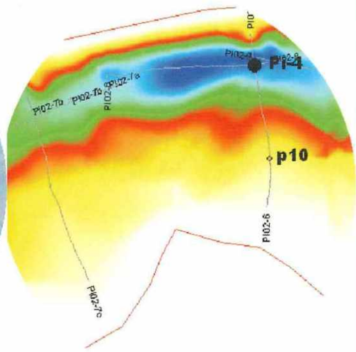
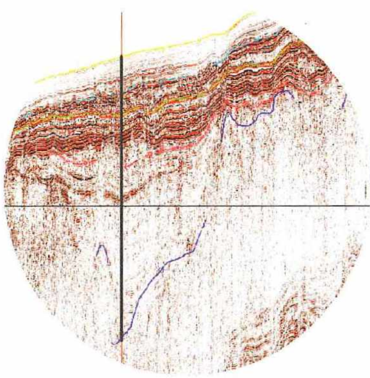
NEWSLETTER

Volume 6, March 2004

International Continental Scientific Drilling Program





CONTENT:

International Continental Scientific Drilling Program

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Newsletter Editor & Contact: Ulrich Harms, GFZ Potsdam, Telegrafenberg, 14473 Potsdam, Germany
ulrich@gfz-potsdam.de; http://www.icdp-online.org

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icdp

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CONTENT:

Coverpage Figure: The GLAD800 Global Lake Drilling Facility will be used in the forthcoming Lake Bosumtwi Drilling in Ghana in 2004; additional paleoclimate lake drilling projects plan to utilize the GLAD800 in the future.

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Progress in the Unzen Scientific Drilling Project

INTRODUCTION

In 1999, an International Cooperative Research Program began to study the eruption mechanisms and magmatic activity of the Unzen Volcano in Southwest Japan. Since then three drillholes have been drilled into the volcanic flanks to help unravel the volcanic and tectonic evolution and to prepare for a deep fourth hole. The goal of the well USDP-4 is to reach the magma conduit that fed a lava dome at the summit during 1990-1995. The eruptive volcanic activity has led to devastating pyroclastic flows which caused loss of lives and serious damages to lands around the volcano.

The feeder dyke is believed to be the site where degassing, the major factor controlling eruption styles, occurs most effectively. The degassing process is controlled by the pressure-dependent solubility of volatiles in the magma. Geophysical signals observed in the area of the conduit indicate the position of the degassing. Drilling allows, for the first time, an in-situ observation and sampling of the conduit and its wall rocks. Geothermal modeling shows an estimated temperature of over 600°C in the conduit center. Drilling the hot conduit region is most effective in understanding the degassing and eruption mechanisms.

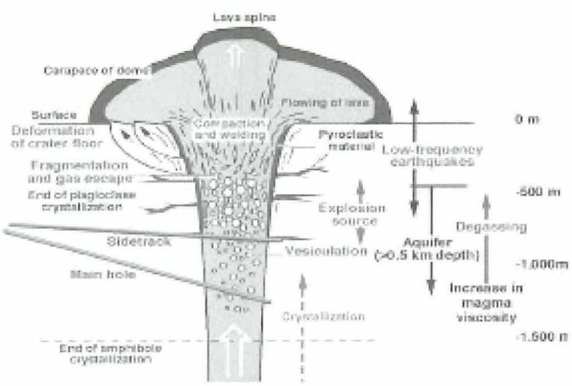


Fig. 1: Schematic section of the Unzen volcanic conduit and magmatic degassing. Note planned well trajectory above the main hole.

Drilling of USDP-4

The USDP-4 well required several infrastructural measures including construction of a new mountain road and drilling of water wells for drill mud supplies. Most of this preparatory work was performed in 2002. The spud in ceremony was held on February 13, 2003 and was attended by Japanese and foreign researchers.

Drilling of the first 260 m with a diameter of 12 $^{1}/_{4}$´´ lasted until March 22 and was complicated by loose upper volcanic formations causing a total loss of drill mud circulation in unconsolidated rubble zones while borehole wall collapses resulted in accidental deviations of the well trajectory. The succeeding 20´´ hole opening for setting of an 18 $^{5}/_{8}$´´ steel casing was finished on April 5. However, new cavities formed during hole opening blocked the casing setting procedure. Therefore, the well was re-opened to an enhanced diameter of 21´´ up to April 16 and finally the casing was set at a depth of 167 m during April 17 - 21. After this first phase of operations the progress and the problems were reviewed in detail to assist further planning.

The experience gained in this first large diameter drilling phase has shown that it was necessary i) to use aerated drill mud and enhanced water supplies (increase of water amount from 30 kl/h to 60 kl/h through a second water well) to better counterstrike the loss of circulation and breakouts, ii) to use a topdrive system for enhanced drilling, reaming, and directional drilling capabilities, iii) to involve additional commercial drilling expertise and iv) to set up of a standing safety and oversight committee.

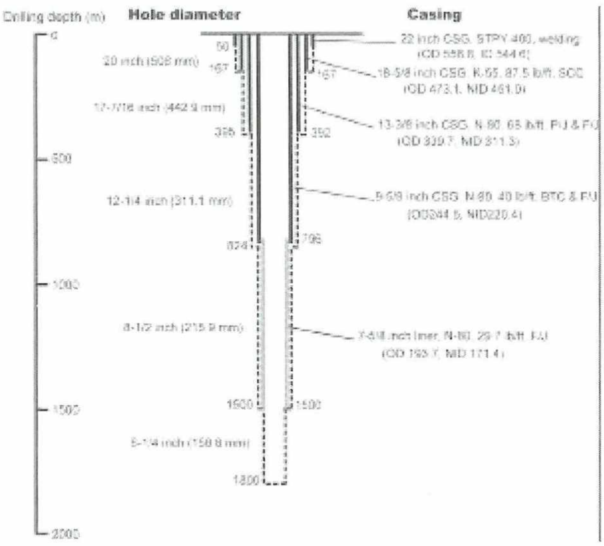


Fig. 2: Casing program for the USDP-4 well

The new water well was drilled and the additional pumping and pipe systems were installed in August 2003, followed in early September by the reanimation of the complete drilling system. Drilling was resumed on September 11, correcting the well inclination in the 12 $^{1}/_{4}$´´ diameter well including an opening to 17 $^{3}/_{16}$´´. A 13 $^{3}/_{8}$´´ casing was set at a depth 396 m on October 15 following a geophysical downhole logging campaign from 167 - 460 m. The well was deepened to 824 m with a 12 $^{1}/_{4}$´´ diameter up to October 29, using the Electromagnetic Measurement-While-Drilling technique (EM-MWD). The maximum inclination of 75° was reached at 794 m. The logging of the 400 - 650 m depth interval and the casing with a 9 $^{5}/_{8}$´´ liner (796 m) were performed during November 5-6 and the operations were finished on November 17.

Plans in 2004

It is now planned to restart drilling operations in May 2004, as soon as funding from the Japanese Government becomes available. Preceded by a Vertical Seismic Profiling experiment and temperature logging, drilling to about 1400 - 1500 m will be operated in 8 $^{1}/_{2}$´´ size, followed by a hostile environment logging campaign. In July, after setting of an additional casing (see Fig 2), drilling will be advanced down to 1800 m in a diameter of 6 $^{1}/_{4}$´´ including the penetration of the conduit, spot coring, and logging. After a review of the drilling operations during the final stage, a sidetracking of the conduit in USDP-4a may be tried to retrieve additional core samples in a shallower level (see Fig. 1). Rig demobilization will take place in August to September 2004.

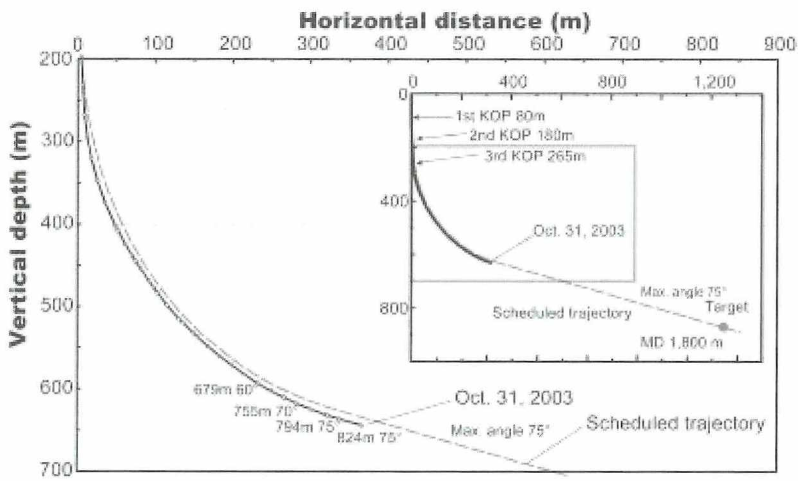


Fig. 3: Trajectory of USDP-4 well. Scheduled tracks and actual results in 2003 are shown in dashed (red) and solid lines, respectively

Setsuya Nakada, University of Tokyo, Japan

Taiwan Chelungpu-Fault Drilling Project (TCDP):
Investigating Physics of Faulting for a Recent Large Earthquake

An opening ceremony was held on January 14, 2004 to begin the Taiwan Chelungpu-Fault drilling which investigates physics of faulting for the 1999 Chi-Chi (Mw7.6) earthquake at Takeng near Central Taiwan. This project is funded by the National Science Council, Taiwan, and supported by the ICDP. The significance of the Taiwan Chelungpu-Fault Drilling Project (TCDP) is to obtain a physical sample of the fault where large displacements occurred during the 1999 Chi-Chi, Taiwan, earthquake (Figure 1), to measure the physical properties and mechanical behavior of the rocks above and below the fault zone and to thoroughly document the state of stress that exists in these rocks following such a large slip event. Physical examination of the fault surface and laboratory analyses of fault rocks and fluids in the laboratory should make it possible to infer important features, such as its dynamic frictional characteristics. The large amount of fault slip at or near the surface of the ruptured Chelungpu fault provides a unique opportunity to study first-hand the physical mechanisms involved in faulting during large earthquakes.

Scientific Objectives

The main objectives of this project are to estimate levels of absolute stress, to understand dynamic faulting process, and to identify physical characteristics of an asperity. The main tasks will include:

- The retrieval and analysis of physical sample from the fault
- The determination of the geophysical and geological characteristics of the site (geophysical imaging, pore pressure, permeability, lithostratigraphy, sedimentary facies)
- The measurement of static stress levels
- The calculation of residual temperatures from earthquake
- The continuation of geophysical monitoring (seismometers, thermometers, pore pressure)

Drilling and Logging Plan

Two holes will be drilled: Hole-A down to a depth of 2000 m, and Hole-B down to 1300 m. Hole-A will be cored from 500 m to 2000 m. Hole-B will be cored near the fault zone only, namely between 800 m to 1300 m. The total duration of drilling will be one year. The casing and logging plans of Hole-A are shown in Figure 2. Three different types of logging will be carried out: the CPC (Chinese Petroleum Corporation, Taiwan), ICDP and Schlumberger, respectively. International collaborations on these issues have been undertaken among Taiwan, US and Japan under the support of ICDP.

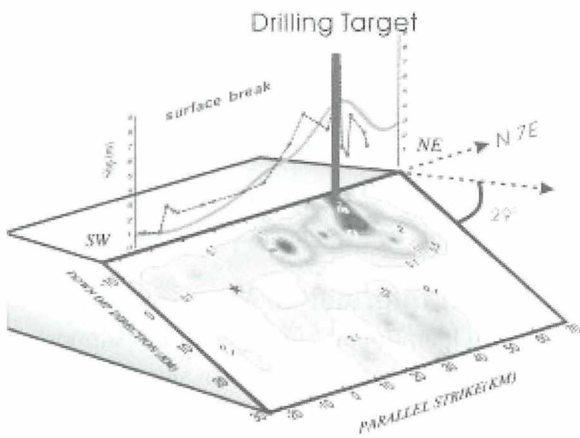


Fig. 1: Spatial slip distribution according to Ma et al. (2000). The contours and colors show the amount of slip in the dipping 29 degree fault plane of the Chelungpu Fault. The field surface breaks along the fault are also shown for comparison. The red bar indicates the drilling target of TCDP.

Project Management

The National Central University and the National Taiwan University provide oversight of field operations, in conjunction with the investigators from other institutions, including oversea institutes. The Chinese Petroleum Corporation provides local infrastructure, permitting and liaison support. An on-site project manager, who is in charge of local logistics and day-to-day operations, reports to the PIs on a daily basis. Proposals on core measurements have been collected and evaluated by a core measurement committee for prioritization of core sampling and analyses. During the course of the entire campaign we hope to recover a total of 1500 m core from Hole-A. The identification of the fault plane related to the 1999 Chi-Chi earthquake from the core will be a challenge.

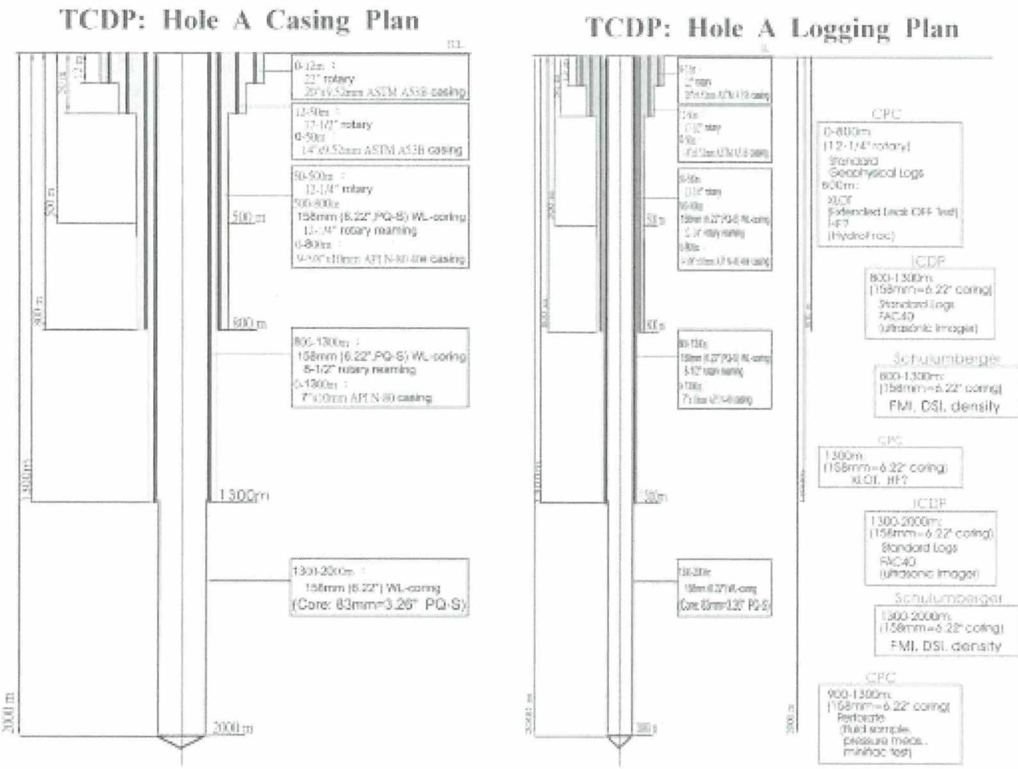


Fig. 2: Casing and logging plans for Hole-A

Data and Information Management

ICDPs Operational Support Group supported the set up of an information system for the Taiwan Chelungpu-fault Drilling Project. During a two weeks training course the specific requirements on data acquisition and documentation were defined and transformed into the TCDP Drilling Information System (TCDP-DIS). A group of four on-site scientists, the chief geologists and the PIs are now providing data input and maintenance the system. A small local area network consisting of one DIS server and two clients is used for the preparation of daily drilling reports, the descriptions and analyses of cuttings and cores, the initial lithological profile, acquisition of on-line gas monitoring data and downhole measurements, as well as sample archiving. One of the main objectives is the structural analysis of core samples from the Chelungpu-fault. Therefore, 360° unrolled digital core images are generated by a core scanner. These images will be used for measuring tectonic features, for core re-orientation through comparison with borehole wall images from Downhole logging. The dissemination and distribution of the data among the TCDP science team is secured by restricted Web access to the ICDP Information Network pages and the so-called Extended DIS, enabling the incorporation of all sort off-site laboratory data. For detailed information about scientific objectives, the team, and the progress, the public web pages are available at: *http://chelungpu.icdp-online.org.*

Kuo-Fong Ma, Institute of Geophysics, National Central University, Taiwan, ROC

ICDP Workshop: Scientific Drilling in Lake Peten-Itza, Guatemala

The Workshop

With sponsorship from ICDP, thirty-five scientists from nine countries met in Flores, Guatemala, this past summer (August 10 and 16, 2003) to discuss scientific drilling of Lake Peten-Itza (Fig. 1). The lake is located in the Department of Peten, northern Guatemala (16° 55'N, 89° 50'W), which covers 36,000 km^2 or nearly one-third of Guatemala's land area. With a surface elevation of 110 masl and a maximum water depth of 160 m, the lake is a cryptodepression that is ~50 m below sea level. It likely held water even during arid glacial periods and contains a valuable sediment archive of paleoclimate and environmental change in the northern lowland Neotropics for the last several glacial-to-interglacial cycles. Lake Peten-Itza is set within the Maya forest which constitutes the largest continuous expanse of tropical forest remaining in Central America and Mexico. The Peten has a long history of human occupation by the Maya civilization and contains some of the most important archaeological sites in Mesoamerica.

Workshop participants included representatives from Argentina, France, Guatemala, Germany, Italy, Mexico, Switzerland, United Kingdom, and the United States. Flores was an ideal location to hold the workshop because it is an island city in the southern basin of Lake Peten-Itza, thereby providing ready access to the lake we propose to drill.

The general purpose of the workshop was twofold: 1.) to define the scientific goals and drilling strategy for recovering long sediment cores from Lake Peten-Itza spanning several glacial-interglacial cycles; and 2.) to assemble an international team of experts who will collaborate to investigate a complete suite of paleoenvironmental proxies in the cores recovered.

The workshop agenda consisted of presentations, break-out groups, discussions and field excursions.

Fig. 1: Participants of ICDP Workshop assembled at Lake Quexil, Department of Peten, Guatemala (August 13, 2004)

Presentations

Mike Binford, Dave Enfield, and Pru Rice began the workshop by providing an overview of the geography, climatology, and archaeology of the Peten region, respectively. The Peten has been a region of paleoenvironmental study for over 30 years, and we compiled a bibliography of the literature that was distributed on CD-ROM at the workshop (see http://plaza.ufl.edu/hodell /info/reports.htm). Mark Brenner and Barbara Leyden reviewed past paleolimnological and palynological studies. Jason Curtis and Michael Rosenmeier presented case studies from cores collected from Lakes Peten-Itza and Salpeten, respectively.

Several talks focused on site selection and drilling operations in Lake Peten-Itza. Flavio Anselmetti presented the seismic stratigraphic architecture derived from site surveys conducted in 1999 and 2002, allowing prediction of sediment thickness and type as well as potential locations of suitable drill sites. David Hodell described the Kullenberg cores that were recovered from the lake in June 2002, providing an example of how Lake Peten-Itza sediments can be used to reconstruct environmental change during the Late Glacial and Holocene periods. Dennis Nielsen reviewed the capabilities of the GLAD 800 and 200 drilling systems, and summarized logistical and operational issues of drilling Lake Peten-Itza. Doug Schnurrenberger discussed core curatorial practices and services offered by the U.S. National Lacustrine Core Repository (LacCore) at the University of Minnesota where cores from Lake Peten-Itza will be housed. Uli Harms described the potential logistical support offered by ICDP including the capabilities of downhole logging tools. Paul Baker shared with us his experience in using GLAD800 to core Lake Titicaca in 2001.

Accurately dating lacustrine sediments is always challenging yet critical for placing events into a chronological framework. Tom Guilderson and Christina Gallup reviewed the strengths and weaknesses of using radiocarbon and U/Th dating techniques to date Peten-Itza sediment, respectively. Lastly, Alayne Street-Perrott described the application of compound-specific stable isotope analysis of organic biomarkers for reconstructing vegetation history of the region.

For further information on individual presentations, consult the Peten-Itza workshop website (http://plaza.ufl.edu/ hodell) where many of the Powerpoint presentations are available for viewing.

Break-out groups

A wide range of issues were discussed in the break-out groups including: drilling operations, logistics, permitting, education, outreach, modeling, climatology, hydrology, site survey and selection, downhole logging, geochemistry, sedimentology, geomicrobiology, organic geochemistry, geochronology, palynology, and microfossils (e.g., diatoms, ostracods, gastropods, chironomids, etc.).

Following the break-out meetings, a team leader presented a summary to the entire group, which was followed by plenary discussion. Many of the issues discussed apply not only to Lake Peten-Itza, but may have general relevance to future ICDP lake drilling projects.

Below we summarize the main points from each of the working groups:

<u>Operations</u>: The operational working group took several trips around the lake and identified a place on the northern shore in the small village of Jobompiche that is suitable for staging drilling operations (i.e., it is a natural boat ramp). The site is located west of two hotels (Camino Real and La Casa de Don David) that could be used as bases for feeding and lodging scientists and crew. The operations group formulated a tentative timeline for the project: Jan. 2004 (submission of proposals to ICDP and other funding agencies); Sep. 2004 (Pre-mobilization site visit); Jan. or Feb. 2005 (Mobilization), Feb./Mar. to Mar./Apr. 2005 (Drilling); early Apr. or May 2005 (Demobilization).

<u>Government regulations and community outreach:</u> Acquiring permits and developing strong working relations with local, regional, and national governmental and non-governmental agencies will be essential for a successful drilling campaign. Michael and Margaret Dix of the Universidad del Valle, Guatemala City, and Julio Hernandez of CONAP (Consejo Nacional de Areas Protegidas), provided guidance in terms of requirements for permits, environmental impact assessment, import/export, visas, etc. This process should be started as soon as possible to avoid delays in drilling. Hiring a local Guatemalan logistics manager and law firm could facilitate compliance with

regulatory policies. Outreach to the local community is important for conveying information about the project and maintaining good community relations. It is important for local and regional officials and the general populace to understand the goals of the project and to avoid any misconceptions that the project involves oil prospecting. Public information could be distributed though local news media (radio, newspaper) and town hall meetings. The project represents an educational opportunity for Guatemalan students and the working group recommended integrating college students into the research program.

Modeling and Modern Processes: Modern and historical observational data are for the most part lacking in and around Lake Peten-Itza, including basic meteorologic, limnologic, and hydrologic information. As is the case for many lakes, there are critical gaps in knowledge of modern processes and how these processes are recorded by lake sediment. Some of the data needs for Peten-Itza include monthly water column profiles (temperature, salinity, geochemistry, etc.), sediment traps, productivity measurements, meteorological data (temperature, precipitation, wind speed, etc.), and rainfall collection for stable isotope analysis. Basic data collection activities have traditionally been difficult to fund, but funding agencies must recognize that modern observational data are essential for calibration of proxy variables to modern lake and climatologic conditions. Routine collection of environmental data in Peten could be accomplished through cooperation with Guatemalan universities and NGOs (e.g., Wildlife Conservation Society, ARCUS, ProPeten, etc.). The Peten Drilling Project will require a strong modeling component to interpret results in a quantitative manner. For example, a hydrologic model will be needed to translate changes in oxygen isotopes and/or lake volume changes into estimates of changing evaporation and precipitation. Quantitative data will be needed for model input, which will require modern calibration of proxies and collaborative research among "paleoscientists", climatologists, hydrologists, and modelers.

Geomicrobiology/Sedimentology: The potential for integrated studies of microbiology, geochemistry, and sedimentology (authigenesis/diagenesis) is great in Lake Peten-Itza's sediment because of its high organic matter content, relatively high temperature, and the presence of dissolved sulfate in the water column and sediment pore waters. Peten-Itza's sediment can be thought of as a "bioreactor" where microbial populations play active roles in mineralization of organic matter, mineral authigenesis, and biogechemical cycling (especially the carbon and sulfur cycles). As an integral part of the Peten-Itza Drilling Project, a geomicrobiology program would entail a dedicated hole for biomass enumeration, contamination monitoring, subsurface microbial ecology, gas monitoring, and pore-water geochemistry to characterize the array of metabolic reactants and products in interstitial waters. Because many of these measurements are ephemeral, they must be made in the field soon after core recovery. The project will require containerized geochemistry and microbiology laboratories. A proposal for these field laboratories will be submitted to ICDP in January 2004 and the labs should be available the following year for use in Lake Peten-Itza. A pressurized core barrel (PCB) and downhole temperature probe would also be desirable. The working group strongly suggested that some cores be split and examined on-site.

Geochronology: Like most lake drilling projects, Lake Peten-Itza faces chronologic challenges that need to be addressed using a multi-method approach including radiocarbon, U/Th, geomagnetic paleointensity, tephrachronology, and possibly amino acid racemization dating. For radiocarbon, hard-water effects are a known problem but reliable dates can be obtained on terrestrial macrofossils (seeds, wood, charcoal, etc.) where they are preserved. U/Th dating of authigenic mineral phases (gypsum, aragonite) holds promise, but there are a number of questions to be addressed including origin of authigenic minerals, incorporation of detrital Th, concentrations of U and Th in modern lake water, and understanding Th adsorption/desorption processes. Ashes are episodically encountered in Peten-Itza sediment cores, thereby providing the possibility of using tephrachronology as a tool for correlation and dating (e.g., Ar/Ar). Paleomagnetism may be useful in Lake Peten-Itza because high-frequency variations in the geomagnetic field (direction and intensity) appear to be coherent over large spatial scales. For example, the Lachamp event is a well know decrease in geomagnetic intensity that has been useful for correlating lake and marine sediment cores and ice cores during the last glaciation (~ 41 kyrs during interstadial 10). Tests are currently underway using existing Kullenberg core material from Lake Peten-Itza to determine the potential application of each of these dating techniques.

Micropaleontology: Various microfossil groups (ostracods, gastropods, diatoms, chironomids, etc.) will be useful for reconstructing past environmental change in Lake Peten-Itza. Both assemblage information and geochemical analysis (elemental and stable isotopes) of microfossil hard parts should be exploited. Modern calibration studies are needed, however, to derive transfer functions relating assemblages to the range of physical and chemical conditions in lakes throughout the Yucatan Peninsula. Because of the large climatic gradients and range of water chemistries in lakes on the Yucatan Peninsula, transfer functions can be developed that span a wide dynamic range of environmental conditions.

Palynology: Previous pollen analysis in Peten lakes has documented the broad changes that occurred in vegetation during the last glacial and Holocene periods, but the response of lowland Neotropical vegetation to high-frequency climate variability and longer-term orbital forcing is not known. For example, there are hints from previous studies of Lake Quexil that vegetation may be responding to stadial-interstadial (Daansgard-Oeschger) cycles during Marine Isotope Stage 3. Pollen is generally well preserved in Peten lake sediments, although sediment resuspension and focusing can confound the record. Additional work on modern pollen rain studies across a broad geographic region would be useful, especially if a modern analogue could be identified for the pollen assemblage found during the cold, dry period of the last glacial maximum. Modern transfer functions are needed for providing quantitative estimates of past temperature and precipitation changes from pollen profiles. Charcoal analysis will be useful for inferring fire history as influenced by humans and/or climate.

Organic Geochemistry: There is great potential for using the stable isotopes of carbon and hydrogen of specific organic compounds of sediments in Peten lakes, as already demonstrated by Huang et al. (2001). Carbon isotopes of terrestrial biomarkers can be used to infer changes in the proportion of C-3 and C-4 biomass. This is a powerful tool when combined with pollen analysis. Hydrogen isotopes of terrestrial and algal biomarkers are proving useful for paleoclimate reconstruction, especially in sediments devoid of biogenic carbonate where construction of an oxygen isotope record is not possible.

Site Survey and Selection: The site survey group reviewed existing seismic and core data from Lake Peten-Itza and formulated a drilling strategy to meet the scientific objectives. Four major depositional sequences overlying basement have been identified that are bounded by unconformities or correlative conformities. Each of these seismic sequences represents depositional cycles that correspond to a rise and fall of lake level. The magnitude of lake level variation can be estimated by combining information from seismic geometries and appropriately placed sediment cores along a depth transect, which can be correlated using seismic stratigraphic techniques. The group recommended drilling a series of sites along a depth transect from ~30 m to near the deepest point (~150 m) in Lake Peten-Itza. Six primary sites will both recover continuous sections for paleoenvironmental reconstruction and constrain the vertical range of past lake level variations for glacial, interstadial, and interglacial stages beyond the last glacial period. For specific information on drilling strategy and site selection, see http://plaza.ufl.edu/hodell/drilling_plan/strategy.htm

Core and down-hole logging: Multiple holes at each site will be necessary to ensure complete recovery of the stratigraphic section. Holes will be correlated using closely-spaced core logging measurements made with the GEOTEK multi-sensor core logger. This needs to be done in near real time so that offsets between holes can be quickly estimated and communicated to the drilling rig. Down-hole logs will permit core-log integration, which is important for correcting composite depths for stretching and squeezing within cores. Lastly, both core and down-hole logging are vital for correlating the drilled sequences to seismic profiles.

Shore-based laboratories: The Peten-Itza Drilling Project will require the construction and use of several shore-based laboratories. Some of equipment needed, such as the Geotek MSCL, are already available through the ICDP logistical support group. Microbiology and pore-water geochemistry containerized laboratories are currently under consideration by ICDP. We envision renting a house in Peten that will serve as our shore-based laboratory. Facilities for splitting and describing some of the cores on site will also be available. We envision that a scientific party of approximately 15 individuals will be needed to man the drilling rig and shorebased laboratories. The laboratories will also provide opportunities for local and international student training.

Excursions
Several excursions were held during the workshop to introduce participants to the Peten Lake District. On the morning of day 2, the entire group went out in boats on Lake Peten-Itza to assess the physical characteristic (size, water depth, etc.) of the lake and the facilities available for logistical support. In the morning of Day 3, the group traveled from Flores to Yaxha by minibus and visited several lakes along the way (Lakes Petenxil, Quexil, Salpeten, Macanche, Sacnab, and Yaxha). We then conducted the break-out group sessions at Ecolodge El Sombrero on the shores of Lake Yaxha. Following the workshop, many attendees took advantage of an optional tour of the Maya site of Tikal led by archaeologist Pru Rice.

Summary of Workshop Findings
Several attributes make Lake Peten-Itza a strong target for drilling using GLAD800:

- It is the only lake known from the northern lowland Neotropics that is deep enough (165 m) that it held water even during full glacial periods.
- It is located in a climatically sensitive region where rainfall is highly seasonal and related to the migration of the ITCZ. It is influenced by the same seasonal variations in trade wind intensity and precipitation that affects upwelling and runoff to the Cariaco Basin, thereby offering a good opportunity to link a terrestrial lacustrine record with the marine Cariaco Basin record.

- Endoheric drainage renders the lake sensitive to the balance between evaporation and precipitation.
- Previous studies have shown that the Peten has undergone profound climate and environmental change from the arid last glaciation to the moist early Holocene. The history on millennial or shorter time scales is not known for the last glacial period and no paleoclimate data exist beyond ~36 kyrs.
- Lake Peten-Itza is set within the Maya forest, offering the opportunity to study the sensitivity and resilience of this tropical lowland environment to disturbance by people, climate, and fire.
- High organic matter and presence of dissolved sulfate renders Lake Peten-Itza's sediment a "bio-reactor" for integrated studies of microbiology, geochemistry, and sedimentology (authigenesis/diagenesis).
- The basin possesses a thick (>100 m) stratigraphic record that spans several glacial-to-interglacial cycles of the late Pleistocene. Drilling is the only means to recover pre-Holocene deposits because attempts using conventional Kullenberg coring have consistently failed because of a thick clay unit (known as the "Maya clay") that halts the penetration of piston corers even when fully loaded with lead weight.
- Three main scientific themes emerged from workshop discussions:
- Paleoclimatic history of the lowland Neotropics on orbital to suborbital time scales emphasizing marine-terrestrial linkages. Recovery of long continuous lacustrine archives from Lake Peten-Itza using GLAD800 will permit a number of hypotheses to be tested related to abrupt variability in temperature and humidity in the lowland Neotropics during the last deglaciation, glacial maximium, MIS 3, and beyond. Comparison of terrestrial records of Peten lakes (located at 17°N) with the marine record from Cariaco Basin (located at 11°N) will help establish the geographic extent and importance of abrupt humidity changes. Although the basal age of the sections to be drilled is not certain, we estimate that sequences should span the last few glacial-to-interglacial cycles. These older sequences will be useful for testing hypotheses dealing with the response of the northern lowland Neotropics to long-term forcing by orbitally-induced solar insolation changes.
- Paleoecology and biogeography of the Maya tropical lowland forest including the history of vegetation change and disturbance by humans, climate change, and fire. Although the Maya forest is the largest continuous expanse of tropical forest remaining in Central America and Mexico, it experienced widespread deforestation during the period of Preclassic and Classic -Maya occupation (~1000 B.C. to 900 A.D.). A long sequence from Peten-Itza would permit comparative study of pollen for the Holocene and older interglacial periods to assess human versus climatic impact on the tropical lowland forest. How did vegetation respond to long-term orbital forcing and abrupt climate change (e..g., Daansgard-Oeschger cycles) during the late Pleistocene? Knowledge of the sensitivity and resilience of this tropical lowland environment to disturbance is societally relevant because the Maya forest has recently been identified as a "hot spot" of deforestation and biotic diversity loss today.
- Biogeochemical cycling in deep lake sediments emphasizing integrated studies of microbiology, geochemistry (interstitial waters), and mineral authigenesis/ diagenesis. Geomicrobiology constitutes a strong complementary aspect to the other objectives of the Lake Peten-Itza Drilling Project and will constitute one of the first studies of the microbial biosphere in deep lake sediments. This project will parallel efforts to characterize the deep marine

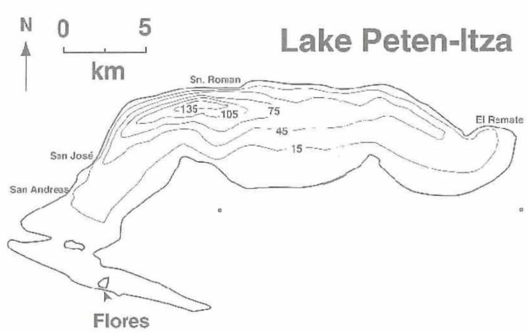
biosphere program by the Integrated Ocean Drilling Program. The program will address the role of microbes in the genesis and diagenesis of authigenic carbonates (dolomite, calcite, aragonite) and other mineral phases (e.g., gypsum, pyrite), and their implications for other studies (e.g., stable isotopes, magnetostratigraphy, U/Th dating, etc.).

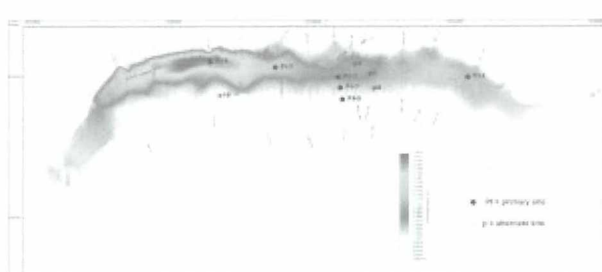
For more information, see the workshop web page (http://plaza.ufl.edu/hodell).

David Hodell, University of Florida, USA and
Mark Brenner, University of Florida, USA

Participants

Flavio Anselmetti, ETH-Zurich, Switzerland
Alex Arrivillaga, Universidad del Valle, Guatemala
Daniel Ariztegui, University of Geneva, Switzerland
Paul Baker, Duke University, USA
Michael Binford, University of Florida, USA
Mark Brenner, University of Florida, USA
Mark Bush, Florida Institute of Technology, USA
Jason Curtis, University of Florida, USA
Margaret Dix, Universidad del Valle, Guatemala
Michael Dix, Universidad del Valle, Guatemala
David Enfield, National Oceanographic and Atmospheric Administration, USA
Christina Gallup, University of Minnesota, USA
Thomas Guilderson, Lawrence Livermore National Laboratory, USA
Piero Guilizzoni, CNR-Istituto per lo Studio degli Ecosistemi (ISE), Pallanza, Italy
James Hall, Carnegie Institute, USA
Ulrich Harms, International Continental Drilling Program, Germany
Julio Hernandez, Consejo Nacional de Areas Protegidas (CONAP), Guatemala
Michael Hillesheim, University of Florida, USA
David Hodell, University of Florida, USA
Yongsong Huang, Brown University, USA
Gerald Islebe, Colegio de la Frontera Sur Chetumal, Mexico
Ulrike Kienel, GFZ-Potsdam, Germany
Barbara Leyden, University of South Florida, USA
Julieta Massaferro, Natural History Museum, London, United Kingdom
Judith McKenzie, ETH-Zurich, Switzerland
Sarah Newell, University of Florida, USA
Dennis Nielson, DOSECC, USA
Eduardo Piovano, Universidad de Cordoba, Argentina
Pru Rice, Southern Illinois University, USA
Michael Rosenmeier, University of Pittsburgh, USA
Douglas Schnurrenberger, University of Minnesota, USA
Antje Schwalb, Technische Universität Braunschweig, Germany
Joseph Stoner, INSTAAR, Univ. of Colorado, USA
Alayne Street-Perrott, University of Swansea, United Kingdom
Florence Sylvestre, Universite d'Angers, France





ICDP Workshop:
Japanese Ultradeep Drilling and Experiment
JUDGE Project

1. Introduction

The JUDGE Project Workshop was held at Chiba University, Chiba, Japan between November 14-and 17, 2002, under the auspices of the ICDP and with additional support from the Science-in-Aid Program of MEXT (Ministry of Education, Culture, Sports, Science & Technology)(Table 1). More than one hundred participants including sixteen from foreign countries whose specialities included earth sciences, drilling engineering and related fields joined the discussion on continental scientific drilling into the seismogenic part of a subduction zone (Table 2).

The Workshop was divided into five parts; namely, 1) statement of the problem of seismogenic zone drilling and review of such drilling projects in the world, 2) geological and geophysical summaries of the proposed JUDGE drill site (Boso Peninsula, Chiba), 3) field excursion to the Boso Peninsula and on-site discussion, 4) deep drilling experience in Japan and new drilling technology after KTB, and, 5) general discussion (Table 1).

The Workshop was a wonderful opportunity for participants to jointly discuss the state-of-the-art science and engineering related to ultra-deep drilling on a difficult target. There is no doubt that the great success of the workshop was made possible through the devotion of the convener Seiji Saito, Professor at Tohoku University. Dr. Saito, however, suddenly passed away on 20 March 2003 at his home in Sendai at the age of 53. I (Urabe) cannot find any words of consolation for his bereaved family as his ceaseless effort for preparation and the follow-up of the Workshop might have deteriorated his physical strength. I still remember his thoughtful condolence call when I was hospitalized two weeks after the Workshop to get surgery to remove my swollen gall bladder. He had both hot enthusiasm and cool knowledge on difficult drilling and had always been our leader and a good friend. The member of the JUDGE Committee still cannot recover from the loss of Saito-san and have lost the track to the further steps.

2. Individual Conclusions:

The discussion during the four days workshop leads us to the following conclusions:

2-1. Site survey:

- Seismic reflection profiles are crucial for the designing of the project. (Note: Dr. Hiroshi Sato of the Earthquake Research Institute conducted a large reflection seismic survey during the time of the workshop. His results show a clear subduction zone beneath the Boso Peninsula and make it possible to find drill site where we can penetrate the seismogenic zone shallower than 10 km.)
- Crossing profiling is necessary to determine the drill site
- A magneto-telluric survey will help to identify the interpretation
- Rock magnetism suggests the existence of oceanic crust beneath the southern Boso Peninsula.
- New thermal regime synthesis indicates that the bottom-hole temperature is 200-300°C at 10 km depth (Dr. Tanaka). This is much lower than previously assumed based on poor data and the temperature may only be 200 °C as the gradient becomes less steep as the hole goes deeper (Dr. Hyndman).

2-2. Seismic activity and its recurrence:

- Two different types of great inter-plate earthquakes were identified at Boso Peninsula based on the different nature of crustal uplift; Taisho type (1923) and Genroku type (1703). The recurrence time is long (>200 years) and the risk of a "next" great earthquake is believed NOT to be "urgent". We must admit, however, that we know very little about the mechanism of generation of "great" earthquake as was indicated by Dr. Kanamori.

- Lateral differential stress is not a problem for the JUDGE project. Stress measurement indicates that the lateral differential stress is low and the value at the nearest deep hole (~2km) indicates that the hole is under the stress condition of normal fault.
- New GPS measurements identified a silent slip event off the east coast of the southern Boso Peninsula. However, the subduction zone thrust seems to be locked beneath the Boso Peninsula.
- A new idea was introduced that the subducting plate is locked 100% at Nankai Trough and 50% at Sagami Trough (Dr. Seno).
- We have to re-evaluate the geophysical results based on new data on seismic Reflection Profiling (Drs. Sato, Ito), GPS measurement (Dr. Sagiya), coseismic uplift (Dr. Shishikura), detailed geology (Dr. Ogawa).

2-3. Drilling technology

- Three key technical problems; coring, the casing program and the high temperature problem were the main targets of the discussion.
- The coring technology is the key issue for a scientific drilling such as the JUDGE project. Russian engineers developed a core barrel and coring bit assembled in BHA for the ultradeep hole of SG-3. This method, however, takes time as tripping is required for every coring operation. The most plausible method is, therefore, wireline coring as was applied for the KTB holes. The 10,000 meter wire is not commercially available at the moment but we may overcome this problem by connecting two 5,000 meter wire to form a 10,000 meter wire.
- The appropriate design of core strings is essential for the success of the project. The coring-while-drilling (CWD) method is an option, which is currently used in the ODP program. The Rotary Core Barrel (RCB) and Advanced Diamond Core Barrel (ADCB) are the most useful tools for the JUDGE drilling to get high quality cores at a high recovery rate. A Pressure Core Sampler (PCS) is also available if necessary at pressures below 10,000psi.
- New technologies such as Casing Drilling and Expandable Casing may substantially reduce the risk of limiting hole depth due to an inappropriate casing program or unexpected borehole instability. The Casing Drilling will reduce time as it enables us to do cementing directly after drilling. However, the technology was not tested in deep holes but in 54 shallow holes whose depth is less than 3,000 meters and needs further evaluation. On the other hand, the Expandable Casing has been used in 97 holes including one at the depth of 8,500 meters and a max. temperature of 200°C. This technology is promising for the JUDGE main hole.
- One of the most difficult challenges in the JUDGE main hole is the high temperature (up to 300°C) as well as its depth. We will face limitation in the use of BHA tools, down-hole measurement tools and drilling mud. Coring may reduce the efficiency of TDS (Top Drive System)-cooling and fast mud circulation and new high temperature tools should be developed to allow for a smoother operation. Especially, high-temperature VDS (Vertical Drilling System) and MWD (Measurement While Drilling) are highly desirable.

3. Overall Conclusions:

Workshop participants unanimously agreed after four days of intensive discussion and a field excursion that the 10 km deep JUDGE hole is not only of prime scientific importance but also technically possible because of the following reasons;

(a) The JUDGE project is complementary to all the existing seismogenic zone drilling programs on land and in the ocean and will answer the essential scientific problem of the generation of great earthquakes, which threatens the life, and property of metropolitan Tokyo in Japan.

(b) Geophysical/geological conditions such as temperature gradient, regional lateral stress, nature of the rocks of the Boso Peninsula are proven to be less hostile as estimated before. The site is proven to be the prime target of land-based ultradeep drilling into a seismogenic zone.

(c) All-coring is strongly recommended by geoscientists both for the pilot and main holes as the detailed geological observation will give essential information on the tectonic development of the area. Therefore, we may modify the original plan of spot coring (about 10%) in the pilot hole, if coring will not add extra cost to the operation through small modifications to the existing oil/gas exploration rig as was suggested by a participant. All-coring is planned for the main hole where the depth exceeds more than that of the pilot hole.

(d) New technologies after KTB and Kola combined with the development of high-temperature instruments and materials, including those which may come in stream in near future make it possible to overcome difficulties we have for the ultra-deep hole.

(f) Further communication and collaboration among a small number of the group (engineers and geoscientists) are needed to integrate new/existing technologies to achieve our common goals.

(e) We had not enough time to come to a conclusion on the necessity of a pilot hole; most Japanese engineers preferred to conduct a pilot hole (6 km deep) to evaluate the geologic condition of the area before we start the main hole. Others, however, claimed that re-evaluation is needed if the purpose of the pilot hole is only to follow the KTB example.

4. Publication

We have published the report of the Workshop as a full paper and two articles in the ICDP-Japan Newsletter.

- Urabe, T. and Y. Suto (2003) JUDGE Project as a Challenge of Geo-technology. *Tsuchi-to-Kiso (Soils and Foundation)*, 4 pages (in Japanese: in press)
- Urabe, T. and S. Saito (2003) A report on JUDGE Project Workshop, ICDP-Japan Newsletter, V.4, p.4 (in Japanese)
- Urabe, T. (2003) JUDGE Project, ICDP-Japan Newsletter, V.5, p.4 (in Japanese)

5. Further Activity

We share a consensus that the present economic situation in Japan makes it difficult to get funding for the JUDGE project in the very near future. So we are going to establish a "Continental Drilling Division" of J-DESC (Japan Drilling Earth Science Consortium) in November 2003. The J-DESC (http://www.aesto.or.jp/j-desc/index.html) was first established in March 2003 as a consortium among forty-one geoscience institutes in Japan to discuss the scientific planning of IODP. The Continental division will discuss the long-range science plan of continental drilling in Japan including the JUDGE project in collaboration with IODP Division people. This will boost the feasibility study of not only JUDGE but also other continental drilling proposals and plans.

6. Acknowledgement

We are deeply indebted to the ICDP for their support and help provided during the preparation of the workshop. We also appreciate financial support from MEXT, which is mainly used to invite Japanese participants. The success of the Workshop was possible through presentation of excellent talks by invited speakers and poster presenters listed in Table 2. The workshop was organized by JUDGE Committee and people from the Chiba University. They includes Ryuji Ikeda, Tanio Ito, Yujiro Ogawa, Masanobu Shishikura, Saneatsu Saito, Yasuo Sakura, Kenji Satake, Akiko Tanaka, Hiroaki Tsukahara, Hitoshi Kojima, Kunio Yoshida, Takahiro Miyauchi, Iyoko Takinami, Yuriko Tomura, Chuichiro Asai, Kuniaki Kato, Akihiro Kimura, Takashi Okabe, Shoichi Ikeda, Jun Tomomoto, Kazuo Minami, Yuko Suto, and Junya Takashima.

Tetsuro Urabe, Department of Earth and Planetary Science, University of Tokyo

Roy D. Hyndman, Pacific Geoscience Centre, Geological Survey of Canada

Seiji Saito*Geo-engineering Department, Tohoku University, (*deceased on 20 March 2003)

Workshop Participants

Kosaku Arai, Ministry of Education, Science and Technology
Chuichiro Asai, SK Engineering Co., Ltd.
Katsuyoshi Daimon, SK Engineering Co., Ltd.
Nader Dutta, Western Geco
Tatsuki Endo, Schlumberger K.K
Ken Fujii, Japan Petroleum Exploration Co., Ltd.
Diaa Hamed, University of Tsukuba
Norikazu Hashimoto, Geophysical Surveying Co.,Ltd.
Tetsuo Hatasaki, Dowa Engineering Co., Ltd.
Ryuji Ikeda, Hokkaido University
Shoichi Ikeda, Teikoku Oil Co., Ltd.
Koki Ikeda, Japan Nuclear Cycle Development Inst.
Atsuyuki Inoue, Chiba University
Tanio Ito, Chiba University
Takeshi Ito, SK Engineering Co., Ltd.
Takatoshi Ito, Tohoku University
Hirokazu Karasawa, National Institute of Advanced Industrial Science and Technology (AIST)
Hirokazu Kato, AIST/GSJ*
Kuniaki Kato, Nikko Exploration & Development
Shunsuke Kawakami, University of Tsukuba
Kazuhiro Kawarura, Teikoku Oil Co., Ltd.
Akihiro Kimura, Japan Technical Association of Drilling
Shomei Kobayashi, JAMSTEC**,
Shinichi Kodama, NLC Co., Ltd.
Hitoshi Kojima, Superdeep Core Drilling Group
Yasushi Komoda, Sumiko Consultants Co., Ltd.
Atsushi Konnno, Telnite Co., Ltd.
Kimiaki Kudo, JAMSTEC**
Shinichi Kuramoto, JAMSTEC**
Takeshi Maki, Teikoku Oil Co., Ltd.
Isao Matsunaga, National Institute of Advanced Industrial Science and Technology
Ryo Matsumoto, The University of Tokyo
Hitoshi Mikada, Japan Marine Science and Technology Center
Kazuo Minami, Teiseki Drilling Co., Ltd.
Takahiro Miyauchi, Chiba University
Nobuo Morita, Waseda University
Takeshi Naganuma, Hiroshima University
Toshiyasu Nagao, Tokai University
Haruya Nakata, Geothermal Energy Research and Development Co., Ltd.
Makoto Nakamukae, Osaka City University
Masao Nakanishi, Chiba University
Nishikawa Toru, JAMSTEC**
Yosuke Nomaguchi, Cosmos Shoji Co., Ltd.
Toru Nomoto, Smith Bits Japan
Yujiro Ogawa, University of Tsukuba
Hiroshi Ohashi, Japan Technical Association of Drilling
Takashi Okabe, Geothermal Energy Research & Development Co., Ltd.
Kentaro Omura, National Research Institute for Earth Science and Disaster Prevention
Toshiki Ohtaki, AIST/GSJ
Jin Oh Park, JAMSTEC**
Takeshi Sagiya, Geographical Survey Institute
Seiji Saito, Tohoku University
Saneatsu Saito, JAMSTEC**
Yasuo Sakura, Chiba University
Akio Sakai, Japan Petroleum Exploration Co., Ltd.
Yutaka Sakai, Research Institute of Environmental Geology, Chiba,
Kenji Satake, AIST/GSJ
Hiroshi Sato, Earthquake Research Institute, University of Tokyo
Tadashi Sato, Fukada Geological Institute
Keizo Sayanai, Tokai University
Tetsuzo Seno, Earthquake Research Institute, University of Tokyo
Kuniaki Shimada, Teiseki Drilling Co., Ltd.
Shoichi Shinada, Japan Petroleum Exploration Co., Ltd.
Masanobu Shishikura, AIST/GSJ
Kiyoshi Suyehiro, Japan Marine Science and Technology Center
Yuko Suto, Tohoku University
Masayoshi Suzuki, Geophysical Surveying Co., Ltd.
Keiichi Suzuki, Daiichi Jitsugyo Co., Ltd.
Junya Takashima, The University of Tokyo
Teruo Takeyama, Nikko Exploration & Development
Iyoko Takinami, The University of Tokyo

Tan Thing Aung, University of Tsukuba
Masuaki Tanada, Japan Nuclear Cycle Development Institute
Akiko Tanaka, AIST/GSJ
Hidemi Tanaka, The University of Tokyo
Ryusuke Tanaka, Daiichi Jitsugyo Co., Ltd.
Yuichiro Tanioka, Meteorological Research Institue
Seiji Tasaki, Teikoku Oil Co., Ltd.
Jun Tomomoto, SK Engineering Co., Ltd.
Yuriko Tomura, Chiba University
Satoshi Tono, Teikoku Oil Co., Ltd.
Hiroaki Tsukahara, Shinshu University
Makoto Tsuruta, Teikoku Oil Co., Ltd.
Akira Ueda, Mitsubishi Materials Corp.
Toshiya Uenoyama, Ministry of Education, Culture, Sports, Science and Technology
Toshiro Kaminishi, Teikoku Oil Co., Ltd.
Tetsuro Urabe, The University of Tokyo
Taigo Wada, JAMSTEC**
Minoru Yamakawa, Japan Marine Science and Technology Center
Toshiya Yamamoto, Geophysical Surveying Co., Ltd
Koji Yamamoto, Japan National Oil Corporation
Muneo Yamano, Daiichi Jitsugyo Co., Ltd.
Takanobu Yokokura, AIST/GSJ
Satoru Yokoi, Japan Petroleum Exploration Co., Ltd.
Kunio Yoshida, Superdeep Core Drilling Group
Kose Yoshida, Superdeep Core Drilling Group
Norifumi Yoshida, Halliburton Overseas Limited
Morimasa Yoshii, SK Engineering Co., Ltd.
Ulrich Harms, GeoForschungsZentrum Potsdam
Tuncay Taymaz, Istanbul Technical University
Harold J. Tobin, New Mexico Tech
Roy Hyndman, Pacific Geoscience Centre
Mark D. Zoback, Stanford University
Hiroo Kanamori, CALTECH
Achim J. Kopf, Scripps Institute of Oceanography
John Rowley, Pajarito Enterprise
Mary Rowley, Pajarito Enterprise
Robert Tessari, TESCO, Canada
Janell Weeks, TESCO, Canada
Bill Dean, Eventure, U.S.A.
Bernd Wundes, BRR, Germany
Mike Gelfgat, Aquatec, Russia

** Prof. Dr. Seiji Saito received his BE and ME degrees from the Department of Mineral Industry and Engineering, Waseda University in 1973 and 1975, respectively. He then joined the Geothermal Division of Japan Metals & Chemicals (JMC) Co., Ltd. as an exploration geologist for geothermal energy. In 1980, he started to pursue a career as a drilling engineer in the company and has been engaged in more than 100 geothermal well drillings since that time at various geothermal fields in Japan, Los Alamos in USA, and La Primavera in Mexico. His talent got into the limelight in 1993 when he successfully drilled an ultra-high temperature geothermal well at the Kakkonda geothermal field, in northern Japan. The bottom-hole temperature reached 540°C at the depth of 3,729 meter which is the highest ever recorded in a drilled hole. He received a Doctor of Engineering Degree from Waseda University for his contribution. He was promoted to a Professor at the Department of Geoscience and Technology, Graduate School of Engineering, Tohoku University in 1998 where he is involved in research on exploration and drilling for geothermal energy, oil, and gas. He has been involved in many continental scientific drilling projects of the world including Lake Baikal, Unzen, super-critical geothermal drilling in Iceland, and the JUDGE project. His experience and knowledge are unique and many geologists and geophysicists request his opinion when they plan scientific drilling. His frankness, earnestness and natural behavior attracted many people around him*

ICDP Workshop:
Orava Deep Drilling Project: Anatomy and evolution of the European/African Collisional Suture in a mantle plume-modified orogen

The ICDP international workshop "Orava Deep Drilling Project: Anatomy and evolution of the European/African collisional suture in a mantle plume-modified orogen" was held on August 31-September 4 in Zakopane, Poland. The workshop was financially supported by the ICDP, the Polish Ministry of Scientific Research and Information, and the Institute of Geophysics of the Polish Academy of Sciences.

The aim of the workshop was to discuss the scientific value and the strategy of the proposed deep drilling located in the Carpathian Mountains at the Polish-Slovak border in Central Europe. Sixty six scientists from thirteen countries participated in this workshop. The special monographic volume (Golonka and Lewandowski, 2003) was published by the Polish Academy of Sciences, Jagiellonian University, and ICDP to accompany the workshop. Another book, containing the results of the workshop, is planned to be published in the near future.

RATIONALE

The scientific backbone for the **O**rava **D**eep **D**rilling **P**roject (ODDP) will be the recognition of structural relationships at depth in the suture zone between the European continent and Africa/Apulia?-derived terranes in the Western Carpathians, the relationship between magmatic records and geodynamic setting, the possibility of an active asthenosphere uplift and related geophysical anomalies, the renewable energy resources, and other issues. A significant progress in the investigations of geodynamics and plate tectonics of the Carpathian Fold Belt (CFB) in Slovakia, Poland, and adjacent areas was achieved in the last years (Birkenmajer, 1986; Golonka et al., 2000; Kovác et al., 1998; Plašienka et al., 2000,). This progress enabled to formulate new scientific ideas and highlight problems that could be solved by the scientific drilling. In Poland, Slovakia, and Czech Republic, CFB consists of an older unit known as the Central (or Inner) West Carpathians (CWC) and a younger one, known as the Outer West Carpathians (OWC after Plašienka et al., 2000), the latter being overthrust onto the southern part of the European platform (Cadomian or Hercynian basement, e.g., Picha, 1996). The depth of the cratonic basement in the suture zone, according to the results of the deep

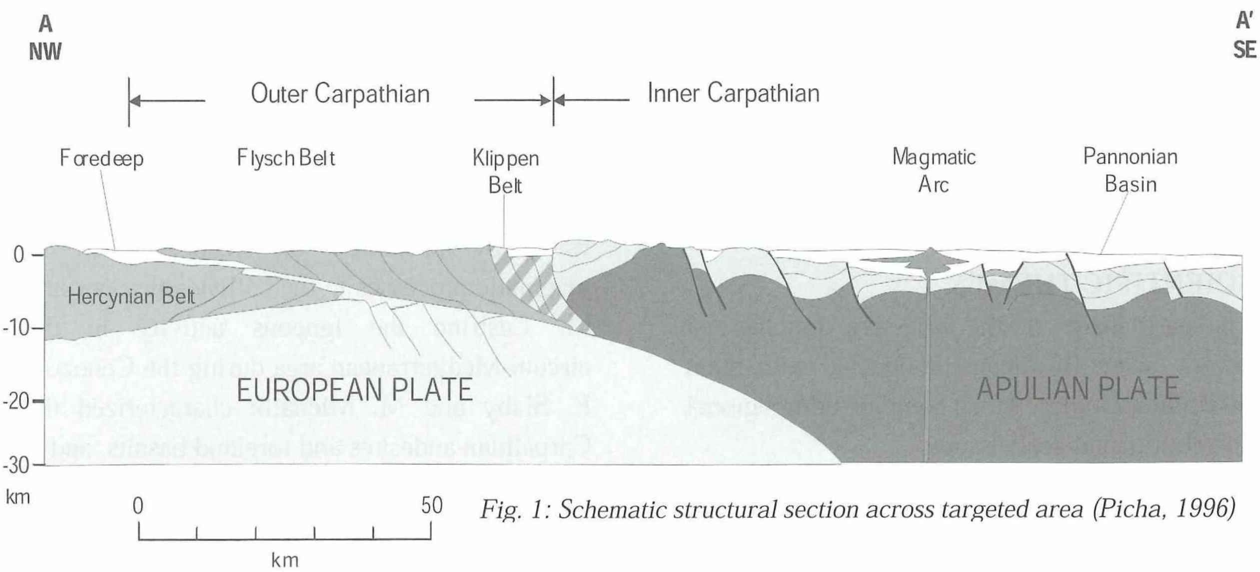


Fig. 1: Schematic structural section across targeted area (Picha, 1996)

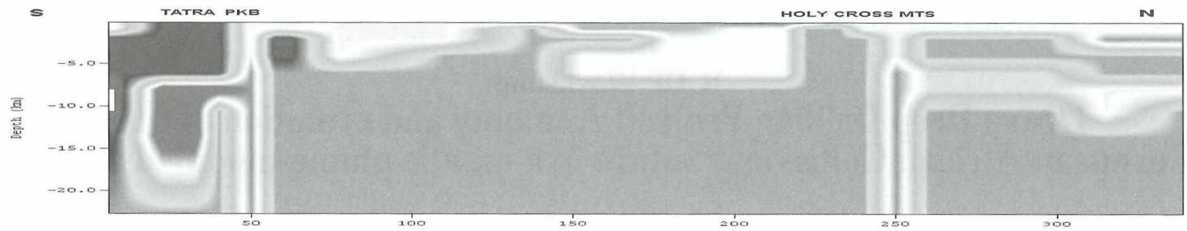


Fig. 2: Distribution of the electric resistivity from the Carpathians (S) to the Precambrian Platform (N)

seismic CELEBRATION profile, (Guterch et al., 2001), magnetotelluric, and magnetic soundings (e.g. Zytko, 1997), is below 6-8 km (the basement depth calculated from the platform bending is 10 km). Enigmatic basement uplift exists despite the general south dip of the European platform under the north-western Carpathians that may be caused by the geothermal uplift of the asthenosphere, replacing delaminated lithosphere, or by mantle plumes, or by the basement-involved thrust faults. The boundary between the overriding CWC (Alcapa plate, e.g. Plašienka et al., 2000) and the European plate is the Pieniny Klippen Belt (PKB, built of the Mesozoic sedimentary successions, once deposited in basins situated between the European craton and the margin of the northern Africa. At present, the PKB is almost 700 km long and strongly compressed constituting a tectonically complicated suture zone. In this relatively narrow belt comprising the PKB and adjacent, still poorly recognized units (Birkenmajer, 1986; Plasienka et al., 2000: Aubrecht et al., 2002), there is a wealth of unanswered questions that hamper a better understanding of the Central European Alpine system evolution. To address these questions a broad geophysical and geological research program is on the way. The ODDP will be an integral component of this research.

SCIENTIFIC THEMES

The participants of the workshop emphasized several scientific themes connected with main disciplinary topics, which combine both regional and continental-scale issues:

TOPIC 1. Structural position of PKB within CFB and its meaning for a reconstruction of the Cenozoic Alpine system of Europe

Several regional geology papers addressed the geology, geophysics, and stratigraphy of the West Carpathian and adjacent areas. Papers by A. Slaczka and N. Oszczypko dealt with the basement of the West Carpathians and its megaregional links. R. Stephenson presented the role of suture zones and terranes in the Central European geology, while Z. Paul et al. discussed the problems of Paleozoic accretion of Eurasia. M. Krobicki et al. presented the geology of the Pieniny Klippen Belt, M. Potfaj the geology of the Slovakian Orava, M. Cieszkowski the flysch of the Outer Carpathians, A. Gaweda et al. the Paleozoic (metamorphic, granites) of the Inner Carpathians (Tatra Mts), A. Uchman the Mesozoic of the Tatra Mountains, J. Lefeld the tectonics of the Tatra Mountains, Z. Stranik the Bohemian Massif and relationship between European and Alcapa platform in the Carpathians. Stratigraphy and micropaleontology issues of the West Carpathians and their basement were presented in papers by D. Rehakova, L. Svabenicka, B. Olszewska, A. Tomas, and M. Moczydlowska.

TOPIC 2. Relationship between geotectonic and geodynamic setting and magmatogenesis

E. Slaby presented the reconstruction of magmatic processes in the collisional zones and M. Lustrino the igneous activity in the circum-Mediterranean area during the Cenozoic. E. Slaby and M. Michalik characterized the Carpathian andesites and foreland basalts, and L. Lawver et al. talked about plumes, orogenesis, and supercontinental fragmentation

TOPIC 3. Nature of the geophysical anomalies

The Carpathian Anomaly of Electrical Conductivity was the topic of the J. Jankowski and O. Praus paper, while the results of the magnetolluric sounding in the Polish Carpathians were presented by M. Stefaniuk et al. The Structure of the Circum-Carpathian lithosphere derived from the deep seismic sounding were the subject of papers by Celebration 2000 Working Group, while M. Bielik presented the actual knowledge of the lithosphere structure in the Orava Drilling area.

TOPIC 4. Geothermal issues

Geothermal regime of the Inner Carpathians in Poland was the topic of paper B. Kepinska and J. Chowaniec, the geothermal issues were also presented in details during the visit in the Geothermal Laboratory in Banska Nizna.

TOPIC 5. Geodynamic reconstruction of the Mesozoic-Cenozoic basins.

Papers by D. Plasienka, J. Golonka, E. Marton, M. Lewandowski et al. presented the various issues of paleomagnetism, plate dynamics, and palinspastic reconstruction of the Carpathians.

TOPIC 6. Oil generation, migration, and timing.

F. Picha presented broad issues of the exploration in the thrustbelt, while the Polish Oil and Gas Company team (P. Dziadzio, R. Florek, and A. Maksym) discussed oil prospects of the Zawoja - Orava area in the West Carpathians.

TOPIC 7. Regional heat-flow evolution.

The heat-flow evolution aspects were included in papers B. Kepinska and J. Chowaniec and by J. Golonka, and also by a paper by J. Safanda, J. Szewczyk, and J. Majorowicz.

TOPIC 8. Identification and definition of the Cadomian-Hercynian basement structure of the Carpathians

This topic was related with Topic 1 and was covered in detail in papers by A. Slaczka and N. Oszczypko and mentioned in many other papers covering the Carpathian geological, geophysical, and micropaleontological themes.

TOPIC 9. Paleostress evolution and its changes in horizontal and vertical section.

These topics were covered in papers by M. Jarosinski and F. Marko.

TOPIC 10. Technical aspects of the deep drilling

These issues were covered by the POGC team and by A. Förster (on behalf of the ICDP Operational Support Group). J. Jarzyna gave an overview of well-logging tools that could be employed.

Fig. 3: Field trip discussion at the Wzar t. andesites (Photo: A. Maksym)

FIELD TRIPS

These cornerstone issues were also discussed and demonstrated during the workshop field trips. The participants got insight into the geology the Tatra Mountains representing the basement and sedimentary cover of the Inner Carpathian, the geology of the Pieniny Klippen Belt, the geology of the flysch unit of the Magura Nappe in the Western Carpathians, the Carpathian andesites, and the geothermal facilities of the Podhale-Orava region.

Fig. 4: A. Gaweda is showing the Inner Carpathian basement at the Kasprowy Wierch (Tarta Mts) (Photo: M. Potfaj)

THE SUMMARY DISCUSSION

The main scientific themes and problems connected with the proposed borehole were discussed during the final summary discussion. The participants agreed upon a main theme of the planned borehole, which is: "Anatomy and evolution of the European/African collisional suture in a mantle plume-modified orogen". The project should concentrate on the following sequence of the most important problems:

1. development of basins and their subsequent tectonic evolution
2. seismic risk
3. nature of the magnetolelluric anomaly
4. geothermal potential
5. hydrocarbon potential

The broad geological and geophysical research program is necessary to pinpoint the exact location of the well in the Orava region. The procedure will be:

1) Recognition of the geology along the N-S or NE-SW Carpathian transect by means of:
   - Compilation of all existing geological and geophysical data
   - Corridor geological mapping
   - Deep seismic reflection profiling
   - Magnetotelluric profiling
   - Gravity and magnetic anomaly mapping
   - Accompanying research on: stratigraphy, petrology, geochemistry, structural geology, magnetometry, paleomagnetics, geothermics, palinspastic reconstruction, hydrogeology, and petroleum systems.
2) Definition of problems and alternatives derived from the research program
3) Well location and drilling

FOLLOW UP TO THIS WORKSHOP

The steering committee for the project:

Supervisors:

Jan Golonka, Jagiellonian University
Mihal Potfaj Geological Survey of the Slovak Republic
Piotr Dziadzio, Polish Oil and Gas Company
Marek Grad, Warsaw University
Ales Spicak, Geophysical Institute, Academy of Sciences of the Czech Republic
Miroslav Bielik, Slovak Academy of Sciences

The steering committee will prepare the research project and submit it to the Polish Ministry of Environment. They will also seek founding from the Polish Oil and Gas Company and Polish State Committee for Scientific Research. The workshop participants are encouraged to submit the scientific papers to be published in the ASGP (Journal of the Polish Geological Society) or by the Polish Academy of Sciences - Special Publication.

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Jan Golonka, Jagiellonian University, Krakow, Poland

Marek Lewandowski, Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland

PARTICIPANTS

Adam Tomas, Polish Geological Institute, Krakow
Aleksander Guterch, Institute of Geophysics, Polish Academy of Sciences, Warsaw
Aleksandra Gaweda, University of Silesia, Sosnowiec
Ales Spicak, Geophysical Institute, Academy of Sciences of the Czech Republic, Praha
Alfred Uchman, Jagiellonian University, Krakow, Poland
Andrea Förster, GeoForschungZentrum Potsdam
Andrzej Khudoley, St. Petersburg State University, St. Petersburg
Andrzej Maksym, Polish Oil and Gas Company, Jaslo,
Andrzej Slaczka, Jagiellonian University, Krakow, Poland
Aneta Mroczko, Jagiellonian University, Krakow
Anna Tomas, Polish Geological Institute, Kraków
Beata Kepinska, Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Krakow
Daniela Reháková, Comenius University, Bratislava
Duncan Keppie, Universidad Nacional Autonoma de Mexico, Mexico City
Dušan Plašienka; Comenius University, Bratislav
Emo Márton, Eötvös Loránd Geophysical Institute of Hungary, Budapest
Ewa Ginal, Ministry of Environment, Warsaw, Poland
Ewa Slaby, Warsaw University, Warsaw
Frank Picha, International Consultants, Walnut Creek, California
František Marko, Comenius University, Bratislava
Hans-Jürgen Förster, University of Potsdam
Igor Popadyuk, Ukrainian State Geological Research Institute, Lviv
Jadwiga Jarzyna, University of Mining and Metallurgy, Krakow
Jan Golonka, Jagiellonian University, Krakow
Jan Šafanda, Geophysical Institute, Academy of Sciences of the Czech Republic, Praha
Jan Szewczyk Polish Geological Institute, Warsaw
Janusz Trzepierczynski, University of Silesia, Sosnowiec
Jean-Louis Mansy, Lille University, Lille
Jerzy Jankowski, Institute of Geophysics, Polish Academy of Sciences, Warsaw
Jerzy Lefeld, Institute of Geological Sciences, Polish Academy of Sciences, Warsaw
Józef Chowaniec, Polish Geological Institute, Kraków
Józef Omulak, Babia Gora National Park, Zawoja
Konrad De Lewenstein, Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Krakow
Larry Lavwer, University of Texas et Austin, Austin
Lilian Švábenická Czech Geological Survey, Praha
Malgorzata Moczydlowska-Vidal Uppsala University, Uppsala
Marcin Kudlik, Jagiellonian University, Krakow
Marek Cieszkowski, Jagiellonian University, Krakow
Marek Grad, Warsaw University, Warsaw
Marek Jarosinski, Polish Geological Institute,Warsaw
Marek Lewandowski, Institute of Geophysics, Polish Academy of Sciences, Warsaw
Marek Michalik, Jagiellonian University, Krakow
Marian Kulawiak, Babia Gora National Park, Zawoja
Mariusz Paszkowski, Institute of Geological Sciences, Polish Academy of Sciences, Krakow
Michal Krobicki, University of Mining and Metallurgy, Krakow
Michal Matašovsky, Comenius University, Bratislava
Michal Stefaniuk, University of Mining and Metallurgy, Krakow
Michelle Lustrino University of Rome La Sapienza, Rome
Mihal Potfaj Geological Survey of the Slovak Republic, Bratislav
Miroslav Bielik, Slovak Academy of Sciences, Bratislava
Olga Karousova Geophysical Institute, Academy of Sciences of the Czech Republic, Praha
Pawel Aleksandrowski Wroclaw Uniwersity, Wroclaw
Piotr Dziadzio, Polish Oil and Gas Company, Jaslo
Radoslaw Florek, Polish Oil and Gas Company, Krakow
Randell Stephenson, Vrije University, Amsterdam
Roman Aubrecht, Comenius University, Bratislava
Ryszard Myszka, Malopolska Province, Krakow
Teresa Grabowska, University of Mining and Metallurgy, Krakow
Tomasz Lamorski, Babia Gora National Park, Zawoja
Waldemar Józwiak, Institute of Geophysics, Polish Academy of Sciences, Warsaw
Zbigniew Bula, Polish Geological Institute, Sosnowiec
Zbigniew Paul, Polish Geological Institute, Kraków
Zdenek Stranik, Czech Geological Survey, Brno
Zofia Wal, Jagiellonian University, Krakow

ICDP Workshop: 4D Geologic Evolution of the Sudbury Impact Structure

Introduction

A second planning workshop for the proposed ICDP project on the *4D Geology of the Sudbury Impact Structure* was held in the Willet Green Miller Mineral and Mining Research Centre on the Laurentian University campus in Sudbury on 17-20 September 2003. The purpose of the workshop was to identify key gaps in our knowledge of the Sudbury Structure, to determine which can be addressed in a deep drilling project, to identify the methods to be used to solve those problems, and to put together an administrative structure for developing the proposal and conducting the research.

The workshop was attended by 78 scientists from 8 countries, including Austria, Canada, Finland, Germany, Iran, Ireland, South Africa, and the United States. A reception at *Dynamic Earth*, attended by the participants and representatives from the City of Greater Sudbury, many of the major and junior mining companies, and Laurentian University, included presentations by Professor Emmermann, President of ICDP, and Dr. John Gammon, Assistant Deputy Minister of Mines for the Province of Ontario. The Workshop was covered by radio (Radio Canada), TV (MTV, Discovery Channel), and both local and national newspapers (*National Post*, *Sudbury Star*).

Background

The Sudbury Impact Structure is a world-class geological site located in northern Ontario, close to the convergence of three structural provinces of the Canadian Shield. It is one of the world's largest meteorite impact structures, it hosts some of the world's largest and most valuable Ni-Cu-PGE deposits, and it represents one of the best places on Earth to solve fundamental problems regarding meteorite impact, melt sheet crystallization, and magmatic ore-forming processes. It is a district of great economic importance, as ores worth ~$110 billion (contained metal in 2003 dollars) have been extracted to date, current production is worth ~$1.2 billion per year, and significant new discoveries continue to be made. Although the area has been the focus of intense mineral exploration, many geological studies, and a *Lithoprobe* transect, many aspects of the geologic evolution of the area remain unknown or open to interpretation and therefore require further investigation. Advances in the understanding of the structure will require a coordinated, intensive, multi-disciplinary approach by a network of experts using state-of-the-art data acquisition, integration, and visualization techniques.

The project will be a multi-disciplinary collaborative partnership between several Canadian and US universities (Laurentian, Toronto, New Brunswick, Western Ontario, McMaster, Ottawa-Carleton, Alberta, British Columbia, Calgary, Manitoba, Memorial), the Ontario Geological Survey and Geological Survey of Canada, several mineral exploration and mining companies (Inco Ltd., Falconbridge Ltd., FNX Ltd.), and several overseas universities (Berlin, Johns Hopkins, Monash, Münster, New Mexico Tech, Potsdam, and Vienna) that will bring together experts in structural geology, surface and borehole geophysics, remote sensing, geochemistry, petrology, ore genesis, meteorite impact mechanisms, crustal fluids, and the deep biosphere.

The project will utilize new and existing surface and near-surface geological, geophysical, geochemical, and structural data, previously inaccessible industrial geological and geophysical data, existing Lithoprobe seismic reflection data, and new geological, geophysical, and petrological data collected from several deep (5-6 km) cores to be drilled in partnership with the International Continental Scientific Drilling Program (ICDP). The state-of-the-art Virtual Reality Laboratory (VRL) at Laurentian will be used to visualize and interpret the results in 3 and 4 dimensions.

Format of the Workshop

The first day included 20-minute summary presentations on key knowledge gaps in each of the research and technical areas to be addressed in the project, followed by 25-minute discussion periods. The morning of the second day included a visit to a deep drilling rig at the Falconbridge Nickel Rim south deposit, a demonstration of the Laurentian University VRL using 3D models of the Sudbury Structure developed by Inco and Falconbridge, and a tour of the Ontario Geoscience Laboratories. The afternoon of the second day and the first part of the morning of the third day involved rotating breakout sessions in each of the research and technical areas to be addressed in the project. The remainder of the third day was spent summarizing the key knowledge gaps, objectives, and research methods in each of those areas, and developing a strategy for writing the proposal(s) for ICDP and the Natural Sciences and Engineering Research Council of Canada (NSERC).

The key scientific knowledge gaps were addressed under the following research themes: 1) downhole geophysics, rock mechanics, and long-term drill hole observatory; 2) surface geophysics and remote sensing; 3) structure and tectonics; 4) petrogenesis and metallogenesis of the SIC; 5) impact mechanics and processes; and 6) deep fluids and biosphere. These in turn fed into the more technical aspects of the project: 1) deep drilling; 2) core handling, processing and storage; and 3) data management and visualization. There were also preliminary discussions about possible drill hole location(s) and the management structure for the project. During discussions of the different themes, it became clear that there were overlaps in many of the key knowledge gaps for different themes. Accordingly, the results of the theme discussions have been recombined to minimize duplication and to place them into a time sequence, in keeping with the objective of determining the 4D evolution of the Sudbury area. There are several time-markers available in the geologic evolution of the area. Here, we have used the timing of the Sudbury impact event at 1.85 Ga as the discriminator.

This report summarizes only the key knowledge gaps that were identified in the workshop and will require deep drilling, field work, and/or laboratory work. The full report containing summaries of potential research methods, probably participants, and project deliverables will be posted on the Project website: http://www.icdp-online.de/sites/sudbury/news/news.html.

Key Scientific Knowledge Gaps

Pre-impact (>1.85 Ga)

1) Pre-impact structural controls on the Sudbury impact structure (Archean and Proterozoic structure and metamorphism)
2) Distribution and composition of target rock types: pre-impact stratigraphy (Archean and Huronian), thickness variation and composition of Huronian rocks across the impact site
3) Timing of uplift of the Levack gneiss complex relative to impact: pre-impact or impact-related?

Impact (1.85 Ga)

Character of the Original Impact Structure

1) Original size, magnitude of erosion, and thermal evolution
2) Peak ring or multi-ring basin? Location and diameter of peak ring (or inner ring)
3) Amount of structural uplift (in the center and at the peak ring)
4) Principal dimensions of the impact basin and transient cavity
5) Radial extent of the melt complex and the Onaping Fm.: was there a melt sheet in the annular trough beyond the peak ring (e.g., Chicxulub)?

Shock Metamorphism

1) Role of temperature of the basement at the time of shock compression
2) Distribution of shock zoning in the sub-SIC basement (as indicated by quartz and shatter cones), especially NE and SW of SIC
3) Role of annealing of shock effects by the SIC in the North Range and at depth

Onaping Formation (upper part of impact

melt sheet)

1) Total thickness (volume) of Onaping Fm. within the Sudbury Structure (current geophysical models predict Onaping Fm. up to 5 km thick beneath the center of the basin)
2) Origin and mode of emplacement of members of the Onaping Fm.: what section is ground surged, fall back from the ejecta plume, redeposited after crater formation, or due to water-induced explosive volcanism at the top of the SIC?
3) Is there a meteoritic signature in the Onaping Fm. or is it due to alteration?
4) Quantitative modal composition of all members of the Onaping Fm., as a function of depth (ratio of Proterozoic vs. Achean clasts ? normal or inverted stratigraphy?)
5) Field relationships and types of contacts between the various lithofacies (grey vs. green vs. black) and members (Garson vs. Sandcherry vs. Dowling) of the Onaping Fm. and the underlying Granophyre and overlying Onwatin Fm.
6) Significance of glass shards in the Green Member and of carbonaceous matter in the Black Member?

SIC (impact melt sheet)

1) Depth of target section affected by impact melting
2) Total volume of impact melt: are any of the proposed empirical figures for the impact melt volume compatible with the crater size obtained by numerical modeling?
3) Proportions of target rocks that make up the SIC, offset dikes, Sudbury breccia, Onaping Fm., as melted matrix and as clasts
4) Nature of SIC: primarily homogeneous or primarily compositionally stratified?
5) Origin, mode, and time of formation of the offset dike melts
6) Origin and mode of emplacement of the Sublayer and of the ultramafic inclusions in the Sublayer

Sudbury Breccias (floor of the crater and lower part of melt sheet)

1) Matrix composition of Sudbury Breccias in terms of major elements, trace elements, and isotopes at all scales
2) Physical state of the matrix during and after emplacement
3) Processes responsible for the generation of Sudbury breccia: frictional melting (E-type pseudotachylite), shock melting (S-type pseudotachylite), injection (E-type pseudotachylite), or fluidized diatreme from transient cavity? Cavitation, melt fracture, lubrication failure, viscous dissipation, shear thinning?
4) Regional distribution pattern of various types of Sudbury Breccia and significance for cratering mechanics
5) Part of crater floor exposed
6) Nature of the lower contact (thermal and mechanical erosion by the SIC)
7) Footwall Breccia and brecciated crater basement as a function of depth and/or radial distance from SIC
6) Variation of thermal metamorphism induced by the SIC as a function of depths
7) Variation in style and intensity of deformation with depth

Post-impact (<1.85 Ga)

SIC

1) Initial distribution of intensive parameters in the SIC: heat, fO_2, fS_2, and composition
2) Compositional variations: lateral (regional) variations, initial vertical stratification, and length scales of heterogeneity
3) Mechanisms of heat loss from the melt sheet
4) Explanation for differences between North and South ranges
5) Chalcophile metal budget of the SIC, QD offset dikes, and ores
6) Why are some portions sulfide-rich?

Sulfides

1) Initial sulfide liquid compositions, fO_2, and fS_2?
2) Evolution of sulfide magmas: fractional vs. equilibrium crystallization? liquid immiscibility? Alteration by fluids?
3) Mechanism(s) of sulfide transportation and deposition: settling, accumulation of large pods, flow through porous cumulates, vein injection?
4) Subsolidus processes

Thermal and Hydrothermal Processes

1) Cooling, crystallization, and differentiation history of the SIC and time relation to the ongoing tectonic deformation
2) Significance of discordant contacts observed within the SIC
3) Degree of interaction between SIC and Footwall (assimilation, contamination by anatectic melts, fluids)
4) Sources of metamorphic fluids in the footwall, SIC, and Onaping Fm.
5) Degree of telescoping of aureole by thermal erosion

Tectonics and Structure

1) Post-impact deformation of the Sudbury Structure: amounts of N-S directed shortening along the South Range Shear Zone (SRSZ) and other faults, possibly north of North Range
2) Mechanics of foreland folding and thrusting in this region: why no apparent ramp-flat-ramp geometry?
3) Lateral strain gradient along thrust faults
4) Location of SIC with respect to the original impact crater orientation: where is the centre?
5) Relationship between the timing of crystallization of the SIC relative to the regional deformation
6) Mechanism of strain partitioning within the SIC (mechanics of rheologically-layered bodies)
7) Basin- and mine-scale structural and tectonic controls on ore deposition and modification
8) Effects of South Range thrust faults on ore horizon location: tectonic uplift of favourable SIC contact zones by thrusts?
9) Presence of a Penokean basal thrust and units in which it is located
10) Continuity of the SIC-footwall contact at depth (the norite-footwall contact is a prominent seismic marker used for integration with exploration grill hole data and for building 3-D models of the Sudbury Structure).
11) Locations and ages of faults (e.g., Onaping, Murray Fault System), many of which show protracted Archean and Proterozoic histories
12) Amount of Grenvillian deformation north of the Grenville Front Tectonic Zone (GFTZ) and the nature pre-Grenville inclusions/remnants within and south of the GFTZ
13) Neotectonic uplift history and amount of post-impact erosion across the impact structure

Deep Fluids and Biosphere

1) Depth to which life exists: to 120°C?
2) Nature of life, how it lives, and relationship to geology
3) Types, origins and relationships of waters and gases; surface sources for water
4) Residence times of the waters and gases
5) Geochemical interactions between groundwater and mineralization (metal complexation)?

Key technical considerations

Downhole Geophysics, Rock Mechanics, and Long-Term Drillhole Observatory

1) Physical properties to assist with geophysical inversions (density, magnetic susceptibility and remnance, P and S wave velocity, electrical conductivity, attenuation + statistical variation)
2) Correlation of geophysical images with existing structure and geology (i.e., ground truthing of geophysical responses using, for example, wellbore seismic measurements to test travel times to depth and *in situ* anisotropy)
3) State of stress and temperatures deeper in the crust and how these might impact future deeper mines and use of robotic mining
4) Explanations for the observed periodicity in rock bursts (tidal, seasonal?)
5) Role of fluids in the subsurface in such a fractured hard-rock environment.

Deep Drilling Technology

Current technologies and consumables exist to obtain diamond drill core to the anticipated depths of ~6,000m and Sudbury is a world leader in diamond drilling technology. The limit of current technology has not been tested. However, because the deepest holes in

Sudbury have only been to ~3000m, there are several intangible unknowns: stress, structure, temperature, and their variation with location. Some constraints include:

1) Environmental permits from MOE
2) Establishing protocols for communicating with and monitoring progress by Contractor(s)
3) Ensuring the project has technical guidance and expertise

Requirements include:

1) Technology: conventional slim-line diamond drill coring technology
2) Drill: HD 600 or HS 150
3) Depth: ~5,000m to 6,000m
4) Diameter: "HQ" (96.0 mm hole, 63.5 mm core) with possible reduction to "NQ" (75.7 mm hole, 47.6 mm core)
5) Rods: aluminum alloy rod with API steel thread?
6) Core recovery: continuous, undisturbed (split tube/sleeved), immediate core preservation
7) Blow out prevention (BOP) required
8) Limited casings
9) Limited use of drill additives and add tracers to any additives used
10) Semi-continuous/periodic core orientation measurements
11) Deviation control using Clappison wedges and/or in-hole motors

Core Handling, Processing, Logging, and Storage

Full life-cycle must be considered, i.e., *Short Term*: from core barrel to the logging room, *Medium Term*: during the life of the drilling project and *Long Term*: after the drill has packed up and everyone has gone home. Some factors include:

1) Core handling and sampling protocols: fluids, biology, geochemistry/petrology; established by a committee with ability to make day-to-day decisions during drilling
2) Security of core during drilling and at core storage location(s)
3) Short-term core logging facilities: probably on site to minimize handling and transport
4) Long-term core storage facilities: whole-core or condensed? Note: Each 6000m drill core will require 2000 core boxes @ 3m per box for NQ or HQ
5) Logging: need dedicated core handler, logger, and vehicle in short term, part-time curator/handler in long term
6) Public education: interpretive displays at Dynamic Earth and/or Science North? On-line, real-time view of drilling in progress? Regularly updated sections of recently drilled core? Creation of type material core collections for distribution to academic institutions and museums. Core logging facility and the drill site can be part of the "Path of Discovery Tours" conducted by Dynamic Earth for public education of drilling activities/results.
7) Long-term storage: build permanent core logging and storage facility with an insulated and heated building capable of finally holding rack space for at least 3500 core boxes (2 x 6000m drill holes less whatever type-section material created for other institutions). Someone from LU and/or UT will need to be responsible for controlling access to the core and managing the facility.

Data management and visualization

The Sudbury proposal's data needs will be significantly different from prior ICDP projects, because of the vast amount of historical knowledge/information that has been generated by industry stakeholders in the Sudbury basin. It is believed that a portion of these data will be made available to the project and will provide significant context to the actual ICDP data.

There are no real knowledge gaps that the Sudbury ICDP project would resolve from an IT perspective but gaps exist in the application of systems and technologies. Thus, proper system analysis, development of policies and selection of technologies would overcome the issues that were identified. At Sudbury the current capabilities in common earth modeling, extensive geological data and expertise with collaborative 3D visualization will provide significant benefits to the project.

Also needed:

1) Protocols for how information will be received from and communicated to the scientific teams.
2) Interface between new data and historical datasets, mechanism for leveling all data, and formats for utilization and presentation in this project.
3) Strict confidentiality of proprietary information (~50% company data), access to new drill data by researchers, and access to public high resolution magnetic, Radarsat, and hyperspectral data. Need clear policy project wide (all new data must be accessible); will require meeting of industry manager to address.
4) Protocols to manage data flow. Typical ICDP datasets are Gigabytes in size, whereas the Sudbury dataset may be Terabytes in size. There will be too much data to possibly include all participants, so a functional analysis will be required determine which data are required to address specific scientific objectives. The large volume of data will require special attention to issues regarding query and retrieval.
5) Meta-data and quality standards for each data type (no "bad" data in the database) and provide meta-data on measurements.

Drill hole locations

Possible locations for the drill holes were discussed only briefly, as the precise locations will be decided only after the goals and objectives have been further refined and the degree of availability of existing industry drill hole information is fully clarified. The general consensus however, was that a deep drill hole was not needed in the North Range, because it is already fairly well known from existing drill holes (including one 3,500' hole) and surface mapping. The geology therefore is unlikely to be significantly different from the current interpretation. There is no particular value in proving continuity.

It was felt that the most important goals of the deep drilling should be to identify gravity and magnetic anomalies in the central part of the Basin and to resolve the uncertainties in interpreting the deep structure and stratigraphy beneath the South Range that were identified in the Lithoprobe deep seismic experiment. It was also proposed that a 3D seismic corridor, integrated with Lithoprobe, gravity, magnetic, and magnetotelluric data, and two deep drill holes, would be very valuable in resolving the structure and permit the researchers to reconstruct the geometry of the crater at the time of impact. This would increase our understanding of the crust at depth and of impact mechanics.

Management Structure

The management structure for the project was discussed on the third day of the workshop and will be established as planning progresses, but the current plan is to have a *Steering Committee* composed of senior industry and government manager and officials; a *Scientific and Technical Advisory Committee* composed of the leaders of the research nodes, the managers of the technical groups, and industry and government scientists with expertise in the areas to be addressed; and a *Project Manager*, who will manage the day-to-day operations of the Project.

C. Michael Lesher, Laurentian University, Mineral Exploration Research Center, Sudbury, Canada
Andrew Dasys, Tony Donaghy, Richard Grieve, Bob Horn, Peter Kaiser, Sean Maloney, Bernd Milkereit, James Mungall, Herb Phelps, Douglas Schmitt, Gregory Slater, Gordon Southam, John Spray, Dieter Stöffler, Brian Thompson, Mike Welch

ICDP Workshop:
Deep Drilling in the Central Crater of the Chesapeake Bay Impact Structure, Virginia, USA

INTRODUCTION

The International Continental Scientific Drilling Program (ICDP) and the U.S. Geological Survey (USGS) sponsored a scientific workshop on the subject of "Deep Drilling in the Central Crater of the Chesapeake Bay Impact Structure" on September 22-24, 2003 (Edwards et al., 2004). The workshop was held near Reston, Virginia, USA, and was hosted by the USGS. The goals of the workshop were to review previous investigations of the Chesapeake Bay impact structure and their scientific conclusions and to provide a forum for creating scientific and operational plans for deep drilling in the structure's central crater. Over 60 scientists representing 10 countries participated in the workshop (Appendix I). The workshop resulted from a preliminary drilling proposal submitted to ICDP by the workshop conveners in January 2003.

The late Eocene Chesapeake Bay impact structure is among the largest and best preserved of the known impact craters on Earth. This complex crater lies buried at shallow to moderate depths beneath post-impact Cenozoic sediments of the Virginia Coastal Plain and adjacent Continental Shelf on the United States Atlantic continental margin (Fig. 1).

The diameter of the Chesapeake Bay impact structure typically is cited as about 85 km (e.g. Poag, 1997; Poag, et al., 2004; Powars and Bruce, 1999; Horton et al., in press). Principal subdivisions of the structure are a 38-km-diameter central crater and a surrounding 24-km-wide annular trough.

Several special characteristics of the Chesapeake Bay impact structure make it an attractive target for a deep drilling program. First is the impact's multi-layered "wet" target, which consisted of a neritic water column, several hundred meters of water-saturated Cretaceous and lower Tertiary sediments, and pre-Mesozoic crystalline rocks. A second characteristic is the proposed association of the Chesapeake Bay impact structure with the well-known North American tektite strewn field. Third, coring of the post-impact, upper Eocene to Quaternary sedimentary section above the buried impact structure would permit comparison with sections cored elsewhere in the U.S. Mid-Atlantic Coastal Plain and Shelf. This experiment would elucidate the long-term effects of a major impact on a trailing continental margin by comparison with cores from areas that represent the "normal" tectonic and sea-level history of that margin. Finally, the documented spatial association of anomalously saline ground water with the impact structure is a resource-management issue that requires scientific investigation of the genetic links between these features.

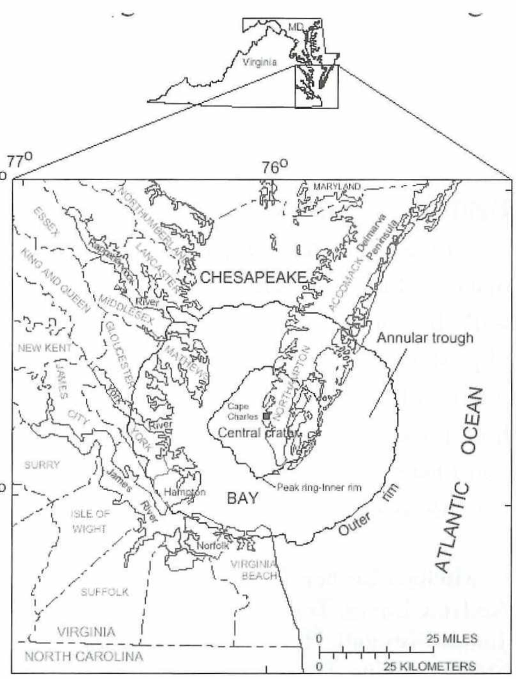

Fig. 1: Location map for the Chesapeake Bay impact structure in southeastern Virginia, USA. Modified from Powars and Bruce (1999)

The workshop began on September 22nd (Appendix II) with welcoming remarks by Dr. Charles G. Groat, Director of the USGS, and

Dr. P. Patrick Leahy, USGS Associate Director for Geology. These speakers indicated continuing USGS interest in cooperative, multi-agency research of the kind represented by the workshop. They noted that the Chesapeake Bay impact structure presents an opportunity for major advances on a topic of international scientific interest that also has major societal consequences (ground-water availability) and captures the public's imagination. The remainder of the first day's program featured reviews of previous corehole and geophysical investigations of the Chesapeake Bay impact structure, summaries of the capabilities of the ICDP Support Group and DOSECC (Drilling, Observation, and Sampling of the Earth's Continental Crust), and an initial discussion of the first-order scientific questions that could be addressed by deep drilling in the Chesapeake Bay crater. The day's program concluded with an evening poster session where research posters provided by workshop participants, and USGS core samples from the Chesapeake Bay impact structure, were examined and discussed.

The second day began with a review of sedimentary, climatic, and tectonic studies of middle Tertiary to Quaternary post-impact sediments of the U.S. Mid-Atlantic continental margin (Appendix II). The morning session continued with a lengthy panel and audience discussion of the scientific objectives and experiments, drilling strategy, site-selection criteria, funding sources, and logistics of a deep drilling program in the Chesapeake Bay central crater. During the afternoon, participants divided into three working groups: impact processes and products, post-impact geology, and hydrology. The second day concluded with reports from these working groups.

The third day's program (Appendix II) consisted of moderated audience discussions of a variety of issues, including the identification of standing science teams, drilling and logging operations, core storage, publication policy, and drill-site protocols. The workshop adjourned at noon on September 24th.

WORKSHOP DELIBERATIONS AND OUTCOMES

Scientific Goals

A significant outcome of the workshop was the identification of scientific goals for the proposed drilling program (Table 1). The goals were limited to research topics that could be addressed specifically by core drilling

Tab:1. Scientific goals for the drilling program in the central crater of the Chesapeake Bay impact structure.

Crater Structure and Morphology

- Determine the crater depth
- Determine the structural character of the cored segment of the central crater

Crater Materials

- Determine target composition and stratigraphy beneath crater
- Determine petrophysical properties of target materials
- Determine target chemistry and mineralogy for comparison with North American tektites
- Search for meteorite component in crater materials to identify projectile type
- Determine radiometric ages for all suitable types of material
- Determine fracture depth and distribution
- Determine the amount and distribution of melt
- Characterize the types of crater breccias and infer their formative processes
- Quantify the volumes of breccia types and melts
- Determine the character of resurge and tsunami sediments
- Determine the stratigraphy of the crater fill
- Conduct paleomagnetic studies of shocked rocks and melt
- Document levels and gradient of shock deformation
- Document shock deformation in fossils

Borehole Geophysical Studies

- Collect a full suite of borehole geophysical logs for determining petrophysical properties, lithologies, and stratigraphy
- Directly measure petrophysical properties of core samples
- Integrate core and log petrophysical data with regional gravity, magnetic, seismic, and electrical conductivity surveys and with numerical models

Impact - Post-impact Transition and Post-impact Events

- Document the impact-produced local biotic crisis and recovery
- Document the physical transition from the high-energy impact environment to the normal shelf environment
- Document the physical stratigraphy, biostratigraphy, and sequence stratigraphy of the post-impact sediments
- Document impact effects on long-term climate
- Determine the post-impact thermal and hydrothermal history and processes

Hydrologic Resources

- Determine the salinity and other chemical attributes of ground water in core samples
- Determine the post-impact hydrogeologic history of the crater area

Modern Deep Biosphere

- Conduct aseptic core sampling
- Determine microbial diversity and abundance in deep subsurface environments
- Determine microbial effects on deep subsurface geochemistry

Tab. 2: Proposed Science Teams for the drilling program in the Chesapeake Bay impact structure.

- Crater Materials
- Regional and Borehole Geophysics
- Hydrothermal Systems and Hydrologic Resources
- Cratering Mechanics and Modeling
- Environmental Effects of Impact and Impact – Post-impact Transition
- Post-impact Sedimentary, Climatic, and Tectonic History
- Deep Biosphere

Science Teams

The workshop participants recommended the formation of standing scientific working groups (Science Teams) to conduct the analyses of the proposed core and corehole. Seven Science Teams were defined on the bases of broad research topics and related methodologies (Tab. 2).

Initial Site Characterization

The corehole and geophysical studies that ultimately led to recognition and characterization of the Chesapeake Bay impact structure began in the late 1980's and continued into the 1990's. Since 2000, the USGS, the Hampton Roads Planning District Commission, the Virginia Department of Environmental Quality, and other affiliated institutions have conducted a second phase of multidisciplinary geophysical, corehole, and hydrologic investigation of the impact structure (see summaries by Poag et al., 2004, and Horton et al., in press). Collectively, over 2,000 km of seismic-reflection data have been analyzed and 8 coreholes have been drilled, geophysically logged, and analyzed.

Investigations during this fifteen year period have defined the location, size, structure, and inferred origin of the major architectural elements of the Chesapeake Bay impact structure (Poag, 1996, 1997; Poag et al., 2004; Powars and Bruce, 1999). Significantly, however, none of the coreholes were drilled in the central crater.

Site Selection

Drill-site selection was addressed in several plenary and breakout sessions. These discussions were guided in large part by interpretations of the regional gravity map (Fig. 2) and the seismic-reflection profiles (e.g. Fig. 3) that cross the central crater.

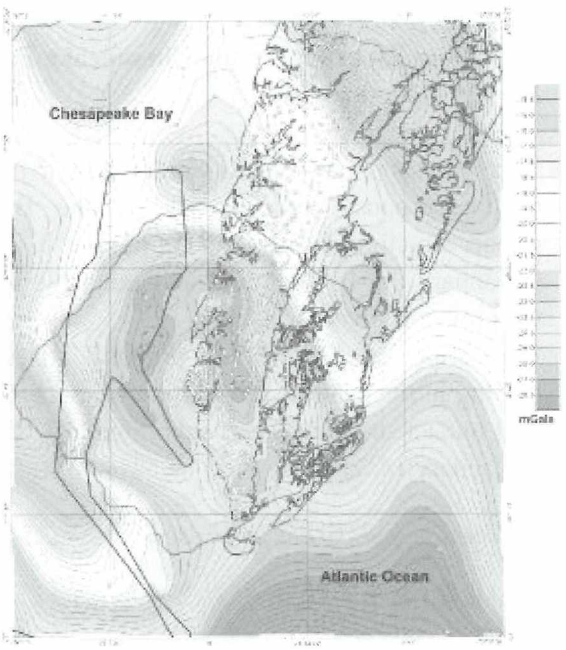

Fig. 2: USGS gravity map for the central crater of the Chesapeake Bay impact structure (data from D.L. Daniels, J.B. Plescia, and C.W. Poag; compiled by D.L. Daniels). Track line for shipboard gravity data is shown in Chesapeake Bay. Features H, M, and G are discussed in the text. Bouger data set on land; free-air data set over water.

Consideration was given to three general features characterized by distinctive gravity anomalies. Specifically, these are the relative gravity high at the center of the central crater (*H* on Fig. 2), the irregular, oval gravity low that surrounds the central gravity high (*M* on Fig. 2), and the gradient from the oval gravity low to surrounding higher gravity values (*G* on Fig. 2). Feature *H* was considered to represent part or all of a central uplift, whereas feature *M* (the "moat") may represent the deepest part of the central crater and contain the greatest variety of impact materials. Gradient *G* was interpreted to represent the rim of the central crater.

The desirability of each potential drilling target was considered relative to more than 20 fundamental scientific questions about the impact structure, for example, the depth of fracturing, the character and origin of the crater fill, the presence and distribution of melt, and the strength properties of the target materials. Following these deliberations, the "moat" was the consensus first choice for a proposed drill site. This decision, combined with the consensus that the planned drilling operation should take place on land, requires that the proposed drill site lie within a northwest-southeast-oriented corridor located northeast of the town of Cape Charles in Northampton County (Fig. 1; feature *M* on Fig. 2)

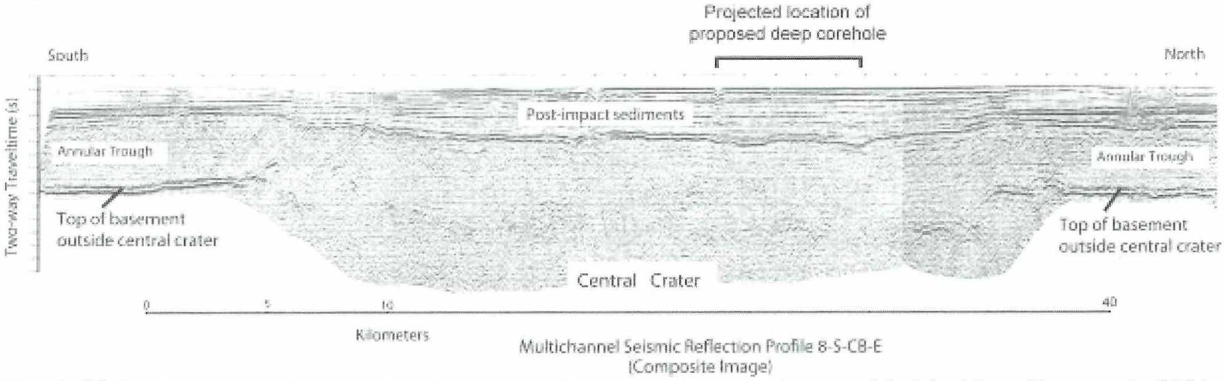

Fig. 3: Multi-channel, marine seismic-reflection profile across the central crater. Modified from Poag et al., 2004

Additional Site Characterization

The need for additional site-characterization studies at and near the proposed drill site was recognized during the workshop. In response, the USGS will conduct three field studies on the Delmarva Peninsula within the central crater of the Chesapeake Bay impact structure in the spring of 2004. In addition, during October-November 2003, the USGS surveyed over 200 new gravity stations within the central crater and annular trough on the Delmarva Peninsula and added them to the pre-existing regional gravity database. Shipboard gravity data collected by the U.S. Naval Research Laboratory in Chesapeake Bay during 2002-2003 (Shah et al., 2003) also will be integrated with the pre-existing database.

A 35-km-long, on-land refraction survey from the center of the central crater to outside its rim is planned for March-May 2004. This survey will provide information on the general structure of the central crater in addition to velocity information. A deep magnetotelluric survey planned for March 2004 will provide a conductivity profile to depths of several kilometers from the center of the central crater to beyond its rim.

An uncored water-monitoring well will be drilled to a depth of about 900 m at the center of the central crater in March-April 2004. The primary reason for this effort is the installation of two screened water-monitoring intervals within crater materials in the lower part of the borehole. In addition, cuttings will be collected for mineralogic, petrologic, and possibly chemical analysis, and a suite of geophysical logs will be collected. One or two spot cores will be collected within the crater section, if permitted by borehole conditions and funding. The geophysical logs will serve to calibrate regional geophysical surveys and determine the general borehole stratigraphy.

A Drilling Program for the Chesapeake Bay Impact Structure

The workshop participants agreed that a full drilling proposal for the Chesapeake Bay impact structure should be submitted to ICDP in January 2004. A provisional timetable for the project is given in Table 3.

(Postscript: A full drilling proposal, "Deep drilling in the central crater of the Chesapeake Bay impact structure," was submitted to ICDP on January 14, 2004.

Tab. 3: Provisional timeline for the proposed drilling program in the Chesapeake Bay impact structure

January 15, 2003	Preliminary drilling proposal submitted to ICDP
September 22-24, 2003	ICDP Chesapeake Bay Crater Workshop
January 15, 2004	Full drilling proposal submitted to ICDP
March-May 2004	Additional site-charac-terization surveys and drilling by USGS
ca. May 2004	ICDP funding decision
May 2004	Science Teams form-ally established
May 2004	Drilling plan finalized
June 2004 onward	Submission of research proposals to other funding agencies
June 2004-July 2005	Site acquisition, per-mitting, and prepar-ation
August-November 2005	Deep drilling in central crater of the Chesapeake Bay impact structure.

WORKSHOP PROCEEDINGS VOLUME

A proceedings volume for the Chesapeake Bay Impact Structure Workshop has been published on-line as USGS Open-File Report 2004-1016. The citation for the proceedings volume is:

Edwards, L.E., Horton, J.W., Jr., and Gohn, G.S., 2004, ICDP-USGS Workshop on deep drilling in the central crater of the Chesapeake Bay impact structure, Virginia, USA – September 22-24, 2003: Proceedings volume: U.S. Geological Survey Open-File Report 2004-1016

This report may be accessed at: http://pubs.usgs.gov/of/2004/1016/

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Edwards, L.E., Horton, J.W., Jr., and Gohn, G.S., 2004, ICDP-USGS Workshop on deep drilling in the central crater of the Chesapeake Bay impact structure, Virginia, USA – September 22-24, 2003: Proceedings volume: U.S. Geological Survey Open-File Report 2004-1016.

Horton, J.W., Jr., Powars, D.S., and Gohn, G.S., in press, Studies of the Chesapeake Bay impact structure—Introduction and discussion, chap. A *of* Horton, J.W., Jr., Powars, D.S., and Gohn, G.S., eds., Studies of the Chesapeake Bay impact structure—The USGS-NASA Langley corehole, Hampton, Virginia, and related coreholes and geophysical surveys: U.S. Geological Survey Professional Paper 1688.

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Shah, A.K., Brozena, John, Martinka, Sandra, and Vogt, Peter, 2003, New shipboard gravity and magnetic surveys on Chesapeake Bay refine impact crater structure: Geological Society of America Abstracts with Programs, v. 35, no. 6, p. 151-152.

Gregory S. Gohn, U.S. Geological Survey, Reston, Virginia, USA

Workshop Participants

Huirong-Anita Ai, (California Institute of Technology, USA)
C.R. "Rick" Berquist, (Virginia Division of Mineral Resources, USA)
John M. Brozena, (U.S. Naval Research Laboratory, USA)
T. Scott Bruce, (Virginia Department of Environmental Quality, USA)
Rufus D. Catchings, (USGS-Menlo Park, USA)
Gareth S. Collins, (University of Arizona, USA)
David Crawford, (Sandia National Laboratories, USA)
David L. Daniels, (USGS-Reston, USA)
Alexander Deutsch, (University of Muenster, Germany)
Henning Dypvik, (University of Oslo, Norway)
Lucy E. Edwards, USGS-Reston, USA)
Scott R. Emry, (Hampton Roads Planning District Commission, USA)
Robert B. Fraser, (USGS-Reston, USA)
Bevan M. French, (Smithsonian Institution, USA)
Billy P. Glass, (University of Delaware, USA)
Gregory S. Gohn, (USGS-Reston, USA)
Samuel Harvey, (Virginia Polytechnic Institute & State University, USA)
Charles E. Heywood, (USGS-Richmond, USA)
John A. Hole, (Virginia Polytechnic Institute & State University, USA)
J. Wright Horton, Jr., (USGS-Reston, USA)
David Jutson, (RWE Dea AG-Wietze, Germany)
Kunio Kaiho, (Tohoku University, Japan)
Thomas Kenkmann, (Humboldt-Universität zu Berlin, Germany)
David T. King, Jr., (Auburn University, USA)
Christian Koeberl, (University of Vienna, Austria)
Michael J. Kunk, (USGS-Denver, USA)
Daniel Larsen, (University of Memphis, USA)
Steven M. Lev, (Towson University, USA)
E. Randolph McFarland, (USGS-Richmond, USA)
Susan McGeary, (University of Delaware, USA)
Peter P. McLaughlin, (Delaware Geological Survey, USA)
Sandra Martinka, (U.S. Naval Research Laboratory, USA)
H. Jay Melosh, (University of Arizona, USA)
Kenneth G. Miller, (Rutgers University, USA)
Daniel J. Milton, (USGS-Reston, USA)
Donald H. Monteverde, (Rutgers University, USA)
Roger H. Morin, (USGS-Denver, USA)Gregory S. Mountain, (Rutgers University, USA)
Dennis L.Nielson, (DOSECC, USA)
Jens Ormö, (Centro de Astrobiologia, INTA/CSIC, Spain)
Gordon Osinski, (University of Arizona, USA)
Amanda Palmer-Julson, (Blinn College–Bryan, USA)
Lauri J. Pesonen, (University of Helsinki, Finland)
Lucille W. Petruny, (Astra-Terra Research, USA)
Elisabetta Pierazzo, (Planetary Science Institute, USA)
Jeffrey B. Plescia, (USGS-Flagstaff, USA)
C. Wylie Poag, (USGS-Woods Hole, USA)
Jason P. Pope, (USGS-Richmond, USA)
David S. Powars, (USGS-Reston, USA)
Donald G. Queen, (USGS-Reston, USA)
James E. Quick, (USGS-Reston, USA)
Wolf Uwe Reimold, (University of Witwatersrand, South Africa)
David P. Russ, (USGS-Reston, USA)
Ward E. Sanford, (USGS-Reston, USA)
Jean M. Self-Trail, (USGS-Reston, USA)
Anjana K. Shah, (U.S. Naval Research Laboratory, USA)
Jan Smit, (Vrije Universiteit-Amsterdam, Netherlands)
Peter J. Sugarman, (New Jersey Geological Survey, USA)
Ryuji Tada, (University of Tokyo, Japan)
Donald M. Thomas, (University of Hawaii / DOSECC, USA)
David A. Vanko, (Towson University, USA)
Suzanne D. Weedman, (USGS-Reston, USA)
James Whitehead, (University of New Brunswick, Canada)

ICDP Workshop:
Lake Qinghai Scientific Drilling Project

The ICDP international workshop on *"Scientific Drilling at Lake Qinghai on the northeastern Tibet Plateau: High-resolution paleoenvironmental records of eastern Asia and their significance for global change"* was held at Xining, China from the 20th to 24th of October 2003. The workshop was sponsored by Institute of Earth Environment, Chinese Academy of Sciences (IEECAS), and financially supported partly by the ICDP, CAS, and the Natural Science Foundation of China (NSFC). The aim of the workshop was to discuss drilling goals and the selection of drill sites on the basis of existing data, scientific justification, technical feasibility, and project management. The workshop was attended by a diverse group of 57 scientists representing a range of countries and scientific disciplines (see appendix). The majority came from China, and the United States, Japan, Austria, France, Germany, England, and Australia are also well represented. Representatives of the Qinghai Provincial Government, the CAS, and the NSFC also attended the meeting.

The first two days of the workshop were devoted to that focused on the geological setting and existing scientific work on Lake Qinghai, results from other lake-drilling projects, and analyses that will be useful on the proposed cores. Workshop discussions were reinforced by a one-day field trip, led by Prof. An Zhisheng and Prof. Stephen Porter, which circumnavigated the lake and examined various late Quaternary landforms and deposits near the lake margin. The fourth day of the workshop was devoted to working groups and plenary sessions that covered details of logistics, the selection of drill sites and their relative priorities, and planning of analytical work on the cores. Four drill sites are planned, some to depths as great as 700 m, and should reach sediments as old as Pliocene at least. Drilling operations are planned for the summer of 2005, pending the outcome of proposals to ICDP and to Chinese funding organizations.

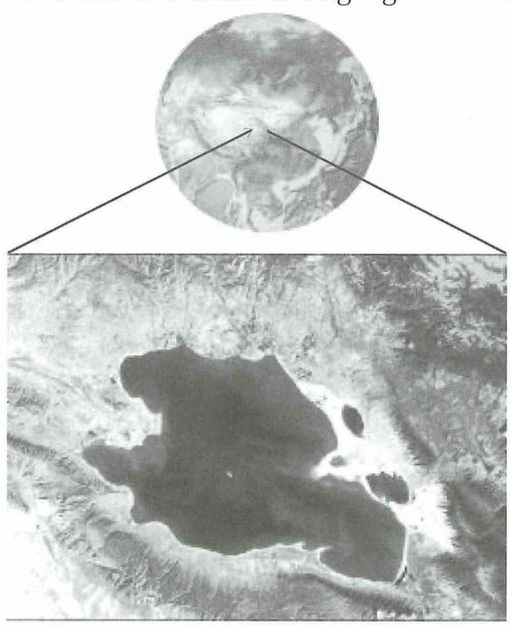

Fig. 1: Location of Lake Qinghai

General setting and previous work

The workshop began with addresses by the Deputy Governor of Qinghai Province and a representative of the Qinghai Provincial Department of Science & Technology; they expressed strong support for this scientific drilling project. An Zhisheng reviewed the background of this workshop, and summarized the proposed drilling program and expected results of the workshop. Ma Haizhou spoke about the geography of Lake Qinghai area, Stephen Porter described the Late Quaternary paleoenvironments of the southern Lake Qinghai basin. Shen Ji and Qin Boqian reviewed data from previous cores and scientific problems, the water balance and level changes of Lake Qinghai. Wan Ping presented recent data on the seismic surveys conducted in Lake Qinghai. Zhang Peizhen and Peter Molnar summarized the Cenozoic tectonic pattern of Lake Qinghai region and its possible links with northeastward growth of the Tibetan Plateau.

Lake Qinghai, the largest saline lake in China and at 3194 m elevation, is one of the highest large lakes in the world. It covers an area of 4400 km^2, has an average water depth of 21 m, a maximum depth of 27 m, and a drainage area of about 29,660 km^2 in the northeastern part of the Qinghai-Tibetan Plateau (Figure 1). During the period from 1908 to 2000, lake level declined from 3205.0 m to 3193.3 m with an average rate of 12.7 cm/yr causing 301.6 km^2 to fall dry. Lake Qinghai, an intra-mountain basin filled with thick sequence of late Cenozoic sediments, sits south of the Qilian Shan within a high terrain of the northeastern margin of Tibetan Plateau. Crustal shortening, mountain uplift, and strike-slip faulting characterize late Cenozoic to present-day tectonic deformation of the Lake Qinghai region, and manifest style and processes of outward growth of the northeastern margin of the Tibetan Plateau[1-3]. As a closed intra-mountain basin, sedimentation within it is likely to contain information about the growth. Therefore, a general consensus reached by the workshop is that drilling at Lake Qinghai is expected to address the issue concerning the plateau growth through providing continuous record of sedimentation from Pliocene (if not from earliest Miocene) to present.

Lake Qinghai is climatically extremely sensitive, for it lies in a critical transitional zone between the humid climate region controlled by the East Asian monsoon and the dry inland region affected by Westerly winds[4~5]. Climatic conditions in the Lake Qinghai region result from the interactions among the three major circulation systems: first, the winter monsoon, induced by Siberian high pressure and associated high-latitude ice cover; second, tropical moisture from low latitudes, carried by the East Asian summer monsoon[6]; and third, climatic changes in the North Atlantic region, the effects of which are transmitted via the Westerlies[7]. Major scientific questions exist concerning the climatic history of this area[8] and the changes in importance of its climatic system. Considerable scientific excitement was generated at the workshop concerning these questions. The concensus of the participants was that Lake Qinghai is an outstanding, world-class location for high-resolution records of climate and environmental history.

Selection of drilling sites

The locations and numbers of cores were thoroughly discussed at the workshop. Considering seismic stratigraphy, continuity of strata and tectonic characteristics of Lake Qinghai, potential approaches of the drilling operation, it was agreed that four long cores should be obtained (See Table and Figure 2).

Drilling operation

Ulrich Harms (ICDP Program Management, GFZ, Germany) gave an outline of the ICDP organization and also reported the latest achievement of the high-resolution analytical work on terrestrial sediment cores. Dennis Nielson (DOSECC and University of Utah) introduced the system and performance of the transportable coring system GLAD800. On 21 October 2003, Dennis Nielson and Ulrich Harms inspected the logistical site conditions such as boat, dock, supply, accommodations, and transportation facilities available and found a very satisfactory infrastructure for lake drilling. During the discussion session, drilling approaches, downhole logging, and on-site core handling were also discussed. After preliminary negotiation, Nielson confirmed that the GLAD 800 system could be employed as coring equipment for the Lake Qinghai project during the summer of 2005. The detail for construction of the drilling rig and on-shore laboratory will be further negotiated once the project is approved.

Core analysis

On October 22 and 23, the participants introduced and discussed various methods of core analysis in terms of different disciplines and available facilities for these measurements. The conclusions were as follows:

Table 1: Summary of the four proposed drill sites

	Site 1	Site 2	Site 3	Site 4
Location	100°08.22'E, 36°48.67' N	100°29.47'E, 36°43.62'N	100°8.95'E, 37°0.74'N	99°57.57'E, 36°48.35'N
Objective	Climate (long -term of for the last 5.0 Ma)	Climate (short- term of 1.5-2.0 Ma)	Tectonic	Climate and Tectonic
Deformation	no	no	no	slightly
Depth of reflectors T_5, T_6, T_7 (m)	578, 740, 909	552, 698, 798	416, 521, 620	283, 342, 408
Target depth (m)	700 m×2	200 m×1	500 m×1	600 m×1
Priority	1st	2nd	4th	3rd
Drilling Order	2nd	1st	4th	3rd

Physical properties: measurements of magnetic susceptibility, grain-size, pore-water, mineralogy, microstructure, digital images, microstructure, laminae, gray-scale, color, and environmental magnetism, tephra, varves, and microtektites will also be recorded, if warranted.

Chronological Studies: paleomagnetism, radiocarbon (including AMS), radioisotopes (^{210}Pb, ^{137}Cs, and related isotopes), luminescence, U-series methods, surface-exposure dating (^{126}Al, ^{10}Be, and ^{36}Cl methods)

Biological Proxies: pollen, charcoal, phytoliths, lacustrine microorganisms (possibly: diatoms, ostracods, chironomids, and biogenic silica); microbial proxies, organic compounds, and macrofossils

Geochemical Proxies: TOC, TN, biomarkers, trace-element compositions (Sr and Mg), oxygen and carbon isotope, carbonate (biogenic and authigenic), specific organic compounds, palmitic acids, phytol, short-chain n-alkanes and alkenones, productivity, and aquatic pCO_2.

International Team

An international team framework was established at the workshop. This project will be directed by five Principal Investigators, An Zhisheng (China), Steven Colman (USA), Gerald Haug (Germany), Peter Molnar (USA), and Takayoshi Kawai (Japan). About 26 Chinese and 34 overseas scientists have expressed interest in the project and their wish to join the Lake Qinghai drilling project.

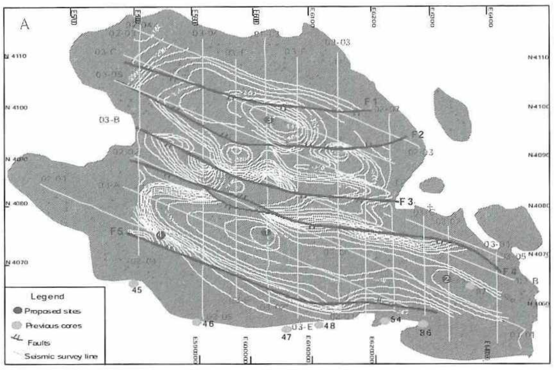

Figure 2: Isobath map of T5 reflector inferred from seismic survey and the proposed sites

Funding

If the planned proposal to ICDP will be approved, the Chinese Academy of Sciences, the Ministry of Science and Technology of China, and the Natural Sciences Foundation of China will provide matching funds to support the drilling project. The PIs and other participants also will apply to various funding agencies from their respective countries to support their research activity.

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An Zhisheng, Institute of Earth Environment, CAS, Xian, China and

Steven M. Colman, U.S. Geological Survey, Woods Hole, MA, USA

on behalf of the organizing committee including Francoise Gasse, Ulrich Harms, Peter Molnar, Jörg Negendank, Dennis Nielson, Stephen Porter, and Takayoshi Kawai

Appendix I: Workshop Participants

China

An Zhisheng, Institute of Earth Environment, CAS
Gao Huijun, Aerial Photogrammetry and Remote Sensing Bureau of China
Guo Huadong, Chinese Academy of Sciences
Ji Junfeng, Nanjing University
Jia Guodong, Guangzhou Institute of Geochemistry, CAS
Jiang Shaoren, Institute of South China Sea, CAS
Liu Baolin, China University of Geology. Beijing
Liu Jiaqi, Institute of Geology and Geophysics, CAS
Lu Zewei, National Sciences Foundation of China
Ma Haizhou, Institute for Salt Lake Studies, CAS
Ma Peihua, Qinghai Provincial Government
Peng Pingan, Institute of Geochemistry, CAS
Qin Boqiang, Institute of Geography & Limnology, CAS
Shen Ji, Institute of Geography & Limnology, CAS
Wang Ping, Institute of South China Sea, CAS
Xie Shucheng, China University of Geology, Wuhan
Zhang Peizhen, Institute of Geology, CSB
Zhang Xinbao, Institute of Mountain Hazards and Environment, CAS
Zhou Liping, Beijing University
Zhou Weijian, Institute of Earth Environment, CAS
Li Xiaoqiang, Institute of Earth Environment, CAS
Song Yougui, Institute of Earth Environment, CAS
Wu Haibin, Institute of Earth Environment, CAS
Xu Hai, Institute of Earth Environment, CAS
Ai Li, Institute of Earth Environment, CAS
Ma Xiaoyan, Institute of Earth Environment, CAS
Zhang Fan, Institute of Earth Environment, CAS
Zhao Hongli, Institute of Earth Environment, CAS
Cheng Peng, Institute of Earth Environment, CAS

U.S.A.
Alexander Prokopenko, University of South Carolina
Catherine Rigsby, East Carolina University
David Dettman, University of Arizona
Dennis Nielson, University of Utah
Dong Hailiang, Miami University
Huang Yongsong, Brown University (RI)
Jay Quade, University of Arizona
Li Hongchun, University of Southern California
Paul Baker, Duke University
Peter Molnar, University of Colorado
Stephen C. Porter, University of Washington
Steve Clemens, Brown University
Steven Colman, U.S. Geological Survey, Woods Hole, MA
Thomas Johnson, Large Lakes Observatory, University of Minnesota, Duluth
Timothy Jull, University of Arizona

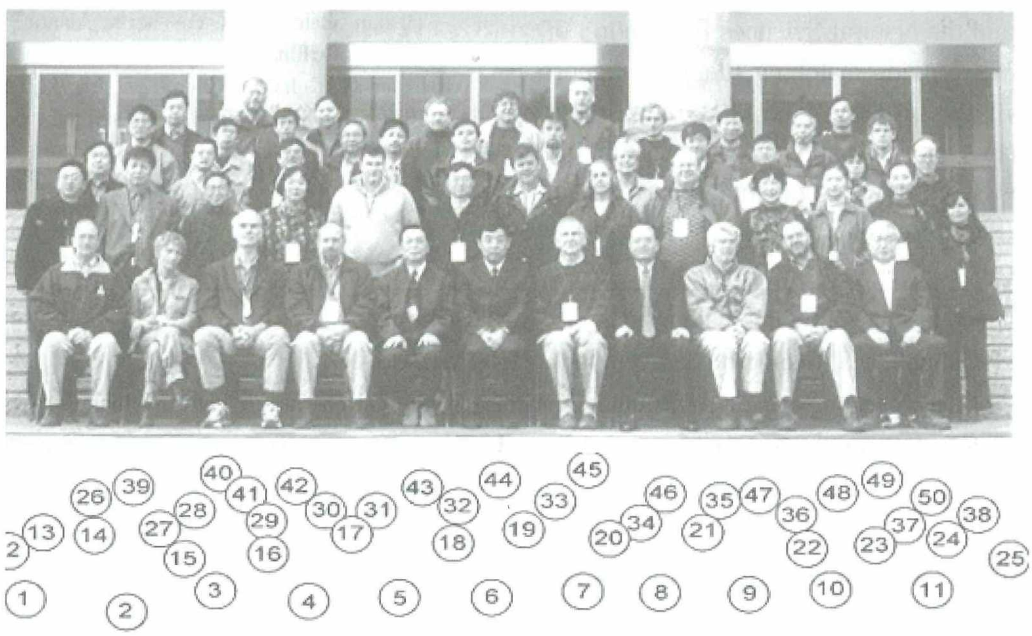
Europe
Alfred Priller, University of Vienna, Austria
Andrew Henderson, Department of Geography, University College London, UK
Christian Koeberl, University of Vienna, Austria
Francoise Gasse, University of Paris Sud, France
Ulrich Harms, ICDP, GFZ, Germany

Australia
John Dodson, University of Western Australia

Japan
Eiji Matsmoto, Nagoya University
John Matthews, Nagoya University
Kenji Kashiwaya, Kanazawa University
Takayoshi Kawai, Nagoya University
Simon Wallis, Nagoya University

Appendix I1: Workshop group picture

Scientific Drilling at Lake Qinghai Workshop, 20-24, Oct. 2003, Xining, China



1. Dennis Nielson
2. Francoise Gasse
3. Ulrich Harms
4. Steven Colman
5. An Zhisheng
6. Ma Peiha
7. Stephen Porter
8. Cao Wenhu
9. Peter Molnar
10. Christian Koeberl
11. Kawai Takayoshi
12. Li Xiaoqiang
13. Liu Baolin
14. Ma Haizhou
15. Eiji Matsumoto
16. Zhou Weijian
17. Andrew Henderson
18. Zhou Liping
19. Alfred Priller
20. Catherine Rigsby
21. Timothy Jull
22. Tai Yihe
23. Zhang Fan
24. Zhao Hongli
25. Barbara Quade
26 Shen Ji
27. Jia Guodong
28. Ji Junfeng
29. Huang Yongcong
30. Zhang Xinbao
31. Dong Hailiang
32. Li hongchun
33. Alexander Prokopenko
34. Candace Kohl
35. Qin Boqiang
36. Wang Ping
37. Ma Xiaoyan
38. Jay Quade
39. Wang Hongtao
40. David Dettman
41. Gao Huijun
42. Ai Li
43. John Matthews
44. John Dodson
45. Paul Baker
46. Thomas Johnson
47. Zhang Peizhen
48. Jiang Shaoren
49. Xie Shucheng
50. Simon Wallis

ICDP Preparatory Workshop

Subsurface Geomicrobiology

within the International Continental Scientific Drilling Program

Workshop Background

One of the major scientific objectives outlined by the International Continental Scientific Drilling Program is to investigate the nature of the deep biosphere and its relation to geologic processes such as hydrocarbon maturation, ore deposition and evolution of life on Earth. By investigating the nature of the deep biosphere through the unprecedented and unique opportunity that the ICDP affords, it is possible to overcome the logistical difficulty and expense that has resulted in the current lack in deep subsurface geomicrobiological terrestrial exploration. A proposal to the ICDP in January 2003 for logistical and technical support of microbiological investigations in planned ICDP projects resulted in a recommendation of the ICDP review panels stating that it would be beneficial to organize a preparatory workshop on this topic, inviting representatives from the international geomicrobiology community with the aim of defining logistical requirements and standards for future work in this area including evaluating the potential for a larger workshop and the considerations and requirements for the construction of a mobile geomicrobiology facility.

Workshop Agenda

This meeting took place at the Clift Hotel, San Francisco, on the 12th December 2003. The seven participants represented both European and US geomicrobiology expertise and are listed in Table 1. The meeting was opened with an introductory overview of the meeting objectives by Dr. Hall, followed by in depth round table discussion on four main sub-sections outlined in section 2 of this report. These were 1) Justification and requirements of an on-site multi-usage geomicrobiology facility. 2) Facility Budget. 3) The needs for a large-scale geomicrobiology workshop. 4) Potential geomicrobiology in Lake Peten-Itza and Chesapeake Bay International Continental Scientific Drilling Projects.

Justification for Field Facility

Initial discussions focused on an evaluation of whether a field facility is needed for the unique samples processing needs of geomicrobiology investigations. The following main points were derived:

Fig. 1: Participants of ICDP workshop assembled in San Francisco. (Dec 12, 2004)

The precedent set from the Ocean Drilling Project (ODP) demonstrated comprehensively that on-going sample strategy benefited significantly by near real-time iterative feedback associated with on-board sample processing and that sample integrity was best preserved from initial processing prior to storage. This is especially true for:

1. Labile samples e.g. reduced geochemical species and RNA.
2. Measurements such as in-situ activity, imperative for studying geochemical fluxes and are most accurately measured near-time as to not to incur any changes due to storage related phenomenon.
3. Contamination analysis to allow for near real time changes in coring strategy.

In addition the following benefits were also identified:

1. The initial time needed and cost incurred is significant in setting up temporary field laboratories and would be largely off-set by the availability of a mobile multi-usage facility.
2. Subsurface drilling campaigns frequently encounter harmful gases such as hydrogen sulfide therefore making gas monitoring facilities such as those proposed in this document desirable.
3. A field laboratory enables sampling protocols and control experiments to be performed, optimizing field protocols for unforeseen circumstances not

provisioned for prior to the field campaign.

Primary Functions of the Facility

The workshop concluded that the primary function of this multi-usage facility should be for necessary and fundamental geochemical analysis and microbiology and that if specialized analysis was required for specific field campaigns (e.g. ion chromatography or polymerized chain reaction), that space and power be available but that the designated equipment be provided by the relevant investigator.

Facility and Hardware Instrumentation Requirements

The workshop participants recognized that there were many possibilities for mobile facility construction but recommended that two shipping containers be purchased to satisfy the criteria summarized in the justification of this facility. The main suite of sample processing facilities (listed in table 2) would be housed in a 40 foot, temperature controlled container. A second auxiliary 20 foot shipping container with no temperature requirements is recommended to house support equipment. It is recommended that both of these facilities be purchased with some laboratory infrastructure in place from a containerized laboratory manufacturer.

The following items were identified as being of fundamental importance for a basic geomicrobiology and geochemistry facility. An approximation of cost for items over $2000 based on the workshop participant's prior experiences is included.

Multi-Usage Facility Budget

The total budget required for the discussed facility including all capital expenditure, shipping container(s) and contract to install basic laboratory infrastructure into the shipping containers is $234,000. It is envisioned that the complexity of this construction would initially require a dedicated person to oversee this project. It is most practical for this to be approximately 4 months funding of a scientific researcher to enable him/her to complete the project (approx $25,000). This person could then be retained by the ICDP for to work for 2 weeks at the end of each drilling campaign to maintain the facility and prepare it for the next drilling campaign. The cost of this technical role (salary, travel to storage location and general maintenance expenses ~ $7,000) should be charged to the previous drilling project. Consumables should be purchased and charged separately by investigators. The cost of hiring this facility should include, shipping (variable depending upon location), $7000 technical assistance, and preparation costs and a weekly charge of approximately $5000 per week for ICDP projects, and $7000 per week for non-ICDP projects. This would allow for the facility to pay for itself fully in approximately two years of ICDP operations (assuming geomicrobiology components in each ICDP project).

Future Workshop on Deep Biosphere Geomicrobiology

A future workshop on the direction and potential for geomicrobiology research in future ICDP drilling campaigns was discussed. The general feeling from the workshop participants was that it would be appropriate to couple this meeting to one of the already existing subsurface microbiology meetings that take place annually (e.g "American Society for Microbiology", "American Geophysical Union" or the "Annual International Workshop on Geomicrobiology". This would enable geomicrobiologists from ICDP, Ocean Drilling Program (ODP) and Department of Energy (DoE) subsurface programs to discuss the latest developments in subsurface microbiology and allow for future geomicrobiology components of ICDP projects to be formulated.

Invitees from the following areas are recommended;

- Representatives from the Inter Continental Drilling Program.
- Geomicrobiologists on current proposed ICDP projects (Chesapeake Bay, Lake Peten-Itza,Taiwan Chelungpu fault and Hawaiian deep drilling projects.
- Geomicrobiologists from past Department of Energy Subsurface Science program projects.
- Microbiologists from the Ocean Drilling Program.
- NSF program managers.
- European funding body representatives.
- Representatives from JAMSTEC.
- Representatives from the current Astrobiology deep drilling project.

Table 2. Capital items and approximate cost of portable geomicrobiology facility

Capital Item	Approx. Cost($1000s)
General Infrastructure	
40' shipping container (w/ basic lab fittings)	80
Auxiliary 20' shipping container	10
(power, lighting, benches, sink, water supply)	
Laminar flow hood	3
Fume hood	3
Water purifier [rev. osmosis + ion exchange)	2
Lap-top computer(s) with Server back-up	3
Autoclave	3
Vacuum pump	3
Gas mixing station	
Air compressor	
Plumbing for gas lines	
Chemical storage cabinet	
Telecommications (ship to shore radio)	
Trash compacting	10
Waste water tanks	
Wet chemistry workstation	
Appropriate waste disposal	
Acid and base disposal	
Microbiological Sampling	
Shaking incubators (2 temperatures)	6
Incubator	2
-80°C freezer	10
-20°C storage (geochemistry)	2
Epi fluorescent microscope	10
Dissecting scope	6
General Equipment	
Hot/stir plate	1
Top-loading balance	2
Anaerobic glove chamber	15
Anaerobic handling well	1
Rock splitter	2
Table-top Centrifuge	3
Sediment squeezers (fluid extraction system)	25
Vacuum pump	3
Ultrasonic for cleaning lab instruments	
Drying Oven	
Fire suppression system	
Contamination Sediment Core Sampling	
Note: Incorporation into ICDP and MtEE drill rigs	
Pump for tracer	2
Perflorocarbon tracer injection apparatus	2
(adaptable for ICDP and MtEE drill rigs)	
A GC perflorocarbon analyses (Capture Detector)	20
Autosampler	2
Geochemical Analyses	
Hand-held probes;	
pH, ORP, DO, TDS, alkal., conduct., temp.	3
APPROXIMATE TOTAL	**$234,000**

It is suggested to hold this meeting in July or August to allow time for preparation and formulation of ICDP projects for the January 15 th annual deadline. The overall objective of this meeting would be to allow a subsurface deep biosphere component of ICDP projects to become standard and to introduce the capabilities of the mobile geomicrobiology facility to the scientific community. However, it was noted at this preparatory meeting that a large workshop for the purposes of developing ICDP and deep biosphere links may not be necessary given the major deep biosphere components of two recently submitted ICDP proposals and the general acceptance within the scientific community of the potential that the ICDP affords for deep biosphere research.

Geomicrobiology in Lake Peten-Itza and Chesapeake Bay ICDP campaigns

At the end of the meeting a brief discussion on the pending ICDP proposals for drilling Lake Peten-Itza and the Chesapeake Bay took place. While out of the scope of this report it is worth noting that all participants were keen to participate in these two upcoming projects. Deep biosphere initiatives have been included with Hall as a principal investigator for the Lake Peten-Itza project and a named Co-Investigator for the Chesapeake Bay project. Initial collaborations to obtain further support from outside funding pending ICDP support were initiated.

Table 1: Participants of the ICDP preparatory geomicrobiology meeting

---

James Hall (Chair), Geophysical Laboratory, Carnegie Institute of Washington, j.hall@gl.ciw.edu,
Steve D'Hondt, School of Oceanography and Geological, Oceanography, University of Rhode Island, dhondt@gsosun1.gso.uri.edu
Todd Stevens, Dept of Biology, Portland State University, tstevens@gorge.net
Duane Moser, Pacific North National Laboratory, Duane.Moser@pnl.gov
Crisogono Vasconcelos, Laboratory of Geomicrobiology, Eidgenössische Technische Hochschule, chris.vasconcelos@erdw.ethz.ch
Stefano Bernasconi Laboratory of Geomicrobiology, Eidgenössische Technische Hochschule, stefano@erdw.ethz.ch
Brain Mailloux, The Earth Institute, Columbia University, bjm2103@columbia.edu

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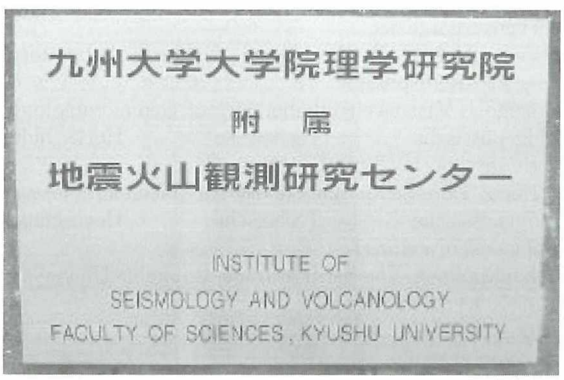
James Hall, Geophysical Laboratory, Carnegie Institute of Washington, USA

ICDP Trainings Course 2003 at the Unzen Volcano in Japan

Is ICDP on excursion to "Animal Farm"? Are the sites of the next ICDP drilling projects situated in a zoo or in a wildlife park? Or what have a doghouse, a monkey board, a mouse hole, a gooseneck, or fish to do with drilling? On the other hand: Driller's depth; logger's depth; lag depth? If we are able to measure distances with an accuracy of parts of millimetre, why can´t we determine the exact depth of a borehole?

Fig. 1: The ICDP training group on excursion at the USDP drill site together with the host of the drilling company

The answer to these and other questions concerning drilling in general and especially scientific drilling is the subject of the ICDP training courses. These courses are organized by the Operational Support Group (OSG) and offered to the ICDP scientific community. The OSG strives to hold the courses in the vicinity of a running drilling project where theoretical lessons can be combined with practical exemplification. This allows drilling proponents to spend a lot of time on site acquiring hand-on experience with drilling and sample handling activities.



Invited by Japanese scientists of the Unzen Scientific Drilling Project (USDP) the 2003 ICDP Trainings Course took place from 10th – 14th of November in Shimabara, Japan, near the Unzen volcano in the rooms of the Institute of Seismology and Volcanology of the Kyushu University.

A total of 35 postgraduates, scientists, and engineers from Canada, China, Germany, Japan, Poland, Taiwan, and Czech Republic participated in this course.
The topics of the theoretical part of the course included:

Drilling Technique	• Fundamentals of Scientific Drilling • Mud and Mud-Systems • Hydraulic Tests and Fluid Sampling • Borehole Stability
Borehole Measurements	• Logging Fundamentals • New Developments • Log Quality • Log Interpretation
On-Site Science	• Organization and Management • Sampling and Sample Handling • On-Site Analyses • Data Management

In addition USDP scientists introduced the Drilling Program in a one and a half day session. This included a field trip to the surroundings of the Unzen Volcano with a visit to the drill site.

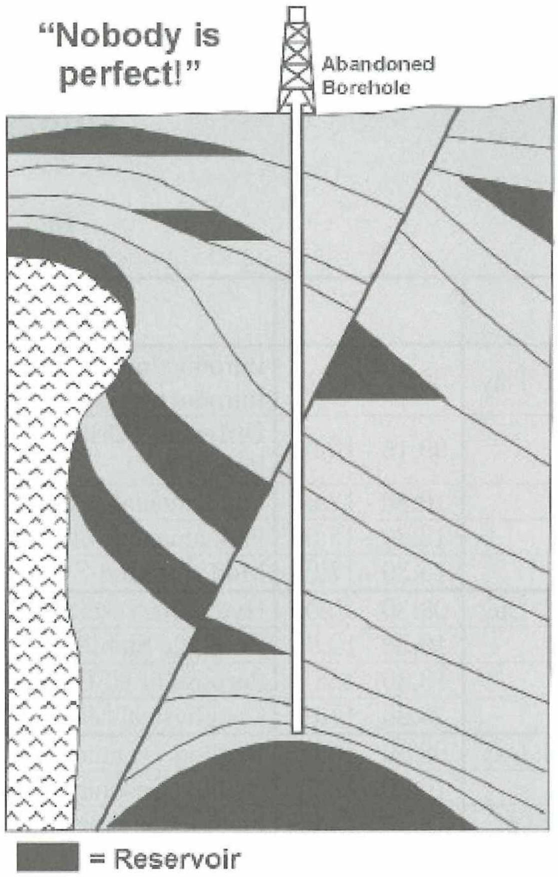
Although drilling activities had just stopped a few days before, it was very interesting especially for those colleagues who had not previously seen a drilling rig in such detail. All tools laid out on the rig floor or on the drill site could be inspected without disturbing the drilling process.

Fig. 2: Sumio Sakuma (left) USDP head drilling engineer answering all questions

From the technical point of view, the USDP is one of the most challenging and exciting ICDP projects. Therefore, special thanks are given to Kozo Uto and Ryo Komatsu for the hospitality and the very time consuming local organization of this ICDP-Training-Course.

The discussions with specialists and members of the USDP team were essential in the training program and will be very beneficial for the many of the forthcoming ICDP drilling projects.

However, even training, unfortunately cannot guarantee for success in a drilling project as demonstrated in the following cartoon.



The explanations of the terms given at the beginning of the text:
<u>Doghouse:</u> A small room on the rig floor used as office or tool store.
<u>Monkey board</u>: A small platform in the derrick to handle the top end of the pipe.
<u>Mouse hole:</u> An opening through the rig floor into which a length of drill pipe is placed temporarily for later connection to the drill string.
<u>Gooseneck:</u> The curved connection between the rotary hose and the rotary tool at the top of the drill string.
<u>Fish:</u> Parts of the drill string stuck in the borehole.

<u>Driller's depth; logger's depth; lag depth:</u>
Sorry, but for these explanations please join the ICDP Training. The next courses will be announced in time at

http://www.icdp-online.org

You are very welcome!

Thomas Wöhrl, ICDP-OSG, GFZ Potsdam, Germany

ICDP / USDP Training 2003

in

Shimabara, Japan

10. - 14. Nov. 2003

1. Day	08:30 - 09:15	Introduction in the Training Program Introduction of the Participants	Wöhrl / USDP
	09:15 - 10:00	Different Drilling Projects = Different Drilling Problems *)	Participants
	10:30 - 12:00	Fundamentals of Scientific Drilling	Wohlgemuth
	13:30 - 15:00	Fundamentals of Scientific Drilling	Wohlgemuth
	15:30 - 17:00	Mud and Mud-Systems	Engeser
2. Day	08:30 - 10:00	Hydraulic Tests and Fluid Sampling	Engeser
	10:30 - 12:00	Borehole Stability	Engeser
	13:30 - 15:00	Purpose of USDP	Uto / Nakada
	15:30 - 17:00	Geophysical Measurements of USDP	Ikeda
3. Day	08:30 - 10:00	Drilling Techniques Used for USDP (at the drill site)	Sakuma
	10:30 - 12:00	Drilling Techniques Used for USDP (at the drill site)	Sakuma
	13:30 - 15:00	Field Excursion: Geology of Unzen Volcano	Hoshizumi
	15:30 - 17:00	Field Excursion: Geology of Unzen Volcano	Hoshizumi
4. Day	08:30 - 10:00	Organization of the Scientific On-Site Program	Wöhrl / de Wall
	10:30 - 12:00	On-Site Geology	de Wall / Wöhrl
	13:30 - 15:00	On-Site Geology	de Wall / Wöhrl
	15:30 - 17:00	Data- and Data Management & Core Scanning	Conze
5. Day	08:30 - 10:00	Logging Fundamentals	Kück
	10:30 - 12:00	Logging Fundamentals and New Developments	Kück
	13:30 - 15:00	Log Quality and Data Analysis	Pechnig
	15:30 - 16:30	Log Interpretation in Scientific Boreholes	Pechnig
	16:30 - 17:00	Final Discussion	Wöhrl

*) The participants of the different ICDP drilling projects were asked to introduce their drilling projects, including possible and expected technical difficulties and problems. Problems can be included in the presentations on the following days or can be discussed in the evening after the daily sessions.

New scanning device integrates optical core scans into ICDP Drilling Information System

The archiving and documentation of recovered samples is an essential task in drilling projects. ICDP´s Operational Support Group together with GFZ Potsdam successfully developed a Drilling Information System (DIS) which provides scientific teams of ICDP projects with information service about all sorts of drill site and sample data through the World Wide Web. Optical scans of core surfaces are used as a reference in the DIS system to integrate all data sets acquired on core samples.

The archived core scans are used to setup a virtual core archive that can be used, for example, as resource for sampling and analyses decisions from every web-connected computer for later investigations in laboratories.

Several ICDP projects have set up the Drilling Information System and have provided digitized core pictures within the DIS. However, a simple to handle, robust and light-weight device for high-quality optical scans of slabbed or 360° core-surfaces, cuttings, and even thin sections as integrated part of the DIS has not been available to date.

A new generation of core scanning devices, the smartCIS (Camera Image Scanner) has now been developed by the company *smartcube* (Berlin, Germany), who had previously already been involved in programming services for the DIS set up of ICDP projects. The scanning facility is designed to fulfill the requirements of ICDP-projects and, at the same time, offers an automatic surface photographing with

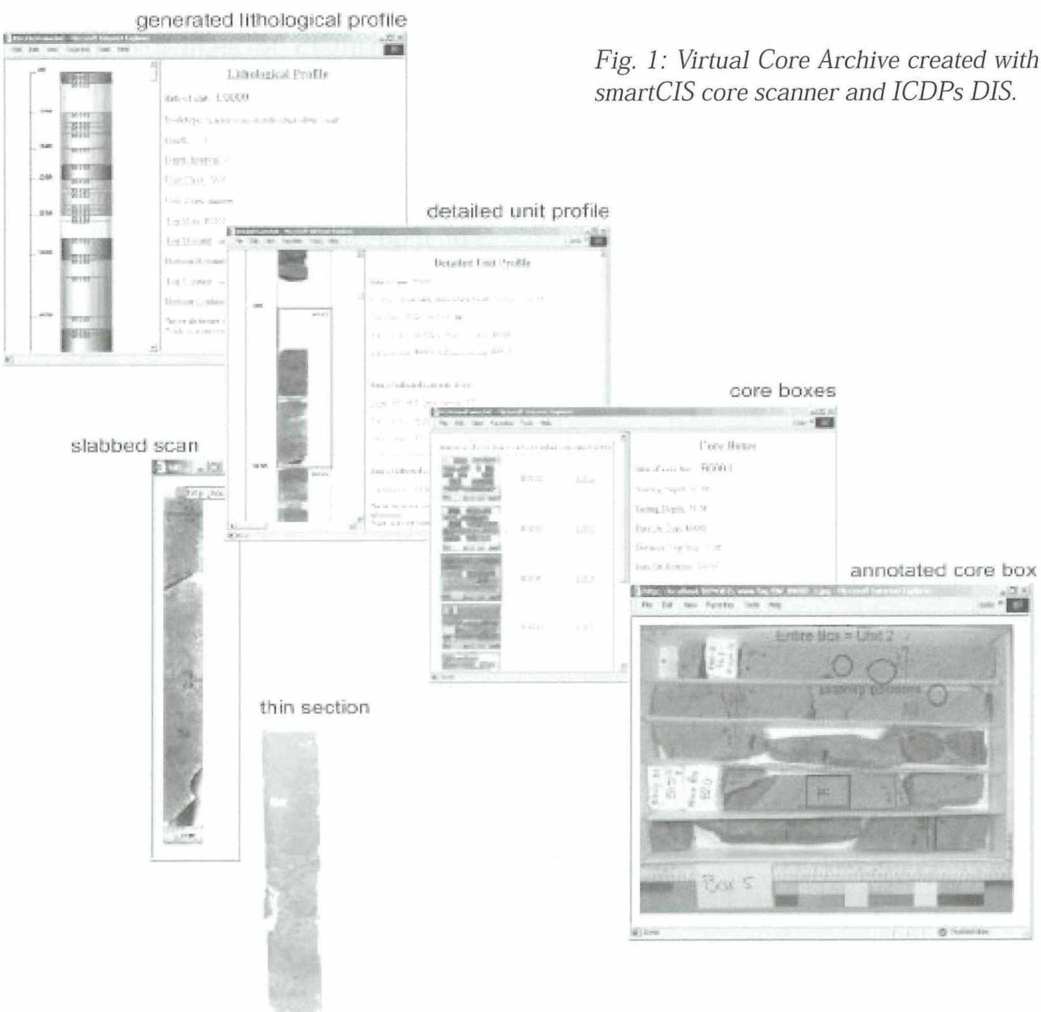


Fig. 1: Virtual Core Archive created with the new smartCIS core scanner and ICDPs DIS.

integration into digital web-based or web accessible archives.

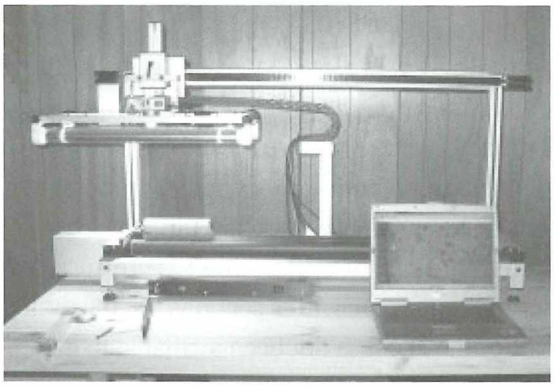


Fig. 2: SmartCIS, the new optical core scanner. Note drill core sitting atop two rollers for 360° scans.

SmartCIS was constructed with an off-the-shelf high-resolution digital still camera, innovative small electric motors for the roller and camera movements and steering, via a standard PC or laptop without the need for special extra hardware. It weighs only 26 kg and is capable of scanning objects of up to one meter length delivering pictures with a maximum resolution of 500 dpi.

The smartCIS software can be operated in a stand alone mode with scans stored and used on the steering computer, but the software also includes a special interface to communicate with the ICDP-DIS. This combination of smartCIS and DIS creates a new quality of core archives. The core surfaces scanned with smartCIS are archived and documented with DIS. This archive can be accessed through different interfaces, especially via the Internet through the eXtended Web interface of DIS (XDIS) defining a Virtual Core Archive.

The software allows for the integration of other software and the application of data analyses tools in the evaluation of the digitized sample images. In cooperation with the ICDP, *smartcube* will add new features to the smartCIS hard- and software such as, for example, spectral analysis of colors. Other analytical or project-specific features will be added according to arising demand in ICDP projects.

The ICDP-supported Taiwan Chelungpu-Fault Drilling Project (TCDP) is the first project using smartCIS to archive digital photos of cores and cuttings and already provides examples of these pictures on the public TCDP Web pages at: *http://chelungpu.icdp-online.de.*

For more information and details please visit also *http://www.smartcube.*

Frank Krysiak, smartcube, Berlin
Ronald Conze, OSG, GFZ Potsdam, Germany

NEWSLETTER

icdp

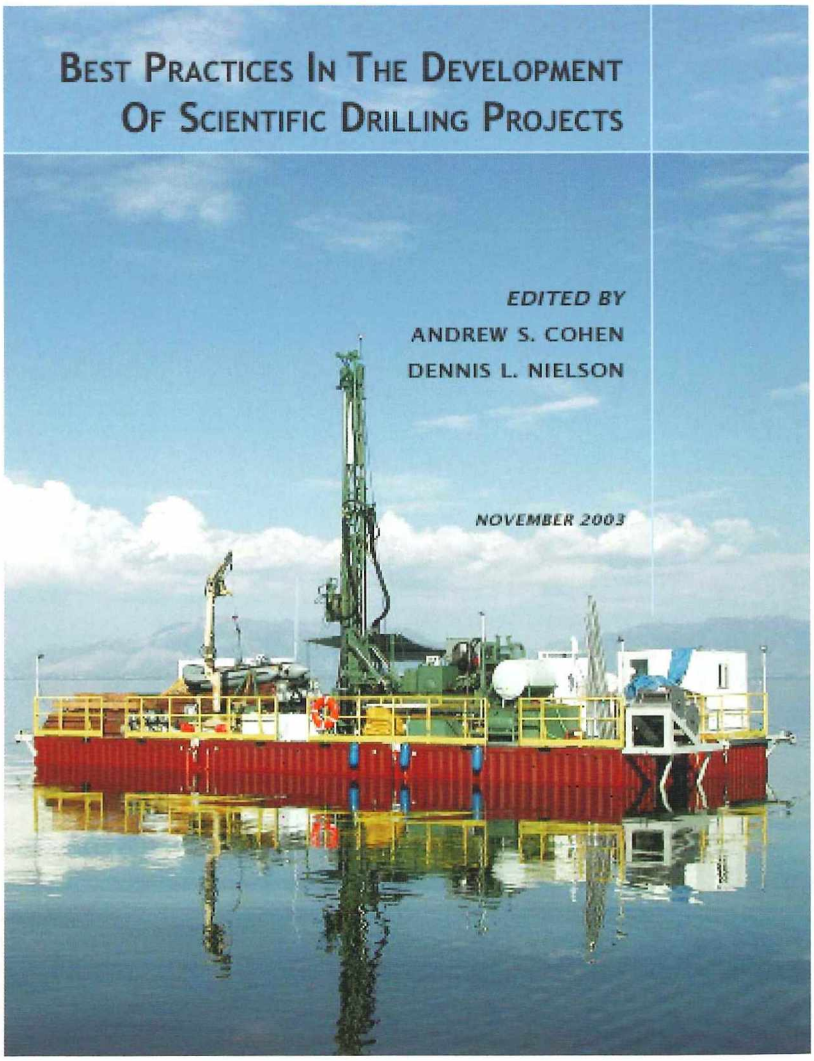
Volume 6, March 2004

International Continental Scientific Drilling Program

Best Practices in the Develepment of Scientific Drilling Projects

In an effort to provide input to funding agencies concerning the scientist's perspective of the proposal process and to provide a road map for scientists contemplating a scientific drilling proposal, DOSECC convened a workshop in May 2003 to address **Best Practices in the Development of Scientific Drilling Projects**. This report defines the stages from initial concept through the post-drilling activities and presents recommendations that will be of interest for proponents of scientific drilling projects, particularly those that will have an international participation.

The report can be obtained through DOSECCs website at ***www.dosecc.org.***



ICDP Members: GERMANY, USA, CHINA, JAPAN, MEXICO, POLAND, CANADA, AUSTRIA, ICELAND, NORWAY, CZECH REPUBLIC, UNESCO, SCHLUMBERGER

Executive Agency: GeoForschungsZentrum Potsdam (GFZ), Germany

Boards: Assembly of Governors (AOG, Chair: Margaret Leinen), Executive Committee (EC, Chair: Rolf Emmermann), Science Advisory Group (SAG, Chair: Mark Zoback)

The ICDP Newsletter is issued once a year and distributed free of charge in digital and printed version

Newsletter Editor & Contact: Ulrich Harms, GFZ Potsdam, Telegrafenberg, 14473 Potsdam, Germany

ulrich@gfz-potsdam.de; http://www.icdp-online.org

The Chelungpu-Fault in Taiwan is being drilled in spring 2004 with ICDP support. This is one of the major ICDP projects dealing with fault zones and earthquake generation.

TCDP

Taiwan Chelungpu-fault Drilling Project

More about Continental Scientific Drilling Projects is available at: www.icdp-online.org

CRL · Lake Titicaca Drilling Project · Gas Hydrate Research Well MALLIK 2002 · Bosumtwi Crater Drilling Project · CCSD · Demonstration ICDP Drilling Project · Chicxulub Scientific Drilling Program YAXCOPOIL ICDP UNAM GFZ · KTB · Lake Malawi Drilling Project · IDDP · Hawaii Scientific Drilling Project 1999 · TCDP Taiwan Chelungpu-fault Drilling Project · Unzen Volcano International Cooperative Research with Scientific Drilling for Understanding Eruption Mechanisms and Magmatic Activity · San Andreas Scientific Drilling Project