

O isotope exchange during the breakdown of dolomite: An experimental study

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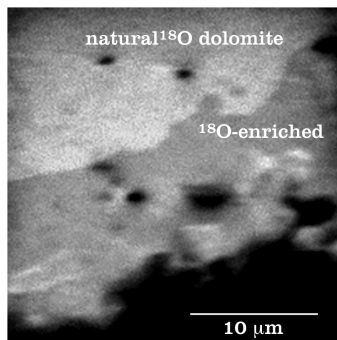
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Dolomite commonly breaks down to periclase + calcite in the presence of an H₂O-rich fluid in contact-metamorphic environments. We investigated the kinetics of the reaction in dolomite rock samples experimentally to determine whether ¹⁸O from the external fluid exchanged only with the neomorphic calcite and periclase or whether exchange between the fluid and preexisting dolomite occurred as well. We sealed 4×6 mm cylinders of rock in gold capsules with an aliquot of ¹⁸O enriched H₂O and heated the capsule to 700 °C at 100 MPa for a period of up to 8 weeks. Samples were examined after experimentation by electron and ion probe techniques. The x-ray images indicated that some reaction took place along grain boundaries, even in the interiors of the sample. Ion images of the reacted sample were obtained from Cameca 4f, 7f, and 1280 ion probes to determine the distribution of ¹⁸O. Calcite produced during reaction showed an enrichment in ¹⁸O wherever the breakdown reaction had occurred. In addition, the dolomite shows a distinct 5–10µm-wide zone adjacent to the grain boundary that is also enriched in ¹⁸O (figure right). Point analyses across the exchanged zone at a scale of 1 µm indicate that the boundary between the exchanged and unexchanged dolomite is a step, although there is some indication of a diffusion profile at the boundary. That step suggests that the exchange occurred by solution–reprecipitation, but there is no secondary porosity or optical misorientation found. It appears that H₂O does it again, greatly facilitating isotope exchange between a fluid and a preexisting mineral grain.



SIMS ion image showing ¹⁶O/(¹⁶O + ¹⁸O) in dolomite near grain boundary (black).

Evolution of the basal dense magma ocean: The ultimate deep mantle rug!

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Since the discovery of the ultralow velocity zones in the lowermost mantle, evidences for the presence of partial melt at the bottom of the mantle have continually accumulated. The maintenance of the magnetic field for at least 3.2 Gyr requires cooling of the core over that period and implies an even larger quantity of melt in the lowermost mantle in the past than at present. We investigated the implications of such an hypothesis in terms of thermal and chemical evolution of the mantle and found that it can offer a explanation for several different observations. The crystallization of melt, controlled by the energy balance, is exponential to first order, with a time scale of about 1Gyr. The melt is denser than the overlying solid that crystallizes from it, due to a larger Fe content. In addition, the huge viscosity contrast renders entrainment of melt by convection in the mantle negligible, preventing any sampling through surface magmatism. The melt is then the ideal hidden reservoir and can contain about 20% of the Earth's budget in incompatible elements. Moreover, because of the difference between the partitioning coefficients of Sm and Nd at high pressure, the evolution of the deep magma ocean-mantle system naturally generates the observed $\epsilon^{143}\text{Nd}$ in mantle derived rocks and explains the systematic of chondrites with all terrestrial samples in $\epsilon^{142}\text{Nd}$. The existence of melt in the lowermost mantle for most of Earth's history, deduced from geophysical arguments offers a solution for some of the long-standing geochemical paradoxes of the Earth's mantle.