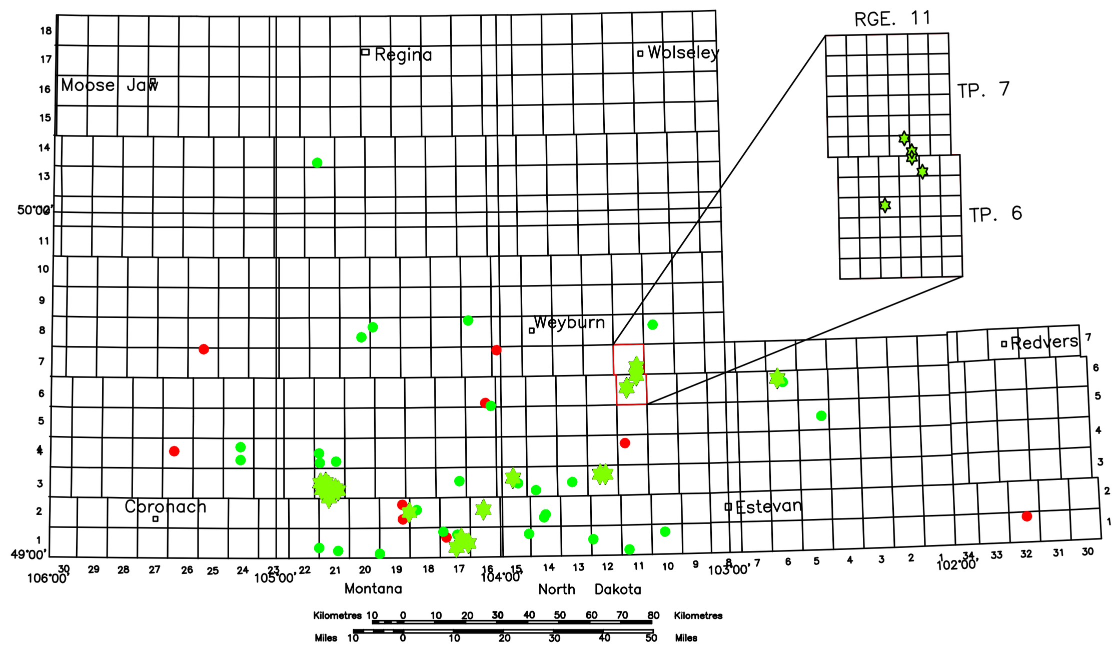
Saskatchewan Energy and Mines
Saskatchewan Geological Survey

REGIONAL MAP SERIES: Geology of the Upper Ordovician Red River Strata (Herald and Yeoman Formations)

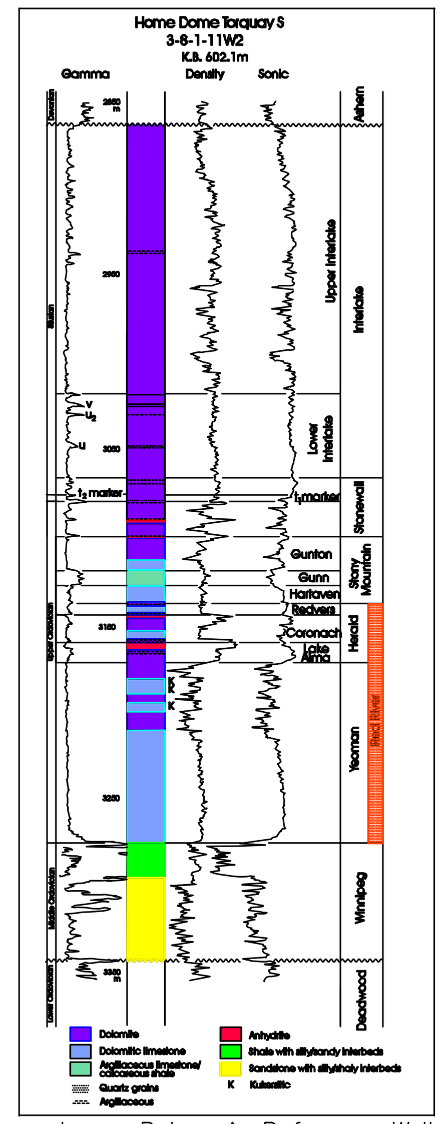
Preliminary Geological Maps (1996)

by L.K. Kreis and F.M. Haidl

Catalogue Number 96-4-(10)



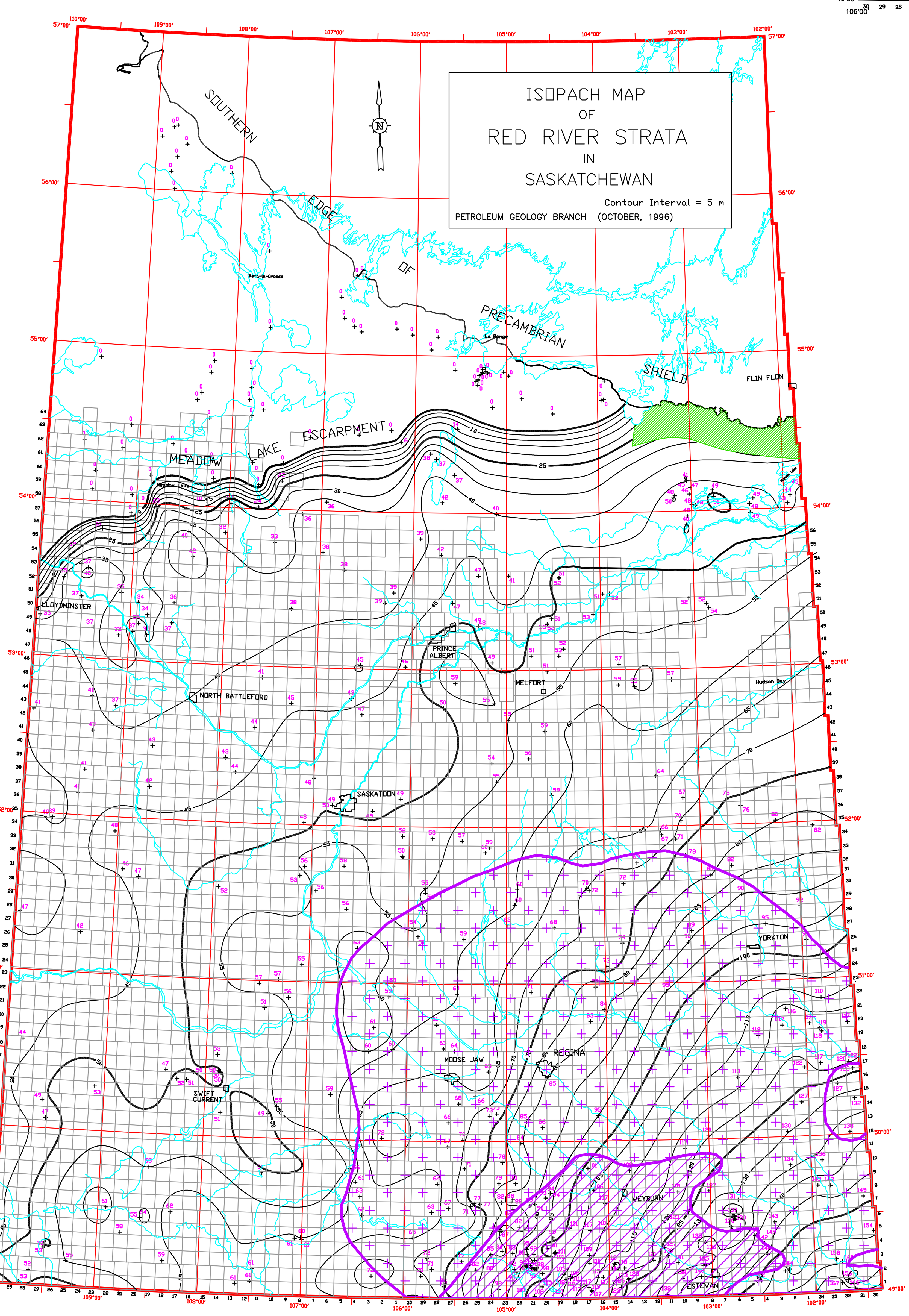
Hydrocarbon Show Map, Red River, Southeastern Saskatchewan



Lower Paleozoic Reference Well

Legend

- Control well, plotted value in m
- Gas show
- Oil/gas show
- Oil produced from Red River
- Coronach Anhydrite
- Lake Alma Anhydrite
- Red River Outcrop Belt
- S Swift Current High
- E Eastend Syncline
- V Val Marie Arch



Introduction

In Saskatchewan, Red River strata comprise a lower unit of burrow-mottled fossiliferous mudstone/wackestone (with varying degrees of dolomitization) and an upper unit of limestones, dolostones and minor evaporites (Porter and Fuller, 1959; Kendall, 1976). In southeastern Saskatchewan, the lower unit is defined as the Yeoman Formation; the upper unit is the Herald Formation which is subdivided into the Lake Alma and Coronach members and the Redvers unit (Kendall, 1976). In the remainder of the province where the Herald and Yeoman formations cannot be differentiated with confidence on geophysical logs, these strata are identified as the Red River Formation.

Red River strata are Upper Ordovician (Edenian, Maysvillian and early Richmondian) in age (Elias et al. 1988). In most of Saskatchewan they overlie clastic rocks of the Winnipeg Formation (Mid-Late Ordovician) with probable disconformity; in western Saskatchewan they unconformably overlie the sandstones, siltstones and shales of the Deadwood/Earlie formations (Cambrian - Early Ordovician). Carbonate rocks of the Stony Mountain Formation (Richmondian) conformably overlie the Herald Formation.

Data have been used from 427 wells that penetrate the Red River in Saskatchewan, including core data from 21 holes drilled during base metal and kimberlite exploration programs. Red River rocks outcrop south of the Precambrian Shield edge in east-central Saskatchewan.

Cyclic sedimentation

The detailed stratigraphic nomenclature adopted in southeast Saskatchewan reflects the cyclic sedimentation which characterizes most of the Red River succession. Each complete cycle begins with deposition of a fossiliferous burrow-mottled mudstone/wackestone unit, passes through a laminated to thin-bedded carbonate mudstone and culminates in deposition of basin-centred evaporites. The Yeoman and the Lake Alma represent the earliest cycle, the Coronach Member encompasses the second cycle and the Redvers unit represents the third cycle, which is incomplete in Saskatchewan. The cycles have been interpreted as "brining-upward" sequences based on the "layer cake" geometry of the deposits, the basin-centred distribution of the anhydrites and the bedded to laminated character of much of the anhydrite (e.g. Kendall, 1976; Kohm and Louden, 1978; Longman et al., 1983; Longman and Haidl, 1996). An alternative interpretation attributes the cycles to progradational "shoaling-upward" processes (e.g. Carroll, 1979; Clement, 1985; Ruzyla and Friedman, 1985).

Stratigraphy

Yeoman Formation

The Yeoman Formation is composed primarily of burrow-mottled fossiliferous lime mudstones and wackestones which have undergone varying degrees of dolomitization (e.g., Kendall, 1976, 1977, 1984, 1985; Kohm and Louden, 1978; Longman et al., 1983, 1984; Longman and Haidl, 1996). The burrows are <u>Thalassinoides</u>-like and commonly have within them a second generation of unidentified burrows (Kendall, 1976, 1977; Zenger and Lemone, 1995). <u>Phycodes</u> trace fossils have also been tentatively identified.

Tabulate and solitary rugose corals, cephalopods, brachiopods, echinoderms, stromatoporoids, and gastropods are the most commonly observed macrofossils in core (Brindle, 1960; Kendall, 1976; Pratt et al., this volume). The microfossil <u>Gloeocapsomorpha prisca</u>, of probable cyanobacterial origin (Foster et al., 1989; Stasiuk and Osadetz, 1990; Stasiuk et al., 1993), is the primary component of organic-rich kerogenites (kukersites) which are preserved in the upper one-third of the Yeoman. These rocks are the source of Ordovician-produced oil in Saskatchewan (Kendall, 1976; Brooks et al., 1987; Osadetz et al., 1992; Osadetz and Snowden, 1995).

Rocks of the Yeoman Formation have a maximum thickness of more than 135 m in the southeastern corner of Saskatchewan. These strata are interpreted as being deposited in marine shelf environments ranging from aerobic to dysaerobic (Kendall, 1976, 1985; Stasiuk and Osadetz, 1990).

Herald/Yeoman contact

The contact between the Yeoman and the overlying Herald (Lake Alma Member) is transitional and, therefore, difficult to pick both in core and on geophysical logs.

In core, the transitional beds between the burrow-mottled rocks typical of the upper Yeoman and the laminated to thinly-bedded dolostones which characterize the basal Lake Alma are of variable lithologies. This transitional unit is thin (<4 m, commonly < 1 m) and composed of poorly mottled, irregularly bedded lime mudstones (with variable dolomitization) with interbeds of fossiliferous and/or lithoclastic packstone/grainstone (Kendall, 1976; Longman and Haidl, 1996). Coated grains are also present in several cores. An anomalous sequence is documented in the LVR et al Steelman 7-28-4-4W2 well where this interval is 8 m thick and includes a stromatoporoid dolorudstone and a microbial doloboundstone (Pratt et al., this volume).

On geophysical logs, the contact between the Lake Alma and Yeoman is picked at the top of "clean" carbonates as indicated by a shift to higher gamma readings which characterize beds below the Lake Alma anhydrite. However, the increase in gamma radiation is never large and is also variable making consistent picks difficult. Recent work on several cores suggests that the higher gamma ray response which marks the base of the Lake Alma on geophysical logs commonly correlates with a distinctive bioturbated (dolo)wackestone, commonly containing oncolites, which is characterized by abundant anastomosing bituminous solution partings (A.C. Kendall, pers. comm.).

Herald Formation

Herald strata are more than 38 m thick in the vicinity of Lake Alma (Tp.1, Rge.17W2) where the Lake Alma Member reaches maximum thickness. This unit thins to the north, west and east due largely to diminishing thicknesses of the Coronach and Lake Alma anhydrites.

<u>Lake Alma Member</u>

Above the transitional beds the basal unit of the Lake Alma Member is composed of laminated to bedded, commonly slightly argillaceous, dolomudstones and calcareous dolomudstones. Interbedded with the dolomudstones in the extreme eastern part of Saskatchewan (Rge. 2W2 and east) are beds of oolitic dolomite which may have originated as oolitic grainstones (Kendall, 1976; Kent, 1960).

The Lake Alma anhydrite, the upper unit of the Lake Alma Member, is composed of nodular, bedded, and laminated anhydrite with interbeds of dolomudstone (commonly anhydritic). This is the most widespread of the Lower Paleozoic evaporite units. It extends outward from the basin centre in North Dakota as far north as Township 33, as far west as Range 5W3 and into Manitoba to the east (Kent, 1960; Kendall, 1976; Norford et al., 1994; Longman and Haidl, 1996). Distribution of the Lake Alma and Coronach anhydrite units in Saskatchewan is shown on adjacent Red River isopach and structure maps and on regional cross sections (Kreis and Haidl, 1995).

<u>Coronach Member</u>

Where fully developed, the Coronach Member comprises 1) a basal slightly argillaceous dolomudstone, locally with scattered quartz grains, 2) a fossiliferous wackestone or dolowackestone, 3) slightly argillaceous laminated dolomudstones (locally lime mudstones) and 4) the Coronach anhydrite (Kendall, 1976). The basin-centred anhydrite unit is less areally extensive than the Lake Alma anhydrite, extending north to Township 11 in south central Saskatchewan.

<u>Redvers Unit</u>

The Redvers Unit is composed of a basal argillaceous dolomudstone bed and an upper laminated dolomudstone or lime mudstone. This unit can be mapped with confidence only where an argillaceous marker bed separates it from the overlying Stony Mountain carbonates.

Structure and Thickness

From its northern edge to Latitude 52 degrees the Red River dips gently to the southwest. To the south of that latitude, contours define the northern flank of the Williston Basin. Subsidence of this basin was initiated during the Early to Middle Ordovician and continued episodically through geologic time. Its present-day shape reflects Laramide deformation (Christopher et al., 1971). The smaller structural bodies such as the Swift Current High, Eastend (Ponteix) Syncline and Val Marie Arch in the southwest and those in the Briercrest (Tp.14, Rge.24W2), Minton (Tp.3, Rge.21W2 and Weir Hill (Tp.6, Rge. 6W2) areas are subsets of the larger deformation. These are also affected by episodic movement of blocks of the Precambrian basement (Christopher et al., 1971; Potter and St. Onge, 1991; Haidl, 1990).

Red River rocks attain a maximum depositional thickness of 167 m in the southeast corner of Saskatchewan. The northern erosional edge of these strata coincides with the southern edge of the Precambrian Shield in the outcrop belt in eastern Saskatchewan and the Meadow Lake Escarpment in west-central Saskatchewan. Most local anomalies are depositional in origin or are related to inconsistencies in picking the contact between the Herald and Stony Mountain formations. Faulting is recognized as the probable cause of an anomalous sequence with 216 m of Red River strata and no Winnipeg rocks in the Imperial Lightning Creek 16-7-6-32W1 well. The local thinning of Yeoman strata in the Cominco SR1 drillhole (11-12-57-8W2), near the southern edge of the Paleozoic outcrop belt, may be related to movement associated with the Tabbernor Fault zone; this movement is documented by a tectonic breccia zone in a core of the Yeoman Formation (Elliot, 1995).

Economic Considerations

Hydrocarbons

Production from Herald and Yeoman reservoirs in twenty-one wells (to July 1996) and numerous hydrocarbon shows in drillstem tests and cores attest to the economic potential of Red River strata in Saskatchewan (see above hydrocarbon show map). The discovery in December 1995 of prolific Red River reservoirs below producing Mississippian strata in the northeastern corner of the Midale Pool (Tp 6 and 7, Rge 11W2) has generated new interest in these Ordovician carbonates. Monthly production data from five new wells indicate that initial production rates in the Midale area are much higher than those achieved in other areas of Red River production. Production from the Yeoman Formation in the discovery well, Berkley et al Midale 4-2-7-11W2 has stabilized at about 100 m3/day (Haidl et al., this volume).

Most Red River oil discovered to date is trapped in small structural closures (e.g. Minton pool, Tp.3, Rge. 21W2; Weir Hill pool, Tp.6, Rge.6W2). The primary control on reservoir quality is dolomitization. The complexity of dolomitization patterns indicate that more than one phase of dolomitization commonly occurred and that different factors may have controlled dolomitization at any given time or place. Major factors include: 1) gravity-driven seepage of dense magnesium-rich brines associated with deposition of the Lake Alma anhydrite ("C" anhydrite), 2) movement of formation waters toward the overlying evaporite basin (Elk Point) during deposition of the Prairie Evaporite, 3) initial higher porosity and permeability of burrows and some interbeds in the Yeoman may have resulted in preferential fluid flow and subsequent dolomitization, and 4) solution-cannibalization of magnesium ions from Mg-rich calcite sediments and subsequent precipitation of dolomite crystals at other locales (e.g., Kendall, 1976, 1977, 1984, 1985, 1989; Kohm and Louden, 1978,1982, 1988; Carroll, 1978; Longman et al., 1983, 1984; Potter and St. Onge, 1991; Neese, 1985; Fisher and Hendricks, 1995; Longman and Haidl, 1996; Thomas, 1968).

Geochemical studies indicate that oil produced from the Red River in Saskatchewan is sourced from kukersitic beds in Ordovician carbonates in Saskatchewan, North Dakota and Montana (Brooks et al., 1987; Osadetz et al., 1992; Osadetz and Snowden, 1995). Numerical modeling indicates that these kukersites have generated a much larger volume of oil than that yet discovered (Burrus et al., 1995). Models suggest that much of this oil migrated updip into southeastern Saskatchewan prior to Late Eocene time, before the development of closure on the present-day Nesson Anticline (Burrus et al., 1995).

In addition to kukersitic-sourced oils, oil stains of other compositions are recognized in Herald carbonates in the Esso Tribune 2-8-3-14W2 well and in Interlake dolostones in the Mobil Sinc Roy N Redvers 5-33-8-32W1 well (Haidl et al. this volume). No source for these oils has been identified. However, certain compositional traits, particularly carbon isotopes, confirm that these oils have a distinctive source, possibly within sub-Bighorn Group strata (Middle Cambrian - Middle Ordovician?) (K. Osadetz, pers. comm.).

Knowledge gleaned from areas of existing Red River production suggests that the keys to new discoveries of hydrocarbons in Lower Paleozoic rocks include:
1) An understanding the tectonic framework of the Precambrian basement and controls exercised by it on the overlying sedimentary sequence, particularly with respect to formation of structural closures and migration of dolomitizing fluids and hydrocarbons. Evidence of basement tectonism can be derived from seismic, gravity and aeromagnetic data, lineament trend analysis, surface drainage patterns, heat flow data, and thickness and facies distribution of Phanerozoic strata.
2) Knowledge of the distribution and maturation history of potential source rocks and the migration pathways of oil generated by them, and
3) The development of dolomitization models for existing pools and application of these models to exploration strategies (Haidl, 1990, 1995; Haidl et al., this volume).

Building Stone and Aggregate

Burrow-mottled upper Yeoman dolostones are currently quarried near Deschambault Lake as a source of rough building stone. Building stone investigations have shown that Saskatchewan Red River dolostones have a dense microcrystalline texture, high compressive strength and low moisture absorption capacity making them suitable for use as polished "marble" tiles and panels (Pearse and Guliov, 1996). In the McNally Lake area near the Manitoba border, Yeoman dolostones are quarried and crushed for use as aggregate.

Selected Bibliography

Brindle, J.E. (1960): The faunas of the Lower Paleozoic carbonate rocks in the subsurface of Saskatchewan; Sask. Dep. Miner. Resour., Rep. 52, 45p.

Brooks, P.W., Snowdon, L.R., and Osadetz, K.G. (1987): Families of oils in southeastern Saskatchewan: in Carlson, C.G. and Christopher, J.E. (eds.); Proceedings of the Fifth International Williston Basin Symposium, Sask. Geol. Soc., Sp. Publ. 9, p253-264.

Burrus, J., Osadetz, K.G., Wolf, S., Doloigez, B., Visser, K., and Dearborn, D. (1995): Resolution of Williston Basin oil system paradoxes through basin modeling: in Hunter, L.D.V. and Schalla, R.A. (eds.); Seventh International Williston Basin Symposium Guidebook, Montana Geol. Soc., p235-251.

Carroll, W.K. (1978): Depositional and paragenetic controls on porosity development, Upper Red River Formation, North Dakota; in 1978 Williston Basin Symposium, Montana Geol. Soc. Guidebook, p79-94.

Christopher, J.E., Kent, D.K., and Simpson, F. (1971): Hydrocarbon potential of Saskatchewan; Sask. Dep. Miner. Resour., Rep. 157, 47p.

Clement, J.H. (1985): Depositional sequences and characteristics of Ordovician Red River reservoirs, Pennel Field, Williston Basin, Montana; in Roehl, P.O. and Choquette, P.W. (eds.); Carbonate Petroleum Reservoirs, Springer-Verlag, NY., p73-84.

Derby, J.R. and Kilpatrick, J.T. (1985): Red River dolomite reservoirs, Killdeer Field, North Dakota; in Roehl, P.O. and Choquette, P.W. (eds.); Carbonate Petroleum Reservoirs, Springer-Verlag, NY., p61-69.

Elias, R.J., Nowlan, G.S. and Bolton, T.E. (1988): Paleontology of the type section, Fort Garry Member, Red River Formation (Upper Ordovician), southern Manitoba; in Wohlberg, D.L. (ed.), Contributions to Paleozoic paleontology in honor of Rousseau H. Flower; New Mexico Bur. Mines and Miner. Resour., Memoir 44, p.341-359.

Elliott, C.G. (1995): The Tabbernor Fault, and Proterozoic and Phanerozoic movements in Saskatchewan and Manitoba; in Hajnal, Z. and Lewry L. (eds.), LITHOPROBE Trans-Hudson Orogen Transect, Report of Fifth Transect Meeting, April 1995: Rep. 48, p148-155.

Fisher, R. and Hendricks, M. (1995): Ordovician Red River Formation reservoir development - field examples from South Horse Creek Field (North Dakota) and Bainville North Field (Montana); in Core Workshop Volume, Seventh International Williston Basin Symposium; Montana Geological Society.

Foster, C. B., Reed, J.D. and Wicander, R. (1989): <u>Gloeocapsomorpha prisca</u> Zalessky, 1917: A new study part I: taxonomy, geochemistry, and paleoecology; Gibos v22, p735-759.

Haidl, F.M. (1990): Ordovician hydrocarbon reservoirs, Herald and Yeoman Formations (Red River), southeastern Saskatchewan; in Summary of Investigations 1990, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 90-4, p176-186.

__________ (1995) Hydrocarbon potential of Lower Paleozoic carbonate strata in southeastern Saskatchewan; in Summary of Investigations 1995, Saskatchewan Geological Survey, Sask. Energy and Mines, Misc. Rep. 95-4, p118-128.

Kendall, A.C. (1976): The Ordovician carbonate succession (Bighorn Group) of southeastern Saskatchewan; Sask. Miner. Resour., Rep. 180, 185p.

__________ (1977): Origin of dolomite mottling in Ordovician limestones from Saskatchewan and Manitoba; Bull. Can. Petrol. Geol., v25, p480-504.

__________ (1984): Origin and geometry of Red River dolomite reservoirs, western Williston Basin: Discussion; Am. Assoc. Petrol. Geol. Bull., v68, p776-779.

__________ (1985): Depositional and diagenetic alterations of Yeoman (Lower Red River) carbonates from Harding Co., South Dakota; in Longman, M.W., Shanley, K.W., Lindsay, R.F. and Eby, D.E., (eds.); Rocky Mountain Carbonate Reservoirs - A Core Workshop; Soc. Econ. Paleon. Mineral., p51-93.

__________ (1989): Brine mixing in Middle Devonian of western Canada and its possible significance to regional dolomitization; Sed. Geol., v64, p271-285.

Kent, D.M. (1960): The evaporites of the Upper Ordovician strata in the northern part of the Williston Basin; Sask. Dep. Min. Resour., Rep. 46, 46p.

Kohm, J.A. and Louden, R.O. (1978): Ordovician Red River of eastern Montana - western North Dakota: Relationships between lithofacies and production; in 1978 Williston Basin Symposium, Montana Geol. Soc. Guidebook, p99-117.

__________ (1982): Ordovician Red River of eastern Montana and western North Dakota: relationships between lithofacies and production; in Christopher, J.E. and Kaldi, J. (eds.), Fourth International Williston Basin Symposium, Sask. Geol. Soc., Sp. Publ. 6, p27-28.

__________ (1988): Red River reservoirs of western North Dakota and eastern Montana; in Goolsby, S.M. and Longman, M.W. (eds.); Occurrence and physical properties of carbonate reservoirs in the Rocky Mountain region, 1988 Carbonate Symposium, Rocky Mtn. Assoc. Geol., p275-290 with plates p451-455.

Kreis, L.K. and Haidl, F.M. (1995): Regional Lower Paleozoic cross sections in Summary of Investigations 1995, Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 95-4.

Longman, M.W., Fertal, T.G. and Glennie, J.S. (1983): Origin and geometry of Red River dolomite reservoirs, western Williston Basin; Am. Assoc. Petrol. Geol. Bull., v67, p744-771.

__________ (1984): Origin and geometry of Red River dolomite reservoirs, western Williston Basin: Reply; Am. Assoc. Petrol. Geol. Bull., v68, p780-784.

Longman, M.W. and Haidl, F.M. (1996): Cyclic deposition and development of porous dolomites in the Upper Ordovician Red River Formation, Williston Basin; in Longman, M.W. and Sonnenfeld, M.D. (eds.); Paleozoic Systems of the Rocky Mountain Region; Rocky Mount. Sec., SEPM, p29-46.

Neese, D.G. (1985): Depositional environment and diagenesis of Red River Formation, "C" interval, Divide County, North Dakota and Sheridan County, Montana; in Longman, M.W., Shanley, K.W., Lindsay, R.F. and Eby, D.E., (eds.); Rocky Mountain Carbonate Reservoirs - A Core Workshop; Soc. Econ. Paleon. Mineral., p95-124.

Norford, B.S., Haidl, F.M., Bezys, R.K., Cecile, M.P., McCabe, H.R. and Paterson, D.F. (1994): Middle Ordovician to Lower Devonian strata of the Western Canada Sedimentary Basin; in Mossop, G.D.and Shetsen, I. (comps.) Geological Atlas of the Western Canada Sedimentary Basin; Can. Soc. Petrol. Geol. and Alberta Res. Counc. p109-127.

Osadetz, K.G. and Haidl, F.M. (1989): Tippecanoe Sequence: Middle Ordovician to lowest Devonian: vestiges of a great epeiric sea; in Western Canada Sedimentary Basin A Case Study; Ricketts, B.D. (ed.); Can. Soc. Petrol. Geol., Calgary, p121-137.

Osadetz, K.G., Brooks, P.W., and Snowdon, L.R. (1992): Oil families and their sources in Canadian Williston Basin (southeastern Saskatchewan and southwestern Manitoba); Bull. Can. Pet. Geol., v40, p254-273.

Osadetz, K.G. and Snowden, L.R. (1995): Significant Paleozoic petroleum source rocks in the Canadian Williston Basin: their distribution, richness and thermal maturity (southeastern Saskatchewan and southwestern Manitoba); GSC Bull. 487, 60p.

Pearse, G. and Guliov, P. (1996): Saskatchewan Stone Preliminary Investigations; Sask. Energy Mines, Misc. Rep. 96-6, 64p.

Porter, J.W. and Fuller, J.G.C.M. (1959): Lower Paleozoic rocks of northern Williston Basin; Am. Assoc. Pet. Geol. Bull., v43, p124-189.

Potter, D. and St. Onge, A. (1991): Minton pool, south-central Saskatchewan: a model for basement induced structural and stratigraphic relationships; in Christopher, J.E. and Haidl, F.M. (eds.), Sixth International Williston Basin Symposium, Sask. Geol. Soc. Sp. Publ. 11, p21-33.

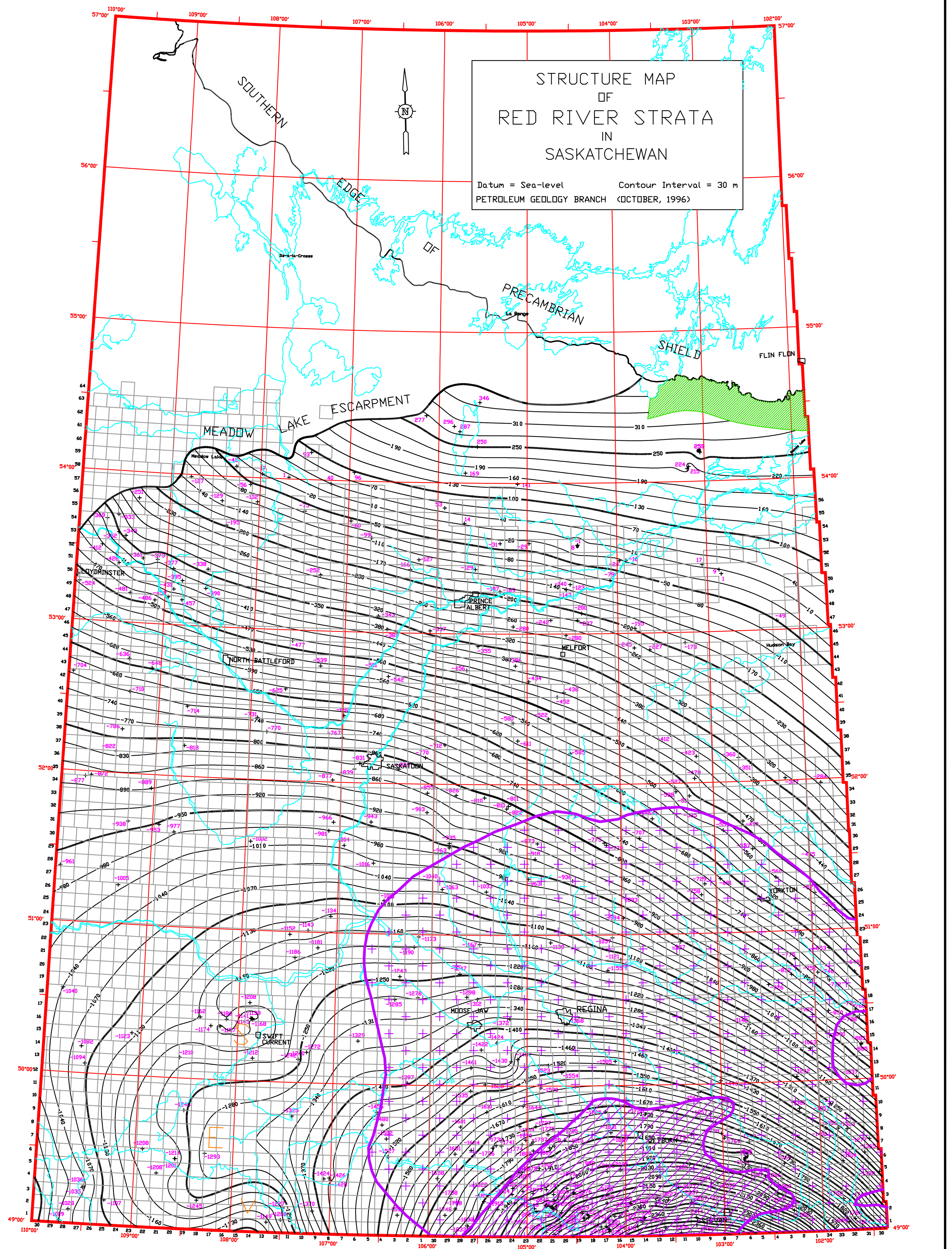
Ruzyla, K. and Friedman, G.M. (1985): Factors controlling porosity in dolomite reservoirs of the Ordovician Red River Formation, Cabin Creek Field, Montana; in Roehl, P.O. and Choquette, P.W. (eds.); Carbonate Petroleum Reservoirs, Springer-Verlag, NY., p41-58.

Stasiuk, L.D. and Osadetz, K.G. (1990): The life cycle and phyletic affinity of <u>Gloeocapsomorpha prisca</u> Zalessky 1917 from Ordovician rocks in the Canadian Williston Basin; in Current Research, Part D, Geol. Surv. Can., Pap. 89-1D, p123-137.

Stasiuk, L.D., Kybett, B.D., and Bend, S.L. (1993): Reflected light microscopy and micro-FTIR of Upper Ordovician <u>Gloeocapsomorpha prisca</u> alginite in relation to paleoenvironment and petroleum generation, Saskatchewan, Canada; Org. Geochem. v20, p707-719.

Thomas, G.E. (1968): Notes on textural and reservoir variations of Ordovician micro-dolomites, Lake Alma-Beaubier producing area, southern Saskatchewan; Saskatchewan Department Mineral Resources and Saskatchewan Geological Society Core Seminar on the Pre-Mississippian rocks of Saskatchewan.

Zenger, D.H. and LeMone, D.V. (1995): Widespread "Bighorn facies", Upper Ordovician, North America; in Cooper, J.D., Droser, M.L., and Finney, S.C. (eds.), Ordovician Odyssey: Short Papers for the Seventh International Symposium on the Ordovician System; Pacific Section, SEPM, Book 77, p389-392.



Scale 1:2 000 000

Kilometres 20 0 20 40 60 80 100 120 140 160 180 Kilometres

Miles 20 0 20 40 60 80 100 120 Miles

This map sheet is a preliminary example of the type of maps envisaged for a regional mapping program initiated by the Petroleum Geology Branch in the spring of 1993. Research by Petroleum Geology staff and others provides detailed stratigraphic information on Lower Paleozoic rocks in the Province along with accurate geophysical log picks from which these maps were generated. Computer contouring of these maps was done with a software program called Personal Computer Mapping System (PCMS) by Zycor Inc. These maps were further processed using AutoCAD Release 12 software. The stratigraphic data used in the construction of these maps are available from the authors on request.

The acquisition of some of the software used in this project was funded by the Province of Saskatchewan under the Canada-Saskatchewan Partnership Agreement on Mineral Development 1990-95.

These preliminary maps of the Red River strata are issued in a package with the Summary of Investigations 1996, Saskatchewan Geological Survey, and are available separately.

This map sheet may be referenced as part of the following publication:
Kreis, L.K. and Haidl, F.M. (1996): Geology of the Upper Ordovician Red River Strata (Herald and Yeoman Formations); 1:2 000 000 scale maps with Summary of Investigations 1996 Saskatchewan Geological Survey, Sask. Energy Mines, Misc. Rep. 96-4.

Although the Department of Energy and Mines has exercised all reasonable care in the compilation, interpretation, and production of this item, it is not possible to ensure total accuracy, and all persons who rely on the information contained herein do so at their own risk. The Department of Energy and Mines and the Government of Saskatchewan do not accept liability for any errors, omissions, or inaccuracies that may be included in or derived from, this item.

Saskatchewan Energy and Mines welcomes comments on the content of these map sheets and would like errors or omissions reported to K. Kreis, (306) 787-2620.

Geology of the Upper Ordovician Red River Strata (Herald and Yeoman Formations)

Preliminary Geological Maps (1996)
by L.K. Kreis and F.M. Haidl
Catalogue Number 96-4-(10)