PROCESS RECONSTRUCTION OF THE LATE CRETACEOUS WETUMPKA IMPACT STRUCTURE (ALABAMA, USA), A SHALLOW MARINE IMPACT FEATURE. D. T. King, Jr.[1], J. Ormö[2], L. W. Petruny[3], J. R. Morrow[4], R. C. Johnson[1], and T. L Neathery[5]. [1]Dept. Geology, Auburn University, AL 36849 [king-dat@auburn.edu]; [2]Centro de Astrobiología (INTA/CSIC), Madrid, Spain [ormo@inta.es]; [3]AstraTerra Research, Auburn, AL 36831-3323; [4]Dept. Earth Sciences, Campus Box 100, University of Northern Colorado, Greeley, CO 80639 [jared.morrow@unco.edu]; [5]1212-H Veteran's Parkway, Tuscaloosa, AL 35404 [tlneathery@prodigy.net]

Introduction: Wetumpka, a Late Cretaceous marine-target impact structure in the inner Coastal Plain of Alabama (Fig. 1), is characterized by a wide, horseshoe-shaped crystalline rim, an interior region of broken and disturbed sedimentary formations, and an extra crater terrain on the south and south-west composed of structurally disturbed target formations [1, 2]. The extant crater rim spans 270 degrees of arc and is open on the southwest, the same side as the structurally disturbed terrain just noted. The northwest-southeast diameter of the crystalline rim alone is approximately 5 km. In order to understand the influence of target properties on the cratering and modification of Wetumpka, we investigated its present state of preservation (i.e., the present erosional level versus an original crater cross section). This was achieved by comparing present geology and topography with standard morphologies for impact craters [3], and further incorporating recent results from studies of marine-target craters, especially those strongly affected by the collapse of a thick sequence of poorly consolidated sediments. Studies of marine-target craters such as Chesapeake Bay and Lockne, have brought to light marine-target cratering processes that are also quite evident at Wetumpka.

Target setting: The Wetumpka impact occurred in marine water of the Gulf of Mexico, which was approximately 30 to 100 m deep and likely shallowed toward the north where the coeval shoreline was located [1, 2]. In reverse stratigraphic order, the target consisted of marine water; poorly consolidated sediment (comprising 30 m of chalky ooze, 30 m of paralic marine sand, and 60 m of terrestrial clayey sand and gravels, and ultimately,weathered crystalline basement. The crystalline basement has a southwest dip of about 10 m per kilometer. This is assumed to play a role in the cratering and modification.

Process reconstruction: We envisioned an initial, fresh crater that would fit to the present day topography and surface geology [4]. In figure 2, the topography and geology along a SSW-NNE profile is connected to a hypothetical subsurface morphology of the crater. Based on standard parameters for impact craters and information from marine-target craters we can reconstruct the dimensions of the fresh crater. The best fit is achieved with a fresh crater having a diameter slightly less than 5,000 m. Based on the relations between fresh crater diameter and transient cavity given by Melosh [3]. The diameter of the transient cavity at target surface would have been about 4,000 m. The water layer was excavated together with the rocks in craters with water depth significantly shallower than the diameter of the impactor [5]. The rim height of a 5 km-wide fresh crater in solid rock, measured from the target surface, should be c. 203 m [6], but we assume slightly higher initial rim (250 m) due to the water layer and soft sediments. This fresh crater rim is, of course, transient and will be lowered by removal of the water layer. Half of the rim height is assumed to be due to structural uplift, and this decreases to zero at approximately 1.3 to 1.7 crater radii from crater center [based on 4]. The structural uplift of the basement would be slightly less on the southern side than the northern due to the structural dip of the basement. Onset of central and slight down-faulting of the rim (Fig. 2) are inferred for craters larger than 4 km in crystalline rock. Due to the large influence of marine water in the rim formation on the southern side, and the lower structural uplift of the basement, this sector of the fresh crater rim immediately collapsed. The collapse was further aided by the onset of a resurge of the seawater. As the seawater was shallower on the northern side, this part of the crater rim could withstand the resurge better. The collapse of this side was possibly further diminished by the more pronounced structural uplift of the basement forming a threshold for the sediments.

With no coherent rim to hold back the fluidized sediments of the target, the collapse of the southern sector could reach far outside the initial diameter of the crater (Fig. 2). This is visible today as a wide zone of horst-graben structures to the southwest of the crater (i.e., in the structurally disturbed terrain). The occurrence of large (d = hundreds of meters) blocks of crystalline rock at the crater center is assumed to be fragments of the southern rim that slumped in to this position.

In these reconstructions we have neglected any influence of the impact angle. Recent numerical simulations of an oblique impact for the Lockne crater have showed a much larger flap-formation and extensive ejecta curtain down-range than up-range [7]. However, the water resurge would have been stronger from the up-range direction. If we assume an impact at Wetumpka from the southwest, then the effects on crater collapse that we now infer from the slope of the basement and the deepening of the water, will be significantly enhanced.

Interpretations: The reconstructions show that, most likely, the erosional level of the crater allows only the present northern crystalline rim to be part of the structural uplift. However, recent field observations of disturbed sediments in a position topographically below crystalline rim material in the southeastern rim indicate that some sectors of the rim may have preserved parts of the crystalline flap. If selective failure of rim is due most probably to resurge flow and instability of the rim due to poorly consolidated sediments (Fig. 2), then the presence of this morphologic feature alone in other craters in the Solar System has great importance for interpreting target composition and pre-impact geologic history.

References: [1] King D. T. Jr. et al. (2002) *Earth & Planet. Sci. Lett., 202*, 541-549. [2] King D. T. Jr. et al. (2003) *Springer Impact Studies*, 97-112. [3] Melosh H. J. (1989) *Impact cratering.* [4] Nelson A. I. (2000) Thesis, Auburn University. [5] Ormo J. et al. (2002) *Jour. Geophys. Res., 107*, E11. [6] Pike R. J. (1977) *Impact and explosion cratering*, 489-509. [7] Shuvalov V. et al. (2005) *Springer Impact Studies*, 405-430.

Fig 1. Shuttle-radar topographic model of Wetumpka impact structure as seen from the southeast.

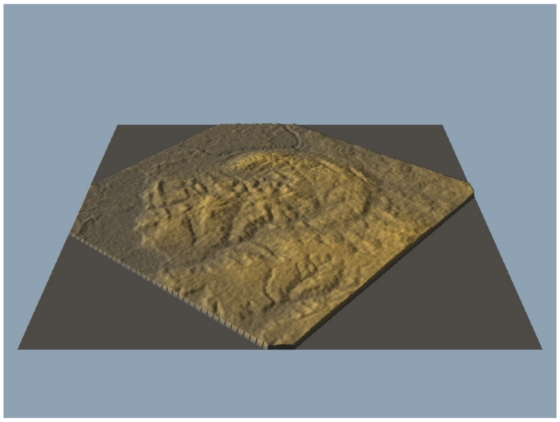

Fig. 2. Interpreted crater cross-section of Wetumpka impact structure showing modification of the rim and adjacent areas outside the southern rim (left side of diagram). The collapse caused large-scale block slumping of poorly consolidated, fluidized sediments outside the crater, which moved inward. A is south, B north. The target consisted of (1) marine water (blue pattern), (2) poorly consolidated sediment (yellow pattern) comprising 30 m of chalky ooze, 30 m of paralic marine sand, and 60 m of terrestrial clayey sand and gravels, and ultimately, (3) the weathered crystalline basement (dark pink pattern). The parauthonous breccia lens is orange.