STRUCTURAL EXPRESSION OF THE CRATER RIM AT THE HEAVILY-ERODED SERPENT MOUND IMPACT STRUCTURE. K. A. Milam[1] and P. Trygstad[1], [1]Department of Geological Sciences, Ohio University, 316 Clippinger Laboratories, Athens, OH 45776.

Introduction: Impact crater forms are well preserved on airless, relatively inactive planetary bodies (e.g. the Moon, Mercury) where only minimal geologic activity serves to erode or bury crater landforms. On Earth, eons of active geologic processes serve to obscure or destroy impacts, making measurement of the size of the original crater and estimate of the magnitude of the impact event a challenging task.

Such is the case at the Serpent Mound impact structure in southern Ohio (Fig. 1). Initial observations of the deformed structure were made in the nineteenth century during the 1st and 2nd geological surveys of Ohio [1-2]. This was in turn followed by mapping activities that began to delineate Serpent Mound as a circular area of deformed rocks, comprised of a centrally-uplifted region surrounded by downthrown strata [3-6]. More recent investigations of deformed sedimentary rock from the center of the structure [7-10] confirm an impact origin for Serpent Mound.

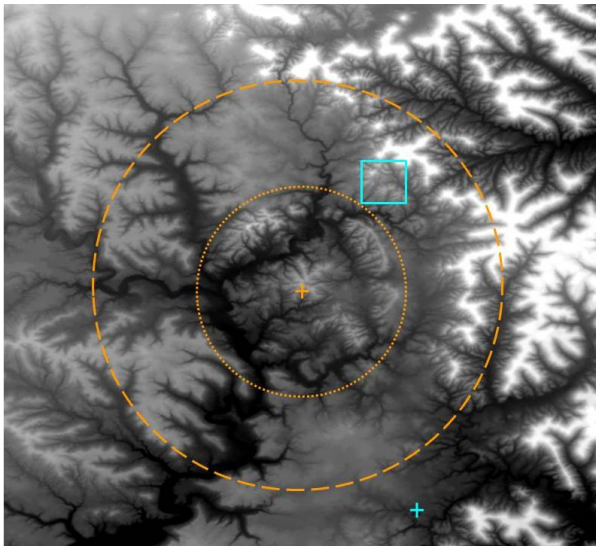

Figure 1. Digital elevation model of the Serpent Mound area in southern Ohio (north is up). Darker shades of gray indicate lower elevations. The dotted orange inner circle indicates the approximate 7-8 km diameter as proposed by [5], whereas the outer dashed circle highlights a 14 km diameter proposed by [11]. The approximate crater center is shown with an orange +. The blue + indicates the location of Plum Run Quarry; blue box indicates the area shown in Fig. 2.

The earliest mapping activities focused on the most deformed rocks near the center, leading [5] to propose a 7-8 km diameter for the structure (Fig. 1). The included central uplift and surrounding transition zone and ring graben (to use terms from [4-5]) however only represent the innermost portions of a complex crater: the central peak and crater floor. Recognizing this, [11] argued the crater morphometric relationship between the final crater diameter and the diameter of the central peak can be used to estimate a 10-25 km diameter for Serpent Mound. Offset of Late Devonian shales in the vicinity and an interpreted morphologic expression of the eroded crater rim east of the originally defined structure led [11] to suggest that the original crater diameter is approximately 14 km (Fig. 1).

Purpose: Ongoing field research in the periphery beyond the original 7-8 km diameter proposed by [5] seeks to delineate a more defined structural expression of this complex crater rim. Pristine complex craters on other solar system bodies [e.g. 12-13] and even some heavily eroded craters on Earth [e.g. 14-16] have normally-faulted crater rims. These faults, concentric to the crater center, result from the collapse of the transient crater rim during the modification stage of impact [17]. In terrestrial complex craters of diameters similar to that proposed for Serpent Mound [11], the throw along these normal faults is typically < 100 m [e.g. 15-16]. This work seeks to identify normal faults within the outermost 15 km of the center of the Serpent Mound impact structure as a means of delineated the final modified crater diameter.

Methods: Field investigations at Serpent Mound involve the mapping and identification of geologic units and key contacts between them in the eastern half of the structure within a 15 km diameter, encompassing the estimated diameter of [11]. In addition, strikes and dips of target rock strata are collected at each exposure. Station locations are recorded as waypoints with a GPS receiver. A series of cross sections extending outward from the crater center are being constructed as a means of identifying displacements that may result from normal faulting of the crater rim. Such faults are proving difficult to detect due to lack of suitable exposures and the fact that most strata in the study area are horizontal/subhorizontal, providing little indication of variations in bedding attitudes due to faulting or folding.

Results: Preliminary data from the crater periphery indicate that deformation of local bedrock extends well beyond the initially postulated 7-8 km diameter [5] of the structure into the the range proposed by [11]. Initial results from mapping activities indicate that normal faults do occur beyond 7-8 km. After considerable

work in the northeastern quadrant of the crater, a normal fault was detected approximately 5 km from the crater center along Highway 124 in western Pike County (Fig.2). Strike of this fault is oriented circumferential with respect to the crater center. As much as 22 m of throw was detected. This was determined by offset of the contact between the Late Devonian Ohio and Olentangy Shales. Detailed field work is ongoing in an effort to identify the presence of additional concentric normal faults.

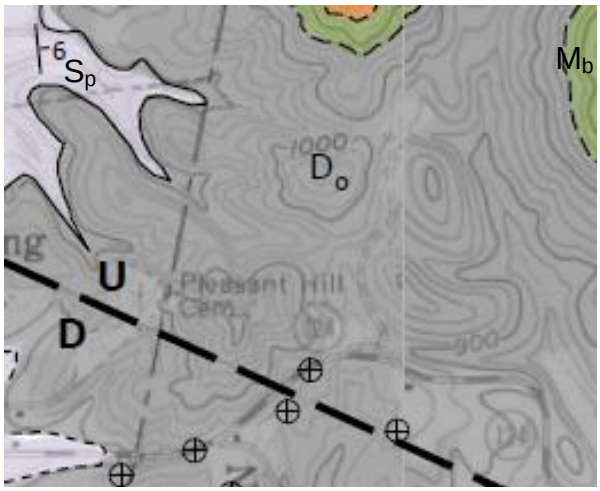

Figure 2. Portion of a bedrock geologic map of the Serpent Mound impact structure showing the normal fault (NW-SE trending dashed black line) in the northeastern quadrant of the crater. Units are denoted as follows: Sp = Peebles Dolomite; Do = Ohio and Olentangy Shales (undivided); Mb = Bedford Shale.

In addition to normal faults, radial faults extending even farther from the crater center have been inferred or observed. Up to 7 radial faults have been inferred due minimal offsets (<15 m throw), mostly in Middle Silurian carbonates of the Lilley and Bisher Formations [this study]. A similar fault has been observed by the main author in the abandoned Plum Run Quarry located (Fig. 1) ESE of Peebles, OH [and by 18]. This fault strikes approximately N24W, toward the center of the Serpent Mound impact structure. Similar NW to SE-trending faults and a graben have also been observed in this quarry (up to 11 km away from center) by [18].

Discussion and Conclusion: As expected, structural deformation is less obvious with distance from the crater center. Faults do occur beyond 7-8 km, but fault blocks are larger and show less variability in bedding orientations compared to those of the central peak, transition zone, and ring graben as mapped by [5]. Concentric normal faults appear at up to 5 km away from the crater center. If outermost normal faults are taken to represent the modified crater rim, then the original modified crater diameter for Serpent Mound is at least 10 km. Radial faults however, which we intepret to be associated with the Serpent Mound event, extend for nearly twice this distance, but still within the 25 km maximum crater diameter estimated from complex crater morphometric relationships [11]. Therefore, the final modified rim to modified rim diameter of the Serpent Mound impact structure lies within the 10-25 km range proposed by [11]. The subtle style of structural deformation, where large fault blocks of subhorizontal target strata bounded by concentric normal and radial faults and the associated small amounts of offset is typical for complex craters of on Earth [e.g. 16, 19].

Initial results suggest that the original (pre-erosion) modified rim diameter of the Serpent Mound impact crater was much larger than that originally proposed by [5]. Additional work should allow us to constrain the diameter and use appropriate morphometric relationships to estimate aspects of original crater mophology, such as rim height and the structural uplift and diameter of the central peak. Such information may prove useful in estimating the magnitude of post-impact erosion and may also allow us to better constrain the age of the impact event.

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