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Oriented chromite-diopside symplectites in lunar olivine

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Cr,Ca-rich symplectites in lunar olivine are known as spinel-pyroxene vermicular intergrowths usually observed as irregular shaped blebs along grain boundaries or rarely as oriented inclusions of either needle-like, or tabular or lamellar and lens shape in interiors of olivine grains.
The oriented Ca,Cr-rich lamellae are observed in Fo77 olivine grain from lunar regolith delivered by the soviet Luna-24 mission. The thickness of lamellae is about 1 μm. The lamellae occur mostly in the interior of the grain far from the grain boundaries and they are not associated with cracks. The lamellae are strongly enriched in Ca and Cr whereas the Ca and Cr contents in the olivine host are very low and almost below the detectable limit of EMPA. The lamellae were studied with EMPA, SEM and TEM. It was found that the lamellae consist of worm-like intergrowth of FeCr2O4 chromite (Chr) and CaMgSi2O6 diopside (Di), with a Chr : Di ratio of approximately 1:2. Chromite, diopside and the olivine host are oriented to each other with (100)Ol // (111)Chr // (100)Di; (001)Ol // (011)Chr // (010)Di; [010]Ol // [211]Chr // [001]Di; [001]Ol // [011]Chr // [010]Di . The lamella/olivine interface is parallel to (100) olivine. The symplectites have a substructure with a chromite of rod-like but not lamellar-like shape. The chromite rods of about 60 – 100 nm in thickness are elongated along [100] of adjusted olivine matrix.
The linear nature and orientations of the symplectic inclusions suggest that they have been nucleated on deformation defects. The symplectite is suggested as formed by a solid-state reaction without inputting of chemical material from environment, due to oxidation Cr2+ - Cr3+. Cellular decomposition is suggested as the mechanism of symplectite formation. Chromite - diopside symplectites in lunar olivine grain are similar to magnetite – augite/diopside symplectites in olivine from terrestrial rocks and chromite/magnetite – augite/diopside symplectites in olivine from martian meteorites. The different compositions of spinel phase in symplectites from lunar, martian and terrestrial olivines reflect the different redox conditions on these planets. Mechanism of oxidation and subsequent formation of oriented Chr/Mgt-Aug/Di symplectitic inclusions in olivines from the Moon, Mars and Earth should be the same but it is not a case of “dry” oxidation because both morphology and chemical composition of phase constituents in symplectites are not consistent with known products of “dry” olivine oxidation.