

GEOCHEMISTRY OF ACCRETIONARY LAPILLI FROM A CRETACEOUS-TERTIARY IMPACT BRECCIA, GUAYAL, MEXICO. E. Burns¹, H. Sigurdsson¹, S. Carey¹, S. D'Hondt¹¹Graduate School of Oceanography, University of Rhode Island

Introduction: Accretionary lapilli are found in a 50-cm-thick grit unit that is 2.5 m below the top of a fining-upward, 35-m-thick impact breccia near Guayal, southeastern Mexico. They were first described in 2000 by Salge et al. [1]. The breccia is thought to be associated with the Cretaceous-Tertiary Chicxulub impact on Yucatán. It is about 600 km from the crater center and consists of carbonate clasts in a carbonate-smectite matrix. The smectite is the alteration product of impact glass. The accretionary lapilli are rounded and flattened, with the long axis lying parallel to bedding (Fig. 1). Average dimensions of a set of 24 lapilli, measured with calipers, are 1.3 x 1.1 x 0.8 cm (s.d. = 0.19, 0.14, and 0.16), with an average aspect ratio of 0.59 (s.d. = 0.13). They are the largest objects in the grit unit, which has carbonate clasts of <0.5 cm. The lapilli are about 90% silica and are medium grey in color, with a waxy luster on freshly broken or sawed surfaces. They appear to have been largely replaced by diagenetic chert, but retain the layered internal structure that is typical of accretionary lapilli (Fig. 2). The centers are amorphous. Outer layers contain angular mineral grains aligned tangentially to the curvature of the layers [1]. Quartz and pyroxene grains have been identified in thin section. The matrix is cryptocrystalline to amorphous, but layers tend to alternate between slightly coarser and finer textures.

Chemistry: Two lapilli were sawed in half, polished, and analyzed for major-element oxides by electron microprobe and for trace elements by laser-ablation ICP-MS. The electron microprobe lines followed the laser-ablation lines. Their REE patterns are very similar to those of whole-rock samples of the surrounding carbonate-smectite grit, but with more pronounced positive Ce and negative Eu anomalies and a slightly steeper slope from LREE to HREE (Fig. 3). The shape of the patterns does not vary between layers within the lapilli or between the two lapilli analyzed, but the cores are slightly more concentrated in REE than the outer layers, and the average REE concentrations in one of the lapilli were greater than in the other. To minimize the effects of silica dilution on more mobile elements, elemental ratios were used to compare the lapilli to impact glass and alteration smectite from Beloc, Haiti [2] and continental crust [3]. These ratios may be the result of diagenetic processes rather than impact processes. The lapilli do not consistently resemble continental crust, impact glass, or smectite in their elemental ratios or overall composition. CaO and MgO are enriched relative to other major oxides, particularly FeO. MgO/FeO values in the lapilli are 3.7 and 4.0, while MgO/FeO in continental crust, glass, and smectite ranges from 0.5-0.9. Heavy metal con-

centrations tend to be lower than those in continental crust, especially Cr, which is 0.01-0.02 ppm compared to 185 ppm in continental crust and around 20-30 for the impact materials. The lapilli are low in Nb, Ta, Rb, and Ba, although Nb/Ta, Rb/Sr, and Rb/Ba ratios are comparable to continental crustal values. The lapilli resemble the yellow impact glass in Zr/Ta and Hf/Ta. Their U/Th is very high, averaging 13 compared to 0.26 for continental crust, and they contain more than 20 ppm U. The black and yellow impact glasses contain an average of 1.24 and 1.10 ppm U respectively, and alteration smectite has 0.36 ppm [2].

Discussion: The accretionary lapilli were most likely formed in the part of the impact vapor cloud where water vapor condenses, i.e. at or below 100° C. Thus their isotherm may have been close to Guayal, 600 km from the crater center. The accretionary lapilli appear to have been extensively replaced by chert. REE are thought to be less mobile during chert replacement than most other elements [4], so the REE patterns may be the best available indicator of the composition of the debris/vapor cloud in which the lapilli formed. The patterns resemble bulk continental crust and probably reflect the composition of the crystalline crust under the impact site, which would contribute more REE overall than would carbonates. It is not known if the Ce and Eu anomalies are the result of conditions in the vapor cloud or of some diagenetic process. SEM analyses by Salge et al. [1] show an average composition of 64% quartz, 19% clay minerals, 9% calcite, and 8% dolomite. The analyses done for this study gave considerably higher silica percentages and Ca and Mg percentages of ~3% or less of each. This could be because of differences among the lapilli or partly because of differences in analytical techniques, since this study did not include analysis of individual minerals or of carbonate. The U enrichment may be the result of U transport by diagenetic fluids from the surrounding carbonate rock into the lapilli during chert replacement.



Figure 1. Lapilli *in situ*, Guayal, Mexico. Divisions on measuring stick are 10 cm. Photo by H. Sigurdsson.

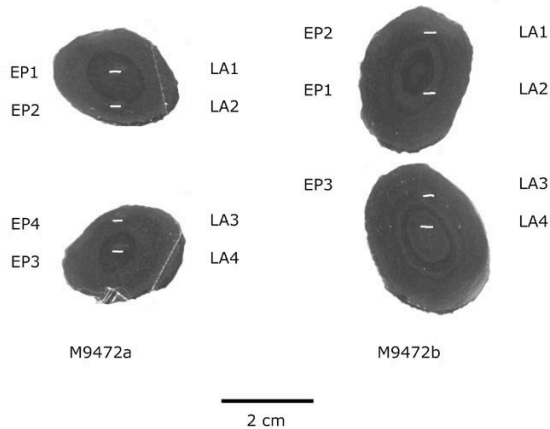


Figure 2. Lapilli in cross-section. Both sawed halves of each lapillus are shown. White lines indicate laser-ablation (LA)/ electron microprobe (EP) lines.

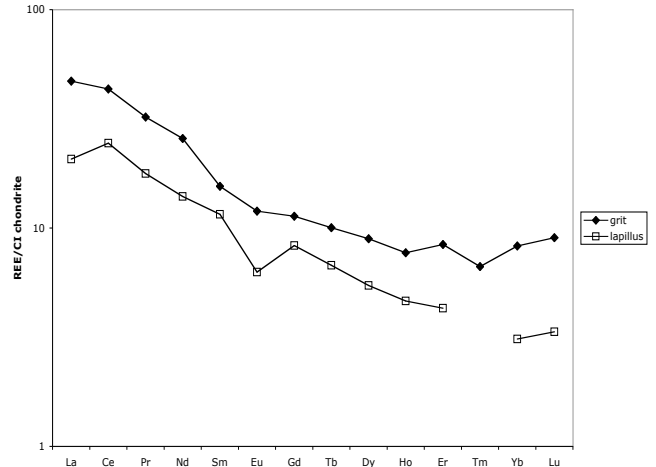


Figure 3. REE pattern of lapillus M9472a from the Guayal deposit compared to the surrounding grit. The lapillus pattern is the average of two laser-ablation lines in the center and two from outer layers. REE in the grit have been calculated on a carbonate-free basis to remove carbonate dilution effects. Samples are normalized to chondrite values from Anders and Grevesse [5].

References: [1] Salge, T. et al. (2000) *63rd Ann. Meteoritical Soc. Mtg.*, abs. 5124. [2] Koeberl, C., and Sigurdsson, H. (1992) *Geochim. Cosmochim. Acta*, 56, 2113-2129. [3] Taylor, S.R., and McLennan, S.M. (1985) *The Continental Crust: its Composition and Evolution*, Blackwell [4] Murray, R.W. (1994) *Sed. Geol.*, 90, 213-232. [5] Anders, E., and Grevesse, N. (1989) *Geochim. Cosmochim. Acta*, 53, 197-214.