THE HOWELL STRUCTURE, LINCOLN COUNTY, TENNESSEE: A REVIEW OF PAST AND CURRENT RESEARCH. B. Deane[1], P. Lee[1,2], K. A. Milam[1], J. C. Evenick[1], and R. L. Zawislak[3] [1]Dept. of Earth and Planetary Sciences, 306 Geological Science Bldg., The University of Tennessee, Knoxville, TN 37996-1410, USA (wdeane@utk.edu) [2]Mars Institute and SETI Institute, NASA Ames Research Center, MS 245-3 Moffett Field, CA 94035-1000, USA (pclee@earthlink.net) [3]Department of Geosciences, Box 9, Middle Tennessee State University, Murfreesboro, TN 37132, USA (rlz1@mtsu.edu).

Introduction: The Howell Structure is a roughly circular feature about 2.5 km in diameter, comprising brecciated, deformed, and disturbed sedimentary strata, located at 35^o 13.9' N and 86^o 36.6' W. The structure is centered on the unincorporated village of Howell, in Lincoln County, Tennessee, USA, about 110 km SSE of Nashville, TN. The feature is delineated on the geologic map of the Fayetteville Quadrangle, Tennessee [1] as an "Area of Disturbance." The western two-thirds of the Howell Structure occur in rolling, grass-covered pastureland, while the eastern one-third consists of forested hills rising 130 m above the surrounding terrain. Exposures are limited.

Fig.1: Aerial view of the Howell structure looking SE.

Regional geology: Howell, TN is located within the Highland Rim geologic province on the southern flank of the Nashville Dome. The stratigraphy of the Highland Rim is primarily composed of flat-lying limestones, dolomites, and shales, and to a much lesser extent, of cherts, siltstones, mudstones, and very fine-grained to conglomeratic sandstones. Strata range from Upper Ordovician to Lower Mississippian in age and contain several prominent unconformities. The regional dip is typically less than 1^o. However, there are some gentle, asymmetric anticlines and synclines that rarely exceed 5^o in dip and some minor fault planes can approach 10^o in dip. Howell is one of four such structures found on the Highland Rim in TN. The other three are the Flynn Creek Structure, Wells Creek Structure, and the Dycus Disturbance. Flynn Creek and Wells Creek are proven impact craters. In contrast, Howell and Dycus have received little attention from the impact community and neither has been confirmed to be an impact structure.

Previous studies: The Howell Structure was brought to the attention of the Tennessee Division of Geology (TDG) in 1934 through the efforts of J. W. Young of Fayetteville, TN. In 1937, Kendall E. Born (TDG) and Charles W. Wilson, Jr. (Vanderbilt University) mapped about 10 miles^2 (26 square km^2) centered on the feature. In their findings [2], they reported a highly eroded crater, slightly oval in shape, about one mile (1.6 km) in diameter, and more than 100 feet (30 m) in depth, with "highly disturbed, contorted, and brecciated strata," parts of which had been "uplifted approximately 100 feet (30 m) relative to surrounding strata." The breccias were described as ranging in size from "shot up to large blocks many feet in dimension" which occurred in a matrix of "powdered limestone." They assigned an age of upper Ordovician to the deformation (primarily based upon the occurrence of the breccias). They took a neutral position as to whether the feature was "cryptovolcanic" or meteoritic in origin.

Fig. 2: Section of breccia sample collected in the Howell structure showing angular clasts welded in a fine grained friable matrix.

In 1968, Charles Marsh Woodruff, Jr., did his thesis research [4] on the Howell Structure to (1) determine the geographic and stratigraphic limits of the deformed rocks of the structure and to (2) re-assess its age. The presence of breccias or a dip greater than 20^o was used to define the perimeter of the feature at six control points. Howell was found to be a slightly irregular ellipse that trended along a NE-SW axis, approximately 8200 feet (2500 m) in length by 6000 feet (1830 m) in width. The structure's age was tightly constrained to the Upper-Devonian between the disturbed basal sand member and the undisturbed upper shale member of the Chattanooga Shale. One unique outcrop was discovered in the hills on the northeast boundary of the structure that was described as a mixture of deformed sand, chert, sulfides and carbonaceous material of Silurian and Devonian age. Quartz grains in thin sections made from this outcrop displayed lineation (some with two sets of cleavage), fragmentation, micro-brecciation, and flow features. One quartz grain had been granulated and reindurated, keeping its original shape. There were no petrography studies of other strata. (The thin sections did not survive the passage of 35 years of time and are lost for further study [4].) In addition, two possible shatter cones were reported. Woodruff concluded that the Howell Structure is probably an impact crater, but conceded that the evidence is not conclusive. The thesis was not published.

Fig. 3: Breccia block from a creek bed running through the northern part of the Howell structure.

During the mid-1960s, a team led by John W. Bensko, a lunar geologist at the Marshall Space Flight Center, drilled a test core hole in the center of the Howell Structure. Bensko verbally informed Woodruff [3] that the drill hole penetrated past the breccias into undisturbed bedrock, and that there was a zone of gradation between the breccias and the normal bedrock. No additional information is known, since the results from the drilling effort were never published and are no longer at Marshall. However, this data might be stored in the National Archives [5].

Current study: In the autumn of 2003, members of the present team made two reconnaissance trips to Howell, including an aerial survey.

Since the extent and shape of the structure were described by the earlier work, our efforts concentrated primarily on searching for evidence of shock metamorphism in local lithologies. Six samples of limestone breccias from wet-weather stream beds in the middle part of the structure and three samples of the Leipers and Catheys Formation (a fine grained, thin to medium-bedded Ordovician limestone exposed at the base of the hills on the eastern side of the structure) were collected and subject to analysis by petrographic microscope, XRD, and XRF.

A sample of the "powdered limestone" breccias, reported by Born and Wilson, was analyzed with a Siemens D500 XRD and a PANanalytical MagikPro XRF. It was found to be primarily composed of calcite, with small amounts of ankerite, and quartz. The percent weights for major elements were determined to be: Al_2O_3 1.92%, CaO 42.61%, Fe_2O_3 0.98%, MgO 2.46%, and SiO_2 3.26%. The only minor element of interest proved to be S at 1646 ppm. (Landowners complain that well water in the structure has a distinct sulfur odor.)

Thin sections were produced for all samples. All observed quartz grains displayed substantial microfragmentation. However, no unequivocal evidence of shock metamorphism such as melt, flow, or planar deformation features (PDFs) was found. Nor could an example of the micro-brecciation as reported by Woodruff be found.

Tasks proposed for future field visits include mapping of a cave in the NE corner of the structure and expanding the sample collection effort to different strata. We will also continue our search for the missing drilling data.

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References: [1] Wilson, C.W. and Barnes, R.H., (1973) *Geologic Map and Mineral Resources Summary of the Fayetteville Quadrangle, Tennessee*. [2] Born, K.E., Wilson, C.W., (1939) Jour. Geol., 47, 37-1-388. [3] Woodruff, C.M., (1968) *The Limits of Deformation of the Howell Structure, Lincoln County, Tennessee*. [4] Personal communication from Woodruff's thesis advisor, Richard Stearns, Professor Emeritus, Dept. of Geology, Vanderbilt Univ. [5] Personal communication from Bob Jaques, History Office, Marshall Space Flight Center.