FROM SHOCK TO IMPACT METAMORPHISM – DISCOVERY OF MELT-BEARING BRECCIAS AND IMPACT MELT VEINS AT THE HUMMELN IMPACT STRUCTURE (SWEDEN).

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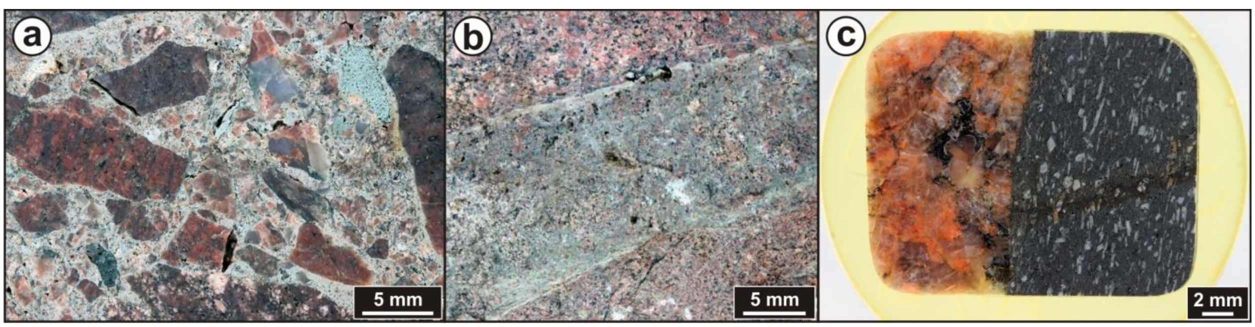
Introduction and Previous work: The term "shock metamorphism" covers all types of shock-induced changes, such as the formation of planar microstructures and phase transformations. "Impact metamorphism" is essentially the same as shock metamorphism, except that it also encompasses the melting, decomposition, and vaporization of target rocks [e.g., 1]. The products of impact melting typically range from small melt particles within melt-bearing breccias to large sheets of impact melt rocks. Their presence is strongly dependent on the lithology (and other properties of the target rock(s)), and is also a function of the magnitude of the impact and of the level of erosion.

In the case of the Hummeln structure, a 1.2 km wide impact crater, excavated in the Precambrian crystalline basement of the Småland province (in southern Sweden), only lithic (without matrix melt and melt particles) monomict and polymict impact breccias have been reported so far [2,3]. It is in these breccia samples that quartz grains with unambiguous evidence of shock metamorphism, i.e., quartz grains with planar deformation features, were recently identified and characterized, providing definite evidence for the hypervelocity impact origin of the Hummeln structure and solving an almost 200-year old enigma [2,3].

Here we report, for the first time, on the finding of melt-bearing breccias and impact melt veins, discovered by L.F. and S.H-A. during fieldwork in October 2015. A sample with a melt vein from H.S. was also investigated.

Results and Discussion: Most of the investigated melt-bearing breccia samples were found as boulders at the southern border of the lake Hummeln or in the close vicinity thereof, but some were also collected in-situ in a dike that was uncovered along the lake shore. This dike, ~25 cm in thickness, consists of matrix-supported breccia with a grey to greenish matrix and mainly angular to sub-angular, more rarely sub-rounded, clasts (a large variety of lithic clasts, dominated by reddish granitic rock clasts) a few mm to a few cm in size (Fig. 1a). Small melt particles, generally <0.5 mm in size and altered to secondary (clay) minerals also occur (Fig. 1a, upper right corner). The dike intrudes highly fractured granitic rock which locally could be described as a monomict, clast supported, breccia.



The impact melt veins are of two distinct types, both found as boulders. The sample collected by H.S. consists of an up to 2 cm greenish melt vein with a light green thin margin and with secondary veinlets branching from the main vein and crosscutting the granitic rock (Fig. 1b). Clasts of the host rock are visible within the vein. The melt vein sample found by L.F. and S.H-A. is much larger, up to 6 cm in thickness, dark grey in color with tiny white and black crystalline inclusions (Fig. 1c; left granitic rock, right melt). The contact with the host granitic rock is not as sharp as in the case of the other sample, but more irregular with locally intrusions of the melt in the host rock, forming a lobate margin. Petrographic observations will be presented at the meeting. The investigated samples are exstensively altered, likely due to weathering, but also due to (impact related?) hydrothermal alteration as indicated by the presence of abundant fluorite crystals (up to a few millimeters in size) in the fractured rocks on the lake shore. The finding of melt particles and impact melt at Hummeln open future possibilities, especially to use isotopic dating methods to confirm the Middle Ordovician age of the crater, which would strengthen the hypothesis that the cratering rate was increased during the Middle Ordovician as a consequence of the L-chondrite parent body break-up event.

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References: [1] Stöffler D. and Grieve R. A. F. 2007. In: Fettes D. and Desmons J. (eds.) Metamorphic rocks: a classification and glossary of terms, Recommendations of the IUGS. pp. 82–92. [2] Ferrière L. et al. 2015. Abstract #1758. 46th Lunar and Planetary Science Conference. [3] Alwmark C. et al. 2015. *Geology* 43(4):279–282.