GEOLOGY AND GRAVITY SURVEY OF THE TULAMEEN COAL BASIN (92H)

By B. N. Church and D. Brasnett

INTRODUCTION

This report reviews the coal deposit and host rocks of the Tulameen basin in the light of new geological and geophysical data. The new information includes petrological and age determinations, and a gravity survey that gives insight into the structure of the basin.

HISTORY

Coal was discovered near Blakeburn Creek in the Tulameen basin prior to 1900. In 1904 control of the deposit was secured by B.C. Coal and Coke Co. and this was soon followed by large-scale exploration. Work commenced simultaneously on the northeast side of the basin on Collins Gulch and near Blakeburn Creek to the south. Activity continued over the next 30 years with the development of five underground mines in the Blakeburn area.

In 1913 Coalmont Collieries Ltd. gained control and initiated work at mine Nos. 1 and 2. An aerial tramway was constructed in 1920 to carry the coal from the minesite to the railway at Coalmont where it could be processed and readily transported to markets. Mines No. 3 and 4 began operations in the mid-1920's, however, floods and fires caused their eventual closures in the mid-1930's. The last operating mine, No. 5, opened in 1931 and produced for nine years. In 24 years of operation 2 144 657 tonnes of coal were shipped from Tulameen Coalfield. In the years 1954 to 1957, Mullin's Strip Mine Ltd. operated at Blakeburn, at the site of some of the old underground workings, producing 148 239 tonnes of coal. Imperial Metals & Power Ltd. continued active exploration in the 1960's with much trenching in the northwest part of the basin. Cyprus Anvil Mining Corporation continued this work plus additional diamond drilling in 1977 and 1978 under option agreement.

GEOLOGICAL SETTING

The Tulameen basin, centred 2 kilometres west of Coalmont, is a Tertiary outlier with an elliptical northwest-southeast elongated sedimentary core measuring 5.4 kilometres by 3.6 kilometres (Fig. 16). The geology of the basin has been previously described by Camsell (1913), Rice (1947), Shaw (1952), and Evans (1978) and examined in specific aspects by Hills, *et al*. (1967), Donaldson (1973), and Peavers, *et al*. (1980).

Eocene volcanic and sedimentary rocks rest unconformably on Triassic greenstones and metasedimentary rocks. They are overlain by Miocene basalt lavas and breccias.

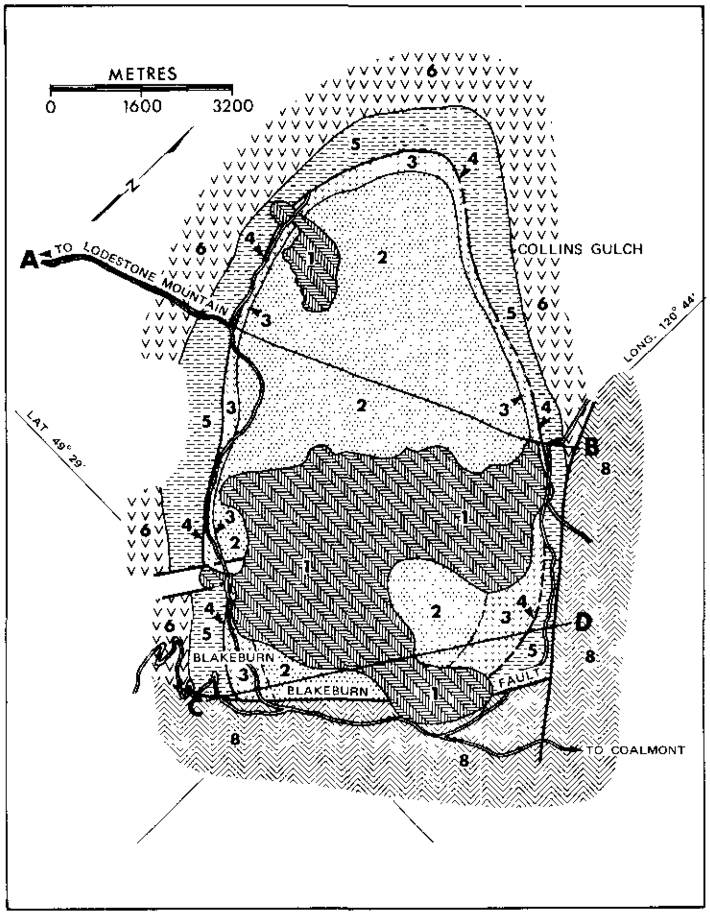

Figure 16. Geology of the Tulameen basin.
(See Fig. 18 for legend.)

TABLE 1. CHEMICAL ANALYSIS OF VOLCANIC ROCKS OF THE TULAMEEN BASIN

Oxides recalculated to 100%	1	2	Oxides as determined	1	2
SiO_2	68.61	80.21	H_2O+	0.85	3.80
TiO_2	0.45	0.11	H_2O-	1.23	3.18
Al_2O_3	16.63	15.98	CO_2	0.70	1.39
Fe_2O_3	2.59	0.01	P_2O_5	0.28	<0.08
FeO	0.38	0.47	S	<0.01	0.03
MnO	0.04	0.01	SrO	0.08	0.003
MgO	1.38	0.48	BaO	0.19	0.07
CaO	2.81	0.51			
Na_2O	4.29	0.10			
K_2O	2.87	2.12			
	100.00	100.00			

Key to Analyses: 1 = Hornblende dacite of Cedar volcanic rocks from road cut on south slope of Hamilton Hill. 2 = Rhyolite tuff band near top of coal measures in Blackburn pit.

The Eocene beds are estimated to be 800 metres thick where best developed. The coal measures, about 30 metres thick (Blakeburn), are sandwiched between 200 metres of sandstone and shale below, and 60 metres of fissile shales above (Collins Gulch section). An estimated thickness of 500 metres of quartzose sandstone and conglomerate forms the uppermost part of the sedimentary succession in the central part of the basin.

The Eocene volcanic rocks, named 'Cedar volcanic series' by Camsell (1913), are partly intercalated with the basal sedimentary units. The volcanic series attains a thickness of about 500 metres on Hamilton Hill and Mount Jackson, where the typical rock is light grey dacite with small hornblende needles (*see* analysis No. 1, Table 1). However, arc fusion analyses of 51 lava samples show a full range in compositions from basalt to rhyolite (Fig. 17). The frequency of felsic volcanic rocks increases stratigraphically upward to where rhyolite ash forms 12 separate bands in the upper part of the coal measures (*see* analysis No. 2, Table 1).

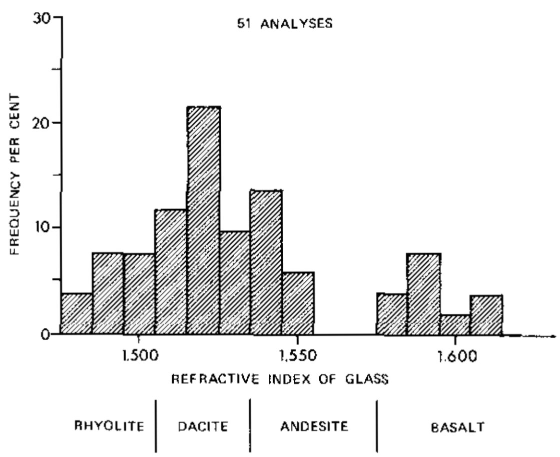

Figure 17. Refractive index frequency plot for the Eocene volcanic rocks of the Tulameen basin.

The age of these rocks is placed near the boundary between Lower and Middle Eocene, based on the recent determination of a sample of amphibole submitted to J. Harakal at the University of British Columbia. This is comparable to previous K/Ar results on beds associated with the Princeton and Hat Creek coal deposits (*see* Table 2).

TABLE 2. RADIOMETRIC AGE DETERMINATIONS OF EOCENE COAL MEASURES, SOUTH-CENTRAL BRITISH COLUMBIA

No.	Rock Source	Mineral	North Lat.	West Long.	K %	Ar^{*40} cc/gm	Ar^{*40} %	Age (Ma)
1	Cedar dacite	amphibole	49°30.2'	120°46'	0.761	1.469	75.6	49.0±1.7
2	Princeton ash	biotite	49°27.4'	120°32'	6.76	1.31	84	49.2±2
3	Hat Creek rhyolite	biotite	50°40.5'	121°34.5'	6.87	1.39	90	51.2±1.4

No. 1 = this study, No. 2 = Mathews (1964, p. 465), and No. 3 = Church (1975, p. G10) corrected according to the method of Steiger and Jager (1977).

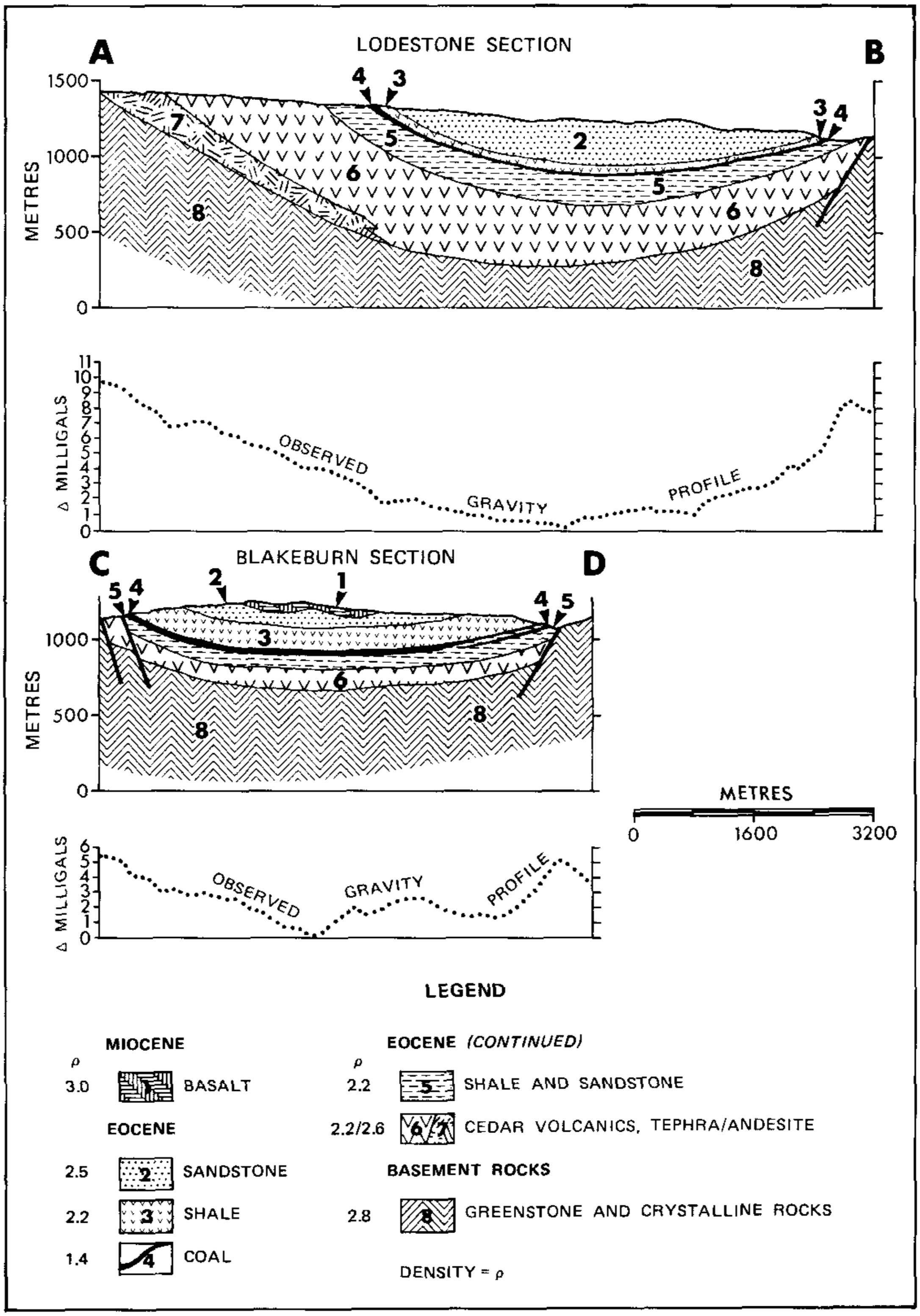

Figure 18. Geological cross-sections and gravity profiles of the Tulameen Basin. (Refer to Fig. 16 for position of sections.)

Miocene basalt (dated 9.0±0.9 Ma by Evans, 1978) are up to about 100 metres thick. These lava flows unconformably overlie the Eocene sedimentary rocks in the southern and west-central part of the basin. Feeder dykes to the basalt flows cut older rocks in the area, including coal beds north of Blakeburn pit. Here a large dyke about 50 metres wide intrudes the fault zone and divides the old mine workings.

GRAVITY SURVEY

A gravity survey conducted by Brasnett (1981), on behalf of the *Ministry, facilitates preparation of structural cross-sections of the* basin. A synthesis of two cross-sections shown on Figure 18 is based on total gravity response in terms of thickness and densities (ρ) of major stratigraphic units.

A LaCoste-Romberg gravity meter was employed in the survey and operated according to manual specifications. Readings were performed at 50-metre intervals at topographic stations established by Ager, Beretta and Associates Ltd.

The north line of the survey proceeds 5.1 kilometres on a course of approximately 060 degrees from 'A,' at the western margin of the basin on the Lodestone Mountain road, and ends at 'B' near the Bear's Den coal prospect on the east side (Fig. 18). The main features seen in this section are gentle-dipping beds (maximum dip of about 35 degrees), a down-faulted eastern margin, and westerly thickening stratigraphic units. The axial plane of this elongated basin is inclined with a keel displaced more than 1 kilometre westerly from the axial trace as seen in surface plan (*see* Evans, 1978, p. 84).

The south line follows an old tramway 3.2 kilometres on a course of 045 degrees from Blakeburn pit. Notably, this section shows a Miocene basalt cap on a relatively thin and gently dipping Eocene sequence. The keel of *the basin on this line is roughly 450 metres higher in elevation than* on the north line, which is closer to the centre of the basin. This indicates that the overall structure is not simply a southeasterly plunging syncline as suggested by Evans.

In summary, the evidence suggests that the basin developed as a drainage trap accumulating first sandstone, then shales and coal which thickened westerly against the still active Cedar volcanic pile. A final influx of quartzose sand and conglomerate completed an infill cycle following a late episode of rhyolite volcanism and subsidence. Preservation of these strata from erosion was effected by normal faulting on the east and southeast margins of the present Eocene outlier and extrusion of capping Miocene basalt lavas.

THE COAL DEPOSIT

Drilling by Cyprus Anvil Mining Corporation in the northwest part of the sedimentary basin shows that coal may occur anywhere in the shale facies. According to Shaw (1952), the lowest coal seam is about 120 metres above the Cedar lavas and breccias and 40 metres below the principal coal measures. Shaw also reported coal in the upper quartzose sandstone-conglomerate unit.

The thickest and most continuous coal deposit is in the Blakeburn area where Donaldson (1973) described in detail a 27-metre section of coal at the site of the old mining operation. The original mining excavation followed a 2 to 4-metre-thick seam with a strike length of 2.3 kilometres. The coal is a high volatile bituminous B and C variety, having 2 to 5 per cent moisture content, 4 to 16 per cent ash, 0.3 per cent sulphur, and yielding about 3 000 kilogram calories. The usual bright character of the coal is due to high vitrinite composition. Reflectance measurements on the vitrinite ($\bar{R}_o$) range from 0.79 to 0.94, showing a general increase downward (*see* Table 3 and Donaldson, 1973, p. 8). Individual seams above and below the mine seam are separated by clay layers, rhyolite ash bands, or shaly partings.

TABLE 3. VARIATION OF VITRINITE REFLECTANCE ($\bar{R}_o$) THROUGH THE BLAKEBURN COAL MEASURES

Metres below top of coal measures	Reflectance $\bar{R}_o$
0.3	0.804
1.0	0.831
2.0	0.846
2.7	0.822
4.2	0.790
8.0	0.847
11.0	0.843
13.0	0.928
17.0	0.884
20.0	0.944

Laterally the coal beds 'shale out' as is typical of limnic deposits. The main coal zone has been traced 3 to 4 kilometres along strike northwest from the Blakeburn pit to where the measures are 15 to 20 metres thick. However, to the east and south the coal horizon diminishes to a few thin seams at Collins Gulch and impure carbonaceous beds at the Bear's Den and Hayes-Vittoni prospects.

According to Peavers, *et al.* (1980), the high vitrinite content of the coal suggests a woody source and probable forest-moor origin. Stagnant acid conditions converted much of the interbedded rhyolite ash to kaolinite. The regularity of alteration textures and the continuity of these ash bands suggests a quiet, low detrital transport domain. The local clastic character of the coal is tectonic, resulting from bedding plane faulting related to concentric folding. Such movements are most prominent in deeper sections of the basin and in steeply dipping segments near the east margin.

The unexpected high rank of the coal is apparently due to a high geothermal gradient, ascribed to Eocene volcanism in the region. Donaldson (1973, p. 9) discounts any contact metamorphic effect from the overlying Miocene basalt. The general downward increase in the reflectance of vitrinite seems to be a function of depth of burial. Peavers, *et al.* (1980) determined the relation between reflectance $\bar{R}_o$, paleotemperatures, and time. Accordingly, observed reflectance values would result from a minimum paleotemperature of 75 degrees Celsius for a period of 50 million years or a more reasonable estimate of 130 degrees Celsius for 10 million years.

CONCLUSIONS

The Tulameen basin is a faulted elliptical structure of possible volcano-tectonic origin. New radiometric determinations give an Eocene age comparable to previous K/Ar results from other major limnic coal deposits of the southern interior region such as in the Hat Creek and Princeton areas.

A gravity survey gives a profile of the Tertiary formations, delineating the basal volcanic and sedimentary rocks and coal measures. The 800 metres of strata comprising the basin record a history of early volcanic eruption causing disruption of drainage patterns, stagnation leading to sedimentation and coal formation, and finally infilling by coarse sandstones and conglomerates. Preservation of these rocks resulted from normal faulting, folding, and extrusion of young basalt lavas.

Rhyolite ash bands concentrated in the upper part of the coal measures may reflect a resurgent volcanic event associated with high geothermal gradients. Evidence suggests that anomalous Eocene geothermal gradients are responsible for the comparatively high rank of the coal.

REFERENCES

Adamson, T. J. (1978): Tulameen Coal Project, *Cyprus Anvil Mining Corporation,* Assessment Rept. 77-(1)A.

Brasnett, D. (1981): The Tulameen and Colwood Gravity Surveys, *University of Victoria,* Co-Op Work Term Rept., 26 pp.

Camsell, C. (1913): Geology and Mineral Deposits of the Tulameen District, British Columbia, *Geol. Surv., Canada,* Mem. 26, 98 pp.

Church, B. N. (1975): Geology of the Hat Creek Coal Basin, *B.C. Ministry of Energy, Mines & Pet. Res.,* Geology, pp. G99-G118.

Donaldson, J. R. (1973): The Petrography of the Coal from the Blakeburn Strip Mine in the Tulameen Coal Area, British Columbia, *Geol. Surv., Canada,* Paper 72-39, 13 pp.

Evans, S. H. (1978): Tulameen Coal Basin, *B.C. Ministry of Energy, Mines & Pet. Res.,* Geological Fieldwork, 1977, Paper 1978-1, pp. 83, 84.

Hills, L. V. and Baadsgaard, H. (1967): Potassium-Argon Dating of Some Lower Tertiary Strata in British Columbia, *Cdn. Pet. Geol.,* Bull., Vol. 15, No. 2, pp. 138-149.

Mathews, W. H. (1964): Potassium-Argon Age Determinations of Cenozoic Volcanic Rocks from British Columbia, *Geol. Soc. Am.,* Bull., Vol. 75, pp. 465-468.

Peavers, D. R., Williams, V. E., and Mustoe, G. E. (1980): Kaolinite, Smectite, and K-Rectorite in Bentonites: Relation to Coal Rank at Tulameen, British Columbia, unpub. manu., 28 pp.

Rice, H.M.A. (1947): Geology and Mineral Deposits of the Princeton Map-Area, British Columbia, *Geol. Surv., Canada,* Mem. 243, 136 pp.

Shaw, W. S. (1952): The Tulameen Coalfield, British Columbia, *Geol. Surv., Canada,* Paper 52-19, 13 pp.

Steiger, R. H. and Jager, E. (1977): Subcommision on Geochronology: Convention of the Use of Decay Constants in Geo and Cosmochronology, *Earth and Planet. Sci. Lett.,* Vol. 36, pp. 359-367.