



Don't Call it a Comeback – Delivering the Goods in the Alida Unit, SE Saskatchewan

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Summary

The Alida unit of SE Saskatchewan, first discovered in 1954, is a mature, low-decline oil and gas field still producing today conventionally from the Alida Beds (Mississippian). The Alida pool is a stratigraphic pinch out with an OOIP of 75MM bbl and OGIP of 70 BCF with a present-day recovery factor of 41%. The reservoir is composed of a thick 5 to 40m carbonate unit, characterized by a typically skeletal, crinoidal, limestone packstone or grainstone which has undergone varying degrees of dolomitization.

Despite the gas cap blow down beginning in 1967, bottom-hole pressures remain near virgin due to the presence of a strong bottom-drive aquifer. While this aquifer provides pressure support to producing wells, it has led to an elevated and irregular oil water contact as water moved in to replace the void space of produced oil and gas. It is also believed that there is water coning to vertical perforations and open-hole horizontals, which can lead to increased water cuts at the well head, while leaving behind unswept oil between existing producers.

After the initial vertical development of 59 wells, the pool now contains 114 horizontal wells producing at 75 to 150m spacing, from various structural elevations within the Alida Beds. Horizontal well results have been extremely successful, producing an additional 15.9MM bbl of oil to date, nearly doubling the unit's overall recovery factor. The horizontal well results by vintage show progressively worse individual initial production rates and ultimate recoveries over time from 2000 to 2012. Renewed stratigraphic correlations and mapping using 3D seismic and reservoir evaluation has helped target the remaining areas of high oil saturation with a systematic approach. This led to the very successful results and strong economics for NAL's 2017 infill drilling program, seeing production rates return to that of the wells drilled during 2005-2009.

Geologic Setting and Pool Reservoir Parameters

The Alida unit (Fig. 1) located at TWP 5-6 RNG 33W1 is one of many pools producing from a pronounced carbonate structural nose within the Alida Beds against the Mississippian unconformity subcrop in SE Saskatchewan. Erosion at this surface cuts down into the sequence package and has led to a wedging out of the Alida Beds towards the up-dip, northeastern edge, as well as down the structural flanks of the reservoir (Fig. 2 and 3). The carbonate stack is capped by a diagenetic anhydrite and dense dolomite of variable thickness, above which the post-Mississippian impermeable lower Watrous beds were deposited. This impermeable cap and overlay combined with the structural closure create the trapping mechanism for the pool.

Deposition of the Alida occurred on a broad carbonate shelf within shallow-marine waters during an overall shallowing upward trend. (Kent, 1984.) Regionally, six main lithofacies have been described within the Alida Beds (Rott, 2005.) While the Alida unit reservoir is a carbonate package with a complex history of diagenesis, for the purposes of this presentation, the reservoir has been divided into two main lithofacies. An upper crinoid unit consisting of a typically limestone packstone or grainstone and a lower algal unit, consisting of partially dolomitic limestone. Other units of importance are smaller argillaceous marker beds

that represent transgressive incursions. The units have slightly elevated gamma ray values and a SP shift, making them good local correlation markers.

Average limestone porosity within the unit is 16%, typically intercrystalline and interparticle with minor vuggy and dissolution porosity. Maximum permeabilities average 30mD, with kvert to k90 ratios of 0.3 – 0.5. This good vertical permeability combined with vertical fractures (as seen in core), leads to the belief that the reservoir is acting locally as a tank.

The Alida Beds within the unit dip to the southwest, toward the center of the Williston Basin, at a present day depth of 1100 – 1140m TVD (-510 - -550m SS). At time of discovery, the reservoir was normally pressured at 10,500 kPa, and over the course of 60 years of production, pool pressures have only declined ~12%, despite gas cap blow down and low voidage replacement through water injection into the Alida. This is due to strong bottom-drive aquifer support as evidenced in production profiles showing increasing water cuts over time with relatively flat overall fluid production. While maintaining pressures, the aquifer support has led to substantial movement of fluid within the reservoir, including elevated oil-water contacts and oil migration into the previous gas cap.

Approach

From 1990 to present, horizontal wells have been used to infill the Alida pool, contributing substantial new reserves, without causing any major interference to existing producers (Vigrass, 1995). This is due to wells in the pool eventually developing water breakthrough due to coning, and considerable oil is left un-swept between producers. (Beveridge, 1991). After over two decades of drilling, horizontal type curves had reduced initial production rates and ultimate recoveries, challenging the economics of future drilling activity.

NAL's approach to high grading better drilling locations was to use integrated detailed mapping, tying logs, core, seismic, and engineering data together to identify high remaining oil in place on a LSD scale. Estimated ultimate recovery factor for the unit is currently 46.5%. Locations that meet the criteria of having 75m interwell spacing, lateral lengths over 600m, and target areas of currently less than 40% recovery factor, are ideal for capturing higher reserves and delivering better economic results.

Examples

After a four-year hiatus from drilling, five new 75m infill horizontal wells were drilled within the Alida unit during 2017. These wells had an average lateral length of 930 m, for drilling and open-hole completion costs of \$0.7MM, and estimated rates of return on investment over 500% .

Combined the wells brought on 739 bbl/d of flush oil and reached average peak initial production rates of 148 bbl/d of oil. Water cuts averaged 32.6%, producing directly in between older horizontals with water cuts typically presently higher than 95%. Preliminary decline analysis suggests ultimate recoveries to be 100M bbl of oil per well. These production results were last seen during drilling programs completed from 2005 to 2009 (Fig. 4). Additional locations have been identified for exploitation through future drilling programs. Complete development could deliver an additional risked 2.3MM bbl of oil, contributing a further 3% ultimate recovery factor for the unit.

Conclusions

When further developing mature pools, detailed geologic work integrated into a multi-disciplinary understanding of the reservoir is crucial for determining areas of high remaining oil saturation. Strategic horizontal drilling locations specifically targeting these areas can capture under-exploited reserves and deliver highly economic results.

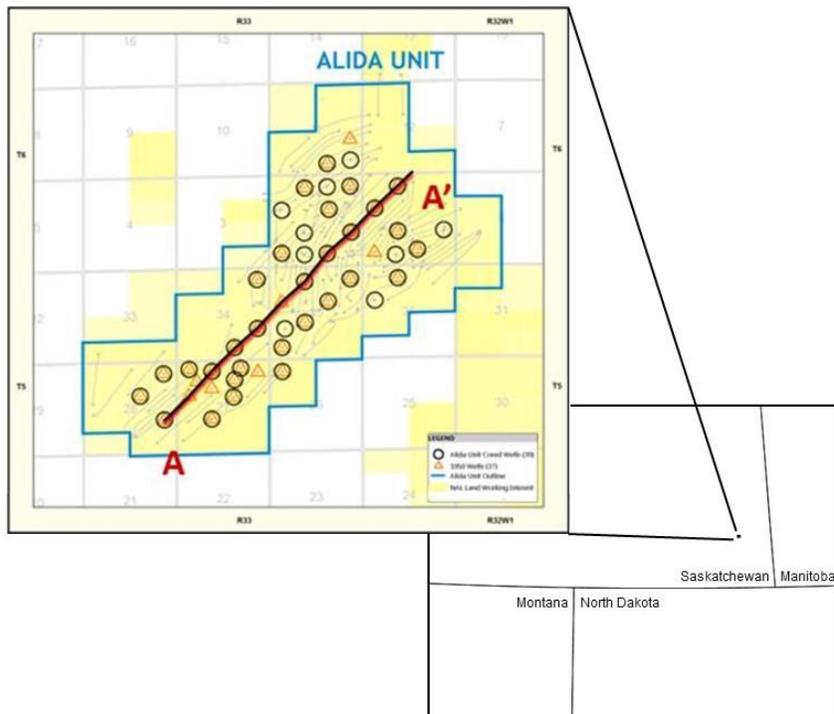


Figure 1. The Alida Unit is located at TWP 5-6 RNG 33W1 in SE Saskatchewan. The pool was originally developed vertically, and wells were typically cored. Unitization occurred in 1957. A – A' cross-section is illustrated in Figure 2.

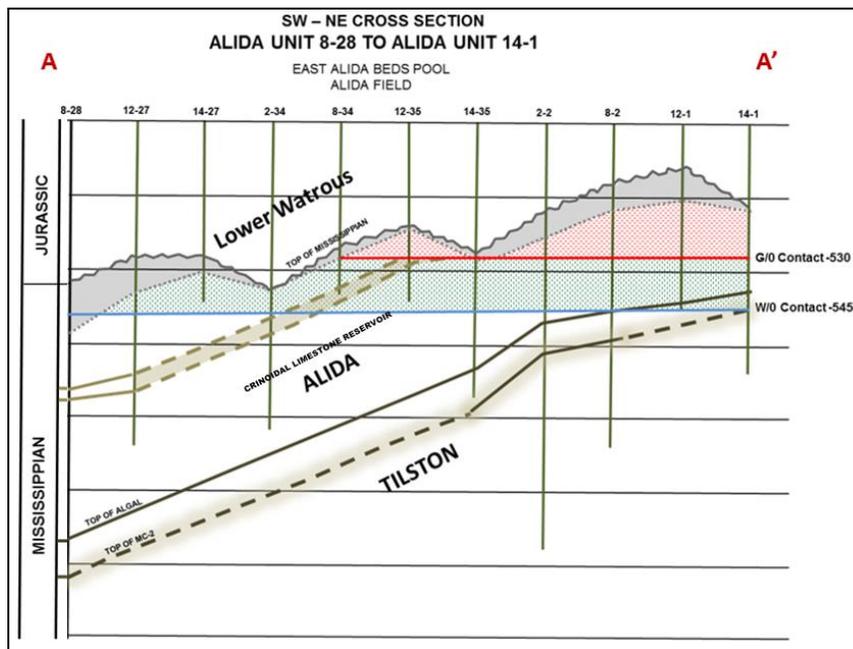


Figure 2. Schematic cross-section of the Alida Unit across A – A' from Figure 1, showing Mississippian unconformity, dipping carbonate beds, and the original oil-water and oil-gas contacts.

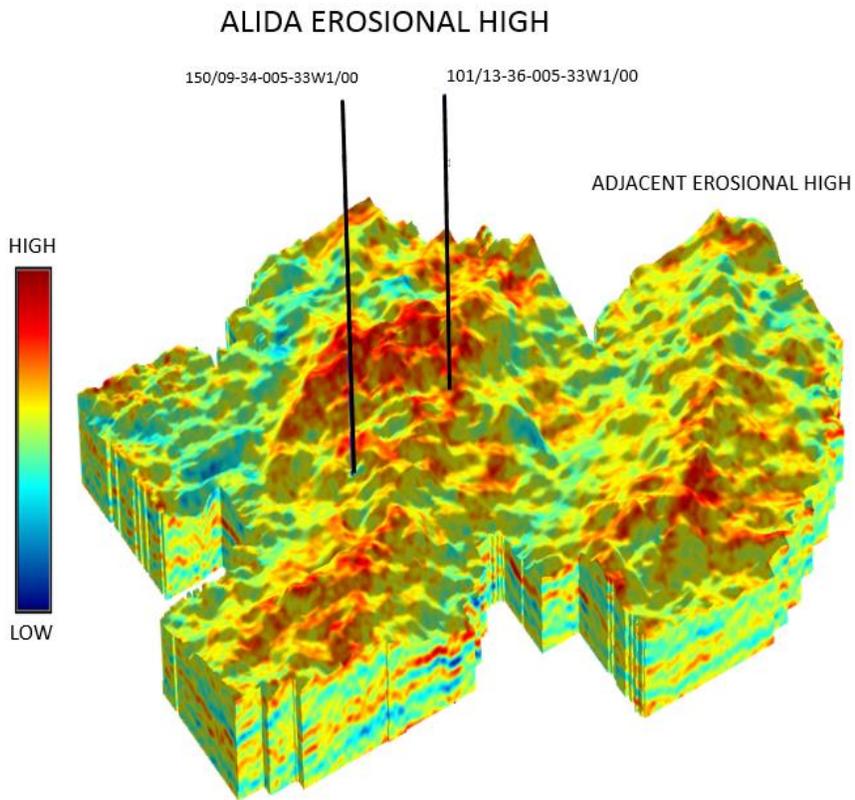


Figure 3. Seismic time structure cube with amplitude overlay. 3D visual clearly showing the Mississippian unconformity surface and resulting remnant high.

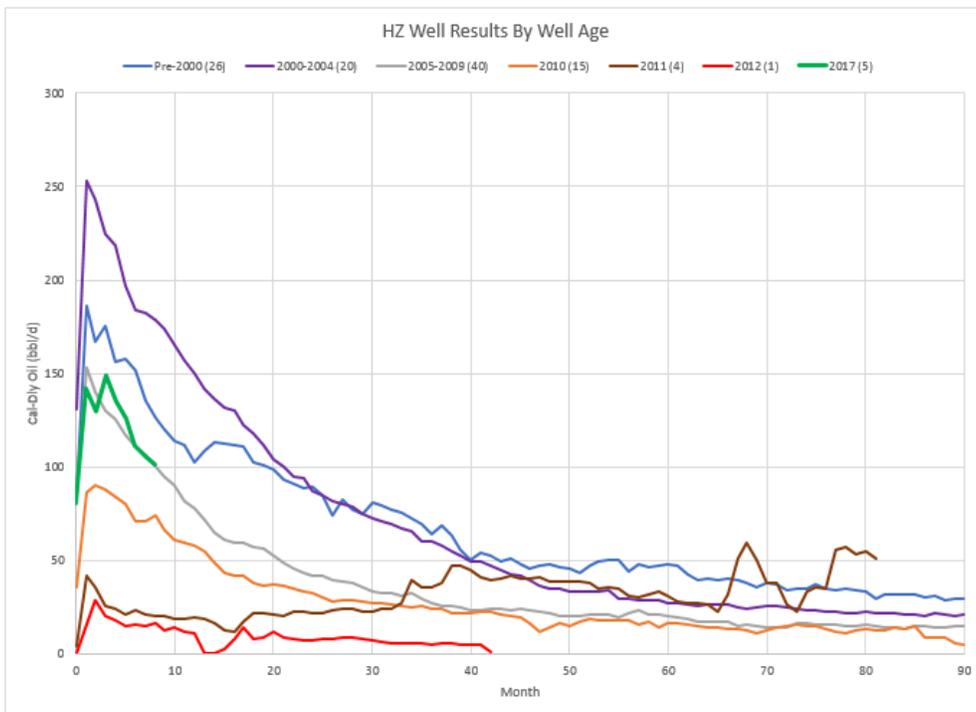


Figure 4. Time-normalized average daily oil, grouped by horizontal drilling program vintage. 2017 drilling results saw a return to rates last obtained from 2005-2009.

References

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