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LOWER CRETACEOUS ROCKS OF SOUTHEASTERN SASKATCHEWAN

(Report, 12 figures, 3 tables, appendix)

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LOWER CRETACEOUS ROCKS OF SOUTHEASTERN SASKATCHEWAN

By

Leon L. Price

D E P A R T M E N T O F

M I N E S A N D T E C H N I C A L S U R V E Y S

C A N A D A

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LOWER CRETACEOUS ROCKS OF SOUTHEASTERN SASKATCHEWAN

INTRODUCTION

The sediments described in this report form a comparatively thin accumulation on the eastern side of the Lower Cretaceous sedimentary basin adjacent to the Canadian Shield, between the Manitoba border and the Third Meridian (106° W) from the Forty-ninth Parallel to Township 40 (about 52° 30'N).

Much drilling activity in this area, largely in exploration of deeper formations, has provided an immense amount of stratigraphic information. However, it has resulted in only one field with Lower Cretaceous production (Wapella). Drilling at the time of completion of this study provided control density of about one hole to 90 square miles.

The writer is grateful for assistance from members of the oil industry, particularly Tide Water Associated Oil Company at Regina; also to the Saskatchewan Department of Natural Resources for free access to the collection of deep-well cores at the Subsurface Geological Laboratory, and to the staff there for their assistance while examining this material. T.G. Allen, L.M. Parsons, and R.D. Ferguson assisted at various times in collecting and processing geological material and data used in the report.

STRATIGRAPHY

Lower Cretaceous rocks of southeastern Saskatchewan can be divided into two major groups, of contrasting lithology and distribution. The upper or Ashville Group, mainly shale, contains marine fossils and glauconitic beds—conspicuously absent in the underlying group. The Ashville Group thins to the northeast, where increasing amounts of sand may indicate the approach to shoreline conditions. The lower group, here designated as the 'basal Cretaceous sandy group', is highly variable in thickness and shows no sign of depositional limits within those now imposed by erosion. Compared with the Ashville Group, it shows considerable stratigraphic complexity.

BASAL CRETACEOUS SANDY GROUP

A variety of existing names from other areas has been applied to rocks of the basal Cretaceous sandy group in southern Saskatchewan. None has proved completely satisfactory. The group has been widely known under the name "Blairmore"—a term taken from the Alberta foothills and used for convenience during the course of petroleum exploration in Saskatchewan. Although rocks of the Blairmore

Group of the Alberta foothills are in part, at least contemporaneous with essentially arenaceous deposits in southern Saskatchewan, they are composed of different kinds of sediments derived from sources on opposite sides of the sedimentary basin. The two areas of deposits are separated geographically by sediments of a third group—the "Mannville"—distinguished by marine beds not recognized in the other two (see Fig. 1).

Glaister (1959, section D-D')[1] indicated a much greater stratigraphic interval for the Blairmore succession in the foothills than for the basal Cretaceous (Mannville) sandy group in the Plains immediately to the east. On his map, he also drew an arbitrary cut-off between the partly marine eastern group and the non-marine Blairmore, believing that the abrupt facies changes alone warrant separate nomenclature.

Use of the name "Mannville" was extended to southern Saskatchewan (Price, 1955) from eastern Alberta. The term was applied first by Nauss (1945) to basal Lower Cretaceous strata of the Plains with some oil production, west of Lloydminster. Badgley (1952) raised the formation to group status and traced the Mannville Group throughout central Alberta.

However, none of the prominent marine interbeds of the Mannville in Alberta are recognizable as such for any great distance into Saskatchewan, and the Mannville Group as found in Alberta therefore does not extend southeastward more than 50 or 60 miles beyond Lloydminster. Workman (1958, p. 240) placed an eastern limit for his "glauconitic sandstone" that is roughly parallel with the eastern limit of the Mannville Group shown in Figure 1 of this report. Part of the abrupt change in thickness that occurs at this boundary is accounted for by the abutment of the "glauconitic sand" and other lower western beds against the western edge of a higher eastern shelf. These changes serve to differentiate tectonic areas with different conditions of deposition during a certain interval of Lower Cretaceous time. Southeastern Saskatchewan lies in the shallow eastern area, whereas the Mannville type section is taken near the eastern limit of the deeper, western area. The eastern boundary of the Mannville Group (Fig. 1) is drawn, as Glaister has done in the west, according to the principle of the arbitrary cut-off described by Wheeler and Mallory (1953, p. 242).

Wickenden (1945) applied the name "Swan River" to a group of Lower Cretaceous sandy strata exposed in river valleys near the Saskatchewan-Manitoba border, north of Township 35. The Swan River Group in the type area includes all sandstone in the lower part of the Cretaceous section. Shaly sand in the upper part of the Swan River Group is marine, and from subsurface studies it appears to be equivalent to marine shale overlying the basal sandy group in Saskatchewan a short distance to the west. In spite of the nearness of this Swan River outcrop, stratigraphic divisions used there are not applicable in southern Saskatchewan because of changes in lithology to the west.

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[1]Dates and/or names in parentheses refer to publications listed in the Bibliography.

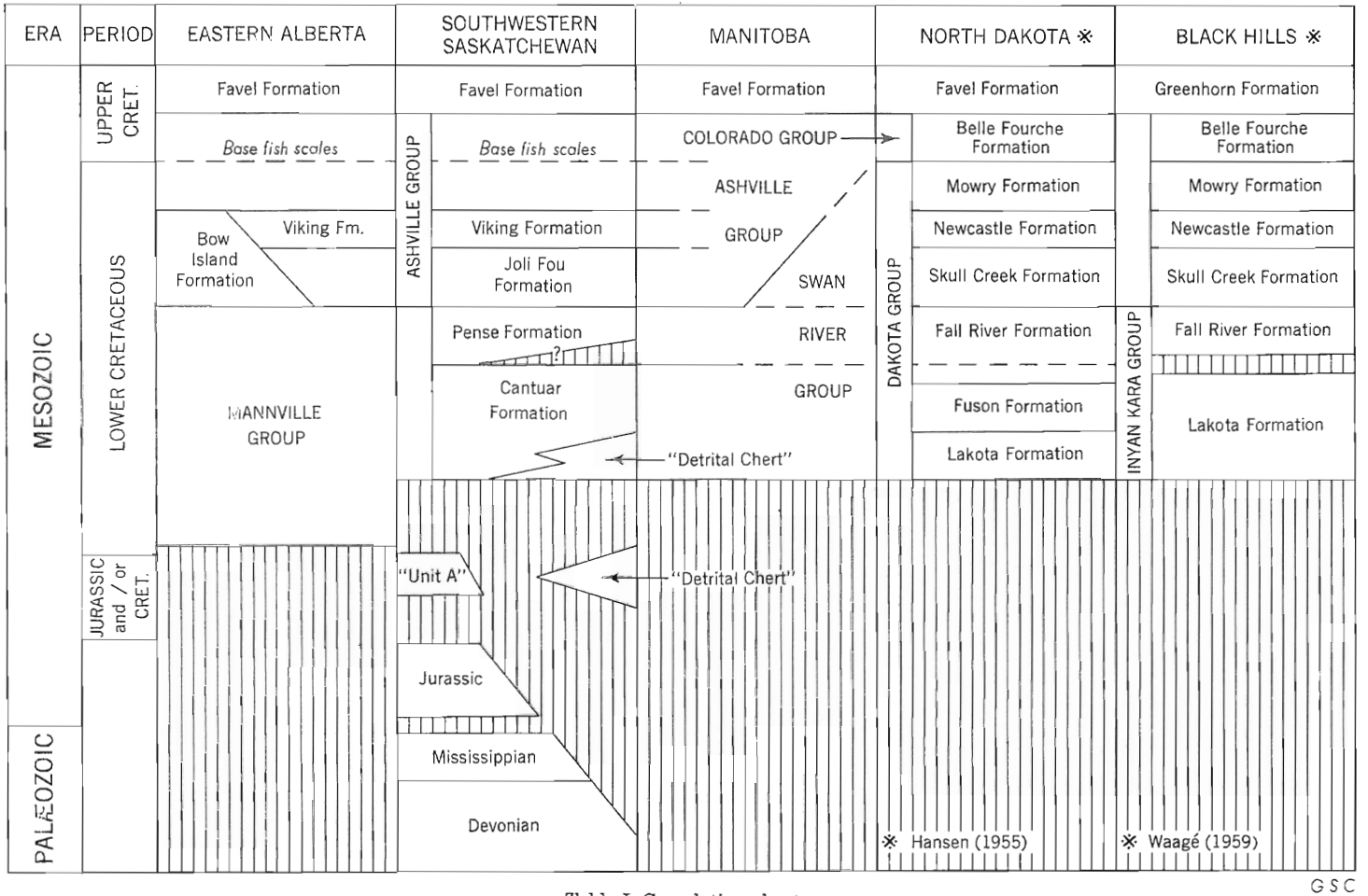

Table I. Correlation chart

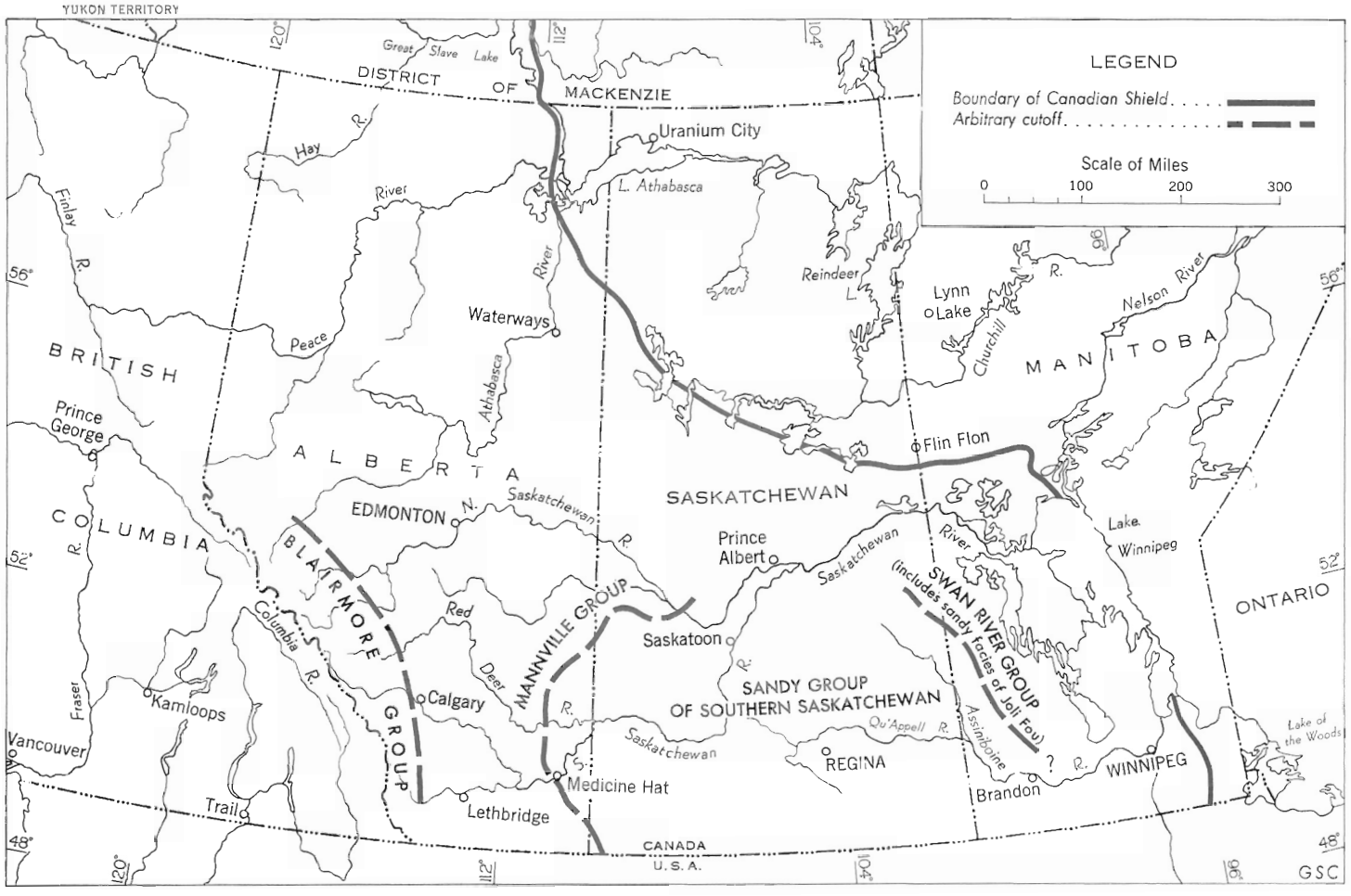

Figure 1. Probable geographic limits of basal Cretaceous (sandy) groups of the Canadian plains

In North Dakota, Hansen (1955) has correlated the corresponding sandy group with exposures in the eastern Black Hills, which were divided by earlier workers into, in ascending order: the Lakota, the Fuson (Darton, 1901, p. 526), and the Fall River (Russel, 1928, pp. 136-137) Formations. Hansen has traced these formations in the subsurface across North Dakota to the vicinity of the Saskatchewan border. In the adjoining regions of Saskatchewan, however, these divisions are not readily recognizable and the beds are commonly treated as a group or as a single formation.

Rubey (1930) found the threefold division similarly obscure in the western part of the Black Hills where he described the Inyan Kara Group from beds believed to be the equivalent of the Lakota, Fuson, and Fall River Formations. The Inyan Kara Group was only mentioned in a preliminary manner and the brief description of the rocks does not permit an accurate evaluation. More recently, the outcrop sections of the type area along Inyan Kara Creek have been described in detail by Waagé (1959) as part of a broader study. Waagé rejects the threefold subdivision of the basal Cretaceous sandy group, contending that it is not generally applicable in the Black Hills area. He recognizes an Inyan Kara Group composed of redefined Lakota and Fall River Formations. The basis of Waagé's twofold division is similar to one in use for the Lower Cretaceous basal sandy group in southwestern Saskatchewan. Application of the term "Inyan Kara" in Saskatchewan is hampered at present however by conflicting correlations of the Fall River Formation in North Dakota and Montana near the Forty-ninth Parallel.

The sandy Cloverly Formation of the Bighorn Mountains (Darton, 1904) appears to be continuous in a general way with the basal Cretaceous sandy group of southern Saskatchewan, and use of the name there has been suggested (Borden, 1956). However, Burk (1958) has pointed out that the Cloverly Formation is clearly recognizable in only a limited area near the type section. He cites subsurface work that shows the entire Cloverly unit to be older than any part of the Fall River Formation. It therefore is probably only a partial equivalent of the basal sandy interval in Saskatchewan.

In summary, it does not seem practicable to adopt, in southern Saskatchewan, any of the existing terms for corresponding basal Cretaceous sandy groups of other areas. In lieu of a satisfactory formal group term, two new formation names are proposed here. New formation names, of course, do not furnish an adequate substitute for a group name, inasmuch as general correlation is accomplished largely through electric logs. In southeastern Saskatchewan, electric-log identification of the twofold division is practical only over small areas linked to adequate lithologic control. The problem of establishing a group name for these basal Cretaceous beds is, however, beyond the scope of this report, and the informal designation 'basal Cretaceous sandy group' will be used here.

The two divisions of the basal group have already been recognized in southern Saskatchewan (Hadley and Milner, 1953, p. 87) and the combinations of facies typical of each division are broadly consistent over most of southern Saskatchewan and probably a considerably greater area. The name "Cantuar" has been informally

applied to the lower division, although no type section has hitherto been described. The name "Pense"—derived from the village of Pense, Saskatchewan—is proposed for the upper division, and the type section is described from a complete core taken from the interval in that locality.

The junction between the Cantuar and Pense Formations is a lithologic boundary, well known locally as the base of an impervious shaly zone that is of some importance in southwestern Saskatchewan as an oil trap. The horizon is identified over a large part of that region by the distinctive electric-log pattern of the 'marker beds' in the base of the Pense Formation. The extent of the marker beds emphasizes the lateral persistence of strata of the upper unit in contrast with the lenticularity of those below. The base of the marker beds represents the upper limit of any soft light-coloured claystone present in the underlying formation and it marks, in general, a change upward to finer-grained sandstone. The two units are further differentiated by divergent patterns of distribution shown on isopach maps (Cumming and Francis, 1957, p. 70; Proctor, 1959, pp. 32, 34).

Cantuar Formation

The name "Cantuar" was first used by oilfield geologists (Humphreys and Rogers, 1954; Elphinstone, 1958) for a producing sand in the vicinity of the Cantuar field near Swift Current, where in places it comprises the entire lower division of the basal Cretaceous sandy group. The meaning of the term was expanded by Milner and Blakeslee (1958) who used the marker beds as datum in diagrams of the underlying Jurassic rocks. They referred all of the intervening Cretaceous strata to the Cantuar, which they extended to include most of southwestern Saskatchewan. The "Cantuar sand" of Elphinstone (1958) and others is a producing interval within the Cantuar Formation. The Cantuar Formation is the "lower Blairmore" of other authors (Hadley and Milner, 1953; Cumming and Francis, 1957).

The Cantuar Formation as defined in this report extends from southwestern Manitoba across southern Saskatchewan as far as the arbitrary cut-off of the Mannville marine beds to the west (Fig. 1). It continues for an indefinite distance north of Township 40 and is probably recognizable well south of the International Boundary. It may be missing in a small area around Redvers, Saskatchewan.

Type Section

The type section for the Cantuar Formation proposed here is described from a cored interval of Tidewater Matador No. 1 well, 8 miles southeast of the townsite of Matador, 24 miles north of the Cantuar field in southwestern Saskatchewan and about 90 miles west of the subject area. The type well lies within the western third of the area of distribution, where the marker beds are clearly recognizable on the electric log. The greater thickness of beds here is more representative of the diverse lithology than at Cantuar where the formation is especially thin.

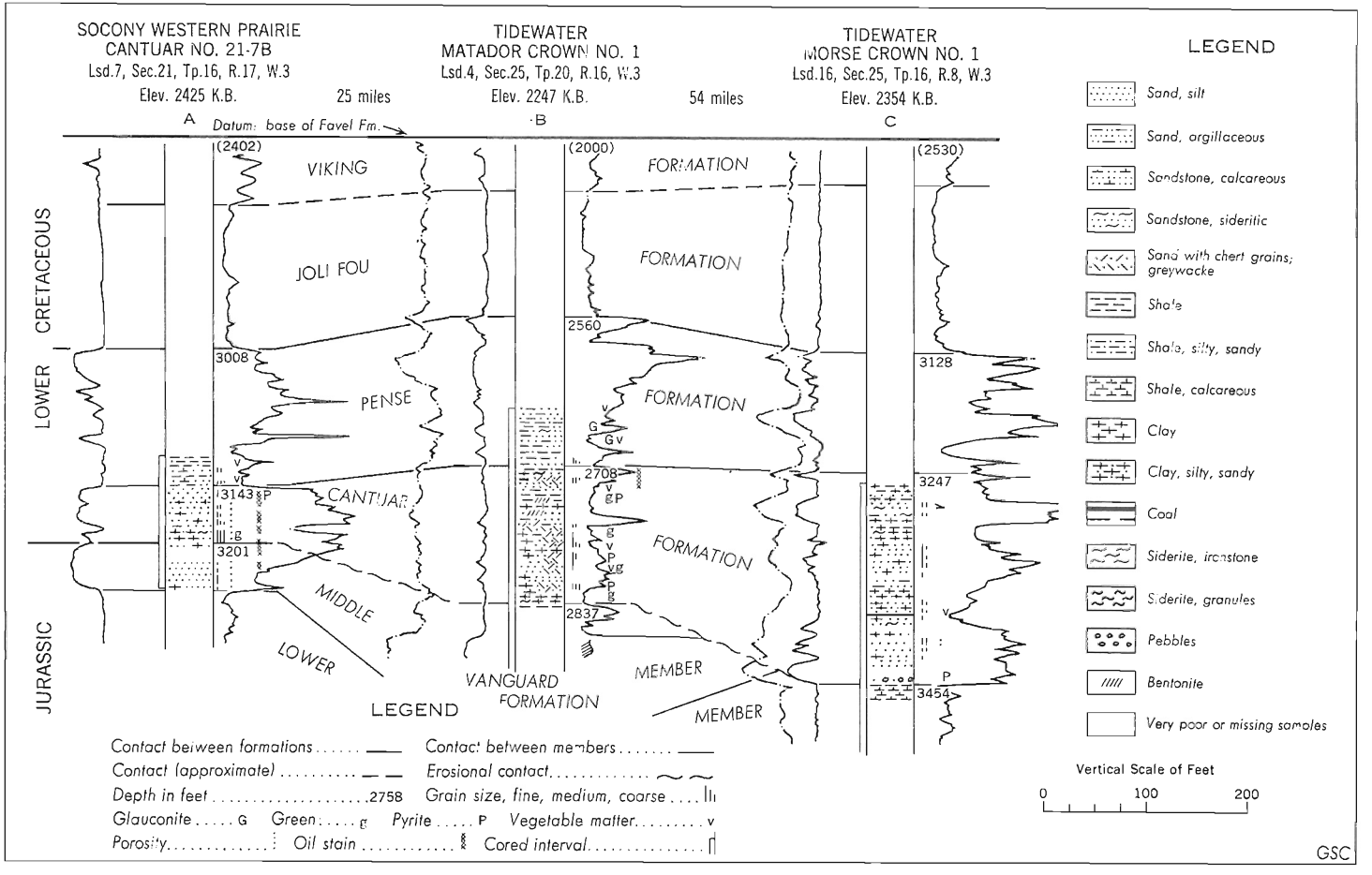

Figure 2. Type section of Cantuar Formation and correlation with adjacent area

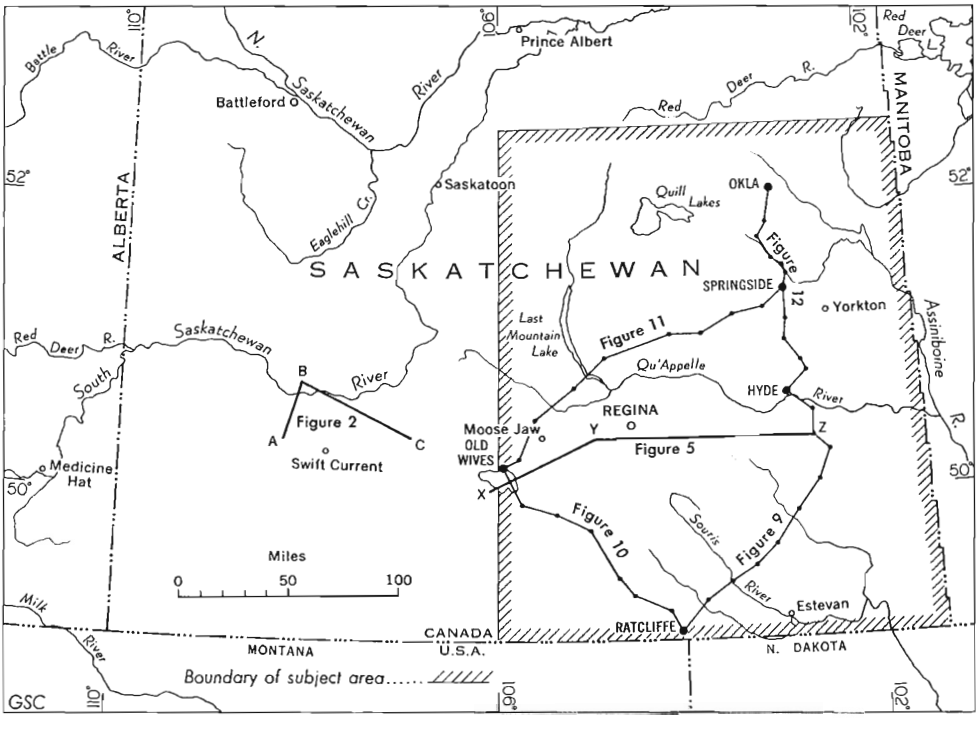

Figure 3. Locations of type sections of Cantuar and Pense Formations with respect to subject area and cross-sections

Details in the following log of the type section are limited to those visible under the binocular microscope using 36 diameters of magnification or less. The terms "quartzose sandstone", "greywacke", "clay" and "shale", as used in the log, are defined, with discussion of the respective lithologies, following the log. Indications of grain size follow the Wentworth scale.

Well: Tidewater Matador Crown No. 1

Location: 1sd. 4, sec. 25, tp. 20, rge. 16, W 3rd mer.

Elevation: 2,247 feet K.B. (Datum)
2,238.6 feet Ground level

Spudded: 14 April 1953
Total depth: 3,325 feet

Core stored at the Subsurface Geological Laboratory of the Saskatchewan Department of Mineral Resources, Regina; core chips stored at the office of the Geological Survey of Canada, Calgary.

Depth	Lithology
	Pense Formation
	("marker beds")
2,696-2,701'	(Core #11, recovered 2'6")
0-2'6"	Siltstone, shaly or very silty shale, medium grey, blocky, with fine, irregular current-bedding; partings with branching, shaly streaks resembling plant stems; rare pyrite; mica; abundant finely divided vegetable matter; spores, fish teeth
2,701-2,707'	(Core #12, recovered 1'6"; core broken)
0-1'6"	Shale, medium to dark grey, silty, soft; irregular fine silty streaks and lenses; zone with abundant coarse grains of quartz; mica; carbonized wood
2,707-2,709'	(Core #13, recovered 2'; core broken)
0-1'	Shale, dark grey, with lenses of fine- to coarse-grained sand containing scattered dark chert grains, abundant chloritic grains, biotite and interstitial clay
	Cantuar Formation (Type section)
1-3'	Clay, light brown, waxy-textured, with minute siderite crystals and nodules, grading to similar smooth-textured shale
2,709-2,712'	(Core #14, recovered 3'9")
0-2'6"	Sandstone, medium- to coarse-grained, poorly indurated, shaly in part

Depth	Lithology
2'6"-3'9"	Sandstone, brown, oil-stained, silty, medium-grained, porous; angular quartz grains (about 45%); dark chert or other rock fragments (20%); green chloritic grains; feldspar; interstitial silt and (?) powdery clay
2,712-2,715'	(Core #15, recovered 4')
0-4'	Sandstone, oil-stained, medium-grained as above; very fine grained tight zones
2,715-2,719'	(Core #16, recovered 3')
0-2'6"	Sandstone, oil-stained, medium-grained, with chert grains and chlorite, as above; fine-grained tight zones; partings with abundant vegetable matter
2'6"-3'	Sandstone as above; coal seams up to 1" thick
2,719-2,724'	(Core #17, recovered 5'9")
0-1'4"	Siltstone, argillaceous, light grey, with oil-stained laminae, blocky, with slight shaly cleavage; abundant carbonized vegetable matter; chlorite flakes
1'4"-4'	Sandstone, oil-stained, fine to very fine grained, silty; dark chert grains; chlorite flakes
4'-5'9"	Siltstone, argillaceous, pale grey with green cast; dark chert grains; chloritic grains; chlorite flakes; carbonized vegetable matter; fine bedding laminae
2,724-2,729'	(Core #18, recovered 1')
0-1'	Siltstone, shaly banded, light to pale grey, grading to fine-grained, speckled sandstone; large fragments of carbonized plants
2,429-2,432'	(Core #19, recovered 1')
0-1'	Shale, light greenish grey, silty to finely sandy, blocky, clayey, grading to argillaceous sandstone; pyritic nodule 1" in diameter
2,732-2,734'	(Core #20, recovered 3')
0-3'	Shale, bentonitic, light greyish green, slightly silty
2,734-2,741'	(Core #21, recovered 13'6")
0-10'6"	Shale, light greenish grey, clayey, with silty to sandy zones, more prominent in upper half of interval
10'6"-13'6"	Clay, light brown, very sandy in part; rare carbonized wood; much drilling mud

Depth	Lithology
2,741-2,748'	(Core #22, recovered 6')
0-6'	Clay, pale brownish green, waxy
2,748-2,753'	(Core #23, recovered 2'3")
0-2'3"	Siltstone, clayey, bentonitic, pale grey with green cast; finely divided black vegetable matter; chloritic grains
2,753-2,758'	(Core #24, recovered 8')
0-8'	Siltstone, clayey, or silty clay, pale green, soft
2,758-2,763'	(Core #25, recovered 6'8")
0-2'6"	Siltstone, clayey, pale greyish green to brown, becoming slightly coarser downward; specks of vegetable matter; green-tinted silt contains chlorite flakes and has appearance of a very fine grained 'greywacke'
2'6"-6'8"	Greywacke, pale grey, speckled, fine- to coarse-grained, tight, calcareous and well indurated in part; zone with brown sand-sized siderite aggregates
2,763-2,770'	(Core #26, recovered 7'6")
0-2'6"	Greywacke(?), medium-grained, pale grey, speckled; abundant interstitial powdery white clay takes the place of much of the chloritic material seen in greywacke above; calcareous zone 6"-1'6"
2'6"-6'	Siltstone, shaly, light grey, with abundant specks of carbonized vegetable matter; grades downward to silty shale in basal 1 foot of interval
6'-7'6"	Clay, dark brown; abundant carbon and small lenses of coal
2,770-2,777'	(Core #27, recovered 3')
0-6"	Clay, dark greyish brown, carbonaceous, silty and sandy in part, grading downward to clayey sandstone
6"-2'6"	Sandstone, light grey, speckled, porous in part, fine- to medium-grained; nearly 50% of grains are quartz with secondary crystal growth; abundant dark chert and other rock fragments; scattered green chloritic grains and grains of white clay
2'6"-3'	Shale, medium grey, flaky, with minute streaks and lenses of siltstone and waxy shale
2,777-2,783'	(Core #28, recovered 2'6")

Depth	Lithology
0-1'3"	Clay, finely sandy or clayey sand, brownish green; chloritic grains, semi-waxy lustre
1'3"-3'	Sandstone, greenish grey, fine-grained and silty at top, grading downward to coarse to very coarse grained, speckled sandstone at base with characteristics of greywacke
2,783-2,788'	(Core #29, recovered 3')
0-3'	Clay, light brown, waxy; minute fragments of carbonized wood; spores
2,788-2,793'	(Core #30, recovered 2'6")
0-8"	Siltstone, sandy, clayey, pale brown; inclusions of waxy clay in branching pattern and in nodules up to 0.3 mm
8"-2'2"	Greywacke, green, speckled, medium- to coarse-grained, poorly indurated; quartz; dark chert or rock fragments; feldspar; green chloritic grains, brown and white 'clay' grains, interstitial green clay
2'2"-2'6"	Clay, brownish green, waxy
2,793-2,796'	(Core #31, recovered 4'6")
0-4"	Clay, brownish to greyish green, waxy, silty near base
4"-4'6"	Sandstone, clayey, greenish grey, fine-grained, finely porous; dark chert(?) grains; chloritic grains; powdery greenish grey clay and silt matrix; a little finely divided pyrite
2,796-2,801'	(Core #32, recovered 6')
0-6'	Greywacke(?), medium- to fine-grained; scattered vegetable matter; coarsest at base, with white interstitial powdery clay
2,801-2,806'	(Core #33, recovered 2'10")
0-1'6"	Greywacke(?), greenish grey, speckled, fine-grained; differs from some greywacke by having a definite white powdery matrix
1'6"-2'10"	Siltstone, argillaceous, greenish grey, speckled; chlorite; abundant finely divided vegetable matter; carbonized plant fragments, pyritized in part
2,806-2,809'	(Core #34, recovered 2'5"; core broken)
0-2'5"	Greywacke, light grey, fine-grained; argillaceous, greenish grey silt and silty clay

Depth	Lithology
2,809-2,814'	(Core #35, recovered 5")
0-5"	Clay, silty to sandy, greenish brown, very soft, consists of brown to green waxy clay with abundant green chlorite flakes and finer quartz and dark chert(?) grains
2,814-2,819'	(Core #36, recovered 2'6")
0-1'10"	Siltstone, light greenish grey, finely speckled; chloritic grains; interstitial clay; finely divided carbon
1'10"-2'6"	Sandstone, calcareous, light grey, speckled, very fine to fine grained; angular quartz and dark chert; chloritic grains; chlorite; abundant white chalky clay matrix; interstitial crystalline calcite
2,819-2,825'	(Core #37, recovered 8'; expanded clay)
0-1'6"	Sandstone, calcareous, speckled as above, but coarser (fine- to medium-grained)
1'6"-5'	Clay, silty or clayey silt, light greenish brown; chlorite; specks of white clay; fine fragments of carbonized wood; grades to fine-grained, argillaceous sandstone
5-6'	Sandstone, shaly, finely banded, light grey; abundant chlorite, green and brown clayey grains, fine carbon and carbonaceous partings
6-8'	Sandstone, pale grey, speckled, argillaceous; medium- to coarse-grained; quartz grains (40% of rock), well-rounded to subangular; chert and other rock fragments (20%), angular to subangular; green chloritic grains; brown clay grains; abundant white earthy clay matrix; pyritic zone
2,825-2,830'	(Core #38, recovered 2'7")
0-3"	Sandstone, pale grey, speckled, slightly porous, but with much interstitial white clay
3-10"	Siltstone, argillaceous, greenish brown, firm; chlorite flakes; abundant finely divided vegetable matter
10"-2'	Sandstone, coarse-grained, with interstitial pale brown clay; scattered subangular black chert; a few red-stained grains; carbonized oval seed cases with spiral markings
2'-2'7"	Clay, finely sandy, pale greenish brown; quartz grains, subangular to subrounded, many with red stain; silty zones; scattered rounded fragments of clay similar to matrix; a few dark chert grains

Depth	Lithology
2,830-2,835'	(Core #39, recovered 2'6")
0-2'6"	Clay, silty to sandy, or clayey siltstone, pale yellowish brown, massive; quartz grains, some stained with coating of hematite(?)
2,835-2,837'	(Core #40, recovered 2')
0-2'	Clay, light yellowish green, almost waxy, finely silty; minute nodules, widely scattered, of dark brown siderite
	Jurassic
2,837-2,842'	(Core #41, recovered 8')
0-2'6"	Shale, light greenish grey, smooth-textured, flaky to clayey, with faint irregular banding due to silty lenses; streaks of finely divided pyrite
2'6"-8'	Shale, greenish grey, waxy, soft, splintery, non-calcareous

Some of the terms in the foregoing log are used in a restricted sense and require definition:

Greywacke: Speckled sandstone, poor in quartz, with abundant chert and other rock fragments in impervious clastic matrix. Low in feldspar by comparison with greywacke of some authors (see Pettijohn, 1957, p. 301).

Quartzose sandstone: Sandstone with grains nearly all composed of quartz.

Lithic sandstone: Sandstone, commonly porous, with at least 5% of chert grains and other rock fragments. Includes all sandstone of a composition between greywacke and quartzose sandstone.

Shale: Essentially argillaceous rock with discernible fissility.

Clay: Argillaceous rock, commonly light-coloured, massive and soft, lacking the fissility of 'shale'.

The heterogeneity of the Cantuar Formation emphasizes the disadvantages of representing a formation by a single type section. Lithology ranges from greywacke to quartzose sandstone interbedded with silt, grey and green shale, and coal and clay, both brown and variegated. The formation also includes quantities of chert detritus and lesser accumulations of a similar nature adjacent to the pre-Cantuar unconformity. Although some combinations of these rocks may constitute separate units, all are limited in distribution and some

are sporadic or regional in occurrence. The type section therefore lacks good examples of such typical lithologies as coal and quartzose sandstone, for example, although these are important constituents of the formation to the north and east respectively.

Major lithologies are described here, in order of grain size.

Greywacke

Greywacke is represented in the type section from 2,759 to 2,763 feet and in a 1 1/2-foot bed, between 2,789 and 2,793 feet. Much greater thicknesses are common in the southwestern part of the province and beds 20 to 30 feet thick are encountered near the Third Meridian within the subject area. Eastward, the amount dwindles rapidly, and only a few inches of doubtful greywacke occurs at scattered localities east of Weyburn.

A distinct gradation from coarse material at base to fine at top is a feature of the example from the type section. The same trend is evident in a greywacke bed at Johnstone Lake in tp. 12, rge. 2, W 3rd mer., about 10 miles west of the subject area. A thin section from a core of this bed of speckled sandstone between depths of 3,460 and 3,470 feet has the following constituents (percentages are approximate):

Chert and argillaceous rock fragments	28%
Clay, white, silty, interstitial	18%
Quartz, in coarse angular grains	17%
Chlorite grains, green, soft, earthy Chlorite, coarse, flaky	15%
Clay, white, microcrystalline Clay, buff, more finely crystalline than white clay	10%
Plagioclase, some grains partly altered	8%
Magnetite, black, brittle, euhedral Clay, brownish red Siderite) interstitial Calcite)	4%

All components occur as more or less well-defined, coarse angular grains except the carbonate and the silty clay.

Another core, at Midale A-7-18 well in tp. 6, rge. 10, W 2nd mer., has a 4-inch bed of non-porous speckled sand at a depth of about 3,500 feet, a short distance above the top of a very coarse 'basal' Cantuar sand. Slightly porous lithic sandstone overlies the greywacke and is separated from it by several feet of coarse, well-rounded, quartzose sand.

Unlike the traditional greywackes, those described here are light in colour and poorly indurated as a result of the earthy nature of the matrix and of the grains of white, buff and red clay and chloritic material embedded in it. The angularity of these earthy grains suggests that they are products of diagenetic alteration of rock and mineral fragments originally brittle enough to fracture and durable enough to withstand transportation.

Numerous beds of greywacke are present near the Third Meridian. They are absent in the northeast as far as Yorkton or Canora. The diminishing number and thickness from southwest to northeast indicates a source of supply for these sands to the west or southwest during deposition of the Cantuar Formation.

Lithic Sandstone

The lithic sandstones range between quartzose sand and greywacke in composition. They contain more quartz than the greywacke, have some voids or appreciable carbonate cement and more than 5% of dark chert or other rock fragments. Like greywacke they are more plentiful near the Third Meridian in southwestern Saskatchewan, diminishing in quantity to the northeast and east. Examples are found in the type section between depths of 2,711 to 2,719 feet and 2,793 to 2,196 feet. Within the subject area, slightly porous lithic sandstone, much like greywacke in appearance, is penetrated between depths of 3,452 and 3,468 feet at Shell Old Wives A-16-11 well in tp. 14, rge. 3, W 2nd mer. Grains consist of dark chert, chloritic material, buff clay and quartz, with shapeless blebs of interstitial white clay. A thin layer of green clay coats most of the grains. At the opposite end of the range of composition, porous lithic sandstone with about 90% subrounded quartz grains is encountered at Shell Midale A-7-18 (Estevan No. 2) well from about 3,425 to 2,432 feet subsurface (core #2, 0 to 7 feet). Subangular dark grains of chert, possibly other rock fragments and chloritic material and numerous blebs of white clay are scattered throughout.

Clay grains are common in lithic sandstone. In addition to the formless blebs just described, it occurs as chalky grains with angular outline, as what appear to be euhedral crystals of clay minerals and as a coating on chert or quartz grains. Clay and carbonate are the common cementing materials where any cement is present. Clay, or silty clay, completely fills the interstices in finer-grained zones of the sandstone from 2,715 to 2,718 feet subsurface in the type section. Lithic sandstone without clay contains calcite at Tidewater Southey Crown #1 well in tp. 22, rge. 18, W 2nd mer. at a depth of 2,168 feet (Fig. 9).

Similar to greywacke in distribution and composition, and to some extent in appearance, the lithic sandstones may originate from the same source as greywacke or may have been derived with some reworking from the greywacke itself.

Quartzose Sandstone

Although quartzose sandstone is predominant in the subject area, no good example is present in the type section. The

lowest Cretaceous sand from 2,827 to 2,830 feet in depth consists largely of quartz grains but, in common with the basal sandstone at other localities, also contains light-coloured, rounded grains of chert and many grains of quartz with red surface-staining. A better example, at Tidewater Southey Crown #1 well, tp. 22, rge. 18, W 2nd mer. (2,327 to 2,330 feet subsurface) is medium to fine grained and poorly sorted. Grains are subangular to subrounded and include rare white clay and widely scattered dark chert. In contrast, quartzose sandstone at Tidewater Grenfell Crown #1 well, tp. 16, rge. 7, W 2nd mer., from 2,565 to 2,620 feet subsurface, is well sorted, with medium grains of high sphericity. This sand also contains a few angular grains of white or grey clay. Secondary crystal growth commonly masks the sphericity of the quartz grains in these examples.

Some of the grains in a quartzose sand may be stained by a coating of red iron oxide or clay, rarely showing extensive crystal growth. Such grains are more common in beds near the base of the formation. In some localities the coarser 'basal' sandstones with red grains also contain grains or pebbles of brown or grey chert.

Most quartzose sandstones are loose or poorly indurated and lack cement or have grains held together by a thin coating of clay. The well-indurated beds are cemented with carbonate or pyrite; silica cement is conspicuously absent in southeastern Saskatchewan. Some thicker beds, otherwise loose, have scattered aggregates of calcite or siderite or both. Brown, crystalline siderite may be the only cementing material in some beds. Thick beds near the base of the formation are cemented with clear secondary calcite that forms large continuous crystals containing medium or coarse quartz grains as inclusions. Pyrite also fills interstices of sandstone, particularly near the base of the formation; at places it is apparently of considerable thickness, but as a rule it occurs in discontinuous lenses an inch or two thick.

Sandstone with the grains or "framework fraction" entirely of quartz, but with clay taking the place of cement is not uncommon in the Cantuar Formation. For example, a clayey sandstone at Yarbo 17s well, tp. 20, rge. 33, W 1, from 1,300 to 1,312 feet subsurface grades upward to sandy clay. This bed constitutes the first (lowest) Cretaceous sandstone, and might be considered the 'basal' sand at this locality. Grains are of quartz, poorly sorted and fine to coarse, with low sphericity. The clay is creamy-white and waxy to chalky textured.

Silt is the interstitial material in some of the sand with coarser quartz grains. The silt occurs alone or with light-coloured clay.

Although present over the entire area, quartzose sandstone is predominant in the northeast and gives way southwestward to, in part, greater quantities of lithic sandstone and greywacke. Proximity to the Canadian Shield suggests a source in that area for the sand in the northeast. The quartzose sand in other areas may be, in part, beach sands produced during a reworking of regolith of the pre-Cantuar emergence. On the other hand, the quartz of the greywacke in the southwest exceeds all other minerals in durability, including the rather brittle dark chert. Some of the

quartzose sandstone in southwestern regions therefore may be the 'mature' end product of reworked greywacke or lithic sandstone.

Siltstone

Beds of poorly indurated siltstone are an important feature of the Cantuar Formation in most of southeastern Saskatchewan. They consist largely of quartz grains in argillaceous matrix and are either shaly or massive, depending on the nature of the argillaceous material. The shaly siltstones are darker in colour and may contain much finely comminuted carbonized vegetable matter like the example between 2,765 and 2,769 feet in the type section. Siltstone with interstitial clay occurs at Yarbo 17s well between 1,286 and 1,290 feet subsurface. The clayey material is more massive and typically contains little carbon. A third type of siltstone, green and blocky, is rare in southeastern Saskatchewan, but is an important constituent of the Cantuar Formation west of the Third Meridian. A bed of green siltstone in the type section, from 2,723 to 2,727 feet, grades to greywacke with large fragments of plant carbon. A similar siltstone from 2,758 to 2,760 feet overlies a bed of greywacke and grades upward to a finer grain-size.

Shale and Clay

Rocks of predominantly clay-size sediment are divided into 'shale' with more or less regular fissility, and generally more massive 'clay' as defined earlier. Other characteristics of shale and clay are compared in Table II.

Three kinds of shale may be distinguished in the Cantuar Formation. West of the subject area, in southwestern Saskatchewan, medium grey shale, flaky or splintery, is most common, forming thin interbeds or laminae in sandstone with siltstone, much like the shale from 2,773 to 2,774 feet subsurface in the type section. The same shale bed contains typical streaks and lenses of light grey silt. It also includes lenses of a second kind of shale which is lighter in colour and has a waxy lustre. Although fissile, the waxy shale has the colour and lustre of many non-fissile clays. A third shale, green, blocky and commonly silty, grades to or is interbedded with green siltstone and greywacke. The shale is rare in southeastern Saskatchewan and present only near the Third Meridian.

Clay, typically brownish white and waxy or satin-lustred, is found throughout the Cantuar Formation, and, as it rarely occurs in the overlying unit, it may be considered as being somewhat diagnostic of the formation. The clay is largely massive but may have a conchoidal fracture on weathering or an irregular fissility where slickensides develop. Slickensided material is common beneath coal seams where the typical light colour may be changed to brown or black due to organic material (e.g. from 2,768 to 2,770 feet in the type section). Variegated clay, red, yellow, green and brown, is widespread, particularly toward the west. All of these varieties may contain spherules of siderite up to 1/2 mm in diameter, like the topmost bed in the type section. Most clay also contains fine quartz grains and may grade to clayey siltstone or sandstone.

Table II

Physical Characteristics of 'Clay' vs. 'Shale'

Property	Clay	Shale
Fissility	Absent, or irregular	Moderate, regular
Mineral grains as observed under binocular microscope	Amorphous or satin-lustred pale clay minerals	Greyish yellow-green micaceous minerals
Mica in interbedded sand	Sparse or absent	Abundant
Iron-carbonate occurrence	Siderite in disseminated small nodules (up to 1 mm in diameter)	Ironstone (rare in Cantuar) in thin beds or concretions
Glauconite occurrence	Very rare	Widely scattered grains in some beds
Presence of fossils	No animal remains; zones of vegetable matter	Fish teeth; worm burrows; vegetable matter
Bedding	Generally massive	Thin current-bedding

Clay differs from shale, not only in colour and texture but in structure and content of minor minerals and fossils. These properties are discussed further under the heading "Environment of Deposition".

Clay Mineralogy

Samples of the foregoing clays and a few of the shale types were submitted to the Petrological Sciences Division of the Geological Survey for X-ray determination of the proportions of chlorite, kaolinite and illite. The object of this preliminary work was to discover for subsequent investigation any trends that, first, might identify specific clay minerals as predominant in any shale or clay type and, secondly, might suggest correlation between clay minerals and environment of deposition. It was desired to explore, in particular, what might be learned of salinity of the depositing medium of the Cantuar strata by comparison of the work of Griffin and Ingram (1955) in their study of modern estuarine sediments. Although most of the samples were collected from the Cantuar Formation, some were taken from beds adjacent or nearby in the stratigraphic column in order to include marine beds not specifically identifiable among Cantuar strata. The partial data presented here are not considered representative or complete enough for conclusive results but may serve as a guide for initiating a more detailed inquiry.

Table III

Clay Mineral Analysis Data

Well	Location	Depth (feet)	Position on Fig. 4		Intensity Ratios* Illite: Kaolinite	Chlorite: Kaolinite	Illite: Chlorite	Remarks	Lithology and Environment (where known)
					'Shale' with regular fissility			(dark-coloured)	
Shell Dahinda #1	6-2-9-23 W2	3,420	G	1	0.10	0.08	1.14		Shale, very sandy
Tidewater Beverly Crown #1	13-14-15-15 W3	3,269	B	2	1.10	1.10	1.00		Shale, greenish grey, blocky (associated with greywacke)
Tidewater Pelletier Crown #1	1-27-12-15 W3	3,696	D	3	2.33	1.67	1.40		Shale, greenish grey
" " " "	"	3,667	D	7	4.22	3.89	1.09		Shale, grey, blocky, very soft (marine)
					Shale with irregular fissility (commonly light-coloured)				
Tidewater Beverly Crown #1	13-14-15-15 W3	3,277	B	3	1.25	0.75	1.67		Shale, pale brown, with waxy lustre
Imperial Tidewater Oakshela #13-25-16-6	13-25-16-6 W2	2,346	R	10	1.27	-	-	No chlorite	Shale, dark brownish grey, with waxy lustre
Imperial Tidewater Wapella #4-3-15-1	4-3-15-1 W2	2,132	H	6	0.94	-	-	No chlorite	Shale, medium brown, very slight fissility, waxy lustre
" " "	"	2,135	H	6a	0.74	-	-	No chlorite	Shale, very slight fissility, medium brown, semi-waxy
Tidewater Imperial Plato Crown #1	9-22-24-19 W3	2,619	N	6e	-	-	-	Kaolinite and montmorillonite	Shale, brownish grey, waxy
" " " "	"	2,828	N	8	2.29	-	-	No chlorite	Shale, sandy, greenish grey, blocky; siderite crystals; rare glauconite; inclusions of limestone
Tidewater Braddock Crown #1	5-7-13-10 W3	3,590	E	5	0.56	-	-	No chlorite	Shale, greenish grey to bright green, highly fissile in part; rare glauconite
Tidewater Frontier Crown #1	13-21-3-20 W3	4,091	A	3a	0.90	-	-	No chlorite	Shale, brownish grey, red-mottled in part, blocky, waxy
						'Clay' without fissility			
" " " "	13-21-3-20 W3	4,089	A	3	0.69	-		No chlorite	Clay, pale green, waxy, with siderite nodules
Tidewater Beverly Crown #1	13-14-15-15 W3	3,292	B	4	-	-	-	Kaolinite only	Interstitial clay in sandstone; pale brown, waxy

Tidewater Java Crown #1	16-29-15-15 W3	3,246	C	4	0.29	-	-	No chlorite	Clay, pale brown, with siderite spherules
Shell Dahinda #1	6-2-9-23 W2	3,474	G	6	-	0.22	-	No illite	Clay, waxy
Tidewater Morse Crown #1	16-25-16-8 W3	3,301	M	6	0.18	0.33	0.55		Clay, with siderite; silty
Tidewater Imperial Plato Crown #1	9-27-24-19 W3	2,477	N	6a	1.81	-	-	No chlorite	Clay, light brown-grey, waxy
" " " " "	"	2,506	N	6c	0.49	-	-	No chlorite	Clay, green, brown, red
" " " " "	"	2,517	N	6d	0.09	-	-	No chlorite	Grains of white clay in sandstone
" " " " "	"	2,494	N	6b	0.87	-	-	No chlorite	Clay, pale brown, grey; underlies coal
" " " " "	"	2,699	N	6f	-	-	-	Kaolinite only	Clay, pale brown, sandy; siderite, spherules
" " " " "	"	2,766	N	6g	-	-	-	Kaolinite only	Clay, pale brown-grey
Tidewater Parkbeg Crown #1	10-32-18-3 W3	3,378	Q	6a	-	-	-	Kaolinite only	Clay, pale brown, sandy; between beds of lignite
Tidewater Imperial Elrose Crown #1	4-6-25-13 W3	2,419	J	8	1.76	-	-	No chlorite	Clay, green; fragments of weathered(?) limestone
Superior Dodsland #2	11-7-32-20 W3	2,485	K	9	0.71	-	-	No chlorite	Clay, white; green shaly laminae
Superior Dodsland #1	9-16-32-21 W3	2,447	L	9	0.06	-	-	No chlorite	Clay, pale greyish brown
Tidewater Instow Crown #1	15-33-18-17 W3	4,203	F	5	0.47	-	-	No chlorite	Clay, pale brown; interbeds in sandstone
					Interstitial material in sandstone				
Tidewater Parkbed Crown #1	10-32-18-3 W3	3,803	Q	6	0.31	0.12	2.60		Sandstone; interstitial clay; chert grains and rock fragments; 'chloritic' grains
Shell Dahinda #1	6-2-9-23 W2	3,590	G	6a	0.11	0.11	1.00		Sandstone with interstitial clay
Tidewater Imperial Broadview #14-17-15-4	14-17-15-4 W2	3,425	S	6	0.98	0.36	2.73		Sandstone, argillaceous
Tidewater Imperial Plato Crown #1	9-22-24-19 W3	2,517	N	6d	0.09	-	-	No chlorite	Sandstone, clayey, soft; white grains of clay

*Intensity values for chlorite and illite are those of the (001) plane; values for kaolinite have been corrected for superposition of the second order chlorite reflection.

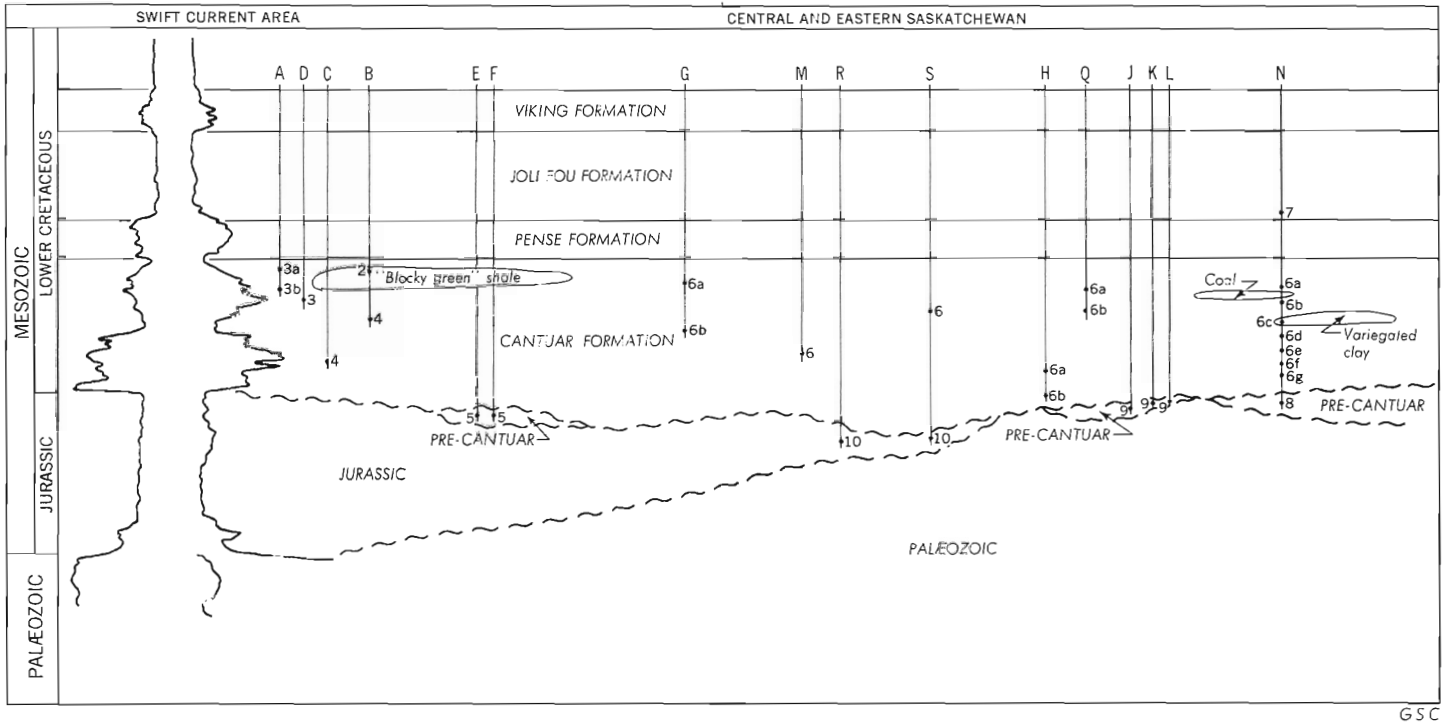

Figure 4. Stratigraphic position of samples for clay mineral analysis (Table III)

The X-ray analyses were made by R. J. Traill who recommended expressing the results as ratios (as has been done by Griffin and Ingram) in order to minimize quantitative error through interference between X-ray intensity patterns of chlorite and kaolinite. Traill feels that this interference makes the ratios unreliable as absolute quantities. They are, however, useful in an empirical way for comparison here between one sample and another.

Chert Detritus

A deposit of chert fragments in the Yorkton area constitutes an important exception to the sand, silt and clay in the foregoing description. The chert occurs in porous, fragile white fragments, some with dimensions greater than the 9-inch diameter of the bore-hole. It contains abundant silicified crinoid ossicles and sponge spicules. Where included in the Cantuar Formation, the chert beds overlie as much as 90 feet of quartzose 'basal' sandstone (penetrated in the Insinger No. 2 well in cross-section (Fig. 6)). The remainder of the chert rests directly on the erosion surface. The deposit is discussed in more detail in the following section

Contact Relationships

The lower boundary of the Cantuar Formation coincides with a major unconformity. Pre-Cantuar rocks dipping gently southwestward from the Canadian Shield are truncated to form bands that cross southeastern Saskatchewan roughly parallel to the Shield boundary. The undulating erosion surface and the wide variety of subjacent rocks are important in determining the characteristics of the Cantuar Formation.

The pre-Cantuar erosion surface intersects Devonian carbonate rocks in the northeast, followed southwestward by the overlying Devonian dolomitic clastic sediments, thin basal Mississippian sand and shale beds, and by the comparatively narrow band of cherty Mississippian carbonate. These Palaeozoic formations are readily distinguished from rocks of the Cantuar Formation.

Jurassic shale and sand underlie the remaining two thirds of southeastern Saskatchewan, and are somewhat similar to Cretaceous rocks. Jurassic sediments (except some basal red beds) may be identified as a rule by evidence of marine origin lacking in the Cantuar Formation and by the presence of calcareous shales not characteristic of Cantuar strata. The problem is intensified, however, where some Jurassic strata lose marine characteristics near their depositional limits, especially where sand rests on sand. Particular consideration is also needed where thin beds of pre-Cantuar sand and shales, both marine and non-marine (Unit A, Fig. 10), rest unconformably on Jurassic formations. The Cretaceous-Jurassic boundary in Saskatchewan is discussed in more detail by Milner and Blakeslee (1958, p. 82).

The basal contact is marked within the Cantuar Formation at many places by a thin layer of brown or grey chert pebbles at the base. Near the unconformity the characteristic coarse

basal sand may be cemented with pyrite, and where it overlies calcareous beds it is cemented with clear, secondary calcite. Where the sand is missing, basal Cantuar beds generally consist of non-calcareous green, or pale, brown clay.

The chert detritus to the northeast of the area also rests directly on the unconformity. The truncated edge of the Mississippian cherty carbonate forms at this point a buried cuesta aligned slightly south of east. The chert detritus lies adjacent to the northern slope of the cuesta. Near the carbonate it rests on the thin Bakken shale and silt members, but farther northward the Bakken is eroded and the detritus overlies 10 to 90 feet of coarse, unindurated sandstone above the unconformity (Fig. 12).

The unconformity represents a hiatus in both Jurassic and Cretaceous time. At its smallest span, the youngest Jurassic rocks are of Oxfordian or possibly Kimmeridgian age (Frebold, 1957, Fig. 4), whereas the overlying Cretaceous beds are correlated with formations probably not older than Aptian.

Cantuar strata are in contact with somewhat similar sand and shale of the overlying Pense Formation. The boundary is identified specifically as the upper limit of soft, pale brown or grey clay, commonly containing minute siderite pellets. Dependable identification of the upper boundary relies on lithologic comparisons involving characteristics of the overlying beds, and the contact is dealt with in more detail in connection with the Pense Formation.

Environment of Deposition

The general heterogeneity of the Cantuar Formation suggests great variation in bottom conditions at a given time of deposition. Irregularity of the pre-Cantuar erosion surface and the probability of shallow water during advancing Cretaceous inundation would suggest local variations in depth, in current velocities, and aeration and salinity*. Variations in fissility and in the occurrence of carbon, pyrite, siderite and clay minerals are reflections of diverse facies. The conclusions drawn from this brief consideration are of course interpretative.

The fissility that distinguishes the shaly beds seems to be due to the presence of finely crystalline olive-green micaceous flakes. The microscopic flakes are thought to be the dark micas and chlorite. Absence of chlorite in the massive (clay) beds may reflect a scarcity of magnesium in a brackish- or fresh-water medium of deposition. Most of the shales with submicroscopic clay minerals listed in Table III, particularly the few with regular fissility, contain generally higher proportions of chlorite and illite to kaolinite. Larger quantities of these magnesia-bearing minerals in the shales points to a medium with appreciable magnesium content. Siderite nodules, confined in occurrence to clay, add validity to a hypothesis of reduced salinity if regarded as representing the ferrous iron that would have

*References to degree of 'salinity' here describe the more or less brackish condition of marine water diluted in part by inflowing fresh water.

been absorbed in the formation of chlorite had the mud been deposited in an environment closer to normal sea water.

Glauconite, although rare in the shaly beds of the Cantuar Formation, is absent in the clay. Glauconite has been regarded as a criterion of marine conditions and its presence in the shales may be indicative at least of more saline water conditions during their deposition.

Carbon is disseminated plentifully throughout the shale and shaly siltstone, largely in the form of specks of carbonized vegetable matter, but also in sparse fish remains. In clay, on the other hand, carbon occurs mainly as scattered larger plant fragments or lenses of coal. The carbon in shale implies a reducing environment. It is less certain, however, whether the non-carbonaceous clays, particularly clay with siderite nodules, indicate an abundance of oxygen. If the source of vegetable matter were constant, the lack of vegetable matter in clay may be the result of a supply of well-oxygenated water. Plentiful oxygen may also explain the lack of fish remains in clay, although it is possible that the clay-producing environment was otherwise inimical to animal life.

Current bedding is conspicuous in the silty parts of the shale facies. It is uncommon in any part of the clay facies and, where present, seems to be represented on a large scale by inclined bedding planes in coarse interbedded sand. Possibly the clay and sandy clay are sediments swept suddenly beyond the range of effective currents into quiet, deeper places on the irregular bottom, whereas the coarse sands were deposited on the shallows by the same currents in their competent state. The finer bedding of the shaly facies would appear to be the product of more gentle but consistent currents.

The Cantuar Formation appears to have accumulated in a shallow depression on a broad shelf with irregular bottom, that was at least partly isolated from deeper marine waters. If inferences drawn from the foregoing comparison of shale and clay are valid, the two facies are a result of irregular mixing of fresh and saline waters. Plentiful plant remains in the shale and interbedded with the clay may be a sign of humid climate and a copious supply of fresh water on the adjacent land. The combinations of fresh and brackish or marine waters and of strong currents and placid water in close proximity are characteristic of deltaic environment, and a deltaic origin is suggested by many authors for corresponding Lower Cretaceous strata elsewhere. The deltaic material is probably combined with a significant amount of near-shore and beach sediments, particularly in the lower part of the formation, and much of the lower sediments probably represents reworked regolith from the pre-Cantuar emergence. Shallow-water conditions seem to have been maintained throughout deposition of the formation by a supply of sediment great enough to keep pace with subsidence of the shelf or basin.

The Cantuar Formation resembles lithologically the Lakota Formation of the Black Hills as redefined by Waagé (1959). The upper boundary of the Cantuar Formation is recognizable in the Swan River area of Manitoba, where pale grey clay with siderite nodules is in abrupt contact with overlying carbonaceous shale. Westward, the formation merges with the lower part of the Mannville Group.

The rare, redeposited parts of thin-shelled pelecypods and fragmentary plants available from subsurface material have yielded no indication of age. Although marine microfossils are lacking, there is plenty of material available for future palynological studies.

Pense Formation

The name "Pense Formation" is proposed for that part of the basal Cretaceous sandy group above the Cantuar Formation and below the Joli Fou shale of the overlying group in Saskatchewan. A typical section of this interval was cored 1 mile southwest of the village of Pense, from which the name is derived. It represents the "Upper Blairmore" of Cumming and Francis (1957) and the "Blairmore" of Milner and Blakeslee (1958). A similar division of the basal sandy group was recognized by Rousell (1956) but limited to southwestern Saskatchewan.

Thickness ranges from more than 100 to 25 feet or less and the unit may be missing over limited areas in the far-eastern part of the province, as in tp. 7, rge. 32, W1. The formation extends from the eastern erosional limit at the Manitoba escarpment to merge to the west and northwest with the Mannville Group in northwestern Saskatchewan and Alberta (Fig. 1). Northern limits are masked by poor subsurface control and drift-covered outcrop. The unit continues south of the Forty-ninth Parallel.

The following type section has a fairly central position in the area of distribution. It is entirely cored and includes a representative section of the 'marker beds'.

Well: Sohic Canadian Devonian Pense No. 1

Location: 1sd. 14, sec. 6, tp. 17, rge. 22, W 2nd mer.

Elevation: 1,909.3 feet R.T. (Datum)
1,897.2 feet Ground level

Spudded: 8 July 1952
Total depth: 5,960 feet

Core stored at the Subsurface Geological Laboratory of the Saskatchewan Department of Mineral Resources, Regina; core chips stored at the office of the Geological Survey of Canada, Calgary.

Depth	Lithology
	Joli Fou Formation
2,633-2,640'	(Core #5, recovered 9'6")
0-9'6"	Shale, dark grey, flaky, pelecypod-shell prisms; partings with fish teeth; zone with abundant shiny spots having faint concentric structure, on cleavage surface of shale, possibly representing crushed micro-organisms 1.33 to 1.1 mm in diameter

Depth	Lithology
2,640-2,643'1"	(Core #6, 7, 8 and 9, recovered nil)
2,643'1"-2,646'	(Core #10, recovered 2'6")
0-2'5"	Shale, darker grey than above; lenses of ferruginous siltstone, in part calcareous, up to 1/4" thick, in basal 6" of interval; minute lenses of very fine grained sandstone with abundant fish-bone fragments
2'5"-2'6"	Ironstone, silty, concretionary
2,646-2,656'	(Core #11, recovered 10'; core broken)
0-3"	Ironstone, concretionary, medium grey; a little pyrite
3"-5'	Shale, dark grey; partings of light grey silt with brown organic matter and carbonized wood; fish scales

Pense Formation

(This boundary appears on electric log at 2,657 feet)

5-10'	Sandstone, very fine grained, and siltstone, light grey; abundant partings and thin interbeds of dark grey shale; worm burrows
2,656-2,666'	(Core #12, recovered 10')
0-2'6"	Sandstone and silt as in base of core #11
2'6"-10'	Shale, sandstone and siltstone, thinly interbedded: dark grey, moderately fissile shale, light grey, poorly indurated, very fine grained sandstone, porous, with scattered grains of dark grey chert or rock fragments; abundant firm yellow-green grains; interstitial white clay; rare earthy chloritic grains
2,666-2,673'9"	(Core #13, recovered 9')
0-3'	Shale, dark grey, interbedded with light grey siltstone; brown organic matter; fish bones
3-9'	Siltstone, more or less shaly, slightly indurated; irregular wavy banding due to current bedding; finely divided vegetable matter; hard 4" band of calcareous ironstone at base of interval

Depth	Lithology
2,673'9"-2,682'9"	(Core #14, recovered 10'; core broken)
0-5'6"	Siltstone, very shaly, light grey with irregular dark grey partings; grades to silty shale; abundant mica; a little chlorite; rare glauconite(?); sideritic zone
5'6"-8'6"	Shale, dark grey; numerous partings and interbeds of fine-grained sandstone; worm burrows; disseminated brown vegetable matter
8'6"-10'	Sandstone, shaly, very fine grained, porous in part; zones with 85% angular quartz with secondary crystal growth; widely scattered dark grains of chert(?); green chloritic grains and scattered grains of white clay; green-grey shaly laminae with abundant mica; scattered grains of brown clay and carbonized vegetable matter; irregular thin interbeds of micaceous, silty laminated dark grey shale and shaly siltstone
2,683'10"-2,693'10"	(Core #15, recovered 10')
0-8"	Siltstone, shaly-laminated, medium to dark grey as in base of core #14; disseminated carbonized vegetable matter
8"-5'	Sandstone, shaly-laminated, very fine grained, light grey with green cast, porous; quartz, about 70%, in angular grains with secondary crystal growth; abundant green chloritic grains; widely scattered white clay; mica; specks of carbon, single grain of bright green glauconite observed; interbedded dark grey shale with many worm burrows
5-7'	Sandstone, shaly as in 8" to 5' (above); small fragments of carbonized wood
7-10'	Siltstone, light grey, shaly, poorly indurated; carbonized vegetable matter
2,693'10"-2,703'11"	(Core #16, recovered 10')
0-10'	Siltstone, light grey, shaly; irregular interbeds of dark grey, silty shale; mica; chlorite; lenses of very fine grained shaly sand in lower part of interval
2,703'11"-2,714'	(Core #17, recovered 7'; core broken)
0-5'	Siltstone, shaly, or silty shale; irregular 'wavy' partings due to current bedding; mica, carbonized vegetable matter; irregular thin lenses and interbeds of poorly sorted, argillaceous,

Depth	Lithology
	fine-grained sandstone with subangular to well-rounded grains; zone with rare smooth grains of black and grey chert with low sphericity up to 1.3 mm diameter; 4" bed of brown-grey, fine-grained, well-sorted, sideritic sandstone with grains almost entirely of subangular quartz, between 2'6" and 5'
5-7'	Sandstone, argillaceous, light grey, friable; irregular shaly partings; very-fine- and fine-grained, coarser, porous zones form lenses in very fine grained sand, which in part contains a matrix of pale brown interstitial clay; coarser lenses consist of quartz (85%); nearly spheroidal (authigenic) chloritic grains (7%); angular, (altered allogenic) grains of white clay (4%); angular grains of brownish grey chert (2%); mica (2%)
2,714-2,724'	(Core #18, recovered 4')
0-5"	Sandstone, very fine grained, poorly indurated with porous lenses of fine-grained sandstone; irregular shaly partings; coarser material has angular quartz, some interstitial pale brown clay, rare white clay grains and very rare chloritic grains.
5"-4'	Shale, dark grey to black, smooth-textured, firm, splintery; partings and interbeds of light grey silt up to 1/4" thick with much interstitial white clay; chloritic grains in coarser zones; worm burrows.
2,724-2,732'	(Core #19, recovered 8')
0-6'	Shale, as in core #18 (5"-4'), with fewer and thinner interbeds of clayey silt; scattered brown organic matter; rare spots with finely crystalline pyrite; worm burrows
6'-6'10"	Shale, dark grey; numerous partings and several interbeds of micaceous light grey, very fine grained sandstone and silt up to 3/4" thick
6'10"-8'	(Core mixed with top core #20) Shale with silt interbeds as in interval above
2,732-2,742'	(Core #20, recovered 10'; core broken)
0-2'6"	Shale, dark grey; interbeds up to 1" thick of poorly indurated siltstone and very fine grained sandstone; mica; disseminated vegetable matter
2'6"-9'	Shale, dark grey to black, firm; rare partings of silt; worm burrows; 6" bed of clayey, blue-grey, massive shale about 5' from top of core
9-10'	Sandstone, very fine grained, shaly; irregular partings; mica; disseminated vegetable matter

Depth	Lithology
2,742'-2,751'11"	(Core #21, recovered 3'; core broken)
0-3'	Shale, silty, medium grey, with irregular bands and two 1" beds of dark grey shale in top 6" of core; becomes more silty toward base; worm burrows; disseminated vegetable matter
2,751'11"-2,762'	(Core #22, recovered 3'4"; core broken and mixed)
0-3'4"	Upper part: siltstone, shaly, in part poorly indurated; interbed of very dark grey shale
	Cantuar Formation
	Lower part: clay, medium light grey, with irregular fissility and abundant large plant fragments; massive light brown-grey clay with minute siderite nodules
2,762-2,772'	(Core #23, recovered 6')
0-2'	Clay, light brown-grey, firm; abundant large plant fragments; 8" bed of pale brown clay with minute (1/32") nodules of siderite
2-6'	Clay, light brown-grey, red mottled; irregular fissility; slickensides

The formation comprises fine-grained sandstone, mostly with interstitial white clay and shaly silt, interbedded with firm, splintery, dark grey, slightly carbonaceous shale. Fish remains, worm burrows, rare pelecypod fragments, sparse glauconite and much current bedding are characteristic. Foraminifera and other marine microfossils have not been found in these beds in southeastern Saskatchewan. The rocks in general seem better indurated and less porous than those of the underlying Cantuar Formation. Some of the coarser sandstone beds in the upper part are loose but calcite and siderite are common cementing materials and ironstone bands of varying thicknesses are typical. The imperviousness of the base of this upper unit is an important factor in the Swift Current area, where the formational boundary can be picked with some confidence in many cores by the upper limit of oil stain

The base of the Pense Formation in general represents the upper limit of the light-coloured clay facies and of the occurrence of siderite nodules. In the Swift Current area to the west, the upper boundary of the underlying Cantuar Formation is identified by an easily recognized electric-log pattern called the "Cantuar marker". This marker is distinguishable in only about the western third of the subject area. The beds that the marker represents are nevertheless lithologically distinct over a much greater area. They have been

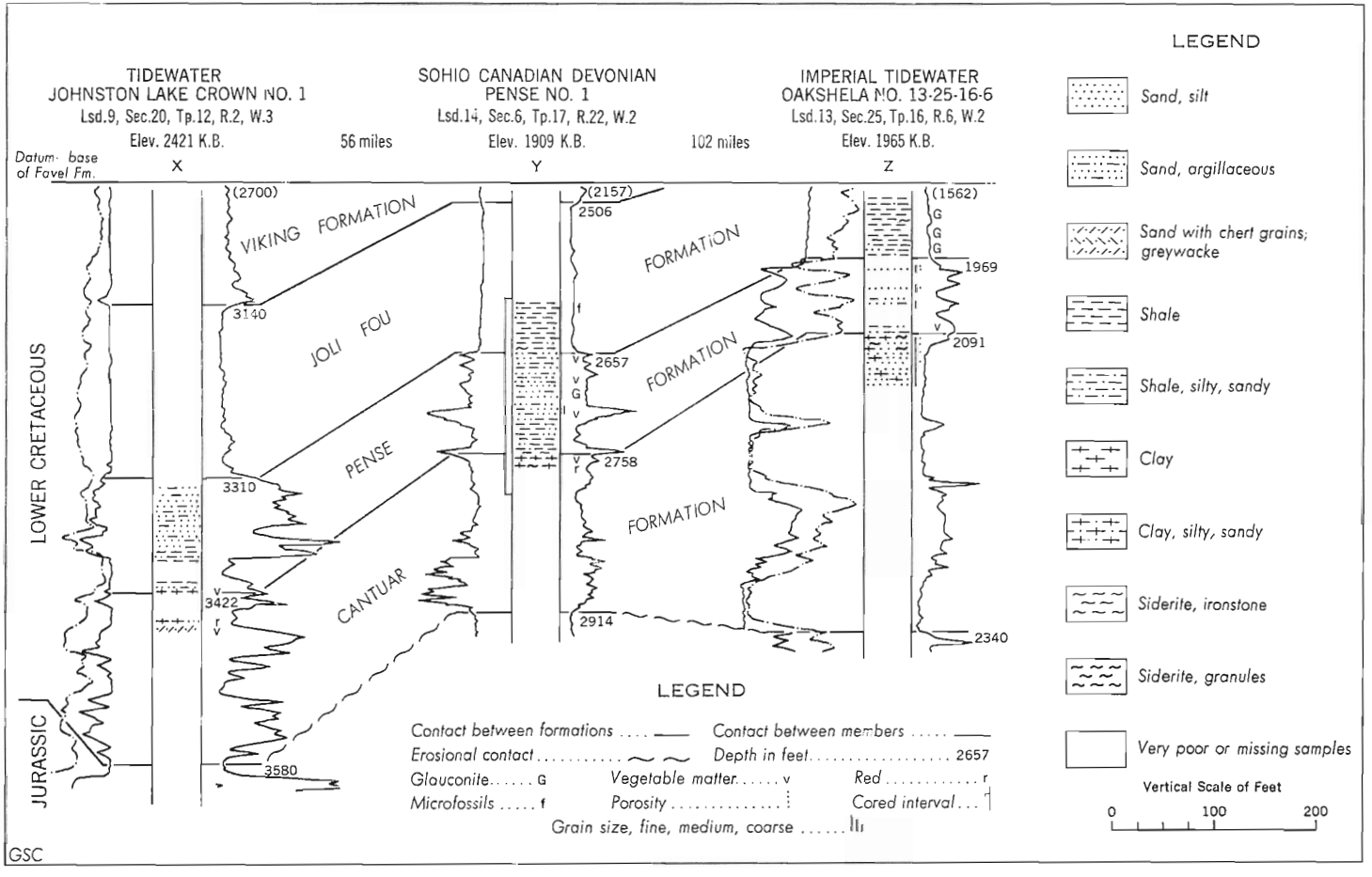

Figure 5. Type section of Pense Formation and correlation with adjacent area

described in detail by Cumming and Francis (1957, p. 68), who report upper and lower beds with abundant plant remains, separated by silty shale and overlying an iron-rich layer. These authors recommend placing the Cantuar's upper boundary above the 'marker beds' on the basis of a postulated soil bed. The 'marker beds', however, are persistent geographically, by contrast with the discontinuous Cantuar strata below, and lateral persistence is a feature of the Pense sequence of deposition. Carbonaceous beds and iron in the form of pyrite or siderite are evident in the base of the formation beyond the area of the typical 'marker' in the subsurface. A carbonaceous shale with wood and other plant fragments, partly pyritized, and with abundant nodules of marcasite, occupies the same stratigraphic position in outcrop along Swan River, about 12 miles northeast of the area. The carbonaceous beds at Swan River, like the 'marker beds' near Swift Current, are shaly, whereas carbonaceous beds in the Cantuar Formation are commonly associated with clay. The boundary is therefore placed here, at the base of the 'marker beds'.

What appears to be the corresponding boundary in the Black Hills is considered by Waagé (1959, p. 52) to be a transgressive disconformity. Indisputable evidence for disconformity is lacking in the subsurface of Saskatchewan, although the findings of Cumming and Francis (1957) seem to support the idea. The boundary apparently marks a decided change in conditions of deposition. More information is needed to determine to what extent this change was transgressive in southeastern Saskatchewan and whether or not it was accompanied by a period of non-deposition or stagnation.

The top of the Pense Formation is placed at the change upward from sand to marine Joli Fou shale. Pense sands may be confused with sands present at some locations in the lower Joli Fou, making the contact in this sense gradational. The Joli Fou sands, however, have distinctly marine characteristics that are lacking in any part of the underlying unit. Unique fossils and lithology in the lower part of the Joli Fou are further criteria of the location of the boundary. These are discussed in the section on the Joli Fou Formation.

The Pense Formation seems to be transitional between the non-marine or deltaic Cantuar and marine Joli Fou. The sediments are generally finer grained than those of the underlying Cantuar and coarser than those of the Joli Fou. Whereas the Cantuar strata are discontinuous and massive, those of the Pense are comparatively persistent in lateral extent. Pense rocks have a scattering of glauconite and much local current bedding, but little coal and no marine fossils. These properties may indicate less competent currents, greater distance from supply of sediment, lower areas of provenance and probably deeper-water conditions, possibly yet within reach of wave base. The Cantuar-Pense boundary may represent an abrupt change in the balance between supply of sediment and subsidence. The Cantuar Formation is regarded as comprising sediments introduced at a rate great enough to maintain a shelf area in a continuously shallow state. The overlying unit probably represents a much slower accumulation in deeper water, coinciding with a suspension of Cordilleran upwarping and submergence of some of the Shield-ward source of supply.

The arguments regarding salinity, presented in connection with the Cantuar Formation, suggest that the Pense sediments have settled from waters uniformly more saline than those of Cantuar deposition, but perhaps not enough like 'normal' sea water to produce the characteristics of marine sediments found in the Joli Fou Formation above.

The few poorly preserved fossils recovered from the Pense Formation have yielded no independent indication of age. In lithology and stratigraphic position the unit resembles the Fall River Formation as redefined by Waagé (1959) for the Black Hills region. Continuity with the Black Hills section is not well authenticated, however, and some confusion still exists in extending the application of the term "Fall River" northward. Only the upper part of the section assigned to the Fall River Formation by Hansen (1955) in North Dakota is equivalent to the Pense Formation in Saskatchewan. The lower Fall River beds of Hansen, comprising in places up to two thirds of the total thickness of the formation, contain siderite nodules. As these nodules are associated with light-coloured clays restricted to the Cantuar Formation in southern Saskatchewan, the Fall River of Hansen is considered here to include strata equivalent to the upper part of the Cantuar Formation.

The Fall River Formation of Montana is shown in correlation charts (Cobban and Reeside, 1951; Cobban et al., 1959) as correlative with the "basal Colorado sand" of Alberta. The basal Colorado sand overlies that part of the Mannville Group that is roughly continuous with the Pense beds and would appear to be correlative with the base of the shale overlying the Pense Formation in Saskatchewan. The exact correlation between the southern Saskatchewan and Black Hills sections requires further study.

ASHVILLE GROUP

Kirk (1930, p. 117) applied the name "Ashville" to exposures of grey marine shale in south-central Manitoba, and the unit was mapped over a greater area by Wickenden (1945, p. 17). It is used here as a group name for convenient reference in those parts of the Plains where subdivisions of the Ashville succession are recognized as formations. The group includes the beds between the top of the sandy Pense Formation and the base of the white speckled calcareous (Favel) shale. It is recognizable from the Manitoba escarpment to southeastern Alberta and probably to a greater distance northwestward. Thickness ranges from 550 feet in the southwest of the subject area to less than 300 feet in the northeast.

The sequence of grey shale beds is divided by the sandy Viking Formation immediately below the middle of the group into the Joli Fou below and an unnamed shale unit above. Two lesser sands are recognized: the "Spinney Hill" near the base, and the widespread but lenticular "Fish Scales" near the top.

Joli Fou Formation

Soft grey marine shale between the sandy Pense strata below and the sandy Viking Formation above are assigned to the Joli Fou Formation. The name was applied by Wickenden (1949) to a similar shale on Athabasca River between the sandy Grand Rapids Formation and the Pelican Formation, which respectively correspond in that area to the basal Cretaceous sandy group and the Viking of Saskatchewan. The formation seems to be continuous between the two areas.

Along the Athabasca River, Wickenden described exposures of dark grey shale subject to extensive slumping. Sand and sandy shale intervals occur near the top and thin interbeds of light grey silt are common near the base. An upper chert-pebble zone present in the type area is not distinct in Saskatchewan, but a second chert-pebble zone near the base forms a good marker over most of the eastern Plains. Thickness in southeastern Saskatchewan decreases from 150 feet at the 49th Parallel to about 80 feet at Township 35. The pattern of distribution diverges from that of the Ashville Group as a whole, with a north-south general isopach gradient in contrast with northeast-southwest for the upper part of the group.

The Joli Fou Formation in Saskatchewan is represented mainly by medium to dark grey shale, mostly soft and clayey, at places bentonitic with scattered thin interbeds of bentonite. The drill-cuttings of some beds of this fissile, almost papery shale are eroded by the mud to produce a typically 'lobate' surface appearance. The "basal chert-pebble zone" commonly occurs in the subject area as a bed of poorly sorted coarse sand, less than 1 foot thick, with polished grains of quartz and black chert. It may be cemented with abundant calcite and contains glauconite and fragments of marine pelecypods. Locally the chert-and-quartz-grain bed deteriorates to a 'zone' of scattered polished granules in shale; in rare cases it thickens greatly (to as much as 6 feet of loose sand in Tidewater Duperow Crown #1 well in tp. 35, rge. 16, W 3rd mer.). The granule bed commonly overlies a dark grey shale bed which varies from a few inches to several feet in thickness; however, in some places it appears to rest directly on top of Pense sandstone.

The shale overlying the granule bed includes a glauconitic zone with bright green grains as large as 1 mm in diameter, abundant enough in places to impart a green colour to the rock. These lower shales include silt and sand, occurring in bodies that range from minute pale grey silt lenses and laminae in dark grey shale to interbeds of fine-grained sandstone. Such sandstones are well developed in a wide area centred at Ratcliffe (cross-sections, Figs. 9 and 10). They are lenticular and discontinuous, but are prominent on some electric logs because of induration with siderite.

Notwithstanding the distinctive features just described from the basal Joli Fou, the lower boundary is defined ultimately by a change upward to beds with definite marine characteristics including marine fossils and abundant glauconite. This change commonly coincides with the top of the highest well-developed sand, but the sand lenses in the base of the lower Joli Fou may be prominent enough locally to require careful discrimination. To the extreme northeast

of the area, toward Swan River, the sand-shale boundary rises stratigraphically above the first occurrence of distinctly marine beds.

The upper Joli Fou boundary is commonly regarded as the base of the lowest sandy beds of the Viking Formation. The lowest prominent sand, however, does not always occur at the same stratigraphic level. On the other hand, electric-log patterns below the sand are found to be consistent over considerable distances. In the cross-sections prepared for this report, an arbitrary horizon boundary was selected in this laterally consistent interval at a depth of 3,190 feet at Shell Albercan Govenlock #1 well, in tp. 1, rge. 28, W 3rd mer.

A well-developed microfauna is known (Wickenden, 1945, 1949) from the Joli Fou Formation and the correlative lower Ashville beds in their respective outcrop areas, but well-preserved specimens are scarce in core. Cores have yielded a number of microfossil collections, not yet thoroughly studied, which promise distinctive assemblages. Wickenden has identified Haplophragmoides gigas Cushman at a number of points in the area from a narrow zone about 20 to 40 feet above the base of the formation. The Haplophragmoides gigas zone occurs in the Joli Fou type area (Wickenden, 1949), and is distinct in many cored sections in the northern and eastern parts of southeastern Saskatchewan.

A thorough search of the same interval cored at Shell Dahinda No. 1 well (1sd. 6, sec. 2, tp. 9, rge. 23, W 2nd mer.) did not yield any recognizable foraminifera. The remains of a prolific micro-organism were seen in the Ashville beds of this well, however, and similar remains have been observed to be widespread in the Ashville Group from near the base upward to within about 15 feet of the top. The preserved part consists of a very fragile test of white, non-calcareous material. The form of the test is inconsistent and part of this variability may result from the presence of more than one type of animal. It commonly appears as a more or less flattened body with extremely irregular periphery, up to 0.4 mm in diameter, merging below (and more rarely above) with the soft shale, as though in life attached to, or partly buried in, the bottom mud. Some of the more complete specimens show an irregular silt-like peripheral opening. The material of these rough tests differs only a little in texture and hardness from the shale in which it is found.

A similar but possibly distinct organism is indicated by a translucent thin-walled shell with less haphazard, roughly bell-like outline and smooth inner wall. The 'bell' is attached to the shale at the apex and apparently rested in an inverted position. It is not clear whether the test consisted of an upper and a lower cup with an opening between, or a single calyx open at the top.

The Joli Fou interval is continuous southward with the Skull Creek shale of North Dakota and westward with the shale between the top of the Mannville Group and the Viking Formation in east-central Alberta. It merges southwestward with the lower part of the Bow Island Formation of southern Alberta. The formation appears to interfinger in the northeast with the glauconitic sand in the upper part of the Swan River Group in Manitoba. This intertonguing is

probably part of a facies change that has a parallel in the increasing prominence northward of sandstone recognized as the Spinney Hill Member (Edwards, 1960) of the Joli Fou in Saskatchewan west of the Third Meridian.

Viking Formation

The name "Viking" was first used by Dowling, Slipper and McLearn (1919, p. 24) for the producing gas sand of the Viking field near the town of that name. The term is applied here to the corresponding sandy interval of the Ashville Group in southeastern Saskatchewan because this designation is used by workers in the central and southern parts of the Canadian Plains. However, the name yields priority to that of the Pelican Formation of the Athabasca region with which the Viking is directly correlative and continuous.

Although the Viking sandy facies gains in importance southwestward from about the Third Meridian, it is missing in the western part of the subject area. It reappears in a broad diagonal band, across the centre of the area, roughly parallel with the boundary of the Canadian Shield, with tongues or lobes extending toward the northeast (Fig. 8). Where the sand is not readily apparent, the corresponding shale interval may be traced in good samples or in core by its greater siltiness. The thickening of the stratigraphic interval (assigned arbitrarily to the Viking Formation for purposes of this report) ranges from 150 feet on the Third Meridian near the Forty-ninth Parallel to about 90 feet near the Manitoba border at Township 35. This regional trend is interrupted by local thickening of the total interval due to intermittent sand development.

The sands of the Viking in southeastern Saskatchewan as a rule are poorly indurated, medium to fine grained, and grade to silt or silty shale. Coarse polished grains about 1.5 mm in diameter of black or grey chert occur in thin beds or in lenses in finer-grained sand. Much of the sand is argillaceous, and shaly bedding and intercalated grey shale are an inherent part of the formation. West of the area the unit has been divided locally into several sand and shale zones for convenience in making detailed oil-field correlations.

In all but the northeastern quarter of this area, most of the Viking sandstones have the characteristic speckled appearance of lithic sandstone. The durable grains consist of angular quartz and angular dark chert and rock fragments. Among the fragile and probably diagenetic minerals are chlorite, glauconite, pale green chloritic grains, biotite and sericite. White clay grains are common in some localities, and at Shell Midale A-7-18 well (tp. 6, rge. 10, W 2nd mer.) the finer-grained sandstone contains abundant clay grains with angular outline. In the same well the lithic sandstone sequence is interrupted by several 4-inch beds of coarse quartzose sand with subrounded grains and much secondary crystal growth.

The proportion of angular chert grains appears to diminish eastward, but chert is found in considerable quantity as far east as the Northern Gas Distributors No. 1 well, in tp. 29, rge. 32, West P.M., in the northern part of the subject area.

Using the thickest Saskatchewan section as standard, horizons corresponding to the upper and lower boundaries of Viking sand in Shell Albercan Govenlock #1 well (tp. 1, rge. 28, W 3rd mer.) have been traced northeastward to form a marker-defined unit that contains the Viking Formation as shown on the cross-sections. As the Viking beds thin from southwest to northeast, the upper and lower sand-shale boundaries depart slightly from the stratigraphic levels they represent at Govenlock, and minor upper and lower sand beds give way to shale, which in turn pinches out or thins northeastward. These arbitrary boundaries are found to be consistent over long distances, although at places close control is needed for accurate correlation.

The Viking Formation is relatively thin and remarkably widespread and there is no simple explanation of its origin. From earliest Cretaceous to the end of the Favel deposition in the Canadian Plains, successive formations record progressive changes from shallow to deeper water. The Viking sands may represent a brief interruption of this trend. A pause or slight reversal of the deepening process might allow sedimentation to overtake subsidence and place the bottom within reach of wave base and consequent re-sorting. The high proportion of chert grains in some of the more porous sands suggests an origin in the reworking or winnowing of sediments akin to greywacke. Accompanying slight rejuvenation of highlands in the areas of provenance also might introduce coarser sediments. Near their eastern limit, Viking beds seem to merge with a segment of the upper, marine part of the Swan River Formation. A non-marine interval that divides these marine Swan River strata may represent the Viking Formation. More study in what appears to be a near-shore region beyond the northeast corner of the subject area may shed additional light on the origin of the Viking sands.

The Viking Formation is equivalent westward to the upper part of the Bow Island Formation in Alberta. The identity of the Viking interval as it extends eastward into Manitoba has not been worked out satisfactorily. The silty development evident in the central part of the Ashville in the eastern part of the map-area and extending into Manitoba, is believed to be the equivalent of the Viking of the western part of the map-area. Proof of this relationship is presently being investigated. It is held with greater certainty, however, that the Viking 'equivalent' in Manitoba merges eastward with marine upper sands of the Swan River Group. To the south the Viking Formation is more or less continuous with the Muddy or Newcastle sandstone of northern United States.

Upper Shale Unit

The shale between the top of the Viking Formation and the base of the overlying (Favel) carbonaceous speckled shale contains the stratigraphic horizon generally regarded as the boundary between Lower and Upper Cretaceous. The specific horizon is not yet identified in the subsurface of the northern Plains.

The upper shale unit as a whole decreases regularly in thickness northeastward from 280 feet at Old Wives (Figs. 10 and 11), to 170 feet at Okla. The shales of the lower part are soft and

fissile, to clayey and bentonitic, similar in texture and appearance to the Joli Fou shale. In the western part of the subject area, 30 to 50 feet of soft, highly glauconitic post-Viking shale bears close resemblance to the glauconitic zone in the lower part of the pre-Viking Joli Fou Formation. The shale above the coarse glauconite zone contains silt-size grains of yellow-green glauconite that is absent in the upper part of the section. The upper limit of glauconite appears to be a stratigraphic horizon with possibilities as a marker in the northeastern sandy facies of the Ashville Group. A short distance above the upper limit of glauconite a narrow oxidized zone has been observed. It has pinkish brown clayey shale and specks of hematite, in part replacing spores. The oxidized zone is well developed in Sohio Canora #1 well in tp. 30, rge. 4, W 2nd mer., at a depth of 740 feet. The shale of the upper part of the Upper Ashville unit becomes increasingly carbonaceous upward by reason of microscopic dark specks of organic matter. This shale is firm and splintery, in contrast to the soft shale below, and resembles the overlying shale of the Favel Formation which has an abundance of brown organic matter.

'Fish Scale' Beds

The lower part of the more carbonaceous shale contains sandy layers and is recognized in some places as a sand. The sandy zone varies in thickness from 100 feet in southwest Saskatchewan to 20 feet in the east, and occurs from 20 to 70 feet below the top of the Ashville Group. In southeastern Saskatchewan, these so-called 'Fish Scale' beds are quartzose sands, mostly of the size of fine to very fine sand or silt, and they may be calcareous by reason of large quantities of pelecypod prisms. Fish scales and bones are plentiful in the more shaly beds, particularly in the shale immediately above and below the sandy layers. Vegetable matter, including spores, greatly exceeds fish remains in quantity in some of the more sandy beds. Glauconite in the 'Fish Scale' beds is rare or absent.

The 'Fish Scale' beds can be mapped over considerable distances and might therefore merit member status. However, in spite of the great area of distribution, which extends from northeastern British Columbia to North Dakota, the sandy facies of the 'Fish Scales' is not everywhere developed. Its distribution and thickness in Saskatchewan are roughly parallel with those of the Viking, being thickest in southwestern Saskatchewan, thinner but persistent in the northern part of the map-area, and less distinct in the south-central and eastern parts.

Owing to the discontinuous nature of the sand, the base of the more carbonaceous 'Fish Scale' beds is identified in the subsurface on the gamma-ray log. For practical purposes the base of the lowest interval of increased gamma-ray intensity in the upper shale unit represents the base of the 'Fish Scales'. This 'marker' appears to be stratigraphically higher (cross-section, Fig. 11) in the central and eastern parts of the province than in the extreme southwest. Although useful as a stratigraphic indicator, the base of the 'Fish Scales' in Saskatchewan is thus not a strictly consistent time-line.

An interval of this upper shale unit containing the 'Fish Scales' is roughly correlative with a part of the Shaftesbury Formation in the Peace River area of northeastern British Columbia. The correlative Shaftesbury sequence also contains a sandy interval with fish-bone beds beneath which a species of the ammonite Neogastroplites, considered to be indicative of the top of the Lower Cretaceous series, was reported by Stelck (Stelck, Wall, and Wetter, 1958, p. 7).

The change in shale facies at the base of the 'Fish Scales' in Saskatchewan corresponds closely to the boundary between contrasting shales of the Mowry and Belle Fourche Formations of northern United States The upper shale in Saskatchewan is not uniformly higher in carbon content than the underlying shale, however, and the boundary in Saskatchewan is less distinct than the Mowry - Belle Fourche contact.

The carbonaceous nature of the upper shale unit persists, with interruptions from the 'Fish Scales' to the top of the Ashville Group and beyond into the overlying Favel Formation. The upper part of the Ashville shale is cored in the Imperial Okla #1-29 well in tp. 35, rge. 8, W 2nd mer. The hole penetrates two horizons of possible stratigraphic importance that mark the upper limits of organic remains common throughout all the underlying beds of the Ashville Group The fragile tests of the mud-dwelling organisms already described are not found in the core above a level 20 feet below the top of the Ashville Group. A few feet above this point is the last occurrence of a blade-shaped spore case about 1.3 mm long and one eighth as wide, found in profusion, commonly in matted layers throughout the lower beds.

The interval from the base of the 'Fish Scales' to the top of the Ashville Group is roughly equivalent to the upper member of the Shaftesbury Formation of the Peace River region, including the 'Fish Scales', and to the Belle Fourche Formation of North Dakota.

TECTONIC SETTING AND GEOLOGICAL HISTORY

The interfingering groups of sandy formations in the base of the Lower Cretaceous succession (Fig. 1) have been separated along arbitrary geographic boundaries. The differences in thickness, stratigraphic interval, lithology and fossil content that identify the separate groups are reflections of broadly different conditions of sedimentation dependent on the position of each in the broad pattern of Cretaceous palaeogeography.

The Blairmore Group on the west comprises a great thickness of coarse sediment containing fossil plants. A part of the Blairmore is roughly continuous with the basal sandy group to the east, most of which may be equivalent to the Mannville Group of eastern Alberta.

The Mannville Group contains beds with marine fossils as well as non-marine strata and others of indeterminate origin. Some lower beds of the Mannville thin rapidly eastward, but higher beds are common to both the Mannville and the southern Saskatchewan sandy group near the arbitrary boundary.

The thinner basal Cretaceous sandy group of southern Saskatchewan contains no marine fossils. Coal seams are prominent in some areas, but the bulk of these sediments consists of beds without definite criteria of marine or continental origin.

Some of the unfossiliferous clay in the Cantuar Formation suggests a depositing medium of low salinity. More fissile argillaceous rocks are also present. They were possibly deposited in saline waters but they contain only fish teeth or finely divided carbon.

Preliminary studies show that the (fissile) marine shale above the Pense Formation in Saskatchewan becomes marine sand northeastward. This sand is included in the Swan River Group in parts of Manitoba. The Swan River Group thus contains younger beds than the Pense Formation, although the equivalents of the Pense and Cantuar continue eastward into the lower Swan River with little change.

From these observations emerges a generalized picture of early Lower Cretaceous sedimentation in the area. Copious sediments from the west maintained the surface of deposition at or above sea-level in the area of the Blairmore Group. Farther out from this source in the Mannville Group embodies a lesser thickness of sediment, and the presence of open sea is indicated by beds with marine fossils. Intervals of Mannville sediments containing no marine fossils may indicate changes in factors affecting depth of water and marine currents—such as tectonic undulation of the sea floor and variations in supply of sediment that at times failed to keep pace with subsidence. The lowest marine Mannville beds do not continue far eastward. They disappear in the western part of the area in which the Cantuar Formation is recognized. This pinching out results in part from abutment of an eastward-shallowing bottom. Evidence of a shallower floor in the southern Saskatchewan 'shelf' area is supported by the suggestion of low salinity, lack of marine fossils and presence of coal.

Above the Pense Formation, rocks of the Ashville Group contain marine fossils; they include fine-grained sediments, but have none of the light-coloured clay that seems to be associated with low salinity. These properties seem to indicate a return to free circulation of marine water following the removal of any restriction that may have existed earlier. Such a change might result from deepening of water over the 'shelf' through further subsidence. That such a deepening process progressed during Ashville deposition is indicated by studies of the Swan River Group. Judging by similar lithology, the lower part of the Swan River sequence was laid down under conditions similar to those of the southern Saskatchewan sandy group with which it is continuous. The change upward to highly glauconitic beds, within the Swan River, is about equivalent to the Pense - Joli Fou contact farther west. In the area of the Swan River Group the (marine) sand-shale contact rises stratigraphically in the direction of the Canadian Shield and may be indicative of proximity to the northeastern shoreline. The sand-shale contact is seen to advance northeastward with upward progression in the section. The shoreline may have done likewise, but it is uncertain whether the shoreline actually advanced through subsidence of a coastal shelf, or remained static while coarse sediments decreased through lower relief in the area of provenance.

These suggestions regarding Lower Cretaceous conditions are based on a few of many factors that need to be considered. They can be confirmed or denied only by further detailed studies.

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— APPENDIX —

Tops of Some Lower Cretaceous Formations

Well	Location	Elevation (Datum)	Tops				Base Cantuar	Pre-Cantuar
			Ashville	Viking*	Joli Fou*	Pense		
Socony Woodley Southern Gainsborough #1	16-29-1-30-W1	1,618	2,036	-	-	2,428	2,780	M. Vang.
Imperial Workman #3-8-1-32	3-8-1-32-W1	1,697	2,400	-	-	2,810	3,173	M. Vang.
Imperial Canadian Superior Workman #16-23	16-23-1-32-W1	1,674	2,261	-	-	2,680	2,987	M. Vang.
Imperial Royalite Hudson's Bay Northgate #4-36-1-2	4-36-1-2-W2	1,902	2,850	-	-	3,300	3,593	M. Vang.
Imperial Federal Co-Op. Palmer North Portal #12-29-1-5	12-29-1-5-W2	1,900	3,140	3,382	3,447	3,637	3,940	U. Vang.
Socony Central Del Rio South East Ratcliffe #1	15-15-1-15-W2	2,281	3,575	3,863	3,930	4,119	4,315	"Unit A"
Socony Central Del Rio Ratcliffe #2	12-36-1-15-W2	2,336	3,641	3,935	3,994	4,192	4,404	"Unit A"
Socony Central Del Rio Ratcliffe #1	5-30-1-15-W2	2,323	3,625	3,920	3,988	4,183	4,315	"Unit A"
Socony Central Del Rio West Ratcliffe #22-13	13-22-1-16-W2	2,337	3,596	3,900	3,967	4,168	4,394	"Unit A"
Socony Sohio East Poplar #15-1	1-15-1-25-W2	2,688	3,377	-	-	4,019	4,292	"Unit A"
Socony Sohio Coronach #15-11	11-15-1-28-W2	2,755	3,437	3,885	3,920	4,100	4,422	U. Vang.
Imperial Gainsborough #7-19-2-30	7-19-2-30-W1	1,628	1,977	-	-	2,378	2,714	M. Vang.
Imperial Carievale #5-16-2-31	5-16-2-31-W1	1,659	2,114	-	-	2,540	2,842	M. Vang.
Imperial Carnduff #11-9-2-33	11-9-2-33-W1	1,762	2,471	-	-	2,898	3,239	M. Vang
Imperial Canadian Superior Carnduff #3-27-2-33	3-27-2-33-W1	1,731	2,353	-	-	2,771	3,092	M. Vang.
Imperial Oxbow #15-36	15-36-2-3-W2	1,887	2,777	-	-	3,218	3,492	U. Vang.
California Standard Frobisher #5-21	5-21-2-4-W2	1,875	2,926	3,164	3,204	3,400	3,732	U. Vang.
J.P. Owen (Kincaid) #1	12-16-2-7-W2	1,888	3,127	-	-	3,596	3,965	"Unit A"
Shell Oungre #1	7-1-2-14-W2	2,206	3,504	3,785	3,881	4,061	4,320	"Unit A"
Socony North Ratcliffe #30-5	5-30-2-15-W2	2,404	3,670	3,955	3,976	4,180	4,388	"Unit A"
Shell Bergfield #A-10-15	10-15-2-21-W2	2,272	-	3,145	3,526	3,749	3,980	"Unit A"
Mobiloil Sohio North Paisley Brook #15-14	14-15-2-23-W2	2,568	3,293	-	-	3,902	4,173	"Unit A"
Socony Woodley Southern North Gainsborough #14-12	12-14-3-30-W1	1,647	1,916	-	-	2,295	2,550	M. Vang.
Imperial Cayuga #4-25-3-30	4-25-3-30-W1	1,632	1,866	-	-	2,242	2,500	M. Vang.
Imperial Canadian Superior Cayuga #14-33-3-30	14-33-3-30-W1	1,683	1,923	-	-	2,303	2,490	U. Vang.
Socony North Carievale #29-9	9-29-3-31-W1	1,702	2,070	-	-	2,470	2,700	M. Vang.
Socony Western Imperial Southern Carievale #1	16-4-3-32-W1	1,617	2,190	-	-	2,600	2,960	M. Vang.
Imperial Antler River #8-34	8-34-3-33-W2	1,780	2,282	2,445	2,578	2,702	2,427	U. Vang.
Imperial Glen Ewen #5-27-3-1	5-27-3-1-W2	1,847	2,473	-	-	2,902	3,096	U. Vang.
Gulf Bishop #13	13-11-3-1-W2	1,840	2,517	-	-	2,947	3,280	M. Vang.
British American Union Pickard #16-27	16-27-3-4-W2	1,932	2,753	3,000	3,020	3,227	3,590	M. Vang.
Gulf Quinn #1	1-34-3-4-W2	1,928	2,747	2,980	3,001	3,199	3,546	U. Vang.
Canadian Devonian Gulf Quinn #15	15-34-3-4-W2	1,936	2,730	2,960	2,985	3,181	3,589	M. Vang.
Gulf Gridoul Alfred #5	5-35-3-4-W2	1,934	2,770	2,976	3,010	3,189	3,550	M. Vang.
British American Mobiloil Estevan #9-14	9-14-3-7-W2	1,924	3,025	3,284	3,203	3,520	3,821	"Unit A"
Compagnie Francaise des Petroles Torquay #1	8-32-3-11-W2	1,878	-	-	-	3,463	3,650	"Unit A"
Shell Torquay #A-8-4	8-4-3-12-W2	1,956	3,062	3,333	3,447	3,600	4,046?	"Unit A"
Socony Central Del Rio Tribune #31-12	12-31-3-14-W2	2,023	3,037	3,320	3,385	3,585	3,829	"Unit A"
Socony Central Del Rio Alma Lake #6-10	6-10-3-17-W2	2,424	3,488	3,780	3,862	4,040	4,245	"Unit A"
Shell Big Muddy Lake #1	14-12-3-21-W2	2,518	3,304	3,630	3,678	3,899	4,160	"Unit A"

Socony Sohio Bulkin Lake #18-5	5-18-3-23-W2	2,780	3,390	-	-	4,013?	4,367	U. Vang.
Sohio Standard Buffalo Gap #1	16-10-3-25-W2	2,746	3,322	-	-	3,937	4,240	U. Vang.
Sun Hintz #14-7	14-7-4-31-W1	1,751	2,097	-	-	2,494	2,635	U. Vang.
Imperial Ingoldsby #15-7-4-31	15-7-4-31-W1	1,748	2,088	-	-	2,478	2,641	Jurassic
Imperial Sun Ingoldsby #3-21-4-31	3-21-4-31-W1	1,760	2,066	-	-	2,445	2,600	U. Vang.
Imperial Nottingham #9-26	9-26-4-32-W1	1,774	2,073	-	-	2,472	2,738	M. Vang.
Imperial Rosebank #16-33-4-32	16-33-4-32-W1	1,792	2,112	-	-	2,514	2,698	U. Vang.
Imperial Rosebank #1-35M-4-32	1-35-4-32-W1	1,779	2,090	-	-	2,487	2,743	U. Vang.
Imperial Gridoil Hastings #16-7-4-33	16-7-4-33-W1	1,819	2,300	-	-	2,720	2,975	U. Vang.
Gulf Collopy #5	5-2-4-4-W2	1,937	2,753	2,960	2,998	3,230	3,552	U. Vang.
Imperial Steelman #5-8M-4-5	5-8-4-5-W2	1,941	2,830	3,080	3,091	3,286	3,612	"Unit A"
British American Union Kingsford #11A-23	11-23-4-7-W2	1,943	2,835	3,081	3,100	3,312	3,761	"Unit A"
Shell Bryant #A-9-36	9-36-4-9-W2	1,955	2,890	3,098	3,120	3,318	3,682	"Unit A"
Shell Elswick #A-12-25	12-25-4-12-W2	1,835	2,776	3,047	3,101	3,290	3,493	"Unit A"
Mobil Oil West Neptune #30-14	14-30-4-16-W2	2,244	3,112	3,396	3,450	3,653	3,869	U. Vang.
Shell Salt Lake #A-10-21	10-21-4-20-W2	2,461	3,190	3,504	3,566	3,780	4,042	"Unit A"
Socony Sohio North Roanmine #29-6	6-29-4-21-W2	2,426	3,070	3,428	3,450	3,657	3,950	"Unit A"
Mobil Sohio Coal Mine Lake #18-9	9-18-4-22-W2	2,585	3,243	3,626	3,638	3,840	4,130	U. Vang.
Socony Sohio Harptree #21-4	4-21-4-26-W2	2,428	2,962	-	-	3,563	3,933	U. Vang.
Socony Sohio Fremington #21-9	9-21-4-28-W2	2,932	3,529	-	-	4,145	4,498	U. Vang.
Socony Sohio Lisieux #1	5-7-4-29-W2	2,761	3,255	3,670	3,710	3,860	4,220	U. Vang.
California Standard Tilston #5-32	5-32-5-29-W1	1,678	1,729	-	-	2,088	2,247	M. Vang.
New Concord Marwayne Dragon Tilston #16-36	16-36-5-30-W1	1,699	1,740	-	-	2,110	2,270	U. Vang.
Mobil Woodley Southern Nottingham #4-2	2-4-5-32-W1	1,791	2,120	-	-	2,520	2,700	U. Vang.
Socony Woodley Southern Nottingham #10-10	10-10-5-32-W1	1,823	2,104	-	-	2,495	2,688	U. Vang.
Socony Woodley Southern Alida #34-8	8-34-5-33-W1	1,910	2,180	2,409	2,450	2,566	2,830	U. Vang.
Imperial Alida #4-35-5-33	4-35-5-33-W1	1,913	2,190	-	-	2,580	2,812	U. Vang.?
Imperial Alida #12-35-5-33	12-35-5-33-W1	1,909	2,192	-	-	2,578	2,834	U. Vang.
Imperial Royalite Auburnton #1-2-5-1	1-2-5-1-W2	1,861	2,322	-	-	2,731	2,890	U. Vang.
Gulf Ludwig #8	8-22-5-4-W2	1,953	2,587	-	-	3,028	3,389	M. Vang.
Gulf Canadian Devonian Walter #1-5	5-14-5-6-W2	1,949	2,650	2,888	2,920	3,105	3,446	"Unit A"
Imperial Lampman #1-25M-5-6	1-25-5-6-W2	1,946	2,624	2,963	2,999	3,099	3,401	"Unit A"
Shell Minard #A-1-4	1-4-5-7-W2	1,958	2,774	3,018	3,076	3,253	3,637	"Unit A"
Shell Minard #A-16-4	16-4-5-7-W2	1,967	2,789	3,043	3,054	3,252	3,648	"Unit A"
Shell Cullen #A-8-28	8-28-5-7-W2	1,955	2,717	2,958	2,970	3,179	3,555	"Unit A"
Shell Cullen #A-13-22	13-22-5-8-W2	1,973	2,762	3,013	3,030	3,240	3,610	"Unit A"
Shell Woodley #16-24	16-24-5-8-W2	1,965	2,742	2,991	3,007	3,200	3,544	"Unit A"
Shell Blewett #A-3-28	3-28-5-9-W2	1,966	2,765	3,024	3,040	3,240	3,630	"Unit A"
Shell Blewett #A-1-22	1-22-5-10-W2	1,938	2,782	-	-	3,270	3,602?	"Unit A"
Killgore Palmer #16-35	16-35-5-11-W2	1,956	2,700	2,940	3,004	3,212	3,617	M. Vang.
Central Del Rio Elswick #11-18	11-18-5-12-W2	1,840	2,650	2,913	3,050	3,186	3,477	"Unit A"
Bennet, Burns & Young, Bell #1	11-19-5-14-W2	2,003	?	3,007	3,069	3,292	3,633	"Unit A"
Norcanols Radville #1	16-36-5-19-W2	2,218	2,910	3,185	3,230	3,439	3,760	U. Vang.

*Taken at boundaries of well-developed sand (disregarding the marker-defined boundaries described in text).

Well	Location	Elevation (Datum)	Tops				Base Cantuar	Pre-Cantuar
			Ashville	Viking*	Joli Fou*	Pense		
Shell Ceylon #1	10-34-5-20-W2	2,406	3,100	3,425	3,471	3,679	3,958	U. Vang.
Socony Sohio Roe #1	5-28-5-21-W2	2,526	3,230	3,575	3,590	3,795	4,085	U. Vang.
Socony Sohio Roncott #1	10-11-5-25-W2	2,302	2,808	-	-	3,390	3,720	U. Vang.
Socony Bailey Selburn Montague Lake #1	11-19-5-28-W2	2,930	3,490	-	-	4,119	4,443	U. Vang.
Socony Woodley Bellegarde #30-3	3-30-6-31-W1	1,864	1,984	-	-	2,383	2,480	U. Vang.
Imperial Lightning Creek #16-7	16-7-6-32-W1	1,949	2,162	-	-	2,554	2,690	U. Vang.
Socony Woodley Southern Ste. Antoine #11-5	5-11-6-32-W1	1,887	2,080	-	-	2,467	2,620	U. Vang.
Socony Woodley Southern Ste. Antoine #1	4-24-6-32-W1	1,915	2,067	-	-	2,450	2,540	Jurassic
McCarty & Coleman Hamel #4-23	4-23-6-34-W1	1,970	2,250	-	-	2,661	2,813	U. Vang.
Tidewater Lampman Crown #1	5-28-6-6-W2	1,982	2,570	2,801	2,812	3,012	3,290	"Unit A"
Shell Benson #A-1-18	1-18-6-8-W2	1,965	2,660	2,909	2,932	3,140	3,560?	M. Vang.
Shell Midale Mattson #3-7	3-7-6-10-W2	1,946	2,666	2,907	2,945	3,166	3,552	"Unit A"
Shell Midale #A-7-18 (Estevan #2)	7-18-6-10-W2	2,000	2,678	2,917	2,952	3,166	3,530	"Unit A"
Imperial Midale #13-21M-6-10	13-21-6-10-W2	1,974	2,652	2,900	2,966	3,130	3,509	"Unit A"
Shell Holloway #A-10-20	10-20-6-11-W2	1,964	2,816	2,860	3,013	3,156	3,552	M. Vang.
Dome Cox-Imperial West Midale #9-27-6-11	9-27-6-11-W2	2,004	2,650	2,896	3,006	3,182	3,565	"Unit A"
Shell Halbrite #A-5-32	5-32-6-11-W2	1,983	2,648	2,897	3,009	3,168	3,572	M. Vang.
Shell East Halbrite #11-14	11-14-6-12-W2	1,922	2,640	2,892	2,996	3,176	3,529	M. Vang.
Shell Halbrite #A-15-18	15-18-6-12-W2	1,885	2,565	2,824	2,915	3,091	3,490	-
Socony Central Del Rio Ralph #28-2	2-28-6-13-W2	1,870	2,516	2,779	2,825	3,030	3,403	M. Vang.
Shell Radville #A-1-35	1-35-6-18-W2	2,122	2,700	3,060	3,108	3,230	(to 3,314 TD)	
Shell Brooking #A-1-13	1-13-6-19-W2	2,229	3,032	3,330	3,370	3,587	3,897	U. Vang.
Socony Sohio Ritchie #1	2-2-6-32-W2	2,399	2,910	3,259	3,275	3,423	3,771	U. Vang.
Sohio Stanolind Viceroy #1	16-11-6-25-W2	2,394	2,820	-	-	3,400	3,821	U. Vang.
Socony Western Prairie Redvers #1	16-36-7-32-W1	1,950	1,995	-	-	2,376?	2,410	U. Vang.
McCarty & Coleman Pedersen	4-35-7-33-W1	2,058	2,167	-	-	2,551	2,600	U. Vang.
McCarty & Coleman O'Higgins #4-1	4-1-7-34-W1	1,994	2,250	-	-	2,655	2,750	U. Vang.
McCarty & Coleman Knight #6-26	6-26-7-34-W1	2,075	2,270	-	-	2,650	2,837	U. Vang.
Tidewater Imperial Carlyle #1	16-23-7-3-W2	1,941	2,252	-	-	2,662	3,030	M. Vang.
Tidewater Imperial South Kisbey Crown #2	12-22-7-6-W2	2,017	2,466	-	-	2,910	3,238	"Unit A"
Tidewater Imperial South Kisbey Crown #1	16-34-7-6-W2	2,011	2,420	-	-	2,870	3,220	"Unit A"
Shell Viewfield #A-1-12	1-12-7-9-W2	2,001	2,629	-	-	3,094	3,489	M. Vang.
Shell Huntoon #A-13-22	13-22-7-9-W2	2,010	2,600	-	-	3,072	3,475	M. Vang.
Sooner Gill #6-8	6-8-7-10-W2	1,994	2,580	2,827	2,854	3,061	3,450	"Unit A"
Shell Huntoon #A-8-12	8-12-7-10-W2	1,986	2,605	2,851	3,060	3,088	3,478	Jurassic
Shell Innes #A-4-22	4-22-7-11-W2	2,006	2,565	2,800	2,892	3,079	3,408	L. Vang.
Shell Griffin #A-8-30	8-30-7-11-W2	2,014	2,591	2,839	2,937	3,085	3,489	"Unit A"
Shell North Halbrite #A-13-4	13-4-7-12-W2	1,927	2,547	2,803	2,864	3,040	3,445	M. Vang.
Central Del Rio Ralph #14-6	14-6-7-13-W2	1,896	2,488	2,762	2,800	2,994	3,362	M. Vang.
Socony Central Del Rio Grassdale #1	6-2-7-16-W2	2,022	2,656	2,950	3,002	3,208	3,492	U. Vang.
Shell Abbott #A-13-32	13-32-7-18-W2	2,145	2,623	2,921	2,995	3,207	3,463	U. Vang.
Shell Forward #A-15-22	15-22-7-19-W2	2,156	2,627	2,928	2,993	3,196	3,491	Jurassic

Norcanols Ogema #1	4-24-7-23-W2	2,420	2,833	3,167	3,200	3,377	3,680	U. Vang.
Socony Sohio Channel Lake #1	9-3-7-24-W2	2,411	2,897	-	-	3,450	3,851	U. Vang.
Sohio Standard Horizon #1	16-5-7-24-W2	2,332	2,898	-	-	3,457	3,850	U. Vang.
Socony Sohio Landscape #14-6	6-14-7-26-W2	2,507	3,021	-	-	3,606	3,592	U. Vang.
Socony Sohio Verwood #1	9-9-7-28-W2	2,525	2,990	3,389	3,423	3,600	3,940	U. Vang.
Socony Sohio Willows #29-14	14-29-7-29-W2	2,365	2,949	3,355	3,396	3,580	3,938	U. Vang.
Tidewater Arcola Crown #1	1-22-8-4-W2	2,043	2,311	2,541	2,600	2,767	3,102	L. Vang.
Imperial Kisbey #13-3	13-3-8-5-W2	1,980	2,344	2,568	2,580	2,784	3,127	"Unit A"
Tidewater Amurex Kisbey #1	4-23-8-6-W2	2,008	2,335	-	-	2,788	3,122	"Unit A"
Bailey Selburn Forget #14-35	14-35-8-7-W2	2,003	2,354	-	-	2,800	3,121	M. Vang.
Shell Estevan #1	6-24-8-9-W2	2,023	2,470	2,720	2,810?	2,945	3,356	"Unit A"
Socony Weyburn #11-8	8-11-8-14-W2	1,882	2,395	2,665	2,706	2,900	3,216	M. Vang.
British American Husky Phillips Trossachs #9-11	9-11-8-17-W2	1,980	2,401	2,685	2,762	2,973	3,298	Jurassic
Shell Pangman #1	9-28-8-21-W2	2,489	2,860	3,289	3,330	3,407	3,711	U. Vang.
Shell Dahinda #A-9-35	9-35-8-23-W2	2,425	3,100	-	-	3,641	3,953	U. Vang.
Socony Sohio Readlyn #10-11	11-10-8-28-W2	2,361	2,830	-	-	3,442	3,879	L. Vang.
Tidewater Mair Crown #1	1-11-9-32-W1	1,992	1,936	-	-	2,313	2,420	U. Vang.
Tidewater Ajax White Bear Crown #4	9-12-9-3-W2	2,421	2,590	2,817	2,841	3,025	3,340	L. Vang.
Tidewater White Bear Crown #1	1-26-9-3-W2	2,480	2,539	2,816	2,845	3,018	3,375	Jurassic
Tidewater Kenosee Crown #1-A	6-26-9-4-W2	2,665	2,779	3,006	3,050	3,220	3,590	L. Vang.
Williston Bobjo Forget #1-19	1-19-9-6-W2	2,122	2,363	-	-	2,813	3,171	M. Vang.
Tidewater Forget Crown #1	2-11-9-7-W2	2,001	2,313	2,546	?	2,769	3,088	M. Vang.
Sohio Stoughton #4-13	13-4-9-8-W2	2,069	2,412	2,655	2,790	2,872	3,238	"Unit A"
Sohio Canamerican Creelman #5-21	5-21-9-11-W2	2,020	2,379	2,627	2,674	2,856	3,266	M. Vang.
Plymouth Sun Talmadge #1	9-22-9-13-W2	2,012	2,404	2,670	2,726	2,902	3,241	U. Vang.
Socony Sohio North Weyburn #11-3	3-11-9-14-W2	1,934	2,371	2,625	2,684	2,870	3,115	U. Vang.
Richfield British American Williston Sandercock #10-28	10-28-9-15-W2	1,887	2,238	2,508	2,571	2,765	3,041	U. Vang. ?
British American Williston Brightmore #1	9-28-9-16-W2	1,917	2,213	2,485	2,559	2,753	3,046	U. Vang.
Shell Ibsen Lake #A-6-14	6-14-9-18-W2	1,983	2,245	2,530	2,600	2,800	3,083	U. Vang.
Shell Moreland #A-16-26	16-26-9-19-W2	2,074	2,350	2,634	2,724	2,912	3,201?	U. Vang.
Norcanols Parry #1	16-8-9-21-W2	2,547	2,838	3,173	3,209	3,312	3,660	U. Vang.
Shell Dahinda #1	6-2-9-23-W2	2,422	2,830	-	-	3,370	3,685	U. Vang.
Shell Kayville #A-5-24	5-24-9-24-W2	2,396	2,955	3,337	3,361	3,523	3,864	M. Vang.
Tidewater Ryerson Crown #1	4-10-10-31-W1	1,925	1,746	-	-	2,112	2,253	M. Vang.
Tidewater Canadian Superior Fairlight Crown #1	4-13-10-33-W1	2,044	1,920	2,141	2,149	2,289	2,345	U. Vang.
Tidewater Ajax White Bear #2	4-3-10-2-W2	2,450	2,475	2,703	2,714	2,888	3,260	L. Vang.
Tidewater Kenosee Crown #2	16-23-10-4-W2	2,472	2,484	-	-	2,918	3,250	L. Vang.
Palmer Moose Mountain #3-18	3-18-10-6-W2	2,334	2,525	2,754	2,767	2,971	3,320	L. Vang.
Imperial Warmley #14-24-10-6	14-24-10-6-W2	2,575	2,668	-	-	3,112	3,470	L. Vang.
Tidewater Handsworth Crown #1	12-28-10-7-W2	2,174	2,275	2,510	2,522	2,726	3,127	L. Vang.
British American Husky Phillips Lost Horse Hill #16-30	16-30-10-8-W2	2,083	2,251	2,485	2,505	2,712	3,131	Vanguard
Sohio Canamerican Creelman #13B-6	13-6-10-10-W2	2,015	2,281	2,517	2,600	2,762	3,182	L. Vang.
Sohio Canamerican Creelman #11-15	15-11-10-11-W2	2,014	2,399	2,530	2,600	2,780	3,184	L. Vang.
Texaco Plymouth South Brough #A-1-2	1-2-10-12-W2	2,003	2,352	2,608	2,660	2,850	3,189	L. Vang.

Well	Location	Elevation (Datum)	Tops				Base Cantuar	Pre-Cantuar
			Ashville	Viking*	Joli Fou*	Pense		
Shell Talmadge #A-9-30	9-30-10-12-W2	2,005	2,310	2,554	2,619	2,789	3,124	M. Vang.
Mobiloil South West Lang. #32-14	14-32-10-19-W2	1,961	2,155	2,465	2,591	2,714	3,061	M. Vang.
I & M Oil Company Limited, Drummer #1	4-20-10-20-W2	2,147	2,360	2,703	2,732	2,904	3,269	M. Vang.
Sohio North Parry #19-5	5-19-10-21-W2	2,136	2,355	-	-	2,833	3,304	"Unit A"
Imperial Dahinda #1	10-23-10-23-W2	2,483	2,720	-	-	3,258	3,645	M. Vang.
Socony Sohio Crystal Hill #1	3-14-10-24-W2	2,465	3,045?	-	-	3,592	3,890	U. Vang.
Socony Sohio North Ormiston #18-3	3-18-10-25-W2	2,411	2,729	3,110	3,140	3,304	3,650	"Unit A"
Socony Sohio North Ormiston #13-13	13-13-10-26-W2	2,403	2,857	3,230	3,260	3,427	3,730	"Unit A"
Tidewater Wawota Crown #1	2-12-11-34-W1	2,166	2,027	2,247	2,309	2,449	2,756	Jurassic
California Standard Fillmore #6-30	6-30-11-9-W2	2,102	2,246	2,466	2,526	2,702	3,101	Jurassic
Plymouth Sun Osage #1	9-30-11-12-W2	1,996	2,201	2,422	2,473	2,663	2,959	M. Vang.
British American Husky Phillips Cedoux #1	8-10-11-14-W2	1,977	2,258	2,475	2,513	2,689	2,950	M. Vang.
L & M Mobil Crown #1	3-13-11-21-W2	2,102	2,257	-	-	2,792	3,164	M. Vang.
Sohio Socony Mossbank #1	13-27-11-28-W2	2,256	2,612	-	-	3,191	3,480	"Unit A"
Socony Sohio Ardill #11-14	14-11-11-29-W2	2,399	2,793	3,180	3,225	3,325	3,673	M. Vang.
Imperial Canadian Superior Martin #1-3	1-3-12-31-W1	1,922	1,605	1,806	1,830	1,970	2,192	L. Vang.
Tidewater Imperial Bender Crown #1	13-11-12-5-W2	2,398	2,375	-	-	2,809	3,196	L. Vang.
British American Husky Phillips Bemersyde #12-11	12-11-12-8-W2	2,185	2,210	2,450	2,459?	2,678	3,039	L. Vang.
British American Husky Phillips Colfax #15-11	15-11-12-14-W2	2,000	2,151	2,406	2,448	2,624	2,893	M. Vang.
Mobiloil North Lang. #11-1	1-11-12-18-W2	1,900	1,987	2,258	2,331	2,567?	2,950	L. Vang.
Sohio Socony Avonlea #1	15-7-12-21-W2	1,912	2,062	-	-	2,593	2,800	M. Vang.
Sohio Socony Avonlea #2	15-20-12-22-W2	1,975	2,573	2,912	2,930	3,097	3,300	M. Vang.
Socony Sohio South Avonlea #4-9	9-4-12-23-W2	2,098	2,379	2,720	2,745	2,901	3,204	M. Vang.
Socony Sohio Claybank #9-11	11-9-12-24-W2	2,735	3,320	3,690	3,716	3,870	4,123	M. Vang.
Shell Mossbank #10-33	10-33-12-29-W2	2,205	2,632	-	-	3,236	3,506	U. Vang.
Central Del Rio Red Jacket #6-19	6-19-13-32-W1	1,972	1,579	1,780	1,800	1,955	2,060	L. Vang.
Tidewater Kipling Crown #2	1-4-13-5-W2	2,308	2,151	-	-	2,591	2,910	L. Vang.
Tidewater Kipling Crown #1	14-22-13-5-W2	2,167	1,958	-	-	2,399	2,788	L. Vang.
British American Husky Phillips Bemersyde #1	3-11-13-8-W2	2,214	2,030	2,360	2,441	2,609	2,997	L. Vang.
British American Husky Phillips Glenavon #1	8-29-13-9-W2	2,198	2,120	2,328	2,380	2,576	2,902	Jurassic
British American Husky Phillips Tyvan #1	9-11-13-13-W2	2,062	2,135	2,377	2,436	2,622	2,911	M. Vang.
British American Husky Phillips Francis #1	8-29-13-14-W2	1,988	2,004	2,257	2,310	2,500	2,915	L. Vang.
Richfield British American Williston Bechard #11-22	11-22-13-16-W2	1,912	1,948	2,209	2,290	2,460	2,826	L. Vang.
Phillips Petroleum Bechard #1	8-29-13-16-W2	1,912	1,942	2,199	2,282	2,449	2,792	L. Vang.
British American Williston Riceton #1	4-29-13-17-W2	1,901	1,985	2,287	2,347	2,498	2,778	Jurassic
Socony Sohio East Corinne #20-9	9-20-13-19-W2	1,925	1,950	2,210	2,250	2,450	2,770	L. Vang.
Norcanols Wilcox #1	16-32-13-20-W2	1,910	1,950	-	-	2,421	2,730	M. Vang.
California Standard Tidewater Boundary #5-14	5-14-14-30-W1	1,700	1,181	-	-	1,583	1,724	U. Shaun.
Tidewater Earlswood #1	1-19-14-33-W1	1,941	1,560	-	-	1,940	2,050	M. Vang.
British American Husky Phillips Kegworth #14-11	14-11-14-9-W2	2,269	2,120	2,335	2,384	2,564	2,880	L. Vang.

British American Husky Phillips Kendall #12-12	12-12-14-12-W2	2,314	2,188	2,439	2,449	2,637	2,991	L. Vang.
Palmer California Standard Manybones #3-16	3-16-14-13-W2	2,163	2,177	2,370	2,420	2,613	2,969	L. Vang.
Socony Sohio Briercrest #11-14	14-11-14-24-W2	1,879	2,362	2,714	2,735	2,890	3,160	M. Vang.
Sohio Standard Leakville #1	4-11-14-26-W2	2,055	2,343	2,710	2,740	2,833	3,080	M. Vang.
Socony Sohio South Buttress #11-2	2-11-14-28-W2	2,390	2,832	3,247	3,253?	3,415	3,681	M. Vang.
Shell Old Wives #A-16-11	16-11-14-30-W2	2,205	2,641	3,000±	3,058	3,218	3,551	M. Vang.
California Standard Red Jacket #10-5	10-5-15-31-W1	1,830	1,314	-	-	1,684	1,799	L. Vang.
Imperial Tidewater Wapella #4-3-15-1	4-3-15-1-W2	1,949	1,590	-	-	1,972	2,158	Vanguard
Sohio North Wapella #11-13	11-13-15-1-W2	1,915	1,554	-	-	1,935	2,148	L. Vang.
Sohio Saint Hubert #14-1	14-1-15-3-W2	2,045	1,700	-	-	2,110	2,450	Jurassic
Imperial Broadview #14-17-15-4	14-17-15-4-W2	2,026	1,694	-	-	2,110	2,456	"Unit A"
Tidewater Imperial Hillesden Crown #1	5-30-15-5-W2	2,151	1,836	-	-	2,280	2,610	Shaun.
British American Husky Phillips Montmartre #1	12-11-15-11-W2	2,275	2,141	2,367	2,420	2,548	2,952	L. Vang.
British American Husky Phillips Vibank #1	5-29-15-14-W2	2,176	2,044	2,290	2,376	2,543	2,779	M. Vang.
Socony Sohio Estlin #1	1-20-15-19-W2	1,922	1,912	2,183?	2,268	2,420	2,700	L. Vang.
Socony Sohio Buttress #1	8-4-15-28-W2	2,558	2,870	-	-	3,439	3,717	M. Vang.
California Standard Burrows #2-34	2-34-16-1-W2	1,975	1,446	-	-	1,814	1,956	Jurassic
Imperial Tidewater Oakshela #13-25-16-6	13-25-16-6-W2	1,965	1,563	-	-	1,970	2,341	"Unit A"
Tidewater Grenfell Crown #1	7-10-16-7-W2	2,177	1,860	-	-	2,330	2,673	Jurassic
C.E. Smith & Sask. Petr. Ltd. Assiniboine #1	16-14-16-12-W2	2,248	2,067	2,280	2,325	2,523	2,800	L. Vang.
Phillips Odessa #1	5-12-16-13-W2	2,214	2,048	2,260	2,321	2,510	2,782	L. Vang.
British American Husky Phillips Strawberry Lake #5-29	5-29-16-13-W2	2,174	1,971	2,200	2,282	2,457	2,708	L. Vang.
British American Husky Phillips Davin #1	12-11-16-16-W2	2,143	1,980	2,270	2,367	2,463	2,721	L. Vang.
Sohio Socony Drinkwater #13-12	13-12-16-23-W2	1,920	2,463	2,800	2,817	2,965	3,282	L. Vang.
Seaboard Tidewater Old Wives #15-22	15-22-16-1-W3	2,099	2,515	2,879	2,909	3,059	3,272	M. Vang.
California Standard Ochapowace #8-33	8-33-17-3-W2	1,920	1,415	-	-	1,804	2,180	Jurassic
Sohio Grenfell #16-20	16-20-17-5-W2	1,934	1,450	-	-	1,842	2,226?	Jurassic
Sohio Grenfell #8-4	8-4-17-6-W2	1,912	1,571	1,795	1,800	1,991	2,351	Jurassic
Sohio Grenfell #9-24	9-24-17-6-W2	1,919	1,437	1,662	1,690	1,832	2,280?	Jurassic
Sohio Grenfell #13-14	13-14-17-7-W2	1,933	1,500	1,730	1,745	1,927	2,235	Jurassic
Canadian Devonian Pense #1	14-6-17-22-W2	1,909	2,156	2,480	2,505	2,657	2,909	L. Vang.
Sohio Standard Pense #1	14-10-17-22-W2	1,895	2,107	-	-	2,597	2,893	L. Vang.
Imperial Cowessess #4-13-18-6	4-13-18-6-W2	1,871	1,374	-	-	1,759	2,160	L. Shaun.
British American Husky Phillips Ellisboro	8-36-18-10-W2	1,866	1,434	1,652	1,740	1,897	2,195	Jurassic
Canadian Devonian Stony Beach #1	4-16-18-23-W2	1,918	1,879	2,200	2,240	2,392	2,637	L. Vang.
Socony Sohio Waldorf #1	4-2-18-24-W2	1,915	1,814	2,190	2,212	2,370	2,548	L. Vang.
Dillman Lindley #14-3	14-3-18-26-W2	1,951	2,150	-	-	2,661	2,882	M. Vang.
Tidewater Imperial Cotham Crown #1	1-2-19-4-W2	1,847	1,243	-	-	1,611	1,970	Jurassic
Imperial Cowesses #2-2	2-2-19-6-W2	1,864	1,317	-	-	1,700	2,085	Jurassic
British American Husky Phillips Hyde #1	12-28-19-7-W2	1,926	1,345	1,543	1,629	1,781	2,228	Jurassic
Imperial Indian Head #16-4-19-11	16-4-19-11-W2	1,587	1,156	1,389	1,438	1,609	1,875	Gravelb.
Tidewater Avonhurst Crown #1	1-24-19-16-W2	2,183	1,860	-	-	2,293	2,529	L. Vang.
Socony Sohio West Marquis #1	12-28-19-28-W2	2,006	2,030	2,261±	2,386	2,537	2,720	L. Vang.
Tidewater Canadian Superior Flint Cutarm #1	1-4-20-32-W1	1,666	925	-	-	1,277	1,405	Jurassic
International Yarbo #4	1-34-20-33-W1	1,681	-	-	-	-	1,300	Jurassic

Well	Location	Elevation (Datum)	Tops				Base Cantuar	Pre-Cantuar
			Ashville	Viking*	Joli Fou*	Pense		
British American Husky Phillips Neudorf #6-20	6-20-20-8-W2	2,048	1,465	1,666	1,752	1,888	2,282?	Jurassic
Realty & Associates Read #9-14	14-9-20-18-W2	2,193	1,881	-	-	2,326	2,628	Shaun.
Socony Sohio Disley #1	15-12-20-23-W2	1,822	1,460	1,767	1,804	1,942	2,174	L. Vang.
Socony Sohio East Bethune #29-11	11-29-20-23-W2	1,761	1,445	1,745	1,781	1,929	2,132	L. Vang.
Sohio Petroleum Company Findlater #2	9-20-20-25-W2	1,898	1,700	2,030	2,055	2,191	2,378	L. Vang.
Sohio East Churchbridge #1	12-32-21-30-W1	1,674	854	-	-	1,192	1,431	Devonian
Sohio Langenburg	3-21-21-31-W1	1,699	835	-	-	1,192	1,455	Bakken
Socony Sohio Killaly #11-14	14-11-21-6-W2	1,804	1,110	1,313	1,350	1,486	1,874	Jurassic
British American Husky Phillips Gillespie #1	8-10-21-11-W2	1,978	1,427	1,631	1,698	1,860	2,078	U. Shaun.
Socony Sohio Dilke #1	13-5-21-23-W2	1,815	1,431	1,754	1,790	1,926	2,190	L. Vang.
Sohio #4	2-4-21-25-W2	1,866	1,650	1,970	2,010	2,180	2,320	L. Vang.
Canadian Export Gas Findlater #2-29	2-29-21-27-W2	1,971	1,736	2,100	2,124	2,268?	2,453	L. Vang.
Sohio Churchbridge #1	6-8-22-32-W1	1,742	834	-	-	1,250	1,415	Jurassic
Sohio North Churchbridge #12-22	12-22-22-32-W1	1,754	916	-	-	1,270	1,463	Jurassic
Sohio Bredenbury #15-10	15-10-22-33-W1	1,728	577	-	-	1,241	1,326	Jurassic
Socony Sohio Bangor #1	14-11-22-2-W2	1,738	913	-	-	1,267	1,422	Jurassic
Duval Yorkton #1	16-29-22-2-W2	1,734	-	-	-	-	1,320	Jurassic
Sohio Waldron #13-16	13-16-22-3-W2	1,746	955	-	-	1,311	1,508	Lodgepole
Socony Sohio Saltcoats #29-4	4-29-22-3-W2	1,748	932	-	-	1,296	1,488	Lodgepole
Socony Sohio Waldron #1	5-11-22-4-W2	1,753	975	-	-	1,395	1,613	Lodgepole
Sohio Melville #1	11-14-22-6-W2	1,795	1,050	-	-	1,427	1,740	Jurassic?
British American Husky Phillips Colmer #5-28	5-28-22-7-W2	1,864	1,124	1,320	1,390	1,529	1,800	Jurassic
J.P. Owen East Peepeekeesis #1	3-6-22-10-W2	2,033	1,413	-	-	1,818?	2,007	Gravelb.
J.P. Owen Socony West Peepeekeesis #1	13-11-22-11-W2	2,126	1,510	1,716	1,772	1,932	2,100	Jurassic
British American Husky Phillips Qu'Appelle #2-29	2-29-22-13-W2	2,073	1,539	-	-	1,964	2,150	U. Shaun.
Tidewater Southey Crown #1	4-29-22-18-W2	1,841	1,471	-	-	1,889	2,180	L. Shaun.
Sohio Gibbs #1	16-29-22-21-W2	1,836	1,372	1,663	1,682	1,798	1,980	L. Vang.
Socony Western Petroleum Leases North Churchbridge #5-12	5-12-23-33-W1	1,759	?	-	-	?	1,430	Jurassic?
British American Husky Phillips Birmingham #1	7-29-23-7-W2	1,912	1,100	1,300	1,321	1,490	1,766	Jurassic
Socony Star Blanket #1	15-6-23-10-W2	2,206	1,528	1,733	1,788	1,942	2,185	L. Shaun.
J.P. Owen Little Black Bear #1	2-29-23-10-W2	2,212	1,510	1,697	1,740	1,893	2,132	Jurassic
Tidewater Marckinch #1	13-29-23-17-W2	1,840	1,411	1,688	1,720	1,835	2,102	Gravelb.
Sohio Petroleum Company Earl Grey #1	9-10-23-20-W2	1,922	1,523	1,800	1,821	1,940	2,195	L. Vang.
Socony Sohio Bulyea #1	8-30-23-20-W2	1,912	1,633	1,911	1,924	2,063	2,180	L. Vang.
Sohio Petroleum Company Edenkillie #1	16-34-23-23-W2	1,726	1,251	1,570	1,586	1,718	1,883	L. Vang.
Socony Sohio Holdfast #1	9-11-23-26-W2	1,806	1,430	1,747	1,762	1,889	1,986	L. Vang.
Sohio Otthon #1	NW 24-24-5-W2	1,719	886	-	-	1,242	1,605	Bakken
California Standard Tidewater Hubbard #1-28	1-28-24-10-W2	2,183	1,422	1,610	1,634	1,780	2,063	Gravelb.
Tidewater Tullymet Crown #1	1-29-24-12-W2	2,210	1,363	1,759	1,819	1,930	2,104	Jurassic

Tidewater Headlands Crown #4-34	4-34-24-14-W2	2,122	1,540	-	-	1,937	2,320?	Jurassic
Tidewater Cupar Crown #4-28	4-28-24-16-W2	2,073	1,543	-	-	1,949	2,321	Gravelb.
Imperial Tidewater Penzance #1	3-30-24-25-W2	1,946	1,339	1,648	1,671	1,813	2,095	Gravelb.
Tidewater Craik Crown #1	3-15-24-29-W2	2,076	1,862	2,164	2,180	2,310	2,520	L. Shaun.
Socony Sohio Kessock #1	8-11-25-33-W1	1,740	1,135	-	-	1,460	1,800	Jurassic?
Flint Fonehill #1	13-29-25-5-W2	716	923	1,111	1,174	1,300	1,570	Jurassic?
British American Husky Phillips Plainview	2-4-25-7-W2	1,945	1,102	1,300	1,338	1,485	1,880	Lodgepole
Tidewater Ituna Crown #2	4-32-25-11-W2	2,225	1,488	1,697	1,721	1,851	2,102	Jurassic
Tidewater Ituna Crown #1	16-11-25-12-W2	2,267	1,555	1,750	1,803	1,924	2,186	Jurassic
Tidewater Ituna Crown #4	1-29-25-12-W2	2,244	1,551	1,747	1,772	1,912	2,166?	Jurassic
Tidewater Bryce Lake Crown	1-14-25-16-W2	2,169	1,634	1,850	1,900	2,003	2,300	Gravelb.
Socony Sohio Elbourne #1	5-11-25-20-W2	1,833	1,410	1,670	1,688	1,810	2,020	L. Shaun.
Socony Sohio Last Mountain #29-8	8-29-25-20-W2	1,824	1,411	-	-	1,813	1,990	Jurassic
Socony Sohio Duval #1	9-20-25-21-W2	2,082	1,760	2,012	-	2,150	2,402	Gravelb.
Sohio Strasbourg #1	4-10-25-23-W2	1,792	1,368	1,650	1,672	1,800	2,020	L. Shaun.
Rio Prado Wroxton #8-13	8-13-26-33-W1	1,738	890	-	-	1,230	1,489	Jurassic?
Sohio Barbour #1	SE 1/4 4-26-2-W2	1,725	830	-	-	1,184	1,486	Jurassic?
Amerada Crown "S-D" #1-29	1-29-26-5-W2	1,688	815	1,000	1,055	1,174	1,410	Devonian
Amerada Crown "S-C" #5-11	5-11-26-6-W2	1,736	1,024	1,206	1,263	1,390 (to TD)		-
Amerada Crown "S-B" #2-29	2-29-26-6-W2	1,735	891	1,085	1,130	1,237	1,490	Devonian
Tidewater Beaver Hills #1-5	1-5-26-9-W2	2,207	1,416	1,594	1,630	1,783	2,100	Lodgepole
Tidewater Beaver Hills Crown #1	16-23-26-9-W2	2,168	1,273	1,467	1,506	1,645	1,837	Lodgepole
Tidewater Ituna Crown #3	16-10-26-11-W2	2,227	1,458	1,656	1,710	1,840?	2,095	Jurassic
Socony Sohio South Raymore #12-29	12-29-26-19-W2	1,856	1,312	-	-	1,700	1,890	Gravelb.
Socony Sohio East Cymric #29-4	4-29-26-21-W2	1,753	1,605	-	-	1,990	2,196	Jurassic
Sohio Duval #1	4-18-26-22-W2	1,735	1,972	2,245	2,266	2,375	2,640	Shaun.
Socony Sohio Cymric #1	10-20-26-22-W2	1,742	1,655	1,930	1,947	2,060	2,320	Gravelb.
Sohio Western Petroleums Rhein #1	4-32-27-2-W2	1,682	780	-	-	1,119	1,357	Devonian
Sohio Western Petroleums Ebenezer #1	4-35-27-3-W2	1,606	670	-	-	1,008	1,190	Devonian
Seaboard Devil's Lake Crown #13-16	13-16-27-5-W2	1,679	780	973	1,067 (to TD)		-	-
Seaboard Devil's Lake Crown #6-32	6-32-27-5-W2	1,643	781	965	1,000	1,148	1,378	Devonian
Seaboard Devil's Lake Crown #15-11	15-11-27-6-W2	1,715	824	1,011	1,035 (to TD)		-	-
British American Husky Phillips Springside #1	8-29-27-7-W2	1,907	931	1,105	1,190	1,313	1,499	Bakken
Husky Phillips Fitzmaurice	16-18-27-8-W2	2,063	1,207	1,382	1,448	1,570	1,800	Miss.
Tidewater Flint Parkerview Crown #1	16-23-27-10-W2	2,209	1,380	1,567	1,601	1,750	2,002	Bakken
Tidewater Beckenham Crown #4-13	4-13-27-11-W2	2,224	1,416	1,623	1,650	1,780	2,066	Bakken
Socony Sohio Raymore #1	1-14-27-19-W2	2,002	1,437	1,690	1,704±	1,815	2,000	Gravelb.
Shell Govan #29-4	4-29-27-22-W2	1,723	1,245	1,525	1,561	1,682	1,933	Jurassic
Tidewater Davidson Crown #1	13-4-27-28-W2	2,038	1,751	2,031	2,048	2,190	2,423	Gravelb.
Tidewater Allenbee & Associates Nash #1	1-17-27-28-W2	2,010	1,723	1,998	2,020	2,155	2,380	L. Shaun.
Sohio Petroleum Company Rhein #1	SE 1/4 28-28-1-W2	1,725	730	-	-	1,090	1,397	Devonian
Seaboard Devil's Lake Crown #3-29	3-29-28-4-W2	1,626	690	889	952	1,080	1,520	Devonian
Seaboard Devil's Lake #16-11	16-11-28-6-W2	1,656	786	976	1,009	1,140	1,342	Devonian
Sohio Standard Theordore #1	4-22-28-7-W2	1,733	904	1,073	?	1,272	1,532	Devonian
Potash Company of America Insinger #2	4-30-28-8-W2	1,948	1,064	1,260	1,300	1,426	1,592	Bakken
Tidewater Flint Westbend Crown	13-22-28-11-W2	2,150	1,316	1,497	1,545	1,660	1,862	Bakken
Tidewater Model Crown #1	4-27-28-13-W2	2,186	1,485	-	-	1,830	2,030	Miss.

Well	Location	Elevation (Datum)	Tops				Base Cantuar	Pre-Cantuar
			Ashville	Viking*	Joli Fou*	Pense		
Tidewater Wynot Crown #1	16-18-28-14-W2	2,202	1,472	-	-	1,821	2,110	Bakken
Socony Sohio Hatfield #11-14	14-11-28-22-W2	1,718	1,270	1,407	1,545	1,665	1,907	Watrous
Sohio Drobot #1	16-22-29-6-W2	1,644	772	970	1,010	1,158	1,450	Devonian
Sohio Western Petroleum Insinger #1	9-16-29-7-W2	1,705	915	1,110	?	1,301	1,998	Devonian
Sohio Standard Insinger #1	SE 1/4 18-29-8-W2	1,828	997	1,070	1,243	1,385	1,680	Devonian
Sohio Baysel Foam Lake #3	4-6-29-9-W2	2,034	1,208	1,390	1,422	1,559	1,718	Bakken
Tidewater Edmore Crown #1	13-20-29-12-W2	2,056	1,217	1,402	1,457	1,564	1,870	Bakken
Socony Sohio Kutawagon #1	12-29-29-19-W2	1,860	1,203	1,432	1,450	1,546	1,820	Devonian
Socony Sohio Nokomis #29-10	10-29-29-21-W2	1,757	1,218	1,440	1,460	1,595	1,930?	Jurassic
Socony Sohio Ambassador #1	1-4-29-22-W2	1,697	1,095	1,320	1,351	1,471	1,785	Gravelb.
Socony Sohio Axe Lake #1	9-29-29-23-W2	1,643	1,023	1,253	1,270	1,391	1,718	Watrous
Sohio Consolidated Allenbee Venn #1	4-16-29-24-W2	1,675	1,417	1,610	1,639	1,745	2,050	Watrous
Sohio Venn #2	4-28-29-24-W2	1,696	1,423	-	-	1,830	2,040	Watrous
Sohio Sheho #1	4-10-30-8-W2	1,725	870	1,101	1,172	1,308	1,589	Devonian
Sohio Insinger #1-34	1-34-30-8-W2	1,723	791	970	1,024	1,168 (to TD)		-
Sohio Foam Lake #1	1-32-30-11-W2	1,852	1,037	1,221	(to TD)	-	-	-
Tidewater Flint Edmore Crown #2	1-28-30-12-W2	1,910	1,060	1,250	1,300	1,420	1,618	Bakken
Tidewater Wishart Crown #1	13-21-30-13-W2	1,961	1,126	1,290	1,355	1,466	1,712	Bakken
Tidewater Krasne Crown #1	15-14-30-16-W2	2,163	1,410	-	-	1,755	2,008	Bakken
Socony Sohio Copeland #1	6-13-30-20-W2	1,818	1,092	1,313	?	1,440	1,660	Jurassic
Sohio Sheho #5-14	5-14-31-9-W2	1,737	870	1,050	1,084	1,237 (to TD)		
Baysel Foam Lake #1	1-34-31-9-W2	1,720	910	1,088	1,161	1,301	1,611	Devonian
Sohio Baysel Foam Lake #2	8-14-31-10-W2	1,820	968	1,153	1,266	1,357	1,590	Devonian
Tidewater Rushville Crown #1	9-23-31-16-W2	2,081	1,270	1,285	1,305	1,615	1,942	Devonian
United States Potash Dafoe #2	9-28-31-18-W2	1,803	1,143	-	-	1,491	1,667	Jurassic
Sohio Standard Watrous #1	13-11-31-25-W2	1,810	1,470	-	-	1,833	2,060	Gravelb.
Canadian Devonian Sohio Watrous #1	11-15-31-27-W2	1,833	1,323	-	-	1,700	1,971	Jur. or Cret.
Tidewater Foam Lake Crown #1	1-29-32-12-W2	1,776	975	1,153	1,165	1,307	1,583	Devonian
United States Potash Wynyard #1	13-29-32-15-W2	1,795	1,014	1,207	1,252	1,363	1,697	Devonian
United States Potash Dafoe #1	8-17-32-18-W2	1,729	1,092	1,310	1,315	1,432	1,621	Jurassic
Imperial Bruno #11-28-22-25	11-28-32-25-W2	1,895	1,350 (to TD)		-	-	-	-
Sohio Petroleum Company Young #1	15-11-32-27-W2	1,756	1,287	1,475	1,510	1,624	1,850	Jurassic
Sohio Canadian Devonian Young #1	15-36-32-27-W2	1,742	1,260	1,473	1,500	1,613	1,910	Jurassic
Sohio Invermay #1	5-6-33-8-W2	1,829	1,000	1,188	1,225	1,384	1,830	Devonian
Baysel Quill Lake #13	12-14-33-15-W2	1,735	1,011 (to 1,136 TD)		-	-	-	-
Imperial Esk #7-14-33-20	7-14-33-20-W2	1,767	1,171	1,366	1,380	1,505 (to TD)		-
Imperial Esk #10-16-33-20	10-16-33-20-W2	1,784	1,039	1,245	1,260	1,382 (to TD)		-
Potash Company of America Lanigan #1	13-4-33-21-W2	1,767	1,118	1,365	1,380	1,505	1,810	Watrous
Imperial Guernsey #13-34-33-23	13-34-33-23-W2	1,791	1,127	1,325	1,338	1,450	1,640	Watrous
Sohio Canadian Devonian Plunkett #2	13-19-33-25-W2	1,858	1,314	1,510	1,524	1,660	1,898	Watrous
Sohio Canadian Devonian Plunkett #1	14-20-33-25-W2	1,846	1,306	1,504	1,530	1,650	1,854	Watrous

Sohio Canadian Devonian Plunkett #4	12-21-33-25-W2	1,843	1,296	1,492	1,520	1,647	1,870	Watrous
Canadian Devonian Sohio Plunkett #3	12-32-33-25-W2	1,860	1,314	1,498	1,521	1,632	1,901	Watrous
Potash Company of America Quill Lake #1	1-18-34-18-W2	1,716	1,000	-	-	1,318	1,525	Watrous
Imperial Leroy #7-20-34-19	7-20-34-19-W2	1,779	1,010	1,211	1,226	1,340 (to TD)		-
Imperial Guernsey #7A-11-34-23	7-11-34-23-W2	1,781	1,163	1,350	1,365	1,479 (to TD)		-
Sohio Petroleum Company Plunkett #1	1-15-34-25-W2	1,845	1,302	1,486	1,505	1,642	1,852	Watrous
Sohio Consolidated Allenbee Okla #1	1-5-35-8-W2	2,017	1,210	1,405	1,444	1,559	1,721	Devonian

ROGER DUHAMEL, F. R. S. C.
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