# Thermodynamic modelling of the mobility of minor and trace elements in metamorphosed chromites

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Chromites in high-Al and high-Cr chromitites from the ultramafic massifs of Golyamo Kamenyane and Jakovitsa (Bulgaria) preserve four types of microstructures: i) partly- altered chromite, with primary cores surrounded by porous chromite enriched in Cr and $Fe^{2+}$ and depleted in Al and Mg; ii) porous chromite, with chlorite in the pores; iii) zoned chromite, with primary cores surrounded by non-porous chromite enriched in $Fe^{3+}$; and iv) non-porous chromite. The different patterns of zoning are the consequences of two-stage processes associated with the infiltration of different fluids.

P-T-X diagrams for high-Al and high-Cr chromitites indicate that the first stage of alteration takes place by reaction of primary chromite with olivine in presence of $SiO_2$-rich fluids, to produce chlorite and porous chromite. The highest changes in Cr# and Mg# in chromites are generated coevally with: i) significant enrichment in Zn, Co and Mn but depletion in Ga, Ni and Sc in high-Al porous chromite, and ii) diffusion of these elements between cores and porous rims (with higher Ga, Ti, Ni, Mn, and Sc, but lower V) in high-Cr partly-altered chromite. Our thermodynamic model suggest that porous chromite is stable from 700 to 450ºC, in eclogite to amphibolite facies. Calculated temperatures for the second stage using isothermal Al-Cr-$Fe^{3+}$ sections indicate the formation of ferrian chromite from 450 to 600ºC, overlapping with those modeled for the first stage. High-Al and high-Cr cores of zoned chromite show the same pattern of minor and trace elements (depleted in Ga, Ni and Sc and enriched in Zn and Co) due to their diffusion through the non-porous chromite (with high Zn, Co, Mn, $Fe_{tot}$ and, more in Ti, Ni and Sc, but low Ga) grains and rims of zoned chromite. Thus, the alteration of chromite is a consequence of the evolution of fluids from reducing $SiO_2$-rich to more oxidizing, obliterating the geochemical fingerprint of the magmatic chromite.