FILAMENTOUS STRUCTURES IN A HYDROTHERMAL SYSTEM OF THE DELLEN IMPACT STRUCTURE, SWEDEN – PUTATIVE MICROFOSSILS? M. Ivarsson[1], P. Lindgren[1], A. Neubeck[1], C. Broman[1], N.G. Holm[1], H. Henkel[2], [1]Dept. of Geology & Geochemistry, Stockholm University, Stockholm S-106 91, Sweden, [2]Kungliga Tekniska Högskolan, Stockholm S-100 44, Sweden. Email: (magnus.ivarsson@geo.su.se), (paula.lindgren@geo.su.se)

Introduction: Impact-generated hydrothermal systems are often suggested as suitable habitats for primitive life [1,2], but fossil evidence of such colonization are rarely reported in the literature.

Here, we report on the occurrence of putative microfossils in a hydrothermal system of the Dellen impact structure, Sweden.

Impact-induced hydrothermal systems: Impacts in water-bearing targets can generate hydrothermal systems. A large impact produces a central uplift and impact melts, which are sources of heat. The impact also creates deep fractures in the target, which provide pathways for water to flow through the rock. Evidence of impact-associated hydrothermal activity have been identified in over a third of the ca. 170 impact craters here on Earth [3]. Hydrothermal systems can prevail in impact craters for thousands of years [4,5], and for substantially longer periods (up to a million years) in very large craters [6].

The Dellen impact structure: Dellen is located in east-central Sweden, and was formed about 89 million years ago [7]. Dellen is a complex impact structure, with a diameter of ca. 20km. A large part of the structure is buried under a thick moraine cover, and most impactite-material is only available as loose blocks and boulders in the moraine. Dellen contains a large volume of both coherent melt and melt-rich breccias (suevite) [8]. The melt-bearing rocks overlie lithic breccias and fractured basement rocks (granitoids).

Samples and analytical procedure: One sample of a monomict lithic impact breccia was prepared as a 150µm thick doubly polished wafer. The sample was analyzed with petrographic microscopy, Raman spectroscopy and environmental scanning electron microscopy (ESEM) equipped with energy dispersive spectrometry (EDS) at Stockholm University, Sweden.

Filamentous structures – setting, morphology and composition: The filaments occur in assemblages throughout interlinked fractures of the lithic breccia (Fig.1). The breccia is composed of granitic minerals, i.e. mainly quartz, feldspar and biotite. The breccia has been hydrothermally altered, and the fractures are filled with zeolites and clay-minerals. The filamentous structures are hosted in the fracture-filling clay-minerals.

The filaments appear as semi-straight, curvi-linear to twirled structures (Fig.2). Sometimes they also appear with star-shaped morphology (Fig.3). The thickness of the filaments are 1-2µm, and their length vary from about 10-100µm. They have an internal structure with segmentation, which is visible as a color variation (in optical microscopy, plane-polarized light) from brown-red to black within a single filament (Fig.3, Fig.4).

The filamentous structures are mainly composed of iron, silica and oxygen. They contain at least 2.83 wt% carbon (Table 1). The sample was not carbon-coated during analyzes.

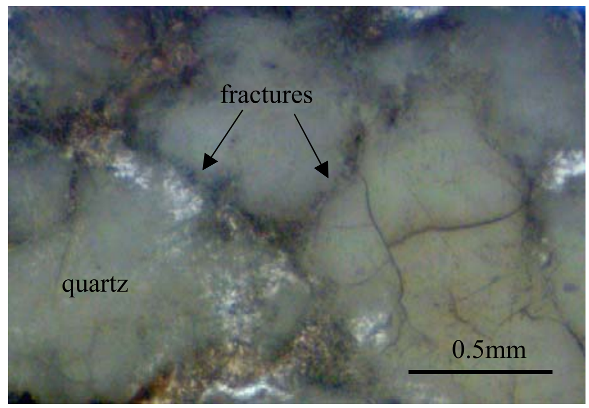

Fig.1. Photomicrograph in plane-polarized light of interconnected fractures in lithic impact breccia from Dellen. The fractures are filled with hydrothermal minerals, hosting the filamentous structures.

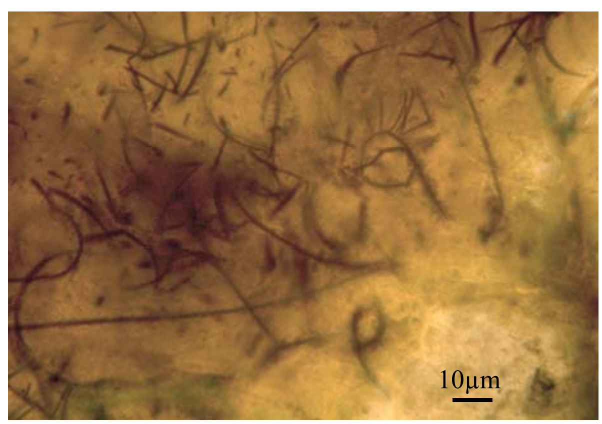

Fig.2. Photomicrograph in plane-polarized light of an assemblage of filamentous structures located in fractures of lithic breccia from Dellen. The filaments appear as semi-straight to twirled structures.

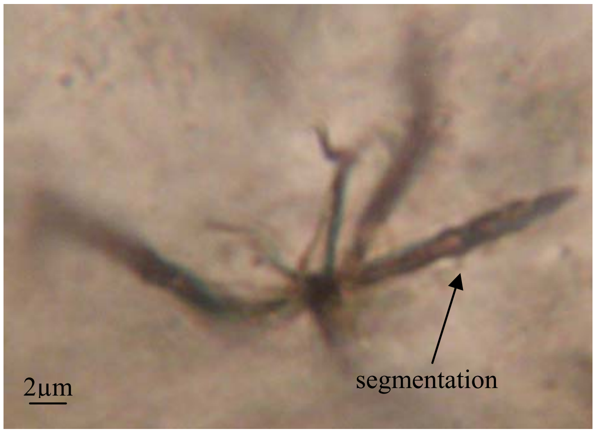

Fig.3. Photomicrograph in plane-polarized light of a star-shaped filamentous structures. Note segmentation.

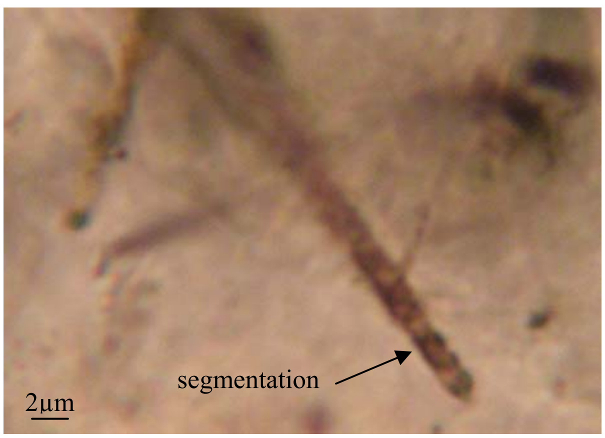

Fig.4. Photomicrograph in plane-polarized light of a segmented filament (arrow).

Table 1. The elemental composition of filamentous structures (normalized values) obtained by EDS/ESEM.

Element	Weight%
C	2.83
O	44.24
Na	0.55
Mg	2.17
Al	7.46
Si	19.37
K	6.78
Mn	0.63
Fe	15.97
Total	100.00

Implications for the search of life on Mars: Impact-generated hydrothermal systems have been proposed as good candidates for hosting primitive life on the early Earth and also on Mars [1]. Impact cratering is widespread on the surface of Mars, and impacts could result in melting of the sub-surface cryosphere, with a hydrothermal cell sustaining for a long period of time [9].

So far, little evidence exists of microfossils in impact-generated hydrothermal systems from the terrestrial record. To our knowledge, the only described occurrence is of fossilized extracellular polymeric substances (EPS) of organisms which possibly lived in a post-impact hydrothermal system in the Siljan impact structure, Sweden [10].

Based on morphology, appearance, size, composition, occurrence and similarity to microfossils previously observed in hydrothermal deposits from other settings, we suggest that the filamentous structures in the Dellen lithic impact breccia represent fossilized microorganisms. Our interpretation is that the microorganisms lived in the fractures while the hydrothermal system was active. Once the fractures were filled with secondary minerals the micro-organisms were trapped and preserved.

This suggests that impact-generated hydrothermal systems are capable of supporting microbial life, and that evidence of this can be preserved in the geological record. Hence, impact-generated hydrothermal systems would be a good target for the search of life on Mars.

Acknowledgements: We are grateful to Marianne Ahlbom for skilled technical support and to the Swedish National Space Board for funding this project.

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