Electrical Resistivity Survey of a Possible Impact Structure, Brushy Creek Feature, St. Helena Parish, LA

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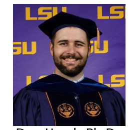
Abstract #2215

Currents in the ground, Showing us buried secrets, Is this a crater?



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Poster #139

Introduction

The Brushy Creek Feature (BCF, Fig. 1) is a 2-km wide depression in eastern Louisiana first suggested in 2003 [1] to be a Pleistocene-age impact structure. This was originally evidenced by an abundance of fractured grains in the vicinity of the structure as well as planar deformation features, all of which were lacking in the surrounding Citronelle sediments. Since 2017, several geophysical surveys have been conducted at the BCF to search for evidence of the feature's impact origin. Previous surveys included Ground Penetrating Radar (GPR) [2] across the feature and gravity surveys [3]. In September 2019, we performed a new survey of subsurface resistivity along the same transect examined by GPR (Fig. 1) to probe the BCF structure more deeply, and simultaneously collected new samples for further grain analysis (Abstract #2361, Poster 517). Here, we present the model of subsurface resistivity from the inversion of that survey and our interpretation of the subsurface structure.

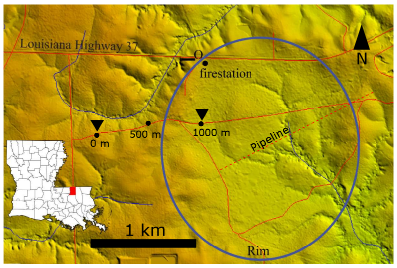

Figure 1. Lidar DEM of the BCF with annotations and a context map of Louisiana. Reference locations, such as the intersecting highway, are marked. The blue ellipse marks the "rim" of the feature, a topographical high, and the dashed red line marks a buried pipeline. The traverse examined in the resistivity survey is marked with black triangles.

Field Methods

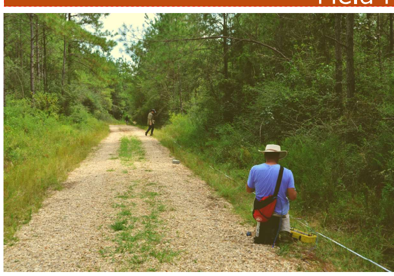

Figure 2. An east facing view of the survey line during the 9/2019 survey. M. Horn sits running the survey while A. Webb and S. Karunatillake check the survey electrodes. This image typifies both the road condition and terrain near the BCF. Image Credit: Anna Sivils

- L&R Instruments, 4-terminal resistivity meter used in survey (Fig. 2)
- Survey was carried out in an advancing dipole-dipole array, array spacing 10m (Fig. 3)
- Total length of 1100 meters surveyed from the BCF exterior and 400m past the "rim"
- Field data inverted with GEOTOMO RES2DINV

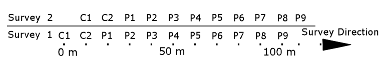

Figure 3. A schematic of the resistivity array setup. C1 and C2 mark the current electrodes and P1-9 mark the probe electrodes. For each survey, pairs of electrodes (P1-P2,P2-P3, etc.) are used with the same C1 and C2. After all sets are measured, the array is shifted 10m along the survey line and the measurements are repeated.

Results

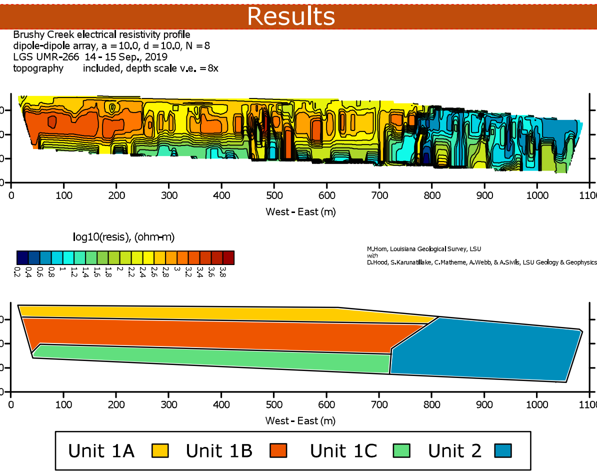

Figure 4. The results of the 2-D inversion (A) and the interpretation of units within the profile (B). Horizontal resolution is 5m, vertical resolution ranges from 2.5m near the surface and 4m at the base of the survey. As shown in the interpretation, laterally continuous and horizontal layering is apparent in the BCF exterior and clearly interrupted in the interior. The high-resistance anomaly at ~500m is of unknown origin and may not be geologically significant.

Modeling Approach

Archie's Law

$$\rho = a\rho_w \varphi^{-m} S^{-n}$$

Formation Factor (a); Porosity and Saturation Exponents (m, n); Observed Resistivity (ρ); Groundwater Resitivity (ρ_w); Porosity (φ); Saturation (S)

$$\varphi = \left(\frac{a\rho_w}{\rho S^n}\right)^{1/m}$$

- Archie's Law is empirical formula to connect observed ρ with geological properties
  - Relies on several parameters typically defined experimentally [4]
    - No deep cores taken within BCF, hard to constrain parameters
  - We calculate φ for each point by assuming parameters for each unit
    - Assumed parameters: ρw=10, m,n = 2, tunable parameters: a, S

Constraining Processes

Question 1. Is unit 2 an uplifted low-resistivity unit contiguous with 1c?
- **Probably not.** Cases 2 and 3 (Fig. 5) show distinct porosities in 1C and 2
- These are not the same unit or substantial modification has occured
- The elevation of 1C is consistent with the water table.
- 1C could be geophysically distinct from 1A and 1B

Question 2. Can a difference in saturation, via a locally uplifted or perched water table solely explain the difference?
- **No.** Case 2 (Fig 5.) shows notably higher porosities within unit 2 compared to 1A and B.
- Unit 1C also appears more porous than 1A and B.
- Nearby creeks outside the BCF are at similar elevation to Brushy Creek.

Question 3. What parameters are required to achieve broadly similar porosities?
- Units 1A and B are reasonably described with similar parameters (Case 2,3)
- In unit 2, a much smaller formation factor (a) is required.
- This formation factor is unusually low, changes in n or m may be more reasonable

Case 1

	a	S
1A	0.5	0.3
1B	1	0.3
1C	0.7	1
2	0.05	0.6

Case 2

	a	S
1A	0.1	0.5
1B	0.1	0.5
1C	0.1	1
2	0.1	1

Case 3

	a	S
1A	0.5	0.5
1B	0.5	0.5
1C	0.5	1
2	0.1	0.5

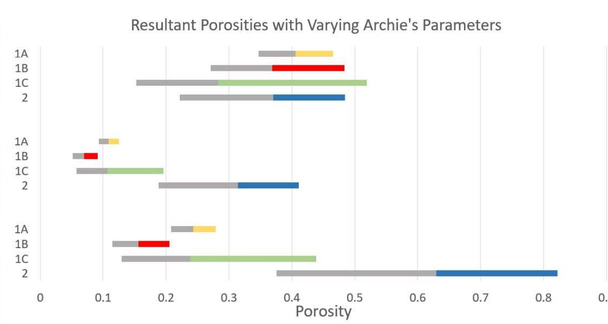

Figure 5. Exploration of potential geophysical parameters to describe the observed units with input parameters (A) and resultant porosities (B) for each case. Each case explores a different scenario that may cause the observed changes in resistivity. Case 1 is one way to achieve similar porosities for all units, demonstrating the substantial changes needed in a and S to achieve this. Cases 2 and 3 assume that the saturation of Unit 2 is either the same as Unit 1C, or Units 1A and B. All cases were constrained such that the resultant porosities fell between 0 and 1 to avoid non-physical solutions.

Conclusions

- Units 1 and 2 are geophysically distinct (Fig. 5)
- Unit 2 is consistent with more porous or less cemented material
- Variation within Unit 1 is broadly captured by changes in porosity and saturation
- Unit 2 could represent a breccia lens or post-impact infill of the impact basin
- Cores could confirm these geophysical findings and provide stronger evidence for an impact origin of the BCF
- Combined with evidence for planar deformation features in quartz grains within the BCF (Abstract #2361 Poster 517, [1]) case is mounting for BCF being an impact structure.

Acknowledgements & References

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[1] P. V. Heinrich, GCAGS/GCSSEPM Transactions, 2003. [2] A. Webb, et. al. in 49th LPSC, 2018, Abs #1619. [3] P. B. James and A. I. Ermakov, in 49th LPSC, 2018, Abs #1512. [4] R. J. Knight and A. L. Endres, in Near-Surface Geophysics, 2005.