MARINE RESURGE SEQUENCES IN DRILL CORES FC67-3 and FC77-3 -- FLYNN CREEK IMPACT STRUCTURE, TENNESSEE USA. L. de Marchi[1], D.T. King Jr.[1], J. Ormö[2], L.W. Petruny[1], D.R. Adrian[1], J.J. Hagerty[3], T.A. Gaither[3], and S.J. Jaret[4], [1]Geosciences, Auburn University, Auburn, AL 36849-5305 USA. [lzd0034@auburn.edu]; [2]Centro de Astrobiología (INTA-CSIC), Madrid, Spain; [3]USGS, Astrogeology Science Center, Flagstaff, AZ 86001 USA; [4]Department of Geosciences, Stony Brook University, Stony Brook, NY 11794 USA.

Introduction and Aims: Roddy [1-4] first presented evidence that the Flynn Creek impact structure is a Late Devonian, 3.8-km diameter, complex, marine-target impact crater, which formed in an epicontinental shelf setting. The Flynn Creek impact structure is located in north-central Tennessee (36° 17' N; 85° 40' W) and is well exposed at the surface. The crater rim has an asymmetric ("pear-shaped") outline and displays a central uplift, breccia-filled crater moat, and terraced crater rim [4-6]. The target stratigraphic section was nearly flat-lying, Upper Ordovician carbonates ranging from Knox Group through Catheys-Leipers Formation [4-6]. Almost all rim exposures consist of Catheys-Leipers Formation, whereas the central uplift exposures consist primarily of Knox and Stones River Groups [4-6]. Central uplift flanking breccias are mainly coarseing upward slump deposits [7]. In a subsequent, post-impact phase, Upper Devonian Chattanooga Shale was deposited in the crater and across the area on what was then a shallow marine shelf [4-6, 8].

In a post-impact phase of erosion, the ejecta blanket, terraced crater rim, crater-moat breccias, and central uplift were subjected to intensive erosion (either prior to or during transgression of the Chattanooga sea). This episode of erosion was followed by local transgression of the Kaskaskia sea, which inundated the erosional unconformity or peneplain [4, 9]. A residuum unit at the base of the Chattanooga Shale has been recognized for over 100 years [refs. in 9]. After Chattanooga Shale was deposited over the area including the crater, several hundreds of meters of other types of sediments were deposited in the area [4, 9]. Regional uplift along the Nashville Dome has promoted erosion in the Flynn Creek area and thus generated an extensive valley network that cuts into, and thus helps expose, the terraced rim, breccia fill, and central peak [4, 9].

Core drilling over the period 1967-1979 extensively sampled the Flynn Creek impact structure. Some cores were obtained by the USGS and others by other entities. All these drill cores were collected by the USGS and transferred to the Astrogeology Center [6, 10]. Drill cores FC67-3 and FC77-3, which were examined in this study, are available for study at the USGS Astrogeology Center in Flagstaff as a result of this collection effort. Figure 1 shows the impact structure outline and the location of core holes FC67-3 and FC77-3 of this study.

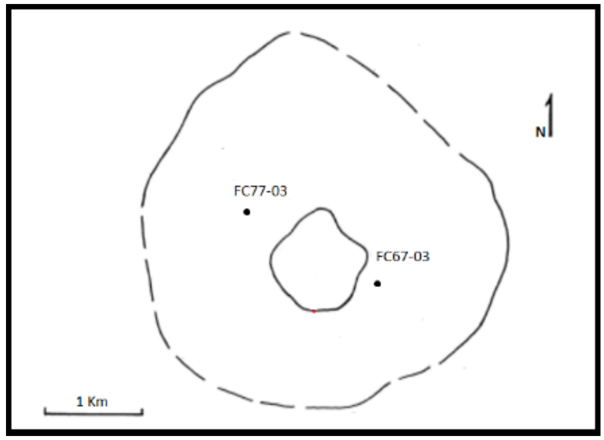

Figure 1. Map of crater rim and central uplift (solid inner circle) and the two core-hole locations used in this study. Flynn Creek impact structure, Tennessee. Modified from astrogeology.usgs.gov.

Previous studies of crater-moat filling sequences at Lockne crater, Sweden, a marine impact into mainly crystalline basement, unconsolidated mud, and consolidated Paleozoic carbonates, has been conducted by Ormö and other workers [11, 12]. Their studies, based on drill-core observations, including line-logging data, indicate a crater-moat filling sequence that consists of two main parts: a coarse, basal (chaotic) breccia and a finer, generally normally graded upper bedded breccia. In an earlier study, Scheiber and Over [8] also noted evidence of similar textural dichotomy in the moat breccias at Flynn Creek.

Methods: As a way of preliminarily assessing the crater-filling resurge breccia deposits at Flynn Creek, we studied the core-box photographs of the resurge sequences in drill cores FC67-3 and FC77-3. We made grain-size estimates in order to characterize the grain sizes, their general sorting and rounding, and clast compositions of these breccia deposits. In this paper, we compare these results with resurge deposits at Lockne crater. In a second phase of this work, presently in progress, detailed data will be collected by observations made directly upon drill cores FC67-3 and FC77-3 with regard to clast sizes, shapes, and lithologies through the potential resurge sequence in each core. In that work, we will use the line-logging method described by Ormö et al. [11] and by Sturkell et al. [12] for the Lockne crater and by Adrian et al. [7] for drill core FC77-1 from the flank of the central uplift of Flynn Creek impact structure.

Results: Preliminary findings from our analysis of core-box photographs show that the dichotomy within the moat breccia, noted above, is evident in both cores examined. However, the sequence is much thicker in drill core FC-67-3 than FC77-3 (note scale difference between the two columnar sections). Figure 2a and 2b show the results, displayed as columnar sections, from FC67-3 and FC77-3, respectively. The right side of the columnar section reflects changes in relative grain size. In both drill cores, the same lithologic sequence appears, as indicated by the description of sub-units within both the lower chaotic breccia and the upper bedded breccia. However, the thickness of comparable units varies between drill cores. Overall, the entire crater moat-filling sequence is fining upward, but there are departures from this overall trend in both drill cores studied.

Conclusions: Preliminary results from our analysis of core-box photographs shows that there is a general fining upward sequence in both crater-moat drill cores examined and that there is a dichotomy of breccia types in both cores, namely a coarser, poorly sorted, basal chaotic breccia and a finer, better sorted, bedded breccia above. These are interpreted to be resurge deposits owing to their similarity to Lockne crater-moat resurge deposits as described by [11, 12]. Asymmetry of the crater shape, varying water depths, and possible obliquity of impact may have played a role in the differences observed between the two drill cores studied, which are located on opposite sides of the central uplift area. Further examination by line-logging methods will help us better understand the processes at Flynn Creek.

References: [1] Roddy D.J. (1966) *The Paleozoic crater at Flynn Creek, Tennessee*. Ph.D. thesis, Cal Tech. [2] Roddy D.J. (1968) In *Shock Metamorphism of Natural Materials*, Mono Book Corp., Baltimore, 291-322. [3] Roddy, D.J. (1977) In *Impact and Explosion Cratering*, Pergamon, 277-308. [4] Roddy D.J. (1979) *LPSC X*, 2519-2534. [5] Evenick J.C. (2006) *Field Guide to the Flynn Creek Impact Structure*. U. Tenn., Knoxville. [6] Gaither T.A. et al. (2015) *LPSC XLVI*, Abst. #2089. [7] Adrian D.A. et al. (2017) *LPSC XXXVIII (abstract in this session).* [8] Schieber J. and Over D.J. (2005) In *Understanding Late Devonian and Permian-Triassic Biotic and Climatic Events: Towards an Integrated Approach*, Elsevier, 51-70. [9] Conant L.C. and Swanson V.E. (1961) USGS Prof. Paper 357. [10] Hagerty J.J. et al. (2013) *LPSC XLIV*, Abst. #2122. [11] Ormö J. et al. (2007) *Met. & Planet. Sci.* 42, 1929-1943. [12] Sturkell et al. (2013) *Met. & Planet. Sci.* 48, 321-338.

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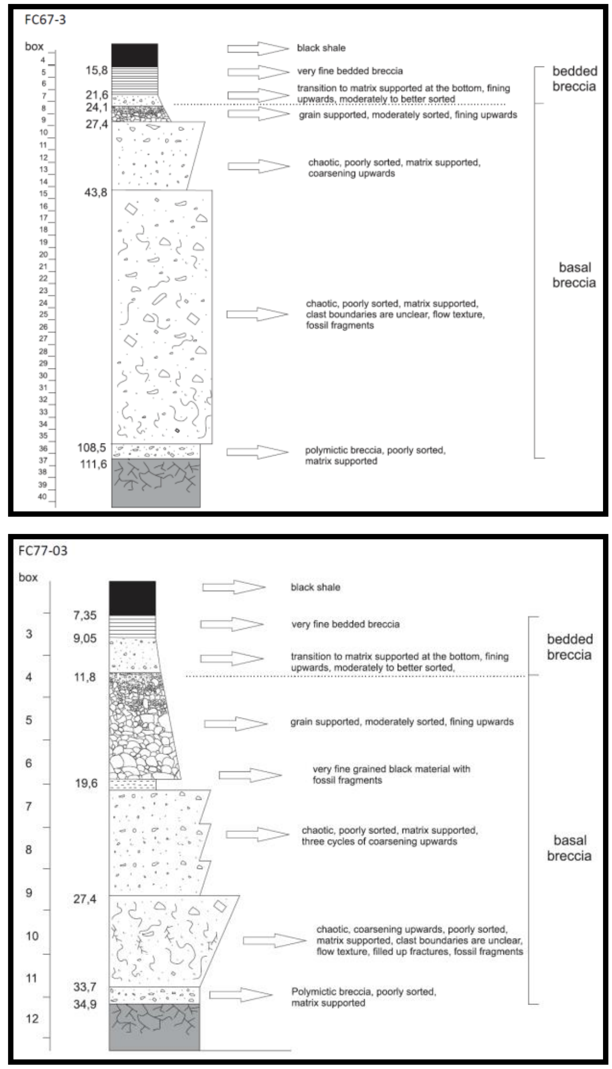

Figure 2a and b. (a) At top, crater-moat filling sequence in drill core FC67-3. (b) At bottom, crater-moat filling sequence in drill core FC77-3. Columnar sections of two drill cores are based on methods described in text. Vertical scale in m is on the left; core box numbers are indicated on left. Sedimentological units observed are described briefly on the right. Right edge of column indicates relative grain size. Note that the basal breccia/bedded breccia dichotomy is evident in both cores. Locations of the two core holes are shown in Fig. 1.