



The Grosmont C at Saleski, Northern Alberta: a Solution-Enhanced, Highly Fractured Dolomite Reservoir

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Summary

The Grosmont C is a richly saturated bitumen-bearing carbonate unit within the Upper Devonian Grosmont Formation in the Saleski area of northern Alberta. The zone can be subdivided into five main lithofacies, three of which exhibit favourable reservoir properties with high porosity values and high bitumen saturations. Much of this is the result of a complicated series of diagenetic processes including pervasive matrix dolomitization, calcite/dolomite dissolution, and extensive fracturing. The lithofacies are both widely correlatable over hundreds of square kilometers and predictable in thickness. The oil column is consistently 15-20 meters in thickness. This core review presents lithofacies descriptions and petrographic analyses of the core from well AA/13-9-86-18W4 drilled by Osum Oil Sands Corp. in 2008. Additional log correlations and seismic interpretations are presented together with the results from laboratory solvent flood experiments and field tests as support for discussion regarding future commercial development in the Grosmont C.

Introduction

Osum acquired bitumen leases in the Saleski region of north-central Alberta beginning in August 2006. The main target of interest are bitumen resources hosted within the Devonian Grosmont Formation. The Grosmont Formation bitumen is trapped in a series of mostly shallow marine carbonate strata that dip to the southwest and subcrop against Cretaceous clastic beds of the Wabiskaw Member (Clearwater Formation) and McMurray Formation (Figure 1A). Of the four informal members that make up most of the Grosmont Formation at Saleski, i.e. the Grosmont A, B, C and D in order of decreasing stratigraphic age, the C and the D exhibit the best reservoir properties and contain the greatest amount of bitumen. Bitumen saturations are particularly high near the subcrop zone of the Grosmont C, which contains highly fractured and solution-enhanced reservoir units. Osum has interests in 125 gross sections (84.8 net sections) in the Saleski area where the bitumen column is thick and the Wabiskaw shale provides containment for future thermal development. Grosmont C vertical-well thermal pilots operated in the 1970s and 1980s used cyclic steam stimulation (CSS), steam drive, and in situ combustion processes and were considered to be uneconomic. However, production of up to 100,000 barrels of bitumen was achieved from individual vertical wells in an era lacking horizontal wells, electrical submersible pumps, under-balanced drilling, and steam-assisted gravity drainage technology. With the advent of these new technologies a reevaluation of the recovery potential of the Grosmont C is necessary.

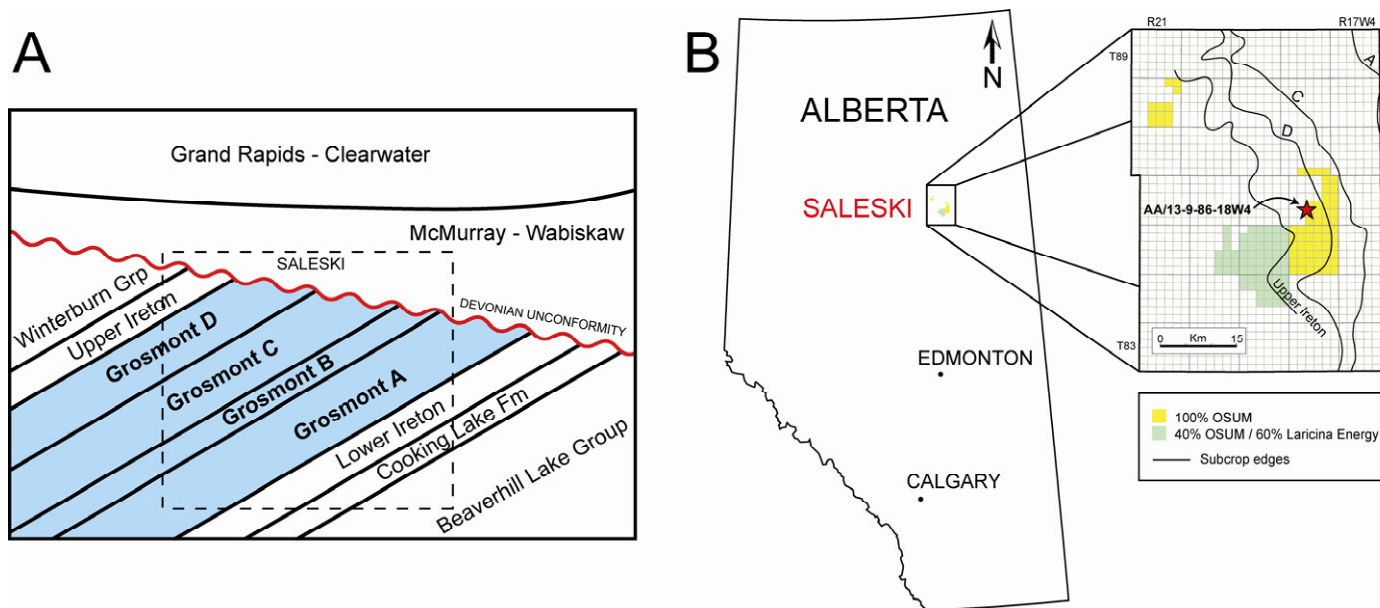


Figure 1: A) Stratigraphic position of the Grosmont Fm at Saleski. B) Location map of Saleski area and OSUM Corp. Saleski 13-9-86-18 well in northern Alberta. Subcrop edges of Grosmont A, C, D and Upper Ireton are also shown.

Core from the Saleski area (Figure 1B) was examined at macroscopic and microscopic scales and tied to detailed analysis of petrophysical well logs. Description of lithofacies in the Grosmont C unit and characterization of its reservoir quality from core and logs formed the basis for our mapping and modelling efforts. We have selected one well from the study area (Osum Corp Saleski 13-9-86-18, 1AA/13-09-086-18W4/00) that represents the average properties of the Grosmont C (Figure 2).

Grosmont C Lithofacies

The Grosmont C can be subdivided into five main lithofacies (C1 to C5) at Saleski, northern Alberta (Figure 2). The facies represent open marine to restricted marine deposits in an overall shallowing-upward succession. The basal two facies (C1, C2) comprise argillaceous dolomudstone of generally poor reservoir quality. The overlying facies constitute bitumen-saturated reservoir units with good to excellent average porosity, permeability, and hydrocarbon saturation. Facies C3 is a highly fractured, partially leached, vuggy dolomudstone (Figure 3), overlain by a sucrosic dolomite layer (facies C4) with anomalously high porosity values. The top unit, facies C5, is composed of a mixture of laminated, massive, and fenestral dolomudstone and dolowackestone. All facies can be easily identified in core, particularly if supplemented by geophysical well log information. Correlation of the lithofacies to adjacent wells and interpretation of regional 2D seismic data supports the observation of Hopkins and Barrett (2008) that these units are laterally continuous over many kilometers.

Pervasive matrix dolomitization, fracturing, and leaching are the main diagenetic processes responsible for the high reservoir quality found in the Grosmont C. Fracturing of massive dolomudstone locally led to the formation of pseudo-breccias where the rock collapsed onto itself. Further fracturing combined with the corrosive action of meteoric fluids percolating through the rock, enhanced the pore space and permeability of the rocks.

Grosmont C Reservoir Quality

Anomalously high porosity and oil saturation values characterize the sucrosic dolomite of facies C4, which can be attributed to extensive diagenetic alteration (dolomitization, calcite and dolomite leaching). The numerous fractures present in the vuggy dolomudstone (facies C3) result in extremely high permeability

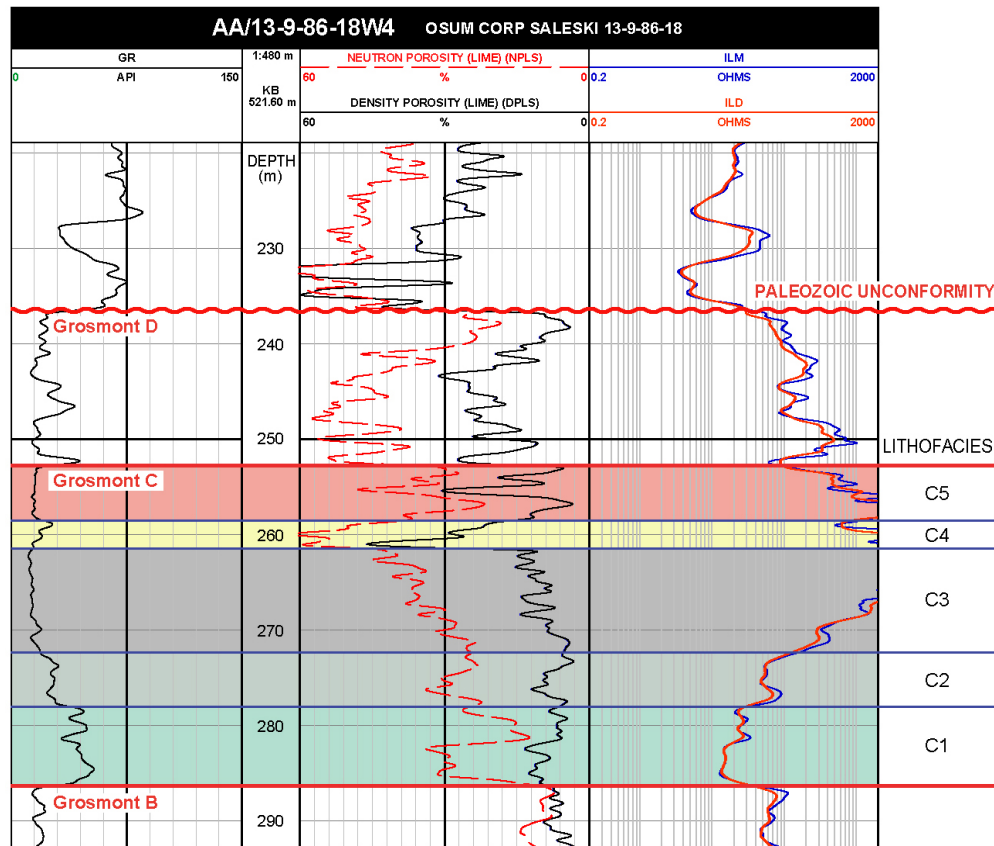


Figure 2: Petrophysical log signature of OSUM Corp. Saleski AA/13-09-086-18W4 well. Lithofacies C1 to C5 identified.

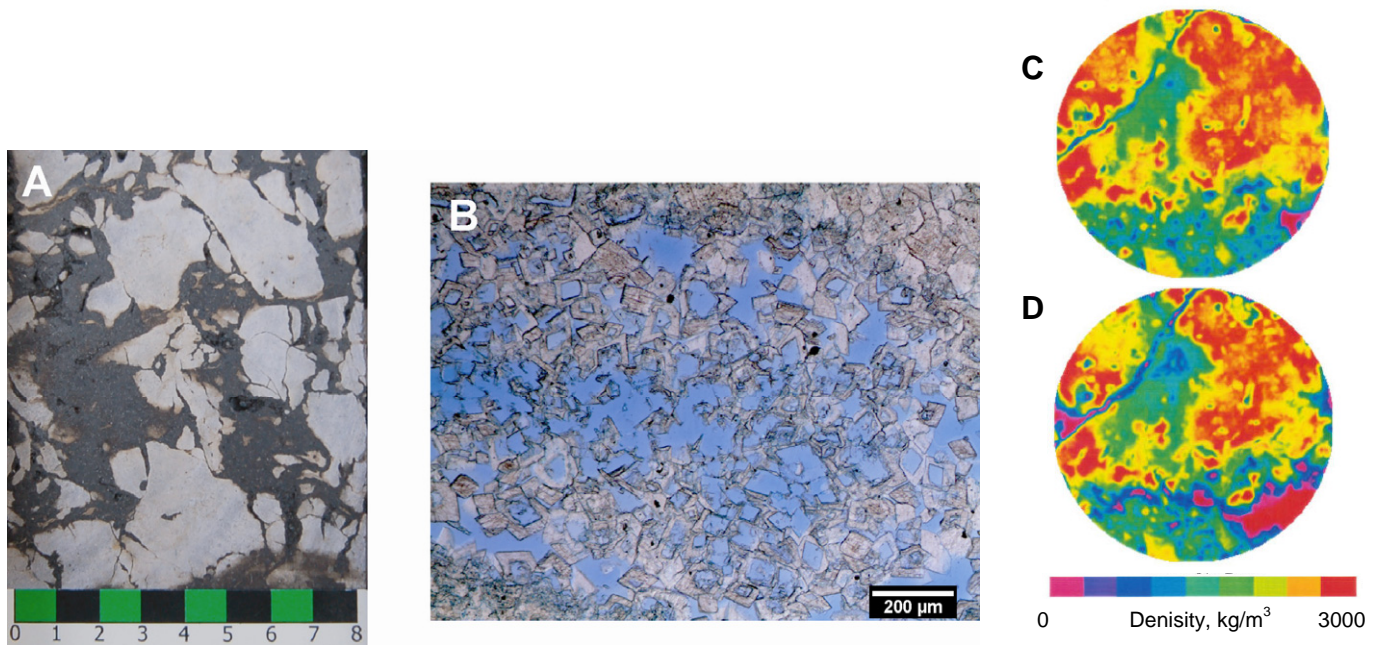


Figure 3: Facies C3, vuggy dolomudstone. A) Core photograph of highly fractured, partially oil-stained dolomudstone. Well AA/12-28-086-18W4, 250.85 m. B) Thin section photomicrograph (plain-polarized light) of solution enhanced dolomudstone. Euhedral dolomite rhombs show various stages of dissolution that initially affected crystal cores and appears to have progressed outward, locally leaching out entire crystals. Stained with blue dye for porosity visualization. Well AA/07-11-085-18W4, 309.40 m. C) CT Density Scan from Grosmont C core in well 1AA/07-26-085-19W4M, depth 374.74 m prior to laboratory soak. D) The same core slice as Figure 3C, post laboratory soak. The relative decrease in density, compared to 'C', is due to the evacuation of bitumen from pores.

values. The porosity and permeability values of facies C3 listed in Table 1 are probably lower than bulk reservoir values, because samples containing large vugs and/or samples affected by extreme fracturing were commonly excluded due to sample disintegration during plugging or core analysis. Bulk effective permeability of the Grosmont C has been estimated based on field injectivity of fluids and history matched simulation (Edmunds *et al.*, 2008). The analysis of Edmunds *et al.* (2008) suggests that the minimum permeability of the Grosmont C is 10 D and permeabilities an order of magnitude greater are required to match steam injectivity with realistic pore compressibility. Additionally, vertical permeability was estimated to exceed horizontal permeability. This conclusion is supported by our observations of vertical fracture intensity in the Grosmont C from core and formation image logs.

| Lithofacies | Porosity, avg. (%) | Porosity range (%) | Kmax, avg. (mD) | Kv, avg. (mD) | S _o , avg. (%) | S _w , avg. (%) |
|-------------|--------------------|--------------------|-----------------|---------------|---------------------------|---------------------------|
| C5 | 14.2 | 1.7 - 41.7 | 392.3 | 215.5 | 71.8 | 19.1 |
| C4 | 24.1 | 6.3 - 44.7 | 562.7 | 317.0 | 77.7 | 14.6 |
| C3 | 15.6 | 1.8 - 41.0 | 1458.8 | 470.5 | 65.8 | 21.0 |
| C1+2 | 9.2 | 2.4 - 24.2 | 312.9 | 33.2 | 35.6 | 41.4 |

Table 1: Reservoir properties of lithofacies in the Grosmont C at Saleski. Based on core data from 66 wells. Note that S_o and S_w do not add up to 1. This suggests the possibility that bitumen loss has occurred prior to analysis by leakage from vugs and open fractures (i.e. bitumen values are understated in the reported core analysis).

Grosmont C Recovery Potential

Laboratory soak tests of the Grosmont C core, using both thermal and solvent processes, achieved recovery factors of 46% and over 60%, respectively. Density measured from the core by CT scan prior to the laboratory soak and following the test, revealed that oil was produced from the fractures, vugs, and pore space within the matrix (Figure 3C, 3D). Field injectivity tests, conducted in 2007, with small volumes of solvent in the Grosmont C indicated that bitumen was mobilized and produced (Edmunds *et al.*, 2008). The test confirmed vertical communication between the Grosmont C and the Grosmont D above. These results give us confidence that one can expand the field test with larger volumes of solvent injection. Future plans involve pilot tests with horizontal wells using steam and solvent processes. The thermal pilot test will build on the results of the most successful of the early Grosmont C pilot experiments where approximately 100,000 barrels of bitumen were recovered using cyclic steam stimulation applied to a vertical well.

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