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FURTHER POTASSIUM-ARGON AGE DATING

AT COPPER MOUNTAIN, B. C.

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PROPERTY FILE

By

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ABSTRACT

Preliminary age dating performed recently on intrusive rocks from Copper Mountain indicates that the satellite Swelter Lake and Voigt stocks have a radiometric age which is indistinguishable from that of the Copper Mountain stock, as determined by Sinclair and White (1967). The complex of intrusive rocks known as the Lost Horse Gutrusions also yields essentially the same radiometric age, as do biotite-sulphide-pegmatite veins on Copper Mountain.

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INTRODUCTION

The Copper Mountain mine is located immediately east of the Similkameen River, some 10 miles south of Princeton, British Columbia, and approximately 20 miles north of the United States border. Copper was first discovered in the area in 1884, and has been mined intermittently from 1900 to 1957, with a total production to date of some 34 million tons of ore having a gross value of approximately 321 million dollars in copper, gold, and silver. All the above production has come from the Copper Mountain mine, but renewed interest in the area has led to the outlining of at least three more large zones of copper mineralization, one of which, the Ingerbelle, lies west of the Similkameen River and in part underlies the Hope Princeton highway. The other two zones are located on Copper Mountain, and are centered on two old open pits. These deposits, which at present are being prepared for production by open-pit methods, are estimated to include a total of 76 million tons of ore averaging 0.53 per cent copper and small but significant values of gold and silver.

Systematic and comprehensive geological work in the area was first undertaken by Dolmage (1934) and later by Rice (1947), Fahrni (1951, 1962, 1966), and Montgomery (1967). A detailed study of the Copper Mountain area, of which this paper is one aspect, was done in 1968 and 1969 by Preto of the British Columbia Department of Mines and Petroleum Resources. In 1967 Sinclair and White obtained the first radiometric ages from the Copper Mountain area, laying the base for the present study.

GENERAL GEOLOGY OF THE COPPER MOUNTAIN AREA

The oldest rocks in the area are part of the Upper Triassic Wolf Creek Formation of the Nicola Group. These include volcanic and sedimentary rocks which generally display a very mild degree of metamorphism and deformation except in the immediate vicinity of intrusive bodies. A number of quartz-poor calc-alkalic plutons, collectively known as the Copper Mountain intrusions (Montgomery, 1967) cut the Nicola rocks and are spatially and genetically related to the ore deposits. The largest, the Copper Mountain stock, is a concentrically differentiated intrusion, elliptical in plan and approximately 6.5 square miles in area. Its long axis is approximately 6 miles and strikes north 60 degrees west. This stock ranges in composition from diorite at its outer edge, through monzonite to syenite and perthosite pegmatite* at the core (Montgomery, 1967). Two smaller satellites, the Smelter Lakes and Voigt stocks, to the north and northeast respectively show no differentiation, but are similar in composition to the outer phase of the Copper Mountain stock. A complex of intrusive rocks ranging in composition from diorite to syenite, and generally porphyritic, occurs mainly north

*Perthosite pegmatite contains about 97 per cent perthite with minor amounts of leucoxene or sphene, quartz, and fine-grained colourless micas.

of Copper Mountain, extending from Wolf Creek to a major northerly trending fault that lies west of the Hope-Princeton highway. These rocks, known as the Lost Horse intrusions, show widespread albitization, saussuritization, and pink feldspar alteration that can be intense. They do not occur as a continuous mass, but as a complex of dykes, sills, and irregular bodies that display variable and complicated contact relationships with rocks of the Wolf Creek Formation. Because of their complexity the Lost Horse intrusions could only be divided into two groups: One composed of irregular bodies of variable size and shape; the other of well-defined dykes of biotite-latite porphyry or biotite-pyroxene microsyenite porphyry that cut the older Lost Horse rocks. The Lost Horse intrusions are believed to be genetically related to the Copper Mountain stock, and in fact to be late phases of the stock, although contact relationships are nowhere clearly displayed in the field. They are also closely related to the orebodies spatially and, it is believed, genetically.

To the northeast of Copper Mountain, diorite of the Voigt stock and older volcanic rocks are cut by a body of younger quartz monzonite that was named Verde Creek granite by Dolmage (1934) and believed by Rice (1947) to be correlative with the Otter intrusions of Upper Cretaceous or younger age. This pluton and older rocks are cut by several northerly trending dykes of felsite, quartz feldspar, and feldspar porphyry which are the eastern continuation of the "mine dykes" swarm of Copper Mountain.

All of the above intrusive, volcanic, and sedimentary rocks are cut and unconformably overlain by intrusive, volcanic, and sedimentary rocks of the Princeton Group of Middle Eocene age.

Both at Copper Mountain and at Ingerbelle faulting and fracturing are very intense and prominent. Major faults trend north 80 to 90 degrees east, north 35 degrees east, north 20 degrees east, and north 45 degrees west, and are important structural controls to mineralization. At Ingerbelle, a regional post-mineral normal fault that trends northerly and dips 60 degrees west cuts off the orebody to the west, and further south truncates the western part of the Copper Mountain stock.

Copper deposits have long been know around the entire periphery of the Copper Mountain stock, but the economic ones to date have been found only on the northeast side of the stock, mostly in the narrow zone of altered and intensely faulted and fractured Nicola rocks which are bound to the south by the main stock and to the north by an almost continuous mass of Lost Horse intrusive rocks. At Copper Mountain most of the early production was from orebodies close to the stock contact, in which the principal ore mineral was bornite. The size and grade of orebodies was largely controlled by the presence and intensity of the so-called "ore fractures," a set of northeast trending fractures and pegmatite veins oriented almost at right angles to the stock contact. Away from the contact, however, large amounts of ore have been and will be produced in which chalcopyrite is the principal ore mineral. These zones do not appear to be so directly dependent on the northeast fractures as on other favourable structural and alteration conditions and on the presence or proximity of Lost Horse rocks.

POTASSIUM-ARGON DATES

The work of Sinclair and White (1968) was confined to the Copper Mountain stock and to a pegmatite-sulphide veinlet close to the stock contact. It indicated a mean age of 193±7 million years for both the stock and the copper mineralization and hence supported the suggestion based on field evidence that the orebodies are genetically related to the Copper Mountain stock.

The present work continues and enlarges that of Sinclair and White, by determining the radiometric age of biotite from the Smelter Lakes and Voigt stocks, the Lost Horse intrusive rocks, and the Verde Creek quartz monzonite.

Adequately large samples of fresh, unaltered rock were collected to produced a concentrate of clean biotite sufficient for argon and for quadruplicate potassium analyses. In the case of sample VP-69KA-1 this meant taking a sample of approximately 100 pounds, although in most other cases samples of 25 to 50 pounds were adequate. Biotite concentrates were obtained in the laboratory of the British Columbia Department of Mines and Petroleum Resources by crushing, grinding, screening heavy mineral separation, and by floating the biotite off in a water column. Biotite concentrates submitted for analysis were 95 to 98 per cent pure by visual estimate and in most cases contained negligible amounts of chlorite. Potassium analyses were done in triplicate or in quadruplicate with a flame photometer, and argon analyses were obtained by using a MS-10 mass spectrometer. All analytical work and calculations were done by J. E. Harakal at the potassium-argon laboratory of the University of British Columbia Department of Geology.

The analytical data and apparent ages of the samples are given in Table 1.

DISCUSSION OF RESULTS

Eight of the nine apparent ages obtained from two biotites each of the Smelter Lakes and Voigt stocks, from four biotites of Lost Horse rocks, and from one of a sulphide-bearing pegmatite vein are identical within the limits of experimental error. Their average is 195±8 million years, which is in very close agreement with the results obtained by Sinclair and White (1968). The ninth of these ages, that from sample VP-69KA-6 of the Voigt stock is slightly lower at 181±7 million years. A possible reason for this discrepancy is that the biotite from this sample is considerably chloritized and markedly poikilitic in habit. Another possible, though unlikely, reason is that differential loss of argon has been caused by the proximity of an unexposed "mine dyke," several of which are found in the area.

The two apparent ages from biotite of the Verde Creek quartz monzonite body yield an average age of 99.5±4 million years, which according to the Kulp (1961) time scale corresponds to the earliest Upper Cretaceous. From the above, the following conclusions can be drawn:

1. The apparent radiometric age of Lost Horse rocks is indistinguishable from that of the Copper Mountain, Smelter Lakes, and Voigt stocks. These rocks, which were regarded by Dolmage (1934) as probably somewhat older than the three stocks are related to them in time and, as Montgomery (1967) suggests, in origin. Their composition, texture, structural setting, commonly altered state, and relationship to zones of alteration and of mineralization in Nicola rocks indicate that they were probably emplaced at a relatively late stage under conditions of prevailing and widespread hydrothermal alteration. No difference can be detected between the apparent age of dykes and that of somewhat older Lost Horse rocks which they cut.

2. The Smelter Lakes and Voigt stocks have apparent radiometric ages that are indistinguishable from those of the Copper Mountain stock obtained by Sinclair and White (1968). This is in agreement with field evidence that they are satellites of the main stock and owe their lack of differentiation either to their smaller size or level of exposure, or both.

3. The apparent radiometric age of all the Copper Mountain intrusions and of the associated mineralization, according to Kulp's time scale, is Upper Triassic, the same age as the Nicola rocks which they cut, as determined from fossil evidence. The above, together with the type, texture, and structural setting of some of the Lost Horse rocks makes one wonder whether some of the Lost Horse dykes were not feeders to Nicola flows higher in the volcanic pile that surrounds the Copper Mountain intrusions at the present level of erosion. This would imply a fairly rapid change from the mesozonal environment in which the three stocks were emplaced, to an epizonal or even sub-volcanic environment in which some of the Lost Horse phases may have been emplaced, thus necessitating a fairly rapid erosion of overlying strata. A similar situation is suggested by Northcote (1969) for the Guichon Creek batholith, another mineralized differentiated intrusion which cuts Nicola rocks and has an apparent age of 200±5 million years (White, et al., 1967).

4. The apparent age of 99.5±4 million years obtained from biotite of the Verde Creek body, which is cut by the eastern continuation of the "mine dykes" swarm, contradicts the suggestion put forth by Sinclair and White (1968) that these dykes may have an age of 150 million years. It is believed that the dykes are of Upper Cretaceous or Tertiary age and may be genetically related to a period of widespread

block faulting which occurred in this part of British Columbia approximately at that time.

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APPENDIX

Petrographic Notes on Samples

VP-69KA-1--Lost Horse. Pinkish latite porphyry. Phenocrysts of zoned sericitized andesine (An40), 60%; K-spar in groundmass, 33%; clinopyroxene phenocrysts, 5%; slightly poikilitic brown biotite, 1%; magnetite, 1%; traces of quartz and apatite.

VP-69KA-2--Smelter Lakes stock. Greengrey biotite-pyroxene diorite, weakly porphyritic. Sericitized plagioclase (An47), 65%; interstitial K-spar, 15%; Augitic clinopyroxene, 13%; reddish brown poikilitic biotite, 4%; magnetite, 3%; traces of epidote, apatite, and chlorite.

VP-69KA-3--Smelter Lakes stock. Green-grey biotite-pyroxene diorite. Plagioclase (AN60), 60%; interstitial K-spar, 13%; augitic clinopyroxene, 18%; reddish brown poikilitic biotite, 4%; magnetite, 3%; traces of epidote and apatite.

VP-69KA-4--Verde Creek. Pinkish grey, leucocratic medium-grained biotite quartz monzonite. Poorly twinned plagioclase (An30), 38%; K-spar, 33%; quartz, 25%; olive brown biotite, 4%; traces of magnetite, epidote, and chlorite.

VP-69KA-5--Verde Creek. Grey, medium-grained biotite quartz monzonite. Poorly twinned plagioclase (An30), 35%; K-spar, 30%; quartz, 30%; olive brown biotite, 5%; traces of epidote, chlorite, and magnetite.

VP-69KA-6--Voigt stock. Grey-green, epidotized biotite-pyroxene diorite. Sericitized plagioclase (An39), 50%; interstitial K-spar, 25%; partly epidotized clinopyroxene, 18%; reddish brown chloritized poikilitic biotite, 4%; magnetite, 3%; traces of epidote, sphene, and apatite.

VP-69KA-7--Voigt stock. Greenish grey, epidotized biotite-pyroxene diorite. Sericitized and saussuritized plagioclase (An35), 64%; interstitial K-spar, 5%; partly chloritized reddish brown biotite, 4%; epidote, 10%; chlorite, 10%; clinopyroxene, 5%; magnetite, 2%; traces of apatite.

VP-69-8--Lost Horse. Pinkish grey micromonzonite porphyry. Phenocrysts of zoned entirely sericitized plagioclase, 50%; interstitial K-spar, 40%; epidotized clino-pyroxene, 7%; brown biotite, 3%; traces of sphene, epidote, apatite, chlorite, and magnetite.

VP-69-9--Lost Horse dyke. Greenish pink biotite-pyroxene latite porphyry. Zoned, sericitized, and poorly twinned plagioclase phenocrysts, 50%; interstitial K-spar, 40%; brown biotite, 3%; altered clinopyroxene, 5%; magnetite, 2%; traces of chlorite, sphene, carbonate, and apatite.

VP-69-10--Lost Horse. Grey-green biotite-pyroxene micromonzonite porphyry. Sericitized and poorly twinned phenocyrsts of zoned plagioclase, 43%; interstitial K-spar, 35%; brown biotite, 3%; phenocrysts of augite clinopyroxene, 15%; magnetite, 4%; traces of apatite and epidote.

VP-69KA-13--The biotite for this sample was separated from an irregular pegmatite vein in altered andesite. The vein contained pink feldspar, black biotite, white calcite, bornite, and chalcopyrite.

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TABLE 1.--ANALYTICAL DATA

SAMPLE NO.	ROCK UNIT	ROCK TYPE	MINERAL	%K$\pm\sigma$	A^{40} rad / A^{40} total	A^{40} rad (10^{-5} cc STP/g)	A^{40} rad / K^{40}	APPARENT AGE
VP-69KA-1	Lost Horse	Latite porphyry	Biotite	6.88±.02	0.92	5.578	0.01198	194±8
VP-69KA-2	Smelter Lakes	Diorite	Biotite	7.11±.03	0.89	5.830	0.01211	197±8
VP-69KA-3	Smelter Lakes	Diorite	Biotite	*4.49±.01	0.87	3.758	0.01236	200±8
VP-69KA-4	Verde Creek	Quartz monzonite	Biotite	5.39±.02	0.84	2.210	0.006057	101±4
VP-69KA-5	Verde Creek	Quartz monzonite	Biotite	6.26±.01	0.82	2.499	0.005899	98±4
VP-69KA-6	Voigt	Diorite	Biotite	5.48±.01	0.85	4.112	0.01109	181±7
VP-69KA-7	Voigt	Diorite	Biotite	7.14±.02	0.91	5.788	0.01198	194±7
VP-69KA-8	Lost Horse	Micromonzonite porphyry	Biotite	*7.82±.04	0.88	6.340	0.01198	194±8
VP-69KA-9	Lost Horse dyke	Latite porphyry	Biotite	7.45±.04	0.86	6.111	0.01212	197±8
VP-69KA-10	Lost Horse	Micromonzonite porphyry	Biotite	6.62±.02	0.87	5.390	0.01203	195±8
VP-69KA-13		Biotite-sulphide pegmatite vein	Biotite	6.44±.04	0.84	5.071	0.01163	189±8

*Done in triplicate only. All other potassium analyses done in quadruplicate.

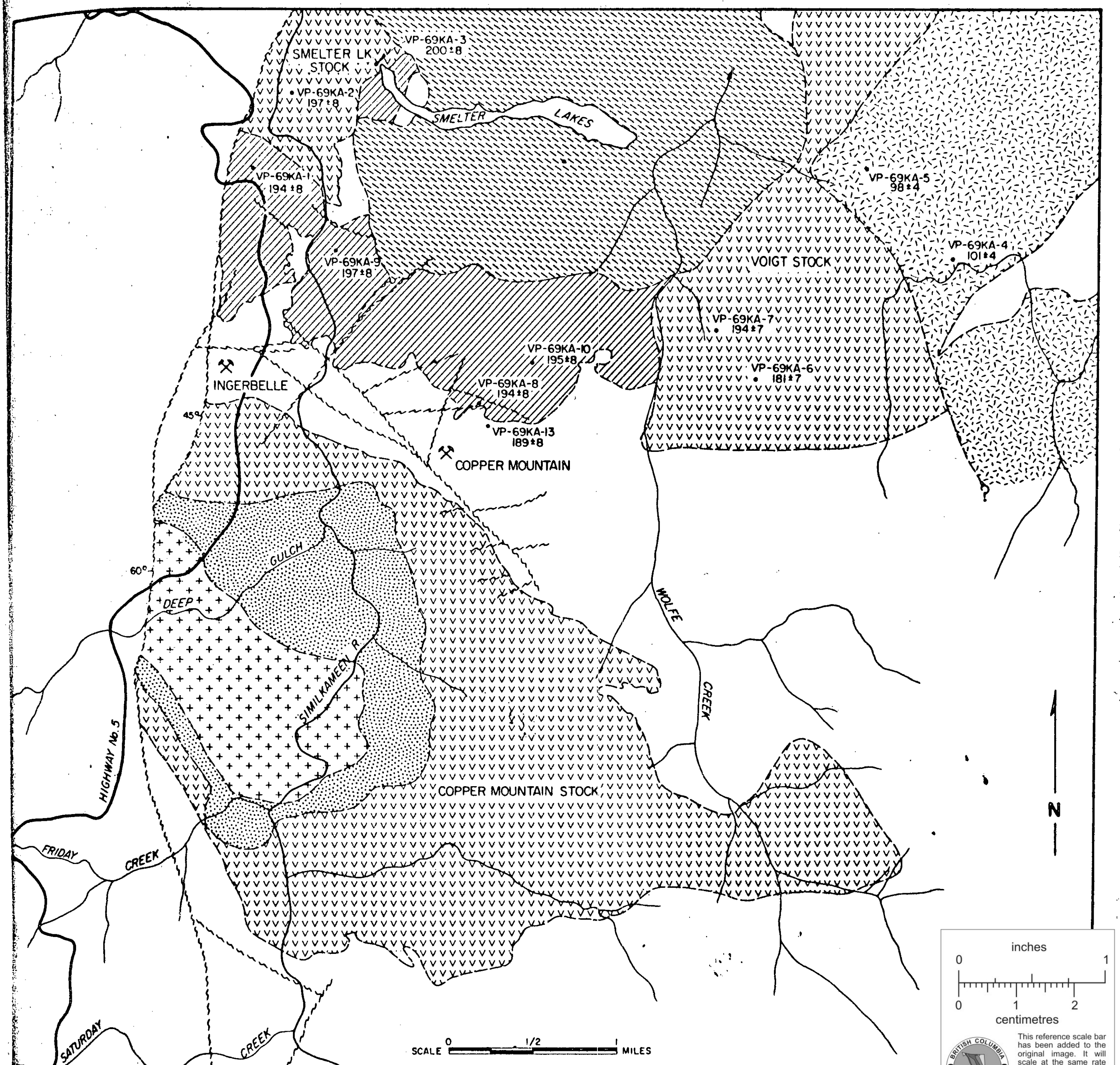
Constants used in model age calculations:

σ = standard deviation

$$\lambda e = 0.585 \times 10^{-10}\ yr^{-1}$$

$$\lambda B = 4.72 \times 10^{-10}\ yr^{-1}$$

$$K^{40}/K = 1.181 \times 10^{-4}$$



GENERAL GEOLOGY OF THE COPPER MOUNTAIN AREA BRITISH COLUMBIA

- PRINCETON GROUP
- VERDE CREEK QTZ. MONZ.
- LOST HORSE INTRUSION
- PERTHOSITE PEGMATITE
- MONZONITE
- DIORITE
- NICOLA GROUP
- VP-69AK-1 194±8 — SAMPLE LOCATION AND AGE IN M.Y

MINING

$K^{40}/K = 1.181 \times 10^{-4}$