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COLUMNAR SECTIONS OF WELLS ACROSS SOUTHERN SASKATCHEWAN

(Summary Account and Figures)

By

Leon L. Price

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INTRODUCTION

A group of wells representative of many studied throughout southern Saskatchewan has been selected to form a section across the northern extension of the Williston Basin. Although lithologic divisions follow accepted usage wherever possible, the position of contacts may be arbitrary or based on information from wells not included in the section. Knowledge of some of the deeper strata awaits further study as more deep wells are drilled.

Precambrian. A few deep wells have penetrated crystalline igneous rocks underlying Palaeozoic formations. These basement rocks are apparently allied to those of the Shield area rather than to the Precambrian of the Waterton region in southern Alberta.

Cambrian. A series of splintery, varicoloured shale and glauconitic sandstone beds cover the irregular surface of the Precambrian Shield, and where cored in wells to the north and south of the line of section these rocks contain Cambrian inarticulate brachiopods. Such glauconitic beds directly underlie Ordovician carbonate rock there, but to the south and east quartzose sandstone above the glauconitic beds may be equivalent to the Ordovician sandstone of the Winnipeg formation in Manitoba.

Ordovician. Carbonate strata overlying the glauconitic beds in wells along the section appear to be equivalent to formations of Upper Ordovician age outcropping in Manitoba (1)[1]. This would indicate a considerable disconformity between Cambrian and Ordovician in Saskatchewan. The contact with overlying Silurian beds is placed where Ordovician "micro-granular" dolomite, commonly containing brown specks of organic or bituminous matter, gives way to compact, finely crystalline, amorphous-looking dolomite. Further study is required to determine whether the Stony Mountain argillaceous beds, recognizable in eastern Saskatchewan, are lost in facies changes westward or eliminated by post-Ordovician erosion.

Silurian. Between the Ordovician below and the red, argillaceous Ashern beds above, occurs a succession of dense dolomite beds that appears continuous, at least in part, with the Interlake group of Silurian age outcropping in Manitoba (2) and northern Saskatchewan (3).

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[1]Numbers in parentheses refer to those of references listed at the end of this report.

Although subdivisions described from outcrops of the Silurian can be distinguished clearly in wells in the northeastern region, further work is needed to extend this detail to southern Saskatchewan. A widespread zone disseminated of silt or sand grains occurs in the dolomite about 40 feet above the base of the Silurian in the wells and several other more or less continuous silty zones make useful local horizon markers.

Devonian. The Devonian strata have been subdivided into four groups and several formations by Baillie (4) and the names he proposed will be used in this paper. All are of Middle or Upper Devonian age.

The lowermost is the Elk Point group at the base of which is the Ashern formation. This consists of red, shaly dolomite and rests disconformably on Silurian dolomite; possibly it represents a post-Silurian, residual deposit. Above this is a brown spore-bearing dolomite equivalent to the Winnipegosis formation which outcrops in Manitoba, and finally the Prairie evaporite. The boundaries of the Elk Point group in southern Saskatchewan are not precisely the same as in Alberta. The Prairie evaporite consists of a thick series of salt beds except over the pre-Devonian 'Swift Current platform' west of south-central Saskatchewan where it is represented by a thin band of anhydrite and north of Swift Current where the salt appears to have been leached away and the overlying beds slumped and brecciated.

Above the Elk Point group lies the more or less argillaceous Manitoba group. There the lowest well-marked argillaceous zone overlies the basal Dawson Bay formation and serves to mark its upper boundary.

The top of the Dawson Bay formation is marked by a thin evaporite member throughout most of the area but includes a thicker series of salt beds in the northeast. Near the middle of the Manitoba group is the Davidson evaporite. This consists of anhydrite in the northeastern part of the line of section but is composed of salt in central Saskatchewan.

The Manitoba group is overlain by the Saskatchewan group, the boundary being placed at the top of the highest well-developed argillaceous zone. A less prominent argillaceous band, roughly 140 feet above the base of the Saskatchewan group, is recognizable throughout most of western Saskatchewan and is about equivalent to the top of the Beaverhill formation of Alberta. A laterally uniform set of carbonate beds at the top of the Saskatchewan group overlies a persistent argillaceous zone that defines its lower boundary. These beds are called locally the Nisku formation, but present information seems to indicate that this unit is not continuous with the lithologically similar Nisku formation of Alberta and the term Nisku is, therefore, not used here.

The uppermost Devonian beds form the Qu'Appelle group, composed largely of clastic sediments. They are undifferentiated across much of the region, but in an area in central Saskatchewan the group may be divided into two formations, the lower of which is the Lyleton formation. This formation consists of red anhydritic shale, and can be recognized in central and southeastern Saskatchewan. The name Three Forks is widely used for the upper, green shale, formation because it corresponds in position to the green shale of the Three Forks formation in Montana. Any other similarity seems slight, however, and a new name, Big Valley, has been proposed for the continuation of this division in Alberta (5). The green shale unit is distinct only in central and northwestern Saskatchewan.

Mississippian. Rocks of the Mississippian period are confined to the southern part of the province, having been elsewhere removed by post-Mississippian erosion. All are included in the Madison group and divisions within the group are those proposed by G. H. MacDonald in a forthcoming Geological Survey of Canada publication.

The black shale at the base of the Madison group (Mississippian) is correlated with the controversial Exshaw formation of Alberta. This has been assigned to the Devonian period by some authorities, on palaeontological evidence, but seems to belong to the Mississippian cycle of sedimentation. It rests conformably on Devonian green shale where the latter is present but near the northeastern limit of Mississippian rocks, where the black shale gives place to red clay, a slight discontinuity in deposition between it and the underlying Devonian was noted. This may also be the case in the extreme southwestern part of the province. The thin middle black shale member of the overlying Lodgepole formation is lithologically similar to the Exshaw and, like it, contains large spores and conodonts. The Lodgepole formation grades upwards into the Mission Canyon formation, and the position of the boundary between the two is arbitrary.

A third Mississippian formation, the Charles, is included in the Madison group in south-central Saskatchewan, south of the line of cross-section. It consists of dolomite and anhydrite and overlies the Mission Canyon formation.

Pennsylvanian, Permian, and Triassic. An unconformity of great magnitude separates Mississippian from Jurassic strata and no Pennsylvanian or Permian deposits are known, nor have Triassic beds been identified in Saskatchewan, although some of the red beds of the Watrous formation, described below, may be Triassic.

Jurassic. Subdivision of the Jurassic system follows closely that set forth by Milner and Thomas (6).

The lowest formation assigned to the Jurassic, the Watrous, is an irregular deposit of red shale with silty and anhydritic phases that fills depressions in the old Palaeozoic surface. The overlying

Gravelbourg formation is largely brownish grey, calcareous or dolomitic shale and non-calcareous shale, but includes some relatively thin lenticular limestone beds. A persistent limestone, commonly oolitic, rests on the Gravelbourg and forms the lower member of the Shaunavon formation. The upper member of the Shaunavon consists of sandy limestone and calcareous sandstone with shale interbeds. The youngest formation, the Vanguard, is divided into a lower, calcareous shale member, with a distinctive greyish green colour, a middle sandstone member, and an upper grey-green, largely non-calcareous shale member. Post-Jurassic erosion has removed the younger beds except in parts of southwestern Saskatchewan.

No non-marine upper Jurassic beds comparable with the Morrison formation of Montana have been identified in Saskatchewan and where continental beds overlie marine Jurassic in that province they have more in common with the Lower Cretaceous.

Cretaceous. Lower Cretaceous strata rest disconformably on an undulating Jurassic surface in the south, and overlap Palaeozoic rocks to the north. In the southwest, where sandy beds of the Manville formation are in contact with Jurassic sandstone, the boundary may be obscure. Cretaceous sand in this area, however, commonly contains a little carbonized vegetable matter, grains of dark chert, and possibly chloritic grains, whereas Jurassic sand is characteristically quartzose, clean, and better sorted. A thin clay zone between the two sands may be detected in some wells.

The Mannville, both along the line of section and in the Vermilion, Alberta (7), and Lloydminster (9) areas, includes both continental and marine deposits. Marine sediments supplant continental in an irregular fashion eastward, but non-marine beds persist here and there into Manitoba. The contact of the Mannville with the overlying Joli Fou formation of the Colorado group is placed at the top of the highest prominent sandy bed, which probably occurs at a slightly different horizon from place to place. In some western localities there is a zone of chert pebbles a short distance above the base of the Joli Fou formation.

The name Mannville is preferred for these lowest Cretaceous beds, to the term Blairmore, as the latter was applied in the Foothills of Alberta to a group of strata of which the upper and lower boundaries were never precisely defined and which probably includes a longer period of deposition than the beds being considered.

The shale unit above the Mannville is the base of the Colorado group, and appears to be more or less continuous with the Joli Fou formation of the Athabasca region in Alberta (10). In the west poorly indurated sandstone beds of the Viking formation separate the Joli Fou shale from the rest of the non-calcareous lower Colorado. To the east the Viking formation gradually disappears and the two merge and together are equivalent to the Ashville formation, which outcrops in the Manitoba escarpment (8).

At the base of the calcareous upper Colorado beds is a much used horizon marker referred to as the 'second white specks'. This is distinguished by characteristic electric and radioactive properties, and by the presence of abundant organic matter, small spheres from calcified foraminifera, and scattered oyster beds. The rocks themselves are firm dark grey shale with white calcareous specks. These speckled shales are continuous from central Alberta through Saskatchewan to the Manitoba escarpment, where they are called the Favel formation (8).

The upper part of the Colorado group consists of medium grey shale with intermittent, speckled, calcareous zones. The top of the uppermost calcareous shale is commonly taken to mark the contact with the non-calcareous Lea Park formation, but in a broad area in west-central Saskatchewan the upper Colorado beds are not conspicuously calcareous. There, where distinctive electrical characteristics are also absent, the position of the boundary between the Colorado group and the Lea Park formation is vague.

In eastern Saskatchewan the beds above the Favel formation ('second white specks') are continuous with part of the Vermilion River formation, which outcrops in Manitoba (8). The Vermilion River, however, also includes the non-calcareous upper Pembina member, which is equivalent to part of the basal Lea Park beds. The Pembina member has been delineated arbitrarily in the subsurface by using a characteristic increase in gamma-ray intensity near the base of the Riding Mountain formation, equivalent in the east to the Lea Park and younger formations.

West of the Williston basin the later Upper Cretaceous has been subdivided into the Lea Park, Oldman and Foremost, and Bearpaw formations, but east of the basin these cannot be distinguished and all are included in the Riding Mountain formation. This formation outcrops in Manitoba.

Beds in Alberta equivalent to the Lea Park formation are subdivided into two formations, and this twofold subdivision can be traced across western Saskatchewan by means of electric logs, although it cannot be recognized in rotary drill cuttings.

The Lea Park-Foremost boundary is placed arbitrarily at the base of a series of sandy beds indicated by the electric log. In western Saskatchewan, the top of the Oldman and Foremost sequence is easily recognized for the upper beds are non-marine deposits and the overlying Bearpaw formation is marine. The boundary is placed at the top of the highest coal seam. Eastward the non-marine beds give place to marine and the formations are indistinguishable.

The Bearpaw beds grade upward into the Eastend formation, and in the one well in which the Eastend beds have been shown on the section their presence is inferred from their occurrence in nearby outcrops.

The thin Battle and Whitemud formations, which overlie Eastend beds where they outcrop not far from the Skull Lake well, are not evident in the drill cuttings. Presumably, they were removed during the erosional interval that separates the Frenchman formation from the rest of the Cretaceous strata. A few feet of sandstone containing carbon fragments has been assigned to the Frenchman formation on the basis of its stratigraphic position beneath a prominent coal seam said to mark the base of the Tertiary in the region.

Tertiary. The Cretaceous-Tertiary contact, placed at the base of the lowest carbonaceous zone, seems to be gradational. The carbonaceous lowest Tertiary beds cover large areas in southern Saskatchewan where they comprise the Paleocene Ravenscrag formation as redefined by Furnival (11). Where it appears in the line of section much of the Ravenscrag has been removed by the erosion that preceded the deposition of younger conglomerate.

The conglomerate and sandstone beds of the Swift Current formation penetrated by the Swift Current well are of Upper Eocene age, older than the lithologically similar early Oligocene Cypress Hills formation present at Skull Lake.

Pleistocene glacial and related deposits are present throughout most of southern Saskatchewan, but their thickness and character are rarely recorded in drilling for petroleum. It should be noted that very fast drilling in the soft upper Cretaceous formations makes the sampling of the drill cuttings difficult and reduces the accuracy of information from that source.

Those desiring more detailed information are referred to publications listed in the recent Annotated Bibliography of Saskatchewan Geology (12).

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