Integrating outcrop and subsurface data to define regional and reservoir-scale patterns in the Lewis Shale and Fox Hills Sandstone of the Great Divide and Washakie basins, Wyoming

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ABSTRACT:

The Cretaceous Lewis Shale and Fox Hills Sandstone of the Great Divide and Washakie basins, Wyoming is a significant gas resource in the Rocky Mountains. Outcrops along the eastern margins of the basins provide a unique opportunity to resolve regional and reservoir-scale patterns in this complex system.

A regional cross section constructed using outcrop and subsurface data from the eastern margins of the Great Divide and Washakie basins reveal several large-scale attributes of the depositional system. Regionally continuous condensed sections in the Lewis Shale define southward-prograding clinoforms that are related to a graded shelf-slope-basin physiography during deposition. The condensed sections form the boundaries to fourth-order stratigraphic cycles/parasequences. The average height of the clinoforms is ~400 m (1300 ft), which is interpreted to reflect the minimum water depth during deposition.

Well log signatures and outcrop data reveal a consistent pattern for sandstone distribution along the physiographic profile of each of the fourth-order stratigraphic cycles. Strata with 50% or more sandstone are located in two physiographically distinct areas: (1) fluvial-deltaic strata on the topset of the clinoforms (shelf) and (2) submarine-fan strata near the bottomset of the clinoforms (base of slope). Slope strata, which occur on the foresets of clinoforms, contain only 15-20% sandstone, on average. Although the sandiest strata are located in shelf and base-of-slope strata, the depocenter of each fourth-order cycle is consistently located in muddy slope strata.

The prograding Lewis Shale depositional system was initiated by rock uplift and associated denudation and sediment bypass in the Lost Soldier, Granite Mountains, and Wind River areas. Flexural subsidence in the Greater Green River basin is associated with this uplift. During deposition of submarine-fan strata, sediment accumulation rates in the thickest parts of clinoforms exceeded basin-subsidence rate by more than two fold, resulting in rapid basinward progradation. A vertical profile through the Lewis Shale contains basin-floor strata in the lower part, slope strata in the middle, and shelf strata in the upper part. This vertical succession results from the southward progradation of the genetically related shelf-slope-basin system through time.

Four outcrops are described below to define how facies and stratigraphic architecture relate to physiographic position on a clinform. The outcrops document (1) shelf-edge strata, (2) slope strata, (3) proximal base-of-slope strata, and (4) medial base-

of-slope strata. Shelf-edge strata are >50% sandstone and are composed of channels, basinward-prograding bars, mudstone sheets, and large slumps. Slumps appear to be related to seafloor instability at the shelf. These deposits are interpreted to record a mechanism for generating sediment gravity flows that transmitted sandstone to the slope and base of slope positions. Incised valleys are not present in any shelf or shelf-edge exposures. The lack of incised valleys is thought to reflect the rapid subsidence rate. Slope strata are ~15-20% sandstone and are composed of mudstone that is locally truncated by submarine channels that display architectural and facies asymmetry. This asymmetry is interpreted to reflect channel sinuosity. A large proportion of the mudstone in slope strata is interpreted to be levee strata. Submarine canyons are not present in any of the slope exposures. Lack of submarine canyons is interpreted to reflect the rapid basinward progradation of the system. Proximal base-of-slope strata are ~50% sandstone and are composed of sandy submarine-fan strata consisting of slumps, amalgamated submarine channels, and turbidite lobes. Medial base-of-slope strata are >80% sandstone and are composed entirely of turbidite lobes. Since wire line logs and borehole images do not unequivocally reveal facies and stratigraphic architecture the patterns described above should prove useful for predicting stratigraphic architecture and facies in reservoirs where physiographic position can be documented on regional cross sections.