Sequence Stratigraphic Correlation of the Bow Island Formation Using Surface Outcrop and Subsurface Data, Liberty and Hill Counties, Montana

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ABSTRACT

The Lower Cretaceous Bow Island Formation, a shallow gas producer across a wide area in north-central Montana, has received little sequence stratigraphic work. Whereas its correlative stratigraphic units, the Viking Formation of Alberta and the Muddy Formation of southeast Montana and Wyoming, have been extensively exploited for oil and gas and are, unsurprisingly, well studied. Although a few studies have described the stratigraphy and sedimentology of the Bow Island, none have directly tied stratigraphic sub units of the formation from the surface to the subsurface. A 260-foot stratigraphic section of the Bow Island was measured at section 15, T36N, R5E Liberty County, Montana. This area located on Dafoe Ranch exhibits a well exposed stratigraphic section. In this study, formation boundaries and stratigraphic subunits recognized in the measured section were correlated to well logs to describe and interpret changes in stratigraphy and sediment distribution throughout a 35-township area in north central Montana. Well logs from exploratory and producing wells provide the opportunity to tie the surface lithologies to the subsurface. Correlation of 814 wells located near East Butte and the surrounding area into Liberty and Hill counties are used to map surfaces recognized in outcrop in the subsurface. Formation and informal subunit tops were correlated across the area: the top of the Bow Island, middle Bow Island, lower Bow Island, and top of the Skull Creek Shale (base of the Bow Island). Four structure contour maps, three isopach maps and two models are made to illustrate the Bow Island Formation. The Bow Island is comprised of five sandstone units and four mudstone units, where sandstones coarsen upwards and are capped by mudstones marking a sequence boundary. Sequences coarsen-upward from offshore marine mud through prodelta or offshore transition sandy muds, to delta mouth bars and uppershorface trough-cross stratified sands and foreshore seaward inclined laminae. A previously recognized bed of chert-pebble lag gravel, at the boundary between middle Bow Island and the Shell Creek Shale marks a position of erosion and an Early Cretaceous eustatic drop in sea-level, interpreted as 2nd order sequence. Four 3rd to 5th order sequence boundaries within the measured section and well logs are recognized by flooding surfaces separating coarsening upward parasequences. The PANalytical TerraSpec Halo Mineral Identifier was used to describe the minerals within samples obtained from the exposed beds of the sediments in the Bow Island Formation to determine the cause for decreased production in wells throughout the Bow Island. Illites and micas are the predominant minerals throughout the column. A combination of processes (particle plugging, clay swelling, change in pH) lead to decreased permeability if reservoir rocks are exposed to water during drilling or by production from another zone.