Lithospheric geodynamics with thermo-chemical density anomalies and mineral phase transitions switched on

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Density is an important physical property of rocks, which e.g. determines the isostatic response of the lithosphere to deformation. The density of a piece of mantle depends on pressure, temperature and composition. These three parameters inevitably change during geological processes such as rifting, but can also vary in apparently passive settings, e.g. at the lithosphere-asthenosphere boundary. The density distribution of the shallow mantle is non-linear and discontinuous due to complex mineralogy and, most importantly, phase transitions. The two shallow phase transitions that have the strongest effect on density are the plagioclase-in transition above ~50 km and the garnet-in reaction below ~40 – 100 km. The depth of these phase transitions strongly depends on the bulk composition of the mantle. The depth of the plagioclase-in boundary is mostly pressure dependent and predominantly controlled by bulk Na_2O/Al_2O_3, whereas the garnet-in transition has a steep and curved Clapeyron slope with a strong depth-dependence on bulk Cr_2O_3/Al_2O_3.

In an extending lithosphere, the density changes in the lithospheric column due to phase transitions can cause significant deviations from purely thermal subsidence. The amount of subsidence depends on the composition of the mantle, in addition to classical parameters such as the thickness of the crust, the initial geotherm and the amount of stretching. The phase-transition effect is most pronounced for thin crust, strong mantle thinning/upwelling and relatively fertile mantle compositions rich in aluminum and sodium, and can match the effect of thermal expansion. This could explain the pronounced syn-rift uplift and accelerated post-rift subsidence observed in some basins. The incompatible nature and strong mobility of sodium may lead to large changes in bulk Na_2O, and therefore density, during minor melting (Na extraction) or metasomatism (Na addition).

Densification of portions of the mantle, e.g., due to melt infiltration and shifts in the location of phase boundaries, might also contribute to the formation of gravitational instabilities and small scale convection, e.g. at the lithosphere-asthenosphere boundary. The combination of 2-D finite element deformation modeling and thermodynamic phase diagram calculations allows us to evaluate and quantify the feedback between geochemical variations and lithospheric deformation.

Elemental and Sr isotope investigations of human tooth enamel by laser ablation-(MC)-ICP-MS: Successes and pitfalls

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Sr isotope analysis of human tissue has proven to be an important tool for examining ancient human migration. Previous studies have typically conducted Sr isotope measurements by TIMS; however, Sr isotopic measurement by solution mode MC-ICP-MS greatly increases sample volume throughput with little (if any) detriment to the quality of individual analyses (e.g. Buzon *et al.*, in press). Recent studies have also reported reliable Sr isotope measurements and elemental concentrations within geologic and biologic samples at high spatial resolution using various LA-(MC)-ICP-MS instrument configurations. The relatively rapid nature of an individual laser ablation Sr isotope analysis (i.e. minutes) could possibly revolutionize (if successful) the manner in which migration studies of ancient civilizations are conducted in the future.

We investigated the elemental and Sr isotope ratios of tooth enamel from remains at the New Kingdom period Egyptian colonial site of Tombos (Sudan) by both laser ablation and solution mode-(MC)-ICP-MS analysis. Elemental abundances for both solution and laser ablation modes of analysis were obtained using a ELAN6000 quadrupole ICP-MS. Sr isotope measurements obtained in both solution and laser ablation modes were acquired with a NuPlasma MC-ICP-MS instrument. Laser ablation analyses were conducted using a UP213 system (New Wave Research).

Elemental abundances determined by both solution mode and laser ablation-ICP-MS analysis yield comparable values; however, $^{87}Sr/^{86}Sr$ values obtained by laser ablation are higher compared to their solution mode counterparts. This discrepancy is related to the production of a molecular interference- Ca+P+O (overlaps ^{87}Sr); hence the higher $^{87}Sr/^{86}Sr$ values recorded during ablation analyses. Laser ablation studies of enamel may provide relatively precise $^{87}Sr/^{86}Sr$ values rather quickly but cannot be used for accurately deciphering historical population migrations (Simonetti *et al.* in press).

References

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