

EXPERIMENTAL STUDY ON THE MECHANISMS OF CaS-MgS-FeS MONOSULFIDES FORMATION : IMPLICATIONS FOR ENSTATITE METEORITES AND THE S BUDGET IN SMALL PLANETARY BODIES. V. Malavergne¹, F. Brunet², K. Righter³, S. Berthet¹. ¹ Université Paris Est-Marne La Vallée, Laboratoire des Géomatériaux, Champs-sur-Marne, 77454 Marne La Vallée Cedex, E-mail: malavergne@lpi.usra.edu. ² Laboratoire de Géologie, ENS-CNRS, 24 rue Lhomond, 75005 Paris, France. ³ NASA Johnson Space Center, Houston, Texas 77058, USA.

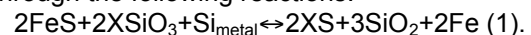
Introduction: The cubic monosulfide series with the general formula (Mg,Mn,Ca,Fe)S are common phases in the enstatite meteorites (enstatite chondrite EH and aubrite). Study of these sulfide minerals is of interest for the mineralogy and petrology of planetary mantles. For example, (Ca, Fe, Mg)S could occur in the primitive mantles of the Earth or Mercury [1, 2] since EH are potential building blocks for these two planets [2, 3]. As these S-rich minerals would remain low density phases compared to metal, then, they would not segregate to the core. (Mg,Ca,Mn,Fe)S sulphides might offer a good way to keep S in mantle and thus be important phases even in planetary differentiation processes. Moreover, the importance of such minerals, their formation, composition and textural relationships for understanding the genesis of enstatite chondrites and aubrites, has long been recognized [4]. The main objective of this experimental study is to understand the formation and evolution of (Mg,Ca,Mn,Fe)S sulphides with pressure, temperature but also with redox conditions since EH and aubrites formed under reduced conditions. Piston-cylinder (PC) experiments at 1 GPa and high temperature (between 1200 and 2000°C) have been performed in order to simulate the evolution of these phases in a small planetary body.

Experimental procedures: The PC experiments were carried out at 1 GPa using the Lunar and Planetary Institute QuickPress at the NASA Johnson Space Center (Houston, TX, USA) and also using the PC press of the Laboratoire de Géologie of ENS (Paris, France). A simplified CI chondritic glass mixed with FeS and Si metal were used as starting material. The oxygen fugacities of the samples have been calculated relative to the buffer iron/wüstite (IW) like in [5].

Results: Grains of (Ca, Mg, Fe)S formed in close association with SiO₂, Fe-Si alloy and sometimes FeS. The silicate phases are pyroxene and melt depending on the temperature. The first evidence of silicate melt is seen at 1350°C. All the starting material is

molten at 1700°C. The S content of the silicate melt depends strongly on the redox conditions of the samples. The PC experiments, where the cooling of the samples was controlled and slow, were performed in order to see if the crystallization of (Mg,Ca)S could occur through the cooling or as already suggested by [6, 7] or through a reaction between sulfides (FeS and MgS) at high temperature [8]. In these samples, a massive crystallization of (Mg, Ca, Fe)S phases been characterized.

Discussion. Highly reduced redox conditions have been reached for most of the experiments with a minimum value of 7 log units below IW buffer (or $\Delta IW-7$). These samples underwent the same range of fO_2 that prevailed during the formation of enstatite meteorites. Because of these very low fO_2 it was possible to form some (Ca,Mg,Fe)S likely through the following reactions:



X could be Ca or Mg. The high amount of dissolved S in the silicate melt that range up to 10wt% at $\Delta IW-7$ could be the result of CaS° and MgS° complexes occurring in the melt at low fO_2 [6, 7], as suggested by the crystallization of (Mg, Ca)S phases in the slow quench PC runs. The valence of S in silicate melt is 2 above $\Delta IW-5$.

Three different mechanisms of formation have been characterized for CaS-MgS phases: (i) a crystallization through process (1) where no melting is required [1], (ii) crystallization from a silicate melt through a slow cooling [6, 7] (iii) crystallization linked to a reaction between at least two different sulfides (FeS and MgS for example) at high temperature [8].

References: [1] Siebert et al., 2004, PEPI., 144, 421-432. [2] Taylor and Scott, 2003, Treatise on Geochemistry, 477-485. [3] Javoy, 1995, GRL 22, 2219-2222. [4] Keil, 1989 Meteoritics, 24: 195-208. [5] Malavergne et al., 2004, GCA, 68, 4201-4211 [6] Fogel 2005 GCA 69, 1633-1648 [7] Mc Coy et al., 1999 Meteoritics 34,735-746. [8] Keil, Chemie der Erde, 67, 37-54. .