Garnet and spinel in the Upper Mantle: Results from thermodynamic modeling in fertile and depleted compositions

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Spinel–garnet relations in the upper mantle have long been investigated from different perspectives, by means of petrological studies on natural samples (orogenic massifs, xenoliths, diamonds), high-P-T experiments, thermodynamic calculations, and geophysical observations. Here we report a refined thermodynamic model that allows one to predict phase relations and mineral compositions in a wide range of realistic mantle compositions [1]. The generated phase diagrams show that the garnet+spinel stability field is always broad at low temperatures and progressively narrows with increasing T. In lithospheric sections with hot geotherms, garnet coexists with spinel across an interval of 10–15 km, at ca. 50–70 km depths. In colder, cratonic, lithospheric sections, the width of the garnet–spinel transition strongly depends on bulk composition: in fertile mantle, spinel can coexist with garnet to about 120 km depth, while in a strongly depleted harzburgitic mantle spinel is stable to over 180 km depth. These results are in agreement with the observed extension of the Hales gradient zone (a seismic impedance increase in the mantle that is usually attributed to the spinel-to-garnet transition) in various geodynamic settings. The model predicts that formation of chromian spinel inclusions in diamonds is restricted to pressures between 4.0 and 6.0 GPa. The calculated modes of spinel decrease rapidly to less than 1 vol% when garnet enters the equilibrium assemblage, hence spinel grains can be easily overlooked during the petrographical characterization of small mantle xenoliths. The very Cr-rich nature of many spinels from xenoliths and diamonds from cratonic settings may simply be a consequence of their low modes in high-P assemblages and does not require ultra-depleted compositions. The model also shows that large Ca and Cr variations in lherzolitic garnets in equilibrium with spinel can be explained by variations of pressure and temperature along a continental geotherm and do not necessarily imply variations of bulk composition.

[1] Ziberna *et al.* (2013), *Contrib. Min. Petrol.*, in press.

Factors controlling the distribution of Neodymium isotopes and REEs in tropical atlantic seawater

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Neodymium (Nd) isotopes and rare earth element (REE) patterns are used as tracers of present day ocean circulation and to fingerprint source materials. We present full water column Nd isotopic compositions and dissolved REE distributions in seawater of the tropical Atlantic Ocean. Samples were collected during the GEOTRACES expedition A11 (R/V Meteor) from Las Palmas (Canary Islands) to Port of Spain (Trinidad and Tobago).

Highly variable REE concentrations and associated REE patterns in surface waters reflect different oceanic provinces and prominent local source provenances, such as volcanic islands and dust particles of continental origin. Generally, concentrations in the eastern basin, in particular in the vicinity of the Canary Islands and off the coast of NW Africa, are higher than in the western basin. In the area of the Canary Islands shale-normalized REE patterns are characterized by a strong increase in concentrations of the heavy REEs relative to the light REEs as a consequence of exchange with the volcanic rocks, while further south comparatively flat REE patterns indicate dust dissolution.

Nd concentrations in surface waters range between a minimum of 14 pmol/kg in low salinity waters (< 33.6 psu) originating from the Amazon river and a broad maximum off NW Africa reflecting the dissolution of Saharan dust. This is also reflected in the dissolved Nd isotope compositions, which range from ε_{Nd} = - 12.7 to - 8.4. The most radiogenic values were measured between Tenerife and Grand Canary and near the Amazon river mouth while the least radiogenic ones are found in the open ocean surface waters off NW Africa, and in the uppermost 100 m of the western basin.

We also present full water column profiles including all major water masses present in the tropical Atlantic Ocean. Southern Ocean sourced intermediate and deep waters are clearly distinct in the eastern and western basins and allow the estimation of mixing proportions between different endmember water masses.

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