Unconventional, low-permeability offshore marine reservoir facies, with hiatal conglomerates developed at internal stratigraphic unconformity surfaces - the Alderson member of the Milk River formation, Upper Cretaceous, southern Alberta and Saskatchewan

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The Campanian Alderson member of the Milk River Formation extends throughout southeastern Alberta and southwestern Saskatchewan where it hosts gas reserves in excess of 30 TCF. An outcrop equivalent of the Alderson member is present in northern and central Montana where it is known as the Upper Eagle member.

This core display will demonstrate Alderson member facies and stratigraphy in a core taken near the Alberta/Saskatchewan border: Nexen Medhat 6-31-14-1, which is located at 100/6-31-14-1w4. The Alderson member is 100 metres thick at this location and the core extends continuously from the overlying Pakowki formation to the underlying First White Specks formation. Alderson member sediments are highly smectitic and these swelling clays are sensitive to water and easily damaged. The Nexen Medhat core has been extremely well-preserved and is undamaged by water; unusually so for an Alderson member core. The facies interpretations and stratigraphy outlined here are derived from over 50 Alderson member cores described from Alberta and Saskatchewan. The Nexen Medhat core demonstrates lithologies, facies and stratigraphy that is typical of the Hatton and surrounding field areas in Saskatchewan, and the Suffield and surrounding field areas in Alberta.

The Alderson member consists of three lithological components: very fine-grained sand, silt and mud. Individual layers of sand, silt or mud are rarely more than a few centimeters thick. More typically the sediment was reworked by moderate to intense bioturbation, resulting in a range of mixed lithologies from silty and muddy sand, to sandy and muddy silt, and silty and sandy mud, with all possible gradations in between. The most common lithological component is silt, which averages 50% or more throughout the Alderson member in the Nexen Medhat core. A significant proportion of mud is always present, with the least mud in the lower 30 metres, where it is 30% or less of the total lithology. The mud proportion increases upwards, being 40% on average in the middle 30 metres, and 50% or more in the upper 45 metres. Sand is mainly present in the lower and middle part of the Alderson member where it averages 25% of the total lithology, up to 40% in short intervals.

The great majority of the sedimentary structures within the Alderson member are wave- and storm-generated. In the lower to middle part of the core, sharp-based sand and silt layers are present, typically up to 3.5cm thick. These layers contain low-angle and undulating laminae, sometimes passing upwards into wave ripples. Small isolated sand lenses and wave ripples up to 2cm in height are also present within the otherwise mixed sandy and silty lithologies. Delicately interlaminated, millimeter thick sand, silt and mud layers also occur.

Graded units between 1cm and 3cm thick occur in the lower and middle part of the Alderson member. These are erosionally based and typically pass upwards from laminated sands into silts and muds. Graded units are present in many Alderson member cores, and stacks of graded units, often up to 10cm thick are sometimes seen in intervals several metres thick.

Marine-derived organic material such as shell fragments and fish-debris are present throughout the Nexen Medhat core. Much of the Alderson member contains low concentrations of detrital glauconite grains and diagenetic pyrite. Early-formed carbonate concretions, consisting of calcite and siderite minerals occur throughout the entire Alderson mamber. These concretions have irregular to subspherical shapes and range from a few cm to several decimeters thick.

Alderson member lithologies have been bioturbated by an assemblage of tracemakers that displays high abundance, uniform distribution of ichnogenera, and moderate diversity. The environment is dominated by large numbers of small deposit-feeding and grazing structures and most burrows are horizontal or weakly inclined with little vertical penetration. The assemblage is typical of a *Cruziana* ichnofacies formed in a stable, low-energy offshore marine environment.

Alderson member ichnoassemblages are dominated by grazing and mining structures such as *Helminthopsis*, *Anconichnus*, and *Phycosiphon,* and by mobile feeding structures such as *Planolites* and *Chondrites*. These ichnogenera are ubiquitous and are present in abundance in every centimeter of the 100 metre thick Alderson section, with the exception of a relatively few, thin tempestite sands. Other commonly occurring ichnogenera are mostly mobile feeding structures such as *Asterosoma, Teichichnus, Zoophycos, Thalassinoides, Siphonichnus,* and *Rosellia*, although these are never dominant within the assemblage. Dwelling structures are uncommon, mostly *Terebellina* and *Skolithos*. *Pilichnus* is abundant in the muddier intervals, usually where mud content is greater than 40%. This ichnogenera is usually branched or curved and occurs in close association with the other members of the ichnoassemblage previously described.

The Alderson member is entirely marine and was deposited in proximal to distal offshore marine environments. In the proximal offshore marine settings wave and storm-generated structures are evident, and thin layers of sand and silt are present. Graded units may have been generated by hyperpycnal flow, and fall-out from muddy sediment plumes. In the more distal offshore marine settings, sedimentary structures and discrete layers of sand and silt are almost entirely absent. The sediment here is muddier with little or no sand and this has resulted in high intensity bioturbation and the almost complete homogenization of the sediment. In the upper Alderson member intervals of these distal homogenized marine sediments can be up to 50 metres thick. Alderson reservoirs are hosted within the proximal layered sediment, and the homogenous sediments have little reservoir potential.

The Alderson member in SW Saskatchewan has been divided into six major stratigraphic units, labelled A to F in descending order, by O'Connell (2004). These Alderson Member units resulted from multiple episodes of variable tectonic subsidence and uplift, giving rise to a series of highstand, lowstand, and transgressive systems tracts, which are often truncated by large regional erosion surfaces. The Upper Alderson consists of the A, B, C and D units, while the lower Alderson consists of the E and F units. These stratigraphic units and their bounding surfaces are present in the Nexen Medhat core.

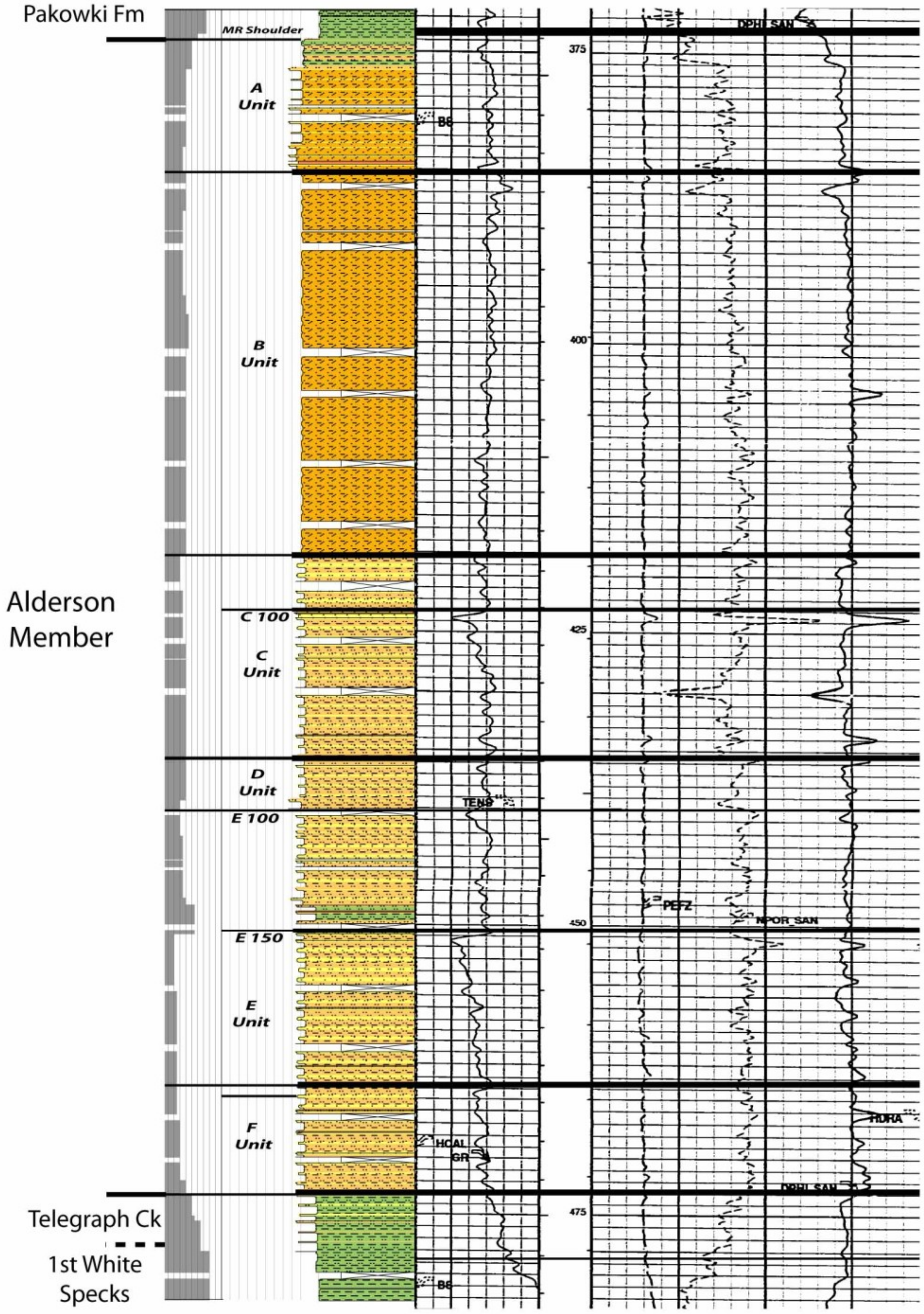
There are many stratigraphic surfaces within the Alderson member of Alberta and Saskatchewan that indicate regional discontinuities. These unconformity surfaces may be accompanied by hiatal deposits resulting from extended periods of non-deposition and erosion. The thickest hiatal deposits consist of reworked diagenetic concretions, usually set within a sideritic mud matrix, and are up to 1metre in thick. The concretionary fragments are up to 8 cm in diameter and consist of siderite-cemented muds, silts and sands. The clasts range from rounded to highly angular in shape, and these shapes reflect the rounded shapes of the original concretions from which they were derived, and the septarian fractures within those concretions. During erosion and re-deposition the concretions broke along these internal fractures giving rise to sharply angular edges. The siderite concretions frequently have bleached white rims indicating that the clasts were exposed to erosion, bleaching and encrustation on the sea floor. Armored clasts are also seen, indicating that the clasts were at times moved by seafloor processes. Accumulations of detrital glauconite are common within these accumulations, but exotic clasts such as chert or quartz pebbles are absent indicating that the formation of these deposits was entirely intraformational. There are four relatively thin hiatal deposits in the Nexen Medhat core. Several examples of hiatal deposits from other cores will be shown in this display, in addition to surfaces overlain by extraformational material, and surfaces showing evidence of subaerial exposure.

Alderson member sediments were derived from a series of sandy shoreline complexes that were present along regional shorelines to the south and the west. Work in progress by this author has described a shoreline equivalent of the Alderson member in outcrop in north-central Montana. These consist of several deltaic complexes that pass from tidally- dominated subtidal sand sheets into thin, muddy mass flow deposits in an offshore direction. The stratigraphic equivalent of this relationship has been correlated in the subsurface of Alberta and Saskatchewan and will be demonstrated here.

Reference

O'Connell, S. C. 2004
The Milk River Formation in southwestern Saskatchewan; a new stratigraphic scheme for the Alderson Member. CSPG CHOA CWLS Joint Conference, Calgary, Program and Abstracts.

Nexen Medhat 6-31-14-1w4
100/6-31-14-1w4



Lithological description of Nexen Medhat 6-31-14-1w4 with gamma - neutron/density log

Green = shale; yellow = sand; silt = orange

Clay content shown on table on left side; scale is 0 to 100%