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ARDLEY COAL ZONE IN THE ALBERTA PLAINS: CENTRAL RED DEER RIVER AREA

by

J. D. Campbell

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Research Council Alberta Report 67-1: ERRATA

Text

p.10, par.4, line 3.	Phrase in brackets should read "(e.g. Fig.7, log 6)"
p.14, par.3, line 4.	End of line should read "... form a pattern of anastomosing ..."
p.28, footnote, line 4.	Definition of "DAF.BTU" should be expanded to read "moisture-free, ash-free calorific value in BTU per lb.;"

Illustrations

Fig.1. In southeast corner of province, small area against Saskatchewan border enclosed by small loop of Bearpaw Formation should be shaded to indicate "Edmonton and Paskapoo Formations and equivalents"

Fig.2. In log of "West Wall, Scollard Canyon", caption "grey-white bentonitic sandstone" refers to the interval between the two thin coal seams.

Fig.5. In Tp.33, R.23 and 24, the four boreholes forming a short straight line should be colored green (to indicate "... recording Ardley coal").

In Tp.34, R.21 and 22, a dashed black line (to indicate "approximate line of Kneehills outcrop ...") should be drawn following the 2600-foot contour line from the south boundary of Sec.24, Tp.34, R.22 northeastward to the northwest quarter, Sec.29, Tp.34, R.21.

Fig.6. The 2800-foot structure-contour on top of Ardley coal should be drawn northward from its apparent termination in Sec.5, Tp.33, R.22 to about the northeast corner Sec.32, Tp.33, R.22, thence north-northeastward to about the northeast corner Sec.18, Tp.36, R.21, and thence approximately northward to about the middle Sec.32, Tp.37, R.21, beyond which its position is unknown.

Fig.7. Legend; the only erosional contacts recognized in these section-logs are at the drift-bedrock contact.

Fig.8. Omit "Spontaneous potential" scale.

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CENTRAL RED DEER RIVER AREA

Abstract

The Ardley, the first coaly zone above the Kneehills Member (Lower Edmonton Formation, sensu Sternberg) is believed to extend from Three Hills in central Alberta northwestward across the province to Nose Mountain southwest of Grande Prairie. This report discusses Ardley zone coal resources in the central Red Deer River area lying between longitudes 112° 30' and 114° west and latitudes 51°30' and 52° 30' north, an area within which lies the type section of the zone, and also a number of coal deposits that have received commercial attention from time to time. The report is based solely on outcrop studies made between 1955 and 1960, augmented by data from selected oil-well electric logs.

In central Alberta, the Ardley zone is 22 to 78 feet thick and consists of 4 units: a coaly shale; an upper coal seam 4 to 6 feet thick with a thin bentonitic clay parting below the middle; a thick, very variable middle part consisting of grey, green and carbonaceous shale and siltstone, with interbedded lenses of bone and coal; and a lower coaly seam 1 to 4 feet thick. The geologic setting of the Ardley coal zone is discussed, and representative analyses of mined coal are presented. Mines in the area recover between 3.5 and 6 feet of Ardley coal; pockets scattered along a 60-mile belt between Alix and Swalwell may contain as much as 350 million tons of Ardley coal recoverable under less than 100 feet of overburden.

INTRODUCTION

In the upper part of the Edmonton Formation, where it is exposed in the Red Deer River valley in central Alberta, lies the "Ardley" or "Number 14 Coal Seam" of Allan and Sanderson (1945). It is not a single seam, but a thick coaly zone, a concentration of coal seams and lenses, referred to in this report as the "Ardley coal zone".

It is believed that the Ardley coal zone forms a more or less continuous chain of coal occurrences across the plains of central and western Alberta from the northwest flank of the Sweetgrass Arch about Tp. 29, Rs. 17 to 24 * northwestward to Nose Mountain about Tp. 64, R. 11, W 6th Mer. (Fig. 1). Although absent south of Tp. 29 west of the Sweetgrass Arch, Ardley equivalents appear east of the arch in the form of a few coaly streaks in the Cypress Hills region of Alberta and as thick lignite seams at the base of the Ravenscrag Formation in southwestern Saskatchewan. Coal resources of this zone in the Alberta plains are subjects of several investigations by the Research Council of Alberta continuing Coal Survey (see Campbell and Almadi, 1964); this report examines the zone where it is best exposed, in the central Red Deer River area, between longitudes 112°30' and 114° west and latitudes 51°30' and 52°30' north (Fig. 1).

Within the central Red Deer River area lie most of the mines that have exploited Ardley coal or equivalents in Alberta (see Appendix A) as well as the excellent outcrops lining the Red Deer River valley. This region also contains numerous mines and considerable strippable reserves in the stratigraphically lower Carbon-Thompson coal zone, and earlier reports (e.g. Allan, 1924, 1943; Allan and Sanderson, 1945; MacKay, 1949; Stansfield and Lang, 1944) have followed an areal pattern of study, discussing resources of the two coal zones indiscriminately. Allan and Sanderson (1945) described stratigraphy and showed thirteen section-logs of the Ardley coal zone, but other authors made no attempt to distinguish coals of different ages. This report, however, is concerned with the reserves of a single coal zone, the Ardley, and its geologic setting.

The following text is based on studies of oilwell electric logs and on the author's field data gathered in the course of six summers from 1955 to 1960. Most Ardley coal zone mines and outcrops within the area were visited and 56 exposures were measured, including 25 of Ardley coal, 10 of Carbon-Thompson coal and 16 of the Kneehills Member (see below for definitions). Elevations were determined barometrically, and intervening outcrop belts interpolated from air photographs. Data on westward extensions of the zone were obtained from four test holes drilled north of Trochu by the Research Council of Alberta and also from electric logs of selected oil and gas exploratory wells.

Geography

The central Red Deer River area is a rolling plain from which rise a few uplands (Fig. 5). The highest of these, Hillsdown ridge, attains heights in excess of 3,400 feet in Tps. 36 and 37, R. 26.

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* All locations given in this report are west of the Fourth Meridian unless otherwise specified.

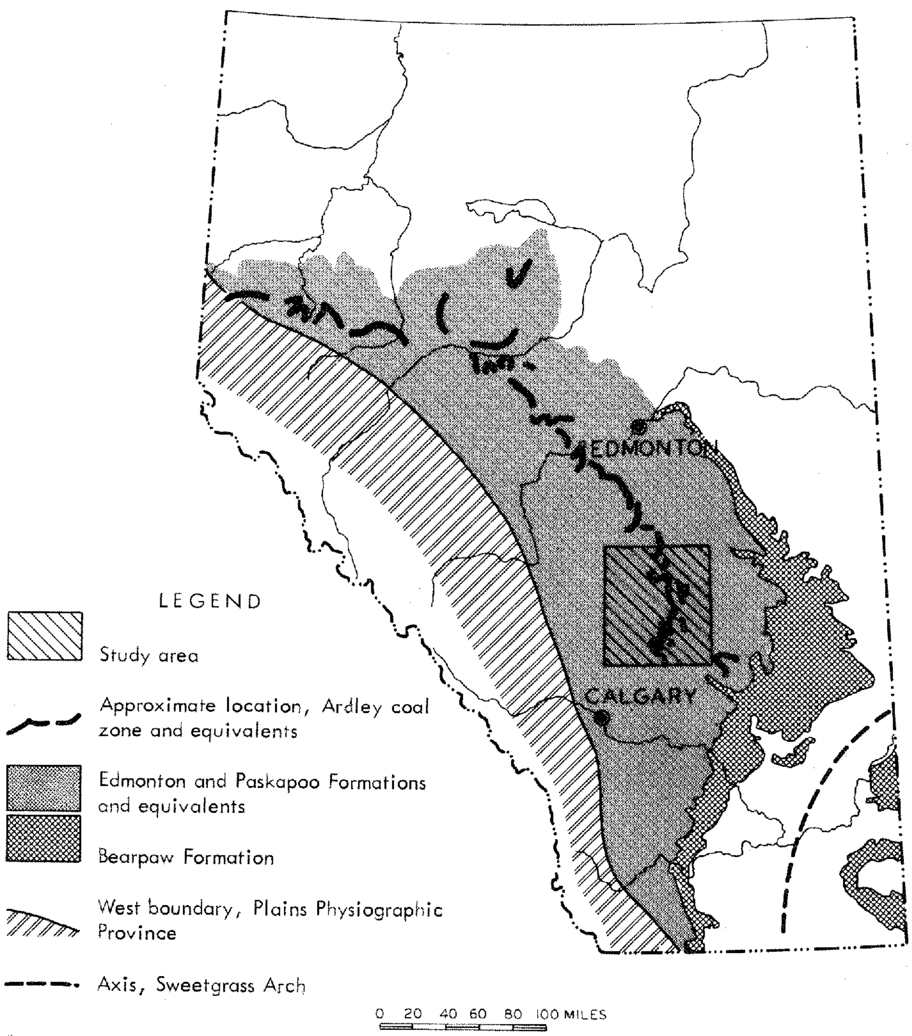

Figure 1. Ardley coal zone in Alberta.

Other uplands are centered in Tp. 32, R. 25 (Knee Hills) and Tp. 36, R. 21. The lowest point in the area is on the Red Deer River in Tp. 29, R. 21 with an elevation of 2,200 feet. The rolling terrain is almost entirely mantled with glacial drift (Craig, 1957; Stalker, 1955, 1960) and varies somewhat in character with the nature of the drift.

One major stream valley, that of the Red Deer River, traverses the area from northwest to southeast; this river and its tributaries drain the whole of the area except for about five townships in the northeast corner tributary to the Battle River, and a few townships east of Fenn, Big Valley and Rowley which have internal drainage.

There are no bedrock outcrops in the area away from the major stream valleys except for a very few ledges of sandstone protruding through the drift mantle on ridge tops. In the valleys bedrock exposures are excellent, especially in the Red Deer River valley from Tp. 38, R. 22 southward, which constitutes the northern part of the famous Red Deer Badlands.

The climate of the area is arid to semi-arid, cold in winter, warm in summer. The boundary between true northern prairie grassland of the southern part of the area and typical aspen parkland is quite sharp, extending from Tp. 33, R. 28 eastward to the vicinity of Fenn in Tp. 36, R. 20. A recent major advance of aspen parkland southward in Rgs. 19 and 20 almost to Morrin is evidence that the area is a zone of tension, ecologically between grassland and woodland, and climatologically between aridity and humidity. Much of the precipitation results from summer thunderstorms (including violent hailstorms) which form a major factor in the process of badland erosion. It is significant that the northern limit of active badlands on the Red Deer River is less than 12 miles north of the present prairie-parkland boundary.

Highways, primary and secondary roads, and railways provide easy access to almost all parts of the central Red Deer River area.

Local economy, including that of Red Deer and Stettler, the two largest towns of the area, is dominated by agriculture: grain farming on the open prairies, mixed and dairy farming in the aspen parkland, and cattle grazing on the more sparsely populated uplands and hummocky moraines. However, the area derives an additional measure of prosperity from a number of Lower Cretaceous and Upper Devonian oil and gas fields including Joffre, Nevis, Erskine, Fenn - Big Valley, Wimborne, Olds and Drumheller. Six small coal mines are currently operating within the area (see Appendix A).

Acknowledgments

This report has been compiled as part of the continuing Research Council of Alberta Strip Coal Assessment Survey, which has received much of its financial support from Calgary Power Limited, Canadian Pacific Railways Natural Resources Division and Canadian Utilities Limited. Mr. M. O. Fuglem, formerly of the Alberta Oil and Gas Conservation Board, Calgary, and Dr. R. Green, Research Council of Alberta, Edmonton, helped greatly in selecting deep wells for information on westward extensions of the Ardley coal zone and in interpreting the electric logs. However, the author accepts full responsibility for the results presented here.

GEOLOGIC SETTING OF ARDLEY COAL ZONE

Ardley coal on the Red Deer River was first mentioned by Tyrrell (1887). At that time he proposed the now generally held view that two rock units outcrop in the central Red Deer River area: the dominantly grey, nonmarine Edmonton Formation, and the dominantly buff-weathering, nonmarine Paskapoo Formation. In arbitrarily placing the boundary between these two formations at the "Big Seam" at the Ardley bend of the river, Tyrrell seems to have assumed that the Edmonton grades upward into the Paskapoo.

Allan and Sanderson (1925, 1945) and Sanderson (1931) divided the Edmonton Formation into lower, middle and upper portions, renamed Tyrrell's "Big Seam" the "Ardley" or "Number 14 Seam", and concluded that, approximately 100 feet above it, there must be a profound unconformity which they recognized as the Edmonton-Paskapoo boundary.

However, the Edmonton-Paskapoo boundary appears to be transitional (see Campbell, 1962a; Campbell and Almadi, 1964; Elliott, 1960; Ower, 1960), and hence any criteria adopted for distinguishing the two formations must be somewhat arbitrary.

For the purpose of this report, all light-colored, irregularly bedded strata overlying the marine Bearpaw Formation and containing coal seams or coaly beds are referred to the Edmonton Formation. This formation is distinguished by light color and enclosed dinosaur bones.

The Paskapoo Formation is defined, in this report, as any massive or thick-bedded, light-buff-weathering, non-dinosaur-bearing sandstone overlying known Edmonton strata, plus any other associated nonmarine strata lying above the sandstone. It is distinguished from the underlying Edmonton Formation also by its coarser-grained sandstones, by its lower content of argillaceous, bentonitic and carbonaceous beds, by its darker grey color in unweathered samples, and by its buff color when weathered, commonly in outcrop appearing definitely yellow.

Edmonton Formation

The most workable subdivision of the Edmonton Formation is that of Ower (1960) who recognized five members designated "A" to "E" in ascending order. Members "A", "B", "C" and "E" consist of complexly interfingered, mostly impersistent clastic strata and coal seams; on the other hand, "Member D", the Kneehills Member, sometimes called the "Kneehills Tuff Zone", is remarkably uniform and persistent, and is the only reliable marker horizon above the top of the Colorado Group in central and western Alberta.

Scollard Canyon Section

Figure 2 represents a section through the Edmonton Formation compiled from outcrops on the west wall of Scollard Canyon in Sec. 13, Tp. 34, R. 22 and the electric log of Gulf P. Mardel No. 9 well, in Sec. 14, Tp. 34, R. 22.

The thickness of "Member A" in this section is about 730 feet, much greater than near Drumheller where it is only about 450 feet (Ower, 1960). Evidently the member is thicker at the expense of the underlying Bearpaw Formation which therefore thins northwestward.

"Member B", Ower's barren or non-coal-bearing member, is obscured by surface casing in the Mardel well and by slumping in the outcrop; it is probably about 260 feet thick.

"Member C" and "Member D" are both well exposed in the Scollard Canyon section; together they are about 95 feet thick. In all outcrops examined, "Member C" is a somewhat irregular coaly zone closely subjacent or even incorporated into the white bentonitic sandstone that forms the lower part of "Member D" (see Fig. 3, adapted from Campbell, 1962a). Allan and Sanderson (1945) interpreted this coaly zone as two continuous seams, the "Carbon" (No. 11) and the "Thompson" (No. 12), but these are irregular in nature, and together are referred to in this report as the Carbon-Thompson coal zone.

In the Scollard Canyon outcrop, the interval between the top of "Member D" (referred to in this report as the Kneehills Member) and the base of a thick-bedded, buff-weathering sandstone of Paskapoo type, is about 290 feet. This interval is Ower's "Member E" and Sternberg's (1947) "Upper Edmonton". It contains, besides a number of minor coaly streaks, the Ardley coal zone which lies between 150 and 234 feet above the base, and consists of one major seam 6 feet thick and other coaly lenses distributed irregularly through greenish, grey-white and grey-brown shale and siltstone (Figs. 2, 3 and 7).

Kneehills Member

The Kneehills Member * (Ower's "Member D") together with its correlatives southeast of the Sweetgrass Arch, the Whitemud and Battle Formations, is a remarkably uniform and widespread stratigraphic unit, probably volcanic in origin; while very similar, though thinner volcanic units have been observed both lower and higher in the stratigraphic column (Campbell, 1966; Ritchie, 1957), the member itself is recognizable in outcrop from the Cypress Hills of Saskatchewan to the Smoky River ** , and in subsurface, westward to a depth in excess of 3,500 feet west of Rocky Mountain House (Elliott, 1960). It is the only reliable marker horizon above the Colorado Group in central and western Alberta, and because of its volcanic nature (characteristically it contains one or more beds of tuff near its top) it is believed to be essentially isochronous.

The Kneehills Member itself is unfossiliferous ***, but Sternberg (1947) and Bell (1949) showed that it marks a break common to dinosaur fauna and macroflora of the Edmonton Formation, a break which also affects the megaspore microflora (Campbell, 1962b). Since in the Scollard Canyon section and, indeed, everywhere else, the lower boundary is markedly gradational, any hiatus indicated by the faunal and floral breaks must lie within the member or at its sharp upper boundary. While there is no evidence of erosion at this upper boundary such as marks the top of the Whitemud-Battle complex in the Cypress Hills, conceivably deposition of the Kneehills Member was followed in some places by a period of non-deposition sufficiently long to account for a part of the biotic discontinuity.

Structure contours on the top of the Kneehills Member within the study area are shown in figure 5. West of the Red Deer River the member dips in a relatively simple monocline at an increasingly steep gradient to

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* For descriptions of the Kneehills Member, see Allan and Sanderson (1945), Campbell (1962a), Ower (1960), Ritchie (1957) and Sanderson (1931).

** Bedrock occurrences here called "Kneehills Member" are referred to by Irish (1965) as "Whitemud and Battle equivalents" after the earlier-named Whitemud and Battle Formations of the Cypress Hills region.

*** Recently a few silicified megaspores have been isolated from Kneehills sediments (P. L. Binda, pers. comm.); although these appear to relate the member floristically to underlying strata, they are not easily identifiable and their full significance is yet to be determined.

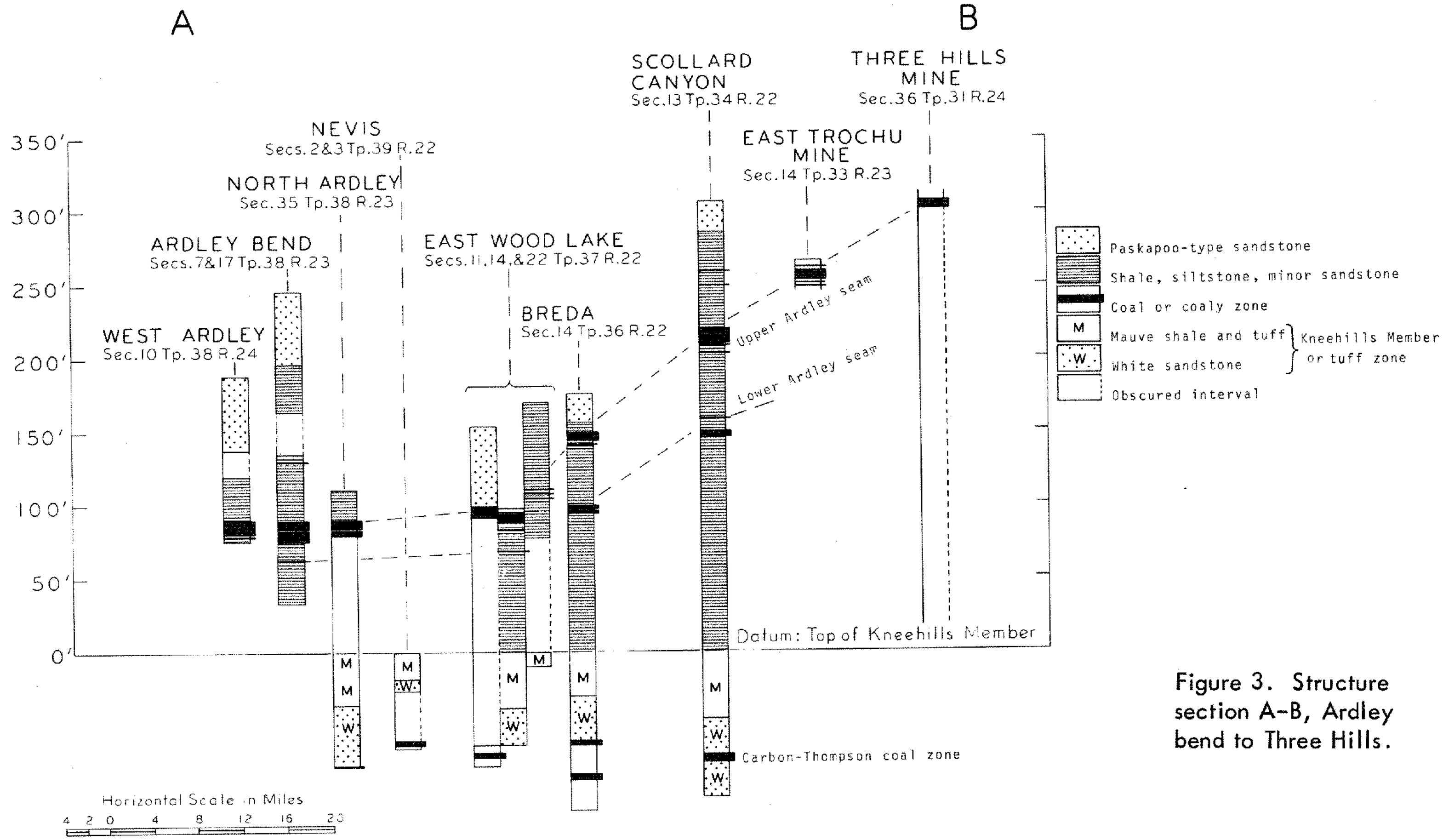

Figure 3. Structure section A–B, Ardley bend to Three Hills.

the west, and lies 1,400 to 1600 feet below surface along the west boundary of the area. East of the river, however, scattered outcrops of erosional remnants north of township 34 seem to indicate that the member lies very close to the general ground level, although south of township 34, it rises to an elevation of 3,000 feet on the north flank of the Hand Hills in Sec. 31, Tp. 30, R. 17 (see Campbell, 1967).

Undisturbed outcrops of the Kneehills Member are found only where exposures have resulted from postglacial channel-cutting, as along the Red Deer River valley. Wherever the member, which consists of extremely soft, incompetent materials, lies close and parallel to the general ground level as in Tps. 31 and 32, Rs. 19 and 20, it has been strongly deformed by glacial action and commonly has foreign material incorporated into it. In many cases, such as in the range of hills west of Nevis in the east side of Tp. 39, R. 22, it is not possible to distinguish glacially deformed Kneehills beds from hummocky moraine whose parent material was Kneehills bedrock; a few areas where this situation exists are shown in figure 5.

"Member E"; Age and Correlation

Sternberg (1947) showed that the Kneehills Member marks a clear break in the dinosaur fauna of the Edmonton Formation, and that strata above the Kneehills (his "Upper Edmonton" and Ower's "Member E"), on the basis of the dominant dinosaur genera Triceratops and Tyrannosaurus, are correlative with the Hell Creek interval (including "Lance") of the western plains of the United States, and with the youngest Cretaceous strata throughout the world (see also Jeletzky, 1960). Bell (1949) on the basis of the macroflora, substantiated both the biotic break and the correlation.

Continuous sedimentation appears to have taken place from the top of the Kneehills Member through "Member E" and into overlying Paskapoo-type strata (Campbell, 1962a). In the middle of "Member E" lies the Ardley coal zone, a concentration of coal seams and lenses 22 to 78 feet thick (see Fig. 7). This zone, almost everywhere in the central Red Deer River area, exhibits a thick upper coal seam with a uniform, thin bentonitic clay parting; consequently it is believed (contrary to Campbell, 1962a) to be approximately isochronous throughout the area, instead of only in a northeast-southwest direction.

It is possible to define the Cretaceous-Tertiary boundary as the time of final extinction of the dinosaurs. Sternberg's (1949) reference to dinosaur remains discovered 90 feet above the Ardley zone in Sec. 5, Tp. 39, R. 22, must be mistaken since, at that location the zone is present at the cliff top and cannot have 90 feet of visible overburden; if Sternberg, however, measured upward from the small seam in the Carbon-Thompson zone that appears near the foot of the cliff here, the remains he mentions would have lain between the Kneehills Member and the base of the Ardley zone. Irish (pers. comm.) has found remains of a Hell Creek dinosaur apparently above the Ardley coal zone at the mines west of Warden (Fig. 7 , log 15); but the section there is extensively disturbed by slumping, and obscured by subsequent slope-wash. With this questionable exception, it appears that no dinosaur remains have been discovered above the middle of the Ardley coal zone (see Campbell, 1962a; Sternberg, 1947, 1949); consequently for the present, the Ardley zone may be considered to mark the end of Cretaceous time in the central Red Deer River area.

The rock interval between the top of the Ardley zone and the top of the Kneehills Member is known to vary in thickness from 85 feet in river outcrops north of Ardley village (Sec. 35, Tp. 38, R. 23) to 360 feet in Shell Olds No. 1 well (Lsd. 16, Sec. 11, Tp. 32, R. 1, W 5th Mer.). Very approximate isopachs of this interval are shown in figure 5; the 300-foot isopach is shown to bend slightly northward to Tp. 31, R. 24 on the basis of a datum quoted by Ower (1960). Figure 3 is a section of the Ardley-Kneehills interval along the Red Deer River from the Ardley bend to Scollard Canyon and thence southwest to Three Hills.

As stated previously, both the Kneehills Member and the Ardley coal zone within the central Red Deer River area are believed to be isochronous; consequently variations in thickness of the interval must result from either variations in rate of deposition, or variations in degree of compaction, or, possibly, differences in duration of a post-Kneehills nondeposition period if such existed. Shafiqullah et al. (1964), determined absolute age dates of tuffs and bentonites from this interval. Kneehills Tuff samples from the top of the Kneehills Member at Strawberry Creek and Whitecourt, west and northwest of Edmonton respectively, yielded dates of 66 ± 1.5 million years; and a bentonitic parting adjacent to the upper seam in the Ardley coal zone of the Scollard Canyon outcrop gave an age of 63 ± 1 million years. Thus approximately 3 million years encompasses the whole history of the Hell Creek fauna including the evolution, dominance and final extinction of the genera Triceratops and Tyrannosaurus, the last of the dinosaurs.

Ardley Coal Zone

Figure 7 consists of a 25 log-diagram of the Ardley coal zone, from the central Red Deer River area. Outcrops of the zone appear always to be variants of a fairly consistent pattern (e.g. Fig. 7b, log 20) which may be generalized as follows:

- shale, coaly;
- coal, 4 to 6 feet thick, thin bentonitic clay parting below the middle (upper seam);

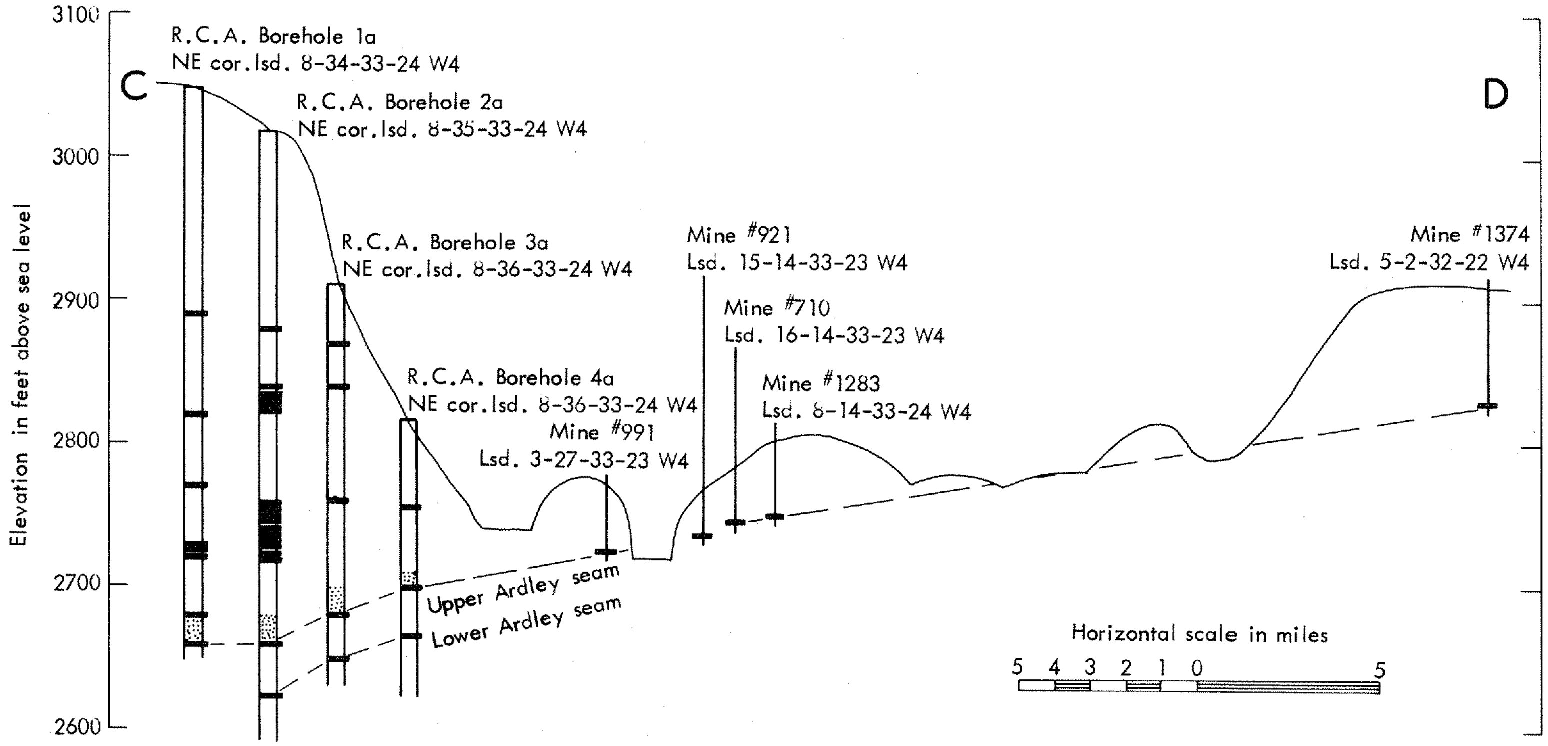

Figure 4. Structure section C-D; Ardley coal zone in Ghostpine Creek Valley.

- thick, very variable middle part, consisting of grey, green and carbonaceous shale and siltstone with interbedded lenses of bone and coal which are usually unrecognizable from one outcrop to the next; commonly bounded at top and base by bentonite beds, 1 to 2 feet thick;

- lower coaly seam, 1 to 4 feet thick, usually more than half coal, remainder carbonaceous shale.

Both the upper seam with its thin bentonitic parting and the lower coaly seam are almost everywhere recognizable. The middle part, however, is extremely variable, both in thickness and in composition; at Scollard Canyon (Fig. 7 , log 9) where it is very thick and carries little coal, both Elliott (1960) and Ower (1960) speak of "Upper Ardley" and "Lower Ardley" as separate, scarcely related seams, while Sanderson (see Allan and Sanderson, 1945) at one time applied the name "Nevis" to the lower coaly seam. Around the Ardley bend of the Red Deer River, however, the middle part is only one quarter to one third as thick, but erratically more coaly than at Scollard.

Westward from the outcrop, identification of the Ardley coal zone in deep boreholes is fairly reliable by means of electric logs, especially the "short normal" resistance curve (Fig. 8). All three basic divisions appear quite distinctly (with variations), especially the upper seam which gives a very strong resistivity "kick". The lower seam, though usually present, apparently is replaced by a thick sandstone bed in Cabeen Exploration Pine Lake No. 10-25 well (Sec. 25, Tp. 36, R. 24); and the upper seam disappears in the southernmost two wells (Bailey Olds No.1, Sec. 18, Tp. 31, R. 27 and Hudson's Bay Olds No. 2a, Sec. 9, Tp. 31, R. 27). In Shell Olds No. 1 well, the farthest southwest datum-point (Sec. 11, Tp. 32, R. 1, W 5th Mer.), the whole sequence becomes much more shaly, hardly coal at all. The changes in the three southern wells may relate to a southward pinchout of the whole zone which is postulated below.

Total thickness of the Ardley coal zone is known to vary from 22 feet in Cal. Standard Joffre 11-25 well (Sec. 25, Tp. 38, R. 26) and Hudson's Bay Olds No. 2a well (Sec. 9, Tp. 31, R. 27) to 78 feet in the Scollard Canyon outcrop (Sec. 13, Tp. 36, R. 22). Thickness distribution is shown in section in figure 3, and as approximate isopachs in figure 6.

Structure

Figure 6 shows structure contours on the top of the Ardley coal

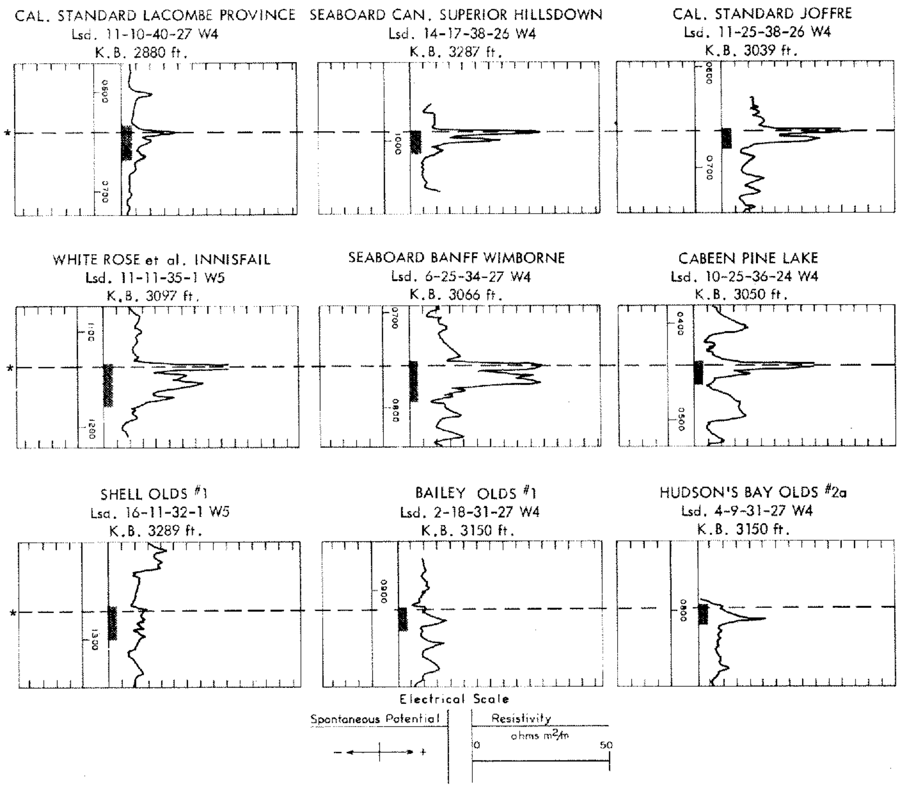

Figure 8. Electric logs showing Ardley coal in selected oil and gas wells.

zone which indicate a gentle westward dip similar to that of the Kneehills Member. North of township 32, the dip decreases eastward so that, in the vicinity of the Red Deer River, the zone lies almost flat. South of township 32, both the Kneehills and Ardley zones rise southeastward towards the Hand Hills outside the area. Figure 4 shows a structure section approximately on the strike of this southeastward rise.

Paskapoo-Type Rocks

Allan and Sanderson (1945) believed that a major unconformity separated rocks of the Edmonton Formation from those of the overlying Paskapoo Formation. This unconformity, they stated, was marked by disconformities at the base of massive, buff-weathering sandstones outcropping in some twenty localities along the Red Deer River. Ower (1960) however, questioned the identification of many of these sandstones as "Paskapoo". Certainly, in some localities, such as the Ardley cliff in Lsd. 9, Sec. 13, Tp. 38, R. 23, there is a break in deposition at the base of the sandstone, but in others, such as Lsd. 15, Sec. 10, Tp. 37, R. 22, thick-bedded, buff-weathered sandstone is seen to rest directly and conformably on the Ardley coal zone.

The sandstone outcrops are believed not to be parts of a continuous "Basal Paskapoo Sandstone"; rather, each appears related to an elongated topographic high, oriented roughly northwest or north-northwest. On aerial photographs, such uplands are seen to form a pattern on anastomosing hill-chains. Thus the buff-weathering sandstones all appear to be individual channel sands, each of approximately the same age as adjacent finer-textured sediments. There appears to be no clear-cut break in sedimentation between the Edmonton and Paskapoo Formations, so that the several hundred feet of strata overlying the Ardley coal zone cannot be assigned with certainty to either formation. Accordingly, no formational boundary is shown on the geological map (Fig. 5).

However, at Joffre Canyon in Tp. 38, R. 26, the Red Deer River has cut across the Hillsdown ridge, a high, east-facing scarp ridge formed of undoubted Paskapoo strata, which are believed (Campbell, 1962a) to belong to the middle part of the formation. The Hillsdown ridge is one of a loose but relatively prominent chain of local scarps shown as "Middle Paskapoo Escarpment" in figure 5; while primarily a geographic feature, the chain is continuous and uniform, and if it be traced south of the study area, it can be seen to link the typical Paskapoo-type outcrop at Joffre Canyon with Paskapoo-type sediments in the Wintering Hills and the Hammer Hill-Gleichen region where, Paskapoo-type sediments lie conformably over Edmonton-type rocks (see Campbell and Almadi, 1964). It is therefore believed to reflect a major Paskapoo-type sandstone occurrence.

Since the "Middle Paskapoo Escarpment" lies more than 500 feet above the top of the Ardley coal zone at Joffre Canyon, but less than 100 feet above it at Swalwell in Tp. 30, R. 24 (Fig. 5), it appears to be diachronous. The apparent absence of Ardley coal south of Swalwell could be explained as a pinchout of the zone under the "Middle Paskapoo Escarpment".

Late Tertiary and Quaternary Deposits

Gravels exploited on the crests of the Hillsdown ridge are possibly early preglacial in age; late preglacial gravels of the "Saskatchewan Sands and Gravels" type certainly occur in the Red Deer River valley, notably at the Ardley bend and at Scollard Canyon.

The Pleistocene geology of the central Red Deer River area has been studied by Craig (1957) and by Stalker (1955, 1960).

A number of older bedrock valleys and stream-trenches, some of them more or less buried, others now occupied by misfit streams, cut across the study area. In age, they vary from late preglacial to late postglacial, and wherever they cut across coal fields, they have removed, by erosion, unknown tonnages of coal. The axes of a number of these valleys and trenches are shown in figure 6 as an aid (and a note of caution) in estimating reserves of coal.

ARDLEY COAL RESOURCES

Mines

Almost certainly the earliest mining of Ardley coal took place around the Ardley bend of the Red Deer River. Both the buffalo-hunting Tail Creek Settlement of the 1860's and 1870's and the pioneer agricultural Content Settlement of the 1890's were situated at the mouth of Tail Creek in Sec. 34, Tp. 38, R. 22, only four or five miles downstream from prominent river outcrops. Settlers at Content are known to have mined coal from the river banks in the early 1890's. Ardley coal zone mines were first formally registered near Three Hills in 1906 and at the Ardley bend in 1908. The largest Ardley zone mine in the central Red Deer River area was No. 384, the Inland Coal Company mine at Three Hills, which probably produced about 1.5 million tons during its 40-year life. At present only four mines produce coal from the Ardley zone within the study area (plus two mines producing from the Carbon-Thompson zone) and all are small operations.

Appendix A lists all registered coal mines that are known to have exploited Ardley coal within the central Red Deer River area. This appendix is excerpted from the "Catalogue of coal mines of the Alberta plains" (Campbell, 1964) with the following emendations:

- the catalogue has been checked regarding identification of the stratigraphic position of the producing formation; appendix A is believed to be a complete and correct list of all mines that have exploited the Ardley coal zone.

- mines Nos. 635, 1130 and 1322 are here placed in Sec. 7, Tp. 38, R. 23 instead of Sec. 7, Tp. 38, R. 24 as (incorrectly) in the catalogue.

Within the pattern described on page 8 , the total thickness of the Ardley coal zone varies from 22 to 78 feet, as shown by isopachs in figure 6. While the upper seam remains relatively constant, the middle part varies tremendously in coaliness, in many places carrying only a few coal lenses near the top, and the lower seam is usually thin and bony (see Fig. 7); consequently all the mines in the area have exploited only the upper seam (and many of them only the upper two thirds of the upper seam). Accordingly thicknesses of coal that have been mined are indicated in figure 6 as a better guide to resources than total thickness.

Analyses

Appendix B presents twenty-five "as received" proximate analyses of coals from Ardley zone mines selected from the following Canadian and Alberta government publications: Campbell (1964), Montgomery and Behnke (1964), Montgomery and Jorgensen (1961), Tibbetts and Montgomery (1960) and Stansfield and Lang (1944).

All analysed coals were collected from operating mines and therefore represent only the upper seam. Since all observed coaly lenses in the middle part as well as the lower seam appear, in weathered outcrop, to be more bony or shaly than the upper seam, coal representing the whole Ardley zone may be expected to have higher ash contents.

For all coals represented in appendix B, the moisture-free, ash-free gross calorific values have been calculated and, with one exception, all have been found to lie within 3.5% of 13,000 BTU per pound. Moisture contents reduced to an "ash-free" basis are also relatively uniform, clustering about the value 20%. It is convenient to consider the dry, ash-free calorific value 13,000 BTU per pound and the moisture content 20% as intrinsic characteristics of Ardley coal. Ash content, however, is one analytical parameter dependent entirely on mining practice, but, through it, the effective calorific value of the fuel can be affected; thus, for instance, if typical Ardley coal be mined to an ash content of 30%, its moisture content may fall to 16%, and its gross calorific value would certainly fall to about 7,000 BTU per pound, from which the heat of vaporization of the water, about 500 BTU per pound, must be subtracted to determine net or effective calorific value.

Cover and Tonnages

Within the central Red Deer River area, overburden covering the Ardley coal zone varies from zero to 1,300 feet. Figure 6 shows approximate areas where Ardley coal probably lies under less than 100 feet of cover. This must be considered a preliminary, and probably maximum estimate. Serious errors can be expected from: (1) basing the area estimates on incorrect or inadequate surface elevation contours and Ardley structure contours; (2) unknown coal losses by glacial planing now masked by thick drift cover; and (3) the presence of buried valleys of unknown width. The author believes that these three factors, especially the second and third, reduce the area actually underlain by Ardley coal with less than 100 feet of cover to about one half that shown in figure 6.

Following is a listing, with annotations, of the areas shown in figure 6, broken down into arbitrary regions.

- West of the Red Deer River and the Ardley-Alix buried valley in Tps. 38 and 39, R. 23 and south of Highway 12; 12.5 square miles may be underlain by Ardley coal with less than 100 feet of cover, from which must be subtracted an unknown area removed by cutting of the Ardley-Alix buried valley.

- North of the Red Deer River and east of the Ardley-Alix buried valley, in Tp. 39, Rs. 22 and 23; 14.7 square miles, less an unknown area removed by erosion in the Ardley-Alix buried valley.

- Ardley region proper, south of the Red Deer River in Tp. 38, Rs. 22 and 23, but north of Sec. 9, Tp. 38, R. 22; 10.8 square miles; cutting of several postglacial spillways in the northwest corner of Tp. 38, R. 22 has probably removed considerable amounts of coal.

- West side of the Red Deer River from Sec. 9, Tp. 38, R. 22 south to Sec. 35, Tp. 36, R. 22; 7.4 square miles.

- East side of Red Deer River north of Sec. 12, Tp. 37, R. 22; about 7.5 square miles including much glacially disturbed ground.

- East side of Red Deer River from Sec. 12, Tp. 37, R. 22 southward; about 5.8 square miles.

- West side of Red Deer River from Sec. 33, Tp. 36, R. 22 south to north boundary of Tp. 34, R. 22; 14.7 square miles.

- West side of Scollard Canyon of the Red Deer River from Sec. 32, Tp. 34, R. 21 to Sec. 21, Tp. 34, R. 22; 8.7 square miles.

- Three uplands east of the Red Deer River and west of Scollard and Rumsey; total area 13 square miles, possibly much planed off by glacial action.

- West side of the Perbeck coulee and Red Deer River from Sec. 20, Tp. 34, R. 22 south to Sec. 21, Tp. 33, R. 22; 6.1 square miles of which the southern half is glacially disturbed.

- Upland east of Trochu between Red Deer River and Ghostpine Creek, from Sec. 34, Tp. 33, R. 23 and Sec. 15, Tp. 33, R. 22 south to Sec. 2, Tp. 32, R. 22; 24.4 square miles, possibly glacially planed, though undisturbed.

- West side of Ghostpine Creek from Sec. 16, Tp. 33, R. 23 south to north boundary of Tp. 31, R. 23; 13.1 square miles, possibly glacially planed.

- Flanks of upland between Ghostpine Creek and Three Hills Creek south of north boundary of Tp. 31, R. 23; 20 square miles, possibly glacially planed.

- Flanks of upland west of Three Hills Creek; 28.8 square miles, possibly glacially planed and probably very close to the pinchout postulated above.

The total area in the foregoing 14 regions described as possibly underlain by the Ardley coal zone with less than 100 feet of cover is 191 square miles.

The areas shown in figure 6 are chiefly important as areas within which strippable Ardley coal might profitable be sought. Coal thicknesses which can be mined depend, as discussed above, primarily on acceptable ash content, and tonnages available depend in turn on thickness. Assuming (1) the author's contention (see above) that about one half the area shown in figure 6 actually is underlain by coal with less than 100 feet of overburden; (2) an average mineable thickness of no more than 4 feet to ensure 9,000 BTU coal; (3) coal specific gravity between 1.3 and 1.4; and (4) about 90% recovery factor; then as much as approximately 350 million tons may be recoverable from the Ardley coal zone in pockets scattered between Alix and Swalwell, a distance of 60 miles, in the central Red Deer River area.

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APPENDIX A: REGISTERED MINES EXPLOITING ARDLEY COAL IN CENTRAL ALBERTA

(u/g, underground mine; s, strip mine; H_2O, moisture percentage; A., ash percentage; V.M., volatile matter percentage; F.C., fixed carbon percentage; G.BTU, gross calorific value)

Location: Lsd. or 1/4	Sec.	Tp.	R.	Mer.	Mine No.	Mine Type	Life Span	Seam Elevation	Cover (feet)	Seam (feet)	Logs(feet); Analyses; Notes
5	19	30	23	4	459	u/g	1914-23				- Soft shale 3; coal 3.4; shale 1; dirty coal .5; coal 2; shale .1; coal .7; shale.
NE	1	31	24	4	681		1917				
2	11	31	24	4	818		1919				
6	14	31	24	4	445	u/g	1914-25		25	3.2	- Ss; clay .7; coal 2.5; clay .2; coal .7; clay.
7	14	31	24	4	444	u/g	1914-40	2800	60	3.2	- Soft ss; clay .7; coal 2.5; clay .2; coal .7; clay.
10	22	31	24	4	117		1906-08				
10,14,15	22	31	24	4	637	u/g	1916-23		55	3.2	- Soapstone; coal .2; clay; coal 2.3; bone .2; coal .7; clay.
11	22	31	24	4	303	u/g	1911-29		40	3.2	- Ss; coal .2; clay .3; coal 2.3; bone .1; coal .7; clay.
11,12	22	31	24	4	142		1907-15				- Clay 1-1.2; coal 3.5.
14	22	31	24	4	1676	s	1948-50		20-40	3.1	
14	22	31	24	4	116	u/g	1906-15				
	22	31	24	4	214		1909-15			3.5	- Clay roof; coal 3.5.
10,11,14, 15,16	25	31	24	4	384	u/g	1913-53	2690	160	5	- Ss; clay .5; coal 2.8; clay .2; coal 2.1; clay. See also Lsd. 1,2,3,6,7,8 Sec. 36-31-24-4.
16	26	31	24	4	113	u/g			70	4.9	
1	35	31	24	4	112	u/g	1906-13				
1,2,3, 6,7,8	36	31	24	4	384	u/g	1913-53				- H_2O 17.4; A. 11.3; V.M. 26.7; F.C. 44.6; G.BTU 9,300. See also Lsd. 10,11,14,15,16 Sec. 25-31-24-4.
9,10,11	36	31	24	4	811	u/g	1919-31		165		- Clay; coal .2; clay .5; coal 3; clay .2; coal 2; clay.
5	2	32	22	4	1374	u/g	1931-34	2831	70	5.4	- Ss; clay .2; coal 2.5; clay .2; coal 2.5; clay.
	16	32	23	4	373		1912-13			3	
SE	34	32	23	4	322	u/g	1911-13		55		- Coal 4.5; clay .2; coal 1.5.
15	22	33	22	4	970		1921-22				
9,10	29	33	22	4	1226	u/g	1926-55	2800	70	5.5	- Clay; coal 2.3; clay .2; coal 3; clay.
SW	32	33	22	4	623		1915-16				
16	12	33	23	4	426	u/g	1914-18		80	6.2	- Clay; coal .5; coal 2; bone .2; coal 3.5; clay.
7,8,9	14	33	23	4	1283	u/g	1928---	2730	30-80	5.8	- Clay; coal .5; coal 1.5; clay .2; coal 3; clay .5; clay. H_2O 18.2; A. 11; V.M. 26.7; F.C. 44.1; G.BTU 9,170.
9,10	14	33	23	4	315	u/g	1911-30		80	5.8	- Clay; coal 1.5; clay .2; coal 3; clay .5; clay.
9,10,15,16	14	33	23	4	710	u/g	1917-61	2750	80	6	- Clay; coal 2.5; bone .2; coal 3; clay .5; coal .5; clay. H_2O 17.8; A. 8.6; V.M. 29.1; F.C. 44.5; G.BTU 9,660.

APPENDIX A: REGISTERED MINES EXPLOITING ARDLEY COAL IN CENTRAL ALBERTA

Location											
Lsd. or 1/4	Sec.	Tp.	R.	Mer.	Mine No.	Mine Type	Life Span	Seam Elevation	Cover (feet)	Seam (feet)	Logs(feet); Analyses; Notes
14	14	33	23	4	859	u/g	1920-27		24	7.2	- Soft ss; clay 1; coal 2.8; clay .2; coal 3.2; clay.
15	14	33	23	4	921	u/g	1921---	2730	up to 100	4.8	- Soft ss; coal .5; coal 1; clay .2; coal 3; clay .7. H_2O 17.8; A. 9.2; V.M. 27.8; F.C. 45.2; G.BTU 9,510. See also Lsd. 2 Sec 23-33-23-4.
SE	16	33	23	4	385		1913				
15	22	33	23	4	423	u/g	1914-18		40-50	5.5	
2	23	33	23	4	921	u/g	1921---				- See also Lsd. 15 Sec. 14-33-23-4.
3	23	33	23	4	859	u/g	1920-27				
	27	33	23	4	991		1922-23				
12	7	34	21	4	1029		1922-24				- Slack coal 6.
15	18	34	21	4	471	u/g	1915-37		up to 70	5.5	- Shale; coal 2.1; bone .3; coal 3.2; clay .4; shale.
3,4,5, 6,7,8	30	34	21	4	376	u/g	1913-15		25	5.3	- Coal .5; coal 1.5; bone .2; coal 3.3; clay .3; dirty coal 2.
7	30	34	21	4	1376	u/g	1931-44		30	5.3	- Shale; coal 1.8; bone .2; coal 3; clay .3; dirty coal.
SW	5	34	22	4	338		1912			4.5	
SW	5	34	22	4	327	u/g	1911-13		20-70	5	
5,6	13	34	22	4	328	u/g	1911-38	2700	60	5.5	- Coal .5; coal 1.5; bone .2; coal 3.3; clay .3; dirty coal 2.
15	24	34	22	4	727		1918			5.7	- Soft ss; coal; shale.
12	7	36	21	4	1190	u/g	1925-29		120	4.8	- Clay; coal 2; bone 1; coal 1.8; shale.
11	12	36	22	4	1179	u/g	1924-29		25	5.2	- Clay 1.2; coal 2.8; clay .4; coal 1; coal 1; clay.
15,16	12	36	22	4	1254	u/g	1927-49		28-38		- Coal 2.2; bone 1.7; coal 1.
16	12	36	22	4	495	u/g	1915-25		28	4.5	- Clay; coal .3; coal 2.4; bone .5; coal 2; soft shale.
1	23	36	22	4	1223	u/g	1925-28		170	3.8	- Ss; coal 3.8; shale.
13	24	36	22	4	799	u/g	1919-24			4.2	- Shaly clay; coal 1.4; bone .5; coal 2.3.
15	22	37	22	4	1663	s	1947-50		0-100	5	- Clay; coal 3; clay .2; coal 1.8.
10	24	37	22	4	617		1915-16				
13	26	37	22	4	1381	u/g	1932-34			5	
5	35	37	22	4	1586	u/g	1942-49		50	5.2	- Ss; bone .2; coal 3; clay .2; coal 1.7; clay. H_2O 20.4; A. 12.9; V.M. 26.4; F. C. 40.3; G.BTU 8.440.
5	2	38	22	4	1127		1923-24			6	
8	4.	38	22	4	1074		1923-24			5.5	

4	7	38	23	4	1130	s					
4	7	38	23	4	635	u/g	1916-24	2550	55	10.4	- Slaty clay 2; coal 4; clay .2; coal 1.5; bone 2; coal 1; clay .8; coal 1.5; shale.
4	7	38	23	4	1135	u/g	1924-53	2600	50-150	5.8	- Shaly clay; coal 4; clay .2; coal 1.5; bone.
14	7	38	23	4	1365	u/g	1931-37	2550	50	5	- Clay; coal 3; bone .7; coal 1.3; clay.
16	7	38	23	4	1322	u/g	1930-47	2574	25-75	7.1	- Clay; coal .3; bony shale 1.2; coal 3.6; clay .2; coal 1.7; clay.
16	7	38	23	4	1675	s	1948-53				- See also Lsd. 13 Sec. 8-38-23-4; Lsd. 4 Sec. 17-38-23-4.
13	8	38	23	4	1675	s	1948-53		15-20	5.5	- Clay & shale 15-20; coal 4; clay .2; coal 1.2; clay. H_2O 19.8; A. 6.6; V.M. 28.4; F.C. 45.2; G.BTU 9,480. See also Lsd. 16 Sec. 7-38-23-4; Lsd. 4 Sec. 17-38-23-4.
14	8	38	23	4	1018	u/g	1922-50				- See also Lsd. 3 Sec. 17-38-23-4.
3	17	38	23	4	1018	u/g	1922-50	2600	50-100		- Shale; clay 1; coal 3.6; clay .2; coal 1.2; shale. See also Lsd. 14 Sec. 8-38-23-4.
4	17	38	23	4	1675	s	1948-53				- See also Lsd. 13 Sec. 8-38-23-4; Lsd. 16 Sec. 7-38-23-4.
5,11,12,13	17	38	23	4	255	u/g;s	1910---	2575	51	6.2	- Soil 10; gravel 1; sandy clay 5; soft sandrock 8; blue clay 4; coal & earth bands 4; coal 4; bone .7; coal 1.5; shale. H_2O 18; A. 7.5; V.M. 28.5; F.C. 46; G.BTU 9,360. See also Mine #1320.
5	17	38	23	4	1320	s	1930-32				- See also Mine #255.
7,8	17	38	23	4	631	u/g	1916-23		0-80	6	- Soft coal; clay 1; coal 6; bone .5; coal.
16	17	38	23	4	973		1922-23				
7,10	20	38	23	4	1734	s	1953---		up to 30	4.2	- Clay; shaly clay; coal 2.9; clay .2; coal 1.1; clay.
9,10,15,16	20	38	23	4	824	u/g	1919-29		18-100		- Cover; clay & bone 18-100; coal 4; clay .2; coal 1.5; shale.
10	20	38	23	4	1085		1923-29				
10	20	38	23	4	1613	s	1943-55		25+	5.5	- Sandy clay 25+, coal 3.7; bone .3; coal 1.5; shaly clay. H_2O 19.7; A. 8.8; V.M. 27.9; F.C. 43.6; G.BTU 10,000.
12,13	21	38	23	4	787	u/g	1918-29		120		- Clay & bone 1.2; coal 4.3; clay .2; coal 1.2; shale.
1,2,7,8, 9,10,15,16	29	38	23	4	314	u/g	1911-19		91	5.8	- Coal & bone; clay .9; bone .3; coal 4.3; clay .2; coal 1.3; slate.
1,8,9	29	38	23	4	912	u/g	1921-40	2600	91		- Clay; coal & shale .7; clay .8; coal 4.2; clay .2; coal 1.3; clay.
3	29	38	23	4	1044	s	1922-24				- Clay 22; sand 3; clay 25; coal.
3	29	38	23	4	951	s	1921-28		24	4	- Slaty clay 2; coal 4; clay .2; coal 1.5; bone 2; coal 2.3; clay .3; coal 1.5; clay & shale.

APPENDIX A: REGISTERED MINES EXPLOITING ARDLEY COAL IN CENTRAL ALBERTA

Location											
Lsd. or 1/4	Sec.	Tp.	R.	Mer.	Mine No.	Mine Type	Life Span	Seam Elevation	Cover (feet)	Seam (feet)	Logs(feet); Analyses; Notes
3,6	29	38	23	4	1488	u/g;s	1935-54	2600	20-75	5.5	- U/g mine: clay; roof coal 1; coal 2.8; clay .2; coal 1.5; shaly clay.
13	29	38	23	4	1486	u/g	1935-40	2600	55	5.5	- Clay; roof coal; coal 2.7; bone .5; coal .3; shaly coal.
2	33	38	23	4	795		1919				
3,4,5,6,9, 10,11,15,16	33	38	23	4	809	u/g;s	1919---		21-80		- Soil 7; gravel 1.2; shale 6; iron nodules 1; shale 3.9; iron nodules .8; shale 6; ss 1.2; shale 4; shaly clay 10; coal, ss, slate 1.5; coal 4.5; bone .2; coal 1.3; bone, soft clay 3.4; coal 1.5; clay .5; coal 1.3; sandrock. See also Lsd. 2,3,4 Sec. 2-39-23-4. H_2O 19.6; A. 5.6; V.M. 27.9; F.C. 46.9; G.BTU 9,490.
9,10,15	33	38	23	4	831	u/g	1919-27		70		- Clay 70; coal 4.9; clay .2; coal 1.3; clay. See Mine #808.
9,10,15	33	38	23	4	808	u/g	1919-27		70		- Clay 70; coal 4.9; clay .2; coal 1.3; clay. See Mine #831.
16	33	38	23	4	1035	u/g;s	1922-24				- See also Lsd. 1 Sec. 3-39-23-4.
16	33	38	23	4	731	s	1918-32		32		- Clay & sand 32; coal 5; clay .2; coal 1.5; clay 1.8; coal splint 2; coal & clay 2; bony coal 3; clay .2; coal .8; clay 1; coal 2.2; shale.
13	34	38	23	4	166	u/g	1908-18				
12	35	38	23	4	1605	s	1943-48		25	4.5	- Gravel & sandy clay 25; clay 2-3; bone 1; coal 3.5; clay .3; coal 1.5. H_2O 19.8; A. 7.2; V.M. 28.8; F.C. 44.2; G.BTU 9,290.
5	2	38	24	4	762		1921-23				
15	2	38	24	4	812	u/g	1919-40	2530	60	10.4	- Slaty clay 2; coal 4; clay .2; coal 1; bone 2; coal 1; clay .8; coal 1.5; shale.
15	2	38	24	4	1178	s	1924-25				
15	2	38	24	4	1050	u/g	1922-23		55	5	- Slaty clay 2; coal 4; clay .2; coal 1.3; bone.
16	2	38	24	4	1136	s	1924-25		15	5.2	- Clay 8; gravel 10; slaty clay 2; coal 3.7; clay .5; coal 1; bone.
16	2	38	24	4	1056	s	1922-23		15	5.2	- Clay 8; gravel 10; slaty clay 2; coal 3.7; clay .5; coal 1; bone.
16	2	38	24	4	1048	s			15		- Clay 8; gravel 10; slaty clay 2; coal 3.7; clay .5; coal 1; bone.

SE	10	38	24	4	835		1919-21				
	10	38	24	4	790		1918-19				
1	11	38	24	4	957	s	1921-32		55		- Slaty clay 2; coal 4; clay .2; coal 1.5; bone 2; coal 2.3; clay .3; coal 1.5; clay & shale.
1	11	38	24	4	1037	s	1922-24				
1	11	38	24	4	1030	u/g	1922-23				
1	11	38	24	4	1729	s	1952-53		18-25	4	
4	11	38	24	4	967	s	1921-27		22	4	- Slaty clay 2; coal 4; clay .2; coal 1.5; bone 2; coal 2.3; clay .3; coal 1.5; clay.
8	11	38	24	4	1291	u/g	1929-40	2565	120	4	- Clay 1.5; coal 4; bone .2; coal 1.5.
8,9	11	38	24	4	1068	s	1922-24				
4	12	38	24	4	946		1921-22				
12	12	38	24	4	891	s			65		- Slaty clay 2; coal 4; clay .2; coal 1.5; bone 2; coal 1; clay .6; coal 2.8; clay & shale.
12	12	38	24	4	810		1919-32				
8	1	39	23	4	667	s	1916-17			7	- Clay; coal 7; clay.
2,3,4	2	39	23	4	809	s	1919---				- See also Lsd. 3,4,5,6,9,10,11,15,16 Sec. 33-38-23-4.
7	2	39	23	4	1125	u/g	1923-25			5.5	
1	3	39	23	4	1035	u/g;s	1922-24		40		- U/g mine; clay 5; coal 5; clay .2; coal 1.4; clay. See also Lsd. 16 Sec. 33-38-23-4.
1,2,7,8	3	39	23	4	731	u/g	1918-23		40		- Clay; coal 5; clay .2; coal 1.4; clay.
4	3	39	23	4	1152		1924-25				
Addendum											
13	32	33	22	4	1961		1964-66				

APPENDIX B: REPRESENTATIVE ANALYSES OF ARDLEY COALS

Location: W 4th Mer. and References cited	Year Sampled	H_2O*	Proximate Analysis ("As received" Basis) A.*	V.M.*	F.C.*	G.BTU*	DAF.BTU*	AFI*
- Tp. 31-33, R. 22-24								
(Stansfield & Lang, 1944)		- 17.4	9	28.3	45.2	9,680	13,170	
- Mine 384, Sec. 36, Tp. 31, R. 24								
(Campbell, 1964)		- 17.4	11.3	26.7	44.6	9,300	13,040	
- Mine 1283, Sec. 14, Tp. 33, R. 23								
(Campbell, 1964)		- 18.2	11	26.7	44.1	9,170	12,950	
- Mine 710, Sec. 14, Tp. 33, R. 23								
(Tibbetts & Montgomery, 1960)	1956	- 16.8	10.7	26.4	46.1	9,370	12,920	1,960
	1956	- 17.3	8.7	27.3	46.7	9,520	12,860	1,960
(Campbell, 1964)		- 17.8	8.6	29.1	44.5	9,660	13,120	
- Mine 921, Sec. 14, Tp. 33, R. 23								
(Campbell, 1964)		- 17.8	9.2	27.8	45.2	9,510	13,020	
- Tp. 37-40, R. 21-25								
(Stansfield & Lang, 1944)		- 18.2	12.3	27.8	41.7	9,000	12,950	
- Mine 1586, Sec. 35, Tp. 37, R. 22								
(Campbell, 1964)		- 20.4	12.9	26.4	40.3	8,440	12,650	
- Tp. 37-40, R. 21-25								
(Stansfield & Lang, 1944)		- 19.8	8.2	28	44	9,260	12,580	
- Mine 1675, Sec. 8, Tp. 38, R. 23								
(Campbell, 1964)		- 19.8	6.6	28.4	45.2	9,480	12,880	
- Mine 255, Sec. 17, Tp. 38, R. 23								
(Campbell, 1964)		- 18	7.5	28.5	46	9,360	12,560	
- Mine 1613, 1734, Sec. 20, Tp. 38, R. 23								
(Tibbetts & Montgomery, 1960)	1955	- 16.8	9.3	28.8	45.1	9,270	12,540	2,160
	1955	- 16.4	9.4	30.3	43.9	9,520	12,830	2,160
	1958	- 19.9	8.1	28.9	43.1	9,230	12,820	2,060
	1958	- 18.4	9	29.5	43.1	9,390	12,930	1,970
(Montgomery & Behnke, 1964)	1963	- 17.2	14.6	30.4	37.8	8,630	12,650	
(Campbell, 1964)		- 19.7	8.8	27.9	43.6	10,000	13,980	
- Mine 809, Sec. 33, Tp. 38, R. 23								
(Tibbetts & Montgomery, 1960)	1955	- 19.2	7.1	27	46.7	9,400	12,750	2,180
	1955	- 16.9	7.4	29	46.7	9,590	12,670	2,160
	1958	- 17.5	7.1	28.6	46.8	9,700	12,860	1,950
	1958	- 17.3	7.4	28.8	46.5	9,630	12,780	2,010
(Montgomery & Jorgensen, 1961)	1960	- 18.6	7.4	29.4	44.6	9,470	12,790	2,110
(Campbell, 1964)		- 19.6	5.6	27.9	46.9	9,490	12,680	
- Mine 1605, Sec. 35, Tp. 38, R. 23								
(Campbell, 1964)		- 19.8	7.2	28.8	44.2	9,290	12,720	

*Abbreviations: H_2O, moisture percentage; A., ash percentage; V.M., volatile matter percentage; F.C., fixed carbon percentage; G.BTU, gross calorific value in BTU per lb.; DAF.BTU, free calorific value in BTU per lb.; AFI, initial ash fusion temperature in degrees Fahrenheit.

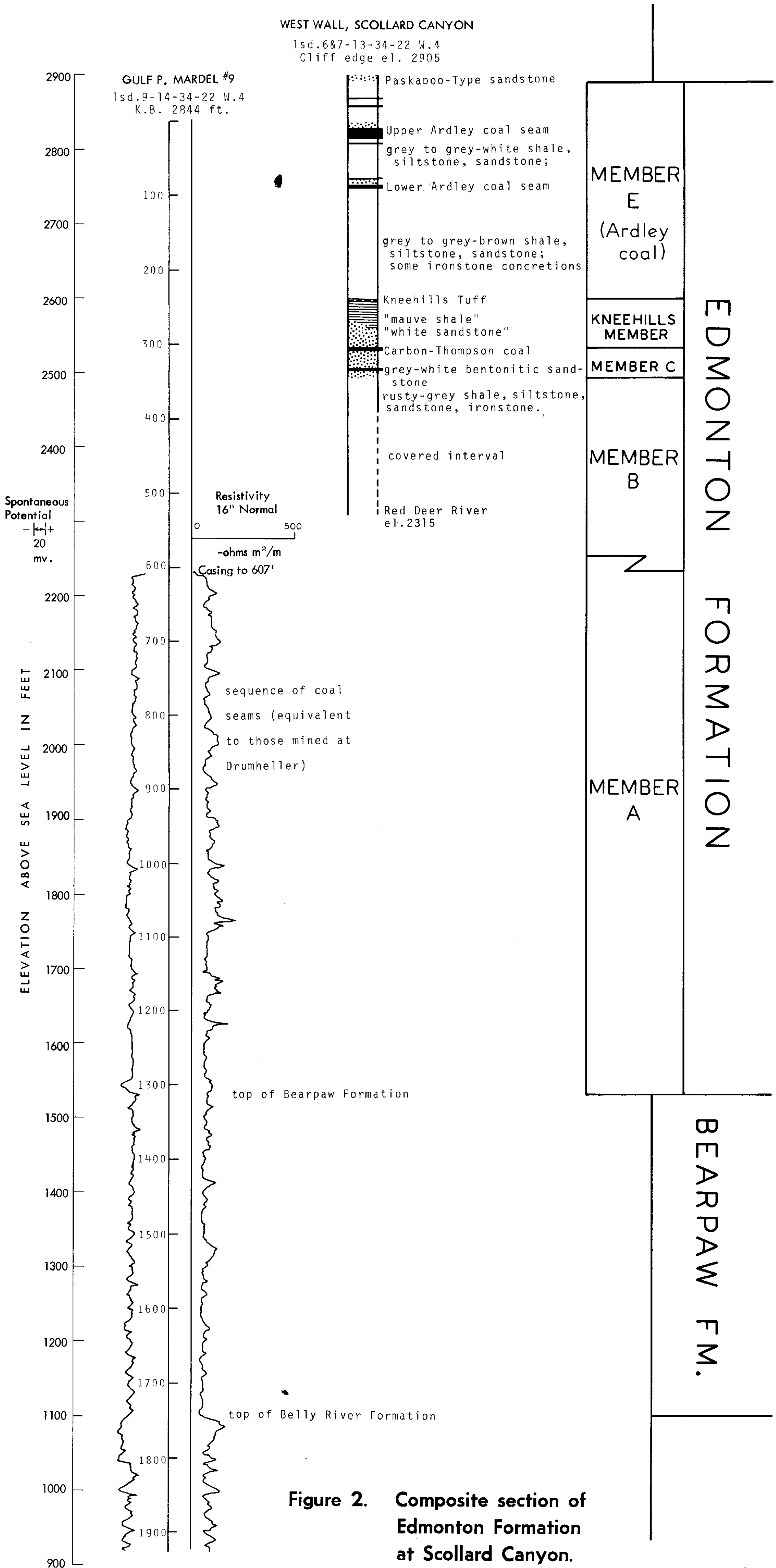

Figure 2. Composite section of Edmonton Formation at Scollard Canyon.

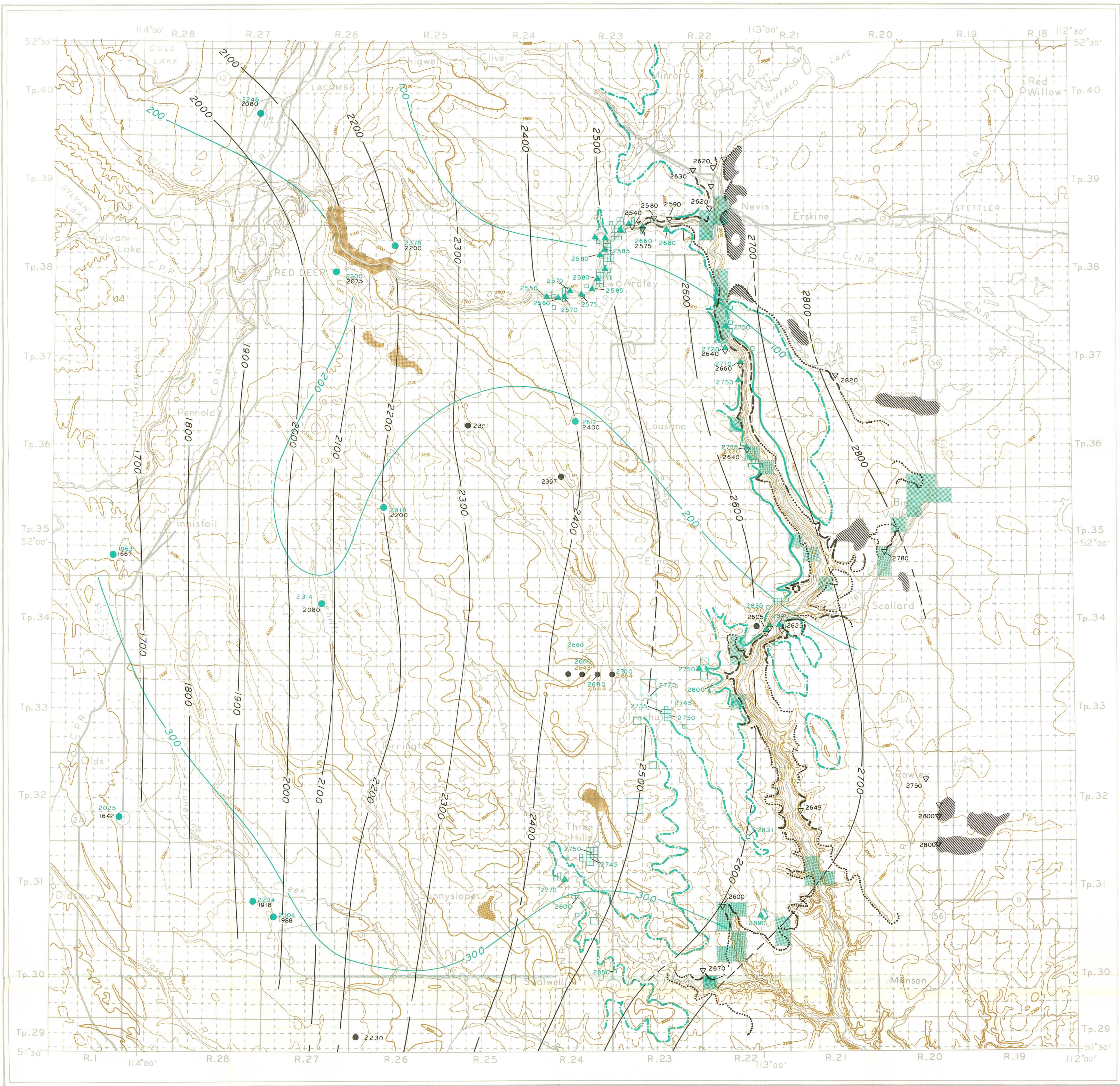

Figure 5. Geologic setting of Ardley coal zone, central Red Deer River area.

5 4 3 2 1 0 5 Miles

LEGEND

Middle Paskapoo Escarpment:
- Line of escarpment
- Outcrop of escarpment rocks*

Ardley Coal Zone Occurrences:
- Outcrop
- Land parcel licensed for mining Ardley coal
- Borehole; log recording Ardley coal
- Line of Ardley coal outcrop or subcrop: approximate; assumed
- Ardley-Kneehills interval: isopach (interval in feet) 300

Kneehills Member Occurrences:
- Structure-contour on top of Kneehills: actual; projected (interval in feet) 2700
- Line of Kneehills outcrop or subcrop: approximate; assumed
- Outcrop
- Moraine hills consisting in part of glacially deformed Kneehills bedrock

Carbon-Thompson Coal Zone Occurrences:
- Survey section in which Carbon-Thompson coal has been mined
- Borehole, log not recording coal

Elevations of datum-points (feet above sea-level):
- Top of upper Ardley coal 2735
- Lower Ardley coal 2750
- Top of Kneehills member 2605

Topographic contours (interval 100 feet) 1000

*Data in part from Stalker 1955, 1960

Topographic Contours and Base Map from Canada, Dept. of Mines and Technical Surveys National Topographic Series Maps 82-P and 83-A (1:250,000)

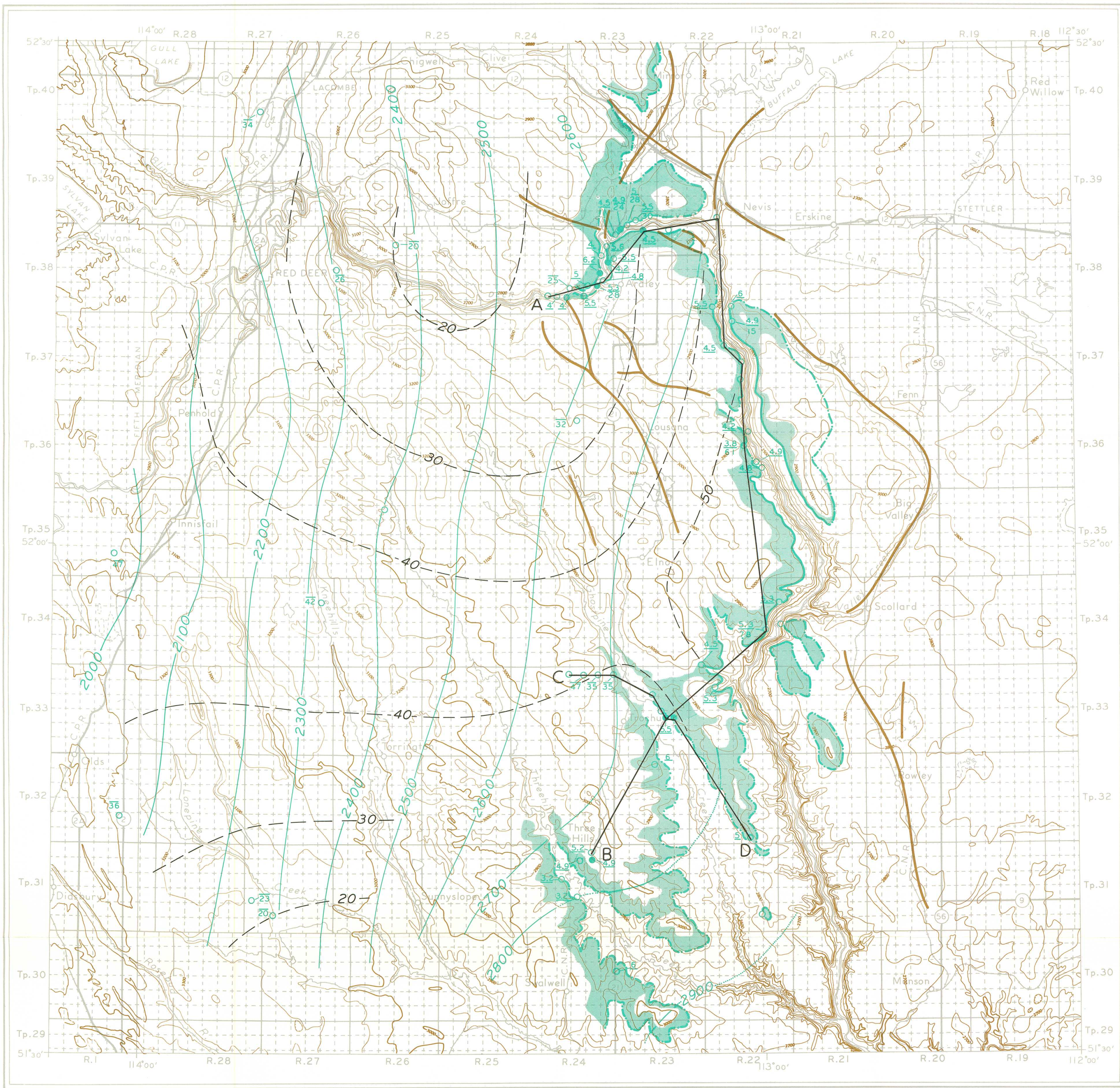

Figure 6. Ardley coal resources, central Red Deer River area.

5 4 3 2 1 0 5 Miles

LEGEND

Datum Point:
Point from which coal analyses are reported in Appendix B
Other points

Mined portion of Ardley coal zone (feet) 5.3
Total Ardley coal zone (in feet) 30

Line of Ardley coal outcrop or subcrop; approximate; assumed

Structure contour on top of Ardley coal; (interval in feet) 2500

Isopach of Ardley coal zone (interval in feet) 30

Overburden on Ardley coal less than 100 feet

Trace of buried valley where Ardley coal may be absent*

Line of section A—B

Topographic contours (interval 100 feet)

*Data in part from Craig (1957); Stalker (1955, 1960)

Topographic Contours and Base Map from Canada, Dept. of Mines and Technical Surveys National Topographic Series Maps 82-P and 83-A (1:250,000)

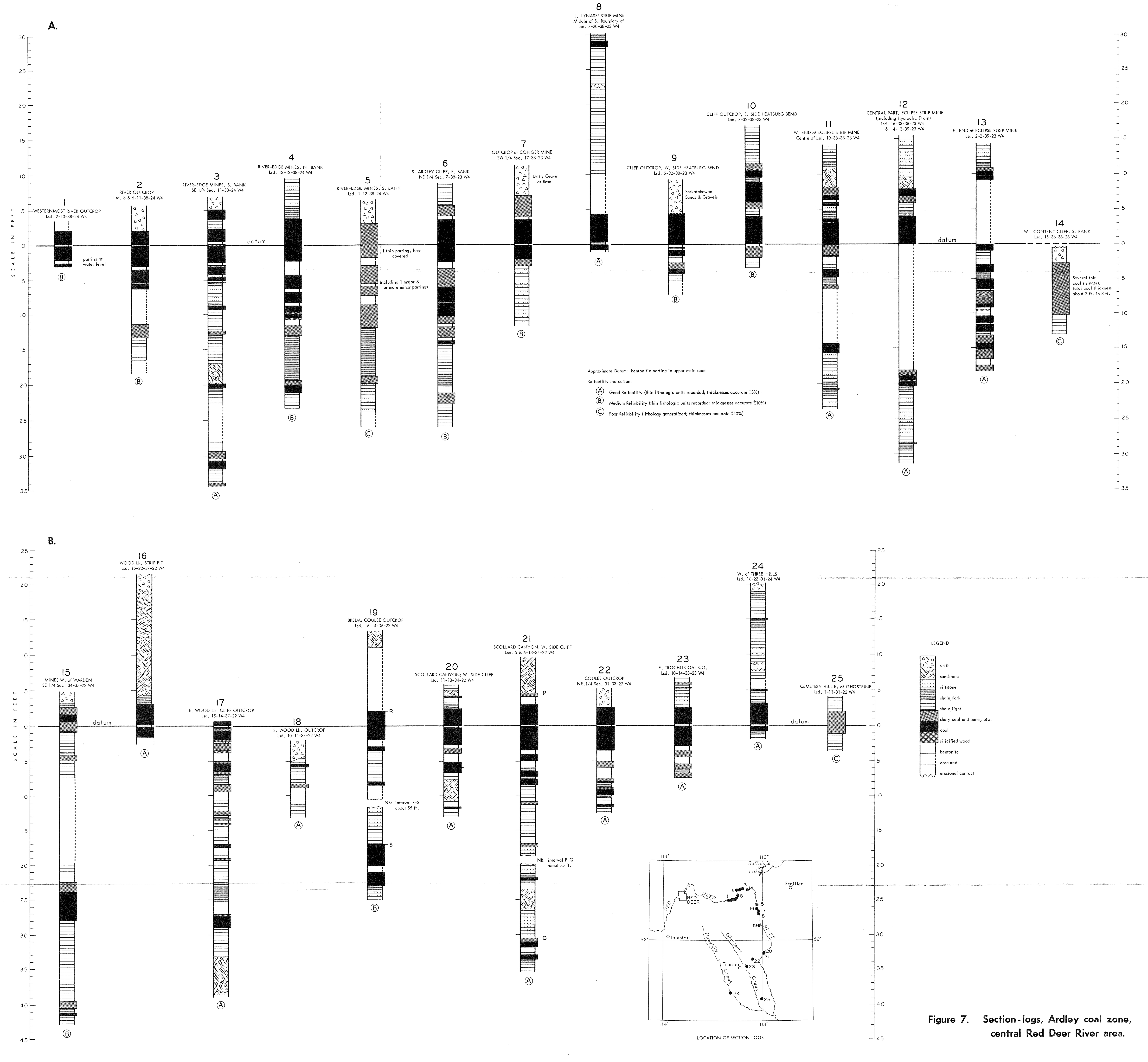

Figure 7. Section-logs, Ardley coal zone, central Red Deer River area.