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 2Cal + $0.89Mg^{2+}$ + $0.01Fe^{2+}$ = Dol + $0.90Ca^{2+}$. Constraints (Part 1) of a dolomitizing fluid with seawater-like salinity, Ca/Mg<0.75 (for dolomitiza-tion at ≈75°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) ≈10^8 cm^3 fluid/cm^2 rock. Given the composition and amount of fluid, spatial distri-butions 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, $\delta^{13}C_{Dol}$ thus is simply inherited from the limestone parent (confirmed by data in Part 1) while $(^{87}Sr/^{86}Sr)_{Dol}$ and $\delta^{18}O_{Dol}$ correspond to equilibration with the dolomitizing fluid. Measured $(^{87}Sr/^{86}Sr)_{Dol}$ is evidence for a Middle Triassic seawater-derived fluid and $\delta^{18}O_{Dol}$ records the T of dolomitization (Part 1). The elevated T recorded by $\delta^{18}O_{Cal}$ (Part 1), indi-cates that physical limits of the flow channels extended into limestone adjacent to Dol and that flow in the lime-stone occurred at lower T. Ranges in $\delta^{18}O_{Dol}$ within individ-ual 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 $\delta^{18}O_{Dol}$ across some vertical flow channels record steep gradients in T ≈10-25°C/m. Quantitative analysis of the T profiles with the heat equation suggests that individual flow pulses had q ≈$2{\cdot}10^5$ cm^3/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≈10^8 cm^3 fluid/cm^2 rock is inadequate to transport the necessary amount of dissolved C.