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High-pressure phase transitions in $FeCr_2O_4$ and structure analysis of new post-spinel $FeCr_2O_4$ and $Fe_2Cr_2O_5$ phases with meteoritical and petrological implications

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Abstract

We determined phase relations in $FeCr_2O_4$ at 12–28 GPa and 800–1600 °C using a multi-anvil apparatus. At 12–16 GPa, $FeCr_2O_4$ spinel (chromite) first dissociates into two phases: a new $Fe_2Cr_2O_5$ phase + Cr_2O_3 with the corundum structure. At 17–18 GPa, the two phases combine into $CaFe_2O_4$-type and $CaTi_2O_4$-type $FeCr_2O_4$ below and above 1300 °C, respectively. Structure refinements using synchrotron X-ray powder diffraction data confirmed the $CaTi_2O_4$-structured $FeCr_2O_4$ (*Cmcm*), and indicated that the $Fe_2Cr_2O_5$ phase is isostructural to a modified ludwigite-type $Mg_2Al_2O_5$ (*Pbam*). In situ high-pressure high-temperature X-ray diffraction experiments showed that $CaFe_2O_4$-type $FeCr_2O_4$ is unquenchable and is converted into another $FeCr_2O_4$ phase on decompression. Structural analysis based on synchrotron X-ray powder diffraction data with transmission electron microscopic observation clarified that the recovered $FeCr_2O_4$ phase has a new structure related to $CaFe_2O_4$-type. The high-pressure phase relations in $FeCr_2O_4$ reveal that natural $FeCr_2O_4$-rich phases of $CaFe_2O_4$- and $CaTi_2O_4$-type structures found in the shocked Suizhou meteorite were formed above about 18 GPa at temperature below and above 1300 °C, respectively. The phase relations also suggest that the natural chromitites in the Luobusa ophiolite previously interpreted as formed in the deep-mantle were formed at pressure below 12–16 GPa.

Keywords: Post-spinel, Rietveld analysis, crystal structure, high pressure, phase transition, shocked meteorite, $FeCr_2O_4$, ophiolite