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SIGNIFICANT RESULTS IN LAYMAN'S TERMS

- Documentation of relative sea-level history during Mississippian time (~350 million yrs ago).
- Documentation of relative effects of subsidence versus inferred sea-level fluctuations on sediment accumulation.
- Developed a conceptual model for the tectonic response of the North American craton (Montana-Idaho region) during the Antler orogeny.
- Documented the diagenetic history of the Mission Canyon Formation in Montana.
- Provided an alternative model (meteoric alteration under shallow burial conditions) that might explain the petrographic and geochemical characteristics of many ancient dolomite sequences.
- Tested the utility of rare earth elements as a geochemical tracer for diagenetic alteration of carbonate rocks.

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Department of Geology
College Station, TX 77843

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Title: Sedimentologic and Diagenetic History of the Mission Canyon Formation (Mississippian) and Stratigraphic Equivalents, Southwestern Montana and East-central Idaho and Determination of Rare Earth Element Abundances in Diagenetic Carbonates

Person in Charge: S.L. Dorobek (409-845-0635)
FAX: 409-845-6162

The Mission Canyon Formation and its stratigraphic equivalents in Montana and Idaho were deposited during collision of the western continental margin of North America with an inferred volcanic arc (Antler orogeny). An integrated petrographic and geochemical study of the diagenetic history of the Mission Canyon Formation was carried out within the sedimentologic context established by field studies. Petrographic and geochemical data from individual diagenetic phases were used to interpret extent of diagenetic alteration, sources of ions incorporated into cements, and paleohydrology of diagenetic fluids.

We have documented third- to fifth-order scale (10^6 to 10^4 yr) cyclic sedimentary sequences in shallow platform to deep basin environments. The third-order cycles have been correlated from the Antler foredeep, across the platform, and into the Williston Basin to the east, an area approximately 1200 km wide (nonpalinspastic). From this analysis, were constructed a detailed sequence stratigraphic model for the Mission Canyon Formation and its stratigraphic equivalents from southwestern Montana to east-central Idaho.

We also completed a regional study of Late Devonian through late Mississippian subsidence in Montana and Idaho. These analyses have shown that subsidence events in the Antler foredeep and on the Montana platform are coupled. Differential subsidence on the cratonic platform is related to reactivation of Proterozoic fault patterns and an inferred changing stress field during the Antler orogeny. Conceptual geodynamic models for the coupled response of the proximal foredeep and adjacent cratonic platform incorporate flexure (vertical loading) and in-plane stresses (horizontal loading). Subsidence analyses suggest that the large-scale sequence stacking patterns within the Devonian-Mississippian platform stratigraphy probably are caused by spatial and temporal changes in subsidence, not by long-term sea level fluctuations.

Regional petrographic and geochemical trends in carbonate diagenetic phases also have been documented in the Mission Canyon Formation. Extensive meteoric diagenesis was related to regional subaerial exposure of the entire platform during post-Mission Canyon time. Meteoric groundwaters caused recrystallization of early-formed dolomites and precipitated calcite cements that occluded most porosity in the Mission Canyon Formation. Petrographic and geochemical data from Mission Canyon dolomites allow identification of two end-member dolomite types: 1) precursor "evaporative" dolomite (zoned to irregular cathodoluminescence, Ca-rich, variable $\delta^{13}\text{C}$, positive $\delta^{18}\text{O}$, enriched trace element content); and 2) meteorically altered dolomite (homogeneous nonluminescence, stoichiometric, invariant $\delta^{13}\text{C}$, negative $\delta^{18}\text{O}$, low trace element content). Most dolomites are intermediate in composition between these two end members. These data suggest that the chemistry and petrography of many ancient dolomites might be

explained by an episode of shallow burial meteoric alteration. Another important aspect of research on the diagenetic history of the Mission Canyon Formation has been utilization of rare earth element (REE) abundances in diagenetic phases as a geochemical tracer. The REE have proven useful as indicators of redox potential in pore fluids. Because of their extremely low concentrations in most natural solutions, very high fluid-rock ratios are required to produce REE abundances in diagenetic phases which are much different from those of the original carbonate sediment. Therefore, the REE may provide an additional constraint on the amount of fluid-rock interaction in carbonate diagenetic systems.