MICROACCRETIONARY AND ACCRETIONARY CARBONATE SPHERULES OF THE CHICXULUB IMPACT EVENT FROM BRAZOS RIVER, TEXAS, AND BASS RIVER, NEW JERSEY. R. N. Guillemette and T. E. Yancey, Department of Geology and Geophysics, Texas A&M University, College Station, TX 77843-3115, guillemette@geo.tamu.edu, yancey@geo.tamu.edu

Accretionary carbonate spherules of small size are a common component of distal Chicxulub impact ejecta deposits and are documented at Brazos River, Texas, and Bass River, New Jersey, located about 1000 km and 2500 km respectively from the crater. This spherule type is also present in northeast Mexico and is related to accretionary carbonate lapilli present in proximal Chicxulub ejecta deposits. Accretionary carbonate spherules are very common throughout the strewn field, but have been confused with altered silicate glass spherules and not recognized as a distinct spherule type having primary carbonate composition.

Accretionary carbonate spherules in distal deposits range in size from less than 50 microns up to 2.5 mm in diameter. On broken margins, the spherules show the presence of small darker spots scattered throughout that appear to be areas of higher clay content. Spherules are generally rounded, but many have a subangular, blocky form as a result of post-fallout reworking. Unstained spherules have a snow white color, a result of being composed of minute, light-scattering crystals and have an accretionary, clotted fabric at both micro and mesoscopic scale that distinguishes them from other carbonate grains. The aggregate texture characteristic of these spherules can be recognized in petrographic thin sections and is well displayed in BSE (backscattered electron) images (Figure 1). The smallest aggregates present within spherules are 10-20 micron diameter rounded clusters of crystals and composed of micron-sized calcite crystals. There are also aggregates in the 50-70 micron diameter range and more heterogeneous aggregates up to 0.5 mm occur in the larger spherules. The smallest component units are one micron size crystallites of low-Mg calcite and another population of grains consisting of uniform calcite crystal masses of 5-10 microns diameter occurs interspersed among the aggregate masses. The spherules show little zoning apart from an outer rim that is darker in color (in transmitted light), composed of smaller aggradational masses than in the interior and is a little more indurated. Crystals in the outer rim are often slightly different in elemental composition than crystals present in the interior of spherules. Calcite crystals in the outer rim are often part of larger plate units that are aligned parallel with the spherule surface.

Small masses of clay ranging in size from 10 micron to 0.5 mm occur interspersed with the calcite aggregates in spherules and are probably areas of altered silicate glass. The smallest (10 micron) clay masses are round and uniformly of clay composition, or contain other mineral components only in sub-micron particles. Larger clay masses (100 microns or more) are heterogeneous in composition and contain small calcite crystals scattered through the clay at varying concentrations.

SEM imagery of Brazos spherules reveals an interior with much porosity, consisting of pore space between the calcite crystals. The crystal units are mostly equidimensional and semi-rhombic in shape, with a range from rhombic to anhedral in form. There are small areas of multicrystal units corresponding to BSE slightly brighter areas in spherules. Pore spaces

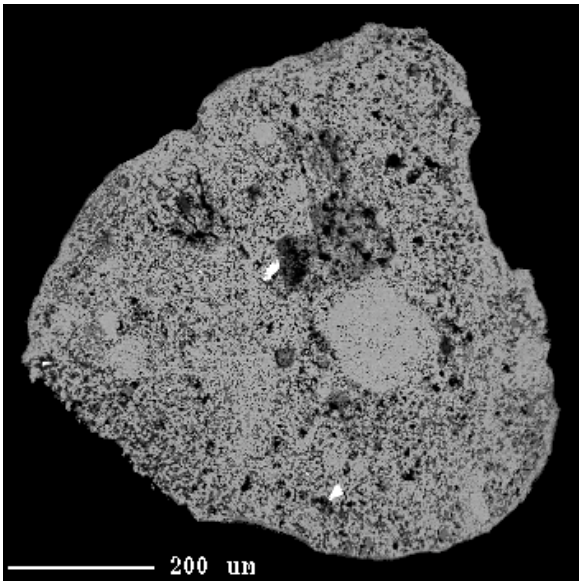

Figure 1. BSE image of Brazos River accretionary spherule, with aggregates of several sizes. Bright white spots are pyrite or barite, the brighter gray areas are low-Mg calcite, and the darker gray areas are smectite clay.

in the spherules are sparsely filled with small platelets of smectite clay that form a three dimensional sponge-like array.

Several lines of evidence indicate that the white grain, accretionary carbonate spherules present in sediments of the Brazos River and Bass River event complex are of impact ejecta origin rather than locally derived particles. They occur only in sediments of the event complex and are dissimilar to

biogenic grains or detrital grains from carbonate rocks. They have a microfabric unlike that of biogenic material and lack pore-filling spar or recrystallization texture like that of altered glass spherules. The microgranular appearance is like some pedogenic (calcrete/caliche) materials, but the

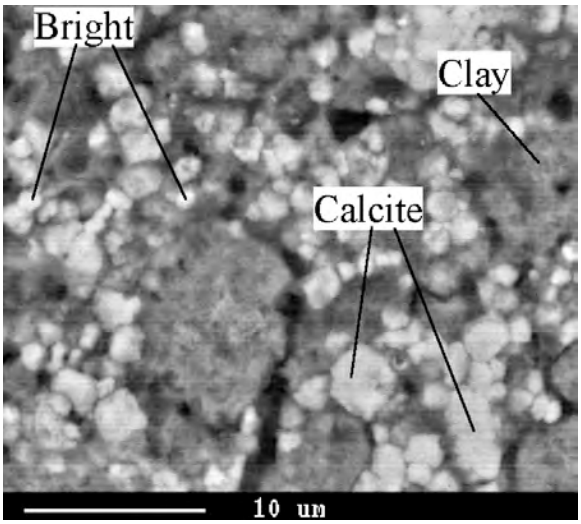

Figure 2. BSE image of Bass River accretionary spherule.

absence of other land-derived components in event deposits makes a pedogenic origin improbable. The spherules are dissimilar to diagenetic calcite, siderite or phosphate concretionary material of marine origin in appearance and texture as well as composition.

The composition of the carbonate particles of several micron size is quite variable in both the Brazos River and the Bass River spherules (Table 1).

	Brazos River (50 pts)	Bass River (calcite - 6 pts)	Bass River (bright - 7 pts)
$CaCO_3$	93.89 *(2.97)*	97.23 *(1.71)*	88.40 *(4.90)*
$MgCO_3$ (MgO)	2.89 *(1.84)*	0.77 *(0.13)*	3.22 *(1.60)*
$FeCO_3$	0.14 *(0.10)*	< 0.4	< 0.4
$MnCO_3$	< 0.1	< 0.4	< 0.4
$SrCO_3$	0.09 *(0.04)*	< 0.7	< 0.7
SO_3	0.84 *(0.37)*	0.62 *(0.31)*	1.13 *(0.47)*
Na_2O	0.07 *(0.02)*	< 0.2	< 0.2
Al_2O_3	0.21 *(0.27)*	< 0.2	0.92 *(0.45)*
SiO_2	0.67 *(0.63)*	0.34 *(0.36)*	2.43 *(1.46)*
Total	98.84 *(1.01)*	99.52 *(1.48)*	96.80 *(2.69)*

Table 1. Electron microprobe analyses (mean and standard deviation) of carbonate minerals in spherules.

This compositional heterogeneity is seen in BSE images of the Bass River material as distinctly darker or brighter one to ten micron diameter particles (Figure 2). The slightly larger, darker particles are low-Mg calcite, while the smaller brighter particles contain higher, more variable Mg and high levels of Al and Si impurities. Both contain unusually high concentrations of S for carbonates, with the small brighter particles containing about twice the S of the low-Mg calcite. BSE images of the Brazos River spherules do not show any significant differences in brightness between different areas of the carbonate, despite the Mg concentration, calculated as $MgCO_3$, varying by almost an order of magnitude, from 2 to 16 percent. When Mg is calculated as $MgCO_3$, the analytical totals for the higher Mg analyses are unreasonably high (up to about 106%), with a direct correlation between Mg content and analytical total for the higher Mg points. Having experimentally eliminated electron beam damage during analysis as the reason for these high totals, an alternate explanation becomes necessary. When the Brazos River analyses are recalculated with the Mg as MgO instead of $MgCO_3$, the high totals are eliminated and only a small amount of variability in totals results for the fifty point analytical data set. This suggests that most of the Mg present in the higher Mg areas is in the form of sub-micron MgO particles, which could have resulted from the low reactivity of the calcined MgO produced in the impact event.

The common accretionary carbonate spherule ejecta particles were formed in the impact vapor plume/ejecta cloud from surface carbonate rocks of the Chicxulub impact site, indicating that much of the carbonate rock was removed and re-deposited as particulate matter and not released as carbon dioxide gas to the atmosphere.