MINERALOGY AND PETROCHEMISTRY OF THE
HURON CLAIM PEGMATITE, SOUTHEASTERN MANITOBA

BY

BRIAN JAMES PAUL

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

MASTER OF SCIENCE

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ABSTRACT

The Huron Claim rare-element pegmatite is located in the Winnipeg River pegmatite district, southeastern Manitoba. The pegmatite outcrops within the Archean Bird River greenstone belt, in the western part of the English River subprovince of the Canadian Shield.

The pegmatite is hosted within metagabbroic rocks of the Lamprey Falls formation, in which it forms a thin, sub-horizontal, tabular body crosscutting the foliation; it is approximately 100 metres long and 45 metres wide, and has a maximum thickness of 3.9 metres. The pegmatite is relatively poorly zoned, with discontinuous units of aplite and graphic pegmatite (albite plus quartz) along it margins, units of medium to coarse-grained albite and blocky microcline-perthite in its interior, and a segmented quartz core. A poorly-defined and texturally variable albite "replacement" unit occurs in the central part of the pegmatite, and may partially replace the blocky microcline unit. Late, metasomatic veinlets of albite are present in the medium to coarse-grained albite unit, and a late, hydrothermal, calcium mineral assemblage occurs in some abundance throughout the pegmatite.

The Huron Claim pegmatite is best classified as a fully-differentiated, partly albitized, gadolinite-type, blocky microcline-biotite pegmatite, containing significant amounts of Be, Nb>Ta, REE, U, Th, Zr>Hf and Rb. Rare-element minerals occurring within the pegmatite include beryl, columbite-tantalite, fersmite, microlite, niobian, rutile, euxenite (?), uraninite, monazite, zircon, thorite, niobian titanite, bavenite, bityite and bertrandite. The pegmatite is a member of the co-genetic Shatford Lake pegmatite group, but differs from the rest of the pegmatites in this group by its high U and Rb, low Sn and F, enrichment in LREE> (HREE+Y), extensive albite development, widespread metasomatic replacement of beryl and columbite-tantalite, and isolated location east of the Lac du Bonnet batholith.

The pegmatite crystallized at intermediate crustal levels and is genetically linked to the Lac du Bonnet leucogranite. It probably formed by continued igneous differentiation at the quartz-feldspar minimum, coupled with separation of supercritical fluids from a volatile-oversaturated residual melt.

Although it is a past producer of beryl, columbite-tantalite and feldspar, the Huron Claim pegmatite is of no commercial importance due to its small size.
Hanging wall contact and zone of blocky K-feldspar at the eastern end of Pit #2 (May, 1977).
ACKNOWLEDGEMENTS

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Much of the analytical work presented in the thesis was done outside the University of Manitoba, and external sources have been acknowledged in the body of the thesis. The author would like to thank the Royal Ontario Museum in Toronto for making available their collection of Huron Claim minerals.

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CHAPTER I
INTRODUCTION

The southwestern margin of the Canadian Shield in Manitoba and adjacent Ontario contains some of the largest rare-element pegmatite fields in the world (Ayres and Černý, 1982). Of these, the Cat Lake-Winnipeg River field in southeastern Manitoba is the best described and economically most important (Černý et al., 1981b). The Huron Claim pegmatite, towards the southern margin of this field, is justifiably famous for its specimens of beryl, uraninite, monazite and Nb-Ta oxide minerals. The economic potential of the pegmatite has been tested on several occasions during the past fifty years.

As a result of its spectacular mineralogy and geochronological importance, the Huron Claim pegmatite has been discussed in a wide variety of publications since 1930. The mineralogical studies have been largely descriptive, and in almost all cases, less than comprehensive. This is somewhat surprising in view of the diversified mineralogy and geochemistry of this pegmatite, particularly within the context of the Cat Lake-Winnipeg River field.

The purpose of the present study is to fully describe the mineralogy and geochemistry of the Huron Claim pegmatite, with the objective of providing a sound petrogenetic evaluation of the pegmatite. The status of the pegmatite as a member of the Shatford Lake group, and its classification as a gadolinite-bearing, partly albitized, blocky microline-biotite pegmatite will be considered in
some detail. The economic significance of the pegmatite will also be reviewed.

LOCATION, ACCESS AND TOPOGRAPHY

The Huron Claim pegmatite is located adjacent to the Manitoba-Ontario border, approximately 135 kilometres northeast of the city of Winnipeg (Figures 1 and 2). It occurs south of the Winnipeg River, about 1.1 kilometres northwest of Greer Lake, within the confines of Whiteshell Provincial Park. With respect to the township surveys in the eastern part of Manitoba, the pegmatite lies within Township 16, Range 16 East. The approximate geographical co-ordinates of the pegmatite are 50 degrees 20' N latitude and 95 degrees 21' W longitude.

The Huron Claim is most easily approached from Garden Bay on the Winnipeg River, some 18 or 19 kilometres upstream from the village of Pointe du Bois. Access to this point is by boat, or alternatively, by float plane from the town of Lac du Bonnet. A trail 1.5 kilometres in length, poorly marked in places, leads from the Winnipeg River to the Huron Claim. A number of other trails exist in the Greer Lake - Waddell Lake area, but at the time of the field work these were very much grown over. Numerous campsites exist along the Winnipeg River close to Garden Bay.

The topography of the area northwest of Greer Lake is typical of much of the Canadian Shield. Subdued outcrops of low relief (less than 15 metres) are surrounded by tracts of swamp, muskeg and glacial drift. The exposure is excellent, probably approaching 40 or 50%. Tree growth consists primarily of spruce, jack pine, balsam fir, poplar and birch.
PLEASE WRITE TO THE AUTHOR FOR INFORMATION, OR CONSULT THE ARCHIVAL COPY HELD IN THE DEPARTMENT OF ARCHIVES AND SPECIAL COLLECTIONS, ELIZABETH DAFOE LIBRARY, UNIVERSITY OF MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.

VEUILLEZ ÉCRIRE À L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DÉPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Figure 1. Location of the Huron Claim, southeastern Manitoba.
Figure 2. Location of the Huron Claim, Cat Lake-Winnipeg River area.
PREVIOUS WORK

Prospecting in the Winnipeg River area of southeastern Manitoba was initiated as early as 1895 (Wright, 1926). This early activity was short-lived, and was concerned primarily with the search for vein deposits of gold and silver. In 1890, the geology of the area adjacent to the west end of Lac du Bonnet was examined by Tyrell (1900), and in 1912, the Oiseau (Bird) River was explored from its mouth to its headwaters in Ontario by Moore and Wallace (Moore, 1914). The early geological surveys were extended along the Winnipeg River by Wallace (1917), in the area west of Bird Lake by Cooke (1922), and along the Manitoba-Ontario boundary by Burwash (1923).

Lepidolite-bearing pegmatites, and molybdenite-bearing pegmatites and quartz veins were discovered in the Falcon Lake - West Hawk Lake area around 1916 (Bruce, 1918; DeLury, 1926). The molybdenite-bearing dykes aroused some interest due to the strategic importance of molybdenum during the First World War. In 1917, a number of sulphide occurrences were discovered near Maskwa Lake and prospecting activity in the area began to increase. The Silverleaf pegmatite was discovered in 1924, by which time additional dykes in the Maskwa Lake and Falcon Lake - West Hawk Lake areas were also known (Wright, 1926). New discoveries were made in the Cat Lake, Shatford Lake and Bernic Lake areas between 1924 and 1926. The occurrence of cassiterite at Shatford Lake heightened interest in the pegmatites, and the entire area between the Bird and Winnipeg Rivers was being systematically prospected by the mid-1920's.
The Huron Claim pegmatite was staked by the Winnipeg River Tin Company during the summer of 1930. The beryl content of the pegmatite was immediately recognized, and the excavation of a number of test pits on the showing unearthed considerable quantities of columbite-tantalite, monazite and uraninite (Delury, 1930). Some 225 kilograms of columbite-tantalite concentrate were removed from the sill, and an undisclosed amount of feldspar was crushed and shipped to Winnipeg for building purposes. Additional minerals noted by McCartney (1930a,b) were epidote, "actinolite", muscovite, biotite, white mica and "weathered beryl". By 1930, the majority of the pegmatites in the Cat Lake - Winnipeg River district had been discovered, but the tin content of these pegmatites was non-economic and interest in them quickly waned.

A number of papers dealing in whole or in part with the Huron Claim pegmatite were published in the years immediately following its discovery. Walker (1931) described topaz, columbite-tantalite, uraninite, monazite and beryl from the pegmatite, and provided a chemical analysis of columbite-tantalite. A brief description of the pegmatite, as well as some comments on the paragenesis of beryl and columbite-tantalite, were given in Derry (1931), although the Huron Claim was not mentioned by name. Perhaps the most important of these early publications was the paper by DeLury and Ellsworth (1931). These authors presented the first analyses of Huron Claim uraninite, and noted that the Pb/(U+Th) ratios in their samples were the greatest of any known uraninite. The great age of the Rice Lake Group rocks hosting the pegmatite, and of the Superior Province of the Canadian
Shield was thus established. The Huron Claim was also described by Ellsworth (1932) and Wright (1932), who made use of the existing accounts.

Great interest was aroused in the antiquity of the Huron Claim pegmatite and it figured prominently in a series of geochronological papers published over the next twenty-five years. New analyses of uraninite and monazite were presented by Hecht in 1933 (Cumming et al., 1955) and by Hecht and Kroupa (1936). Using the chemical lead method, the latter authors produced the first independent age date of 1850 million years (1.85 Ga). The first isotopic analysis of uraninite was published by Nier (1939), along with a revised age estimate of 2.46 Ga. An isotopic analysis of monazite was subsequently published by Nier et al. (1941). These analyses were discussed by Holmes (1948), who suggested an age for the pegmatite based on the presumed loss of uranium from both uraninite and monazite. The age dates of Nier were also discussed by Ahrens (1949), who compared them with strontium age determinations from the nearby Silverleaf pegmatite. A second chemical analysis of monazite from the Huron Claim pegmatite was reported by Meunch (1950). The discordant monazite and uraninite ages of Nier were further discussed by Collins et al. (1954) and Ahrens (1955), who ascribed the discrepancies to a recent loss of lead or uranium from the minerals in question. The existing data was summarized by Cumming et al. (1955), who also presented new isotopic analyses of uraninite and revised age dates of 2.54 and 2.58 Ga. Additional isotopic analyses of uraninite, and yet another discussion of the discordant mineral ages were provided by Eckelmann and Kulp (1957a,b). A final paper dealing
with potassium-argon dating of plagioclase feldspar from the Huron Claim pegmatite was published by Carr and Kulp (1957).

During the 1940's, mineral exploration in the Cat Lake - Winnipeg River area began to increase. Chromite was discovered north of the Bird River and at Euclid Lake in 1942, and a number of the cassiterite-bearing pegmatites were re-examined (Bateman, 1943a,b). Regional mapping of the area was undertaken by the Manitoba Mines Branch in 1948, 1949 and 1951 (Davies, 1952; Springer, 1949, 1950). The widespread search for base metals after the Second World War and the "lithium rush" of the early to mid-1950's ensured a high level of exploration activity. Additional mapping by the Manitoba Mines Branch was undertaken in the Shatford Lake - Winnipeg River area during 1956 (Davies, 1957). The Huron Claim was re-staked by Dalhart Beryllium Mines and Metals Corporation Limited, who were in the process of assessing the beryllium potential of the Greer Lake pegmatites. Field work on the combined properties was carried out during 1957 and 1958. An unspecified amount of diamond drilling was completed (Dawson, 1974),¹ and a bulk sample weighing 85 tonnes and grading 0.33% BeO was removed from the pegmatite (Central Geophysics Ltd., 1958).

1. The Huron Claim was certainly drilled during 1957, as the casing from one hole south of the pegmatite and the remains of several core boxes are still in evidence. However, the number of holes and metreage are in doubt. Dawson's figure of seven hundred and seventy metres for the Grace and Huron Claims is identical to that in diamond drill reports from the Grace and Cleo claims (Russell, 1957).
Combined property mapping was done at a scale of 1"=200' (1:2400), and the Huron Claim pegmatite was itself mapped at a scale of 1"=10' (1:120). Albite (and cleavelandite), biotite, muscovite, chlorite, "euxenite-polycrase" and "zoisite" were reported from the pegmatite by Davies (1957), who noted that most of the rare-element mineralization was confined to a 12 x 3 metre area near the crest of the sill. In a general treatment of the lithium and beryllium pegmatites of southeastern Manitoba, Davies (1958) mentioned the accessory minerals uraninite, monazite, etc., although he did not list the Huron Claim by name. Age dates from the Silverleaf pegmatite as well as a general discussion of the plutonic history in the vicinity of the Huron Claim were included in a short note by Eckelmann and Gast (1957). A brief description of the Greer Lake pegmatitic granite, which occurs north of the Huron Claim pegmatite appeared in Eckelmann et al. (1958). Abbreviated descriptions of the pegmatite were included in the reports of Lang (1951, 1952) and Rowe (1958).

The Huron Claim lay idle during the 1960's, while mineral exploration and development in the remainder of the Cat Lake - Winnipeg River area continued at a steady pace. Production began at the Dumbarton Mines Cu-Ni Property and at the well-known TANCO pegmatite during 1969. X-ray powder data for magnetite, epidote, chlorite and uranophane-sklodowskite from the Huron Claim pegmatite were reported by Bristol (1962), who also reported the mineral species columbite-tantalite, beryl and low albite. The Huron Claim was briefly mentioned in reports by Davies et al. (1962), Sabina (1963) and Mulligan (1968).
The first detailed classification of the pegmatites in the Cat Lake - Winnipeg River area was made by Černý and Turnock (1971a, 1972). The outcrop configuration and zoning of the Huron Claim pegmatite were described by these authors, as were the mineral species beryl, columbite-tantalite, fersmite, monazite, zircon, thorite, uraninite, magnetite and titanite. The similarities of the pegmatite to the Shatford Lake group as a whole, and the evidence for late, widespread Ca-metasomatism were also discussed. In Černý and Turnock (1971b), chemical and crystallographic data for columbite-tantalite were given, along with a rigorous description of the mineral fersmite. Pyrochlore-microlite was mentioned as a probable accessory mineral in the Huron Claim pegmatite. The Huron Claim Nb-Ta oxide minerals were compared with similar species from the Greer Lake pegmatite group, and comments on the paragenesis of these minerals were provided.

The mineral species albite, oligoclase, microcline-perthite, garnet, "clinozoisite", columbite-tantalite, fersmite, pyrochlore-microlite, thorite, zircon, titanite, uranophane-sklodowskite, bavenite and bititite were reported by Černý and Bristol (1972). The Huron Claim was briefly mentioned by Bannatyne (1972, 1974), Dawson (1974) and Phillips (1978). Rubidium-strontium age dates from Huron Claim albite and microcline were reported by Farquharson and Clark (1971). With the advent of higher commodity prices, particularly tantalum, in the latter part of the 1970's, the Tantalum Mining Corporation of Canada Ltd. was able to significantly expand its exploration program in southeastern Manitoba. A limited amount of work was carried out in the Greer Lake
area, including 130 metres of diamond drilling on the Huron Claim in late 1977. This work formed part of the present study, as is discussed in the following section. The Huron Claim has lain dormant since the fall of 1977.

PRESENT STUDY

The present work formed a small part of the pegmatite mineral evaluation program carried out by the Centre for Precambrian Studies at the University of Manitoba during the period 1975 to 1979. The evaluation program was contracted to the university by the Manitoba Department of Mines and Environmental Management under the auspices of a Canada-Manitoba Subsidiary Agreement on exploration and development in Manitoba. The federal government interests in the program were supervised by the Department of Regional Economic Expansion. The results of this program have been presented in a number of publications, notably Černý and Trueman (1978), Goad and Černý (1981), Černý et al. (1981b) and Goad (1984). Parts of the present study have been previously published in Paul (1976), Černý and Puchelt (1976), Černý (1977), Paul et al. (1981), Černý (1981) and Černý and Ercit (1984).

Field work was carried out during the periods July 12 - July 23, 1976 and May 14 - May 22, 1977. Grab sampling as well as feldspar channel sampling were done during both years, and the pegmatite was remapped at a scale of 1"=10' (1:120) during 1977. Five diamond drill holes were collared on the Huron Claim between October 1 and October 7, 1977, and 130 metres of core were taken to Winnipeg for study. A small amount of blasting was done on the property during 1976.
Four hundred and eighty-four hand specimens were collected from the pegmatite, fifty-four of these from a dump at the east end of Greer Lake. The collection was augmented with an additional 46 specimens from the University of Manitoba, and a series of 98 specimens from the Royal Ontario Museum in Toronto. The latter samples date from the original sampling of the pegmatite (Walker, 1931). A representative suite of minerals from the Huron Claim pegmatite has been set up in the petrogenetic collection at the University of Manitoba.

The following minerals were chemically analyzed in the present study: 49 microcline-perthites, 16 columbite-tantalites, 14 albites, 9 garnets, 6 muscovites, 5 uraninites, 5 zircons, 4 monazites, 4 fersmites, 3 microlites, 3 thorites, 2 epidotes and one specimen each of chlorite, niobian rutile, euxenite, magnetite, ilmenite, titanite, bavenite and bertrandite/montmorillonite. Additional specimens were used in some instances for x-ray diffraction, optical and other physical studies. Twenty-eight polished sections, 42 polished thin sections and 125 thin sections were prepared during the course of the study.
CHAPTER II

EXPERIMENTAL METHODS

Most of the rock samples collected during the present study are located on a plan view of the Huron Claim pegmatite shown in Chapter V (Figure 9). The samples collected from the communal dump east of Greer Lake (GL series), and the samples from the Royal Ontario Museum (M17 series) and University of Manitoba (GL-10 series) collections, remain unlocated. Most of the samples shown in Figure 9 are representative of dump material, meaning that very few hand specimens were actually located within the pegmatite. Paragenetic studies suffered to some extent from the overall lack of precisely located samples. Continuous feldspar channel samples were collected from the exposed pegmatite in two opposing outcrop bluffs, and vertical sections through the entire pegmatite were obtained in two locations (profiles #8 and #9/10; Figure 11). The channel samples were intended as K-feldspar sampling profiles, but were also of much use in deciphering the internal zonation within the pegmatite. A number of other samples were collected in-situ from the various pegmatite outcrops. The distribution, and total number of hand specimens are listed in the previous chapter.

The individual minerals obtained for chemical analysis are also noted in the previous chapter. Mineral specimens used for standard wet chemical analysis, X-ray diffraction studies and other determinative procedures were selected for their purity, lack of alteration and representativeness. These minerals were all manually separated, with the exception of the garnets; garnet-bearing samples were crushed in a
ring shatterbox and sieved to the average garnet size, with the residue being run through an elutriation tube using water as the separation medium. All the mineral specimens were manually separated under a binocular microscope to ensure that they were free of inclusions and/or altered material. Mineral separates were comminuted in a mechanical mortar and pestle (agate). The muscovites used for polytype determinations were filed to a fine powder and were not pulverised.

CHEMICAL ANALYSES

In addition to the compositional data, references to the analytical technique (and analyst) are given throughout the text. Most minerals, including microcline-perthite, muscovite, chlorite, garnet, epidote, beryl, bavenite and bertrandite/montmorillonite, were analyzed in the chemical laboratory of the Department of Earth Sciences at the University of Manitoba. The techniques employed during the present study include the following:

1. X-ray fluorescence spectrometry (Si, Al, Ti, total Fe, K and Ca)
2. atomic absorption spectrometry (flame-Li, Na, K, Rb, Cs, Ca, Mg, Be, Sr, Pb, flameless low Cs)
3. combustion (H2O)
4. combustion, plus acid digestion (CO2)
5. titration (FeO)
6. spectrophotometry (P)

The standards used in the microcline-perthite, beryl and muscovite analyses, which were the most voluminous, are given in Table 1a.
X-ray fluorescence analyses of the major elements in three samples of plagioclase feldspar were done at the Hahn-Meitner Institute in West Berlin (Dr. P. Möller), in conjunction with trace element analyses of these feldspars. Analyses of major and minor elements in two Huron Claim monazites were done at the Technical University, Karlsruhe, West Germany (Dr. K. Puchelt); P₂O₅, SiO₂, TiO₂ and Fe₂O₃ were determined by photometry, and MgO, CaO and Al₂O₃ were done by atomic absorption spectrometry.

Neutron Activation Analyses

Neutron activation analyses of a number of trace elements in albite, muscovite, epidote and beryl were done at the Hahn-Meitner Institute. The trace elements determined in each mineral are shown in Table 1b. Neutron activation analyses of rare-earth elements in two Huron Claim monazites were obtained from the Technical University in Karlsruhe. The high rare-earth concentrations caused some analytical problems, and the monazite samples were ultimately mixed in a 1:25 ratio with high purity silicon. Despite the dilution correction, the absolute totals of the REE's determined by neutron activation analysis seem to be somewhat low.

X-Ray Fluorescence - REE's

X-ray fluorescence analyses of the rare-earth element contents in five Huron Claim monazites were done at Memorial University in St. John's, Newfoundland. These samples were analyzed using a modified version (Fryer, 1977) of the thin film X-ray fluorescence procedure of Eby (1972). The absolute totals of the REE's determined by this method
Table 1a. Standards used for analyses of K-feldspar, muscovite and beryl from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Standards</th>
</tr>
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<tbody>
<tr>
<td>K-feldspar</td>
<td>NBS 70a</td>
</tr>
<tr>
<td>Beryl</td>
<td>USGS BCR, AGV</td>
</tr>
<tr>
<td></td>
<td>NBS 27e, 70a, 181, 183</td>
</tr>
<tr>
<td></td>
<td>CCRMP B1, B2, SY2, SY3</td>
</tr>
<tr>
<td>Muscovite</td>
<td>USGS AGV, GSP-1, BCR</td>
</tr>
<tr>
<td></td>
<td>NBS 27e, 70a, 181, 183</td>
</tr>
<tr>
<td></td>
<td>CCRMP B2, SY1, SY2, SY3</td>
</tr>
<tr>
<td></td>
<td>ANRT Ga</td>
</tr>
</tbody>
</table>

Table 1b. Trace elements analyzed by NAA.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plagioclase</td>
<td>Ba, Cu, Li, Pb, Sc, Sr, Ta, Zn</td>
</tr>
<tr>
<td>Muscovite</td>
<td>Sc, Co, Ga, Hf, Ta, W</td>
</tr>
<tr>
<td>Epidote</td>
<td>Sc, Cr, Co, Ga, As, Sr, Zr, Ta</td>
</tr>
<tr>
<td></td>
<td>La, Ce, Sm, Eu, Tb, Yb, Lu, Hf, U</td>
</tr>
<tr>
<td>Beryl</td>
<td>Sc, Co, Zn, Ga, Br, Rb, Sm, Ta</td>
</tr>
</tbody>
</table>
are only 50 to 80% of their expected value, indicating that the technique is not suitable for major constituents. The relative abundances of the REE's, however, are thought to be reliable.

**Electron Microprobe Analyses**

Most of the electron microprobe analyses were done at the University of Manitoba, on a MAC-5 electron microprobe. The early analyses by F.C. Hawthorne were done in the wavelength dispersive mode (WDS), using an acceleration voltage of 20 kV and a specimen current of 0.04 mA. Raw data was reduced using the EMPADR VII computer program of Rucklidge and Gasparrini (1969). Subsequent analyses by R. Chapman were done mainly in the energy dispersive mode (EDS), using an acceleration voltage of 15 kV and a specimen current of 0.005 mA. Spectra were collected with a KEVEX Model 7000 ED spectrometer and were reduced with KEVEX software using the MAGIC V computer program (Colby, 1980). Peak overlap problems encountered during analysis of the ED spectra were resolved by stripping techniques using library spectra. The standards used during electron microprobe analysis are listed in Table 2.

Electron microprobe analyses of zircon and thorite were done by G.W. Robinson at Queen's University, Kingston. These analyses were done on an ARL AMX electron microprobe with a takeoff angle of 52.5°, using an acceleration voltage of 20 kV and a specimen current of 0.035 mA. The beam diameter was estimated to be one micron. X-ray intensity data were reduced and corrected using a computer program written by P.L. Roeder, following the technique of Bence and Albee (1968); standards are again listed in Table 2.
Plagioclase and K-feldspar were analyzed with an electron microprobe at the University of Chicago by J.S. Delaney. Wavelength dispersive analyses were made using an acceleration voltage of 25 kV, a specimen current of 2.0 μA and a beam diameter of 20 μm.

Electron microprobe analyses of five zoned uraninite grains were done by C. Gasparrini at MinMet Scientific Ltd. in Toronto. Spectra were obtained by energy dispersive spectrometry on an ARL AMX electron microprobe (Gasparrini, 1980), and were reduced using the PESTRIPS computer program (Statham, 1975) modified by M.P. Gorton at the University of Toronto.

**Ion Microprobe Analyses**

Plagioclase and K-feldspar were analyzed for minor and trace elements on the ion microprobe at the University of Chicago. The elements Li, Rb, Cs, Mg, Sr, Ba, Pb, Fe, P, B and F were all analyzed. The feldspar standards were first analyzed for minor elements on the electron microprobe by wavelength dispersive methods (25 kV, 0.4 μA, 20 μm) and for major elements by energy dispersive methods (15 kV, 0.1 μA, 20 μm). Detection levels for the minor elements are between 50 and 100 ppm (26), and the major elements are accurate to ±2%. Following electron microprobe analysis, the samples and standards were cleaned, coated with gold and inserted into the ion microprobe. The analytical techniques are described in Steele et al. (1980, 1981), Mason (1982) and Mason et al. (1982). The following instrument settings were used: ^{16}O− primary beam, 10 nA beam current, 20 kV accelerating voltage and 20 μm beam diameter. Molecular interferences at masses 56 (Fe), 85 (Rb) and 88 (Sr) require analysis at a mass resolution sufficient to
separate the interference from the isotope of interest. These three isotopes were measured at a mass resolution of approximately 4100. Careful high resolution examination of various isotopes of the other elements showed them to be interference-free, and they were measured at low mass resolution.

Titanite PC-16 was analyzed on an ARL ion microprobe primarily to quantify its fluorine content. Operating conditions were similar to those given in Hinthorne and Anderson (1975), with a beam diameter of 15 μm. The fluorine content was derived from a working curve given in the same publication.

X-RAY DIFFRACTION METHODS

Standard X-ray diffraction techniques were carried out for mineral identification, and for quantifying a number of physical parameters. A Philips-Norelco powder X-ray diffractometer and fast-scan goniometer chart recording unit were used for most of the X-ray diffraction work, with Debye-Scherrer and Gandolfi cameras being utilized in some instances. All studies were done using Cu (Kα1) radiation, which was transmitted through a nickel filter. Internal standards, either quartz (Frondel, 1962) or annealed fluorite (800°C, a = 5.462 Å), were used when absolute values of 2θ were required. Different operating conditions were used, depending on the mineral species and requisite data.

The obliquity of the K-feldspars was determined using the method of Goldsmith and Laves (Orville, 1967), and the orthoclase content of the K-feldspar component in the microcline-perthites was determined by the technique of Bowen and Tuttle (Orville, 1967). A number of plagioclase specimens were X-rayed to determine their structural state, using
Table 2. Standards used for electron microprobe analysis.

<table>
<thead>
<tr>
<th>University of Manitoba</th>
<th>Queen's University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb manganotantalite, stibiotantalite</td>
<td>---</td>
</tr>
<tr>
<td>( \text{Ba}_2 \text{Na Nb}<em>5 \text{O}</em>{15} )</td>
<td>---</td>
</tr>
<tr>
<td>Ba ( \text{Ba}_2 \text{Na ND}<em>5 \text{O}</em>{15} )</td>
<td>---</td>
</tr>
<tr>
<td>Ta manganotantalite, stibiotantalite</td>
<td>MnCO$_3$</td>
</tr>
<tr>
<td>Mn manganotantalite, spessartine</td>
<td>Fe$_2$SiO$_7$</td>
</tr>
<tr>
<td>Fe chromite, olivine</td>
<td>ZrO$_2$</td>
</tr>
<tr>
<td>Zr zircon</td>
<td>---</td>
</tr>
<tr>
<td>Hf zircon, baddeleyite, Hf metal</td>
<td>HfO$_2$</td>
</tr>
<tr>
<td>Sn cassiterite</td>
<td>---</td>
</tr>
<tr>
<td>Ti titanite, benitoite</td>
<td>---</td>
</tr>
<tr>
<td>Ca titanite, CaWO$_4$, pyrope, microlite</td>
<td>anorthite (S-91)$^1$</td>
</tr>
<tr>
<td>Al titanite, chromite, spessartine</td>
<td>Al$_2$O$_3$</td>
</tr>
<tr>
<td>Y YAG, REE glass</td>
<td>Y metal$^2$</td>
</tr>
<tr>
<td>Nd REE glass</td>
<td>Nd metal$^2$</td>
</tr>
<tr>
<td>Sm REE glass</td>
<td>Sm metal$^2$</td>
</tr>
<tr>
<td>Ce CeO$_2$, REE glass</td>
<td>Ce$_2$O$_3$</td>
</tr>
<tr>
<td>La LaB$_6$, REE glass</td>
<td>---</td>
</tr>
<tr>
<td>Sc metallic Sc</td>
<td>---</td>
</tr>
<tr>
<td>Sb stibiotantalite</td>
<td>---</td>
</tr>
<tr>
<td>Th ThO$_2$</td>
<td>fused ThO$_2$</td>
</tr>
<tr>
<td>U metallic U</td>
<td>fused UO$_2$</td>
</tr>
<tr>
<td>Mg chromite, olivine</td>
<td>brucite$^3$</td>
</tr>
<tr>
<td>Na albite, microlite</td>
<td>---</td>
</tr>
<tr>
<td>Si spessartine, silicon</td>
<td>SiO$_2$</td>
</tr>
<tr>
<td>P apatite</td>
<td>Ca$_3$P$_2$O$_7$</td>
</tr>
<tr>
<td>W CaWO$_4$</td>
<td>---</td>
</tr>
<tr>
<td>V V$_2$O$_5$</td>
<td>---</td>
</tr>
<tr>
<td>Cr chromite</td>
<td>---</td>
</tr>
<tr>
<td>K ---</td>
<td>K-feldspar (S-75)$^1$</td>
</tr>
<tr>
<td>Gd ---</td>
<td>Gd metal$^2$</td>
</tr>
<tr>
<td>Dy ---</td>
<td>Dy$_2$O$_3$ bead$^2$</td>
</tr>
</tbody>
</table>

1. Queen's University standard
2. Standardized using RE glasses (Drake and Weill, 1972)
3. Standardized using pure MgSiO
4. Standardized using pure ZrSiO
the method of Bambauer et al. (1967). Muscovite samples were hand-filed to produce a powder for X-ray diffraction; the samples were then X-rayed in a Debye-Scherrer camera, and the photographs were compared to those in Rinaldi et al. (1972) in order to determine the polytype. Garnet cell dimensions were calculated using the X-ray diffraction technique of Nuffield (1966); quartz was used as an internal standard.

Columbite-tantalite, epidote, beryl, fersmite, niobian rutile, uraninite, monazite, zircon, thorite, magnetite, ilmenite, titanite, apatite, bavenite and bityrite were all X-rayed to determine their unit cell dimensions. Columbite-tantalite, uraninite, monazite, zircon, thorite and titanite were also X-rayed after heating, the conditions of which are described in the text. Chlorite, euxenite, bertrandite/montmorillonite, chalcopyrite and pyrite were X-rayed for identification purposes only.

**Unit Cell Refinement**

Unit cell refinements of a number of mineral species were made using the self-indexing computer program of Evans et al. (1963). The program is a least-squares refinement of the unit cell dimensions, with a weighting factor applied to each reflection based on its clarity and degree of reproduction. Errors quoted in the text are standard errors about the mean.

**REFRACTIVE INDICES**

The refractive indices of epidote, beryl and apatite were determined using a Zeiss transmitting microscope, a sodium light source (590.5 nm) and a Zeiss refractometer. Immersion oils were calibrated
in 0.001 increments, with the fourth decimal place being estimated from the intensity, colour and motion of the Becke line.

**Density**

Density determinations of garnet, epidote, columbite-tantalite, uraninite and titanite were obtained on a Berman torsion balance, using toluene as a displacement liquid.

**DTG-EGA-TG Studies**

Thermal gravimetric (TG) and derivative thermogravimetric (DTG) studies, as well as evolved gas analyses (EGA), were carried out on seven clay mineral specimens at the Royal Ontario Museum in Toronto (analyst, R.A. Ramik). The samples were run without a pre-wash treatment, and were subjected to a preliminary vacuum test. Heating rates were 10°C/minute. On the mass spectrometer, the samples were run in a high vacuum, residual atmosphere of 1x10E-8 torr.

**Thin and Polished Sections**

A large number of thin sections, polished thin sections and polished sections were prepared during the present study, as noted in the previous chapter. These were utilized for textural studies and in the identification of accessory mineralization. Polished sections were prepared primarily for use on the electron microprobe.
CHAPTER III
REGIONAL GEOLOGIC SETTING

The large number of recent, and comprehensive, reports on the geology of southeastern Manitoba make a description of the Winnipeg River area a relatively simple task. The regional significance of the western part of the English River subprovince is discussed in Beakhouse (1977) and Breaks et al. (1978), and the geology of the Bird River greenstone belt is revised and updated in Trueman (1980). The major intrusive bodies in the area, the pegmatitic granites and the pegmatites themselves are thoroughly discussed in the reports of Černý et al. (1981b), Goad and Černý (1981) and Goad (1984).

The Cat Lake - Winnipeg River pegmatite district lies in the western part of the Archean English River subprovince of the Canadian Shield. The pegmatites occur mainly within the Bird River greenstone belt, one of three lithostratigraphic-tectonic units making up the western part of the English River subprovince (Beakhouse, 1977). The Huron Claim pegmatite lies near the southern margin of the Bird River greenstone belt, adjacent to its contact with the Winnipeg River batholithic belt. To the north of the greenstone belt lies the Manigotogan - Ear Falls gneissic belt. The location of the English River subprovince within the Canadian Shield, and the location of the Huron Claim pegmatite within the western part of the English River subprovince, are shown respectively in Figures 3 and 4.
Figure 3. Major lithological units and subprovinces in the Superior province (from Ayres and Černý, 1982).
Figure 4. Location of the Huron Claim (HC) in the western part of the English River subprovince (after Černý et al., 1981b).
THE MANIGOTAGAN - EAR FALLS GNEISSIC BELT

Along the northern margin of the Bird River greenstone belt are rocks belonging to Manigotagan - Ear Falls gneissic belt. The main rock types in this belt are paragneiss, and early, syn- and late tectonic intrusive rocks and their metamorphic equivalents. The paragneisses are equivalent to rocks of the Rice Lake group in the Uchi subprovince, and to the Flanders Lake formation in the Bird River greenstone belt (Trueman, 1980). For this reason, the term "Rice Lake group" is applied with some certainty to the rocks of the Bird River greenstone belt.

THE WINNIPEG RIVER BATHOLITHIC BELT

To the south of the Bird River greenstone belt lies the Winnipeg River batholithic belt. Quartz-feldspar-biotite gneisses, which host enclaves of older and more mafic gneiss, are the major rock type in the belt. The relative age of the gneissic rocks is unknown; in the Greer Lake - Eaglenest Lake area, the Bird River greenstone belt is both in intrusive and faulted contact with the batholithic belt. South of Greer Lake, the gneisses are intruded by pegmatites equivalent in age to those found in the greenstone belt. The gneissic rocks are assigned to their position in the stratigraphic table on the basis of their common fault boundary, and common intrusive history with the Bird River greenstone belt (Trueman, 1980). However, the gneissic rocks may be older than, or equivalent in age, to the greenstone belt lithologies.
THE BIRD RIVER GREENSTONE BELT

Stratigraphy

The Bird River greenstone belt is comprised of metavolcanic and metasedimentary rocks belonging to the Rice Lake group. The rocks of the greenstone belt are divisible into six formations, the Eaglenest Lake, Lamprey Falls, Peterson Creek, Bernic Lake, Flanders Lake and Booster Lake formations, as illustrated in Table 3 and Figure 5. The Eaglenest Lake formation, consisting of fine to coarse-grained volcaniclastic sediments, is the oldest recognizable unit in the greenstone belt. It is fault-bounded to the south by the Winnipeg River batholithic belt, and to the north by the Lamprey Falls formation. The Lamprey Falls formation, which hosts the Huron Claim pegmatite, consists primarily of basalt and closely related intrusive rocks, including the ultramafic Bird River sill. Cherty iron formation occurs extensively throughout this unit. The Peterson Creek formation is made up of a mixture of rhyolite and its volcaniclastic derivatives. This unit is infolded and deformed along with the younger Bernic Lake formation, which lies unconformably on top of the preceding three units. Clastic sedimentary rocks and iron formation, interlayered with basic to acidic volcanic rocks, make up the bulk of the Bernic Lake formation, although it is intruded in places by composite stocks of mafic to felsic composition. The rocks of this unit occupy the core of a synclinorium and are infolded to some extent with the underlying Peterson Creek formation. The Flanders Lake formation, which is in unconformable contact with the Bernic Lake formation in the eastern part of the greenstone belt, consists primarily of lithic to pebbly arenites interbedded with conglomerate. This unit has undergone
<table>
<thead>
<tr>
<th>Formation</th>
<th>Dominant lithology</th>
<th>Intrusive rocks</th>
<th>Metamorphic rocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Booster Lake</td>
<td>metamorphosed greywacke-mudstone</td>
<td>pegmatites, Lac du Bonnet monzogranite Inconnu granite Black River Suite granodiorite tonalite</td>
<td>migmatite-complex paragneiss</td>
</tr>
</tbody>
</table>

| Flanders Lake | lithic meta-arenite metaconglomerate | |

| Bernic Lake | clastic derivatives metamorphosed metamorphosed: metarhyolite metadacite meta-andesite metabasalt | gabbro diorite quartz-feldspar porphyries granodiorite |

| Peterson Creek | metarhyolite, clastic equivalents | |

| Lamprey Falls | metabasalts | Bird River Sill, metagabbro |
| Eaglesnest Lake | metamorphosed volcanic wacke | |

Table 3. Stratigraphy in the Cat Lake-Winnipeg River area (after Černý et al., 1981b).
Figure 5. Stratigraphic and metamorphic subdivisions of the Bird River greenstone belt (from Černý et al., 1981b).
multiple deformation and is infolded in part with rocks of the Peterson Creek and Bernic Lake formations. Greywacke-mudstone turbidites and iron formation are characteristic of the Booster Lake formation, which sits in the core of a fault-bounded synclinorium.

Synvolcanic intrusive rocks occurring within the Bird River greenstone belt include the ultramafic Bird River sill, high-alumina metagabbro and composite stocks with various proportions of gabbro, tonalite and granodiorite. Somewhat less abundant are dyke-like intrusions of gabbro, glomeroporphyritic gabbro and quartz porphyry.

The metamorphic history of the Bird River greenstone belt is complex, and an extended discussion would be superfluous. The greenstone belt has been divided into a number of metamorphic "subareas" by Trueman (1980), utilizing the facies classification of Winkler (1979). The various subareas and major sub-vertical faults are illustrated along with the stratigraphy in Figure 5. Of note is the fact that the Huron Claim pegmatite is hosted by rocks of greenschist facies metamorphism.

**Intrusive Rocks**

The Bird River greenstone belt, as shown in Figure 6, is flanked by three major igneous intrusions. To the north of the greenstone belt is the Maskwa Lake batholith, to the east is the Marijane Lake batholith and to the southwest, the Lac du Bonnet batholith. Both the Maskwa Lake and Marijane Lake batholiths consist of quartz diorite, which is rimmed and intruded by younger biotite granite. The quartz diorites vary chemically from quartz-poor tonalite through to
trondhjemite, and have been classified by McRitchie (1971) as early to
syn-tectonic.

Three distinct intrusive phases have been recognized within the
Lac Du Bonnet batholith. Hornblende-biotite granodiorite occurs in
isolated outcrops towards the eastern end of the batholith, biotite
granite predominates in the western and central parts, and an early,
strained leucogranite forms the eastern nose of the batholith, as well
as occurring in irregular areas along its margins (Černý et al. 1981b).
The leucogranite, which is parental to the Shatford Lake pegmatite
group, is alaskitic and highly fractionated, and is related to the
pegmatitic granites within the greenstone belt. The composition of the
biotite granite is similar to the late phases in the Maskwa Lake and
Marijane Lake batholiths. The biotite granite is less fractionated
than the early leucogranite, and the two rock types cannot be linked by
any mechanism of igneous differentiation or partial melting.

Major intrusions of pegmatitic granite occur north of Greer Lake,
west of Eaglenest Lake, at Tin Lake, and northeast of Osis Lake (Figure
6). In addition, there is a small intrusion of pegmatitic granite, the
Axial intrusion, southeast of Tin Lake. These bodies have been
intruded along a number of early sub-vertical faults which give the
greenstone belt its characteristic "fault-slice" configuration
(Figures 5 and 6). The intrusions are texturally and compositionally
inhomogeneous, consisting of bodies of pegmatitic leucogranite,
fine-grained leucogranite, and layered sequences of sodic aplite and
potassic pegmatite. Accessory minerals occurring within the potassic
bodies vary from intrusion to intrusion, but closely correspond to
those in the surrounding pegmatite aureoles. In addition, there is a
close compositional relationship between the trace element contents in the rock-forming minerals of the pegmatitic granites and their related pegmatites (Goad and Černý, 1981).

The pegmatites in the Winnipeg River district are divisible into various groups on the basis of their spatial association, and mineralogical and geochemical similarities. These pegmatite groups were first described by Černý and Turnock (1971a), and are discussed in greater detail by Černý et al. (1981b). The pegmatites range from essentially barren (Axial group), through Be and Nb-Ta varieties (Greer Lake and Eaglenest Lake groups) and Be, Nb-Ta, REE, U-Th enriched pegmatites (Shatford Lake group), to Li-rich (Lac du Bonnet group) and complex Li, Rb, Cs, Be and Ta-bearing pegmatites (Rush Lake and Bernic Lake groups). Despite its proximity to the Greer Lake pegmatite group, the Huron Claim pegmatite more closely resembles the pegmatites in the Shatford Lake group, and has been formally assigned to this group in recent publications (Černý et al., 1981b; Černý and Ercit, 1984).
CHAPTER IV
LOCAL GEOLOGY

The Huron Claim pegmatite outcrops about 1.1 kilometres west of Greer Lake, within metavolcanic rocks of the Lamprey Falls formation (Figure 7). The metavolcanic rocks are bounded to the north by the Greer Lake pegmatitic granite and to the south by gneissic rocks of the Winnipeg River batholithic belt. The metavolcanics are intruded by the Lac du Bonnet leucogranite approximately 1.7 kilometres west of the Huron Claim pegmatite. Outcrop within the general area is extensive. The 1:2400 scale geological map produced by Central Geophysics Ltd. during 1958 contains the most information on the local geology. The provincial government map of Davies (1957) is at a larger scale (1:12000) and is less detailed than the aforementioned map. Other noteworthy mineral occurrences in the area include the Silverleaf pegmatite, about half a kilometre west of the Huron Claim, and several mineralized pegmatite pods within the Greer Lake pegmatitic granite (Goad, 1984).

GNEISSIC TONALITE OF THE WINNIPEG RIVER BATHOLITHIC BELT

Gneissic rocks of the Winnipeg River batholithic belt outcrop about 500 metres southeast of the Huron Claim pegmatite. The dominant rock type is a grey, medium to coarse-grained, gneissic tonalite. The tonalite is frequently porphyritic, and contains numerous large inclusions of amphibolite. The gneissosity in these rocks trends NE-SW
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Figure 7. Geology of the area northwest of Greer Lake (after Davies, 1957).
and is steeply dipping. Intrusive into the grey tonalite are substantial bodies of pink, fine to medium-grained, aplitic-textured granite, which are massive to mildly gneissic in appearance. The fault contact between the gneissic rocks and the Lamprey Falls formation west of Greer Lake is largely obscured by drift.

THE LAMPREY FALLS FORMATION

Northwest of Greer Lake, the Lamprey Falls formation consists primarily of massive to pillowed metabasalt flows. These flows are dark greenish-black, fine to medium-grained, and massive to very weakly schistose. As indicated in Figure 7, the pillow tops are all northerly facing. Thin, less than three metre wide, mafic tuff horizons of limited lateral extent occur throughout the metabasalt. A discontinuous, 15 centimetre wide horizon of mafic tuff occurs immediately south of the Huron Claim pegmatite. The tuffs are fine to medium-grained and strongly schistose, and they contain no recognizable fragments.

Hypabyssal, metagabbroic sills are also widespread throughout the Lamprey Falls formation. The Huron Claim pegmatite crosscuts and is enclosed almost entirely within one of these hypabyssal sills. In general, the sills are less than 20 metres wide and 150 metres long, although the sill hosting the Huron Claim pegmatite is 60 to 75 metres wide, and considerably in excess of 150 metres long.

The sills are massive, medium to coarse-grained and generally ophitic. They consist of saussuritized plagioclase within a matrix of tremolite-actinolite, magnetite, titanite and secondary quartz
(Davies, 1957). The metabasalt also occurs in large, irregular stocks such as the one north of Greer Lake; they are massive and coarse-grained, but become progressively finer grained toward their margins.

Cherty iron formation occurs as thin, one to four metre wide horizons throughout the metabasalt, and is present as a conspicuous band along the metabasalt-pegmatitic granite contact. The latter band is preserved along a shear zone within the pegmatitic granite, providing evidence of stoping during the intrusion of the pegmatitic granite (Goad, 1984). A discontinuous, one metre wide band of iron formation occurs 30 metres north of the main body of the Huron Claim pegmatite. The iron formations are typically rusty and rubbly-textured, and consist of varying amounts of chert, magnetite, secondary hematite and iron sulphides.

THE GREER LAKE PEGMATITIC GRANITE

The Greer Lake pegmatitic granite extends in an east-west direction along the south side of the Winnipeg River, covering about four square kilometres. Only the westernmost two-thirds of this body are shown in Figure 7. The contact between the pegmatitic granite and the Lamprey Falls formation lies about 425 metres north of the Huron Claim pegmatite. The intrusion of the pegmatitic granite was apparently controlled by the east-west fault separating the Lamprey Falls formation from the Winnipeg River batholithic belt (Goad, 1984). A narrow shear zone runs parallel to the southern contact, cutting across the intrusion near its western extremity.
Four discrete phases have been recognized within the Greer Lake pegmatitic granite, specifically leucogranite, pegmatitic leucogranite, potassic pegmatite and sodic aplite. The leucogranite phase is scattered throughout the intrusion as pod-like accumulations. The pegmatitic leucogranite is comprised of large, 5 to 100 centimetre long megacrysts of K-feldspar and graphic quartz, in a fine-grained matrix of quartz, plagioclase and muscovite. The sodic aplite phase consists of sub-parallel, rhythmic bands of plagioclase and garnet in contact with the potassic pegmatite phase. Incomplete separation of the sodic aplite and potassic pegmatite phases is common. The potassic pegmatite phase, which is somewhat enriched in rare accessory minerals, occurs as pods within the leucogranite and pegmatitic leucogranite; it also occurs adjacent to the sodic aplite phase.

Mineralized pegmatite pods are a unique feature of the Greer Lake intrusion and they do not occur in the other pegmatitic granites of the Winnipeg River district. Although there are several minor occurrences well within the pegmatitic granite and along its northern margin, the most noteworthy examples are the Annie and Lobe occurrences along the southern margin of the intrusion. The Lobe pegmatite pod is slightly enriched, mineralogically and geochemically, in relation to the main body of pegmatitic granite (Goad, 1984), and it contains both beryl and columbite-tantalite. On the Annie Claim, potassic pegmatite pods evolved from the surrounding pegmatitic granite contain appreciable amounts of beryl, lithian muscovite and Nb-Ta oxide minerals.

The Silverleaf pegmatite is a distinct pegmatite dyke, but its location, style of intrusion, mineralogy and geochemistry are all
related to the Greer Lake pegmatitic granite (and the Annie Claim mineralized pegmatite pod), and it is probably an apophysis of this intrusion (Goad, 1984). The Silverleaf pegmatite is enriched in lithium, rubidium, manganese, niobium, tantalum and tin, and contains spodumene, topaz, lithian muscovite, amblygonite, triphylite, monazite, cassiterite, zircon, beryl and columbite-tantalite as accessory minerals.
CHAPTER V

SIZE, SHAPE AND INTERNAL ZONATION OF THE HURON CLAIM PEGMATITE

If the regional and local geology are fairly well understood, the morphology and internal structure of the Huron Claim pegmatite are somewhat less so. The flat-lying nature of the pegmatite and its restricted exposure make the gross aspects of its geology difficult to interpret. The existing reports on the Huron Claim pegmatite are of only minor assistance in interpreting the geometry and structure of the pegmatite. Nevertheless, examination of the existing outcrops, a limited amount of diamond drill core, 7 feldspar channel samples and the numerous dump specimens collected during the present study has produced a reasonable picture of the internal structure and mineral distribution within the pegmatite.

MORPHOLOGICAL FEATURES

A plan view of the Huron Claim pegmatite (1:500 scale) is shown in Figure 8. The diamond drill hole and hand specimen locations are superimposed on this map in Figure 9. The pegmatite is exposed in two opposing metagabbro bluffs, which occur on either side of a scrub-filled depression (Figure 10). The pegmatite forms a thin, tabular body which occupies a sub-horizontal fracture in the metagabbro. The pegmatite is mildly anticlinal, and dips into the bluffs at an angle of about ten degrees. The upper contact is
NOTICE/AVIS

PAGE(s) 41-43  MAPS WITH COLOUR

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Figure 10. Cross-sectional view of the Huron Claim pegmatite, looking northwest. Section line is shown in Figure 8.
apparently bulgy and irregular, as indicated by the individual measurements in Figure 8. The anticlinal nature of the pegmatite is important from an economic standpoint, as much of the rare-element mineralization is confined to the apical part of the sill (Davies, 1957). The pegmatite is hosted almost entirely within the metagabbro sill, which is some 60 to 65 metres wide. The confinement of the pegmatite to the metagabbro is indicative of some sort of competency control during its emplacement; the metagabbro may have been more amenable to fracturing than the surrounding metabasalt. All of the pegmatites in the Bird River greenstone belt are hosted within dilational foliation planes or concomitantly opened, sub-horizontal joint systems (Černý et al., 1981b). In the general vicinity of Greer Lake, the Huron Claim and Silverleaf pegmatites are the only sub-horizontal intrusions; the pegmatites of the Greer Lake group are all sub-vertically dipping. This is also the case in the Shatford Lake area, where all but two of the Shatford Lake group pegmatites are sub-vertically dipping.

The Huron Claim pegmatite is exposed over a length of 100 metres, including the flat-lying outcrops which form its western extremity. The pegmatite is exposed over a width of 30 metres between the opposing bluffs of metagabbro, and its maximum width is probably not more than about 45 metres. The maximum thickness of pegmatite, determined from feldspar profiles #9 and #10, is about 3.9 metres. Diamond drill hole #8 was collared several metres north of the thickest section of the pegmatite in Pit #2, and intersected less than 2 metres of pegmatite; the pegmatite apparently pinches out rapidly to both the north and
south. Diamond drill holes #4 through #7, all indicated in Figure 9, did not intersect the pegmatite and confirm its rather limited extent. Much of the pegmatite may have been "plucked" from the outcrop surface during Pleistocene glaciation.

The contacts between the pegmatite and enclosing metagabbro are very sharp. The biotite and chlorite contents of the metagabbro increase in the immediate vicinity of the upper contact, and foliation in the near-contact rocks is obliterated. A thin, four to seven millimetre wide biotite selvage is present along most of the upper contact; the micas constituting the selvage are oriented perpendicular to the contact. Thin (<1mm), irregular veinlets of albite and quartz are sometimes present near the upper contact. The upper part of the Huron Claim pegmatite, including the upper contact, is much better exposed than its lower sections. The lower contact is exposed only in Pits #2 and #4, and in several flat-lying outcrops near the eastern and western extremities of the pegmatite.

Fracturing and brecciation are characteristic features of the medium to coarse-grained albite unit in the Huron Claim pegmatite. A significant proportion of the rare-element mineralization in the pegmatite is confined to fractures, and sub-parallel, quartz-filled fractures are a distinctive feature of the exposed wall above Pit #4 (Plate 1). The presence of quartz, minor fine-grained albite and certain of the rare-element minerals in many of the fractures suggests that they are mainly hydrothermal in origin. Certainly, parts of the medium to coarse-grained albite unit were fractured soon after consolidation. However, a tectonic origin for at least some of the fracturing is possible. Post-consolidation tectonic disturbance, for
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Plate 1. Sub-parallel to cross-cutting, quartz-filled fractures in the medium to coarse-grained albite unit (sample P3-94). These fractures are best developed in the wall above Pit #4. Coin is 17 millimetres in diameter.

Plate 2. Garnetiferous aplite from Pit #3 (P3-76). Coin is 17 millimetres in diameter.
example, is noted in most of the pegmatites belonging to the Shatford Lake group (Černý et al., 1981b). No wall rock inclusions have been observed in the Huron Claim pegmatite.

INTERNAL ZONATION

The Huron Claim pegmatite is relatively poorly zoned. Although seven or eight distinctive units or mineral assemblages have been recognized within the pegmatite, they are discontinuous and often gradational into one another. Extensive lateral development of the units does not occur, and well-defined, concentric zoning is not present. Černý and Turnock (1971a) describe the Huron Claim pegmatite as having medium-grained, garnetiferous, plagioclase plus quartz rims, and a coarse-grained, plagioclase plus quartz core with abundant blocks of microcline-perthite. On a gross scale, this is an accurate description, although the pegmatite can be further subdivided. A zonal sequence has been devised for the Huron Claim pegmatite which is comparable to the classification scheme developed by Beus (1966) for beryllium-bearing, granitic pegmatites. In Beus' classification, a zone refers to a spatial segregation of a specific mineral assemblage in a pegmatite, which results from a certain stage in the pegmatitic process. A non-genetic term, "unit", is used in the description of the Huron Claim pegmatite.

The zonal sequence in the Huron Claim pegmatite was derived from field observations, and relies heavily on the feldspar channel samples shown in Figure 11. Subdivision of the pegmatite into units proved difficult, due to the discontinuity of the various units and
2

graphic pegmatite unit

3

medium to coarse-grained albite unit

4

blocky microcline-perthite

6

albite "replacement" unit

a) albite + K-feldspar (unaltered)

b) coarse-grained, vuggy albite

c) red, albitized K-feldspar

d) mainly albite, with remnant K-feldspar

7

late vein, or granular pink albite

aplite border unit(1), quartz core(5) and the late calcium mineral assemblage(8) are not shown

- K-feldspar sample

**FIGURE II. FELDSPAR SECTIONS THROUGH THE HURON CLAIM PEGMATITE**
insufficient exposure in the lower half of the pegmatite. Zoning similar to that found in the Huron Claim pegmatite does not occur in any of the other pegmatites belonging to the Shatford Lake group. From the outer margins of the pegmatite inward, the units comprising the Huron Claim pegmatite are as follows:

1. Aplitic Border Unit
2. Graphic Pegmatite Unit
3. Medium to Coarse-Grained Albite Unit
4. Blocky Microcline Unit
5. Quartz Core
6. Albite "Replacement" Unit, including
   a. albite + K-feldspar (unaltered)
   b. coarse-grained, vuggy albite
   c. red, albitized K-feldspar
   d. albite, with remnant K-feldspar
7. Late Vein Albite
8. Late, Hydrothermal Ca-Mineral Assemblage

Aplitic Border Unit

The aplite border unit is sporadically developed as a thin fringe along the outer margins of the pegmatite. It is best developed in the northern part of Pit #3, in Pit #5 and in the flat-lying outcrops near the western extremity of the pegmatite. In most instances the aplite border unit is missing, with the units of graphic pegmatite or medium to coarse-grained albite being virtually continuous to the upper contact. In the westernmost outcrops, the unit is fine-granular rather than aplitic textured.
The best specimens of garnetiferous aplite were obtained from Pit #3 (Plate 2). Albite, quartz and garnet are the minerals in greatest abundance, occurring with accessory amounts of muscovite and beryl. Pyrite and chalcopyrite occur as accessory minerals in the granular albite comprising the westernmost outcrops. In the garnetiferous aplite, the albite crystals range in size from .05 to 1.0 millimetres and are frequently platy in appearance. Flow fabrics are common. In Pit #5, the aplite border unit is gradational into the graphic pegmatite unit, and biotite occurs as a rare accessory.

The aplite border unit is representative of the first stages of crystallization; in the Huron Claim pegmatite this unit is volumetrically unimportant. Extensive development of an aplite border unit occurs most frequently in barren pegmatites (Beus, 1966).

**Graphic Pegmatite Unit**

The graphic pegmatite unit, which is quite conspicuous, is discontinuously developed along both the upper and lower contacts. In some instances, the unit is absent and the medium to coarse-grained albite unit is virtually continuous through to the contact. The unit is volumetrically significant, reaching a maximum thickness of 18 to 25 centimetres, and is comparable with the medium-grained wall zone of Černý and Turnock (1971a). In most cases, the graphic pegmatite unit passes gradationally inwards into the medium to coarse-grained albite zone (Plate 3). Where the unit occurs close to the top of the blocky microcline unit, it often passes into medium-grained albite containing
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PAGE(s) 51 IS/ARE EST/SONT colour photos

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Plate 3. The graphic pegmatite unit, passing downward into the medium to coarse-grained albite unit, in Pit # 2. Lens cap is 53 mm in diameter.

Plate 4. The graphic pegmatite unit, passing downward into medium-grained albite which contains altered, reddish blocks of K-feldspar (sample FP1-01).
altered blocks of K-feldspar (Plate 4). The graphic intergrowth is oriented perpendicular to the contact, with individual rods of quartz up to 2.5 centimetres in maximum dimension. Albite is the dominant feldspar, although altered microcline-perthite is also present. The albite frequently appears platy in thin section. Chloritized biotite is a frequent accessory mineral in the graphic pegmatite unit, whereas garnet is exceedingly scarce. The graphic pegmatite unit in most beryl-bearing pegmatites is imperfectly developed (Beus, 1966), and the Huron Claim pegmatite is no exception. The graphic unit is extensively developed only in barren pegmatites, and it consists largely of K-feldspar plus quartz intergrowths. In this respect, the predominantly albite-based composition of the unit in the Huron Claim pegmatite is rather exceptional.

**Medium to Coarse-Grained Albite Unit**

The medium to coarse-grained albite unit is the single most extensive unit in the Huron Claim pegmatite. This unit can be up to 1 or 2 metres in thickness, as seen in the bluff above Pit #4 (Plate 5), and occasionally extends through the full thickness of the pegmatite. Although discontinuous in places, the medium to coarse-grained albite unit comes closest to a continuous shell among the various units making up the Huron Claim pegmatite. The unit corresponds in part to the medium-grained wall zone of Černý and Turnock (1971a), and seems to be a combination of the medium to coarse-grained pegmatite and small block pegmatite units described by Beus (1966). The albite making up the
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Plate 5. Part of the medium to coarse-grained albite unit above Pit #4. Below and to the right of the hammer is the blocky K-feldspar unit; the quartz core appears below and to the left of the hammer.

Plate 6. Beryl crystals in coarse-grained albite, approximately 8 cm below the upper(?) contact (sample 77-B3-08). Coin is 17 mm in diameter.
bulk of this unit is apparently primary in origin. It occurs in white to pale pink, equidimensional to short tabular crystals which often reach six or seven centimetres in maximum dimension. Chloritized biotite is a common accessory, especially in the periphery of this zone, whereas garnet is relatively rare. Almost all of the rare-element minerals in the pegmatite, including the Nb-Ta oxide minerals, beryl, uraninite, monazite, thorite and zircon, occur in the medium to coarse-grained albite unit as primary intergrowths with the feldspar, or in fractures. In some instances, the unit extends to within several centimetres if not completely through to the upper contact, and it is in the upward bulges of the unit where most of the rare-element mineralization is probably accommodated (Plate 6). Despite the abundance of rare-element minerals, the unit is essentially monomineralic. The albite seems quite fresh, with visible alteration being confined to late veinlets and breccia infillings of fine-grained albite. As discussed previously, the unit is brecciated in some areas, and laced with sub-parallel, quartz-filled fractures.

Similar accumulations of coarse-grained tabular albite occur in the wall and border zones of pegmatites in the Shatford Lake and Greer Lake groups, but in none of these pegmatites is the albite as extensively developed as it is in the Huron Claim pegmatite. As mentioned previously, this unit is correlative with the medium to coarse-grained pegmatite zone of Beus (1966).

**Blocky Microcline Unit**

The blocky microcline unit is an essentially monomineralic unit,
comprised of large blocky crystals of microcline-perthite. The unit is observed only in Pits #2 and #4, and is apparently confined to the thickest and most central part of the pegmatite. The large dump immediately south of Pit #2 consists almost entirely of large blocks of microcline-perthite. The maximum thickness of unit is 1.25 metres in feldspar profile #8. The blocky microcline unit is not observed in the peripheral parts of the pegmatite sill, and pinches out rapidly away from the central part of the pegmatite. For example, the unit is 90 centimetres thick in the wall above Pit #2, yet is completely absent in diamond drill hole #8 which is a scant three metres away. An abrupt lateral termination of the unit is visible in the wall above Pit #4 (Plate 5). In the combined profiles #9 and #10, the blocky microcline unit appears in two sections separated by a zone of albite and remnant microcline (Plate 7). The rare alkali contents in the microclines from this profile increase with increasing distance away from the upper contact, suggesting that the two sections were once continuous. If this is the case, a substantial part of the blocky microcline unit, up to 120 centimetres, has been replaced by albite.

The blocky K-feldspar crystals vary texturally from microcline to microcline-perthite, although the latter variety is probably more abundant. The crystals reach a maximum size of 30 x 20 centimetres and are roughly oriented perpendicular to the contacts. Small inclusions of quartz occur in the blocky microcline unit, and columbite-tantalite crystals are occasionally found in apophyses of the quartz core extending upward into this unit. The colour of the unaltered K-feldspar varies from grey to pale pink. The blocky microcline unit
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Plate 7. Location of feldspar profiles # 9 and # 10 in Pit # 2. Lower contact is exposed just below photograph. Pegmatite is 3.9 metres thick in this section.
is usually overlain by the medium to coarse-grained albite unit, as seen in the wall above Pit #4. The unit overlies the quartz core in Pit #2, and is adjacent to the quartz core in Pit #4. The unit comes to within 1 centimetre of the upper contact in some parts of Pit #2, where the graphic pegmatite and medium to coarse-grained albite units are absent. The unit frequently passes upward into a unit of medium-grained granular albite containing remnant blocks of K-feldspar. On the periphery of the blocky microcline unit, the K-feldspars are frequently wine-red in colour, and flooded with albite lamellae. These feldspars occur along the margins of the albite "replacement" unit and represent incipient albitization of the blocky microcline.

Blocky K-feldspar units, indicative of advanced internal zonation (Černý, 1982a) are typical core-margin constituents of beryl-bearing pegmatites (Beus, 1966). They are observed in most pegmatites of the Greer Lake and Shatford Lake groups (Černý et al., 1981b).

Quartz Core

The quartz core is comprised of a number of small, ovoid pods in the central part of the pegmatite. Apophyses penetrating the blocky microcline unit, and the quartz-filled fractures in the medium to coarse-grained albite unit, are probably fracture-filling offshoots of the quartz core. The unit is essentially monomineralic; minor amounts of muscovite, beryl and columbite-tantalite occur along the periphery of the quartz core, where it is in contact with the blocky microcline or medium to coarse-grained albite units. Most of the quartz is grey, but dark, smoky quartz generally accompanies the Nb-Ta oxide minerals.
The largest quartz pod in Pit #4 is about 190 centimetres long, and 70 centimetres thick. The pods occur at the base of, or adjacent to the blocky microcline unit, where this unit is present. Otherwise, the quartz pods are confined to the medium to coarse-grained albite or albite "replacement" units in the central part of the pegmatite (Plate 8).

Quartz cores, essentially continuous and confined to the thickest parts of texturally well-differentiated pegmatites, are common features of beryl-bearing pegmatites (Beus, 1966).

Albite "Replacement" Unit

The albite "replacement" unit is a volumetrically important unit in the Huron Claim pegmatite, but for various reasons is rather ill-defined. The unit encompasses the albitized (reddish) K-feldspar along the periphery of the blocky microcline unit, the medium-grained albite containing remnant blocks of K-feldspar, the vuggy, tabular albites in feldspar profiles #7 and #9/10, and some fine to medium-grained, granular albite. The unit is defined by any one of these feldspar varieties, but assemblages of two or more of them are generally present within a given location. The albite "replacement" unit is not a fine-grained replacement unit in the true sense of the word, and the terminology may be somewhat misleading. Discrete bodies of fine-grained saccharoidal to cleavelanditic albite are not present in the Huron Claim pegmatite. Although the unit seems to have formed largely at the expense of the blocky microcline unit, it does have some textural affinities with the primary, medium to coarse-grained albite
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The albite "replacement" unit is confined partly to the upper part of the pegmatite, reaching a maximum thickness of 30 centimetres in section profiles #9 and #10. Medium-grained, granular albite containing quartz blocks of alteration, between the albite "replacement" and the upper contact, has also been observed in the albite "replacement" unit. The contacts between beryl (and unaltered albite) may occasionally carry any rare-

Plate 8. The quartz core in the S-shaped pit. In this location, the quartz is surrounded by coarse-grained albite.
unit. The unit is devoid of any rare-element mineralization.

The albite "replacement" unit is confined mainly to the central part of the pegmatite, reaching a maximum thickness of 90 centimetres in feldspar profiles #9 and #10. Medium grained, granular albite containing remnant blocks of K-feldspar, between the top of the blocky microcline unit and the upper contact, has also been assigned to the albite "replacement" unit.

**Late Vein Albite**

The late vein and granular albites in the Huron Claim pegmatite are unquestionably metasomatic. Volumetrically, these albites are unimportant. Reddish vein albite occurs as narrow veinlets and breccia in-fillings in the course-grained, primary albite. Granular, pink albite occurs as veinlets and irregular masses, mainly in the central part of the pegmatite. Thicknesses of granular albite up to 30 centimetres were observed in feldspar profiles #9 and #10, but concentrations of this magnitude are unusual. Like the albite "replacement" unit, the late vein and granular albites do not appear to carry any rare-element mineralization. However, they occasionally occur along the contacts between beryl (and columbite-tantalite), and quartz or K-feldspar.

Several generations of late albite are observed in many mineralized pegmatites (e.g., Zalashkova, 1957; Beus, 1966), and the Huron Claim pegmatite is no exception in this regard.
Late Hydrothermal Calcium Mineral Assemblage

Late hydrothermal alteration is a characteristic feature of the Shatford Lake pegmatite group (Černý et al., 1981b), and the Huron Claim pegmatite is no exception. A low temperature alteration assemblage consisting of bavenite, bityite, bertrandite, epidote, chlorite and clay minerals is conspicuously developed throughout much of the pegmatite. Of these minerals, bavenite, bityite and epidote contain calcium as an essential constituent. Although it might be expected in this paragenesis, calcite has yet to be identified in the Huron Claim pegmatite. Epidote occurs throughout the pegmatite in small vugs, and is present in the medium to coarse-grained albite unit as crystalline masses filling fractures. The clay minerals are developed throughout the pegmatite, occurring primarily as vug-fillings. The rare minerals bavenite and bityite are abundant as pseudomorphs and partial pseudomorphs after beryl; bityite is also found coating fractures in the broader vicinity of the pseudomorphs. Fine granular chlorite occurs as an open-space filling in the medium to coarse-grained albite zone.

Although not a discrete unit like the others in the pegmatite, the calcium mineral assemblage is, nevertheless, a distinctive and widespread assemblage of minerals representative of the last stages of pegmatite crystallization. It is dispersed to some extent throughout the entire pegmatite, but is best developed in the medium to coarse-grained albite zone. Secondary calcium and beryllium-bearing minerals are known as decomposition products of beryl from many pegmatites (Beus, 1966), but they rarely occur on such an extensive
scale as in the Huron Claim pegmatite. Epidote is a decidedly rare mineral in rare-element granitic pegmatites of all types (Cerny, pers. comm.).

MINERAL DISTRIBUTION WITHIN THE PEGMATITE

The various units making up the Huron Claim pegmatite are distinguished on the basis of their textural characteristics and mineral composition. An attempt is made in Table 4 to summarize the distribution of minerals among the different units. Some minerals could not be ascribed to a particular zone, and the overall abundances were difficult to estimate. The pegmatite is relatively poorly exposed, but seems to be comprised mainly of albite, microcline-perthite and subordinate quartz; the remaining minerals in the pegmatite are present only in minor amounts.
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<th>Albite Microcline Unit</th>
<th>Medium to Coarse-Grained Albite Unit</th>
<th>Albitic Core Unit</th>
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<td>✓</td>
</tr>
<tr>
<td>Euxenite(?)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Columbite-Tantalite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Microlite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Apatite</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Nonaitite</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Bavenite</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Bityte</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Bertrandite</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Uranophane-Sklodowskite</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Clay Minerals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

- **abundant, rock forming**
- **subordinate**
- **x accessory**
- **• rare**
- **• mineral present within a unit, but part of the late, hydrothermal calcium mineral assemblage**
CHAPTER VI
GEOCHRONOLOGY

A summary of the geochronological work on the Huron Claim pegmatite was given in an earlier chapter. The initial uraninite analyses of DeLury and Ellsworth (1931), with their unusually high (Pb/U+Th) ratios and concomitant age significance, gave rise to a substantial body of later work. The isotopic analyses published by Nier (1939) and Nier et al. (1941) were the basis for some of the most reliable age dates ever obtained from the Huron Claim. Additional isotopic data for uraninite was published by Cumming et al. (1955) and Eckelmann and Kulp (1957). Rubidium-strontium age dates published by Farquharson and Clark (1971) are in general agreement with the early lead isotope work.

A compilation of the geochronological work performed on the Huron Claim pegmatite is provided in Tables 5a and 5b. The uraninite and monazite ages have been recalculated using modern decay constants (Faure, 1977), and the initial lead isotope compositions of Doe (1962). Where isotopic data is lacking, chemical lead ages have been calculated using the following formula from Harper (1973):

\[ t = \frac{Pb}{U + 0.38 Th} \times 7.4 \text{ Ga} \]

The Pb\textsuperscript{206} /U\textsuperscript{238}, Pb\textsuperscript{207} /U\textsuperscript{235}, Pb\textsuperscript{208} /Th\textsuperscript{232} and Pb\textsuperscript{207} /Pb\textsuperscript{206} ages have been calculated using the following equations:
Table 5A. Summary of geochronological work, Huron Claim.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Reference</th>
<th>U %</th>
<th>Th %</th>
<th>Pb %</th>
<th>204</th>
<th>206</th>
<th>207</th>
<th>208</th>
<th>Age(Publ.)</th>
<th>Age(Recalc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Uraninite</td>
<td>Hecht(1933); in Cumming et al(1955)</td>
<td>38.61</td>
<td>4.11</td>
<td>13.67</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.42Ga(a)</td>
</tr>
<tr>
<td>2. Monazite</td>
<td>Hecht and Kroupa(1936)</td>
<td>0.12</td>
<td>12.67</td>
<td>1.21</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.85Ga</td>
<td>1.81Ga(a)</td>
</tr>
<tr>
<td>3. Uraninite</td>
<td>DeLury and Ellsworth (1931)</td>
<td>53.50</td>
<td>12.46</td>
<td>15.44(f)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.96Ga(a)</td>
</tr>
<tr>
<td>4. Uraninite</td>
<td>Nier(1939)</td>
<td>-uses average of (3)</td>
<td>-recalculated using (f)</td>
<td>0.018</td>
<td>81.50</td>
<td>13.18</td>
<td>5.31</td>
<td>2.46Ga</td>
<td>2.45Ga(b)</td>
<td></td>
</tr>
<tr>
<td>5. Monazite</td>
<td>Meunch(1950)</td>
<td>0.281</td>
<td>15.63</td>
<td>1.524</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.81Ga(a)</td>
<td></td>
</tr>
<tr>
<td>6. Monazite</td>
<td>Nier et al(1941)</td>
<td>-same analysis as (5)</td>
<td>0.0097</td>
<td>10.2</td>
<td>1.86</td>
<td>87.93</td>
<td>2.57Ga</td>
<td>2.56Ga(b)</td>
<td>1.83Ga</td>
<td>1.85Ga(e)</td>
</tr>
</tbody>
</table>
Table 58. Summary of geochronological work, Huron Claim(2).

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Reference</th>
<th>U %</th>
<th>Th %</th>
<th>Pb %</th>
<th>204</th>
<th>206</th>
<th>207</th>
<th>208</th>
<th>Age(Publ.)</th>
<th>Age(Recalc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Uraninite</td>
<td>Cumming et al (1955)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.032</td>
<td>80.31</td>
<td>13.50</td>
<td>6.10</td>
<td>2.54Ga</td>
<td>2.48Ga(b)</td>
</tr>
<tr>
<td>8. Uraninite</td>
<td>Cumming et al (1955)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.045</td>
<td>79.83</td>
<td>14.02</td>
<td>6.11</td>
<td>2.58Ga</td>
<td>2.54Ga(b)</td>
</tr>
<tr>
<td>9. Uraninite</td>
<td>Eckelmann and Kulp (1957)</td>
<td>6.09</td>
<td>1.49</td>
<td>2.12</td>
<td>0.014</td>
<td>81.80</td>
<td>13.32</td>
<td>4.86</td>
<td>2.51Ga</td>
<td>2.46Ga(b)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.86Ga</td>
<td>1.83Ga(c)</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.17Ga</td>
<td>2.15Ga(d)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.36Ga</td>
<td>1.37Ga(e)</td>
</tr>
<tr>
<td>10. Albite</td>
<td>Carr and Kulp (1957)</td>
<td>0.52%K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.18Ga</td>
<td>-</td>
</tr>
<tr>
<td>11. Microcline</td>
<td>Farquharson and Clark (1971)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.51Ga</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7030ppmRb, 81.2ppm Sr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.51Ga</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Rb$^87$/Sr$^{86}$ = 1944.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.51Ga</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Sr$^{87}$/Sr$^{86}$ = 69.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.51Ga</td>
<td>-</td>
</tr>
<tr>
<td>12. Albite</td>
<td>Farquharson and Clark (1971)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.50Ga</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>30.03ppmRb, 45.22 ppm Sr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.50Ga</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Rb$^87$/Sr$^{86}$ = 1.9855</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.50Ga</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Sr$^{87}$/Sr$^{86}$ = 1.0427</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.50Ga</td>
<td>-</td>
</tr>
</tbody>
</table>

(a) chemical Pb, (b) 207/206, (c) 206/238, (d) 207/235 and (e) 208/232
2. \[ \frac{\text{Pb}_{206}}{\text{Pb}_{204}} = \left( \frac{\text{Pb}_{206}}{\text{Pb}_{204}} \right)_0 + \frac{\text{U}_{238}}{\text{Pb}_{206}} (e^{t_{U-238}} - 1) \]

3. \[ \frac{\text{Pb}_{207}}{\text{Pb}_{204}} = \left( \frac{\text{Pb}_{207}}{\text{Pb}_{204}} \right)_0 + \frac{\text{U}_{235}}{\text{Pb}_{207}} (e^{t_{U-235}} - 1) \]

4. \[ \frac{\text{Pb}_{208}}{\text{Pb}_{204}} = \left( \frac{\text{Pb}_{208}}{\text{Pb}_{204}} \right)_0 + \frac{\text{Th}_{232}}{\text{Pb}_{208}} (e^{t_{Th-232}} - 1) \]

5. \[ \frac{\text{Pb}_{207}}{\text{Pb}_{206}} = \frac{\text{U}_{235}}{\text{U}_{238}} (e^{t_{U-235}} - 1) \]

In recalculating the published age dates, the isotopic composition of lead incorporated into uraninite and monazite at the time of crystallization was taken as \(204/206/207/208 = 1/14.42/15.07/33.81\). This approximates the composition of lead in galena formed 2500 million years ago (Doe, 1962). The decay constants employed were \(\lambda_{238} = 1.55125 \times 10^{-10} \text{ yr}^{-1}\), \(\lambda_{235} = 9.8485 \times 10^{-10}\) and \(\lambda_{232} = 4.998 \times 10^{-11} \text{ yr}^{-1}\), as listed in Faure (1977). Values of \(t\) in equation (5) were calculated from the tables in Faure (1977), and the atomic weight of the various Pb isotopes was taken from Weast and Astle (1982).

The uranium-lead and thorium-lead ages from the Huron Claim pegmatite are strongly discordant, indicating non-closed system behaviour of both uraninite and monazite. The lead-lead ages vary from 2.45 to 2.56 Ga, whereas the rubidium-strontium microcline age is 2.51 Ga and the rubidium-strontium albite age, 2.50 Ga. Rubidium-strontium ages on lepidolite from the nearby Silverleaf pegmatite vary from 2.63 to 2.68 Ga, while the rubidium-strontium microcline age from this pegmatite is 2.34 Ga (Farquharson and Clark, 1971). Potassium-argon dates from the Silverleaf lepidolite vary from 2.35 to 2.48 Ga. The
rubidium-strontium lepidolite ages seem to be concordant with the primary ages of the Greer Lake pegmatites. These pegmatites were seemingly emplaced from 2500 to 2600 million years ago, with subsequent metamorphic conditions resetting the equilibria of certain minerals. The relatively young Rb/Sr, K/Ar, U/Pb, Th/Pb and Pb/Pb ages are all reflections of open system behaviour. The wide variation in mineral ages is a good indication that the area remained heated and buried for a considerable time after the emplacement of the pegmatites (Farquharson and Clark, 1971).

Absolute mineral ages of regional metamorphism and intrusion in the Precambrian Shield of southeastern Manitoba range from 2.55 to 2.70 Ga (Cerny et al., 1981b). The Lac du Bonnet batholith has been dated at 2.68 Ga (Farquharson, 1975), the Maskwa Lake batholith at 2.64 Ga (Penner and Clark, 1971) and the volcanic rocks of the Bird River greenstone belt at 2.65 Ga (Penner and Clark, 1971). The coincidence of these ages indicates that there was a relatively short period of regional evolution.
CHAPTER VII
DESCRIPTIVE MINERALOGY

Twenty-nine mineral species have been identified in the Huron Claim pegmatite (Table 6). This does not include the clay minerals, not fully characterized, thorogummite and coffinite, only tentatively identified during microprobe analyses of thorite, and the amorphous iron hydroxides. Ilmenite occurring in hydrothermal veinlets in the host metagabbro also formed part of the study. Two mineral species listed in earlier reports, triphyllite-lithiophilite and tourmaline, have been more or less descredited.

In the following section, the mode of occurrence, chemistry and physical properties of the various pegmatite minerals are discussed. The section falls somewhat short of a complete mineralogical study, as only the genetically significant properties of the minerals were looked at in earnest.

QUARTZ

Quartz occurs throughout the Huron Claim pegmatite, but is volumetrically less important than either albite or microcline-perthite. The largest accumulations, up to 190 centimetres long and 70 centimetres thick, are found in the quartz core. Quartz is conspicuously developed in the graphic pegmatite unit, where it occurs as small rods up to 2.5 centimetres long intergrown with albite. In the aplite border unit, albite "replacement" unit and late vein albite, the
Table 6. List of minerals occurring in the Huron Claim Pegmatite

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microline-perthite</td>
<td>KAlSi$_3$O$_8$</td>
</tr>
<tr>
<td>Oligoclase</td>
<td>(Na, Ca)AlSi$_3$O$_8$</td>
</tr>
<tr>
<td>Albite</td>
<td>NaAl$_2$O$_8$</td>
</tr>
<tr>
<td>Quartz</td>
<td>SiO$_2$</td>
</tr>
<tr>
<td>Biotite</td>
<td>K(Mg, Fe$^{2+}$)$_2$(Al, Fe$^{3+}$)$_3$Si$<em>3$O$</em>{10}$(OH, F)$_2$</td>
</tr>
<tr>
<td>Muscovite</td>
<td>KAl$_2$(Si$<em>2$Al)O$</em>{10}$(OH, F)$_2$</td>
</tr>
<tr>
<td>Epidote</td>
<td>Ca$_2$(Al, Fe$^{3+}$)$_2$(SiO$_4$)$_3$(OH)</td>
</tr>
<tr>
<td>Chlorite (Chamosite)</td>
<td>(Fe$^{2+}$, Mg, Fe$^{3+}$)$_3$Al(Si$<em>3$Al)O$</em>{10}$(OH, F)$_8$</td>
</tr>
<tr>
<td>Garnet (Almandine)</td>
<td>(Fe$^{2+}$, Mn$^{2+}$)$_3$Al$_2$(SiO$_4$)$_3$</td>
</tr>
<tr>
<td>Topaz</td>
<td>Al$_2$SiO$_4$(F, OH)$_2$</td>
</tr>
<tr>
<td>Beryl</td>
<td>Be$_3$Al$_2$Si$<em>6$O$</em>{18}$</td>
</tr>
<tr>
<td>Titanite</td>
<td>Ca$_7$TiSiO$_5$</td>
</tr>
<tr>
<td>Zircon</td>
<td>(Zr, Hf)SiO$_4$</td>
</tr>
<tr>
<td>Thorite</td>
<td>ThSiO$_4$</td>
</tr>
<tr>
<td>Uraninite</td>
<td>(U, Th)O$_3$</td>
</tr>
<tr>
<td>Magnetite</td>
<td>Fe$^{2+}$Fe$^{3+}$</td>
</tr>
<tr>
<td>Niobian Rutile</td>
<td>(Nb, Ti)O$_2$</td>
</tr>
<tr>
<td>Fersmite</td>
<td>Ca(Nb, Ta)$_2$O$_6$</td>
</tr>
<tr>
<td>Euxenite (?)</td>
<td>(Y, Ca, Ce, U, Th)(Nb, Ta, Ti)$_2$O$_6$</td>
</tr>
<tr>
<td>Columbite-Tantalite (Pseudo-ixoite)</td>
<td>(Fe$^{2+}$, Mn$^{2+}$)(Nb, Ta)$_2$O$_6$</td>
</tr>
<tr>
<td>Microlite</td>
<td>(Na, Ca)$_2$(Ta, Nb)$_2$O$_6$(O, OH, F)</td>
</tr>
<tr>
<td>Apatite</td>
<td>Ca$_5$(PO$_4$)$_3$(OH, F)</td>
</tr>
<tr>
<td>Monazite</td>
<td>(Ce, La, Nd, Th)PO$_4$</td>
</tr>
<tr>
<td>Bavenite</td>
<td>Ca$_4$Be$_2$Al$_2$Si$<em>9$O$</em>{26}$(OH)$_2$</td>
</tr>
<tr>
<td>Bityrite</td>
<td>CaLiAl$_2$(Al, Be, Si)$<em>2$O$</em>{10}$(OH)$_2$</td>
</tr>
<tr>
<td>Bertrandite</td>
<td>Be$_4$Si$_2$O$_7$(OH)$_2$</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>CuFeS$_2$</td>
</tr>
<tr>
<td>Pyrite</td>
<td>FeS$_2$</td>
</tr>
<tr>
<td>Uranophane-Sklodowskite</td>
<td>(Ca, Mg)(UO$_2$)$_2$Si$_2$O$_6$(OH)$_2$SH$_2$O</td>
</tr>
</tbody>
</table>

Clay Minerals (Nontronite, mixed layer Montmorillonite-Illite ?)

Iron Hydroxide Minerals

Coffinite and thorogummite may be present in minor amounts.
Tourmaline and triphyllite-lithiophilite have been discredited.
Ilmenite occurs in hydrothermal veinlets outside the pegmatite proper.
constituent quartz is generally fine-grained and interstitial. Quartz occurs in minor amounts in the blocky microcline and medium to coarse-grained albite units, generally in the interstitial areas between feldspars. Certain areas of the medium to coarse-grained albite unit are cut by sub-parallel quartz veinlets, but these veinlets are more a fracture-filling feature than an intrinsic part of the unit. In most instances, the quartz in the Huron Claim pegmatite is grey to colourless. Dark, smoky quartz is accompanied by Nb-Ta oxide minerals in small apophyses of the quartz core penetrating the blocky microcline unit. Smoky quartz also occurs in some of the sub-parallel veinlets cutting the medium to coarse-grained albite unit. No laboratory work was done on the quartz during the present study.

**FELDSPAR MINERALS**

Feldspar minerals make up almost the entire bulk of the Huron Claim pegmatite. Albite is the single most abundant species in the pegmatite, and microcline-perthite forms volumetrically significant masses in the central part of the pegmatite. Oligoclase is present in minor amounts along the outer margins of the pegmatite. The plagioclase feldspars are both primary and metasomatic in origin, but there are little or no compositional differences between the two generations. Almost all of the alkali feldspar is confined to the blocky microcline unit, where it seems to have crystallized inward from the upper contact. Microcline-perthite is replaced by albite in a number of localities.
Potassium Feldspar

Potassium feldspar is present in the Huron Claim pegmatite mainly as microcline-perthite; non-perthitic microcline occurs only in minor amounts. Almost all of the K-feldspar occurs as large crystals in the blocky microcline unit. Some microcline is present in the graphic pegmatite unit, and altered remnants of K-feldspar occur in certain parts of the albite "replacement" unit.

The blocky microcline unit is essentially monomineralic, consisting of large crystals of microcline-perthite. The microcline-perthite crystals, the largest of which are 20 centimetres wide and 30 centimetres long, are roughly oriented perpendicular to the upper contact. The colour of the microcline-perthite varies from pale pink to grey (Plate 9), the grey variety occurring closer to the central part of the pegmatite. Throughout most of the unit, the K-feldspar appears fresh and unaltered, although thin albite veinlets are relatively common. This is not so along the margins of the unit, where the K-feldspar is sometimes conspicuously altered (Plate 10). The reddish K-feldspar in these areas is enriched in perthitic albite and quartz, and is very heavily sericitized. Iron hydroxides accompanying the sericitic alteration apparently cause the reddish colouration. The relict K-feldspar in the albite "replacement" zone is similar in appearance to the reddish feldspar along the margins of the blocky microcline unit, but is usually much more altered. These relict feldspars indicate that parts of the blocky microcline unit have undergone metasomatic replacement. The large "chessboard" albites in the albite "replacement" unit have almost certainly formed by complete pseudomorphic replacement of microcline-perthite.
NOTICE/AVIS

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VEUILLEZ ÉCRIRE À L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLZE CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DÉPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 9. Grey microcline-perthite veined by pink albite - coin is 17 mm. in diameter (FP8-11).

Plate 10. Reddish "altered" K-feldspar from feldspar profile #4; sample contains 5.13 wt.% Na₂O. Coin is 17 mm. in diameter (FP4-12).
Textural variation in the K-feldspar is evident on a microscopic scale, the two main varieties being microcline and microcline-perthite. Cross-hatched twinning seems to be more characteristic of the K-feldspar in the innermost parts of the blocky microcline unit, although it does occur to some extent throughout the entire unit. Perthitic K-feldspar without cross-hatched twinning was observed only in the outer parts of the unit. Some of the K-feldspar crystals are completely twinned, but most contain discrete bands of cross-hatched twin lamellae. In the marginal parts of the blocky microcline unit, the cross-hatched twinning is particularly coarse (Plate 11). Veins of perthitic albite, from 0.1 to 0.5 millimetres wide, are conspicuous in much of the K-feldspar. In some instances, the perthitic albite is present in small quantities (Plate 12), but it is sufficiently abundant in other specimens to form interlocking perthite (Plate 13). The amount of perthitic albite in a given sample is correlative to some extent with the amount of metasomatic alteration. Strings of perthitic albite, 0.1 to 1.0 millimetres long and approximately 10 microns wide, are almost always present in the untwinned K-feldspar. The strings are oriented in two directions, and braided textures are common. The string albite is untwinned on an optical scale, unlike the vein albite.

Forty-nine samples of K-feldspar were prepared for chemical analysis, with X-ray determinations being made on all but four of these samples. The deviation from monoclinic symmetry of the feldspars (obliquity) was determined using the method of Goldsmith and Laves (1954). The $\Delta (d_{1\overline{3}3} - d_{\overline{1}3\overline{1}})$ values and corresponding obliquities of the Huron Claim feldspars are listed in Table 7. In general, values of obliquity range from 0.00 to 1.00; the higher values are indicative of
NOTICE/AVIS

PAGE(S) 15 + 16 EST/SONT COLOUR PHOTOS

PLEASE WRITE TO THE AUTHOR FOR INFORMATION, OR CONSULT THE ARCHIVAL COPY HELD IN THE DEPARTMENT OF ARCHIVES AND SPECIAL COLLECTIONS, ELIZABETH DAFOE LIBRARY, UNIVERSITY OF MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.

VEUILLEZ ECRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 11. Well-developed microcline twinning, sample FP8-10. Patchy albite is present, but lamellar albite is absent. Long dimension of photograph is equivalent to 3 millimetres.

Plate 12. Microcline-perthite, sample FP8-13. Note strings of albite in between albite lamellae. Long dimension of photograph is equivalent to 3 mm.
Plate 13. Interlocking perthite, sample FP8-03. Perthitic albite predominates over microline (white). Long dimension of photograph is equivalent to 3 mm.
Table 7. Obliquity of K-feldspar from the Huron Clain pegmatite.

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mean = 0.951
greater degrees of departure from monoclinic symmetry, and increasing Si/Al order. As illustrated in Figure 12, the values of obliquity in the Huron Claim pegmatite range from 0.88 to 1.00. The values are close to maximum microcline and indicative of low-temperature, ordered feldspar. A similar range is noted for K-feldspar in the blocky, internal zones of other pegmatites in the Winnipeg River district (Černý et al., 1981b).

The orthoclase content in the K-feldspar component of microcline-perthite was determined using the X-ray powder technique of Bowen and Tuttle (Orville, 1967). The $\triangle (2\theta 201 \text{ microcline} - 2\theta 101 \text{ KBrO}_3)$ values and corresponding orthoclase contents are listed in Table 8. The range of orthoclase contents is shown graphically in Figure 13. The orthoclase contents range from 92.7 to 100.0, and are in reasonably good agreement with the orthoclase contents determined by microprobe analysis.

Electron microprobe and AAS analyses of 51 Huron Claim K-feldspars are listed in Tables 9 through 11. Compositional trends from the outer to inner margins of the blocky microcline unit were determined by sampling the unit at 3 inch (7.62 centimetre) intervals on four continuous profiles. The sample locations are shown in the internal zonation section (Figure 11). Sample P2-06, an albitized K-feldspar from Pit #2, was also chosen for analysis. Two unpublished analyses from P. Černý are among those listed in Table 11. Fifty partial chemical analyses, including one replicate analysis, were done by atomic absorption spectrometry at the University of Manitoba. These analyses are representative of the bulk chemistry of the microcline-perthites, including the albite lamellae. Electron microprobe analyses
Figure 12. Obliquity of K-feldspar from the Huron Claim pegmatite.
Table 8. Orthoclase content of the K-feldspar component in microcline-perthite.

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Mean = 97.1

$\Delta^* = 2\theta(201 \text{ microcline}) - 2\theta(101 \text{ KBrO}_3)$
Figure 13. Orthoclase content of the K-feldspar component in microcline-perthite from the Huron Claim pegmatite.
Table 9. Electron microprobe and A.A.S. data for K-feldspar (1).

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nd - not detected; quantities given in weight %; TiO$_2$, MgO and SrO not detected.
Table 10. Electron microprobe and A.A.S. data for K-feldspar (11).

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nd = not detected; quantities given in weight %; TiO$_2$, MgO and SrO not detected.
Table 11. Electron microprobe and A.A.S. data for K-feldspar (III).

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Electron microprobe analyses by J.S. Delaney, University of Chicago (1978); A.A.S. analyses (in brackets) by R.M. Hill and R. Chapman, University of Manitoba.

nd—not detected; quantities given in weight %; TiO$_2$, MgO and SrO not detected; samples GL-10-3 and GL-10-4 from P. Cerny - unpublished data.
of thirty of the specimens were done subsequently at the University of Chicago. The cation contents (Na, Ca, K) and albite/anorthite/orthoclase ratios determined from the microprobe analyses are shown in Table 12. The minor and trace element contents in nineteen of the microcline-perthites were determined on the University of Chicago ion microprobe, and these are listed in Table 13. The Li, Cs and Pb contents, and K/Rb and K/Cs ratios determined by atomic absorption spectrometry are shown in Table 14. Microclines from the graphic pegmatite zone were not analyzed during the present study.

In general, the major alkalis (Na, Ca, K) exhibit poorly-developed to non-existent trends in all the feldspar profiles, regardless of the analytical method. The bulk analyses of a number of K-feldspars from the periphery of the blocky microcline unit (P2-06, FP8-03, FP4-12-T) show very high Na contents indicating that these feldspars have been considerably albitized. Among the electron microprobe analyses, samples FP9-24-T and FP10-15-B have unusually high Na contents, and these analyses have apparently been affected by feldspar overlap. The microprobe analyses have been affected not only by perthitic and late vein albite, but also by small inclusions of clay or sericitic mica. The orthoclase contents of the K-feldspar component of microcline-perthite, disregarding the two Na-rich analyses, vary from 91.6 to 96.7%. This is a somewhat smaller range than that indicated by the X-ray work (92.7 to 100.0). The anorthite contents of the K-feldspar component range from 0.03 to 0.68%. The albite contents range from 3.2 to 8.2%, and in feldspar profiles #3 and #8, show a slight increase toward the central part of the pegmatite. In the Věžná pegmatite, Czechoslovakia, Černý et al. (1984) documented an increase in Na and a
Table 12. Cation contents, anorthite/albite/orthoclase ratios, and trace element abundances of the microprobed K-feldspar.

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<th>K</th>
<th>An</th>
<th>Ab</th>
<th>Or</th>
<th>Rb</th>
<th>Ba</th>
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Cations on the basis of 32 oxygen anions.
Rb, Ba, Sr* and P given in ppm.
Sr* values as determined by the ion microprobe.
Table 13. Ion microprobe data for K-feldspar.

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<th>Sample</th>
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<th>Cs</th>
<th>Rb</th>
<th>Sr</th>
<th>Ba</th>
<th>Pb</th>
<th>Fe</th>
<th>P</th>
<th>B</th>
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Ion microprobe analyses by R.A. Mason, University of Chicago (1978).
Quantities given in ppm by weight, except F*, for which counts/second are reported.
Table 14. Trace element contents, K/Rb ratio and K/Cs ratio for K-feldspar from the Huron 
Clay pegmatite (AAS analyses).

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A.A.S. analyses by R.N. Hill and R. Chapman, University of Manitoba.
decrease in the K/Na ratio in successive generations of K-feldspar. Although the Huron Claim K-feldspars were taken from a single unit, a similar but poorly defined Na-enrichment trend seems to be present. However, the major element data, taken as a whole, is quite erratic.

In the Věžná pegmatite, the Rb, Ti and P contents, as well as the K/Ba ratio, increase in successive generations of K-feldspar (Černý et al., 1984). In the Huron Claim pegmatite, Rb and K/Ba increase towards the central part of the pegmatite, but phosphorus is relatively constant. Titanium was not detected in the microprobe analyses. Plots of the K/Rb ratio versus the Rb content for both the bulk chemical and electron microprobe analyses are shown for the various feldspar profiles in Figures 14 through 17. Fractionation trends from the bulk chemical analyses are evident in feldspar profiles #8 and #9/10, but are absent to possibly reversed in profiles #3 and #4. Much smoother fractionation trends are defined by the electron microprobe data, vis a vis feldspar profiles #3 and #8. In general, the microcline-perthites have higher Rb contents closer to the central part of the pegmatite.

The erratic nature of both the bulk chemical and electron microprobe data may be partly due to the sampling technique. Continuous channel samples were taken through the blocky microcline unit, and samples were then selected at three inch intervals irrespective of the orientation of the K-feldspar crystals. The K-feldspar crystals are quite large, and internal zonation within individual crystals may have affected the overall trend from top to bottom. In the bulk chemical analyses, the minor and trace element contents are affected to a large degree by the amount of perthitic albite present. K-feldspars from the
Figure 14. K/Rb versus Rb plot for K-feldspar from profiles 3 and 4 (AAS data).
Figure 15. K/Rb versus Rb plot for K-feldspar from profiles 8, 9 and 10 (AAS data).
Figure 16. K/Rb versus Rb plot for K-feldspar from profiles 3 and 4 (electron microprobe data).
Figure 17. K/Rb versus Rb plot for K-feldspar from profiles 8, 9 and 10 (electron microprobe data).
marginal areas of the blocky microcline unit are susceptible to contamination by perthitic albite, and the inclusion of such samples in a number of the profiles may be responsible for the erratic chemical trends. Feldspar profile #4, in which the K/Rb versus Rb trend is apparently reversed, was resampled in June, 1984, and the new samples are currently being analyzed.

The cesium contents in the K-feldspar, although uniformly low, also show some enhancement towards the central part of the pegmatite. Figures 18 and 19 show K/Cs versus Cs plots for the different feldspar profiles. Fractionation trends are indicated in feldspar profiles #8 and #9/10, but the trends are erratic to reversed in profiles #3 and #4. In the Huron Claim pegmatite, cesium should have been concentrated in the residual melt (and thus the late K-feldspar), due to the paucity of primary muscovite. Barium behaves consistently in feldspar profiles #3 and #8, decreasing in a systematic manner towards the central part of the pegmatite. In profiles #4 and #9/10, the barium contents show no obvious trends. The lithium and magnesium contents of the K-feldspars are uniformly low. The iron, boron, fluorine, lead and strontium contents of the K-feldspars are all reasonably uniform.

Microprobe analyses of the albite lamellae in thirteen samples of microcline-perthite are listed in Table 17, in the plagioclase feldspar section. These analyses were collected from different samples than were the analyses of the K-feldspar component, and data on adjacent K-feldspar and albite pairs are not available. Nevertheless, a comparison of the two groups of analyses shows that Rb, Ba, Cs and Pb are strongly partitioned into the K-feldspar phase, whereas Ca and F are partitioned into the albite lamellae. Strontium and lithium show a
Figure 18. K/Rb versus Cs plot for K-feldspar from profiles 3 and 4 (AAS data).
Figure 19. K/Rb versus Cs plot for K-feldspar from profiles 8, 9 and 10 (AAS data).
weak preference for the K-feldspar component, while the iron, phosphorus, magnesium and boron contents of the two phases are similar. With the possible exception of iron, the minor and trace element behaviour in the Huron Claim microcline-perthites is consistent with that documented by Mason (1982) for a variety of perthites from granitic pegmatites. With the exception of Li, discrete pairs of co-existing plagioclase and K-feldspar show much the same behaviour, (Smith, 1974). The trace element contents in individual K-feldspar lamellae are usually zoned (Mason, 1982), which may account for some of the variability in the Huron Claim analyses.

**Plagioclase**

Plagioclase feldspar is by far the most abundant mineral in the Huron Claim pegmatite. The bulk plagioclase content of the pegmatite is difficult to estimate, but it certainly comprises more than 50% (by volume) of the preserved and accessible pegmatite, possibly as much as 60 or 70%. The cross-sections shown in Figure 11 are not representative of the total feldspar ratio, as they were selected primarily as blocky K-feldspar sampling profiles. Plagioclase makes up the bulk of the medium to coarse-grained albite and albite "replacement" units, and constitutes a substantial part of the vein albite, aplite and graphic pegmatite units. Veinlets of plagioclase feldspar also occur in the blocky K-feldspar unit and the quartz core.

Virtually all of the plagioclase feldspar in the pegmatite is albite (An_{1-5}); oligoclase (An_{26}) occurs in minor amounts immediately adjacent to the upper contact. As discussed in the section on pegmatite zonation, there is some difficulty in establishing whether
The albite is primary or metasomatic in origin, especially in the central part of the pegmatite. Four morphological varieties of albite were distinguished in the present study:

1) coarse-grained, tabular albite
2) albite of variable grain size, possibly after K-feldspar
3) aplitic albite
4) late vein albite

Medium to coarse-grained, tabular albite is perhaps the most abundant variety of plagioclase in the pegmatite (Plates 14 and 15). The medium to coarse-grained albite unit can be up to 1 or 2 metres in thickness, as observed in the bluff above Pit #4, and it occasionally extends through the full thickness of the pegmatite. The albite comprising the medium to coarse-grained albite unit occurs in equi-dimensional to short tabular crystals, up to six or seven centimetres in maximum dimension. The crystals are white or pale pink, and apparently randomly intergrown. Polysynthetic twinning is ubiquitous. Albite of this type, although occasionally containing epidote and clay-filled vugs, is generally in pristine condition, and there can be little doubt that it is primary in origin. Tabular albite occurs in the wall and border zones of many of the pegmatites in the Shatford Lake and Greer Lake pegmatite groups (Černý et al., 1981b), but in none of these pegmatites is it as abundant as in the Huron Claim pegmatite. Almost all of the rare-element mineralization in the Huron Claim pegmatite occurs in association with the coarse-grained, tabular albite.

The second morphological variety of albite is less well-defined. Albite of variable grain size, possibly replacing K-feldspar, occurs
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Plate 14. Late veinlet of reddish albite cutting coarse-grained primary albite, which contains beryl and columbite-tantalite. Coin is 17 mm. in diameter (GL-37).

Plate 15. Late veinlet of muscovite and reddish albite cutting coarse-grained, primary albite. Coin is 17 mm. in diameter (P2-12).
mainly in the central part of the pegmatite, although it is also recognized along the periphery of the blocky K-feldspar unit. The best examples of this type of albite are found in feldspar profiles #7, #9 and #10. The albite is of variable grain size, though coarse-grained and tabular throughout feldspar profile #7. It is polysynthetically twinned, and commonly assumes a mosaic texture due to discontinuities in the albite lamellae. The albite is frequently vuggy, and inclusions of quartz are common. The presence of this type of albite, along with remnant K-feldspar and reasonable amounts of granular, metasomatic albite defines the albite "replacement" unit. As discussed in the section on pegmatite zonation, this unit lacks the fine-grained appearance typical of most replacement units, and the term "replacement" may not apply to the entire extent of this unit. Most of the replacement albite separated for electron microprobe and XRD work was relatively coarse-grained. In thin section, this coarse-grained albite usually turns out to be chessboard albite, which is distinguished by an alternating pattern of twin lamellae resembling the squares on a chessboard (Plates 16 and 17). The crystals of chessboard albite contain abundant albite twins; the lamellae consist of short plates parallel to (010) and wedge out or are abruptly terminated. Chessboard albite is found in a variety of rock types, and in most instances may be attributed to sodium metasomatism causing replacement of K-feldspar (Smith, 1974). Andersen (1928) attributed chessboard albite in some Norwegian granitic pegmatites to the replacement of perthite by late albite. The tendency of the chessboard albite to occur in sinuous bands may be influenced by the configuration of the original exsolution albite in the perthite precursor. The K-feldspar/albite boundaries
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VEUILLEZ ECRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 16. Chess-board albite, sample FP9-16. Long dimension of photograph is equivalent to 3 millimetres.

Plate 17. Another photograph of the chess-board albite in sample FP9-16. Note remnant islands of microcline (cross-hatch twinning). Same scale as above.
could conceivably have served as channelways for the metasomatizing fluids. In the Huron Claim pegmatite, microcline-perthite along the periphery of the blocky K-feldspar unit is frequently albitized in a perthite-like manner, and the large chessboard albites may represent the culmination of this process in the central part of the pegmatite.

The late vein albites, as well as the granular albites in the central part of the pegmatite, are definitely metasomatic. Volumetrically, these albites are insignificant, and they seldom occur in large accumulations. Reddish vein albite usually occurs in narrow veinlets within the coarse-grained primary albite (Plates 14 and 15). It is characteristically fine-grained (.05 to .5 mm) and equant, although the grain boundaries are irregular. Granular pink albite occurs in veinlets and irregular masses, primarily in the central part of the pegmatite.

Much of the albite present in the aplitic and granular albite units adjacent to the contacts is platy in appearance (Plate 18). This albite is also volumetrically insignificant. In the aplitic unit, albite occurs in elongate, lath-shaped crystals with fluted margins, as well as in fine-grained aggregates. Flow fabrics are relatively common in this unit (Plate 19).

Several specimens of "near-contact" albite were selected for electron microprobe and XRD studies. This albite, which is medium-grained and primary in textural appearance, was collected mainly from the graphic pegmatite unit. The graphic pegmatite unit is frequently gradational into the medium to coarse-grained albite unit, the albite in the two units differing only in grain size.
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VEUILLEZ ÉCRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DÉPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITÉ DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 18. Platy albite in sample P3-72 from the aplite border unit. Scale is similar to below.

Plate 19. Weakly-developed flow fabric in sodic aplite; Black, rounded grains are garnet. Field of view is approximately 3 mm (sample P3-75).
The anorthite contents of nine plagioclase feldspar samples, determined by the optical method of Morse (1968), are shown in Table 15. Sample GL-10-5a, from the immediate vicinity of the upper contact, has an anorthite content of An_{26}. High calcium contents were indicated in two other, near-contact plagioclases examined by the author. The oligoclase occurs immediately adjacent to the upper contact, in the graphic pegmatite unit, and extends only one or two millimetres into the pegmatite. Calcic plagioclase occurring along the margins of granitic pegmatites is generally attributed to calcium assimilation from the wall rocks (Černý et al., 1984), which in the case of the Huron Claim, are metagabbroic. The pegmatites of the Winnipeg River district contain albite with anorthite contents ranging from An_{0} to An_{6} (Černý et al., 1981b). The Huron Claim albites, by comparison, range from An_{1} to An_{5}.

Seven samples of albite, representing the various morphological varieties, were X-rayed to determine their structural state. The resulting $2\theta_{131}-2\theta_{131}$ values are given in Table 16, along with the anorthite contents determined by microprobe analysis. As indicated in Figure 20, the albites are all in the low structural state. This is not surprising in view of the fact that plagioclase from the pegmatites of the Winnipeg River district is always in the low structural state, regardless of its composition and mineral association (Černý et al., 1981b).

Electron microprobe analyses of thirteen albites from the Huron Claim pegmatite are shown in Table 17. Also shown in the table are thirteen analyses of albite lamellae in microcline-perthite. These albites were selected for analysis on the basis of their morphological
Table 15. Optical determinations of the anorthite content of plagioclase from the Huron Claim pegmatite.

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GL-10 series from Černý, unpublished data; GL-10-5a, adjacent to upper contact; GL-10-5b, 2 cm. from contact; GL-10-5c, 6 cm. from contact.

Determinations on 77-TH-04 and P3-77 by J. Macek, Manitoba Mines Branch.

Table 16. \( \theta_{131} - \theta_{131} \) (CuKα) values for plagioclase from the Huron Claim pegmatite.

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Anorthite content from microprobe analyses.
Figure 20. Boundary curves for the variation of $\theta_{131}-\theta_{131}$(CuKα) with the anorthite content of plagioclase. (Bambauer et al., 1967).
Red dots are plagioclase from the Huron Claim pegmatite.
Table 17. Electron microprobe data for plagioclase feldspar.

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<tr>
<th>Sample</th>
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<th>Fe₂O₃</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>H₂O</th>
<th>BaO</th>
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Electron microprobe analyses by J.S. Delaney, University of Chicago (1978). nd = not detected; quantities given in weight %; TiO₂ and SrO not detected.
variety. Samples were also prepared of the late vein and near-contact albite, but these samples were not microprobed. Consequently, there is no compositional data for these two important varieties of albite. The minor and trace element contents of the various albites were determined on the ion microprobe, and are shown in Table 18. The cation contents (Ca, Na and K) and anorthite/albite/orthoclase ratios of the analyzed samples are listed in Table 19. XRF and NAA analyses of three additional Huron Claim albites are shown in Table 20.

Disregarding three of the analyses, which are obviously contaminated, the albite content of the plagioclase feldspars varies from 94 to 98%, and the orthoclase content from 1 to 3%. The anorthite contents of 1 to 5% are in agreement with the anorthite contents determined by optical methods. The high potassium content in samples FP9-14 and FP10-17 may be due to relict K-feldspar, although these feldspars are highly sericitized as well. Sample FP9-02, which contains 6.9% K₂O, is almost certainly contaminated by K-feldspar. Of all the albites, the primary tabular variety seems to have the highest and most consistent anorthite contents. Sodium enrichment in successive generations of albite would not be unexpected, and has recently been documented for the plagioclases of the Věžná pegmatite in Czechoslovakia (Černý et al., 1984). Other than the enhanced anorthite content in the coarse-grained tabular albite, no compositional distinctions can be made between the different morphological varieties of albite. The albite lamellae in microcline-perthite are enriched in sodium relative to the primary and "replacement" albites, as expected (Černý, pers. comm.). No compositional data is available for the late generations of vein albite.
Table 18. Ion microprobe data for plagioclase feldspar.

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<tr>
<th>Sample</th>
<th>Li</th>
<th>Rb</th>
<th>Cs</th>
<th>Na</th>
<th>Mg</th>
<th>Sr</th>
<th>Ba</th>
<th>Pb</th>
<th>Fe</th>
<th>P</th>
<th>B</th>
<th>F*</th>
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<td>0.03</td>
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Ion microprobe analyses by R.A. Masen, University of Chicago (1978). Quatities given in ppm by weight, except F*, for which counts/second are reported. na - not analyzed.
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<th>Ab</th>
<th>Or</th>
<th>Rb</th>
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<td>P3-20</td>
<td>1.123</td>
<td>3.5723</td>
<td>.0440</td>
<td>3.3</td>
<td>95.5</td>
<td>1.2</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>392</td>
</tr>
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<td>P3-24</td>
<td>1.125</td>
<td>3.7839</td>
<td>.0691</td>
<td>3.1</td>
<td>95.2</td>
<td>1.8</td>
<td>-</td>
<td>161</td>
<td>60</td>
<td>379</td>
</tr>
<tr>
<td>coarse-grained tabular albite</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>FP8-02</td>
<td>.1620</td>
<td>3.2667</td>
<td>.0612</td>
<td>4.7</td>
<td>94.1</td>
<td>1.2</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>462</td>
</tr>
<tr>
<td>FF3-03</td>
<td>.1235</td>
<td>3.4030</td>
<td>.0272</td>
<td>3.5</td>
<td>95.8</td>
<td>0.8</td>
<td>-</td>
<td>143</td>
<td>10</td>
<td>340</td>
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<td>near-contact albite</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>FP10-01</td>
<td>.0705</td>
<td>3.6632</td>
<td>.0316</td>
<td>1.9</td>
<td>97.3</td>
<td>0.8</td>
<td>-</td>
<td>125</td>
<td>-</td>
<td>266</td>
</tr>
<tr>
<td>FP10-02</td>
<td>.0673</td>
<td>2.2283</td>
<td>1.6182</td>
<td>1.2</td>
<td>57.3</td>
<td>41.4</td>
<td>2742</td>
<td>161</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>F3-24</td>
<td>.125</td>
<td>3.1852</td>
<td>.2832</td>
<td>3.2</td>
<td>88.9</td>
<td>7.9</td>
<td>-</td>
<td>143</td>
<td>-</td>
<td>39</td>
</tr>
</tbody>
</table>

| Fine-grained tabular albite |       |       |      |       |       |       |     |     |     |     |
| FP7-14       | .0487 | 4.0305| .0342| 1.4   | 97.7  | 0.8   | -   | 56  | 15  | 685 |
| FP8-02-B     | .1159 | 3.6861| .0274| 3.1   | 96.2  | 0.7   | -   | 278 | 22  | 410 |
| FP9-14       | .0337 | 3.7677| .3681| 0.8   | 90.4  | 8.8   | 238 | 108 | 20  | 296 |
| FP9-30       | .0935 | 3.8996| .0631| 2.3   | 96.1  | 1.6   | -   | 188 | -   | 336 |
| FP10-17      | .0946 | 3.0119| .6589| 7.5   | 80.0  | 17.5  | -   | 125 | -   | 26  |
| FP9-01       | .0705 | 3.6632| .0316| 1.9   | 97.3  | 0.8   | -   | 125 | -   | 266 |
| FP9-02       | .0673 | 2.2283| 1.6182| 1.2 | 57.3  | 41.4  | 2742| 161 | -   | 4   |

| Albite lamellae in microcline-perthite |     |       |      |       |       |       |     |     |     |     |
| FP3-06       | .0304 | 3.6688| .1173| 0.8   | 96.1  | 3.1   | 55  | -   | -   | 423 |
| FP3-08       | .0221 | 3.9125| .0126| 0.6   | 99.1  | 0.3   | -   | 72  | -   | 528 |
| FP4-02       | .0306 | 3.9889| .0106| 0.3   | 99.5  | 0.3   | -   | 469 | -   | 449 |
| FP4-04       | .0388 | 3.8150| .0230| 1.0   | 98.4  | 0.6   | -   | 36  | -   | 344 |
| FP4-05-T     | .0394 | 3.9857| .0872| 1.0   | 96.9  | 2.1   | -   | 430 | -   | 440 |
| FP4-09       | .0453 | 4.0802| .1012| 1.1   | 96.5  | 2.4   | -   | 72  | -   | 144 |
| FP4-12-T     | .0222 | 3.8234| .0127| 0.6   | 99.1  | 0.3   | -   | 90  | -   | 501 |
| FP8-03       | .0276 | 3.8032| .0627| 0.7   | 97.7  | 1.6   | -   | 36  | -   | 545 |
| FP8-06       | .0323 | 3.7688| .0375| 0.8   | 98.2  | 1.0   | -   | -   | -   | 580 |
| FP8-08       | .2517 | 3.4021| .2196| 6.5   | 87.8  | 5.7   | 82  | 63  | -   | 249 |
| FP10-06      | .0251 | 3.7685| .0272| 0.7   | 98.6  | 0.7   | -   | 54  | -   | 510 |
| FP10-11-T    | .0352 | 3.6831| .0145| 0.9   | 98.7  | 0.4   | -   | 170 | -   | 445 |
| FP10-16      | .1152 | 3.1852| .2832| 3.2   | 88.9  | 7.9   | -   | 143 | -   | 39  |

Cations on the basis of 32 oxygen anions.
Rb, Ba, Sr*, and P given in ppm.
Sr* values as determined by the ion microprobe.
Table 20. XRF and NAA data for plagioclase feldspar from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th>Sample</th>
<th>TC-59</th>
<th>TC-60</th>
<th>TC-62</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂, wt.%</td>
<td>66.1</td>
<td>66.5</td>
<td>66.4</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>18.8</td>
<td>18.9</td>
<td>19.1</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.020</td>
<td>0.034</td>
<td>0.022</td>
</tr>
<tr>
<td>MgO</td>
<td>0.025</td>
<td>0.041</td>
<td>0.027</td>
</tr>
<tr>
<td>CaO</td>
<td>0.72</td>
<td>0.57</td>
<td>1.79</td>
</tr>
<tr>
<td>Na₂O</td>
<td>10.66</td>
<td>10.08</td>
<td>10.77</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.99</td>
<td>2.05</td>
<td>0.94</td>
</tr>
<tr>
<td>Rb₂O</td>
<td>0.007</td>
<td>0.007</td>
<td>0.009</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>0.089</td>
<td>0.069</td>
<td>0.099</td>
</tr>
<tr>
<td></td>
<td>97.411</td>
<td>98.251</td>
<td>99.157</td>
</tr>
<tr>
<td>Ba, ppm</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Cu</td>
<td>6</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Li</td>
<td>5</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Pb</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Sc</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>Sr</td>
<td>80</td>
<td>80</td>
<td>82</td>
</tr>
<tr>
<td>Ta</td>
<td>0.2</td>
<td>0.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Zn</td>
<td>22</td>
<td>18</td>
<td>14</td>
</tr>
</tbody>
</table>

Unpublished data of G. Morteani, H.V. Maravic and P. Moller (samples unlocated).
SiO₂, Al₂O₃, CaO, Na₂O and K₂O by XRF; remaining elements by neutron activation analysis.
The minor and trace element contents of the albite exhibit no obvious trends. In the Věžná pegmatite, Černý et al. (1984) documented an increase in phosphorus and a decrease in cesium, strontium, barium and lithium for successive generations of albite. Magnesium, iron, titanium, lead, boron and fluorine behaved erratically. The low, but uniform (200-700 ppm) phosphorus content in the Huron Claim albites probably reflects the low overall phosphorus content of this particular pegmatite. The magnesium content in the albites is low (6 to 692 ppm, ion probe), but erratic. The highest values are found in the samples with the highest potassium contents, suggesting clay mineral or mica contamination. The rubidium contents of the plagioclase feldspar are very low (0.2 to 47 ppm, ion probe), as this element is strongly partitioned into K-feldspar and muscovite. Iron, which presumably occurs in the trivalent state, is present in amounts ranging from .01 to .02% FeO. Barium occurs in amounts ranging from 9 to 278 ppm (1 to 51 ppm on the ion microprobe), which is about an order of magnitude lower than the barium contents in K-feldspar. The very low lithium contents in the albite (0.1 to 3.0 ppm) reflect the low overall lithium content of the pegmatite; lithium seems to be weakly partitioned into K-feldspar. Cesium shows a preference for K-feldspar, and is present only in minor amounts in albite (0.01 to 4.0 ppm). Strontium values of 5 to 100 ppm in the albite are similar to the values in K-feldspar. The zinc and copper values reported for three of the plagioclase feldspars are comparable to values for plagioclase given by Smith (1974). Tantalum is seldom reported in plagioclase feldspar, the values given here (0.2 to 0.9 ppm) being about an order of magnitude higher than the few analyses quoted in the literature (Smith, 1974).
Scandium is generally more abundant in plagioclase from basic igneous rocks, and the values reported for the Huron Claim albites are exceptionally low (.02 to .04 ppm). Boron in the Huron Claim albites is uniformly low, and probably reflects the low concentration of boron in the pegmatite; tourmaline is virtually absent in the Shatford Lake and Greer Lake pegmatite groups (Černý et al., 1981b). Lead is strongly partitioned into K-feldspar, the distribution in the Huron Claim feldspars comparing favourably with the four-fold concentration reported from the Věžná pegmatite (Černý et al., 1984).

A rigorous petrogenetic evaluation of the plagioclase feldspar in the Huron Claim pegmatite is beyond the reach of the present study, due partly to the incomplete analytical coverage of the different albite types. The difficulty in distinguishing between primary and metasomatic albite, and the apparent contamination in certain of the microprobe analyses makes definitive characterization of the feldspars difficult. Apart from the calcic plagioclase along the margins of the pegmatite and the apparent calcium enrichment in the early tabular albites, no obvious compositional trends are apparent. The pegmatite is comprised mainly of primary albite, with some development of metasomatic albite, especially in its central parts. Fine-grained replacement albite shows only rudimentary development in this particular pegmatite.

**Distribution of Minor and Trace Elements Between the Feldspars**

The distribution of minor and trace elements between alkali feldspar and plagioclase has been discussed to some extent in the preceding sections. The feldspars in the Huron Claim pegmatite co-exist on a large scale only, as they tend to form monomineralic segregations
in the various pegmatite units. Thus the distribution coefficients between co-existing feldspar phases are poorly defined and not truly comparable with data obtained on pairs of co-precipitated, adjacent feldspars. As the feldspars are the most abundant minerals in the Huron Claim pegmatite, their chemistry has probably been little affected by other trace element scavengers (e.g., very subordinate muscovite).

The microcline-perthite and plagioclase analyses have been compared in toto, irrespective of their individual associations, and certain elements have been plotted on the trace element versus major element diagrams of Smith (1974). Rubidium is overwhelmingly partitioned into K-feldspar (Figure 21a), as expected from the published distribution coefficients. Barium is slightly enriched in K-feldspar, but shows considerable overlap with plagioclase (Figure 21b). The strontium values in K-feldspar and plagioclase are similar (Figure 22a), despite the fact that strontium shows a slight preference for plagioclase in co-existing mineral pairs (Smith, 1974). The phosphorus values are similar in the two types of feldspar (Figure 22b). As shown in Figure 23a, lithium is enriched in K-feldspar with an average value about five times that in plagioclase. This is not the case for co-existing feldspar pairs, in which lithium is slightly concentrated in plagioclase (Smith, 1974). Lead is strongly fractionated into K-feldspar, with an average value about 14 times that of plagioclase (Figure 23b). Cesium is also strongly fractionated into K-feldspar, as indicated in Figure 24. The iron and boron contents in plagioclase and K-feldspar are very similar, whereas fluorine is enriched in plagioclase by a factor of about 10.
Figure 21. Relations between minor and major elements in the Huron Claim feldspars (I). Plagioclase is plotted at mol.% An and K-feldspar at mol.% Or. An arbitrary choice was made of some ion and electron microprobe analytical data.
Figure 22. Relations between minor and major elements in the Huron Claim feldspars (II). Plagioclase is plotted at mol.% An and K-feldspar at mol.% Or. An arbitrary choice was made of some ion and electron microprobe analytical data.
Figure 23. Relations between minor and major elements in the Huron Claim Feldspars (III). Plagioclase is plotted at mol % An and K-feldspar at mol % Or.
Figure 24. Cs versus major element content in the Huron Claim feldspars. Plagioclase is plotted at mol % An and K-feldspar at mol % Or.
Muscovite

"Early" muscovite, categorized by Hawthorne and Černý (1982), occurs in subordinate amounts in the Huron Claim pegmatite. It is intergrown with, or penetrates along fractures in coarse-grained albite, in close association with quartz and beryl. Most of the muscovite occurs in large, semi-transparent books, the largest of which are 9 centimetres across and 2 centimetres thick.

Two localities in the pegmatite are particularly enriched in muscovite. In the area adjacent to Pit #4, muscovite occurs as large, transparent green books in association with albite, quartz and beryl. Associated minerals are epidote and columbite-tantalite. The books of muscovite are intergrown and frequently "interleaved" with albite, which is often reddish-brown. The muscovite also envelopes large beryl crystals surrounded by albitic rims.

A second large accumulation of muscovite is found in the rubble pile east of the "S"-Pit. Here, large books of bronze-coloured muscovite occur intergrown with both pink and reddish-brown albite. This muscovite seems to marginally corrode the albite in places, and is occasionally altered to chlorite. Quartz is a conspicuous associate.

Several hand specimens, consisting almost entirely of green muscovite in the form of small (1 to 10 millimetre wide) books, were collected from the vicinity of Pit #3. Intergrown with this muscovite are small amounts of beryl, quartz and albite. Muscovite occurs infrequently as fine-grained (<1 mm) aggregates in albite (Plate 20),
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VEUILLEZ ECRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 20. Late (?) muscovite, bavenite, clays and reddish vein albite eroding coarse-grained, primary albite. Coin is 17 millimetres in diameter.
and as aggregate masses with quartz and columbite-tantalite. These fine-grained muscovites may postdate the more conspicuous book muscovites, although the mineral associations seem to be identical. As discussed in Hawthorne and Černý (1982), "early" and metasomatic muscovites are often difficult to distinguish in simple pegmatites such as the Huron Claim. Muscovite has also been found in association with bertrandite, chlorite and clay minerals in large pseudomorphs after beryl.

The $n_\gamma(001)$ refractive indices of the Huron Claim muscovite vary from 1.600 to 1.602 (Černý, unpublished data). Eight samples of muscovite were X-rayed with a Debye-Scherrer camera in order to determine their structural polytype. All the muscovites are 2M$_1$, polytypes, including the fine-grained "late" muscovites in samples P2-01 and P2-21.

Partial chemical analyses of six Huron Claim muscovites, including a number of trace elements, are shown in Tables 21 and 22. The samples, all book muscovites, were chosen for analysis on the basis of differences in their location and general appearance. The most obvious feature of these muscovites is their compositional similarity. They have high iron and magnesium contents, and are depleted in rare alkalis, similar to the "early" muscovites described by Hawthorne and Černý (1982). The rubidium content of these micas is very high, matching or exceeding that of the Shatford Lake group as a whole (1590 to 10900 ppm). As a result, the K/Rb ratios of the Huron Claim muscovites are significantly lower than those occurring in the Shatford Lake pegmatites.
Table 21. Partial chemical analysis of muscovite from the Huron Claim pegmatite

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>WP-09</th>
<th>WP-11</th>
<th>WP-44</th>
<th>SP-04</th>
<th>SP-05</th>
<th>77-MU 01, 02</th>
</tr>
</thead>
<tbody>
<tr>
<td>K&lt;sub&gt;2&lt;/sub&gt;O, wt.%</td>
<td>8.85</td>
<td>8.75</td>
<td>8.75</td>
<td>8.85</td>
<td>9.10</td>
<td>8.60</td>
</tr>
<tr>
<td>Na&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>0.56</td>
<td>0.56</td>
<td>0.64</td>
<td>0.54</td>
<td>0.60</td>
<td>0.62</td>
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<tr>
<td>CaO</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td>0.03</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>MgO</td>
<td>0.59</td>
<td>0.61</td>
<td>0.66</td>
<td>0.61</td>
<td>0.59</td>
<td>0.61</td>
</tr>
<tr>
<td>Fe&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
<td>2.89</td>
<td>2.80</td>
<td>2.51</td>
<td>2.50</td>
<td>2.51</td>
<td>2.68</td>
</tr>
<tr>
<td>F</td>
<td>0.06</td>
<td>0.09</td>
<td>0.08</td>
<td>0.12</td>
<td>0.07</td>
<td>0.09</td>
</tr>
<tr>
<td>Li, ppm</td>
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<td>370</td>
<td>420</td>
<td>360</td>
<td>440</td>
<td>400</td>
</tr>
<tr>
<td>Rb</td>
<td>11400</td>
<td>10600</td>
<td>10400</td>
<td>10700</td>
<td>11000</td>
<td>10300</td>
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<tr>
<td>Cs</td>
<td>320</td>
<td>250</td>
<td>240</td>
<td>250</td>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td>K/Rb</td>
<td>6.45</td>
<td>6.85</td>
<td>6.98</td>
<td>6.87</td>
<td>6.86</td>
<td>6.93</td>
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<td>Polytype</td>
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<td>2M&lt;sub&gt;1&lt;/sub&gt;</td>
<td>2M&lt;sub&gt;1&lt;/sub&gt;</td>
<td>2M&lt;sub&gt;1&lt;/sub&gt;</td>
<td>2M&lt;sub&gt;1&lt;/sub&gt;</td>
<td>2M&lt;sub&gt;1&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

Total Fe reported as Fe<sub>2</sub>O<sub>3</sub>
Table 22. Trace element contents of muscovite from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>WP-09</th>
<th>WP-11</th>
<th>WP-44</th>
<th>SP-04</th>
<th>SP-05</th>
<th>77-MU-01,02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sc, ppm</td>
<td>35</td>
<td>50</td>
<td>59</td>
<td>57</td>
<td>39</td>
<td>64</td>
</tr>
<tr>
<td>Co</td>
<td>3.2</td>
<td>2.8</td>
<td>2.4</td>
<td>2.7</td>
<td>2.8</td>
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<td>319</td>
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<td>323</td>
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<tr>
<td>Hf</td>
<td>0.96</td>
<td>0.85</td>
<td>-</td>
<td>-</td>
<td>0.83</td>
<td>1.01</td>
</tr>
<tr>
<td>Ta</td>
<td>182</td>
<td>157</td>
<td>153</td>
<td>160</td>
<td>181</td>
<td>171</td>
</tr>
<tr>
<td>W</td>
<td>43</td>
<td>41</td>
<td>40</td>
<td>42</td>
<td>42</td>
<td>46</td>
</tr>
</tbody>
</table>

These characteristics manifest themselves in the K/Rb vs. Cs, and K/Rb vs. Li plots shown in Figures 25 and 26, in which the Huron Claim muscovites occur outside of the Shatford Lake compositional fields (the Huron Claim K-feldspars, it should be mentioned, also contain significant amounts of rubidium). The muscovites are compositionally similar, and differentiation trends are not apparent. In the suspected single generation of muscovite in the Huron Claim pegmatite, compositional trends might not be expected.

"Early" book muscovites occurring along the margin of the quartz core are characteristic of barren, or relatively simple pegmatites with Be and Nb-Ta mineralization (Hawthorne and Černý, 1982). Similarly, in gadolinite-bearing, blocky microcline-biotite pegmatites, muscovite occurs in subordinate amounts near the quartz core (Beus, 1966). This adequately describes the situation in the Huron Claim pegmatite, in which muscovite is associated with albite, quartz and beryl. In the Huron Claim, the quartz core is irregularly developed, but two of the best exposures are in the "S" and #4 pits, from which the majority of muscovite samples were collected.

**Biotite**

Biotite occurs in subordinate amounts in the Huron Claim pegmatite, and is less abundant than muscovite. Pristine biotite is not present in the pegmatite, as it is altered to chlorite in all instances. For this reason, chemical analyses and physical determinations on biotite were not attempted during the present study.

In the Huron Claim pegmatite, biotite is present in two morphological varieties. It occurs in the graphic, aplitic and granular
Figure 25. K/Rb vs. Cs plot of Huron Claim muscovites. Compositional fields for the Shatford Lake and Greer Lake pegmatite groups from Černý et al. (1981b).
Figure 26. K/Rb vs. Li plot of Huron Claim muscovites. Compositional fields for the Shatford Lake and Greer Lake pegmatite groups from Černý et al. (1981b).
albitic outer zones of the pegmatite, as thin, lath-like crystals up to 21 millimetres long and 6 millimetres wide. The laths of biotite seem relatively fresh in hand specimen, but microscopic examination indicates that they are completely altered to chlorite. The laths are ragged and corroded by plagioclase, and are frequently intergrown with garnet. Perhaps the best occurrences of this variety of biotite are in the graphic and granular albitic zones exposed in Pit #5.

The second and more conspicuous occurrence of biotite in the Huron Claim pegmatite is as large, but very thin plates in the medium to coarse-grained albite unit. Plates 6 centimetres long and 7 centimetres wide occur in specimens from the University of Manitoba collection, but larger plates undoubtedly exist. Most specimens of this variety of biotite were collected from dumps, but it occurs abundantly in the flat-lying outcrops near the southwest tip of the pegmatite. The plates of biotite are present in coarse-grained albite, close to the outer margins of the pegmatite. In hand specimen this variety of biotite seems to be arranged along sub-parallel fractures in the albite, but this may be somewhat illusory due to the thin nature of the plates. The radiating aggregate of chloritized biotite shown in Plate 21 is rather untypical of biotite in the medium to coarse-grained albite unit. An $n_0(001)$ value of 1.630 was obtained from one of these large plates of chloritized biotite (Černý, unpublished data).

Subordinate to accessory amounts of biotite are characteristic of simple, non-mineralized to Be, Ti, Nb>Ta, REE, U and Th-bearing pegmatites (Hawthorne and Černý, 1982). In the Winnipeg River district, accessory lath-shaped biotites are developed in the outer zones of the less differentiated pegmatites, notably the Shatford Lake,
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Plate 21. Radiating aggregate of coarsely-crystalline chlorite after biotite. Coin is 17 mm. in diameter (P3-53).

Table 23. Partial chemical analysis of biotite from the Shatford Lake pegmatite group (from Černý et al., 1981b).

<table>
<thead>
<tr>
<th></th>
<th>SHS-E3</th>
<th>SHS-W1</th>
<th>SHE-1A</th>
<th>SHE-2S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li₂O, wt.%</td>
<td>0.50</td>
<td>0.92</td>
<td>0.80</td>
<td>0.36</td>
</tr>
<tr>
<td>Na₂O</td>
<td>0.52</td>
<td>0.21</td>
<td>0.23</td>
<td>0.19</td>
</tr>
<tr>
<td>K₂O</td>
<td>8.90</td>
<td>10.40</td>
<td>9.30</td>
<td>9.40</td>
</tr>
<tr>
<td>Rb₂O</td>
<td>0.26</td>
<td>0.34</td>
<td>0.31</td>
<td>0.50</td>
</tr>
<tr>
<td>Cs₂O</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>CaO</td>
<td>0.003</td>
<td>0.03</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Analysts K. Ramilal and R. Chapman.
Biotites occur in the wall zones of pegmatites from the Shatford Lake group, which are intruded into metabasalts of the Lamprey Falls formation.
Greer Lake and Axial pegmatite groups (Černý et al., 1981b). In gadolinite-bearing blocky pegmatites (Beus, 1966), biotite occurs adjacent to the boundary between the quartz core and blocky microcline zones, or scattered throughout the outer zones of the pegmatite. In this type of pegmatite, biotite also occurs on occasion within the albite replacement units. Primitive types of rare-element pegmatites, in general, contain biotite as laths and dendritic aggregates in the outer graphic and granitic zones, and as giant plates and books adjacent to the quartz core (Hawthorne and Černý, 1982). Both of these morphological types occur within the Huron Claim pegmatite, although the association of biotite with the quartz core has not been demonstrated, and is more typical of muscovite.

Partial chemical analyses of four biotites from the Shatford Lake pegmatite group are shown in Table 23. These biotites were apparently able to concentrate rare alkali elements, even when the bulk compositions of the host pegmatites were depleted in these elements (Černý et al., 1981b). They may approximate the composition of the Huron Claim biotites before alteration. The complete alteration of biotite to chlorite even in the freshest hand specimens indicates that subsolidus leaching was much more extensive in the Huron Claim pegmatite than in the pegmatites along the north shore of Shatford Lake.

**Chlorite**

Chlorite occurs in the Huron Claim pegmatite in two distinct varieties. As discussed in the previous section, it is ubiquitous as an alteration product of biotite in the outermost units of the pegmatite. More conspicuously, it occurs as an open-space filling in
the medium to coarse-grained albite unit, forming part of the late calcium mineral assemblage.

The primary biotite in the Huron Claim pegmatite is completely pseudomorphed by chlorite in all instances. The original size and shape of the plates is preserved, and the smaller plates in the graphic pegmatite unit maintain their splendent lustre. Thin section examination of the freshest-looking biotites confirms their alteration to chlorite. The largest plates are dark, greenish black, and very soft. Refractive index data for the chlorite after biotite is given in Table 24. The chlorites are optically inhomogeneous, and vermiculite may be admixed with chlorite in certain of the pseudomorphs. Sub-solidus leaching of biotite to form chlorite was apparently widespread and thorough in the Huron Claim pegmatite.

The second variety of chlorite in the pegmatite is the fine-flaked variety forming an essential part of the late calcium mineral assemblage. Dark green, fine-flaked aggregates of this chlorite fill voids or fractures in the medium to coarse-grained albite unit. Associated minerals are bavenite, bertrandite, bityite and epidote. In some instances, the chlorite is partially replaced by clay minerals. Chlorite of this type, it should be noted, is found in many of the pegmatites belonging to the Shatford Lake group, as well as in several pegmatites belonging to the Greer Lake group (Černý et al., 1981b).

The optical properties of the fine-flaked chlorite from the Huron Claim pegmatite are shown in Table 24. In general, chlorites change their optic sign at $n_b$ values of about 1.630 and total $Fe/(total\ Fe + Mg)$ values of about 0.52 (Albee, 1962). Chlorites with $n_b$ greater than 1.630 are optically negative and length slow, and display abnormal
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Plate 22. Fine-flaked chlorite (violet interference colours) intergrown with fibrous bavenite — minor amounts of muscovite, epidote and clays (P3-83).

Table 24. Optical properties of chlorite from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th></th>
<th>chlorite after biotite</th>
<th>fine-flaked chlorite</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>1.56 - 1.68</td>
<td>1.634</td>
</tr>
<tr>
<td>$\beta - \gamma$</td>
<td>-</td>
<td>1.630</td>
</tr>
<tr>
<td>optic sign</td>
<td>-</td>
<td>(-)ve</td>
</tr>
<tr>
<td>orientation</td>
<td>-</td>
<td>length (+)ve</td>
</tr>
<tr>
<td>2V</td>
<td>-</td>
<td>small</td>
</tr>
<tr>
<td>dispersion</td>
<td>-</td>
<td>high</td>
</tr>
</tbody>
</table>

P. Cerny, unpublished data.
violet or blue interference colours near the sign change. The fine-flaked chlorite from the Huron Claim pegmatite exhibits all of these properties, including abnormal violet interference colours (Plate 22), but is length fast.

Chemical analyses of fine-flaked chlorite from the Huron Claim pegmatite and the SHS-C pegmatite on the south shore of Shatford Lake are shown in Table 25. In Figure 27, the two chlorite samples have been plotted in the compositional diagram of Foster (1962). Both chlorites are highly ferruginous, and they can be classified as magnesium aluminian chamosites (Bayliss, 1975). The Huron Claim chlorite has Fe\(^{2+}\) approximately equal to Mg, and therefore closely approaches clinochlore; the total Fe/(total Fe + Mg) ratio in sample P3-83 is 0.57.

Both varieties of chlorite were X-rayed for identification purposes. X-ray powder diffraction data for fine-flaked chlorite from the Huron Claim pegmatite is given in Bristol (1962).

**Bityite**

Bityite is an extremely rare, layered beryllo-aluminosilicate first described from the lithian pegmatites of Madagascar (Lacroix, 1908). In the Huron Claim pegmatite, it is a volumetrically unimportant but relatively widespread alteration product after beryl. Bityite occurs with epidote in small cavities in the medium to coarse-grained albite unit, and also as pseudomorphs or partial pseudormorphs after beryl (Plate 23). In the latter occurrence, the bityite often forms "shells" around cores of bavenite and remnant beryl. The mineral occurs in silvery-white, pseudohexagonal plates rarely exceeding 0.5
Table 25. Chemical composition of chlorite

<table>
<thead>
<tr>
<th>Sample</th>
<th>P3-83</th>
<th>SHS-C</th>
<th>P3-83'</th>
<th>SHS-C'</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>23.50</td>
<td>22.25</td>
<td>S↓5</td>
<td>5.025</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>0.56</td>
<td>0.48</td>
<td>P</td>
<td>0.101</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>20.40</td>
<td>21.64</td>
<td>Al</td>
<td>2.874</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>7.50</td>
<td>6.48</td>
<td>Fe³⁺</td>
<td>1.207</td>
</tr>
<tr>
<td>TlO₂</td>
<td>nd</td>
<td>nd</td>
<td>Tl³⁺</td>
<td>3.475</td>
</tr>
<tr>
<td>FeO</td>
<td>23.36</td>
<td>31.56</td>
<td>Fe²⁺</td>
<td>4.177</td>
</tr>
<tr>
<td>MgO</td>
<td>12.50</td>
<td>5.44</td>
<td>Mg</td>
<td>3.983</td>
</tr>
<tr>
<td>MnO</td>
<td>0.82</td>
<td>0.86</td>
<td>Mn</td>
<td>0.149</td>
</tr>
<tr>
<td>CaO</td>
<td>0.10</td>
<td>0.10</td>
<td>Ca</td>
<td>0.017</td>
</tr>
<tr>
<td>BeO</td>
<td>0.24</td>
<td>0.06</td>
<td>Be</td>
<td>0.123</td>
</tr>
<tr>
<td>Na₂O</td>
<td>0.05</td>
<td>0.05</td>
<td>Na</td>
<td>0.021</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.05</td>
<td>0.11</td>
<td>K</td>
<td>0.013</td>
</tr>
<tr>
<td>Li₂O</td>
<td>0.13</td>
<td>0.15</td>
<td>Li</td>
<td>0.113</td>
</tr>
<tr>
<td>H₂O⁺</td>
<td>10.73</td>
<td>10.41</td>
<td>H₂O⁻</td>
<td>0.021</td>
</tr>
<tr>
<td>H₂O⁻</td>
<td>0.44</td>
<td>0.27</td>
<td>Li⁺</td>
<td>0.147</td>
</tr>
<tr>
<td>CO₂</td>
<td>0.02</td>
<td>0.06</td>
<td>OH</td>
<td>15.804</td>
</tr>
<tr>
<td></td>
<td>100.40</td>
<td>99.87</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fe²⁺/ R²⁺ (at.) 0.49 0.75

total Fe/(total Fe+Mg) at. 0.57 0.79

AA and XRF analyses by R. Chapman and K. Ramal

nd - not detected; sample SHS-C from the SHS pegmatite on the south shore of Shafford Lake

1-cations on the basis of 36 oxygen anions; CaCO₃ extracted from analyses

P3-83 \( (R³⁺₁.₇₄ R²⁺₄.₂₂ R⁺₀.₀₇) (Si₂.₅₁Al₁.₄₄P₀.₀₅) O₁₀ OH₇.₆₅ \)

SHS-C \( (R³⁺₁.₉₁ R²⁺₃.₉₃ R⁺₁.₀) (Si₂.₄₈Al₁.₄₇P₀.₀₅) O₁₀ OH₇.₇₄ \)
Figure 27. Classification of chlorites based on the two principal types of ionic replacement (Foster, 1962). Varietal names have been superceded by the end-member compositions clinochlore (Mg), chamosite (Fe), nimate (Ni) and pennantite (Mn, Al) - Bayliss (1975), Fleischer (1983).
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Plate 23. Two examples of bityite forming the outer margin of a beryl pseudomorph. Associated minerals are chlorite (black), bavenite and remnant beryl. Coins are approximately the same size (17-18 mm.).

Plate 24. Complete pseudomorphs of bityite after beryl, in twinned albite (X nicols).
millimetres in maximum dimension. Associated minerals are beryl, bavenite, bertandite, chlorite and epidote.

Much the same morphology is evident in thin section. Bityite occurs as colourless, platy aggregates in cavities within albite, and also as crystal aggregates which partially or completely pseudomorph beryl (Plate 24). Individual crystals are generally less than 0.5 millimetres in maximum dimension, the largest being about one millimetre. Wavy extinction is characteristic of the bityite aggregates, as are the grey to light brown interference colours and low birefringence.

Unit cell dimensions and optical properties of several specimens of bityite are presented in Table 26. This data is in general agreement with previously published work on bityite from the type locality in Madagascar (Strunz, 1956).

The di-octahedral brittle mica margarite, CaAl₂[Al₂Si₂O₁₀](OH)₂, is structurally analagous to bityite, bowleyite and beryllian margarite. Among the latter minerals, there is variable substitution of beryllium for aluminum at the octahedral positions, balanced by the introduction of lithium into the vacant octahedral sites. A tetra-hedral substitution of Al by Be, compensated by O/(OH) substitution, was also proposed by Beus (1966):

\[
^\text{VI} \text{Al} \leftrightarrow \text{Be}^{2+} + \text{Li}^+ \\
^\text{IV} [\text{AlO}_4]^{5-} \leftrightarrow [\text{BeO}_3(\text{OH})]^{5-}
\]

There seems to be a complete isomorphous series from beryllium-free margarite, to bowleyite with up to 8.0% BeO (Vlasov, 1966). The calcium plus sodium, and silicon contents of these minerals are relatively constant, whereas Li₂O varies from 0.47 to 2.61%, BeO from 0.91 to 8.05% and Al₂O₃ from 35.58 to 47.35%. Bowleyite has a
Table 26. Physical properties of bityite.

<table>
<thead>
<tr>
<th></th>
<th>GL-34$^1$</th>
<th>WP-21$^1$</th>
<th>HC$^2$</th>
<th>Madagascar$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a,\text{(Å)}$</td>
<td>4.923(8)</td>
<td>4.927(6)</td>
<td>4.969(1)</td>
<td>4.98</td>
</tr>
<tr>
<td>$b,\text{(Å)}$</td>
<td>8.687(8)</td>
<td>8.704(5)</td>
<td>8.698(1)</td>
<td>8.67</td>
</tr>
<tr>
<td>$c,\text{(Å)}$</td>
<td>18.88(3)</td>
<td>18.90(2)</td>
<td>18.61(2)</td>
<td>18.74</td>
</tr>
<tr>
<td>$\beta$</td>
<td>90°13'</td>
<td>90°15'</td>
<td>91°07'</td>
<td>90°</td>
</tr>
<tr>
<td>$V(\text{Å}^3)$</td>
<td>807.6</td>
<td>810.7</td>
<td>804.5</td>
<td>809.1</td>
</tr>
<tr>
<td>$a/b/c$</td>
<td>.567/1/2.173</td>
<td>.566/1/2.171</td>
<td>.571/1/2.140</td>
<td>.574/1/2.161</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>HC$^2$</th>
<th>Madagascar$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>1.642</td>
<td>1.651</td>
</tr>
<tr>
<td>$\beta$</td>
<td>1.654-1.655</td>
<td>1.659</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>1.660</td>
<td>1.661</td>
</tr>
<tr>
<td>2$V$</td>
<td>small</td>
<td>35.52°</td>
</tr>
<tr>
<td></td>
<td>(-)</td>
<td>(-)</td>
</tr>
</tbody>
</table>

considerably higher beryllium content than either bityite or beryllian margarite. The Li₂O contents of bityite and bowleyite considerably exceed those of beryllian margarite. Although the BeO and Li₂O contents of the Huron Claim bityite (Table 27) are lower than those of the type specimen from Madagascar, they are sufficiently high for its chemical characterization as bityite. Also shown in Table 27 are chemical analyses of beryllian margarite and bowleyite.

Bityite has been identified in the Lower TANCO pegmatite (Ferreira, 1984), and in the Huron pegmatite, as well as from the type locality in Madagascar. Bowleyite, the high BeO analogue, has been described only from Western Australia. Beryllian margarite occurs in the USSR in both pegmatites and pneumatolytic-hydrothermal veins in ultrabasic rocks; it has also been described from South Africa (Vlasov, 1966). These beryllian micas all form by the replacement of plagioclase at the contacts between pegmatite and ultrabasic or carbonate wall rocks, or during the hydrothermal decomposition of beryl; beryllian margarites with low BeO contents are most typical of desilicated pegmatites (Beus, 1966). Bityite is a relatively late mineral, forming in hydrothermal environments which are characterized by an abundance of Ca-rich fluids (Ginsburg, 1957). Early-formed minerals in ubiquitous association with bityite are albite and alkali beryl.

GARNET

Garnet is an abundant accessory mineral in the Huron Claim pegmatite only in the aplitic and granular albite units which are irregularly developed along the upper and lower contacts. Garnetiferous
Table 27. Chemical compositions in the beryllian margarite-bityite-bowleyite group.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>1'</th>
<th>2'</th>
<th>4'</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂, wt.%</td>
<td>29.84</td>
<td>31.95</td>
<td>-</td>
<td>32.22</td>
<td>Si</td>
<td>1.98</td>
<td>2.06</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>47.35</td>
<td>41.75</td>
<td>-</td>
<td>35.58</td>
<td>Al</td>
<td>3.71</td>
<td>3.17</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.81</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Fe³⁺</td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>MgO</td>
<td>1.22</td>
<td>0.13</td>
<td>0.48</td>
<td>-</td>
<td>Mg</td>
<td>0.12</td>
<td>0.01</td>
</tr>
<tr>
<td>CaO</td>
<td>11.70</td>
<td>14.30</td>
<td>13.18</td>
<td>15.35</td>
<td>Ca</td>
<td>0.83</td>
<td>0.99</td>
</tr>
<tr>
<td>BeO</td>
<td>1.18</td>
<td>2.27</td>
<td>0.91</td>
<td>8.05</td>
<td>Be</td>
<td>0.19</td>
<td>0.35</td>
</tr>
<tr>
<td>Li₂O</td>
<td>0.47</td>
<td>2.73</td>
<td>1.05</td>
<td>2.61</td>
<td>Li</td>
<td>0.13</td>
<td>0.71</td>
</tr>
<tr>
<td>Na₂O</td>
<td>1.93</td>
<td>0.40</td>
<td>0.31</td>
<td>0.55</td>
<td>Na</td>
<td>0.25</td>
<td>0.05</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.55</td>
<td>0.16</td>
<td>0.50</td>
<td>0.09</td>
<td>K</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>H₂O⁻</td>
<td>0.12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>OH</td>
<td>1.98</td>
<td>2.79</td>
</tr>
<tr>
<td>H₂O⁺</td>
<td>4.47</td>
<td>6.50</td>
<td>-</td>
<td>5.80</td>
<td>F</td>
<td>0.15</td>
<td>-</td>
</tr>
<tr>
<td>F₂</td>
<td>0.70</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100.35</td>
<td>100.19</td>
<td></td>
<td>100.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-O=F₂</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of ions on the basis of 10 O + 2(OH).

2. Bityite, Madagascar (Lacroix, 1908).
4. Bowleyite, Londonderry, Western Australia (Rowledge and Hayton, 1948).

1. \((Ca,Na,K)_{1.13} (Al, Li, Mg, Fe)_{2.17} (Si, Al, Be)_{4} (O, 0.87F, 1.13) (OH, F)_{2}\)
2. \((Ca, Na, K)_{1.05} (Al, Li, Mg)_{2.30} (Si, Al, Be)_{4} (O, 0.921, 0.79) (OH)_{2}\)
3. \((Ca, Na, K)_{1.13} (Al, Li)_{2.62} (Si, Al, Be)_{4} (O, 0.53, 0.47) (OH)_{2}\)
Aplites occur in Pits #3 and #5, as well as in the flat-lying outcrops near the southwestern end of the pegmatite. Garnets are very rarely found in the units of graphic pegmatite (Pit #5), and medium to coarse-grained albite (Pit #4).

The reddish garnet in the aplitic units is almost always euhedral, exhibiting dodecahedral and trapezohedral crystal forms. The garnet is associated with albite, quartz, beryl and muscovite in Pit #3, and granular albite, quartz and sulphide in the flat-lying southwestern outcrops. The aplitic garnets are very clean, and easily separated by crushing and elutriation. The grain size of these garnets is generally less than 1.5 millimetres. In Pit #5, garnet is associated with granular albite and quartz, and is occasionally sandwiched between laths of chloritized biotite (Plate 25). The garnets in the medium to coarse-grained albite unit tend to be larger than those in the aplitic unit (4 mm., maximum size); they are generally subhedral and somewhat poikilitic.

The cell dimensions of three garnet samples were determined by X-ray diffraction, using the quartz-calibrated (611) diffraction peak, and pycnometric density determinations were made on two of these samples (Table 28). Both the unit cell dimensions and densities suggest that the garnets are enriched in the Fe end-member, almandine.

Chemical analyses of the Huron Claim garnets are shown in Table 29. Calcium is a negligible component in these garnets, and the compositions have been plotted in the pyralspite garnet triangle in Figure 28. Mn/(Mn + Fe) ratios in the garnets range from 0.29 to 0.40. The magnesium content of the garnets is uniformly low, suggesting that wall rock contamination was negligible.
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Plate 25. Poikilitic garnet (with thin muscovite rims) in association with chloritized biotite, cleavelandite and columbite-tantalite (P5-04).

Table 28. Physical properties of garnet from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>2θ(611)</th>
<th>d</th>
<th>a(Å)</th>
<th>density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3-78/80</td>
<td>48.565</td>
<td>1.8730</td>
<td>11.546</td>
<td>4.33</td>
</tr>
<tr>
<td>P5-04/05</td>
<td>48.525</td>
<td>1.8745</td>
<td>11.555</td>
<td>-</td>
</tr>
<tr>
<td>SW-01/04</td>
<td>48.535</td>
<td>1.8741</td>
<td>11.553</td>
<td>4.30</td>
</tr>
<tr>
<td>Almandine</td>
<td>-</td>
<td>-</td>
<td>11.526¹</td>
<td>4.33²</td>
</tr>
<tr>
<td>Spessartine</td>
<td>-</td>
<td>-</td>
<td>11.621¹</td>
<td>4.19²</td>
</tr>
</tbody>
</table>

Garnet end-members as reported in Deer et al. (1968)¹, and Winchell (1958)².
Table 29. Chemical composition of garnet from the Huron Claim pegmatite

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>WP-051 (core)</th>
<th>WP-051 (edge)</th>
<th>WP-052 (core)</th>
<th>WP-052 (edge)</th>
<th>P3-80a (core)</th>
<th>P3-80a (edge)</th>
<th>P3-80b (core)</th>
<th>P3-80b (edge)</th>
<th>P3-78</th>
<th>P5-04</th>
<th>P5-04</th>
<th>SW-01</th>
<th>SW-01</th>
<th>SW-06</th>
<th>SW-06</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂ wt%</td>
<td>36.65</td>
<td>36.65</td>
<td>36.29</td>
<td>36.82</td>
<td>37.07</td>
<td>36.91</td>
<td>37.08</td>
<td>36.92</td>
<td>35.60</td>
<td>36.05</td>
<td>35.87</td>
<td>35.10</td>
<td>36.10</td>
<td>36.10</td>
<td>36.27</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>0.09</td>
<td>0.07</td>
<td>0.05</td>
<td>0.04</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.07</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.12</td>
<td>0.11</td>
<td>0.16</td>
<td>0.16</td>
<td>0.07</td>
<td>0.08</td>
<td>0.07</td>
<td>0.08</td>
<td>0.05</td>
<td>0.10</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>TiO₂</td>
<td>25.51</td>
<td>25.51</td>
<td>26.83</td>
<td>26.94</td>
<td>29.43</td>
<td>29.44</td>
<td>29.43</td>
<td>29.44</td>
<td>30.12</td>
<td>29.90</td>
<td>29.89</td>
<td>34.16</td>
<td>29.88</td>
<td>30.65</td>
<td>30.61</td>
</tr>
<tr>
<td>MgO</td>
<td>0.24</td>
<td>0.31</td>
<td>0.21</td>
<td>0.23</td>
<td>0.28</td>
<td>0.32</td>
<td>0.32</td>
<td>0.25</td>
<td>0.27</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>CaO</td>
<td>0.04</td>
<td>0.04</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.04</td>
<td>0.04</td>
<td>0.03</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mn/(Mn+Fe)</td>
<td>.39</td>
<td>.40</td>
<td>.36</td>
<td>.36</td>
<td>.32</td>
<td>.30</td>
<td>.31</td>
<td>.29</td>
<td>.31</td>
<td>.31</td>
<td>.32</td>
<td>.20</td>
<td>.30</td>
<td>.29</td>
<td>.29</td>
</tr>
</tbody>
</table>

Samples WP-051, WP-052, P3-80, P5-04, SW-01 and SW-06: electron microprobe analyses by F.C. Hawthorne (1980).
Samples P3-78/80, P5-04/05 and SW-01/04: AA and XRF analyses by K. Ramal.
Figure 28. Compositional range of garnets from the Huron Claim pegmatite.
Four garnets were analyzed at both the core and grain margin in order to detect any internal zonation. As is evident from Table 29, these garnets are very nearly homogeneous. A slight increase in manganese towards the edge of the grain is noticeable in sample WP-051, while slight to moderate decreases in manganese towards the edge of the grain are evident in samples WP-052 and P3-80. Samples P3-80, P3-78/80 and P5-04/05 are all from the aplitic or granular albite border units, and they have Mn/(Mn + Fe) ratios ranging from 0.29 to 0.32. Samples WP-051 and WP-052, from the medium to coarse-grained albite unit, have Mn/(Mn + Fe) ratios ranging from 0.36 to 0.40. A progressive increase in the Mn/(Mn + Fe) ratio is indicated for successive stages of pegmatite crystallization.

**EPIDOTE**

Epidote in the Huron Claim pegmatite is a characteristic mineral of the late stage calcium mineral assemblage. It occurs in fractures in the medium to coarse-grained albite unit, as vug fillings in albite, and as a replacement mineral after beryl. Two colour varieties, a dark green epidote and a pale yellow epidote, have been noted within the pegmatite. The largest and best-developed crystals of epidote occur as fracture fillings and breccia fillings in albite (Plates 26 and 27). Bundles of slender, prismatic crystals up to nine centimetres long and five centimetres wide have been noted in some hand specimens. The dark green variety was apparently the first to crystallize, as the yellow epidote forms epitaxial overgrowths on, and fills the interstices between, the green epidotes. Epidote of both colour varieties occurs as vug fillings in albite, although the yellow epidote predominates.
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These vug-filling epidotes are extensively altered to chlorite. Epidote also occurs with chlorite, fayalite, hornblende, biotite and clay minerals in the green and yellow epidote zonation. These epidotes are difficult to distinguish in thin section. Both green and yellow epidote, therefore, are considered under the green epidote pair.

Plate 26. Albite "breccia" with interstitial filling of epidote, sample P3-01. Coin is 17 millimetres in diameter.

Plate 27. Co-existing green and yellow epidote coating a fracture surface in albite, sample P3-07. Coin is 17 millimetres in diameter.
These vug-filling epidotes are extensively altered to clay minerals. Epidote also occurs with chlorite, bavenite, bertrandite, bityite and clay minerals in pseudomorphs or partial pseudomorphs after beryl.

In thin section, the two colour varieties of epidote are difficult to distinguish, although the interference colours are slightly higher in the green variety. Individual crystals often show concentric colour zonation (Plate 28). Determinations on a number of the yellow epidotes indicate that they are optically negative with $r>v$, and therefore they are conventionally classified as epidote (Deer et al., 1962).

The specific gravities of the two colour varieties of epidote are indistinguishable at about 3.35 grams/cm$^3$ (Table 30). Refractive index determinations were made on six pairs of co-existing green and yellow epidotes, on two vug-filling epidotes, and on one epidote associated with the alteration of beryl (Table 31). Data for the co-existing epidote pairs is related to composition in Figure 29. The range in $n_\beta$ values for both colour varieties of epidote is difficult to explain. Crystals are occasionally zoned and some compositional variation in each variety might be expected, but probably not as much as indicated by the refractive index values. Values of $n_\beta$ were calculated from the mol % pistacite $[\text{Fe}^{3+}/(\text{Fe}^{3+} + \text{Al})]$ contents of two chemically analyzed samples using the method of Kepezhinskas (1969). The calculated values of $n_\beta$ are slightly higher than the measured ranges for both varieties of epidote.

The cell dimensions of nine Huron Claim epidotes are shown in Table 32. As expected, the cell dimensions of the green variety of epidote are greater than those of the yellow variety, which is relatively iron poor. In the clinzoisite-epidote series, the unit
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Plate 28. Concentric colour zonation in epidote (P3-01).

Table 30. Specific gravity of epidote from the Huron Claim pegmatite (g/cm³).

<table>
<thead>
<tr>
<th></th>
<th>P3-SP (green)</th>
<th>P3-03 (yellow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.370</td>
<td></td>
<td>3.331</td>
</tr>
<tr>
<td>3.347 (average)</td>
<td>3.31</td>
<td>3.351 (average)</td>
</tr>
<tr>
<td>3.323</td>
<td>3.371</td>
<td></td>
</tr>
</tbody>
</table>
Table 31. Refractive indices ($n_0$) of epidote from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th></th>
<th>green, fracture-filling</th>
<th>yellow, fracture-filling</th>
<th>yellow, vug-filling</th>
<th>yellow, after beryl</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3-01</td>
<td>1.727</td>
<td>1.726</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P3-03</td>
<td>1.735</td>
<td>1.723</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P3-04</td>
<td>1.732</td>
<td>1.720</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P3-07</td>
<td>1.729</td>
<td>1.721</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P3-15</td>
<td>1.731</td>
<td>1.720</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P3-SP</td>
<td>1.731</td>
<td>1.727</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>GL*</td>
<td>1.728</td>
<td>1.726</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SE-01</td>
<td>-</td>
<td>-</td>
<td>1.722</td>
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<td>SW-14</td>
<td>-</td>
<td>-</td>
<td>1.711</td>
<td>-</td>
</tr>
<tr>
<td>PC-03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.727</td>
</tr>
</tbody>
</table>

* P. Černý, unpublished data
Figure 29. Dependence of $N_\beta$ on composition for Al-Fe epidotes. Refractive index data is for co-existing yellow and green epidotes only. Trend line from Holdaway (1972). $N_\beta$ values for P3-17 were calculated using the equation of Kepezhinskas (1969).
Table 32. Cell dimensions of epidote from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th></th>
<th>GREEN</th>
<th>P3-01</th>
<th>P3-04</th>
<th>P3-07</th>
<th>P3-SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a(Å)</td>
<td>8.88(2)</td>
<td>8.88(1)</td>
<td>8.891(5)</td>
<td>8.892(4)</td>
<td></td>
</tr>
<tr>
<td>b(Å)</td>
<td>5.628(9)</td>
<td>5.624(3)</td>
<td>5.624(2)</td>
<td>5.628(2)</td>
<td></td>
</tr>
<tr>
<td>c(Å)</td>
<td>10.15(2)</td>
<td>10.18(1)</td>
<td>10.181(8)</td>
<td>10.172(9)</td>
<td></td>
</tr>
<tr>
<td>V(Å³)</td>
<td>459.9(8)</td>
<td>460.3(6)</td>
<td>459.7(3)</td>
<td>459.8(3)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>YELLOW</th>
<th>P3-01</th>
<th>P3-04</th>
<th>P3-07</th>
<th>P3-SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a(Å)</td>
<td>8.870(6)</td>
<td>8.867(3)</td>
<td>8.877(3)</td>
<td>8.874(6)</td>
<td></td>
</tr>
<tr>
<td>b(Å)</td>
<td>5.610(4)</td>
<td>5.602(2)</td>
<td>5.606(2)</td>
<td>5.611(3)</td>
<td></td>
</tr>
<tr>
<td>c(Å)</td>
<td>10.15(1)</td>
<td>10.138(5)</td>
<td>10.150(5)</td>
<td>10.157(5)</td>
<td></td>
</tr>
<tr>
<td>V(Å³)</td>
<td>456.9(4)</td>
<td>455.9(3)</td>
<td>456.1(2)</td>
<td>457.1(3)</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th></th>
<th>P-24</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a(Å)</td>
<td>8.86(1)</td>
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</tr>
<tr>
<td>b(Å)</td>
<td>5.61(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c(Å)</td>
<td>10.14(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V(Å³)</td>
<td>456.0(6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

YELLOW, AFTER BERYL
cell dimensions increase with increasing substitution of Fe$^{3+}$ for Al at the M3 octahedral position, and substitution of Fe$^{2+}$, Mg and Mn for Ca at the A2 octahedral position (Dollase, 1971). Regression equations relating the unit cell parameters of the epidote group to their chemical composition (Kepezhinskas, 1969) can be written as follows:

$$Ps(\text{mol}%) = 7.1285a - 63.1633 + 0.028 \quad (1)$$

$$Ps(\text{mol}%) = 4.1305b - 23.0182 + 0.024 \quad (2)$$

Inserting values of $a$ for the co-existing pairs of green and yellow epidote into the first of these equations gives pistacite values in the range 12.4 to 22.3% for the green epidotes, and 4.5 to 11.6% for the yellow epidotes. Pistacite values calculated from the $b$ cell dimension vary from 21.2 to 22.8% in the green epidotes, and from 12.1 to 15.8% in the yellow epidotes. Equation (2) produces pistacite values which are closer to the values of 20.1% (P3-17, green) and 16.4% (P3-17, yellow) determined by chemical analysis.

The chemical composition of the two colour varieties of epidote is shown in Table 33. The trace element contents in the yellow variety of epidote are listed in Table 34. The chemical differences between the two colour varieties of epidote are not great. In the green variety of epidote, there is increased substitution of Fe$^{3+}$ for Al at the M3 octahedral position, as well as increased substitution of Fe$^{2+}$, Mg and Mn for Ca at the A2 octahedral site. The pistacite contents of 20.1 mol% in the green epidote and 16.1 mol% in the yellow epidote are both characteristic of low-iron epidote (Winchell and Winchell, 1967). Potassium, sodium and strontium substitution for calcium in the A2 site is minimal. The tetrahedral substitutions in epidote are quite small (Dollase, 1971), and the phosphorus content of 0.5 wt.% P$_2$O$_5$ in sample
### Table 33. Chemical composition and unit cell contents of epidote.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>1'</th>
<th>2'</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂ wt.%</td>
<td>38.10</td>
<td>37.80</td>
<td>Si</td>
<td>2.881</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>25.28</td>
<td>27.28</td>
<td>Al</td>
<td>0.090</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>9.54</td>
<td>7.95</td>
<td>P</td>
<td>0.029</td>
</tr>
<tr>
<td>FeO</td>
<td>1.16</td>
<td>0.28</td>
<td></td>
<td>3.000</td>
</tr>
<tr>
<td>MgO</td>
<td>0.23</td>
<td>0.10</td>
<td>Al</td>
<td>2.163</td>
</tr>
<tr>
<td>CaO</td>
<td>21.90</td>
<td>22.90</td>
<td>Fe³⁺</td>
<td>0.543</td>
</tr>
<tr>
<td>Na₂O</td>
<td>0.05</td>
<td>0.06</td>
<td></td>
<td>2.706</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.20</td>
<td>0.16</td>
<td>Fe²⁺</td>
<td>0.073</td>
</tr>
<tr>
<td>H₂O⁺</td>
<td>2.19</td>
<td>2.11</td>
<td>Mg</td>
<td>0.026</td>
</tr>
<tr>
<td>H₂O</td>
<td>0.14</td>
<td>0.11</td>
<td>Ca</td>
<td>1.774</td>
</tr>
<tr>
<td>CO₂</td>
<td>0.01</td>
<td>0.04</td>
<td>Na</td>
<td>0.007</td>
</tr>
<tr>
<td>TiO₂</td>
<td>nd</td>
<td>nd</td>
<td>K</td>
<td>0.019</td>
</tr>
<tr>
<td>P₂O₅</td>
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<td>0.49</td>
<td>Mn</td>
<td>0.030</td>
</tr>
<tr>
<td>MnO</td>
<td>0.46</td>
<td>0.33</td>
<td>OH</td>
<td>1.105</td>
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<tr>
<td></td>
<td>99.58</td>
<td>99.61</td>
<td></td>
<td>0.001</td>
</tr>
</tbody>
</table>

**Cation charge**

+24.999 +24.997

1. P3-17 (green) 2. P3-17 (yellow)

AA and XRF analyses by K. Ramal and R. Chapman

1'2'. cations on the basis of 12.5 oxygen anions

1. \((\text{Ca,Fe,Mg,K,Na})_{1.93} (\text{Fe}^{3+},\text{Al})_{0.71} \text{Al}_2\text{O(OH)}_{1.11} \text{Si}_{2.7} \text{Si}_4\)

2. \((\text{Ca,Fe,K,Mg,Na})_{1.92} (\text{Fe}^{3+},\text{Al})_{0.74} \text{Al}_2\text{O(OH)}_{1.06} \text{Si}_{2.7} \text{Si}_4\)
Table 34. Trace element contents of epidote from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th>Element</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sc</td>
<td>5.24</td>
</tr>
<tr>
<td>Cr</td>
<td>6</td>
</tr>
<tr>
<td>Co</td>
<td>0.83</td>
</tr>
<tr>
<td>Ga</td>
<td>477</td>
</tr>
<tr>
<td>As</td>
<td>4.3</td>
</tr>
<tr>
<td>Sr</td>
<td>430</td>
</tr>
<tr>
<td>Zr</td>
<td>540</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>La</td>
<td>21.0</td>
</tr>
<tr>
<td>Ce</td>
<td>17.1</td>
</tr>
<tr>
<td>Sm</td>
<td>302</td>
</tr>
<tr>
<td>Eu</td>
<td>2.07</td>
</tr>
<tr>
<td>Tb</td>
<td>3.90</td>
</tr>
<tr>
<td>Yb</td>
<td>5.68</td>
</tr>
<tr>
<td>Lu</td>
<td>1.16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ta</td>
<td>3.86</td>
</tr>
<tr>
<td>Hf</td>
<td>0.57</td>
</tr>
<tr>
<td>U</td>
<td>17.8</td>
</tr>
</tbody>
</table>

P3-17 is rather high for epidote. The rare-earth element content of epidote in the Huron Claim pegmatite is very low, which is somewhat surprising given the concentration of these elements in this particular pegmatite. There must have been no remobilization of the rare-earth elements during the late stage calcium metasomatic event responsible for the formation of epidote. The rare-earth element-bearing epidote, allanite, is found as a primary phase in two other pegmatites of the Shatford Lake group. Epidote can contain considerable quantities of BeO (Winchell and Winchell, 1967), and it would be interesting to have a chemical analysis of the epidote associated with altered beryl in the Huron Claim pegmatite.

In hand specimen, the contacts between the green and yellow varieties of epidote are quite distinct, with absolutely no evidence of gradation. The zonation observed in some individual crystals, and the range of refractive index values, are suggestive of a compositional range in the epidotes, although this is not supported by the physical appearance of the two varieties of epidote. Additional microprobe work would be necessary to establish a possible compositional gap between the green and yellow varieties of epidote. Compositional gaps between clinozoisite and Al-Fe epidote in metabasic rocks have been described by a number of authors, notably Strens (1964, 1965) and Raith (1976), but there is no experimental evidence for a solvus in this system, possibly due to slow reaction rates below 500°C (Holdaway, 1972). Recent studies indicate compositional continuity through the above gaps, in decidedly different rock types (Grapes and Watanabe, 1984).

Oxygen fugacity, and the bulk composition of the hydrothermal fluids from which the epidote was crystallizing, would have been the
dominant compositional controls during epidote crystallization. Iron-rich epidotes crystallize under oxidizing conditions, and become more aluminous as fO₂ is reduced (Holdaway, 1972; Liou, 1973). A sudden drop in fO₂ during the last stages of hydrothermal activity could well be responsible for the two colour varieties of epidote seen in the Huron Claim pegmatite. It should be noted that epidote is an extremely rare mineral in granitic pegmatites (Rao and Rao, 1971), although it is known as a hydrothermal alteration product in plutonic granites (Liou, 1973).

BERYL

Beryl is the most abundant accessory mineral in the Huron Claim pegmatite, and is of some economic significance. An 85 tonne sample grading 0.33% BeO was removed from the pegmatite during 1957 (Central Geophysics Ltd., 1958).

Beryl-rich zones were described in two localities during the initial development work on the pegmatite (McCartney, 1930). The first of these was on the north side of the depression in which much of the Huron Claim pegmatite is exposed. The remnants of this zone are contained in two beryl-rich dumps in the vicinity of Pit #2 (77-BE, 77-83 series). Individual crystals and crystalline masses of beryl up to 30 cm in size were observed over a width of 4.5 metres (McCartney, 1930). The beryl occurs in the medium to coarse-grained albite zone, often in close proximity to the quartz core. Concentrations of beryl occur within 10 centimetres of the upper contact, suggesting that the beryl-rich zones were developed in the uppermost, or apical, parts of the pegmatite. Beryl from the vicinity of Pit #2 is light green to
amber and generally unaltered (Plates 29 and 30). Some specimens from this locality are crudely banded, with alternating layers of albite and weakly aligned beryl crystals (Plate 31). Associated minerals are uraninite, monazite and columbite-tantalite.

The second beryl-rich zone may coincide with the area around Pit #4 (WP series). Individual beryl crystals from 5 to 10 centimetres long, and 1 centimetre wide, were found concentrated over an area of about 15 square metres. Once again, the beryl occurs in the medium to coarse-grained albite zone close to the quartz core. Isolated crystals are more common in this zone, and their colour varies from green to pale blue. Thin rims, inclusions and cross-cutting veinlets of albite are common (Plate 32). Muscovite commonly envelopes the beryl crystals, and bavenite and bitylite are widespread as alteration products. Columbite-tantalite is a commonly associated mineral.

Beryl also occurs infrequently in the outermost zones of aplite and granular albite (P3-78/80), where the size of the crystals is much reduced. Several conical beryls with inclusions of quartz and albite were found in Pit #5 (P5-10). Specimens collected from the dump at the east end of Greer Lake were eliminated from the analytical work, whereas four colour varieties from the Royal Ontario Museum collection (M17 series) were included.

Partial chemical analyses and refractive indices \( (n_W) \) of eighteen Huron Claim beryls are presented in Tables 35 and 36. Selected trace element contents are shown in Table 37. The refractive indices of beryl are influenced by a number of compositional parameters, including the replacement of silicon by phosphorus and boron at the tetrahedral sites, and the replacement of aluminum by ferric iron, chromium,
NOTICE/AVIS

PAGE(S) 157 + 158 | IS/ARE EST/SONT COLOUR PHOTOS

PLEASE WRITE TO THE AUTHOR FOR INFORMATION, OR CONSULT THE ARCHIVAL COPY HELD IN THE DEPARTMENT OF ARCHIVES AND SPECIAL COLLECTIONS, ELIZABETH DAFOE LIBRARY, UNIVERSITY OF MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.

VEUILLEZ ESCRIE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 29. Beryl crystals in coarse-grained albite from the vicinity of Pit #2. Coin is 17 mm. in diameter (77-BE-10).

Plate 30. Beryl-rich specimen from the vicinity of Pit #2. Dark grey material is smoky quartz (77-B3-03).
Plate 31. Crude alignment of beryl crystals in albite (transmitted light).

Plate 32. Hexagonal crystals of beryl in smoky quartz, rimmed by albite and small crystals of columbite-tantalite.
Table 35. Partial chemical analyses of beryl from the Huron Claim pegmatite (1).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>77-B3-01</th>
<th>77-B3-02</th>
<th>WP-02</th>
<th>WP-09</th>
<th>WP-10</th>
<th>P3-78/80</th>
<th>GL-10-11</th>
<th>GL-10-12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>77-B3-02</td>
<td>WP-02</td>
<td>WP-09</td>
<td>WP-10</td>
<td>P3-78/80</td>
<td>GL-10-11</td>
<td>GL-10-12</td>
<td></td>
</tr>
<tr>
<td>K₂O, wt.%</td>
<td>0.02</td>
<td>0.04</td>
<td>0.04</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Na₂O</td>
<td>0.36</td>
<td>0.38</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>0.35</td>
<td>0.34</td>
<td>0.31</td>
</tr>
<tr>
<td>CaO</td>
<td>0.03</td>
<td>0.07</td>
<td>0.03</td>
<td>0.11</td>
<td>0.03</td>
<td>0.05</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.39</td>
<td>0.43</td>
<td>0.50</td>
<td>0.50</td>
<td>0.38</td>
<td>0.49</td>
<td>0.53</td>
<td>0.41</td>
</tr>
<tr>
<td>MgO</td>
<td>0.11</td>
<td>0.11</td>
<td>0.12</td>
<td>0.08</td>
<td>0.10</td>
<td>0.09</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>Li, ppm</td>
<td>110</td>
<td>110</td>
<td>59</td>
<td>59</td>
<td>59</td>
<td>59</td>
<td>42</td>
<td>41</td>
</tr>
<tr>
<td>Cs</td>
<td>300</td>
<td>600</td>
<td>450</td>
<td>450</td>
<td>440</td>
<td>440</td>
<td>430</td>
<td>430</td>
</tr>
<tr>
<td>R₂O</td>
<td>0.50</td>
<td>0.64</td>
<td>0.55</td>
<td>0.68</td>
<td>0.51</td>
<td>0.54</td>
<td>0.50</td>
<td>0.48</td>
</tr>
<tr>
<td>Na/Li</td>
<td>12.27</td>
<td>7.18</td>
<td>9.26</td>
<td>6.10</td>
<td>7.14</td>
<td>8.39</td>
<td>8.12</td>
<td>8.33</td>
</tr>
<tr>
<td>n₀</td>
<td>1.573</td>
<td>1.574</td>
<td>1.572</td>
<td>1.574</td>
<td>1.572</td>
<td>1.572</td>
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<tr>
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<td>amber</td>
<td>yellow, green</td>
<td>blue</td>
<td>blue</td>
<td>blue</td>
<td>blue</td>
<td>pale to emerald green</td>
<td>yellow</td>
</tr>
</tbody>
</table>
| total Fe reported as Fe₂O₃

1. Present study: AA and XRF analyses by K. Ramlal
2. Černý, unpublished data: n₀ for both GL-10-11 and GL-10-12 is 1.570
Table 36. Partial chemical analyses of beryl from the Huron Claim pegmatite (11).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>77-BE-02</th>
<th>77-BE-03</th>
<th>77-BE-06</th>
<th>77-BE-08</th>
<th>M17307 (core)</th>
<th>M17307 (rim)</th>
<th>M17306-N</th>
<th>M17306-R</th>
<th>PS-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>K₂O, wt.%</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Na₂O</td>
<td>0.29</td>
<td>0.34</td>
<td>0.36</td>
<td>0.33</td>
<td>0.31</td>
<td>0.38</td>
<td>0.31</td>
<td>0.33</td>
<td>0.38</td>
</tr>
<tr>
<td>CaO</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.07</td>
<td>0.05</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.50</td>
<td>0.53</td>
<td>0.49</td>
<td>0.50</td>
<td>0.41</td>
<td>0.36</td>
<td>0.36</td>
<td>0.60</td>
<td>0.86</td>
</tr>
<tr>
<td>MgO</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.12</td>
<td>0.08</td>
<td>0.10</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Li, ppm</td>
<td>200</td>
<td>240</td>
<td>240</td>
<td>250</td>
<td>280</td>
<td>400</td>
<td>310</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>Rb</td>
<td>65</td>
<td>110</td>
<td>86</td>
<td>97</td>
<td>73</td>
<td>53</td>
<td>48</td>
<td>140</td>
<td>51</td>
</tr>
<tr>
<td>Co</td>
<td>340</td>
<td>380</td>
<td>420</td>
<td>500</td>
<td>300</td>
<td>320</td>
<td>420</td>
<td>460</td>
<td>500</td>
</tr>
<tr>
<td>R₂O</td>
<td>0.42</td>
<td>0.47</td>
<td>0.49</td>
<td>0.48</td>
<td>0.44</td>
<td>0.39</td>
<td>0.50</td>
<td>0.46</td>
<td>0.57</td>
</tr>
<tr>
<td>Na/Li</td>
<td>11.00</td>
<td>10.42</td>
<td>11.25</td>
<td>9.60</td>
<td>8.21</td>
<td>7.00</td>
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</tr>
<tr>
<td>n</td>
<td>1.573</td>
<td>1.574</td>
<td>1.574</td>
<td>1.572</td>
<td>1.576</td>
<td>1.572</td>
<td>1.573</td>
<td>1.576</td>
<td>1.574</td>
</tr>
<tr>
<td>colour</td>
<td>light green</td>
<td>greenish blue</td>
<td>greenish blue</td>
<td>pale yellow</td>
<td>pale amber</td>
<td>blue</td>
<td>amber</td>
<td>olive green</td>
<td></td>
</tr>
</tbody>
</table>

total Fe reported as Fe₂O₃

AA and XRF analyses by K. Ramlal
Table 37. Trace element contents of beryl from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sc, ppm</td>
<td>17.6</td>
<td>16.1</td>
</tr>
<tr>
<td>Co</td>
<td>0.506</td>
<td>0.56</td>
</tr>
<tr>
<td>Zn</td>
<td>128</td>
<td>147</td>
</tr>
<tr>
<td>Ga</td>
<td>49</td>
<td>32</td>
</tr>
<tr>
<td>Br</td>
<td>19.6</td>
<td>16.7</td>
</tr>
<tr>
<td>Rb</td>
<td>153</td>
<td>132</td>
</tr>
<tr>
<td>Sm</td>
<td>0.34</td>
<td>0.233</td>
</tr>
<tr>
<td>Ta</td>
<td>2.36</td>
<td>0.74</td>
</tr>
</tbody>
</table>

vanadium, scandium and titanium at the octahedral positions. Also affecting the magnitude of the refractive indices of beryl is the replacement of aluminum by magnesium, manganese, ferrous iron and nickel at the octahedral sites, with the concomitant addition of alkali metals in the open channels of the beryl structure. The replacement of beryllium by lithium at the tetrahedral sites balanced by the addition of alkalies and alkaline earth elements in the channels, and the presence of molecular water in the channels, also affect the refractive indices. There is a straightforward relationship between the refractive index $n_w$, and the $R_2O + CaO$ contents in primary (Na, Li) and Na, Li, Cs-enriched beryls for which the octahedral substitutions are minimal (Černý and Hawthorne, 1976). The refractive indices of the Huron Claim beryls fall at the extreme lower end of the established trend line (Figure 30), as expected from their low $R_2O + CaO$ totals (0.5%).

The unit cell dimensions of anhydrous, alkali-free beryl are $a = 9.212$ Å and $c = 9.188$ Å (Gibbs et al., 1968). As alkali elements enter the structure, the $c$ dimension gradually increases whereas $a$ remains constant or slightly decreases (Beus, 1966). The $c/a$ ratio varies from 0.9966 in alkali-free beryl to 1.0030 in Li, Cs-enriched beryl. The morphology of beryl depends to a large degree on the alkali content, due to the variation in $c/a$ (Beus, 1966). The unit cell dimensions of sample GL-10-11 from the Huron Claim pegmatite are $a = 9.210$ Å and $c = 9.197$ Å (Černý, unpublished data).

Common beryls vary in colour from light green, through green and yellowish-green, to pale amber. Aquamarines are blue and bluish-green. The green and yellow colours are caused by admixed iron in various
Figure 30. Plot of $R_2O + CaO$ vs. $n_w$ for beryl. Trend line is from Černý and Hawthorne (1976).
degrees of oxidation (Beus, 1966). Among the Huron Claim beryls, there is no apparent correlation of chemistry with colour; however, the different oxidation states of iron were not distinguished in the chemical analyses.

The specific gravity of beryl varies according to the total alkali content, much in the same manner as the refractive indices. Not only is the total alkali content important, but also the relative quantities of the individual alkali ions. The structural water content of beryl, and fluid inclusions, also affect the specific gravity. The specific gravity of sample GL-10-11 varies from 2.645 to 2.670 g/cm³ (average, 2.658), and that of sample GL-10-12 from 2.660 to 2.680 g/cm³ (average, 2.673). These densities are very low, and characteristic of the alkali-free varieties of beryl (Beus, 1966).

Sodium, lithium, cesium and molecular water are present in significant amounts in many beryls. Of lesser importance are magnesium, manganese, ferrous and ferric iron, chromium, rubidium, potassium and carbon dioxide. Beryls can be subdivided into four types on the basis of the content and composition of their alkalis (Beus, 1960). Alkali-free beryls have \( R_2O \leq 0.5\% \), sodium beryls have \( R_2O > 0.5\% < 1.0\% \). The \( R_2O \) contents of the Huron Claim beryls range from 0.41 to 0.58%, straddling the division between alkali-free and sodium beryl. The Huron Claim beryls are chemically similar, although on a fine scale there may be some subdivision of the various morphological varieties (Figure 31). Sample M17307 shows a decrease in the Na/Li ratio, and a decrease in \( n_w \), from core to rim.

Alkali-free beryls and related varieties of sodium beryl have \( R_2O \) contents less than or slightly exceeding 0.5%. Primary beryls of this
Figure 31. Na/Li vs. Cs plot of beryl from the Huron Claim pegmatite; red dots represent the GL-10 series samples. Individual sample groups represent different morphological varieties of beryl. Compositional field of beryl from the Shatford Lake pegmatite group (green) is from Černý et al. (1981b).
type are characterized by long prismatic to prismatic crystals with length to width ratios of 15:1 to 2:1 (Beus, 1966). In granitic pegmatites, the crystals are generally well-formed, occurring in pockets or as isolated individuals. Crystal intergrowths are rare, being more characteristic of pneumatolytic-hydrothermal deposits. Primary pegmatitic beryls are usually large and prismatic, with dimensions exceeding 4.0 x 0.5 centimetres. Crystals with dimensions of 5 x 20 to 10 x 30 centimetres are common in granitic pegmatites and crystals with dimensions of 15 x 50 to 20 x 80 centimetres are not rare (Beus, 1966). Conical beryls with inclusions of albite, quartz and muscovite are more characteristic of sodium beryl.

Beryl in the Huron Claim pegmatite has been extensively altered, and is often completely replaced by aggregates of bavenite, bertrandite, bityite, chlorite, epidote and clays. Perfectly fresh and completely altered beryls are often found side by side in the same hand specimen, and single crystals can be altered at one end and perfectly fresh at the other. However, there is some suggestion that the smaller beryl crystals were more susceptible to alteration. A single large pseudomorph of muscovite, bertrandite, chlorite and clay minerals after beryl was found in Pit #3.

The occurrence of beryl in the medium to coarse-grained albite zone, in close association with the quartz core, is somewhat more characteristic of sodium beryl than it is of the alkali-free varieties. In the remainder of the Shatford Lake pegmatite group, beryl occurs as conical green crystals in the albite, quartz and muscovite assemblage (Černý et al., 1981b). Large quantities of beryl are not characteristic of the gadolinite-bearing, blocky microcline-biotite pegmatites to which the Huron Claim is so closely related (Beus, 1966).
NIOBium-TANTALUM-TITANium oxide minerals

Oxide minerals containing niobium, tantalum and titanium are among the more conspicuous accessory minerals in the Huron Claim pegmatite. Partly disordered columbite-tantalite is the most abundant species, although the rare calcium niobate, fersmite, is also present in significant quantities. Niobian rutile, microlite and a metamict, euxenite-like phase are all relatively rare. An unidentified, calcium and tantalum-rich phase occurs in minor amounts, intergrown with columbite-tantalite. Almost all of the columbite-tantalite is found in the medium to coarse-grained albite unit, either as discrete crystals or fracture-filling aggregates. The minor oxide phases are all closely associated with the columbite-tantalite. Detailed microscopic studies of the columbite-tantalite were not attempted during the present study. Individual grains of columbite-tantalite are generally inhomogeneous, and exhibit intergrowths of two or more phases with slight to moderate differences in optical behaviour and chemical composition. Additional microscopic and electron microprobe studies are certainly warranted. Other rare-element minerals, including beryl, uraninite, monazite, zircon and thorite, are usually found in association with the Nb-Ta oxide mineralization.

Columbite-Tantalite

Partly disordered columbite-tantalite occurs as an apparent single generation in the medium to coarse-grained albite unit. Crystals of columbite-tantalite are found on occasion in apophyses of the quartz core penetrating the blocky microcline unit. The columbite-tantalite occurs most frequently as flat, prismatic crystals intergrown with
tabular albite (Plates 29 and 30). Radial aggregates are seen on occasion (Plate 31), and the smaller crystals are frequently found along fractures in the coarse-grained albite (Plate 32). The crystals, which are dull black, attain a maximum length of ten centimetres. The columbite-tantalite seems to have been concentrated in one or more zones close to the apical parts of the pegmatite, as was much of the beryllium mineralization. McCartney (1930) describes an area of mineralization 0.8 x 1.6 metres in size near the northernmost gabbro bluff, from which 225 kilograms of columbite-tantalite concentrate was subsequently removed. Much of the beryllium and niobium-tantalum mineralization may have been concentrated in separate "pods". However, the columbite-tantalite is also frequently dispersed with the other rare-element minerals in the pegmatite, particularly beryl, uraninite, monazite, zircon and thorite.

The columbite-tantalite is extensively replaced by fersmite, from which is is largely indistinguishable in hand specimen. In sample M17303-A, ferrocolumbite is intimately intergrown with niobian rutile, in association with a metamict, euxenite-like phase. Microlite, and an unidentified calcium and tantalum-rich phase, are distinguishable only in polished section as small grains or intergrowths in columbite-tantalite.

Density determinations were made on 40 samples of columbite-tantalite, and these are listed along with the accompanying unit cell dimensions, in Tables 38 and 39. The densities range from 5.07 to 6.52 g/cm³. The average value of 5.88 g/cm³ (Figure 32) corresponds to a Ta/(Ta + Nb) ratio of about 0.25 (Vlasov, 1966), close to the average value of 0.22 determined by electron microprobe analysis. The
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VEUILLEZ ÉCRIRE À L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DÉPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPÉCIALES, BIBLIOTHÈQUE ELIZABETH DAFOE, UNIVERSITÉ DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 29. Large blades of columbite-tantalite in pink albite, on the margin of an altered, reddish K-feldspar crystal. The large crystal is approximately six centimetres long (F2-26).

Plate 30. Large, prismatic crystals of columbite-tantalite in coarse-grained albite. Penetration twin is evident in the largest crystal. Coin is 17 millimetres in diameter. Unnumbered specimen from the collection of the author.
Plate 31. Blades and radial aggregates of ferrocolbomite in vuggy albite - sample M17303-A. Ferrocolbomite is intergrown with niobian rutile and a metamict, euxenite-like phase, which are not distinguishable in the photo.

Plate 32. Small crystals of columbite-tantalite following a fracture in coarse-grained albite. Coin is 17 millimeters in diameter (P3-50).
Figure 32. Specific gravity of columbite-tantalite from the Huron Claim pegmatite; the average value is 5.88 g/cm³.
densities below 5.60 g/cm³ are indicative of significant fersmite contamination. With the exception of these contaminated samples, the measured densities seem to accurately reflect the compositional range of the columbite-tantalite.

Columbite-tantalite structures vary from largely ordered (Sturdivant, 1930) to essentially disordered (Nickel et al., 1963; "pseudo-ixiolite"). The disordered members of the group, \((\text{Fe, Mn, Nb, Ta})_4\text{O}_8\) with \(a = 4.76\), \(b = 5.75\) and \(c = 5.14\ \text{Å}\), develop an ordered structure, \((\text{Fe, Mn})_4(\text{Nb, Ta})_8\text{O}_{24}\) with \(a = 14.34\), \(b = 5.75\) and \(c = 5.07\ \text{Å}\), following heating at about 1000°C. The \(a\) dimension increases, and the \(c\) dimension decreases with increasing order, making the \(a/c\) ratio a useful indicator of the degree of order (Komkov, 1970). The \(a\) (3\(a\) for disordered phases) versus \(c\) plot (Černý and Turnock, 1971b), is a good graphical representation of the degree of order; it is also an indicator of the Fe/Mn ratio, but is relatively insensitive to changes in the Nb and Ta content (Černý and Ercit, 1984).

The unit cell dimensions of 39 columbite-tantalites from the Huron Claim pegmatite, including one sample from Černý and Turnock (1971b), are given in Tables 38 and 39. Two of the samples used in the density determinations contained too much fersmite to be of any use in the X-ray studies. The samples are plotted on the \(a\) versus \(c\) diagram in Figure 33. In this particular version of the diagram, the ordered end-member compositions are taken from Weitzel (1976). The disordered end-members are natural samples from two pegmatites in the Winnipeg River district (Černý, pers. comm.). The majority of the columbite-tantalite samples are in the intermediate structural state, although the overall range is extensive. Most could be classified as "pseudo-ixiolite", as
Table 3B. Unit cell dimensions and specific gravity of columbite-cantalite from the Huron Claim pegmatite (II).

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*Samples heated for three hours in air at 1000°C.
Table 39. Unit cell dimensions and specific gravity of columbite-tantalite from the Huron Claim pegmatite (1).

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<td>SG,g/cm³</td>
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*Samples heated for three hours in air at 1000°C.
Figure 33. Unit cell dimensions of columbite-tantalite in the $a$-$c$ diagram of Černý and Turnock (1971b). All data is based on the ordered supercell. The ordered end-member compositions are after Weitzel (1976). Disordered end-member compositions from unpublished data of P. Černý.
defined by Nickel et al. (1963). All of the samples plot in the iron-rich part of the diagram. After heating in air for 3 hours at 1000°C, the samples attain much higher degrees of cation order, close to the fully ordered columbite-tantalite structure. There is considerable scatter amongst the samples, which is largely the result of imperfect laboratory techniques. The heating period was insufficiently long (cf. Černý and Turnock, 1971b), and high XRD scanning speeds resulted in high standard errors in the unit cell refinements. In some groups of co-genetic columbite-tantalites with variable compositions, the degree of ordering increases with increasing manganese content (Černý and Ercit, 1984); this effect is seen to some extent in the Huron Claim pegmatite.

The chemical composition and unit cell contents of 17 columbite-tantalites from the Huron Claim pegmatite are compiled in Tables 40 through 42. Sixteen of the samples were analyzed on the electron microprobe, one of these at Stanford University, while the remaining sample (HC-2) was done by X-ray fluorescence (Černý and Turnock, 1971b). Several spots were analyzed in most specimens, but a systematic study of internal zonation was not attempted. Five of the six analyses of sample M17303-A, which represent ferrocolumbite intergrown with niobian rutile, are also shown in the section on niobian rutile. For the sake of completeness, two wet chemical analyses of columbite intergrown with fersmite are given in Table 43.

In the Huron Claim pegmatite, the Ta/(Ta + Nb) ratios, including those of ferrocolumbite intergrown with niobian rutile, range from 0.02 to 0.56 (Figure 34a). The range of values (0.18 to 0.56) is considerably smaller if the ferrocolumbite intergrown with niobian rutile is not included. The average Ta/(Ta + Nb) ratio is 0.22. The
### Table 40. Chemical composition of columbite-tantalite from the Huron Claim pegmatite (1).

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1. Electron microprobe analyses by F.C. Hawthorne.
2. Electron microprobe analyses by R. Chapman.
4. Electron microprobe analysis by E.E. Food, Stanford University: recalculated from atomic %.
Cations on the basis of 24 oxygen anions.
Table 41. Chemical composition of columbite-tantalite from the Huron Claim pegmatite (I).

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1. Electron microprobe analyses by F.C. Hawthorne.
2. Electron microprobe analyses by R. Chapman.
3. Cations on the basis of 24 oxygen anions.
Table 42. Chemical composition of columbite-tantalite from the Huron Claim pegmatite (III).

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| (Ta+Nb) | .24    | .20    | .20    | .23    | .23    | .22    | .25    | .23    | .26    | .18    |
| Mn/(Mn+Fe) | .16    | .16    | .16    | .18    | .18    | .18    | .16    | .16    | .18    | .15    |

1. Electron microprobe analyses by F.C. Hawthorne.
Table 43. Wet chemical analyses of columbite-tantalite contaminated by fersmite.

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<thead>
<tr>
<th>Sample</th>
<th>HC-1 (^1)</th>
<th>Walker (1931) (^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{Ta}_2\text{O}_5, \text{wt.}%)</td>
<td>29.50</td>
<td>26.41</td>
</tr>
<tr>
<td>(\text{Nb}_2\text{O}_5)</td>
<td>47.50</td>
<td>52.26</td>
</tr>
<tr>
<td>(\text{TiO}_2)</td>
<td>0.20</td>
<td>0.49</td>
</tr>
<tr>
<td>(\text{SnO}_2)</td>
<td>0.00</td>
<td>nd</td>
</tr>
<tr>
<td>(\text{ZrO}_2)</td>
<td>nd</td>
<td>0.65</td>
</tr>
<tr>
<td>(\text{FeO})</td>
<td>13.00</td>
<td>14.77</td>
</tr>
<tr>
<td>(\text{MnO})</td>
<td>3.80</td>
<td>2.17</td>
</tr>
<tr>
<td>(\text{MgO})</td>
<td>1.42</td>
<td>0.45</td>
</tr>
<tr>
<td>(\text{CaO})</td>
<td>1.42</td>
<td>2.66</td>
</tr>
<tr>
<td>(\text{H}_2\text{O})</td>
<td>nd</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>95.42</td>
<td>100.20</td>
</tr>
<tr>
<td>(\text{S.G. g/cm}^3)</td>
<td>5.82</td>
<td>5.87</td>
</tr>
</tbody>
</table>

2. Analyst V.J. Oswald.
   nd - not determined
Figure 34a. Ta/(Ta+Nb) ratios of columbite-tantalite from the Huron Claim pegmatite - the average value is 0.22. Cross-hatching represents columbite in symplectic intergrowth with niobian rutile.

Figure 34b. Mn/(Mn+Fe) ratios of columbite-tantalite from the Huron Claim pegmatite - the average value is 0.19. Cross-hatching represents columbite in symplectic intergrowth with niobian rutile.
Mn/(Mn + Fe) ratios vary from 0.07 to 0.47, and have an average value of 0.19 (Figure 34b). In general, the most tantalum- and manganese-enriched members of the columbite-tantalite group are found in the most differentiated pegmatites in any given pegmatite group, or in the late generations of columbite-tantalite in single pegmatites (Černý and Ercit, 1984). The Ta/(Ta + Nb) and Mn/(Mn + Fe) ratios are therefore of considerable petrogenetic significance. The ratios are related to one another in the columbite-tantalite (tapiolite) quadrilateral (Figure 35), in which all of the Huron Claim analyses have been plotted. Two fractionation trends are apparent in the diagram, one of increasing tantalum with constant Mn/(Mn + Fe) values, and the other of increasing manganese with relatively constant Ta/(Ta + Nb) values. The interpretation is limited by the small number of analyses. The overall fractionation pattern is best described as being relatively extensive, but non-uniform, yet still within the limits of expectation for a single pegmatite (Černý and Ercit, 1984). More common in beryl and columbite-bearing pegmatites are two distinct generations of columbite-tantalite, the later generation being manganese-rich (e.g., the PLEX pegmatite on Baffin Island; Černý and Ercit, 1984). The overall composition of the columbite-tantalite minerals is also evident in Figure 35. With the exception of sample P2-07 (two analyses), a ferrotantalite, all of the samples are ferrocolumbites. It is interesting to note that the Ta/(Ta + Nb) ratios in the columbite-tantalite are more or less preserved on replacement by fersmite. Tantalum-rich microlite in association with tantalum-poor columbite, as in the Huron Claim pegmatite, is not an unusual paragenesis in this type of pegmatite (Černý and Turnock, 1971b).
Figure 35. Compositions of columbite-tantalite from the Huron Claim pegmatite in the columbite-tantalite (tapiolite) quadrilateral. The six samples with Ta/(Ta+Nb) less than 0.10 represent columbite in symplectic intergrowth with niobian rutile.
The substitution of minor elements (Ti, Sn, Sc, Sb and W) into the columbite-tantalite structure is minimal in the Huron Claim specimens. The compositions are plotted in the \((\text{Ta}_2\text{O}_5 + \text{Nb}_2\text{O}_5) - (\text{FeO} + \text{MnO}) - (\text{TiO}_2 + \text{SnO}_2 + \text{Sc}_2\text{O}_3 \text{ etc.})\) ternary diagram in Figure 36. Only the ferrocolumbite intergrown with niobian rutile contains significant amounts of titanium.

**Fersmite**

Fersmite is a relatively rare calcium niobate of the \([\text{AB}_2\text{O}_6]\) group, first described from the Vishnev Mountains, central Urals, USSR (Bohnstedt-Kupletskaya and Burova, 1946). In the Huron Claim pegmatite, fersmite is a common and widespread alteration product of columbite-tantalite. The Huron Claim pegmatite is the only pegmatite in the Shatford Lake group from which fersmite has been described (Černý and Turnock, 1971b).

In hand specimen, the Huron Claim fersmite cannot be distinguished from columbite-tantalite, as both minerals are dull black. However, on cut surfaces the fersmite assumes a greyish cast. Fersmite preferentially replaces columbite-tantalite along the crystal terminations, crystal margins and cross-fractures, and occasionally forms complete pseudomorphs. It also occurs as irregular grains closely associated with the pseudomorphs. In all instances, the mineral is granular and microcrystalline. In thin section, the fersmite is dirty brown and semi-transparent. It is readily identified in thin section by its high birefringence (Plate 37), and neutral to pale brown pleochroism. The fersmite is optically positive with moderate 2V (Černý and Turnock, 1971b). In polished section, the fersmite is darker grey and softer
Figure 36. Columbite-tantalite from the Huron Claim pegmatite, in the \((\text{FeO} + \text{MnO}) / (\text{Ta}_2\text{O}_5 + \text{Nb}_2\text{O}_5) / (\text{TiO}_2 + \text{SnO}_2 + \text{ScO}_2 \text{ etc.})\) triangular plot. All oxide values are in wt. %.
NOTICE/AVIS

PLEASE WRITE TO THE AUTHOR FOR INFORMATION, OR CONSULT THE ARCHIVAL COPY HELD IN THE DEPARTMENT OF ARCHIVES AND SPECIAL COLLECTIONS, ELIZABETH DAFOE LIBRARY, UNIVERSITY OF MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.

VEUILLEZ ECRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 37. Fersmite replacing a platy crystal of columbite-tantalite (black) in twinned albite (X nicsls).

Table 47. Ta/(Ta+Nb) ratios in fersmite and co-existing columbite-tantalite.

<table>
<thead>
<tr>
<th>Sample Number:</th>
<th>Fersmite:Ta/(Ta+Nb)</th>
<th>Columbite-tantalite:Ta/(Ta+Nb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3-19</td>
<td>.19</td>
<td>.24</td>
</tr>
<tr>
<td>P3-47</td>
<td>.20</td>
<td>.22/.25</td>
</tr>
<tr>
<td>77-3T-02/77-3T-03</td>
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<td>.18</td>
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<td>GL-10-1a</td>
<td>.22</td>
<td>.21</td>
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<tr>
<td>77-TA-02</td>
<td>.17/.23/.27</td>
<td>.23/.26</td>
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</table>
than columbite-tantalite, and shows some bireflectance. Reddish internal reflections are noticeable in oil immersion (Černý and Turnock, 1971b). Under an electron beam, the fersmite exhibits blue cathodoluminescence (Foord, 1976).

The unit cell dimensions of five Huron Claim fersmites, and five additional fersmites from the literature are listed in Table 44.

Electron microprobe analyses of the Huron Claim fersmite, as well as other chemical analyses of fersmite from the literature, are presented in Tables 45 and 46. The Huron Claim fersmites, like those of the Foote Mine in South Carolina, the Himalaya dyke system in California and Minas Gerais in Brazil, are all calcium-based with negligible rare earths. The three Russian examples, from pegmatites in the Vishnev and Il'men mountains in the central Urals, all contain appreciable quantities of rare-earth elements, as does the fersmite from a marble horizon in Montana, and fersmite in metamict polycrase from Norway. Fersmite from Novara, Italy contains half a per cent cerium trioxide. The compositional variation among these fersmites is shown schematically in Figure 37. It is interesting to note that the first analysis of columbite-tantalite from the Huron Claim pegmatite (Walker, 1931) contains 2.66% CaO, indicating that this original sample was a mixture of columbite-tantalite and fersmite.

The oxide percentages shown in Tables 45 and 46 have been converted to unit cell contents on the basis of 24 oxygen atoms. The A cation totals are highly variable, ranging from 3.1 to 4.6. The B cations are much closer to the stoichiometric total, although large deviations are noted in the Brazilian and Norwegian samples. This deviation from stoichiometry may be partly an analytical problem.
Table 44. Unit cell dimensions of ferromite.

<table>
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<tr>
<th></th>
<th>P3-19</th>
<th>P3-45</th>
<th>P3-4B</th>
<th>GL-10-1a</th>
<th>77-3T-O2</th>
<th>77-3T-O2</th>
<th>Montana</th>
<th>Vishnev</th>
<th>Illmen</th>
<th>Novara</th>
<th>Minas Gerais</th>
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<tr>
<td>a(A)</td>
<td>5.766(2)</td>
<td>5.752(3)</td>
<td>5.759(1)</td>
<td>5.732(4)</td>
<td>5.755(1)</td>
<td>5.767(5)</td>
<td>5.766</td>
<td>5.718(3)</td>
<td>5.657(5)</td>
<td>5.755(3)</td>
<td>5.71</td>
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<tr>
<td>b(A)</td>
<td>14.94(1)</td>
<td>14.95(1)</td>
<td>14.957(4)</td>
<td>15.06(1)</td>
<td>14.920(3)</td>
<td>14.943(9)</td>
<td>15.09</td>
<td>14.91(1)</td>
<td>14.78(1)</td>
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<td>14.981</td>
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<td>c(A)</td>
<td>5.227(3)</td>
<td>5.225(6)</td>
<td>5.225(1)</td>
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<td>5.225(1)</td>
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<td>V(A^3)</td>
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<td>448.7(1)</td>
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<td>455.1</td>
<td>445.1</td>
<td>436.4</td>
<td>451.1</td>
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1. Huron claims present study.
5. Pomeranceblum and Baptista (1968).
Table 45. Chemical composition and unit cell contents of forsterite (I).

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<tr>
<th></th>
<th>P3-19</th>
<th>P3-47</th>
<th>GL-10-1a</th>
<th>77-3T-03</th>
<th>77-TA-02</th>
<th>77-TA-02</th>
<th>77-TA-02</th>
<th>California 3</th>
<th>California 3</th>
<th>South Carolina 2</th>
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<td>3.32</td>
<td>15.5</td>
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<td>26.7</td>
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<td>24.9</td>
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<tr>
<td>B</td>
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<tr>
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<td>.20</td>
<td>.22</td>
<td>.17</td>
<td>.23</td>
<td>.17</td>
<td>.27</td>
<td>.24</td>
<td>.47</td>
<td>.13</td>
</tr>
</tbody>
</table>

No of cations on the basis of 24 O.
2. Foord and Morse (1978). GL-10-1a is from the Huron Claim.
Table 46. Chemical composition and unit cell contents of trinite (I).

<table>
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<tr>
<th></th>
<th>Montane 1</th>
<th>Vision 1</th>
<th>Vision 3</th>
<th>NaCl 1</th>
<th>Nernst 1</th>
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<th>Nernst 3</th>
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<tbody>
<tr>
<td>CaO</td>
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Origin calculated by difference.

1. Busu and Treadwell (1949); REO's mainly CeO₂F₂ with minor CeO₂.
2. Belostotskii and Kupferman (1948); REO's B 8 Ce group.
3. Y group and 8 Ce group.
4. Belostotskii et al. (1953); text has complete substitution of REO's.
6. REO's = 69 CeO₂F₂. 5. Estin (1946); REO's B 8 Ce group and REO 8 Ce group.
Figure 37. Compositions in the rynersonite-fersmite series (after Foord, 1976).
Attention is drawn to the differences between sample GL-10-la, analyzed at Stanford University, and the remaining fersmites from the Huron Claim which were analyzed at the University of Manitoba.

Ta/(Ta + Nb) ratios for the Huron Claim fersmites fall within the narrow range of 0.17 to 0.27 (Table 47). Columbite-tantalites replacing, and co-existing with fersmite possess a similar range of Ta/(Ta + Nb) values (.18 to .26). The metasomatic process seems to have involved the complete replacement of Fe and Mn by Ca, but left intact or only marginally affected the Ta/(Ta + Nb) ratio in the columbite-tantalite precursor. Late stage fluids were obviously able to react with columbite-tantalite to produce partial or complete pseudomorphs of fersmite. This is somewhat at variance with the occurrences in North Carolina and Montana, where fersmite occurs mainly as epitaxial overgrowths on columbite-tantalite (White and Nelen, 1975; Hess and Trumpour, 1959). The formation of fersmite after columbite-tantalite may be related in part to the late stage Ca-metasomatism which affected large parts of the Huron Claim pegmatite.

Niobian Rutile

Niobian rutile is present in the Huron Claim pegmatite only in very minor amounts. A single symplectitic intergrowth of niobian rutile and disordered columbite occurs in sample M17303-A (from the Royal Ontario Museum collection). Associated minerals are albite, partly-leached quartz, pale green zircon (Plate 38) and a reddish-brown, euxenite-like phase. The symplectite is two by three centimetres in size.
NOTICE/AVIS

PAGE(s)  193  IS/ARE EST/SONT black+white photos

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Plate 38. Inclusions of zircon in the niobian rutile-columbite symplectite, surrounded by radial fractures.

Plate 39. Niobian rutile-columbite symplectite (light) surrounded by a metamict euxinite-like phase (dark, with dense fissure pattern).
Minor amounts of coarse, patchy niobian rutile co-exist with the fine-grained, symplectic intergrowth of niobian rutile and columbrite. Occurring along the margins of the intergrowth is a metamict, euxenite-like phase (with characteristic "mud-cracks") which is in smooth, convoluted contact with the interior phase (Plate 39). The symplectite has an average composition of 52.5% niobian rutile and 47.5% columbite. In the fine-grained intergrowth, each mineral species is interconnected in a vermiform manner, with no clear distinction as to which is the host. The "grain" size in the intergrowth is on the order of 0.1 to 0.5 millimetres. The finer-grained parts of the intergrowth are irregular and ragged, whereas the coarser parts are quasi-graphic (Plates 40 and 41). The grain size and structure of the intergrowth vary at random, and show gradual transitions. Coarse patches of niobian rutile occur locally; they are irregular and roughly equi-dimensional in shape, and are one to two millimetres wide. These patches may be separated from both phases, or transitional into niobian rutile of the fine-grained symplectite. Discrete laths of niobian rutile also occur in sample M17303-A.

In transmitted light, both niobian rutile and columbrite are faintly translucent towards the edge of the thin section. The niobian rutile is strongly dichroic from dark brown (ε) to dark green (ω), whereas the columbrite is weakly pleochroic in dark brown. In reflected light, both minerals are cream-coloured, the columbrite being darker and slightly brownish. The coarse patches of niobian rutile have a slightly higher reflectance than the niobian rutile intergrown with columbrite. Bireflectance and anisotropy between crossed nicols are more evident in columbrite than in niobian rutile.
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PAGE($) 195 IS/ARE EST/SONT BLACK+WHITE PHOTOS

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VEUILLEZ ECRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUillez CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 40. Fine-grained symplectite of niobian rutile (light) and columbite (dark) with ragged grain boundaries.

Plate 41. Coarse-grained, quasi-graphic intergrowth of niobian rutile (light) and columbite (dark) with simple angular grain boundaries.
X-ray powder data for the two minerals show a monorutile structure for niobian rutile, and a disordered, ixiolite-like unit-cell for columbite. The disordered columbite is converted to the ordered variety after heating in air at 1000°C for three hours. The unit cell dimensions of the two species are as follows:

Nb rutile: $a = 4.638(2), c = 3.001(3)$

Columbite (natural): $a = 4.726(2), b = 5.711(1), c = 5.114(2)$

Columbite (heated): $a = 14.271(5), b = 5.724(2), c = 5.063(2)$

The chemical compositions of niobian rutile and co-existing, disordered columbite are shown in Table 48. Three adjacent niobian rutile-columbite pairs from the fine symplectite were analyzed, as well as two of the coarse patches of niobian rutile, and two additional grains of columbite. The columbite compositions are uniform, regardless of their association, with high titanium contents and high Fe/Mn and Nb/Ta ratios. Large compositional differences are evident between the coarse patches of niobian rutile, and the niobian rutile in the symplectite. The coarse patches are inhomogeneous and rich in iron and niobium, whereas the niobian rutile in the symplectite is generally inhomogeneous and depleted in iron and niobium. Linear scans of the coarse grains show considerable variation in the titanium, iron and niobium contents. Titanium is inversely correlated with niobium, but niobium shows little correlation with iron. Despite the differences between the two types of niobian rutile, all the compositions have lower Fe/Mn and Nb/Ta ratios than the co-existing columbite.

Niobian and tantalian rutiles have variable Nb/Ta ratios, but they invariably show high, tapiolite-like, Fe/Mn ratios (Figure 38a). The composition of these rutiles is often described in terms of a
### Table 48. Chemical composition of niobian rutile and co-existing, disordered columbite (from Ernst et al. 1981).

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1. Ta
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*Total Fe calculated as FeO*  

Electron microprobe analyses by R. Chapman and T.E. Hancock.
Figure 38. a) Bulk composition of niobian and tantalian rutiles with respect to Ta/(Ta+Nb) and Mn/(Mn+Fe) fractionation; b) co-existing and exsolved Nb/Ta rutile and columbite-tantalite pairs from (a): Nb rutile (1) and columbite (2) from the Huron Claim symplectite, also large grains of Nb rutile from the Huron Claim (3), solid dot is the host and arrowhead is the inclusion for the remaining examples - solid dot and open circle pairs are co-existing discrete phases of rutile and columbite; c) frequency plot of the (Fe+Mn+Mg)/(Nb+Ta) ratio in Nb and Ta rutile - triangle denotes the "ideal" composition, while x's denote the ratios from the Huron Claim; d) cation totals in Nb and Ta rutile, on the basis of four oxygen anions (from Černý et al., 1981).
TiO<sub>2</sub> - (Fe>Mn)(Ta, Nb)<sub>2</sub>O<sub>6</sub> solid solution, but they contain Fe>(Mg, Mn, Ca) in excess of the ideal (Fe, Mn)/(Nb, Ta) ratio of 0.5 (Figure 38c and 39a). This discrepancy could be caused by the incorporation of a rutile-like compound, Fe<sup>3+</sup>Nb<sub>2</sub>O<sub>4</sub>, into solid solution, or it may be the result of iron substitution independent of niobium and tantalum. The cation totals in niobian and tantalian rutiles exceed the ideal value of 2.0 when normalized to 4 oxygens (Figure 38d), and it seems that there is an oxygen deficiency involved with the substitutions Ti<sup>4+</sup> → 2Fe<sup>2+</sup>, and 3Ti<sup>4+</sup> → 4Fe<sup>3+</sup>. Some niobian and tantalian rutiles contain large amounts of ferric iron in place of ferrous iron. Most compositions with appreciable substitution and Nb>Ta are inhomogeneous, and contain exsolved columbite or ilmenite (Figure 39d). The only exsolved mineral with Nb<Ta is the Fe-rich variety described by Lugovskoi and Stolyerova (1969). This preference of niobium for the orthorhombic columbite structure is well-known from co-existing columbite and tapiolite pairs. All niobian and tantalian rutiles have the monorutile unit cell.

Due to the nature of the niobian rutile-columbite intergrowth, the oxidation state of iron in the niobian rutile was not determined. In all other aspects, the Huron Claim rutile matches the characteristics listed in the previous paragraph. True exsolution textures are absent, which is surprising in view of the high iron and niobium contents in both types of niobian rutile. In terms of its Fe/Mn and Nb/Ta ratios, the disordered columbite is close to end-member ferrocolumbite. The titanium content of this columbite is high, but it does not reach the extreme values of 8.8 to 12.8% known in disordered columbites from other localities.
Figure 39. a,b,c) Niobian and tantalian rutile compositions in the Ti,Sn/Fe,Mn/Nb,Ta triangle: a) most of the bulk compositions plot on the Fe,Mn-rich side of the Ti,Sn "columbite-tapiolite" join; b) co-existing and exsolved Nb and Ta rutile and columbite-tantalite pairs (symbols as in b); c) Nb rutile (solid dots) and columbite (open circles) from the Huron Claim (numbering as in b); d) bulk compositions of Nb and Ta rutile in the Ti,Sn/Nb/Ta triangle - open circles are homogeneous phases, x's denote that the homogeneity is not known, solid dots are the Nb-rich (with one exception) phases, and triangles are the Huron Claim compositions; e) co-existing and exsolved Nb and Ta rutile and columbite-tantalite in the (Ti,Sn),/(Fe,Mn)Nb,/(Fe,Mn)Ta, triangle (from Černý et al., 1981).
Niobian rutile with exsolved columbite, and columbite with inclusions of niobian rutile are often described in the literature, but compositional data on these co-existing mineral pairs is scarce. Figures 38b, 39b and 39e include compositions from Siivola (1970) and Černý et al. (1981b), as well as analyses of co-existing columbite-tantalite and Nb/Ta rutile from Černý et al. (1979, 1981b). The compositions all show preferential partitioning of iron and tantalum into rutile, and manganese and niobium into columbite, regardless of the genetic relationship of the two phases. This partitioning has also been described for titanium-poor columbite-tantalite and tapiolite (Foord, 1976; Clark and Fejer, 1978). The columbites show only minor variations in their titanium content, as opposed to the extensive and variable (Fe>Mn) and Nb, Ta substitutions in rutile (Figure 39e). The compositions could conceivably follow an asymmetric solvus, with the apex close to the columbite side of the TiO_2-FeNb_2O_6 system. The absence of exsolution in the tantalian varieties of rutile indicates that there is either a reduction of the two-phase region in the TiO_2-FeTa_2O_6 system, or more persistence of metastable phases. The compositions in the Huron Claim symplectite conform to the general partitioning pattern, as the Fe/Mn and Nb/Ta ratios show the preference of iron and tantalum for the rutile structure. The large patches of niobium and iron-enriched rutile seem to have been metastable during crystallization of the enclosing symplectite.

The ratio and composition of the two phases making up the symplectite and quasi-graphic structure are not indicative of a metasomatic origin. Exsolution is common in niobian rutiles, but the host predominates over the exsolved grains and the textures are quite
different (Černý et al., 1964). If the symplectite were formed by exsolution, the large patches of niobium and iron-enriched rutile would represent metastable anomalies in the midst of an exsolved phase. The large patches of rutile are not relics of a homogeneous parent phase, as they differ chemically from the bulk composition of the symplectite. The textural and compositional features of the symplectite suggest that it formed by simultaneous crystallization of both phases, following a brief period of crystallization of niobium and iron-enriched rutile. After crystallization, the entire intergrowth must have been temperature quenched, or shielded against the late fluids and volatile components that would have promoted re-equilibration.

**Microlite**

In the pegmatites comprising the Greer Lake and Shatford Lake pegmatite groups, microlite is fairly common as an alteration mineral after columbite-tantalite (Černý et al., 1981b). It was tentatively identified in the Huron Claim pegmatite by Černý and Turnock (1971b). In the present study, microlite was identified in three specimens during electron microprobe analyses of columbite-tantalite.

Analyses of the Huron Claim microlites are shown in Table 49. The totals are uniformly low, presumably due to the presence of water and/or fluorine. Considerable amounts of uranium were detected in three of the analyses, but not nearly enough to classify the specimens as uranmicrolites (Hogarth, 1977; Foord, 1982). All three specimens show large deficiencies in the A cation positions. The microlite compositions are plotted in the microlite-pyrochlore-betafite triangle in Figure 40.
Table 49. Chemical composition of microlite from the Huron Claim pegmatite.

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<td>Sn</td>
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<td>-</td>
<td>-</td>
<td>Mn</td>
<td>0.06</td>
<td>0.07</td>
<td>-</td>
<td>-</td>
<td>Mn</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>BaO</td>
<td>-</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>Pb</td>
<td>-</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
<td>Pb</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td>CaO</td>
<td>15.50</td>
<td>12.60</td>
<td>10.09</td>
<td>12.04</td>
<td>Ca</td>
<td>2.82</td>
<td>2.37</td>
<td>2.04</td>
<td>2.17</td>
<td>Ca</td>
<td>2.79</td>
<td>2.35</td>
</tr>
<tr>
<td>Na&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>0.20</td>
<td>0.20</td>
<td>1.80</td>
<td>1.35</td>
<td>Na</td>
<td>0.07</td>
<td>0.07</td>
<td>0.06</td>
<td>0.44</td>
<td>Na</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>97.20</td>
<td>98.44</td>
<td>88.30</td>
<td>92.41</td>
<td>Σ(A)</td>
<td>3.02</td>
<td>2.81</td>
<td>3.06</td>
<td>2.83</td>
<td>Σ(A)</td>
<td>2.99</td>
<td>2.79</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>cation charge</th>
<th>26.08</th>
<th>25.95</th>
<th>25.98</th>
<th>25.99</th>
<th>25.82</th>
<th>25.76</th>
<th>25.40</th>
<th>24.79</th>
</tr>
</thead>
</table>
1) (Ca,Na,Mn,Fe,Sb,Sm)<sub>2.99</sub> (Ta,Nb,Ti)<sub>4.00</sub> 0.12 (50,OH,F)<sub>1.82</sub>
2) (Ca,U,Na,Mn,Pb,Sn,Fe)<sub>2.79</sub> (Ta,Nb,Ti)<sub>4.00</sub> 0.12 (50,OH,F)<sub>1.76</sub>
3) (Ca,Na,U,Fe)<sub>2.99</sub> (Ta,Nb,Ti)<sub>4.00</sub> 0.12 (50,OH,F)<sub>1.40</sub>
4) (Ca,Na,Fe,U)<sub>2.71</sub> (Ta,Nb,Ti)<sub>4.00</sub> 0.12 (50,OH,F)<sub>0.79</sub>

1. P2-07, electron microprobe analysis by F.C. Hawthorne.
2. P2-07, electron microprobe analysis by R. Chapman.
3. 77-3T-03, electron microprobe analysis by R. Chapman.
4. BP-09, electron microprobe analysis by R. Chapman.
1',2',3',4' - cations on the basis of 13 oxygen anions.
1'',2'',3'',4'' - cations normalized to 4.00 (Ta+Nb+Ti).
Figure 40. Plot of microlite from the Huron Claim pegmatite, in the betafite-pyrochlore-microlite triangle.
The analyses were obtained during routine microbeam scans of columbite-tantalite, and there is some uncertainty regarding the location and appearance of the microlite within the large crystals of columbite-tantalite. Several small grains were removed from sample P2-07 for X-raying, but these could not be identified and certainly are not microlites. During the microprobe analyses of columbite-tantalite, altered grain margins were specifically avoided, suggesting that the microlite occurs as tiny grains or intergrowths well within the columbite-tantalite. The columbite-tantalite crystals are themselves optically inhomogeneous, making identification of the included phases difficult. Small, pale yellow grains occurring along the margins of columbite-tantalite crystals were noticed in a number of samples, but these grains were not microprobed or X-rayed. Similar pale yellow material occurs in abundance along the grain margins of columbite-tantalite in several specimens, and X-ray identification of this material is warranted. In any case, the microlite is inconspicuous in hand specimen.

The microlite occurring in the pegmatites of the Greer Lake group is generally intergrown with columbite-tantalite, occasionally penetrating into the surrounding quartz and albite (Černý and Turnock, 1971b). It also fills the interstices between grains of columbite-tantalite. Isolated grains of microlite are rare. In reflected light, the microlite is greyish-brown and difficult to distinguish from the columbite-tantalite with which it is intergrown. The microlites in the Greer Lake pegmatites are apparently all crystalline.

In the Huron Claim pegmatite, the tantalum contents in microlite are considerably higher than those in the co-existing
columbite-tantalite. Tantalum-rich microlite is common in granitic pegmatites co-existing with or replacing tantalum-poorer columbite-tantalite (Černý and Turnock, 1971b). The microlites are titanium-poor, reflecting the low level of titanium in the pegmatite as a whole.

Euxenite

Euxenite-polycrase was first reported from the Huron Claim pegmatite by Davies (1957); several small grains were apparently recovered from columbite-tantalite rich hand specimens. These grains may not have been correctly identified, and their equivalence to the euxenite-like phase discovered during the present study is somewhat in doubt. The euxenite-like phase was found in a single specimen co-existing with ferrocolumbite and niobian rutile. It is relatively abundant in this specimen, occurring as reddish, translucent masses that are easily separated under a microscope. In thin section, as previously described, the euxenite-like phase occurs on the margins of a ferrocolumbite-niobian rutile intergrowth and exhibits a characteristic "mud-crack" texture.

An electron microprobe analysis of the euxenite-like phase is given in Table 50. The low total is attributable in part to the metamict and hydrated nature of the phase. Although the euxenite-like phase was not completely characterized by X-ray diffraction studies, it does seem to belong to the orthorhombic, rare-earth, \( \text{AB}_{2}\text{O}_6 \) - type group of Nb-Ta-Ti oxides in terms of chemical composition. In this group of minerals, the only unambiguously defined species are euxenite, \( \text{YNbTiO}_6 \), and aeschynite, \( \text{CeNbTiO}_6 \) (Ewing and Chakoumakos, 1982). Polycrase is generally regarded as a titanium-rich variety of euxenite. The oxide
Table 50. Electron microprobe analysis of a euxenite-like phase from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th>Sample</th>
<th>M17303-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ta&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;, wt %</td>
<td>2.6</td>
</tr>
<tr>
<td>Nb&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</td>
<td>4.50</td>
</tr>
<tr>
<td>TiO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>6.0</td>
</tr>
<tr>
<td>U&lt;sub&gt;3&lt;/sub&gt;O&lt;sub&gt;8&lt;/sub&gt;</td>
<td>1.0</td>
</tr>
<tr>
<td>ThO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>5.4</td>
</tr>
<tr>
<td>Y&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
<td>11.2</td>
</tr>
<tr>
<td>CeO&lt;sub&gt;3&lt;/sub&gt;</td>
<td>0.5</td>
</tr>
<tr>
<td>FeO</td>
<td>4.7</td>
</tr>
<tr>
<td>MnO</td>
<td>0.4</td>
</tr>
<tr>
<td>CaO</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Analyst: R. Chapman

Table 51. Major compositional characteristics of the orthorhombic, rare-earth, AB<sub>2</sub>O<sub>6</sub>-type Nb-Ta-Ti oxides (from Ewing and Ehlmann, 1975).

<table>
<thead>
<tr>
<th>Polycrase</th>
<th>Ti&lt;sub&gt;2&lt;/sub&gt; &gt;&gt; (Nb&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt; + Ta&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ThO&lt;sub&gt;2&lt;/sub&gt; &gt; U&lt;sub&gt;3&lt;/sub&gt;O&lt;sub&gt;8&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>Y&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt; &gt; Ce&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Euxenite</th>
<th>TiO&lt;sub&gt;2&lt;/sub&gt; &gt; (Nb&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt; + Ta&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ThO&lt;sub&gt;2&lt;/sub&gt; &lt; U&lt;sub&gt;3&lt;/sub&gt;O&lt;sub&gt;8&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>Y&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt; &gt; Ce&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aeschynite</th>
<th>TiO&lt;sub&gt;2&lt;/sub&gt; &lt; (Nb&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt; + Ta&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ThO&lt;sub&gt;2&lt;/sub&gt; &gt; U&lt;sub&gt;3&lt;/sub&gt;O&lt;sub&gt;8&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>Y&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt; &lt; Ce&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M17303-A</th>
<th>TiO&lt;sub&gt;2&lt;/sub&gt; &lt;&lt; (Nb&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt; + Ta&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ThO&lt;sub&gt;2&lt;/sub&gt; &gt; U&lt;sub&gt;3&lt;/sub&gt;O&lt;sub&gt;8&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>Y&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt; &gt;&gt; Ce&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
</tr>
</tbody>
</table>
minerals of the group are variable in composition and frequently metamict, or altered, making their classification difficult. The elements niobium, tantalum and titanium are among the least affected by alteration (Ewing, 1975), and therefore of much practical importance in any classification scheme. Despite the low total in sample M17303-A, the sum of the Nb, Ta and Ti oxides, 53.6%, is about that expected for the euxenite and aeschynite group of minerals (Vlasov, 1966). However, the niobium content is unusually high, and the titanium content unusually low, compared to the normal range of compositions. Until it is more fully characterized, sample M17303-A is perhaps best classified as a euxenite-like phase, on the basis of its yttrium content exceeding that of cerium. The major compositional characteristics of the orthorhombic, rare-earth, AB₂O₆-type Nb-Ta-Ti oxides are shown in Table 51.

The euxenite-like phase was not completely characterized during X-ray diffraction studies. It is partially to completely metamict, the natural specimens producing undecipherable X-ray powder patterns with only a few reflections of low intensity. Specimens heated in air for three hours at 1050°C, produced reasonable X-ray powder patterns, as shown in Figure 41. Although not totally identical, the phase seems to most closely resemble aeschynite-(Y), as described by Horne and Butler (1965). Annealing studies on the orthorhombic, rare-earth, AB₂O₆-type Nb-Ta-Ti oxides have been carried out by a number of authors, notably Lima de Faria (1964) and Ewing and Ehlmann (1975). In general, a priorite-aeschynite phase was found to crystallize at low temperatures (400°C), and an euxenite phase at higher temperatures. The priorite-aeschynite to euxenite transition occurs over the range 550 to 750°C.
Figure 41. X-ray powder diffractogram of the euxenite-like phase in sample M17303-A. D-spacings based on similar pattern calibrated with CaF$_2$. 
for yttrium-rich compositions, and from 900 to 1100°C for cerium-rich compositions (Ewing and Ehlmann, 1975). A cubic pyrochlore phase is generally present over the temperature interval 400 to 1100°C. The stability field of the euxenite phase decreases with increasing values of ThO₂/UO₂, and decreasing values of Ce₂O₃/Y₂O₃. Given the yttrium-rich composition of the Huron Claim specimen, and the temperature of the annealing run, euxenite should have crystallized rather than aeschynite. However, this did not happen. The X-ray powder pattern illustrated in Figure 41 could conceivably be the result of a mixture of several phases, but it does closely resemble the aeschynite-(Y) pattern. Sample M17303-A does have some of the compositional attributes of aeschynite, including ThO₂>UO₂ and TiO₂<(Nb₂O₅ + Ta₂O₅), but its cerium content is much subordinate to yttrium. Additional material is available, and further annealing studies are warranted. Until the phase is fully characterized, it is best described as euxenite on the basis of its high yttrium content.

**Unidentified Nb-Ta Oxide Mineral**

A calcium and tantalum-rich oxide mineral was discovered in a number of samples during electron microprobe studies of columbite-tantalite. Analyses of the unknown oxide mineral are shown in Table 52. As with the microlites, there is some uncertainty regarding the location and appearance of the unknown phase within the larger grains of columbite-tantalite. In this case, the unknown oxide mineral may actually form thin rims on the columbite-tantalite (P. Cerny, pers. comm.). The unknown phase has a microlite-like composition, but the relatively high calcium contents, the uniform totals in separate
Table 52. Chemical composition of the unidentified Nb/Ta oxide mineral intergrown with columbite-tantalite.

<table>
<thead>
<tr>
<th>Sample</th>
<th>P2-04</th>
<th>P2-05</th>
<th>P3-23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ta₂O₅</td>
<td>68.03</td>
<td>65.20</td>
<td>60.79</td>
</tr>
<tr>
<td>Nb₂O₅</td>
<td>8.59</td>
<td>11.30</td>
<td>13.44</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0.80</td>
<td>1.03</td>
<td>2.10</td>
</tr>
<tr>
<td>CaO</td>
<td>16.84</td>
<td>16.63</td>
<td>17.97</td>
</tr>
<tr>
<td></td>
<td>94.21</td>
<td>94.16</td>
<td>94.31</td>
</tr>
</tbody>
</table>

Electron microprobe analyses by R. Chapman, 1984
samples and the lack of minor constituents other than titanium, all suggest a discrete variety of microlite, or another phase altogether. Further studies of this phase are presently under way.

URANINITE

Uraninite is one of the better-known minerals from the Huron Claim pegmatite, as it originally occurred in amounts sufficient for its use in geochronological work. Partial chemical, and isotopic, analyses of uraninite have already been presented (Tables 5 and 6).

Uraninite is confined to the medium to coarse-grained albite unit, although in some instances its crystallization may postdate the formation of this unit. It occurs for the most part as small, subhedral to anhedral crystals embedded in albite (Plate 42), in association with monazite, columbite-tantalite, beryl, and minor muscovite. The uraninite also follows fissures within the albite (Plate 43), and occurs infrequently with monazite in a set of late, quartz-filled fractures. The size of the uraninite grains varies from three to six millimetres. The colour of the grains varies from steely grey to pitch black, depending on the degree of alteration. Yellow rims and thin, cross-cutting veinlets of hydrated urano-silicates accompany the majority of the grains. Similar material accompanying magnetite and coffinite in sample 2026 was identified as uranophane-sklodowskite (Bristol, 1962).

In reflected light, the uraninite grains are light grey and optically homogeneous. Inclusions are absent, but nearly all the grains have altered margins. Many of the grains are fissured, and most show moderately developed octahedral cleavage.
NOTICE/AVIS

PLEASE WRITE TO THE AUTHOR FOR INFORMATION, OR CONSULT THE ARCHIVAL COPY HELD IN THE DEPARTMENT OF ARCHIVES AND SPECIAL COLLECTIONS, ELIZABETH DAFOE LIBRARY, UNIVERSITY OF MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.

VEUILLEZ ECRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Density determinations were made on eleven samples, and the results are listed in Table 41 along with the original determinations of Henry and Ellsworth (103). The data show that much of the variation in density is due to differences in the content of the rare earth elements and cerium, although changes in density due to solution have apparently also taken place. The change in cell dimensions is due to the oxidation of the U⁶⁺ to U⁶⁺, as well as the replacement of the Th⁴⁺ ion in the uraninite molecule by U⁶⁺ ion (Table 42 and Figure 42). These results lead to the complete separation into U and Th end-member compositions. During the U-Th-OH solid solution stage, the rare earth elements and cerium are present in the uraninite and a complete solid solution exists between the two minerals. In the Würmian period, the (U/Th) ratio is relatively constant at 0.13 to 0.19. Inorium, cerium, and yttrium are all common in pegmatitic uraninites, but the latter two elements were

Plate 42. Solitary grain of uraninite embedded in coarse albrite. Coin is 17 mm. in diameter (PC-06).

Plate 43. Large grain of uraninite and associated fractures in coarse albite (M17305-H).
Density determinations were made on eleven samples, and these are listed in Table 53 along with the original determinations of DeLury and Ellsworth (1931). The densities vary from 8.0 to 9.1 g/cm³, and cover much of the range (7.5 to 9.7 g/cm³) reported for natural uraninites. Density differences in uraninite are generally due to alteration; changes in density with the entrance of additional elements into solid solution have not been observed in natural samples (Frondel, 1958).

When natural uraninites are heated and UO₂ is one of the products formed, the cell dimensions of the recrystallized material are generally smaller than those of the original material (Frondel, 1958). The change in cell dimensions is due to the oxidation of the U⁴⁺ ion, as well as the removal of radiation damage. This effect is evident in Table 53 and Figure 42. The heated Huron Claim uraninites show a complete separation into U and Th end-member compositions. Sample "X" was heated in air for 30 minutes (Frondel, 1958), which resulted in a decrease in the a cell dimension of 0.083 Å.

Electron microprobe analyses of five Huron Claim uraninites are presented in Table 54. The original analyses of DeLury and Ellsworth (1931) are shown for comparative purposes in Table 55. The lead and thorium contents of the Huron Claim uraninites are among the highest ever recorded for this species in granitic pegmatites (cf. Frondel et. al., 1967). The high lead contents are caused by the decay of uranium and thorium producing radiogenic lead. Thorianite (ThO₂) is isostructural with uraninite and a complete solid solution exists between the two minerals; in the microprobed samples, the Th/(U + Th) ratio is relatively constant at 0.13 to 0.15. Thorium, cerium and yttrium are all common in pegmatitic uraninites, but the latter two elements were
Table 53. Physical properties of uraninite from the Huron Clain pegmatite.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Colour</th>
<th>Density (g/cm³)</th>
<th>$\rho(\AA)^2$</th>
<th>$\rho(\AA)^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>GL-37</td>
<td>grey</td>
<td>9.10</td>
<td>5.525(1)</td>
<td>5.464(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.592(6)</td>
</tr>
<tr>
<td>M17304-19</td>
<td>grey</td>
<td>9.09</td>
<td>5.520(1)</td>
<td>5.454(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.598(1)</td>
</tr>
<tr>
<td>11</td>
<td>grey</td>
<td>8.97</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P3-SP-01</td>
<td>grey</td>
<td>8.64</td>
<td>5.526(1)</td>
<td>5.466(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.587(6)</td>
</tr>
<tr>
<td>M17305-H</td>
<td>grey</td>
<td>8.64</td>
<td>5.536(3)</td>
<td>5.468(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.587(8)</td>
</tr>
<tr>
<td>GL-34</td>
<td>grey</td>
<td>8.53</td>
<td>5.477(6)</td>
<td>5.462(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.587(9)</td>
</tr>
<tr>
<td>77-RE-06</td>
<td>yellow alteration</td>
<td>8.39</td>
<td>5.559(1)</td>
<td>5.466(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.599(11)</td>
</tr>
<tr>
<td>PC-06</td>
<td>black, yellow alteration</td>
<td>8.33</td>
<td>5.534(1)</td>
<td>5.470(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.591(3)</td>
</tr>
<tr>
<td>M17304-3</td>
<td>black</td>
<td>8.30</td>
<td>5.496(4)</td>
<td>5.467(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.593(6)</td>
</tr>
<tr>
<td>77-RE-01</td>
<td>black</td>
<td>8.27</td>
<td>5.467(1)</td>
<td>5.466(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.589(5)</td>
</tr>
<tr>
<td>P3-SP-02</td>
<td>black</td>
<td>8.12</td>
<td>5.481(4)</td>
<td>5.468(2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.592(9)</td>
</tr>
<tr>
<td>1</td>
<td>grey, albite contamination</td>
<td>8.08</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>77-RE-10</td>
<td>much yellow alteration</td>
<td>8.00</td>
<td>5.496(3)</td>
<td>5.457(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.600(7)</td>
</tr>
</tbody>
</table>

1. Delury and Ellsworth (1931).
2. Natural uraninites.
3. Uraninites heated one hour in N₂ at 1000°C.

Five of the natural uraninites contain a second phase. These "two-phase" uraninites may represent zoned grains, with altered (oxidized) rims and relatively pristine cores.
Figure 42. Variation in the a unit cell dimension - Huron Claim uraninites.
Table 54. Chemical composition of uraninite from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>P3-SP (core)</th>
<th>P3-SP (edge)</th>
<th>77-RE-03 (core)</th>
<th>77-RE-03 (edge)</th>
<th>PC-06 (core)</th>
<th>PC-06 (edge)</th>
<th>1976 (core)</th>
<th>1976 (edge)</th>
<th>77-RE-15 (core)</th>
<th>77-RE-15 (edge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UO$_2$, wt.%</td>
<td>67.24</td>
<td>66.00</td>
<td>67.80</td>
<td>67.60</td>
<td>67.87</td>
<td>67.80</td>
<td>73.75</td>
<td>69.29</td>
<td>74.43</td>
<td>73.32</td>
</tr>
<tr>
<td>ThO$_2$</td>
<td>11.28</td>
<td>10.48</td>
<td>10.71</td>
<td>10.51</td>
<td>10.60</td>
<td>10.26</td>
<td>10.54</td>
<td>11.54</td>
<td>12.12</td>
<td>12.40</td>
</tr>
<tr>
<td>PbO</td>
<td>15.77</td>
<td>18.08</td>
<td>16.95</td>
<td>17.10</td>
<td>17.33</td>
<td>17.91</td>
<td>16.59</td>
<td>9.61</td>
<td>11.56</td>
<td></td>
</tr>
<tr>
<td>Ce$_2$O$_3$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Y$_2$O$_3$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td></td>
<td>94.29</td>
<td>94.56</td>
<td>95.46</td>
<td>95.21</td>
<td>95.80</td>
<td>95.97</td>
<td>94.68</td>
<td>97.42</td>
<td>96.16</td>
<td>97.28</td>
</tr>
<tr>
<td>U</td>
<td>3.05</td>
<td>3.01</td>
<td>3.05</td>
<td>3.05</td>
<td>3.04</td>
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<tr>
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<td>.48</td>
<td>.49</td>
<td>.47</td>
<td>.47</td>
<td>.52</td>
<td>.54</td>
<td>.55</td>
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<td>Pb</td>
<td>.86</td>
<td>1.00</td>
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<td>.93</td>
<td>.94</td>
<td>.97</td>
<td>.56</td>
<td>.88</td>
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<tr>
<td></td>
<td>4.43</td>
<td>4.50</td>
<td>4.46</td>
<td>4.46</td>
<td>4.47</td>
<td>4.48</td>
<td>4.28</td>
<td>4.44</td>
<td>4.25</td>
<td>4.30</td>
</tr>
<tr>
<td>cation charge</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
<td>15.98</td>
<td>16.00</td>
<td>15.98</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Pb/(U+Th)</td>
<td>.24</td>
<td>.29</td>
<td>.26</td>
<td>.26</td>
<td>.27</td>
<td>.28</td>
<td>.15</td>
<td>.25</td>
<td>.13</td>
<td>.16</td>
</tr>
</tbody>
</table>

Electron microprobe analyses by C. Gasparriini.

Some hexavalent U in the structure of uraninite probably accounts in part for the low totals; minor elements other than Ce and Y (Fe and Cu appear on some X-ray spectra) account for the remainder.

Cations on the basis of 8 oxygen anions.

Samples P3-SP and 1976 are uncatalogued fragments collected by the author during 1976.
Table 55. Chemical composition of uraninite from the Huron Claim pegmatite - the original analyses of DeLury and Ellsworth (1931).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>wt.% oxides</th>
<th>cations</th>
<th>wt.% oxides</th>
<th>cations</th>
</tr>
</thead>
<tbody>
<tr>
<td>UO₂</td>
<td>60.68₁</td>
<td>2.51</td>
<td>62.40₁</td>
<td>2.55</td>
</tr>
<tr>
<td>ThO₂</td>
<td>14.18</td>
<td>.60</td>
<td>13.94</td>
<td>.58</td>
</tr>
<tr>
<td>PbO</td>
<td>16.63</td>
<td>.83</td>
<td>16.71</td>
<td>.83</td>
</tr>
<tr>
<td>(Ce,La,Dy)₂O₃</td>
<td>0.37</td>
<td>.03²</td>
<td>0.28</td>
<td>.02²</td>
</tr>
<tr>
<td>(Y,Er)₂O₃</td>
<td>1.02</td>
<td>.10²</td>
<td>1.19</td>
<td>.12²</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.64</td>
<td>.09</td>
<td>0.75</td>
<td>.10</td>
</tr>
<tr>
<td>MnO</td>
<td>0.18</td>
<td>.03</td>
<td>0.13</td>
<td>.02</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.10</td>
<td>.02</td>
<td>0.12</td>
<td>.03</td>
</tr>
<tr>
<td>CaO</td>
<td>1.45</td>
<td>.29</td>
<td>1.72</td>
<td>.34</td>
</tr>
<tr>
<td>MgO</td>
<td>0.07</td>
<td>.02</td>
<td>0.06</td>
<td>.02</td>
</tr>
<tr>
<td>SiO₂</td>
<td>0.67</td>
<td>.12</td>
<td>0.37</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>95.99</td>
<td>4.64</td>
<td>97.67</td>
<td>4.68</td>
</tr>
<tr>
<td>Pb/(U+Th)</td>
<td>.27</td>
<td></td>
<td>.27</td>
<td></td>
</tr>
<tr>
<td>Th/(U+Th)</td>
<td>.19</td>
<td></td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>cation charge</td>
<td>15.98</td>
<td></td>
<td>16.03</td>
<td></td>
</tr>
</tbody>
</table>

¹ UO₂ recalculated from U₃O₈.
² (Ce,La,Dy)₂O₃ taken as 100% Ce₂O₃; (Y,Er)₂O₃ taken as 100% Y₂O₃.

Cations on the basis of 8 oxygen anions.
Sample I contains minor amounts of albite.
not detected during electron microprobe analysis. Both cerium and yttrium are reported as minor constituents by DeLury and Ellsworth (1931). The iron, aluminum, manganese, calcium and silicon values reported by these authors are probably due to contamination by other minerals (Frondel, 1958).

In general, the Pb/(U + Th) ratios increase towards the margins of the uraninite grains. Uraninite is easily oxidized under natural conditions, and frequently hydrated. During the initial stages of alteration, leaching of uranium and thorium with respect to lead may occur (Frondel, 1958). The differential loss of uranium, thorium and lead from uraninite and monazite may be responsible in part for the highly discordant age dates obtained from these minerals. The Th/(Th + U) ratios are relatively uniform from core to rim, whereas the lead oxide contents are highly variable, ranging from 9.61 to 18.08 wt%.

The alteration of uraninite occurs in two stages, one of which has already been described. The first stage involves oxidation and hydration with a concomitant colour change from steely grey to pitch black. The first alteration products are generally hydrated uranyl-oxides, in which lead is an essential constituent (Frondel, 1958). During the second stage of alteration, the hydrated oxides are converted into silicates such as uranophane-sklodowskite. The Huron Claim uraninites are not greatly altered, as secondary urano-silicates occur only as thin coatings on the grain margins and cross-cutting fractures.

The Huron Claim is an excellent example of a uranium and thorium-enriched, rare-earth element pegmatite. The uranium in these pegmatites generally precipitates as uraninite, in isolated and well-formed crystals containing considerable quantities of thorium and the
rare-earth elements. Uranium also occurs in significant quantities in the rare-earth, thorium-, and zirconium-based accessory minerals. Associated minerals include monazite, titanite, Nb-Ta oxide minerals, zircon, thorite and allanite. The Huron Claim pegmatite is the only member of the Shatford Lake group in which uraninite is reported.

COFFINITE

Coffinite has not been positively identified in the Huron Claim pegmatite, but electron microprobe analyses suggest that the mineral is present in minor amounts in at least two specimens. In thorite sample GL-10-1b, an inclusion originally described as a "uranium silicate" (G.W. Robinson, pers. comm.), is probably a coffinite-like phase. The radioactive inclusions in magnetite from sample 2026, contain significant amounts of SiO₂ suggesting that they are coffinite-like as well. Microprobe analyses of the coffinite-like phases are shown in Table 56.

Coffinite is a hydrated silicate of quadrivalent uranium, isostructural with thorite, thorogummite and zircon (Frondel, 1958). It generally occurs as a low temperature alteration product of uraninite. A complete solid solution series between coffinite and thorogummite has not been demonstrated, although it might be expected to exist. In thorogummite, uranium can substitute up to a 1:1 ratio with thorium (Frondel, 1958). Coffinite analyses, which tend to be variable, are infrequent in the literature. The analyses shown in Table 56 have low totals, and both samples are undoubtedly hydrated. The structural water in coffinite and thorogummite is typically present in amounts ranging from 6 to 12 weight per cent H₂O (Frondel, 1958). The silica and (U + Th)O₂ contents of the two Huron Claim analyses look reasonable
Table 56. Electron microprobe analyses of two coffinite-like phases from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th>Sample</th>
<th>GL-10-1b¹</th>
<th>2026²</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂ wt %</td>
<td>17.81</td>
<td>10.87</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>3.65</td>
<td>-</td>
</tr>
<tr>
<td>ThO₂</td>
<td>7.44</td>
<td>16.77</td>
</tr>
<tr>
<td>UO₂</td>
<td>36.65</td>
<td>26.52</td>
</tr>
<tr>
<td>ZrO₂</td>
<td>-</td>
<td>2.48</td>
</tr>
<tr>
<td>FeO³</td>
<td>7.67</td>
<td>19.11</td>
</tr>
<tr>
<td>CaO</td>
<td>0.47</td>
<td>0.16</td>
</tr>
<tr>
<td>MgO</td>
<td>0.50</td>
<td>-</td>
</tr>
<tr>
<td>PbO</td>
<td>-</td>
<td>2.78</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>1.79</td>
<td>1.22</td>
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<tr>
<td>Ce₂O₃</td>
<td>0.32</td>
<td>-</td>
</tr>
<tr>
<td>Nd₂O₃</td>
<td>0.57</td>
<td>-</td>
</tr>
<tr>
<td>Gd₂O₃</td>
<td>0.46</td>
<td>-</td>
</tr>
<tr>
<td>Total Fe</td>
<td>77.38</td>
<td>79.91</td>
</tr>
</tbody>
</table>

1. Inclusion in thorite. Electron microprobe analysis by C.W. Robinson, Queen's University (1976); Pb, Cu, and Ta also detected.


3. Total Fe reported as FeO.
when compared to other analyses of coffinite and thorogummite in the literature. The iron content of sample 2026 is particularly high. The two samples have been tentatively identified as coffinite on the basis of UO₂ exceeding ThO₂, although the thorium contents are much higher than those usually reported for this mineral (Frondel, 1958). A full characterization of the coffinite-like phases would require X-ray identification. It is quite conceivable that both samples are mixtures of several phases. A thorogummite-like phase is also present in sample GL-10-1b, and is discussed briefly in the thorite section. Given the metamict and hydrated nature of the Huron Claim thorites, thorogummite should be abundant. Further X-ray studies of the thorite specimens are warranted.

**MONAZITE**

Monazite is one of the more abundant accessory minerals in the Huron Claim pegmatite. The use of this mineral in early geochronological studies of the pegmatite was discussed in a previous section.

Monazite occurs as euhedral crystals, from 0.3 to 3.2 centimetres long, within the medium to coarse-grained albite unit. The crystals are generally dark brown, with a resinous to waxy appearance, although several dark grey to black examples have been documented. Generally embedded in albite, the crystals are also found along fissures in the albite, and in quartz-filled fractures with uraninite. In the Huron Claim pegmatite, monazite has much the same distribution as uraninite, and the two species seem to be closely associated. The monazite crystals are generally flattened parallel to (001), but thick tabular to wedge-shaped crystals are also present. Many of the crystals are
twinned and show re-entrant angles on the c-axis termination. A single large, dark grey monazite was obtained from sample 77-3T-05, and a unique "bow-tie"-shaped monazite was found associated with chlorite in sample 77-P3-01. The latter specimen, which is surrounded by radial fractures, consists of a rectangular black core and dark brown terminations. In thin section and polished section, the monazites appear completely homogeneous and free of inclusions.

Although monazite can be extremely abundant in individual hand specimens (Plates 44 and 45), it was probably originally confined, like the other rare accessories, to isolated areas within the medium to coarse-grained albite unit. The specimens collected during the present study were all obtained from dump material; the very best samples came from the dump at the east end of Greer Lake and from the Royal Ontario Museum collection.

The unit cell dimensions of nine Huron Claim monazites are shown in Table 57. In the natural samples, a varies from 6.730 to 6.760 Ǻ, b from 6.947 to 6.972 Ǻ and c from 6.443 to 6.501 Ǻ; the brown and black varieties of monazite do not show any systematic differences. The unit cells of the heat-treated monazites are consistently smaller than their natural counterparts, presumably due to the elimination of radiation damage. No refractive index or density determinations were done during the present study. The refractive indices of monazite increase substantially with increasing thorium content (Vlasov, 1966), and optical determinations are often a useful adjunct to chemical analyses.

Chemical analyses of two Huron Claim monazites, HC-UM(1) and HC-ROM, are presented in Table 58. Yttrium, zirconium, lead and tin
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BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA,
WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 44. Euhedral, brown monazite crystals in coarse-grained albite (M17305-L).

Plate 45. Euhedral monazite crystal closely associated with fractures in coarse-grained albite (M17305-0).
Table 58. Unit cell dimensions of the Huron Claim monazites.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>4'</th>
<th>5</th>
<th>5'</th>
</tr>
</thead>
<tbody>
<tr>
<td>a(Å)</td>
<td>6.732(7)</td>
<td>6.731(2)</td>
<td>6.753(2)</td>
<td>6.741(2)</td>
<td>6.744(1)</td>
<td>6.738(3)</td>
<td>6.734(1)</td>
</tr>
<tr>
<td>b(Å)</td>
<td>6.955(5)</td>
<td>6.947(2)</td>
<td>6.958(2)</td>
<td>6.961(2)</td>
<td>6.941(1)</td>
<td>6.970(2)</td>
<td>6.951(1)</td>
</tr>
<tr>
<td>c(Å)</td>
<td>6.443(5)</td>
<td>6.458(1)</td>
<td>6.461(2)</td>
<td>5.452(2)</td>
<td>6.426(2)</td>
<td>6.465(3)</td>
<td>6.432(2)</td>
</tr>
<tr>
<td>V(Å³)</td>
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<td>293.04</td>
<td>294.65</td>
<td>293.75</td>
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<td>292.45</td>
</tr>
<tr>
<td></td>
<td>103°42'</td>
<td>103°56'</td>
<td>103°55'</td>
<td>104°01'</td>
<td>103°58'</td>
<td>104°05'</td>
<td>103°44'</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample No.</th>
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<th>6'</th>
<th>7</th>
<th>7'</th>
<th>8</th>
<th>8'</th>
<th>9</th>
<th>9'</th>
<th>10</th>
<th>10'</th>
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</thead>
<tbody>
<tr>
<td>a(Å)</td>
<td>6.760(5)</td>
<td>6.724(1)</td>
<td>6.730(2)</td>
<td>6.703(4)</td>
<td>6.753(4)</td>
<td>6.720(2)</td>
<td>6.743(4)</td>
<td>6.723(2)</td>
<td>6.754(3)</td>
<td>6.758(4)</td>
</tr>
<tr>
<td>b(Å)</td>
<td>6.953(3)</td>
<td>6.938(1)</td>
<td>6.947(1)</td>
<td>6.949(3)</td>
<td>6.976(3)</td>
<td>6.941(3)</td>
<td>6.962(3)</td>
<td>6.926(1)</td>
<td>6.972(3)</td>
<td>6.954(3)</td>
</tr>
<tr>
<td>c(Å)</td>
<td>6.475(6)</td>
<td>6.416(2)</td>
<td>6.463(2)</td>
<td>6.438(5)</td>
<td>6.483(9)</td>
<td>6.396(2)</td>
<td>6.501(4)</td>
<td>6.411(3)</td>
<td>6.461(2)</td>
<td>6.465(5)</td>
</tr>
<tr>
<td>V(Å³)</td>
<td>295.13</td>
<td>290.49</td>
<td>293.69</td>
<td>291.95</td>
<td>296.21</td>
<td>290.07</td>
<td>296.43</td>
<td>290.26</td>
<td>295.42</td>
<td>294.85</td>
</tr>
<tr>
<td></td>
<td>103°09'</td>
<td>103°58'</td>
<td>103°47'</td>
<td>103°11'</td>
<td>104°07'</td>
<td>103°32'</td>
<td>103°45'</td>
<td>103°52'</td>
<td>103°51'</td>
<td>103°59'</td>
</tr>
</tbody>
</table>

1 to 10, natural samples.
4' to 10', heated in air at 1050°C for three hours.

1) PC-06 2) HC-0M(1) 3) HC-ROM 4) 77-RE-01 5) 77-RE-11 6) 77-PJ-01 (core) 7) 77-PJ-01 (rim) 8) 77-3T-05 9) SP 10) M17305-C
Table 58. Chemical composition and unit cell contents of two Huron Claim monazites.

<table>
<thead>
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<th></th>
<th>1a</th>
<th>1b</th>
<th>2a</th>
<th>2b</th>
<th>1a'</th>
<th>1b'</th>
<th>2a'</th>
<th>2b'</th>
<th>1a''</th>
<th>1b''</th>
<th>2a''</th>
<th>2b''</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na₂O, wt. %</td>
<td>0.02</td>
<td>0.01</td>
<td>3.74</td>
<td>3.95</td>
<td>3.67</td>
<td>3.77</td>
<td>3.48</td>
<td>3.55</td>
<td>3.42</td>
<td>3.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P₂O₅</td>
<td>25.70</td>
<td>29.70</td>
<td>24.30</td>
<td>25.30</td>
<td>3.56</td>
<td>5.50</td>
<td>6.27</td>
<td>4.44</td>
<td>5.52</td>
<td>4.59</td>
<td>5.8</td>
<td>4.28</td>
</tr>
<tr>
<td>SiO₂</td>
<td>3.27</td>
<td>3.19</td>
<td>3.49</td>
<td>2.51</td>
<td>4.30</td>
<td>4.45</td>
<td>4.29</td>
<td>4.21</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.04</td>
<td>0.23</td>
<td>0.04</td>
<td>0.15</td>
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<td>.01</td>
<td>-</td>
<td>-</td>
<td>Na</td>
<td>.01</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.01</td>
<td>.01</td>
<td>0.01</td>
<td>0.01</td>
<td>Fe³⁺</td>
<td>.05</td>
<td>.05</td>
<td>.09</td>
<td>Fe³⁺</td>
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La and 1b, HC-UM(1); 2a and 2b, HC-ROM; analyses by H. Puchelt, Karlsruhe University: P₂O₅, SiO₂, TiO₂, and Fe₂O₃ by wet chemical methods (photometry); MgO, CaO, and Al₂O₃ by atomic absorption; REE's by neutron activation, except Pr₂O₃ which was calculated.

1a', 1b', 2a', 2b': cations on the basis of 16 oxygen anions.

1a'', 1b'', 2a'', 2b'': unit cell contents normalized to 6.00 (P+Si).

1a) Mo₇₁H₃₁H₆₂₄ 1b) Mo₇₁H₃₁H₆₂₃ 2a) Mo₇₁H₃₁H₆₂₃ 2b) Mo₇₁H₆₂₄
were not analyzed for in these samples, which may partly explain the low totals. Problems were encountered during neutron activation analysis of the rare-earth elements (Puchelt, pers. comm.), and the rare-earth element totals are probably low as well. The praseodymium values were interpolated from chondrite normalized rare-earth plots. Of note in these analyses are the relatively enhanced amounts of thorium, uranium, calcium and silicon. The analyses compare favourably with the partial chemical determinations of Hecht and Kroupa (1936), and Meunch (1950). The former authors reported 14.42% ThO₂, 8.50% SiO₂, 1.30% PbO and 0.14% UO₂; the analysis of Meunch contains 17.79% ThO₂, 1.64% PbO and 0.33% UO₂.

The ideal composition of monazite is 34.99% Ce₂O₃, 34.74% La₂O₃ and 30.27% P₂O₅. In natural samples, the most frequent substitutions are Th⁴⁺ and Si⁴⁺ for Ce³⁺ and P⁵⁺, and Th⁴⁺ and Ca²⁺ for 2Ce³⁺, leading to the formulae of huttonite, ThSiO₄, and cheralite, ThCa(PO₄)₂. The analyses of the Huron Claim monazites suggest compositions ranging from Mo₇₂Hu₇Ch₂₁ to Mo₇₀Hu₈Ch₂₄; however, the low totals and probably low total REE's indicate that these molecular proportions are only approximate. The thorium contents in monazite vary from several wt.% to more than 30 wt.% ThO₂, and monazites with 4 to 9 wt.% ThO₂ are common (Frondel, 1958). Because thorium substitution is partly accommodated by the substitution of calcium (and magnesium), the silicon to thorium ratio in monazite is generally less than one. The thorium contents of monazites from individual occurrences are relatively constant (Frondel, 1958); the Huron Claim monazites contain from 14.4 to 17.8% ThO₂. Monazites containing as much as 6.0 wt.% SiO₂ and 1.0 wt.% UO₂ are reported by Frondel (1958).
To complement the analyses in Table 58, an additional set of rare-earth element analyses was obtained from Memorial University in St. John's, Newfoundland. This second set of analyses includes the original two samples, as well as three monazites selected by the author. The rare-earth element totals are only 50 to 80% of their expected values, indicating that the trace element XRF technique used during these analyses is not suitable for major constituents. Despite the low totals, the relative abundances of the individual rare-earth elements are thought to be reliable (Fryer, pers. comm.). A comparison of the analyses from the two laboratories (sample HC-UM-1) is given in Figure 43. The rare-earth element values from both sets of analyses have been normalized to the chondrite composite of Osborne et al. (1974); the resultant data is shown in Table 60, and Figures 44 to 47. The maxima at praseodymium shown by the Memorial data do not occur in the earlier analyses, suggesting that the calculated praseodymium values in the earlier analyses are too low.

The rare-earth element patterns in monazites are variable, and often characteristic of individual pegmatites or pegmatite districts (Heinrich et al., 1960). The light rare-earth elements (La to Gd) predominate, and the heavier rare-earth elements (Tb to Lu) are present only in subordinate amounts. In granitic pegmatites, the heavy rare-earth elements and yttrium often crystallize separately as xenotime. Negative europium anomalies are characteristic of the rare-earth element patterns in monazites, as europium prefers the divalent state and is readily incorporated into calcium minerals.

In a series of monazites analyzed by Murata et al. (1953), \((\text{La} + \text{Nd})\) was constant at 42±2%, \((\text{Ce} + \text{Sm} + \text{Gd} + \text{Y})\) was constant at 53±3%,
Table 59. Rare earth element and yttrium contents of five Huron Grain monazites.

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1. M17305-C  2. HC-UM(1)  3. HC-UM(2)  4. 77-P3-01(core)  5. 77-P3-01(rim)  6. HC-KOM

XRF analyses by B.J. Fryer, Memorial University (1981).
Figure 43. Sample HC-UM-1: A comparison of the rare earth element data from Memorial and Karlsruhe Universities.
Table 60. Chondrite-normalized rare earth element and yttrium contents of Huron Claim monazites.

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</table>

1. M17305-C  2. HC-UM(1)  3. HC-UM(2)  4. 77-P3-01(core)  5. 77-P3-01(rim)  
6. HC-ROM  7. HC-UM(1)  8. HC-ROM 
normalized to the chondrite composite of Osborne et al. (1974)
Figure 44. Rare earth element abundances in monazite HC-UM-1.
Figure 45. Rare earth element abundances in monazite HC-ROM.
Figure 46. Rare earth element abundances in monazite 77-P3-01.
Figure 47. Rare earth element abundances in monazite M17305-C.
and praseodymium was constant at 5±1%. These relative abundances are not characteristic of all monazites (Heinrich et al., 1960), and certainly do not apply to the monazites from the Huron Claim pegmatite. The rare-earth element contents of the Huron Claim monazites (normalized to 100% TR_2O_3) are listed in Table 61, along with five monazites from granitic pegmatites in the USSR. A comparison of these monazites shows the Huron Claim specimens to be depleted in lanthanum and cerium, and enriched in samarium and gadolinium with respect to the Russian monazites, which have more "typical" rare-earth contents. The rare-earth pattern in the Huron Claim monazites is Ce>Nd>Gd>Pr>La, although the exterior part of sample 77-P3-01 shows Ce>Sm>Nd>Gd>Pr>La. These patterns closely resemble those reported from the Brown Derby pegmatites in Colorado by Heinrich et al. (1960).

Chondrite normalized rare-earth element patterns for monazites from the Greer Lake and Shatford Lake pegmatite groups are shown in Figures 48 and 49, respectively. A comparison of Figures 44 through 49 shows clearly the lanthanum and cerium depletion, and samarium, gadolinium and terbium enrichment in the Huron Claim monazites with respect to the monazites from the two pegmatite groups. These differences are even more obvious in Figure 50, which shows the chondrite-normalized rare-earth concentrations as a percentage of the total normalized rare-earths, plus yttrium. The Greer Lake and Shatford Lake group monazites have "typical" rare-earth element patterns (although they also show lanthanum depletion), whereas the Huron Claim monazites are depleted in the light rare-earth elements and enriched in the intermediate rare-earths.

Monazite from granitic pegmatites is generally enriched in thorium and the intermediate rare-earth elements (Nd, Sm, Gd), compared to the
Table 61. Composition of rare earths (Σ TR₂O₃= 100%) in monazite.

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<tr>
<td>Y₂O₃</td>
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<td>6.9</td>
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</table>

Huron Claim monazites (Memorial analyses) 1. M17305-C 2. HC-UM-1 3. HC-UM-2 4. 77-P3-01(core) 5. 77-P3-01(rim) 6. HC-ROM. 7-11 pegmatite monazites, USSR (Vlasov, 1966).
Figure 48. Rare earth element abundances in monazites from the Greer Lake pegmatite group.
Figure 49. Rare earth element abundances in monazites from the Shatford Lake pegmatite group.
Figure 50. Rare earth element patterns of monazite from the Shatford Lake and Greer Lake pegmatite groups, and the Huron Claim pegmatite. The vertical axis shows the rare earth composition expressed as a ratio of the rare earth concentration in chondritic meteorites, normalized to 100% rare earths + yttrium.
monazite from average granites (Vlasov, 1966). At equal concentrations of neodymium, monazite from pegmatites will carry 7 to 10% Sm$_2$O$_3$ whereas monazite from average granites will contain only 3 to 5% Sm$_2$O$_3$. The Nd/Sm ratio in monazite from granitic pegmatites is approximately 2.5 (1.0 to 1.2 in the Huron Claim pegmatite), whereas the ratio in monazite from average granites is about 6.0. Similar fractionation trends are reported from individual pegmatites by Murata et al. (1958). In certain Brazilian pegmatites, the xenotime to monazite ratio was found to increase from the wall zone to the core, and the content of thorium and the heavy rare-earth elements in monazite increased in the same direction. The data indicates progressive enrichment of the heavy rare-earth elements and thorium in monazite during fractionation. The fractionation trends may also be applicable to individual pegmatite groups within pegmatite districts (Černý and Puchelt, 1976). The Huron Claim monazites, with their high thorium contents and relative enrichment in the intermediate rare-earths would seem to be more fractionated than other monazites from the Greer Lake and Shatford Lake pegmatite groups.

**ZIRCON**

In the Huron Claim pegmatite, zircon is present in relatively small amounts and is variable in appearance. Three morphological varieties of zircon can be distinguished. The first of these is an olive-green to light-brown zircon, occurring in clusters of small, well-formed crystals adjacent to columbite in vuggy albite (samples M17303-A and M17303-R). The zircons associated with niobian rutile and columbite are undoubtedly of this variety. Green zircon was also found
in sample 77-RE-08, associated with monazite in a quartz-filled fracture. The largest green zircon is 2 millimetres in cross-section. For analytical purposes, green zircons from M17303-A and M17303-R were included indiscriminately in the same polished mount. The grains are dark grey in reflected light and apparently homogeneous, with no inclusions or patches of alteration. A grain of pyrite is present on the margin of one of the zircon crystals.

The second variety of zircon consists of large, reddish-brown, composite grains which are associated with and easily mistaken for thorite. Zircons of this variety in samples P2-18 and 77-TH-SP are associated with plates of chloritized biotite in the medium to coarse-grained albite unit. In sample P3-38, the reddish-brown zircon occurs with columbite-tantalite in a fracture veinlet within the albite. The zircons occur as mottled, light-brown to dark reddish-brown grains which commonly show vicinal crystal faces. Flattened crystals as large as 9 x 4 millimetres and 7 x 7 millimetres were recovered from several hand specimens. In reflected light, these zircons are grey and reasonably homogeneous, although they do contain small (50 to 60 micron), irregular patches of a light grey phase. Infrequent blebs of pyrite, and patches of a dark grey phase are also present within the grains. The zircons are moderately fractured, and the fractures show some alteration along their margins. The fractures commonly contain grains of pyrite.

Dark reddish-black to jet black anhedral grains embedded in albite constitute the third variety of zircon in the Huron Claim pegmatite. These grains, which have a maximum diameter of 2 millimetres, are commonly associated with thorite (with which they are easily confused).
Zircons of this variety were found in specimens 77-ZR-01, 77-ZR-02 and GL-10-1c. They are indistinguishable in hand specimen, and show only minor variations in polished section. The grains in sample 77-ZR-02 are grey, optically homogeneous and dotted with small blebs of pyrite. Sample GL-10-1c (Plate 46) is similar, despite small differences in its chemistry.

The cell dimensions for eight Huron Claim zircons are shown in Table 62. Due to lack of material, it was not possible to obtain unit cell dimensions for the material used in microprobe analysis. With the exception of sample M17303-A, the zircons gave extremely poor to unrecognizable patterns in their natural state. Good XRD patterns were obtained after the zircons were heated in air for one hour at 1000°C. With the exception of sample GL-10-1c, the cell dimensions of the heated zircons plot along the trend line of Holland and Gottfried (1955) for increasing radiation damage in hafnium-poor zircons (Figure 51). The disposition of the samples along the trend line probably reflects varying degrees of crystal structure restoration among the individual samples. No subdivision on the basis of morphology is evident from the cell dimensions, although the uranium and thorium-richest samples tend to have the poorest quality patterns. Sample GL-10-1c is an anomaly in that the a cell dimension falls significantly below the range reported for natural and synthetic zircon (Speer, 1980). This sample is completely metamict in its natural state, and is particularly enriched in uranium and thorium.

Electron microprobe analyses of five Huron Claim zircons are shown in Tables 63 and 64. With the exception of analysis #8, the weight per
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VEUILLEZ ECRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUilleZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.
Plate 46. Zircon sample GL-10-1c in reflected light, showing small specks of pyrite. Width of photograph is about 2 millimetres across.
Table 62. Cell dimensions of zircon from the Huron Claim pegmatite.

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<td>a(Å)</td>
<td>6.600(1)</td>
<td>6.606(2)</td>
<td>6.601(2)</td>
<td>6.612(2)</td>
</tr>
<tr>
<td>c(Å)</td>
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<td>5.999(3)</td>
<td>5.988(3)</td>
<td>5.989(2)</td>
</tr>
<tr>
<td>V(Å³)</td>
<td>260.62</td>
<td>261.75</td>
<td>260.94</td>
<td>261.85</td>
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</table>

<table>
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<th>7</th>
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</tr>
</thead>
<tbody>
<tr>
<td>a(Å)</td>
<td>6.612(2)</td>
<td>6.601(2)</td>
<td>6.611(3)</td>
<td>6.560(3)</td>
</tr>
<tr>
<td>c(Å)</td>
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<td>5.984(4)</td>
<td>5.979(6)</td>
<td>5.975(6)</td>
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<tr>
<td>V(Å³)</td>
<td>262.69</td>
<td>260.73</td>
<td>261.34</td>
<td>260.25</td>
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1. 77-RE-08, green zircon occurring with monazite and uraninite in a quartz-filled fracture; 2. M17303-A, green zircon; 3. M17303-A, a mixture of red and green zircon associated with columbite-tantalite in vuggy albite; 4. P2-18, reddish zircon occurring with thorite and chloritized biotite; 5. P3-38, reddish-brown zircon occurring with columbite in fractures in albite; 6. 77-TH-SP, large red, recrystallized(?) zircon; 7. 77-2R-02, reddish-black anhedral grains of zircon occurring with thorite in albite; 8. GL-10-1c, discrete grains of anhedral black zircon in albite.

All samples were heated for one hour in air at 1000°C.
Figure 51. Cell dimensions of zircon from the Huron Claim pegmatite, heated for one hour in air at 1000°C. Trend line shows the effect of increasing radiation damage in Hf-poor zircon (Holland and Gottfried, 1955).
Table 63. Chemical composition of zircon from the Huron Clain pegmatite (11).

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| Zr/Hf(at.) | 26.64 | 16.45 | 14.72 | 23.13 | 12.89 | 12.79 |
| Si/(Zr+Hf)at. | 1.09 | 1.06 | 1.00 | 1.06 | 0.96 | 0.95 |
| 100 Hf/(Zr+Hf)at. | 3.90 | 5.73 | 6.36 | 4.15 | 7.20 | 7.25 |

10. MI7303-A/R 11. 77-TH-SP, large red zircon 12. 77-TH-SP
Analyses 8,9 and 10 by C.W. Robinson, Queen’s University (1976).
Unit cell contents on the basis of 16 oxygen anions.
### Table 64. Chemical composition of zircon from the Huren Claim pegmatite (1).

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</tbody>
</table>

**Note:**
- 87.66 90.13 86.67 79.13 79.02 93.29
- 4.90 4.00 3.86 3.73 3.67 3.91
- Zr 3.43 3.62 3.54 3.05 3.62
- 3.62

### Chemical Analyses

1. 77-ZK-02, reddish-black zircon 2. 77-ZK-02 3. GL-10-lc, black zircon 4. GL-10-lc 5. GL-10-1c 6. 77-TH-05, large red zircon.

Analyses 1, 2, 3 and 6 by R. Chapman (1984).
Analyses 4 and 5 by G.W. Robinson, Queen's University, (1976).
Unit cell contents on the basis of 16 oxygen anions.
cent oxide totals are low and the "unit cell" contents high. These results reflect the partial to complete metamictization of the zircons and their presumed hydration. Analyses of the pale green zircon, M17303-A/R, show reasonably high totals and acceptable stoichiometry. Analysis #7 is apparently from the same polished section, but contains considerable amounts of uranium and thorium and has much lower totals, indicating compositional differences between grains in this particular sample.

Sample GL-10-1c is the most difficult to interpret. Analysis #3 was collected from this specimen and shows enhanced amounts of uranium and thorium, as well as relatively low totals. Analyses #4 and #5 are from the same phase, and they show exceedingly high contents of U and Th as well as the lowest totals in the entire set of analyses. The U and Th contents in these two analyses (12% UO₂ and 5.75% ThO₂) are much higher than the maximum contents reported in the literature (Speer, 1980), and they must represent X-ray amorphous mixtures of various oxides.

A crude subdivision of the various zircon varieties seems possible on the basis of their uranium and thorium contents. Although the data base is not large, there is a progressive increase in the actinide-element content from the pale green zircons through the reddish-brown variety, to the reddish-black and black zircons (Tables 63 and 64). However, there is considerable overlap between the three varieties. Yttrium is a frequent constituent of the Huron Claim zircons. The Hf/Hf + Zr ratios in the three varieties of zircon show no discernable trends, and this ratio may well have been affected during the metamictization process (Černý and Siivola, 1980).
A complete solid solution series exists between ZrSiO$_4$ and HfSiO$_4$, and zirconian hafnons with bulk compositions containing 78 mol % hafnon have been described from Mozambique (Correia Neves et al., 1974). The highest mol % hafnon in the Huron Claim zircons is 7.25% in sample 77-TH-SP. Similar hafnon contents (3.5 to 8.0 mol %) are reported for zircons from the Greer Lake and Shatford Lake pegmatite groups (Černý et al., 1981b). The Hf/(Hf + Zr) ratio in zircons increases along with the other fractionation indicators in granitic pegmatites (Černý and Siivola, 1980). Increases in the Hf/(Hf + Zr) ratios in zircon with concomitant increases in the Ta/(Ta + Nb) ratios of co-existing Nb-Ta oxide minerals have been reported by Fontan et al. (1980).

Yttrium and the rare-earth elements can occur in zircon in amounts up to 25 wt.% R$_2$O$_3$ + Y$_2$O$_3$ (Medenbach, 1976). High rare-earth contents are usually accompanied by high phosphorus contents, although the rare-earth substitution can also be charge balanced by the addition of calcium, iron, aluminum and sulphur. Zircon is isostructural with xenotime, and the highest yttrium plus phosphorus contents in zircon amount to about 25% YPO$_4$ (Medenbach, 1976). Yttrium is present in the Huron Claim zircons in amounts up to 1.65 wt.% Y$_2$O$_3$, but phosphorus was not detected in the microprobe analyses (R. Chapman, pers. comm.).

The maximum uranium and thorium contents in zircon, determined by microprobe analysis, are 5.06% UO$_2$ and 3.68% ThO$_2$ (Medenbach, 1976). Natural zircons co-existing with uranium and thorium silicates and oxides are assumed to have incorporated maximum amounts of uranium and thorium (Speer, 1980). The relatively small quantities of U and Th in the zircon structure are indicative of wide miscibility gaps along the ZrSiO$_4$ - USiO$_4$ and ZrSiO$_4$ - ThSiO$_4$ joins (Speer, 1980). In most
zircons, the Th/U ratio is less than one. Excluding the U and Th-rich phases in sample GL-10-1c, the highest uranium and thorium contents in the Huron Claim zircons are 2.60\% UO\textsubscript{2} and 0.21\% ThO\textsubscript{2}, in sample 77-ZR-02.

**THORITE**

Thorite is a rare accessory mineral in the Huron Claim pegmatite. It was identified in one hand specimen from the vicinity of Pit #3, in several hand specimens from the dump south of Pit #2, and occurs in-situ in a flat-lying outcrop near the southwest extremity of the pegmatite. In each case, the thorite is found embedded in medium to coarse-grained albite. The P2 and 77-TH series samples are characterized by large sheets of chloritized biotite with which a number of the thorite grains seem to be intergrown. Other prominent associated minerals are beryl and zircon. In sample 77-ZR-02, the thorite grains appear embedded in albite in close association with beryl. Thorite is among the earliest minerals to form in many granitic pegmatites (Frodel, 1958), and the Huron Claim material, it seems, is no exception. Thorite is closely associated with the early-formed accessories beryl and biotite, and occurs in-situ in the medium to coarse-grained albite zone within half a metre of the lower contact. The maximum grain size of the thorites remaining in the University of Manitoba collection is 4.5 millimetres, although slightly larger grains have been observed in the field. The colour of the thorite grains, which are anhedral and vitreous, varies from black to dark reddish-brown. Most of the grains are surrounded by halos of discoloured reddish-brown albite.
In polished section, the thorite grains are variable in appearance. Samples of the black, vitreous thorite (GL-10-1b and 77-ZR-02) are dark grey and relatively homogeneous in reflected light, although both samples contain small patches or inclusions of a lighter-coloured phase (thorogummite?). The grains are well fractured and the edges of the fractures, as well as the grain margins, are somewhat altered. Specks of pyrite, on the order of 10 to 20 microns in size, are scattered throughout the grains. Large aggregate grains of pyrite occur peripheral to the thorite grains, suggesting some mobilization of sulphur during metamictization of the thorite. Sample P2-1, a reddish-brown thorite, is different from the preceding samples in that it is visibly more altered. "Ice-cake" textures are developed in this specimen, whereby remnant islands of thorite are enveloped by what seems to be an admixture of thorogummite and several other phases (Plate 47). The "grain" size of the islands varies from 1.5 to 10.1 millimetres, and they have inclusions of a lighter-coloured phase similar to the more homogeneous samples.

Because they were found to be partially to completely metamict, the three Huron Claim were heated in air for three hours at 1000°C to restore their crystallinity. Samples GL-10-1b and 77-TH-03 gave extremely poor X-ray powder patterns in their natural state, but a reasonably good pattern was obtained from sample 77-TH-04. After heating, good patterns were obtained from samples GL-10-1b and 77-TH-04, and a moderately well-developed pattern was obtained from sample 77-TH-03. The resulting patterns were readily identified as thorite; no attempt was made to identify additional phases that might have developed during heating. Metamict thorites generally
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Veuillez écrire à l'auteur pour les renseignements ou veuillez consulter l'exemplaire dont possède le Département des Archives et des Collections Spéciales, Bibliothèque Elizabeth Dafoe, Université du Manitoba, Winnipeg, Manitoba, Canada, R3T 2N2.
Plate 47. "Ice-cake" texture in thorite. The interstitial material is unidentified, but may be an admixture of thorogummite and another phase (P2-1).

Table 65. Unit cell dimensions of thorite.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>a (Å)</td>
<td>7.074(2)</td>
<td>7.09(1)</td>
<td>7.075(7)</td>
<td>7.12(3)</td>
<td>7.1328(2)</td>
</tr>
<tr>
<td>c (Å)</td>
<td>6.258(2)</td>
<td>6.29(2)</td>
<td>6.26(1)</td>
<td>6.32(3)</td>
<td>6.3188(2)</td>
</tr>
<tr>
<td>V (Å³)</td>
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<td>316.9</td>
<td>313.6</td>
<td>320.4</td>
<td>321.5</td>
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<td>1:0.887</td>
<td>1:0.885</td>
<td>1:0.888</td>
<td>1:0.886</td>
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</tbody>
</table>

1. GL-10-1b, black thorite, Huron Claim.
2. 77-TH-03, reddish-brown thorite, Huron Claim.
3. 77-TH-04, reddish-brown thorite, Huron Claim.
4. uranothorite, New Zealand, Pabst (1951).
recrystallize after heating to mixtures of thorite and huttonite (monoclinic $\text{ThSiO}_4$), or mixtures of these two phases plus $(\text{U,Th})\text{O}_2$ (Lima de Faria, 1964). Above 1400°C, huttonite is the predominant phase (Frondel, 1958). The products produced during heating depend on the degree of metamictization in the original material, as well as the heating temperature, treatment length and atmosphere.

Unit cell dimensions of three Huron Claim thorites are presented in Table 65. The unit cells of the Huron Claim samples are smaller than the examples quoted for comparison, both of which represent unheated material. Electron microprobe analyses of three Huron Claim thorites are given in Tables 66 and 67. The low totals in these analyses, approximately 80 wt.%, are caused by a number of factors. Foremost of these is the metamictization of the thorites, which is commonly followed by strong hydration and (partial) leaching of some components. The rare-earth element contents vary considerably, and these elements were not routinely analyzed. Uranium and iron are reported as $\text{UO}_2$ and $\text{FeO}$ respectively, when in fact both of these elements may be highly oxidized (Frondel, 1958). Lead is present in significant amounts in the Huron Claim thorites, but is concentrated in the altered portions of the grains which were avoided during microbeam analysis (R. Chapman, pers. comm.).

Considering the inhomogeneity of the thorite grains, the analyses from the University of Manitoba and Queen's University, Kingston, are in reasonable agreement. Manganese is generally absent in the Manitoba analyses, and there is considerable variation in the $R_2O_3$ contents between the two sets of analyses. The Huron Claim thorites have high phosphorus contents (3.27 to 6.71 wt.%), and sample GL-10-1b is notable for its high content of $\text{UO}_2$ (17.71 to 23.12 wt.%).
### Table 66. Electron microprobe analyses and unit cell contents of thorite (1)

<table>
<thead>
<tr>
<th></th>
<th>P2-1(1)</th>
<th>P2-1(2)</th>
<th>P2-3(3)</th>
<th>GL-10-1b</th>
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<th>P2-1(2)</th>
<th>P2-1(3)</th>
<th>GL-10-1b</th>
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<th>P2-1(2)</th>
<th>P2-1(3)</th>
<th>GL-10-1b</th>
</tr>
</thead>
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<td>.62</td>
<td>.63</td>
<td>.85</td>
<td>.76</td>
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</tr>
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<td>-</td>
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<td>-</td>
<td>-</td>
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<tr>
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<td>.05</td>
<td>.09</td>
<td>Nd .08</td>
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<td>.09</td>
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<td>2.31</td>
<td>Sm .14</td>
<td>.08</td>
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<td>.08</td>
<td>Sm .14</td>
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<tr>
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<td>.08</td>
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<td>.18</td>
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<td>.17</td>
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<td>Zr₂O₃</td>
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<td>.09</td>
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<td>Y .52</td>
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<td></td>
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<td>.10</td>
<td>4.22</td>
<td>6.21</td>
<td>3.03</td>
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</table>

**Cation charge:**
- P₂-1(1)¹: +32.01, +31.96, +31.99, +31.98
- P₂-1(2)¹: +32.78, +29.67, +34.63, +30.51

2. Electron microprobe analyses by G.W. Robinson, Queen's University (1976): Pb, U and Ta detected on X-ray spectra.

P2-1(1)¹' etc. cations on the basis of 32 oxygen anions.
P2-1(3)" etc. unit cell contents normalized to 4.00(Si+P).
Table 67: Electron Microprobe analyses and unit cell contents of thorite (11).

<table>
<thead>
<tr>
<th>GL-10-1b(2)</th>
<th>GL-10-1b(3)</th>
<th>77-2R-02</th>
<th>GL-10-1b(2)</th>
<th>GL-10-1b(3)</th>
<th>77-2R-02</th>
<th>GL-10-1b(2)</th>
<th>GL-10-1b(3)</th>
<th>77-2R-02</th>
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<tbody>
<tr>
<td>SiO₂</td>
<td>0.14</td>
<td>0.16</td>
<td>SiO₂</td>
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<td>SiO₂</td>
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<td>Y₂O₃</td>
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<td>Cation charge</td>
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<td>+28.77</td>
<td>Cation charge</td>
<td>+29.95</td>
<td>+30.43</td>
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</table>


GL-10-1b(2) etc. cations on the basis of 32 oxygen anions.
GL-10-1b(3) etc. unit cell contents normalized to 4.00 (Si+P).
Considering the highly metamict state of the thorites, formula calculations cannot be expected to yield stoichiometric results. This is confirmed by the atomic contents based on 32 oxygens (Tables 66 and 67). Normalization of the unit cell contents to 4.00 (Si + P) does not improve the variable A cation totals. However, both recalculations show at least an approximation to the crystal chemistry of the original thorites.

For all thorites, the predominant chemical substitutions are uranium and the rare-earth elements for thorium. There is some substitution of calcium, magnesium, ferrous iron, ferric iron and aluminum for thorium, and phosphorus replaces silicon to some extent. Calcium is usually present in amounts ranging from 1 to 2 wt.% CaO, iron is present in amounts ranging from 1 to 8 wt.% combined oxides, lead occurs in amounts less than 2 wt.% PbO and zirconium occurs infrequently in amounts up to 2 wt.% ZrO₂ (Frondel, 1958). In natural thorites, there seems to be limited substitution of zirconium for thorium, and uranium substitution predominates. Uranoan thorites can contain up to 20 wt.% UO₂ (Robinson and Abbey, 1957), but this much uranium is unusual. The rare-earth elements consist mainly of cerium, and are usually present in amounts up to several wt.% R₂O₃ (Frondel, 1958). A problem with establishing chemical substitution limits in thorite is that a large percentage of the existing analyses are of relatively poor quality.

Of the two ThSiO₄ polymorphs, thorite is generally considered to be the low temperature phase (Taylor and Ewing, 1978). With increasing temperature, the low-density and high-symmetry tetragonal phase, thorite, is converted to the high-density and low-symmetry monoclinic
phase, huttonite. The main difference between the two polymorphs is the presence in the thorite structure of void spaces interconnected parallel to the c-axis. The resulting channels presumably act as conduits for the diffusion of water into the structure, and hydration may thus play a major role in the metamictization process (Taylor and Ewing, 1978).

Metamictization with accompanying oxidation of uranium and iron is the first stage of thorite alteration. In the second stage, thorogummite is developed along the grain margins and cross-cutting fractures, or forms complete pseudomorphs. Thorogummite is isostructural with thorite, as various amounts of (OH)\(_4\) substitute for SiO\(_4\). It forms at relatively low temperatures and is usually fine-grained (Frondel, 1958). Many natural thorites contain admixed thorogummite. Thorite analyses frequently show a deficiency silicon relative to the other cations, suggesting leaching during alteration or replacement of SiO\(_4\) by (OH)\(_4\). The interstitial material in sample P2-1 from the Huron Claim contains more than 31 wt.% SiO\(_2\), suggesting an admixture of thorogummite and some other phase(s).

Thorite occurs in granitic pegmatites as a primary mineral in association with zircon, titanite, monazite, xenotime, allanite and a variety of Nb-Ta oxide minerals. It is particularly common in gadolinite-bearing, blocky microcline-biotite pegmatites (Beus, 1966). In the Winnipeg River pegmatite district, the only other occurrence of thorite is in the TANCO pegmatite, where it is present as rare microscopic inclusions in zircon.
TITANITE

Titanite is a reasonably rare mineral in the Huron Claim pegmatite. First described by Černý and Bristol (1972), it has been physically separated from only a single hand specimen (PC-16). The titanite in sample PC-16 is niobium-rich, and co-exists with granular albite and minor quartz (Paul et al., 1981). Titanite is somewhat more abundant as small euhedral crystals accompanying the late hydrothermal mineral assemblage, but this variety of titanite has been observed only in thin section (Plate 48). Titanite replacing ilmenite occurs in chlorite-calcite veinlets in the exomorphic zone of the pegmatite.

The niobian titanite occurs as dark brown crystals, one to three millimetres in length, which are poorly formed, but which exhibit the "letter-envelope" habit typical of the species. The crystals are skeletal and are commonly intergrown with albite. (Nb-Ta)-bearing minerals, which are abundant elsewhere in the pegmatite, are not associated with the titanite, nor are any of the related mineral species (monazite, zircon, uraniumite and thorite). In thin section, the crystals are pale brown, sometimes exhibiting darker concentric zones that are faintly pleochroic. The high indices of refraction (>1.8), birefringence and optical orientation (optic axial plane || 010, 2V intermediate) correspond qualitatively to those of ordinary titanite. The density of the titanite was determined as 3.55 g/cm³. Good diffraction patterns and a satisfactory unit cell refinement were obtained from the titanite, with the α value falling slightly below that given by Higgins and Ribbe (1976). After heating in air at 800°C for 3 hours, as described by Černý and Povondra (1972), slight shifts in b and α were the only statistically significant changes. The physical properties of titanite PC-16 are summarized in Table 68.
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Plate 48. Skeletal crystal of titanite intergrown with epidote (high relief) and clays (yellow). Sample SW-17. Photograph is about 3 mm across.

Table 48. Physical properties of niobian titanite from the Huron Claim pegmatite.

<table>
<thead>
<tr>
<th></th>
<th>natural</th>
<th>heated</th>
</tr>
</thead>
<tbody>
<tr>
<td>a(Å)</td>
<td>7.047(2)</td>
<td>7.045(2)</td>
</tr>
<tr>
<td>b(Å)</td>
<td>8.665(4)</td>
<td>8.693(5)</td>
</tr>
<tr>
<td>c(Å)</td>
<td>6.545(2)</td>
<td>6.556(4)</td>
</tr>
<tr>
<td>β</td>
<td>113.63(3)</td>
<td>114.02(5)</td>
</tr>
<tr>
<td>V(Å³)</td>
<td>336.1(2)</td>
<td>336.8(2)</td>
</tr>
<tr>
<td>D(22°C)</td>
<td>3.55g/cm³</td>
<td></td>
</tr>
</tbody>
</table>
Titanite also occurs as a replacement of ilmenite in diamond drill hole #5. Due to its small size, this titanite was examined by microprobe analysis only.

Table 69 gives the results of electron and ion microprobe analyses of the two Huron Claim titanites, as well as a tantalian titanite from Craveggia, Italy (Clark, 1974). The high Nb₂O₅ content of titanite PC-16 is the highest recorded for the species, and the combined Nb-Ta pentoxides are second only to the Craveggia titanite. The alumina content in both the Craveggia titanite and titanite PC-16 is also very high.

In a review paper by Higgins and Ribbe (1976), the authors examined a collection of precisely analyzed titanites and came to the conclusion that most of the cationic substitutions were in the octahedral sites, with the tetrahedral positions populated exclusively with silicon. The substitutions Ca ↔ REE and Ti ↔ (Al, Fe) were the only appreciable ones among their samples, and normalization of the atomic formulae to 1.00 Si gave good overall site populations and charge balances. The titanite from the exomorphic zone of the Huron Claim pegmatite (DDH-#5) is very much a "normal" titanite; however, normalization of the Nb- and Ta-enriched titanites to stoichiometric Si results in excess cations in the Ca and Ti sites, as well as cationic charges in excess of +40.00 (Table 69, columns 1' and 3'). The excess is particularly high for the octahedral cations and beyond the limits of possible analytical error.

Normalization of the titanites to eight octahedral and tetrahedral cations gives formulae with reasonable site populations and charge balances (Table 69, columns 1" and 3"). The formulae require slight to
Table 69. Chemical composition of Huron Claim and Craveggia titanites.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1'</th>
<th>2'</th>
<th>3'</th>
<th>1''</th>
<th>2''</th>
<th>3''</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>29.0</td>
<td>30.8</td>
<td>26.9</td>
<td>Si</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>Si</td>
<td>3.92</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>4.7</td>
<td>2.2</td>
<td>5.1</td>
<td>Al</td>
<td>0.76</td>
<td>0.34</td>
<td>0.90</td>
<td>Al</td>
<td>0.08</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>Fe³⁺</td>
<td>0.05</td>
<td>0.05</td>
<td>0.11</td>
<td>(IV)</td>
<td>4.00</td>
</tr>
<tr>
<td>TiO₂</td>
<td>26.5</td>
<td>37.2</td>
<td>22.2</td>
<td>Ti</td>
<td>2.74</td>
<td>3.64</td>
<td>2.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SnO</td>
<td>0.9</td>
<td>0.05</td>
<td>0.1</td>
<td>Sn</td>
<td>0.05</td>
<td>-</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nb₂O₅</td>
<td>6.5</td>
<td>0.2</td>
<td>2.9</td>
<td>Nb</td>
<td>0.41</td>
<td>0.01</td>
<td>0.19</td>
<td>Al³⁺</td>
<td>0.67</td>
</tr>
<tr>
<td>Ta₂O₅</td>
<td>3.7</td>
<td>0.04</td>
<td>16.0</td>
<td>Ta</td>
<td>0.14</td>
<td>-</td>
<td>0.65</td>
<td>Fe³⁺</td>
<td>0.05</td>
</tr>
<tr>
<td>CaO</td>
<td>27.3</td>
<td>29.1</td>
<td>25.6</td>
<td>Ca</td>
<td>4.15</td>
<td>4.04</td>
<td>4.34</td>
<td>Ti</td>
<td>2.69</td>
</tr>
<tr>
<td>MnO</td>
<td>-</td>
<td>0.03</td>
<td>0.05</td>
<td>Mn</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
<td>Sn</td>
<td>0.05</td>
</tr>
<tr>
<td>Na₂O</td>
<td>-</td>
<td>0.06</td>
<td>0.3</td>
<td>Na</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
<td>Nb</td>
<td>0.40</td>
</tr>
<tr>
<td>F₂</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
<td>Na</td>
<td>-</td>
<td>0.02</td>
<td>0.08</td>
<td>Ta</td>
<td>0.16</td>
</tr>
<tr>
<td>99.9</td>
<td>100.2</td>
<td>100.1</td>
<td>Ca</td>
<td>3.95</td>
<td>4.02</td>
<td>3.91</td>
<td>(V)</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>0 = F₂</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>Mn</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>99.6</td>
<td>100.2</td>
<td>100.1</td>
<td>Na</td>
<td>-</td>
<td>-</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cation charge</td>
<td>40.40</td>
<td>39.88</td>
<td>41.43</td>
<td></td>
<td></td>
<td></td>
<td>(F,OH)</td>
<td>0.35</td>
<td>0.32</td>
</tr>
<tr>
<td>0</td>
<td>19.65</td>
<td>19.65</td>
<td>19.72</td>
<td></td>
<td></td>
<td></td>
<td>(0,OH,F)</td>
<td>20.00</td>
<td>20.00</td>
</tr>
</tbody>
</table>

1. Niobian titanite, Huron Claim (FC-16): electron microprobe analysis by R. Chapman, 1980; ion microprobe analysis of F2 by J.R. Hinthorne, 1981. Mg, Mn, V, P, K and Na detected on ion microprobe in the range 50-1000 ppm; Li, B, Cr (less than 1 ppm), Be, Zr (less than 10 ppm) and Ce, La, Pr, Cl (less than 50 ppm) were not detected - detection limits estimated.


(1,2,3)' Unit cell contents normalized to 4.00 Si.

(1,2,3)" Unit cell contents normalized to 8.00 (AIV+AlIV); anions adjusted to fit cation charge.
moderate tetrahedral substitution of Al for Si. This substitution is
absent in Nb-Ta poor titanites, and possibly takes place in tetrahedra
linked to Nb-Ta populated octahedra in order to satisfy the bond-
valency requirements of the local oxygens. This hypothesis is
supported by the rough correlation between the (Nb, Ta)$^{VI}$ and Al$^{IV}$
contents.

The anionic part of the unit cell contents shown in Table 69 is an
approximation. It is fortuitous that the analyzed F$_2$ alone fits the
charge balance of titanite PC-16. The lack of data for H$_2$, Na and REE,
and the low Ca-site totals in the Huron Claim and Craveggia titanites
suggest that the cation and (0, OH, F) contents need additional
refinement. No information is provided on the F$_2$ and H$_2$ contents of
the Craveggia titanite, but the sum of cationic charges suggests that
(F, OH) substitution at the 0(5) position is likely. Despite the
uncertainties, it is obvious that 35% of the Ti sites in titanite
PC-16 and 40% of the Ti sites in the Craveggia specimen are occupied by
Nb, Ta, Al, Fe and Sn.

Four mechanisms seem to be responsible for cationic substitution
in the Ti site:

\[
\begin{align*}
\text{VI} \text{Ti}^{4+} & \leftrightarrow \text{VI} \text{Sn}^{4+} \\
\text{VI}2\text{Ti}^{4+} & \leftrightarrow \text{VI}(\text{Nb, Ta})^{5+} + \text{VI}(\text{Al, Fe})^{3+} \\
\text{VI} \text{Ti}^{4+} + \text{IV} \text{Si}^{4+} & \leftrightarrow \text{VI}(\text{Nb, Ta})^{5+} + \text{IV} \text{Al}^{3+} \\
\text{VI} \text{Ti}^{4+} + 0^{2-} & \leftrightarrow \text{VI}(\text{Al, Fe})^{3+} + (\text{F, OH})^{-}
\end{align*}
\]

The second substitution is by far the most important, compensating in-
ternally for most of the charge imbalance produced by the heterovalent
substitution for Ti$^{4+}$. 
Expanding the Higgins and Ribbe (1976) formula for the calculation of effective octahedral cation radius (EOCR) in titanite to accommodate Nb, Ta and Sn gives EOCR = 0.605 - (0.075 Al/Si) + (0.04 Fe³⁺/Si) + (0.035 Ta/Si) + (0.085 Sn/Si), and a value of 0.597 Å for titanite PC-16. A reasonable comparison with the regression lines of Higgins and Ribbe (1976) should be possible, as the amount of tetrahedral substitution is limited. As shown in Figure 52, however, only the \( b \) dimension falls within the predicted range. The \( a \) dimension is lower and the \( c \) dimension higher than the predicted values.

**MAGNETITE**

Magnetite from the Huron Claim pegmatite was first described by Bristol (1962). With the exception of an unspecified dyke in the Booster Lake area (Davies, 1956) and two other pegmatites in the Shatford Lake group, the Huron Claim is the only pegmatite in the Cat Lake-Winnipeg River district from which the mineral has been reported. No specimens were recovered during the course of the present study.

The original sample, 2026, consists of massive black magnetite in association with quartz and uranophane-sklodowskite. The chemical composition and unit cell dimensions of the Huron Claim magnetite are presented in Table 70. Examination of sample 2026 in polished thin section resulted in the discovery of euhedral coffinite inclusions, rimmed by hematite, within the magnetite (Plate 49). Similar textures are reported from pegmatites in the Kenora-Dryden area of Ontario by Ruzicka (1979); however, the included phase is uraninite rather than coffinite.
Figure 52. Variation of the effective octahedral cation radius (EOCR) in titanite with the a, b and c cell edges (after Higgins and Ribbe, 1976).
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Plate 49. Euhedral inclusions of coffinite, rimmed by hematite, in magnetite (2026).

Table 70. Chemical composition and the $a$ unit cell dimension of magnetite.

<table>
<thead>
<tr>
<th></th>
<th>FeO, wt.%</th>
<th>Fe$^{+2}$</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn</td>
<td>0.08</td>
<td>Mn</td>
<td>-</td>
</tr>
<tr>
<td>MgO</td>
<td>-</td>
<td>Mg</td>
<td>-</td>
</tr>
<tr>
<td>Fe$_2$O$_3$</td>
<td>69.07</td>
<td>Fe$^{+3}$</td>
<td>2.00</td>
</tr>
<tr>
<td>V$_2$O$_3$</td>
<td>0.02</td>
<td>V</td>
<td>-</td>
</tr>
<tr>
<td>Cr$_2$O$_3$</td>
<td>-</td>
<td>Cr</td>
<td>-</td>
</tr>
</tbody>
</table>

$100.24$

Electron microprobe analysis by F.C. Hawthorne, 1980. Analysis recalculated from total Fe=FeO.

$\alpha = 8.390(2) \, \AA$
The occurrence of coffinite, uranophane-skloodowskite and magnetite within a single hand specimen would seem to cast some doubt on the provenance of the sample (Černý et al., 1981b). On the other hand, magnetite is a frequent accessory mineral in the gadolinite-bearing, blocky microcline-biotite pegmatites to which the Huron Claim is most closely related (Beus, 1966). Its occurrence in the pegmatite might well be expected.

**ILMENITE**

Ilmenite is not found in the Huron Claim pegmatite proper. It occurs only in diamond drill hole #5, which was collared to the south-east of the Huron Claim and did not intersect the pegmatite. Black, bladed crystals of ilmenite up to 15 mm long and 1.5 mm wide occur in narrow veinlets in association with black, flaky chlorite and white calcite. A similar occurrence has been noted from the Silverleaf pegmatite (Goad, 1984), where ilmenite is found in a chlorite-calcite-albite veinlet beneath the main pegmatite. The chlorite-calcite association, the general proximity of the veinlets to the Huron Claim pegmatite, and the trace amounts of Nb and Ta in the ilmenite suggest strongly that the ilmenite is related to the main pegmatite intrusion.

Analyses of the Huron Claim ilmenite, and three additional ilmenites from granitic pegmatites are given in Table 72. All except the TANCO ilmenite have low MnO contents. Unit cell dimensions for the Huron Claim ilmenite are listed in Table 71.

The ilmenite is replaced along grain boundaries by titanite, which also contains trace amounts of Nb and Ta (Plate 50). The rare-element content of the titanite, however, is much lower than that of the
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Plate 50. Titanite replacing ilmenite along the grain margins (DDH #5).

Table 72. Unit cell dimensions of the Huron Claim ilmenite.

\[
\begin{align*}
a_o &= 5.087(2) \text{ Å} \\
c_o &= 14.085(7) \text{ Å} \\
V &= 315.6(2) \text{ Å}^3
\end{align*}
\]
Table 71. Chemical composition of ilmenites from the Cat Lake-Winnipeg River and Wekusko Lake pegmatite fields, Manitoba.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>1'</th>
<th>2'</th>
<th>3'</th>
<th>4'</th>
</tr>
</thead>
<tbody>
<tr>
<td>FeO, wt.%</td>
<td>44.93</td>
<td>46.13</td>
<td>36.0</td>
<td>45.80</td>
<td>Fe⁺²</td>
<td>1.91</td>
<td>1.97</td>
<td>1.57</td>
</tr>
<tr>
<td>MnO</td>
<td>2.13</td>
<td>1.41</td>
<td>9.1</td>
<td>1.46</td>
<td>Mn</td>
<td>0.09</td>
<td>0.06</td>
<td>0.40</td>
</tr>
<tr>
<td>MgO</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
<td>0.01</td>
<td>Mg</td>
<td>-</td>
<td>-</td>
<td>0.04</td>
</tr>
<tr>
<td>CaO</td>
<td>0.03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Ca</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TiO₂</td>
<td>52.02</td>
<td>51.80</td>
<td>51.0</td>
<td>51.90</td>
<td>Ti</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.11</td>
<td>0.01</td>
<td>-</td>
<td>0.03</td>
<td>Al</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SiO₂</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Si</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nb₂O₅</td>
<td>0.03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Nb</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ta₂O₅</td>
<td>0.08</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Ta</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cr₂O₃</td>
<td>-</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
<td>Cr</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>99.40</td>
<td>99.40</td>
<td>96.6</td>
<td>99.21</td>
<td></td>
<td>+11.99</td>
<td>+12.02</td>
<td>+12.02</td>
</tr>
</tbody>
</table>

1. Ilmenite, Huron Claim pegmatite (DDH 5): electron microprobe analysis of 1, 2 and 4 by F.C. Hawthorne, 1980.
2. Ilmenite, Silverleaf pegmatite.
4. Ilmenite, Dion Creek, Wekusko Lake pegmatite field.
titanite occurring in the main body of the pegmatite. Ilmenite is rarely replaced by titanite, the more usual alteration products being rutile, hematite, "leucoxene" and hydrated Fe-oxides (Foord, 1982).

Ilmenite occurs in small amounts, but is a relatively widespread accessory mineral in granitic pegmatites (Foord, 1982). It occurs in the early crystallized zones, as well as in the late metasomatic zones of complex pegmatites, as in the TANCO pegmatite. Pegmatitic ilmenites commonly contain up to 10% MnO, as well as appreciable contents of Nb and Ta. Ilmenite is a highly characteristic accessory mineral of gadolinite-bearing, blocky microcline-biotite pegmatites (Beus, 1966). In the pegmatite dykes of the Dolni Bory, Czechoslovakia, ilmenite is a late metasomatic mineral occurring along cracks in K-feldspar (Staněk and Štecl, 1954). In the Baringer Hill pegmatite in central Texas, considerable quantities of ilmenite were reported in the albite replacement zone (Landes, 1932). The Huron Claim ilmenite, because of its occurrence in a chlorite-calcite veinlet in the examorphic zone of the pegmatite, may have formed during the late Ca-metasomatic event which affected much of the pegmatite.

TOPAZ

Topaz from the Huron Claim pegmatite is described by Walker (1931). The mineral "occurs in large masses sometimes half a pound in weight. It is greyish to aquamarine...and shows continuous cleavage surfaces an inch or more in area. It seems to have been one of the later minerals to form". A single specimen (M17309) in the Royal Ontario Museum collection is labelled as topaz. This specimen has been
completely pseudomorphed by coarse mica, but does retain the prismatic morphology typical of topaz. Topaz is a widespread and characteristic accessory mineral in the Shatford Lake pegmatite group (Černý et al., 1981b), and its occurrence in the Huron Claim pegmatite should not be surprising. In the opinion of the present author, the occurrence of topaz in the Huron Claim pegmatite is well established, despite the fact that it has not been found or reported since the initial description.

**APATITE**

Apatite is a rare mineral in the Huron Claim pegmatite, having been identified in only a single hand specimen (77-B3-04). The hand specimen comes from a small beryl-rich dump south of Pit #3. A small radiating group of columnar, greyish-white apatite crystals (showing moderately well-developed basal cleavage) occurs on the surface of a vuggy block of albitized K-feldspar (Plate 51). The largest crystal is 35 mm in length and 4 mm in cross-section. Associated minerals are platy black chlorite (after biotite) and quartz. Although no systematic search was undertaken, apatite may be slightly more widespread in the pegmatite on a microscopic scale; it was observed in minute quantities in a number of thin sections.

The physical properties of the Huron Claim apatite are shown in Table 73. Both the unit cell dimensions and the $n_W$ value suggest a composition in the fluorine-rich part of the apatite field. The apatite was not microprobed, nor did it yield enough material for standard wet chemical analysis.
Plate 51. Apatite crystals on albitized K-feldspar (77-B3-04).

Table 73. Physical properties of the Huron Claim apatite.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>a(Å)</th>
<th>c(Å)</th>
<th>c/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorapatite</td>
<td>9.37</td>
<td>6.88</td>
<td>0.734</td>
</tr>
<tr>
<td>Chlorapatite</td>
<td>9.64</td>
<td>6.78</td>
<td>0.703</td>
</tr>
<tr>
<td>Hydroxyapatite</td>
<td>9.42</td>
<td>6.88</td>
<td>0.730</td>
</tr>
<tr>
<td>Dahllite</td>
<td>9.45</td>
<td>6.90</td>
<td>-</td>
</tr>
<tr>
<td>Francolite</td>
<td>9.36</td>
<td>6.89</td>
<td>0.736</td>
</tr>
<tr>
<td>(77-B3-04)</td>
<td>9.359(1)</td>
<td>6.875(1)</td>
<td>0.735</td>
</tr>
</tbody>
</table>

n_w = 1.631

Apatite end-member UCD's from McConnell (1973).
Apatite is one of the primary phosphate minerals (Moore, 1982), but it also crystallizes throughout the various late stages of pegmatite consolidation. The Huron Claim apatite is clearly not vug or fracture-filling, but it does seem to be associated with the late-stage albitization of microcline-perthite. The rare-earth phosphate, monazite, occurs strictly in association with coarse-grained plagioclase. The relative scarcity of both apatite and monazite in the Huron Claim pegmatite is indicative of the low concentration of phosphorus in this particular pegmatite, and in the Shatford Lake group as a whole.

**URANOPHANE-SKLODOWSKITE**

Uranophane-skloadowskite was identified in the Huron Claim pegmatite by Bristol (1962). It occurs as pale yellow, scaly encrustations on sample 2026, associated with magnetite, quartz and coffinite. There is some doubt as to the provenance of this sample, as magnetite and coffinite have not been identified elsewhere in the pegmatite. Similar yellow encrustations occur around many of the uraninite grains, and fractures within the grains are generally coated with the same material. Although the uraninite encrustations were not X-rayed, it seems probable that they belong to the uranophane-skloadowskite series as well, as uranophane-skloadowskite is one of the most common alteration products of uraninite in granitic pegmatites (Frondel, 1958).

**BAVENITE**

Bavenite is a rare beryllium-calcium aluminosilicate first described from Baveno, Italy (Artini, 1901). In the Huron Claim pegmatite, it is relatively abundant as an alteration product of beryl.
Found in the medium to coarse-grained albite unit but forming part of the late Ca-mineral assemblage, the bavenite occurs in large irregular masses and definite pseudomorphs after beryl (Plates 52 and 53). The bavenite masses consist of very fine-grained, sheaf-like crystal aggregates. The aggregates, which have a distinctive silky lustre, have been found in pods up to 4 or 5 centimetres in diameter. The colour of the bavenite varies from grey, through greenish-yellow, to pale yellow. Remnants of beryl are often observed with the bavenite, as the degree of alteration is completely variable. In some pseudomorphs, a core of relictic beryl and bavenite is surrounded by a thin rind of bityite. Chlorite and epidote are frequent associated minerals.

In thin section, the sheaf-like nature of the aggregates is more apparent, the largest individual crystals reaching a length of one millimetre. The bavenite is colourless to dirty brown in transmitted light, and exhibits light grey interference colours. The bavenite occurs as monomineralic patches in albite, as partial or complete pseudomorphs after beryl with bityite, and as intergrowths with chlorite and epidote (Plate 54).

Unit cell dimensions of four Huron Claim bavenites are given in Table 74. The unit cell dimensions of bavenites from the Himalaya dyke system in California, and from the type locality at Baveno, Italy, are given for comparative purposes in the same table. No optical work on bavenite was done during the present study.

Chemical analyses of bavenite from the Huron Claim, the Ural Mountains, Western Australia and the Himalaya dyke system, California, are presented in Table 75. The general formula given by Beus (1966) is
Plate 52. Progressive alteration of beryl by light yellow bavenite. The large beryl crystal on the lower right is only partially altered.

Plate 53. Intergrowth of bavenite (light green) and chlorite (dark green) in coarse-grained albite. Coin is 17 millimetres in diameter (P3-83).
Plate 54. Bavenite (dirty brown) intergrown with chlorite (green) and epidote (colourless, high relief).

Table 74. Unit cell dimensions of bavenite.

<table>
<thead>
<tr>
<th></th>
<th>P3-83$^1$</th>
<th>P3-89$^1$</th>
<th>GL-34$^1$</th>
<th>GL-37$^1$</th>
<th>California$^2$</th>
<th>Italy$^3$</th>
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</thead>
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<tr>
<td>a(A)</td>
<td>23.22(1)</td>
<td>23.20(1)</td>
<td>23.19(1)</td>
<td>23.08(4)</td>
<td>23.22(5)</td>
<td>23.19(2)</td>
</tr>
<tr>
<td>b(A)</td>
<td>4.965(4)</td>
<td>4.955(4)</td>
<td>4.973(2)</td>
<td>4.966(3)</td>
<td>4.99(1)</td>
<td>5.005(9)</td>
</tr>
<tr>
<td>c(A)</td>
<td>19.407(5)</td>
<td>19.407(7)</td>
<td>19.392(7)</td>
<td>19.39(1)</td>
<td>19.43(3)</td>
<td>19.39(2)</td>
</tr>
<tr>
<td>V(A$^3$)</td>
<td>2237.2</td>
<td>2230.8</td>
<td>2236.4</td>
<td>2221.9</td>
<td>2251.0</td>
<td>2250.5</td>
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1. Huron Claim present study.
Table 75. Chemical composition of bavellite.

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<th>2</th>
<th>3</th>
<th>4</th>
<th>1'</th>
<th>2'</th>
<th>3'</th>
<th>4'</th>
<th>1''</th>
<th>2''</th>
<th>3''</th>
<th>4''</th>
</tr>
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<tr>
<td>SiO₂</td>
<td>59.30</td>
<td>59.13</td>
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<td>Si₄</td>
<td>9.26</td>
<td>9.11</td>
<td>8.84</td>
<td>8.87</td>
<td>Si</td>
<td>9.00</td>
<td>9.00</td>
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<td>wt. %</td>
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<td></td>
<td></td>
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<td>1.25</td>
<td>1.19</td>
<td>1.79</td>
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<td>7.00</td>
<td>6.46</td>
<td>9.60</td>
<td>Al</td>
<td>0.50</td>
<td>0.11</td>
<td>Fe³⁺</td>
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<td>-</td>
</tr>
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<td>Fe₂O₃</td>
<td>-</td>
<td>-</td>
<td>0.31</td>
<td>0.11</td>
<td>B</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BeO</td>
<td>7.42</td>
<td>7.14</td>
<td>7.66</td>
<td>6.60</td>
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<td>2.78</td>
<td>2.64</td>
<td>2.82</td>
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</tr>
<tr>
<td>MnO</td>
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<td>Ca</td>
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<td>K</td>
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<td>K₂O</td>
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<td>3.64</td>
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<td>3.56</td>
<td>1.87</td>
<td>CO₂</td>
<td>.06</td>
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<td>CO₂</td>
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<td>H₂Oᵣ</td>
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<td>CO₂</td>
<td>0.26</td>
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<tr>
<td></td>
<td>99.76</td>
<td>100.01</td>
<td>99.60</td>
<td>99.90</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Londonderry, Western Australia (Rowledge and Hayton, 1948).
3. Himilaya dyke system, California (Fleischer and Switzer, 1953).

Cations on the basis of 26 O + 2(OH). Normalized to 9.0 Si in 1", 2", 3" and 4".

1) (Ca, Mg, Na, K), (Be, Al, Fe), 4.16 Si₄O₂₆(OH, CO₂), * 1.09
2) (Ca, Mg, Na), 3.95 (Be, Al), 1.86 Si₄O₂₆(0.025, 0.05) (OH, 0.85) (OH), 1.65
3) Ca₄(Be, Al), 4.06 Si₄O₂₆(OH, 0.20) (OH), 2.51
4) Ca₄, (Be, Al, Fe, B), 4.38 Si₄O₂₆(OH), 2.50 *

* Anion deficiency.
Ca$_4$(Be, Al)$_4$ Si$_9$ O$_{26}$m (OH)$_{2+m}$. There is a complete compositional range from Ca$_4$[(Be$_2$Al$_2$)Si$_9$O$_{26}$](OH)$_2$ to Ca$_4$[(Be$_3$Al)Si$_9$O$_{26}$ (OH)](OH)$_2$, as increasing substitution of beryllium in the octahedral positions is offset by the replacement of oxygen by hydroxyl ions. The variation in hydroxyl content is evident in the analyses shown in Table 75. The beryllium oxide content of bavenite varies from 5.52 to 7.72 wt.% and there is minor substitution of iron, magnesium, manganese, sodium and potassium (Burt, 1982). Normalization of the analyses in Table 75 to nine silicon ions results in surplus cations in the Huron Claim and Ural Mountain specimens.

Bavenite is a low temperature, hydrothermal accessory mineral in some beryl-bearing pegmatites and greisens. In addition, it is occasionally found in skarns with the mineral helvite (Vlasov, 1966). In granitic pegmatites, bavenite generally occurs as a replacement after beryl, or as crystal aggregates in leached cavities in feldspar. Beryl reacts with late, calcium-bearing hydrothermal solutions to produce bavenite, during the last stages of the pegmatitic process (Ginsburg, 1957; Černý, 1968). The octahedral aluminum in beryl is converted to tetrahedral aluminum, and minor amounts of aluminum are extracted.

Bavenite has been reported from Italy (Artini, 1901), Western Australia (Rowledge and Hayton, 1948), Switzerland (Vlasov, 1966), Czechoslovakia (Černý, 1956), California (Schaller and Fairchild, 1932), Virginia (Vlasov, 1966), North Carolina (Foord, 1976) and Connecticut (Henderson, 1970). In the USSR, bavenite is generally found in the plagioclase-rich parts of desilicated granite pegmatites (Vlasov, 1966). It also occurs in hydrothermal veins, and in garnet-bearing skarns after helvite.
BERTRANDITE

Bertrandite, a beryllium diorthosilicate, was first identified in the Huron Claim pegmatite by Bannatyne (1974). The original sample, consisting of albite and small patches of greenish clay, on examination contains no recognizable bertrandite. During the present study, an olive-green clay forming the core of a large beryl pseudomorph in the wall of Pit #3 was separated for chemical analysis and XRD studies. The resulting partial chemical analysis and X-ray diffraction data (Tables 76 and 77) show that the olive-green "clay" is in fact a mixture of bertrandite and montmorillonitic clay. A muscovite-rich sample separated from the margin of the beryl pseudomorph also contains a considerable amount of BeO, and the beryllium content must again be due to admixed bertrandite. The admixture must be extremely fine-grained, as the olive-green "clay" appears as a uniform phase under the binocular microscope. Thin section examination of a number of altered beryls showed only bavenite, bityite and clay minerals. The beryllium content of sample P3-95(1) indicates a mixture of about 30 to 35% bertrandite and 65 to 70% montmorillonitic clay.

Bertrandite is known to form as a low temperature alteration product of primary beryl, and is commonly associated with muscovite and albite (Burt, 1982). The beryls in the wall of Pit #3 are perhaps the most highly altered of any in the pegmatite, and are often completely decomposed. More frequently, small remnants of pristine beryl are found in association with bavenite, bityite and chlorite. It seems likely that the bertrandite-muscovite-clay mineral assemblage is representative of the latest and most intense stages of beryl decomposition in the Huron Claim pegmatite. Bertrandite and muscovite are indeed
Table 76. Partial chemical analyses of bertrandite-clay, and bertrandite-muscovite-albite-clay admixtures after beryl.

<table>
<thead>
<tr>
<th>Sample</th>
<th>P3-95(1)</th>
<th>P3-95(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe$_2$O$_3$ wt.%</td>
<td>8.61</td>
<td>8.22</td>
</tr>
<tr>
<td>CaO</td>
<td>1.16</td>
<td>0.99</td>
</tr>
<tr>
<td>MgO</td>
<td>10.40</td>
<td>4.33</td>
</tr>
<tr>
<td>BeO</td>
<td>12.20</td>
<td>14.30</td>
</tr>
<tr>
<td>K$_2$O</td>
<td>1.95</td>
<td>6.90</td>
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<td>Na$_2$O</td>
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<tr>
<td>Rb$_2$O</td>
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<td>0.41</td>
</tr>
<tr>
<td>Cs$_2$O</td>
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<td>0.01</td>
</tr>
</tbody>
</table>

AA and XAF analyses by K. Ramlal.

P3-95(1) olive-green clay at core of beryl pseudomorph; microcrystalline admixture with bertrandite

P3-95(2) muscovite-bertrandite-clay-albite admixture from the marginal area of the pseudomorph
Table 7. X-ray powder diffraction data for bertrandite.

<table>
<thead>
<tr>
<th>Mt. Isa, Queensland</th>
<th>Virginia</th>
<th>72P-20-1a</th>
<th>P3-95(1)</th>
<th>P3-95(1)</th>
<th>CL-10</th>
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<tbody>
<tr>
<td>d(Å) I hkl</td>
<td>d(Å) I hkl</td>
<td>d(Å) I hkl</td>
<td>d(Å) I hkl</td>
<td>d(Å) I hkl</td>
<td>d(Å) I hkl</td>
</tr>
<tr>
<td>7.56 10 020/110</td>
<td>7.56 10 020/110</td>
<td>4.4 100 130/200</td>
<td>4.41 10 021/111</td>
<td>3.95 18 020/200</td>
<td>3.16 45 133</td>
</tr>
<tr>
<td>4.85 C2 Ni</td>
<td>4.38 55 130</td>
<td>4.38 55 130</td>
<td>4.38 55 130</td>
<td>4.38 55 130</td>
<td>4.38 55 130</td>
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<tr>
<td>4.38 100 130/200</td>
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<td>4.35 35 200</td>
<td>4.35 35 200</td>
<td>4.35 35 200</td>
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<tr>
<td>3.96 40 111/021</td>
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<td>3.96 20 021/111</td>
<td>3.92 20 021/111</td>
<td>3.92 20 021/111</td>
<td>3.92 20 021/111</td>
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<tr>
<td>3.80 8 220/040</td>
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<td>3.80 &gt;100 040/220</td>
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<td>3.16 45 131</td>
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<td>2.92 4 041</td>
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<tr>
<td>2.54 80 060/330</td>
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<td>2.54 75 060</td>
<td>2.54 75 060</td>
<td>2.54 75 060</td>
<td>2.54 75 060</td>
</tr>
<tr>
<td>2.42 6 311</td>
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<td>2.37 4 311</td>
</tr>
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<td>2.22 16 001</td>
<td>2.22 16 001</td>
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<tr>
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1. JCPDS file, 17-515(1)
2. JCPDS file, 12-452.
3. Huron Claim, unpublished data of the Manitoba Mines Branch
4. Huron Claim, Gondoliff camera - 16 hour exposure; "x" denotes an intense line, H-montmorillonite
5. Huron Claim, X-ray powder diffractogram
characteristic of late stage, secondary assemblages which form in neutral rather than alkaline environments (Černý, 1968). Although the greenish montmorillonitic clays are reasonably widespread throughout the pegmatite, only in a few instances do they seem to be admixed with bertrandite. Bavenite and bityrite are much more frequently associated with the clay minerals, to the apparent exclusion of bertrandite.

**SULPHIDE MINERALS**

Chalcopyrite and pyrite are present in very minor amounts in the marginal parts of the Huron Claim pegmatite. They occur in the granular variants of the aplite border unit along with albite, quartz and garnet, and also in the outermost part of the medium to coarse-grained albite unit. The sulphide minerals are most abundant in the flat-lying outcrops along the southwestern margin of the pegmatite. The presence of the sulphide minerals in the outermost parts of the pegmatite suggests some mobilization of copper, iron and sulphur from the metagabbroic host rocks.

**Chalcopyrite**

Chalcopyrite is present only in the flat-lying outcrops along the southwestern margin of the pegmatite. It occurs in large, subhedral crystals, which fill voids in the medium to coarse-grained albite zone close to its contact with the granular border unit. The chalcopyrite is often intergrown with pyrite. The largest crystal (in sample SW-01) is 16 x 30 millimetres in cross-section. The chalcopyrite is occasionally rimmed by grey chalcocite, and epidote. Other weathering and/or alteration products include covellite and very minor malachite.
The chalcopyrite was identified using X-ray methods, but no other laboratory work was done during the present study.

Pyrite

Pyrite is more abundant in the Huron Claim pegmatite than chalcopyrite. As well as occurring in the flat-lying southwestern outcrops, it is also found in Pit #3. The pyrite forms small subhedral crystals, and fine-grained crystal aggregates, in both the granular variants of the aplite border unit and the medium to coarse-grained albite unit. The largest pyrite crystals are about 5 x 15 millimetres in cross-section. Like chalcopyrite, with which it is often intergrown, the pyrite occurs mainly as an open space filling. It is frequently replaced by reddish-brown, iron hydroxides which give hematite XRD powder patterns upon heating. The pyrite was identified using X-ray powder methods.

CLAY MINERALS

Clays are reasonably abundant in the Huron Claim pegmatite, occurring in two distinct assemblages. Vug-filling clays in albite are relatively common, being particularly well-developed in the bluff near the southwestern end of the pegmatite. They are soft, soapy and pale green in their natural state, but tend to dehydrate after separation at room temperature. Following dehydration, the clays are friable and pale greenish-white. In a given sample of vuggy albite, the clay minerals fill only a small proportion of the available cavities. Botryoidal black unknowns, possibly hydrocarbons, are occasionally intergrown with the clays. In thin section, the vug-filling clays
appear as fine-grained to spherulitic aggregates with bright, first or second order interference colours. They are generally muddy brown or yellow, and are frequently mixed with iron hydroxides.

Perhaps more conspicuous than the vug-filling clays are the masses of greyish-green clay associated with the secondary beryllium minerals. Included in this assemblage are the dirty green clay minerals replacing epidote. Bavenite, bertrandite, bityite, chlorite and epidote are frequently intergrown with these clays, and microcrystalline mixtures of clay and one or more of these phases are not unusual. Microscopically, these clays resemble the vug-filling varieties, although their morphology is somewhat more variable. The maximum grain size in certain of the spherulitic aggregates is on the order of 20 or 30 microns. The clays form an intrinsic part of the alteration assemblage after beryl, and are apparently the last minerals to crystallize in this assemblage. Early formed epidote and chlorite (to a lesser extent) are both partially replaced by the clay minerals.

X-ray powder diffraction data from several specimens of clay from the Huron Claim pegmatite are given in Table 78. The clays were X-rayed in their natural state only. The vug-filling clay has a 12Å basal spacing, indicative of a montmorillonitic or, more probably, a mixed-layer (illite-montmorillonite) clay. The greyish-green clays associated with the secondary beryllium minerals have 14Å basal spacings, indicative of montmorillonitic clays; a 7Å spacing, typical of chlorite or admixed kaolinite, is not present. The greyish-green clays, it should be mentioned, were all mixed with bertrandite, making interpretation of the powder patterns difficult.
Table 78. X-ray powder diffraction data for the Huron Clairn clay minerals.

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<thead>
<tr>
<th></th>
<th>SW-07</th>
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<td>X(b)</td>
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Strongest peaks indicated with X; X(b) indicates a bertrandite peak.

Gandolfi camera - 16 hour exposure; clays were X-rayed in their natural state.
Chemical analyses of clay-bertrandite, and clay-bertrandite-muscovite-albite mixtures were given in a previous section (Table 76). Based on its BeO content, sample P3-95(1) is a mixture of 30% bertrandite and 70% montmorillonitic clay. Adjusting the oxide totals to take account of the admixed bertrandite gives a montmorillonitic clay with about 12% Fe₂O₃, 15% MgO, 1.7% CaO, 0.1% Na₂O and 2.8% K₂O. If only a single clay species were present, its composition would correspond to ferroan saponite, but the high magnesium content may also be due to admixed chlorite. Intermediate compositions between saponite (ⅥMg) and nontronite (ⅥFe³⁺) are relatively rare, although a number of examples are reported in the literature (e.g., Ross and Hendricks, 1945). The potassium content in sample P3-95(1) is somewhat high for montmorillonite, and may be due to admixed illite.

Thermal gravimetric (TG) and derivative thermogravimetric (DTG) studies, as well as evolved gas analyses (EGA), were carried out on seven clay mineral specimens at the Royal Ontario Museum in Toronto. The results are shown in Table 79, and in Figures 53 through 58. TG-DTG-EGA studies are of limited use for straightforward identification (MacKenzie, 1981), and this proved to be the case with the Huron Claim specimens. The white, vug-filling clays are represented in samples SW-07 and SW-08, the latter sample having one of the most complicated EGA patterns in the entire suite (Figure 53). Significant interlayer water was lost at 90°C, and the water loss continued to a major peak at about 640°C. There was a significant loss of CO⁺ at 330 and 410°C, presumably due to the decomposition of hydrocarbons. The high temperature loss in sample SW-08 consists mainly of CO⁺ and H₂⁺. The green clays associated with the secondary beryllium minerals are
Table 79. Thermal gravimetric analyses of clay minerals from the Huron Claim pegmatite.

<table>
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<tr>
<th>Sample</th>
<th>Loss, weight %</th>
<th>Total</th>
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<tr>
<td>SW-07(^a)</td>
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<td>SW-08</td>
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<td>P3-95(2)(^b)</td>
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<td>9.3</td>
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<td>P5-27</td>
<td>5.1</td>
<td>11.8</td>
</tr>
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<td>PC-24</td>
<td>5.9</td>
<td>11.2</td>
</tr>
<tr>
<td>WP-15</td>
<td>2.8</td>
<td>9.3</td>
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</table>


Loss 1: in vacuum, ambient T, prior to run, H₂O⁻
Loss 2: main loss during run, primarily H₂O, with minor CO⁺, hydrocarbons
Loss 3: high T loss - generally incomplete, primarily CO⁺ with some undetected volatiles

a - results of lesser reliability due to instrument problem
b - sample contains minor muscovite and albite, as well as bertrandite
c - loss 1 subject to largest errors
Figure 53. Thermal gravimetric and evolved gas curves for clay sample SW-08 (white, vug-filling). M/E 28 is mainly CO⁺; m/e 19 is an unidentified volatile.
Figure 54. Evolved gas curves for sample P3-95(1). M/E (28) is mainly CO$. Sample contains about 30% bertrandite.
Figure 55. Thermal gravimetric and evolved gas curves for clay sample P3-95(2). M/E (28) is mainly CO⁺. Sample is contaminated with bertrandite, muscovite and albite.
Figure 56. Thermal gravimetric and evolved gas curves for clay sample P5-27. M/E (28) is mainly CO₄. Green clay after epidote.
Figure 57. Evolved gas curves for clay sample PC-24. M/E 28 is mainly CO⁺. Greenish-grey clay associated with secondary beryllium minerals.
Figure 58. Evolved gas curves for clay sample WP-15. M/E (28) is mainly CO\textsuperscript{+}. Green clay associated with secondary beryllium minerals.
represented by samples P3-95, P5-27, PC-24 and WP-15. With the exception of sample P5-27, these clays show continual if sporadic water loss between 40 and 800°C, the major loss occurring in a narrow range from 650 to 670°C; significant amounts of CO₂ are evolved above 900°C. Sample P5-27 is markedly different in that the major water loss occurs at 415 and 570°C.

Bursting in all the Pₜ curves was evident above 1200°C, presumably due to gas evolution from a melt (R. Ramik, pers. comm.). A sharp, but minor peak at 910°C in sample P3-95(1) may be due to bertrandite dehydroxylation. DTG curves, which are not shown, have minima at about 700°C. The TG-DTG-EGA data are consistent with a montmorillonitic composition for the clays. Differential thermal analyses of montmorillonite show a major dehydroxylation peak at about 700°C (Greene-Kelly, 1957), which would correspond to the DTG-EGA results for the Huron Claim clays. The major dehydroxylation peak for nontronite is in the vicinity of 500 or 550°C, whereas for saponite, the main water loss is between 800 and 900°C. Thermal gravimetric curves for chlorite show deflections at 600 and 850°C, corresponding to successive losses of water from the brucite and talc layers (Caillère and Hénin, 1957).

The clay minerals in the Huron Claim pegmatite have not been fully characterized. The available data suggests two distinct varieties; a vug-filling, mixed layer illite-montmorillonite, and an iron and magnesium-rich montmorillonite associated with secondary beryllium minerals. The secondary beryllium minerals formed during alkaline decomposition of beryl, and an alkaline environment is required for the formation of montmorillonite. Iron, magnesium and calcium may have been provided by the breakdown of epidote and chlorite, as leaching of these elements must have been minimal.
DISCREDITED MINERALS

Tourmaline

Tourmaline was reported from the Huron Claim pegmatite by Mulligan (1968). No specimens exist in the Royal Ontario Museum collection, nor was this mineral found in more recent examinations of the pegmatite by Černý and Turnock (1971a) and Paul (present study). Its presence in the Huron Claim pegmatite has been more or less discredited (e.g., Černý et al., 1981b).

Triphylite-Lithiophilite

Walker (1931) describes a single specimen of lithiophilite given to him by the original proprietors of the Huron Claim. In his report, he specifically mentions that the specimen comes not from the Huron Claim, but from another pegmatite in its immediate vicinity (in all likelihood, the Silverleaf pegmatite). Three samples (M17310A, B and C) of a dark bluish-green mineral in the Huron Claim collection of the Royal Ontario Museum may be remnants of the original specimen. Like the Shatford Lake group as a whole, the Huron Claim pegmatite is depleted in rare alkalis, and triphylite-lithiophilite should not occur. It is recommended that the Royal Ontario Museum specimens be distinguished from the remainder of the collection.
CHAPTER VIII
GENESIS AND CLASSIFICATION

There are gaps in the mineralogical and petrochemical data base for the Huron Claim pegmatite. A number of mineral species have not been properly identified, and chemical data is lacking for certain of the minerals. Also, the internal zonation and feldspar relations within the pegmatite are incompletely understood. Nevertheless, a petrogenetic evaluation of the Huron Claim pegmatite is still possible. The mineralogical data is adequate for proper classification of the pegmatite, and for a comparison to other Be, Nb-Ta and REE-bearing pegmatites in the literature. Some comments are required on the relationship of the Huron Claim pegmatite to the Shatford Lake group as a whole, and on the setting of the Shatford Lake group within the Winnipeg River pegmatite district.

MINERALOGICAL AND PETROCHEMICAL CHARACTERISTICS
OF THE HURON CLAIM PEGMATITE

Bulk Composition

The bulk composition of most rare-element pegmatites is similar to granite (Černý, 1982a). These pegmatites deviate from average granitic compositions in having low CaO, variable K₂O/Na₂O ratios due to varying contents of alkali feldspar, high Al₂O₃, and peraluminous compositions due to the presence of mica, garnet, topaz and other peraluminous
species. Components other than the main rock-forming ones never reach significant concentrations (> 1%), except for Li₂O, Rb₂O, B₂O₃, F and rarely Cs₂O. The other constituents remain at low concentration levels even in the most fractionated pegmatite types, and do not significantly affect the bulk composition of the pegmatites. Fractionation enhances the geochemical trends observed in plutonic granites, leading to extremely low values of K/Rb, K/Cs, Ba/Rb, Sr/Rb, Rb/Cs, Ti/(Nb+Ta), Nb/Ta, Th/U and Zr/Hf.

A reliable estimate of the bulk composition of the Huron Claim pegmatite is not possible, as the pegmatite is poorly exposed and there is very little drill hole data. Certainly the pegmatite seems to be albite-rich, to the detriment of the alkali feldspar and quartz components. Much of the apical part of the pegmatite has been eroded, and this part of the pegmatite may have been enriched in alkali feldspar (Norton, 1970). However, field observations suggest that the blocky microcline unit pinches out rapidly away from the central part of the pegmatite, and that the preponderance of albite is a salient feature of the sill. The restricted extent of the blocky microcline unit is evident from the exposures in the northern and southern bluffs, and from diamond drill hole #8.

The remaining pegmatites in the Shatford Lake group also contain considerable quantities of albite, but in none of these is the albite as conspicuously developed as it is in the Huron Claim pegmatite. Albite-rich rare-element pegmatites are poorly documented in the literature (Černý, pers. comm.), and are apparently uncommon.
Internal Zonation and Feldspar Relationships

The Huron Claim pegmatite, on a gross scale, is relatively poorly zoned. Individual units are recognizable, but most of them are discontinuous and show little lateral continuity. This is in sharp contrast to the well-defined graphic wall zone, blocky intermediate zone and quartz core observable in most gadolinite-bearing, blocky microcline-biotite pegmatites. An interpretation of the zonation within the Huron Claim pegmatite is hampered to some extent by its poor exposure. However, the lack of lateral development is a salient feature and there are no units, with the possible exception of the medium to coarse-grained albite unit, which can be described as concentric shells. This lack of concentric zoning is characteristic of many of the pegmatites in the Shatford Lake group.

Albite is present in unusual amounts in the Huron Claim pegmatite, and may constitute as much as 50% (or more) of the pegmatite by volume. A large percentage of this occurs in the medium to coarse-grained albite unit, which seems to be primary in origin. Discrete albite replacement units, as seen in the Baringer Hill and Rode Ranch pegmatites in central Texas (Landes 1932; Ehlmann et al., 1964) are not present in the Huron Claim pegmatite. Fine, granular albite occurs only in small segregations in the central part of the pegmatite and in rare, cross-cutting veinlets. Albite crystallization seems to have taken place throughout the consolidation history of the pegmatite. The graphic pegmatite unit, which is comprised of albite and quartz, is particularly unusual. In most other blocky microcline-biotite pegmatites, this unit is comprised of graphic quartz and K-feldspar.
The blocky microcline unit consolidated in the central and apical portions of the pegmatite, with crystallization progressing inward towards the central part of the pegmatite. At the same time that the blocky microcline unit was forming, medium to coarse-grained albite was apparently forming elsewhere in the pegmatite. As a result, the Huron Claim pegmatite has a potassic inner zone and albite-rich margins. The albite "replacement" unit in the central part of the pegmatite, which contains coarse-grained, granular and "chessboard" albite as well as remnant microcline, exhibits both primary and replacement textures. This unit seems to be late, and carries virtually no rare-element mineralization. Albitization visibly affects only the margins of the blocky microcline unit and isolated, small crystals of K-feldspar, but "chessboard" albite is reasonably abundant in certain areas. If the latter variety of albite represents total replacement of K-feldspar, the albitization process in at the central part of the pegmatite must have been significant.

Albite and microcline-perthite are the two most abundant minerals in the Huron Claim pegmatite, whereas quartz is relatively impoverished. The quartz core is poorly developed and volumetrically unimportant, in comparison to other blocky microcline-biotite pegmatites (Beus, 1966).

**Rare-Element Spectrum**

The Huron Claim pegmatite contains a number of rare elements, all of which are intrinsic to its classification, and to a comparison with other rare-element bearing pegmatites. Beryllium, which occurs primarily in beryl, is perhaps the most abundant rare element in the
The richest beryl-bearing pegmatites in the Greer Lake area, including the Huron Claim, are estimated to contain about 0.5% beryl (Central Geophysics Ltd., 1958). This would correspond to a beryllium content of about 700 ppm, which is well within the limits established for tantalum and beryllium-bearing, complex rare-element pegmatites (Kuzmenko et al., 1976). Both niobium and tantalum are present in significant amounts, but niobium predominates; they are contained mainly in columbite-tantalite, which has an average Nb/Ta ratio of about 3 to 1. Together, niobium and tantalum in the pegmatite are slightly less abundant than beryllium. Uranium and thorium are present in very minor amounts, but their presence is significant. Uraninite is the main actinide-bearing accessory mineral, and uranium is apparently more abundant than thorium in this particular pegmatite. The rare-earth elements occur in a variety of minerals, the most common of which is monazite. The cerium rare-earths (LREE's) predominate, whereas the yttrium earths (Y+HREE's) are much depleted. The paucity of yttrium and its related rare-earth elements may explain the lack of xenotime, and other yttrium-bearing minerals such as gadolinite, yttrotantalite, fergusonite and samarskite. The euxenite-like accessory mineral in the Huron Claim pegmatite is the only phase to contain substantial amounts of yttrium. Zirconium is present in minor amounts, mainly in zircon, and is much in excess of hafnium. Tin is a minor element occurring in some abundance in the remainder of the Shatford Lake pegmatite group, but it is limited to insignificant substitution in columbite-tantalite in the Huron Claim pegmatite. No cassiterite has been identified, and tin does not occur in significant amounts in the other oxide minerals. The high rubidium content of the
Huron Claim pegmatite, and its depletion in lithium and cesium, have been discussed previously. With Rb values up to 1.14 wt.% Rb₂O in muscovite and 0.70 wt.% Rb₂O in microcline-perthite, the Huron Claim is by far the most Rb-enriched pegmatite in the Shatford Lake group.

The Huron Claim pegmatite is best classified as a fully differentiated, blocky microcline-biotite pegmatite (Beus, 1966), containing significant amounts of Be, Nb>Ta, REE, U, Th, Zr>Hf and Rb.

**Hydrothermal Alteration of Beryl**

In granitic pegmatites, beryl is susceptible to high temperature replacement, and it yields a wide variety of secondary, low-temperature mineral assemblages. In the Huron Claim pegmatite, beryl is extensively replaced by secondary beryllium silicates formed during late, low temperature hydrothermal alteration. The decomposition of beryl occurs readily in distinctly basic or acidic hydrothermal solutions. Forty-seven different alteration assemblages are listed by Černý (1968), who classifies the assemblages according to their quantitative chemical composition. The development of the main secondary assemblages after beryl is shown schematically in Figure 59.

Bavenite and bityite are the most common alteration products after beryl in the Huron Claim pegmatite. Both of these silicate minerals contain beryllium in a complex anionic framework, with cations of alkaline affinity (Ca) in the high-coordination cation sites. High pH values are required for their formation, due to the chemical properties of beryllium (Černý, 1970); the parent solutions giving rise to bavenite and bityite are low temperature, alkaline solutions. Of the two minerals, bavenite is the most common alteration product after
Figure 59. Secondary hydrothermal parageneses formed by the acid and alkaline decomposition of beryl (from Černý, 1970). Dashed arrows indicate stages of decomposition in the Huron Claim pegmatite.
beryl in granitic pegmatites (Černý, 1970). In the Huron Claim pegmatite, bavenite and bityite are accompanied by epidote, magnesium aluminian chamosite and montmorillonitic clay. The clay minerals were apparently the last minerals to form, as they replace much of the epidote and chamosite.

Bertrandite occurs in the Huron Claim pegmatite in association with montmorillonitic clay, muscovite and albite. It seems to be less abundant than bavenite and bityite. Whereas bavenite and bityite are frequently found with remnant beryl, bertrandite always seems to be associated with complete dissolution of the primary mineral. The presence of all three secondary minerals in the Huron Claim pegmatite suggests alkaline dissolution of beryl, but in two different types of fluids.

Late, calcium-rich hydrothermal solutions and secondary beryllium minerals are relatively common in granitic pegmatites (Jahns, 1982; Černý, 1970), but the development of secondary beryllium minerals in the Huron Claim pegmatite is particularly extensive. Despite the abundance of pristine beryl, the alteration assemblage is very abundant and very widespread. The origin of the hydrothermal fluids is in some doubt. They may have been residual fluids derived from the pegmatitic process, or possibly they were related to the interstitial fluids in the enclosing country rocks. The calcium, magnesium, iron and titanium characteristic of the hydrothermal fluids could well have been derived from the metagabbroic host rocks, in which case the hydrothermal event may have been truly late, following consolidation of the pegmatite.
Late hydrothermal alterations are rather typical of the Shatford Lake pegmatite group. Calcite and chlorite are ubiquitous, muscovite commonly replaces topaz and REE fluorocarbonates replace monazite and allanite (Černý et al., 1981b). However, extensive development of the alteration assemblages as documented in the Huron Claim pegmatite is unknown in the remainder of the Shatford Lake group.

EVolUtIOn OF tHe HurOn ClAIrM PegMatItE

Sequence of Crystallization

The gross textural relationships between individual units, and thus the internal evolution of the Huron Claim pegmatite, are incompletely understood. Certainly, in many respects, the pegmatite deviates from the generalized genetic model outlined by Jahns and Burnham (1969), and Jahns (1982). A brief review of this model is required prior to commenting on the Huron Claim pegmatite.

The evolution of a pegmatite from a volatile-enriched granitic magma is envisaged as a four-stage process. During the first or magmatic stage, crystallization occurs from a volatile-rich, but undersaturated granitic melt. Anhydrous silicates and some hydroxyl-bearing phases coalesce in the fine-grained border, and graphic pegmatite zones. These zones, because they crystallize from a granitic magma, generally have a granitic minimum composition. As the anhydrous phases crystallize in the outer parts of the pegmatite, the residual melt becomes progressively enriched in volatiles to the point of saturation. Resurgent boiling occurs, at which point crystallization commences from both the silicate melt and a co-existing aqueous fluid. This is the second and most characteristic phase of
pegmatite evolution. The evolved aqueous phase accumulates as a thin film along the crystal-melt interfaces, eventually forming an interstitial fluid connecting large areas of the nascent pegmatite. The rapid diffusion of constituents through the interstitial fluid promotes rapid crystal growth, and thus the blocky interior zones of the pegmatite are developed. The partitioning of constituents between the melt and aqueous fluid, the rapid diffusion of these constituents in the aqueous fluid and the gravitational influence on the aqueous fluid are intrinsic to the formation of zones or mineral segregations of unusual composition and texture. The third stage of pegmatite evolution involves the exhaustion of the silicate melt and continued crystallization from the aqueous fluid. The quartz core is formed during this stage, and earlier formed crystalline phases are subject to alteration and/or replacement. In the final, or hydrothermal, stage of pegmatite evolution, hot residual water circulates in the fissures and open spaces within the pegmatite. The role of water, as a dissolved constituent of granitic magmas, and as the major component of a fluid phase which is in the supercritical state during most stages of pegmatite development, is intrinsic to this evolutionary model.

The model can be applied to the Huron Claim pegmatite, although certain parts of this pegmatite defy interpretation. A magmatic stage may have been responsible for the formation of the albite border and graphic pegmatite units. That this stage was short-lived is evidenced by the thinness and discontinuity of these two units. Albite began crystallizing very early in the development of the pegmatite, from what must have been on unusually sodium-rich magma. The second stage of pegmatite evolution, involving both a silicate melt and an aqueous
fluid phase, seems to have been the dominant stage in the development of the Huron Claim pegmatite. The extension of the medium to coarse-grained albite, and blocky microcline units virtually to the contact in places, suggests that this stage was operative shortly after the intrusion of the pegmatite. The medium to coarse-grained albite and blocky microcline units are truly representative of the pegmatitic stage of development. Gravitational processes or selective alkali transfer were in effect in the Huron Claim pegmatite, as evidenced by the microcline-perthite segregations in the central and apical portions of the sill; the marginal areas of the Huron Claim pegmatite are extremely sodic. The blocky microcline unit crystallized toward the central part of the pegmatite, undoubtedly in concert with albite formation elsewhere in the pegmatite.

The rare-element minerals, namely zircon, thorite, uraninite, monazite, columbite-tantalite and beryl, show some evidence of early crystallization. These minerals occur both intergrown with albite in the medium to coarse-grained albite unit, and as fracture-fillings within the same unit. Rare-element mineralization in the other units of the pegmatite is extremely scarce. Chemical differences between the two types of rare-element mineralization are not immediately obvious, and the two types seem to be closely related in space and time. Beryl is present in small crystals in the aplite border unit and also occurs in significant accumulations in the coarse-grained albite, often within several centimetres of the uppermost contact. This mineral, in particular, seems to have crystallized very early. Small bulges in the pegmatite near its upper contact were apparently the loci for rare-element accumulation. Crystallization of the rare-element minerals
began as early as the magmatic stage, but in many instances it postdated the formation of coarse-grained albite. Syn- to post-consolidation fracturing of the medium to coarse-grained albite unit was apparently widespread. The development of rare-element phases in gadolinite-bearing pegmatites, and in rare-element pegmatites in general, is highly variable. The Huron Claim pegmatite shows some affinity to the gadolinite-bearing pegmatites of southern Scandinavia (Björlykke, 1937; Brotzen, 1959a), in which the rare-element minerals seem to have crystallized relatively early. The rare-element minerals in the Baringer Hill and Rode Ranch pegmatites in central Texas (Landes, 1932: Ehlmann et al., 1964) in contrast, are associated with a late albite replacement unit.

The third stage in pegmatite evolution, involving depletion of the silicate melt and crystallization from the aqueous fluid alone, was perhaps of limited duration in the Huron Claim pegmatite. Certainly there are no albite replacement units, in the true sense of the word, within the pegmatite. The quartz core formed during this stage, and there was some albitization at the margins of the blocky microcline unit. The so-called albite "replacement" unit in the central part of the pegmatite, which contains coarse-grained tabular, granular and "chessboard" albite as well as remnant microcline, exhibits both primary and replacement textures. The complex evolution of this particular part of the pegmatite is not well understood.

The hydrothermal alteration of beryl was described in a previous section. Interaction of the hydrothermal fluids with the enclosing metagabbro may be indicated by the Ca-, Fe-, Mg- and Ti-enriched composition of the alteration assemblage. The somewhat higher temperature replacement of ferrocolumbite by fersmite, however, does
point to the presence of calcium-rich fluids in the later stages of pegmatite crystallization.

**Pressure - Temperature Estimates**

The physical and chemical conditions of pegmatite formation are outlined in Jahns and Burnham (1969) and Jahns (1982). The majority of granitic pegmatites crystallize from $\text{H}_2\text{O}$-saturated derivative magmas within the temperature range 1000 to 650°C. The liquidus-solidus span for individual pegmatites varies from 50 to 200°C, and it occurs within the overall range as a function of the dissolved $\text{H}_2\text{O}$ content of the magma. Complex, rare-element pegmatites containing significant amounts of boron, fluorine and lithium can crystallize at temperatures as low as 550°C. Water is a significant component of natural pegmatite-forming systems, and it affects the viscosity, liquidus and solidus temperatures and crystallization kinetics of these systems. The concentration of water in a pegmatitic magma and its phase properties are largely functions of the confining pressure. For rare-element granitic pegmatites, these pressures can vary from 2 to 4 kilobars depending on the depth of occurrence.

As there are no diagnostic minerals or mineral assemblages in the Huron Claim pegmatites, an estimate of the pressure and temperature of formation is not possible. Certainly the pegmatite was formed at intermediate levels, as indicated by the lack of pockets or primary cavities, and by the subsolvus crystallization of alkali feldspar. Estimates have been made of the pressure and temperature of formation of the Winnipeg River pegmatitic granites (Goad, 1984) and the TANCO pegmatite, and these are perhaps applicable to the Huron Claim pegmatite.
The TANCO pegmatite crystallized in the high temperature-low pressure stability field of petalite, indicating a primary crystallization range of 650 to 500°C and 2.0 to 2.5 kilobars (Černý, 1982c). The presence of eucryptite indicates that $P_{H_2O}$ must have dropped below 1.5 kilobars during the latter stages of crystallization. Recent fluid inclusion studies on minerals from the TANCO pegmatite suggest crystallization pressures of 3.0 kilobars, corresponding to an emplacement depth at 12 kilometres (Goad, 1984). Crystallization temperatures of the Winnipeg River pegmatitic granites were probably between 640 and 600°C (Goad and Černý, 1981). Based on this data, a reasonable estimate of the primary crystallization conditions for the Huron Claim pegmatite would be 2.5 kilobars (10 kilometres) and 600°C.

THE SHATFORD LAKE PEGMATITE GROUP

Mineralogical, Chemical and Morphological Characteristics

Although a number of pegmatites in the vicinity of Shatford Lake were examined by the author, none of these pegmatites were studied in detail, and the following section relies extensively on the description provided in Černý et al. (1981b). The pegmatites of the Shatford Lake group are arranged around the eastern end of the Lac du Bonnet batholith (Figure 60); the pegmatites are spatially associated with the leucogranite phase of the batholith. On the north side of the batholith, the pegmatites occur less than 800 metres from the contact, but they occur up to 4.4 kilometres from the batholith along its southern margin. The Huron Claim pegmatite is situated about 2.2 kilometres east of the eastern nose of the batholith. The northernmost pegmatites occur next to a near-vertical granite contact, whereas the
Figure 60. Disposition of the Shatford Lake pegmatite group around the eastern tip of the Lac du Bonnet batholith (cf. figure 6).
Huron Claim pegmatite is situated above the eastward-plunging nose of the batholith. With the exception of the sub-horizontal SHCR-1, SHCR-2, SHNW and Huron Claim pegmatites, the pegmatites are near-vertical, and concordant with the foliation/gneissosity in the host rocks. The largest of the dykes, the SHS pegmatite, is 400 metres long and 8 metres thick. The contacts between the pegmatites and the enclosing host rocks are sharp, and there is negligible exomorphism.

The internal structure of the Shatford Lake pegmatites varies greatly. The well-zoned examples, such as the SHEE-2 pegmatite, contain a muscovite-albite-quartz border zone, an albite-quartz-Kspar (partly graphic) - muscovite intermediate zone, a K-feldspar plus quartz blocky zone and a quartz core in some bodies. The poorly-zoned examples are characterized by a coarse-grained, albite-quartz-muscovite assemblage, containing megacrysts of graphic and blocky K-feldspar, patches of quartz and bands of saccharoidal albite-quartz-garnet, all distributed in a haphazard manner. The NUTT pegmatite is unique in that it is fine to medium-grained, unzoned and apparently sheared. Post-consolidation fracturing is evident in most members of the Shatford Lake group.

The mineralogy of the Shatford Lake pegmatite group is summarized in Table 80. The most important rare elements are beryllium, niobium and tantalum, but zirconium, hafnium, the rare-earth elements, uranium and thorium are also characteristic. The rare-element minerals are usually associated with albite, and their distribution in the pegmatites is irregular. In many instances, the rare-element minerals are contained in fractures, and in the well-zoned pegmatites, beryl and topaz occur at the boundary between the quartz core and blocky microcline zone.
Table 80. Paragenesis of the Shatford Lake pegmatite group (after Černý et al., 1981b).

<table>
<thead>
<tr>
<th></th>
<th>NW</th>
<th>NORTH</th>
<th>SOUTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HB</td>
<td>SHCR-1</td>
<td>SHCR-2</td>
</tr>
<tr>
<td>MICROCLINE - PERTHITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>OLIGOCLASE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>ALBITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>QUARTZ</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>BIOTITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>MUSCOVITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>EPIDOT</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>CHLORITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>GARNET</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>TOPAZ</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>BERYL</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>TITANITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>ALANITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>GADOLINITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>ZIRCON</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>THORITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>URANINITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>MAGNETITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>NIOBIAN RUTILE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>FERSMITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>EUXENITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>YTTROTANTALITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>CASSITERITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>COLUMBITE-TANTALITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>&quot;pseudo-xiolite&quot;</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>MICROLITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>APATITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>MONAZITE</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
<tr>
<td>SULPHIDES of Fe,CuMo</td>
<td>★★</td>
<td>★★</td>
<td>★★</td>
</tr>
</tbody>
</table>
The blocky K-feldspar and muscovite occurring in the Shatford Lake pegmatites show a wide range of rare alkali contents, but the overall level is low. The core muscovites are iron-rich, with up to 8.5 wt.% Fe₂O₃ in certain of the pegmatites. The pale green, sodic beryls, which frequently carry inclusions of quartz and albite, contain only minor amounts of lithium and cesium. Topaz occurs in a number of the pegmatites; crystals are up to 20 centimetres long, and contain 18.5 to 19.5 wt.% fluorine. The minerals of the columbite-tantalite group are highly disordered, and are generally enriched in titanium and tin. The Ta/(Ta+Nb) ratio in these minerals is quite variable, reaching a maximum in the SHP pegmatite. Additional minerals carrying niobium and tantalum occur in minor amounts in a number of the pegmatites. The rare-earth elements are an important component of the Shatford Lake pegmatites and are carried in a number of phosphate, complex oxide and silicate minerals. With the possible exception of the SHS-M and Huron Claim pegmatites, the absolute quantities of the rare-earth elements are very low. Uranium and thorium occur in the pegmatites mainly in metamict zircon. As discussed previously in this section, late hydrothermal alteration is a characteristic feature of the Shatford Lake pegmatite group. Calcite and chlorite are relatively common, muscovite replaces topaz, and REE fluorocarbonates replace monazite and allanite.

Variations in mineralogy and gross texture among the pegmatites of the Shatford Lake group, especially as they pertain to the feldspar minerals, suggest major differences in the course of crystallization and mutual properties of magma and supercritical fluids among the
individual pegmatite bodies. The major mineralogical and geochemical differences between the Huron Claim pegmatite and the remainder of the Shatford Lake group are discussed in the following section.

The Huron Claim Pegmatite — An Atypical Member of the Shatford Lake Group

The Huron Claim pegmatite obviously has many of the characteristics of the Shatford Lake pegmatite group, and has been formally assigned to this group by Černý et al. (1981b). Among the major similarities are the abundances of beryllium, niobium, tantalum, the rare-earth elements and sodium. Despite its inclusion in the Shatford Lake pegmatite group, certain features of the Huron Claim pegmatite distinguish it from the remainder of the group. The isolated location of the Huron Claim pegmatite, close to the Greer Lake pegmatite group, is one of the most obvious dissimilarities; it is the only member of the Shatford Lake pegmatite group east of the Lac du Bonnet batholith, with the possible exception of several small, flat-lying pegmatites situated approximately 200 metres east of the Huron Claim (Central Geophysics Ltd., 1958). The latter pegmatites were not examined by the author. The widespread and abundant development of sodic plagioclase in the Huron Claim pegmatite is not seen in the other pegmatites of the Shatford Lake group. Late, calcium metasomatic effects are much more pronounced in the Huron Claim pegmatite than they are in the other pegmatites of the group. The widespread replacement of columbite-tantalite by fersmite is a unique feature of the Huron Claim pegmatite.
Geochemically, the Huron Claim pegmatite shows some deviation from the trends evident in the remainder of the Shatford Lake group. Selected minerals from the Shatford Lake pegmatite group are compared to the Huron Claim pegmatite in Table 81. Enhanced values of $\text{Rb}_2\text{O}$ in both microcline-perthite and muscovite are very characteristic of the Huron Claim pegmatite. The pegmatite is enriched in uranium and thorium, and is the only member of the Shatford Lake group to carry uraninite. Tin is depleted in the Huron Claim pegmatite, in comparison to the other pegmatites in the Shatford Lake group. Cassiterite is absent, and tin is not a significant component of the multiple oxide minerals. The pegmatite shows significant enrichment in the light rare-earth elements, but the yttrium earths are depleted. This is in contrast to the remainder of the Shatford Lake group, in which euxenite, yttrotantalite and gadolinite are rare accessories. Fluorine is not a significant component of the Huron Claim pegmatite; topaz, if present, is extremely rare and the fluorine contents of muscovite are very low. Muscovite pseudomorphs after topaz, and fluorite, were not encountered during the present study.

The Huron Claim pegmatite was originally postulated as a hybrid geochemical type between the Shatford Lake and Greer Lake pegmatite groups (Černý and Turnock, 1971a). In contrast to the Shatford Lake group, the Greer Lake pegmatites are well-differentiated, albititized, beryl and columbite-bearing, blocky muscovite-microcline pegmatites. Despite small deviations from the norm, the gross mineralogical, chemical and morphological characteristics of the Huron Claim pegmatite show it to be a bona fide member of the Shatford Lake pegmatite group.
Table 81. Compositional characteristics of selected minerals from the Shattord Lake pegmatite group, compared to the Huron Claim pegmatite (modified from Černý et al., 1981b).

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Fe</th>
<th>Mn</th>
<th>Ca</th>
<th>Mg</th>
<th>Mn/(Mn+Fe) at.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garnet</td>
<td>(22.8)</td>
<td>(10.2)</td>
<td>(0.05)</td>
<td>(0.11)</td>
<td>0.50 (0.31)</td>
</tr>
<tr>
<td>6(16)</td>
<td>16.0</td>
<td>13.2</td>
<td>0.20</td>
<td>0.04</td>
<td>0.38 - 0.62 (0.20 - 0.40)</td>
</tr>
<tr>
<td>12.3 - 21.0</td>
<td>(19.8 - 26.6)</td>
<td>(6.5 - 12.8)</td>
<td>(0.00 - 0.11)</td>
<td>(0.00 - 0.20)</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>0.19</td>
<td>0.49</td>
<td>0.07</td>
<td>24.2</td>
<td>6.80</td>
</tr>
<tr>
<td>10(6)</td>
<td>(0.04)</td>
<td>(1.07)</td>
<td>(0.03)</td>
<td>13.4 - 53.3 (6.50 - 7.50)</td>
<td></td>
</tr>
<tr>
<td>0.02 - 0.50</td>
<td>0.16 - 1.09</td>
<td>0.01 - 0.54</td>
<td>0.02 - 0.03</td>
<td>6.1 - 12.3</td>
<td></td>
</tr>
<tr>
<td>L/H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(8.90)</td>
</tr>
<tr>
<td>Beryl</td>
<td>0.06</td>
<td>0.35</td>
<td>0.05</td>
<td>9.7</td>
<td>Na/L</td>
</tr>
<tr>
<td>17(18)</td>
<td>(0.03)</td>
<td>(0.25)</td>
<td>(0.05)</td>
<td></td>
<td>8.90</td>
</tr>
<tr>
<td>0.01 - 0.19</td>
<td>0.11 - 0.76</td>
<td>0.01 - 0.16</td>
<td>0.03 - 0.09</td>
<td>6.1 - 12.3</td>
<td></td>
</tr>
<tr>
<td>Blocky k-feldspar</td>
<td>0.17</td>
<td>0.35</td>
<td>0.052</td>
<td>81.3</td>
<td>K/Rb</td>
</tr>
<tr>
<td>53(50)</td>
<td>(0.03)</td>
<td>(0.11 - 0.70)</td>
<td>(0.003 - 0.0180)</td>
<td>(0.0008 - 0.0085)</td>
<td></td>
</tr>
<tr>
<td>0.09 - 0.30</td>
<td>0.11 - 0.22</td>
<td>0.00 - 0.19</td>
<td>0.00 - 0.056</td>
<td>14.4 - 36.5</td>
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<tr>
<td>Columbite-Tantalite</td>
<td>0.56</td>
<td>0.25</td>
<td>0.29</td>
<td>0.29 - 0.72 (0.07 - 0.47)</td>
<td></td>
</tr>
<tr>
<td>12(31)</td>
<td>(0.22)</td>
<td>(0.02 - 0.56)</td>
<td>(0.07 - 0.47)</td>
<td>31.0</td>
<td></td>
</tr>
</tbody>
</table>

Elements and ratios given in weight %, unless indicated.
Figures without brackets refer to the Shattord Lake pegmatite group, excluding the Huron Claim pegmatite.
Figures in brackets refer to the Huron Claim pegmatite.
Fractionation Trends Within the Shatford Lake Pegmatite Group

The well-established fractionation trends present in several other of the pegmatite groups in the Winnipeg River district are not observed in Shatford Lake pegmatite group. Plots of K/Rb and K/Cs in microcline-perthite, and K/Rb in the core muscovites are inconclusive. Along the north side of the Lac du Bonnet batholith, the least fractionated pegmatites seem to be clustered around the centre of Shatford Lake, and more fractionated pegmatites lie to the east and west. Certainly the Huron Claim pegmatite, with its low K/Rb and Th/U ratios and enhanced LREE content, is one of the most fractionated pegmatites in the entire group. This may be due more to its position above the nose of the Lac du Bonnet batholith than to its lateral distance away from Shatford Lake.

PARENTAL GRANITOID - THE LAC DU BONNET LEUCOGRAINITE

In the Winnipeg River district, the rare-element pegmatites have been established as the final, late to post-tectonic intrusive event. For this reason, recent petrogenetic investigations (e.g., Černý et al., 1981b) have been concerned with the youngest plutonic intrusions in the area, namely the Maskwa Lake, Marijane Lake and Lac du Bonnet composite batholiths, and the various pegmatitic granites. The composite batholiths, as described in the section on regional geology, consist largely of an older quartz diorite and a younger biotite granite. Structural, bulk chemical and trace element evidence indicates that there is a genetic difference between the quartz diorite and biotite granite. As evidenced by its compositional, oxygen isotope and Rb-Sr isotope characteristics, the quartz diorite probably originated
by partial melting of amphibolite in the lower crust or upper mantle, at depths of less than 60 kilometres. On the other hand, the biotite granite seems to have had a deep-seated juvenile origin, and probably formed by the melting of intermediate to mafic source rocks (Černý et al., 1981b).

The early, but highly fractionated leucogranite occurring within the Lac du Bonnet batholith is genetically separate from the late, less fractionated biotite granite. The leucogranite is characterized by undepleted HREE contents, a prominent negative europium anomaly, low contents of calcium and strontium and high contents of rubidium and cesium, all indicative of plagioclase removal during magma evolution. Igneous differentiation from granitoid parents with relatively flat, log-linear REE abundances would produce the geochemical signature observed in the Lac du Bonnet leucogranite. Low values of $\delta^{18}O$ in the leucogranite suggest a deep-seated, juvenile provenance. The leucogranite is apparently a shallow-seated igneous differentiate which evolved during the ascent of a deep-seated, juvenile granitoid precursor (Černý et al., 1981b). However, these authors also pointed out that the Lac du Bonnet leucogranite is very similar to the pegmatitic granites of the district in many of its geochemical characteristics.

The genetic evidence for the pegmatitic granites is inconclusive (Goad and Černý, 1981). The existing geochemical and isotopic data suggest a juvenile origin of parental magmas modified by later fractionation and reaction with the greenstone belt lithologies, or shallow anatexis of the greenstone belt lithologies followed by fractionation and reaction with these same rocks. The enhanced peraluminous
character of the pegmatitic granites and their depleted total REE contents have been attributed to the loss of fluids to the country rock (Goad and Černý, 1981).

In general, the rare-element pegmatites of the Winnipeg River district show a close spatial affinity to either the Lac du Bonnet leucogranite or the various pegmatitic granites (Černý et al., 1981b). The pegmatites are not associated with the quartz diorites and biotite granites of the composite batholiths. The spatial affinity of the pegmatites to the leucogranite and pegmatitic granites, the geochemical specialization of the granitic intrusions and the similarity in accessory mineralization between the granitic intrusions and their adjacent pegmatite groups provide unequivocal evidence for a genetic link between the granitic intrusions and the pegmatites. The similarity in accessory mineralization is particularly striking (Table 82), and there can be no doubt that the Shatford Lake pegmatite group is genetically linked to the Lac du Bonnet leucogranite. The leucogranite probably generated the Shatford Lake pegmatite group by continued igneous differentiation at the quartz-feldspar minimum, coupled with separation of supercritical fluids from a volatile oversaturated residual melt (Černý et al., 1981b). Although the data base is not voluminous, there seem to be no internal fractionation trends within the Lac du Bonnet leucogranite equivalent to those described for the pegmatitic granites (Goad, 1984). Geochemically, the leucogranite is quite uniform.
Table 82. Correlation of the accessory mineral content of the major granitic intrusions and their associated pegmatites, Winnipeg River district (after Černý et al., 1981b).

<table>
<thead>
<tr>
<th>Accessory Minerals</th>
<th>Local Mineralization</th>
<th>Characteristic Minor Elements</th>
<th>Accessory Minerals</th>
<th>Rare-Element Spectrum</th>
<th>Minor Elements</th>
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<tr>
<td><strong>LAC du BONNET LEUCOGRANITE</strong></td>
<td></td>
<td></td>
<td><strong>SHATFORD LAKE GROUP</strong></td>
<td></td>
<td></td>
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<tr>
<td>ZIRCON</td>
<td>Be - rare</td>
<td>Th. U - high</td>
<td>BERYL</td>
<td>Be</td>
<td>Th. U - high</td>
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<tr>
<td>ALLANITE</td>
<td></td>
<td>Li. Rb. Cs - very low</td>
<td>GARNET</td>
<td>Nb + Ta</td>
<td>Li. Cs - very low</td>
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<tr>
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<td></td>
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<td></td>
<td>ALLANITE</td>
<td>Zr</td>
<td>Rb - low</td>
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<td></td>
<td></td>
<td></td>
<td>MONAZITE</td>
<td>Th</td>
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<td></td>
<td></td>
<td></td>
<td>ZIRCON</td>
<td>Nb + Ta OXIDE MINERALS</td>
<td>minor Sn</td>
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<td></td>
<td></td>
<td></td>
<td>GARNET</td>
<td>U</td>
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<td></td>
<td>GARNET</td>
<td>Hf + Sn OXIDE MINERALS</td>
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<td></td>
<td></td>
<td>GARNET</td>
<td>Ti</td>
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<td>GARNET</td>
<td>LIOFALINITE</td>
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<td>GARNET</td>
<td>K-E</td>
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<td>GARNET</td>
<td>Ti + Nb OXIDE MINERALS</td>
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<td>LIOFALINITE</td>
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<td></td>
<td></td>
<td></td>
<td>GARNET</td>
<td>Li</td>
<td></td>
</tr>
</tbody>
</table>

| **GREER AND EAGLENEST LAKE PEGMATITIC GRANITES** | | | **GREER AND EAGLENEST LAKE GROUPS** | | |
| GARNET | Be | Li. Rb. Cs - moderate | GARNET | Be | Li. Rb. Cs - moderate |
| CORDIERITE | Nb + Ta | | CORDIERITE | Nb + Ta | |
| GARNET (rare) | Li. Rb. Cs - minor | | BERYL | | |
| | | | Nb + Ta OXIDE MINERALS | minor Li |
| | | | GARNET (rare) | | |

| **AXIAL PEGMATITIC GRANITE** | | | **AXIAL GROUP** | | |
| GARNET | | Li. Rb. Cs - low | GARNET | | Li. Rb. Cs - low |

| **TIN LAKE PEGMATITIC GRANITE** | | | **BIRSE LAKE GROUP** | | |
| GARNET | Mo - very rare | Li. Rb. Cs - very low | TOURMALINE | Be | Li. Rb. Cs - very low |
| TOURMALINE (rare) | | | BERYL | | |

| **OSIS LAKE PEGMATITIC GRANITE** | | | **RUSH LAKE GROUP** | | |
| GARNET | Li - rare | Li. Rb. Cs - moderate | TOURMALINE | Li | Li. Rb. Cs - moderate to very high |
| TOURMALINE | | | BERYL | Rb | Sn Be - high |
| Apatite | | | Li. AL SILICATES | minor Cs | Nb + Ta - high |
| | | | Li. PHOSPHATES | Be | P.B.F. - high |
| | | | Nb + Ta OXIDE MINERALS | Sn | |
| | | | POLLUCITE + | Ta + Nb | |
GADOLINITE-BEARING, BLOCKY MICROCLINE-BIOTITE PEGMATITES

Mineralogical, Chemical and Morphological Characteristics

The Shatford Lake pegmatite group was classified as a gadolinite-type, beryllium-enriched, partly albitized, blocky microcline-biotite group by Černý et al. (1981b), following the classification scheme of Beus (1951). For this reason, the Huron Claim pegmatite has been referred to as a "gadolinite-bearing" type throughout the text despite the fact that gadolinite has not been found at this locality.

Blocky, and fully-differentiated biotite-microcline pegmatites were distinguished as a distinctive type of beryllium-bearing pegmatite by Beus (1951). Although rare-earth element minerals are common in these pegmatites, they contain beryl or gadolinite only infrequently. They occur as fracture-filling bodies in gneissic, basic and ultrabasic rocks adjacent to granitic intrusions, or within the endocontact zones of the same intrusions. Gadolinite-bearing pegmatites are associated both with orogenic, calc-alkaline granites and anorogenic, alkaline granites.

The outer zone of gadolinite-bearing pegmatites is generally graphic quartz-microcline, or quartz-oligoclase. The interior parts of the pegmatites consist of a zone of blocky pegmatite surrounding a quartz core. At the boundary between the quartz core and blocky pegmatite zone occur scattered accumulations of tabular biotite. Small books of biotite are also present in the outer pegmatite zone. Muscovite is present only in subordinate amounts, generally close to the quartz core-blocky pegmatite contact.

The gadolinite-bearing pegmatites with the greatest concentration of rare-earth element minerals are usually albitized. The albite
replacement zones are generally discrete units of lamellar to granular albite, in which most of the rare-earth minerals are concentrated. Gadolinite may occur in the quartz core, or in the blocky microcline zone close to its contact with the quartz core. It is usually closely associated with the albite replacement zone, and with either biotite or muscovite. Thalenite, allanite, zircon, fergusonite, samarskite and other yttrium, niobium and tantalum-bearing minerals usually accompany the gadolinite. The pegmatites can also contain significant quantities of fluorite.

Common to all pegmatitic deposits of gadolinite are substantial quantities of the rare-earth elements, particularly the yttrium earths. The iron content is generally high, as indicated by the minerals biotite, magnetite and ilmenite. Fluorine occurs as a significant component of the pegmatites in the form of fluorite or topaz. Boron is generally insignificant.

The rarity, small size and low beryllium content of the gadolinite-bearing pegmatites makes them of no practical importance, although they have been worked for their feldspar and yttrium contents. Major pegmatite populations of this type have been documented in Scandinavia and the southern United States, in addition to southeastern Manitoba.

The Baringer Hill District, Central Texas

The gadolinite-bearing pegmatites of the Baringer Hill district in central Texas have been described by a number of authors, notably Hidden and MacKintosh (1889), Landes (1932), Ehlmann et al. (1964), Ewing and Ehlmann (1973) and Crook (1977). Much of the recent work by
Crook is of suspect authenticity (Peacor et al., 1982). There are twelve pegmatites in the district; the Baringer Hill, Rode Ranch and Clear Creek pegmatites are the only pegmatites of significant size. The pegmatites occur within Precambrian gneisses and schists, and also within the endocontact zone of the Precambrian Lone Grove pluton. The Baringer Hill deposit, now submerged under Lake Buchanan, was probably the world's largest pegmatitic deposit of gadolinite and other rare-earth minerals (Beus, 1966).

The pegmatites are present as irregular pods in their host rocks, and attain cross-sectional sizes of 75 x 30 metres and 250 x 100 metres in the Baringer Hill and Clear Creek occurrences, respectively. Most of the pegmatites have an outer zone of graphic, quartz-microcline pegmatite. This zone passes inward into a zone of blocky microcline-perthite, and ultimately into a quartz core. Discrete albite replacement zones comprised of coarse-grained to lamellar albite occur in the Baringer Hill and Rode Ranch pegmatites.

Biotite is a significant component of the Baringer Hill pegmatites, as are magnetite, fluorite and ilmenite. Gadolinite has been found in masses up to 90 kilograms, and allanite in masses up to 135 kilograms. Other rare-earth element minerals occurring in the pegmatites include fergusonite, samarskite, rowlandite, yttrialite and polycrase. Uraninite has also been found in several of the pegmatites.

The Gadolinite-Bearing Pegmatites of Southern Norway

The gadolinite-bearing pegmatites of southern Norway occur in Iveland County and the coastal regions west of Oslofjord, and also in the Frederikshald district east of Oslofjord. In the Iveland district
alone, more than 150 pegmatites have been quarried for their feldspar and rare-earth element contents. The descriptive accounts by Björlykke (1935; 1937) and Schneiderhöhn (1961) provide the basis for the following discussion.

The pegmatites are mainly zoned, blocky microcline-biotite pegmatites, although they are transitional in some areas into blocky microcline-muscovite pegmatites. They occur predominantly as irregular, lens-shaped pegmatites which have been intruded into Precambrian, amphibolitic host rocks. Dyke-like pegmatites in the district are notably deficient in rare-element minerals. The pegmatites can be subdivided into quartz-microcline and quartz-microcline-plagioclase varieties, but there is no relationship between the bulk composition of the pegmatites and their rare-element contents. In addition, cleavelandite-quartz "replacement" units carrying minor amounts of tourmaline, topaz, lithian micas and microlite are recognized in several pegmatites in the Iveland district. Björlykke (1937) separates the blocky microcline pegmatites into Ca-rich and Ca-poor varieties on the basis of their accessory mineral content.

Of all the gadolinite-bearing pegmatite districts in the world, the Norwegian pegmatites show the most similarity to the Shatford Lake group. They contain abundant Be, Nb, Ta, Ti, REE's, Th, U, Zr, Hf and W, and are depleted in Li and Sn. Biotite is a prominent accessory, and beryl is common in large crystals up to 1000 kilograms in weight. The rare-earth element minerals include gadolinite, thalenite, allanite, fergusonite, yttrotantalite, euxenite, samarskite, monazite and xenotime. The rare-element minerals apparently crystallized very early in the development of the pegmatites, and these minerals have undergone considerable syn-consolidation deformation.
Gadolinite-Bearing Pegmatites of the Stockholm District, Sweden

The gadolinite-bearing pegmatites of the Stockholm area are dealt with in Nordenskjöld (1906), Sundius (1948), Brotzen (1959a,b) and Schneiderhöhn (1961). Somewhat inadequately described on a regional basis, the pegmatites occur in Precambrian gneissic rocks and are genetically related to the Stockholm granite. Twenty-three gadolinite-bearing occurrences are listed by Brotzen (1959b), one of which is the famous Ytterby pegmatite located 20 kilometres ENE of Stockholm. In most instances, the pegmatites are comprised of a wall zone of graphic pegmatite, an intermediate zone of blocky microcline which is oligoclase- and biotite-rich in its outer section, and a quartz core. The rock-forming minerals of the pegmatite include microcline-perthite, quartz, oligoclase, biotite and muscovite. Prominent accessory minerals are beryl, apatite and garnet. The rare-earth element minerals include gadolinite, fergusonite, xenotime, yttrotantalite, allanite, euxenite, polycrase and aeschynite-(Y).

The Kangasala District, Southwestern Finland

The Pyoronmaa and Varola pegmatites in the Kangasala district of southwestern Finland occur within a late tectonic, Precambrian granite (Vorma et al., 1966). They consist of a wall zone of graphic pegmatite, an intermediate zone of microcline and albite, and a quartz core. The intermediate zone is particularly rich in albite, and contains all of the rare-earth element minerals. Allanite, xenotime, gadolinite, britholite-(Y), thalenite and fergusonite are all found within the Pyoronmaa pegmatite.
The pegmatite province west of Pitkaranta on the northern shore of Lake Ladoga is also reported to be a REE-enriched province (Vorma et al., 1966). The pegmatites of the Kimito district in southwestern Finland (Pehrman, 1945) are enriched in Y, Sc, Ta and Be, and have many of the attributes of the gadolinite-bearing pegmatite type. However, these pegmatites are sufficiently enriched in P and Li to eliminate them from further consideration.

Gadolinite-Bearing Pegmatites Related to Anorogenic, Alkaline Granitoids

The South Platte pegmatite district in Colorado is located within the northern part of the subalkaline Pikes Peak batholith (Simmons and Heinrich, 1980). In the vicinity of the South Platte district, the batholith consists of two different granitoids. Both granitoids are diopside-hedenbergite normative, Fe-rich and Mg-poor and both have high Ba/Rb ratios and high REE contents. There are about 50 pegmatites in the district, all of which occur at elevations between 2050 and 2340 metres within the Pikes Peak batholith. The pegmatites are distinguished by a core marginal zone of fluorite (yttriofluorite), and an albite replacement zone which contains accessory minerals of the yttrium earths, niobium and fluorine (Simmons and Heinrich, 1980).

Partly albitized, blocky microcline-biotite pegmatites containing gadolinite and other rare-earth element minerals occur in the Kola Peninsula, USSR, in association with alkaline granites (Beus, 1966). They occur as thin, transgressive veins along the contact between the alkaline granite and the surrounding gneissic rocks. Microcline-perthite (amazonite) and biotite are the distinguishing rock-forming
minerals, whereas gadolinite, fluorite, magnetite, hematite and zircon occur as accessory minerals.

The gadolinite-bearing pegmatites of the South Platte district and the Kola Peninsula, due to their alkaline affinity, constitute a separate class of rare-earth element pegmatites which cannot be directly compared to the gadolinite-bearing pegmatites in Scandinavia, southeastern Manitoba and central Texas.

Paragenetic Summary

Having discussed the characteristics of the Huron Claim pegmatite, the Shatford Lake pegmatite group and gadolinite-bearing, blocky microcline-biotite pegmatites in general, some commentary is warranted. A paragenetic comparison of the important rare-earth element pegmatite districts is provided in Table 83.

Sodium occurs in unusual amounts in the Shatford Lake pegmatite group (particularly in the Huron Claim pegmatite), in comparison to the other pegmatite districts discussed in the text. The presence of biotite, iron-rich muscovite, chamosite, almandine, epidote and magnetite in the Huron Claim pegmatite indicates a surfeit of iron over magnesium, a feature common to all gadolinite-bearing pegmatites. Boron is present in negligible amounts in the Shatford Lake pegmatites, as it is in all the gadolinite-bearing pegmatite groups. Fluorine plays an important role in most rare-earth element pegmatites, but this element is not as obvious in the Shatford Lake pegmatite group as it is in the other occurrences. Phosphorus is present in apatite and monazite in the Huron Claim pegmatite, but is not a major constituent.
| Mineral                  | Bartholomew Hill District, Central Texas | Shafter Lake District, Southern Oregon, Washington, Idaho, Nevada | Stockton District, Southern California, Baja California, Mexico | Kangasala District, Southern Finland | Golcany, Southern Ontario 
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<tr>
<td>Microcline-Perthite</td>
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<tr>
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<td>Secondary U, Th Oxides</td>
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It is the rare elements, rather than the major and subordinate elements, which best characterize the gadolinite-bearing pegmatites. The Shatford Lake group contains only a single occurrence of gadolinite, but is very rich in sodic beryl. The cerium rare earths are predominant throughout the Shatford Lake pegmatite group, particularly in the Huron Claim pegmatite, and this may account for the lack of gadolinite, xenotime and yttrium-niobium-tantalum oxide minerals. Similarly, the relative abundance of columbite-tantalite (and fersmite) may be due to yttrium depletion. Zirconium, hafnium, uranium and thorium are very significant minor elements in the Huron Claim pegmatite, as they seem to be in all gadolinite-bearing pegmatites. Lithium and cesium are extremely depleted in the Shatford Lake pegmatites, and this seems to be the case in most rare-earth element pegmatite groups. The rubidium content in the Huron Claim pegmatite is high by Shatford Lake standards, but a comparison with other gadolinite-bearing pegmatites is impossible, due to a lack of data for these pegmatites.

A comparison of the Huron Claim pegmatite to the Shatford Lake group as a whole, and to the other rare-earth element pegmatites in the literature, suggests that it is adequately characterized as a gadolinite-bearing, blocky microcline-biotite pegmatite, despite minor differences in its rare-element spectrum.
CHAPTER IX
ECONOMIC CONSIDERATIONS

The Huron Claim pegmatite, which is a past producer of beryl, feldspar and columbite-tantalite, contains a number of minerals of economic importance. During the initial development work in 1930, 225 kilograms of columbite-tantalite concentrate were recovered from the pegmatite, as well as an undisclosed amount of feldspar. An 85 tonne sample containing about 2 tonnes of beryl was removed from the pegmatite during 1957. Other minerals of economic importance in the pegmatite include monazite and uraninite. Despite the diversity and commercial value of its mineral constituents, the Huron Claim pegmatite is not an economically viable deposit due to its extremely small size. Bulk sampling done during the two main periods of exploitation has virtually exhausted the rare mineral content of the pegmatite.

Beryllium and tantalum are the main commodities of interest in the Huron Claim pegmatite, and an estimate of the minimum resource size for these commodities is required to place the Huron Claim in proper perspective. During the past 25 years, the value of beryl in concentrate form, in the United States, has fluctuated between US$3/kilogram and US$14/kilogram; the present value is about US$9/kilogram. The largest beryllium deposit in North America is located at Spor Mountain, Utah, where there are reserves of 3,625,000 tonnes grading 0.64% BeO. The Thor Lake deposit in the Northwest Territories, which is currently in the "feasibility study" stage, contains proven reserves of 1,600,000 tonnes at a grade of 0.75% BeO (additional reserves are thought to be present). These deposits are being, or will be, mined by opencast
methods. Given the size and grade of these two deposits, the smallest beryllium deposit that could be brought into production would probably be on the order of 900,000 tonnes at a grade of 0.60% BeO (W.C. Hood, pers. comm.). The beryliferous pegmatites south and west of Greer Lake, including the Huron Claim pegmatite, were evaluated by Central Geophysics Ltd. of Winnipeg during 1957 and 1958. Some 15 individual pegmatites occur in the Greer Lake group, most of which are less than 100 metres long and 10 metres wide (Černý et al., 1981b). The total reserve for this group of pegmatites was estimated to be several million tonnes at a grade of 0.40% beryl, or 0.06% BeO (Central Geophysics Ltd., 1958). The grade is uniformly low, with no high grade material available for selective mining. Mining costs would be high due to the small size of the pegmatites. A comparison of the Greer Lake reserve with the previously quoted minimum resource figure, indicates that the beryllium content of these pegmatites is much too low to support commercial production. Additional problems are encountered in the Huron Claim pegmatite, due to widespread alteration of the beryl component. In general, gadolinite-bearing blocky microcline-biotite pegmatites are too small and too low grade to be of any importance as beryllium producers (Beus, 1962).

The price of Ta₂O₅ concentrate over the past 25 years has varied from US$15/kilogram to US$265/kilogram, and at present is about US$65/kilogram. Most of the world's tantalum is recovered as a by-product from alluvial tin mining, and underground operations like the TANCO mine are the exception rather than the rule. The minimum reserve and grade figures for an economically viable tantalum deposit are estimated to be 900,000 tonnes at a grade of 0.10% Ta₂O₅.
(W.C. Hood, pers. comm.). Material grading 0.04% \( \text{Ta}_2\text{O}_5 \) is mined from the Greenbushes pegmatite in Western Australia, but this is an open-cast operation from which substantial amounts of tin are recovered. Not only is columbite-tantalite present in very small accounts in the Huron Claim pegmatite, it is also niobium-rich and extensively altered to fersmite. Only very small quantities of this material remain in the pegmatite at the present time.

Other minerals of economic interest in the Huron Claim pegmatite include monazite, uraninite and feldspar. Monazite is an important ore mineral of thorium and the light rare-earth elements, but it occurs in commercially recoverable quantities only in certain alluvial deposits. In the Huron Claim pegmatite, it is not present in sufficient amounts to justify its extraction. Gadolinite-bearing, blocky microcline-biotite pegmatites have been mined in the past for their yttrium-earth content (Beus, 1966). Gadolinite has been mined from the Baringer Hill pegmatite in central Texas (Landes, 1932), and also from a number of pegmatites in southern Norway (Björlykke, 1935). The Norwegian pegmatites were mined primarily for their feldspar content, with gadolinite being produced as a by-product. Uraninite and thorite in the Huron Claim pegmatite are also present in insignificant amounts. Radioactive minerals pose extraction problems in some deposits, as they are included in and readily contaminate the rare mineral concentrates. The feldspar minerals in the Huron Claim pegmatite could conceivably be quarried, provided there was a local demand; feldspar at one time was removed commercially from a large quarry on the south shore of Greer Lake (Central Geophysics Ltd., 1958).
For several reasons, particularly its small size, the Huron Claim pegmatite is not an economically exploitable deposit. The pegmatite is readily classified in the field on the basis of its mineralogy, and its economic potential quickly ascertained. The economic potential of individual pegmatites can also be established by geochemical means, and this becomes increasingly important in unexplored pegmatite fields or partially outcropping pegmatites. In the latter case, preliminary geochemical evaluation can eliminate costly diamond drilling or trenching. The geochemical signature of the Huron Claim pegmatite, as it applies to its mineralization potential, is considered next.

One of the more useful schemes for pegmatite evaluation is based on the lithium, rubidium and cesium contents of K-feldspar and muscovite (Gordiyenko, 1970; 1971). Five pegmatite groups are defined on the basis of the average content of rare alkalies in the two minerals (Figures 61 to 63). The data on which the pegmatite subdivisions are based include muscovite and K-feldspar from a number of generations, meaning that paragenetic differences among samples have little effect on the reliability of the graphs. Table 84 lists the average content of lithium, rubidium and cesium in K-feldspar and muscovite from the Huron Claim pegmatite. The Huron Claim specimens cover a range from the least fractionated to moderately fractionated pegmatite types. With one exception, Li in muscovite, the alkali contents in muscovite and K-feldspar do not approach the values found in the most fractionated spodumene and lepidolite-bearing pegmatites.
Figure 61. Rb contents of muscovite and K-feldspar typical of barren pegmatites in mica-bearing provinces (lb), barren pegmatites in rare-element provinces (la), spodumene pegmatites containing Be,Nb and Ta (II), spodumene pegmatites containing Li,Be and Ta with subsidiary Nb and Sn (III), and spodumene and lepidolite pegmatites containing Li,Cs,Be and Ta with subsidiary Nb and Sn (IV). Vertical bars represent one standard deviation. Horizontal bars are the average values of specimens from the Huron Claim pegmatite (upper bar = muscovite, lower bar = K-feldspar).
Figure 62. Li contents of muscovite and K-feldspar as an indicator of economic potential. Pegmatite subdivisions as in preceding figure.
Figure 63. Cs contents of muscovite and K-feldspar as an indicator of economic potential. Pegmatite subdivisions as in Figure 61.
Table 84. Average Li, Rb and Cs values in muscovite and K-feldspar from the Huron Claim pegmatite.

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<th>No. of samples</th>
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<tr>
<td>muscovite</td>
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<td>398</td>
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<td>10733</td>
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<td>K-feldspar</td>
<td>50</td>
<td>7.7</td>
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\( \bar{x} \) - mean \hspace{1cm} \( \bar{6} \) - standard deviation
A second method of geochemical classification involves the K/Cs to Na₂O ratio in K-feldspar (Gordiyenko, 1976). The pegmatite groups in this classification scheme are shown in Figure 64, on which data from the Huron Claim has been superimposed. The Huron Claim K-feldspars cover parts of three fields, overlapping into the field of mica-bearing pegmatites. The K-feldspars are confined to the least fractionated to moderately fractionated pegmatite fields, and do not approach the fields of the most fractionated, Li-bearing pegmatites. The wet chemical analyses include only one or two albitized K-feldspars, suggesting that metasomatic effects are only marginally responsible for the wide range in sodium values.

The K/Rb to Cs ratios in K-feldspar have been used by Černý et al. (1981b) to evaluate the pegmatites in the Winnipeg River district. The data base of these authors consists exclusively of blocky K-feldspar from the inner intermediate zone of the pegmatites, close to the quartz core. As expected, the Huron Claim K-feldspars plot in the barren to Be-bearing pegmatite fields (Figure 65).

The variation in the alkali content of beryl is also a useful estimate of the degree of pegmatite fractionation. The Na/Li to Cs ratio in beryl was used by Černý (1975) to discriminate between different types of pegmatites. As discussed in an earlier section, beryl from the Huron Claim contains very little cesium, relegating the pegmatite to the field of barren or Be, Nb and Ta-bearing pegmatites.

According to Gordiyenko (1970), prospective Ta-rich pegmatites should contain muscovite with an average Ta₂O₅ content greater than 80 or 90 ppm. The Huron Claim muscovites greatly exceed this minimum value, as they contain an average value of 204 ppm Ta₂O₅ (standard deviation, 7 ppm).
Figure 64. K/Cs versus Na$_2$O diagram for pegmatitic K-feldspars. Subdivision (3) is the field for mica-bearing pegmatite provinces, while subdivisions (1) and (2) represent rare-element pegmatite provinces (2=Li-bearing pegmatites without Cs, 1=Cs-bearing pegmatites). Dots are Huron Claim K-feldspars.
Figure 65. K/Rb versus Cs in blocky K-feldspar. Heavy lines represent the first appearance of significant mineralization in the Winnipeg River pegmatite district. Dots are K-feldspar from the Huron Claim.
It should be noted that the area northwest of Greer Lake received extensive lithogeochemical coverage during the late 1970's, as part of an evaluation of the Bird River greenstone belt by the Tantalum Mining Corporation. A number of lithium lithogeochemical anomalies were outlined in the area, but these were not pursued, as subsequent exploration activity was confined to the central and western parts of the greenstone belt (W.C. Hood, pers. comm.). For several reasons, the eastern part of the greenstone belt, which includes the Greer Lake area, is not a particularly good area for pegmatite exploration. Dilational features are not well-developed in this part of the greenstone belt, and the pegmatite groups showing asymmetric fractionation trends are differentiated westward, presumably towards a lower pressure structural regime (Černý et al., 1981b). No economically significant pegmatite finds have been made in the eastern part of the greenstone belt. The only realistic economic target would be an extremely fractionated, giant pegmatite of the TANCO type, a pegmatite type that is far more likely to be found in the central and western parts of the Bird River greenstone belt than in the area around Greer Lake.
CHAPTER X

CONCLUSIONS

In the preceding chapters, the general geologic setting, gross shape, internal structure, mineralogy and geochemistry of the Huron Claim pegmatite have all been discussed. The internal evolution of the pegmatite, and the conditions under which it formed, have been briefly commented on. Some emphasis has been placed on the paragenetic position of the pegmatite within the Winnipeg River district, and on its similarity to other rare-element pegmatites of the gadolinite-bearing type. A number of conclusions can be drawn from the present work, all of which have been expressed by other authors (e.g., Cerny et al., 1981b). No significantly different opinions on the genesis and classification of the Huron Claim pegmatite are presented in the current study. The main conclusions are as follows:

1. The Huron Claim pegmatite, on the basis of its rock-forming and rare-element constituents, is best classified as a gadolinite-type, partly albitized, blocky microcline-biotite pegmatite, containing significant amounts of Be, Nb>Ta, REE, U, Th, Zr>Hf and Rb.

2. The pegmatite shows all of the geochemical characteristics of the Shatford Lake group, and is properly classified as a member of this group.

3. Despite its overall similarity, the Huron Claim pegmatite has certain mineralogical and geochemical characteristics which distinguish it from the remainder of the Shatford Lake group.
Albite is particularly abundant in the Huron Claim pegmatite, and late calcium minerals extensively replace beryl and columbite-tantalite. The high U and Rb contents of the pegmatite, low Sn and F contents, and marked enrichment in LREE/(HREE + Y) are unmatched in the rest of the Shatford Lake group. Of the pegmatites forming this group, the Huron Claim pegmatite is certainly the most fractionated.

4. The Huron Claim pegmatite is of no economic importance, due mainly to its small size. The nature of the pegmatite, a "gadolinite-bearing" rare-element type, combined with its location in the southeastern part of the Bird River greenstone belt, indicate that the area in the immediate vicinity of Greer Lake is not a prospective one for economically viable deposits of Ta, Be, Li, Cs and related rare elements.
CHAPTER XI
SUGGESTIONS FOR FUTURE WORK

The Huron Claim pegmatite has been thoroughly investigated in the past, but the possibilities for further research have certainly not been exhausted. Certain aspects of the internal structure and mineralogy of the pegmatite are incompletely understood despite the small size of the pegmatite and relatively small number (30) of mineral species. In addition to the present study, the pegmatite has also been examined on a number of occasions in the past. The present work has touched on most aspects of the mineralogy and geochemistry of the Huron Claim pegmatite, but small gaps exist in the mineralogical record, and detailed work is required on certain of the mineral species.

The Huron Claim pegmatite has been extensively sampled in the past, and the dumps at the present time are very much overgrown. It is unlikely that additional sampling would turn up much of mineralogical interest. The internal zonation of the pegmatite and the albite "replacement" unit, in particular, are rather ill-defined. The author did little work on this thesis between May, 1980 and February, 1984, during which time most of the original specimens were discarded. The description of the internal zonation is based on the author's early field and laboratory notes, which could not be correlated with the original hand specimens. Although the overall aspects of the internal zonation are undoubtedly correct, field re-examination of the various feldspar exposures (using the present thesis as a guide) might well clear up some of the uncertainties surrounding the "replacement" albite.
Mineralogical areas requiring further work will be evident from the text. A large number of thin sections, polished thin sections and polished sections were produced during the present study, and detailed examination of these sections would be the best means of identifying additional species. A number of mineral species in the Huron Claim pegmatite would benefit from additional work. The Nb-Ta-Ti oxide minerals, in particular, require additional work before they are completely characterized. Additional microprobe analyses of columbite-tantalite are needed to fully identify the fractionation trends, and an investigation of the optical and chemical inhomogeneity of individual grains is also warranted. The microlite occurrences require further documentation and the unknown Nb-Ta oxide mineral should be identified. Euxenite should be annealed and X-rayed, and additional microprobe analyses of this mineral would be valuable. The monazites in the Shatford Lake and Greer Lake pegmatite groups show interesting compositional differences, and additional analyses (particularly of the REE's) are required. The monazites could be microprobed, given an adequate set of REE standards. Additional compositional data is also needed for the near-contact, late vein and granular albites, and this data would have to be obtained on the electron microprobe, due to the grain size of these albites. One of the potassium feldspar profiles has been resampled, and these samples are currently being analyzed. Additional microscopic examination of the "replacement" albite might be of some use in deciphering the feldspar relations. An analysis of one of the fine-grained "late" muscovites would be desirable, although there might be some difficulty in separating the requisite amount of material for analysis. Electron
microprobe analyses of epidote are warranted, to accurately describe any compositional differences between the two colour varieties. The hydrated U- and Th-silicates should be identified, although this might be difficult due to their fine grain size. Enough apatite exists for a chemical analysis, and the bertrandite requires better documentation. The clay minerals show some variety, and they should be properly identified using X-ray techniques.


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