Metasomatism in Eucrites

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Introduction

The breakdown of pyroxene to silica and troilite was first identified as an alteration process in eucrites by Duke and Silver [1]; however, metasomatism was not identified as a potential cause of these features until the 1990s [2] and has been increasingly identified in the last 10 years [3, 4, 5, 6, 7]. Many eucrite studies were conducted prior to this time and, while metasomatic features may have been identified, they were not attributed to this process.

Barrat et al. [4] proposed a three-stage alteration process to explain the products of metasomatic alteration found in eucrites:

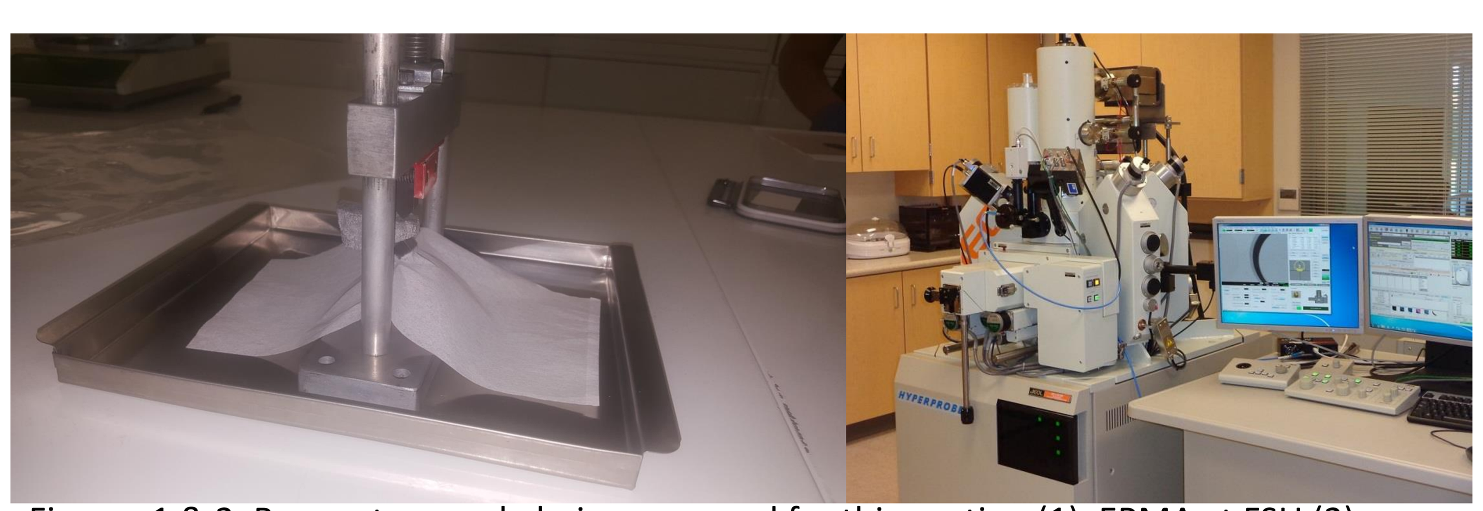
(1) Fe-enrichments along cracks in pyroxenes
(2) Fe-rich olivine deposits in cracks and troilite
(3) Al-depletion coincident with Fe-enrichment of pyroxene

While metasomatism within eucrites is now commonly identified within the literature, the mechanism for this alteration is not well understood. Possible mechanisms proposed involve hydrous fluid alteration [4] or sulfurization from a S-rich vapor [6, 7]. The addition of sulfur is required to produce troilite from the breakdown of pyroxene, which has been observed in several eucrites [3, 4, 5, 6, 7]. Zhang et al. [5] suggested that the sulfur may have been present in the form of a dry S-O-P vapor, formed by the volatilization of pre-existing S- and P-rich material as a result of impacts. Additional petrological studies are needed to test if metasomatism was consistently driven by S-O-P vapors or if some metasomatism lacks the P-component expected for impact derived vapor.

Metasomatism has been directly investigated for only a handful of eucrites. This study will investigate metasomatism in both Stannern and Main-Group-Nuevo-Laredo (MGNL) eucrites to investigate the com-position of the altering fluid/vapor and overarching processes that drive metasomatism on the eucrite parent body. Our preliminary work is focused on the Stannern-trend eucrites Bouvante and LEW 88010, the main group eucrite, and the polymict eucrite NWA 4834.

Methods

The samples from this study are on loan from the following: Béréba (USNM 5745-2, USNM 6003-2; National Meteorite Collection, Smithsonian Institution), Lewis Hills 88010 (LEW 88010) (LEW 88010,4; Meteorite Working Group), Bouvante and Northwest Africa 4834 (NWA 4834) (M1224.3, M1224.5, and M2049.2; Monnig Meteorite Collection).



Figures 1 & 2. Bouvante sample being prepared for thin section (1). EPMA at FSU (2).

Petrographic analysis was conducted via optical microscopy with an Olympus BX51 polarizing light microscope at the Oscar Monnig Meteorite Collection at Texas Christian University. Backscatter electron (BSE) maps and major element data for pyroxenes in Bouvante, LEW 88010, and NWA 4834 were measured by a JEOL JXA-8530F HyperProbe electron microprobe analyzer (EMPA) at Fayetteville State University's Southeastern North Carolina Regional Microanalytical and Imaging Consortium. Backscatter maps were generated for each thin section and energy dispersive x-ray spectrometry (EDS) point analyses were performed.

Results

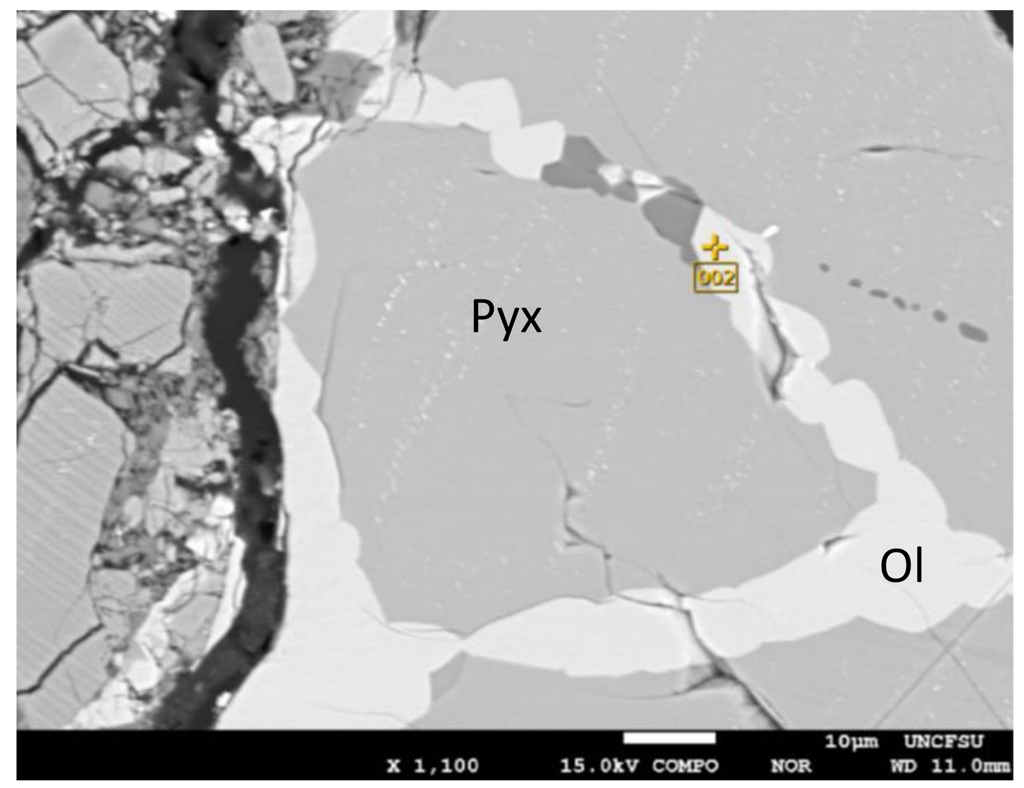


Figure 1: BSE image showing Fe-rich olivine surrounding a pyroxene grain in NWA 4834. The pyroxene also contains abundant troilite.

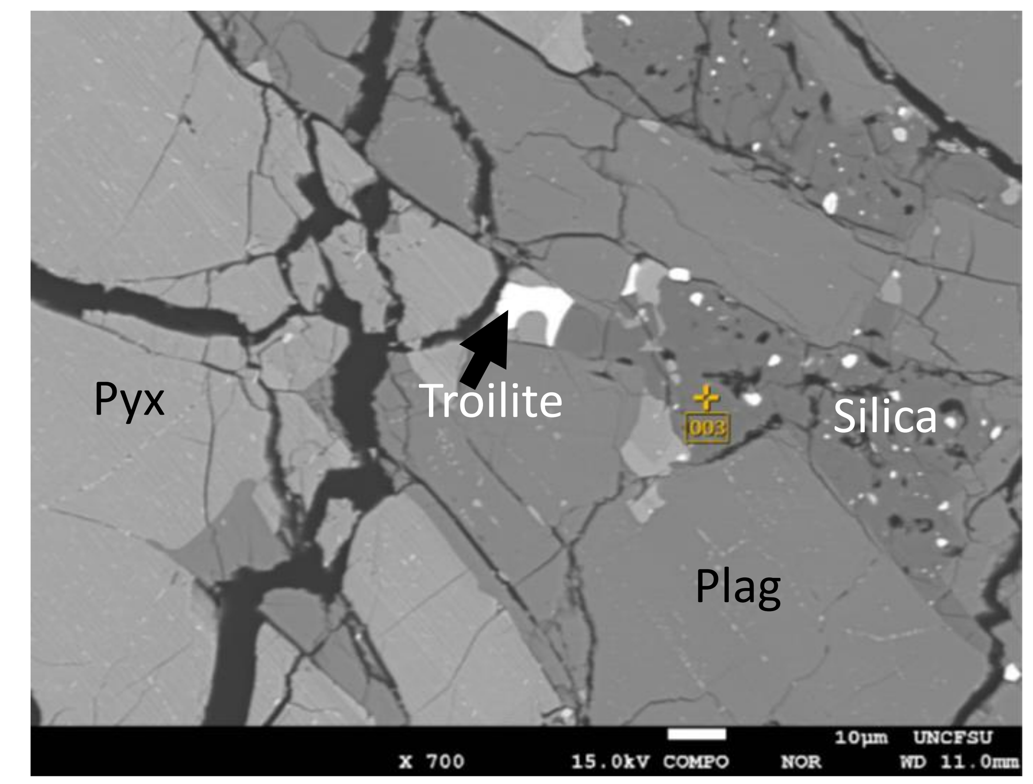


Figure 2: Troilite and silica replacing pyroxene in Bouvante.

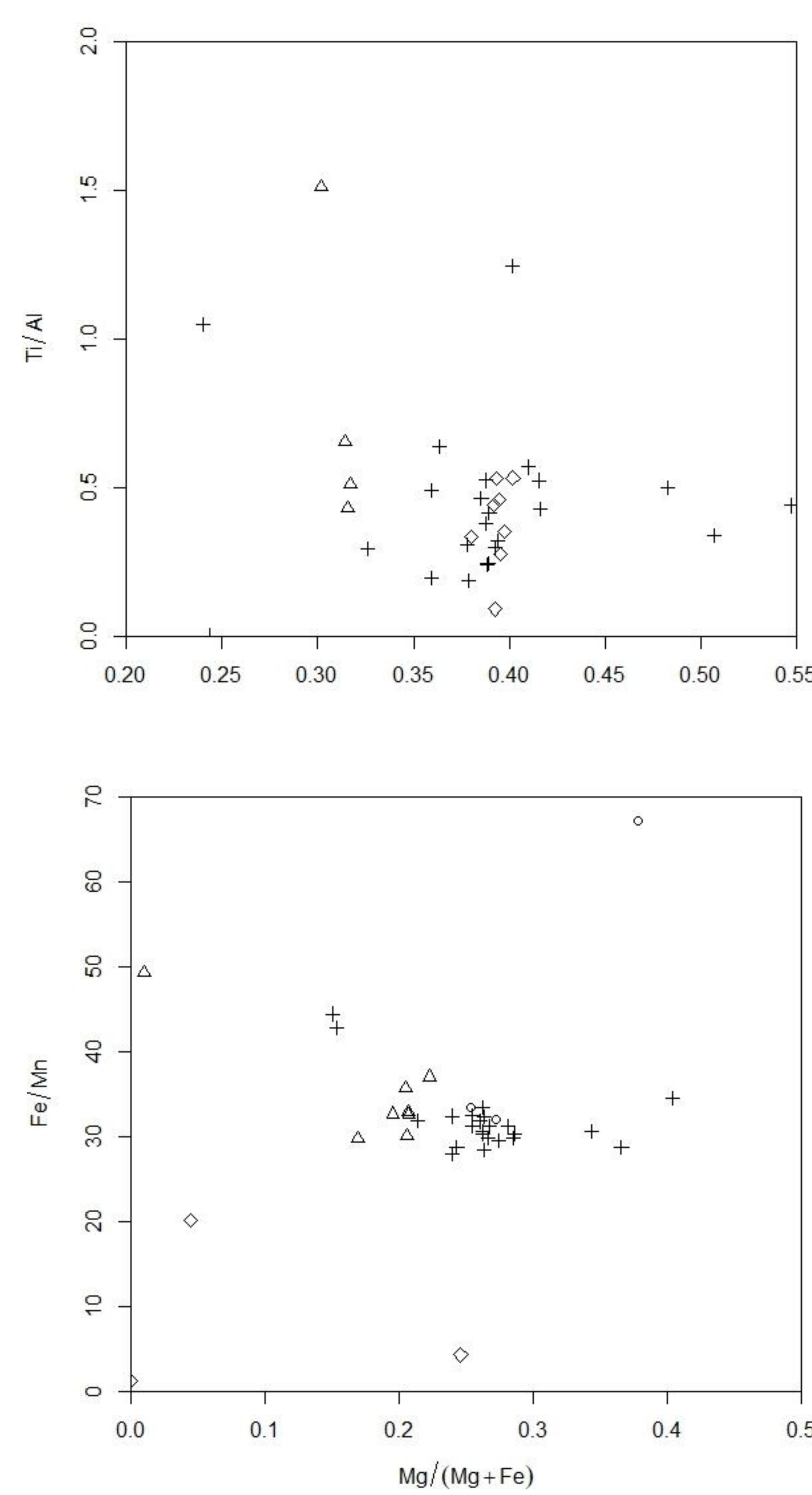


Figure 3: Ti/Al and Fe/Mn vs. Mg/(Mg + Fe) plots for pyroxenes from NWA 4834, Bereba, and Bouvante.

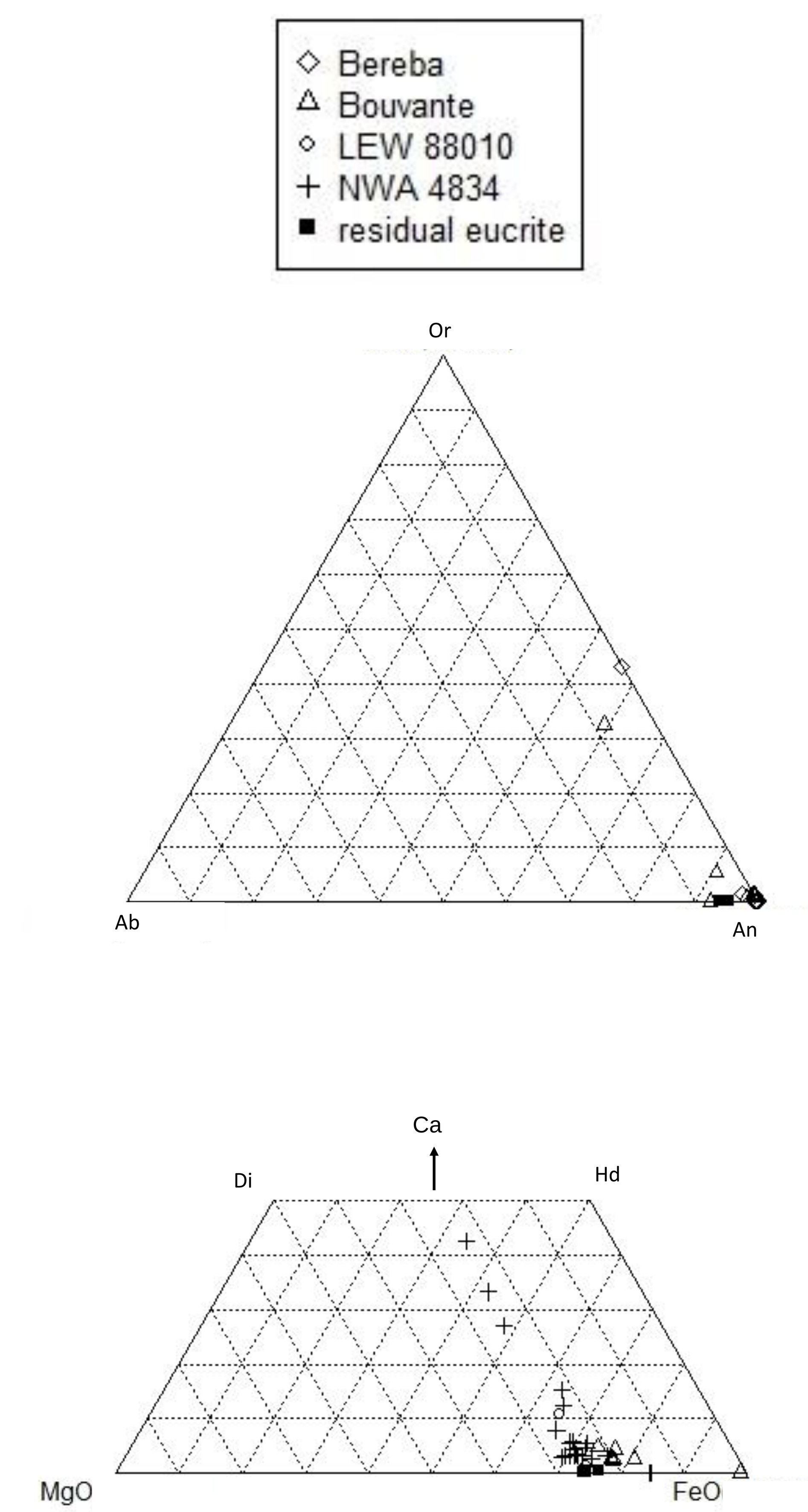
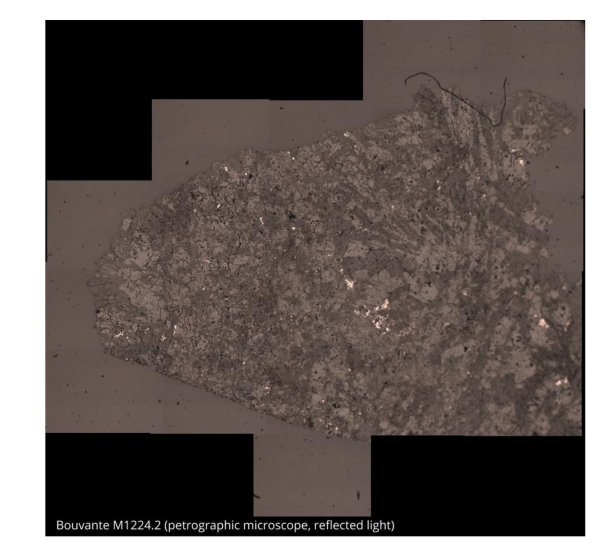
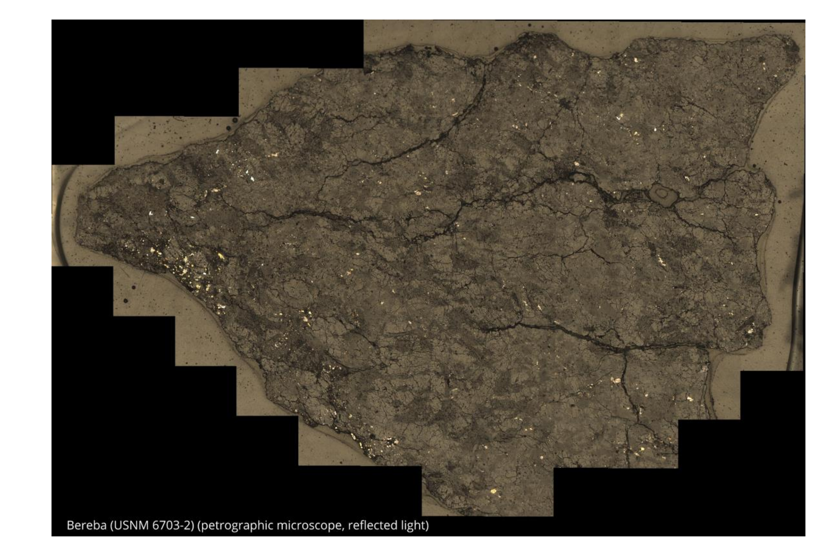


Figure 4: Ternary diagrams for plagioclase and pyroxene for NWA 4834, Bereba, Bouvante, and LEW 88010, and residual eucrite data (from literature, Yamaguchi 2009).

Discussion and Conclusions

Of the four samples selected for this study so far, one is unbrecciated (LEW 88010), two are monomict (Béréba and Bouvante), and one is polymict (NWA 4834). These samples were selected as they were observed to contain possible metasomatic features during our petrographic survey, but have not been included in the current literature regarding metasomatism. All samples are either falls or were observed to show little to no terrestrial alteration. Mineralogically, they are typical eucrites, being dominated by pyroxene and plagioclase, with lesser phases including troilite, chromite, ilmenite, Fe-rich olivine, and silica.





LEW 88010	Stannern-trend	Unbrecciated
Béréba	MGNL	Monomict
Bouvante	Stannern-trend	Monomict
NWA 4834	MGNL	Polymict

- Fe-rich olivine was observed in NWA 4834
- Petrographic analysis identified the breakdown of pyroxene into troilite and silica in all four samples
- Preliminary results indicate that Fe-enrichment of pyroxene rims, along with an associated Al-depletion may be occurring due to metasomatism

Future Work

Additional quantitative pyroxene and plagioclase data will be collected to further assess the Al-depletion along with Fe-enrichment in pyroxenes. We will also investigate the presence of phosphates in these samples to investigate the P-component that would be present in an impact derived vapor.

[References: 1] Duke M.B. and Silver L.T. (1967) *GCA, 31,* 1637-1665. [2] Takeda H., et al. (1994) *Earth & Planet. Sci. Letters, 122,* 183-194. [3] Rosjzar H. et al. (2011) *Meteoritics & Planet. Sci. 46,* 1754-1773. [4] Barrat J.A. et al., (2011) *GCA, 75,* 3839-3852. [5] Zhang A.-C. et al., (2013) *GCA 109*, 1-13 [6] Mayne R.G. et al., (2016) *Meteoritics & Planet. Sci. 51,* 2387-2402. [7] Chen, H. Y. et al., (2016) *78th MetSoc,* Abstract #1856. [8] Yamaguchi, A. et al., (2009) *GCA*, 73, 7162-7182.