Introduction: An ovoid structure was found in a thin section of the Nakhla meteorite (BM1911,369) during a visible light microscopy survey (figure 1).

The thin section containing the structure was originally prepared using non-polar solvents and polished with Al₂O₃ in order to reduce contamination and dissolution of soluble materials. The shape and certain structural details (figure 2) were suggestive of a possible biological origin and so a detailed study using Raman spectroscopy, TOF-SIMS, AFM, X-Ray tomography, EFTEM and HRTEM was carried out to try and elucidate its origin.

The ovoid sits solidly within a narrow mesostasis area composed of amorphous material and between two pyroxene crystals. Its size, structure and relationship to surrounding minerals dictate that it originated on Mars within the rock that went to make up the Nakhla meteorite and not through subsequent alteration whilst on Earth.

The structure is composed of several highly distinct concentric zones with an internal void. Within the void space are two masses referred to as ‘islands’ that are chemically and structurally similar to the walls. A symmetrical fissure cuts through the wall of the ovoid. The fissure is now blocked by a filamentous deposit that also covers the internal walls of the ovoid and the outer boundary of the islands.

Figure 1. Transmitted light optical image of the ovoid structure demonstrating its reddish-orange colour (slightly magnified in the inset). Areas (a) and (b) are shown on the right magnified to enhance some details (see text). The non-transparent phase is Ti-magnetite (Mt), while the structure sits between the two large pyroxene crystals (Pyx) and the amorphous mesostasis phase (M).

Figure 2. BSE SEM images of the area of the ovoid structure, which clearly demonstrate the presence of a highly symmetrical fissure. Frame (a) depicts the fissure, the gap between the mesostasis and the wall of the ovoid, as well as the hollow volume of the structure. Frame (b) shows details of the ovoid walls with arrows indicating gaps probably opened due to mechanical stress.
The wall of the ovoid structure is divided into 5 areas based upon crystallinity and morphology. These are labeled L1-L5 in figure 3 and some extra detail of the interface between L1 and L2 is shown in figure 4. Details of other layers and HRTEM imaging will be detailed during presentation.

The layers L1-L5 show varying degrees of crystallinity with nanocrystalline sheet silicates mixed with amorphous materials in L1-L4 and iron-rich phases in L5. Stoichiometry suggests a trioctohedral clay, interpreted as an iron-rich saponite. This is the first time that crystalline clay is reported for Nakhla.

Several inorganic scenarios could be invoked to explain the origin and formation of the ovoid, these include the complete replacement of a pre-existing mineral phase through alteration or deposition of a transported phase in a hollow amygdaloid. There are difficulties however with each of these possible scenarios which will be discussed in presentation. An alternative hypothesis is that the pre-existing structure was of biological origin as suggested by its morphology. Replacement and fossilization of soft tissues by clays is well known [1] and terrestrial analogues of known biological origin are documented [2,3]. A biological origin for other structures in Nakhla, ALH84001 and Tissant have been advanced [4-7] and whilst there is no conclusive evidence at present that the ovoid structure in Nakhla reported here is of biological origin, it strongly resembles terrestrial analogues of known biological origin.

References:

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