

The origin of replacement dolomite, Dolomites, northern Italy: Part 2

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Analysis of the spatial distribution of elements, isotopes, and heat with transport theory leads to insights into the flow system that produced dolomite (Dol) in the Latemar buildup. From Part 1, Dol typically replaced calcite (Cal) in limestone by $2\text{Cal} + 0.89\text{Mg}^{2+} + 0.01\text{Fe}^{2+} = \text{Dol} + 0.90\text{Ca}^{2+}$. Constraints (Part 1) of a dolomitizing fluid with seawater-like salinity, $\text{Ca}/\text{Mg} < 0.75$ (for dolomitization at $\approx 75^\circ\text{C}$), and significant Fe, Mn, and Zn point to fluid similar in chemistry and T to modern diffuse effluent. The development of Dol over a distance ≈ 1 km along the inferred flow path then requires, by mass balance of Ca and Mg, a time-integrated fluid flux (q) $\approx 10^8 \text{ cm}^3 \text{ fluid}/\text{cm}^2 \text{ rock}$. Given the composition and amount of fluid, spatial distributions of isotope compositions were computed from the advection-diffusion equation. Carbonate rock is predicted to have equilibrated with respect to ^{18}O - ^{16}O , ^{87}Sr - ^{86}Sr , and ^{13}C - ^{12}C exchange with dolomitizing fluid over distances 850x, 24x, and 0.11x the extent of dolomitization along the flow path. Near Dol-limestone interfaces, $\delta^{13}\text{C}_{\text{Dol}}$ thus is simply inherited from the limestone parent (confirmed by data in Part 1) while $(^{87}\text{Sr}/^{86}\text{Sr})_{\text{Dol}}$ and $\delta^{18}\text{O}_{\text{Dol}}$ correspond to equilibration with the dolomitizing fluid. Measured $(^{87}\text{Sr}/^{86}\text{Sr})_{\text{Dol}}$ is evidence for a Middle Triassic seawater-derived fluid and $\delta^{18}\text{O}_{\text{Dol}}$ records the T of dolomitization (Part 1). The elevated T recorded by $\delta^{18}\text{O}_{\text{Cal}}$ (Part 1), indicates physical limits of the flow channels extended into limestone adjacent to Dol and that flow in the limestone occurred at lower T. Ranges in $\delta^{18}\text{O}_{\text{Dol}}$ within individual outcrops almost as large as for all analyzed samples is qualitative evidence that fluid flow occurred in multiple pulses of limited spatial extent and at variable T. Profiles in $\delta^{18}\text{O}_{\text{Dol}}$ across some vertical flow channels record steep gradients in $T \approx 10\text{-}25^\circ\text{C}/\text{m}$. Quantitative analysis of the T profiles with the heat equation suggests that individual flow pulses had $q \approx 2 \cdot 10^5 \text{ cm}^3/\text{cm}^2$ and a duration of ≈ 0.5 y. Dolomitization in the area was accomplished by ≈ 500 flow pulses over a total duration of flow and reaction only ≈ 300 y. The occurrence of 10-15% porosity in many Dol samples confirms that most (but not all) Dol replaced Cal at constant C rather than at constant volume. Replacement at constant volume does not make geochemical sense because even $q \approx 10^8 \text{ cm}^3 \text{ fluid}/\text{cm}^2 \text{ rock}$ is inadequate to transport the necessary amount of dissolved C.

Geochemistry, mineralogy, and chronology of K-metasomatism of volcanic rocks near Socorro, New Mexico, USA

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Potassium metasomatism, thought to be caused by deep circulation of alkaline-saline brines, affects an area of roughly 1000 km² near Socorro, New Mexico, increasing the K₂O content of local volcanic rocks by up to 10 wt.%. Petrographic and microbeam analyses indicate that during the chemical changes associated with metasomatism, Na-rich phases, primarily plagioclase, are dissolved and replaced by secondary mineral phases, mainly adularia and clay minerals. Bulk geochemical analyses of altered rocks compared to fresh rocks demonstrate consistent chemical patterns, including enrichments of K₂O, Fe₂O₃, As, Rb, Pb, Sb, Ba, and Cs and depletions of MgO, CaO, Na₂O, Eu and Sr. Analyses of alteration phases hand-picked from relict plagioclase grains provide the clearest picture of the chemical processes that occur during alteration, and allow quantitative correlations between the presence of alteration phases and the abundance of elements such as K₂O, Rb, CaO, Na₂O, Eu and Sr. This analysis also suggests that variations of elements such as As, Pb, Sb, Ba, and Cs are related to hydrothermal alteration, either overprinting, or overprinted by, potassic metasomatism. A final chemical signature observed in hand-picked alteration mineral suites is that the REE content of samples from a low-REE rock unit increase during metasomatism, whereas there is a significant decrease in samples from a unit with higher initial REE contents, suggesting that the variation in REE contents may be related to equilibration between the rocks and the metasomatizing fluid. Results suggest that the enrichment of REE may be roughly related to the abundance of metasomatism-derived clay minerals in the sample.

The chronology of metasomatism determined by ⁴⁰Ar/³⁹Ar analysis of hand-picked secondary potassium feldspar, indicates that metasomatic alteration began at around 15 Ma, and continued to around 7 Ma. The areas that show the most intense effects of alteration yield the youngest ages, suggesting that this may represent the deepest, most central and longest-lived part of the playa system. The age range determined here is consistent with inferred timing of playa deposition from independent geological evidence.