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Mg-Fe diffusivity patterns in sub-continental and ophiolite mantle chromitites

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Mg-Fe cation exchange between olivine and spinel has been studied in the past, as its dependence from T and P allowed the calibration of several geothermometers. These can be used to infer temperatures from high-T conditions down to at least 650 °C. Moreover, cation exchange produces diffusivity patterns close to the intergranular limits, providing information on the thermal history of ultramafic rocks. In rocks where spinel is an accessory phase, diffusion patterns are fully developed only in olivine as the small size of spinel grains prevents the preservation of primary compositions. Chromitites are the focus of the present work. In these rocks diffusivity patterns are fully developed both in olivine and spinel, due to higher chromite modal content and larger grain size. Therefore, they represent a powerful tool to unravel the thermal history of chromitite-bearing mantle rocks.

Subcontinental mantle was studied in Finero mafic-ultramafic massif (Southern Alps, Italy) where fresh chromitite lenses are hosted within the Phlogopite-Peridotite unit. Oceanic mantle was studied in the Puka peridotite massif of the Mirdita ophiolite (Northern Albania) and in the Nea Roda peridotite massif of the Halkidiki ophiolite belt (Northern Greece). Puka massif hosts major chromitite occurrences, as tens of meters long and some meters thick lenses, within fresh dunites, exploited at the Iballe mine, while Nea Roda massif hosts small, little serpentinized, centimeter-size chromitite pods, surrounded by small dunite haloes.

In order to avoid scattering of data due to coupled rim-rim analyses, diffusivity patterns were modeled with an exponential function through software OriginLab. In Finero, diffusivity curves show trends ascribable to continuous cooling, with an increase in Mg contents approaching the rim in olivines and the opposite trend in chromites. Cooling rates were qualitatively assessed following the approach of Ozawa (1984), and highlighted an increasing cooling rate with decreasing temperature, due to rapid exhumation.

Puka and Nea Roda curves are not as well constrained due to minor serpentinization developing from the intergranular rims. However, it is possible to infer that Puka chromitites underwent continuous cooling but do not show the trend of rapid decrease in cooling rates observed in Finero. Nea Roda diffusivity patterns are the most puzzling. They do not fit a continuous cooling model, and suggest that local conditions affected Mg-Fe exchange.

REFERENCE:

Ozawa, K. (1984). Olivine-spinel geospeedometry: Analysis of diffusion-controlled Mg-Fe2+ Exchange. Geochimica et Cosmochimica Acta, 48(12), 2597-2611.