RE-INTERPRETATION OF THE FLYNN CREEK IMPACT STRUCTURE, TENNESSEE. D. T. King, Jr.[1] J. Ormö[2], L. W. Petruny[1], M. C. Adams[1], D. R. Adrian[1], and L. De Marchi, [1]Geosciences, Auburn University, Auburn, Alabama 36849 USA, [2]Centro de Astrobiologiá, Torrejon de Ardoz, 28850, Spain

Introduction: Flynn Creek is a 3.8 km marine-target impact structure that was formed during Late Devonian. Flynn Creek occurs at the surface, and is relatively well exposed, however, there is minimal topography owing to its mode of origin as noted herein. Figure 1 shows Flynn Creek's location and geology.

Flynn Creek is best known as one of the original six proven impact craters on Earth and has an interesting history of investigation. USGS geologist David Roddy, who completed his dissertation on Flynn Creek in 1966, was the champion of the hypothesis that Flynn Creek was formed by cosmic impact [1]. His 1968 paper on Flynn Creek, included as a chapter in the influential monograph *Shock Metamorphism of Natural Materials* [2], reviewed Roddy's surficial geology and early drilling results. His paper firmly established Flynn Creek as a *bona fide* impact crater in the days before there was an agreed set of criteria for recognizing impacts. At that time, in the absence of established crater models (simple versus complex), and without the benefit of geophysical data such as a seismic cross-section, Flynn Creek was described as an impact structure with an exposed central uplift. Today, an impact structure with a central uplift is classified as complex.

Here we argue that Flynn Creek is not a complex impact structure. This is evident from several lines of evidence, including (1) subsurface data from more than 20 drill cores within the impact structure (Fig. 2) and (2) the remarkable and painstakingly prepared 1968 structure contour map of the base of the Chattanooga Shale made by Roddy [2].

Lines of evidence: Subsurface data from the drill cores show that resurge breccia fills the impact structure to a depth of about 20 to 40 m, and further indicates that a small, inner crater about 1 km in diameter is filled with large breccia blocks [3] (Figs. 3 and 4). Drill cores located between the inner crater rim and the outer limit of Flynn Creek's annular brim show that resurge breccia lies upon slumped deposits that in turn overlie relatively undisturbed target bedrock. At deeper levels, lenses of parautochthonous breccia occur in distinct zones. Drill cores do not show stratigraphic uplift (i.e., strata dipping away from the crater center). In fact, most sub-crater strata in the drill cores are nearly flat-lying [4].

Regarding Roddy's structure contour map, this unique map reveals that Flynn Creek appears to be a small, simple crater that is encircled by a wide brim, which includes several slump blocks and radial resurge gullies (Fig. 5). These features are clearly evident and it is remarkable that they would not interpreted as such long before now [5-7].

Implications: It is now evident that Flynn Creek, which was an important impact structure in the early history of impact geology research, does not fit well as an example of either a simple or a complex impact structure. Flynn Creek's annular brim is in essence a miniature version of the Chesapeake Bay impact structure (CBIS), whose geomorphology is characterized by a 'nested crater' [8] in basement rocks and surrounded by a much wider outer crater that expanded through extensive, post-impact collapse of the poorly consolidated upper sedimentary target rocks, which in turn was partially affected (erosion and deposition) by aquatic resurge. The "central peak" is a consequence of the radial convergence of slump blocks of the upper target strata. Similarly to CBIS, the outer crater lacks an elevated rim as it merely delimits the extent of the inward collapse. Possibly, the absence of an elevated rim at the nested crater is also a consequence of the collapse of the upper target layer. As can be seen in the present re-interpretation, Flynn Creek is actually an outstanding example of a small concentric crater, and should be re-examined as such [4]. This paper summarized our research group's efforts at re-examination of Flynn Creek [5-7].

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References: [1] Roddy D. J. (1964) Cal Tech Ph.D. dissert. [2] Roddy D. J. (1968) in *Shock Metamorphism of Natural Materials*. [3] King Jr. D. T. et al. 2022 GSA Abst. #381607. [4] King Jr. D. T. et al. 2019 LPSC Abst. #2494. [5] Adrian D. R. et al. 2018 *MAPS*. [6] De Marchi et al. 2019 *MAPS*. [7] Adrian et al. 2019 *MAPS*. [8] Horton J. W. et al. 2006 *MAPS*.

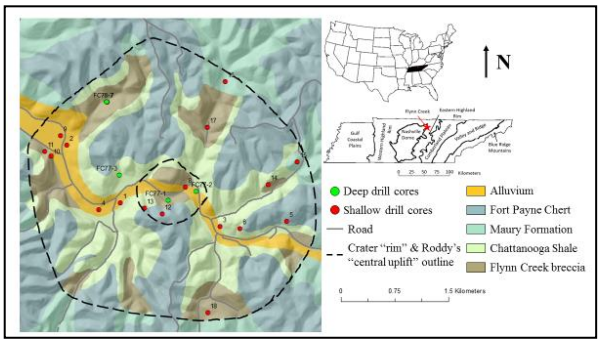

Figure 1. Flynn Creek's location and geology [7]. Dashed lines mark Roddy's "central uplift" and "crater rim."

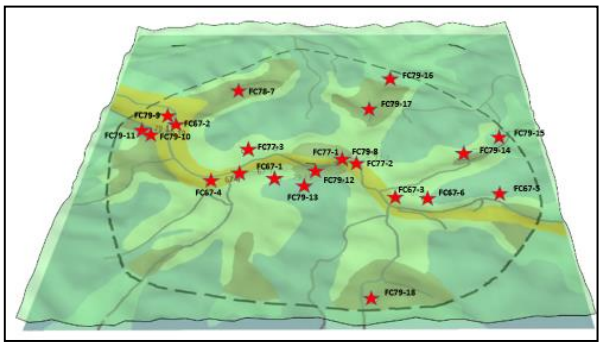

Figure 2. Location of drill cores with numbers. Same geology legend as Figure 1.

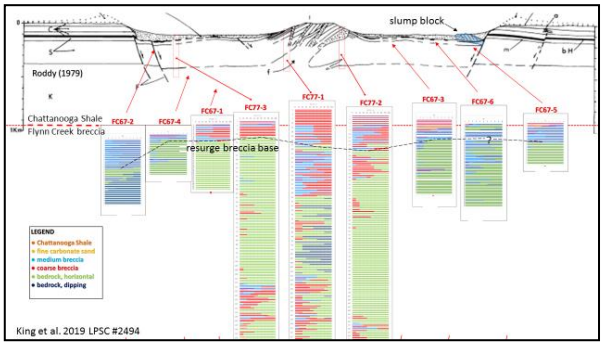

Figure 3. Subsurface data (see color legend) for key drill cores, which are shown in relation to Roddy's E-W cross section of 1979. Resurge breccia base is marked. For more detail, see [4].

Figure 5. At right. Upper – Roddy's structure contour map of Flynn Creek impact structure [2]. Note that contour lines are in English units. Lower – Our interpreted view of Roddy's map: blue are slump blocks and red arrows are resurge gullies [3]. →

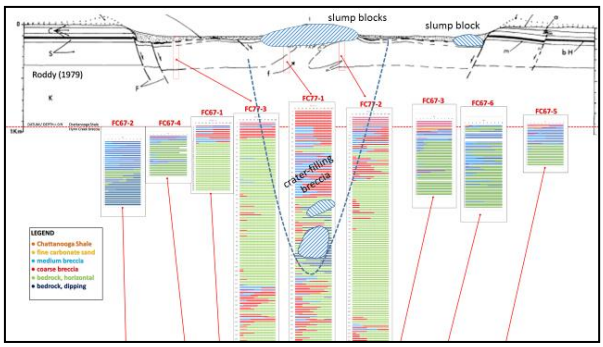

Figure 4. Subsurface data [4] interpreted to show crater-filling breccia blocks (intervals of variously dipping bedrock strata [3]). Drill cores same as above. Interpreted slump blocks are added to cross-section.