High-resolution Sequence Stratigraphy of the Glauconitic Sandstone, Upper Mannville C Pool, Cessford Field: a Record of Evolving Accommodation

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INTRODUCTION

In southern Alberta, reservoirs in the middle part of the Mannville Group, such as the C Pool in the Cessford area of south-eastern Alberta, are hosted in permeable quartzose sandstones of the Middle Mannville Formation (Jackson, 1984). To date, the C Pool has produced 3.45×10^6 m^3 oil and 2.4×10^6 E^3m^3 gas (largely solution gas) from 219 wells. Quartzose sandstones of the Middle Mannville have been incised by Upper Mannville paleovalleys that are filled with lithic sandstones and shales. The lithic sandstones are relatively impermeable, so the Upper Mannville paleovalleys can form lateral seals for the Middle Mannville reservoirs, although they may form local reservoirs and may be high-risk oil and gas targets (Hopkins and Meyer, *in press*). In the C Pool, reservoir characteristics are related to the depositional facies, syn-depositional collapse of the underlying evaporite facies, and sedimentary bedding type.

The study area extends from Townships 25 to 26 and Ranges 11 to 13 west of the Fourth Meridian and contains 732 wells that penetrate the Mannville Group. Of these, 105 wells have been cored through the Mannville Group interval. The five cores displayed in this presentation, 04-30-025-11W4, 06-14-025-12W4, 12-22-025-12W4, 14-29-025-12W4, and 12-30-025-12W4, serve to illustrate the stratigraphic and thickness relationships between three depositional sequences that comprise the Middle Mannville. Changes in thickness of the units due to syn-depositional collapse of underlying evaporites.

REGIONAL

The Middle Mannville sandstones in the Cessford field were deposited on the western flank of the Sweetgrass Arch. The western boundary of the field is marked by a NE-SW trending basement fault. This fault influenced the position of the estuarine funnel as well as local structural lows and highs that formed as sections of the evaporite horizons of the underlying Wabamun and Leduc formations were dissolved while other sections remained intact (Figure 1).

In the Cessford area, Mannville Group sediments unconformably overlie Mississippian carbonates. Lower Mannville sediments are generally thin and lap out against against a paleotopographic high to the east. Middle Mannville sandstones are concentrated by subsidence within the throat of the estuarine funnel. Local subsidence occurred by dissolution of underlying salt. The locus of subsidence moved with time and caused local changes in accommodation space relative to other areas in the estuary. The top of the Middle Mannville is marked by a coal and is followed by an undifferentiated succession of Upper Mannville shales and lithic sandstones.

DEPOSITIONAL SEQUENCES

The Middle Mannville in the C Pool was deposited in an estuarine complex and is composed of three stacked depositional sequences (Figure 2) designated respectively, from base to top: DS1, DS2, and DS3. The sequences are separated by coal and/or paleosols. The mineralogy of the sandstones changes subtly from quartzose (quartz and chert) in DS1 to lithic (sedimentary rocks fragments, chert and quartz) in DS3.

Similar facies are found in each sequence but have different proportions and different distributions. Sandstones are generally fine- to medium-grained, but locally are coarse-grained where they are associated with pebble conglomerates (clasts up to about 1 cm). Sedimentary structures include planar cross beds, trough cross beds, ripple cross lamination, parallel lamination, as well a succession homogenized by interstitial meiofauna (Casas and Walker, 1997). Laminae in cross beds vary from mineralogic sand segregations (quartz and chert) though carbonaceous and micaceous laminae to clay laminae.

DS1 is a quartz-chert sandstone with black chert grains and bioturbation by *Planolites*. The sandstones are coarsening-upwards with sedimentary structures varying between ripples and cross-beds. The depositional sequence is capped gray mudstone, locally with roots, pedogenic slickensides, carbonaceous material, and soft-sediment deformation. Across much of the area the mudstone is less than a metre thick, but in the vicinity of the basement fault increases to 6 m in thickness.

DS2 is a chert-quartz sandstone containing carbonaceous fragments and *Teichichnus* burrows. The top part of this coarsening-upward sequence is a paleosol with roots, carbonaceous fragments, slickensides, and local coals. Fine-grained sandstones in DS3 tend to contain less chert. The most common sedimentary structure is cross-bedding, although ripples also occur in this sequence.

DS3 is a lithic-chert-quartz sandstone. Sedimentary structures in the sandstones grade from ripples at the base to cross-bedding at the top. The sequence is capped by coal. An irregular zone of authigenic kaolinite up to 3 m thick partly occurs within sandstones beneath the coal.

DIAGENESIS

Diagenesis in the Middle Mannville includes quartz overgrowth cements and compaction of rock fragments. As well, kaolinite is found infiltrating the sandstones below coals and paleosols. All of these factors, particularly the infiltration of kaolinite, reduce the porosity and permeability of the sandstones.

PETROFACIES

Generally, porosity in the sandstones ranges from 20-30% and permeability from 100-1000 md. Porosity and permeability are controlled by (in order of importance): grain size, sedimentary laminations and bioturbation, mineralogy and corresponding compaction, and authigenic kaolinite. The coarsest sands have the highest porosity and permeability. Different ripple types affect the porosity and permeability, with sandstones that are massive and bioturbated by interstitial meiofauna generally having the highest porosity and permeability values, while very fine grained sandstones with shale laminae generally have very low permeability values. Chert will compact more than quartz, so sandstones that are more chert-rich will exhibit greater compaction and therefore reduced porosity and permeability. Authigenic kaolinite plugs up pores and reduces permeability.

CORES DISPLAYED

The cores chosen for this display show the different units in each part of the pool: 4-30 shows the DS2 and DS3 sequences on a structural high formed by a salt ridge, 6-14 shows the sequences from the top of DS1 to DS3 on the ridge, 12-22 shows all of the sequences DS1-DS3 on the ridge, 14-29 shows the DS2 and DS3 sequences in the basin, and 12-30 shows the DS1 sequence in the basin.

REFERENCES

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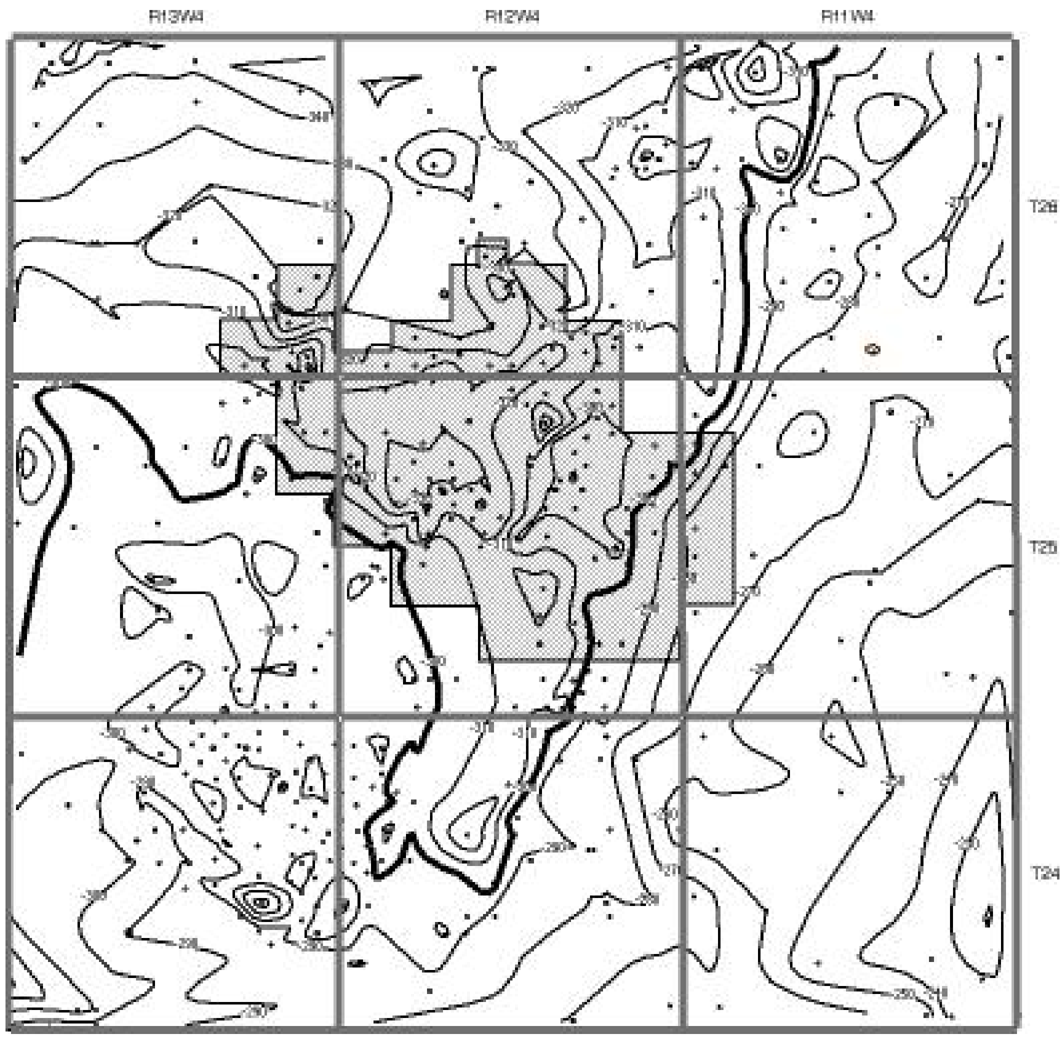

Figure 1. Map of Mississippi structure and location of the Mannville C Pool. The thick line outlines the funnel shape of the estuary. The eastern edge of the estuary is defined by a NE-SW trending basement fault. The shaded area shows the location of the C Pool.

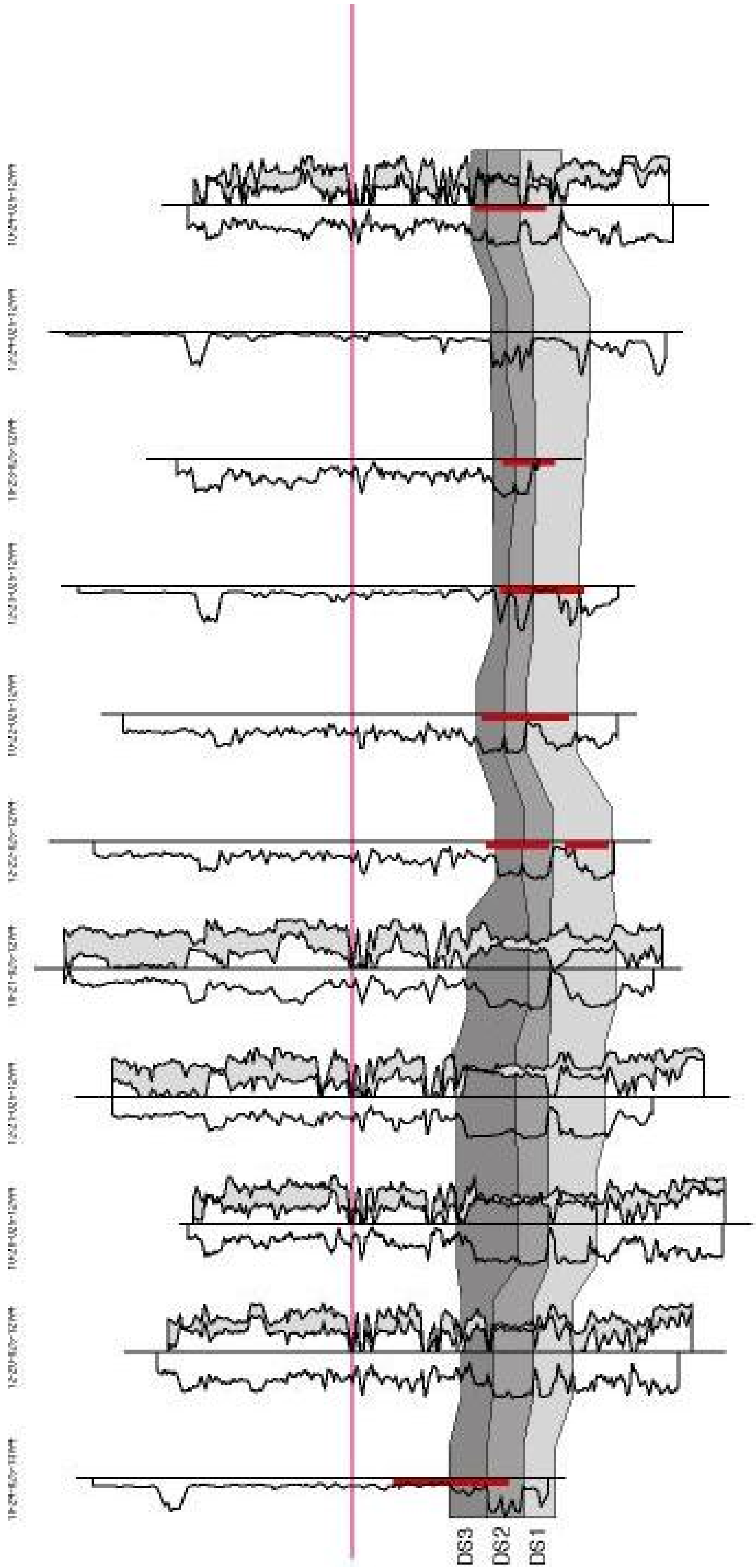

Figure 2. Stratigraphic cross section through C Pool showing the three sequences DS1, DS2, and DS3. The variation in thickness of the sequences across the section is apparent, with the sands in the DS2 and DS3 thickening considerably to the west, which is an area of increased accommodation space as a result of salt dissolution in underlying units.