An equilibrium phase diagram model to study the metamorphism experienced by the parent asteroid of Villalbeto de la Peña ordinary chondrite

MARIA J. HERRERO-PÉREZ[1], JOAN RECHE ESTRADA[2] JOSEP M. TRIGO RODRÍGUEZ[1]

[1]Institute of Space Sciences (CSIC-IEEC), Barcelona, Spain, meri.h.p.9@gmail.com, trigo@ice.csic.es

[2]Dept. de Geologia, Universitat Autonoma de Barcelona, 08193 Cerdanyola del Valles, Spain, joan.reche@uab.cat;

Chondritic meteorites have not been altered by melting or differentiation of their parent body. As such, they help to constrain the evolutionary history of asteroids. The Villalbeto de la Peña (VP) chondrite fell in 2004 in central Spain. It shows considerable thermal metamorphism and was classified as L6 [1]. It has experienced a significant degree of shock as well, as evidenced by the presence of dark impact veins, cracks filled with merillite and other high-P minerals [2,3]. Moreover, it shows signs of short-lived water-rock reactions consistent with hydrothermal activity on its parent body [4]. We constructed a phase diagram model that has proved to be useful to aproximate the P, T, redox (XFe^{3+}) and XH_2O conditions during metamorphism of VP in its parent body.

Nowadays new thermodynamic data have been calibrated for solid and melt phases in terrestrial mantle rocks [5], a bulk composition (BC) similar to that of ordinary chondrites. This allows using phase equilibria modelling to investigate metamorphism in ordinary chondrites [5]. We present NCFMASOCr chemical system, P-T, T-XFe^{3+} and T-H_2O phase diagrams for the Villalbeto BC contoured for modes and compositions for olivine, pyroxene, plagioclase and chromite. Our study suggests higher than average P of c. 8-9 kbar. for a high-T (c. 1050 ºC) near solidus episode, during probably increassing fO_2. We also assess the value of phase equilibria modelling to set key constraints on the evolution in chondritic asteroids.

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