

Experiments on hydrous carbonated sediment interaction with peridotite under supersolidus conditions at 6-10 GPa

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To gain better insight into processes in deep subduction zones, the interaction between sediment and peridotite was experimentally studied at 6-10 GPa and 900-1400°C in a multianvil apparatus. Two synthetic materials similar to the GLOSS composition of Plank & Langmuir (1998, Chemical Geology, 145: 325-394) with both H₂O and CO₂ and with differing K/Na ratios were used as model sediment starting materials. The peridotite material was a mixture of natural olivine, orthopyroxene and garnet separates from a peridotite xenolith. Sediment (bottom) and peridotite (top) were packed into a Re-lined Pt capsule and run at pressure and temperature for 24-72 h. In order to distinguish the effect of peridotite on sediment melting, several experiments were conducted with pure sediment mixtures. Run products were analysed by electron microprobe.

Pure sediment melting produces carbonate-rich melts near the solidus and SiO₂ richer liquids at higher temperatures. The residual mineral assemblage is dominated by coesite/stishovite, kyanite and jadeite-rich pyroxene. Peridotite-sediment interaction results in (1) rapid replacement of olivine in the peridotite zone by low-Ca pyroxene and magnesite (the latter disappears at increasing temperature and run duration????), (2) formation of a transitional garnet-rich zone containing low-Ca pyroxene and silica, (3) disappearance of kyanite and stabilization of carbonate in the sediment layer. The peridotite zone is transformed into a low-Ca pyroxene-garnet aggregate, whose garnet/pyroxene ratio increases with increasing temperature. The sediment zone evolves with increasing temperature from coesite/stishovite + jadeite + garnet + carbonate + rutile to coesite/stishovite + jadeite + garnet. Partial melting is accompanied by a series of mineral reactions, the most important among which are (Mg,Fe)₂SiO₄ + CO₂ = (Mg,Fe)SiO₃ + (Mg,Fe)CO₃ and (Mg,Fe)₂SiO₄ + SiO₂ (melt) = 2(Mg,Fe)SiO₃ in peridotite and Al₂SiO₅ + 2SiO₂ + 3(Mg,Fe,Ca)O (melt) = (Mg,Fe,Ca)₃Al₂Si₃O₁₂ and Al₂SiO₅ + 2SiO₂ + 3(Mg,Fe)CO₃ = (Mg,Fe)₃Al₂Si₃O₁₂ + CO₂ in sediment. Mass transfer is dominated by the transport of Si from sediment to peridotite and divalent cations from peridotite to sediment. The composition of melt produced in the layered experiments differs from that from pure sediment melting in higher Mg and Si contents and much lower Ca.

Interaction with peridotite may be important for the development of metasomatising melts (fluids) in subducted sediments. The high stability of jadeitic pyroxene in the transitional zone and altered sediment diminishes Na mobility and leads to the formation of high K/Na liquids. The increasing stability of carbonate in metasediment is favourable for deep CO₂ recycling and decoupling of H₂O and CO₂. The formation of a garnet-rich reaction zone and replacement of “sterile” olivine and kyanite by more capacious pyroxene and garnet will significantly increase element fractionation in the produced melts (fluids).