A PREVIOUSLY UNRECOGNIZED IMPACT STRUCTURE AT BRUSSELS HILL, DOOR COUNTY, WISCONSIN: BRECCIATION AND SHOCK-METAMORPHIC FEATURES

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ABSTRACT

Brussels Hill is an anomalous area of intensely fractured, faulted, and folded bedrock in a region of otherwise undeformed lower Silurian dolostone in Door County, WI. The area of disturbed rock coincides with a distinctive, nearly circular, flat-topped topographic high ca. 2 km in diameter, standing 40 m above the surrounding landscape and ringed by rugged tree-covered slopes. Bedding orientations vary dramatically over distances of meters. Coherent structures are difficult to discern, and fragmentation appears to have happened at multiple scales. Both mono- and polymict breccias occur, commonly as wedges that seem to have been intruded between bedding planes. Silurian dolostone is the only bedrock normally exposed in this area, but fault-bounded blocks of sandstone occur at Brussels Hill. This atypical rock likely comes from Cambrian strata that lie up to 300-400 meters below the surface. Although we have not found shatter cones in the host dolostones, we have identified shock-metamorphic planar microstructures (PMs) in the quartz grains of the sandstones. Planar fractures (PFs) typically occur in multiple parallel sets that stretch the length of the grain. In addition, these sandstones feature mechanically twinned and mosaicized grains. The age of the Brussels Hill disturbance is not well constrained but must date between post-Early Silurian and pre-Late Pleistocene as its target rocks are lower Silurian and the site lies in a recently glaciated shield area. As Brussels Hill shares many striking similarities with the central uplift of the Rock Elm impact structure in western Wisconsin—in diameter, topographic rise, stratigraphic uplift, and PMs—we conclude that Brussels Hill is likely the eroded remnant of a central peak of a larger impact structure.

LOCATION AND SAMPLING

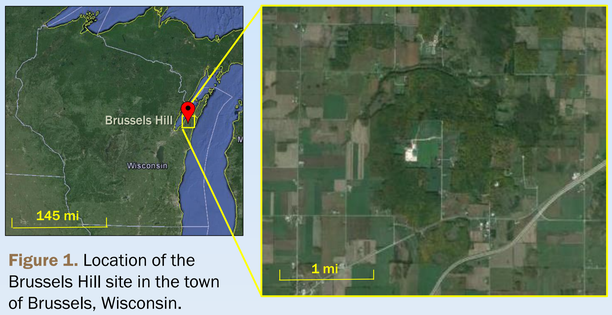

Figure 1. Location of the Brussels Hill site in the town of Brussels, Wisconsin.

We conducted a focused microscopic study of the dolostones, breccias, and sandstones found at Brussels Hill to look for shock-metamorphic features that could be diagnostic of an impact origin. By examining thin sections made from samples collected in the field, our goals were to (1) determine the stratigraphic origin of the in situ sandstones, (2) examine deformational characteristics of the breccias on the micro-level, (3) classify and describe any shock-metamorphic features found in the samples, and (4) determine if an impact origin is the best fit for explaining the disturbance at Brussels Hill.

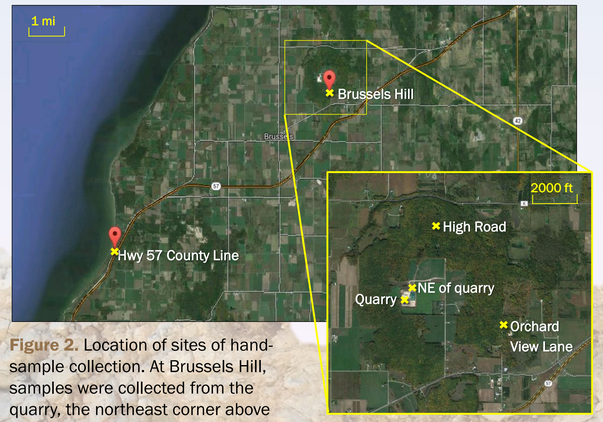

Figure 2. Location of sites of hand-sample collection. At Brussels Hill, samples were collected from the quarry, the northeast corner above the quarry, from High Road, and Orchard View Lane. Samples were also collected from the Hwy 57 Kewaunee/Door County Line.

THIN SECTIONS: SANDSTONES AND BRECCIAS

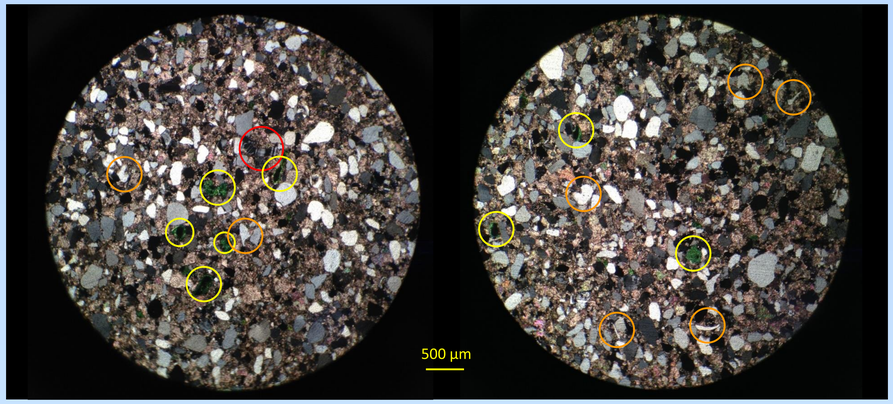

Figure 3. Thin sections from sandstone block sample Bru N149-3. Yellow circles around select grains of glauconite; red circles around feldspar grains; orange circles around angular grains/fragments and grains with concave margins. (Cross-polarized light.)

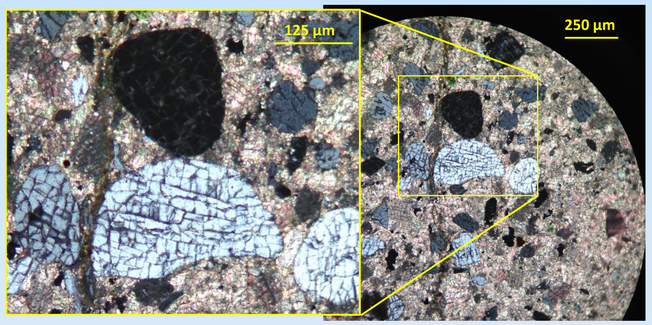

Figure 4. Fracturing in quartz grains from reconstituted sandstone sample Bru N149-4. Fractures extend the length of the grain, but sometimes appear slightly more curviplanar than planar. May possibly be PFs, which are alone not diagnostic of an impact but are an important shock-metamorphic feature. (Cross-polarized light.)

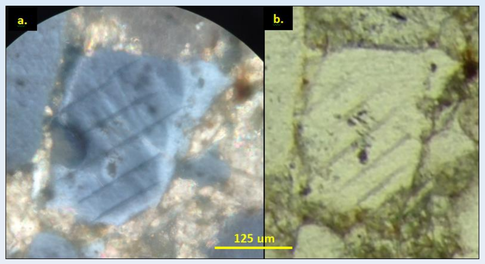

Figure 5. Linear features (true planar microstructures?) in grain from sandstone Bru N149-4. Features can be seen in both a.) cross-polarized light and b.) plane-polarized light.

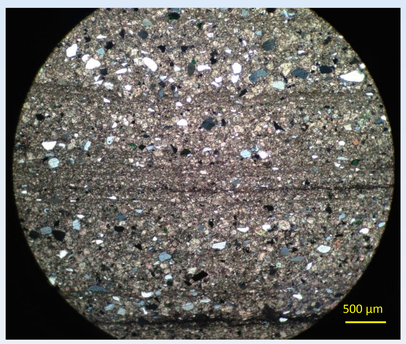

Figure 6. Thin section from reconstituted sandstone Bru-Sh1. Has a crushed-dolomite matrix but displays the same types of grain features as the sandstone blocks. Sample displays strong foliation, along which the quartz grains tend to lie. (Cross-polarized light.) [See Fig. 8 for sandstone in outcrop.]

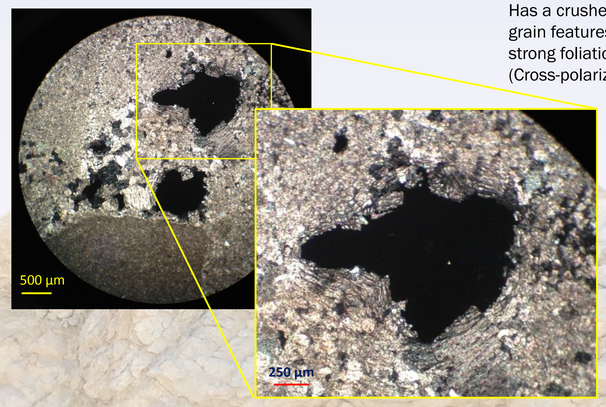

Figure 7. Some vugs, like this vug from breccia BRS1A, display unusual concentric fracturing around the void space, indicative of deformation post-vug formation. All of the breccias contained numerous vugs, which varied in size and number between samples. This concentric fracturing is possibly indicative of tensile spallation radially inward toward the center of the vug.

SANDSTONE ORIGIN

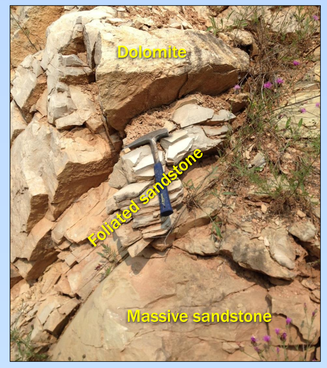

Figure 8. In situ sandstone found 149 m north of the southwest corner of the quarry. Contact between the sandstone block and the dolomite features portion of strongly foliated, likely reconstituted, sandstone. The sandstones contain abundant grains of glauconite. Glauconite is indicative of shallow marine depositional settings and is a staple of Wisconsin Cambrian sandstones. The sandstones also contain plagioclase feldspar, which is unusual in sandstone but is more common in Wisconsin Cambrian sandstone units.

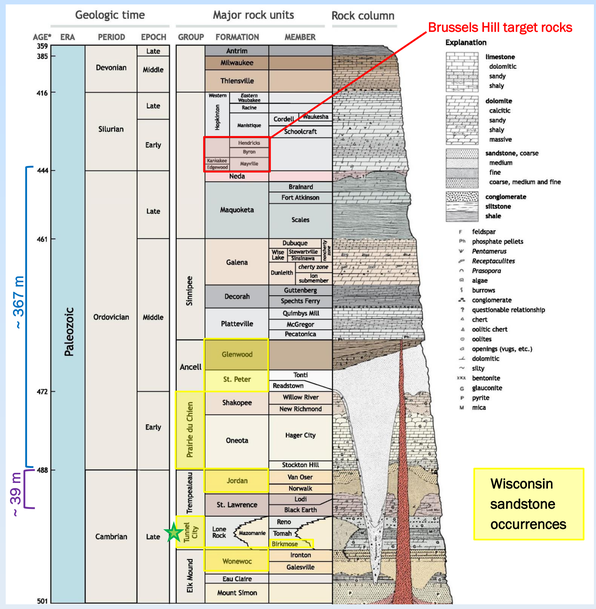

Figure 9. Brussels Hill target rocks are comprised of the Mayville and Burnt Bluff Formations, all Early Silurian dolostone (highlighted in red). All occurrences of Wisconsin sandstone—restricted to the Ordovician and the Late Cambrian—are highlighted in yellow. The last occurrence of glauconite is in the Prairie du Chien Group of the Early Ordovician—283–367 m depth below the Brussels Hill target rocks. Green star highlights the Tunnel City group, the likely source for the Brussels Hill sandstones and ~406 m below its target rocks. (Figure adapted from Wisconsin Geological and Natural History timescale.)

CONCLUSIONS

Although Brussels Hill lacks certain diagnostic criteria of an impact structure, its shape, local deformation, stratigraphic uplift, and microscale deformation indicate that a meteorite impact is the most likely explanation for its formation. As a distinctive, nearly circular feature ~2 km in diameter with localized deformation and units excavated from great depth, Brussels Hill fits the general morphological criteria of a terrestrial impact structure. In addition to abundant mono- and polymict breccias, Brussels Hill features Cambrian sandstones, likely from the Tunnel City Group and excavated from up to ~406 m depth. Grains in the sandstones display fracturing and possible planar microstructures. The reconstituted sandstone indicates an intermixing between the sandstones and the surrounding dolostone. The site is overlain by glacial till and features glaciated breccias, indicating that the deformation was pre-Late Pleistocene. Its Early Silurian target rocks also indicate that the deformation was post-Early Silurian. Based upon macro-, meso-, and primarily micro-scale observations, we conclude that Brussels Hill is the eroded remnant of the central peak of a larger impact structure.