PRELIMINARY REPORT ON ^{40}Ar/^{39}Ar GEOCHRONOLOGY OF THE WARNER PASS, NOAXE CREEK AND BRIDGE RIVER MAP AREAS*

(92O/3, 2; 92J/16)

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INTRODUCTION

The Warner Pass, Noaxe Creek and Bridge River map areas lie approximately 200 kilometres north of Vancouver on the eastern margin of the Coast Mountains. These areas have been the focus of recent detailed geological mapping to provide a better understanding of the geology and mineral potential. The isotopic dating project, using ^{40}Ar/^{39}Ar geochronology, is being carried out in cooperation with project geologists and scientists from the Geological Survey of Canada (Pacific Geoscience Centre) and is directed toward establishing the age of magmatic, tectonic and mineralizing events in these and adjoining areas. Few radiometric ages have been reported and ^{40}Ar/^{39}Ar dating has not been applied to problems in this part of British Columbia. This report presents the first such results for 15 samples collected during the 1987 field season and includes 18 total-fusion dates and two age spectra.

GEOLOGY

The regional and detailed geology are summarized in Glover *et al.* (1988) and Glover and Schiarizza (1987). The area is underlain by Mesozoic sedimentary and volcanic rocks that lie within a northwest-trending, structurally complex zone along the western margin of the Intermontane Belt, east of the Coast plutonic complex (Figure 1-16-1). These rocks comprise several fault-bounded tectonostratigraphic packages that record episodic tectonism. This study focuses on the Late Cretaceous and Tertiary events which include:

1. Deposition of the nonmarine Silverquick conglomerate and overlying continental andesitic volcanics of the Powell Creek formation, (informal; Glover *et al.*, 1988). This occurred during and after major compressional tectonics, documented by thrusting and folding of mid-Cretaceous strata in the Tyaughton-Methow basin (Garver *et al.*, 1988). Biostratigraphic control is poor in these Late Cretaceous rocks but hornblende-phyric volcanic rocks offer the opportunity for potassium-argon radiometric dating.
2. Northwest-trending dextral wrench faulting involving a total displacement of probably several hundred kilometres, distributed across a broad brittle to semi-brittle shear zone. The timing of movement along individual faults within this zone is poorly constrained but several of these structures are truncated by granitoid plutons or contain alteration minerals suitable for radiometric dating. In several cases the plutons are spatially associated with mineralization, some of which has gold potential.
3. Eocene volcanism and associated extensional faulting probably related to dextral displacement along the Fraser–Straight Creek fault system (Monger, 1985; Glover *et al.*, 1988).
4. Several episodes of plutonism, with available dates ranging from mid-Cretaceous to mid-Eocene. Min-

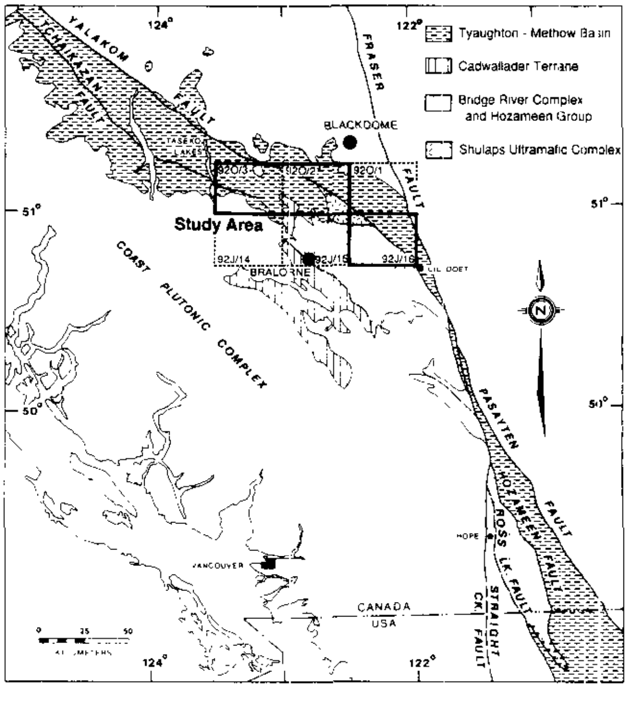

Figure 1-16-1. Location and geological setting, Warner Pass (92O/3), Noaxe Creek (92O/2) and Bridge River (92J/16) map areas.

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eral deposits within the region show a definite spatial relationship to areas of intrusive activity.

SAMPLING AND $^{40}Ar/^{39}Ar$ ANALYTICAL METHODS

Samples were collected from 25 sites. These were selected to provide a temporal framework for the magmatic, tectonic and mineralizing events in the area. Two samples of hornblende-phyric andesite flows, near the base of the Powell Creek formation, were collected in an attempt to bracket the age of the unconformity at the base of this unit and to assess the thermal history of these rocks which are being studied paleomagnetically by P.J. Wynne (Pacific Geoscience Centre). These rocks also host the Taylor-Windfall gold deposit and a sample of alteration from this deposit was obtained for dating. One of the four intrusive units mapped by Glover and Schiarizza (1987) is chlorite-epidote-altered hornblende plagioclase porphyry which may be related to this episode of mineralization. Samples of this and the other three intrusive units and related alteration material are the basis of this report.

With the exception of the andesitic flows and very fine-grained alteration material, most samples yielded high-purity mineral separates. These were prepared using heavy organic liquids and a Frantz magnetic separator. The volcanic rocks are altered and minerals are intergrown to such an extent that pure separates could not be obtained. It was, however, possible to split the sample into several density/magnetic fractions to concentrate the potassium-bearing minerals. Sericite in alteration material was concentrated by hand-picking from coarsely crushed samples.

Samples and four flux monitors (standards) were irradiated with fast neutrons in position 5C of the McMaster Nuclear Reactor (Hamilton, Ontario) for 25 hours. The monitors were distributed throughout the irradiation container, and J-values for individual samples were determined by interpolation.

For step-heating experiments, irradiated samples were loaded into a quartz furnace tube and heated using a Lindberg tube furnace. The bakeable, UHV, stainless-steel argon-extraction system is operated on-line to a substantially modified, A.E.I. MS-10 mass-spectrometer run in the static mode. Total-fusion analyses were done using a custom, five-position turret system and resistively-heated, tantalum-tube crucibles. Measured mass spectrometric ratios were extrapolated to zero-time, corrected to an $^{40}Ar/^{36}Ar$ atmospheric ratio of 295.5, and corrected for neutron induced ^{40}Ar from potassium, and ^{39}Ar and ^{36}Ar from calcium (*see* Table 1-16-1). Ages and errors were calculated using formulae given by Dalrymple *et al.* (1981), and the constants recommended by Steiger and Jäger (1977). The errors shown in Tables 1-16-1 and 1-16-2 represent the analytical precision at 2-sigma assuming that the error in J-value is zero.

PRESENTATION AND DISCUSSION OF THE DATA

The isotopic data for eighteen $^{40}Ar/^{39}Ar$ total-fusion determinations on fifteen samples are presented in Table 1-16-1; $^{40}Ar/^{39}Ar$ step-heating data for three mineral separates (including one additional rock sample) are listed in Table 1-16-2. The ages and locations of the samples are plotted in Figure 1-16-2; two of the $^{40}Ar/^{39}Ar$ age spectra are shown in the inset.

POWELL CREEK VOLCANICS

Gently warped and tilted continental volcanic rocks of the Powell Creek formation lie with marked angular unconformity on mid-Cretaceous (Albian) and older strata within the Warner Pass map area (Glover and Schiarizza, 1987). Similar volcanic rocks sit gradationally above the nonmarine Silverquick conglomerate in the southern Noaxe Creek area. There, the Silverquick conglomerate and Powell Creek volcanics are separated from underlying Albian strata by an

TABLE 1-16-1
$^{40}Ar/^{39}Ar$ TOTAL-FUSION DATA FOR WARNER PASS AND NOAXE CREEK AREAS

Sample#	Min. (1)	$^{40}Ar/^{39}Ar$ (1)	$^{36}Ar/^{39}Ar$ (1,2)	$^{37}Ar/^{39}Ar$	Vol. $^{39}Ar_K$ $\times 10^{-7}$ cm^3NTP (3)	%^{40}Ar rad. (5)	Date ± 2σ Ma
TL-87-17	Maf.	56.910	0.1841	140.600	0.0144	22.90	148.8 ± 14.1
TL-87-17	F.P.	10.435	0.0121	6.355	0.2020	70.20	77.6 ± 1.5
TL-87-17	WR	6.842	0.0059	0.581	0.9887	74.60	54.4 ± 0.3
TL-87-13a	Maf.	21.970	0.0067	127.100	0.0204	52.60	131.0 ± 7.4
TL-87-4	Hb	11.362	0.0144	8.647	0.2080	68.10	82.1 ± 2.0
TL-87-4	Bi	8.606	0.0061	0.046	1.7620	78.80	71.8 ± 0.6
DH-87-163.3	Aln.	8.244	0.0042	0.011	6.1280	84.60	73.7 ± 0.5
TL-87-11	Hb	15.690	0.0320	11.690	0.0926	45.20	75.6 ± 2.8
TL-87-14	A.P.	9.062	0.0095	2.139	0.2680	70.30	67.6 ± 0.6
TL-87-6	Hb	12.150	0.0239	13.080	0.1080	49.80	64.7 ± 2.1
TL-87-1	Hb	7.495	0.0087	6.132	0.1645	71.50	57.2 ± 1.4
TL-87-8	Hb	7.671	0.0108	7.245	0.1547	65.30	53.5 ± 0.8
TL-87-8	Bi	6.577	0.0072	0.235	1.0650	67.70	47.4 ± 0.5
TL-87-20	Bi	5.356	0.0042	0.071	1.2250	76.80	43.9 ± 0.6
TL-87-7	Bi	5.504	0.0048	0.027	1.7910	74.20	43.5 ± 0.3
TL-87-16	Hb	10.412	0.0274	12.340	0.1460	30.90	34.7 ± 1.9
TL-87-12	Ser.	3.279	0.0024	0.013	2.9810	77.90	27.3 ± 0.2
J = 5.892x10-3							

Abbreviations: Maf. = mafic concentrate obtained by heavy liquids and Frantz magnetic separator; F.P. = fresh plagioclase; A.P. = altered (sericitized) plagioclase; WR = whole-rock; Ser. = sericite ± quartz; Aln. = alunite, nearly pure; Bi = biotite separate; Hb = hornblende separate.

(1) True ratios corrected for fractionation and discrimination $^{40}Ar/^{36}Ar$ atmos. = 295.5
Ratios are not corrected for system blank, Ar, but:
Vol. of blank ^{40}Ar: 500°C<T<1050°C, 1 × 10-8 cc STP
at T = 500°C and T>1050°C, 2.2 × 10-8 cc STP.
Vol. of blank ^{36}Ar: 500°C<T<1050°C, 3 × 10-12 cc STP.
at T - 500°C and T>1050°C, 7.4 × 10-12.
$^{40}Ar/^{36}Ar$ blank = 297.

(2) $^{37}Ar/^{39}Ar$ is corrected for the decay of ^{37}Ar during and after irradiation λ37 = 1.975 × 10-2 days-1).

(3) Volume of ^{39}Ar determined using the equilibration peak height and mass spectrometer sensitivity.

(4) Isotope production ratios for the McMaster Reactor (Masliwec, 1981):
(40/39) K = 0.0156
(36/39) Ca = 0.390169
(37/39) Ca = 1536.1

(5) Ages calculated using the constants recommended by Steiger and Jäger (1977). Errors represent the analytical precision only (i.e., error in J-values = 0).
Flux monitor used: DA-83-48-BB biotite (97.5 Ma) referenced to mmHb-1 hornblende and LP-6 biotite.

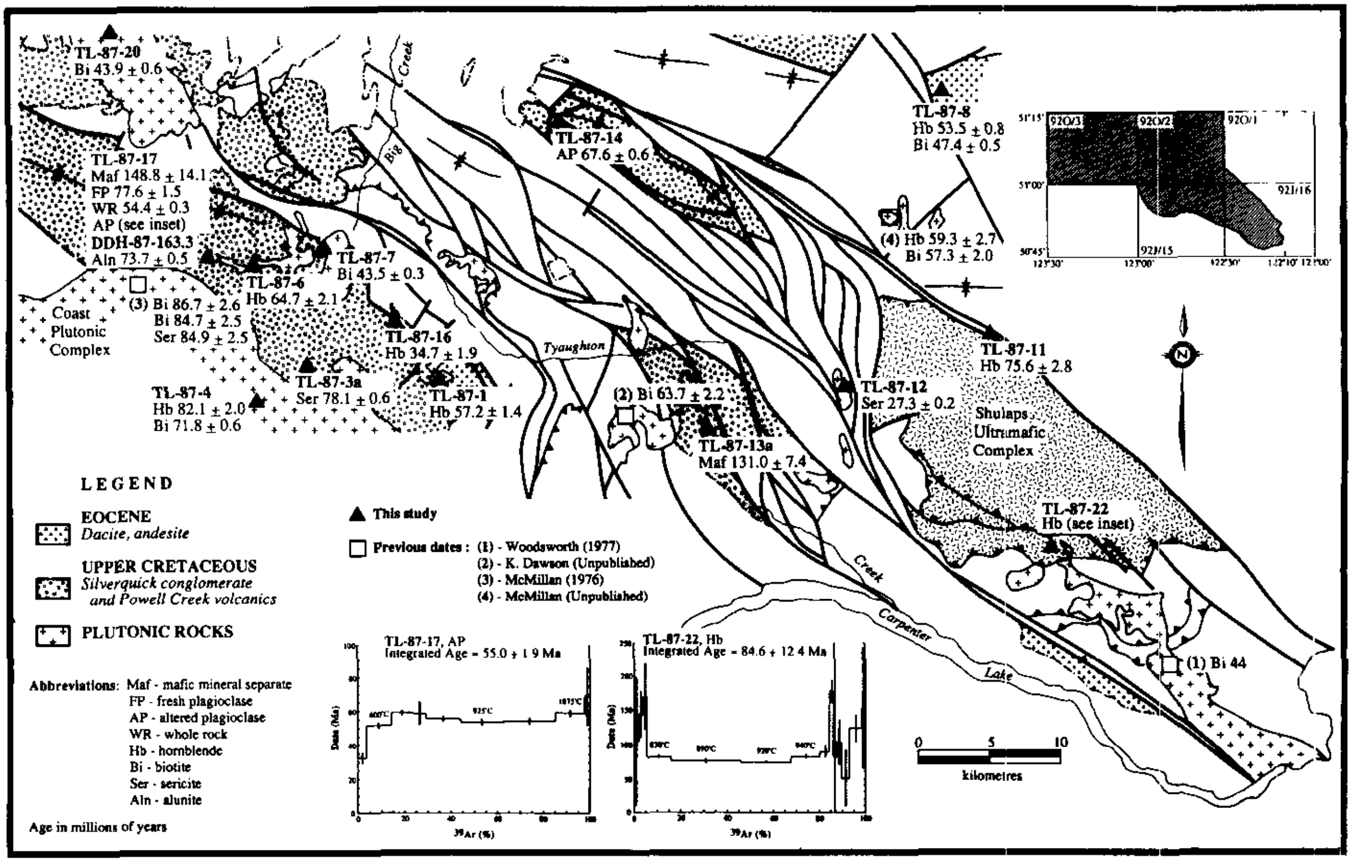

Figure 1-16-2. Distribution of Late Cretaceous and Tertiary rocks in Warner Pass, Noaxe Creek and Bridge River map areas.

apparent unconformity, but have themselves been involved in overturned folding and thrusting (Garver *et al.*, 1989, this volume). Thus, these rocks were deposited during and after an important phase of compressional tectonism that affected mid-Cretaceous and older strata.

Two samples of hornblende-phyric andesite, both from near the base of the Powell Creek formation, were dated. One (TL-87-17) is from the central part of the Warner Pass sheet, and the other (TL-87-13a) is from the southern Noaxe sheet. As the samples are chlorite-epidote altered no pure mineral separates could be obtained. The dates for the whole-rock, "fresh" plagioclase, and the mafic fraction are 54.4 ± 0.8, 78 ± 2 and 149 ± 14 Ma, respectively for TL-87-17; the integrated age of the "altered" plagioclase from this sample which was step-heated (*see below*) is 55 ± 2 Ma. The mafic fraction from TL-87-13a yields a date of 131 ± 7 Ma. These dates are highly discordant and suggest that both samples have suffered some degree of argon or potassium loss or redistribution. As both sample sites are within 2 kilometres of younger plutons and contain abundant fine-grained alteration minerals, this is not unexpected.

As shown in Table 1-16-1, the mafic fractions of these two samples are characterized by high ^{37}Ar/^{39}Ar ratios, proportional to the Ca:K ratio; these are typical of calcic pyroxene and this phase clearly exceeds amphibole in this fraction. Pyroxene commonly contains excess argon and it is probable that the apparent dates (greater than the stratigraphic age) for these fractions are a reflection of this. As discussed below ^{40}Ar/^{39}Ar step-heating may permit useful ages to be determined from these partial separates.

The concordance of the dates for the whole-rock and the "altered" plagioclase for TL-87-17 suggests that the bulk of the potassium is now bound in the fine-grained sericite that has replaced some, but not all, of the smaller plagioclase laths in this sample. The age spectrum is plotted in Figure 1-16-2. The ^{37}Ar/^{39}Ar ratios and the volumes of ^{39}Ar (Table 1-16-2) indicate this sample is a two-phase system. The argon released in the initial, low-temperature step yields a date of 32 Ma and subsequent dates increase to 60 Ma before decreasing to a minimum of 54 Ma (925 and 1000°C steps). The maximum date from the first pulse of ^{39}Ar released may correlate with release from fine-grained sericite whereas the higher temperature plateau (for 41 per cent of the ^{39}Ar released) may be related to the smaller plagioclase phenocrysts. The "fresh" plagioclase appears to be a product of the larger phenocrysts (typically 2 by 5 millimetres) which have not been as altered. Thus, the 78 Ma date for the "fresh plagioclase" is not likely to be a reliable age of extrusion and may be the result of mixing of the much younger sericite and a primary plagioclase; or overprinting of primary plagioclase during younger thermal events. Additional ^{40}Ar/^{39}Ar step-heating will help resolve this problem.

COAST PLUTONIC COMPLEX

Granodiorite of the Coast plutonic complex underlies the southwest corner of the Warner Pass map area, where it intrudes the Powell Creek formation and older rocks. Previous potassium-argon dates on biotite from granodiorite; sericite from an alteration zone; and biotite from a postmineralization dyke were reported from the Mohawk porphyry deposit. All three ages (84.7 ± 2.5, 84.9 ± 2.5, 86.7 ± 2.6 Ma; McMillan, 1976) were the same within the limits of analytical precision. Sample TL-87-4, collected about 10 kilometres southeast of the Mohawk showing, yields dates of 82.1 ± 2.0 Ma on hornblende and 71.8 ± 0.6 Ma on biotite. The hornblende date is consistent with the previous mica dates, but the new biotite date is significantly younger. This is undoubtedly the result of thermal overprinting which may be related to a zone of sericitization several kilometres to the west within the batholith. It is of interest that a similar zone of alteration at the Warner property (Sample TL-87-3a) yields a date of 78.1 ± 0.6 Ma and that alunite (Sample DDH-87-163.3) from the Taylor-Windfall property yields a slightly younger date of 73.7 ± 0.5 Ma. The difference may be due to argon loss from the very fine-grained alunite. These dates strongly suggest that mineralization and at least some of the alteration in the western part of the Warner Pass area occurred at, or just prior to, 74 Ma. Such events may have been related to the final stages of crystallization and cooling of the Coast plutonic complex.

TABLE 1-16-2
^{40}Ar/^{39}Ar STEP-HEATING DATA

Temp. °C	^{40}Ar/^{39}Ar	^{36}Ar/^{39}Ar	^{37}Ar/^{39}Ar	Vol. ^{39}Ar$_K$ × 10^{-9} cm^{3}NTP	%^{39}Ar of Total	%^{40}Ar rad	Date ± 2σ Ma
TL-87-22 Hb							
550	177.290	0.5691	13.112	0.2576	1.84	5.69	105.3 ± 92.9
650	30.846	0.0605	13.924	0.2848	2.05	45.42	144.5 ± 34.1
750	38.028	0.0731	5.561	0.2011	1.44	44.26	171.3 ± 47.5
830	10.616	0.0124	10.799	1.4997	10.75	72.96	81.1 ± 1.4
890	9.007	0.0097	12.655	4.1584	29.83	78.36	74.1 ± 4.1
920	9.042	0.0102	11.842	3.0841	22.12	76.48	72.6 ± 0.5
940	9.677	0.0093	11.713	1.7570	12.60	80.33	81.4 ± 2.7
960	16.391	0.0303	14.393	0.6256	4.49	51.92	89.0 ± 8.5
980	35.189	0.0653	20.529	0.2024	1.44	49.49	178.5 ± 15.4
1005	46.282	0.1363	23.903	0.1884	1.35	16.83	81.6 ± 185.9
1025	42.277	0.1165	25.114	0.2486	1.77	22.99	102.2 ± 33.0
1055	27.969	0.0839	20.031	0.4875	3.49	16.63	49.6 ± 41.3
1100	27.792	0.0582	17.524	0.7561	5.42	42.79	123.9 ± 20.6
1200	81.121	0.2281	16.494	0.1896	1.36	18.43	153.8 ± 88.8

Total ^{39}Ar 13.9400 e-9
integrated age = 84.6 ± 12.4
wt. = 0.250 mg
J = 5982 e-3
mesh size = 60/115

Temp. °C	^{40}Ar/^{39}Ar	^{36}Ar/^{39}Ar	^{37}Ar/^{39}Ar	Vol. ^{39}Ar$_K$ × 10^{-9} cm^{3}NTP	%^{39}Ar of Total	%^{40}Ar rad	Date ± 2σ Ma
TL-87-17 A.P.							
500	15.868	0.0436	0.434	3.2300	4.02	18.45	32.1 ± 3.4
600	7.686	0.0095	0.703	8.1300	10.11	63.69	52.1 ± 0.4
700	7.500	0.0065	0.600	7.9120	9.84	74.46	59.5 ± 1.7
775	7.396	0.0062	0.384	4.1190	5.12	75.06	58.9 ± 7.1
850	6.232	0.0033	0.174	12.1210	15.08	84.10	55.7 ± 1.3
925	5.998	0.0031	0.152	14.9600	18.60	84.39	53.9 ± 1.1
1000	6.259	0.0030	0.196	18.1120	22.53	81.36	54.1 ± 1.0
1075	10.716	0.0174	0.399	10.0280	12.47	53.48	59.3 ± 1.7
1200	26.956	0.0694	1.275	1.7807	2.21	25.30	69.3 ± 17.0

Total ^{39}Ar 80.0390 e-9
integrated age = 55.0 ± 1.9
wt. = 0.120 g
J = 5.9820 e-3
mesh size = 80/170

Temp. °C	^{40}Ar/^{39}Ar	^{36}Ar/^{39}Ar	^{37}Ar/^{39}Ar	Vol. ^{39}Ar$_K$ × 10^{-9} cm^{3}NTP	%^{39}Ar of Total	%^{40}Ar rad	Date ± 2σ Ma
TL-87-14 Maf.							
<800	Lost						
1000	17.721	0.0324	0.476	5.6512		46.01	86.1 ± 10.3
1200	94.522	0.2762	2.607	1.3965		13.85	136.3 ± 37.4

Total ^{39}Ar —
integrated age —
wt. = 0.120 g
J = 5.920 e-3
mesh size = 60/120

(*See* footnotes and abbreviations in Table 1-16-1.)

HORNBLENDE PLAGIOCLASE PORPHYRIES

Dates were determined for three small hornblende plagioclase porphyry intrusions (Unit A of Glover and Schiarizza, 1987). These units are compositionally similar to the andesitic volcanics of the Powell Creek formation and two of the three are spatially associated with these volcanics. Like the enclosing volcanics, the porphyries are chlorite-epidote altered. The oldest reliable date, 75.6 ± 2.8 Ma on hornblende from sample TL-87-11, is from a narrow dyke that can be traced for 1500 metres within the Yalakom fault zone, in the southeastern Noaxe sheet. Although the dyke margins are sheared, this date is interpreted as an upper limit for major strike-slip movement along the Yalakom fault.

Hornblende from the Dorrie Peak stock (Sample TL-86-6) yielded a date of 64.7 ± 2.1 Ma. This date is concordant, within analytical error, with the 63.7 Ma date obtained by K. Dawson (personal communication, 1987) for the Eldorado pluton to the southeast; it is consistent with part of this suite being younger than the Coast plutonic complex and Early Paleocene in age.

The North Relay porphyry is associated with a zone of intense alteration, some of which is gold-bearing. The pluton is itself very altered and the sericitized plagioclase (Sample TL-87-14) yielded a date of 67.6 ± 0.6 Ma. This area is remote from other plutons and the date may provide a good estimate of the time of alteration and mineralization in this zone. An attempt to step-heat a small mafic separate from this sample was largely unsuccessful (in part, the result of severe carbonate alteration). However, the fraction of the gas released between 800 and 1000°C (Table 1-16-2) yielded a date of 86 ± 10 Ma. This date has a large analytical uncertainty, but it may indicate that the hornblende plagioclase porphyries in this zone are of a different age than elsewhere. The 86 Ma date is consistent with the inferred Late Cretaceous age for the Powell Creek volcanics. Samples of less-altered rock were collected in 1988 for additional ^{40}Ar/^{39}Ar step-heating experiments.

HORNBLENDE-PLAGIOCLASE-BIOTITE-QUARTZ PORPHYRIES

Small stocks of this composition (Unit C of Glover and Schiarizza, 1987), occur within restricted areas of andesitic to rhyolitic volcanics. The volcanic rocks unconformably overlie Upper Cretaceous units and have been correlated with Eocene strata elsewhere in the region. The Mount Sheba stock, which intrudes these volcanics in the southeastern Warner Pass map area, yields a date of 57.2 ± 1.4 Ma on hornblende (Sample TL-87-1). The Red Mountain porphyry intrudes similar volcanics in the northeastern corner of the Noaxe Creek map area. Hornblende and biotite from a sample of this porphyry (Sample TL-87-8) yield discordant dates of 53.5 ± 0.8 and 47.4 ± 0.5 Ma, respectively. The spread in the dates may be caused by excess argon in the hornblende or argon loss from the biotite. The first is possible as both samples contain small mafic, hornblende-bearing xenoliths. A Paleocene age for this suite, however, is also possible as potassium-argon dating of intrusion, potassic alteration and mineralization at the Poison Mountain porphyry copper deposit, 10 kilometres southwest of Red Mountain, has yielded concordant biotite and hornblende dates of about 58 Ma (Glover *et al.*, 1988). Although a Tertiary age for these plutons is not in doubt, ^{40}Ar/^{39}Ar step-heating is required to explain the discordant dates and define their ages precisely.

BEECE CREEK AND LORNA LAKE STOCKS

Equigranular monzogranite (Unit D of Glover and Schiarizza, 1987), occurs as two relatively large plutons in the Warner Pass map area; these comprise the Beece Creek pluton in the northwest corner of the sheet and the Lorna Lake stock at the head of Big Creek. Biotite from both stocks is very fresh and in each case has yielded dates of about 44 Ma (Samples TL-87-7 at 43.5 ± 0.3 and TL-87-20 at 43.9 ± 0.6). These dates suggest a Middle Eocene age for these bodies. The Beece Creek pluton is one of the largest stocks east of the Coast plutonic complex. Although no mineral showings are associated with it in the Warner Pass map area, it is cut by small quartz-tourmaline-epidote veins and stockwork, and may be genetically related to extensive chlorite-epidote alteration peripheral to it. The Lorna Lake stock was apparently emplaced along a north-northeast-trending normal fault which occupies the Big Creek valley. It has a narrow chlorite-epidote alteration envelope and minor associated chalcopyrite-molybdenite mineralization.

The 44 Ma dates from the Beece Creek and Lorna Lake plutons are identical to the 44 Ma date obtained by Woodsworth (1977, potassium-argon on biotite), from the compositionally similar Mission Ridge pluton, which outcrops in the Bridge River area to the southeast (Schiarizza *et al.*, 1989, this volume).

LIZARD STOCK AND BIG SHEEP MOUNTAIN ALTERATION

The two youngest dates obtained so far, are from the Lizard stock in the Warner Pass area and from a sericitic alteration zone on Big Sheep Mountain in the Noaxe Creek area. The Lizard stock is a small (less than 500 metres diameter) body of very fine-grained hornblende porphyry which was emplaced across the Chita Creek fault and an unmineralized, rusty carbonate alteration zone in Powell Creek volcanics and older rocks. The hornblende from the Lizard stock (Sample TL-87-16) yields a date of 34.7 ± 1.9 Ma. This provides an upper limit (Oligocene) for faulting and alteration events in the western part of the area.

The sericitic alteration zone on Big Sheep Mountain, which was developed in a highly silicified hornblende porphyry, has attracted interest for its gold potential. A sericite-rich sample (TL-87-12) yielded a date of 27.3 ± 0.2 Ma. As the host porphyry is not yet dated, it is difficult to assess the significance of this date. Samples of less-altered host rock and several other dykes in the area were collected for dating in 1988.

AMPHIBOLITE AT THE BASE OF THE SHULAPS ULTRAMAFIC COMPLEX

In preparation for 1988 field work in the Bridge River and Bralorne map areas (92J/16 and 92J/15, respectively), a reconnaissance was made of the south side of the Shulaps ultramafic complex in an area previously mapped by Potter (1983). The upper Hog Creek area is underlain by Potter's "imbricate zone", consisting of sheared serpentinite that contains "knockers" of a wide variety of igneous lithologies, ranging in composition from ultramafic to intermediate, as well as a variety of sedimentary rocks, some of which appear to correlate with those of the Bridge River complex. The sample selected for dating is a medium-grained, massive to coarsely brecciated, equigranular amphibolite that occurs as a knocker within the imbricate zone. This rock-type differs from the foliated to lineated amphibolite which Potter viewed as part of the basal metamorphic aureole of the Shulaps ultramafic complex; it is most likely part of the sheeted to brecciated, mafic dyke complex of an ophiolite succession. As the metamorphism may have been a sea-floor process, it was hoped that dating the amphibole in this sample would provide the age of the Shulaps complex. However, mapping in 1988 by T. Calon (Memorial University of Newfoundland) and the authors reveals that this zone has had a more complex thermal history than previously thought.

The ^{40}Ar/^{39}Ar age spectrum for the amphibole separate (Sample TL-87-22) is shown in Figure 1-16-2 and the analytical data are listed in Table 1-16-2. Overall, the spectrum has a U-shaped form characteristic of minerals that contain excess argon. The bottom of the "U" corresponds to the main pulse of ^{39}Ar release (over 70 per cent) from the amphibole. Steps in this segment of the age spectrum are characterized by similar ^{37}Ar/^{39}Ar ratios (proportional to the Ca:K ratio). The dates for the higher temperature steps are derived from a phase with a higher ^{37}Ar/^{39}Ar ratio and with a much lower potassium content. The amphibole in this sample is actinolitic and appears somewhat fibrous in thin section; this may account for the relatively low temperature of the release of the bulk of the ^{39}Ar. Thus, although the integrated date is 84.6 ± 12 Ma, the minimum date, 72.6 ± 0.5 Ma, is taken as the best estimate of the age for this sample.

To interpret this date it is necessary to consider the geology of, and the thermal processes that were active in, the imbricate zone. Detailed mapping of the serpentinite mélange beneath the Shulaps ultramafic complex has revealed the presence of synkinematic dykes of mafic to intermediate composition. Locally the dykes reacted with the serpentinite to form rodingite and, near larger bodies, to regenerate olivine in the serpentinite (T. Calon, personal communication, 1988). The temperature within this part of the mélange was probably *circa* 500°C and would be sufficiently high to thermally overprint or recrystallize amphibole. It is probable that any pre-existing amphibole, such as was dated, would record a secondary metamorphic age. Thus, we interpret the 73 Ma date as indicating the time of cooling of the mélange following this magmatic event. This may mark the uplift and final emplacement of the Shulaps ultramafic complex. Late Cretaceous movement is supported by the fact that undeformed hornblende plagioclase porphyry cuts penetratively deformed metasedimentary knockers within the mélange, but does not extend into the serpentinite. This particular porphyry is characterized by acicular hornblende phenocrysts and is very similar to the dyke within the Yalakom fault zone which yielded a date of 75.6 ± 2.8 Ma (Sample TL-87-11). More samples were collected of this and other amphibole-bearing rocks from this zone in 1988, to better define the thermal history of the Shulaps complex.

CONCLUSIONS

There are several preliminary conclusions that have a bearing on the timing of magmatism, mineralization and tectonism in this region:

1. Andesitic volcanics of the Powell Creek formation, are intruded by 87 to 82 Ma granodiorite of the Coast plutonic complex and must therefore be Santonian or older in age. Mineralization and alteration within these volcanics along the margins of the Coast plutonic complex may have occurred between 74 and 78 Ma, during the final stages of crystallization of the complex.
2. Hornblende plagioclase porphyries (Unit A of Glover and Schiarizza, 1987), may be of several different ages; intrusive events at 86, 76 and 65 Ma are suspected, but not proven.
3. Hornblende-plagioclase-biotite-quartz porphyries (Unit C of Glover and Schiarizza, 1987), may be Paleocene (57 Ma) or Middle Eocene (47 Ma) or both.
4. Dates of 44 Ma for the Beece Creek pluton and Lorna Lake stock are concordant with a previously published age for the Mission Ridge pluton, thus confirming an important magmatic event during Middle Eocene time.
5. Oligocene dates from a small hornblende porphyry stock and a distant sericitic alteration zone may indicate the presence of magmatic and hydrothermal events of this age.
6. A 76 Ma hornblende plagioclase porphyry dyke within the Yalakom fault zone is interpreted to post-date major strike-slip movement along the fault. This compares with dates of 85 to 87 Ma on granodiorite which truncates the Tchaikazan fault, and a 64 Ma date (K. Dawson, personal communication, 1987), on the Eldorado pluton which truncates the Castle Pass fault. The three faults are part of an important dextral strike-slip system which cuts the early Late Cretaceous Powell Creek formation and older rocks; movement must therefore have been during the Late Cretaceous.
7. The final stage in the emplacement of the Shulaps ultramafic complex may also have occurred in the Late Cretaceous, between 76 and 73 Ma. This does not rule out, however, an earlier history of deformation within and adjacent to the complex.

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