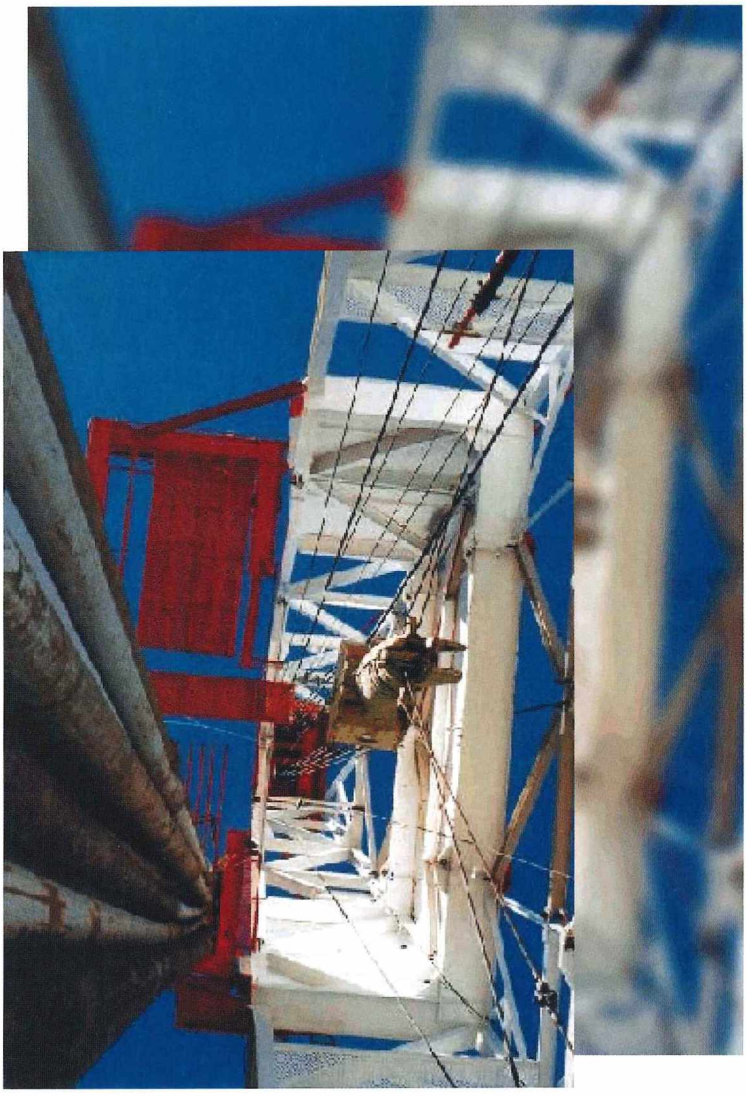
NEWSLETTER

Vol. 2, April 2000

International Continental Scientific Drilling Program



CONTENT:

International Continental Scientific Drilling Program

The ICDP Newsletter

ICDP Members: GERMANY, USA, CHINA, JAPAN, MEXICO, POLAND, UNESCO, SCHLUMBERGER

Executive Agency: GeoForschungsZentrum Potsdam (GFZ), Germany

Boards: Assembly of Governors (AOG), Executive Committee (EC), Science Advisory Group (SAG)

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

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PROGRAM

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UNESCO United Nations Educational, Scientific and Cultural Organization.

Schlumberger

IMPRINT:

ICDP Newsletter, Vol. 2, April 2000

Editor: Ulrich Harms, GFZ Potsdam, Germany

Printed in Potsdam, May 2000

THE INTERNATIONAL CONTINENTAL SCIENTIFIC DRILLING PROGRAM (ICDP)

MISSION OF THE ICDP

Great advances have been made in recent years in the understanding of the evolution of the Earth's continental crust; and modern techniques have also allowed great progress in geophysical or remote sensing survey and geological mapping of large areas. As a result it has become clear over the last decade that scientific drilling is a critical tool in our understanding of Earth processes and structure. Drilling can provide unique opportunities for the direct study of Earth processes and it also critically tests geological models developed on the basis of surface observations and remote sensing. Results obtained from drilling is an essential component for a responsible management strategy for the Earth's natural resources and environment.

These general considerations prompt to the following mission of the ICDP: „Through the unique capacities of scientific drilling to provide exact, fundamental and globally significant knowledge of the composition, structure and processes of the Earth's crust" with particular focus on research themes such as:

The specific objectives of the ICDP in carrying our its mission are:

- To obtain secure funding for an effective planning, implementation and execution of a viable strategic program to meet scientific objectives of socio-economic significance.
- To identify sites for international cooperation in scientific drilling, and thus to provide cost effective means of answering key scientific question in the ICDP's priority fields.
- To ensure that appropriate pre-site surveys are carried out.
- To provide a core of technical support for drilling project to facilitate their efficient planning and operation.
- To ensure appropriate monitoring of the program and accountability to sponsors in terms of scientific effectiveness and financial efficiency.
- To ensure effective publication and dissemination of the results.

- The physical and chemical processes responsible for earthquakes and volcanic eruptions
- The manner in which the Earth's climate has changed in the recent past and the reasons for such changes
- The effects of major impacts on climate and mass extinctions
- The nature of the deep biosphere and its relation to geological processes such as hydrocarbon maturation, ore deposition and evolution of life on Earth
- How to safely dispose of radioactive and other toxic waste
- How sedimentary basins and hydrocarbon resources originate and evolve
- How ore deposits are formed in diverse geological settings
- The fundamental physics of plate tectonics and heat, mass and fluid transfer through Earth's crust

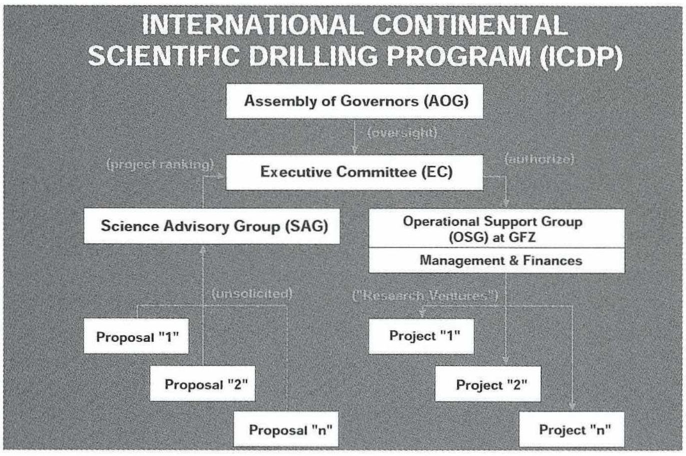
MANAGEMENT

The ICDP is a multinational program designed to coordinate international continental drilling projects with a variety of scientific targets and a wide range of depth targets and technical difficulty. Drilling projects are selected from unsolicited proposals, submitted by scientists from member countries, and countries considering membership, on the basis of their scientific merit, by an international group of scientific and technical experts. Each project is independently organized in the form of a national, binational or multinational Joint Research Venture between the ICDP and the Principle Investigator(s) and other interested parties, such as, governmental agencies, industries and private research groups and funding organizations. The Joint Research Venture specifies the scientific goals and the respective funding responsibilities, operational procedures and conditions of technical cooperations and exchange for all partners in a specific project.

A program structure has been developed which is simple and flexible in its procedure to meet individual project requirements and is inexpensive in its administration.

1. Oversight and determination of policy – by the **Assembly of Govenors (AOG)** representing the funding countries and agencies.
2. Scientific assessment of project proposals submitted for ICDP participation – by the **Science Advisory Group (SAG).**
3. Program management and operation, including project priorization and budget allocation – by the **Executive Committee (EC)** with **Operational Support Group (OSG).**
4. Project management - by teams in host countries under the leadership of the Principal Investigators with the assistance of the Operational Support Group.
5. Project monitoring – by the Executive Committee, for reporting to the Assembly of Govenors, with the assistance of project committees.

The main objective of the program structure is to maintain autonomous continental drilling projects of any type, independently organized and managed in the form of a Joint Research Venture with national, binational or multinational partners, connected through an ICDP funding contribution and committed to certain principles of scientific cooperation and exchange. The EC is served by the ICDP Operational Support Group (OSG) who provides the EC with the operational capabilities to manage projects as determined by the terms of the individual Joint Research Ventures.



The OSG acts through authorization from the EC as the legal contractual partner for the ICDP to manage each project under the terms of a Joint Research Venture negotiated for each project. A "Joint Research Venture" is a negotiated contract between the Operational Support Group, on behalf of ICDP, and the Principle Investigators and other partners who have an interest in the project. The Joint Research Venture will set the terms by which the partners and the primary programmatic and scientific goals of the project.

The OSG is established at the GeoForschungs-Zentrum Potsdam and provides broad logistical support for the ICDP the incorporates the following support functions:

- Provide technical and scientific liasion to SAG and EC.
- Support for scientific and engineering drill site operations and management.
- Provide a minimal set of downhole capability, develop special downhole tools.
- Develop Joint Research Ventures for each project authorized by EC.
- Management and support of Secretariats for AOG and EC.
- Provide all data collected during each project through a readily accessible data management system for ICDP projects.

Salaries and office accommodation for the nucleus of the OSG are provided by the GeoForschungsZentrum Potsdam while additional costs for services are charged on a project-by-project basis to the ICDP.

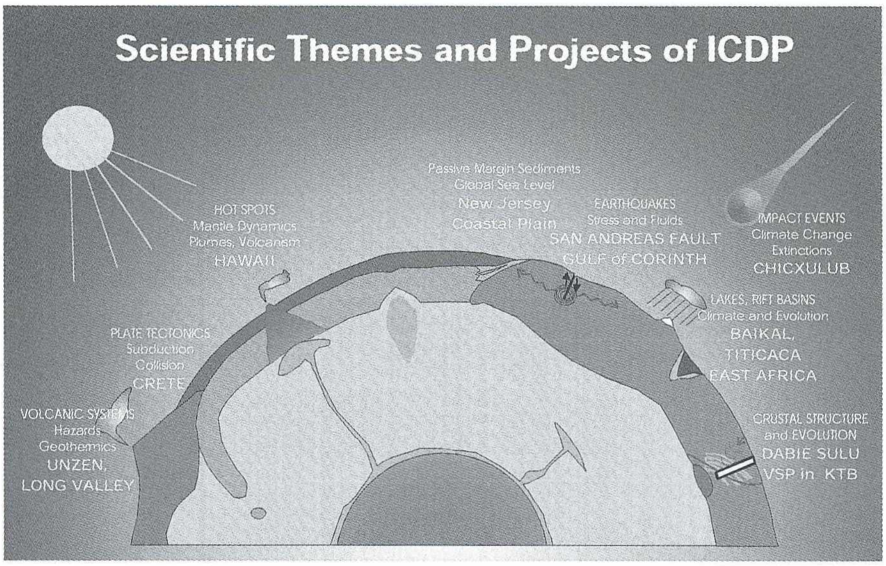
PROGRAM-STATUS

The ICDP was inaugurated in February 1996 in Germany, China and the USA. Major Science Organizations represent these countries namely the National Science Foundation for USA, the Ministry of Land and Resources of the People's Republic of China and for the German side the GeoForschungsZentrum Potsdam and the German Research Foundation (DFG). Japan decided to join the ICDP in 1998 and is represented by the Science and Technology Agency (STA). Meanwhile Mexico and Poland are members of ICDP. From the industrial side Schlumberger Inc. (France) has joined ICDP. In addition, ICDP has close contacts to the Ocean Drilling Program (ODP) and to the UNESCO (both organizations are so-called Liaison Members).

Members of the International Continental Scientific Drilling Program contribute annually with a membership fee depending on the economic power of the respective country. The European Science Foundation, ESF and ICDP invite interested European countries to join ICDP through an ESF Consortium that will allow for a reduced membership fee. Norway, Finland and Austria have already expressed their interest to join the program. The ESF will be a full member of ICDP and represent such European consortium. This implies that all member countries of the consortium will have all benefits mentioned below (except direct membership in ICDP boards which is determined by the ESF) and that Europe will be represented adequately in the ICDP. ESF's membership will also imply the already existing ESF programs (i.e. the European Lake Drilling Program, ELDP) will be represented in ICDP.

During the first five years ICDP has received more than 70 project proposals from all over the world. These projects range from big programs such as drilling into San Andreas Fault in order to study earthquake activity in an active strike-slip regime or smaller projects such as drilling small volcanic lakes within the framework of global paleoclimate research. The first drilling projects have already been accomplished: (1) Drilling in Lake Baikal for paleoclimate research and (2) drilling of a 3 km deep hole into the Long Valley Caldera, Califormia to help understand hydrothermal processes and earthquake activities stimulated by an underlying magma chamber. In April 1999 the third ICDP project started in Hawaii in order to study the geochemistry and active processes of hot spot volcanism. In 2000 two further ICDP projects will start: drilling a 3 km hole into the Chicxulub impact structure in Mexico and drilling a 5 km hole in the Dabie-Sulu Ultrahigh Pressure rocks in Eastern China. Also the two boreholes of the German Continental Deep Drilling Program (KTB) are used for ICDP experiments. In a joint German-US-Japanese cooperation a complete vertical seismic profile down to about 9 km was successfully recorded in April 1999. In autumn 1999 an additional MSP-Experiment using the two boreholes was performed. Further projects planned for the future are research bores in the

Eastern Mediterranean (Crete/Gulf of Corinth), drilling lake sediments in Lake Titicaca and in the East African Rift, as well as the San Andreas Fault Zone Observatory at Depth (SAFOD).



In addition to these activities, ICDP funds international workshops for discussion and preparation of drilling projects. A third area of activity covers Training Courses and Summer Schools. ICDP has prepared a complete training course over three months covering all topics from drilling engineering, logging, sampling, sample investigations to documentation. This course was first held in 1997 for a group of Chinese scientists and engineers and was already repeated twice. Moreover ICDP is prepared to organize so-called Summer Schools in different fields. These Summer Schools address in particular students and young post-graduates. The first Summer School for scientific logging of bore holes and log-interpretation was held 1998 at the drill site of the KTB in Germany. A second Summer School was organized in August 1999 at the drill site of the Hawaii Drilling project. ICDP will also set up a program of undergraduate fellowships to fund students of member countries for working on actual drilling projects and thereby "learning on the job".

BENEFITS OF BEING ICDP-MEMBER

The general philosophy of ICDP is the support of drilling projects which aim to study basic geoscientific problems at critical sites (so-called World Geological Sites). ICDP funds only drilling projects carried out within the framework of broad international cooperation for the benefit of the project itself and the geoscientific community at large. Member countries benefit from ICDP activities in the following way:

- Representatives of the member countries are members of the ICDP boards (Assembly of Govenors, Executive Committee, Science Advisory Group) and can thus influence ICDP activities.
- Scientists of member countries have the right to participate in all ICDP projects.
- Scientists information, samples, data and results of ICDP projects are available for all scientists of member countries. Data and information are available by Internet services through the GeoForschungs-Zentrum Potsdam.
- Scientists of member countries can attend ICDP workshops.
- Training courses and Summer Schools are open for individuals from member countries.
- Members of ICDP have access to services of the Operational Support Group i.e. for the preparation of drilling projects.
- Scientists of member countries have access to equipment of ICDP (e.g. drilling equipment, instruments as far as available).
- Young scientists of member countries may apply for the Undergraduate Fellowship Program.

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The Chicxulub Scientific Drilling Project: Strategy

As a result of an international workshop in Merida, Yucatan, Mexico, on March 21-23, the International Continental Scientific Drilling Program (ICDP) will provide funds to drill a continously cored drill hole into the Chicxulub Impact Crater located in Yucatan, Mexico. With available funds and support from Mexican institutions, a 2500 to 3500 meter hole will be drilled 60-75 kilometers SW of the center of the crater this year. The hole will be sited in the vicinity of Pemex well Yucatan-6 in order to tie it in to the available well core data and well logs. The primary coring objective is to recover a complete section through the impact generated melt rocks and breccias. In doing so, a complete section through the Cenozoic open-water carbonates will also be recovered, providing collateral information on the evolution of the crater and the Yucatan platform.

The Chicxulub Scientific Drilling Project is a multi-phase project involving geophysical, geologicalstudies and drilling. To date, magnetic, gravity and seismic studies have been conducted as well as a shallow drilling program led by UNAM.

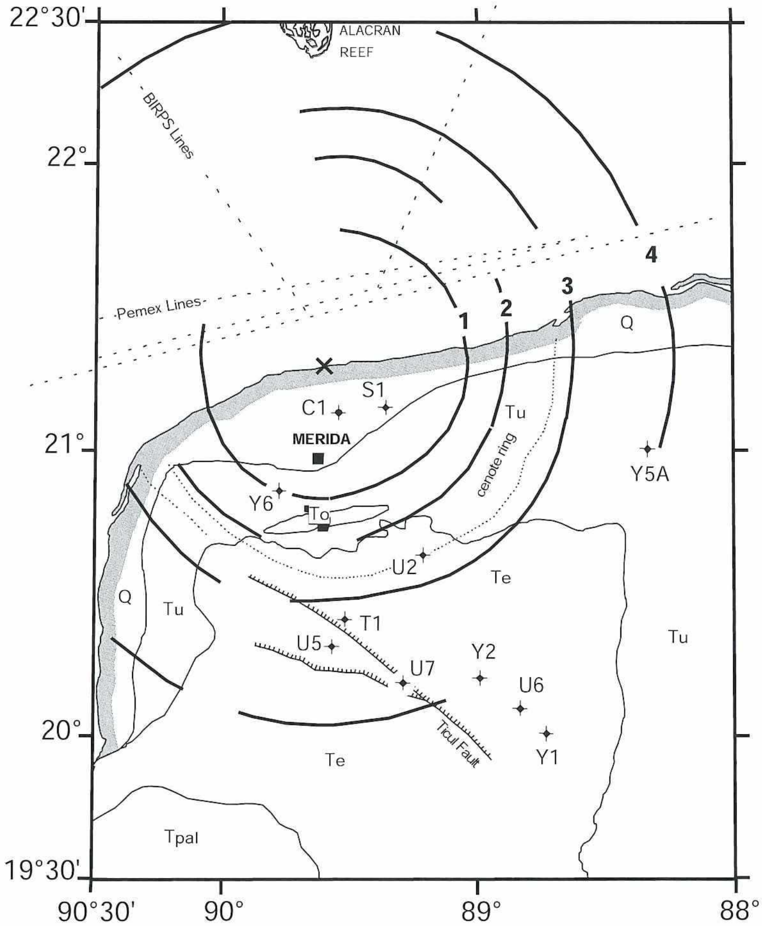


Fig. 1: Surface geology, ring locations from gravity data, and wells in the vicinity of the Chicxulub multring impact basin. The three wells that penetrated impact melt rocks and breccias beneath the carbonate cover rocks are C1(Chicxulub1) S1 (Sacapuc1) and Y6 (Yucatan6). Other Pemex well sites shown are Yucatan 1 (Y1), Yucatan2 (Y2), Yucatan5a (Y5A), and Ticul1 (T1). The Yucatan 4 (Y4) well site is located off the map ~65 km east of Y5A. Important sites of recent shallow drill-coring, led by UNAM scientists, are denoted by U2 through U7. Carbonates units at the surface are Q (Quaternary; < 1.6 Ma.),Tu (Upper Tertrary; ~1.6 Ma to 38 Ma), To (Oligocene;~24 to 38 Ma), Te (Eocene; ~38 to ~55 Ma), and Tpal (Paleocene; ~55 to ~66.0 Ma). Hatchured lines represent the Ticul fault system. Dashed lines indicate trends of ringlike zones of cenotes or sinkholes. Existing (Pemex) and (BIRPS offshore seismic lines are shown by broken line patterns).

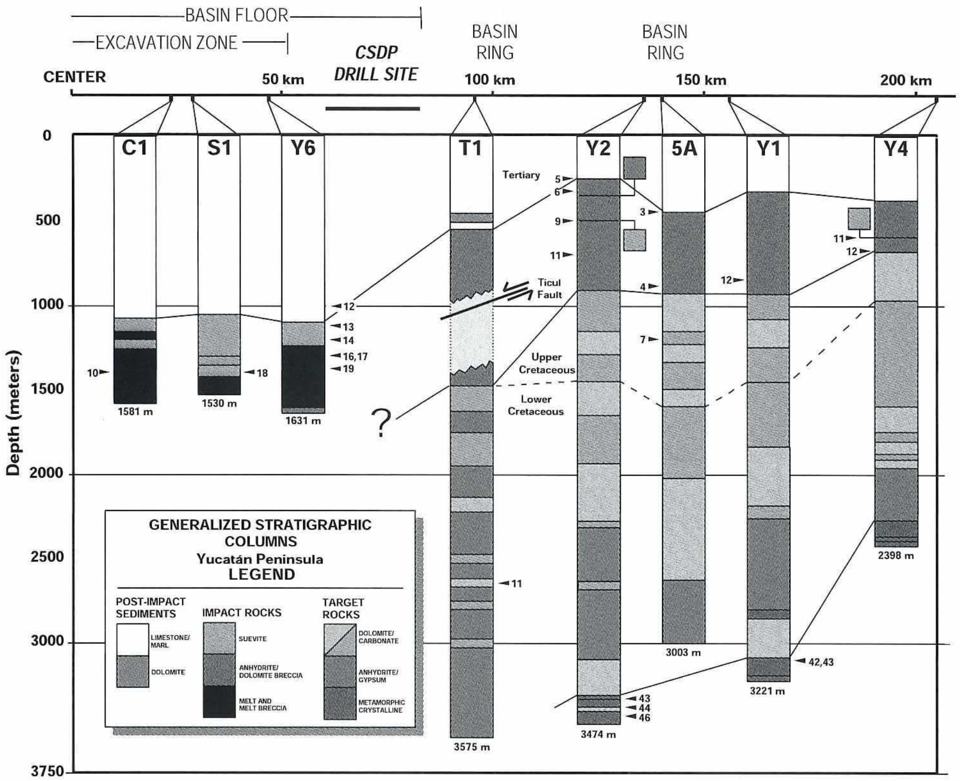
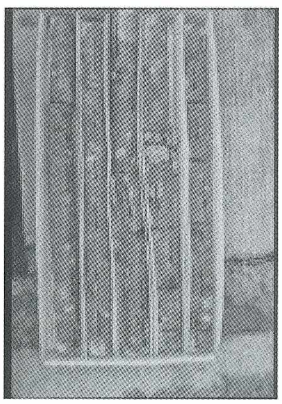


Fig. 2: Schematic lithologic columns of drill holes UNAM's Scientific drilling program.

This year we will be drilling three shallow holes as well as one deep hole. The first three are seven hundred meter holes and the second is on the order of 2.5 - 3 thousand meters.

The first shallow hole will be used as pilot hole before drilling the three thousand meter hole. We plan on conducting geophysical tomography experiments between these two holes. We are planning on casing all wells at appropriate depths to monitor shallow and deep ground water geochemistry.

Recovered cores will be split into two halves. The first half will be used for different physical and chemical determinations, and the second half will be archived.



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Chicxulub Scientific Drilling Project: Geophysics and Well-Logging

As part of the international collaboration under the ICDP, a comprenhensive project to study the Chicxulub impact crater that includes geophysical surveys, deep drilling and detailed well-logging is being implementend. Chicxulub, which is considered as the Cretaceous/ Tertiary crater, has been the subject of detailed offshore and onshore studies by several research groups.

The deep drilling project is built on early exploratory drilling by the Mexican oil company Pemex. and the recently conducted shallow drilling program by UNAM. The proposed deep drilling site will be located between Pemex wells Yucatan-6 and Ticul-1. Although only intermittent cores were recovered in the oil exploratory wells, this location will allow use of well logs, biostratigraphic and lithologic information. UNAM wells, with high core recovery rates, are also located in the southern sector of the basin, close to and south of Ticul-1 well. Three of these wells have already sampled the impact breccias. Deep drilling down to 2.5 to 3.0 km should sample the Tertiary carbonate sequence, the impact breccias and the melts. Available geophysical data are being integrated with the borehole information to aid in planning the pre-site geophysical studies that include gravity, magnetics and magnetotelluric surveys. Seismic reflection profiling is planned to tie the various wells (though this study may not precede drilling).

A proposed 2.5 - 3.0 km Section through Chicxulub

In order to address substantial issues related to the formation of the Chicxulub crater and how it initiated a global environmental crisis, we are proposing for a continuously-cored drill hole to a depth of ~3 km to be located on the southern side of the Chicxulub impact basin between 60 and 80 km from the crater center.

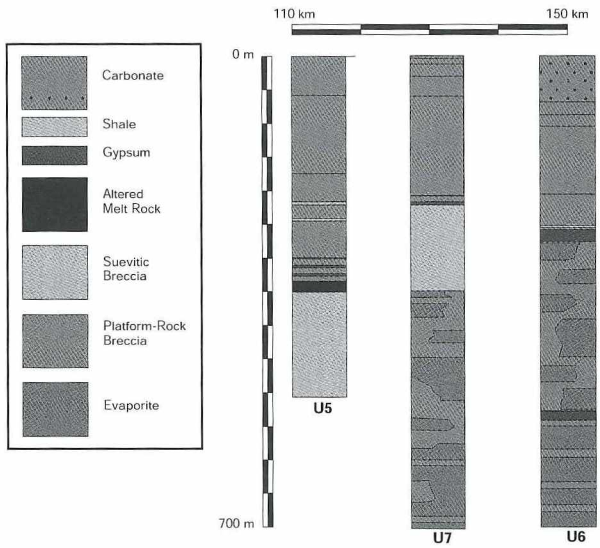


Figure 1: Previously drilled UNAM Wells

This corresponds to a locality that is approximately midway between existing Pemex boreholes Ticul-1 and Yucatan-6, which provide some important local controls over stratigraphy and lithology. The outer boundary to this zone is the "Cenote Ring". Existing drill-core and seismic data provide some insights into the lithological units the drilling would encounter and recover. Major uncertainties in these predictions clearly exists, however, and the fundamental goals of this project are to test and refine this basic stratigraphic model.

Upon the completion of CSDP we will have the following unique products available for scientific analysis:

1. A complete lithological record of early Cenozoic platform sedimentation for the southern Gulf of Mexico.
2. A complete section through the impact sequence, which from existing well logs and shallow drill coring in this region, is known to contain silicate-rich melt, melt-breccia, suevite, and bunte breccia. Within this assemblage are clasts of deep Paleozoic basement and clasts of Mesozoic platform rocks.

3. The upper parts of the downfaulted Mesozoic section that comprises the terrace zone or, by analogy with smaller terrestrial craters such as Ries (Germany) and Haughton (Canada), the megablock zone.

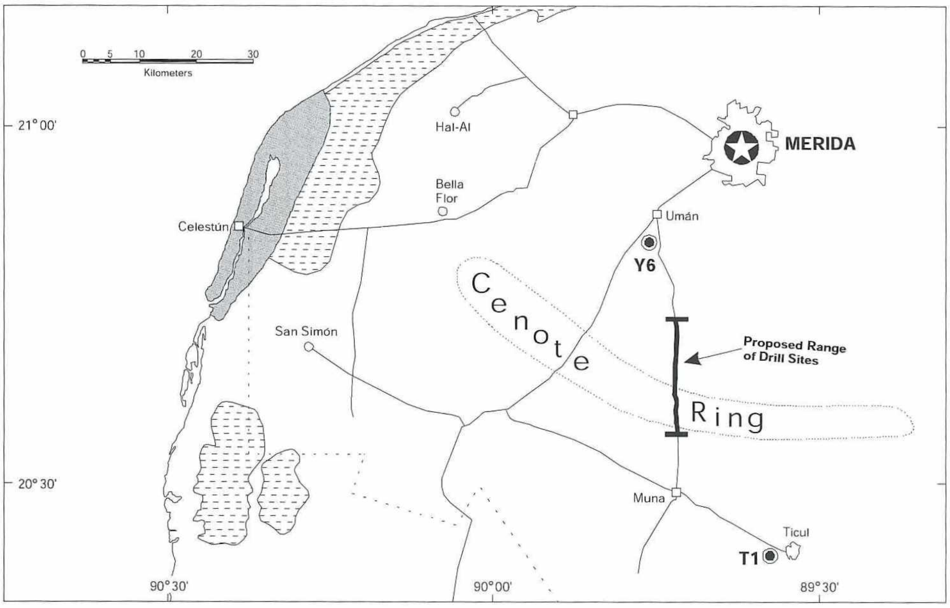
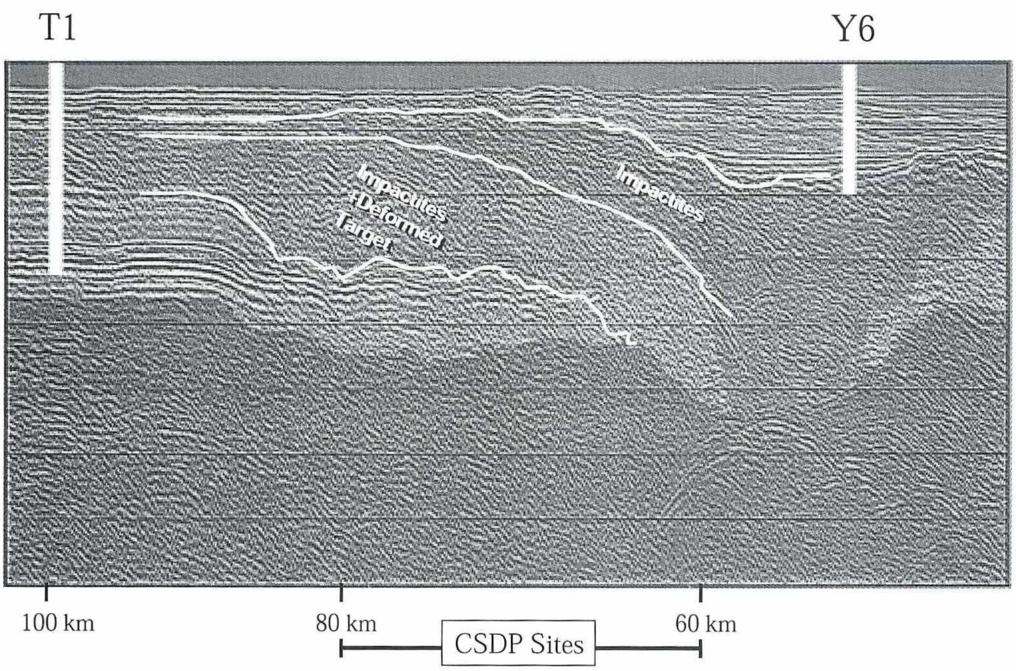


Figure 2: Sites of planned new drillholes along the road from Merida to Ticul



Figures 3: Seismic profile between the two previous boreholes Y6 and T1. The new deep hole will potentially truncate the impact melt sheet, impactites and the deformed target rocks.

The recovered cores will provide an unprecedented record of the extended evolution of this region, punctuated dramatically 65 Ma. ago with the formation of the Chicxulub impact basin. Although our goals are specifically to gather new information on the impact rock sequence relevant to understanding the impact process and gauging its destructiveness, we realize the cores can and should be used to approach a diverse suite of other science objectives. To expand the present science plan we are open for further participation of outside investigators with special skills and objectives whose goals in the Chicxulub research are complementary to our own.

Issues to be addressed

1) The nature of the impact event:
   a) How much melt rock and breccia are produced during a given event?
   b) How much of the projectile is incorporated in these materials?.
2) The nature of shock deformation:
   a) How efficiently are target materials shocked as a function of radial distance, depth and lithology?
   b) What is the role of volatile, pore spaces and heterogeneities in the expression of shock deformation, shock melting, phase transitions, etc.?
3) The nature of crater excavation:
   a) How deep did the crater penetrate?
   b) How does the excavation cavity grow?
   c) How efficiently is the ejected debris comminuted, shocked, and mixed during excavation.
4) The nature of the ejection process:
   a) How material is transported (e.g. ballistically, base-surge, etc.)
   b) How the ejecta interacts with and incorporates local materials
5) The nature of late-stage modification:
   a) Is there overlap in time between modification and ejecta emplacement?
   b) How are the allogenic impact units rearranged by modification?

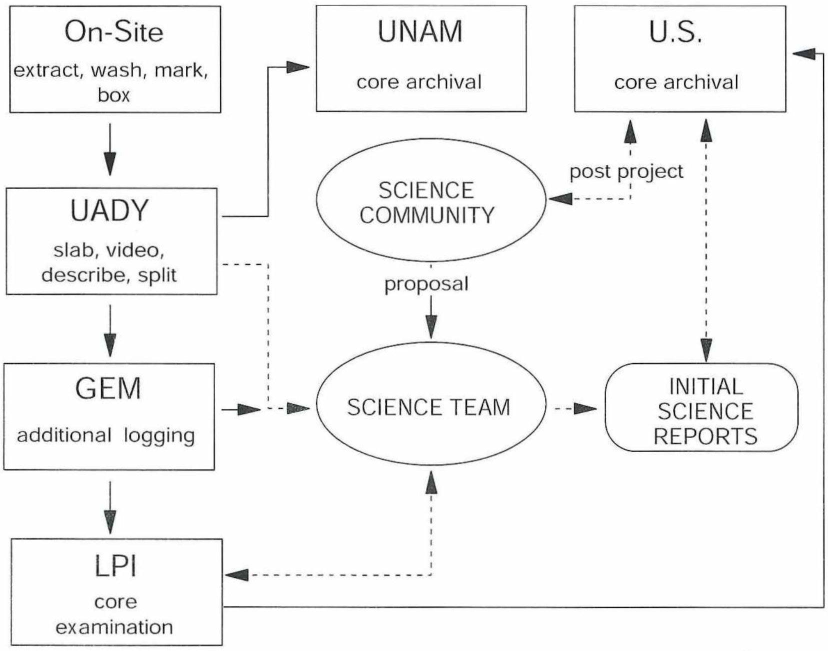
The basic downhole logging tools and expertise will be provided by GFZ-OSG; a team will supervised by Jochem Kück (GFZ-OSG) and Dr. Martin Bremer (Instituto Tecnológico de Monterrey).

Downhole Logging Tools

MEASUREMENT	PURPOSE
1. Sonic Velocity	P-wave velocity, seismic ties
2. Density	gravity modeling, impedance determination
3. Neutron porosity	fracture characteristics, porosity, density
4. Electrical Resistivity	fracture characteristics, log-ties (induction, laterolog)
5. Natural gamma	log-ties, lithology
6. Caliper, SP	Hole stability for drilling management
7. 4-arm Dipmeter	breakouts (stress) fractures
8. Acoustic Televiewer	breakouts, fractures, orientation data
9. Full Waveform Sonic	shear-wave velocity, fractures
10. Magnetic	correlation between core and susceptibility well logs, etc.
11. Temperature	hole stability for drilling management

The main goals of the downhole logging plan are, to assist in correlating the continuous core recovered, with other wells.

- To determine fracture patterns and fluid flow and stress relationship.
- To determine in situ stress orientation and magnitude.
- To calibrate gravity measurements.
- To orient core using log images.
- To determine P, S and Stonely wave parameters.
- To determine what, if any, characteristics of log responses are associated with impact units.



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Chinese Continental Scientific Drilling Program in the Sulu Ultrahigh Pressure Metamorphic Belt

Introduction

The Chinese Continental Scientific Drilling Program (CCSD) has been approved in 1999 as a national key scientific engineering project by the Chinese government and as an international project by ICDP. A 5000-m-deep scientific drillhole will be drilled in the Donghai area of the Dabie-Sulu ultrahigh pressure metamorphic (UHPM) belt, eastern-central China (Fig. 1). So far many detailed geological and geophysical surveys have been completed, and two pre-pilot holes (CCSD-PP1, 432-m-depth and CCSD-PP2, 1000-m-depth) have been drilled at the Donghai site of the CCSD. The main hole of 5000 m in depth will penetrate through coesite-bearing eclogite, garnet peridotite, gneiss, schist and other rocks unexposed possibly on the surface. These rocks were subducted to at least 100 km into the upper mantle and have experienced UHP metamorphism, before being then exhumed to the surface. The CCSD aims

- to reveal deep geological processes and dynamics of the convergent plate boundary,
- to understand crustal behavior and crustal-mantle interaction, and the mechanism of formation and exhumation of UHPM rocks,
- to test geophysical data in the deep structure
- to investigate the composition of the crust, and
- to establish a long-term, natural laboratory for the study of the deep continental crust.

Geological background of the CCSD site-selection

The Donghai site is located in the eastern part of the Dabie-Sulu UHPM belt between the North China Plate and the Yangtze Plate (Fig. 1). The lithospheric tectonic profile crossing the Sulu UHP metamorphic belt, which inferred based on the deep seismic reflective data, shows that the Sulu terrain consists of an upper UHP and HP metamorphic slice including gneiss, eclogite and peridotite, and a lower unexposed metamorphic slice associated with the emplacement of granites, and the Yangtze craton subducted beneath the Sulu terrain (Fig. 2). The protoliths of most UHPM rocks are supracrustal rocks with a formation age of about 800 Ma. Isotopic age determinations show that the collision between the Sino-Korean and the Yangtze plates started

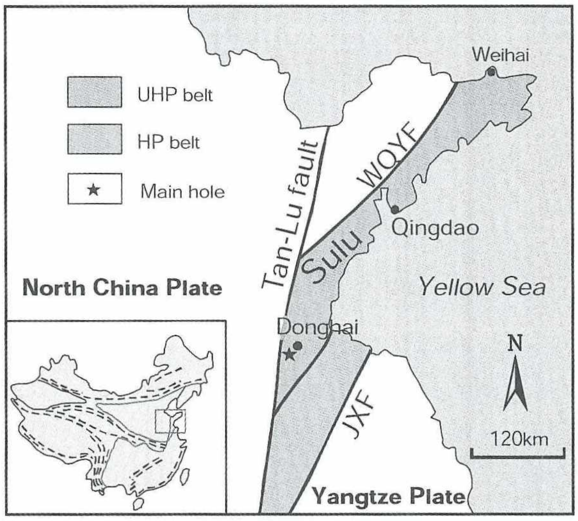

Fig.1 Sketch map of Sulu UHPM belt, showing the main hole site of CCSD

at about 240 Ma and the UHP metamorphism took place at about 220 Ma.

In comparison with other UHP terrains in the world, the Sulu UHP meta,orphic rocks are unique in the occurrence of: 1) many kinds of typical UHP rocks (Fig. 3); 2) volatile-bearing phases in eclogites and ultramafic rocks; 3) the lowest ^{18}O values (-15 per mil) for eclogitic minerals, the highest REE total content for UHP ultramafic rocks and the highest εNd (0) values (+170 to +264) ever measured for terrestrial rocks for eclogites; and 4) at least two distinct types of garnet peridotites. Type A mantle-derived peridotites are fragments of mantle wedges of the North China plate; Type B crustal-hosted peridotites are portions of mafic-ultramafic complexes of the Yangtze plate emplaced into continental crust prior to subduction. Rutile, kyanite and pyrope deposits related to UHP and HP metamorphism have

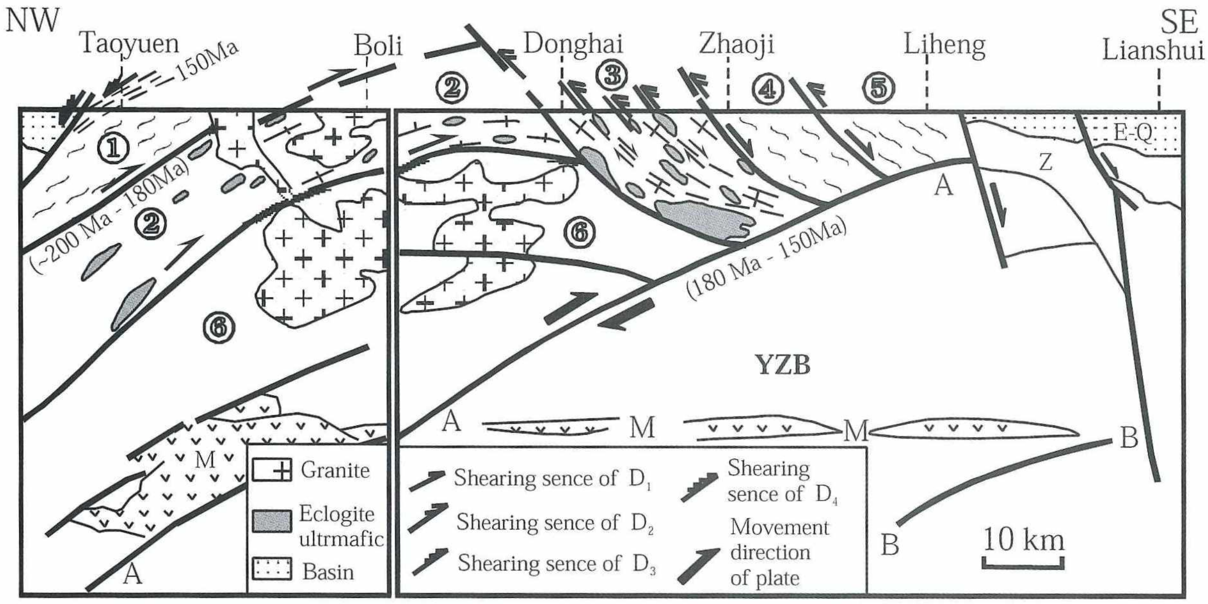

Fig. 2 Inferred deep structural profile crossing the Sulu orogenic belt. 1 - Wulian supracrustal nappe; 2 - Jiaonan UHPM nappe; 3 - Donghai UHPM thrust slice; 4 - Northern HP thrust slice; 5 - Southern HP thrust slice; 6 - Sulu metamorphic slab; YZB, Yangtze Block; A-A and B-B, the top and bottom boundary of Yangtze Block, representatively; M, Moho

been identified and prospected by shallow drilling and trenching. A larger grain of diamond crystal was also discovered in eclogite from the Donghai site (Fig. 4). Tectonically, the Donghai area consists of five stacked structural slices separated by four NE-SW striking and gently southeastward dipping ductile shear zones (Fig.5). Geophysical investigations demonstrate the presence of a high resistance, high reflectivity, high density (3.2 g/cm^3) and high velocity (6.8 km/s) layer at depths between 3.2 km to 4.3 km, which can be penetrated by a 5 km deep drillhole.

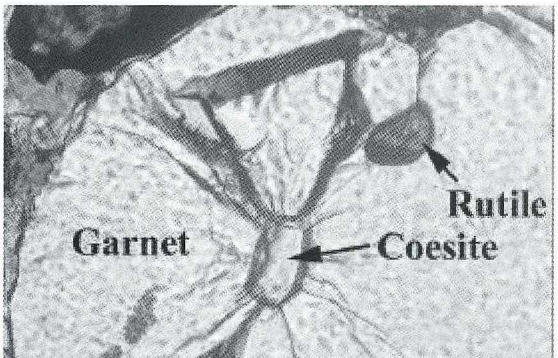

Fig. 3 Typical UHPM rock: coesite-bearing eclogite from Donghai

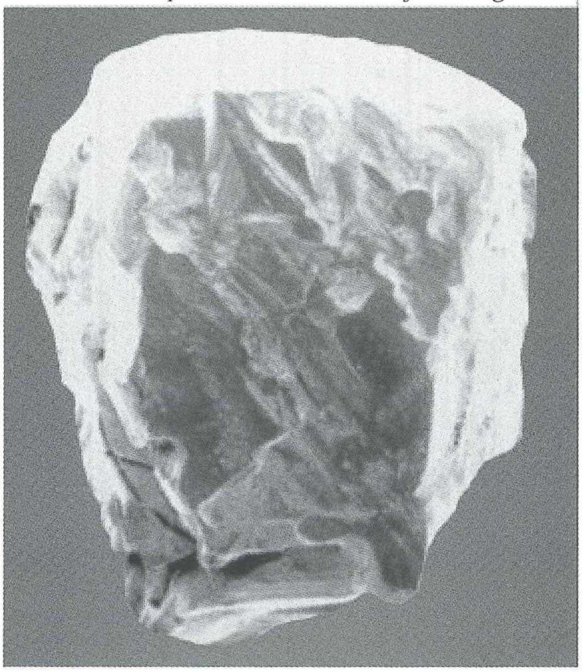

Fig. 4: A larger grain of a diamond crystal

Inferred petrotectonic column for the main hole of CCSD

According to the detailed geological and geophysical investigation, the 5 km hole will penetrate five tectonic slices separated by four ductile or brittle deformation zones (Fig. 6). They are from top to botom: 1) slice A: consisting mainly of coesite-bearing eclogites and minor thin layers of gneiss and garnet peridotite; slice B: biotite-amphibole gneiss with thin layers of schist and amphibolite, and lenses

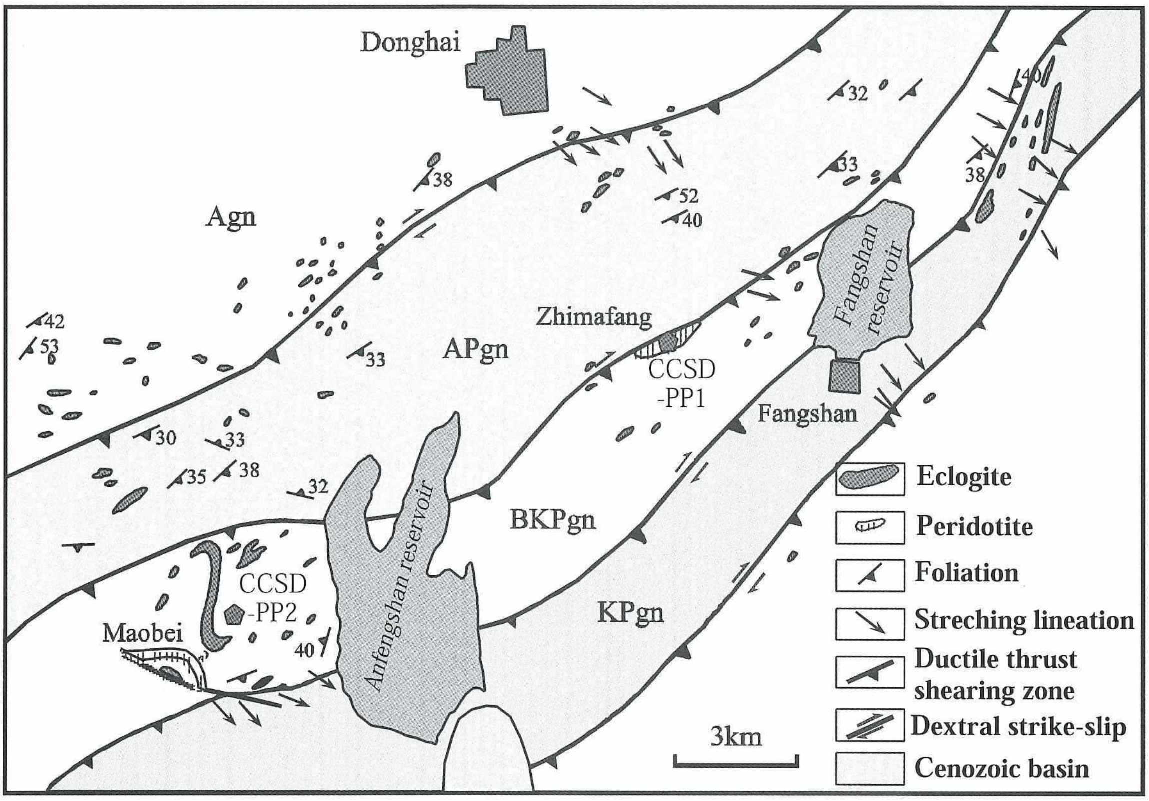

Fig. 5 Tectonic sketch map of the Donghai area, showing the locations of CCSD-PP1 and CCSD-PP2. Agn-aegirine gneiss, Apgn-amphibolite-plagioclase gneiss, BKpgn- Biotite-monzogneiss, Kpgn: monzogneiss

of eclogite; slice C: aegirine-bearing gneiss with thin layers and lenses of eclogite and amphibolite; slice D: eclogite and peridotite, characterized by the high reflectivity, high seismic velocity (6.8 km/s) and high density (3.2 g/cm^3); slice E: biotite gneiss with lower velocity than that of the upper slice.

A preliminary investigation of the pre-pilot hole

The first pre-pilot hole to a depth of 432 m (CCSD-PP1) is located in the Zhimafang ultramafic body, 9km SE of Donghai (Fig. 3). Three large petrologic units can be distinguished in the drillhole they are from top: (1) gneiss unit, consisting mainly of two-feldspar biotite gneiss, amphibole-bearing two-mica two-feldspar gneiss and epidote biotite amphibole plagioclase gneiss, and minor layers of eclogite and epidote amphibole schist; (2) peridotite unit, including garnet buchnerite, garnet peridotite and harzburgite. Intense serpentinization occurs in the upper and lower part of the unit; (3) gneiss and granitic gneiss unit, including epidote amphibole plagioclase gneiss and amphibole biotite plagioclase gneiss with layers of phengite eclogite and kyanite phengite quartz schist. Three layers of granitic gneisses were recognized. A 20 m thick mylonite zone forms the bottom of the peridotite segment. Preliminary studies indicate that the protoliths of UHP rocks derived from supracrustal rocks of different chemical composition, including ultra-mafic, mafic, intermediate, intermediate-acidic and acidic rocks and sediments. The granitic gneiss with no evidence of UHP metamorphism was formed by the partial melting of UHP rocks during the uplift. Shear strain analysis and fabric measurements of quartz from gneiss indicate the existence of a shearing sense from NW to SE at the early stage of deformation and from SE to NW at the late stage. The P-T conditions of peak metamorphism of UHP rocks are more than 28-40 Kbar and 700-860 °C.

The second pre-pilot hole (CCSD-PP2) with a depth of 1000 m was drilled near Maobei, (Fig. 3), close to the main hole site of CCSD. The drilled rock types are paragneiss, schist, eclogite, amphibolite and granitic gneiss. Well-logging

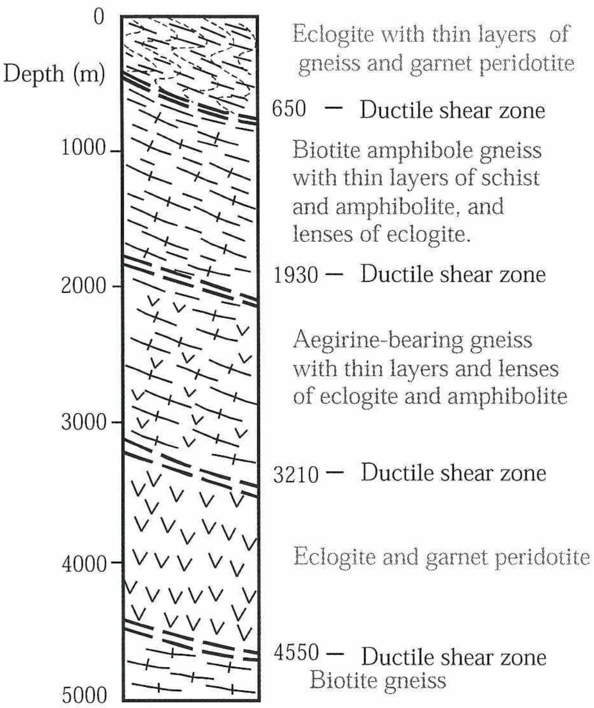

Fig. 6 Inferred petro-tectonic column of the CCSD main hole.

and VSP have been completed. The geothermal survey of the hole indicates that the temperature will not exceed 150 °C at 5000 m.

Scientific goals of the CCSD

The Dabie-Sulu UHP belt has been recognized as one of the most significant natural geological laboratories for studying petrotectonic processes associated with continental collision and convergent plate boundaries and the best site for international continental scientific drilling.

A 5000 m scientific drillhole will provide a lot of important information which cannot be obtained from outcrops. The drillcore will record changes in petrography, mineralogy, geochemistry and geophysics with depth, the detailed location and nature of geological and structural boundaries and, the relationship between earthquake foci and lithology. The boreholes will also allow logging and cross-hole experiments to be carried out in order to obtain a 3-D picture of the crust. The following concrete scientific goals will be achieved using the above information:

- Testing the composition and structure of the lowest parts of the UHP metamorphic belt established by geophysical surveying.
- Revealing the crustal behavior and crust-mantle interaction at convergence plate boundary
- Investigating mechanism of formation and exhumation of UHP rocks
- Studying fluid-rock interaction of convergent plate boundary and modern crust.
- Establishing a long-term, natural laboratory for observation of the deep crust

Framework of CCSD

The CCSD project consists of three components:

(1) Deep geological telemetry, including surface geological and geophysical investigations and 3D seismic reflection and VSP using the pilot hole.

(2) Drilling and well-logging, including two holes. A pilot hole will be drilled to a depth of 2,000 m and fully cored. The hole will be used to test drilling and well-logging techniques, inferred petrology and structures around the drill site, and for 3D seismic surveying and VSP.

A 5000 m main hole will be drilled near the pilot-hole site. It will penetrate the target layer of high-velocity and high-density material. Full coring and well-logging will be performed and in-situ chemical and fluid experiments will be conducted.

(3) Long-term crustal observatory

Basic facilities for the long-term observation of geophysical fields and geological experiments will be built around the main and the pilot holes.

The CCSD project will be carried out between 2000 and 2004, excluding site-selection studies and pre-pilot drilling, which have already been completed. A 2000 m deep pilot hole will be drilled at the end of 2000, and the main hole reaching a depth of 5000 m at the end of 2001.

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Introduction and Lithologic Description of the First Pre-Pilot Drillhole of CCSD

Introduction

The first pre-pilot drillhole of the Chinese Continental Scientific Drilling Project (CCSD-PP1) was drilled to a depth of 432 m as part of the pilot study for the CCSD. The main objective for drilling this hole was to test the lithology and structure of the UHP slices and the Zhimafang ultramafic body at depth. Drilling commenced in June and ended successfully in August 1997 with 80% core recovery.

Lithologic summaries

Preliminary core logging was carried out at the drilling site, while detailed lithologic and structural logging was completed in Beijing. 96 lithologic units were identified, which can be grouped into four lithologic types: (1) eclogite, (2) gneiss with schists layers, (3) granitic gneiss and (4) ultramafic rocks (Fig. 1). Gneiss and granitic gneiss generally have transitional contacts, but are in abrupt contact with eclogites and ultramafic rocks. No direct contact between eclogites and ultramafics has been observed.

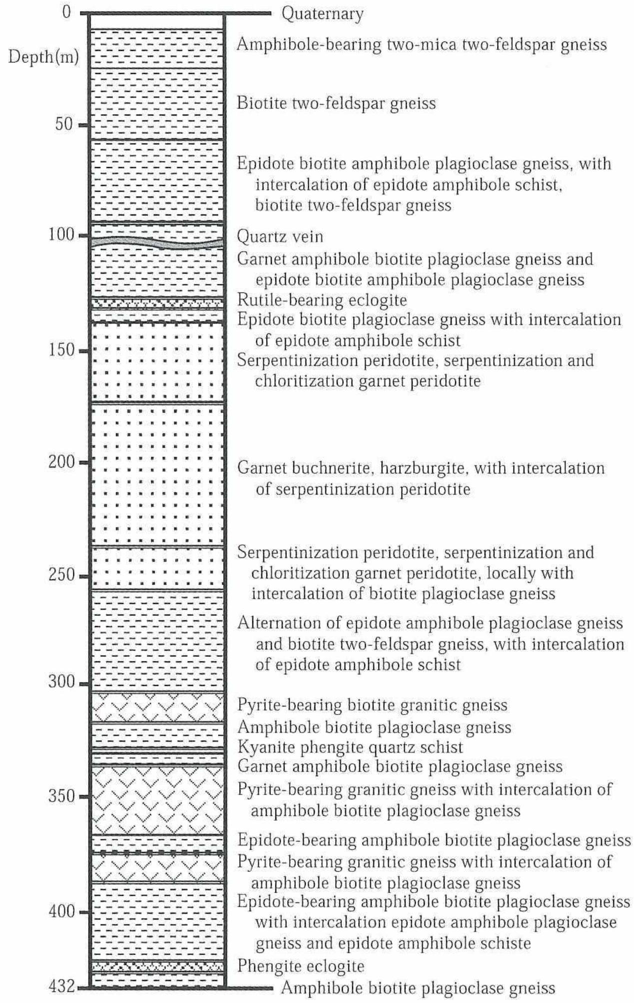

Fig.1 Simplified lithologic column of hole CCSD-PP1.

Eclogites

There are two layers of eclogites in the core, from 127.2 m - 130.3 m and 420.9 m - 425.3 m. These are mainly composed of 1) rutile-bearing eclogite with garnet + omphacite + rutile ± quartz; and 2) phengite-eclogite with the typical mineral assemblage of garnet + omphacite + phengite ± rutile±quartz. Contacts to the host rocks are transitional. From the center to the margin, the eclogite shows a regular retrogressive variation: from eclogite to amphibolized eclogite, to plagioclase-amphibolite.

Gneisses

Gneiss constitutes about 48% of the total lithology and occurs mainly at the depth intervals of 41.1 -137.8 m, 256.4 - 299.4 m, 316.8 - 337.2 m and 360 - 431.1 m. The contact between gneiss and granitic gneiss is transitional in the range of centimeters. According to major and minor minerals, the gneisses can be divided into four types: (1) titanite and garnet-bearing epidote biotite albite gneiss with a typical mineral assemblage of titanite + garnet + epidote + biotite + albite + quartz; (2) epidote biotite albite or two-feldspar gneiss with the typical mineral assemblage of epidote + biotite + albite ± K-feldspar + quartz; (3) epidote two-mica albite gneiss with the mineral assemblage of epidote + biotite + phengite + albite + quartz; (4) garnet-bearing epidote amphibole biotite albite gneiss with the mineral assemblage of garnet + epidote + amphibole + biotite + albite + quartz.

Granitic gneisses

Granitic gneisses make up19% of the cores. They are mainly distributed at a depth of 4 - 41.1 m and 337.2 - 360 m, and usually form thin layers intercalated with gneisses in the interval between 360 -400 m. According to their mineral assemblage, the granitic gneisses can be subdivided into: (1) garnet and pyrite-bearing two-feldspar granitic gneiss with albite + K-feldspar + quartz ± garnet ± pyrite; (2) epidote biotite two-feldspar granitic gneiss with albite + potash feldspar + epidote + biotite + quartz; (3) epidote two-mica two-feldspar granitic gneiss with albite + K-feldspar + epidote + biotite + phengite; (4) magnetite two-feldspar granitic gneiss comprising magnetite + albite + K-feldspar + quartz.

Ultramafic rocks

An ultramafic body was detected in the 137.8 m to 256.4 m interval (Fig. 1). It occurs in biotite gneiss with a fault contact inbetween. The ultramafics are all peridotite, which is generally massive or porphyritic, but subordinately foliated. The rocks can be subdivided into garnet peridotite and garnet-free peridotite. In total, 10 layers of garnet peridotite (total 51 m thick) and 11 layers of garnet-free peridotite (total 64 m thick) have been recognized in the ultramafic body. Individual layers vary in thickness from 0.5 - 11 m. The contacts between the different lithologic units are transitional. A 4.5 m layer of biotite plagioclase gneiss is intercalated in the ultramafic body near its bottom contact.

Garnet peridotites are mainly medium- to coarse-grained and characterized by porphyroblastic garnets (up to >10 mm). Normally they consist of 5-10% gt, 70-80% ol, 5-15% opx, 5-10% cpx, 3-5% phlogopite, and 1-2 of chromite (Fig. 3 and 4). Most garnets have a thin kelyphitic rim. Garnet-free peridotite is characterized by containing less than 5% clinopyroxene, about 10% orthopyroxene, 1% or less chromite and, in some cases, some Ti-clinohumite with ilmenite rods in it. Both garnet peridotite and garnet-free peridotite are more or less serpentinized, although large amounts of fresh minerals remain. Intense serpentinization is observed in the rocks near to the upper and lower contacts, where fractures were locally developed.

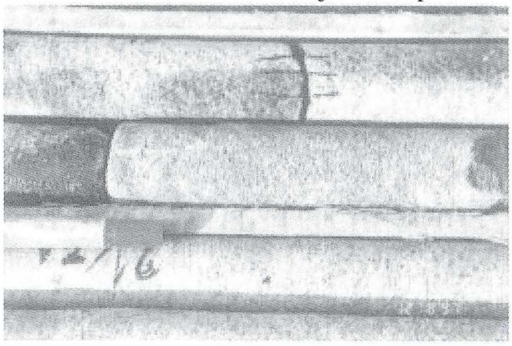

Fig. 2: A picture taken from very fresh core of garnet peridotite in the CCSD-PP1.

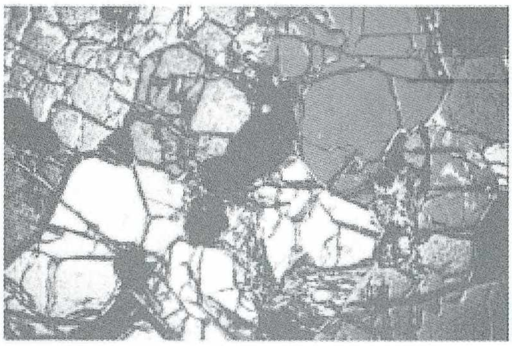

Fig.3: A photomicrograph of fresh garnet-peridotite from the CCSD-PP1.

Research Progress

Gneisses have chemical compositions suggesting intermediate to acidic igneous tuffs and clastic sedimentary rocks as precursor rocks. Two types of granitic gneisses were recognized according to their lithochemical characteristics. Type 1 may be formed by partial melting of continental crustal rocks with low maturity, and type2 may be formed by melting of clastic sedimentary rocks with high maturity.

According to mineral assemblages and calculations of metamorphic temperature-pressure condition, the metamorphic temperature of gneisses and granitic gneisses ranges from 550 - 650^{0}C, the pressure is about 0.4 - 0.56 GPa. However, coesite, a typical

UHP mineral, has been discovered in the intercalated eclogite. These features indicate that the gneisses and granitic gneisses may have undergone an earlier UHP metamorphism.

Garnet peridotite contains high SiO_2 and Al_2O_3, low NiO, CaO and Na_2O, and variable Mg content. Garnet-free peridotite has low SiO_2, Al_2O_3 ,CaO and Na_2O, and high NiO and MgO. Both, the garnet and the garnet-free peridotites exhibit LREE enriched patterns. Trace element spidergrams of garnet-peridotite and garnet-free peridotite show that they are enriched in Rb and Ba but depleted in Ti, Zr and Hf in comparison to primitive mantle. Applying Ca-in-Opx geothermometer and the geobarometer of Al-in-Opx coexisting with garnet the equilibrium temperature and pressure for the garnet peridotite is 641 ~ 726°C and 4.30 ~ 4.65 GPa.

Structure of the UHP slices

TEM studies show that the olivine in peridotite remains high-temperature [100] fabric and (100) dislocation, which indicates the high-temperature plastic deformation of olivine (1200-1600 °C) in upper mantle.

The study of preferential orientation of quartz fabric from the gneiss in the core shows that the rocks have undergone two phases of large-scale shear strain, the shearing direction of the early one was from NW to SE, which is a high-temperature shearing stain accompanied with the UHP metamorphism ($T > 650$ °C); the late one is from SE to NE, which is a medium-low temperature shearing strain accompanied with retrogressive metamorphism ($T < 550$ °C).

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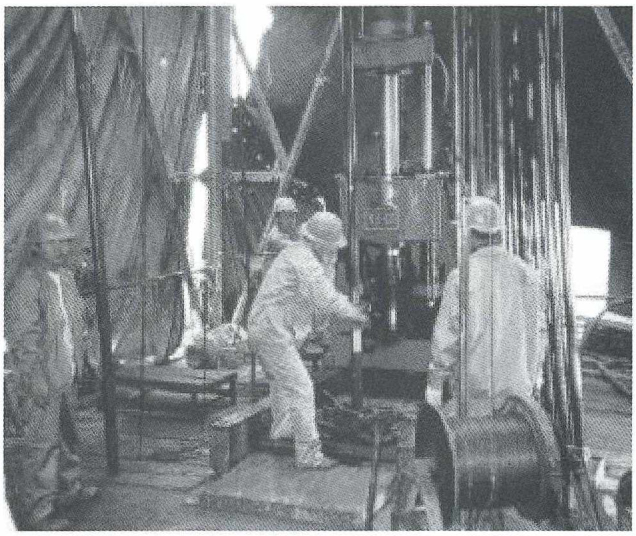

Introduction and Lithologic Description of the Second Pre-Pilot Drillhole of CCSD

Lithological Unit Summaries

The CCSD-PU2 drillhole is located at Lat.34°25' N, Long. 118°39' E near the village of Maobei, about 15 km SW of Donghai. The hole was drilled to a depth of 1028.68 m and core recovery was 90%. The core diameter is 75 mm. Drilling commenced in December 1998 and ended in May 1999. According to the lithological characteristics, five major lithological units were identified. The lithologic profile of the CCSD-PP2 is shown in Fig. 1.

Eclogite

Eclogite occurs at the depth intervals 182.95 - 202.94 m, 264.74 - 288.64 m, 673.56 - 699.33 m and 977.67 - 999.30 m and constitutes about 8% of the recovered material (Fig. 1). The eclogites, as thin layers, are intercalated in the gneiss. Eclogite layers usually contain some thin interlayers of gneisses and amphibolite. According to the major and minor minerals, the eclogites can be divided into three types: (1) rutile eclogite with typical mineral assemblage of garnet + omphacite + rutile, in which the content of rutile is more than 2%; (2) quartz eclogite with typical mineral assemblage of garnet + omphacite + quartz ± rutile; (3) phengite eclogite with mineral assemblage of garnet + omphacite + phengite + quartz ± rutile. The quartz pseudomorph after coesite occur as mineral inclusions in garnet and omphacite. This suggests that the eclogites have experienced UHP metamorphism. The majority of eclogites are medium-grained in texture and massive in structure. However, some eclogites are gneissose or banded in structure. Some eclogite are partly or completely retrograded at amphibolite facies. A continuous sequence of retrogressive rocks can be observed.

Gneiss

Gneiss is the major metamorphic rock and makes up about 63% of the lithology. The gneisses are mainly distributed at the depths

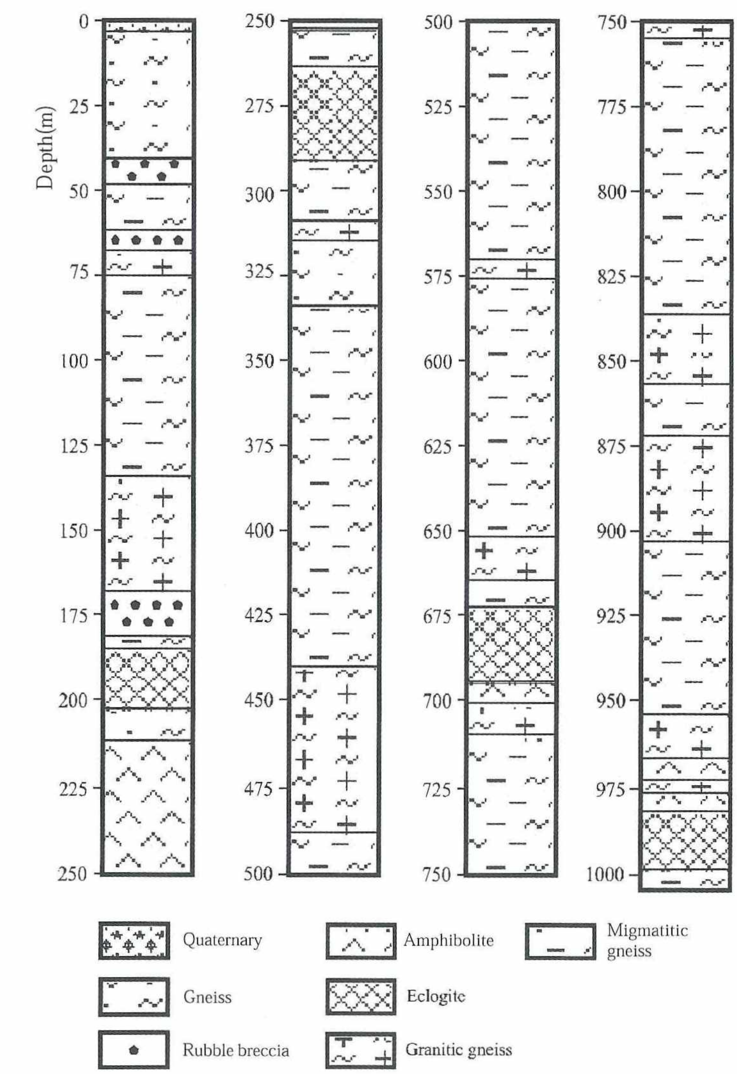

Fig. 1 Simplified Lithologic column of CCSD-PP2

0.56 - 136.06 m, 288.64 - 443.72 m, 485.0 - 673.56 m, 715.84 - 836.3 m and 903.29 - 954.04 m. The gneisses can be divided into following types: (1) epidote biotite plagioclase or two-feldspar gneiss with the typical mineral assemblage of epidote + biotite + plagioclase ± potash feldspar ± titanite + quartz; (2). Garnet biotite plagioclase gneiss with mineral assemblage of garnet + biotite + plagioclase + quartz ± titanite; (3) garnet amphibole biotite plagioclase gneiss with mineral assemblage of garnet + amphibole + biotite + plagioclase ± titanite + quartz; (4) biotite-phengite monzonitic gneiss with typical mineral assemblage of biotite + phengite ± epidote + plagioclase + potash feldspar + quartz. The contacts among different gneisses are concordant. Layers of different mineral assemblages or layers of various mineral contents can be distinguished. In addition, partial melting and migmatization phenomena are identified in the gneiss types. Due to retrogressive metamorphism in hole CCSD-PP2 only gneisses recorded the epidote-amphibolite facies metamorphism Whether the gneisses in hole CCSD-PP2 were also subjected to UHP metamorphism is still a matter of disputed issues exacerbated by lack of UHP record in the gneisses.

Granitic gneiss

Granitic gneiss mainly occurs at the depth intervals between 136.06 - 170.55 m, 443.72 - 485 m and 836.3 - 903.29 m and make up 20% of the cores. Some granitic gneisses, as thin layers, are intercalated in the gneiss. The contacts between gneisses and granitic gneisses are not sharp but a continuously transitional zone in a range of centimeters. The gneisses are mainly comprised of pyrite-bearing granitic gneiss, epidote and biotite-bearing granitic gneiss and garnet and biotite-bearing granitic gneiss, with granitic blastic texture and gneissic-massive structure. Major mineral assemblages of the granitic gneisses are potash feldspar + plagioclase + quartz with minor pyrite, biotite, epidote and garnet. The granular pyrite and garnet are evenly distributed in granitic gneisses. The granitic gneiss is usually interlayered with gneisses.

Amphibolite

Amphibolite occurs in the depths 213.59 - 250.77 m, 692.98 - 701 m and 963.91 - 977.67 m. In the bottom of the hole, the amphibolite directly contacts with eclogite. The contacts between amphibolite and eclogite are continuously transitional. According to the major and minor minerals, the amphibole can be divided into two types: (1) epidote amphibolite with typical mineral assemblage of amphibole + plagioclase + epidote + quartz ± titanite; (2) biotite epidote amphibolite with mineral assemblage of biotite + epidote + amphibole + plagioclase + quartz ± titanite.

Fault breccia

Fault breccia is mainly distributed in a depth of 41.89 - 48.95 m, 62.96 - 67.61 m and 170.55 - 180.69 m. The thickness of the rubble breccia ranges from 4.65m to 10.14m. The host rocks of rubble breccia are gneiss and granitic gneiss. Up to now, the tape-recorded of the lithological cores in hole CCSD-PP2 has been finished, other research works including UHP metamorphism, geochemistry, tectonics and chronology are currently in progress.

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Understanding Seismic Reflectors in UHP Crust via CCSD-PP2 Hole

We have performed geophysical investigations around the borehole CCSD-PP2, including seismic profiles, VSP and well-logging, gravity and geothermal measurement.

About 400 rock samples were collected for measurement of physical properties. Eclogites in Maobei have highest density of 3.4-3.6 g/cm^3, peridotites slightly less and the gneissic host rock have low densities of 2.6-2.7 g/cm^3. With such a high-density contrast, positive gravity anomalies are expected as shown on Fig.1. They consist of two anomalies: a shallow anomaly corresponds to exposed eclogites with its center located at the place where a diamond was found, and the deep anomaly with its center marked by a flag shown in Fig.1. As the CCSD main hole will reach a depth of 5000 m, we expect that it will penetrate the high-density source of the deep anomaly, probably deep eclogites and peridotites. However, in order to reveal geometry of these deep high-density sources we need seismic profiles and a 3-D inversion of the potential fields.

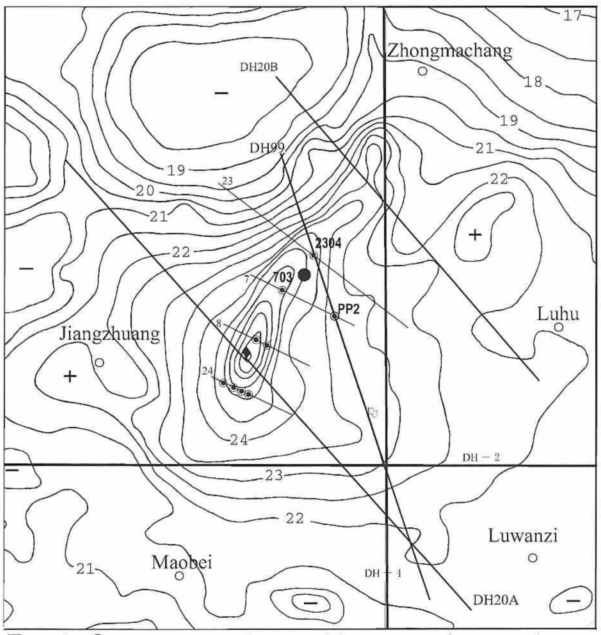

Fig. 1: Gravity anomalies and location of survey lines in Maobei area. Holes 703 and 2304 have depth 500-600m, PP2 1024m. Data of lines DH20A and DH20B are being processed. Seismic profile of DH99 is shown in Figure 3.

Comparison of well-logging, VSP and petrology of cores from CCSD-PP2 hole indicates seismic reflection characteristics (Fig.2). Four eclogites with a thickness of 10-20 m appear in the hole, corresponding to logging density high, sonic velocity high and VSP interval velocity high (marked by I, II, IV and V in Fig.2). They also cause seismic reflections with variable amplitudes. However, fracturing zones that have low velocities may also produce strong reflections (e.g. mark III), while a reflection from eclogite III can be missed after stack. We can conclude that density logging is the best method for the identification of eclogites and sources of gravity anomalies, while strong seismic reflections may be correlated to eclogites or fractures, thrusts, even foliation in metamorphic rocks.

The seismic profile DH99 crosses CCSD-PP2. Fig. 3 shows the 4.5 km depth migration profile, with basic structures that seems different from what we thought before. Strong SE dipping reflectors, such as F1 revealed by PP2 hole, are likely to correlate with thrusts or foliation, terminating at some curved reflectors which seem correlated with the deep gravity sources. These curved events look like diffraction from high-density/velocity lenses such as eclogites or peridotites. As we do not expect many gneiss cores for the CCSD main hole, drilling through the deep gravity sources and the diffraction curves seems reasonable.

Geothermal measurements in the PP2 hole show that at 5000 m a temperature of about 135 °C can be expected. The estimated heat flow value is 77mW/m^2.

Seismic reflection and tomographic experiments are carried out with lines DH20A and DH20B (see Fig.1 for locations). Line DH20A crosses the center of the shallow gravity anomaly while DH20B with 100 receivers crosses the northern

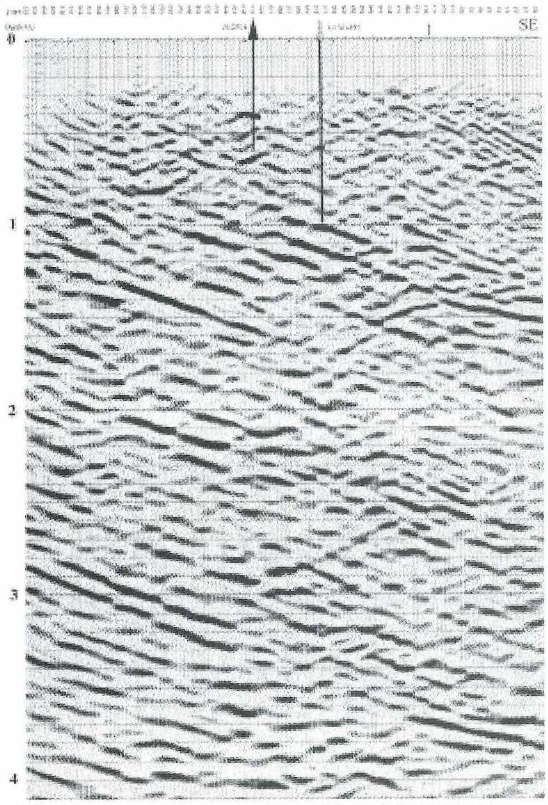

Fig.2: Depth migration profile of DH99. Strong reflectors of dipping SE correlated with thrusts or foliation in metamorphic rocks, they are terminate by some diffraction curves which may correlate to deep gravity anomalies as shown in Fig.1.

segment of the Maobei eclogite body, proving a 'cross-hole' tomographic velocity image for building geophysical models. It is clear that high-velocity (>6000 m/s) bedrocks are located in the Maobei eclogites and their dipping spaces; therefore the deep drilling location can be selected to penetrate these high density/velocity sources. At present, 3-D geophysical inversion and modeling are being performed to delineate a geometry of these sources.

In conclusion, geophysical data reveal complicated metamorphic structures in the Maobei area where thrusts, foliation and eclogites/peridotite lenses occurred. The CCSD main hole of 5000m will be selected at the best location to drill through most geological units, revealing the nature of the geophysical anomalies and UHP metamorphism.

Fig. 3: Seismic velocity image between lines DH20A and DH20B showing a high-velocity bedrock anomaly in Maobei area.

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Well Logging in CCSD-PP2 Borehole

Introduction

The borehole depth PP2 is 1028 m deep and has a bottom hole diameter of 75 mm. The maximum casing depth is less than 70 m. The main lithological units are: gneiss, amphibolite, migmatite and eclogite. Well logging was performed by the Shandong Coalfiled Digital Logging Station.

Site Logging

The MOUNT·SOPRIS (USA) Logging system was used for gathering data. The logging data acquired are: ultrasound imaging, gamma ray, compensated density, focused resistivity, apparent resistivity, spontaneous potential, longitudinal sonic velocity, sonic amplitude, completion wave series, neutron-neutron, caliper, temperature, mud resistivity, ultrasound imaging etc.

The logging tools were calibrated according to the standard coalfield logging in China. In order to inspect the quality of logging data and the stability of logging tools, repetitive measurement of 50m well sections were executed.

Logging Data Processing (LDP)

The logging depth and data had been corrected before LDP. The rock physical parameters had been scaled based on calibration equations of logging tools. The LDP of all logging data gathered by LOGSYS System was done. The original information and results include:

- Logging original record tables
- Logging tools calibration record tables
- The monitoring plots of the original logging record on site
- Borehole deviation tables the projecture figure of borehole plane position and the projecture figure of borehole profile position
- Borehole temperature result curve figure
- Synthetic result curve figure
- Lithology parameter curve figure
- Acoustic completion wave series curve figure
- Acoustic imaging original and result figure
- Lithology layering result tables
- Synthetic logging interpretation report

Physical Properties

15 petrophysical parameters could be obtained by the downhole logging program. The main parameters and results are shown in Table 1.

Table 1: Statistics parameters of main petrophysical properties in CCSD-PP2 borehole

Rock type	Focused resistivity [O·m] Min– Max Average	DEN [g/cm^3] Min– Max Average	CNL [%] Min– Max Average	GR [API] Min– Max Average
Eclogite	600-3250 2020	2.9-3.2 3.07	10-25 17	16-75 35
Amphibole schist	1200-2700 1680	2.7-3.0 2.90	14-20 17	37-75 51
Amphibolite	800-2600 1580	2.7-3.0 2.90	14-20 16	30-70 50
Gneiss	600-2900 1815	2.6-2.75 2.7	4-10 6.4	55-100 85
Migmatitic gneiss	400-2200 1300	2.6-2.8 2.7	5-15 7	70-110 88
Migmatite	600-2250 1460	2.55-2.75 2.64	4-11 7.2	70-150 98

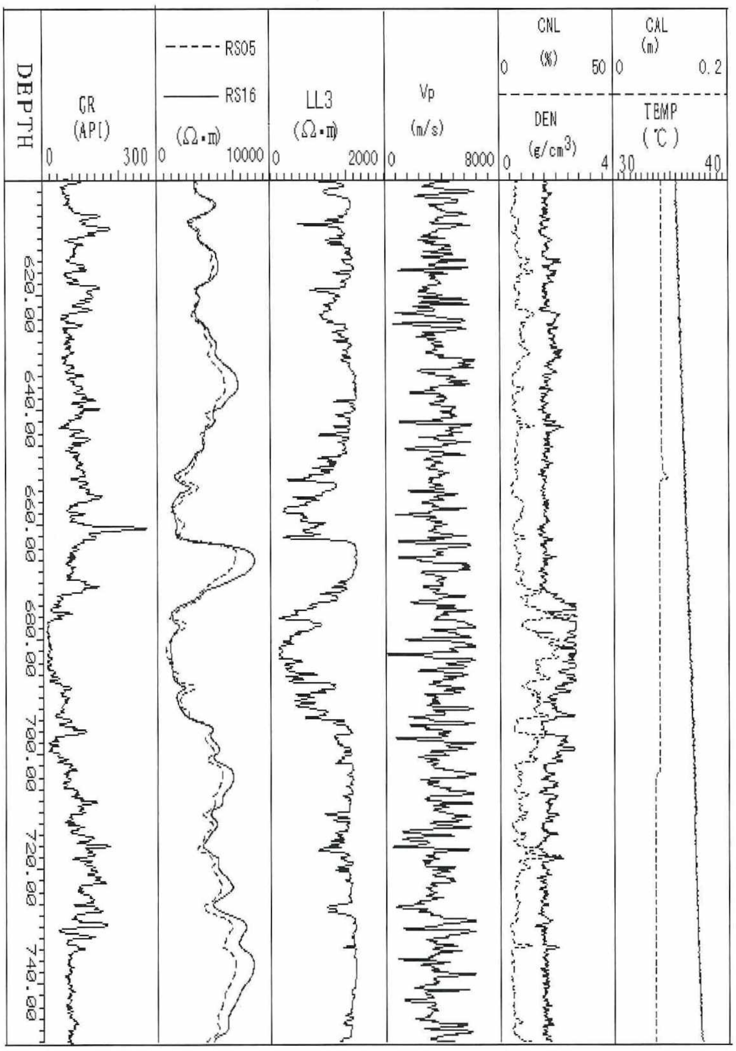

Fig.1: Logging Curves in CCSD-PP2 Borehole

The logging data allow for a detailed geological interpretation of the borehole lithology (Fig 1.) on the base of petrophysical differences. Ultrasound image logging scans rotate 5-times/second around the borehole wall and gather 300 data points every circle. These image logging data were used to interprete faults, layering and other tectonic and petrophysical features.

Conclusions

- The logging and logging interpretation of CCSD-PP2 borehole are successful.
- The interpretation results of this borehole are very useful for rock evaluation, structure analysis, drilling work and other research fields, but the results are still initial, and will be studied further.
- We will analyze core samples to study the logging response laws of rocks for enhancing the precision of interpretation results and the capacities of solving geological problem.
- In order to do logging and logging interpretation of the pilot and main holes of CCSD successfully, we must summarize further the experience of this borehole about logging, logging interpretation and others.

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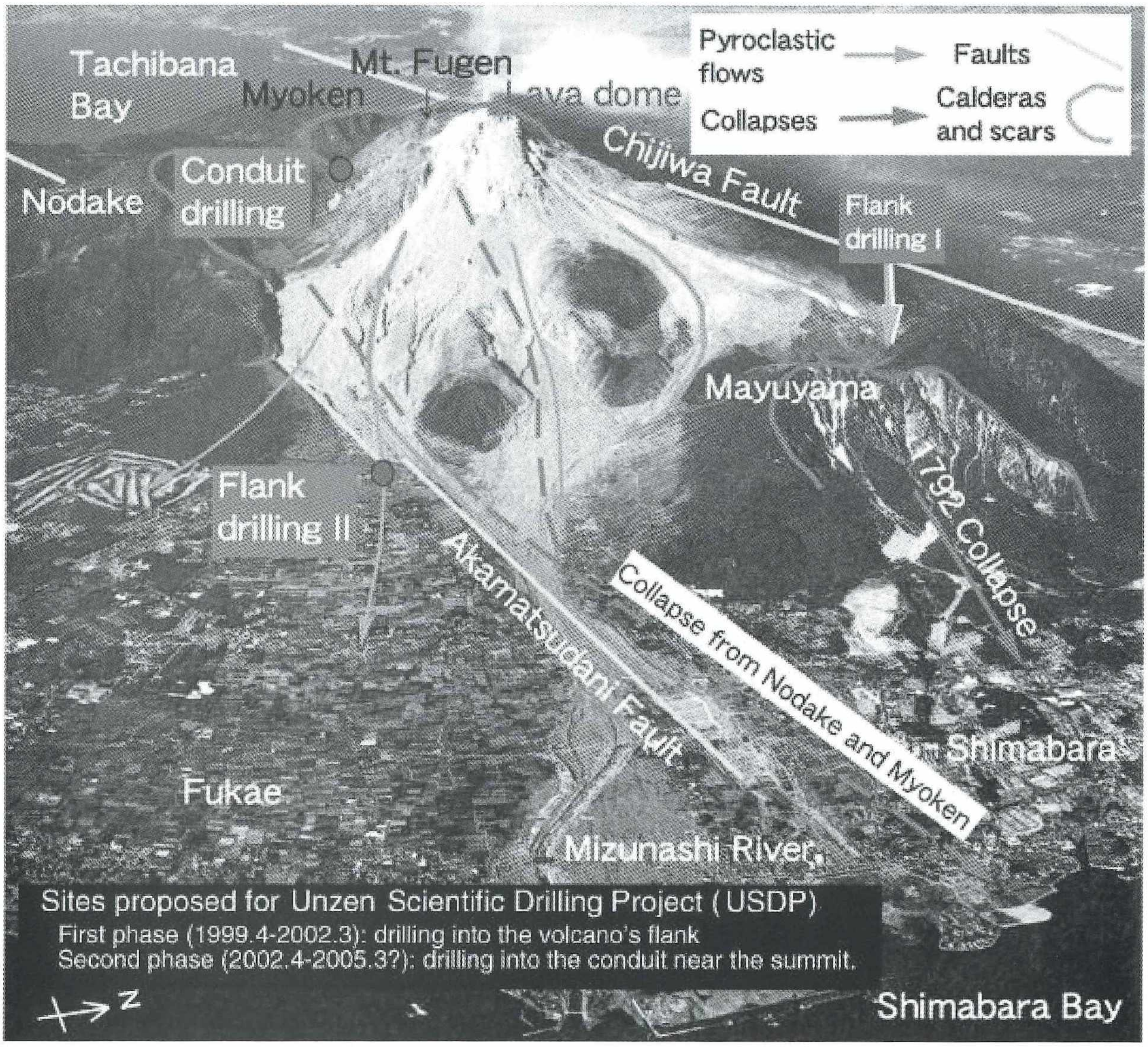
Unzen Scientific Drilling Project (USDP)

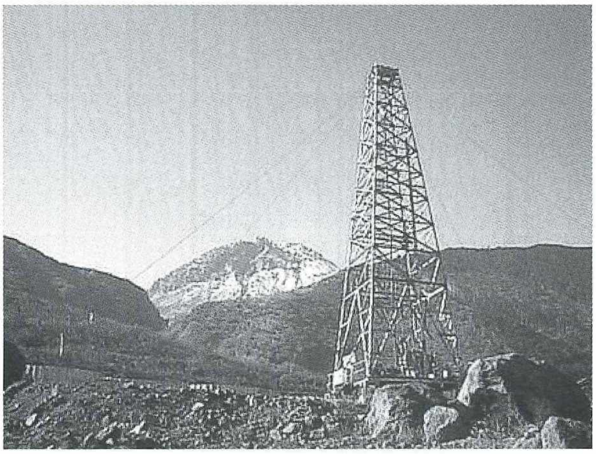
Unzen Volcano: International Cooperative Research with Scientific Drilling for Understanding Eruption Mechanisms and Magmatic Activity

We are happy to announce that the first phase of the Unzen Scientific Drilling Project (USDP) has started as an international research project funded by the Science and Technology Agency (STA) of Japan. The project is formally named "Unzen Volcano: International Cooperative Research with Scientific Drilling for Understanding Eruption Mechanisms and Magmatic Activity" and includes not only scientific drilling but also related geological, geophysical and geochemical studies to understand the growth history, subsurface structure and magma ascending mechanism of the Unzen Volcano. Unzen Volcano is one of the active volcanoes in Japan, located in the Southwest behind the volcanic front of the Ryukyu Arc. The 1990-95 eruption caused $ 2 billion damage and took 44 lives. A large-scale collapse of an old lava dome during the 1792 eruption resulted in death of 15,000 people around the volcano. The volcano has become the focus of international volcanological attention through its designation as a Decade Volcano by the International Association of Volcanology and Chemistry of Earth's Interior (IAVCEI).



USDP is expected to be a six-year term project and is divided into two phases (three years each). It started in April 1999. Only the first phase (Phase I) is currently endorsed by STA, and an external review will be made in the third year before proceeding to the second phase (Phase II). Phase I consists of drilling two boreholes into the flanks of Unzen Volcano and conducting associated research to reveal the three-dimensional structure and the growth history of the volcano. Phase II is drilling into the conduit of the 1990-95 magmas to clarify the ascending and degassing mechanisms of magmas and to evaluate eruption models developed during the 1990-95 eruptions. We are planning to submit a proposal to ICDP for Phase II as a joint venture between STA project and ICDP. International joint researches on a limited scale have already started in Phase I, but would be expanded in the Phase II by the collaboration and support of ICDP.

The first drilling on the northeastern flank of the volcano will be completed at a depth of 750 m by the end of March 2000. The hole is thought to have reached pre-Unzen volcanic rocks, but we need to confirm this by detailed examinations of cores. Average core recovery rate exceeded 90% even though most of the obtained cores were of non- to loosely consolidated volcaniclastic materials. Contrary to our expectation of encountering mostly thick andesite-dacite lava flows of Older Unzen Volcano (0.2-0.5 Ma), more than 90 % of obtained cores are volcaniclastic materials, either block and ash flow (pyroclastic flow with dense essential blocks) deposits or secondary debris flow deposits. Such deposits have rarely been recognized among Older Unzen Volcano on the surface. Another significant result is that pyroclastic flow deposits with abundant vesicular pumices were recovered at the bottom of Unzen Volcano. Unzen Volcano had been considered to have been characterized by non violent eruptions during its life due to the lack of pumice deposits. The recovery of vesiculated pumices is clear evidence that Unzen had explosive eruptions in its early stage of activity. We will soon start detailed geological, petrological, geochemical and geochronological studies on the core samples. We are expecting to significantly expand our knowledge of Unzen Volcano, reconstructing its entire eruptive history over the past half million years. The second flank drilling down to about 1200 m, is currently planned to start in summer of 2000 at the eastern foot of the volcano. In the Younger Unzen Volcano stage, during the past 100,000 years, dome-collapse type block and ash flows are believed to have been emanated from the summit area toward east. We are expecting to reconstruct the detailed eruption history in the past 100,000 years using core from this second hole.



Drilling rig at ***Unzen flank drilling I***

Phase II targets the upper part of the conduit through which the lava domes of 1991-1995 eruption emerged. In the last kilometer of ascent, magma is subjected to an order of magnitude decrease in solubility of water in melt with more than an order of magnitude increase in melt viscosity, more than two orders of magnitude decrease in vapor density, and the onset of crystal growth. This huge change in magmatic properties is responsible for a number of geophysical phenomena and signals prior to or during eruption; i.e., isolated tremor events (1.5-0.5 km deep), low-frequency earthquake events (0.5-0 km), sources of vulcanian explosions and deformation-and-inflation (1.2 km and 0.5 km-deep). These phenomena and signals are thought to reflect magmatic degassing during ascent and also interaction of magma with groundwater in an aquifer below 0.5-km depth. Direct drilling into the conduit in this depth range level is critical in order to verify interpretation of monitoring data during eruptions and to understand these important magmatic processes.

The conduit drilling poses several difficulties, including high temperature, logistics, precise targeting and complex permitting of drilling. The plan and the design of the conduit drilling are now under discussion. An international technical workshop is currently proposed to ICDP in order to discuss the most suitable drilling techniques for high-temperature and unstable volcanic formations. The summit area of the Unzen volcano is protected as a special area of natural preservation of Unzen National Park, and the drilling plan should have a minimum disturbance to the ecological system and be permitted by the Environment Agency, Agency of Culture Affairs and Forestry Agency. Environment assessment around the currently proposed drilling site (Azamidani) is now underway.

Proposals of international research cooperation are welcome not only for the future STA-ICDP joint project in Phase II, but also for Phase I of domestic STA-USDP.

Kozo UTO, Setsuya NAKADA, Hiroshi SHIMIZU, John C. EICHELBERGER and Hiroshi SHINOHARA
Geological Survey of Japan, University of Tokyo, Kyushu Universit, University of Alaska

STA-USDP project

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USDP home page, URL = http://www.hakone.eri.u-tokyo.ac.jp/vrc/usdp/index.html

KTB VSP/MSP Experiment 1999

A comprehensive program of seismic borehole measurements comprising Vertical Seismic Profiling (VSP) and Moving Source Profiling (MSP) has been performed in the ultradeep borehole of the german Continental Deep Drilling Program KTB.

The objective is to obtain essentially new information for understanding crustal processes. In particular the effect of fluids on seismic wave propagation is critically important because of the great effect of even relatively small amounts of fluids on crustal processes.

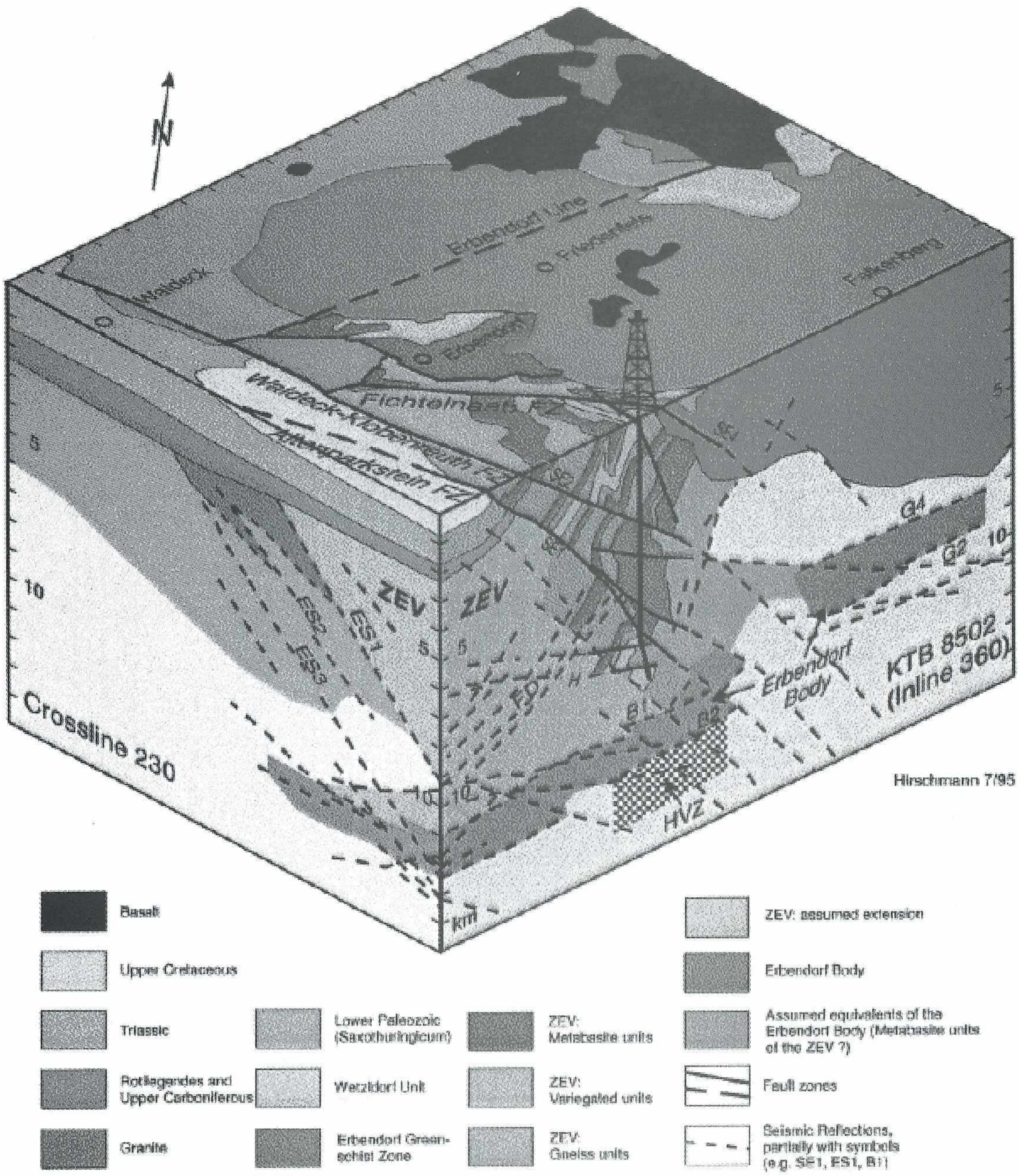

Fig. 1: 3D geologic block diagram of the KTB area (Hirschmann et al., 1995)

The deepest part of this ultradeep borehole, from 6000 m to 8500m, has now been sampled for the first time by Vertical Seismic Profiling. The measurements were performed with a HP/HT borehole geophone, newly developed by Createch Industries, France, in order of the GFZ Potsdam. The borehole geophone can withstand temperatures up to 250° C and pressure up to 140 MPa.

During 19 days of active field work between April and November 1999 509 depth positions were sampled with 615 shots, 835 kg of explosives, and 279 vibrator points.

fluid filled fractures of varying spatial density and orientation, and the so called Erbendorf body, a highly reflective mid crustal layer about 2 km below the end of the borehole (Figure. 1).

VSPs were recorded for two different shotpoints, one at near offset, and one at 8 km offset of the KTB (Figure 2). For comparison, the signal spectra of each shot were recorded in the KTB pilot hole with a reference geophone at 3.8 km depth. Since the frequency spectrum of the data is very wide and shows strong similarities for almost all the shots the data quality can be generally regarded as very good. The seismic

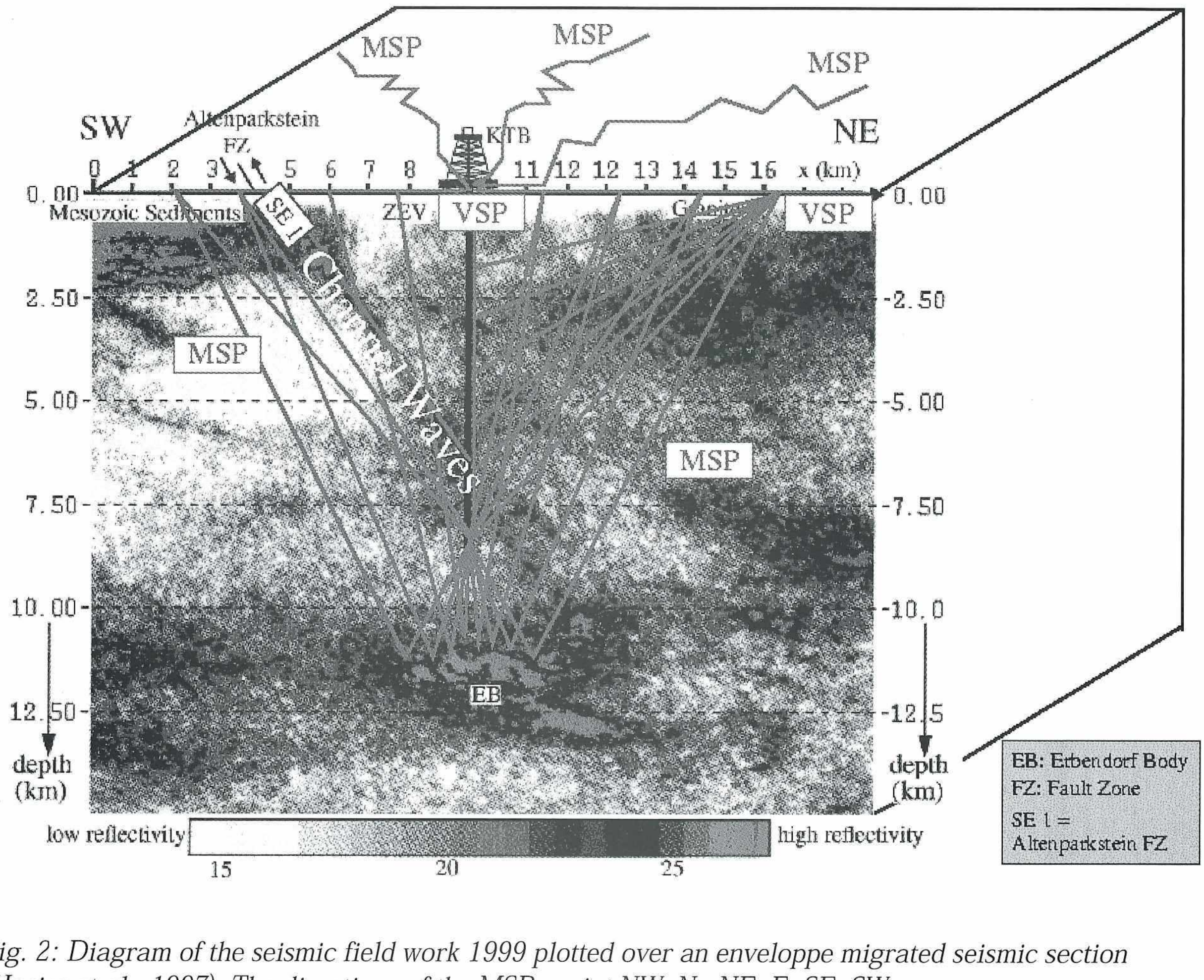

Fig. 2: Diagram of the seismic field work 1999 plotted over an enveloppe migrated seismic section (Harjes et al., 1997). The directions of the MSPs point NW, N, NE, E, SE, SW

The most important objectives are: A major thrust related fault intersecting the well at about 7 km depth (so called SE 1 reflection), stacks of steeply inclined deformed felsic and mafic layers,

arrivals carry signal energy between 10 and 250 Hz corresponding to wavelengths between some 100 m and some 5 m, respectively.

VSPs were recorded for two different shotpoints, one at near offset, and one at 8 km offset of the KTB (Figure 2). For comparison, the signal spectra of each shot were recorded in the KTB pilot hole with a reference geophone at 3.8 km depth. Since the frequency spectrum of the data is very wide and shows strong similarities for almost all the shots the data quality can be generally regarded as very good. The seismic arrivals carry signal energy between 10 and 250 Hz corresponding to wavelengths between some 100 m and some 5 m, respectively.

The three component readings of the VSPs show compressional, shear and converted waves, in transmission and reflection. For compressional waves following vertical ray paths, the velocity depth profile can be read directly from the first breaks of the near offset VSP. Seismic velocities can be compared with the geological profile and the observed depth function of the dip of rock foliation. In situ, the amphibolite units show an average P-wave velocity of 6500 m/s with local variation of 10 % mainly caused by fractures. The influence of anisotropy can be observed in a Gneiss sequence where changes in the dip of foliation create a low velocity layer of 5500 m/s between 8000 m and 8500 m depth.

The investigation of the 3D velocity field will be based on the offset VSP and on MSPs covering up to 8 km source offset in 6 azimuthal directions (Figure 2). The MSPs were completed in November 1999.

An additional experiment, the so called Erbendorf Body Endoscopy, is going to be carried out at the end of May 2000. The objective of this experiment is the determination of the velocity within the Erbendorf body. 90 kg charges will be shot at offsets of 40-50 km.

The project is co-funded by DFG, ICDP, and NSF. Further support was provided by GFZ Potsdam and GGA Hannover. Seismic contractor work was performed by Geophysik GGD, Leipzig and THOR Geophysical, Kiel.

Further information is available at:
http:// icdp.gfz-potsdam.de/html/ktb
http://www.geophysik.uni-kiel.de
->Seismics ->ICDP/KTB

W. Rabbel & T. Beilecke, Universität Kiel,
J. Kück, *GFZ Potsdam*

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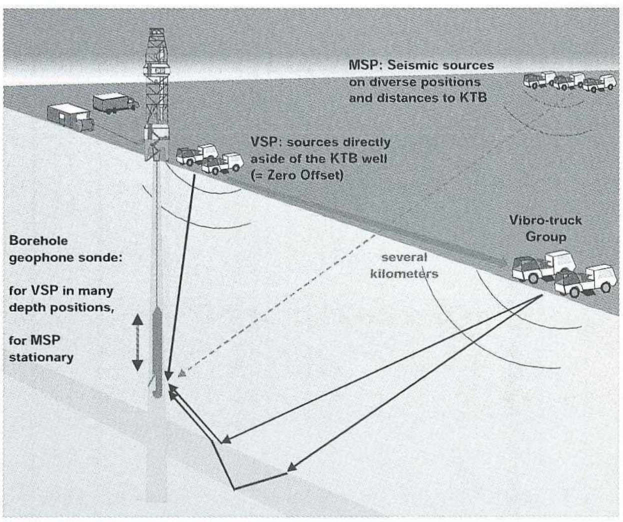
Harjes, H.-P., Bram, K., Dürbaum, H.-J., Gebrande, H., Hirschmann, G., Janik, M., Klöckner, M., Lüschen, E., Rabbel, W., Simon, M., Thomas, R., Tormann, J., and Wenzel, F., 1997, Origin and nature of crustal reflections: Results from integrated seismic measurements at the KTB superdeep drilling site. Jour. Geophys. Res. 102: 18,267-18,288.



GLAD800

The GLAD800 (Global Lake Drilling 800) system is a Joint Venture between ICDP [funding and ownership] and DOSECC (Drilling, Observation and Sampling of the Earth's Continental Crust, Inc.) [construction and operation]. The system was specifically designed, with input from the PAGES community, for obtaining long sedimentary records from modern lakes. The drill rig itself is a modified Christensen LC1500 that has been modified by DOESCC to increase the hoist capacity, improve the hydraulic system and make the rig more environmentally friendly. The drill rig is versatile and can be used for drilling on land as a conventional diamond core rig as well as mounted on its own raft system for coring lakes.

The GLAD800 system will be equipped with a variety of down-hole tools that will allow collection of samples of all sediment and rock types expected in lakes. Tools will include push, hydraulic piston and diamond coring as well as rotary drilling. Cores of 66 mm diameter will be collected in butylrate liners (Ocean Drilling Program standard) in 3-meter lengths. The hole will have a diameter of 134 mm. Using a core system of this size, the drill rig has the capacity for the collection of core to a total depth (water + sediment) of 800 m. This depth can be extended to perhaps 1200m if a 101 mm hole is drilled.

For drilling on lakes, the drill rig will be mounted on a barge formed by linking eight 20-foot shipping containers in a 3 by 3 configuration. These will form a platform 7.3 m wide by 18.3 m long with a moonpool formed by the missing center container. The containers will have internal foam and air bladders for buoyancy, but will also contain water as ballast to provide stability. At the present time, the rig does not have heave compensation, and drilling operations will be suspended in rough water conditions. The barge will be positioned over the hole using anchors, which should allow the system to be used in up to 200 m water depth.

The drill rig portion of the system will be used initially on the Koolau Scientific Drilling Project in Honolulu, sponsored by the U. S. National Science Foundation and other research organizations, including ICDP. The PI is Dr. Mike Garcia of the University of Hawaii. This project will collect continuous core of the Koolau volcanic sequence starting at the bottom of a water monitoring well. The rig will then move to the Island of Hawaii to install strain gauges as part of a U. S. Geological Survey volcano hazards program. In July, the rig will be returned to Idaho for fitting to the barge system. The entire GLAD800 system will then move to the Great Salt Lake for the collection of core at four sites. The cores will provide important information on the paleoclimate history as well as the magnitude and recurrence intervals of faulting on the East Great Salt Lake fault. The rig is then scheduled to move to Bear Lake in northern Utah for two 100-meter cores for paleoclimate research. These lake drilling projects are funded by the ESH Program at NSF and the U. S. Geological Survey. The Principal Investigators are Kerry Kelts (U. Minnesota); Andrew Cohen, Owen Davis and Roy Johnson (U. Arizona); Jack Oviatt (Kansas State U.); David Dinter (U. Utah) and Walter Dean (USGS).

The GLAD800 will be operated by DOSECC. Use of the system will be coordinated through a committee that includes representation from ICDP, PAGES and DOSECC. Additional information on the GLAD800 is available at: www.dosecc.org.

Dennis Nielson, *Energy and Geoscience Institute, Utah*

SPECIFICATIONS FOR DRILLING RIG ON GLAD800

Depth Capacity Coring (Wireline or Conventional)
HMQ Wireline 4590 ft (1350 m) - DLS Wireline 2830 ft (800 m)

Hoisting Capacity

Main - Capacity: Single Line-Bare Drum 17,500 lb (7955 kg) - Double Line-Bare Drum 35,000 lb (15,900 kg) - Line Speeds: Bare Drum 132 ft/min (40 m/min) - Cable Size: 110 ft (33.6 m) X 5/8 in (15.9 mm)

Wireline - Capacity: Single Line-Bare Drum 2,500 lb (1,136 kg) - Single Line-Full Drum 840 lb (382 kg) - Line Speeds: Bare Drum 390 ft/min (119 m/min) - Full Drum 1,260 ft/min (984 m/min) - Cable Size: 4000 ft (975 m) X 3/8 in

Feed System
Feed Travel: 11.5 ft (3.5m)
Feed Speeds: Fast and Slow with Variable control
Thrust: 15,000 lb (6800 kg)
Pull: 30,000 lb (13,600 kg)

Power Unit
Mfg: 1 each Cummins
Power: 175 hp (196 KW)
RPM: 1,800
Engine Type: 6 cyl. Diesel Turbocharged/after cooled c/w clutch
Cooling: Water

Hydraulic System
Primary Pump: 3,500 psi - 45.6 gpm (24.3 MPa - 173 lpm)
Secondary Pump: 1,500 psi - 12.5 gpm (10.3 MPa - 47.3 lpm)
Auxilary Pump: 3,000 psi - 13.4 gpm (20.8 MPa - 50.7 lpm)

Drillhead and Spindle Speeds
Power: Hydraulic Motor - Variable speed/reversible - Final Drive: HV Chain drive in oil bath - 2.5 ratio - Spindle: 4-5/8 in (117 mm)

Spindle Speeds:	*Gear*	*Ratio*	*Speed (rpm)*	*Torque, ft lb (nm)*
	1st	*6.63:1*	*130-195*	*3,2232-2,218 (4,382-3,007)*
	2nd	*3.17:1*	*270-410*	*1,545-1,060 (2,095-1,437)*
	3rd	*1.72:1*	*500-756*	*839-575 (1,138-780)*
	4th	*1.00:1*	*867-1,300*	*468-335 (662-454)*

Speed Control: Manual Control from Operator's Station - Hinged Head: Swing Away

Chuck Assembly
Type: Hydraulic Open, Spring Closed - Maximum Inside Diameter: 4-5/8 in (117 mm) - Holding Capacity: 40,000 lb (18,181 kg)

Weight
Rig Weight: 14,000 lb (6,363 kg) - Recommended Truck GVW: 32,000 lbs (14,545 kg)

Standard Equipment
Dump Mast - Derrick in Two Sections - Wireline Speed Control - Foot Clamp 4-5/8 in (117 mm) - Hydraulic Slide Control Panel - Hydraulic Rod Centralizer - Hydraulic Oil Reservoir Fill Pump and Filtration - Additional Fuel Filter and Water Separator - Four Hydraulic Jacks 24 in Stroke

Mud Pump Hydraulic Driven - Standard Equipment
Type: FMC L11 22D - Max Flow: 72 gpm (272 lpm) - Max. Pressure: 1000 psi (7 MPa)

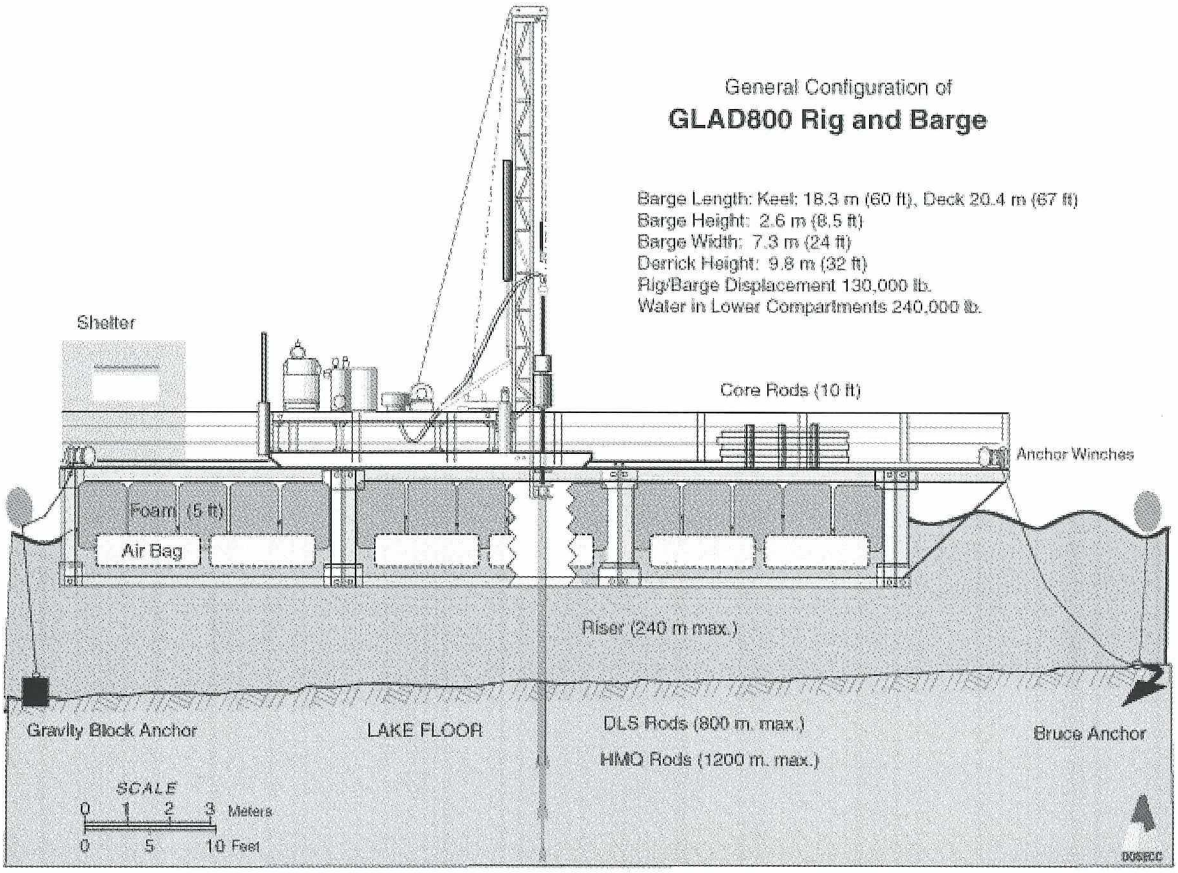
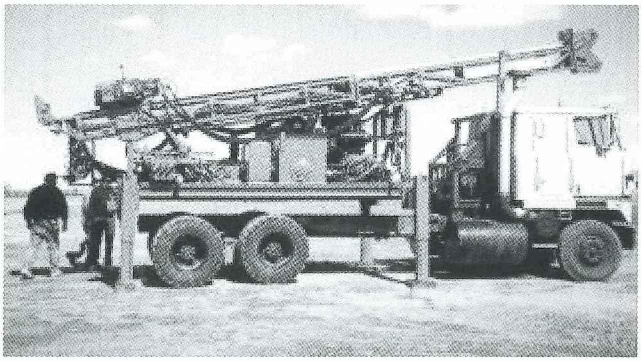
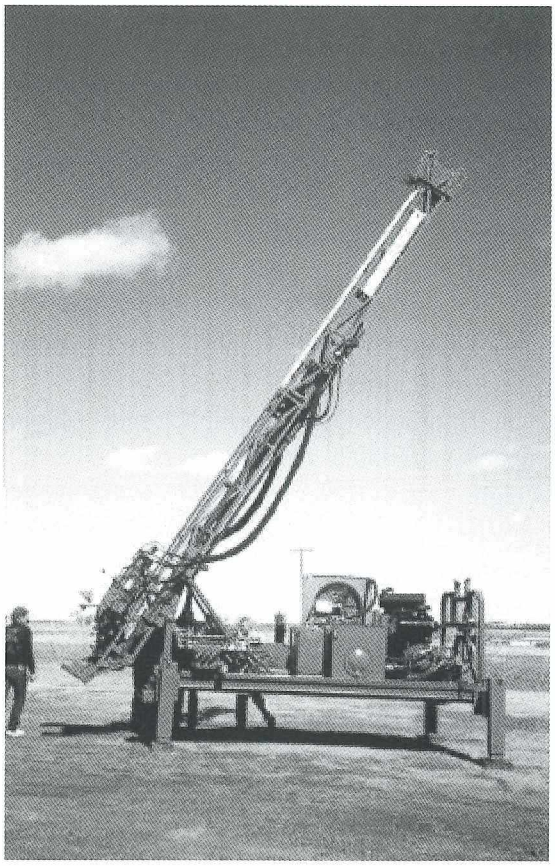


Fig. 1: General Configuration of the Global Lake Drilling Facility GLAD 800

Fig. 2 + 3: Glad800 drilling rig during the constructionn and modification Phase in march 2000, truck-mounted and dismounted.





Scientific Drilling on Lakes Malawi and Tanganyika

An NSF/ICDP Workshop, October 10-16, 1999, Southwestern lakeshore of Lake Malawi

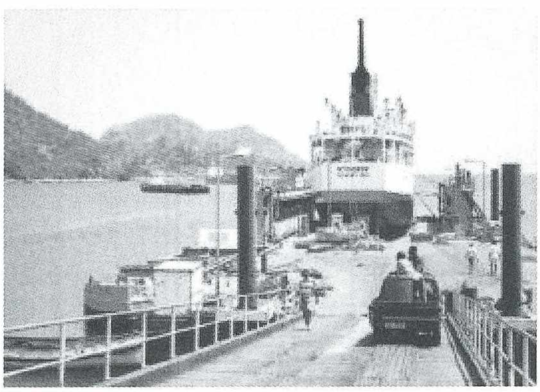
During the week of October 10, 1999, a group of 47 scientists, engineers, local institutional representatives, and funding agency administrators met at Club Makakola, Malawi, on the shore of Lake Malawi, to review the prospects for scientific drilling on Lakes Malawi and Tanganyika. The meeting was opened by the Hon. Harry Thomson, Minister for Natural Resources and Environmental Affairs of Malawi, and was followed by an open discussion of the natural resources of Lake Malawi. Participants included representatives from Malawi, Tanzania, the United States, and 8 other nations in Africa and Europe. Support for the workshop was provided by the U.S. National Science Foundation (Paleoclimate, Continental Dynamics, and Geology and Paleontology programs), and from the International Continental Scientific Drilling Program.

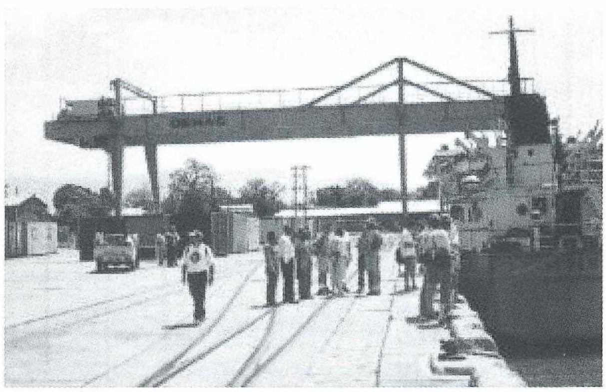
Major topics considered during the meeting included reviews of the major scientific themes to be addressed through drilling, roles of local institutions, engineering and logistical concerns, and the funding environments within likely target funding agencies.

Many of the workshop discussions were centered around the current proposal submitted to the ICDP and NSF for the GLAD800 drilling rig, a lightweight coring system designed for sampling lake basins to a total drilling depth of 800-1200 meters. Administrative, financial and engineering infrastructure of the GLAD800 concept were considered during this opening session.

Following brief summaries of the existing science programs, several speakers presented science reviews in the areas of crustal structure and rift basin evolution, paleoclimatology, environmental background to human origins, paleoecology and evolutionary biology, and geochronology and paleomagnetic studies in lacustrine basins. Several breakout sessions provided the opportunity for international groups to consider key questions to be addressed during scientific drilling. Summary white papers on the four main scientific themes are presented with the full workshop report.

A 1-day field trip to the Lake Malawi port facility and shipyard at Monkey Bay, the container port at Chipoka, and to the Limnological Field Station at Senga Bay provided participants with a sense of local infrastructure around the lakeshore.





Figures: Shipyard with dry dock facilities at Monkey Bay and container port at Chipoka, Southwestern Lake Malawi

Chris Scholz, *Syracuse University, USA*

Virtual Global Hawaii Scientific Drilling Project Field Lab

ICDP On-Site Drilling Information System extends to a Lab Information System

In March 2000, a ten-day training course for administration and maintaining the Drilling Information System of the Hawaii Scientific Drilling Project (HSDP-DIS) was performed by the ICDP Operational Support Group at GFZ Potsdam. The only student was Caroline Seaman from California Institute of Technology, Division for Geology and Planetary Sciences, Pasadena. She will be the administrator for the new Lab Information of the Virtual Global HSDP Field Lab.

Fig. 1: Training of the HSDP-DIS administrator Caroline Seaman (in foreground) from CalTech, Pasadena at OSG/GFZ, March 2000.

Extended DIS Lab Information System

The new Lab Information of the Virtual Global HSDP Field Lab is the consequential advancement of the on-site Drilling Information System DIS. Whereas the on-site version is designed for the use at the drill location, the extended version has a special Web interface. This Web interface allows direct remote access to the DIS database. The access is restricted exclusively to the members of the HSDP project.

In the case of HSDP, on completion of the HSDP drilling phase, a two-year period of scientific investigation has started. Samples are distributed to different labs and institutes in the world. Different analyses are performed on shared core samples. To ensure data integrity, the extended DIS will continuously be provided via a Web interface, which allows researchers to download the archived data of cores and the reference profile, and to upload new measurements and results as data sets and documents.

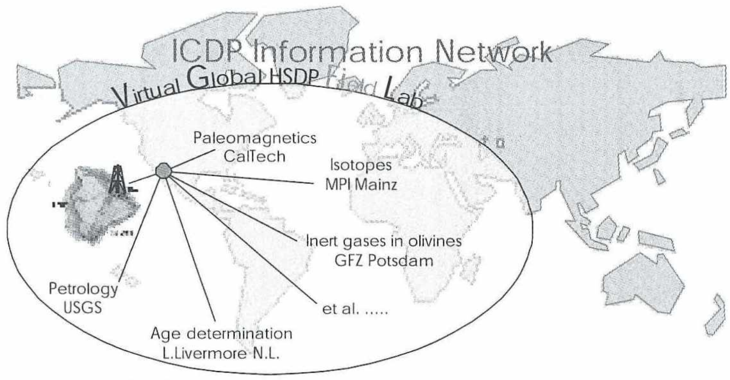


Fig. 2: Principle configuration of the extended HSDP-DIS within the ICDP Information Network.

The HSDP is the first testbed for the new lab information system. Forthcoming ICDP projects, like the Chicxulub, Sulu (Donghai) and Unzen, will take advantage of this new technology.

Acknowledgements

The ICDP Information Network is a service provided by the Operational Support Group of ICDP (OSG). The Network has been planned and implemented in cooperation with the OSG and the Data and Computing Center at the GFZ, sponsored by ICDP and the Deutsche Forschungsgemeinschaft, DFG. Design and implementation of DIS has been performed in cooperation with Frank Krysiak (smartcube).

Ronald Conze, Joachim Wächter, ***GFZ Potsdam****, Frank Krysiak,* ***smartcube Potsdam***

The Cluster of European Energy and Environment Projects for the Rift of Corinth (Corinth Rift Cluster)

Following up an ICDP-Workshop on "The Development of a Multi-Borehole Observatory at the Gulf of Corinth" held in Athens, Oct. 1997, an executive committee and a scientific advisory board were constituted in order to define the project goals and a reasonable time schedule. ICDP-funded coordinating meetings and workshops during 1998 and 1999 led to three concerted international research proposals which were submitted to the European Commission in 06'99 and 09'99 and to a proposal for a *Corinth Rift Cluster* infrastructure in 02'00.

The development of an in-situ earth sciences laboratory has been undertaken in the rift of Corinth in order to investigate various aspects of crustal deformation. It is, in particular, centered on seismic risk assessment. The facility will also be instrumental for the development of methods for more efficient exploration and production of hydrocarbons. Particular topics of interest are the role of fluids on fault mechanics and on the physics of earthquake sources. Correlatively, special attention is given to the role of faults on regional fluid flow and to the propagation of seismic waves in complex sedimentary basins.

The *DGLab-Corinth* project "Deep Geodynamic Laboratory-Gulf of Corinth" will contribute to the development of an European seismic hazard research facility articulated around an in situ laboratory. Its objective concerns the documentation of the hydraulic and mechanical behavior of faults as well as the acquisition of data required by the development of methods for seismic risk mitigation. The mechanical behavior of faults will be investigated through the instrumentation of deep boreholes intersecting active faults and designed for obtaining data on the physics of earthquakes and aseismic fault motion. Particular emphasis will be placed on documenting the role of fluids on fault behavior and the role of earthquake faulting on regional hydrogeology. In addition, new laboratory facilities will be developed for investigating the healing process of faults in order to improve our understanding of the so-called earthquake cycle. This facility will also include a set of deep permanent seismic sensors in order to document seismic signals at depth. This project is centered on the development of an efficient research infrastructure.

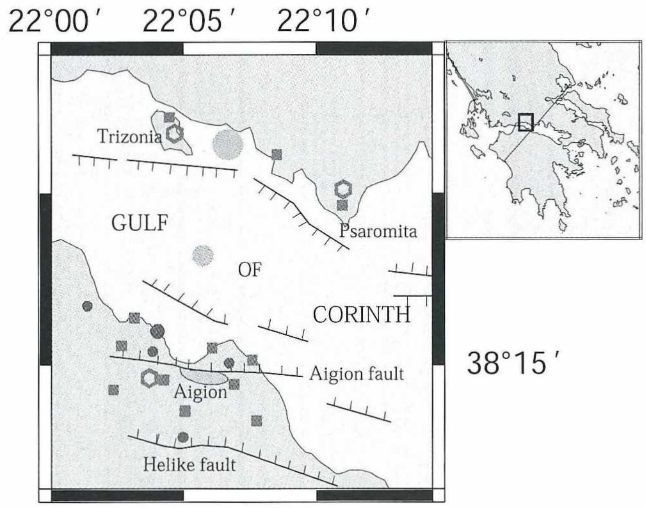


Fig. 1: Site of the geodynamic deep lab and location of planned drillholes (blue dots) and observation stations (red symbols)

The *CorSeis* project "An integrated study of seismic hazard assessment in the area of Aigion, Gulf of Corinth, Greece" will improve the observational, experimental, and theoretical methodologies for seismic hazard assessment. Work is focussed within the highly seismic Aigion area. Tectonic studies with geomorphology, trenching, and coring in quaternary sediments associated with dating, will provide information on long and mid term deformation and rupture sequences of the major faults. Continuous GPS monitoring will bring space and time variability of the strain field. Recording of the seismic activity with an array of borehole velocity-meters will allow detailed analyses of source and structure characteristics, in particular with multiples. Borehole and surface high dynamic accelerometers in soft soil sites will provide means to study non-linear effects with respect to reference accelerometric sites. Continuous geophysical (strain, tilt, pore water pressure,...) and geochemical monitoring are aimed at detecting crustal transients to be analysed together with seismicity.

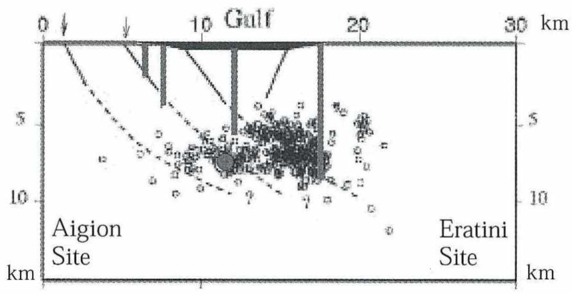


Fig. 2: Schematic cross section through the Gulf of Corinth with 1995 Aigion mainshock (circle) and aftershocks (dots). --- faults; | planned boreholes

The *3F-Corinth* project "Fault, Fractures and Fluids: Gulf of Corinth" will take advantage of the *DGLab-Corinth* and *CorSeis* projects to better understand the fluid transfer in and around fault zones. *3F-Corinth* will use partly data related to drilling and coring an active normal fault *in DGLab-Corinth.* Such normal faults are of importance to the hydrocarbon industry because they form natural trap for oil and gas. *3F-Corinth* will complement the DGLab program by providing a more complete logging program and, more importantly, by conducting mini-3D seismic and vertical seismic profiles. Additional stress measurements will be conducted in two other wells so as to constrain better regional gradients. Moreover, the fluid geochemistry will be analyzed continuously. Data obtained in this in situ laboratory will constitute unique benchmarks for calibrating numerical codes for 3D modeling of large crustal deformation. For the first time we will have a full set of data: stress (versus depth, time and position of the fault), strain (versus time and position to the fault), fluid (flow rate and chemical analysis, paleo-fluids by cement and fluid inclusion data), as well as core and borehole imaging. This should provide a unique opportunity for understanding the relations between fault hydraulics and fault mechanics and to calibrate tools commonly used for fractured reservoirs characterization. Special attention will be devoted to a better understanding of the opening of fractures in connection with the in-situ stress field.

While these projects have been conceived to be self-supporting, they will greatly benefit from each other if close interactions are encouraged, or even imposed - as for joint in situ experimentation. The main objective of the *Corinth Rift Cluster* project, therefore, is to set up a common site management structure in order to facilitate exchanges with other partners. It will enforce not only the close coordinationof the three European funded and future national projects including non European countries. It will provide thus a much better visibility to the whole undertaking, given that the various projects will appear as a single entity. This will further facilitate exchanges with other international programs like ICDP or ODP.

For information, please contact:
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***Günter Borm,** GFZ Potsdam*

Poland as a new member of ICDP

In January 2000 Poland joined the International Continental Scientific Drilling Program (ICDP), after signing The Memorandum of Understanding by Prof. Aleksander Guterch (Association for Deep Geological Investigations of Poland - ADGIP) and Prof. Michal Szulczewski (Chairman of VII Section, P.A.S.) from the Polish side and Prof. Rolf Emmermann and Dr. B. Raiser from the GeoForschungZentrum (Potsdam, F.R. Germany), on behalf of the members of ICDP. The membership fee to ICDP was provided by the State Committee for National Research (KBN).

By joining the in-group of China, Germany, Japan, Mexico, UNESCO and USA, Poland takes on responsibilities to be an active and creative partner in all scientific aspects related to ICDP. Widely expressed expectations concerning better understanding of the geological framework of Central Europe make Poland a cornerstone area for international co-operation. It is due to rather unique position of the country on the geologic map of Europe (see Fig. 1), where a history of crust evolution can be looked over from the Precambrian through Phanerozoic sequences. Attempts to unravel a time-space relationship between the Precambrian East European craton and crustal blocks presently amalgamated south-west to the craton boundary were undertaken at subsequent workshops of the EUROPROBE Trans European Suture Zone (TESZ) sub-project (Gee & Zeyen, 1996). Although there are still many possibilities to contribute to this problem by means of surface geology methods, we understand better than ever that acceleration in data accumulation may only be due to extensive seismic projects (e.g. CELEBRATION 2000) and deep drilling programme.

The current problems of deep geophysical and geological investigations in Poland were summarised by Guterch et al. (1996). The TESZ is considered as an amalgamation zone spanning from Bohemian Massif to the SW margin of the East European craton, while the Tornquist-Teisseyre Zone (TTZ) is a backbone axis stretching from the Baltic down to the Black Sea. Guterch et al. (1996) proposed dozen or so drilling sites that could help to get insight into the deeper structures of TESZ. One of the purely scientific projects, aimed at identification of the consolidated basement in the Holy Cross Mts. (HCM), was approved by governmental authorities, but still remains frozen because of lack of necessary funds.

Certainly, there are other than HCM sites where deep drilling may significantly contribute to our knowledge about the TESZ. One can imagine a deep drilling project situated north of Sudetes searching for concealed Variscan structures or in the West Carpathians, where Palaeozoic structures are covered by Alpine formations (see http://icdp.igf.edu.pl). Geoscientists from Poland as well as from other countries may want to present their own arguments for different localities, so that the eventual project will be established as a result of comprehensive discussion and final compromise. At the moment, we are at the beginning of the road.

References

Gee, D.G. & Zeyen, H.J. (Eds) 1996. Lithosphere Dynamics. Origin and Evolution of Continents. European Science Foundation, EUROPROBE Research Programme, 138 pp.

Guterch A., Lewandowski, M. Dadlez R., Pokorski, J. Wybraniec, S., Zytko K., Grad, M. Kutek, J., Szulczewski, M. & Zelazniewicz, A. Podstawowe problemy glebokich badan geofizycznych i geologicznych obszaru Polski (Basic problems of deep geophysical and geological investigations of Poland). Publ. Inst. Geoph. Pol. Ac. Sc., M-20(294), 44pp

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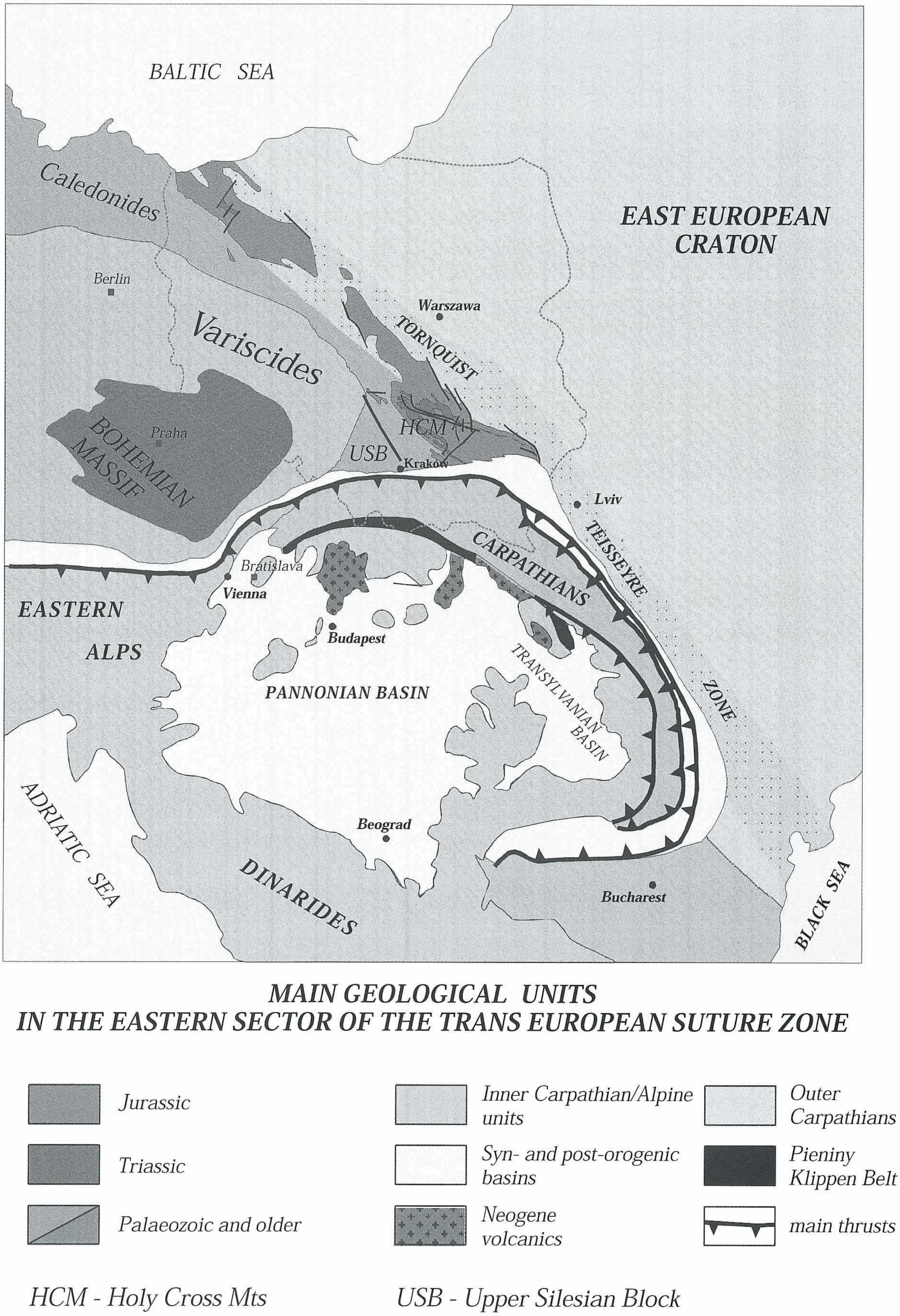
Fig. 1: Main geological units of Poland and surrounding areas



NEWSLETTER

icdp

Vol. 2, April 2000

International Continental Scientific Drilling Program

GEOFISICA

GFZ POTSDAM

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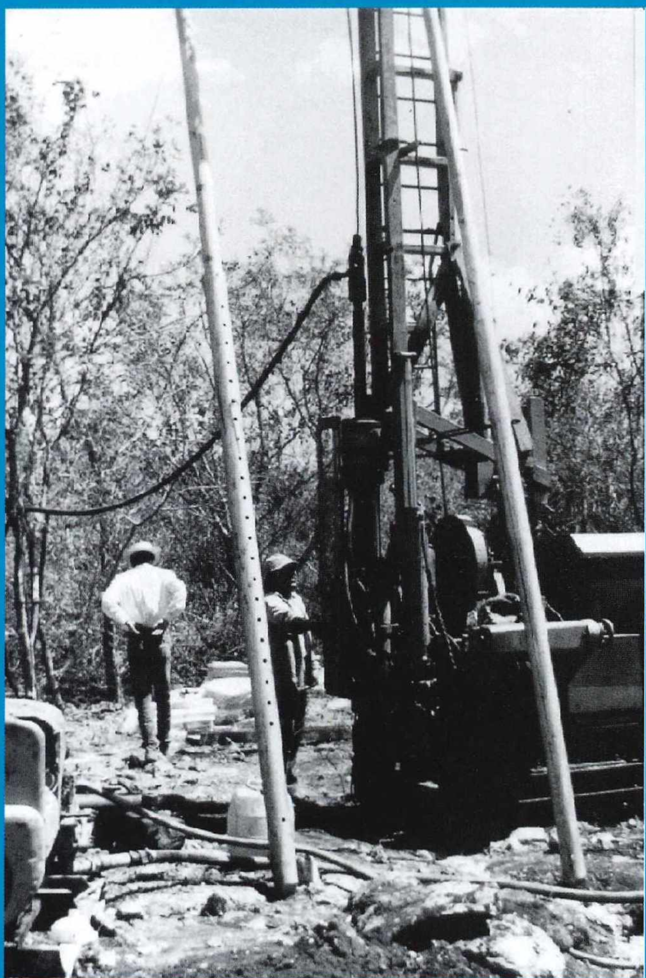
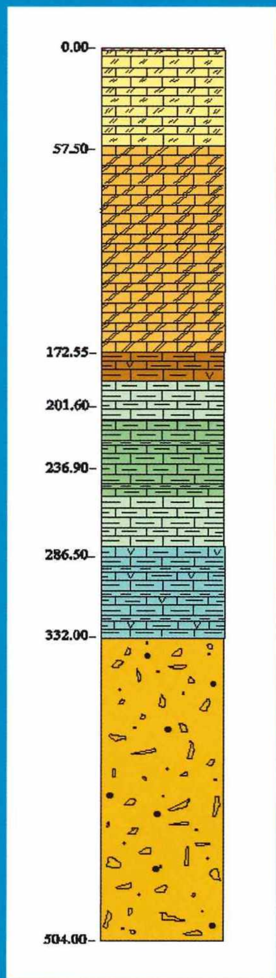
Science Advisory Group Meeting
Executive Committee Meeting

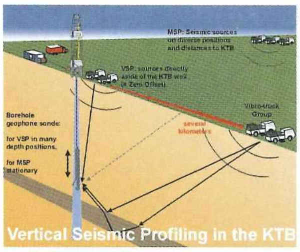


UNAM SCIENTIFIC SHALLOW DRILLING PROGRAM



UNAM-5 BOREHOLE
Scale 1:4000

Mérida, Yucatán, México
April 1-6, 2000


Vertical Seismic Profiling in the KTB