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CARBONATITES AND RELATED ROCKS OF THE PRINCE AND GEORGE CLAIMS, NORTHERN ROCKY MOUNTAINS* (93J, 93I)

By Urs K. Mäder and Hugh J. Greenwood
Department of Geological Sciences,
The University of British Columbia

KEYWORDS: Economic geology, alkalic igneous rocks, carbonatites, niobium, rare earth elements, Rocky Mountain Trench, ultrabasic rocks.

LOCATION

Teck Explorations Limited holds the Prince and George groups of claims (162 units, Cariboo Mining Division) near Wicheeda Lake, 80 kilometres northeast of Prince George at latitude 54°31′ north, longitude 122°04′ west (93I/5, 93J/8, 93J/9, Figure 3-3-1). Access is by helicopter, although some areas may be reached from nearby logging roads.

HISTORY

Prospecting in the area in 1976 and 1977 yielded minor base metal showings. Later assaying of these samples indicated anomalous niobium values. The claims were staked between April and August 1986 by Teck Explorations Limited. Work completed in 1986 and 1987 included geological mapping, geochemical (soil, stream) as well as total field magnetic surveys, trenching and bedrock geochemical analyses (Betmanis, 1987).

REGIONAL GEOLOGY

The regional geology has been mapped by Armstrong *et al.*, 1969, McLeod Lake) and Taylor and Stott (1979, Monkman Pass). Both map sheets cover parts of the property. The area forms part of a steeply dipping, complexly faulted package of sediments between the McLeod Lake fault to the southwest and the Parsnip River to the northeast. The Rocky Mountain Trench follows the Parsnip Valley farther to the north but loses its identity in the study area. The trench resumes its course further to the southeast, with a 20-degree change in direction at the upper Fraser Valley.

Neither the age of the sediments nor the structure is established. Armstrong *et al.* (1969) indicate that the property is underlain by upper Cambrian Kechika Group sedimentary rocks overthrust by lower Cambrian Misinchinka Group clastic rocks. Lower Cambrian dolomites and limestones overlie the Misinchinka Group southwest of Wichcika Creek. Taylor and Stott (1979) indicate that the property is underlain by lower Ordovician Chushina Formation limestones and argillaceous rocks, and middle Ordovician Skoki Formation dolomites overthrust by metamorphosed Precambrian Misinchinka Group limy sediments. The subvertical thrust fault is mapped on both map sheets on the western slope of the main ridge west of the Parsnip Valley, a short distance to the west of the instrusive bodies examined (Figure 3-3-1).

LOCAL GEOLOGY

A series of carbonatite plugs, sill-like bodies and dykes (Figure 3-3-1) with associated alkaline silicate rocks intrude argillaceous rocks and limestones probably within the same tectonic slab. The intrusions follow the trend of the Rocky Mountain structures, parallel to the steeply dipping schistosity and bedding. Sparse outcrop and the fine-grained lithologies prevent the determination of stratigraphic tops and local structures. The main tectonic feature appears to be thrust faults parallel to bedding. Tight isoclinal structures, however, may be present. Steep faults at high angles to the Rocky Mountain trend are commonly outlined by topographic features.

AGE

No radiometric date has been obtained. Material suitable for radiometric dating includes biotite in carbonatite and zircon in some syenitic rocks.

Unambiguous field relationships are not exposed, so that it is possible to imagine a pre-Rocky Mountain or a post-Rocky Mountain age. Well-developed parallel fabrics are visible in thin section in most intrusive rocks. These fabrics are concordant with fabrics in the adjacent sedimentary rocks. The authors believe that the intrusions were emplaced prior to the formation of the Rocky Mountains and were subsequently deformed during the Columbian orogeny. It should be emphasized that carbonatites are very resistant to deformation and weathering, if contained in incompetent host rocks (Aley carbonatite complex, Mäder, 1987).

It is therefore likely that the intrusions are related to the Devono-Mississippian group of alkaline/carbonatite intrusive bodies emplaced into the old North American continental margin, which roughly follows the trend of the present-day Rocky Mountain Trench (Pell, 1986, 1987).

INTRUSIVE ROCKS

All intrusions show mineralogies typical of true igneous carbonatites and alkaline rocks (Table 3-3-1), but each stock has its distinctive petrographic features.

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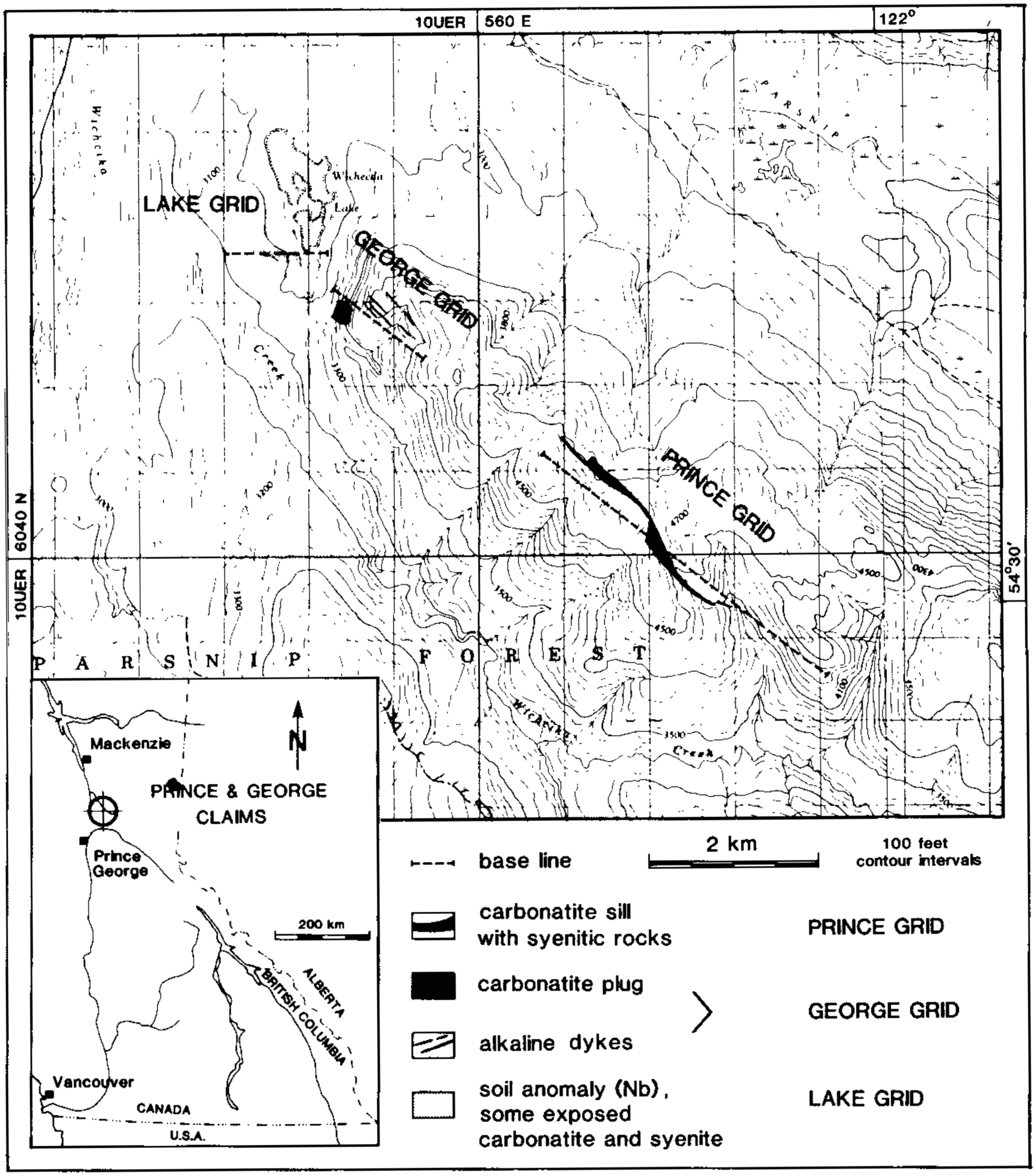

Figure 3-3-1. Location map of the intrusive bodies of the Prince and George groups of claims.

Carbonatites range from almost pure calcite carbonatite to pyroxene-biotite-rich varieties and rare-earth-rich ferrocarbonatite. Feldspathic rocks range from albite-rich and potassium-feldspar-rich leuco to mesotype syenites to leucitites. The suite is therefore a highly differentiated series of alkaline rocks. Unfortunately, sparse outcrop does not permit the establishment of field relationships between most units.

The group of igneous rocks as a whole is characterized by the ubiquitous presence of ilmenite and sodic pyroxene. A summary of the mineralogy is presented in Table 3-3-1. Methods of mineral identification include transmitted and reflected light microscopy, X-ray diffraction and the scanning electron microscope with an energy-dispersive analytical system.

CARBONATITE SILL (PRINCE GRID)

The carbonatite/alkaline sill can be traced for nearly 3 kilometres along strike (Figure 3-3-2) and may extend further to the northwest. The northwestern half of the intrusion, west of a northerly trending, steeply dipping fault, is petrographically distinct from the thickened southeastern half.

The northwestern part consists of medium to coarse-grained calcite carbonatites with variable amounts of aegirine

TABLE 3-3-1. LIST OF MINERALS

Mineral		Carbona-tite	Silcate Rocks
Aegirine	AEG	x	x
Albite	ALB	x	x
Alstonite[1]	ALS	x	x
Ancylite ?	ANC	x	
Ankerite	ANK	x	
Apatite	APA	x	x
Arag-stront[2]	ASS	x	x
Arfvedsonite	ARF		x
Augite	AUG		x
Barite	BAR	x	
Biotite	BIO	x	x
Burbankite	BUR	x	
Calcite	CAL	x	x
Cancrinite	CAN	x	x
Dolomite	DOL	x	x
Garnet (Ca-Fe)	GAR		x
Hyalophane	HYA		x
Ilmenite	ILM	x	x
K-feldspar	KSP	x	x
Leucite	LEU		x
Magnetite	MAG	x	x
Melanite	MEL		x
Monazite	MON	x	
Muscovite[1]	MUS		x
Parisite[3]	PAR	x	
Phlogopite	PHL		x
Pyrite	PYR	x	x
Pyrochlore	PCH	x	x
Rutile	RUT	x	
Sodalite	SOD		x
Sphalerite	ZNS	x	x
Sphene	SPH	x	x
Zircon	ZIR		x

[1] Alteration product.
[2] Aragonite-strontianite solid solution.
[3] Or röntgenite, synchysite.

and biotite and a pronounced subvertical mineral layering (Figure 3-3-3, Table 3-3-2). Felsic rocks, interbedded with carbonatites, include albite-rich and minor potassium-feldspar-rich leucocratic to mesocratic varieties with aegirine and biotite. The contacts between silicate and carbonatite rocks are distinct or gradational, but without clearly defined relationships, possibly indicating closely timed pulses of magma or *in situ* differentiation of the sill. Contacts with the argillaceous wallrock sediments appear to be conformable, but with surprisingly little visible alteration or contact metamorphism.

The southeastern, thickened part of the intrusion is comprised of white, layered calcite carbonatite, coarse-grained leucosyenite, augite leucite syenite and thinly layered, fine-grained, mesocratic augite syenite (Figure 3-3-4, Table 3-3-2). All rock types contain abundant sphene. The carbonatite clearly intrudes the leucosyenite (irregular on a small scale) and the layered mesocratic syenite (formation of intrusive breccia). The relation of the undersaturated syenite to the other rocks is unknown. The relationship between the two distinctly different parts of the sill across the fault is unclear.

CARBONATITE PLUG (GEORGE GRID)

The oval carbonatite intrusion is about 250 metres in diameter with an undefined northwestern boundary. A series of trenches from southwest to northeast exposes a nearly complete cross-section. The intrusion consists largely of uniform ankerite carbonatite, in parts with 5-centimetre rhombic ankerite phenocrysts and 2-centimetre pyrite cubes. Minor constituents include potassium feldspar, ilmenite, and a parisite-like rare-earth carbonate (20 to 200 microns). Toward the southwestern margin, a variety of albite-rich

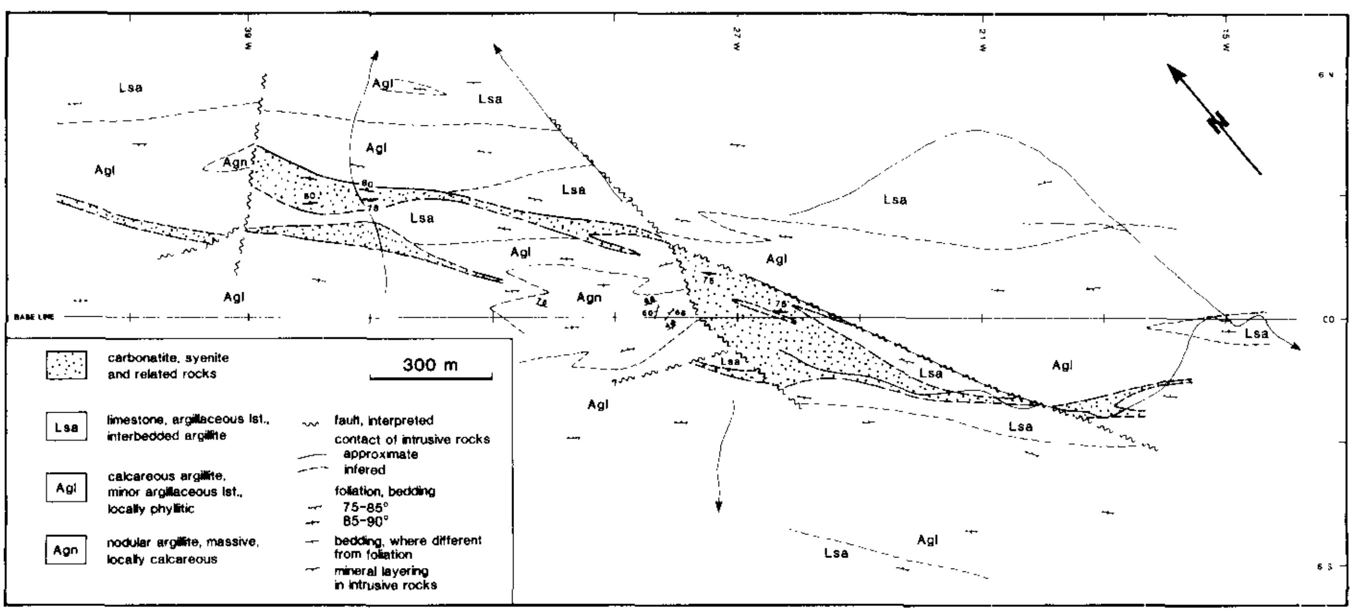

Figure 3-3-2. Geological map of the Prince grid, simplified after Betmanis, 1987, Teck Explorations Limited.

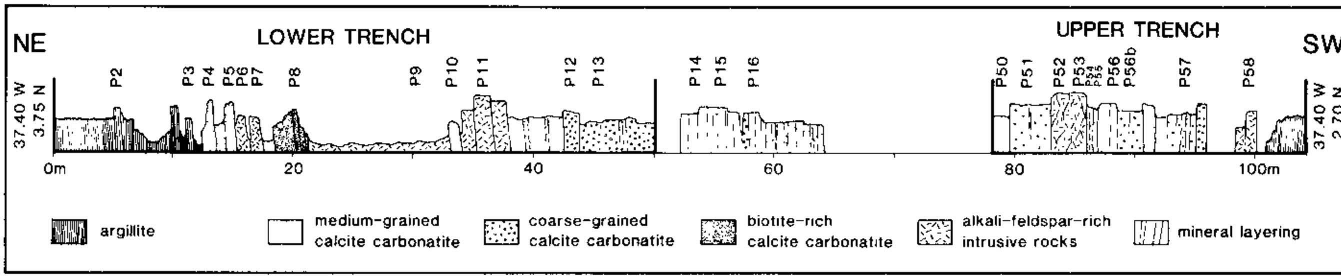

Figure 3-3-3. Geological cross-section of the northeastern part of the Prince grid.

TABLE 3-3-2.
MODAL COMPOSITION OF ROCKS FROM THE PRINCE GRID

Sample	CAL	ALB	KSP	LEU	BIO	AEG	AUG	CAN	BUR	APA	Accessory
Rocks of Figure 3-3-3											
P8	30	11			27	21				6	MAG(4),PYR
P9	5	44	30			15		3		2	PYR,ILM,PCH
P10	88				2	6			3		PYR,PCH
P11		42				11		45			DOL(1).ILM
P12	79	5				15					PYR,PCH
P13	78	19				2					PYR
P15	75	12			5	5			2		PCH,PYR,ILM
P16	78				8	6		4	3		PCH,ZNS,PYR
P50	69	25				4				2	ILM
P53	3	76				18				3	ILM
P54	73				4	5		17			PYR,ZNS
P56	80	2			8	5			5		PCH,ZNS,PYR
P57	88	1				4			6		PYR,PCH,ILM
P58	10		76		2					2	alteration(10)
Rocks of Figure 3-3-4											
Carb[1]	93		6	<1						<1	SPH
Syen[2]	10		5	76		2	2	2			ALS,ZIR,PCH
Leuc[3]	2		19[5]	58			18			<1	SPH(2),MEL
b-syen[4]	10		43				45			1	SPH(1)

[1] Carbonatite.
[2] Leucosyenite.
[3] Augite-leucite syenite.
[4] Banded mesotype augite syenite.
[5] Barian feldspar (hyalophane).

rocks are mixed with ilmenite-rich carbonatite. The argillaceous and calcareous sediments close to the intrusion appear somewhat baked, but with no macroscopically visible contact metamorphic mineral assemblages.

ALKALINE DYKES (GEORGE GRID)

Three types of dykes (50 to 150 centimetres in thickness) are slightly discordant to the trend defined by bedding and schistosity. The dykes appear to be undeformed.

The first type is a potassium-feldspar-phyric rock with a fine-grained albite-rich matrix with abundant iron-rich biotite. Accessory minerals include poikilitic calcite, ilmenite and zircon.

The second type has abundant blue sodalite phenocrysts, rare xenoliths of microsyenite and a fine-grained matrix of albite and sodalite. Accessory minerals include calcite, ilmenite, sphalerite and zircon.

The third type is a feldspar-augite-phyric intermediate dyke with an aphanitic groundmass. This type is observed to cut the sodalite dykes and appears to be of much younger age.

The alkaline dykes (Types 1 and 2) may well be related to the carbonatite intrusions of the area, although at present neither the extent of the dyke swarm nor its relationship to the carbonatite stock are known.

CARBONATITE INTRUSION (LAKE GRID)

Outcrop is scarce, with good exposure limited to three trenches, but soil anomalies appear to be well defined and to be capable of defining the underlaying intrusive bodies rather well.

The main rock type appears to be a deeply weathered, medium to coarse-grained calcite carbonatite with accessory feldspar, pyrite and apatite. A band of fresh, distinctly pink fine-grained calcite carbonatite with aegirine mineral layering contains relatively large (0.1 to 0.8 millimetre) euhedral pyrochlore grains accumulated within pyroxene-rich layers. At least one syenite body of unknown size and shape appears to be associated with the carbonatites. Besides laths of potassium feldspar, variable amounts of aegirine, albite, biotite, cancrinite and calcite are present with accessory pyrite, apatite, ilmenite and sphene.

GEOCHEMISTRY

Limited data on bedrock samples are available at present (Betmanis, 1987). All the intrusive rocks are enriched in the elements typical of alkaline/carbonatite rocks, enabling the use of niobium, barium, strontium or cerium to define geochemical anomalies in soil surveys.

Chondrite-normalized rare-earth patterns fall into the range of values defined by other intrusions in British Columbia enriched in light rare-earth elements (Betmanis, 1987; Pell, 1987).

ECONOMIC ASPECTS

Niobium: The only niobium-bearing mineral observed is pyrochlore, $(Na,Ca)_2(Nb,Ti,Fe)_2O_6(OH,F)$, mostly of grain sizes less than 0.3 millimetre. Pyrochlore occurs in both carbonatite and syenitic rocks. All specimens examined with the energy-dispersive system of the scanning electron microscope show thorium and uranium contents below or near detection limits. All pyrochlores are titaniferous, with low or undetectable contents of iron and other elements (Sr, Ba, Ta), which explains the occurrence of some colourless, glass-clear grains visible in thin section.

The absence of other thorium/uranium-bearing minerals explains the observed strong correlation between pyrochlore

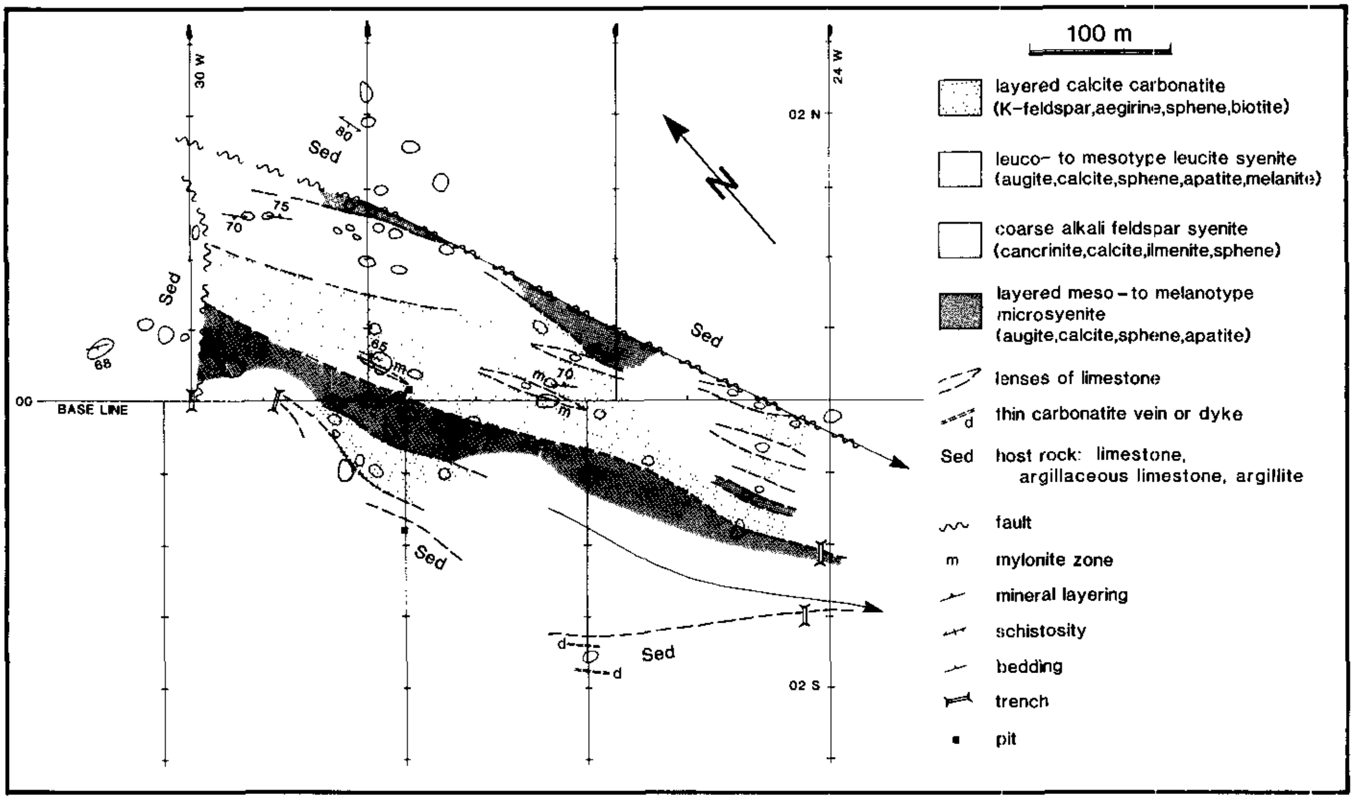

Figure 3-3-4. Geological map of the southwestern part of the Prince grid based on mapping by Greenwood, Hora and Mäder (July 1987).

content (niobium grade) and gamma activity (scintillometer readings) (Betmanis, personal communication, 1987).

Rare-earth Elements: Many carbonatite samples from the Prince grid show visible, pinkish, fine-grained rare-earth carbonates (mostly burbankite) in hand specimen.

The ferrocarbonatite plug on the George grid shows no mesoscopic rare-earth mineralization, but abundant fine-grained monazite (Ce-La phosphate) and parisite (Ca-Ce-La fluor-carbonate) are visible in thin section and under the scanning electron microscope.

All rare-earth minerals analysed are strongly enriched in light rare-earth elements, dominated by cerium, followed by lanthanum, neodymium and praseodymium. Yttrium and heavy rare-earth elements were not observed at the detection limits of the energy-dispersive system.

DISCUSSION

Although the age of the intrusions is not established, we think that they must be older than the Columbian orogeny, possibly of mid-Paleozoic age. The nature of the petrogenetic link amongst carbonatites and syenites, if it exists, is not known. The close spatial relationship was most probably present prior to the formation of the Rocky Mountains. The shapes of the igneous bodies prior to deformation may be envisaged as sills and tube or laccolith-like plugs with dykes subparallel to bedding. The depth of the intrusions and the ages of the host rocks are not known. There is no evidence of volcanic activity associated with the intrusions.

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