

STUDY OF Fe²⁺- Mg²⁺ ORDER-DISORDER IN PYROXENE FROM THE CACHARI METEORITE.

Y. A. Abdu¹, R. B. Scorzelli², I. Souza Azevedo² and M. E. Varela³. ¹Department of Geological Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada. ²Centro Brasileiro de Pesquisas Físicas, Rua Xavier Sigaud 150, 22290-180 Rio de Janeiro, Brasil. ³Complejo Astronómico El Leoncito (CASLEO), Av. España 1512 Sur, CP J5402DSP, San Juan, Argentina.

Introduction: The Cachari meteorite, found in 1916 in Argentina, is a monomictic eucrite that belongs to the basaltic achondrites. It is composed mainly of low-Ca pyroxene and plagioclase [1, 2]. Mössbauer spectroscopy indicates that the only Fe-containing mineral present in the Cachari eucrite is pyroxene [3]. The study of intracrystalline distribution of Fe²⁺ and Mg²⁺ between the nonequivalent octahedral sites M1 and M2 in pyroxenes is useful in tracing the thermal history of a rock. In unshocked and slowly cooled pyroxenes, Fe²⁺ orders at the M2 site whereas Mg²⁺ occurs predominately at the M1 site [4].

Here we study the partitioning of Fe²⁺ and Mg²⁺ between the M1 and M2 sites in orthopyroxene from the Cachari eucrite by Mössbauer spectroscopy in the temperature range (300 K – 80 K) and electron microprobe analysis.

Results: The average chemical composition of the Cachari pyroxene determined by electron microprobe analysis is (Fe²⁺_{1.16}Mg_{0.75}Ca_{0.04}Mn_{0.04}Al_{0.01}) Si_{2.00}O₆.

The room temperature (300 K) Mössbauer spectrum of bulk Cachari is composed of two overlapping doublets due to Fe²⁺ at the M1 and M2 sites in pyroxene, and very small amounts of Fe³⁺ and an impurity component. The resolution of the M1 and M2 doublets increases with decreasing temperature as a result of the differential dependence of the quadrupole splittings on temperature. Using the normalized Mössbauer relative areas of the doublets at 80 K, the Fe²⁺ fractions at the M1 and M2 sites are found to be 0.36 and 0.64, respectively. The site occupancies X_{Fe²⁺(M1)} and X_{Fe²⁺(M2)} are obtained by multiplying the above Fe²⁺ fractions by the total amount of Fe²⁺ given by electron microprobe analysis. This gives X_{Fe²⁺(M1)} = 0.42 and X_{Fe²⁺(M2)} = 0.74. Assuming complete order of Ca and Mn at the M2 site, and Al at the M1 site, Mg²⁺ is then distributed over the M1 and M2 sites as: X_{Mg²⁺(M1)} = 0.57 and X_{Mg²⁺(M2)} = 0.18. The Fe²⁺ and Mg²⁺ site populations can be related to the disordering parameter, p, defined by $p = (X_{Fe^{2+}(M1)} \cdot X_{Mg^{2+}(M2)}) / (X_{Fe^{2+}(M2)} \cdot X_{Mg^{2+}(M1)})$, and we obtain a disordering parameter p = 0.18 for the Cachari pyroxene.

In light of the work done on heated orthopyroxenes [4, 5], the disordering parameter (0.18) obtained for the Cachari pyroxene corresponds to an equilibrium temperature of ~ 800 °C. This temperature is consistent with the reported equilibration temperatures for eucrites (800 °C – 900 °C) estimated using the coexisting ortho- and clinopyroxes geothermometer [6].

References: [1] Fredricsson K. And Kraut, F. 1967. *Geochimica et Cosmochimica Acta* 31: 1701-1704. [2] Boctor et al. 1987. *Meteoritics* 22: 332. [3] Abdu et al. 2005. *Hyperfine Interactions* 166: 543-547. [4] Dundon, R.W. and Hafner, S. S. 1971. *Science* 174: 581-583. [5] Virgo, D. and Hafner, S. S. 1969. *Mineral. Soc. Amer. Spec. Pap.* 2: 67-81. [6] Yamaguchi et al. 1996. *ICARUS* 124: 97-112.