Experimental characterization of mantle wedge-metasomatism by sediment-peridotite reaction in subduction zones

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The subduction of oceanic crust may be accompanied by the burial of an average of 300-500 m of sediment. During subduction metamorphism, sediments heat up and dehydrate or partially melt. Progressive fluid release from the slab metasomatizes the fore-arc mantle wedge, forming serpentinite at low temperatures, while hydrous melting of sediments commences at ~700 ºC. These partial melts of sediment rise and react with the fore-arc mantle wedge to produce phlogopite pyroxenites in front of the arc magma generation zone.

In this study, we present experiments investigating the reaction between marine sediment and peridotite at 2–6 GPa/750–1100 ºC, corresponding to conditions at the surface of a subducting slab beneath the fore-arc and arc. We use novel LA-ICP-TOFMS element mapping of the reaction products to visualize the behaviour of trace elements during mantle metasomatism caused by melting of hydrous sediments. The reaction leads to separation of elements, and re-arrangement into a layered assemblage involving metasomatic phases including phlogopite, clinopyroxene, orthopyroxene, and magnesite. The selective enrichment of major and trace elements into these metasomatic phases closely resembles geochemical patterns that are characteristic for post-collisional K-rich magmas, thus resolving an enigmatic magmatic igneous suite.

We also estimate the rates of melt infiltration by means of an experimental series with varying experimental duration. Melt infiltration rates are found to range from 1–5 m/ky – about one order of magnitude lower than plate subduction rates. Our results are the first direct experimental evidence of metasome growth within the fore-arc mantle.