70-52

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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RADIOACTIVITY IN WESTERN CANADIAN COALS

(Report, 9 tables and 20 figures)

A. R. Cameron and T. F. Birmingham

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1970

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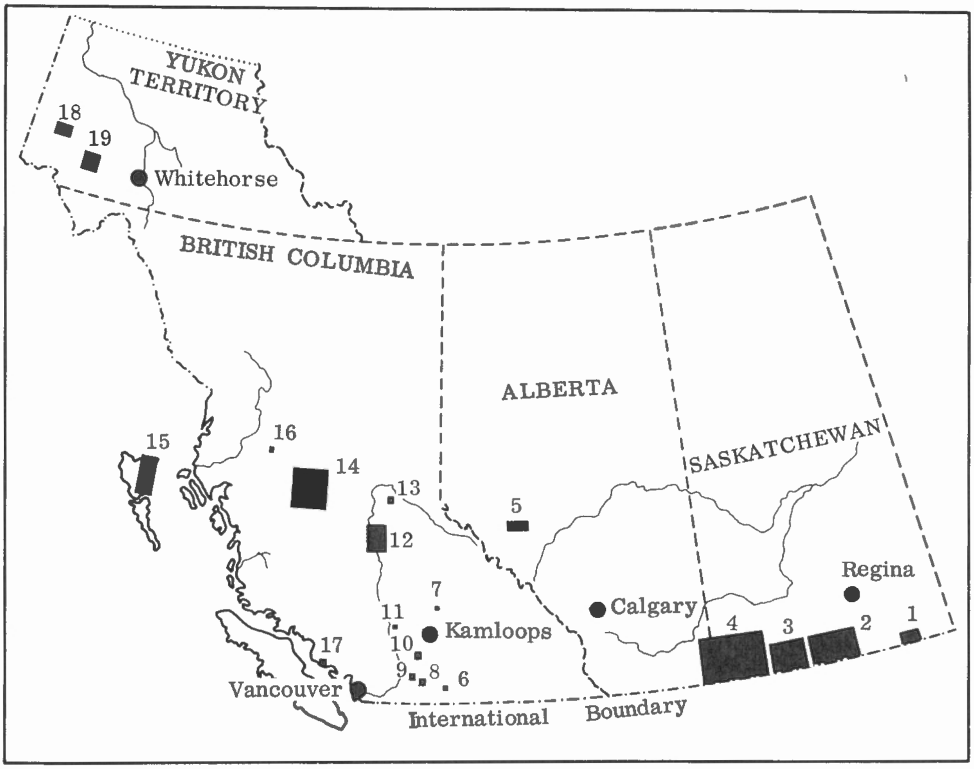
ABSTRACT

Significant concentrations of uranium have been found in Cretaceous and younger coals and carbonaceous shales in the mid-western United States. This report presents field and laboratory data obtained during a study of lignite and other Tertiary coals of western Canada. The Cypress Hills area of Saskatchewan holds the best promise for commercial concentrations of uranium.



1.	Estevan	11.	Hat Creek
2.	Willow Bunch	12.	Alexandria-Quesnel
3.	Mankota	13.	Bowron River
4.	Cypress Hills	14.	François Lake-Cheslatta Lake
5.	Coalspur	15.	Graham Island
6.	White Lake	16.	Driftwood Creek
7.	Chu-Chua	17.	Lang Creek
8.	Princeton	18.	Burwash Landing
9.	Tulameen	19.	Haines Junction
10.	Merritt		

Figure 1. Index map of western Canada showing areas checked for radioactivity.

RADIOACTIVITY IN WESTERN CANADIAN COALS

INTRODUCTION

Because of renewed interest in uranium exploration in the past few years the Geological Survey of Canada has increased its activity in the assessment of Canada's reserves including that present in coal particularly the lignites and other Tertiary coals of western Canada. The Coal Research Section of the Survey has spent part of the last four field seasons in this effort. This report contains both field and laboratory data obtained during the course of this investigation.

In the United States significant concentrations of uranium have been found in Cretaceous and younger coals and carbonaceous shales in North and South Dakota, Montana, Wyoming, New Mexico and Idaho (Denson et al., 1959; Denson and Gill, 1965). In North and South Dakota these concentrations have been high enough for commercial production.

In their studies of such deposits geologists of the U.S. Geological Survey have come to certain conclusions regarding the source of the uranium and controls affecting its concentration (Denson and Gill, 1965). They have suggested that the uranium was leached from younger volcanic rocks, carried downward by groundwater and adsorbed by the carbonaceous material in coals and shales. In the majority of deposits the richest concentrations have been found in the carbonaceous beds (usually lignites) closest to the volcanics, that is in the highest coaly beds in a section. In the economically attractive occurrences in the Dakotas the highest concentrations have usually been found in the upper part of the seams and where the bed is immediately overlain by sandstone. Where more impervious shales overlie the coal the concentration is commonly markedly lower. The more favourable seams appear to be the thinner and high ash beds. Shallow synclines or downwarps of relatively local extent in the coals also appear to have acted in many instances as loci for uranium accumulation. In the present investigation field measurements were carried out with these criteria in mind.

The lignites of southern Saskatchewan, particularly those in the Cypress Hills area, were the first coals checked because of their relative proximity to the Dakota deposits. In addition a series of relatively small basins in British Columbia and the Yukon Territory containing coal of Tertiary age, in many cases intimately associated with volcanics, were checked. These various areas are indicated on Figure 1. The data presented

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Original manuscript submitted 15 April, 1970
Final version approved for publication 15 June, 1970
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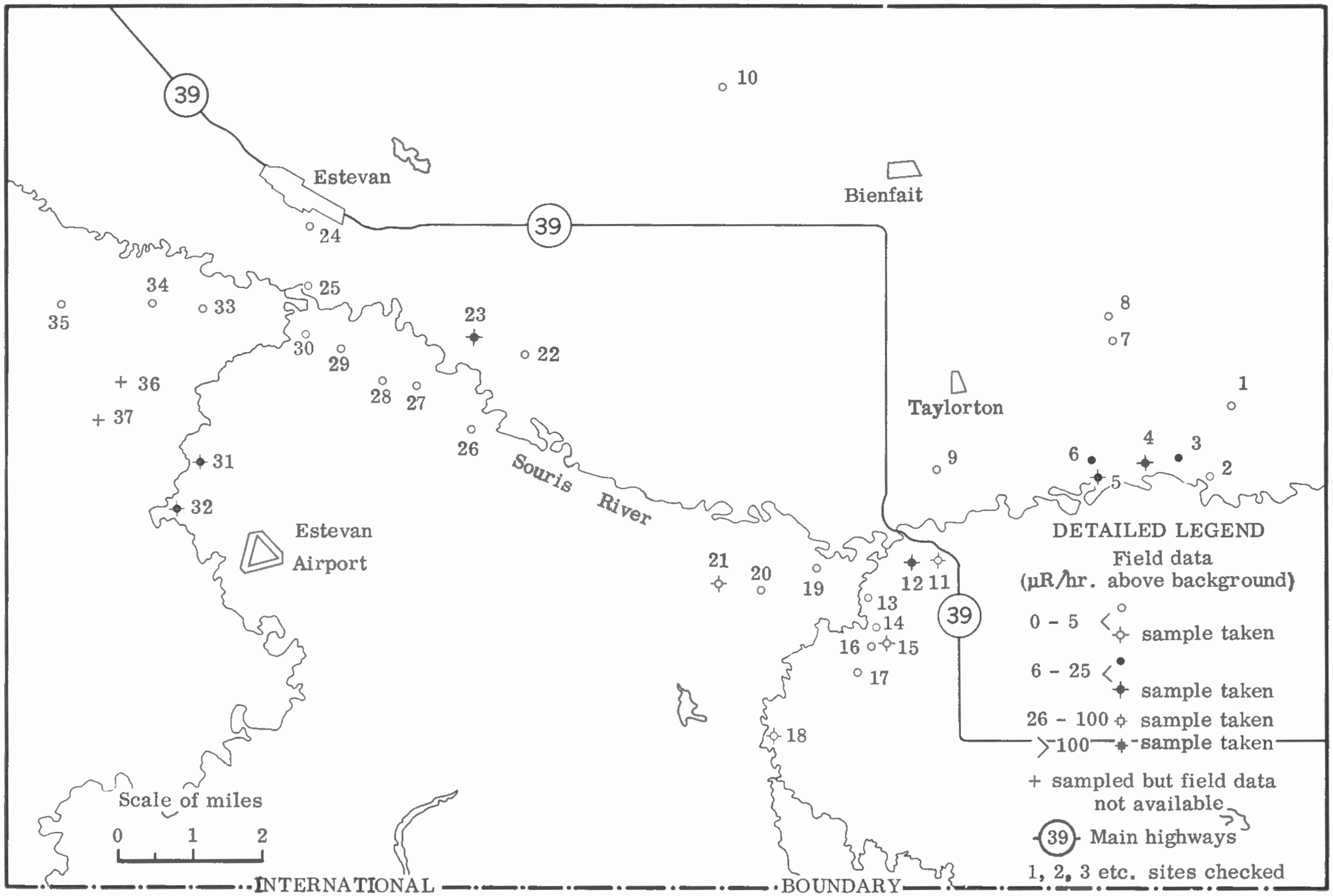

Figure 2. Estevan area, Saskatchewan.

in this report are not intended to be exhaustive for any one area. They are intended only to give an indication of the presence or absence of radioactivity in the various areas and thus possibly to aid in prospecting.

The publications of Dowling (1915) and MacKay (1947) have been important references in this investigation. Other important references of more local interest are listed with the individual areas.

The authors gratefully acknowledge assistance rendered in the collection of field data by P.A. Hacquebard, J.R. Donaldson, J. Fraser and M. Fortier. Other Geological Survey personnel whose assistance is appreciated are H.W. Little, T.J. Bottrill and G.R. Lachance. Much appreciated also is the assistance of W.J. Montgomery of the Mines Branch who arranged for the ashing of samples. Finally the co-operation of personnel from the Department of Indian Affairs and Northern Development is acknowledged especially in providing helicopter service in the Yukon Territory.

METHODS

The field work consisted of measuring the radioactivity of coal and carbonaceous beds by scintillometer. Two types of such counters were used. One was the Precision "Scintillator", Model 111, manufactured by Precision Radiation Instruments of Los Angeles, California; the other was the Ratemeter, Type NE 148A, manufactured by Rank Nucleonics and Controls, Hertfordshire, England. The data were recorded in microroentgens per hour. Outcrops were checked along road-cuts, buttes, cliffs and streams. Readings were also obtained in abandoned strip mines and in several instances in active mines. The number of coal seams and coaly layers checked at given stations varied from one to twenty. All were checked but particular attention was paid to the highest (stratigraphically) beds in a given section.

Figures 2 through 20 are maps of the areas investigated with the individual stations located and numbered. The scintillometer readings obtained at these stations are indicated on the maps by different symbols representing 0-5, 6-25, 26-100 and greater than 100 microroentgens per hour (uR/hr.) above background. The highest value obtained at a given station is the one symbolized on the map.

Samples for more accurate determination of uranium in the laboratory were collected at a number of sites. In the laboratory these samples were analyzed by two methods. In one method radioactivity was measured by the end-window Beta counter. The samples were crushed to minus ten mesh and 50 to 60 grams riffled out for the determination. Data in terms of counts per second were obtained on each sample. These were then used to calculate a U_3O_8 equivalent value in parts per million based on comparison with standards of known uranium content. The results of these analyses are given in Tables 1 through 8.

In the second laboratory method a number of the samples tested in the Beta counter as well as others not so tested were ashed at temperatures between 700-750°C and the residue submitted for fluorimetric determination of uranium content according to the method described by Grimaldi et al. (1954) and modified by Smith (1968). The results of these analyses are also recorded in Tables 1 through 8. A comparison of the results obtained by both the Beta counter and fluorimetric techniques on the same samples show fairly close agreement.

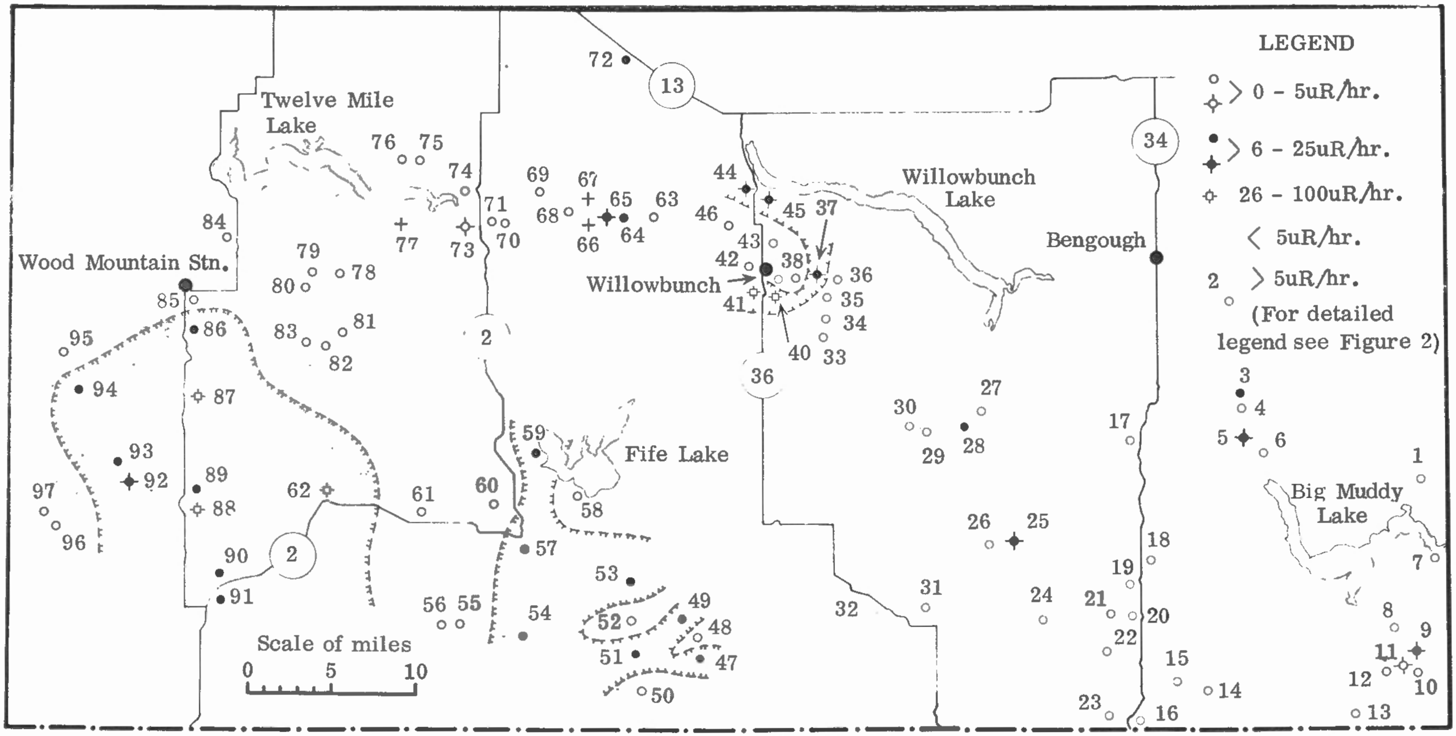

Figure 3. Willowbunch area, Saskatchewan.

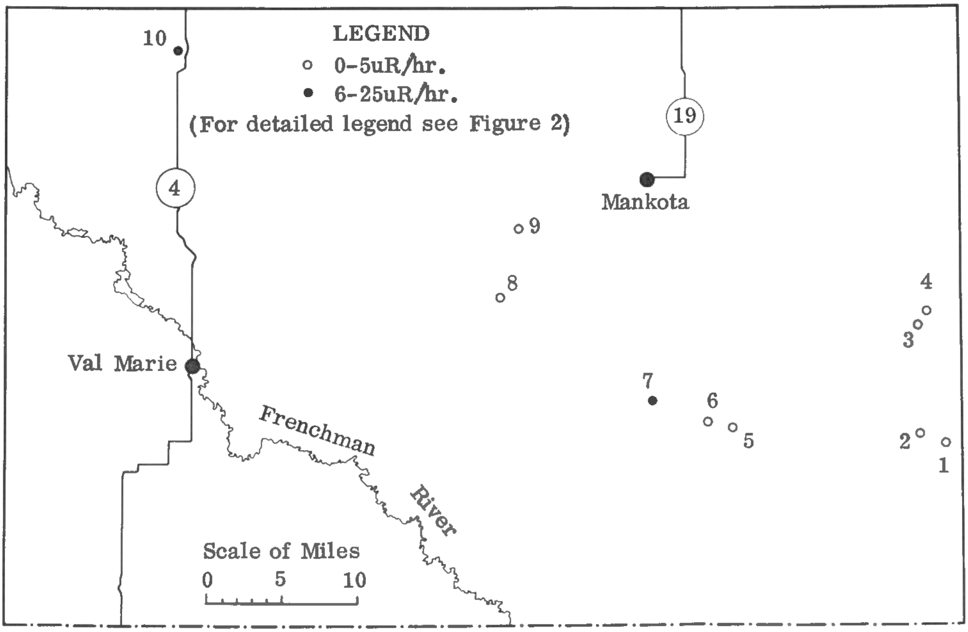

Figure 4. Mankota area, Saskatchewan

In addition a selected group of these samples were checked by X-ray fluorescence for molybdenum and vanadium. The resulting data are recorded in Table 9.

RESULTS

Saskatchewan and southeastern Alberta

Figures 2, 3, 4, and 5 are maps of the Estevan, Willowbunch, Mankota and Cypress Hills areas respectively showing the location of sites checked for radioactivity and the field data obtained at these sites. Tables 1 through 4 contain laboratory data on samples collected in Saskatchewan. The significant beds are lignites of early Tertiary age. These occur in the Ravenscrag Formation which is correlative with the Fort Union Formation in the Dakotas. In the Cypress Hills area the Ravenscrag is overlain by the Cypress Hills beds which have been correlated in part with the White River Group in the Dakotas. The latter contains considerable tuffaceous material and is considered to be the source of the uranium. In Saskatchewan volcanic ash has been observed interbedded with lignite at St. Victor and in association with the Cypress Hills beds near Duncairn.

In the Estevan and Mankota areas only a few sites gave field readings of more than 5 uR/hr. (see Figs. 2 and 4 and Table 1). In the Willowbunch sector better readings were obtained especially in the area south of Wood Mountain Station where three sites (62, 87 and 88) showed field readings in the range of 26-100 uR/hr. above background (see Fig. 3 and Table 2). Beta counter data on samples from this area showed U_3O_8 values

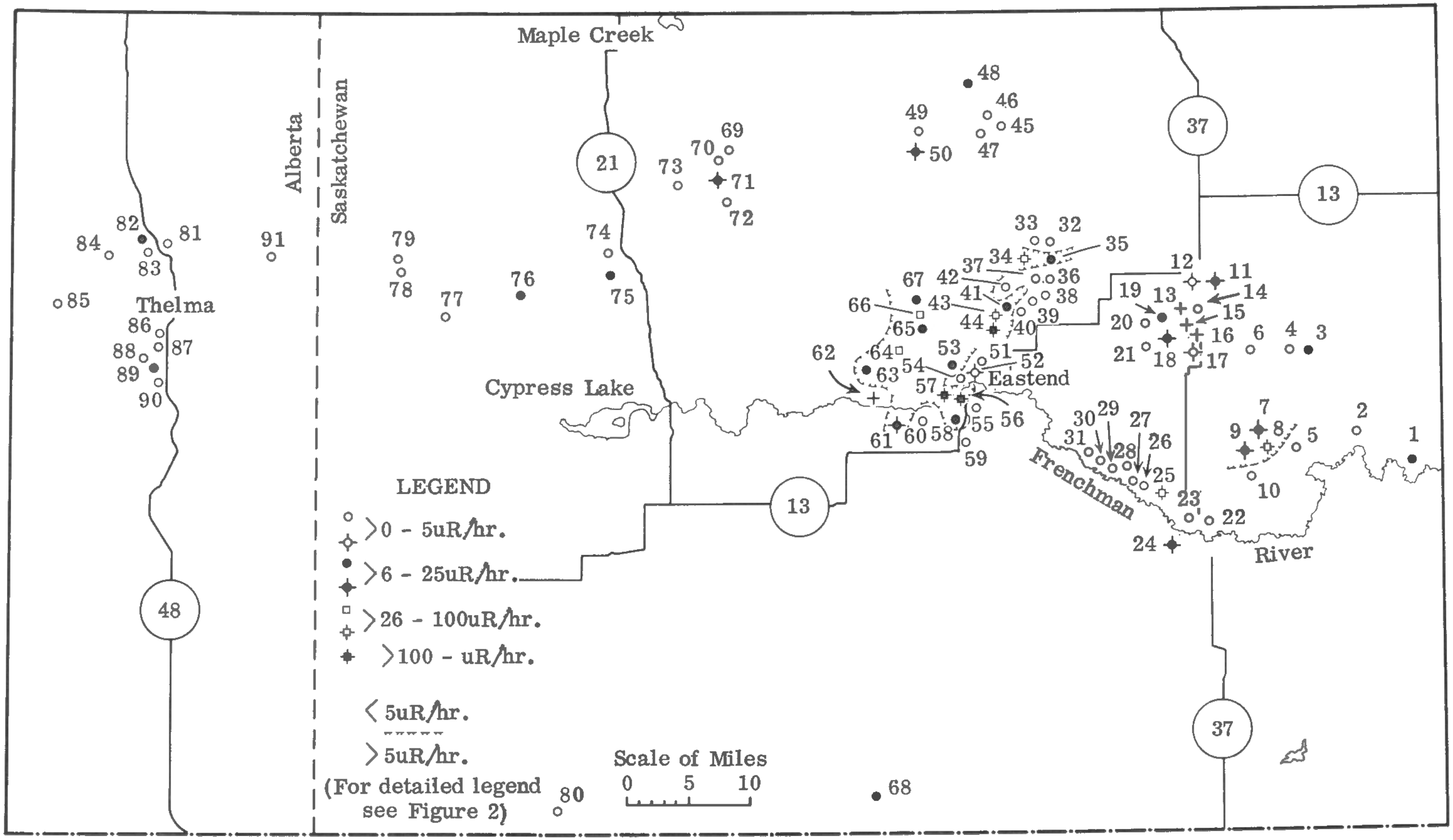

Figure 5. Cypress Hills area, Saskatchewan - Alberta.

in ppm equivalent of 284 at station 88 and 148 at station 92. A second area south of Fife Lake shows a cluster of stations with field readings somewhat higher than normal. A third area around the town of Willowbunch and south of Willowbunch Lake shows another cluster of stations with above normal field readings. The best laboratory reading on material from this last locale was recorded on sample S69-3 from station 40 which showed a value of 90 ppm U_3O_8 on the Beta counter.

Station 66 near St. Victor on the Willowbunch map (Fig. 3) is of interest because it is an exposure of two seams of lignite separated by a bed of volcanic ash. Samples CQ44 and CQ46 represent the two lignite beds. However these samples gave low laboratory readings as shown in Table 2. In the Cypress Hills area a sample of volcanic ash (S5) was collected near Duncairn. It too gave a relatively low U_3O_8 count in the laboratory (see Table 3).

Figure 5 shows the location of stations and field values obtained in the Cypress Hills area. Laboratory data are given in Tables 3 and 4. The best results obtained were found in this area. Nine stations gave field readings in excess of 25 uR/hr. above background. Of these, stations 34, 43, and 44 located in the vicinity of Anxiety Butte northeast of the town of Eastend, gave field values above background of 71, 93 and 131 uR/hr. respectively. Two other stations, 56 and 57, located in the bluffs on the south side of Frenchman River near Eastend gave respectively scintillometer readings of 381 and 609 uR/hr. above background. The latter was the best field reading obtained in this study. At stations 56 and 57 the best readings were obtained on the highest seam in the section and near the top within the seam. For example, at station 56 five seams are exposed in the bluff. All were checked and eight samples were collected for laboratory determinations (see Table 3). The lowest seam in the section (sample CQ78) showed 30 ppm, the third seam from the bottom represented by sample CQ79 analyzed 24 ppm while the uppermost seam sampled over a lateral distance of approximately 150 feet (samples CQ80 and CQ81) gave fluorimetric values of 370 and 650 ppm on the ash. Samples S9A and B also obtained from this seam close to station 56 analyzed 200 and 330 ppm respectively by the Beta counter. At station 57 only the upper seam was sampled. The results for these samples S10 and S10A are given in Table 3. S10 yielded a fluorimetric value of 4,400 ppm on the ash and a calculated value of 825 ppm on the unashed coal. This was the best value obtained on a sample.

In order to show variation from top to bottom within the seam, two series of samples were collected near Station 57. These were collected in six-inch increments. They are identified as BD 22A and BD 22B and as Table 4 shows, the highest values occur in the upper two intervals of both sets of samples.

Extensive surveys have been carried out in selected parts of the above area, particularly Saskatchewan, by companies such as Atlantic Richfield, Dome and Scoteire. Important references: Fraser et al. (1935); Furnival (1946).

Coalspur area, Alberta

The Coalspur area (see Fig. 6) is part of the much larger Outer Foothills belt as described by MacKay in 1947. It contains coals of both

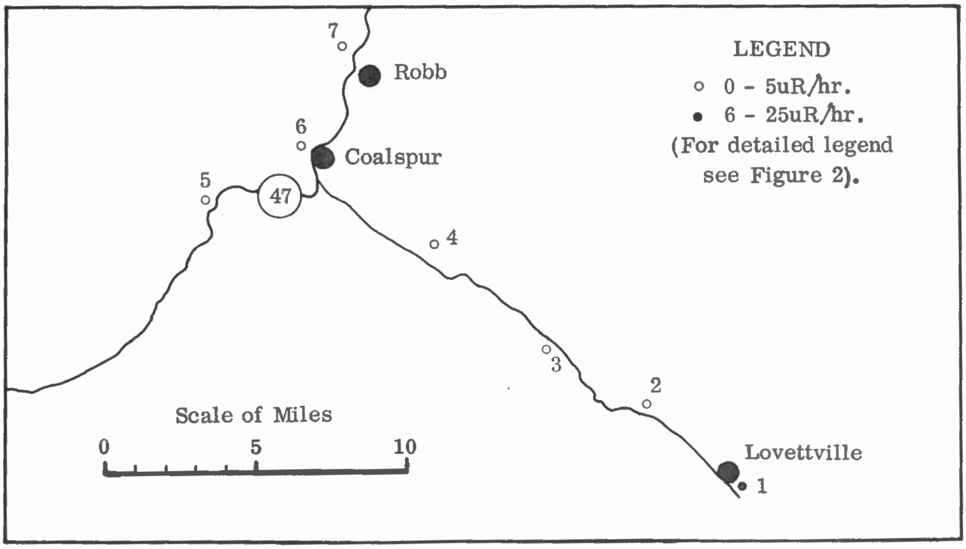

Figure 6. Coalspur area, Alberta.

Upper Cretaceous and Tertiary age. The latter occur in the Coalspur beds which consist of sandstone, shale, conglomerate, volcanic ash and coal. These Tertiary coals have been upgraded in rank to bituminous. In the present study outcrops and abandoned mine workings were checked for radioactivity. All appear to be on Tertiary occurrences. The highest result obtained was at station 1 south of Lovettville where thin seams exposed along the highway gave a value of 10 uR/hr. above background.

In addition three other sites south and east of the area portrayed on Figure 6 were checked. These were near Nordegg and along the Clearwater River. Low values were recorded. Important references: Rutherford (1925); Erdman (1950).

White Lake area, British Columbia

The White Lake area (see Fig. 7, Table 5) is a small isolated basin containing Tertiary coals located six miles west of Okanagan Falls. The coals have been upgraded in rank to bituminous. They occur in the White Lake Formation thought to be mainly of Eocene age which also contains intermixed volcanic material. The formation is overlain by younger volcanics and there are few outcrops. The best value was obtained at station 10 where a breccia in the overlying volcanics was checked and gave a reading of 20 uR/hr. above background. Important references: Bostock (1941); Church (1967).

Chu-Chua area, British Columbia

A small area around Newhykulston Creek in the North Thompson Valley approximately 50 miles north of Kamloops contains Tertiary coal of Middle Eocene age (see Fig. 8 and Table 5). The coal-bearing rocks belong to the Chu-Chua Formation and are overlain unconformably by andesitic lavas and breccias of the Skull Hill Formation. The coals are subbituminous to

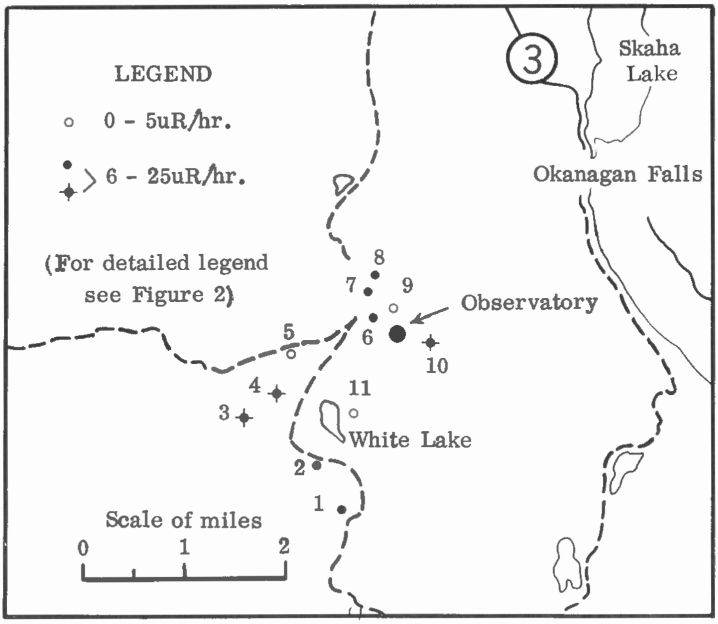

Figure 7. White Lake area, British Columbia.

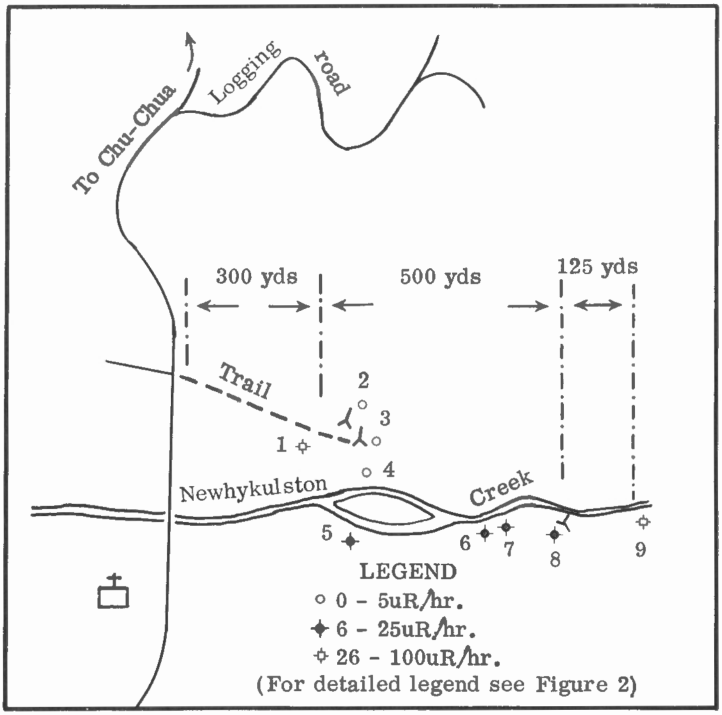

Figure 8. Chu-Chua area, British Columbia.

bituminous in rank. Field readings were relatively low, most occurring between 11 and 50 uR/hr. Important references: Uglow (1922); Campbell and Tipper (1969).

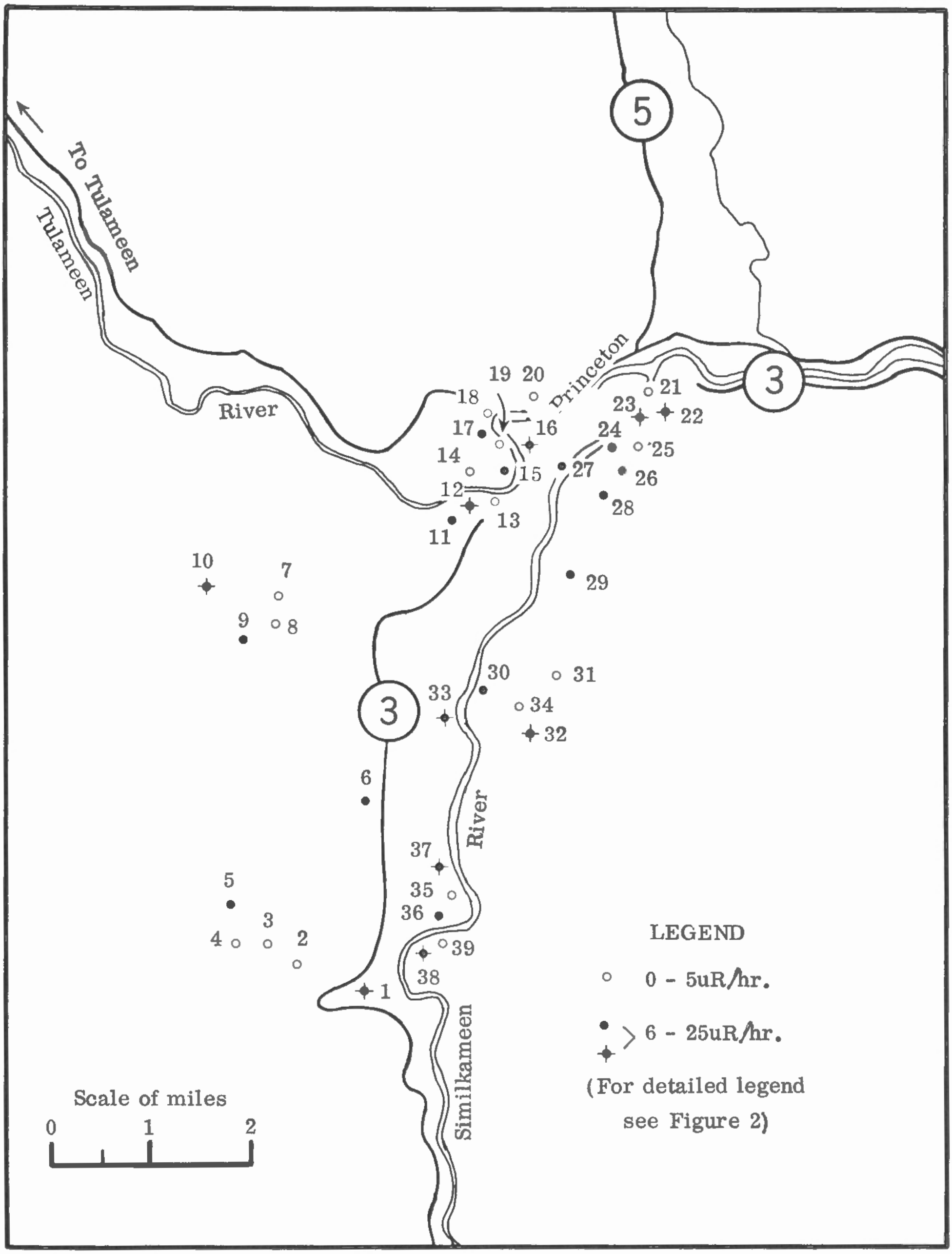

Figure 9. Princeton area, British Columbia.

Princeton area, British Columbia

The coal seams of the Princeton area (see Fig. 9 and Table 5) range in rank from lignite to subbituminous 'A'. They are contained within the Allenby Formation which may be Middle Eocene in age. Bentonites occur

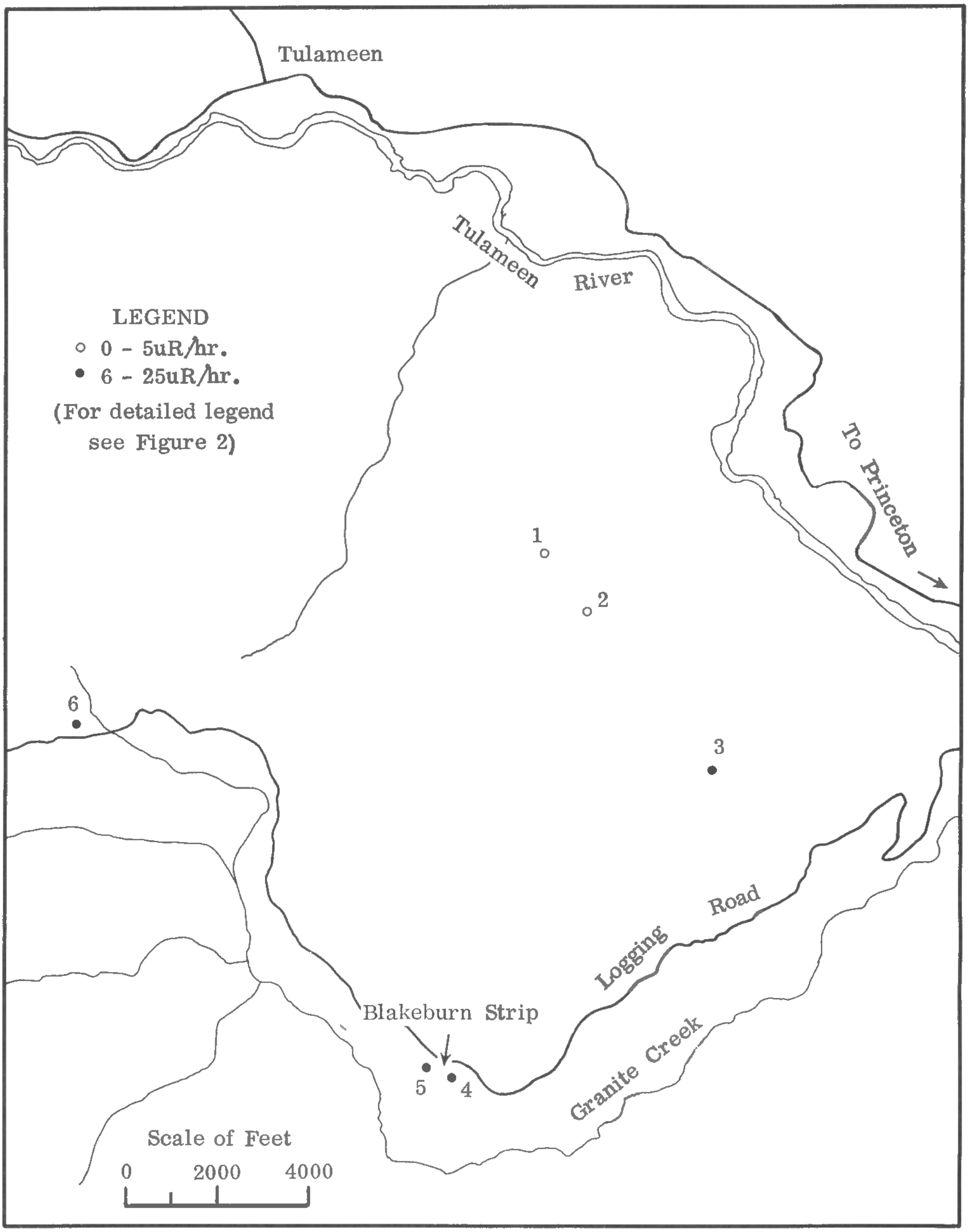

Figure 10. Tulameen area, British Columbia.

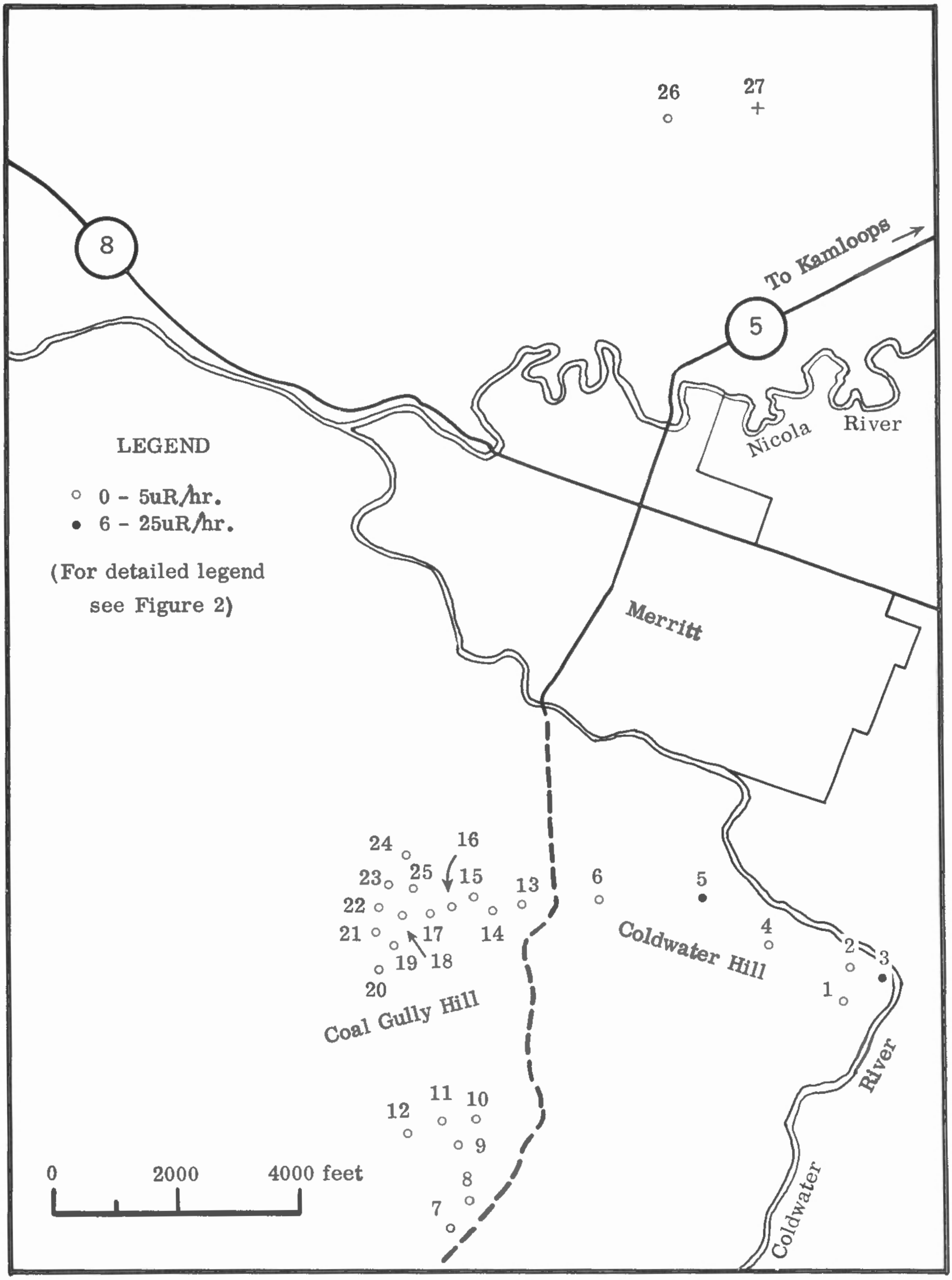

Figure 11. Merritt area, British Columbia.

within the formation. Basalts and breccias of possible Miocene age unconformably overlie the Allenby beds. The total area of the field is about 45 square miles. All the readings were low with the highest being 25 uR/hr. at station 10. Twenty-two other stations registered readings of more than 5 uR/hr. above background. Important references: Shaw (1952); Mathews (1964).

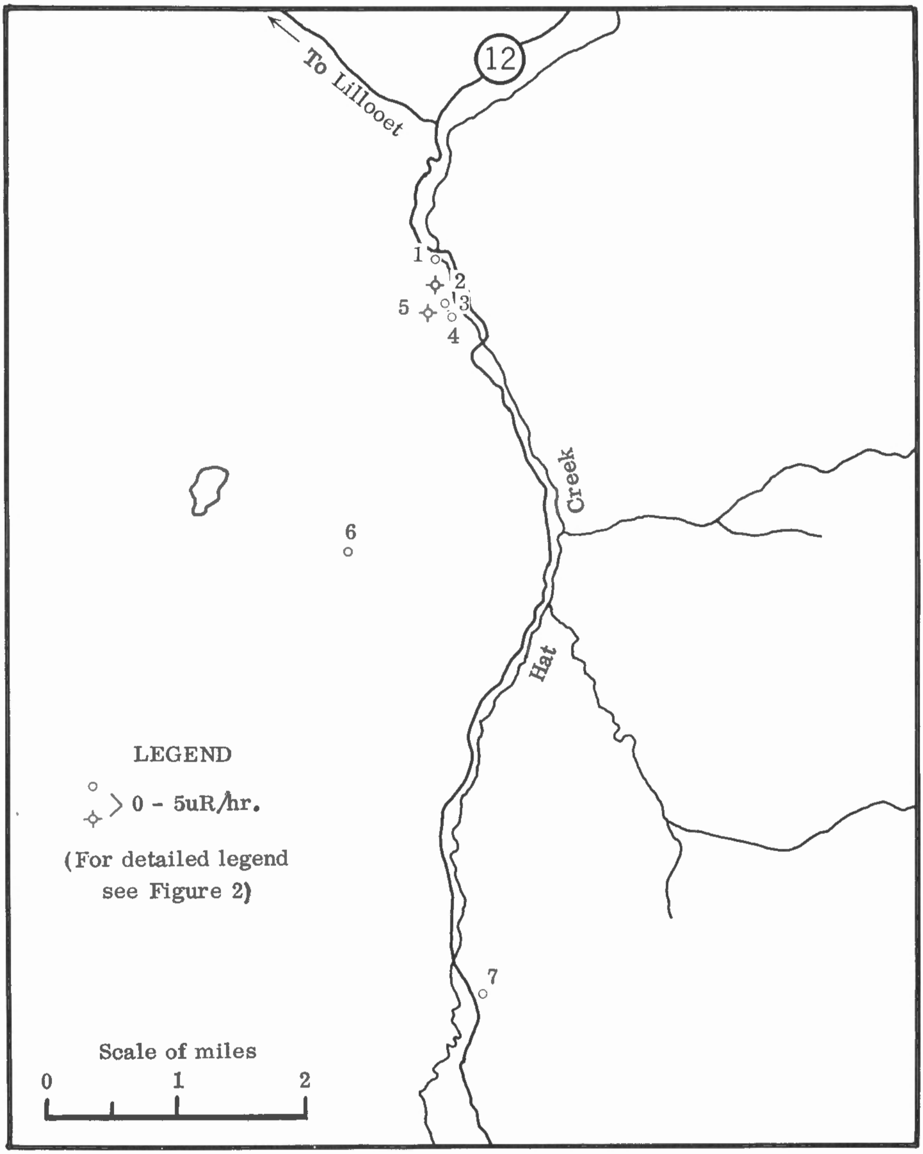

Figure 12. Hat Creek area, British Columbia.

Tulameen area, British Columbia

The coal-bearing rocks underlie an area of about six square miles (see Fig. 10). They are Early Tertiary in age and consist of sandstone, siltstone, shale, coal and bentonite. Volcanic rocks overlie them with angular unconformity. Radioactivity was measured in the field but no samples were analyzed in the laboratory. Important reference: Shaw (1952).

Merritt area, British Columbia

The coal in the Merritt Basin (see Fig. 11 and Table 6) occurs in the Coldwater beds of probable Oligocene or lower Miocene age. Younger volcanics occur in the Merritt area and appear to be unconformable with the underlying Coldwater beds. The Merritt coals are bituminous in rank. In addition to the sites shown on the map two other sites were checked on coal and coaly shale along Quilchena Creek south of Nicola Lake. Also a thin coal seam was checked at the site of the old Normandale mine which lies beyond the east side of the map in Figure 11. All three stations gave values below 10 uR/hr. consistent with the low values obtained elsewhere in the Merritt field. Important reference: Cockfield (1948).

Hat Creek area, British Columbia

A small basin of Tertiary sedimentary rocks contains coal of lignitic rank along Hat Creek (see Fig. 12 and Table 6). The deposit is unusually thick being composed of nearly 100 feet of interbedded clay and lignite. Within this unit several thick beds of relatively pure lignite occur. The main exposure is along Hat Creek a mile south of the eastern entrance to Marble Canyon. The beds are overlain by Tertiary volcanics. All the field readings obtained were below 10 uR/hr. Important reference: Duffell and McTaggart (1952).

Alexandria-Quesnel area, British Columbia

The lignites in this area (see Fig. 13 and Table 6) occur in the Fraser River Formation, an assemblage of gravels, sands, clays, diatomaceous earth and lignite of Eocene and (?) later age. They outcrop along the Fraser River from the vicinity of Alexandria to above Quesnel and are overlain by basaltic volcanics which are considered to be Miocene in age. All the field readings were below 10 uR/hr. Important references: Reinecke (1920); Tipper (1959).

Bowron River area, British Columbia

The Bowron River (see Fig. 14 and Table 6) coals occur in Tertiary coal-bearing sediments underlying Bowron River valley. The coal measures consist of sandstone and shale with several beds of conglomerate and the surrounding rocks are largely volcanic. They outcrop along the

Bowron River from Bear Canyon southward for about seven miles. The presence of thucolite, a carbonaceous mineral containing uranium oxide was identified (1960) in a sample of shale. Only three exposures were checked; two gave readings above 10 uR/hr. Important references: B.C. Dept. of Mines Ann. Rept. (1949); James (1960).

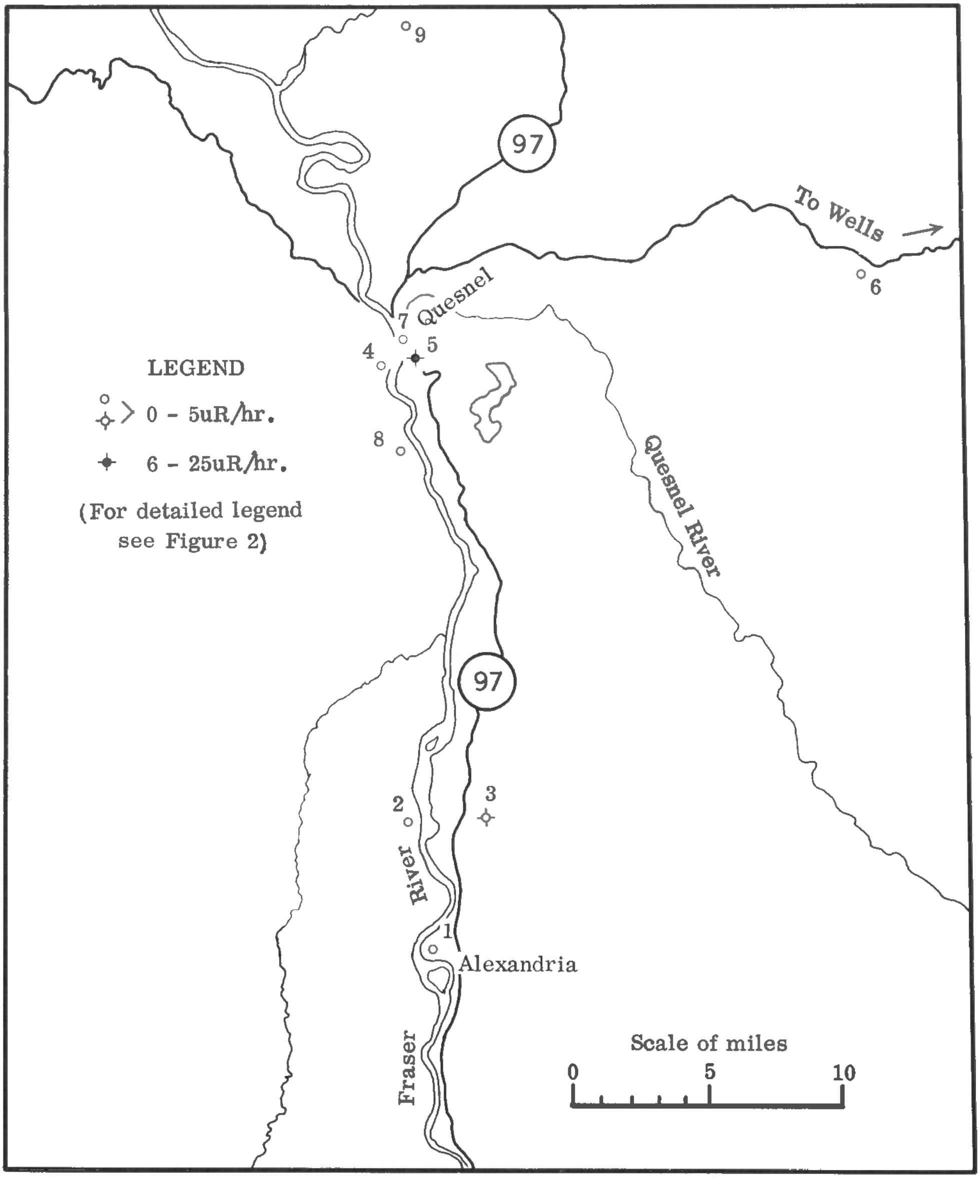

Figure 13. Alexandria - Quesnel area, British Columbia.

Francois Lake-Cheslatta Lake area, British Columbia

Large areas in central British Columbia including the vicinities of Burns, Francois and Cheslatta Lakes and along Nechako River are underlain

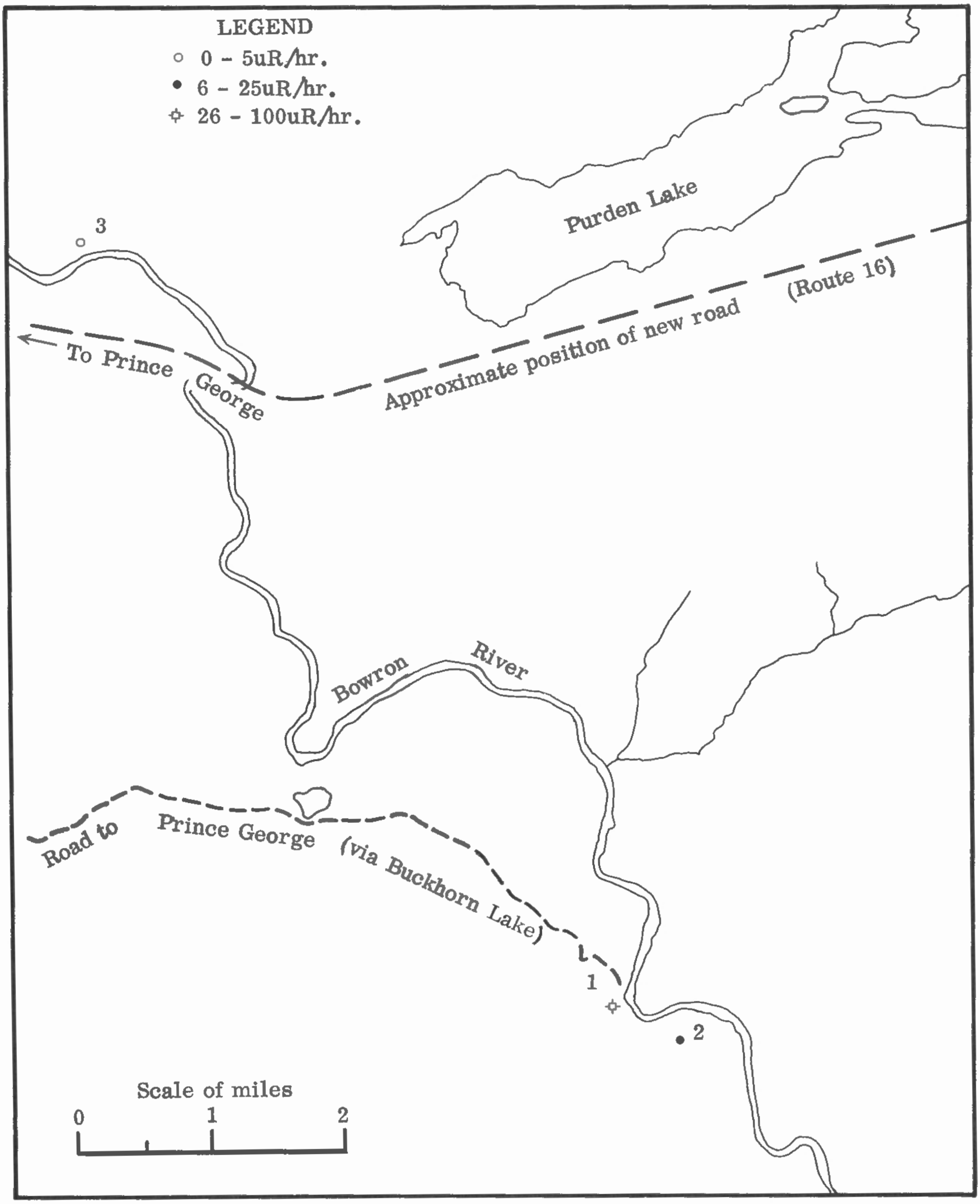

Figure 14. Bowron River area, British Columbia.

by Tertiary rocks (see Fig. 15 and Table 7). These beds contain lenses and thin seams of lignite although exposures are rare and most of the lignite seen is in the form of float along rivers and creeks. The best readings obtained in this area were found on exposures at stations 2 and 10. At the latter site the scintillometer registered 25 uR/hr. above background and a sample from this site yielded a value of 72 ppm U_3O_8 in the laboratory. Important reference: Tipper (1963).

Graham Island area, British Columbia

Coal of Middle Jurassic and Tertiary age occurs on Graham Island (see Fig. 16 and Table 8) in the Queen Charlotte Group. The Jurassic coal is found in several small basins in the southern part of the island in the Yakoun Formation (Haida?) and has been upgraded in rank to low volatile bituminous and even to anthracite apparently by igneous intrusion. The Tertiary beds of Late Miocene or Early Pliocene age contain lignites and the best exposures in the Skonun Formation are on the northern coast of the

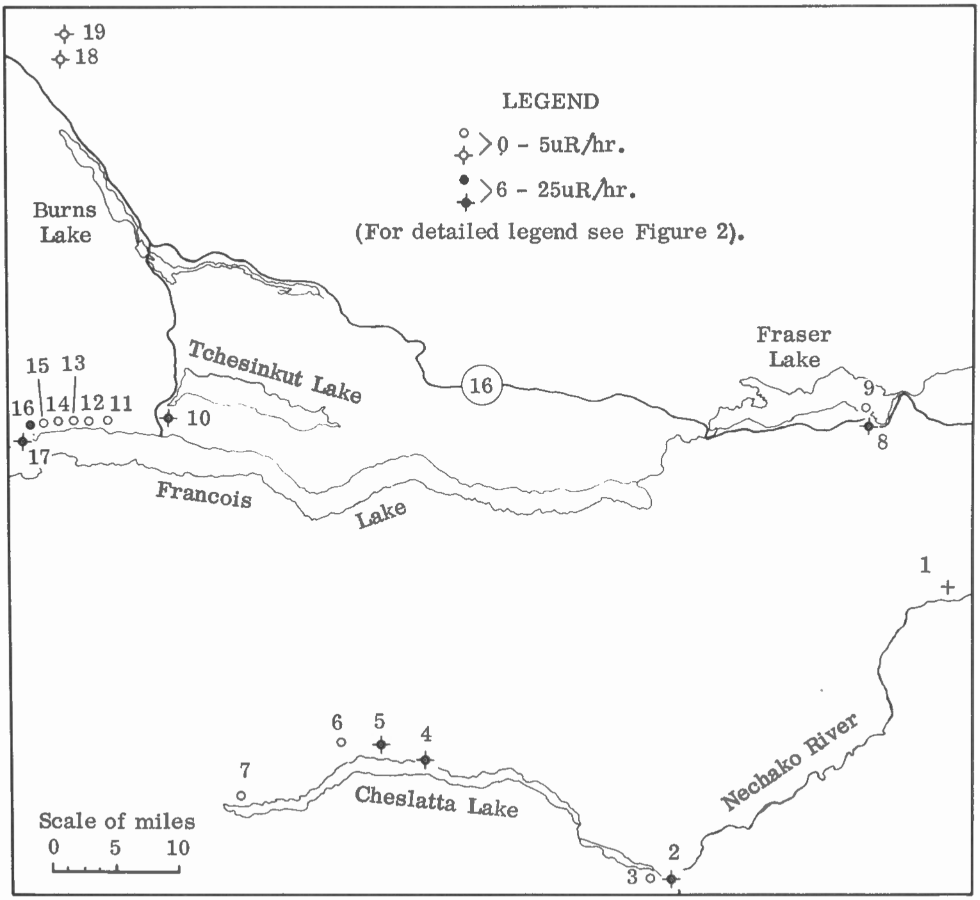

Figure 15. Francois Lake - Cheslatta Lake area, British Columbia.

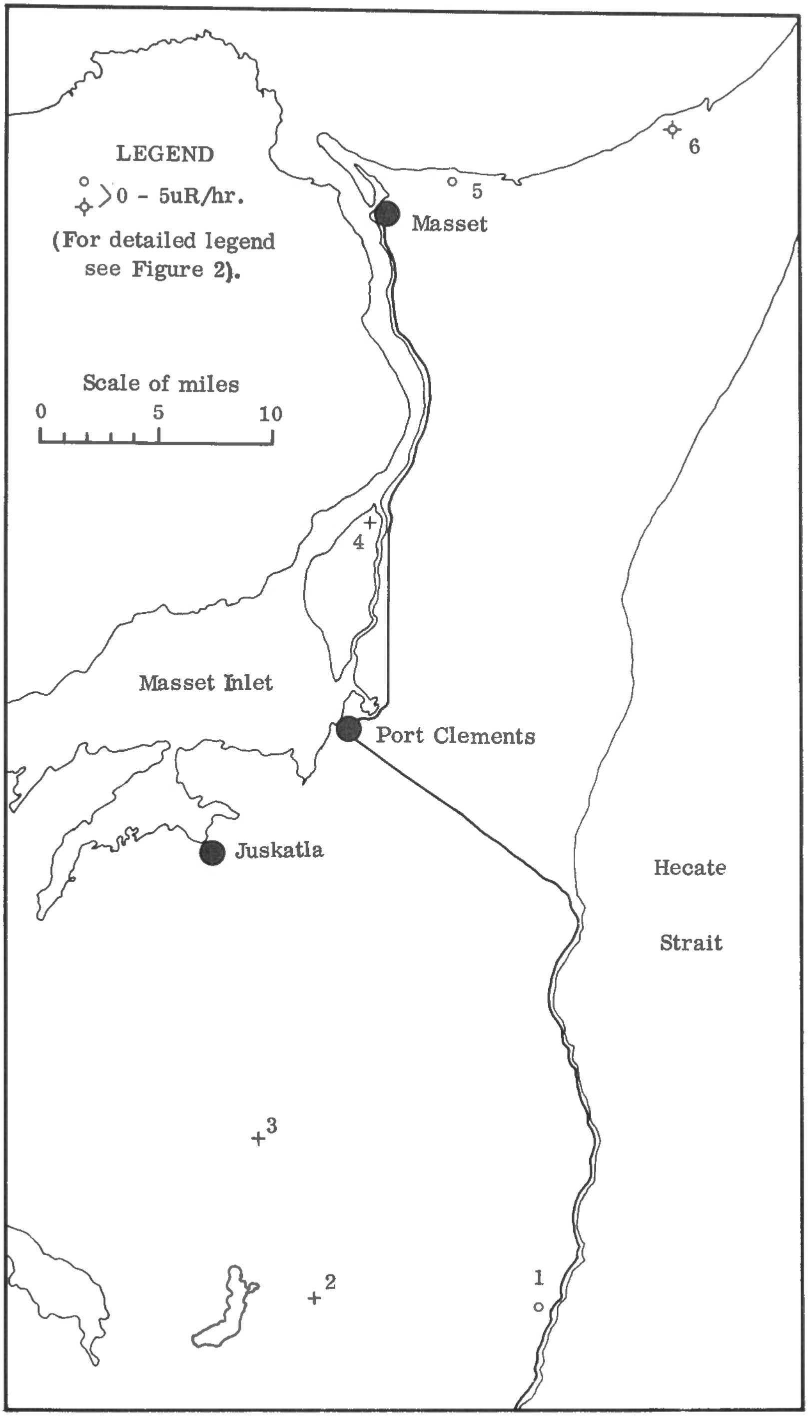

Figure 16. Graham Island area, British Columbia.

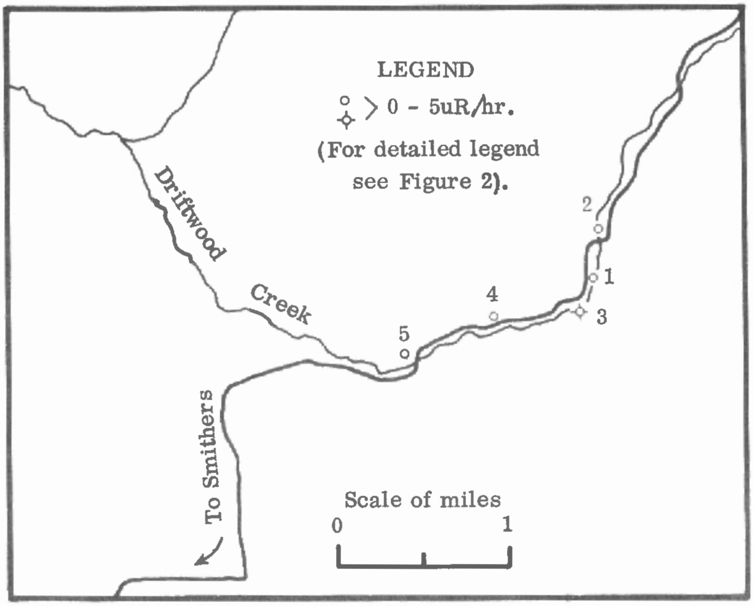

Figure 17. Driftwood Creek area, British Columbia.

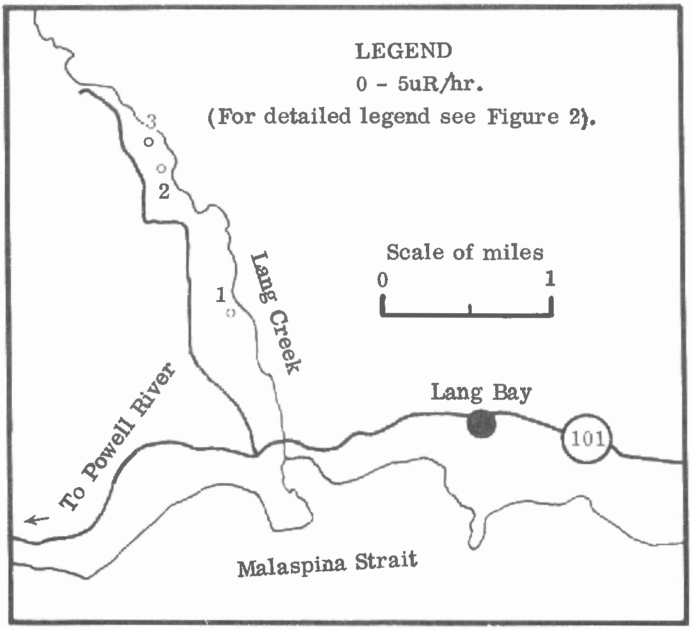

Figure 18. Lang Creek area, British Columbia.

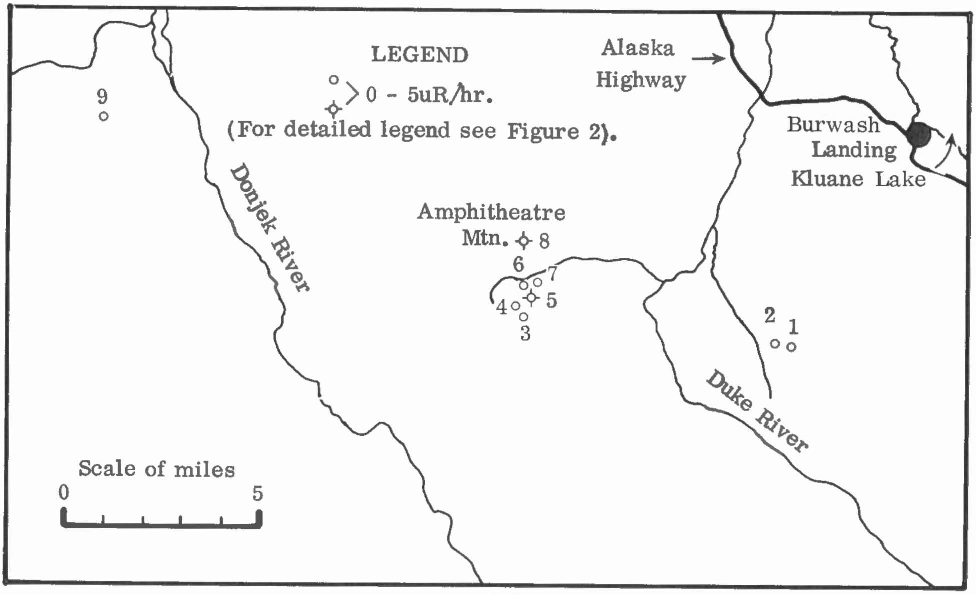

Figure 19. Burwash Landing area, Yukon Territory.

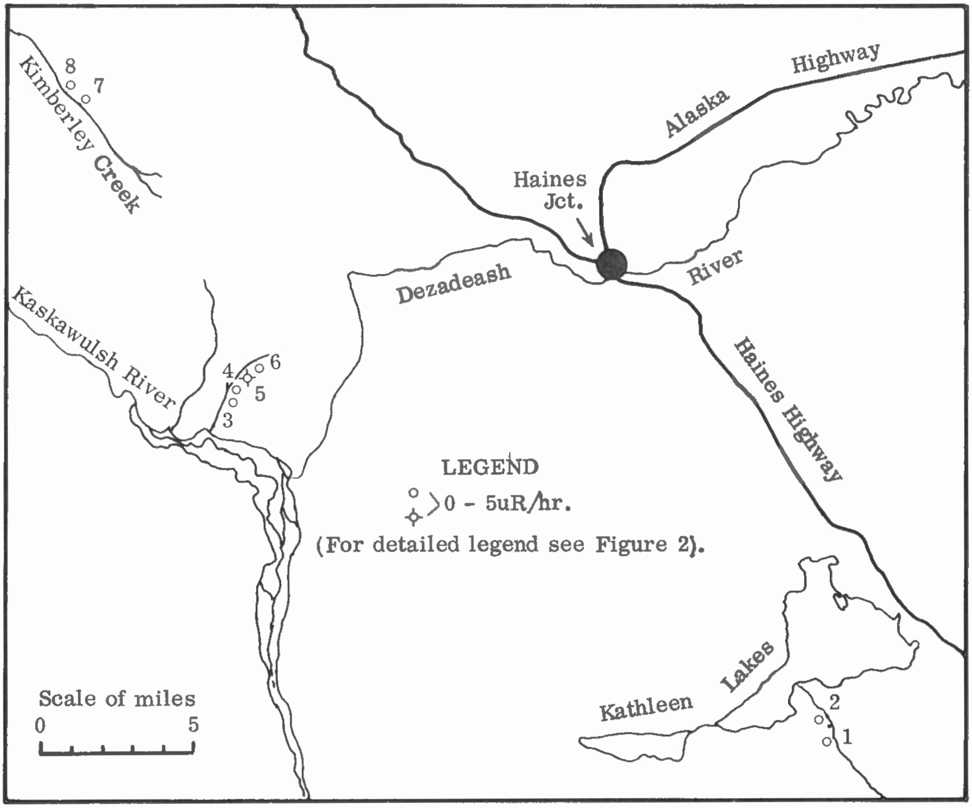

Figure 20. Haines Junction area, Yukon Territory.

island at Skonun Point. The field readings obtained on Graham Island were all low and so were the laboratory results with the exception of 60 ppm U_3O_8 value obtained on a sample of float lignite collected on Kumdis Island in Masset Inlet. Important references: MacKenzie (1916); Sutherland Brown (1968).

Driftwood Creek area, British Columbia

A patch of rocks of Eocene or younger age occurs along Driftwood Creek east of Smithers (see Fig. 17 and Table 8). The rocks consist of conglomerate, sandstone and shale with some thin beds of impure lignite. Readings made along Driftwood Creek were all below 5 uR/hr. above background. In the general area of Smithers readings were also made on a seam of bituminous coal being actively mined near Telkwa and on exposures of anthracitic coal near Kathlyn Lake. Both of these occurrences are in Cretaceous rocks. The readings were low. Important reference: Armstrong (1944).

Lang Creek area, British Columbia (see Fig. 18)

North of Lang Bay sedimentary rocks of Eocene age are exposed along Lang Creek. These consist of poorly consolidated sandstones, shales and conglomerates and they contain lenses, stringers and irregular masses of lignite. In the past 15 years there has been sporadic exploration of these lignite masses for their germanium content. Some high values were prospected in late 1957 and early 1958. At the three sites checked for uranium in the present study the readings were all low. Important references: B.C. Dept. of Mines Ann. Rept. (1960); Buckland (1959).

Burwash Landing area, Yukon Territory (see Fig. 19 and Table 8)

The Amphitheatre Formation of Paleocene to Eocene age occurs as a number of patches west of Kluane Lake and contains beds of lignite. Good exposures are found on Amphitheatre Mountain, south of Cement Creek and on a tributary of Granite Creek. These beds are overlain by lavas and tuffs. All the field readings obtained were in the 0-5 uR/hr. range and samples analyzed in the laboratory from a fairly complete section with ten thin seams or coaly layers on Amphitheatre Mountain showed uniformly low Beta counter readings. Important reference: Muller (1967).

Haines Junction area, Yukon Territory (see Fig. 20 and Table 8)

Thin coal seams have been found in the Cretaceous Dezadeash Group in the Haines Junction area. This group consists of conglomerate, shale, sandstone, tuff and chert. Exposures are found on a creek east of Sugden Creek and north of the Kaskawalsh River, on Kimberley Creek and near the Kathleen Lakes. Coal was found at the first two localities; on Goat Creek south of Kathleen Lakes only dark grey and black shales were found and checked. The field readings and laboratory results were low. Important reference: Kindle (1953).

MOLYBDENUM AND VANADIUM DETERMINATIONS

In at least one of the operations in North Dakota where lignite has been mined for its uranium content molybdenum was also being recovered. It was decided therefore to check the molybdenum content of some of the western Canadian samples. This was done by the X-ray fluorescence technique on the ash residue of these samples.

The samples chosen included those in which the highest uranium contents had been found. These were from the Cypress Hills area of Saskatchewan. Also submitted from Saskatchewan were two samples from the Estevan area and one from Willowbunch. In addition one sample was submitted from each of the following areas in British Columbia; Princeton, Merritt, Hat Creek, Chu-Chua, Alexandria-Quesnel and the Bowron River. Vanadium determinations on these samples were also carried out. The resulting data are given in Table 9.

The molybdenum values obtained were all quite low with the exception of the sample (BR-1D) from the Bowron River which gave a count of 580 ppm on the ash. Vanadium values were higher, especially for the British Columbia samples, with the above mentioned Bowron River sample yielding the highest result of 1,050 ppm on the ash or 268 ppm on the whole coal. A sample from the Estevan area of Saskatchewan (CQ52) also gave one of the higher vanadium values of 800 ppm in the ash. The Bowron River sample is from a seam with 26 per cent ash exposed along the river. Nearby active explorations has been going on for several years on the fuel potential of another seam in the section. The Estevan sample came from a thin seam exposed on a bluff north of the Souris River. Another sample (S33) of coaly shale collected on a small mine dump north of Merritt, British Columbia gave a calculated value of 270 ppm vanadium on the unashed material.

CONCLUSIONS

Of the Tertiary coal areas examined in western Canada, Cypress Hills, particularly in the vicinity of Eastend, Saskatchewan, holds the best promise for commercially attractive concentrations of uranium. The best sample from this area (sample S10) showed 825 ppm or about 0.08 per cent U_3O_8 on the whole coal. This approaches present ore grade material in Canada. During the early 1960s in the United States material with 0.1 per cent or more uranium was considered of economic interest and the uraniferous lignite operations in the Dakotas probably used this as a cut-off value. Elsewhere in Saskatchewan the several localities with higher than normal readings in the Willowbunch area may be worthy of further exploration. Most of the stations checked in the Estevan area showed low concentrations.

In British Columbia and Yukon Territory none of the sites checked approached the values obtained in the Cypress Hills. Most of the areas such as Merritt, Hat Creek, Graham Island and the Yukon localities appear to be particularly barren. The readings obtained at Princeton, Chu-Chua, François Lake and the Bowron River were somewhat better, especially at Chu-Chua and the Bowron River. The readings at White Lake were mostly low.

Although the molybdenum and vanadium contents of the few samples analyzed are generally low there are several samples with values which, if not ore-grade, might at least provide a stimulus for prospecting in the areas where they were collected. One such sample is CQ52 from Estevan, Saskatchewan, another is sample S33 from the Merritt area of British Columbia. The most interesting sample is BR-1D from the Bowron River area of British Columbia. This sample shows 268 ppm vanadium and 147 ppm molybdenum on the whole coal basis. It also has above normal values for uranium.

The molybdenum and vanadium contents of the samples analyzed are below ore-grade. According to Rose (1967) vanadium deposits are mineable down to grades of slightly less than 1 per cent. In by-product recovery however, this threshold may be lowered to less than 0.1 per cent which is less than 1,000 ppm. Vokes (1963) stated that for a deposit to be mined for molybdenum alone there should be an ore-grade of about 0.5 per cent MoS_2, that is about 0.3 per cent or 3,000 ppm molybdenum. Also the reserves should be at least 1 million tons. One large-scale open-pit operation in British Columbia is mining a deposit with an average content of 0.2 per cent MoS_2. Of course, as with vanadium, this threshold would be lowered considerably if the molybdenum were recovered as a by-product.

Such by-product recovery operations might be feasible if coal from any of the areas with higher than normal concentrations of uranium, molybdenum or vanadium was to be used in large quantity as a fuel, as for example in a thermal power station.

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Table 1. Laboratory Data on Samples Collected in Estevan Area (see Fig. 2)

Stn.	Sample	Location		Ash Content (pct.)	Fluorimetric Data		Beta Counter Data		Remarks
		NTS Map	Quarter, Sec., Tp., Rge.		U_3O_8 ppm on ash	U_3O_8 ppm on coal	Counts per sec.	U_3O_8 ppm equivalent	
4	CQ 51	62E/2E	NE, 34, 1, 6	65.56	15	10	0.39	35	Two-inch layer in river bank
5	CQ 52	62E/2E	NE, 33, 1, 6	32.18	63	20	0.33	30	Third layer from bottom in section with 8 seamlets
11	CQ 55	62E/2W	SE, 30, 1, 6	32.60	49	16	0.36	32	Rider seam in old strip pit
12	CQ 56	62E/2W	SW, 30, 1, 6	44.68	32	14	0.44	40	Same seam as at station 11
15	CQ 53	62E/2W	SE, 24, 1, 7	41.59	8	3	0.11	10	Upper bed of two on bluff
18	CQ 54	62E/2W	SW, 14, 1, 7	26.54	21	6	0.14	13	Lower of two beds near bridge
21	CQ 84	62E/2W	SE, 27, 1, 7	38.46	13	5	NA	NA	Thin seam in old strip pit
23	CQ 58	62E/2W	SW, 7, 2, 7	92.00	<1	<1	NA	NA	Ash pile near power plant
31	CQ 60	62E/3E	NE, 33, 1, 8	63.90	<1	<1	NA	NA	Thin coaly bed near lake
32	CQ 59	62E/3E	SW, 33, 1, 8	62.81	<1	<1	NA	NA	Same as station 31
36	CQ 48A	62E/3E	SE, 8, 2, 8	9.47	6	<1	NA	NA	Samples CQ 47 (A and B) and CQ 48 (A and B) were provided by the Sask. Pwr. Corp. from a strip mine. They represent the top few inches of a 10-foot thick seam. CQ 47 (A and B) had a clay overburden while that of CQ 48 (A and B) was sand.
36	CQ 48B	62E/3E	SE, 8, 2, 8	9.64	6	<1	NA	NA	
37	CQ 47A	62E/3E	SW, 5, 2, 8	8.40	15	1	NA	NA	
37	CQ 47B	62E/3E	SW, 5, 2, 8	8.82	8	<1	NA	NA	

NA = Not analyzed

Table 2. Laboratory Data on Samples Collected in Willowbunch Area (see Fig. 3)

Stn.	Sample	Location		Ash Content (pct.)	Fluorimetric Data		Beta Counter Data		Remarks
		NTS Map	Quarter, Sec., Tp., Rge.		U_3O_8 ppm on ash	U_3O_8 ppm on coal	Counts per sec.	U_3O_8 ppm equivalent	
5	CQ 70	72H/3E	SW, 35, 3, 23	83.77	12	10	NA	NA	Lower of two shaly beds
9	CQ 61	72H/2W	NE, 19, 1, 21	81.84	1	1	NA	NA	Thin bed of lignite and clay
11	CQ 62	72H/2W	NW, 19, 1, 21	45.09	15	7	NA	NA	Top 10 ins. of lignite bed
25	69S 4	72H/3W	NE, 30, 2, 25	NA	NA	NA	0.61	57	Top ft. of seam at old adit
37	CQ 63	72H/5E	SW, 15, 5, 27	68.82	13	9	NA	NA	Four coaly layers in section, lowest
37	CQ 64	72H/5E	SW, 15, 5, 27	68.05	13	9	NA	NA	(CQ 63), second from top (CQ 64),
37	CQ 65	72H/5E	SW, 15, 5, 27	76.62	31	24	NA	NA	uppermost (CQ 65)
40	69S 3	72H/5E	NW, 7, 5, 27	NA	NA	NA	0.99	90	Lower seam of two sampled
41	69S 3A1	72H/5E	NE, 12, 5, 28	NA	NA	NA	0.33	31	Bed of lignite and clay; 69S 3A1 (clay),
41	69S 3A2	72H/5E	NE, 12, 5, 28	NA	NA	NA	0.59	54	69S 3A2 (lignite)
44	CQ 66	72H/5E	SW, 12, 6, 28	79.37	33	26	NA	NA	6 seamlets in ravine; second from bottom
44	CQ 67	72H/5E	SW, 12, 6, 28	43.12	11	5	NA	NA	(CQ 66), third from bottom (CQ 67), fourth
44	CQ 68	72H/5E	SW, 12, 6, 28	54.13	13	7	NA	NA	(CQ 68)
45	CQ 69	72H/5E	NW, 6, 6, 27	56.21	18	10	NA	NA	Third from top in sequence of 7 beds
62	69S 5A	72G/1E	SW, 10, 3, 2	NA	NA	NA	0.54	51	Clay and lignite; 69S 5B has more lignite
62	69S 5B	72G/1E	SW, 10, 3, 2	NA	NA	NA	0.59	56	
65	CQ 71	72H/5W	SW, 3, 6, 29	64.76	15	10	NA	NA	Second from top of 4 beds
66	CQ 44	72H/5W	NE, 33, 5, 29	26.91	14	4	NA	NA	CQ 44 from top ft. of 4-foot bed
66	CQ 46	72H/5W	NE, 33, 5, 29	29.29	11	3	NA	NA	CQ 46 from next lowest bed
67	CQ 41	72H/5W	NW, 4, 6, 29	24.67	29	7	NA	NA	Three thin coaly beds in pit, CQ 41 is
67	CQ 42	72H/5W	NW, 4, 6, 29	33.36	30	10	NA	NA	highest bed, CQ 42 middle, CQ 43
67	CQ 43	72H/5W	NW, 4, 6, 29	66.35	13	9	NA	NA	lowest
73	CQ 72	72G/8E	NW, 36, 5, 1	56.23	11	6	NA	NA	Second from top in sequence of 7 beds
77	CQ 39	72G/8E	SW, 32, 5, 1	79.65	10	8	NA	NA	2 thin layers of coaly shale; CQ 39 (upper),
77	CQ 40	72G/8E	SW, 32, 5, 1	66.14	9	6	NA	NA	CQ 40 (lower)
87	69S 8	72G/8W	SW, 8, 4, 3	NA	NA	NA	0.46	43	Shaly lignite, 1 1/2 ft. thick
88	69S 6	72G/1W	NW, 5, 3, 3	NA	NA	NA	3.02	284	10-inch bed of lignite and clay
92	69S 7	72G/1W	NW, 15, 3, 4	NA	NA	NA	1.57	148	10-inch layer of lignite and dark clay

NA = Not analyzed

Table 3. Laboratory Data on Samples Collected in the Cypress Hills Area (see Fig. 5)

Stn.	Sample	Location		Ash Content (pct.)	Fluorimetric Data		Beta Counter Data		Remarks
		NTS Map	Quarter, Sec., Tp., Rge.		U_3O_8 ppm on ash	U_3O_8 ppm on coal	Counts per sec.	U_3O_8 ppm equivalent	
7	69S 1	72F/8W	SW, 12, 6, 18	NA	NA	NA	0.59	54	One-foot lignite near Mule Creek
8	69S 2	72F/8W	NE, 1, 6, 18	NA	NA	NA	1.65	151	Thin seam near Mule Creek
9	CQ 74	72F/8W	SW, 35, 5, 18	84.27	4	3	NA	NA	Middle bed of three shaly beds
11	CQ 76	72F/9W	SW, 8, 8, 18	39.50	27	11	NA	NA	Basal part of seam in road cut
12	CQ 75	72F/9W	SE, 7, 8, 18	66.94	21	14	NA	NA	Refuse from small mine dump
13	CQ 34	72F/9W	NE, 25, 7, 19	22.88	12	3	NA	NA	Coal from dump (CQ 34); 31 in. bed in
13	CQ 35	72F/9W	NE, 25, 7, 19	35.04	37	13	NA	NA	place (CQ 35)
15	CQ 36	72F/9W	SW, 30, 7, 18	60.91	265	161	1.84	167	Carbonaceous lens in stream bank (CQ 36)
15	CQ 37	72F/9W	SW, 30, 7, 18	59.19	26	15	NA	NA	Coaly shale on dump (CQ 37)
16	CQ 38	72F/9W	NW, 19, 7, 18	31.68	25	8	NA	NA	Lignite from old strip mine
17	CQ 77	72F/9W	NE, 19, 7, 18	47.49	21	10	NA	NA	Top bed of two beds in strip mine.
18	S 3	72F/9W	SW, 23, 7, 19	56.10	NA	NA	0.07	0-10	Two-foot clay and lignite
24	CQ 73	72F/8W	NE, 27, 4, 19	85.70	2	2		NA	Thin dark shale in cliff
25	S 4	72F/8W	SE, 16, 5, 19	81.00	NA		0.99	90	Dark brown shale
34	S 6	72F/10E	SE, 19, 8, 20	59.71	68	41	0.61	50	Samples spaced 100 ft. horizontally on top
34	S 6A	72F/10E	SE, 19, 8, 20	NA	NA	NA	0.75	70	seam of a sequence of three seams
34	S 6B	72F/10E	SE, 19, 8, 20	47.85	NA	NA	0.92	80	
43	S 7	72F/10W	NW, 27, 7, 21	NA	NA	NA	1.35	120	Top seam exposed on Anxiety Butte,
43	S 7A	72F/10W	NW, 27, 7, 21	NA	NA	NA	1.46	120	sampled in two places

NA = Not analyzed

Table 3 (continued)

Stn.	Sample	Location		Ash Content (pct.)	Fluorimetric Data		Beta Counter Data		Remarks
		NTS Map	Quarter, Sec., Tp., Rge.		U_3O_8 ppm on ash	U_3O_8 ppm on coal	Counts per sec.	U_3O_8 ppm equivalent	
44	S 8A	72F/10W	SE, 28, 7, 21	45.36	440	200	1.90	170	Nine coaly layers on south side of Anxiety Butte; Third from top (S 8A), Second from top (S 8B), S 8C and S 8D from top seam
44	S 8B	72F/10W	SE, 28, 7, 21	NA	NA	NA	1.66	150	
44	S 8C	72F/10W	SE, 28, 7, 21	45.12	920	415	5.17	480	
44	S 8D	72F/10W	SE, 28, 7, 21	37.39	NA	NA	2.08	180	
50	S 2	72F/15W	NE, 4, 10, 22	47.99	158	76	0.77	70	Thin layer exposed in creek
52	CQ 33	72F/10W	SE, 6, 7, 21	81.74	24	20	NA	NA	Coaly shale in old clay pit
56	CQ 78	72F/7W	SW, 25, 6, 22	29.70	30	9	NA	NA	Five seams exposed on bluff with radio tower south of river, lowest seam (CQ 78), third from bottom (CQ 79), top seam sampled along outcrop at 4 sites over several hundred feet (CQ 80 and 81, S9 A and B), thin rider seam over upper seam (CQ 82), dark shale below upper seam (CQ 83)
56	CQ 79	72F/7W	SW, 25, 6, 22	71.02	24	17	NA	NA	
56	CQ 80	72F/7W	SW, 25, 6, 22	39.17	370	145	1.46	133	
56	CQ 81	72F/7W	SW, 25, 6, 22	40.13	650	261	3.36	306	
56	CQ 82	72F/7W	SW, 25, 6, 22	45.37	90	41	0.61	56	
56	CQ 83	72F/7W	SW, 25, 6, 22	89.04	8	7	NA	NA	
56	S 9A	72F/7W	SW, 25, 6, 22	31.51	NA	NA	2.18	200	
56	S 9B	72F/7W	SW, 25, 6, 22	45.84	700	321	3.52	330	
57	S 10	72F/7W	SE, 26, 6, 22	18.76	4400	825	5.95	560	Top seam sampled on ridge 300 yds. west of station 56; 2 samples
57	S 10A	72F/7W	SE, 26, 6, 22	36.85	1060	391	4.59	440	
61	CQ 85	72F/7W	SE, 13, 6, 23	53.72	13	7	NA	NA	Top seam of 3 on cliff
62	CQ 31	72F/11E	SE, 27, 6, 23	26.84	7	2	NA	NA	At least 10 seams and seamlets exposed in clay pit, main seam near base of section (CQ 32), thin rider over main seam (CQ 31), 3 higher seams (S 11, 12 and 13), 13A is clean coal from S 13
62	CQ 32	72F/11E	SE, 27, 6, 23	14.38	40	6	NA	NA	
62	S 11	72F/11E	SE, 27, 6, 23	60.60	32	19	0.36	30	
62	S 12	72F/11E	SE, 27, 6, 23	23.56	NA	NA	0.06	0-10	
62	S 13	72F/11E	SE, 27, 6, 23	44.85	NA	NA	0.09	0-10	
62	S 13A	72F/11E	SE, 27, 6, 23	24.76	NA	NA	0.08	0-10	
71	S 1	72F/14W	NW, 24, 9, 25	80.73	NA	NA	0.24	20	Black clay
	S 5	72K/1E	NW, 18, 13, 15	NA	NA	NA	0.38	30	Volcanic ash near Duncairn

NA = Not analyzed

Table 4. Laboratory Data on Channel Samples Collected in Cypress Hills

Sample	Ash Content (per cent)	Fluorimetric Data		Beta Counter Data	
		U_3O_8 ppm on ash	U_3O_8 ppm on coal	Counts per sec.	U_3O_8 ppm equivalent
BD 22A					
AI	68.09	106	72	1.25	120
AII	34.38	NA	NA	1.35	130
AIII	23.29	NA	NA	0.36	30
AIV	19.97	NA	NA	0.29	20
AV	16.57	NA	NA	0.12	10
BD 22B					
BI	74.87	240	180	2.43	210
BII	23.09	1380	319	3.13	270
BIII	17.75	NA	NA	0.86	80
BIV	19.21	NA	NA	0.23	20
BV	20.13	NA	NA	0.23	20

The samples were taken close to station 57. AI represents 0-6 inches measured from top of seam; AII represents 6-12 inches etc. The samples in series BD 22B are similarly arranged. Samples BI, BII, BIII and BIV were also tested for molybdenum and vanadium; see results in Table 9.

Table 5. Laboratory Data on Samples Collected in White Lake (Fig. 7), Chu-Chua (Fig. 8) and Princeton (Fig. 9) Areas

Stn.	Sample	Location		Ash Content (pct.)	Beta Counter Data		Remarks
		NTS Map	UTM Grid		Counts per sec.	U_3O_8 ppm equivalent	
3(WL)	S 16	82E/5E	073 646	38.48	0.08	0-10	Coal near old adit along Park Rill
4(WL)	S 17	82E/5E	080 652	17.23	0.16	10	Coal in dry creek bed near old shaft
10(WL)	S 15	82E/5E	103 660	NA	0.44	40	Breccia at mouth of creek SE of observatory
1(CC)	H 1	92P/8E	990 891	57.14	0.14	10	Tailings pile; 300 yds. east of highway
5(CC)	H 3	92P/8E	991 890	49.42	erratic	0-10	Coaly shale
6(CC)	H 4	92P/8E	993 890	19.38	0.07	0-10	Coal on south bank of creek
7(CC)	H 5	92P/8E	993 890	68.65	0.25	20	Coal and clay
8(CC)	H 6	92P/8E	994 890	14.43	0	0	Coal from outcrop near old adit
8(CC)	H 7	92P/8E	994 890	79.43	0.22	20	Coaly shale in roof above old adit
9(CC)	H 8	92P/8E	995 890	61.54	0.22	20	2-inch coaly layer; south bank of creek
K	H 2	92I/9W	781 183	NA	0.43	40	Coaly material from gully near CP tracks
1(P)	S 18	92H/7	765 712	NA	0.15	10	Burned-out seam overlooking creek
10(P)	S 30	92H/7	738 777	NA	0.11	10	Clinker from old strip pit
12(P)	S 31A	92H/7	781 793	31.09	0.28	20	Thin coal seam in cliff
12(P)	S 31B	92H/7	781 793	NA	0.45	30	Brown shale over coal of S 31A
16(P)	S 22	92H/7	790 802	NA	0.35	30	Coaly shale exposed on east bank of river
16(P)	S 23	92H/7	790 802	NA	0.45	40	Brown shale overlying coal of sample S 22
22(P)	S 29	92H/7	811 815	80.13	0.36	30	Basal 2 inches of seam in old strip pit
23(P)	S 19	92H/7	809 809	NA	0.43	40	Coal and shale on east bank of river
32(P)	S 20	92H/7	792 752	69.07	0.28	20	Thin shaly coal in railway cut
33(P)	S 28	92H/7	780 756	66.06	0.17	10	Shale and coal layer 5 inches thick
33(P)	S 27	92H/7	780 756	NA	0.37	30	Brown clay under 5-inch layer of sample S 28
37(P)	S 24	92H/7	780 733	NA	0.33	30	Yellow underclay of thin coal seam
37(P)	S 25	92H/7	780 733	NA	0.57	50	Siltstone between coaly layers above underclay
38(P)	S 26	92H/7	776 721	NA	0.17	10	Coal from fossilized tree stump

K = Kamloops (not shown on maps of this report), WL = White Lake, CC = Chu-Chua, P = Princeton

Table 6. Laboratory Data on Samples Collected in Merritt (Fig. 11), Hat Creek (Fig. 12), Alexandria-Quesnel (Fig. 13) and Bowron River (Fig. 14) Areas

Stn.	Sample	Location		Ash Content (pct.)	Beta Counter Data		Remarks
		NTS Map	UTM Grid		Counts per sec.	U_3O_8 ppm equivalent	
	S 32[1]	92I	FL 79 57	NA	0.19	10	Brown shale associated with thin coal streaks
27(M)	S 33	92I/2	586 550	59.99	0.32	30	Refuse from small tailings pile near Merritt
2(HC)	S 37	92I/13E	983 258	59.98	0.16	10	Coaly shale with yellow stain
5(HC)	S 34	92I/13E	986 253	NA	0.09	0-10	Brown shale exposed near old air shaft
5(HC)	S 35	92I/13E	986 253	7.24	0.01	0-10	Bright coal
5(HC)	S 36	92I/13E	986 253	6.00	0.05	0-10	Coal with woody structure
3(AQ)	F 3	93B/9W	379 413	13.88	0	0	3-foot seam exposed on Australian Creek
5(AQ)	F 5A	93B/16W	338 686	NA	0.08	0-10	Red baked clay, east bank Fraser River
5(AQ)	F 5B	93B/16W	338 686	79.99	0.09	0-10	Coaly material over baked shale
1(BR)	BR 1C	93H/13W	712 651	4.37	0.07	0-10[2]	Coal outcrop upstream from new mine
1(BR)	BR 1D	93H/13W	712 651	25.58	1.04[3]	90	Section seam from section along river
1(BR)	BR 1E	93H/13W	712 651	NA	0.40	30	Shale from above section
1(BR)	BR 1H	93H/13W	712 651	43.91	0.45	40	Third coaly layer in above section

[1] Exposure on hill east of Quilchena Creek, 2 miles south of Nicola Lake, not shown on accompanying map

[2] Fluorimetric data obtained on BR 1C shows 129 ppm on ash and 6 ppm on whole coal

[3] Fluorimetric data obtained on BR 1D shows 98 ppm on ash and 25 ppm on whole coal

M = Merritt, HC = Hat Creek, AQ = Alexandria-Quesnel, BR = Bowron River, NA = Not analyzed

Table 7. Laboratory Data on Samples Collected in the Francois Lake-Cheslatta Lake Area (Fig. 15)

Stn.	Sample	Location		Beta Counter Data		Remarks
		NTS Map	UTM Grid	Counts per sec.	U_3O_8 ppm equivalent	
1	CQ 150	93F	DQ 01 73	0.13	12	Lignite float collected along Nechako River
2	CQ 138	93F	CQ 72 46	0.05	0-10	Five seamlets of lignite exposed in 30 feet of section at
2	CQ 139	93F	CQ 72 46	0.43	41	east end of Murray Lake. Second from bottom was sampled
2	CQ 140	93F	CQ 72 46	0.45	43	(CQ 138); in ascending order above this bed rusty siltstone
2	CQ 141	93F	CQ 72 46	0.30	29	(CQ 139), greenish clay (CQ 140) and coaly clay (CQ 141)
2	CQ 142	93F	CQ 72 46	0.12	11	were sampled. Top seam (CQ 142) and bottom seam (CQ 144)
2	CQ 143	93F	CQ 72 46	0.32	31	also sampled. In addition coal and clay below top seam
2	CQ 144	93F	CQ 72 46	0.14	14	was sampled (CQ 143).
4	CQ 145	93F	CQ 45 58	0.52	52	Light coloured amygdoloidal volcanics on shore of lake
5	CQ 146	93F	CQ 42 60	0.12	12	Two beds of lignite exposed along creek, lower one
5	CQ 147	93F	CQ 42 60	0	0	sampled (CQ 146), coaly fragments from fossilized stump
5	CQ 148	93F	CQ 42 60	0.15	14	(CQ 147) and two samples of lignite float (CQ 148 and 149)
5	CQ 149	93F	CQ 42 60	0.10	10	along creek were collected.
8	CQ 137	93K/2E	928 913	0.31	30	Rusty agglomerate exposed in railway cut
10	CQ 128	93K/4W	200 947	0.22	22	Ten or 12 coaly layers in road cut, best one sampled (CQ 128),
10	CQ 129	93K/4W	200 947	0.51	53	sandy layer below it (CQ 129) dark shale above (CQ 130);
10	CQ 130	93K/4W	200 947	0.69	72	Tuff layer over shale (CQ 131). Coaly material from fossilized
10	CQ 131	93K/4W	200 947	0.42	44	tree trunk (CQ 133 and 134). Second tuff layer lower down in
10	CQ 132	93K/4W	200 947	0.38	40	section (CQ 132).
10	CQ 133	93K/4W	200 947	0	0	
10	CQ 134	93K/4W	200 947	0	0	
17	CQ 136	93K/4W	067 924	0.13	13	Coarse tuffaceous rock with carbonaceous(?) blebs
18	CQ 126	93K/5W	115 318	0.11	11	Coaly lenses in conglomerate and shale along creek
19	CQ 127	93K/5W	116 324	0.16	15	Black shale exposed along same creek as CQ 126

Table 8. Laboratory Data on Samples Collected in Graham Island (Fig. 16), Driftwood Creek (Fig. 17), Burwash Landing (Fig. 19) and Haines Junction (Fig. 20) Areas

Stn.	Sample	Location		Beta Counter Data		Remarks
		NTS Map	UTM Grid	Counts per sec.	U_3O_8 ppm equivalent	
2(GI)	QC 8A	103F/8E	861 123	0	0-10	Coal samples from Robertson prospect east of Yakoun Lake
2(GI)	QC 8B	103F/8E	861 123	0	0-10	
3(GI)	QC 4A	103F/8W	822 237	0	0-10	Coal samples from Wilson prospect, along Wilson Creek
3(GI)	QC 4B	103F/8W	822 237	0	0-10	
4(GI)	QC 3	103F/16E	881 673	0.62	60	Float lignite from north end of Kumdis Island
6(GI)	QC 6A	103J/4W	146 947	0	0-10	Lignite float and carbonaceous lenses in outcrop from
6(GI)	QC 6B	103J/4W	146 947	0	0-10	Yakan Point
3(DC)	CQ 122A	93L/14E	270 769	0	0	Thin coaly layers in bank near creek; CQ 122A is coal,
3(DC)	CQ 122B	93L/14E	270 769	0.27	25	CQ 122B is associated shale
5(BL)	CQ 110	115G	ET 87 95	0	0	Lignite exposed on creek
8(BL)	CQ 111	115G	ET 87 98	0	0	Samples CQ 111 through CQ 118 represent in descending
8(BL)	CQ 112	115G	ET 87 98	0.06	0-10	order coaly layers in approximately 1,200 feet of section
8(BL)	CQ 113	115G	ET 87 98	0	0	exposed on Amphitheatre Mountain with CQ 111 representing
8(BL)	CQ 114	115G	ET 87 98	0.02	0-10	the highest bed at an estimated distance of 40 feet below the
8(BL)	CQ 115	115G	ET 87 98	0	0	overlying volcanics
8(BL)	CQ 116	115G	ET 87 98	0	0	
8(BL)	CQ 117	115G	ET 87 98	0.07	0-10	
8(BL)	CQ 118	115G	ET 87 98	0	0	
5(HJ)	CQ 119	115A	LC 43 32	0.13	14	Thin seamlets of highly altered and contorted coal in
5(HJ)	CQ 120	115A	LC 43 32	0	0	association with volcanics

GI = Graham Island, DC = Driftwood Creek, BL = Burwash Landing, HJ = Haines Junction

Table 9. Molybdenum and Vanadium Contents in Selected Samples (Ashed) of Lignites and Coaly Shales (for location see indicated Figure and Station)

Sample	Location		Ash	Molybdenum ppm[1]		Vanadium ppm[1]	
	Figure	Station	Content %	On Ash	On Coal[3]	On Ash	On Coal[3]
CQ 48B	2	36	9.64	ND[2]	-	<50	<50
CQ 52	2	5	32.18	ND	-	800	257
CQ 66	3	44	79.37	ND	-	100	79
CQ 81	5	56	40.13	ND	-	100	40
BD 22BI	5	57	74.87	ND	-	50	<50
BD 22BII	5	57	23.09	ND	-	<50	<50
BD 22BIII	5	57	17.75	30	<30	<50	<50
BD 22BIV	5	57	19.21	ND	-	<50	<50
S 2	5	50	47.99	50	<50	100	48
S 8A	5	44	45.36	ND	-	100	45
S 10	5	57	18.76	ND	-	<50	<50
S 29	9	22	80.13	ND	-	150	120
S 33	11	27	59.99	100	60	450	270
S 37	12	2	59.98	ND	-	250	150
F 3	13	3	13.88	110	15	350	49
BR-1D	14	1	25.38	580	147	1050	268
H 7	8	8	79.43	ND	-	250	199

[1] Values should be considered as ± 50 ppm

[2] Not Detected

[3] Values for coal have been calculated from ash content