

Geochemical and lithological processing of oceanic crust during subduction to fore-arc depths

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The transfer of volatiles and incompatible elements from subducting slab to volcanic arcs possibly represents the most fundamental chemical recycling process on Earth, yet many aspects of this process remain poorly understood. Combining information gained from high pressure (HP) terranes that represent previously subducted crust, with HP hydrothermal experiments, we gain important insights into the nature of subduction-zone processes. The blueschist to eclogite-facies terrane from northern New Caledonia (P~2.0 GPa, T~600°C) is composed of complex melange of HP rocks with hybrid talc-chlorite rocks formed between ultramafic and mafic or metasedimentary rocks. Geochemical analysis of a range of rock-types reveals that there is large variety of mafic protoliths, and the mafic and pelitic rocks experienced limited trace-element loss during dehydration associated with eclogite-facies metamorphism. The large variation in mafic protoliths and complex melange structure of the New Caledonia HP rocks indicates that subducting oceanic crust may be lithological and geochemically variable; a point which should be considered during geochemical or geophysical modelling of subduction processes.

Hydrothermal piston-cylinder experiments conducted on a synthetic, trace-element doped pelite have been designed to trap hydrous fluids/melts at HP as inclusions in recrystallizing quartz. Experiments at 2.2 GPa reveal that the wet solidus for pelite is located at 675°C, with hydrous fluid coexisting with pelite below the solidus and hydrous fluid, hydrous melt and pelite residue coexisting above the solidus, at least to 750 °C. Laser-ablation ICP-MS analysis of the fluids from experiments at 600°C and 650°C reveal that subsolidus fluids are surprisingly dilute.

Based on our results, we suggest that metamorphic dehydration of oceanic crust subducted to fore-arc depths causes minimal element loss from mafic or pelitic rocks, allowing efficient recycling of many incompatible trace elements (LILE, U, LREE) at least to subarc (90-150 km) depths. Volatiles may be stored in serpentinite and newly-formed hybrid rock-types (talc-chlorite schists), which may be stable to relatively high P and T conditions. Devolatilization of these rocks at sub-arc depths may induce fluid-present melting of pelitic and/or mafic rocks. The melts produced may be important agents for transferring trace elements and volatiles from the slab to arc magmas.