NOTES ON THE PENTICTON GROUP
A PROGRESS REPORT ON A NEW STRATIGRAPHIC SUBDIVISION OF THE TERTIARY SOUTH-CENTRAL BRITISH COLUMBIA

(82E/L)

By B.N. Church

The name Penticton Group has been proposed for Eocene volcanic and sedimentary rocks of the Okanagan-Boundary region. The areas of recent study required to delineate these rocks are shown on Figure 1.

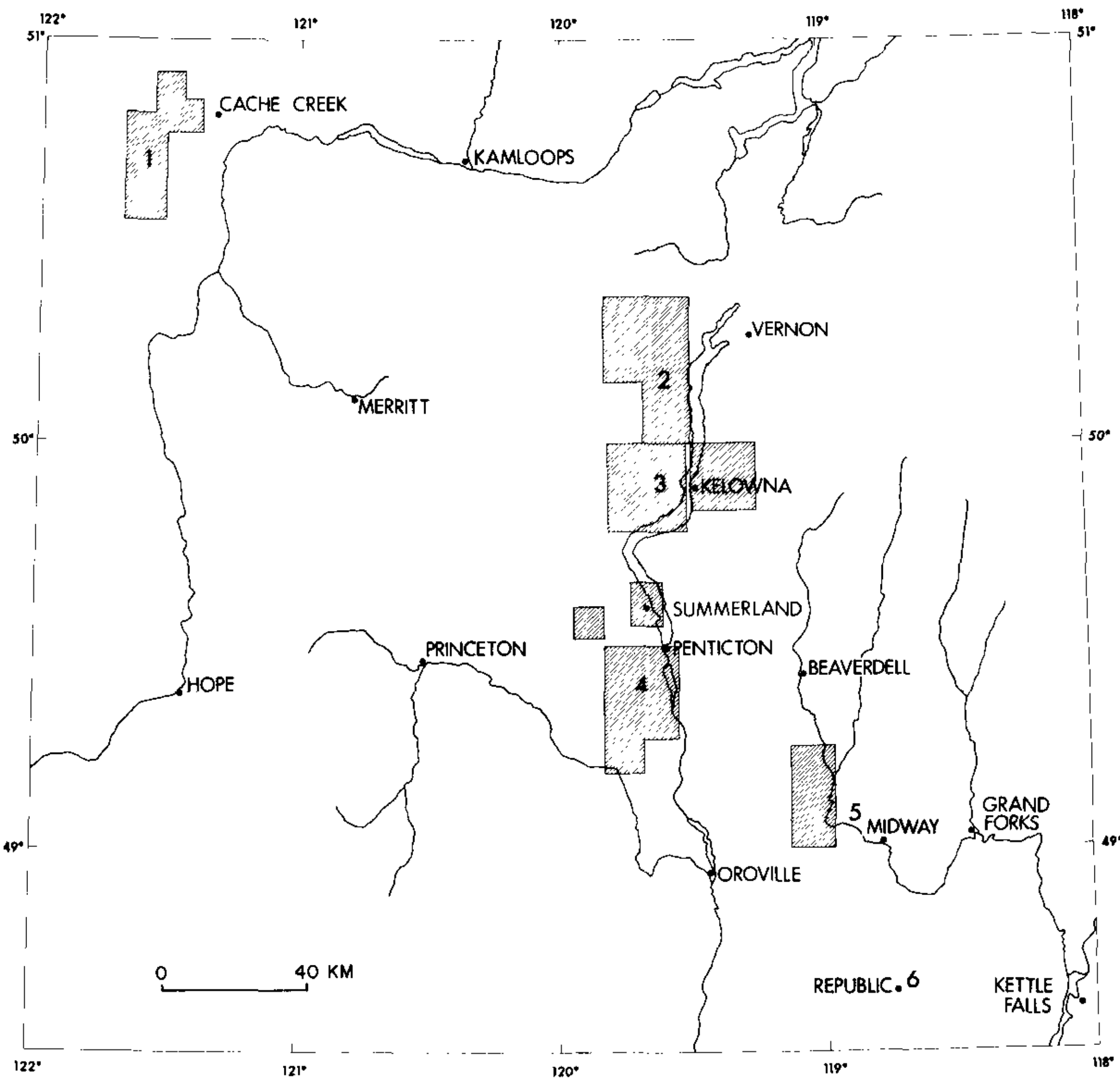

Figure 1. Index map of areas of detailed study.

The principal resources of the Penticton Group are coal, precious metal deposits, uranium, and geothermal energy.

The Group consists of six well-defined formations having an aggregate thickness of about 2 500 metres in the type area near Penticton (No. 4, Figure 2). At the base are polymictic conglomerates and breccias referred to as the Springbrook Formation and coeval beds of the Kettle River Formation consisting of granite boulder conglomerate, rhyolite breccia, and tuffaceous sedimentary rocks. Above this is the Marron Formation composed mainly of thick andesite, trachyte, and phonolitic lava flows, succeeded upward by dacitic and some andesitic domes of the Marama Formation. This is followed by volcanic breccias and lacustrine and fluvial sedimentary rocks of the White Lake Formation and, uppermost, the Skaha Formation consisting of a landslide complex and fanglomerate beds. The Group rests unconformably on pre-Tertiary granitoids, metamorphosed Mesozoic sedimentary and volcanic rocks, and older schists and gneisses.

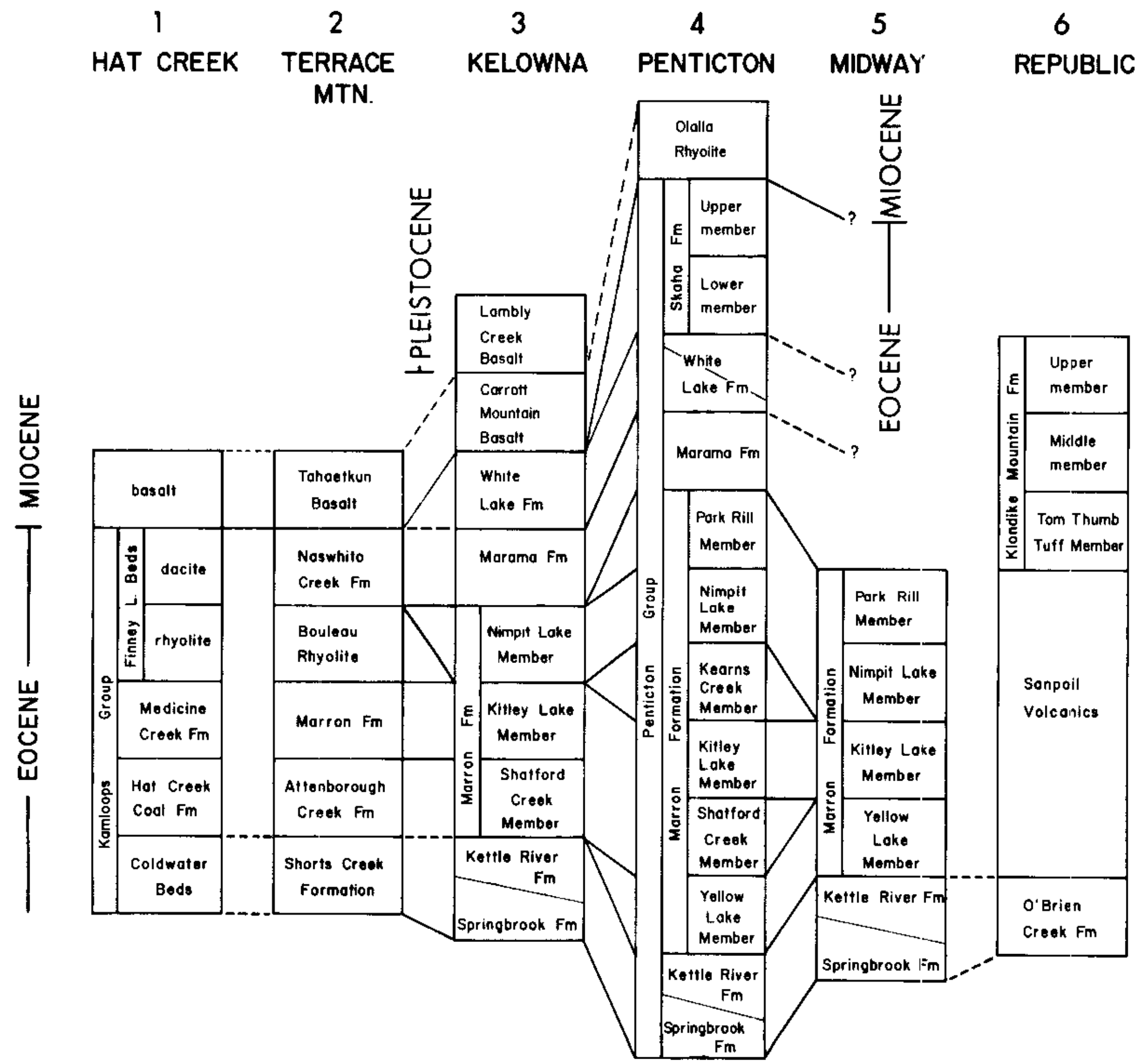

Figure 2. Correlation chart of major Tertiary units.

The age range for the Group, as determined by potassium-argon radiometric methods, is 48.4 Ma (whole rock) to 53.1 Ma (biotite) ±1.8 Ma. Preliminary tests performed on the principal lava members indicate normal magnetic polarity. Overlying the Group are isolated patches of Miocene rhyolite (Olalla rhyolite, 13 Ma) 'plateau basalt', and younger 'valley basalt.'

In the Kelowna area 'plateau basalt' occurs on Carrot Mountain (11.8 Ma) and Daves Creek (14.9 Ma). The Lambly Creek basalt (0.762 Ma) is the only so-called 'valley basalt' of the region.

North and west of the type area (see Nos. 1, 2, and 3, Figures 1 and 2) the constitutent formations interfinger and are replaced by units of the Kamloops Group (Ewing, 1981). At Terrace Mountain near Vernon the names Naswhito Creek Formation, Bouleau Rhyolite, Attenborough Creek Formation, and Shorts Creek Formation are applied to Eocene volcanic and sedimentary units that only partly correlate with the Penticton Group (Figure 2). Further west at Hat Creek few comparisons can be made other than to say that the Coldwater Beds partly resemble the basal Tertiary sedimentary rocks in the Okanagan area. Recent studies suggest that some part of these basal successions may be Cretaceous (K. Shannon, pers. comm.).

To the southeast near Midway in the Boundary area the Eocene section is incomplete but strikingly similar to the type assemblage (Monger, 1968).

In northern Washington State near the Republic area the O'Brien Creek Formation and Klondike Mountain Formation, at the base and top of the Eocene section respectively, are correlated in part with the Kettle River Formation and Skaha Formation of the Penticton Group (Pearson and Obradovich, 1977). However, the dacite-rich Sanpoil volcanics which underlie part of the Republic graben are lithologically unlike the Marron Formation and represent a significant uncorrelated unit.

A check with Dr. T.E. Bolton in the special projects section of the Geological Survey of Canada on the pre-occupation of stratigraphic names has cleared the following list for formal use in south-central British Columbia:

Area	Name	Age
Hat Creek	Finney Lake Beds	(Eocene)
	Medicine Creek Formation	(Eocene)
	Hat Creek Formation	(Eocene)
Terrace Mountain	Naswhito Creek Formation	(Eocene)
	Bouleau Rhyolite	(Eocene)
	Attenborough Creek Formation	(Eocene)
	Shorts Creek Formation	(Eocene)
Penticton	Penticton Group	(Eocene)
Kelowna	Lambly Creek Basalt	(Pleistocene)

It is considered that name Hat Creek Coal Formation (Eocene) is sufficiently different from Hat Creek beds (Oligocene) of Wyoming and Hat Creek Basalt (Recent) of northern California.

Structural control of the various outliers of the Penticton Group relates to some east-west-trending synclines and to a pattern of north-south gravity faults and pronounced conjugate shears of northeast and northwest orientation. These folds and fractures are viewed as essential elements in a north-south directed stress scheme thought to be responsible for the many graben-like structures and overall basin and range-like fabric of the region.

The Hat Creek basin is a typical graben. In this example the central zone of the valley has been downdropped on a series of north-south tension faults trending subparallel to the direction of regional maximum stress, the walls of this graben having been offset by northwest and northeast-trending conjugate shears.

Vertical movement on the graben faults is commonly in the range of hundreds of metres. As viewed on Shorts Creek near Vernon, the Tertiary beds have been downfaulted in excess of 700 metres against older limestone and granite; at Hat Creek the vertical displacement is locally in excess of 1 000 metres. As a net result of this movement, commonly the base of these continental beds is displaced well below mean sea level elevation.

Lateral movement on the shear faults is not readily documented although it is suspected that the southern Okanagan and Boundary areas may have resided on a northeast-trending geothermal lineament similar to the present Reno, Nevada-Billings, Montana volcanic-geothermal belt (Grim, 1977). This could explain the marked similarity of the stratigraphy and petrography of the Eocene volcanic rocks of the Okanagan and Boundary areas. This might also partly account for the resetting to Eocene of radiometric dates of crystalline basement rocks in the region (Ross, 1974).

The hypothetical repositioning of Penticton Group rocks in the south Okanagan and Boundary areas to juxtaposition on a northeast-trending geothermal belt would require a southeast-northwest translation of about 80 kilometres. Extending the hypothetical geothermal belt and lithological correlations to the Highwood area of central Montana (similarities noted by Church, 1973, p. 75), a translation in the order of several hundred kilometres would be required. It is noted that lateral translations of this magnitude have been recorded in the Northern Cordillera (Norris, 1981, G.A.C. abstract, p. 29).

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THE RIDDLE CREEK URANIUM-THORIUM PROSPECT

(82E/12W)

By B.N. Church

The Riddle Creek uranium-thorium prospect, 15 kilometres west of Summerland, was discovered in 1977 and acquired the same year by British Newfoundland Exploration Ltd. Work on the property to date includes line-cutting, mapping, soil geochemistry, and several short drill holes.

The present report is based on recent geological and scintillometer surveys and a lithogeochemical study sponsored by the Ministry.

GEOLOGICAL SETTING

A large radioactive anomaly coincides with an Eocene volcanic centre near the headwaters of Riddle Creek (Figure 1). The principal radioactive rocks include trachytes and mafic phonolites of the Marron Formation and consanguineous igneous intrusions of the Coryell-type.

LOW-RADIOACTIVE COUNTRY ROCKS

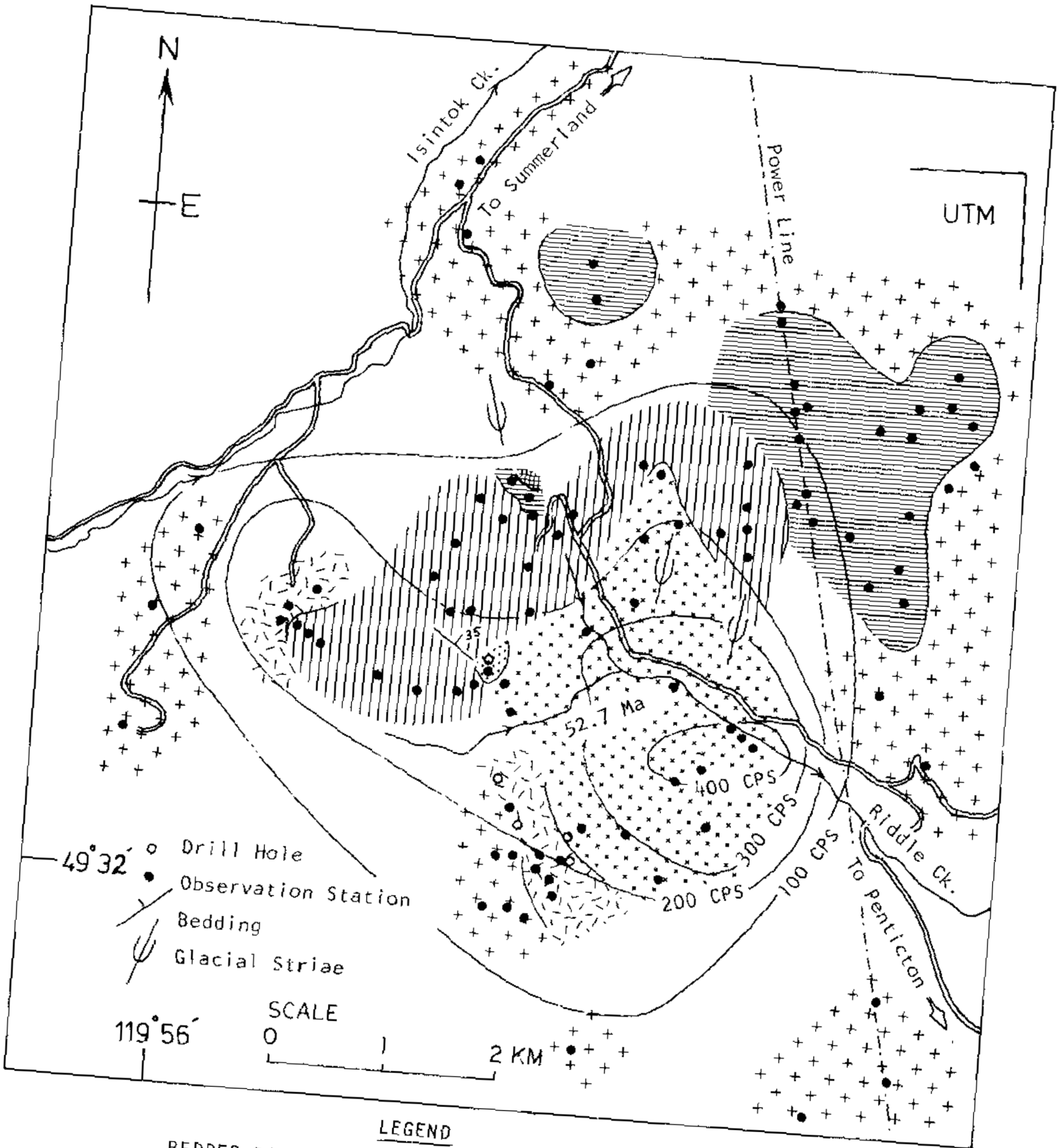
At the base of the Tertiary section and north of the zone of anomalous radioactivity, poorly exposed polymictic boulder conglomerate beds are tentatively assigned to the Springbrook Formation. These rocks appear to be unconformably underlain by granitic phases of the Okanagan Batholith (Jurassic-Cretaceous) and overlain by unnamed andesites. The andesites form a significant formation in the northeast part of the area where lava and breccia are 250 metres thick. Alkaline andesite dominates (No. 1, Table 1) and is characterized by scattered microphenocrysts of plagioclase and hornblende usually less than 1 millimetre in diameter.

Scintillometer readings on these rocks and other basal and basement units range from 40 to 80 counts per second.

RADIOACTIVE ROCKS

Rocks that show anomalous radioactivity are principally mafic phonolites and trachyte lavas and breccias (Nos. 2 and 4, Table 1). These overlie the andesites and onlap parts of the Okanagan Batholith. They are dated 52.7±1.8 Ma (K/Ar on biotite) and correlate with the Yellow Lake Member of the Marron Formation near Penticton.

Mafic phonolites, which form the base of the Yellow Lake Member, are exposed on the ridges north and northeast of Riddle Creek where interlayered lava flows and lahar deposits attain a thickness of about 75 metres. Petrographic examination shows conspicuous rhomb-shaped anorthoclase phenocrysts to 2 centimetres in length and smaller subhedral



LEGEND

BEDDED ROCKS

MARRON FORMATION (Eocene)

- Trachyte lava and breccia
- Ash flow and conglomerate beds
- Mafic phonolite lava, breccia

- Andesite lava and breccia

SPRINGBROOK FORMATION ?

- Polymictic conglomerate

IGNEOUS INTRUSIONS

CORYELL INTRUSIONS (Eocene)

- Syenite and monzonite

BASEMENT ROCKS

- Mostly granitiod bodies

Figure 1. Geology of the Riddle Creek radioactive volcanic centre.

Table of Chemical Analyses

	1	2	3	4	5	6
Oxides recalculated to 100						
SiO_2	57.89	57.37	63.87	61.39	57.58	66.51
TiO_2	0.96	0.93	0.64	0.84	0.87	0.49
Al_2O_3	16.38	19.16	17.92	17.05	16.21	17.01
Fe_2O_3	4.43	3.01	3.14	3.43	3.83	2.58
FeO	1.03	1.77	0.73	1.07	2.48	0.24
MnO	0.08	0.09	0.11	0.09	0.12	0.14
MgO	4.33	2.40	1.10	1.99	3.73	0.28
CaO	6.90	4.05	0.64	3.34	5.22	0.84
Na_2O	4.12	5.83	4.71	5.47	4.71	6.05
K_2O	3.88	5.39	7.14	5.33	5.25	5.86
	100.00	100.00	100.00	100.00	100.00	100.00
Oxides and elements as determined						
$+H_2O$	0.56	2.02	0.90	0.20	1.14	0.70
$-H_2O$	0.58	0.35	0.75	0.18	0.41	0.70
CO_2	0.25	0.25	<0.11	0.25	0.25	0.25
S	0.02	<0.01	<0.005	0.01	0.02	0.01
P_2O_5	0.82	0.46	0.25	0.32	0.68	<0.15
BaO	0.21	0.30	0.10	0.20	0.23	0.013
SrO	0.30	0.42	0.07	0.21	0.31	0.02
Molecular Norm						
Quartz	2.0	-	5.7	1.3	-	6.6
Orthoclase	22.7	31.1	41.8	31.0	30.6	34.0
Albite	36.7	38.8	41.8	48.3	41.8	53.0
Nepheline	-	7.3	-	-	-	-
Anorthite	14.6	10.0	3.1	6.1	7.5	1.9
Wollastonite	7.7	3.9	-	4.1	7.2	0.9
Enstatite	11.8	-	3.0	5.4	0.6	0.8
Ferrosilite	-	-	-	-	-	-
Forsterite	-	4.9	-	-	7.2	-
Fayalite	-	-	-	-	-	-
Ilmenite	1.3	1.3	0.9	1.2	1.2	0.7
Magnetite	0.4	2.1	0.4	0.7	3.9	-
Hematite	2.8	0.6	1.9	1.9	-	2.1
Corundum	-	-	1.4	-	-	-

Key to Analyses

1. Alkaline andesite, basal volcanic assemblage
2. Mafic phonolite lava (rhomb porphyry), Yellow Lake Member, Marron Formation
3. Trachyte ash flow, Yellow Lake Member, Marron Formation (Skaha Creek area)
4. Trachyte lava (rectangular porphyry), Yellow Lake Member, Marron Formation
5. Coryell-type monzodiorite intrusion
6. Trachyte dyke, on north fork of Riddle Creek

and euhedral phenocrysts of green diopsidic augite, biotite, apatite, and magnetite set in a devitrified glassy or fine-grained feldspathic matrix. Scintillometer readings are in the range 140 to 180 counts per second.

The most radioactive rocks are thick trachyte lava flows that comprise the upper part of the Yellow Lake Member in this area. This unit is estimated to be between 150 to 200 metres in thickness. It underlies the ridges and slopes immediately northeast and south of the confluence of the forks of Riddle Creek. The trachyte contains large rectangular or platy mixed feldspar phenocrysts of anorthoclase, sanidine, and plagioclase; otherwise it is petrographically similar to the mafic phonolite (rhomb porphyry) suite. Scintillometer measurements are in the range 300 to 420 counts per second.

Coryell plutonic rocks crop out on the hillsides north and south of the westerly source of Riddle Creek. These are high level miarolitic syenomonzonite and monzodiorite phases (No. 5, Table 1) that are mineralogically akin, and feeders to, the overlying Yellow Lake volcanic pile into which the Coryell pluton has evidently stoped. The rock is composed of about 80 per cent alkali feldspar, mostly orthoclase with rhomb-shaped anorthoclase cores, and 20 per cent smaller phenocrysts and interstitial grains of amphibole and pyroxene with poikilitic inclusions of biotite, magnetite, apatite, and sphene. The average scintillometer reading is 250 counts per second.

SCINTILLOMETER SURVEY

In the course of routine geological investigation of the Riddle Creek area, rock outcrops were tested in a manner outlined by McDermott (1977) using a portable gamma ray scintillometer (GeoMetrics/Exploranium Model GRS-101). Quantitative control was obtained for uranium from neutron activation of 24 samples, courtesy of D.R. Boyle of the Geological Survey of Canada, and for thorium from spectrometer analysis performed by the Analytical Division of the Ministry. The relationship between counts per second and uranium/thorium composition can be reduced to two equations:

$$U = \text{c.p.s.}\ (0.072) - 0.538$$
$$Th = \text{c.p.s.}\ (0.231) + 6.913$$

Accordingly, the following averages are calculated for uranium and thorium levels for the main rock types, based on c.p.s. values at 93 stations:

Rock Unit	U ppm	Th ppm
Trachyte (Yellow Lake Member)	27	94
Mafic phonolite (Yellow Lake Member)	11	45
Coryell Intrusions	18	66
Andesite Unit (unnamed)	5	23
Springbrock Formation	4	22
Okanagan Batholith	4	22

Scintillometer results (Figure 1) were contoured using the method outlined in Geological Fieldwork, 1980, Paper 1981-1, page 27. A bull's-eye arrangement of contours lies immediately south of the main course of

Riddle Creek in an area underlain by trachyte lavas and a volcanic centre. Thoroughly altered rocks are exposed below the trachyte on Riddle Creek and more distally on the slopes to the west. Pervasive hydrothermal alteration of the trachyte and vent (?) breccia has produced cream and white kaolinized rocks of variable radioactive response.

THE PROSPECT

A diamond-drill program consisting of approximately 270 metres in seven holes was completed in 1978. Six holes were sited south of Riddle Creek near the west boundary of the trachyte and one hole sited north of the creek. The purpose of the drilling was to test bedrock near geochemical soil anomalies and projected structural traps for uranium-bearing solutions.

North of Riddle Creek, drill hole No. 7 was directed at a northeast-dipping section of strata +30 metres thick of coarse clastic sedimentary rocks that is overlain by partly welded ash flow breccia at the base of the trachyte unit. (This stratigraphic-structural target is strikingly similar to the occurrence of radioactive trachyte ash and breccia in clastic sedimentary beds in the vicinity of Farleigh Lake and Skaha Creek, 15 to 20 kilometres to the southeast (No. 3, Table 1 - unit 1b on Preliminary Map 35). Although no significant uranium was found, the drilling proved good porosity of the beds below the ash flow and thus potential for further exploration.

Most of the drilling in the area of soil anomalies south of Riddle Creek intersected Coryell intrusive rocks. However, hole No. 1 near the west boundary of the trachyte cut altered rocks showing vestiges of conglomerate and breccia similar to the rocks at site No. 7.

A few prominent radioactive high spots were not tested by the drilling. The most important of these is an easterly trending felsic dyke about 4 metres wide exposed 450 metres north of the confluence of the forks of Riddle Creek. This is thought to be a feeder to the trachyte lavas of the Marron Formation (No. 6, Table 1). Scintillometer readings here averaging 1500 c.p.s. correspond to rock analyses showing 121 ppm U and 342 ppm Th. Radiographs of slabbed samples show that radioactive elements are concentrated on manganese pitch and dendritic growths on numerous small cracks. A similar dyke with scintillometer readings in the range of 600 to 900 c.p.s. was found at the contact between Coryell plutonic rocks and mafic phonolite lavas in the northwest part of the map-area between Isintok Creek and the western headwaters of Riddle Creek.

DISCUSSION

The Riddle Creek Tertiary outlier lies near the western extremity of a belt of Eocene alkaline volcanic rocks that are characterized by anomalous uranium and thorium contents (Church and Johnson, 1978). It is suggested that these rocks are the source of the relatively high uranium levels in streams of the Okanagan-Boundary area found by the 1976 URP survey. The possibilities of secondary uranium deposition and enrichment in this setting are numerous, including dykes, permeable sedimentary rocks and alteration zones associated with volcanic vents (Culbert and Leighton, 1978).

High radioactive response near the headwaters of Riddle Creek coincides with what appears to be a trachyte volcanic centre (Figure 1). In 1978, a program of short diamond-drill holes was conducted peripheral to this centre and yielded low uranium values. For future study the volcanic centre and associated ash flow deposits offer the best target.

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