PRF Grant Number: 56442
Project Title: Discriminating Sediment Supply versus Accommodation Controls on Foreland Basin Stratigraphic Architecture in the Book Cliffs, Central Utah Using Detrital Double Dating
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During the past academic year, this grant supported three graduate students and an undergraduate student. The work performed by this team resulted in one publication (Bartschi et al., 2018) and an additional publication that is accepted and in revision (Odoh et al., accepted). The two student first-authors of these papers have finished their master's degrees. The grant also supported a Ph.D. student, Tyson Smith, and an undergraduate student, Kendall Hatfield. Grant support for Mr. Smith resulted in one paper submitted to Basin Research (Smith et al., in review). Finally, support for Mr. Hatfield enabled him to finish an undergraduate research project which was presented at the University of Houston Student Research Day (Hatfield et al., 2018).

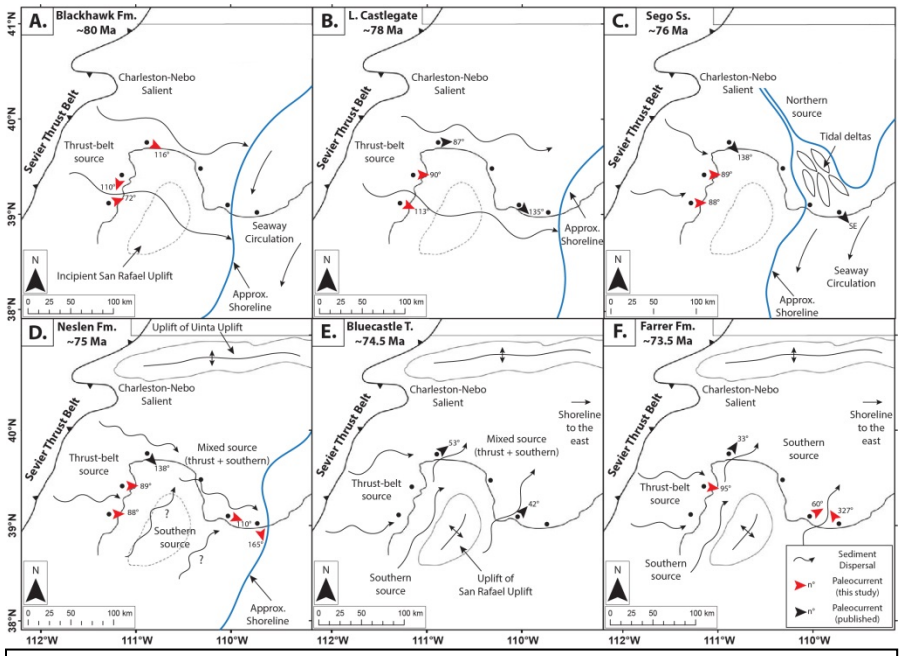

Figure 1. Reconstruction of sediment dispersal patterns in the Book Cliffs study area from ca. 80 to 73.5 Ma

In the Book Cliffs, new U-Pb radiometric ages of zircon crystals from sandstones demonstrate that there were rapid changes in sediment provenance between 80 and ~73.5 million years ago. Specifically, the new data show that during deposition of the Blackhawk Formation and Lower Castlegate Sandstone sand was derived primarily from the Sevier fold-thrust belt to the west of the Book Cliffs (Figure 1A and 1B). However, during rapid progradation and deposition of the Sego Sandstone there was additional mixture of material from a northern source in the easternmost Book Cliffs (Figure 1C). We attribute the disappearance of the northern source to uplift of the Unita Mountains to the north of the Book Cliffs (Figure 1D), which was coincident with increased tectonically driven erosion (and therefore sediment influx) in the Charlestone-Nebo Salient (Figure 1D). Finally, and at the same time as these previous events, we see an increase in southern-sourced sand (Figure 1D). Once this southern source appears in the record, its persists and its importance increases through time (Figure 1 E and 1 F).

Because the Book Cliffs is the cradle of outcrop-based sequence stratigraphic concepts, this research sheds new light on the reasons for development of stratigraphic sequences in this classic location. Specifically, it suggests that stratigraphic sequences and rapid progradation are, at least in part, a function of the rate of sediment influx. Increases in sediment influx, due to contributions from multiple sediment sources, or tectonically driven increases in erosion result in development of stratigraphic sequence boundaries and rapid progradation. This is consistent with observations based on numerical modelling , but has rarely been identified in empirical studies. This research provides a mechanism apart from base-level fall to account for rapid progradation between 76 and 75 million years ago in the Western Interior Basin.

The success of this research led us to pursue applications in other tectonic settings. In the Eastern Cordillera of Colombia, we documented rapid progradation and deposition of coarse-grained sandstones and conglomerate associated with periods of accelerated tectonic exhumation and introduction of new sediment sources in the sediment dispersal system. Specifically, coarse progradation associated with the Mirador and Guayabo formations are associated with increases in tectonically driven erosion rate and as well as introduction of identifiable Upper Cretaceous and Lower Cretaceous sedimentary sources, respectively (Figure 2, Odoh et al., accepted).

Both the previous examples involve very short transit distance from the sediment source to its ultimate depositional sink. However, the direct connections between tectonic activity and both sediment caliber and progradation rate led us to examine the impact of tectonic activity on transport of sediment via large, transcontinental river systems to a far distant marine depositional site. We therefore explored links between the western USA and the Gulf of Mexico during the early Cenozoic. In this setting we found the unexpected result that periods of tectonic activity in New Mexico were correlated with a decrease in sediment derived from New Mexico in the Gulf of Mexico (Smith et al., in review). We attributed this unexpected result to basin formation along the pathway of the large transcontinental river (the El Rito-Galisteo Basin and associated Laramide basins). The implication is that formation of intraplate basins may disrupt the expected relationship between increased tectonic activity and coarse-grained deposition and rapid progradation in associated basins.

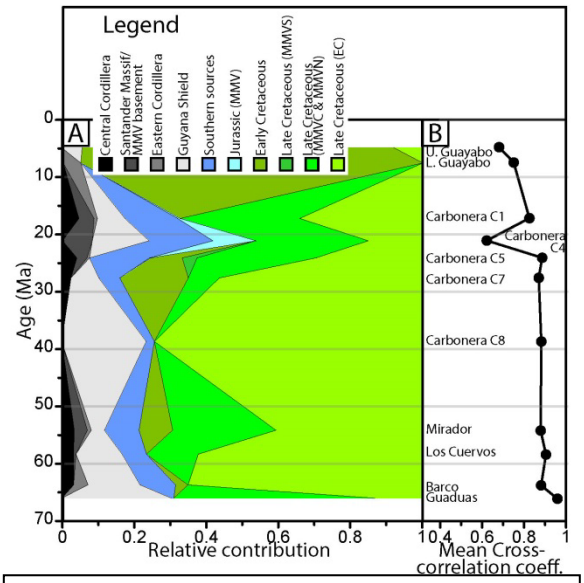

Figure 2. Relative contributions from potential source regions based on the inverse mixture model of Sundell and Saylor (2017).

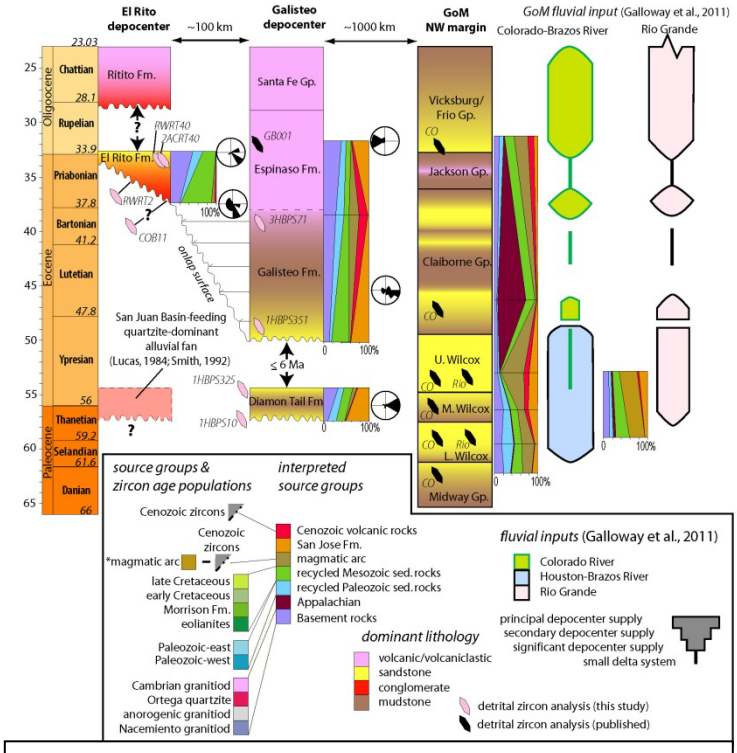

Figure 3. Chronostratigraphy, dominant lithologies, and interpreted source contributions for the El Rito depocenter, Galisteo depocenter, and the northwest margin of the Gulf of Mexico with approximate separation distances displayed

Works Cited

Bartschi, N.C., Saylor, J.E., Lapen, T.J., Blum, M.D., Pettit, B., Andrea, R.A., 2018. Tectonic controls on Late Cretaceous sediment provenance and stratigraphic architecture in the Book Cliffs, Utah. Geological Society of America Bulletin.

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