CARBONATITES AND RELATED ROCKS IN BRITISH COLUMBIA (82L, 83D, 93I, 93N)

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INTRODUCTION

Carbonatites are ultramafic igneous rocks composed of more than 50 per cent carbonate minerals. They may contain significant amounts of olivine, magnetite, pyroxene, sodic amphibole, biotite, vermiculite, apatite, columbite, zircon, and pyrochlore. Carbonatites have been prospected the world over because they are commercial sources of niobium (from columbite and pyrochlore), phosphates (from apatite), rare earths, vermiculite, copper, and fluorite.

Carbonatites are often associated with other alkaline rocks such as nepheline and sodalite syenites, urtites, and ijolites (nepheline and feldspathoid-rich rocks). Metasomatic rocks (fenites) enriched in sodium and ferric iron and depleted in silica may be present along the margins of carbonatite complexes. Locally, kimberlite dykes and diatremes are associated with carbonatitic material. Occurrences of kimberlites in British Columbia will be dealt with in future studies.

A number of known carbonatite localities in British Columbia occur in a broad belt along the Rocky Mountain Trench. Most other Canadian examples occur in Quebec and Ontario, for example, Oka and Callander Bay (Currie, 1976a).

Carbonatites examined for this study were the Lonnie (Granite Creek) and Vergil prospects near Manson Creek (93N/9); the Verity (Lempriere), Paradise Lake, and Bone Creek prospects (83D/6), the Mud Lake showing (83D/3) and the Howard Creek site (83D/7) all near Blue River; and an exposure near Three Valley Gap (82L/16) in the Revelstoke area (Fig. 21). In addition, although it has no known associated carbonatites, a sodalite syenite on Bearpaw Ridge northeast of Prince George (93I/4) was also mapped. Other examples of British Columbia carbonatites and related rocks, which were not studied during this field season, are found in the vicinity of the Frenchman Cap gneiss dome, northwest of Revelstoke (Jordan River-Mount Copeland area, Fyles, 1970; Currie, 1976b; Perry River and Ratchford River, McMillan, 1970; McMillan and Moore, 1974; and Mount Grace, Hoy and Kwong, in prep.), along McNaughton Lake near the Mica Dam (Kinbasket Lake and Trident Mountain, Currie, 1976a), and in Yoho National Park, east of Golden (Ice River Complex, Currie 1975; Peterson, 1983).

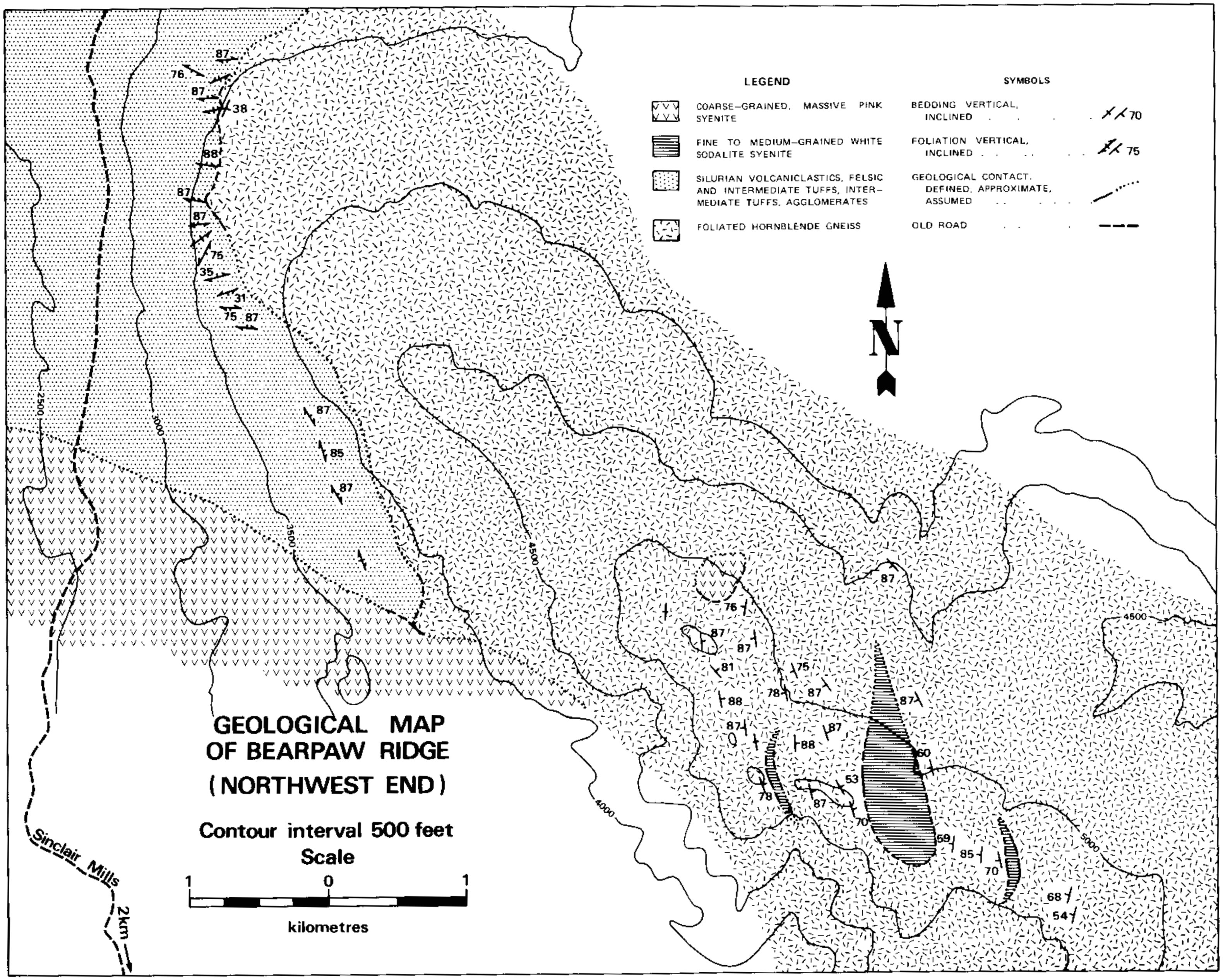

Figure 22. Geological map of Bearpaw Ridge (northern end).

GENERAL GEOLOGY

The carbonatites and related rocks studied this year were all injected into Upper Precambrian to Lower Paleozoic miogeoclinal rocks. The time of emplacement appears, in all cases, to be prior to the deformation and metamorphism associated with the Jurassic-Cretaceous Columbian orogeny. The age of the Ice River Complex has been estimated at 245 Ma using whole rock Rb/Sr analyses (Currie, 1975). Okulitch, *et al.* (1981) have dated intrusive rocks from the Mount Copeland area at 773 Ma. One U/Pb zircon date has been obtained from the Verity deposit (G. White, personal communication, 1984) which places its age at 325 Ma. Further isotopic dating is currently in progress.

All the deposits examined exhibit many similarities, but the most marked similarities occur within localities in an individual region. In the following discussion the carbonatites will be described by area.

MANSON CREEK AREA (93N/9)

Syenite, monzonite, and carbonatite occur together on both the Lonnie (Granite Creek) and Vergil claims. The two showings are located 3 kilometres apart approximately 8 kilometres east of the gold mining village of Manson Creek, 230 kilometres northwest of Prince George. Exposures are in trenches at 1 000 to 1 100 metres in elevation. Except for these trenches and along Granite Creek, outcrop is sparse.

At both Lonnie and Vergil the intrusive rocks occur in single, northwest-trending, sill-like horizons within uppermost Precambrian metasedimentary rocks. The metasedimentary rocks are part of the Wolverine Complex and have, along with the intrusive rocks, been metamorphosed to lower amphibolite facies. Within each intrusive zone the various rock units are distributed in interfingering lenses (Hankinson, 1958; Rowe, 1958; Halleran, 1980). The Lonnie (Granite Creek) carbonatite is up to 50 metres in thickness and traceable for nearly 500 metres; the Vergil showing is approximately 30 metres thick and can only be traced for a few hundred metres.

Carbonatites of two varieties are present within the Lonnie Complex; one is aegirine sovite in which the principal components are calcite, microcline, and aegirine, the other is biotite sovite with calcite, biotite, and plagioclase. Both varieties are foliated and contain apatite and pyrochlore. The biotite sovite occurs along the northeastern margin of the complex; the aegirine sovite along its southwestern margin. Feldspathic intrusive rocks, monzodiorites, monzonites, and syenites, separate the carbonatite units. These intrusive rocks consist of K-feldspar and plagioclase in varying proportions, with biotite, muscovite, and minor amounts of calcite, zircon, columbite, and ilmenorutile (Halleran, 1980). Nepheline syenite has also been recognized (Hankinson, 1958) within this suite.

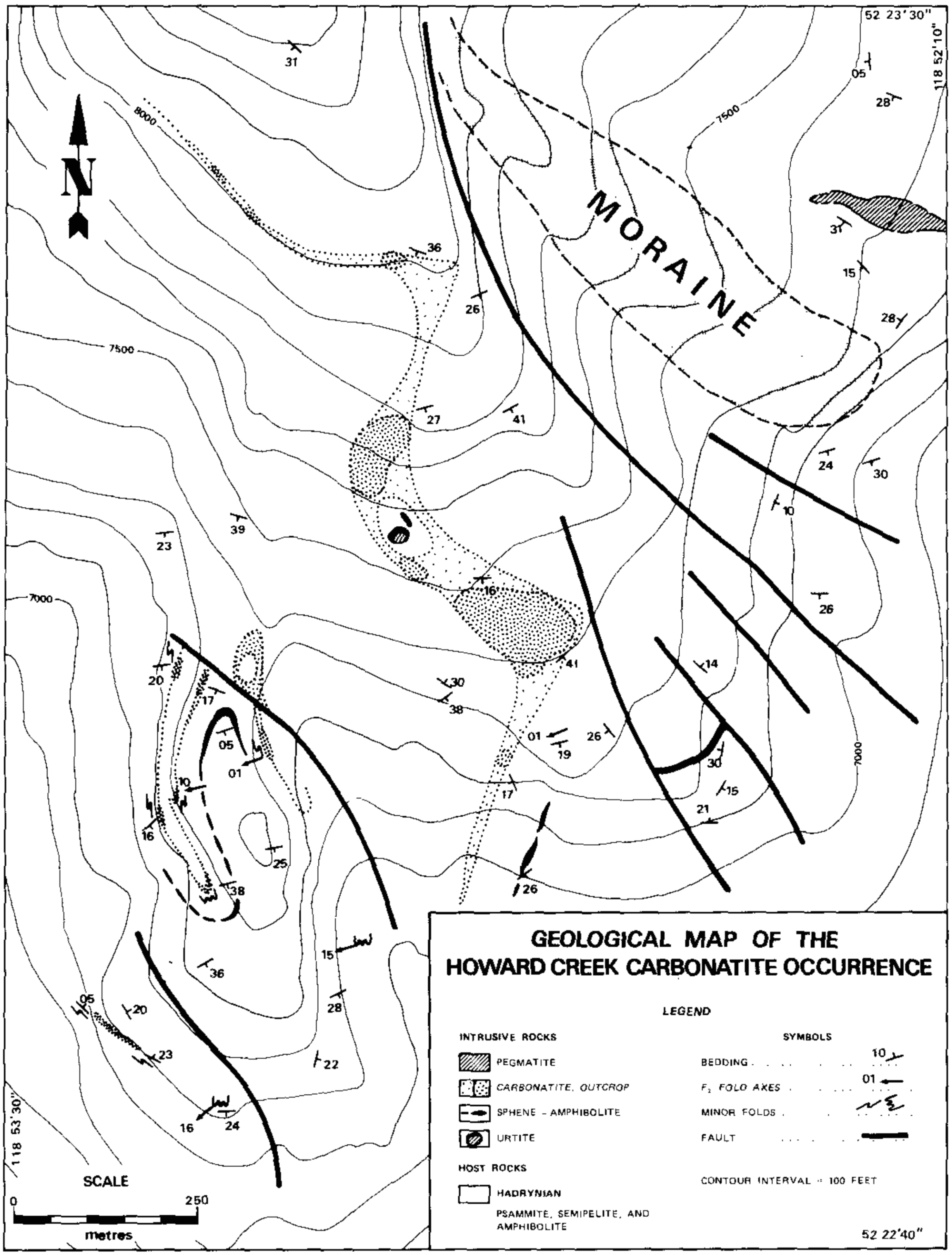

Figure 23. Geological map of the Howard Creek carbonatite occurrence.

The biotite sovite is mylonitized. To the northeast its contact with psammites and micaceous quartzites of the Wolverine Complex is not exposed; to the southwest it is in contact with fenite, that consists dominantly of aegirine, crossite, and microcline (Halleran, 1980), and interlayered sovite and fenitized metasedimentary rocks that were originally psammites and are now dominantly microcline, quartz, and aegirine.

The Vergil showing is not as well exposed as the Lonnie occurrence. Feldspathic monzonites to syenites border a lensoid layer of biotite sovite. Some mafic fenite, similar to that found at Granite Creek, occurs in the Vergil showing. The contact with host metasediments is not exposed. Fault breccia zones are abundant.

BEARPAW RIDGE (93I/4)

A body of sodalite syenite was mapped on Bearpaw Ridge in the Rocky Mountains approximately 60 kilometres northeast of Prince George. The syenite intrudes Silurian volcaniclastic rocks, which are predominantly banded felsic and intermediate tuffs and agglomerates containing limestone clasts. The syenite is massive, fine to medium grained, and white weathering. It is composed primarily of K-feldspar with varying amounts of hornblende, magnetite, and sodalite. Sodalite syenite is exposed on Bearpaw Ridge (Fig. 22) as three independent bands. Although the main bodies are roughly parallel to bedding in the volcaniclastic rocks, crosscutting dykelets were observed. Regionally, the host rocks have attained the lower greenschist facies of metamorphism; however, adjacent to the sodalite syenite, biotite is present in the Silurian rocks. Although the relationships are slightly ambiguous, it appears that the main body of sodalite syenite on Bearpaw Ridge is exposed in the core of a synform. The other two apparent layers seem to be part of a single sheet folded by the synform and now exposed on its limbs.

Another body of syenite present on Bearpaw Ridge (Fig. 22) is a massive, coarse-grained rock with a buff to pink fresh surface. In it, feldspar laths, which can be 1.5 centimetres long, are randomly oriented. Opaques, predominantly magnetite, can comprise up to 10 per cent of the rock. Unlike the sodalite syenite, this body appears to be post-orogenic; it crosscuts both the foliated hornblende gneisses of unknown age and the Silurian volcaniclastic rocks (Fig. 22).

BLUE RIVER AREA (83D/3, 6, 7)

A number of carbonatite layers occur within the Semipelite-Amphibolite Division of the Hadrynian Horsethief Creek Group in the Monashee Mountains near Blue River, 250 kilometres north of Kamloops. All are bedding parallel, sill-like bodies which were intruded prior to deformation and metamorphism associated with the Columbian orogeny. The

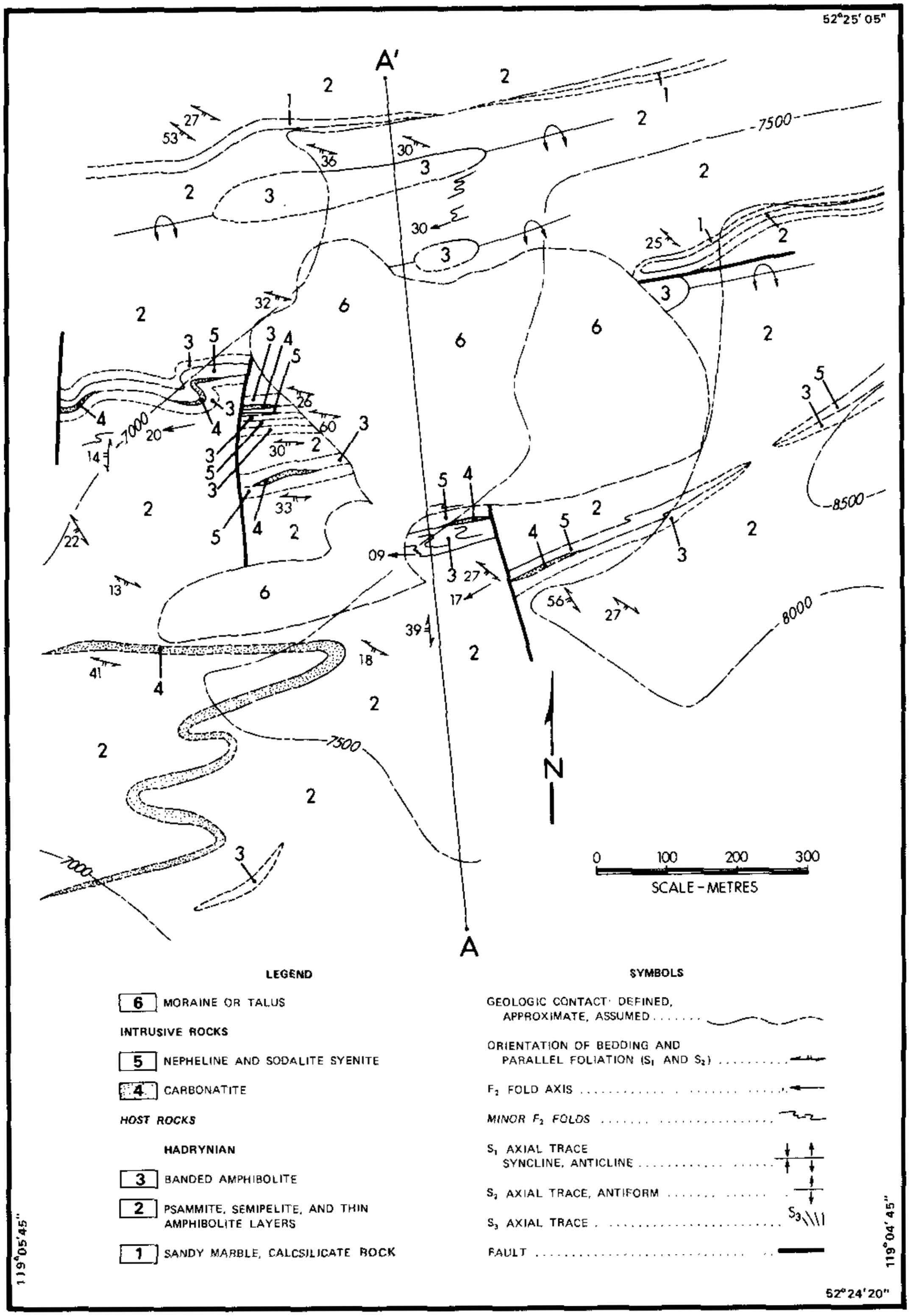

Figure 24a. Geology of the area south of Paradise Lake.

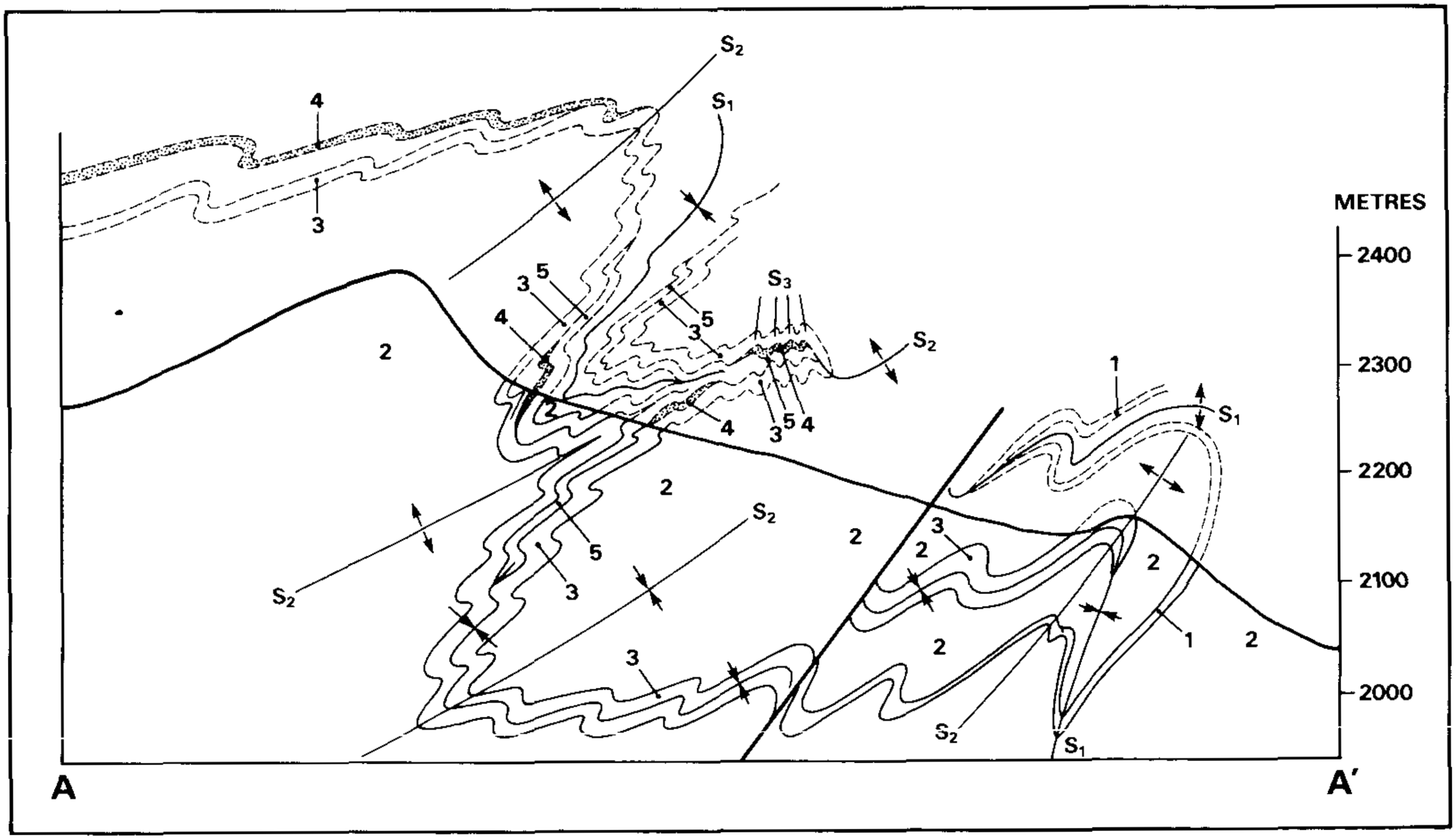

Figure 24b. Cross-section A-A', area south of Paradise Lake.

carbonatites and surrounding sedimentary rocks have been metamorphosed to upper amphibolite grade (kyanite to sillimanite zone). The Mud Lake, Bone Creek, and Verity showings (Fig. 21) occur below treeline at elevation 2 000 metres; consequently, exposure is limited. The Paradise Lake and Howard Creek carbonatites are above treeline, well exposed, and therefore could be mapped in detail (Fig. 23; Figs. 24a and 24b).

Two types of carbonatite occur within this suite (*see also* Aaquist, 1982). One is calcitic (sovite) and contains variable amounts of olivine, magnetite, apatite, zircon, and biotite or vermiculite. The second, a buff-weathering variety, is dolomitic (beforsite) with amphibole (richterite and/or tremolite), magnetite, apatite, pyrochlore, zircon, and columbite. Apatite and amphibole within the beforsite define a foliation parallel to both the edges of the carbonatite and the external schistosity. Compositional banding with alternating amphibole, apatite, and carbonate-rich layers, parallels foliation in some outcrops. At Verity, separate bands of sovite and beforsite occur. The sovite locally contains calcite and olivine crystals 2.5 to 3 centimetres in size, and clusters of magnetite crystals over 20 centimetres in diameter. Although the beforsite is not usually as coarse grained, 3 to 4-centimetre pyrochlore crystals have been found. Zircon crystals 1 to 1.5 centimetres in size occur in both the sovite and beforsite layers. At Paradise Lake apparently continuous horizons grade from sovite into beforsite. The other showings contain either sovite or beforsite but not both. Mafic fenites, 1 to 30 centimetres thick, locally separate the carbonatites and host metasedimentary rocks. The fenites may be either amphibole rich, similar to those in the Manson Creek area, or predominantly composed of biotite or vermiculite. Metasedimentary rocks adjacent to these fenites appear unaltered.

At Howard Creek urtite and sphene-bearing amphibolite (Fig. 23) are present. The sphene amphibolite can be layered and foliated or massive with dark green amphibole crystals exceeding 35 centimetres in length, and euhedral, honey-coloured sphene crystals up to 2 centimetres in size. Minor amounts of nepheline and calcite may also occur. This amphibolite is transitional at one locality to meta-ijolite or urtite, with 40 to 70 per cent coarse nepheline, 50 to 20 per cent amphibole, and 10 per cent sphene. Although the urtite and sphene amphibolite (meta-melteigite ?) are not interlayered with the carbonatite, they are presumably part of the same intrusive event.

Nepheline, sodalite, and calcareous syenites crop out in the Paradise Lake area. The syenites are foliated and medium grained; they consist of feldspar, nepheline, biotite, muscovite, calcite, zircon, and minor amounts of sodalite. They are migmatitic with massive, medium to coarse-grained, lensoid leucosomes that are predominantly composed of nepheline and sodalite. Locally, biotite sovite is interlayered with the syenites; the sovite can contain nepheline and the syenites can contain as much as 30 per cent carbonate. One zone is predominantly syenite (Figs. 24a and 24b); outward from the syenite the same horizon is prone to carbonatite development.

At both Paradise Lake and Howard Creek the carbonatites and related rocks are folded by second generation structures (Figs. 23 and 24). At Paradise Lake it is evident that these rocks are also involved in the earliest recognizable deformational event in the area (Fig. 24).

THREE VALLEY GAP AREA (82L/16)

Carbonatites are found along the Victor Lake main logging road, 3 kilometres east of Three Valley Gap, between 900 and 1 500 metres in elevation. Outcrop is limited to logging road cuts, therefore these carbonatites have not been mapped in detail. They occur as bedding parallel lenses in Hadrynian metasedimentary rocks. Both the carbonatites and host rocks have been metamorphosed to upper amphibolite grade (sillimanite zone), and the metasedimentary rocks have been extensively migmatized. The carbonatites are primarily composed of calcite, biotite, amphibole, and apatite. In places they contain feldspathic lenses similar to migmatitic leucosome. All display a well-defined biotite foliation. Amphibole-rich fenite, which locally contains zircons, separates the carbonatites from adjacent rocks. Coarse sphene crystals are developed in the pegmatites where they are adjacent to carbonatites.

CONCLUSIONS

Carbonatites and related rocks intruded Upper Precambrian to Lower Paleozoic miogeoclinal host rocks prior to onset of the Columbian orogeny. There has apparently been more than one period of intrusive activity. Nepheline syenites at Mount Copeland are dated at 770 Ma (Okulitch, *et al.*, 1981) while other bodies are in the 350 to 250 Ma range (Ice River, Currie, 1975; Verity, White, personal communication).

None of the carbonatites in British Columbia are currently being mined. Although many have been tested as niobium and vermiculite prospects, information about their abundance, distribution, and economic potential are currently sketchy.

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