POSSIBLE PLEISTOCENE IMPACT IN LOUISIANA AS AN ANALOG FOR CRATERS IN MARTIAN DUSTSTONE SETTINGS. Marty Horn,[1] Paul Heinrich,[1] Don Hood,[2] Andrew Herr,[3] Andrew Webb,[3] Peter James,[2] Suniti Karunatillake,[3] Anton Ermakov,[4] Juan Lorenzo[3] [1]Louisiana Geological Survey, Louisiana State University, Baton Rouge, mhorn@lsu.edu, [2]Baylor University, [3]Louisiana State University, [4]UC Berkeley

Introduction: Martian landscapes bear semi-lithified, fine-grained "duststone" of poorly known provenance[1]. Duststone is sufficiently rigid to preserve impact craters[2] that are useful for gaining genetic insights from exposed stratigraphy and impact response of the substrate. However, modeling such processes has been thwarted by a dearth of preserved analog impact craters on Earth[3]. A proposed impact crater in the semi-lithified Plio-Pleistocene Citronelle Formation in southeast Louisiana may serve as a suitable analog.

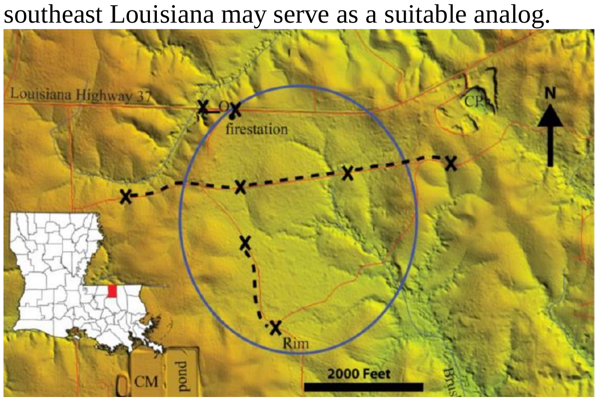

Fig 1. LiDAR-DEM image of approximate BCF ('rim' shown in blue) in southeast Louisiana (inset). Dashed curves map transects of five geophysical surveys to date.

The Brushy Creek Feature (BCF) was first recognized as a landform anomaly in the Gulf Coastal Plain geologic province of southeast Louisiana (Fig 1). LiDAR imagery reveals this as a ~ 2 km diameter circular topographic basin set in a regional fluvial system of North-South bearing drainages and interfluves[4]. Possibilities of volcanic, karst, or salt diapir origin have been dismissed based upon lithologic criteria[4]. However, a late Pleistocene impact origin is consistent with the topographic expression and is implied by the discovery of deformed quartz grains from interior sediment in an initial study[4].

Methods: We examine the BCF with petrography of additional specimens[5] and geophysical surveys[6]. The initial surveys in gravity, ground penetrating radar (GPR), and electrical resistivity (ER) mostly follow a hunter's road that traverses a chord of the feature from the western flank, across the interior floor, and out onto the eastern flank with two additional GPR transects confined to exterior and interior areas (Fig 1).

Petrography: Seventeen samples from 10 surface sites and one ~8 m deep core drilled within the BCF were sieved to -1 to 4 φ range in order to capture grains sufficiently large to preserve observable impact effects. As in Fig 2, pictomicrographs of anomalous features were produced using a Leica DM-500 petrographic microscope in cross polarized (XPL) and plane polarized light (PPL).

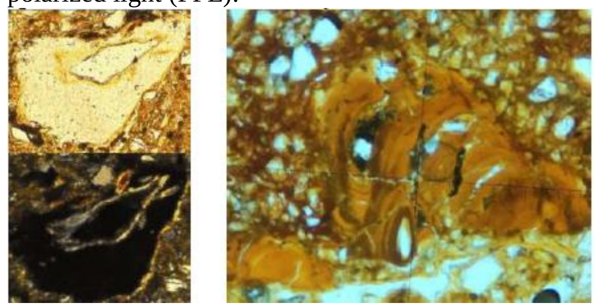
Fig 2: (Left) Pictomicrograph of diaplectic quartz grains in PPL (upper) and XPL (lower) with the central superimposed grain suggestive of recrystallization. (Right) PPL image of suspected lechatelierite.

Geophysical surveys: GPR data were collected on 0.25 m spacing using a 100 MHz antenna and common offset reflection with Pulse Ekko 1000 and SmartCart. The field data were processed using Ekko software.

An ER profile was performed over the western rim using a dipole-dipole array with eight potential electrode pairs spaced 10.0 m apart to yield about 25.0 m of tomography depth and roughly five m of spatial resolution. One gravimetric survey over the entire hunter's road chord was performed to produce a Bouger anomaly profile[8].

Results and Discussion: *Geophysics:* GPR results indicate layered, unconsolidated sediment with rapid depth attenuation consistent with clay enrichment in the upper 2 – 3 m. That contrasts stratigraphically with a nearby quarry outside the BCF exposing clay-depleted sand and silt through 9 – 12 m depths[4,6]. Corrected gravity measurements along the entire West-East transect (Fig 1) yielded a maximum relative Bouger anomaly of 0.5 mGal[8].

The resistivity inversion model profile (Fig 3) shows a distinctly conductive (cool colors), ambiguously structured substrate in the BCF interior distinctly bounded near the topographic rim from a layered suite of resistive intervals in the exterior substrate (warm colors). The exterior model substrate is interpreted as resistivity facies of the Citronelle formation consisting of a discontinuous or fragmentary resistive interval about 10 m thick (red shading) superjacent to a conductive interval, possibly marking the water table, and subjacent to a ~ 5 – 7 m thick cap of slightly lower resistivity (yellow shading). The disjointed structure of the resistive interval can be interpreted in terms of discontinuous clay-depleted lenses of the Citronelle or in terms of numerous small displacement dip-slip faults (Fig 3) that, being inconsistent with regional tectonism, can be viewed as genetically related to the BCF.

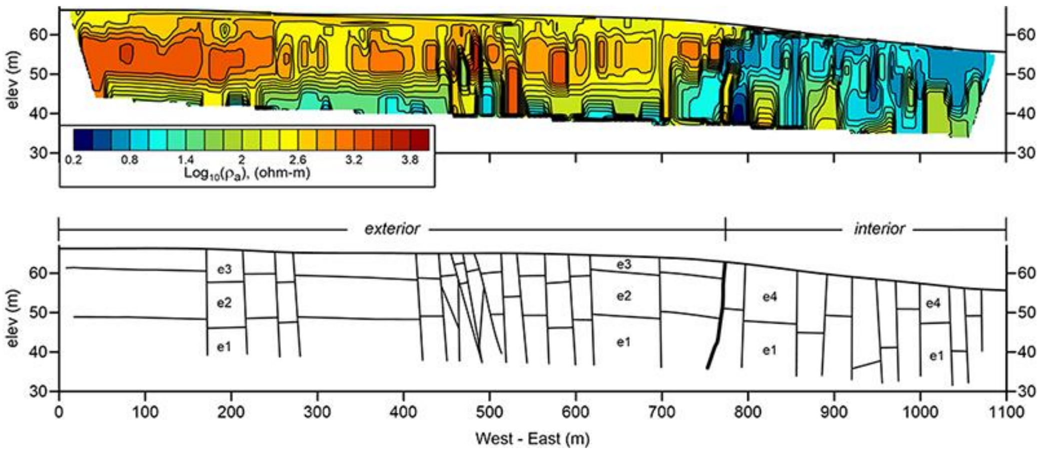

Fig 3. Upper diagram is a color contoured inversion model of electrical resistivity profile across the western rim of BCF. The topographic rim is located at X = 650.0 m. The lower schematic interprets model resistivity facies as 'e' intervals in context of layered Citronelle lithofacies segmented by small offset dip-slip faults.

Petrography: Four of the 10 thin sections from core samples examined under cathodoluminescence reveal a minimum total of 64 Planar Deformation Features (PDFs) in the form of fractures and alteration consistent with a high-stress impulse event. Sparse amounts of diaplectism, mosaicism, melt-flow structures, and grain surface re-crystallization are also evident (Fig 2). These alteration and deformation features in quartz grains are potentially diagnostic of impactite and have not been found in undisturbed Citronelle sediment surrounding BCF. An impact origin is also supported by lithology and geophysical data. The mineralogically mature Citronelle strata extend to a depth of about 100 m at the study locality, overlying Miocene strata with submature signatures of feldspar and mica[4]. Thin sections from core depth and surface exposures of Brushy Creek, whose drainage basin is confined to the BCF interior (Fig 1), reveal an increase with depth of feldspar and mica point count densities and possible PDFs. This contrast in mineralogy between the interior vs. exterior of BCF suggests mixing of Citronelle with components of underlying submature units.

For a simple impact crater in a sedimentary target, the excavation depth approximates[9] 0.13*(post impact diameter)$^{1.06}$. For a BCF diameter of 2 km, this yields a disturbance depth of ~270 m, sufficient to incorporate immature components of the Citronelle sub-strata while producing the observed point count density variation.

Geophysical modeling also suggests an excavation-backfill origin of BCF's interior. A recent ER study of cemetery graves produced electrically conductive anomalies that likely reflect an increase in moisture porosity imparted by the excavation and backfill process[10,11]. Moreover, a Bouger anomaly up to 0.5 mGal produced by our gravity survey corresponds to a density contrast of up to –45 kg/m^3 for 270 m of interior backfill compared to the undisturbed exterior, yielding a porosity increase of about 0.022 for the backfill[8].

Conclusions: While the disparate geomorphic, petrographic, and geophysical observations may not individually prove an impact feature, their combination presents a compelling case for BCF's impact origin. The geophysical evidence suggests "fluffing" of Citronelle texture in the interior while petrographic evidence from mineral components points to a high stress impulse event.

Testing and modeling of the impact origin hypothesis for the BCF, as a promising analog to duststone impact sites on Mars, requires additional field and laboratory work. Along with continued examination of thin sections and whole-rock specimens from both within and outside BCF, geophysical surveys stand to reap significant gains from multiple additional transects in the BCF as well as baseline data from distal sites within the Citronelle formation.

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References: [1]Bridges & Muhs *Sediment. Geol. Mars* 169–182 (2012) [2] Karunatillake *et al. J. Geophys. Res.* **114**, E12001 (2009) [3] Ormo et al. *Meteorit. Planet. Sci.* **37**, 1507–1521 (2002) [4] Heinrich *Gulf Coast Assn. Geol. Soc. Trans.* **53**, 313–322 (2003) [5] Herr *et al.* in *52nd LPSC* Abstract 2548 (2021) [6] Webb, A. *et al.* in 49th *LPSC* Abstract 1619 (2018) [8] James & Ermakov in *49th LPSC* Abstract 1512 (2018) [9] Robbins *et al. Meteorit. Planet. Sci.* **44**, (2017) [10] Horn, *Geoarchaeology* submitted (2021) [11] Friedman, *Comput. Electron. Agric.* **46**, 45–70 (2005).