FIELD, DRILL-CORE, AND GEOPHYSICAL ANALYSIS, WETUMPKA IMPACT STRUCTURE, ALABAMA. D. T. King, Jr.[1], J. Ormö[2], L. W. Petruny[1], L. De Marchi[1], and V. Agrawal[1,3] [1]Geosciences, Auburn University, Auburn University, Auburn, AL 36849 USA (kingdat@auburn.edu); [2]Centro de Astrobiologia INTA-CSIC, 28850 Torrejon de Ardoz, Spain, [3]Aerospace Engineering, Auburn University, Auburn AL 36849 USA.

Introduction: The Late Cretaceous Wetumpka impact structure is a marine-target crater located in central Alabama [1, 2]. The target region was comprised of weathered crystalline rock of the Piedmont metamorphic terrane, which was overlain by several tens of meters of poorly consolidated sediments, specifically the Upper Cretaceous Tuscaloosa Group and Eutaw Formation. The water depth is interpreted to have been approximately in the range of 35 to 100 m [1, 3]. Wetumpka averages about 5 km in diameter but it reaches a maximum NE-SW diameter of 7.6 km [1, 3] (Fig. 1). Wetumpka's surficial geology consists of a deformed, semi-circular, crystalline-rim, and a relatively lower relief area, composed by deformed sediments and mega-blocks from sedimentary and crystalline target rocks, as well as resurge chalk deposits [4]. It is noteworthy that Wetumpka impact structure has no evident central uplift, despite a diameter where such a feature is generally thought likely to develop [3, 5].

Wetumpka impact structure's crater-filling materials have been investigated during field campaigns (1997-date) and core-drilling campaigns (1998 and 2009), which are briefly summarized below. A geophysical (i.e., gravity) profile, which lends insights into the deeper part of the crater fill not observed in the field or by drilling, is also summarized below. The crater-filling materials, and their vertical sequence, informs us of the modification stage of crater formation and helps to validate numerical models of the Wetumpka impact event.

Synopsis of field campaigns: The results of field studies at Wetumpka impact structure, which began in 1997 and continue to present, include the definition of three main impact-related terrains. These are impact structure crystalline rim, interior structure-filling unit, and the exterior disturbed terrain [1, 3, 4]. The impact structure rim is an asymmetrical feature that spans approximately 270 degrees of arc; open on the southern side. The width of the impact structure rim is not the same all around and neither is the orientation of constituent foliation within the rim [3, 4]. The interior structure-filling unit consists of broken sedimentary formations, which is a term that is intended to mean that the formations have been intensively deformed and in some instances disintegrated, yet these interior components are still recognizable as to formation of origin [3, 4]. The interior structure-filling unit has several distinctive components. In apparent order of formation during impact, these components are impactite sands, trans-crater slide unit, polymict boulder-bearing bed, and resurge chalk deposits. Impactite sands are monomict clastics that contain sedimentary target blocks; the trans-crater slide unit is related to the failure of the southern rim [3, 4]. The polymict boulder-bearing unit consists of shocked proximal ejecta and crystalline boulders up to 45 m in diameter [3, 5]. Resurge chalks are resedimented beds of Mooreville Chalk that contains fine ejecta components, and contain evidence of long-distance transport from the coeval shelf area (suggesting a turn-around of the original rim-wave tsunami). All these various interior-filling components comprise the upper few tens of meters of the Wetumpka impact structure's interior structure-filling materials. The exterior disturbed terrain, which comprises a limited area outside the southern open area of the structure's rim, consists of a target formations that are part of large slump blocks that appear to have rotated and moved toward the crater interior. In this regard, Wetumpka's exterior disturbed terrain mimics the annular slumped feature at Chesapeake Bay impact structure [3, 4].

Synopsis of core-drilling campaigns: The 1997 drilling campaign consisted of drilling two core holes to depth of approximately 200 m near the Wetumpka impact structure's geographic center. Both drill cores showed approximately the same sequence: the lower 100 m of the drill cores is comprised of impactite sands, the middle part (~ 10 m) is impact breccia and crystalline blocks, and the upper part is broken sedimentary formations, which appear to be related to the trans-crater slide and the polymict boulder-bearing bed. The 2009 drilling campaign consisted of drilling four core holes of various depths ranging from ~ 30 to 215 m. One core was drilled in the crystalline rim, and one was drilled in the polymict boulder-bearing bed (~ 30 m). The other two were drilled in the interior crater-filling terrain. One of these drill cores penetrated ~ 25 m of resurge chalk and ~ 70 m of impactite sand; and the other drill core penetrated trans-crater slide unit (~ 15 m) and ~ 200 m of impactite sand. Therefore, of the five drill cores that penetrate materials of the interior crater-filling terrain, nearly all of the crater materials penetrated is of sedimentary target origin.

Overview of deeper crater-filling materials: Outcrops and cores drilled so far reveal some details of the upper ~ 200 m of the Wetumpka crater-filling materials, yet the crater bowl of Wetumpka is likely to have as much as 1 km of material within it. For insight about deeper crater-filling materials, some limited geophysical data are pertinent. A gravity model, based a single gravimeter-based, west-east, trans-crater profile, shows an interpreted cross section of the crater fill [7]. Figure 2 shows the results of the gravity model. The depth scale on Figure 2 suggests that field studies and drilling have revealed details only about the upper lower density unit. We suggest that the lower unit of higher density is likely composed of crystalline bedrock blocks or that it contains a much higher proportion of crystalline blocks than the upper unit.

The implications of field, drill core, and geophysical analysis is that the sequence of events in the development of Wetumpka impact crater involved collapse of crystalline materials from the transient crater rim, which was followed in turn by collapse of a substantial volume of sedimentary rim materials. This includes the impactite sands, trans-crater slide unit, and polymict boulder-bearing beds (originally proximal ejecta [5]). Resurge deposits complete the modification sequence of deposits at Wetumpka.

This sequence of events in the development and modification of Wetumpka impact structure are evident in new digital (iSALE) modeling results for the Wetumpka impact event [8].

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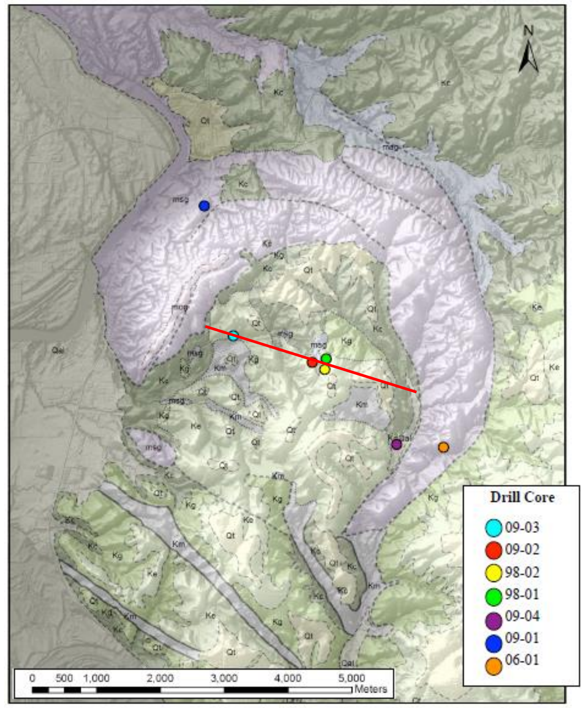

Figure 1. Geological map of Wetumpka impact structure (based on field mapping [6] and draped on a digital elevation model). Grey is crystalline rock; Green is sedimentary target, except Qal (Quaternary alluvium). Drill-core locations are indicated. Red line is geophysical (gravity) survey noted in the text.

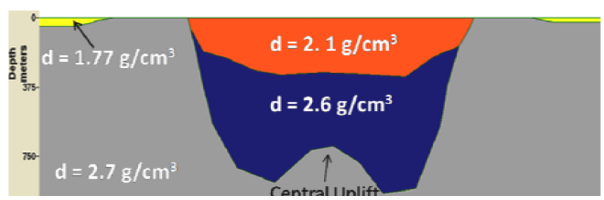

Figure 2. Gravity profile (inferred cross-section) taken from [7] that shows a two-layer model interpretation of Wetumpka crater-filling materials.