FIRST RESULTS FROM THE 2004 ICDP BOSUMTWI IMPACT CRATER, GHANA, DRILLING PROJECT: IMPACT AND GEOPHYSICAL ASPECTS.

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Introduction: The Bosumtwi impact crater in Ghana, West Africa, was the target of a recent (2004) international drilling project funded mostly by the International Continental Scientific drilling Program (ICDP). The following summary is based on [1]. The crater is centered at 06°32'N and 01°25'W, and is almost completely filled by a lake. Bosumtwi is one of only four known impact craters associated with a tektite strewn field [2]. It is a well-preserved complex impact structure that displays a pronounced rim. The crater is excavated in 2.1-2.2 Ga metasediments and metavolcanics of the Birimian Supergroup. Impact deposits are suevites and fragmental breccia outside the crater rim (e.g., [3]). Seismic reflection and refraction data [4,5] allowed locating a 1.9-km-diameter central uplift that is buried by post-impact lake sediments and is situated just northwest of the center of the lake.

Drilling at Bosumtwi: A drilling project was conceived that would combine two major scientific interests in this crater: to obtain a complete paleoenvironmental record from the time of crater formation about one million years ago, at a near-equatorial location in Africa, for which very few data are available so far, and to obtain a complete record of impactites at the central uplift and in the crater moat of the largest young impact structure known on Earth, for ground truthing and comparison with other structures.

Within the framework of an international and multidisciplinary ICDP-led drilling project, 16 drillcores were obtained at 6 locations within the 8.5-km-diameter Lake Bosumtwi (Fig. 1). Drilling and related geophysical studies and logging took place from June to October 2004. For the first time the GLAD-800 lake drilling system (see www.dosecc.org) cored an entire lacustrine sediment fill from lakefloor to bedrock and deep into the impactite crater fill. The 14 sediment cores were shipped to the US and are currently investigated for paleoenvironmental indicators (e.g., [6]). The two impactite cores, LB-07A and LB-08A, were shipped to ICDP headquarters in Potsdam, Germany, and scanned from November 2004 to January 2005. Samples were distributed to the impact science community after the “sampling party” in late January 2005. At a special session at the 2006 Lunar and Planetary Science Conference, more than 20 abstracts were presented with the first results from the deep drilling into the impactite sequences (cf. [1]). Results from the Lake Bosumtwi scientific drilling project are important for comparative studies and re-evaluation of existing data from other terrestrial impact craters, and to understand essential aspects of the impact process.

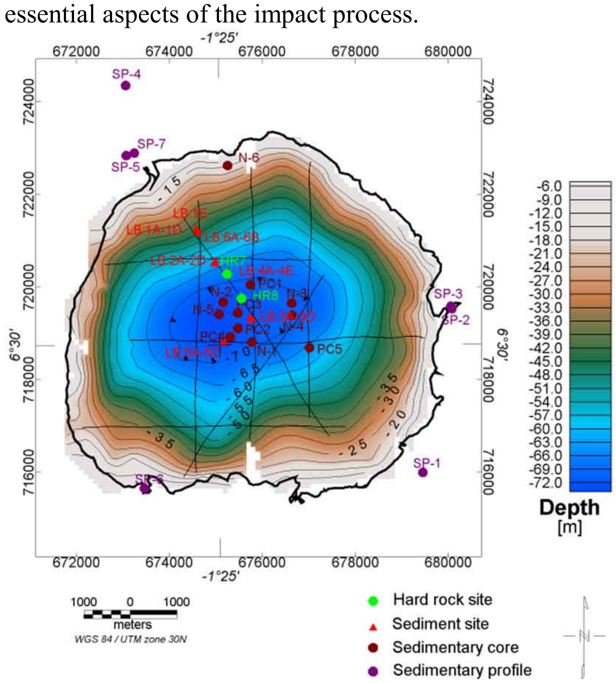

Fig. 1. Location map with ICDP boreholes.

Geophysics: Deep drilling results confirmed the gross structure of the crater as imaged by the pre-drilling seismic surveys including multi-channel reflection seismic and refraction seismic studies [4,5]: a 1.9 km wide central uplift with a height of approximately 130 m above the adjacent annular moat. Borehole geophysical studies conducted in the two boreholes (including downhole logging and vertical seismic profiling [VSP]) confirmed the low seismic velocities for the post-impact sediments (less than 1800 m/s) and the impactites (2600-3300 m/s). These velocities are important for the conversion of reflection times to reflector depth. The analysis of full waveform sonic logs, resistivity logs in conjunction with the petrophysical studies of selected core retrieved during drilling revealed some surprising results [7]: the impactites exhibit extremely high porosities (> 30 vol%). These high porosities (close to the critical porosity) have important implications for mechanical rock stability. The statistical analysis of the velocities and densities reveals a seismically transparent impactite sequence (free of prominent internal reflections) - an observation consistent with results from the pre-site seismic surveys across the center of the impact structure. The densities obtained from the physical rock property studies on core material provided the basis for a new 3D gravity model for the Bosumtwi structure. The central gravity anomaly is controlled by laterally varying densities (and porosities) [7,8]. However, the drilling, downhole logging, and petrophysical core analysis provide no support for the presence of a proposed homogeneous magnetic unit (melt breccia?) within the center of the structure. Borehole vector-magnetic data point to a patchy distribution of highly magnetic rocks within the impactite sequence [8]. No layer of highly magnetized melt rocks, predicted from aerogeophysical data, was encountered; shock-induced remagnetization of the preexisting pyrrhotite could be responsible for the several times higher magnetization compared to the surrounding fall-out suevite [9].

Impact Fallback Layer: The complete 1 Ma lacustrine sediment fill was recovered in 14 cores at six locations. In one (LB-05) of 16 cores drilled in 2004 by ICDP into the lake sediments in the Bosumtwi crater, the zone between the impact breccias and the post-impact sediments was penetrated, preserving the final, fine-grained impact fallout layer. This unit represents the uppermost impact sedimentation and provides an important age constraint for the overlying sedimentary sequence. In this ca. 30-cm-thick final ejecta layer, a variety of lithic fragments, glass shards and microtektite-like spherules, as well as shocked quartz grains, in a microbreccia setting, were found. A comparison of the compositions of the glass-shards and spherules in sample LB-05B-117-A1 with those of Ivory Coast tektites and microtektites shows a close similarity, except for higher CaO contents in the fallback glass.

Impactite Cores LB-07A and LB-08A: These two boreholes, were drilled to a depth of 540 m in the deep crater moat, and to 450 m on the outer flank of the central uplift, respectively, and their locations were correlated with existing seismic profiles [4, 5]. Care was taken to make sure that all drilling operations took place on good-quality seismic lines. Drilling progressed in both cases through the melt rock/impact breccia layer into fractured bedrock.

LB-07A comprises lithic (in the uppermost part) and suevitic impact breccias with appreciable amounts of impact melt fragments (suevite is defined as polymict breccia with a melt component). The lithic clast content is dominated by greywacke, besides various metapelites, quartzite and a so far not known carbonate target component. Shock deformation in the form of quartz grains with PFs and PDFs is abundant; diaplectic quartz is rare. First observations do not indicate a specific trend of shock degree of clastic material with depth. First chemical results indicate a number of suevite samples that are strongly enriched in siderophile elements and Mg, but further analysis is required to confirm the presence of a definite meteoritic component in these samples. Core LB-08A comprises suevitic breccia in the uppermost part, followed with depth by a thick sequence of greywacke dominated metasediment with suevite and a few granitoid dike intercalations. It is assumed that the metasediment package represents bedrock intersected in the flank of the central uplift. Initial shock investigation does not indicate that average shock deformation of central uplift strata changes consistently with depth (i.e., shock heterogeneity). Both 7A and 8A suevite intersections differ from suevites outside of the northern crater rim in lack of significant amounts of ballen quartz, different size ranges for melt fragments, and modal melt proportions. For more details on these drillcores, see, for example, Coney et al. [10], Ferriere et al. [11], Luetke et al. [12], Deutsch et al. [13], and Morrow [14].

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