

HEATING EXPERIMENTS OF A BASALTIC EUCRITE AND IMPLICATIONS FOR CHRONOLOGY AND GEOCHEMISTRY. A. Yamaguchi¹, T. Mikouchi², M. Ito^{3,4}, N. Shirai⁵, M. Ebihara⁵, J.A. Barrat⁶, and S. Messenger³, ¹National Institute of Polar Research, Tokyo 173-8515, Japan (yamaguch@nipr.ac.jp), ²Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, Tokyo 113-0033, Japan, ³Lunar and Planetary Institute, Houston, Texas, USA, ⁴Kochi Institute for Core Sample Research, JAMSTEC, Nankoku, Japan, ⁵Department of Chemistry, Tokyo Metropolitan University, Tokyo 192-0397, Japan, ⁶Université Européenne de Bretagne, Brest, France. Domaines Océaniques, UMR 6538, Université de Brest, CNRS, IUEM, Plouzané, France.

Introduction:

Most achondrites experienced secondary processes after their formation such as shock and thermal metamorphism, brecciation, melting, and metasomatism. These secondary events hamper the understanding of geologic history of the parent body. Thus, it is important to understand the mechanism of secondary disturbance of textures, bulk chemistry, and chronology. Following our previous work [1], we performed further chemical and textural analysis of the experimentally heated basaltic eucrites to infer the bulk chemical compositions and isotopic ages.

Results and Discussion:

Thin slices of an unbrecciated basaltic eucrite, HaH 262 were placed inside the Pt foil suspended in an alumina tube of a vertical 1 atm gas-mixing furnace at University of Tokyo. The heating temperatures were 1050, 1070, and 1100 °C for 24 hours and the samples were quenched in air. Experimental temperatures were measured with thermocouples calibrated by using melting point of gold. Gas mixture of CO₂-H₂ was used to control the oxygen fugacity at log fO₂ = IW-1.

PTSs of the starting and heated samples were examined optically and with a SEM, EPMA, Raman spectrometer at NIPR. The REE compositions of phases of the starting and heated samples were determined by NanoSIMS 50L at JSC/NASA. The bulk major and trace element compositions (REEs etc.) of unheated HaH 262 were determined by PGA, INAA, and ICP-MS at Tokyo Metropolitan University.

The PTSs of the starting eucrite display a subophitic to ophitic texture composed of anhedral pyroxenes and plagioclase laths. Recrystallized mesostasis occurs interstitially between grains of pyroxene and plagioclase. Minor minerals include quartz, ilmenite, chromite, apatite, troilite and Fe-metal. Textures and compositions of pyroxenes indicate that HaH 262 is a typical type 4 eucrite. Bulk REE compositions of this eucrite are roughly CI x10, indicating that this is a typical basaltic eucrite.

The samples heated at 1050 and 1070 °C preserve original basaltic textures at a large scale. Small amount (<1 %) of partial melts occur pervasively in grains of pyroxene and plagioclase, and in mesostasis.

These melts occur as thin veins (<1 μm thick) along fractures, cleavages, and as films coated on the surfaces of pore space in constituent minerals (Fig. 1). These melt veins are interconnected. The surface and fractures of these crystals are wetted with the partial melts. The occurrence indicates that mobilization of melts takes place very rapidly.

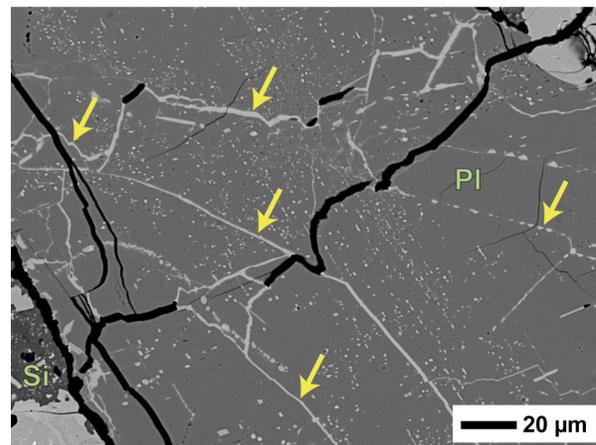


Fig.1. Backscattered electron image of the sample heated at 1070 °C for 24 hrs. Thin melt veins occur along preexisting fractures and cleavages in plagioclase lath (Pl: dark gray). Si: Silica minerals.

In the sample heated at 1100°C, melt pockets occur pervasively as thin veins in relict pyroxene and plagioclase and as melt pockets (>10%). Grains of pyroxene and plagioclase are irregularly resorbed. Mesostasis portions are totally melted. However the original framework of pyroxene grains and elongated plagioclase are preserved. There are aggregates of fine-grained cristobalite laths and grains of Fe-rich olivine that possibly crystallized during quenching.

In all heated samples, chemical compositions of relict pyroxene remain unchanged. Compositional variations in plagioclase in the 1050°C and 1070°C samples are similar to that of the unheated one, but the variation in the 1100°C sample is narrower due to melting of K and Na-rich rim of plagioclase.

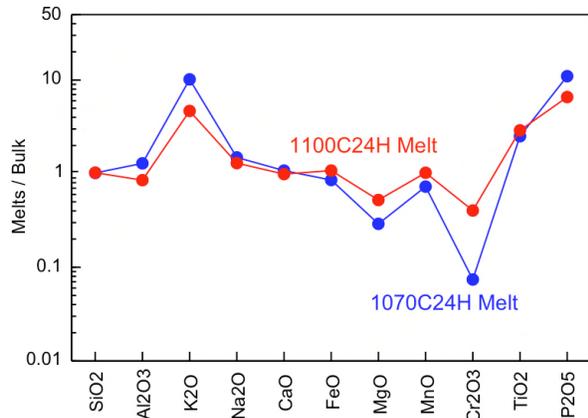


Fig. 2. Compositions of partial melts normalized to bulk compositions of the unheated HaH 262. Note the enrichments of K, Ti, and P.

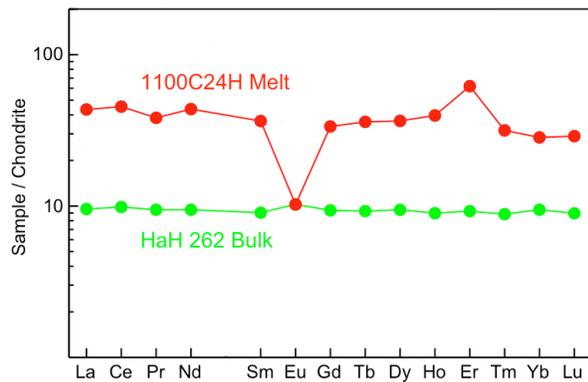


Fig.3. REE compositions partial melts in the 1100 °C sample and bulk HaH 262 normalized to chondrites.

results imply that significant mobilization of REEs induce by melting of Ca-phosphate takes place at lower temperatures (at ~1050 °C). Since most of REEs are stored in Ca-phosphates in the case of basaltic rocks [2], melting, mobilization and fractionation of melt derived from Ca-phosphate near the solidus cause redistribution of REEs in eucrites.

Our experiments show that small amounts of partial melts formed near the solidus mobilize through preexisting cracks, fractures, cleavages, and pore spaces. In contrast to diffusion in solid, this process takes place extremely rapidly, enhancing the speed of elemental redistribution among minerals. This process occurs near the solidus (~1050 °C) for a short time. Such conditions would have been common in the early crust of protoplanets. This process may explain depletions of REEs and disturbance of Sm-Nd ages in some basaltic eucrites [3-5].

References: [1] Yamaguchi A., and Mikouchi T. (2005) LPSC, #1574. [2] Hsu W. et al. (1996) GCA 60, 4571-4591. [3] Barrat J.A., et al. (2008) GCA 71, 4108-4124. [4] Yamaguchi A., et al. (2010) GCA 73, 7162-7182. [5] Yamaguchi A., et al. (2001) GCA 65, 3577-3599.

The partial melts in the heated samples are enriched in P₂O₅, K₂O, and TiO₂, indicating melting of Ca-phosphates and ilmenite, the rims of zoned plagioclase (or minor K-feldspar) (Fig. 2). The abundances of K₂O (bulk x~10) and P₂O₅ (bulk x~11) in the 1070 °C melts are higher than those in the 1100 °C sample (K₂O: x~5; P₂O₅: x~6.5). The Na₂O abundance is slightly higher in the 1070 °C sample (x~1.5) than that in the 1100 °C sample (x~1.3). These facts indicate preferential melting of Ca-phosphate and K-rich phases at lower temperatures. We could only made SIMS analysis for melts in the 1100 °C sample since melt veins in the samples 1050°C and 1070°C are too thin (<1 μm thick). The REE concentrations in the melts are enriched with the CI x ~30-40 with a negative Eu anomaly (Fig. 3). Melt veins in the 1050 °C sample are too thin to analyze reliably by EPMA, but the enrichments of Ti and P are clearly seen in the X-ray maps. Such melt would be enriched in REEs. The