A GEOPHYSICAL SEARCH FOR THE FLOOR OF A CONCEALED IMPACT CRATER IN NORTHWEST OHIO

STIERMAN, Donald J., COUSINO, Luke K., DILWORTH, John R. and DZIEKAN, Mitchell R. (dsterrm@utent.utoledo.edu)
Department of Environmental Sciences, University of Toledo, 2801 Bancroft Ave, Toledo, OH 43606

Abstract: We are using geophysical methods to map a sediment-filled gap in the carbonate bedrock under Sections 17, 18, 19 and 20 of Liberty Township, Seneca County, Ohio. No evidence of the 100 m thick Lockport dolomite documented in oil wells logs north and south of this anomaly has been detected inside an approximately circular feature about 980 m in diameter. The feature is interpreted as an unmined crater which may be concealed by about 10 m of drift. Our working hypothesis is that we are studying an impact crater. Electrical resistivity measurements used to map the crater suggest that the edge of the carbonate does not everywhere mark the edge of this hole. A wet-drilling attempt outside the northwestern edge encountered only a thin layer of limestone dolomite before penetrating shale that should be at least 80 meters deeper. Rocks of the crater floor are uplifted. A Schlumberger sounding east of the crater’s center discovered 80 mhem material extending from 57 m under the surface to at least 200 m. Trytten (1995) reports crater fill 600 m to the northwest in the 20–70 m range. The P-wave velocity of the refractor under drift west of the crater center is about 2100 m/s, significantly less than the 2800 m/s measured in the northwest quadrant. Cuttings from an 80 m deep borehole drilled near the crater lie in an unusual sequence. The upper sequence of groundwater is calcite-cemented silt, pinkish gray when dry and dark red clay when wet. Another well drilled into the crater encountered salt water. We speculate that brine from the oil-bearing Trenton limestone just over 400 m down migrated into the crater, forming a lake that was mostly salt water except for the northwest quadrant. We have not encountered electrical resistivity values this low, under 10 ohm-meters, elsewhere in northwest Ohio except locations involving landfall leachate. The 2100 m/s refractor under the cuttings shows evidence of the Glaciers that swept 400 m down migrated into the crater, forming a lake that was mostly salt water except for the northwest quadrant. We have not encountered electrical resistivity values this low, under 10 ohm-meters, elsewhere in northwest Ohio except locations involving landfall leachate. The 2100 m/s refractor under the cuttings shows evidence of the Glaciers.

Figure 2: water wells and attempted water wells that help define the crater edge along State Route 635. Wells 7 and 8 tap the carbonate aquifer. 1 was the discovery well. Well 6 encountered uplifted stratigraphic特征 of an impact crater rim. Summary information is listed in Table 1. Wells 7 and 8 are old water wells tapping the regional aquifer.

Table 1: summary information from well logs, descriptions and observations with property owners. Salt water encountered in Well 10 is documented on the original well log but was not transcribed when the water well digital database was developed.

Well info is a handbook of cuttings when Well 1 was drilled in 1990. Cuttings fizz vigorously when tested with a geologist’s standard 1% HCI solution. HCI was used to disaggregate several samples. Dry weight of the disaggregated, rinsed samples was about 15% less than the dry original, calcite-cemented samples. Cuttings from that well are pinkish gray when dry (Munsell 7.5 YR 7/4) and dark gray when wet (Munsell 5 Y 5/1). The sample was preserved in 10% HCl.

Refractive Profile 1 (Figures 7 and 8) consists of 2 overlapping geophone spreads extending east of the base of topographic high into which Well 1 (Figure 2, Table 1) was drilled. This was our initial search for shallow bedrock in which the home owner hoped to tap the carbonate rift. The deepest layer is based on only a few arrivals in one direction only so there is no way to discriminate between true velocity and contact dip. P-waves propagate with little amplitude loss along the 2.7 km/sec refractor. We have not encountered similar behavior (2.7 km/sec, efficient propagation) elsewhere. The shallow geophone spread (closely spaced geophones) for profile 11 2015 was used in an unsuccessful attempt to detect reflections from the crater bottom. Although reflections were not observed, first breaks served as input for Geometrics’ SeismTuner2D software. The basin fill refractor is significantly shallower than Profile 1.

Discussion: Geophysical profiles have mapped an approximately circular hole about 980 m in diameter in the Lockport Dolomite. There are geophysical hints of uplifted strata at the crater edge under some profiles, but drilling near the crater edge for a water well (unsucccessful) encountered shale and other rocks elevated 70 – 80 m above the depth predicted based on nearby borehole logs and the gentle regional dip, proof of uplift. Sinkholes do not have uplifted rims. An isolated circular basin with uplifted strata on the rim, hundreds of kilometers from the nearest post-Proterozoic plastic belt or mantle plume, is probably not volanic in origin. It is probably an impact crater. The northwest quadrant exhibits a higher seismic velocity and higher electrical resistivity than fill along the eastern edge of the crater. I speculate that hard water from the carbonate aquifer precipitated calcite cement that indurated silty clay in the NW quadrant, while brine from the Trenton limestone, exposed when the meteorite exploded, lowers the electrical resistivity in the eastern half. Brine may have prevented hard water from the ‘Big Lime’ aquifer from precipitating calcite, resulting in a lower P- wave velocity in the east. A Schlumberger sounding that should detect any change less than 25% of oil. The lack of any clear failure to reveal evidence of a crater floor. Even if this feature is not an impact crater, a deep bedrock hole with low-energy sediment might hold a continuous record of hundreds to thousands of years of climate change.

Acknowledgments: I am grateful to property owners for permission to work on their land including Donald J. Stierman, John R. Dilworth and Bradley B. Trytten. This work was supported by the College of Arts and Sciences who assisted in many field expeditions, and the Department of Environmental Sciences for use of the Department’s F-150, computer resources and geophysical instruments.

Figure 1: Location map showing position of the study area. The cored borehole was drilled to the Precambrian carbonate shelf by the Ohio Geological Survey (Wickstrom et al., 1985).

Figure 2: Water wells and attempted water wells that help define the crater edge along State Route 635. Wells 7 and 8 tap the carbonate aquifer. 1 was the discovery well. Well 6 encountered uplifted stratigraphic characteristic of an impact crater rim. Summary information is listed in Table 1. Wells 7 and 8 are old water wells tapping the regional aquifer.

Figure 3: Sediment refractive spreads (left) and seismogram (right) for Well 1 cuttings.

Figure 4: Locations of Schlumberger soundings (dots, cross) and dipole-dipole profiles used to map variations in water wells under about 10 m of till. 

Figure 5: Resistivity models (Earthimaging Geosciences, inc.) of 4 dipole-dipole profiles shown in Figure 4. (a) shows the complete output of the resistivity-depth model. Space limits preclude showing the entire output for all profiles.

Figure 6: Resistivity models (Earthimaging Geosciences, inc.) of 4 dipole-dipole profiles shown in Figure 4. (a) shows the complete output of the resistivity-depth model. Space limits preclude showing the entire output for all profiles.

Figure 7: Seismic refraction profiles (seismic spreads and shots) with the core at the H.R. Collins Lab and 600 m of drift. Our working hypothesis is that we are studying an impact crater.