AN INTERNATIONAL AND MULTIDISCIPLINARY DRILLING PROJECT INTO A YOUNG COMPLEX IMPACT STRUCTURE: THE 2004 ICDP BOSUMTWI IMPACT CRATER, GHANA, DRILLING PROJECT – AN OVERVIEW.

C. Koeberl[1], B. Milkereit[2], J.T. Overpeck[3], C.A. Scholz[4], W.U. Reimold[5], P.Y.O. Amoako[6], D. Boamah[6], P. Claeys[7], S. Danuor[8], A. Deutsch[9], R.E. Hecky[10], J. King[11], H. Newsom[12], J. Peck[13], and D.R. Schmitt[14]. [1]Dept. Geological Sciences, Univ. Vienna, Althanstrasse 14, Vienna, A-1090, Austria, (christian.koeberl@univie.ac.at), [2]Dept. Physics, Univ. Toronto, Toronto, ON M5S 1A7, Canada; [3]ISPE, Univ. of Arizona, Tucson, AZ 85719-5037, USA; [4]Dept. Earth. Sci., Syracuse Univ., Syracuse, NY 13244-1070, USA. [5]Inst. Mineralogy, Museum for Natural History, Humboldt-University in Berlin, Invalidenstrasse 43, D-10115 Berlin, Germany; [6]Geological Survey of Ghana, Accra, Ghana; [7]Free Univ. Brussels, Belgium; [8]Dept. Physics, KNUST, Kumasi, Ghana; [9]Inst. Planetologie, Univ. Münster, Germany; [10]Univ. Waterloo, Biology Dept., Waterloo, Canada; [11]Grad. School Oceanography, Univ. Rhode Island, Narranganset, RI 02882, USA. [12]Univ. New Mexico, Albuquerque, NM 87131, USA; [13]Dept. Geology, Univ. Akron, Akron, OH 44325, USA; [14]Univ. Alberta, Edmonton, Canada.

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. 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. The crater is excavated in 2.1-2.2 Ga metasediments and metavolcanics of the Birimian Supergroup. Deposits associated with the crater formation are suevites and fragmental breccia outside the crater rim (e.g., [2]). High-resolution airborne magnetic studies indicated the possible presence of magnetic rocks underneath the crater floor [3] and seismic reflection and refraction data [4,5] defined the position of a 1.9-km-diameter central uplift situated just northwest of the center of the lake.

Drilling at Bosumtwi: Apart from some shallow drilling efforts outside the N crater rim in 1999, no information on the subsurface structure of Bosumtwi was available until 2004. 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 at the GFZ in Potsdam, Germany, and scanned from 11/2004 to 1/2005. First samples were distributed to the impact science community following a sampling party in late January 2005. The session at the 2006 LPSC represents the first detailed presentations of results from the deep drilling into the impactite sequences. 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.

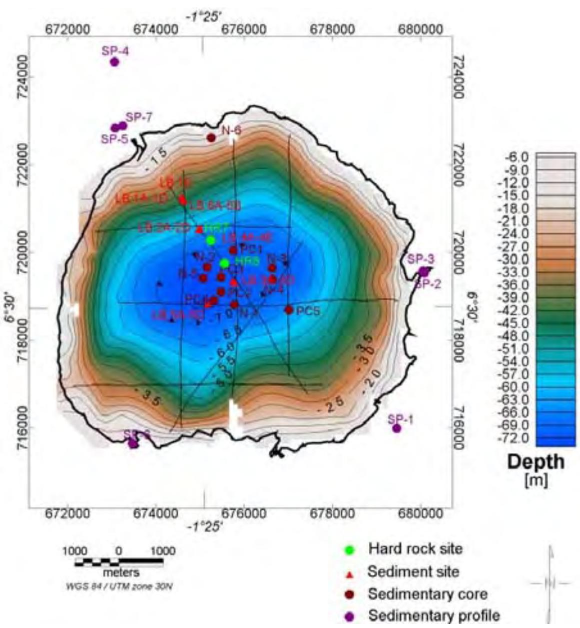

Fig. 1. Location map with ICDP boreholes.

A limnological study showed that the ICDP drilling program had no discernible affect on the lake's hydrographic structure or biogeochemistry. The lake is permanently anoxic at depth, but annual mixing does allow degassing of intermediate depths and prevents build up of high gas concentrations.

Results of Drilling Operations: The complete 1 Ma lacustrine sediment fill was recovered from the crater ending, in the case of core LB-05B, in impact-glass bearing, accretionary lapilli fallout. 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 with compositions similar to those of Ivory Coast tektites, as well as shocked quartz grains, in a microbreccia setting, were found.

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: 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]. 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 [7].

Impactite Cores LB-07A and LB-08A: These 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. 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. The lithic clast content is dominated by greywacke, besides various metapelites, quartzite and a, hitherto unknown, carbonate target component. Shock deformation in the form of quartz grains with PFs and PDFs is abundant; 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. See Coney et al. and Ferriere et al. (this volume) for more detail.

Acknowledgments: Drilling operations were supported by the International Continental Drilling Program (ICDP), the U.S. NSF-Earth System History Program under Grant No. ATM-0402010, the Austrian FWF (project P17194-N10), the Canadian NSERC, and the Austrian Academy of Sciences. Drilling operations were performed by DOSECC, Inc. We appreciate the logistical support of the Geological Survey of Ghana (Accra) and the University of Science and Technology (Kumasi), and the assistance of the local people as well as tribal and government authorities, without whose support this project would not have been possible. The help of the Operational Support Group of ICDP (especially J. Kück, and T. Wöhrl) was essential, as was the guidance of U. Harms (ICDP). In addition, we express our gratitude to a large number of colleagues, scientists, students, technicians, drilling engineers, and helpers, who spent long hours under difficult conditions, ensuring success of this project.

References: [1] Koeberl C. et al. (1997) *Geochim. Cosmochim. Acta* **61**, 1745-1772. [2] Koeberl, C., and Reimold, W.U. (2005) *Jb. Geol. B.-A., Vienna, 145*, 31-70. [3] Plado et al. (2000) *Meteoritics Planet. Sci.* 35, 723-732. [4] Scholz C.A. et al. (2002) *Geology* 30, 939-942. [5] Karp et al. (2002) *Planet. Space Sci.* 50, 735-742. [6] Peck J.A. et al., AGU Fall Meeting 2005. [7] Ugalde et al. (this volume).