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Potentials of the modern crystal structure analysis for the investigation of mineral chemistry

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Recent instrumental and computational developments have led to the construction of the crystallographic probe – an instrument capable of fast recording of a complete diffraction picture on samples with diverse textural characteristics. The speed of acquisition has dramatically decreased measurement time and made systematic structural studies on large sets of samples a real possibility. The completeness of diffraction picture combined with high resolution offers very accurate results and treatment of samples which are not simple single crystals but multiples like twins and other types of intergrowths so common in minerals. The potentials of the method for investigations of mineral chemistry are illustrated by determinations of the structural role of light elements elucidated from experimental electron densities, determination of the actual oxidation state of multivalent elements from the accurate geometry of the crystal structure, and determinations of compositions of micro- and nanosized exsolution domains by multiphase refinement of their crystal structures, all recent results from our laboratory.

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Low temperature alteration of the Kop Ultramafic Massif, Eastern Turkey, and Cr mobility

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The Kop Ultramafic Massif comprising harzburgite and minor dunite with local small occurrences of lherzolite, wherlite, clinopyroxenite and orthopyroxenite is interpreted as an alpine-type ultramafic body emplaced during a failed rifting event and mantle upwelling [1]. Dunite is heavily serpentinized and contains a pervasive alteration assemblage of chrysotile + talc ± chlorite ± clinochlore ± "iddingsite". A 5–6 m-long by 10–30 cm-wide vein exposed on the southeast wall of the Bulent mine contains an assemblage of clinochlore + kämmererite + chrysotile + brucite. The dunite margins of the vein contain secondary uvarovitic garnet.

Primary chromite in the dunite margins of the vein are moderately to extensively altered to highly porous "ferrian chromite", $Fe^{2+}(Cr,Fe^{3+})_2O_4$. Chromium has been mobilized in the fluid which has precipitated chromian clinochlore and kämmererite. The chromian clinochlore forms large (up to 5 cm) unzoned light-green translucent crystals containing up to 2.1 wt% Cr_2O_3 with an average stoichiometry of $Mg_{9.84}Al_{1.61}Cr_{0.31}Fe_{0.23}K_{0.28}(Si_{5.8}Al_{2.2})O_{20}(OH)_{16}$ (n=5). In contrast, deep purple kämmererite crystals are smaller, sometimes forming 0.2–0.5 cm-long monoclinic barrels with tapered {110} and {010} forms. All crystals of kämmererite are highly zoned (up to 14 zones per 0.5 mm perpendicular to {001}). Abundances of Cr_2O_3 range 2.5–8.7 wt% and the average stoichiometry of three crystals is (n=70): $Mg_{10.19–10.30}Al_{0.83–0.95}Cr_{0.59–0.71}Fe_{0.17–0.20}Na_{0.05–0.10}(Si_{6.47–6.50}Al_{1.50–1.53})O_{20}(OH)_{16}$. The relative growth-rates of different forms and the change of external morphology during growth (revealed by BSE imaging), as well as the occurrence of growth zoning may preserve evidence of variability of Cr abundance in the fluid during kämmererite growth. However, no zoning is preserved in cogenetic chromian clinochlore so that growth zoning in kämmererite likely reflects variable growth rates related to "poisoning" of the growth surface by high abundance Cr partitioning. The occurrence of chromian clinochlore and kämmererite (and uvarovitic garnet in dunite) indicates that Cr released by chromite breakdown migrated only cm's to tens-of-cm's before incorporation in alteration minerals. The *P-T* conditions during kämmererite formation are likely to be <1 kbar and temperature less than ~300 °C, but greater than the upper *T* stability for lizardite.

References

[1] Kolayli (1996) Unpub. PhD thesis, KTU.