Using PHAST Reaction-Transport Modeling to Study the Formation of Zebra Limestone

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Zebra rock formation is often associated with carbonate-hosted lead-zinc Mississippi Valley Type (MVT) ore deposits and hydrothermal dolomite-hosted hydrocarbon reservoirs. These features are controlled by complex interactions between fluid chemistry, temperature, and pressure. Theoretically, such conditions can be reconstructed using Reaction-Transport Modeling (RTM), which simultaneously simulates solute transport and geochemical reactions. However, most RTMs are developed to address specific case studies, often requiring custom code or proprietary software. This presents limitations such as low computational efficiency, limited portability across platforms, and poor documentation, ultimately making these models difficult for other researchers to reuse or adapt.

PHAST, a modeling tool that integrates PHREEQC, a geochemical modeling software with HST3D, a solute transport model, is a free and open-source program developed by the USGS. It is designed to simulate three-dimensional groundwater flow, solute transport, and multicomponent geochemical reactions. PHAST offers a user-friendly interface, accessible tutorials, and multithreaded processing, which improves computational performance. These advantages raise the question of whether PHAST can be applied more broadly, for instance, to simulate the geochemical processes involved in ore deposit formation.

This study aims to adapt PHAST to predict the development of zebra limestone, which is characterized by alternating millimeter- to centimeter-scale bands of light and dark calcite crystals. These features have been observed at the Gypsum Valley salt diapir in the Paradox Basin, Colorado. By using PHAST, we explore whether this tool can be utilized to yield insights into ore formation processes.