NWA 7188 Eucrite:
Petrology, Chemical Compositions and Evolution History

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INTRODUCTION

This work focuses on the petrographic description and geochemical analysis of an eucrite from Northwest Africa, NWA 7188. Also provided is an outline of the geological settings involved in its formation. Finally, the application of widely used pyroxene Fe/Mn ratio plot was revised in this work. Fe/Mn values of this meteorite may provide another evidence for the heterogenity of eucrite parent body, or the existence of different eucrite parent bodies.

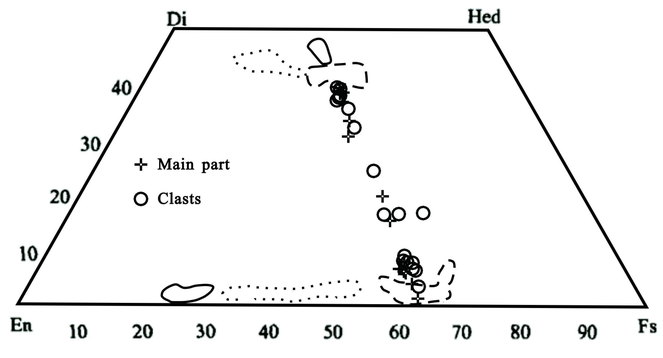

Fig.3 Pyroxene quadrilateral for NWA 7188. Ranges of diogenites (line), cumulate eucrites (dotted line) and ordinary eucrites (dashed line) after (Takeda, 1997). Plots outside the restricted areas are due to the relatively larger laser beam than the width of lamellae.

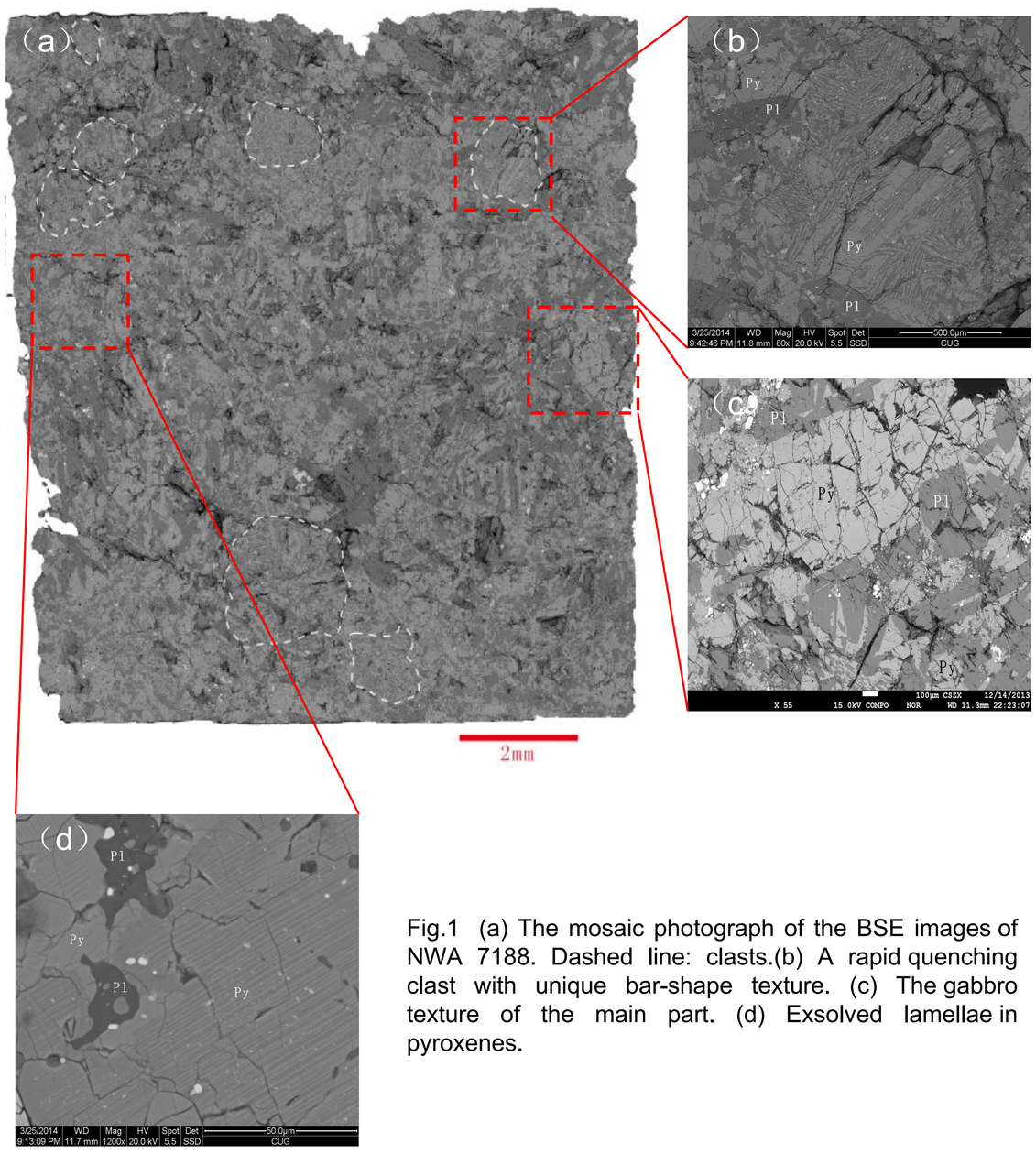

Fig.1 (a) The mosaic photograph of the BSE images of NWA 7188. Dashed line: clasts.(b) A rapid quenching clast with unique bar-shape texture. (c) The gabbro texture of the main part. (d) Exsolved lamellae in pyroxenes.

THE ANOMALOUS Fe/Mn VALUES

NWA 7188 does not contain condrules; it possesses typical magmatic crystallization textures in both of the two texturally distinct parts. An% of NWA 7188 are higher than those of Martian meteorites. Indications acquired from the Mn/Fe plot are that NWA 7188 belongs to either HED or Martian meteorites and can be obliviously distinguished with lunar meteorites and angrites in a Fe (afu) versus Mn (afu) plot (Fig.4).

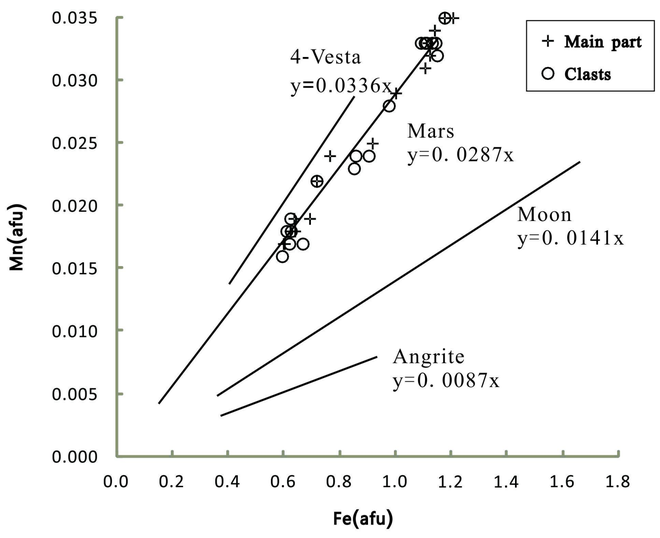

Fig.4 Fe (afu) versus Mn (afu) plot of pyroxene (Papike, 2003).

Samples used to make a distinction among myriad achondrites are unequilibrated meteorites (Papike, 2003), i.e. those not suffering from severe metamorphism. For HED meteorites, samples without exsolution phenomenon could the optimal choice for classification. Thus, when plotted with equilibrated samples, we would probably obtain a compositional region, not a single line. Overlapping between adjacent regions, especially those with approximate ratios, will ineluctably casuses confusions. As for the comparison in this paper, the relatively small difference between Mn/Fe ratio for HED meteorites (0.0336) and Martian meteorites (0.0287) is the key inducemnet generating the deviation of plots from the "HED meteorites" line.

PETROGRAPHY

NWA 7188 mainly consists of ~59 vol% pyroxene and 38 vol% plagioclase, with minor amounts of opaque minerals (~2 vol%) and silica minerals.Two distinct portions have been recognized in this meteorite: the main part with a gabbro texture and clasts showing ophitic to sub-ophitic texture. The main part is dominated by coarse pyroxene and plagioclase grains with the similar size. Some exceptive pyroxenes can extend up to 1.2mm × 0.5mm. Both pyroxenes and plagioclases exhibit euhedral to subhedral characters. Exsolution textures are developed in almost all the pyroxenes except for some grains with obvious secondary alteration marks left by post-thermometamorphism.

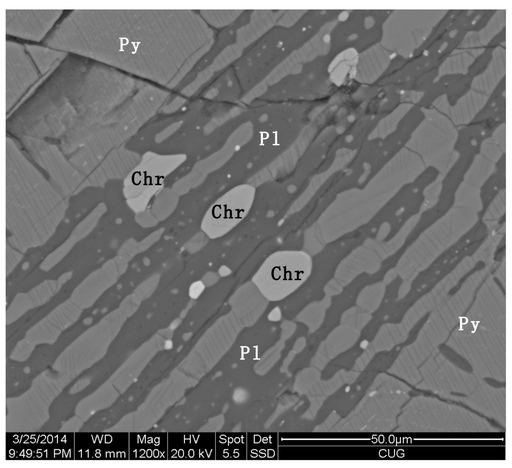

Fig.2 The bar-shape texture of a special clast.
Py:pyroxene, Pl:plagioclase, Chr:chromite.

A large pyroxene grain (Fig.2) commensurate with those in the main part present a complex poikilitic texture. Plagioclases show oriented features, and pyroxenes show corroded rims and resemble residual grains. Such a texture is similar to barred chondrules, though olivine and pyroxene are the " bars " instead of plagioclase. Thus, this clast probably formed through rapid cooling similar to processes forming barred chondrules.

MINERALOGY

Compositions of pyroxenes and plagioclases are homogeneous within individual grains and between the main part and clasts. Both parts contain ferrosilite which was converted from pigeonite during high-degree metamorphism.

Other accessory minerals are metallic and silica minerals existing within pyroxene grains or as interstitial residual melts.

References:
[1].Lindsley D H, Andersen D J. A two - pyroxene thermometer[J]. Journal of Geophysical Research: Solid Earth (1978–2012), 1983, 88(S02): A887-A906.
[2].Papike J J, Karner J M, Shearer C K. Determination of planetary basalt parentage: A simple technique using the electron microprobe[J]. American Mineralogist, 2003, 88(2-3): 469-472.
[3].Takeda H, Graham A L. Degree of equilibration of eucritic pyroxenes and thermal metamorphism of the earliest planetary crust[J]. Meteoritics, 1991, 26(2): 129-134.
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EVOLUTION HISTORY

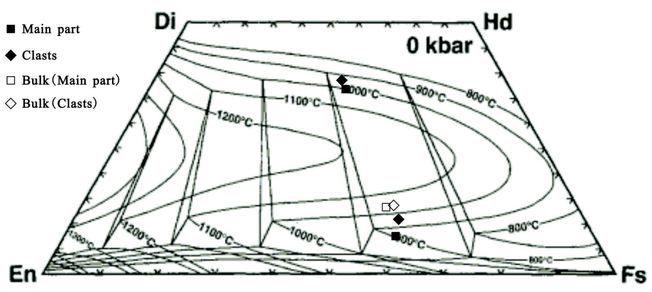

Fig.5 The two-pyroxene thermometer (Lindsley, 1983).

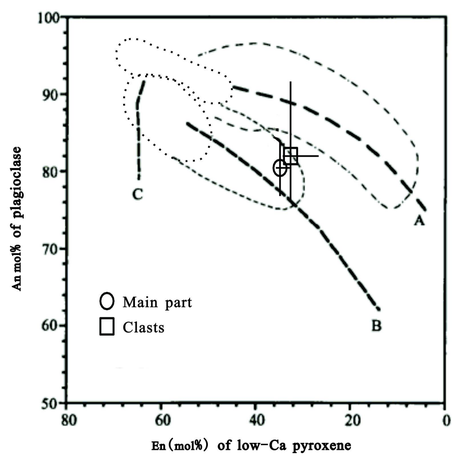

Fig.6 Hypothetical crystallization trends of HED meteorites plotted in an An vs. En diagram (Takeda, 1997).

Using the two-pyroxene thermometer (Lindsley, Andersen, 1983)(Fig.5), we obtain the crystallization and equilibration temperatures from the average compositions above: the primary magma for NWA 7188 crystallized at about 1050 ℃ and reached equilibrium at about 900℃.

A proposed evolution history for NWA 7188 is:
(1) After the primary magma of the main part formed, it intruded into the deep crust of Vesta;
(2) During the uplift of magma, clasts broken up from the surrounding rocks were captured and suffered assimilation, causing chemical equilibration between clasts and the main part;
(3) After the magma took position and crystallized, a short period of metamorphism took place, giving rise to the ubiquitous pyroxene lamellae;
(4) In the final stage, an impact event which caused the widespread cracks in this sample escavated this meteorite out of the crust, ejecting it from the parent body — Vesta.

On the basis of hypothetic crystallization trends proposed by Takeda (1997), both the main part and clasts approach the Na-rich trend (Trend B)(Fig.6). Therefore, the primitive magma of NWA 7188 was located at rather deep level of the magma ocean, which was the cause for the richness of volatile sodium in plagioclase.

Acknowledgement
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