OXYGEN ISOTOPES IN ISOLATED AND CHONDRULE OLIVINES OF MURCHISON.

I. Jabeen[1] and H. Hiyagon[1], [1]Department of Earth and Planetary Science, The University of Tokyo, Bunkyo Ku, Tokyo 113-0033, Japan, email: jabeen@space.eps.s.u-tokyo.ac.jp, hiyagon@space.eps.s.u-tokyo.ac.jp

Introduction: Olivine in carbonaceous chondrites is one of the dominant components of chondrules and occurs as isolated grains in matrix as well. The origin of such isolated grains is still under debate whether these are condensates or crystallized from chondrule melts. [1,2]. Only a few oxygen isotope studies have been made in recent decade to understand the origin of such isolated grains in CI and CO chondrites [3,4]. Murchison is one of the most studied CM with respect to oxygen isotopes [5,6]. We choose Murchison to carry out extensive chemical and isotopic studies on such isolated olivine grains and chondrule olivines to look at their origin and formation processes. We conducted major and minor element analysis by SEM-EDS and in-situ oxygen isotope analysis by secondary ion mass spectrometry (SIMS) for olivines from chondrules and as isolated grains in the matrix of Murchison. Five analyses groups were selected; (i) Mg-rich isolated olivines (MgOl), (ii) Mg-rich chondrule olivines (MgChOl), (iii) Fe-rich "isolated" olivines (FeOl), (iv) Fe-rich chondrule olivines (FeChOl) and, (v) isolated olivines with Mg rich core (Ol-core) and Fe rich rim (Ol-rim). The isolated olivines from 125 to 250 μm mesh size separated by freeze-thaw cycles and ultrasonic treatment were handpicked and mounted with epoxy along with San Carlos olivine standard for the analyses. We also prepared a thin section of Murchison, with which a San Carlos olivine grain was mounted and polished together, and used for the analysis.

Analytical techniques: Major and minor element analysis was performed with a scanning electron microscope (SEM) JEOL JSM-5310, equipped with an energy dispersive X-ray spectrometer (EDS). For Ca, Ti, Cr, Mn and Fe, a long counting time of 1000 sec was applied to obtain good precision. Cathodoluminescence (CL) Imaging was done using Gatan MiniCL. Oxygen isotope analysis was performed using a Cameca IMS 6F secondary ion microprobe. A Cs^+ primary beam of 10keV energy was used for the analysis. Secondary ions were measured at mass resolution of ~5000. A Faraday cup (for $^{16}O^-$) and an electron multiplier-based ion counting system (for $^{17}O^-$, $^{16}OH^-$ and $^{18}O^-$) were used as detectors. San Carlos olivine [7] was used as a standard. It was repeatedly analyzed before and after the sample analyses and all the data were corrected using the average of the standard analysis. The precision (1σ) of the analyses was ±1.1‰ for $\delta^{17}O$ and ±1.2‰ for $\delta^{18}O$. We also used a synthetic forsterite standard of known O-isotopic composition to examine possible matrix effect for different Fa content in olivine. However, we observed almost no matrix effect (≤1 permil for $\delta^{18}O$) between San Carlos olivine and pure forsterite in the present analytical conditions.

Major and Minor element compositions: The Mg–rich isolated olivines studied are clean crystals and no zoning was observed in back scattered electron (BSE) images. They have very emitting CL images. Some grains contain Fe-Ni metal inclusions. These isolated grains have low Fa contents from 0.2 to 0.7 mol %, high CaO from 0.24 to 0.73 wt% and low MnO from 0.0 to 0.06 wt.%.

The Fe-rich isolated olivines have Fa contents from 17 to 56 mol%. No cathode luminescence (CL) was observed. They are mostly zoned under BSE images. Melt inclusions are occasionally observed within individual grains. They have low CaO concentrations from 0.04 to 0.16 wt% and relatively high concentrations of MnO from 0.12 to 0.35 wt%, respectively.

The Mg-rich chondrule olivines have moderate emitting CL images. Their Fa contents are from 0.5 to 2.4 mol %, CaO from 0.21 to 0.29 wt% and MnO from 0.03 to 0.31 wt.%.

The Fe-rich chondrule olivines have no CL images. They have Fa contents from 10.4 to 56.3 mol%, CaO and MnO contents from 0.20 to 0.22 wt% and 0.29 to 0.43 wt%, respectively. They show Fe zoning visible under BSE images.

Two isolated olivine grains have Mg-rich core with Fa contents of 0.55 to 2.15 mol% and Fe-rich rim with Fa from 22.6 to 27.8 mol%. They show very brilliant CL emission in the core, while no CL was observed in the rims. The core and rim of these olivines have MnO contents from 0.0 to 0.02 wt% and 0.24 to 0.31 wt% and CaO contents from 0.45 to 1.05 wt% and 0.28 to 0.41 wt%, respectively.

Oxygen isotopic compositions: The $\delta^{18}O$ value ranges in MgOl, FeOl, MgChOl, FeChOl, Ol-core and Ol-rim are from -6.95 to 9.84, -1.80 to 5.62, -3.77 to 5.42, 0.82 to 7.13, -2.44 to 8.87 and -1.36 to 5.23 ‰, respectively. These data sets are shown in Fig-1.

Two populations of isolated olivine grains are observed. The MgOl and FeOl isolated olivines shown as filled legends in Fig.1 define two well distinct areas. The forsteritic olivines are falling towards more ^{16}O-enriched side with lower $\Delta^{17}O$ values of ~-7‰. While the more fayalitic olivines are falling relatively upper area with Δ^{17}O of ~-2‰.

A similar observation is made in the case of Fe-poor and Fe-rich chondrules (MgChOl and FeChOl). The magnesian chondrule data fall along the CCAM line while the fayalitic chondrule data well fits over the data for the isolated Fe-rich olivines (FeOl).

The similarities in the chemical composition and O-isotopic composition of Fe-rich "isolated" olivines and FeChOl suggest that they have a common origin. Presence of melt inclusions in FeOl and chemical zoning similar to those found in FeChOl also support this view.

The oxygen isotope data of relic grains with magnesian core (Ol-core) and fayalitic overgrowths (Ol-rim) are also worth noting. The core data fall among the MgOl region while the rim data satisfy well the FeOl bunch. This suggests that Mg-rich isolated olivine existed as a precursor of chondrules.

The most significant observation obtained in this study is that the magnesian isolated olivines (MgOl) are O-isotopically distinct from any other groups. The distribution of the data starts somewhere near the CCAM line but expands far towards the right side of this line. This makes clear contrast to the Mg-rich chondrule olivine data, which fit well on the slope ~1 line. Matrix effect is not likely the cause for this deviation because we see almost no matrix effect even for the pure forsterite. The present O-isotope results, therefore, strongly suggest a separate origin for the Mg-rich isolated olivines. These grains also have refractory signatures in chemical compositions, e.g., high CaO content (up to ~0.7 wt%) and low MnO content (<0.06 wt%) (Figs. 2 and 3). The O-isotopic compositions distinct from chondrule olivines and their refractory nature may suggest condensation origin for the Mg-rich isolated olivines. However, the relationship between these grains and AOAs is unclear, both of which are very different in the grain size and O-isotopes. We need more information to better understand the origin and formation processes of these different types of olivine grains.

References:

[1] Weinbruch, S. et al. (2000) MAPS, 35, 161-171. [2]. Jones, R.H. GCA, 1992, 56, 467-482. [3] Leshin, L. A. et al. (1997) GCA, 61, 835-845. [4]. Jones, R.H. et al. (2000) MAPS, 35, 849-857. [5] Clayton, R.N. and Mayeda T.K. (1984) EPSL, 67, 151-161. [6]. Hiyagon H. and Hashimoto A. (1999) Science, *283,* 828-831. [7]. Jabeen et al. (1998). AMR, 11, 124-137.

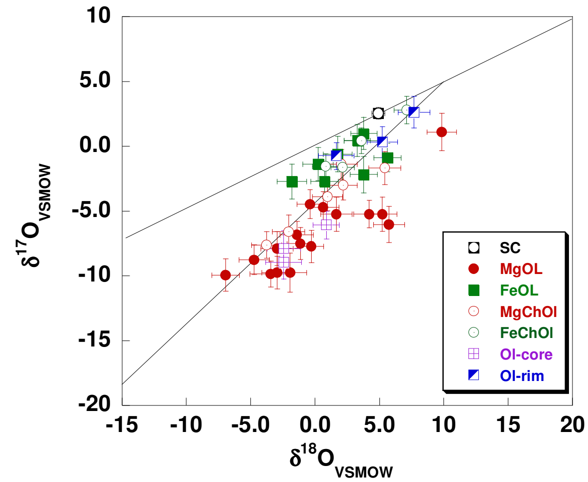

Fig. 1. Oxygen isotopes in various fractions of Murchison.

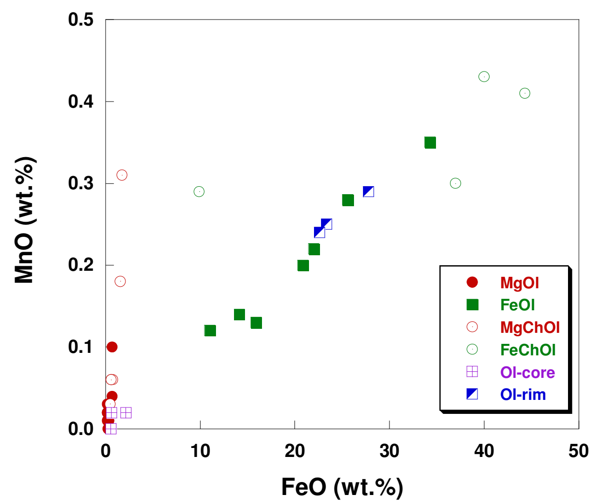

Fig. 2. Relationship of MnO with FeO concentration.

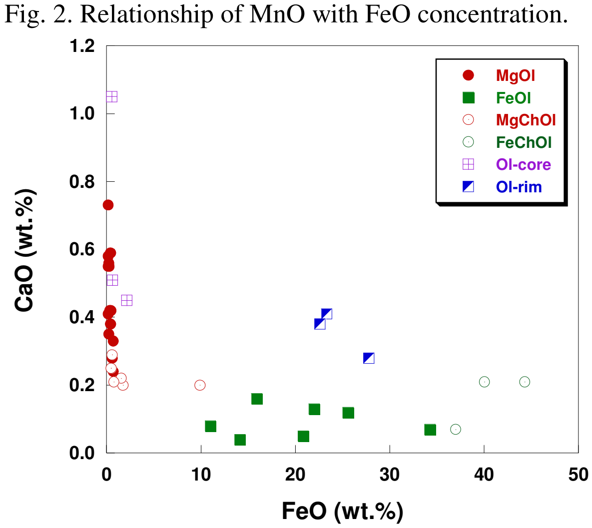

Fig. 3. Relationship of CaO with FeO concentration.