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THE PRINCETON COALFIELD
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THE PRINCETON COALFIELD, BRITISH COLUMBIA

By
W. S. Shaw

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The Princeton Coalfield, British Columbia

INTRODUCTION

Location and Size

The coal-bearing rocks that constitute the Princeton coalfield underlie an elongate, northerly trending, rectangular area of about 45 square miles centred about the town of Princeton at the confluence of Tulameen and Similkameen Rivers. The Kettle Valley branch of the Canadian Pacific Railway and the recently completed Hope-Princeton highway make the area readily accessible. The waterways are not navigable.

History of Mining

Production from this coalfield has never been on a large scale. Only rarely has any one mine exceeded a daily production of 500 tons, and the peak annual output for the entire field was 125,288 tons, attained in 1942. Detailed statistics of production are shown in Table I. Rice (1947, pp. 123-127)[1] has outlined the history of the individual operations. Their locations are indicated on the coal-facies maps (Figure 2) accompanying this report.

[1]Dates in parentheses are those of publications listed in References at the end of this report.

Mining in the Princeton coalfield has been characterized by short-lived operations that ended when difficulties were encountered at depth, due to squeezing and crumbling of the roof and the pavement — factors largely attributable to the relatively low strength of the partly consolidated sediments and the presence of bentonite beds near and within the coal seams. The bentonite, which expands when wet, is capable of exerting much pressure, which commonly results in disruption of the enclosing strata. Mr. E. R. Hughes (1947, pp. 674-676), British Columbia Inspector of Mines for the Similkameen district, has discussed the bentonite problem, and offers some suggestions for minimizing its effects. He suggests, principally: (1) that the operation be planned in such a way that a block of coal sufficient for the year's output be developed, exhausted, and closed off within the same year; (2) that large roadway barrier pillars be retained for the entire life of the mine; and (3) that the mine be kept unwatered during the period of the slack summer market. He indicates that this latter requirement may consume all the profits of the preceding winter's production, and suggests that even a limited summer market would be highly beneficial.

Production came practically to a standstill in 1950 when Tulameen Collieries Limited closed their Pleasant Valley No. 4 mine. The Taylor-Burson Coal Company continued to operate the Jackson mine on a small scale during the winter of 1950-51, but the mine was not in operation late in 1951. The Taylor-Burson Coal Company is presently engaged in reclaiming several large pillars near the surface in the Blue Flame mine on Lamont (Nine Mile) Creek.

1	2	3	4	5	6	7	8	9	10	11	12	13
1931		64,671	14,112								13,037	91,820
1932		57,965	16,346		411						11,780	86,502
1933		54,061	9,479		1.062						10,373	74,975
1934		21,529	10,147		1,060						13,030	45,766
1935		9,601	5,799		786						26,603	42,789
1936		12,362	7,202	899	1,298						21,576	43,337
1937			5,255	16,477	22,480						6,730	50,942
1938				18,513	74,164							92,677
1939				21,856	93,742							115,598
1940				26,434	94,030							120,464
1941		4,152		29,250	79,488			30				112,880
1942		10,617		30,620	83,981	70						125,288
1943		15,699		30,375	62,255	2,254						110,583
1944		47,687		18,038				233				65,958
1945		51,802						141	2,380			54,323
1946		37,877							1,012			38,889
1947		41,634							2,380			44,014
1948		22,580					24,230		3,049			49,859
1949	437	29,776					15,618		4,075			49,906
1950	1,311	11,048					25		4,400			16,784
1951												

Grand total - 2,025,461

[1] Figures from B.C. Department of Mines Annual Reports

TABLE I
Production from Princeton Coalfield[1]

1	2	3	4	5	6	7	8	9	10	11	12	13
YEAR	Princeton Coal and Land Co. Ltd.	Tulameen Collieries	Pleasant Valley Mining Co. Ltd.	Princeton Tulameen Coal Co. Ltd.	Granby Collieries	Black Coal Mine	Inland Collieries (strip mine)	Jackson's Coal Mine	Taylor-Burson Coal Company	United Empire Mining Company	Blue Flame Collieries	TOTALS
1909	150											150
1910	11,868											11,868
1911	23,396											23,396
1912	28,174									500		28,674
1913	27,206									1,752		28,958
1914	19,535											19,535
1915	15,548											15,548
1916	29,458											29,458
1917	48,926											48,926
1918	38,673											38,673
1919	24,702											24,702
1920	24,211											24,211
1921	16,865											16,865
1922	23,880											23,880
1923	20,264											20,264
1924	11,875	1,581										13,456
1925	7,725	7,350										15,075
1926	911	14,558										15,469
1927		15,800									3,343	19,143
1928		20,148									20,855	41,003
1929		41,773	5,874								5,530	53,177
1930		45,765	21,663								12,248	79,676

Purpose of the Investigation

It has already been noted that production from the Princeton coalfield has declined rapidly during the past 7 years. Operators have been plagued with two major sources of trouble, one economic and the other geological.

The economic problem is chiefly one of obtaining year around production. This depends largely upon the storing quality of the coal and the facilities for furnishing a clean product. If full production is to be maintained through the summer months under present market conditions it would be essential to store the coal until the winter market provided a demand. Past experience has indicated that most of the Princeton coal slakes when alternately wetted and dried, and is subject to spontaneous combustion. Because fairly elaborate facilities may be required to store the coal without risk of fire it seems obvious that immediate consumption is the best answer. Varied suggestions, pointing generally to the desirability of increased local industry or a regional power plant located at Princeton, or both, have been made by people directly concerned with the future of the area. They suggest also that even a limited summer production might carry the mines over without the excessive losses experienced in the past.

The geological problem involves several factors, chiefly: (1) the intimate association of bentonite with the coal seams; (2) the relatively weak strata enclosing the seams; (3) rapid lateral variations within the seams; (4) structural configuration of the seams; and (5) correlation of coal seams among more or less isolated mining areas within the coalfield.

The first two of these factors are apparently common to the entire area, and require control by improved mining techniques. Bentonite becomes exceedingly troublesome when wet, so that well-drained workings are essential. The low strength of the enclosing strata necessitates larger supporting pillars, particularly along the roadways. The difficulties engendered by the breaking and crumbling of the strata are multiplied by the increased quantity of water brought into contact with the bentonite beds. In general, speedy development and extraction under dry conditions seem to best minimize these adverse conditions.

The remaining three factors control the selection of mineable areas. Knowledge of the variation in the thickness and quality of the seams, and of the structural features to be encountered, is essential to long-range planning for the layout of a mine and provides a basis for computing the mineable reserves. The lack of such information has been a principal reason for the high incidence of small, poorly planned, marginal operations in the past. Because these factors can usually be evaluated by a detailed stratigraphic study, supported by an exploratory drilling program, a field investigation was undertaken by the Geological Survey during the field season of 1951.

Field Work and Acknowledgments

The earliest record of coal in the Princeton area dates back to 1860 when H. Bauerman made a reconnaissance survey of the region bordering the Forty-ninth Parallel. At the confluence of Similkameen and Tulameen Rivers, Bauerman (1885, p. 32B) noted the presence of "earthy carbonaceous shale or imperfect coals containing plant remains and masses of retinite or amber". In all probability he had observed the weathered, exceptionally dirty, lower section of the Princeton seam, which outcrops near this point.

In 1887, G. M. Dawson (1887-88), on a reconnaissance survey through the southern interior of British Columbia, briefly examined parts of Tulameen and Similkameen River Valleys in the vicinity of Princeton. He noted the occurrence of several lignite seams and the brilliantly coloured cliffs that inspired the naming of Vermilion Forks (former name of the town of Princeton).

No further work was recorded until Camsell (1907) published a report of studies made in 1906 on the Princeton coal basin and surrounding metal mining camps, mainly Copper Mountain. In that report the first large-scale map (1 inch to ½ mile) of the Princeton coal basin was provided. Camsell outlined the area underlain by coal-bearing rocks, and indicated lignite outcrops, workings, and bore-holes. His legend indicates a Palaeozoic basement on which the Tertiary coal-bearing sediments were laid. Tertiary volcanic rocks are indicated as overlying the coal-bearing beds as well as the Palaeozoic rocks.

In 1939, Rice (1947) began systematic mapping of the Princeton map-area on a scale of 1 inch to 4 miles. In his report he has compiled the available information concerning bore-holes and mine workings in the Princeton coalfield up to 1944. Rice indicates that the Nicola group, which forms the basement of the Princeton coal basin, is of Upper Triassic age. He also showed that some Tertiary lavas conformably underlie the coal measures of the basin.

In 1951, the author began a detailed study of the sedimentation and stratigraphy of the coal-bearing rocks of the Princeton coalfield.

The British Columbia Department of Mines provided excellent office space, and thus contributed in no small way toward the progress of this work. A large measure of gratitude is due Mr. E. R. Hughes, resident British Columbia Inspector of Mines, for his unceasing efforts to facilitate the writer's field work. His intimate knowledge of the coalfield was drawn on continuously. Grateful acknowledgment is also given to Dr. H. M. A. Rice of the Geological Survey for many fruitful discussions, and to Messrs. Keith Fahrni, P. W. Gregory, Francis Glover, James Fairley, Elmer Burr, Arthur Hilton, E. N. Freding, and many others who contributed toward the progress of the work. Messrs. M. J. Copeland, S. E. Acres, and D. W. Johnson rendered willing and capable assistance in the field.

Physiography

The Princeton coal basin occupies a broad shallow valley that is largely coextensive with the surface distribution of the relatively incompetent coal-bearing strata. The major streams occupy deep channels several hundred feet below the general level of the valley floor. Remnants of gravel terraces are found bordering the stream channels at intervals up to an elevation of 3,000 feet. Low, rounded hills, covered only with grass, or sparsely wooded with spruce and pine, characterize the main valley floor.

The rapidly flowing Similkameen River enters the valley of the Princeton coal basin at its southern extremity and flows northward to the town of Princeton, where it is joined from the west by Tulameen River. At the confluence of the two rivers, the Similkameen turns eastward. One Mile Creek is the principal drainage channel in the northern part of the area; it enters the valley at its northwestern extremity and flows diagonally across it to join the Similkameen about 1½ miles below Princeton.

Procedure

The procedure used in this investigation was similar to that followed by the author in past studies of this type. The general sequence may be outlined briefly as follows:

(1) Preliminary surface mapping of the coalfield to determine general geologic relationships, such as the degree of structural complexity and type of sedimentation.

(2) Preparation of columnar sections for selected parts of the field to provide a basis for correlating seams from place to place. These sections are assembled from bore-hole data, sections measured on the surface, and mine information.

(3) Preparation of a coal-facies map for each coal zone: lithological and thickness data are illustrated graphically to provide a three-dimensional picture of the coal zone. These maps generally bring out the important trends relating to the nature of the included coal seams. Mine entries, outlines of the workings, and bore-holes are shown. Where sufficient data are available, isopach contours are drawn to elucidate the thickness trends.

(4) Preparation of structure-contour maps: the selection of the horizons to be contoured depends upon local conditions. Where sufficient data are available, all coal-bearing zones are contoured; where they are limited, as in the case of the Princeton coalfield, only one contour map need be prepared. Here the Princeton-Black coal zone was selected, as present knowledge indicates that it has the best areal continuity, and it is probably the most important seam from a mining standpoint. Over large areas where little or no data are available the structure is speculative, and the map is intended only to provide a tentative basis for exploration.

(5) Preparation of a surface geological map, generally accompanied by several structure-sections; this map shows the position of the coal seam outcrops, bore-holes, and mine entries, along with usual geological information recorded on topographic maps. Thus, it provides a master plan for the specialized sub-surface maps. Because a topographic base map on the required scale is not available for the Ptinceton coalfield, the corresponding geological map is not yet prepared, but a skeleton topographic map was constructed from data acquired from various sources, including original surveys by the author, in order to provide a sufficiently accurate base for the subsurface maps.

GENERAL GEOLOGY

Introduction

The discussion will be concerned principally with the Tertiary rocks of the Princeton coalfield. General descriptions of the pre-Tertiary rocks will be incorporated in a brief résumé of the geological history of the area. The following table of formations designates the broad features of the sequence.

Table of Formations

Period	Epoch	Formation	Lithology
Tertiary	Miocene ?	'Upper Volcanic'	Dark brown, grey, vesicular and amygdaloidal basaltic lavas and breccias
		Unconformity	
	Oligocene ?	Allenby	Buff-coloured, granule- and pebble-conglomerate; sandstone; massive to fissile shales; massive clay, including bentonite; coal
		'Lower Volcanic'	Brown, red, and grey, partly banded, in places vesicular, basalt and andesite
		Unconformity	
Triassic (mainly)	Upper Triassic (mainly)	Nicola group (mainly)	Mainly volcanic rocks[1]

[1] See Rice, 1947, p. 6, for details.

Tertiary Rocks

General Statement

The Interior Plateau region of southern British Columbia is dotted with discontinuous, generally small, areas of Tertiary rocks. Most of these are of volcanic origin, but in several places the volcanic rocks are interbedded with thick sections of sedimentary rocks, mainly of fluviatile and lacustrine origin. Considerable difficulty attends any attempt to fix precisely the age of the various occurrences because the most prolific fossils are long-ranging species of plants and insects. Thus, in most instances, the occurrences are believed to be of Oligocene or early Miocene age (Rice, 1947, pp. 30-31). In Princeton map-area, the Tertiary rocks lie unconformably on all older rocks, including the youngest intrusions (Upper Cretaceous and Tertiary), thus denoting a period of deep erosion preceding deposition of Tertiary volcanic and sedimentary rocks in that area. Rice has assigned all Tertiary sedimentary and volcanic rocks in the vicinity of Princeton to the Princeton group, which includes all the Tertiary rocks of Princeton coalfield. For the purpose of more detailed treatment these rocks have been divided into three smaller rock units, in ascending order, as follows: 'Lower Volcanic', Allenby, and 'Upper Volcanic' formations.

'Lower Volcanic' Formation

The oldest Tertiary rocks in the Princeton coalfield consist of 4,500 feet or more of massive and banded lavas. These are best exposed along the ridge that borders the southern part of the coalfield on the west. The north fork of Findlay Creek has cut a narrow, deep ravine through the ridge at a point opposite the Jackson and Taylor-Burson mines, and offers the best exposure of these rocks.

The maximum thickness indicated above appears to persist southerly for some distance beyond the coalfield, but toward the east the volcanic rocks wedge out between the pre-Tertiary basement rocks and the overlying Allenby formation.

The banded structures appeared to be concordant with the top and bottom of the flows, and attitudes were determined on them. On the north fork of Findlay Creek and on the ridge west of the Black mine, the attitudes indicated conformity with the overlying Allenby formation.

No sedimentary beds were found within this group of lavas, but their apparent conformity with the overlying beds of the Allenby formation would suggest that they are only slightly older.

Allenby Formation

A formation consisting of fluvial and lacustrine sediments and intercalated coal beds succeeds the 'Lower Volcanic' rocks in the western part of the coalfield, and overlaps the pre-Tertiary basement rocks on the northwest, north, east, and southeast.

These strata, which have a maximum exposed thickness of 3,500 feet, underlie most of the Princeton coalfield. The name 'Allenby formation' is here proposed for these strata, which are well exposed along the banks of Similkameen River near the village of Allenby.

The Allenby formation consists predominantly of massive, crossbedded granule- and pebble-conglomerate, sandstone, and massive and thinly bedded shale, with intercalated beds of coal, carbonaceous siltstone and shale, and bentonite. All size gradations between conglomerate and siltstone are represented, but granule-conglomerate and coarse sandstone seem to predominate.

The conglomerate and sandstone of the formation are prevailingly arkosic, but locally contain much volcanic material. The beds are extremely massive, and commonly give no evidence of bedding except by the orientation of carbonaceous material and occasional thin clay or silty partings. Where exposures are large, the coarse-grained sedimentary beds are almost invariably seen to be lenticular. Rough counts made on the granule-conglomerate from several parts of the formation indicate a content of 60 to 80 per cent clastic fragments and 20 to 40 per cent clay minerals, which form the matrix. Angular to subrounded grains of feldspar comprise 20 to 30 per cent of the rock, and angular to subrounded grains of quartz, some of which are strained, from 20 to 30 per cent. Fragments of granite and granodiorite constitute as much as 40 per cent, and various volcanic materials from 10 to 25 per cent. It is apparent that these materials were derived from a dominantly granitic terrain and suffered little abrasion in passing from the source to the site of deposition. The wide areas in which the Coast intrusions and younger intrusive rocks are exposed are the obvious sources. The volcanic content has undoubtedly been provided by the nearby large areas of the dominantly volcanic Nicola group and Cretaceous volcanic rocks that now occupy lesser areas.

The sandstone and conglomerate are generally friable. Normally, the grains are held together by a clayey paste, mostly kaolinite, that forms the matrix, but where the rock is in, or near, contact with younger volcanic extrusions, the grains have been strongly bonded by silica deposited in the interstices of the rock.

The sandy shales and siltstones are commonly massive, lens-like, and sparingly fossiliferous. Where fossils are found, however, they are commonly well preserved. The rock colours are dominantly brownish red and grey. Thick beds of fissile shale outcrop near the southern extremity of the coalfield. They are richly fossiliferous, but are so friable that it is difficult to preserve specimens intact. Beds of impure bentonite occur throughout the formation; two such, both about 15 feet thick, may be of commercial value.

Coal, carbonaceous shale, bone, grey and reddish shale, and thin beds of bentonite are common associates. Thin, lensing coal beds are nearly everywhere in evidence, but thick beds of commercial coal are localized in zones near the middle of the formation. Four such zones have been recognized, and at least one additional zone is indicated. These zones are discussed in detail later.

Except for the zoning of thick coal beds, the Allenby formation does not display great differences in aspect from bottom to top. The coarser pebble-conglomerate appears to be confined to the strata below the lowest known important coal zone, but finer pebble-conglomerate may be found throughout the formation. Thus, no good basis for subdivision, other than the coal-bearing zones, is apparent.

Abundant evidence of baking and burning of the strata of the Allenby formation is available, particularly in the southern half of the coalfield. In places a coal seam, which is reduced to ashes at the outcrop, is found to be in normal condition at some distance down-dip. Sediments of all types are found indurated to an extreme degree in many outcrops of strata that lie at widely separated horizons within the Allenby formation. Other outcrops of strata at the same or other horizons within the formation are unaffected.

It appears certain that the Allenby formation was deformed, truncated by erosion, and cover d over a wide area by lava flows that most probably belonged to the 'Upper Volcanic' formation. Heat generated by these eruptions indurated and burned the underlying sedimentary strata. Later erosion removed most of the volcanic rocks and some of the sedimentary beds, leaving a surface patched with burned and indurated areas of Allenby strata.

The age relationship of the Allenby formation has been discussed by Rice (1947, pp. 30, 31), who provisionally accepted an Oligocene age. Nothing further can be added by the writer. The fossils collected were almost exclusively plant and insect remains, and it seems doubtful that they will change the present age determination which has been made on similar materials. A careful search failed to reveal further mammal remains such as were described by Russell (1935).

'Upper Volcanic' Formation

Lying in a more or less continuous belt that extends along the east side of the coalfield from about 2 miles northeast of Princeton southward beyond the coalfield, is a group of volcanic rocks that appear to lie with structural discordance on the Allenby formation, and, farther east, on the pre-Tertiary rocks. Smaller, disconnected areas are underlain by the same groups of rock at the following localities: (1) at the northern extremity of the coalfield immediately east of Summers Creek; (2) on the western margin of the northern half of the coalfield about 1 mile north of China (Asp) Creek; (3) astride Tulameen River about 2 miles upstream from the town of Princeton; and (4) two small areas on either side of the Princeton-Merritt road about 1½ miles north of Princeton.

Where this volcanic formation is exposed within and at the edges of the coalfield, it is not more than 500 feet thick, but, apparently, thickens southeastwardly toward Wolfe Creek. It is composed mainly of lavas, some of which are banded, and volcanic breccias.

Structure

The regional structural setting of the Princeton coal-field is described by Rice (1947, pp. 52-54). He indicates two major fold axes in the Triassic rocks that enclose the coalfield (Map 889A). A curving synclinal axis extends through a point lying about 3 miles east of Copper Mountain and along the eastern margin of the southern part of the coalfield. An anticlinal axis, with a curvature similar to that of the synclinal axis, extends along the western margin of the coalfield. Thus the area of the coalfield is situated on the eastward dipping limb of the structure indicated in the Triassic rocks.

In the southern half of the coalfield, the structure of the Allenby formation is best illustrated by the accompanying structural contour map (Figure 1B) based on the Princeton-Black coal-bearing zone. Broadly, it appears as a large basin-like structure into which project three large anticlinal noses disposed at random about the periphery. Along the western margin of the southern area the strata dip steeply eastward but flatten gradually toward the central part of the basin.

A broad anticlinal nose trends about south 10 degrees east across Tulameen River at a point about 2 miles upstream from Princeton. The nose pitches south-southeast at 15 to 20 degrees, and loses its identity before reaching Similkameen River. The old workings of the Pleasant Valley Company's mines are wrapped almost completely around the structure, and thus present an accurate outline of it near the outcrop of the Princeton seam. Toward the western flank of the structure several normal faults of small displacement were encountered.

Just south of Allenby, an asymmetric, east-trending anticlinal area is indicated in outcrops along the banks of Similkameen River. The outcrops observed along the railway to the east seem to indicate partial closure of the structure, but its eastward extension is vague. At the river the northern limb of the structure dips as steeply as 67 degrees, whereas the southern limb dips more gently, probably not exceeding 30 degrees. Because the structure will be of considerable importance in future exploitations of the coal reserves in this area, the structure was considered worthy of a name, and the term 'Allenby anticline' is proposed to satisfy the need.

The third, and probably the most poorly defined, anti-clinal nose is located in the southwestern corner of the area. A small structure is indicated in the workings of the Blue Flame mine, and its axis appears to curve from northwest, in the mine area, to more nearly north, with apparent broadening of the structure in this direction. As the Blue Flame seam is thought to lie some distance stratigraphically below the Princeton-Black zone, the highest contours on the latter lie north of the Blue Flame mine area and, therefore, the northwest-trending part of the structure is not shown on the contour map.

The interference of these anticlinal structures within the main basin area has resulted in a rather peculiar configuration that is strongly reminiscent of a dumbbell in plan. The long axis of the 'dumbbell' trends east. For the most part, the strata dip gently toward the deepest part of the structure, but locally, as in the northern flank of the Allenby anticline and in the Bromley-Vale area at the west end of the 'dumbbell', the dips are as steep as 50 to 70 degrees.

In one place, a large well-defined drag-fold was observed. At the intersection of the Hope-Princeton highway and the narrow road leading into the southern end of the Dobey Meadows, a section of finely bedded shales more than 20 feet thick is involved in a sharp, slightly overturned drag-fold whose axis trends about northwest. On the steep northeast flank, the shales are sharply crenulated in a manner similar to that of small shear folds in metamorphic rocks. A smaller, less sharply folded, but otherwise similar structure was observed in similar rocks in the west bank of the Similkameen at a point roughly east from the first locality. It is probable that these structures are more common than apparent. They are known only in the softer, incompetent beds, and in places may be found to involve coal seams. As they appear to be of limited extent they would not seriously hamper mining operations unless a succession of such structures were encountered.

The structure of the northern half of the coalfield (See Figure 2D) is poorly defined by the few outcrops that appear through the thick cover of sand and gravel. In its central and western parts, the strata dip gently eastward. In the region of the United Empire and Red Triangle mines, at the eastern margin of the area, they dip eastward at angles up to 40 degrees. North of the mine area, between Deer Valley and the Princeton-Belfort road, a shallow north trending syncline breaks the apparent regularity of the structure. There is no indication of its extent except that it does not reach the mine area to the south. On the other hand, the strata dipping gently eastward in the Belfort area could represent the west flank of the structure if it extends that far north.

In the Summers Creek area (See Figure 2D) it is of particular interest to note that where the Allenby formation was prospected for coal, the strata strike directly into a narrow area of pre-Tertiary (Nicola group) rocks exposed at similar elevations. South of the area of pre-Tertiary rocks, which is not more than 1,000 feet across, the strata also strike directly into it in conformity with the strata on the north side. No faulting is evident, and it appears that the Tertiary sediments were here deposited around a small ridge on the floor of the Tertiary valley. Examination of the maps reveals several less well defined occurrences where the strata strike directly into pre-Tertiary rocks. Where no faulting has occurred, these relations indicate the irregularity of the surface upon which the sedimentary rocks were deposited.

Geological History

The pre-Tertiary history of the site of the Princeton coalfield is summarized largely from the works of Rice (1947) and Eardley (1951).

Rice (1947, p. 55) believes that marine conditions persisted through at least part of Carboniferous time, and that similar conditions of deposition existed in Upper Triassic time. The intervening period has not been recognized in the rock record. The marine sedimentary strata are intercalated with volcanic rocks, which are preponderant in the Upper Triassic, Nicola group.

Sedimentary rocks of definite Jurassic age are not known in the vicinity of the Princeton coalfield, but widespread intrusive rocks of that age mark a period of intense igneous activity. At this time the Princeton area was situated near the western edge of a belt of deformation, termed by Eardley (1951, Plate 13) the "Nevadan Orogenic Belt". Eardley indicates that a basin of Jurassic deposition existed immediately west of this belt.

Eardley (1951, Plate 15) indicates that a similar relation held through Lower Cretaceous time with only a small eastward shift of the western edge of the orogenic belt. This seems to agree with Rice's deductions (1947, p. 55) concerning the Dewdney Creek group (earliest Lower Cretaceous), which he indicates was laid down at the edge of a shallow marine basin. Evidence of nearby vulcanism is attested by the great accumulation of volcanic fragmental material within the Dewdney Creek group.

Late Lower Cretaceous sedimentation is represented by the great thickness of the non-marine Pasayten group, which also includes large quantities of volcanic material. The Pasayten group lies unconformably on the Coast intrusions (Jurassic) and thereby records extensive erosion, which must have preceded early Cretaceous time in order to unroof the granitic rocks, which presumably were emplaced at considerable depth.

The Pasayten sedimentary rocks are exposed in a north-northwest trending belt lying southwest of the site of the Princeton coalfield. In a belt paralleling that of the Pasayten strata and lying across the site of the Princeton coalfield is a thick sequence of dominantly volcanic rocks that includes the late Lower Cretaceous Spence Bridge and Kingsvale groups (Rice, 1947, Map 888A). Both groups appear to be closely related in age to the Pasayten group and are probably in part contemporaneous. Thus, volcanic activity is indicated across the site of the Princeton coalfield in early Cretaceous time while non-marine sedimentation persisted to the southwest.

There is no record of Upper Cretaceous sedimentation, but intrusive activity is marked by the Otter and Lightning Creek intrusions, which appear to be concentrated along the same trend as the early Cretaceous volcanic belt, thus suggesting a possible relationship.

Eardley (1951, Plate 16) indicates that the "Nevadan Orogenic Belt" was subject to epeirogenic uplift during late Upper Cretaceous times, and that a region, including the site of the Princeton coalfield, was subject to erosion while a narrow basin of deposition persisted in the area lying along the present site of the Strait of Georgia on the Pacific Coast.

Thus, it appears that, following Lower Cretaceous time, no sediments were deposited in the region of the Princeton coalfield until the deposition of the Allenby formation in about Oligocene time. During the long erosion interval, more or less continuous uplift promoted the formation of wide, deep valleys. Present knowledge of the Tertiary sediments is such that the individual areas cannot be linked in a reconstruction of the valley system. The occurrence of thick lava flows conformably beneath the Allenby formation suggests a cause and effect relationship. It seems highly probable that alluviation was initiated through damming of the valley by the lava flows. However, this process seems inadequate to account for almost 4,000 feet of sediment, and it is probable that later regional subsidence brought about the backfilling of the valley system.

As the valley bottom was aggraded, a wide flood plain was formed and over its broad flat surface the main river channel meandered among swamps, lakes, and levees. A luxuriant plant growth supplied vast quantities of vegetable debris, which accumulated in the bogs and lakes; some was piled up by the stream in irregular masses and great quantities were washed away to the lower reaches of the river. Where the accumulations of vegetable material were protected from oxidation by a water cover and, finally, were buried safely out of reach of the erosive power of the shifting stream channel they form our present coal deposits. The size, shape, and distribution of the coal beds depend entirely on the characteristics of the environment of their deposition. In this instance they may be expected to be irregular, lensing, in places extremely thick, and commonly without great areal extent. Detailed exploration to outline workable deposits must proceed with due recognition of the inherent irregularities that accompany this type of deposit.

The flat-lying 'Upper Volcanic' formation of Oligocene or early Miocene age lies unconformably on the folded strata of the Allenby formation, thus recording a period of deformation and extrusive activity. Most of these volcanic rocks have since been eroded, leaving patches scattered over the area of the coal basin.

COAL DEPOSITS

Introduction

The coal beds of the Princeton coalfield occur entirely in the Allenby formation. The coal ranges in rank from lignite to sub-bituminous "A" (A.S.T.M. classification). When freshly exposed it is black, and breaks with a rectangular, blocky and subconchoidal fracture. When exposed to the air, the coal slacks readily because of its high moisture content, which ranges up to 20 per cent. The ash content of the mineable coal ranges from as low as 4 per cent upward to the allowable limit under the particular mining conditions. The sulphur content is enerally low, the few available analyses showing less than 1 per cent.

Outcrops of coal beds of varying thickness and quality are widely distributed over the area of the coalfield, but workable coals have been found only in the southern half of that area. For practical purposes the Princeton-Coalmont road affords a convenient line along which to separate the productive southern area from the non-productive northern part of the coalfield. It is also a convenient boundary line between the areas covered by the large-scale maps, and accords with earlier divisions (Hughes, 1947).

The stratigraphic position of the rocks in the northern area, relative to those of the south, is not clearly understood because of the lack of sufficient outcrops on which to construct anything but short sections, separated by wide intervals where no structural information is available. The sections observed gave little indication that workable coal seams exist in the north. The southern area provides much more information concerning the structure and sedimentation of the strata known to include several coal-bearing zones in which mineable coal has been found. The study was directed primarily toward assembling and interpreting the information provided by surface outcrops, bore-holes, mine workings, etc., in order to lay a basis for further exploratory and development work in this more promising area.

Before presenting the facts and interpretations relating to the individual coal-bearing zones, it will be necessary to acquaint the reader with the more important limitations placed on this study. As described in the introductory pages, each coal-bearing zone is selected for separate treatment on individual maps. In this regard it is important to remember that the inclusion of each coal section is dependent on the validity of the correlations, which, in this coalfield, are commonly made over long distances. Within the coal zones in the Princeton coalfield, paucity of information and a high degree of variability in the coal beds allow only the broadest interpretations. Indeed, although it seemed possible to correlate coal-bearing zones from place to place, in no case can any one seam within a zone be definitely correlated over a large area unless actually connected by mine workings.

It is apparent that thick, workable coals, though highly variable, do exist within definable coal-bearing zones, and that these zones could be explored by shallow bore-holes and crosscuts, in conjunction with the mining of any one coal bed within the zone. If such exploration were done during development work, a sufficiently large reserve might be outlined in advance to permit continuous operation when the particular coal bed being mined became non-commercial.

Actual mining and exploratory work have been confined largely to the northern end of the southern coal area, with the exception of one mine, which is located on Lamont (Nine Mile) Creek at the southern extremity. The latter operation was confined to a zone whose stratigraphic position, relative to the coal-bearing zones mined at the northern end of the southern area, is uncertain. Several poorly exposed coal zones were located on Similkameen River at the southeastern extremity of the southern area and also farther downstream in the vicinity of Allenby, which occupies an east-central position in the area. Where the structure could be determined approximately, a vague correlation was suggested by the stratigraphic spacing of these coal-bearing zones, and it appears that these zones may be continuous for long distances and that some may persist over the entire southern area. It is certain, however, that a reliable correlation cannot be made over large areas of the coalfield on the basis of presently available information and, if the economic possibilities of the field are to be adequately determined, a program of core-drilling will be essential[1].

A suggested drilling program is outlined on the accompanying maps. The bore-hole locations have been controlled by the necessity for well distributed information on a given coal zone, and each of the holes is designed to cut a stratigraphic section sufficiently long to verify the correlation at each point.

Southern Area

Correlation of Coal Zones

In the vicinity of the town of Princeton it was possible to construct a reliable columnar section relating the various coal zones (See Figure 1c). Four zones, each containing coal seams of workable quality, lie within a stratigraphic interval of about 1,700 feet. The known commercial seams within these zones are, from the lowermost up, the Princeton, Pleasant Valley (or Princeton No. 2), Gem, and an unnamed seam intersected in Blakemore's bore-hole No. 2.

In the Bromley Vale area, lying about 5 miles west-southwest of Princeton, a second columnar section was constructed relating the four coal zones that were mined or prospected in that area (See Figure 1c). The known seams within these zones are, in order upwards, the Black, Jackson, Bromley Vale, and Golden Glow (or Bromley Vale No. 2).

The coal zones thus defined in the vicinity of the town of Princeton could not be traced around the syncline separating the town area from the Bromley Vale area because of the lack of structural data. However, an acceptable correlation is indicated from a comparison of the columnar sections as illustrated on Figure 1c.

It is notable that the stratigraphic intervals between the coal zones in the town area closely match the intervals in the Bromley Vale area. In view of the type of control probably exerted on the sedimentation in the Princeton coalfield—backfilling of a Tertiary valley without significant differential subsidence within the area of deposition—parallelism is to be expected, and will form the basis for further correlations as more information is acquired.

When considered individually, the coal zones of one area bear little detailed resemblance to their equivalents in another. However, some general resemblances are notable. For example, in the town area, the coal zone containing the Princeton seam is much the thickest and in the Bromley Vale area the coal zone containing the Black seam bears this same relation to the others to an even

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[1] The difficulty, or impossibility, of recognizing lithological horizons in the Allenby formation, except through the correlation of coal seams, is a feature that should constantly be borne in mind in any drilling program.— Ed.

greater degree. The coal zone containing the Jackson and Pleasant Valley seams is indicated as containing more coal in the Bromley Vale area than in the town area, but this may be more apparent than real because this zone has not been adequately explored in the latter area. The coal zone containing the Gem and Bromley Vale seams appears to be relatively restricted in coal content in both areas, and the same is true for the coal zone containing the Golden Glow seam and its equivalent or near-equivalent in the town area.

In the following detailed discussion of the various coal zones each will be named after the important seams that it contains; for example, the zone containing the Princeton and Black seams will be referred to as the Princeton-Black coal zone. When knowledge of the coalfield is such that correlations are definite, a less cumbersome nomenclature may then be introduced, but for the present it is desirable to use the more descriptive terms.

Princeton-Black Coal Zone

Description. The coal-facies map that accompanies this report (Figure 2A) illustrates all the recorded information relating to areas worked, seam measurements, etc. It is apparent that the seams worked are only parts of a thick coal zone that has been extensively exposed at only two points, namely, at the Princeton No. 1 Colliery and in the Granby Company strip-mine. A description of the strata cut in the Cross-measures tunnel driven at the Pleasant Valley No. 4 mine to intersect the coal zone from above was not available. However, it seems that no great amount of coal was found above the seam that was worked.

The writer was informed orally, and by qualitative descriptions in the mine reports, that in all the mines exploiting the Princeton seam in the town area a thick section of dirty coal lay below the mineable part. It would appear, then, that the mineable part occupies a comparable position within the coal zone from the Princeton No. 1 mine westward to the Pleasant Valley No. 2 mine, and is probably more or less equivalent over that area. In places where thinning is indicated in the illustrated sections, as in the Pleasant Valley No. 4 mine and the Tulameen No. 3 mine, it is not known whether this is due to actual thinning or to selection of a suitable part of the seam for mining. It is doubtful, too, whether any partings or set of partings can be traced far, and, in the absence of more complete descriptions of the coal zone, nothing further can be added in so far as detailed correlation is concerned.

The most complete section of the coal zone is exposed in the Granby strip-mine, where several thick seams of varying degrees of purity are contained within a section measuring about 120 feet thick. The coal zone there is obviously much thicker than that observed in the town area, and there is no indication as to what part of it might be equivalent to the smaller section noted in the latter area. No recognizable exposures of the coal zone occur south of those described. Although it seems possible that the Blue Flame mine on Lamont Creek may be operating in this coal zone, the available data are best interpreted as indicating that the Blue Flame coal occupies a position several hundred feet stratigraphically-below the Princeton-Black coal zone.

Bore-holes drilled in the southern area have given little information regarding the coal zone. Only three holes, all at shallow depth (See Figures 1B, 2A) have encountered any part of the coal zone, and these were not located so as to furnish added information regarding its lateral extension.

A structure-contour map was prepared for the Princeton-Black coal zone (See Figure 1B). Contours are drawn on the pavement of the mined part of the zone in the town area and, in the Bromley-Vale area, the pavement of the seam second from the top of the section (8 feet 6 inches thick) was used. The vertical interval is 100 feet, and the relative precision of the contours in various places is indicated by the type of line.

The structure is readily visualized from the contours, and the important features related to mining will need little description. It is notable that no faults of large displacement are apparent, and over wide areas the dip of the strata is sufficiently low to present no great difficulty in mining. The most significant structure, from the standpoint of prospecting in the region south of the town area, is the Allenby anticline, which brings the Princeton-Black coal zone close to the surface along its crest. Provided that mineable coal were found in this area, the gently dipping southern limb of the anticline would furnish a suitable structure for mining. The position of the outcrop of the zone along the southern extremity of the coalfield is uncertain, as the structure in this region is highly speculative.

Summary and Recommendations. That the Princeton-Black coal zone contains a large proportion of coal is shown by the Granby strip-mine section and the section measured at the Princeton No. 1 mine. The coal seams within the zone appear to form broad, discontinuous lenses, and, consequently, the zone should be systematically explored within the area being mined in order to locate the highest quality coal.

It seems assured that the Princeton-Black coal zone is continuous across the northern margin of the area; farther south, it may underlie an area of more than 25 square miles. However, as the coal zone is not definitely recognizable in outcrop anywhere in the latter direction, and in order that systematically spaced data may be obtained, a series of six bore-holes has been proposed. These bore-holes will provide the necessary data on the structure and continuity of the coal zone and thus lay the framework for the more detailed investigation required for selection of actual mine locations. The locations of the proposed bore-holes are illustrated on the coal-facies map (Figure 2A) and on the structural contour map (Figure 1B). A summary of the pertinent data relating to each proposed bore-hole is given near the end of this report.

Pleasant Valley-Jackson Coal Zone

Description. The coal-facies map for this coal zone (Figure 2B) will serve to illustrate the available information that is considered reliable in so far as the actual coal content of the zone is concerned.

In the town of Princeton area, a thin coal seam was mined at the Pleasant Valley No. 1 mine. The seam is described in a mine inspector's report as "a fairly thick seam of coal and the lower section is intersected with several bands of shale, fireclay, and bone, with the result that the operations are confined to the upper section, which averages from 3 to 4½ feet in thickness of good clean domestic coal overlaid by a fairly good shale roof" (B.C. Dept. of Mines, Ann. Rept., 1930, p. A406). It appears, therefore, that the seam mined there is part of a much thicker coal zone. Nowhere in the town area is there a wide exposure of the coal zone, but components of it are probably represented in sections of interbedded thin coal seams and shale at: (1) the railway cut 350 feet southwest of a railway bridge crossing Tulameen River just west of the tunnel under the main highway south of the town; (2) the east bank of Tulameen River 800 feet north of the same railway bridge; and (3) the east bank of Similkameen River opposite the swimming pool at the southeastern extremity of the town. The sections at these points are illustrated on an enclosed map (See Figure 2D) showing the various sections that could not be closely correlated or that belong to an unimportant coal zone. The above locations are indicated by localities 20, 21, and 18 in the same order.

In the Bromley Vale area, more complete details of the coal zone are available. Two mines, the Jackson and the Taylor-Burson, have operated seams within this coal zone, and by tunnelling and exploratory crosscutting have exposed a large section of the coal zone. Although these mines are less than 2,000 feet apart, it could not be ascertained whether they had mined from the same coal bed, but if so several feet of coal lying about 7 feet below the Taylor-Burson seam must be correlated with a barren section below the Jackson seam. A more acceptable interpretation might be to correlate the Jackson seam with the coal bed lying below the Taylor-Burson seam, for it is notable that above the Taylor-Burson seam there is a section of interbedded coal and shale at least 45 feet thick. The lowest seam observed in this coal zone was in the tunnel of the Jackson mine, where about 2½ feet of clean coal, interbedded with dirty coal and shale, lies about 45 feet stratigraphically below the pavement of the Jackson seam.

The Pleasant Valley-Jackson coal zone lies near the surface or is actually truncated by erosion where Similkameen River crosses the axis of the Allenby anticline (See Figures 1B, 1C). Several sections of coal-bearing strata were observed on both limbs of the structure, but their stratigraphic positions could not be accurately determined. It appears probable that the lower sections of interbedded shale and thin coal seams may be correlated with the upper part of this coal zone. South of the Allenby anticline, the coal zone was nowhere recognizable. Where its position had been estimated from structural data there were no exposures to either verify or disprove the projection, and no bore-holes are known to have intersected the coal zone.

Because the data do not warrant the construction of a structure-contour map of the coal zone, reference is made to the map (Figure 1B) of the underlying Princeton-Black coal zone. The stratigraphic interval between these zones is about 450 feet, and t the interval between individual coal seams in them will vary, depending on which seams within the coal zones are being compared. The elevation of the Pleasant Valley-Jackson coal zone at a given location may be easily calculated from the stratigraphic interval and the dip of the strata at that locality. The structural characteristics considered for the Princeton-Black coal zone are generally applicable to this coal zone.

Summary and Recommendations. The Pleasant Valley-Jackson coal zone is best represented in the Bromley Vale area, where it contains two or possibly three seams of workable thickness within a total observed stratigraphic interval of about 100 feet. In the vicinity of Princeton only one seam of workable thickness is known, but there are no records to indicate that the coal zone has been adequately explored; as in the case of the Princeton-Black coal zone, it may well be continuous under a wide area stretching southward, but no information in that direction bears directly on the content and quality of the coal within the coal zone. The bore-holes proposed to test the Princeton-Black coal zone, with the possible exception of proposed bore-hole C, are designed also to intersect the Pleasant Valley-Jackson coal zone. Bore-hole C, because of its position near the crest of the Allenby anticline, could miss the coal zone, which may have been eroded from the crest of the structure.

Gem-Bromley Vale Coal Zone

Description. The coal-facies map (Figure 2C) illustrates the data obtained from measurements on seams within the coal zone.

In the vicinity of Princeton, a thin seam of coal was worked to a limited extent in the Gem mine, which operated during 1921, 1922, and 1929. The writer had the workings drained during the field season in order to procure the measurement of the coal seam shown on the coal-facies map. Blakemore's bore-hole No. 2 (No. 6 on figures) intersected a thick seam between depths of 665 feet 8 inches and 676 feet 3 inches. As recorded, the seam consists of 9 feet 8 inches of coal split by a 5-inch band of shale at 3 feet 11 inches above the pavement of the seam. An analysis of the coal was not made, so there are no data on the quality of the coal found in the bore-hole. Because this seam is directly on the line of projection of the Gem seam it is considered to lie within the same coal zone and may be continuous with the Gem seam itself; in view of the irregularity characteristic of all the seams, a definite correlation is unwarranted.

In the Bromley Vale area, the Granby Company's No. 1 mine exploited a section of the coal zone. Their workings exposed a coal-bearing section about 16 feet thick, of which only the lower 6 feet proved suitable for mining (See Figure 2C). Former officials of the mine stated that the coal deteriorated and became too dirty to mine at the northern extremity of the workings. Sharp's bore-hole (No. 11 bore-hole on Figures 1B and 2C) intersected the zone at a depth of 536 feet, and passed through a succession of seams to 630 feet. The record is too generalized to be of value in determining the actual nature of the seams, and the thicknesses of strata intervening between the seams are not recorded. However, a zone of coal-bearing strata about 85 feet thick is indicated. South of these areas, the coal zone was not identified at the surface.

The structure of the Gem-Bromley Vale coal zone can be interpreted from the structural contour map for the Princeton-Black coal zone (Figure 1B), used in conjunction with the stratigraphic interval between the coal zones, which averages about 1,200 feet.

Summary and Recommendations. In the town of Princeton and Bromley Vale areas, the Gem-Bromley Vale coal zone contains seams of workable thickness and quality, but they cannot be correlated individually across the intervening area. The maximum known thickness of coal was intersected by Sharp's bore-hole on Bromley Creek, which recorded about 25 feet of coal in a stratigraphic interval of about 85 feet. Considerably less coal is known within the coal zone in the town area. Lack of information leaves open the possibility that the coal zone is continuous over the large area to the south.

As indicated on Figure 2G, proposed bore-holes A. B. D, and F are designed to intersect the Gem-Bromley Vale coal zone in conjunction with exploration for the two underlying coal zones.

Golden Glow Coal Zone

Description. A coal-facies map was not constructed for this coal zone because the available information did not warrant it.

Mining in this coal zone was confined to the Bromley Vale area where the Granby Company's No. 2 mine (See Figure 2D, locality M15) developed it for a short distance. A seam was entered from the south bank of Bromley Creek at a point about 850 feet downstream from the tunnel mouth of the Granby No. 1 mine. About 800 feet northeast of the mouth of the No. 2 mine, a short prospect slope, called the Golden Glow mine, was driven westward to intersect the same seam from above, but little development was done on the seam, which apparently proved too dirty to exploit. These appear to be the only attempts to work the seam. The section of the seam, as recorded on the Granby No. 2 mine plan, is as follows:

	Feet	Inches
Coal	2	4
Bentonite		½
Coal		10
Shale		3½
Coal		7
Shale		2
Coal	1	10
Total thickness of coal ...	5	7

Sharp's bore-hole (bore-hole No. 11 on Figure 1B), located about 150 feet downstream from the mouth of the Granby No. 2 mine, cut this seam, and the record indicates that three thin seams underlie it within an interval of about 18 feet. Thus, an aggregate thickness of about 10 feet of coal is contained with a total stratigraphic interval of about 24 feet.

In the town of Princeton area, the record of the Blakemore No. 2 bore-hole (No. 6 on Figure 1B) indicates that 7 feet 6 inches of coal was intersected at a depth of about 225 feet. No coal is indicated either above or below this seam within a distance that would warrant including it in a zone with the latter seam. It would appear from the record that a rather thick coal seam, uninterrupted by shale or bentonite beds, occurs here. Because, in some instances, these bore-hole records appear to have been greatly generalized, it would be well to retest this occurrence. The seam appears to be the only one that can be correlated with the Golden Glow seam of the Bromley Vale area. As the seam has not been named in the town area, the zone is termed the Golden Glow coal zone.

In ascertaining the approximate structure of the coal zone, the structural contour map for the Princeton-Black coal zone (Figure 1B) should be consulted. The stratigraphic interval separating the zones averages 1,630 feet.

Summary and Recommendations. Little information is available on the continuity of the Golden Glow coal zone, and further evaluation of its coal content must await more data. Proposed bore-holes A and B are designed to intersect the coal zone, and possibly D and F will cut it at shallow depths. The structure in the vicinity of the locations for D and F, and the surface elevations, are known only approximately, so it cannot be certain whether or not these bore-holes will cut the coal zone.

Other Coal Occurrences

Several coal occurrences other than those previously mentioned were examined, but, because of uncertain structure and limited sections, their stratigraphic positions could not be determined. Most of these occurrences are illustrated on the map of miscellaneous coal-bearing sections (Figure 2D). Because some of these may represent components of the important known coal zones or components of unknown coal zones that may contain coal of commercial value, those that appear most significant will be discussed. Even those containing small seams of coal may, however, be of some importance in correlating sections obtained from future drilling. Each occurrence will be discussed by locality whose number corresponds to that shown on Figure 2D.

Locality M 14, Blue Flame Mine. Here a coal-bearing zone 31½ feet thick is exposed. Mining was confined to about 8½ feet of this section, slightly below the middle of the coal zone. An analysis of the coal is not available, but it has been described by many as the best coal in the Princeton coalfield. It is believed that the dirty part of the mined section of the seam may be discontinuous, but the area available for examination was limited. The measurements above and below the mined part of the seam were submitted by Mr. James Fairley who is conducting the reclamation of formerly abandoned pillars for the Taylor-Burson Coal Company. During October and November 1951, he obtained the information for the writer from roof cavings and small faults, which brought a more complete section into view.

The old workings of the Blue Flame mine are wrapped around the northwesterly plunging nose of a gentle anticline. Surface prospecting with a bulldozer was successful in tracing the outcrop eastward beyond the workings to the Hope-Princeton highway. Further projection of the outcrop appears to link the seam with a coal-bearing section noted at locality 1. Only thin seams are now exposed, but prospectors claim that much thicker coal seams were exposed in the bed of the river near this latter locality.

The stratigraphic position of the Blue Flame seam is uncertain. If the southward projection of the Princeton-Black coal zone is approximately correct, the Blue Flame seam lies at least 1,000 feet below that zone. At locality 2, a section of weathered dirty coal is exposed. It is possible that this may represent a component of the Princeton-Black coal zone, and, if so, the contours as shown would have to be adjusted downward (See Figure 1B). However, the basis of correlation is much too extended to allow any definite conclusion.

Localities 7, P2, 11, and 12, Allenby Anticline Area. A series of coal-bearing sections is exposed around the westerly plunging nose of the Allenby anticline. At locality P2, Elmer Burr prospected a coal seam on the west bank of Similkameen River southwest of Allenby. The seam proved too dirty to be mineable, but is significant in so far as it may constitute a component of a larger coal zone, possibly one of those already identified. On structural evidence alone, the seam found at locality P2 appears to correlate with the thickest seam exposed at locality 12 and with the seam exposed at locality 7. This seam lies about 600 feet above the Princeton-Black coal zone as contoured. Thus, it coincides closest with the Pleasant Valley-Jackson zone, and, if the contours are approximately correct, would lie near the upper part of the latter coal zone.

Localities P3 and 13. The coal-bearing sections at these localities are either identical or closely related. At locality P3 the coal was prospected by a short adit, but the coal was much too thin and dirty to be mined. The seams represented at these localities are significant in so far as they are stratigraphically the highest known occurrences of coal in the southern area.

Northern Area

General Statement

Most of the northern area of the Princeton coalfield is covered with a thick mantle of sand and gravel, and exposures of the Allenby coal-bearing formation are strictly limited. Coal is known to occur in five localities: (1) China (Asp) Creek; (2) Ashington mine; (3) Summers Creek; (4) Deer Valley; and (5) United Empire and Red Triangles mines on One Mile (Allison, Hunter) Creek. The latter three occurrences could not be related to the first two, but the stratigraphic positions of the first two can be readily related on a structural basis to the strata of the southern area.

A series of specialized maps was unwarranted in view of the restricted data. One map (Figure 2D) is presented showing the area underlain by the Allenby formation, the location and attitude of outcrops, the mines and prospects, and the details of the coal-bearing sections. The coal occurrences will be discussed individually.

China (Asp) Creek

A coal-bearing section, about 16 feet thick, is exposed in the south bank of the creek about 1,200 feet upstream from the Princeton-Coalmont road. The section contains about 6 feet of dirty coal concentrated near the base (See Figure 2D, locality P6). A short adit, now completely caved, was driven into the outcrop many years ago, but no information on it has been preserved. As calculated from a structure-section along the creek, this coal occurrence lies about 350 feet stratigraphically below the Princeton seam, and is probably correlative with the coal-bearing section encountered near the bottom of bore-hole No. 1. The log of the latter bore-hole notes that 4 feet of clean coal is contained in a coaly section totalling 8 feet. It does not say how this 4 feet of coal was distributed in the section, so its value remains doubtful.

Ashington Mine

A level adit was driven northward into the hill immediately northwest of the bridge crossing Tulameen River at Princeton (See Figure 2D, locality M 16). At 280 feet, the adit cut 6 feet of dirty coal dipping 15° south. (B.C. Dept. of Mines, Ann. Rept. 1929, p. 477). The adit was continued across the strata for 700 feet, and at this point a bore-hole was driven down 300 feet (B.C. Dept. of Mines, Ann. Rept. 1930, p. 400). These operations would have explored a total stratigraphic section of about 468 feet, of which 397 feet is below the 6-foot bed of dirty coal. From a projection of the structure, this 6-foot seam, known generally as the Ashington seam, correlates best with the section of dirty coal encountered in bore-hole No. 1 at 102 feet 3 inches. The bore-hole driven from the end of the adit in the Ashington mine should have cut the dirty seam exposed on China Creek but, as a log of the hole was not preserved, it provides no information regarding that seam. It may be concluded, however, that workable coal does not occur in this locality within the section tested. The only plan of the mine available to the writer shows a level driven about 450 feet westward in the Ashington seam, and it is reported by Hughes (1947, p. 672) that a very small tonnage of poor quality coal was extracted.

Summers Creek

Three adits were driven in the east bank of Summers Creek about 1½ miles upstream from its mouth (See Figure 2D, locality P 9). The work was done by E.N. Freding and associates from Princeton some 20 years ago. Coal is not exposed at the surface, and optimistic reports concerning the coal intersected by the various adits led the writer to dewater the main adit for inspection. Three sections of coal-bearing strata were found. In each the intimate association of coal with coarse, crossbedded sandstone, and the obvious irregularity of the coal indicate that the vegetable material that formed the coal was deposited in stream channels. Although it is entirely possible that lenses or pockets of coal of workable size may be found, the irregularity attendant upon this type of deposition warrants little optimism.

Deer Valley

A small creek that enters Deer Valley at its northern extremity has cut a small gorge through a gently westward dipping series of coaly shales and thin, dirty coal seams (See Figure 2D, locality 22). Scattered exposures farther upstream expose mainly coarse sandstone and pebble-conglomerate. At least 40 years ago, an adit was driven into the east wall of the valley (locality P8) in search of coal. No records of the operation have been preserved, but older mining men say that the adit was driven through the sedimentary rocks for about 1,000 feet and was abandoned when the volcanic rocks of the Nicola group were encountered. It is said that the strata dip eastward into the contact; this could not be confirmed at the surface because the attitudes measured along the contact in this area appear to be variable, suggesting minor faulting or slumping.

Westward from Deer Valley, the strata lie in a broad open syncline, and if workable coal is associated with the fine-grained beds referred to above, the latter structure would provide easy access. It was noted that only thin, dirty seams outcrop along the creek, and the sequence is underlain, so far as can be determined, by coarser strata. However, as the rocks overlying the fine-grained coaly strata are not exposed, the section might well be much thicker and conceivably contain coal in a workable deposit.

United Empire and Red Triangle Mines

An outline of the history of this property is given by Rice (1947, p. 127). The United Empire mine is reported to have worked two seams, the lower and upper in the section measured by the Inspector of Mines (B.C. Dept. of Mines, Ann. Rept. 1913, p. 381) and illustrated on the accompanying map (See Figure 2D, locality M 17). There is no information on the quality of the coal. The mine plans available to the writer could not be oriented accurately, as some of the portals were not readily identifiable and accurate bearings were not shown. Thus, the exact relation between the workings of the Red Triangle and United Empire mines is not known. The Red Triangle adit is reported to have cut the older United Empire workings, but the point of intersection is also not known. As nearly as can be determined, the Red Triangle mine worked the upper seam; it produced a small tonnage from the upper 5 feet of the seam, which was reported to be fairly good.

The writer measured two coal-bearing sections at these mines. One was obtained in an adit high on the hill above, and 300 feet east of, the slumped portal of the Red Triangle mine (See Figure 2D, locality M 18). The adit was easily opened, and the section shown on the accompanying map was measured. It is possible that the two prominent concentrations of dirty coal correlate with the lower and middle coal seams indicated on the section measured in the United Empire mine (locality M17). If so, the lower seam, which was mined in the United Empire mine, has deteriorated. The other section was measured in an adit (locality P 7) that enters the hill at a point about 400 feet southeast of the United Empire mine portal. A heavy fall has blocked this adit about 150 feet in from the portal, so a section was measured back from this point and illustrated on Figure 2D. The coal-bearing zone exposed in the adit is more than 30 feet thick, but contained only thin, dirty coal seams. It is notable that this coal-bearing zone is underlain by a thick bed of interlensing, coarse sandstone and fine conglomerate, in the same manner as the section exposed in the other adit. In detail, however, the coal-bearing zones bear little resemblance, and their correlation is very uncertain.

Summary and Recommendations

The dearth of both outcrop and subsurface information makes this northern area extremely difficult to evaluate. Among the five known occurrences of coal, only one has been mined and even there the coal is of poor quality and is restricted in distribution.

If the few outcrops found in the area are representative, it appears that a thick section of strata, dipping gently eastward, extends midway along the area from Summers Creek, where it abuts the Nicola group rocks, southward to a point opposite the United Empire-Red Triangle area. The outcrops along this belt are lithologically indistinguishable from those of the southern area, and although little coal has been observed, the apparently thick section of relatively unexplored strata offers the possibility of coal in commercial deposits. Drilling would be the most effective way of determining the possibilities, and a bore-hole near the eastern edge of this apparently monoclinal belt should be adequate as a preliminary test. Probably the best location would be on, or immediately west of, the Princeton-Belfort road at a point midway between the United Empire-Red Triangle area and the Belfort railway station. If the inferred structure is correct, and if the strata overlap the basement rocks, the drill may enter the basement within a short distance. The actual distance will depend upon the angular relationship between the bedding and the wall of the original valley. If the results are encouraging, the remaining section can be explored by stepping westward at suitable intervals.

The shallow syncline that trends north between Deer Valley and the railroad may be worth testing. As noted earlier, a section of coal-bearing strata was observed in the east limb of the structure, which is partly exposed in the small creek at the head of Deer Valley. A test in this area would probably be best located between 500 and 1,000 feet west of the creek.

Summary of Proposed Exploratory Drilling

The field study of the Princeton coalfield by the writer does not provide sufficient factual data on which to evaluate its coal reserves as an aid to prospective mining. As this is the ultimate purpose of the investigation it remains incomplete, the inconclusiveness of the results being attributable mainly to sparse and poorly distributed surface exposures of the coal-bearing beds and limited subsurface data, such as bore-hole records, mine records, etc.

The significant issues that have been resolved relate to the adequacy of past exploration in testing the complete stratigraphic section; zoning of the coal-bearing strata; correlation of coal zones; probable areal extension of the coal zones; and their structural configurations. These factors have been evaluated in terms of their significance to future mining operations, but it is emphasized that further exploratory subsurface work is necessary if this study is to be brought to the point of practical usefulness.

Accordingly, a drilling program has been drawn up which, it is hoped, will provide an adequate framework on which the structure and areal extent of the various coal zones may be more accurately determined. It is highly probable that some coal zones may be found to contain better coal seams than are presently known, and it is possible that hitherto unknown but important coal zones may be discovered. It is not intended that this program will obtain the detailed data required for spotting a mine operation, but rather that it will serve to delimit the areas most favourable for the necessary detailed work that normally precedes selection of a mine site.

A summary of the data pertinent to the proposed bore-holes is given in Table II, which may be used for a rough estimation of costs, etc. The positions of the various holes are indicated on the structural contour map (Figure 1B). In considering the depths estimated for the various bore-holes, the relative precision of the structural contours and surface elevations should be kept in mind. Most of the proposed drill-sites are readily accessible by truck; their precise locations are not critical, and can be varied by as much as several hundred feet in adapting them to the convenience of the drilling operation, but where possible any such shifts should be made in the direction of the strike of the rocks.

It is to be noted that a specific drilling program has been drawn up for the southern area only. Present lack of knowledge of well-defined coal zones or promising occurrences in the northern area place it in a position of secondary importance. However, it does include a thick section of unexplored strata, and it is entirely possible that this contains significant coal-bearing zones. It is suggested that such a possibility be tested if facilities are available after work in the more promising southern area is completed.

Summary of Data on Proposed Bore-holes

Proposed bore-hole	Coal zones to be tested (in descending order)[1]	Elevation Princeton-Black coal zone	Surface elevation	Total depth	Dip of strata
		Feet	Feet	Feet	Degrees
A	GG; G-BV; J-PV; P-B	300	2,220	1,920	5 - 10
B	GG; G-BV; J-PV; P-B	600	2,840	2,240	20 - 30
C	P-B; BF[2]	2,125	* 2,500	1,400	10 - 20
D	G-BV; J-PV; P-B	900	* 2,200	1,300	10 - 20
E	P-B; BF[2]	2,500	* 2,900	1,500	20 - 30
F	GG; G-BV; J-PV; P-B	1,000	* 3,200	2,200	20 - 30

* Surface elevation estimated from small scale maps - hence approximate only.

1 Abbreviations: GG, Golden Glow; G-BV, Gem-Bromley Vale; J-PV, Jackson-Pleasant Valley; P-B, Princeton-Black; and BF, Blue Flame.

2 It is not certain that BF is a separate zone - See text re. BF.

NOTE. It may be stressed that the proposal to drill these six holes in the southern part of the field constitutes a minimum initial program. Anything less could not supply the 'framework' that is necessary before more detailed investigations can be undertaken effectively and with due regard to costs.

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