INVESTIGATING THE BRUSHY CREEK SUSPECTED IMPACT CRATER, ST. HELENA PARISH, LOUISIANA.

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Introduction: Located 54 km North East of Baton Rouge, in St. Helena Parish, Louisiana, the Brushy Creek Feature (BCF) is a semi-enclosed basin. This feature likely formed less than 30 ka ago [1]. , has a relief of 15 m, and is only ~2km in diameter (Fig 1). The basin is composed of unconsolidated alluvial sediments from the Pleistocene Citronelle formation [1]. If of impact origin, the small size is suggestive of a low energy impact into semi-lithified target rock, with the high erosion rates within the area suggesting extremely low preservation potential. Only ~13 confirmed impact craters with a diameter of <2km exist on earth, and in depth studies of terrestrial impact structures into unconsolidated targets are exceedingly rare [2][3]. The relative uncommonness of small impact craters in unconsolidated or semi-lithified substrates across solar system bodies (e.g., Mars, Moon) makes BCF a valuable resource not only for the future identification of comparable earthly craters, but as a useful terrestrial analogue for the study of extraterrestrial impacts on Mars and beyond.

Methods: Initial studies focused on identifying planar deformation features (PDFs) on quartz grains from core samples of the feature, as well as documentation of other possible impact related petrogenic structures (diaplectism, Lechelierite, mosaicism, recrystallized grain boundaries). Subsequent geophysical work includes ground penetrating radar (GPR), electrical resistivity, gravity, and geomorphological survey.

Petrographic Analysis: 17 samples from an 8m deep core drilled within the BCF and 10 surface samples were first sieved to (-1- 4 φ) sand size to ensure grains were large enough to preserve easily observable impact features and then treated with H_2O_2 to remove organic material [4]. Using the Leica DM-500 petrographic microscope, Cross polarized light (XPL) and plane polarized light (PPL) pictomicrographs of anomalous features within the thin sections were recorded. Cathodoluminescence (CL) images were taken by Connor Matherne to distinguish the suspected impact related PDFs which luminesce in the red-infrared wavelengths from tectonically originated lamellae which are generally nonlumescent [4].

Geomorphology: 3DEP elevation data from the Louisiana LIDAR project was used in conjunction with the USGS National Map Advanced Viewer (NMAV) software to produce a highly detailed (15-30 cm root mean square error: RMS) model of the BCF'S diameter, relief, and topographic expression. Additionally, four 2km long topographic transects of the LIDAR were taken perpendicularly from near the rim to the center point of the depression oriented in the cardinal directions E-W, NE-SW, N-S, and NW-SE. Ongoing work consists of employing ArcGIS and a specialized MATLAB program to extract equally radially oriented transects to attain a more robust set of topographic transects.

Electrical Resistivity: As described in their 49th LPSC abstract [5] a dipole-dipole array survey was completed along an E-W transect towards the center of the features topographic rim. Starting 500m outside the rim, the survey covered a total of nearly 1100m. Archie's law, a formula that calculates observed resistivity using experimentally determined variables such as groundwater resistivity, porosity, and saturation to determine an observed resistivity value was then used to model the resultant data.

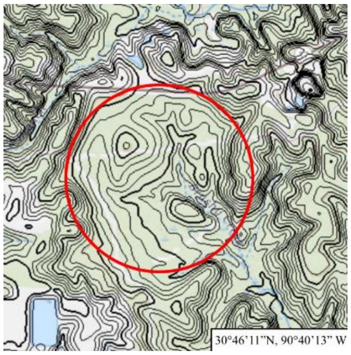

Fig 1*: 3DEP data topographic map of the BCF, red annotated circle is ~2km in diameter denotes the rim of the feature*

Ground Penetrating Radar: Five transects were collected using a 100 MHz antenna at 0.25m shot spacing [6]. Transect lines were located as follows: oriented E-W on the northern rim, North-South on the southern rim, and three continuous lines oriented E-W bisecting the crater near its center. The lines were processed to improve signal to noise ratio and resolution [6].

Gravity Anomaly: Peter B. James and Anton I. Ermakov of Baylor University collected relative gravity measurements with a relative gravimeter at 1 Hz reading frequency and 60 second testing time [7]. The First and last measurements were corrected at the point of origin to eliminate residual drift. Elevation data from Louisiana's statewide LIDAR project which is accurate to 15-30cm in RMS was used to reference the gravity measurements and remove interference from obstructions and vegetation [7].

Results: Thus far a total of 64 possible PDFs have been identified and documented. Four of the 10 thin sections prepared from the core drilling have undergone CL imagery and revealed extensive fracturing and apparent high-stress alteration events. At least one grain each displaying suspected but unconfirmed diaplectism (Fig 2), mosaicism, melt-flow structures (Fig 2), or recrystallized grain boundaries (Fig 2) have also been identified via petrographic observation. Electrical resistivity surveys showed a high-resistance anomaly at ~500m into the transect which bisects the center of the crater at 10-20m depth. This high resistance anomaly gives way to a striking low-resistivity anomaly 700-800m from the starting point of the transect at 10-20m depth [5]. Although the GPR data are relatively free of reflections or data-processing artifacts, the physical data collections integrity suffered due to a number of deep ditches, puddles, buried metal drainage culverts, and other unknown buried objects. However, the GPR lines unambiguously reveal 2-3m of layered, unconsolidated sediment which abruptly transitions to a layer with high signal loss [5]. After Bouguer correction using the LIDAR DTM and measured free-air anomaly values the range of gravity anomaly across the structure was found to be 0.8 mGal with a general trend of westward decrease, inconclusive of an impact structure [6].

Interpretations: The highly fractured, and possibly melted appearance of quartz grains from within the structure are not solely indicative of a meteorite impact, but are strongly suggestive of the occurrence of a high energy event. Additionally, these highly altered mineral phases are very rare or nonexistent in the strata surrounding the rim of the crater. The quartz rich sediment of the Citronelle formation extends from the surface to nearly 100m below the BCF, and is underlain by a layer of feldspar and mica rich strata [1]. Within thin sections taken from the deepest sections of the core (6-8m) and from the banks of the eponymous Brushy Creek whose headwaters originate within the BCF, there is a greatly increased number of mica and feldspar grains compared with the shallow surface strata. Mica grains with possible kink banding, and highly fractured feldspar grains are also present. The intermixing of these typically discrete layers is highly unusual, but consistent with the exhumation and uplift of at least 100m of sediment. Utilizing the relationship for simple craters, depth = 0.13(Diameter) ^1.06 [9], the estimated depth of the crater is 0.27km, well within the range of possibility for the scale of excavation needed to uplift mica-feldspar enriched sediments from below the Citronelle formation. The topographic transects and aspect map show the feature having a circular semi-polygonal, partially enclosed morphology, consistent with an impact hypothesis. High and low electrical resistivity anomalies present at the BCF approximately coincide with the rim, and center of the feature which is indicative of a change of strata density at these locations. GPR results show a slight downwards dip in the same location as the increased gravity anomaly, at roughly 550m along the center transect. Although a total anomaly range of 0.8 mGal is lower than expected of a typical impact crater, this could be related to the semi-lithified nature of the target sediments, and analysis of similar environments to calibrate and further refine these measurements is needed [6]. The 2-3m of unconsolidated sediment atop a thick layer which produces rapid GPR signal loss is consistent with observations made by the Kentwood Brick and tile company which noted the presence of an undifferentiated clay layer below 10m depth [1]. Seismic surveys did not reveal any significant variations, which may be due to the relatively shallow depth and ground level inconsistencies reducing the effective sensitivity of measurements

Conclusions: Despite the inconclusiveness of the individual data types, they are collectively consistent with a relatively recent excavating event. PDFs and other high energy mineral alterations have been observed due to lightning strikes, but the widespread distribution of PDFs and other phases makes such an explanation extremely unlikely as lightning induced phases are generally localized to the actual strike location[4]. Combined with the symmetrical bowl-shaped morphology, electrical resistivity and gravity anomaly data, the heavily modified mineral grains can reasonably be explained by few other processes than a meteor impact. Confirmation of the BCF as an impact crater would enable future researchers to reference their observations of other small scale, unconsolidated sediment impact sites for which little data exists, to the BCF and achieve greater certainty in their experiments. The BCFs analogous qualities with Martian and Lunar impact craters provide a critical resource in the study of planetary impact processes. Future work may include: the use of Electron Microprobe (EMP) analysis to map geochemical zonation of sediment grains, Universal-stage analysis of PDFs determine the approximate pressure-temperature regime of impact, aerial drone survey to produce high-resolution 3D Digital Terrain Models, radio-isotope dating of Zircon polymorphs to differentiate them from Chicxulub Impact fallout, radial topographic transects via ArcGIS and MATLAB, and the drilling of cores at least 100-200m in depth at various locations both inside and outside the potential rim crest to better understand the stratigraphy and any disturbances thereof the region.

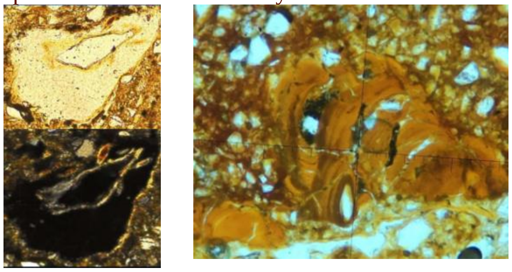

Fig 2: *(Left) Pictomicrograph of diaplectic quartz grain the smaller superimposed grain in the center also features a recrystallized grain boundary. (Right) PPL image of suspected lechatelierite.*

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