THE GATUN STRUCTURE: A PETROGRAPHIC AND GEOCHEMICAL INVESTIGATION INTO A POSSIBLE TERTIARY IMPACT STRUCTURE NEAR GAMBOA, REPUBLIC DE PANAMA.

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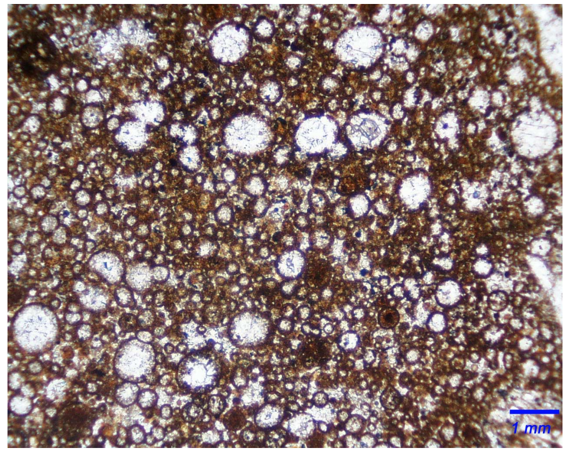
Introduction: The Gatun Structure, located in the Republic de Panama (N 09º 05' 58.1", W 79º 47' 21.8"), is a quasi-circular, rimmed feature 2.2 - 3 km in diameter. The structure is reputed to be the result of a hypervelocity impact which disrupted three lower Tertiary units of intercalated marine and volcanic and siliciclastic facies materials. These units unconformably overlie an altered and strongly deformed volcanic basement, and are intruded by dioritic magmas [1]. An impact hypothesis for the structure is based on, morphology, which appears to be consistent with that of a small, eroded complex crater; a concentric distribution of disturbed geologic units, and the presence of impact glasses and several types of breccias [2].

Morphology: The structure is partially inundated on the NW side and is covered by triple-canopy rainforest, but is clearly distinguishable in aerial photography. Although weathered, it preserves a an elevated, circular central feature approximately 70m high; and arcuate boundary ridges - 50-110 m above sea level, expressed as ridges on land, and as an arcuate chain of islands where partially submerged. The topography of the Gatun structure suggests the inner peak ring structure is 1-1.5 km in diameter and the central uplift is approximately 600 meters in diameter. Based on scaling relationships from other complex craters, in which the peak ring and uplift diameters are ~0.5 and ~0.22 x the crater diameter, respectively [3], the approximate crater diameter inferred for the Gatun structure would be 2.72-3 km. This diameter appears to be consistent with the diameter of the boundary ridges and the overall morphology of the structure.

Geology and Petrography: Within the central peak, highly altered and fractured siltstone and sandstone (the Gatuncillo Formation (?) (Eocene) are uplifted and exposed through surrounding volcanic and marine facies of the Caimito and/or the La Boca formation, the major ‘disturbed’ rock units within the structure [1, 2] (clastic carbonate rocks contain Lepidocyclina miraflorensis, which is most abundant in the Upper Miocene La Boca Fm.). The structure is cross-cut by numerous dikes of unshocked basalt and basaltic andesite related to volcanism along the Panamanian segment of the Central American arc ~45-50 kilometers to the SSW [4]. Also found within the site, are rocks that may represent the four most common impactites, after Stoffler and Grieve [5]: glass and melt-bearing breccias (suevites and impact-melt breccias?), glasses (impact melt rocks?), and polymict-lithic breccias (fragmental impact breccias?).

From the central feature outward concentrically within the structure, one may find limestones with anomalous ‘glassy’ inclusions; both black and white hypocrystalline glasses; polymict-lithic breccias and melt-bearing breccias, some of which appear to contain flow features and evidence for selective melting.



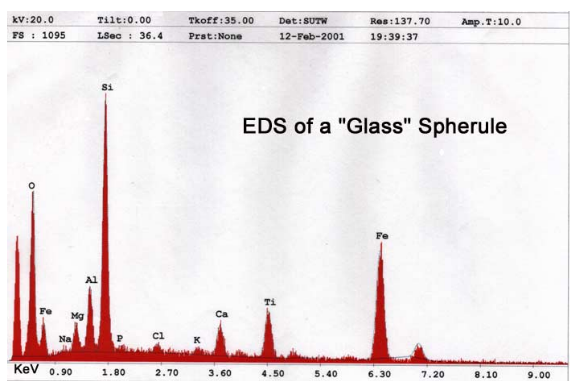


Figure 1. A) PPL 40x image of the Gatun spherules from sample GS-06a-00 (possible suevite?). The largest spherules (~ 1 mm in diameter) contain cores bearing a composition that is consistent with clays and zeolites. **B)** However, rims show a wide range of chemical variation, which indicates that they may be the result of melting and mixing of common volcanic and carbonate phases.

Three types of spherules (glass, fluid-drop and lithic) (Figure 1a) and pyroxene-quartz “necklace” disequilibrium structures are petrographic indicators of a possible impact event. In addition, non- to low birefringent areas in plagioclase feldspars, possibly representing maskelynite has been tentatively recognized based on petrography, SEM-EDS and RAMAN spectroscopy.

Analytical Techniques: Analysis of mineral assemblages of the units within the structure, and mineral compositions were measured via SEM-EDS and electron microprobe, using the JEOL SEM-Probe facility at the Center for the Study of Materials in Extreme Conditions (CeSMEC) at Florida International University, Miami. Bulk chemical and trace element analysis of whole rock samples were conducted via DC Plasma spectrometry (DCP-AES). Further studies on sample GS-06a-00, observed to be a possible suevite, was conducted on the modified, fully automated, Cameca SX-50 electron microprobe at the Univ. Tennessee, Knoxville.

Results: Gatun glasses and melt-bearing breccias exhibit chemical systematics that distinguishes them from local volcanic rocks. EDS measurements of spherule compositions suggest an origin through the melting and mixing of mineral phases that occur within sample GS-06a-00: in particular, magnetite, plagioclase and alkali feldspar, pyroxene and possibly calcite (Figure 1b).

RAMAN spectral results indicated that many plagioclase grains in sample GS-06a-00 (possible suevite?) were highly disordered and amorphous. EMP analyses of some of these grains yield analcime ($NaAlSi_2O_6 \bullet 2H_2O$) compositions for these non- to low birefringent areas in the altered plagioclase feldspars. Since glass is metastable, it should alter readily under tropical conditions. With these considerations, maskelynite may be present, but may have been largely replaced by analcime since its formation.

Conclusions: While classical distinctive shock metamorphic evidence is limited, the field geometry of the site, and the petrography and field occurrences of various breccias and glasses associated with the structure all found only within a roughly 3 km radius, suggests an anomalous geologic event. Whether it is the result of a hypervelocity impact, an anomalous explosive volcanic event (e.g. phreatomagmatic), or another mode of origin, remains uncertain at this time.

References: [1] Woodring W. P. (1982) *Geology and Paleontology of Canal Zone and Adjoining Parts of Panama: U.S. Geological Survey Paper,* 306-f, 745 p. [2] Stewart, R. H. (2000) Personal communication. [3] Melosh, H. J. (1989) Impact Cratering: A geologic process, 245 p. [4] Defant et. al. (1992) *Jour. Geol. Soc. London*, 149, 569-579. [5] Stoffler, D. and Grieve, R. A. F. (1994) *European Science Foundation Network on Impact Cratering Newsletter*, 2, 8-15.