THE HALLERAN ALKALINE COMPLEX

MANSON CREEK AREA, BRITISH COLUMBIA

ARTHUR A. D. HALLERAN

 MARCH 30, 1988

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DR. J. K. RUSSELL
ADVISOR

ARTHUR A. D. HALLERAN

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ABSTRACT

The Halleran Alkaline Complex rocks can be divided into 3 groups based on their petrology and rare earth geochemistry.

Group 1 is the upper crustal melt quartz-rich pegmatites, enriched in light rare earths but relatively depleted in europium.

Group 2 have a carbonatite chondrite-normalized rare earth abundance pattern and are the following alkalic rocks; alkali-feldspar-aegirine-augite syenite, banded aegirine-augite-alkali-feldspar-syenite, nepheline syenite pegmatite, quartz syenite, allanite-monzonite pegmatite, monzonite, aegirine-augite monzodiorite. This group indicates more than one episode of alkalic intrusions as the aegirine-augite monzondiorite is crosscut by an aegirine-augite syenite dyke with associated potassic alteration, and numerous alkali-feldspar syenite dykes.

The third Group is enriched in heavy rare earth elements, is bleached in places and appears very altered, which might indicate hydrothermal solutions percolating from the alkali rocks. In places, the Wolverine plagioclase amphibolite has been metasomatized to an aegerine-augite-plagioclase amphibolite.

Four rare earth minerals were found; monazite, allanite, cerorthite and an unidentified Ba-Fe-REE-Silicate. The allanite and cerorthite occur in a unique coarse allanite-monzonite pegmatite.

The Mt. Bison Monzonite and the Ursa #1 Monzonite were emplaced after the last metamorphism, 69-43 million years ago.

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INTRODUCTION

The Halleran Alkaline Complex occurs in the Wolverine Complex 64 km west of the town of Mackenzie (Figure 1). There are five major occurences of alkaline rocks along a 10 km mountain- the Laura, Will #1, Will #2, Ursa and the Mount Bison Monzonite. The rock types comprise alkali-feldspar syenite dyke, aegirine-augite syenite dyke, alkali-feldspar-aegirine-augite syenite, banded aegirine-augite alkali-feldspar syenite, nepheline syenite pegmatite, quartz syenite, allanite-monzonite pegmatite, monzonite, aegirine-augite monzodiorite, cataclastic gneiss and a fenite. Other alkaline complexes in the region include: the Lonnie (Halleran 1980, Pell 1987), Vergil (Pell 1987) and Aley Carbonatite (Mader 1986,1987) complexes and the Prince and George Carbonatites (Mader and Greenwood 1988).

LOCATION AND PHYSIOGRAPHY

The Halleran Alkaline Complex is located on Mount Bison within the Finlayson Mountain Range 80 km southeast of the Village of Manson Creek and 64 km west of the town of Mackenzie. Access to the area is via the Munro Creek/Manson Creek logging road. The area is mountainous with steep creek valleys; elevation gain is approximately 900 meters from

Munro Creek to the 1,829 meter high Mount Bison with the tree line at the 1,640 meter level and heavy timber in the valley.

PREVIOUS WORK

The rocks of the Wolverine Complex occur in the Wolverine Mountain Range. McConnell (1893) was the first to map these rocks; his geological boundary north of the village of Manson Creek remains virtually unchanged.

Dolmage (1927) mapped the Finlay River district north of Manson Creek, and added much to the understanding of the Wolverine rock types. Later work (Armstrong, 1949) added to petrology of the complex and provided ages of the rocks. Armstrong (1949) also explained the western contact relationship between the Wolverine Complex and the Cache Creek Group as a fault. Muller (1961) then mapped the southernmost part of the Wolverine Complex east of the 124 line of longitude. Published work by H.W. Tripper et al (1974) included a number of age dates for the metamorphosed Wolverine rocks and plutonic intrusive rocks. Current work is being carried out by Ferri (personal communication 1987) for the British Columbia Ministry of Energy, Mines and Petroleum Resources.

The first claims staked in the study area were the Carb Claims, AH and Infill Claims in 1983 by the writer. The

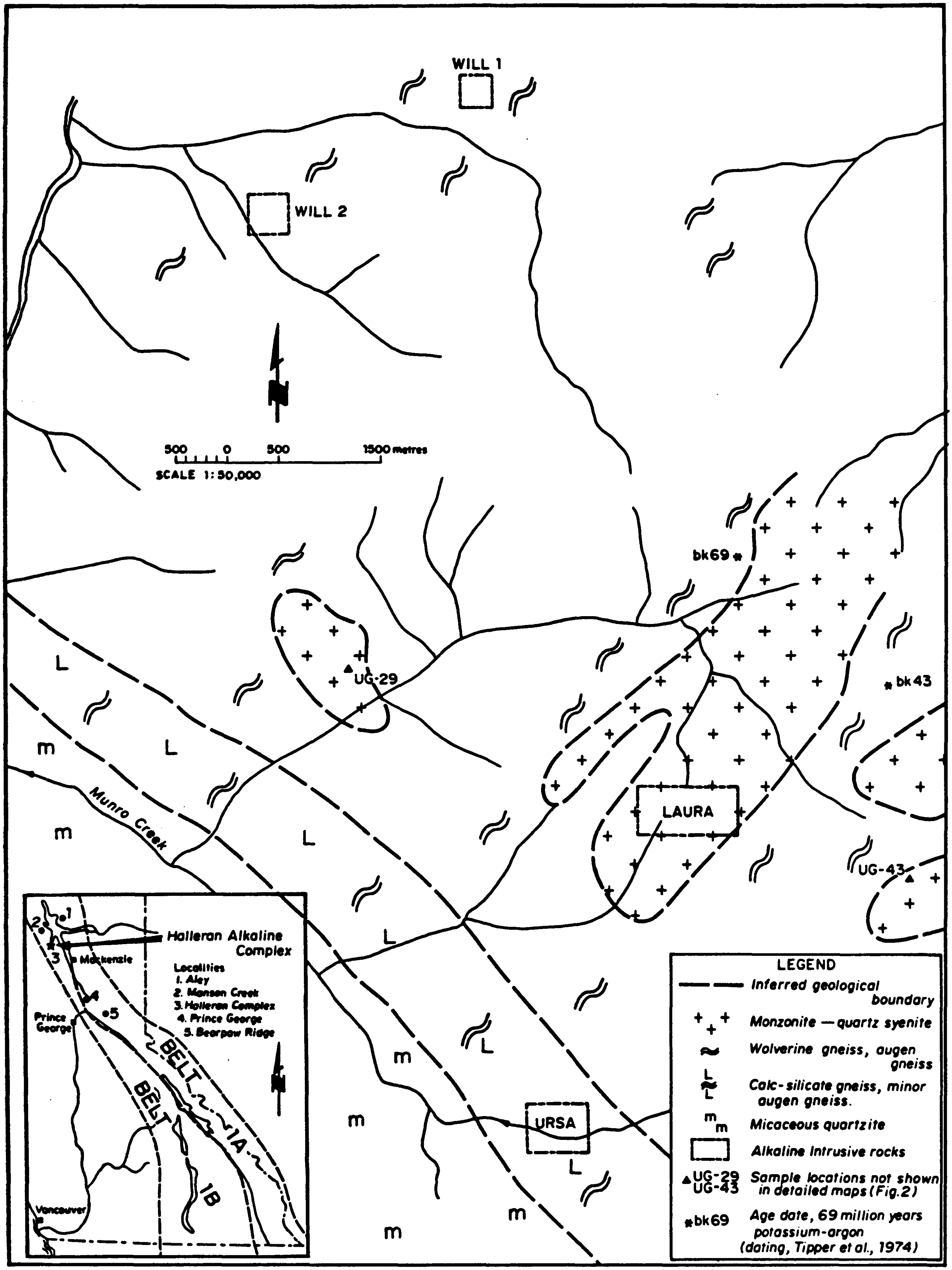


Figure 1. Local geology of the Study Area and Location Map of the Intrusive Bodies on the Halleran Alkaline Complex.

claims covered a sequence of rocks thought to be a carbonatite, including a graphite deposit found during further prospecting. In 1984, the Mon Claims were staked. Two mill tests proved the graphite deposit uneconomic. Then in September of 1986 the first monazite showing, Ursa #1, was discovered, followed by the Will #1, Laura and Will #2 in 1987. To date, preliminary mapping and sampling have been completed.

GEOLOGY OF THE AREA OF STUDY

General Geology

The main unit within the area of study is the Wolverine Metamorphic Complex. The eastern edge of the complex is a thrust sheet (Muller 1961) while the western contact between the Manson Creek belt of the Cache Creek Group and Wolverine Metamorphic Complex is a fault (Armstrong 1949) located in the Munro Creek valley.

The Wolverine Complex is divided into two mappable divisions (Armstrong 1949). One division is the western front of the range and consists of interbedded quartzite, garnetiferous chloritic schists and limestone. The limestone is blue-grey to creamy in color, coarsely crystalline, poorly bedded and commonly containing much sericite. The second division, exposed in the center of the Wolverine Range, contains granitic gneiss, granodiorite, quartz-mica schists and pegmatites. The pegmatites are coarse-grained and contain quartz, plagioclase, orthoclase, muscovite, biotite, garnet (Armstrong 1949) with trace tourmaline and beryl (Dolmage 1927). The southeastern end of the Wolverine Complex comprises two large amphibolite and pseudodiorite bodies (Muller 1961). Ferri et al (1988) has mapped the area as amphibolite and calc-silicate gneiss, schist and quartz-feldspar-gneiss intruded by granodiorite and pegmatite.

The age of the Wolverine Complex in this particular area was determined as Late Proterozoic and Lower Cambrian by Armstrong (1949). Potassium-argon dating of Wolverine metamorphic rocks in the study area gave 69 to 43 million years (Tipper et al 1974) which might indicate a metamorphic resetting, while an intrusion just south of the area was determined to be 78 million years old (Tipper et al 1974). The age dates of the metamorphism could be used to date any rocks that show no metamorphic fabric.

Pell (1987) demonstrated that in British Columbia, alkaline rocks occur in three northwest-trending belts. Two of the belts contain the Aley Carbonatite Complex, the Prince George Carbonatite and the Bearspaw Ridge (Belt 1A, Figure 1) and the Manson Creek Carbonatites and Halleran Alkaline Complex (Belt 1B, Figure 1).

LOCAL GEOLOGY

The Halleran Alkaline Complex (Halleran 1987) is comprised of the following: an alkali-feldspar syenite dyke, aegerine-augite syenite dyke, alkali-feldspar-aegirine-augite syenite, banded aegirine-augite alkali-feldspar-syenite, nepheline syenite pegmatite, quartz syenite, allanite-monzonite pegmatite, monzonite, aegirine-augite monzodiorite, cataclastic gneiss and fenite and is hosted by the Wolverine Metamorphic Complex. The Cache Creek Group outcrops just to the west across Munro Creek Valley which is an expression of a fault.

The Wolverine Complex is divided into three mappable units trending northwest across the study area (Figure 1). The three units starting at the northern core are:

1) A sequence of quartz-feldspar gneiss, augen gneisses, pegmatites and minor biotite schists. It is within this unit that all alkalic rocks are emplaced, with the exception of the Ursa.

2) There is a central belt of marbles and calc-silicate gneisses associated with amphibolite gneisses. The marbles are grey, coarse crystalline, contain phlogopite, garnet, diopsite, calcite, and the calc-silicate gneisses are diopsite, plagioclase, garnet and calcite (Ferri and Melville 1988). Within this unit schists and quartz-feldspar gneisses occur.

3) The southernmost unit is classified as the Middle Ingenika Group by Ferri and Melville (1988). It consists of micaceous quartzite, quartzite, quartz mica schists and minor amphibolite, gneisses and pegmatites.

The farthest southwest corner of the study area is the calcareous graphitic phyllite/argillite to limestone Cache Creek Group.

ANALYTICAL METHODS

The Halleran Alkalic Complex rocks were studied through petrology, feldspar staining, x-ray diffraction, and scanning electron microscope.

DETAIL GEOLOGY OF THE HALLERAN ALKALIC ROCKS

LAURA ALKALINE INTRUSIONS

Alkalic rocks outcrop over 300 meters (Figure 2); no attempt was made to map or understand any of the field relationships other than the Wolverine biotite-gneiss. Biotite-amphibole schists also outcrop throughout and appear to interfinger with the alkaline rocks; only the alkaline outcrop was mapped.

There are two coarse crystalline pegmatites; a unique

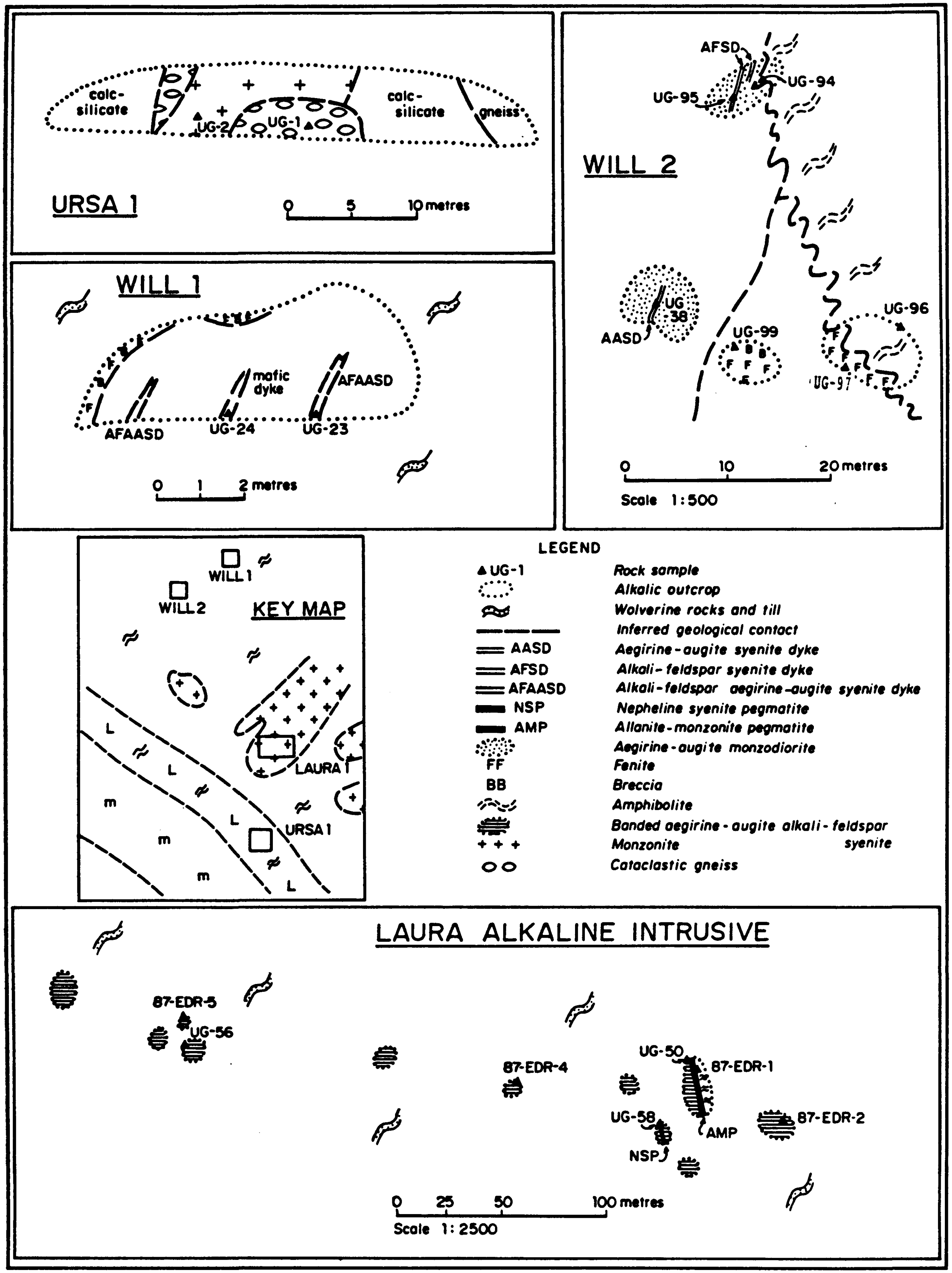


Figure 2. Geology of the Alkalic Showings.

allanite-monzonite pegmatite and a nepheline pegmatite and a banded aegirine-augite alkali-feldspar syenite.

Allanite-Monzonite Pegmatite

The Allanite-Monzonite pegmatite (Figure 2) is coarse-grained and has 35% .5 to 2 cm tabular allanite in part cerorthite, in a matrix of plagioclase, potassium-feldspar (11% each). Hornblende and augite 15%, coarse sphene and well-formed apatite 1 - 3%; minor monazite and trace biotite are also present. It is 1 to 1.5 meters wide and roughly 30 meters long, covered in part by till. The eastern contact with the Wolverine gneisses is very sharp while the western edge appears to gradually grade into a fine-grained, banded aegirine-augite alkali-feldspar syenite. Quartz occurs in local areas up to 5% but this might be due to late cross cutting quartz bearing veins.

Nepheline Syenite Pegmatite

The nepheline syenite pegmatite (Figure 2) outcrops 25 meters southwest of the allanite-monzonite pegmatite and consists mainly of coarse potassium feldspar, augite and hornblende. In handspecimen, nepheline was identified and very coarse crystals 1-4 cm of monazite and ilmenite were found. This pegmatite appears to become coarsely layered and is 2 meters wide, but buried under till. The field relationships are not known.

Banded Aegirine-Augite Alkali-Feldspar Syenite

The most widely occurring unit is the aegirine-augite banded alkalic-feldspar syenite (Figure 2). This unit outcrops 30 meters east and 100 and 300 meters west of the allanite pegmatite. It grades from a fine to a coarse pegmatite appearance, and a gradational contact with the allanite-monzonite was found. This rock consists of alternating (mm to cm wide) dark bands of aegirine-augite, minor hornblende, sphene, monazite, allanite, ilmenite, magnetite, hematite, zircon, biotite, chlorite, and an unidentified Ba-Fe-REE-Silicate; and light bands (cm wide) of potassium feldspar with minor monazite up to 2% in places, zircon and well-formed apatite.

The easternmost mapped occurence of this unit is slightly pegmatitic and has larger dark bands of the mafics. The biotite, 1 - 2 %, is always as intergrowths (replacement) in the aegirine-augite. Some of the biotite has kink banding and others have a rim of hornblende. Hornblende is normally scattered as well-formed crystals in the aegirine-augite and could be replacing the aegirine-augite or was encompassed by the growing aegirine-augite.

The bands appear to be metamorphic fabric as the minerals are roughly aligned. Sorensen (1974) feels that centimeter layering in augite syenite might be evidence of successive growth and accumulation of layers of crystals.

The field relationship between the pegmatites and the banded unit are not clear but the mineralogy appears the same and a gradual contact was observed in one place.

WILL #1

Outcrop is scarce but an eight meter square exposure surrounded by Wolverine gneisses has two alkali-feldspar aegirine-augite syenite dykes with a mafic dyke between them (Figure 2). A syenite breccia with a green, fine grained matrix, (metasomatized?) is found between the alkali rocks and the Wolverine gneiss. The exact contact was not observed, however, due to lack of outcrop.

Alkalí-Feldspar Aegirine-Augite Syenite

Two .5 meter wide alkali feldspar Aegirine-Augite Syenite dykes (Figure 2) outcrop for only 2 to 4 meters before being covered by till. The dykes contain abundant coarse crystalline aegirine-augite 60%, potassium feldspar 35%, 1% apatite, 3% coarse sphene and 1% albite An 10, trace magnetite, chalcopyrite and malachite. The potassium feldspar appears to be microcline with albite exsolved to form perthite; larger feldspar crystals are recrystallized to small albite and potassium feldspar at their grain boundaries. The apatite is well-formed and occurs as inclusions in the sphene and aegirine-augite.

Between the two dykes is a small monazite and ilmenite bearing mafic (>95%) dyke. The relationship of this unit to the syenites is not known.

Surrounding the two syenite dykes and mafic dyke is a breccia-like looking metasomatic syenite.

Syenite Breccia

This metasomatic syenite (Figure 2) still has relic potassium feldspar 25% and 10% plagioclase and a very altered light yellow-green to blue-green pleochroic amphibole, trace sphene and apatite in a green fine-grained matrix. It is very likely that this rock is a fenite. In handspecimen it has a fine green matrix with an intrusive clast breccia appearance.

URSA

Cataclastic Gneiss

A cataclastic gneiss (Figure 2) 10 meters long and 1-2 meters wide contains coarse to fine-grained monazite in disseminated clotty layers. This cataclastic gneiss is surrounded by the Wolverine biotite schist, graphitic marble and biotite-phlogopite calsilicate rocks on the eastern side. On the western side is a medium-grained fresh looking quartz monzonite (10-15% quartz, 45% plagioclase, 45% potassium feldspar).

The cataclasitc gneiss consists mainly of recrystallized potassium feldspar, quartz and aligned rounded albite with slightly aligned monazite, trace biotite, chlorite and sphene. The biotite is associated with the large albite and potasssium feldspars and is altering to chlorite.

There are coarse crystalline monazite bearing pegmatites in the area and the Ursa could represent a partly mylonized and recrystallized one.

WILL # 2

A complicated sequence of alkalic rocks, aegirine-augite monzodiorite, aegirine-augite syenite dyke and alkali-feldspar syenite dyke intruded into and altered the Wolverine amphibolites(Figure 2).

Plagioclase Amphibolite

The Wolverine amphibolite (Figure 2) is found on the eastern side of the alkalic rocks. It consists of coarse-grained hornblende 50-60%, augite 20%, aligned biotite in the hornblende (Fe rich) 20%, oligoclase (An27), trace sphene and allanite. The contact with the alkalic rocks to the northwest is very gradational and there are local eyes of 60-80% oligoclase with 10-15% aegirine-augite in the amphibolite, which is the same mineralogy as the aegirine-augite monzodiorite. Dark aegirine-augite plagioclase rocks with an increase in Fe and Ca is probably a fenitized plagioclase amphibolite (Sorensen 1974). The first alkaline rock at the contact is a light colored aegirine-augite monzodiorite.

Aegirine-Augite Monzodiorite

The aegirine-augite monzodiorite (Figure 2) is the most abundant rock found and it is a fine-grained light colored 80-90% oligoclase, 1-10% aegirine-augite, very altered, minor apatite, trace monazite, allanite and sphene alkalic unit.

The relationship of the southern contact between the amphibolite and monzodiorite is not known. There is a metasomatized unit between the two and part of the western closest amphibolite is extremely altered.

This aergirine-augite monzodiorite is cut by two types of alkali dykes; aegirine-augite syenite dyke and an alkali-feldspar syenite dyke.

Aegirine-Augite Syenite Dyke

The aegirine-augite syenite dyke (Figure 2), 10 cm wide and >5 meters long, consists of very large intergrown inclusion-filled crystals of aegirine-augite 80%, with 8% potassium-spar, 2% plagioclase, 3% allanite, 5% apatite and 2% sphene. The contact with the aegirine-augite monzodiorite is sharp for the aegirine-augite component but gradual for the potassium feldspars. From the contact of the dyke outwards, the potassium feldspar decreases and the plagioclase increases until 5 cm from the dyke only plagioclase is present. This could indicate a potassium alteration associated with the dyke. Several small perpendicular fractures cut across the dyke and aegirine-augite monzodiorite and consist of potassium feldspar with minor plagioclase.

Alkali-Feldspar Syenite Dyke

The alkali-feldspar syenite dykes (Figure 2), .20 and .15 meters wide (length unknown) consist of 90% potassium feldspar rimmed by plagioclase and 10% disseminated aegirine-augite.

Metasomatized Amphibolite

The amphibolite (Figure 2) has the hornblende and aegirine-augite altering to a red fibrous material; the biotite is also altering and there are radioactive halos in the biotite, hornblende and aegirine-augite. The albite and oligoclase are very cloudy and exhibit undulose wavy extinction. At the farthest western part of the outcrop there is up to 4% thorite as well-formed and irregular grains (mm). This grades into a fine-grained green looking rock that has relic hornblende laths and about 10% plagioclase, 25% potassium feldspar, minor apatite, trace sphene, zircon and thorite. The matrix is a very fine submicroscopic-grained green mass. The appearance of these rocks would indicate that solutions from the alkaline intrusions are altering the Wolverine amphibolite.

MT. BISON AND OTHER MONZONITES

A fresh looking fine-grained quartz monzonite to quartz syenite outcrops throughout the property (Figure 1). Mapping is incomplete but there are four very large bodies ranging up to 1 by 3 kms; their relationship with any of the other alkalic rocks are not known. They consist of 52-60% potassium feldspar, 34-28% plagioclase, 14% quartz, trace biotite, chlorite and allanite. Petrographically the rock appears to have undergone a very brief period of recrystallization, which indicates that this occurred after the main metamorphism events of the wolverine rocks; therefore, an approximate age of 60-70 million years can be placed on them. This is roughly the same as the nearest dated intrusive by Tipper (1974) of 78 million years.

RARE EARTH GEOCHEMISTRY

On the Halleran Alkaline Complex no carbonatite rocks have been found, but the chondrite-normalized rare earth element abundance patterns of the majority of the rocks are typical of carbonatites and fall within the field defined by the other B.C. carbonatites (Figure 3). On the average however, the Halleran Alkaline Complex contains more rare earths than other B.C. occurrences.

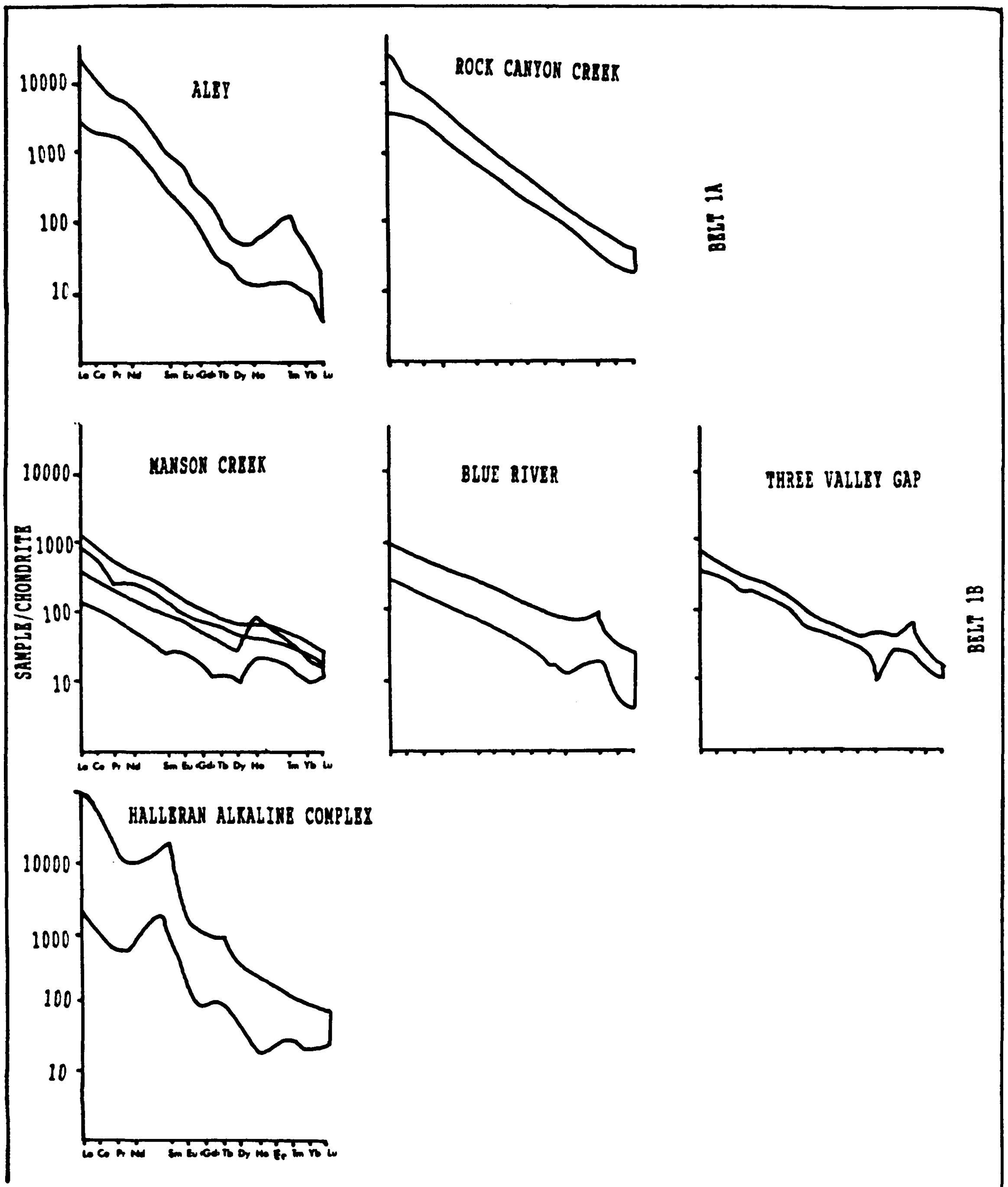


Figure 3 Comparison of the Halleran Alkaline Complex with other Belt 1A and 1B carbonatites. Chondrite-normalized rare earth element plots, B.C. Carbonatites. All data for the Rock Canyon, Aley, Manson Creek, Blue River, and Three Valley Gap is from Pell (1987).

The relative abundance of the chondrite-normalized rare earth element abundance patterns were calculated. This approach allows a better comparison between well mineralized rocks and those that are poorly mineralized. Similar relative chrondrite normalized plots would indicate similar origin. If the similarity is substantiated by petrology, then the rocks might be grouped. The relative abundance of the chrondrite-normalized rare earth elements in a sample were calculated with the following formula:

$$\left[\frac{\left(\frac{X(La)measured}{Chondrite\ (La)}\right)}{\frac{X(La)}{Chondrite\ (La)} + \frac{X(Ce)}{Chondrite\ (Ce)} \ldots\ldots\ldots\ldots \frac{X(Lu)}{Chondrite\ (Lu)}}\right] \times \frac{10,000}{1}$$

Group 1 are upper crustal melt (Figure 4), granitic-quartz rich pegmatites- UG-1, UG-9, 87-R-3. These pegmatites are relatively depleted in europium but strongly enriched in heavy rare earths. Meucke and Moller (1988) have found that if a pegmatite crystallizes from an upper crust that is already enriched in REE it will be strongly enriched in light REE but relatively depleted in europium (Figures 5 and 6). The plagioclase residue of crustal melts preferentially retains europium. It is very likely that the cataclastic gneiss UG-1 is a cataclastic UG-9 or 87-R-3, and represents a mylonized pegmatite. Petrologically they are identical.

Group 2 (Figure 4) consists of all the alkaline rocks

"RELATIVE" NORMALIZED CHONDRITE RARE EARTH ABUNDANCE PLOTS

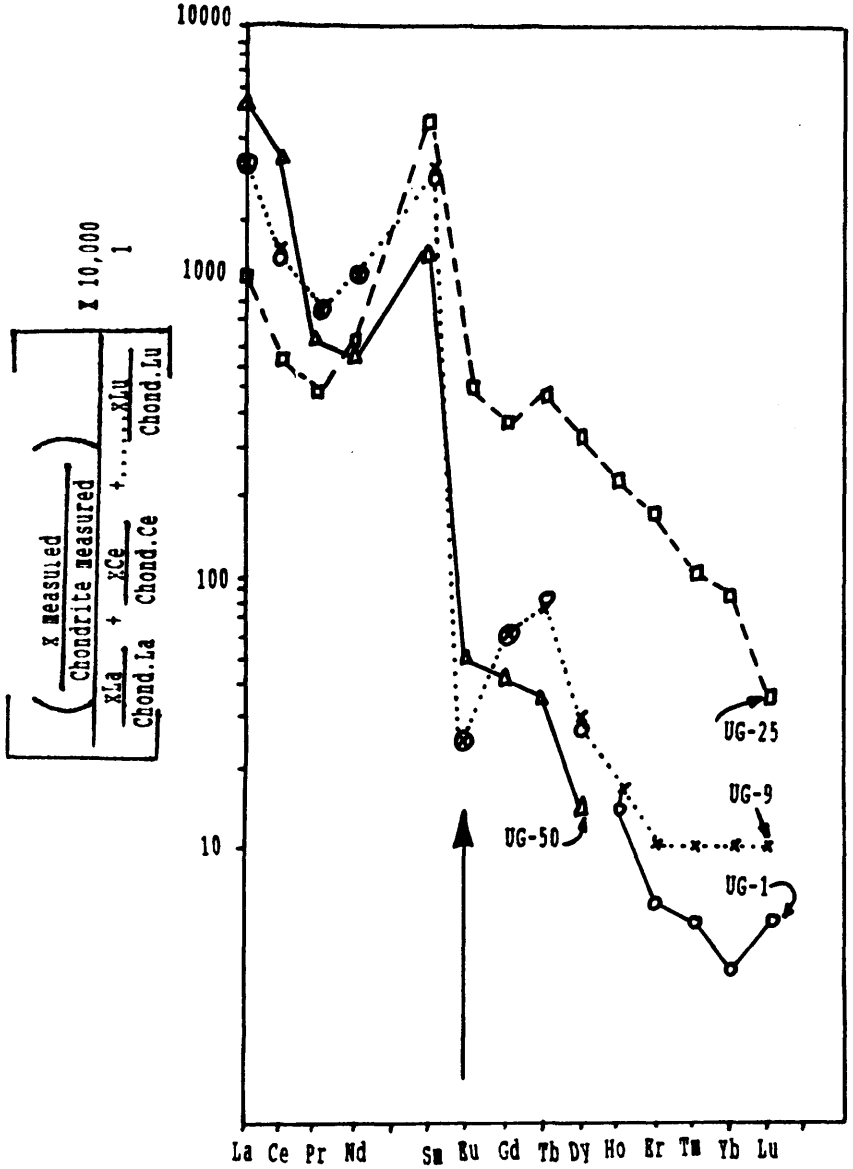
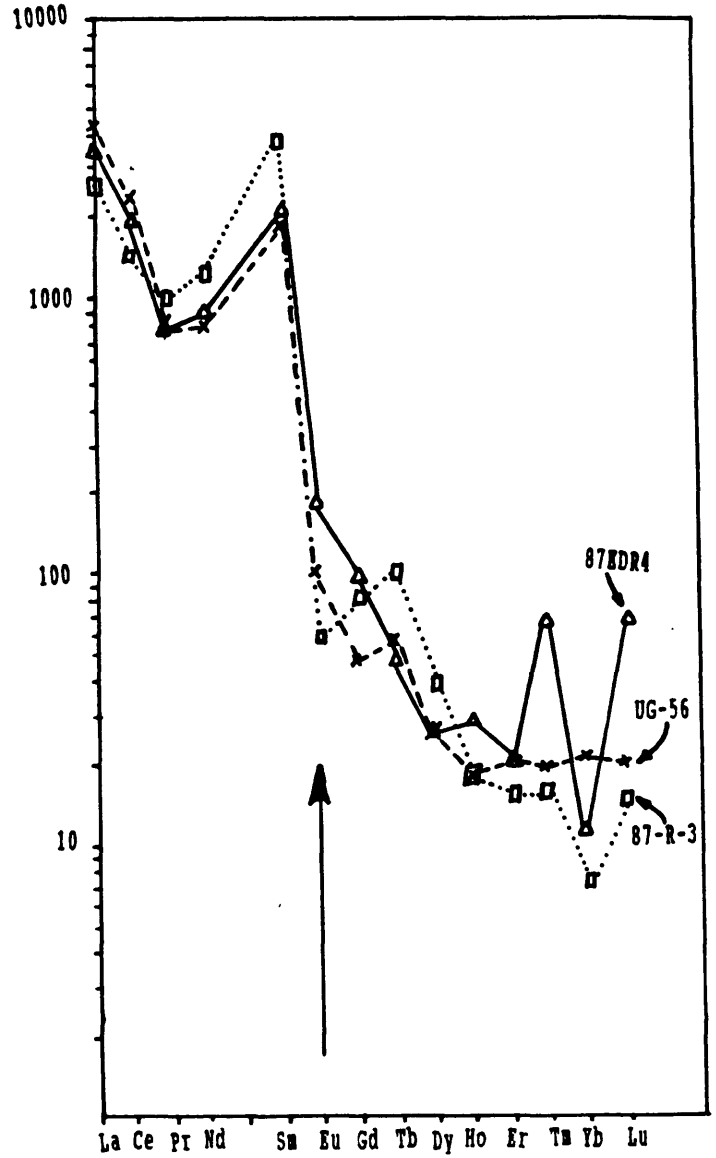


Figure 4 Normalized Chondrite Rare Earth Abundance Plot
Note the 3 groups;
Group 1: UG-1 cataclastic gneiss (Ursa), UG-9, 87R3,: they are all granitic quartz pegmatites relatively depleted in europium.



Group 2: UG-50, UG-56, 87EDR4,: alkalic rocks, not relativily depleted in europium.
Group 3: UG-25,: metasomatic unit enriched relatively in heavy rare earths.

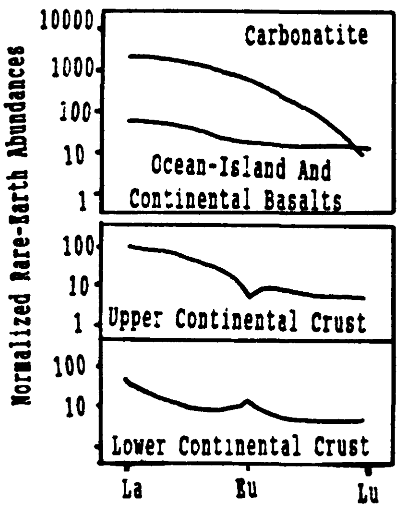


Figure 5 Rocks that are less than 2.5 billion years old reflect the melting and crystallization of their formation by either being enriched or depleted in the lighter rare-earths. The discrepancies in the abundances of europium in rocks from the upper and lower continental crust is the result of the lower crust preferentially retains europium (Muecke and Moller 1988).

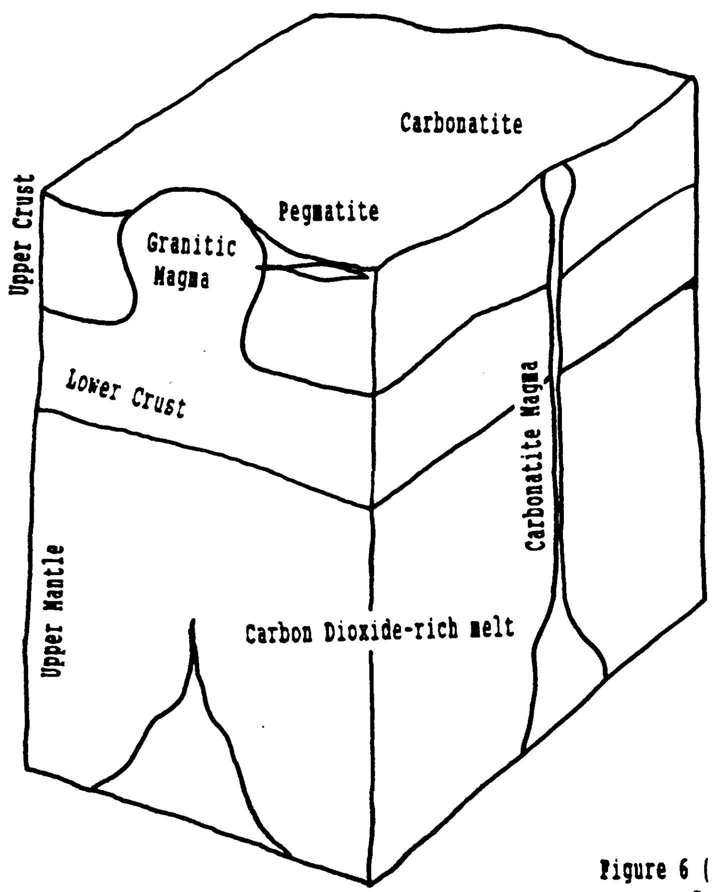


Figure 6 (Muecke and Moller 1988)
Crustal material melts to form granitic pegmatites that after extensive crystallization can be enriched in light rare earth. If the magma originates from the upper crust it will be relatively depleted in europium. If the melt is a carbon dioxide rich deep melt it will be a carbonatite.

except for UG-25 and UG-97. These rocks have a carbonatite chondrite-normalized rare earth abundance signature (Figures 3 and 5) and could be related to an undiscovered carbonatite; the presence of a Ba-Fe-REE-Silicate supports a carbonatite environment interpretation. The relative chondrite-normalized rare earth abundance displays no depletion in europium. The alkali pegamtites could have been the residual liquids of the banded aegirine-augite alkali-feldspar syenite as one gradational contact is evident.

Group 3, UG-25 and UG-97, the metasomatized unit or fenite, is enriched in the heavy REE group (Figure 4). In hydrothermal solutions heavy REE have a strong tendency to remain in solution while the light rare earths have a greater chance of being incorporated into the crystals that grow in hydrothermal solution (Meucke and Moller 1988). This results in light REE being deposited first, then heavy REE. With the rocks not only appearing very altered but also relatively enriched in Heavy REE, indicates that REE rich solutions percolated through these rocks. Local concentrations of thorite might indicate hydrothermal veins associated with syenite rocks (Sorensen 1974) The alteration could be related to alkali rocks, and might be a fenite.

ECONOMIC ASPECTS

The Halleran Alkaline Complex has light and heavy rare earths (Table 1), niobium and zirconium potential.

Three economic rare earth bearing minerals were identified- monazite, allanite, and cerorthite; an unknown Ba-Fe-REE-Silicate was also found.

Monazite is the most widespread rare earth mineral and occurs as coarse to fine-grained disseminated crystals in clotty layers in the cataclastic gneiss. It is disseminated to very coarse from 2% to trace in the mafic dyke, allanite monzonite pegmatite, nepheline syenite pegmatite, banded aegirine-augite alkali-feldspar syenite: 2% in the mafic layers and aegirine-augite monzodiorite.

The most interesting rare earth minerals are allanite and cerorthite which make up to 35% of a unique allanite-monzonite pegmatite as coarse .5-2.0 cm tabular crystals, 3% of the aegirine-augite syenite, minor amounts in the banded aegirine-augite alkali-feldspar syenite in the mafic bands, and as trace amounts in the remaining feldspathic units.

Compared to the other alkaline complexes, the Halleran Alkaline Complex is heavily enriched in the rare earth elements. This deposit also has heavy rare earths to a total of >600 ppm.

TABLE 1

RARE EARTH CONCENTRATIONS IN PPM IN ROCK SAMPLES

Sample	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Y
UG-1	5929	6529	708	4369	3643	10	97	24	58	6	8	1	4	193
UG-9	2659	3175	314	1941	1681	5	44	10	27	3	6	1	6	86
UG-17	7	8	1	6	15	1	2	1	5	1	2	1	2	29
UG-23	56	76	8	41	53	1	1	1	2	1	1	1	3	13
UG-25	311	461	49	371	847	32	84	19	93	15	30	3	18	403
UG-29	265	293	24	136	102	2	1	1	2	1	1	1	1	12
UG-43	261	379	20	90	67	2	3	1	2	1	1	1	1	10
UG-50	25050	36220	1675	7361	4674	63	193	30	77	11	26	3	18	282
UG-51	5806	9226	592	2760	1670	29	56	9	20	3	8	1	9	75
UG-56	2086	2869	160	774	545	11	19	4	13	2	7	1	7	64
87R3	2033	2406	263	1648	1548	9	49	11	29	3	6	1	3	90
87EDR1	638	1030	56	262	214	5	14	2	10	2	5	1	6	53
87EDR2	906	1215	68	357	300	10	17	2	9	1	4	1	4	41
87EDR4	548	792	48	256	187	6	12	1	4	1	2	1	2	38
87EDR5	612	1067	72	406	401	3	19	2	4	1	1	1	1	12
Detect.	1	2	1	1	1	1	1	1	1	1	1	1	1	2

Analysis by Acme Analytical Laboratories Ltd.
Whole rock ICP-MS analysis
.100 gram sample fused with .6 gm LIBO2 and is dissolved and diluted to 50 ml with 5% HNO3. Analysis by ICP-Mass Spectrometer

Rock descriptions;

UG-1, cataclastic gneiss, Ursa #1
UG-9, granite-quartz pegmatite
UG-17, Tourmaline quartz pegmatite, not this area, for background.
UG-23, Will #1, alkali-feldspar aegirine-augite dyke
UG-25, Will #1, metasomatic amphibolite
UG-29, monzonite
UG-43, Mount Bison quartz-monzonite to quartz-syenite
UG-50, Laura #1, allanite-monzonite pegmatite
UG-51, Laura #1, allanite-monzonite pegmatite
UG-56, Laura #1, banded aegirine-augite-alkali-feldspar syenite
87R3, granite-quartz pegamtite
87EDR1, Laura #1, allanite-monzonite pegmatite
87EDR2, Laura #1, banded aegirine-augite-alkali-feldspar syenite
87EDR4, Laura #1, banded aegirine-augite-alkali-feldspar syenite
87EDR5, Laura #1, banded aegirine-augite-alkali-feldspar syenite

Niobium

One sample, which was taken from a large granitic pegmatie boulder in talus, had .42% niobium.

Zircon

Zirconuim occurs in all the alkalic rocks; the concentration is low with the highest being .17%. However, it could be recovered as a byproduct.

CONCLUSION

The field relationships of the alkalic rocks on the Halleran Alkaline Complex are not certain. However, with petrography, chondrite-normalized rare earth abundances and relative chondrite-normalized rare earth abundance patterns, the following conclusions are made:

1) The rocks can be divided into three groups.

2) The cataclastic gneiss on the Ursa #1 is a mylonized granitic-quartz rare-earth bearing pegmatite. These pegmatites represent an upper crustal melt, Group 1, depleted in europium, and are not related to the alkalic rocks.

3) All the alkalic rocks, Group 2, give a carbonatite chondrite-normalized REE abundance pattern and could be related to an undiscovered carbonatite.

4) The allanite-monzonite pegmatite is a very unique find in B.C.

5) There was more than one episode of alkalic rock intrusion as the aegirine-augite monzodiorite is crosscut by two types of alkalic dykes:an aegirine-augite syenite dyke and alkali-feldspar syenite dykes.

6) The aegirine-augite syenite dyke had potassium alteration associated with it that altered the contacting aegirine-augite monzodiorite.

7) The layers in the banded aegirine-augite alkali-feldspar might be evidence of successive growth and accumulation of layers of crystals that underwent a period of metamorphism.

8) The alkalic rocks on Will #1 & #2 had solutions (Hydrothermal) that metasomatized the surrounding Wolverine amphibolite and possibly a syenite. These rocks are Group 3 and are enriched in heavy REE and in part, thorite, which might indicate hydrothermal solutions percolating from the alkali rocks. They are bleached in places and the aegirine-augite plagioclase amphibolite, Will #2, might be a fenitized plagioclase amphibolite.

9) Three rare earth minerals were found- monazite, allanite and cerorthite as well as an unidentified Ba-Fe-REE-Silicate.

10) The ages are not known. The Mt. Bison Monzonite and

the Ursa #1 monzonite occurred after the last metamorphism 69-43 million years ago (Tipper et al 1974) while an intrusive just south was dated at 79 million years (Tipper et al 1974).

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