Geodynamic regimes of intra-oceanic subduction: Thermomechanical modeling of geochemical signatures

B. BAITSCH GHIRARDELLO[1*], A. STRACKE[2], AND T.V. GERYA[1]

[1]ETHZ, Switzerland, Institut f. Geophysik (*), baitsch@erdw.ethz.ch

[2]Westfälische Wilhelms-Universität Münster, Institut f. Mineralogie, Germany, stracke.andreas@uni-muenster.de

The aim of this study is to investigate isotope signatures in different geodynamic regimes of intra-oceanic subduction processes with our 2D coupled geochemical-petrological-thermomechanical numerical model (I2ELVIS). We investigated systematically influences of fluid and melt weakening effects, which are responsible for the degree of plate coupling/decoupling and the mechanical strength of the overriding plate. Based on results of systematic experiments we distinguish the following three geodynamic regimes a) retreating regime, b) stable regime and c) advancing regime.

a) Retreating subduction regime is characterized by a strong rheological weakening of the overriding plate mantle by hydration/serpentinization and melt propagation processes. A necking of the (fore) arc causes the onset of decompression melting in the mantle wedge. Differently to the isotope signatures in the magmatic arc, decompression melting causes a MORB-like isotope signatures in the newly formed crust.

b) The volcanic rocks in a stable subduction regime are mainly produced from the subducted oceanic crust and molten hydrated mantle. Some of the stable subduction regimes are characterized by development of a broad area of subduction mélange in which subducted basaltic crust is strongly mechanically mixed with the serpentinized fore-arc mantle. These intense mixing is promoted by increased degree of fluid related weakening. The correspondent isotopic signature in the arc depends on the degree of fluid related weakening that controls intensity of flux melting.

c) Advancing subduction regime develops under condition of notably reduced fluid-related weakening that results in strong coupling between the plates in the fore-arc region. Strong coupling between plates produces large stresses that are able to overcome the mechanical resistance of the serpentinized fore-arc mantle that starts to subduct together with the plate. Large amount of new basaltic crust forms at the surface as the result of enhanced fluid-fluxed melting of the mantle wedge that coins the isotope signature of the arc.

Diffusion of water through quartz: a fluid inclusion study

RONALD J. BAKKER*, MIRIAM BAUMGARTNER, GERALD DOPPLER

Resource Mineralogy, University of Leoben, Austria, bakker@unileoben.ac.at (* presenting author)

Introduction

Diffusion of H_2O through minerals, such as quartz, that do not incorporate water at regular lattice positions is of major importance to understand fluid-rock interaction processes in deep rock, and to interpret fluid inclusion studies. The outcome of a variety of re-equilibration experiments with natural and synthetic fluid inclusions indicate that diffusion of H_2O plays an important role in these processes. Diffusion coefficients of H_2O in nominally anhydrous minerals were experimentally estimated from H_2O molecules (or part of these molecules) that replace oxygen at regular lattice positions in silicates, and which positions were detected in quenched samples after re-equilibration experiments.

Experiments

The properties of fluid inclusions in quartz can be relatively easily obtained from a variety of analytical techniques. Fluid inclusions can be regarded as constant volume containers inside a crystal lattice, which are more or less protected by the surrounding crystal from material exchange with rock pore volumes. Any change in fluid inclusion density and compositions is directly the result of diffusion processes. The exchange of fluid components in our experiments is provoked at high temperatures and pressures. Deoendent on experimental conditions, time, fluid inclusion size, and distance of fluid inclusions to the grain boundary, a variety of compositional changes are detected. similar effects are observed in assembalges of ynthetoc and natural fluid inclusions in quartz.

Conclusions

Concentration profiles based on fluid inclusion composition and density are not confirm diffusion coefficients obtained by altered isotopic compositions of quartz grains (i.e. the traditional technique to trace water in quartz). This illustrates that the mobility of H_2O in quartz must be a complex interaction of bulk diffusion and other processes suh as micro-crack enhanced or dislocation-enhanced diffusion. The reliability of natural fluid inclusions in metamorphic rock to determine rock-forming conditions can only be improved if these re-equilibration processes are fully understood.