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Spinels Renaissance: The past, present, and future of those ubiquitous minerals and materials

Low intra-crystalline closure temperatures of Cr-bearing spinels from the mantle xenoliths of the Middle Atlas Neogene-Quaternary Volcanic Field (Morocco): Mineralogical evidence of a cooler mantle beneath the West African Craton†

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Abstract

The crystal chemistry of nine Cr-spinels from lherzolite and harzburgite xenoliths from the Middle Atlas Neogene-Quaternary Volcanic Field of Morocco have been studied by means of X-ray single-crystal diffraction and electron microprobe analyses. Cell edges are usually within the range 8.13–8.14 Å, but there are three samples with longer *a* value, so that the whole analyzed series is within the range 8.1334(4)–8.2021(2) Å, while the oxygen positional parameter values are very similar ranging between 0.2626(1) and 0.2629(2) for all of them. The cation distribution shows that the crystal structure is ordered with almost all divalent cations in the tetrahedral site and trivalent cations in the octahedral site. The determined intracrystalline temperatures are in the range 550–750 °C that are the lowest values ever found for Cr-spinels from mantle xenoliths as these are usually higher than 730 °C. If we consider the behavior of some geotherms from literature, the determined temperatures are confined in a depth range of about 20–40 km. Lithospheric models for the studied area indicate that the lower crust reaches its deepest value in a range between 30 and 40 km. Consequently, we can assume that the studied xenoliths were emplaced at a "shallow" depth of about 20–30 km, just beneath the lower crust, where they were disrupted and brought to the surface from the ascending alkaline lavas. This assumption is consistent with the concomitant presence of some crustal xenoliths. It is important to notice that even in the case of a mantle xenoliths where all the silicates could be heavily altered, the presence of one single crystal of Cr-spinel and the study of its oxygen coordinates (*u*), inversion parameters (*i*), Cr content, and calculated closure temperatures can be used to validate the thermal history of the mantle xenoliths. The combined approach of structural data, intra- and inter-crystalline temperatures, and the literature geophysical data seems to be an interesting tool to assess the pre-exhumation history of the mantle xenoliths.

Keywords: Cr-spinels, mantle xenoliths, crystal chemistry, intracrystalline temperature, Morocco