THE WOODBURY-MANCHESTER IMPACT STRUCTURE: CONFIRMATION OF A LARGE LOW-ANGLE OBLIQUE IMPACT ON EARTH IN THE EARLY NEOPROTEROZOIC. R. S. Harris[1], S. J. Jaret[2], and E. F. Albin[1,3], [1]Department of Space Science, Fernbank Science Center, 156 Heaton Park Drive, Atlanta, Georgia 30307, [2]Department of Earth and Planetary Sciences, American Museum of Natural History, New York, New York 10024, [3]Department of Space Studies, American Public University, Charles Town, West Virginia 25414; scott.harris@fernbank.edu.

Introduction: Terada et al. [1] recently reported KAGUYA evidence that an asteroid shower on the Moon excavated at least 8 craters with diameters greater than 20 km approximately 800 Ma, including the 93 km-wide Copernicus. They calculated a corresponding terrestrial flux of nearly 5×10^{16} kg that could have produced one or more Chicxulub-sized structures, and several smaller ones, on Earth during the same interval. They speculate about what effects such a cataclysm might have had on the global climate, possibly setting the stage for the Cryogenian Period, but note the difficulty in assessing such hypotheses with a paucity of large Neoproterozoic craters preserved in the geologic record. The coincident observation published by Arnscheidt and Rothman [2] that the descent into Snowball Earth most likely resulted from a rapid decline in solar insolation further highlights the importance of documenting this part of the terrestrial impact record.

The Woodbury-Manchester Impact Structure: We previously have presented petrographic and geochemical evidence of an early Neoproterozoic astrobleme preserved in the Pine Mountain Terrane of west-central Georgia, U.S.A, about 90 km south of Atlanta, referred to as the Woodbury structure [3]. Recent field work has allowed us to identify abundant evidence of weak to moderate hypervelocity shock (e.g. shatter cones and shatter cleavages) in Grenvillian quartzites that were uplifted in a narrow complex of anticlinal ridges extending more than 100 km from northeast to southwest bisecting the center of the Terrane (Fig. 1: blue). The ridges generally are surrounded by an elliptical moat (Fig. 1: orange) of dense charnockitic melt rocks and vibrant red regolith often dissected by hydrothermal veins, both of which contain blocks of quartzite that commonly exhibit decorated planar deformation features (PDFs) (Fig. 2) indicative of moderate to strong shock (Fig. 3). Between the massive charnockite exposures and an outermost discontinuous arcuate band of quartzite hills bound by inward dipping listric faults lies a secondary low-lying moat (Fig. 1: green) floored mostly by basement rock but with occasional isolated pods and sills of fine-grained charnockite.

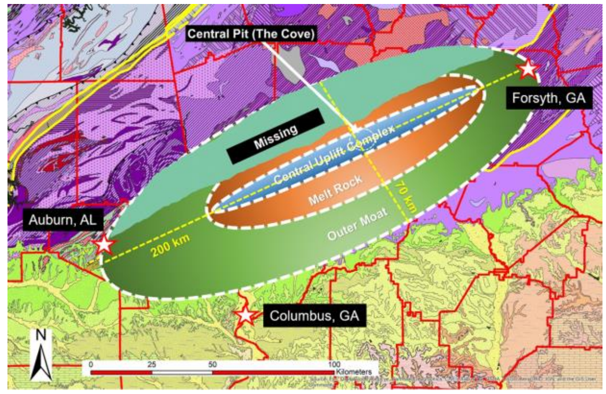

Figure 1. Geologic and county map of west-central Georgia and east-central Alabama with a schematic overlay illustrating the three major zones of deformation that define the extent of the Woodbury-Manchester Impact Structure. The interpreted impact direction trajectory is from northeast to southwest.

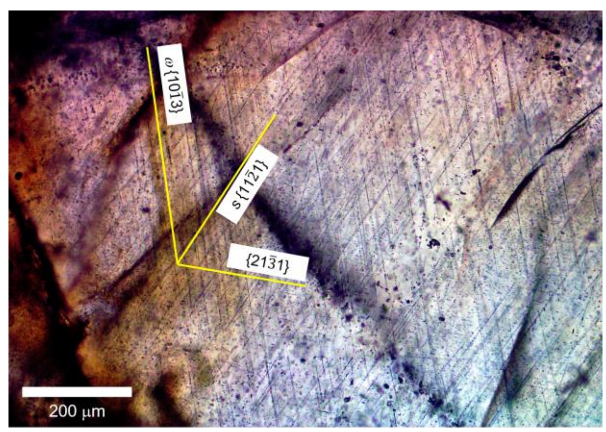

Figure 2. Plane-polarized light (PPL) photomicrograph of a quartz grain from a quartzite xenolith in charnockite exhibiting multiple intersecting sets of decorated planar deformation features (PDFs) diagnostic of hypervelocity shock.

An oblong structure of at least 200 km in length and 70 km wide is required to encompass the full extent of uplifted quartzite and melting. Although the northern third of the structure appears to have been removed or displaced by the Towaliga fault, a regional Alleghanian to early Mesozoic right-lateral fault [4]; and the southwestern edge of the structure may have been modified by a number of shear zones, we have not identified evidence to suggest major disruption of the overall architecture due to Paleozoic compression. The central collapse pit (Fig. 4), known locally as The Cove, remains especially undisturbed and is surrounded by scroll-like ridges and troughs similar to those described by Kenkmann and von Dalwigk [5] We suggest that thin-skinned Alleghanian tectonics played a major role in exhuming the large low-angle oblique crater that we hereafter recommend be referenced as the Woodbury-Manchester Impact Structure in recognition of the fact that both towns are equally situated at the center of a very large structure.

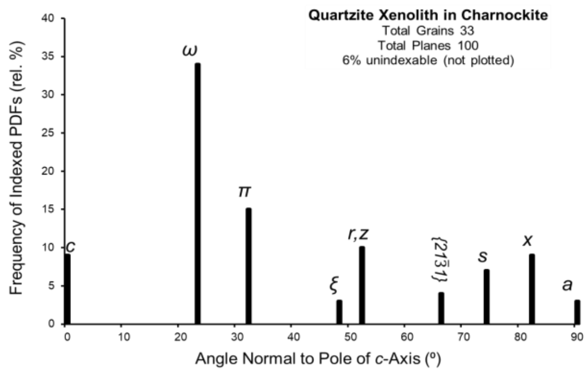

Figure 3. Histogram of indexed PDFs in quartzite xenolith contained with ~800 Ma charnockite collected near the base of an uplifted Grenvillian quartzite ridge. The frequency of orientations, as determined by Universal-stage measurement using the method of Engelhardt and Bertsch [6] is indicative of moderate to strong shock in a competent crystalline target [7].

Impact Age: The age of the impact is presumed to be the age of the charnockitic melt rock which we have investigated using the U-Pb geochronology of zircons measured by laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) at the Facility for Isotope Research and Student Training (FIRST) laboratory at Stony Brook University, performed by S.J.J. Based on these analyses, the charnockite has a maximum age between 800 and 900 Ma. Lack of zircons younger than 809 ± 65 Ma suggests a crystallization age of at or near this bound. Older zircons, ranging to 1161 ± 71 Ma, have ages consistent with the being inherited from Grenvillian target rocks.

Impactor Size and Implications: Using the relationships of crater size to impactor diameter and trajectory from Schultz and Crawford [8], and assuming a transient crater close to the current erosional diameter (~70 km) and an approach angle between 10-15º, the structure could have been formed by an asteroid larger than 25 km in diameter. That would account for more than 50% of the flux predicted Terada et al. [1]

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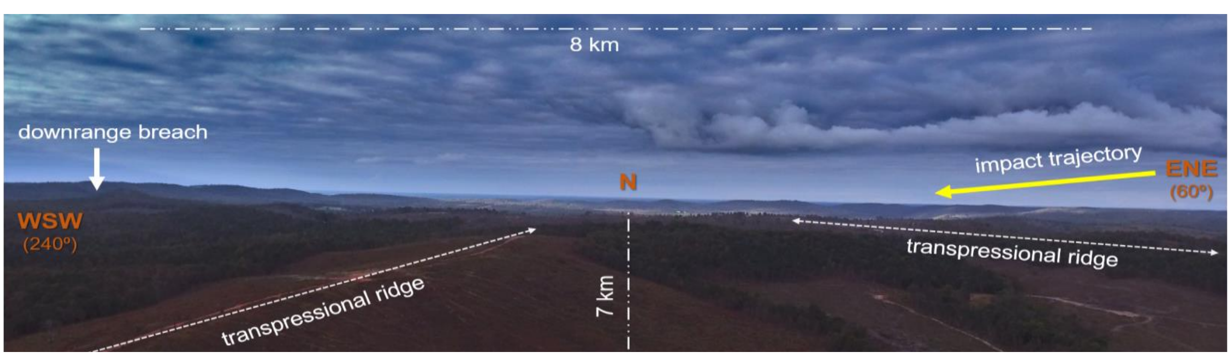

Figure 4. Photographic panorama showing the eroded central-pit (“The Cove”) of the medial uplifted quartzite ridge complex of the Woodbury-Manchester Impact Structure. The pit is bound by inward dipping listric faults and outward dipping quartzite hills that are breached on the southwestern perimeter, presumably along the downrange trajectory of the impactor. Synclinal transpressional ridges occur like spokes around the southern to southeastern portion of The Cove.