

## **Depositional Model of Mission Canyon and Charles Stratigraphy East of the Nesson Anticline, Williston Basin: A New Perspective**

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### **Abstract**

The relationship between the individual parasequences of the Mission Canyon Fm east of the Nesson Anticline in North Dakota and Saskatchewan and the thick anhydrites that occupy the eastern margin of the Williston Basin has been described as deposition of anhydrite and supratidal sediments behind a topographic barrier separating open marine from salina depositional environments. An alternate model identifies a major regional erosional unconformity (Mission Canyon Regressive Surface; MCRS) separating the older Mission Canyon limestones from younger Mississippian anhydrites deposited within a continental seaway that projects north into Saskatchewan. Sea level fall in a falling stage system tract (FSST) led to stair-step erosion eastwards of each Mission Canyon parasequence, starting with the Rival Beds in Burke County, through the Bluell, Sherwood and Mohall Beds across Renville and Bottineau Counties, to the Alida Beds and possibly even into the Tilston Beds within the MCRS basin center. Erosion of the Mission Canyon to the east explains the absence of supratidal facies in the rock record. The greatest porosity identified in each Mission Canyon parasequence is located along each stair-step of erosion following long term subaerial erosion and exposure, creating vadose porosity, structures and textures. Oil and gas exploration has focused upon each of these steps in porous carbonates against up-dip anhydrite. In cores reviewed across this erosional surface, detrital carbonate sediments are typically deposited upon the underlying Mission Canyon, presumably washed off the uplands to the west. Up to 30m of basal detrital sediments are first deposited upon eroded Mission Canyon within the basin center, overlain by anhydrites with the thinnest bedded anhydrites at the top, just below the State A Marker. Basal detrital sediments include thick carbonate clastic sediments, siltstone and sandstone, finely laminated limestone and dense dolomite marker beds. Deposition of the anhydrite beds is clearly aggradational; dense lime mudstones, siltstone and sandstone separate the anhydrites with a rose colored weathered surface immediately below each overlying anhydrite bed. In total, up to 90m of detrital sediments and anhydrite are deposited upon this erosional surface below the State A marker in a well-defined north-south trending basin. The Mission Canyon parasequences dip westward at roughly 11m/km versus 10m/km for the anhydrites, including the State A Marker and overlying Frobisher Evaporite. Hence, the isopach of the State A to MCRS unconformity thickens dramatically to the east, while the State A to K1 Marker bed isopach thickens dramatically to the west, confirming two entirely different basins. Each and any anhydrite mapped may contact Mission Canyon parasequences across the MCRS unconformity at different stratigraphic levels, confirming aggradational infill of a hypersaline basin, much like the Devonian Prairie Evaporite Formation deposited in the Elk Point Basin. Deep erosional canyons spaced roughly 10km apart erode from southwest to northeast into the evaporite basin from uplands to the southwest in North Dakota into a basin center in W1 Saskatchewan. Erosion cuts progressively deeper down the canyons through Mission Canyon sediments to the lower Alida. Each of the five anhydrite beds and the basal detrital sediments recognized in the center of the anhydrite basin in North Dakota are clearly recognized within the deep erosional canyons. Steep paleotopographic ridges between canyons are preserved at the Sub-Mesozoic unconformity and trap significant quantities of oil. Several Alida oil pools partially eroded at the Sub-Mesozoic unconformity may have been erosional outliers, as seen in North

Dakota. The detrital sediments and evaporites, including the Frobisher Evaporite, are considered lower Charles Formation in age, as is the overlying Nesson limestone. The top of the Nesson is possibly the lower Charles sequence boundary. The overlying Midale, Ratcliffe and Poplar Beds represent upper Charles stratigraphy . The early explorers in the basin had it right.