CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH

GEOLOGICAL SURVEY

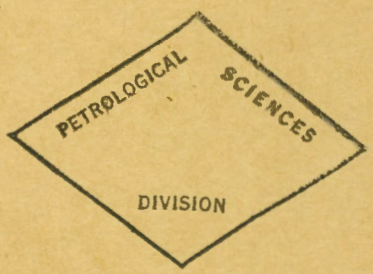
PAPER 45-11

ENTRANCE MAP-AREA, ALBERTA

(Report and Map)

BY

A. H. Lang



OTTAWA

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Illustration

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INTRODUCTION

Entrance map-area (latitudes 53°15'-53°30', longitudes 117°30'-117°45') includes 180 square miles in that part of the Foothills Belt drained by Athabaska River. The area is crossed by the main line of the Canadian National Railways and the Edmonton-Jasper highway, from which a short branch road leads to Entrance, a small but busy outfitting centre for pack-trains travelling north into the country between Athabaska and Smoky Rivers.

Automobiles cross the Athabaska near Entrance on an abandoned railway bridge, whence poor roads lead westward to Brûlé, northwestward toward Hay River, and northeastward to the Athabaska Ranch. From this ranch a logging road that is passable in dry weather extends beyond the east boundary of the map-area. North of Athabaska River the area is timbered, chiefly by poplar and scattered jackpine, and can be travelled without great difficulty on foot or horseback, although there are many large muskegs to be avoided. A good forestry trail extends southeastward from Hinton and follows the crest of High Divide Ridge. The southernmost part of the area is difficult to travel because of the few trails, the rugged topography, the dense stands of spruce and jackpine, and much windfall.

For several years the area has been the scene of small-scale coal mining, and it is part of the large Foothills region that is now being investigated for oil. In 1944 a well was being drilled at Coalspur, 20 miles southeast of the Entrance area, on a structure that crosses the map-area; and another was being drilled at Folding Mountain, 2 miles west of the area.

PHYSICAL FEATURES

Entrance map-area is in the western part of the Foothills Belt, and has a relief of about 2,450 feet, ranging from about 3,150 feet at Athabaska River to 5,600 feet on High Divide Ridge.

A transverse valley 2 to 3 miles wide crosses the centre of the area in a northeasterly direction. The northern half of this valley contains the Athabaska, flanked by gravel terraces, but the river enters the area through a narrower valley that, for convenience, may be called Entrance Valley. The southern part of the main valley is occupied by Maskuta Creek, which flows into the Athabaska where the two valleys meet. A large river evidently carved the main valley in Tertiary time, and, at one stage, this river, or a tributary of it, cut Entrance Valley. At the close of Pleistocene time great accumulations of glacial gravels and of lake deposits lay chiefly west of the map-area. As the Athabaska drained these lakes and eroded the gravels and silts, it re-deposited the material in the form of river terraces, chiefly at the north side of Entrance Valley and at both sides of the main valley below the mouth of Maskuta Creek. Recent regional uplift has caused the Athabaska to cut a rock canyon about 100 feet deep above the mouth of Maskuta Creek, and a similar canyon extends about a mile up this creek.

The remainder of the map-area, on both sides of the transverse valley, consists of a series of ridges and valleys trending northwest parallel to the trend of the Rocky Mountains and to the strike of the bedrock formations. Almost all of these valleys drain to the Athabaska, but a small creek in the northwest corner of the area drains to Hay River; and Wigwam and Teepee Creeks in the southeast corner drain to McLeod River.

GENERAL GEOLOGY

The map-area is underlain by marine and non-marine sedimentary strata ranging in age from Lower Cretaceous to Paleocene. Rock outcrops are confined mainly to canyons, rocky ridges, and railway and highway cuts. Most of the formations are insufficiently exposed to permit measuring complete sections, and estimates of total thickness can only be made graphically from cross-sections. As there is probably some minor folding and faulting obscured by overburden, these estimates may be too high.

The sequence of formations for the Foothills Belt was first established in southern Alberta, and although the stratigraphy there does not correspond precisely with that of the Athabaska district many of its formational names can be used. In order to clarify this usage, the following summary of the history of the formational names is given.

The oldest strata exposed in the map-area are principally marine shales, containing fossils that prove them equivalent to the Upper Cretaceous Alberta shale of southern Alberta. The uppermost part is of Montana age, and the remainder is Colorado. In the Bighorn coal basin these beds were subdivided by Malloch (1911, pp. 35-37)[1] into a lower Blackstone, an intermediate Bighorn, and an upper Wapiabi formation. This subdivision now holds throughout the Foothills, and in southern Alberta these names are being used to replace those of the corresponding Lower Alberta, Cardium, and Upper Alberta formations.

In southern Alberta the continental strata of Montana age overlying the marine beds of the Wapiabi (Upper Alberta) formation are termed the Belly River formation. At Turner Valley the Alberta shales are overlain by a sandstone bed 50 or more feet thick called the Highwood sandstone, which is capped by a thin pebble-bed and overlain by about 300 feet of marine shale, which, in turn, is overlain by the Belly River formation. The Belly River is overlain by the marine Bearpaw shales, which thin out to the northwest and have not been recognized in the Foothills north of Bow River. The Bearpaw is overlain by the non-marine Edmonton formation of late Upper Cretaceous age, which extends from the International Boundary to districts north of the city of Edmonton, but which is difficult to separate from the underlying Belly River beds where the Bearpaw is missing. The Edmonton formation is overlain, in places disconformably, by the Paskapoo formation of Paleocene age, which, being similar lithologically to the Edmonton, is difficult to separate in localities where the disconformity cannot be recognized or where fossil evidence is indefinite. In places, as in the Cypress and Hand Hills, the Paskapoo is capped unconformably by remnants of conglomerate of probable Oligocene age.

In the Bighorn area Malloch (1911, page 37) gave the name "Brazeau formation" to the non-marine beds that there overlie the Wapiabi formation. The Brazeau is equivalent stratigraphically to the Belly River of the southern Foothills, and is the youngest formation in the area covered by Malloch.

Allan and Rutherford, working in the Saunders Creek and Nordegg coal basins in 1923, applied the name Saunders group to a thick series of continental beds of Montana age. They divided this group into a Lower Saunders formation, which they stated probably corresponded to Malloch's Brazeau formation, a middle unit called the Saunders coal series, and an Upper Saunders formation, which they stated probably included beds equivalent to the Paskapoo. In later reports they abandoned the subdivisions of the Saunders group because they could not be applied in other areas. Rutherford (1925, page 48) stated "The whole series of continental deposits represented

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[1] Year and page references to reports are listed at the end of this report.

by the Saunders may be equivalent to the Belly River, Edmonton, and part of the Paskapoo formation represented in the plains of central and eastern Alberta".

Since 1924 B.R. MacKay of the Geological Survey has mapped a number of areas between North Saskatchewan and Athabaska Rivers. In tracing the Brazeau formation northward from the Bighorn basin he found it to correspond with the Lower Saunders, and adhered to the term Brazeau on the basis of priority (1930, page 4). In the Cadomin area, which adjoins the Entrance area, he mapped as Brazeau all the strata above the Wapiabi, including the commercial coal seams and the overlying beds, but in a more recent publication (1943) he separated these strata into the Brazeau and Edmonton formations, drawing the base of the Edmonton at the base of a conspicuous conglomerate bed about 900 feet below the lowest commercial coal seam. On several of his maps MacKay distinguished a narrow transitional zone between the Wapiabi and Brazeau beds, and classed it as the upper member of the Wapiabi. This corresponds in part to what is termed the "Solomon sandstone" in Entrance area.

Table of Formations

Period or epoch	Formation and approximate thickness (feet)	Subdivision and approximate thickness (feet)	Lithology
Paleocene	Paskapoo 3,500 +		Sandstone, shale, conglomerate (non-marine)
Upper Cretaceous	Edmonton 3,500 +		Chiefly sandstone and shale; conglomerate (non-marine)
		Entrance conglomerate 20 +	Coarse pebble-conglomerate
	Brazeau 6,000 +		Chiefly, sandstone, shale, and pebble beds (non-marine)
		Transition zone 100 +	Sandstone and shale
		Solomon sandstone 87 +	Sandstone (marine?)
	Wapiabi 1,600 +	Baculites ovatus zone Scaphites ventricosus zone	Chiefly black shale (marine)

	Bighorn 246 +		Quartzite, sandstone, shale (marine)
	Blackstone 1,500 +	Prionotropus zone	Chiefly black shale (marine)
Lower Cretaceous	Luscar (not exposed)		Shale, sandstone, coal (non-marine)

Lower Cretaceous

Luscar Formation. Beds of the Luscar formation, consisting of arenaceous shale, sandstone, and coal seams, are known from an outcrop and from drilling to occur about half a mile south of the map-area, and these beds are inferred to underlie the extreme southwest corner of the area, which is drift-covered. In districts to the south, the Luscar formation is overlain by a succession of green sandstone and shale beds distinguished as the Mountain Park formation, which thins rapidly toward the north (MacKay, 1928, page 12). It is not known whether this formation is represented in Entrance map-area or whether it dies out farther south.

Upper Cretaceous and Tertiary

Blackstone Formation. The oldest formation exposed in Entrance map-area is the Blackstone, composed of friable, black, concretionary, marine shale. These beds outcrop along the upper part of Maskuta Creek, on both flanks of a syncline, and presumably they overlie the Luscar (or Mountain Park) formation. The presence of Prionocyclus sp. and Inoceramus capulus indicate that the Prionotropis zone of the Upper Cretaceous is definitely represented. The formation is not sufficiently exposed for the measurement of a detailed section, and the base is concealed, but the thickness is estimated graphically to be about 1,500 feet.

Bighorn Formation. The Bighorn formation overlies the Blackstone conformably. It crosses the southwest corner of the area in three bands, due to repetition by folding. The formation consists chiefly of hard, grey, quartzitic sandstone with interbeds of shale and sandy shale. The occurrence of Cardium pauperculum and Inoceramus fragilis prairiensis indicates that these beds are equivalent to the Bighorn and Cardium formations of other parts of Alberta. In addition to marine beds the formation includes strata containing plant remains, indicating near-shore deposition. A section measured at Maskuta Creek, immediately south of the map-area, is 246 feet thick, and is composed as follows:

Top of section	Thickness Feet
Shale, hard, dark grey, sandy	10
Shale, friable, black; with interbeds of sandy shale up to 8 inches thick	10
Quartzite, grey, varying from fine-grained to gritty	11
Chiefly grey, quartzitic sandstone, in beds up to 4 feet thick, with interbeds of shaly sandstone; the latter contain both plant remains and marine shells	206
Quartzite, hard, fine-grained, grey	9
Total thickness	246

Wapiabi Formation. Overlying the Bighorn beds are black, marine shales of the Wapiabi formation. The basal beds are exposed in a syncline that crosses Maskuta Creek at the south boundary of the map-area. These beds contain Scaphites ventricosus, Inoceramus inconstans, and I. umbonatus. The uppermost beds of the formation, consisting of dark green, sandy shale, are repeated by faulting on the ridge north of Seabolt Creek. The formation is not sufficiently well exposed to permit measurement of a section or an accurate estimate of thickness, but it is estimated graphically to be 1,600 feet thick.

Brazeau Formation. The Brazeau formation underlies about one-half of the map-area, occurring on both flanks of a large synclinal structure.

The lowest stratum mapped as Brazeau is a bed of hard, fine-grained, greenish grey, quartzitic sandstone 80 to 100 feet thick, which has been termed the Solomon sandstone, and is a useful horizon marker. It contains poorly preserved shells and is probably of marine origin. The member is overlain by about 100 feet of dark green sandstone and shale containing plant remains, and these, in turn, are overlain by the lowest typical pebble beds of the Brazeau formation. The Solomon sandstone and the overlying sandstone and shale are mapped together, and they correspond to the transitional zone that MacKay has included with the Wapiabi formation. The writer has grouped them with the Brazeau in conformity with the more common practice of grouping passage beds with the overlying formation.

The remainder of the formation consists of interbedded sandstone, shale, and pebble conglomerate, with a few bentonitic beds and thin coal seams. The sandstone is generally grey, weathers brown and greenish grey, and some of it has a "pepper and salt" appearance due to the inclusion of small, black chert and lignitic fragments. The shales are grey and greenish grey. The conglomerate, which is much more abundant in the lower half of the formation, consists of pebbles of quartzite and chert averaging one-half inch in diameter in a sandy matrix that fractures around the pebbles. The uppermost bed of the formation is a distinctive, massive bed of grey, buff-weathering sandstone about 70 feet thick.

The upper part of the formation contains Upper Cretaceous plant remains at several horizons, and from a bed near Entrance Mr. R.C. Sibley, of Entrance, has collected several dinosaur bones. He sent some of these to Dr. Barnum Brown of the American Museum of Natural History, who reported that they were probably wash accumulation; that a tooth was probably from Gorgosaurus libratus; and that a toe bone was probably from Corythosaurus (casuarius?). Coleman and Parks (1922, page 325) state that Corythosaurus is a typical Belly River dinosaur, and that Gorgosaurus is also found in the Belly River.

Several thick sections of parts of the Brazeau formation were measured, but these do not approach a complete section, and the estimate of 6,000 feet for the total thickness is indefinite.

Edmonton and Paskapoo Formations. These formations occupy the central part of a large synclinal basin, and occur also in the northern and eastern parts of the map-area.

The base of the Edmonton is assumed to be at the base of a conspicuous bed of conglomerate termed the "Entrance conglomerate". This member has an average thickness of about 20 feet, but is about 50 feet thick at Entrance. It consists of closely packed pebbles of quartzite and chert averaging 1 to 2 inches in diameter, although some are as much as 6 inches. The matrix is sandy, and the rock fractures around the pebbles. In places the bed is all conglomerate; elsewhere there are sandstone interbeds, but, generally, there is little difficulty in recognizing the member, as the pebbles are larger and more closely packed than in the pebble beds of the Brazeau formation. The only exposure that is likely to be in doubt is the most easterly one near the head of Hardisty Creek; this has been correlated with the Entrance conglomerate because it conforms with the structure of higher beds outcropping on High Divide Ridge.

Overlying the Entrance conglomerate is a thick succession of relatively soft, interbedded sandstone and shale, with minor conglomerate, bentonitic beds, and coal seams. The sandstone is generally rather coarse, and much of it is crossbedded. It is grey and weathers grey, brown, and green. The shale is generally greenish grey and rather clayey. The conglomerate consists of pebbles and cobbles of waxy lustred quartzite up to 12 inches in diameter, and ranges from streaks one pebble or cobble wide to beds about 10 feet thick.

High Divide ridge consists largely of cobble-conglomerate. Most of the ridge is strewn with loose cobbles, but the rock does not outcrop well as it is rather loosely cemented. The contours of the ridge indicate that the beds have been folded conformably with the Edmonton beds.

No Upper Cretaceous plant remains were found in the Edmonton formation within the map-area. Fossil leaves were found at Fish Creek at an horizon about 3,500 feet above the Entrance conglomerate, and another collection was obtained from about the same horizon just east of the map-area. W.A. Bell of the Geological Survey reports that these are probably of Paleocene age; therefore, it is concluded that the Edmonton has a maximum thickness of about 3,500 feet in this area, and that higher strata represent the Paskapoo formation. Both Edmonton and Paskapoo beds have, however, been mapped together, as no change in lithology or break in sedimentation was observed. The base of the conglomerate on High Divide Ridge is about 3,500 feet above the Entrance conglomerate, so this rock also is considered a part, probably a lower part, of the Paskapoo formation. It appears that some change in sedimentation caused a concentration of conglomerate in this part of the area. The configuration of High Divide Ridge seems to indicate definitely that the conglomerate is folded conformably with the Edmonton beds, and, therefore, it is unlikely that this rock could be of post-Paskapoo age.

STRUCTURE

The strata of the map-area are considerably disturbed by folds and faults that trend northwest parallel to the mountain front. The rocks are sufficiently well exposed to permit interpretation of the major structures, but it is probable that minor folds and faults are obscured by drift and their effects not recognized.

The most conspicuous structure is a broad syncline, which may be termed the Entrance syncline. The pronounced southeastward plunge of this fold is well demonstrated by the curved trace of the Entrance conglomerate.

The Entrance syncline is flanked to the northeast by a broad anticlinal structure termed the Prairie Creek anticline; farther to the southeast, beyond the map-area, the same structure is known as the Coalspur anticline. Dips on the northeast limb are fairly flat, whereas those on the southwest limb are steep. Where rock exposures are most plentiful, as near the mouth of Prairie Creek, the beds are seen to be folded into a series of minor anticlines and synclines, and this condition probably exists elsewhere in areas not as well exposed. The Edmonton-Brazeau contact is so much nearer the anticlinal axis on the south limb of the fold than on the north limb that it seems necessary to assume that the anticline is faulted, with the south limb depressed. Such a fault would probably dip northeast.

Southwest of the Entrance syncline, the Brazeau formation is folded in a fairly broad anticline, which may be called the Seabolt Creek anticline. On the east limb of this fold two closely spaced faults bring to the surface the Solomon sandstone and a little of the Wapiabi formation. The fault planes are not exposed, so the dips of these faults are doubtful.

The Seabolt Creek anticline is flanked to the southwest by a broad syncline and, still farther southwest, by a broad anticlinal structure that appears to be the continuation of the Solomon Creek anticline of the adjoining Brûlé map-area. The central part of this structure, in the soft Blackstone shale, consists of two narrow anticlines and a syncline. In the southwestern corner of the area a syncline is postulated, containing a narrow band of the Wapiabi formation flanked by bands of the Bighorn. The Wapiabi and the southwestern band of the Bighorn do not outcrop in the area, but they are exposed in the canyon of Maskuta Creek immediately to the southeast.

OIL AND GAS POSSIBILITIES

No wells have been drilled in the map-area, but three are being drilled nearby to test the Palaeozoic limestone. One of these, at Folding Mountain 2 miles east of the map-area, is being drilled by Anglo-Canadian Oil Company, Limited, on a structure that does not cross the Entrance map-area. A second well was drilled in 1943 to a depth of 4,774 feet by Shell Oil Company of Canada, to test the Solomon Creek anticline at a point about 10 miles northwest of the map-area. Drilling was suspended pending further geological work. A well is also being drilled near Coalspur by Imperial Oil Company of Canada, on the southward continuation of the Prairie Creek anticline. This well is 22 miles southeast of the map-area.

The Seabolt Creek anticline has not been drilled. If the writer's assumption is correct that the faults on the east flank of this structure dip eastward, this anticline is of interest because it is fairly broad, and the crest should bring the top of the Wapiabi close to the surface. As the pitch of the Entrance syncline probably indicates a similar pitch to the Seabolt Creek anticline, the most favourable part of the structure is probably northwest of Entrance map-area.

COAL

Coal is being mined at Drinnan by Jasper Collieries, Limited. Here a mine capable of producing about 300 tons a day was operated on a seam about 1,600 feet stratigraphically above the Entrance conglomerate, but was abandoned 5 years ago. McAndrew (1931, page 1,380) states that this seam corresponded to the Silkstone seam of the Coal Branch, and had a total thickness of 18 feet, divided by clay bands. In 1943 mining was resumed on a small scale on a 4-foot seam about 800 feet above the conglomerate. In the following year this mine was producing 40 tons of good domestic coal a day. Other seams have been proved by drilling. The seams appear to have the same stratigraphic and structural position as the seams at the Bryan and Balkan mines near the Coal Branch. They should be fairly continuous across the map-area, and the delineation of the Entrance conglomerate is a guide to their prospecting. The same seams may lie in the Entrance syncline in a structural position similar to those at Mercoal and Coalspur. A seam is partly exposed in an old prospect on Cold Creek, as indicated on the map accompanying this report.

Steam coal of good grade was mined for a few years at Hinton by Hinton Collieries, Limited, but the mine was abandoned in 1941. The coal is said to have been taken from a lens 3 feet 9 inches thick and, apparently, occurs in the Brazeau formation. The workings, however, are flooded, and the few rock exposures in the vicinity do not permit a close determination of the stratigraphic position of the seam. Although there has been a tendency to assume that all commercial seams lie in the Edmonton formation, thin seams are known to occur in the Brazeau, and, as the Hinton seam is said to have been mined only at a lens, it seems reasonable to assume that it is part of the Brazeau formation.

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