AGE AND GENESIS OF CARIBOO GOLD MINERALIZATION DETERMINED BY ISOTOPE METHODS

(93H)

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INTRODUCTION

The Cariboo area in southeastern central British Columbia (Fig. 107) is one of the oldest gold-producing regions in Canada (Sutherland Brown, 1957). Gold-bearing quartz veins occur in Hadrynian to Cambrian metasedimentary strata of the Omineca Belt. Triassic volcanic strata in the adjacent Intermontane Belt also host quartz-gold veins. Galena-lead isotope data were obtained from veins in both terranes (Fig. 107) in order to determine any genetic relationship that might exist between them. Galena was also collected and analysed from stratiform and vein type mineralization in the Mosquito Creek Gold mine near Wells (Fig. 107, No. 427), to investigate the possibility that at least some of the mineralization there might be syngenetic. K/Ar dates were obtained for muscovite from a quartz-barite vein associated with the Cariboo Gold Quartz mine, and for regionally metamorphosed phyllite.

Locations of galena and K/Ar samples are shown on Figure 107, and analyses are listed in Tables 1 and 2. Most galena samples were collected by D. Klepacki and R. Cook. Mosquito Creek and Cariboo Gold Quartz samples were collected by the author, and Pin Money samples were collected by B. Price and C. I. Godwin. Most lead isotope analyses were by B. D. Ryan. For these analyses galena was dissolved in hydrochloric acid and this solution was purified using anion exchange columns and electrodeposition. Samples, loaded using the silica gel-phosphoric acid technique, were analysed on a 30-centimetre, solid source mass spectrometer in the Department of Geophysics and Astronomy. Analyses of Pin Money, Cariboo Gold Quartz and Mosquito Creek samples were by A. Andrew who followed similar chemical separation and loading techniques but did the analyses on a V. G. Micromass 54R mass spectrometer in the Department of Geological Sciences. K/Ar dates were determined by J. Harakal and K. Scott (*see* Table 2).

GEOLOGY

Triassic andesitic volcanic rocks of the Intermontane Belt are juxtaposed against Proterozoic to Early Paleozoic metasedimentary strata of the Omineca Belt (Fig. 107). The boundary is thought to be a low-angle, southwesterly dipping thrust fault (Klepacki, personal communication, 1981; Rees, 1981). East of this boundary the Proterozoic to Cambrian Kaza and Cariboo Groups are made up of conglomerates, arkosic and quartzose sandstones, shales and carbonate rocks (Campbell, *et al.*, 1972;

1972). The Snowshoe Formation (Sutherland Brown, 1963) is equivalent to the Kaza Group (Campbell, *et al.*, 1972; Struik, 1981a). Kaza Group and Cariboo Group rocks are overlain unconformably by rocks of the Black Stuart Formation, which are dark argillites and chert and dolomite breccias with Lower Devonian fossils at their base (Campbell, *et al.*, 1972; Struik, 1979). Mississippian volcanic and sedimentary rocks of the Guyet Formation unconformably overlie the Black Stuart Formation. Several minor ankeritic, acidic dykes of pre-Mississippian age intrude the Cariboo Group and are known as the Proserpine dykes (Sutherland Brown, 1957).

West of the boundary, Triassic volcanic strata of the Intermontane Belt are predominantly andesitic and have been interpreted as arc-type volcanic rocks (Monger, *et al.*, 1972). Several intrusions occur within this belt, and most have Jurassic K/Ar ages of approximately 180 Ma. The Cariboo Bell and Mitchell Bay porphyry deposits also have 180 Ma K/Ar ages and are auriferous (Hodgson, *et al.*, 1976; Schink, 1974).

Quartz-gold veins that occur within the Snowshoe Formation contain galena, sphalerite, free gold, scheelite, and locally pyrrhotite or arsenopyrite. All these veins contain important values in silver. Veins that occur in the Triassic strata differ in that they lack scheelite and sphalerite; sulphide minerals are mainly galena and chalcopyrite.

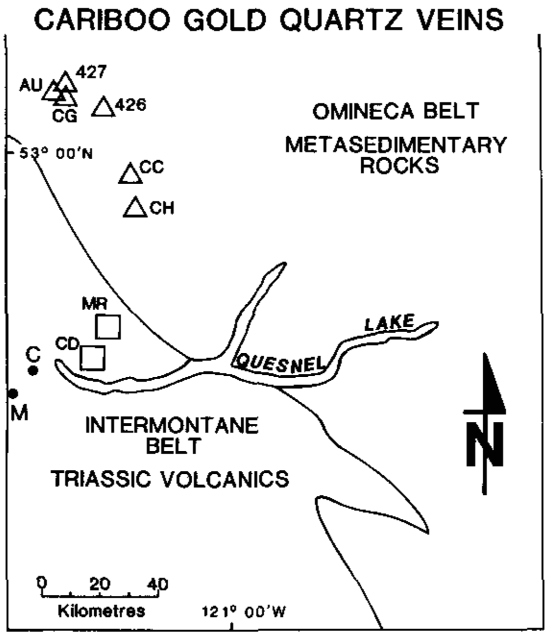

Figure 107. Locations of gold deposits from which galena-lead isotope analyses were obtained (refer to Table 1 for deposit names). K/Ar analyses were obtained from a vein and phyllite near CG. The line dividing the Omineca and Intermontane Belts is probably a generally west-dipping thrust. C is Cariboo Bell porphyry deposit, and M is Mitchell Bay porphyry deposit.

LEAD ISOTOPE DATA

Lead-lead plots of the data (Table 1) from each of the deposits (Fig. 107) are shown on Figure 108. The Omineca Belt data forms a single group (Cluster 1), which plots above but close to the 'shale curve' of Godwin and Sinclair (1982), but markedly above the average crustal curve of Stacey and Kramers (1975); both of these model curves are shown for reference on Figure 108. Data from stratiform mineralization at the Mosquito Creek mine plot within Cluster 1.

Vein leads from Triassic volcanic rocks are less radiogenic than those of the Omineca Belt, plotting below the 'shale curve' on Figure 108. Thus they are distinctly different from Cluster 1.

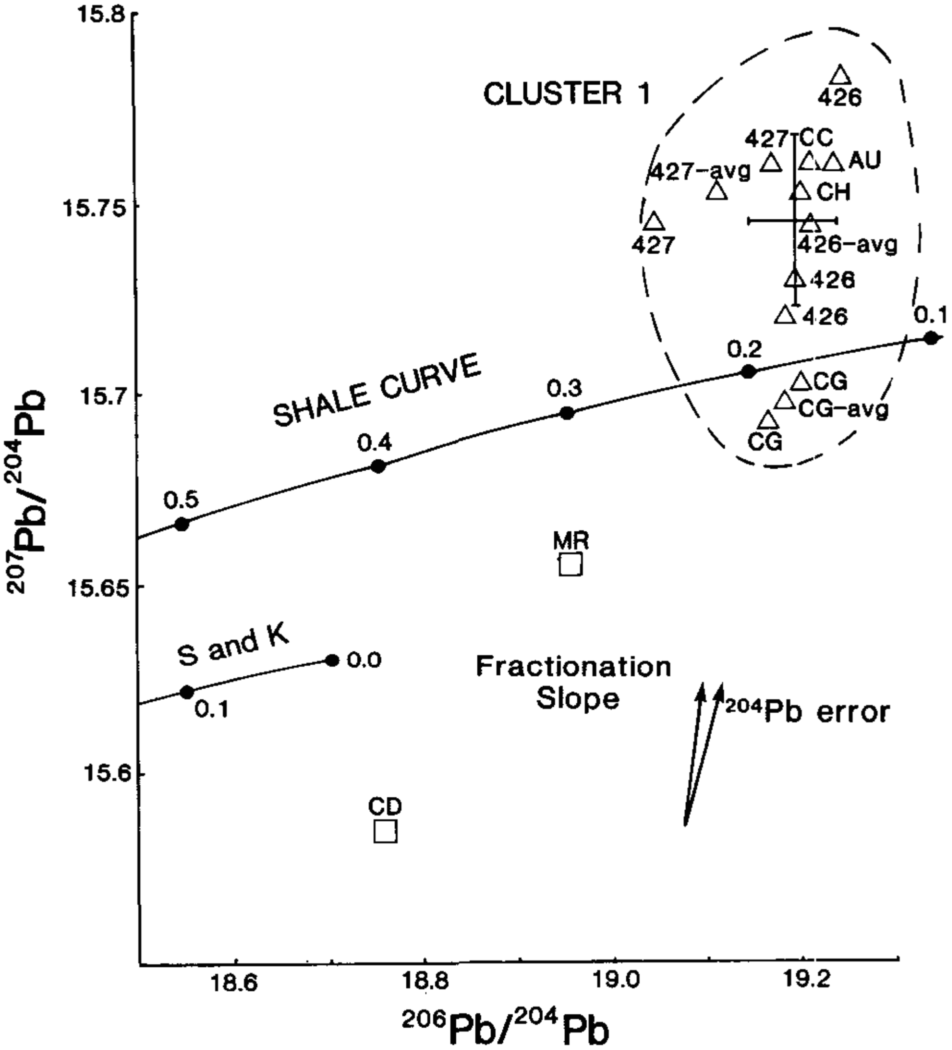

Figure 108. $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot of galena analyses from Cariboo and adjacent Intermontane Belt gold deposits (Table 1). Symbols are the same as those of Figure 107.

DISCUSSION

Coincidence of Cluster 1 (Figs. 108 and 109) with the 'shale curve' model suggests that a model age can be given to the gold mineralization event. If the 'shale curve' model applies, it also implies that the source of the lead, and by inference gold, is upper crustal, since the 'shale curve' represents lead evolution in a sialic, upper crustal environment (Godwin and Sinclair, 1982).

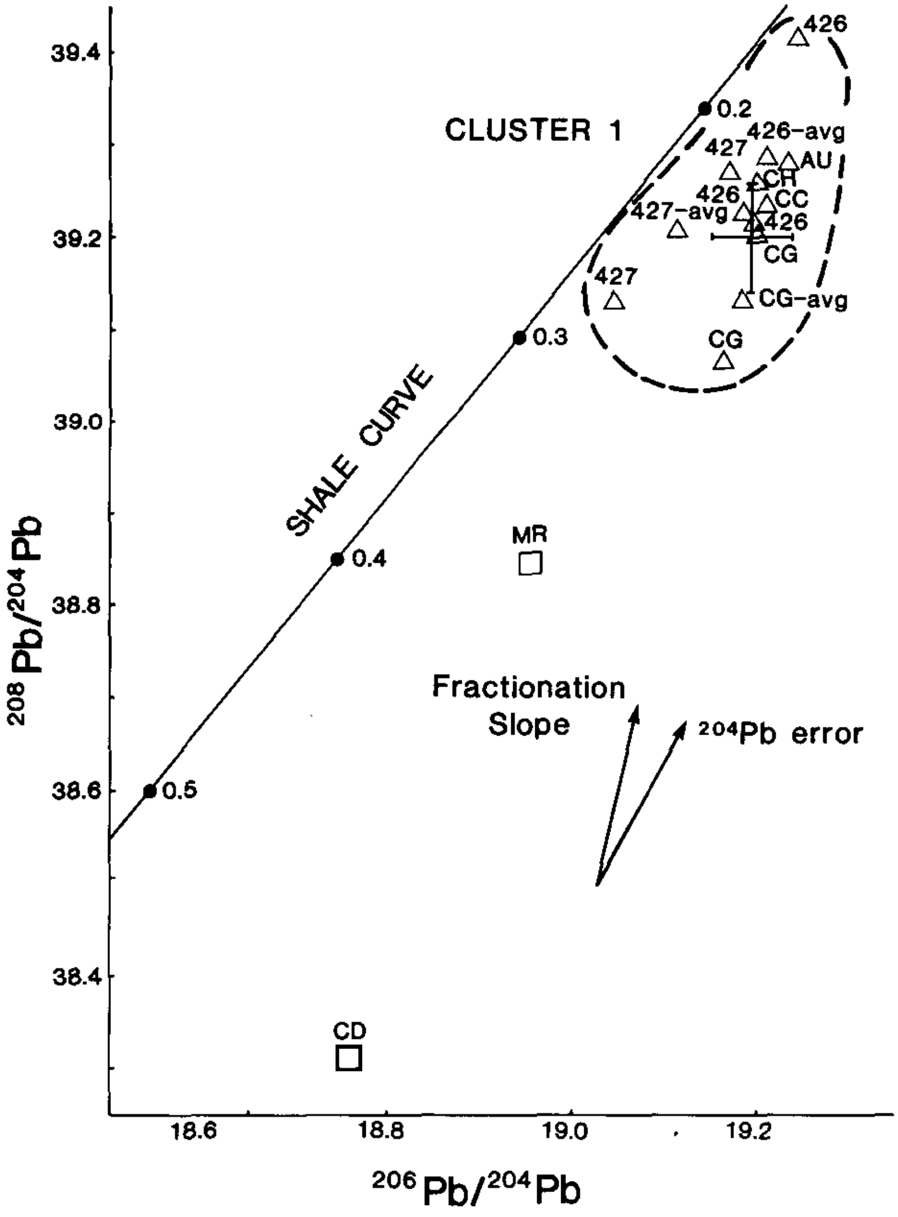

Figure 109. $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot of galena analyses from Cariboo and adjacent Intermontane Belt gold deposits (Table 1). Symbols are the same as those of Figure 107.

Justification for using the 'shale curve' model in this part of the Omineca Belt comes from four lines of evidence:

(1) Lead data from Sullivan, which is in the southern Omineca Belt, were used in the construction of the curve.

(2) Similarities in the geology of the Barkerville-Cariboo River area with the Selwyn basin and Cassiar platform of northern British Columbia and the Yukon have been noted (Struik, 1981b). Therefore although most of the lead data used in the construction of the 'shale curve' were from the Selwyn basin, Omineca Belt lead should have similar characteristics.

(3) The provenance of sedimentary rocks in the Omineca Belt is essentially the same as for those in the Selwyn shale basin, since they are both autochthonous terranes which formed at the western margin of the North American craton. Therefore similar geochemical and isotopic characteristics are to be expected for the Selwyn basin and Omineca Belt.

(4) Stratabound carbonate-hosted deposits from the Cariboo area also have lead isotopic compositions which fall on the 'shale curve', giving ages which agree with the Cambrian age of their host rocks. These deposits (*Maeford Lake and Comin Thro' Bear*), clearly epigenetic as crosscutting bodies in carbonate rocks (Holbek, personal communication, 1982), are probably only slightly younger than their host rocks. Some epigenetic carbonate-hosted deposits in the Yukon can apparently be dated with the 'shale curve' model (Godwin, *et al.*, 1980). Therefore carbonate-hosted deposits also support the hypothesis that the 'shale curve' model is generally applicable to the Omineca Belt.

The calculated age for the gold mineralization event is 185 Ma according to the 'shale curve' model, but this is only accurate to approximately 50 Ma (Godwin and Sinclair, 1982). K/Ar dating of a regionally metamorphosed phyllite gives an age of 179±8 Ma (Table 2) which is interpreted as being the age of the latest metamorphism. This agrees with previous estimates for the age of metamorphism by Pigage (1977) and Wanless, *et al.* (1965). Struik (1981b) suggests that metamorphism occurred during the Middle Mesozoic Columbian orogeny. Similarity in metamorphic and mineralization ages suggest that the veins may be synmetamorphic, rather than magmatic in origin.

At least three phases of veins are present in the Cariboo Gold Quartz mine, and not all vein phases are gold-bearing (F. Beaumann, personal communication, 1981). Muscovite from one quartz-barite vein yielded a K/Ar model age of 141±5 Ma (Table 2), which is the same as ages obtained for post-tectonic granodiorite plutons southeast of the area (Pigage, 1977). Thus at least one set of veins is post-tectonic and may be related distally to plutonic activity. Although none are seen in the immediate area of the mine, plutons may be present at depth. Whether the veins are synmetamorphic or magmatic in origin does not alter the conclusion that most of the lead and gold were derived from the host rocks, either by lateral secretion during regional metamorphism (Boyle, 1979), or by hydrothermal activity related to magmatism.

Lead isotope data from stratiform mineralization at the Mosquito Creek Gold mine are indistinguishable from those of the quartz-gold veins of Cluster 1 (Figs. 108 and 109). Since the Snowshoe Formation is Paleozoic or older and the mineralization is Mesozoic, the difference between syngenetic and epigenetic lead would be readily distinguishable by lead isotope analyses. The lead from Mosquito Creek is clearly epigenetic based on lead isotopic composition.

Lead isotopic characteristics of quartz-gold veins in Triassic strata are distinctly different from those of the Omineca Belt deposits (Figs. 108 and 109), indicating a fundamental difference in the source of lead (and perhaps gold) in these tectonic belts. Markedly different mineralogy supports the hypothesis that the two vein types have lead sources which are different and unrelated. For example, lithophile tungsten in scheelite-bearing veins in the Snowshoe Formation could have been derived from the sialic host rocks; its absence from veins in the more mafic Intermontane Belt is to be expected on chemical grounds if the veins have a host rock source. Thus, the differences in the lead isotopes can be attributed to growth of lead in different uranium and thorium environments. Figure 110 shows data from this study plotted with Insular Belt data from Andrew, *et al.* (1982) to display the contrast between these three different lead provinces. Intermontane Belt lead is more like lead from the Insular Belt than lead in the Omineca Belt.

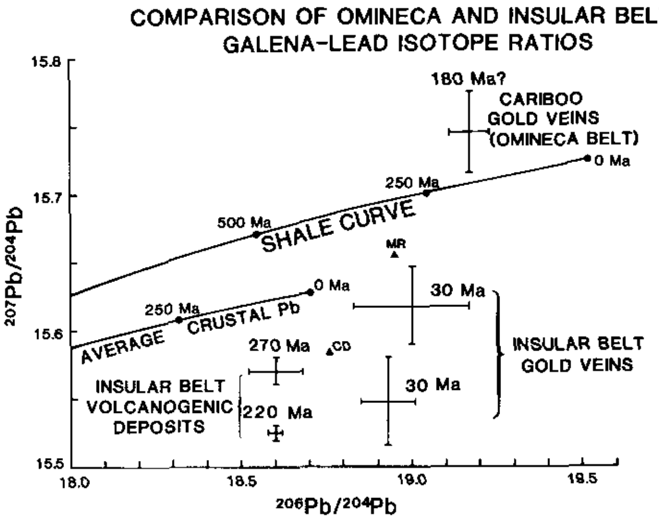
COMPARISON OF OMINECA AND INSULAR BELTS GALENA-LEAD ISOTOPE RATIOS

Figure 110. Comparison of Omineca, Insular, and Intermontane Belt galena-lead isotope ratios. Triangles represent Intermontane Belt deposits in Table 1. Error bars on the five clusters shown mark standard deviation of the suite for each cluster. The two growth curves shown are the 'shale' curve (Godwin and Sinclair, 1982), and the average crustal curve (Stacey and Kramers, 1975).

The age of mineralization of the veins in the Intermontane Belt is not known, but is probably Jurassic, *ca.* 180 Ma, based on the plutonic and volcanic activity related to auriferous porphyry deposits in this part of the Intermontane Belt.

CONCLUSIONS

The difference in isotopic composition of veins in Hadrynian metasedimentary rocks and in Triassic volcanic rocks precludes derivation of lead from the same source, thus ruling out the possibility that the gold in the Cariboo area was derived from the Intermontane Belt. Similarity in lead isotopic composition of stratiform galena from the Mosquito Creek deposit with galena from clearly epigenetic quartz-gold veins in the Omineca Belt suggests that syngenetic mineralization is not present.

Lead isotope and K/Ar evidence indicate that the age of mineralization of the Omineca Belt quartz-gold veins is Mesozoic. Location of Cluster 1 (Figs. 108, 109, and 110) near the 'shale curve' model suggests that the lead and gold have an upper crustal, host-rock source. The process by which metals were mobilized from their host rocks into the quartz-gold veins was probably by lateral secretion during regional metamorphism. Support for this theory comes from coincident metamorphic and mineralization ages, but the possibility that the veins are related to distant Jurassic plutons is not ruled out completely.

A host-rock source for the gold in quartz-gold veins in the Triassic arc-volcanic rocks may explain the unradiogenic nature of the lead in these veins.

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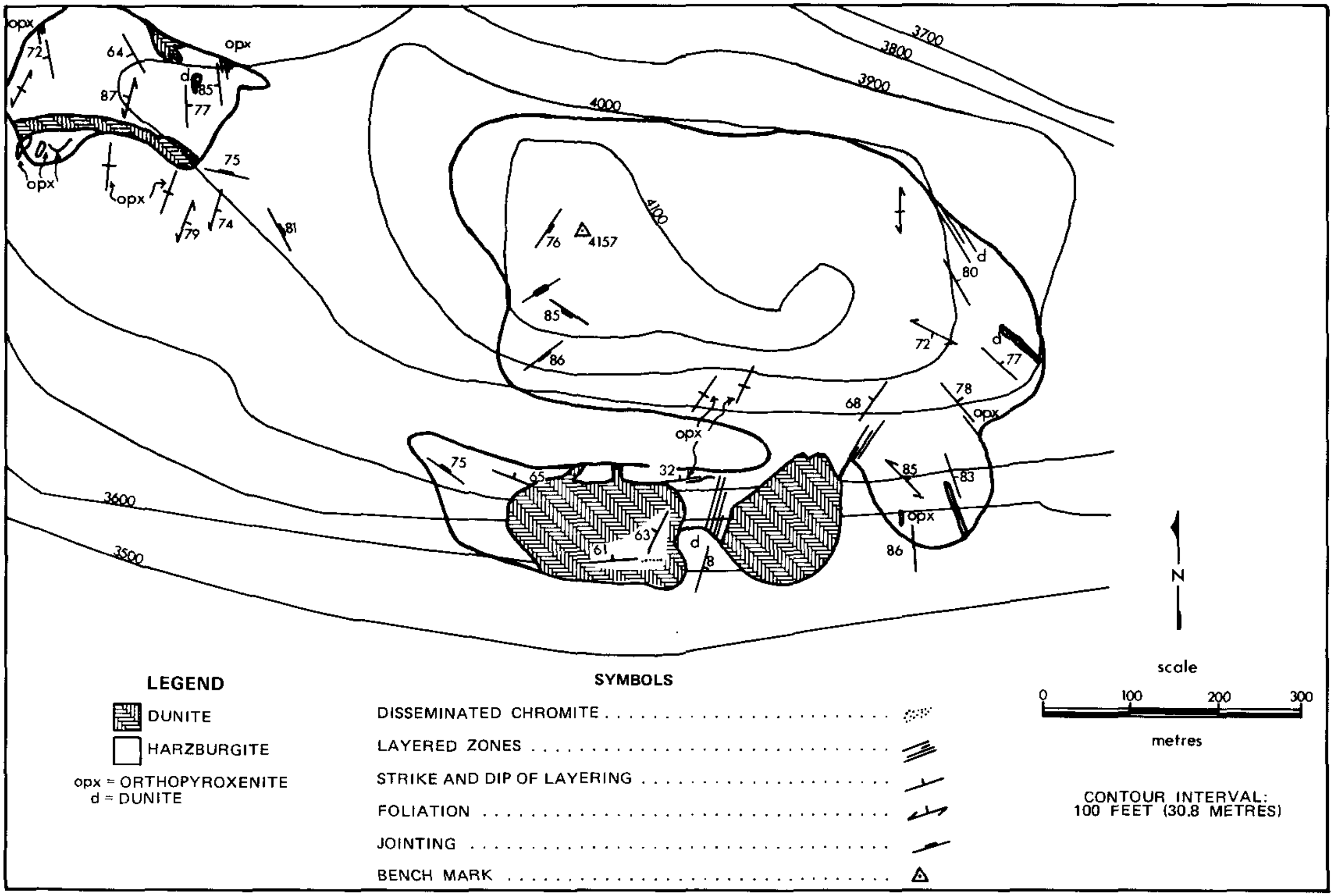

Figure 112. Geology of the upper part of Pinchi Mountain.