Chicxulub High-Altitude Ballistic Ejecta from Central Belize. K.O. Pope[1] and A.C. Ocampo[2], [1]Geo Eco Arc Research, 3220 N Street, NW, #132, Washington, DC 20007 kpope@primenet.com, [2]Jet Propulsion laboratory and NASA Headquarters, Code SD, Washington, DC 20546, aocampo@hq.nasa.gov.

Introduction: Chicxulub ejecta deposits are found in the Cayo District of central Belize, 475 km southeast of the impact crater center. We interpret these deposits as ballistic ejecta that were launched along high-altitude trajectories above the atmosphere and deposited as a thin, discontinuous sheet of debris on the terminal Cretaceous land surface. This interpretation is based on characteristics of the central Belize ejecta that compare favorably with other ejecta and with ablation features on meteorites.

Teakettle Diamictite: The Cayo ejecta are found in the Teakettle diamictite, a 10 to 30-m-thick heterogeneous deposit of pebbles, cobbles, and boulders supported in a matrix of red clay and silt. The Teakettle diamictite overlies the Upper Cretaceous Barton Creek Formation at five locations along the northern flanks of the Maya Mountains. The upper contact of Barton Creek Formation is an irregular karst surface with relief of 10-30 m. The only site found with Tertiary sediments overlying the Teakettle diamictite is Pook's Hill 2 (PH2). These Tertiary sediments are a cream-colored fossiliferous dolomite with abundant rocky-shore fauna that mark the beginning of the Tertiary marine transgression in northern Belize. Lower Eocene El Cayo Group limestone, representing a deeper-water lagoon environment, overly the fossiliferous dolomite. Chicxulub ejecta of the Albion Formation near the Belize-Mexican border also overlie the weathered karst surface of the Barton Creek Formation [1,2]. We conclude that the Teakettle diamictite was deposited upon a Cretaceous land surface and subsequently submerged in the Paleocene. Arguments presented below indicate that the Teakettle diamictite contains impact ejecta, however we suspect that the diamictite is mostly regolith from the weathered Cretaceous surface.

Pook's Pebbles: The most intriguing aspect of the Teakettle diamictite is the occurrence at four sites of sub-rounded, polished, pitted, and striated pebbles and cobbles, which we call Pook's Pebbles after the type locality PH2. These features are described in detail below. Where percentages are given, they are based on an analysis of 40 Pook's Pebbles that were collected because they had polish or striations. Clast diameters range from 4 to 23 cm (mean diameter of 8.6 cm) in this sample collection.

Nearly all (92%) Pook's Pebbles are an extremely fine (1-10 µm) grained pink recrystallized limestone. The pink color of the Pook's Pebbles is not uniform and when examined in cut sections its patchy nature can be traced to halos around small (~100 µm) hematite grains. Pook's Pebbles that lack these iron oxide grains are white. Most Pook's Pebbles are disk shaped (68%), but spheroidal (18%) and rod (15%) shapes are also common. All are faceted. Both interior and exterior corners of the facets have been rounded. Most (80%) samples have pits, and several (35%) have pitting that covers half the clast. Pits are elliptical depressions with abrupt rims. The larger pits look like thumb impressions made in soft clay. Typical pits are 0.3-2.0 cm in diameter and are about half as deep as they are wide. In a few examples the pits are much deeper, forming 0.5-2 cm deep holes that are 0.1-0.5 cm in diameter. All Pook's Pebbles have patches of a white, chalky calcite crust that covers on average 24% of the clast. The chalky crust is a few mm thick and composed of mostly 40-µm-sized calcite crystals. The crust also contains about 1 % sand and pebble-sized clasts (same lithology as Pook's Pebbles), which are abundant in a few (8%) samples. Patches of the crust are a gray, translucent, coarse (100-µm-sized) calcite. A few (8%) examples of this denser crust contain vugs 1-3 mm in diameter and laminations with truncations. Nearly half (43%) of the clasts examined have one facet (and only one) that is mostly covered with crust. Many (42%) of these clasts with crust on one side have extensive pitting on the opposite side. Where the crust is missing, the clast surface is typically polished and/or striated and it is apparent that the crust has been stripped away in the process. A fine polish occurs in patches and rarely covers the entire clasts. In several (15%) examples the harder gray translucent crust is also polished, including the small pebbles embedded in the crust. Striations are common, occurring in parallel sets, typically within distinct gouges 2-10 mm wide. These gouges also occur in parallel sets, resulting in a striated surface. Many examples of striated gouges have curves and kinks, or end in an abrupt, angular facet. We found several (20%) examples where small pebbles or sand grains remained embedded at the end of a striated gouge, clearly indicating that the striations were formed by the impacting grains. In rare examples, we found pits with striated walls indicating impacting grains hit more perpendicular to the surface and actually penetrated the Pook's Pebble for up to 5 mm. Many Pook's Pebbles have multiple generations of parallel gouges and striations in different directions, indicating that the clast was rotating relative to the trajectory of the impacting grains. Striations and gouges are also found on the patches of crust.

Comparisons and Interpretations: The irregular shapes, facets, rounded corners, crusts, and pits in the Pook's Pebbles bear a striking resemblance to similar features on meteorites. The scale, morphology, and distribution of pits are especially striking. The Pook's Pebble "thumb impressions" are nearly identical to piezoglypts on meteorites. The deeper pitting resembles pits found in iron meteorites where ablation has preferentially removed troilite impurities. The common occurrence on Pook's Pebbles of a single side with extensive pitting has parallels in oriented meteorites. The crusts on the Pook's Pebbles also have several elements in common with fusion crusts on meteorites. Vesicular fusion crusts, sometimes with 2-3 mm-sized fragments, have been reported from oriented meteorites where a frothy slag formed terraced flows on the backside. These vesicular flows are similar to the crusts with vugs and layered crusts with truncations found in the Pook's Pebbles. We propose that these surface features of the Pook's Pebbles formed by ablation during atmospheric re-entry of high-altitude ejecta from Chicxulub.

Carbonate pebbles and cobbles with polish, striations, gouges, and impact penetrating grains, like those found on the Pook's Pebbles, also occur in impact ejecta from the Albion Formation [1,2] and the continuous ejecta blanket (Bunte breccia) of the Ries Crater in Germany [3]. Given that these features are superimposed on the ablation features, we propose that they were formed by particle interactions as the ejecta passed through a near-surface debris cloud and struck the regolith-covered Cretaceous land surface.

References: [1] Ocampo, A.C., Pope, K.O., and Fischer, A.G., 1996, Ejecta blanket deposits of the Chicxulub crater from Albion Island, Belize, *Geological Society of America Special Paper* 307, 75-88. [2] Pope, K.O., Ocampo, A.C., Fischer, A.G., Alvarez, W., Fouke, B.W., Webster, C.L., Jr., Vega, F.J., Smit, J., Fritsche, A.E., and Claeys, Ph., 1999. Chicxulub impact ejecta from Albion Island, Belize, *Earth and Planetary Science Letters* 170, 351-364. [3] Chao, E.C.T., 1976. Mineral produced high pressure striae and clay polish: Key evidence for nonballistic transport of ejecta from Ries crater, *Science* 194, 615-618.