Mineralogy and petrology of the Murrili meteorite

Conference or Workshop Item

Mineralogy and Petrology of the Murrili Meteorite

G.K. Benedix[1], L.V. Forman[1], L.Daly[1], R.C. Greenwood[2], I. A. Franchi[2], J.M. Friedrich[3], M.M.M. Meier[4], C. Maden[4], H. Busemann[4], K.C. Welten[5], M.W. Caffee[6], P.A. Bland[1], J. Paxman[1], M. Towner[1], M. Cupak[1], E.K. Sansom[1], R. Howie[1], H. Devillepoix[1], M. A. Cox, T. Jansen-Sturgeon, K. Merigot[7], D. Stuart[8], and D. Strangway[8].
[1]Dept. Applied Geology, Curtin University, GPO Box U1987, Perth, WA 6845, Australia (g.benedix@curtin.edu.au), [2]PSSRI, Open University, Milton Keynes, UK MK7 6AA; [3]Dept. of Chemistry, Fordham University, Brooklyn, NY, USA; [4]ETH Zurich, Institute for Geochemistry and Petrology, Zurich, Switzerland. [5]Space Sciences Laboratory, University of California, Berkeley, CA 94720, USA. [6]Department of Physics, Purdue University, West Lafayette, IN 47907, USA. [7]John de Laeter Centre, Bldg 301, Curtin University, Bentley, 6845. Western Australia; [8]23 Main Street, Port Augusta, South Australia

Introduction: Murrili (pronounced moo-RRil-y) is the 3rd meteorite recovered by the Desert Fireball Network (for details of the fall and orbit see [1]). It fell as a single, heart-shaped, 1.68 kg stone, measuring ~13 × 7 × 6 cm, and was entirely fusion crusted. Two small wedges and a thin slab were cut from the main mass for examination and analyses. Cut surfaces reveal pervasive alteration with rusty staining heterogeneously distributed in a wormy pattern. Chips and powders of both altered and unaltered sample were sent for oxygen isotope, bulk composition, cosmogenic nuclide, porosity/density, and Mössbauer analyses.

Analytical techniques: Mineral compositions were determined on a thick section with a JEOL 8530F electron microprobe (20kV, 20nA). Modal mineralogy was determined using a Tescan Integrated Mineral Analyzer. Oxygen isotopes were measured using the method described in [2]. Bulk trace and major element compositions were determined using the method described in [3,4]. Cosmogenic nuclides were measured as described in [5,6].

Results: Mössbauer and porosity/density results are reported elsewhere in this volume [7,8]. We focus here on the classification, mineralogy and a preliminary petrologic description of the meteorite.

Physical characteristics: Distinct chondrule (barred olivine, the remnants of porphyritic olivine, and possible radiating pyroxene) outlines, as well as large single mineral crystal clasts, are set in a relatively coarse-grained matrix. The section is dominated (all in vol%) by olivine (32%) and orthopyroxene (32%), with smaller amounts of plagioclase (7%), metal and Fe-oxides (10%) and sulfides (6.5%). Phosphate and chromite make up < 1% of the section. Examination of the minerals in thin section shows no evidence of shock – olivine has normal extinction across the section indicating a shock stage of 1 [9].

Geochemistry: Olivine has an average composition of $Fa_{18.8\pm0.5}$ (n=15). The orthopyroxene average is $Fs_{16.4\pm0.3}Wo_{1.1\pm0.3}$ (n=8). Chromite (n=7) Cr/Cr+Al ranges from 0.85 to 0.87 and Fe/Fe+Mg varies from 0.84 to 0.86. The oxygen isotopic composition of the unaltered material is $\delta^{17}O=2.76\pm0.02$‰, $\delta^{18}O=3.99\pm0.06$‰. The isotopic composition of the altered material is shifted to slightly higher $\delta^{17}O$ (2.85±0.02‰) and $\delta^{18}O$ (4.18±0.04‰). Bulk elemental data and cosmogenic nuclide results will be reported at the meeting.

Discussion: The overall texture of the sample indicates that the meteorite is a type 5 ordinary chondrite, which is consistent with the chromite [10] and OPX Wo values [11]. The average olivine, orthopyroxene and oxygen isotope compositions indicate the meteorite is chemically classified as an H chondrite [12,13]. The cosmic ray exposure (CRE) age of ~7 Ma coincides with the main CRE age cluster for H-chondrites. Cosmogenic nuclide ratios are compatible with a small pre-atmospheric size (few 10 cm).

The alteration of the meteorite is extensive due to the time spent in the lake bed. The lake is generally a dry salt bed, but the area had experienced some precipitation between the fall and collection of the meteorite. Cut surfaces revealed red staining of the silicates and significant rusting of metal grains. However, the alteration does not seem to have affected the interiors of silicate minerals. Mineral and oxygen isotopic composition of unaltered areas are within error of the altered material.

Conclusions: The Murrili meteorite is classified as an H5 chondrite, based on olivine, orthopyroxene and oxygen isotope compositions, as well as textural features. It has a shock stage of S1. It is weathered due to exposure to the lake bed mud, but the alteration has not completely pervaded the rock.

References: [1] Bland P.A. et al. 2016, this conference. [2] Miller M.F. et al. (1999) *Rapid. Comm. Mass Spec.* 13, 1211-1217. [3]Friedrich et al. 2003, *GCA*, 67, 2467-2479. [4] Wolf et al. 2012, *Talanta* 1000, 276-281.[5] Welten et al., 2011, *MAPS* 46, 177-198. [6] Meier M. M. M. et al., 2016, *MAPS* submitted. [7] Cadogen S. et al. 2016, this conference. [8] Macke, R. Et al., 2016, this conference. [9] Stöffler D. et al., 1991, *GCA*, 55, 3845-3867. [10] Bunch et al., 1967, *GCA* 31, 1569-1582. [11] Scott et al., 1986, *Proc. Lunar Planet. Sci. Conf.* 17, E115-E123. [12] Gomes C.B. and Keil K. 1980, *Brazilian Stone Meteorites*, Univ. New Mexico Press, 161pp. [13] Clayton et al. 1991 *GCA* 55, 2317-2337.