

THE FLYNN CREEK CRATER DRILL CORE COLLECTION AT THE USGS IN FLAGSTAFF, ARIZONA. J. J. Hagerty, J. F. McHone, and T. A. Gaither. U.S. Geological Survey, Astrogeology Science Center, 2255 N. Gemini Drive, Flagstaff, AZ 86001, email: jhagerty@usgs.gov

Introduction: Flynn Creek crater is a 3.8 km diameter, 360 million year old structure located in north-central Tennessee ($N\ 36^{\circ}17'$, $W\ 85^{\circ}40'$) (Figure 1). The impactor likely struck a shallow sea, punching a relatively flat hole into underlying Ordovician marine limestones [1-3]. The crater was filled with black Devonian muds that underwent lithification to become the Chattanooga Shale [1-3]. It should be noted that no Silurian rocks were present at the time of impact [1-3].

Between 1967 and 1979 Dr. David Roddy of the US Geological Survey conducted a drilling program at Flynn Creek crater [1-3]. The project produced more than 3.8 km of nearly continuous core from 18 separate bore holes. These samples are now contained in 1,271 standard core storage boxes archived at the USGS in Flagstaff, Arizona where the cores are currently being organized and are available for scientific study (Figures 2 and 3).

Brief History of Impact Research at Flynn Creek Crater: A relatively thin 3-10 m thick deposit of Devonian black shale occurs over much of the North American interior, from Michigan and Vermont to Alabama. Now known in Tennessee as the Chattanooga Shale, its persistence and distinct appearance have been exploited as a geological marker for more than 140 years [4]. Black shales are of economic interest as potential fuels and industrial minerals and are frequent targets for mapping programs. In 1926, while field mapping the recently published Gainesboro, TN 15-minute topographic quadrangle, Lusk [5] discovered uniquely thick outcrops of shale. For instance, shale exposed at Flynn Creek in Jackson County was up to 150 ft (~46 m) thick compared to a regional thickness of 10-50 ft (~3-15 m). A belt of well-developed surface karst lies less than 20 miles east, and Lusk [5] interpreted the Flynn Creek anomaly as a sinkhole formed in underlying Ordovician limestone and filled with organic-rich Devonian sea muds.

In 1936 Wilson and Born [6] carefully mapped the intensely disturbed Flynn Creek area and identified large blocks uplifted as much as 500 ft (~152 m) above their normal positions. They concluded the site was an explosion structure in which a “crypto-volcano” deep beneath Ordovician limestone blasted a crater which eventually filled with up to 250 ft (~76 m) of Devonian black mud. That same year, Boon and Albritton [7] suggested Flynn Creek and other “cryptovolcanic structures” could, in fact, be meteorite impact structures.

In 1946, Dietz [8] proposed the non-genetic term “cryptoexplosion” and commented on similarities be-

tween Flynn Creek and the Steinheim crater in Germany. He further suggested Flynn Creek and Steinheim were impact features analogous to central peak craters on the Moon [8].



Figure 1. Google Earth view of Flynn Creek crater with an outline overlay of the crater diameter from Wikimapia (3.8 km diameter). Source: “Flynn Creek crater,” $36^{\circ}16'58.4036''N\ 85^{\circ}39'57.0622''W$, Google Earth 2012, January 4, 2013.



Figure 2. Flynn Creek Crater samples in standard core boxes at the USGS Astrogeology Science Center, Flagstaff, Arizona.

During the 1940s black shales around the world were discovered to be radioactive due to the presence of uranium. The presence of uranium was the main justification for the Manhattan Engineering District funding the USGS to study North American black

shales, emphasizing the Chattanooga, as a future uranium source [9]. Bore holes at Flynn Creek further revealed its buried crater-like structure [1-3]. Shoemaker and Eggleton in their 1961 report to the Atomic Energy Commission [10] described Flynn Creek as a “buried crater with the form and structure of a meteorite crater”.

More recent research investigations have used a combination of field studies and sample analysis to further establish the impact origin of Flynn Creek crater. For instance, Evenick et al. [12] identified melt and flow features, as well as shatter cones at the crater. Milam et al. [13, 14] used surficial exposures, sample analysis, and caves within the central uplift to identify macro- and micro-structural features produced by the impact. These structural features were shown to be similar to features found at other complex craters [13, 14]. Lastly, although an impact origin for the crater is no longer in question, bulk rock geochemical analyses have shown little or no evidence of a chondritic or iron-rich meteoritic component within samples from the crater [15]; therefore, additional work remains to be done in order to determine the composition of the impacting body.

Flynn Creek Crater Drilling Program: Dr. Eugene Shoemaker approved the Flynn Creek structure as a doctoral study topic for USGS geologist David J. Roddy. Roddy not only completed a 1966 Cal. Tech. PhD dissertation [11], but also established a successful multi-year core drilling program [1, 2]. A total of 18 separate holes were drilled with nearly complete recovery of over 3.8 km of continuous core [3]. As cores were recovered and examined, they were warehoused locally in standard boxes until operations were completed in late 1979 [3]. Eventually the entire collection was transported to Flagstaff, Arizona with plans to establish a facility for public access. Such plans were unfortunately interrupted with Dr. Roddy’s untimely death in 2002. The cores were neglected and fell into obscurity. However, with increasing international interest in impact processes, and a renewed interest in methane-rich shales, a core recovery and preservation effort was revived. The core boxes were located, and in some cases refreshed, then transported and shelved in a secure SeaVan shipping container at the USGS Astrogeology Science Center in Flagstaff. The cores (Figure 3) are presently in the process of being documented, inventoried (all 1,271 boxes of NX and BX core), and catalogued for access by interested scientists.

Using the USGS Meteor Crater Sample Collection [16] as a template, it is our hope that the Flynn Creek Drill Core Collection will provide new information that will help to constrain the origin and evolution of Flynn Creek crater.

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Figure 3. Example of drill cores in standard boxes from the USGS Flynn Creek Crater Drill Core Collection in Flagstaff, AZ.