THE CARIBOO-BELL ALKALINE STOCK,

BRITISH COLUMBIA

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

Richard James Bailes

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ABSTRACT

The Upper Triassic Cariboo-Bell alkaline stock, in south-central British Columbia, near Williams Lake, intruded contemporaneous alkaline volcanic flows and pyroclastic rocks. Evidence in the stock and in the volcanic strata suggests that the Cariboo-Bell stock was a volcanic centre.

The stock, which ranges in composition from nepheline syenite to gabbro, is slightly elongated in a northwesterly direction, parallel to the trend of volcanic strata. It underlies about 30 km^2 and is approximately 7 km by 5 km in dimensions. The main units of the stock are three stacked lenses which are concordant with the volcanic strata, thus prompting the description of the stock as a tilted multiple laccolith (Hodgson et al, 1976).

The most complex unit in the stock is an intrusion breccia which occurs near the contact of monzonite porphyry and syenodiorite, two of the stacked lenses. It contains fragments of syenodiorite, monzonite porphyry and volcanic rock in a monzonite porphyry matrix, and resulted from the upward intrusion of monzonite porphyry through volcanic strata, syenodiorite, and consolidated monzonite porphyry. The intrusion breccia was the focus for crackle brecciation, rock alteration and copper mineralization, all of which are closely associated with one another, and are zoned around intrusion breccia. It is suggested that the crackle breccia resulted from the sudden explosive release of built-up fluid pressure following partial consolidation of the monzonite porphyry. Dispersion of these fluids resulted in alteration and sulphide mineralization of the breccia zones.

Several features at Cariboo-Bell are characteristic of sub-volcanic intrusion. Numerous cavities, fine-grained porphyritic textures, numerous dykes, volcanic screens, and high temperature minerals such as sanidine and pseudoleucite indicate that Cariboo-Bell was intruded at a high

stratigraphic level in the contemporaneous volcanic strata. Chemical and physical similarities between Cariboo-Bell and the surrounding volcanic rock suggest a common origin. The distribution of volcanic rock indicates that the Cariboo-Bell intrusion was a focal point for volcanic eruptions in the area.

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INTRODUCTION

Location and Access

The Cariboo-Bell alkaline stock, which is Triassic in age, is 55 km northeast of the town of Williams Lake in south-central British Columbia (Fig. 1). A subeconomic porphyry copper deposit is located in the eastern part of the stock, between Polley and Bootjack lakes. Access to the property is by 90 km of all-weather gravel road from Highway 97 at 150 Mile House.

Statement of Problem

The Cariboo-Bell alkaline stock is a member of the little studied and poorly understood syenitic suite of porphyry copper deposits which are found in the Canadian Cordillera (Sutherland Brown et al, 1971). It is important geologically because it displays the coeval relationship between itself and surrounding volcanic strata. This thesis is a study of the structure, mineralogy and petrology of the Cariboo-Bell alkaline stock in an attempt to better understand its petrogenesis.

The present study involved a two-week examination of the Cariboo-Bell stock and surrounding strata by the author in 1970, and two weeks of mapping and core logging by the author and C.J. Hodgson in July 1971. Seventy-four thin sections from the stock were examined, and ten whole rock analyses were done for the author by the AMAX Exploration laboratory. The stock was re-examined by the author and C.J. Hodgson in September, 1975.

Previous Work and Property History

The Cariboo-Bell stock was first mapped by R.B. Campbell during the course of reconnaissance mapping for the Geological Survey of Canada

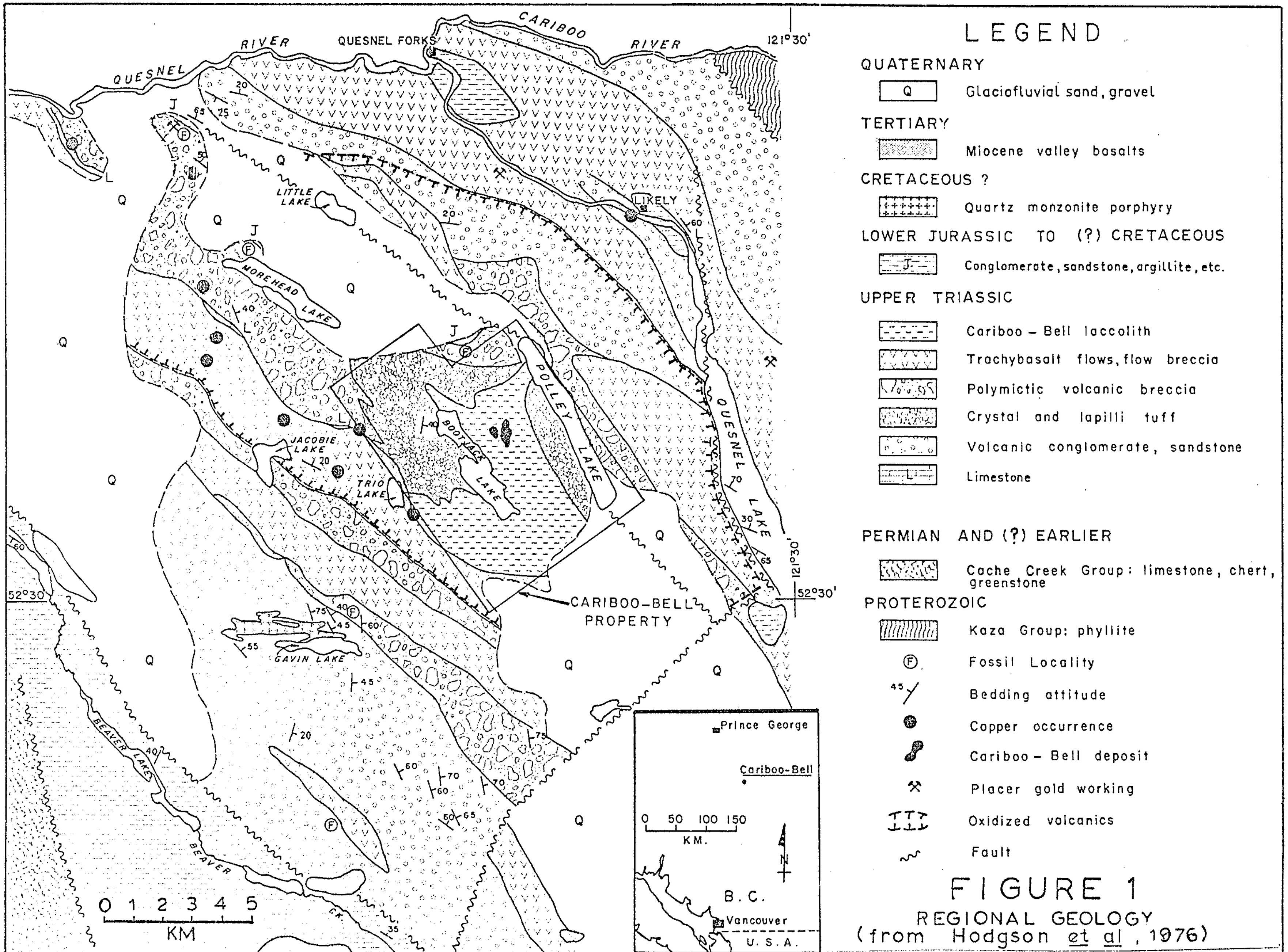

FIGURE 1
REGIONAL GEOLOGY
(from Hodgson *et al*, 1976)

in the late 1950's (Campbell, 1961). In 1964, a strong aeromagnetic anomaly caused by the stock, and expressed on Geological Survey of Canada Map 7221G, brought the area to the attention of Mastadon Highland Bell Mines Ltd. which staked the anomaly in the same year. Subsequent examination showed copper and gold mineralization to be associated with the stock, and a new company called Cariboo-Bell Copper Mines Ltd. was formed. Drilling commenced in 1966 and was largely financed by a consortium of Japanese companies which later withdrew due to metallurgical difficulties caused by oxidation of the copper minerals. Teck Corporation Ltd. acquired control of Cariboo-Bell Copper Mines in 1969.

Between 1966 and 1974 a total of 18,264 metres of diamond drilling and 8,734 metres of percussion drilling were carried out on the property. Thirty-four million tonnes of rock with a grade of 0.5% Cu and 0.68 gm/tonnes Au were outlined. The property is not considered to be economic at present (February, 1976).

Sutherland Brown (1967) wrote a preliminary report on the geology of the east half of the stock, between Polley and Bootjack lakes. Lee (1970) mapped the main mineralized area, and his geological map was used as a guide in the initial stages of the author's work; however, the geological map and the interpretation produced in this thesis are entirely the author's.

REGIONAL SETTING

The thesis area is in the copper-rich Quesnel Trough in the Intermontane Tectonic Belt of the Northwestern Cordillera. The Intermontane Belt is one of five north-trending subparallel tectonic belts in the Canadian Cordillera.

The Intermontane Belt is composed principally of Late Paleozoic, Triassic, and Jurassic eugeosynclinal volcanic and volcaniclastic rocks (Sutherland Brown et al, 1971). It is about 2,000 km long, extending from the 49th to the 59th Parallel, and about 250 km wide. Canadian Cordilleran porphyry copper deposits occur preferentially in this belt.

The Quesnel Trough is a long narrow zone of dominantly weakly deformed Lower Mesozoic rocks along the eastern edge of the Intermontane Belt. It is flanked by older geanticlines composed of more deformed rocks (Campbell and Tipper, 1970), and is about 50 km wide extending from the United States border to north-central British Columbia.

The Quesnel Trough is economically important because it contains numerous porphyry copper deposits. These include Copper Mountain, Afton, Lornex, Valley Copper, Bethlehem and Gibraltar.

Sutherland Brown et al (1971) subdivided porphyry copper deposits of the Canadian Cordillera into two petrogenetic suites: (1) calc-alkaline and (2) syenitic. Mineralized plutons of the main calc-alkaline suite are described as dominantly quartz monzonite, and less commonly granodiorite, quartz diorite or granite in composition. Molybdenite is almost always present although molybdenum/copper ratios are variable. Mineralized porphyries of the syenitic suite have a wide range in composition but many are monzonite. As described by Sutherland Brown et al (1971), common features of the syenitic porphyry deposits are complex structural relations to country rocks as well as complex internal intrusive relations, and intense fenitization of adjacent or included volcanic rocks. Fractures and breccia voids are generally filled with biotite, feldspar, zeolites, and ore minerals. Examples of the calc-alkaline suite are Lornex, Bethlehem, Valley Copper and Gibraltar. The syenitic suite includes Copper Mountain, Afton and Cariboo-Bell.

VOLCANIC STRATA

In the vicinity of Cariboo-Bell, the Quesnel Trough is about 35 km wide. Country rocks near this deposit, which is centrally located in the trough, are Upper Triassic to Lower Jurassic, purple to grey crystal and lapilli-tuffs, polymictic volcanic breccias, reworked volcanic sedimentary rocks, flows and flow-breccias. They trend about 150°, parallel to the elongation of Bootjack and Polley lakes (Fig. 1), and dip moderately to steeply to the east.

The volcanic rocks are alkaline in character. Flow rocks are green augite trachybasalt and purple analcite trachybasalt; the former contains abundant prominent phenocrysts of augite and minor serpentinized olivine in a groundmass of augite, aegerine-augite, orthoclase and calcic andesine, and the latter, which contains 5-10% analcite both in the groundmass and as phenocrysts, is a finer grained rock with less prominent mafic phenocrysts (Hodgson et al, 1976). Many of the volcanic rocks collected in the area were etched in hydrofluoric acid and then immersed in a saturated solution of sodium cobaltinitrite. In all cases, the matrix and many of the fragments were observed to stain yellow, indicating the presence of potassium (Jackson and Ross, 1956). Yellow staining affected from 20 to 70% of the rock surfaces tested.

Of particular interest is the volcanic breccia, which occurs in several localities near the centre of the trough (Fig. 4). This unit is unsorted and contains angular volcanic fragments up to block size. Clasts of crystal and lapilli-tuff, syenodiorite, monzonite porphyry, and syenite as well as trachybasalt are present in a thick polymictic breccia unit northwest of Cariboo-Bell (Fig. 1). The proximity of this unit to Cariboo-Bell, and the similarity of many of the plutonic fragments in the volcanic breccia to rocks from the Cariboo-Bell stock originally led to the hypothesis that Cariboo-Bell was a volcanic centre.

Hodgson et al (1976) suggested that the gross stratigraphic features of the entire volcanic sequence display several stages in the development of a major volcanic centre at Cariboo-Bell. They wrote:

> "Volcanic conglomerate at the base of the sequence forms a widespread blanket deposit derived from unknown, distant volcanic sources. All remaining strata comprise a proximal volcanic assemblage. Lower proximal strata are grey-green and contain pillow breccias and slump structures indicative of submarine deposition. Succeeding strata, with the exception of limestone and green crystal and lapilli tuff, are maroon and purple and were subaerially deposited. They form a zone of oxidized volcanic strata (Figure 1) which is widest at Cariboo-Bell and tapers gradually along strike to terminate at points roughly 30 km on either side of Cariboo-Bell outside the map-area. The limited lateral extent and thickness of the crystal and lapilli tuff apron adjacent to the Cariboo-Bell intrusion suggest that it formed by airfall deposition at the eruptive centre. Polymictic breccias immediately adjoining the apron incorporate fragments of this material and represent mudflow deposits farther downslope."

INTRUSIVE ROCKS

The Cariboo-Bell alkaline stock, which underlies about 30 km^2 between Polley Lake and Trio Lake, is centred on Bootjack Lake (Fig. 1). Here, Upper Triassic volcanic rocks were intruded by a complex stock of alkaline rocks that range in composition from nepheline syenite to gabbro. The stock is slightly elongate in a northwesterly direction and is about 7 km by 5 km in dimensions; the long direction is parallel to the trend of the volcanic strata. The main units of the stock are three stacked lenses, which are concordant with volcanic strata, thus prompting the description of the stock by Hodgson et al (1976) as a tilted multiple laccolith.

The lenses are, from east to west: monzonite porphyry (Unit 5, Fig. 2); syenodiorite (Unit 4, Fig. 2); and pseudoleucite nepheline syenite (Unit 3, Fig. 2). Intrusion breccia (Unit 6, Fig. 2) occurs near the contact of monzonite porphyry and syenodiorite. Pyroxenite and gabbro (Unit 8a,b, Fig. 2) occur in syenodiorite along the eastern shore of Bootjack Lake. The volcanic strata and intrusive lenses strike about 140° and dip moderately to the east (Fig. 3).

The relative age of the pseudoleucite nepheline syenite is not known; however, the sequence of intrusion of the rocks east of Bootjack Lake is syenodiorite, followed by monzonite porphyry accompanied by brecciation, and pyroxenite-gabbro.

Several dyke rocks cut the Cariboo-Bell stock. These are crowded monzonite porphyry (not shown on Fig. 2), sanidine monzonite porphyry (Unit 7, Fig. 2), augite porphyry (Unit 8c, Fig. 2), and quartz monzonite porphyry (Unit 9, Fig. 2).

The Cariboo-Bell alkaline stock was emplaced at a high level in the contemporaneous Upper Triassic volcanic strata. An absolute age of 184 ± 7 m.y. (Upper Triassic) was obtained from coarsely crystalline

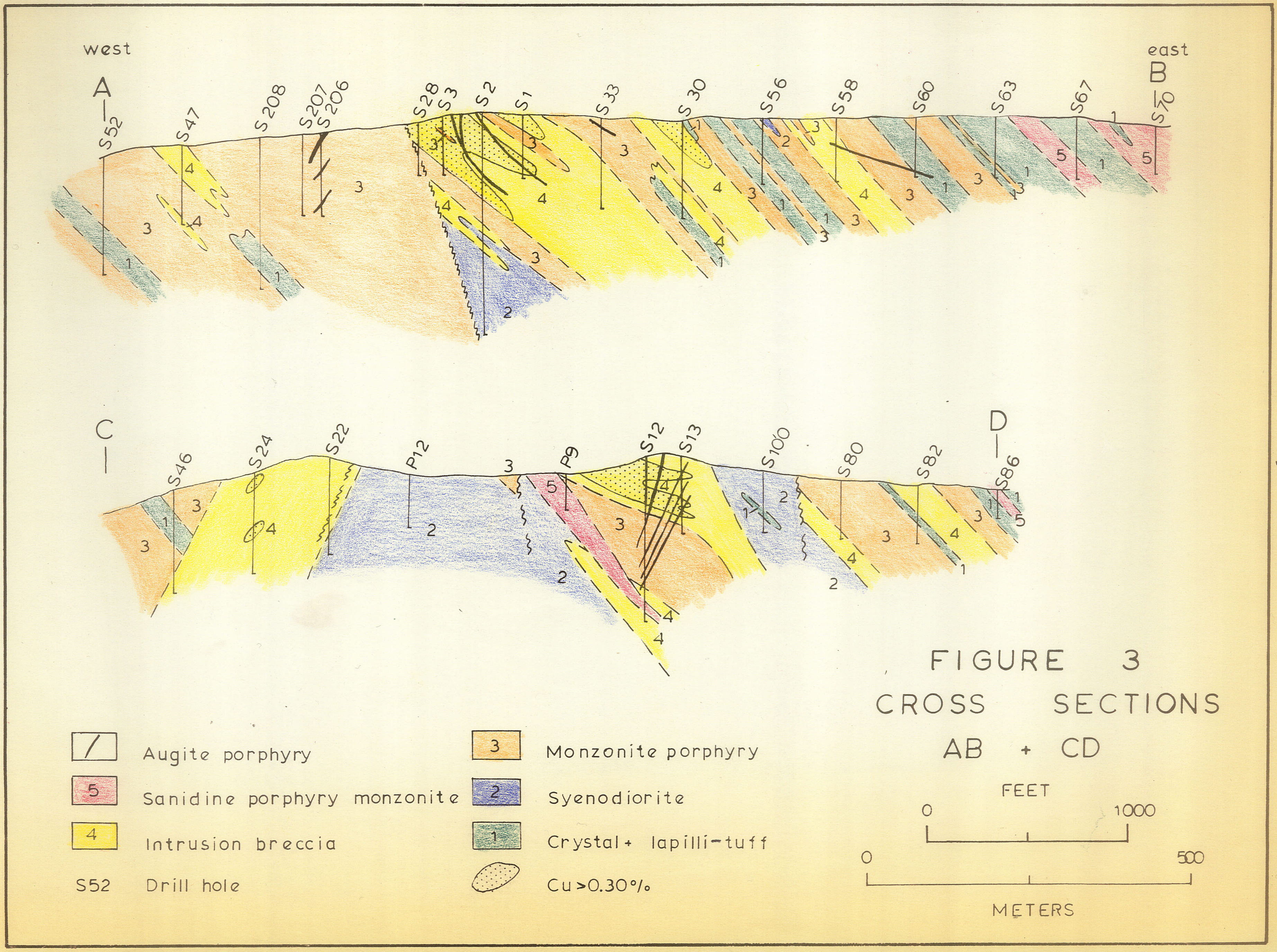

FIGURE 3
CROSS SECTIONS
AB + CD

FIGURE 4. Photograph of polymictic volcanic breccia showing unsorted angular fragments of monzonite porphyry, syenite(?) (pink and beige) and trachybasalt (brown) in a tuffaceous matrix.

in a tuffaceous

biotite in the No. 2 Cu zone by K/Ar dating (Hodgson et al, 1976). The stock displays several features characteristic of high level intrusion: numerous cavities, breccias, fine-grained porphyritic textures, numerous dykes, volcanic screens, and high temperature minerals such as sanidine and pseudoleucite (Tuttle, 1952a).

The units in the stock are concordant with coeval volcanic strata and were therefore emplaced horizontally and subsequently tilted about 50° to the northeast. Features characteristic of high level intrusion are much more pronounced in the eastern, or upper part of the stock; whereas the western, or lower part of the stock displays coarser plutonic textures.

Pseudoleucite Nepheline Syenite (Unit 3, Fig. 2)

The westernmost or lowest unit is a pseudoleucite nepheline syenite. It is light grey to pink in colour, grey weathering, medium to coarse-grained, and is characterized by poorly defined spherules of pseudoleucite (from 0.5 to 4 cm) in a groundmass of alkali feldspar, nepheline, aegirine-augite, hornblende and magnetite. Two major phases have been recognized, an eastern leucocratic phase (Unit 3a) containing less than 10 per cent mafic minerals and a western more melanocratic phase (Unit 3b) containing more than 10 per cent mafic minerals (Figs. 5, 6).

Varieties of the pseudoleucite nepheline syenite, which were not mapped separately, comprise areas of a very coarse-grained phase composed principally of nepheline-alkali feldspar intergrowths which outcrops south of Bootjack Lake, and a pseudoleucite phonolite phase with euhedral, zoned, trapezohedral crystals of pseudoleucite (up to 2 cm) in a fine-grained light grey groundmass of nepheline, alkali feldspar and biotite, which is exposed near the southwestern edge of Bootjack Lake (Fig. 7). The phonolite may be volcanic flow or a chilled margin of the leucocratic pseudoleucite nepheline syenite.

FIGURE 5. Photograph of leucocratic pseudoleucite nepheline syenite showing characteristic spherules of pseudoleucite.

FIGURE 6. Photograph of typical weathered surface of pseudoleucite nepheline syenite (leucocratic variety).

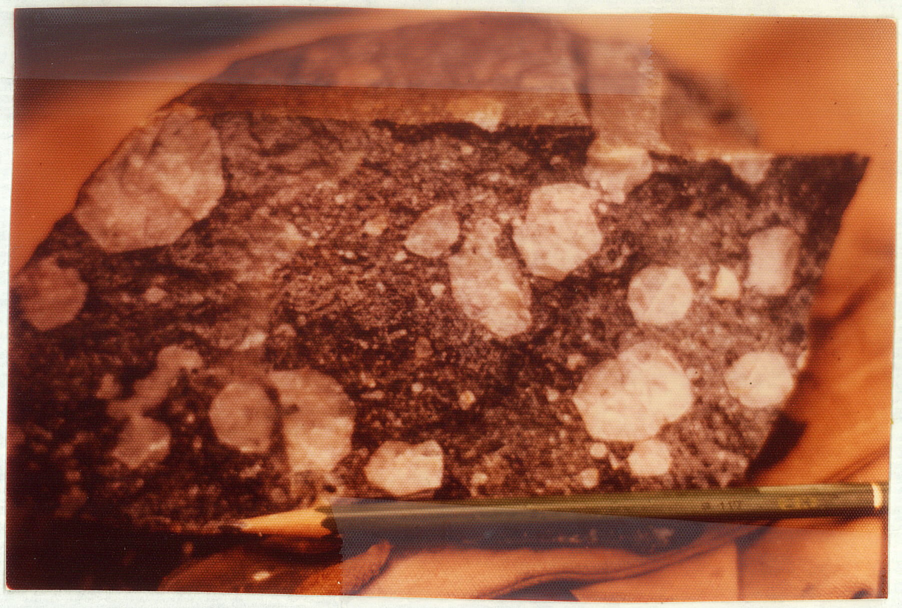

FIGURE 7. Photograph of phonolite(?) showing zoned, trapezohedral crystals of pseudoleucite.

Pseudoleucite nepheline syenite contains about 20 to 80 per cent pseudoleucite, 15 to 20 per cent alkali feldspar and 10 to 20 per cent nepheline as separate phases, 3 to 20 per cent aegirine-augite, 2 to 5 per cent magnetite, 0 to 2 per cent hornblende, and 0 to 5 per cent biotite.

Pseudoleucite spherules, which are a pseudomorphic intergrowth of nepheline and potassium feldspar after leucite (Seki and Kennedy, 1964), characterize the nepheline syenite. They tend to stand out on the weathered surfaces of the leucocratic phase and prompted the field name "golf ball syenite" (Fig. 6). The pseudoleucite is well defined and concentrically zoned in the fine-grained phonolite phase (Fig. 7), but as the grain size of the rock increases, the boundaries of the pseudoleucite become more diffuse and zoning is absent (Fig. 5).

Alkali feldspar is subhedral, 0.5 to 2 mm in diameter and is dusted by clay alteration products which make identification difficult; however, both albite and sanidine have been identified in the nepheline syenite. Perthitic intergrowths are present in some of the coarser-grained rocks.

Nepheline is subhedral to anhedral and is also 0.5 to 2 mm in diameter. In pseudoleucite it tends to concentrate near the edges of the spherules.

Aegirine-augite occurs as stumpy crystals (0.5 to 2 mm in diameter) which are commonly rimmed by hornblende and biotite. Where magnetite is in contact with augite it is generally rimmed by biotite.

Deuteric alteration and weak propylitic alteration are ubiquitous in the nepheline syenite.

Alkali feldspar is generally dusted by light brown alteration products which are largely clay minerals, carbonate and hematite. A colourless stumpy mineral with good polysynthetic twinning and at least two cleavages is locally present in the alteration products. It was tentatively identified as either epistilbite or scolecite from its optical properties: biaxial negative, moderate 2V, index of refraction near 1.510 and birefringence of about 0.01.

Nepheline is moderately altered to a variety of minerals. In places it is replaced by a dark brown, high relief, highly birefringent mineral that is probably carbonate. Other alteration products include: (1) felted masses of sericite that are locally accompanied by biaxial positive, platy thomsonite(?), which has a high 2V and mosaic extinction; (2) bladed prehnite crystals that commonly occur within thomsonite, and have anomalous blue interference colours; and (3) less commonly, rounded grains of zoisite and rare datolite and alkali feldspar.

Aegirine-augite is generally fresh, but it is locally completely altered to celadonite(?), which commonly merges into the surrounding biotite. Celadonite is a green micaceous mineral which is similar in form to biotite. At Cariboo-Bell, the green colour varies from pale to brilliant.

Syenodiorite (Unit 4, Fig. 2)

Syenodiorite forms the central lens in the stock and a second smaller lens in monzonite porphyry 600 m northeast of Bootjack Lake. This second lens is closely associated with intrusion breccia within which it occurs as fragments.

Syenodiorite is a dark grey, fine to medium-grained equigranular rock which is characterized by poikilitic crystals of alkali feldspar and locally biotite enclosing plagioclase and augite (Figs. 8 and 9). It contains 40 to 60 per cent andesine, 15 to 25 per cent alkali feldspar, 15 to 25 per cent augite, 5 per cent hornblende, 5 per cent biotite, 3 per cent magnetite, and accessory sphene, zircon and apatite.

Andesine grains are subhedral to anhedral and range in size from 0.2 to 1.5 mm. Andesine is generally fresh but in places is altered to sericite, brown carbonate and small amounts of chlorite which has

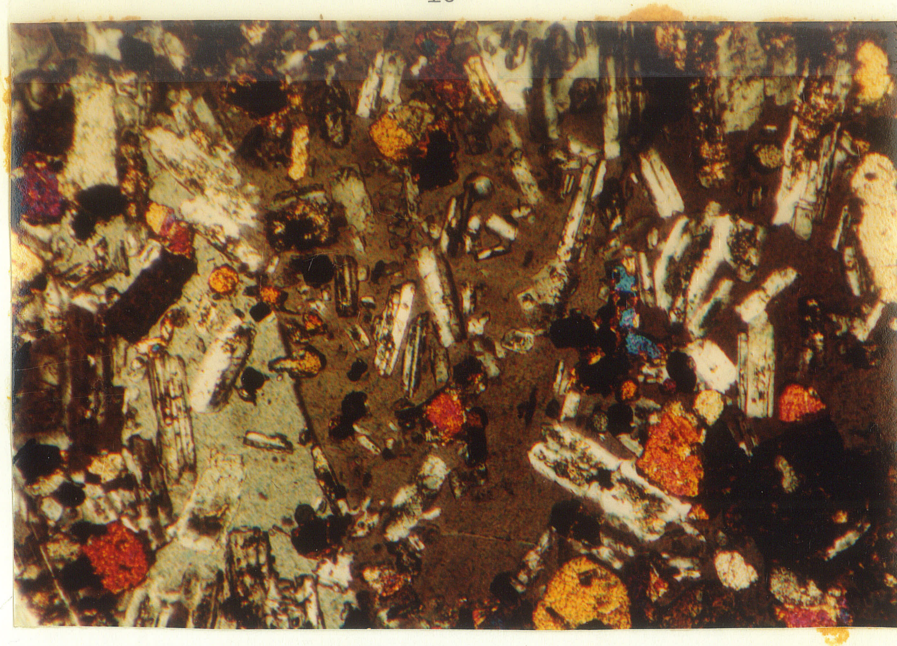

FIGURE 8. Alkali feldspar crystal poikilitically enclosing plagioclase and augite. Note the flow alignment of plagioclase. Section is from the syenodiorite. (40 x; crossed polars)

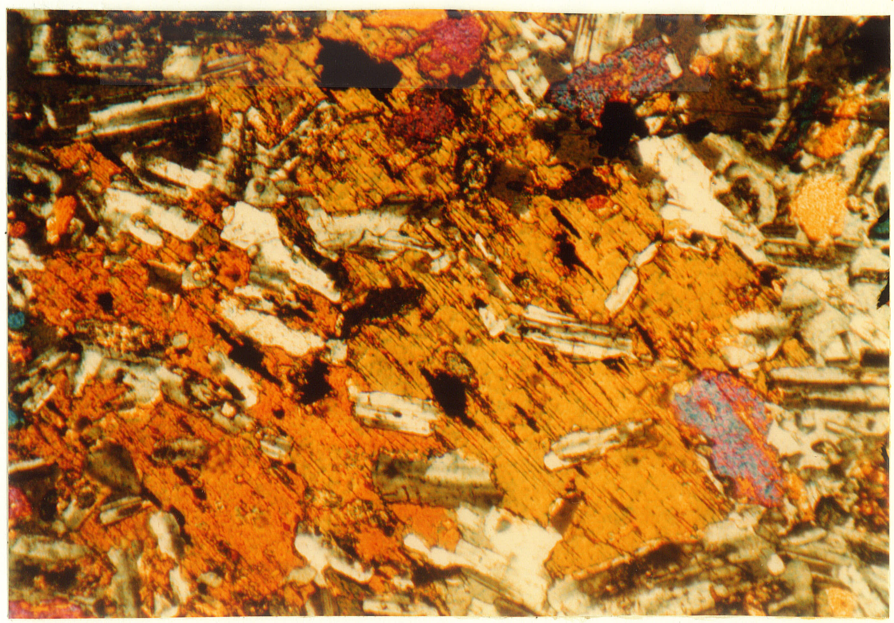

FIGURE 9. Biotite crystal poikilitically enclosing flow aligned plagioclase and augite. Section is from the syeno-diorite.
(40 x; crossed polars)

anomalous blue birefringence. Small grains of a colourless, high relief mineral within these alteration products may be clinozoisite. Andesine is locally rimmed by albite. Subparallel alignment of andesine crystals produces a good flow structure even in samples which appear to be massive in hand specimen. Some plagioclase crystals are poikilitically included in biotite and alkali feldspar crystals (Figs. 8 and 9).

Alkali feldspar is interstitial to poikilitic in nature and forms crystals up to 5 mm long. It is generally fresh but is commonly dusted around the edges by a reddish-brown mineral which is probably hematitic clay alteration.

Biotite is also poikilitic to interstitial and is up to 5 mm in size. In general it contains more augite inclusions and fewer plagioclase inclusions than alkali feldspar

Augite is light green, generally subhedral, is rimmed by biotite and hornblende and is from 0.1 to 0.8 mm in size. Augite included in biotite is usually corroded and anhedral.

Magnetite is generally associated with biotite and augite, and is 0.2 to 0.3 mm in diameter with embayed grain boundaries against augite and biotite.

Monzonite Porphyry (Unit 5, Fig. 2)

Monzonite porphyry forms the eastern or uppermost part of the stock. It is characterized by internal complexity, variable grain size, and corroded subparallel plagioclase laths generally less than 2 mm long in a fine-grained, grey, brown or pink alkali feldspar groundmass. Zeolite-carbonate cavity fillings, about 2 mm in diameter, are common.

Monzonite porphyry contains numerous screens and inclusions of andesitic crystal tuff, lapilli-tuff, and volcanic breccia. The volcanic crystal tuff and monzonite porphyry are similar in appearance and are difficult to distinguish from one another especially when alteration is intense.

Monzonite porphyry contains 40 to 70 per cent fine-grained groundmass alkali feldspar (altered to clay minerals, hematite and carbonate), 20 to 40 per cent andesine phenocrysts (altered to sericite, zeolites, prehnite, zoisite, epidote and carbonate), 3 per cent augite (altered to chlorite and biotite), 1 per cent magnetite and accessory apatite, zircon, and sphene. Ten per cent of the rock is composed of cavities and fractures which are largely filled with zeolites, carbonate, epidote and prehnite although 25 per cent of these cavities are empty.

Groundmass alkali feldspar is generally light brown to light grey or pink and is altered to an opaque dust-like reddish-brown aggregate of aphanitic minerals that is thought to be a mixture of clay minerals and hematite. The red colouration is most pronounced near intrusion breccia. Carbonate also occurs as an alteration product and locally replaces as much as 25 per cent of the groundmass but it is usually present in amounts of less than 5 per cent.

Plagioclase phenocrysts are up to 2 mm long, subhedral to euhedral, usually broken and corroded, and generally aligned. They are largely altered to sericite, zeolites, prehnite, zoisite, epidote and carbonate, but where fresh, display zoning in the andesine range.

Augite is not common in this unit, but where present, it is almost completely altered to chlorite and biotite.

Thomsonite, prehnite, epidote and carbonate occur as cavity fillings, fracture fillings and groundmass replacements. Thomsonite is the most common cavity filling and groundmass replacement and forms mosaics of embayed crystals (Fig. 10). The cavities are usually between 1 mm and 3 mm in diameter but are rarely as large as 2 cm in diameter. The thomsonite has a high birefringence, near 0.020, which indicates that it

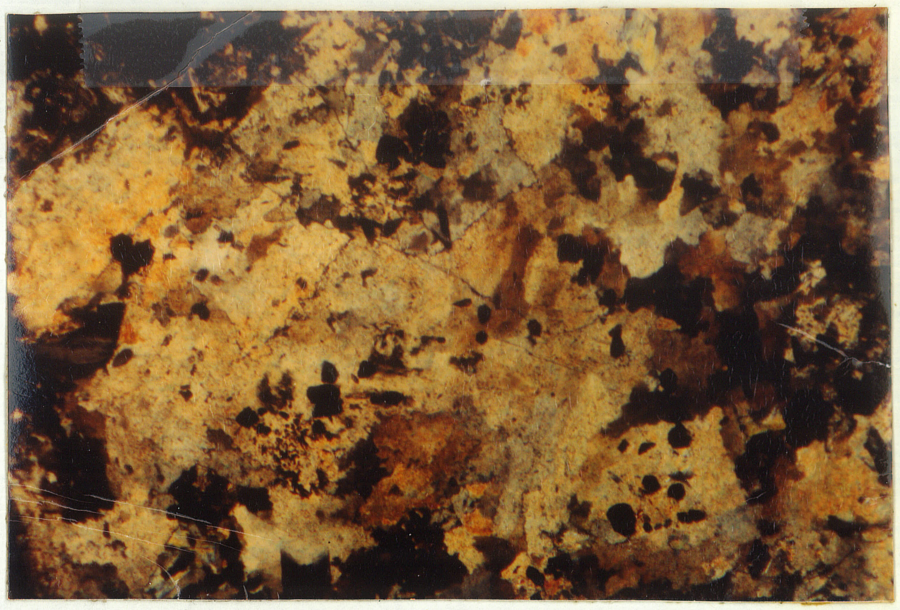

FIGURE 10. Cavity filling of thomsonite showing embayed grains and minor prehnite around edges. Section is from the monzonite porphyry. (30 x; crossed polars)

is an aluminium-rich variety. Bladed crystals of prehnite are commonly associated with thomsonite and also occur as separate cavity fillings and groundmass replacements. In many cases, prehnite completely fills the smaller cavities. An almost isotropic light yellow chlorite locally occurs around the edges of thomsonite-bearing cavities.

Replacement aggregates and cavity fillings are difficult to distinguish from one another. Many of the aggregates contain small clots of crystals which lack replacement structures and textures and have the same mineralogy as fracture fillings; however, others, which have a similar mineralogy, definitely appear to be growing into and replacing the alkali feldspar groundmass. In all probability, many of the replacement aggregates began as smaller cavity fillings which grew out into and replaced the surrounding groundmass.

<u>Intrusion Breccia</u> (Unit 6, Fig. 2)

Intrusion breccia is the most complicated unit in the stock and is peripheral to the eastern syenodiorite lens where it is in contact with monzonite porphyry. It is an important unit because it is in close association with the best copper mineralization and the most intense alteration.

In section, the intrusion breccia associated with the No. 3 Cu zone (westernmost breccia) plunges to the west; whereas the eastern breccias appear to be concordant with the intrusive lenses and the volcanic screens, and dip moderately to the east (Fig. 3).

Intrusion breccia consists of angular to subangular fragments of syenodiorite ($\simeq$60 per cent), monzonite porphyry ($\simeq$30 per cent) and volcanic rock ($\simeq$10 per cent) in an igneous matrix of altered monzonite porphyry. The fragment types are difficult to distinguish from one another because of intense potassic alteration. Total percentage of fragments varies from 0 to 80 per cent (Fig. 11).

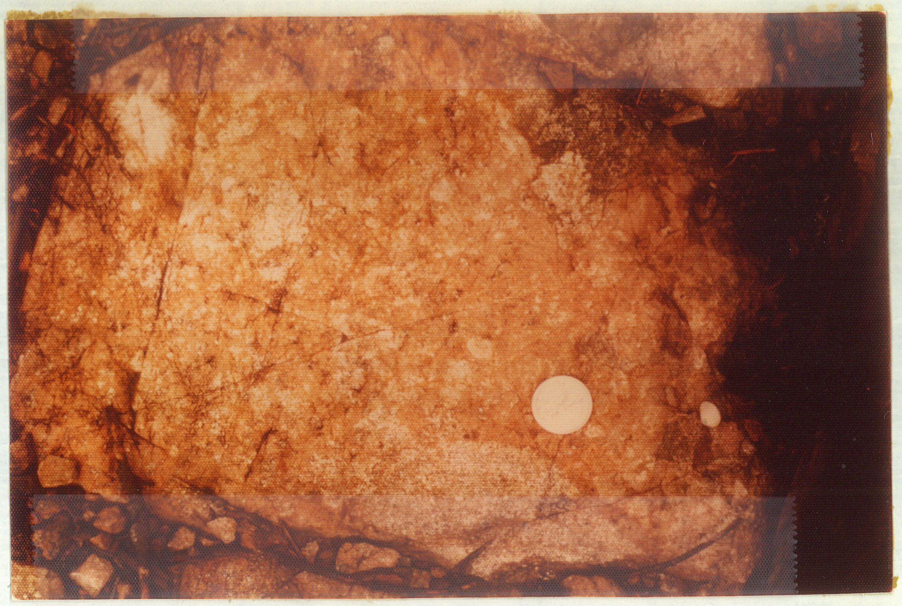

FIGURE 11. Intrusion breccia: showing syenodiorite fragment (below dime), volcanic fragment (upper right), and numerous small monzonite fragments in an altered monzonite matrix. Note subtle nature of monzonite fragments.

FIGURE 12. Intrusion breccia matrix showing increasing salmon pink potash feldspar alteration from left to right.

FIGURE 13. Altered monzonite porphyry fragment in monzonite porphyry matrix with irregular patches of magnetite, chalcopyrite, and carbonate.

FIGURE 14. Crackle breccia superimposed on the intrusion breccia monzonite porphyry matrix. Note the "shattered" appearance of the rock. Fractures are filled with magnetite and trace chalcopyrite.

Fragments are usually 3 to 6 cm in diameter, although syenodiorite fragments range in size up to 30 m blocks, especially near the contact with syenodiorite. Syenodiorite fragments tend to be concentrated near this contact; whereas monzonite porphyry and volcanic fragments are much more uniformly distributed. The latter two fragment types also tend to be much more uniform in size. The monzonite fragments closely resemble the matrix and result in a subtle breccia (Fig. 11).

Breccia matrix is an altered monzonite porphyry which is usually salmon pink in colour. The matrix commonly contains 0.5 to 1 mm rounded sericitized plagioclase phenocrysts (5-25%) in a very fine-grained alkali feldspar groundmass. Locally, potassic alteration is so intense that the matrix is completely altered to an aphanitic salmon pink mass of potassium feldspar (Figs. 12 and 13).

Drusy cavity fillings and mineral aggregates of carbonate, prehnite and zeolites up to 2 cm are common (2-20%) in the matrix.

The easternmost intrusion breccia, on Polley Mountain (Fig. 2), differs from the other intrusion breccia exposures in that it contains sanidine monzonite porphyry fragments , and a much higher percentage of volcanic fragments with a corresponding lower percentage of syenodiorite fragments. Everywhere else, sanidine monzonite porphyry cuts the intrusion breccia as dykes, indicating that the Polley Mountain intrusion breccia is younger than its western counterparts.

Intrusion breccia is the focus for development of crackle breccia, which consists of a network of fracture fillings, small veinlets and cavity fillings, and gives the rock a shattered appearance. Crackle breccia is most intense in the intrusion breccia but is weakly developed over a much larger area, the outer limits of which are roughly coincident with the 0.05% Cu limit (Fig. 2) (Hodgson et al, 1976). Copper grade is directly related to the intensity of development of crackle breccia; the $>$0.30% Cu zones are coincident with the most intense crackle breccia.

Development of crackle breccia is also directly associated with intensity of alteration. Common minerals in the space fillings and veinlets are potassium feldspar, carbonate, magnetite, prehnite and chalcopyrite. Less abundant minerals are diopside, zeolites, garnet, biotite and sphene. Carbonate-prehnite veinlets commonly cut and displace magnetite-chalcopyrite veinlets. There is a complete gradation between sharp, well defined hairline fracture fillings (Fig. 14) and poorly defined veinlets with gradational contacts into the host rock.

The crackle breccia affects both matrix and fragments in the intrusion breccia. Development of crackle breccia is locally variable; intensity of fracturing locally varies from 10 fractures per cm^2 to zero across a few centimetres.

Pyroxenite-Gabbro (Unit 8a,8b, Fig. 2)

Pyroxenite-gabbro, which is a coarse-grained phase,does not outcrop, except for one small area on line 0+00 near the southernmost exposure of intrusion breccia. This exposure was originally interpreted by the author as a small, coarse-grained, mafic phase of syenodiorite; however subsequent drilling to test ground magnetic highs near the eastern shore of Bootjack Lake intersected the main pyroxenite body (Fig. 2). The extent of this unit is based mainly on ground magnetic data supplemented by one diamond drill hole and several percussion drill holes (Hodgson et al, 1976).

A rough mode of this poorly exposed unit is: augite, 10 to 60 per cent; plagioclase, 10 to 70 per cent; alkali feldspar, 10 to 20 per cent; magnetite, 5 per cent; biotite, 0 to 10 per cent; and trace apatite. Locally, 2 to 5 mm aggregates of prehnite and zeolites make up about 5 per cent of the rock.

Augite is euhedral, locally porphyritic, 1 to 5 mm in diameter, and forms stumpy crystals which are generally rounded and somewhat corroded around the edges. Augite is locally twinned and zoned.

Plagioclase is usually subhedral, 0.5 to 3 mm in length and moderately altered to sericite. Locally, flow alignment of plagioclase and augite is weakly developed.

Alkali feldspar, which is usually fresh, is interstitial to rarely poikilitic and up to 2 mm in diameter.

Magnetite is 0.5 to 1.0 mm in diameter and forms rounded subhedral grains. Biotite commonly rims magnetite and locally poikilitically encloses several magnetite grains.

Post-Mineral Dykes (Units 7,8c,9, Fig. 2)

Four dyke rocks have been identified which cut at least one of the main intrusive lenses of the Cariboo-Bell stock and the intrusion breccia. These are, in order of intrusion, crowded monzonite porphyry, sanidine monzonite porphyry (Unit 7), augite porphyry (Unit 8c), and quartz monzonite porphyry (Unit 9).

Crowded monzonite porphyry occurs very commonly as small dykes in and around the intrusion breccia. These dykes are less than 5 m in width and have complicated but unmapped cross-cutting relationships with monzonite porphyry and sanidine monzonite porphyry. Although they are not shown on Figure 2, they comprise an estimated 5 to 10 per cent of the area mapped as monzonite porphyry (Unit 5). This rock differs from monzonite porphyry only in that it is less altered, and contains up to 60 per cent andesine laths (Fig. 15).

Sanidine monzonite porphyry (Unit 7) occurs as dykes up to 50 m in width which occur within, and to the northeast of intrusion breccia. Only the larger dykes are shown on Figure 2; numerous smaller dykes with similar complicated cross-cutting relationships to the crowded monzonite porphyry are unmapped (but comprise about 5 per cent of the area mapped as monzonite porphyry to the northeast of the intrusion breccia). Sanidine monzonite porphyry also occurs as fragments in the intrusion breccia on Polley Mountain.

FIGURE 15. Crowded monzonite porphyry showing 50% andesine laths in an alkali feldspar matrix. Upper half of rock was stained by sodium cobaltinitrite.

The sanidine monzonite porphyry is characterized by large zoned sanidine phenocrysts* up to 2 cm long (Figs. 16 and 17). The groundmass is similar to monzonite porphyry, but much fresher. It contains small phenocrysts of plagioclase in a matrix of alkali feldspar, augite, magnetite and accessory apatite and biotite.

Augite porphyry (Unit 8c) is the youngest rock type related to the stock. It occurs as thin dykes (0.5 to 20 m in width) of which only the larger ones are shown on Figures 2 and 3. Augite porphyry dykes occur in a swarm about 1,000 metres wide extending from the pyroxenite-gabbro bodies near Bootjack Lake, to the north end of Polley Lake (Fig. 2). In this zone dykes occur about one per 50 metres and trend northeasterly. The dykes are most common in intrusion breccia, less common in monzonite porphyry and least common in syenodiorite.

The augite porphyry dykes are similar in appearance and are probably related to the pyroxenite-gabbro unit (Hodgson et al, 1976). They are also compositionally similar to trachybasalt flows which occur east of Polley Lake. It is suggested that the dykes acted as feeders to flows formerly present at higher stratigraphic levels.

Cretaceous quartz monzonite porphyry dykes cut the pseudoleucite nepheline syenite and are related to a quartz monzonite stock which occurs 4 km to the southwest (Hodgson et al, 1976).

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* The phenocrysts have an Or content of 70 weight per cent as indicated by their refractive index (ny) of 1.526 (Tuttle, 1952b); however 40 weight per cent is indicated by their 2V of 40°(?). Because the refractive index was measured more accurately, and because the 2V determinative curve is relatively flat and a 5° error in the 2V measurement would bring the Or content to 65 per cent, it is felt that the Or content is probably closer to 70 weight per cent and the phenocrysts are thus sanidine rather than anorthoclase.

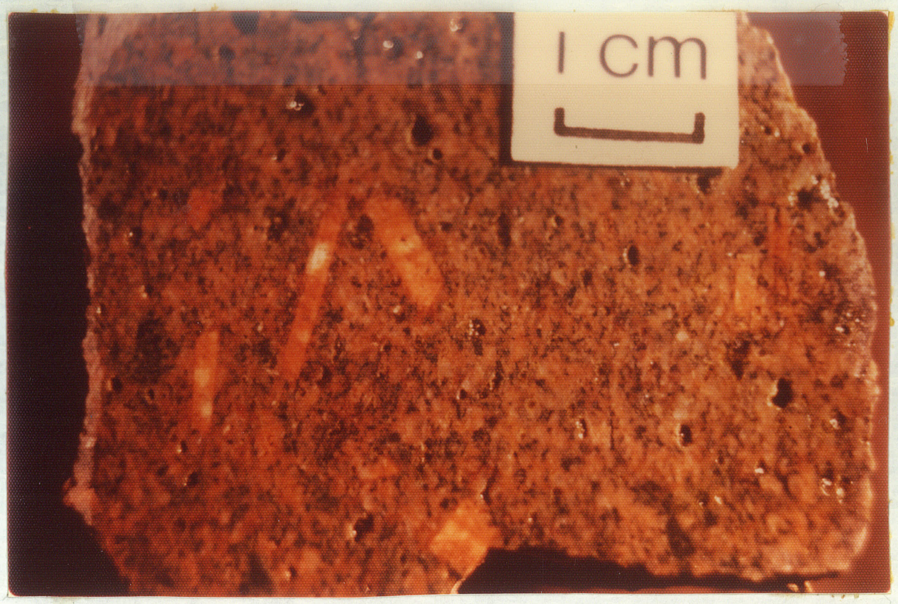


FIGURE 16. Sanidine monzonite porphyry. Note the large number of empty cavities.

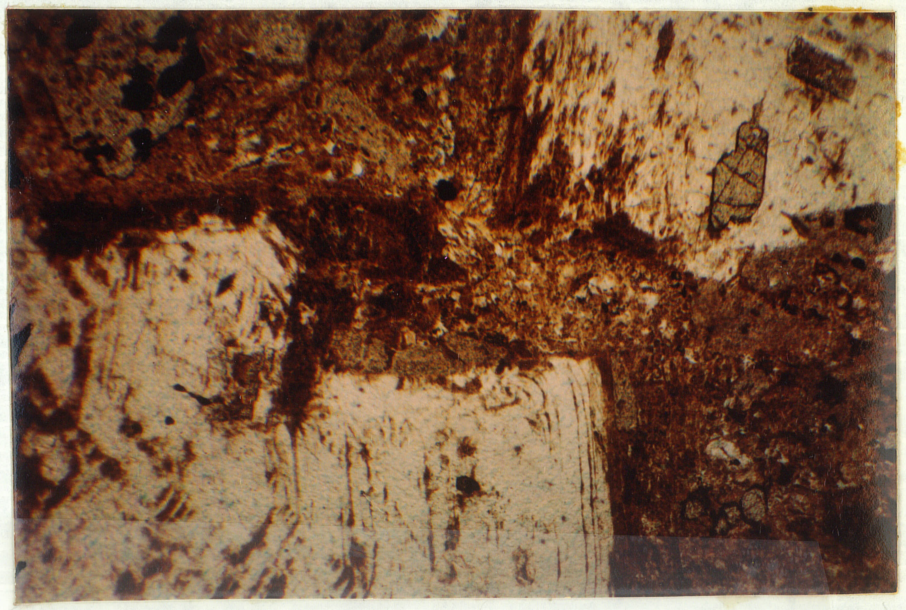


FIGURE 17. Large zoned sanidine phenocrysts. Corroded along edges. Note reddish brown groundmass. Section is from the sanidine monzonite porphyry (20 x; plain light)

Intrusive Relations

Cross-cutting relations of the rocks between Bootjack Lake and Polley Lake indicate that syenodiorite, which is cut by all other units and which occurs as fragments in the Cariboo-Bell breccia, is the oldest intrusive rock type. Monzonite porphyry, which occurs both as fragments and as matrix in the intrusion breccia, is at least in part synchronous with intrusion breccia. Crowded monzonite porphyry and sanidine monzonite porphyry cut all of the above rock types as dykes; however sanidine monzonite porphyry also occurs as fragments in the Cariboo-Bell intrusion breccia. The youngest rock in the Cariboo-Bell stock is augite porphyry which cuts all units except for pyroxenite-gabbro to which it is believed to be related.

The above relationships of monzonite porphyry and sanidine monzonite porphyry to intrusion breccia are indicative of multiple intrusion of these phases.

Pseudoleucite nepheline syenite, which occurs southwest of Bootjack Lake, does not exhibit intrusive relations with the other phases of the Cariboo-Bell stock, and its relative age is unknown.

Chemical Composition

Ten samples from the stock have been analyzed for major elements (Table 1). Water and carbon dioxide were not determined. Of the rocks analyzed, two were nepheline syenite, three were syenodiorite, two were monzonite porphyry, one was sanidine monzonite porphyry, one was intrusion breccia, and one was augite porphyry (numbered 1-10 on Fig. 2). Analyses were all done by the AMAX Exploration Laboratory in Burnaby, B.C.

None of the analyses total more than 98.09 per cent and most are in the 95 per cent range. These low totals probably reflect the large amount of hydrous and carbonate alteration minerals in the rocks analyzed.

Table 1: Chemical Analyses of Ten Representative Rocks from Cariboo-Bell

	1 %	2 %	3 %	4 %	5 %	6 %	7 %	8 %	9 %	10 %
SiO_2	53.00	51.50	50.50	50.00	49.50	48.00	51.00	58.50	55.50	50.50
Al_2O_3	22.50	22.00	16.00	15.80	17.00	15.40	16.20	16.20	16.70	11.20
FeO	[	3.94	7.25	5.94	6.45	7.60	7.30	5.20	[	7.05
	[3.30								[5.60	
Fe_2O_3	[	1.56	3.15	3.46	3.25	5.80	1.90	0.20	[	4.55
CaO	1.40	4.40	8.00	6.20	8.60	6.20	6.30	2.80	2.80	10.60
MgO	0.50	1.40	3.10	2.70	3.10	3.30	2.70	1.00	0.80	7.50
K_2O	12.20	7.00	3.30	4.00	3.00	4.00	4.70	4.80	4.90	3.50
Na_2O	3.75	5.41	3.55	3.70	3.40	3.30	3.75	5.70	5.40	1.50
MnO	0.07	0.14	0.18	0.16	0.18	0.13	0.21	0.08	0.13	0.20
Cr_2O_3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06
TiO_2	0.20	0.40	0.96	1.00	0.92	1.32	1.32	0.56	0.54	0.72
P_2O_5	0.18	0.33	0.50	0.46	0.39	0.42	0.34	0.15	0.17	0.33
Total	97.11	98.09	96.50	93.43	95.80	95.48	95.73	95.20	92.55	97.71

1. Coarse-grained nepheline syenite
2. Pseudoleucite syenite (Unit 3b on Figure 2)
3. Fine-grained syenodiorite (Unit 4)
4. Fine-grained flow-textured syenodiorite (Unit 4)
5. Medium-grained syenodiorite (Unit 4)
6. Monzonite porphyry (Unit 5)
7. Monzonite porphyry (Unit 5)
8. Sanidine monzonite porphyry (Unit 7)
9. Breccia (Unit 6)
10. Augite andesite porphyry (Unit 8c)

Note: Sample locations on Figure 2

All analyses done by Amax Exploration Laboratory using a whole rock analysis method which involves fusion of the sample with lithium meta-borate ($LiBO_2$) followed by HNO_3 extraction and atomic absorption analysis.

The rocks in the Cariboo-Bell stock are distinctly alkaline in composition. A plot of alkalies versus silica content (Fig. 18) shows that all the rocks, except for augite porphyry, plot well within Irvine and Baragar's (1971) alkaline field; augite porphyry plots on the boundary. This type of diagram is used by Irvine and Baragar to distinguish alkaline and subalkaline rock series, and they concluded that the diagram correctly classified the rock 90 per cent of the time.

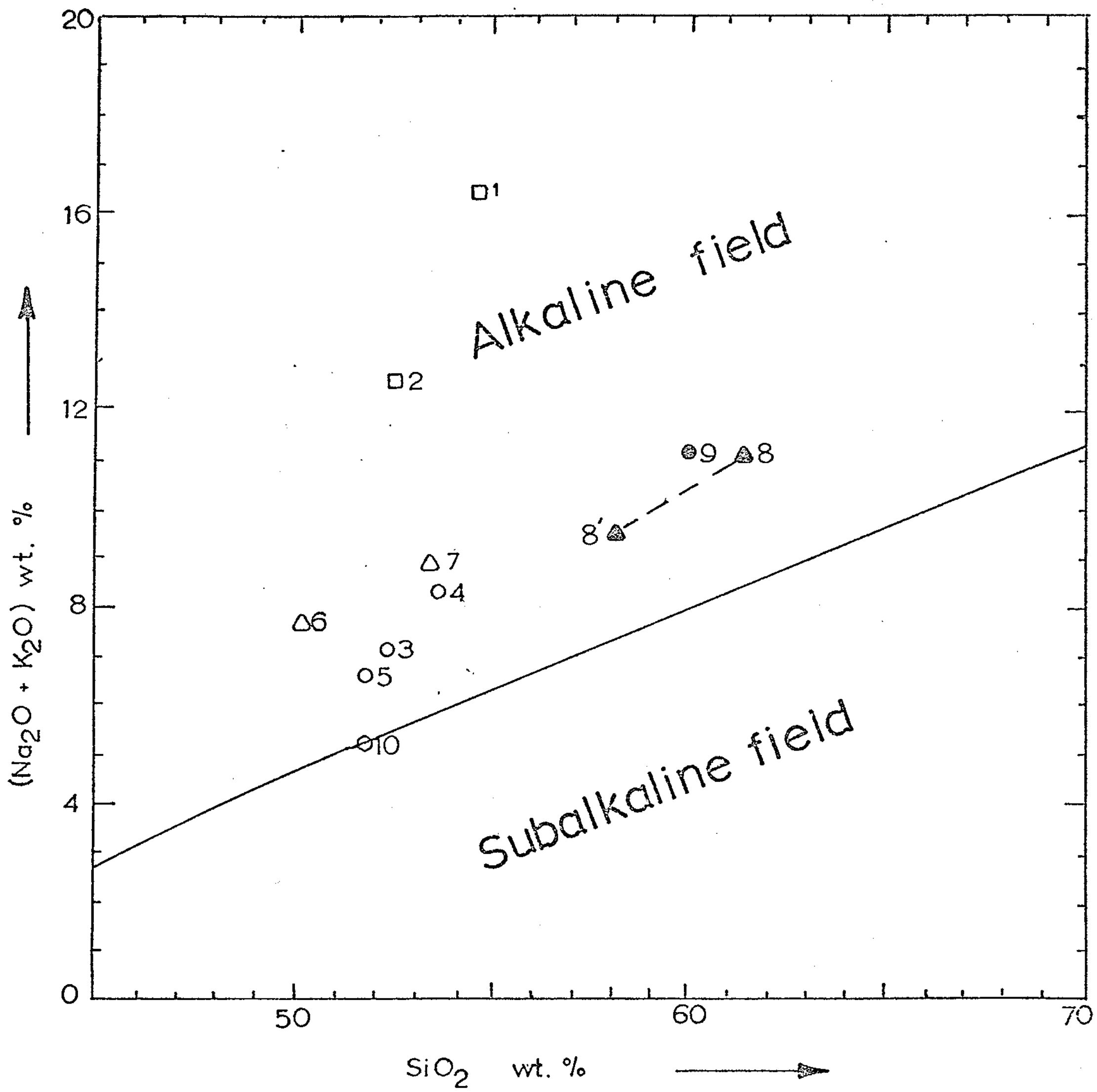


FIGURE 18 - PLOT SHOWING ALKALIES VS SILICA CONTENT FOR THE TEN ANALYSES IN TABLE 1

□ nepheline syenite, o syenodiorite, Δ monzonite porphyry, ▲ sanidine monzonite porphyry, o augite porphyry dyke rock, ● breccia

The numbers are keyed to Table 1, 8' is the plot of 8 recalculated to delete the effect of 35 per cent sanidine phenocrysts. The solid line is the boundary between the alkaline and subalkaline fields taken from Irvine and Baragar (1971). The percentages of Na_2O, K_2O and SiO_2 were recalculated so that the totals in Table 1 would total 100 per cent, prior to plotting on Figure 18.

ROCK ALTERATION

A complicated assemblage of rock alteration products is associated with the Cariboo-Bell stock. The most intense alteration is coincident with and grades outward from the main mineralized breccia zones (Fig. 19).

This alteration is concentrically zoned around the mineralized areas (Fig. 19). A central potassium feldspar-biotite-diopside zone corresponds with the area underlain by the mineralized breccias which are associated with copper zones 1, 2, 3, and 4 (Fig. 2). This zone grades outward into an intermediate garnet-epidote zone which grades into an outer epidote zone, the outer limits of which are about the same as the outer limits of monzonite porphyry.

Alteration products which are not related to the main alteration zoning include pervasive sericitic and argillic alteration of feldspars, and strong argillic alteration of alkali feldspar near shear zones.

Potassium Feldspar-Biotite-Diopside Zone

The central potassium feldspar-biotite-diopside zone is about 800 m in diameter and contains most of the $>0.30\%$ Cu rock. It is characterized by an intense salmon-pink colouration (Fig. 12). Besides potassium feldspar, biotite and diopside, secondary minerals in this zone are, in approximate decreasing order of abundance, carbonate, prehnite, magnetite, chlorite, zeolites, hematite, pyrite and sphene. These products occur as disseminations, patches, discontinuous veinlets, fracture fillings and drusy cavity fillings.

Pink colouration of the rock is caused by primary and secondary alkali feldspar, however the intense salmon tone is attributed to exsolution of Fe^{3+} in the alkali feldspar as hematite, a phenomenon typical

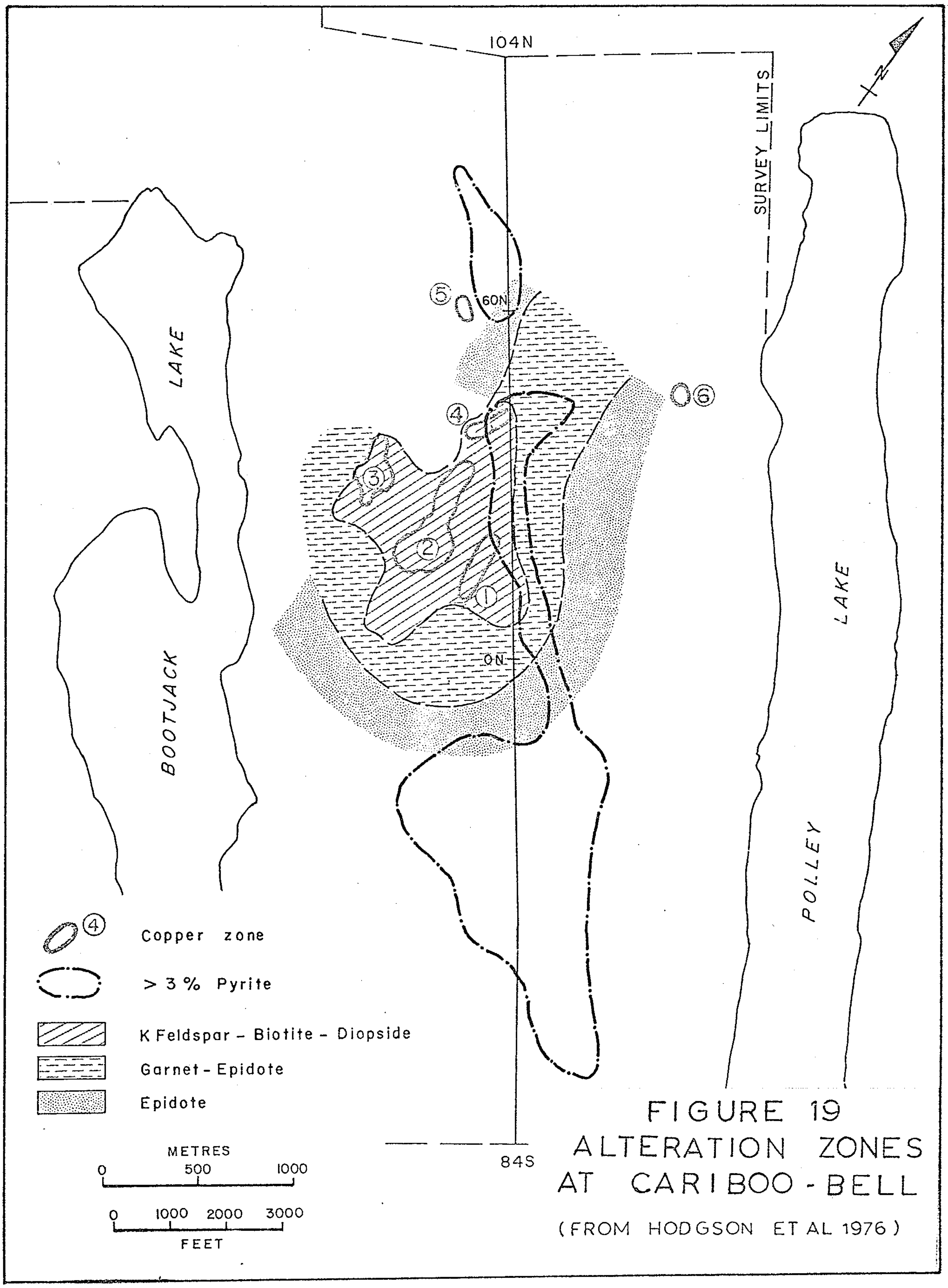


FIGURE 19
ALTERATION ZONES AT CARIBOO-BELL

(FROM HODGSON ET AL 1976)

of potassium silicate alteration assemblages as defined by Meyer and Hemley (1967).

The potassium feldspar occurs mainly as a very fine-grained replacement which is difficult to quantify because of the presence of alkali feldspar in the original groundmass. Secondary potassium feldspar commonly occurs as envelopes adjacent to fractures and locally forms rims around plagioclase and distinct fracture fillings and veinlets. Locally, the entire rock is altered to fine-grained potassium feldspar which has an intense salmon-pink colour.

Both primary and secondary alkali feldspar are affected by clay alteration, however, the presence of secondary alkali feldspar in the rock is indicated by a direct correlation between increased amounts of alkali feldspar and increased amounts of other secondary minerals. Local variations in the degree of replacement by potassium feldspar are directly related to variations in the intensity of crackle brecciation; these variations in secondary potassium feldspar give the rock a mottled pink appearance and were probably caused by local variations in permeability.

Biotite which is pale green to brown forms replacement aggregates up to 2 cm in diameter but is also present as secondary rims around augite and magnetite, and in veinlets. Biotite forms about 0.5 per cent of the rock but locally forms up to 20 per cent.

Diopside is uncommon and was not identified in the field; however, it was seen in thin section and locally occurs in veinlets with magnetite and carbonate where it forms euhedral crystals up to 1 mm in diameter.

Secondary magnetite (4-8%) occurs with chalcopyrite (1-5%) as veinlets, fracture and cavity fillings, and disseminations in the groundmass. Both minerals are most abundant where alteration is most intense. The pyrite content in the potassium feldspar-biotite-diopside zone is generally less than 1 per cent.

Carbonate, prehnite and zeolites are generally associated with one another and form about 2 per cent of the rock (locally 10 per cent) as fracture fillings, veinlets and drusy cavities. Carbonate is also abundant as a fine-grained,high relief, brown replacement of groundmass alkali feldspar. Chabazite, thomsonite, and analcite are present; chabazite tends to form in fracture fillings; thomsonite usually forms in large aggregates and drusy cavities; analcite is rare and occurs in fractures.

Chlorite forms locally as rims around augite and around the edges of prehnite-zeolite drusy cavities.

A typical veinlet or drusy cavity filling consists of prehnite, calcite, analcite and thomsonite in the centre, surrounded by biotite, diopside, potassium feldspar, sphene, chalcopyrite and magnetite, indicating that prehnite, calcite, analcite and thomsonite formed last. This is supported by the fact that these four minerals occur in all rock types between Bootjack and Polley lakes including the youngest, augite porphyry; whereas biotite, diopside, potassium feldspar, sphene, chalcopyrite and magnetite alteration did not affect the post-mineral dykes.

Garnet-Epidote Zone

An intermediate garnet-epidote zone occurs surrounding the potassium feldspar-biotite-diopside zone (Fig. 19). This zone is 200 to 300 m wide and is characterized by the appearance of epidote and melanite(?) garnet, and the disappearance of potassium feldspar, biotite and diopside. The key mineral in this zone is a light brown melanite garnet which is not abundant ($<$ 1 per cent), and occurs in veinlets and fracture fillings with prehnite, carbonate and locally magnetite, chalcopyrite and sphene.

Epidote Zone

The epidote zone, which differs from the garnet-epidote zone only in its lack of garnet, grades outwards to about the limit of monzonite porphyry where it is weakly developed (Fig. 19). It affects monzonite porphyry and included volcanic tuff equally.

This zone is characterized by epidote-prehnite drusy cavities and groundmass replacement aggregates (2-25%). Other secondary minerals, in approximate decreasing order of abundance, are carbonate (1%), chlorite (1%), zeolites (1%), clinozoisite (trace), sphene (trace) and albite (trace). This zone also contains secondary pyrite, magnetite and chalcopyrite.

Pyrite, which generally forms less than 1 per cent of the rock in the main copper zones, forms an umbrella-like zone containing 3-10 per cent pyrite stratigraphically above the main copper zones. The "umbrella" is about 5,000 m long and is largely restricted to the garnet-epidote and epidote alteration zones. Its lateral extent is controlled by the distribution of monzonite porphyry.

Secondary magnetite and chalcopyrite form less than 1 per cent of the epidote zone.

ORIGIN OF THE BRECCIAS AT CARIBOO-BELL

Brecciation at Cariboo-Bell is thought to have resulted, in part, from igneous intrusion of monzonite porphyry into syenodiorite and volcanic tuff, and in part, from subsequent fluid pressure build-up and explosive release of this pressure.

The important features of the Cariboo-Bell breccias are summarized below:

(1) Intrusion breccia is the focus for development of crackle breccia which is in turn directly related to intensity of alteration and mineralization of the stock.

(2) Intrusion breccia occurs on the southern periphery of the northeastern syenodiorite lens where it is in contact with monzonite porphyry (Figs. 2 and 3).

(3) Monzonite porphyry forms the matrix for intrusion breccia. Fragments are syenodiorite (60%), monzonite porphyry (30%) and volcanic rock (10%).

(4) Syenodiorite fragments are largest and most abundant near the syenodiorite contact with intrusion breccia, where they reach a maximum size of 30 m. Monzonite and volcanic fragments are 3-6 cm across and are more evenly distributed.

(5) The westernmost intrusion breccia is discordant and plunges steeply to the west; whereas the eastern breccias are concordant and dip moderately east.

(6) The easternmost intrusion breccia on Polley Mountain contains fragments of sanidine porphyry monzonite but breccias elsewhere are intruded by sanidine porphyry. This indicates that the Polley Mountain Breccia is younger than the other exposures of breccia and documents multiple periods of brecciation and intrusion.

(7) Crackle breccia intensity varies from 10 fractures per cm^2 to zero over a few centimetres.

Two brecciation mechanisms appear to have been operative at Cariboo-Bell: (1) igneous intrusion, and (2) explosive action of expanding fluids. These are summarized by Bryant (1968) as follows:

[1] Igneous Intrusion:

> "Intrusion or protoclastic breccias, also referred to as contact breccias, formed by the push or drag of viscous intruding magma are generally restricted to the igneous contact. The matrix is commonly igneous and the fragments may be broken and sheared wallrock or chilled border zone. If brecciation is intense, the matrix may be clastic."

[2] Explosive Action of Expanding Fluids:

> "Explosive action results from the violent and sudden release of fluids, probably gases, which have collected under high pressure. The common result is a vertical circular opening or a diatreme. The force of the expansion envisaged is so violent that the opening is necessarily vertical and circular to provide immediate relief of pressure. The rock formerly occupying the diatreme is broken up and redistributed by the expanding fluid. The diatreme is generally filled with fragments, some rounded, of igneous material, country rock or both."

The distribution, matrix composition, and size range and composition of clasts are consistent with an intrusion breccia mechanism in which several pulses of monzonite porphyry intruded syenodiorite and volcanic tuff, resulting in fragments of syenodiorite, volcanic tuff and monzonite porphyry (autobrecciation of a "chilled border zone") in a matrix of monzonite porphyry. Large rafted blocks of syenodiorite are common in the monzonite porphyry, away from the breccia, suggesting that syenodiorite was formerly much more extensive (Hodgson _et al_, 1976).

The intrusion brecciation mechanism does not explain the crackle breccia which is superimposed on intrusion breccia. The shattering of rocks, which resulted in numerous fractures (up to 10 per cm^2), is suggestive of explosive action (Fig. 14). A sudden release of fluids, which had collected under pressure, as described by Bryant (1968), is a probable mechanism for the shattering of the rock. The presence of such a fluid phase in the monzonite is supported by the numerous cavities in this phase. Rising fluids, which accompanied the final stages of monzonite porphyry emplacement, or which followed the same path as monzonite porphyry, were probably trapped, due to partial consolidation of monzonite, and collected under high pressure. Sudden release of this pressure resulted in shattering of the rock in the breccia zone and to a lesser degree in the surrounding rock, thus explaining the weak development of crackle breccia over a large area (Fig. 2). Dispersion and further concentration of fluids was probably responsible for alteration and sulphide mineralization, which is most intense in the intrusion breccia.

According to Bryant (1968), the common result of explosive action of expanding fluids is a vertical circular opening or a diatreme. There is no conclusive evidence that such a structure existed at Cariboo-Bell; however, since the Cariboo-Bell breccia appears to be related to volcanic eruptions there must have been some upward movement of the breccia.

The Cariboo-Bell breccia is considered to have resulted from igneous intrusion of monzonite porphyry into syenodiorite and volcanic tuff followed by explosive action resulting from a build-up of fluid pressures. Brecciation by igneous intrusion predates explosive action because both fragments and matrix are strongly affected by crackle breccia and alteration.

RELATION TO VOLCANISM

Evidence in the Cariboo-Bell stock and in the surrounding volcanic sequence suggests a very close relationship between the formation of the stock and formation of the host volcanic strata.

An absolute age date of 184 ± 7 m.y. was obtained for the Cariboo-Bell stock. This age date is Upper Triassic and is the same age as the host volcanic rocks (Hodgson et al, 1976).

Several features in the Cariboo-Bell stock are characteristic of high level subvolcanic intrusion:

(1) numerous cavities

(2) breccia zones

(3) numerous fine-grained porphyritic dykes

(4) high temperature minerals such as pseudoleucite and sanidine

(5) mutual cross-cutting relationships indicative of multiple intrusion

(6) crackle breccia (shattered rock) indicative of violent explosive pressure release.

There are chemical and physical similarities between the Cariboo-Bell stock and volcanic strata: both are alkaline in character and anomalously rich in copper (Hodgson et al, 1976); clasts of plutonic rock in polymictic volcanic breccia, stratigraphically above Cariboo-Bell on the east side of Polley Lake, are identical to rocks found in the stock; and augite porphyry dykes, which form a 1,000 m wide northeasterly trending swarm in the stock, may be feeders for compositionally similar trachybasalts in the overlying volcanic strata.

The distribution of volcanic units suggests that Cariboo-Bell was a focal point for volcanic eruptions. A 12 km wide zone containing oxidized pyroclastic volcanic rocks is thickest adjacent to Cariboo-Bell (Hodgson et al, 1976) and decreases away from the stock (Fig. 1).

To summarize, Cariboo-Bell intruded compositionally similar coeval volcanic strata at a high stratigraphic level. Chemical and physical evidence and several features in the Cariboo-Bell stock suggest that Cariboo-Bell was subvolcanic and a focal point for volcanic eruptions.

SUMMARY AND CONCLUSIONS

The Cariboo-Bell alkaline stock intruded coeval Upper Triassic volcanic strata whose gross stratigraphic features were described by Hodgson et al (1976) as displaying several stages in the development of a major volcanic centre at Cariboo-Bell. The intrusive rocks range in composition from nepheline syenite to gabbro and occur as stacked lenses which were intruded concordantly into the contemporaneous volcanic strata. The intrusive rocks display features indicative of high level, subvolcanic intrusion such as cavities, breccia zones, porphyritic dykes, high temperature minerals and mutual cross-cutting relationships, and they support volcanic evidence (Hodgson et al, 1976) that tops are to the east.

Intrusion breccia, which occurs in monzonite porphyry and syenodiorite close to the syenodiorite-monzonite porphyry contact, resulted from intrusion of monzonite porphyry into syenodiorite and volcanic tuff, and is made up of fragments of syenodiorite, volcanic tuff and monzonite porphyry in a monzonite porphyry matrix. Intrusion breccia is the focus for superimposed crackle breccia, intense alteration, and sulphide mineralization, all of which are closely associated with one another. It is concluded that intense fracturing resulted from pressure release of fluids which were concentrated due to partial consolidation of monzonite subsequent to its emplacement. Further concentration and dispersion of fluids was responsible for alteration and mineralization.

There is a close relationship between Cariboo-Bell, a high level subvolcanic stock, and the coeval volcanic strata into which it was emplaced. Numerous features in the volcanic rocks and in the intrusion indicate that Cariboo-Bell was a volcanic centre: (1) the distribution of volcanic rocks around Cariboo-Bell; (2) the presence of angular plutonic fragments closely resembling Cariboo-Bell rocks in overlying volcanic pyroclastic strata; and (3) chemical and physical similarities between Cariboo-Bell and the volcanic rocks.

It is suggested that the Cariboo-Bell breccia, which acted as a feeder for emplacement of the monzonite porphyry, as a pathway for hydrothermal fluids, and as a preferred route for the intrusion of post-mineral dykes, probably acted as a feeder to volcanic eruptions as well. An interpretive cross-section through EF (Fig. 2) demonstrates what the breccia pipe may have looked like after tilting and before erosion (Fig. 20). The steeply dipping discordant western breccia zone is interpreted as the feeder and the eastern breccia zones as offshoots.

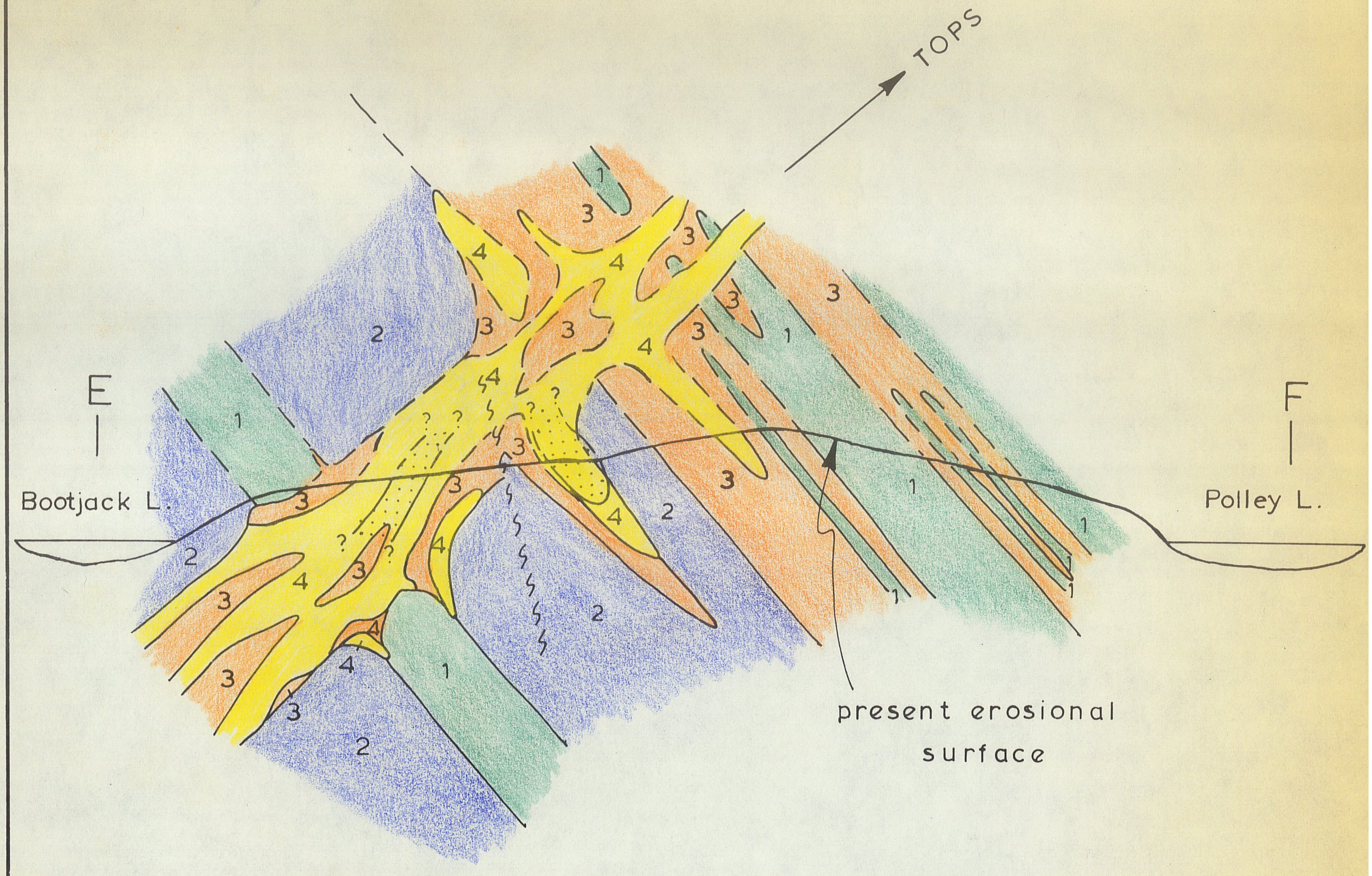
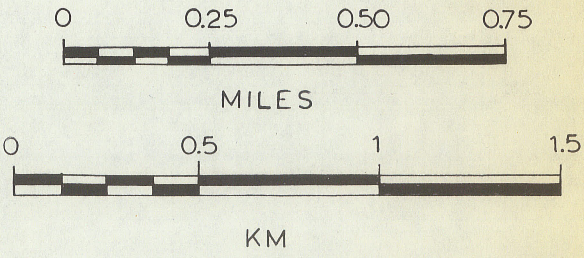


FIGURE 20

INTERPRETIVE CROSS SECTION THROUGH E F (LOOKING N)

- Cu zone
- 4 Intrusion breccia
- 3 Monzonite porphyry
- 2 Syenodiorite
- 1 Volcanic rock



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LEGEND

CRETACEOUS (?)

9	Quartz monzonite porphyry

UPPER TRIASSIC

CARIBOO-BELL STOCK

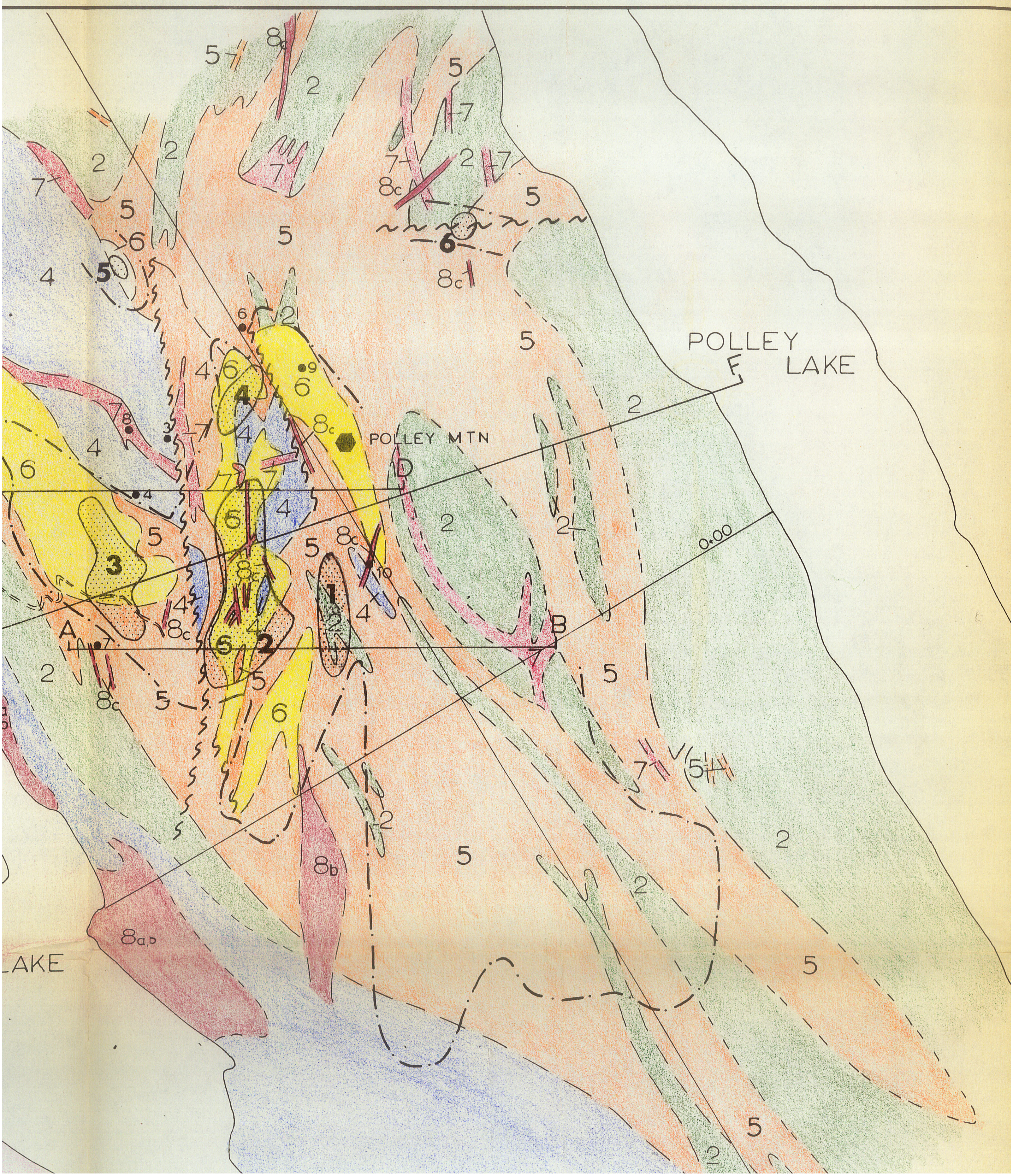
8	8a, pyroxenite; 8b, gabbro; 8c, augite porphyry
7	Sanidine Monzonite porphyry
6	Intrusion breccia
5	Monzonite porphyry
4	Syenodiorite
3	Pseudoleucite nepheline syenite; 3a, leucocratic; 3b, melanocratic

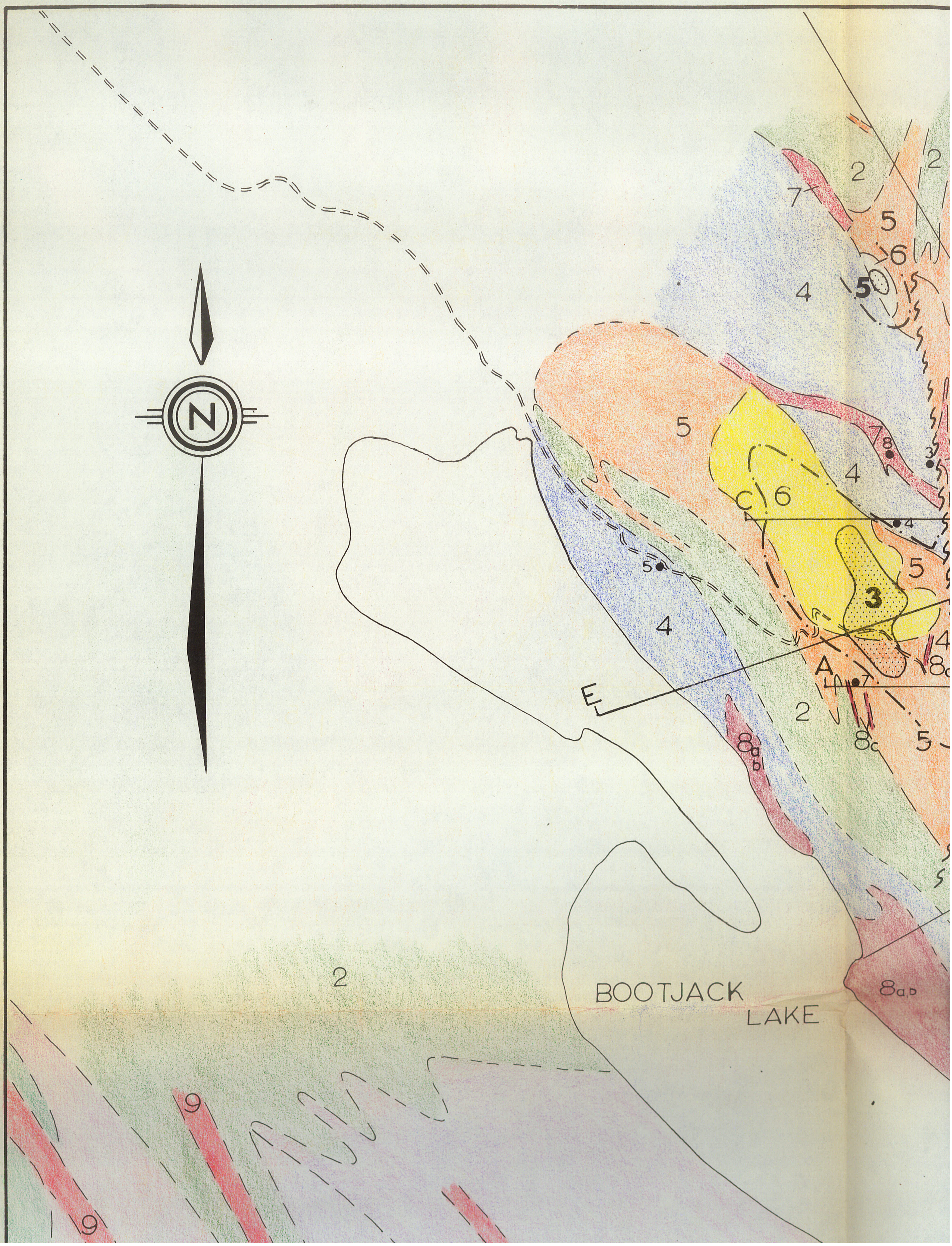
EXTRUSIVE ROCKS

2	Crystal and lapilli-tuff
1	Trachybasalt

2	Cu zone, > 0.30% Cu
	Contact: defined, approximate, assumed
	Fault
	Mineral foliation
	Access road
	Outline of > 0.05% Cu (crackle breccia)
•5	Sample number and location

FIGURE 2


POLLEY LAKE
POLLEY MTN
LAKE
0.00
A
B
D
F



N
BOOTJACK
LAKE

2 — Cu zone, > 0.30% Cu

Contact: defined, approximate, assumed

Fault

Mineral foliation

Access road

Outline of > 0.05% Cu (crackle breccia)

•5 — Sample number and location

FIGURE 2

GEOLOGY OF THE CARIBOO-BELL ALKALINE STOCK

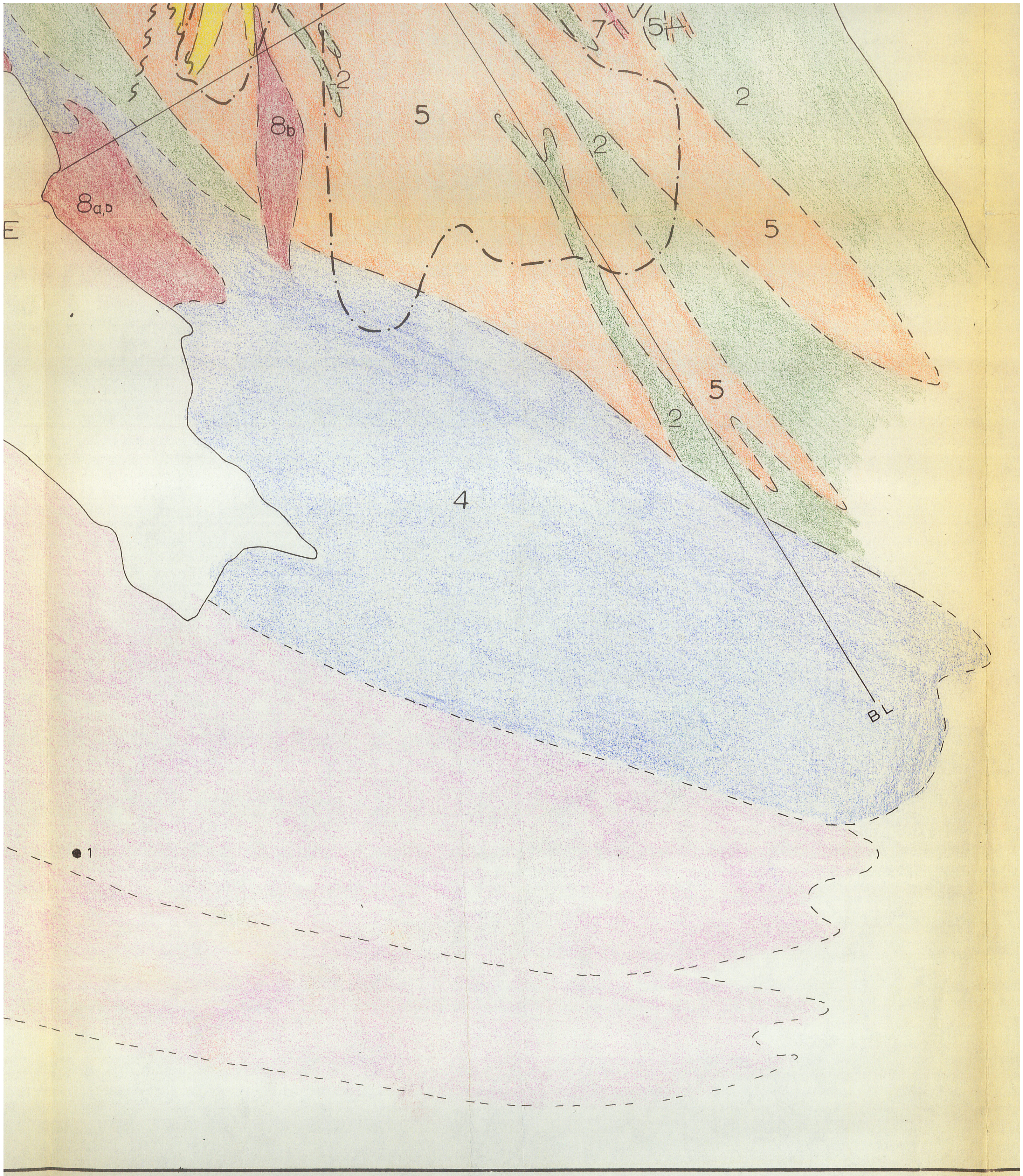
0 — 0.25 — 0.50 — 0.75 — 1.0 — 1.25

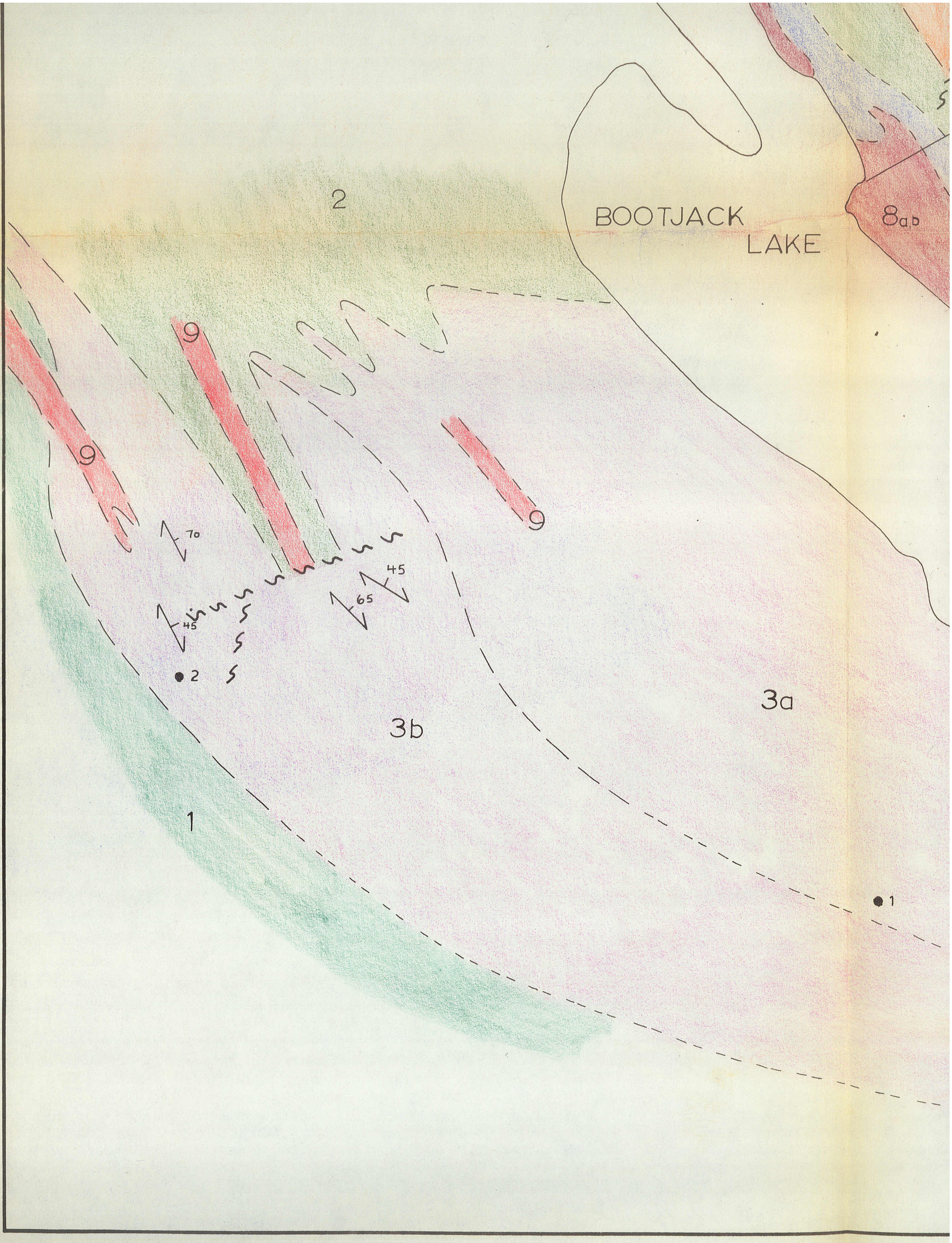
Miles

0 — 500 — 1000 — 1500 — 2000

Meters

Geology by C.J. Hodgson and R.J. Bailes - 1970, 1971 and 1975


7
5
2
2
5
2
8b
8a,b
E
5
5
2
4
BL
1



BOOTJACK
LAKE
8a,b
2
9
9
9
70
45
65
45
2
3b
3a
1
1