite is recrystallized to multicrystal chlorite or tremolite that is variably disseminated or concentrated along cleavages, fractures or near the margins of pseudomorphs. Chlorite occurs mostly as aggregates of randomly oriented, multicrystal grains after oikocrysts (Fig. 24) where chlorite grain size is commonly less than 0.01 mm; chlorite also occurs as a relatively common constituent of aggregates after cumulus grains. Where part of pseudomorphs after cumulus grains, chlorite occurs as optically continuous grains occupying most of the central part of the pseudomorph and is crosscut by finer grained chlorite; optically, chlorite that replaces cumulus grains has greenish grey interference colours. Chlorite in pseudomorphs after cumulus grains also occurs locally as multicrystal aggregates (Figure 19), similar to chlorite that replaces poikilitic orthopyroxene (Fig. 24); optically, this chlorite has green interference colours; Oikocrysts that are replaced by serpentine only occur in zone 9. Clinozoisite comprises trace to 99% of individual oikocrysts within samples and is randomly distributed, patchy or massive. Clinozoisite that is randomly distributed occurs in pseudomorphs comprised mostly of chlorite and is associated with clinopyroxene chadacrysts and clinopyroxene outside of oikocrysts. Clinozoisite that has patchy habits occurs adjacent to clinopyroxene chadacrysts, especially in oikocrysts with more than average abundance of chadacrysts, is more common in cores of oikocrysts than margins, and mostly occurs in oikocrysts with less abundant chlorite; shape of the patches varies from tabular to irregular. Massive clinozoisite is associated with randomly distributed carbonate and/or chlorite that is commonly restricted to cross-cutting fractures or occurs in samples that also contain plagioclase.
Plagioclase	Plagioclase is completely replaced by single crystal albite and/or clinozoisite plus less common chlorite, actinolite, carbonate and Fe-Ti oxides. Clinozoisite is the most abundant recrystallization product and albite was observed only rarely; the abundant clinozoisite, which generally occurs as massive replacement, obscures recognition of individual plagioclase pseudomorphs. Chlorite and actinolite, which are spatially associated with adjacent olivine or clinopyroxene, respectively, commonly crosscut clinozoisite aggregates; actinolite most commonly extends from adjacent clinopyroxene. Chlorite and actinolite are also commonly concentrated adjacent cross-cutting fractures. Chlorite abundance in plagioclase is a direct function of proximity to oikocrysts, with highest chlorite abundance in plagioclase adjacent to oikocrysts.
Oxides	Partly to completely replaced by (a) single crystal chromite with partial magnetite rims (Fig. 27) or (b) multicrystal aggregates, which have fine serrated margins, of chromite and/or magnetite. Grains that occur between silicate minerals or enclosed in minerals replaced by pseudomorphs have chromite margins or are completely replaced by chromite (Figs 27 and 28); Cr/Fe ratios range from 0.26 to 0.48 in the core to 0.31 to 1.02 in the margin. Oxide grain size also has a bearing on replacement with smaller grains having a higher degree of replacement than larger grains in the same sample. Sphene occurs locally along pseudomorph margins.

in the ratio of enstatite component to ferrosilite component (En/Fs) (Plate 1; Table 7). In order to dampen these effects and better analyze clinopyroxene fractionation En/Fs is used throughout the remainder of this thesis.

Relationships between adjacent clinopyroxene grains vary from classic cumulus textures (Figure 6, Wager et al., 1960; Wager and Brown, 1967) to highly irregular intergrowths (Figure 7). Within the plane of a thin section some clinopyroxene grains are discontinuous and comprise several separated segments that have optical continuity (Figure 8). Boundaries between adjacent clinopyroxene grains vary from straight to curved (Figure 6) to wavy to lobate or dentate (Figures 8, 9, and 10) to intergrown (Figure 7).

Straight to curved grain margins are the most common type of margin. Straight to curved margins occur (a) most commonly along only part of a grain circumference, but vary widely in proportion relative to other types of grain margins (Figures 8 and 11); or (b) less commonly along the complete circumference. Grains that have straight to curved boundaries along the complete circumference occur as local grains in individual samples or, as in zone 3, the predominant grain type (Figure 6). Where boundaries are mostly irregular with local straight to curved segments, the apparent straight to curved boundaries may be an artifact of the two dimensional nature of thin sections; these grains may have variable boundaries in three dimensions.

Intermediate in degree of complexity between straight to curved type margins and intergrown type margins are irregular margins that vary from wavy to lobate to dentate (Figures 8, 9 and 10). These types of boundaries are the second most abundant type of margin; most clinopyroxene grains have boundaries that are partly wavy or lobate or dentate and partly straight to curved. Wavy margins have systematic or random undulations that generally have an amplitude of about 0.2 mm. Ubiquitous lobate or dentate margins, of which dentate margins are more common, have relatively low amplitude interdigitations that parallel (Figure 9c) or crosscut cleavage (Figures 9a, 9b) of the adjacent grain. Interdigitations generally penetrate about 0.1 to 0.4 mm, but in some places are larger. Interdigitations that have larger amplitude vary from thin and elongate to

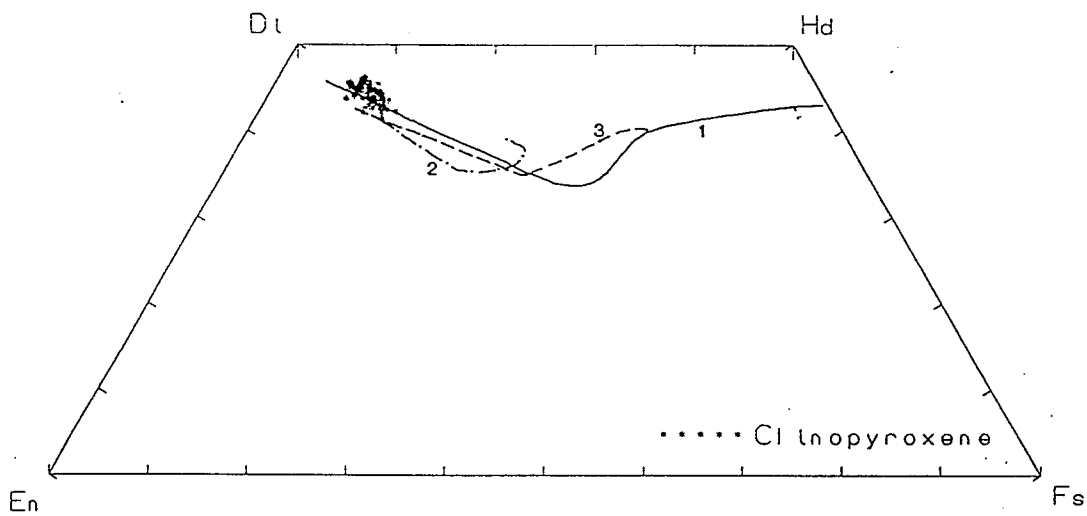


Figure 4. Clinopyroxene composition plotted in the pyroxene quadrilateral. Data points are the average composition of clinopyroxene from each sample (Table 7). The compositional trend of clinopyroxene from other intrusions include: (1) Bushveld Complex (Atkins, 1969); (2) Jimberlana Complex (Campbell and Borley, 1974); and (3) Skaergaard Intrusion (Brown and Vincent, 1963). Abbreviations are: Di - diopside; Hd - hedenbergite; Fs - ferrosilite; En - enstatite.

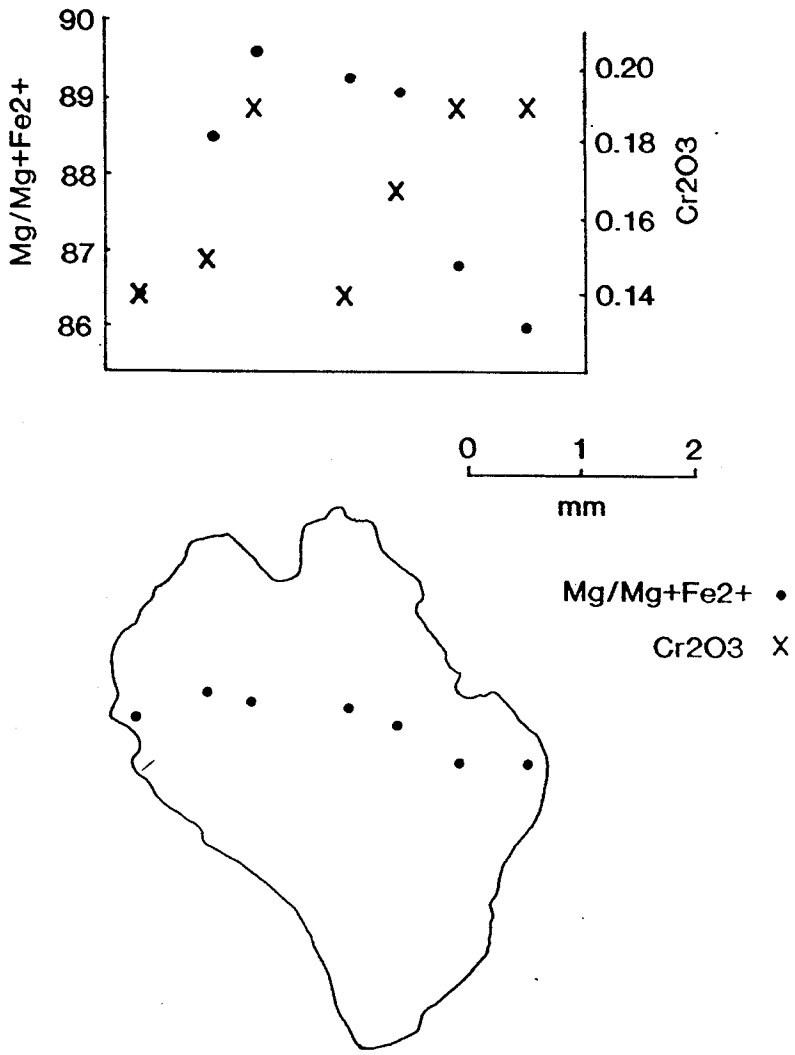


Figure 5. Compositional variation in Mg/(Mg+Fe^{2+}) and weight percent Cr_2O_3 from a reconnaissance microprobe traverse across a cumulus clinopyroxene grain from sample 338 (Table B.1; Appendix B).

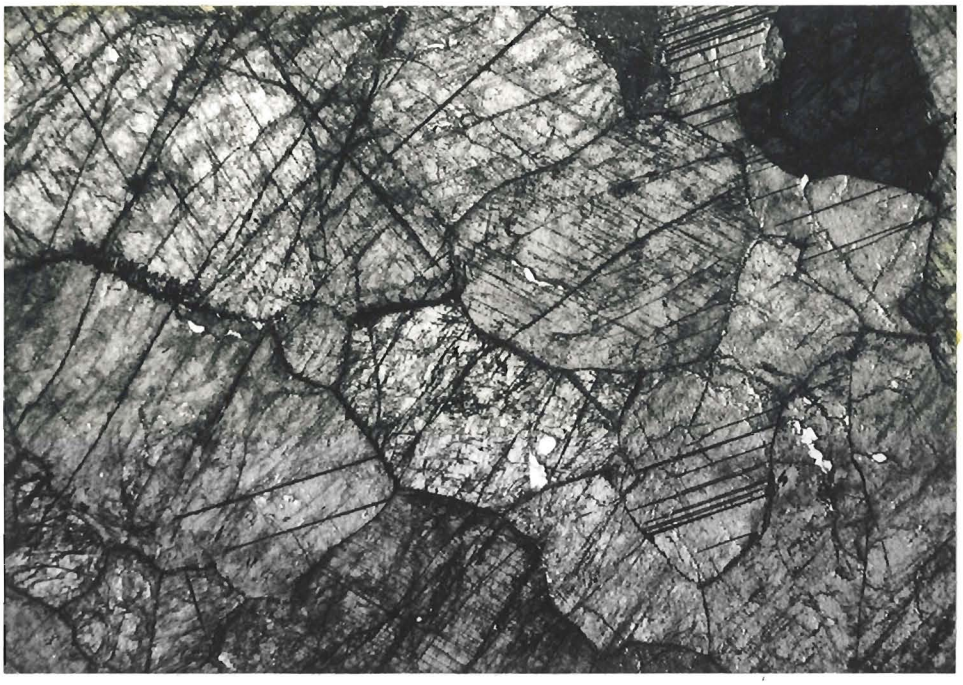


Figure 6. Cumulus clinopyroxene with postcumulus overgrowths. Grains have straight to curved, concave to convex margins. *Clinopyroxenite, zone 3. Field of view = 7.5 mm. Plane light*

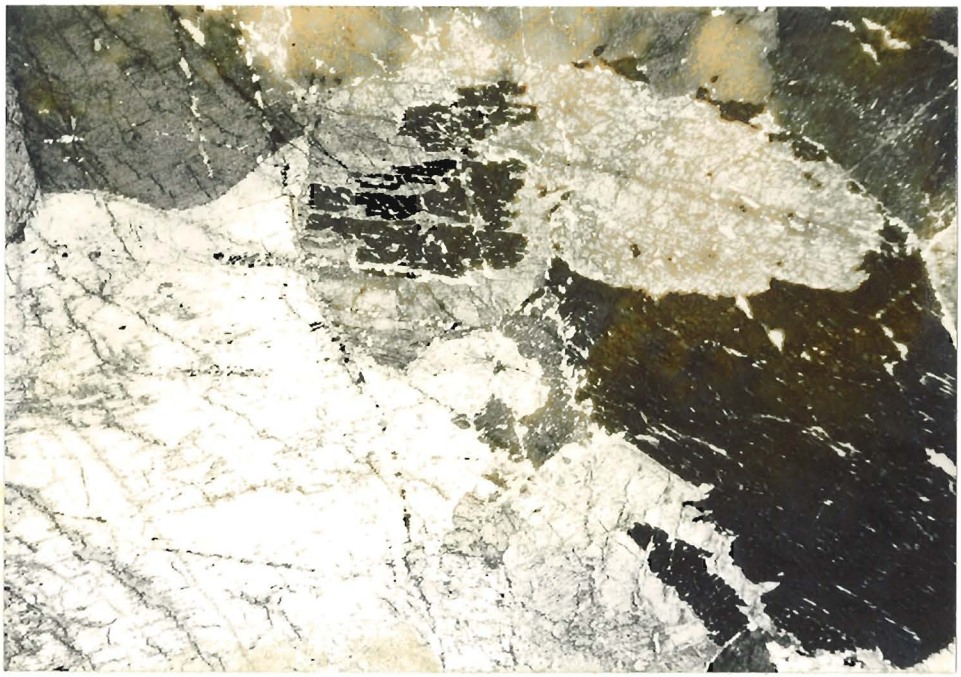


Figure 7. Cumulus clinopyroxene with common straight to curved margins, except for an interpenetrating boundary between two grains in the upper center to right side of the photomicrograph. The elongate grey grain in the upper center of the photomicrograph consists of two parts: an equant part that contains discontinuous intergrowths, which parallel cleavage, of an adjacent grain (dark grey to black) and a large leaf-shaped apophysis that is largely surrounded by the adjacent grain (dark grey to black); the apophysis is elongate, parallel to subparallel to cleavage in the darker clinopyroxene. Secondary actinolite occurs as optically continuous partial margins (light grey to white) or as randomly distributed patches that are optically continuous with the actinolite margins. *Orthopyroxene-bearing clinopyroxenite, zone 8. Field of view = 8.0 mm. Crossed nicols.*

Figure 8. Diagram traced from a magnified thin section of olivine-bearing clinopyroxenite. No olivine occurs in this figure. Grain margins on clinopyroxene are irregular, dentate to lobate or less commonly straight to curved. Clinopyroxene is highly irregular and commonly discontinuous within the plane of the thin section. Discontinuous segments are optically continuous as exemplified here by one clinopyroxene grain that is shaded green. Cleavage traces are plotted as straight lines to better differentiate between various grains.

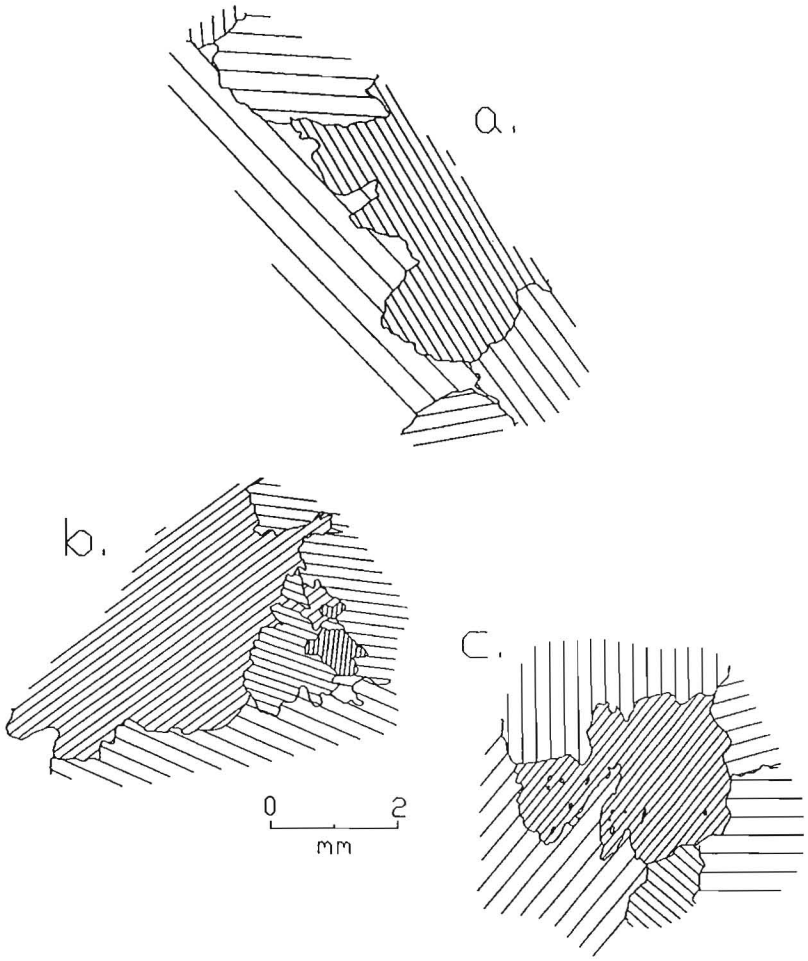


Figure 9. Variations in nature of boundaries between cumulus clinopyroxene grains traced from magnified thin sections. Cleavage traces are plotted as straight lines to better differentiate between various grains. **a.** Slightly irregular, dentate to locally lobate, grain margins between several clinopyroxene grains in clinopyroxenite. Interdigitations vary in amplitude along the grain margins and tend to be only slightly wavy along a part of the margin between two grains in the upper left of the diagram. **b.** Intergrown clinopyroxene grains in clinopyroxenite. Two grains on the right center of the diagram are discontinuous in the plane of the thin section. Interdigitations are irregular, lobate to dentate and occur randomly along grain margins. **c.** Highly irregular, dentate to locally lobate, grain margin between two grains in olivine-bearing clinopyroxenite; no olivine occurs in the diagram. One interdigitation extends almost halfway across the adjacent grain, the outer part of which is slightly mottled by secondary actinolite (green).

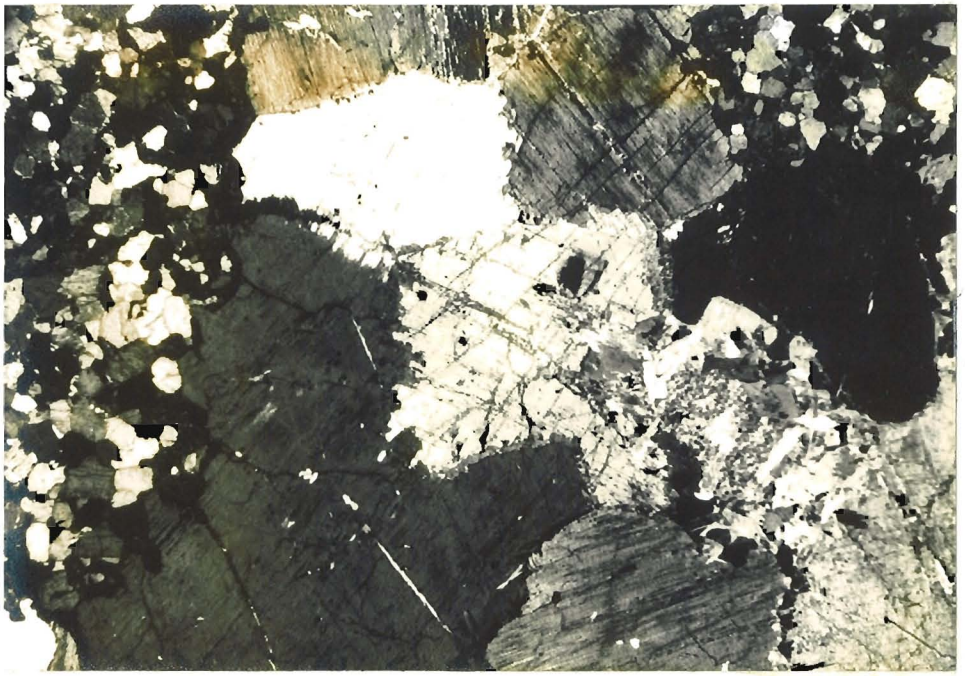


Figure 10. Aggregate of cumulus clinopyroxene adjacent to poikilitic orthopyroxene containing finer grained cumulus clinopyroxene (left and top right) and a pseudomorph after amoeboid olivine (right center, multicrystal aggregate). Grain margins between clinopyroxene are straight to curved to locally irregular. The irregular margins vary from an undulatory habit to dentate. *Olivine-bearing clinopyroxenite, zone 11. Field of view = 8.0 mm. Crossed nicols.*

stubby, relatively equant apophyses (Figure 11). Larger amplitude, thin, elongate apophyses commonly parallel cleavage in adjacent grains, but stubby apophyses do not have a well defined orientation relative to cleavage in adjacent grains.

Intergrown grains are the most complex type of grain margin. Intergrowths consist of one or more clinopyroxene grains that, in the plane of the thin section, are partly, or possibly entirely, enclosed by an adjacent clinopyroxene grain (Figures 7 and 12). In places, differences between intergrowths and irregular types of grain margins are slight, and the two types appear to be gradational (Figures 9c and 12b). The enclosed part of a grain is continuous with, or is separated from, but has the same optic orientation as, an adjacent parent grain. (Figure 7). Enclosed grains occur as irregular, equant to, more commonly, elongate patches approximately parallel to cleavage of the adjacent enclosing grain (Figures 7 and 12a). Secondary actinolite, which is optically continuous, occurs along part of the boundary between the clinopyroxene grains in an intergrowth (Figure 7).

Intergrowths vary in complexity, both between and within samples. The abundance of enclosed grains ranges from 0 to 18.3%. The degree to which two grains are intergrown varies from isolated patches of clinopyroxene comprising about 1% of an adjacent grain to patches of clinopyroxene that extend across, and comprise more than half of, an adjacent clinopyroxene. Furthermore, clinopyroxene that has the same optic orientation as intergrown parts of grains, but is not enclosed by the adjacent grain can also enclose parts of other grains. There are 1 to 10 intergrown grains enclosed in any one clinopyroxene grain.

4.2 Olivine

Olivine occurs as 0.07 to 4.6 mm, equant to ovoid to tabular, anhedral to euhedral, cumulus grains; olivine abundance ranges from 0 to 80%. Except locally in the upper cycles, olivine is completely replaced by secondary minerals (Table 3; Figures 13 and 14). In outcrop, olivine occurs as rusty weathering recessed areas, which are generally smaller than, or the same size as adjacent clinopyroxene, or as white weathering areas that are smaller than adjacent clinopyroxene; as the abundance of rusty weathering olivine increases, olivine and clinopyroxene generally become similar in size.

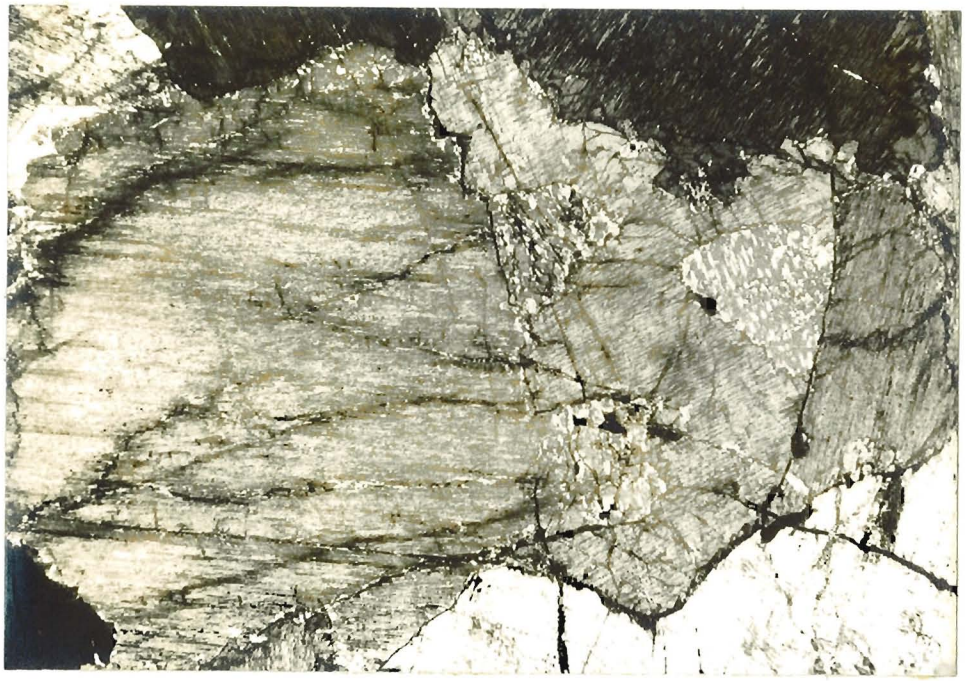


Figure 11. Relatively equant cumulus clinopyroxene grains that have relatively straight to curved grain margins, except for two grains near the center of the photograph that have more complex margins. Along the right side of the large clinopyroxene (grey to patchy white grain on left side of photograph, crosscut by black to grey fractures) two stubby finger-like apophyses extend into the adjacent clinopyroxene. Disseminated white patches in the apophyses and near the margins of the clinopyroxene are optically continuous actinolite that is replacing the clinopyroxene. Secondary Fe-Ti oxides occur along clinopyroxene margins or are associated with crosscutting fractures. *Clinopyroxenite, zone 15. Field of view = 9.0 mm. Crossed nicols.*

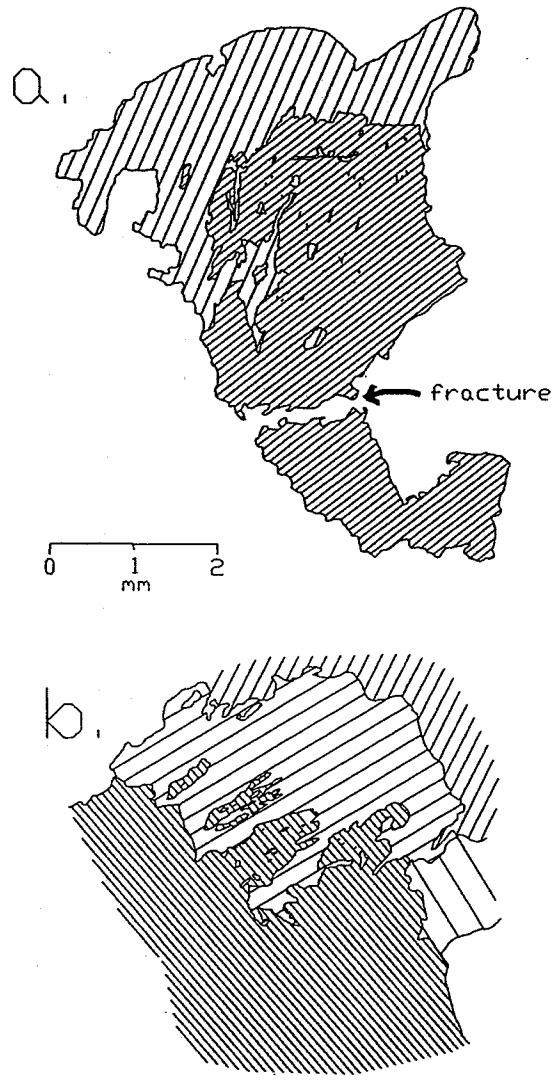


Figure 12. Intergrown cumulus clinopyroxene grains traced from magnified thin sections. Cleavage traces are plotted as straight lines to better differentiate between various grains. **a.** Two intergrown clinopyroxene grains in olivine-bearing clinopyroxenite; no olivine occurs in this figure. The intergrown part of the grain forms continuous to discontinuous, mottled elongate patches that extend about half way across the adjacent grain. Intergrown parts of grains are relatively parallel to cleavage in the adjacent grain. **B.** Two intergrown clinopyroxene grains in clinopyroxenite. The parent grain to the lower left grades into the intergrown part of the grain as defined by: (1) mottling by patches of an adjacent clinopyroxene in an intergrown patch that increases in amount towards the adjacent clinopyroxene; and (2) the irregular apophyses and isolated patches of intergrown grain that are elongated relatively parallel to cleavage in the adjacent grain.

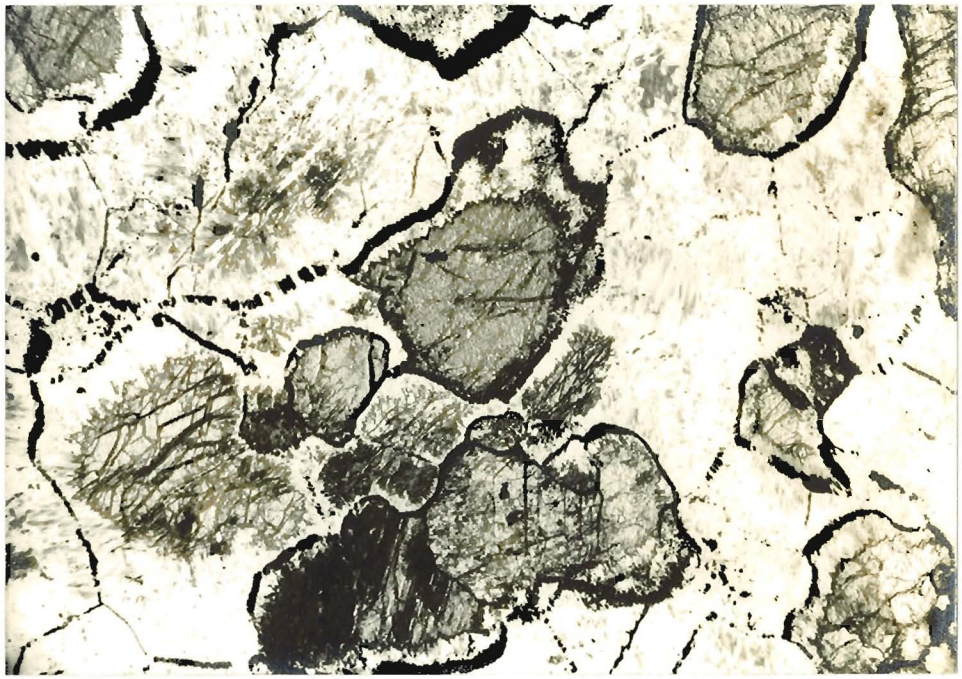


Figure 13. Relict, cumulus olivine (grey, highly fractured mineral, left to lower left side) and clinopyroxene (grey, center, has cleavage). The olivine is largely replaced by aggregates of radiating serpentine (white to grey). The original texture is preserved by the net pattern that is enhanced by an increased abundance of Fe-Ti oxides along pseudomorph margins. *Lherzolite, zone 14. Field of view = 5.1 mm. Plane light.*

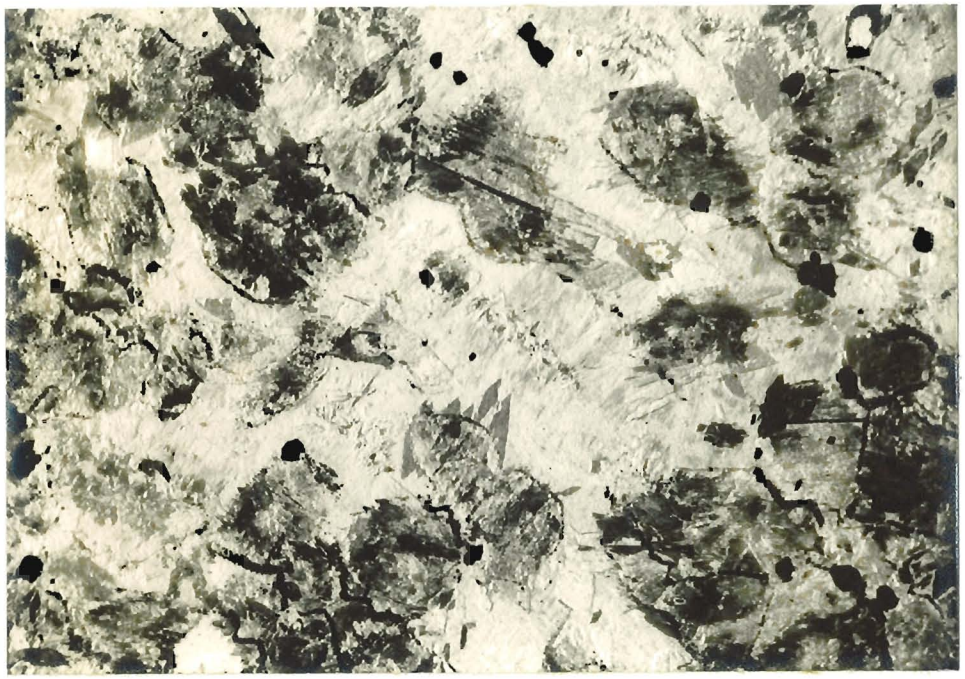


Figure 14. Serpentine pseudomorphs after cumulus olivine associated with cumulus clinopyroxene that is largely replaced by single to multicrystal actinolite plus Fe-Ti oxides. Porphyroblastic actinolite (dark grey, center of photograph) from the clinopyroxene extends into serpentine pseudomorphs after olivine; Fe-Ti oxides are concentrated along grain margins or are patchily to randomly distributed. Cumulus chromium spinel is largely enclosed in olivine or occurs between clinopyroxene and adjacent grains. *Olivine clinopyroxenite, zone 4. Field of view = 4.5 mm. Plane light.*

Olivine has two habits: a) equant to ovoid to locally tabular, subhedral to anhedral, cumulus grains between cumulus clinopyroxene (Figure 15); and b) smaller, equant to ovoid, subhedral to euhedral, cumulus grains that are enclosed in cumulus clinopyroxene (Figure 16). Cumulus grains that occur between clinopyroxene have a grain size of 0.1 to 4.6 mm and relatively straight to curved margins; curved margins vary from concave to convex. In addition to the common broad curvature, concave margins are locally wavy or more commonly scalloped adjacent to clinopyroxene (Figure 15); convex margins only appear to have a broad curvature. In some layers, olivine texture is more complex and olivine is irregular to amoeboid (Figures 17 and 18). Although most olivine occurs at the junction of several clinopyroxene grains, pseudomorphs also occur along grain margins between two grains; these grains are generally more irregular than olivine that occurs at the junction of several clinopyroxene. Olivine that occurs at the junction of three or more clinopyroxene commonly has thin fingers projecting outward between adjacent clinopyroxene. Finger length is up to 50% of the diameter of the parent olivine grain.

Olivine that is enclosed by clinopyroxene is commonly subhedral to locally euhedral and has relatively polygonal habits (Figure 16). This olivine type ranges from 0 to 50% of the total olivine, but only exceeds 5% of the total olivine in about 15% of the layers; grain size ranges from 0.07 to 1.3 mm. Grain margins are largely straight to slightly curved and 6-sided and 8-sided shapes are relatively common.

In zones 3, 4, 5, 11, and 13, some olivine, particularly grains between clinopyroxene, contain up to 5%, rounded, equant to tabular, fine-grained clinopyroxene, which is much smaller than clinopyroxene adjacent to olivine (Figures 16, 17 and 18). The small clinopyroxene grains most commonly occur near the margins of the olivine (Figures 17 and 18).

4.3 Orthopyroxene

Orthopyroxene, which ranges in abundance from 0 to 64%, occurs as a) cumulus grains with or without postcumulus overgrowths (Figures 19 and 20); b) discrete postcumulus grains (Figure 21); and c) poikilitic grains (Figures 18, 22

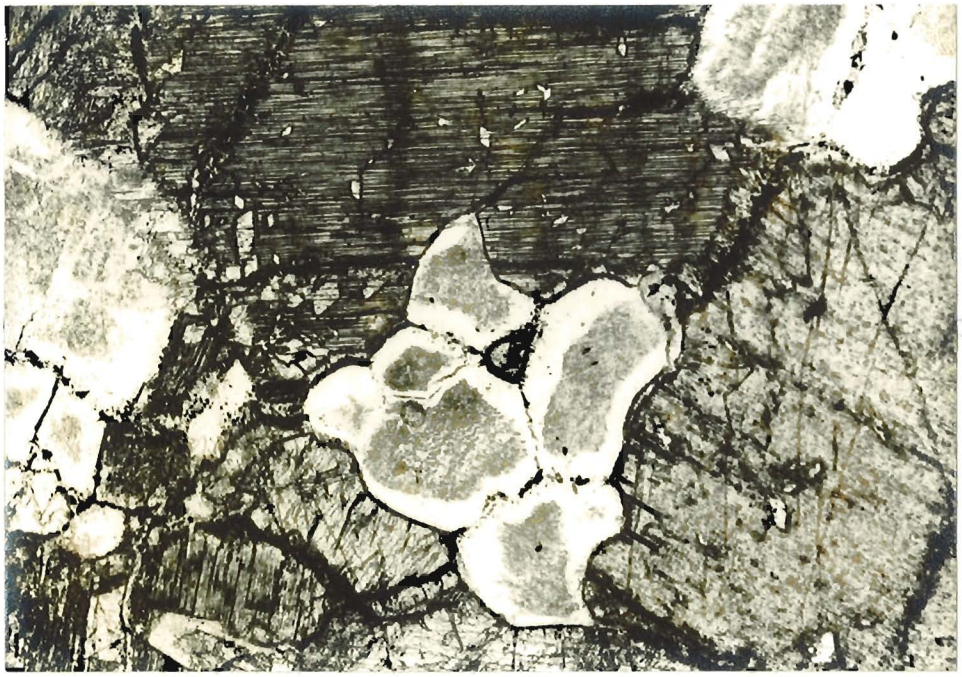


Figure 15. Multigrain aggregate of anhedral to subhedral, cumulus olivine (white to light grey) between clinopyroxene (grey). A couple of olivine grains have scalloped concave margins adjacent to clinopyroxene. The olivine is replaced by multicrystal aggregates of serpentine(white) + tremolite(grey) + chromite ± magnetite. Serpentine occurs as an outward radiating aggregate of parallel blades that is cored by a finer grained aggregate of randomly oriented tremolite and serpentine. Chromite and magnetite are largely concentrated along pseudomorph margins, but some grains are randomly distributed. *Olivine clinopyroxenite, zone 5. Field of view = 4.5 mm. Plane light.*

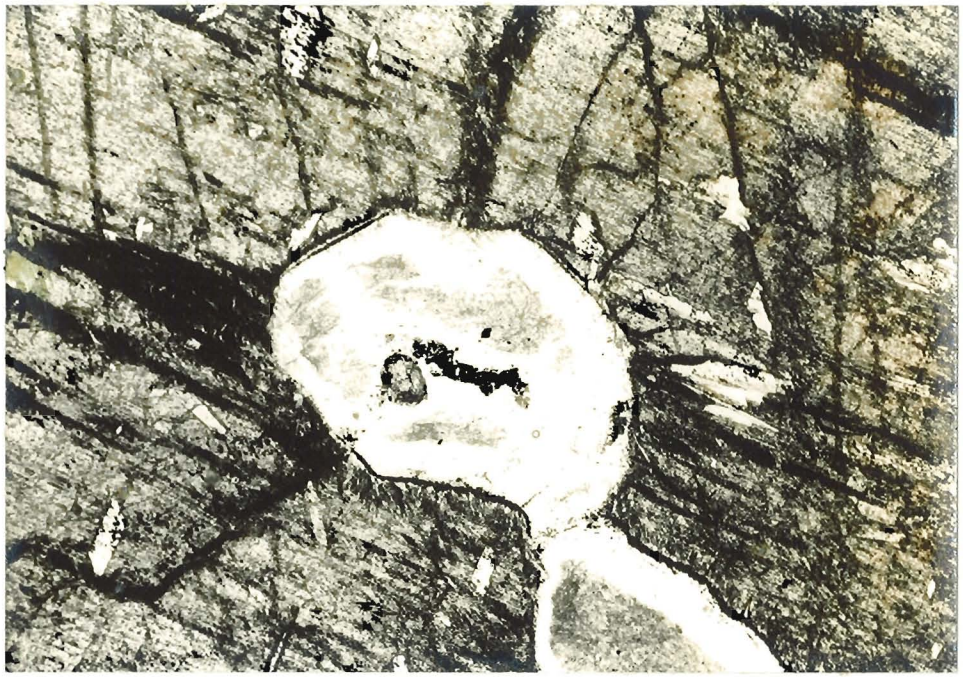


Figure 16. Two pseudomorphs after euhedral cumulus olivine enclosed by clinopyroxene. A fine-grained, rounded cumulus clinopyroxene grain occurs near the center of one olivine pseudomorph. The olivine is replaced by a rim of serpentine (white) and an aggregate of finer-grained tremolite + serpentine (grey) in the core. Magnetite occurs as an irregular aggregate in the core of the pseudomorph in the center of the photomicrograph or concentrated along the margins of the pseudomorph. The enclosing clinopyroxene (grey) is partly recrystallized to multicrystal tremolite (white) and Fe-Ti oxides; Fe-Ti oxides occur largely along cleavages and fractures. *Olivine websterite, zone 4. Field of view = 9.0 mm. Plane light.*

Figure 17. Pseudomorph after anhedral cumulus olivine (white to light grey) that occurs between several cumulus clinopyroxene grains (grey). The olivine has a resorbed, amoeboid shape. Fine-grained, rounded, cumulus clinopyroxene (grey, high relief in olivine) occurs near the margins of the olivine. The fine-grained clinopyroxenes are not optically continuous with clinopyroxene adjacent to olivine. Olivine is replaced by optically continuous tremolite (white to light grey), the core of which has been recrystallized to an aggregate of fine-grained tremolite + carbonate + chlorite + Fe-Ti oxides. Porphyroblastic bladed tremolite (white crystals, left side of pseudomorph) crosscuts the core of the pseudomorph. *Olivine clinopyroxenite, zone 6. Field of view = 5.0 mm. Crossed nicols.*

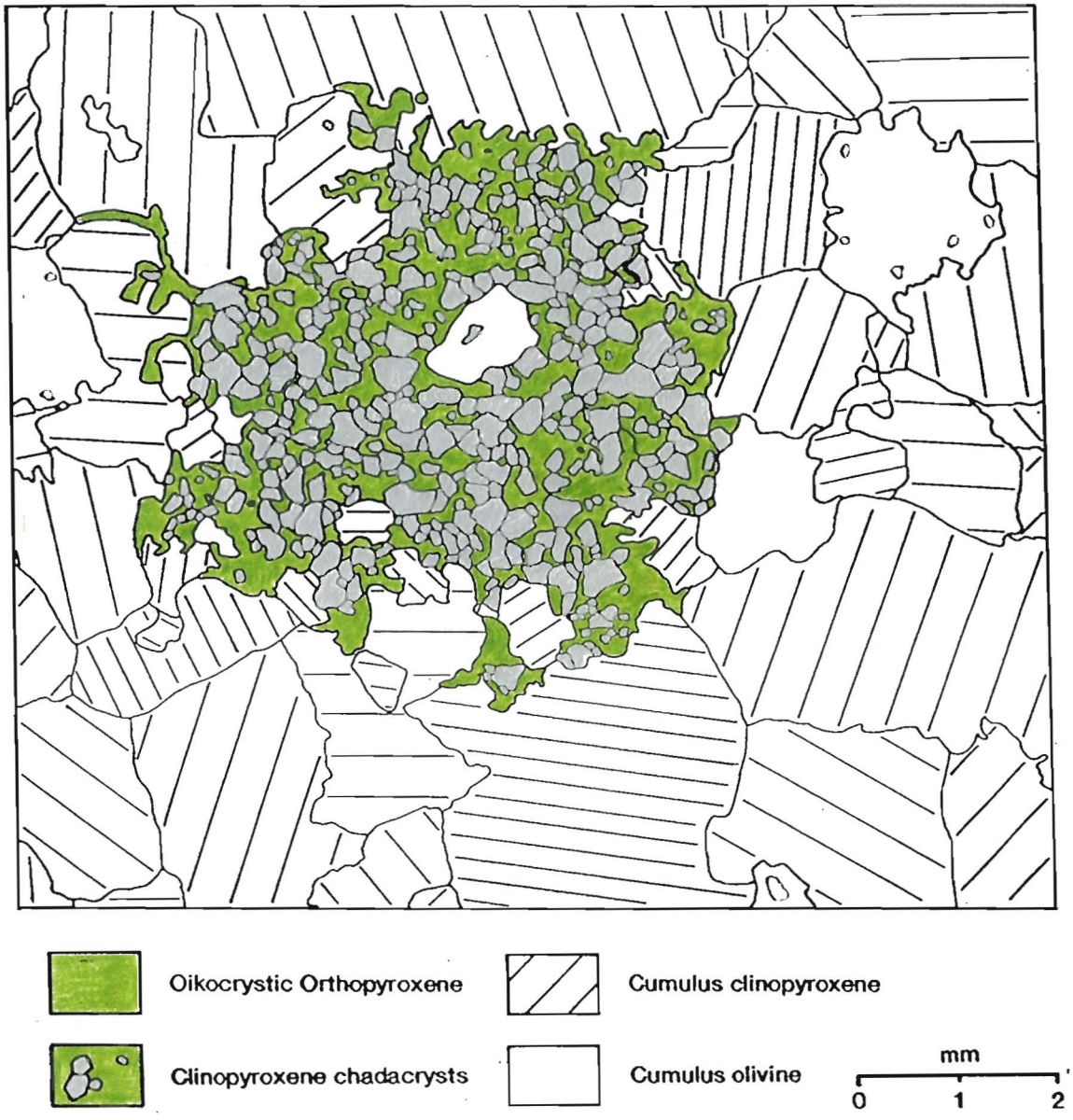


Figure 18. Diagram traced from a magnified thin section of olivine websterite. Irregular to amoeboid, cumulus olivine between cumulus clinopyroxene or enclosed in poikilitic orthopyroxene. Several small clinopyroxene grains occur along the margins of the olivine. Poikilitic orthopyroxene that is relatively equant hosts largely subhedral, fine-grained clinopyroxene; included clinopyroxene is much smaller than clinopyroxene adjacent to the oikocryst. Grain margins between the orthopyroxene and clinopyroxene are straight to curved to irregular to lobate.

and 23). Orthopyroxene ranges from 0.09 to more than 21.0 mm. Orthopyroxene is completely replaced by one of five assemblages of secondary minerals that are dependent, in part, on the type of orthopyroxene that the assemblage is replacing (Table 3).

Cumulus orthopyroxene occurs as 0.09 to 6.3 mm, anhedral to subhedral, equant to tabular grains with straight to scalloped to irregular grain margins where adjacent to clinopyroxene and olivine (Figures 19 and 20). Cumulus grains range in abundance from 0 to 64% in any one layer, and are either distributed throughout layers or are concentrated in orthopyroxene-rich laminae. Cumulus orthopyroxene occurs in about half of the examined zones. Postcumulus overgrowths are recognized by the anhedral shapes and scalloped margins on clinopyroxene and olivine. Although the abundance of postcumulus overgrowth was not determined, it appears to increase in abundance upwards in any one layer.

Discrete postcumulus orthopyroxene is relatively rare with a maximum abundance of about 3%; grain size is up to 14 mm. It forms irregular interstitial areas that variably enclose cumulus clinopyroxene that is generally slightly smaller than clinopyroxene not enclosed in postcumulus orthopyroxene (Figure 21). Clinopyroxene that is adjacent to discrete postcumulus orthopyroxene commonly has at least partial crystal form.

Orthopyroxene oikocrysts ranges in abundance from 0 to 50% and have a much greater distribution than the other orthopyroxene habits; grains are up to 21.0 mm. In outcrop oikocrysts are rounded, equant to tabular, recessed features (Figure 22) that vary in abundance and size within and between layers. Within a layer the distribution of oikocrysts varies from upward changes in abundance and size, to an irregular patchy distribution, to a relatively uniform distribution. Where oikocrysts are touching, mutual grain boundaries are sharply defined.

Petrographically, oikocrysts are equant to tabular to more irregular shaped (Figures 18 and 23) and commonly touch where oikocrysts are abundant. Grain margins with adjacent cumulus clinopyroxene vary from locally straight to more commonly irregular; in some oikocrysts the contact has an irregular lobate form with an amplitude up to 0.5 mm (Figures 18 and 24). In some places, orthopy-

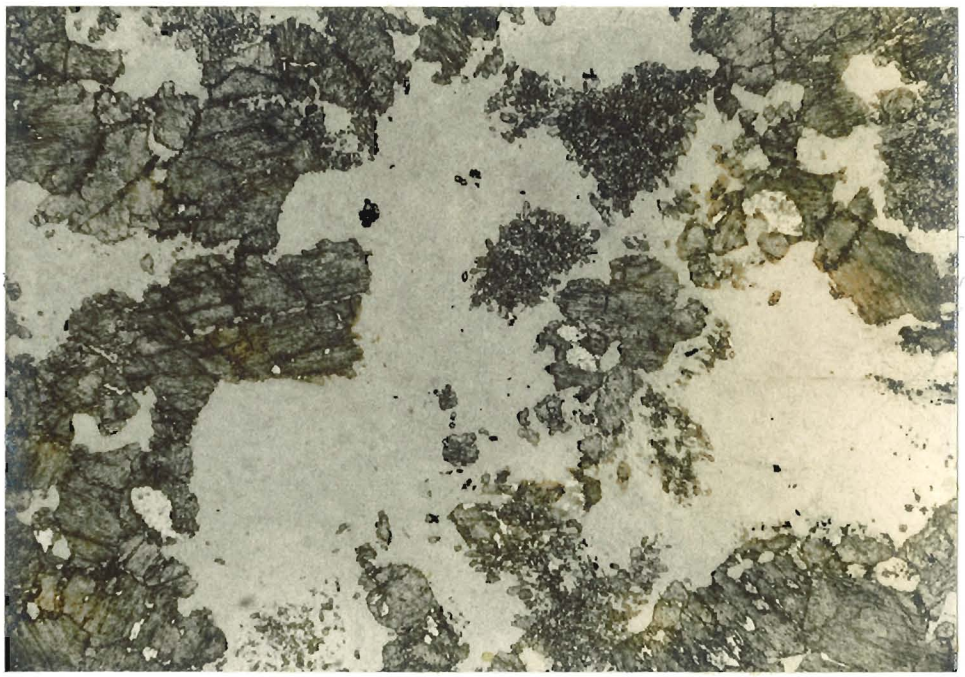


Figure 19. Chlorite pseudomorphs after cumulus orthopyroxene (light grey), which have tabular shapes, associated with cumulus clinopyroxene (dark grey to grey, grains have cleavage lines) and diopside + chlorite pseudomorphs after cumulus olivine (dark, fine-grained, multicrystal aggregates, lower center). The clinopyroxene has slightly scalloped margins adjacent to the orthopyroxene. *Olivine websterite, zone 4. Field of view = 9.0 mm. Plane light.*

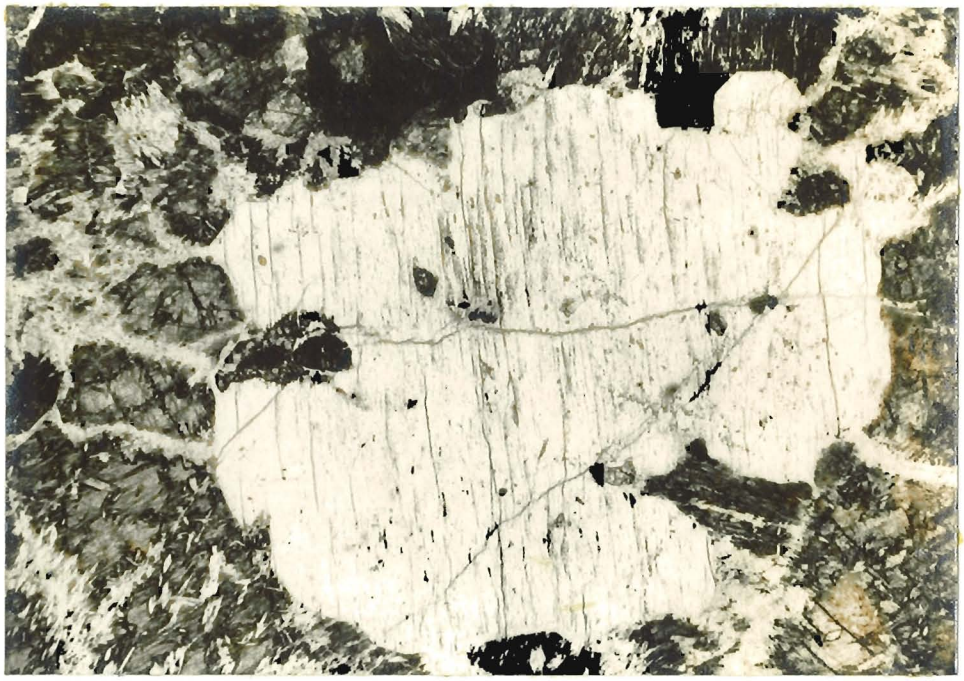


Figure 20. Single crystal actinolite pseudomorph after cumulus orthopyroxene (light grey) is surrounded by finer-grained cumulus clinopyroxene (grey), which is partly recrystallized to multicrystal actinolite (light grey). The boundary between orthopyroxene and adjacent clinopyroxene is smoothly rounded to scalloped with local reentrants. *Websterite, zone 2. Field of view = 4.5 mm. Crossed nicols.*

Figure 21. Optically continuous tremolite pseudomorph after discrete postcumulus orthopyroxene (white) that surrounds cumulus clinopyroxene (light to dark grey). *Olivine clinopyroxenite, zone 5. Field of view = 9.0 mm. Plane light.*

Figure 22. Recessed weathering, relatively equant to tabular, orthopyroxene oikocrysts from zone 1 adjacent to cumulus clinopyroxene. Pencil for scale.

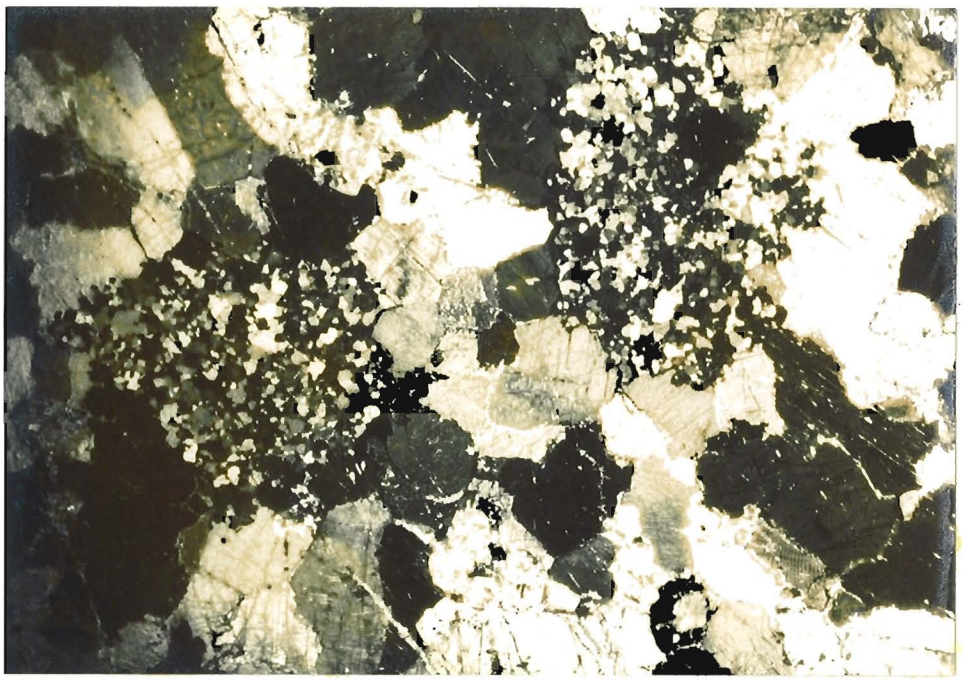


Figure 23. Two equant to tabular poikilitic orthopyroxene oikocrysts (upper right and center left) containing finer-grained cumulus clinopyroxene (black, with randomly distributed finer-grained clinopyroxene). *Olivine websterite, zone 4. Field of view = 20.5 mm. Crossed nicols.*

roxene extends outward from the oikocryst, as relatively long fingers, between adjacent clinopyroxene (Figure 18). Adjacent to olivine, oikocrysts are commonly scalloped and enclose olivine to varying degrees.

Oikocrysts are highly poikilitic and contain 3 to 75%, 0.03 to 1.7 mm, equant to tabular and rarely prismatic, subhedral to anhedral, cumulus clinopyroxene chadacrysts, 0 to 60%, 0.03 to 2.4 mm rounded to polygonal, equant to tabular and locally irregular, cumulus olivine chadacrysts, and 0 to 2% oxide chadacrysts (Figures 18 and 24). Clinopyroxene chadacrysts in each oikocryst are compositionally uniform, but from sample to sample chadacrysts composition varies within the limits of $Wo_{45.9-39.2}$ $En_{48.9-43.3}$ $Fs_{12.0-7.8}$. Most chadacrysts have an En/Fs ratio that is similar or higher than clinopyroxene outside of oikocrysts (Figure 25). Chadacrysts are commonly touching adjacent chadacrysts and are generally smaller than clinopyroxene outside of oikocrysts (Figure 18). Some included clinopyroxenes, though, are coarser grained, more irregular and similar in size to clinopyroxene outside of the oikocryst (Figure 24); these clinopyroxenes are probably part of the adjacent cumulate and reflect highly irregular shapes of both oikocrysts and clinopyroxene outside of the oikocrysts. In some oikocrysts, fine-grained clinopyroxene occurs in aggregates of several grains that have irregular to tabular shapes; these aggregates are similar in size to clinopyroxene outside of, but adjacent to, the oikocryst.

Where olivine is included in oikocrysts, it is randomly distributed or more commonly occurs near oikocryst margins. In most oikocrysts olivine chadacrysts are smaller than cumulus olivine grains in the surrounding rock, but they are much closer in size to olivine outside of the oikocryst than clinopyroxene chadacrysts are to clinopyroxene outside of the oikocryst. The ratio of olivine to clinopyroxene chadacrysts differs from the ratio of olivine to clinopyroxene outside of oikocrysts (Figure 26).

4.4 Plagioclase

In the ultramafic zones, plagioclase ranges in abundance from 0 to 89% but is completely replaced, and individual pseudomorphs are poorly defined (Table 3). Grain size ranges from 0.06 to 3.6 mm. Cumulus plagioclase grains have

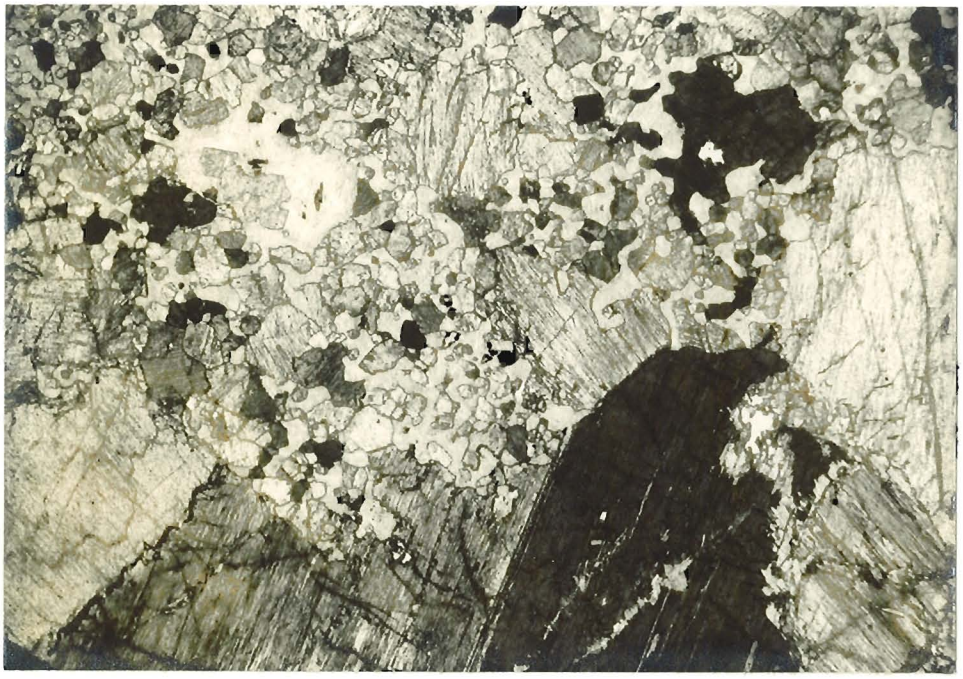


Figure 24. Chlorite pseudomorph after poikilitic orthopyroxene (light grey) containing fine-grained cumulus clinopyroxene chadacrysts adjacent to coarser-grained clinopyroxene outside of the oikocryst (top and left of photograph). Grain margins between orthopyroxene and adjacent clinopyroxene are relatively irregular, and, in detail, orthopyroxene forms embayments in the clinopyroxene and vice versa (center of photograph). The orthopyroxene oikocrysts contains numerous clinopyroxene grains of two sizes: a) finer-grained chadacrysts with straight to curved grain margins; and b) coarser-grained, irregular shaped grains (dark grey to black, lower left side). The coarser grained clinopyroxenes in the orthopyroxene oikocrysts are probably part of the aggregate of clinopyroxene outside of, and adjacent to the oikocryst. *Olivine-bearing websterite, zone 4. Field of view = 7.3 mm. Partial crossed nicols.*

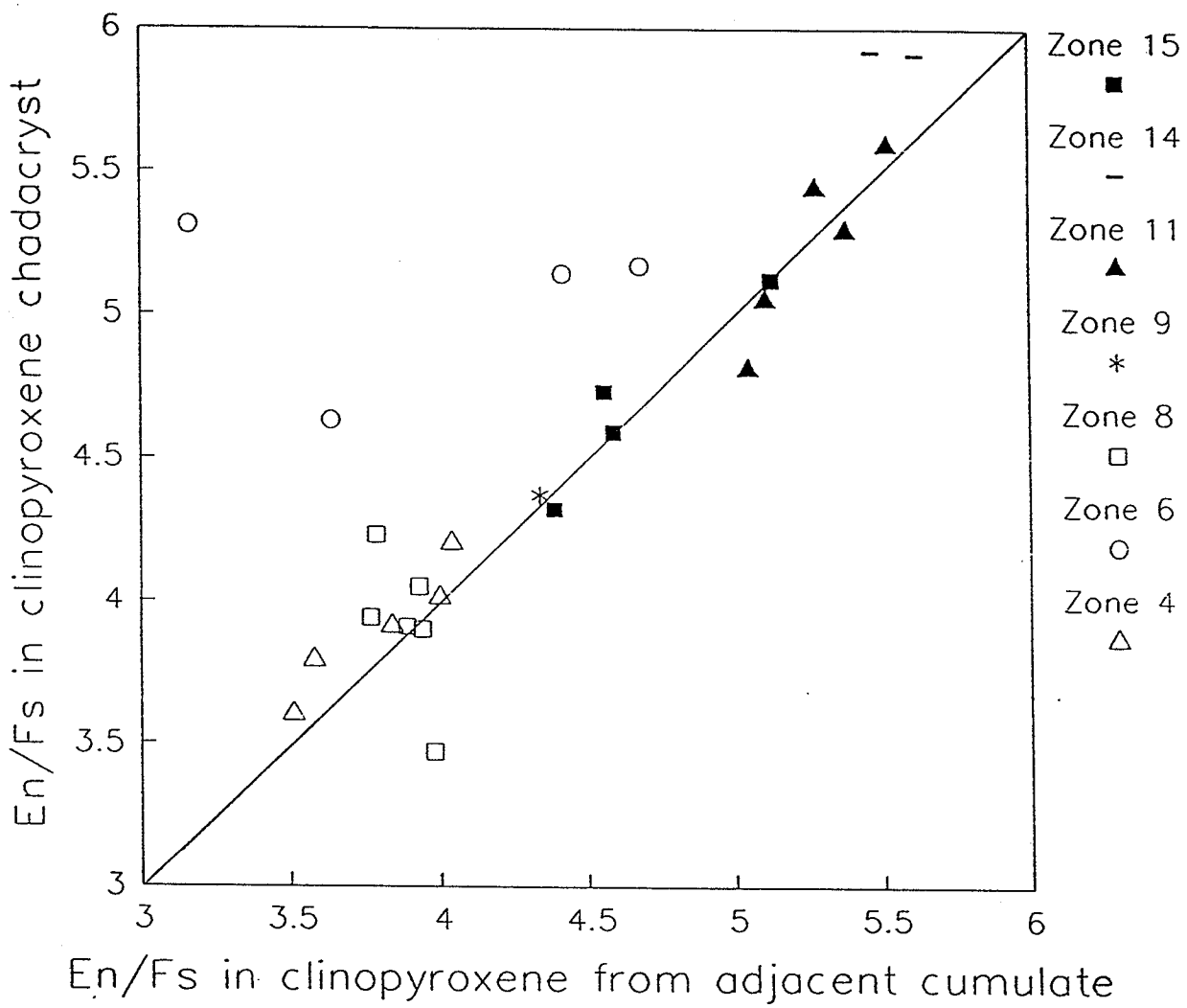


Figure 25. En/Fs ratio in clinopyroxene chadacrysts in orthopyroxene oikocrysts versus En/Fs in cumulus clinopyroxene adjacent to oikocrysts. Data points are listed by zone and diagonal line extending across the diagram defines a ratio of 1

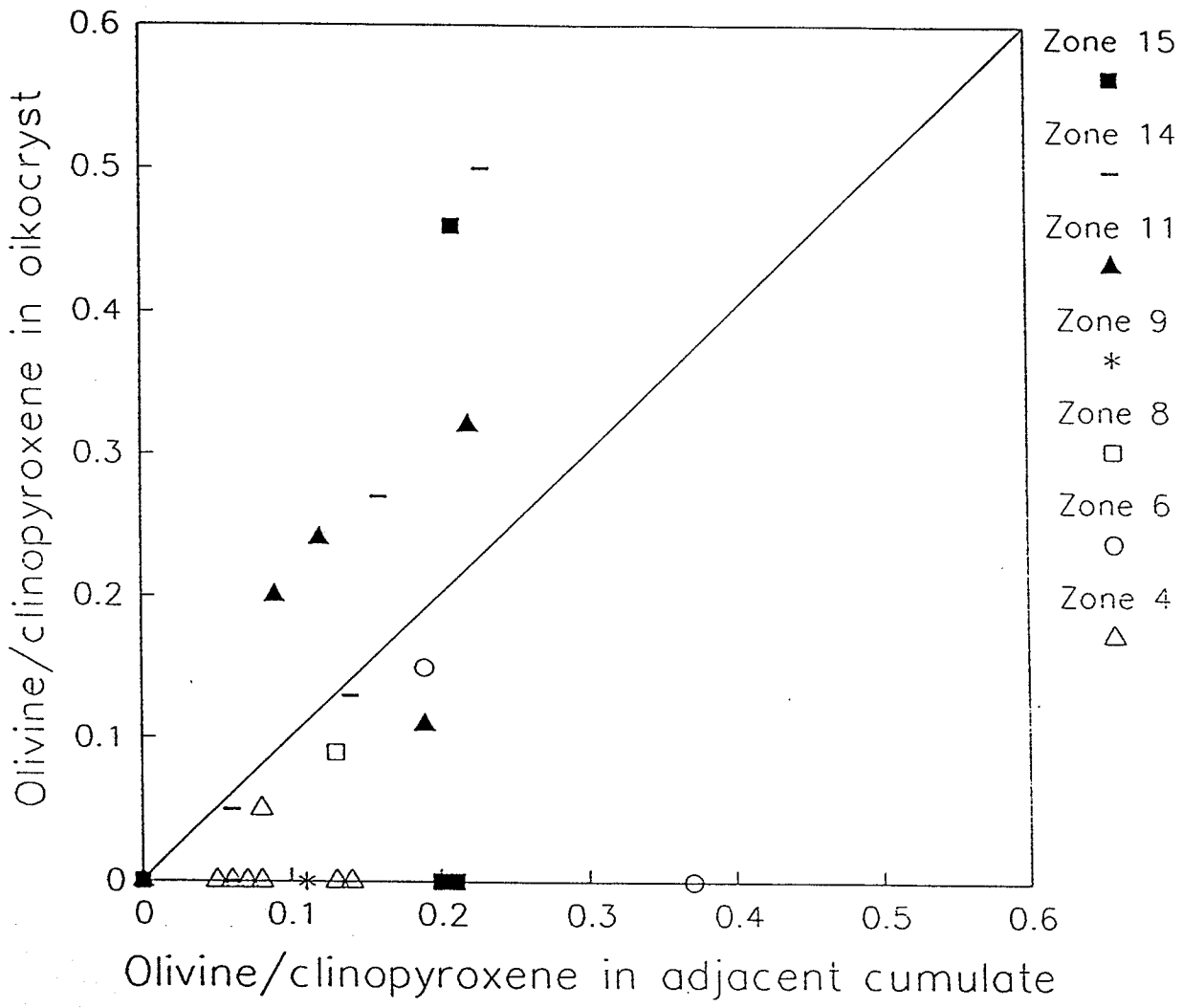


Figure 26. Olivine/clinopyroxene ratio of chadacrysts enclosed in oikocrysts versus olivine/clinopyroxene in adjacent cumulate outside of the oikocrysts. Data points are listed by zone and diagonal line extending across the diagram defines a ratio of 1.

subhedral to anhedral, equant to prismatic habit; subhedral grains are partly enveloped by postcumulus overgrowths of clinopyroxene. Where cumulus plagioclase is abundant, postcumulus overgrowths are common, but are only recognized by the lack of postcumulus overgrowths on clinopyroxene. Postcumulus overgrowths on plagioclase were not observed where plagioclase is less abundant.

Discrete postcumulus plagioclase occurs interstitial to cumulus clinopyroxene in several zones. Abundance ranges from trace to 22%.

4.5 Oxides

Oxides consist of chromium spinel which generally ranges in abundance from 0 to 3%, and is most abundant where olivine is abundant. Grain size ranges from 0.01 to 1.1 mm. Grains are equant to tabular, with common polygonal margins that have variably rounded corners (Figures 27 and 28). Compositionally, primary oxides have a Cr/FeTot that ranges from 0.15 to 0.86 and $Fe^{2+}/(Fe^{2+} + Mg^{2+})$ that ranges from 0.84 to 0.97 (Figure 29).

Oxides mostly occur between silicates and are most commonly associated with olivine. Oxides are locally enclosed in silicates; in terms of abundance, enclosed oxides are most common in olivine, followed by clinopyroxene, then orthopyroxene. Grains occurring along margins of silicate minerals or enclosed in minerals that are replaced by pseudomorphs are partly to completely recrystallized to chromite ± magnetite (Table 3; Figures 27 and 30). Oxides that occur in orthopyroxene are most common in poikilitic varieties; oxides were only rarely observed in cumulus grains and no oxides were observed in discrete postcumulus orthopyroxene. Layers containing cumulus orthopyroxene have less abundant oxides than other layers.

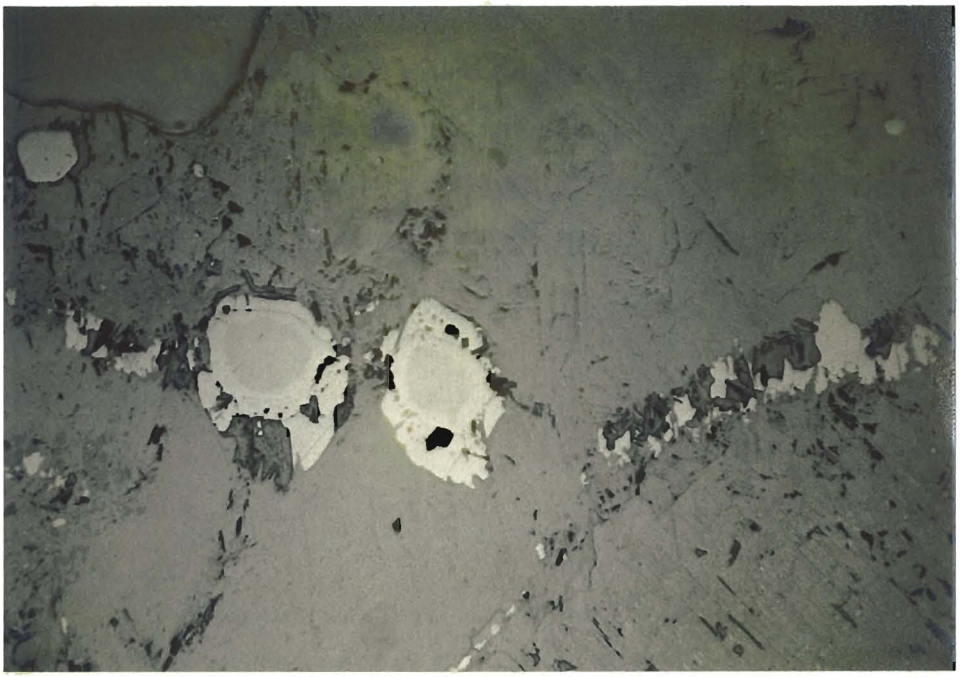


Figure 27. Reflected light photomicrograph of two chromite grains between serpentine pseudomorphs after olivine. The chromite grains have cores of chromium spinel (grey) surrounded by a margin of chromite that has a crudely polygonal outline (white). Secondary magnetite (white) forms an irregular partial mantle on the zoned oxide. To the lower right is a clinopyroxene grain (shows cleavage traces) with a margin defined by an increased abundance of magnetite. *Olivine clinopyroxenite, zone 6. Field of view = 1.5 mm. Plane light.*

Figure 28. Reflected light photomicrograph of zoned chromium spinel that occurs between two clinopyroxene grains (shows cleavage traces). Several smaller chromium spinels that are only partly zoned or unzoned are enclosed in clinopyroxene (grey, center right). A fracture partly filled by magnetite crosscuts clinopyroxene on the right side of the photograph. The olivine is replaced by multicrystal aggregates of serpentine + tremolite + chromite ± magnetite. *Olivine clinopyroxenite, zone 13. Field of view = 1.5 mm. Plane light.*

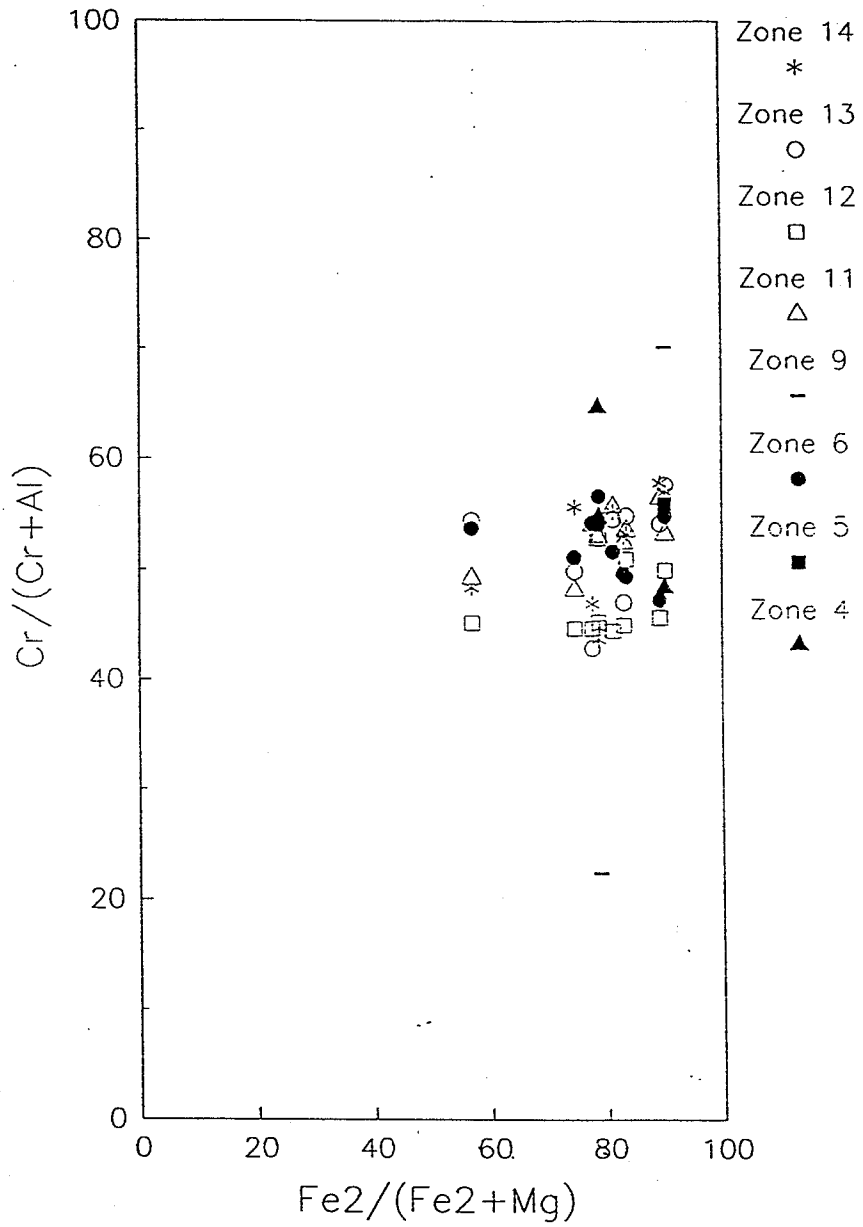


Figure 29. Cr/(Cr + Al) versus $Fe^{2+}/(Fe^{2+} + Mg)$ in chromium spinel. Compositions represent averages of chromium spinel analyses from individual samples. Data is plotted according to sample distribution in zones.

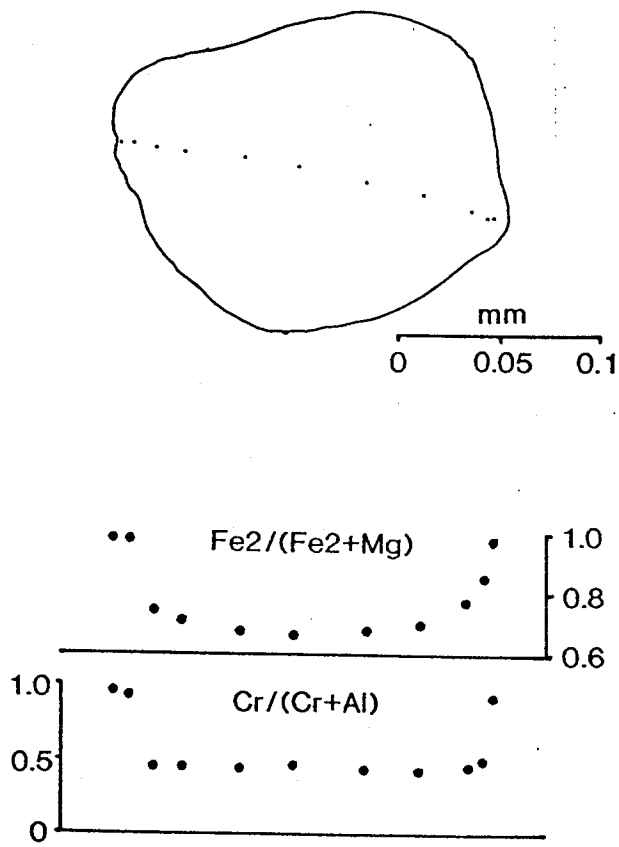


Figure 30. Compositional zoning in a partly replaced oxide grain. Compositional profile of (1)$Fe^{2+}/(Fe^{2+} + Mg)$ and (2) Cr/(Cr+Al). The core of the grain, which has not been replaced, is richer in Mg and Al, and poorer in Fe and Cr than the margins.

CHAPTER 5

PETROLOGY OF THE ULTRAMAFIC ROCKS

The ultramafic rocks form 15 zones, which range in thickness from 1.6 to 15.4 m, separated by gabbroic rocks (Figure 31). These zones are dominated by cumulus clinopyroxene with less abundant cumulus olivine; cumulus orthopyroxene and plagioclase occur locally in varying abundances whereas cumulus oxides, a more ubiquitous phase, are a minor component. Each zone comprises between 1 and 6 layers defined by changes in modal abundance, occurrence or disappearance of cumulus phases, changes in texture from granular to poikilitic, and grain size (Plate 1). Layers range in thickness from 0.3 to 10.2 m. Except for local zones, zones and layers were traced laterally for only 20 to 50 m.

5.1 Layer Types

Forty three layers were defined in the 15 ultramafic zones; additional zones may occur under the covered interval in cycle 14 (Figure 3). These layers have a combined thickness of 98.8 m. Layers are grouped into 4 types:

1. ungraded layers (18 layers) - abundance of olivine relative to clinopyroxene is constant throughout the layer (Plate 1; Table 4);
2. normally graded layers (12 layers) - abundance of olivine relative to clinopyroxene decreases upwards (Plate 1; Table 4);
3. reversely graded layers (1 layer) - abundance of olivine relative to clinopyroxene increases upwards (Plate 1; Table 4); and
4. complexly graded layers (12 layers) - abundance of olivine relative to clinopyroxene has a symmetrical or discontinuous trend (Plate 1; Table 4).

Layers are designated by number for the zone in which they occur and by letter for each individual layer, starting at 'a' for the basal layer in the zone and increasing alphabetically upwards (Plate 1, Fig. 31).

5.2 Ungraded layers

There are 18 ungraded layers ranging in thickness from 0.4 to 10.2 m (Table 4); 12 of these layers occur below the upper septum (Figure 31). Laterally, over

Figure 31. Schematic of layer types in the 15 ultramafic zones of the Mafic-Ultramafic Group. Ultramafic zones are drawn to scale, but intervening mafic zones are plotted by equal spaces within which is listed true thickness. Zone numbers and layer letter designations are listed on the right side of the stratigraphic column. Grain size data for clinopyroxene is plotted proportionally, both within and between layers, to the right of the section.

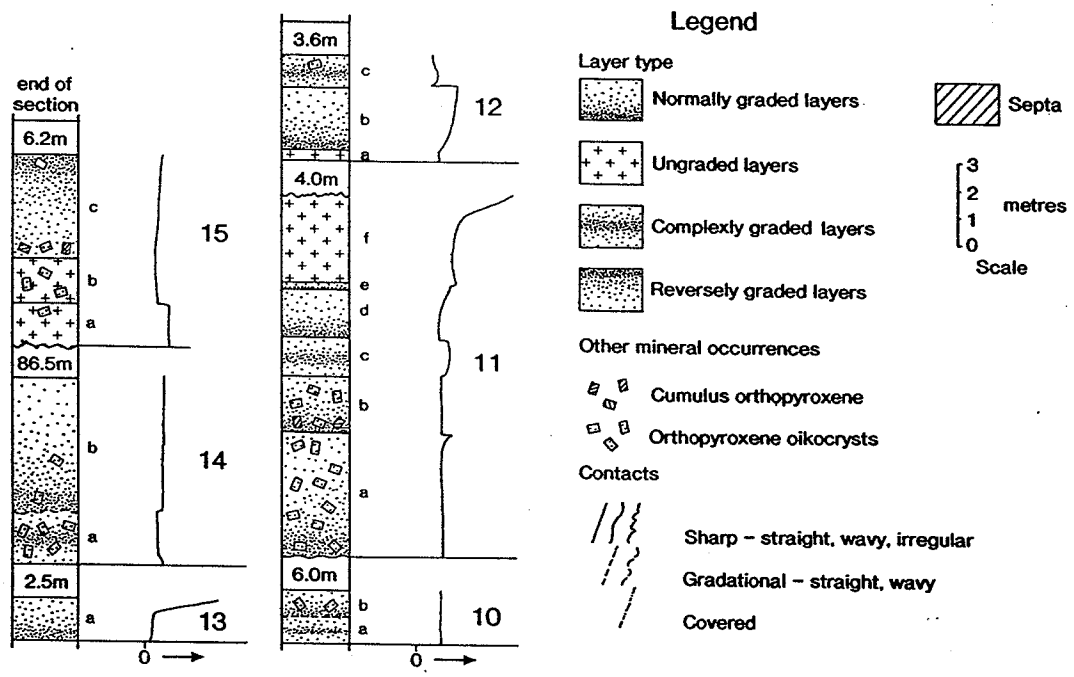


Figure 31. continued...

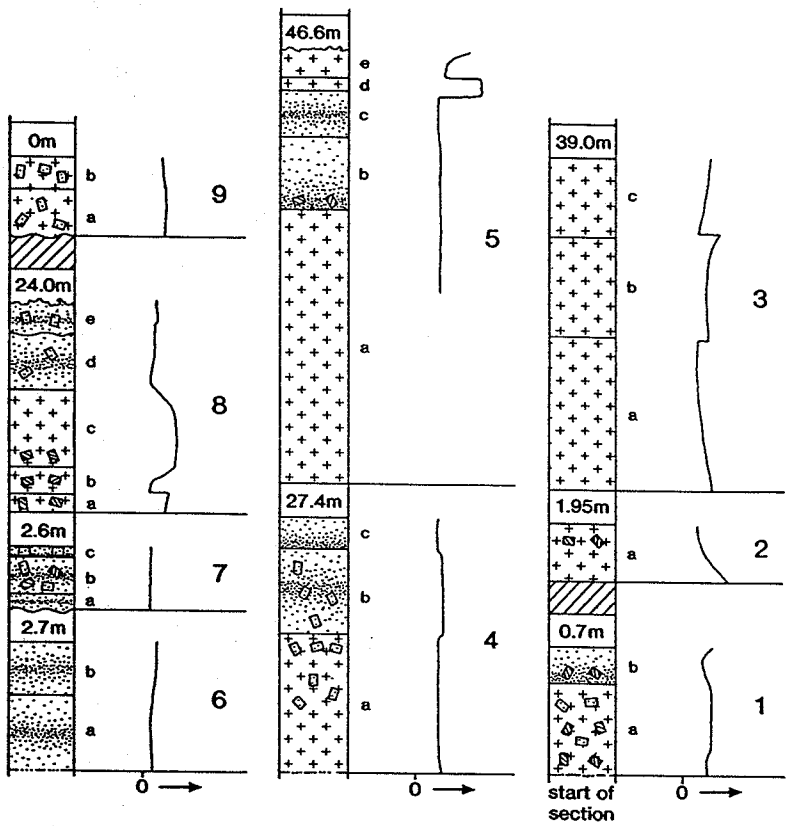


Table 4. Summary of ultramafic layer types.

LAYER TYPE	% OF LAYERS	THICKNESS (m)	MEAN (m)	LOWER CONTACTS	UPPER CONTACTS	CUMULATES
UNGRADED	42	0.4 to 10.2	2.69	All contacts are sharp, but contacts at the base of zones 1 and 4 are not exposed: of the nine contacts that do not form the base of the zone, 6 are phase contacts, marking the disappearance of plagioclase (layers 8b, 11f, and 15b), olivine (layers 5d and 9b), or orthopyroxene (layer 15b), or the appearance of olivine (layers 5e and 15b) or orthopyroxene (layer 8c), and 3 are grain size contacts (layers 3b, 3c, and 5d). Two of the phase contacts are combined with grain size changes in layers 5d and 5e.	Sharp. Almost half the contacts are phase contacts, with 3 modal contacts and 2 grain size contacts. Combination contacts include phase ± textural ± grain size and modal ± grain size contacts. Three phase contacts and 1 phase + textural contact also involve a change in olivine/clinopyroxene.	1. Clinopyroxene + olivine ± plagioclase ± orthopyroxene 2. Clinopyroxene ± plagioclase 3. Clinopyroxene + orthopyroxene ± plagioclase
NORMAL	28	0.3 to 5.0	2.04	Mostly sharp, except layers 10b and 14b, which are gradational over several cm and are marked by an upward increase in the abundance of olivine. Other than 2 layers at the base of zones, only layer 14b has a wavy contact: contacts of other layers are straight. Phase contacts are defined by either (a) appearance of cumulus olivine (layers 1b, 4c, 5b, 7c, and 11b); (b) appearance of cumulus orthopyroxene (layers 5b, 7c, and 11b): or (c) disappearance of cumulus plagioclase (layers 1b, 4c, and 11d). Phase contacts are locally combined with changes in grain size (layer 11b) or texture (layer 7c). Modal contacts, defined by changes in olivine/clinopyroxene, form the base of layers 10b, 11d, 11e, 12b, and 14b: the modal contact at the base of layer 14b is also defined by a decrease in orthopyroxene oikocrysts. Modal contacts are locally combined with changes in grain size (layer 11e) or texture (layer 10b).	Sharp, over half the contacts are phase contacts and only two are modal contacts. Combination contacts include phase + textural ± grain size contacts. Three of the contacts that include phase changes also involve change in olivine/clinopyroxene.	Clinopyroxene + olivine ± plagioclase ± orthopyroxene
REVERSE	2	3.8	3.8	Sharp: phase contact that also involves a change in olivine/clinopyroxene. The phase contact is defined by disappearance of olivine at the base of layer 15c and the appearance of orthopyroxene.	Sharp phase contact at top of zone.	Clinopyroxene + olivine + orthopyroxene
COMPLEX	28	0.6 to 3.2	1.72	All sharp, but one contact at the base of zone 6 was not observed. Phase contacts mark the appearance of orthopyroxene (layer 7b) or olivine (layers 8d and 12c) or the disappearance of plagioclase (layers 8d, 8e, 11c, and 12c). Phase contacts are combined with changes in grain size (layer 12c), texture (layer 7b and 8d), or modal proportions (layer 11c) Modal contacts define changes in olivine/clinopyroxene (layers 4b, 5c, and 6b): layer 4b is combined with a textural contact.	Most are sharp, but layers 10a and 14c are gradational over several cm. Two thirds of contacts are phase contacts and the remainder are modal, modal + grain size or modal + grain size + textural contacts. Two phase contacts also involve changes in olivine/clinopyroxene	Clinopyroxene + olivine ± plagioclase ± orthopyroxene

distances of about 20 m, thicknesses vary by up to 30%. In zone 9, layers are truncated by the overlying zone and are laterally discontinuous.

Based on the abundance of olivine relative to clinopyroxene, 3 types of ungraded layers are defined: a) clinopyroxene + olivine ± plagioclase cumulates that contain 6 to 17% olivine (layers 4a, 5a, 12a, and 15b) (Tables 5 and 6); b) clinopyroxene + olivine ± plagioclase ± orthopyroxene cumulates that contain trace to 2% olivine (layers 5e, 9a, 11f, and 15a)(Tables 5 and 6); and c) clinopyroxene ± orthopyroxene ± plagioclase cumulates that lack olivine (layers 1a, 2a, 3a, 3b, 3c, 5d, 8a, 8b, 8c, 9b)(Tables 5 and 6).

Nine of the 18 ungraded layers occur at the base of zones and their basal contacts will be described later as part of zone contacts. In the other layers, basal contacts are sharp and straight (Table 4). Phase contacts form the base of 4 layers, grain size contacts the base of 3 layers and modal contacts the base of 2 layers (Table 4). Phase contacts are also combined with grain size and grain size + textural contacts at the base of layers 8b and 16b, respectively.

5.2.1 Type 1 ungraded layers

Ungraded layers that contain 6 to 17% olivine are largely olivine clinopyroxenites (layers 4a, 5a, and 12a) or olivine websterites (layer 15b) (Figure 32; Table 5). These layers range in thickness from 0.4 to 10.2 m (Table 5). Igneous lamination, defined by poorly aligned orthopyroxene oikocrysts, occurs in layer 4a, but is absent in the rest of the layers.

Cumulus plagioclase occurs as part of thin discontinuous gabbro layers and patches just below the middle of layer 4a (Plate 1). Orthopyroxene oikocrysts occur in layers 4a and 15b, but differ in distribution. In layer 4a there are 10 to 20 cm thick oikocryst-rich layers that alternate with oikocryst-poor layers and in layer 15b, oikocrysts occur throughout.

Mean grain size of cumulus clinopyroxene, including postcumulus overgrowths, is uniform (Figure 31). Clinopyroxene intergrowths occur in trace abundances in layer 12a, but in layers 4a, 5a, and 15b intergrowths are more common

Table 5. Petrologic summary of ungraded layers.

Type	Layers	Thickness	Mineralogy	Internal variations
1	4	0.4 to 10.2	Clinopyroxene: 49-96%, 0.1 to 8.3 mm cumulus grains with postcumulus overgrowths; grain size is ungraded in all layers. Clinopyroxene is slightly coarser in layers 4a and 5a than in layers 12a and 15b. Intergrowths are in trace abundance in layer 12a. In layers 4a, 5a, and 15b, where intergrowths are more abundant, the abundance of intergrowths is greatest near the top of layers 4a and 5a, and near the bottom of layer 15b. Near the top of layers 4a and 5a, intergrowths have a symmetrical trend; data are not available for the lower half of layers 4a and 5a. Olivine: 6 to 17%, 0.12 to 2.8 mm cumulus grains; between 0 and 10% is enclosed in clinopyroxene. Orthopyroxene: 0 to 50%, 0.3 to 19.2 mm, oikocrystic grains that occur in layers 4a and 15b; oikocrysts have chadacryst free areas up to 1.3 mm across. In layer 4a, abundance of oikocrysts varies vertically and laterally, with local areas without oikocrysts. No apparent systematic variation occurs in abundance of oikocrysts in layer 15b. Plagioclase: 0 to 51%, 0.06 to 1.15 mm cumulus grains with postcumulus overgrowths. Oxides: 0-1.7%, 0.03 to 0.38 mm cumulus grains.	Cumulate assemblage: cpx + ol ± plag Largely olivine clinopyroxenite, except for 20 cm thick, discontinuous layers and apparently irregular patches of gabbro in the lower part of layer 4a. Igneous lamination defined by slightly aligned oikocrysts occurs only in layer 4a. In the upper part of layer 5a there are local olivine-rich patches that are up to 5 cm thick and 40 cm long; Patches are tabular and have rounded ends. Long direction of patches is concordant with layer contacts. Leucogabbro to gabbro patches occur in layers 5a and 15b.

Table 5. Petrologic summary of ungraded layers (continued).

Type	Layers	Thickness	Mineralogy	Internal variations
2	4	1.0 to 3.2	Clinopyroxene: 65-100%, 0.06 to 31 mm, cumulus grains with postcumulus overgrowths. Grain size is relatively uniform in layers 9a and 15a, but in the upper half of layers 5e and 11f, which occur at the top of zones, grain size increases upwards to very coarse grains. Intergrowths are more abundant in the lower part of layers 5e and 15a and absent in layer 9a. In layer 11f, intergrowths are most abundant about the middle of the layer with a secondary maximum near the base of the layer. Olivine: tr to 2%, 0.17 to 2.3 mm cumulus grains with up to 20% enclosed in clinopyroxene in layer 5e and up to 50% in parts of layer 15a. In layers 9a and 11f, olivine is not included in clinopyroxene. Orthopyroxene: 0 to 33%, 0.3 to 6.7 mm grains that vary from oikocrysts throughout layer 9a, discrete postcumulus grains throughout layer 11f or cumulus grains with abundant postcumulus overgrowths in the upper part of layer 15a. Opx does not occur in layer 5e. Plagioclase: 0 to 7.0%, 0.14 to 3.6 mm, cumulus or discrete postcumulus grains. Local cumulus phases occur in the top 30 cm of layer 5e, but are absent in other layers. Discrete postcumulus grains occur in layers 5e, 11f and 15a. Oxides: 0-1.2%, 0.05 to 0.8 mm cumulus grains.	Cumulate assemblage: cpx + ol ± plag ± opx Largely olivine-bearing clinopyroxenite, except in layer 9a where there is olivine-bearing websterite. Only in layer 5e does clinopyroxene define a slight igneous lamination. A single patch of gabbro was observed in layer 15a. Plagioclase-bearing phases occur in the lower and middle parts of layer 5e and the lower part of layer 11f; feldspathic clinopyroxenite occurs in the upper 20 to 30 cm of layers 5e and 15a.

Table 5. Petrologic summary of ungraded layers (continued)

Type	Layers	Thickness	Mineralogy	Internal variations
3	10	0.7 to 5.7	Clinopyroxene: 10-100%, 0.16 to 15 mm, cumulus grains with postcumulus overgrowths. Grain size varies from a decreasing upwards trend (layers 2a, 3a, and 8c), to an increasing upwards trend (layers 3c, 8a, 8b) to a uniform trend (layers 1a, 5d and 9b); in layer 3b the trend in grain size is symmetric, decreasing to increasing upwards. Except in layers 5d, 8a and 8c, intergrowths are rare; in layers 8a and 8c, intergrowth abundance correlates positively with abundance of cumulus orthopyroxene, but in layer 5d cumulus orthopyroxene is absent. Olivine: absent Orthopyroxene: 0 to 48%, 0.1 to 25 mm, cumulus grains with postcumulus overgrowths; in layers 1a and 9b up to 35% occurs as oikocrysts. Chadacrysts are less abundant in oikocrysts from layer 9b than from other layers. Cumulus orthopyroxene occurs in layers 1a, 2a, 8a, 8b, and 8c. Plagioclase: 0-90%, 0.1 to 1.4 mm cumulus grains with up to 1.7% discrete postcumulus grains. Oxides: 0-1%, 0.03 to 0.7 mm grains that only occur in layer 1a.	Cumulate assemblages: (1) cpx ± plag (layers 3a, 3b, 3c, and 9b); and (2) cpx + opx ± plag (1a, 2a, 5d, 8a, 8b, 8c). Opx-bearing clinopyroxenites or websterites occur at the base of the layer and grade upward to websterite or clinopyroxenite in the middle of the layer to overlying gabbro or gabbronorite at the top, except in layer 8b where clinopyroxenites occur at the top of the layer. Gabbro patches occur in layers 3a, 3c, 8b, and 8c.

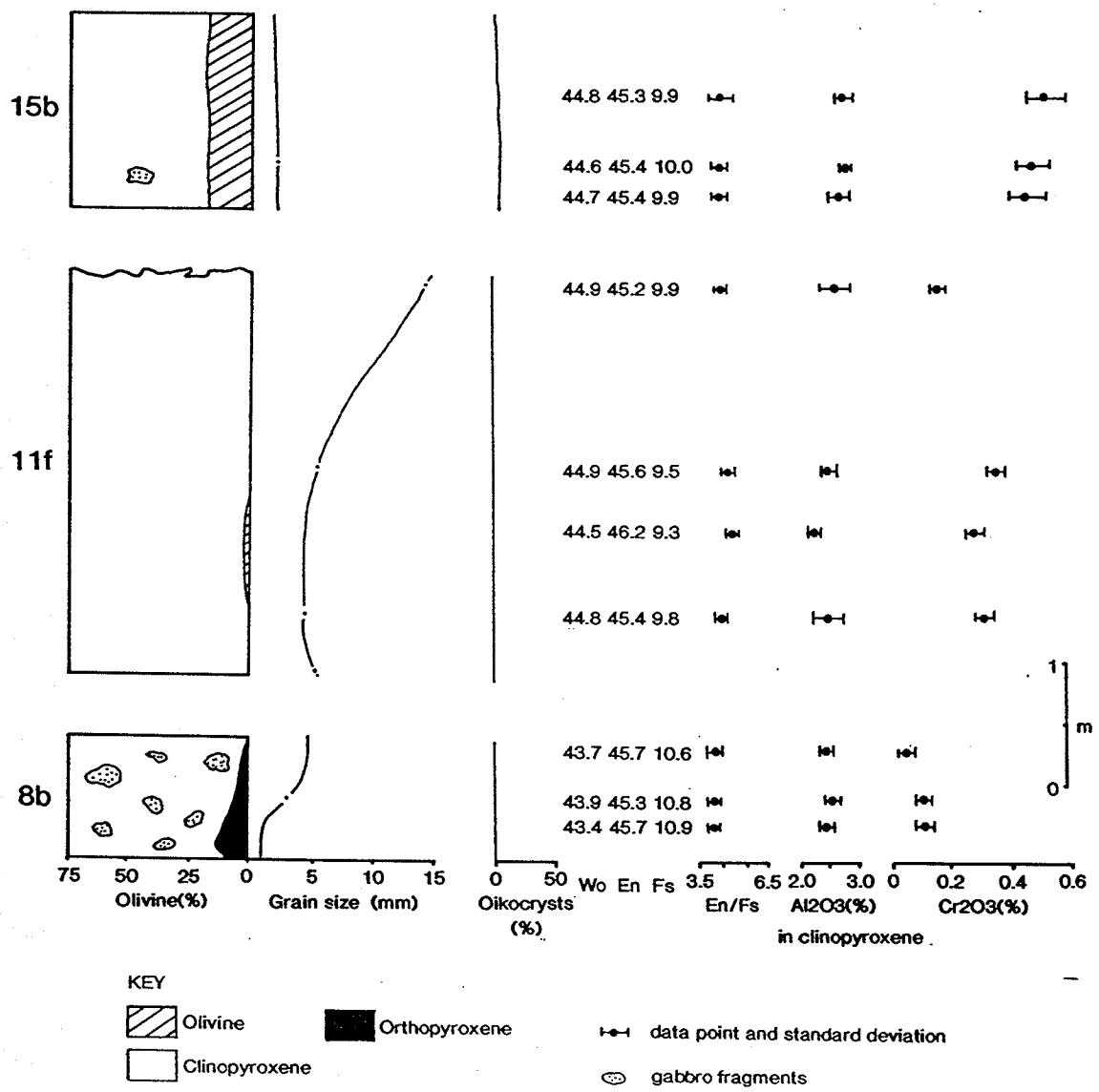
Cpx = clinopyroxene; Ol = olivine; Opx = orthopyroxene; Plag = plagioclase.

Table 6. Measured modal abundances of the primary minerals in ultramafic zones including cumulus and postcumulus material (see Appendix A) compiled from analysis of thin sections and polished slabs. CPX=clinopyroxene; OL=olivine; OPX=orthopyroxene; PLAG=plagioclase; OX=oxides.

SAMPLE	LAYER	CPX	OL	OPX	PLAG	OX
			Cycle 15			
460	c	86.1	13.9			
459	c	77.3		14.7	9.0	
458	b	72.7	16.3	10.8		0.2
457	b	82.7	17.3			
455	b	79.1	15.8	5.1		
453	a	96.7	0.1	2.3		
452	a	99.2	0.8			tr
			Cycle 14			
407	b	83.3	5.1	11.6		
381	b	91.3	5.7	3.1		
380	b	84.9	13.8	1.2		0.1
379	b	85.8	13.8		0.4	tr
377	b	85.5	11.5	2.9		0.1
375b	b	75.2	18.5	5.3		1.1
374	a	38.4	34.6	26.6		0.4
372	a	28.2	60.6	9.8		1.4
370	a	34.4	62.1	3.4		0.2
			Cycle 13			
364	a	91.3	8.7			
363	a	75.7	24.0			0.4
362	a	67.4	32.2			0.4
			Cycle 12			
356	c	61.3	36.7	0.5		1.4
355	c	66.8	33.2			
354	c	74.7	25.3			
351	b	96.2	3.7	0.1		0.1
350	b	87.4	12.6			
349	a	83.4	16.6			
			Cycle 11			
338	f	99.3		0.7		
337	f	99.6		0.4		
336	f	99.5	0.5			
335	f	98.1	1.7	0.3		
334	f	98.9		0.8	0.4	
333	f	99.6	0.1	0.3		
332b	e	99.2	0.8			
332a	e	81.2	18.5	0.3		
331	e	58.6	41.4			
330	d	95.5	4.3			0.2
329	d	81.9	18.1			
326	d	34.3	65.6			0.1
325	d	39.3	60.6			0.1
324a	c	80.3	9.7		10.1	
323b	c	97.5	2.5			
322	c	95.7	3.8	0.5		
321	c	98.5	1.5			
319	c	96.7	0.8	2.4		0.1
318d	b	80.0	7.1		12.9	
317	b	75.6	9.7	14.7		
316	b	82.3	15.7	1.9		0.1
315	b	85.3	14.7			
314	b	79.1	17.8	2.8		0.3
320b	b	80.2	19.7			0.1
313	b	91.3	8.7			
312	a	98.0	0.1	1.9		0.1
311	a	92.2	7.7			0.1
310	a	74.6	18.2	7.1		0.1

308a	a	78.6	21.2			0.2
304	a	79.3	20.7			0.1
303	a	72.6	20.4	7.0		
			Cycle 10			
55	b	62.1	19.7	17.4		0.8
54	b	63.0	17.2	19.3		0.5
78	a	66.9	11.5	21.4		0.2
74	a	85.5	14.5			
			Cycle 9			
71	a	70.4		28.3		1.2
			Cycle 8			
245	e	83.9	6.5	9.6		tr
241	d	83.0	8.5	8.3		0.1
239	d	80.9	8.8	10.3		
235	c	98.4		1.6		
233	b	98.3		1.6		
231	a	93.2		6.8		
			Cycle 7			
224	c	76.1	3.5	6.0	14.2	0.2
221a	b	45.4	54.2	0.3		0.1
218	a	73.4	9.7	0.5	15.9	0.4
			Cycle 6			
210	b	76.0	12.3	11.7		
208	a	52.1	15.9	30.9		1.1
199b	a	60.2	38.0			1.8
197	a	64.4	34.9			0.8
			Cycle 5			
47	e	92.4		0.7	7.0	
30	e	98.9	1.1			
45	c	94.9	5.1			
44	c	84.2	14.2	1.6		tr
42	c	90.6	9.3			tr
40	b	92.5	7.4			0.1
39	b	92.9	7.1			
37	b	90.4	9.6			
35a	a	93.4	6.5			0.1
34	a	91.8	8.2			
33	a	93.1	6.4			0.5
			Cycle 4			
14	c	88.2	11.6	0.7		
110	b	83.9	6.1	9.8		0.2
11	b	88.0	4.6	7.2		0.2
10	b	87.7	5.4	6.6		0.1
09	b	85.7	3.6	9.8		0.1
08	a	70.2	8.8	20.9		0.1
06	a	74.4	10.1	12.1		1.7
05	a	81.6	7.6	10.2		0.6
			Cycle 3			
467	c	96.9		1.7	1.2	0.2
468	c	100.0				
471	b	100.0				
472	b	100.0				
474	b	100.0				
476	b	100.0				
481	a	100.0				
			Cycle 2			
485	a	94.4		5.6		
486	a	97.1		2.9		

Figure 32 .Detailed stratigraphic variation in ungraded layers 15b (Type 1), 11f (Type 2), and 8b (Type 3). Modal abundance of olivine and poikilitic orthopyroxene, grain size and clinopyroxene chemistry of selected oxides and ratios are plotted to scale. Cumulus orthopyroxene are plotted qualitatively according to stratigraphic position.



(Plate 1); intergrowths are most abundant at the base or top of layers (Table 5).

In the upper part of layer 5a there are local finer-grained olivine-rich patches that are up to 5 cm thick and 40 cm long. Patches are tabular and have rounded ends; long direction of patches is concordant with layer contacts.

Mineral chemistry was done on all layers, although in layer 12a only 1 sample was analysed and in layers 4a and 5a only samples from the top 20 to 40% of the layer were analysed. Over the vertical distances that were examined, En/Fs, CaO, Cr_2O_3, and Al_2O_3 have uniform values (Figure 33, Table 7, Plate 1). In layers 4a and 15b clinopyroxene chadacrysts are chemically similar to cumulus clinopyroxene (Tables 7 and 8, Plate 1).

5.2.2 Type 2 ungraded layers

Ungraded layers that contain trace to 2% olivine are largely olivine-bearing clinopyroxenites. Layers range in thickness from 1.0 to 3.2 m (Table 5). Igneous lamination, defined by slight alignment of clinopyroxene, only occurs in layer 5e.

Cumulus plagioclase occurs only in the top 30 cm of layers 5e and 15a and cumulus orthopyroxene occurs only in the top part of layer 15a (Table 5). Where cumulus plagioclase appears in layer 5e, cumulus olivine disappears. Orthopyroxene oikocrysts are rare in layer 15a and absent in layer 5e.

In layers that occur at the base of zones (layers 9a and 15a) grain size is uniform, but in layers at the top of zones grain size increases in the upper part of the layer (layers 5e and 11f)(Figures 31 and 32). Clinopyroxene intergrowths are absent in layer 9a, but are relatively common in layers 5e, 11f, and 15a (Plate 1); maximum abundance occurs in the lower half of layers 5e and 15a and in the middle of layer 11f (Table 5).

Mineral chemistry was not done on samples from layer 9a and only 1 sample was analysed from layer 5e (Table 7). In layer 11f, En/Fs is ungraded and Cr_2O_3 is lower at the top of the layer than at the base (Figure 33). In layer 15a, En/Fs and Cr_2O_3 are uniform throughout most of the layer (Figure 33). At the top of layer 15a where cumulus orthopyroxene and cumulus plagioclase

Figure 33. Stratigraphic variation diagram of clinopyroxene chemistry through ultramafic zones in the Mafic-Ultramafic Group. Layer type patterns as in Figure 31.

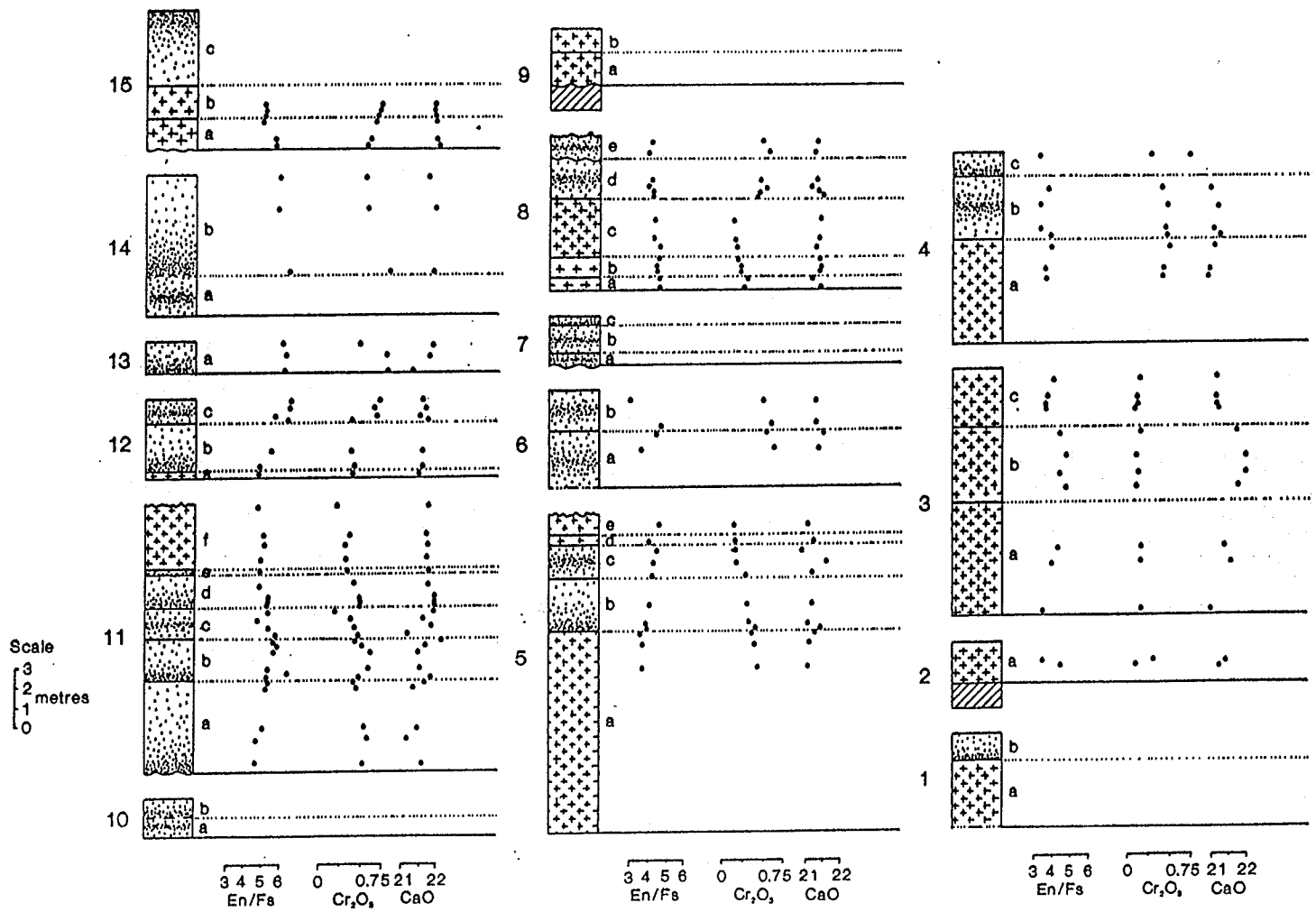


Table 7. Average analyses of several cumulus clinopyroxene from individual samples. All analyses and standard deviations are listed in Table B.1.

Sample	458	457	455	453	452	456	407
Layer	15b	15b	15b	15a	15a	15a	14b
SiO_2	51.88	51.97	52.23	52.23	52.33	52.43	52.67
TiO_2	0.14	0.20	0.16	0.15	0.12	0.13	0.17
Al_2O_3	2.70	2.80	2.69	2.51	2.73	2.58	2.95
Cr_2O_3	0.51	0.47	0.45	0.43	0.36	0.32	0.42
MnO	0.19	0.18	0.17	0.18	0.16	0.18	0.14
MgO	15.92	15.96	15.99	15.82	16.02	15.97	16.52
CaO	21.87	21.87	21.90	21.96	21.98	22.17	22.00
NiO	0.03	0.03	0.03	0.03	0.04	0.03	0.05
CoO	0.03	0.02	0.02	0.02	0.01	0.02	0.03
Na_2O	0.21	0.20	0.19	0.22	0.18	0.22	0.19
FeO	4.58	4.71	4.94	5.04	5.02	4.68	4.43
Fe_2O_3	1.60	1.54	1.22	1.34	0.43	0.67	0.77
Total	99.66	99.96	99.99	99.93	99.30	99.40	100.35
			Tetrahedral site = 2				
Si	1.915	1.913	1.921	1.924	1.933	1.934	1.922
Al	0.085	0.087	0.079	0.076	0.067	0.066	0.078
			Octahedral site				
Al	0.032	0.034	0.037	0.033	0.051	0.046	0.049
Ti	0.004	0.005	0.004	0.004	0.003	0.003	0.005
Cr	0.015	0.014	0.013	0.013	0.011	0.009	0.012
Mn	0.006	0.005	0.005	0.006	0.005	0.006	0.004
Mg	0.876	0.876	0.876	0.869	0.882	0.879	0.899
Ca	0.865	0.862	0.863	0.867	0.866	0.876	0.860
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.001	0.001	0.001	0.001	0.000	0.001	0.001
Na	0.015	0.014	0.014	0.016	0.013	0.015	0.013
Fe^{2+}	0.141	0.145	0.152	0.155	0.155	0.145	0.135
Fe^{3+}	0.045	0.043	0.034	0.037	0.012	0.019	0.021
Total	2.001	2.000	2.000	2.002	1.999	2.002	2.000
Wo	44.75	44.64	44.72	44.83	45.10	45.51	44.82
En	45.32	45.37	45.39	44.93	45.94	45.66	46.85
Fs	9.93	9.99	9.89	10.24	8.96	8.83	8.34
Mg*	86.14	85.80	85.02	84.86	85.05	85.84	86.94
En/Fs	4.56	4.54	4.59	4.39	5.13	5.17	5.62

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	381	375	364	363	361	356	355
Layer	14b	14b	13a	13a	13a	12c	12c
SiO_2	52.65	51.90	53.21	52.67	52.40	52.48	52.66
TiO_2	0.14	0.19	0.15	0.13	0.12	0.11	0.08
Al_2O_3	2.80	3.08	2.41	2.82	2.96	2.91	2.69
Cr_2O_3	0.43	0.73	0.38	0.75	0.76	0.72	0.63
MnO	0.15	0.13	0.16	0.15	0.14	0.16	0.16
MgO	16.36	16.39	16.66	16.75	17.00	16.33	16.38
CaO	22.35	22.22	22.57	22.19	21.48	21.94	22.13
NiO	0.03	0.06	0.05	0.05	0.03	0.03	0.05
CoO	0.01	0.01	0.02	0.01	0.04	0.02	0.02
Na_2O	0.17	0.22	0.16	0.19	0.19	0.21	0.20
FeO	4.34	3.36	4.21	3.75	3.89	4.24	4.37
Fe_2O_3	0.90	1.38	0.78	1.13	1.12	0.12	0.16
Total	100.33	99.67	100.76	100.59	100.12	99.26	99.53
			Tetrahedral site = 2				
Si	1.923	1.906	1.933	1.916	1.913	1.931	1.935
Al	0.077	0.094	0.067	0.084	0.087	0.069	0.065
			Octahedral site				
Al	0.044	0.039	0.036	0.037	0.040	0.057	0.051
Ti	0.004	0.005	0.004	0.004	0.003	0.003	0.002
Cr	0.012	0.021	0.011	0.022	0.022	0.021	0.018
Mn	0.005	0.004	0.005	0.005	0.004	0.005	0.005
Mg	0.891	0.897	0.903	0.908	0.925	0.896	0.897
Ca	0.875	0.874	0.879	0.865	0.840	0.865	0.871
Ni	0.001	0.002	0.001	0.001	0.001	0.001	0.001
Co	0.000	0.000	0.001	0.000	0.001	0.001	0.001
Na	0.012	0.016	0.011	0.013	0.013	0.015	0.014
Fe^{2+}	0.133	0.103	0.128	0.114	0.119	0.131	0.134
Fe^{3+}	0.025	0.038	0.021	0.031	0.031	0.003	0.004
Total	2.002	1.999	2.000	2.000	1.999	1.998	1.998
Wo	45.36	45.62	45.40	44.98	43.77	45.53	45.58
En	46.19	46.82	46.64	47.22	48.20	47.01	46.94
Fs	8.45	7.57	7.95	7.80	8.03	7.46	7.48
Mg*	87.01	89.70	87.58	88.85	88.60	86.74	87.00
En/Fs	5.47	6.18	5.87	6.05	6.01	6.30	6.28

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	354	353	351	350	349	338	336
Layer	12c	12c	12b	12b	12a	11f	11f
SiO_2	51.61	52.56	52.13	51.52	51.68	52.11	52.47
TiO_2	0.12	0.09	0.10	0.12	0.11	0.14	0.15
Al_2O_3	2.75	2.53	2.68	2.49	2.48	2.59	2.45
Cr_2O_3	0.67	0.35	0.34	0.39	0.35	0.15	0.35
MnO	0.17	0.15	0.17	0.18	0.16	0.17	0.17
MgO	16.60	16.51	15.77	16.29	16.55	16.05	16.19
CaO	21.92	22.25	21.96	21.96	21.77	22.17	22.18
NiO	0.02	0.04	0.04	0.03	0.03	0.03	0.03
CoO	0.02	0.01	0.02	0.02	0.02	0.03	0.02
Na_2O	0.20	0.16	0.26	0.13	0.12	0.22	0.20
FeO	3.08	4.09	4.78	3.76	3.77	4.21	4.49
Fe_2O_3	2.43	0.62	0.65	2.52	2.57	2.13	1.47
Total	99.57	99.35	98.89	99.41	99.61	99.99	100.17
			Tetrahedral site = 2				
Si	1.900	1.934	1.944	1.906	1.906	1.916	1.924
Al	0.100	0.066	0.056	0.094	0.094	0.084	0.076
			Octahedral site				
Al	0.019	0.044	0.044	0.015	0.014	0.028	0.030
Ti	0.003	0.002	0.002	0.004	0.003	0.004	0.004
Cr	0.020	0.010	0.009	0.012	0.010	0.004	0.010
Mn	0.005	0.005	0.005	0.006	0.005	0.005	0.005
Mg	0.911	0.906	0.872	0.898	0.910	0.880	0.885
Ca	0.865	0.877	0.893	0.870	0.860	0.873	0.872
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.000	0.000	0.001	0.001	0.001	0.001	0.001
Na	0.014	0.011	0.011	0.009	0.009	0.016	0.014
Fe^{2+}	0.095	0.126	0.152	0.116	0.116	0.129	0.138
Fe^{3+}	0.067	0.017	0.010	0.070	0.071	0.059	0.041
Total	2.000	1.999	2.000	2.002	2.000	2.000	2.001
Wo	44.52	45.42	46.24	44.39	43.83	44.86	44.93
En	46.89	46.92	45.13	45.82	46.38	45.22	45.60
Fs	8.59	7.66	8.62	9.79	9.79	9.92	9.48
Mg*	90.56	87.79	85.19	88.56	88.69	87.22	86.51
En/Fs	5.46	6.13	5.24	4.68	4.74	4.56	4.81

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	335	334	332	330	328	326	325
Layer	11f	11f	11e	11d	11d	11d	11d
SiO_2	52.85	52.15	52.94	51.79	52.64	52.61	52.54
TiO_2	0.14	0.17	0.13	0.20	0.16	0.13	0.12
Al_2O_3	2.24	2.48	2.66	2.68	2.41	2.50	2.61
Cr_2O_3	0.28	0.31	0.32	0.38	0.46	0.47	0.44
MnO	0.19	0.16	0.17	0.18	0.18	0.18	0.19
MgO	16.42	16.14	15.92	15.94	16.00	15.87	15.88
CaO	22.00	22.22	22.56	22.14	22.56	22.59	22.60
NiO	0.04	0.02	0.04	0.01	0.04	0.04	0.03
CoO	0.02	0.02	0.03	0.01	0.02	0.02	0.03
Na_2O	0.19	0.21	0.20	0.19	0.20	0.22	0.19
FeO	4.78	4.13	5.01	4.28	4.53	4.57	4.55
Fe_2O_3	1.03	2.13	0.94	1.74	0.94	0.83	0.94
Total	100.18	100.14	100.91	99.54	100.14	100.03	100.11
			Tetrahedral site = 2				
Si	1.936	1.915	1.929	1.913	1.931	1.931	1.928
Al	0.064	0.085	0.071	0.087	0.069	0.069	0.072
			Octahedral site				
Al	0.033	0.022	0.043	0.030	0.035	0.039	0.040
Ti	0.004	0.005	0.004	0.006	0.004	0.004	0.003
Cr	0.008	0.009	0.009	0.011	0.013	0.014	0.013
Mn	0.006	0.005	0.005	0.006	0.006	0.006	0.006
Mg	0.897	0.884	0.865	0.878	0.875	0.869	0.868
Ca	0.863	0.874	0.881	0.876	0.886	0.889	0.888
Ni	0.001	0.001	0.001	0.000	0.001	0.001	0.001
Co	0.000	0.001	0.001	0.000	0.001	0.001	0.001
Na	0.013	0.015	0.014	0.014	0.014	0.016	0.014
Fe^{2+}	0.146	0.127	0.153	0.132	0.139	0.140	0.140
Fe^{3+}	0.028	0.059	0.026	0.048	0.026	0.023	0.026
Total	1.999	2.002	2.002	2.001	2.000	2.002	2.000
Wo	44.48	44.84	45.65	45.15	45.86	46.13	46.06
En	46.24	45.36	44.82	45.26	45.29	45.10	45.02
Fs	9.28	9.80	9.53	9.59	8.85	8.77	8.92
Mg*	86.00	87.44	84.97	86.93	86.29	86.12	86.11
En/Fs	4.97	4.63	4.70	4.72	5.12	5.14	5.05

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	324	323	321	319	318	317	316
Layer	11c	11c	11c	11c	11b	11b	11b
SiO_2	52.87	51.22	52.77	52.30	53.11	51.76	52.81
TiO_2	0.16	0.17	0.17	0.14	0.23	0.14	0.16
Al_2O_3	2.32	2.60	2.66	2.78	2.45	2.77	2.82
Cr_2O_3	0.15	0.34	0.37	0.43	0.40	0.47	0.59
MnO	0.17	0.18	0.17	0.14	0.16	0.16	0.16
MgO	16.07	15.95	16.18	16.41	16.05	16.37	16.54
CaO	22.58	22.04	22.40	21.25	22.96	22.15	21.81
NiO	0.05	0.06	0.05	0.03	0.00	0.04	0.08
CoO	0.02	0.01	0.03	0.01	0.07	0.02	0.02
Na_2O	0.20	0.21	0.21	0.20	0.22	0.21	0.20
FeO	4.57	3.56	4.53	4.96	4.47	3.30	4.72
Fe_2O_3	0.67	2.93	1.05	0.27	0.15	2.02	0.75
Total	99.81	99.25	100.59	98.92	100.28	99.41	100.65
			Tetrahedral site = 2				
Si	1.942	1.900	1.925	1.934	1.938	1.908	1.923
Al	0.058	0.100	0.075	0.066	0.062	0.092	0.077
			Octahedral site				
Al	0.042	0.015	0.039	0.055	0.045	0.028	0.034
Ti	0.004	0.005	0.005	0.004	0.005	0.004	0.004
Cr	0.004	0.010	0.011	0.013	0.013	0.014	0.017
Mn	0.005	0.006	0.005	0.005	0.005	0.005	0.005
Mg	0.880	0.882	0.880	0.904	0.882	0.900	0.898
Ca	0.888	0.876	0.876	0.842	0.875	0.875	0.851
Ni	0.001	0.002	0.001	0.001	0.001	0.001	0.002
Co	0.000	0.000	0.001	0.000	0.001	0.001	0.001
Na	0.014	0.015	0.015	0.014	0.015	0.015	0.014
Fe^{2+}	0.140	0.110	0.138	0.153	0.151	0.102	0.144
Fe^{3+}	0.018	0.082	0.029	0.008	0.008	0.056	0.021
Total	1.996	2.003	2.000	1.999	2.001	2.001	1.991
Wo	45.99	44.79	45.44	44.04	45.55	45.15	44.35
En	45.57	45.09	45.64	47.28	45.91	46.44	46.80
Fs	8.84	10.12	8.92	8.68	8.54	8.41	8.86
Mg*	86.27	88.91	86.44	85.53	85.38	89.82	86.18
En/Fs	5.15	4.46	5.12	5.45	5.38	5.52	5.28

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	314	313	312	311	308	306	303
Layer	11b	11b	11a	11a	11a	11a	11a
SiO_2	52.46	51.80	52.39	52.50	51.83	51.58	52.06
TiO_2	0.14	0.14	0.13	0.16	0.15	0.14	0.16
Al_2O_3	2.77	2.59	2.90	2.71	2.66	2.75	2.85
Cr_2O_3	0.56	0.42	0.39	0.39	0.52	0.54	0.49
MnO	0.16	0.15	0.17	0.16	0.17	0.18	0.20
MgO	16.02	16.03	15.97	16.33	15.84	15.97	15.68
CaO	21.83	22.38	22.16	21.52	21.77	21.14	21.88
NiO	0.04	0.04	0.05	0.03	0.04	0.04	0.05
CoO	0.02	0.02	0.02	0.02	0.01	0.00	0.02
Na_2O	0.22	0.21	0.22	0.20	0.21	0.23	0.20
FeO	5.02	3.67	4.68	5.12	4.81	5.00	5.26
Fe_2O_3	0.48	1.96	0.87	0.80	1.52	1.20	1.29
Total	99.74	99.41	99.95	99.93	99.54	98.77	100.13
			Tetrahedral site = 2				
Si	1.930	1.914	1.923	1.927	1.916	1.919	1.916
Al	0.070	0.086	0.077	0.073	0.084	0.081	0.084
			Octahedral site				
Al	0.050	0.027	0.048	0.044	0.032	0.040	0.039
Ti	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Cr	0.016	0.012	0.011	0.011	0.015	0.016	0.014
Mn	0.005	0.005	0.005	0.005	0.006	0.006	0.006
Mg	0.879	0.883	0.874	0.896	0.873	0.886	0.860
Ca	0.861	0.886	0.872	0.843	0.865	0.843	0.864
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.001	0.001	0.001	0.001	0.000	0.000	0.000
Na	0.016	0.015	0.016	0.014	0.015	0.017	0.014
Fe^{2+}	0.154	0.113	0.144	0.158	0.147	0.156	0.161
Fe^{3+}	0.013	0.054	0.024	0.023	0.043	0.034	0.035
Total	1.989	2.001	2.000	2.002	2.001	2.003	1.998
Wo	45.03	45.65	45.44	43.81	44.73	43.79	44.86
En	45.97	45.49	45.54	46.55	45.14	46.03	44.65
Fs	9.00	8.86	9.02	9.64	10.13	10.18	10.49
Mg*	85.09	88.65	85.85	85.07	85.58	85.03	84.23
En/Fs	5.11	5.13	5.05	4.83	4.46	4.52	4.26

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	56	246	245	244	241	240	239
Layer	9a	8e	8e	8e	8d	8d	8d
SiO_2	51.78	51.00	51.05	51.92	51.23	51.01	51.25
TiO_2	0.14	0.14	0.18	0.15	0.13	0.19	0.18
Al_2O_3	2.83	2.93	3.02	2.86	3.01	3.03	3.05
Cr_2O_3	0.52	0.38	0.47	0.33	0.36	0.43	0.37
MnO	0.19	0.19	0.19	0.20	0.18	0.19	0.18
MgO	15.92	15.50	15.51	15.48	15.64	15.78	15.60
CaO	21.37	21.35	21.21	21.42	21.30	20.99	21.75
NiO	0.03	0.03	0.05	0.04	0.02	0.04	0.03
CoO	0.02	0.02	0.03	0.02	0.02	0.01	0.03
Na_2O	0.22	0.44	0.42	0.42	0.40	0.39	0.40
FeO	5.06	3.88	4.20	5.01	4.17	4.13	3.71
Fe_2O_3	1.58	3.27	3.24	2.23	3.14	3.47	3.54
Total	99.66	99.13	99.57	100.08	99.59	99.66	100.09
			Tetrahedral site = 2				
Si	1.912	1.896	1.892	1.913	1.896	1.888	1.888
Al	0.088	0.104	0.108	0.087	0.104	0.112	0.112
			Octahedral site				
Al	0.035	0.024	0.024	0.037	0.027	0.020	0.020
Ti	0.004	0.004	0.005	0.004	0.004	0.005	0.005
Cr	0.015	0.011	0.014	0.010	0.011	0.013	0.011
Mn	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Mg	0.877	0.859	0.857	0.850	0.863	0.871	0.857
Ca	0.846	0.850	0.842	0.845	0.844	0.832	0.859
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.001	0.001	0.001	0.001	0.001	0.000	0.001
Na	0.016	0.032	0.030	0.030	0.029	0.028	0.029
Fe^{2+}	0.156	0.121	0.130	0.154	0.129	0.128	0.114
Fe^{3+}	0.044	0.091	0.090	0.062	0.087	0.097	0.098
Total	2.001	2.000	2.000	2.000	2.002	2.001	2.001
Wo	43.86	44.11	43.74	44.08	43.75	43.02	44.42
En	45.46	44.58	44.52	44.34	44.74	45.04	44.31
Fs	10.68	11.31	11.74	11.58	11.51	11.94	11.27
Mg*	84.90	87.65	86.83	84.66	87.00	87.19	88.26
En/Fs	4.34	3.94	3.79	3.83	3.89	3.77	3.93

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample Layer	238 8d	237 8c	236 8c	235 8c	234 8b	233 8b	232 8b
SiO_2	51.43	51.77	52.05	53.05	53.03	52.84	51.65
TiO_2	0.17	0.14	0.14	0.13	0.15	0.14	0.12
Al_2O_3	3.04	2.51	2.52	2.45	2.45	2.54	2.44
Cr_2O_3	0.32	0.03	0.04	0.04	0.05	0.11	0.11
MnO	0.19	0.19	0.20	0.22	0.19	0.18	0.20
MgO	15.58	15.97	16.04	16.23	16.11	15.95	16.15
CaO	21.62	21.46	21.40	21.32	21.42	21.53	21.39
NiO	0.03	0.03	0.03	0.03	0.04	0.03	0.03
CoO	0.02	0.02	0.02	0.01	0.03	0.02	0.02
Na_2O	0.41	0.36	0.34	0.34	0.32	0.34	0.31
FeO	4.07	4.19	4.56	5.51	5.68	5.52	4.02
Fe_2O_3	3.07	2.75	2.72	1.16	0.90	1.19	2.95
Total	99.95	99.43	100.06	100.49	100.37	100.39	99.40
			Tetrahedral site = 2				
Si	1.896	1.915	1.915	1.939	1.941	1.935	1.911
Al	0.104	0.085	0.085	0.061	0.059	0.065	0.089
			Octahedral site				
Al	0.028	0.024	0.024	0.044	0.047	0.045	0.017
Ti	0.005	0.004	0.004	0.004	0.004	0.004	0.003
Cr	0.009	0.001	0.001	0.001	0.001	0.003	0.003
Mn	0.006	0.006	0.006	0.007	0.006	0.006	0.006
Mg	0.856	0.881	0.880	0.884	0.879	0.871	0.891
Ca	0.854	0.851	0.844	0.835	0.840	0.845	0.848
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.001	0.001	0.001	0.000	0.001	0.001	0.001
Na	0.029	0.026	0.024	0.024	0.023	0.024	0.022
Fe^{2+}	0.126	0.130	0.140	0.168	0.174	0.169	0.125
Fe^{3+}	0.085	0.077	0.075	0.032	0.025	0.033	0.082
Total	2.000	2.002	2.000	2.000	2.001	2.002	1.999
Wo	44.32	43.75	43.39	43.35	43.66	43.92	43.44
En	44.42	45.30	45.24	45.90	45.69	45.27	45.65
Fs	11.26	10.95	11.36	10.75	10.65	10.81	10.91
Mg*	87.17	87.14	86.27	81.55	83.48	83.75	87.70
En/Fs	3.94	4.14	3.98	4.27	4.29	4.19	4.18

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	231	230	211	209	208	199	24
Layer	8a	8a	6b	6b	6a	6a	5
SiO_2	52.34	52.85	52.65	51.47	52.14	52.09	52.14
TiO_2	0.17	0.16	0.14	0.13	0.11	0.16	0.14
Al_2O_3	2.67	2.68	2.65	2.73	2.65	2.77	2.35
Cr_2O_3	0.20	0.17	0.49	0.60	0.54	0.64	0.08
MnO	0.19	0.19	0.17	0.17	0.17	0.21	0.22
MgO	16.33	16.45	16.22	16.19	16.26	15.95	15.69
CaO	21.13	21.58	21.78	21.73	22.10	21.83	21.62
NiO	0.03	0.02	0.02	0.05	0.04	0.03	0.03
CoO	0.03	0.02	0.02	0.01	0.02	0.03	0.02
Na_2O	0.34	0.34	0.34	0.38	0.38	0.43	0.21
FeO	4.75	4.60	4.50	3.01	3.19	3.80	5.63
Fe_2O_3	2.08	2.22	1.49	2.74	2.49	2.42	1.69
Total	100.26	101.25	100.47	99.20	100.09	100.36	99.80
			Tetrahedral site = 2				
Si	1.918	1.918	1.924	1.903	1.911	1.908	1.927
Al	0.082	0.082	0.076	0.097	0.089	0.092	0.073
			Octahedral site				
Al	0.033	0.032	0.038	0.022	0.025	0.028	0.029
Ti	0.005	0.004	0.004	0.004	0.003	0.004	0.004
Cr	0.006	0.005	0.014	0.018	0.016	0.019	0.002
Mn	0.006	0.006	0.005	0.005	0.005	0.007	0.007
Mg	0.892	0.890	0.883	0.893	0.888	0.871	0.865
Ca	0.829	0.839	0.853	0.861	0.868	0.857	0.856
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.001	0.001	0.001	0.000	0.001	0.001	0.001
Na	0.024	0.024	0.024	0.027	0.027	0.031	0.015
Fe^{2+}	0.146	0.139	0.137	0.093	0.098	0.116	0.173
Fe^{3+}	0.057	0.061	0.137	0.076	0.069	0.067	0.048
Total	2.000	2.002	2.001	2.000	2.001	2.002	2.001
Wo	42.95	43.36	42.33	44.66	45.02	44.68	43.92
En	46.22	45.99	43.82	46.32	46.06	45.41	44.38
Fs	10.83	10.65	13.85	9.02	8.92	9.91	11.70
Mg*	85.93	86.49	86.57	90.57	90.06	88.25	83.33
En/Fs	4.28	4.32	3.16	4.68	4.42	3.64	3.79

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	25	30	32	45	44	42	40
Layer	5	5e	5c	5c	5c	5c	5b
SiO_2	52.10	52.63	52.10	51.88	52.07	52.26	52.51
TiO_2	0.15	0.10	0.13	0.10	0.10	0.15	0.14
Al_2O_3	2.34	2.23	2.27	1.97	2.36	2.31	2.29
Cr_2O_3	0.08	0.10	0.11	0.13	0.12	0.26	0.29
MnO	0.23	0.20	0.23	0.22	0.20	0.24	0.23
MgO	15.82	16.20	16.02	16.75	15.46	16.02	15.62
CaO	21.52	21.16	21.49	20.86	22.16	21.42	21.51
NiO	0.02	0.03	0.04	0.03	0.02	0.03	0.03
CoO	0.02	0.01	0.02	0.02	0.02	0.01	0.04
Na_2O	0.18	0.19	0.20	0.18	0.19	0.18	0.21
FeO	5.61	5.75	5.01	4.48	5.34	5.49	6.16
Fe_2O_3	1.83	0.38	2.03	2.20	1.13	1.21	0.35
Total	99.89	99.12	99.73	98.83	99.16	99.58	99.38
			Tetrahedral site = 2				
Si	1.924	1.949	1.925	1.928	1.934	1.932	1.945
Al	0.076	0.051	0.075	0.072	0.066	0.068	0.055
			Octahedral site				
Al	0.026	0.047	0.023	0.014	0.037	0.033	0.046
Ti	0.004	0.003	0.003	0.003	0.003	0.004	0.004
Cr	0.002	0.003	0.004	0.004	0.004	0.008	0.009
Mn	0.007	0.006	0.007	0.007	0.006	0.008	0.007
Mg	0.871	0.885	0.882	0.928	0.856	0.883	0.863
Ca	0.852	0.853	0.856	0.830	0.882	0.848	0.854
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.001	0.000	0.001	0.001	0.001	0.000	0.001
Na	0.013	0.014	0.014	0.013	0.014	0.013	0.015
Fe^{2+}	0.173	0.178	0.155	0.139	0.165	0.171	0.191
Fe^{3+}	0.051	0.011	0.055	0.062	0.032	0.032	0.010
Total	2.001	2.001	2.001	2.002	2.001	2.001	2.001
Wo	43.60	44.13	43.79	42.22	45.44	43.67	44.36
En	44.58	45.78	45.12	47.20	44.10	45.47	44.83
Fs	11.82	10.09	11.10	10.58	10.46	10.87	10.81
Mg*	83.43	83.25	85.05	86.97	83.84	83.78	81.88
En/Fs	3.77	4.54	4.06	4.46	4.22	4.18	4.15

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	38	36	35	34	33	14	110
Layer	5b	5b	5a	5a	5a	4c	4b
SiO_2	51.08	52.21	51.91	51.28	52.02	52.02	51.85
TiO_2	0.17	0.12	0.15	0.15	0.16	0.21	0.20
Al_2O_3	2.38	2.45	2.35	2.31	2.33	2.92	3.00
Cr_2O_3	0.30	0.38	0.37	0.39	0.44	0.28	0.44
MnO	0.25	0.25	0.24	0.22	0.24	0.21	0.22
MgO	15.83	15.45	15.50	15.43	15.52	16.09	15.70
CaO	21.25	22.00	21.79	21.40	21.30	20.17	21.05
NiO	0.03	0.03	0.03	0.04	0.03	0.02	0.02
CoO	0.02	0.02	0.02	0.03	0.01	0.03	0.03
Na_2O	0.20	0.23	0.29	0.23	0.23	0.23	0.27
FeO	4.61	4.47	5.83	5.24	6.03	6.58	5.74
Fe_2O_3	2.37	2.31	1.67	1.87	1.05	1.52	2.07
Total	98.56	98.80	99.65	98.59	99.35	100.30	100.59
			Tetrahedral site = 2				
Si	1.910	1.912	1.923	1.920	1.932	1.912	1.904
Al	0.090	0.088	0.077	0.080	0.068	0.088	0.096
			Octahedral site				
Al	0.015	0.020	0.026	0.022	0.034	0.039	0.034
Ti	0.005	0.003	0.004	0.004	0.004	0.006	0.006
Cr	0.009	0.011	0.011	0.012	0.013	0.008	0.013
Mn	0.008	0.008	0.007	0.007	0.008	0.006	0.007
Mg	0.883	0.863	0.870	0.861	0.859	0.879	0.859
Ca	0.852	0.872	0.840	0.859	0.848	0.801	0.828
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.001	0.001	0.001	0.001	0.000	0.001	0.000
Na	0.015	0.017	0.015	0.017	0.017	0.016	0.019
Fe^{2+}	0.143	0.140	0.181	0.163	0.189	0.199	0.176
Fe^{3+}	0.070	0.067	0.047	0.054	0.028	0.044	0.057
Total	2.002	2.001	2.003	2.001	2.001	1.999	2.001
Wo	43.56	44.72	43.19	44.19	43.89	41.51	42.97
En	45.14	44.26	44.73	44.29	44.46	45.59	44.58
Fs	11.30	11.02	12.08	11.52	11.65	12.90	12.45
Mg*	86.06	86.08	82.78	84.08	81.97	81.53	83.00
En/Fs	3.99	4.02	3.70	3.84	3.82	3.53	3.58

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	11	109	9	8	6	5	102
Layer	4b	4b	4b	4a	4a	4a	3c
SiO_2	52.07	51.77	51.70	51.19	50.75	51.33	52.45
TiO_2	0.22	0.18	0.17	0.14	0.14	0.15	0.20
Al_2O_3	2.75	3.04	2.92	2.79	2.81	2.90	2.51
Cr_2O_3	0.51	0.48	0.50	0.53	0.45	0.44	0.12
MnO	0.22	0.25	0.20	0.22	0.24	0.22	0.17
MgO	15.54	15.42	15.48	15.48	15.47	15.39	16.61
CaO	21.69	21.33	21.76	21.35	21.17	21.10	21.43
NiO	0.03	0.03	0.03	0.04	0.03	0.03	0.03
CoO	0.01	0.01	0.02	0.02	0.01	0.02	0.02
Na_2O	0.27	0.28	0.26	0.30	0.27	0.26	0.23
FeO	5.74	5.70	5.08	4.76	4.63	5.60	4.58
Fe_2O_3	1.69	2.08	1.81	2.04	2.80	1.54	2.80
Total	100.48	100.57	99.93	98.87	98.78	98.98	101.15
			Tetrahedral site = 2				
Si	1.913	1.903	1.908	1.909	1.897	1.913	1.908
Al	0.087	0.097	0.092	0.091	0.103	0.087	0.092
			Octahedral site				
Al	0.032	0.035	0.035	0.031	0.021	0.041	0.016
Ti	0.006	0.005	0.005	0.004	0.004	0.004	0.005
Cr	0.015	0.014	0.015	0.016	0.013	0.013	0.003
Mn	0.007	0.008	0.006	0.007	0.008	0.007	0.005
Mg	0.851	0.845	0.852	0.860	0.862	0.855	0.901
Ca	0.854	0.840	0.861	0.853	0.848	0.843	0.835
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.000	0.000	0.001	0.001	0.000	0.001	0.001
Na	0.019	0.020	0.019	0.021	0.019	0.019	0.016
Fe^{2+}	0.168	0.175	0.157	0.149	0.145	0.175	0.139
Fe^{3+}	0.047	0.058	0.050	0.057	0.079	0.043	0.077
Total	2.000	2.001	2.002	2.000	2.000	2.002	1.999
Wo	44.31	43.61	44.70	44.29	43.67	43.84	42.67
En	44.19	43.87	44.24	44.65	44.39	44.46	46.04
Fs	11.50	12.51	11.06	11.06	11.95	11.70	11.29
Mg*	83.54	82.84	84.44	85.23	85.60	83.01	86.63
En/Fs	3.84	3.51	4.00	4.04	3.71	3.80	4.08

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	467	468	469	471	472	473	474
Layer	3c	3c	3c	3b	3b	3b	3b
SiO_2	52.64	52.40	52.59	51.52	52.48	52.51	51.59
TiO_2	0.16	0.20	0.21	0.21	0.17	0.19	0.16
Al_2O_3	2.32	2.61	2.35	2.77	2.38	2.60	2.76
Cr_2O_3	0.08	0.09	0.06	0.15	0.07	0.08	0.09
MnO	0.19	0.18	0.19	0.15	0.15	0.17	0.14
MgO	16.35	16.54	16.43	15.96	16.21	16.24	16.11
CaO	21.44	21.41	21.53	22.26	22.91	22.87	22.53
NiO	0.03	0.02	0.03	0.02	0.04	0.04	0.03
CoO	0.02	0.03	0.03	0.02	0.02	0.04	0.02
Na_2O	0.23	0.24	0.23	0.23	0.22	0.22	0.21
FeO	5.20	4.62	4.92	3.60	3.47	3.49	3.10
Fe_2O_3	2.58	3.59	3.31	3.14	2.86	3.35	3.30
Total	101.25	101.93	101.88	100.03	100.98	101.79	100.05
			Tetrahedral site = 2				
Si	1.917	1.897	1.906	1.897	1.911	1.900	1.896
Al	0.083	0.103	0.094	0.103	0.089	0.100	0.104
			Octahedral site				
Al	0.017	0.008	0.010	0.017	0.013	0.011	0.016
Ti^{4+}	0.004	0.005	0.006	0.006	0.005	0.005	0.004
Cr^{3+}	0.002	0.003	0.002	0.005	0.002	0.002	0.003
Mn^{2+}	0.006	0.006	0.006	0.005	0.005	0.005	0.005
Mg	0.888	0.893	0.888	0.877	0.880	0.886	0.883
Ca	0.837	0.830	0.836	0.877	0.894	0.894	0.887
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Na	0.016	0.017	0.016	0.016	0.016	0.016	0.015
Fe^{2+}	0.158	0.140	0.149	0.112	0.106	0.106	0.095
Fe^{3+}	0.071	0.098	0.090	0.086	0.078	0.091	0.091
Total	2.001	2.002	2.005	2.003	2.001	2.001	2.000
Wo	42.70	42.20	42.46	44.81	45.54	44.60	45.24
En	45.31	45.40	45.10	44.81	44.83	45.12	45.02
Fs	11.99	12.40	12.44	10.38	9.63	10.28	9.74
Mg*	84.89	86.45	85.63	88.68	89.25	89.24	90.26
En/Fs	3.78	3.66	3.63	4.32	4.66	4.39	4.62

Table 7. Average analyses of several cumulus clinopyroxene (continued)

Sample	476	478	481	485	486
Layer	3a	3a	3a	2a	2a
SiO2	52.52	52.49	52.56	52.96	52.33
TiO2	0.23	0.22	0.18	0.28	0.19
Al_2O_3	2.27	2.17	2.27	2.23	2.69
Cr_2O_3	0.14	0.14	0.11	0.21	0.19
MgO	16.55	16.46	16.00	16.72	16.11
CaO	21.79	22.06	21.11	21.26	21.38
MnO	0.15	0.15	0.22	0.16	0.23
NiO	0.03	0.03	0.02	0.03	0.03
CoO	0.01	0.02	0.02	0.01	0.01
Na_2O	0.22	0.21	0.24	0.25	0.24
FeO	4.43	4.23	6.10	5.21	5.29
Fe_2O_3	3.12	3.15	2.26	1.49	2.98
Total	101.64	101.46	101.10	100.81	101.67
			Tetrahedral site = 2		
Si	1.904	1.908	1.922	1.933	1.900
Al	0.096	0.092	0.078	0.067	0.100
			Octohedral site		
Al(oct)	0.005	0.006	0.019	0.028	0.015
Ti^{4+}	0.005	0.006	0.005	0.006	0.005
Cr^{3+}	0.004	0.004	0.003	0.006	0.006
Mg	0.896	0.896	0.872	0.908	0.872
Ca	0.865	0.848	0.827	0.831	0.834
Mn^{2+}	0.005	0.004	0.007	0.005	0.007
Ni	0.002	0.001	0.001	0.001	0.001
Co	0.001	0.000	0.001	0.000	0.000
Na	0.016	0.015	0.017	0.018	0.017
Fe^{2+}	0.111	0.135	0.187	0.158	0.159
Fe^{3+}	0.093	0.085	0.063	0.040	0.084
Total	2.001	2.003	2.002	2.001	2.000
Wo	43.90	43.07	42.37	42.77	42.66
En	45.49	45.52	44.67	46.73	44.60
Fs	10.61	11.41	12.96	10.50	12.74
Mg*	89.02	86.92	82.34	85.18	84.57
En/Fs	4.29	3.99	3.45	4.45	3.50

Table 8. Average analyses of several clinopyroxene chadacrysts from individual samples. All analyses and standard deviations are listed in Table B.2.

Sample	458	455	453	456	407	375	318	317
Layer	15b	15b	15a	15a	14b	14b	11b	11b
SiO_2	52.03	52.53	52.44	52.52	52.90	51.70	53.20	51.83
TiO_2	0.17	0.13	0.18	0.12	0.18	0.13	0.18	0.12
Al_2O_3	2.53	2.60	2.64	2.55	2.76	3.04	2.49	2.52
Cr_2O_3	0.51	0.45	0.43	0.32	0.47	0.82	0.41	0.44
MnO	0.26	0.20	0.15	0.17	0.12	0.14	0.18	0.15
MgO	16.15	15.94	15.52	16.19	16.47	16.40	16.51	16.46
CaO	21.63	21.92	22.16	21.77	22.77	22.02	22.20	22.23
NiO	0.01	0.04	0.03	0.03	0.03	0.06	0.04	0.03
CoO	0.03	0.02	0.04	0.02	0.07	0.02	0.04	0.02
Na_2O	0.22	0.18	0.21	0.21	0.18	0.22	0.23	0.22
FeO	4.58	5.37	5.66	5.00	3.87	3.29	4.61	3.08
Fe_2O_3	1.35	0.67	0.65	0.52	1.04	1.68	0.83	2.24
Total	99.48	100.06	100.11	99.42	100.86	99.52	100.92	99.33
				Tetrahedral site = 2				
Si	1.921	1.930	1.930	1.936	1.921	1.903	1.932	1.912
Al	0.079	0.070	0.070	0.064	0.079	0.097	0.068	0.088
				Octahedral site				
Al	0.031	0.043	0.044	0.047	0.039	0.035	0.039	0.022
Ti	0.005	0.004	0.005	0.003	0.005	0.004	0.005	0.003
Cr	0.015	0.013	0.013	0.009	0.013	0.024	0.012	0.013
Mn	0.008	0.006	0.005	0.005	0.004	0.004	0.006	0.005
Mg	0.889	0.873	0.851	0.890	0.892	0.900	0.894	0.905
Ca	0.856	0.863	0.874	0.860	0.886	0.868	0.864	0.879
Ni	0.000	0.001	0.001	0.001	0.001	0.002	0.001	0.001
Co	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Na	0.016	0.013	0.015	0.015	0.013	0.016	0.016	0.016
Fe^{2+}	0.142	0.165	0.174	0.154	0.118	0.101	0.140	0.095
Fe^{3+}	0.038	0.019	0.018	0.015	0.029	0.047	0.023	0.062
Total	2.001	2.001	2.001	2.000	2.002	2.002	2.001	2.002
Wo	44.28	44.81	45.47	44.70	45.93	45.21	44.84	45.17
En	45.99	45.33	44.28	46.26	46.24	46.88	46.39	46.51
Fs	9.73	9.87	10.25	9.04	7.83	7.92	8.77	8.32
Mg*	86.23	84.10	83.02	85.25	88.32	89.91	86.46	90.50
En/Fs	4.73	4.59	4.32	5.12	5.91	5.92	5.29	5.59

Table 8. Average analyses of clinopyroxene chadacrysts (continued)

Sample	316	314	313	312	306	303	56	246
Layer	11b	11b	11b	11a	11a	11a	9a	8f
SiO_2	52.62	52.51	52.11	52.84	52.12	52.70	51.22	50.88
TiO2	0.13	0.14	0.14	0.14	0.13	0.16	0.18	0.18
Al_2O_3	2.64	2.67	2.37	2.60	2.70	2.54	2.95	2.88
Cr_2O_3	0.56	0.53	0.46	0.37	0.58	0.42	0.59	0.37
MnO	0.13	0.17	0.16	0.18	0.23	0.19	0.19	0.23
MgO	16.58	16.03	16.35	16.84	17.15	16.28	15.77	15.42
CaO	21.90	21.96	22.31	20.78	19.16	21.26	21.84	21.33
NiO	0.05	0.05	0.06	0.02	0.05	0.07	0.01	0.05
CoO	0.04	0.04	0.04	0.03	0.01	0.01	0.03	0.02
Na_2O	0.22	0.24	0.19	0.20	0.22	0.19	0.23	0.45
FeO	4.22	4.87	3.60	5.55	6.05	5.79	4.05	3.84
Fe_2O_3	1.20	0.69	2.00	0.55	1.29	0.47	2.45	3.31
Total	100.29	99.90	99.79	100.10	99.69	100.08	99.52	98.95
				Tetrahedral site = 2				
Si	1.922	1.929	1.917	1.934	1.919	1.934	1.896	1.896
Al	0.078	0.071	0.083	0.066	0.081	0.066	0.104	0.104
				Octahedral site				
Al	0.036	0.045	0.020	0.046	0.036	0.044	0.025	0.022
Ti	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005
Cr	0.016	0.015	0.013	0.011	0.017	0.012	0.017	0.011
Mn	0.004	0.005	0.005	0.006	0.007	0.006	0.006	0.007
Mg	0.903	0.878	0.897	0.919	0.941	0.891	0.870	0.857
Ca	0.857	0.864	0.879	0.815	0.756	0.836	0.866	0.852
Ni	0.001	0.001	0.002	0.001	0.001	0.002	0.000	0.001
Co	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001
Na	0.016	0.017	0.014	0.014	0.016	0.014	0.017	0.033
Fe^{2+}	0.129	0.150	0.111	0.170	0.186	0.178	0.125	0.120
Fe^{3+}	0.033	0.019	0.055	0.015	0.036	0.013	0.068	0.093
Total	2.000	1.999	2.001	2.002	2.000	2.000	2.000	2.002
Wo	44.50	45.09	45.15	42.34	39.25	43.45	44.75	44.17
En	46.88	45.82	46.07	47.74	48.86	46.31	44.96	44.43
Fs	8.62	9.08	8.78	9.92	11.89	10.24	10.29	11.40
Mg*	87.50	85.41	88.99	84.39	83.50	83.35	87.44	87.72
En/Fs	5.44	5.05	5.25	4.81	4.11	5.52	4.37	3.90

Table 8. Average analyses of clinopyroxene chadacrysts (continued)

Sample Layer	245 8f	241 8e	240 8e	239 8e	211 6b	209 6b	208 6a
SiO_2	51.14	51.10	51.25	51.37	53.36	51.17	52.09
TiO_2	0.16	0.21	0.17	0.18	0.10	0.12	0.14
Al_2O_3	2.59	3.21	2.91	2.96	1.86	2.76	2.72
Cr_2O_3	0.40	0.39	0.39	0.39	0.48	0.72	0.64
MnO	0.20	0.17	0.20	0.16	0.15	0.18	0.18
MgO	15.57	15.59	15.36	15.92	15.85	16.20	16.21
CaO	21.77	21.33	22.02	21.38	23.44	21.73	22.20
NiO	0.01	0.03	0.02	0.07	0.06	0.05	0.02
CoO	0.05	0.01	0.02	0.02	0.03	0.01	0.03
Na_2O	0.43	0.41	0.43	0.39	0.28	0.42	0.40
FeO	3.43	4.10	3.64	3.80	4.11	2.43	3.03
Fe_2O_3	3.26	3.15	3.45	3.38	1.16	3.32	2.64
Total	99.01	99.70	99.87	100.02	100.88	99.10	100.29
			Tetrahedral site = 2				
Si	1.902	1.889	1.893	1.892	1.944	1.894	1.906
Al	0.098	0.111	0.107	0.108	0.056	0.106	0.094
			Octahedral site				
Al	0.016	0.029	0.020	0.020	0.024	0.014	0.023
Ti	0.004	0.006	0.005	0.005	0.003	0.003	0.004
Cr	0.012	0.011	0.011	0.011	0.014	0.021	0.019
Mn	0.006	0.005	0.006	0.005	0.005	0.006	0.006
Mg	0.864	0.859	0.846	0.874	0.861	0.894	0.884
Ca	0.868	0.845	0.872	0.844	0.915	0.862	0.870
Ni	0.000	0.001	0.001	0.002	0.002	0.001	0.001
Co	0.001	0.000	0.001	0.001	0.001	0.000	0.001
Na	0.031	0.029	0.031	0.028	0.020	0.030	0.028
Fe^{2+}	0.107	0.127	0.113	0.117	0.125	0.075	0.093
Fe^{3+}	0.091	0.088	0.096	0.094	0.032	0.092	0.073
Total	2.000	2.000	2.002	2.001	2.002	1.998	2.002
Wo	44.83	43.92	45.11	43.64	47.21	44.69	45.17
En	44.63	44.65	43.77	45.19	44.43	46.35	45.90
Fs	10.54	11.43	11.12	11.17	8.36	8.97	8.93
Mg*	88.98	87.12	88.22	88.19	87.32	92.26	90.48
En/Fs	4.23	3.91	3.94	4.05	5.31	5.17	5.14

Table 8. Average analyses of clinopyroxene chadacrysts (continued)

Sample	199	110	11	109	9	8
Layer	6a	4b	4b	4b	4b	4a
SiO_2	51.35	51.74	51.99	51.82	51.83	51.48
TiO_2	0.12	0.21	0.19	0.17	0.20	0.12
Al_2O_3	2.79	2.96	2.71	3.05	2.83	2.56
Cr_2O_3	0.58	0.41	0.55	0.52	0.51	0.51
MnO	0.19	0.22	0.20	0.20	0.21	0.20
MgO	15.67	15.59	15.38	15.18	15.41	15.65
CaO	22.05	21.78	21.82	21.80	22.01	21.91
NiO	0.02	0.03	0.03	0.01	0.03	0.01
CoO	0.02	0.04	0.01	0.02	0.01	0.01
Na_2O	0.41	0.27	0.28	0.31	0.27	0.29
FeO	3.23	4.86	5.46	5.50	5.02	4.17
Fe_2O_3	2.91	2.48	1.51	2.02	1.78	2.54
Total	99.34	100.59	100.13	100.59	100.11	99.44
			Tetrahedral site = 2			
Si	1.901	1.899	1.917	1.904	1.910	1.908
Al	0.099	0.101	0.083	0.096	0.090	0.092
			Octahedral site			
Al	0.023	0.027	0.035	0.036	0.033	0.020
Ti	0.003	0.006	0.005	0.005	0.006	0.003
Cr	0.017	0.012	0.016	0.015	0.015	0.015
Mn	0.006	0.007	0.006	0.006	0.007	0.006
Mg	0.865	0.853	0.845	0.832	0.847	0.865
Ca	0.870	0.857	0.862	0.858	0.869	0.870
Ni	0.001	0.001	0.001	0.000	0.001	0.000
Co	0.001	0.001	0.000	0.001	0.000	0.000
Na	0.029	0.019	0.020	0.022	0.019	0.021
Fe^{2+}	0.100	0.149	0.168	0.169	0.155	0.129
Fe^{3+}	0.081	0.069	0.042	0.056	0.049	0.071
Total	2.001	2.001	2.000	2.000	2.001	2.000
Wo	45.41	44.29	44.83	44.66	45.10	44.82
En	44.89	44.08	43.94	43.31	43.95	44.56
Fs	9.70	11.63	11.23	12.02	10.95	10.61
Mg*	89.64	85.13	83.42	83.12	84.53	87.02
En/Fs	4.63	3.79	3.91	3.60	4.01	4.20

occur, En/Fs is lower than at the base and Cr_2O_3 is higher (Plate 1); CaO and Al_2O_3 are uniform. Chemistry of cumulus clinopyroxene is similar to chemistry of clinopyroxene chadacrysts (Tables 7 and 8).

5.2.3 Type 3 ungraded layers

Ungraded layers, in which olivine is absent, consist largely of websterites (8b) or orthopyroxene-bearing clinopyroxenites (1a, 2a, 8a, and 8c) or clinopyroxenites (3a, 3b, 3c, 5d and 9b). Layers range in thickness from 0.7 to 5.7 m (Table 5). No layers have an igneous lamination.

Cumulus orthopyroxene with postcumulus overgrowths occurs in half of type 3 uniform layers. Orthopyroxene abundance decreases upwards (layer 8c), increases upwards (layers 2a and 8a), or has a symmetric trend of increasing upwards to a maximum abundance about 25% above the base and then decreasing upwards (layers 1a and 8b) . Cumulus plagioclase occurs in 5 layers, but varies in distribution. Plagioclase occurs at the top of layers 1a, 2a and 8a, in the upper part of layer 3a and at the base of layer 8b. Of the layers that contain cumulus plagioclase only layer 3a does not contain cumulus orthopyroxene (Figure 31).

Poikilitic orthopyroxene oikocrysts only occur in layers 1a and 9b. Oikocrysts have a uniform abundance in layer 9b, but there is insufficient data in layer 1a to determine trends. Discrete postcumulus plagioclase occurs throughout layer 3c and discrete postcumulus orthopyroxene occurs over a thin interval in the lower part of the layer 3c and throughout layer 5d (Table 5).

Grain size of clinopyroxene varies from layer to layer. Grain size decreases upwards (layers 2a, 3a, and 8c), increases upwards (layers 3c, 8a, and 8b), has a symmetric decreasing to increasing upwards trend (layer 3b), or is uniform (layers 1a, 5d and 9b) (Figure 31; Table 5). Clinopyroxene intergrowths are rare, except in layers 5d, 8a and 8c (Table 5); in layers 8a and 8c, intergrowth abundance correlates correlate positively with abundance of cumulus orthopyroxene (Plate 1).

Mineral chemistry was done on 7 of the 10 layers, but in layers 2a and

3a, clinopyroxene analyses were obtained from only selected parts of layers. In the remaining 5 layers, En/Fs, Cr_2O_3, Al_2O_3 and CaO generally have uniform values throughout layers (Figure 33), but there are local variations in some oxides in three layers. These variations include: (a) in layer 3b, lower CaO and higher Cr_2O_3 and Al_2O_3 in the sample at the top of the layer than lower in the layer; (b) in layer 3c, a slight decrease in Al_2O_3 where discrete postcumulus orthopyroxene occurs; and (c) in layer 8b, slightly lower Cr_2O_3 in the lower part of the layer than at the top of the layer (Table 5). No chemistry was collected on clinopyroxene chadacrysts.

5.3 Normally graded layers

The 12 normally graded layers range in thickness from 0.3 to 5.0 m (Table 4); 8 of these layers occur above the upper septum (Figure 31). Based on variations in abundance of olivine relative to clinopyroxene, 3 types of normally graded layers are defined: (1) normally graded from base to top with either relatively small variations in olivine/clinopyroxene (layers 5b, and 12b), or large variations in olivine/clinopyroxene and olivine abundance decreasing to near zero in the upper part of the layer (layers 1b, 7c, and 11e); (2) reversely graded lower part and normally graded middle and upper parts (layers 11a, 11b, 11d, 13a, and 14b); and (3) ungraded lower and middle part that abruptly changes to a normally graded upper part (layers 4c and 10b) (Plate 1; Table 9). The rate of upward decrease in olivine abundance is variable from layer to layer and includes both continuous and discontinuous changes. Except for clinopyroxene + olivine cumulates that are restricted to layers that have an ungraded lower and middle part and a normally graded upper part, layers consist of clinopyroxene + olivine ± plagioclase ± orthopyroxene cumulates (Tables 4 and 9). In contrast to ungraded layers, normally graded layers have a generally higher olivine content, orthopyroxene occurs in a lower proportion of layers, and more than half of normally graded layers occur above the upper septum.

Two of the 12 layers occur at the base of zones and their basal contacts will be

described later as part of zone contacts. The basal contacts of the other 10 layers are sharp, except for layers 10b and 14b, where basal contacts are gradational over several centimeters (Table 4). Contacts at the base of most layers are straight, but layer 14b has a wavy basal contact. Contacts are either phase contacts (6 layers; Table 4) or modal contacts (4 layers; Figure 34 and Table 4); several of these contacts are combined with textural and grain size changes (Table 4).

5.3.1 Type 1 normally graded layers

Olivine clinopyroxenites predominate in layers that are normally graded from base to top. Olivine abundance is about 12% at the base of layers 5b and 12b, but ranges from 41 to 53% at the base of layers 1b, 7c, and 11e (Plate 1; Table 9). At the top of all layers olivine ranges from 0 to 4%. In layers 5b and 12b the upward decrease in olivine content is relatively continuous, in contrast to the discontinuous trends and abrupt decreases in olivine in layers 1b, 7c, and 11e. No layers have an igneous lamination.

Cumulus orthopyroxene occurs in layers 1b, 5b and 7c (Figure 31). In layers 1b and 7c cumulus orthopyroxene occurs throughout the layer and is normally graded in terms of abundance; in layer 1b the abundance of orthopyroxene decreases abruptly at the same stratigraphic height as a similarly abrupt decrease in olivine (Plate 1). In layer 7c the abundance of orthopyroxene is highest at the base and correlates less strongly with olivine than in layer 1b. At the base of layer 5b there is a thin zone of olivine websterite that grades upward into olivine clinopyroxenite (Table 9).

Cumulus plagioclase occurs in layers 7c, 11e, and 12b. Olivine websterite at the base of layer 7c grades upward into melagabbros (Table 9). In layers 11e and 12b, olivine clinopyroxenites grade upward into melagabbro (layer 11e; Figure 34) or olivine melagabbro and gabbro (layer 12b; Table 9).

Orthopyroxene oikocrysts are absent. Discrete postcumulus orthopyroxene occurs only at the top of layer 11e. Grain size of cumulus clinopyroxene, including postcumulus overgrowths, is relatively constant in most layers (Figure 31). In

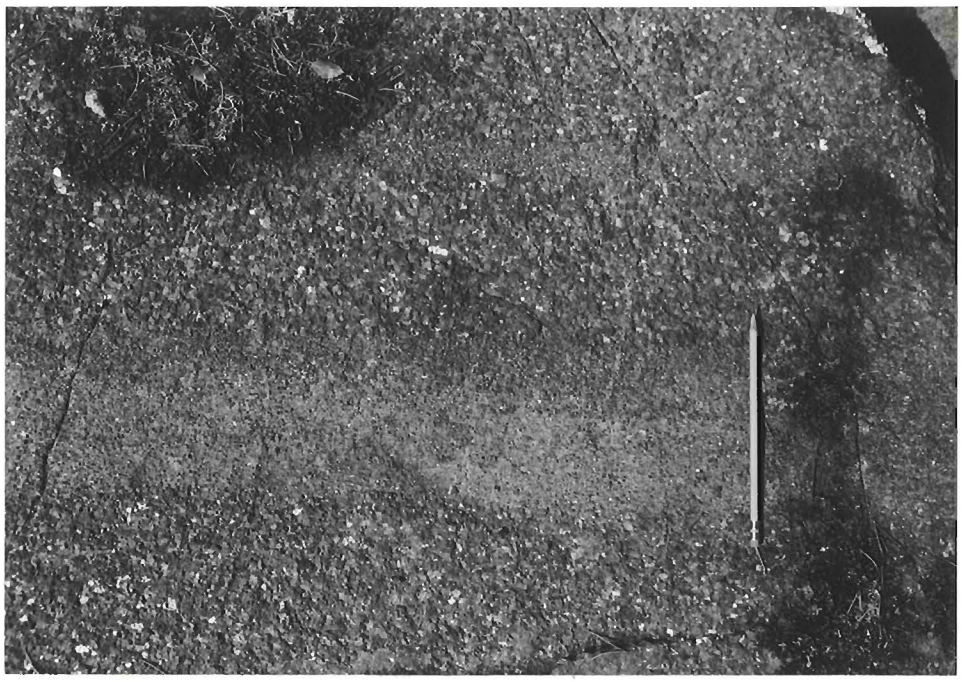


Figure 34. Normally graded layer, 11e, grades from basal wehrlite (fine-grained, light grey) to olivine clinopyroxenite (coarse-grained, grey) to thin gabbro lamina (fine-grained, light grey) at top. Olivine abundance decreases abruptly between the wehrlite and olivine clinopyroxenite. Basal modal contact and upper phase contact of the layer are sharp. Stratigraphic top is to the top of the photograph. Pencil for scale.

layer 12b though, grain size increases upwards and correlates with decreasing olivine abundance (Plate 1). Clinopyroxene intergrowths occur in layer 11e, where intergrowths are most abundant at the top, layer 12b, where intergrowths are most abundant at the base, and layer 5b, where intergrowths are most abundant near the base (Table 9).

Clinopyroxene chemistry was done on samples in the lower half of layers 5b and 12b. No mineral chemistry was done on samples in layers 1b and 7c and only one sample was analyzed in layer 11e. En/Fs, Cr_2O_3, Al_2O_3, and CaO are uniform, except in layer 12b where En/Fs is slightly higher in the middle of the layer than at the base (Figure 33; Table 7). No chemistry was collected on clinopyroxene chadacrysts.

5.3.2 Type 2 normally graded layers

Layers that have a reversely graded lower part and a normally graded upper part consist of largely olivine clinopyroxenites. At the base of layers, olivine abundance ranges from 8 to 70%, but only at the base of layer 11d is there more than 16% olivine (Table 9, Figure 35). Olivine increases in abundance over the lower 4 to 29% of layers, but decreases throughout the remainder of the layers (Figure 35); maximum abundance of olivine is between 8 and 20% higher than the abundance at the base of the layer. Olivine abundance ranges between 0 and 10% at tops of layers. No layers have an igneous lamination.

Cumulus orthopyroxene only occurs as part of several discontinuous, olivine websterite laminae in the lower 20 cm of layer 11b (Table 9; Figures 35 and 36). The amount of clinopyroxene in these laminae is greater than in adjacent olivine clinopyroxenite.

Cumulus plagioclase occurs in discontinuous sublayers of gabbro at the top of layers 11b and 14b (Figure 37; Table 9). In layer 14b gabbro is discontinuous; it occurs in the measured section, but is absent 25 m south (Figure 35); underlying olivine clinopyroxenites are 4 to 4.5 m thick where the modally layered gabbros occur, but are about 5 m thick where modally layered gabbros are absent.

Figure 35. Detailed stratigraphic variation in three Type 2 normally graded layers. Modal abundance of olivine, clinopyroxene, and poikilitic orthopyroxene oikocrysts, grain size and clinopyroxene chemistry of selected oxides and ratios are plotted to scale. Cumulus plagioclase are plotted qualitatively according to stratigraphic location.

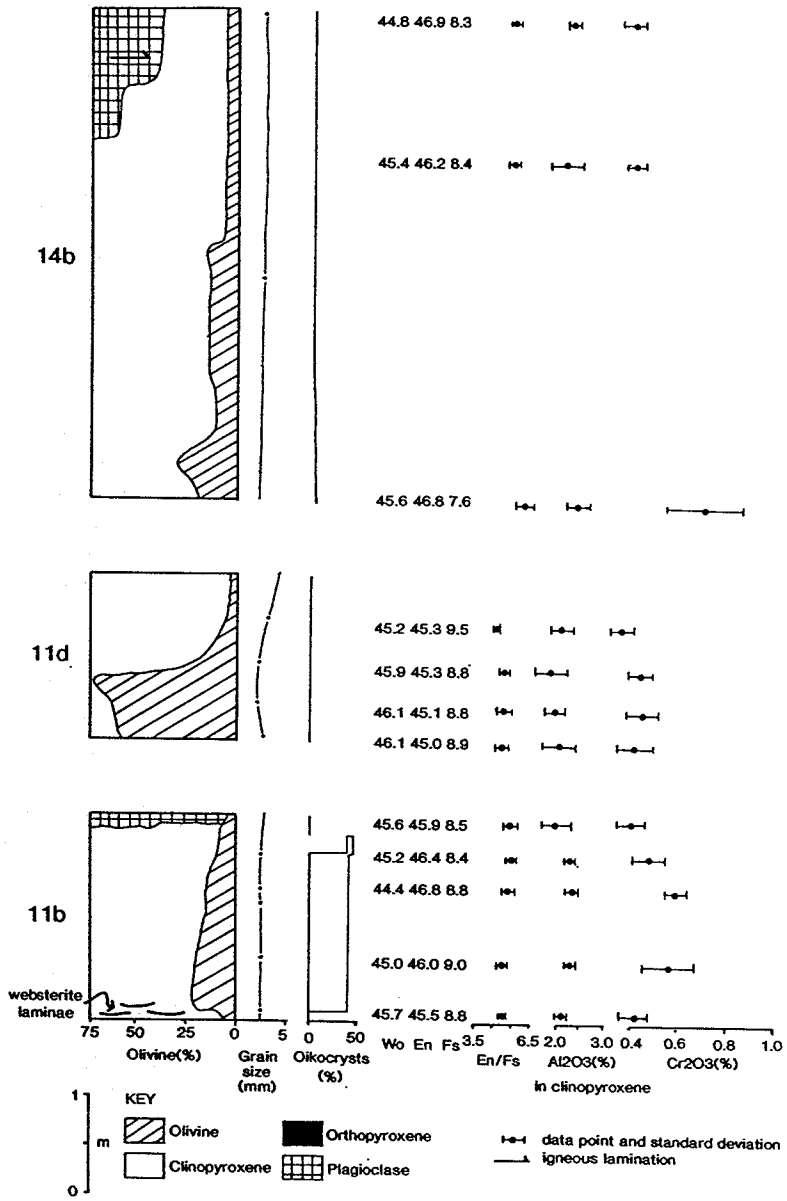


Figure 36. Thin, irregular, discontinuous laminae of finer grained websterite in olivine clinopyroxenite near the base of layer 11b. Laminae have wispy ends and relatively sharp curving contacts. Below the websterite lamina in the lower half of the photograph there is a sharp modal + grain size contact between layers 11a and 11b. Stratigraphic top is to the top of the photograph. Pencil for scale.

Figure 37. Sharp curving contact between layers 11b and 11c (extends across the upper part of the photograph above the pencil). Thin gabbroic laminae at the top of normally graded layer 11b (fine-grained, light grey band) is directly underlain along the left side of the photograph by a fine-grained lamina of gabbro that is absent in the center of the photograph. Stratigraphic top is to the top of the photograph. Pencil for scale.

Orthopyroxene oikocrysts vary in distribution and abundance from layer to layer. Oikocrysts occur throughout layer 11a, and throughout most of layer 11b, except for thin intervals at the base and top; oikocrysts are absent in layers 11d and 13a. In layer 14b oikocrysts occur in trace to rare abundances.

All 5 layers have similar grain size in their lower half, but in layers 11a, 11d, and 13a, grain size increases abruptly in the upper part of the layer (Figure 31; Table 9); the magnitude of the grain size increase varies from layer to layer. Clinopyroxene intergrowths occur in trace abundances, except in layers 11a and 11b (Table 9).

Mineral chemistry was done for all layers. Most layers have relatively uniform trends in En/Fs, CaO and Al_2O_3, except for layer 11a, where there is a progressive upward increase in En/Fs (Figure 33). Cr_2O_3, on the other hand, is generally higher in clinopyroxene from the lower parts of layers than the upper parts of layers (Table 7, Figures 33 and 35); the exception is layer 11b where Cr_2O_3 increases towards the middle of the layer and has about the same values at the base and top of layer 11b (Plate 1).

In layers 11a, 11b, and 14b clinopyroxene chadacrysts were analysed (Table 8, Plate 1). Chadacrysts have similar values of En/Fs and Cr_2O_3 as cumulus clinopyroxene, except at the base of layer 11a where Cr_2O_3 is lower in chadacrysts than in adjacent cumulus clinopyroxene (Plate 1).

5.3.3 Type 3 normally graded layers

These layers consist of olivine clinopyroxenites (layer 4c) or olivine websterites (layer 10b) that are ungraded in the lower or middle part, but in the upper part, there is an abrupt change to normal grading (Table 9, Plate 1). The abundance of olivine is constant, throughout most of these layers, ranging from 18 to 20%; in the upper 15 to 20%, olivine abundance rapidly decreases to 0 (Tables 6 and 9). Both layers are at the top of zones and overlie complexly graded layers. Igneous lamination, defined by parallel orthopyroxene oikocrysts, only occurs in layer 10b.

Cumulus orthopyroxene and cumulus plagiclase are absent in both layers. Poikilitic orthopyroxene oikocrysts only occur in layer 10b (Figure 31) and have a relatively uniform distribution, but decrease in size upwards (Table 9). Discrete postcumulus orthopyroxene occurs in layer 4c (Plate 1).

Although clinopyroxene grain size is relatively similar and ungraded in both layers (Figure 31), the abundance of clinopyroxene intergrowths is greater in layer 4c than layer 10b (Table 9).

Mineral chemistry was not done for layer 10b and only 1 sample was analysed in layer 4c (Table 7).

5.4 Reversely Graded Layer

Layer 15c, which occurs at the top of the observed section, is the only reversely graded layer. Layer thickness is 3.8 m (Table 4), but about 50% of the layer is covered by overburden. Layer 15c consists of a 60 cm thick websterite unit at the base, a 2.7 m thick olivine clinopyroxenite middle part, and a 50 cm thick olivine websterite unit at the top. Olivine ranges from 0% at the base to 22% at the top (Plate 1). Several, finer grained, discontinuous olivine-rich layers, which end abruptly, occur in the upper half of layer 15c. The basal contact is a sharp phase contact (Table 4).

Mean grain size of clinopyroxene is relatively uniform across the layer (Figure 31). Clinopyroxene intergrowths occur in trace abundances. Any changes that occur are within error limits.

No mineral chemistry was done on samples from this layer.

5.5 Complexly Graded Layers

There are 12 complexly graded layers ranging in thickness from 0.6 to 3.2 m (Table 4). Three complex layers vary laterally, over distances of up to 25 m, in thickness by 16 to 70%, but the thickness of the other layers is relatively uniform. Based on the abundance of olivine relative to clinopyroxene, 2 layer types are defined: (1) symmetrical distribution with a reversely graded lower part and a normally graded upper part (layers 5c, 6b, 7a, 7b, 8d, and 14a);

and (2) more variable distribution across layers, but with broad symmetrical trends and local discontinuities (layers 4b, 6a, 8e, 10a, 11c, and 12c); trends are normal to reverse graded, reverse to normal graded, or repeated reverse to normal graded. In contrast to other types of layers, complexly graded layers have a mean thickness that is thinner (Table 4), layers are more widely distributed, cumulus orthopyroxene is limited, and orthopyroxene oikocrysts are more widely distributed. The maximum abundance of olivine occurs over 35% above the base of type 2 complexly graded layers, but below 30% above the base of type 2 normally graded layers.

Four of the 12 layers form the base of zones and their basal contacts will be described later as part of zone contacts. Contacts at the base of the other complexly graded layers are either phase contacts (layers 7b, 8d, 8e, 11c, and 12c) (Figure 38, Table 4), in combination with textural contact (layer 7b) or modal contact (layer 11c), or are modal contacts (layers 4b, 5c, and 6b) (Figure 39).

5.5.1 Type 1 Complexly graded layers

Olivine/clinopyroxene has a symmetrical trend in 6 layers. Abundance of olivine changes gradually across layers 5c, 6b and 8d, but the change is more abrupt in layers 7a, 7b, and 14a (Plate 1). Layers are largely olivine clinopyroxenites (layer 5c), olivine websterites (layers 6b, 7b, 8d and 14a) or feldspathic olivine clinopyroxenites (layer 7a). Igneous lamination, defined by slight alignment of clinopyroxene, occurs in layer 5c.

The three layers in which olivine abundance changes gradually (5c, 6b and 8d), cumulus orthopyroxene is absent, and oikocrysts occur in layers 6b and 8d (Figure 31; Table 10). Layer 8d is the only one of these three layers that contains cumulus plagioclase; plagioclase occurs at the top of the layer where olivine/clinopyroxene is uniform in abundance. Clinopyroxene grain size is uniform and the abundance of clinopyroxene intergrowths is low, except in layer 5c where maximum abundance of intergrowths is slightly above the base and correlate with maximum abundance of olivine and the occurrence of discrete

Figure 38. Sharp, straight phase contact at the base of layer 8d. White weathering lamina containing cumulus plagioclase occurs at the top of layer 8c (light coloured band in the center of the photograph). Stratigraphic top is to the top of the photograph. Pencil for scale.

Figure 39. Relatively sharp, but subtle, basal modal contact (marked by pencil) between olivine websterite (layer 6b) and underlying olivine websterite (layer 6a). Note mottled appearance in layer 6a (below the pencil) and the lack of mottling in layer 6b. In layer 6a the mottled appearance is due to weathering of poikilitic orthopyroxene oikocrysts, but in layer 6b poikilitic orthopyroxene oikocrysts do not produce mottled areas. Stratigraphic top is to the top of the photograph. Pencil for scale.

postcumulus orthopyroxene (Table 10).

In contrast to layers where olivine abundance changes gradually, olivine abundance in layers 7a, 7b, and 14a, changes abruptly and is higher; layers 7a and 7b also contain cumulus orthopyroxene. Cumulus orthopyroxene in layer 7b occurs in a basal feldspathic websterite sublayer and an olivine websterite sublayer near the middle of layer 7b (Table 10; Plate 1). Cumulus plagioclase occurs throughout layer 7a, in the lower half of layer 7b, but is absent in layer 14a (Table 10). Orthopyroxene oikocrysts occur in layers 7b and 14a and generally increase in abundance and size upwards. In layer 7b oikocrysts occur with cumulus orthopyroxene in both thin sublayers, and elsewhere in the layer. Clinopyroxene grain size is relatively uniform, except in the lower part of layer 14a, where clinopyroxene is coarser (Figure 31). There are also local patchy variations in grain size in the lower part of layer 7a; in outcrop, patches of differing grain size have a mixed appearance. Clinopyroxene intergrowths are absent.

Olivine-rich patches locally occur between oikocrysts in lherzolite from layer 7b. In outcrop, the patches have the same colour and weathering characteristics as oikocrysts, but they are irregularly shaped and larger than oikocrysts.

Mineral chemistry was done on all layers with gradually changing olivine abundance, but no mineral chemistry was collected from samples in layers with abruptly changing olivine abundance. In layers with gradually changing olivine abundance, no samples were analyzed from the upper half of layer 8d and only 2 samples from layer 6b were analysed (Table 7). En/Fs, CaO, and Al_2O_3 are relatively uniform, except in layer 6b where En/Fs is higher in the lower part of the layer than the upper part (Figure 33). Cr_2O_3 is higher in the lower reversely graded part of layers 5c and 6b than in the upper normally graded part (Figures 33 and 40). In layer 8d, though, Cr_2O_3 is slightly lower at the base and uniform throughout the remainder of the lower half.

Chadacrysts were analysed in layers 6b and 8d (Table 8). Compared to cumulus clinopyroxene, chadacrysts have similar En/Fs and Cr_2O_3, except in

Table 10. Petrologic summary of complexly graded layers.

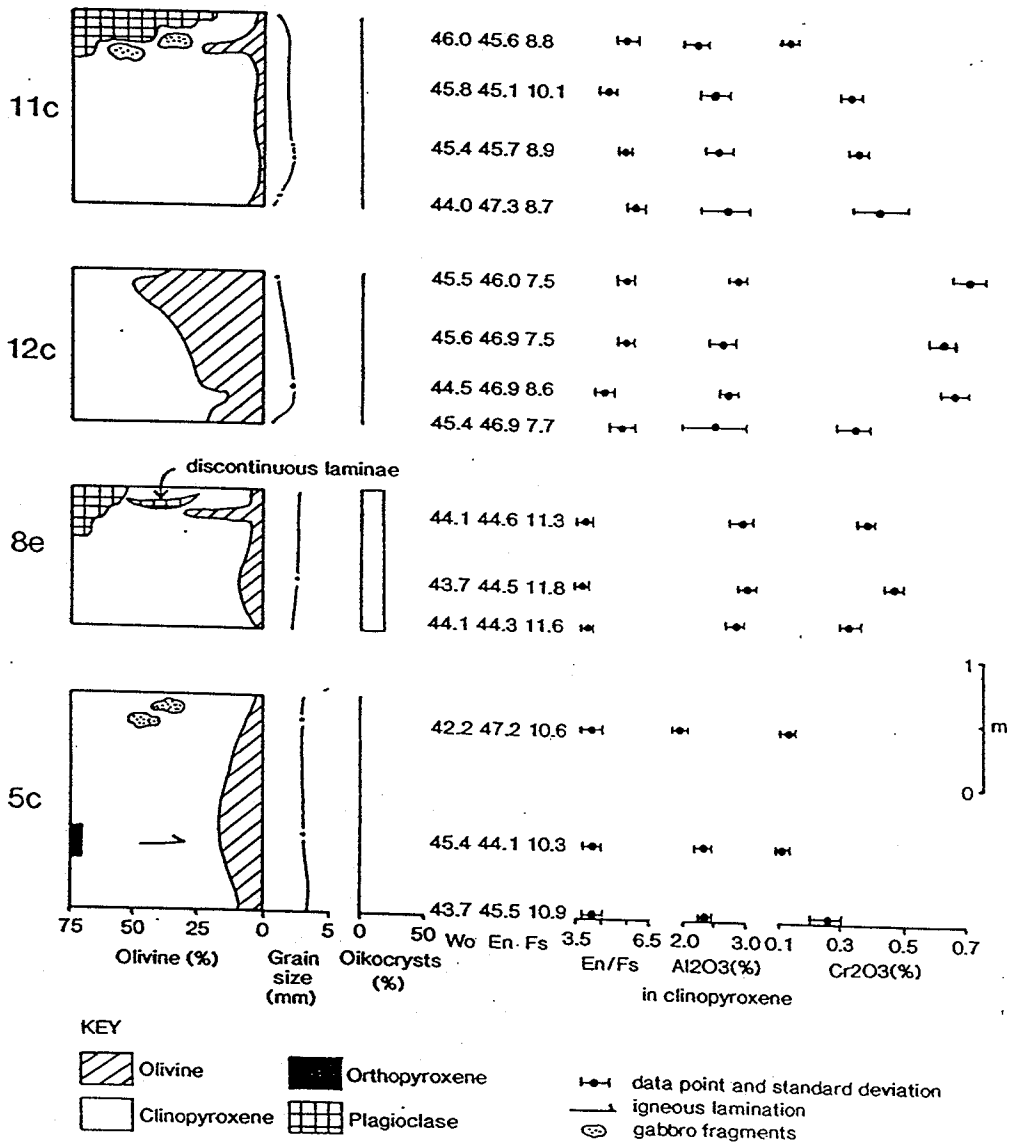
Type	Layers	Thickness	Mineralogy	Internal variations
1	6	0.6 to 2.1	Clinopyroxene: 15-99%, 0.13 to 13.2 mm cumulus grains with postcumulus overgrowths; grain size and intergrowths in clinopyroxene are relatively uniform, although grain size in the lower 20 to 40 cm of layer 14a is slightly coarser than the rest of layer 14a. Intergrowths are more abundant slightly above the base of layer 5c where olivine is more abundant, but no variations occur in other layers; intergrowths are absent in layers with more pronounced changes in olivine/clinopyroxene. Olivine: 0 to 80%, 0.12 to 5.3 mm, cumulus grains; includes up to 2% that is enclosed in clinopyroxene. The maximum abundance of olivine occurs 36 to 67% above the base of layers. Orthopyroxene: 0 to 63.5%, 0.09 to 20 mm grains comprising both cumulus (layer 7b) and oikocrystic grains (layers 6b, 7b, 8d and 14a). Cumulus grains rarely exceed 5 mm, but oikocrysts are up to 20 mm, except in layer 8d where maximum size is about 14 mm. Plagioclase: 10 to 89%, 0.08 to 1.1 mm cumulus grains that occur in thin gabbroic layers in layer 8d, throughout layer 7a and in the lower half of layer 7b. Oxides: 0-1.5%, 0.01 to 0.8 mm cumulus grains.	Cumulate assemblages: (1) cpx + ol (layers 5c, 6b, and 14a); and (2) cpx + ol + plag ± opx (layers 7a, 7b, 8d) Olivine/clinopyroxene has a symmetric variation with a reversely graded lower part and normally graded upper part. Two subtypes can be defined on the basis of nature of transition from reverse to normal grading and degree of variation in olivine/clinopyroxene. In subtype 1 layers 5c, 6b, and 8d the reverse to normal transition is gradual and maximum olivine abundance is 12 to 14% and occurs between 36 and 43% above the base of layers; in layer 8d the symmetric varaition is topped by a uniform trend. In subtype 2 layers 7a, 7b and 14a the transition from reversely graded to normally graded is more pronounced than in subtype 1 and there is greater variation in olivine/clinopyroxene. Olivine abundance has a maximum of 51 to 60%, which occurs 36 to 67% above the base of the layer. Layers that contain only cumulus clinopyroxene and cumulus olivine are 1.7 to 2.0 m thick and layers that also contain cumulus plagioclase or cumulus orthopyroxene are 0.6 to 2.1 m thick. A weak igneous lamination defined by clinopyroxene occurs in layer 5c. No gabbroic patches.

Table 10. Petrologic summary of complexly graded layers (continued).

Type	Layers	Thickness	Mineralogy	Internal variations
2	6	1.0 to 3.2	Clinopyroxene: 19-100%, 0.1 to 16 mm, cumulus grains with postcumulus overgrowths. Grain size is relatively uniform. Abundance of intergrowths is uniform and low in layers 8e and most of layer 11c; intergrowths increase abruptly in the olivine-rich sublayer. Intergrowths are absent in layer 6a. In other layers trends are symmetrical (layers 4b and 10a), increase upwards (layer 11c) or are more abundant in the lower to middle part (layer 12c); where distribution is symmetrical, intergrowths are more abundant in the center of layers. Olivine: 0-50%, 0.1 to 4.5 mm cumulus grains with 0 to 1% of the olivine enclosed in clinopyroxene. Maximum olivine abundance occurs 8 to 92% above the base of layers. Orthopyroxene: 0 to 40%, 3 to 20 mm poikilitic oikocrysts (layers 4b, 6a, 8e, and 12c) and no cumulus grains. Oikocrysts in layer 8e range in size from 1.3 to 5.5 mm, but in other layers are up to 20 mm. Discrete postcumulus orthopyroxene only occurs in the lower half of layer 11c. Orthopyroxene is absent in layer 10a. Plagioclase: 0 to 89%, 0.1 to 2.2 mm cumulus grains; occur in 30 to 40 cm thick gabbroic sections at the top of layers 4b, 8e, and 11c. Cumulus plagioclase occurs at the base of layer 10a, but is absent in layers 6a and 12c. Oxides: 0-2%, 0.01 to 0.7 mm cumulus grains.	Cumulate assemblage: cpx + ol ± plag Three general trends are defined that vary in degree from place to place: (a) limited symmetric, reverse to normal grading; near the top of each layer there is a relatively thin, olivine-rich sublayer (layers 8e and 11c); olivine has a maximum abundance of 29% that occurs 82% above the base of layer 8e and 23% about 87% above the base of layer 11c; local gabbro patches occur in layer 8e; (b) the lower 10 to 20 cm is normally graded, but abruptly changes to reversely graded over most (layer 12c) or only a thin part of (layer 10a) layers; above the reversely graded part the layer is normally graded (layer 12c) or uniform (layer 10a); in layers 10a and 12c olivine has a maximum abundance of 18 or 50% and occurs 8 or 92% above the base of layers, respectively; and (c) double symmetric, reverse to normal grading with higher olivine contents occurring at two levels in the layer; (layers 4b and 6a); in layers 4b and 6a, olivine has a maximum abundance of 12 or 50% that occurs 26 or 57% above the base of layers, respectively. A weak igneous lamination defined by clinopyroxene occurs in layer 4b. In layer 6a there are several ultramafic patches that range in size from 20 cm to > 1 m; patches have an irregular shape and larger patches parallel layering.

Cpx = clinopyroxene; Ol = olivine; Opx = orthopyroxene; Plag = plagioclase.

Figure 40. Detailed stratigraphic variation diagram of Type 1 complexly graded layer 5c, and Type 2 complexly graded layers 11c, 12c, and 8e. Modal abundance of olivine, clinopyroxene and poikilitic orthopyroxene oikocrysts, grain size, and clinopyroxene chemistry of selected oxides and ratios are plotted to scale. Cumulus plagioclase and orthopyroxene are plotted qualitatively according to stratigraphic location.



layer 6b, where, in the upper sample, En/Fs is higher in chadacrysts than cumulus clinopyroxene and, in the lower sample, Cr_2O_3 is higher in chadacrysts than cumulus clinopyroxene (Tables 7 and 8).

5.5.2 Type 2 Complexly graded layers

The 6 other complexly graded layers have discontinuous trends that include: (1) limited symmetric, reverse to normal grading with a thin olivine-rich sublayer in the upper 40 cm of layers (layers 8e and 11c)(Table 10); (2) a thin normally graded olivine-poor part at the base that is overlain in turn by a reversely graded part and then by either an ungraded (layer 10a) or a normally graded upper part (layer 12c)(Table 10); or (3) reversely graded lower part overlain by a normally graded part with this pattern repeated upwards (layer 4b and 6a)(Table 10). Igneous lamination, defined by slight alignment to clinopyroxene, only occurs in layer 4b.

Layers 8e and 11c, which have limited symmetric grading with an olivine-rich sublayer in the upper part of the layer, vary from olivine-bearing clinopyroxenites (layer 11c) and olivine-bearing websterites (layer 8e) in the lower part of layers to olivine gabbro (layer 11c), gabbro (layer 11c), and olivine gabbronorite (layer 8e) in the upper part. Cumulus orthopyroxene is absent, but cumulus plagioclase occurs at the top of both layers (Figure 40; Table 10). Orthopyroxene oikocrysts only occur in layer 8e (Figures 31 and 40). Discrete postcumulus orthopyroxene occurs in the lower part of layer 11c, but none occurs in layer 8e.

Clinopyroxene grain size is relatively uniform, but is slightly coarser in the middle of layer 11c than at the top or bottom of the layer (Fiugre 31). Clinopyroxene intergrowths are rare in layer 8e and generally low in abundance in layer 11c, except for an abrupt increase in the olivine-rich sublayer (Table 10).

Layers 10a and 12c, which have a normally graded olivine-poor part at the base overlain by a reversely graded middle part, are mostly olivine clinopyroxenites. Orthopyroxene is absent and cumulus plagioclase only occurs at the base of layer 10a (Table 10). Clinopyroxene has relatively uniform grain size in layer

10a, but in layer 12c, grain size is slightly coarser just above the base (Figure 31). The abundance of clinopyroxene intergrowths is relatively low and correlates with grain size (Table 10).

Layers 4b and 6a, which have a repeated, symmetrical, reversely to normally graded trend, are olivine websterites. Cumulus orthopyroxene is absent and cumulus plagioclase only occurs at the top of layer 4b (Table 10); olivine is rare where cumulus plagioclase occurs. In layer 4b, orthopyroxene oikocrysts are most abundant at the base and decrease upwards, but in layer 6a oikocrysts are absent near the base, and are abundant and uniformly distributed throughout the remainder of the layer. Associated with cumulus plagioclase is an abrupt decrease in clinopyroxene grain size; where cumulus plagioclase is absent clinopyroxene grain size is relatively uniform. Clinopyroxene intergrowths are relatively abundant in layer 4b, but are absent in layer 6a; intergrowths are most abundant in the middle of layer 4b (Table 10).

Several rusty weathering, irregular to angular, ultramafic patches occur in layer 6a (Figure 41); larger patches parallel layering (Table 10).

Mineral chemistry was done on most layers except layer 10a, but samples from layer 6a are restricted to the upper half of the layer. In layers having limited symmetric variation (layers 8e and 11c) there is a marked difference in trends. In layer 8e, En/Fs is uniform, but in layer 11c, En/Fs has a symmetric, decreasing upwards to increasing upwards trend; the change in trend occurs at about the olivine-rich sublayer (Figure 40). Al_2O_3 is less abundant in the lowest sample in layer 8e, although relatively uniform above, but in layer 11c Al_2O_3 decreases upward, except above the stratigraphic interval where olivine occurs, at which point Al_2O_3 increases (Figure 40). Cr_2O_3 follows a similar trend to Al_2O_3 in both layers. Clinopyroxene chadacrysts were only analysed in two samples from layer 8e. Compared to cumulus clinopyroxene, chadacrysts have similar Cr_2O_3, but En/Fs in chadacrysts is higher in the lower sample than the upper sample (Plate 1, Tables 7 and 8).

Figure 41. Slightly discordant, fine-grained patches of rusty weathering ultramafic material enclosed by poikilitic olivine clinopyroxenite, layer 6a. Stratigraphic top is to the top of the photograph. Pencil for scale.

Clinopyroxene analyses were obtained from only one of the layers that have a thin, normally graded lower part overlain by a reversely graded middle part In the lower part of layer 12c, En/Fs is relatively constant except for an olivine-poor sample in the lower part of the layer which has lower En/Fs (Figure 40). Cr_2O_3 is low at the base, but is relatively uniform elsewhere. Al_2O_3 and CaO are uniform.

In layers with a repeated pattern of reverse to normal grading, all oxides and ratios have relatively uniform trend (Figure 33). In layer 4b though, one analysis has much lower En/Fs than adjacent samples (Table 7). Clinopyroxene chadacrysts have slightly higher values of En/Fs and Cr_2O_3 than cumulus clinopyroxene outside of oikocrysts.

5.6 Discrete ultramafic occurrences

In addition to the ultramafic zones, clinopyroxene + olivine cumulates occur as:

1. irregular, elongate patches along the upper contact of the upper septum (Figure 42); thickness ranges from 0 to 1.3 m; and
2. rare patches, up to 1 m across, enclosed in the upper septum (Figure 42).

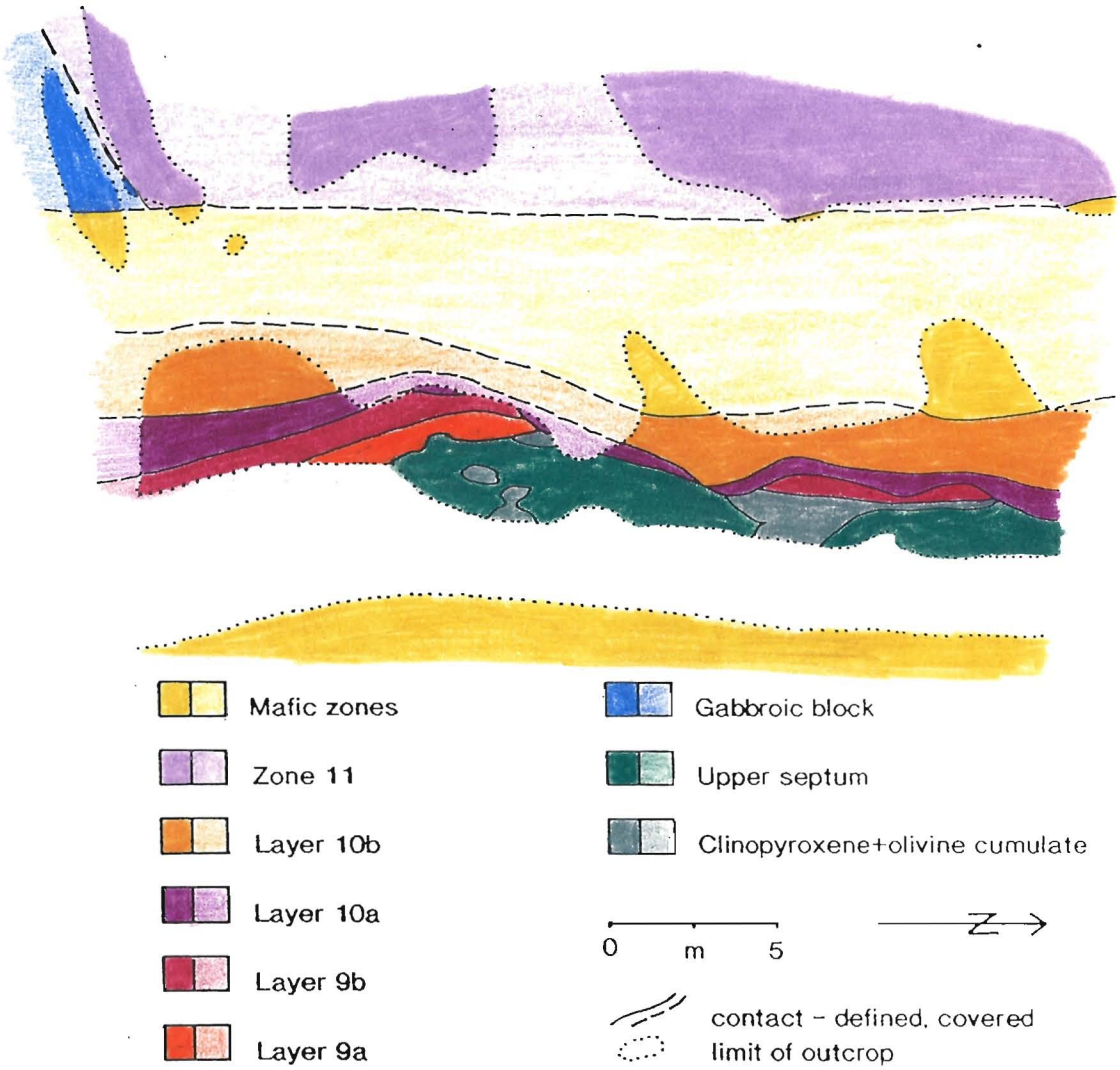
Enclosed in these clinopyroxene + olivine cumulates are up to 20%, 0.5 to 40 cm long, equant to ovoid to irregular serpentinite clots that contain up to 10% magnetite. Larger clots are ovoid to irregular with rounded corners and smaller clots are equant with rounded corners.

5.7 Discrete gabbro occurrences

Plagioclase-bearing gabbroic material that is not obviously related to cumulus processes occurs in 8 layers. This gabbroic material occurs as: (a) randomly distributed to locally isolated, rounded, equant to elongate to irregular, fine- to medium-grained patches, or (b) clusters of rounded, equant to ovoid to cylindrical, medium-grained clots.

Patches, which occur in coarser-grained olivine websterite, olivine clinopyroxenite and websterite in layers 8a, 8b, 8c, 8e, 10a, and 11b, range in abundance from rare to 70% of a layer and have a diameter of 2 to 20 mm. Patches are

Figure 42. Detailed outcrop map of zone 9 truncated by overlying ultramafic zone of cycle 10. Both ultramafic zones of cycles 9 and 10 have variable thickness along strike; contact of cycle 9 and the septum is locally irregular. A large mafic xenolith occurs at the base of cycle 11 in the south part of the outcrop.



medium-grained leucogabbro, gabbro and melagabbro, and some patches contain up to 5%, fine-grained olivine. At the top of layers 8a, 8c and 11b and the base of layer 10a, there are gabbroic layers that are similar in grain size to the patches. Internally, most patches are uniform, but some are modally layered.

Contacts of the patches with the adjacent ultramafic cumulates are sharp; in layer 8a there is a 4 cm wide, black weathering rim on one patch, but similar rims were not observed elsewhere. Elongate patches are largely concordant, but in the lower three layers of zone 8, layer contacts end abruptly adjacent to patches. Near the top of layer 11b, a 10 cm thick section of ultramafic cumulates that contains 20% gabbro patches occurs directly below a sequence of gabbro, melagabbro and olivine gabbro. The gabbro, melagabbro and olivine gabbro layer varies from 1 cm to several cm in thickness along strike; patches are more abundant where the gabbroic layer thins.

Clots, which occur in layers 3a and 3c, range in abundance from 10 to 60%. Equant clots have a diameter of about 0.4 to 3.5 cm and ovoid to cylindrical clots are 9 to 60 cm long and 0.8 to 1.5 cm wide. Clots of similar shape tend to occur in the same area, particularly in the lower part of layers, so that equant clots occur in some areas, ovoid clots occur in others and cylindrical clots in still other areas. In general, clots increase in size and abundance upwards in each layer. Clots consist of medium- to coarse-grained leucogabbro, gabbro, melagabbro and feldspathic pyroxenite; some clots contain up to 5% finer grained orthopyroxene. Contacts with adjacent clinopyroxenite are sharp, although in layer 3c some coarser-grained clots have a grain size similar to that of adjacent clinopyroxenite and vague boundaries. Some coarser-grained clots in layer 3c, appear to form part of a discontinuous gabbroic layer.

5.8 Mineral variations in zones

Of the 13 zones that comprise 2 or more layers, variation in olivine/clinopyroxene defines 4 different zonal trends. There are insufficient data in zone 5 to adequately define trends and the lack of data in the lower part of

zone 4 makes identification of trends less reliable than in other zones. Based on the mean olivine to clinopyroxene ratio of each layer, which was calculated by measuring the area right of the trend line for each layer on Plate 1 and dividing by layer thickness (Figure 42), zones are divided into:

1. ungraded trend (zones 3, 4, 9, and 10): mean olivine abundance is relatively constant across zones (Figure 43; Table 11);
2. normally graded trend (zones 6, 7, 11, and 14): mean olivine abundance decreases upward; in zone 11 there is a discontinuity at the top of layer 11c with a repetition in the trend in layers 11d to 11f (Figure 43; Table 11);
3. reversely graded trend (zones 1 and 8): olivine occurs in the upper part of zones, but is absent in the lower part (Figure 43; Table 11); and
4. complexly graded trend (zones 12 and 15): mean olivine abundance is either reversely graded in the lower part of zones and ungraded in the upper part (zone 15) or normally graded in lower parts of zones and reversely graded in the upper part (zone 12) (Figure 43; Table 11).

5.8.1 Zones that have ungraded trends

Zones that have ungraded trend consist of either 2 (zone 10) or 3 layers (zones 3 and 4); zones 4 and 10 contain olivine and olivine is absent in zone 3 (Plate 1). Cumulus plagioclase occurs as part of thin gabbroic layers in the lower half of zones 3 and 4 and at the base of zone 10; cumulus plagioclase only occurs at the top of 1 layer, which is in zone 4, and does not occur at the tops of zones.

Cumulus orthopyroxene does not occur in any of these zones and oikocrysts occur in zones that contain olivine (zones 4 and 10). Oikocrysts decrease in abundance upwards in zone 4 and increase in abundance upwards in zone 10.

Mineral chemistry was only collected for zone 3 and the upper 2/3 of zone 4 (Figures 33 and 43). There is no similarity in mineral chemistry variations in zones 3 and 4 (Table 11; Figure 43).

5.8.2 Zones that have normally graded trends

Zones that have normally graded trends comprise either 2 layers (zones 6 and

Figure 43. Mean abundance of olivine/clinopyroxene, clinopyroxene chemistry, cumulus orthopyroxene and poikilitic orthopyroxene oikocrysts from layers. Means of mineral abundances were calculated by measuring the area right of the trend line for each layer in Plate 1 and dividing by layer thickness. Means of mineral chemistry were calculated by averaging the mean sample analyses for the complete layer.

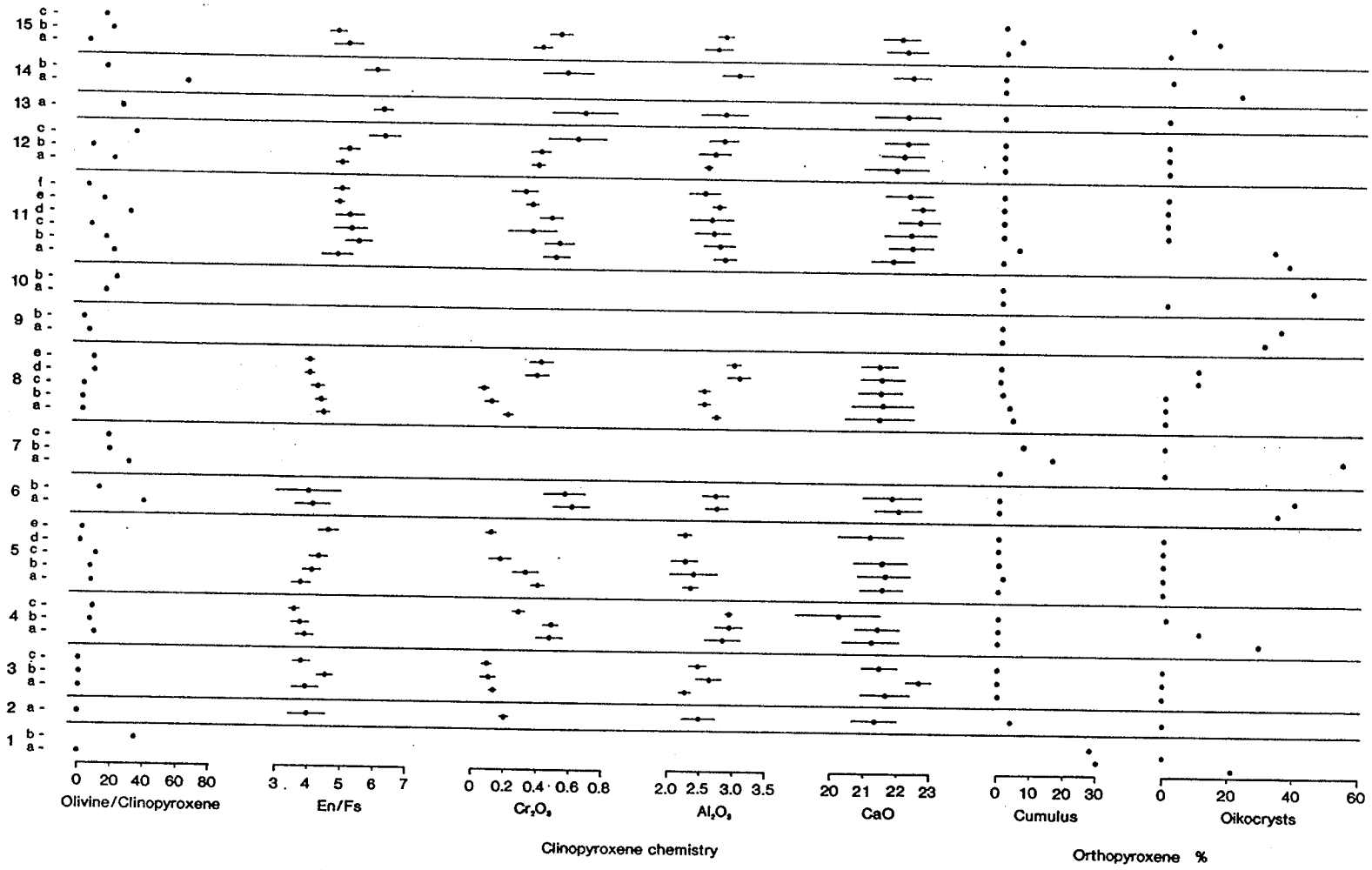


Table 11. Summary of ultramafic zones.

ZONE TYPE	# OF ZONES	MINERAL VARIATIONS	MINERAL CHEMISTRY
UNGRADED	4	Olivine/clinopyroxene is ungraded, but there is no petrographic data for the lower part of zone 4. Olivine is absent in zone 3 and occurs in zones 4 and 10. Cumulus orthopyroxene is absent. Orthopyroxene oikocrysts are common in zones 4, 9 and 10. In zone 4 oikocrysts decrease in abundance upwards, but oikocrysts are more abundant in the upper part of zones 9 and 10. Cumulus Plagioclase occurs in most ungraded zones, but varies in distribution; plagioclase occurs in the middle part of the lower layer in zones 3 and 4 and at the base of zone 10; plagioclase is absent in zone 9.	Mineral chemistry was not done on zones 9 and 10, but trends and abundances are different in zones 3 and 4. In zone 4 values are relatively uniform, but in zone 3 En/Fs, Al_2O_3, and CaO have trends that are symmetric increasing upwards to decreasing upwards; Cr_2O_3 decreases upwards in zone 4 and is uniform in zone 3.
NORMAL	4	Olivine/clinopyroxene decreases upwards, but the amount of decrease varies from zone to zone; in zone 11, there is an abrupt discontinuity at the contact between the lower half of the zone (layers 11a-c) the upper half of the zone (layers 11d-f). Cumulus orthopyroxene only occurs in zones 7 and 11: in both zones cumulus orthopyroxene occurs towards the middle of the zone, but is abundant in zone 7 and rare in zone 11; in the middle part of zone 7, cumulus orthopyroxene occurs in two sublayers separated by olivine clinopyroxenite. Orthopyroxene oikocrysts occur in all zones but varies in distribution and abundance. In zones 6 and 9 oikocrysts are more abundant in the upper part of the zone than the lower part; in zones 11 and 14 oikocrysts decrease in abundance upwards and are absent in the upper half of the zone. Oikocrysts only occur in the middle layer of zone 7. Cumulus Plagioclase occurs at the top of zones 5, 7, and 14, but in zone 14 plagioclase occurs in a gabbro sublayer that is discontinuous. Plagioclase also occurs throughout the lower half of zone 7. Plagioclase occurs at the top of three layers in zone 11, but not at the top of the zone. No plagioclase occurs in zone 6.	Mineral chemistry was not done in zone 7 and there are insufficient data to define trends in zone 14. In zone 6 mineral chemistry is uniform, but in zone 11, there is (1) an upwards increase in En/Fs in the lower part of zone; (2) an abrupt increase in at the contact between the lower half of zone 11 (layers a-c) and the upper half (layers e-f) and (3) upwards decrease in Cr_2O_3 in the upper half of zone; Cr_2O_3 has a lower value in layer 11c relative to overlying and underlying layers.
REVERSE	2	Olivine is absent in the lower half, but occurs in the upper half of zones 1 and 8. Cumulus orthopyroxene occurs in both zones, but its distribution differs from that of olivine in that cumulus orthopyroxene is more abundant and does not vary upwards in zone 1 compared to zone 8; in zone 8 cumulus orthopyroxene is less abundant and decreases upwards. Orthopyroxene oikocrysts occur in parts of zone 1 that do not contain olivine and occur in parts of zone 8 that do contain olivine. Cumulus Plagioclase occurs at the top of layers in both zones, except layer 8b where plagioclase occurs at the base and layer 1b where plagioclase is absent.	No mineral chemistry was collected in zone 1, but in zone 8, En/Fs, Cr_2O_3 and Al_2O_3 decrease upwards in the lower part of the zone, but there is an abrupt discontinuity at the contact between layers 8c and 8d. Cr_2O_3 and Al_2O_3 are higher in layers 8d-e than in layers 8a-c. CaO is uniform.
COMPLEX	2	Olivine/clinopyroxene has a symmetric normally graded to reversely graded trend in zone 12, but in zone 15 the lower part is normally graded and the upper part is ungraded. Cumulus orthopyroxene is restricted to zone 15 which also contains orthopyroxene oikocrysts that have a symmetric reversely graded to normally graded distribution; rare oikocrysts occur in zone 12. Cumulus Plagioclase occurs at the top of layers 12a and 15b only.	Mineral chemistry was not collected for the upper half of zone 15. In the lower part of both zones clinopyroxene chemistry is uniform. In the upper part of zone 12, En/Fs and Cr_2O_3 are higher than in the lower part, but CaO and Al_2O_3 are uniform across the zone.

14), 3 layers (zone 7) or 6 layers (zone 11). The trend of olivine/clinopyroxene in zone 11 is repeated with a discontinuity between layers 11c and 11d (Figure 43). In zones 11 and 14, which are thicker than other zones, cumulus plagioclase occurs at the top of some layers (Table 11).

Cumulus orthopyroxene occurs in the lower half of zone 11 and locally throughout zone 7, but not in other zones. Oikocrysts decrease upwards (zones 14, 11), increase upwards (zones 6) or have a maximum abundance in the middle of the zone (zone 7) (Table 13); in the upper half of zone 11 oikocrysts are absent as they are in the upper and lower parts of zone 7.

Mineral chemistry was not done for zone 7 and is insufficient in zone 14 to define trends (Table 7). En/Fs, Al_2O_3 and CaO are uniform in zone 6 the lower part of zone 11 and the upper part of zone 11 (Figure 43). Cr_2O_3 is also uniform except in the upper half of zone 11, where Cr_2O_3 decrease upwards (Figure 43).

5.8.3 Zones that have reversely graded trends

Zones that have reversely graded trends comprise 2 layers (zone 1) or 5 layers (zone 8) (Figure 31). Olivine is absent or only occurs in trace abundances in the lower 60 to 70% of both zones. Both zones underlie septa, but are separated from the septa by mafic zones of different thickness (Figure 31).

Cumulus orthopyroxene has a similar trend in both zones, but is more abundant in zone 1 than in zone 8 (Figure 43); cumulus orthopyroxene is absent in the top half of zone 8 (Plate 1). Cumulus plagioclase occurs in all layers except the top layer of zone 1. Except in layer 8b, plagioclase generally occurs at the top of layers (Table 11).

Although both zones have oikocrysts, oikocryst distribution is different. Orthopyroxene oikocrysts occur in the lower 60% of zone 1 and the upper half of zone 8 (Figure 43).

No mineral chemistry was collected in zone 1 and therefore no comparisons between zones can be be made. In zone 8, there is an abrupt discontinuity in trends of Cr_2O_3 and Al_2O_3 at the boundary between layers 8c and 8d from lower

values to much higher values (Figure 43). En/Fs in zone 8 decreases upwards and CaO is uniform.

5.8.4 Zones that have complexly graded trends

Complexly graded zones comprise 3 layers and define two trends:

1. olivine/clinopyroxene is reversely graded in the lower part and ungraded in the upper part (zone 15) (Plate 1).
2. olivine/clinopyroxene is normally graded in the lower part and reversely graded in the upper part (zone 12) (Plate 1).

Comparison of zones 12 and 15 indicate few similarites. Cumulus orthopyroxene is absent and oikocrysts are rare in zone 12. In zone 15 cumulus orthopyroxene occurs in local sublayers and oikocrysts are abundant in the center and upper parts of the zone. Cumulus plagioclase occurs in both zones, but varies in distribution (Table 11); cumulus plagioclase occurs at the top of one layer from each zone (Plate 1).

Comparison of mineral chemistry between zone 12 and the lower half of zone 15 indicates that in the lower half of both zones, En/Fs, Cr_2O_3, Al_2O_3, and CaO have uniform trends (Figure 43). In zone 12, En/Fs and Cr_2O_3 are higher in the upper part of the zone than in the lower part (Figure 43).

5.9 Zone contacts

The lower and upper contacts of ultramafic zones are sharp, although lower contacts to zones 1, 4, and 6 are not exposed; lower contacts to zones 2 and 9 are with septa and the lower contact of zone 10 is with an ultramafic zone. Along the section line, contacts between ultramafic zones and mafic zones of underlying cycles are (a) straight, (b) wavy, or (c) irregular. Between the ultramafic zones and the mafic zones there are 5 straight contacts, 3 wavy contacts and 1 irregular contact. All contacts appear relatively concordant, except at the base of zone 10 (Figure 42).

Contacts that are wavy occur at the base of zones 5, 7, and 11. Wavy contacts have amplitudes up to 10 centimetres. Contacts 9 and 10 are also wavy,

but do not overlie mafic zones; zone 9 directly overlies the upper septum and its form is probably controlled by waviness of the top surface of the septum and zone 10.

At the base of zone 15, the contact is irregular. Commonly, gabbroic material extends upwards for several tens of centimetres into the ultramafic rocks. Fine-grained, equant to ovoid, gabbro patches, 5 to 20 cm long occur in the lower 60 cm of the lowest ultramafic layer; ovoid patches parallel layer contacts. Patches were not found associated with other types of contacts.

The contact at the base of zone 10 is discordant to, and cuts across, zone 9 (Figure 42). No mafic zone occurs in cycle 9 and zone 10 is in direct contact with the ultramafic rocks of zone 9. The thickness of zone 9 also varies markedly along strike and in zone 9 is locally absent.

Contacts between ultramafic zones and overlying mafic zones of the same cycle are (a) straight or (b) irregular. There are 8 straight contacts and 7 irregular contacts. Irregular contacts are characterized by: (1) centimetre to metre scale discordant relationships, with fingers of clinopyroxenite extending upward into the mafic zone; (b) angular blocks of gabbro that are partly detached from the overlying gabbro and hang down into the ultramafic zone; and/or (c) angular to rounded, blocks of pyroxenite that are enclosed in the basal part of overlying mafic zones. The degree to which any one of these features has developed varies from zone to zone.

Upper contacts of zones 1, 2, 8, and 13 are slightly irregular with convex-upward, clinopyroxenite fingers that extend upward as much as 30 cm into mafic zones. Centimetre-sized pieces of clinopyroxenite, which are angular to rounded and vary in shape from equant to elongate to irregular, occur in the lower part of overlying mafic zones (Figure 44).

Upper contacts of the three thickest zones, zones 3, 5 and 11, are highly irregular. Medium- to coarse-grained clinopyroxenite, with grain size up to 5 cm, occurs as fingers that extend upward as much as 50 cm into the mafic zone.

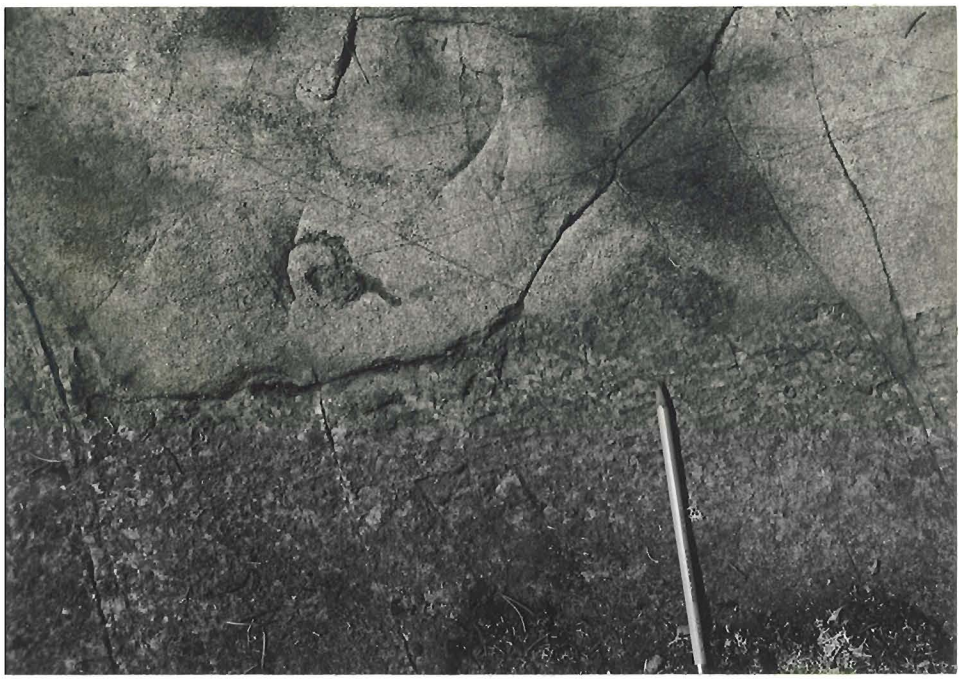


Figure 44. Sharp, wavy contact between olivine clinopyroxenite and overlying gabbro at the top of the ultramafic zone, cycle 13. Small contorted fragment of pyroxenite (coarse-grained, dark grey) occurs in gabbro. Stratigraphic top is to the top of the photograph. Pencil for scale.

In the fingers, clinopyroxene grain size increases upwards. Layers in the lower parts of mafic zones are truncated, but are not folded or otherwise disturbed. Discrete gabbro blocks that are up to 50x100 cm in size occur in the upper part of ultramafic zone 11 (Figure 45). Larger gabbroic septa, 15 to 50 cm thick and more than 5 m long, are partly detached from the mafic zone by semiconcordant clinopyroxenite fingers (Figure 45).

5.10 Geochemistry

Thirty-one samples were analyzed for major and trace element geochemistry. Most samples were selected from the center of an ultramafic layer. In several layers two samples were selected because of: a) rapidly changing modal abundance of olivine in the center of layers; or b) patchy distribution of poikilitic orthopyroxene oikocrysts in the center of layers. All analyses are listed in Table 12 and have been recalculated on a volatile-free basis to detemine molecular norms (Table 13). The amount of Fe_2O_3 and FeO was not determined and total Fe is listed as FeO*. The recalculated data have been compiled into Plate 1.

For sample preparation, weathered surfaces were cleaned and large fractures cut out to limit alteration affects. Samples were crushed and pulverized in the Department of Geological Sciences, at the University of Manitoba using a steel jaw crusher and an agate swing mill. About 3 g of powder per sample was analyzed on a Phillips PW1410-AMP x-ray fluorescence spectrometer for major elements and the trace elements Ba, Cr, Zr, Sr, Rb, Y, Nb, Zn, Ni, and V at the University of Ottawa. Standards used were PCC-1, MRG-1, UB-N and DR-N. Trace element data less than 10 ppm is reported as <10. P_2O_5, Zr, Rb, Y, and Nb are below detection limits and are not listed.

Four samples were analyzed for Pt, Pd, and Au (Table 13). Ten grams of sample were prepared by fire assay and analyzed using ICP at Acme Analytical Labs in Vancouver, B.C..

Twenty-six of the 42 layers were geochemically analyzed; no samples were analyzed from zones 1, 2, 9, and 10. Data are too sparse to determine upward

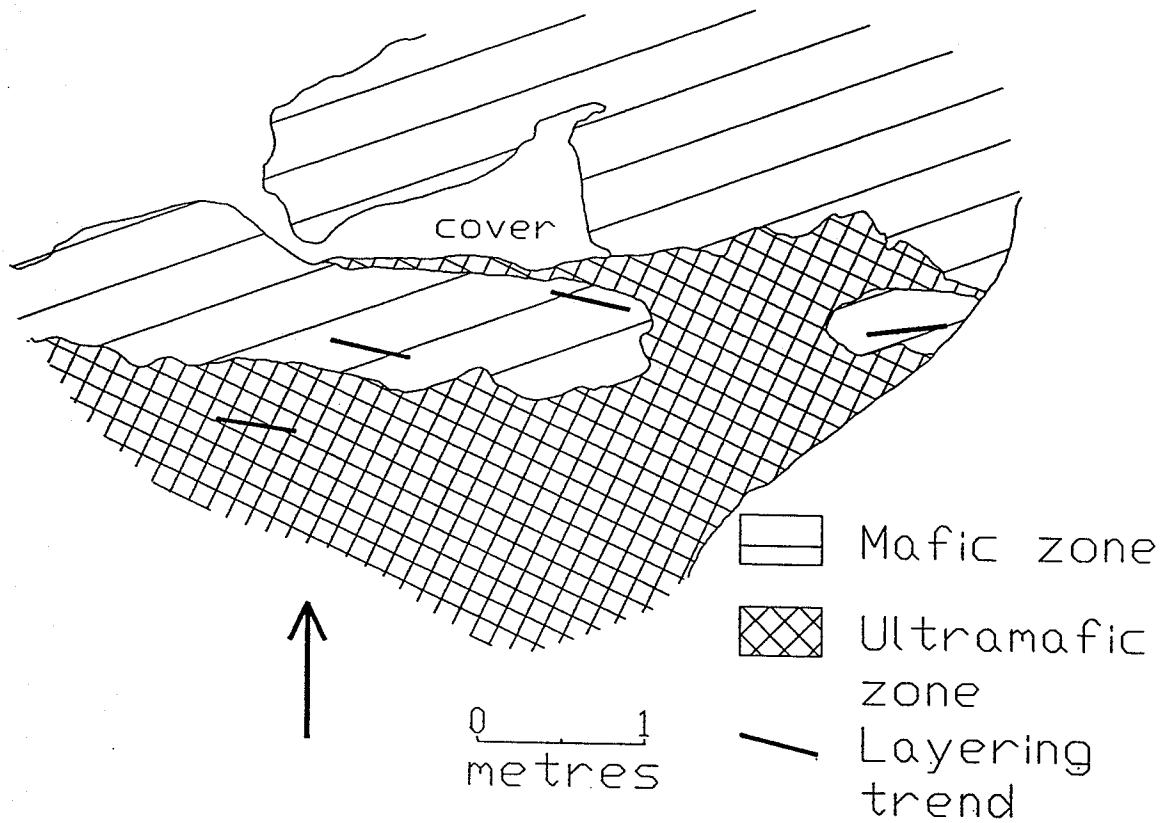


Figure 45. Irregular contact between the mafic zone (ruled pattern) and ultramafic zone (hatched pattern) of cycle 11; overburden is not patterned. Relatively thin gabbro wedges, partly detached from overlying mafic zone by semiconcordant clinopyroxenite fingers, hang down into the ultramafic zone. Arrow shows direction of stratigraphic tops (↑) and straight lines (—) represent layering strike. Drawing from photographs taken oblique to outcrop surface; no corrections have been made.

Table 11. Major and trace element geochemistry from selected ultramafic layers.

Major element analyses (weight percent oxide) and trace element analyses (ppm)
Au, Pt and Pd in ppb* (P_2O_5, Rb, Nb, Zr, and Y not detected)

Sample	472	467	S1-48	08	10	33	34	40	44	30	199
Layer	3b	3c	4a	4a	4b	5a	5a	5b	5c	5c	6a
Lithology	1	1c	2	2	2	1a	1a	1a	1d	1b	1a
SiO_2	51.11	50.82	48.08	48.00	50.02	50.13	50.70	50.54	50.68	52.38	43.69
TiO_2	0.22	0.22	0.17	0.16	0.18	0.18	0.17	0.17	0.14	0.13	0.10
Al_2O_3	2.34	2.41	3.86	4.63	3.48	2.21	2.17	2.14	2.45	2.50	1.91
FeO*	7.01	8.80	9.56	9.37	8.68	10.65	9.65	9.55	7.29	7.73	14.02
MnO	0.15	0.18	0.21	0.21	0.22	0.24	0.23	0.23	0.19	0.20	0.25
MgO	15.42	15.18	17.56	17.15	16.60	17.40	17.21	17.14	17.08	16.89	25.63
CaO	21.51	19.70	16.58	16.59	18.15	17.54	17.70	17.86	19.82	18.05	7.89
Na_2O	0.44	0.60	0.58	0.46	0.64	0.47	0.34	0.66	0.34	0.53	0.43
K_2O	–	0.01	–	–	–	–	–	–	–	–	–
S	–	0.04	–	–	0.01	0.01	–	0.01	–	–	–
LOI	.71	.87	1.84	2.86	1.62	1.26	1.98	1.29	1.42	1.40	6.32
Total	99.06	99.04	99.23	100.02	100.11	100.65	100.66	99.99	100.34	100.02	101.02
Cr	552	594	4674	3323	2843	3198	2753	2043	2384	700	4483
Ni	126	265	311	202	190	229	231	212	179	144	565
V	265	428	328	294	313	350	317	315	298	297	220
Zn	27	23	42	35	32	36	26	31	19	33	63
Ba	52	87	38	32	71	79	81	59	58	60	49
Sr	35	17	18	18	19	10	13	11	10	13	<10
Au*	nd	nd	5	nd	nd	nd	nd	nd	nd	nd	13
Pt*	nd	nd	11	nd	nd	nd	nd	nd	nd	nd	8
Pd*	nd	nd	14	nd	nd	nd	nd	nd	nd	nd	2

Sample	221a	233	241	308	311	315	316	322	326	330	332
Layer	7b	8b	8c	11a	11a	11b	11b	11c	11d	11d	11e
Lithology	3	1c	2	1a	1a	1a	1d	1b	3	1b	1a
SiO_2	41.42	50.69	49.35	47.24	50.38	48.54	49.10	49.48	41.03	50.86	50.57
TiO_2	0.07	0.18	0.17	0.14	0.17	0.15	0.15	0.15	0.07	0.17	0.16
Al_2O_3	1.23	5.62	4.25	2.07	2.63	2.22	2.69	6.66	1.09	2.44	2.31
FeO*	15.71	6.86	8.75	10.94	7.32	8.52	7.76	6.61	15.19	7.64	7.89
MnO	0.20	0.22	0.18	0.21	0.16	0.16	0.16	0.17	0.17	0.18	0.18
MgO	29.23	16.60	16.42	21.51	17.66	20.35	19.96	14.92	29.02	17.33	18.03
CaO	3.67	19.79	18.23	13.54	18.44	15.90	16.74	19.54	4.56	18.84	17.39
Na_2O	0.66	0.90	0.77	0.47	0.31	0.43	0.20	0.42	0.40	0.65	0.90
K_2O	–	0.03	–	–	–	–	–	0.02	–	–	–
S	0.01	0.01	0.01	0.01	–	–	–	–	–	–	–
LOI	8.68	1.48	1.83	3.65	1.36	2.90	2.97	1.42	8.23	1.44	3.81
Total	101.32	100.64	100.36	100.38	98.93	99.76	100.36	99.77	100.12	100.01	101.62
Cr	1998	2843	2188	3214	2568	3129	3503	1910	1544	2430	1998
Ni	821	190	264	613	336	511	400	225	721	213	197
V	157	313	301	247	315	279	255	260	143	359	305
Zn	53	32	26	36	20	29	23	19	42	22	24
Ba	50	71	60	79	64	51	78	66	62	49	100
Sr	0	19	13	8	15	12	11	124	0	13	12
Au*	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Pt*	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Pd*	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Sample	336	349	351	354	356	363	380	452	457	458
Layer	11f	12a	12b	12c	12c	13a	14b	15a	15b	15b
Lithology	1	1a	1b	1a	1a	1a	1d	1	1a	2
SiO_2	51.34	48.54	51.31	48.78	45.10	48.02	48.69	51.37	48.28	48.26
TiO_2	0.22	0.12	0.14	0.12	0.10	0.11	0.14	0.17	0.15	0.15
Al_2O_3	2.11	2.01	2.44	2.26	2.06	2.23	3.24	2.70	2.47	2.98
MnO	0.18	0.18	0.19	0.17	0.18	0.16	0.14	0.19	0.20	0.19
FeO*	6.63	8.91	7.29	7.78	10.13	7.79	7.64	7.46	9.54	9.27
MgO	16.43	20.57	17.08	20.35	24.96	22.08	19.96	17.00	19.95	20.18
CaO	20.17	15.64	19.82	16.54	11.50	15.31	16.46	19.56	15.81	15.13
Na_2O	0.61	0.49	0.34	0.62	0.49	0.45	0.45	0.36	0.51	0.49
K_2O	–	–	0.01	–	–	–	–	–	–	–
S	–	–	0.01	–	–	–	0.01	–	–	–
LOI	.76	3.22	1.10	2.85	5.18	3.95	3.47	1.14	3.41	3.25
Total	98.71	100.13	100.16	100.06	100.69	100.89	100.90	100.46	100.83	100.42
Cr	1600	1917	2384	3382	5866	4481	4016	2960	2665	2808
Ni	172	262	179	383	690	577	453	204	324	270
V	260	251	298	236	197	212	260	390	343	343
Zn	21	25	19	21	51	26	27	23	31	32
Ba	67	73	58	52	45	48	55	61	62	62
Sr	14	<10	10	13	10	11	12	14	<10	<10
Au*	nd	nd	nd	nd	1	1	nd	nd	nd	nd
Pt*	nd	nd	nd	nd	11	1	nd	nd	nd	nd
Pd*	nd	nd	nd	nd	11	7	nd	nd	nd	nd

Lithologies: 1.Clinopyroxenite; 1a.Olivine Clinopyroxenite: 1b.Ol-bearing Clinopyroxenite: 1c.Opx-bearing Clinopyroxenite: 1d.Opx-bearing olivine clinopyroxenite; 2.Olivine Websterite: 3.Wehrlite. FeO*=total Fe. nd=not determined

Table 12. Normalized major element geochemistry and normative abundances.

Normalized Major element analyses (weight percent oxide)
(Volatile free)

Sample	472	467	S1-48	08	10	33	34	40	44	30	199
Layer	3b	3c	4a	4a	4b	5a	5a	5b	5c	5e	6a
Lithology	1	1c	2	2	2	1a	1a	1a	1d	1b	1a
SiO_2	52.05	51.88	49.77	49.70	51.06	50.73	51.65	51.42	51.72	53.23	46.52
TiO_2	0.22	0.22	0.18	0.17	0.18	0.18	0.17	0.17	0.14	0.13	0.11
Al_2O_3	2.38	2.46	4.00	4.79	3.55	2.24	2.21	2.18	2.50	2.54	2.03
FeO*	7.14	8.98	9.90	9.70	8.86	10.78	9.83	9.72	7.49	7.85	14.93
MnO	0.15	0.18	0.22	0.22	0.22	0.24	0.23	0.23	0.19	0.20	0.27
MgO	15.70	15.50	18.18	17.76	16.94	17.61	17.53	17.44	17.43	17.16	27.29
CaO	21.90	20.11	17.16	17.18	18.53	17.75	18.03	18.17	20.23	18.34	8.40
Na_2O	0.45	0.61	0.60	0.48	0.65	0.48	0.35	0.67	0.35	0.54	0.46
K_2O	–	0.01	–	–	–	–	–	–	–	–	–
Mg#	79.66	75.46	76.59	76.54	77.31	74.43	76.06	76.17	80.57	79.57	76.51
Molecular Norms											
Ilmenite	0.30	0.30	0.25	0.23	0.25	0.25	0.23	0.23	0.19	0.18	0.15
Orthoclase		0.06									
Albite	1.93	5.45	5.30	4.25	5.76	4.27	3.11	5.95	3.10	4.83	3.97
Anorthite	4.44	3.93	8.09	10.76	6.68	3.92	4.42	2.91	5.18	4.49	3.34
Diopside	82.86	76.37	60.55	58.58	67.27	66.70	67.40	68.98	75.04	68.95	29.39
Hypersthene		0.90	0.32	2.90	1.54	4.83	10.82	3.32	1.73	11.18	11.76
Olivine	9.42	12.99	25.49	23.28	18.49	20.02	14.01	18.61	14.76	10.36	51.38
Nepheline	1.25										
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Normalized Major element analyses (weight percent oxide)
(Volatile free)

Sample	221a	233	241	308	311	315	316	322	326	330	332
Layer	7b		8e	11a	11a	11b	11b	11c	11d	11d	11e
Lithology	3	1c	2	1a	1a	1a	1d	1b	3	1b	1a
SiO_2	44.93	51.19	50.30	49.15	51.90	50.42	50.74	50.52	44.65	51.84	51.90
TiO_2	0.08	0.18	0.17	0.15	0.18	0.16	0.15	0.15	0.08	0.17	0.16
Al_2O_3	1.33	5.68	4.33	2.15	2.71	2.31	2.78	6.80	2.33	2.49	2.37
FeO*	17.04	6.93	8.92	11.38	7.54	8.85	8.02	6.75	16.53	7.79	8.10
MnO	0.22	0.22	0.18	0.22	0.16	0.17	0.16	0.17	0.19	0.18	0.18
MgO	31.71	14.88	16.73	22.38	18.19	21.14	20.63	15.23	31.58	17.66	18.51
CaO	3.98	19.98	18.58	14.09	19.00	16.52	17.30	19.95	4.96	19.20	17.85
Na_2O	0.72	0.91	0.78	0.49	0.32	0.46	0.21	0.43	0.72	0.66	0.92
K_2O	–	0.03	–	–	–	–	–	0.02	–	–	–
Mg#	76.83	79.28	76.97	77.80	81.13	80.97	82.09	80.08	77.29	80.15	80.28
Molecular Norms											
Ilmenite	0.11	0.25	0.23	0.20	0.25	0.22	0.20	0.21	0.20	0.23	0.22
Orthoclase		0.17						0.12			
Albite	6.13	4.49	4.17	4.28	2.83	4.02	1.84	3.56	3.50	5.83	8.09
Anorthite	0.38	11.18	8.20	3.57	5.86	4.13	6.48	16.36	1.25	3.77	2.29
Diopside	14.67	69.33	66.15	51.59	69.49	60.55	61.80	65.09	17.80	71.96	67.55
Hypersthene	12.18			6.39	7.83	4.53	8.19		10.97	1.08	1.52
Olivine	66.54	12.43	19.60	33.96	13.74	26.56	21.48	14.52	67.28	17.12	20.33
Nepheline		2.15	1.64					0.15			
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Lithologies: 1.Clinopyroxenite; 1a.Olivine Clinopyroxenite; 1b.Ol-bearing Clinopyroxenite; 1c.Opx-bearing Clinopyroxenite; 1d.Opx-bearing olivine clinopyroxenite; 2.Olivine Websterite; 3.Wehrlite. FeO*=total Fe

Table 12. (continued)

Normalized Major element analyses (weight percent oxide) (Volatile free)										
Sample	336	349	351	354	356	363	380	452	457	458
Layer	11f	12a	12b	12c	12c	13a	14b	15a	15b	15b
Lithology	1	1a	1b	1a	1a	1a	1d	1	1a	2
SiO_2	52.56	50.32	52.03	50.49	47.71	49.94	50.34	51.99	49.82	49.93
TiO_2	0.23	0.12	0.14	0.12	0.10	0.11	0.14	0.17	0.15	0.16
Al_2O_3	2.16	2.08	2.47	2.34	2.18	2.32	3.35	2.73	2.55	3.08
FeO^*	6.79	9.24	7.39	8.05	10.72	8.10	7.90	7.55	9.84	9.59
MnO	0.18	0.19	0.19	0.18	0.19	0.17	0.14	0.19	0.21	0.20
MgO	16.82	21.32	17.32	21.06	26.41	22.96	20.64	17.20	20.59	20.88
CaO	20.65	16.21	20.10	17.12	12.17	15.92	17.02	19.80	16.31	15.65
Na_2O	0.62	0.51	0.34	0.64	0.52	0.47	0.47	0.36	0.53	0.51
K_2O	–	–	0.01	–	–	–	–	–	–	–
Mg#	81.53	80.43	80.68	82.34	81.44	83.47	82.32	80.23	78.85	79.50
Molecular Norms										
Ilmenite	0.32	0.16	0.19	0.16	0.13	0.15	0.19	0.23	0.20	0.22
Orthoclase			0.06							
Albite	5.49	4.46	3.01	5.08	4.47	4.07	4.10	3.19	4.65	4.46
Anorthite	3.07	3.30	5.12	3.41	3.46	4.07	6.84	5.76	4.47	5.96
Diopside	78.37	60.01	74.63	63.25	43.43	57.72	60.22	72.98	59.65	55.79
Hypersthene	0.15	4.17	4.14		1.86	2.30	2.88	5.34	1.94	5.61
Olivine	12.61	27.91	12.85	27.79	46.65	31.68	25.77	12.50	29.08	27.96
Nepheline				0.30						
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Lithologies: 1.Clinopyroxenite; 1a.Olivine Clinopyroxenite; 1b.Ol-bearing Clinopyroxenite; 1c.Opx-bearing Clinopyroxenite; 1d.Opx-bearing olivine clinopyroxenite; 2.Olivine Websterite; 3.Wehrlite. FeO^*=total Fe

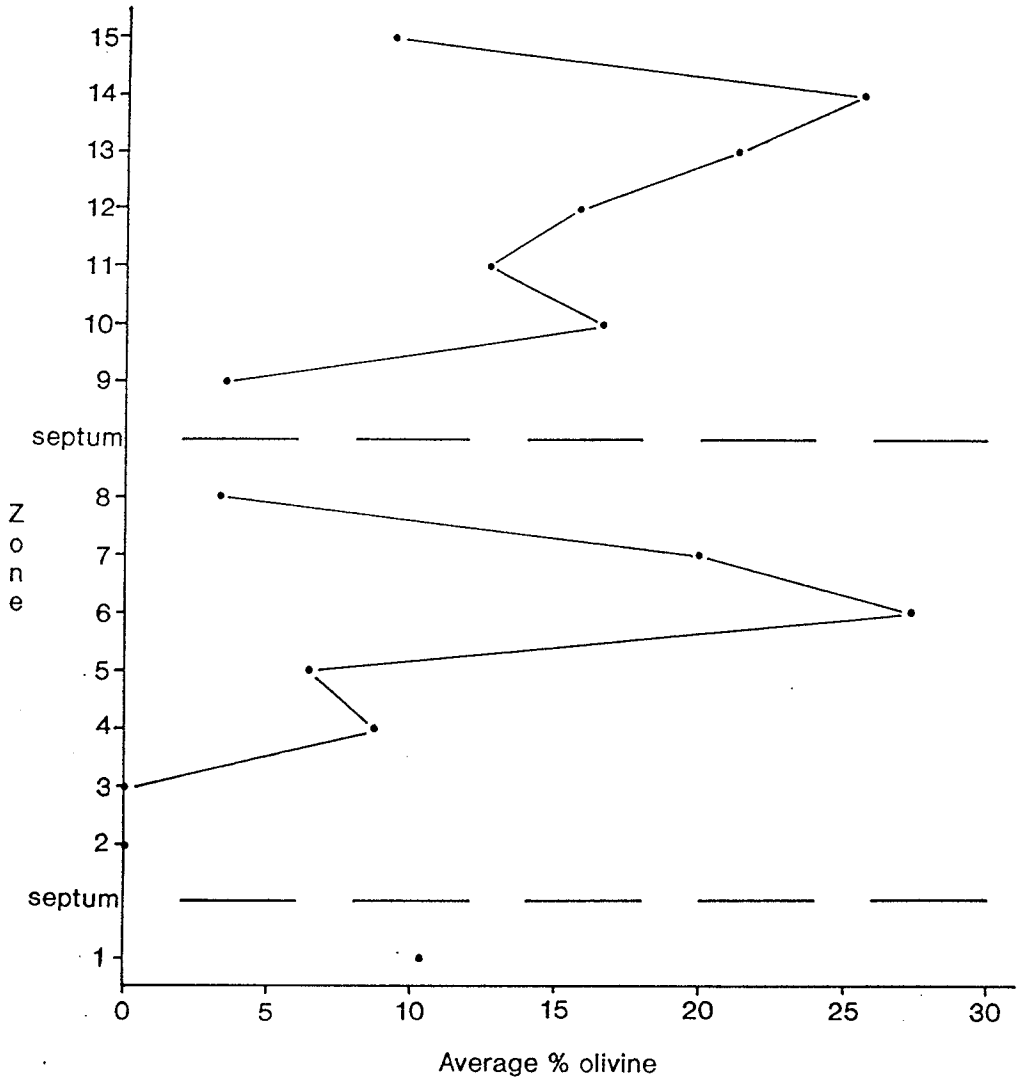
variations across layers or zones. Most analyses are hypersthene-normative, but not quartz-normative (Table 13). Values of Au, Pt, and Pd are low (Table 13)

5.11 Petrologic variations in the Mafic-Ultramafic Group

When olivine/clinopyroxene is averaged for each zone, there is an apparent symmetrical stratigraphic variation relative to the lower and upper septa. Olivine/clinopyroxene increases upwards from zone 2 through zone 6, but is lower in zones 7 and 8 (Figure 46). Above the upper septum olivine/clinopyroxene follows a similar trend by generally increasing upwards through zone 14, but decreasing in zone 15 (Figure 46).

Cumulus orthopyroxene and poikilitic orthopyroxene appear to have a random distribution relative to the lower and upper septa. Cumulus orthopyroxene occurs immediately below the lower septum; between the septa, it is most abun-

Figure 46. Average olivine plotted for each zone. Average abundances were determined by calculating the area to the right of the trend line in Plate 1 and dividing by the thickness of the zone.



dant in zone 7; above the upper septum, it occurs in several widely scattered layers (Plate 1; Figures 31 and 43). Orthopyroxene oikocrysts are more widely scattered than cumulus orthopyroxen (Figure 43). Cumulus plagioclase does not correlate with changing modal ratios or abundances of other cumulus phases.

Generally, En/Fs and Cr_2O_3 in clinopyroxene are higher above the upper septum than between the septa. (Figure 43, Table 7). Between the septa En/Fs and Cr_2O_3 in clinopyroxene do not correlate with variations in olivine abundance; Cr_2O_3 is highest in zone 6. Above the upper septum, En/Fs and Cr_2O_3 appear to correlate with variations in olivine abundance. Both En/Fs and Cr_2O_3 are highest in zone 13; whole rock Mg# is highest where En/Fs is highest (Plate 1).

Oxide chemistry was done on grains from various stratigraphic locations, but the lack of oxides in many samples prohibits determination of upward trends. Generally $Mg/(Mg+Fe^{2+})$ and $Cr/(Cr+Al)$ in oxide grains mimics values from clinopyroxene chemistry (Plate 1).

CHAPTER 6
DISCUSSION

Layering in ultramafic rocks has long been recognized as a reflection of fractionation processes, but few detailed layer by layer studies exist (Irvine, 1970, 1974, 1987a; Raedeke and McCallum, 1984). Furthermore, most studies have focussed on large intrusive bodies in which relatively thick sections of ultramafic rocks form the lower part of the intrusion (e.g. Bushveld, Stillwater, Muskox and Jimberlana); models developed for crystallization in magma chambers have generally come from study of these intrusions. At Reed Lake, ultramafic rocks occur in thin, repeated zones, each comprising several layers, within a dominantly gabbroic sequence. Many studies have been made of other smaller mafic-ultramafic intrusions in Precambrian volcano-sedimentary belts (Watkinson and Irvine, 1964; MacRae, 1969; James and Hawke, 1984; and Anhaeusser, 1985;), but most have focussed on overall fractionation trends and relationship with adjacent volcanic sequences; few studies have examined layering in detail (Scoates *et al.*, 1986)

The Reed Lake Pluton is a well layered body that comprises three major groups. Only vertical variations were examined and only cursory examination was made to mafic zones, thereby restricting discussion to vertical changes. Reconnaissance mapping north and south of the section line suggests that there are lateral variations.

6.1 Recognition of pseudomorphs

In the Mafic-Ultramafic Group, clinopyroxene is largely preserved, but most other silicate minerals are replaced by secondary minerals. Traces of relict olivine were found in the upper part of the group. Precursor minerals were identified by pseudomorph shape and products of recrystallization.

6.1.1 Olivine vs. Orthopyroxene

Pseudomorphs after olivine and orthopyroxene can normally be distinguished by differences in shape and mineralogy. Pseudomorphs after olivine are gener-

ally composed dominantly of serpentine, whereas pseudomorphs after orthopyroxene are dominantly actinolite and chlorite (Table 3). Some pseudomorphs after olivine, however, are composed of tremolite ± chlorite ± Fe-Ti oxides ± carbonate, and the distinction between these pseudomorphs and pseudomorphs after orthopyroxene, or possibly after pigeonite, is more difficult. Pigeonite is an unlikely primary phase because the high Mg/Fe of the clinopyroxene is incompatible with primary crystallization of pigeonite (Hess, 1941; Fleet, 1974). Even if pigeonite did crystallize, it should have inverted to orthopyroxene during cooling. The problem is thus the distinction between pseudomorphs after olivine and orthopyroxene.

In the ultramafic zones, pseudomorphs that consist of tremolite ± chlorite ± Fe-Ti oxides ± carbonate, were identified as replacements of olivine by one or more of the following:

1. pseudomorphs are anhedral to euhedral, equant to ovoid grains (Figure 17);
2. tremolite ± chlorite is restricted to pseudomorphs in samples that also contain abundant oikocrystic orthopyroxene, now replaced by actinolite + chlorite, and/or where olivine abundance is relatively low compared to the abundance of clinopyroxene;
3. in one sample, pseudomorphs of similar size, shape and internal distribution of secondary minerals only differ because chlorite occurs in some pseudomorphs and serpentine in others (Table 3); and
4. chlorite occurs largely as a multicrystal mat that is surrounded by optically continuous tremolite or crosscut by multicrystal tremolite (Table 3).

In the Reed Lake Pluton, the replacement of olivine by tremolite ± chlorite appears to be a function of the abundance of clinopyroxene or orthopyroxene relative to the abundance of original olivine. Pseudomorphs that contain abundant tremolite and/or chlorite occur in samples where the abundance of these pseudomorphs is relatively low. Tremolite is most abundant in samples with abundant clinopyroxene and chlorite is most abundant in samples where the abundance

of orthopyroxene oikocrysts is high. The occurrence of different pseudomorph assemblages after olivine in the same sample probably reflects local variations in alteration and replacement of olivine. In other intrusions, tremolite ± chlorite is a common replacement product of olivine, but is ascribed to higher degrees of recrystallization than occurs at Reed Lake (Williams, 1971; Raudsepp, 1979).

Chlorite-bearing pseudomorphs after olivine were further distinguished from chlorite-bearing pseudomorphs after orthopyroxene by:

1. chlorite occurs in aggregates of randomly oriented grains in the core of pseudomorphs after olivine, but in pseudomorphs after orthopyroxene chlorite occurs largely as single crystals that probably reflect cleavage directions of the original orthopyroxene; and
2. many pseudomorphs of chlorite after olivine contain an aggregate of fine-grained tremolite similar to aggregates that occur in the core of serpentine pseudomorphs after olivine (cf. Figures 15 and 17); similar aggregates were not observed in pseudomorphs identified as replacements of orthopyroxene.

In rare pseudomorphs that were identified as replacements of olivine, chlorite occurs as single crystals much like chlorite pseudomorphs after orthopyroxene. In these pseudomorphs there are margins of single crystal tremolite, and multicrystal tremolite occurs in the core in a similar manner as in other pseudomorphs after olivine.

6.1.2. Clinozoisite in orthopyroxene oikocrysts

Other than the problem of distinguishing some pseudomorphs after olivine from pseudomorphs after orthopyroxene, the only other problem in recognition of primary minerals is the occurrence of clinozoisite in some pseudomorphs after orthopyroxene oikocrysts. Although clinozoisite is a common replacement product of plagioclase, both in the Reed Lake Pluton and elsewhere, clinozoisite has not been reported as a replacement product of orthopyroxene.

In the Mafic-Ultramafic Group clinozoisite in oikocrysts has the following characteristics:

1. clinozoisite grains are randomly distributed, occur in multigrain aggregates that are irregular or tabular in shape, or occur as massive replacement (Table 3);
2. clinozoisite is most abundant in areas of more intense recrystallization or in stratigraphic intervals that also contain plagioclase;
3. clinozoisite most commonly occurs adjacent to chadacrysts of clinopyroxene or in the marginal part of oikocrysts, adjacent to cumulus clinopyroxene outside of the oikocryst (Table 3); and
4. clinozoisite varies from trace to 99% of oikocrysts, both on the scale of individual pseudomorphs and among pseudomorphs from a sample; the remainder of these oikocrysts consists of chlorite and in some pseudomorphs lesser abundances of carbonate.

Massive replacement of oikocrysts by clinozoisite in samples where cumulus clinopyroxene has only been partly replaced suggests that some oikocrysts may have originally been plagioclase rather than orthopyroxene. However, the wide variation in abundance of clinozoisite in oikocrysts, both between and within samples, and the similarity in habit of oikocrysts replaced by clinozoisite with oikocrysts that are mostly to completely replaced by chlorite suggests that these pseudomorphs are after orthopyroxene rather than replacement of plagioclase oikocrysts.

The problem is then the reason for the occurrence of clinozoisite in these oikocrysts. In some samples clinozoisite has a patchy, tabular habit and could be pseudomorphs after chadacrysts of plagioclase within orthopyroxene. These tabular patches of clinozoisite occur in the center of oikocrysts, occur adjacent to clinopyroxene chadacrysts, and occur locally in areas where pseudomorphs after cumulus plagioclase occur outside of the oikocrysts. On the other hand, the association of clinozoisite patches with clinopyroxene chadacrysts and the irregular habits of many aggregates of clinozoisite (Table 3), suggest that clinozoisite development may have been due to local variations possibly related to submi-

croscopic alteration of clinopyroxene. Whether the clinozoisite occurs because of replacement of original plagioclase chadacrysts or by variations in replacement of the clinopyroxene is unknown.

6.2 Composition of the magma

In most plutons, original magma composition can be determined from analyses of chilled border phases or calculated from a representative suite of chemical analyses that are weighted relative to stratigraphic height. In the Reed Lake Pluton, crystallization initially produced layered gabbros of the Lower Mafic Group. Analyses of chilled margin phases, if available, would not give the composition of the magma from which the ultramafic zones crystallized.

In the Reed Lake Pluton, no olivine was analyzed, but in a suite of 15 olivine clinopyroxenites that contain only olivine and clinopyroxene, and in which olivine abundance ranges from 0.6 to 65.5%, forsterite contents were calculated from the difference between bulk composition and clinopyroxene composition. Calculated olivine compositions range from Fo_{81} to Fo_{62} (Table 14; Figure 47).

Olivine has a wide range in calculated forsterite content compared to the relatively restricted range in $100Mg^{2+}/(Mg^{2+} + Fe^{2+})$ of clinopyroxenes (Table 7, Figure 47). There are several possible reasons for this large variation in Fo.

1. Olivine and clinopyroxene compositions may have been modified by intercumulus fluid. Clinopyroxene comprises both cumulus and postcumulus components and clinopyroxenes that were originally in equilibrium with the magma may have been compositionally modified during postcumulus crystallization. Postcumulus modification of clinopyroxene compositions may have resulted in a wide range of calculated olivine compositions that also would not be in equilibrium with the magma;
2. Where olivine content is less than 9%, olivine has been replaced by tremolite rather than serpentine. The replacement by tremolite may not have been isochemical; and
3. Where olivine is abundant, the degree of error in modal calculations is smaller

Table 14. Chemical composition of olivine calculated from clinopyroxene chemistry and whole rock chemical composition in samples consisting only of olivine and clinopyroxene. Calculated 100Mg/(Mg+Fe) for magmas from which olivine accumulated are listed below the forsterite content.

Sample	363	356	354	351	349	336	330	326
Layer	13a	12c	12c	12b	12a	11f	11e	11d
Olivine(%)	24	36.7	25.3	3.7	16.6	0.5	4.3	65.6
SiO_2	38.86	34.40	38.87	38.40	35.65	36.62	37.49	37.79
MgO	42.76	44.48	40.68	38.65	40.77	37.19	34.72	39.84
FeO	18.38	21.12	20.45	22.96	23.58	26.19	27.79	22.37
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Si	0.99	0.90	1.00	1.00	0.94	0.97	1.00	0.98
Mg	1.63	1.74	0.44	1.50	1.60	1.47	1.56	1.55
Fe^{2+}	0.39	0.46	1.56	0.50	0.52	0.58	0.44	0.49
Total	3.01	3.10	3.00	3.00	3.06	3.02	3.00	3.02
Fo	80.6	79.0	78.0	75.0	75.5	71.7	69.0	76.0
100Mg/(Mg+Fe)	55.5	53.0	52.7	47.4	48.0	43.2	40.0	48.7

Sample	311	308	199	30	40	33	34
Layer	11a	11a	6a	5e	5b	5a	5a
Olivine(%)	7.7h	21.2	38.0	1.1	7.4	6.4	8.2
SiO_2	40.42	38.24	38.40	36.49	36.49	35.33	36.49
MgO	34.73	37.98	38.65	30.36	30.36	32.07	30.36
FeO	24.85	23.78	22.96	33.16	33.16	36.60	33.16
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Si	1.05	1.00	1.00	1.00	1.00	0.97	1.00
Mg	1.35	1.48	1.50	1.24	1.24	1.31	1.24
Fe^{2+}	0.54	0.52	0.50	0.76	0.76	0.75	0.76
Total	2.94	3.000	3.000	3.00	3.00	3.03	3.00
Fo	71.4	74.0	75.0	62.0	62.0	63.7	62.0
100Mg/(Mg+Fe)	42.8	46.1	47.4	32.9	32.9	34.5	32.9

than where olivine is less abundant. In addition, there is less clinopyroxene in olivine-rich samples and, therefore, less possible compositional modification due to postcumulus crystallization. Hence, olivine compositions are more likely to be in equilibrium with the magma from which they crystallized in olivine-rich samples than in samples that have low olivine contents.

The amount of olivine at which equilibrium calculations would be acceptable is unknown, but the replacement of olivine by serpentine rather than tremolite in samples with more than 20% olivine suggests a minimum of 20% olivine.

$Mg^{2+}/(Mg^{2+} + Fe^{2+})$ of the magma at the level where ultramafic lay-

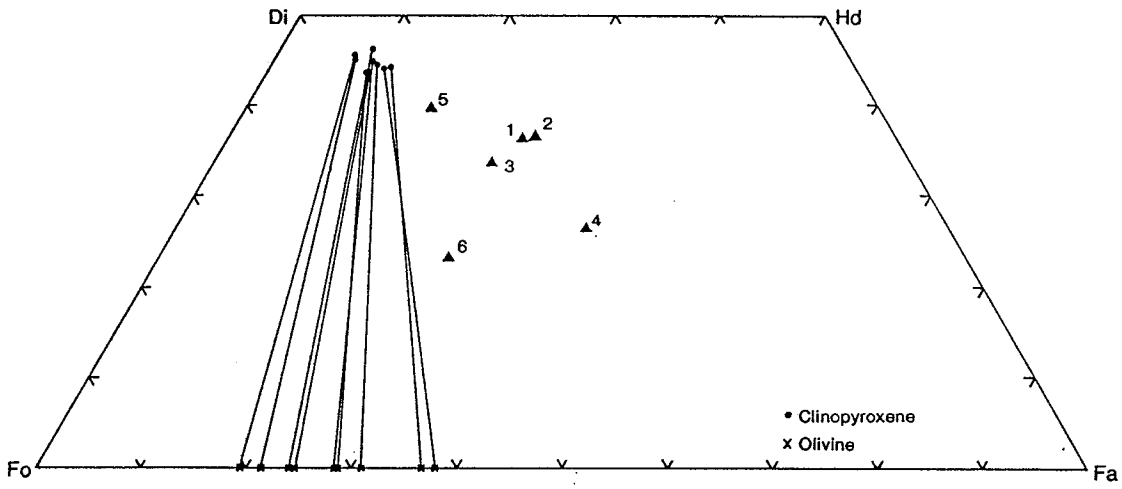


Figure 47. Clinopyroxene and calculated olivine compositions in the pyroxene quadrilateral. Tie lines join mineral in the same sample. Chilled margin phases (▲) are plotted for (1) White Lake sill (Bailes and Syme, 1989); (2) Benn Lake pluton (Bailes and Syme, 1989); (3) Josland Lake intrusion (Bailes, 1980); (4) Garrison intrusion (MacRae, 1969); (5) Primary MORB (Langmuir *et al.*, 1977); and (6) Muskox intrusion (Smith and Kapp, 1963).

ers accumulated was determined using relationships developed by Duke (1976). Forsterite contents in olivine from samples with more than 20% olivine suggest equilibrium with magmas that had $100Mg^{2+}/(Mg^{2+} + Fe^{2+})$ ranging from 56 to 46 (Duke, 1976). In samples with less than 20% olivine calculated $100Mg^{2+}/(Mg^{2+} + Fe^{2+})$ is as low as 32 (Table 14). In samples containing similar abundances of olivine, the $100Mg^{2+}/(Mg^{2+} + Fe^{2+})$ of the magma increases upwards across the Mafic-Ultramafic Group (Table 14). The change upwards from more fractionated compositions to less fractionated compositions is also suggested by upward changes in clinopyroxene chemistry.

Compositions that would be in equilibrium with olivine from Reed Lake are found in chilled margins of tholeiitic intrusions in the west half of the Flin Flon-Snow Lake greenstone belt such as: (a) White lake sill (Bailes and Syme, 1989; Figure 47), which has a $100Mg^{2+}/(Mg^{2+} + Fe^{2+}) = 50.8$; (b) Benn Lake pluton (Bailes and Syme, 1989), which has a $100Mg^{2+}/(Mg^{2+} + Fe^{2+}) = 50.2$; and (c) the Josland Lake intrusion, which occurs north of the Reed Lake Pluton and has a $100Mg^{2+}/(Mg^{2+} + Fe^{2+}) = 54.2$ (Figure 46; Bailes, 1980). None of these intrusions have ultramafic components.

Two other magma compositions are plotted in Figure 47 for comparison. MORB that is considered to be primary by Langmuir *et al.*, (1977) has $100Mg^{2+}/(Mg^{2+} + Fe^{2+}) = 66$ to 72 and the chilled margin of the Muskox Intrusion has $100Mg^{2+}/(Mg^{2+} + Fe^{2+}) = 66$ (Smith and Kapp, 1963). The $100Mg^{2+}/(Mg^{2+} + Fe^{2+})$ of both of these magmas suggest that the Reed Lake magma was more evolved.

The ultramafic layers probably accumulated from a tholeiitic basaltic magma because:

a. calculated magma compositions have low $100Mg^{2+}/(Mg^{2+} + Fe^{2+})$, similar to the chilled margins of several tholeiitic intrusions in the Flin Flon-Snow Lake greenstone belt; and

b. clinopyroxene compositions have low Ti, and low Ca + Na (Leterrier *et al.*,

1982).

6.3 Emplacement of the ultramafic zones

The most prominent feature of the Mafic-Ultramafic Group is the 15 cycles (Table 2). In most cycles, the thickness of the mafic zone ranges from about 15% to 3 times the thickness of the ultramafic zone; in 40% of the cycles the mafic zone is thinner than the ultramafic zone, but in other cycles it is thicker (Table 2; Figure 31). Exceptions are cycle 9 where the mafic zone is missing and cycle 14 where the mafic zone is 12 times thicker that the ultramafic zone. A large part of cycle 14 is covered by overburden and additional ultramafic zones may be present.

Cyclic variation probably developed because of influx of new batches of less evolved, magma into the chamber (Brown, 1956; Irvine and Smith, 1967; Dunham and Wadsworth, 1978; Scoates, 1990). In the Reed Lake Pluton evidence that supports the formation of each cycle from individual batches of magma are:

1. abrupt upward change from mafic zones that contain abundant plagioclase to ultramafic zones, many of which contain olivine (Brown, 1956; Irvine, 1970; Wilson, 1982; Raedeke and McCallum, 1984);
2. occurrence of all ultramafic zones well above the base of the pluton (Figure 3);
3. highly variable thickness of overlying mafic zones compared to ultramafic zones (Table 2; Figure 3); thickness of zones is independent of stratigraphic location;
4. scouring of zone 9 at the base of zone 10 (Brown, 1956; Dunham and Wadsworth, 1978; Renner and Palacz, 1987);
5. olivine/clinopyroxene increases upward from zone 2 through zone 6, but is lower in zones 7 and 8; above the upper septum, olivine/clinopyroxene follows a similar trend of generally increasing upward, but decreasing in zone 15; and
6. septa occur at the base of zones 2 and 9.

The septa could be either rafted slices of country rock that were transported

to their present location or *in situ* septa split off the roof of the chamber by successive injections of magma. The occurrence of septa well above the base of the pluton and at cycle boundaries support the interpretation that septa are *in situ* slices of country rock. However, if septa are *in situ*, they would divide the Mafic-Ultramafic Group into three thin magma chambers; zone 1 would have crystallized at the roof of the lower chamber and cycles 2 to 8 in a thin, chamber. Layering or convection is unlikely to develop in chambers this thin and therefore the septa are more likely to be rafted slices.

Besides the development of new cycles characterized by an abrupt change from crystallization of abundant plagioclase to crystallization by of olivine, there are also less pronounced discontinuities between layers in zones 1, 8 and 11. These discontinuities are characterized by:

1. crystallization sequence changes upwards from orthopyroxene, clinopyroxene, plagioclase to olivine, clinopyroxene, orthopyroxene, plagioclase (zone 1);
2. olivine is rare or absent in the lower part of zones, but in the upper part, there is an abrupt change to higher olivine abundances (zones 1, 8 and 11; Figure 46); and
3. Cr_2O_3 and Al_2O_3 in clinopyroxene increase abruptly at about the same stratigraphic level as modal changes including disappearance of plagioclase (zones 8 and 11; Plate 1).

Discontinuities within zones may have developed because of addition of small magma batches in much the same manner as batches of magma that formed new cycles. The difference between development of internal discontinuities within zones and development of new zones is a function of the time at which new magma was injected. Internal discontinuities represent injection of new magma before cumulus plagioclase became a major crystallizing phase, whereas new zones represent injection of magma after plagioclase became a major cumulus phase.

6.4 Evidence of magma movement

In the Reed Lake Pluton the following characteristics suggest that there was movement of magma at varying times during crystallization, but the nature of the movement varied from place to place:

1. igneous lamination occurs in several ultramafic layers and is defined by alignment of (a) cumulus clinopyroxene (layers 4a, 5c, and 5e); or (b) orthopyroxene oikocrysts (layers 6a and 10b) (Hess, 1960; Irvine, 1987a);
2. thin discontinuous laminae and layers of websterite occur near the base of several layers and thin discontinuous olivine-rich layers occur in the upper part of rare layers; the layers and laminae have different modal proportions than adjacent parts of layers, and in places, have different mineral phases (e.g. orthopyroxene in websterite near the base of layer 11b) (Irvine, 1980a; Figures 34 and 35);
3. thin discontinuous layers of gabbro occur in a couple of uniform layers in the lower parts of zones and in the upper parts of rare normally graded layers (McBirney and Noyes, 1979; Irvine, 1980a; Plate 1);
4. the base of some layers, expecially those at the base of zones, are wavy or concave (Irvine, 1987a); gabbro xenoliths occur at the base of layer 15a;
5. zone 9 is truncated by zone 10 and is locally absent (Figure 42); and
6. some gabbro in the mafic zones has an igneous lamination.

Igneous lamination throughout layers and wavy or concave contacts at the base of layers may have been produced by magma flow in the chamber (Hess, 1960; Wager and Brown, 1967; Irvine, 1980a, 1987a). Igneous lamination was observed in only four zones, although igneous lamination of clinopyroxene in other zones could have been obscured by postcumulus overgrowths. The paucity of igneous lamination in ultramafic layers suggests that magma flow during crystal accumulation was relatively weak and varied in intensity from zone to zone. However, igneous lamination in the mafic zones suggests that magma flow may have occurred periodically throughout crystal accumulation.

Although magma flow appears to have been relatively weak, scouring of zone

9 by zone 10 is evidence of turbulent flow (Martin *et al.*, 1987). However, igneous lamination is absent in zone 10 suggesting that magma flow slowed rapidly, probably with the onset of crystallization (McBirney, 1985; Marsh, 1989).

Thin discontinuous olivine-rich and websterite layers and laminae that occur in the lower parts of layers are concave upward. The concave upward form and lack of lateral continuity suggest that these layers were produced by small density currents scouring out shallow depressions and depositing crystals. Small density currents could have originated by slumping of crystals off chamber walls (Irvine, 1980a). In the Mafic-Ultramafic Group, however, these layers occur at least 3 km from the sides of the pluton in the present plane of exposure. Long lateral transport by small density currents to deposit crystals in such thin discontinuous layers and lamine is unlikely. More likely, once the area had been scoured, small packets of crystals detached from above and were deposited on the floor of the chamber (Brandeis and Jaupart, 1986; Morse, 1986b).

6.5 Crystallization

Crystallization of subalkaline basaltic magmas at low pressure have been modelled by Irvine (1970) in the system olivine-clinopyroxene-plagioclase-quartz. Based on liquidus relations, Irvine (1970) defined 18 possible crystallization orders and their associated cumulate assemblages.

Ultramafic layers at Reed Lake consist mostly of olivine, clinopyroxene, orthopyroxene and plagioclase. Olivine and clinopyroxene are cumulus phases, but the amount of postcumulus overgrowth on clinopyroxene is unknown. Olivine occurs in 34 layers and clinopyroxene occurs in all layers. Orthopyroxene crystallized as cumulus grains in 12 layers, oikocrysts in 19 layers, and discrete postcumulus phases in 8 layers and plagioclase crystallized as cumulus in 21 layers and discrete postcumulus phases in 3 layers.

6.5.1 Crystallization of orthopyroxene oikocrysts

Many of the features observed in oikocrysts from the Reed Lake Pluton are similar to those observed from other intrusions. Orthopyroxene oikocrysts in the

Reed Lake Pluton have the following characteristics:

1. most grains are tabular and commonly rounded (Figures 22 and 23);
2. abundance and distribution of oikocrysts varies markedly from layer to layer and zone to zone (Plate 1);
3. chadacrysts of clinopyroxene and olivine in oikocrysts are smaller than clinopyroxene and olivine outside of oikocrysts (Figures 18 and 23);
4. the size difference between olivine chadacrysts and cumulus olivine is less than that between clinopyroxene chadacrysts and cumulus clinopyroxene;
5. the volume ratio of olivine to clinopyroxene chadacrysts in oikocrysts is commonly different than the ratio of olivine to clinopyroxene in enclosing cumulates (Figure 26);
6. chadacrysts of olivine are absent in some oikocrysts from samples that also contain cumulus olivine (Figure 26);
7. in several layers oikocrysts are aligned parallel to layer contacts; and
8. oikocryst grain margins vary from straight to lobate adjacent to cumulus clinopyroxene (Figures 18 and 24).

Oikocrysts in other intrusions are interpreted to have formed by (1) *in situ* crystallization from trapped liquid under conditions of rapid accumulation (Jackson, 1961; Morse, 1986a; Campbell, 1987), (2) *in situ* crystallization at the magma-crystal interface (Barnes, 1986; Mathison, 1987); or (3) crystallization above the magma-crystal interface.

Rounded shape, varied distribution, abundant chadacrysts smaller than enclosing cumulate minerals, and a lower abundance of olivine chadacrysts in oikocrysts than in enclosing cumulates are characteristics of oikocrysts that are thought to have formed from trapped liquid (Brown, 1956; Jackson, 1961; Campbell, 1977). At Reed Lake, however, the uniform size of chadacrysts throughout oikocrysts, plus the abrupt increase in grain size between clinopyroxene chadacrysts and clinopyroxene outside of oikocrysts suggest that oikocrysts did not crystallize from trapped liquid. In the *in situ* crystallization model differ-

ences in abundance of olivine in oikocrysts relative to the abundance outside of oikocrysts are interpreted to be due to variable resorption of olivine (Jackson, 1961). In such oikocryst, however, there is commonly an increase in size of olivine chadacrysts from centre to margin. In Reed Lake oikocrysts, olivine is generally most abundant near the margins, but there is no change in grain size of olivine chadacrysts. The lack of chadacryst size variations suggest that other crystallization models should be investigated.

Chadacrysts of similar sizes to chadacrysts in Reed Lake occur in some intrusions where oikocrysts are interpreted to have formed by *in situ* crystallization at the magma crystal interface (Mathison, 1987). In these intrusions, chadacrysts are less evolved than cumulus minerals outside of oikocrysts (Barnes, 1986) and have an elongate habit which is interpreted to represent supercooled crystallization. Such features are not found at Reed Lake, where the composition of most clinopyroxene chadacrysts is similar to clinopyroxene outside of oikocrysts (Figure 25) and chadacrysts are generally equant, closely packed and commonly touching. This is further evidence against *in situ* crystallization.

In several layers oikocrysts define an igneous lamination suggesting that oikocrysts and the enclosed chadacrysts nucleated elsewhere and were deposited in their present position. The proportion of olivine to clinopyroxene chadacrysts is commonly different than the proportion of cumulus olivine to cumulus clinopyroxene adjacent to the oikocrysts; this also suggests that the chadacrysts nucleated elsewhere. The large size of the oikocrysts relative to cumulus olivine and clinopyroxene suggests that oikocrysts may have settled gravitationally after crystallization above the magma-crystal interface.

Nucleation of chadacrysts above the magma-crystal interface suggests that chadacrysts formed by homogenous nucleation, which would require a relatively high degree of supercooling (Campbell, 1978, 1987). However, the equant habit and closely packed character of the chadacrysts do not support chadacryst crystallization in supercooled conditions. Instead, chadacrysts have shapes that in-

dicate a high degree of textural equilibrium (Hunter, 1987). Chadacrysts with equant habits may also form in relatively thick boundary layers (Martin *et al.*, 1987). The origin of the chadacrysts is problematic, but it is probably a complex relationship between local crystallization conditions, the crystallization kinetics of olivine and clinopyroxene chadacrysts, and the crystallization of the orthopyroxene oikocryst.

Although oikocrysts probably formed at a location away from their site of deposition, there was minor crystallization after incorporation in layers. Postcumulus overgrowths of orthopyroxene on oikocrysts is suggested by finger-like projections between adjacent cumulus clinopyroxene. In other places though, irregular to lobate margins adjacent to clinopyroxene suggest reaction with intercumulus liquid (Figure 18).

6.5.2 Crystallization of plagioclase

Plagioclase occurs as cumulus grains in half of the layers and as discrete postcumulus phases in 3 isolated layers, each of which occurs at the top of a zone. Cumulus plagioclase occurs at the top of 15 layers, in the lower part of 2 layers, at the base of 3 layers and throughout 1 layer: cumulus plagioclase at the top of layers occurs in feldspathic pyroxenites or layered sequences of melagabbro to leucogabbro; cumulus plagioclase in the lower parts of layers occurs in discontinuous gabbro and melagabbro layers that are compositionally distinct form enclosing ultramafic rocks; and cumulus plagioclase at the base or throughout layers is disseminated in relatively low abundances. As in other intrusions, cumulus plagioclase at the top of layers or cycles (MacRae, 1969; Irvine, 1970; Scoates, 1990) is a normal product of phase equilibria of tholeiitic systems. The abundance of plagioclase varies from the top of one layer to another; these differences are probably related to the differences in initial composition of the liquid from which the layers accumulated and the degree to which crystallization proceeded. At Reed Lake, plagioclase is also absent from numerous layers; crystallization in these layers is less complete and was probably halted prior to

plagioclase crystallization by the onset of crystallization in the overlying layer (Irvine, 1970, 1979).

Plagioclase that occurs in other parts of layers is more difficult to reconcile with fractionation processes. Where cumulus plagioclase occurs at the base of layers there is (a) cumulus plagioclase at the top of underlying layers and (b) a lower abundance of olivine than higher in the layer where plagioclase is absent. The lower abundance of olivine at the base of the layers suggests that the magma from which these minerals accumulated was more fractionated than magma that produced higher parts of the layers. This inverse relationship may have been caused by mixing of magma with crystals, including plagioclase, and magma from the underlying layer.

Plagioclase in the lower parts of layers occurs in discontinuous gabbroic layers and laminae. These layers and laminae probably formed by deposition from magmatic currents; this suggests that some plagioclase nucleated elsewhere and was transported to its present location. Where plagioclase occurs occurs throughout a layer, the relationship of cumulus plagioclase to crystallization is uncertain.

6.5.3 Crystallization sequence

In the ultramafic layers 8 crystallization sequences have been defined (Table 15). In 4 of these crystallization sequences the first mineral to crystallize was olivine, in 4 other sequences the first crystallizing mineral was clinopyroxene. These sequences give rise to numerous complicated lithologic orders that are not easily related to crystal accumulation by fractional crystallization.

Chromite, which is not included in the crystallization sequences and is not always present, crystallized with, or prior to, olivine. Even though whole rock chemistry suggests abundant Cr in the system (Table 12), the lack of chromite in parts of the ultramafic zones indicates that most Cr was incorporated in clinopyroxene and orthopyroxene (Irvine, 1967; Wilson, 1982).

6.5.3.1 Crystallization sequence 1

Table 15. Crystallization sequences in the ultramafic layers. Crystallization sequences that were observed are listed by letter. Complete crystallization sequences, as defined by Irvine (1970, 1979) are listed in bold by number. No petrographic data were collected on layer 5d and the crystallization sequence could not be confirmed. Therefore layers only total to 42.

Crystallization Sequences	# of layers
1. **Ol, cpx, opx, plag**	
a. Ol, cpx, opx, plag	12
b. Ol, cpx, opx	13
c. Ol, cpx, plag	5
d. Ol, cpx	4
2. **Cpx, opx, plag**	
a. Cpx, opx, plag	4
b. Cpx, opx	2
c. Cpx, plag	1
d. Cpx	1

The dominant crystallization sequence 1 is olivine, clinopyroxene, orthopyroxene, plagioclase; cumulus orthopyroxene is uncommon. The sequence is based on the following textural criteria:

1. olivine that is smaller than olivine outside of clinopyroxene is enclosed in clinopyroxene; and
2. olivine in oikocrysts is closer in size to cumulus olivine than are clinopyroxene chadacrysts to cumulus clinopyroxene.

In tholeiitic magmas olivine will generally crystallize before clinopyroxene (Irvine, 1970; Kushiro, 1972), possibly producing olivine cumulates, but in layers at Reed Lake dunitic cumulates are absent at the base. Thus, at Reed Lake, either olivine accumulation was inefficient or crystallization of olivine and clinopyroxene occurred at about the same time. The low abundance of olivine in the Mafic-Ultramafic Group suggests that minerals accumulated from a magma at, or near, the cotectic (Irvine, 1970; 1979). Also, the textures indicate that, although olivine probably nucleated first, clinopyroxene began to nucleate before olivine had completely crystallized. Slight variations in the time and rates of crystallization of either olivine or clinopyroxene would affect the order of crystal-

lization (Kirkpatrick, 1983; Brandeis and Jaupart, 1987). Therefore, lithologic orders in these layers may be controlled not only by phase equilibria, but also by nucleation and diffusion (Brandeis and Jaupart, 1987).

6.5.3.2 Crystallization sequence 2

The crystallization order clinopyroxene, orthopyroxene, plagioclase occurs in 8 layers. In contrast to crystallization order 1, orthopyroxene more commonly occurs as a cumulus phase than as oikocrysts. The temporal relationship between crystallization of clinopyroxene and orthopyroxene is not well defined, because both minerals are commonly anhedral when adjacent to each other (Figure 20). However, there is some evidence that clinopyroxene crystallized prior to orthopyroxene:

1. orthopyroxene does not always occur at the base of layers and is reversely graded in some parts of layers; and
2. in some layers orthopyroxene is scalloped adjacent to clinopyroxene.

6.6 Postcumulus crystallization

In most layered intrusions the amount of postcumulus material ranges from about 25% to 60% (Wager and Brown, 1967; Hess, 1960; Morse, 1969; Irvine, 1970; Campbell, 1977). In these intrusions postcumulus material comprises discrete postcumulus phases, postcumulus overgrowths on cumulus minerals, and poikilitic grains (Jackson, 1971). The abundance of postcumulus material was not determined in the Reed Lake Pluton because of (a) the lack of zoning in clinopyroxene grains, and (b) the irregular habit of many clinopyroxene and olivine grains. Furthermore, poikilitic orthopyroxene at Reed Lake is not considered to represent postcumulus crystallization.

6.6.1 Development of intergrowths in clinopyroxene

Except for the Fox River Sill (Scoates, 1990), intergrowths in clinopyroxene, like those observed in the Reed Lake Pluton, have not been documented from other layered intrusions. In other intrusions most cumulus minerals, including postcumulus overgrowths, cumulates have straight to curved grain boundaries

(Wager and Brown, 1967) suggesting an approach to textural equilibrium (Hunter, 1987).

In the Mafic-Ultramafic Group highly interdigitated boundaries between adjacent clinopyroxene grade into complex intergrowths that have the following characteristics:

1. individual grains are intergrown with between 2 and 10 other grains;
2. intergrowths vary from isolated patches of clinopyroxene enclosed in a resident grain to patches that extend completely across resident grains (Figure 12);
3. the abundance of enclosed grains ranges from 0 to 18.3% of samples, but they can comprise more than half of any one grain in the plane of a thin section (Plate 1);
4. in samples containing intergrowths, cumulus clinopyroxene grain margins are commonly highly irregular; the greater the degree of interdigitation the greater the abundance of intergrowths; and
5. distribution and abundance of intergrowths varies from layer to layer and zone to zone; in 6 zones no intergrowths were observed (Plate 1).

Intergrowths occur throughout the Mafic-Ultramafic Group, but there is no apparent relationship between occurrence or abundance of intergrowths and the crystallization sequence or distribution of layer types; this suggests that intergrowths were not formed during cumulus stages. Rather, intergrowth abundance appears to vary relative to zone or layer boundaries (Plate 1); this suggests that intergrowths are constrained by such boundaries. The marginal nature of most intergrowths and the association with layers and zones, suggest that intergrowths formed by postcumulus processes (Scoates, 1990). Since intergrowths are apparently postcumulus, the wide variation in abundance of intergrowths suggests that the amount of postcumulus growth varied from layer to layer.

Theoretically, grain ripening during postcumulus processes should lead to relatively straight to curved grain margins (Hunter, 1987). Such textural equi-

librium occurs under relatively stable conditions where intercumulus liquid can migrate through the crystal pile (Sparks *et al.*, 1985). The lack of textural equilibrium in the Reed Lake Pluton suggests that conditions for migration of intercumulus liquid may have been different than those in most other intrusions. Development of intergrowths at Reed Lake may be related to the relative thinness of ultramafic zones and the development of numerous cyclic units, both of which are related to rates of accumulation and replenishment of magma.

6.6.2 Clinopyroxene chemistry

The ratio of Fe to Mg in mafic minerals has been used in many intrusions to document upwards variations in fractionation (Irvine, 1979; Wilson, 1972; Raedeke and McCallum, 1984). Clinopyroxenes were analyzed in layers throughout the Mafic-Ultramafic Group for major and trace elements (Table 7). Four chemical parameters are used to help document upward trends in layers. These parameters are: (1) En/Fs, (2) Cr_2O_3, (3) Al_2O_3, and (4) CaO.

In the Reed Lake Pluton, clinopyroxene chemistry has the following characteristics:

1. En/Fs and Cr_2O_3 are uniform throughout both cumulus and postcumulus parts of most clinopyroxene grains (Figure 5);
2. En/Fs is relatively uniform throughout most layers, but locally increases upwards, decreases upwards or has a symmetric trend; these trends commonly do not correlate with variations in the abundance of cumulus minerals (Plate 1);
3. in many layers En/Fs in samples directly below layer contacts is similar to En/Fs in samples directly above layer contacts (Plate 1);
4. there is a greater standard deviation in En/Fs from samples near some layer contacts than in samples that occur in the middle part of layers (Plate 1);
5. Cr_2O_3 and Al_2O_3 are positively correlated and are more variable than En/Fs across layers, but they also have a poor correlation with abundances of cumulus minerals; values directly below and above most layer contacts are similar

(Plate 1); and

6. CaO is relatively uniform throughout all layers (Figure 33).

There are two problems in interpretation of clinopyroxene chemistry. First is the compositional homogeneity of individual clinopyroxene grains and the second is the lack of variation in clinopyroxene chemistry across many layers; both problems are probably intimately related.

The lack of chemical zoning in clinopyroxene suggests continual equilibration of crystals with the magma either by (a) primary adcumulus growth during relatively slow crystal accumulation which allowed for continual interchange of interstitial magma between crystals interstices that had accumulated and magma above the crystals (Wager, 1963; Campbell, 1987), or (b) re-equilibration of crystals with intercumulus magma as magma is removed upward out of the pile of accumulated crystals (Irvine, 1980a; Tait, 1985; Kerr and Tait, 1985; Petersen, 1987). The lack of discrete postcumulus phases, the cumulus nature of orthopyroxene oikocrysts, and the many, ungraded layers indicate that accumulation was relatively slow compared to crystallization (Hess, 1960; Morse, 1986a). The high abundance of clinopyroxene in many layers and common postcumulus overgrowths on clinopyroxene suggest that the lack of chemical zoning is probably caused by re-equilibration of crystals with intercumulus magma.

The truncation of zone 9 by zone 10 to a depth of at least 2 m suggests that intercumulus liquid was present to a depth of at least 2 m in the crystal pile. The common clinopyroxene intergrowths suggest abundant postcumulus growth and relatively high porosities. Although this crystal mush, consisting of crystals and intercumulus liquid, would still be permeable to the magma-crystal interface, the high porosities and thickness of the crystal mush are not compatible with primary adcumulus growth (Campbell, 1987).

The uniform trends in En/Fs of clinopyroxene across most layers at Reed Lake suggest that fractionation trends recorded by the accumulation of crystals are either too small to be obvious or were altered after the accumulation of crys-

tals. The similar En/Fs or Cr_2O_3 values on either side of layer contacts and the greater variation in clinopyroxene composition in samples near layer contacts than in the middle part of layers support abundant intercumulus migration. Considering the upward decrease in olivine relative to clinopyroxene in about 40% of layers and the occurrence of plagioclase at the top of many layers at Reed Lake, the uniform trends are probably a function of postcumulus processes.

Although correlation of En/Fs and Cr_2O_3 in clinopyroxene with the proportion of cumulus minerals is generally poor, there are layers in which Cr_2O_3 is better correlated with mineral proportions than En/Fs suggesting that variation result from fractionation. However, variations in Cr_2O_3 could be caused by re-equilibration with varying amounts of intercumulus liquid (Raedeke and McCallum, 1984). Furthermore, local occurrences of oxides may be responsible for some of the variation in Cr_2O_3 in clinopyroxene; the correlation between oxide abundances and Cr_2O_3 in clinopyroxene was not examined.

It is thus concluded that clinopyroxene chemistry cannot be used to document fractionation trends during cumulus growth because of postcumulus modification. The degree of postcumulus modification probably varied from place to place.

6.7 Layer development

There are 43 layers in the ultramafic zones at Reed Lake, all of which crystallized from a tholeiitic basalt magma; 34 layers record the crystallization sequence olivine, clinopyroxene, orthopyroxene, plagioclase, and 8 layers record the sequence clinopyroxene, orthopyroxene, plagioclase. Poikilitic orthopyroxene oikocrysts that occur in many layers apparently crystallized above the magma-crystal interface, probably settling to their present location and, in some layers, being transported by relatively weak magmatic flow. Currents operated during different stages of crystal accumulation and may have operated, at differing degrees, throughout the deposition of the Mafic-Ultramafic Group. However, magma flow and crystal settling were not the main mechanisms for crystal accu-

mulation because:

1. Clinopyroxene and olivine are the most abundant minerals in the ultramafic layers, but grains are generally equant to tabular and lack an igneous lamination; and
2. Grain size of cumulus clinopyroxene could not be determined so that the contribution of crystal settling to the accumulation of these minerals is unknown.

In situ crystallization was probably the dominant process for accumulation of crystals in layers.

In situ crystallization occurs in a boundary layer at the magma-crystal interface. Crystals nucleate and accumulate in the boundary layer according to the degree of supercooling, ease of nucleation of the different mineral types, and rates of diffusion or transport of elements (Jaupart and Brandeis, 1986; Morse, 1986a; Campbell, 1987; Martin *et al.*, 1987).

6.7.1 Ungraded Layers

Eighteen layers have limited variations in olivine/clinopyroxene across layers and have been defined as ungraded. Based on olivine abundance, three subtypes were defined: 1) 4 layers with more than 4% olivine, 2) 4 layers with trace to 2% olivine, and 3) 10 layers that lack olivine. Ungraded layers have the following characteristics:

1. cumulus plagioclase is found in all subtypes, but the highest incidence of occurrence is in layers that lack olivine; cumulus plagioclase is most common at the top of layers (5 layers), but also occurs in the middle part of layers (2 layers) or at the base (1 layer) (Plate 1);
2. cumulus orthopyroxene occurs only in half of the layers that lack olivine and in 1 layer with trace to 2% olivine; in layers that lack olivine, orthopyroxene increases upwards in 2 layers, decreases upwards in 2 layers, and has a symmetric upwards increasing to decreasing trend in 1 layer; in the layer with trace to 2% olivine, orthopyroxene only occurs at the top (Plate 1);

3. orthopyroxene oikocrysts occur in all subtypes, but in only 5 layers (Figure 31); oikocrysts are uniformily distributed or form sublayers; and
4. in most layers clinopyroxene grain size is uniform, but in some layers that lack olivine, grain size decreases upwards, increases upwards or has a symmetric trend of upwards decreasing to increasing grain size (Plate 1).

Formation of ungraded layers is attributed to a constant rate of accumulation during *in situ* crystallization (Hess, 1960; McBirney and Noyes, 1979). During *in situ* crystallization, there must be efficient movement of elements across boundary layers. Residual, more evolved magma that is produced by crystallization will be transported out of the boundary layer and continually swept away and mixed with the magma above the boundary layer. In dealing with *in situ* formation of ungraded layers, there are three problems to be resolved.

1. There are five layers that lack olivine, but instead contain cumulus orthopyroxene. In these layers the distribution of orthopyroxene is much the same as the distribution of olivine in graded layers. The distribution of orthopyroxene may have been produced by the same processes that produced the distribution of olivine in graded layers; these layers will be discussed later in conjunction with layers that are graded.

2. Olivine occurs in 8 layers that are ungraded and must have accumulated at the same rate as clinopyroxene. The lack of variation in olivine/clinopyroxene across these layers suggest that the composition of the boundary layer in which these minerals crystallized remained constant throughout the formation of the layer. Lighter, more evolved liquid produced by crystallization would have been removed and replaced by homogenous liquid from above. Olivine nucleated first and was followed by clinopyroxene in an upward advancing boundary layer at the magma-crystal interface (Campbell, 1987; Brandeis and Jaupart, 1987). Differences in time of nucleation between olivine and clinopyroxene was relatively small or these two minerals may have nucleated simultaneously. Olivine and clinopyroxene continued to nucleate throughout the layer in equal proportions with little

or no downward crystal transport. Nucleation would be followed by a prolonged period of crystal growth whereby olivine and clinopyroxene would have increased in size (Brandeis *et al.*, 1984), but were unable to move downward. The degree of crystallization would have been controlled by an intimate balance between chemical diffusion and removal of latent heat (Brandeis and Jaupart, 1987). Orthopyroxene oikocrysts would have been able to settle or be transported to the growing crystal pile with the distribution of oikocrysts being related to the rate of supply of oikocrysts and the rate of upward growth of the magma-crystal interface. Furthermore, small crystal-laden packets could have locally penetrated the boundary layer and spread out to deposit crystals in thin layers of gabbro (Brandeis and Jaupart, 1986).

3. In 5 layers clinopyroxene is the only ferromagnesian cumulus phase, although one of these layers contains orthopyroxene oikocrysts and another contains cumulus plagioclase. Three of these layers occur in zone 3 and are defined by differences in grain size. Because the present size of clinopyroxene is probably the result of postcumulus overgrowths, primary differences, if any, between layers are uncertain. The lack of olivine and the lack of orthopyroxene, except in one layer, suggest that the magma was more evolved than that from which other layers crystallized and was not saturated in olivine or less commonly saturated in orthopyroxene

6.7.2 Normally graded layers

Twelve layers have upwards decreasing olivine/clinopyroxene across layers and have been defined as normally graded. Based on olivine/clinopyroxene variations, three subtypes were defined: 1) 5 layers with upwards decreasing olivine/clinopyroxene throughout the layer, 2) 5 layers with a reversely graded lower part and a normally graded middle and upper part, and 3) 2 layers with an ungraded lower and middle part and a normally graded upper part. The rate of upward decrease is variable from layer to layer and includes both continuous and discontinuous changes.

6.7.2.1 Formation of normally graded layers with upwards decreasing olivine/clinopyroxene throughout the layer

In the Reed Lake pluton mineral variations in normally graded layers with upwards decreasing olivine/clinopyroxene throughout the layer follow general fractionation trends observed in many intrusions (Irvine, 1970; McBirney and Noyes, 1979; Wilson, 1982; Raedeke and McCallum, 1984; Conrad and Naslund; 1989). In the Reed Lake Pluton these layers have the following characteristics:

1. cumulus plagioclase occurs at the top of 3 layers, but is absent in the other 2 layers;
2. cumulus orthopyroxene occurs throughout 2 layers and its distribution correlates positively with olivine; cumulus orthopyroxene also occurs as thin discontinuous layers near the base of another layer; cumulus orthopyroxene is absent in 2 of the 3 layers that contain cumulus plagioclase;
3. orthopyroxene oikocrysts are absent; and
4. grain size is uniform in three layers, but increases upwards or has a symmetric trend of increasing upwards to decreasing upwards in the other two layers.

The maximum abundance of olivine at the base of layers suggests that grains nucleated at the magma-crystal interface adjacent to existing crystals with a minimal degree of undercooling (McBirney and Noyes, 1979; Campbell, 1987; Martin *et al.*, 1987). In normally graded layers with the maximum abundance of olivine at the base, cumulus plagioclase occurs at the top of layers and cumulus orthopyroxene mimics the distribution of olivine (Plate 1); orthopyroxene in some ungraded layers has a similar distribution as olivine suggesting that both crystallized by a similar process. Plagioclase at the top of layers suggest minerals accumulated by following general fractionation trends. The boundary layer from which these minerals accumulated acted as a closed evolving system, so that changes in boundary layer composition are reflected within the layer itself (McBirney and Noyes, 1979; Martin *et al.*, 1987). The boundary layer from which minerals accumulated to form ungraded layers, on other hand, was continually

homogenized by interchange with overlying magma. Fluctuations in nucleation and diffusion during formation of these normally graded layers are suggested by both continuous and discontinuous grading in these layers. In the two thinnest layers, which have a lower olivine-rich half and an upper olivine-poor half, olivine probably accumulated in a boundary layer where there were large compositional gradients and efficient diffusion of elements during crystallization (McBirney and Noyes, 1979).

6.7.2.2 Formation of normally graded layers with reversely graded lower part and normally graded upper part

The occurrence of the maximum abundance of olivine some distance above the base of layers in large layered intrusions is rarely documented. In the Mafic-Ultramafic Group, these layers have the following characteristics:

1. cumulus plagioclase occurs only as part of discontinuous gabbro layers at the top of 2 layers;
2. cumulus orthopyroxene only occurs as part of discontinuous websterite layers near the base of 1 layer;
3. orthopyroxene oikocrysts occur throughout 3 layers, but are absent in the other 2 layers; and
4. grain size of clinopyroxene is uniform or is coarser at the top of the layer than in the middle or lower parts of the layer.

In these layers two features have to be explained: (a) the upper, normally graded part, and (b) the lower, reversely graded part. The upper graded part probably accumulated in a similar manner as the accumulation of normally graded layers with upwards decreasing olivine/clinopyroxene throughout the layer. Cumulus plagioclase occurs at the top of some layers; this suggests that efficient diffusion of elements occurred within the upper part of the boundary layer as more evolved magma was expelled from crystallizing ferromagnesian minerals and transported to the top of the boundary zone where saturation occurred. The lack of plagioclase at the top of other layers indicates that magma

in some layers did not evolve to the same extent before onset of nucleation that resulted in the overlying layer.

In normally graded layers with a reversely graded lower part the maximum abundance of olivine above the base of the layer could have been produced by (a) nucleation and transport of olivine to its present position, or (b) crystallization at the present location with little or no movement after nucleation. In these layers there is some evidence of magma flow and transport of crystals but, crystallization of olivine well above the magma-crystal interface and crystallization of clinopyroxene closer to the interface is difficult to reconcile with known or inferred magma properties.

The other possibility is olivine crystallization at its present location slightly above the magma crystal interface with little or no downward movement of olivine by gravitional settling or magma flow. High degrees of undercooling are necessary to nucleate minerals above the base of layers (Brandeis and Jaupart, 1987). In the Mafic-Ultramafic Group some layers with reversely graded lower parts occur at the base of zones, but most overlie layers that probably still contained intercumulus magma; this suggests that the amount of undercooling at the magma-crystal interface was probably minimal.

The occurrence of maximum olivine abundances above the base of the layer is problematic, but does not appear to be related to thermal gradients and nucleation kinetics (Brandeis and Jaupart, 1986). At the magma-crystal interface, the degree of supercooling is largely dominated by compositional gradients rather than thermal gradients (Martin *et al*, 1987). Therefore, the distribution of olivine in the layers at Reed Lake are probably controlled by compositional gradients. Two possible mechanisms are:

1. Higher concentrations of incompatible elements at the magma-crystal interface and a local temperature increase cause supersaturated crystallization above the magma-crystal interface and nucleation of olivine above the base of the layer; and

2. At magma compositions close to the cotectic the density gradient in the boundary layer may give an upward increase in Mg/(Mg+Fe) causing nucleation of olivine above the base of the layer.

More data are needed before these two models for the origin of the maximum accumulation of olivine above the base of the layer can be determined

Mineral differences produced by either model could be further enhanced by abundant intercumulus migration across layer contacts; the degree to which layers are reversely graded would then be related, either partly or totally, to the amount of intercumulus migration and the onset of crystallization in the overlying layer. Abundant migration of more evolved intercumulus magma mixing with less evolved magma of the overlying boundary layer could enhance reverse grading at the base of the layer (Wilson, 1982).

As discussed earlier, thin discontinuous websterite layers near the base of one layer probably formed by deposition from small crystal + liquid packets that crystallized elewhere (Brandeis and Jaupart, 1986; Morse, 1986a); these layers occur below the maximum concentration of olivine (Plate 1). If olivine crystallized above the magma-crystal interface, these packets probably would not have penetrated the zone of olivine crystallization to be deposited below this zone unless the packets moved downward soon after crystallization was initiated in the boundary layer and penetrated the zone of maximum olivine crystallization before olivine formed a rigid crystal network. Furthermore, oikocrysts occur throughout three layers and also indicate downward transport; some oikocrysts occur below the zone of maximum olivine abundance. These features suggest that, although olivine may have crystallized above the magma-crystal interface, crystallization more likely occurred at the interface with crystals accumulated upwards under differing degrees on nucleation of olivine and clinopyroxene.

Orthopyroxene in one ungraded layer has a similar distribution as olivine in type 2 normally graded layers. Orthopyroxene is difficult to nucleate (Lindsley, 1983); this suggests that orthopyroxene needs to be strongly supersaturated for

nucleation to occur and its nucleation probably occurs after clinopyroxene. A delay in nucleation is compatible with a maximum concentration of orthopyroxene above the base of these layers.

6.7.3 Reversely graded layer

Olivine/clinopyroxene increases upwards across only one layer and has been defined as reversely graded. This layer has the following characteristics:

1. cumulus orthopyroxene occurs in two sublayers; one at the base of the layer and one at the top;
2. orthopyroxene oikocrysts occur at the base of one layer and decrease in abundance upwards; cumulus plagioclase is absent;
3. grain size is relatively uniform across the layer.

The occurrence of reversely graded layers in other intrusions has been only rarely documented (Wager and Brown, 1967; Morse, 1969; Parsons, 1979; Irvine, 1980a). Where observed, reversely graded layers in other intrusions have been interpreted to have formed by:

1. density currents and reverse sorting of grain size (Irvine, 1980a); or
2. *in situ* crystallization during complex interaction of crystal nucleation and growth related to supercooling in the magma (Parsons, 1979).

At Reed Lake there is little evidence for deposition from density currents and the primary grain size distribution is obscured by postcumulus overgrowths. Furthermore the model developed by Parsons (1979) is specific to the syenitic magma and minerals that crystallized from that magma in the Klokken Intrusion.

Considering how other layer types are thought to have formed, the one reversely graded layer probably formed by *in situ* crystallization, but the reason for the large abundance of olivine at the top of the layer is unknown. The cumulus orthopyroxene at both the base and top of the layer indicate complex changes in magma composition that may have enhanced differences in nucleation and diffusion. More data are necessary before the origin of this layer can be determined.

6.7.4 Complexly graded layers

Twelve layers that have generally symmetric trends in olivine/clinopyroxene have been defined as complexly graded. Two subtypes were defined: 1) 6 layers that have a reversely graded lower part and a normally graded upper part, and 2) 6 layers that have broad symmetric trends with local discontinuities (Table 10).

Complexly graded layers are characterized by:

1. cumulus plagioclase occurs in both subtypes, but has a higher incidence of occurrence in subtype 2; in subtype 1 cumulus plagioclase occurs at the top of layers, the base of layers, and throughout layers, but in subtype 2 occurs at the top of most layers except for one layer where it occurs at the base;
2. cumulus orthopyroxene is absent in subtype 2, and only occurs in 1 layer of subtype 1 where is is confined to two sublayers, one at the base and one in the middle of the layer;
3. orthopyroxene oikocrysts occur in three layers of subtype 1 and two layers of subtype 2; oikocrysts are uniformly distributed, decrease in abundance upwards, or are locally absent in a layer; and
4. in most layers clinopyroxene grain size is relatively uniform, but it is coarser at the top of one layer where plagioclase occurs, and near the lower or middle part of two other layers; in one layer where cumulus plagioclase occurs throughout, there are local patchy variations in grain size.

Complexly graded layers have a generally similar distribution of olivine and clinopyroxene as type 2 normally graded layers and probably developed by similar processes related to compositional gradients in a lower boundary layer. The major differences between complexly graded layers and type 2 normally graded layers are (a) maximum olivine abundance occurs higher in complexly graded layers and (b) the distribution of olivine in at least 6 of the complexly graded layers is less symmetric than in type 2 normally graded layers. Although, in general, these processes may account for the reversely graded to normally graded distribution of olivine, complexly graded layers that have a less symmetric distribution have

three features that are difficult to reconcile with the proposed model. These are:

1. thin olivine-rich sublayers at or near the top of a couple of layers directly below where cumulus plagioclase occurs;
2. repeated pattern of reverse to normal grading; and
3. occurrence of cumulus plagioclase throughout one layer and in the lower part of the overlying layer.

If crystallization was entirely *in situ*, then the occurrence of thin olivine-rich sublayers near the top of layers indicates a change from crystallization of relatively small amounts of olivine to large abundances. Intermittent layers of this type in other intrusions have been interpreted to be related to occasional variations in the continual accumulation of crystals by *in situ* crystallization (McBirney and Noyes, 1979; Brandeis and Jaupart, 1986); these variations may have been caused by temperature changes related to cotectic crystallization and changing liquid compositions (Brandeis *et al.*, 1984). The olivine-rich sublayers in the Reed Lake complexly graded layers occur directly below the appearance of cumulus plagioclase; this suggests that crystallization of plagioclase may have been initiated by sudden increase in olivine crystallization that in turn led to enrichment of more evolved components in the immediately overlying magma and depletion of less evolved components. Although the occurrence of thin sublayers near the top of the layers can be accounted for by local variations in crystal accumulation, the reason for such large abundances of olivine is difficult to explain. However, some crystallization may have occurred above the magma-crystal interface and these sublayers may have been deposited by magma flow (Irvine, 1980a). Olivine may have crystallized elsewhere and have been deposited by these currents in relatively large abundances prior to accumulation of cumulus plagioclase. The sublayers lack mineral alignment suggesting that olivine may have accumulated *in situ*. The lateral extent of these sublayers are unknown and more data is needed before a conclusion can be reached on their genesis.

A repeated reversely graded to normally graded pattern occurs in a couple

of layers, both of which contain orthopyroxene oikocrysts; cumulus plagioclase only occurs at the top of one of these layers (Table 10). Both layers also show evidence of magma flow (Table 10). In terms of mineralogy, these layers are not much different from other layers, but the occurrence of magma flow, which was only rarely documented occurs in other layer types, suggests some relationship between magma flow and the repeated pattern of reverse to normal grading with two levels of maximum olivine abundance in one layer.

Cumulus plagioclase occurs throughout layer 7a and in the lower half of layer 7b. Plagioclase at the base of other layers probably represents accidental incorporation of plagioclase from the underlying layer. The occurrence of plagioclase throughout layer 7a, however, was not likely caused by accidental incorporation because plagioclase would have to have been evenly mixed throughout the whole layer and into the overlying layer. However, *in situ* crystallization of plagioclase in these layers also appears unlikely considering the large variation in olivine and orthopyroxene abundances. Unusual conditions must have existed for accumulation of plagioclase throughout one layer and half of the other.

In summary, complexly graded layer types have different patterns of olivine abundance. The olivine maxima occur at (a) levels higher than in normally graded layers, (b) more than once in a layer, and (c) in thin intervals well above the base of a layer. The complexly graded layers probably formed in much the same manner as type 2 normally graded layers, although other variables such as local variation in accumulation rates were superimposed on this process.

6.7.5 Sequences of layers

At Reed Lake the layers apparently formed by *in situ* crystallization in a lower boundary layer. Magma composition was close to a cotectic and, variations in nucleation and diffusion, as magma composition fluctuated, produced the observed variations in the abundance and distribution of olivine/clinopyroxene, and, in some layers, orthopyroxene/clinopyroxene. Orthopyroxene oikocrysts crystallized above the magma-crystal interface and were transported by magma flow

or by crystal settling to the magma-crystal interface. Plagioclase occurs near the top of most layers, apparently the normal consequence of magma evolution, but it is also locally found in thin layers deposited by crystal + liquid packets. Some cumulus orthopyroxene was also deposited in thin layers by crystal + liquid packets. Plagioclase at the base of layers probably represents mixing of magma with underlying plagioclase-bearing layers.

The ultramafic zones comprise four different types of layers defined by variation in olivine/clinopyroxene. These layers are combined to form sequences of layers in the 13 zones that comprise more than 1 layer. In addition, there are also three zones that were probably formed from more than one batch of magma.

Based on the distribution of layers, 3 different types of sequences are defined:

1. 5 zones that consist of a single type of layer, either uniform or complex;
2. 5 zones in which more than half of the layers are the same type, either uniform or normally graded and the other layers are different types; and
3. 4 zones that comprise 2 or 3 layers, of which 1 layer is always normally graded and another layer is always complexly graded; ungraded layers only occur at the base.

Although, there are three different types of layer sequences, in most zones more than half of the layers are of a single type; this suggests that conditions were relatively constant throughout the accumulation of most layers in these zones. Changes that do occur between layer types may be caused by local fluctuations in conditions or by a progressive change in conditions of accumulation. In zones that consist of completely different layer types, layer types that have similar patterns suggest that there were local fluctuations in conditions or gradual, progressive changes in conditions. In these zones, layer types generally follow a regular pattern; this indicates that conditions probably changed in a gradual, progressive manner.

6.8 Irregular zone contacts

Two types of irregular contacts were defined at the top of ultramafic zones:

(1) highly irregular contacts with clinopyroxenite fingers that extend upward into the overlying mafic zone; and (2) slightly irregular convex upward contacts. Highly irregular contacts occur at the top of ungraded layers at the top of the three thickest zones. These contacts have the following characteristics:

1. clinopyroxenite occurs in thin fingers that penetrate upwards into the overlying mafic zone;
2. clinopyroxene is coarse-grained and grain size increases markedly upwards;
3. layers in the lower parts of mafic zones are truncated, but not folded or otherwise disturbed; and
4. partly detached mafic septa are semiconcordant with clinopyroxenite fingers.

The upward penetration of the clinopyroxenite fingers and the truncation of layers in the lower parts of mafic zones without any deformation suggest that fingers penetration occurred after the overlying zone was solid enough to fracture and they therefore represent postcumulus processes. The coarse grain size of the clinopyroxene suggests continual upward migration of intercumulus liquid and growth of crystals. The overlying mafic zone would not have been completely solidified because the underlying ultramafic zone was still partly liquid.

Zone contacts that are slightly irregular and convex upward occur at the top of 4 zones. These contacts differ from the highly irregular contacts because ultramafic layers penetrated only short distances into the overlying mafic zone and small deformed fragments of clinopyroxenite occur in the overlying mafic zone. The small fragments of deformed clinopyroxenite and the concave nature of the contact suggest that the ultramafic zone was scoured by the overlying mafic zone However, the lack of mineral alignment in three of the four zones (Table 3) suggests that magma flow for a relatively short time.

6.9 Development of cycles

Each of the 15 cycles that have been identified in the Mafic-Ultramafic Group is thought to have formed from a separate batch of magma.

The Mafic-Ultramafic Group has the following characteristics:

1. between the two septa, olivine increases in abundance upwards to a maximum in zone 6 before decreasing; above the upper septum olivine abundance has a similar pattern (Figure 45); and
2. there is a general upwards change to less evolved compositions, generally following the pattern of olivine distribution; the most Mg-rich compositions occur in zone 13.

These changes in composition suggest that successive magma batches initially tapped progressively lower into the source to withdraw progressively less evolved magma. At some point, marked by the change toward more evolved compositions in zone 7, magma batches tapped a more evolved source. This pattern was then repeated in the upper part of the group. The change in the mean abundance of olivine from zones from progressively increasing upwards to progressively decreasing upwards may be related to the rate of magma replenishment in the Mafic-Ultramafic Group and the rate of fractionation in the source.

CHAPTER 7

CONCLUSIONS

Ultramafic layers comprise about 20% of the Mafic-Ultramafic Group of the Reed Lake Pluton. They occur in at least 15 zones, ranging in thickness from 0.3 to 15.3 m and consist of between 1 and 6 layers. A number of conclusions can be made from this study.

1. Calculated olivine compositions, crystallization sequences, and clinopyroxene chemistry suggest that ultramafic layers formed from a subalkaline tholeiitic magma. Low abundances of olivine and low forsterite contents also suggest that the magma had undergone some fractionation prior to emplacement.
2. Cycles consist of a lower ultramafic zone and an upper mafic zone, except for cycle 9 in which the mafic zone is absent. Most cycles probably represent a separate batch of magma that tapped progressively lower into the source magma chamber. Discontinuities in olivine abundance, clinopyroxene chemistry and crystallization sequences suggest that zones 1, 8 and 11 probably formed from at least two magma batches.
3. Clinopyroxene grains have a uniform composition and En/Fs and Cr_2O_3 in clinopyroxene correlates poorly with mineral variations. Original clinopyroxene compositions have probably been modified by intercumulus migration.
4. Crystallization followed the order olivine, clinopyroxene, orthopyroxene, plagioclase in 34 layers and clinopyroxene, orthopyroxene, plagioclase in 8 layers. Olivine and clinopyroxene crystallized at about the same time.
5. Based on olivine/clinopyroxene the 43 layers in the group can be subdivided into 12 normally graded layers, 18 uniform layers, 12 complexly graded layers, and 1 reversely graded layer. Four layers that are defined as uniform are graded with respect to orthopyroxene.

6. Layers crystallized *in situ*, although orthopyroxene oikocrysts crystallized above the magma-crystal interface and may have undergone some crystal settling. Convection occurred as small scale currents and possibly as larger scale convection, but varied in degree from zone to zone and layer to layer. Small crystal + liquid packets locally penetrated the boundary layer to deposit crystals.
7. Postcumulus crystallization is common, but abundances of the different mineral phases was not determined. Depth of the crystal mush would have been at least 2 m in some places. Migration of intercumulus liquid contributed to deformation of contacts at the top of zones 3, 5 and 11.
8. Ungraded layers formed by accumulation of constant proportions of olivine and clinopyroxene from a homogenized boundary layer. Some ungraded layers that lack olivine crystallized from magma that was more evolved than other layers that contain olivine.
9. Graded layers, either complexly or normally graded, formed by *in situ* crystallization at the magma-crystal interface. The distribution of olivine and clinopyroxene were probably controlled by compositional gradients. Local variations in thermal gradients may be superimposed on the compositional gradients.
10. Sequences of layers in zones indicate that conditions at which layers form were relatively constant throughout the accumulation of the zone or changes were gradual and progressive.

REFERENCES

ANHAEUSSER, C.R., 1985. Archean layered ultramafic complexes in the Barberton Mountain Land, South Africa, in *Evolution of Archean Supracrustal Sequences*, L.D. Ayres, P.C. Thurston, K.D. Card, and W. Weber eds., Geological Association of Canada, Special Paper 28, p.281-301.

ATKINS, F.B., 1969. Pyroxenes of the Bushveld Intrusion, South Africa. *Journal of Petrology*, vol. 10, p. 222-249.

AYRES, L.D. and YOUNG, J., 1989. Characterization of mafic–ultramafic intrusive rocks in the Flin Flon–Snow Lake area, Manitoba. in *Investigations by the Geological Survey of Canada in Manitoba and Saskatchewan during the 1984–1989 Mineral Development Agreements*, A.G. Galley, compiler, Geological Survey of Canada Open File 2133, p.64-68.

BAILES, A.H., 1980. Geology of the File Lake Area. *Manitoba Mineral Resources Division*, Geological Report 78-1, 134 p.

_____, 1971. Preliminary compilation of the geology of the Snow Lake-Flin Flon Sherridon area. *Manitoba Department of Mines and Natural Resources.* Geological Paper 1/71, 27 p.

_____, and SYME, E.C., 1983. Flin Flon/Schist Lake project (parts of 63K/12,13): in *Manitoba Energy and Mines*, Report of Field Activities, p. 23-29.

_____, and _____, 1989. Geology of the Flin Flon - White Lake area. *Manitoba Energy and Mines*, Geological Report GR-87, 313 p.

_____, _____, GALLEY, A.G., PRICE, D.P., SKIRROW, R., and ZIEHLKE, D.J., 1987. Trip 1: Early Proterozoic volcanism, hydrothermal alteration, and associated ore deposits at Flin Flon and Snow Lake, Manitoba. *GAC/MAC Field Trip Guidebook*, 95 p.

BAILEY, S.W., 1988. Chlorites: Structures and crystal chemistry. In: Bailey, S.W.(ed.), *Hydrous Phyllosilicates, (exclusive of micas)*, Reviews in Mineralogy, vol. 19, p.347-403.

BARNES, S.J., 1986. The effect of trapped liquid crystallization on cumulus mineral compositions in layered intrusions. *Contributions to Mineralogy and Petrology*, vol. 93, p.524-531.

BRANDEIS, G. and JAUPART, C., 1987. Characteristic dimensions and times for dynamic crystallization. in *Origins of Igneous Layering*, I. Parsons, ed., D. Reidel Publishing Co., p.613-640.

_____, _____, 1986. On the interaction between convection and crystallization in cooling magma chambers. *Earth and Planetary Science Letters*, vol.

77, p.345-361.

———, ———, ALLEGRE, C.J., 1984. Nucleation, crystal growth and the thermal regime of cooling magmas. *Journal of Geophysical Research*, vol. 89, p.10161-10177.

BROWN, G.M., 1956. The layered ultrabasic rocks of Rhum, Inner Hebrides. *Philosophical Transactions of the Royal Society of London, A* vol. 240, p.1-53.

———, VINCENT, E.A., 1963. Pyroxenes from late stages of fractionation of the Skaergaard intrusion, East Greenland. *Journal of Petrology* vol. 4, p.175-197.

CAMERON, E.N., 1980. Evolution of the Lower Critical Zone, central sector, Eastern Bushveld Complex, and its chromite deposits. *Economic Geology*, vol. 75, p.845-871.

CAMPBELL, I.H., 1977. A study of macro-rhythmic layering and adcumulate processes in the Jimberlana Intrusion, Western Australia: The upper layered series. *Journal of Petrology*, vol. 18, p.183-215.

———, 1978. Some problems with cumulus theory. *Lithos*, vol. 11, p.311-323.

———, 1987. Distribution of orthocumulate textures in the Jimberlana Intrusion. *Journal of Geology*, vol., 95, p.35-54.

———, and BORLEY, G.D., 1974. The geochemistry of pyroxenes from the Lower Layered series of the Jimberlana Intrusion, Western Australia. *Contribution to Mineralogy and Petrology*, vol. 47, p.281-297.

CONRAD, M.E., and NASLUND, H.R., 1989. Modally-graded rhythmic layering in the Skaergaard Intrusion. *Journal of Petrology*, vol., 30, p.251-269.

CHAYES, F., 1956. Petrographical modal analysis — an elementary statistical approach. John Wiley and Sons, Inc., New York, 113 p.

DEER,W.A., HOWIE,R.A., and ZUSSMAN, J., 1966. An introduction to the rock-forming minerals. Longman Group Ltd., London, 528 p.

DUNHAM, A.C. and WADSWORTH, W.J., 1978. Cryptic variation in the Rhum layered intrusion. *Mineralogical Magazine*, vol. 42, p.347-356.

DUKE, D.M., 1976. Distribution of the period four transition elements among olivine, calcic clinopyroxene and mafic silicate liquid: experimental results. *Journal of Petrology*, vol. 17, p.499-521.

FLEET, M.E., 1974. Partition of Mg and Fe^{2+} in coexisting pyroxenes. *Contributions to Mineralogy and Petrology*, vol., 44, p.251-257.

FROESE, E., and MOORE, J.M., 1980. Metamorphism in the Snow Lake area, Manitoba. *Geological Survey of Canada*, Paper 78-27.

GORDON, T.M., and GALL, Q., 1982. Metamorphism in the Crowduck Bay area, Manitoba. *Geological Survey of Canada*, Paper 82-1A, p.197-201.

G.S.C., 1983. Experimental colour compilation (high resolution aeromagnetic vertical gradient), Iskwasum Lake, Manitoba. *Geological Survey of Canada*, Map C40,082G.

HESS, H.H., 1941. Pyroxenes of common mafic magmas. Part 2. *American Mineralogist*, vol. 26, p.573-594.

———, 1960. Stillwater Igneous Complex, Montana: A quantitative mineralogical study. *Geological Society of America*, Memoir 80, 230 p.

HOSAIN, I.T., 1985. Interpretation of airborne magnetic gradiometer surveys of the area south of the Flin Flon-Snow Lake belt. *Manitoba Energy and Mines, Mines Branch*, Open File Report OF84-2, 26p.

HUNTER, R.H., 1987. Textural equilibrium in layered igneous rocks. in *Origins of Igneous Layering*, I. Parsons, ed., D. Reidel Publishing Co., p.473-503.

HUPPERT, H.E., and SPARKS, R.F.J., 1984. Double-diffusive convection due to crystallization in magmas. *Annual Review, Earth and Planetary Sciences*, vol. 12, p.11-37.

IRVINE, T.N., 1967. Chromian spinel as a petrogenetic indicator, Part 1. Theory. *Canadian Journal of Earth Sciences*, vol. 2, p.648-672.

———, 1970. Crystallization sequences in the Muskox intrusion and other layered intrusions, I. Olivine- pyroxene-plagioclase relations. in *Bushveld igneous complex and other layered intrusions*, Geological Society of South Africa, Special Publication 1, p.441-476.

———, 1974. Petrology of the Duke Island ultramafic complex, southeastern Alaska. *Memoir, Geological Society of America*, vol. 138, 240 p.

———, 1979. Rocks whose composition is determined by crystal accumulation and sorting, in *The Evolution of Igneous Rocks, Fiftieth Anniversary Perspectives*, H.S. Yoder, Jr., ed., Princeton University Press, Princeton, New Jersey, p.245-306.

———, 1980. Magmatic density currents and cumulus processes. *American Journal of Science (Jackson Volume)*, vol. 280A, p.1-58.

———, 1982. Terminology for Layered Intrusions. *Journal of Petrology*, vol. 23, p.127-162.

———, 1987a. Layering and related structures in the Duke Island and Skaergaard Intrusions: similarities, differences and origins. in *Origins of Igneous Layering*, I. Parsons, ed., D. Reidel Publishing Co., p.185-245.

———, 1987b. Appendix I. Glossery of terms for layered intrusions. in *Origins of Igneous Layering*, I. Parsons, ed., D. Reidel Publishing Co., p.641-647.

———, KEITH, D.W., and TODD, S.G., 1983. The J-M platinum-palladium reef of the Stillwater Complex, Montana II. Origin by double-diffusive convective magma mixing and implications for the Bushveld Complex. *Economic Geology*, vol. 78, p.1287-1334.

——— and SMITH, C.H., 1967. The ultramafic rocks of the Muskox Intrusion, in *Ultramafic and Related Rocks*, P.J. Wyllie, ed., J. Wylie & Sons, New York, p. 38-49.

JACKSON, E.D., 1961. Primary textures and mineral associations in the ultramafic zone of the Stillwater Complex, Montana. *U.S. Geological Survey,* Prof. Paper, 358.

———, 1970. The cyclic unit in layered intrusions — a comparison of the repetitive stratigraphy in the ultramafic parts of the Stillwater, Muskox, Great Dyke and Bushveld Complexes. in *Bushveld igneous complex and other layered intrusions* Geological Society of South Africa, Special Publication 1, p.391-424.

JAMES, R.S., and HAWKE, D., 1984. Geology and petrogenesis of the Kanichee Layered Complex, Ontario. *Canadian Mineralogist*, vol. 22, p.93-109.

JAUPART, C., and BRANDEIS, G., 1986. The stagnant bottom layer of convecting magma chambers. *Earth and Planetary Science Letters,* vol. 80, p.183-199.

KERR,R.C. and TAIT, S.R., 1985. Convective exchange between pore fluid and an overlying reservoir of dense fluid, a postcumulus process in layered intrusions. *Earth and Planetary Science Letters*, vol. 75, p.147-156.

KUSHIRO, I., 1972. Determination of liquidus relations in synthetic silicate systems with electron probe analysis: the system forsterite-diopside-silica at 1 atmosphere. *American Mineralogist*, vol. 57, p.1260-1271.

KIRKPATRICK, R.J., 1983. Theory of nucleation in silicate melts. *American Mineralogist*, vol. 68, p.66-77.

LANGMUIR, C.H., BENDER, J.F., BENCE, A.E., HANSON, G.N., and TAYLOR, S.R. 1977. Petrogenesis of basalts from the FAMOUS area: Mid-Atlantic Ridge. *Earth and Planetary Science Letters*, vol. 36, p.133-156.

LETERRIER, J., MAURY, R.C., THONON, P., GIRARD, D., and MARCHAL, M., 1982. Clinopyroxene composition as a method of identification of the magmatic affinities of paleo-volcanic series. *Earth and Planetary Science Letters*, vol. 59, p.139-154.

LINDSLEY, D.H., 1983. Pyroxene thermometry *American Mineralogist*, vol. 68, p.477-493.

MACRAE, N.D., 1969. Ultramafic intrusions of the Abitibi area, Ontario. *Canadian Journal of Earth Sciences*, vol. 6, p.281-303.

MARSH, B.D., 1989. On convective style and vigor in sheet-like magma chambers. *Journal of Petrology*, vol 30., p.479-530.

MARTIN, D. GRIFFITHS, R.W. and CAMPBELL, I.H., 1987. Compositional and thermal convection in magma chambers. *Contribution to Mineralogy and Petrology*, vol. 96, p.465-475.

MATHISON, C.I., 1987. Pyroxene oikocrysts in troctolitic cumulates — evidence for supercooled crystallisation and postcumulus modification. *Contributions to Mineralogy and Petrology*, vol. 97, p.228-236.

———, 1985. Further considerations of double diffusive stratification and layering in the Skaergaard Intrusion. *Journal of Petrology*, vol. 26, p.993-1001.

———and BAKER, B.H., and NILSON, R.H., 1985. Liquid fractionation. Part I: Basic principles and experimental simulations. *Journal of Volcanology and Geothermal Research,* vol 24, p.1-24.

———and NOYES, R.M., 1979. Crystallization and layering in the Skaergaard Intrusion. *Journal of Petrology,* vol 20, p.487-554.

MORIMOTO, N., FABRIES, J., FERGUSON, A.K., GINSBURG, I.V., ROSS, M., SEIFERT, F.A., and ZUSSMAN, J., 1988. Nomenclature of pyroxenes. *American Mineralogist*, vol. 73, p.1123-1133.

MORSE, S.A., 1969. The Kiglapait Layered Intrusion. *Geological Society of America*, Memoir 112, 204 p.

———, 1986a. Convection in aid of adcumulus growth. *Journal of Petrology*, vol. 27, p.1183-1214.

———, 1986b. Thermal structure of crystallizing magma with two-phase convection. *Geological Magazine*, vol. 123, p.205-214.

PARSONS, I., 1979. The Klokken gabbro-syenite complex, South Greenland: cryptic variation and origin of inversely graded layering. *Journal of Petrology*, vol. 20, p.653-694.

PETERSEN, J.S., 1987. Solidification contraction: another approach to cumulus processes and the origin of igneous layering, in *Origins of Igneous Layering*, I. Parsons, ed., D.Riedel Publishing Company, p.505-526.

RAEDEKE, L.D. and MCCALLUM, I.S., 1984. Investigations of the Stillwater complex: Part II. Petrology and petrogenesis of the Ultramafic Series. *Journal of Petrology*, vol. 25, p.395-420.

RAUDSEPP, M., 1979. Petrology and emplacement of a differentiated subvolcanic mafic sill complex in the early Precambria Favourable Lake Volcanic Complex, Northwestern Ontario. Unpublished, M.Sc. thesis, Univeristy of Manitoba, 115p.

RENNER, R. and PALACZ, Z., 1987. Basaltic replenishment of the Rhum magma chamber: evidence from unit 14. *Journal of Geological Society, London*, vol. 144, p.961-970.

ROBINSON, P., SPEAR, F.S., SCHUMACHER, J.C., LAIRD, J., KLEIN, C., EVANS, B.W., and DOOLAN, B.L., 1982. Phase relations of metamorphic amphiboles: natural occurence and theory. In: Veblen, D.R. and Ribbe, P.H.(eds.), *Amphiboles: petrology and experimental phase relations*, Reviews in Mineralogy, vol. 9B, p.1-228.

ROUSELL, D.H., 1970. Geology of the Iskwasum Lake area (East Half). *Manitoba Department of Mines and Natural Resources,* Mines Branch Publication 66-3, 26 p.

SCOATES, R.F.J., 1990. The Fox River Sill, Northeastern Manitoba - A Major Stratiform Intrusion *Manitoba Energy and Mines*, Geological Report GR82-3, 192 p.

———, WILLIAMSON, B.L., and DUKE, J.M., 1986. Igneous layering in the Ultramafic Series, Bird River Sill; in *Layered intrusions of southeastern Manitoba and northwestern Ontario*, R.F.J. Scoates, B.L. Williamson, J.M. Duke, W. Mandziuk, W.C. Brisbin, R.H. Sutcliffe. Geological Association of Canada Field Trip 13 Guidebook, p.1-19.

SMITH, C.H., and KAPP, H.E., 1963. The Muskox Intrusion, a recently discovered layered intrusion in the Coppermine River area, Northwest Territories, Canada. *Mineralogical Society of America*, Special paper 1, p.30-35.

SPARKS, R.S.J., HUPPERT, H.E., KERR, R.C., MACKENZIE, D.P., and TAIT, S.R., 1985. Postcumulus processes in layered intrusions. *Geological Magazine*, vol. 122, p.555-568.

STRECKEISEN, A.L., 1976. To each plutonic rock it proper name. *Earth Science Reviews*, vol. 12, p.1-33.

TAIT, S.R., 1985. Fluid dynamic and geochemical evolution of cyclic unit 10, Rhum, Eastern Layered Series *Geological Magazine*, vol. 122, p.469-484.

TURNER, J.S. and CAMPBELL, I.H., 1986. Convection and mixing in magma chambers. *Earth Science Reviews*, vol 23, p.255-352.

WAGER, L.R., 1963. The mechanism of adcumulus growth in the layered series of the Skaergaard intrusion. *Mineralogical Society of America Special Paper*, vol. 1, p.1-9.

———, 1959. Differing powers of crystal nucleation as a factor producing diversity in layered igneous intrusions. *Geological Magazine*, vol. 96, p.75-80.

———, and DEER, W.A., 1939. Geological investigations in East Greenland, Pt. III. The petrology of the Skaergaard intrusion, Kangerdlugssuaq, East Greenland. *Meddelelser Om Grønland*, 105, no. 4, 352p.

———, and BROWN, G.M., 1967. Layered Igneous Rocks. Oliver and Boyd, Edinburgh, 588 p.

———, ———, and WADSWORTH, W.J., 1960. Types of igneous cumulates. *Journal of Petrology*, vol. 1, p.73-85.

WATKINSON, D.H., and IRVINE, T.N., 1964. Peridotite intrusions near Quetico and Shebandowan, Northwestern Ontario: A contribution to the petrology and geochemistry of ultramafic rocks. *Canadian Journal of Earth Sciences*, vol. 1, p.63-98.

WILLIAMS, D.A.C., 1971. Determination of primary mineralogy and textures in ultramafic rocks from Mount Monger, western Australia. *Special Publication, Geological Society of Australia*, 3, p.259-268.

WILSON, A.H., 1982. The geology of the Great 'Dyke', Zimbabwe: The ultramafic rocks. *Journal of Petrology*, vol. 23, p.240-292.

YOUNG, J., and AYRES, L.D., 1985. Characterization of mafic-ultramafic rocks in the Flin Flon-Snow Lake area, Manitoba. Unpublished report, Geological Survey of Canada, 57 p.

Appendix A
Petrographic Data

Petrographic data listed in this appendix includes: (1) modal analyses of thin sections, ultramafic rocks; (2) modal analyses of thin sections, mafic rocks; (3) modal analyses of rock slabs, ultramafic rocks; and (4) grain size of clinopyroxene.

Modal analyses were done on 102 samples from the ultramafic zones in the Mafic-Ultramafic Group. Samples were selected from most zones, but a large proportion of the samples were from zones 5 and 11, which are the two zones that are best exposed and are well layered. Analyses were done to maintain a maximum standard deviation of 2.5 (Chayes, 1956). Samples that were geochemically analysed were modally analysed to maintain a maximum standard deviation of <2 (Chayes, 1956); these samples are marked by an asterisk in Table A.1.

Several samples also contain gabbroic clots, xenoliths and layers that was included in the modal analyses. This data has been separated from analyses of ultramafic rocks and listed in Table A.2. Standard deviation on gabbroic material was not determined, but is much higher than that determined for ultramafic rocks.

Twelve large samples that were modally analysed were also cut into slabs and polished. These polished slabs were used to determine the modal abundance of orthopyroxene oikocrysts, which, being very coarse grained, were not amenable to modal analysis from thin section. Smaller samples were not slabbed, but the abundance of orthopyroxene oikocrysts was estimated from outcrop. Modal data determined from thin secttions were adjusted for oikocryst abundance.

Mean grain size of clinopyroxene from 70 ultramafic rocks was calculated by measuring maximum grain dimensions and dimensions normal to this direction (generally the minimum dimension). Data are listed in Table A.4. Measurements were done in an area of about 2.5 cm^2 from one edge of each thin section. Samples that are very coarse-grained were analysed in a 5 cm^2 area from polished slabs (Jackson, 1961).

Table A.1 Modal analyses

Sample	RL460	RL459	RL458*	RL457*	RL455	RL453
Layer	15c	15c	15b	15b	15b	15a
Clinopyroxene + alteration products	**86.1**	**77.3**	**72.7**	**82.3**	**79.1**	**96.7**
clinopyroxene	41.0	69.4	50.3	53.8	55.8	84.8
actinolite	40.7	4.4	0.5		16.8	12.0
+chlorite						
+Fe-Ti oxides			0.1			
-single crystal			0.2	0.2		
-oxide dusted						
-multicrystal			2.7	6.3		
-oxide dusted			14.3	8.6		
-serpentine						
-carbonate						
chlorite		3.5	0.3		0.4	
Fe-Ti oxides	3.4		4.0	7.6	5.1	
sphene						
epidote/clinozoisite						
carbonate	0.3			0.3		
serpentine	0.7		0.6	1.6	1.2	
-Fe-Ti oxides				1.4		
-amphibole						
-carbonate						
cryptocrystalline - undefined			0.4	2.5		
Olivine	**13.9**		**16.3**	**17.2**	**15.8**	**0.1**
alteration products						
tremolite	7.2		1.4		7.1	
-single crystal			0.8	0.2		0.1
-oxide dusted				0.5		
-multicrystal			5.4	3.1		
-oxide dusted						
-carbonate						
serpentine	4.0		7.0	12.0	8.5	
-oxide dusted						
-amphibole						
chlorite			0.6			
carbonate	2.5		0.6	1.1	0.2	
Fe-Ti oxides	0.2		0.4	0.2	0.1	
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene						
cryptocrystalline - undefined						
Orthopyroxene		**14.7**	**10.8**	**0.5**	**5.1**	**3.2**
alteration products						
amphibole		0.5	0.7	0.2		
-single crystal tremolite						
-multicrystal tremolite						
-multitwinned					0.5	0.9
chlorite		13.4	10.0	0.3	4.6	2.3
Fe-Ti oxides			0.1			
clinozoisite						
serpentine						
carbonate						
clinopyroxene		0.9				
Plagioclase		**9.0**				
alteration products						
clinozoisite		5.4				
chlorite		3.3				
amphibole		0.2				
carbonate		0.1				
Fe-Ti oxides						
Oxides			**0.2**			
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL452*	RL407	RL381	RL380*	RL379	RL377
Layer	15a	14b	14b	14b	14b	14b
Clinopyroxene + alteration products	**99.2**	**79.9**	**91.3**	**84.9**	**85.8**	**85.5**
clinopyroxene	80.2	68.8	72.8	60.3	57.7	73.7
actinolite	6.2	16.8	18.1		24.6	10.1
+chlorite	1.9					
+Fe-Ti oxide						
-single crystal	4.5			3.7		
-oxide dusted				4.2		
-multicrystal	7.4			3.1		
-oxide dusted	1.4			8.3		
-serpentine				0.3		
-carbonate				0.1		
chlorite		tr	0.3	0.1	0.1	0.1
Fe-Ti oxides	0.6	0.1		1.3	0.9	1.1
sphene						
epidote/clinozoisite						
carbonate	0.3	0.4	0.2	0.6	0.2	
serpentine				0.5	2.2	0.6
-Fe-Ti oxides				0.1		
-amphibole						
-carbonate				0.2		
cryptocrystalline - undefined	2.9					
Olivine	**0.8**	**5.1**	**5.7**	**13.8**	**13.8**	**11.5**
alteration products						
tremolite		0.6				
-single crystal	0.3	3.5	4.7	4.9	5.0	8.2
-oxide dusted						
-multicrystal	0.3	0.2	0.4	5.1	0.8	1.9
-oxide dusted				tr		
-carbonate				0.2		
serpentine				2.2	7.0	1.4
-oxide dusted						
-amphibole						
chlorite						tr
carbonate	0.2	0.7	0.6	1.3	1.0	0.2
Fe-Ti oxides		0.1			tr	tr
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene						
cryptocrystalline - undefined						
Orthopyroxene		**11.6**	**3.1**	**2.1**		**2.9**
alteration products						
amphibole		1.2	0.7			tr
-single crystal tremolite						
-multicrystal tremolite				0.3		
-multitwinned						
chlorite		10.4	2.1	0.9		2.8
Fe-Ti oxides						tr
clinozoisite						
serpentine						
carbonate			0.2			
clinopyroxene						
Plagioclase						
alteration products						
clinozoisite						
chlorite						
amphibole						
carbonate						
Fe-Ti oxides						
Oxides	**tr**			**0.1**	**tr**	**0.1**
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL375b	RL374	RL372	RL370	RL364	RL363*
Layer	14b	14a	14a	14a	13a	13a
Clinopyroxene + alteration products	**72.4**	**38.4**	**28.2**	**34.4**	**91.3**	**75.7**
clinopyroxene	61.9				39.5	52.9
actinolite	3.4				48.4	
+chlorite						
+Fe-Ti oxide						
-single crystal						1.4
-oxide dusted						0.4
-multicrystal						6.0
-oxide dusted						0.2
-serpentine						0.4
-carbonate						
chlorite	0.2				0.5	
Fe-Ti oxides	3.9				0.1	6.2
sphene					0.1	
epidote/clinozoisite						
carbonate	0.3				2.6	0.2
serpentine	2.6					6.6
-Fe-Ti oxides						0.5
-amphibole						
-carbonate						
cryptocrystalline - undefined						0.4
Olivine alteration products	**18.5**	**34.6**	**60.6**	**62.1**	**8.7**	**24.0**
tremolite	2.0				7.0	
-single crystal						0.1
-oxide dusted						
-multicrystal						0.4
-oxide dusted						
-carbonate						
serpentine	10.7					19.8
-oxide dusted						
-amphibole						
chlorite	0.6					
carbonate	4.9				1.7	2.9
Fe-Ti oxides	0.3					0.7
sphene						
biotite						
undefined yellow brown aggregate						0.1
clinopyroxene						
cryptocrystalline - undefined						
Orthopyroxene alteration products	**8.0**	**26.6**	**9.8**	**3.4**		
amphibole	0.2					
-single crystal tremolite						
-multicrystal tremolite						
-multitwinned						
chlorite	7.8					
Fe-Ti oxides						
clinozoisite						
serpentine						
carbonate						
clinopyroxene						
Plagioclase alteration products						
clinozoisite						
chlorite						
amphibole						
carbonate						
Fe-Ti oxides						
Oxide	**1.2**	**0.4**	**1.4**	**0.2**		**0.4**
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL362	RL356*	RL355	RL354*	RL351	RL350
Layer	13a	12c	12c	12c	12b	12b
Clinopyroxene + alteration products	**67.4**	**61.3**	**66.8**	**74.7**	**96.2**	**87.4**
clinopyroxene	45.2	42.4	49.7	54.7	78.0	67.7
actinolite	5.9					
+chlorite						
+Fe-Ti oxides						
-single crystal		0.1	3.9	0.3	5.5	0.6
-oxide dusted			0.9	0.7	0.7	0.1
-multicrystal		3.2	4.6	2.0	4.1	0.4
-oxide dusted		1.6	1.3	0.7	0.6	1.5
-serpentine		tr				
-carbonate						
chlorite						
Fe-Ti oxides	4.1	2.1	3.7	6.2	3.0	8.5
sphene					0.1	
epidote/clinozoisite						
carbonate	0.6		0.5		0.1	
serpentine	6.6	12.3	12.6	5.4		3.1
-Fe-Ti oxides		1.1		1.5		1.2
-amphibole		0.1				
-carbonate						
cryptocrystalline - undefined	0.1	0.1		0.2	0.2	
Olivine	**32.2**	**36.7**	**33.2**	**25.3**	**3.7**	**12.6**
alteration products						
tremolite	0.4					
-single crystal					2.2	
-oxide dusted						
-multicrystal		1.0	2.6	0.5	1.3	0.1
-oxide dusted			0.2	0.1		0.1
-carbonate						
serpentine	30.9	33.8		24.2		11.0
-oxide dusted				0.1		0.1
-amphibole						
chlorite			0.1		0.1	
carbonate	0.6	0.6	1.6			
Fe-Ti oxides	0.2	1.0	0.4	0.3	0.1	0.2
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene					0.1	
cryptocrystalline - undefined			0.2	0.1		
Orthopyroxene		**0.5**			**0.1**	
alteration products						
amphibole		0.1				
-single crystal tremolite						
-multicrystal tremolite						
-multitwinned						
chlorite		0.4			0.1	
Fe-Ti oxides						
clinozoisite						
serpentine						
carbonate						
clinopyroxene						
Plagioclase						
alteration products						
clinozoisite						
chlorite						
amphibole						
carbonate						
Fe-Ti oxides						
Oxide	**0.4**	**1.4**			**0.1**	
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL349*	RL338	RL337	RL336*	RL335	RL334
Layer	12a	11f	11f	11f	11f	11f
Clinopyroxene + alteration products	**83.4**	**99.3**	**99.6**	**99.5**	**98.1**	**98.9**
clinopyroxene	52.7	64.4	64.9	75.7	78.5	76.6
actinolite						
+chlorite						
+Fe-Ti oxide						
-single crystal	0.2	3.4	5.0	0.2	1.3	3.1
-oxide dusted	0.3					
-multicrystal	3.1	10.3	22.1	5.3	5.3	13.0
-oxide dusted	5.9	1.0		2.7	2.9	0.6
-serpentine						0.5
-carbonate				0.5		0.9
chlorite						0.2
Fe-Ti oxides	10.3	2.8	0.1	1.7	1.3	0.65
sphene						
epidote/clinozoisite						
carbonate			1.1			
serpentine	4.9					
-Fe-Ti oxides	0.9					
-carbonate						
-amphibole						
cryptocrystalline - undefined	0.1	5.7	1.7	2.1	1.0	3.4
Olivine	**16.6**			**0.5**	**1.7**	
alteration products						
tremolite				0.1	0.5	
-single crystal						
-oxide dusted						
-multicrystal	3.0					
-oxide dusted	0.1					
-carbonate						
serpentine	13.6			0.4	1.0	
-oxide dusted	0.1					
-amphibole						
chlorite						
carbonate	0.4				0.1	
Fe-Ti oxides	0.5					
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene						
cryptocrystalline - undefined						
Orthopyroxene		**0.7**	**0.4**		**0.3**	**0.8**
alteration products						
amphibole						
-single crystal tremolite		0.3				0.6
-multicrystal tremolite					0.3	0.1
-multitwinned		0.3	0.3			
chlorite		0.1				0.1
Fe-Ti oxides						
clinozoisite						
serpentine						
carbonate			0.1			
clinopyroxene						
Plagioclase						**0.4**
alteration products						
clinozoisite						0.2
chlorite						0.2
amphibole						
carbonate						
Fe-Ti oxides						
Oxides						
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL333	RL332b	RL332a*	RL331	RL330*	RL329
Layer	11f	11e	11e	11d	11d	11d
Clinopyroxene + alteration products	**99.6**	**99.2**	**81.2**	**58.6**	**95.5**	**81.9**
clinopyroxene	68.0	79.1	81.2	0.1	67.4	54.3
actinolite +chlorite +Fe-Ti oxide						
-single crystal	7.2	4.5	13.4		7.3	1.3
-oxide dusted		0.5	2.1	21.8	2.1	1.2
-multicrystal	17.9	10.6	10.6	32.7	7.0	5.6
-oxide dusted		1.1	1.9	0.2	7.7	7.5
-serpentine						0.5
-carbonate			0.7	0.5		0.9
chlorite			0.2			0.4
Fe-Ti oxides	0.1	0.4	2.0	2.1	2.1	4.1
sphene						
epidote/clinozoisite					0.1	
carbonate	0.2	0.1				0.7
serpentine			1.7	3.0		2.4
-Fe Ti oxides			0.8			1.7
-amphibole			0.4			
-carbonate						
cryptocrystalline - undefined	6.8	1.9	0.6		1.1	1.2
Olivine	**0.1**	**0.8**	**0.1**	**41.4**	**4.3**	**18.1**
alteration products						
tremolite				9.0		3.2
-single crystal		0.2	2.3		1.3	
-oxide dusted				0.1	0.1	
-multicrystal	0.1	0.6	3.3		1.8	0.7
-oxide dusted			0.1		0.2	
-carbonate			0.7		0.1	0.1
serpentine			9.6	23.2		12.6
-oxide dusted			0.1			
-amphibole						
chlorite		0.1				
carbonate			2.0	7.7	0.4	1.3
Fe-Ti oxides			0.2	1.4	0.1	0.3
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene						
cryptocrystalline - undefined						
Orthopyroxene	**0.3**		**0.3**			
alteration products						
amphibole						
-single crystal tremolite						
-multicrystal tremolite	0.3		0.1			
-multitwinned						
chlorite						
Fe-Ti oxides						
clinozoisite						
serpentine						
carbonate			0.2			
clinopyroxene						
Plagioclase						
alteration products						
clinozoisite						
chlorite						
amphibole						
carbonate						
Fe-Ti oxides						
Oxides					**0.2**	
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL326*	RL325	RL324a	RL323b	RL322*	RL321
Layer	11d	11d	11c	11c	11c	11c
Clinopyroxene + alteration products	**34.3**	**39.3**	**79.9**	**97.5**	**95.7**	**98.5**
clinopyroxene	14.1	18.8	58.4	69.2	79.8	78.4
actinolite						
+chlorite						
+Fe-Ti oxides						
-single crystal		0.3	12.9	10.6	7.8	1.9
-oxide dusted				0.1		0.6
-multicrystal	9.9	3.0	6.3	11.1	4.1	9.4
-oxide dusted		1.8		0.3		1.6
-serpentine						
-carbonate						
chlorite			0.2	0.1		0.5
Fe-Ti oxides	2.8	7.6		3.0	1.2	3.0
sphene						
epidote/clinozoisite						
carbonate	0.2	0.3				
serpentine	7.3	7.5				
-Fe-Ti oxides						
-amphibole						
-carbonate						
cryptocrystalline - undefined			1.8			0.5
Olivine	**65.6**	**60.6**	**9.7**	**2.5**	**3.8**	**1.5**
alteration products						
tremolite	0.6			6.6		
-single crystal			1.9	0.2	0.8	0.2
-oxide dusted						
-multicrystal		0.1	5.4	2.0	2.4	1.2
-oxide dusted						0.1
-carbonate						
serpentine	54.7	55.5				
-oxide dusted						
-amphibole						
chlorite			2.5	0.1	0.6	
carbonate	1.2	1.3				
Fe-Ti oxides	9.1	3.7				
sphene						
undefined yellow brown aggregate						
clinopyroxene				0.1		
cryptocrystalline - undefined				0.1		
Orthopyroxene					**0.5**	
alteration products						
amphibole						
-single crystal tremolite					0.1	
-multicrystal tremolite						
-multitwinned					0.4	
chlorite						
Fe-Ti oxides						
clinozoisite						
serpentine						
carbonate						
clinopyroxene						
Plagioclase			**10.1**			
alteration products						
clinozoisite			3.8			
chlorite			3.8			
amphibole			2.5			
carbonate						
Fe-Ti oxides						
Oxides	**0.1**	**0.1**				
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL319	RL318d	RL317	RL316*	RL315*	RL314
Layer	11c	11b	11b	11b	11b	11b
Clinopyroxene +	**96.7**	**80.0**	**75.6**	**82.3**	**85.3**	**79.1**
alteration products						
clinopyroxene	67.3	61.8	61.7	62.1	48.5	61.1
actinolite				0.6		0.3
+chlorite						
+Fe-Ti oxides				1.3		
-single crystal	4.6	8.8	7.8		2.1	2.6
-oxide dusted	1.3	2.8	0.5		1.2	3.2
-multicrystal	11.5	2.1	0.9	4.4	8.9	0.4
-oxide dusted	4.9	2.0		4.5	13.2	
-serpentine						
-carbonate		0.3			0.1	
chlorite		1.0	0.8			0.4
Fe-Ti oxides	1.8	1.1	2.2	3.3	3.3	8.6
sphene						
epidote/clinozoisite						
carbonate				0.4		
serpentine				3.3	2.8	1.5
-Fe-Ti oxides				1.4	2.0	1.1
-amphibole						
-carbonate						
cryptocrystalline - undefined	2.0	0.3	1.9	1.0	1.5	
Olivine	**0.8**	**7.1**	**9.7**	**15.7**	**14.7**	**17.8**
alteration products						
tremolite			7.4	0.1		3.3
-single crystal	0.4	3.8		1.1	2.0	
-oxide dusted						
-multicrystal	0.2	2.3		1.3	2.2	
-oxide dusted						
-carbonate	0.1			0.5	0.4	
serpentine				11.7	9.0	13.3
-oxide dusted						
-amphibole						
chlorite		0.5	1.7	0.1	0.1	0.2
carbonate	0.1				0.6	
Fe-Ti oxides				0.3	0.3	0.5
sphene						
biotite						
undefined yellow brown material						
clinopyroxene		0.6	0.8			
cryptocrystalline - undefined				0.6	0.1	0.6
Orthopyroxene	**2.4**		**14.7**	**1.9**		**2.8**
alteration products						
amphibole				0.2		0.1
-single crystal tremolite	0.8					
-multicrystal tremolite	1.4					
-multitwinned						
chlorite	0.1		14.5	1.5		2.7
Fe-Ti oxides	0.1					
clinozoisite						
serpentine						
carbonate	0.1		0.2	0.1		
clinopyroxene						
Plagioclase		**12.9**				
alteration products						
clinozoisite		5.3				
chlorite		6.3				
amphibole		0.7				
carbonate						
Fe-Ti oxides		0.3				
Oxides	**0.1**			**0.1**		**0.1**
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL320	RL313	RL312	RL311*	RL310	RL308a*
Layer	11b	11b	11a	11a	11a	11a
Clinopyroxene + alteration products	**80.2**	**91.3**	**98.0**	**92.2**	**74.6**	**78.6**
clinopyroxene	61.6	52.0	87.3	64.6	55.6	59.4
actinolite					0.2	
+chlorite					0.1	
+Fe-Ti oxides						
-single crystal	1.0	11.5	0.6	0.8	1.6	0.4
-oxide dusted	2.0		0.3	5.3	1.6	0.1
-multicrystal	1.1	25.0	5.2	3.3	4.1	1.8
-oxide dusted	2.9	0.2	3.7	11.9	5.8	4.0
-serpentine	0.2					
-carbonate						
chlorite		0.5	0.1	0.5		
Fe-Ti oxides	2.4	1.1	0.8	3.9	3.4	5.5
sphene						
epidote/clinozoisite						
carbonate				0.3	0.1	
serpentine	2.5			0.2	1.3	4.6
-Fe-Ti oxides	2.9			0.3	1.0	1.0
-amphibole						
-carbonate						
cryptocrystalline - undefined				0.6	0.1	0.1
Olivine	**19.7**	**8.7**	**0.1**	**7.7**	**18.2**	**21.2**
alteration products						
tremolite					1.0	
-single crystal	2.9	5.4	0.1	2.6	6.7	0.3
-oxide dusted	0.1			0.2		
-multicrystal	3.6	2.2		1.6	2.1	
-oxide dusted	0.2			0.1		
-carbonate				0.7		
serpentine	12.4			1.3	8.1	20.1
-oxide dusted	0.3					0.1
-amphibole				0.6		0.5
-carbonate						
chlorite		0.8			0.2	
carbonate	0.3	0.2		0.7	0.1	
Fe-Ti oxides	0.4	0.2		0.1		0.3
sphene						
biotite						
undefined yellow brown aggregate						
crpytocrystalline - undefined				0.1		
Orthopyroxene			**1.9**		**7.1**	
alteration products						
amphibole						
-single crystal tremolite						
-multicrystal tremolite			1.6			
-multitwinned						
chlorite			0.1		7.1	
Fe-Ti oxides			0.1			
clinozoisite						
serpentine						
carbonate						
clinopyroxene						
Plagioclase						
alteration products						
clinozoisite						
chlorite						
amphibole						
carbonate						
Fe-Ti oxides						
Oxides	**0.1**		**0.1**	**0.2**	**0.1**	**0.2**
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL304	RL303	RL55	RL54	RL78	RL74
Layer	11a	11a	10b	10b	10a	10a
Clinopyroxene + alteration products	**79.3**	**72.6**	**62.1**	**63.0**	**66.9**	**85.5**
clinopyroxene	52.9	49.9	42.8	55.9	58.4	29.8
actinolite		0.5	17.7	6.9	6.8	54.6
+chlorite						
+Fe-Ti oxides						
-single crystal	0.4	3.4				
-oxide dusted	0.7					
-multicrystal	2.2	3.3				
-oxide dusted	8.3					
-serpentine						
-carbonate						
chlorite		0.2	0.9	0.2	0.4	
Fe-Ti oxides	4.8	9.3	tr			1.2
sphene						
epidote/clinozoisite						
carbonate			0.5		1.5	
serpentine	6.1	1.4				
-Fe-Ti oxides	2.9					
-amphibole	0.2					
-carbonate						
cryptocrystalline - undefined		3.7				
Olivine	**20.7**	**20.4**	**19.7**	**17.2**	**11.5**	**14.5**
alteration products						
tremolite		7.7	4.8	3.4	11.3	
-single crystal	0.1		2.4	6.1		6.5
-oxide dusted						
-multicrystal	0.7		11.2	6.4		5.6
-oxide dusted						
-carbonate						
serpentine	18.8	10.9				
-oxide dusted	0.1					
-amphibole	0.3					
chlorite		0.5	0.2	1.0		0.1
carbonate	0.5		1.1	0.3	0.2	2.3
Fe-Ti oxides	0.4	0.7				
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene		0.1				
cryptocrystalline - undefined						
Orthopyroxene		**7.0**	**17.4**	**19.3**	**21.4**	
alteration products						
amphibole			3.0	1.0	0.7	
-single crystal tremolite		0.5				
-multicrystal tremolite						
-multitwinned						
chlorite		5.2	14.0	17.7	16.9	
Fe-Ti oxides			0.1		0.1	
clinozoisite					3.5	
serpentine		0.1				
carbonate		1.2	0.4	0.5	0.2	
clinopyroxene						
Plagioclase						
alteration products						
clinozoisite						
chlorite						
amphibole						
carbonate						
Fe-Ti oxides						
Oxides	**0.1**		**0.8**	**0.5**	**0.2**	
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL71	RL245	RL241*	RL239	RL235	RL233*
Layer	9	8f	8e	8e	8c	8b
Clinopyroxene + alteration products	**70.5**	**83.9**	**83.0**	**80.9**	**98.4**	**98.3**
clinopyroxene	37.6	69.8	70.0	68.8	76.3	70.7
actinolite	4.8	9.2		7.9	13.2	
+chlorite						
+Fe-Ti oxides	15.4					
-single crystal			2.3			15.1
-oxide dusted						
-multicrystal			6.1			8.7
-oxide dusted			0.1			
-serpentine						
-carbonate						
chlorite		0.6	1.5	0.5		
Fe-Ti oxides	7.0	0.1	0.1	0.1		0.1
sphene						
epidote/clinozoisite					0.7	
carbonate		tr		0.1		0.1
serpentine	5.6					
-Fe-Ti oxides						
-amphibole						
-carbonate						
cryptocrystalline - undefined			1.3			2.9
Olivine		**6.5**	**8.5**	**8.8**		
alteration products						
tremolite		5.8		8.3		
-single crystal			2.3			
-oxide dusted						
-multicrystal			5.3			
-oxide dusted						
-carbonate						
serpentine						
-oxide dusted						
-amphibole						
chlorite		0.6	0.5	0.4		
carbonate		0.1	0.1	0.2		
Fe-Ti oxides			3.2			
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene			0.1			
cryptocrystalline - undefined						
Orthopyroxene	**28.3**	**9.6**	**8.3**	**10.3**	**1.6**	**1.6**
alteration products						
amphibole	3.7	0.1	0.3	0.6	0.9	
-single crystal tremolite						0.7
-multicrystal tremolite						0.9
-multitwinned						
chlorite		6.2	7.5	8.4	0.5	
Fe-Ti oxides	1.3				0.1	
clinozoisite		3.1	0.4	1.0		
serpentine	22.8				0.1	
carbonate	0.5	0.2	0.1	0.3		
clinopyroxene						
Plagioclase						
alteration products						
clinozoisite						
chlorite						
amphibole						
carbonate						
Fe-Ti oxides						
Oxides	**1.2**		**0.1**			**0.1**
Total	100.0	100.0	, 100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL231	RL224	RL221b*	RL218	RL210	RL208
Layer	8a	7c	7b	7a	6b	6a
Clinopyroxene + alteration products	**93.2**	**76.1**	**45.4**	**73.4**	**76.0**	**52.1**
-clinopyroxene	73.3	58.1		60.5	69.5	37.2
actinolite	17.2	16.0		12.4	4.4	13.9
+chlorite						
+Fe-Ti oxides						
-single crystal			2.9			
-oxide dusted						
-multicrystal			17.3			
-oxide dusted			10.9			
-serpentine						
-carbonate						
chlorite		1.9		0.5	0.4	0.5
Fe-Ti oxides	tr	0.1	2.6			0.2
sphene						
epidote/clinozoisite				0.1		
carbonate	0.2	0.5	tr			0.2
serpentine			11.7			
-Fe-Ti oxides						
-amphibole						
-carbonate						
cryptocrystalline - undefined			6.0			
Olivine alteration products		**3.5**	**54.2**	**9.7**	**12.3**	**15.9**
tremolite		3.3	1.0	8.8	9.7	13.4
-single crystal						
-oxide dusted						
-multicrystal						
-oxide dusted						
-carbonate						
serpentine			46.6			
-oxide dusted						
-amphibole						
chlorite		0.2		0.9	3.9	1.4
carbonate			3.3		0.1	1.0
Fe-Ti oxides			3.2			0.2
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene					0.4	
cryptocrystalline - undefined						
Orthopyroxene alteration products	**6.8**	**6.0**	**0.3**	**0.5**	**11.7**	**30.9**
amphibole						1.3
-single crystal tremolite		3.1	tr			
-multicrystal tremolite	6.2				0.6	
-multitwinned	0.6			0.5		
chlorite		2.6	0.2		11.1	29.2
Fe-Ti oxides						
clinozoisite						
serpentine						
carbonate			0.1			0.4
clinopyroxene		0.3				
Plagioclase alteration products		**14.2**		**15.9**		
clinozoisite		8.8		7.2		
chlorite		4.5		7.8		
amphibole		1.0		0.8		
carbonate						
Fe-Ti oxides				0.1		
Oxides		**0.2**	**0.1**	**0.4**		**1.1**
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL199b*	RL197	RL24	RL25	RL26	RL28
Layer	6a	6a				
Clinopyroxene + alteration products	**60.2**	**64.4**	**78.6**	**87.9**	**93.4**	**94.7**
clinopyroxene	13.1	0.9	57.8	60.7	29.4	11.8
actinolite		57.5	16.8	14.9	57.4	73.4
+chlorite						
+Fe-Ti oxides						
-single crystal	0.3					
-oxide dusted	0.2					
-multicrystal	4.8					
-oxide dusted	21.4					
-serpentine						
-carbonate						
chlorite			0.9	0.2		
Fe-Ti oxides	8.0	5.4				
sphene						
epidote/clinozoisite						
carbonate		0.2			6.7	9.6
serpentine	6.5	0.4				
-Fe-Ti oxides						
-amphibole						
-carbonate						
cryptocrystalline - undefined	6.0					
Olivine alteration products	**38.0**	**34.9**				**5.3**
tremolite	3.5	19.2				5.1
-single crystal						
-multicrystal						
-oxide dusted						
-carbonate						
serpentine	33.2	11.0				
-oxide dusted						
-amphibole						
chlorite						
carbonate	0.9	3.9				0.1
Fe-Ti oxides	0.2	0.8				
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene						
cryptocrystalline - undefined	0.1					
Orthopyroxene alteration products			**6.2**	**4.9**	**6.6**	
amphibole						
-single crystal tremolite			6.0			
-multicrystal tremolite				4.8	6.4	
-multitwinned						
chlorite			0.2			
Fe-Ti oxides						
clinozoisite						
serpentine						
carbonate				tr	0.2	
clinopyroxene						
Plagioclase alteration products			**15.3**	**7.3**		
clinozoisite			8.7	1.8		
chlorite			4.5	4.0		
amphibole			2.1	1.4		
carbonate			0.1	tr		
Fe-Ti oxides						
Oxides	**1.8**	**0.8**				
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL47	RL30*	RL45	RL44*	RL42	RL40*
Layer	5e	5e	5c	5c	5c	5b
Clinopyroxene + alteration products	**92.4**	**98.1**	**94.9**	**84.2**	**90.6**	**92.5**
clinopyroxene	47.7	67.9	75.4	63.2	67.0	73.1
actinolite	44.2		13.0		19.9	
+chlorite						
+Fe-Ti oxides						
-single crystal		15.8		6.9		2.5
-oxide dusted				2.6		5.0
-multicrystal		13.9		3.9		3.3
-oxide dusted				1.7		3.6
-serpentine						
-carbonate						
chlorite				0.2		
Fe-Ti oxides			3.2	4.4	1.8	2.4
sphene						
epidote/clinozoisite	0.1					
carbonate		0.6				tr
serpentine			0.8		0.7	
-Fe-Ti oxides						
-amphibole						
-carbonate						
cryptocrystalline - undefined				0.5		0.3
Olivine alteration products		**1.0**	**5.1**	**14.2**	**9.3**	**7.4**
tremolite			2.3		4.6	
-single crystal		0.6		3.0		3.7
-oxide dusted						
-multicrystal		0.4		4.7		2.5
-oxide dusted				0.2		
-carbonate						0.4
serpentine			2.7	2.8	4.6	0.5
-oxide dusted						
-amphibole						
chlorite						
carbonate				0.2		0.2
Fe-Ti oxides			tr	3.0	0.2	0.1
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene						
cryptocrystalline - undefined						
Orthopyroxene alteration products	**0.7**			**1.6**		
amphibole						
-single crystal tremolite				0.1		
-multicrystal tremolite	0.2					
-multitwinned	0.4					
chlorite	0.1			1.5		
Fe-Ti oxides				tr		
clinozoisite						
serpentine						
carbonate						
clinopyroxene						
Plagioclase alteration products	**7.0**	**0.9**		**1.6**		
clinozoisite	5.4	0.3				
chlorite				1.5		
amphibole	1.6	0.5		0.1		
carbonate		0.1				
Fe-Ti oxides						tr
Oxides	**0.1**			**tr**	**tr**	**0.1**
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL39	RL37	RL35a	RL34*	RL33*	RL14
Layer	5b	5b	5a	5a	5a	4c
Clinopyroxene + alteration products	**92.9**	**90.4**	**93.4**	**91.8**	**93.1**	**88.2**
clinopyroxene	69.0	68.7	73.3	64.5	66.4	45.4
actinolite	19.7	19.7	15.9			
+chlorite						
+Fe-Ti oxide						
-single crystal				3.4	1.7	18.9
-oxide dusted				4.9	9.2	
-multicrystal				4.9	2.8	13.9
-oxide dusted				6.0	7.7	
-serpentine						
-carbonate						
chlorite						0.5
Fe-Ti oxides	1.4	0.4	1.6	3.4	3.3	0.1
sphene						
epidote/clinozoisite						
carbonate						
serpentine	0.3		0.5			0.1
-Fe-Ti oxide						
-amphibole						
-carbonate						
cryptocrystalline - undefined		1.8		0.8	0.1	2.4
Olivine alteration products	**7.1**	**9.6**	**6.5**	**8.2**	**6.4**	**11.6**
tremolite	3.9	9.5	3.4			
-single crystal				3.6	3.0	4.7
-oxide dusted				0.2		
-multicrystal				4.4	2.8	5.2
-oxide dusted						
-carbonate						
serpentine	3.1		3.1		0.3	
-oxide dusted						
-amphibole						
chlorite	0.2					0.5
carbonate						0.3
Fe-Ti oxides	0.1	0.1		0.1	0.2	0.2
sphene						0.2
biotite					0.1	
undefined yellow brown aggregate						
clinopyroxene						
cryptocrystalline - undefined		0.1				2.4
Orthopyroxene alteration products						**0.7**
amphibole						
-single crystal tremolite						
-multicrystal tremolite						0.2
-multitwinned						0.4
chlorite						0.1
Fe-Ti oxides						
clinozoisite						
serpentine						
carbonate						
+amphibole						
clinopyroxene						
Plagioclase alteration products						
clinozoisite						
chlorite						
amphibole						
carbonate						
Fe-Ti oxides						
Oxides			**0.1**		**0.5**	
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL10*	RL11	RL110	RL09	RL08*	RL06
Layer	4b	4b	4b	4b	4a	4a
Clinopyroxene + alteration products	**87.7**	**88.0**	**83.9**	**85.7**	**70.2**	**74.4**
clinopyroxene	72.1	80.2	72.6	74.7	52.9	
actinolite	0.7	0.2	0.1	0.2	1.5	
+chlorite		7.2	11.5	10.5		
+Fe-Ti oxide	1.3	7.2				
-single crystal	5.3				4.5	
-oxide dusted						
-multicrystal	5.3				7.3	
-oxide dusted	0.7				0.9	
-serpentine						
-carbonate						
chlorite	0.6	7.2		0.8	2.1	
Fe-Ti oxides	0.4					
sphene	0.1				0.1	
epidote/clinozoisite						
carbonate	6.7	9.6			0.1	
serpentine						
-Fe-Ti oxides						
-amphibole						
-carbonate						
cryptocrystalline - undefined	0.5				2.5	
Olivine	**5.4**	**4.6**	**6.1**	**3.6**	**8.8**	**11.9**
alteration products						
tremolite		4.6	5.9	3.5		
-single crystal	2.0				3.6	
-oxide dusted						
-multicrystal	3.1				4.1	
-oxide dusted	0.1					
-carbonate						
serpentine						
-oxide dusted						
-amphibole						
chlorite	0.1		0.2	0.2	0.8	
carbonate					0.2	
Fe-Ti oxides	0.1					
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene						
cryptocrystalline - undefined					0.1	
Orthopyroxene	**6.6**	**7.2**	**9.8**	**9.8**	**20.9**	**12.4**
alteration products						
amphibole	0.3				1.6	
-single crystal tremolite		5.6	2.9			
-multicrystal tremolite						
-multitwinned						
chlorite	6.3	6.7	8.5	6.0	16.4	
Fe-Ti oxides						
clinozoisite						
serpentine				1.9		
carbonate						
+amphibole		0.5	1.3	1.5	2.9	
clinopyroxene						
Plagioclase						
alteration products						
clinozoisite						
chlorite						
amphibole						
carbonate						
Fe-Ti oxides						
Oxides	**0.1**	**0.2**	**0.2**	**0.1**	**0.1**	**1.4**
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL05	RL467*	RL468	RL471	RL472*	RL474
Layer	4a	3c	3c	3b	3b	3b
Clinopyroxene + alteration products	**81.6**	**96.9**	**100.0**	**100.0**	**100.0**	**100.0**
clinopyroxene	44.7	57.4	94.4	87.9	89.4	95.0
actinolite			5.6	12.1		5.0
+chlorite	32.2					
+Fe-Ti oxide						
-single crystal		20.6			1.9	
-oxide dusted						
-multicrystal		8.4			3.9	
-oxide dusted						
-serpentine						
-carbonate						
chlorite						
Fe-Ti oxides		2.3			0.1	
sphene						
epidote/clinozoisite		0.6				
carbonate						
serpentine						
-Fe-Ti oxides						
-amphibole						
-carbonate						
cryptocrystalline - undefined		7.4			4.6	
Olivine alteration products	**7.6**					
tremolite	7.5					
-single crystal						
-oxide dusted						
-multicrystal						
-oxide dusted						
-carbonate						
serpentine						
-oxide dusted						
-amphibole						
chlorite	0.1					
carbonate						
Fe-Ti oxides						
sphene						
biotite						
undefined yellow brown aggregate						
clinopyroxene						
cryptocrystalline - undefined						
Orthopyroxene alteration products	**10.2**	**1.7**				
amphibole		0.5				
-single crystal tremolite	4.1	0.5				
-multicrystal tremolite		0.4				
-multitwinned						
chlorite	1.0					
Fe-Ti oxides		0.2				
clinozoisite	5.1	0.6				
serpentine						
carbonate						
clinopyroxene						
Plagioclase alteration products		**1.2**				
clinozoisite		1.1				
chlorite						
amphibole						
carbonate						
Fe-Ti oxides		0.1				
Oxides	**0.6**	**0.2**				
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A.1 Modal analyses (continued)

Sample	RL476	RL481	RL485	RL485
Layer	3a	3a	2a	2a
Clinopyroxene +	100.0	100.0	94.4	97.1
alteration products				
clinopyroxene	87.8	76.0	47.1	56.0
secondary				
actinolite	12.2	23.2	46.6	
+chlorite				
+Fe-Ti oxide				
-single crystal				10.8
-oxide dusted				
-multicrystal				11.7
-oxide dusted				
-serpentine				
-carbonate				
chlorite				
Fe-Ti oxides				
sphene				
epidote/clinozoisite				
carbonate		6.7	9.6	0.5
serpentine				
-Fe-Ti oxides				
-amphibole				
-carbonate				
cryptocrystalline - undefined				
Olivine				
alteration products				
tremolite				
-single crystal				
-oxide dusted				
-multicrystal				
-oxide dusted				
-carbonate				
serpentine				
-oxide dusted				
-amphibole				
chlorite				
carbonate				
Fe-Ti oxides				
sphene				
biotite				
undefined yellow brown aggregate				
clinopyroxene				
cryptocrystalline - undefined				
Orthopyroxene			5.6	2.9
alteration products				
amphibole				
-single crystal tremolite			5.6	2.9
-multicrystal tremolite				
-multitwinned				
chlorite				
Fe-Ti oxides				
clinozoisite				
serpentine				
carbonate				
clinopyroxene				
Plagioclase				
alteration products				
clinozoisite				
chlorite				
amphibole				
carbonate				
Fe-Ti oxides				
Oxides				
Total	100.0	100.0	100.0	100.0

Table A.2 Modal analyses of polished rock slabs

SAMPLE	CLINOPYROXENE	OLIVINE	OIKOCRYSTS
		Cycle 15	
458	72.0	11.9	16.1
455	83.3	9.5	7.1
453	93.7	2.3	3.0
		Cycle 14	
407	69.9	4.5	25.6
375	68.5	18.3	13.2
		Cycle 11	
317	70.3	7.2	22.5
314	72.7	20.0	6.3
310	75.5	11.1	13.4
303	73.2	13.5	12.3
		Cycle 4	
110	78.0	4.5	20.8
11	82.3*		17.7
9	78.0	3.3	18.7

Table A.3 Modal analyses of included metagabbro

Sample	RL322	RL321	RL312	RL235	RL233
Cycle	11c	11c	11a	8b	8a
Metagabbro[1]	**16.0**	**17.8**	**12.3**	**5.3**	**10.4**
Clinopyroxene + alteration products	**35.9**	**42.4**	**64.7**	**36.2**	**25.8**
magmatic					
granular	32.4	23.5	56.0	27.6	12.9
secondary					
actinolite				8.6	4.0
+Fe-Ti oxides					
-single crystal	2.8	0.8	1.4		7.3
-oxide dusted			0.5		
-multicrystal	0.7	9.8	1.4		1.7
-oxide dusted					
Fe-Ti oxides		0.8	5.0		
Plagioclase + alteration products	**64.1**	**57.6**	**31.7**	**63.8**	**74.2**
clinozoisite	51.4	52.3	31.2	39.7	64.6
chlorite	8.1	2.3			1.7
amphibole	4.7		0.5	24.1	4.5
Fe-Tioxides					0.6
muscovite				0.6	
single crystal albite				1.7	
Total[2]	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Sample	RL468	RL476	RL481	RL485		
Cycle	1	1	1	2		
Metagabbro[1]	**20.1**	**7.1**	**10.5**	**16.7**		
Clinopyroxene + alteration products	**52.9**	**76.7**	**47.3**	**49.6**		
magmatic						
granular	45.8	74.4	29.7	28.9		
secondary						
actinolite	7.1	2.3	17.6	20.7		
+Fe-Ti oxides						
-single crystal						
-oxide dusted						
-multicrystal						
-oxide dusted						
Fe-Ti oxides						
Plagioclase + alteration products	**47.1**	**23.3**	**52.7**	**43.8**		
clinozoisite	45.8	23.3	47.3	40.0		
chlorite						
amphibole	1.3		5.4	3.8		
Fe-Ti oxides						
muscovite						
single crystal albite						
Total[2]	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

1. Abundance of metagabbro material included in ultramafic cumulate as a percentage of the whole rock.
2. Total modal composition of the metagabbro material only.

Table A.4 Mean grain size of clinopyroxene in mm

SAMPLE	GRAIN SIZE	SAMPLE	GRAIN SIZE
		Cycle 15	
460	1.30	459	0.75
457	0.98	452	0.98
		Cycle 14	
407	1.38	380	1.23
375	0.72		
		Cycle 13	
364	6.31	362	0.68
		Cycle 12	
356	0.51	354	1.04
351	2.25	350	1.15
349	0.89		
		Cycle 11	
338	7.40	336	2.60
334	2.32	333	2.56
330	1.46	329	1.04
326	0.86	325	1.10
322	2.02	321	2.12
319	1.06	317	1.14
316	1.10	314	1.13
315	1.08	320	1.02
312	2.12	311	1.38
310	1.20	308	1.08
304	1.24	303	1.25
		Cycle 10	
54	0.95	78	0.88
		Cycle 8	
245	1.31	239	0.90
237	2.35	233	1.53
231	2.34		
		Cycle 7	
224	0.59		
		Cycle 6	
210	0.91	199	0.62
		Cycle 5	
47	5.50	30	2.46
45	1.54	44	1.58
42	1.72	40	1.70
39	1.63	37	1.45
34	1.67	33	1.62
		Cycle 4	
14	1.34	110	1.71
9	1.71	8	1.44
5	1.53		
		Cycle 3	
102	1.72	468	1.92
469	1.11	471	2.15
472	1.73	474	1.82
476	1.01	478	1.20
481	2.00		

Appendix B

Mineral Chemistry

Electron microprobe mineral analyses were collected on 101 samples representing a stratigraphic section through 15 cycles of the Mafic-Ultramafic Group. Minerals analysed were: clinopyroxenes, oxides, amphiboles, chlorites, and serpentines. Samples were prepared by the author in the thin section labs of the Department of Geological Sciences, University of Manitoba. Samples were examined in both transmitted and reflected light. Points were picked from scale drawings that were made for various parts of each polished section.

Analyses were done using an automated Cameca SX50 electron microprobe in the microbeam facilities of the Department of Geological Sciences, University of Manitoba. Analyses were done under the supervision of Ron Chapman. Wavelength Dispersive Spectrometry (WDS) was used for quantitative analyses. An accelerating potential of 15 keV was used, along with a beam current of 20 nA and a rastered 1 μ beam; effective beam diameter is about 2 μ. Counts for each element were collected for 20 seconds. Data was collected by three spectrometers simultaneously. All data was then manipulated for matrix corrections (ZAF) using an internal program (WDSACQ) to the RSM-11 work station. Mineral analyses were recalculated to cation abundances using the program MINCAL.

Detection limits of the minor and trace elements are listed in Table B.1. Major elements Si, Ca, Fe, and Al are not listed. Limits are given for element abundance and oxide abundance to 3σ.

Pyroxenes

The structural formulae for clinopyroxenes were calculated on the basis of 4 cations and normalized to 6 anions (Morimoto *et.al.*, 1988); Fe_2O_3 content was determined from stoichiometry. Cation abundances were recalculated to $Mg/(Fe^{2+} + Mg)$ ratios (Irvine, 1979). Wo-En-Fs ratios (Tables 7 and 8) were also calculated where the Ca component is reported as Wo, the Mg component is reported as En, and Fs is defined by $Fe^{2+} + Fe^{3+} + Mn$ (Deer, Howie and Zussman, 1966). En/Fs was also calculated to adjust for spurious Fe_2O_3 results.

Analyses totaling less than 98% and more than 101% were discarded. Exam-

Table B.1 Detection Limits of Minor and Trace Elements

Element	Spectrometer	Standard	Percent	L.L.D. Oxide	L.L.D. Element	Minerals
Na	TAP	albite	8.50	0.025	0.019	Cpx,Amph
V	LIF	VP_2O_7	22.65	0.069	0.047	Ox
Mn	LIF	fluoreib	1.08	0.041	0.032	Cpx,Amph,Ox
Ti	LIF	pyrope	0.30	0.056	0.034	Cpx,Amph,Ox
Co	LIF	cobaltite	21.63	0.081	0.065	Cpx
Cr	LIF	chromite	31.18	0.064	0.044	Cpx,Chl,Serp
	PET			0.049	0.034	
Mg	TAP	arfed	0.27	0.021	0.013	Ox
Ni	LIF	olivine	0.22	0.042	0.034	Cpx,Chl,Serp

L.L.D.=lower limit of detection; fluoreib=fluoreibeckite; arfed=arfvedsonite

ination of the beam area in samples that have poor totals suggests that there may have been slight changes in the operating system and collection during the run or the area of analysis may be contain submicroscopic incipient recrystallization to amphiboles.

Oxides

Oxides are normalized on the basis of the unit cell containing 24 cations and 32 anions. Many analyses for oxides do not total correctly in stoichometric calculations of cation abundances, and oxide totals are commonly low. Low totals were caused by drift in the chromite standard, which had to be recollected twice during the analysis period; correction factors were applied to improve data.

Amphiboles

Amphiboles were examined in a number of samples to determine relationships between clinopyroxene and its recrystallization products. All analyses are of good quality. Determination of mineral formula by electrom microprobe is hampered by the inability of the probe to distinguish between O and (OH), or Fe^{2+} and Fe^{3+}. Mineral formulas were calculated using the program AMPHIBOL assuming 23(O) and 13 cations excluding Ca, Na, K (Robinson et al., 1982).

Chlorites and Serpentines

Chlorites were examined in 8 samples from 6 cycles. Although chlorites tend to volatize during analysis, and data were collected using the same method as used for clinopyroxenes. Larger beam diameters are preferrable. This method

was used because of ease in programing the probe and difficulty in getting good polish over larger areas. Similar problems occur with serpentines, but polishing was more effective.

Chlorites were normalized to 14 O excluding H_2O because of common octahedral vacancies found in trioctahedral chlorites (Bailey, 1988). Serpentines were also normalized to 14 O excluding H_2O.

Table B.2: Chemical composition of clinopyroxene

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Total
						Cycle 15							
458	52.08	0.17	2.76	0.57	0.20	16.41	20.62	0.00	0.00	0.19	5.71	1.02	99.73
458	51.72	0.21	2.78	0.46	0.18	15.86	22.61	0.03	0.10	0.20	3.59	1.96	99.71
458	52.07	0.23	2.83	0.53	0.20	15.67	22.29	0.00	0.00	0.22	4.79	1.41	100.24
458	52.04	0.25	2.60	0.51	0.13	15.69	22.74	0.00	0.04	0.22	4.20	1.45	99.87
458	51.55	0.14	2.79	0.49	0.22	15.96	21.66	0.13	0.02	0.19	4.36	2.12	99.62
458	50.76	0.09	2.59	0.65	0.25	15.62	20.81	0.01	0.02	0.37	4.31	3.05	98.52
458	51.92	0.11	2.78	0.56	0.20	16.07	21.22	0.05	0.00	0.20	5.21	1.25	99.57
458	51.79	0.09	2.83	0.49	0.20	15.86	22.03	0.00	0.02	0.20	4.40	1.44	99.35
458	51.76	0.07	2.77	0.50	0.18	15.91	21.86	0.01	0.01	0.17	4.63	1.60	99.47
458	52.02	0.11	2.69	0.32	0.18	16.04	22.14	0.05	0.05	0.18	4.27	1.60	99.65
458	52.09	0.11	2.55	0.48	0.22	15.89	22.06	0.05	0.01	0.20	4.63	1.31	99.59
458	52.80	0.10	2.41	0.54	0.18	16.06	22.39	0.00	0.02	0.19	4.86	0.95	100.51
avg(12)	51.88	0.14	2.70	0.51	0.19	15.92	21.87	0.03	0.03	0.21	4.58	1.60	99.66
stdev	0.45	0.06	0.13	0.07	0.03	0.21	0.65	0.04	0.03	0.05	0.51	0.54	0.46
455	52.15	0.13	2.62	0.48	0.25	16.06	21.87	0.01	0.00	0.18	4.77	1.34	99.85
455	52.34	0.14	2.57	0.48	0.17	16.04	22.06	0.03	0.03	0.20	4.73	0.88	99.68
455	51.50	0.11	2.60	0.40	0.21	15.98	21.78	0.07	0.05	0.18	4.16	2.28	99.33
455	52.32	0.13	2.79	0.37	0.22	15.78	21.91	0.01	0.00	0.21	5.31	0.64	99.69
455	52.83	0.18	2.57	0.44	0.17	16.15	21.61	0.07	0.06	0.18	5.41	0.00	99.67
455	52.47	0.23	2.74	0.59	0.21	15.77	21.99	0.03	0.00	0.22	5.44	0.47	100.16
455	51.95	0.14	2.63	0.52	0.15	16.11	21.56	0.04	0.06	0.19	4.81	1.68	99.84
455	52.90	0.13	2.50	0.48	0.24	15.85	22.41	0.00	0.05	0.18	5.32	0.72	100.77
455	51.79	0.07	2.78	0.43	0.21	15.86	22.29	0.07	0.04	0.20	3.95	2.59	100.28
455	51.97	0.14	2.81	0.46	0.19	16.17	21.47	0.03	0.00	0.21	4.78	1.61	99.84
455	52.18	0.15	2.77	0.49	0.15	15.68	22.29	0.00	0.00	0.20	4.98	1.30	100.19
455	52.49	0.22	2.81	0.42	0.13	15.68	22.13	0.04	0.00	0.21	5.55	0.68	100.36
455	52.64	0.19	2.81	0.53	0.14	16.60	20.49	0.00	0.02	0.18	6.31	0.61	100.52
455	52.23	0.15	2.83	0.47	0.21	15.58	22.52	0.00	0.00	0.21	4.81	1.25	100.27
455	52.28	0.17	2.71	0.46	0.20	15.98	21.75	0.02	0.00	0.17	5.34	0.87	99.95
455	51.80	0.16	2.84	0.51	0.12	15.78	22.27	0.00	0.00	0.18	4.50	1.44	99.60
455	51.70	0.24	2.72	0.43	0.19	16.10	22.22	0.00	0.03	0.16	3.94	2.05	99.79
455	51.95	0.21	2.82	0.43	0.14	15.67	22.16	0.02	0.03	0.22	4.81	1.37	99.83
455	52.86	0.11	2.15	0.23	0.00	16.88	21.31	0.07	0.04	0.19	4.96	1.48	100.28
avg(19)	52.23	0.16	2.69	0.45	0.17	15.99	21.90	0.03	0.02	0.19	4.94	1.22	99.99
stdev	0.39	0.04	0.16	0.07	0.05	0.32	0.46	0.03	0.02	0.02	0.57	0.64	0.35
453	51.86	0.10	2.71	0.42	0.25	15.38	22.48	0.02	0.03	0.24	4.51	1.59	99.59
453	52.05	0.11	2.48	0.47	0.19	15.71	21.89	0.04	0.02	0.22	5.05	1.09	99.32
453	52.16	0.19	2.61	0.44	0.11	16.02	21.54	0.02	0.02	0.23	5.21	1.43	99.97
453	51.88	0.13	2.59	0.37	0.20	15.79	21.89	0.06	0.00	0.22	4.71	1.80	99.64
453	52.21	0.17	2.54	0.47	0.18	15.82	22.17	0.03	0.00	0.25	4.65	1.90	100.39
453	52.02	0.12	2.65	0.38	0.16	15.71	22.02	0.06	0.00	0.15	5.22	1.43	99.91
453	52.35	0.20	2.54	0.45	0.16	16.93	19.51	0.03	0.05	0.18	6.56	0.97	99.94
453	53.12	0.14	1.57	0.45	0.20	15.88	23.53	0.06	0.03	0.21	3.96	1.45	100.61
453	52.12	0.22	2.72	0.48	0.20	15.48	22.06	0.03	0.01	0.23	5.39	0.85	99.80
453	52.34	0.12	2.42	0.35	0.17	15.75	22.17	0.00	0.03	0.25	4.89	1.36	99.85
453	52.42	0.14	2.67	0.42	0.17	15.75	22.01	0.00	0.00	0.25	5.24	1.15	100.21
453	52.25	0.13	2.63	0.43	0.19	15.59	22.25	0.03	0.08	0.25	4.88	1.41	100.12
avg(12)	52.23	0.15	2.51	0.43	0.18	15.82	21.96	0.03	0.02	0.22	5.04	1.34	99.93
stdev	0.32	0.04	0.30	0.04	0.03	0.37	0.87	0.02	0.02	0.03	0.60	0.30	0.34
452	52.66	0.11	2.71	0.36	0.16	15.65	22.53	0.00	0.01	0.18	5.16	0.00	99.53
452	52.55	0.10	2.78	0.40	0.17	15.66	22.37	0.05	0.03	0.23	4.98	0.00	99.32
452	52.36	0.18	2.74	0.39	0.15	16.77	20.60	0.06	0.00	0.17	5.52	0.50	99.44
452	52.11	0.13	2.67	0.43	0.16	15.78	22.28	0.00	0.04	0.20	4.66	0.36	98.83
452	52.14	0.02	2.71	0.28	0.13	15.54	22.72	0.06	0.00	0.19	4.52	0.76	99.07
452	52.01	0.14	2.72	0.35	0.19	16.43	21.29	0.06	0.03	0.17	4.72	0.86	98.98
452	52.38	0.19	2.72	0.34	0.17	16.11	21.57	0.06	0.03	0.19	5.35	0.45	99.55
452	52.41	0.10	2.74	0.32	0.15	16.23	21.48	0.05	0.02	0.15	5.36	0.00	99.01
452	52.68	0.14	2.71	0.36	0.11	16.20	21.96	0.03	0.01	0.17	5.20	0.41	99.98
452	52.17	0.13	2.81	0.34	0.21	15.87	22.17	0.05	0.00	0.18	4.75	0.70	99.38
452	52.08	0.11	2.79	0.39	0.15	16.26	21.46	0.00	0.00	0.17	4.99	0.77	99.17
452	52.40	0.10	2.63	0.38	0.19	15.76	22.20	0.05	0.00	0.20	5.08	0.39	99.38
avg(12)	52.33	0.12	2.73	0.36	0.16	16.02	21.89	0.04	0.01	0.18	5.02	0.43	99.30
stdev	0.22	0.04	0.05	0.04	0.03	0.36	0.59	0.02	0.01	0.02	0.30	0.30	0.30
456	52.76	0.18	2.52	0.21	0.17	16.36	21.78	0.00	0.01	0.19	5.00	0.00	99.18
456	52.26	0.09	2.48	0.37	0.18	16.18	21.78	0.00	0.07	0.21	4.64	0.50	98.76

Table B.2: Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
456	52.76	0.13	2.33	0.33	0.19	16.11	21.91	0.04	0.00	0.19	5.34	0.21	99.54
456	52.04	0.12	2.78	0.31	0.17	15.94	22.13	0.07	0.01	0.20	4.43	0.97	99.17
456	52.41	0.11	2.69	0.35	0.17	15.87	22.34	0.03	0.02	0.24	4.56	0.90	99.69
456	52.04	0.11	2.58	0.27	0.20	15.93	22.14	0.03	0.00	0.23	4.30	1.55	99.39
456	52.87	0.11	2.78	0.33	0.17	15.73	22.31	0.01	0.01	0.22	5.23	0.00	99.77
456	52.58	0.18	2.29	0.35	0.19	15.94	22.65	0.01	0.04	0.23	4.33	1.17	99.96
456	52.17	0.13	2.77	0.35	0.18	15.71	22.48	0.07	0.04	0.24	4.33	0.70	99.17
avg(9)	52.43	0.13	2.58	0.32	0.18	15.97	22.17	0.03	0.02	0.22	4.68	0.67	99.40
stdev	0.30	0.03	0.18	0.05	0.01	0.20	0.29	0.03	0.02	0.02	0.38	0.51	0.35
457	52.03	0.16	2.82	0.42	0.20	16.76	20.20	0.05	0.00	0.17	5.60	1.52	99.93
457	51.96	0.22	2.80	0.52	0.17	16.13	21.61	0.03	0.01	0.20	4.79	1.28	99.72
457	52.10	0.27	2.88	0.48	0.17	15.71	22.45	0.02	0.04	0.20	4.65	1.60	100.57
457	52.19	0.27	2.81	0.52	0.19	15.60	22.37	0.00	0.00	0.21	5.05	0.84	100.05
457	52.35	0.19	2.72	0.48	0.19	16.26	20.98	0.06	0.02	0.17	5.88	0.94	100.24
457	51.85	0.19	2.72	0.44	0.17	15.95	22.10	0.01	0.06	0.20	4.29	1.80	99.78
457	51.71	0.06	2.86	0.55	0.18	15.71	22.38	0.11	0.04	0.24	3.80	2.34	99.98
457	51.56	0.19	2.79	0.50	0.17	15.95	22.08	0.00	0.00	0.20	4.04	2.21	99.69
457	51.97	0.22	2.81	0.36	0.15	15.61	22.68	0.00	0.02	0.22	4.30	1.31	99.65
avg(9)	51.97	0.20	2.80	0.47	0.18	15.96	21.87	0.03	0.02	0.20	4.71	1.54	99.96
stdev	0.23	0.06	0.05	0.06	0.01	0.36	0.76	0.03	0.02	0.02	0.66	0.49	0.28
Cycle 14													
407	52.29	0.25	3.04	0.46	0.14	16.54	21.64	0.00	0.06	0.16	4.64	0.73	99.94
407	53.42	0.14	2.90	0.42	0.14	16.80	21.86	0.04	0.05	0.18	5.02	0.35	101.33
407	52.65	0.09	2.94	0.44	0.12	16.94	21.37	0.04	0.06	0.18	4.45	0.89	100.17
407	52.22	0.15	3.09	0.49	0.15	16.18	22.25	0.04	0.00	0.20	4.15	1.05	99.96
407	52.33	0.24	2.96	0.40	0.15	16.44	21.86	0.09	0.07	0.21	4.24	1.01	99.99
407	52.55	0.13	2.98	0.50	0.17	16.20	22.38	0.05	0.00	0.22	4.20	0.90	100.28
407	52.83	0.18	2.95	0.38	0.14	16.48	22.25	0.01	0.02	0.19	4.43	1.02	100.88
407	52.58	0.15	2.99	0.38	0.13	16.43	22.09	0.11	0.00	0.17	4.43	0.71	100.17
407	52.84	0.21	2.85	0.44	0.16	16.58	21.93	0.10	0.04	0.00	5.17	0.00	100.32
407	52.88	0.19	2.91	0.36	0.14	16.50	21.94	0.08	0.05	0.19	4.77	0.31	100.32
407	52.52	0.14	2.82	0.41	0.11	16.47	22.60	0.06	0.00	0.20	3.55	1.44	100.32
407	52.93	0.16	2.99	0.34	0.08	16.68	21.79	0.02	0.00	0.16	4.89	0.00	100.04
avg(12)	52.67	0.17	2.95	0.42	0.14	16.52	22.00	0.05	0.03	0.19	4.43	0.77	100.35
stdev	0.32	0.04	0.07	0.05	0.02	0.21	0.32	0.03	0.03	0.05	0.42	0.43	0.39
381	52.65	0.12	3.01	0.41	0.19	15.92	23.01	0.00	0.00	0.18	4.21	0.55	100.26
381	52.40	0.19	2.83	0.46	0.11	16.42	22.42	0.00	0.02	0.18	3.90	1.26	100.20
381	52.64	0.09	2.82	0.38	0.18	16.34	22.41	0.01	0.03	0.19	4.12	1.15	100.37
381	53.12	0.18	2.64	0.49	0.16	16.44	22.21	0.00	0.00	0.18	4.96	0.16	100.54
381	52.69	0.18	2.97	0.39	0.13	16.42	21.91	0.03	0.00	0.18	4.87	0.45	100.21
381	52.47	0.10	2.94	0.40	0.14	16.20	22.17	0.00	0.01	0.18	4.60	0.60	99.81
381	52.75	0.18	2.98	0.44	0.13	16.82	21.40	0.05	0.02	0.20	4.75	0.77	100.49
381	52.83	0.15	3.01	0.45	0.14	17.26	20.85	0.11	0.04	0.18	4.74	1.33	101.09
381	52.37	0.14	2.91	0.47	0.18	16.16	22.53	0.05	0.00	0.20	3.95	1.12	100.08
381	51.80	0.09	2.97	0.37	0.13	16.10	22.50	0.07	0.00	0.18	3.50	2.06	99.77
381	53.37	0.13	1.78	0.40	0.16	15.87	24.45	0.05	0.02	0.03	3.99	0.57	100.82
avg(11)	52.65	0.14	2.80	0.43	0.15	16.36	22.35	0.03	0.01	0.17	4.34	0.90	100.33
stdev	0.39	0.04	0.34	0.04	0.02	0.38	0.87	0.03	0.01	0.05	0.46	0.51	0.38
375	51.88	0.17	3.20	0.75	0.14	16.46	21.76	0.05	0.01	0.22	3.79	1.19	99.62
375	52.11	0.17	3.09	0.74	0.11	16.42	21.86	0.08	0.06	0.16	4.24	0.57	99.61
375	51.49	0.20	3.23	0.83	0.14	16.14	22.53	0.08	0.00	0.24	2.82	1.95	99.65
375	51.72	0.16	3.18	0.79	0.09	16.28	22.11	0.10	0.03	0.21	3.49	1.28	99.44
375	51.72	0.24	3.15	0.87	0.13	16.55	22.01	0.09	0.00	0.27	2.93	1.99	99.95
375	51.77	0.17	3.09	0.77	0.16	16.22	22.46	0.09	0.00	0.23	3.09	1.55	99.59
375	52.64	0.20	2.46	0.32	0.11	16.64	23.01	0.06	0.04	0.17	3.02	1.12	99.79
375	52.00	0.18	3.08	0.60	0.14	16.46	22.47	0.00	0.00	0.23	3.04	1.62	99.82
375	51.78	0.25	3.26	0.86	0.11	16.32	21.80	0.00	0.01	0.04	4.82	0.00	99.25
avg(9)	51.90	0.19	3.08	0.73	0.13	16.39	22.22	0.06	0.01	0.22	3.36	1.38	99.67
stdev	0.31	0.03	0.23	0.16	0.02	0.15	0.40	0.04	0.02	0.06	0.65	0.61	0.20
364	54.26	0.01	1.21	0.12	0.15	16.24	24.12	0.05	0.03	0.04	4.33	0.00	100.56
364	53.00	0.17	2.51	0.42	0.14	16.82	22.22	0.05	0.02	0.17	4.12	0.88	100.52
364	53.29	0.06	1.51	0.28	0.15	16.42	24.15	0.01	0.00	0.05	3.21	1.34	100.46
364	53.32	0.14	2.55	0.36	0.15	16.78	22.24	0.00	0.05	0.19	4.44	0.57	100.79
364	53.20	0.15	2.51	0.40	0.17	17.44	21.20	0.03	0.00	0.18	4.50	0.90	100.68

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
364	53.45	0.17	2.50	0.41	0.18	17.52	20.62	0.06	0.01	0.18	5.37	0.11	100.58
364	53.73	0.11	2.52	0.33	0.16	16.39	22.41	0.05	0.01	0.17	4.97	0.00	100.85
364	53.35	0.16	2.59	0.42	0.12	16.33	22.81	0.04	0.03	0.20	4.53	0.39	100.97
364	52.59	0.21	2.63	0.51	0.17	16.97	22.07	0.05	0.00	0.17	3.57	1.56	100.51
364	53.01	0.21	2.60	0.40	0.16	16.43	22.83	0.02	0.02	0.20	3.95	0.89	100.72
364	53.10	0.19	2.53	0.42	0.20	17.10	21.86	0.10	0.00	0.16	4.17	1.15	100.99
364	52.75	0.12	2.65	0.46	0.15	16.44	22.88	0.07	0.01	0.18	3.54	1.54	100.78
364	52.83	0.15	2.69	0.42	0.15	16.22	23.15	0.11	0.01	0.23	3.44	1.60	101.00
364	53.05	0.21	2.74	0.44	0.17	16.17	23.49	0.03	0.05	0.18	3.66	1.19	101.38
avg(14)	53.21	0.15	2.41	0.38	0.16	16.66	22.57	0.05	0.02	0.16	4.21	0.78	100.76
stdev	0.41	0.06	0.44	0.09	0.02	0.43	0.96	0.03	0.02	0.05	0.59	0.55	0.24
363	53.01	0.23	2.67	0.62	0.17	16.34	22.94	0.05	0.00	0.19	4.01	0.70	100.93
863	52.44	0.13	2.81	0.69	0.11	16.41	22.68	0.02	0.00	0.19	3.54	1.12	100.13
363	52.76	0.12	2.87	0.80	0.15	16.59	22.56	0.00	0.00	0.18	3.77	1.11	100.91
363	52.84	0.09	2.76	0.70	0.15	16.82	22.16	0.04	0.00	0.23	3.67	1.28	100.74
363	52.40	0.18	2.94	0.85	0.13	16.15	22.94	0.03	0.00	0.20	3.59	1.27	100.68
363	52.46	0.14	2.93	0.81	0.15	16.49	22.54	0.11	0.00	0.19	3.48	1.14	100.44
363	53.08	0.07	2.85	0.72	0.16	17.74	20.32	0.08	0.00	0.19	4.79	0.63	100.63
363	52.82	0.05	2.94	0.74	0.15	17.32	20.96	0.07	0.05	0.20	4.32	0.97	100.59
363	52.76	0.13	2.94	0.79	0.13	16.71	21.95	0.01	0.01	0.18	4.35	0.66	100.62
363	52.88	0.21	2.95	0.87	0.14	16.82	22.29	0.08	0.00	0.20	3.77	0.96	101.17
363	52.77	0.13	2.25	0.55	0.20	16.53	23.33	0.08	0.03	0.11	3.08	1.13	100.18
363	51.97	0.10	2.84	0.83	0.16	17.55	21.24	0.04	0.00	0.19	2.69	2.86	100.48
363	52.52	0.10	2.97	0.77	0.15	16.31	22.56	0.03	0.00	0.21	3.79	0.81	100.22
avg(14)	52.67	0.13	2.82	0.75	0.15	16.75	22.19	0.05	0.01	0.19	3.75	1.13	100.59
stdev	0.29	0.05	0.19	0.09	0.02	0.48	0.83	0.03	0.01	0.03	0.52	0.54	0.30
361	52.59	0.16	2.83	0.76	0.16	16.30	22.52	0.01	0.00	0.20	4.06	0.32	99.91
361	52.42	0.10	3.00	0.77	0.14	16.71	22.24	0.00	0.09	0.21	3.33	1.51	100.51
361	52.40	0.09	2.89	0.79	0.12	17.01	21.43	0.03	0.01	0.20	3.91	1.20	100.08
361	52.25	0.10	2.91	0.71	0.14	16.41	22.35	0.00	0.09	0.23	3.42	1.20	99.81
361	52.05	0.12	2.93	0.84	0.18	17.56	20.17	0.09	0.09	0.18	4.05	1.40	99.66
361	52.53	0.11	2.92	0.74	0.11	18.02	19.87	0.04	0.02	0.17	4.41	1.53	100.47
361	52.65	0.10	2.94	0.73	0.18	16.55	22.10	0.04	0.03	0.19	4.14	0.66	100.31
361	52.26	0.21	2.97	0.71	0.12	17.06	21.68	0.05	0.00	0.19	3.48	1.66	100.39
361	52.04	0.15	3.08	0.76	0.10	16.87	21.80	0.02	0.03	0.16	3.51	1.09	99.61
361	52.78	0.09	3.12	0.83	0.12	17.48	20.65	0.06	0.02	0.17	4.63	0.46	100.41
avg(10)	52.40	0.12	2.96	0.76	0.14	17.00	21.48	0.03	0.04	0.19	3.89	1.12	100.12
stdev	0.24	0.04	0.08	0.04	0.03	0.52	0.89	0.03	0.04	0.02	0.42	0.45	0.33
						Cycle 12							
356	52.78	0.12	2.91	0.63	0.21	16.66	21.04	0.00	0.01	0.20	4.85	0.00	99.41
356	52.31	0.15	2.96	0.72	0.14	16.23	21.91	0.08	0.03	0.22	4.38	0.00	99.13
356	52.37	0.13	2.91	0.80	0.20	16.59	21.81	0.00	0.01	0.20	4.12	0.10	99.24
356	52.64	0.10	2.89	0.80	0.14	16.13	22.62	0.02	0.04	0.22	4.12	0.14	99.85
356	51.96	0.11	2.86	0.67	0.15	16.16	22.18	0.04	0.00	0.22	3.83	0.84	99.02
356	53.26	0.10	2.75	0.77	0.15	15.94	22.74	0.05	0.05	0.20	3.95	0.00	99.96
356	52.12	0.02	3.01	0.69	0.14	15.79	22.65	0.09	0.02	0.18	4.13	0.10	98.94
356	52.97	0.20	2.86	0.58	0.17	16.91	21.42	0.01	0.00	0.19	4.44	0.00	99.75
356	52.11	0.10	2.90	0.77	0.17	15.88	22.47	0.01	0.00	0.24	3.99	0.00	98.64
356	52.28	0.11	3.01	0.75	0.15	17.01	20.59	0.01	0.04	0.19	4.56	0.00	98.70
avg(10)	52.48	0.11	2.91	0.72	0.16	16.33	21.94	0.03	0.02	0.21	4.24	0.12	99.26
stdev	0.40	0.04	0.07	0.07	0.02	0.41	0.70	0.03	0.02	0.02	0.30	0.25	0.44
355	52.59	0.06	2.55	0.68	0.16	16.05	22.78	0.03	0.06	0.20	4.00	0.44	99.60
355	53.01	0.07	2.55	0.62	0.19	16.36	22.70	0.04	0.06	0.19	4.07	0.31	100.17
355	52.71	0.07	2.68	0.61	0.14	16.14	22.73	0.02	0.03	0.23	3.98	0.57	99.91
355	52.88	0.18	2.70	0.57	0.14	16.09	22.33	0.04	0.03	0.19	4.26	0.00	99.41
355	52.57	0.12	2.73	0.64	0.15	16.46	22.02	0.02	0.01	0.22	4.25	0.60	99.79
355	52.05	0.05	2.70	0.61	0.19	16.50	21.89	0.03	0.01	0.20	3.70	0.72	98.65
355	52.61	0.07	2.87	0.76	0.11	16.72	21.49	0.05	0.00	0.17	4.70	0.00	99.55
355	52.41	0.09	2.80	0.62	0.15	16.24	21.99	0.07	0.00	0.19	4.42	0.00	98.98
355	53.05	0.09	2.65	0.67	0.14	17.28	20.41	0.12	0.00	0.15	5.08	0.00	99.64
355	52.75	0.04	2.66	0.57	0.17	15.94	22.93	0.05	0.00	0.22	4.12	0.16	99.61
avg(11)	52.66	0.08	2.69	0.63	0.16	16.38	22.13	0.05	0.02	0.20	4.37	0.16	99.53
stdev	0.28	0.04	0.09	0.05	0.02	0.38	0.72	0.03	0.02	0.02	0.38	0.27	0.42
354	51.72	0.11	2.69	0.64	0.13	16.66	21.57	0.00	0.03	0.21	3.51	2.08	99.35
354	51.41	0.14	2.64	0.57	0.17	17.02	21.37	0.04	0.00	0.20	2.78	3.18	99.52

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
354	52.02	0.13	2.78	0.72	0.12	17.41	20.56	0.00	0.00	0.16	4.11	1.74	99.75
354	51.46	0.12	2.78	0.66	0.20	16.44	21.91	0.00	0.03	0.21	3.09	2.76	99.67
354	51.94	0.06	2.75	0.72	0.19	16.89	21.50	0.02	0.01	0.16	3.58	2.27	100.09
354	51.24	0.16	2.75	0.64	0.14	16.95	21.68	0.00	0.01	0.20	2.38	3.29	99.44
354	51.14	0.17	2.76	0.78	0.14	16.37	22.20	0.00	0.00	0.19	2.69	2.59	99.03
354	51.55	0.15	2.78	0.78	0.13	16.31	22.57	0.06	0.02	0.22	2.59	2.57	99.73
354	51.59	0.14	2.76	0.71	0.13	16.17	22.52	0.01	0.07	0.16	3.22	1.95	99.44
354	51.26	0.11	2.71	0.66	0.22	16.74	22.00	0.06	0.00	0.20	2.19	3.69	99.84
354	51.64	0.10	2.80	0.64	0.19	16.24	22.55	0.00	0.00	0.21	2.87	2.53	99.76
354	51.74	0.04	2.95	0.64	0.11	16.17	22.14	0.03	0.04	0.21	3.60	1.61	99.28
354	51.92	0.07	2.61	0.64	0.22	16.24	23.09	0.05	0.00	0.18	2.55	2.27	99.84
354	51.72	0.14	2.80	0.66	0.20	16.28	22.48	0.02	0.04	0.22	2.90	2.20	99.66
354	51.32	0.12	2.84	0.63	0.21	16.44	22.22	0.01	0.00	0.22	2.49	2.93	99.43
354	51.93	0.15	2.78	0.70	0.21	16.32	22.10	0.00	0.02	0.22	3.61	1.86	99.90
354	51.58	0.14	2.71	0.68	0.13	17.62	20.02	0.06	0.00	0.18	3.75	2.32	99.19
354	51.74	0.13	2.62	0.57	0.13	16.47	22.00	0.06	0.00	0.17	3.50	1.90	99.29
avg(18)	51.61	0.12	2.75	0.67	0.17	16.60	21.92	0.02	0.02	0.20	3.08	2.43	99.57
stdev	0.25	0.03	0.08	0.06	0.04	0.42	0.72	0.02	0.02	0.02	0.54	0.55	0.27
353	52.90	0.09	2.04	0.12	0.13	15.76	23.70	0.01	0.03	0.06	4.47	0.14	99.44
353	53.52	0.08	1.46	0.16	0.15	16.34	23.78	0.05	0.00	0.02	4.05	0.00	99.61
353	52.81	0.01	2.56	0.41	0.17	17.15	21.08	0.01	0.00	0.16	4.69	0.67	99.72
353	52.93	0.08	2.60	0.50	0.14	16.82	21.69	0.00	0.02	0.13	4.86	0.15	99.93
353	52.25	0.05	2.49	0.37	0.17	16.52	22.01	0.00	0.04	0.14	4.05	0.96	99.05
353	52.21	0.09	2.65	0.30	0.11	16.53	22.01	0.08	0.00	0.17	3.91	0.77	98.83
353	52.60	0.04	2.63	0.37	0.19	16.29	22.54	0.04	0.03	0.17	4.01	0.99	99.90
353	52.72	0.10	2.56	0.44	0.10	16.21	22.61	0.05	0.00	0.16	4.41	0.13	99.49
353	52.54	0.12	2.57	0.36	0.17	16.16	22.76	0.01	0.03	0.19	3.91	0.63	99.45
353	52.36	0.03	2.56	0.33	0.17	16.43	22.32	0.03	0.04	0.17	3.76	0.89	99.09
353	52.13	0.12	2.52	0.45	0.17	16.54	21.90	0.06	0.05	0.21	3.68	1.41	99.24
353	51.84	0.01	2.64	0.32	0.12	16.54	22.10	0.01	0.00	0.19	3.22	1.52	98.51
353	52.28	0.09	2.58	0.35	0.16	16.52	21.89	0.00	0.00	0.19	4.09	0.81	98.96
353	52.12	0.15	2.57	0.33	0.15	16.47	21.86	0.02	0.00	0.15	4.26	0.79	98.87
353	52.69	0.00	2.55	0.32	0.14	16.74	21.35	0.00	0.06	0.16	4.74	0.00	98.75
353	52.51	0.15	2.64	0.35	0.14	16.54	22.24	0.03	0.00	0.17	4.02	0.41	99.20
353	52.36	0.06	2.48	0.36	0.14	16.40	22.63	0.01	0.03	0.18	3.46	1.05	99.16
353	52.49	0.15	2.65	0.34	0.12	16.14	22.97	0.05	0.02	0.19	3.67	0.85	99.63
353	52.56	0.09	2.62	0.38	0.17	16.36	22.29	0.06	0.01	0.19	4.12	0.04	98.89
353	52.50	0.09	2.60	0.37	0.13	16.37	22.52	0.05	0.00	0.16	3.94	0.90	99.63
353	52.25	0.09	2.65	0.29	0.09	16.74	21.78	0.00	0.04	0.16	3.98	1.08	99.15
353	53.40	0.11	1.92	0.36	0.11	16.83	23.03	0.05	0.00	0.17	3.53	0.34	99.85
353	52.37	0.12	2.45	0.32	0.15	16.37	22.89	0.08	0.00	0.16	3.29	1.20	99.40
353	52.28	0.15	2.60	0.34	0.18	16.24	22.36	0.09	0.01	0.20	3.88	0.60	98.93
353	52.72	0.09	2.68	0.36	0.18	16.17	22.73	0.01	0.00	0.18	4.18	0.37	99.68
353	52.63	0.04	2.61	0.36	0.11	16.45	22.31	0.04	0.01	0.18	4.10	0.47	99.32
353	52.36	0.04	2.59	0.31	0.17	16.57	21.95	0.06	0.04	0.19	3.87	1.11	99.26
353	52.55	0.14	2.65	0.30	0.15	16.65	22.27	0.03	0.00	0.15	3.91	0.60	99.40
353	52.89	0.16	2.68	0.38	0.20	17.50	20.56	0.06	0.00	0.15	4.93	0.35	99.87
353	52.20	0.14	2.63	0.32	0.19	16.18	22.62	0.00	0.00	0.18	3.73	0.89	99.08
353	52.90	0.11	2.65	0.39	0.18	17.22	21.22	0.04	0.03	0.18	4.42	0.52	99.86
353	52.49	0.08	2.65	0.37	0.12	16.85	21.97	0.12	0.00	0.19	3.57	1.42	99.83
353	52.99	0.15	2.59	0.38	0.11	16.34	22.38	0.03	0.00	0.17	4.57	0.00	99.71
avg(33)	52.56	0.09	2.53	0.35	0.15	16.51	22.25	0.04	0.01	0.16	4.09	0.62	99.35
stdev	0.35	0.04	0.25	0.07	0.03	0.34	0.66	0.03	0.02	0.04	0.42	0.43	0.38
351	52.38	0.14	2.38	0.36	0.24	15.86	22.40	0.03	0.06	0.18	4.66	0.64	99.33
351	52.77	0.05	2.30	0.24	0.20	17.15	20.15	0.04	0.06	0.16	5.75	0.46	99.34
351	51.87	0.06	2.36	0.31	0.15	15.70	22.53	0.02	0.04	0.15	4.36	0.73	98.27
351	52.71	0.08	2.43	0.31	0.17	15.98	22.18	0.03	0.00	0.13	4.89	0.00	98.91
351	53.18	0.08	2.10	0.26	0.14	15.39	23.62	0.06	0.00	0.15	4.83	0.00	99.81
351	52.32	0.09	2.47	0.31	0.14	15.74	22.43	0.09	0.00	0.16	4.91	0.33	98.99
351	53.12	0.03	1.42	0.16	0.16	15.83	23.64	0.06	0.00	0.04	4.55	0.00	99.01
351	52.31	0.12	2.31	0.34	0.17	15.73	22.35	0.04	0.00	0.19	4.93	0.18	98.67
351	52.32	0.06	2.31	0.40	0.15	15.72	22.61	0.03	0.03	0.18	4.62	0.55	98.97
351	52.28	0.11	2.10	0.26	0.15	15.62	23.11	0.06	0.02	0.12	4.41	0.65	98.90
351	52.66	0.09	2.39	0.33	0.16	15.67	22.50	0.05	0.08	0.16	5.10	0.00	99.19
351	52.41	0.09	2.50	0.30	0.17	15.76	22.55	0.08	0.03	0.13	4.92	0.55	99.48
351	52.00	0.13	2.54	0.34	0.23	15.63	22.40	0.00	0.05	0.16	4.75	0.67	98.90
351	52.49	0.08	1.83	0.30	0.20	15.88	22.33	0.02	0.00	0.17	4.94	0.61	98.85

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
351	52.33	0.10	2.35	0.35	0.18	15.78	22.31	0.03	0.00	0.17	4.99	0.52	99.11
351	52.19	0.13	2.39	0.31	0.20	15.66	22.47	0.00	0.00	0.14	5.00	0.23	98.72
351	52.31	0.00	2.48	0.25	0.17	15.58	22.54	0.02	0.00	0.13	5.14	0.01	98.63
351	52.61	0.02	2.60	0.31	0.15	15.34	22.83	0.01	0.02	0.20	5.26	0.14	99.49
avg(18)	52.13	0.10	2.68	0.34	0.17	15.77	21.96	0.04	0.02	0.26	4.78	0.65	98.89
stdev	0.33	0.04	0.28	0.05	0.03	0.37	0.70	0.02	0.03	0.03	0.32	0.27	0.36
350	50.89	0.18	2.48	0.36	0.22	16.69	21.51	0.09	0.00	0.14	2.78	3.77	99.11
350	51.67	0.03	2.43	0.40	0.18	16.70	21.28	0.01	0.01	0.13	4.01	2.87	99.72
350	51.82	0.05	2.47	0.45	0.11	16.31	21.84	0.01	0.02	0.13	4.25	1.79	99.25
350	51.09	0.09	2.50	0.44	0.16	16.40	21.88	0.02	0.02	0.13	3.14	3.35	99.21
350	51.16	0.06	2.51	0.36	0.15	16.58	21.18	0.00	0.00	0.13	3.82	2.69	98.64
350	51.91	0.06	2.54	0.36	0.21	16.07	21.94	0.05	0.07	0.14	4.43	1.79	99.57
350	51.64	0.14	2.49	0.40	0.17	15.91	22.58	0.03	0.03	0.12	3.83	2.28	99.63
350	51.46	0.20	2.44	0.37	0.20	15.99	22.38	0.03	0.01	0.14	3.68	2.30	99.20
350	52.09	0.17	2.45	0.36	0.20	16.25	22.04	0.06	0.00	0.13	4.41	1.92	100.07
350	51.58	0.09	2.45	0.46	0.19	16.18	22.23	0.05	0.00	0.13	3.63	2.44	99.42
350	51.18	0.13	2.51	0.36	0.17	16.27	22.10	0.00	0.04	0.13	3.22	2.92	99.03
350	51.79	0.29	2.59	0.37	0.15	16.07	22.55	0.03	0.04	0.11	3.96	2.06	100.01
avg(12)	51.52	0.12	2.49	0.39	0.18	16.29	21.96	0.03	0.02	0.13	3.76	2.52	99.41
stdev	0.35	0.07	0.04	0.04	0.03	0.25	0.44	0.03	0.02	0.01	0.49	0.60	0.40
349	51.29	0.15	2.50	0.34	0.13	16.33	22.20	0.08	0.01	0.12	3.17	3.11	99.43
349	51.62	0.09	2.43	0.29	0.15	16.07	22.70	0.05	0.03	0.10	3.42	2.27	99.22
349	51.46	0.09	2.41	0.35	0.12	16.00	22.34	0.03	0.02	0.11	3.83	2.28	99.04
349	51.30	0.11	2.44	0.31	0.18	16.06	22.81	0.01	0.03	0.13	2.80	3.35	99.52
349	51.64	0.02	2.51	0.43	0.16	16.02	22.45	0.02	0.05	0.10	3.79	2.29	99.48
349	52.03	0.20	2.47	0.33	0.17	17.78	19.41	0.03	0.00	0.11	5.16	1.98	99.67
349	51.68	0.03	2.49	0.43	0.17	16.79	21.54	0.04	0.00	0.11	3.61	2.64	99.53
349	51.84	0.04	2.52	0.36	0.14	16.02	22.43	0.01	0.00	0.14	3.96	1.98	99.45
349	51.53	0.16	2.49	0.38	0.16	16.12	22.72	0.05	0.02	0.19	2.84	3.09	99.75
349	52.10	0.16	2.45	0.35	0.16	17.07	20.96	0.03	0.00	0.12	4.45	2.28	100.13
349	51.73	0.15	2.55	0.34	0.14	16.53	21.91	0.02	0.04	0.12	3.74	2.51	99.77
349	51.92	0.11	2.46	0.32	0.21	17.61	19.69	0.06	0.02	0.11	4.80	2.69	100.00
349	51.89	0.13	2.49	0.33	0.15	16.32	22.41	0.00	0.00	0.14	3.60	2.39	99.85
349	51.50	0.15	2.56	0.40	0.16	16.95	21.19	0.06	0.03	0.14	3.49	3.13	99.76
avg(14)	51.68	0.11	2.48	0.35	0.16	16.55	21.77	0.03	0.02	0.12	3.77	2.57	99.61
stdev	0.24	0.05	0.04	0.04	0.02	0.58	1.06	0.02	0.02	0.02	0.65	0.43	0.28
Cycle 11													
338	52.15	0.14	2.22	0.18	0.17	16.26	22.18	0.02	0.03	0.17	4.11	2.38	100.01
338	52.22	0.11	2.28	0.16	0.17	16.44	21.45	0.04	0.00	0.15	4.88	1.57	99.48
338	52.64	0.16	2.17	0.12	0.14	15.65	23.20	0.05	0.00	0.18	4.48	1.47	100.26
338	51.99	0.11	2.32	0.13	0.20	15.72	22.63	0.00	0.00	0.17	4.30	2.26	99.83
338	51.66	0.11	2.30	0.13	0.17	15.86	22.31	0.03	0.00	0.20	3.92	2.46	99.16
338	52.49	0.14	2.15	0.16	0.20	16.13	22.35	0.00	0.02	0.15	4.62	1.62	100.03
338	53.34	0.14	2.18	0.15	0.15	15.90	22.77	0.00	0.00	0.21	5.30	0.66	100.81
338	53.10	0.10	1.54	0.10	0.17	15.88	23.51	0.06	0.06	0.06	4.63	0.96	100.17
338	52.00	0.13	2.30	0.15	0.17	15.80	22.70	0.00	0.00	0.17	4.12	1.98	99.52
338	51.66	0.18	2.38	0.19	0.15	15.84	22.78	0.00	0.04	0.18	3.52	2.50	99.42
338	52.25	0.10	2.12	0.15	0.19	16.01	22.59	0.07	0.05	0.13	4.21	1.83	99.70
338	52.27	0.16	2.43	0.13	0.20	15.95	22.15	0.04	0.06	0.19	4.69	1.64	99.91
338	52.11	0.06	2.44	0.14	0.17	16.27	22.08	0.03	0.00	0.20	3.98	2.50	99.98
338	52.65	0.25	2.36	0.15	0.14	16.49	21.49	0.04	0.07	0.19	5.16	1.84	100.83
338	52.12	0.22	2.50	0.13	0.18	16.03	22.76	0.05	0.09	0.15	3.81	2.38	100.42
338	52.41	0.08	2.62	0.14	0.18	16.98	20.44	0.00	0.03	0.12	5.55	0.90	99.45
338	51.77	0.14	2.42	0.12	0.17	16.45	21.70	0.04	0.05	0.15	3.99	2.68	99.68
338	51.76	0.12	2.96	0.14	0.18	16.13	22.23	0.04	0.01	0.16	3.83	2.52	100.08
338	52.96	0.18	2.06	0.19	0.15	15.89	22.96	0.00	0.02	0.24	4.50	1.39	100.54
338	52.13	0.15	2.40	0.13	0.15	15.72	23.05	0.03	0.04	0.19	3.85	2.26	100.11
338	51.88	0.14	2.51	0.13	0.17	16.09	22.45	0.02	0.06	0.15	3.81	2.75	100.16
338	52.54	0.13	2.46	0.14	0.18	16.68	21.48	0.04	0.07	0.12	4.88	1.92	100.64
338	52.43	0.11	2.32	0.13	0.17	15.91	22.60	0.08	0.01	0.15	4.56	1.79	100.26
338	52.32	0.18	2.44	0.14	0.16	15.88	22.61	0.02	0.00	0.18	4.47	1.75	100.14
338	52.88	0.02	1.69	0.15	0.17	16.00	23.76	0.00	0.00	0.09	3.73	1.81	100.30
338	52.23	0.10	2.38	0.19	0.21	16.13	22.97	0.06	0.02	0.17	3.32	2.70	100.48
338	52.12	0.20	2.38	0.14	0.21	15.81	23.31	0.06	0.00	0.18	3.39	2.67	100.47
338	51.94	0.13	2.27	0.17	0.18	15.46	23.64	0.00	0.02	0.18	3.38	2.47	99.84

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
338	51.92	0.05	2.79	0.19	0.20	15.79	22.42	0.10	0.00	0.15	4.30	2.08	99.99
338	52.47	0.16	2.39	0.19	0.19	16.03	22.39	0.06	0.06	0.15	4.66	1.78	100.53
avg(31)	52.11	0.14	2.59	0.15	0.17	16.05	22.17	0.03	0.03	0.22	4.21	2.13	99.99
stdev	0.41	0.05	0.26	0.02	0.02	0.32	0.70	0.03	0.03	0.04	0.56	0.55	0.42
336	52.66	0.11	2.18	0.24	0.15	16.85	21.97	0.08	0.02	0.19	3.79	2.11	100.35
336	52.19	0.15	2.25	0.26	0.17	16.61	21.62	0.03	0.04	0.21	4.06	2.43	100.01
336	52.63	0.10	2.32	0.25	0.16	16.37	22.58	0.00	0.00	0.19	3.91	2.20	100.71
336	52.04	0.10	2.22	0.25	0.15	16.38	22.54	0.07	0.00	0.19	3.18	3.05	100.17
336	52.33	0.17	2.25	0.23	0.18	16.81	21.52	0.00	0.02	0.16	4.28	2.20	100.15
336	52.46	0.18	2.27	0.29	0.16	16.06	23.14	0.11	0.04	0.16	3.60	2.49	100.96
336	51.74	0.14	2.32	0.27	0.17	16.63	21.70	0.09	0.07	0.23	3.19	3.39	99.94
336	52.43	0.18	2.27	0.34	0.15	17.13	20.82	0.03	0.03	0.16	4.73	2.03	100.30
336	52.53	0.12	2.32	0.29	0.21	16.13	22.58	0.10	0.01	0.17	4.17	1.98	100.61
336	52.81	0.16	2.16	0.27	0.14	17.51	20.25	0.02	0.00	0.17	5.22	1.72	100.43
336	52.24	0.20	2.25	0.22	0.21	16.37	21.97	0.07	0.03	0.19	4.16	2.14	100.05
336	52.33	0.12	2.18	0.29	0.15	16.93	21.51	0.07	0.01	0.18	3.92	2.65	100.33
336	52.32	0.12	2.17	0.23	0.19	17.26	20.57	0.01	0.06	0.16	4.58	2.46	100.14
336	52.31	0.16	2.28	0.23	0.20	16.63	21.62	0.03	0.00	0.19	4.27	2.04	99.96
avg(14)	52.47	0.15	2.45	0.35	0.17	16.19	22.18	0.03	0.02	0.20	4.49	1.47	100.17
stdev	0.26	0.03	0.05	0.03	0.02	0.41	0.79	0.04	0.02	0.02	0.54	0.43	0.29
335	52.67	0.13	2.22	0.32	0.19	16.62	21.98	0.00	0.00	0.19	4.27	1.55	100.15
335	52.81	0.12	2.29	0.30	0.19	16.38	22.17	0.02	0.00	0.20	4.55	1.46	100.49
335	53.15	0.10	2.32	0.30	0.19	16.22	22.24	0.03	0.00	0.19	5.17	0.21	100.12
335	52.54	0.13	2.26	0.24	0.20	16.08	22.74	0.08	0.00	0.20	3.97	1.75	100.20
335	52.12	0.09	2.35	0.26	0.21	16.39	22.54	0.07	0.03	0.16	3.30	2.07	99.59
335	52.44	0.19	2.34	0.29	0.17	16.07	22.21	0.03	0.00	0.20	4.68	1.47	100.09
335	52.43	0.13	2.23	0.28	0.24	16.18	22.26	0.00	0.01	0.18	4.40	1.04	99.37
335	53.19	0.21	2.14	0.27	0.16	16.93	21.29	0.07	0.05	0.18	5.26	0.91	100.66
335	53.48	0.18	2.13	0.31	0.12	17.01	20.72	0.09	0.02	0.20	6.07	0.00	100.33
335	52.99	0.14	2.15	0.24	0.18	16.69	21.22	0.01	0.03	0.21	5.39	0.81	100.06
335	53.58	0.13	2.24	0.29	0.19	16.10	22.65	0.00	0.03	0.17	5.49	0.02	100.89
avg(11)	52.85	0.14	2.24	0.28	0.19	16.42	22.00	0.04	0.02	0.19	4.78	1.03	100.18
stdev	0.44	0.04	0.08	0.03	0.03	0.32	0.62	0.03	0.02	0.01	0.75	0.68	0.48
334	52.05	0.10	2.36	0.29	0.11	16.01	22.73	0.00	0.05	0.18	3.71	2.27	99.86
334	52.59	0.25	2.47	0.36	0.17	16.04	22.54	0.06	0.01	0.20	4.51	1.87	101.07
334	51.58	0.25	2.51	0.37	0.17	16.64	21.42	0.03	0.04	0.20	3.67	3.42	100.29
334	52.60	0.12	2.38	0.33	0.13	16.35	22.19	0.01	0.00	0.25	4.17	1.72	100.24
334	52.48	0.18	2.05	0.27	0.12	15.97	22.87	0.00	0.01	0.23	3.98	1.97	100.14
334	52.19	0.09	2.49	0.30	0.18	16.33	21.86	0.02	0.00	0.22	4.19	1.88	99.75
334	52.18	0.21	2.48	0.31	0.18	17.08	19.99	0.10	0.04	0.14	5.59	1.26	99.57
334	52.21	0.20	2.39	0.26	0.24	15.84	22.79	0.00	0.02	0.25	3.79	2.12	100.11
334	51.55	0.16	2.41	0.31	0.19	16.17	22.36	0.01	0.05	0.18	3.26	3.35	100.01
334	51.71	0.15	3.29	0.36	0.14	15.73	22.43	0.01	0.02	0.23	3.99	2.11	100.17
334	52.44	0.11	2.41	0.33	0.13	16.17	22.34	0.00	0.04	0.21	4.25	2.13	100.56
334	52.08	0.22	2.51	0.27	0.15	15.75	22.64	0.02	0.00	0.21	4.28	1.73	99.86
334	52.26	0.17	2.49	0.30	0.18	15.78	22.70	0.00	0.00	0.22	4.26	1.92	100.28
avg(13)	52.15	0.17	2.48	0.31	0.16	16.14	22.22	0.02	0.02	0.21	4.13	2.13	100.14
stdev	0.34	0.05	0.26	0.03	0.03	0.37	0.75	0.03	0.02	0.03	0.53	0.59	0.37
332	52.76	0.09	2.61	0.30	0.17	16.03	22.57	0.11	0.08	0.20	4.43	1.60	100.95
332	52.85	0.22	2.62	0.38	0.15	15.95	23.03	0.00	0.03	0.20	4.39	1.29	101.11
332	53.56	0.06	2.51	0.34	0.19	15.86	22.84	0.00	0.00	0.21	5.44	0.35	101.35
332	53.58	0.12	2.77	0.33	0.15	15.94	22.21	0.00	0.01	0.20	6.08	0.00	101.39
332	52.85	0.18	2.62	0.28	0.17	15.72	22.85	0.08	0.00	0.20	4.92	0.87	100.74
332	52.58	0.19	2.67	0.39	0.12	15.93	22.63	0.00	0.03	0.20	4.61	1.73	101.08
332	52.57	0.12	2.62	0.27	0.17	15.75	22.90	0.05	0.05	0.19	4.44	1.29	100.42
332	53.47	0.06	2.66	0.29	0.19	16.26	21.89	0.08	0.00	0.19	5.85	0.30	101.24
332	52.92	0.05	2.66	0.31	0.20	16.15	21.99	0.06	0.05	0.19	5.21	0.49	100.28
332	52.25	0.18	2.84	0.29	0.15	15.57	22.75	0.04	0.02	0.18	4.73	1.44	100.44
avg(10)	52.94	0.13	2.66	0.32	0.17	15.92	22.56	0.04	0.03	0.20	5.01	0.94	100.91
stdev	0.43	0.06	0.09	0.04	0.02	0.19	0.38	0.04	0.03	0.01	0.58	0.58	0.39
330	51.04	0.15	2.72	0.30	0.18	15.99	22.17	0.00	0.01	0.23	3.04	3.46	99.29
330	52.01	0.20	2.67	0.38	0.16	16.08	21.59	0.03	0.00	0.18	5.06	1.03	99.38
330	52.12	0.18	2.78	0.39	0.15	15.93	22.10	0.00	0.00	0.21	4.68	1.79	100.33
330	51.27	0.20	2.79	0.41	0.23	15.63	22.18	0.02	0.05	0.25	3.78	2.12	98.93
330	51.87	0.12	2.70	0.38	0.20	16.17	21.81	0.03	0.02	0.18	4.32	2.02	99.81
330	51.72	0.24	2.87	0.44	0.18	15.93	22.04	0.01	0.00	0.21	4.30	1.75	99.68

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
330	51.67	0.33	2.77	0.41	0.21	16.01	21.98	0.00	0.00	0.14	4.56	1.61	99.69
330	52.05	0.22	2.60	0.37	0.15	15.79	22.18	0.01	0.03	0.20	4.79	0.60	98.99
330	51.74	0.21	2.72	0.39	0.24	16.14	21.57	0.02	0.01	0.20	4.49	1.85	99.57
330	51.14	0.24	2.99	0.45	0.18	15.80	22.36	0.02	0.00	0.21	3.41	2.22	99.02
330	52.60	0.17	1.91	0.30	0.22	15.80	23.65	0.00	0.00	0.11	3.89	1.47	100.12
330	52.31	0.21	2.69	0.34	0.13	15.96	22.04	0.00	0.04	0.20	4.99	1.07	99.98
avg(12)	51.79	0.20	2.68	0.38	0.18	15.94	22.14	0.01	0.01	0.19	4.28	1.74	99.54
stdev	0.45	0.05	0.25	0.05	0.03	0.15	0.51	0.01	0.02	0.04	0.60	0.69	0.44
328	51.94	0.21	2.75	0.47	0.13	15.66	22.15	0.00	0.02	0.28	4.59	1.32	99.52
328	52.60	0.15	2.55	0.46	0.15	15.80	22.90	0.06	0.00	0.23	4.29	1.25	100.43
328	52.55	0.14	2.50	0.46	0.33	16.37	21.10	0.11	0.00	0.21	5.37	1.10	100.24
328	52.30	0.25	2.57	0.46	0.12	15.83	22.73	0.08	0.00	0.21	4.29	1.27	100.11
328	52.55	0.18	2.62	0.41	0.18	15.83	22.58	0.01	0.00	0.24	4.58	1.49	100.67
328	52.66	0.17	2.40	0.49	0.20	15.90	23.34	0.05	0.01	0.19	3.77	1.32	100.50
328	53.42	0.18	2.12	0.44	0.14	16.45	22.65	0.00	0.00	0.19	4.64	0.00	100.23
328	53.02	0.13	2.37	0.58	0.18	15.75	22.73	0.02	0.05	0.21	5.13	0.25	100.43
328	52.94	0.16	2.38	0.43	0.17	15.74	22.20	0.03	0.02	0.23	5.70	0.00	100.00
328	51.72	0.22	2.75	0.47	0.18	15.88	22.11	0.03	0.00	0.20	4.31	1.76	99.63
328	52.05	0.13	2.76	0.49	0.17	15.90	21.84	0.09	0.07	0.17	4.95	1.27	99.90
avg(11)	52.64	0.16	2.41	0.46	0.18	16.00	22.56	0.04	0.02	0.20	4.53	0.94	100.14
stdev	0.60	0.05	0.43	0.05	0.05	0.36	0.77	0.04	0.02	0.05	0.77	0.58	0.33
326	52.90	0.13	2.58	0.45	0.18	15.73	22.60	0.08	0.00	0.21	5.18	0.33	100.37
326	51.97	0.13	3.01	0.62	0.17	15.30	22.61	0.00	0.00	0.23	4.82	0.77	99.63
326	52.76	0.19	2.37	0.43	0.15	15.85	23.29	0.02	0.01	0.19	4.14	0.72	100.12
326	52.53	0.11	2.25	0.46	0.18	15.98	23.02	0.06	0.00	0.19	3.85	1.04	99.66
326	52.61	0.08	2.32	0.42	0.13	15.94	22.43	0.00	0.02	0.21	4.74	0.58	99.48
326	53.06	0.08	2.43	0.42	0.17	15.90	22.58	0.01	0.04	0.24	4.95	0.68	100.56
326	52.30	0.15	2.49	0.50	0.21	15.78	22.91	0.03	0.04	0.22	3.93	0.93	99.49
326	52.82	0.16	2.42	0.49	0.21	16.15	22.85	0.07	0.00	0.20	4.07	1.41	100.85
326	52.52	0.08	2.65	0.47	0.20	15.59	22.71	0.06	0.03	0.22	4.71	0.66	99.91
326	52.33	0.20	2.53	0.42	0.16	15.96	22.38	0.05	0.06	0.24	4.29	1.80	100.42
326	53.23	0.07	2.33	0.60	0.21	16.43	21.70	0.02	0.00	0.21	5.45	0.02	100.27
326	52.32	0.17	2.56	0.41	0.15	15.86	22.03	0.07	0.00	0.24	4.92	0.87	99.60
avg(12)	52.61	0.13	2.50	0.47	0.18	15.87	22.59	0.04	0.02	0.22	4.57	0.83	100.03
stdev	0.34	0.04	0.19	0.07	0.03	0.27	0.41	0.03	0.02	0.02	0.50	0.44	0.45
325	52.76	0.03	2.76	0.44	0.13	16.58	21.58	0.00	0.04	0.14	5.08	0.00	99.54
325	52.50	0.13	2.29	0.38	0.14	15.88	22.52	0.06	0.04	0.20	4.60	1.38	100.13
325	52.23	0.17	2.71	0.53	0.23	15.98	22.09	0.02	0.00	0.20	4.68	1.52	100.35
325	53.04	0.13	2.21	0.42	0.21	15.96	23.74	0.00	0.01	0.17	3.70	1.00	100.59
325	53.05	0.17	2.28	0.41	0.21	15.82	23.32	0.01	0.00	0.16	4.43	0.00	99.86
325	52.02	0.13	3.25	0.43	0.19	15.25	22.29	0.03	0.04	0.21	5.38	0.50	99.72
325	52.75	0.00	2.06	0.34	0.17	16.40	23.73	0.05	0.06	0.16	2.45	1.74	99.91
325	51.72	0.17	3.02	0.56	0.18	15.27	22.80	0.07	0.03	0.24	4.21	1.68	99.95
325	52.39	0.15	3.06	0.52	0.17	15.46	22.55	0.00	0.05	0.21	5.17	0.62	100.35
325	52.99	0.09	2.48	0.34	0.17	15.83	22.87	0.05	0.06	0.23	4.62	1.11	100.83
325	52.59	0.13	2.50	0.36	0.23	15.80	22.71	0.06	0.00	0.21	4.51	1.47	100.57
avg(12)	52.54	0.12	2.61	0.44	0.19	15.88	22.60	0.03	0.03	0.19	4.55	0.94	100.11
stdev	0.40	0.05	0.36	0.07	0.03	0.40	0.77	0.03	0.02	0.03	0.82	0.61	0.42
324	52.45	0.23	2.34	0.12	0.11	15.85	22.95	0.05	0.03	0.23	4.05	1.33	99.74
324	52.54	0.22	2.37	0.11	0.14	15.97	22.83	0.07	0.00	0.22	4.11	0.98	99.56
324	52.68	0.02	2.34	0.16	0.15	15.84	23.16	0.03	0.06	0.21	3.92	0.87	99.45
324	52.51	0.12	2.43	0.12	0.13	16.02	22.49	0.07	0.00	0.22	4.34	0.95	99.41
324	52.39	0.20	2.20	0.16	0.16	16.07	22.42	0.13	0.02	0.17	4.40	0.58	98.90
324	53.14	0.15	2.30	0.14	0.20	15.89	22.62	0.13	0.04	0.23	4.98	0.53	100.34
324	52.89	0.11	2.29	0.08	0.17	15.97	22.94	0.08	0.00	0.19	4.39	1.01	100.12
324	52.45	0.19	2.31	0.12	0.19	16.28	22.32	0.04	0.00	0.21	4.10	1.57	99.79
324	52.85	0.13	2.34	0.18	0.18	15.87	22.86	0.03	0.04	0.20	4.59	0.65	99.93
324	52.70	0.21	2.31	0.17	0.17	16.16	22.21	0.08	0.00	0.23	4.66	1.02	99.92
324	52.69	0.16	2.41	0.17	0.13	15.92	22.56	0.03	0.00	0.20	4.81	0.75	99.84
324	53.67	0.06	2.45	0.16	0.17	16.22	22.03	0.02	0.00	0.19	5.18	0.00	100.15
324	53.21	0.18	2.38	0.16	0.19	16.09	22.89	0.03	0.00	0.18	4.76	0.35	100.43
324	53.11	0.14	2.28	0.13	0.21	15.99	23.10	0.08	0.02	0.20	4.33	0.38	99.97
324	53.09	0.14	2.07	0.15	0.15	16.36	22.32	0.01	0.03	0.20	4.77	0.75	100.03
324	53.04	0.21	2.09	0.14	0.22	16.13	22.42	0.01	0.01	0.19	5.05	0.23	99.73
324	53.05	0.12	2.45	0.16	0.17	16.65	21.37	0.08	0.00	0.19	4.70	0.00	98.94
324	52.89	0.22	2.38	0.19	0.12	15.98	22.86	0.00	0.05	0.18	4.70	0.63	100.20

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
324	53.15	0.18	2.30	0.18	0.21	16.12	22.58	0.04	0.00	0.18	5.00	0.08	100.02
avg(19)	52.87	0.16	2.32	0.15	0.17	16.07	22.58	0.05	0.02	0.20	4.57	0.67	99.81
stdev	0.32	0.05	0.10	0.03	0.03	0.20	0.42	0.04	0.02	0.02	0.36	0.42	0.41
323	51.61	0.18	2.58	0.33	0.15	16.36	21.18	0.08	0.00	0.25	4.22	2.70	99.64
323	51.64	0.25	2.67	0.35	0.18	15.53	22.33	0.05	0.00	0.22	4.47	1.84	99.52
323	50.78	0.16	2.62	0.36	0.16	16.14	21.95	0.06	0.02	0.19	2.89	3.84	99.16
323	50.79	0.17	2.56	0.36	0.22	16.11	21.98	0.03	0.00	0.21	2.82	3.97	99.22
323	50.94	0.18	2.44	0.31	0.15	15.91	22.17	0.01	0.03	0.24	3.04	3.63	99.05
323	51.03	0.13	2.43	0.35	0.18	15.99	22.30	0.10	0.00	0.22	2.80	3.79	99.32
323	51.21	0.27	2.89	0.41	0.20	15.85	22.06	0.06	0.01	0.22	3.71	2.49	99.38
323	51.54	0.21	2.58	0.38	0.15	15.79	22.30	0.00	0.05	0.21	3.96	2.41	99.58
323	51.80	0.14	2.52	0.32	0.23	15.90	21.83	0.05	0.00	0.20	4.58	1.82	99.39
323	51.50	0.13	2.64	0.33	0.22	15.70	22.39	0.08	0.00	0.18	3.93	2.19	99.29
323	51.55	0.12	2.15	0.25	0.16	16.09	22.34	0.07	0.03	0.20	3.30	3.04	99.29
323	50.26	0.09	3.07	0.37	0.13	16.01	21.61	0.09	0.01	0.17	2.97	3.40	98.18
avg(12)	51.22	0.17	2.60	0.34	0.18	15.95	22.04	0.06	0.01	0.21	3.56	2.93	99.25
stdev	0.44	0.05	0.22	0.04	0.03	0.21	0.35	0.03	0.02	0.02	0.64	0.76	0.36
321	52.57	0.20	2.89	0.35	0.14	15.97	22.57	0.01	0.00	0.24	4.43	1.42	100.79
321	52.44	0.14	2.75	0.35	0.13	16.24	22.44	0.06	0.02	0.21	3.99	1.77	100.54
321	52.80	0.17	2.62	0.30	0.18	16.08	22.92	0.08	0.03	0.18	4.17	1.13	100.66
321	52.25	0.15	2.68	0.39	0.19	16.17	22.18	0.05	0.03	0.18	4.30	1.50	100.07
321	52.75	0.19	2.53	0.41	0.13	16.32	21.82	0.05	0.06	0.25	4.84	0.51	99.86
321	52.94	0.07	2.20	0.32	0.18	15.31	23.73	0.02	0.03	0.19	4.60	0.88	100.47
321	52.71	0.16	2.64	0.38	0.18	16.68	21.46	0.02	0.06	0.20	4.79	0.86	100.15
321	53.20	0.26	2.70	0.39	0.18	16.21	22.53	0.11	0.00	0.17	5.05	0.35	101.14
321	53.11	0.11	2.78	0.38	0.21	16.57	21.91	0.03	0.00	0.21	4.82	0.94	101.06
321	52.90	0.21	2.82	0.40	0.14	16.27	22.49	0.03	0.03	0.22	4.44	0.95	100.91
avg(10)	52.77	0.17	2.66	0.37	0.17	16.18	22.40	0.05	0.03	0.21	4.53	1.05	100.59
stdev	0.28	0.05	0.18	0.03	0.03	0.35	0.60	0.03	0.02	0.03	0.32	0.42	0.41
319	51.82	0.12	3.79	0.13	0.13	15.95	22.48	0.06	0.01	0.18	3.84	1.18	99.69
319	51.76	0.10	2.77	0.31	0.15	16.54	20.54	0.06	0.02	0.21	5.02	0.30	97.78
319	52.66	0.16	2.51	0.43	0.14	17.04	19.94	0.02	0.00	0.16	5.73	0.00	98.79
319	52.23	0.24	2.60	0.25	0.14	15.74	22.07	0.02	0.00	0.22	4.77	0.00	98.28
319	51.94	0.07	2.71	0.34	0.13	16.05	21.95	0.06	0.00	0.22	4.26	0.71	98.44
319	52.30	0.11	2.77	0.80	0.12	15.98	21.84	0.02	0.02	0.20	4.79	0.00	98.95
319	53.01	0.13	2.50	0.41	0.16	18.08	18.64	0.01	0.00	0.14	6.41	0.00	99.49
319	52.57	0.24	2.56	0.40	0.18	15.98	22.40	0.00	0.02	0.22	4.71	0.07	99.35
319	52.45	0.07	2.85	0.81	0.15	16.29	21.36	0.00	0.00	0.24	5.15	0.15	99.51
avg(9)	52.30	0.14	2.78	0.43	0.14	16.41	21.25	0.03	0.01	0.20	4.96	0.27	98.92
stdev	0.39	0.06	0.37	0.22	0.02	0.70	1.22	0.02	0.01	0.03	0.72	0.39	0.62
318	53.23	0.23	2.61	0.41	0.17	16.16	22.15	0.06	0.00	0.21	5.29	0.00	100.52
318	53.32	0.25	2.58	0.48	0.14	16.87	21.62	0.05	0.07	0.21	5.02	0.92	101.52
318	54.22	0.09	1.48	0.30	0.10	16.31	23.52	0.02	0.03	0.11	4.65	0.00	100.83
318	53.68	0.23	2.49	0.44	0.12	16.44	21.88	0.06	0.00	0.24	5.39	0.00	100.97
318	53.12	0.16	2.58	0.45	0.16	16.20	22.66	0.06	0.00	0.22	4.55	0.71	100.87
318	52.99	0.14	2.50	0.46	0.18	16.10	22.70	0.01	0.00	0.23	4.48	0.84	100.63
318	52.69	0.12	2.62	0.48	0.14	16.10	22.35	0.04	0.04	0.22	4.58	0.48	99.86
318	53.44	0.16	2.70	0.49	0.14	16.00	22.29	0.04	0.02	0.23	5.31	0.00	100.82
318	53.20	0.21	2.22	0.39	0.13	16.31	22.28	0.03	0.01	0.23	4.98	0.38	100.38
318	52.55	0.21	2.59	0.40	0.15	16.10	22.48	0.02	0.00	0.20	4.46	0.73	99.89
318	53.05	0.16	2.79	0.56	0.11	16.00	22.35	0.02	0.02	0.22	5.14	0.00	100.42
318	53.51	0.12	2.37	0.45	0.17	16.58	22.18	0.05	0.02	0.19	5.04	0.60	101.28
318	52.78	0.19	2.63	0.44	0.19	16.02	22.51	0.06	0.07	0.26	4.40	0.80	100.35
318	52.75	0.21	2.67	0.38	0.16	16.30	22.20	0.00	0.03	0.22	4.59	0.98	100.49
avg(15)	53.11	0.23	2.45	0.40	0.16	16.05	22.96	0.00	0.07	0.22	4.47	0.15	100.28
stdev	0.43	0.05	0.31	0.06	0.03	0.24	0.42	0.02	0.02	0.03	0.34	0.37	0.45
317	51.46	0.12	2.74	0.40	0.16	16.84	21.92	0.06	0.00	0.21	2.38	2.79	99.08
317	51.93	0.15	2.72	0.40	0.18	16.12	22.75	0.02	0.02	0.26	2.96	2.07	99.58
317	51.26	0.13	3.00	0.67	0.13	16.10	22.01	0.01	0.00	0.22	3.39	1.76	98.68
317	51.60	0.08	2.67	0.49	0.16	16.18	22.22	0.07	0.02	0.21	3.28	2.11	99.09
317	52.18	0.20	2.75	0.51	0.10	16.21	22.36	0.00	0.01	0.18	4.12	1.14	99.76
317	51.40	0.17	2.82	0.46	0.21	16.15	22.47	0.05	0.04	0.25	2.61	2.64	99.27
317	51.66	0.19	2.69	0.45	0.10	16.14	22.29	0.03	0.05	0.21	3.50	1.85	99.15
317	51.81	0.13	2.77	0.53	0.19	16.15	22.16	0.07	0.05	0.19	3.74	1.81	99.59
317	51.70	0.14	2.80	0.44	0.16	16.71	21.54	0.10	0.04	0.19	3.42	1.89	99.13

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
317	51.82	0.17	2.74	0.50	0.17	16.45	21.87	0.09	0.00	0.24	3.44	2.14	99.62
317	51.28	0.12	2.80	0.51	0.16	16.42	22.19	0.05	0.03	0.21	2.55	2.56	98.88
317	52.22	0.11	2.73	0.45	0.16	16.36	22.35	0.00	0.05	0.25	3.41	1.84	99.93
317	52.13	0.09	2.84	0.45	0.18	17.20	20.68	0.06	0.01	0.17	4.26	1.51	99.58
317	51.86	0.20	2.71	0.48	0.17	16.22	22.70	0.00	0.00	0.19	3.18	2.19	99.90
317	52.05	0.14	2.74	0.37	0.15	16.26	22.67	0.03	0.00	0.21	3.22	2.03	99.86
avg(15)	51.76	0.14	2.77	0.47	0.16	16.37	22.15	0.04	0.02	0.21	3.30	2.02	99.41
stdev	0.30	0.04	0.08	0.07	0.03	0.31	0.51	0.03	0.02	0.03	0.51	0.41	0.38
316	53.02	0.15	2.70	0.59	0.15	16.05	23.05	0.03	0.04	0.23	4.14	0.83	100.98
316	52.80	0.17	2.93	0.63	0.21	16.13	22.38	0.07	0.00	0.21	4.65	0.98	101.16
316	53.01	0.11	2.76	0.55	0.15	16.91	20.87	0.07	0.02	0.20	5.47	0.04	100.16
316	52.75	0.11	2.70	0.55	0.17	16.59	21.36	0.10	0.01	0.20	5.07	0.78	100.39
316	52.58	0.19	2.74	0.51	0.21	16.46	21.83	0.11	0.02	0.21	4.46	0.83	100.15
316	52.83	0.17	2.85	0.61	0.16	17.04	20.88	0.15	0.02	0.16	5.17	0.78	100.82
316	52.68	0.18	2.82	0.62	0.16	17.27	20.28	0.08	0.06	0.18	5.29	0.51	100.13
316	52.58	0.22	2.88	0.61	0.18	16.32	22.26	0.00	0.00	0.21	4.34	1.06	100.66
316	52.81	0.09	2.76	0.53	0.12	16.30	22.44	0.10	0.02	0.20	4.30	1.17	100.84
316	53.09	0.19	2.99	0.59	0.13	16.53	21.91	0.07	0.03	0.22	4.91	0.22	100.87
316	52.77	0.20	2.91	0.65	0.15	16.34	22.66	0.07	0.03	0.20	3.98	1.13	101.09
avg(11)	52.81	0.16	2.82	0.59	0.16	16.54	21.81	0.08	0.02	0.20	4.72	0.75	100.65
stdev	0.16	0.04	0.09	0.04	0.03	0.37	0.82	0.04	0.02	0.02	0.48	0.35	0.37
314	52.45	0.17	2.53	0.36	0.14	15.96	22.45	0.05	0.03	0.19	4.59	0.68	99.61
314	52.53	0.16	2.87	0.56	0.17	15.97	21.94	0.06	0.00	0.20	5.26	0.32	100.04
314	52.62	0.13	2.75	0.56	0.17	15.46	22.32	0.02	0.07	0.21	5.27	0.00	99.58
314	52.70	0.14	2.80	0.52	0.17	16.80	20.21	0.04	0.02	0.20	5.88	0.00	99.48
314	52.24	0.14	2.72	0.59	0.13	15.92	22.40	0.07	0.00	0.24	4.24	1.43	100.12
314	51.93	0.13	2.89	0.54	0.15	15.77	22.03	0.01	0.00	0.23	4.68	0.62	98.98
314	52.27	0.15	2.84	0.52	0.19	15.98	22.24	0.05	0.00	0.22	4.43	1.24	100.13
314	52.79	0.15	2.74	0.60	0.16	16.43	21.30	0.06	0.02	0.19	5.40	0.00	99.84
314	52.63	0.12	2.81	0.80	0.20	15.90	21.60	0.04	0.00	0.27	5.47	0.00	99.84
avg(9)	52.46	0.14	2.77	0.56	0.16	16.02	21.83	0.04	0.02	0.22	5.02	0.48	99.74
stdev	0.26	0.01	0.10	0.11	0.02	0.36	0.68	0.02	0.02	0.02	0.52	0.53	0.35
313	52.06	0.19	2.60	0.49	0.17	15.93	22.73	0.05	0.02	0.19	3.82	1.50	99.75
313	52.15	0.15	2.62	0.37	0.15	16.19	22.05	0.05	0.04	0.24	4.07	1.54	99.61
313	51.54	0.16	2.71	0.33	0.15	15.86	22.57	0.00	0.04	0.23	3.36	2.28	99.24
313	51.85	0.15	2.45	0.42	0.13	16.02	22.24	0.03	0.00	0.22	3.94	1.62	99.07
313	50.84	0.14	2.70	0.48	0.12	15.85	22.95	0.00	0.05	0.18	2.29	3.12	98.72
313	52.02	0.11	2.49	0.39	0.15	15.96	22.65	0.08	0.00	0.20	3.71	1.84	99.60
313	51.78	0.12	2.49	0.42	0.13	16.07	22.24	0.06	0.06	0.20	3.75	1.76	99.08
313	51.85	0.15	2.68	0.48	0.18	15.86	22.63	0.05	0.00	0.21	3.70	1.99	99.78
313	52.12	0.13	2.49	0.32	0.19	16.07	22.33	0.04	0.02	0.23	3.90	1.87	99.72
313	51.77	0.13	2.64	0.49	0.14	16.53	21.42	0.06	0.01	0.19	4.06	2.16	99.60
avg(10)	51.80	0.14	2.59	0.42	0.15	16.03	22.38	0.04	0.02	0.21	3.67	1.96	99.41
stdev	0.37	0.02	0.09	0.06	0.02	0.20	0.41	0.02	0.02	0.02	0.50	0.45	0.34
312	52.44	0.03	2.77	0.40	0.15	15.93	22.08	0.07	0.03	0.23	4.77	1.03	99.92
312	52.56	0.10	3.02	0.43	0.15	15.80	22.30	0.04	0.00	0.24	4.93	0.71	100.28
312	52.00	0.12	2.94	0.43	0.17	15.83	22.06	0.04	0.01	0.22	4.60	0.91	99.33
312	52.76	0.19	2.78	0.41	0.21	16.05	22.33	0.05	0.01	0.21	4.83	0.83	100.66
312	52.21	0.11	2.84	0.44	0.14	15.89	22.10	0.00	0.01	0.21	4.80	0.91	99.66
312	52.19	0.22	3.10	0.34	0.12	16.05	22.30	0.07	0.04	0.20	4.30	1.17	100.11
312	51.85	0.14	2.84	0.41	0.13	15.98	22.02	0.04	0.01	0.21	4.31	1.40	99.34
312	52.01	0.10	3.10	0.40	0.17	16.11	21.97	0.08	0.02	0.20	4.26	1.08	99.50
312	52.46	0.11	2.93	0.37	0.16	15.92	22.36	0.07	0.01	0.24	4.49	0.87	99.99
312	52.70	0.14	2.79	0.34	0.17	15.96	22.21	0.05	0.02	0.22	5.01	0.39	100.00
312	52.59	0.20	2.89	0.41	0.19	15.78	22.47	0.01	0.05	0.21	4.96	0.43	100.19
avg(11)	52.39	0.13	2.90	0.39	0.17	15.97	22.16	0.05	0.02	0.22	4.68	0.87	99.95
stdev	0.33	0.05	0.12	0.03	0.03	0.14	0.19	0.03	0.02	0.01	0.28	0.28	0.42
311	52.40	0.11	2.61	0.38	0.14	15.79	22.25	0.00	0.01	0.19	5.11	0.58	99.57
311	52.58	0.17	2.72	0.36	0.19	16.11	21.38	0.03	0.04	0.21	5.61	0.00	99.40
311	52.97	0.12	2.61	0.40	0.18	17.25	19.89	0.00	0.01	0.18	6.22	0.51	100.34
311	53.00	0.22	2.68	0.41	0.13	16.23	21.93	0.00	0.09	0.17	5.53	0.00	100.39
311	51.72	0.12	2.69	0.36	0.14	16.08	22.08	0.09	0.03	0.20	3.85	2.10	99.46
311	52.44	0.23	2.67	0.36	0.14	16.06	22.10	0.08	0.00	0.20	4.86	0.98	100.12
311	52.52	0.16	2.84	0.46	0.15	16.01	22.07	0.02	0.00	0.22	4.97	0.65	100.08
311	51.85	0.06	3.55	1.27	0.16	15.29	22.20	0.06	0.05	0.26	4.92	0.51	100.18
311	51.47	0.15	3.44	1.01	0.15	15.45	22.04	0.05	0.00	0.24	4.62	0.80	99.42

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
311	52.67	0.13	2.79	0.41	0.12	16.26	21.80	0.02	0.04	0.19	5.16	0.76	100.35
311	52.38	0.15	2.72	0.40	0.18	15.84	22.20	0.03	0.00	0.21	4.94	0.56	99.61
311	52.70	0.15	2.68	0.35	0.25	17.32	19.86	0.03	0.01	0.20	5.65	1.42	100.62
311	52.09	0.18	2.76	0.39	0.18	16.67	21.11	0.00	0.03	0.24	4.40	1.28	99.33
avg(13)	52.37	0.15	2.83	0.50	0.16	16.18	21.61	0.03	0.02	0.21	5.08	0.77	99.91
stdev	0.45	0.04	0.29	0.28	0.03	0.58	0.81	0.03	0.03	0.02	0.58	0.55	0.44
308	51.74	0.19	2.51	0.47	0.18	16.25	21.06	0.00	0.00	0.17	5.16	1.59	99.32
308	51.94	0.14	2.55	0.51	0.18	16.26	21.24	0.03	0.00	0.20	4.93	2.22	100.20
308	51.68	0.18	2.79	0.56	0.17	15.59	22.42	0.00	0.00	0.23	4.24	1.89	99.75
308	51.90	0.12	2.76	0.64	0.22	16.10	21.18	0.02	0.00	0.23	5.06	2.03	100.26
308	51.85	0.10	2.56	0.51	0.18	16.26	20.82	0.08	0.05	0.17	5.37	0.93	98.88
308	51.92	0.17	2.79	0.51	0.18	15.77	21.60	0.10	0.01	0.19	5.32	1.02	99.58
308	51.72	0.13	2.66	0.50	0.16	15.69	22.05	0.03	0.00	0.22	4.57	1.61	99.34
308	52.80	0.17	1.69	0.31	0.18	15.71	23.21	0.04	0.04	0.12	4.77	0.68	99.72
308	51.61	0.22	2.67	0.51	0.18	15.55	22.22	0.10	0.01	0.23	4.40	1.70	99.40
308	51.84	0.12	2.66	0.42	0.20	15.60	22.21	0.08	0.01	0.17	4.79	1.29	99.39
308	51.80	0.12	2.70	0.54	0.17	15.97	20.97	0.03	0.00	0.24	5.43	1.16	99.14
308	51.76	0.12	2.72	0.59	0.12	15.49	22.26	0.01	0.03	0.22	4.72	0.97	99.02
308	51.93	0.13	2.59	0.50	0.15	15.74	22.59	0.04	0.02	0.23	3.97	2.19	100.08
308	52.11	0.15	2.63	0.48	0.18	15.69	22.33	0.05	0.05	0.22	4.60	1.16	99.66
avg(13)	51.90	0.15	2.59	0.50	0.18	15.83	21.87	0.04	0.02	0.20	4.83	1.44	99.54
stdev	0.28	0.03	0.26	0.07	0.02	0.27	0.70	0.03	0.02	0.03	0.42	0.48	0.41
306	51.34	0.11	2.71	0.53	0.16	15.93	21.07	0.04	0.00	0.22	4.91	1.48	98.50
306	51.61	0.17	2.78	0.55	0.15	15.71	21.53	0.00	0.00	0.22	5.14	0.70	98.56
306	51.76	0.02	2.67	0.56	0.19	15.97	20.89	0.03	0.04	0.18	5.62	0.84	98.77
306	51.54	0.19	2.78	0.62	0.18	16.06	21.12	0.06	0.00	0.26	4.70	1.46	98.98
306	51.47	0.15	2.75	0.46	0.22	15.90	21.65	0.03	0.00	0.27	4.13	1.97	99.00
306	51.88	0.13	2.72	0.33	0.18	15.74	21.80	0.00	0.00	0.23	4.95	0.62	98.58
306	51.60	0.18	2.71	0.46	0.19	16.36	20.80	0.07	0.00	0.21	4.85	1.77	99.21
306	51.63	0.20	2.65	0.49	0.14	15.59	21.96	0.00	0.02	0.22	4.85	0.93	98.67
306	51.67	0.14	2.79	0.65	0.19	16.26	20.41	0.09	0.00	0.22	5.51	1.16	99.10
306	51.78	0.16	2.79	0.66	0.20	16.41	20.19	0.08	0.00	0.24	5.58	1.19	99.28
306	51.09	0.10	2.94	0.60	0.23	15.78	21.11	0.03	0.00	0.26	4.57	1.30	98.01
avg(10)	51.58	0.14	2.75	0.54	0.18	15.97	21.14	0.04	0.00	0.23	5.00	1.20	98.77
stdev	0.21	0.05	0.07	0.09	0.03	0.26	0.53	0.03	0.01	0.02	0.44	0.41	0.36
303	52.12	0.15	2.84	0.46	0.16	15.86	21.42	0.01	0.01	0.21	5.62	1.48	100.34
303	52.37	0.18	2.88	0.58	0.24	15.70	21.75	0.01	0.01	0.18	5.87	0.75	100.53
303	52.59	0.16	2.27	0.49	0.19	15.64	22.86	0.06	0.00	0.17	4.86	0.29	99.58
303	52.05	0.10	2.62	0.43	0.14	15.25	22.18	0.13	0.00	0.21	5.52	0.94	99.57
303	51.96	0.11	2.77	0.48	0.23	15.84	21.81	0.04	0.00	0.21	4.84	1.99	100.28
303	52.43	0.18	2.97	0.50	0.20	15.54	21.87	0.07	0.04	0.19	5.98	0.69	100.66
303	51.78	0.10	2.73	0.45	0.22	15.90	21.24	0.00	0.03	0.20	5.31	1.94	99.89
303	52.24	0.14	2.91	0.45	0.20	15.26	22.43	0.03	0.00	0.21	5.48	0.83	100.18
303	52.58	0.17	2.91	0.53	0.22	15.44	21.95	0.03	0.01	0.20	6.23	0.52	100.79
303	51.85	0.19	2.96	0.54	0.18	15.67	21.49	0.03	0.02	0.22	5.49	1.49	100.13
303	52.06	0.28	2.73	0.50	0.19	15.50	22.74	0.02	0.05	0.19	4.63	1.34	100.23
303	51.66	0.13	2.80	0.46	0.17	15.58	21.67	0.09	0.04	0.22	5.07	1.58	99.47
303	51.92	0.15	2.89	0.55	0.16	15.58	21.96	0.07	0.01	0.19	5.23	1.69	100.40
303	52.26	0.10	2.63	0.50	0.22	15.95	22.25	0.09	0.02	0.16	4.61	1.61	100.39
303	52.33	0.14	2.94	0.46	0.19	15.59	21.96	0.06	0.00	0.20	5.63	1.01	100.51
303	52.14	0.17	2.86	0.47	0.19	15.54	21.86	0.00	0.03	0.23	5.54	1.40	100.43
303	52.02	0.18	3.09	0.50	0.19	16.01	21.50	0.08	0.01	0.22	5.02	1.07	99.89
303	50.79	0.18	3.47	0.52	0.22	16.33	20.95	0.05	0.06	0.20	3.72	2.60	99.09
avg(17)	52.06	0.16	2.85	0.49	0.20	15.68	21.88	0.05	0.02	0.20	5.26	1.29	100.13
stdev	0.40	0.04	0.23	0.04	0.03	0.26	0.48	0.03	0.02	0.02	0.58	0.57	0.45
Cycle 9													
56	52.08	0.19	2.29	0.36	0.21	16.15	21.96	0.04	0.03	0.17	4.49	1.67	99.64
56	51.90	0.18	2.96	0.46	0.19	15.52	21.59	0.02	0.00	0.22	5.70	0.78	99.52
56	51.17	0.15	3.16	0.70	0.19	15.30	21.81	0.00	0.04	0.23	4.84	1.59	99.18
56	51.49	0.11	3.11	0.64	0.19	15.62	21.89	0.07	0.03	0.19	4.64	1.40	99.38
56	51.83	0.07	2.88	0.57	0.18	15.71	21.65	0.03	0.01	0.23	5.05	1.33	99.53
56	51.48	0.15	2.88	0.51	0.13	16.06	20.84	0.00	0.00	0.24	5.15	2.01	99.45
56	52.74	0.14	2.33	0.29	0.24	16.35	21.52	0.06	0.03	0.22	5.16	1.31	100.39
56	51.51	0.12	3.07	0.64	0.18	16.67	19.72	0.00	0.01	0.24	5.45	2.49	100.10
avg(8)	51.78	0.14	2.83	0.52	0.19	15.92	21.37	0.03	0.02	0.22	5.06	1.58	99.66
stdev	0.45	0.04	0.32	0.14	0.03	0.43	0.70	0.03	0.01	0.02	0.38	0.48	0.37

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
						Cycle 8							
246	51.03	0.15	2.96	0.36	0.17	15.73	20.98	0.05	0.02	0.44	3.99	3.57	99.45
246	50.93	0.12	2.89	0.30	0.22	15.43	21.40	0.04	0.02	0.44	3.80	3.36	98.95
246	50.85	0.12	3.12	0.35	0.14	15.37	20.88	0.06	0.04	0.46	4.43	3.10	98.92
246	51.77	0.20	2.74	0.36	0.22	15.49	21.55	0.00	0.03	0.46	4.51	2.47	99.81
246	51.21	0.06	2.85	0.38	0.18	15.40	21.13	0.08	0.07	0.47	4.29	2.94	99.06
246	51.06	0.13	2.95	0.39	0.17	15.41	21.70	0.04	0.00	0.44	3.69	3.27	99.25
246	51.45	0.17	3.05	0.32	0.21	15.77	20.62	0.03	0.00	0.44	4.90	2.58	99.54
246	50.51	0.16	2.81	0.53	0.18	15.35	22.13	0.06	0.00	0.44	2.58	4.21	98.96
246	51.42	0.09	2.96	0.42	0.22	15.52	21.22	0.01	0.00	0.47	4.34	2.78	99.45
246	50.89	0.10	2.99	0.36	0.23	15.20	22.16	0.04	0.02	0.51	2.84	4.18	99.52
246	51.16	0.16	2.75	0.38	0.19	15.30	22.02	0.00	0.00	0.41	3.78	2.96	99.11
246	50.52	0.19	2.98	0.40	0.13	15.68	20.96	0.02	0.03	0.42	3.68	3.70	98.71
246	50.87	0.21	2.93	0.43	0.18	15.87	20.72	0.00	0.00	0.43	4.04	3.02	98.70
246	50.39	0.12	2.99	0.38	0.21	15.45	21.47	0.02	0.04	0.34	3.50	3.49	98.40
avg(14)	51.00	0.14	2.93	0.38	0.19	15.50	21.35	0.03	0.02	0.44	3.88	3.27	99.13
stdev	0.37	0.04	0.10	0.05	0.03	0.19	0.49	0.02	0.02	0.04	0.61	0.51	0.38
245	51.19	0.12	3.03	0.46	0.23	15.42	21.50	0.04	0.04	0.44	3.97	3.23	99.67
245	50.70	0.17	2.99	0.54	0.15	15.54	21.37	0.05	0.07	0.49	3.19	4.61	99.87
245	50.74	0.20	3.03	0.46	0.21	15.50	21.15	0.09	0.01	0.43	3.86	3.89	99.57
245	50.80	0.22	3.12	0.53	0.16	15.17	21.93	0.08	0.07	0.49	3.26	3.85	99.69
245	51.15	0.12	3.00	0.47	0.16	15.45	21.42	0.06	0.02	0.38	4.32	3.20	99.75
245	50.75	0.25	2.99	0.47	0.17	15.20	21.78	0.00	0.03	0.39	3.94	3.34	99.30
245	51.94	0.17	2.99	0.48	0.18	16.68	18.95	0.08	0.02	0.32	6.52	1.70	100.03
245	50.94	0.19	3.10	0.53	0.23	15.26	21.37	0.00	0.00	0.40	4.45	2.88	99.35
245	50.90	0.13	3.11	0.47	0.18	15.44	21.75	0.06	0.01	0.43	3.38	4.01	99.87
245	51.28	0.20	2.95	0.42	0.14	15.05	21.78	0.07	0.00	0.40	4.74	2.48	99.51
245	51.06	0.19	2.92	0.45	0.22	15.89	20.58	0.11	0.00	0.44	4.20	3.66	99.72
245	51.48	0.18	2.99	0.43	0.23	15.55	21.02	0.02	0.07	0.42	4.84	2.40	99.63
245	50.65	0.20	3.05	0.47	0.20	15.49	21.20	0.00	0.00	0.45	3.72	3.24	98.66
avg(13)	51.05	0.18	3.02	0.47	0.19	15.51	21.21	0.05	0.03	0.42	4.20	3.24	99.57
stdev	0.35	0.04	0.06	0.04	0.03	0.39	0.74	0.04	0.03	0.04	0.84	0.75	0.33
244	51.43	0.10	2.80	0.32	0.18	15.46	20.94	0.00	0.00	0.41	5.15	2.44	99.23
244	51.92	0.14	2.77	0.38	0.21	15.16	21.79	0.03	0.06	0.45	4.92	1.87	99.70
244	52.08	0.13	2.77	0.31	0.28	15.99	20.26	0.02	0.05	0.37	5.90	1.67	99.83
244	51.86	0.13	2.88	0.37	0.21	15.50	21.45	0.09	0.00	0.41	4.85	2.10	99.85
244	52.21	0.17	2.82	0.33	0.20	15.43	21.70	0.01	0.03	0.45	4.98	2.11	100.44
244	52.16	0.12	2.82	0.33	0.18	15.57	21.23	0.01	0.03	0.42	5.39	1.45	99.72
244	51.80	0.20	2.86	0.29	0.21	15.45	21.68	0.09	0.05	0.49	4.22	3.06	100.40
244	51.98	0.12	2.77	0.30	0.18	15.91	20.62	0.03	0.00	0.33	5.78	1.80	99.82
244	51.96	0.20	3.01	0.29	0.18	15.44	21.59	0.04	0.02	0.36	5.25	2.00	100.34
244	52.03	0.14	2.92	0.31	0.20	15.19	22.07	0.04	0.03	0.47	4.57	2.37	100.35
244	51.65	0.16	2.92	0.35	0.17	15.59	21.50	0.08	0.00	0.38	4.59	3.02	100.41
244	51.92	0.19	2.97	0.35	0.18	15.38	21.62	0.03	0.05	0.47	4.74	2.83	100.72
244	52.16	0.18	2.94	0.33	0.18	15.48	21.64	0.04	0.00	0.39	5.22	2.12	100.68
244	51.87	0.07	2.86	0.30	0.21	15.19	21.75	0.10	0.02	0.41	4.95	2.31	100.04
244	51.84	0.27	2.88	0.35	0.28	15.44	21.49	0.00	0.00	0.46	4.79	2.23	100.03
avg(15)	51.92	0.15	2.86	0.33	0.20	15.48	21.42	0.04	0.02	0.42	5.01	2.23	100.08
stdev	0.20	0.05	0.07	0.03	0.03	0.22	0.46	0.03	0.02	0.04	0.43	0.45	0.40
241	51.25	0.14	2.95	0.36	0.13	15.65	21.18	0.07	0.00	0.40	4.36	3.19	99.68
241	50.83	0.18	3.09	0.38	0.18	15.72	21.04	0.03	0.00	0.36	4.12	3.22	99.15
241	51.48	0.17	2.96	0.38	0.16	15.79	20.98	0.03	0.02	0.44	4.47	2.59	99.47
241	51.34	0.09	2.96	0.31	0.16	15.88	20.82	0.00	0.04	0.41	4.42	3.11	99.54
241	51.98	0.13	2.97	0.41	0.23	15.62	21.73	0.00	0.02	0.37	4.66	2.68	100.80
241	50.88	0.04	3.12	0.32	0.23	15.10	21.83	0.03	0.07	0.47	3.52	3.41	99.02
241	51.36	0.14	3.02	0.26	0.17	15.51	22.08	0.00	0.00	0.41	3.57	3.96	100.48
241	51.40	0.17	3.13	0.40	0.17	16.02	20.61	0.01	0.08	0.38	4.67	2.83	99.86
241	50.86	0.16	2.95	0.38	0.16	15.67	21.02	0.01	0.00	0.35	4.34	2.92	98.81
241	50.88	0.07	2.93	0.38	0.18	15.47	21.67	0.00	0.00	0.43	3.42	3.61	99.04
avg(10)	51.23	0.13	3.01	0.36	0.18	15.64	21.30	0.02	0.02	0.40	4.17	3.14	99.59
stdev	0.35	0.04	0.07	0.04	0.03	0.24	0.47	0.02	0.03	0.04	0.45	0.40	0.62
240	51.00	0.29	3.13	0.39	0.19	15.75	20.95	0.08	0.02	0.31	4.64	3.20	99.95
240	50.21	0.18	3.14	0.48	0.15	16.07	20.37	0.05	0.00	0.43	3.30	4.66	99.04
240	51.33	0.18	3.07	0.41	0.18	17.10	18.66	0.05	0.00	0.37	5.24	3.57	100.16
240	51.20	0.20	2.38	0.46	0.22	15.57	21.97	0.03	0.00	0.35	3.66	3.31	99.35
240	50.69	0.21	3.12	0.44	0.25	15.64	21.36	0.00	0.00	0.42	3.39	4.09	99.61

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
240	51.49	0.14	3.17	0.42	0.19	15.83	20.89	0.04	0.01	0.48	4.28	3.43	100.37
240	51.11	0.25	3.21	0.48	0.18	15.09	21.83	0.08	0.03	0.44	4.18	2.76	99.64
240	50.97	0.18	3.03	0.45	0.18	15.47	21.60	0.00	0.03	0.37	3.97	3.29	99.54
240	51.12	0.13	3.02	0.38	0.18	15.49	21.31	0.01	0.00	0.38	4.41	2.98	99.41
avg(9)	51.01	0.19	3.03	0.43	0.19	15.78	20.99	0.04	0.01	0.39	4.13	3.47	99.66
stdev	0.36	0.05	0.24	0.03	0.03	0.53	0.95	0.03	0.01	0.05	0.58	0.55	0.39
239	50.82	0.15	3.03	0.43	0.16	15.60	21.67	0.02	0.00	0.39	3.38	3.86	99.51
239	50.96	0.25	3.25	0.48	0.20	15.64	21.46	0.00	0.00	0.38	3.86	3.68	100.16
239	50.98	0.21	3.23	0.53	0.19	15.44	21.86	0.00	0.02	0.45	3.36	3.79	100.06
239	50.67	0.18	3.23	0.29	0.20	15.81	21.37	0.04	0.02	0.35	3.34	4.38	99.88
239	51.48	0.12	3.07	0.41	0.18	15.44	21.97	0.08	0.00	0.42	3.82	3.31	100.30
239	51.05	0.18	3.09	0.43	0.15	15.43	22.13	0.09	0.04	0.46	2.97	4.16	100.19
239	51.64	0.14	3.03	0.39	0.20	16.15	20.64	0.03	0.05	0.38	4.64	3.04	100.32
239	51.32	0.11	3.03	0.30	0.17	15.56	21.84	0.03	0.02	0.38	3.80	3.60	100.16
239	51.17	0.29	3.18	0.42	0.16	15.24	22.17	0.06	0.00	0.43	3.70	3.32	100.14
239	51.27	0.14	3.21	0.31	0.15	15.21	22.02	0.00	0.04	0.40	4.10	3.16	100.01
239	51.60	0.15	3.16	0.34	0.19	15.57	21.42	0.04	0.05	0.42	4.45	2.81	100.20
239	52.10	0.24	2.16	0.15	0.18	16.08	22.47	0.02	0.06	0.32	3.36	3.13	100.26
avg(12)	51.25	0.18	3.05	0.37	0.18	15.60	21.75	0.03	0.03	0.40	3.71	3.54	100.09
stdev	0.39	0.05	0.28	0.10	0.02	0.28	0.46	0.03	0.02	0.04	0.47	0.45	0.21
238	51.57	0.13	3.08	0.32	0.18	15.13	22.35	0.01	0.00	0.38	4.26	2.50	99.91
238	51.42	0.25	3.01	0.29	0.19	15.27	22.23	0.05	0.05	0.39	3.95	2.93	100.03
238	51.47	0.22	3.07	0.32	0.25	15.54	21.37	0.04	0.03	0.36	4.71	2.65	100.02
238	51.42	0.19	3.00	0.32	0.16	16.36	20.19	0.00	0.05	0.37	4.74	3.33	100.12
238	51.63	0.27	3.16	0.30	0.15	15.40	22.08	0.03	0.01	0.46	3.95	2.74	100.18
238	51.40	0.21	3.05	0.35	0.21	15.42	21.80	0.01	0.01	0.44	4.00	3.19	100.09
238	51.81	0.18	3.04	0.29	0.21	15.31	22.11	0.04	0.01	0.46	4.14	2.66	100.26
238	51.50	0.21	2.97	0.31	0.17	15.47	21.81	0.01	0.03	0.42	4.13	2.98	100.01
238	51.19	0.09	2.98	0.20	0.21	15.72	21.72	0.02	0.00	0.42	3.30	3.64	99.48
238	51.61	0.17	2.70	0.30	0.15	16.13	20.87	0.00	0.05	0.36	4.54	2.89	99.77
238	51.49	0.21	3.12	0.29	0.22	15.28	22.39	0.00	0.00	0.41	3.75	3.08	100.24
238	51.36	0.20	3.22	0.42	0.24	15.51	21.61	0.04	0.00	0.42	4.07	3.12	100.20
238	51.02	0.14	3.08	0.32	0.19	15.72	21.36	0.07	0.01	0.38	3.75	3.55	99.58
238	51.52	0.10	3.07	0.31	0.17	15.69	21.34	0.02	0.06	0.42	4.22	2.84	99.76
238	50.97	0.02	3.11	0.42	0.18	15.81	21.04	0.05	0.00	0.44	3.59	3.94	99.57
avg(15)	51.43	0.17	3.04	0.32	0.19	15.58	21.62	0.03	0.02	0.41	4.07	3.07	99.95
stdev	0.22	0.06	0.11	0.05	0.03	0.32	0.59	0.02	0.02	0.03	0.38	0.39	0.25
237	51.69	0.18	2.57	0.05	0.17	15.85	20.95	0.02	0.04	0.33	5.15	1.72	98.72
237	51.69	0.10	2.50	0.02	0.22	16.53	20.43	0.10	0.00	0.30	4.58	2.12	98.59
237	51.91	0.06	2.48	0.04	0.16	15.72	22.04	0.02	0.02	0.37	3.98	2.56	99.37
237	51.67	0.18	2.53	0.04	0.17	16.07	21.36	0.00	0.03	0.40	3.91	3.18	99.55
237	51.94	0.06	2.55	0.04	0.16	15.75	21.80	0.09	0.00	0.41	4.04	2.52	99.36
237	52.45	0.13	2.55	0.03	0.24	15.99	21.50	0.06	0.07	0.40	4.60	2.39	100.41
237	51.47	0.20	2.53	0.02	0.19	15.61	22.25	0.00	0.00	0.34	3.66	2.79	99.06
237	51.83	0.15	2.47	0.06	0.19	16.08	21.53	0.01	0.01	0.35	4.06	3.09	99.83
237	51.78	0.20	2.46	0.02	0.19	16.64	20.44	0.00	0.07	0.28	4.72	2.51	99.31
237	51.38	0.15	2.42	0.00	0.17	16.42	20.67	0.00	0.00	0.33	4.15	3.33	99.02
237	52.02	0.13	2.49	0.06	0.14	15.57	22.20	0.03	0.06	0.40	4.08	2.65	99.83
237	51.80	0.14	2.60	0.03	0.19	15.76	21.69	0.09	0.00	0.41	4.04	2.84	99.58
237	51.94	0.12	2.56	0.03	0.25	15.95	21.53	0.00	0.04	0.37	4.23	2.85	99.87
237	50.94	0.09	2.59	0.03	0.19	15.94	21.39	0.03	0.00	0.34	3.41	3.99	98.94
237	51.92	0.21	2.09	0.06	0.21	16.02	21.73	0.03	0.00	0.34	4.09	2.95	99.66
237	51.93	0.13	2.68	0.03	0.16	15.58	21.83	0.04	0.00	0.38	4.55	2.27	99.58
avg(16)	51.77	0.14	2.51	0.03	0.19	15.97	21.46	0.03	0.02	0.36	4.19	2.75	99.43
stdev	0.32	0.05	0.12	0.02	0.03	0.32	0.55	0.03	0.03	0.04	0.41	0.51	0.46
236	52.22	0.20	2.55	0.08	0.17	15.77	21.64	0.00	0.00	0.35	5.03	1.78	99.79
236	52.11	0.13	2.44	0.08	0.25	16.70	20.08	0.00	0.03	0.26	5.48	2.76	100.32
236	52.17	0.15	2.51	0.01	0.20	15.99	21.44	0.05	0.05	0.29	4.94	2.36	100.16
236	51.98	0.16	2.59	0.05	0.19	15.85	22.04	0.02	0.02	0.33	4.08	3.06	100.38
236	52.03	0.11	2.44	0.03	0.20	15.70	22.29	0.05	0.00	0.34	3.98	2.65	99.81
236	51.93	0.15	2.57	0.00	0.24	15.77	22.02	0.06	0.04	0.38	3.84	3.19	100.19
236	51.70	0.14	2.47	0.02	0.19	16.36	20.63	0.07	0.00	0.33	4.60	2.76	99.27
236	52.09	0.11	2.52	0.05	0.22	16.90	19.82	0.07	0.05	0.31	5.13	3.07	100.34
236	51.88	0.18	2.49	0.03	0.19	15.91	21.62	0.02	0.08	0.39	4.08	3.28	100.15
236	52.19	0.17	2.56	0.05	0.18	16.29	21.04	0.04	0.00	0.37	4.66	2.55	100.11
236	52.18	0.08	2.68	0.07	0.17	15.65	22.05	0.00	0.00	0.40	4.33	2.91	100.52

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
236	52.10	0.15	2.47	0.06	0.20	15.59	22.09	0.03	0.00	0.39	4.34	2.58	100.00
avg(12)	52.05	0.14	2.52	0.04	0.20	16.04	21.40	0.03	0.02	0.34	4.56	2.72	100.06
stdev	0.15	0.03	0.07	0.03	0.02	0.41	0.79	0.03	0.03	0.04	0.50	0.39	0.32
235	52.93	0.16	2.53	0.02	0.22	16.53	20.73	0.02	0.04	0.30	5.77	0.87	100.13
235	53.27	0.05	2.42	0.03	0.23	15.84	22.50	0.06	0.03	0.37	4.68	1.50	100.98
235	52.66	0.11	2.40	0.03	0.15	15.78	22.02	0.03	0.00	0.40	4.73	1.45	99.75
235	53.25	0.19	2.55	0.00	0.25	16.52	20.69	0.05	0.03	0.34	6.02	1.08	100.97
235	53.11	0.17	2.46	0.11	0.20	16.83	20.71	0.05	0.00	0.35	5.29	1.91	101.19
235	53.25	0.13	2.32	0.10	0.26	17.25	19.61	0.01	0.00	0.27	6.43	1.40	101.03
235	53.86	0.13	2.11	0.07	0.21	15.93	21.88	0.02	0.00	0.34	6.32	0.00	100.87
235	52.99	0.15	2.56	0.05	0.18	16.05	21.31	0.00	0.00	0.30	6.05	0.48	100.12
235	52.65	0.12	2.56	0.00	0.29	16.00	21.36	0.00	0.02	0.33	5.37	0.79	99.49
235	52.82	0.15	2.50	0.01	0.23	16.28	21.40	0.00	0.00	0.32	5.18	1.75	100.64
235	52.90	0.04	2.46	0.06	0.21	16.09	21.47	0.01	0.00	0.37	5.20	1.41	100.22
235	52.95	0.20	2.49	0.01	0.16	15.64	22.16	0.10	0.00	0.41	5.10	1.30	100.52
avg(12)	53.05	0.13	2.45	0.04	0.22	16.23	21.32	0.03	0.01	0.34	5.51	1.16	100.49
stdev	0.32	0.05	0.12	0.04	0.04	0.45	0.76	0.03	0.01	0.04	0.57	0.52	0.52
234	53.05	0.08	2.48	0.04	0.20	15.90	21.67	0.04	0.00	0.30	5.81	0.69	100.26
234	52.99	0.13	2.49	0.03	0.20	16.13	21.40	0.05	0.03	0.32	5.58	1.04	100.39
234	52.91	0.18	2.41	0.09	0.23	16.40	20.95	0.03	0.00	0.36	5.46	1.70	100.72
234	52.28	0.21	2.51	0.06	0.22	15.72	22.03	0.04	0.05	0.29	4.84	1.57	99.82
234	53.03	0.08	2.48	0.09	0.17	15.91	21.76	0.01	0.00	0.30	5.70	1.11	100.64
234	53.32	0.11	2.30	0.05	0.21	16.51	20.48	0.05	0.00	0.34	6.39	0.17	99.93
234	52.77	0.21	2.57	0.08	0.14	15.51	22.46	0.01	0.09	0.25	5.51	0.70	100.30
234	53.12	0.12	2.36	0.05	0.26	16.90	19.58	0.00	0.07	0.30	6.73	0.20	99.69
234	53.23	0.07	2.44	0.00	0.14	16.61	20.39	0.03	0.00	0.31	6.41	0.63	100.26
234	53.54	0.18	2.41	0.04	0.17	15.88	21.97	0.00	0.05	0.40	5.69	0.59	100.92
234	52.74	0.16	2.54	0.09	0.17	15.69	22.15	0.10	0.04	0.28	5.29	0.92	100.17
234	53.41	0.21	2.46	0.07	0.14	17.27	19.34	0.04	0.05	0.26	7.09	0.41	100.75
234	53.05	0.11	2.45	0.00	0.17	15.63	22.55	0.02	0.00	0.33	5.09	0.87	100.28
234	53.24	0.24	2.30	0.06	0.22	15.88	22.30	0.08	0.02	0.34	5.14	1.10	100.92
234	52.82	0.22	2.56	0.05	0.19	15.64	22.23	0.09	0.04	0.35	5.09	1.02	100.30
avg(15)	53.03	0.15	2.45	0.05	0.19	16.11	21.42	0.04	0.03	0.32	5.68	0.90	100.37
stdev	0.30	0.06	0.08	0.03	0.03	0.50	1.00	0.03	0.03	0.04	0.64	0.42	0.36
233	52.28	0.13	2.41	0.13	0.18	17.36	18.83	0.00	0.07	0.32	5.86	2.39	99.96
233	52.53	0.10	2.51	0.07	0.14	15.72	21.97	0.05	0.05	0.33	5.00	1.42	99.89
233	52.59	0.20	2.60	0.07	0.22	15.62	22.15	0.03	0.00	0.30	5.24	1.27	100.29
233	52.44	0.22	2.50	0.13	0.16	15.55	22.43	0.02	0.01	0.36	4.62	1.53	99.97
233	53.50	0.08	2.53	0.12	0.16	16.25	21.07	0.07	0.00	0.32	6.41	0.44	100.94
233	52.95	0.08	2.49	0.10	0.22	15.79	22.05	0.07	0.01	0.31	5.29	0.89	100.25
233	52.57	0.17	2.81	0.12	0.21	15.58	21.99	0.01	0.00	0.39	5.07	1.64	100.56
233	52.73	0.15	2.55	0.12	0.17	15.72	21.98	0.00	0.02	0.34	5.27	1.35	100.41
233	53.13	0.06	2.53	0.08	0.19	16.69	20.19	0.00	0.00	0.31	6.37	0.68	100.23
233	53.12	0.13	2.55	0.15	0.17	15.90	21.47	0.01	0.05	0.29	6.25	0.41	100.49
233	53.14	0.15	2.50	0.13	0.14	15.52	22.10	0.04	0.00	0.34	5.98	0.46	100.50
233	53.12	0.23	2.44	0.12	0.21	15.75	22.15	0.07	0.00	0.43	5.03	1.56	101.12
avg(12)	52.84	0.14	2.54	0.11	0.18	15.95	21.53	0.03	0.02	0.34	5.52	1.19	100.39
stdev	0.34	0.05	0.09	0.02	0.03	0.51	0.96	0.03	0.02	0.04	0.56	0.56	0.35
232	51.79	0.12	2.46	0.11	0.22	15.79	21.87	0.04	0.00	0.34	4.07	2.76	99.57
232	51.97	0.03	2.49	0.08	0.20	16.21	21.03	0.06	0.05	0.29	4.71	2.20	99.32
232	51.54	0.12	2.45	0.10	0.21	15.74	21.99	0.02	0.04	0.35	3.65	3.27	99.48
232	51.59	0.17	2.36	0.15	0.20	15.76	22.17	0.04	0.03	0.31	3.67	2.72	99.17
232	51.58	0.06	2.53	0.08	0.19	16.82	19.98	0.05	0.01	0.30	4.55	3.29	99.44
232	51.51	0.16	2.54	0.14	0.23	16.92	19.47	0.01	0.00	0.24	5.31	2.30	98.83
232	51.69	0.17	2.39	0.15	0.21	15.80	21.94	0.08	0.01	0.32	3.94	2.90	99.60
232	51.44	0.07	2.23	0.07	0.17	16.17	21.48	0.03	0.00	0.36	3.39	3.60	99.01
232	51.54	0.10	2.59	0.12	0.22	16.20	21.74	0.00	0.02	0.31	3.34	3.22	99.40
232	51.40	0.18	2.44	0.15	0.14	15.97	22.23	0.04	0.01	0.30	3.13	3.69	99.68
232	52.05	0.17	2.40	0.09	0.17	16.23	21.41	0.00	0.01	0.32	4.40	2.66	99.91
avg(11)	51.65	0.12	2.44	0.11	0.20	16.15	21.39	0.03	0.02	0.31	4.02	2.95	99.40
stdev	0.20	0.05	0.09	0.03	0.03	0.39	0.86	0.02	0.02	0.03	0.64	0.47	0.29
231	52.44	0.13	2.76	0.19	0.20	15.99	21.96	0.09	0.01	0.39	4.11	2.09	100.36
231	52.53	0.08	2.64	0.14	0.14	16.36	21.18	0.03	0.04	0.34	4.84	2.08	100.40
231	52.33	0.15	2.70	0.19	0.16	16.70	20.68	0.03	0.04	0.35	4.63	2.85	100.80
231	52.31	0.19	2.68	0.20	0.20	17.03	19.73	0.03	0.00	0.29	5.55	1.68	99.89
231	52.51	0.13	2.64	0.19	0.18	16.06	22.09	0.06	0.05	0.41	3.82	2.64	100.78

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
231	52.48	0.16	2.75	0.22	0.22	15.85	22.30	0.02	0.05	0.40	3.96	2.30	100.71
231	52.41	0.20	2.70	0.22	0.24	15.85	22.39	0.04	0.04	0.37	3.91	2.42	100.79
231	52.37	0.24	2.66	0.19	0.22	17.00	19.71	0.01	0.00	0.33	5.55	1.82	100.10
231	52.20	0.17	2.59	0.24	0.17	16.20	21.07	0.00	0.00	0.29	5.22	1.68	99.83
231	52.41	0.17	2.69	0.21	0.12	16.56	20.63	0.00	0.00	0.31	5.35	1.44	99.89
231	52.66	0.20	2.58	0.21	0.19	16.68	20.26	0.03	0.04	0.31	5.79	1.33	100.28
231	51.71	0.23	2.84	0.19	0.21	15.77	21.56	0.03	0.02	0.37	4.36	2.34	99.63
231	52.04	0.15	2.56	0.20	0.19	16.30	21.09	0.06	0.04	0.30	4.64	2.32	99.89
avg(13)	52.34	0.17	2.68	0.20	0.19	16.33	21.13	0.03	0.03	0.34	4.75	2.08	100.26
stdev	0.23	0.04	0.08	0.02	0.03	0.41	0.87	0.02	0.02	0.04	0.66	0.44	0.40
230	52.98	0.13	2.84	0.10	0.13	17.09	19.90	0.04	0.00	0.34	5.80	1.94	101.28
230	52.23	0.24	2.51	0.17	0.19	15.47	23.21	0.00	0.01	0.31	3.75	1.94	100.03
230	52.83	0.19	2.61	0.20	0.18	15.80	22.57	0.00	0.01	0.39	4.30	2.11	101.19
230	53.18	0.17	2.64	0.16	0.17	17.07	21.25	0.02	0.03	0.31	4.47	2.43	101.89
230	52.92	0.21	2.69	0.17	0.20	16.57	21.71	0.01	0.04	0.38	4.14	2.81	101.85
230	53.28	0.19	2.68	0.16	0.21	16.55	21.77	0.05	0.05	0.31	4.78	2.23	102.25
230	53.03	0.08	2.80	0.15	0.20	15.97	22.62	0.02	0.03	0.34	4.24	2.27	101.76
230	52.57	0.11	2.67	0.19	0.22	15.80	22.51	0.00	0.02	0.36	4.08	2.10	100.63
230	52.63	0.11	2.59	0.18	0.17	16.83	20.76	0.04	0.02	0.30	4.85	2.48	100.96
230	53.18	0.13	2.56	0.20	0.20	17.10	20.27	0.02	0.02	0.34	5.47	1.64	101.13
230	52.87	0.16	2.65	0.20	0.20	17.68	19.66	0.07	0.03	0.36	4.73	3.34	101.94
230	52.78	0.23	2.65	0.21	0.20	15.77	22.20	0.03	0.01	0.36	4.89	1.14	100.47
230	52.37	0.18	2.73	0.17	0.19	15.82	22.64	0.00	0.02	0.33	3.87	2.50	100.82
230	52.98	0.13	2.84	0.10	0.13	17.09	19.90	0.04	0.00	0.34	5.80	1.94	101.28
230	52.23	0.24	2.51	0.17	0.19	15.47	23.21	0.00	0.01	0.31	3.75	1.94	100.03
230	52.83	0.19	2.61	0.20	0.18	15.80	22.57	0.00	0.01	0.39	4.30	2.11	101.19
230	53.18	0.17	2.64	0.16	0.17	17.07	21.25	0.02	0.03	0.31	4.47	2.43	101.89
230	52.92	0.21	2.69	0.17	0.20	16.57	21.71	0.01	0.04	0.38	4.14	2.81	101.85
230	53.28	0.19	2.68	0.16	0.21	16.55	21.77	0.05	0.05	0.31	4.78	2.23	102.25
230	53.03	0.08	2.80	0.15	0.20	15.97	22.62	0.02	0.03	0.34	4.24	2.27	101.76
230	52.57	0.11	2.67	0.19	0.22	15.80	22.51	0.00	0.02	0.36	4.08	2.10	100.63
230	52.63	0.11	2.59	0.18	0.17	16.83	20.76	0.04	0.02	0.30	4.85	2.48	100.96
230	53.18	0.13	2.56	0.20	0.20	17.10	20.27	0.02	0.02	0.34	5.47	1.64	101.13
230	52.87	0.16	2.65	0.20	0.20	17.68	19.66	0.07	0.03	0.36	4.73	3.34	101.94
230	52.78	0.23	2.65	0.21	0.20	15.77	22.20	0.03	0.01	0.36	4.89	1.14	100.47
avg(25)	52.85	0.16	2.66	0.17	0.19	16.45	21.58	0.02	0.02	0.34	4.60	2.22	101.25
stdev	0.29	0.05	0.09	0.03	0.02	0.66	1.10	0.02	0.01	0.03	0.56	0.51	0.63
						Cycle 6							
211	52.37	0.18	2.73	0.17	0.19	15.82	22.64	0.00	0.02	0.33	3.87	2.50	100.82
211	52.78	0.10	2.51	0.62	0.17	16.18	21.87	0.00	0.05	0.37	4.44	1.38	100.47
211	52.72	0.01	2.35	0.55	0.16	16.09	22.35	0.06	0.02	0.35	3.91	1.38	99.95
211	52.50	0.14	2.80	0.58	0.16	17.09	19.98	0.03	0.01	0.33	5.15	1.85	100.61
211	52.66	0.12	2.90	0.62	0.19	15.67	22.65	0.01	0.00	0.34	4.38	1.41	100.95
211	52.71	0.19	2.53	0.52	0.12	16.04	21.56	0.00	0.01	0.33	5.36	0.30	99.67
211	52.24	0.08	2.77	0.51	0.18	16.06	22.25	0.00	0.00	0.35	3.63	2.27	100.35
211	53.14	0.25	2.58	0.50	0.13	16.15	22.39	0.00	0.03	0.35	4.54	1.11	101.17
211	52.74	0.16	2.60	0.52	0.20	16.84	20.63	0.07	0.00	0.32	5.04	1.17	100.29
211	52.66	0.13	2.78	0.31	0.17	16.11	21.70	0.05	0.08	0.37	4.59	1.42	100.37
avg(10)	52.65	0.14	2.65	0.49	0.17	16.22	21.78	0.02	0.02	0.34	4.50	1.49	100.47
stdev	0.22	0.06	0.15	0.13	0.02	0.40	0.80	0.03	0.02	0.02	0.52	0.56	0.41
209	51.25	0.04	2.75	0.48	0.14	16.00	22.26	0.02	0.02	0.41	2.23	3.29	98.89
209	51.47	0.12	2.99	0.76	0.14	16.29	21.50	0.04	0.05	0.33	3.35	3.11	100.15
209	51.74	0.18	2.52	0.45	0.11	16.48	21.82	0.07	0.00	0.31	3.12	2.47	99.27
209	50.60	0.19	2.86	0.55	0.16	15.76	22.30	0.07	0.00	0.37	2.10	3.48	98.44
209	51.29	0.09	2.94	0.77	0.21	15.64	22.29	0.01	0.00	0.42	2.84	2.62	99.12
209	51.11	0.11	3.03	0.68	0.21	15.88	22.12	0.04	0.00	0.39	2.54	3.38	99.49
209	52.45	0.17	2.14	0.38	0.18	16.32	22.29	0.06	0.00	0.38	3.25	2.10	99.72
209	51.39	0.14	2.79	0.67	0.15	15.88	21.89	0.09	0.00	0.43	3.03	2.42	98.87
209	51.74	0.14	2.65	0.53	0.16	16.10	22.02	0.06	0.03	0.39	3.06	2.46	99.35
209	51.69	0.12	2.69	0.73	0.24	17.60	18.86	0.02	0.00	0.39	4.35	2.27	98.96
avg(10)	51.47	0.13	2.73	0.60	0.17	16.19	21.73	0.05	0.01	0.38	3.01	2.74	99.20
stdev	0.46	0.04	0.25	0.13	0.04	0.53	0.99	0.02	0.02	0.04	0.61	0.48	0.46
208	52.41	0.07	2.57	0.51	0.15	16.07	22.65	0.00	0.06	0.41	2.99	2.49	100.38
208	52.04	0.18	2.59	0.50	0.20	15.92	22.64	0.00	0.06	0.41	2.88	2.58	100.00
208	52.17	0.06	2.66	0.55	0.17	16.60	21.54	0.06	0.00	0.32	3.57	2.51	100.21
208	51.74	0.10	2.84	0.65	0.16	16.81	20.38	0.07	0.00	0.36	4.02	2.38	99.51

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
208	52.12	0.13	2.82	0.57	0.17	15.79	22.67	0.00	0.00	0.43	3.12	2.29	100.11
208	52.36	0.11	2.44	0.47	0.15	16.38	22.70	0.08	0.02	0.37	2.50	2.75	100.32
avg(6)	52.14	0.11	2.65	0.54	0.17	16.26	22.10	0.04	0.02	0.38	3.19	2.49	100.09
stdev	0.22	0.04	0.14	0.06	0.02	0.37	0.87	0.04	0.03	0.04	0.49	0.15	0.29
199	51.11	0.17	2.82	0.63	0.22	16.22	21.48	0.06	0.03	0.36	2.89	3.52	99.51
199	52.15	0.07	2.65	0.45	0.22	15.84	22.59	0.00	0.02	0.36	3.37	2.64	100.35
199	52.88	0.05	2.45	0.32	0.17	16.00	22.96	0.03	0.00	0.34	3.60	1.54	100.33
199	51.29	0.11	2.87	0.71	0.22	15.70	21.88	0.02	0.04	0.45	3.08	3.31	99.68
199	52.31	0.18	2.64	0.56	0.20	15.96	22.60	0.05	0.00	0.34	3.51	1.61	99.96
199	51.57	0.10	2.84	0.68	0.20	16.07	21.47	0.00	0.00	0.43	3.44	2.55	99.34
199	51.58	0.11	3.02	0.68	0.21	15.94	21.38	0.06	0.00	0.49	3.46	2.66	99.60
199	51.88	0.08	3.10	0.68	0.23	15.65	22.28	0.01	0.01	0.42	3.50	2.44	100.28
199	51.43	0.16	3.00	0.80	0.22	16.22	20.98	0.03	0.00	0.40	3.78	2.50	99.52
199	52.14	0.10	2.63	0.61	0.22	16.79	20.53	0.10	0.00	0.37	4.20	2.53	100.22
199	51.87	0.11	2.82	0.56	0.15	16.26	20.71	0.01	0.05	0.43	4.44	1.88	99.29
199	51.84	0.11	2.80	0.61	0.20	16.06	21.71	0.03	0.01	0.40	3.58	2.46	99.82
199	52.59	0.12	2.52	0.55	0.19	15.96	22.16	0.00	0.09	0.43	3.91	2.06	100.59
199	51.44	0.23	2.95	0.81	0.21	15.88	21.70	0.05	0.05	0.44	3.29	3.13	100.18
199	52.13	0.20	2.78	0.61	0.27	16.27	21.16	0.05	0.00	0.44	4.08	2.57	100.56
199	52.60	0.10	2.61	0.52	0.18	15.93	22.08	0.00	0.00	0.41	4.25	1.81	100.49
199	51.70	0.15	3.01	0.70	0.20	15.70	22.03	0.03	0.03	0.45	3.43	2.55	99.99
avg(17)	52.09	0.16	2.77	0.64	0.21	15.95	21.83	0.03	0.03	0.43	3.80	2.42	100.36
stdev	0.48	0.05	0.18	0.12	0.03	0.27	0.66	0.03	0.03	0.04	0.41	0.54	0.42
Cycle 5													
24	52.53	0.12	2.25	0.05	0.19	15.45	21.95	0.00	0.00	0.20	6.17	0.71	99.62
24	52.13	0.08	2.24	0.04	0.21	15.55	21.67	0.02	0.04	0.20	5.76	1.57	99.51
24	51.88	0.13	2.33	0.08	0.27	15.66	21.68	0.01	0.06	0.23	5.09	2.38	99.80
24	52.63	0.16	2.18	0.11	0.22	15.52	21.73	0.06	0.00	0.20	6.40	0.50	99.71
24	52.28	0.08	2.59	0.09	0.27	15.92	20.89	0.04	0.01	0.23	6.09	1.06	99.55
24	52.18	0.14	2.44	0.09	0.15	15.58	21.66	0.02	0.00	0.21	5.89	1.74	100.09
24	52.40	0.11	2.29	0.11	0.24	15.65	21.88	0.00	0.04	0.25	5.42	1.33	99.72
24	51.70	0.18	2.43	0.06	0.19	15.72	21.60	0.01	0.03	0.21	5.12	2.25	99.49
24	52.84	0.18	2.17	0.08	0.21	15.90	21.68	0.07	0.00	0.20	6.05	1.36	100.75
24	52.03	0.13	2.16	0.00	0.24	15.82	21.52	0.03	0.00	0.18	5.49	1.85	99.44
24	52.16	0.12	2.35	0.08	0.21	15.47	21.99	0.00	0.00	0.20	5.62	1.57	99.78
24	52.37	0.18	2.24	0.05	0.22	15.54	22.00	0.06	0.05	0.19	5.72	0.85	99.48
24	52.04	0.18	2.33	0.09	0.27	15.75	21.51	0.04	0.02	0.22	5.44	1.84	99.72
24	51.27	0.07	2.81	0.13	0.24	15.72	21.62	0.00	0.04	0.19	4.52	2.78	99.39
24	52.15	0.18	2.38	0.11	0.19	15.68	21.56	0.01	0.00	0.21	5.81	1.68	99.96
24	51.96	0.21	2.42	0.09	0.22	15.89	21.55	0.00	0.03	0.20	5.24	2.62	100.43
24	51.93	0.12	2.42	0.06	0.19	15.81	21.29	0.05	0.08	0.17	5.67	2.04	99.83
24	51.74	0.16	2.44	0.11	0.16	15.41	21.77	0.07	0.02	0.23	5.37	2.38	99.86
avg(18)	52.14	0.14	2.35	0.08	0.22	15.69	21.62	0.03	0.02	0.21	5.63	1.69	99.80
stdev	0.35	0.04	0.16	0.03	0.03	0.16	0.26	0.02	0.02	0.02	0.43	0.59	0.35
25	52.41	0.14	2.20	0.08	0.28	15.44	22.31	0.04	0.04	0.18	5.53	1.71	100.36
25	51.18	0.12	2.55	0.06	0.24	15.77	21.83	0.00	0.05	0.17	4.18	3.22	99.37
25	51.96	0.15	2.41	0.10	0.19	15.69	21.75	0.02	0.03	0.20	5.30	2.26	100.06
25	52.15	0.14	2.43	0.05	0.28	16.10	20.35	0.04	0.05	0.17	6.59	1.08	99.43
25	52.23	0.17	2.39	0.03	0.22	16.47	20.19	0.01	0.00	0.17	6.39	1.36	99.64
25	51.79	0.18	2.22	0.07	0.22	16.09	21.21	0.00	0.00	0.14	5.40	2.40	99.72
25	52.07	0.15	2.27	0.09	0.24	15.67	21.94	0.02	0.01	0.18	5.28	1.84	99.76
25	52.54	0.13	2.20	0.11	0.26	16.04	21.06	0.01	0.02	0.20	6.18	1.50	100.25
25	52.49	0.13	2.18	0.05	0.22	16.34	20.42	0.00	0.00	0.18	6.57	0.94	99.52
25	52.32	0.15	2.32	0.10	0.20	15.70	22.02	0.03	0.00	0.19	5.42	1.82	100.27
25	52.20	0.19	2.48	0.05	0.22	15.41	22.12	0.00	0.06	0.21	5.56	2.01	100.51
25	51.89	0.12	2.41	0.05	0.18	15.44	22.03	0.04	0.00	0.20	5.30	1.87	99.53
25	51.82	0.20	2.55	0.08	0.21	15.51	21.91	0.04	0.00	0.15	5.52	1.77	99.76
25	52.32	0.14	2.11	0.14	0.29	15.74	22.08	0.06	0.03	0.16	5.26	1.88	100.21
avg(14)	52.10	0.15	2.34	0.08	0.23	15.82	21.52	0.02	0.02	0.18	5.61	1.83	99.89
stdev	0.34	0.02	0.14	0.03	0.03	0.33	0.70	0.02	0.02	0.02	0.62	0.55	0.37
30	52.49	0.18	2.25	0.12	0.16	15.74	22.19	0.01	0.00	0.19	5.42	0.85	99.61
30	52.83	0.01	2.25	0.07	0.17	15.90	21.63	0.06	0.02	0.19	5.88	0.00	99.01
30	52.86	0.11	2.13	0.11	0.16	16.12	21.36	0.00	0.00	0.21	6.10	0.24	99.40
30	52.31	0.19	2.24	0.09	0.21	15.72	22.31	0.00	0.00	0.21	4.96	0.98	99.23
30	52.38	0.11	2.33	0.14	0.24	15.64	22.22	0.05	0.00	0.21	5.16	1.03	99.50
30	52.36	0.13	2.28	0.12	0.21	15.58	22.37	0.05	0.01	0.18	5.23	0.37	98.89

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
30	52.48	0.05	2.34	0.06	0.23	16.32	20.19	0.03	0.00	0.20	6.68	0.08	98.67
30	52.74	0.11	2.25	0.09	0.22	16.47	20.17	0.03	0.00	0.18	6.78	0.00	99.04
30	52.72	0.12	2.22	0.11	0.20	15.65	22.71	0.01	0.05	0.22	4.91	0.46	99.38
30	52.31	0.11	2.37	0.11	0.21	16.59	20.17	0.03	0.00	0.16	6.29	0.47	98.82
30	53.53	0.05	1.92	0.06	0.16	15.95	22.36	0.04	0.01	0.18	5.09	0.00	99.35
30	52.54	0.04	2.19	0.07	0.22	16.54	20.16	0.03	0.00	0.18	6.50	0.13	98.59
avg(12)	52.63	0.10	2.23	0.10	0.20	16.02	21.49	0.03	0.01	0.19	5.75	0.38	99.12
stdev	0.33	0.05	0.11	0.03	0.03	0.36	0.99	0.02	0.01	0.02	0.67	0.37	0.32
32	52.17	0.10	2.22	0.14	0.22	15.62	22.51	0.00	0.00	0.21	4.63	2.33	100.14
32	52.48	0.08	2.16	0.10	0.34	16.42	20.98	0.09	0.03	0.18	5.42	1.38	99.66
32	52.45	0.18	2.18	0.11	0.21	15.79	22.13	0.04	0.01	0.22	5.13	1.79	100.24
32	52.02	0.17	2.18	0.10	0.24	16.16	21.27	0.03	0.00	0.20	5.13	2.21	99.71
32	51.63	0.06	2.32	0.13	0.27	16.35	20.92	0.01	0.07	0.21	4.55	2.97	99.50
32	52.16	0.16	2.29	0.14	0.17	15.79	22.24	0.05	0.02	0.25	4.51	2.56	100.34
32	52.20	0.13	2.52	0.09	0.21	15.95	21.62	0.00	0.01	0.16	5.48	1.03	99.39
32	52.24	0.13	2.26	0.08	0.24	16.15	21.65	0.05	0.00	0.18	4.97	1.58	99.53
32	51.72	0.19	2.37	0.14	0.20	16.04	21.30	0.05	0.03	0.17	5.10	2.23	99.54
32	51.88	0.05	2.23	0.11	0.18	16.13	20.97	0.03	0.00	0.23	5.22	2.18	99.21
avg(11)	52.10	0.13	2.27	0.11	0.23	16.04	21.56	0.04	0.02	0.20	5.01	2.03	99.73
stdev	0.27	0.05	0.10	0.02	0.05	0.24	0.54	0.03	0.02	0.03	0.33	0.55	0.36
45	51.95	0.08	1.93	0.09	0.18	16.23	22.27	0.00	0.05	0.20	3.60	2.03	98.61
45	51.73	0.08	2.01	0.12	0.23	16.69	21.10	0.05	0.03	0.17	4.08	2.60	98.89
45	51.76	0.08	2.06	0.20	0.13	16.57	21.20	0.05	0.02	0.17	4.31	2.34	98.89
45	51.58	0.16	2.00	0.14	0.17	16.27	22.16	0.04	0.07	0.21	3.21	3.53	99.54
45	52.02	0.16	2.02	0.14	0.19	16.99	20.73	0.01	0.02	0.19	4.43	2.56	99.47
45	51.90	0.14	2.01	0.20	0.19	16.89	20.65	0.00	0.00	0.20	4.54	1.47	98.19
45	51.77	0.07	1.98	0.06	0.33	17.52	18.95	0.05	0.02	0.19	5.21	2.48	98.63
45	51.32	0.09	1.98	0.14	0.27	16.29	21.48	0.05	0.00	0.19	3.72	2.83	98.36
45	52.06	0.09	1.98	0.10	0.30	16.00	22.12	0.05	0.04	0.17	4.33	1.56	98.80
45	52.92	0.11	1.64	0.15	0.24	16.69	21.56	0.00	0.00	0.15	5.10	0.39	98.95
45	51.63	0.14	2.05	0.15	0.29	17.00	20.26	0.00	0.06	0.18	4.45	2.98	99.19
45	51.89	0.13	1.94	0.15	0.22	18.18	18.61	0.08	0.00	0.12	5.09	2.98	99.40
45	51.85	0.07	1.94	0.07	0.17	16.45	20.96	0.02	0.00	0.19	4.85	1.98	98.55
45	51.99	0.05	2.05	0.12	0.18	16.77	19.97	0.02	0.00	0.18	5.73	1.05	98.12
avg(14)	51.88	0.10	1.97	0.13	0.22	16.75	20.86	0.03	0.02	0.18	4.48	2.20	98.83
stdev	0.35	0.03	0.10	0.04	0.06	0.55	1.08	0.03	0.02	0.02	0.66	0.82	0.44
44	51.95	0.09	2.53	0.12	0.23	15.30	22.19	0.04	0.03	0.18	5.40	1.22	99.28
44	52.43	0.23	2.38	0.07	0.22	15.28	22.41	0.00	0.00	0.21	5.79	0.71	99.73
44	52.20	0.23	2.41	0.12	0.15	15.55	22.19	0.02	0.05	0.20	5.37	1.02	99.50
44	52.27	0.09	2.36	0.07	0.21	15.47	22.22	0.03	0.00	0.20	5.40	0.88	99.21
44	52.37	0.07	2.09	0.11	0.15	15.70	22.76	0.00	0.01	0.15	4.72	0.95	99.07
44	52.24	0.04	2.32	0.12	0.26	15.42	22.04	0.08	0.01	0.21	5.49	1.24	99.47
44	51.69	0.13	2.37	0.17	0.20	15.30	22.43	0.00	0.01	0.18	4.90	1.10	98.48
44	51.69	0.15	2.28	0.13	0.14	15.33	22.27	0.02	0.03	0.18	5.10	1.47	98.79
44	52.16	0.01	2.45	0.14	0.24	15.45	22.40	0.04	0.00	0.20	4.97	1.67	99.73
44	52.42	0.01	2.27	0.10	0.24	16.12	20.59	0.00	0.04	0.18	6.50	0.64	99.10
44	51.80	0.08	2.44	0.15	0.16	15.43	21.99	0.00	0.00	0.20	5.28	1.47	99.00
44	51.65	0.10	2.44	0.14	0.20	15.11	22.45	0.01	0.03	0.17	5.16	1.13	98.59
avg(12)	52.07	0.10	2.36	0.12	0.20	15.46	22.16	0.02	0.02	0.19	5.34	1.13	99.16
stdev	0.29	0.07	0.11	0.03	0.04	0.25	0.51	0.02	0.02	0.02	0.45	0.30	0.39
42	52.73	0.12	2.04	0.28	0.23	16.27	21.12	0.05	0.05	0.16	5.98	0.00	99.03
42	52.53	0.14	2.22	0.20	0.29	16.47	20.95	0.05	0.07	0.18	5.53	0.96	99.59
42	51.99	0.11	2.06	0.27	0.35	16.11	21.63	0.00	0.00	0.17	4.73	2.28	99.70
42	51.32	0.18	2.50	0.32	0.24	15.83	21.87	0.07	0.00	0.17	4.23	2.25	98.98
42	52.16	0.23	2.26	0.19	0.28	15.99	21.13	0.01	0.00	0.20	5.82	1.47	99.74
42	52.56	0.19	2.57	0.31	0.23	16.00	21.04	0.02	0.01	0.19	6.43	0.74	100.29
42	53.02	0.15	1.98	0.20	0.18	16.58	20.92	0.06	0.00	0.19	5.85	0.00	99.13
42	52.01	0.11	2.45	0.24	0.20	15.71	21.81	0.02	0.00	0.21	5.18	1.70	99.64
42	51.59	0.12	2.48	0.28	0.21	15.52	22.06	0.01	0.01	0.20	4.74	1.99	99.21
42	52.27	0.17	2.46	0.29	0.21	15.62	21.94	0.02	0.00	0.17	5.72	1.29	100.16
42	52.63	0.14	2.38	0.25	0.27	16.16	21.11	0.03	0.00	0.17	6.15	0.63	99.92
avg(11)	52.26	0.15	2.31	0.26	0.24	16.02	21.42	0.03	0.01	0.18	5.49	1.21	99.58
stdev	0.48	0.04	0.20	0.04	0.05	0.32	0.42	0.02	0.02	0.02	0.65	0.78	0.43
40	51.86	0.17	2.37	0.32	0.24	15.57	21.40	0.00	0.03	0.18	5.92	1.23	99.29
40	52.24	0.08	2.37	0.37	0.24	15.86	20.75	0.08	0.01	0.23	6.32	0.53	99.08

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
40	52.62	0.10	2.21	0.29	0.25	15.37	21.78	0.00	0.04	0.22	5.98	0.00	98.86
40	52.70	0.17	2.37	0.32	0.23	15.72	22.03	0.06	0.04	0.20	5.70	0.36	99.91
40	52.70	0.13	2.18	0.26	0.28	16.02	21.13	0.01	0.01	0.17	6.45	0.07	99.41
40	52.98	0.11	2.37	0.29	0.19	15.28	21.80	0.05	0.04	0.23	6.89	0.00	100.23
40	52.39	0.16	2.28	0.34	0.23	15.38	22.00	0.05	0.09	0.21	5.88	0.94	99.95
40	51.94	0.14	2.49	0.22	0.25	15.43	21.85	0.00	0.00	0.23	5.45	0.95	98.96
40	52.69	0.12	2.26	0.33	0.20	16.14	20.61	0.02	0.07	0.22	6.33	0.00	98.99
40	52.64	0.11	2.25	0.20	0.27	15.33	21.53	0.00	0.01	0.21	6.58	0.00	99.13
40	52.50	0.18	2.32	0.32	0.16	15.42	21.76	0.04	0.02	0.21	6.42	0.13	99.47
40	52.91	0.15	2.03	0.20	0.26	15.97	21.50	0.05	0.08	0.16	5.95	0.00	99.26
avg(12)	52.51	0.14	2.29	0.29	0.23	15.62	21.51	0.03	0.04	0.21	6.16	0.35	99.38
stdev	0.34	0.03	0.11	0.05	0.03	0.29	0.45	0.03	0.03	0.02	0.39	0.43	0.42
38	51.61	0.14	2.34	0.29	0.24	15.70	21.81	0.03	0.05	0.20	4.70	2.23	99.33
38	50.81	0.23	2.50	0.27	0.24	15.68	21.21	0.00	0.02	0.25	4.45	3.09	98.75
38	50.93	0.14	2.35	0.26	0.23	15.62	21.62	0.03	0.00	0.21	4.28	2.70	98.37
38	51.08	0.18	2.38	0.30	0.29	15.65	21.05	0.02	0.03	0.20	5.14	2.34	98.66
38	50.84	0.17	2.36	0.23	0.29	16.41	19.15	0.00	0.00	0.20	5.97	2.18	97.80
38	50.67	0.14	2.18	0.28	0.24	15.82	21.85	0.02	0.00	0.17	3.50	3.06	97.94
38	51.12	0.24	2.38	0.33	0.22	15.85	21.30	0.03	0.04	0.17	4.76	2.32	98.75
38	51.39	0.18	2.38	0.32	0.23	16.20	20.82	0.00	0.05	0.17	5.02	2.18	98.95
38	50.96	0.19	2.45	0.27	0.23	15.82	21.14	0.11	0.00	0.21	4.55	2.85	98.78
38	51.00	0.15	2.57	0.35	0.21	15.49	21.92	0.00	0.02	0.20	4.30	2.48	98.69
38	50.56	0.13	2.37	0.30	0.29	15.54	21.88	0.03	0.00	0.22	3.53	3.53	98.38
38	51.93	0.15	2.28	0.40	0.26	16.14	21.23	0.03	0.01	0.20	5.07	0.66	98.36
36	51.64	0.14	2.43	0.39	0.25	15.45	22.57	0.04	0.02	0.24	4.03	2.45	99.64
36	51.01	0.07	2.39	0.40	0.21	15.89	20.50	0.03	0.07	0.25	5.03	2.27	98.13
36	51.36	0.18	2.39	0.37	0.23	15.82	21.52	0.04	0.04	0.23	4.46	2.52	99.16
36	51.34	0.08	2.49	0.35	0.24	15.44	21.98	0.08	0.04	0.26	4.25	2.41	98.96
36	51.19	0.02	2.28	0.39	0.29	15.34	22.14	0.05	0.03	0.19	4.30	2.58	98.80
36	53.13	0.03	0.05	0.00	0.33	14.70	25.08	0.02	0.08	0.01	4.78	1.37	99.58
36	51.66	0.16	2.29	0.43	0.22	15.65	22.07	0.04	0.00	0.23	4.45	1.89	99.09
36	51.36	0.08	2.54	0.40	0.22	15.39	22.14	0.04	0.00	0.24	4.35	2.11	98.87
36	50.40	0.09	2.70	0.39	0.29	15.58	20.98	0.08	0.01	0.23	4.28	3.15	98.19
36	51.18	0.11	2.57	0.32	0.17	15.41	21.50	0.02	0.01	0.24	5.00	1.74	98.27
36	51.27	0.24	2.49	0.34	0.29	15.38	22.10	0.00	0.00	0.25	4.38	2.17	98.91
36	51.15	0.11	2.14	0.32	0.24	15.51	22.01	0.04	0.02	0.20	4.22	2.53	98.49
36	51.25	0.13	2.43	0.37	0.20	15.69	21.15	0.04	0.01	0.20	5.19	2.09	98.75
36	50.85	0.04	2.64	0.44	0.23	15.49	21.60	0.00	0.04	0.25	4.16	3.40	99.14
36	51.53	0.15	2.47	0.36	0.31	15.26	22.48	0.00	0.00	0.22	4.45	2.08	99.31
36	50.91	0.16	2.47	0.41	0.23	15.14	22.11	0.00	0.01	0.22	4.48	2.22	98.36
avg(16)	51.33	0.11	2.30	0.36	0.25	15.45	22.00	0.03	0.02	0.22	4.49	2.31	98.85
stdev	0.56	0.06	0.60	0.10	0.04	0.27	0.96	0.02	0.02	0.06	0.33	0.48	0.45
35	51.72	0.16	2.32	0.39	0.31	16.03	20.74	0.00	0.05	0.20	5.59	1.80	99.31
35	52.29	0.15	2.24	0.36	0.20	15.49	21.98	0.05	0.01	0.22	5.64	1.14	99.77
35	52.25	0.21	2.30	0.35	0.18	15.52	21.90	0.07	0.00	0.23	5.66	1.38	100.05
35	51.68	0.16	2.38	0.32	0.23	16.10	20.29	0.03	0.02	0.19	6.12	1.76	99.28
35	51.54	0.14	2.38	0.41	0.23	15.51	21.22	0.09	0.00	0.20	5.71	1.86	99.29
35	51.98	0.15	2.33	0.38	0.21	16.18	19.89	0.00	0.05	0.20	6.81	1.81	99.99
35	52.03	0.07	2.48	0.36	0.18	15.48	21.70	0.01	0.00	0.23	5.66	1.71	99.91
35	51.76	0.16	2.34	0.38	0.22	15.45	21.83	0.03	0.00	0.21	5.34	1.74	99.45
35	52.00	0.17	2.36	0.39	0.23	15.76	21.03	0.00	0.02	0.24	5.96	1.40	99.56
35	51.85	0.12	2.35	0.38	0.25	15.86	20.95	0.04	0.02	0.20	5.79	2.07	99.89
avg(10)	51.91	0.15	2.35	0.37	0.22	15.74	21.15	0.03	0.02	0.29	5.83	1.67	99.65
stdev	0.23	0.03	0.06	0.02	0.04	0.27	0.68	0.03	0.02	0.02	0.38	0.26	0.29
34	51.33	0.21	2.49	0.37	0.17	14.91	21.98	0.09	0.01	0.24	5.48	0.95	98.24
34	51.80	0.21	2.22	0.44	0.36	15.44	20.71	0.00	0.00	0.19	6.86	0.71	98.94
34	51.52	0.09	2.26	0.23	0.15	15.33	21.84	0.09	0.05	0.21	5.15	1.58	98.50
34	51.57	0.16	2.33	0.40	0.25	15.81	20.15	0.03	0.02	0.23	6.48	1.50	98.93
34	51.15	0.18	2.45	0.44	0.22	15.20	21.50	0.04	0.10	0.25	5.20	1.74	98.47
34	51.90	0.16	2.02	0.35	0.25	15.13	22.73	0.02	0.03	0.21	4.87	1.22	98.89
34	50.82	0.09	2.38	0.42	0.17	15.23	21.67	0.01	0.03	0.22	4.74	1.91	97.69
34	51.45	0.20	2.34	0.46	0.25	16.05	20.35	0.00	0.07	0.21	5.76	2.69	99.83
34	51.46	0.15	2.33	0.40	0.21	15.51	21.32	0.08	0.04	0.25	5.25	2.24	99.24
34	51.03	0.09	2.25	0.44	0.20	15.49	21.26	0.00	0.03	0.22	5.03	1.72	97.76
34	51.66	0.11	2.31	0.41	0.20	15.22	21.83	0.05	0.01	0.22	5.53	1.91	99.46

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
34	51.05	0.08	2.31	0.41	0.21	15.32	21.09	0.04	0.02	0.24	5.44	1.68	97.89
34	51.17	0.20	2.46	0.44	0.27	15.39	21.59	0.04	0.03	0.24	4.85	2.26	98.95
34	50.84	0.18	2.23	0.36	0.22	15.21	22.18	0.02	0.07	0.22	4.13	2.67	98.33
34	50.44	0.15	2.28	0.33	0.18	16.14	20.78	0.06	0.00	0.23	3.78	3.29	97.66
avg(15)	51.28	0.15	2.31	0.39	0.22	15.43	21.40	0.04	0.03	0.23	5.24	1.87	98.59
stdev	0.39	0.05	0.11	0.06	0.05	0.33	0.68	0.03	0.03	0.02	0.76	0.66	0.65
33	52.01	0.13	2.45	0.49	0.19	14.98	21.32	0.03	0.00	0.24	6.99	0.43	99.26
33	51.65	0.18	2.40	0.45	0.20	15.07	21.94	0.04	0.01	0.27	5.48	1.73	99.42
33	51.40	0.11	2.38	0.49	0.21	15.66	20.60	0.00	0.00	0.26	5.87	2.09	99.07
33	51.84	0.14	2.46	0.37	0.18	15.06	21.73	0.09	0.02	0.24	6.06	1.19	99.38
33	51.83	0.23	2.48	0.46	0.24	15.12	21.59	0.00	0.00	0.26	6.16	0.76	99.13
33	51.90	0.21	2.39	0.47	0.25	15.32	21.54	0.06	0.04	0.20	6.10	1.50	99.98
33	52.45	0.14	2.07	0.41	0.24	16.18	20.72	0.07	0.02	0.18	6.27	0.00	98.75
33	52.01	0.20	2.25	0.46	0.23	15.42	21.81	0.00	0.00	0.20	5.82	0.91	99.30
33	52.10	0.17	2.33	0.46	0.26	15.62	21.10	0.00	0.00	0.22	6.33	0.45	99.03
33	52.98	0.19	1.90	0.43	0.30	17.08	19.72	0.00	0.02	0.17	5.78	0.00	98.57
33	51.95	0.11	2.31	0.40	0.21	15.45	21.78	0.01	0.00	0.21	5.61	1.04	99.08
33	52.10	0.15	2.39	0.42	0.27	15.62	21.11	0.06	0.00	0.25	6.09	1.19	99.65
33	52.04	0.07	2.41	0.49	0.28	15.48	21.36	0.04	0.00	0.20	6.12	1.54	100.02
33	52.01	0.18	2.44	0.35	0.23	15.25	21.87	0.05	0.00	0.26	5.70	1.89	100.23
avg(23)	52.02	0.16	2.33	0.44	0.24	15.52	21.30	0.03	0.01	0.23	6.03	1.05	99.35
stdev	0.35	0.04	0.16	0.04	0.03	0.53	0.59	0.03	0.01	0.03	0.36	0.64	0.46
32	52.51	0.11	2.05	0.18	0.24	15.70	22.34	0.02	0.04	0.22	4.99	1.64	100.04
32	52.35	0.06	2.21	0.11	0.20	15.67	22.06	0.00	0.05	0.18	5.41	1.52	99.81
32	51.79	0.14	2.23	0.06	0.19	15.84	21.58	0.03	0.04	0.19	5.06	2.16	99.32
32	52.43	0.15	2.08	0.13	0.16	15.96	22.06	0.02	0.02	0.21	4.98	1.70	99.90
32	51.86	0.12	2.31	0.10	0.21	15.84	21.88	0.06	0.00	0.20	4.69	2.26	99.53
avg	52.19	0.12	2.18	0.12	0.20	15.80	21.98	0.03	0.03	0.20	5.03	1.86	99.72
stdev	0.30	0.03	0.10	0.04	0.03	0.11	0.25	0.02	0.02	0.01	0.23	0.30	0.26
Cycle 4													
14	52.29	0.21	2.84	0.29	0.21	17.08	18.24	0.09	0.00	0.20	7.71	1.61	100.77
14	52.21	0.25	2.89	0.27	0.21	16.75	19.23	0.03	0.06	0.25	6.74	1.20	100.09
14	51.84	0.15	2.89	0.31	0.22	16.25	19.82	0.02	0.03	0.23	6.46	1.81	100.03
14	52.10	0.21	2.93	0.28	0.26	15.67	21.57	0.08	0.00	0.20	5.69	2.07	101.06
14	51.75	0.25	2.97	0.25	0.17	15.10	22.25	0.00	0.03	0.23	5.45	1.56	100.01
14	52.36	0.22	2.96	0.30	0.22	15.15	21.95	0.02	0.00	0.23	6.41	0.89	100.71
14	52.44	0.16	2.90	0.20	0.15	16.32	19.83	0.01	0.06	0.22	7.15	1.22	100.65
14	51.57	0.27	2.98	0.34	0.27	15.51	20.79	0.00	0.03	0.23	6.29	1.80	100.08
14	51.73	0.18	2.94	0.30	0.24	16.59	19.27	0.01	0.02	0.23	6.46	2.09	100.06
avg(9)	52.37	0.19	2.80	0.26	0.22	16.10	19.59	0.03	0.02	0.22	7.74	0.58	100.12
stdev	0.30	0.04	0.04	0.04	0.04	0.68	1.30	0.03	0.02	0.01	0.65	0.39	0.38
110	52.19	0.20	2.87	0.43	0.20	15.58	21.82	0.04	0.06	0.28	5.30	1.86	100.83
110	52.30	0.17	2.95	0.47	0.15	15.64	21.37	0.07	0.06	0.27	5.94	2.12	101.51
110	51.59	0.11	3.13	0.47	0.27	15.49	21.58	0.04	0.00	0.29	4.91	2.87	100.75
110	52.17	0.23	2.85	0.50	0.21	15.60	22.05	0.03	0.06	0.25	5.11	1.92	100.98
110	51.49	0.25	3.06	0.45	0.21	15.61	21.11	0.00	0.00	0.30	5.36	2.48	100.32
110	51.97	0.22	2.94	0.42	0.18	15.53	21.35	0.00	0.07	0.28	5.79	1.61	100.36
110	51.87	0.16	3.16	0.42	0.20	15.35	21.77	0.02	0.00	0.26	5.52	1.94	100.67
110	52.23	0.12	2.97	0.52	0.20	15.43	21.44	0.05	0.03	0.25	6.19	1.53	100.95
110	51.74	0.12	2.99	0.37	0.22	16.33	20.06	0.00	0.00	0.23	5.91	2.55	100.53
110	51.67	0.23	2.94	0.45	0.19	16.15	19.98	0.00	0.04	0.24	6.30	2.19	100.38
110	51.62	0.28	3.08	0.44	0.25	15.59	20.86	0.03	0.00	0.27	5.96	2.01	100.39
110	51.76	0.10	3.03	0.51	0.24	16.16	20.09	0.09	0.02	0.23	6.06	1.98	100.27
110	51.77	0.20	3.00	0.45	0.22	15.81	20.69	0.00	0.03	0.25	6.02	1.85	100.28
110	51.80	0.19	3.01	0.48	0.18	15.52	21.24	0.02	0.00	0.28	5.77	1.65	100.13
110	52.22	0.24	2.92	0.45	0.26	16.59	19.29	0.00	0.05	0.24	6.98	1.90	101.14
110	51.58	0.28	2.91	0.41	0.22	15.60	21.47	0.05	0.01	0.27	5.12	2.23	100.14
110	51.40	0.21	2.86	0.36	0.20	15.40	21.70	0.00	0.00	0.26	5.03	2.74	100.15
110	51.54	0.33	2.89	0.51	0.19	15.97	20.21	0.00	0.05	0.22	6.34	1.92	100.17
110	52.57	0.22	2.89	0.47	0.22	16.08	20.47	0.03	0.05	0.23	6.84	1.51	101.58
110	51.56	0.24	3.90	0.41	0.22	15.42	20.86	0.06	0.03	0.52	4.97	2.66	100.86
110	51.61	0.31	2.88	0.32	0.22	15.36	22.03	0.00	0.01	0.27	4.94	2.46	100.41
110	52.03	0.08	2.79	0.48	0.33	15.28	21.61	0.00	0.02	0.28	5.75	1.77	100.42
avg(22)	51.85	0.20	3.00	0.44	0.22	15.70	21.05	0.02	0.03	0.27	5.74	2.07	100.59
stdev	0.31	0.07	0.22	0.05	0.04	0.35	0.74	0.03	0.02	0.06	0.58	0.39	0.42

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
11	51.53	0.20	2.64	0.53	0.18	15.47	22.03	0.07	0.00	0.28	4.48	2.79	100.20
11	52.12	0.19	2.60	0.54	0.20	15.57	22.22	0.02	0.00	0.27	4.83	2.25	100.82
11	51.56	0.22	2.63	0.48	0.18	15.51	21.76	0.00	0.00	0.31	4.74	2.59	99.98
11	51.75	0.10	2.79	0.52	0.24	15.18	22.51	0.03	0.02	0.28	4.52	2.75	100.69
11	51.97	0.27	2.79	0.54	0.19	15.63	21.54	0.02	0.02	0.27	5.48	1.69	100.41
11	52.04	0.12	2.80	0.47	0.21	15.57	21.44	0.08	0.04	0.28	5.52	1.91	100.48
11	52.26	0.17	2.67	0.51	0.19	15.82	21.22	0.00	0.00	0.26	5.89	0.70	99.69
11	52.14	0.18	2.83	0.52	0.21	15.56	21.82	0.00	0.05	0.28	5.29	1.62	100.50
11	52.28	0.17	2.52	0.50	0.21	15.45	22.24	0.07	0.00	0.24	5.27	1.47	100.43
11	52.15	0.22	3.04	0.51	0.22	15.55	21.71	0.00	0.02	0.31	5.38	1.80	100.91
11	51.78	0.20	2.80	0.60	0.27	15.37	22.44	0.06	0.01	0.26	4.44	2.20	100.43
11	52.69	0.31	2.78	0.53	0.20	16.33	20.34	0.03	0.00	0.27	6.67	1.33	101.47
11	52.54	0.26	2.71	0.49	0.27	15.56	21.75	0.09	0.04	0.26	5.89	1.29	101.15
11	52.10	0.16	2.79	0.51	0.25	15.47	21.85	0.04	0.00	0.27	5.36	1.65	100.46
11	51.95	0.17	2.61	0.54	0.25	15.78	21.12	0.00	0.02	0.23	5.78	1.54	99.99
11	52.33	0.19	2.81	0.50	0.20	15.67	21.63	0.04	0.05	0.26	5.64	1.76	101.08
11	52.16	0.19	2.86	0.51	0.21	15.37	21.95	0.03	0.00	0.28	5.52	1.64	100.71
11	52.18	0.16	2.75	0.44	0.21	15.57	21.69	0.02	0.01	0.26	5.58	1.72	100.59
11	51.78	0.31	2.77	0.50	0.27	15.52	21.74	0.01	0.00	0.29	5.08	2.16	100.44
11	51.76	0.27	3.03	0.43	0.27	16.10	19.97	0.00	0.00	0.23	6.55	1.66	100.27
11	52.40	0.08	2.62	0.43	0.19	15.55	21.89	0.06	0.00	0.26	5.55	1.27	100.30
11	52.26	0.23	2.76	0.55	0.19	15.16	22.01	0.05	0.06	0.28	5.91	0.95	100.42
11	51.84	0.21	2.78	0.50	0.24	15.12	21.79	0.01	0.01	0.26	5.87	1.17	99.81
11	52.22	0.24	2.77	0.50	0.22	15.60	21.50	0.00	0.01	0.28	5.81	1.40	100.55
11	51.63	0.21	2.72	0.57	0.21	15.42	21.94	0.03	0.03	0.26	4.89	2.02	99.93
11	52.10	0.72	2.66	0.48	0.25	15.09	22.39	0.03	0.00	0.27	5.86	1.07	100.93
11	52.27	0.20	2.74	0.46	0.25	15.70	21.17	0.04	0.00	0.28	6.02	1.13	100.25
avg(27)	51.92	0.22	2.89	0.51	0.22	15.55	21.58	0.03	0.01	0.27	5.44	1.78	100.42
stdev	0.83	0.11	0.74	0.05	0.03	0.26	0.79	0.03	0.02	0.02	0.59	0.72	0.50
109	51.90	0.16	2.99	0.47	0.32	15.52	20.93	0.00	0.05	0.28	6.09	1.92	100.62
109	51.61	0.04	2.96	0.45	0.21	15.43	21.50	0.06	0.00	0.28	5.17	2.23	99.93
109	51.67	0.30	3.18	0.50	0.19	15.39	21.36	0.00	0.00	0.26	5.89	2.23	100.97
109	51.66	0.18	3.31	0.47	0.21	15.02	21.71	0.02	0.00	0.27	5.90	1.76	100.51
109	51.55	0.16	3.07	0.55	0.28	15.05	21.95	0.01	0.02	0.27	5.31	1.95	100.17
109	51.84	0.23	3.04	0.42	0.22	14.98	22.30	0.00	0.02	0.27	5.46	1.91	100.69
109	51.87	0.22	2.96	0.46	0.27	15.61	20.96	0.00	0.02	0.27	6.03	2.01	100.68
109	51.91	0.13	3.00	0.44	0.28	15.46	21.70	0.01	0.00	0.31	5.13	2.06	100.44
109	51.74	0.17	3.02	0.57	0.24	15.59	20.70	0.02	0.00	0.29	6.14	2.16	100.64
109	52.42	0.23	2.68	0.58	0.25	15.32	22.27	0.06	0.00	0.29	5.43	1.67	101.20
109	51.65	0.23	3.23	0.39	0.27	15.82	20.33	0.08	0.01	0.28	6.10	2.36	100.75
109	51.42	0.07	3.02	0.42	0.21	15.79	20.23	0.04	0.00	0.26	6.06	2.31	99.83
avg(12)	51.77	0.18	3.04	0.48	0.25	15.42	21.33	0.03	0.01	0.28	5.70	2.08	100.57
stdev	0.24	0.07	0.15	0.06	0.04	0.27	0.67	0.03	0.01	0.01	0.38	0.21	0.38
9	51.77	0.16	2.71	0.50	0.13	15.37	21.85	0.05	0.07	0.24	5.33	1.49	99.67
9	51.86	0.16	2.56	0.53	0.22	14.90	23.09	0.02	0.01	0.19	4.92	1.74	100.19
9	51.70	0.16	2.94	0.51	0.23	15.35	22.09	0.02	0.02	0.25	4.91	1.71	99.88
9	51.15	0.14	3.05	0.54	0.25	15.26	21.79	0.00	0.00	0.28	4.65	2.48	99.60
9	52.44	0.09	2.79	0.44	0.22	15.86	21.43	0.01	0.00	0.23	5.80	0.90	100.21
9	51.05	0.21	3.30	0.50	0.22	15.68	21.05	0.06	0.02	0.27	4.80	2.21	99.36
9	52.08	0.21	2.85	0.51	0.15	15.53	21.84	0.07	0.01	0.28	5.31	1.70	100.54
9	51.53	0.19	3.06	0.46	0.23	15.34	21.76	0.07	0.02	0.27	5.03	2.15	100.10
9	51.58	0.19	3.04	0.55	0.19	15.44	21.89	0.00	0.02	0.26	4.90	2.25	100.30
9	51.80	0.25	2.87	0.48	0.20	16.08	20.78	0.02	0.00	0.28	5.39	1.25	99.41
avg(10)	51.70	0.17	2.92	0.50	0.20	15.48	21.76	0.03	0.02	0.26	5.08	1.81	99.93
stdev	0.39	0.04	0.20	0.03	0.04	0.31	0.59	0.03	0.02	0.03	0.33	0.47	0.38
8	50.83	0.10	2.74	0.45	0.24	15.40	21.54	0.07	0.00	0.32	4.06	2.58	98.33
8	51.40	0.17	2.85	0.49	0.19	15.27	21.90	0.04	0.02	0.33	4.59	1.95	99.21
8	51.55	0.20	2.50	0.51	0.26	15.36	22.19	0.01	0.01	0.26	4.56	2.09	99.50
8	50.85	0.22	3.26	0.51	0.22	16.12	19.87	0.02	0.00	0.26	5.40	2.10	98.83
8	50.99	0.18	2.72	0.58	0.20	15.19	21.82	0.04	0.02	0.32	4.39	2.47	98.92
8	51.42	0.15	2.95	0.60	0.23	15.49	20.79	0.00	0.04	0.29	5.79	0.92	98.67
8	50.97	0.17	2.80	0.55	0.21	15.34	21.71	0.03	0.00	0.34	4.16	2.91	99.19
8	52.07	0.10	2.41	0.51	0.30	16.16	19.85	0.09	0.07	0.25	6.46	0.00	98.27
8	50.97	0.15	2.80	0.56	0.22	15.45	21.44	0.04	0.05	0.29	4.46	2.57	99.00
8	50.84	0.12	2.78	0.53	0.21	15.20	21.93	0.03	0.03	0.28	4.17	2.53	98.65

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Total
8	51.22	0.03	2.83	0.56	0.19	15.32	21.77	0.05	0.03	0.32	4.36	2.35	99.03
avg(11)	51.19	0.14	2.79	0.53	0.22	15.48	21.35	0.04	0.02	0.30	4.76	2.04	98.87
stdev	0.37	0.05	0.21	0.04	0.03	0.32	0.78	0.02	0.02	0.03	0.74	0.81	0.36
6	50.59	0.09	2.83	0.42	0.27	15.32	21.27	0.02	0.00	0.29	4.41	3.12	98.63
6	51.01	0.09	2.66	0.50	0.28	15.13	22.04	0.05	0.00	0.27	4.32	2.96	99.31
6	50.64	0.21	2.82	0.46	0.23	15.91	20.48	0.01	0.01	0.30	4.53	3.91	99.51
6	50.90	0.21	2.98	0.42	0.22	15.07	21.38	0.04	0.01	0.30	5.17	1.54	98.24
6	51.00	0.02	2.89	0.28	0.19	15.21	22.42	0.00	0.00	0.26	3.80	2.78	98.85
6	50.72	0.09	2.54	0.45	0.26	16.99	18.33	0.04	0.00	0.21	5.72	3.27	98.62
6	50.85	0.17	2.95	0.53	0.22	15.13	21.71	0.04	0.00	0.28	4.65	2.89	99.42
6	50.26	0.14	2.94	0.56	0.27	15.19	21.33	0.00	0.02	0.27	4.31	3.22	98.51
6	50.99	0.18	2.57	0.39	0.25	15.54	21.14	0.03	0.02	0.25	4.92	1.76	98.05
6	50.58	0.24	2.89	0.46	0.21	15.23	21.63	0.08	0.05	0.22	4.51	2.58	98.69
avg(10)	50.75	0.14	2.81	0.45	0.24	15.47	21.17	0.03	0.01	0.27	4.63	2.80	98.78
stdev	0.23	0.07	0.15	0.07	0.03	0.56	1.07	0.02	0.02	0.03	0.50	0.67	0.47
5	51.41	0.16	2.96	0.49	0.19	14.87	21.91	0.00	0.00	0.27	5.63	1.03	98.92
5	50.88	0.22	3.35	0.50	0.20	15.04	21.47	0.00	0.06	0.28	5.20	1.77	98.97
5	51.99	0.19	2.99	0.45	0.27	16.08	19.22	0.03	0.03	0.27	7.50	0.46	99.48
5	50.91	0.19	2.96	0.50	0.22	15.44	20.36	0.05	0.02	0.27	5.93	2.08	98.93
5	50.36	0.19	3.21	0.52	0.19	15.01	21.52	0.06	0.00	0.24	4.73	2.11	98.14
5	51.97	0.19	2.58	0.33	0.23	15.45	21.42	0.05	0.03	0.27	5.81	1.35	99.68
5	50.47	0.13	3.30	0.50	0.22	15.44	21.16	0.06	0.00	0.28	4.29	3.10	98.95
5	50.93	0.11	3.01	0.48	0.19	15.41	20.51	0.00	0.03	0.28	5.77	1.79	98.51
5	51.91	0.14	2.95	0.38	0.21	15.46	20.60	0.03	0.03	0.25	6.85	0.26	99.08
5	51.28	0.10	2.85	0.43	0.21	15.06	21.87	0.05	0.00	0.26	5.11	1.60	98.82
avg(10)	51.33	0.15	2.90	0.44	0.21	15.39	21.10	0.03	0.02	0.26	5.60	1.54	98.98
stdev	0.67	0.05	0.42	0.09	0.02	0.37	0.81	0.02	0.02	0.01	0.90	0.76	0.40
Cycle 3													
102	52.34	0.16	2.32	0.09	15.94	22.12	0.12	0.06	0.01	0.20	4.89	1.84	100.09
102	52.42	0.16	2.38	0.17	17.30	19.84	0.19	0.08	0.01	0.23	5.26	2.62	100.66
102	52.72	0.19	2.56	0.11	16.98	20.39	0.16	0.03	0.02	0.18	5.81	1.52	100.67
102	52.69	0.18	2.48	0.10	17.27	20.43	0.16	0.03	0.02	0.23	4.96	3.12	101.67
102	52.44	0.13	2.47	0.11	15.97	22.39	0.18	0.02	0.00	0.23	4.44	2.22	100.60
102	51.69	0.21	2.58	0.16	16.31	22.05	0.18	0.00	0.01	0.19	3.64	3.62	100.63
102	52.47	0.27	2.67	0.12	16.00	22.44	0.14	0.10	0.02	0.25	4.33	2.64	101.45
102	52.50	0.21	2.62	0.13	16.21	21.89	0.19	0.01	0.00	0.24	4.75	2.52	101.26
102	51.98	0.23	2.59	0.07	17.13	20.75	0.14	0.02	0.00	0.23	4.05	3.92	101.11
102	52.52	0.16	2.37	0.12	16.44	22.24	0.16	0.01	0.02	0.20	4.06	2.51	100.81
102	52.65	0.17	2.54	0.11	16.28	22.16	0.18	0.00	0.06	0.26	4.29	2.80	101.50
102	52.84	0.24	2.53	0.10	17.49	20.09	0.19	0.06	0.02	0.23	5.18	3.14	102.11
102	52.58	0.23	2.56	0.13	16.57	21.73	0.18	0.02	0.05	0.25	4.33	3.44	102.06
avg(13)	52.45	0.20	2.51	0.12	16.61	21.43	0.17	0.03	0.02	0.23	4.58	2.80	101.15
stdev	0.30	0.04	0.10	0.03	0.53	0.93	0.02	0.03	0.02	0.02	0.57	0.66	0.59
467	52.38	0.26	2.46	0.06	16.53	20.79	0.14	0.05	0.00	0.22	5.59	2.59	101.07
467	52.13	0.22	2.35	0.08	16.26	21.21	0.26	0.02	0.06	0.26	4.86	3.06	100.78
467	52.79	0.20	2.31	0.03	16.15	21.88	0.21	0.03	0.02	0.23	5.19	1.97	101.01
467	52.80	0.19	2.19	0.11	16.29	22.04	0.20	0.07	0.01	0.20	4.86	2.16	101.12
467	52.91	0.11	2.22	0.07	16.73	20.82	0.15	0.02	0.00	0.22	5.72	2.19	101.16
467	52.77	0.08	2.33	0.12	16.63	21.26	0.19	0.00	0.03	0.22	5.08	3.15	101.87
467	53.03	0.23	2.38	0.06	16.47	21.35	0.07	0.03	0.03	0.24	5.70	2.02	101.61
467	52.78	0.10	2.28	0.09	16.13	22.15	0.23	0.02	0.00	0.25	4.70	3.07	101.80
467	52.27	0.18	2.40	0.11	16.27	21.48	0.16	0.03	0.00	0.23	4.92	3.17	101.22
467	52.55	0.06	2.37	0.08	16.02	21.47	0.24	0.02	0.02	0.23	5.52	2.37	100.95
467	52.64	0.13	2.28	0.10	16.38	21.37	0.18	0.05	0.02	0.22	5.25	2.54	101.16
avg(11)	52.64	0.16	2.32	0.08	16.35	21.44	0.19	0.03	0.02	0.23	5.20	2.58	101.25
stdev	0.27	0.06	0.08	0.03	0.21	0.42	0.05	0.02	0.02	0.02	0.35	0.45	0.34
468	51.92	0.29	2.56	0.09	16.74	20.99	0.13	0.02	0.04	0.21	4.48	4.10	101.57
468	52.32	0.15	2.58	0.06	16.52	21.42	0.19	0.01	0.00	0.25	4.48	3.52	101.50
468	52.44	0.18	2.65	0.12	16.66	21.04	0.19	0.00	0.00	0.26	4.85	3.54	101.93
468	52.87	0.24	2.61	0.04	16.65	21.18	0.16	0.04	0.04	0.26	5.21	3.00	102.30
468	52.37	0.27	2.64	0.10	16.41	21.59	0.21	0.01	0.07	0.25	4.54	3.67	102.13
468	52.41	0.18	2.46	0.12	16.40	21.84	0.22	0.00	0.00	0.23	4.36	3.49	101.71
468	52.58	0.27	2.69	0.14	16.41	21.65	0.15	0.04	0.04	0.24	4.82	3.61	102.64
468	52.48	0.14	2.56	0.05	16.50	21.40	0.22	0.03	0.03	0.20	4.88	3.05	101.54
468	52.06	0.16	2.74	0.08	16.44	21.24	0.19	0.07	0.07	0.25	4.43	3.89	101.62

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
468	52.62	0.15	2.60	0.11	16.66	21.50	0.21	0.03	0.07	0.24	4.43	3.95	102.57
468	52.38	0.18	2.60	0.08	16.54	21.64	0.17	0.01	0.00	0.25	4.28	3.65	101.79
avg(11)	52.40	0.20	2.61	0.09	16.54	21.41	0.18	0.02	0.03	0.24	4.62	3.59	101.93
stdev	0.25	0.05	0.07	0.03	0.12	0.26	0.03	0.02	0.03	0.02	0.27	0.32	0.40
469	52.81	0.28	2.29	0.06	16.44	21.43	0.19	0.00	0.00	0.21	5.51	2.19	101.41
469	52.78	0.23	2.22	0.09	16.51	21.29	0.21	0.00	0.02	0.23	5.35	2.87	101.80
469	52.63	0.14	2.34	0.08	16.60	21.11	0.18	0.06	0.00	0.24	5.10	3.21	101.69
469	52.77	0.15	2.31	0.06	16.53	21.28	0.21	0.03	0.00	0.24	5.19	3.21	101.98
469	52.58	0.21	2.28	0.02	16.44	21.90	0.19	0.05	0.05	0.23	4.38	3.82	102.15
469	52.53	0.28	2.36	0.12	16.13	22.11	0.13	0.03	0.01	0.25	4.69	3.18	101.82
469	52.75	0.23	2.26	0.03	16.59	21.25	0.18	0.06	0.06	0.19	5.34	2.91	101.85
469	52.56	0.18	2.44	0.07	16.34	21.38	0.22	0.03	0.01	0.23	5.20	3.27	101.93
469	52.75	0.29	2.41	0.08	16.62	21.18	0.20	0.04	0.09	0.21	5.31	2.88	102.06
469	53.10	0.19	2.25	0.01	16.06	22.30	0.19	0.01	0.02	0.24	5.17	2.71	102.25
469	52.50	0.14	2.38	0.01	16.71	20.96	0.21	0.03	0.05	0.21	5.04	3.56	101.80
469	52.16	0.22	2.41	0.07	16.42	21.74	0.20	0.00	0.00	0.23	4.21	4.22	101.88
469	52.06	0.20	2.48	0.07	16.44	21.61	0.17	0.03	0.00	0.20	4.35	3.92	101.52
469	52.22	0.21	2.42	0.05	16.25	21.92	0.19	0.08	0.04	0.26	4.10	4.35	102.10
avg(14)	52.59	0.21	2.35	0.06	16.43	21.53	0.19	0.03	0.03	0.23	4.92	3.31	101.88
stdev	0.27	0.05	0.08	0.03	0.18	0.39	0.02	0.02	0.03	0.02	0.46	0.59	0.22
471	51.25	0.19	2.84	0.19	16.04	22.49	0.15	0.00	0.04	0.21	2.92	3.77	100.09
471	51.87	0.19	2.79	0.13	16.03	22.22	0.11	0.00	0.00	0.22	4.05	2.75	100.37
471	51.90	0.24	2.76	0.18	15.95	22.32	0.14	0.00	0.05	0.22	4.07	2.92	100.75
471	51.64	0.17	2.83	0.14	15.87	22.33	0.16	0.00	0.02	0.21	3.88	3.29	100.54
471	51.44	0.27	2.78	0.11	15.90	22.26	0.14	0.00	0.00	0.20	3.86	2.88	99.84
471	52.01	0.15	2.76	0.15	15.96	22.16	0.14	0.04	0.06	0.22	4.26	2.23	100.14
471	50.72	0.26	2.78	0.15	15.93	22.10	0.16	0.06	0.01	0.23	2.91	3.94	99.25
471	51.98	0.24	2.66	0.17	16.02	22.31	0.19	0.03	0.03	0.21	4.04	2.84	100.72
471	51.40	0.20	2.72	0.11	16.03	22.15	0.21	0.00	0.00	0.23	3.45	2.71	99.20
471	51.49	0.24	2.70	0.12	16.03	22.26	0.18	0.06	0.01	0.21	3.50	2.87	99.68
471	51.83	0.25	2.74	0.14	15.90	22.04	0.15	0.05	0.03	0.22	4.41	2.14	99.89
471	51.49	0.05	2.72	0.18	15.97	22.18	0.11	0.00	0.06	0.24	3.48	2.95	99.44
471	51.63	0.19	2.79	0.17	15.87	22.05	0.18	0.00	0.00	0.27	3.97	2.56	99.68
471	50.96	0.30	2.83	0.18	16.12	22.17	0.18	0.03	0.00	0.24	2.78	3.93	99.72
471	51.38	0.20	2.82	0.11	15.94	22.39	0.14	0.04	0.00	0.18	3.54	3.41	100.15
471	51.74	0.21	2.82	0.19	15.91	22.19	0.18	0.02	0.00	0.27	3.85	2.58	99.96
471	51.64	0.22	2.62	0.19	15.98	22.18	0.14	0.05	0.02	0.21	3.90	3.06	100.21
471	51.50	0.24	2.71	0.17	15.98	22.45	0.14	0.00	0.00	0.23	3.38	3.63	100.42
471	50.92	0.19	2.78	0.19	16.00	22.35	0.12	0.00	0.00	0.25	2.66	4.36	99.82
471	51.49	0.12	2.79	0.14	15.88	22.15	0.16	0.00	0.00	0.21	3.89	2.92	99.75
avg(20)	51.52	0.21	2.77	0.15	15.96	22.26	0.15	0.02	0.02	0.23	3.60	3.14	100.03
stdev	0.34	0.05	0.06	0.03	0.07	0.15	0.03	0.02	0.02	0.02	0.48	0.57	0.46
472	52.72	0.16	2.29	0.09	16.11	23.05	0.20	0.04	0.00	0.24	3.62	2.88	101.40
472	52.32	0.21	2.23	0.11	16.17	22.55	0.14	0.01	0.00	0.22	3.90	2.43	100.29
472	52.34	0.19	2.39	0.08	16.18	22.81	0.14	0.06	0.03	0.24	3.39	3.25	101.10
472	52.39	0.00	2.30	0.08	16.20	22.87	0.18	0.00	0.00	0.21	3.35	2.96	100.54
472	51.89	0.13	2.51	0.01	16.26	23.00	0.11	0.01	0.06	0.23	2.50	3.62	100.33
472	52.36	0.19	2.38	0.11	16.29	22.73	0.13	0.00	0.06	0.18	3.63	2.74	100.80
472	52.92	0.09	2.02	0.01	15.88	23.32	0.16	0.03	0.00	0.25	3.86	1.99	100.53
472	52.83	0.12	2.43	0.00	16.23	22.91	0.07	0.05	0.02	0.25	3.74	2.59	101.24
472	52.64	0.30	2.34	0.07	16.32	22.72	0.15	0.03	0.02	0.23	3.78	2.34	100.94
472	52.34	0.12	2.36	0.02	16.27	22.84	0.15	0.05	0.03	0.17	3.45	2.94	100.73
472	52.90	0.25	2.40	0.09	16.03	23.34	0.15	0.00	0.00	0.26	3.68	2.16	101.27
472	52.25	0.24	2.55	0.12	16.40	22.95	0.10	0.06	0.01	0.21	2.95	3.32	101.16
472	52.40	0.15	2.48	0.08	16.35	22.68	0.16	0.07	0.03	0.22	3.35	3.09	101.06
472	52.55	0.21	2.45	0.07	16.24	22.89	0.20	0.05	0.04	0.20	3.57	3.30	101.77
472	52.42	0.18	2.46	0.07	16.41	22.76	0.11	0.06	0.04	0.21	3.29	3.19	101.20
472	52.46	0.15	2.41	0.08	16.06	23.21	0.16	0.06	0.01	0.16	3.57	2.82	101.14
avg(16)	52.48	0.17	2.38	0.07	16.21	22.91	0.15	0.04	0.02	0.22	3.47	2.86	100.98
stdev	0.26	0.07	0.12	0.04	0.14	0.22	0.03	0.02	0.02	0.03	0.34	0.44	0.39
473	52.51	0.17	2.55	0.07	16.32	22.71	0.19	0.01	0.00	0.21	3.62	3.33	101.68
473	52.98	0.20	2.55	0.08	16.05	23.01	0.16	0.02	0.00	0.21	4.32	2.34	101.92
473	52.77	0.16	2.68	0.07	16.14	22.74	0.23	0.00	0.03	0.23	4.05	2.85	101.95
473	52.75	0.21	2.51	0.11	16.29	22.92	0.16	0.03	0.01	0.24	3.58	3.21	102.02
473	52.42	0.20	2.64	0.02	16.36	22.95	0.11	0.06	0.06	0.21	3.13	3.71	101.87
473	52.43	0.26	2.46	0.12	16.41	22.87	0.16	0.08	0.05	0.22	3.10	3.56	101.73

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
473	52.35	0.15	2.63	0.06	16.37	22.91	0.16	0.04	0.08	0.23	2.89	3.88	101.75
473	52.57	0.18	2.65	0.09	16.12	22.69	0.17	0.05	0.07	0.23	3.90	3.16	101.88
473	51.84	0.22	2.75	0.07	16.09	22.99	0.15	0.03	0.03	0.23	2.81	4.07	101.28
avg(9)	52.59	0.18	2.48	0.07	16.23	23.05	0.17	0.03	0.04	0.21	3.41	3.28	101.74
stdev	0.37	0.05	0.39	0.03	0.13	0.56	0.03	0.02	0.03	0.04	0.52	0.53	0.26
474	51.48	0.17	2.68	0.11	16.07	22.23	0.13	0.03	0.02	0.23	3.37	3.01	99.53
474	51.72	0.14	2.64	0.05	16.09	22.32	0.17	0.03	0.00	0.22	3.51	2.94	99.82
474	51.93	0.23	2.73	0.05	16.08	22.46	0.17	0.03	0.00	0.23	3.63	2.78	100.32
474	50.86	0.13	2.69	0.05	16.01	21.94	0.16	0.05	0.00	0.21	3.14	2.78	98.02
474	51.15	0.12	2.72	0.15	15.77	22.16	0.15	0.02	0.05	0.20	3.66	2.39	98.54
474	50.96	0.14	2.70	0.11	15.96	21.68	0.13	0.04	0.02	0.22	3.66	2.28	97.90
474	51.87	0.17	2.84	0.07	16.14	22.36	0.18	0.03	0.02	0.23	3.50	3.10	100.51
474	52.02	0.19	2.71	0.03	16.17	22.72	0.15	0.00	0.00	0.19	3.44	3.07	100.70
474	51.57	0.18	2.94	0.15	16.03	22.86	0.15	0.07	0.00	0.23	2.71	3.87	100.77
474	51.86	0.19	2.90	0.13	16.06	22.85	0.12	0.03	0.04	0.23	3.06	3.66	101.13
474	51.70	0.19	2.88	0.10	16.06	22.67	0.17	0.01	0.01	0.22	3.14	3.42	100.57
474	51.51	0.25	2.83	0.11	16.27	22.84	0.13	0.04	0.02	0.24	2.29	4.40	100.93
474	52.17	0.17	2.96	0.15	16.14	22.33	0.14	0.08	0.02	0.21	3.98	2.05	100.41
474	51.77	0.13	2.79	0.09	16.18	22.58	0.12	0.03	0.00	0.22	3.11	3.34	100.36
474	51.08	0.13	2.87	0.10	16.19	22.45	0.14	0.03	0.03	0.19	2.53	4.04	99.77
474	51.54	0.12	2.75	0.06	16.39	22.52	0.11	0.00	0.02	0.21	2.60	3.76	100.08
474	51.48	0.09	2.77	0.10	16.14	22.88	0.13	0.02	0.00	0.21	2.47	4.48	100.77
474	51.38	0.13	2.92	0.13	16.15	22.28	0.13	0.05	0.02	0.25	2.90	3.59	99.93
474	52.10	0.17	2.16	0.06	16.18	23.96	0.16	0.00	0.03	0.12	2.20	3.80	100.94
avg(20)	51.67	0.15	2.69	0.09	16.11	22.63	0.15	0.03	0.02	0.21	3.07	3.27	100.09
stdev	0.51	0.05	0.36	0.04	0.12	0.63	0.02	0.03	0.01	0.03	0.51	0.67	0.92
476	52.56	0.15	2.22	0.16	16.63	22.32	0.16	0.06	0.03	0.22	3.51	3.73	101.75
476	52.54	0.22	2.21	0.17	16.66	22.30	0.10	0.04	0.01	0.23	3.58	3.28	101.34
476	52.54	0.20	2.21	0.16	16.80	22.32	0.20	0.02	0.02	0.23	3.19	4.14	102.03
476	52.83	0.13	2.43	0.15	16.67	22.29	0.15	0.01	0.07	0.23	3.76	3.11	101.82
476	52.44	0.20	2.38	0.12	16.62	22.36	0.18	0.06	0.03	0.20	3.45	4.01	102.05
476	52.53	0.14	2.28	0.14	16.56	22.31	0.18	0.13	0.05	0.21	3.54	3.65	101.73
476	52.25	0.21	2.33	0.12	16.64	22.05	0.21	0.06	0.06	0.22	3.44	3.51	101.10
476	52.56	0.16	2.45	0.14	16.65	22.12	0.16	0.09	0.01	0.22	3.73	3.12	101.41
476	52.26	0.16	2.61	0.13	16.43	22.40	0.20	0.02	0.04	0.19	3.54	3.73	101.71
476	53.09	0.17	2.51	0.12	16.20	22.31	0.14	0.00	0.00	0.28	4.77	1.91	101.50
avg(11)	52.60	0.17	2.33	0.14	16.61	22.27	0.16	0.05	0.03	0.24	3.59	3.52	101.71
stdev	0.39	0.04	0.37	0.03	0.15	0.67	0.03	0.04	0.02	0.12	0.39	0.84	0.32
478	51.99	0.20	2.26	0.17	16.48	22.06	0.16	0.01	0.00	0.26	3.36	4.21	101.16
478	52.66	0.28	2.31	0.12	16.48	21.71	0.11	0.09	0.01	0.19	4.98	2.68	101.62
478	52.78	0.23	2.33	0.15	16.56	21.66	0.14	0.01	0.00	0.20	5.01	2.58	101.65
478	52.35	0.28	2.25	0.12	16.58	21.75	0.15	0.05	0.01	0.22	4.23	3.46	101.46
478	52.65	0.17	2.26	0.14	16.47	21.81	0.17	0.02	0.07	0.24	4.47	2.91	101.38
478	52.56	0.18	2.17	0.14	16.49	22.36	0.17	0.00	0.02	0.19	3.93	3.15	101.37
478	52.24	0.23	2.37	0.16	16.44	21.73	0.12	0.00	0.00	0.22	4.42	3.21	101.14
478	52.67	0.23	2.09	0.13	16.88	21.44	0.20	0.02	0.01	0.23	4.37	3.45	101.72
478	52.81	0.30	2.36	0.14	16.55	21.56	0.10	0.03	0.00	0.23	5.13	2.45	101.67
avg(11)	52.55	0.22	2.12	0.14	16.46	22.11	0.15	0.03	0.02	0.21	4.23	3.13	101.37
stdev	0.31	0.05	0.32	0.02	0.27	0.82	0.03	0.03	0.02	0.04	0.76	0.48	0.48
481	52.34	0.21	2.34	0.09	15.80	21.19	0.20	0.05	0.06	0.25	6.03	2.42	100.98
481	53.01	0.07	2.31	0.07	16.00	20.77	0.23	0.08	0.00	0.22	7.02	1.13	100.91
481	52.18	0.25	2.32	0.10	16.09	21.55	0.26	0.00	0.00	0.25	4.94	3.50	101.44
481	52.45	0.16	2.36	0.13	15.75	22.21	0.15	0.00	0.01	0.23	5.14	3.09	101.68
481	52.97	0.25	2.13	0.11	15.87	20.49	0.17	0.00	0.00	0.27	7.63	0.15	100.05
481	52.34	0.19	2.40	0.15	15.83	21.16	0.22	0.10	0.02	0.25	5.97	3.22	101.84
481	52.94	0.23	2.21	0.12	15.65	22.31	0.21	0.01	0.00	0.23	5.78	2.50	102.19
481	52.57	0.10	2.19	0.11	15.62	22.50	0.22	0.03	0.02	0.26	4.84	2.94	101.39
481	52.52	0.17	2.29	0.09	16.16	20.47	0.23	0.02	0.03	0.24	6.56	1.70	100.48
481	52.80	0.20	2.21	0.11	16.58	20.11	0.27	0.00	0.05	0.25	6.55	1.51	100.64
481	52.17	0.12	2.23	0.12	16.80	19.07	0.26	0.00	0.02	0.22	6.84	2.78	100.63
481	52.44	0.29	2.20	0.08	15.81	21.49	0.20	0.00	0.00	0.27	5.83	2.32	100.93
avg(12)	52.56	0.18	2.27	0.11	16.00	21.11	0.22	0.02	0.02	0.24	6.10	2.26	101.10
stdev	0.29	0.06	0.08	0.02	0.35	0.96	0.03	0.03	0.02	0.02	0.83	0.94	0.60

Table B.2 Chemical composition of clinopyroxene (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Oxsum
						Cycle 2							
485	51.80	0.86	2.43	0.20	16.62	20.93	0.23	0.04	0.00	0.22	5.02	2.16	100.51
485	53.65	0.18	2.15	0.16	17.52	20.11	0.18	0.02	0.01	0.22	6.12	0.41	100.73
485	52.84	0.25	2.27	0.25	16.93	20.78	0.12	0.02	0.01	0.24	5.38	1.26	100.35
485	53.60	0.19	2.07	0.21	17.03	20.47	0.12	0.00	0.00	0.23	6.20	0.00	100.12
485	52.74	0.34	2.38	0.20	16.03	22.60	0.15	0.00	0.00	0.26	4.52	1.68	100.90
485	52.77	0.13	2.25	0.25	17.20	19.84	0.16	0.01	0.00	0.25	5.84	2.28	100.98
485	52.87	0.32	2.23	0.24	16.33	22.10	0.20	0.10	0.04	0.25	4.62	1.94	101.24
485	53.37	0.16	1.97	0.16	16.42	22.48	0.17	0.05	0.04	0.33	4.14	1.57	100.86
485	52.99	0.13	2.31	0.24	16.36	22.00	0.15	0.07	0.00	0.26	4.74	2.49	101.74
avg(9)	52.96	0.28	2.23	0.21	16.72	21.26	0.16	0.03	0.01	0.25	5.21	1.49	100.81
stdev	0.53	0.22	0.14	0.03	0.46	0.99	0.03	0.03	0.02	0.03	0.70	0.80	0.46
486	52.17	0.20	2.72	0.23	16.17	20.96	0.25	0.05	0.02	0.24	5.49	3.50	102.00
486	52.09	0.19	2.63	0.14	15.83	22.04	0.21	0.03	0.02	0.25	4.62	3.67	101.72
486	52.52	0.24	2.57	0.22	16.22	21.27	0.25	0.04	0.03	0.25	5.41	2.75	101.76
486	52.20	0.22	2.64	0.21	15.98	21.99	0.22	0.10	0.01	0.26	4.46	4.13	102.42
486	52.15	0.21	2.68	0.21	15.90	21.70	0.24	0.03	0.00	0.23	5.10	3.09	101.54
486	52.53	0.13	2.59	0.20	16.27	20.97	0.21	0.01	0.00	0.25	5.72	2.38	101.26
486	51.77	0.23	3.19	0.18	16.24	21.08	0.27	0.00	0.00	0.20	4.99	3.22	101.37
486	52.26	0.15	2.64	0.16	16.25	21.19	0.20	0.03	0.00	0.22	5.30	3.64	102.03
486	52.76	0.17	2.57	0.17	16.15	21.05	0.17	0.00	0.05	0.24	6.18	1.57	101.09
486	52.22	0.18	2.73	0.20	15.84	21.81	0.22	0.01	0.00	0.25	5.07	2.90	101.43
486	52.99	0.18	2.61	0.20	16.35	21.08	0.24	0.03	0.00	0.27	5.88	1.86	101.70
avg(11)	52.33	0.19	2.69	0.19	16.11	21.38	0.23	0.03	0.01	0.24	5.29	2.98	101.67
stdev	0.32	0.03	0.17	0.03	0.18	0.40	0.03	0.03	0.02	0.02	0.49	0.75	0.37

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mn	Ca	Mg	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
							Cycle 15								
458	1.919	0.120	0.081	0.039	0.005	0.017	0.006	0.902	0.814	0.000	0.000	0.014	0.176	0.028	4.000
458	1.907	0.121	0.093	0.028	0.006	0.013	0.006	0.872	0.893	0.001	0.003	0.014	0.111	0.054	4.000
458	1.913	0.123	0.087	0.036	0.006	0.015	0.006	0.858	0.877	0.000	0.000	0.016	0.147	0.039	4.000
458	1.917	0.113	0.083	0.030	0.007	0.015	0.004	0.862	0.897	0.000	0.001	0.016	0.129	0.040	4.000
458	1.905	0.122	0.095	0.027	0.004	0.014	0.007	0.879	0.858	0.004	0.001	0.014	0.135	0.059	4.000
458	1.901	0.114	0.099	0.015	0.003	0.019	0.008	0.872	0.835	0.000	0.001	0.027	0.135	0.086	4.000
458	1.918	0.121	0.082	0.039	0.003	0.016	0.006	0.885	0.840	0.001	0.000	0.014	0.161	0.035	4.000
458	1.915	0.123	0.085	0.038	0.003	0.014	0.006	0.874	0.873	0.000	0.001	0.014	0.136	0.040	4.000
458	1.914	0.121	0.086	0.035	0.002	0.015	0.006	0.877	0.866	0.000	0.000	0.012	0.143	0.044	4.000
458	1.918	0.117	0.082	0.035	0.003	0.009	0.006	0.882	0.874	0.001	0.001	0.013	0.132	0.044	4.000
458	1.923	0.111	0.077	0.034	0.003	0.014	0.007	0.875	0.873	0.001	0.000	0.014	0.143	0.036	4.000
458	1.931	0.104	0.069	0.035	0.003	0.016	0.006	0.876	0.877	0.000	0.001	0.013	0.149	0.026	4.000
avg(12)	1.915	0.117	0.085	0.032	0.004	0.015	0.006	0.876	0.865	0.001	0.001	0.015	0.141	0.045	4.000
stdev	0.008	0.006	0.008	0.007	0.002	0.002	0.001	0.011	0.023	0.001	0.001	0.004	0.016	0.015	
455	1.920	0.114	0.080	0.034	0.004	0.014	0.008	0.882	0.863	0.000	0.000	0.013	0.147	0.037	4.000
455	1.928	0.112	0.072	0.040	0.004	0.014	0.005	0.881	0.871	0.001	0.001	0.014	0.146	0.025	4.000
455	1.909	0.114	0.091	0.023	0.003	0.012	0.007	0.883	0.865	0.002	0.001	0.013	0.129	0.064	4.000
455	1.929	0.121	0.071	0.050	0.004	0.011	0.007	0.867	0.865	0.000	0.000	0.015	0.164	0.018	4.000
455	1.943	0.111	0.057	0.054	0.005	0.013	0.005	0.885	0.851	0.002	0.002	0.013	0.166	0.000	3.997
455	1.927	0.119	0.073	0.046	0.006	0.017	0.007	0.863	0.865	0.001	0.000	0.016	0.167	0.013	4.000
455	1.915	0.114	0.085	0.029	0.004	0.015	0.005	0.885	0.851	0.001	0.002	0.014	0.148	0.046	4.000
455	1.932	0.108	0.068	0.040	0.004	0.014	0.007	0.863	0.877	0.000	0.001	0.013	0.162	0.020	4.000
455	1.903	0.120	0.097	0.023	0.002	0.012	0.007	0.869	0.877	0.002	0.001	0.014	0.121	0.072	4.000
455	1.913	0.122	0.087	0.035	0.004	0.013	0.006	0.888	0.847	0.001	0.000	0.015	0.147	0.045	4.000
455	1.917	0.120	0.083	0.037	0.004	0.014	0.005	0.859	0.878	0.000	0.000	0.014	0.153	0.036	4.000
455	1.925	0.121	0.075	0.046	0.006	0.012	0.004	0.857	0.869	0.001	0.000	0.015	0.170	0.019	4.000
455	1.924	0.121	0.076	0.045	0.005	0.015	0.004	0.905	0.802	0.000	0.001	0.013	0.193	0.017	4.000
455	1.918	0.122	0.082	0.040	0.004	0.014	0.007	0.853	0.886	0.000	0.000	0.015	0.148	0.035	4.000
455	1.924	0.118	0.076	0.042	0.005	0.013	0.006	0.877	0.857	0.001	0.000	0.012	0.164	0.024	4.000
455	1.912	0.124	0.088	0.036	0.004	0.015	0.004	0.869	0.881	0.000	0.000	0.013	0.139	0.040	4.000
455	1.905	0.118	0.095	0.023	0.007	0.013	0.006	0.884	0.877	0.000	0.001	0.011	0.121	0.057	4.000
455	1.915	0.123	0.085	0.038	0.006	0.013	0.004	0.861	0.875	0.001	0.001	0.016	0.148	0.038	4.000
455	1.933	0.093	0.067	0.026	0.003	0.007	0.000	0.920	0.835	0.002	0.001	0.013	0.152	0.041	4.000
avg(19)	1.921	0.119	0.079	0.037	0.004	0.013	0.005	0.876	0.863	0.001	0.001	0.014	0.152	0.034	4.000
stdev	0.010	0.007	0.010	0.009	0.001	0.002	0.002	0.017	0.020	0.001	0.001	0.001	0.018	0.018	
453	1.918	0.118	0.082	0.036	0.003	0.012	0.008	0.848	0.891	0.001	0.001	0.017	0.139	0.044	4.000
453	1.928	0.108	0.072	0.036	0.003	0.014	0.006	0.868	0.869	0.001	0.001	0.016	0.157	0.030	4.000
453	1.920	0.113	0.080	0.033	0.005	0.013	0.003	0.879	0.849	0.001	0.001	0.016	0.160	0.039	4.000
453	1.917	0.113	0.083	0.030	0.004	0.011	0.006	0.870	0.867	0.002	0.000	0.016	0.146	0.050	4.000
453	1.916	0.110	0.084	0.026	0.005	0.014	0.006	0.865	0.872	0.001	0.000	0.018	0.143	0.053	4.000
453	1.919	0.115	0.081	0.034	0.003	0.011	0.005	0.864	0.870	0.002	0.000	0.011	0.161	0.040	4.000
453	1.925	0.110	0.075	0.035	0.006	0.013	0.005	0.928	0.769	0.001	0.001	0.013	0.202	0.027	4.000
453	1.943	0.068	0.057	0.011	0.004	0.013	0.006	0.866	0.922	0.002	0.001	0.015	0.121	0.040	4.000
453	1.924	0.118	0.076	0.042	0.006	0.014	0.006	0.852	0.872	0.001	0.000	0.016	0.166	0.024	4.000
453	1.929	0.105	0.071	0.034	0.003	0.010	0.005	0.865	0.875	0.000	0.001	0.018	0.151	0.038	4.000
453	1.925	0.116	0.075	0.041	0.004	0.012	0.005	0.862	0.866	0.000	0.000	0.018	0.161	0.032	4.000
453	1.922	0.114	0.078	0.036	0.004	0.013	0.006	0.855	0.877	0.001	0.002	0.018	0.150	0.039	4.000
avg(12)	1.924	0.109	0.076	0.033	0.004	0.013	0.006	0.869	0.867	0.001	0.001	0.016	0.155	0.037	4.000
stdev	0.007	0.013	0.007	0.008	0.001	0.001	0.001	0.020	0.034	0.001	0.001	0.002	0.019	0.008	
452	1.941	0.118	0.059	0.059	0.003	0.010	0.005	0.860	0.890	0.000	0.000	0.013	0.159	0.000	3.999
452	1.940	0.121	0.060	0.061	0.003	0.012	0.005	0.862	0.885	0.001	0.001	0.016	0.154	0.000	3.999
452	1.929	0.119	0.071	0.048	0.005	0.011	0.005	0.921	0.813	0.002	0.000	0.012	0.170	0.014	4.000
452	1.933	0.117	0.067	0.050	0.004	0.013	0.005	0.873	0.886	0.000	0.001	0.014	0.145	0.010	4.000
452	1.932	0.118	0.068	0.050	0.001	0.008	0.004	0.859	0.902	0.002	0.000	0.014	0.140	0.021	4.000
452	1.925	0.119	0.075	0.044	0.004	0.010	0.006	0.907	0.844	0.002	0.001	0.012	0.146	0.024	4.000
452	1.931	0.118	0.069	0.049	0.005	0.010	0.005	0.885	0.852	0.002	0.001	0.014	0.165	0.012	4.000
452	1.939	0.119	0.061	0.058	0.003	0.009	0.005	0.895	0.851	0.001	0.001	0.011	0.166	0.000	4.000
452	1.932	0.117	0.068	0.049	0.004	0.010	0.003	0.886	0.863	0.001	0.000	0.012	0.160	0.011	4.000
452	1.927	0.122	0.073	0.049	0.004	0.010	0.007	0.874	0.877	0.001	0.000	0.013	0.147	0.020	4.000
452	1.926	0.122	0.074	0.048	0.003	0.011	0.005	0.896	0.850	0.000	0.000	0.012	0.154	0.021	4.000
452	1.936	0.114	0.064	0.050	0.003	0.011	0.006	0.868	0.879	0.001	0.000	0.014	0.157	0.011	4.000
avg(12)	1.933	0.118	0.067	0.051	0.003	0.011	0.005	0.882	0.866	0.001	0.000	0.013	0.155	0.012	4.000
stdev	0.005	0.002	0.005	0.005	0.001	0.001	0.001	0.020	0.025	0.001	0.000	0.001	0.009	0.009	
456	1.945	0.109	0.055	0.054	0.005	0.006	0.005	0.899	0.860	0.000	0.000	0.014	0.154	0.000	3.999
456	1.938	0.108	0.062	0.046	0.003	0.011	0.006	0.895	0.865	0.000	0.002	0.015	0.144	0.014	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mn	Ca	Mg	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
456	1.944	0.101	0.056	0.045	0.004	0.010	0.006	0.885	0.865	0.001	0.000	0.014	0.165	0.006	4.000
456	1.925	0.121	0.075	0.046	0.003	0.009	0.005	0.879	0.877	0.002	0.000	0.014	0.137	0.027	4.000
456	1.929	0.117	0.071	0.046	0.003	0.010	0.005	0.871	0.881	0.001	0.001	0.017	0.140	0.025	4.000
456	1.923	0.112	0.077	0.035	0.003	0.008	0.006	0.878	0.877	0.001	0.000	0.016	0.133	0.043	4.000
456	1.942	0.120	0.058	0.062	0.003	0.010	0.005	0.862	0.878	0.000	0.000	0.016	0.161	0.000	3.997
456	1.932	0.099	0.068	0.031	0.005	0.010	0.006	0.873	0.892	0.000	0.001	0.016	0.133	0.032	4.000
456	1.929	0.121	0.071	0.050	0.004	0.010	0.006	0.866	0.891	0.002	0.001	0.017	0.134	0.020	4.000
avg(9)	1.934	0.112	0.066	0.046	0.003	0.009	0.006	0.879	0.876	0.001	0.001	0.015	0.145	0.019	4.000
stdev	0.008	0.008	0.008	0.009	0.001	0.001	0.000	0.013	0.011	0.001	0.001	0.001	0.012	0.015	
457	1.913	0.122	0.087	0.035	0.004	0.012	0.006	0.919	0.796	0.001	0.000	0.012	0.172	0.042	4.000
457	1.915	0.122	0.085	0.037	0.006	0.015	0.005	0.886	0.853	0.001	0.000	0.014	0.147	0.036	4.000
457	1.908	0.124	0.092	0.032	0.007	0.014	0.005	0.858	0.881	0.001	0.001	0.014	0.142	0.044	4.000
457	1.920	0.122	0.080	0.042	0.007	0.015	0.006	0.855	0.881	0.000	0.000	0.015	0.155	0.023	4.000
457	1.922	0.118	0.078	0.040	0.005	0.014	0.006	0.890	0.825	0.002	0.001	0.012	0.181	0.026	4.000
457	1.911	0.118	0.089	0.029	0.005	0.013	0.005	0.876	0.873	0.000	0.002	0.014	0.132	0.050	4.000
457	1.904	0.124	0.096	0.028	0.002	0.016	0.006	0.862	0.883	0.003	0.001	0.017	0.117	0.065	4.000
457	1.903	0.121	0.097	0.024	0.005	0.015	0.005	0.878	0.873	0.000	0.000	0.014	0.125	0.061	4.000
457	1.917	0.122	0.083	0.039	0.006	0.010	0.005	0.858	0.896	0.000	0.001	0.016	0.133	0.036	4.000
avg(9)	1.913	0.121	0.087	0.034	0.005	0.014	0.005	0.876	0.862	0.001	0.001	0.014	0.145	0.043	4.000
stdev	0.007	0.002	0.007	0.006	0.002	0.002	0.001	0.021	0.032	0.001	0.001	0.002	0.021	0.014	
Cycle 14															
407	1.916	0.131	0.084	0.047	0.007	0.013	0.004	0.904	0.850	0.000	0.002	0.011	0.142	0.020	4.000
407	1.930	0.123	0.070	0.053	0.004	0.012	0.004	0.905	0.846	0.001	0.001	0.013	0.152	0.010	4.000
407	1.922	0.126	0.078	0.048	0.002	0.013	0.004	0.922	0.836	0.001	0.002	0.013	0.136	0.025	4.000
407	1.914	0.133	0.086	0.047	0.004	0.014	0.005	0.884	0.874	0.001	0.000	0.014	0.127	0.029	4.000
407	1.917	0.128	0.083	0.045	0.007	0.012	0.005	0.898	0.858	0.003	0.002	0.015	0.130	0.028	4.000
407	1.920	0.128	0.080	0.048	0.004	0.014	0.005	0.882	0.876	0.001	0.000	0.016	0.128	0.025	4.000
407	1.919	0.126	0.081	0.045	0.005	0.011	0.004	0.892	0.866	0.000	0.001	0.013	0.135	0.028	4.000
407	1.922	0.129	0.078	0.051	0.004	0.011	0.004	0.895	0.865	0.003	0.000	0.012	0.135	0.020	4.000
407	1.929	0.123	0.071	0.052	0.006	0.013	0.005	0.902	0.858	0.003	0.001	0.000	0.158	0.000	3.997
407	1.929	0.125	0.071	0.054	0.005	0.010	0.004	0.897	0.858	0.002	0.001	0.013	0.145	0.009	4.000
407	1.916	0.121	0.084	0.037	0.004	0.012	0.003	0.896	0.884	0.002	0.000	0.011	0.108	0.040	4.000
407	1.933	0.129	0.067	0.062	0.004	0.010	0.002	0.908	0.852	0.001	0.000	0.011	0.149	0.000	3.999
avg(12)	1.922	0.127	0.078	0.049	0.005	0.012	0.004	0.899	0.860	0.001	0.001	0.013	0.135	0.021	4.000
stdev	0.006	0.003	0.006	0.006	0.001	0.001	0.001	0.010	0.013	0.001	0.001	0.004	0.013	0.012	
381	1.924	0.130	0.076	0.054	0.003	0.012	0.006	0.868	0.901	0.000	0.000	0.013	0.129	0.015	4.000
381	1.916	0.122	0.084	0.038	0.005	0.013	0.003	0.895	0.878	0.000	0.001	0.013	0.119	0.035	4.000
381	1.922	0.121	0.078	0.043	0.002	0.011	0.006	0.889	0.877	0.000	0.001	0.013	0.126	0.032	4.000
381	1.935	0.113	0.065	0.048	0.005	0.014	0.005	0.893	0.867	0.000	0.000	0.013	0.151	0.004	4.000
381	1.925	0.128	0.075	0.053	0.005	0.011	0.004	0.895	0.858	0.001	0.000	0.013	0.149	0.012	4.000
381	1.926	0.127	0.074	0.053	0.003	0.012	0.004	0.886	0.872	0.000	0.000	0.013	0.141	0.017	4.000
381	1.921	0.128	0.079	0.049	0.005	0.013	0.004	0.913	0.835	0.001	0.001	0.014	0.145	0.021	4.000
381	1.913	0.128	0.087	0.041	0.004	0.013	0.004	0.932	0.809	0.003	0.001	0.013	0.144	0.036	4.000
381	1.918	0.126	0.082	0.044	0.004	0.014	0.006	0.882	0.884	0.001	0.000	0.014	0.121	0.031	4.000
381	1.905	0.129	0.095	0.034	0.002	0.011	0.004	0.883	0.887	0.002	0.000	0.013	0.108	0.057	4.000
381	1.945	0.076	0.055	0.021	0.004	0.012	0.005	0.862	0.955	0.001	0.001	0.002	0.122	0.016	4.000
avg(11)	1.923	0.121	0.077	0.044	0.004	0.012	0.005	0.891	0.875	0.001	0.000	0.012	0.133	0.025	4.000
stdev	0.010	0.015	0.010	0.009	0.001	0.001	0.001	0.018	0.035	0.001	0.000	0.003	0.014	0.014	
375	1.906	0.139	0.094	0.045	0.005	0.022	0.004	0.902	0.857	0.001	0.000	0.016	0.116	0.033	4.000
375	1.915	0.134	0.085	0.049	0.005	0.022	0.003	0.900	0.861	0.002	0.002	0.011	0.130	0.016	4.000
375	1.894	0.140	0.106	0.034	0.006	0.024	0.004	0.885	0.888	0.002	0.000	0.017	0.087	0.054	4.000
375	1.904	0.138	0.096	0.042	0.004	0.023	0.003	0.894	0.872	0.003	0.001	0.015	0.107	0.036	4.000
375	1.895	0.136	0.105	0.031	0.007	0.025	0.004	0.904	0.864	0.003	0.000	0.019	0.090	0.055	4.000
375	1.904	0.134	0.096	0.038	0.005	0.022	0.005	0.889	0.885	0.003	0.000	0.016	0.095	0.043	4.000
375	1.927	0.106	0.073	0.033	0.006	0.009	0.003	0.908	0.902	0.002	0.001	0.012	0.092	0.031	4.000
375	1.905	0.133	0.095	0.038	0.005	0.017	0.004	0.899	0.882	0.000	0.000	0.016	0.093	0.045	4.000
375	1.911	0.142	0.089	0.053	0.007	0.025	0.003	0.898	0.862	0.000	0.000	0.003	0.149	0.000	4.000
avg(9)	1.906	0.133	0.094	0.039	0.005	0.021	0.004	0.897	0.874	0.002	0.000	0.016	0.103	0.038	4.000
stdev	0.010	0.010	0.010	0.007	0.001	0.005	0.001	0.007	0.014	0.001	0.001	0.004	0.020	0.017	
Cycle 13															
364	1.976	0.052	0.024	0.028	0.000	0.003	0.005	0.882	0.941	0.001	0.001	0.003	0.132	0.000	3.997
364	1.929	0.108	0.071	0.037	0.005	0.012	0.004	0.913	0.866	0.001	0.001	0.012	0.125	0.024	4.000
364	1.945	0.065	0.055	0.010	0.002	0.008	0.005	0.893	0.944	0.000	0.000	0.004	0.098	0.037	4.000
364	1.935	0.109	0.065	0.044	0.004	0.010	0.005	0.908	0.865	0.000	0.001	0.013	0.135	0.016	4.000
364	1.930	0.107	0.070	0.037	0.004	0.011	0.005	0.943	0.824	0.001	0.000	0.013	0.137	0.025	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
364	1.940	0.107	0.060	0.047	0.005	0.012	0.006	0.948	0.802	0.002	0.000	0.013	0.163	0.003	4.000
364	1.949	0.108	0.051	0.057	0.003	0.009	0.005	0.886	0.871	0.001	0.000	0.012	0.151	0.000	3.996
364	1.936	0.111	0.064	0.047	0.004	0.012	0.004	0.883	0.887	0.001	0.001	0.014	0.137	0.011	4.000
364	1.915	0.113	0.085	0.028	0.006	0.015	0.005	0.921	0.861	0.001	0.000	0.012	0.109	0.043	4.000
364	1.927	0.111	0.073	0.038	0.006	0.011	0.005	0.891	0.889	0.001	0.001	0.014	0.120	0.024	4.000
364	1.924	0.108	0.076	0.032	0.005	0.012	0.006	0.924	0.849	0.003	0.000	0.011	0.126	0.031	4.000
364	1.918	0.114	0.082	0.032	0.003	0.013	0.005	0.891	0.891	0.002	0.000	0.013	0.108	0.042	4.000
364	1.918	0.115	0.082	0.033	0.004	0.012	0.005	0.878	0.901	0.003	0.000	0.016	0.104	0.044	4.000
364	1.919	0.117	0.081	0.036	0.006	0.013	0.005	0.872	0.911	0.001	0.001	0.013	0.111	0.032	4.000
avg(14)	1.933	0.103	0.067	0.036	0.004	0.011	0.005	0.903	0.879	0.001	0.001	0.011	0.128	0.021	4.000
stdev	0.016	0.019	0.016	0.011	0.002	0.003	0.001	0.023	0.038	0.001	0.000	0.004	0.018	0.015	
363	1.924	0.114	0.076	0.038	0.006	0.018	0.005	0.884	0.892	0.001	0.000	0.013	0.122	0.019	4.000
363	1.917	0.121	0.083	0.038	0.004	0.020	0.003	0.894	0.888	0.001	0.000	0.013	0.108	0.031	4.000
363	1.915	0.123	0.085	0.038	0.003	0.023	0.005	0.898	0.877	0.000	0.000	0.013	0.114	0.030	4.000
363	1.919	0.118	0.081	0.037	0.002	0.020	0.005	0.911	0.862	0.001	0.000	0.016	0.111	0.035	4.000
363	1.909	0.126	0.091	0.035	0.005	0.024	0.004	0.877	0.895	0.001	0.000	0.014	0.109	0.035	4.000
363	1.912	0.126	0.088	0.038	0.004	0.023	0.005	0.896	0.880	0.003	0.000	0.013	0.106	0.031	4.000
363	1.925	0.122	0.075	0.047	0.002	0.021	0.005	0.959	0.789	0.002	0.000	0.013	0.145	0.017	4.000
363	1.919	0.126	0.081	0.045	0.001	0.021	0.005	0.938	0.816	0.002	0.001	0.014	0.131	0.026	4.000
363	1.919	0.126	0.081	0.045	0.004	0.023	0.004	0.906	0.855	0.000	0.000	0.013	0.132	0.018	4.000
363	1.913	0.126	0.087	0.039	0.006	0.025	0.004	0.907	0.864	0.002	0.000	0.014	0.114	0.026	4.000
363	1.928	0.097	0.072	0.025	0.004	0.016	0.006	0.900	0.913	0.002	0.001	0.008	0.094	0.031	4.000
363	1.891	0.122	0.109	0.013	0.003	0.024	0.005	0.952	0.828	0.001	0.000	0.013	0.082	0.078	4.000
363	1.918	0.128	0.082	0.046	0.003	0.022	0.005	0.888	0.883	0.001	0.000	0.015	0.116	0.022	4.000
avg(14)	1.916	0.121	0.084	0.037	0.004	0.022	0.005	0.908	0.865	0.001	0.000	0.013	0.114	0.031	4.000
stdev	0.009	0.008	0.009	0.009	0.001	0.002	0.001	0.025	0.034	0.001	0.000	0.002	0.016	0.015	
361	1.926	0.122	0.074	0.048	0.004	0.022	0.005	0.890	0.884	0.000	0.000	0.014	0.124	0.009	4.000
361	1.908	0.129	0.092	0.037	0.003	0.022	0.004	0.907	0.867	0.000	0.003	0.015	0.101	0.041	4.000
361	1.914	0.124	0.086	0.038	0.002	0.023	0.004	0.926	0.839	0.001	0.000	0.014	0.119	0.033	4.000
361	1.915	0.126	0.085	0.041	0.003	0.021	0.004	0.897	0.878	0.000	0.003	0.016	0.105	0.033	4.000
361	1.908	0.127	0.092	0.035	0.003	0.024	0.006	0.960	0.792	0.003	0.003	0.013	0.124	0.039	4.000
361	1.909	0.125	0.091	0.034	0.003	0.021	0.003	0.976	0.773	0.001	0.001	0.012	0.134	0.042	4.000
361	1.921	0.126	0.079	0.047	0.003	0.021	0.006	0.900	0.864	0.001	0.001	0.013	0.126	0.018	4.000
361	1.904	0.128	0.096	0.032	0.006	0.020	0.004	0.927	0.846	0.001	0.000	0.013	0.106	0.045	4.000
361	1.908	0.133	0.092	0.041	0.004	0.022	0.003	0.922	0.857	0.001	0.001	0.011	0.107	0.030	4.000
361	1.918	0.134	0.082	0.052	0.002	0.024	0.004	0.947	0.804	0.002	0.001	0.012	0.141	0.013	4.000
avg(10)	1.913	0.127	0.087	0.040	0.003	0.022	0.004	0.925	0.840	0.001	0.001	0.013	0.119	0.031	4.000
stdev	0.007	0.004	0.007	0.006	0.001	0.001	0.001	0.027	0.036	0.001	0.001	0.001	0.013	0.012	
Zone 12															
356	1.937	0.126	0.063	0.063	0.003	0.018	0.007	0.912	0.828	0.000	0.000	0.014	0.149	0.000	3.994
356	1.929	0.129	0.071	0.058	0.004	0.021	0.004	0.892	0.866	0.002	0.001	0.016	0.135	0.000	4.000
356	1.927	0.126	0.073	0.053	0.004	0.023	0.006	0.910	0.860	0.000	0.000	0.014	0.127	0.003	4.000
356	1.929	0.125	0.071	0.054	0.003	0.023	0.004	0.881	0.888	0.001	0.001	0.016	0.126	0.004	4.000
356	1.921	0.125	0.079	0.046	0.003	0.020	0.005	0.891	0.878	0.001	0.000	0.016	0.118	0.023	4.000
356	1.945	0.118	0.055	0.063	0.003	0.022	0.005	0.868	0.890	0.001	0.001	0.014	0.121	0.000	3.989
356	1.928	0.131	0.072	0.059	0.001	0.020	0.004	0.871	0.898	0.003	0.001	0.013	0.128	0.003	4.000
356	1.936	0.123	0.064	0.059	0.005	0.017	0.005	0.921	0.839	0.000	0.000	0.013	0.136	0.000	3.996
356	1.931	0.127	0.069	0.058	0.003	0.023	0.005	0.878	0.892	0.000	0.000	0.017	0.124	0.000	4.000
356	1.930	0.131	0.070	0.061	0.003	0.022	0.005	0.936	0.814	0.000	0.001	0.014	0.141	0.000	3.997
avg(10)	1.931	0.126	0.069	0.057	0.003	0.021	0.005	0.896	0.865	0.001	0.001	0.015	0.131	0.003	3.998
stdev	0.006	0.004	0.006	0.005	0.001	0.002	0.001	0.022	0.028	0.001	0.000	0.001	0.009	0.007	
355	1.934	0.111	0.066	0.045	0.002	0.020	0.005	0.880	0.897	0.001	0.002	0.014	0.123	0.012	4.000
355	1.936	0.110	0.064	0.046	0.002	0.018	0.006	0.891	0.888	0.001	0.002	0.013	0.124	0.009	4.000
355	1.931	0.116	0.069	0.047	0.002	0.018	0.004	0.882	0.892	0.001	0.001	0.016	0.122	0.016	4.000
355	1.943	0.117	0.057	0.060	0.005	0.017	0.004	0.881	0.879	0.001	0.001	0.014	0.131	0.000	3.992
355	1.928	0.118	0.072	0.046	0.003	0.019	0.005	0.900	0.865	0.001	0.000	0.016	0.130	0.017	4.000
355	1.928	0.118	0.072	0.046	0.001	0.018	0.006	0.911	0.869	0.001	0.000	0.014	0.115	0.020	4.000
355	1.931	0.124	0.069	0.055	0.002	0.022	0.003	0.915	0.845	0.001	0.000	0.012	0.144	0.000	4.000
355	1.935	0.122	0.065	0.057	0.002	0.018	0.005	0.894	0.870	0.002	0.000	0.014	0.136	0.000	3.999
355	1.941	0.114	0.059	0.055	0.002	0.019	0.004	0.943	0.800	0.004	0.000	0.011	0.155	0.000	3.995
355	1.938	0.115	0.062	0.053	0.001	0.017	0.005	0.873	0.903	0.001	0.000	0.016	0.126	0.004	4.000
avg(11)	1.935	0.116	0.065	0.051	0.002	0.018	0.005	0.897	0.871	0.001	0.001	0.014	0.134	0.004	4.000
stdev	0.005	0.004	0.014	0.015	0.001	0.001	0.001	0.020	0.029	0.001	0.001	0.002	0.011	0.008	
354	1.907	0.117	0.093	0.024	0.003	0.019	0.004	0.916	0.852	0.000	0.001	0.015	0.108	0.058	4.000
354	1.893	0.115	0.107	0.008	0.004	0.017	0.005	0.934	0.843	0.001	0.000	0.014	0.086	0.088	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
354	1.907	0.120	0.093	0.027	0.004	0.021	0.004	0.952	0.808	0.000	0.000	0.011	0.126	0.048	4.000
354	1.896	0.121	0.104	0.017	0.003	0.019	0.006	0.903	0.865	0.000	0.001	0.015	0.095	0.077	4.000
354	1.903	0.119	0.097	0.022	0.002	0.021	0.006	0.922	0.844	0.001	0.000	0.011	0.110	0.063	4.000
354	1.888	0.119	0.112	0.007	0.004	0.019	0.004	0.931	0.856	0.000	0.000	0.014	0.073	0.091	4.000
354	1.894	0.120	0.106	0.014	0.005	0.023	0.004	0.904	0.881	0.000	0.000	0.014	0.083	0.072	4.000
354	1.896	0.121	0.104	0.017	0.004	0.023	0.004	0.894	0.889	0.002	0.001	0.016	0.080	0.071	4.000
354	1.904	0.120	0.096	0.024	0.004	0.021	0.004	0.890	0.890	0.000	0.002	0.011	0.099	0.054	4.000
354	1.884	0.117	0.116	0.001	0.003	0.019	0.007	0.918	0.867	0.002	0.000	0.014	0.067	0.102	4.000
354	1.899	0.121	0.101	0.020	0.003	0.019	0.006	0.891	0.889	0.000	0.000	0.015	0.088	0.070	4.000
354	1.910	0.128	0.090	0.038	0.001	0.019	0.003	0.890	0.876	0.001	0.001	0.015	0.111	0.045	4.000
354	1.907	0.113	0.093	0.020	0.002	0.019	0.007	0.889	0.909	0.001	0.000	0.013	0.078	0.063	4.000
354	1.903	0.121	0.097	0.024	0.004	0.019	0.006	0.893	0.886	0.001	0.001	0.016	0.089	0.061	4.000
354	1.893	0.123	0.107	0.016	0.003	0.018	0.007	0.904	0.878	0.000	0.000	0.016	0.077	0.081	4.000
354	1.907	0.120	0.093	0.027	0.004	0.020	0.007	0.894	0.870	0.000	0.001	0.016	0.111	0.051	4.000
354	1.901	0.118	0.099	0.019	0.004	0.020	0.004	0.968	0.791	0.002	0.000	0.013	0.116	0.064	4.000
354	1.910	0.114	0.090	0.024	0.004	0.017	0.004	0.907	0.870	0.002	0.000	0.012	0.108	0.053	4.000
avg(18)	1.900	0.119	0.100	0.019	0.003	0.020	0.005	0.911	0.865	0.001	0.000	0.014	0.095	0.067	4.000
stdev	0.007	0.003	0.007	0.008	0.001	0.002	0.001	0.022	0.029	0.001	0.001	0.002	0.017	0.015	
353	1.951	0.089	0.049	0.040	0.002	0.003	0.004	0.867	0.937	0.000	0.001	0.004	0.138	0.004	4.000
353	1.966	0.063	0.034	0.029	0.002	0.005	0.005	0.895	0.936	0.001	0.000	0.001	0.124	0.000	3.999
353	1.935	0.111	0.065	0.046	0.000	0.012	0.005	0.937	0.827	0.000	0.000	0.011	0.144	0.018	4.000
353	1.937	0.112	0.063	0.049	0.002	0.014	0.004	0.918	0.850	0.000	0.001	0.009	0.149	0.004	4.000
353	1.930	0.108	0.070	0.038	0.001	0.011	0.005	0.910	0.871	0.000	0.001	0.010	0.125	0.027	4.000
353	1.930	0.115	0.070	0.045	0.003	0.009	0.003	0.911	0.872	0.002	0.000	0.012	0.121	0.021	4.000
353	1.929	0.114	0.071	0.043	0.001	0.011	0.006	0.891	0.885	0.001	0.001	0.012	0.123	0.027	4.000
353	1.939	0.111	0.061	0.050	0.003	0.013	0.003	0.889	0.891	0.001	0.000	0.011	0.136	0.004	4.000
353	1.933	0.111	0.067	0.044	0.003	0.010	0.005	0.887	0.897	0.000	0.001	0.014	0.120	0.018	4.000
353	1.932	0.111	0.068	0.043	0.001	0.010	0.005	0.904	0.882	0.001	0.001	0.012	0.116	0.025	4.000
353	1.923	0.110	0.077	0.033	0.003	0.013	0.005	0.910	0.866	0.002	0.001	0.015	0.114	0.039	4.000
353	1.923	0.115	0.077	0.038	0.000	0.009	0.004	0.915	0.878	0.000	0.000	0.014	0.100	0.042	4.000
353	1.931	0.112	0.069	0.043	0.003	0.010	0.005	0.910	0.866	0.000	0.000	0.014	0.126	0.022	4.000
353	1.929	0.112	0.071	0.041	0.004	0.010	0.005	0.909	0.867	0.001	0.000	0.011	0.132	0.022	4.000
353	1.947	0.111	0.053	0.058	0.000	0.009	0.004	0.922	0.845	0.000	0.002	0.011	0.146	0.000	3.999
353	1.934	0.115	0.066	0.049	0.004	0.010	0.004	0.908	0.877	0.001	0.000	0.012	0.124	0.011	4.000
353	1.931	0.108	0.069	0.039	0.002	0.010	0.004	0.902	0.894	0.000	0.001	0.013	0.107	0.029	4.000
353	1.928	0.115	0.072	0.043	0.004	0.010	0.004	0.884	0.904	0.001	0.001	0.014	0.113	0.023	4.000
353	1.941	0.114	0.059	0.055	0.002	0.011	0.005	0.901	0.882	0.002	0.000	0.014	0.127	0.001	4.000
353	1.929	0.113	0.071	0.042	0.002	0.011	0.004	0.897	0.886	0.001	0.000	0.011	0.121	0.025	4.000
353	1.926	0.115	0.074	0.041	0.002	0.008	0.003	0.920	0.860	0.000	0.001	0.011	0.123	0.030	4.000
353	1.951	0.083	0.049	0.034	0.003	0.010	0.003	0.917	0.902	0.001	0.000	0.012	0.108	0.009	4.000
353	1.928	0.106	0.072	0.034	0.003	0.009	0.005	0.898	0.903	0.002	0.000	0.011	0.101	0.033	4.000
353	1.933	0.113	0.067	0.046	0.004	0.010	0.006	0.895	0.886	0.003	0.000	0.014	0.120	0.017	4.000
353	1.935	0.116	0.065	0.051	0.002	0.010	0.006	0.885	0.894	0.000	0.000	0.013	0.128	0.010	4.000
353	1.937	0.113	0.063	0.050	0.001	0.010	0.003	0.902	0.880	0.001	0.000	0.013	0.126	0.013	4.000
353	1.929	0.112	0.071	0.041	0.001	0.009	0.005	0.910	0.866	0.002	0.001	0.014	0.119	0.031	4.000
353	1.931	0.115	0.069	0.046	0.004	0.009	0.005	0.912	0.877	0.001	0.000	0.011	0.120	0.017	4.000
353	1.932	0.115	0.068	0.047	0.004	0.011	0.006	0.953	0.805	0.002	0.000	0.011	0.151	0.010	4.000
353	1.928	0.114	0.072	0.042	0.004	0.009	0.006	0.891	0.895	0.000	0.000	0.013	0.115	0.025	4.000
353	1.933	0.114	0.067	0.047	0.003	0.011	0.006	0.938	0.831	0.001	0.001	0.013	0.135	0.014	4.000
353	1.922	0.114	0.078	0.036	0.002	0.011	0.004	0.920	0.862	0.004	0.000	0.013	0.109	0.039	4.000
353	1.942	0.112	0.058	0.054	0.004	0.011	0.003	0.893	0.879	0.001	0.000	0.012	0.140	0.000	3.998
avg(33)	1.934	0.110	0.066	0.044	0.002	0.010	0.005	0.906	0.877	0.001	0.000	0.011	0.126	0.017	4.000
stdev	0.009	0.011	0.009	0.006	0.001	0.002	0.001	0.017	0.027	0.001	0.001	0.003	0.013	0.012	
351	1.936	0.104	0.064	0.040	0.004	0.011	0.008	0.874	0.887	0.001	0.002	0.013	0.144	0.018	4.000
351	1.944	0.100	0.056	0.044	0.001	0.007	0.006	0.942	0.795	0.001	0.002	0.011	0.177	0.013	4.000
351	1.937	0.104	0.063	0.041	0.002	0.009	0.005	0.874	0.901	0.001	0.001	0.011	0.136	0.020	4.000
351	1.950	0.106	0.050	0.056	0.002	0.009	0.005	0.881	0.879	0.001	0.000	0.009	0.151	0.000	3.995
351	1.956	0.091	0.044	0.047	0.002	0.008	0.004	0.844	0.931	0.002	0.000	0.011	0.149	0.000	3.998
351	1.940	0.108	0.060	0.048	0.003	0.009	0.004	0.870	0.891	0.003	0.000	0.012	0.152	0.009	4.000
351	1.968	0.062	0.032	0.030	0.001	0.005	0.005	0.874	0.938	0.002	0.000	0.003	0.141	0.000	3.999
351	1.945	0.101	0.055	0.046	0.003	0.010	0.005	0.872	0.890	0.001	0.000	0.014	0.153	0.005	4.000
351	1.940	0.101	0.060	0.041	0.002	0.012	0.005	0.869	0.898	0.001	0.001	0.013	0.143	0.015	4.000
351	1.942	0.092	0.058	0.034	0.003	0.008	0.005	0.865	0.920	0.002	0.001	0.009	0.137	0.018	4.000
351	1.948	0.104	0.052	0.052	0.003	0.010	0.005	0.864	0.892	0.001	0.002	0.011	0.158	0.000	3.998
351	1.935	0.109	0.065	0.044	0.002	0.009	0.005	0.868	0.892	0.002	0.001	0.009	0.152	0.015	4.000
351	1.932	0.111	0.068	0.043	0.004	0.010	0.007	0.866	0.892	0.000	0.001	0.012	0.147	0.019	4.000
351	1.951	0.080	0.049	0.031	0.002	0.009	0.006	0.880	0.889	0.001	0.000	0.012	0.154	0.017	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
351	1.939	0.103	0.061	0.042	0.003	0.010	0.006	0.872	0.886	0.001	0.000	0.012	0.155	0.015	4.000
351	1.941	0.105	0.059	0.046	0.004	0.009	0.006	0.868	0.895	0.000	0.000	0.010	0.156	0.006	4.000
351	1.946	0.109	0.054	0.055	0.000	0.007	0.005	0.864	0.898	0.001	0.000	0.009	0.160	0.000	4.000
351	1.943	0.113	0.057	0.056	0.001	0.009	0.005	0.845	0.903	0.000	0.001	0.014	0.162	0.004	4.000
avg(18)	1.944	0.100	0.056	0.044	0.002	0.009	0.005	0.872	0.893	0.001	0.001	0.011	0.152	0.010	4.000
stdev	0.008	0.012	0.008	0.007	0.001	0.002	0.001	0.019	0.028	0.001	0.001	0.002	0.010	0.008	
350	1.888	0.108	0.108	0.000	0.005	0.011	0.007	0.923	0.855	0.003	0.000	0.010	0.086	0.105	4.000
350	1.905	0.106	0.095	0.011	0.001	0.012	0.006	0.918	0.841	0.000	0.000	0.009	0.124	0.080	4.000
350	1.917	0.108	0.083	0.025	0.001	0.013	0.003	0.900	0.866	0.000	0.001	0.009	0.131	0.050	4.000
350	1.894	0.109	0.106	0.003	0.003	0.013	0.005	0.906	0.869	0.001	0.001	0.009	0.097	0.093	4.000
350	1.905	0.110	0.095	0.015	0.002	0.011	0.005	0.920	0.845	0.000	0.000	0.009	0.119	0.075	4.000
350	1.918	0.111	0.082	0.029	0.002	0.011	0.007	0.885	0.868	0.001	0.002	0.010	0.137	0.050	4.000
350	1.908	0.108	0.092	0.016	0.004	0.012	0.005	0.877	0.894	0.001	0.001	0.009	0.118	0.064	4.000
350	1.908	0.107	0.092	0.015	0.006	0.011	0.006	0.884	0.889	0.001	0.000	0.010	0.114	0.064	4.000
350	1.915	0.106	0.085	0.021	0.005	0.010	0.006	0.891	0.868	0.002	0.000	0.009	0.135	0.053	4.000
350	1.908	0.107	0.092	0.015	0.003	0.013	0.006	0.892	0.881	0.001	0.000	0.009	0.112	0.068	4.000
350	1.900	0.110	0.100	0.010	0.004	0.011	0.005	0.900	0.879	0.000	0.001	0.009	0.100	0.082	4.000
350	1.906	0.112	0.094	0.018	0.008	0.011	0.005	0.882	0.889	0.001	0.001	0.008	0.122	0.057	4.000
avg(12)	1.906	0.109	0.094	0.015	0.004	0.012	0.006	0.898	0.870	0.001	0.001	0.009	0.116	0.070	4.000
stdev	0.008	0.002	0.008	0.008	0.002	0.001	0.001	0.015	0.016	0.001	0.001	0.001	0.015	0.017	
349	1.897	0.109	0.103	0.006	0.004	0.010	0.004	0.901	0.880	0.002	0.000	0.009	0.098	0.087	4.000
349	1.912	0.106	0.088	0.018	0.003	0.008	0.005	0.887	0.901	0.001	0.001	0.007	0.106	0.063	4.000
349	1.911	0.105	0.089	0.016	0.003	0.010	0.004	0.886	0.889	0.001	0.001	0.008	0.119	0.064	4.000
349	1.897	0.106	0.103	0.003	0.003	0.009	0.006	0.885	0.904	0.000	0.001	0.009	0.087	0.093	4.000
349	1.910	0.109	0.090	0.019	0.001	0.013	0.005	0.883	0.890	0.001	0.001	0.007	0.117	0.064	4.000
349	1.912	0.107	0.088	0.019	0.006	0.010	0.005	0.974	0.764	0.001	0.000	0.008	0.158	0.055	4.000
349	1.906	0.108	0.094	0.014	0.001	0.013	0.005	0.923	0.851	0.001	0.000	0.008	0.111	0.073	4.000
349	1.916	0.110	0.084	0.026	0.001	0.011	0.004	0.883	0.888	0.000	0.000	0.010	0.122	0.055	4.000
349	1.900	0.108	0.100	0.008	0.004	0.011	0.005	0.886	0.897	0.001	0.001	0.014	0.088	0.086	4.000
349	1.910	0.106	0.090	0.016	0.004	0.010	0.005	0.933	0.823	0.001	0.000	0.009	0.136	0.063	4.000
349	1.905	0.111	0.095	0.016	0.004	0.010	0.004	0.907	0.864	0.001	0.001	0.009	0.115	0.069	4.000
349	1.906	0.106	0.094	0.012	0.003	0.009	0.007	0.964	0.774	0.002	0.001	0.008	0.147	0.074	4.000
349	1.909	0.108	0.091	0.017	0.004	0.010	0.005	0.895	0.883	0.000	0.000	0.010	0.111	0.066	4.000
349	1.896	0.111	0.104	0.007	0.004	0.012	0.005	0.930	0.836	0.002	0.001	0.010	0.107	0.087	4.000
avg(14)	1.906	0.108	0.094	0.014	0.003	0.010	0.005	0.910	0.860	0.001	0.001	0.009	0.116	0.071	4.000
stdev	0.006	0.002	0.006	0.006	0.001	0.001	0.001	0.030	0.044	0.001	0.000	0.002	0.020	0.012	
Cycle 11															
338	1.918	0.096	0.082	0.014	0.004	0.005	0.005	0.892	0.874	0.001	0.001	0.012	0.126	0.066	4.000
338	1.928	0.099	0.072	0.027	0.003	0.005	0.005	0.905	0.849	0.001	0.000	0.011	0.151	0.044	4.000
338	1.933	0.094	0.067	0.027	0.004	0.003	0.004	0.857	0.913	0.001	0.000	0.013	0.137	0.041	4.000
338	1.919	0.101	0.081	0.020	0.003	0.004	0.006	0.865	0.895	0.000	0.000	0.012	0.133	0.063	4.000
338	1.917	0.101	0.083	0.018	0.003	0.004	0.005	0.878	0.887	0.001	0.000	0.014	0.122	0.069	4.000
338	1.930	0.093	0.070	0.023	0.004	0.005	0.006	0.884	0.880	0.000	0.001	0.011	0.142	0.045	4.000
338	1.945	0.094	0.055	0.039	0.004	0.004	0.005	0.864	0.890	0.000	0.000	0.015	0.162	0.018	4.000
338	1.951	0.067	0.049	0.018	0.003	0.003	0.005	0.870	0.925	0.002	0.002	0.004	0.142	0.027	4.000
338	1.922	0.100	0.078	0.022	0.004	0.004	0.005	0.871	0.899	0.000	0.000	0.012	0.127	0.055	4.000
338	1.912	0.104	0.088	0.016	0.005	0.006	0.005	0.874	0.903	0.000	0.001	0.013	0.109	0.069	4.000
338	1.928	0.092	0.072	0.020	0.003	0.004	0.006	0.881	0.893	0.002	0.001	0.009	0.130	0.051	4.000
338	1.925	0.105	0.075	0.030	0.004	0.004	0.006	0.876	0.874	0.001	0.002	0.014	0.144	0.046	4.000
338	1.916	0.106	0.084	0.022	0.002	0.004	0.005	0.892	0.870	0.001	0.000	0.014	0.122	0.069	4.000
338	1.921	0.101	0.079	0.022	0.007	0.004	0.004	0.897	0.840	0.001	0.002	0.013	0.158	0.051	4.000
338	1.910	0.108	0.090	0.018	0.006	0.004	0.006	0.876	0.894	0.001	0.003	0.011	0.117	0.066	4.000
338	1.930	0.114	0.070	0.044	0.002	0.004	0.006	0.932	0.807	0.000	0.001	0.009	0.171	0.025	4.000
338	1.910	0.105	0.090	0.015	0.004	0.003	0.005	0.905	0.858	0.001	0.001	0.011	0.123	0.074	4.000
338	1.901	0.128	0.099	0.029	0.003	0.004	0.006	0.883	0.875	0.001	0.000	0.011	0.118	0.070	4.000
338	1.937	0.089	0.063	0.026	0.005	0.005	0.005	0.866	0.900	0.000	0.001	0.017	0.138	0.038	4.000
338	1.917	0.104	0.083	0.021	0.004	0.004	0.005	0.862	0.908	0.001	0.001	0.014	0.118	0.063	4.000
338	1.907	0.109	0.093	0.016	0.004	0.004	0.005	0.882	0.884	0.001	0.002	0.011	0.117	0.076	4.000
338	1.739	0.459	0.261	0.198	0.013	0.008	0.003	0.899	0.491	0.002	0.000	0.129	0.099	0.158	4.000
338	1.919	0.106	0.081	0.025	0.004	0.004	0.006	0.908	0.841	0.001	0.002	0.008	0.149	0.053	4.000
338	1.925	0.100	0.075	0.025	0.003	0.004	0.005	0.871	0.889	0.002	0.000	0.011	0.140	0.050	4.000
338	1.922	0.106	0.078	0.028	0.005	0.004	0.005	0.870	0.890	0.001	0.000	0.013	0.137	0.048	4.000
338	1.939	0.073	0.061	0.012	0.001	0.004	0.005	0.875	0.933	0.000	0.000	0.006	0.114	0.050	4.000
338	1.912	0.103	0.088	0.015	0.003	0.005	0.007	0.880	0.901	0.002	0.001	0.012	0.102	0.074	4.000
338	1.910	0.103	0.090	0.013	0.006	0.004	0.007	0.864	0.915	0.002	0.000	0.013	0.104	0.074	4.000
338	1.916	0.099	0.084	0.015	0.004	0.005	0.006	0.850	0.934	0.000	0.001	0.013	0.104	0.069	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
338	1.912	0.121	0.088	0.033	0.001	0.006	0.006	0.867	0.884	0.003	0.000	0.011	0.132	0.058	4.000
338	1.922	0.103	0.078	0.025	0.004	0.006	0.006	0.875	0.879	0.002	0.002	0.011	0.143	0.049	4.000
avg(31)	1.916	0.112	0.084	0.028	0.004	0.004	0.005	0.880	0.873	0.001	0.001	0.016	0.129	0.059	4.000
stdev	0.034	0.064	0.034	0.032	0.002	0.001	0.001	0.017	0.075	0.001	0.001	0.021	0.018	0.024	
336	1.924	0.094	0.076	0.018	0.003	0.007	0.005	0.918	0.860	0.002	0.001	0.013	0.116	0.058	4.000
336	1.917	0.097	0.083	0.014	0.004	0.008	0.005	0.910	0.851	0.001	0.001	0.015	0.125	0.067	4.000
336	1.920	0.100	0.080	0.020	0.003	0.007	0.005	0.890	0.882	0.000	0.000	0.013	0.119	0.061	4.000
336	1.910	0.096	0.090	0.006	0.003	0.007	0.005	0.896	0.886	0.002	0.000	0.014	0.097	0.084	4.000
336	1.918	0.097	0.082	0.015	0.005	0.007	0.006	0.919	0.845	0.000	0.001	0.011	0.131	0.061	4.000
336	1.913	0.098	0.087	0.011	0.005	0.008	0.005	0.873	0.904	0.003	0.001	0.011	0.110	0.068	4.000
336	1.903	0.101	0.097	0.004	0.004	0.008	0.005	0.912	0.855	0.003	0.002	0.016	0.098	0.094	4.000
336	1.918	0.098	0.082	0.016	0.005	0.010	0.005	0.935	0.816	0.001	0.001	0.011	0.145	0.056	4.000
336	1.921	0.100	0.079	0.021	0.003	0.008	0.007	0.879	0.885	0.003	0.000	0.012	0.127	0.054	4.000
336	1.927	0.093	0.073	0.020	0.004	0.008	0.004	0.953	0.792	0.001	0.000	0.012	0.159	0.047	4.000
336	1.919	0.097	0.081	0.016	0.006	0.006	0.007	0.897	0.865	0.002	0.001	0.014	0.128	0.059	4.000
336	1.915	0.094	0.085	0.009	0.003	0.008	0.005	0.924	0.843	0.002	0.000	0.013	0.120	0.073	4.000
336	1.918	0.094	0.082	0.012	0.003	0.007	0.006	0.943	0.808	0.000	0.002	0.011	0.141	0.068	4.000
336	1.921	0.099	0.079	0.020	0.004	0.007	0.006	0.911	0.851	0.001	0.000	0.014	0.131	0.056	4.000
avg(14)	1.924	0.106	0.076	0.030	0.004	0.010	0.005	0.885	0.872	0.001	0.001	0.014	0.138	0.041	4.000
stdev	0.006	0.002	0.006	0.005	0.001	0.001	0.001	0.022	0.031	0.001	0.001	0.002	0.016	0.012	
335	1.929	0.096	0.071	0.025	0.004	0.009	0.006	0.907	0.862	0.000	0.000	0.013	0.131	0.043	4.000
335	1.930	0.099	0.070	0.029	0.003	0.009	0.006	0.892	0.868	0.001	0.000	0.014	0.139	0.040	4.000
335	1.946	0.100	0.054	0.046	0.003	0.009	0.006	0.886	0.873	0.001	0.000	0.013	0.158	0.006	4.000
335	1.927	0.098	0.073	0.025	0.004	0.007	0.006	0.879	0.893	0.002	0.000	0.014	0.122	0.048	4.000
335	1.919	0.102	0.081	0.021	0.002	0.008	0.007	0.900	0.889	0.002	0.001	0.011	0.101	0.057	4.000
335	1.926	0.101	0.074	0.027	0.005	0.008	0.005	0.880	0.874	0.001	0.000	0.014	0.144	0.041	4.000
335	1.935	0.097	0.065	0.032	0.004	0.008	0.008	0.891	0.880	0.000	0.000	0.013	0.136	0.029	4.000
335	1.938	0.092	0.062	0.030	0.006	0.008	0.005	0.920	0.831	0.002	0.001	0.013	0.160	0.025	4.000
335	1.952	0.092	0.048	0.044	0.005	0.009	0.004	0.926	0.810	0.003	0.001	0.014	0.185	0.000	4.000
335	1.942	0.093	0.058	0.035	0.004	0.007	0.006	0.912	0.833	0.000	0.001	0.015	0.165	0.022	4.000
335	1.950	0.096	0.050	0.046	0.004	0.008	0.006	0.873	0.883	0.000	0.001	0.012	0.167	0.000	4.000
avg(12)	1.936	0.097	0.064	0.033	0.004	0.008	0.006	0.897	0.863	0.001	0.000	0.013	0.146	0.028	4.000
stdev	0.010	0.003	0.010	0.009	0.001	0.001	0.001	0.017	0.026	0.001	0.000	0.001	0.023	0.019	
334	1.916	0.102	0.084	0.018	0.003	0.008	0.003	0.879	0.897	0.000	0.001	0.013	0.114	0.063	4.000
334	1.916	0.106	0.084	0.022	0.007	0.010	0.005	0.871	0.880	0.002	0.000	0.014	0.137	0.051	4.000
334	1.893	0.109	0.107	0.002	0.007	0.011	0.005	0.910	0.842	0.001	0.001	0.014	0.113	0.094	4.000
334	1.925	0.103	0.075	0.028	0.003	0.010	0.004	0.892	0.870	0.000	0.000	0.018	0.128	0.047	4.000
334	1.927	0.089	0.073	0.016	0.005	0.008	0.004	0.874	0.900	0.000	0.000	0.016	0.122	0.055	4.000
334	1.921	0.108	0.079	0.029	0.002	0.009	0.006	0.896	0.862	0.001	0.000	0.016	0.129	0.052	4.000
334	1.923	0.108	0.077	0.031	0.006	0.009	0.006	0.938	0.789	0.003	0.001	0.010	0.172	0.035	4.000
334	1.918	0.103	0.082	0.021	0.006	0.008	0.007	0.868	0.897	0.000	0.001	0.018	0.116	0.059	4.000
334	1.898	0.105	0.102	0.003	0.004	0.009	0.006	0.888	0.882	0.000	0.001	0.013	0.101	0.093	4.000
334	1.898	0.142	0.102	0.040	0.004	0.010	0.004	0.861	0.882	0.000	0.001	0.016	0.122	0.058	4.000
334	1.918	0.104	0.082	0.022	0.003	0.010	0.004	0.882	0.875	0.000	0.001	0.015	0.130	0.059	4.000
334	1.919	0.109	0.081	0.028	0.006	0.008	0.005	0.865	0.894	0.001	0.000	0.015	0.132	0.048	4.000
334	1.918	0.108	0.082	0.026	0.005	0.009	0.006	0.863	0.893	0.000	0.000	0.016	0.131	0.053	4.000
avg(13)	1.915	0.107	0.085	0.022	0.005	0.009	0.005	0.884	0.874	0.001	0.001	0.015	0.127	0.059	4.000
stdev	0.011	0.011	0.011	0.010	0.002	0.001	0.001	0.021	0.029	0.001	0.000	0.002	0.016	0.016	
332	1.922	0.112	0.078	0.034	0.002	0.009	0.005	0.871	0.881	0.003	0.002	0.014	0.135	0.044	4.000
332	1.921	0.112	0.079	0.033	0.006	0.011	0.005	0.865	0.897	0.000	0.001	0.014	0.133	0.035	4.000
332	1.942	0.107	0.058	0.049	0.002	0.010	0.006	0.857	0.887	0.000	0.000	0.015	0.165	0.010	4.000
332	1.941	0.118	0.059	0.059	0.003	0.009	0.005	0.861	0.862	0.000	0.000	0.014	0.184	0.000	3.999
332	1.929	0.113	0.071	0.042	0.005	0.008	0.005	0.856	0.894	0.002	0.000	0.014	0.150	0.024	4.000
332	1.915	0.115	0.085	0.030	0.005	0.011	0.004	0.865	0.883	0.000	0.001	0.014	0.140	0.047	4.000
332	1.925	0.113	0.075	0.038	0.003	0.008	0.005	0.860	0.898	0.001	0.001	0.013	0.136	0.035	4.000
332	1.940	0.114	0.060	0.054	0.002	0.008	0.006	0.879	0.851	0.002	0.000	0.013	0.177	0.008	4.000
332	1.936	0.115	0.064	0.051	0.001	0.009	0.006	0.881	0.862	0.002	0.001	0.013	0.159	0.014	4.000
332	1.916	0.123	0.084	0.039	0.005	0.008	0.005	0.851	0.894	0.001	0.001	0.013	0.145	0.040	4.000
avg(10)	1.929	0.114	0.071	0.043	0.004	0.009	0.005	0.865	0.881	0.001	0.001	0.014	0.153	0.026	4.000
stdev	0.010	0.004	0.010	0.009	0.002	0.001	0.001	0.009	0.016	0.001	0.001	0.001	0.017	0.016	
330	1.892	0.119	0.108	0.011	0.004	0.009	0.006	0.884	0.880	0.000	0.000	0.017	0.094	0.097	4.000
330	1.923	0.116	0.077	0.039	0.006	0.011	0.005	0.886	0.855	0.001	0.000	0.013	0.156	0.029	4.000
330	1.912	0.120	0.088	0.032	0.005	0.011	0.005	0.871	0.869	0.000	0.000	0.015	0.144	0.049	4.000
330	1.906	0.122	0.094	0.028	0.006	0.012	0.007	0.866	0.884	0.001	0.001	0.018	0.118	0.059	4.000
330	1.911	0.117	0.089	0.028	0.003	0.011	0.006	0.888	0.861	0.001	0.001	0.013	0.133	0.056	4.000
330	1.907	0.125	0.093	0.032	0.007	0.013	0.006	0.876	0.871	0.000	0.000	0.015	0.133	0.048	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
330	1.907	0.120	0.093	0.027	0.009	0.012	0.007	0.881	0.869	0.000	0.000	0.010	0.141	0.045	4.000
330	1.930	0.114	0.070	0.044	0.006	0.011	0.005	0.873	0.881	0.000	0.001	0.014	0.149	0.017	4.000
330	1.910	0.118	0.090	0.028	0.006	0.011	0.008	0.889	0.853	0.001	0.000	0.014	0.139	0.051	4.000
330	1.898	0.131	0.102	0.029	0.007	0.013	0.006	0.874	0.889	0.001	0.000	0.015	0.106	0.062	4.000
330	1.933	0.083	0.067	0.016	0.005	0.009	0.007	0.866	0.931	0.000	0.000	0.008	0.119	0.041	4.000
330	1.923	0.117	0.077	0.040	0.006	0.010	0.004	0.875	0.868	0.000	0.001	0.014	0.153	0.030	4.000
avg(12)	1.913	0.117	0.087	0.030	0.006	0.011	0.006	0.878	0.876	0.000	0.000	0.014	0.132	0.048	4.000
stdev	0.012	0.011	0.012	0.009	0.001	0.001	0.001	0.008	0.020	0.000	0.000	0.003	0.018	0.019	
328	1.919	0.120	0.081	0.039	0.006	0.014	0.004	0.862	0.877	0.000	0.001	0.020	0.142	0.037	4.000
328	1.925	0.110	0.075	0.035	0.004	0.013	0.005	0.862	0.898	0.002	0.000	0.016	0.131	0.034	4.000
328	1.927	0.108	0.073	0.035	0.004	0.013	0.010	0.895	0.829	0.003	0.000	0.015	0.165	0.030	4.000
328	1.920	0.111	0.080	0.031	0.007	0.013	0.004	0.867	0.894	0.002	0.000	0.015	0.132	0.035	4.000
328	1.920	0.113	0.080	0.033	0.005	0.012	0.006	0.862	0.884	0.000	0.000	0.017	0.140	0.041	4.000
328	1.925	0.103	0.075	0.028	0.005	0.014	0.006	0.866	0.914	0.001	0.000	0.013	0.115	0.036	4.000
328	1.950	0.091	0.050	0.041	0.005	0.013	0.004	0.895	0.886	0.000	0.000	0.013	0.142	0.000	4.000
328	1.940	0.102	0.060	0.042	0.004	0.017	0.006	0.859	0.891	0.001	0.001	0.015	0.157	0.007	4.000
328	1.946	0.103	0.054	0.049	0.004	0.012	0.005	0.862	0.874	0.001	0.001	0.016	0.175	0.000	4.000
328	1.910	0.120	0.090	0.030	0.006	0.014	0.006	0.874	0.875	0.001	0.000	0.014	0.133	0.049	4.000
328	1.917	0.120	0.083	0.037	0.004	0.014	0.005	0.873	0.862	0.003	0.002	0.012	0.153	0.035	4.000
avg(11)	1.931	0.104	0.069	0.035	0.004	0.013	0.006	0.875	0.886	0.001	0.001	0.014	0.139	0.026	4.000
stdev	0.016	0.019	0.016	0.008	0.001	0.002	0.002	0.018	0.028	0.001	0.001	0.003	0.024	0.016	
326	1.937	0.111	0.063	0.048	0.004	0.013	0.006	0.859	0.886	0.002	0.000	0.015	0.159	0.009	4.000
326	1.919	0.131	0.081	0.050	0.004	0.018	0.005	0.842	0.894	0.000	0.000	0.016	0.149	0.021	4.000
326	1.934	0.102	0.066	0.036	0.005	0.012	0.005	0.866	0.915	0.001	0.000	0.014	0.127	0.020	4.000
326	1.934	0.098	0.066	0.032	0.003	0.013	0.006	0.877	0.908	0.002	0.000	0.014	0.118	0.029	4.000
326	1.940	0.101	0.060	0.041	0.002	0.012	0.004	0.877	0.886	0.000	0.001	0.015	0.146	0.016	4.000
326	1.938	0.105	0.062	0.043	0.002	0.012	0.005	0.866	0.884	0.000	0.001	0.017	0.151	0.019	4.000
326	1.929	0.108	0.071	0.037	0.004	0.015	0.007	0.868	0.905	0.001	0.001	0.016	0.121	0.026	4.000
326	1.924	0.104	0.076	0.028	0.004	0.014	0.006	0.877	0.892	0.002	0.000	0.014	0.124	0.039	4.000
326	1.932	0.115	0.068	0.047	0.002	0.014	0.006	0.855	0.895	0.002	0.001	0.016	0.145	0.018	4.000
326	1.917	0.109	0.083	0.026	0.006	0.012	0.005	0.872	0.878	0.001	0.002	0.017	0.131	0.050	4.000
326	1.946	0.100	0.054	0.046	0.002	0.017	0.007	0.896	0.850	0.001	0.000	0.015	0.167	0.000	4.000
326	1.930	0.111	0.070	0.041	0.005	0.012	0.005	0.872	0.871	0.002	0.000	0.017	0.152	0.024	4.000
avg(12)	1.931	0.108	0.069	0.039	0.004	0.014	0.006	0.869	0.889	0.001	0.001	0.016	0.140	0.023	4.000
stdev	0.008	0.009	0.008	0.008	0.001	0.002	0.001	0.013	0.017	0.001	0.001	0.001	0.015	0.012	
325	1.938	0.119	0.062	0.057	0.001	0.013	0.004	0.908	0.849	0.000	0.001	0.010	0.156	0.000	4.000
325	1.929	0.099	0.071	0.028	0.004	0.011	0.004	0.870	0.886	0.002	0.001	0.014	0.141	0.038	4.000
325	1.915	0.117	0.085	0.032	0.005	0.015	0.007	0.873	0.868	0.001	0.000	0.014	0.143	0.042	4.000
325	1.935	0.095	0.065	0.030	0.004	0.012	0.006	0.868	0.928	0.000	0.000	0.012	0.113	0.028	4.000
325	1.947	0.099	0.053	0.046	0.005	0.012	0.007	0.866	0.917	0.000	0.000	0.011	0.136	0.000	3.999
325	1.920	0.141	0.080	0.061	0.004	0.013	0.006	0.839	0.881	0.001	0.001	0.015	0.166	0.014	4.000
325	1.934	0.116	0.066	0.050	0.003	0.015	0.007	0.895	0.831	0.000	0.001	0.014	0.177	0.008	4.000
325	1.906	0.131	0.094	0.037	0.005	0.016	0.006	0.839	0.900	0.002	0.001	0.017	0.130	0.047	4.000
325	1.921	0.132	0.079	0.053	0.004	0.015	0.005	0.845	0.886	0.000	0.001	0.015	0.159	0.017	4.000
325	1.932	0.107	0.068	0.039	0.002	0.010	0.005	0.860	0.893	0.001	0.002	0.016	0.141	0.030	4.000
325	1.924	0.108	0.076	0.032	0.004	0.010	0.007	0.862	0.890	0.002	0.000	0.015	0.138	0.040	4.000
avg(11)	1.927	0.115	0.073	0.042	0.004	0.013	0.006	0.866	0.884	0.001	0.001	0.014	0.145	0.024	4.000
stdev	0.011	0.014	0.011	0.011	0.001	0.002	0.001	0.021	0.026	0.001	0.001	0.002	0.017	0.016	
324	1.930	0.101	0.070	0.031	0.006	0.003	0.003	0.870	0.905	0.001	0.001	0.016	0.125	0.037	4.000
324	1.935	0.103	0.065	0.038	0.006	0.003	0.004	0.877	0.901	0.002	0.000	0.016	0.127	0.027	4.000
324	1.941	0.102	0.059	0.043	0.001	0.005	0.005	0.870	0.914	0.001	0.002	0.015	0.121	0.024	4.000
324	1.936	0.106	0.064	0.042	0.003	0.003	0.004	0.881	0.889	0.002	0.000	0.016	0.134	0.026	4.000
324	1.942	0.096	0.058	0.038	0.006	0.005	0.005	0.888	0.890	0.004	0.001	0.012	0.136	0.016	4.000
324	1.945	0.099	0.055	0.044	0.004	0.004	0.006	0.867	0.887	0.004	0.001	0.016	0.152	0.014	4.000
324	1.939	0.099	0.061	0.038	0.003	0.002	0.005	0.873	0.901	0.002	0.000	0.014	0.135	0.028	4.000
324	1.928	0.100	0.072	0.028	0.005	0.003	0.006	0.892	0.879	0.001	0.000	0.015	0.126	0.044	4.000
324	1.941	0.101	0.059	0.042	0.004	0.005	0.006	0.869	0.899	0.001	0.001	0.014	0.141	0.018	4.000
324	1.935	0.100	0.065	0.035	0.006	0.005	0.005	0.885	0.874	0.002	0.000	0.016	0.143	0.028	4.000
324	1.937	0.104	0.063	0.041	0.004	0.005	0.004	0.873	0.889	0.001	0.000	0.014	0.148	0.021	4.000
324	1.959	0.105	0.041	0.064	0.002	0.005	0.005	0.883	0.861	0.001	0.000	0.013	0.158	0.000	3.991
324	1.943	0.102	0.057	0.045	0.005	0.005	0.006	0.876	0.895	0.001	0.000	0.013	0.145	0.010	4.000
324	1.947	0.098	0.053	0.045	0.004	0.004	0.007	0.874	0.907	0.002	0.001	0.014	0.133	0.010	4.000
324	1.946	0.089	0.054	0.035	0.004	0.004	0.005	0.894	0.876	0.000	0.001	0.014	0.146	0.021	4.000
324	1.950	0.091	0.050	0.041	0.006	0.004	0.007	0.884	0.883	0.000	0.000	0.014	0.155	0.006	4.000
324	1.955	0.106	0.045	0.061	0.003	0.005	0.005	0.915	0.844	0.002	0.000	0.014	0.145	0.000	3.993
324	1.937	0.103	0.063	0.040	0.006	0.006	0.004	0.873	0.897	0.000	0.001	0.013	0.144	0.017	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
324	1.948	0.099	0.052	0.047	0.005	0.005	0.007	0.881	0.887	0.001	0.000	0.013	0.153	0.002	4.000
avg(19)	1.942	0.100	0.058	0.042	0.004	0.004	0.005	0.880	0.888	0.001	0.000	0.014	0.140	0.018	3.999
stdev	0.008	0.004	0.008	0.008	0.001	0.001	0.001	0.011	0.016	0.001	0.001	0.001	0.011	0.012	
323	1.905	0.112	0.095	0.017	0.005	0.010	0.005	0.900	0.838	0.002	0.000	0.018	0.130	0.075	4.000
323	1.912	0.116	0.088	0.028	0.007	0.010	0.006	0.857	0.886	0.001	0.000	0.016	0.138	0.051	4.000
323	1.886	0.115	0.114	0.001	0.004	0.011	0.005	0.894	0.873	0.002	0.001	0.014	0.090	0.107	4.000
323	1.886	0.112	0.112	0.000	0.005	0.011	0.007	0.892	0.874	0.001	0.000	0.015	0.087	0.111	4.000
323	1.894	0.107	0.106	0.001	0.005	0.009	0.005	0.882	0.883	0.000	0.001	0.017	0.095	0.102	4.000
323	1.893	0.106	0.106	0.000	0.004	0.010	0.006	0.884	0.886	0.003	0.000	0.016	0.087	0.106	4.000
323	1.896	0.126	0.104	0.022	0.008	0.012	0.006	0.875	0.875	0.002	0.000	0.016	0.115	0.069	4.000
323	1.906	0.112	0.094	0.018	0.006	0.011	0.005	0.871	0.884	0.000	0.001	0.015	0.123	0.067	4.000
323	1.918	0.110	0.082	0.028	0.004	0.009	0.007	0.878	0.866	0.001	0.000	0.014	0.142	0.051	4.000
323	1.909	0.115	0.091	0.024	0.004	0.010	0.007	0.868	0.889	0.002	0.000	0.013	0.122	0.061	4.000
323	1.910	0.094	0.090	0.004	0.003	0.007	0.005	0.889	0.887	0.002	0.001	0.014	0.102	0.085	4.000
323	1.882	0.135	0.118	0.017	0.003	0.011	0.004	0.894	0.867	0.003	0.000	0.012	0.093	0.096	4.000
avg(12)	1.900	0.113	0.100	0.015	0.005	0.010	0.006	0.882	0.876	0.002	0.000	0.015	0.110	0.082	4.000
stdev	0.011	0.010	0.011	0.011	0.001	0.001	0.001	0.012	0.014	0.001	0.000	0.002	0.020	0.021	
321	1.916	0.124	0.084	0.040	0.005	0.010	0.004	0.868	0.881	0.000	0.000	0.017	0.135	0.039	4.000
321	1.915	0.118	0.085	0.033	0.004	0.010	0.004	0.884	0.878	0.002	0.001	0.015	0.122	0.049	4.000
321	1.925	0.113	0.075	0.038	0.005	0.009	0.006	0.874	0.895	0.002	0.001	0.013	0.127	0.031	4.000
321	1.918	0.116	0.082	0.034	0.004	0.011	0.006	0.885	0.872	0.001	0.001	0.013	0.132	0.041	4.000
321	1.936	0.109	0.064	0.045	0.005	0.012	0.004	0.893	0.858	0.001	0.002	0.018	0.148	0.014	4.000
321	1.940	0.095	0.060	0.035	0.002	0.009	0.006	0.837	0.932	0.001	0.001	0.014	0.141	0.024	4.000
321	1.928	0.114	0.072	0.042	0.004	0.011	0.006	0.910	0.841	0.001	0.002	0.014	0.147	0.024	4.000
321	1.930	0.115	0.070	0.045	0.007	0.011	0.006	0.877	0.876	0.003	0.000	0.012	0.153	0.009	4.000
321	1.926	0.119	0.074	0.045	0.003	0.011	0.006	0.896	0.851	0.001	0.000	0.015	0.146	0.026	4.000
321	1.922	0.121	0.078	0.043	0.006	0.011	0.004	0.882	0.876	0.001	0.001	0.016	0.135	0.026	4.000
avg(10)	1.925	0.114	0.075	0.039	0.005	0.011	0.005	0.880	0.876	0.001	0.001	0.015	0.138	0.029	4.000
stdev	0.008	0.008	0.008	0.004	0.001	0.001	0.001	0.018	0.024	0.001	0.001	0.002	0.010	0.012	
319	1.903	0.164	0.097	0.067	0.003	0.004	0.004	0.873	0.884	0.002	0.000	0.013	0.118	0.033	4.000
319	1.935	0.122	0.065	0.057	0.003	0.009	0.005	0.922	0.823	0.002	0.001	0.015	0.157	0.009	4.000
319	1.946	0.109	0.054	0.055	0.004	0.013	0.004	0.939	0.790	0.001	0.000	0.011	0.177	0.000	3.994
319	1.944	0.114	0.056	0.058	0.007	0.007	0.004	0.874	0.880	0.001	0.000	0.016	0.149	0.000	3.996
319	1.931	0.119	0.069	0.050	0.002	0.010	0.004	0.890	0.874	0.002	0.000	0.016	0.133	0.020	4.000
319	1.935	0.121	0.065	0.056	0.003	0.023	0.004	0.881	0.866	0.001	0.001	0.014	0.148	0.000	3.997
319	1.943	0.108	0.057	0.051	0.004	0.012	0.005	0.988	0.732	0.000	0.000	0.010	0.196	0.000	3.998
319	1.938	0.111	0.062	0.049	0.007	0.012	0.006	0.878	0.885	0.000	0.001	0.016	0.145	0.002	4.000
319	1.931	0.124	0.069	0.055	0.002	0.024	0.005	0.894	0.842	0.000	0.000	0.017	0.158	0.004	4.000
avg(9)	1.934	0.121	0.066	0.055	0.004	0.013	0.005	0.904	0.842	0.001	0.000	0.014	0.153	0.008	3.998
stdev	0.012	0.016	0.012	0.005	0.002	0.006	0.001	0.036	0.049	0.001	0.000	0.002	0.022	0.011	
318	1.941	0.112	0.059	0.053	0.006	0.012	0.005	0.879	0.865	0.002	0.000	0.015	0.161	0.000	3.998
318	1.926	0.110	0.074	0.036	0.007	0.014	0.004	0.909	0.837	0.001	0.002	0.015	0.151	0.025	4.000
318	1.969	0.063	0.031	0.032	0.002	0.009	0.003	0.883	0.915	0.001	0.001	0.008	0.141	0.000	3.996
318	1.946	0.106	0.054	0.052	0.006	0.013	0.004	0.889	0.850	0.002	0.000	0.017	0.163	0.000	3.996
318	1.932	0.111	0.068	0.043	0.004	0.013	0.005	0.878	0.883	0.002	0.000	0.016	0.138	0.020	4.000
318	1.932	0.107	0.068	0.039	0.004	0.013	0.006	0.875	0.887	0.000	0.000	0.016	0.137	0.023	4.000
318	1.934	0.113	0.066	0.047	0.003	0.014	0.004	0.881	0.879	0.001	0.001	0.016	0.140	0.013	4.000
318	1.943	0.116	0.057	0.059	0.004	0.014	0.004	0.867	0.868	0.001	0.001	0.016	0.161	0.000	3.996
318	1.943	0.096	0.057	0.039	0.006	0.011	0.004	0.888	0.872	0.001	0.000	0.016	0.152	0.011	4.000
318	1.929	0.112	0.071	0.041	0.006	0.012	0.005	0.881	0.884	0.001	0.000	0.014	0.137	0.020	4.000
318	1.936	0.120	0.064	0.056	0.004	0.016	0.003	0.871	0.874	0.001	0.001	0.016	0.157	0.000	3.999
318	1.938	0.101	0.062	0.039	0.003	0.013	0.005	0.895	0.861	0.001	0.001	0.013	0.153	0.016	4.000
318	1.930	0.113	0.070	0.043	0.005	0.013	0.006	0.873	0.882	0.002	0.002	0.018	0.134	0.022	4.000
318	1.925	0.115	0.075	0.040	0.006	0.011	0.005	0.887	0.868	0.000	0.001	0.016	0.140	0.027	4.000
318	1.940	0.105	0.060	0.045	0.006	0.012	0.005	0.874	0.899	0.000	0.002	0.016	0.137	0.004	4.000
avg(15)	1.938	0.107	0.062	0.045	0.005	0.013	0.005	0.882	0.875	0.001	0.001	0.015	0.151	0.008	4.000
stdev	0.010	0.013	0.010	0.007	0.001	0.002	0.001	0.010	0.018	0.001	0.001	0.002	0.010	0.010	
317	1.900	0.119	0.100	0.019	0.003	0.012	0.005	0.927	0.867	0.002	0.000	0.015	0.073	0.077	4.000
317	1.911	0.118	0.089	0.029	0.004	0.012	0.006	0.885	0.897	0.001	0.001	0.019	0.091	0.057	4.000
317	1.904	0.131	0.096	0.035	0.004	0.020	0.004	0.892	0.876	0.000	0.000	0.016	0.105	0.049	4.000
317	1.910	0.116	0.090	0.026	0.002	0.014	0.005	0.893	0.881	0.002	0.001	0.015	0.101	0.059	4.000
317	1.918	0.119	0.082	0.037	0.006	0.015	0.003	0.888	0.880	0.000	0.000	0.013	0.127	0.032	4.000
317	1.899	0.123	0.101	0.022	0.005	0.013	0.007	0.890	0.889	0.001	0.001	0.018	0.081	0.073	4.000
317	1.911	0.117	0.089	0.028	0.005	0.013	0.003	0.890	0.883	0.001	0.001	0.015	0.108	0.051	4.000
317	1.910	0.120	0.090	0.030	0.004	0.015	0.006	0.888	0.875	0.002	0.001	0.014	0.115	0.050	4.000
317	1.909	0.122	0.091	0.031	0.004	0.013	0.005	0.920	0.852	0.003	0.001	0.014	0.106	0.052	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
317	1.907	0.119	0.093	0.026	0.005	0.015	0.005	0.903	0.862	0.003	0.000	0.017	0.106	0.059	4.000
317	1.900	0.122	0.100	0.022	0.003	0.015	0.005	0.907	0.881	0.001	0.001	0.015	0.079	0.071	4.000
317	1.915	0.118	0.085	0.033	0.003	0.013	0.005	0.894	0.878	0.000	0.001	0.018	0.105	0.051	4.000
317	1.914	0.123	0.086	0.037	0.002	0.013	0.006	0.942	0.814	0.002	0.000	0.012	0.131	0.042	4.000
317	1.905	0.117	0.095	0.022	0.006	0.014	0.005	0.888	0.893	0.000	0.000	0.014	0.098	0.061	4.000
317	1.911	0.119	0.089	0.030	0.004	0.011	0.005	0.890	0.892	0.001	0.000	0.015	0.099	0.056	4.000
avg(15)	1.908	0.120	0.092	0.028	0.004	0.014	0.005	0.900	0.875	0.001	0.001	0.015	0.102	0.056	4.000
stdev	0.006	0.004	0.006	0.005	0.001	0.002	0.001	0.016	0.020	0.001	0.000	0.002	0.016	0.011	
316	1.926	0.116	0.074	0.042	0.004	0.017	0.005	0.869	0.897	0.001	0.001	0.016	0.126	0.023	4.000
316	1.917	0.125	0.083	0.042	0.005	0.018	0.006	0.873	0.871	0.002	0.000	0.015	0.141	0.027	4.000
316	1.936	0.119	0.064	0.055	0.003	0.016	0.005	0.921	0.817	0.002	0.001	0.014	0.167	0.001	4.000
316	1.927	0.116	0.073	0.043	0.003	0.016	0.005	0.904	0.836	0.003	0.000	0.014	0.155	0.022	4.000
316	1.924	0.118	0.076	0.042	0.005	0.015	0.007	0.898	0.856	0.003	0.001	0.015	0.136	0.023	4.000
316	1.920	0.122	0.080	0.042	0.005	0.018	0.005	0.923	0.813	0.004	0.001	0.011	0.157	0.021	4.000
316	1.924	0.121	0.076	0.045	0.005	0.018	0.005	0.941	0.794	0.002	0.002	0.013	0.162	0.014	4.000
316	1.916	0.124	0.084	0.040	0.006	0.018	0.006	0.887	0.869	0.000	0.000	0.015	0.132	0.029	4.000
316	1.921	0.118	0.079	0.039	0.002	0.015	0.004	0.884	0.875	0.003	0.001	0.014	0.131	0.032	4.000
316	1.927	0.128	0.073	0.055	0.005	0.017	0.004	0.894	0.852	0.002	0.001	0.015	0.149	0.006	4.000
316	1.914	0.124	0.086	0.038	0.005	0.019	0.005	0.884	0.881	0.002	0.001	0.014	0.121	0.031	4.000
avg(11)	1.923	0.121	1.909	0.034	0.004	0.017	0.005	0.898	0.851	0.002	0.001	0.014	0.144	0.021	4.000
stdev	0.006	0.004	0.006	0.006	0.001	0.001	0.001	0.021	0.031	0.001	0.001	0.001	0.015	0.010	
314	1.932	0.110	0.068	0.042	0.005	0.010	0.004	0.877	0.886	0.001	0.001	0.014	0.141	0.019	4.000
314	1.928	0.124	0.072	0.052	0.004	0.016	0.005	0.874	0.863	0.002	0.000	0.014	0.161	0.009	4.000
314	1.940	0.119	0.060	0.059	0.004	0.016	0.005	0.850	0.882	0.001	0.002	0.015	0.162	0.000	3.996
314	1.938	0.121	0.062	0.059	0.004	0.015	0.005	0.921	0.796	0.001	0.001	0.014	0.181	0.000	3.997
314	1.917	0.118	0.083	0.035	0.004	0.017	0.004	0.871	0.881	0.002	0.000	0.017	0.130	0.040	4.000
314	1.925	0.126	0.075	0.051	0.004	0.016	0.005	0.871	0.875	0.000	0.000	0.017	0.145	0.017	4.000
314	1.917	0.123	0.083	0.040	0.004	0.015	0.006	0.874	0.874	0.001	0.000	0.016	0.136	0.034	4.000
314	1.936	0.118	0.064	0.054	0.004	0.017	0.005	0.899	0.837	0.002	0.001	0.014	0.166	0.000	3.998
314	1.934	0.122	0.066	0.056	0.003	0.023	0.006	0.871	0.851	0.001	0.000	0.019	0.168	0.000	3.999
avg(9)	1.930	0.120	0.070	0.050	0.004	0.016	0.005	0.879	0.861	0.001	0.001	0.016	0.154	0.013	3.999
stdev	0.008	0.004	0.008	0.008	0.000	0.003	0.001	0.019	0.027	0.001	0.001	0.002	0.016	0.015	
313	1.917	0.113	0.083	0.030	0.005	0.014	0.005	0.874	0.897	0.001	0.001	0.014	0.118	0.042	4.000
313	1.921	0.114	0.079	0.035	0.004	0.011	0.005	0.889	0.870	0.001	0.001	0.017	0.125	0.043	4.000
313	1.908	0.118	0.092	0.026	0.004	0.010	0.005	0.875	0.895	0.000	0.001	0.017	0.104	0.064	4.000
313	1.921	0.107	0.079	0.028	0.004	0.012	0.004	0.885	0.883	0.001	0.000	0.016	0.122	0.045	4.000
313	1.892	0.118	0.108	0.010	0.004	0.014	0.004	0.880	0.915	0.000	0.001	0.013	0.071	0.087	4.000
313	1.918	0.108	0.082	0.026	0.003	0.011	0.005	0.878	0.895	0.002	0.000	0.014	0.114	0.051	4.000
313	1.918	0.109	0.082	0.027	0.003	0.012	0.004	0.888	0.883	0.002	0.002	0.014	0.116	0.049	4.000
313	1.910	0.116	0.090	0.026	0.004	0.014	0.006	0.871	0.893	0.001	0.000	0.015	0.114	0.055	4.000
313	1.920	0.108	0.080	0.028	0.004	0.009	0.006	0.882	0.881	0.001	0.001	0.016	0.120	0.052	4.000
313	1.908	0.115	0.092	0.023	0.004	0.014	0.004	0.908	0.846	0.002	0.000	0.014	0.125	0.060	4.000
avg(10)	1.914	0.113	0.086	0.027	0.004	0.012	0.005	0.883	0.886	0.001	0.001	0.015	0.113	0.054	4.000
stdev	0.009	0.004	0.009	0.006	0.001	0.002	0.001	0.010	0.018	0.001	0.001	0.001	0.015	0.013	
312	1.927	0.120	0.073	0.047	0.001	0.012	0.005	0.873	0.869	0.002	0.001	0.016	0.146	0.028	4.000
312	1.924	0.130	0.076	0.054	0.003	0.012	0.005	0.862	0.875	0.001	0.000	0.017	0.151	0.019	4.000
312	1.921	0.128	0.079	0.049	0.003	0.013	0.005	0.872	0.873	0.001	0.000	0.016	0.142	0.025	4.000
312	1.925	0.120	0.075	0.045	0.005	0.012	0.006	0.873	0.873	0.001	0.000	0.015	0.147	0.023	4.000
312	1.923	0.123	0.077	0.046	0.003	0.013	0.004	0.873	0.872	0.000	0.000	0.015	0.148	0.025	4.000
312	1.913	0.134	0.087	0.047	0.006	0.010	0.004	0.877	0.876	0.002	0.001	0.014	0.132	0.032	4.000
312	1.916	0.124	0.084	0.040	0.004	0.012	0.004	0.880	0.872	0.001	0.000	0.015	0.133	0.039	4.000
312	1.916	0.135	0.084	0.051	0.003	0.012	0.005	0.885	0.867	0.002	0.001	0.014	0.131	0.030	4.000
312	1.924	0.127	0.076	0.051	0.003	0.011	0.005	0.871	0.879	0.002	0.000	0.017	0.138	0.024	4.000
312	1.933	0.121	0.067	0.054	0.004	0.010	0.005	0.873	0.873	0.001	0.001	0.016	0.154	0.011	4.000
312	1.927	0.125	0.073	0.052	0.006	0.012	0.006	0.862	0.882	0.000	0.001	0.015	0.152	0.012	4.000
avg(11)	1.923	0.125	0.077	0.048	0.004	0.011	0.005	0.874	0.872	0.001	0.001	0.016	0.144	0.024	4.000
stdev	0.006	0.005	0.006	0.004	0.001	0.001	0.001	0.007	0.007	0.001	0.000	0.001	0.008	0.008	
311	1.933	0.113	0.067	0.046	0.003	0.011	0.004	0.868	0.879	0.000	0.000	0.014	0.158	0.016	4.000
311	1.939	0.118	0.061	0.057	0.005	0.010	0.006	0.886	0.845	0.001	0.001	0.015	0.173	0.000	3.999
311	1.934	0.112	0.066	0.046	0.003	0.012	0.006	0.939	0.778	0.000	0.000	0.013	0.190	0.014	4.000
311	1.936	0.115	0.064	0.051	0.006	0.012	0.004	0.884	0.858	0.000	0.003	0.012	0.169	0.000	4.000
311	1.910	0.117	0.090	0.027	0.003	0.011	0.004	0.886	0.874	0.003	0.001	0.014	0.119	0.058	4.000
311	1.924	0.115	0.076	0.039	0.006	0.010	0.004	0.878	0.869	0.002	0.000	0.014	0.149	0.027	4.000
311	1.926	0.123	0.074	0.049	0.004	0.013	0.005	0.875	0.867	0.001	0.000	0.016	0.153	0.018	4.000
311	1.905	0.154	0.095	0.059	0.002	0.037	0.005	0.837	0.874	0.002	0.001	0.019	0.151	0.014	4.000
311	1.903	0.150	0.097	0.053	0.004	0.030	0.005	0.852	0.873	0.001	0.000	0.017	0.143	0.022	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
311	1.926	0.120	0.074	0.046	0.004	0.012	0.004	0.887	0.854	0.001	0.001	0.013	0.158	0.021	4.000
311	1.930	0.118	0.070	0.048	0.004	0.012	0.006	0.870	0.877	0.001	0.000	0.015	0.152	0.015	4.000
311	1.920	0.115	0.080	0.035	0.004	0.010	0.008	0.941	0.775	0.001	0.000	0.014	0.172	0.039	4.000
311	1.920	0.120	0.080	0.040	0.005	0.011	0.006	0.916	0.834	0.000	0.001	0.017	0.136	0.035	4.000
311	1.924	0.123	0.076	0.047	0.004	0.015	0.005	0.886	0.851	0.001	0.001	0.015	0.156	0.021	4.000
avg(13)	1.924	0.123	0.076	0.047	0.004	0.015	0.005	0.886	0.851	0.001	0.001	0.015	0.156	0.021	4.000
stdev	0.011	0.013	0.011	0.009	0.001	0.008	0.001	0.029	0.034	0.001	0.001	0.002	0.017	0.015	
308	1.917	0.110	0.083	0.027	0.005	0.014	0.006	0.897	0.836	0.000	0.000	0.012	0.160	0.044	4.000
308	1.910	0.110	0.090	0.020	0.004	0.015	0.006	0.891	0.837	0.001	0.000	0.014	0.152	0.061	4.000
308	1.908	0.121	0.092	0.029	0.005	0.016	0.005	0.858	0.887	0.000	0.000	0.016	0.131	0.052	4.000
308	1.907	0.120	0.093	0.027	0.003	0.019	0.007	0.882	0.834	0.001	0.000	0.016	0.156	0.056	4.000
308	1.926	0.112	0.074	0.038	0.003	0.015	0.006	0.901	0.829	0.002	0.001	0.012	0.167	0.026	4.000
308	1.919	0.122	0.081	0.041	0.005	0.015	0.006	0.869	0.855	0.003	0.000	0.014	0.164	0.028	4.000
308	1.916	0.116	0.084	0.032	0.004	0.015	0.005	0.867	0.875	0.001	0.000	0.016	0.142	0.045	4.000
308	1.948	0.073	0.052	0.021	0.005	0.009	0.006	0.864	0.918	0.001	0.001	0.009	0.147	0.019	4.000
308	1.912	0.117	0.088	0.029	0.006	0.015	0.006	0.859	0.882	0.003	0.000	0.017	0.136	0.047	4.000
308	1.920	0.116	0.080	0.036	0.003	0.012	0.006	0.862	0.881	0.002	0.000	0.012	0.148	0.036	4.000
308	1.922	0.119	0.078	0.041	0.003	0.017	0.004	0.858	0.886	0.000	0.001	0.016	0.147	0.027	4.000
308	1.911	0.112	0.089	0.023	0.004	0.015	0.005	0.863	0.890	0.001	0.001	0.016	0.122	0.061	4.000
308	1.923	0.114	0.077	0.037	0.004	0.014	0.006	0.863	0.883	0.001	0.001	0.016	0.142	0.032	4.000
avg(13)	1.919	0.113	0.081	0.032	0.004	0.015	0.006	0.873	0.866	0.001	0.001	0.014	0.149	0.040	4.000
stdev	0.010	0.012	0.010	0.007	0.001	0.002	0.001	0.015	0.027	0.001	0.000	0.002	0.040	0.013	
306	1.916	0.119	0.084	0.035	0.003	0.016	0.005	0.887	0.843	0.001	0.000	0.016	0.153	0.041	4.000
306	1.924	0.122	0.076	0.046	0.005	0.016	0.005	0.873	0.860	0.000	0.000	0.016	0.160	0.020	4.000
306	1.927	0.117	0.073	0.044	0.001	0.016	0.006	0.886	0.833	0.001	0.001	0.013	0.175	0.024	4.000
306	1.913	0.122	0.087	0.035	0.005	0.018	0.006	0.889	0.840	0.002	0.000	0.019	0.146	0.041	4.000
306	1.911	0.120	0.089	0.031	0.004	0.014	0.007	0.880	0.861	0.001	0.000	0.019	0.128	0.055	4.000
306	1.931	0.119	0.069	0.050	0.004	0.010	0.006	0.873	0.869	0.000	0.000	0.017	0.154	0.017	4.000
306	1.912	0.118	0.088	0.030	0.005	0.013	0.006	0.904	0.826	0.002	0.000	0.015	0.150	0.049	4.000
306	1.924	0.116	0.076	0.040	0.006	0.014	0.004	0.866	0.877	0.000	0.001	0.016	0.151	0.026	4.000
306	1.917	0.122	0.083	0.039	0.004	0.019	0.006	0.899	0.811	0.003	0.000	0.016	0.171	0.033	4.000
306	1.917	0.122	0.083	0.039	0.004	0.019	0.006	0.906	0.801	0.002	0.000	0.017	0.173	0.033	4.000
avg(10)	1.919	0.121	0.081	0.040	0.004	0.016	0.006	0.886	0.843	0.001	0.000	0.017	0.156	0.034	4.000
stdev	0.006	0.004	0.006	0.006	0.001	0.003	0.001	0.012	0.023	0.001	0.000	0.002	0.014	0.011	
303	1.914	0.123	0.086	0.037	0.004	0.013	0.005	0.869	0.843	0.000	0.000	0.015	0.173	0.041	4.000
303	1.920	0.124	0.080	0.044	0.005	0.017	0.007	0.858	0.854	0.000	0.000	0.013	0.180	0.021	4.000
303	1.941	0.099	0.059	0.040	0.004	0.014	0.006	0.860	0.904	0.002	0.000	0.012	0.150	0.008	4.000
303	1.928	0.114	0.072	0.042	0.003	0.013	0.004	0.842	0.880	0.004	0.000	0.015	0.171	0.026	4.000
303	1.910	0.120	0.090	0.030	0.003	0.014	0.007	0.868	0.859	0.001	0.000	0.015	0.149	0.055	4.000
303	1.921	0.128	0.079	0.049	0.005	0.014	0.006	0.849	0.858	0.002	0.001	0.013	0.183	0.019	4.000
303	1.911	0.119	0.089	0.030	0.003	0.013	0.007	0.875	0.840	0.000	0.001	0.014	0.164	0.054	4.000
303	1.922	0.126	0.078	0.048	0.004	0.013	0.006	0.837	0.884	0.001	0.000	0.015	0.169	0.023	4.000
303	1.924	0.126	0.076	0.050	0.005	0.015	0.007	0.843	0.861	0.001	0.000	0.014	0.191	0.014	4.000
303	1.914	0.118	0.086	0.032	0.008	0.015	0.006	0.849	0.896	0.001	0.001	0.014	0.142	0.037	4.000
303	1.914	0.122	0.086	0.036	0.004	0.013	0.005	0.861	0.860	0.003	0.001	0.016	0.157	0.044	4.000
303	1.908	0.125	0.092	0.033	0.004	0.016	0.005	0.854	0.865	0.002	0.000	0.014	0.161	0.047	4.000
303	1.916	0.114	0.084	0.030	0.003	0.014	0.007	0.872	0.874	0.003	0.001	0.011	0.141	0.044	4.000
303	1.919	0.127	0.081	0.046	0.004	0.013	0.006	0.852	0.863	0.002	0.000	0.014	0.173	0.028	4.000
303	1.915	0.124	0.085	0.039	0.005	0.014	0.006	0.851	0.860	0.000	0.001	0.016	0.170	0.039	4.000
303	1.913	0.134	0.087	0.047	0.005	0.015	0.006	0.878	0.847	0.002	0.000	0.016	0.154	0.030	4.000
303	1.882	0.152	0.118	0.034	0.005	0.015	0.007	0.902	0.832	0.001	0.002	0.014	0.115	0.072	4.000
avg(17)	1.916	0.123	0.084	0.039	0.004	0.014	0.006	0.860	0.864	0.001	0.000	0.014	0.161	0.035	4.000
stdev	0.011	0.010	0.011	0.007	0.001	0.001	0.001	0.016	0.019	0.001	0.001	0.001	0.018	0.016	
Cycle 9															
56	1.922	0.100	0.078	0.022	0.005	0.011	0.007	0.889	0.868	0.001	0.001	0.012	0.139	0.046	4.000
56	1.920	0.129	0.080	0.049	0.005	0.013	0.006	0.856	0.856	0.001	0.000	0.016	0.176	0.022	4.000
56	1.902	0.138	0.098	0.040	0.004	0.021	0.006	0.848	0.869	0.000	0.001	0.017	0.151	0.044	4.000
56	1.907	0.136	0.093	0.043	0.003	0.019	0.006	0.862	0.868	0.002	0.001	0.014	0.144	0.039	4.000
56	1.916	0.125	0.084	0.041	0.002	0.017	0.006	0.866	0.858	0.001	0.000	0.016	0.156	0.037	4.000
56	1.906	0.126	0.094	0.032	0.004	0.015	0.004	0.886	0.827	0.000	0.000	0.017	0.160	0.056	4.000
56	1.931	0.101	0.069	0.032	0.004	0.008	0.007	0.893	0.844	0.002	0.001	0.016	0.158	0.036	4.000
56	1.895	0.133	0.105	0.028	0.003	0.019	0.006	0.914	0.777	0.000	0.000	0.017	0.168	0.069	4.000
avg(8)	1.912	0.123	0.088	0.035	0.004	0.015	0.006	0.877	0.846	0.001	0.001	0.016	0.156	0.044	4.000
stdev	0.010	0.014	0.010	0.008	0.001	0.004	0.001	0.016	0.014	0.001	0.000	0.002	0.011	0.010	

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
							Cycle 8								
246	1.892	0.129	0.108	0.021	0.004	0.011	0.005	0.869	0.833	0.001	0.001	0.032	0.124	0.099	4.000
246	1.897	0.127	0.103	0.024	0.003	0.009	0.007	0.857	0.854	0.001	0.001	0.032	0.118	0.094	4.000
246	1.896	0.137	0.104	0.033	0.003	0.010	0.004	0.854	0.834	0.002	0.001	0.033	0.138	0.087	4.000
246	1.911	0.119	0.089	0.030	0.006	0.011	0.007	0.853	0.852	0.000	0.001	0.033	0.139	0.069	4.000
246	1.906	0.125	0.094	0.031	0.002	0.011	0.006	0.854	0.842	0.002	0.002	0.034	0.134	0.082	4.000
246	1.896	0.129	0.104	0.025	0.004	0.011	0.005	0.853	0.863	0.001	0.000	0.032	0.114	0.091	4.000
246	1.904	0.133	0.096	0.037	0.005	0.009	0.007	0.870	0.817	0.001	0.000	0.032	0.152	0.072	4.000
246	1.882	0.123	0.118	0.005	0.004	0.016	0.006	0.853	0.884	0.002	0.000	0.032	0.080	0.118	4.000
246	1.905	0.129	0.095	0.034	0.003	0.012	0.007	0.857	0.842	0.000	0.000	0.034	0.134	0.077	4.000
246	1.886	0.131	0.114	0.017	0.003	0.011	0.007	0.840	0.880	0.001	0.001	0.037	0.088	0.117	4.000
246	1.903	0.121	0.097	0.024	0.004	0.011	0.006	0.848	0.877	0.000	0.000	0.030	0.117	0.083	4.000
246	1.886	0.131	0.114	0.017	0.005	0.012	0.004	0.873	0.838	0.001	0.001	0.030	0.115	0.104	4.000
246	1.896	0.129	0.104	0.025	0.006	0.013	0.006	0.882	0.827	0.000	0.000	0.031	0.126	0.085	4.000
246	1.888	0.132	0.112	0.020	0.003	0.011	0.007	0.863	0.862	0.001	0.001	0.025	0.110	0.098	4.000
avg(14)	1.896	0.128	0.104	0.024	0.004	0.011	0.006	0.859	0.850	0.001	0.001	0.032	0.121	0.091	4.000
stdev	0.008	0.005	0.008	0.008	0.001	0.002	0.001	0.010	0.019	0.001	0.001	0.002	0.018	0.014	
245	1.894	0.132	0.106	0.026	0.003	0.013	0.007	0.851	0.852	0.001	0.001	0.032	0.123	0.090	4.000
245	1.875	0.130	0.125	0.005	0.005	0.016	0.005	0.857	0.847	0.001	0.002	0.035	0.099	0.128	4.000
245	1.882	0.132	0.118	0.014	0.006	0.013	0.007	0.857	0.841	0.003	0.000	0.031	0.120	0.109	4.000
245	1.882	0.136	0.118	0.018	0.006	0.016	0.005	0.838	0.870	0.002	0.002	0.035	0.101	0.107	4.000
245	1.893	0.131	0.107	0.024	0.003	0.014	0.005	0.853	0.849	0.002	0.001	0.027	0.134	0.089	4.000
245	1.888	0.131	0.112	0.019	0.007	0.014	0.005	0.843	0.868	0.000	0.001	0.028	0.122	0.093	4.000
245	1.911	0.130	0.089	0.041	0.005	0.014	0.006	0.915	0.747	0.002	0.001	0.023	0.201	0.047	4.000
245	1.893	0.136	0.107	0.029	0.005	0.016	0.007	0.845	0.851	0.000	0.000	0.029	0.138	0.081	4.000
245	1.881	0.135	0.119	0.016	0.004	0.014	0.006	0.851	0.861	0.002	0.000	0.031	0.105	0.111	4.000
245	1.903	0.129	0.097	0.032	0.006	0.012	0.004	0.833	0.866	0.002	0.000	0.029	0.147	0.069	4.000
245	1.889	0.127	0.111	0.016	0.005	0.013	0.007	0.876	0.816	0.003	0.000	0.032	0.130	0.102	4.000
245	1.905	0.130	0.095	0.035	0.005	0.013	0.007	0.858	0.833	0.001	0.002	0.030	0.150	0.067	4.000
245	1.891	0.134	0.109	0.025	0.006	0.014	0.006	0.862	0.848	0.000	0.000	0.033	0.116	0.091	4.000
avg(13)	1.892	0.132	0.108	0.024	0.005	0.014	0.006	0.857	0.842	0.001	0.001	0.030	0.130	0.090	4.000
stdev	0.010	0.003	0.010	0.009	0.001	0.001	0.001	0.020	0.031	0.001	0.001	0.003	0.026	0.021	
244	1.911	0.123	0.089	0.034	0.003	0.009	0.006	0.857	0.834	0.000	0.000	0.030	0.160	0.068	4.000
244	1.920	0.121	0.080	0.041	0.004	0.011	0.007	0.836	0.863	0.001	0.002	0.032	0.152	0.052	4.000
244	1.921	0.120	0.079	0.041	0.004	0.009	0.009	0.880	0.801	0.001	0.001	0.026	0.182	0.046	4.000
244	1.914	0.125	0.086	0.039	0.004	0.011	0.007	0.853	0.848	0.003	0.000	0.029	0.150	0.058	4.000
244	1.916	0.122	0.084	0.038	0.005	0.010	0.006	0.844	0.853	0.000	0.001	0.032	0.153	0.058	4.000
244	1.925	0.123	0.075	0.048	0.003	0.010	0.006	0.857	0.839	0.000	0.001	0.030	0.166	0.040	4.000
244	1.903	0.124	0.097	0.027	0.006	0.008	0.007	0.846	0.853	0.003	0.001	0.035	0.130	0.085	4.000
244	1.918	0.120	0.082	0.038	0.003	0.009	0.006	0.875	0.815	0.001	0.000	0.024	0.178	0.050	4.000
244	1.910	0.130	0.090	0.040	0.006	0.008	0.006	0.846	0.850	0.001	0.001	0.026	0.161	0.055	4.000
244	1.912	0.126	0.088	0.038	0.004	0.009	0.006	0.832	0.869	0.001	0.001	0.033	0.141	0.066	4.000
244	1.899	0.126	0.101	0.025	0.004	0.010	0.005	0.854	0.847	0.002	0.000	0.027	0.141	0.084	4.000
244	1.903	0.128	0.097	0.031	0.005	0.010	0.006	0.840	0.849	0.001	0.001	0.033	0.145	0.078	4.000
244	1.911	0.127	0.089	0.038	0.005	0.010	0.006	0.846	0.849	0.001	0.000	0.028	0.160	0.059	4.000
244	1.914	0.124	0.086	0.038	0.002	0.009	0.007	0.836	0.860	0.003	0.001	0.029	0.153	0.064	4.000
244	1.910	0.125	0.090	0.035	0.007	0.010	0.009	0.848	0.848	0.000	0.000	0.033	0.148	0.062	4.000
avg(15)	1.913	0.124	0.087	0.037	0.004	0.010	0.006	0.850	0.845	0.001	0.001	0.030	0.154	0.062	4.000
stdev	0.007	0.003	0.007	0.006	0.001	0.001	0.001	0.013	0.017	0.001	0.001	0.003	0.013	0.013	
241	1.896	0.129	0.104	0.025	0.004	0.011	0.004	0.863	0.840	0.002	0.000	0.029	0.135	0.089	4.000
241	1.889	0.135	0.111	0.024	0.005	0.011	0.006	0.871	0.838	0.001	0.000	0.026	0.128	0.090	4.000
241	1.905	0.129	0.095	0.034	0.005	0.011	0.005	0.871	0.832	0.001	0.001	0.032	0.138	0.072	4.000
241	1.899	0.129	0.101	0.028	0.003	0.009	0.005	0.876	0.825	0.000	0.001	0.029	0.137	0.087	4.000
241	1.902	0.128	0.098	0.030	0.004	0.012	0.007	0.852	0.852	0.000	0.001	0.026	0.143	0.074	4.000
241	1.894	0.137	0.106	0.031	0.001	0.009	0.007	0.838	0.871	0.001	0.002	0.034	0.110	0.096	4.000
241	1.886	0.131	0.114	0.017	0.004	0.008	0.005	0.849	0.869	0.000	0.000	0.029	0.110	0.109	4.000
241	1.895	0.136	0.105	0.031	0.005	0.012	0.005	0.881	0.814	0.000	0.002	0.027	0.144	0.078	4.000
241	1.896	0.130	0.104	0.026	0.004	0.011	0.005	0.871	0.840	0.000	0.000	0.025	0.135	0.082	4.000
241	1.893	0.128	0.107	0.021	0.002	0.011	0.006	0.858	0.864	0.000	0.000	0.031	0.106	0.101	4.000
avg(10)	1.896	0.131	0.104	0.027	0.004	0.011	0.006	0.863	0.844	0.001	0.001	0.029	0.129	0.087	4.000
stdev	0.005	0.003	0.005	0.005	0.001	0.001	0.001	0.013	0.018	0.001	0.001	0.003	0.014	0.011	
240	1.884	0.136	0.116	0.020	0.008	0.011	0.006	0.868	0.829	0.002	0.001	0.022	0.143	0.089	4.000
240	1.869	0.138	0.131	0.007	0.005	0.014	0.005	0.892	0.812	0.001	0.000	0.031	0.103	0.130	4.000
240	1.886	0.133	0.114	0.019	0.005	0.012	0.006	0.937	0.735	0.001	0.000	0.026	0.161	0.099	4.000
240	1.902	0.104	0.098	0.006	0.006	0.014	0.007	0.862	0.874	0.001	0.000	0.025	0.114	0.093	4.000
240	1.877	0.136	0.123	0.013	0.006	0.013	0.008	0.864	0.848	0.000	0.000	0.030	0.105	0.114	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
240	1.891	0.137	0.109	0.028	0.004	0.012	0.006	0.867	0.822	0.001	0.000	0.034	0.132	0.095	4.000
240	1.893	0.140	0.107	0.033	0.007	0.014	0.006	0.833	0.866	0.002	0.001	0.032	0.129	0.077	4.000
240	1.889	0.132	0.111	0.021	0.005	0.013	0.006	0.855	0.858	0.000	0.001	0.027	0.123	0.092	4.000
240	1.897	0.132	0.103	0.029	0.004	0.011	0.006	0.857	0.847	0.000	0.000	0.027	0.137	0.083	4.000
avg(9)	1.888	0.132	0.112	0.020	0.005	0.013	0.006	0.871	0.832	0.001	0.000	0.028	0.128	0.097	4.000
stdev	0.009	.010	0.009	0.009	0.001	0.001	0.001	0.028	0.039	0.001	0000	0.04	0.018	0.015	
239	1.883	0.132	0.117	0.015	0.004	0.013	0.005	0.862	0.860	0.001	0.000	0.028	0.105	0.108	4.000
239	1.878	0.141	0.122	0.019	0.007	0.014	0.006	0.859	0.847	0.000	0.000	0.027	0.119	0.102	4.000
239	1.879	0.140	0.121	0.019	0.006	0.015	0.006	0.849	0.863	0.000	0.001	0.032	0.103	0.105	4.000
239	1.872	0.141	0.128	0.013	0.005	0.008	0.006	0.871	0.846	0.001	0.001	0.025	0.103	0.122	4.000
239	1.893	0.133	0.107	0.026	0.003	0.012	0.006	0.846	0.866	0.002	0.000	0.030	0.118	0.092	4.000
239	1.880	0.134	0.120	0.014	0.005	0.013	0.005	0.847	0.873	0.003	0.001	0.033	0.092	0.115	4.000
239	1.896	0.131	0.104	0.027	0.004	0.011	0.006	0.884	0.812	0.001	0.001	0.027	0.142	0.084	4.000
239	1.890	0.132	0.110	0.022	0.003	0.009	0.005	0.854	0.862	0.001	0.001	0.027	0.117	0.100	4.000
239	1.886	0.138	0.114	0.024	0.008	0.012	0.005	0.837	0.875	0.002	0.000	0.031	0.114	0.092	4.000
239	1.892	0.140	0.108	0.032	0.004	0.009	0.005	0.837	0.871	0.000	0.001	0.029	0.126	0.088	4.000
239	1.898	0.137	0.102	0.035	0.004	0.010	0.006	0.854	0.844	0.001	0.001	0.030	0.137	0.078	4.000
239	1.912	0.093	0.088	0.005	0.007	0.004	0.006	0.880	0.884	0.001	0.002	0.023	0.103	0.086	4.000
avg(12)	1.888	0.132	0.112	0.020	0.005	0.011	0.006	0.857	0.859	0.001	0.001	0.029	0.114	0.098	4.000
stdev	0.010	0.012	0.010	0.008	0.002	0.003	0.000	0.015	0.018	0.001	0.001	0.003	0.014	0.013	
238	1.903	0.134	0.097	0.037	0.004	0.009	0.006	0.833	0.884	0.000	0.000	0.027	0.131	0.069	4.000
238	1.896	0.131	0.104	0.027	0.007	0.008	0.006	0.840	0.878	0.001	0.001	0.028	0.122	0.081	4.000
238	1.898	0.133	0.102	0.031	0.006	0.009	0.008	0.855	0.844	0.001	0.001	0.026	0.145	0.073	4.000
238	1.892	0.130	0.108	0.022	0.005	0.009	0.005	0.897	0.796	0.000	0.001	0.026	0.146	0.092	4.000
238	1.898	0.137	0.102	0.035	0.007	0.009	0.005	0.844	0.870	0.001	0.000	0.033	0.121	0.076	4.000
238	1.894	0.132	0.106	0.026	0.006	0.010	0.007	0.847	0.861	0.000	0.000	0.031	0.123	0.089	4.000
238	1.904	0.132	0.096	0.036	0.005	0.008	0.007	0.839	0.871	0.001	0.000	0.033	0.127	0.074	4.000
238	1.898	0.129	0.102	0.027	0.006	0.009	0.005	0.850	0.861	0.000	0.001	0.030	0.127	0.083	4.000
238	1.894	0.130	0.106	0.024	0.003	0.006	0.007	0.867	0.861	0.001	0.000	0.030	0.102	0.101	4.000
238	1.905	0.117	0.095	0.022	0.005	0.009	0.005	0.887	0.825	0.000	0.001	0.026	0.140	0.080	4.000
238	1.894	0.135	0.106	0.029	0.006	0.008	0.007	0.838	0.882	0.000	0.000	0.029	0.115	0.085	4.000
238	1.890	0.140	0.110	0.030	0.006	0.012	0.007	0.851	0.852	0.001	0.000	0.030	0.125	0.086	4.000
238	1.888	0.134	0.112	0.022	0.004	0.009	0.006	0.867	0.847	0.002	0.000	0.027	0.116	0.099	4.000
238	1.901	0.134	0.099	0.035	0.003	0.009	0.005	0.863	0.844	0.001	0.002	0.030	0.130	0.079	4.000
238	1.886	0.136	0.114	0.022	0.001	0.012	0.006	0.872	0.834	0.001	0.000	0.032	0.111	0.110	4.000
avg(15)	1.896	0.132	0.104	0.028	0.005	0.009	0.006	0.856	0.854	0.001	0.001	0.029	0.126	0.085	4.000
stdev	0.006	0.005	0.006	0.005	0.002	0.001	0.001	0.018	0.023	0.001	0.001	0.002	0.012	0.011	
237	1.925	0.113	0.075	0.038	0.005	0.001	0.005	0.880	0.836	0.001	0.001	0.024	0.160	0.048	4.000
237	1.923	0.110	0.077	0.033	0.003	0.001	0.007	0.917	0.814	0.003	0.000	0.022	0.143	0.059	4.000
237	1.921	0.108	0.079	0.029	0.002	0.001	0.005	0.867	0.874	0.001	0.001	0.027	0.123	0.071	4.000
237	1.909	0.110	0.091	0.019	0.005	0.001	0.005	0.885	0.846	0.000	0.001	0.029	0.121	0.089	4.000
237	1.921	0.111	0.079	0.032	0.002	0.001	0.005	0.869	0.864	0.003	0.000	0.029	0.125	0.070	4.000
237	1.922	0.110	0.078	0.032	0.004	0.001	0.007	0.874	0.844	0.002	0.002	0.028	0.141	0.066	4.000
237	1.912	0.111	0.088	0.023	0.006	0.001	0.006	0.864	0.885	0.000	0.000	0.024	0.114	0.078	4.000
237	1.911	0.107	0.089	0.018	0.004	0.002	0.006	0.884	0.850	0.000	0.000	0.025	0.125	0.086	4.000
237	1.915	0.107	0.085	0.022	0.006	0.001	0.006	0.918	0.810	0.000	0.002	0.020	0.146	0.070	4.000
237	1.908	0.106	0.092	0.014	0.004	0.000	0.005	0.909	0.822	0.000	0.000	0.024	0.129	0.093	4.000
237	1.919	0.108	0.081	0.027	0.004	0.002	0.004	0.856	0.877	0.001	0.002	0.029	0.126	0.074	4.000
237	1.914	0.113	0.086	0.027	0.004	0.001	0.006	0.868	0.859	0.003	0.000	0.029	0.125	0.079	4.000
237	1.914	0.111	0.086	0.025	0.003	0.001	0.008	0.876	0.850	0.000	0.001	0.026	0.130	0.079	4.000
237	1.896	0.114	0.104	0.010	0.003	0.001	0.006	0.885	0.853	0.001	0.000	0.025	0.106	0.112	4.000
237	1.919	0.091	0.081	0.010	0.006	0.002	0.007	0.883	0.860	0.001	0.000	0.024	0.126	0.082	4.000
237	1.919	0.117	0.081	0.036	0.004	0.001	0.005	0.858	0.864	0.001	0.000	0.027	0.140	0.063	4.000
avg(16)	1.915	0.109	0.085	0.024	0.004	0.001	0.006	0.881	0.851	0.001	0.001	0.026	0.130	0.077	4.000
stdev	0.007	0.005	0.007	0.008	0.001	0.000	0.001	0.019	0.021	0.001	0.001	0.003	0.013	0.014	
236	1.925	0.111	0.075	0.036	0.006	0.002	0.005	0.867	0.855	0.000	0.000	0.025	0.155	0.049	4.000
236	1.913	0.106	0.087	0.019	0.004	0.002	0.008	0.914	0.790	0.000	0.001	0.019	0.168	0.076	4.000
236	1.919	0.109	0.081	0.028	0.004	0.000	0.006	0.877	0.845	0.001	0.001	0.021	0.152	0.065	4.000
236	1.908	0.112	0.092	0.020	0.004	0.001	0.006	0.867	0.867	0.001	0.001	0.023	0.125	0.085	4.000
236	1.919	0.106	0.081	0.025	0.003	0.001	0.006	0.863	0.881	0.001	0.000	0.024	0.123	0.073	4.000
236	1.909	0.111	0.091	0.020	0.004	0.000	0.007	0.864	0.867	0.002	0.001	0.027	0.118	0.088	4.000
236	1.915	0.108	0.085	0.023	0.004	0.001	0.006	0.903	0.819	0.002	0.000	0.024	0.142	0.077	4.000
236	1.910	0.109	0.090	0.019	0.003	0.001	0.007	0.924	0.779	0.002	0.001	0.022	0.157	0.085	4.000
236	1.909	0.108	0.091	0.017	0.005	0.001	0.006	0.873	0.852	0.001	0.002	0.028	0.125	0.091	4.000
236	1.917	0.111	0.083	0.028	0.005	0.001	0.006	0.892	0.828	0.001	0.000	0.026	0.143	0.071	4.000
236	1.913	0.116	0.087	0.029	0.002	0.002	0.005	0.855	0.866	0.000	0.000	0.028	0.133	0.080	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
236	1.919	0.107	0.081	0.026	0.004	0.002	0.006	0.856	0.872	0.001	0.000	0.028	0.134	0.072	4.000
avg(12)	1.915	0.109	0.085	0.024	0.004	0.001	0.006	0.880	0.844	0.001	0.001	0.024	0.140	0.075	4.000
stdev	0.005	0.003	0.005	0.005	0.001	0.001	0.001	0.022	0.031	0.001	0.001	0.003	0.015	0.011	
235	1.939	0.109	0.061	0.048	0.004	0.001	0.007	0.903	0.814	0.001	0.001	0.021	0.177	0.024	4.000
235	1.938	0.104	0.062	0.042	0.001	0.001	0.007	0.859	0.877	0.002	0.001	0.026	0.142	0.041	4.000
235	1.938	0.104	0.062	0.042	0.003	0.001	0.005	0.866	0.868	0.001	0.000	0.029	0.146	0.040	4.000
235	1.937	0.109	0.063	0.046	0.005	0.000	0.008	0.896	0.806	0.001	0.001	0.024	0.183	0.030	4.000
235	1.927	0.105	0.073	0.032	0.005	0.003	0.006	0.910	0.805	0.001	0.000	0.025	0.160	0.052	4.000
235	1.935	0.099	0.065	0.034	0.004	0.003	0.008	0.935	0.764	0.000	0.000	0.019	0.195	0.038	4.000
235	1.962	0.091	0.038	0.053	0.004	0.002	0.006	0.865	0.854	0.001	0.000	0.024	0.192	0.000	4.000
235	1.943	0.111	0.057	0.054	0.004	0.001	0.006	0.878	0.837	0.000	0.000	0.021	0.186	0.013	4.000
235	1.942	0.111	0.058	0.053	0.003	0.000	0.009	0.880	0.844	0.000	0.001	0.024	0.166	0.022	4.000
235	1.929	0.108	0.071	0.037	0.004	0.000	0.007	0.886	0.837	0.000	0.000	0.023	0.158	0.048	4.000
235	1.938	0.106	0.062	0.044	0.001	0.002	0.007	0.879	0.843	0.000	0.000	0.026	0.159	0.039	4.000
235	1.937	0.107	0.063	0.044	0.006	0.000	0.005	0.853	0.869	0.003	0.000	0.029	0.156	0.036	4.000
avg(12)	1.939	0.105	0.061	0.044	0.004	0.001	0.007	0.884	0.835	0.001	0.000	0.024	0.168	0.032	4.000
stdev	0.008	0.005	0.008	0.007	0.001	0.001	0.001	0.023	0.031	0.001	0.000	0.003	0.017	0.014	
234	1.944	0.107	0.056	0.051	0.002	0.001	0.006	0.869	0.851	0.001	0.000	0.021	0.178	0.019	4.000
234	1.939	0.107	0.061	0.046	0.004	0.001	0.006	0.880	0.839	0.001	0.001	0.023	0.171	0.029	4.000
234	1.931	0.104	0.069	0.035	0.005	0.003	0.007	0.892	0.819	0.001	0.000	0.025	0.167	0.047	4.000
234	1.927	0.109	0.073	0.036	0.006	0.002	0.007	0.864	0.870	0.001	0.001	0.021	0.149	0.044	4.000
234	1.938	0.107	0.062	0.045	0.002	0.003	0.005	0.867	0.852	0.000	0.000	0.021	0.174	0.030	4.000
234	1.956	0.099	0.044	0.055	0.003	0.001	0.007	0.903	0.805	0.001	0.000	0.024	0.196	0.005	4.000
234	1.936	0.111	0.064	0.047	0.006	0.002	0.004	0.848	0.883	0.000	0.003	0.018	0.169	0.019	4.000
234	1.952	0.102	0.048	0.054	0.003	0.001	0.008	0.926	0.771	0.000	0.002	0.021	0.207	0.006	4.000
234	1.947	0.105	0.053	0.052	0.002	0.000	0.004	0.906	0.799	0.001	0.000	0.022	0.196	0.017	4.000
234	1.948	0.103	0.052	0.051	0.005	0.001	0.005	0.862	0.857	0.000	0.001	0.028	0.173	0.016	4.000
234	1.936	0.110	0.064	0.046	0.004	0.003	0.005	0.859	0.871	0.003	0.001	0.020	0.162	0.025	4.000
234	1.944	0.106	0.056	0.050	0.006	0.002	0.004	0.937	0.754	0.001	0.001	0.018	0.216	0.011	4.000
234	1.943	0.106	0.057	0.049	0.003	0.000	0.005	0.854	0.885	0.001	0.000	0.023	0.156	0.024	4.000
234	1.940	0.099	0.060	0.039	0.007	0.002	0.007	0.863	0.870	0.002	0.001	0.024	0.157	0.030	4.000
234	1.936	0.111	0.064	0.047	0.006	0.001	0.006	0.855	0.873	0.003	0.001	0.025	0.156	0.028	4.000
avg(15)	1.941	0.106	0.059	0.047	0.004	0.001	0.006	0.879	0.840	0.001	0.001	0.023	0.174	0.025	4.000
stdev	0.007	0.004	0.007	0.006	0.002	0.001	0.001	0.027	0.040	0.001	0.001	0.003	0.019	0.012	
233	1.920	0.104	0.080	0.024	0.004	0.004	0.006	0.951	0.741	0.000	0.002	0.023	0.180	0.066	4.000
233	1.933	0.109	0.067	0.042	0.003	0.002	0.004	0.863	0.866	0.001	0.001	0.024	0.154	0.039	4.000
233	1.930	0.112	0.070	0.042	0.006	0.002	0.007	0.855	0.871	0.001	0.000	0.021	0.161	0.035	4.000
233	1.929	0.108	0.071	0.037	0.006	0.004	0.005	0.853	0.884	0.001	0.000	0.026	0.142	0.042	4.000
233	1.947	0.108	0.053	0.055	0.002	0.003	0.005	0.882	0.821	0.002	0.000	0.023	0.195	0.012	4.000
233	1.941	0.108	0.059	0.049	0.002	0.003	0.007	0.863	0.866	0.002	0.000	0.022	0.162	0.025	4.000
233	1.924	0.121	0.076	0.045	0.005	0.003	0.007	0.850	0.862	0.000	0.000	0.028	0.155	0.045	4.000
233	1.932	0.110	0.068	0.042	0.004	0.003	0.005	0.859	0.863	0.000	0.001	0.024	0.162	0.037	4.000
233	1.944	0.109	0.056	0.053	0.002	0.002	0.006	0.910	0.791	0.000	0.000	0.022	0.195	0.019	4.000
233	1.944	0.110	0.056	0.054	0.004	0.004	0.005	0.867	0.842	0.000	0.001	0.021	0.191	0.011	4.000
233	1.945	0.108	0.055	0.053	0.004	0.004	0.004	0.847	0.867	0.001	0.000	0.024	0.183	0.013	4.000
233	1.933	0.105	0.067	0.038	0.006	0.003	0.006	0.855	0.864	0.002	0.000	0.030	0.153	0.043	4.000
avg(12)	1.935	0.110	0.065	0.045	0.004	0.003	0.006	0.871	0.845	0.001	0.001	0.024	0.169	0.033	4.000
stdev	0.008	0.004	0.008	0.009	0.001	0.001	0.001	0.029	0.040	0.001	0.001	0.003	0.018	0.016	
232	1.915	0.107	0.085	0.022	0.003	0.003	0.007	0.870	0.866	0.001	0.000	0.024	0.126	0.077	4.000
232	1.923	0.109	0.077	0.032	0.001	0.002	0.006	0.894	0.834	0.002	0.001	0.021	0.146	0.061	4.000
232	1.908	0.107	0.092	0.015	0.003	0.003	0.007	0.869	0.872	0.001	0.001	0.025	0.113	0.091	4.000
232	1.914	0.103	0.086	0.017	0.005	0.004	0.006	0.872	0.881	0.001	0.001	0.022	0.114	0.076	4.000
232	1.907	0.110	0.093	0.017	0.002	0.002	0.006	0.927	0.791	0.001	0.000	0.021	0.140	0.092	4.000
232	1.914	0.111	0.086	0.025	0.004	0.004	0.007	0.937	0.775	0.000	0.000	0.017	0.165	0.064	4.000
232	1.912	0.104	0.088	0.016	0.005	0.004	0.007	0.871	0.869	0.002	0.000	0.023	0.122	0.081	4.000
232	1.911	0.098	0.089	0.009	0.002	0.002	0.005	0.895	0.855	0.001	0.000	0.026	0.105	0.101	4.000
232	1.905	0.113	0.095	0.018	0.003	0.004	0.007	0.893	0.861	0.000	0.001	0.022	0.103	0.089	4.000
232	1.899	0.106	0.101	0.005	0.005	0.004	0.004	0.880	0.880	0.001	0.000	0.021	0.097	0.103	4.000
232	1.916	0.104	0.084	0.020	0.005	0.003	0.005	0.891	0.844	0.000	0.000	0.023	0.135	0.074	4.000
avg(11)	1.911	0.106	0.089	0.017	0.003	0.003	0.006	0.891	0.848	0.001	0.001	0.022	0.125	0.082	4.000
stdev	0.006	0.004	0.006	0.007	0.001	0.001	0.001	0.022	0.034	0.001	0.000	0.002	0.020	0.013	
231	1.919	0.119	0.081	0.038	0.004	0.005	0.006	0.872	0.861	0.003	0.000	0.028	0.126	0.057	4.000
231	1.922	0.114	0.078	0.036	0.002	0.004	0.004	0.892	0.830	0.001	0.001	0.024	0.148	0.057	4.000
231	1.908	0.116	0.092	0.024	0.004	0.005	0.005	0.908	0.808	0.001	0.001	0.025	0.141	0.078	4.000
231	1.921	0.116	0.079	0.037	0.005	0.006	0.006	0.932	0.776	0.001	0.000	0.021	0.170	0.047	4.000
231	1.915	0.113	0.085	0.028	0.004	0.005	0.006	0.873	0.863	0.002	0.001	0.029	0.117	0.072	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
231	1.916	0.118	0.084	0.034	0.004	0.006	0.007	0.863	0.872	0.001	0.001	0.028	0.121	0.063	4.000
231	1.913	0.116	0.087	0.029	0.005	0.006	0.007	0.862	0.875	0.001	0.001	0.026	0.119	0.066	4.000
231	1.919	0.115	0.081	0.034	0.007	0.006	0.007	0.929	0.774	0.000	0.000	0.023	0.170	0.050	4.000
231	1.922	0.112	0.078	0.034	0.005	0.007	0.005	0.889	0.831	0.000	0.000	0.021	0.161	0.047	4.000
231	1.925	0.116	0.075	0.041	0.005	0.006	0.004	0.907	0.812	0.000	0.000	0.022	0.164	0.040	4.000
231	1.928	0.111	0.072	0.039	0.006	0.006	0.006	0.911	0.795	0.001	0.001	0.022	0.177	0.037	4.000
231	1.909	0.124	0.091	0.033	0.006	0.006	0.007	0.868	0.853	0.001	0.001	0.026	0.135	0.065	4.000
231	1.916	0.111	0.084	0.027	0.004	0.006	0.006	0.895	0.832	0.002	0.001	0.021	0.143	0.064	4.000
avg(13)	1.918	0.115	0.082	0.033	0.005	0.006	0.006	0.892	0.829	0.001	0.001	0.024	0.146	0.057	4.000
stdev	0.006	0.003	0.006	0.005	0.001	0.001	0.001	0.023	0.033	0.001	0.000	0.003	0.020	0.012	
230	1.920	0.121	0.080	0.041	0.004	0.003	0.004	0.923	0.772	0.001	0.000	0.024	0.176	0.053	4.000
230	1.920	0.109	0.080	0.029	0.007	0.005	0.006	0.848	0.914	0.000	0.000	0.022	0.115	0.054	4.000
230	1.920	0.112	0.080	0.032	0.005	0.006	0.006	0.856	0.879	0.000	0.000	0.027	0.131	0.058	4.000
230	1.915	0.112	0.085	0.027	0.005	0.005	0.005	0.916	0.820	0.001	0.001	0.022	0.135	0.066	4.000
230	1.909	0.114	0.091	0.023	0.006	0.005	0.006	0.891	0.839	0.000	0.001	0.027	0.125	0.076	4.000
230	1.916	0.114	0.084	0.030	0.005	0.005	0.006	0.887	0.839	0.001	0.001	0.022	0.144	0.060	4.000
230	1.917	0.119	0.083	0.036	0.002	0.004	0.006	0.861	0.876	0.001	0.001	0.024	0.128	0.062	4.000
230	1.920	0.115	0.080	0.035	0.003	0.005	0.007	0.860	0.881	0.000	0.001	0.025	0.125	0.058	4.000
230	1.915	0.111	0.085	0.026	0.003	0.005	0.005	0.913	0.809	0.001	0.001	0.021	0.148	0.068	4.000
230	1.928	0.109	0.072	0.037	0.004	0.006	0.006	0.924	0.787	0.001	0.001	0.024	0.166	0.045	4.000
230	1.904	0.112	0.096	0.016	0.004	0.006	0.006	0.949	0.758	0.002	0.001	0.025	0.142	0.090	4.000
230	1.930	0.114	0.070	0.044	0.006	0.006	0.006	0.860	0.870	0.001	0.000	0.026	0.150	0.031	4.000
230	1.911	0.117	0.089	0.028	0.005	0.005	0.006	0.861	0.885	0.000	0.001	0.023	0.118	0.069	4.000
230	1.920	0.121	0.080	0.041	0.004	0.003	0.004	0.923	0.772	0.001	0.000	0.024	0.176	0.053	4.000
230	1.920	0.109	0.080	0.029	0.007	0.005	0.006	0.848	0.914	0.000	0.000	0.022	0.115	0.054	4.000
230	1.920	0.112	0.080	0.032	0.005	0.006	0.006	0.856	0.879	0.000	0.000	0.027	0.131	0.058	4.000
230	1.915	0.112	0.085	0.027	0.005	0.005	0.005	0.916	0.820	0.001	0.001	0.022	0.135	0.066	4.000
230	1.909	0.114	0.091	0.023	0.006	0.005	0.006	0.891	0.839	0.000	0.001	0.027	0.125	0.076	4.000
230	1.916	0.114	0.084	0.030	0.005	0.005	0.006	0.887	0.839	0.001	0.001	0.022	0.144	0.060	4.000
230	1.917	0.119	0.083	0.036	0.002	0.004	0.006	0.861	0.876	0.001	0.001	0.024	0.128	0.062	4.000
230	1.920	0.115	0.080	0.035	0.003	0.005	0.007	0.860	0.881	0.000	0.001	0.025	0.125	0.058	4.000
230	1.915	0.111	0.085	0.026	0.003	0.005	0.005	0.913	0.809	0.001	0.001	0.021	0.148	0.068	4.000
230	1.928	0.109	0.072	0.037	0.004	0.006	0.006	0.924	0.787	0.001	0.001	0.024	0.166	0.045	4.000
230	1.904	0.112	0.096	0.016	0.004	0.006	0.006	0.949	0.758	0.002	0.001	0.025	0.142	0.090	4.000
230	1.930	0.114	0.070	0.044	0.006	0.006	0.006	0.860	0.870	0.001	0.000	0.026	0.150	0.031	4.000
avg(25)	1.918	0.114	0.082	0.032	0.004	0.005	0.006	0.890	0.839	0.001	0.001	0.024	0.139	0.061	4.000
stdev	0.007	0.003	0.007	0.007	0.001	0.001	0.001	0.032	0.047	0.001	0.000	0.002	0.017	0.014	
Cycle 6															
211	1.911	0.117	0.089	0.028	0.005	0.005	0.006	0.861	0.885	0.000	0.001	0.023	0.118	0.118	4.000
211	1.928	0.108	0.072	0.036	0.003	0.018	0.005	0.881	0.856	0.000	0.001	0.026	0.136	0.136	4.000
211	1.934	0.102	0.066	0.036	0.000	0.016	0.005	0.880	0.878	0.002	0.001	0.025	0.120	0.120	4.000
211	1.914	0.120	0.086	0.034	0.004	0.017	0.005	0.929	0.780	0.001	0.000	0.023	0.157	0.157	4.000
211	1.918	0.124	0.082	0.042	0.003	0.018	0.006	0.851	0.884	0.000	0.000	0.024	0.133	0.133	4.000
211	1.940	0.110	0.060	0.050	0.005	0.015	0.004	0.880	0.850	0.000	0.000	0.024	0.165	0.165	4.000
211	1.911	0.119	0.089	0.030	0.002	0.015	0.006	0.876	0.872	0.000	0.000	0.025	0.111	0.111	4.000
211	1.928	0.110	0.072	0.038	0.007	0.014	0.004	0.873	0.870	0.000	0.001	0.025	0.138	0.138	4.000
211	1.927	0.112	0.073	0.039	0.004	0.015	0.006	0.917	0.808	0.002	0.000	0.023	0.154	0.154	4.000
211	1.925	0.120	0.075	0.045	0.004	0.009	0.005	0.878	0.850	0.001	0.002	0.026	0.140	0.140	4.000
avg(10)	1.924	0.114	0.076	0.038	0.004	0.014	0.005	0.883	0.853	0.001	0.001	0.024	0.137	0.137	4.000
stdev	0.009	0.006	0.009	0.006	0.002	0.004	0.001	0.022	0.033	0.001	0.001	0.001	0.017	0.017	
209	1.900	0.120	0.100	0.020	0.001	0.014	0.004	0.884	0.884	0.001	0.001	0.029	0.069	0.069	4.000
209	1.889	0.129	0.111	0.018	0.003	0.022	0.004	0.892	0.846	0.001	0.001	0.023	0.103	0.103	4.000
209	1.910	0.110	0.090	0.020	0.005	0.013	0.003	0.907	0.863	0.002	0.000	0.022	0.096	0.096	4.000
209	1.888	0.126	0.112	0.014	0.005	0.016	0.005	0.877	0.891	0.002	0.000	0.027	0.066	0.066	4.000
209	1.900	0.128	0.100	0.028	0.003	0.023	0.007	0.864	0.885	0.000	0.000	0.030	0.088	0.088	4.000
209	1.888	0.132	0.112	0.020	0.003	0.020	0.007	0.874	0.875	0.001	0.000	0.028	0.079	0.079	4.000
209	1.928	0.093	0.072	0.021	0.005	0.011	0.006	0.894	0.878	0.002	0.000	0.027	0.100	0.100	4.000
209	1.907	0.122	0.093	0.029	0.004	0.020	0.005	0.878	0.870	0.003	0.000	0.031	0.094	0.094	4.000
209	1.910	0.115	0.090	0.025	0.004	0.015	0.005	0.886	0.871	0.002	0.001	0.028	0.095	0.095	4.000
209	1.909	0.117	0.091	0.026	0.003	0.021	0.008	0.969	0.746	0.001	0.000	0.028	0.134	0.134	4.000
avg(10)	1.903	0.119	0.097	0.022	0.004	0.018	0.005	0.893	0.861	0.001	0.000	0.027	0.093	0.093	4.000
stdev	0.012	0.011	0.012	0.005	0.001	0.004	0.001	0.028	0.040	0.001	0.000	0.003	0.018	0.018	
208	1.915	0.111	0.085	0.026	0.002	0.015	0.005	0.876	0.887	0.000	0.002	0.029	0.091	0.091	4.000
208	1.910	0.112	0.090	0.022	0.005	0.015	0.006	0.871	0.890	0.000	0.002	0.029	0.088	0.088	4.000
208	1.909	0.115	0.091	0.024	0.002	0.016	0.005	0.906	0.845	0.002	0.000	0.023	0.109	0.109	4.000
208	1.906	0.123	0.094	0.029	0.003	0.019	0.005	0.923	0.804	0.002	0.000	0.026	0.124	0.124	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
208	1.911	0.122	0.089	0.033	0.004	0.017	0.005	0.863	0.890	0.000	0.000	0.031	0.096	0.096	4.000
208	1.913	0.105	0.087	0.018	0.003	0.014	0.005	0.892	0.888	0.002	0.001	0.026	0.076	0.076	4.000
avg(6)	1.911	0.114	0.089	0.025	0.003	0.016	0.005	0.888	0.868	0.001	0.001	0.027	0.098	0.098	4.000
stdev	0.003	0.006	0.003	0.005	0.001	0.002	0.000	0.021	0.033	0.001	0.001	0.003	0.015	0.015	
199	1.888	0.123	0.112	0.011	0.005	0.018	0.007	0.893	0.850	0.002	0.001	0.026	0.089	0.089	4.000
199	1.910	0.114	0.090	0.024	0.002	0.013	0.007	0.865	0.887	0.000	0.001	0.026	0.103	0.103	4.000
199	1.932	0.105	0.068	0.037	0.001	0.009	0.005	0.871	0.899	0.001	0.000	0.024	0.110	0.110	4.000
199	1.894	0.125	0.106	0.019	0.003	0.021	0.007	0.864	0.866	0.001	0.001	0.032	0.095	0.095	4.000
199	1.919	0.114	0.081	0.033	0.005	0.016	0.006	0.873	0.888	0.001	0.000	0.024	0.108	0.108	4.000
199	1.905	0.124	0.095	0.029	0.003	0.020	0.006	0.885	0.850	0.000	0.000	0.031	0.106	0.106	4.000
199	1.902	0.131	0.098	0.033	0.003	0.020	0.007	0.876	0.845	0.002	0.000	0.035	0.107	0.107	4.000
199	1.902	0.134	0.098	0.036	0.002	0.020	0.007	0.855	0.875	0.000	0.000	0.030	0.107	0.107	4.000
199	1.898	0.130	0.102	0.028	0.004	0.023	0.007	0.892	0.829	0.001	0.000	0.029	0.117	0.117	4.000
199	1.910	0.114	0.090	0.024	0.003	0.018	0.007	0.917	0.806	0.003	0.000	0.026	0.129	0.129	4.000
199	1.916	0.123	0.084	0.039	0.003	0.016	0.005	0.896	0.820	0.000	0.001	0.031	0.137	0.137	4.000
199	1.907	0.121	0.093	0.028	0.003	0.018	0.006	0.881	0.856	0.001	0.000	0.029	0.110	0.110	4.000
199	1.921	0.108	0.079	0.029	0.003	0.016	0.006	0.869	0.867	0.000	0.003	0.030	0.120	0.120	4.000
199	1.890	0.128	0.110	0.018	0.006	0.024	0.007	0.870	0.854	0.001	0.001	0.031	0.101	0.101	4.000
199	1.906	0.120	0.094	0.026	0.005	0.018	0.008	0.887	0.829	0.001	0.000	0.031	0.125	0.125	4.000
199	1.923	0.112	0.077	0.035	0.003	0.015	0.006	0.868	0.865	0.000	0.000	0.029	0.130	0.130	4.000
199	1.901	0.130	0.099	0.031	0.004	0.020	0.006	0.861	0.868	0.001	0.001	0.032	0.106	0.106	4.000
avg(17)	1.908	0.120	0.092	0.028	0.004	0.019	0.007	0.871	0.857	0.001	0.001	0.031	0.116	0.116	4.000
stdev	0.012	0.008	0.012	0.007	0.001	0.004	0.001	0.015	0.024	0.001	0.001	0.003	0.013	0.013	
Cycle 5															
24	1.944	0.098	0.056	0.042	0.003	0.001	0.006	0.852	0.870	0.000	0.000	0.014	0.191	0.020	4.000
24	1.933	0.098	0.067	0.031	0.002	0.001	0.007	0.860	0.861	0.001	0.001	0.014	0.179	0.044	4.000
24	1.919	0.102	0.081	0.021	0.004	0.002	0.008	0.864	0.859	0.000	0.002	0.016	0.157	0.066	4.000
24	1.946	0.095	0.054	0.041	0.004	0.003	0.007	0.856	0.861	0.002	0.000	0.014	0.198	0.014	4.000
24	1.933	0.113	0.067	0.046	0.002	0.003	0.008	0.878	0.828	0.001	0.000	0.016	0.188	0.029	4.000
24	1.925	0.106	0.075	0.031	0.004	0.003	0.005	0.857	0.856	0.001	0.000	0.015	0.182	0.048	4.000
24	1.936	0.100	0.064	0.036	0.003	0.003	0.008	0.862	0.866	0.000	0.001	0.018	0.168	0.037	4.000
24	1.917	0.106	0.083	0.023	0.005	0.002	0.006	0.869	0.858	0.000	0.001	0.015	0.159	0.063	4.000
24	1.935	0.094	0.065	0.029	0.005	0.002	0.007	0.868	0.851	0.002	0.000	0.014	0.185	0.038	4.000
24	1.929	0.094	0.071	0.023	0.004	0.002	0.008	0.874	0.855	0.001	0.000	0.013	0.170	0.051	4.000
24	1.929	0.102	0.071	0.031	0.003	0.002	0.007	0.853	0.871	0.000	0.000	0.014	0.174	0.044	4.000
24	1.940	0.098	0.060	0.038	0.005	0.001	0.007	0.858	0.873	0.002	0.001	0.014	0.177	0.024	4.000
24	1.925	0.102	0.075	0.027	0.005	0.003	0.008	0.869	0.852	0.001	0.001	0.016	0.168	0.051	4.000
24	1.902	0.123	0.098	0.025	0.002	0.004	0.008	0.870	0.859	0.000	0.001	0.014	0.140	0.078	4.000
24	1.925	0.104	0.075	0.029	0.005	0.003	0.006	0.863	0.853	0.000	0.000	0.015	0.179	0.047	4.000
24	1.911	0.105	0.089	0.016	0.006	0.003	0.007	0.871	0.849	0.000	0.001	0.014	0.161	0.073	4.000
24	1.920	0.105	0.080	0.025	0.003	0.002	0.006	0.872	0.844	0.001	0.002	0.012	0.175	0.057	4.000
24	1.915	0.106	0.085	0.021	0.004	0.003	0.005	0.851	0.863	0.002	0.001	0.017	0.166	0.066	4.000
avg(18)	1.927	0.102	0.073	0.029	0.004	0.002	0.007	0.865	0.856	0.001	0.001	0.015	0.173	0.048	
stdev	0.011	0.007	0.011	0.008	0.001	0.001	0.001	0.008	0.011	0.001	0.001	0.001	0.013	0.017	
25	1.930	0.095	0.070	0.025	0.004	0.002	0.009	0.848	0.880	0.001	0.001	0.013	0.170	0.047	4.000
25	1.901	0.112	0.099	0.013	0.003	0.002	0.008	0.873	0.869	0.000	0.001	0.012	0.130	0.090	4.000
25	1.917	0.105	0.083	0.022	0.004	0.003	0.006	0.863	0.860	0.001	0.001	0.014	0.164	0.063	4.000
25	1.933	0.106	0.067	0.039	0.004	0.001	0.009	0.890	0.808	0.001	0.001	0.012	0.204	0.030	4.000
25	1.930	0.104	0.070	0.034	0.005	0.001	0.007	0.907	0.799	0.000	0.000	0.012	0.198	0.038	4.000
25	1.917	0.097	0.083	0.014	0.005	0.002	0.007	0.888	0.841	0.000	0.000	0.010	0.167	0.067	4.000
25	1.926	0.099	0.074	0.025	0.004	0.003	0.008	0.864	0.869	0.001	0.000	0.013	0.163	0.051	4.000
25	1.933	0.095	0.067	0.028	0.004	0.003	0.008	0.880	0.830	0.000	0.001	0.014	0.190	0.041	4.000
25	1.941	0.095	0.059	0.036	0.004	0.001	0.007	0.901	0.809	0.000	0.000	0.013	0.203	0.026	4.000
25	1.925	0.101	0.075	0.026	0.004	0.003	0.006	0.861	0.868	0.001	0.000	0.014	0.167	0.050	4.000
25	1.920	0.107	0.080	0.027	0.005	0.001	0.007	0.845	0.872	0.000	0.002	0.015	0.171	0.056	4.000
25	1.924	0.105	0.076	0.029	0.003	0.001	0.006	0.854	0.875	0.001	0.000	0.014	0.164	0.052	4.000
25	1.918	0.111	0.082	0.029	0.006	0.002	0.007	0.856	0.869	0.001	0.000	0.011	0.171	0.049	4.000
25	1.928	0.092	0.072	0.020	0.004	0.004	0.009	0.865	0.872	0.002	0.001	0.011	0.162	0.052	4.000
avg(14)	1.924	0.102	0.076	0.026	0.004	0.002	0.007	0.871	0.852	0.001	0.001	0.013	0.173	0.051	
stdev	0.009	0.006	0.009	0.007	0.001	0.001	0.001	0.019	0.027	0.001	0.001	0.001	0.019	0.015	
30	1.939	0.098	0.061	0.037	0.005	0.004	0.005	0.867	0.878	0.000	0.000	0.014	0.168	0.024	4.000
30	1.958	0.098	0.042	0.056	0.000	0.002	0.005	0.878	0.859	0.002	0.001	0.014	0.182	0.000	3.999
30	1.953	0.093	0.047	0.046	0.003	0.003	0.005	0.888	0.845	0.000	0.000	0.015	0.189	0.007	4.000
30	1.938	0.098	0.062	0.036	0.005	0.003	0.007	0.868	0.886	0.000	0.000	0.015	0.154	0.027	4.000
30	1.937	0.102	0.063	0.039	0.003	0.004	0.008	0.862	0.880	0.001	0.000	0.015	0.159	0.029	4.000
30	1.946	0.100	0.054	0.046	0.004	0.004	0.007	0.863	0.891	0.001	0.000	0.013	0.162	0.010	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mn	Ca	Mg	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
30	1.952	0.103	0.048	0.055	0.001	0.002	0.007	0.905	0.805	0.001	0.000	0.014	0.208	0.002	4.000
30	1.954	0.098	0.046	0.052	0.003	0.003	0.007	0.910	0.801	0.001	0.000	0.013	0.210	0.000	3.999
30	1.948	0.097	0.052	0.045	0.003	0.003	0.006	0.862	0.899	0.000	0.001	0.016	0.152	0.013	4.000
30	1.942	0.104	0.058	0.046	0.003	0.003	0.007	0.918	0.802	0.001	0.000	0.012	0.195	0.013	4.000
30	1.971	0.083	0.029	0.054	0.001	0.002	0.005	0.876	0.882	0.001	0.000	0.013	0.157	0.000	3.991
30	1.954	0.096	0.046	0.050	0.001	0.002	0.007	0.917	0.803	0.001	0.000	0.013	0.202	0.004	4.000
avg(12)	1.949	0.098	0.051	0.047	0.003	0.003	0.006	0.885	0.853	0.001	0.000	0.014	0.178	0.011	
stdev	0.009	0.005	0.009	0.007	0.002	0.001	0.001	0.021	0.038	0.001	0.000	0.001	0.021	0.010	
32	1.922	0.096	0.078	0.018	0.003	0.004	0.007	0.858	0.888	0.000	0.000	0.015	0.143	0.064	4.000
32	1.936	0.094	0.064	0.030	0.002	0.003	0.011	0.903	0.829	0.003	0.001	0.013	0.167	0.038	4.000
32	1.929	0.094	0.071	0.023	0.005	0.003	0.007	0.866	0.872	0.001	0.000	0.016	0.158	0.049	4.000
32	1.922	0.095	0.078	0.017	0.005	0.003	0.008	0.890	0.842	0.001	0.000	0.014	0.159	0.061	4.000
32	1.912	0.101	0.088	0.013	0.002	0.004	0.008	0.903	0.830	0.000	0.002	0.015	0.141	0.083	4.000
32	1.917	0.099	0.083	0.016	0.004	0.004	0.005	0.865	0.876	0.001	0.001	0.018	0.139	0.071	4.000
32	1.931	0.110	0.069	0.041	0.004	0.003	0.007	0.880	0.857	0.000	0.000	0.011	0.169	0.029	4.000
32	1.930	0.098	0.070	0.028	0.004	0.002	0.008	0.890	0.857	0.001	0.000	0.013	0.153	0.044	4.000
32	1.916	0.103	0.084	0.019	0.005	0.004	0.006	0.886	0.845	0.001	0.001	0.012	0.158	0.062	4.000
32	1.926	0.098	0.074	0.024	0.001	0.003	0.006	0.893	0.834	0.001	0.000	0.017	0.162	0.061	4.000
32	1.935	0.089	0.065	0.024	0.003	0.005	0.007	0.862	0.882	0.001	0.001	0.016	0.154	0.045	4.000
avg(11)	1.925	0.098	0.075	0.023	0.003	0.004	0.007	0.882	0.856	0.001	0.001	0.014	0.155	0.055	
stdev	0.008	0.005	0.008	0.008	0.001	0.001	0.001	0.016	0.020	0.001	0.001	0.002	0.010	0.015	
45	1.933	0.085	0.067	0.018	0.002	0.003	0.006	0.900	0.888	0.000	0.001	0.014	0.112	0.057	4.000
45	1.921	0.088	0.079	0.009	0.002	0.004	0.007	0.924	0.840	0.001	0.001	0.012	0.127	0.073	4.000
45	1.923	0.090	0.077	0.013	0.002	0.006	0.004	0.918	0.844	0.001	0.001	0.012	0.134	0.065	4.000
45	1.908	0.087	0.087	0.000	0.004	0.004	0.005	0.897	0.878	0.001	0.002	0.015	0.099	0.098	4.000
45	1.920	0.088	0.080	0.008	0.004	0.004	0.006	0.935	0.820	0.000	0.001	0.014	0.137	0.071	4.000
45	1.935	0.088	0.065	0.023	0.004	0.006	0.006	0.939	0.825	0.000	0.000	0.014	0.141	0.041	4.000
45	1.926	0.087	0.074	0.013	0.002	0.002	0.010	0.972	0.755	0.001	0.001	0.014	0.162	0.069	4.000
45	1.918	0.087	0.082	0.005	0.003	0.004	0.009	0.908	0.860	0.002	0.000	0.014	0.116	0.080	4.000
45	1.937	0.087	0.063	0.024	0.003	0.003	0.009	0.887	0.882	0.001	0.001	0.012	0.135	0.044	4.000
45	1.959	0.072	0.041	0.031	0.003	0.004	0.008	0.921	0.855	0.000	0.000	0.011	0.158	0.011	4.000
45	1.914	0.090	0.086	0.004	0.004	0.004	0.009	0.939	0.805	0.000	0.002	0.013	0.138	0.083	4.000
45	1.915	0.084	0.084	0.000	0.004	0.004	0.007	1.000	0.736	0.002	0.000	0.009	0.157	0.083	4.000
45	1.933	0.085	0.067	0.018	0.002	0.002	0.005	0.914	0.837	0.001	0.000	0.014	0.151	0.056	4.000
45	1.943	0.090	0.057	0.033	0.001	0.004	0.006	0.934	0.800	0.001	0.000	0.013	0.179	0.030	4.000
avg(14)	1.928	0.086	0.072	0.014	0.003	0.004	0.007	0.928	0.830	0.001	0.001	0.013	0.139	0.062	
stdev	0.013	0.004	0.012	0.010	0.001	0.001	0.002	0.029	0.043	0.001	0.001	0.002	0.021	0.023	
44	1.929	0.111	0.071	0.040	0.003	0.004	0.007	0.847	0.883	0.001	0.001	0.013	0.168	0.034	4.000
44	1.938	0.104	0.062	0.042	0.006	0.002	0.007	0.842	0.888	0.000	0.000	0.015	0.179	0.020	4.000
44	1.932	0.105	0.068	0.037	0.006	0.004	0.005	0.858	0.880	0.001	0.001	0.014	0.166	0.028	4.000
44	1.939	0.103	0.061	0.042	0.003	0.002	0.007	0.856	0.883	0.001	0.000	0.014	0.168	0.025	4.000
44	1.943	0.091	0.057	0.034	0.002	0.003	0.005	0.868	0.905	0.000	0.000	0.011	0.146	0.026	4.000
44	1.936	0.101	0.064	0.037	0.001	0.004	0.008	0.852	0.875	0.002	0.000	0.015	0.170	0.035	4.000
44	1.932	0.104	0.068	0.036	0.004	0.005	0.006	0.853	0.898	0.000	0.000	0.013	0.153	0.031	4.000
44	1.929	0.100	0.071	0.029	0.004	0.004	0.004	0.853	0.891	0.001	0.001	0.013	0.159	0.041	4.000
44	1.928	0.107	0.072	0.035	0.000	0.004	0.008	0.851	0.887	0.001	0.000	0.014	0.153	0.046	4.000
44	1.946	0.099	0.054	0.045	0.000	0.003	0.008	0.892	0.819	0.000	0.001	0.013	0.202	0.018	4.000
44	1.928	0.107	0.072	0.035	0.002	0.004	0.005	0.856	0.877	0.000	0.000	0.014	0.164	0.041	4.000
44	1.931	0.108	0.069	0.039	0.003	0.004	0.006	0.842	0.899	0.000	0.001	0.012	0.161	0.032	4.000
avg(12)	1.934	0.103	0.066	0.037	0.003	0.004	0.006	0.856	0.882	0.001	0.001	0.014	0.165	0.032	
stdev	0.006	0.005	0.006	0.004	0.002	0.001	0.001	0.013	0.021	0.001	0.000	0.001	0.014	0.008	
42	1.954	0.089	0.046	0.043	0.003	0.008	0.007	0.899	0.839	0.001	0.001	0.011	0.185	0.000	4.000
42	1.938	0.097	0.062	0.035	0.004	0.006	0.009	0.906	0.828	0.001	0.002	0.013	0.171	0.027	4.000
42	1.922	0.090	0.078	0.012	0.003	0.008	0.011	0.888	0.857	0.000	0.000	0.012	0.146	0.063	4.000
42	1.910	0.110	0.090	0.020	0.005	0.009	0.008	0.878	0.872	0.002	0.000	0.012	0.132	0.063	4.000
42	1.928	0.098	0.072	0.026	0.006	0.006	0.009	0.881	0.837	0.000	0.000	0.014	0.180	0.041	4.000
42	1.931	0.111	0.069	0.042	0.005	0.009	0.007	0.876	0.828	0.001	0.000	0.014	0.198	0.020	4.000
42	1.959	0.086	0.041	0.045	0.004	0.006	0.006	0.913	0.828	0.002	0.000	0.014	0.181	0.000	3.998
42	1.924	0.107	0.076	0.031	0.003	0.007	0.006	0.866	0.864	0.001	0.000	0.015	0.160	0.047	4.000
42	1.917	0.109	0.083	0.026	0.003	0.008	0.007	0.860	0.878	0.000	0.000	0.014	0.147	0.056	4.000
42	1.925	0.107	0.075	0.032	0.005	0.008	0.007	0.858	0.866	0.001	0.000	0.012	0.176	0.036	4.000
42	1.938	0.103	0.062	0.041	0.004	0.007	0.008	0.887	0.833	0.001	0.000	0.012	0.189	0.017	4.000
avg(11)	1.932	0.101	0.068	0.033	0.004	0.008	0.008	0.883	0.848	0.001	0.000	0.013	0.171	0.032	
stdev	0.014	0.009	0.014	0.010	0.001	0.001	0.001	0.017	0.018	0.001	0.001	0.001	0.020	0.022	
40	1.928	0.104	0.072	0.032	0.005	0.009	0.008	0.863	0.852	0.000	0.001	0.013	0.184	0.034	4.000
40	1.941	0.104	0.059	0.045	0.002	0.011	0.008	0.879	0.826	0.002	0.000	0.017	0.196	0.015	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mn	Ca	Mg	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
40	1.957	0.097	0.043	0.054	0.003	0.009	0.008	0.852	0.868	0.000	0.001	0.016	0.186	0.000	3.996
40	1.940	0.103	0.060	0.043	0.005	0.010	0.007	0.863	0.869	0.002	0.001	0.014	0.176	0.010	4.000
40	1.950	0.095	0.050	0.045	0.004	0.008	0.009	0.884	0.838	0.000	0.000	0.012	0.200	0.002	4.000
40	1.950	0.103	0.050	0.053	0.003	0.008	0.006	0.839	0.860	0.001	0.001	0.016	0.212	0.000	4.000
40	1.935	0.099	0.065	0.034	0.004	0.010	0.007	0.847	0.871	0.001	0.003	0.015	0.182	0.026	4.000
40	1.933	0.109	0.067	0.042	0.004	0.006	0.008	0.856	0.871	0.000	0.000	0.017	0.170	0.027	4.000
40	1.953	0.099	0.047	0.052	0.003	0.010	0.006	0.892	0.819	0.001	0.002	0.016	0.196	0.000	3.997
40	1.955	0.098	0.045	0.053	0.003	0.006	0.008	0.849	0.857	0.000	0.000	0.015	0.204	0.000	3.997
40	1.945	0.101	0.055	0.046	0.005	0.009	0.005	0.852	0.864	0.001	0.001	0.015	0.199	0.004	4.000
40	1.958	0.089	0.042	0.047	0.004	0.006	0.008	0.881	0.852	0.001	0.002	0.011	0.184	0.000	3.997
avg(12)	1.945	0.100	0.055	0.046	0.004	0.009	0.007	0.863	0.854	0.001	0.001	0.015	0.191	0.010	
stdev	0.010	0.005	0.010	0.007	0.001	0.002	0.001	0.016	0.017	0.001	0.001	0.002	0.012	0.012	
38	1.916	0.102	0.084	0.018	0.004	0.009	0.008	0.869	0.868	0.001	0.001	0.014	0.146	0.062	4.000
38	1.900	0.110	0.100	0.010	0.006	0.008	0.008	0.874	0.850	0.000	0.001	0.018	0.139	0.087	4.000
38	1.909	0.104	0.091	0.013	0.004	0.008	0.007	0.873	0.868	0.001	0.000	0.015	0.134	0.076	4.000
38	1.912	0.105	0.088	0.017	0.005	0.009	0.009	0.873	0.844	0.001	0.001	0.015	0.161	0.066	4.000
38	1.915	0.105	0.085	0.020	0.005	0.007	0.009	0.922	0.773	0.000	0.000	0.015	0.188	0.062	4.000
38	1.906	0.097	0.094	0.003	0.004	0.008	0.008	0.887	0.881	0.001	0.000	0.012	0.110	0.087	4.000
38	1.909	0.105	0.091	0.014	0.007	0.010	0.007	0.883	0.852	0.001	0.001	0.012	0.149	0.065	4.000
38	1.913	0.104	0.087	0.017	0.005	0.009	0.007	0.899	0.830	0.000	0.001	0.012	0.156	0.061	4.000
38	1.904	0.108	0.096	0.012	0.005	0.008	0.007	0.881	0.846	0.003	0.000	0.015	0.142	0.080	4.000
38	1.906	0.113	0.094	0.019	0.004	0.010	0.007	0.863	0.878	0.000	0.001	0.014	0.134	0.070	4.000
38	1.897	0.105	0.103	0.002	0.004	0.009	0.009	0.869	0.880	0.001	0.000	0.016	0.111	0.100	4.000
38	1.937	0.100	0.063	0.037	0.004	0.012	0.008	0.898	0.849	0.001	0.000	0.014	0.158	0.018	4.000
avg(12)	1.910	0.105	0.090	0.015	0.005	0.009	0.008	0.883	0.852	0.001	0.001	0.015	0.143	0.070	
stdev	0.010	0.004	0.010	0.009	0.001	0.001	0.001	0.016	0.028	0.001	0.000	0.002	0.021	0.020	
36	1.912	0.106	0.088	0.018	0.004	0.011	0.008	0.853	0.895	0.001	0.001	0.017	0.125	0.068	4.000
36	1.916	0.106	0.084	0.022	0.002	0.012	0.007	0.890	0.825	0.001	0.002	0.018	0.158	0.064	4.000
36	1.910	0.105	0.090	0.015	0.005	0.011	0.007	0.877	0.857	0.001	0.001	0.017	0.139	0.070	4.000
36	1.913	0.109	0.087	0.022	0.002	0.010	0.008	0.858	0.878	0.002	0.001	0.019	0.132	0.068	4.000
36	1.914	0.100	0.086	0.014	0.001	0.012	0.009	0.855	0.887	0.002	0.001	0.014	0.135	0.072	4.000
36	1.979	0.002	0.002	0.000	0.001	0.000	0.010	0.816	1.001	0.001	0.002	0.001	0.149	0.038	4.000
36	1.921	0.100	0.079	0.021	0.004	0.013	0.007	0.867	0.879	0.001	0.000	0.017	0.138	0.053	4.000
36	1.915	0.112	0.085	0.027	0.002	0.012	0.007	0.855	0.884	0.001	0.000	0.017	0.136	0.059	4.000
36	1.895	0.120	0.105	0.015	0.003	0.012	0.009	0.873	0.845	0.002	0.000	0.017	0.135	0.089	4.000
36	1.919	0.114	0.081	0.033	0.003	0.009	0.005	0.862	0.864	0.001	0.000	0.017	0.157	0.049	4.000
36	1.912	0.109	0.088	0.021	0.007	0.010	0.009	0.855	0.883	0.000	0.000	0.018	0.136	0.061	4.000
36	1.916	0.094	0.084	0.010	0.003	0.009	0.008	0.866	0.883	0.001	0.001	0.015	0.132	0.071	4.000
36	1.915	0.107	0.085	0.022	0.004	0.011	0.006	0.874	0.847	0.001	0.000	0.014	0.162	0.059	4.000
36	1.895	0.116	0.105	0.011	0.001	0.013	0.007	0.861	0.863	0.000	0.001	0.018	0.130	0.095	4.000
36	1.915	0.108	0.085	0.023	0.004	0.011	0.010	0.845	0.895	0.000	0.000	0.016	0.138	0.058	4.000
36	1.911	0.109	0.089	0.020	0.005	0.012	0.007	0.847	0.889	0.000	0.000	0.016	0.141	0.063	4.000
avg(16)	1.916	0.101	0.084	0.017	0.003	0.011	0.008	0.859	0.880	0.001	0.001	0.016	0.140	0.065	
stdev	0.018	0.026	0.022	0.007	0.002	0.003	0.001	0.016	0.037	0.001	0.001	0.004	0.010	0.013	
35	1.933	0.098	0.067	0.031	0.004	0.011	0.006	0.854	0.871	0.001	0.000	0.016	0.174	0.032	4.000
35	1.928	0.100	0.072	0.028	0.006	0.010	0.006	0.854	0.866	0.002	0.000	0.016	0.175	0.038	4.000
35	1.921	0.104	0.079	0.025	0.004	0.009	0.007	0.892	0.808	0.001	0.001	0.014	0.190	0.049	4.000
35	1.919	0.104	0.081	0.023	0.004	0.012	0.007	0.861	0.846	0.003	0.000	0.014	0.178	0.052	4.000
35	1.921	0.101	0.079	0.022	0.004	0.011	0.007	0.892	0.788	0.000	0.001	0.014	0.211	0.050	4.000
35	1.923	0.108	0.077	0.031	0.002	0.011	0.006	0.853	0.859	0.000	0.000	0.016	0.175	0.048	4.000
35	1.922	0.102	0.078	0.024	0.004	0.011	0.007	0.855	0.868	0.001	0.000	0.015	0.166	0.049	4.000
35	1.927	0.103	0.073	0.030	0.005	0.011	0.007	0.871	0.835	0.000	0.001	0.017	0.185	0.039	4.000
35	1.918	0.102	0.082	0.020	0.003	0.011	0.008	0.875	0.830	0.001	0.001	0.014	0.179	0.058	4.000
avg(10)	1.923	0.102	0.077	0.026	0.004	0.011	0.007	0.870	0.840	0.001	0.001	0.015	0.181	0.047	
stdev	0.004	0.003	0.004	0.004	0.001	0.001	0.001	0.016	0.026	0.001	0.000	0.001	0.012	0.017	
34	1.928	0.110	0.072	0.038	0.006	0.011	0.005	0.835	0.885	0.003	0.000	0.017	0.172	0.027	4.000
34	1.935	0.098	0.065	0.033	0.006	0.013	0.011	0.860	0.829	0.000	0.000	0.014	0.214	0.020	4.000
34	1.929	0.100	0.071	0.029	0.003	0.007	0.005	0.856	0.876	0.003	0.002	0.015	0.161	0.044	4.000
34	1.925	0.103	0.075	0.028	0.004	0.012	0.008	0.880	0.806	0.001	0.001	0.017	0.202	0.042	4.000
34	1.918	0.108	0.082	0.026	0.005	0.013	0.007	0.850	0.864	0.001	0.003	0.018	0.163	0.049	4.000
34	1.936	0.089	0.064	0.025	0.004	0.010	0.008	0.841	0.908	0.001	0.001	0.015	0.152	0.034	4.000
34	1.919	0.106	0.081	0.025	0.003	0.013	0.005	0.857	0.877	0.000	0.001	0.016	0.150	0.054	4.000
34	1.906	0.102	0.094	0.008	0.006	0.013	0.008	0.887	0.808	0.000	0.002	0.015	0.178	0.075	4.000
34	1.916	0.102	0.084	0.018	0.004	0.012	0.007	0.861	0.851	0.002	0.001	0.018	0.164	0.063	4.000
34	1.924	0.100	0.076	0.024	0.003	0.013	0.006	0.871	0.859	0.000	0.001	0.016	0.159	0.049	4.000
34	1.921	0.101	0.079	0.022	0.003	0.012	0.006	0.844	0.870	0.001	0.000	0.016	0.172	0.054	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mn	Ca	Mg	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
34	1.925	0.103	0.075	0.028	0.002	0.012	0.007	0.861	0.852	0.001	0.001	0.018	0.171	0.048	4.000
34	1.910	0.108	0.090	0.018	0.006	0.013	0.009	0.857	0.864	0.001	0.001	0.017	0.152	0.064	4.000
34	1.910	0.099	0.090	0.009	0.005	0.011	0.007	0.852	0.893	0.001	0.002	0.016	0.130	0.075	4.000
34	1.902	0.101	0.098	0.003	0.004	0.010	0.006	0.907	0.839	0.002	0.000	0.017	0.119	0.093	4.000
avg(15)	1.920	0.102	0.080	0.022	0.004	0.012	0.007	0.861	0.859	0.001	0.001	0.017	0.163	0.054	
stdev	0.010	0.005	0.010	0.009	0.001	0.002	0.002	0.018	0.028	0.001	0.001	0.001	0.023	0.019	
33	1.938	0.108	0.062	0.046	0.004	0.014	0.006	0.832	0.851	0.001	0.000	0.017	0.218	0.012	4.000
33	1.921	0.105	0.079	0.026	0.005	0.013	0.006	0.836	0.874	0.001	0.000	0.019	0.171	0.048	4.000
33	1.917	0.105	0.083	0.022	0.003	0.014	0.007	0.871	0.823	0.000	0.000	0.019	0.183	0.059	4.000
33	1.928	0.108	0.072	0.036	0.004	0.011	0.006	0.835	0.866	0.003	0.001	0.017	0.189	0.033	4.000
33	1.931	0.109	0.069	0.040	0.006	0.014	0.008	0.840	0.862	0.000	0.000	0.019	0.192	0.021	4.000
33	1.921	0.104	0.079	0.025	0.006	0.014	0.008	0.845	0.854	0.002	0.001	0.014	0.189	0.042	4.000
33	1.951	0.091	0.049	0.042	0.004	0.012	0.008	0.897	0.826	0.002	0.001	0.013	0.195	0.000	4.000
33	1.933	0.099	0.067	0.032	0.006	0.014	0.007	0.854	0.868	0.000	0.000	0.014	0.181	0.025	4.000
33	1.939	0.102	0.061	0.041	0.005	0.014	0.008	0.867	0.841	0.000	0.000	0.016	0.197	0.013	4.000
33	1.963	0.083	0.037	0.046	0.005	0.013	0.009	0.943	0.783	0.000	0.001	0.012	0.179	0.000	3.991
33	1.933	0.101	0.067	0.034	0.003	0.012	0.007	0.857	0.868	0.000	0.000	0.015	0.175	0.029	4.000
33	1.917	0.105	0.083	0.022	0.003	0.014	0.007	0.871	0.823	0.000	0.000	0.019	0.183	0.059	4.000
33	1.928	0.108	0.072	0.036	0.004	0.011	0.006	0.835	0.866	0.003	0.001	0.017	0.189	0.033	4.000
33	1.931	0.109	0.069	0.040	0.006	0.014	0.008	0.840	0.862	0.000	0.000	0.019	0.192	0.021	4.000
33	1.921	0.104	0.079	0.025	0.006	0.014	0.008	0.845	0.854	0.002	0.001	0.014	0.189	0.042	4.000
33	1.951	0.091	0.049	0.042	0.004	0.012	0.008	0.897	0.826	0.002	0.001	0.013	0.195	0.000	4.000
33	1.933	0.099	0.067	0.032	0.006	0.014	0.007	0.854	0.868	0.000	0.000	0.014	0.181	0.025	4.000
33	1.939	0.102	0.061	0.041	0.005	0.014	0.008	0.867	0.841	0.000	0.000	0.016	0.197	0.013	4.000
33	1.963	0.083	0.037	0.046	0.005	0.013	0.009	0.943	0.783	0.000	0.001	0.012	0.179	0.000	3.991
33	1.933	0.101	0.067	0.034	0.003	0.012	0.007	0.857	0.868	0.000	0.000	0.015	0.175	0.029	4.000
33	1.930	0.104	0.070	0.034	0.004	0.012	0.008	0.862	0.838	0.002	0.000	0.018	0.189	0.033	4.000
33	1.924	0.105	0.076	0.029	0.002	0.014	0.009	0.853	0.846	0.001	0.000	0.014	0.189	0.043	4.000
33	1.920	0.106	0.080	0.026	0.005	0.010	0.007	0.839	0.865	0.001	0.000	0.019	0.176	0.052	4.000
avg(23)	1.932	0.102	0.068	0.034	0.004	0.013	0.008	0.859	0.848	0.001	0.000	0.017	0.189	0.028	
stdev	0.013	0.007	0.013	0.008	0.001	0.001	0.001	0.030	0.025	0.001	0.000	0.002	0.010	0.018	
Cycle 4															
14	1.913	0.122	0.087	0.035	0.006	0.008	0.000	0.932	0.715	0.003	0.000	0.014	0.236	0.044	4.000
14	1.918	0.125	0.082	0.043	0.007	0.008	0.007	0.918	0.757	0.001	0.002	0.018	0.207	0.033	4.000
14	1.911	0.126	0.089	0.037	0.004	0.009	0.007	0.893	0.783	0.001	0.001	0.016	0.199	0.050	4.000
14	1.911	0.129	0.089	0.040	0.007	0.007	0.005	0.831	0.880	0.000	0.001	0.016	0.168	0.043	4.000
14	1.921	0.128	0.079	0.049	0.006	0.009	0.007	0.829	0.863	0.001	0.000	0.016	0.197	0.025	4.000
14	1.921	0.125	0.079	0.046	0.004	0.006	0.005	0.891	0.778	0.000	0.002	0.016	0.219	0.033	4.000
14	1.905	0.130	0.095	0.035	0.008	0.010	0.008	0.854	0.823	0.000	0.001	0.016	0.194	0.050	4.000
14	1.906	0.128	0.094	0.034	0.005	0.009	0.007	0.911	0.761	0.000	0.001	0.016	0.199	0.058	4.000
avg(8)	1.912	0.127	0.088	0.039	0.006	0.008	0.006	0.879	0.801	0.001	0.001	0.016	0.199	0.044	
stdev	0.006	0.002	0.006	0.006	0.001	0.001	0.002	0.036	0.052	0.001	0.001	0.001	0.020	0.011	
110	1.910	0.124	0.090	0.034	0.006	0.012	0.006	0.850	0.856	0.001	0.002	0.020	0.162	0.051	4.000
110	1.905	0.127	0.095	0.032	0.005	0.014	0.005	0.849	0.834	0.002	0.002	0.019	0.181	0.058	4.000
110	1.893	0.135	0.107	0.028	0.003	0.014	0.008	0.847	0.848	0.001	0.000	0.021	0.151	0.079	4.000
110	1.907	0.123	0.093	0.030	0.006	0.014	0.007	0.850	0.864	0.001	0.002	0.018	0.156	0.053	4.000
110	1.896	0.133	0.104	0.029	0.007	0.013	0.007	0.857	0.833	0.000	0.000	0.021	0.165	0.069	4.000
110	1.911	0.127	0.089	0.038	0.006	0.012	0.006	0.852	0.841	0.000	0.002	0.020	0.178	0.045	4.000
110	1.903	0.137	0.097	0.040	0.004	0.012	0.006	0.840	0.856	0.001	0.000	0.018	0.169	0.054	4.000
110	1.913	0.128	0.087	0.041	0.003	0.015	0.006	0.842	0.841	0.001	0.001	0.018	0.189	0.042	4.000
110	1.899	0.129	0.101	0.028	0.003	0.011	0.007	0.894	0.789	0.000	0.000	0.016	0.181	0.071	4.000
110	1.901	0.127	0.099	0.028	0.006	0.013	0.006	0.886	0.788	0.000	0.001	0.017	0.194	0.061	4.000
110	1.900	0.134	0.100	0.034	0.008	0.013	0.008	0.856	0.823	0.001	0.000	0.019	0.184	0.056	4.000
110	1.905	0.131	0.095	0.036	0.003	0.015	0.007	0.887	0.792	0.003	0.001	0.016	0.186	0.055	4.000
110	1.906	0.130	0.094	0.036	0.006	0.013	0.007	0.868	0.816	0.000	0.001	0.018	0.185	0.051	4.000
110	1.909	0.131	0.091	0.040	0.005	0.014	0.006	0.853	0.839	0.001	0.000	0.020	0.178	0.046	4.000
110	1.906	0.126	0.094	0.032	0.007	0.013	0.008	0.903	0.754	0.000	0.001	0.017	0.213	0.052	4.000
110	1.901	0.126	0.099	0.027	0.008	0.012	0.007	0.857	0.848	0.001	0.000	0.019	0.158	0.062	4.000
110	1.898	0.124	0.102	0.022	0.006	0.011	0.006	0.848	0.858	0.000	0.000	0.019	0.155	0.076	4.000
110	1.901	0.126	0.099	0.027	0.009	0.015	0.006	0.878	0.799	0.000	0.001	0.016	0.196	0.053	4.000
110	1.912	0.124	0.088	0.036	0.006	0.014	0.007	0.872	0.798	0.001	0.001	0.016	0.208	0.041	4.000
110	1.885	0.168	0.115	0.053	0.007	0.012	0.007	0.840	0.817	0.002	0.001	0.037	0.152	0.073	4.000
110	1.900	0.125	0.100	0.025	0.009	0.009	0.007	0.843	0.869	0.000	0.000	0.019	0.152	0.068	4.000
110	1.915	0.121	0.085	0.036	0.002	0.014	0.010	0.839	0.852	0.000	0.001	0.020	0.177	0.049	4.000
avg(22)	1.904	0.130	0.096	0.034	0.006	0.013	0.007	0.859	0.828	0.001	0.001	0.019	0.176	0.057	
stdev	0.007	0.009	0.007	0.007	0.002	0.001	0.001	0.019	0.030	0.001	0.001	0.004	0.018	0.011	

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
11	1.900	0.115	0.100	0.015	0.006	0.015	0.006	0.851	0.870	0.002	0.000	0.020	0.138	0.077	4.000
11	1.909	0.112	0.091	0.021	0.005	0.016	0.006	0.850	0.872	0.001	0.000	0.019	0.148	0.062	4.000
11	1.904	0.114	0.096	0.018	0.006	0.014	0.006	0.854	0.861	0.000	0.000	0.022	0.146	0.072	4.000
11	1.901	0.121	0.099	0.022	0.003	0.015	0.007	0.831	0.886	0.001	0.001	0.020	0.139	0.076	4.000
11	1.910	0.121	0.090	0.031	0.007	0.016	0.006	0.857	0.848	0.001	0.001	0.019	0.168	0.047	4.000
11	1.912	0.121	0.088	0.033	0.003	0.014	0.007	0.853	0.844	0.002	0.001	0.020	0.170	0.053	4.000
11	1.929	0.116	0.071	0.045	0.005	0.015	0.006	0.871	0.839	0.000	0.000	0.019	0.182	0.019	4.000
11	1.914	0.122	0.086	0.036	0.005	0.015	0.007	0.851	0.858	0.000	0.001	0.020	0.162	0.045	4.000
11	1.921	0.109	0.079	0.030	0.005	0.015	0.007	0.847	0.876	0.002	0.000	0.017	0.162	0.041	4.000
11	1.907	0.131	0.093	0.038	0.006	0.015	0.007	0.848	0.851	0.000	0.001	0.022	0.164	0.050	4.000
11	1.904	0.121	0.096	0.025	0.006	0.017	0.008	0.842	0.884	0.002	0.000	0.019	0.136	0.061	4.000
11	1.915	0.119	0.085	0.034	0.008	0.015	0.006	0.885	0.792	0.001	0.000	0.019	0.203	0.036	4.000
11	1.919	0.117	0.081	0.036	0.007	0.014	0.008	0.847	0.851	0.003	0.001	0.018	0.180	0.035	4.000
11	1.914	0.121	0.086	0.035	0.004	0.015	0.008	0.847	0.860	0.001	0.000	0.019	0.165	0.046	4.000
11	1.917	0.114	0.083	0.031	0.005	0.016	0.008	0.868	0.835	0.000	0.001	0.016	0.178	0.043	4.000
11	1.912	0.121	0.088	0.033	0.005	0.014	0.006	0.854	0.847	0.001	0.001	0.018	0.172	0.048	4.000
11	1.913	0.124	0.087	0.037	0.005	0.015	0.007	0.840	0.862	0.001	0.000	0.020	0.169	0.045	4.000
11	1.915	0.119	0.085	0.034	0.004	0.013	0.007	0.852	0.853	0.001	0.000	0.018	0.171	0.047	4.000
11	1.904	0.120	0.096	0.024	0.009	0.015	0.008	0.851	0.857	0.000	0.000	0.021	0.156	0.060	4.000
11	1.905	0.131	0.095	0.036	0.007	0.013	0.008	0.884	0.788	0.000	0.000	0.016	0.201	0.046	4.000
11	1.926	0.113	0.074	0.039	0.002	0.012	0.006	0.852	0.862	0.002	0.000	0.019	0.170	0.035	4.000
11	1.922	0.120	0.078	0.042	0.006	0.016	0.006	0.831	0.867	0.001	0.002	0.020	0.182	0.026	4.000
11	1.919	0.121	0.081	0.040	0.006	0.015	0.008	0.834	0.864	0.000	0.000	0.019	0.182	0.033	4.000
11	1.916	0.120	0.084	0.036	0.007	0.015	0.007	0.854	0.845	0.000	0.000	0.020	0.178	0.039	4.000
11	1.907	0.118	0.093	0.025	0.006	0.017	0.007	0.849	0.868	0.001	0.001	0.019	0.151	0.056	4.000
11	1.910	0.115	0.090	0.025	0.020	0.014	0.008	0.825	0.879	0.001	0.000	0.019	0.180	0.030	4.000
11	1.922	0.119	0.078	0.041	0.006	0.013	0.008	0.861	0.834	0.001	0.000	0.020	0.185	0.031	4.000
avg(27)	1.913	0.119	0.087	0.032	0.006	0.015	0.007	0.851	0.854	0.001	0.000	0.019	0.168	0.047	
stdev	0.007	0.005	0.007	0.008	0.003	0.001	0.001	0.014	0.023	0.001	0.001	0.001	0.017	0.014	
109	1.907	0.129	0.093	0.036	0.004	0.014	0.010	0.850	0.824	0.000	0.001	0.020	0.187	0.053	4.000
109	1.907	0.129	0.093	0.036	0.001	0.013	0.007	0.850	0.851	0.002	0.000	0.020	0.160	0.062	4.000
109	1.894	0.137	0.106	0.031	0.008	0.014	0.006	0.841	0.839	0.000	0.000	0.018	0.181	0.061	4.000
109	1.901	0.144	0.099	0.045	0.005	0.014	0.007	0.824	0.856	0.001	0.000	0.019	0.182	0.049	4.000
109	1.903	0.134	0.097	0.037	0.004	0.016	0.009	0.828	0.868	0.000	0.001	0.019	0.164	0.054	4.000
109	1.905	0.132	0.095	0.037	0.006	0.012	0.007	0.821	0.878	0.000	0.001	0.019	0.168	0.053	4.000
109	1.905	0.128	0.095	0.033	0.006	0.013	0.008	0.855	0.825	0.000	0.001	0.019	0.185	0.055	4.000
109	1.907	0.130	0.093	0.037	0.004	0.013	0.009	0.847	0.854	0.000	0.000	0.022	0.158	0.057	4.000
109	1.902	0.131	0.098	0.033	0.005	0.017	0.007	0.854	0.815	0.001	0.000	0.021	0.189	0.060	4.000
109	1.915	0.115	0.085	0.030	0.006	0.017	0.008	0.834	0.871	0.002	0.000	0.021	0.166	0.046	4.000
109	1.895	0.140	0.105	0.035	0.006	0.011	0.008	0.865	0.799	0.002	0.000	0.020	0.187	0.065	4.000
109	1.903	0.132	0.097	0.035	0.002	0.012	0.007	0.871	0.802	0.001	0.000	0.019	0.188	0.064	4.000
avg(12)	1.903	0.132	0.097	0.035	0.005	0.014	0.008	0.845	0.840	0.001	0.000	0.020	0.175	0.058	
stdev	0.005	0.007	0.005	0.004	0.002	0.002	0.001	0.015	0.026	0.001	0.000	0.001	0.011	0.006	
9	1.917	0.118	0.083	0.035	0.004	0.015	0.004	0.848	0.867	0.001	0.002	0.017	0.165	0.041	4.000
9	1.914	0.111	0.086	0.025	0.004	0.015	0.007	0.820	0.913	0.001	0.000	0.014	0.152	0.048	4.000
9	1.909	0.128	0.091	0.037	0.004	0.015	0.007	0.845	0.874	0.001	0.001	0.018	0.151	0.047	4.000
9	1.897	0.133	0.103	0.030	0.004	0.016	0.008	0.844	0.866	0.000	0.000	0.020	0.144	0.069	4.000
9	1.926	0.121	0.074	0.047	0.002	0.013	0.007	0.868	0.843	0.000	0.000	0.016	0.178	0.025	4.000
9	1.893	0.144	0.107	0.037	0.006	0.015	0.007	0.867	0.836	0.002	0.001	0.019	0.149	0.062	4.000
9	1.911	0.123	0.089	0.034	0.006	0.015	0.005	0.850	0.859	0.002	0.000	0.020	0.163	0.047	4.000
9	1.901	0.133	0.099	0.034	0.005	0.013	0.007	0.844	0.860	0.002	0.001	0.019	0.155	0.060	4.000
9	1.899	0.132	0.101	0.031	0.005	0.016	0.006	0.847	0.863	0.000	0.001	0.019	0.151	0.062	4.000
9	1.916	0.125	0.084	0.041	0.007	0.014	0.006	0.887	0.823	0.001	0.000	0.020	0.167	0.035	4.000
avg(10)	1.908	0.127	0.092	0.035	0.005	0.015	0.006	0.852	0.861	0.001	0.001	0.019	0.157	0.050	
stdev	0.010	0.009	0.010	0.006	0.001	0.001	0.001	0.017	0.023	0.001	0.001	0.002	0.010	0.013	
8	1.905	0.121	0.095	0.026	0.003	0.013	0.008	0.860	0.865	0.002	0.000	0.023	0.127	0.073	4.000
8	1.910	0.125	0.090	0.035	0.005	0.014	0.006	0.846	0.872	0.001	0.001	0.024	0.143	0.055	4.000
8	1.912	0.109	0.088	0.021	0.006	0.015	0.008	0.849	0.882	0.000	0.000	0.019	0.141	0.058	4.000
8	1.894	0.143	0.106	0.037	0.006	0.015	0.007	0.895	0.793	0.001	0.000	0.019	0.168	0.059	4.000
8	1.903	0.120	0.097	0.023	0.005	0.017	0.006	0.845	0.873	0.001	0.001	0.023	0.137	0.069	4.000
8	1.919	0.130	0.081	0.049	0.004	0.018	0.007	0.862	0.831	0.000	0.001	0.021	0.181	0.026	4.000
8	1.897	0.123	0.103	0.020	0.005	0.016	0.007	0.851	0.866	0.001	0.000	0.025	0.129	0.082	4.000
8	1.946	0.106	0.054	0.052	0.003	0.015	0.009	0.900	0.795	0.003	0.002	0.018	0.202	0.000	4.000
8	1.900	0.123	0.100	0.023	0.004	0.017	0.007	0.859	0.856	0.001	0.001	0.021	0.139	0.072	4.000
8	1.902	0.123	0.098	0.025	0.003	0.016	0.007	0.848	0.879	0.001	0.001	0.020	0.131	0.071	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
8	1.907	0.124	0.093	0.031	0.001	0.016	0.006	0.850	0.868	0.001	0.001	0.023	0.136	0.066	4.000
avg(11)	1.909	0.122	0.091	0.031	0.004	0.016	0.007	0.860	0.853	0.001	0.001	0.021	0.149	0.057	
stdev	0.014	0.009	0.014	0.011	0.001	0.001	0.001	0.018	0.031	0.001	0.001	0.002	0.023	0.023	
6	1.895	0.125	0.105	0.020	0.003	0.012	0.009	0.856	0.854	0.001	0.000	0.021	0.138	0.088	4.000
6	1.900	0.117	0.100	0.017	0.003	0.015	0.009	0.840	0.879	0.001	0.000	0.019	0.135	0.083	4.000
6	1.881	0.123	0.119	0.004	0.006	0.014	0.007	0.881	0.815	0.000	0.000	0.022	0.141	0.109	4.000
6	1.911	0.132	0.089	0.043	0.006	0.012	0.007	0.843	0.860	0.001	0.000	0.022	0.162	0.044	4.000
6	1.902	0.127	0.098	0.029	0.001	0.008	0.006	0.846	0.896	0.000	0.000	0.019	0.119	0.078	4.000
6	1.896	0.112	0.104	0.008	0.003	0.013	0.008	0.947	0.734	0.001	0.000	0.015	0.179	0.092	4.000
6	1.892	0.129	0.108	0.021	0.005	0.016	0.007	0.839	0.865	0.001	0.000	0.020	0.145	0.081	4.000
6	1.887	0.130	0.113	0.017	0.004	0.017	0.009	0.850	0.858	0.000	0.001	0.020	0.135	0.091	4.000
6	1.916	0.114	0.084	0.030	0.005	0.012	0.008	0.871	0.851	0.001	0.001	0.018	0.155	0.050	4.000
6	1.894	0.128	0.106	0.022	0.007	0.014	0.007	0.850	0.868	0.002	0.002	0.016	0.141	0.073	4.000
avg(10)	1.897	0.124	0.103	0.021	0.004	0.013	0.008	0.862	0.848	0.001	0.000	0.019	0.145	0.079	
stdev	0.010	0.007	0.010	0.011	0.002	0.002	0.001	0.031	0.043	0.001	0.001	0.002	0.016	0.018	
5	1.918	0.130	0.082	0.048	0.004	0.014	0.006	0.827	0.876	0.000	0.000	0.020	0.176	0.029	4.000
5	1.898	0.147	0.102	0.045	0.006	0.015	0.006	0.836	0.858	0.000	0.002	0.020	0.162	0.050	4.000
5	1.902	0.130	0.098	0.032	0.005	0.015	0.007	0.860	0.815	0.002	0.001	0.020	0.185	0.058	4.000
5	1.947	0.076	0.053	0.023	0.001	0.006	0.006	0.885	0.874	0.000	0.001	0.017	0.148	0.039	4.000
5	1.894	0.142	0.106	0.036	0.005	0.015	0.006	0.842	0.867	0.002	0.000	0.018	0.149	0.060	4.000
5	1.924	0.113	0.076	0.037	0.005	0.010	0.007	0.853	0.850	0.001	0.001	0.019	0.180	0.038	4.000
5	1.883	0.145	0.117	0.028	0.004	0.015	0.007	0.859	0.846	0.002	0.000	0.020	0.134	0.087	4.000
5	1.908	0.133	0.092	0.041	0.003	0.014	0.006	0.861	0.823	0.000	0.001	0.020	0.181	0.050	4.000
5	1.931	0.129	0.069	0.060	0.004	0.011	0.007	0.857	0.821	0.001	0.001	0.018	0.213	0.007	4.000
5	1.915	0.125	0.085	0.040	0.003	0.013	0.007	0.838	0.875	0.002	0.000	0.019	0.160	0.045	4.000
avg(10)	1.912	0.127	0.088	0.039	0.004	0.013	0.007	0.852	0.851	0.001	0.001	0.019	0.169	0.046	
stdev	0.018	0.020	0.018	0.010	0.001	0.003	0.001	0.016	0.022	0.001	0.001	0.001	0.022	0.020	
Cycle 3															
102	1.925	0.101	0.075	0.026	0.004	0.003	0.874	0.872	0.004	0.002	0.000	0.014	0.151	0.051	4.000
102	1.914	0.102	0.086	0.016	0.004	0.005	0.942	0.776	0.006	0.002	0.000	0.016	0.161	0.072	4.000
102	1.923	0.110	0.077	0.033	0.005	0.003	0.924	0.797	0.005	0.001	0.001	0.013	0.177	0.042	4.000
102	1.906	0.106	0.094	0.012	0.005	0.003	0.931	0.792	0.005	0.001	0.001	0.016	0.150	0.085	4.000
102	1.919	0.107	0.081	0.026	0.004	0.003	0.871	0.878	0.006	0.001	0.000	0.016	0.136	0.061	4.000
102	1.893	0.111	0.107	0.004	0.006	0.005	0.890	0.865	0.006	0.000	0.000	0.013	0.111	0.100	4.000
102	1.906	0.114	0.094	0.020	0.007	0.003	0.867	0.873	0.004	0.003	0.001	0.018	0.132	0.072	4.000
102	1.910	0.112	0.090	0.022	0.006	0.004	0.879	0.853	0.006	0.000	0.000	0.017	0.144	0.069	4.000
102	1.891	0.111	0.109	0.002	0.006	0.002	0.929	0.809	0.004	0.001	1.000	0.016	0.123	0.107	4.000
102	1.915	0.102	0.085	0.017	0.004	0.003	0.894	0.869	0.005	0.000	0.001	0.014	0.124	0.069	4.000
102	1.910	0.109	0.090	0.019	0.005	0.003	0.881	0.861	0.006	0.000	0.002	0.018	0.130	0.076	4.000
102	1.903	0.107	0.097	0.010	0.007	0.003	0.939	0.775	0.006	0.002	0.001	0.016	0.156	0.085	4.000
102	1.910	0.109	0.101	0.008	0.006	0.004	0.892	0.841	0.006	0.001	0.001	0.018	0.131	0.093	4.000
avg(13)	1.910	0.108	0.091	0.017	0.005	0.003	0.901	0.835	0.005	0.001	0.078	0.016	0.140	0.076	4.000
stdev	0.010	0.004	0.010	0.009	0.001	0.001	0.027	0.038	0.001	0.001	0.266	0.002	0.017	0.018	4.000
467	1.911	0.106	0.089	0.017	0.007	0.002	0.899	0.813	0.004	0.001	0.000	0.016	0.171	0.071	4.000
467	1.909	0.101	0.091	0.010	0.006	0.002	0.888	0.832	0.008	0.001	0.002	0.018	0.149	0.084	4.000
467	1.925	0.099	0.075	0.024	0.005	0.001	0.878	0.855	0.006	0.001	0.001	0.016	0.158	0.054	4.000
467	1.923	0.094	0.077	0.017	0.005	0.003	0.885	0.860	0.006	0.002	0.000	0.014	0.148	0.059	4.000
467	1.926	0.095	0.074	0.021	0.003	0.002	0.908	0.812	0.005	0.001	0.000	0.016	0.174	0.060	4.000
467	1.911	0.099	0.089	0.010	0.002	0.003	0.898	0.825	0.006	0.000	0.001	0.015	0.154	0.086	4.000
467	1.922	0.102	0.078	0.024	0.006	0.002	0.890	0.829	0.002	0.001	0.001	0.017	0.173	0.055	4.000
467	1.914	0.097	0.086	0.011	0.003	0.003	0.872	0.860	0.007	0.001	0.000	0.018	0.142	0.084	4.000
467	1.906	0.103	0.094	0.009	0.005	0.003	0.885	0.839	0.005	0.001	0.000	0.016	0.150	0.087	4.000
467	1.921	0.102	0.079	0.023	0.002	0.002	0.873	0.841	0.007	0.001	0.001	0.016	0.169	0.065	4.000
467	1.919	0.098	0.081	0.017	0.004	0.003	0.890	0.834	0.006	0.001	0.001	0.016	0.160	0.070	4.000
avg(11)	1.917	0.100	0.083	0.017	0.004	0.002	0.888	0.836	0.006	0.001	0.001	0.016	0.159	0.070	4.000
stdev	0.007	0.003	0.007	0.006	0.002	0.001	0.011	0.016	0.002	0.000	0.001	0.001	0.011	0.012	4.000
468	1.887	0.110	0.110	0.000	0.008	0.003	0.907	0.817	0.004	0.001	0.001	0.015	0.136	0.112	4.000
468	1.900	0.110	0.100	0.010	0.004	0.002	0.894	0.833	0.006	0.000	0.000	0.018	0.136	0.096	4.000
468	1.897	0.113	0.103	0.010	0.005	0.003	0.899	0.816	0.006	0.000	0.000	0.018	0.147	0.096	4.000
468	1.906	0.111	0.094	0.017	0.007	0.001	0.895	0.818	0.005	0.001	0.001	0.018	0.157	0.081	4.000
468	1.893	0.112	0.107	0.005	0.007	0.003	0.885	0.836	0.006	0.000	0.002	0.018	0.137	0.100	4.000
468	1.901	0.105	0.099	0.006	0.005	0.003	0.887	0.849	0.007	0.000	0.000	0.016	0.132	0.095	4.000
468	1.893	0.114	0.107	0.007	0.007	0.004	0.881	0.835	0.005	0.001	0.001	0.017	0.145	0.098	4.000
468	1.906	0.110	0.094	0.016	0.004	0.001	0.893	0.833	0.007	0.001	0.001	0.014	0.148	0.083	4.000
468	1.891	0.117	0.109	0.008	0.004	0.002	0.890	0.827	0.006	0.002	0.002	0.018	0.134	0.106	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
468	1.894	0.110	0.106	0.004	0.004	0.003	0.894	0.829	0.006	0.001	0.002	0.017	0.133	0.107	4.000
468	1.897	0.111	0.103	0.008	0.005	0.002	0.893	0.840	0.005	0.000	0.000	0.018	0.130	0.100	4.000
avg(11)	1.897	0.111	0.103	0.008	0.005	0.002	0.893	0.830	0.006	0.001	0.001	0.017	0.140	0.098	4.000
stdev	0.006	0.003	0.005	0.005	0.001	0.001	0.007	0.010	0.001	0.001	0.001	0.001	0.008	0.009	4.000
469	1.919	0.098	0.081	0.017	0.008	0.002	0.891	0.835	0.006	0.000	0.000	0.015	0.167	0.060	4.000
469	1.914	0.095	0.086	0.009	0.006	0.003	0.892	0.827	0.006	0.000	0.001	0.016	0.162	0.078	4.000
469	1.909	0.100	0.091	0.009	0.004	0.002	0.898	0.821	0.006	0.002	0.000	0.017	0.155	0.088	4.000
469	1.910	0.099	0.090	0.009	0.004	0.002	0.892	0.825	0.006	0.001	0.000	0.017	0.157	0.088	4.000
469	1.901	0.097	0.097	0.000	0.006	0.001	0.886	0.848	0.006	0.001	0.001	0.016	0.132	0.104	4.000
469	1.905	0.101	0.095	0.006	0.008	0.003	0.872	0.859	0.004	0.001	0.000	0.018	0.142	0.087	4.000
469	1.912	0.097	0.088	0.009	0.006	0.001	0.896	0.825	0.006	0.002	0.002	0.013	0.162	0.079	4.000
469	1.905	0.104	0.095	0.009	0.005	0.002	0.883	0.830	0.007	0.001	0.000	0.016	0.158	0.089	4.000
469	1.907	0.103	0.093	0.010	0.008	0.002	0.896	0.821	0.006	0.001	0.003	0.015	0.161	0.078	4.000
469	1.918	0.096	0.082	0.014	0.005	0.000	0.865	0.863	0.006	0.000	0.001	0.017	0.156	0.074	4.000
469	1.904	0.102	0.096	0.006	0.004	0.000	0.903	0.814	0.006	0.001	0.001	0.015	0.153	0.097	4.000
469	1.892	0.103	0.103	0.000	0.006	0.002	0.888	0.845	0.006	0.000	0.000	0.016	0.128	0.115	4.000
469	1.893	0.106	0.106	0.000	0.005	0.002	0.891	0.842	0.005	0.001	0.000	0.014	0.132	0.107	4.000
469	1.891	0.103	0.103	0.000	0.006	0.001	0.877	0.851	0.006	0.002	0.001	0.018	0.124	0.119	4.000
avg(14)	1.906	0.100	0.093	0.007	0.006	0.002	0.888	0.836	0.006	0.001	0.001	0.016	0.149	0.090	4.000
stdev	0.009	0.003	0.007	0.005	0.001	0.001	0.010	0.015	0.001	0.001	0.001	0.001	0.014	0.016	4.000
471	1.885	0.123	0.115	0.008	0.005	0.006	0.880	0.886	0.005	0.000	0.001	0.015	0.090	0.104	4.000
471	1.902	0.121	0.098	0.023	0.005	0.004	0.876	0.873	0.003	0.000	0.000	0.016	0.124	0.076	4.000
471	1.899	0.119	0.101	0.018	0.007	0.005	0.870	0.875	0.004	0.000	0.001	0.016	0.125	0.080	4.000
471	1.894	0.122	0.106	0.016	0.005	0.004	0.868	0.877	0.005	0.000	0.001	0.015	0.119	0.091	4.000
471	1.897	0.121	0.103	0.018	0.007	0.003	0.874	0.880	0.004	0.000	0.000	0.014	0.119	0.080	4.000
471	1.911	0.119	0.089	0.030	0.004	0.004	0.874	0.872	0.004	0.001	0.002	0.016	0.131	0.062	4.000
471	1.883	0.122	0.117	0.005	0.007	0.004	0.882	0.879	0.005	0.002	0.000	0.017	0.090	0.110	4.000
471	1.902	0.115	0.098	0.017	0.007	0.005	0.874	0.874	0.006	0.001	0.001	0.015	0.124	0.078	4.000
471	1.904	0.119	0.096	0.023	0.006	0.003	0.885	0.879	0.007	0.000	0.000	0.017	0.107	0.075	4.000
471	1.900	0.117	0.100	0.017	0.007	0.004	0.882	0.880	0.006	0.002	0.000	0.015	0.108	0.080	4.000
471	1.909	0.119	0.091	0.028	0.007	0.004	0.873	0.870	0.005	0.001	0.001	0.016	0.136	0.059	4.000
471	1.904	0.119	0.096	0.023	0.001	0.005	0.880	0.879	0.003	0.000	0.002	0.017	0.108	0.082	4.000
471	1.905	0.121	0.095	0.026	0.005	0.005	0.873	0.872	0.006	0.000	0.000	0.019	0.122	0.071	4.000
471	1.881	0.123	0.119	0.004	0.008	0.005	0.887	0.877	0.006	0.001	0.000	0.017	0.086	0.109	4.000
471	1.891	0.122	0.109	0.013	0.006	0.003	0.874	0.883	0.004	0.001	0.000	0.013	0.109	0.095	4.000
471	1.904	0.122	0.096	0.026	0.006	0.006	0.873	0.875	0.006	0.001	0.000	0.019	0.118	0.071	4.000
471	1.899	0.114	0.101	0.013	0.006	0.006	0.876	0.874	0.004	0.001	0.001	0.015	0.120	0.085	4.000
471	1.890	0.117	0.110	0.007	0.007	0.005	0.874	0.883	0.004	0.000	0.000	0.016	0.104	0.100	4.000
471	1.880	0.121	0.120	0.001	0.005	0.006	0.881	0.884	0.004	0.000	0.000	0.018	0.082	0.121	4.000
471	1.901	0.121	0.099	0.022	0.003	0.004	0.874	0.876	0.005	0.000	0.000	0.015	0.120	0.081	4.000
avg(20)	1.897	0.120	0.103	0.017	0.006	0.005	0.877	0.877	0.005	0.001	0.001	0.016	0.112	0.086	4.000
stdev	0.009	0.002	0.009	0.008	0.002	0.001	0.005	0.004	0.001	0.001	0.001	0.001	0.015	0.016	4.000
472	1.914	0.098	0.086	0.012	0.004	0.003	0.872	0.897	0.006	0.001	0.000	0.017	0.110	0.079	4.000
472	1.918	0.096	0.082	0.014	0.006	0.003	0.884	0.886	0.004	0.000	0.000	0.016	0.120	0.067	4.000
472	1.906	0.103	0.094	0.009	0.005	0.002	0.878	0.890	0.004	0.002	0.001	0.017	0.103	0.089	4.000
472	1.916	0.099	0.084	0.015	0.000	0.002	0.883	0.896	0.006	0.000	0.000	0.015	0.102	0.081	4.000
472	1.900	0.108	0.100	0.008	0.004	0.000	0.888	0.902	0.003	0.000	0.002	0.016	0.077	0.100	4.000
472	1.910	0.102	0.090	0.012	0.005	0.003	0.886	0.889	0.004	0.000	0.002	0.013	0.111	0.075	4.000
472	1.935	0.087	0.065	0.022	0.002	0.000	0.866	0.914	0.005	0.001	0.000	0.018	0.118	0.055	4.000
472	1.918	0.104	0.082	0.022	0.003	0.000	0.878	0.891	0.002	0.001	0.001	0.018	0.113	0.071	4.000
472	1.916	0.100	0.084	0.016	0.008	0.002	0.886	0.886	0.005	0.001	0.001	0.016	0.115	0.064	4.000
472	1.911	0.102	0.089	0.013	0.003	0.001	0.886	0.893	0.005	0.001	0.001	0.012	0.105	0.081	4.000
472	1.920	0.103	0.080	0.023	0.007	0.003	0.867	0.907	0.005	0.000	0.000	0.018	0.112	0.059	4.000
472	1.899	0.109	0.101	0.008	0.007	0.003	0.889	0.894	0.003	0.002	0.000	0.015	0.090	0.091	4.000
472	1.907	0.106	0.093	0.013	0.004	0.002	0.887	0.884	0.005	0.002	0.001	0.016	0.102	0.085	4.000
472	1.903	0.105	0.097	0.008	0.006	0.002	0.877	0.888	0.006	0.001	0.001	0.014	0.108	0.090	4.000
472	1.905	0.105	0.095	0.010	0.005	0.002	0.889	0.886	0.003	0.002	0.001	0.015	0.100	0.087	4.000
472	1.910	0.103	0.090	0.013	0.004	0.002	0.872	0.905	0.005	0.002	0.000	0.011	0.109	0.077	4.000
avg(16)	1.912	0.102	0.088	0.014	0.005	0.002	0.881	0.894	0.004	0.001	0.001	0.015	0.106	0.078	4.000
stdev	0.009	0.005	0.009	0.005	0.002	0.001	0.008	0.008	0.001	0.001	0.001	0.002	0.010	0.012	4.000
473	1.902	0.109	0.098	0.011	0.005	0.002	0.881	0.881	0.006	0.000	0.000	0.015	0.110	0.091	4.000
473	1.914	0.109	0.086	0.023	0.005	0.002	0.865	0.891	0.005	0.001	0.000	0.015	0.131	0.064	4.000
473	1.907	0.114	0.093	0.021	0.004	0.002	0.869	0.880	0.007	0.000	0.001	0.016	0.122	0.077	4.000
473	1.904	0.107	0.096	0.011	0.006	0.003	0.877	0.886	0.005	0.001	0.000	0.017	0.108	0.087	4.000
473	1.895	0.112	0.105	0.007	0.005	0.001	0.882	0.889	0.003	0.002	0.002	0.015	0.095	0.101	4.000
473	1.898	0.105	0.102	0.003	0.007	0.003	0.885	0.887	0.005	0.002	0.001	0.015	0.094	0.097	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
473	1.894	0.112	0.106	0.006	0.004	0.002	0.883	0.888	0.005	0.001	0.002	0.016	0.088	0.105	4.000
473	1.902	0.113	0.098	0.015	0.005	0.003	0.870	0.880	0.005	0.001	0.002	0.016	0.118	0.086	4.000
473	1.886	0.118	0.114	0.004	0.006	0.002	0.873	0.896	0.005	0.001	0.001	0.016	0.086	0.111	4.000
avg(9)	1.900	0.111	0.100	0.011	0.005	0.002	0.876	0.886	0.005	0.001	0.001	0.016	0.106	0.091	4.000
stdev	0.008	0.004	0.008	0.007	0.001	0.001	0.007	0.005	0.001	0.001	0.001	0.001	0.015	0.014	4.000
474	1.901	0.117	0.099	0.018	0.005	0.003	0.885	0.880	0.004	0.001	0.001	0.016	0.104	0.084	4.000
474	1.905	0.115	0.095	0.020	0.004	0.001	0.884	0.881	0.005	0.001	0.000	0.016	0.108	0.081	4.000
474	1.903	0.118	0.097	0.021	0.006	0.001	0.879	0.882	0.005	0.001	0.000	0.016	0.111	0.077	4.000
474	1.904	0.119	0.096	0.023	0.004	0.001	0.894	0.880	0.005	0.002	0.000	0.015	0.098	0.078	4.000
474	1.908	0.120	0.092	0.028	0.003	0.004	0.877	0.886	0.005	0.001	0.001	0.014	0.114	0.067	4.000
474	1.910	0.119	0.090	0.029	0.004	0.003	0.892	0.871	0.004	0.001	0.001	0.016	0.115	0.064	4.000
474	1.898	0.122	0.102	0.020	0.005	0.002	0.881	0.877	0.006	0.001	0.001	0.016	0.107	0.085	4.000
474	1.900	0.117	0.100	0.017	0.005	0.001	0.881	0.889	0.005	0.000	0.000	0.013	0.105	0.084	4.000
474	1.884	0.127	0.116	0.011	0.005	0.004	0.873	0.895	0.005	0.002	0.000	0.016	0.083	0.107	4.000
474	1.888	0.124	0.112	0.012	0.005	0.004	0.872	0.891	0.004	0.001	0.001	0.016	0.093	0.100	4.000
474	1.892	0.124	0.108	0.016	0.005	0.003	0.876	0.889	0.005	0.000	0.000	0.016	0.096	0.094	4.000
474	1.878	0.122	0.122	0.000	0.007	0.003	0.885	0.892	0.004	0.001	0.001	0.017	0.070	0.121	4.000
474	1.908	0.128	0.092	0.036	0.005	0.004	0.880	0.875	0.004	0.002	0.001	0.015	0.122	0.057	4.000
474	1.896	0.120	0.104	0.016	0.004	0.003	0.884	0.886	0.004	0.001	0.000	0.016	0.095	0.092	4.000
474	1.883	0.125	0.117	0.008	0.004	0.003	0.890	0.887	0.003	0.001	0.001	0.014	0.078	0.112	4.000
474	1.892	0.119	0.108	0.011	0.003	0.002	0.897	0.886	0.004	0.000	0.001	0.015	0.080	0.104	4.000
474	1.882	0.119	0.118	0.001	0.002	0.003	0.880	0.896	0.004	0.001	0.000	0.015	0.075	0.123	4.000
474	1.890	0.127	0.110	0.017	0.004	0.004	0.886	0.878	0.005	0.001	0.001	0.018	0.089	0.099	4.000
474	1.900	0.093	0.093	0.000	0.005	0.002	0.880	0.936	0.005	0.000	0.001	0.008	0.067	0.104	4.000
avg(19)	1.896	0.120	0.104	0.016	0.004	0.003	0.883	0.887	0.005	0.001	0.001	0.015	0.095	0.091	4.000
stdev	0.009	0.007	0.010	0.009	0.001	0.001	0.007	0.013	0.001	0.001	0.000	0.002	0.016	0.018	4.000
476	1.903	0.095	0.095	0.000	0.004	0.005	0.898	0.866	0.004	0.002	0.001	0.015	0.106	0.102	4.000
476	1.907	0.095	0.093	0.002	0.006	0.005	0.902	0.867	0.003	0.001	0.000	0.016	0.109	0.090	4.000
476	1.897	0.094	0.094	0.000	0.005	0.005	0.904	0.863	0.006	0.001	0.001	0.016	0.096	0.113	4.000
476	1.908	0.103	0.092	0.011	0.004	0.004	0.898	0.863	0.005	0.000	0.002	0.016	0.113	0.084	4.000
476	1.894	0.101	0.101	0.000	0.005	0.003	0.895	0.865	0.006	0.002	0.001	0.014	0.104	0.109	4.000
476	1.903	0.097	0.097	0.000	0.004	0.004	0.894	0.866	0.006	0.004	0.001	0.015	0.107	0.100	4.000
476	1.902	0.100	0.098	0.002	0.006	0.003	0.903	0.860	0.006	0.002	0.002	0.016	0.105	0.096	4.000
476	1.906	0.105	0.094	0.011	0.004	0.004	0.900	0.859	0.005	0.003	0.000	0.015	0.113	0.085	4.000
476	1.893	0.111	0.107	0.004	0.004	0.004	0.888	0.870	0.006	0.001	0.001	0.013	0.107	0.102	4.000
476	1.923	0.107	0.077	0.030	0.005	0.003	0.875	0.866	0.004	0.000	0.000	0.020	0.145	0.052	4.000
avg(10)	1.904	0.101	0.095	0.006	0.005	0.004	0.896	0.865	0.005	0.002	0.001	0.016	0.111	0.093	4.000
stdev	0.008	0.005	0.007	0.009	0.001	0.001	0.008	0.003	0.001	0.001	0.001	0.002	0.012	0.016	4.000
478	1.895	0.097	0.097	0.000	0.005	0.005	0.895	0.861	0.005	0.000	0.000	0.018	0.103	0.115	4.000
478	1.911	0.099	0.089	0.010	0.008	0.003	0.892	0.844	0.003	0.003	0.000	0.013	0.151	0.073	4.000
478	1.913	0.100	0.087	0.013	0.006	0.004	0.895	0.841	0.004	0.000	0.000	0.014	0.152	0.070	4.000
478	1.902	0.096	0.096	0.000	0.008	0.003	0.898	0.847	0.005	0.001	0.000	0.016	0.129	0.095	4.000
478	1.913	0.097	0.087	0.010	0.005	0.004	0.892	0.849	0.005	0.001	0.002	0.017	0.136	0.080	4.000
478	1.910	0.093	0.090	0.003	0.005	0.004	0.893	0.870	0.005	0.000	0.001	0.013	0.119	0.086	4.000
478	1.904	0.102	0.096	0.006	0.006	0.005	0.893	0.848	0.004	0.000	0.000	0.016	0.135	0.088	4.000
478	1.908	0.089	0.089	0.000	0.006	0.004	0.912	0.832	0.006	0.001	0.000	0.016	0.132	0.094	4.000
478	1.914	0.101	0.086	0.015	0.008	0.004	0.894	0.837	0.003	0.001	0.000	0.016	0.156	0.067	4.000
avg(9)	1.908	0.097	0.091	0.006	0.006	0.004	0.896	0.848	0.004	0.001	0.000	0.015	0.135	0.085	4.000
stdev	0.006	0.004	0.014	0.006	0.001	0.001	0.006	0.011	0.001	0.001	0.001	0.002	0.016	0.014	4.000
481	1.918	0.101	0.082	0.019	0.006	0.003	0.863	0.832	0.006	0.001	0.002	0.018	0.185	0.067	4.000
481	1.939	0.100	0.061	0.039	0.002	0.002	0.873	0.814	0.007	0.002	0.000	0.016	0.215	0.031	4.000
481	1.902	0.100	0.098	0.002	0.007	0.003	0.875	0.842	0.008	0.000	0.000	0.018	0.151	0.096	4.000
481	1.909	0.101	0.091	0.010	0.004	0.004	0.854	0.866	0.005	0.000	0.000	0.016	0.156	0.085	4.000
481	1.952	0.093	0.048	0.045	0.007	0.003	0.872	0.809	0.005	0.000	0.000	0.019	0.235	0.004	4.000
481	1.906	0.103	0.094	0.009	0.005	0.004	0.859	0.825	0.007	0.003	0.001	0.018	0.182	0.088	4.000
481	1.918	0.094	0.082	0.012	0.006	0.003	0.846	0.866	0.006	0.000	0.000	0.016	0.175	0.068	4.000
481	1.917	0.094	0.083	0.011	0.003	0.003	0.849	0.879	0.007	0.001	0.001	0.018	0.148	0.081	4.000
481	1.929	0.099	0.071	0.028	0.005	0.003	0.885	0.806	0.007	0.001	0.001	0.017	0.202	0.047	4.000
481	1.933	0.095	0.067	0.028	0.006	0.003	0.905	0.789	0.008	0.000	0.001	0.018	0.201	0.042	4.000
481	1.916	0.097	0.084	0.013	0.003	0.003	0.920	0.750	0.008	0.000	0.001	0.016	0.210	0.077	4.000
481	1.921	0.095	0.079	0.016	0.008	0.002	0.863	0.843	0.006	0.000	0.000	0.019	0.179	0.064	4.000
avg(12)	1.922	0.098	0.078	0.019	0.005	0.003	0.872	0.827	0.007	0.001	0.001	0.017	0.187	0.063	4.000

Table B.2 Chemical composition of clinopyroxene (continued)

Structural formula normalized to 4 cations and 6 (O)															
Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
Cycle 2															
485	1.949	0.092	0.051	0.041	0.005	0.005	0.949	0.783	0.006	0.001	0.000	0.015	0.186	0.011	4.000
485	1.931	0.098	0.069	0.029	0.007	0.007	0.923	0.814	0.004	0.001	0.000	0.017	0.164	0.035	4.000
485	1.958	0.089	0.042	0.047	0.005	0.006	0.928	0.801	0.004	0.000	0.000	0.016	0.189	0.000	4.000
485	1.922	0.102	0.078	0.024	0.009	0.006	0.871	0.883	0.005	0.000	0.000	0.018	0.138	0.046	4.000
485	1.922	0.097	0.078	0.019	0.004	0.007	0.934	0.774	0.005	0.000	0.000	0.018	0.178	0.062	4.000
485	1.922	0.096	0.078	0.018	0.009	0.007	0.885	0.861	0.006	0.003	0.001	0.018	0.141	0.053	4.000
485	1.941	0.084	0.059	0.025	0.004	0.005	0.890	0.876	0.005	0.001	0.001	0.023	0.126	0.043	4.000
485	1.919	0.099	0.081	0.018	0.004	0.007	0.883	0.853	0.005	0.002	0.000	0.018	0.144	0.068	4.000
avg(8)	1.933	0.095	0.067	0.028	0.006	0.006	0.908	0.831	0.005	0.001	0.000	0.018	0.158	0.040	4.000
stdev	0.014	0.006	0.014	0.010	0.002	0.001	0.027	0.040	0.001	0.001	0.000	0.002	0.023	0.022	4.000
486	1.893	0.116	0.107	0.009	0.005	0.007	0.875	0.815	0.008	0.001	0.001	0.017	0.167	0.096	4.000
486	1.895	0.113	0.105	0.008	0.005	0.004	0.858	0.859	0.006	0.001	0.001	0.018	0.140	0.100	4.000
486	1.906	0.110	0.094	0.016	0.007	0.006	0.878	0.827	0.008	0.001	0.001	0.018	0.164	0.075	4.000
486	1.887	0.112	0.112	0.000	0.006	0.006	0.861	0.852	0.007	0.003	0.000	0.018	0.135	0.112	4.000
486	1.899	0.115	0.101	0.014	0.006	0.006	0.863	0.847	0.007	0.001	0.000	0.016	0.155	0.085	4.000
486	1.914	0.111	0.086	0.025	0.004	0.006	0.884	0.819	0.006	0.000	0.000	0.018	0.174	0.065	4.000
486	1.885	0.137	0.115	0.022	0.006	0.005	0.882	0.822	0.008	0.000	0.000	0.014	0.152	0.088	4.000
486	1.895	0.113	0.105	0.008	0.004	0.005	0.878	0.823	0.006	0.001	0.000	0.015	0.161	0.099	4.000
486	1.924	0.110	0.076	0.034	0.005	0.005	0.878	0.823	0.005	0.000	0.001	0.017	0.189	0.043	4.000
486	1.902	0.117	0.098	0.019	0.005	0.006	0.860	0.851	0.007	0.000	0.000	0.018	0.154	0.080	4.000
avg(10)	1.900	0.115	0.100	0.015	0.005	0.006	0.872	0.834	0.007	0.001	0.000	0.017	0.159	0.084	4.000
stdev	0.011	0.008	0.011	0.009	0.001	0.001	0.009	0.016	0.001	0.001	0.000	0.001	0.015	0.019	4.000

Table B.3: Chemical composition of clinopyroxene chadacrysts

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Total
						Zone 15							
458	52.37	0.26	2.40	0.51	0.26	16.51	21.26	0.00	0.01	0.20	5.02	0.81	99.61
458	51.69	0.08	2.66	0.51	0.25	15.79	22.00	0.02	0.05	0.23	4.20	1.84	99.31
avg(2)	52.03	0.17	2.53	0.51	0.26	16.15	21.63	0.01	0.03	0.22	4.58	1.35	99.48
stdev	0.34	0.09	0.13	0.00	0.01	0.36	0.37	0.01	0.02	0.01	0.41	0.51	0.15
455	52.21	0.15	2.56	0.38	0.21	15.84	22.04	0.04	0.06	0.16	5.08	1.17	99.90
455	53.09	0.07	2.58	0.41	0.22	15.82	22.24	0.04	0.00	0.18	5.79	0.24	100.68
455	52.31	0.14	2.52	0.53	0.21	16.15	21.44	0.04	0.05	0.18	5.32	0.90	99.79
455	52.43	0.15	2.59	0.43	0.19	16.00	22.04	0.05	0.00	0.22	4.84	1.16	100.11
455	52.60	0.16	2.75	0.48	0.19	15.91	21.83	0.04	0.00	0.17	5.73	0.01	99.87
avg(5)	52.53	0.13	2.60	0.45	0.20	15.94	21.92	0.04	0.02	0.18	5.37	0.67	100.06
stdev	0.31	0.03	0.08	0.05	0.01	0.12	0.27	0.00	0.03	0.02	0.37	0.48	0.32
453	52.44	0.18	2.64	0.43	0.15	15.52	22.16	0.03	0.04	0.21	5.66	0.65	100.11
456	52.87	0.14	2.38	0.29	0.13	15.86	22.57	0.03	0.04	0.22	4.91	0.00	99.44
456	52.70	0.07	2.52	0.33	0.16	16.03	22.17	0.04	0.00	0.22	4.91	0.46	99.62
456	52.48	0.11	2.47	0.35	0.14	15.80	22.68	0.03	0.00	0.23	4.43	0.61	99.33
456	52.69	0.16	2.51	0.33	0.17	16.29	21.54	0.01	0.06	0.21	5.33	0.66	99.97
avg(4)	52.52	0.12	2.55	0.32	0.17	16.19	21.77	0.03	0.02	0.21	5.00	0.52	99.42
stdev	0.14	0.03	0.06	0.02	0.02	0.19	0.45	0.01	0.03	0.01	0.32	0.26	0.24
						Zone 14							
407	53.34	0.18	2.41	0.43	0.11	16.52	22.86	0.04	0.06	0.17	4.25	0.55	100.91
407	52.56	0.19	3.01	0.49	0.12	16.17	23.18	0.00	0.06	0.20	3.43	1.27	100.68
407	52.80	0.18	2.87	0.49	0.14	16.72	22.26	0.06	0.08	0.17	3.94	1.31	101.02
avg(3)	52.90	0.18	2.76	0.47	0.12	16.47	22.77	0.03	0.07	0.18	3.87	1.04	100.86
stdev	0.33	0.00	0.26	0.03	0.01	0.23	0.38	0.02	0.01	0.01	0.34	0.35	0.14
375	52.69	0.09	2.47	0.63	0.11	16.87	21.91	0.03	0.04	0.18	3.96	1.06	100.05
375	51.46	0.18	3.31	0.86	0.12	16.14	22.23	0.08	0.00	0.24	3.17	1.65	99.43
375	51.19	0.16	2.86	0.86	0.13	16.56	21.81	0.03	0.02	0.19	2.87	2.06	98.74
375	51.53	0.05	3.36	0.86	0.16	16.00	22.44	0.10	0.00	0.26	2.96	1.81	99.53
375	51.62	0.19	3.20	0.89	0.16	16.41	21.73	0.05	0.02	0.22	3.59	1.70	99.78
avg(5)	51.70	0.13	3.04	0.82	0.14	16.40	22.02	0.06	0.02	0.22	3.29	1.68	99.52
stdev	0.52	0.05	0.33	0.10	0.02	0.31	0.27	0.03	0.01	0.03	0.41	0.33	0.44
						Zone 11							
318	53.18	0.18	2.49	0.44	0.15	16.24	22.41	0.03	0.03	0.21	4.94	0.31	100.61
318	53.72	0.15	2.47	0.37	0.20	17.39	21.01	0.00	0.02	0.19	5.39	0.65	101.55
318	53.06	0.24	2.61	0.44	0.17	15.96	23.00	0.11	0.03	0.25	4.32	0.62	100.80
318	52.81	0.15	2.39	0.42	0.17	16.18	22.59	0.00	0.05	0.23	4.25	1.10	100.34
avg(4)	53.20	0.18	2.49	0.41	0.18	16.51	22.20	0.04	0.04	0.23	4.61	0.83	100.92
stdev	0.33	0.04	0.08	0.03	0.02	0.56	0.75	0.05	0.01	0.02	0.47	0.28	0.45
317	51.74	0.07	2.62	0.42	0.16	16.31	22.27	0.02	0.00	0.23	3.11	2.26	99.22
317	51.66	0.15	2.53	0.44	0.18	16.73	21.64	0.02	0.02	0.22	3.15	2.24	98.98
317	51.86	0.11	2.33	0.47	0.13	16.64	22.32	0.05	0.04	0.20	2.74	2.63	99.52
317	52.06	0.15	2.62	0.42	0.13	16.16	22.72	0.02	0.02	0.22	3.32	1.82	99.65
avg(4)	51.83	0.12	2.52	0.44	0.15	16.46	22.23	0.03	0.02	0.22	3.08	2.24	99.33
stdev	0.15	0.03	0.12	0.02	0.02	0.23	0.39	0.01	0.01	0.01	0.21	0.29	0.26
316	52.54	0.07	2.68	0.53	0.16	16.80	21.44	0.09	0.07	0.22	4.17	1.54	100.31
316	52.63	0.08	2.47	0.54	0.06	16.45	22.60	0.03	0.02	0.21	3.68	1.48	100.25
316	52.44	0.17	2.69	0.51	0.14	16.87	21.00	0.05	0.05	0.22	4.66	1.01	99.81
316	52.66	0.15	2.78	0.60	0.21	16.18	22.37	0.02	0.03	0.21	4.40	0.75	100.37
316	52.84	0.17	2.58	0.60	0.10	16.61	22.11	0.05	0.01	0.23	4.21	1.20	100.71
avg(5)	52.62	0.13	2.64	0.56	0.13	16.58	21.90	0.05	0.04	0.22	4.22	1.20	100.29
stdev	0.13	0.04	0.11	0.04	0.05	0.25	0.60	0.02	0.02	0.01	0.32	0.29	0.29
314	52.79	0.24	2.61	0.51	0.17	16.36	21.80	0.06	0.03	0.22	5.01	0.91	100.70
314	52.44	0.04	2.65	0.52	0.17	16.30	21.33	0.03	0.05	0.26	4.94	0.61	99.34
314	52.64	0.18	2.69	0.49	0.18	15.93	21.95	0.07	0.00	0.22	5.35	0.31	100.01
314	52.28	0.18	2.83	0.60	0.15	15.55	22.58	0.10	0.06	0.23	4.69	0.39	99.64
314	52.41	0.06	2.58	0.55	0.17	16.00	22.16	0.00	0.06	0.25	4.46	1.13	99.82
avg(5)	52.51	0.14	2.67	0.53	0.17	16.03	21.96	0.05	0.04	0.24	4.87	0.69	99.90
stdev	0.18	0.08	0.09	0.04	0.01	0.29	0.41	0.03	0.02	0.02	0.30	0.31	0.46
313	52.23	0.12	2.29	0.45	0.15	16.38	22.13	0.06	0.05	0.16	4.05	1.60	99.67
313	52.68	0.18	2.25	0.49	0.17	16.66	21.96	0.06	0.03	0.19	4.22	1.36	100.25

Table B.3: Chemical composition of clinopyroxene chadacrysts (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Total
313	51.41	0.12	2.57	0.44	0.16	16.01	22.84	0.04	0.03	0.21	2.61	2.95	99.40
avg(3)	52.11	0.14	2.37	0.46	0.16	16.35	22.31	0.06	0.04	0.19	3.60	2.00	99.79
stdev	0.53	0.03	0.14	0.02	0.01	0.27	0.38	0.01	0.01	0.02	0.72	0.70	0.35
312	53.36	0.15	2.47	0.36	0.25	18.39	18.08	0.00	0.00	0.19	6.90	0.05	100.19
312	52.48	0.10	2.52	0.40	0.15	15.94	22.39	0.04	0.08	0.21	4.54	1.07	99.92
312	52.67	0.16	2.80	0.36	0.16	16.19	21.88	0.03	0.00	0.20	5.15	0.60	100.20
avg(3)	52.84	0.14	2.60	0.37	0.18	16.84	20.78	0.02	0.03	0.20	5.55	0.55	100.10
stdev	0.38	0.03	0.15	0.02	0.04	1.10	1.92	0.02	0.04	0.01	1.00	0.42	0.13
306	52.23	0.06	2.61	0.51	0.20	18.06	17.66	0.00	0.00	0.19	6.64	1.62	99.78
306	52.02	0.11	2.68	0.58	0.24	17.49	18.49	0.07	0.05	0.23	6.05	1.69	99.70
306	52.40	0.20	2.71	0.62	0.25	16.95	19.25	0.07	0.00	0.23	6.61	0.34	99.62
306	51.85	0.13	2.79	0.62	0.22	16.10	21.24	0.06	0.00	0.23	4.89	1.51	99.64
avg(4)	52.12	0.13	2.70	0.58	0.23	17.15	19.16	0.05	0.01	0.22	6.05	1.29	99.69
stdev	0.21	0.05	0.06	0.04	0.02	0.72	1.33	0.03	0.02	0.02	0.71	0.55	0.06
303	52.22	0.20	2.71	0.48	0.25	15.55	22.41	0.06	0.00	0.19	5.03	1.14	100.24
303	52.35	0.17	2.69	0.43	0.20	16.93	19.72	0.03	0.00	0.20	6.18	1.25	100.16
303	53.57	0.16	2.34	0.36	0.15	16.89	20.09	0.12	0.03	0.18	5.76	0.00	99.65
303	52.66	0.12	2.42	0.40	0.15	15.74	22.81	0.09	0.03	0.21	4.59	1.27	100.49
avg(4)	52.70	0.16	2.54	0.42	0.19	16.28	21.26	0.07	0.01	0.19	5.79	0.47	100.08
stdev	0.53	0.03	0.16	0.04	0.04	0.64	1.37	0.03	0.02	0.01	0.62	0.53	0.31
Zone 9													
56	51.15	0.20	3.02	0.58	0.14	15.94	21.22	0.00	0.03	0.22	4.59	2.10	99.19
56	51.39	0.27	2.95	0.55	0.24	15.64	22.19	0.00	0.07	0.23	4.04	2.49	100.06
56	51.48	0.08	2.95	0.58	0.15	15.86	21.61	0.07	0.01	0.24	4.36	2.15	99.55
56	50.65	0.16	3.10	0.62	0.25	15.43	21.86	0.00	0.01	0.24	3.86	2.66	98.84
56	51.41	0.17	2.72	0.59	0.19	15.99	22.34	0.00	0.00	0.22	3.33	2.94	99.89
avg(5)	51.22	0.18	2.95	0.59	0.19	15.77	21.84	0.01	0.03	0.23	4.05	2.45	99.52
stdev	0.30	0.06	0.13	0.02	0.04	0.21	0.40	0.03	0.02	0.01	0.43	0.32	0.45
Zone 8													
246	50.94	0.26	2.80	0.37	0.23	15.54	21.24	0.02	0.02	0.46	3.86	3.48	99.22
246	50.81	0.10	2.96	0.36	0.24	15.30	21.42	0.09	0.03	0.44	3.76	3.18	98.70
avg(2)	50.88	0.18	2.88	0.37	0.23	15.42	21.33	0.05	0.02	0.45	3.84	3.31	98.95
stdev	0.07	0.08	0.08	0.00	0.00	0.12	0.09	0.03	0.00	0.01	0.05	0.15	0.26
245	50.52	0.17	3.12	0.46	0.24	15.52	21.32	0.00	0.00	0.43	3.38	4.04	99.20
245	50.68	0.13	2.90	0.50	0.17	15.23	21.47	0.02	0.06	0.51	3.48	3.36	98.52
245	52.22	0.17	1.74	0.25	0.17	15.97	22.52	0.02	0.10	0.35	3.40	2.39	99.30
avg(3)	51.14	0.16	2.59	0.40	0.20	15.57	21.77	0.01	0.05	0.43	3.43	3.26	99.01
stdev	0.77	0.02	0.61	0.11	0.03	0.30	0.53	0.01	0.04	0.07	0.04	0.68	0.35
241	50.52	0.14	3.50	0.33	0.19	15.27	22.13	0.04	0.03	0.39	2.93	4.15	99.61
241	51.29	0.26	3.21	0.35	0.17	15.48	21.22	0.03	0.00	0.41	4.72	2.32	99.46
241	51.48	0.24	2.93	0.48	0.15	16.01	20.64	0.03	0.00	0.44	4.60	3.03	100.03
avg(3)	51.10	0.21	3.21	0.39	0.17	15.59	21.33	0.03	0.01	0.41	4.10	3.15	99.70
stdev	0.42	0.05	0.23	0.07	0.02	0.31	0.61	0.00	0.01	0.02	0.82	0.75	0.24
240	51.18	0.21	2.98	0.35	0.21	15.06	22.40	0.01	0.00	0.48	3.43	3.40	99.71
240	51.55	0.10	2.63	0.46	0.21	15.44	22.21	0.02	0.04	0.42	3.57	3.24	99.89
240	50.90	0.19	2.97	0.34	0.18	15.52	21.59	0.03	0.00	0.40	3.68	3.66	99.46
240	51.35	0.18	3.04	0.40	0.21	15.43	21.89	0.03	0.05	0.41	3.86	3.57	100.42
avg(4)	51.25	0.17	2.91	0.39	0.20	15.36	22.02	0.02	0.02	0.43	3.64	3.45	99.87
stdev	0.24	0.04	0.16	0.05	0.01	0.18	0.31	0.01	0.02	0.03	0.16	0.16	0.35
239	51.29	0.20	2.77	0.42	0.15	16.04	21.30	0.02	0.01	0.36	3.81	3.06	99.44
239	51.67	0.19	2.99	0.34	0.18	16.13	21.22	0.12	0.06	0.41	3.80	3.65	100.76
239	51.16	0.14	3.13	0.41	0.15	15.58	21.61	0.08	0.00	0.39	3.84	3.36	99.85
avg(3)	51.37	0.18	2.96	0.39	0.16	15.92	21.38	0.07	0.02	0.39	3.80	3.38	100.02
stdev	0.22	0.03	0.15	0.04	0.01	0.24	0.17	0.04	0.03	0.02	0.02	0.24	0.55
236	52.11	0.15	2.69	0.03	0.20	15.33	22.12	0.07	0.00	0.38	4.78	2.13	99.99
236	51.42	0.23	2.47	0.04	0.19	15.61	21.68	0.03	0.04	0.35	4.24	2.81	99.11
avg(2)	51.77	0.19	2.58	0.04	0.19	15.47	21.90	0.05	0.02	0.36	4.55	2.44	99.55
stdev	0.34	0.04	0.11	0.00	0.01	0.14	0.22	0.02	0.02	0.01	0.27	0.34	0.44
Zone 6													
211	52.51	0.09	2.63	0.59	0.15	15.66	22.85	0.02	0.06	0.37	3.77	1.90	100.60
211	52.86	0.18	2.79	0.63	0.13	15.87	22.64	0.06	0.06	0.43	3.87	1.52	101.04

Table B.3: Chemical composition of clinopyroxene chadacrysts (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Total
211	53.04	0.18	2.63	0.69	0.18	16.20	22.71	0.05	0.00	0.34	3.84	2.20	102.06
avg(3)	52.80	0.15	2.68	0.64	0.15	15.91	22.73	0.04	0.04	0.38	3.83	1.87	101.23
stdev	0.22	0.04	0.08	0.04	0.02	0.22	0.09	0.02	0.03	0.04	0.04	0.28	0.61
209	50.83	0.18	2.84	0.77	0.19	15.82	22.25	0.08	0.01	0.45	1.90	4.01	99.33
209	51.68	0.10	2.56	0.69	0.13	16.29	21.93	0.03	0.03	0.36	2.93	2.40	99.13
209	51.54	0.09	2.72	0.74	0.17	15.89	22.07	0.01	0.02	0.42	3.00	2.48	99.15
209	50.72	0.15	3.02	0.79	0.17	16.40	20.90	0.02	0.00	0.38	2.85	3.30	98.70
209	51.47	0.10	2.58	0.64	0.19	16.12	22.26	0.10	0.00	0.49	1.86	3.46	99.27
209	51.27	0.18	2.71	0.70	0.20	16.48	21.42	0.10	0.00	0.46	2.25	3.80	99.57
209	50.69	0.06	2.89	0.71	0.19	16.39	21.29	0.04	0.03	0.36	2.28	3.68	98.61
avg(7)	51.17	0.12	2.76	0.72	0.18	16.20	21.73	0.05	0.01	0.42	2.43	3.32	99.10
stdev	0.39	0.04	0.15	0.05	0.02	0.24	0.49	0.04	0.01	0.05	0.45	0.59	0.32
208	52.54	0.05	2.86	0.63	0.18	17.03	20.42	0.06	0.03	0.40	4.26	2.35	100.82
208	51.75	0.09	2.82	0.44	0.18	16.01	22.59	0.00	0.05	0.38	2.52	3.05	99.89
208	52.13	0.20	2.63	0.65	0.19	15.81	22.83	0.00	0.02	0.45	2.82	2.47	100.20
208	52.10	0.17	2.51	0.62	0.17	16.21	22.71	0.00	0.05	0.39	2.47	3.01	100.41
208	51.57	0.21	3.07	0.88	0.16	16.06	21.91	0.03	0.00	0.40	3.14	2.57	100.01
208	52.47	0.12	2.41	0.61	0.17	16.17	22.73	0.04	0.05	0.37	2.97	2.35	100.46
avg(6)	52.09	0.14	2.72	0.64	0.18	16.21	22.20	0.02	0.03	0.40	3.03	2.64	100.29
stdev	0.35	0.06	0.22	0.13	0.01	0.39	0.85	0.02	0.02	0.03	0.60	0.29	0.31
199	51.17	0.09	2.94	0.74	0.19	15.47	21.96	0.00	0.02	0.45	3.29	2.83	99.15
199	51.21	0.13	2.69	0.43	0.15	15.79	21.84	0.02	0.01	0.39	3.27	2.90	98.83
199	51.71	0.06	2.88	0.66	0.26	15.64	22.19	0.00	0.00	0.41	3.45	2.69	99.95
199	51.74	0.13	2.60	0.53	0.16	15.72	22.48	0.02	0.00	0.40	3.16	3.01	99.95
199	51.23	0.14	2.64	0.49	0.17	15.73	21.98	0.04	0.02	0.44	2.95	3.09	98.92
199	51.49	0.10	3.10	0.66	0.20	15.25	22.51	0.06	0.03	0.51	3.02	3.40	100.33
199	50.98	0.26	2.85	0.60	0.17	15.75	21.33	0.01	0.01	0.43	3.64	2.61	98.64
199	51.14	0.10	2.70	0.51	0.23	15.73	22.21	0.02	0.05	0.36	2.81	3.34	99.20
199	51.52	0.10	2.68	0.58	0.21	15.98	21.96	0.00	0.00	0.34	3.32	2.53	99.22
avg(9)	51.35	0.12	2.79	0.58	0.19	15.67	22.05	0.02	0.02	0.41	3.23	2.91	99.34
stdev	0.25	0.05	0.16	0.09	0.03	0.20	0.34	0.02	0.02	0.05	0.24	0.29	0.55
Zone 4													
110	51.61	0.27	3.29	0.35	0.18	15.64	22.04	0.09	0.08	0.28	4.23	2.81	100.87
110	51.65	0.13	3.14	0.37	0.22	15.42	21.92	0.08	0.02	0.24	4.91	2.15	100.24
110	51.85	0.23	2.99	0.35	0.21	15.57	22.56	0.01	0.04	0.24	4.21	2.29	100.55
110	51.61	0.24	2.99	0.39	0.22	15.69	21.68	0.00	0.03	0.30	4.58	3.14	100.86
110	51.46	0.21	3.00	0.51	0.26	16.08	19.81	0.00	0.06	0.30	6.00	2.70	100.39
110	51.77	0.16	2.62	0.47	0.23	15.34	22.49	0.00	0.00	0.24	4.58	2.40	100.30
110	52.21	0.26	2.72	0.46	0.19	15.38	21.98	0.00	0.03	0.30	5.51	1.90	100.94
avg(7)	51.74	0.21	2.96	0.41	0.22	15.59	21.78	0.03	0.04	0.27	4.86	2.48	100.59
stdev	0.22	0.05	0.21	0.06	0.02	0.24	0.86	0.04	0.02	0.03	0.62	0.39	0.27
11	52.34	0.13	2.67	0.53	0.22	15.63	20.89	0.02	0.02	0.26	6.64	0.51	99.86
11	52.19	0.26	2.89	0.52	0.22	15.18	22.20	0.00	0.02	0.31	5.50	1.53	100.81
11	51.92	0.22	2.45	0.55	0.21	15.33	22.36	0.07	0.00	0.27	4.81	1.61	99.80
11	51.77	0.17	2.82	0.64	0.18	15.43	21.85	0.00	0.00	0.29	5.07	2.05	100.26
11	51.71	0.17	2.70	0.53	0.15	15.32	21.81	0.04	0.00	0.28	5.28	1.88	99.87
avg(5)	51.99	0.19	2.71	0.55	0.20	15.38	21.82	0.03	0.01	0.28	5.46	1.51	100.13
stdev	0.24	0.05	0.15	0.04	0.03	0.15	0.51	0.03	0.01	0.02	0.63	0.54	0.38
109	51.44	0.18	2.70	0.45	0.26	15.33	21.39	0.00	0.00	0.31	5.28	2.13	99.46
109	51.57	0.17	3.17	0.60	0.18	15.09	21.97	0.00	0.00	0.30	5.23	2.40	100.68
109	51.72	0.12	3.28	0.56	0.16	14.98	22.08	0.00	0.01	0.29	5.48	2.42	101.10
109	52.32	0.19	2.85	0.46	0.16	15.34	21.76	0.00	0.01	0.33	5.84	1.51	100.77
109	52.03	0.19	3.25	0.55	0.22	15.16	21.79	0.05	0.05	0.30	5.77	1.48	100.84
avg(5)	51.82	0.17	3.05	0.52	0.20	15.18	21.80	0.01	0.02	0.31	5.50	2.02	100.59
stdev	0.32	0.03	0.23	0.06	0.04	0.14	0.24	0.02	0.02	0.01	0.25	0.42	0.57
9	52.41	0.17	2.50	0.42	0.19	15.61	22.20	0.05	0.06	0.24	5.18	1.30	100.33
9	51.92	0.16	2.45	0.50	0.16	15.55	22.27	0.02	0.00	0.23	4.76	1.88	99.91
9	51.85	0.20	2.86	0.57	0.24	15.73	21.61	0.08	0.00	0.31	4.73	2.42	100.60
9	51.36	0.14	3.02	0.54	0.18	15.10	22.26	0.02	0.00	0.31	4.50	2.13	99.56
9	51.61	0.32	3.34	0.51	0.27	15.05	21.70	0.00	0.00	0.29	5.79	1.32	100.20
avg(5)	51.83	0.20	2.83	0.51	0.21	15.41	22.01	0.03	0.01	0.27	5.02	1.78	100.11
stdev	0.35	0.06	0.33	0.05	0.04	0.28	0.29	0.03	0.02	0.03	0.46	0.44	0.36

Table B.3: Chemical composition of clinopyroxene chadacrysts (continued)

	Weight percent oxides												
Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	MnO	MgO	CaO	NiO	CoO	Na_2O	FeO	Fe_2O_3	Total
8	50.82	0.11	2.79	0.53	0.22	15.79	21.24	0.02	0.01	0.33	3.76	3.63	99.25
8	51.91	0.14	2.38	0.52	0.18	15.46	22.54	0.02	0.00	0.26	4.39	1.77	99.57
8	51.69	0.10	2.51	0.50	0.20	15.71	21.95	0.00	0.03	0.29	4.23	2.36	99.57
avg(3)	51.48	0.12	2.56	0.51	0.20	15.65	21.91	0.01	0.01	0.29	4.17	2.54	99.44
stdev	0.47	0.02	0.17	0.01	0.02	0.14	0.53	0.01	0.01	0.03	0.27	0.78	0.15

Table B.3: Chemical composition of clinopyroxene chadacrysts (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
Zone 15															
458	1.929	0.104	0.071	0.033	0.007	0.015	0.008	0.907	0.839	0.000	0.000	0.014	0.155	0.022	4.000
458	1.915	0.116	0.085	0.031	0.002	0.015	0.008	0.872	0.873	0.001	0.001	0.017	0.130	0.051	4.000
avg(2)	1.921	0.110	0.079	0.031	0.005	0.015	0.008	0.889	0.856	0.000	0.001	0.016	0.142	0.038	4.000
stdev	0.007	0.006	0.007	0.001	0.002	0.000	0.000	0.017	0.017	0.001	0.001	0.001	0.012	0.014	
455	1.924	0.111	0.076	0.035	0.004	0.011	0.007	0.870	0.870	0.001	0.002	0.011	0.156	0.032	4.000
455	1.939	0.111	0.061	0.050	0.002	0.012	0.007	0.862	0.870	0.001	0.000	0.013	0.177	0.007	4.000
455	1.927	0.109	0.073	0.036	0.004	0.015	0.007	0.887	0.846	0.001	0.001	0.013	0.164	0.025	4.000
455	1.925	0.112	0.075	0.037	0.004	0.012	0.006	0.876	0.867	0.001	0.000	0.016	0.149	0.032	4.000
455	1.935	0.119	0.065	0.054	0.004	0.014	0.006	0.872	0.860	0.001	0.000	0.012	0.176	0.000	4.000
avg(5)	1.930	0.113	0.070	0.043	0.004	0.013	0.006	0.873	0.863	0.001	0.001	0.013	0.165	0.019	4.000
stdev	0.006	0.003	0.006	0.008	0.001	0.001	0.000	0.008	0.009	0.000	0.001	0.002	0.011	0.013	
453	1.930	0.114	0.070	0.044	0.005	0.013	0.005	0.851	0.874	0.001	0.001	0.015	0.174	0.018	4.000
456	1.948	0.103	0.052	0.051	0.004	0.008	0.004	0.871	0.891	0.001	0.001	0.016	0.151	0.000	4.000
456	1.940	0.109	0.060	0.049	0.002	0.010	0.005	0.880	0.874	0.001	0.000	0.016	0.151	0.013	4.000
456	1.937	0.107	0.063	0.044	0.003	0.010	0.004	0.870	0.897	0.001	0.000	0.016	0.137	0.017	4.000
456	1.934	0.109	0.066	0.043	0.004	0.010	0.005	0.892	0.847	0.000	0.002	0.015	0.164	0.018	4.000
avg(4)	1.936	0.111	1.930	0.044	0.003	0.009	0.005	0.890	0.860	0.001	0.001	0.015	0.154	0.015	4.000
stdev	0.005	0.002	0.005	0.003	0.001	0.001	0.000	0.009	0.019	0.000	0.001	0.000	0.010	0.007	
Zone 14															
407	1.936	0.103	0.064	0.039	0.005	0.012	0.003	0.894	0.889	0.001	0.002	0.012	0.129	0.015	4.000
407	1.913	0.129	0.087	0.042	0.005	0.014	0.004	0.877	0.904	0.000	0.002	0.014	0.104	0.035	4.000
407	1.915	0.123	0.085	0.038	0.005	0.014	0.004	0.904	0.865	0.002	0.002	0.012	0.120	0.036	4.000
avg(3)	1.921	0.118	0.079	0.039	0.005	0.013	0.004	0.892	0.886	0.001	0.002	0.013	0.118	0.029	4.000
stdev	0.010	0.011	0.010	0.002	0.000	0.001	0.000	0.011	0.016	0.001	0.000	0.001	0.010	0.010	
375	1.927	0.106	0.073	0.033	0.002	0.018	0.003	0.920	0.858	0.001	0.001	0.013	0.121	0.029	4.000
375	1.896	0.144	0.104	0.040	0.005	0.025	0.004	0.887	0.878	0.002	0.000	0.017	0.098	0.046	4.000
375	1.898	0.125	0.102	0.023	0.004	0.025	0.004	0.916	0.866	0.001	0.001	0.014	0.089	0.057	4.000
375	1.897	0.146	0.103	0.043	0.001	0.025	0.005	0.878	0.885	0.003	0.000	0.019	0.091	0.050	4.000
375	1.896	0.139	0.104	0.035	0.005	0.026	0.005	0.899	0.855	0.001	0.001	0.016	0.110	0.047	4.000
avg(5)	1.903	0.132	0.097	0.035	0.004	0.024	0.004	0.900	0.868	0.002	0.001	0.016	0.101	0.047	4.000
stdev	0.012	0.015	0.012	0.007	0.002	0.003	0.001	0.016	0.011	0.001	0.000	0.002	0.012	0.009	
Zone 11															
318	1.936	0.105	0.064	0.041	0.004	0.011	0.006	0.934	0.811	0.000	0.001	0.013	0.162	0.018	4.000
318	1.931	0.112	0.069	0.043	0.007	0.013	0.005	0.866	0.897	0.003	0.001	0.018	0.131	0.017	4.000
318	1.931	0.103	0.069	0.034	0.004	0.012	0.005	0.882	0.885	0.000	0.001	0.016	0.130	0.030	4.000
avg(3)	1.932	0.107	0.068	0.039	0.005	0.012	0.006	0.894	0.864	0.001	0.001	0.016	0.140	0.023	4.000
stdev	0.002	0.004	0.002	0.004	0.001	0.001	0.000	0.029	0.038	0.001	0.000	0.002	0.015	0.006	
317	1.911	0.114	0.089	0.025	0.002	0.012	0.005	0.898	0.881	0.001	0.000	0.016	0.096	0.063	4.000
317	1.911	0.110	0.089	0.021	0.004	0.013	0.006	0.922	0.857	0.001	0.001	0.016	0.098	0.062	4.000
317	1.910	0.101	0.090	0.011	0.003	0.014	0.004	0.914	0.881	0.001	0.001	0.014	0.084	0.073	4.000
317	1.915	0.114	0.085	0.029	0.004	0.012	0.004	0.886	0.896	0.001	0.001	0.016	0.102	0.050	4.000
avg(4)	1.912	0.110	0.088	0.022	0.003	0.013	0.005	0.905	0.879	0.001	0.001	0.016	0.095	0.062	4.000
stdev	0.002	0.005	0.002	0.007	0.001	0.001	0.001	0.014	0.014	0.000	0.000	0.001	0.007	0.008	
316	1.919	0.115	0.081	0.034	0.002	0.015	0.005	0.915	0.839	0.003	0.002	0.016	0.127	0.042	4.000
316	1.924	0.106	0.076	0.030	0.002	0.016	0.002	0.896	0.885	0.001	0.001	0.015	0.112	0.041	4.000
316	1.923	0.116	0.077	0.039	0.005	0.015	0.004	0.922	0.825	0.001	0.001	0.016	0.143	0.028	4.000
316	1.923	0.111	0.077	0.034	0.005	0.017	0.003	0.901	0.862	0.001	0.000	0.016	0.128	0.033	4.000
avg(5)	1.922	0.114	1.912	0.015	0.004	0.016	0.004	0.903	0.857	0.001	0.001	0.016	0.129	0.033	4.000
stdev	0.002	0.005	0.002	0.005	0.001	0.001	0.001	0.014	0.022	0.001	0.001	0.000	0.010	0.008	
314	1.925	0.112	0.075	0.037	0.007	0.015	0.005	0.889	0.852	0.002	0.001	0.016	0.153	0.025	4.000
314	1.934	0.115	0.066	0.049	0.001	0.015	0.005	0.896	0.843	0.001	0.001	0.019	0.152	0.017	4.000
314	1.933	0.116	0.067	0.049	0.005	0.014	0.006	0.872	0.864	0.002	0.000	0.016	0.164	0.009	4.000
314	1.927	0.123	0.073	0.050	0.005	0.017	0.005	0.855	0.892	0.003	0.002	0.016	0.145	0.011	4.000
314	1.927	0.112	0.073	0.039	0.002	0.016	0.005	0.877	0.873	0.000	0.002	0.018	0.137	0.031	4.000
avg(5)	1.929	0.116	0.071	0.045	0.004	0.015	0.005	0.878	0.864	0.001	0.001	0.017	0.150	0.019	4.000
stdev	0.004	0.004	0.004	0.006	0.002	0.001	0.000	0.014	0.017	0.001	0.001	0.001	0.009	0.008	
313	1.924	0.099	0.076	0.023	0.003	0.013	0.005	0.899	0.873	0.002	0.001	0.011	0.125	0.044	4.000
313	1.927	0.097	0.073	0.024	0.005	0.014	0.005	0.909	0.861	0.002	0.001	0.013	0.129	0.037	4.000

Table B.3: Chemical composition of clinopyroxene chadacrysts (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
313	1.900	0.112	0.100	0.012	0.003	0.013	0.005	0.882	0.905	0.001	0.001	0.015	0.081	0.082	4.000
avg(3)	1.917	0.103	0.083	0.020	0.004	0.013	0.005	0.897	0.879	0.002	0.001	0.014	0.111	0.055	4.000
stdev	0.012	0.007	0.012	0.005	0.001	0.000	0.000	0.011	0.019	0.000	0.000	0.002	0.022	0.020	
312	1.943	0.106	0.057	0.049	0.004	0.010	0.008	0.999	0.705	0.000	0.000	0.013	0.210	0.001	4.000
312	1.929	0.109	0.071	0.038	0.003	0.012	0.005	0.874	0.882	0.001	0.002	0.015	0.139	0.030	4.000
312	1.928	0.121	0.072	0.049	0.004	0.010	0.005	0.884	0.858	0.001	0.000	0.014	0.158	0.017	4.000
avg(3)	1.934	0.112	0.066	0.046	0.004	0.011	0.006	0.919	0.815	0.001	0.001	0.014	0.170	0.015	4.000
stdev	0.007	0.006	0.007	0.005	0.000	0.001	0.001	0.057	0.078	0.000	0.001	0.001	0.030	0.012	
306	1.918	0.113	0.082	0.031	0.002	0.015	0.006	0.989	0.695	0.000	0.000	0.014	0.204	0.045	4.000
306	1.915	0.116	0.085	0.031	0.003	0.017	0.007	0.960	0.729	0.002	0.001	0.016	0.186	0.047	4.000
306	1.930	0.118	0.070	0.048	0.006	0.018	0.008	0.931	0.760	0.002	0.000	0.016	0.203	0.009	4.000
306	1.914	0.121	0.086	0.035	0.004	0.018	0.007	0.886	0.840	0.002	0.000	0.016	0.151	0.042	4.000
avg(4)	1.919	0.117	0.081	0.036	0.004	0.017	0.007	0.941	0.756	0.001	0.000	0.016	0.186	0.036	4.000
stdev	0.006	0.003	0.006	0.007	0.001	0.001	0.001	0.038	0.054	0.001	0.000	0.001	0.021	0.016	
303	1.919	0.117	0.081	0.036	0.006	0.014	0.008	0.852	0.883	0.002	0.000	0.014	0.155	0.032	4.000
303	1.920	0.116	0.080	0.036	0.005	0.012	0.006	0.926	0.775	0.001	0.000	0.014	0.190	0.035	4.000
303	1.961	0.101	0.039	0.062	0.004	0.010	0.005	0.922	0.788	0.004	0.001	0.013	0.176	0.000	3.985
303	1.928	0.104	0.072	0.032	0.003	0.012	0.005	0.859	0.895	0.003	0.001	0.015	0.141	0.035	4.000
avg(4)	1.934	0.110	0.066	0.044	0.004	0.012	0.006	0.891	0.836	0.002	0.000	0.014	0.178	0.013	4.000
stdev	0.017	0.007	0.017	0.012	0.001	0.001	0.001	0.034	0.054	0.001	0.001	0.001	0.019	0.015	
Zone 9															
56	1.898	0.132	0.102	0.030	0.006	0.017	0.004	0.882	0.844	0.000	0.001	0.016	0.142	0.059	4.000
56	1.894	0.128	0.106	0.022	0.007	0.016	0.007	0.859	0.876	0.000	0.002	0.016	0.125	0.069	4.000
56	1.903	0.129	0.097	0.032	0.002	0.017	0.005	0.874	0.856	0.002	0.000	0.017	0.135	0.060	4.000
56	1.889	0.136	0.111	0.025	0.004	0.018	0.008	0.858	0.874	0.000	0.000	0.017	0.120	0.075	4.000
avg(5)	1.894	0.118	0.106	0.012	0.005	0.017	0.006	0.878	0.882	0.000	0.000	0.016	0.102	0.081	4.000
stdev	0.005	0.003	0.005	0.004	0.002	0.001	0.002	0.010	0.013	0.001	0.001	0.000	0.009	0.007	
Zone 8															
246	1.894	0.123	0.106	0.017	0.007	0.011	0.007	0.861	0.846	0.001	0.001	0.033	0.120	0.097	4.000
246	1.898	0.130	0.102	0.028	0.003	0.011	0.008	0.852	0.857	0.003	0.001	0.032	0.118	0.089	4.000
avg(2)	1.896	0.126	0.104	0.022	0.005	0.011	0.007	0.857	0.852	0.001	0.001	0.033	0.120	0.093	4.000
stdev	0.002	0.004	0.002	0.006	0.002	0.000	0.000	0.004	0.005	0.001	0.000	0.001	0.001	0.004	
245	1.879	0.137	0.121	0.016	0.005	0.014	0.008	0.860	0.849	0.000	0.000	0.031	0.105	0.113	4.000
245	1.896	0.128	0.104	0.024	0.004	0.015	0.005	0.849	0.860	0.001	0.002	0.037	0.109	0.095	4.000
245	1.933	0.076	0.067	0.009	0.005	0.007	0.005	0.881	0.893	0.001	0.003	0.025	0.105	0.067	4.000
avg(3)	1.902	0.114	0.098	0.016	0.004	0.012	0.006	0.864	0.868	0.000	0.001	0.031	0.107	0.091	4.000
stdev	0.023	0.027	0.023	0.006	0.000	0.004	0.001	0.013	0.019	0.000	0.001	0.005	0.002	0.019	
241	1.871	0.153	0.129	0.024	0.004	0.010	0.006	0.843	0.878	0.001	0.001	0.028	0.091	0.116	4.000
241	1.900	0.140	0.100	0.040	0.007	0.010	0.005	0.855	0.842	0.001	0.000	0.029	0.146	0.065	4.000
241	1.896	0.127	0.104	0.023	0.007	0.014	0.005	0.879	0.815	0.001	0.000	0.031	0.142	0.084	4.000
avg(3)	1.889	0.140	0.111	0.029	0.006	0.011	0.005	0.859	0.845	0.001	0.000	0.029	0.127	0.088	4.000
stdev	0.013	0.011	0.013	0.008	0.001	0.002	0.000	0.015	0.026	0.000	0.000	0.001	0.025	0.021	
240	1.894	0.130	0.106	0.024	0.006	0.010	0.007	0.831	0.888	0.000	0.000	0.034	0.106	0.095	4.000
240	1.903	0.114	0.097	0.017	0.003	0.013	0.007	0.850	0.878	0.001	0.001	0.030	0.110	0.090	4.000
240	1.888	0.130	0.112	0.018	0.005	0.010	0.006	0.858	0.858	0.001	0.000	0.029	0.114	0.102	4.000
240	1.888	0.132	0.112	0.020	0.005	0.012	0.007	0.846	0.862	0.001	0.001	0.029	0.119	0.099	4.000
avg(4)	1.893	0.127	0.107	0.020	0.005	0.011	0.006	0.846	0.872	0.001	0.001	0.031	0.113	0.096	4.000
stdev	0.006	0.007	0.006	0.003	0.001	0.001	0.000	0.010	0.012	0.000	0.001	0.002	0.005	0.005	
239	1.898	0.121	0.102	0.019	0.006	0.012	0.005	0.885	0.844	0.001	0.000	0.026	0.118	0.085	4.000
239	1.889	0.129	0.111	0.018	0.005	0.010	0.006	0.879	0.831	0.004	0.002	0.029	0.116	0.100	4.000
239	1.889	0.136	0.111	0.025	0.004	0.012	0.005	0.858	0.855	0.002	0.000	0.028	0.119	0.093	4.000
avg(3)	1.892	0.128	0.108	0.020	0.005	0.011	0.005	0.874	0.844	0.002	0.001	0.028	0.117	0.094	4.000
stdev	0.004	0.005	0.004	0.003	0.001	0.001	0.000	0.010	0.008	0.001	0.001	0.001	0.001	0.005	
236	1.921	0.117	0.079	0.038	0.004	0.001	0.006	0.842	0.873	0.002	0.000	0.027	0.147	0.059	4.000
236	1.912	0.108	0.088	0.020	0.006	0.001	0.006	0.865	0.864	0.001	0.001	0.025	0.132	0.079	4.000
avg(2)	1.916	0.113	0.084	0.029	0.005	0.001	0.006	0.854	0.869	0.001	0.001	0.026	0.141	0.068	4.000
stdev	0.004	0.004	0.005	0.009	0.001	0.000	0.000	0.011	0.004	0.000	0.001	0.001	0.007	0.010	
Zone 6															
211	1.919	0.113	0.081	0.032	0.002	0.017	0.005	0.853	0.895	0.001	0.002	0.026	0.115	0.115	4.000
211	1.920	0.119	0.080	0.039	0.005	0.018	0.004	0.860	0.881	0.002	0.002	0.030	0.118	0.118	4.000

Table B.3: Chemical composition of clinopyroxene chadacrysts (continued)

Structural formula normalized to 4 cations and 6 (O)

Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
211	1.911	0.112	0.089	0.023	0.005	0.020	0.005	0.870	0.877	0.001	0.000	0.024	0.116	0.116	4.000
avg(5)	1.944	0.080	0.056	0.024	0.003	0.014	0.005	0.861	0.915	0.002	0.001	0.020	0.125	0.125	4.000
stdev	0.034	0.044	0.034	0.011	0.002	0.006	0.001	0.020	0.042	0.001	0.001	0.009	0.015	0.015	
209	1.882	0.124	0.118	0.006	0.005	0.023	0.006	0.873	0.883	0.002	0.000	0.032	0.059	0.059	4.000
209	1.910	0.112	0.090	0.022	0.003	0.020	0.004	0.898	0.869	0.001	0.001	0.026	0.091	0.091	4.000
209	1.907	0.119	0.093	0.026	0.003	0.022	0.005	0.877	0.875	0.000	0.001	0.030	0.093	0.093	4.000
209	1.885	0.132	0.115	0.017	0.004	0.023	0.005	0.909	0.832	0.001	0.000	0.027	0.089	0.089	4.000
209	1.901	0.112	0.099	0.013	0.003	0.019	0.006	0.888	0.881	0.003	0.000	0.035	0.057	0.057	4.000
209	1.889	0.118	0.111	0.007	0.005	0.020	0.006	0.905	0.846	0.003	0.000	0.033	0.069	0.069	4.000
209	1.886	0.127	0.114	0.013	0.002	0.021	0.006	0.909	0.849	0.001	0.001	0.026	0.071	0.071	4.000
avg(7)	1.894	0.120	0.106	0.014	0.003	0.021	0.006	0.894	0.862	0.001	0.000	0.030	0.075	0.075	4.000
stdev	0.011	0.007	0.011	0.007	0.001	0.001	0.001	0.014	0.018	0.001	0.000	0.003	0.014	0.014	
208	1.910	0.123	0.090	0.033	0.001	0.018	0.006	0.923	0.795	0.002	0.001	0.028	0.130	0.130	4.000
208	1.901	0.122	0.099	0.023	0.002	0.013	0.006	0.877	0.889	0.000	0.001	0.027	0.077	0.077	4.000
208	1.910	0.114	0.090	0.024	0.006	0.019	0.006	0.864	0.896	0.000	0.001	0.032	0.086	0.086	4.000
208	1.904	0.108	0.096	0.012	0.005	0.018	0.005	0.883	0.889	0.000	0.001	0.028	0.075	0.075	4.000
208	1.893	0.133	0.107	0.026	0.006	0.026	0.005	0.879	0.862	0.001	0.000	0.028	0.097	0.097	4.000
208	1.916	0.104	0.084	0.020	0.003	0.018	0.005	0.881	0.889	0.001	0.001	0.026	0.091	0.091	4.000
avg(6)	1.906	0.117	0.094	0.023	0.004	0.019	0.006	0.884	0.870	0.001	0.001	0.028	0.093	0.093	4.000
stdev	0.007	0.010	0.007	0.006	0.002	0.004	0.001	0.018	0.035	0.001	0.000	0.002	0.018	0.018	
199	1.899	0.129	0.101	0.028	0.003	0.022	0.006	0.856	0.873	0.000	0.001	0.032	0.102	0.102	4.000
199	1.904	0.118	0.096	0.022	0.004	0.013	0.005	0.875	0.870	0.001	0.000	0.028	0.102	0.102	4.000
199	1.903	0.125	0.097	0.028	0.002	0.019	0.008	0.858	0.875	0.000	0.000	0.029	0.106	0.106	4.000
199	1.905	0.113	0.095	0.018	0.004	0.015	0.005	0.863	0.887	0.001	0.000	0.029	0.097	0.097	4.000
199	1.903	0.116	0.097	0.019	0.004	0.014	0.005	0.871	0.875	0.001	0.001	0.032	0.092	0.092	4.000
199	1.891	0.134	0.109	0.025	0.003	0.019	0.006	0.835	0.886	0.002	0.001	0.036	0.093	0.093	4.000
199	1.900	0.125	0.100	0.025	0.007	0.018	0.005	0.875	0.852	0.000	0.000	0.031	0.113	0.113	4.000
199	1.897	0.118	0.103	0.015	0.003	0.015	0.007	0.870	0.883	0.001	0.001	0.026	0.087	0.087	4.000
199	1.907	0.117	0.093	0.024	0.003	0.017	0.007	0.882	0.871	0.000	0.000	0.024	0.103	0.103	4.000
avg(9)	1.901	0.122	0.099	0.023	0.003	0.017	0.006	0.865	0.875	0.001	0.001	0.029	0.100	0.100	4.000
stdev	0.005	0.007	0.005	0.004	0.001	0.003	0.001	0.013	0.010	0.001	0.000	0.003	0.008	0.008	
Zone 4															
110	1.887	0.007	0.142	0.113	0.029	0.010	0.006	0.853	0.864	0.003	0.002	0.020	0.129	0.077	4.000
110	1.901	0.004	0.136	0.099	0.037	0.011	0.007	0.846	0.865	0.002	0.001	0.017	0.151	0.059	4.000
110	1.901	0.006	0.129	0.099	0.030	0.010	0.007	0.851	0.886	0.000	0.001	0.017	0.129	0.063	4.000
110	1.890	0.007	0.129	0.110	0.019	0.011	0.007	0.857	0.851	0.000	0.001	0.021	0.140	0.086	4.000
110	1.895	0.006	0.130	0.105	0.025	0.015	0.008	0.883	0.781	0.000	0.002	0.021	0.185	0.075	4.000
110	1.907	0.004	0.114	0.093	0.021	0.014	0.007	0.842	0.887	0.000	0.000	0.017	0.141	0.067	4.000
110	1.912	0.007	0.117	0.088	0.029	0.013	0.006	0.840	0.862	0.000	0.001	0.021	0.169	0.052	4.000
avg(7)	1.899	0.128	0.101	0.027	0.006	0.012	0.007	0.853	0.857	0.001	0.001	0.019	0.149	0.069	
stdev	0.008	0.001	0.009	0.008	0.006	0.002	0.001	0.013	0.033	0.001	0.001	0.002	0.019	0.011	
11	1.932	0.116	1.886	0.048	0.004	0.015	0.007	0.860	0.826	0.001	0.001	0.019	0.205	0.014	4.000
11	1.912	0.125	1.883	0.037	0.007	0.015	0.007	0.829	0.872	0.000	0.001	0.022	0.168	0.042	4.000
11	1.919	0.107	0.114	0.026	0.006	0.016	0.007	0.845	0.886	0.002	0.000	0.019	0.149	0.045	4.000
11	1.906	0.122	0.117	0.028	0.005	0.019	0.006	0.847	0.862	0.000	0.000	0.021	0.156	0.057	4.000
11	1.912	0.118	1.886	0.030	0.005	0.015	0.005	0.845	0.864	0.001	0.000	0.020	0.163	0.052	4.000
avg(5)	1.917	0.118	0.083	0.035	0.005	0.016	0.006	0.845	0.862	0.001	0.000	0.020	0.168	0.042	
stdev	0.009	0.006	0.009	0.008	0.001	0.002	0.001	0.010	0.020	0.001	0.000	0.001	0.019	0.015	
109	1.910	0.005	0.118	0.090	0.028	0.013	0.008	0.849	0.851	0.000	0.000	0.022	0.164	0.059	4.000
109	1.895	0.005	0.137	0.105	0.032	0.017	0.006	0.827	0.865	0.000	0.000	0.021	0.161	0.066	4.000
109	1.894	0.003	0.142	0.106	0.036	0.016	0.005	0.818	0.866	0.000	0.000	0.021	0.168	0.067	4.000
109	1.917	0.005	0.123	0.083	0.040	0.013	0.005	0.838	0.854	0.000	0.000	0.023	0.179	0.042	4.000
109	1.907	0.005	0.140	0.093	0.047	0.016	0.007	0.828	0.855	0.001	0.001	0.021	0.177	0.041	4.000
avg(5)	1.904	0.132	0.096	0.036	0.005	0.015	0.006	0.832	0.858	0.000	0.001	0.022	0.169	0.056	
stdev	0.009	0.001	0.010	0.009	0.007	0.002	0.001	0.011	0.006	0.000	0.000	0.001	0.007	0.011	
9	1.925	0.108	0.075	0.033	0.005	0.012	0.006	0.855	0.874	0.001	0.002	0.017	0.159	0.036	4.000
9	1.917	0.107	0.083	0.024	0.004	0.015	0.005	0.856	0.881	0.001	0.000	0.016	0.147	0.052	4.000
9	1.902	0.124	0.098	0.026	0.006	0.017	0.007	0.860	0.849	0.002	0.000	0.022	0.145	0.067	4.000
9	1.903	0.132	0.097	0.035	0.004	0.016	0.006	0.834	0.884	0.001	0.000	0.022	0.139	0.059	4.000
9	1.903	0.145	0.097	0.048	0.009	0.015	0.008	0.827	0.857	0.000	0.000	0.021	0.178	0.037	4.000
avg(5)	1.910	0.123	0.090	0.033	0.006	0.015	0.007	0.847	0.869	0.001	0.000	0.019	0.155	0.049	
stdev	0.009	0.014	0.009	0.008	0.002	0.002	0.001	0.013	0.014	0.001	0.001	0.003	0.014	0.012	

Table B.3: Chemical composition of clinopyroxene chadacrysts (continued)

Structural formula normalized to 4 cations and 6 (O)															
Sample	Si	Al	Al_{iv}	Al_{vi}	Ti	Cr	Mg	Ca	Mn	Ni	Co	Na	Fe^{2+}	Fe^{3+}	Cat
8	1.889	0.122	0.111	0.011	0.003	0.016	0.007	0.875	0.846	0.001	0.000	0.024	0.117	0.102	4.000
8	1.921	0.104	0.079	0.025	0.004	0.015	0.006	0.853	0.894	0.001	0.000	0.019	0.136	0.049	4.000
8	1.912	0.109	0.088	0.021	0.003	0.015	0.006	0.867	0.870	0.000	0.001	0.021	0.131	0.066	4.000
avg(3)	1.908	0.112	0.092	0.020	0.003	0.015	0.006	0.865	0.870	0.000	0.000	0.021	0.129	0.071	
stdev	0.013	0.008	0.013	0.006	0.000	0.000	0.000	0.009	0.020	0.000	0.000	0.002	0.008	0.022	

Table B.4 Chemical composition of primary oxides

	Weight percent oxide								
Sample	V_2O_5	TiO_2	Cr_2O_3	Al_2O_3	MnO	MgO	FeO	Fe_2O_3	Total
375	0.39	0.72	32.71	16.52	1.97	1.85	30.58	14.20	98.94
375	0.32	0.42	28.71	23.74	1.38	4.28	28.43	12.26	99.55
375	0.27	0.36	28.91	24.96	1.36	4.33	28.56	11.12	99.87
375	0.29	0.48	30.00	22.67	1.24	4.52	28.01	12.21	99.42
375	0.26	0.53	31.36	22.41	0.30	9.15	21.55	13.06	98.62
375	0.37	0.73	33.60	17.91	0.52	5.23	27.41	14.26	100.03
375	0.37	0.72	32.62	17.72	0.95	3.74	28.92	14.05	99.09
375	0.27	0.60	31.92	19.00	1.50	3.29	28.89	13.25	98.72
375	0.38	0.66	31.64	18.61	1.49	3.23	29.27	13.84	99.13
375	0.42	0.64	33.50	16.35	1.94	2.01	30.24	13.60	98.70
avg(10)	0.33	0.59	31.50	19.99	1.27	4.16	28.19	13.19	99.21
stdev	0.06	0.13	1.68	2.99	0.52	1.95	2.39	0.98	0.44
363	0.31	0.52	36.91	18.16	0.26	8.43	22.42	12.60	99.60
363	0.25	0.42	32.84	19.65	1.71	2.88	29.12	11.49	98.36
363	0.37	0.48	34.47	20.26	0.33	7.78	23.52	11.69	98.90
363	0.23	0.36	28.34	25.26	1.44	4.27	28.32	10.90	99.12
avg(4)	0.29	0.45	33.14	20.83	0.94	5.84	25.85	11.67	99.00
stdev	0.06	0.06	3.13	2.67	0.65	2.33	2.92	0.61	0.45
361	0.24	0.52	34.66	19.39	0.88	5.99	25.57	12.19	99.44
361	0.33	0.40	31.76	21.43	1.63	3.39	28.76	10.46	98.16
361	0.28	0.57	35.03	19.58	0.41	8.55	21.93	12.07	98.42
361	0.30	0.46	30.54	22.98	0.76	5.84	26.36	11.68	98.92
361	0.28	0.53	35.51	19.55	0.38	8.82	21.77	12.41	99.24
361	0.37	0.48	34.87	19.78	0.44	8.98	21.37	12.26	98.56
361	0.29	0.44	28.38	25.31	1.20	4.99	27.87	11.41	99.89
361	0.22	0.36	29.41	25.32	0.90	6.17	25.86	10.60	98.84
361	0.29	0.50	31.53	22.62	0.38	6.92	24.95	11.37	98.56
361	0.36	0.47	29.81	23.49	1.11	5.70	26.08	10.83	97.84
avg(10)	0.30	0.47	32.15	21.95	0.81	6.54	25.05	11.53	98.79
stdev	0.05	0.06	2.52	2.22	0.40	1.71	2.44	0.68	0.58
356	0.22	0.50	25.74	17.28	2.26	2.46	26.39	16.02	90.86
356	0.21	0.48	25.30	20.89	1.87	4.05	24.89	13.05	90.74
356	0.31	0.52	26.24	21.30	0.83	5.72	24.10	13.18	92.20
356	0.34	0.53	25.72	21.31	0.55	6.29	23.31	13.37	91.42
356	0.28	0.52	26.43	21.53	0.56	6.46	23.19	13.10	92.06
356	0.22	0.53	25.80	21.44	0.55	6.23	23.10	13.10	90.97
356	0.25	0.50	25.74	21.54	0.85	5.56	24.03	13.03	91.49
356	0.25	0.55	26.15	21.43	1.36	4.86	24.70	12.43	91.72
356	0.27	0.52	30.49	19.67	0.29	8.76	20.07	13.38	93.45
356	0.33	0.45	27.75	22.12	0.81	6.27	23.77	11.86	93.36
356	0.32	0.52	29.41	20.20	0.47	7.28	21.95	12.10	92.25
356	0.30	0.47	25.50	21.56	2.02	3.96	25.48	12.58	91.87
avg(12)	0.28	0.51	26.69	20.86	1.04	5.66	23.75	13.10	91.87
stdev	0.04	0.03	1.59	1.25	0.64	1.59	1.58	1.00	0.84
355	0.24	0.50	27.82	17.80	2.04	2.02	27.10	12.24	89.77
355	0.30	0.58	29.27	20.22	0.44	7.68	22.01	13.75	94.26
355	0.27	0.60	30.16	19.20	0.37	7.79	21.61	13.90	93.89
355	0.31	0.55	27.61	19.55	1.86	3.12	27.01	12.85	92.87
355	0.24	0.60	29.21	18.94	0.92	6.12	23.37	14.04	93.45
avg(5)	0.27	0.56	28.81	19.14	1.13	5.35	24.22	13.36	92.85
stdev	0.03	0.04	0.96	0.80	0.70	2.37	2.39	0.70	1.60
354	0.32	0.58	32.47	19.14	0.29	7.70	23.16	14.25	97.91
354	0.21	0.50	31.53	17.74	1.83	1.60	30.15	13.26	96.82
354	0.31	0.53	36.17	17.16	0.22	8.29	22.35	14.11	99.13
avg(3)	0.28	0.54	33.39	18.01	0.78	5.86	25.22	13.87	97.95
stdev	0.05	0.03	2.00	0.83	0.74	3.02	3.50	0.44	0.94
326	0.55	1.00	23.99	14.13	1.75	1.38	30.95	23.49	97.24
326	0.56	0.82	23.26	13.93	1.66	1.28	31.10	24.95	97.56
326	0.51	0.97	25.33	15.00	1.86	1.65	30.70	21.84	97.86
avg(3)	0.54	0.93	24.19	14.35	1.76	1.44	30.92	23.43	97.56
stdev	0.02	0.08	0.86	0.46	0.08	0.16	0.17	1.27	0.25
318	0.44	1.20	30.38	17.27	1.54	0.56	33.36	13.36	98.11

Table B.4 Chemical composition of primary oxides (continued)

	Weight percent oxide								
Sample	V_2O_5	TiO_2	Cr_2O_3	Al_2O_3	MnO	MgO	FeO	Fe_2O_3	Total
306	0.51	0.50	19.21	13.26	1.51	0.89	31.04	29.83	96.75
306	0.69	1.42	19.94	14.36	1.87	1.12	31.39	25.06	95.85
306	0.57	1.18	22.04	11.74	1.75	0.92	31.68	28.23	98.12
306	0.67	1.47	21.51	13.05	1.79	1.02	31.59	25.24	96.34
306	0.57	1.17	22.71	13.19	1.84	0.92	31.43	24.95	96.78
306	0.73	1.13	21.61	11.15	1.77	0.83	31.90	29.00	98.12
avg(6)	0.62	1.15	21.17	12.79	1.76	0.95	31.51	27.05	96.99
stdev	0.08	0.32	1.21	1.06	0.12	0.10	0.27	2.02	0.85
56a	1.25	1.72	14.07	4.00	1.24	0.31	33.96	43.88	100.43
56b	0.35	0.13	16.76	38.97	1.47	3.88	31.06	6.40	99.02
209	0.50	1.03	25.28	13.94	1.14	0.54	32.58	21.53	96.55
209	0.42	1.03	26.59	13.63	1.13	0.51	32.62	21.07	97.00
209	0.51	1.13	25.23	14.33	1.19	0.59	32.77	21.25	97.01
209	0.44	1.23	24.63	13.90	1.23	0.49	32.81	22.35	97.01
avg(4)	0.47	1.11	25.43	13.95	1.17	0.53	32.70	21.55	96.91
stdev	0.04	0.08	0.72	0.25	0.04	0.04	0.10	0.49	0.21
208	0.47	0.95	25.52	14.69	1.66	0.71	32.37	21.99	98.36
208	0.42	1.05	24.68	15.78	1.46	0.78	32.65	21.51	98.32
208	0.52	0.90	26.61	16.65	1.28	1.78	31.70	19.54	98.98
208	0.45	0.90	25.04	16.98	1.39	1.68	31.50	20.52	98.47
avg(4)	0.47	0.95	25.46	16.03	1.45	1.24	32.06	20.89	98.53
stdev	0.04	0.06	0.73	0.89	0.14	0.49	0.47	0.94	0.26
199b	0.55	1.12	24.79	14.19	2.01	1.01	31.78	23.03	98.49
199b	0.49	0.83	24.97	13.61	1.97	1.35	30.48	23.63	97.33
199b	0.39	1.03	26.30	13.95	1.21	2.36	30.22	23.24	98.70
199b	0.64	1.15	20.81	12.83	2.00	0.94	31.56	27.88	97.81
199b	0.43	1.00	25.75	14.73	1.23	2.23	30.61	22.85	98.83
199b	0.45	1.02	24.77	16.19	2.15	1.25	31.29	21.10	98.22
avg(6)	0.49	1.03	24.57	14.25	1.76	1.52	30.99	23.62	98.23
stdev	0.08	0.10	1.77	1.04	0.39	0.56	0.58	2.07	0.52
199a	0.46	0.97	25.37	17.44	0.49	5.57	26.13	20.56	96.99
199a	0.42	1.07	22.55	16.87	1.79	1.80	30.31	21.55	96.36
199a	0.45	0.93	22.00	16.95	1.92	1.39	29.94	20.23	93.82
199a	0.71	1.00	21.89	16.89	1.70	1.59	30.17	19.36	93.31
199a	0.47	0.98	22.32	16.92	1.82	1.72	29.81	20.40	94.43
199a	0.49	1.03	22.08	16.73	1.81	1.61	30.16	20.96	94.88
199a	0.45	0.97	21.17	16.78	1.85	1.44	29.85	21.04	93.55
199a	0.49	0.83	22.00	16.98	1.97	1.23	30.46	20.97	94.93
199a	0.52	0.98	24.45	16.00	1.42	1.69	30.76	20.39	96.21
199a	0.54	0.93	23.44	16.19	1.96	1.17	31.45	21.93	97.62
avg(10)	0.50	0.97	22.73	16.78	1.67	1.92	29.90	20.74	95.21
stdev	0.08	0.06	1.24	0.39	0.42	1.23	1.34	0.69	1.42
36	0.59	1.33	21.97	11.56	1.78	0.44	32.15	27.08	96.90
109	0.61	0.29	18.58	13.31	1.29	0.47	32.66	32.08	99.29
8	0.65	0.87	21.85	12.09	1.33	0.36	32.38	27.01	96.53
5	1.01	0.48	13.84	5.07	0.78	2.25	28.31	42.98	94.72

Table B.4 Chemical composition of primary oxides (continued)

Cation abundances normalized to 24 cations and 32 (O)									
Sample	V	Ti^{4+}	Al	Mg	Mn	Fe^{2+}	Fe^{3+}	Total	
375	0.071	0.150	7.150	5.382	0.461	0.762	7.069	2.955	24.00
375	0.055	0.083	5.937	7.317	0.306	1.669	6.219	2.414	24.00
375	0.046	0.070	5.926	7.625	0.299	1.673	6.191	2.170	24.00
375	0.050	0.095	6.229	7.016	0.276	1.770	6.151	2.414	24.00
375	0.044	0.102	6.364	6.778	0.065	3.501	4.625	2.522	24.00
375	0.065	0.146	7.057	5.606	0.117	2.071	6.089	2.850	24.00
375	0.066	0.147	6.987	5.657	0.218	1.511	6.551	2.863	24.00
375	0.048	0.122	6.840	6.068	0.344	1.329	6.546	2.702	24.00
375	0.068	0.134	6.771	5.936	0.342	1.303	6.626	2.819	24.00
375	0.077	0.133	7.334	5.335	0.455	0.830	7.003	2.833	24.00
avg(10)	0.059	0.118	6.660	6.272	0.288	1.642	6.307	2.654	
stdev	0.011	0.027	0.484	0.799	0.122	0.730	0.649	0.245	
363	0.053	0.102	7.597	5.571	0.057	3.272	4.880	2.468	24.00
363	0.045	0.086	7.054	6.291	0.393	1.166	6.616	2.348	24.00
363	0.064	0.094	7.104	6.223	0.073	3.023	5.127	2.293	24.00
363	0.040	0.071	5.841	7.760	0.318	1.660	6.173	2.138	24.00
avg(4)	0.051	0.088	6.899	6.461	0.210	2.280	5.699	2.312	
stdev	0.009	0.011	0.647	0.801	0.148	0.889	0.718	0.119	
361	0.042	0.103	7.225	6.024	0.196	2.354	5.637	2.419	24.00
361	0.059	0.081	6.754	6.792	0.371	1.359	6.468	2.116	24.00
361	0.048	0.112	7.233	6.026	0.091	3.329	4.789	2.372	24.00
361	0.052	0.090	6.302	7.068	0.168	2.272	5.754	2.294	24.00
361	0.048	0.103	7.269	5.964	0.083	3.404	4.712	2.417	24.00
361	0.064	0.094	7.165	6.058	0.097	3.479	4.645	2.398	24.00
361	0.049	0.085	5.782	7.686	0.262	1.917	6.006	2.213	24.00
361	0.037	0.070	5.996	7.694	0.197	2.372	5.577	2.057	24.00
361	0.050	0.098	6.489	6.938	0.084	2.685	5.430	2.227	24.00
361	0.063	0.093	6.200	7.282	0.247	2.236	5.736	2.143	24.00
avg(10)	0.051	0.093	6.642	6.753	0.180	2.541	5.475	2.266	
stdev	0.008	0.012	0.535	0.659	0.090	0.654	0.565	0.127	
356	0.043	0.111	6.035	6.038	0.568	1.088	6.543	3.574	24.00
356	0.040	0.104	5.758	7.087	0.456	1.738	5.991	2.827	24.00
356	0.057	0.109	5.807	7.026	0.197	2.387	5.641	2.776	24.00
356	0.063	0.112	5.711	7.052	0.131	2.633	5.474	2.824	24.00
356	0.052	0.109	5.819	7.065	0.132	2.682	5.399	2.744	24.00
356	0.041	0.112	5.750	7.122	0.131	2.618	5.445	2.779	24.00
356	0.047	0.106	5.734	7.152	0.203	2.336	5.661	2.762	24.00
356	0.047	0.117	5.844	7.138	0.326	2.048	5.837	2.644	24.00
356	0.049	0.107	6.574	6.321	0.067	3.561	4.576	2.746	24.00
356	0.060	0.093	6.025	7.158	0.188	2.567	5.458	2.451	24.00
356	0.059	0.109	6.461	6.614	0.111	3.016	5.100	2.530	24.00
356	0.056	0.010	5.726	7.216	0.486	1.677	6.051	2.689	24.00
avg(12)	0.051	0.107	5.937	6.916	0.250	2.363	5.598	2.779	
stdev	0.007	0.006	0.280	0.364	0.160	0.628	0.475	0.264	
355	0.047	0.113	6.589	6.283	0.518	0.902	6.788	2.760	24.00
355	0.054	0.119	6.298	6.485	0.101	3.116	5.010	2.817	24.00
355	0.049	0.124	6.537	6.202	0.086	3.184	4.953	2.866	24.00
355	0.059	0.118	6.239	6.584	0.450	1.329	6.456	2.764	24.00
355	0.044	0.126	6.442	6.226	0.217	2.545	5.452	2.947	24.00
avg(5)	0.051	0.120	6.421	6.356	0.274	2.215	5.732	2.831	
stdev	0.005	0.005	0.134	0.151	0.178	0.935	0.754	0.070	
354	0.056	0.115	6.794	5.969	0.065	3.038	5.125	2.837	24.00
354	0.039	0.106	7.000	5.870	0.435	0.670	7.079	2.802	24.00
354	0.054	0.105	7.520	5.317	0.049	3.250	4.914	2.791	24.00
avg(3)	0.050	0.109	7.105	5.719	0.183	2.319	5.706	2.810	
stdev	0.008	0.004	0.305	0.287	0.178	1.169	0.975	0.020	
326	0.104	0.215	5.430	4.767	0.424	0.589	7.410	5.060	24.00
326	0.106	0.176	5.262	4.697	0.402	0.546	7.440	5.371	24.00
326	0.095	0.206	5.661	4.996	0.445	0.695	7.257	4.644	24.00
avg(3)	0.102	0.199	5.451	4.820	0.424	0.610	7.369	5.025	
stdev	0.005	0.017	0.164	0.128	0.018	0.063	0.080	0.298	
318	0.081	0.253	6.731	5.703	0.365	0.234	7.817	2.816	24.00

Table B.4 Chemical composition of primary oxides (continued)

Cation abundances normalized to 24 cations and 32 (O)

Sample	V	Ti^{4+}	Al	Mg	Mn	Fe^{2+}	Fe^{3+}	Total	
306	0.098	0.109	4.417	4.544	0.372	0.386	7.548	6.526	24.00
306	0.132	0.310	4.583	4.919	0.460	0.485	7.630	5.480	24.00
306	0.109	0.256	5.032	3.995	0.428	0.396	7.650	6.135	24.00
306	0.129	0.322	4.955	4.480	0.442	0.443	7.696	5.533	24.00
306	0.109	0.255	5.208	4.509	0.452	0.398	7.624	5.445	24.00
306	0.140	0.246	4.953	3.809	0.435	0.359	7.733	6.326	24.00
avg(6)	0.120	0.250	4.858	4.376	0.432	0.411	7.647	5.908	
stdev	0.015	0.069	0.271	0.369	0.029	0.041	0.058	0.437	
56a	0.245	0.384	3.301	1.399	0.312	0.137	8.426	9.797	24.00
56b	0.057	0.024	3.268	11.325	0.307	1.427	6.405	1.188	24.00
209	0.096	0.225	5.798	4.765	0.280	0.234	7.903	4.700	24.00
209	0.080	0.224	6.080	4.645	0.277	0.220	7.888	4.586	24.00
209	0.097	0.245	5.747	4.865	0.290	0.253	7.896	4.607	24.00
209	0.084	0.267	5.625	4.731	0.301	0.211	7.924	4.858	24.00
avg(4)	0.089	0.240	5.813	4.752	0.287	0.230	7.903	4.688	
stdev	0.007	0.018	0.167	0.079	0.009	0.016	0.013	0.107	
208	0.088	0.203	5.725	4.911	0.399	0.300	7.680	4.694	24.00
208	0.078	0.223	5.506	5.247	0.349	0.328	7.703	4.566	24.00
208	0.095	0.188	5.829	5.436	0.300	0.735	7.343	4.074	24.00
208	0.083	0.188	5.509	5.568	0.328	0.697	7.330	4.298	24.00
avg(4)	0.086	0.201	5.642	5.291	0.344	0.515	7.514	4.408	
stdev	0.006	0.014	0.140	0.247	0.036	0.202	0.178	0.240	
199b	0.103	0.239	5.557	4.741	0.483	0.427	7.536	4.914	24.00
199b	0.093	0.179	5.663	4.600	0.479	0.577	7.309	5.100	24.00
199b	0.072	0.217	5.833	4.611	0.287	0.987	7.088	4.905	24.00
199b	0.122	0.249	4.739	4.355	0.488	0.404	7.602	6.043	24.00
199b	0.079	0.210	5.688	4.849	0.291	0.929	7.150	4.804	24.00
199b	0.083	0.215	5.500	5.358	0.511	0.523	7.348	4.460	2400
avg(6)	0.092	0.218	5.497	4.752	0.423	0.641	7.339	5.038	
stdev	0.017	0.022	0.355	0.310	0.095	0.232	0.186	0.489	
199a	0.083	0.200	5.490	5.625	0.114	2.273	5.980	4.235	24.00
199a	0.079	0.228	5.061	5.643	0.430	0.762	7.194	4.603	24.00
199a	0.087	0.204	5.071	5.823	0.474	0.604	7.299	4.438	24.00
199a	0.137	0.220	5.063	5.823	0.421	0.693	7.381	4.261	24.00
199a	0.090	0.213	5.102	5.765	0.446	0.741	7.206	4.437	24.00
199a	0.093	0.223	5.036	5.687	0.442	0.692	7.276	4.550	24.00
199a	0.087	0.213	4.896	5.785	0.458	0.628	7.302	4.631	24.00
199a	0.093	0.180	5.023	5.779	0.482	0.530	7.356	4.557	24.00
199a	0.098	0.210	5.520	5.384	0.343	0.719	7.344	4.381	24.00
199a	0.101	0.198	5.240	5.395	0.469	0.493	7.437	4.666	24.00
avg(10)	0.095	0.209	5.150	5.671	0.408	0.814	7.178	4.476	
stdev	0.015	0.013	0.194	0.155	0.105	0.494	0.405	0.143	
36	0.114	0.293	5.096	3.996	0.442	0.192	7.888	5.978	24.00
109	0.115	0.062	4.185	4.469	0.311	0.200	7.781	6.877	24.00
8	0.126	0.192	5.077	4.187	0.331	0.158	7.956	5.973	24.00
5	0.205	0.111	3.368	1.839	0.203	1.032	7.286	9.955	24.00

Table B.5 Chemical composition of secondary oxides

	Weight percent oxide								
Sample	V_2O_5	TiO_2	Cr_2O_3	Al_2O_3	MnO	MgO	FeO	Fe_2O_3	Total
458	0.42	0.43	17.79	0.18	1.33	0.08	30.35	47.47	98.04
458	0.64	0.98	22.11	0.32	1.59	0.15	30.81	41.06	97.66
375	0.18	0.86	28.24	1.81	1.87	0.43	29.49	34.40	97.27
375	0.09	1.05	29.53	1.11	1.73	0.44	29.87	34.51	98.34
375	0.09	1.07	24.72	1.93	1.71	0.39	29.78	37.75	97.44
375	0.22	0.84	24.45	0.75	1.61	0.25	30.08	39.89	98.09
375	0.17	0.87	25.96	2.49	1.53	0.46	30.41	37.14	99.03
375	0.15	1.01	29.07	1.65	1.89	0.37	29.96	34.21	98.31
375	0.16	1.01	27.25	0.66	2.01	0.34	29.26	36.21	96.90
375	0.16	0.97	29.09	1.74	1.87	0.39	29.78	33.78	97.77
375	0.14	1.11	29.63	0.64	1.92	0.49	28.95	33.17	96.05
361	0.20	1.18	27.94	0.66	1.79	0.30	29.86	35.24	97.17
361	0.22	1.04	25.96	1.25	1.71	0.28	29.81	36.47	96.74
361	0.14	0.91	23.22	0.54	1.44	0.23	30.09	41.29	97.86
361	0.28	0.84	23.66	0.50	1.79	0.19	29.87	40.45	97.58
361	0.14	1.00	25.46	0.97	1.76	0.29	29.05	36.55	95.22
361	0.28	0.95	25.66	2.04	1.69	0.33	29.98	36.07	97.00
356	0.19	0.85	21.96	1.45	2.06	0.39	26.96	36.18	90.04
356	0.13	0.83	23.99	1.66	2.21	0.37	26.85	34.18	90.21
356	0.06	0.93	22.44	0.77	2.25	0.34	26.03	35.97	88.79
355	0.14	1.17	24.28	1.88	2.02	0.35	27.72	33.56	91.12
314	0.24	1.28	18.85	0.47	1.11	0.16	29.65	41.89	93.64
314	0.13	1.07	18.48	0.20	1.08	0.17	29.00	42.76	92.89
314	0.17	1.52	19.75	0.47	1.02	0.16	30.94	43.09	97.12
314	0.15	1.20	21.75	0.90	1.16	0.56	28.9	39.07	93.68
308	0.49	1.48	18.35	0.33	1.19	0.19	31.46	44.63	98.13
308	0.34	1.32	17.08	0.96	1.07	0.20	30.29	43.70	94.97
306	0.37	1.85	19.31	0.36	1.58	0.51	29.80	41.27	95.05
303	0.21	1.23	16.83	0.20	1.13	0.13	31.37	48.57	99.66
58	0.99	0.55	8.73	0.11	0.36	0.01	33.10	56.78	100.63
58	0.80	0.57	7.50	0.12	0.35	0.03	32.64	58.18	100.20
58	1.16	1.05	12.84	0.19	0.57	0.06	33.09	49.96	98.92
58	0.74	0.44	6.83	0.15	0.25	0.04	32.49	59.21	100.15
58	0.99	0.55	9.06	0.11	0.36	0.01	33.19	56.65	100.92
58	0.80	0.57	7.78	0.12	0.35	0.03	32.72	58.07	100.44
58	1.16	1.04	13.34	0.19	0.57	0.06	33.23	49.78	99.37
56	0.75	1.20	12.64	0.09	0.77	0.11	32.66	51.94	100.16
56	0.77	1.27	15.84	0.09	1.08	0.14	32.16	47.86	99.20
56	0.88	0.62	8.29	0.10	0.36	0.05	33.04	57.69	101.04
244	2.24	1.61	17.66	1.30	0.91	0.02	35.24	39.64	98.62
244	2.56	1.71	18.21	1.38	1.04	0.03	35.51	37.52	97.97
208	0.34	1.18	22.95	0.85	1.19	0.09	31.27	40.27	98.14
199b	0.11	0.27	0.04	0.03	0.10	0.03	29.39	70.63	100.60
199a	0.49	0.78	21.34	2.00	1.73	0.24	29.53	38.78	94.88
199a	0.36	0.72	20.31	1.75	1.58	0.14	29.25	39.93	94.04
199a	0.14	0.13	0.06	0.02	0.04	0.02	26.26	70.86	97.54
199a	0.29	0.60	20.7	2.67	1.55	0.24	29.38	39.62	95.06
199a	0.27	0.70	18.54	0.60	1.70	0.12	28.45	42.64	93.02
199a	0.19	0.15	0.19	0.00	0.07	0.00	27.70	70.49	98.79
40	0.46	0.95	15.71	0.14	1.20	0.02	29.75	45.54	93.77
40	0.22	0.65	6.51	0.35	0.44	0.48	28.12	59.17	95.95
40	0.53	1.73	16.54	0.17	1.30	0.10	31.23	44.91	96.52
36	0.14	0.32	0.70	0.18	0.02	0.21	29.83	69.13	100.52
36	0.22	1.15	13.82	0.23	0.92	0.02	31.30	50.87	98.53
33	0.43	1.87	17.24	0.17	1.38	0.15	31.72	45.69	98.64
33	0.56	1.88	16.69	0.35	1.31	0.20	31.59	44.89	97.46
33	0.48	1.97	17.04	0.14	1.21	0.14	32.07	45.61	98.67
110	1.55	0.30	7.75	0.39	0.34	0.04	33.74	56.43	100.54
110	1.56	0.57	17.48	1.58	0.73	0.04	33.51	43.56	99.03
110	1.37	0.58	17.93	1.62	0.77	0.06	33.37	44.02	99.72
110	1.03	0.50	16.93	1.20	0.72	0.03	32.58	46.14	99.13
110	1.67	0.45	11.41	0.72	0.48	0.01	33.79	51.04	99.57
110	0.81	0.35	18.07	1.34	0.74	0.05	32.09	45.73	99.18
110	1.23	0.15	6.23	0.32	0.22	0.00	33.07	58.78	100.00
11	0.58	0.27	17.64	1.65	0.91	0.03	31.56	46.55	99.19
11	0.63	0.28	17.93	2.22	0.84	0.06	31.90	45.72	99.58

Table B.5 Chemical composition of secondary oxides (continued)

	Weight percent oxide								
Sample	V_2O_5	TiO_2	Cr_2O_3	Al_2O_3	MnO	MgO	FeO	Fe_2O_3	Total
109	0.59	0.36	15.73	3.51	0.93	0.14	32.05	46.78	100.09
109	0.52	0.43	15.60	0.34	0.86	0.07	31.08	49.44	98.34
9	0.90	0.31	19.21	2.01	1.22	0.03	32.10	44.09	99.86
9	0.87	0.44	22.75	1.76	1.15	0.09	31.91	40.09	99.06
9	1.00	0.38	18.06	1.44	0.95	0.05	32.43	45.52	99.83
9	0.76	0.31	18.38	3.51	0.96	0.11	32.23	43.51	99.78
8	0.57	0.31	16.61	0.76	0.77	0.04	31.53	48.58	99.16
6	0.89	0.51	15.26	1.45	0.76	0.02	31.46	45.88	96.22
6	0.82	0.47	16.82	1.74	0.9	0.04	31.14	44.08	96.01
6	0.85	0.49	15.06	1.35	0.72	0.04	31.91	47.57	97.99
6	0.69	0.43	10.75	0.91	0.56	0.05	32.24	54.43	100.06
6	0.82	0.50	14.06	1.16	0.66	0.00	32.21	49.43	98.84
5	1.30	0.50	15.95	1.57	0.79	0.00	32.90	45.69	98.69
5	1.13	0.52	13.31	1.34	0.71	0.00	32.53	48.79	98.32

Table B.5 Chemical composition of secondary oxides (continued)

Cation abundances normalized to 24 cations and 32 (O)

Sample	V	Ti	Cr	Al	Mn	Mg	Fe^{2+}	Fe^{3+}	Total
458	0.086	0.100	4.372	0.066	0.350	0.037	7.887	11.102	24.00
458	0.131	0.229	5.431	0.117	0.418	0.069	8.004	9.600	24.00
375	0.037	0.199	6.871	0.656	0.487	0.197	7.588	7.965	24.00
375	0.018	0.241	7.131	0.400	0.448	0.200	7.630	7.932	24.00
375	0.018	0.248	6.012	0.700	0.446	0.179	7.660	8.738	24.00
375	0.045	0.195	5.956	0.272	0.420	0.115	7.750	9.248	24.00
375	0.034	0.197	6.190	0.885	0.391	0.207	7.668	8.428	24.00
375	0.030	0.232	7.006	0.593	0.488	0.168	7.636	7.847	24.00
375	0.033	0.236	6.706	0.242	0.530	0.158	7.615	8.480	24.00
375	0.032	0.223	7.044	0.628	0.485	0.178	7.626	7.784	24.00
375	0.029	0.261	7.337	0.236	0.509	0.229	7.582	7.817	24.00
361	0.041	0.275	6.856	0.241	0.470	0.139	7.748	8.229	24.00
361	0.045	0.243	6.384	0.458	0.450	0.013	7.754	8.536	24.00
361	0.029	0.212	5.680	0.197	0.377	0.106	7.786	9.613	24.00
361	0.057	0.196	5.806	0.183	0.471	0.088	7.753	9.447	24.00
361	0.029	0.238	6.371	0.362	0.472	0.137	7.689	8.703	24.00
361	0.057	0.221	6.264	0.742	0.442	0.152	7.741	8.381	24.00
356	0.042	0.213	5.793	0.570	0.582	0.194	7.521	9.084	24.00
356	0.029	0.207	6.303	0.650	0.622	0.183	7.460	8.546	24.00
356	0.013	0.237	6.024	0.308	0.647	0.172	7.390	9.190	23.98
355	0.030	0.289	6.307	0.728	0.562	0.171	7.617	8.296	24.00
314	0.051	0.312	4.829	0.179	0.305	0.077	8.033	10.213	24.00
314	0.028	0.263	4.782	0.077	0.299	0.083	7.938	10.530	24.00
314	0.035	0.357	4.878	0.173	0.270	0.075	8.083	10.129	24.00
314	0.032	0.290	5.530	0.341	0.316	0.268	7.770	9.453	24.00
308	0.100	0.345	4.492	0.120	0.312	0.088	8.146	10.398	24.00
308	0.072	0.316	4.306	0.361	0.289	0.095	8.076	10.485	24.00
306	0.078	0.443	4.860	0.135	0.426	0.242	7.931	9.886	24.00
303	0.042	0.283	4.067	0.072	0.292	0.059	8.016	11.168	24.00
58	0.199	0.126	2.102	0.039	0.093	0.005	8.427	13.009	24.00
58	0.162	0.131	1.814	0.043	0.091	0.014	8.351	13.395	24.00
58	0.236	0.244	3.133	0.069	0.149	0.028	8.540	11.601	24.00
58	0.150	0.101	1.653	0.054	0.065	0.018	8.318	13.641	24.00
58	0.199	0.126	2.174	0.039	0.093	0.005	8.426	12.939	24.00
58	0.161	1.310	1.877	0.043	0.090	0.014	8.350	13.334	24.00
58	0.235	0.240	3.239	0.069	0.148	0.027	8.536	11.505	24.00
56	0.151	0.275	3.047	0.032	0.199	0.050	8.329	11.917	24.00
56	0.156	0.293	3.848	0.033	0.281	0.064	8.261	11.064	24.00
56	0.176	0.141	1.988	0.036	0.092	0.023	8.379	13.165	24.00
244	0.454	0.371	4.281	0.470	0.236	0.009	9.034	9.146	24.00
244	0.521	0.396	4.438	0.501	0.272	0.014	9.154	8.704	24.00
208	0.069	0.274	5.594	0.309	0.311	0.041	8.060	9.342	24.00
199b	0.022	0.062	0.010	0.011	0.026	0.014	7.482	16.179	23.80
199a	0.102	0.186	5.340	0.746	0.464	0.113	7.814	9.235	24.00
199a	0.076	0.173	5.142	0.660	0.428	0.067	7.831	9.622	24.00
199a	0.029	0.031	0.015	0.007	0.011	0.009	6.853	16.641	23.59
199a	0.060	0.142	5.154	0.991	0.413	0.113	7.738	9.389	24.00
199a	0.058	0.172	4.782	0.231	0.470	0.058	7.761	10.469	24.00
199a	0.039	0.035	0.046	0.000	0.018	0.000	7.157	16.392	23.68
40	0.099	0.232	4.040	0.054	0.331	0.010	8.090	11.145	24.00
40	0.046	0.155	1.630	0.131	0.118	0.227	7.445	14.097	23.84
40	0.110	0.410	4.125	0.063	0.347	0.047	8.238	10.660	24.00
36	0.028	0.073	0.168	0.065	0.005	0.095	7.590	15.829	23.85
36	0.028	0.073	0.168	0.065	0.005	0.095	7.590	15.829	23.85
36	0.045	0.268	3.385	0.084	0.241	0.009	8.108	11.859	24.00
33	0.088	0.434	4.204	0.062	0.360	0.069	8.180	10.604	24.00
33	0.115	0.441	4.114	0.129	0.346	0.093	8.234	10.530	24.00
33	0.098	0.457	4.155	0.051	0.316	0.064	8.272	10.586	24.00
110	0.315	0.131	4.219	0.568	0.189	0.018	8.554	10.007	24.00
110	0.274	0.132	4.296	0.579	0.198	0.027	8.457	10.038	24.00
110	0.208	0.115	4.094	0.432	0.186	0.014	8.331	10.619	24.00
110	0.338	0.104	2.762	0.260	0.124	0.005	8.650	11.758	24.00
110	0.163	0.080	4.362	0.482	0.191	0.023	8.193	10.505	24.00
110	0.249	0.035	1.510	0.116	0.057	0.000	8.476	13.558	24.00
11	0.117	0.062	4.253	0.593	0.235	0.014	8.047	10.680	24.00
11	0.126	0.064	4.291	0.792	0.215	0.027	8.074	10.412	24.00

Table B.5 Chemical composition of secondary oxides (continued)

Cation abundances normalized to 24 cations and 32 (O)									
Sample	V	Ti	Cr	Al	Mn	Mg	Fe^{2+}	Fe^{3+}	Total
109	0.117	0.081	3.720	1.237	0.236	0.062	8.017	10.530	24.00
109	0.106	0.100	3.823	0.124	0.226	0.032	8.056	11.532	24.00
9	0.180	0.070	4.587	0.715	0.312	0.014	8.105	10.018	24.00
9	0.175	0.101	5.469	0.631	0.296	0.041	8.144	9.174	24.00
9	0.200	0.087	4.329	0.514	0.244	0.023	8.221	10.383	24.00
9	0.150	0.070	4.355	1.240	0.244	0.049	8.079	9.813	24.00
8	0.115	0.071	4.027	0.275	0.200	0.018	8.085	11.209	24.00
6	0.185	0.121	3.798	0.538	0.203	0.009	8.280	10.867	24.00
6	0.170	0.111	4.184	0.645	0.240	0.019	8.194	10.436	24.00
6	0.174	0.114	3.684	0.492	0.189	0.018	8.255	11.075	24.00
6	0.139	0.098	2.588	0.327	0.144	0.023	8.209	12.472	24.00
6	0.166	0.116	3.417	0.420	0.172	0.000	8.277	11.432	24.00
5	0.263	0.115	3.868	0.567	0.205	0.000	8.437	10.544	24.00
5	0.230	0.121	3.248	0.487	0.186	0.000	8.396	11.331	24.00

Table B.6 Chemical composition of amphiboles

	Weight percent oxide									
Sample	SiO_2	TiO_2	Al_2O_3	MnO	MgO	CaO	Na_2O	FeO	Total	
					Replacing clinopyroxene					
58a	56.19	0.03	1.15	0.22	19.44	12.95	0.11	0.03	7.58	97.70
58b	56.09	0.14	1.22	0.20	21.21	12.68	0.01	0.03	5.70	97.28
58f	58.57	0.01	0.08	0.17	22.96	13.43	0.00	0.00	2.91	98.13
avg(3)	56.95	0.06	0.82	0.20	21.20	13.02	0.04	0.02	5.40	97.70
stdev	1.15	0.06	0.52	0.02	1.44	0.31	0.05	0.01	2.35	0.35
56a	57.07	0.10	0.90	0.19	21.41	12.92	0.11	0.02	4.84	97.56
56b	57.82	0.00	0.39	0.19	21.71	13.38	0.03	0.01	4.21	97.74
avg(2)	57.45	0.05	0.65	0.19	21.56	13.15	0.07	0.02	4.23	97.65
stdev	0.38	0.05	0.26	0.00	0.15	0.23	0.04	0.00	0.45	0.09
110a	58.39	0.00	0.35	0.09	21.91	13.33	0.01	0.01	4.45	98.54
110b	58.54	0.05	0.22	0.10	22.00	13.51	0.00	0.00	4.37	98.79
110c	58.69	0.02	0.28	0.12	23.26	13.13	0.00	0.01	3.09	98.60
110d	58.50	0.01	0.20	0.19	21.65	13.36	0.00	0.01	4.75	98.67
110e	57.77	0.00	0.28	0.15	21.04	13.46	0.00	0.01	5.65	98.36
110f	57.70	0.00	0.31	0.16	21.26	13.48	0.02	0.02	5.39	98.34
110i	57.61	0.00	0.25	0.10	21.36	13.47	0.00	0.00	5.21	98.00
110j	57.80	0.06	0.31	0.12	20.93	13.36	0.02	0.02	5.86	98.48
avg(8)	58.13	0.02	0.28	0.13	21.68	13.39	0.01	0.01	4.90	98.47
stdev	0.42	0.02	0.05	0.03	0.70	0.12	0.01	0.01	0.94	0.23
472b	53.81	0.00	3.66	0.14	17.31	13.03	0.47	0.12	8.84	97.38
472c	53.52	0.09	4.58	0.10	17.69	12.76	0.19	0.04	8.11	97.08
avg(2)	53.67	0.05	4.12	0.12	17.50	12.90	0.33	0.08	8.48	97.23
stdev	0.14	0.05	0.46	0.02	0.19	0.13	0.14	0.04	0.23	0.15
471a	54.90	0.12	2.14	0.14	17.59	12.95	0.19	0.05	8.11	96.19
471b	54.32	0.00	2.10	0.16	17.80	12.89	0.19	0.05	8.45	95.96
471c	53.49	0.13	2.79	0.11	16.70	12.70	0.32	0.10	8.74	95.08
471d	54.46	0.17	2.20	0.11	17.72	12.99	0.24	0.07	8.38	96.34
471e	52.83	0.04	3.69	0.10	17.08	12.77	0.49	0.13	9.30	96.43
avg(5)	54.00	0.09	2.58	0.12	17.38	12.86	0.29	0.08	8.60	96.00
stdev	0.74	0.06	0.61	0.02	0.42	0.11	0.11	0.03	0.45	0.49
473a	48.23	0.63	8.36	0.14	15.28	12.68	1.45	0.06	10.68	97.51
473b	53.00	0.61	4.21	0.11	17.75	12.89	0.68	0.10	8.66	98.01
473c	48.53	0.69	8.77	0.14	15.58	12.42	1.63	0.05	9.67	97.48
avg(3)	49.92	0.64	7.11	0.13	16.20	12.66	1.25	0.07	9.67	97.67
stdev	2.18	0.03	2.06	0.01	1.10	0.19	0.41	0.02	1.01	0.24
476a	56.51	0.05	1.51	0.14	20.05	13.35	0.12	0.02	6.02	97.77
478a	55.54	0.03	2.05	0.13	18.22	12.88	0.22	0.04	8.63	97.74
478b	53.19	0.04	3.59	0.15	16.65	12.75	0.42	0.12	10.37	97.28
avg(2)	54.37	0.04	2.82	0.14	17.44	12.82	0.32	0.08	9.50	97.51
stdev	1.17	0.00	0.77	0.01	0.79	0.06	0.10	0.04	1.23	0.23
481a	55.31	0.14	2.03	0.19	17.29	13.07	0.22	0.05	10.28	98.58
481b	55.83	0.00	2.08	0.15	17.50	13.02	0.24	0.07	10.16	99.05
481c	54.99	0.06	2.06	0.09	17.31	12.96	0.23	0.07	10.57	98.34
481d	55.35	0.07	1.80	0.12	17.44	13.20	0.21	0.03	10.59	98.81
481e	56.36	0.03	0.91	0.17	16.94	12.85	0.10	0.03	11.56	98.95
481f	54.00	0.03	2.71	0.16	17.17	13.10	0.32	0.07	10.17	97.73
481g	54.17	0.00	2.04	0.18	17.22	12.96	0.24	0.07	10.43	97.31
481h	52.42	0.34	2.48	0.23	15.06	20.51	0.26	0.00	7.86	99.16
481i	54.05	0.17	2.61	0.13	16.86	12.94	0.37	0.06	9.83	97.02
481j	55.50	0.04	1.73	0.18	17.74	13.09	0.18	0.07	9.88	98.41
481k	54.80	0.22	2.52	0.21	17.55	12.42	0.39	0.03	9.68	97.82
avg(11)	54.80	0.10	2.09	0.16	17.10	13.65	0.25	0.05	10.09	98.29
stdev	1.04	0.10	0.49	0.04	0.69	2.18	0.08	0.02	0.90	0.69
485a	55.14	0.00	2.02	0.18	18.56	13.02	0.20	0.06	8.23	97.41
485f	55.03	0.26	2.37	0.22	18.18	13.17	0.24	0.05	9.06	98.58
avg(2)	55.09	0.13	2.20	0.20	18.37	13.10	0.22	0.06	8.65	98.00
stdev	0.06	0.13	0.17	0.02	0.19	0.07	0.02	0.01	0.59	0.58
486a	54.85	0.02	2.06	0.17	17.27	13.04	0.20	0.05	10.50	98.16
486b	52.78	0.06	3.78	0.23	16.42	12.99	0.51	0.14	11.00	97.91
486c	56.14	0.05	0.99	0.22	18.41	13.14	0.09	0.02	9.66	98.72
486d	52.23	0.08	4.28	0.18	16.06	13.07	0.58	0.20	11.82	98.50

Table B.6 Chemical composition of amphiboles (continued)

	Weight percent oxide									
Sample	SiO_2	TiO_2	Al_2O_3	MnO	MgO	CaO	Na_2O	FeO	Total	
486e	53.02	0.00	4.19	0.25	16.30	12.99	0.59	0.17	11.17	98.68
486f	54.43	0.01	2.27	0.15	17.55	13.03	0.21	0.06	9.48	97.19
486g	53.71	0.07	3.02	0.16	17.07	12.87	0.40	0.10	10.78	98.18
486k	57.48	0.19	1.80	0.11	21.59	13.29	0.20	0.05	4.15	98.86
486l	55.84	0.00	1.30	0.20	17.63	13.06	0.17	0.06	9.87	98.13
486m	54.56	0.06	2.65	0.18	17.18	13.08	0.29	0.09	10.15	98.24
486n	55.69	0.13	1.09	0.20	17.65	13.06	0.13	0.02	9.96	97.93
avg(3)	54.61	0.06	2.49	0.19	17.56	13.06	0.31	0.09	9.87	98.23
stdev	1.53	0.06	1.14	0.04	1.43	0.10	0.17	0.06	2.02	0.45
	Replacing olivine									
407a	58.08	0.00	0.23	0.11	21.80	13.25	0.00	0.00	4.72	98.19
407b	58.28	0.00	0.17	0.07	21.74	13.47	0.00	0.01	4.75	98.49
407c	57.89	0.00	0.49	0.08	21.48	13.42	0.01	0.00	4.86	98.23
407d	58.16	0.02	0.25	0.08	21.86	13.53	0.00	0.00	4.25	98.15
407e	57.59	0.00	0.24	0.11	21.93	13.33	0.00	0.00	4.13	97.33
avg(5)	58.00	0.00	0.28	0.09	21.76	13.40	0.00	0.00	4.54	98.08
stdev	0.24	0.01	0.11	0.02	0.15	0.10	0.00	0.00	0.33	0.39
381a	58.52	0.06	0.27	0.13	21.70	13.46	0.00	0.03	4.20	98.37
381b	58.88	0.00	0.09	0.09	22.81	13.43	0.00	0.00	2.67	97.97
381c	58.04	0.00	0.22	0.10	21.30	13.62	0.00	0.00	4.71	97.99
381d	57.94	0.00	0.12	0.09	22.40	13.72	0.00	0.00	3.20	97.47
avg(4)	58.35	0.02	0.18	0.10	22.05	13.56	0.00	0.01	3.70	97.95
stdev	0.38	0.03	0.07	0.02	0.59	0.12	0.00	0.01	0.93	0.32
321a	58.02	0.00	0.33	0.08	21.68	13.46	0.03	0.03	4.63	98.26
321b	58.99	0.00	0.15	0.07	22.46	13.63	0.00	0.01	3.33	98.64
avg(2)	58.51	0.00	0.24	0.08	22.07	13.55	0.02	0.02	3.98	98.45
stdev	0.48	0.00	0.09	0.00	0.39	0.08	0.02	0.01	0.92	0.19
319a	57.84	0.06	0.12	0.12	21.53	13.18	0.01	0.01	3.80	96.67
319b	57.70	0.04	0.16	0.13	20.71	13.19	0.03	0.03	4.87	96.86
319c	57.33	0.00	0.10	0.09	21.49	13.15	0.02	0.02	3.66	95.86
avg(3)	57.62	0.03	0.13	0.11	21.24	13.17	0.02	0.02	4.11	96.46
stdev	0.22	0.02	0.02	0.02	0.38	0.02	0.01	0.01	0.66	0.43
317a	55.70	0.00	0.34	0.12	18.60	13.04	0.00	0.00	8.49	96.29
317b	57.51	0.04	0.44	0.14	21.72	13.41	0.07	0.01	4.12	97.46
317c	57.16	0.00	0.23	0.17	21.23	13.12	0.02	0.02	5.06	97.01
avg(3)	56.79	0.01	0.34	0.14	20.52	13.19	0.03	0.01	5.89	96.92
stdev	0.96	0.02	0.11	0.03	1.68	0.19	0.04	0.01	2.30	0.59
313a	55.09	0.04	0.18	0.17	15.79	12.73	0.00	0.00	12.48	96.48
313b	55.40	0.00	0.33	0.14	16.63	12.83	0.02	0.00	11.43	96.78
avg(2)	55.25	0.02	0.26	0.16	16.21	12.78	0.01	0.00	11.99	96.63
stdev	0.22	0.03	0.11	0.02	0.59	0.07	0.01	0.00	0.70	0.21
78a	57.31	0.03	0.41	0.13	22.14	13.15	0.01	0.00	4.04	97.22
78b	57.07	0.00	0.41	0.09	21.88	13.28	0.01	0.02	4.44	97.20
78c	57.73	0.00	0.30	0.10	22.16	13.18	0.02	0.00	4.33	97.82
avg(3)	57.37	0.01	0.37	0.11	22.06	13.20	0.01	0.01	4.27	97.41
stdev	0.27	0.01	0.05	0.02	0.13	0.06	0.00	0.01	0.21	0.29
58c	58.17	0.00	0.18	0.18	20.89	13.32	0.00	0.00	5.52	98.26
58d	58.93	0.00	0.09	0.11	23.23	13.66	0.01	0.01	2.54	98.58
58e	58.85	0.00	0.09	0.19	22.99	13.52	0.00	0.01	3.06	98.71
avg(3)	58.65	0.00	0.12	0.16	22.37	13.50	0.00	0.01	3.71	98.52
stdev	0.34	0.00	0.04	0.04	1.05	0.14	0.00	0.00	1.59	0.19
56c	58.23	0.00	0.05	0.22	21.82	13.28	0.00	0.01	4.29	97.90
56d	58.70	0.00	0.05	0.21	21.79	13.37	0.00	0.00	4.35	98.47
avg(2)	58.47	0.00	0.05	0.22	21.81	13.33	0.00	0.01	4.32	98.19
stdev	0.23	0.00	0.00	0.00	0.02	0.05	0.00	0.01	0.04	0.29
233a	58.97	0.00	0.04	0.05	22.80	13.61	0.01	0.02	2.88	98.38
233b	59.06	0.00	0.04	0.10	22.80	13.55	0.00	0.03	3.02	98.60
233c	58.90	0.00	0.14	0.08	22.31	13.69	0.03	0.01	3.22	98.48
233d	58.77	0.00	0.18	0.13	22.32	13.66	0.02	0.02	3.50	98.60
233e	58.03	0.00	0.33	0.15	20.33	12.80	0.02	0.00	6.46	98.12
avg(5)	58.75	0.00	0.15	0.10	22.11	13.46	0.02	0.02	3.81	98.44
stdev	0.37	0.00	0.11	0.04	0.92	0.33	0.01	0.01	1.50	0.18

Table B.6 Chemical composition of amphiboles (continued)

	Weight percent oxide									
Sample	SiO_2	TiO_2	Al_2O_3	MnO	MgO	CaO	Na_2O	FeO	Total	
36a	53.49	0.04	0.07	0.33	14.67	24.76	0.00	0.00	6.01	99.37
36b	53.09	0.01	0.05	0.33	14.97	24.82	0.00	0.02	5.76	99.05
36c	52.95	0.00	0.05	0.30	15.01	24.86	0.00	0.00	5.46	98.63
avg(3)	53.18	0.02	0.06	0.32	14.88	24.81	0.00	0.01	5.74	99.02
stdev	0.23	0.02	0.01	0.01	0.15	0.04	0.00	0.01	0.28	0.30
	After orthopyroxene									
110g	57.89	0.00	0.23	0.16	21.67	13.47	0.01	0.01	5.14	98.58
110h	57.58	0.00	0.21	0.09	21.07	13.57	0.00	0.01	5.49	98.02
avg(2)	57.74	0.00	0.22	0.13	21.37	13.52	0.01	0.01	5.32	98.30
stdev	0.15	0.00	0.01	0.04	0.30	0.05	0.01	0.00	0.25	0.28
486h	56.14	0.00	1.11	0.22	18.50	13.26	0.10	0.02	8.83	98.18
486i	56.56	0.00	0.84	0.22	18.89	13.34	0.11	0.01	8.29	98.26
486j	56.98	0.00	1.24	0.20	19.44	13.14	0.21	0.03	7.07	98.31
avg(3)	56.56	0.00	1.06	0.21	18.94	13.25	0.14	0.02	8.06	98.25
stdev	0.34	0.00	0.17	0.01	0.39	0.08	0.05	0.01	0.90	0.05
485b	57.11	0.09	1.13	0.14	20.82	13.38	0.15	0.03	5.39	98.24
485c	57.59	0.00	0.95	0.16	22.27	13.38	0.10	0.01	3.40	97.86
485d	57.58	0.06	1.04	0.16	21.25	13.11	0.12	0.00	4.87	98.19
485g	56.61	0.10	1.61	0.23	19.88	13.01	0.16	0.03	6.46	98.09
485h	57.32	0.00	1.60	0.16	20.83	13.50	0.17	0.03	5.28	98.89
485i	56.92	0.00	1.18	0.13	19.97	13.30	0.13	0.03	6.47	98.13
485j	54.64	0.04	2.33	0.22	18.34	13.14	0.22	0.06	8.49	97.48
avg(7)	56.82	0.04	1.41	0.17	20.48	13.26	0.15	0.03	5.77	98.13
stdev	0.95	0.04	0.45	0.04	1.15	0.16	0.04	0.02	1.59	0.39

Table B.6 Chemical composition of amphiboles (continued)

Cation abundances normalized to 15 cations and 23 (O)

Sample	Tetrahedral=8 Si	Al_{IV}	C-site=5 Fe^{3+}	Al_{IV}	Fe^{3+}	Ti	Mg	Fe^{2+}	Mn	B-site Ca	Na	B	A-site Ca	Na	K	A	Cations	Anions
Replacing clinopyroxene																		
56a	7.866	0.134	0.000	0.012	0.253	0.010	4.398	0.305	0.022	1.908	0.029	1.937	0.000	0.000	0.004	0.004	14.941	23.000
56b	7.970	0.030	0.000	0.033	0.036	0.000	4.460	0.450	0.022	1.976	0.008	1.984	0.000	0.000	0.002	0.002	14.986	23.000
avg(2)	7.918	0.082	0.000	0.023	0.145	0.005	4.429	0.378	0.022	1.942	0.019	1.961	0.000	0.000	0.003	0.003	14.964	
stdev	0.052	0.052	0.000	0.010	0.109	0.005	0.031	0.072	0.000	0.034	0.010	0.023	0.000	0.000	0.001	0.001	0.022	
58a	7.849	0.151	0.000	0.038	0.195	0.003	4.047	0.691	0.026	1.938	0.030	1.968	0.000	0.000	0.005	0.005	14.973	23.000
58b	7.742	0.199	0.059	0.000	0.470	0.015	4.363	0.129	0.023	1.875	0.003	1.878	0.000	0.000	0.005	0.005	14.883	23.000
58c	7.976	0.013	0.012	0.000	0.103	0.001	4.660	0.217	0.020	1.960	0.000	1.960	0.000	0.000	0.000	0.000	14.960	23.000
avg(3)	7.856	0.121	0.024	0.013	0.256	0.006	4.357	0.346	0.023	1.924	0.011	1.935	0.000	0.000	0.003	0.003	14.939	
stdev	0.096	0.079	0.025	0.018	0.156	0.006	0.250	0.247	0.002	0.036	0.013	0.041	0.000	0.000	0.002	0.002	0.040	
110a	7.969	0.031	0.000	0.025	0.103	0.000	4.456	0.405	0.010	1.949	0.003	1.952	0.000	0.002	0.002	0.002	24.954	23.000
110b	7.980	0.020	0.000	0.016	0.047	0.005	4.470	0.451	0.012	1.973	0.000	1.973	0.000	0.000	0.000	0.000	14.973	23.000
110c	7.916	0.045	0.040	0.000	0.283	0.002	4.675	0.025	0.014	1.898	0.000	1.898	0.000	0.000	0.000	0.000	14.899	23.000
110d	7.993	0.007	0.000	0.026	0.065	0.001	4.409	0.477	0.022	1.956	0.000	1.956	0.000	0.000	0.002	0.002	14.958	23.000
110e	7.963	0.037	0.000	0.009	0.050	0.000	4.322	0.601	0.018	1.988	0.000	1.988	0.000	0.000	0.002	0.002	14.990	23.000
110f	7.947	0.050	0.003	0.000	0.066	0.000	4.364	0.552	0.019	1.989	0.005	1.994	0.000	0.000	0.004	0.004	14.998	23.000
110i	7.952	0.041	0.007	0.000	0.063	0.000	4.394	0.531	0.012	1.992	0.000	1.992	0.000	0.000	0.000	0.000	14.992	23.000
110j	7.959	0.041	0.000	0.010	0.067	0.006	4.295	0.608	0.014	1.971	0.005	1.977	0.000	0.000	0.004	0.004	14.980	23.000
avg(8)	7.960	0.034	0.006	0.011	0.093	0.002	4.423	0.456	0.015	1.965	0.002	1.966	0.000	0.000	0.002	0.002	14.968	
stdev	0.022	0.013	0.013	0.010	0.074	0.002	0.111	0.176	0.004	0.029	0.002	0.030	0.000	0.000	0.001	0.001	0.030	
471a	7.875	0.125	0.000	0.237	0.000	0.013	3.760	0.973	0.017	1.990	0.010	2.000	0.000	0.043	0.009	0.052	15.052	23.090
471b	7.801	0.199	0.000	0.156	0.014	0.000	3.809	1.000	0.019	1.983	0.017	2.000	0.000	0.036	0.009	0.045	15.045	23.000
471c	7.798	0.202	0.000	0.278	0.000	0.014	3.628	1.066	0.014	1.984	0.016	2.000	0.000	0.074	0.019	0.093	15.093	23.091
471d	7.806	0.194	0.000	0.178	0.000	0.018	3.785	1.005	0.013	1.995	0.005	2.000	0.000	0.062	0.013	0.075	15.075	23.046
471e	7.586	0.414	0.000	0.211	0.104	0.004	3.655	1.013	0.012	1.965	0.035	2.000	0.000	0.101	0.024	0.125	15.125	23.000
avg(5)	7.773	0.227	0.000	0.212	0.024	0.010	3.727	1.011	0.015	1.983	0.017	2.000	0.000	0.063	0.015	0.078	15.078	
stdev	0.098	0.098	0.000	0.043	0.041	0.007	0.072	0.030	0.003	0.010	0.010	0.000	0.000	0.023	0.006	0.029	0.029	
472b	7.650	0.350	0.000	0.264	0.000	0.000	3.668	1.051	0.017	1.985	0.015	2.000	0.000	0.115	0.022	0.136	15.136	23.018
472c	7.544	0.456	0.000	0.306	0.217	0.010	3.716	0.739	0.012	1.927	0.052	1.979	0.000	0.000	0.007	0.007	14.986	23.000
avg(2)	7.597	0.403	0.000	0.285	0.109	0.005	3.692	0.895	0.015	1.956	0.034	1.990	0.000	0.058	0.014	0.072	15.061	
stdev	0.053	0.053	0.000	0.021	0.109	0.005	0.024	0.156	0.003	0.029	0.018	0.011	0.000	0.058	0.008	0.065	0.075	
473a	6.937	1.063	0.000	0.355	0.248	0.068	3.275	1.036	0.017	1.954	0.046	2.000	0.000	0.358	0.011	0.369	15.369	23.000
473b	7.472	0.528	0.000	0.172	0.129	0.065	3.729	0.892	0.013	1.947	0.053	2.000	0.000	0.133	0.018	0.151	15.151	23.000
473c	6.947	1.053	0.000	0.427	0.206	0.074	3.324	0.952	0.017	1.905	0.095	2.000	0.000	0.357	0.009	0.367	15.367	23.000
avg(3)	7.119	0.881	0.000	0.318	0.194	0.069	3.443	0.960	0.016	1.935	0.065	2.000	0.000	0.283	0.013	0.296	15.296	
stdev	0.250	0.250	0.000	0.107	0.049	0.004	0.203	0.059	0.002	0.022	0.022	0.000	0.000	0.106	0.004	0.102	0.102	
476a	7.869	0.131	0.000	0.117	0.000	0.005	4.161	0.701	0.017	1.992	0.008	2.000	0.000	0.024	0.004	0.028	15.028	23.008
478a	7.809	0.191	0.000	0.149	0.088	0.003	3.818	0.927	0.015	1.940	0.060	2.000	0.000	0.000	0.007	0.008	15.008	23.000
478b	7.593	0.407	0.000	0.197	0.163	0.004	3.542	1.075	0.018	1.950	0.050	2.000	0.000	0.066	0.022	0.088	15.088	23.000
avg(2)	7.701	0.299	0.000	0.173	0.126	0.004	3.680	1.001	0.017	1.945	0.055	2.000	0.000	0.033	0.014	0.048	15.048	
stdev	0.108	0.108	0.000	0.024	0.038	0.001	0.138	0.074	0.001	0.005	0.005	0.000	0.000	0.033	0.008	0.040	0.040	
481a	7.787	0.213	0.000	0.124	0.047	0.015	3.628	1.164	0.023	1.972	0.028	2.000	0.000	0.032	0.009	0.041	15.041	23.000
481b	7.805	0.195	0.000	0.148	0.068	0.000	3.646	1.120	0.018	1.950	0.050	2.000	0.000	0.015	0.012	0.028	15.028	23.000
481c	7.755	0.245	0.000	0.098	0.142	0.006	3.638	1.105	0.011	1.958	0.042	2.000	0.000	0.021	0.013	0.034	15.034	23.000
481d	7.781	0.219	0.000	0.079	0.086	0.007	3.654	1.160	0.014	1.988	0.012	2.000	0.000	0.046	0.005	0.051	15.051	23.000
481e	7.920	0.080	0.000	0.070	0.101	0.003	3.548	1.257	0.020	1.935	0.027	1.962	0.000	0.000	0.005	0.005	14.967	23.000
481f	7.676	0.324	0.000	0.131	0.095	0.003	3.638	1.114	0.019	1.995	0.005	2.000	0.000	0.084	0.013	0.096	15.096	23.000
481g	7.729	0.271	0.000	0.072	0.157	0.000	3.662	1.087	0.022	1.981	0.019	2.000	0.000	0.048	0.013	0.060	15.060	23.000
481h	8.035	0.000	0.000	0.448	0.000	0.039	3.440	1.008	0.030	2.000	0.000	2.000	1.334	0.077	0.000	1.411	16.446	24.705
481i	7.746	0.254	0.000	0.187	0.000	0.018	3.601	1.178	0.016	1.987	0.013	2.000	0.000	0.090	0.011	0.101	15.101	23.029
481j	7.806	0.194	0.000	0.093	0.084	0.004	3.719	1.078	0.021	1.973	0.027	2.000	0.000	0.022	0.013	0.034	15.034	23.000
481k	7.713	0.287	0.000	0.131	0.252	0.023	3.681	0.888	0.025	1.873	0.106	1.979	0.000	0.000	0.005	0.005	14.985	23.000
avg(11)	7.796	0.207	0.000	0.144	0.094	0.011	3.623	1.105	0.020	1.965	0.030	1.995	0.121	0.040	0.009	0.170	15.168	
stdev	0.097	0.089	0.000	0.102	0.069	0.011	0.071	0.092	0.005	0.035	0.008	0.012	0.383	0.031	0.004	0.394	0.406	
485a	7.773	0.227	0.000	0.109	0.119	0.000	3.899	0.851	0.021	1.967	0.033	2.000	0.000	0.021	0.011	0.032	15.032	23.000
485f	7.702	0.298	0.000	0.094	0.125	0.027	3.792	0.936	0.026	1.975	0.025	2.000	0.000	0.040	0.009	0.049	15.049	23.000
avg(2)	7.738	0.263	0.000	0.102	0.122	0.014	3.846	0.894	0.024	1.971	0.029	2.000	0.000	0.031	0.010	0.041	15.041	
stdev	0.035	0.035	0.000	0.007	0.003	0.014	0.053	0.042	0.002	0.004	0.004	0.000	0.000	0.009	0.001	0.008	0.009	
486a	7.754	0.246	0.000	0.098	0.130	0.002	3.639	1.112	0.020	1.975	0.025	2.000	0.000	0.030	0.009	0.039	15.039	23.000
486b	7.528	0.472	0.000	0.164	0.159	0.006	3.490	1.153	0.028	1.985	0.015	2.000	0.000	0.126	0.025	0.152	15.152	23.000
486c	7.844	0.156	0.000	0.007	0.177	0.005	3.833	0.952	0.026	1.967	0.024	1.991	0.000	0.000	0.004	0.004	14.995	23.000
486d	7.436	0.564	0.000	0.155	0.208	0.009	3.408	1.199	0.022	1.994	0.006	2.000	0.000	0.154	0.036	0.190	15.190	23.000

Table B.6 Chemical composition of amphiboles (continued)

Cation abundances normalized to 15 cations and 23 (O)

	Tetrahedral=8			C-site=5					B-site				A-site					
Sample	Si	Al_{IV}	Fe^{3+}	Al_{IV}	Fe^{3+}	Ti	Mg	Fe^{2+}	Mn	Ca	Na	B	Ca	Na	K	A	Cations	Anions
486e	7.508	0.492	0.000	0.207	0.150	0.000	3.440	1.172	0.030	1.971	0.029	2.000	0.000	0.133	0.031	0.164	15.164	23.000
486f	7.748	0.252	0.000	0.129	0.077	0.001	3.723	1.052	0.018	1.987	0.013	2.000	0.000	0.045	0.011	0.056	15.056	23.000
486g	7.596	0.404	0.000	0.100	0.260	0.007	3.598	1.015	0.019	1.950	0.050	2.000	0.000	0.060	0.018	0.078	15.078	23.000
486k	7.826	0.174	0.000	0.115	0.082	0.019	4.381	0.391	0.013	1.939	0.053	1.992	0.000	0.000	0.009	0.009	15.000	23.000
486l	7.884	0.116	0.000	0.101	0.006	0.000	3.710	1.160	0.024	1.976	0.024	2.000	0.000	0.022	0.011	0.033	15.033	23.000
486m	7.712	0.288	0.000	0.153	0.065	0.006	3.619	1.135	0.022	1.981	0.019	2.000	0.000	0.060	0.016	0.077	15.077	23.000
486n	7.880	0.120	0.000	0.062	0.032	0.014	3.722	1.147	0.024	1.980	0.020	2.000	0.000	0.016	0.004	).075	15.019	23.000
avg(11)	7.701	0.299	0.000	0.117	0.122	0.006	3.688	1.044	0.022	1.973	0.025	1.998	0.000	0.059	0.016	0.075	15.073	
stdev	0.152	0.152	0.000	0.052	0.074	0.006	0.252	0.218	0.005	0.015	0.014	0.003	0.000	0.052	0.010	0.063	0.064	
Replacing olivine																		
407a	7.958	0.037	0.005	0.000	0.152	0.000	4.451	0.384	0.013	1.945	0.000	1.945	0.000	0.000	0.000	0.000	14.945	23.000
407b	7.983	0.017	0.000	0.010	0.052	0.000	4.438	0.492	0.008	1.977	0.000	1.977	0.000	0.000	0.002	0.002	14.979	23.000
407c	7.954	0.046	0.000	0.031	0.058	0.000	4.399	0.501	0.009	1.976	0.000	1.976	0.000	0.000	0.000	0.000	14.978	23.000
407d	7.986	0.014	0.000	0.027	0.001	0.002	4.474	0.487	0.009	1.991	0.000	1.991	0.000	0.000	0.000	0.000	14.991	23.000
407e	7.956	0.039	0.005	0.000	0.098	0.000	4.515	0.374	0.013	1.973	0.000	1.973	0.000	0.000	0.000	0.000	14.973	23.000
avg(5)	7.967	0.031	0.002	0.014	0.072	0.000	4.455	0.448	0.010	1.972	0.000	1.972	0.000	0.000	0.000	0.000	14.973	
stdev	0.014	0.013	0.002	0.014	0.050	0.001	0.038	0.056	0.002	0.015	0.000	0.015	0.000	0.000	0.001	0.001	0.015	
381a	8.021	0.000	0.000	0.044	0.000	0.006	4.433	0.480	0.015	1.956	0.000	1.956	0.000	0.000	0.005	0.005	14.982	23.028
381b	8.033	0.000	0.000	0.014	0.000	0.000	4.630	0.305	0.010	1.930	0.000	1.930	0.000	0.000	0.000	0.000	14.963	23.003
381c	8.021	0.000	0.000	0.036	0.000	0.000	4.387	0.544	0.012	1.996	0.000	1.996	0.000	0.000	0.000	0.000	15.017	23.056
381d	7.994	0.006	0.000	0.014	0.000	0.000	4.606	0.369	0.011	2.000	0.000	2.000	0.000	0.000	0.000	0.028	15.028	23.033
avg(4)	8.017	0.002	0.000	0.027	0.000	0.002	4.516	0.425	0.012	1.971	0.000	1.971	0.000	0.000	0.001	0.008	14.998	
stdev	0.014	0.003	0.000	0.013	0.000	0.003	0.108	0.093	0.002	0.029	0.000	0.029	0.000	0.000	0.002	0.012	0.026	
321a	7.968	0.032	0.000	0.022	0.036	0.000	4.437	0.496	0.009	1.981	0.008	1.989	0.00	0.00	0.005	0.005	14.994	23.000
321b	8.031	0.000	0.000	0.024	0.000	0.000	4.557	0.379	0.008	1.957	0.000	1.957	0.00	0.00	0.002	0.002	14.990	23.033
avg(2)	8.000	0.016	0.000	0.023	0.018	0.000	4.497	0.438	0.009	1.969	0.004	1.973	0.00	0.00	0.004	0.004	14.992	
stdev	0.032	0.016	0.000	0.001	0.018	0.000	0.060	0.058	0.000	0.012	0.004	0.016	0.00	0.00	0.001	0.001	0.002	
319a	8.051	0.000	0.000	0.020	0.000	0.006	4.466	0.442	0.014	1.915	0.003	1.917	0.000	0.000	0.002	0.002	14.970	23.035
319b	8.068	0.000	0.000	0.026	0.000	0.004	4.316	0.570	0.015	1.908	0.008	1.916	0.000	0.000	0.005	0.005	14.990	23.069
319c	8.047	0.000	0.000	0.017	0.000	0.000	4.496	0.430	0.011	1.930	0.005	1.936	0.000	0.000	0.004	0.004	14.987	23.038
avg(3)	8.055	0.000	0.000	0.021	0.000	0.003	4.426	0.481	0.013	1.918	0.005	1.923	0.000	0.000	0.004	0.004	14.982	
stdev	0.009	0.000	0.000	0.004	0.000	0.002	0.079	0.063	0.002	0.009	0.002	0.009	0.000	0.000	0.001	0.001	0.009	
317a	8.007	0.000	0.000	0.031	0.000	0.004	3.420	1.517	0.021	1.976	0.000	1.976	0.000	0.000	0.000	0.000	14.982	23.009
317b	7.980	0.020	0.000	0.036	0.018	0.000	3.570	1.359	0.017	1.980	0.006	1.986	0.000	0.000	0.000	0.000	14.986	23.000
317c	7.955	0.045	0.000	0.012	0.041	0.000	3.959	0.973	0.015	1.996	0.000	1.996	0.000	0.000	0.000	0.000	14.996	23.000
avg(3)	7.981	0.022	0.000	0.026	0.020	0.001	3.650	1.283	0.018	1.984	0.002	1.986	0.000	0.000	0.000	0.000	14.988	
stdev	0.026	0.023	0.000	0.013	0.021	0.002	0.278	0.280	0.003	0.011	0.003	0.010	0.000	0.000	0.000	0.000	0.007	
313a	7.954	0.046	0.000	0.026	0.017	0.004	4.477	0.460	0.016	1.987	0.013	2.000	0.000	0.006	0.002	0.008	15.008	23.000
313b	7.952	0.038	0.010	0.000	0.128	0.000	4.402	0.451	0.020	1.956	0.005	1.961	0.000	0.000	0.004	0.004	14.965	23.000
avg(2)	7.953	0.042	0.005	0.013	0.073	0.002	4.440	0.456	0.018	1.972	0.009	1.981	0.000	0.003	0.003	0.006	14.987	
stdev	0.001	0.006	0.007	0.018	0.078	0.002	0.053	0.006	0.003	0.022	0.006	0.028	0.000	0.004	0.001	0.003	0.030	
78a	7.901	0.067	0.033	0.000	0.206	0.003	4.549	0.227	0.015	1.942	0.003	1.945	0.000	0.000	0.000	0.000	14.945	23.000
78b	7.897	0.067	0.036	0.000	0.159	0.000	4.512	0.318	0.011	1.969	0.003	1.972	0.000	0.000	0.004	0.004	14.975	23.000
78c	7.915	0.049	0.036	0.000	0.207	0.000	4.528	0.253	0.012	1.936	0.005	1.942	0.000	0.000	0.000	0.000	14.942	23.000
avg(3)	7.904	0.061	0.035	0.000	0.191	0.001	4.530	0.266	0.013	1.949	0.004	1.953	0.000	0.000	0.001	0.001	14.954	
stdev	0.008	0.008	0.001	0.000	0.022	0.001	0.015	0.038	0.002	0.014	0.001	0.013	0.000	0.000	0.002	0.002	0.015	
58c	8.021	0.000	0.000	0.029	0.000	0.000	4.293	0.637	0.021	1.947	0.000	1.947	0.000	0.000	0.000	0.000	14.968	23.003
58d	7.991	0.009	0.000	0.005	0.031	0.000	4.694	0.257	0.013	1.985	0.003	1.988	0.000	0.000	0.002	0.002	14.989	23.000
58e	7.974	0.014	0.011	0.000	0.098	0.000	4.643	0.238	0.022	1.963	0.000	1.963	0.000	0.000	0.002	0.002	14.965	23.000
avg(2)	7.995	0.008	0.004	0.011	0.043	0.000	4.543	0.377	0.019	1.965	0.001	1.966	0.000	0.000	0.001	0.001	14.974	
stdev	0.019	0.006	0.005	0.013	0.041	0.000	0.178	0.184	0.004	0.016	0.001	0.016	0.000	0.000	0.001	0.001	0.011	
56c	8.004	0.000	0.000	0.008	0.071	0.000	4.470	0.422	0.026	1.952	0.000	1.952	0.000	0.000	0.002	0.002	14.958	23.000
56d	8.028	0.000	0.000	0.008	0.016	0.000	4.442	0.481	0.028	1.931	0.000	1.931	0.000	0.000	0.000	0.000	14.959	23.000
avg(2)	8.016	0.000	0.000	0.008	0.044	0.000	4.456	0.452	0.025	1.942	0.000	1.942	0.000	0.000	0.001	0.001	14.959	
stdev	0.012	0.000	0.000	0.000	0.028	0.000	0.014	0.029	0.001	0.010	0.000	0.010	0.000	0.000	0.001	0.001	0.000	
233a	8.032	0.000	0.000	0.006	0.000	0.000	4.628	0.328	0.006	1.954	0.006	1.957	0.000	0.000	0.003	0.003	14.992	23.024
233b	8.023	0.000	0.000	0.006	0.000	0.000	4.616	0.343	0.012	1.949	0.000	1.949	0.000	0.000	0.005	0.005	14.978	23.001
233c	8.047	0.000	0.000	0.023	0.000	0.000	4.542	0.379	0.009	1.957	0.008	1.965	0.000	0.000	0.002	0.002	15.014	23.067
233d	8.018	0.000	0.000	0.029	0.000	0.000	4.538	0.399	0.015	1.979	0.005	1.984	0.000	0.000	0.003	0.003	15.006	23.034
233e	8.004	0.000	0.000	0.054	0.149	0.000	4.179	0.597	0.018	1.887	0.005	1.893	0.000	0.000	0.000	0.000	14.897	23.000
avg(5)	8.025	0.000	0.000	0.024	0.030	0.000	4.501	0.409	0.012	1.945	0.004	1.950	0.000	0.000	0.003	0.003	14.977	
stdev	0.014	0.000	0.000	0.018	0.060	0.000	0.165	0.097	0.004	0.031	0.003	0.031	0.000	0.000	0.002	0.002	0.042	

Table B.6 Chemical composition of amphiboles (continued)

Cation abundances normalized to 15 cations and 23 (O)

Sample	Tetrahedral=8 Si	Al_{IV}	Fe^{3+}	C-site=5 Al_{IV}	Fe^{3+}	Ti	Mg	Fe^{2+}	Mn	B-site Ca	Na	B	A-site Ca	Na	A	Cations	Anions	
36a	8.609	0.000	0.000	0.013	0.000	0.005	3.519	0.809	0.045	2.000	0.000	2.000	1.661	0.000	0.000	1.661	17.270	25.891
36b	8.567	0.000	0.000	0.010	0.000	0.001	3.600	0.777	0.045	2.000	0.000	2.000	1.725	0.000	0.004	1.729	17.296	25.866
36c	8.583	0.000	0.000	0.010	0.000	0.000	3.626	0.740	0.041	2.000	0.000	2.000	1.735	0.000	0.000	1.735	17.318	25.906
avg(3)	8.586	0.000	0.000	0.011	0.000	0.002	3.582	0.775	0.044	2.000	0.000	2.000	1.707	0.000	0.001	1.708	17.295	
stdev	0.017	0.000	0.000	0.001	0.000	0.002	0.046	0.028	0.002	0.000	0.000	0.000	0.033	0.000	0.002	0.034	0.020	
After orthopyroxene																		
110g	7.931	0.037	0.032	0.000	0.110	0.000	4.424	0.447	0.019	1.977	0.003	1.980	0.000	0.000	0.002	0.002	14.982	23.000
110h	7.972	0.028	0.000	0.006	0.000	0.000	4.348	0.636	0.011	2.000	0.000	2.000	0.013	0.000	0.002	0.015	15.015	23.003
avg(2)	7.952	0.033	0.016	0.003	0.055	0.000	4.386	0.542	0.015	1.989	0.002	1.990	0.007	0.000	0.002	0.009	14.999	
stdev	0.020	0.004	0.016	0.003	0.055	0.000	0.038	0.095	0.004	0.011	0.002	0.010	0.007	0.000	0.000	0.006	0.017	
486h	7.882	0.118	0.000	0.066	0.031	0.000	3.871	1.005	0.026	1.995	0.005	2.000	0.000	0.022	0.004	0.026	15.026	23.000
486i	7.921	0.079	0.000	0.060	0.000	0.000	3.943	0.971	0.026	2.000	0.000	2.000	0.002	0.030	0.002	0.034	15.034	23.008
486j	7.923	0.077	0.000	0.126	0.000	0.000	4.028	0.822	0.024	1.958	0.042	2.000	0.000	0.014	0.005	0.020	15.020	23.013
avg(3)	7.909	0.091	0.000	0.084	0.010	0.000	3.947	0.933	0.025	1.984	0.016	2.000	0.001	0.022	0.004	0.027	15.027	
stdev	0.019	0.019	0.000	0.030	0.015	0.000	0.064	0.079	0.001	0.019	0.019	0.000	0.001	0.007	0.001	0.006	0.006	
485b	7.884	0.116	0.000	0.068	0.025	0.009	4.284	0.598	0.016	1.979	0.021	2.000	0.000	0.019	0.005	0.025	15.025	23.000
485c	7.891	0.109	0.000	0.044	0.108	0.000	4.548	0.282	0.019	1.964	0.027	1.991	0.000	0.000	0.002	0.002	14.993	23.000
485d	7.902	0.098	0.000	0.070	0.128	0.006	4.346	0.431	0.019	1.928	0.032	1.960	0.000	0.000	0.000	0.000	14.960	23.000
485g	7.845	0.155	0.000	0.108	0.114	0.010	4.106	0.635	0.027	1.932	0.043	1.975	0.000	0.000	0.005	0.005	14.980	23.000
485h	7.860	0.140	0.000	0.119	0.003	0.000	4.257	0.602	0.019	1.984	0.016	2.000	0.000	0.029	0.005	0.034	15.034	23.000
485i	7.906	0.094	0.000	0.099	0.000	0.000	4.134	0.752	0.015	1.979	0.021	2.000	0.000	0.014	0.005	0.020	15.020	23.002
485j	7.718	0.282	0.000	0.106	0.119	0.004	3.861	0.883	0.026	1.989	0.011	2.000	0.000	0.049	0.011	0.060	15.060	23.000
avg(7)	7.858	0.142	0.000	0.088	0.071	0.004	4.219	0.598	0.020	1.965	0.024	1.989	0.000	0.016	0.005	0.021	15.010	
stdev	0.061	0.061	0.000	0.025	0.054	0.004	0.199	0.183	0.004	0.023	0.010	0.015	0.000	0.017	0.003	0.020	0.032	

Table B.7 Chemical composition of chlorite

	Weight percent oxide						
Sample	SiO_2	Al_2O_3	Cr_2O_3	MgO	NiO	FeO	Total
455	32.72	13.94	0.22	31.70	0.05	7.37	86.00
407	28.84	19.28	0.05	25.09	0.07	14.08	87.41
381	29.30	17.96	0.49	24.68	0.14	14.02	86.59
381	30.55	16.11	0.32	26.38	0.10	13.66	87.12
avg(2)	29.93	17.04	0.41	25.53	0.12	13.84	86.86
stdev	0.62	0.93	0.08	0.85	0.02	0.18	0.27
375	27.35	23.17	0.01	28.40	0.08	6.82	85.83
375	33.29	12.74	0.00	33.60	0.11	6.31	86.05
avg(2)	30.32	17.96	0.01	31.00	0.10	6.57	85.94
stdev	2.97	5.21	0.01	2.60	0.01	0.25	0.11
318	28.11	19.98	0.02	24.45	0.04	14.08	86.68
318	30.11	16.07	0.06	26.62	0.18	12.83	85.87
avg(2)	29.11	18.03	0.04	25.54	0.11	13.46	86.28
stdev	1.00	1.95	0.02	1.09	0.07	0.62	0.40
78	27.22	19.46	0.40	22.39	0.13	16.04	85.64
78	27.09	20.00	0.00	22.29	0.09	16.33	85.80
avg(2)	27.16	19.73	0.20	22.34	0.11	16.19	85.72
stdev	0.06	0.27	0.20	0.05	0.02	0.15	0.08
246	26.24	21.05	0.03	20.63	0.15	17.40	85.50
246	26.94	19.69	0.06	21.59	0.12	17.28	85.68
avg(2)	26.59	20.37	0.05	21.11	0.14	17.34	85.59
stdev	0.35	0.68	0.02	0.48	0.01	0.06	0.09
241	27.20	19.79	0.04	21.18	0.06	18.06	86.33
241	27.45	19.33	0.00	21.38	0.05	17.41	85.62
avg(2)	27.33	19.56	0.02	21.28	0.06	17.74	85.98
stdev	0.13	0.23	0.02	0.10	0.01	0.33	0.35
110	26.45	20.31	0.17	20.56	0.00	19.38	86.87
110	26.41	19.31	0.06	20.93	0.02	18.90	85.63
avg(2)	26.56	19.84	0.10	20.84	0.02	19.14	86.50
stdev	0.18	0.41	0.05	0.20	0.01	0.20	0.61
11	30.00	18.25	1.49	33.67	0.23	3.68	87.32
11	28.05	18.64	0.04	21.68	0.06	18.60	87.07
11	27.21	19.21	0.08	21.52	0.06	19.31	87.39
11	27.23	19.49	0.41	21.23	0.14	19.02	87.52
11	26.74	19.78	0.06	21.48	0.02	18.52	86.60
11	27.20	19.52	0.08	21.14	0.06	19.31	87.31
11	26.41	20.02	0.04	20.99	0.03	18.96	86.45
11	27.65	19.33	0.23	21.60	0.04	18.16	87.01
11	27.32	19.31	0.36	21.74	0.04	19.05	87.82
11	26.75	19.05	0.50	20.88	0.09	19.10	86.37
avg(10)	27.46	19.26	0.33	22.59	0.08	17.37	87.09
stdev	0.96	0.49	0.42	3.70	0.06	4.58	0.46

Table B.7 Chemical composition of chlorite (continued)

Structural formula normalized to 14(O)							
Sample	Si	Al	Cr	Mg	Ni	Fe	Total
455	3.185	1.599	0.017	4.601	0.004	0.600	10.007
407	2.862	2.255	0.004	3.713	0.006	1.169	10.008
381	2.939	2.123	0.039	3.691	0.011	1.176	9.980
381	3.038	1.888	0.025	3.911	0.008	1.136	10.006
avg(2)	2.989	2.006	0.032	3.801	0.010	1.156	9.993
stdev	0.049	0.118	0.007	0.110	0.002	0.020	0.013
375	2.663	2.659	0.001	4.123	0.006	0.555	10.007
375	3.224	1.454	0.000	4.851	0.009	0.511	10.049
avg(2)	2.944	2.056	0.001	4.487	0.008	0.533	10.028
stdev	0.280	0.603	0.001	0.364	0.001	0.022	0.021
318	2.815	2.358	0.002	3.650	0.003	1.179	10.006
318	3.027	1.904	0.005	3.990	0.015	1.079	10.019
avg(2)	2.921	2.131	0.004	3.820	0.009	1.129	10.013
stdev	0.106	0.227	0.001	0.170	0.006	0.050	0.006
78	2.798	2.357	0.033	3.431	0.011	1.379	10.008
78	2.779	2.417	0.000	3.409	0.007	1.401	10.013
avg(2)	2.789	2.387	0.017	3.420	0.009	1.390	10.011
stdev	0.009	0.030	0.017	0.011	0.002	0.011	0.002
246	2.718	2.570	0.002	3.186	0.012	1.507	9.996
246	2.784	2.398	0.005	3.326	0.010	1.493	10.015
avg(2)	2.751	2.484	0.004	3.256	0.011	1.500	10.006
stdev	0.033	0.086	0.001	0.070	0.001	0.007	0.009
241	2.797	2.398	0.003	3.247	0.005	1.553	10.003
241	2.835	2.353	0.000	3.292	0.004	1.504	9.988
avg(2)	2.816	2.376	0.002	3.270	0.005	1.529	9.996
stdev	0.019	0.023	0.002	0.023	0.000	0.025	0.008
110	2.755	2.409	0.006	3.219	0.002	1.644	10.037
110	2.726	2.466	0.014	3.159	0.000	1.670	10.034
110	2.758	2.377	0.005	3.259	0.002	1.651	10.051
avg(3)	2.746	2.417	0.008	3.212	0.001	1.655	10.041
stdev	0.014	0.037	0.004	0.041	0.001	0.011	0.007
11	2.848	2.041	0.112	4.765	0.018	0.292	10.076
11	2.866	2.244	0.003	3.303	0.005	1.589	10.010
11	2.786	2.318	0.006	3.285	0.005	1.653	10.052
11	2.781	2.346	0.033	3.233	0.012	1.625	10.029
11	2.752	2.399	0.005	3.296	0.002	1.594	10.046
11	2.785	2.356	0.006	3.228	0.005	1.654	10.034
11	2.730	2.439	0.003	3.235	0.002	1.639	10.049
11	2.822	2.325	0.019	3.287	0.003	1.550	10.006
11	2.780	2.316	0.029	3.298	0.003	1.621	10.048
11	2.775	2.329	0.041	3.230	0.008	1.657	10.040
avg(10)	2.793	2.311	0.026	3.416	0.006	1.487	10.039
stdev	0.039	0.103	0.032	0.451	0.005	0.400	0.020

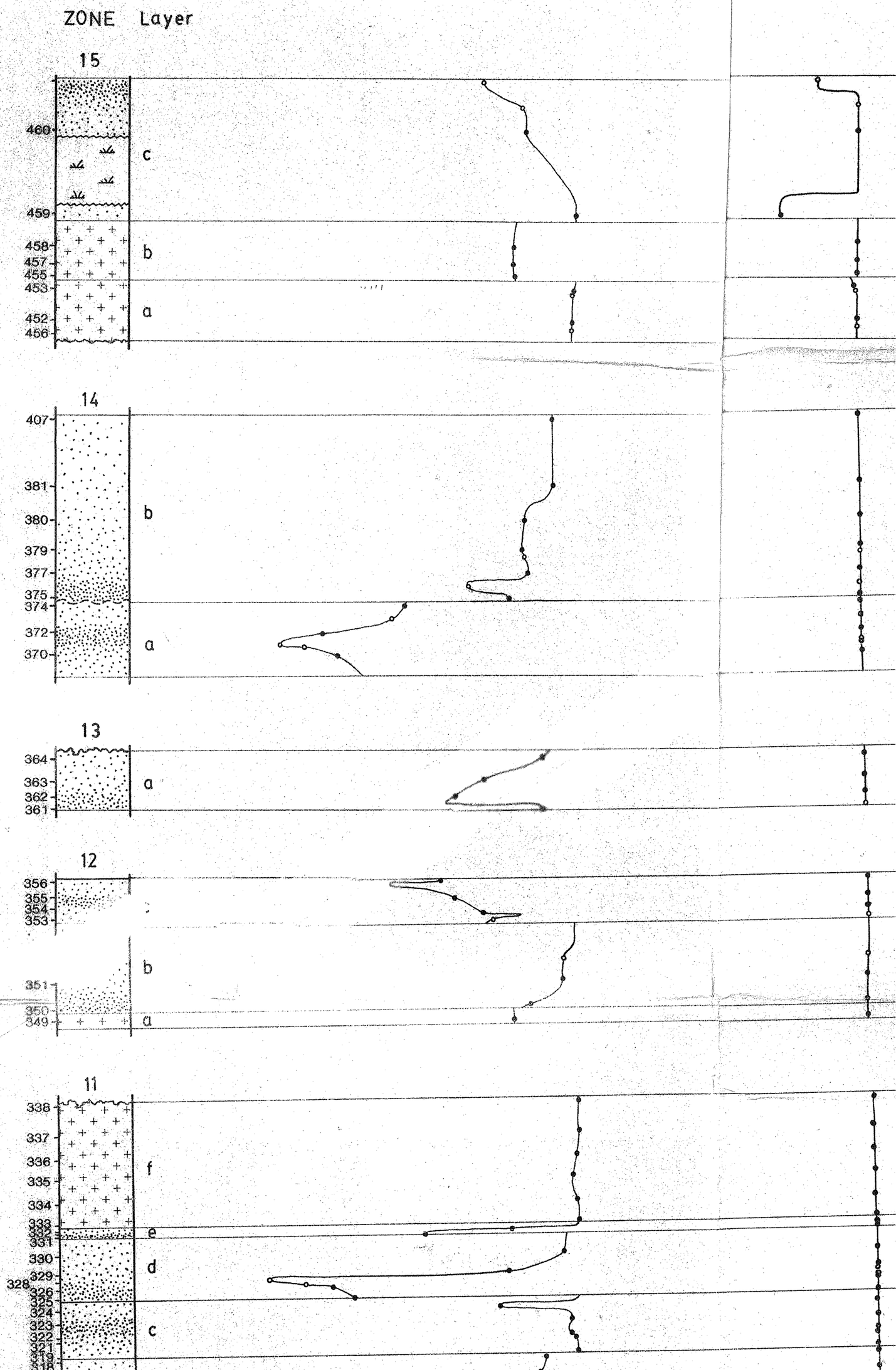
Table B.8: Chemical composition of the serpentines

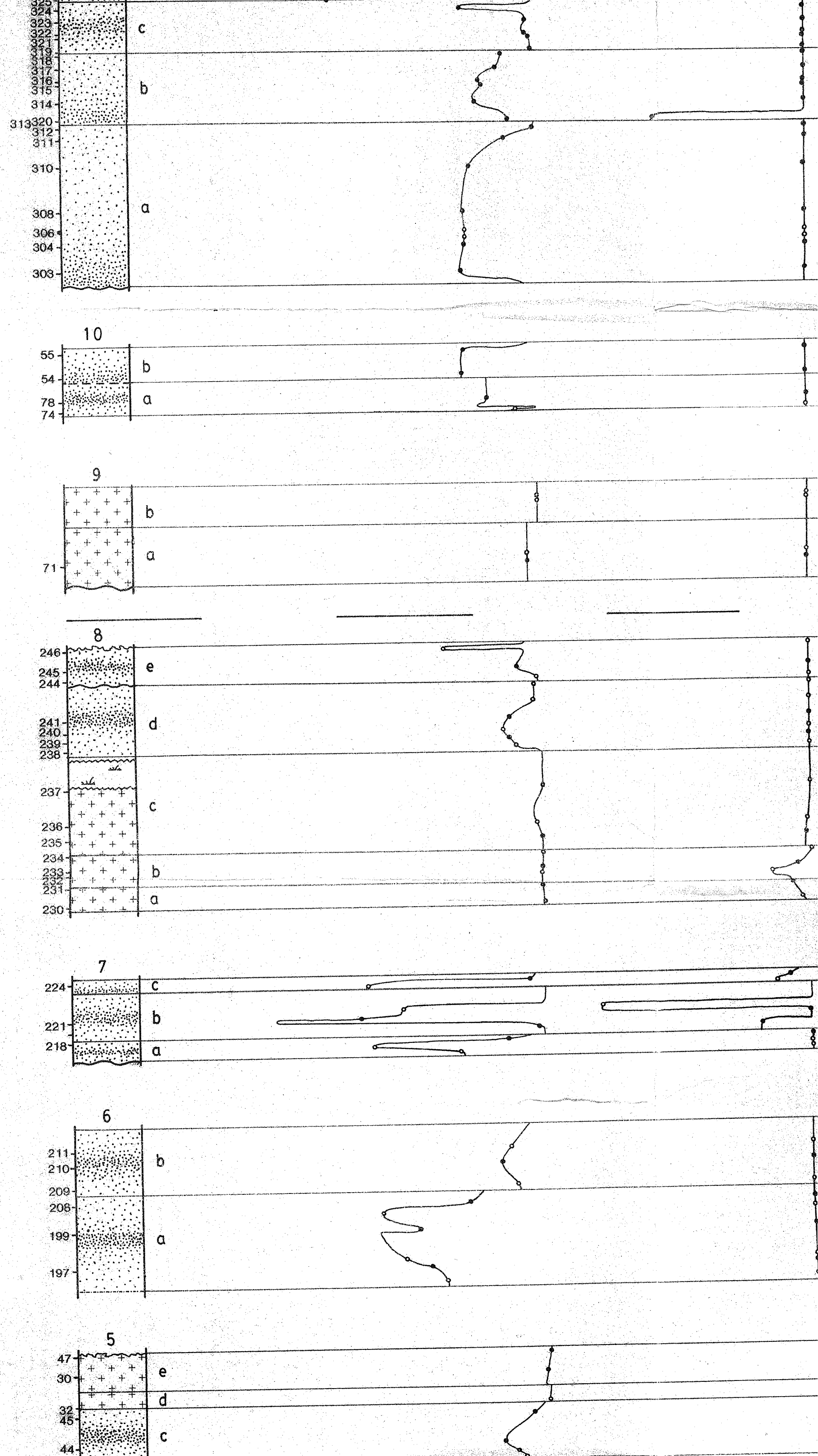
	Weight percent oxide						
Sample	SiO_2	Al_2O_3	Cr_2O_3	MgO	NiO	FeO	Total
356	43.77	0.67	0.00	38.91	0.12	3.40	86.87
356	43.69	0.44	0.00	39.03	0.05	3.33	86.54
356	43.73	0.56	0.00	38.97	0.09	3.37	86.71
stdev	0.04	0.11	0.00	0.06	0.03	0.03	0.16
355	42.66	1.01	0.00	37.13	0.12	6.17	87.09
355	43.40	0.59	0.04	37.43	0.12	5.23	86.81
355	43.03	0.80	0.02	37.28	0.12	5.70	86.95
stdev	0.37	0.21	0.02	0.15	0.00	0.47	0.14
354	41.67	1.32	0.04	36.44	0.07	7.23	86.77
354	41.89	0.74	0.05	36.79	0.12	6.64	86.23
354	41.78	1.03	0.05	36.62	0.10	6.94	86.50
stdev	0.11	0.29	0.00	0.17	0.03	0.29	0.27
353	41.93	1.11	0.03	35.17	0.13	8.58	86.95
353	42.60	0.69	0.00	36.11	0.09	7.71	87.20
353	42.27	0.90	0.02	35.64	0.11	8.15	87.08
stdev	0.33	0.21	0.02	0.47	0.02	0.44	0.13
350	41.73	1.23	0.00	35.74	0.07	8.02	86.79
350	41.88	0.98	0.00	35.54	0.06	7.82	86.28
350	41.81	1.11	0.00	35.64	0.07	7.92	86.54
stdev	0.07	0.13	0.00	0.10	0.01	0.10	0.25
349	41.96	0.75	0.01	36.22	0.10	7.24	86.28
349	42.47	0.50	0.06	35.72	0.07	7.51	86.33
349	42.22	0.63	0.03	35.97	0.09	7.38	86.31
stdev	0.25	0.13	0.03	0.25	0.02	0.14	0.02
336	44.69	0.43	0.01	37.57	0.08	5.29	88.07
336	43.54	0.57	0.02	34.21	0.11	9.50	87.95
336	44.12	0.50	0.02	35.89	0.10	7.40	88.01
stdev	0.57	0.07	0.00	1.68	0.01	2.10	0.06
328	41.57	2.03	0.05	34.14	0.08	9.50	87.37
328	40.21	3.77	0.10	33.01	0.07	10.45	87.61
328	42.16	1.07	0.01	34.59	0.09	9.32	87.24
328	41.31	2.29	0.05	33.91	0.08	9.76	87.41
stdev	0.82	1.12	0.04	0.66	0.01	0.50	0.15
326	43.43	0.31	0.02	37.40	0.13	6.91	88.20
326	43.12	0.42	0.00	36.91	0.18	6.95	87.58
326	41.71	1.05	0.07	36.57	0.13	7.32	86.85
326	42.51	0.41	0.00	35.54	0.14	8.52	87.12
326	42.69	0.55	0.02	36.61	0.15	7.43	87.44
stdev	0.66	0.29	0.03	0.68	0.02	0.65	0.51
325	42.55	0.70	0.00	36.39	0.08	7.35	87.07
325	43.02	0.34	0.00	36.25	0.12	7.33	87.06
325	42.79	0.52	0.00	36.32	0.10	7.34	87.07
stdev	0.23	0.18	0.00	0.07	0.02	0.01	0.00
314	42.01	1.52	0.00	34.04	0.10	9.85	87.52
314	43.15	0.73	0.00	34.26	0.10	9.80	88.04
314	42.58	1.13	0.00	34.15	0.10	9.83	87.78
stdev	0.57	0.40	0.00	0.11	0.00	0.02	0.26
311	41.74	1.02	0.02	32.21	0.09	12.16	87.24
308	42.20	1.13	0.05	34.24	0.11	9.26	86.99
303	42.24	1.39	0.00	32.89	0.11	11.42	88.05
56	40.84	2.28	0.42	32.21	0.08	11.35	87.18
56	43.09	0.43	0.00	33.36	0.08	10.82	87.78
56	42.51	0.87	0.00	33.54	0.04	10.99	87.95
56	42.38	1.08	0.02	32.89	0.02	11.17	87.56
56	42.50	0.99	0.00	32.94	0.06	11.32	87.81
56	42.26	1.13	0.09	32.99	0.06	11.13	87.66
stdev	0.75	0.62	0.17	0.46	0.02	0.20	0.27
199	41.52	1.18	0.00	34.68	0.13	9.50	87.01
199	42.07	1.10	0.00	35.04	0.06	8.79	87.06
199	41.80	1.14	0.00	34.86	0.10	9.15	87.04
stdev	0.27	0.04	0.00	0.18	0.04	0.36	0.02

Table B.8: Chemical composition of the serpentines (continued)

	Structural formula normalized to 14(O)						
Sample	Si	Al	Cr	Mg	Ni	Fe	Total
356	4.094	0.074	0.000	5.426	0.009	0.266	9.869
356	4.100	0.049	0.000	5.461	0.004	0.261	9.875
356	4.097	0.062	0.000	5.444	0.007	0.264	9.872
stdev	0.003	0.012	0.000	0.017	0.002	0.003	0.003
355	4.043	0.113	0.000	5.247	0.009	0.489	9.901
355	4.101	0.066	0.003	5.273	0.009	0.413	9.865
355	4.072	0.090	0.002	5.260	0.009	0.451	9.883
stdev	0.029	0.023	0.002	0.013	0.000	0.038	0.018
354	3.992	0.149	0.003	5.204	0.005	0.579	9.932
354	4.027	0.084	0.004	5.272	0.009	0.534	9.930
354	4.010	0.117	0.004	5.238	0.007	0.557	9.931
stdev	0.018	0.032	0.001	0.034	0.002	0.022	0.001
353	4.032	0.126	0.002	5.043	0.010	0.690	9.903
353	4.063	0.078	0.000	5.135	0.007	0.615	9.898
353	4.048	0.102	0.001	5.089	0.009	0.653	9.901
stdev	0.015	0.024	0.001	0.046	0.001	0.037	0.002
350	4.010	0.139	0.000	5.121	0.005	0.645	9.920
350	4.042	0.111	0.000	5.114	0.005	0.631	9.903
350	4.026	0.125	0.000	5.118	0.005	0.638	9.912
stdev	0.016	0.014	0.000	0.003	0.000	0.007	0.009
349	4.040	0.085	0.001	5.200	0.008	0.583	9.917
349	4.087	0.057	0.005	5.125	0.005	0.604	9.883
349	4.064	0.071	0.003	5.163	0.007	0.594	9.900
stdev	0.023	0.014	0.002	0.037	0.001	0.010	0.017
336	4.153	0.047	0.001	5.205	0.006	0.411	9.823
336	4.142	0.064	0.002	4.853	0.008	0.756	9.825
336	4.148	0.056	0.002	5.029	0.007	0.584	9.824
stdev	0.006	0.008	0.001	0.176	0.001	0.173	0.001
328	3.994	0.230	0.004	4.891	0.006	0.763	9.889
328	3.877	0.428	0.008	4.745	0.005	0.843	9.905
328	4.052	0.121	0.001	4.957	0.007	0.749	9.887
328	3.974	0.260	0.004	4.864	0.006	0.785	9.894
stdev	0.073	0.127	0.003	0.089	0.001	0.041	0.008
326	4.079	0.034	0.001	5.237	0.010	0.543	9.903
326	4.080	0.047	0.000	5.207	0.014	0.550	9.897
326	3.997	0.119	0.005	5.224	0.010	0.587	9.941
326	4.077	0.046	0.000	5.082	0.011	0.683	9.900
326	4.058	0.062	0.002	5.188	0.011	0.591	9.910
stdev	0.035	0.034	0.002	0.062	0.002	0.056	0.018
325	4.058	0.079	0.000	5.174	0.006	0.586	9.903
325	4.100	0.038	0.000	5.150	0.009	0.584	9.881
325	4.079	0.059	0.000	5.162	0.008	0.585	9.892
stdev	0.021	0.020	0.000	0.012	0.001	0.001	0.011
314	4.035	0.172	0.000	4.874	0.008	0.791	9.879
314	4.111	0.082	0.002	4.866	0.008	0.781	9.848
314	4.073	0.127	0.001	4.870	0.008	0.786	9.864
stdev	0.038	0.045	0.001	0.004	0.000	0.005	0.016
311	4.070	0.117	0.035	4.683	0.007	0.992	9.870
308	4.065	0.128	0.003	4.917	0.009	0.746	9.869
303	4.061	0.157	0.000	4.715	0.009	0.918	9.860
56	3.976	0.262	0.032	4.676	0.006	0.924	9.877
56	4.138	0.049	0.000	4.776	0.006	0.869	9.838
56	4.082	0.098	0.000	4.802	0.003	0.883	9.868
56	4.089	0.123	0.002	4.732	0.002	0.901	9.848
56	4.093	0.112	0.000	4.729	0.005	0.912	9.851
56	4.076	0.129	0.007	4.743	0.004	0.898	9.856
stdev	0.054	0.071	0.013	0.043	0.002	0.020	0.014
199	4.012	0.134	0.000	4.996	0.010	0.768	9.921
199	4.042	0.125	0.000	5.019	0.005	0.706	9.896
199	4.027	0.130	0.000	5.008	0.008	0.737	9.909
stdev	0.015	0.005	0.000	0.012	0.002	0.031	0.012

PLATE 1. Modal and textural data, mineral chemistry and whole rock chemistry from the Mafic-Ultramafic Group, Reed Lake Pluton. Modal estimates to complete modal and grain size columns. Vertical scale: 1cm = 1m.

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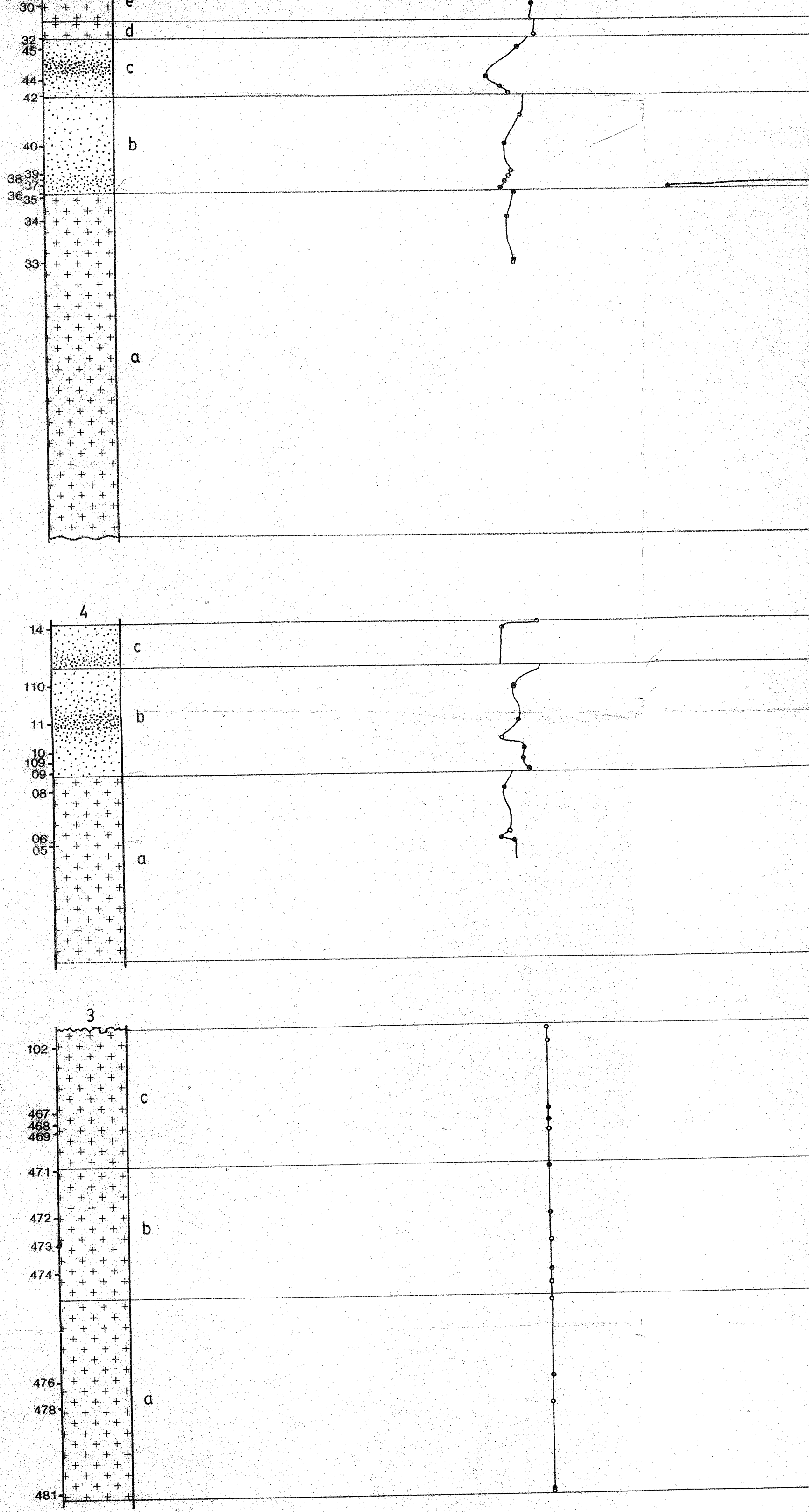
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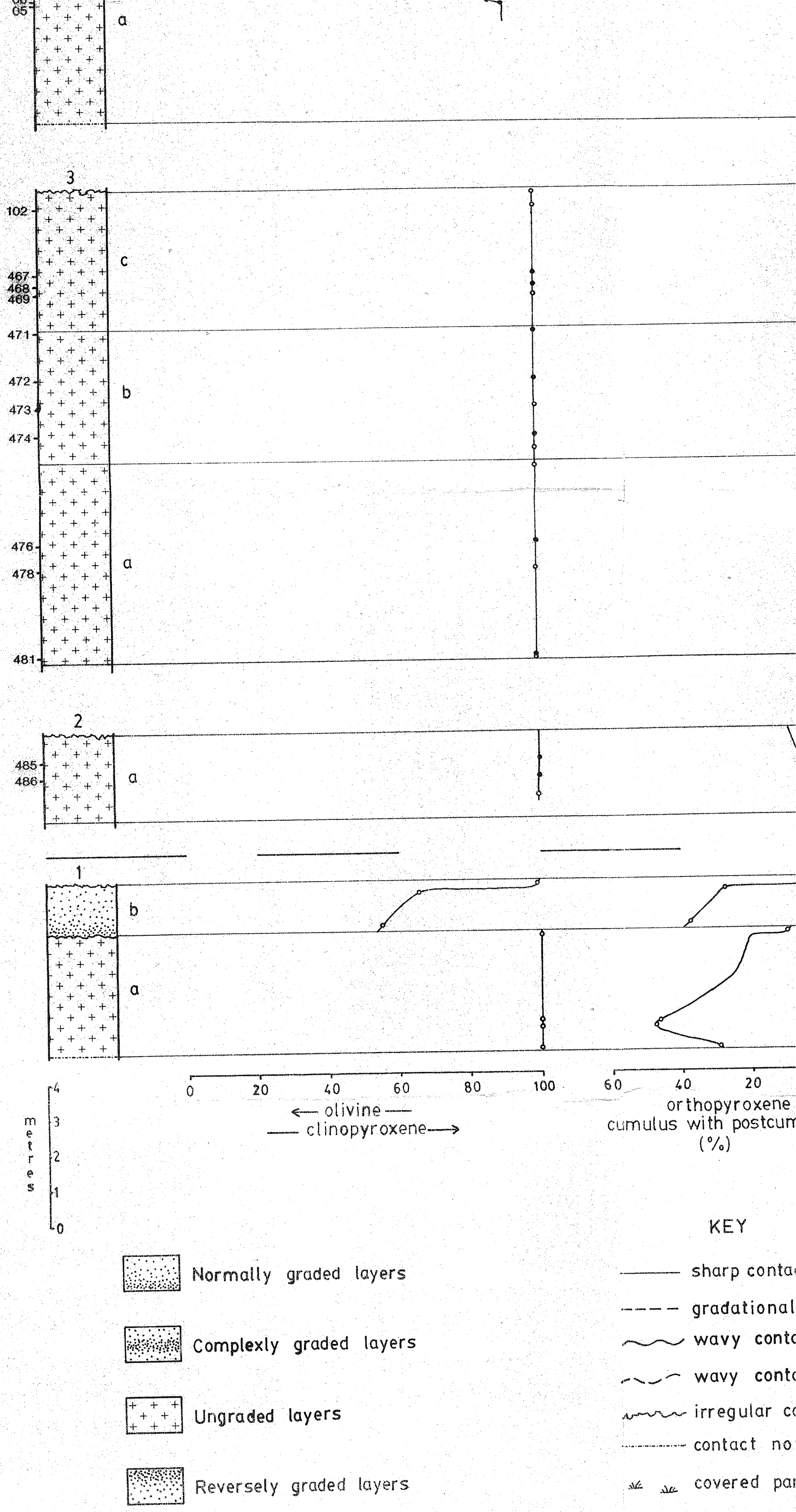
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Complexly graded layers
Ungraded layers
Reversely graded layers
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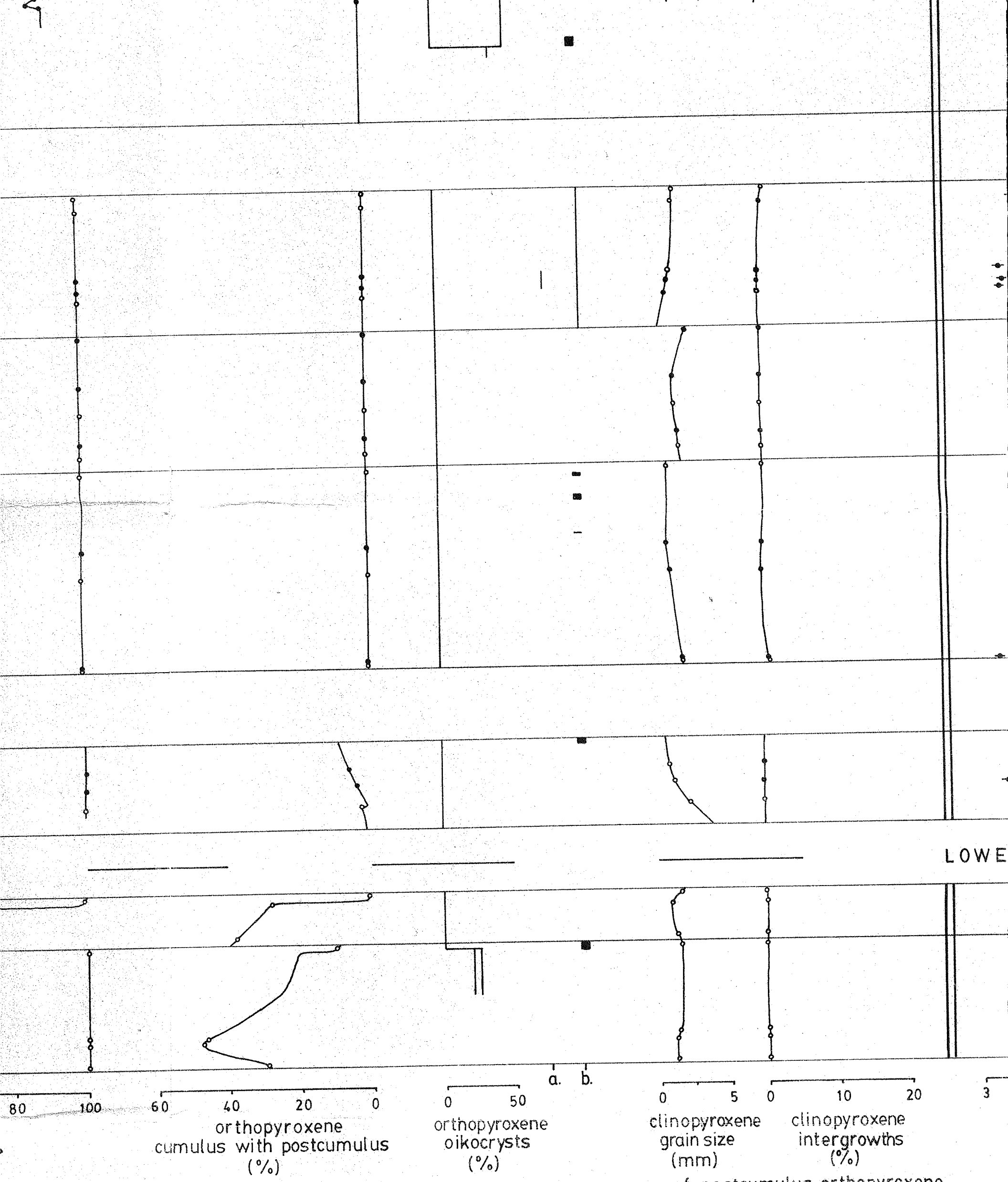

KEY

sharp contact

gradational contact

wavy contact - sharp

wavy contact - gradational

irregular contact

contact not exposed

covered part of section

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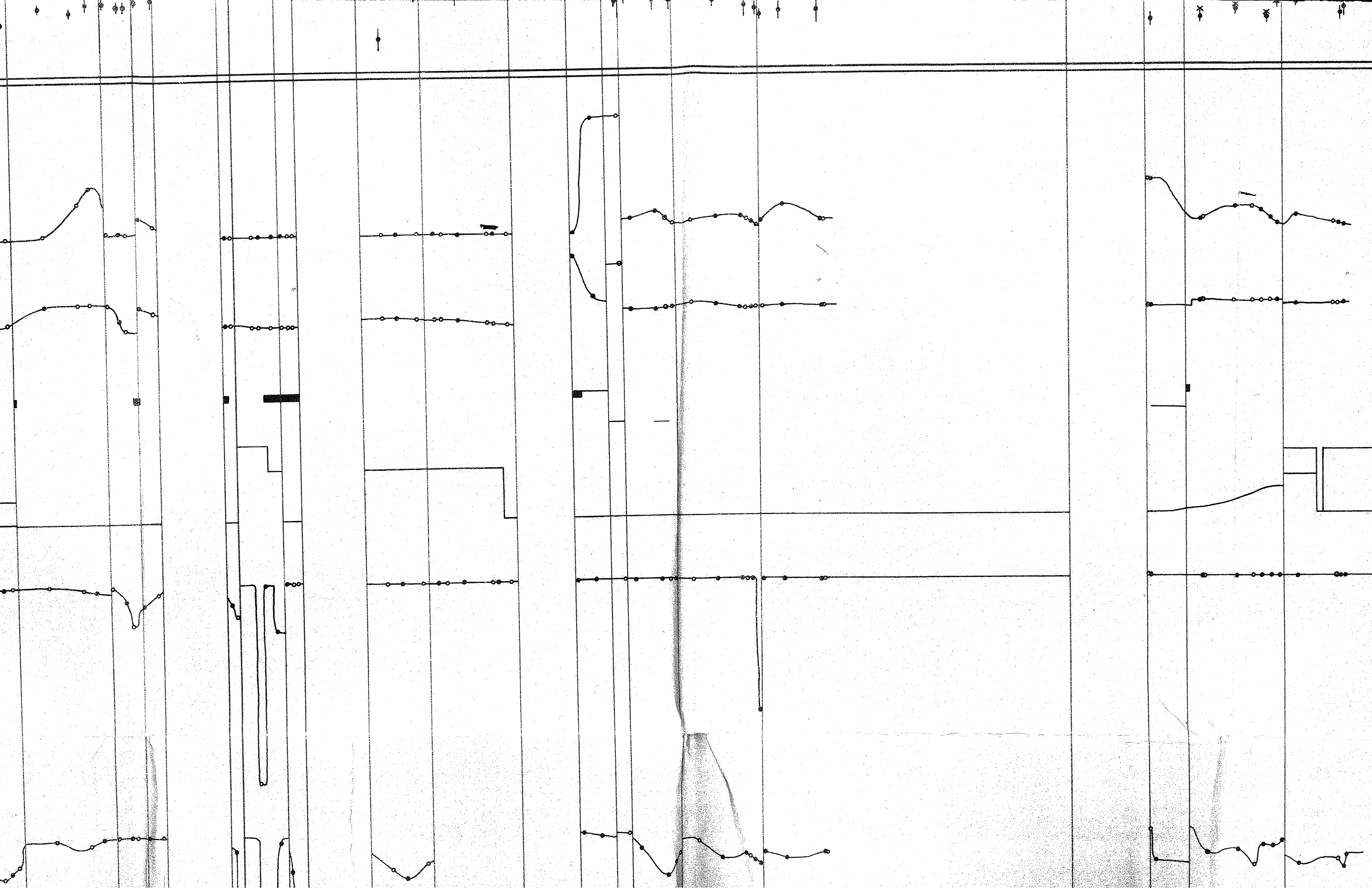
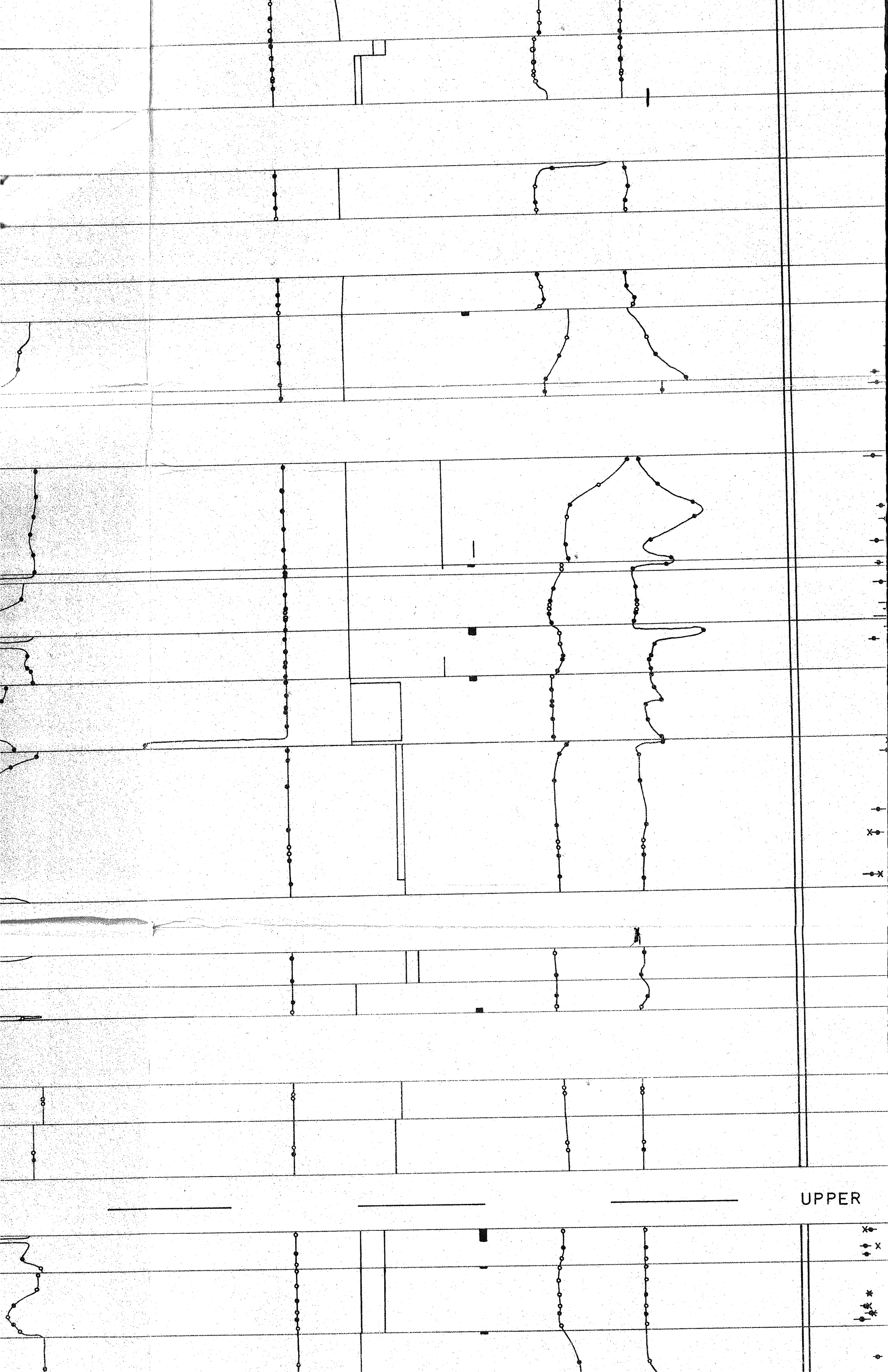
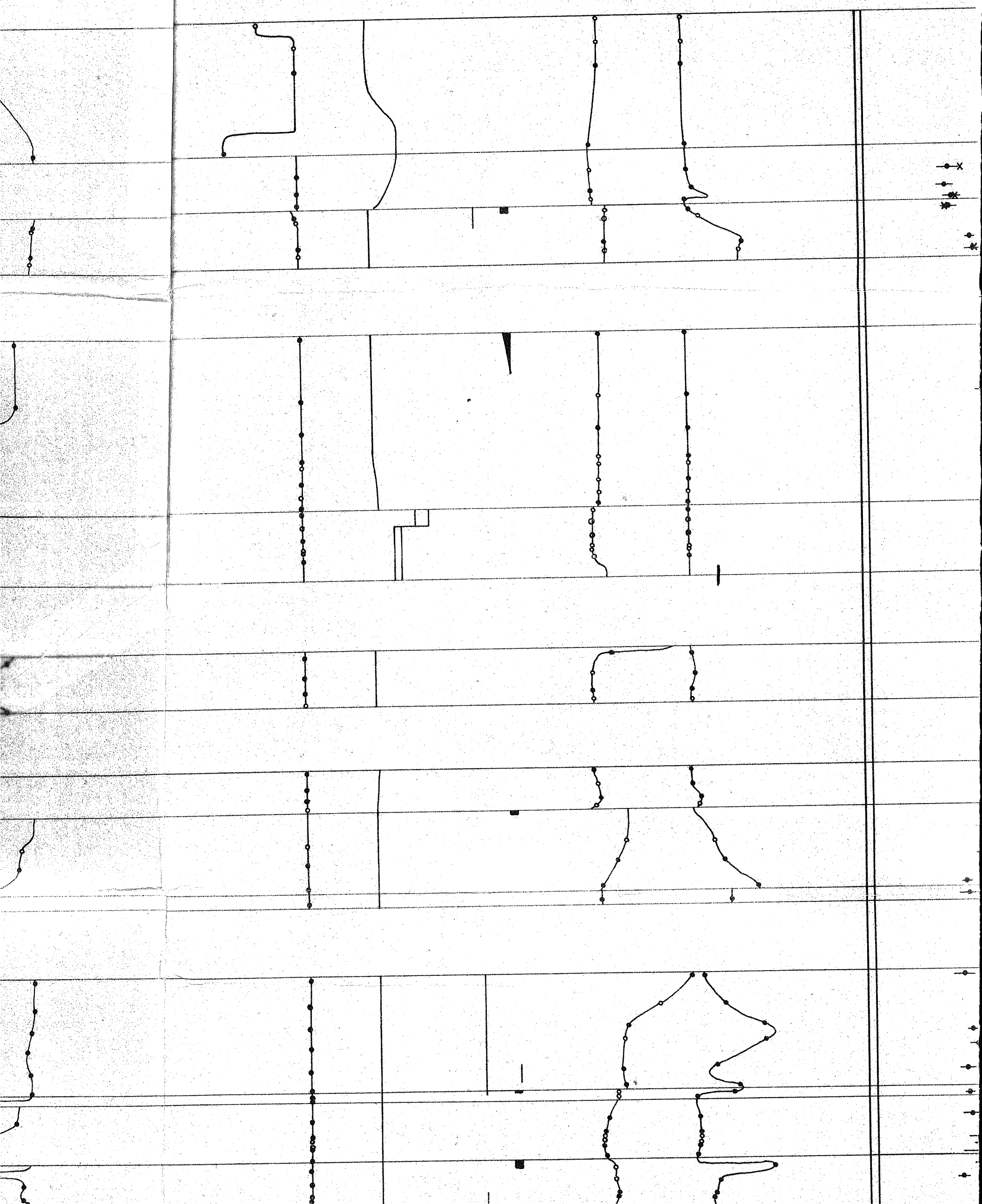
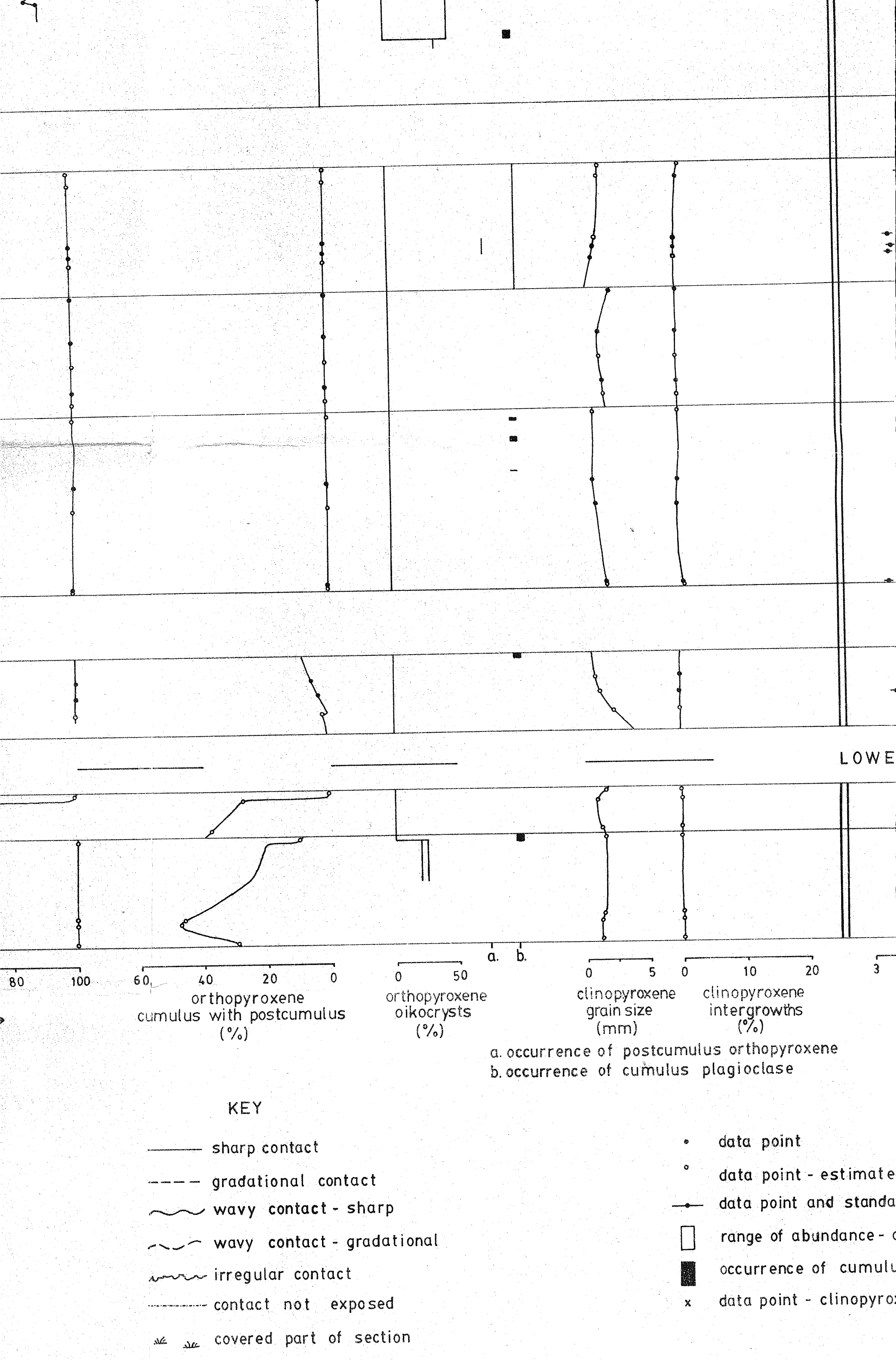
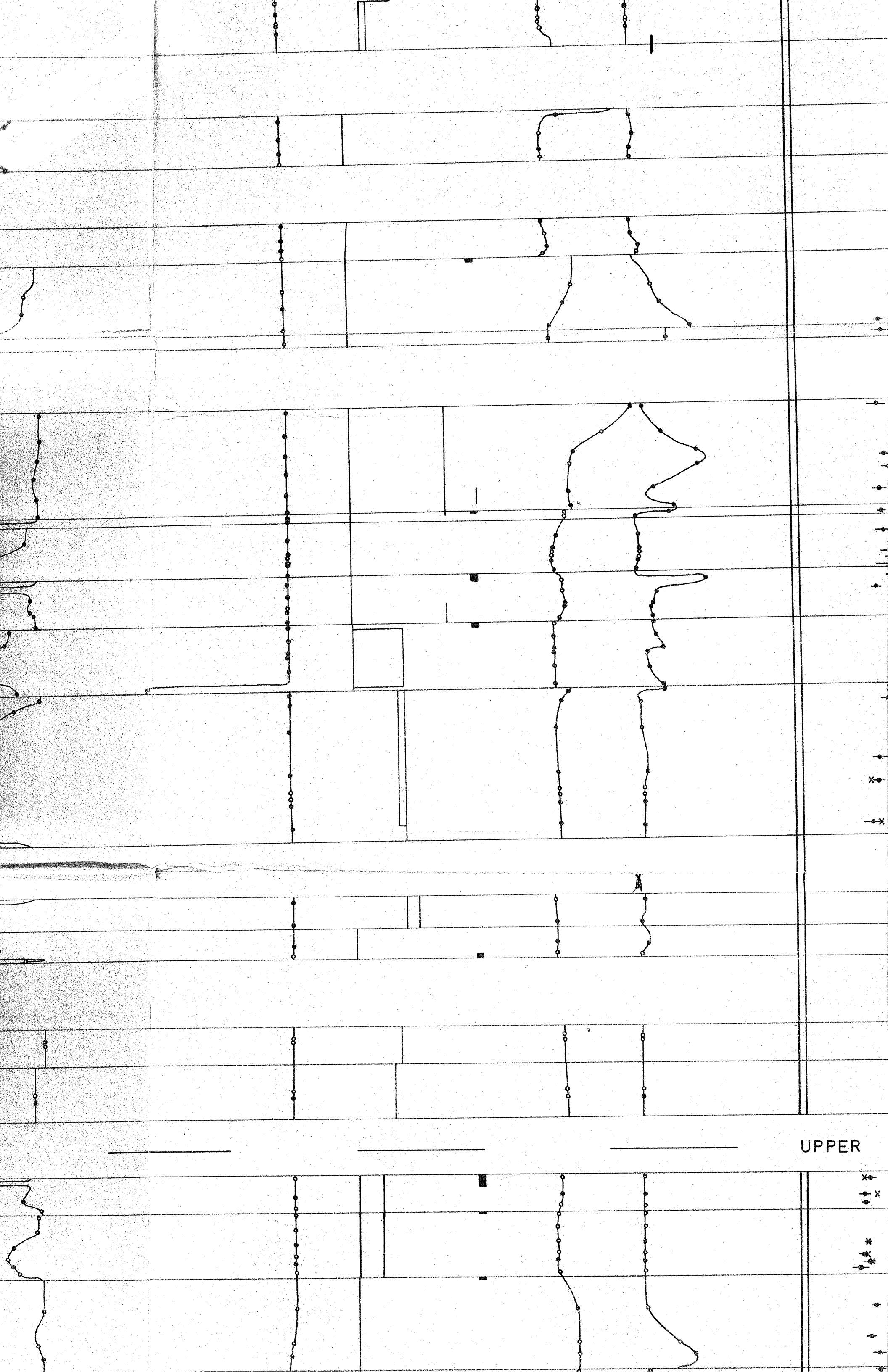



UPPER

chemistry and whole rock chemistry of ultramafic layers and zones
Reed Lake Pluton. Modal estimates from field data are used
olumns. Vertical scale: 1cm = 1m.




LOWE
80
100
60
40
20
0
orthopyroxene
cumulus with postcumulus
(%)
0
50
orthopyroxene
oikocrysts
(%)
a.
b.
0
5
clinopyroxene
grain size
(mm)
0
10
20
clinopyroxene
intergrowths
(%)
3
a. occurrence of postcumulus orthopyroxene
b. occurrence of cumulus plagioclase
KEY
sharp contact
gradational contact
wavy contact - sharp
wavy contact - gradational
irregular contact
contact not exposed
covered part of section
data point
data point - estimate
data point and standa
range of abundance - c
occurrence of cumulu
data point - clinopyro


UPPER

hemistry and whole rock chemistry of ultramafic layers and zones
Reed Lake Pluton. Modal estimates from field data are used
lumns. Vertical scale: 1cm = 1m.

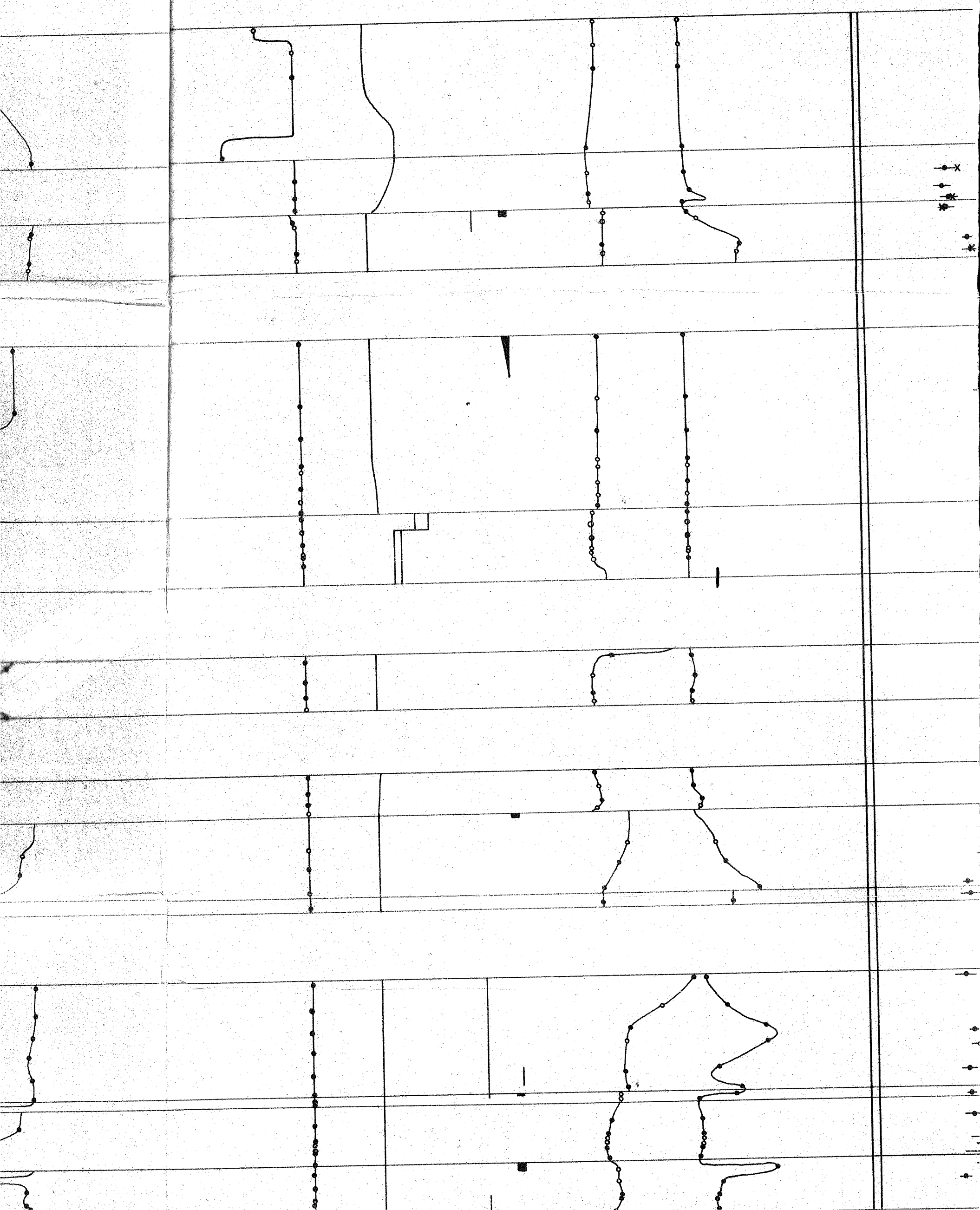
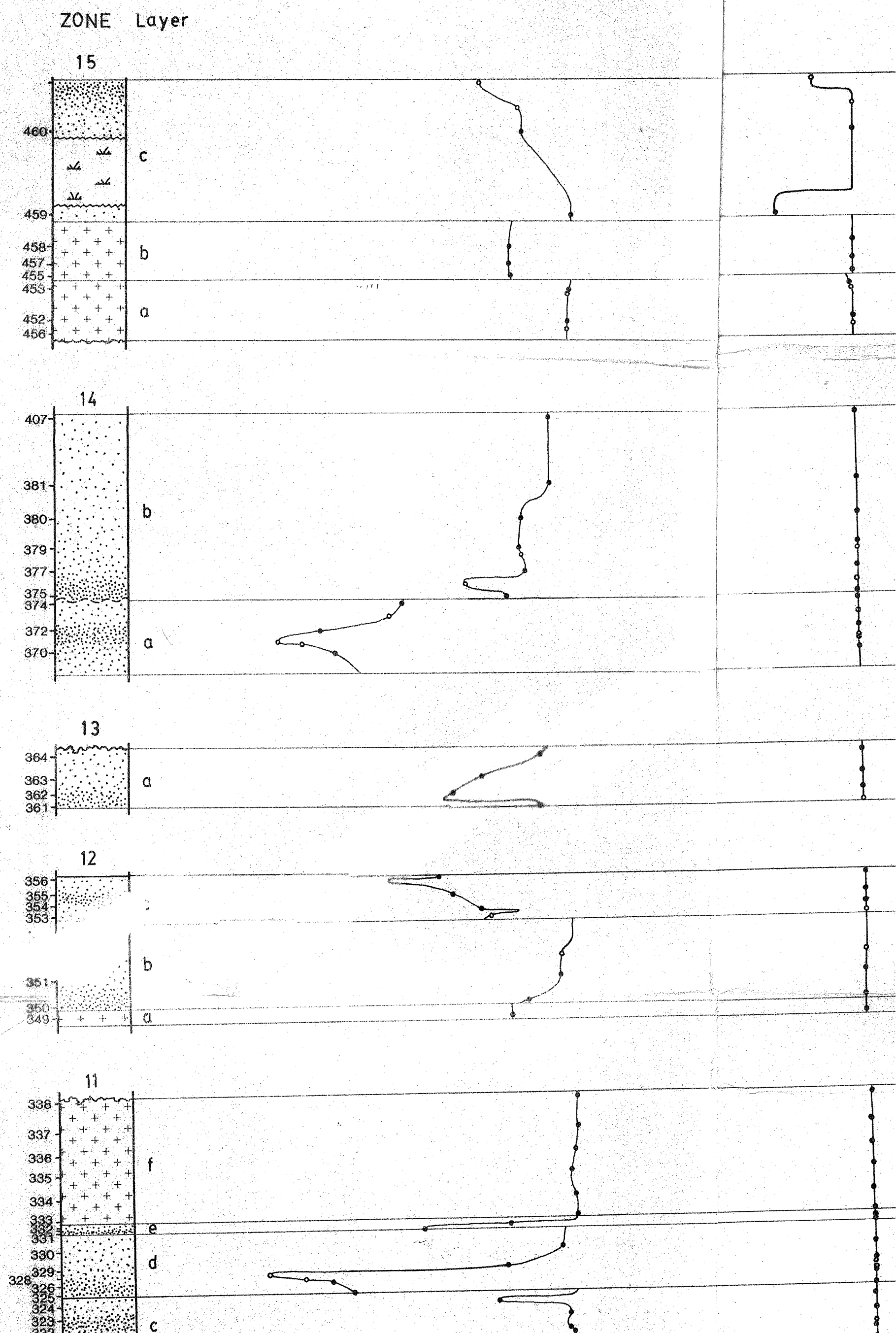
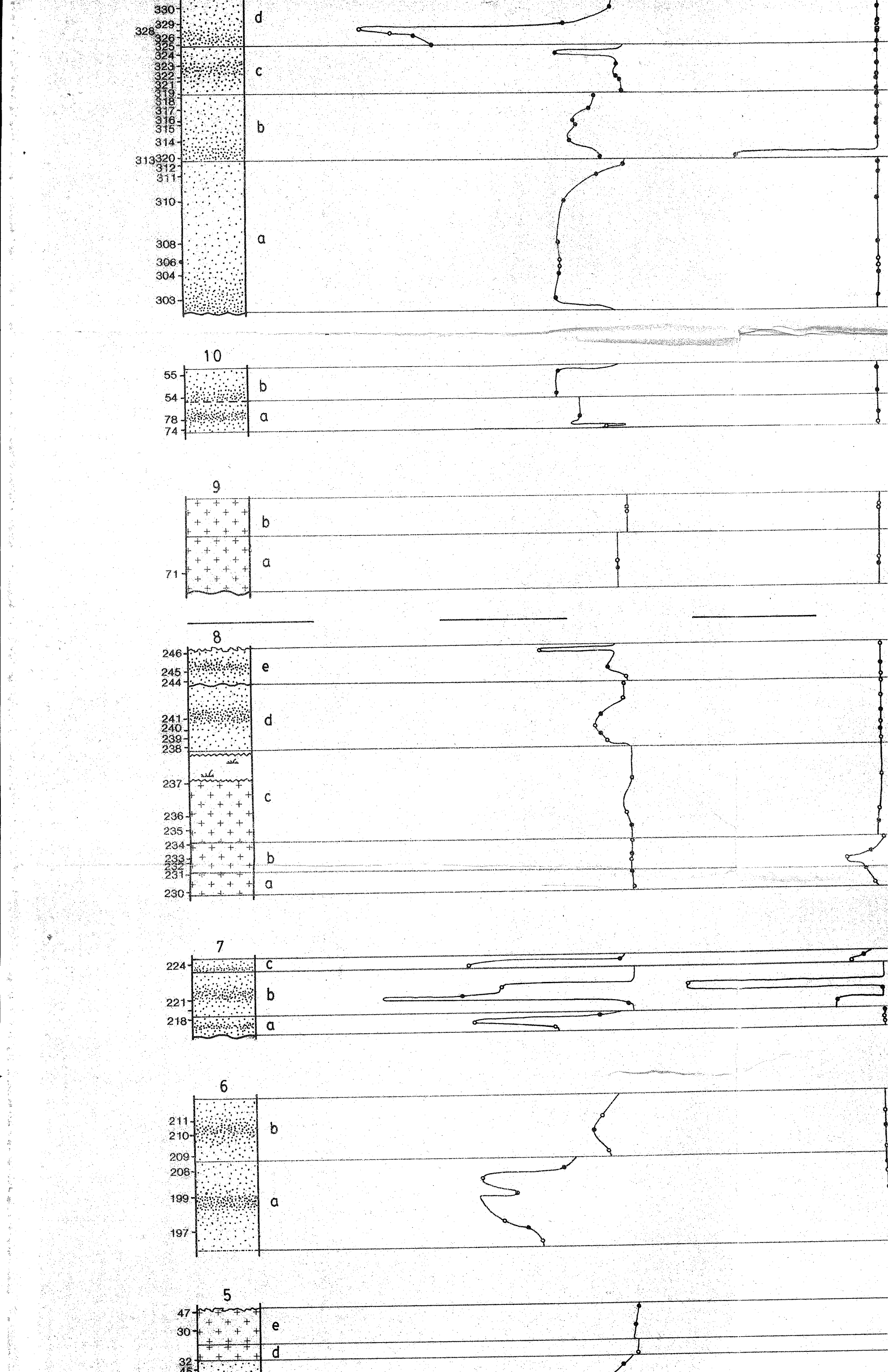
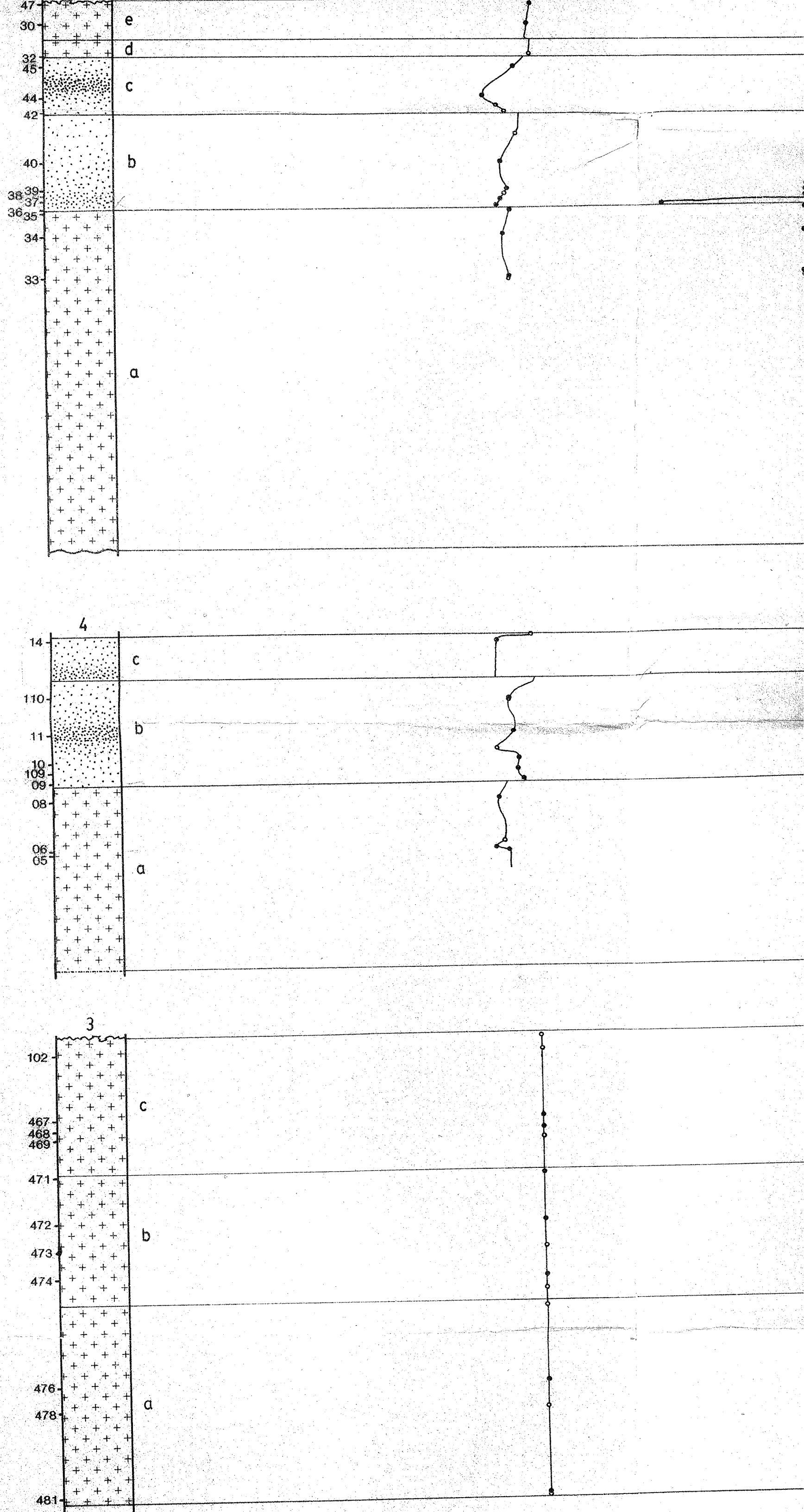
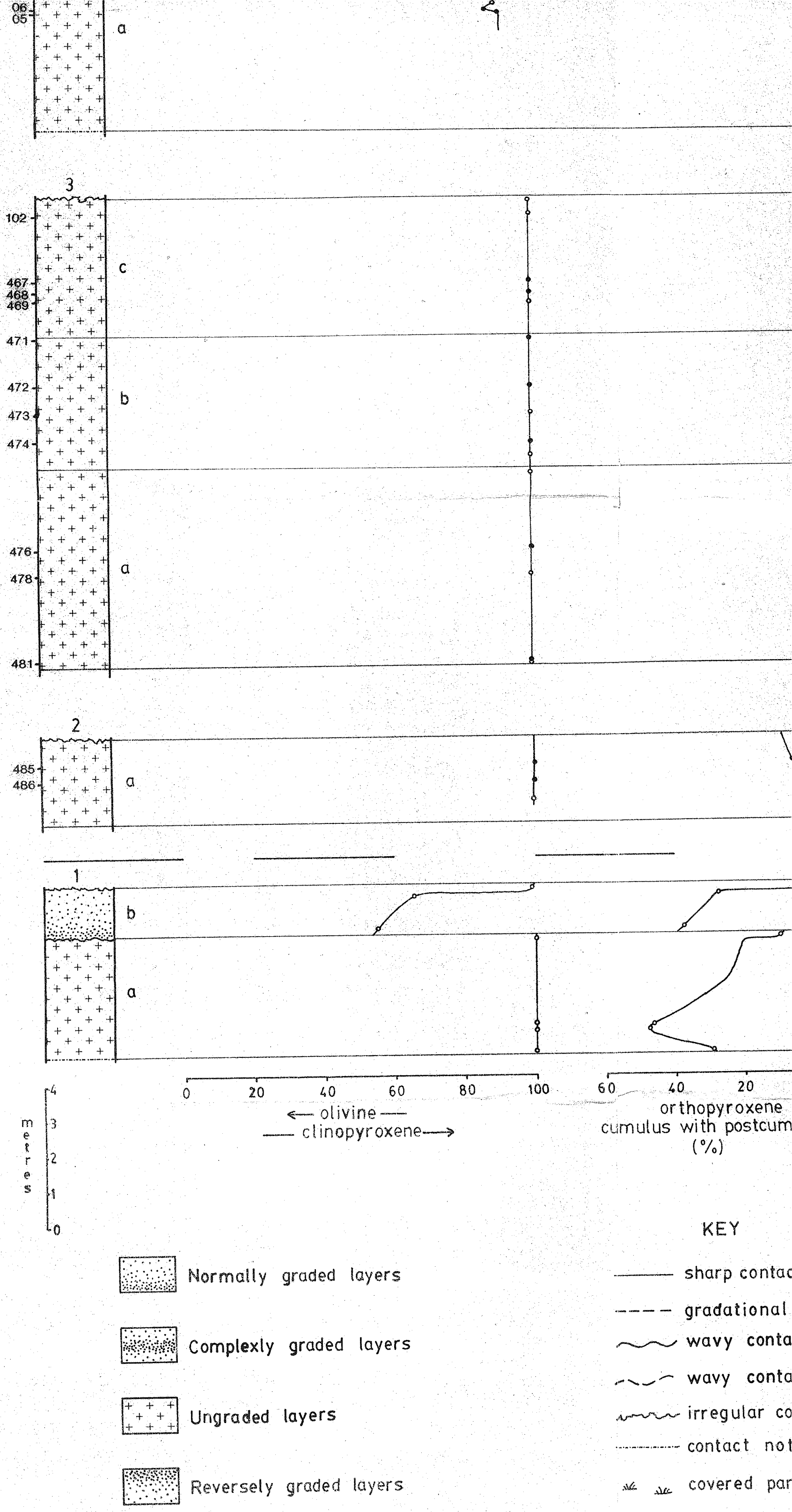


PLATE 1. Modal and textural data, mineral chemistry and whole rock chemistry from the Mafic-Ultramafic Group, Reed Lake Pluton. Modal estimates to complete modal and grain size columns. Vertical scale: 1cm = 1m.




10
55
54
78
74
b
a
9
71
b
a
8
246
245
244
241
240
239
238
237
236
235
234
233
232
231
230
e
d
c
b
a
7
224
221
218
c
b
a
6
211
210
209
208
199
197
b
a
5
47
30
32
e
d


47
30
32
45
44
42
40
39
38
37
36
35
34
33
e
d
c
b
a
4
14
110
11
10
109
09
08
06
05
c
b
a
3
102
467
468
469
471
472
473
474
476
478
481
c
b
a


06
05
a
3
102
467
468
469
471
472
473
474
476
478
481
c
b
a
2
485
486
a
1
b
a
0
20
40
60
80
100
60
40
20
← olivine —
— clinopyroxene →
orthopyroxene
cumulus with postcum
(%)
metres
4
3
2
1
0
KEY
Normally graded layers
Complexly graded layers
Ungraded layers
Reversely graded layers
sharp contac
gradational
wavy conta
wavy conta
irregular co
contact not
covered par