RESULTS OF A MAGNETOMETER SURVEY AT THE DECORAH IMPACT STRUCTURE.

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Introduction: The recently confirmed Decorah Impact Structure, located in Decorah, IA, is of Early to Middle Ordovician age (470 m.y.). Regional lithology of the area generally consists of sandstones, limestones, and dolomites. In addition, the Winneshiek Shale Formation is newly recognized and only found in the Decorah structure. Speculation of an unidentified impact structure began in the early 2000's with the discovery of an unidentified, local breccia from drill cores. During mineralogical examination of retrieved core, shocked quartz was identified. However, not until 2013 when the US Geological Survey (USGS) completed an aerial geophysical survey of the region, incidental to the impact structure, was the structure sufficiently confirmed to be of impact origin [1].

USGS collected gravity and resistivity data during their aerial survey and their results suggest an approximate 5.5 km diameter structure with the center beneath Decorah, Iowa (Figs. 1 and 2). In 2011, boring data were used by the Iowa Geological and Water Survey (IGWS) to construct a regional geological cross-section (Fig. 3) for water quality and resource usage. The IGWS cross-section suggests a smaller structure approximately 3 km in diameter. The IGWS cross-section illustrates a bowl type structure filled with the local, un-named breccia and overlying Winneshiek Shale. The St. Peter Formation overlies the Winneshiek Shale and resumes the regional stratigraphy [2].

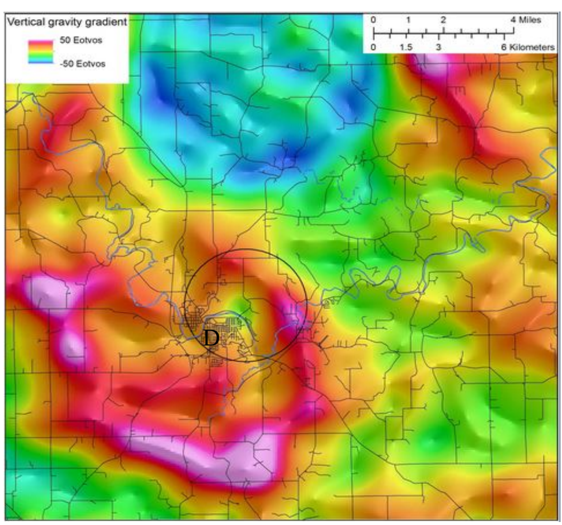

Fig. 1. Aerial gravity survey results with inferred structure boundary overlay. Image courtesy of USGS.

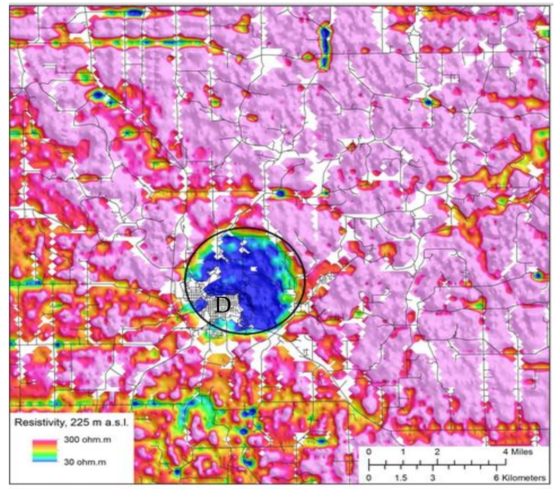

Fig. 2. Aerial resistivity survey results with inferred structure boundary overlay. Image courtesy of USGS.

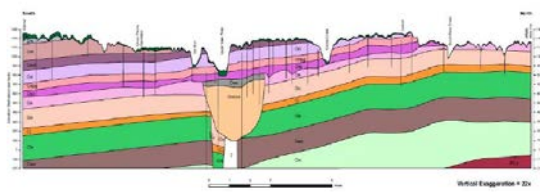

Fig. 3. Regional geologic cross-section including the Decorah Impact Structure. Image courtesy of IGWS.

Methods: Magnetometer Survey and Data Analysis: A Geometrics G856 Proton Precession Magnetometer survey was conducted of the structure in June 2015 to further evaluate the extent of the inferred structure boundary. During data collection, strict adherence to magnetic cleanliness for error attenuation was employed. The magnetic survey consisted of collecting 27 data points with 8 data points selected to construct a southwest to northeast magnetic anomaly profile. Golden Software Surfer 8 was used to contour magnetic anomaly data.

Results: Magnetic survey results support that the structure better aligns with the proposed 3 Km boundary limits indicated by boring data. Magnetometer values range from 52,056 nT to 58,931 nT. Values in the 52,000 nT to 55,000 nT correspond to the structure limits whereas higher values correspond to what is observed outside the structures limits.

Magnetic Anomaly. The magnetic anomaly map indicates that low values conform to a circular depression with the lowest value at the center of the structure

(Fig. 4). Regional magnetic values tend to be nearer 58,000 nT whereas the structure's center has a low of 52,000 nT.

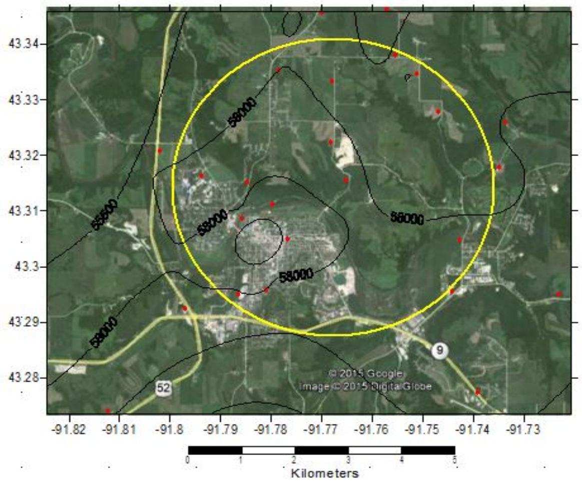

Fig. 4. Magnetic anomaly map of the structure with inferred boundary overlay.

Magnetic Anomaly Profile. A magnetic anomaly profile of the structure was constructed using 8 data points along a southwest-northeast trajectory (Fig. 5). The profile reveals a sloped depression, with the center of the structure near the center of Decorah (Fig. 6). Based on acquired data, it is difficult to determine if the structure is a complex or simple crater. Simple craters are small and bowl-shaped, while complex craters exhibit a central peak, annular trough, and terraces [2].

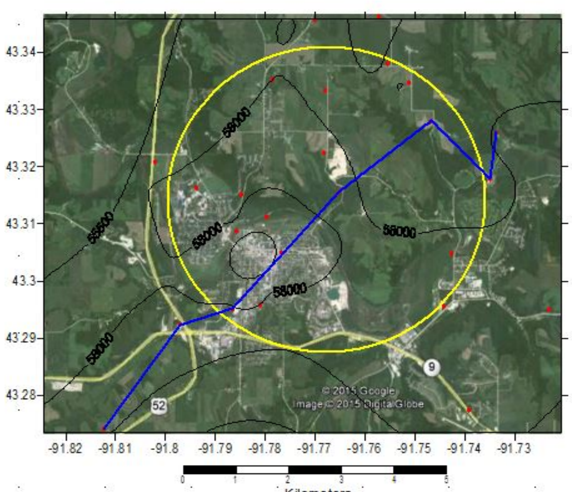

Fig. 5. Magnetic anomaly map with SW to NE profile line with inferred boundary overlay.

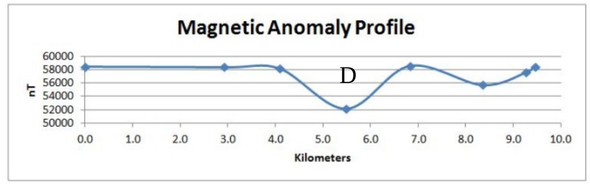

Fig. 6. SW-NE magnetic profile of the impact structure.

Based on the IGWS cross-section and acquired magnetic data we suggest that the structures is closer to 3 km in diameter (Fig. 7).

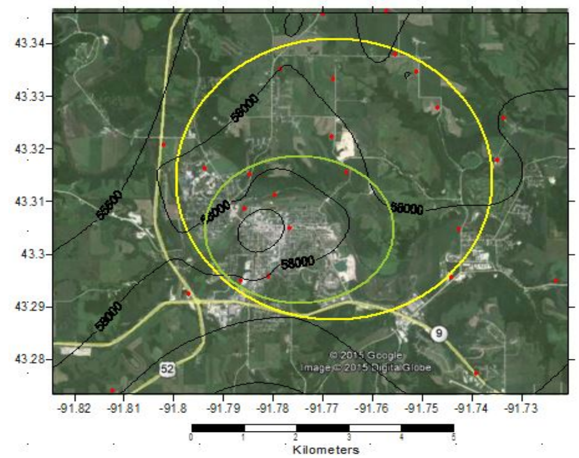

Fig. 7. Redefined Decorah Impact Structure boundary.

Discussion: Prior to confirmation in 2013 by the USGS, the Decorah structure was only suspected to be of impact origin. USGS Aerial resistivity and gravity results identify a 5.5-km circular feature centered beneath Decorah, IA. An IGWS cross-section of the area identifies an impact structure closer to 3 km in diameter, which is more closely supported by our data. Additionally, when our magnetic anomaly profile is compared to that of the Kardla structure, a similar-sized complex impact structure, the absence of a central peak is apparent. The lack of an exhibited central peak at Decorah may be a result of the small size of the structure and relative depth [3]. To determine if a central peak is present, a drill core would have to be retrieved and analized.

References: [1] Koontz, H. (2015 March 5) Iowa Meteorite Crater Confirmed. Retrieved from http://www.usgs.gov/newsroom/article.asp?ID=3521#.Vah-F_lVikp. [2] Wolter, C.F., McKay, R., et. al. (2007) Geologic Mapping for Water Quality Projects in the Upper Iowa River Watershed. Iowa Geological and Water Survey TIS 54. p 38. [3] Plado, J, et. al., (1996) Geophysical Research on the Kardla Impact Structure, Hiiumma Island, Estonia. Meteorics & Planetary Science, v. 31, p. 289-298