Possible Meteorite Impact Crater in St. Helena Parish, Louisiana*

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Introduction

Between 1996 and 1997, Richard P. McCulloh, the author, and John Snead of the Louisiana Geological Survey compiled McCulloh et al. (1997). This research revealed an anomalous circular feature, which McCulloh et al. (1997) mapped as "Quaternary undifferentiated," southwest of Greensburg, Louisiana (Figure 1), in the southwest corner of St. Helena Parish. This feature is named the "Brushy Creek feature" for the headwaters of Brushy Creek, which lie within this feature.

The regional landscape consists of narrow, closely spaced ridges and deeply cut valleys. The regional relief is about 90 to 110 ft (27 to 34 m). Drainages exhibit rectilinear patterns that often form well defined lineaments. Within this area, erosion has destroyed all construction topography except possibly for concordant summits along the major drainage divides.

Brushy Creek Feature

Physiography, Stratigraphy, and Petrography

Within this region of narrow, closely spaced ridges and stream valleys, the Brushy Creek feature occurs as a noticeable circular "hole" about 1.2 mi (2 km) in diameter. Its rim has a relief of about 50 ft (15 m) and exhibits a slightly polygonal shape (Figure 2). The main channel of Brushy Creek has breached the feature's southeast rim and drains its interior.

The Brushy Creek feature lies in the region which Snead and McCulloh (1984) and Mossa and Autin (1989) mapped as the "high terraces." Pliocene fluvial sediments of the Citronelle Formation underlie the high terraces. Regionally, they consist largely of variegated and mottled, poorly sorted, fine- to very coarse-grained, sandy gravel, gravelly sand, sand, and minor beds of silt, clay, and mud. Typically, individual beds are have limited vertical and lateral extent. As classified by Folk (1980), the sand within the Citronelle Formation consists of quartzarenites to sublitharenites that completely lack feldspar. Within the area of this feature, the Citronelle Formation is about 300 to 350 ft (91 to 107 m) thick (Campbell, 1971; Mossa and Autin, 1989).

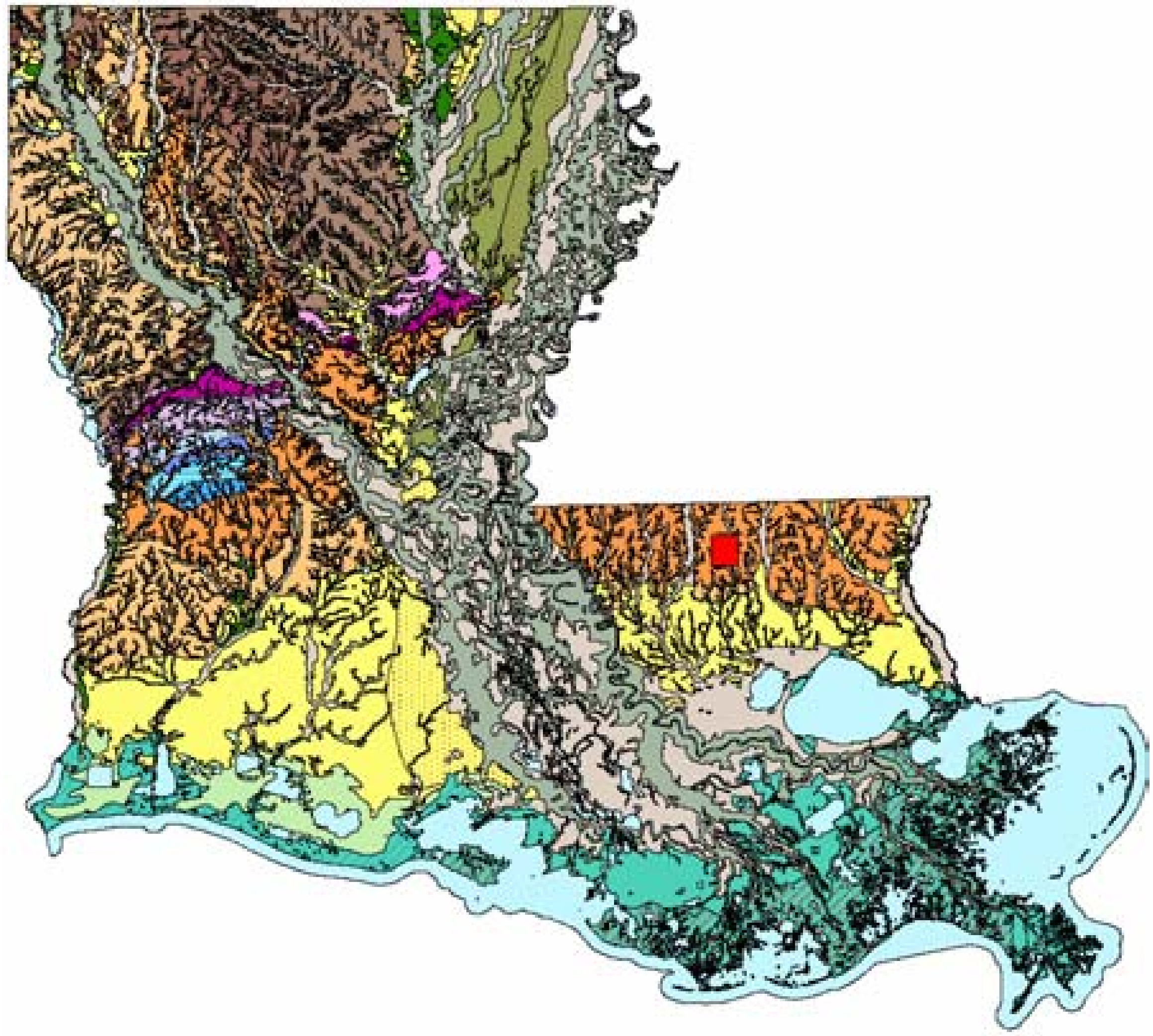

Figure 1. Geologic map of Louisiana, as location map for Greensburg quadrangle (red) (from Louisiana Geological Survey, 1999).

According to Mossa and Autin (1989), over 6 ft (2 m) of loess blankets the Citronelle Formation within the region of the Brushy Creek feature. This loess consists of both Late Wisconsinan Peoria Loess and underlying older Sicily Island Loess. However, soil descriptions in McDaniel (1996) and examination of local soil profiles indicated that the actual loess thickness within the area of the Brushy Creek feature is about 3 ft (1 m).

Field investigations found that the Citronelle Formation within the area of the Brushy Creek feature consists of poorly sorted, fine- to coarse-grained sand overlying laminated clays and silts. The sand is 30 to 40 ft (9 to 12 m) thick and consists of deeply weathered, reddish brown, fine- to very coarse-grained, moderately well sorted sand. In outcrops, the sand can be both massive and cross-bedded. At least 20 ft (6 m) of laminated silts and clays that underlie these sands were found in the Kentwood Brick and Tile Company brick pit lying just east of this feature. They consist of meter-thick, fining-upward, cyclic beds of laminated silt and clay. Discussions with the staff at the Kentwood Brick and Tile

Company revealed that drilling indicated that these sediments occur on either side of this feature, but are absent within it. Very little is known about the sediments of the Citronelle Formation underlying the silts and clays.

Within the area of the Brushy Creek feature, about 6 to 7 mi (10 to 11 km) of older Cenozoic to Mesozoic sediments underlie the Citronelle Formation. The uppermost 11,000 to 12,000 ft (3,350 to 3,660 m) of these sediments consists of Cenozoic sediments of the Midway, Wilcox, Claiborne, Jackson, and Vicksburg groups and undifferentiated Neogene strata. The undifferentiated Neogene sediments consist of siliciclastic sediments lacking any significant carbonates. These strata dip homoclinally to the southwest and lack any indication of major faulting or salt structures (Howe, 1962; Bebout and Gutiérrez, 1983).

Field studies indicated that the rim of the Brushy Creek feature consists of massive silty sand and sandy silt, in which a mature soil profile with well developed A and B horizons has developed. The only complete exposure occurs on the feature's northwest distal edge. It consists of 7 to 10 ft (2 to 3 m) of massive silty sand and sandy silt overlying 5- to 12-in. (13- to 30-cm) thick bed of gravelly mud. The gravelly mud contains abundant rounded clasts of mud, clay, and frequently magnetic ironstone nodules. It lies directly on the truncated surface of deeply weathered, cross-bedded, and highly fractured Citronelle Formation. Within the silty sand and sandy silt, an 8-in. (20-cm) thick zone contains numerous rounded, dime-size, and matrix-supported clasts of purple silty clay derived from the underlying Citronelle Formation.

Numerous sediment samples were collected for study from the rim and interior of the Brushy Creek feature. Additional sediments were collected from a bar in Brushy Creek downstream from where it cuts deeply into the rim of this feature. Within a radius of 1.5 to 4.5 miles (2.4 to 7.2 km) of the Brushy Creek feature and at two localities at greater distances, sediment samples were collected from outcrops of the Citronelle Formation. Finally, dozen of ironstone nodules from exposures and streambeds draining this feature were collected.

All samples were processed to separate the sand fraction. Then, the sand from each sample was separated into 18 to 60 mesh (0.0 to 2.0 phi), and 60 to 200 mesh (2.0 to 3.75 phi), fractions by dry sieving. Petrographic thin-sections were made from these fractions for each sample and from, for selected samples, intact clods.

Both outside and inside the Brushy Creek feature, the sand consists of subangular to well rounded, quartzarenite to sublitharenite sand containing about 90 to 95 percent quartz. Except for two samples from the rim of this feature, neither feldspar nor mica was noted in these samples. Some of the sand associated with the Brushy Creek feature exhibited ragged edges resulting from disintegration of sand grains during processing.

Figure 2. A digital elevation model of LIDAR (Light Detection and Ranging) data from the southwest quarter of the Greensburg 7.5-minute quadrangle; downloaded from the Atlas: The Louisiana Statewide GIS website (http://atlas.lsu.edu) and viewed with MacDEM Viewer.

Miscroscopic Features of Quartz Grains

Within samples from the Brushy Creek feature and Brushy Creek, intensely fractured quartz occurs in variable proportions. Both rectilinear fractures and interlocking, irregular network of fractures were found (Figures 3 and 4). Kieffer (1971) and Shoemaker and Kieffer (1979) illustrated similar, intensely fractured sand from shocked Coconino Sandstone from Barringer (Meteor) Crater in Arizona. Also, Dr. W. Feathergale Wilson, (2002, personal communication) has observed similarly fractured quartz from the Bee Bluff Impact Structure in Texas. The presence of iron oxides coating fractures in deeply weathered grains shows that they are not artifacts of thin-section preparation. In contrast, none of the control samples showed the intensity of fracturing observed in samples associated with the Brushy Creek feature.

Shocked quartz occurs in samples from sand collected from the alluvium of Brushy Creek. It consists of several quartz grains with single and two sets of planar features (Figure 5). The average orientation of quartz grains with two sets of planes is 45 degrees and 33 degrees, which, respectively, are the {1012} and {1122} crystalligraphic orientations (Stephen Benoist, 2003, personal communication). As discussed by Koerbel (1997) and Stoffler and Langenhorst (1994), both orientations are characteristic of planar deformation features (PDF) created by shock metamorphism. The multiple grains found with PDFs and planar features argues against them having been reworked from distant sources; e.g., a Cretaceous - Tertiary boundary layer. Instead, it indicates that they came from a nearby primary source; i.e., the upstream Brushy Creek feature. Sand from the gravelly mud within the feature's rim contains numerous quartz grains with planar fractures that are currently under study.

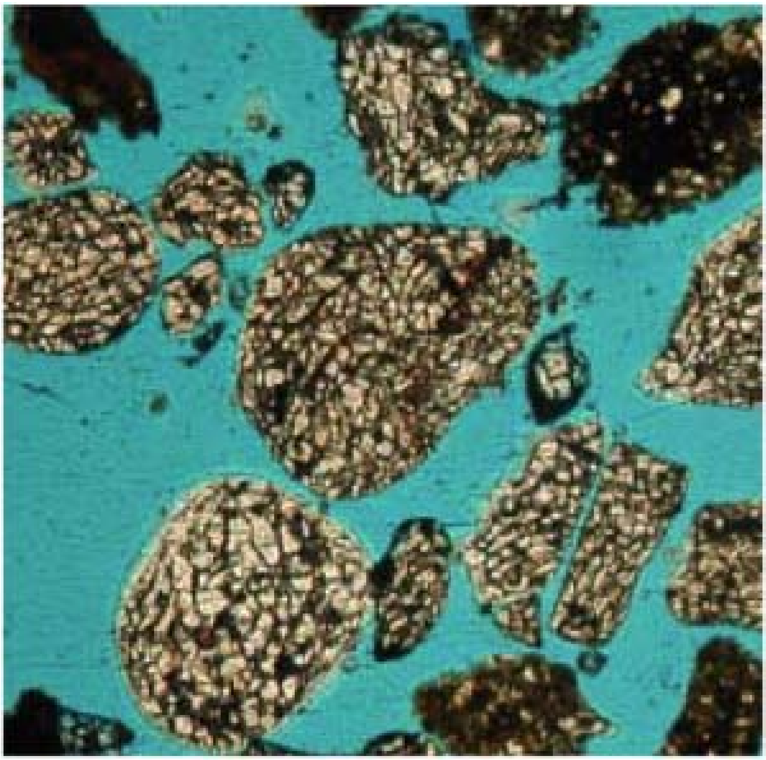

Figure 3. Intensely fractured coarse-grained sand from within the Brushy Creek feature, locality 16SHPQ. Opaque material filling fractures consists of iron-oxides that accumulated along them as the result of later weathering.

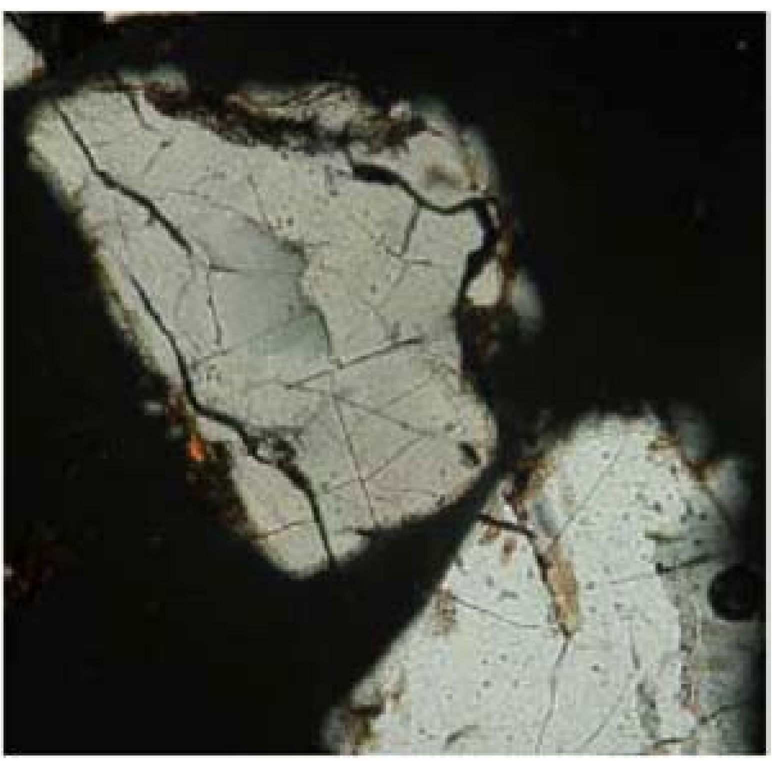

Figure 4. Intensely fractured, coarse-grained quartz exhibiting rectilinear fractures from location 16SAPD. Viewed in polarized light.

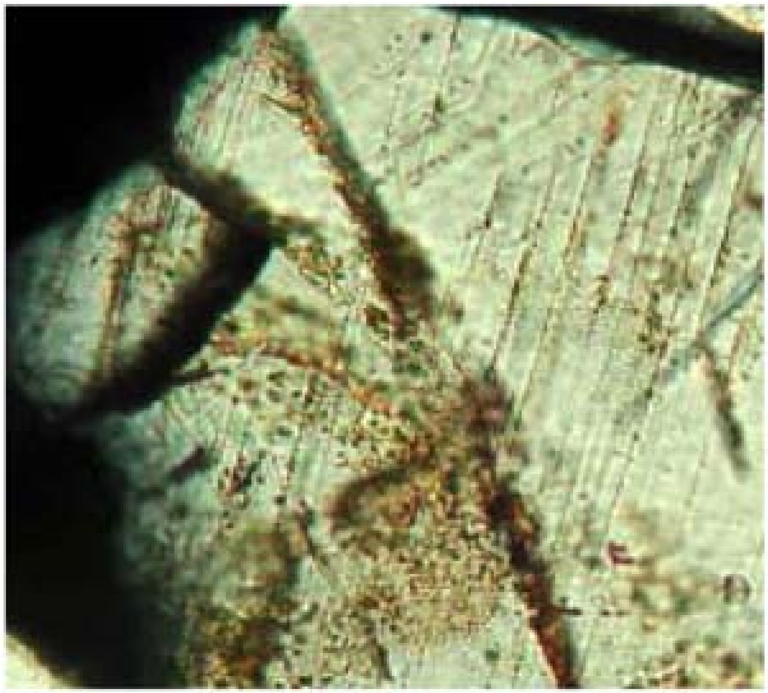

Figure 5. Coarse grain of shocked quartz exhibiting two sets of PDFs from location 16SAPA. Note dissolution of quartz grain and accumulation of iron oxides along PDFs. Viewed in polarized light.

Pedogenic Ironstone

Numerous ironstone nodules were cut and examined and, sometimes either thin-sectioned or tested for high concentrations of nickel using dimethylglyoxime. Highly weathered meteorites, called “iron shale” or “shale balls,” were not found. Instead, the ironstone nodules examined were all pedogenic in origin. as the nodules typically found in local soils.

Conclusion

A number of processes, including salt diapirism, solution karst, and volcanism, can produce circular landforms, similar to the Brushy Creek feature. Because this feature lies in a portion of the Louisiana Gulf Coastal Plain devoid of salt diapirs and major salt structures, salt diapirism cannot be invoked to explain this feature. Similarly, the complete absence of volcanic sediments from this feature and the complete absence of Pleistocene and Holocene volcanism within Louisiana Gulf Coastal Plain also preclude this feature from being a volcanic maar. Similarly, the lack of significant carbonates within the upper 11,000 to 12,000 ft (3,350 to 3,660 m) precludes carbonate karst processes as an explanation.

Siliciclastic karst can create landforms similar to the Brushy Creek feature, as discussed by (May and Warne, 1999) for the origin of the Carolina Bays within the Atlantic Coastal Plain and circular depressions found within the Mississippi and Alabama coastal plains. However, siliciclastic karst develops on flat, poorly drained, and undissected geomorphic surfaces lacking well defined drainage systems. In contrast, the Brushy Creek feature occurs within an area that is deeply dissected and drains well. Such relief and well developed drainage systems would cause lateral flow of surface and near-surface water and erosion and greatly inhibit the vertical-drainage weathering needed to create siliciclastic karst (May and Warne, 1999). The Brushy Creek feature also is an isolated circular landform unlike siliciclastic karst; e.g., the Carolina Bays, which occur typically as clusters of multiple depressions. Lastly, the siliciclastic karst hypothesis fails to explain the direct association of shocked and intensively fractured quartz with the Brushy Creek feature.

The hypothesis that the Brushy Creek feature was created by either a meteorite or comet impact, and, in fact, is the Brushy Creek Impact Crater, is the most promising hypothesis. The Brushy Creek feature constitutes a well defined unique "hole" in the regional topography, which appears to be associated with a "hole" in the local stratigraphy. The presence of feldspars and mica in two samples from the rim of this feature indicates that less-weathered sediments from strata underlying the Citronelle Formation have been brought to the surface from hundreds of feet below the surface. All of these observations are consistent with the formation of the Brushy Creek feature by impact processes. The intensively fractured nature of the quartz sand from the rim of this feature and the presence of shocked quartz provide direct evidence of impact processes.

If it is an impact crater, the age of the Brushy Creek feature remains unresolved. The age of the Citronelle Formation provides a maximum age of about 1.9 million years for it. Judging from the degree of preservation of constructional landforms on terraces forming the surfaces of the Avoyelles and Deweyville Allogroups, the presence of a recognizable rim on the Brushy Creek feature indicates that it is likely less than 20,000 to 30,000 years old. An apparent absence of loess covering its rim would argue for it being less than 13,000 to 11,000 years old. However, loess might only appear to be absent because it has been either mixed by pedogenic processes into the underlying rim deposits; eroded by surface processes; difficult to distinguish from the silty rim sediments, or some combination of these.

References

Bebout, D.G., and Gutiérrez, D.R., 1983, Regional cross sections Louisiana Gulf Coast {eastern part}: Louisiana Geological Survey Folio series, no. 6., 11 p.

Campbell, C.L., 1971, The gravel deposits of St. Helena and Tangipahoa parishes: Ph.D. dissertation, Department of Geology, Tulane University, New Orleans, LA, 295 p.

Folk, R.L., 1980, Petrology of Sedimentary Rocks: Hemphill Publishing Company, 84 p.

Howe, H.J., 1962, Subsurface geology of St. Helena, Tangipahoa, Washington and St. Tammany parishes, Louisiana: GCAGS Transactions, v. 7, p. 121-135.

Kieffer , S.W., 1971, I. Shock metamorphism of the Coconino Sandstone at Meteor Crater, Arizona. II. Specific heat of solids of geophysical interest: Ph.D. Dissertation, California Institute of Technology, Pasadena, California, p. 191.

Koerbel, C., 1997, Impact cratering: the mineralogical and geochemical evidence, *in* K. S. Johnson and J. A. Campbell, eds., Ames structure in northwest Oklahoma and similar features: Origin and petroleum production (1995 Symposium): Oklahoma Geological Survey Circular, no. 100, p. 30-54.

Louisiana Geological Survey, 1999, Geologic map (GIS) of Louisiana: Louisiana GIS CD, v. 1.
May, J.H., and Warne, A.G., 1999, Hydrologic and geochemical factors required for the development of Carolina Bays along the Atlantic and Gulf Coastal Plain, U.S.A.: Engineering Geology. v. 5, p. 61-270.
McDaniel, D., 1996, Soil survey of St. Helena Parish, Louisiana: Natural Resources Conservation Service, U.S. Department of Agriculture, Washington, D.C., p. 143.
Mossa, J., and Autin, W.J., 1989, Quaternary geomorphology and stratigraphy of the Florida parishes, southeastern Louisiana: Louisiana Geological Survey Guidebook Series no. 5, 98 p.
McCulloh, R.P., Heinrich, P.V., and Snead, J., compilers, 1997, Amite, Louisiana 30 x 60 minute geologic quadrangle (preliminary): Prepared in cooperation with U.S. Geological Survey, STATEMAP program, under cooperative agreement no. 1434-HQ-96-AG-1490, 1:100,000-scale map plus explanation and notes.
Shoemaker, E.M., and Kieffer, S.W., 1979, Guidebook to the geology of Meteor Crater, Arizona: Publication No. 17, Center for Meteorite Studies, Arizona State University, Tempe, Arizona, 65 p.
Snead, J.I., and McCulloh, R.P., 1984, Geologic map of Louisiana: Louisiana Geological Survey, Baton Rouge.
Stoffler, D., and Langenhorst. F., 1994, Shock metamorphism of quartz in nature and experiment. 1. Basic observation and theory: Meteoritics. v. 29, p. 155-181.

Status of Research

At this time, the author and other researchers are conducting ongoing research and planning future research of the Brushy Creek feature. For example, John Wrenn of the Louisiana State University (LSU) Department of Geology and Geophysics and the author are looking at various ways to date it. Douglas Carlson, Richard McCulloh, and the author are considering the use of various geophysical techniques with the LGS Giddings Soil Probe to study the internal structure of this feature. Finally, Stephen Benoist of the LSU Department of Geology and Geophysics and the author are studying evidence of shock metamorphism in samples from the Brushy Creek feature. A preliminary report on the Brushy Creek feature will be presented as a poster at the October 2003 Gulf Coast Association of Geological Societies Annual Convention in Baton Rouge, Louisiana. Additional papers concerning the results of the above ongoing research are planned.

Acknowledgments

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Dedication

This and ongoing research at the Brushy Creek feature is dedicated to the memory, courage, and curiosity of the crew of Space Shuttle Columbia (STS-107) and to the manned exploration of space by astronauts and cosmonauts of all nations, creeds, and races of which they were a part.