Petrology and geochemistry of a silicate clast from the Mount Padbury mesosiderite:
Implications for metal-silicate mixing events of mesosiderite

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Abstract—Petrological and bulk geochemical studies were performed on a large silicate clast from the Mount Padbury mesosiderite. The silicate clast is composed mainly of pyroxene and plagioclase with minor amounts of ilmenite, spinel, and other accessory minerals, and it shows subophitic texture. Pyroxenes in the clast are similar to those in type 5 eucrites and could have experienced prolonged thermal metamorphism after rapid crystallization from a near-surface melt. Ilmenite and spinel vary chemically, indicating growth under disequilibrium conditions. The clast seems to have experienced an episode of rapid reheating and cooling, possibly as a result of metal-silicate mixing. Abundances of siderophile elements are obviously higher than in eucrites, although the clast is also extremely depleted in highly siderophile elements. The fractionated pattern can be explained by injection of Fe-FeS melts generated by partial melting of metallic portions during metal-silicate mixing.

The silicate clast had a complex petrogenesis that could have included: 1) rapid crystallization from magma in a lava flow or a shallow intrusion; 2) prolonged thermal metamorphism to equilibrate the mineral compositions of pyroxene and plagioclase after primary crystallization; 3) metal-silicate mixing probably caused by the impact of solid metal bodies on the surface of the mesosiderite parent body; and 4) partial melting of metal and sulfide portions (and silicate in some cases) caused by the collisional heating, which produced Fe-FeS melts with highly fractionated siderophile elements that were injected into silicate portions along cracks and fractures.

INTRODUCTION

Mesosiderites are stony-iron meteorites consisting of roughly equal amounts of silicates and metal. Silicate portions of mesosiderites consist of lithic clasts and individual silicate mineral fragments in a fine-grained matrix. The lithic clasts are largely basalt, gabbro, and pyroxenite, with minor amounts of dunite (Powell 1971; Floran 1978; Mittlefehldt 1979, 1990). Mineralogical, chemical, and isotopic studies have revealed that these clasts were derived from diverse levels of a compositionally stratified asteroid that was similar but not necessarily identical to the howardite-eucrite-diogenite (HED) parent body (e.g., Mittlefehldt et al. 1998). Metal occurs as clasts, constituents of some lithic clasts, and as veins in silicate clasts and matrices. Composition of metallic portions is similar to IIIAB irons that are thought to have originated in the core of an asteroidal body (Powell 1969; Wasson et al. 1974; Hassanzadeh et al. 1990).

Oxygen isotopic compositions of mesosiderites have been indistinguishable from the mean of the HED meteorite suite, the IIIAB irons, and the main-group pallasites (Clayton and Mayeda 1996). Recent relatively high-precision analyses show that the silicate portions of pallasites and mesosiderites are derived from two distinct asteroidal sources (Greenwood et al. 2006). On the other hand, the extremely close coincidence of oxygen isotopic compositions for mesosiderites and HEDs further strengthens the case for a genetic link between these two groups.

Evidence for the presence of live ²⁶Al, ¹⁰⁷Pd, and ¹⁴⁶Sm in mesosiderites indicates that the mesosiderite parent body formed at a very early stage of solar system history (Stewart et al. 1994; Chen and Wasserburg 1996; Bizzarro et al. 2005).

Mesosiderites could have been formed by impact and mixing of Fe-Ni core material from a differentiated body with silicates from the basaltic surface of a large body (Powell 1971; Floran 1978; Delaney et al. 1981; Hewins 1983;
Wasson and Rubin 1985). Alternatively, internal processes may be responsible, with the mixing of basaltic crust and core materials in a single body (Hewins 1983; Greenberg and Chapman 1984; Scott et al. 2001).

The formational histories of mesosiderites and the origin of their constituents remain rather enigmatic because most of them have undergone multiple episodes of secondary processing involving thermal metamorphism, redox reactions, and planetary disruption, which have obscured primary textures and chemistry of silicate portions, as indicated by petrographic, mineralogical, and chronological studies (Powell 1971; Floran 1978; Delaney et al. 1981; Stewart et al. 1994). Numerous studies have used mesosiderite silicate clasts to clarify primary magmatic signatures (Rubin and Jerde 1987, 1988; Ikeda et al. 1990; Mittlefehldt 1990; Kimura et al. 1991; Rubin and Mittlefehldt 1992). These studies have shown that there are systematic differences between basaltic and gabbroic clasts in mesosiderites and eucrites. Compared with eucrites, basaltic and gabbroic clasts in mesosiderites contain more abundant modal silica minerals and phosphates, and their pyroxenes tend to be more MgO-rich and have lower Fe/Mn ratios. Some gabbroic clasts are extremely depleted in rare earth elements (REE) and have extremely high Eu/Sm ratios, which could be explained by remelting of crustal mafic igneous rocks after metal-silicate mixing (Mittlefehldt 1990; Rubin and Mittlefehldt 1992). These clasts are not directly comparable to eucrites because their mineral chemistry and bulk compositions were not established by the same processes that generated eucrites. However, some basaltic clasts in mesosiderites are almost indistinguishable from eucrites. These clasts are primary, and are directly comparable to eucrites.

To better understand the origin of mesosiderite silicates, thorough investigation of metamorphic effects on silicate clasts is needed. In this study, we carefully selected a single clast from one lithologic source (“monogenic”) basaltic clast from one of the least metamorphosed types of mesosiderite, Mount Padbury (Powell 1971). This was done to clarify the effects of metamorphism on mesosiderites, and to elucidate the petrogenesis of mesosiderite silicates.

**SAMPLE AND EXPERIMENTAL PROCEDURES**

Mount Padbury (original mass was 272 kg) consists of fine-grained silicates and reticulated metal with HED-like clasts, olivine clasts, and large metallic nodules, and is considered to be one of the least metamorphosed mesosiderites (Floran 1978). A large silicate slab (45 × 18 × 2 mm) from Mount Padbury was supplied by the Western Australian Museum. One side of the slab exposes brown Fe hydrates that may have been in contact with metallic portions. The sample was cut into several portions and two pieces were analyzed (Fig. 1). One was from the portion in contact with Fe hydrates (#1), and the other was from the opposite side (#2). Each piece was divided into two parts. One part was used for the preparation of polished thin sections (PTSs) and the remaining was used for bulk chemical analysis.

The PTSs were examined optically and with a scanning electron microscope (SEM, model JEOL JSM-5900) equipped with an energy-dispersive system (Oxford LINK ISIS). Chemical compositions of minerals were determined with an electron microprobe analyzer (EPMA, model JEOL JXA-8800M) at the National Institute of Polar Research, Tokyo, Japan. Analytical conditions were 20 kV, 40 nA for pyroxene; 15 kV, 12 nA for plagioclase and tridymite; and 15 kV, 30 nA for metallic Fe-Ni, troilite, ilmenite, and spinel. Natural and synthetic minerals of well-known compositions were used as standards, and data were corrected using a ZAF calibration method using an inductively coupled mass isotope dilution mass spectrometry (IDMS) with an external calibration method using a pure Ge (coaxial-type) detector system in the interuniversity gamma ray analysis (PGA), each powdered sample weighing ~150 mg was put into a thin fluorinated ethylene propylene resin film bag and irradiated for about 2 h by a cold neutron beam at a flux of 1.4 × 10^8 n/cm²/s, guided out from the research reactor JRR-3M at the Japan Atomic Energy Research Institute (JAERI). Prompt gamma rays were detected by a Ge detector coupled to a 16 k channel pulse-height analyzer. The analytical procedure for PGA was essentially the same as that described by Oura et al. (2003). For instrumental neutron activation analysis (INAA), powdered samples weighing ~30 mg were sealed in clean polyethylene bags, irradiated for 10 s at a neutron flux of 5 × 10¹³ n/cm²/s for the determination of Ti and V, and were immediately measured for gamma ray emissions. Samples were re-irradiated for 20 min at a neutron flux of 3 × 10¹³ n/cm²/s. After cooling for several days, gamma ray intensities were measured with a pure Ge detector system in the interuniversity laboratory at the JAERI and Tokyo Metropolitan University. Measurements were repeated several times after appropriate cooling intervals.

Abundances of Y, REE, U, and Th were determined by isotope dilution mass spectrometry (IDMS) with an external calibration method using an inductively coupled mass spectrometer (ICP-MS, model VG Plasma Quad3). About 20 mg powdered samples were dissolved with a mixture of HF-HClO₄-HNO₃ in sealed Teflon vials. After decomposition, samples were evaporated to dryness and then dissolved in 7 M HNO₃. The solutions were finally diluted to 15 ml with deionized water (18.3 MΩ/cm). Isotopic compositions were measured by ICP-MS at Tokyo Metropolitan University. The analytical procedures are essentially identical to those described in Shinotsuka and Ebihara (1997). Abundances of the platinum group elements (PGE) were determined by IDMS and by an external calibration method, only for Rh, using ICP-MS combined
with a fire-assay preconcentration technique. The charges, consisting of 500 mg powdered sample, 500 mg high-purity nickel powder, 300 mg sulfur, flux materials (sodium tetraborate, sodium carbonate, and silica), and PGE-enriched spike solution, were loaded into porcelain crucibles and were heated at 850 °C for 20 min followed by 1000 °C for 20 min in an electrical furnace. After dissolving the NiS bead in 6 M HCl and filtering the solution, the precipitate was dissolved in 6 M HCl with H 2O2. After complete dissolution, internal standards (In and Tl) for Rh measurement were added. The final solution was prepared by diluting to 15 ml with deionized water. The analytical procedures are essentially identical to those described in Shirai et al. (2003).

RESULTS

Petrography and Mineralogy

The clast displays a fine-grained texture (Fig. 2) and is mainly composed of plagioclase (43.6 vol%) and pyroxene (52.9 vol%) with minor accessory minerals (4.5 vol%) such as tridymite, chromite, ilmenite, phosphate, troilite, Fe-Ni metal, and baddeleyite (Table 1). Pyroxene occurs as grains up to 1 mm in length and tends to be anhedral. Plagioclase shows granoblastic texture. There are few ambiguous remnant igneous textures. Aggregates of plagioclase grains in many cases are lath-shaped (<2 × 0.4 mm) and partially surround anhedral pyroxenes; they may represent vestiges of an original basaltic (subophitic) texture. Boundaries of plagioclase and pyroxene are curved. Tridymite grains occur as lath-shaped to irregular discrete crystals (<0.6 × 0.1 mm) in the interstices between plagioclase and pyroxene. Ilmenite and spinel (<100 µm across) are the most common types of opaque minerals and are often associated with each other. These minerals typically occur in pyroxene grains or along grain boundaries between plagioclase and pyroxene with tridymite. Irregularly shaped Ca phosphates occur in association with plagioclase and are distributed heterogeneously. Two types of Fe metal are observed (Fig. 3). One occurs throughout the silicates as fine-grained droplets coexisting with troilite, and the other occurs as angular grains coexisting with chromite. Baddeleyite is irregularly shaped and typically occurs within or adjacent to ilmenite, and ranges from 1 to 15 µm in size.

Pigeonite contains closely spaced thin (several µm thick) augite lamellae that are homogeneously distributed, similar to those found in type 5 eucrites (Takeda and Graham 1991). Pyroxene is clouded by tiny opaque mineral inclusions and also contains large rounded inclusions of plagioclase. The Mg/Fe ratios of pigeonite are constant (Fig. 4) and are in the same range of those of other basaltic clasts from mesosiderites and basaltic eucrites. Plagioclase has limited composition (An88.3–89.4) and igneous zoning is not apparent. The most abundant minor mineral is tridymite, which occurs as a massive interstitial phase between pyroxene and plagioclase, and as lath-shaped to discrete crystals. Titanium contents of spinel vary gradually in the range Usp6.7–67.3 Chm28.7–75.3 (Fig. 5). Other trace phases include troilite and Fe metals. There are systematic differences in Ni and Co contents of metal. Fine-grained metal droplets with troilite have higher Ni and Co contents, typically 20–30 wt% and 0.4–0.8 wt%, respectively, than most of the angular metal grains coexisting with chromite (Table 3 and Fig. 6).

Bulk Compositions

Major and trace element compositions of two bulk samples (#1 and #2) from different parts of the slab do not show systematic differences (Table 4). Thus, we used averaged values as bulk chemical compositions for the following discussion. Major element compositions determined by PGA and INAA are consistent with those
estimated using modal abundances and assumed densities of constituent silicate minerals. On a plot of La versus Sc (Fig. 7), the clast lies between Nuevo Laredo and the main group of eucrites, including Juvinas (Warren and Jerde 1987).

Figure 8 compares REE abundances of the clast with literature data. The clast has a relatively high REE abundance level (~10 × CI) and shows an unfractionated pattern, resembling basaltic eucrites and basaltic clasts in mesosiderites (e.g., Juvinas, Millbillillie, and Vaca Muerta pebble 16) (Yamaguchi et al. 2002; Rubin and Mittlefehldt 1992).

Compared to basaltic eucrites, siderophile element concentrations of the clast are highly enriched. On a Co versus Ni diagram (Fig. 9), the clast falls in the same region as other basaltic clasts from mesosiderites, significantly higher than the average value of basaltic eucrites (Ni = 20 μg/g, Co = 6.5 μg/g) (Kitts and Lodders 1998). Figure 10 shows the CI-normalized siderophile element distribution of the clast. The abundance pattern of siderophiles is extremely fractionated. Abundances of Os and Ir are below the detection limit (0.01 ng/g).

**DISCUSSION**

**Petrogenesis**

This clast is petrographically similar to the Mount Padbury eucrite enclave W of McCall (1966), and clast RV-05 of Mittlefehldt (1979). In particular, clast RV-05 is also similar in mineral chemistry and bulk composition to the clast studied here, but siderophile element concentrations (e.g., nickel concentration of RV-05 is 600 μg/g) are significantly higher than the clast (270 μg/g).
The clast shows a fairly flat REE pattern; the Eu/Sm and La/Lu abundance ratios are 0.98 and 1.06, respectively. Pyroxene in the clast has a mean molar Fe/Mn ratio (31.3 ± 0.5) within the range of basaltic eucrite (31.2–32.2) (Mittlefehldt 2005). Its nickel concentration of 270 μg/g is lower than that of most meso siderite clasts. These features indicate that the clast formed by endogenous igneous processes on the parent body and is directly comparable to basaltic eucrites (Rubin and Mittlefehldt 1992).

The relict subophitic texture invokes relatively rapid cooling of magma. Judging from the maximum widths of relict plagioclase laths (<400 μm), the initial cooling rate of this rock from magma is estimated to be ~100 °C/h (Walker et al. 1978). Such a cooling rate would have occurred in a lava flow on the surface of a parent body or in a shallow intrusion.

On a plot of abundances of La versus Sc (Fig. 9), the clast is intermediate between Nuevo Laredo and the main group eucrites. Hence, the clast appears to be part of the Nuevo Laredo trend, indicating that the clast is probably formed by fractional crystallization from parent magma similar in composition to main group eucrites. The clast has an unfracti onated REE pattern similar to main group eucrites (Barrat et al. 2000), suggesting that it could have formed before plagioclase became exhausted from the source region.

**Metamorphic History**

The rapid cooling from melt would have inevitably produced chemical zoning in pyroxene and plagioclase, similar to that observed in unequilibrated eucrites (e.g., Takeda and Graham 1991). However, in the Mount Padbury clast, pigeonite and plagioclase are unzoned, suggesting that compositional zoning in plagioclase and pyroxene has been erased by subsequent thermal metamorphism. The recrystallization of plagioclase may have taken place during the metamorphism. The equilibration temperatures of the clast using the two-pyroxene geothermometer of Kretz (1982) are 833–932 °C similar to those of basaltic eucrites (Yamaguchi et al. 1996). These temperatures are below the solidus temperatures of basaltic eucrites (1050 °C) (Stolper 1977; Yamaguchi and Mikouchi 2005). The metamorphic degree of Mount Padbury pyroxenes is comparable to those of type 5 eucrites (Takeda and Graham 1991). Peak metamorphic temperatures of type 5 eucrite pyroxene could have been ~1000 °C, high enough to homogenize Ca-zoning in primary-zoned pigeonites (Yamaguchi et al. 1996). Subsequent slow cooling produced exsolution of augite in pigeonite. This metamorphism could have been caused by internal heating rather than shock heating during the formation of the mesosiderites as suggested by Keil et al. (1997).
The granular texture of the plagioclase suggests recrystallization from a highly strained state, such as maskelynite. Pyroxenes are fractured and in some parts appear to be recrystallized. These features indicate that the clast experienced brecciation and recrystallization by impact that mixed metal and silicate at high temperatures. It is generally understood that the granoblastic texture is produced when shock is applied while material is still hot (Karato et al. 1980).

Cloudy pyroxene due to the precipitation of tiny opaque minerals is also a characteristic of thermal metamorphism. During metamorphism, chromite begins to exsolve in pyroxene (Harlow and Klimentidis 1980; Mori and Takeda 1985). As the metamorphism proceeds further, chromite continues to grow larger crystals (Arai et al. 1998). The assemblage of Ti-chromite, ilmenite, and Fe metal is commonly observed in lunar mare basalts and eucrites (El Goresy and Ramdohr 1975; Yamaguchi et al. 2001). This assemblage occurs in the Mount Padbury clast. The composition of Ti-chromite ranges continuously from Ti-rich to Ti-poor (Fig. 5), suggesting that spinel formed at >1000 °C (Sack and Ghiorso 1991). The variable Ti contents of inter- and intragrain chromite indicate that it was formed by disequilibrium processes or due to slow cooling below 700 °C as suggested by Liermann and Ganguly (2001) for diogenite spinels.

Backscattered electron images show fine curvilinear trails of tiny Fe-Ni metal and troilite grains. These trails could have been formed by the injection of molten metal from the metallic portion of the mesosiderite. The low Fe-FeS eutectic temperature (988 °C) causes the metal and sulfide to be readily melted and mobilized during impact heating, as observed in shocked ordinary chondrites (Rubin 1992).

### Highly Fractionated Siderophile Elements

Compared to most monomict and unbrecciated eucrites, siderophile elements in the clast are highly enriched. Because the enrichment of siderophile elements of the clast cannot be explained in terms of igneous processes (Righter et al. 2000), the clast could have been contaminated by the metallic portion of mesosiderite. However, the contamination did not take place in a simple manner. In contrast to the flat siderophile element pattern of the metallic portion, (CI-normalized Ir/Ni = 1.00–1.74) (Hassanzadeh et al. 1990), the clast shows a highly fractionated siderophile pattern (CI-normalized Ir/Ni < 0.0096). This fractionated pattern may have been produced by impact vaporization/fractional condensation of the metallic portion and the transportation of residual liquids into the silicate clast. In this case, metal formed by such processes would be depleted in refractory siderophile elements (e.g., Re, Os, Ir, Ru, Pt, and Rh) but would not be depleted in W (Rubin 1999). The abundance of W in the clast is, however, below the detection limit (0.5 ppm).

A more plausible cause of the fractionated pattern is the injection of fractionated liquid from the metallic portion. Mobility of a metallic liquid maybe be enhanced due to the

### Table 2. Representative chemical compositions (wt%) of pyroxene and plagioclase in the basaltic clast studied.

<table>
<thead>
<tr>
<th></th>
<th>Low-Ca pxa</th>
<th>High-Ca pxa</th>
<th>Pla</th>
<th>Chr*</th>
<th>IIm*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO2</td>
<td>50.0</td>
<td>50.5</td>
<td>46.7</td>
<td>0.05</td>
<td>0.08</td>
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<tr>
<td>Al2O3</td>
<td>0.36</td>
<td>1.02</td>
<td>33.6</td>
<td>9.86</td>
<td>3.54</td>
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<tr>
<td>TiO2</td>
<td>0.31</td>
<td>0.59</td>
<td>0.02</td>
<td>4.94</td>
<td>18.3</td>
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<td>FeO</td>
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<td>17.7</td>
<td>0.27</td>
<td>37.0</td>
<td>49.7</td>
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<td>MnO</td>
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<td>n.d.</td>
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<td>0.01</td>
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<tr>
<td>K2O</td>
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<td>0.00</td>
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<tr>
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<td>0.34</td>
<td>0.00</td>
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<td>26.4</td>
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<tr>
<td>V2O3</td>
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<td>n.d.</td>
<td>n.d.</td>
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<tr>
<td>Total</td>
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<td>99.7</td>
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<tr>
<td>Wo1.9</td>
<td></td>
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<tr>
<td>En15.7</td>
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<table>
<thead>
<tr>
<th></th>
<th>Low-Ca pxa</th>
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<tr>
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*a px = pyroxene; pl: plagioclase; chr = chromite; ilm = ilmenite.

n.d. = not determined.

### Table 3. Representative compositions (wt%) of Fe-Ni metal and troilite in the basaltic clast studied.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Ni-rich</th>
<th>Ni-poor</th>
<th>Troilite</th>
</tr>
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<tbody>
<tr>
<td>Fe</td>
<td>75.4</td>
<td>98.7</td>
<td>60.6</td>
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<tr>
<td>Co</td>
<td>0.49</td>
<td>0.16</td>
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</tr>
<tr>
<td>Ni</td>
<td>23.4</td>
<td>0.20</td>
<td>0.00</td>
</tr>
<tr>
<td>Cr</td>
<td>0.15</td>
<td>0.66</td>
<td>0.01</td>
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<tr>
<td>S</td>
<td>0.06</td>
<td>0.00</td>
<td>35.7</td>
</tr>
<tr>
<td>P</td>
<td>0.00</td>
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<td>0.00</td>
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<td>Total</td>
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<td>99.7</td>
<td>96.4</td>
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<tr>
<td>Wo1.9</td>
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<td>En15.7</td>
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</table>

m = not determined.

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The assemblage of Ti-chromite, ilmenite, and Fe metal is commonly observed in lunar mare basalts and eucrites (El Goresy and Ramdohr 1975; Yamaguchi et al. 2001). This assemblage could have formed by the breakdown of chromian-ulvöspinel as a result of subsolidus reduction. The same assemblage occurs in the Mount Padbury clast. The composition of Ti-chromite ranges continuously from Ti-rich to Ti-poor (Fig. 5), suggesting that spinel formed at >1000 °C (Sack and Ghiorso 1991). The variable Ti contents of inter- and intragrain chromite indicate that it was formed by disequilibrium processes or due to slow cooling below 700 °C as suggested by Liermann and Ganguly (2001) for diogenite spinels.

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Compared to most monomict and unbrecciated eucrites, siderophile elements in the clast are highly enriched. Because the enrichment of siderophile elements of the clast cannot be explained in terms of igneous processes (Righter et al. 2000), the clast could have been contaminated by the metallic portion of mesosiderite. However, the contamination did not take place in a simple manner. In contrast to the flat siderophile element pattern of the metallic portion, (CI-normalized Ir/Ni = 1.00–1.74) (Hassanzadeh et al. 1990), the clast shows a highly fractionated siderophile pattern (CI-normalized Ir/Ni < 0.0096). This fractionated pattern may have been produced by impact vaporization/fractional condensation of the metallic portion and the transportation of residual liquids into the silicate clast. In this case, metal formed by such processes would be depleted in refractory siderophile elements (e.g., Re, Os, Ir, Ru, Pt, and Rh) but would not be depleted in W (Rubin 1999). The abundance of W in the clast is, however, below the detection limit (0.5 ppm).
presence of grain boundaries in the metallic portion: experiments by Jones (1983) demonstrated significant sintering of solid iron metal when it was held below its solidus at 1050 °C for 10 days. The partitioning of siderophile elements between solid metal and liquid metal-sulfide is markedly dependent on the S content (Jones and Drake 1983; Chabot et al. 2003). Chabot et al. (2003) performed solid metal-liquid metal partitioning experiments. They showed that the partition coefficients ($D$) for Ir, Re, and Os increase by nearly three orders of magnitude, $D$(Pt) increase by two orders of magnitude, and $D$(Pd) increase only several times from the S-free system to compositions near the Fe-FeS eutectic. These results are consistent with degree of fractionation of siderophile element in the clast (in order of the partition coefficients: Os, Ir < Pt < Pd). The S content of the clast (0.57%) is higher than eucrites (e.g., 0.21% from Kitts and Lodders 1998). This is also consistent with the model of the injection of S-bearing fractionated liquid from the metallic portion.

The current consensus of the state of the Fe-Ni metal during metal-silicate mixing favors a molten origin because the metal forms a three-dimensional network and siderophile elements show undifferentiated patterns (Powell 1969; Hassanzadeh et al. 1990). However, this scenario is not the case for the Mount Padbury silicate. If the metallic portion of Mount Padbury was largely molten during metal-silicate mixing, the metallic liquid would have been unfractionated. So, an alternative scenario is that the fractionated liquid may be injected by impact melting of contiguous metal after a major metal-silicate mixing event. However, the clast has significantly lower Ir/Ni ratio than metallic portion of mesosiderite. Rubin and Jerde (1987) and Kimura et al. 2003.
(1991) also noted that the Ir/Ni ratios of the monogenic clasts they analyzed are very low. It is likely that all of the contamination of siderophile elements in monogenic clasts is due to a metal-silicate mixing event, but are not the result of subsequent impact because these clasts do not show evidence for shock deformation (Haack et al. 1996). We therefore suggest that the fractionated liquid may be injected during metal-silicate mixing.

CONCLUSIONS

We performed petrologic and bulk geochemical studies of a basaltic clast from the Mount Padbury mesosiderite. Combined investigations using petrology, mineralogy, and geochemical studies have allowed us to make the following inferences regarding its crystallization and post-crystallization thermal histories. The Mount Padbury clast experienced the following thermal history:

1. Rapid crystallization from a magma in a lava flow on the surface or as a shallow intrusion.
2. Following primary igneous crystallization, the basaltic clast underwent prolonged thermal metamorphism to re-equilibrate the mineral compositions of pyroxene and plagioclase.
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REFERENCES


3. Metal-silicate mixing caused by an impact of a solid metal fragment on the surface of the mesosiderite parent body.

4. Collisional heating caused partial melting of metal and sulfide (and silicate portions in some cases) to produce Fe-FeS melts with highly fractionated siderophile elements that were mobilized into silicates along cracks and fractures.


