POSSIBLE EVIDENCE FOR SULFIDIZATION REACTIONS IN THE MILLER RANGE BRACHINITES (?)

S. A. Singerling, T. J. McCoy, and K. G. Gardner-Vandy

Smithsonian
National Museum of Natural History

Introduction

Six ungrouped achondrites (MIL 090206, 090340, 090356, 090405, 090805, and 090963) were recovered in Miller Range, Antarctica during the 2009 ANSMET field season. Preliminary classification of these meteorites concluded that they were ureilites/ungrouped achondrites [1-4]. Subsequent work by [5] and [6] argued that these MIL samples are brachinites based on their petrology.

A prominent feature of these meteorites is a grain boundary symplectite (Fig. 1) that is ubiquitous throughout this pairing group. Although previous studies have focused extensively on the relationship of the MIL pairing group to other achondrites, here we focus specifically on the petrology, mineralogy, and origin of these symplectites.

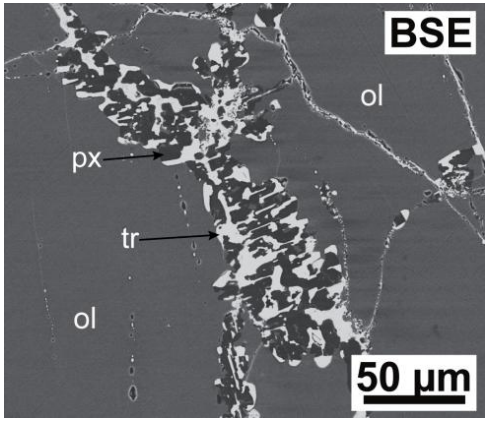

Fig. 1. BSE image of the symplectic intergrowth texture that occurs along olivine grain boundaries in the MIL ungrouped achondrites.

Methods

BSE images and X-ray maps were obtained using the FEI Nova NanoSEM 600 at NMNH Min. Sci. Dept. with 15 kV accelerating potential and 6 mm working distance.

Results

- Symplectites are composed of a subequal mixture of orthopyroxene and troilite and occur at olivine grain boundaries.
- Large olivine ($Fo_{71.5-73.4}$) and opx ($En_{72.4}Wo_{2.3}$) grains are in equilibrium [5,6], but symplectite opx is more magnesian ($En_{75.9}Wo_{1.3}$ [5] to $En_{78.2}Wo_1$ [6]).
- Minor phases observed in intergrowths are chromite and hydrated Fe-oxide (terrestrial origin) (Fig. 2).
- Symplectites do not occur evenly distributed and instead are less common in opx grains than in adjacent olivine grains even when the two are in contact.
- Symplectites are not observed at opx-troilite interfaces (Fig. 3). Intergrowth formation is preferred in olivine.

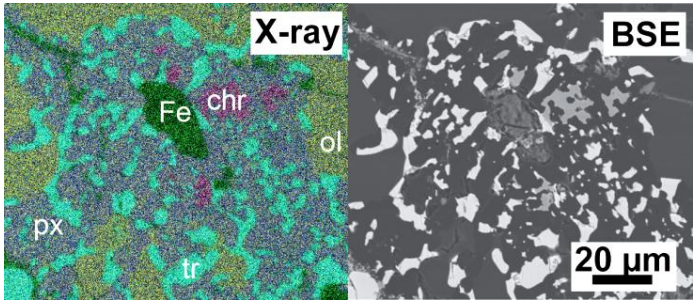

Fig. 2. X-ray map and corresponding BSE image depicting the different phases present in symplectites. (chr – chromite, tr – troilite, px – pyroxene, ol – olivine, Fe – hydrated iron oxide)

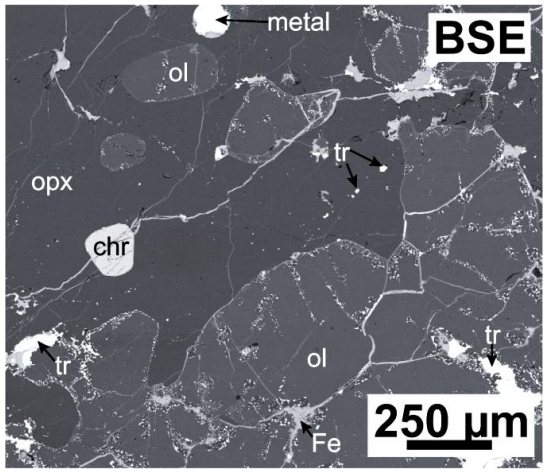

Fig. 3. BSE image of MIL 090206 illustrating the relationship between the intergrowths, opx, and ol (metal – Fe,Ni metal)

Discussion

Three possible origins for the intergrowths:

1. Partial melting occurred; the melt migrated and was trapped at grain boundaries
2. Small amounts of melt were produced along grain boundaries as a result of impact.
3. Sulfidization reactions between an S-rich fluid or gas and primary olivine produced the opx-sulfide symplectites. An idealized version of such a reaction could follow the formula:

$$2(Fe,Mg)_2SiO_4 + S_2(g) \rightarrow 2MgSiO_3 + 2FeS + O_2(g)$$

Conclusions

- Symplectic intergrowth texture observed in MIL ungrouped achondrites is likely the result of a sulfidization reaction that occurred post-crystallization from infiltrating S-rich gas.
- If MIL ungrouped achondrites are linked to brachinites, the presence of symplectite textures in other brachinites suggests this was a widespread process on the brachinite parent body.
- Late-stage sulfidization reactions do not appear to have been common on other primitive achondrite parent bodies.

References

[1] *Ant. Met. Newsl.* 34(1), 2011. [2] *Ant. Met. Newsl.* 34(2), 2011. [3] *Ant. Met. Newsl.* 35(1), 2012. [4] *Ant. Met. Newsl.* 35(2), 2012. [5] Warren P. H. and Rubin A. E. (2012) *LPS XLIII,* Abstract #2528. [6] Goodrich et al. (2012) *Ann. Met. Soc. LXXV,* Abstract #5272.