THE 2004 ICDP BOSUMTWI IMPACT CRATER, GHANA, WEST AFRICA, DRILLING PROJECT: A FIRST REPORT.

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Summary. The 10.5-km-diameter 1.07 Ma Bosumtwi impact crater was the subject of an interdisciplinary and international drilling effort of the International Continental Scientific Drilling Program (ICDP) from July to October 2004. Sixteen different cores were drilled at six locations within the lake, to a maximum depth of 540 m. A total of about 2.2 km of core material was obtained.

Introduction and Geological Setting. The Bosumtwi impact crater is centered at 06°32'N and 01°25'W., and is almost completely filled by a lake. It is one of 170 meteorite impact craters known on Earth. Bosumtwi is one of only four known impact craters associated with a tektite strewn field [1]. It is a well-preserved complex impact structure that displays a pronounced rim and is almost completely filled by the 8 km diameter Lake Bosumtwi. The crater is excavated in 2 Ga metamorphosed and crystalline rocks of the Birimian System; it is surrounded by a slight near-circular depression and an outer ring of minor topographic highs with a diameter about 20 km. Only limited petrographic studies of rocks found along the crater rim and of ejecta (suevitic breccias) are availble so far [2].

Geophysical Studies: The first magnetic field studies of the structure were conducted in 1960, and revealed a central negative anomaly of ~40 nT, attributed to a breccia lens below the lake sediments. Gravity measurements, collected around the lake at this time, reflected only the regional trends. In 1997 a high-resolution airborne geophysical survey revealed a halo-shaped magnetic anomaly [3]. Seismic reflection and refraction data [4,5] defined the position of a 1.9 –km-diameter central uplift situated northwest of the center of the lake.

The goal of the integrated drilling, rock property and surface geophysical study was to study the three-dimensional building blocks of the impact crater (delineate key lithological units, image fault patterns, and define alteration zones). Results from the Lake Bosumtwi scientific drilling project are important for comparative studies and re-evaluation of existing geophysical data from large terrestial impact sites (for example, Sudbury, Vredeford, Chicxulub and Ries).

Paleoclimatic Studies at Bosumtwi. Owing to its impact origin, Bosumtwi possesses several important characteristics that make it well suited to provide a record of tropical climate change. First, because of the age of the crater and location in West Africa, the lake sediments can provide a long record of change in North African monsoon strength. Second, the high crater rim surrounding the lake results in a hydrologically-closed lake with a water budget extremely sensitive to the precipitation/evapotranspiration balance. Third, the steep crater wall and deep lake basin limit wind wave mixing of the water column. As a result, the deep water is anoxic, thereby limiting bioturbation and allowing for the preservation of laminated sediment varves and the potential for high resolution (annual) paleoclimate reconstruction.

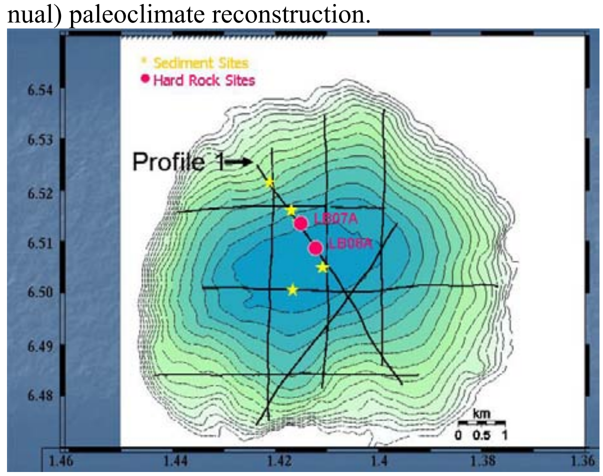

Fig. 1. Location map with ICDP boreholes and seismic profile shown in Fig. 3.

In order to gain greater insight into the role of the tropics in triggering, intensifying and propagating climate changes, scientific drilling for the recovery of long sediment records from Lake Bosumtwi was undertaken. Five drill sites (Fig. 1) were occupied along a water-depth transect in order to facilitate the reconstruction of the lake level history. At these five drill sites, a total of 14 separate holes were drilled. Total sediment recovery was 1,833 m. For the first time the GLAD lake drilling system (a system specifically constructed for drilling at lakes, see www.dosecc.org) cored an entire lacustrine sediment fill from lakefloor to bedrock.

The complete 1 Ma lacustrine sediment fill was recovered from the crater ending in impact-glass bearing, accretionary lapilli fallout. This accretionary lapilli unit represents the initial post-impact sedimentation and provides an important age constraint for the overlying sedimentary sequence. The initial lacustrine sediment is characterized by a bioturbated, light-gray mud with abundant gastropod shells suggesting that a shallow-water oxic lake environment was established in the crater. Future study of the earliest lacustrine sediment will address important questions related to the formation of the lake and the establishment of biologic communities following the impact. Most of the overlying 294 m of mud is laminated thus these sediment cores will provide a unique 1 million year record of tropical climate change in continental Africa at extremely high resolution. The shallow water drill sites consist of alternating laminated lacustrine mud (deep-water environment), moderately-sorted sand (near-shore beach environment) and sandy gravel (fluvial or lake marginal environments). These sediments preserve a record of major lake level variability that will greatly advance the present Bosumtwi lake level histories obtained from highstand terraces and shorter piston cores. All of the drill sites will be used to produce a basin-scale stratigraphic framework for the crater sediment fill.

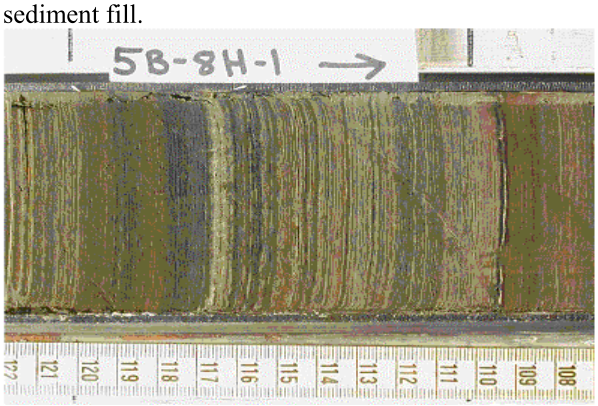

Fig. 2. Varved lake sediments from Bosumtwi core.

Geophysics and Impact Results: The new deep drill holes LB07A and LB08A are tied to the potential field and seismic data that define the Lake Bosumtwi impact structure (Fig. 1). Acquisition of zero-offset and multi-offset VSP data in deep hardrock holes LB07A and LB08A (Fig. 1) established a link with existing seismic data. Slim-hole borehole geophysical studies provide crucial information about the distribution of magnetized formations within the breccia and help locate discontinuous melt units in the proximity of the scientific drill hole(s). Information about the distribution of magnetic susceptibility and remanance of breccias and impact melt holds the key to an improved three-dimensional model for the Bosumtwi crater and its thermal history. Multi-offset vertical seismic (VSP) profiling support the integration of conventional logs and existing grid of multi-channel seismic and refraction seismic data. The offset VSP experiments are well suited for the integration of core/laboratory data, logs, and conversion of reflection seismic images from time to depth. By documenting the distribution of magnetic susceptibility and the impact related thermo-magnetic remanance, the distribution of the thermal effects of the impact will be outlined. Combining the horizontal resolution of the seismic surveys with the enhanced verticalresolution of the borehole magnetic surveys provide an ideal set-up for 3D modeling through data integration.

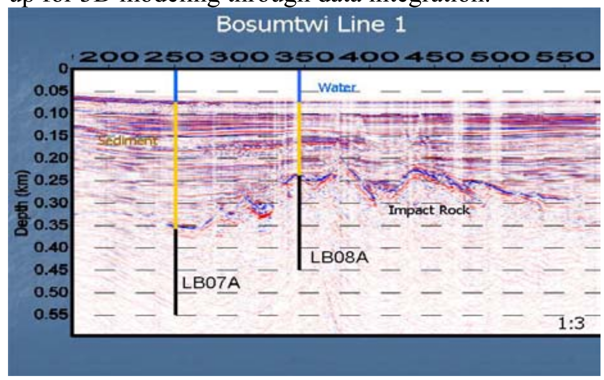

Fig. 3. Seismic section [4] with deep boreholes.

The hard rock drilling phase, as well as borehole logging and geophysical studies, was completed on October 2, 2004. During that phase two boreholes, to depths of 540 and 450 m, respectively, were drilled in the deep crater moat, and on the outer flank of the central uplift as identified in seismic profiles. Care was taken to make sure that all drilling operations took place on good-quality seismic lines (Fig. 3). In both cases casing was set through the lake sediment part of the section, and drilling, using diamond coring tools, started at the sediment/impactite (fallback suevite) interface. Drilling progressed in both cases through the melt rock / impact breccia layer into fractured bedrock.

After completion of the drilling operations, the hard rock cores (122 core boxes) were shipped to the GeoForschungsZentrum in Potsdam, Germany, for scanning and documentation; a sampling party took place in January 2005; first results are expected in mid to late 2005.

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