

CORROSION OF SOLAR-COMPOSITION FE-BASED ALLOYS: FIRST RESULTS FROM THE NINE CIRCLES EXPERIMENTAL COSMOCHEMISTRY LABORATORY.

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Introduction: Iron-based alloys are abundant in many types of primitive meteorites. Since metal is highly reactive, there is potential for significant interaction between it and any external fluid phase. Metal corrosion likely occurred: 1) during the formation and alteration of the first solar system solids, 2) after chondrule formation when volatiles liberated from chondrule melts recondensed, and 3) on chondrite parent bodies as a result of aqueous alteration, thermal metamorphism, and/or shock heating.

Meteoritic metals contain significant amounts of Fe, Ni, Co, P, and Cr [1-4]. The mineralogy resulting from corrosion of such complex metals varies with the conditions of the alteration fluid. Therefore, such phases can provide a record of the metal alteration environment. Thermodynamic calculations can be used to predict metal corrosion products [1-2]. However, such calculations do not take into consideration reaction kinetics, transport mechanisms, and communication between phases, which determine the mineralogy of metal corrosion layers (e.g., [5-7]). Experimental simulation of these environments is required.

Techniques: The experimental apparatus contains: a gas-handling system, furnaces, temperature monitors, and a quadrupole mass spectrometer (QMS). An ultra-high purity gas mixture of 1% H₂S in H₂ at 1 atm total pressure was used. The H₂S/H₂ ratio corresponds to ~300x the solar S/H ratio. Gas composition was continuously monitored using the QMS. The experiments were performed at 1000, 900, 800, 700, 600, 500, and 400 °C. Temperatures were monitored using type-R thermocouples. Fe-based alloys were custom manufactured to contain 5 at.% Ni, 1% P, 1% Cr, and 0.2% Co, equal to relative CI abundances. Metal foils were exposed to the H₂S-H₂ gas mixture for 4.5 hours.

Results: Reaction kinetics were determined using: 1) S-depletion from the gas phase and 2) total weight gain of the sample. Activation energies determined from these techniques are 52±10 kJ/mole and 44±9 kJ/mole, respectively. These values are slightly lower than those determined by sulfurization of pure Fe under similar conditions [5]. Detailed kinetic behavior is determined by monitoring the abundance of H₂S throughout the experiment. The reaction rate is most rapid immediately after the foil is introduced to the hot zone. At 400 – 700 °C the reaction rate decreases rapidly and reaches a steady-state value after less than one hour of reaction time. At 800 and 900 °C a similar behavior is observed but the reaction rate continues to decrease throughout the experiment. At 1000 °C, above the Fe-FeS eutectic, the reaction rate is constant for 1.5 hours then decreases.

The sample formed at 1000 °C had a rounded droplet morphology. Troilite contained 0.2 – 1.3 (at.%) Cr, 0.2 – 0.6% Ni, and 0.1 – 0.2% Co. In addition schreibersite contained 0.2 – 1.2% S, 2.4 – 4.1% Co, and 8.0 – 12% Ni. The remnant metal contained 1.3% P, 3.9% Co, and 20% Ni, balance Fe.

References: [1] Lauretta et al. 2001 *Geochimica et Cosmochimica Acta* **65**, 1337. [2] Lauretta and Buseck 2003 *Meteoritics and Planetary Science* **38**, 59. [3] Rambaldi and Wasson 1981 *Geochimica et Cosmochimica Acta* **45**, 1001. [4] Zanda et al. 1994 *Science* **285**, 1846. [5] Lauretta et al. 1996 *Icarus* **122**, 288. [6] Lauretta et al. 1997 *Science* **277**, 358. [7] Lauretta et al. 1998 *Meteoritics & Planetary Science* **33**, 821.

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