

PETROLOGY, BULK CHEMICAL AND OXYGEN ISOTOPIC COMPOSITION OF A LOW-FeO ORDINARY CHONDRITE, YAMATO 982717. A. Yamaguchi¹, M. Kimura^{1,2}, J.A. Barrat³, R.C. Greenwood⁴ and I.A. Franchi⁴. ¹National Institute of Polar Research, Tokyo 173-8515, Japan (E-mail: yamaguch@nipr.ac.jp), ²Faculty of Science, Ibaraki University, Mito 310-8512, Japan, ³Université Européenne de Bretagne, U.B.O.-I.U.E.M., CNRS UMR 6538, Place Nicolas 20 Copernic, 29280 Plouzané Cedex, France, ⁴Planetary and Space Sciences, Department of Physical Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom.

Introduction: Ordinary chondrites (OC) are the largest meteorite clan, comprising approximately 80% of the global collection. OCs are generally classified into three chemical types, H, L, and LL groups. However, some OCs do not fit into these groups. Such OCs include “low-FeO OC” [1-3].

Yamato (Y) 982717 (original mass = 10.3 gram) has been classified as an anomalous H chondrite because of its very low Fa and Fs values [4]. Here we report the petrology, bulk chemical and oxygen isotopic composition of Y982717 and discuss its origin.

Methods: A polished thin section of Y982717 was examined optically, with a scanning electron microscope, electron microprobe analyzer (EPMA), and Raman spectrometer. Mapping of major elements (7.5 x 7.5 mm²) using an EPMA was performed to check chemical homogeneity of mafic minerals and the distribution of minor minerals.

The bulk chemical composition of Y982717 was determined by ICP-MS [5]. Oxygen isotope analysis was performed by infrared laser-assisted fluorination. All analyses were obtained on ~2mg whole rock samples. In order to remove terrestrial weathering products one fraction of Y982717 was leached using a solution of ethanolamine thioglycollate (EATG) [6].

Results and discussion: A PTS of Y982717 shows a chondritic texture composed of chondrules and chondrule fragments set in a finer-grained (clastic?) matrix (Fig. 1). Several pyroxenes within chondrules and fragments display polysynthetic twinning. Mesostasis glass is devitrified. Feldspar is very fine-grained (<~5 μm). Texturally, Y982717 is identical to typical H4 ordinary chondrites.

Modes of kamacite, taenite, and troilite are ~8, ~0.5, ~5 vol%, respectively. The FeS/metal (wt%/wt%) value is ~0.3 and therefore similar to that of a typical H chondrite [7]. Olivine and pyroxene show minor mottled extinction indicating a shock stage of S2. Y982717 is slightly weathered, and contains ~1% of weathering products (weathering grade = A). Fe-hydroxide occurs pervasively along cracks and fractures in mafic minerals.

Silica minerals (tridymite and cristobalite?) (<0.2 vol%) occur interstitially between pyroxenes in both

chondrules and lithic fragments. This textural association indicates that pyroxene is a primary phase in the meteorite and was not formed later by reduction during parent body metamorphism.

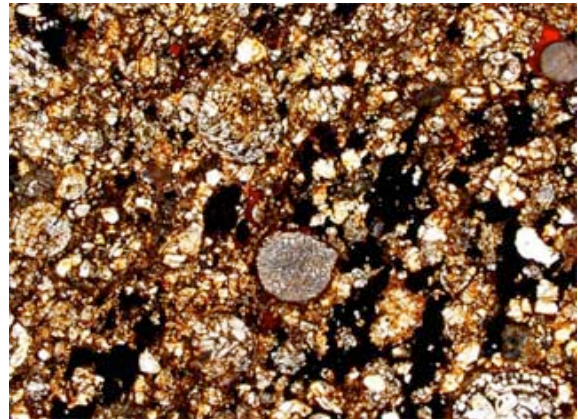


Figure 1. Photomicrograph of Y982717, showing a typical chondritic texture. Plane light. Width = 4.7 mm.

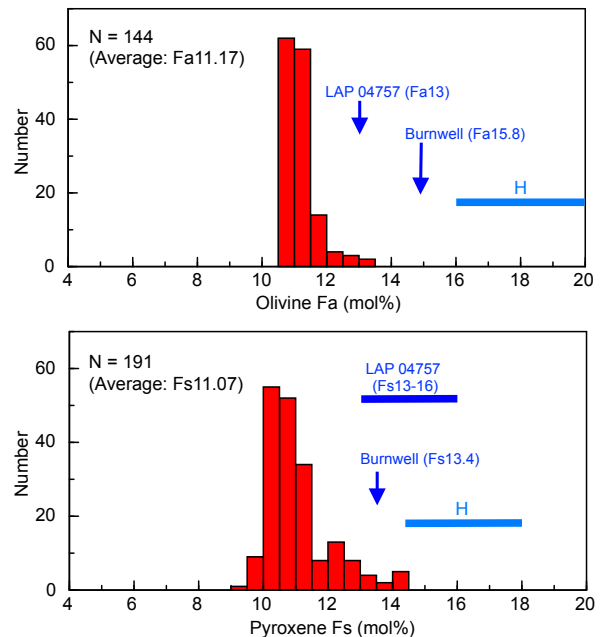


Figure 2. Chemical composition of olivine and pyroxene in Y982717. Data for Burnwell, LAP 04757, and H chondrites are from [2,3,8].

The composition of olivine (Fa_{10.6-13.3}, average Fa_{11.2}) and low-Ca pyroxene (Fs_{9.6-14.4}Wo_{0.2-4.8}, average Fs_{11.1}Wo_{0.9}) are significantly more magnesian than those of typical H chondrites, as well as other known low-FeO ordinary chondrites [1-3,8] (Fig. 2).

Ni (5.9-6.8 wt%) and Co (0.35-0.45 wt%) contents in Kamacite in Y982717 overlap with, but are slightly lower than, the range of H chondrites (Ni: 6.3-7.48 wt%, and Co: 0.44-0.51 wt%) [9]. Ni contents in taenite vary from 48.4-69.1 wt%.

Chromite compositions in Y982717 are Usp_{1.6-3.0}Sp_{11.7-16.2}Chm_{82.0-85.9} and Mg# (molar Mg/(Mg+Fe) x 100 = 12.0-16.5. Most feldspar grains are too small (<5 μm) to analyze by EPMA, but the few grains that could be measured were in the range Ab₋₁₀₋₄₀. Some silica minerals contain minor elements (<0.07 wt% Al₂O₃, <0.4 wt% FeO). Phosphate minerals are apatite and whitlockite. Apatite contains Cl (5.2-6.1 wt%) and a small amount of F (<0.3 wt%).

Refractory lithophile abundances in Y982717 are within or near the range of H chondrites. On a diagram of Zn/Mn vs. Al/Mn, Y982717 plots on the border of the OC range [10,11] (Fig. 3). The bulk chemical composition of Y982717 is similar to that of typical H chondrites.

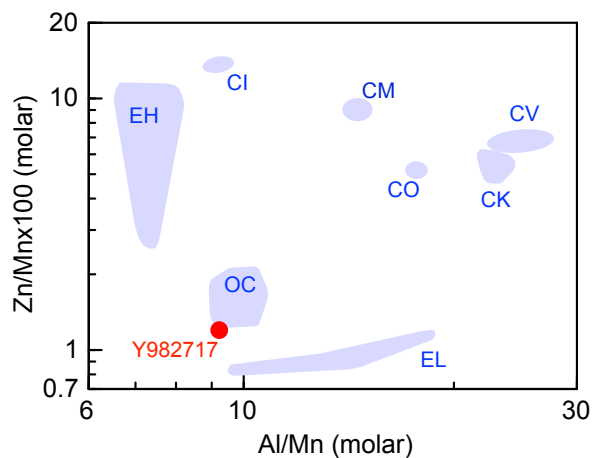


Figure 3. Bulk compositions of Y982717 plotted on a diagram of Zn/Mn vs. Al/Mn. Range of various chondrites are from [11].

Oxygen isotope analyses of treated and untreated fractions of Y982717 are plotted in Fig. 4. The untreated fraction of Y982717 is significantly shifted to lower $\delta^{18}\text{O}$ values compared to the EATG-treated fraction (Fig. 4). This is a common feature of metal and sulphide-rich Antarctic finds and reflects interaction with $\delta^{18}\text{O}$ depleted precipitation [6]. The EATG-treated residue, from which terrestrial weathering products have largely been removed, plots near the edge of the H chon-

drite field. On an olivine $\Delta^{17}\text{O}$ vs. Fa diagram (not shown), Y982717 plots outside the range of ordinary chondrites close to other low FeO ordinary chondrites [3].

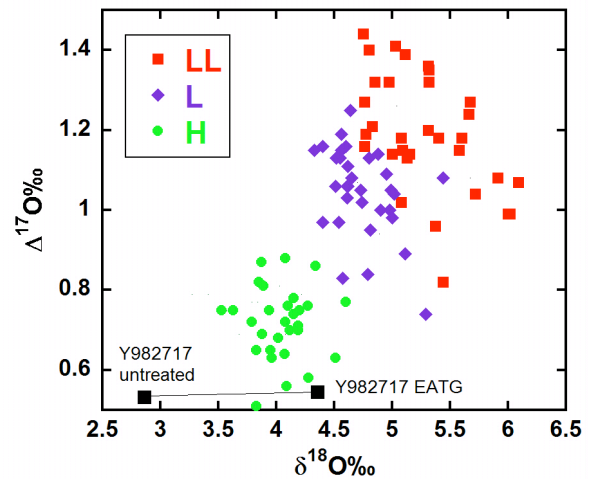


Figure 4. Oxygen isotope composition of treated and untreated fractions of Y982717 plotted in relation to the ordinary chondrite analyses of [12].

Conclusions: Textural evidence and bulk chemical and oxygen isotope compositions are all consistent with an ordinary chondrite affinity for Y982717. However, in most cases Y982717 plots close to the border of known H chondrite ranges. Y982717 is petrologic type 4, however, Fs and Fa values are slightly outside the normal H chondrite range. There are two processes that could produce low-FeO ordinary chondrites, nebular or parent body [1]. In the latter setting some form of reduction during metamorphism would be involved [11]. However, there is no clear evidence that Y982717 experienced reduction during metamorphism (FeS/metal ratios, reduction textures). Consequently we conclude that Y982717 is the lowest-FeO H chondrite found to date and indicates that the H chondrites are more compositionally diverse than has been previously recognized.

References: [1] McCoy T.J. (1994) LPSC XXV, 865-866. [2] Russell S.S. (1998) MAPS 33, 853-856. [3] Troiano J. et al. (2011) GCA 75, 6511-6519. [4] Yamaguchi A. et al. (2013) Meteorite Newsletter 22. [5] Barrat J.A. et al. (2012) GCA 83, 79-92. [6] Greenwood R.C. et al. (2012) GCA 94, 146-163. [7] McSween H.Y. et al. (1991) Icarus 90, 107-116. [8] Brearley A.J. and Jones R.H. (1998) Planetary Materials, Chap. 3. [9] Rubin A.E. (1990) GCA 54, 1217-1232. [10] Kallemeyn G.W. et al. (1989) GCA 53, 2747-2767. [11] Wasson J.T. et al. (1993) GCA 57, 1867-1878. [12] Clayton R.N. et al. (1991) GCA 55, 2317-2337.