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Megaregional Correlation and Sequence Architecture of the Fox Hills Sandstone: Implications for Unconventional and Conventional Reservoir Prediction

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Summary:

The Campanian to Maastrichtian Fox Hills Sandstone records the terminal retreat of the Western Interior Seaway (WIS) in which shoreline sandstones regressed >1300 km in only 2 My. This forced-regressive sandstone unit is one of the best-exposed and most regionally exposed examples of a forced regressive shoreline deposits on Earth. The Fox Hills Sandstone is important for clarifying paleogeographic interpretations for the WIS (Fig. 1), but also provides considerable insight into the processes and products (oil/gas reservoirs) of forced regression.

Despite numerous local studies of the Fox Hills Sandstone, the transregional "source-to-sink" connection of the fluvial-to-marginal marine depositional systems is not documented. This study built an updated chronostratigraphic framework, and developed a transregional sequence-stratigraphic framework of the Fox Hills S.s. from Colorado to Montana that integrates biostratigraphic and geochronologic data (Figs 2 and 3). The framework produced in this project elucidates the fluvial feeder systems, shoreline orientations, facies, facies stacking and architectural elements of the Fox Hills forced-regressive shoreline sandstones. Seventeen facies define eleven depositional environments within the Fox Hills S.s. including: offshore marine, lower shoreface, middle shoreface, upper shoreface, pro-delta, delta front, delta plain, delta distributary channel, fluvial channel, estuary, and flood plain. Shifts in these facies and regional surfaces of truncation highlight two transregional unconformities (i.e., sequence boundaries) that define two incised valley systems. The two incised-valley systems were the primary sediment feeders for regressive shorelines of the Fox Hills S.s. The oldest incised valley system in Casper, WY fed three paleoshorelines that form a SE-prograding, flat-to-falling, progradational parasequence set. By contrast, the youngest incised valley system fed five paleoshorelines that form a NE-prograding, more vertically-stacked progradational parasequence set in Glendive, MT; NE to E of Glendive, MT the number of parasequences increases up to eight. In general, parasequencess are more numerous and more vertically stacked from SW-W to NE-E, indicating a NE-E increase in the ratio of accommodation to sediment supply. Accommodation in the Fox Hills system could be driven by eustasy, Sevier and Laramide tectonics, and/or dynamic subsidence migration (Liu et al., 2014). We infer a main control of migrating dynamic

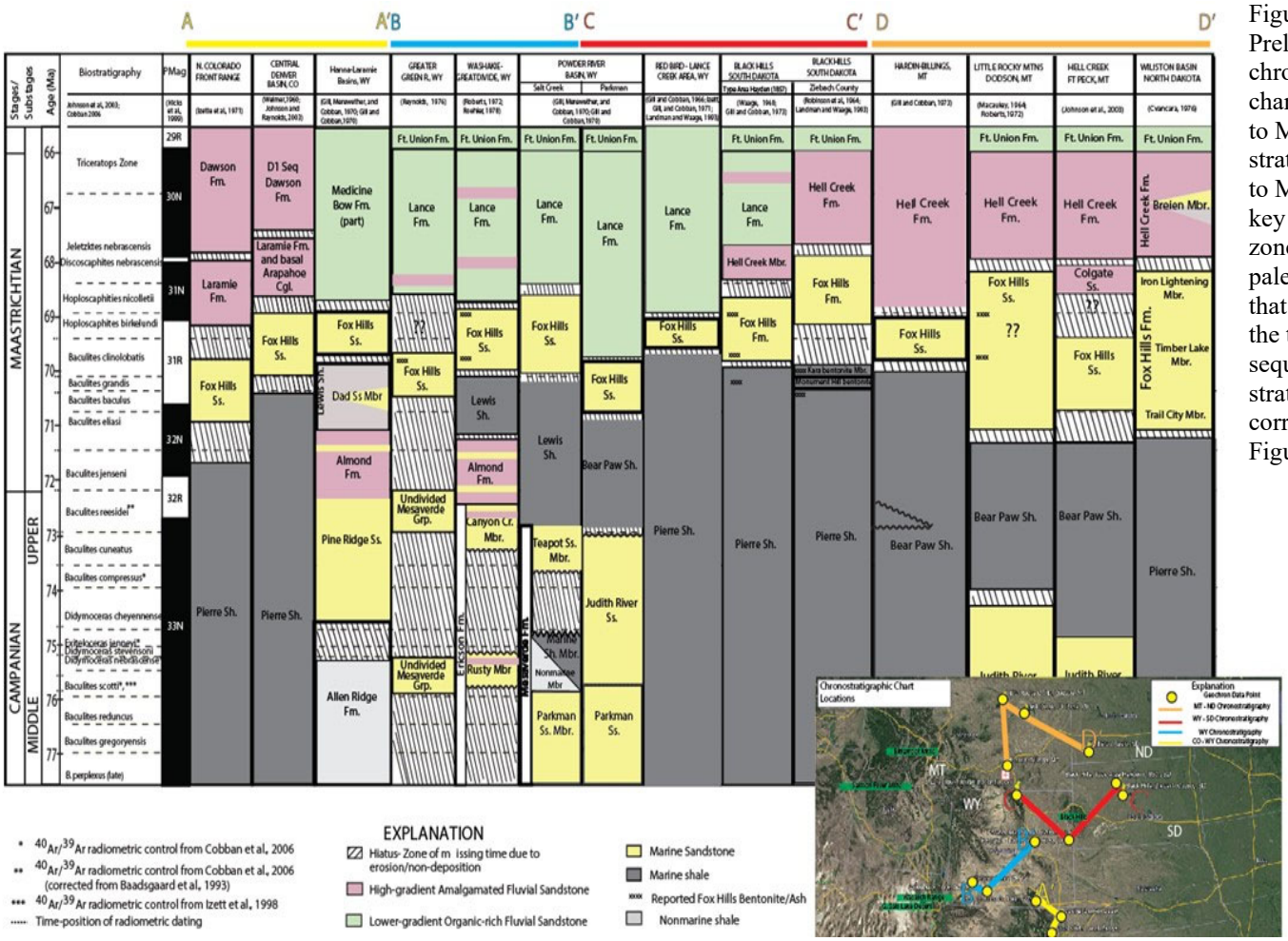

Figure 1. Preliminary chronostratigraphic chart for Campanian to Maastrichian strata from Colorado to Montana showing key biostratigraphic zones, ashes, and paleomagnetic zones that help constrain the transregional sequence stratigraphic correlation shown in Figure 2.

subsidence because: 1) the Fox Hills S.s. progrades a distance far greater than any Sevier- or Laramide-related flexural subsidence and 2) Fox Hills shorelines generally parallel dynamic basin-margins.

The project supported one of the first two graduate students in the Department of Geological Sciences at the University of Alaska, Anchorage. This student gained training in field- and core-based facies analysis, sequence stratigraphy, well-log interpretation and subsurface database management. The graduate student is in the final stages of writing his thesis supported by this research grant, and at least 1 publication is planned. This graduate student will begin an appointment with the USGS soon. Additionally, this project partially supported and undergraduate researcher who gained skills that made her a competitive graduate applicant. She is currently a PhD student at the University of Texas at Austin.

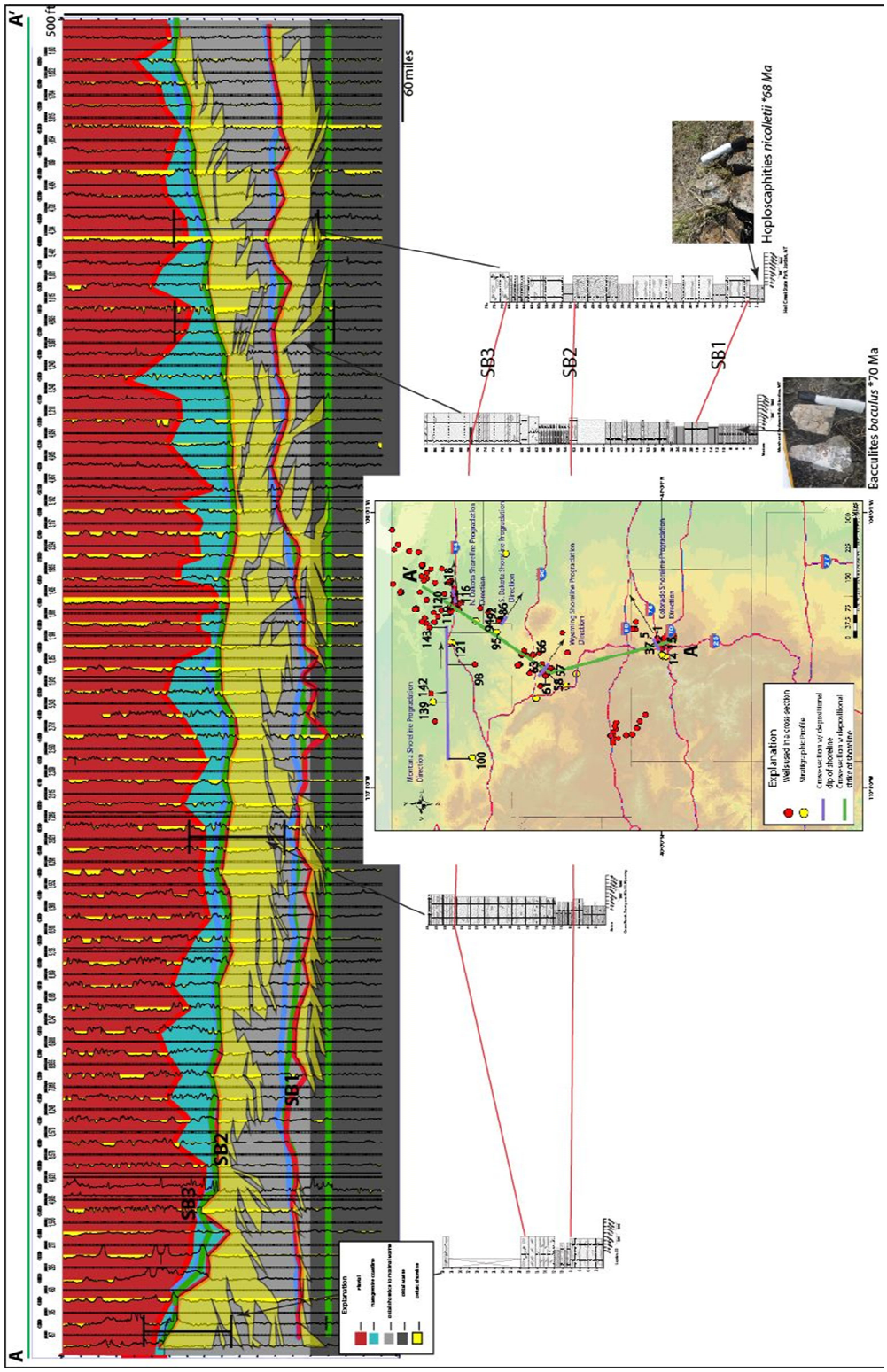

Figure 2. Transregional Sequence-Stratigraphic Framework elucidating the depositional strikes of deltaic shorelines and sandbody distribution. Stratigraphic columns indicate grainsize, depositional environments, location where measured, and arrows point to the horizon where *bacculites baculus* and *hoploscaphites nicolletti* were found. Pairing this chronostratigrapic data with the framework indicates the younger shoreline traveled over 200 km in less than 2 ma.