Observation of the Continental Crust through Drilling - Observations of a Symposium

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The 'International Symposium on observation of the continental crust through drilling' was held at the Hilton Hotel, Tarrytown, New York on 21-24 May 1984. About 120 attended, mainly from the USA, but including one or two participants from each of Germany, France, Belgium, Iceland, Japan and Canada. Paul Robinson of Dalhousie University and the writer were the only participants from Canada. US participation was from universities, governments and industry. The largest single contingent was from the Los Alamos Scientific Laboratories, where the geothermal hot dry rock project has been based. Other large groups came from Sandia Laboratories and the U.S. Geological Survey.

Although the meeting was spread over five days it would have been better if fitted into three. Some of the talks, although interesting, bore little relevance to the idea of deep drilling. The timetable is attached as Appendix 1, and only minor perturbations were made in the order of presentation.

There is no uniformity of opinion in the U.S. on deep drilling for scientific purposes. Some speakers took it for granted that, now the Russians have drilled to 11.5 km or more, the U.S. must do likewise. Others felt that an international effort was needed. Others considered that several holes to 5 km or even 2 km would cost less than one to 12 km, and they could yield more information, although obviously not the same information. Quantifying information remains an impossible task. Some represented special interests, such as mining of specific types of ore deposits. Some scientists recounted how they had made use of industrial drilling, sometimes by purchased 'add-on' projects, such as coring into basement rocks below deep oil exploration wells. The extreme industrial view was presented by a representative of Union Oil, as usual, who said that scientists must make use of all the vast amount of information from industrial drilling, all of which is freely available, before requesting funding for scientific drilling. This prompted a spirited verbal exchange.

Frank Stehli reported that there is a "Continental scientific drilling committee" in the United States, which has fifteen members with Shoemaker as chairman. The Committee has panels on Basement and deep basins; Mineral resources; Downhole measurements and fault zones; Thermal regimes; Drilling, logging and instrument technology; and Data and sample management. The present priority is a hole to about 10 km in the southern Appalachians, for which they expect to have funding in the next financial year (beginning Oct. 1984). The forecast is M$45 over three years. There is a newsletter, for which I asked to be put on the mailing list. The concept of international cooperation was mentioned in the context of finding the best sites for specific targets, e.g. old crust in Canada.

The Germans have been preparing for drilling for sime time. They regard this as an attempt to convert earth sciences to a 'big science' in terms of funding. They have narrowed the field to two sites for the first hole to 10 km or more - the Black Forest area or the edge of the Bohemian Massif. The final decision is to be made in 1985. Meanwhile surface surveys and shallow drilling is in progress. The speaker, Dr. Seibold, would like to see an international club on the JOIDES model.

Dr. Megnien, speaking for France, said that their main aim is to understand the deep geology of France. Their three main areas of interest are the basins, basement outcrops, and allochthons of the Alps and Pyrenees. Their first priority target is the magnetic anomaly of the Paris Basin. International cooperation is highly desirable.

Dr. Bouckaert, speaking for Belgium, said that they have had a scientific drilling programme since 1952, and that 15 holes have been drilled to depths exceeding 2000 m. The Jeumont hole penetrates an overthrust zone.

Dr. Niitsuma of Japan said that they wish to begin deep scientific drilling before the end of this century.

Dr. Eriksson of Sweden pointed out that his country is virtually all exposed Precambrian shield. Drilling to 5-7 km is expected to start in 1986 or 1987, and thr first priority at present is the Siljan Ring, believed to be an ancient meteorite impact structure. A series of holes is planned over 20 years, to permit work on radioactive waste disposal, geothermal energy from hot dry rock, and the deep gas theory.

At a discussion meeting on Wednesday evening some of the organisers attempted to start some action on the subject of scientific drilling. Sandra Toye of NSF described the activities and organisation of IPOD, the International Panel on Ocean Drilling, which is responsible for scientific drilling at sea. She pointed out the benefits of joint funding and access to a large number of interested scientists in the subscribing nations. She also mentioned the problems of a rigid formal structure and the possible problems that might arise in choosing drill sites on the territory of member states. A draft statement was produced for discussion, but a recipient for this statement had not been identified. Pembroke Hart invited the organizers to submit this statement to the Committee on Drilling of the International Lithosphere Committee. The existence of this Committee was unknown to most of the participants, but at least one member was present - N. Niitsuma of Japan. It was agreed that this should be done, and a copy of the revised statement is attached as Appendix 2. Prospects for significant action by such a Committee were obviously not regarded with any great optimism. I later asked Dr. Niitsuma what the Committee intended to do, and he replied that it intended to 'collect information'.

The deep ocean drilling programme is not a good model for continental drilling. When the ocean drilling began it was a new technology, which had not been previously available. Drilling at sea had been done only by fixed rigs on continental shelves, and re-entry of a hole in the deep sea-floor was

a new possibility. Drilling on the continent is not new. Many countries have the capabilities of drilling to 5 km, and several are capable of 8-10 km. New developments, such as turbine drills, are appearing, and these will assist in reaching new depths, but most of the affordable technology is readily available. There is no need to focus effort into a single drilling facility, unless the object is unprecedented depth. Several countries, including Canada, could elect to begin a scientific drilling programme, with or without international participation, and the US could choose to emulate the Russian achievement if that were perceived as a national priority.

Paul Robinson's presentation on the drilling in Cyprus and Ingvar Fridleifsson's presentation on the East Iceland Drilling Project made strong impressions on the meeting. Here were successful scientific drilling projects being carried out with a minimum of organisational structure and a modest budget, yet the well-designed drilling programmes and the participation of enthusiastic scientists were achieving significant success. The choice of drilling targets in small countries of limited financial resources is believed to have facilitated international participation with a minimum of political interference. The leadership of Canadians is also probably more generally favourable than would be a U.S. lead.

Although there is perhaps scope for a cooperative programme for the drilling of a very deep hole for scientific purposes, scientific drilling is not waiting for this. 'Scientific purposes' come in many gradations. The Earth Physics Branch had drilling programmes for both geothermics and crater studies until they were squeezed out. We have benefitted very cheaply from industrial drilling by mining companies in the Shield and Cordillera and by oil companies in the North. We now have a geothermal energy drilling programme, but this is applied rather than pure science. The hot dry rock project at Los Alamos, USA, and in the Carnmenellis Granite in England are applied scientific projects. M. Bickford at University of Kansas has acquired

cores of Precambrian basement from many wells drilled by oil companies by paying for extra drilling in exploratory or production wells. This has led to new information on the age of metamorphic provinces. There are many such projects in progress, dependent generally on the activities of enthusiastic individuals rather than of committees.

The role of Cocorp as an identifier of targets was presented by Jack Oliver. There was some enthusiasum among participants for drilling to intersect these seismic reflectors, particularly in the Appalachians. Canada is in the process of developing these same options. We are beginning a programme of seismic reflection under the name of 'Lithoprobe'. If we choose we can examine the reflectors by other surface surveys such as electrical, magnetic, gravity, and we can complete the job by drilling to those targets that seem to be worthwhile and are within our reach. Only by drilling will we find out with certainty what is down there. Alternatively, we can stop short of a complete investigation and we can leave ourselves subjects for lengthy conjecture. One of the more cynical speakers commented that he did not perceive much enthusiasm among scientists for drilling, particularly those engaged in surface surveys, since it is not in their interests to have definite answers about the nature of reflectors.

APPENDIX 1

INTERNATIONAL SYMPOSIUM ON OBSERVATION OF THE CONTINENTAL CRUST THROUGH DRILLING

May 20-25, 1984

PROGRAM

Sunday evening, May 20

Registration starting at 4:00 p.m.

Cocktails-Buffet
Sunnyside South/Center at 7:30 p.m.

Monday, May 21

Breakfast - Hendrick Hudson Room-0800

I. REVIEW OF NATIONAL DRILLING PROGRAMS

Rapporteur - Dr. Frank Stehli

Dr. Barry Raleigh Lamont-Doherty Geological Observatory	Welcome	0900
Dr. Frank Stehli University of Oklahoma	U. S. National Scientific Drilling Program	0910
Dr. Eugen Seibold Deutsche Forschungsgemeinschaft Dr. Hansjurgen Behr George-August-Universitat	German approaches to continental deep drilling	0925
Dr. C. Megnien, Bureau de Recherches Geologiques et Minieres Dr. C. Weber, Union Internationale des Sciences Geologiques	French programme on deep drilling, first year's results	0955
	Coffee	1025
Dr. J. Bouckaert Belgische Geologische Dienst	Results of deep drilling in Belgium	1040
Dr. N. Niitsuma Shizuoka University	Scientific continental drilling project in Japan and the scientific goals	1110
Dr. K. Gosta Eriksson Chalmers University of Technology	Review of the Swedish Drilling Program	1140
	Lunch-Hendrick Hudson Room	1210

II. THERMAL REGIMES

Rapporteur: Dr. John Hermance

Dr. W. A. Elders University of California	Observations of possible transitions between oceanic and continental crust by drilling to 5.5 km in the Salton Sea geothermal field, California, USA	1330
Dr. John F. Hermance Brown University	Understanding thermal energy and mass transport in major volcanic centers; motivation for intermediate depth continental scientific drilling	1400
Dr. J. B. Rundle Sandia National Laboratories	Models for volcanic processes in Long Valley, California: testing by continental drilling	1430
	Coffee	1500
Dr. J. C. Eichelberger Dr. P. C. Lysne Sandia National Laboratories	Coring to solve magmatic problems: results and plans at Inyo Domes, Long Valley, California	1515
Dr. Murli H. Manghnani, Univ. of Hawaii Dr. William C. Luth, Sandia National Laboratories	Elastic, anelastic, electrical and thermal properties of Kilauea Iki Lava Lake samples	1545
Dr. K. Aki Massachusetts Institute of Technology	High resolution of high precision seismology for the study of thermal regimes	1605
Dr. Alan Ryall, Dr. U. R. Vetter, Dr. C. O. Sanders and Dr. F. D. Ryall University of Nevada	Seismological investigation of tectonic and magmatic processes in Long Valley, California	1625

Dinner - Hendrick Hudson Room-1900

Poster Session-Tappan Zee 2000

Tuesday, May 22

Breakfast - Hendrick Hudson Room-0800

III. GEOCHEMISTRY, PETROLOGY AND MINERAL RESOURCES

Rapporteur: Dr. William Luth

Dr. Roger Hart Oregon State University	Mantle heterogeneities and degassing history: evidence from submarine glassy basalts	0900

Dr. Robert O. Fournier U. S. Geological Survey	Brine evolution and fluid circulation in active hydrothermal systems relative to modeling of mineral genesis	0930
Dr. J. Eidel, Coastal Mining Co. Dr. C. Meyer, University of California	Scientific drilling to study the roots and margins of mineralized hydrothermal systems	1000
	Coffee	1030
Dr. P. M. Bethke U. S. Geological Survey	Proposed scientific drilling program, Creede mining district, Colorado	1045
Dr. Barry Raleigh Lamont-Doherty Geological Observatory	Fluid-rock interaction and the mechanics of earthquakes	1115
	Lunch-Hendrick Hudson Room	1200

IV. IN-SITU BOREHOLE MEASUREMENT

Rapporteur: Dr. Mark Zoback

Dr. Paul Witherspoon Lawrence Berkeley Laboratory	Permeability distribution along well holes in fractured rock - problems of testing and interpretation and/or hydraulic fracturing stress measurement in non-elastic rock	1315
Dr. Mark D. Zoback U. S. Geological Survey	State of stress and physical property measurements in the earth's crust	1345
Dr. F. Rummel Ruhr-Universitat Bochum	Deep hydrofracture stress measurements in the Bharat gold mines, Kolar gold fields, India	1415
Dr. Bezalel C. Haimson University of Wisconsin	Crustal stress in Iceland and its relation to active volcanism	1445
	Coffee	1505
Dr. Amos Nur Stanford University	Seismic imaging using boreholes	1520
Dr. J. N. Albright, Dr. D. A. Terry Los Alamos National Laboratory	Seismic measurements in deep boreholes	1550

Dr. H. Tsukahara National Research Center for Disaster Prevention, Japan	Deep-hole techniques for continuous monitoring of crustal activity and in-situ stress measurement in Japan	1610
Dr. Jeffrey Daniels U. S. Geological Survey	In-situ physical property measurements in boreholes	1640

Dinner-Hendrick Hudson Room-1900

Poster Session-Tappan Zee 2000

Wednesday, May 23

Breakfast-Hendrick Hudson Room-0745

V. ADVANCES IN DRILLING AND LOGGING TECHNOLOGY

Rapporteur: Dr. Edward Schreiber

Dr. Frank Schuh ARCO Production	Deep drilling constraints/challenge	0845
Dr. R. K. Traeger, Dr. Peter C. Lysne Sandia National Laboratory	Geoscience experiments in boreholes: instrumentation	0915
Dr. Bert R. Dennis Los Alamos National Laboratory	Logging technology for high temperature geothermal boreholes	0945
	Coffee	1005
Dr. Michael Storms Scripps Institution of Oceanography	The evaluation of scientific coring technology within the Deep Sea Drilling Project	1020
Dr. Roger N. Anderson Lamont-Doherty Geological Observatory	Scientific logging methods, techniques and requirements	1040
Dr. John Finger Sandia National Laboratories	Research and development activities in geothermal drilling, completion and logging	1105
Dr. Gary R. Olhoeft U. S. Geological Survey	In-situ geochemical measurements in boreholes	1125
Dr. Mark A. Mathews Los Alamos National Laboratory	Log responses from two geothermal wells	1145

Lunch-Hendrick Hudson Room-1215

VI. RECENT RESULTS FROM SCIENTIFIC DRILLING

Rapporteur: Dr. W. R. Van Schmus

Dr. Paul T. Robinson Dr. James M. Hall Dalhousie University	The Cyprus crustal study project: a deep drilling investigation of ocean lithosphere	1330
Dr. I. B. Fridliefsson National Energy Authority	Deep crustal drilling in Iceland	1415
	Coffee	1500
Dr. Hugh Murphy Los Alamos National Laboratory	Borehole measurements in the Carnmenelles granite, Cornwall, UK	1515
Dr. John C. Rowley Los Alamos National Laboratory	Deep drilling technology for hot crystalline rock	1530
Dr. Hermann Spoerker OEMV Aktiengellschaft	Results of deep drilling in Austria	1600

Dinner-TappanZee/Rockland-1900

Thursday, May 24

Breakfast-Hendrick Hudson-0800

RECENT RESULTS FROM SCIENTIFIC DRILLING - CONTINUED

Rapporteur: Dr. Roger N. Anderson

Dr. W. Van Schmus University of Kansas	Holes of opportunity: examples from the central U. S.	0900
Dr. G. Ross Heath Oregon State University	Scientific results of the deep sea drilling project	0930
	Coffee	1000
Dr. J. H. Healy U. S. Geological Survey	The application of data from deep drillholes to earthquake prediction	1015
Dr. J. C. Dunn, Dr. J. C. Eichelberger, Dr. T. M. Gerlach, Dr. H. C. Hardee and Dr. W. C. Luth, Sandia National Laboratories	Drilling in subsurface molton rock: methods and results	1045
Dr. Dennis Nielson, Dr. Jeffrey B. Hulen, University of Utah	Results of deep drilling in the Valles Caldera, New Mexico	1115

Dr. A. William Laughlin Dr. L. Maassen Los Alamos National Laboratory	Methods, problems and results of reservoir characterization, Fenton Hill, New Mexico	1135
	Lunch-Hendrick Hudson Room	1215

VII. DEEP STRUCTURE OF CONTINENTS

Rapporteur: Dr. Barry Raleigh

Dr. Jack Oliver Cornell University	Some possible drilling targets based on COCORP surveys	1330
Dr. Karl Fuchs Karlsruhe University	Rationale for deep drill hole into the seismic active area of the Hohenzollern-graben in southwestern Germany	1400
Dr. George Thompson Stanford University	Deep structure of basin and range faults	1430
	Coffee	1500
Dr. Robert D. Hatcher, Jr. University of South Carolina	Possibilities and options for deep scientific drilling in the Appalachians	1515
Dr. M. E. Bickford, Dr. W. R. Van Schmus University of Kansas	Identification of Middle Proterozoic granite-rhyolite terranes in the southern midcontinent of North America through study of basement samples from drilling	1545
Dr. Gerard Bond, Ms. Michelle Kominz, Mr. William J. Devlin Lamont-Doherty Geological Observatory	Obtaining data on deeply buried crystalline basement in orogens indirectly from quantitative analyses of miogeoclinal stratigraphy constrained by outcrop, refraction and deep drilling studies	1605
Dr. Leon Silver California Institute of Technology	Integration geochemical, petrological and tectonic objectives in some deep continental drilling experiments	1630

Cocktails-East Foyer-~~1930~~ 1900

BANQUET - Ballroom

Dr. Ralph DeVries, White House Office of Science And Technology Policy
Prospects for Deep Continental Drilling in the United States

Friday, May 25

Breakfast-Hendrick Hudson-0800

VIII. SCIENTIFIC DRILLING AND THE ORIGINS OF SEDIMENTARY BASINS

Dr. Anthony Watts Lamont-Doherty Geological Observatory	The scientific drilling and the tectonic evolution of continental margins	0900
Dr. Arthur Green Exxon Research and Production Co.		0945
	Coffee	1030
Round table discussion on scientific drilling and the search for petroleum.		1045
	Chairman: Dr. Howard Gould	
	Lunch-Hendrick Hudson Room	1215

POSTER SESSIONS

Monday Evening

Dr. A. William Laughlin, Dr. D. G. Brookins, Dr. R. B. Forbes, Dr. R. Laney, Dr. C. W. Naeser, Dr. D. L. Turner, Dr. R. E. Zartman	Geochronology of Precambrian basement rocks from the Fenton Hill, New Mexico hot dry rock site
Dr. Mark A. Mathews, Dr. Carol M. LaDelfe, Los Alamos National Laboratory Dr. James Scott, U. S. Geological Survey	Fractured igneous rock environment test pit results.
Dr. Robert M. Potter Los Alamos National Laboratory	Measurement of heat flow with depth in the basement rock adjacent to the Valles Caldera, New Mexico
Dr. Charles O. Grigsby Los Alamos, National Laboratories	Fluid geochemistry of geothermal systems in the Valles Caldera, NM
Dr. Dr. Robert Hendron Los Alamos National Laboratory	Deep coring technology for hot crystalline rock
Dr. Paul Witherspoon Lawrence Berkeley Laboratory	Salton Sea Project

Tuesday Evening

Dr. Kris A. Dines XDATA Corporation	Computed reflection tomography for underground imaging
Dr. R. J. Lytle Lawrence Livermore National Laboratory	Vertical electromagnetic profiling (VEMP)
Dr. Hugh Murphy, Dr. Zora Dash and Dr. R. A. Aamodt Los Alamos National Laboratory	In-situ measurements near the Valles Caldera, New Mexico
Dr. Terry Engelder Lamont-Doherty Geological Observatory	Loading paths to joint propagation during a tectonic cycle: an example from the Appalachian plateau
Dr. Hisao Ito Geological Survey of Japan	Hydraulic fracturing stress measurements in Tohoku, Japan
Dr. Richard A. Plumb Schlumberger-Doll Research	Deep crustal Stress orientation in eastern North American determined from borehole elongation
Dr . Keir Becker XDATA Corporation	Computed reflection tomography for underground imaging

APPENDIX 2

INTERNATIONAL COOPERATION STATEMENT OF PARTICIPANTS IN THE INTERNATIONAL SYMPOSIUM ON THE OBSERVATION OF THE CONTINENTAL CRUST THROUGH DRILLING

Many countries are undertaking programs of drilling on land for scientific purposes. These programs are aimed toward achieving a better understanding of the processes of the earth's crust and thus toward the solution of problems related to supplies of energy, mineral, and hydrologic resources, safe isolation of toxic wastes, and hazards associated with earthquake and volcanic eruptions.

The effectiveness of programs of drilling on land for scientific purposes in the various countries could be significantly enhanced through international cooperation. Such cooperation might include:

1. Meetings for discussion of scientific and technological aspects, and the planning of joint scientific enterprises and the coordination of scientific and technological efforts.
2. Exchange of information on the availability of drill holes, logging data, core or other drilling samples, for joint cooperative scientific study and add-on experiments.
3. Availability through publication or other means of basic scientific and technological information developed in programs of drilling on land for scientific purposes.
4. Expediting the participation of scientists and engineers in international cooperative programs (and associated planning meetings), and expediting the international shipment of cores, rock and fluid samples, and experimental equipment.

There was a clear consensus that:

1. The importance of such international cooperation should be called to the attention of authorities in various countries who are responsible for programs of drilling on land for scientific purposes, and,
2. Encouragement be given to the Coordinating Committee on Continental Drilling of the Inter-Union Commission on the Lithosphere to continue its efforts toward fostering international cooperation in the programs of drilling on land for scientific purposes.