Regional Stratigraphy and Reservoir Units of the Grosmont Formation: Laricina's Saleski and Burnt Lakes Leases

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Introduction

The Grosmont Formation is comprised of shallow-water carbonates deposited in a platform to ramp succession during the Late Devonian. Early dolomitization pervasively replaced the limestone hosts. Erosion and truncation of the Grosmont Formation along its subcrop edge established a karst regime that resulted in leaching of the dolostones by meteoric waters, fracturing, and local clay infiltration. An extensive seal above the subcrop was provided by Lower Cretaceous shale. In the Early Tertiary, the Grosmont Formation was tilted to the west prior to bitumen charge.

Dolomitization and karst processes have significantly altered the fabric of Grosmont carbonates and several studies of reservoir properties emphasize reservoir heterogeneity. In this presentation we emphasize a regional stratigraphic framework to compare and contrast reservoir properties of two lease areas roughly 100km apart: Saleski Twp085 Rge19W4 and Burnt Lakes Twp095 Rge24W4 some100km to the northwest.

Regional Stratigraphy

The Grosmont Formation is divided into four members separated by three regionally distributed argillaceous carbonate horizons, variously referred to as shale or marl markers. Correlation of 5 wells spaced over 105km is shown in Figure 1. The members have been interpreted as chronostratigraphic units by Cutler (1983) and are identified, from base to top, as the Lower Grosmont, Upper Grosmont 1, Upper Grosmont 2, Upper Grosmont 3; designated LG,UG1 UG2, UG3 or A,B,C,D in contemporary terminologies. Harrison (1982) and Cutler (1983) interpreted this framework to represent depositional systems ranging from reef-rimmed platforms (Members A and B) through ramps (Members C and D).

*Member A r*anges from limestone in the southeast, locally with anhydrite (Cutler 1983), to dolostone and shale in the northwest (Theriault 1987). The transition northwards into a local shale basin within the Grosmont platform is partly governed by subsidence thickening of the formation and hints at a complex of several depositional sequences within Member A.

Member B is comprised of stacked parasequences of shale to calcareous nodular dolostones that thicken and become highly fossiliferous towards the northwest before thinning into argillaceous carbonates.

Member C is represented by two upward shallowing parasequences of argillaceous dolomudstones, through nodular to laminated dolostones. The lower parasequence thins to the south. At the top of Member C is the *CD marl,* interpreted as a separate depositional sequence of argillaceous carbonate by Hopkins and Barrett (2008).

Member D includes at least two depositional sequences. The lower part is laminated peritidal dolostones and dolostone breccias with accessory detrital quartz. A regionally correlative surface marks a basin wide transgression into overlying fossiliferous to laminated dolostone parasequences.

HYDROCARBON DISTRIBUTION

The bulk of heavy oil trapped within the Grosmont Formation is contained within Members C and D in a belt parallel to the subcrop and about 20km wide (Dembicki and Machel 1996). The heavy oil column at Saleski reaches a maximum of 65m thick (LEL 2007). At Burnt Lakes it is 45m thick and occurs in the upper part of Member C and Member D.

DEVELOPMENT

The Laricina Saleski lease is currently being developed for heavy oil production from a pilot project in section 26-085-19W4 (LEL 2007, 2009). Steam injection is planned to commence later in year 2010. The Burnt Lakes lease is undergoing drilling/seismic evaluation for future pilot development.

RESERVOIR UNITS

Reservoir units are correlated from log properties and comprise one or more dolostone lithologies that have similar petrophysical characteristics. Eight reservoir units in Members C and D have been correlated throughout 20 wells in Twp 085 Rge19W4 of Laricina's Saleski lease. 1AA/07-26-085-19W4 is a key well from Saleski described by Hopkins and Barrett (2008) and presented at the 2008 CSPG Core Conference. The core from 1AA/06-17-095-24W4, to be displayed at the 2010 CSPG Core Conference, is from the Burnt Lakes lease 105km to the northwest. Core log, wireline log profiles and reservoir units for these wells are shown in Figure 2 and described in Table 1. HMI logs were used in 1AA/06-17-095-24W4 in conjunction with core to assess lost core intervals as well as section that were not cored. The description for units 1, 2 and 3 is from core in 1AA/12-15-095-25W4.

Core logs emphasize the mechanical stratigraphy as well as the lithologic reservoir units. Dolomite dissolution has been widespread throughout Members C and D resulting in various degrees of lithification (de-lithification) that has important implications for development. A peculiarity of the Grosmont Formation is for some reservoir units to be comprised of various proportions of two end member lithologies: (1) dolostones with an inherent strength (lithified) and low matrix porosity and (2) friable microdolomites with very high matrix porosity. Friable microdolomites are interpreted as leached crystal residues (Hopkins and Barrett 2009).

REGIONAL TRENDS

Stratigraphic continuity of reservoir units of Members C and D between the Saleski and Burnt Lakes leases underscores the broad uniformity of sedimentary and diagenetic processes across the Grosmont carbonate ramp. Within reservoir units, there is a general trend towards more open marine conditions to the northwest, from Saleski (restricted) to Burnt Lakes (less restricted). This is deduced from the increase in fossils, burrows and broken shell material. Also laminites, indicative of increase in hydrodynamic sorting of carbonate host, are much more common at Burnt Lakes.

Manifestations of karst processes as fissures (vugs, channels, fractures, siliciclastic fills) and highly porous leached friable microdolomites are more prominent at Saleski than in the Burnt Lakes area. In contrast, calcitization of dolomite (dedolomitization) is much more common at Burnt Lakes than Saleski. Calcitization is a feature of fine-crystalline dolostones of the Grosmont Formation in the Liege Field (Theriault and Hutcheon 1987) adjacent to Burnt Lakes. According to these authors, calcitization of dolomite rhombs and leaching to form highly porous microdolomite are related but spatially variable processes.

The reasons for differences in styles of alteration are not clear at this time. It is possible that it may relate to lithologic susceptibility to karst leaching. Regional data suggests a more marine aspect to Burnt Lake carbonates implying differences in grain size and perhaps composition of the host carbonates.

Conclusions

Regional stratigraphy of the Grosmont Formation along a section parallel to its eastern subcrop indicates deposition as carbonate platform to ramp successions with local subsidence and thickening.

Correlation of reservoir units within Members C and D in the Saleski and Burnt Lakes leases, 100km apart, underscores a basic sedimentary theme of marine to peritidal carbonates with subtle differences in the importance and distribution of facies.

Manifestations of karst processes as fissured dolostones and friable microdolomites are more common and more intense at Saleski.

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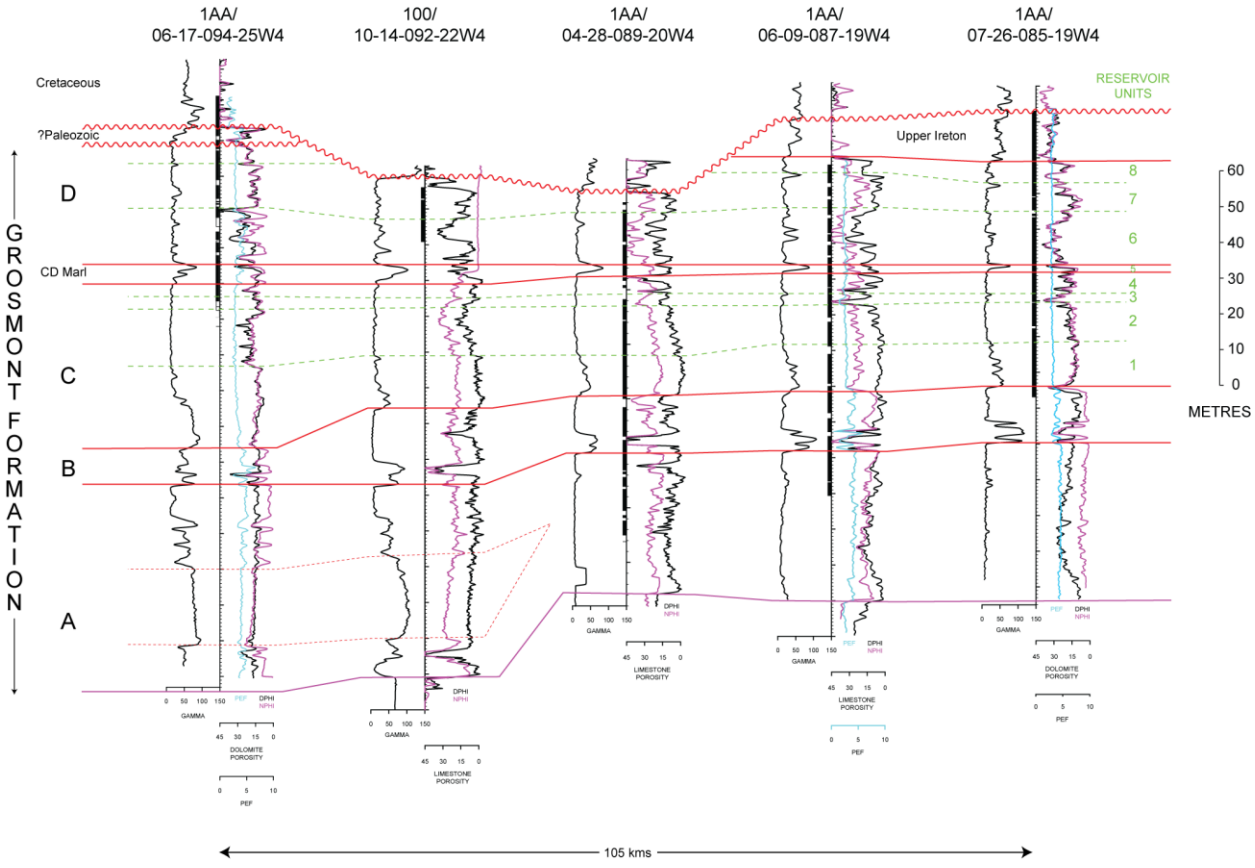

Figure 1

Regional northwest-southeast cross section oriented roughly parallel to strike of sub-Cretaceous subcrop. Key wells 1AA/06-17-094-25W4 and 1AA/07-26-085-19W4, at each end of the line of section, are from the Burnt Lakes and Saleski areas respectively.

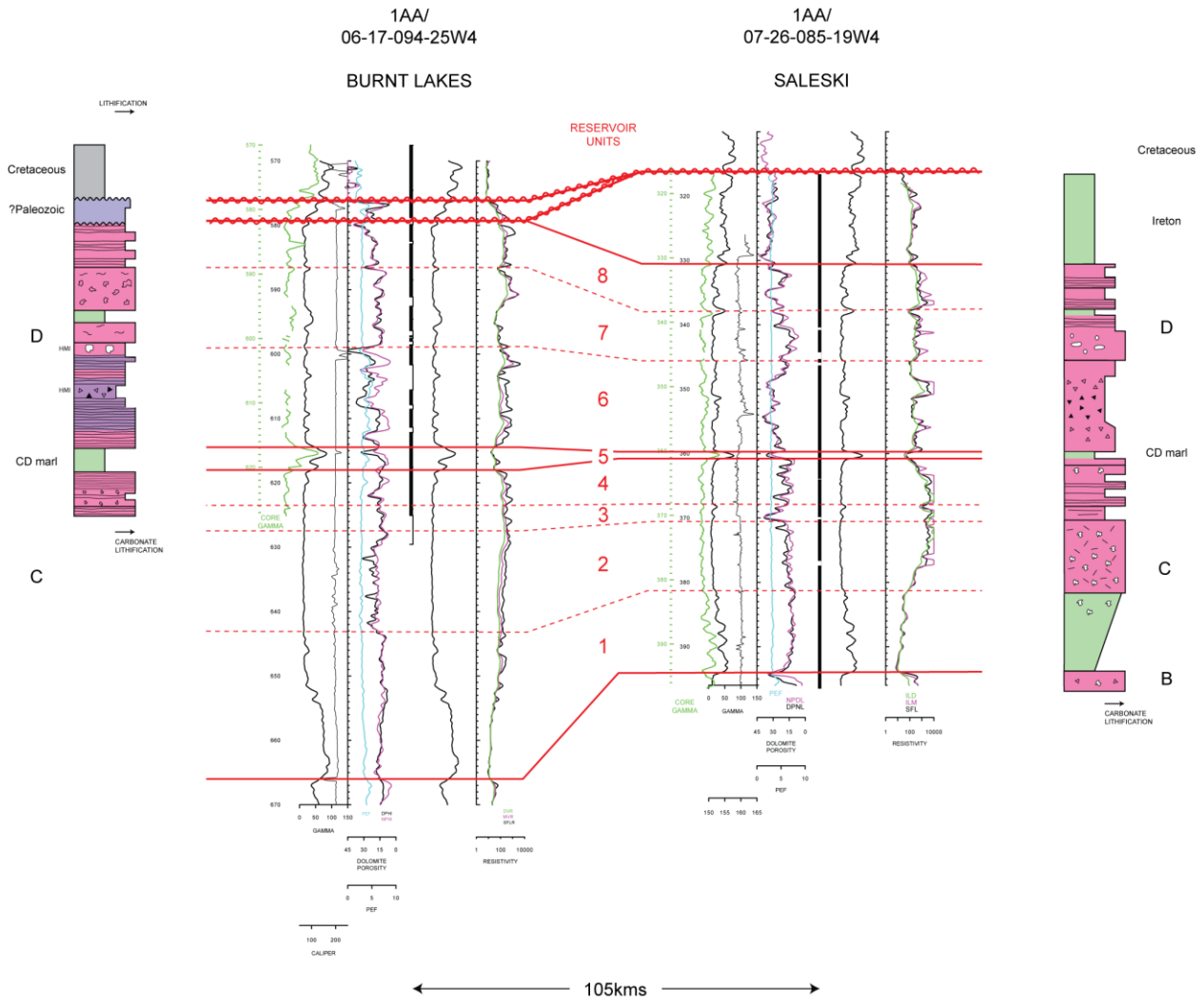

Figure 2

Correlations and core logs for Members C and D of the Grosmont Formation in wells 1AA/06-17-095-24W4 (Burnt Lakes) and 1AA/07-26-085-19W4 (Saleski).
Note that the vertical scale of logs is double the scale in Figure 1.
1AA/06-17-095-24W4 is the 2010 Core Conference display well.

Table 1

Core descriptions

UNIT	BURNT LAKES 1AA/06-17-095-24W4	SALESKI 1AA/07-26-085-19W4
8	- interbedded massive vuggy and laminated dolostones - low to high matrix porosity	- massive dolostone to friable wispy laminated dolostone successions - low to high matrix porosity
7	- vuggy, skelmoldic, dolowackestones - bioturbated argillaceous dolostones - low matrix porosity and permeability	- vuggy and locally fractured Amphipora and coral dolowackestone - low matrix porosity and permeability
6	- laminated dolostones - brecciated and cavernous porosity in upper part (HMI logs) - calcitization of dolostones - moderate to high intercrystalline matrix porosity	- leached, commonly friable, laminated dolostone and breccia arranged in four bed sets - lateral changes in thickness and degrees of brecciation as recognised from HMI logs - high matrix porosity
5	- bioturbated and patterned argillaceous dolomudstone - low porosity and permeability	- argillaceous dolostone to marl - bioturbated to crinkly laminated - low matrix porosity and permeability
4	- laminated dolosiltstone and mudstone - interbedded vuggy dolostone and microdolomite - variable matrix porosity	- stromatolites - interbedded friable microdolomite to massive and vuggy dolomudstones - variable matrix porosity
	1AA/12-15-095-25W4	1AA/07-26-085-19W4 - continued
3	- current laminated dolograinstone/dolosiltstone - scattered ripple cross lamination - escape burrows - intergranular porosity	- leached (friable) microdolomite; leaching diminishes upwards revealing laminated host - matrix porosity up to 45%
2	- skelmoldic dolograinstone above bedded fossil-melodic dolomudstone with local intraformational fractures - low matrix porosity; moderate permeability	- fenestral dolostone above nodular vuggy and fissured dolostones with abundant intraformational fractures - low matrix porosity; Darcy permeability value on whole core samples.
1	- fossiliferous argillaceous dolomudstones with scattered vugs and fossil molds - low porosity and permeability	- argillaceous burrowed and fossiliferous dolostones (marls) that grade up into nodular vuggy dolostones - low porosity and permeability