ORIGIN OF MODERATELY VOLATILE ELEMENTS IN PRIMITIVE METEORITES;

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When normalized to CI-chondrites (Orgueil) chondritic meteorites have fractionated patterns of moderately volatile elements (e.g. Mn, Au, Ga, Na, Zn, Se, S). Abundances decrease continually with decreasing condensation temperatures, independent of geochemical properties. Similar patterns are found in bulk planets: Earth, Moon, EPB, SPB and iron meteorite parent bodies (1). Sr-isotopes indicate fractionation of moderately volatile elements very early in the history of the solar system (2,3). Possible processes are: (a) incomplete condensation or (b) evaporation of condensed matter.

A series of heating experiments were performed on bulk samples of Allende and Murchison within a range of temperatures (from 1050 °C to 1300 °C) and oxygen fugacities (from very reducing to very oxidizing) controlled with a CO-CO_2 gas mixing system. Run times were about 4 days, in most cases. Residues were analysed by INAA-techniques and in some cases separate analyses for C and S were performed.

The depletion sequence of moderately volatile elements obtained in the experiments is shown in Fig. 1. Elements are arranged in the order of decreasing condensation temperatures. A strong influence of oxygen fugacity on the volatility of moderately volatile elements is obvious. Patterns obtained with Murchison as starting material are almost identical. Four groups of elements may be distinguished: (a) Au and As are only volatile under oxidizing conditions (b) Cu, K, Na, Ga, Sb, Zn, only under reducing conditions, (c) C, S, Se, Br, under all conditions, and (d) loss of Mn was never observed. In Fig. 1 Allende/CI-ratios are given for comparison. Similar trends between this pattern and the depletion pattern produced by heating Allende are obtained under weakly reducing conditions log fO_2 = -13.5 (Fe-FeO) and log fO_2 = -12.3 (FeO-Fe_3O_4), however, far above the solar nebula fO_2 wich is below the experiment with the lowest fO_2. Evaporation, more likely at oxidizing conditions (4) is unlikely to have produced the Allende pattern as indicated by the low Au and As and the high Na, Ga, and in particular Zn, in the residues of experiments at oxidizing conditions. At reducing conditions, the absence of losses of Au (Au gain in the upper left of Fig. 1 is contamination), As and of Mn also excludes evaporation as a mechanism to produce the Allende pattern from initially undepleted material. Similar, although more pronounced trends, are obtained at higher temperatures (1300 C): no loss of Au, As and Mn under reducing conditions, but nearly complete loss of the other moderately volatile elements. It appears that there is no set of fO_2,T - conditions that would allow to produce the observed abundance pattern of Allende by volatilization of CI-like material during thermal metamorphism. The same arguments apply to condensation which is, equilibrium assumed, equvivalent to volatilization. A model of gradual removal of gas during condensation, such as suggested by Wasson and Chou (5), may be a better explanation for the origin of the observed patterns of moderately volatile elements in meteorites.

Lit.: (1) Palme H. et al. (1988) in J.F. Kerridge (eds.), pp. 436-461. (2) Tilton G.R. (1988) in J.F. Kerridge (eds.), pp. 259-275. (3) Minster J.F. et al. (1982) Nature 300, pp. 414-419. (4) Davis A.M. et al. (1982) Geochim. Cosmochim. Acta 46, pp. 1627-1651. (5) Wasson J.T. & Chou C.L. (1974) Meteoritics 9, pp. 69-84.

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