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Reactive transport modeling of ferroan dolomitization by seawater interaction with mafic igneous dikes and carbonate host rock at the Latemar platform, Italy

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The Middle Triassic Latemar carbonate platform, northern Italy, has featured prominently in the longstanding debate regarding dolomite petrogenesis [1–4]. Recent studies agree that ferroan and non-ferroan dolomite replaced calcite in limestone during reactive fluid flow at <0.1 GPa and 40–80°C. Regional igneous activity drove heating that provided kinetically favorable conditions for the replacement reaction. However, the origin of the dolomitizing fluid is unclear. Seawater may have been an important component, but its Fe concentrations are insufficient to account for ferroan dolomite.

New field, petrographic, XRD, and geochemical data document a spatial, temporal, and geochemical link between ferroan replacement dolomite and altered mafic igneous dikes that densely intrude the platform. A critical observation is that ferroan dolomite abundances increase towards the dikes. We hypothesize that seawater interacted with mafic minerals in the dikes, leading to Fe enrichment in the fluid that subsequently participated in dolomitization. This requires that dolomite formation was preceded by dike alteration reactions that liberated Fe and did not consume Mg. Another requirement is that ferroan and non-ferroan dolomite (instead of other Fe- and Mg-bearing minerals) formed during fluid circulation within limestone host rock.

We present reactive transport numerical simulations (Coores–Arxim, [5]) that predict equilibrium mineral assemblages and the evolution of fluid dolomitizing potential from dike crystallization, through dike alteration by seawater, to replacement dolomitization in carbonate host rock. The simulations are constrained by observations. A major advantage of the simulations is that stable mineral assemblages are identified based on a forward modeling approach. In addition, the dominant igneous minerals (plagioclase, clinopyroxene olivine and their alteration products) are solid solutions. Most reactive transport simulations of carbonate petrogenesis do not share these benefits (e.g. [6]).

Predicted alteration mineral assemblages are consistent with observations on dikes and with ferroan and non-ferroan dolomite genesis. The simulation results also show that fluid dolomitizing potential (Mg/Ca and Fe/Mg) increases during dissolution of igneous solid solution minerals. Enrichment in fluid Fe concentration is sufficient to stabilize ferroan replacement dolomite. Consistent with field observations, ferroan dolomite forms closest to dikes due to the abundance of Fe associated with the dikes. This leads to depletion of Fe in fluid flowing away from dikes and formation of non-ferroan replacement dolomite further afield.

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