Geology and Natural Gas Production of the Upper Cretaceous Medicine Hat Sandstone, Southwestern Saskatchewan

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The Medicine Hat Sandstone, upper Coniacian to lower Santonian in age, is close to the top of Colorado Group strata in southeast Alberta and southwest Saskatchewan. It is of both economic and historical significance in that it contains the largest and oldest gas pool in Canada. The Medicine Hat Sandstone is stratigraphically equivalent to the Martin Sandstone (Niobrara Formation) in north-central and eastern Montana (Rice, 1981; Gilboy, this paper).

1. Previous Work

Despite a high drilling density and the consequent large amount of log data available for the Medicine Hat Sandstone, specifically relevant geological studies have only rarely been published (Martin, 1965; Hancock and Glass, 1968; Kendall and Simpson, 1974; Simpson, 1981; Hankel *et al*., 1989). Several consultants' reports (e.g. Last, Kloepfer Ltd., 1973; Martin Petroleum Consulting Ltd., 1985) contain useful assessments of the regional geology of the sandstone.

2. Nomenclature

The type locality for the Medicine Hat Sandstone is the City of Medicine Hat in southeast Alberta, where a well drilled in 1890 in search of coal encountered a considerable flow of wet gas at a depth of about 200 m (and therefore probably from the Milk River Formation). The follow-up well drilled in 1904 discovered a larger supply of drier gas at about 310 m from the Medicine Hat Sandstone. Rigorous definitions of this and enclosing lithological units appear not to have been published. Current nomenclature is, therefore, largely based on popular usage, particularly that established by Alberta's Energy Resources Conservation Board.

Three separate gas-producing sandy horizons are widely developed over an approximately 50 m wide vertical section underlying the shale at the top of the Colorado Group (the First White-speckled Shale, see Figure 1 and Section B-B' in map holder). These have been named, from the top down, Medicine Hat A, C and D Sandstones, following pool designations used by the Energy Resources Conservation Board (1975, 1977). The Medicine Hat B Sandstone is no longer recognised as the name originally including parts of the C and D Sandstones (Energy Resources Conservation Board, 1975). In recent years, reference has increasingly been made to the Medicine Hat Formation (Energy Resources Conservation Board, 1975; Warren, 1985; Hankel *et al*., 1989) but without clear explanation of the stratigraphic interval encompassed by this unit. Warren (1985) shows a type log (in Figure 4 of his paper) which suggests the Medicine Hat Formation extends from the base of the First White-speckled Shale to about the top of a regionally developed bentonitic(?) marker horizon (immediately below which Rice (1981) places the top of the Carlile Shale in northern Montana; see also Gilboy, this paper).

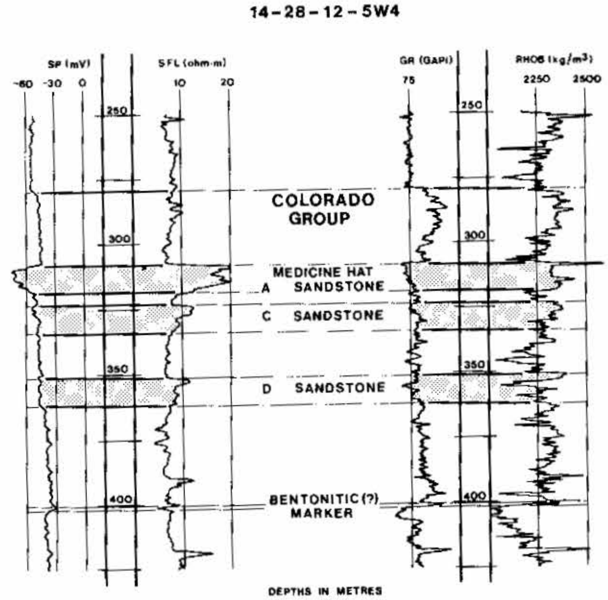

Figure 1 - Electric, gamma ray and lithodensity logs of a typical producing well in southeastern Alberta, showing signatures of the three main Medicine Hat producing horizons (the well is located immediately east of the City of Medicine Hat).

Although stratigraphic terminology in the western Canadian Great Plains region is generally unsatisfactory, it is deeply entrenched in existing literature and may be difficult to change. For example, Meijer Drees and Myhr, (1981), carefully defined the Alderson Formation as the marine equivalent of the Milk River Formation, but their work seems to have gained little acceptance by other workers in this field who are overwhelmingly familiar with the Milk River Formation as being the sandier equivalent of Lea Park Formation shales.

3. Lithology

The Medicine Hat Sandstone does not crop out in either southeastern Alberta or southwestern Saskatchewan. In the study area (Figure 2), it has been cored in 25 wells, the majority of which are situated in the Hatton Gas Field (Rgs. 27 to 30W3, Twps. 13 to 16 inclusive). The condition of recovered core is only fair in most of these wells owing to poor consolidation of the rock and a moderately high content of expandable clay minerals. Stratigraphic cross-sections from southeast Alberta into southwest Saskatchewan (Gilboy, this paper) show that the cored (gas-producing) interval in the Hatton-Burstall area is laterally continuous with the Medicine Hat A Sandstone. The D Sandstone is also recognizable on geophysical logs (Figure 3), but barely so as it gradually shales out towards the northeast.

The most abundantly preserved sedimentary structures include fine parallel lamination, low-angle current rippled sand layers one to two centimetres thick, starved ripples, and normally-graded bedding (layers several centimetres thick). Several of these features are illustrated in Plate 1. Small-scale erosion surfaces with up to about one centimetre relief are also present, though rare, as are thin coquinoid layers (Plate 2). Sand grain size is mostly in the 88 to 125 micron range, but locally

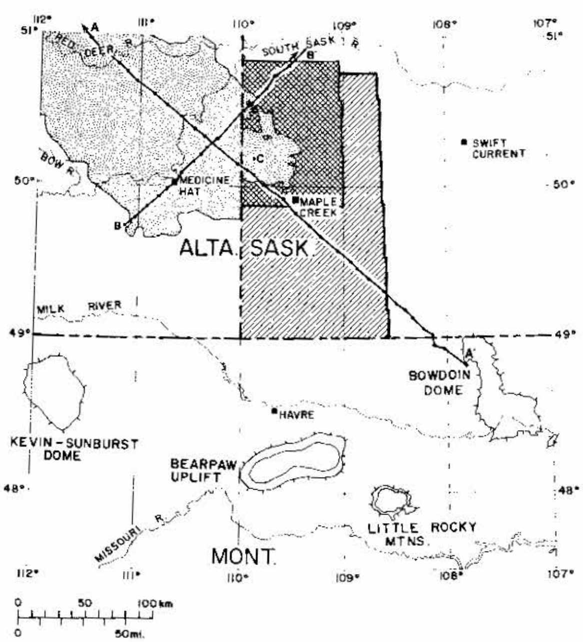

Figure 2 - Natural gas fields (stippled), Medicine Hat Sandstone, northern Great Plains region, showing locations of: 1) the study area (diagonally hatched); 2) parts of the stratigraphic cross-section lines which transect the area covered by the map (A-A', B-B'); 3) the location (c) of the well used in Figure 3; 4) the area covered by the structure and cumulative gas-production map in Figure 4 (cross-hatched); and 5) major tectonic uplifts (hachured).

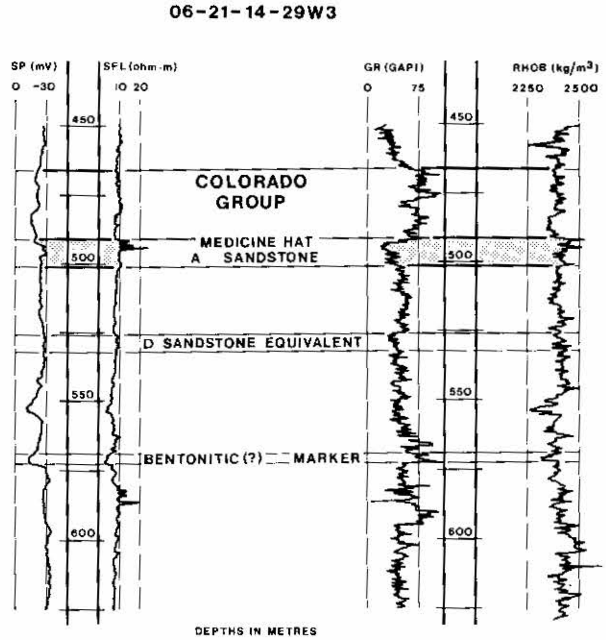

Figure 3 - Electric, gamma ray and lithodensity logs from a typical Medicine Hat producing well in the Hatton Gas Field, southwestern Saskatchewan

reaches 125 to 177 microns. Grains are subrounded to subangular. Rare bentonitic horizons occur at different levels through the Medicine Hat Sandstone, which is moderately calcareous throughout its thickness.

Bioturbated layers a few centimetres thick are common (Plate 1), but identifiable trace fossils have yet to be found. Organic remains in the Medicine Hat Sandstone include, in addition to the coquinoid shell debris, white specks presumably made up of coccoliths and coccospheres, fish bones and scales, *Inoceramus* fragments, lignitic plant remains, and rare ammonite shells.

4. Depositional Environment

Graded bedding and parallel laminations, along with local shell-rich layers, suggest that the sediments of the Medicine Hat A Sandstone were probably deposited as a result of storm activity. Coccolithic shales may have accumulated during inter-storm periods. The presence of ammonites attests to the marine origin of these rocks. The relatively high clay content of the sands, their very fine grain size, and sedimentary structures indicate a prodelta environment of deposition.

5. Natural Gas Production

In southwest Saskatchewan, the first well (10-23-14-30W3) to produce from the Medicine Hat Sandstone was drilled in 1953 in the Hatton area. Currently, 505 wells produce sweet dry methane from this stratigraphic interval, and an additional 845 wells deliver co-mingled Medicine Hat-Milk River gas. In 1972, Medicine Hat gas was discovered to the north in the Burstall area, where 5

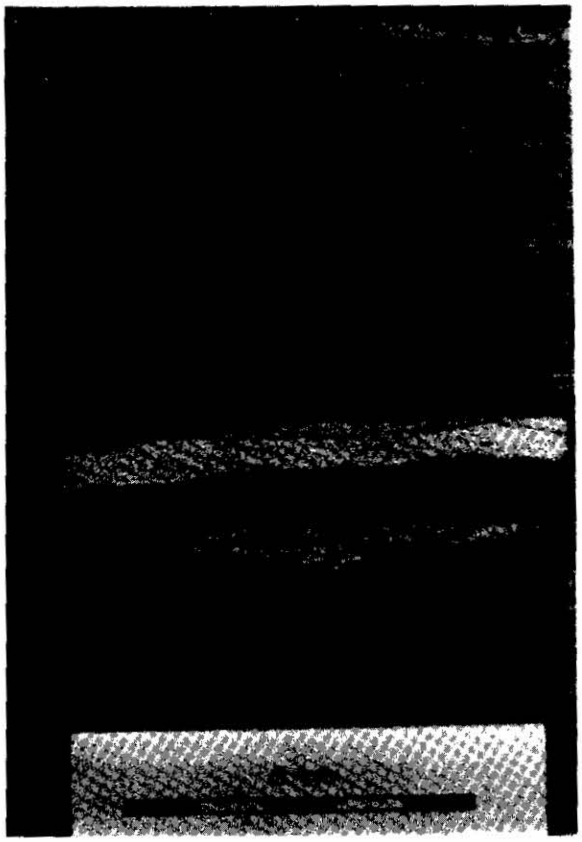

Plate 1 – Bioturbated shaly sand lying between layers of finely laminated, very fine-grained sandstone, siltstone and shale; these rest upon a thin band of coarser-grained, carbonate-cemented, ripple-bedded sandstone (from well 07-22-09-28W3M, 641.3 m below Kelly Bushing).

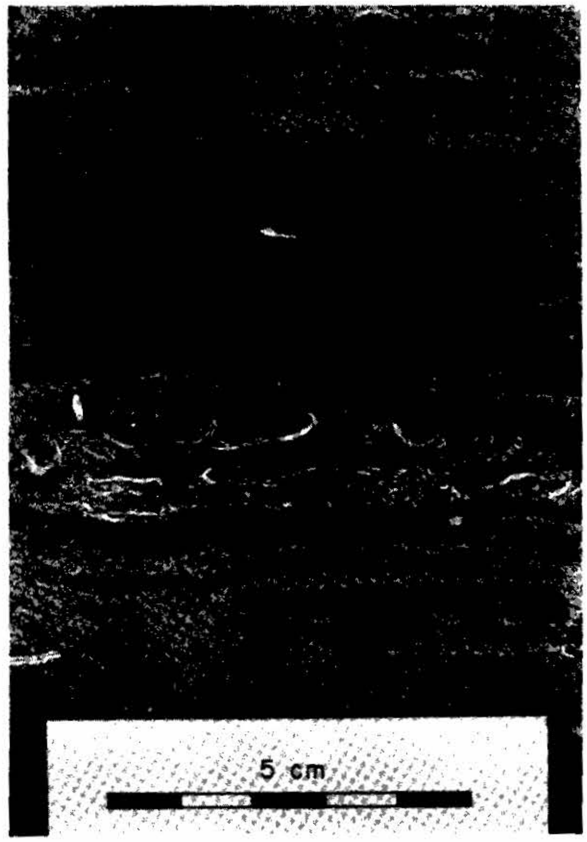

Plate 2 – Thin coquinoid band overlying laminated sandstone in which lamination is locally disrupted, possibly by dewatering, and overlain by several one- to two-centimetre thick, normally graded beds.

wells now produce solely from this reservoir and 55 comingle Medicine Hat and Milk River gas. Initial gas in place in the Medicine Hat Sandstone is estimated to be approximately 20 x 10^6 m^3 (Saskatchewan Energy and Mines, in press). The most highly productive area (using cumulative figures) lies along the border between Saskatchewan and Alberta (Figure 4), towards the shallowest up-dip region of the sandstone. Higher up-dip, in Twp. 12, some wells encounter water problems, and a similar up-dip water-trap mechanism to that proposed by Hankel *et al.*, (1989) appears to apply. Structure contour maps on the top of the Medicine Hat Sandstone (Mahnic, 1989a,b) show that this surface is gently warped along northwest-southeast and southwest-northeast axes. This cross-folding has produced shallow domes and basins. The cumulative production pattern bears no obvious relationship to these structures, which therefore appear not to have major control on gas accumulation in this area. Elsewhere in southwestern Saskatchewan, however, such structures might be important.

6. References

Energy Resources Conservation Board (1975): Zone terminology and pool designations in the Medicine Hat Formation (attachment to examiners' report on Application no. 8981).

________ (1977): Relationship between the Medicine Hat Zone of zone designation no. 390 and the Medicine Hat A, C and D pools (attachment to Decision 77-9 respecting Application no. 770202).

Hancock, W.P. and Glass, D.J. (1968): Medicine Hat – Hatton Gas Field, Alberta and Saskatchewan; *in* Beebe, D.W. (ed.), Natural Gases of North America; Am. Assoc. Petrol. Geol. Bull., Mem.9, v1, p731-735.

Hankel, R.C., Davies, G.R. and Krouse, H.R. (1989): Eastern Medicine Hat gas field : a shallow, Upper Cretaceous, bacteriogenic gas reservoir of southeastern Alberta; Bull. Can. Petrol. Geol., v37, p98-112.

Kendall, A.C. and Simpson, F. (1974): Calcite layers in the uppermost Medicine Hat Sandstone (Upper Cretaceous) of southwestern Saskatchewan; Bull. Can. Petrol. Geol., v22, p34-41.

Last, Kloepfer Ltd. (1973): Shallow gas reserve potential, southeast Alberta and southwest Saskatchewan, Townships 10 to 25, Ranges 25W3M to 20W4M : a study prepared for Dome Petroleum Ltd.; Last, Kloepfer Ltd., Calgary, 26p.

Mahnic, P. (1989a): Structural contours on the Medicine Hat Sandstone, Liebenthal area; Sask Energy Mines, Map K-14(N)-2.

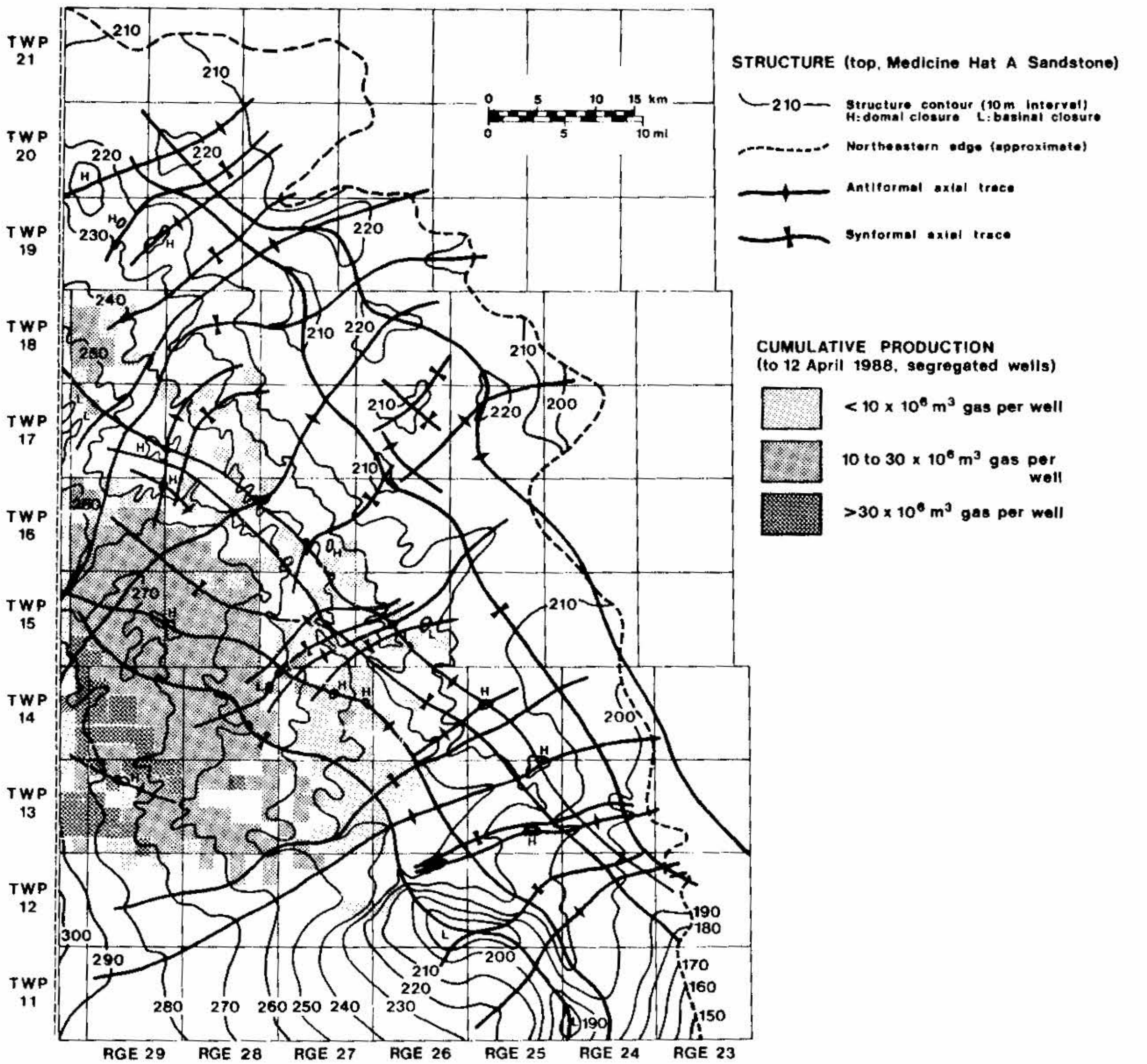

Figure 4 – Structure and cumulative gas-production map, Hatton-Burstall Fields (see Figure 2 for location) and adjacent area, southwestern Saskathewan; structure contours from Mahnic (1989a,b).

________ (1989b): Structural contours on the Medicine Hat Sandstone, Hatton area; Sask Energy Mines, Map K-14(S)-2.

Martin, I. (1965): The Medicine Hat Gas Field; J. Can. Petrol. Tech., 1965, p23-29.

Martin Petroleum and Consulting Ltd. (1985): Reservoir study of the Medicine Hat Field for Many Islands Pipe Lines (Canada) Ltd.

Meijer Dress, N.C. and Mhyr, D.W. (1981): The Upper Cretaceous Milk River and Lea Park Formations in southeastern Alberta; Bull. Can. Petrol. Geol., v29, p42-74.

Rice, D.D. (1981): Subsurface cross-section from southeastern Alberta, Canada, to Bowdoin Dome area, north-central Montana, showing correlation of Cretaceous rocks and shallow, gas-productive zones in low-permeability reservoirs; U.S. Geol. Surv., Oil and Gas Invest. Chart OC-112.

Saskatchewan Energy and Mines (in press): 1988 Reservoir Annual.

Simpson, F. (1981): Low-permeability gas reservoirs in marine Cretaceous sandstones of Saskatchewan : 11. Well-log analysis of Medicine Hat Sandstone (Santonian) of southwestern Saskatchewan and southeastern Alberta; *in* Summary of Investigations 1981, Sask. Geol. Surv., Misc. Rep. 81-4, p159-162.

Warren, A. (1985): Southeastern Alberta shallow gas pools reserves and performance data; Alta. Resour. Conserv. Board Bull., 18p.