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The Péclet and Damköhler numbers relationship with mineralization textures and ore grade

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In order to meet the increasing resource demands associated with the shift towards a green, circular economy, we need a better understanding of what controls ore deposition. Clastic-dominated (CD-type) deposits contain a significant proportion of the global resources of Zn, Pb, and Ag. Some of the largest CD-type deposits formed through subseafloor replacement of diagenetic carbonate, resulting in highly variable mineralization textures. The models presented here demonstrate the association between mineral kinetics and flow rate with mineralization textures. Dissolution patterns in carbonate units can be constrained by dimensionless parameters (Péclet and Damköhler numbers) that represent fundamental properties of reactive flow. Using reaction transport modeling of a CD-type deposit, this work investigates the relationships between Péclet and Damköhler numbers with textures and ore grades. In 1-D and 2-D simulations, a Zn-rich brine reacted with a host rock at variable rates of fluid flow and dolomite dissolution, resulting in different mineralization textures depending on the spatial relationship of the inflowing brine to the reaction front and the flow and dolomite dissolution rate. Ahead of the front, disseminated textures developed at low Damköhler numbers. At, or behind, the front where the Damköhler number was higher, massive or interfingered textures formed, depending on the Péclet number. The shift between massive (higher-grade) to interfingering to disseminated (lower-grade) mineralization caused a correlation between Damköhler and Péclet numbers with ore grade. Therefore, understanding the implications of Damköhler and Péclet numbers can help in interpreting textures on a hand-sample to outcrop scale and patterns of grade and ore geometry. While the models were based on a CD deposit, the use of Damköhler and Péclet numbers is theoretically transferrable to other hydrothermal systems.