

METAMORPHISM AND MELTING IN AN “UNMETAMORPHOSED” MESOSIDERITE. R. G. Mayne¹ and T. J. McCoy¹, ¹Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0119 USA (mayner@si.edu).

Introduction: The mesosiderites are amongst the most enigmatic of all the meteorite groups and their formation is not fully understood. Evidence taken from both the metal and silicate portions indicates that they have a multi-stage formation history [1,2]:

1. Initial crystallization and cooling of silicates, followed by brecciation on the surface of the parent body
2. Metal-silicate mixing, some melting, and recrystallization, followed by rapid cooling, as evidenced by the formation of overgrowths on the silicates.
3. Deep burial and slow cooling at low temperature.

Mesosiderites are classified according to both their petrology and degree of metamorphism [3,4]. The metamorphic scale is based purely on the texture of the matrix and, therefore, does not give any information on the history of the individual clasts or the metal-silicate mixing prior to cooling. It is these first two stages that are the least understood and, therefore, samples that preserve evidence of them, i.e. the least metamorphosed, will be the key to understanding the formation of the mesosiderites.

Here we present SEM and EMP analyses from two silicate clasts within Crab Orchard specifically to compare the degree of metamorphism of these clasts to similar clasts in eucrites and to understand the igneous processes that occurred upon mixing with metal.

Eucrite-like clast: This clast consists of a core of inverted pigeonite which poikilitically encloses a finely-exsolved augite (Fig. 1). The inverted pigeonite contains both fine-grained exsolution lamellae and blebs (Fig. 1b). This core is overgrown by a Mg-rich

orthopyroxene.

Pyroxene compositions in this clast (excluding the orthopyroxene rims) are similar to cumulate eucrites (e.g., Moore County) for both major quadrilateral and minor elements (Al, Ti, Cr) (Fig. 2). However, the exsolution within this grain is of a much finer scale than that of the cumulate eucrites, likely reflecting a different cooling history.

Diogenite-like clast: The core of this clast has a relatively constant orthopyroxene composition similar to that of diogenites, but exhibits a complex overgrowth resulting in an overall normal zonation (Fig. 3). Unlike the overgrowths described by [6] for similar clasts, in which FeO zoning is the prominent feature, this clast displays a thin inner rim of augite between the magnesian orthopyroxene core and the FeO-rich orthopyroxene rim.

Discussion: While Crab Orchard has been described as a type 1 mesosiderite [3], the clasts exhibit evidence of significant metamorphic equilibration and exsolution in their cores. We can compare the degree of equilibration to that observed in eucrites using calculated two-pyroxene exsolution temperatures and equilibration of elements (both major and minor) within the pyroxenes, as was done for unbrecciated eucrites [5]. We calculate an exsolution temperature for the Crab Orchard eucrite-like clast of 704 ± 54 °C [7], lower than that of Moore County (934 ± 54 °C) but comparable to the cumulate Serra de Magé (794 ± 24 °C). Basaltic eucrite GRO 95533 has an almost identical calculated exsolution temperature of 706 ± 30 °C. It is also texturally similar, containing fine-scale exso-

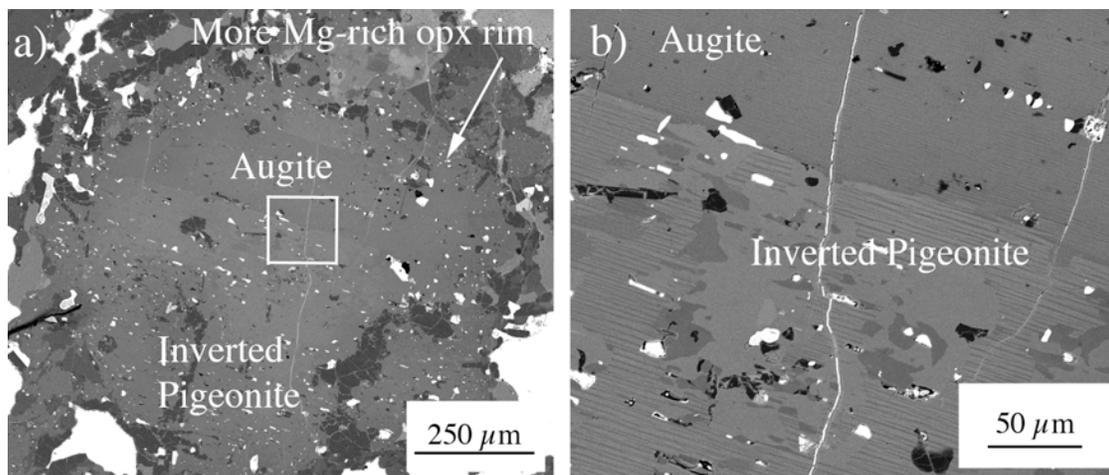


Figure 1: BSE images of the eucrite-like clast within Crab Orchard. a) The inverted pigeonite grain encloses an augite, which can be seen faintly as a darker area within the inverted pigeonite. Area in white box is enlarged in b) which shows the boundary between the augite and the inverted pigeonite.

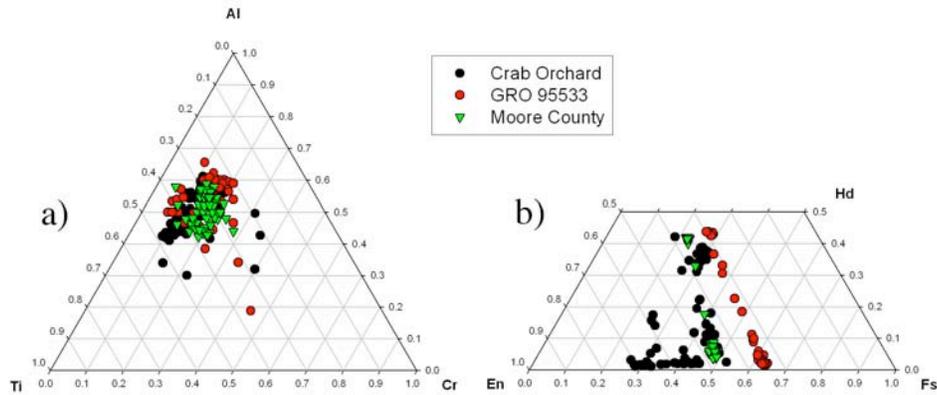


Figure 2: Pyroxene compositions of the eucrite-like clast with Crab Orchard compared to the basaltic eucrite GRO 95533 and cumulate eucrite Moore County. a) The minor elements (Al, Ti, Cr) within the pyroxenes. The compositions for each meteorite are mostly clustered together, with Moore County being the least scattered, this reflects the metamorphic equilibration of these elements. b) The major (quadrilateral) elements of the pyroxenes. The eucrites Moore County and GRO 95533 both have equilibrated compositions and are exsolved into two separate compositions. The core of the Crab Orchard eucrite clast is also equilibrated with respect to these elements, with the apparent outlying, more Mg-rich orthopyroxene analyses from the overgrowths at the rim of the inverted pigeonite grains. Pyroxene data for Moore County and GRO 95533 are taken from [5].

lution and grains of augite, and shows the same partial equilibration with respect to the minor elements in pyroxene (Fig. 2a). Interestingly, despite being magnesian and similar to cumulate eucrites, the Crab Orchard clast yields a two-pyroxene temperature lower than that of any unbrecciated cumulate eucrite and finer-exsolution, perhaps suggesting derivation from a shallower level in the crust of the mesosiderite (HED?) parent body.

The overgrowths on these clasts are similar in composition to each other and likely crystallized from a melt formed at the time of metal-silicate mixing, as suggested by [8]. The strongest evidence for formation of the overgrowths from melts rather than through solid-state diffusion comes from FeO and MnO profiles through the rim of the diogenite-like clast. While yielding low molar Fe/Mn ratios, FeO and MnO zoning profiles mimic each other, reflecting igneous partitioning during crystallization (Fig. 3). While similar, the rims do differ. The diogenite-like clast exhibits evidence for a CaO-rich inner rim that must have crystallized shortly after metal-silicate mixing. We suggest that formation of this inner rim preceded phosphate crystallization, with CaO, P₂O₅ and FeO present in the melt as a result of complex (?) redox reactions, including oxidation of P from the metal [9].

It seems clear that the current metamorphic classification for mesosiderites doesn't capture the complexity of their formation or metamorphism. In this type 1 mesosiderite, we have identified equilibrated and exsolved clasts which have subsequently interacted with melt prior to rapid cooling. The nature of this melt and its formation is poorly-understood, in large part because we lack complementary quantitative information

about the chemical composition of the co-existing metal. One might predict, for example, that a suite of elements (e.g., P, Fe, Cr, W) would be depleted in the metal phase if oxidation occurred. We intend to test this idea using LA-ICP-MS analyses of the metal, as well as to expand our study of the silicate clasts, to better understand the formation of these rocks.

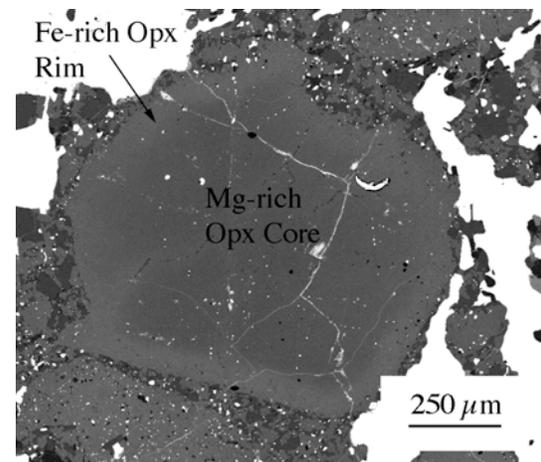


Figure 3: A BSE image of the diogenite-like clast. The zoned appearance can be seen, with the Mg-rich core being darker in the image than the more Fe-rich rims. The transitional zone with higher Ca compositions is not visible.

References: [1] Rubin and Mittlefehldt (1993) *Icarus* 101, 201 [2] Mittlefehldt et al. (1998) *Planetary Materials*. [3] Powell (1971) *GCA* 35, 5 [4] Floran (1978) *LPSC VIII*, 1053-1081. [5] Mayne et al., (In Press) *GCA* [6] Delaney et al. (1981) *LPSC XII*, 1315 [7] Anderson et al. (1993) *Comp. GeoSci.* 19, 1333 [8] Hassanzadeh et al. (1990) *GCA* 54, 3197 [9] Agosto et al. (1980) *LPSC XI*, 1027