AN UPCOMING GEOPHYSICAL SURVEY OF THE KENTLAND CRATER FORMATION.

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Introduction: The Kentland Crater area in northern Indiana has not been the subject of a comprehensive geophysical study since the year 1971 [1]. During the summer of 2022, a team consisting of the authors of this abstract will be conducting a gravity survey of the Kentland area with more modern and more precise instruments to get improved constraints on the origin and spatial distribution of fracturing and structural deformation within the Kentland Crater structure.

The Kentland Crater structure is unique, as it provides a nearly flat, horizontal cross-section of a ~12-kilometer-wide crater. Most of the surface material was eroded off due to glaciation processes during the most recent ice age.

Therefore, this is an ideal location for gravity measurements, as topographic corrections will be minimal. Because of this advantage, we will be able to take measurements nearly anywhere within the crater.

Guidance on where specifically we will plan to acquire data will be provided by A structural study performed by Lany and Van Schmus [2] illuminates the major rock units surrounding the central uplift of the crater. We will use this study as guidance in planning where to acquire our data in order to compile a comprehensive dataset that accounts for the varying properties of the structural units within the formation.

Within the crater structure lies a quarried area, where we will acquire gravity gradient measurements that will help us constrain the density of the top ~100-meters of rock material. Along with gravity data, we will be incorporating updated seismic and radar data which will allow us to put more precise constraints on the extent of fracturing in the area compared to gravity data alone.

Methods and Instruments: In this study, we will create a series of gravity profiles of the region and incorporate seismic reflection profiles and ground-penetrating radar in our analysis.

Gravimetry. Our primary instrumentation will be a Scintrex CG-6 gravimeter in tandem with a Real-time kinematic GNSS system for quick cm-accuracy positioning. The CG-6 gravimeter uses a fused quartz spring which typically provides 1–3 microGal accuracy in gravimetry measurements, and will allow us to acquire the most accurate, updated gravity data for the area.

Active and passive seismic data. A unique passive/active seismic program was carried out in late 2021 over the site. This employed the Purdue 6000 lb-seismic vibrator providing energy into a 5 km high resolution 2D reflection profile following procedures from earlier studies on similar structures [3]. This was combined with an array of 102 continuously recording 3-C nodal seismometers covering > 30 km^2 along the SW portion of the inferred crater. This seismic reflection/refraction data will provide tomographic information on the seismic velocities and thicknesses of near-surface layers combined with the 2D seismic structural image from the central peak to the rim faults.

Ground-penetrating radar (GPR). This method will be used to elucidate properties of the subsurface structure such as porosity, contrasts in material properties, and possibly the extent of fracturing throughout the area. The seismic and ground penetrating radar data sets will allow us to correct for the gravitational contribution of low-density glacial till and will allow us to better isolate the gravity anomaly associated with fracturing.

Scientific Importance: Most broadly, any analysis we can do of crater structures on Earth will provide insight into crater formation processes throughout the Solar System. Kentland Crater is a significantly easier and less expensive location at which to perform fieldwork than any crater on another celestial body and will still provide essential insight into extraterrestrial crater-formation-related fracturing processes. For example, impact-induced fracturing is the primary cause of the high porosities observed in the crust of the Moon [4] and Mars [5]. Recent advances in iSALE modeling have yielded predictions of target fragmentation [6] that could be tested with field observations using density and seismic wavespeed deficits obtained from geophysical proxy measurements [7].

In an economic sense, Kentland Crater is an analog for the buried Red Wing Creek crater in the Williston basin, which is currently in use as an oil and gas reservoir. The reservoir exists uniquely because of the porosity of the crater formation itself [8]. Impact-induced fractures also facilitate the migration of hydrocarbons from their source rocks to the final reservoir, so studying craters like Kentland can elucidate how impact-related fracturing processes can provide ideal environments for oil reservoirs, ultimately streamlining oil exploration efforts. Similarly, pore fluid flow in fracture networks may have played a crucial role in supporting habitable hydrothermal environments on the Hadean Earth [9] and Noachian Mars [10].

Location: Figure 1 provides the location that we are interested in. The quarry is located within the central uplift of the crater. The town of Kentland, IN is located to the northwest of the indicated outer rim.

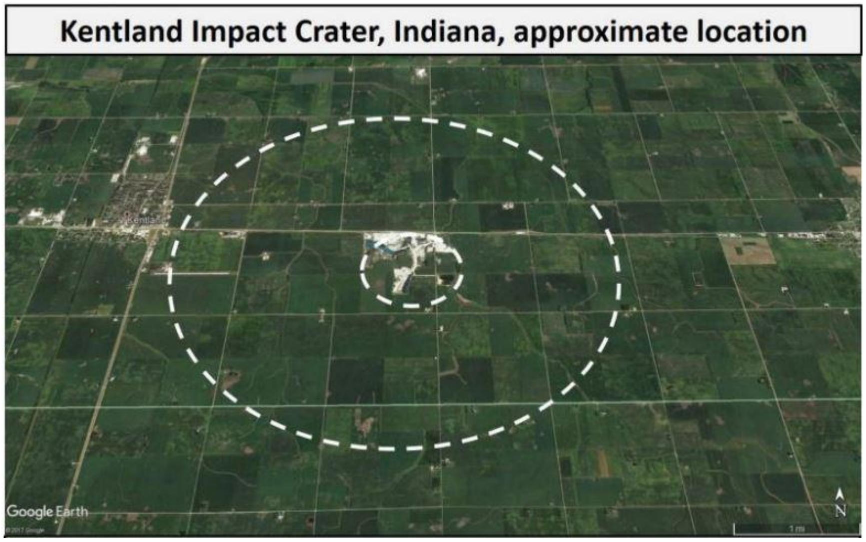

Figure 1. Kentland Crater location with the central uplift and outer rim denoted by a dashed white line [11].

Digitization Efforts: The most recent geophysical survey was performed by Daniel Tudor in 1971 [1]. This survey provided several gravity profiles, but the profiles have not been digitized. A portion of this project is to digitize those data and incorporate the 1971 survey results into our analysis.

Acknowledgments: This work is supported by the American Chemical Society and the Petroleum Research Fund (#61587-DNI8).

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