Geophysical Research Abstracts
Vol. 20, EGU2018-8163, 2018
EGU General Assembly 2018

Modelling trace element behaviour during slab dehydration

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Subduction results in chemical differentiation and is probably responsible for most of the continental crust formation on Earth. Indeed the bulk continental crust shares many geochemical affinities with subduction zone magmas. As such, subduction is a key contributor to Earth's chemical evolution. The geochemical characteristics of arc melts are partly inherited from the different lithologies that source the fluids which will participate in mantle melting processes. The resulting chemical signal observed in primitive arc melts results from a series of complex processes involving the slab and the overlying mantle wedge.. Deciphering these processes and origins that lead to the formation of primitive arc melts is not straightforward. Several key trace elements are widely used to estimate the slab contribution to the melt that ultimately forms volcanic arcs. But until precise trace element behaviour during slab dehydration and subsequent mantle interaction is combined with quantitative modelling, these results remain somewhat qualitative.

In this study, we present numerical models that assess trace element composition of slab-derived fluids sourced from the igneous slab crust. First, we compiled a wide range of data from the literature to parameterise the mineral/fluid partitioning of trace elements as a function of temperature for minerals. Next, we built a numerical 2-D geodynamical model to predict subduction P-T conditions and to calculate how slabs of different ages and convergence rates dehydrate. The trace element composition of the released fluids is then calculated using the newly derived parameterizations.

Results shows a good agreement with expected trace element behavior observed in experiments, where the released fluids are enriched in fluid-mobile elements and LILEs in comparison to REEs and HFSEs, with an enrichment negatively correlated with temperature. We further applied our models to a rather cold subduction zones, such as the Marianas, and to a hot subduction zone such as Vanuatu, to better understand the processes leading to different geochemical signatures.