Classification and ^{53}Mn-^{53}Cr chronology of enstatite chondrite meteorites from a new strewn field in Oman

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Introduction

Enstatite Chondrites

- Enstatite chondrites constitute ~1% of all meteorites. They are characterized by reduced and anhydrous mineral assemblages including enstatite, metallic Fe–Ni, and sulphides.
- They are further divided into high iron (EH) or low iron (EL) categories.

Sample collection and description

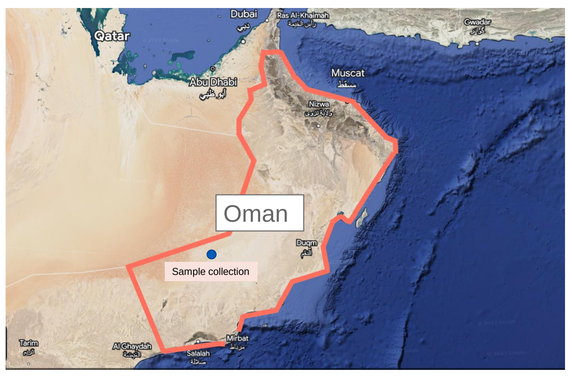

Figure 1- Twenty-six paired enstatite chondrite meteorites were collected from a new strewn field in the Rub-al-Khali desert in Oman in 2020 and 2022.

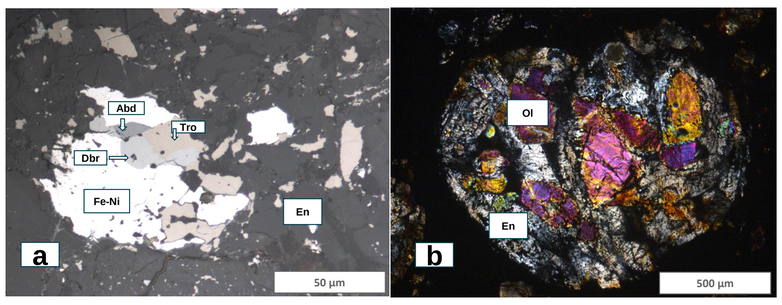

Figure 2- Typical assemblage of an enstatite chondrite meteorite. (a)Kamacite (Fe-Ni) including troilite (Tro), alabandite (Abd) and daubréelite (Dbr), surrounded by enstatite. Reflected light. (b)An enstatite (En) chondrule containing olivine (Ol). Cross polars.

Research questions

1. Sample classification

Classic petrographic methods such as microscopy, scanning electron microscope analysis and electron microprobe are applied to classify the sample.

2. Mn-Cr isotope systematics

$^{53}Mn \longrightarrow {}^{53}Cr$ **half life: 3.7 ± 0.4 X 10^6 a**

- Sequential digestion of the bulk rock was undertaken to dissolve different phases with different Mn/Cr ratios.
- The Cr isotopic ratios are measured by Thermal Ionization Mass Spectrometry (TIMS) while the elemental concentrations of ^{55}Mn and ^{52}Cr are measured on an Inductively-coupled plasma–optical emission spectrometer.
- The isochron produced places an age constraint on the last metamorphic episode.

3. Cosmic ray exposure age

- Exposure of the meteoroid to galactic cosmic ray bombardment. The process produces a variety of cosmogenic stable and radioactive nuclides.
- The noble gas mass spectrometer measures He, Ne and Ar ratios[1].
- The results gives the duration the meteoroid has been exposed to the cosmic rays after breaking off from the parent body.

4. Strewn field data

- The strewn field demarcates the area in which meteorites from a single fall are dispersed.
- Olivine content is determined by X-ray diffraction and Zn concentration is measured by X-ray fluorescence to distinguish ordinary chondrites from enstatite chondrites.
- The mass distribution of the samples over the strewn field helps calculate the fall trajectory.

Results

Results indicate a typical enstatite chondrite composition with enstatite (En_{98}) and minor olivine (Fo_{99}) in addition to heterogeneous plagioclase and abundant sulphides.

Classification of EL/EL group

Criteria	EL	EH
Dominant sulphide	**Alabandite (MnS)**	Niningerite (MgS)
Ni content in Phosphide	**~30 wt.%**	~20 wt.%
Chondrule size	**500 µm**	200 µm

Table 1- Criteria assessed to assign the isochemical group to the analysed sample. Values in bold signify the results obtained from the sample, indicating EL.

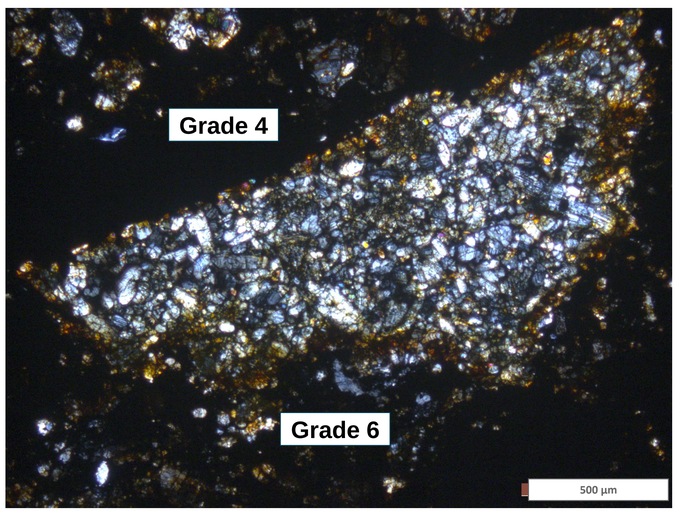

Figure 3- The presence of clasts of petrographic grade 6- as indicated by the absence of chondrules and >50 µm size of plagioclase, surrounded by grade 4- suggests the meteorite is a breccia. Cross polars.

Weathering degree

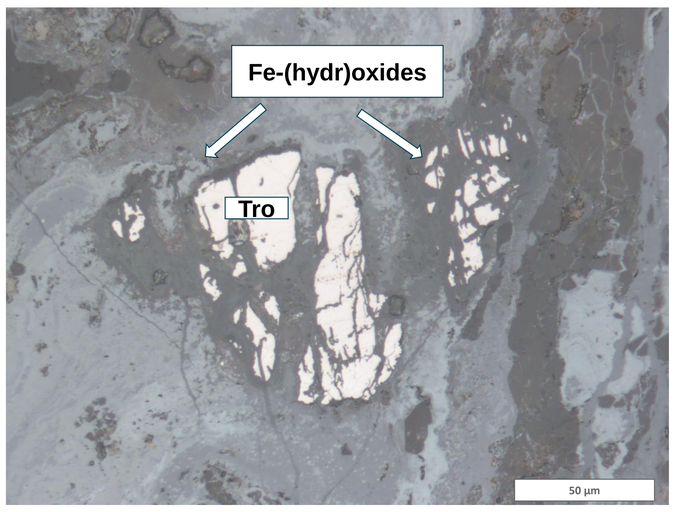

Figure 4- A large range of the degree of weathering ranging from W1 to W4 is indicated by the degree of oxidation of iron and troilite from minor to complete transformation. Tro= troilite. Reflected light.

Shock stage

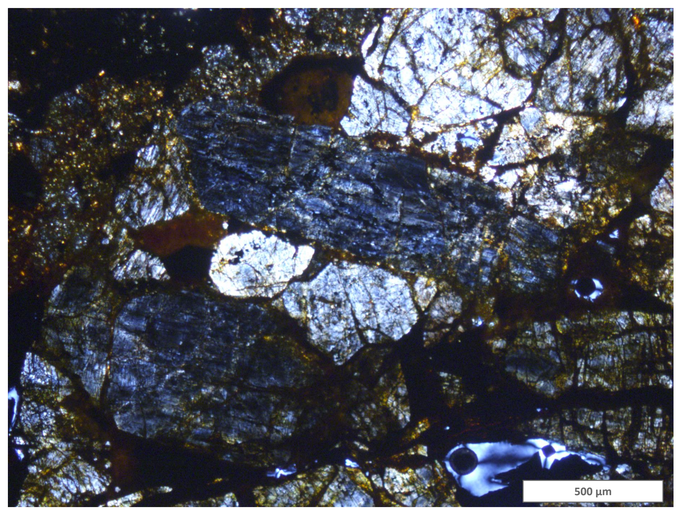

Figure 5- Petrographic features such as undulous extinction of silicates (here-enstatite) and the lack of planar fractures suggest shock stages from S1 to S2- i.e., unshocked to very weakly shocked [2]. Cross polars.

Metamorphic age

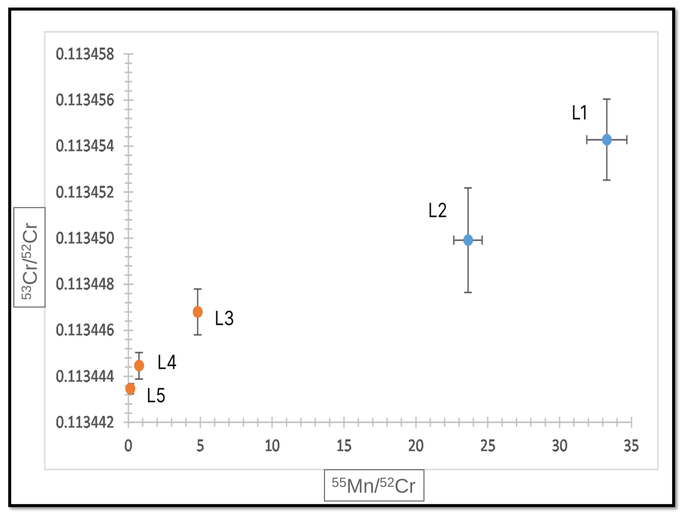

Figure 6- The metamorphic age calculated from leachate L3, L4 and L5 is 10.84 +1.31/-1.05 Ma after CAI when anchored to D'Orbigny angrite.

Strewn field

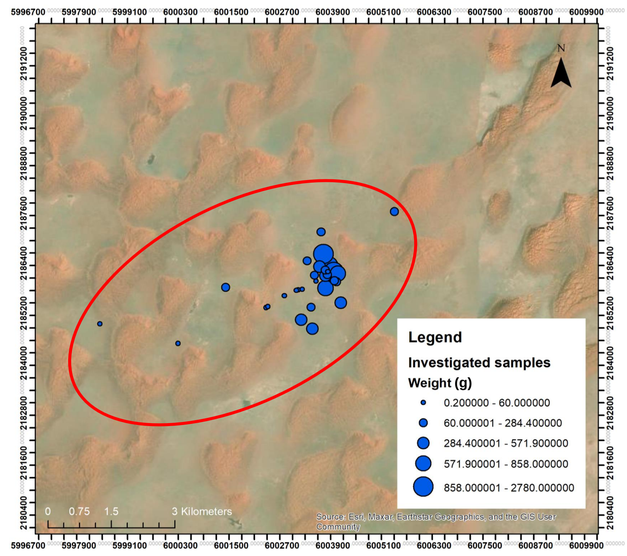

Figure 7- Shape and mass distribution of the investigated samples plotted on a satellite image. The strewn field extends in the NE to SW direction.

Conclusions

- The meteorite is a breccia classified as EL4-6.
- The shock stage ranges from S1 to S2.
- The weathering range is from W1 to W4.
- The metamorphic age obtained does not correspond to the low petrographic grade. This can be due to diffusion of Cr out of the early crystallising phases that form before the peak metamorphism. This needs further evaluation and comparison with ages of other grade 4 meteorites.

Ongoing work

Cosmic ray exposure age in addition to 14C dating help us reconstruct the history of the meteorite.

References

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[2] Rubin, A. E., Scott, E. R., & Keil, K. (1997). Shock metamorphism of enstatite chondrites. Geochimica et Cosmochimica Acta, 61(4), 847-858.

Acknowledgements

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