2D geochemical-thermomechanical modelling of Pb, Hf, Sr and Nd isotopes evolution in intra-ocean subduction zones

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Isotopes behave differently in different processes involved in a subduction zone such as slab dehydration, mantle wedge hydration and partial melting. Therefore, they are indicative of when and where different processes are active. The aim of this study is to extend the 2D coupled petrological-thermomechanical numerical model (I2ELVIS) of intra–oceanic subduction processes to include a treatment of isotopic signatures. With this extension we hope to gain more insights into the recycling system within the mantle wedge and are able to visualize the interaction between slab components and the depleted mantle. This will allow us to draw conclusions form isotopic signatures in arc lavas about the involved chemical processes.

A chemical contamination of slab components with wedge peridotite leads to specified signatures in arc magmas. Two slab components play a key role in this contamination: first, the altered oceanic basalt crust, and second its thin layer of sediment (e.g. Poli & Schmidt, 2002). Based on these results and the well known enrichment of LILE, Pb, U, and Th as well as the decrease of HFSE, Nd and Hf in island arcs in respect to the N-MORB, we focus on a limited number of elements (Pb, Hf, Sr and Nd) for our numerical model.

Our first results show that combination of finite differences and marker in cell techniques allows successful coupling of thermomechanical evolution of subduction with mobilisation, transport and radioactive decay of isotopes. Preliminary modelling results reconcile well with observations. Particularly, our models predict a significant increase of Strontium and Lead and a slight increase of Hafnium and Neodymium in the newly formed magmatic arc crust relative to the depleted mantle (DMM), which is comparable with data from the literature. In addition, our model confirmed the evidence for slab derived fluid /melt in the newly formed crust.

Pyromorphite formation from natural and surfactant-modified montmorillonite adsorbed lead

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The objective of this study was to evaluate potential application of natural and surfactant-modified montmorillonite for sorption of Pb^{2+} and subsequent pyromorphite formation by the reaction of Pb-adsorbed smectite with aqueous PO_4 of various concentrations. Amine hexadecyltrimethylammonium bromide (HDTMA-Br) in the amounts of 2.0 Cation Exchange Capacity (CEC) of the clay was used to obtain surfactant-modified organo-smectite.

The reaction of Pb-adsorbed natural montmorillonite with aqueous solutions containing PO_4 and Cl ions results in the decrease in phosphate concentration associated with the formation of a new phase – pyromorphite $Pb_5(PO_4)_3Cl$. Precipitation of brom-pyromorphite $Pb_5(PO_4)_3Br$ is observed when surfactant is used for modification of montmorillonite.

Pyromorphite precipitates homogenously in the solution but crystals generally cover the surface of smectite (Fig. 1a). High concentration of K and Ca cations leads to a high desorption of Pb and formation of very fine crystals. On the other hand, low concentrations of cations results in the formation of larger crystals.

When PO_4 was sorbed on Pb–surfactant-modified smectite, formation of brom-pyromorphite $Pb_5(PO_4)_3Br$ was noted in the reaction products. Pyromorphite forms crystals on the surface of a surfactant-modified smectite (Fig. 1b). We gratefully acknowledge support of the MNiSW through grant N N525 461236.

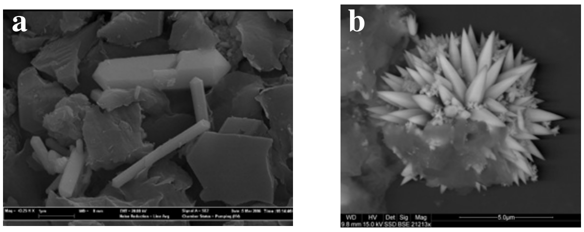

Figure 1: SEM microphotographs of (a) chlor-pyromorphite formed in the reaction of aqueous PO_4 and Pb-adsorbed montmorillonite, and (b) brom-pyromorphite formed in the reaction of aqueous PO_4 and Pb–surfactant-modified montmorillonite.