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Chromian dissakisite-(Ce) in a garnet lherzolite from the Chinese Su-Lu UHP metamorphic terrane: Implications for Cr incorporation in epidote-group minerals and recycling of REE into the Earth's mantle

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ABSTRACT

Chromian dissakisite-(Ce), a Cr-enriched Mg analogue of allanite-(Ce), is found in a garnet lherzolite from the Su-Lu ultrahigh-pressure (UHP) metamorphic terrane, eastern China. Major minerals of the lherzolite are olivine [X_{Mg} = Mg/(Mg + Fe) = 0.92], pyrope-rich garnet ($Prp_{70.1–73.2}Alm_{11.3–13.4}Grs_{6.9–8.3}Uvr_{3.6–5.1}Anr_{0–0.4}Sps_{0.7–1.7}$), orthopyroxene ($X_{Mg}$ = 0.92–0.93), and clinopyroxene (X_{Mg} = 0.92–0.95). The chromian dissakisite-(Ce) occurs as a single-crystal inclusion in a clinopyroxene neoblast that also contains several irregularly shaped olivine grains. It is partly metamict, and there is intensive radial cracking in the surrounding clinopyroxene. Its composition is represented by the averaged formula: $(Ca_{0.86}Na_{0.03})_{0.89}(REE_{0.86}Th_{0.04})_{0.90}(Mg_{0.98}Fe^{2+}_{0.20}Fe^{3+}_{0.21}Cr_{0.36}Al_{1.39}Ti_{0.04})Si_{3.03}O_{12}(OH)$, with Ce_2O_3, MgO and Cr_2O_3 contents up to 13.1, 7.3, and 5.4 wt%, respectively. Because the M3 site in the chromian dissakisite-(Ce) is fully occupied by Mg and Fe^{2+}, Fe^{3+} and Cr can only occupy the smaller M1 site. Similar site occupancy is noted for a chromian allanite from the Sanbagawa metamorphic belt, Japan, which contains up to 0.547 Cr atoms per formula unit (apfu). Such compositional characteristics of the chromian dissakisite/allanite and existing polarized absorption data on Cr-bearing epidote suggest the existence of possible end-members, "$CeCa(Mg,Fe)CrAlSi_3O_{12}(OH)$," for the epidote-group minerals, which may form solid solution with $Ca_2Al_3Si_3O_{12}(OH)$ through coupled substitutions of $REEMgCa_{-1}Al_{-1}$, $REEFeCa_{-1}Al_{-1}$, and $CrAl_{-1}$. The rare earth elements (REE), Ca, and Na total 1.79 apfu, implying that Mn and Fe^{2+} are also present on the nine-coordinated A1 site. The high REE abundance, the presence of minor Na, and the Mg and Cr-enriched characteristics of the mineral suggest that it was formed as a result of reaction between the host lherzolite and crust-derived melt/fluid at UHP conditions. Textural relations suggest that the chromian dissakisite-(Ce) was unstable in the garnet lherzolite and reacted with olivine to form clinopyroxene. Dissakisite-(REE) in subducted ultramafic rocks can transport rare earth elements into the Earth's mantle.