***IN SITU* SEDIMENTARY ROCK AND PSEUDOTACHYLITIC BRECCIA VEINS IN THE RIM OF THE SÖDERFJÄRDEN IMPACT CRATER STRUCTURE, FINLAND.**

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Introduction: The Söderfjärden meteorite impact crater (63°00’20"N, 21°34’30"E) is located in Ostrobothnia, central-western Finland close to the city of Vaasa. It is an early Paleozoic structure filled by post-impact Cambrian and Quaternary sediments. The crater's diameter is 6.6 km with a structurally elevated crater rim and a depth of 330–410 m [1,2]. The target consists of Svecofennian rocks, such as metasedimentary mica gneisses and various granodioritic migmatites aged ~1.88 Ga [3]. From 1975 to 1983, seven holes have been drilled into the crater, the deepest reaching 347.3 m below ground. The drillings yielded polymict allochthonous breccias containing planar deformation features (PDFs) [4].

The crater's age has been estimated at ~540–520 Ma based on microfossils in the Cambrian sediments [5]. A Neoproterozoic age of ~640 Ma is based on a 40Ar/39Ar dating of a melt vein from a boulder [6]. Söderfjärden is a remarkably well-preserved crater due to long–term burial and late (post-Cretaceous) re-exposure.

New observations: Here, we describe finds of *in situ* sedimentary and pseudotachylitic cataclastic rock veins. These are located in the southern rim (~2.8 km from the crater's center; Figs. 1 and 2). At the site, the crater rim is ~30 m above the central peneplane and slightly slopes towards the crater center. The veins were exposed during the construction work of a new residential area in late 2020. As a result of earthwork, multiple, most likely Cambrian aged sedimentary rock veins were found cutting the old Paleoproterozoic migmatite (Fig. 2 A-C). Four greenish silt- and light-brown sandstone veins were found in 25°–45° strike direction with a dip of 80°–85° towards SE. One siltstone vein was followed ~4 meters in length. The width of the veins is 10–20 cm.

Green-colored glauconite-bearing siltstone veins contain quartz grains with PDFs in one or two directions (Fig. 2D), and euhedral pyrite crystals are abundant. The pseudotachylite-bearing cataclastic vein is ~1 cm in width with a strike of 100° and a dip of 60° towards SE. (Fig. 1A). The vein is brecciated, containing very fragmented minerals and isotropic parts that can be considered pseudotachylite or melt (Fig. 2E). On the surface of the vein, a slickenside plane occurs in two different directions. One siltstone sample contains an unidentified microfossil (Fig. 2F).

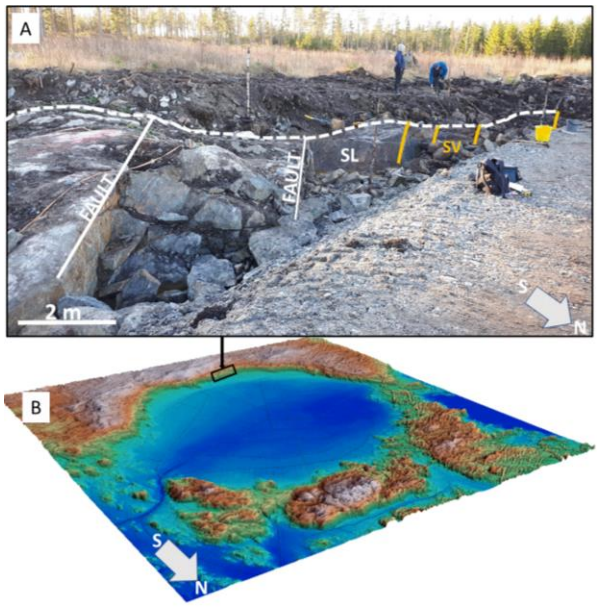

Figure 1 A. Veins are situated in an area 50 m^2 in size in SW to NE direction, the same direction as fault structures (white straight lines). Slickenside (SL) surfaces occur in the direction NW-SE. Bedrock surface with white dashed line. The cataclastic vein is on the surface of the slickenside. B. The black rectangle in a LiDar image of the Söderfjärden crater shows the study area. Sedimentary rock veins (SV) are situated in the rim area, S part of the crater.

Conclusions: Söderfjärden has been buried since the formation and preserves original crater forms holding post-impact sedimentary rocks. The crater fill material, consisting up to 240 meters of Paleozoic sediments has been found from drill cores [5] and loose boulders. No outcrops that would include sedimentary rocks have been earlier seen in the rim area.

Here we suggest that:

a) Sedimentary rock veins represent ejecta that has been injected into the fault structures of target rock during the impact. PDFs in quartz of siltstone indicate that the material has gone through a pressure of at least 10 GPa and originates from the center part of the crater or the bottom.

b) Material within the sedimentary veins may originate from a sedimentary cover that covered the Precambrian basement at the moment of impact. It is possible that during the collapse, the slightly uplifted terraces on the rim faulted, cracks in the bedrock opened, and unconsolidated cover sediments fell into the cracks.

c) Green siltstone with glauconite and pyrite indicates a reducing and shallow marine environment during the impact. So far, the sediments cannot be associated with particular stratigraphic layers or sequences of the crater.

d) A microfossil study should be carried out to study possible traces of Cambrian life. While studying the Lappajärvi impact structure, [7] reported a Terreneuvian age (541-520 Ma) microfossil record from Vimpeli (110 km from Söderfjärden) drill core. According to their study, microfossils in Vimpeli are sourced from a Cambrian deposit. The Söderfjärden and Vimpeli sedimentary rocks may represent the same Cambrian lithological unit.

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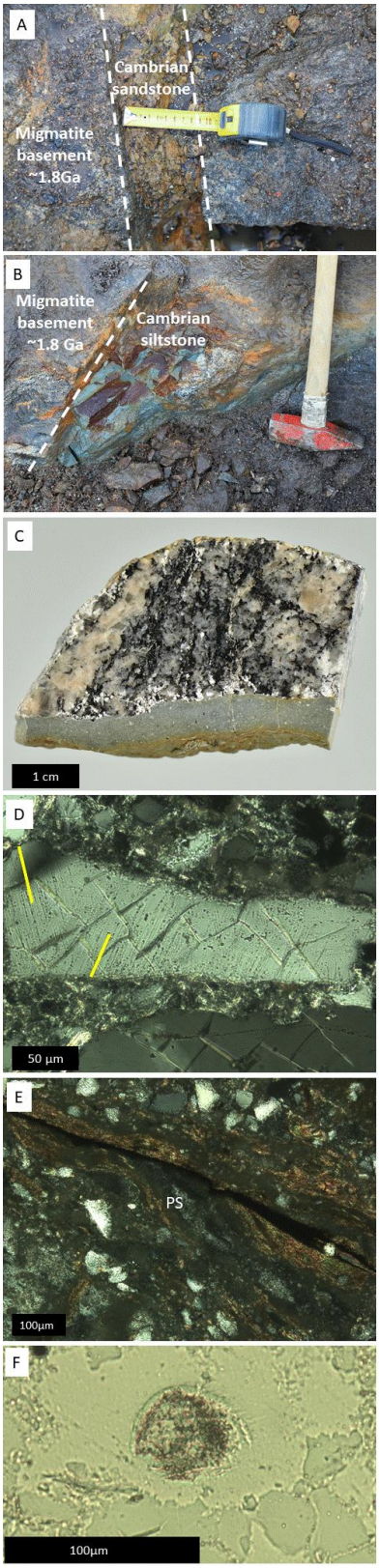

Figure 2. A-B. Cambrian sedimentary rock veins within the Precambrian migmatite basement. C. Hand sample from the outcrop showing contact between fine-grained green siltstone and migmatite. D. Siltstone with PDFs in quartz grain in two directions; crossed polars. E. Cataclastite with pseudotachylitic vein; crossed polars. F. Unidentified microfossil from siltstone; plane polarized light.