89-503

Executive Summary

Shipboard Measurements Panel
Second Meeting
Lamont-Doherty Geological Observatory
2-3 October 1989

The meeting focused on four main topics: (a) improvements to current laboratory procedures and equipment; (b) potential upgrades to sedimentological/visual core description; (c) requirements for full integration of downhole and shipboard measurements; and (d) specific shipboard requirements for upcoming legs. Specific recommendations are listed below. The most urgent requirement is the development of standard methods for the measurement and calculation of bulk density, water content, and grain density. Some improvements have been made since our first meeting in Underway Geophysics and the panel is closely monitoring this progress. Potential upgrades to sedimentological methods and visual core descriptions were discussed in detail and the panel encourages the upgrades to the barrel sheets as proposed by TAMU. The panel discussed the requirements for downhole and shipboard data integration. It is recommended that DMP and SMP meet together to prepare a plan for full data correlation and integration. Specific requests made by the Working Group on Fluid Regimes of Accretionary Wedges were discussed. Some of these requests overlap with the requirements and concerns of SGPP. The most technologically difficult requirement identified in our discussions is the development of sample handling equipment (for fluids and for bulk physical properties) for the pressure core barrel (PCB). As requested by PCOM, SMP discussed the requirements for guidelines on radioisotope use onboard JOIDES RESOLUTION. Specific guidelines will be drafted at the next SMP meeting (6-7 March, 1990).

SMP Recommendations
2-3 October 1989

The panel recommends that temperature-dependent susceptibility equipment be purchased for the paleomagnetics laboratory (89-26).

The panel recommends that an ARM coil be built at TAMU by an electronics technician (89-27) for the paleomagnetics laboratory.

The panel recommends that a group of physical property specialists prepare a document of standard methods for shipboard determinations of bulk density, grain density and water content (89-28).

The panel recommends that (1) a list of the shipboard micropaleontological library material be distributed to paleontologists from the most recent ten legs and request suggested additions; (2) paleontological material should be indexed for access by shipboard scientists and (3) the older taxonomic literature should be accessible in the paleontology lab (89-29).

SMP recommends that a documented reference slide collection be made available on the Resolution and at TAMU. This collection should be checked at the end of each leg and deficiencies should be corrected in order to maintain the collection (89-30).

The panel recommends that a proper Angstrom shatterbox be purchased ($7k - $8K) and that the cracked vessel be replaced ($5k) or repaired ($3k) in time for Leg 134 (89-31).

SMP recommends the following actions by TAMU related to computers and data:

(1) where the same plots are generated for each leg, standard plot templates should be developed using Mac and PC plotting software;
(2) a variety of software with manuals that provide flexible data manipulation such as spreadsheets, databases and graphics packages should be made available onboard for Mac and PC environments;
(3) develop data entry software as described above for the micropaleontology lab; and
(4) provide data transfer from VMS XRD/XRF files to the Mac and PC environments (89-32).

TAMU should begin the development of a sedimentological visual core description computerized form to be compatible with the new developments in the Barrel sheets (89-33).

The panel re-emphasizes the importance of our recommendation made at the first meeting which states: the evaluation of the smear slides should not be broken down into absolute percentages; rather the percent composition should be represented by descriptive terms which represent ranges of percent compositions (89-20).

SMP re-emphasizes their recommendation that _if_ VSP becomes a routine part of the program (i.e. a zero offset VSP is run at each site where a sonic log is collected), underway geophysical operations should be integrated with the VSP program (89-9).

SMP recommends that TAMU purchase a photocopier and adapt it for photocopy of whole core rock samples (89-34).

Shipboard Measurements Panel
2-3 October 1989
Minutes

I Introduction of new members, guests, and TAMU representatives. The meeting was attended by the following:

Jack Baldauf (ODP/TAMU)
Henry Elderfield (guest; SGPP)
Ian Gibson (member)
Xenia Golovchenko (ODP/LDGO-BHRG)
Dennis Graham (ODP/TAMU)
John King (member)
Kate Moran (chair)
Mike Mottl (member)
John Mutter (guest; host)
Adrian Richards (member)
Mike Rhodes (member)
Ellen Thomas (member)
Hidekazu Tokuyama (member)
Jean-Pierre Valet (member)
Robert Whitmarsh (member)
Paul Worthington (liaison; DMP chair)

II The chair called for additions to agenda which resulted in a modified agenda (attachment #1).

III Minutes of the last meeting were reviewed and approved. Business arising from the last meeting was discussed as follows:

Paleomagnetics (J. King)

J. King evaluated the needs for a pulse magnetizer and came up with some cost estimates. This equipment is commercially available. However, the equipment would have to be placed far away from the cryogenic magnetometer and this option is not practical. An alternative is to measure the temperature dependence of magnetic susceptibility. This equipment is also available commercially from Bartington Instruments at an approximate cost of $18k. After further discussion, **the panel recommended that temperature-dependent susceptibility equipment be purchased for the paleomagnetics laboratory (89-26).**

J. King and J-P. Valet also reported that an ARM coil may not be available in the paleomagnetics lab. This equipment is important for hard rock legs. There is very little capital cost for making this available and **the panel recommends that an ARM coil be built at TAMU by an electronics technician (89-27). Action: J. King will**

provide technical drawings to TAMU.

Contamination of core samples which influences the quality of paleomagnetics data was reported by J. King at the first meeting. **Action: J. King will assess Broken Ridge XCB cores and will report to the next SMP meeting.**

Physical Properties (K. Moran)

The measurement of bulk density, grain density and water content onboard the vessel has not been consistent from leg to leg. Shipboard scientists report problems with the penta-pycnometer; scientists change the software for calculation of these properties; and some established standard methods are not being employed onboard. **The panel is very concerned about these trends which may mean that measurements are not consistent from leg to leg and may not be able to be used in comparison with other data collected worldwide. The panel therefore recommends that a group of physical property specialists prepare a document of standard methods for shipboard determinations of bulk density, grain density and water content (89-28).** This group should consist of the following membership: A. Richards, K. Moran, E. Taylor, A. Fisher, M. Mottl, and R. Chaney. In addition, M. Mottl pointed out that since electrical resistivity equipment is available for use onboard, recommended resistivity methods should also be documented by this group.

Considering the wide variety of equipment in the physical properties laboratory and the variety of scientific staff expertise which utilizes the equipment on each leg, the panel feels that a workshop attended by previous physical property specialists would be very productive. The objectives of the workshop would be to:

1. review current equipment and procedures;
2. evaluate these procedures for consistency and discuss problems which have been identified by individual scientists;
3. identify any equipment/procedures/measurements which are not presently done onboard, but should be done routinely;
4. discuss measurements which should be incorporated into the current suite of physical property measurements in order to link shipboard measurements with downhole measurements;
5. identify and recommend upgrades to standard procedures; and
6. review the job description of the physical properties specialist.

The panel requests PCOM's endorsement of this proposal.

Micropaleontology (E. Thomas)

1. There have been numerous complaints regarding the shipboard paleontological library; these problems can be broken down into two categories:
   a) There is not enough documentation of Mesozoic material and there are still deficiencies in documentation of the Cenozoic.
   b) Some material onboard is not very accurate, including the reprint collection and the old taxonomic bound volumes from the Challenger. This material is not indexed; the older taxonomic literature should be indexed and placed in the paleo lab. Indexing should be done so that valuable material is present on the ship, and cannot be used because of lack of documentation.

   The panel recommends that (1) a list of the shipboard library material be distributed to paleontologists from the most recent ten legs and request suggested additions; and (2) paleontological material should be indexed for access by shipboard scientists and the older taxonomic literature should be accessible in the paleontology lab (89-29). Action: E. Thomas to monitor and coordinate suggestions from shipboard paleontologists.

2. Micropaleontological reference collections are not available to shipboard scientists with the exception of the badly depleted slides of planktonic foraminifers from the Challenger. Availability of theses slides is essential so that reliable data can be generated onboard. Relatively small groups of scientists could provide most of the material for each of the major fossil groups of planktonic foraminifers, benthic foraminifers, calcareous nannofossils, diatoms, radiolarians, and silicaflagellates.

   SMP recommends that a documented reference slide collection be made available on the Resolution and at TAMU. This collection should be checked at the end of each leg and deficiencies should be corrected in order to maintain the collection (89-30). The panel discussed how this may best be accomplished and agreed that funding for individual scientists to duplicate slides for the collection could come from USSAC and that the coordination of this effort would best be done from TAMU. In order to initiate this effort, TAMU should send a letter to appropriate micropaleontologists to ask for their participation. **Action: E. Thomas to provide a list of scientists names to J. Baldauf at TAMU.**

3. J. Baldauf reported that HF is no longer a problem onboard. However, some safety issues need to be addressed. The fumes should be tested and checked when HF is in use to be sure that a proper job is being done. Also, can the medical facilities onboard handle HF burns? **Action: J. Baldauf to report at the next meeting on status of HF safety.**

Petrology (M. Rhodes)

The XRF/XRD laboratory is working well. Very good results were achieved on Leg 126, particularly with the XRD. However, geochemical standards need to be provided. Standards are available from the USGS, France, Japan, and Canada. **Action: M. Rhodes and J. Baldauf to coordinate and report at the next SMP meeting.**

The cracked vessel for the shatterbox has not yet been repaired, although it has been successfully used. The next leg where this equipment will be heavily utilized is Leg 134. **The panel recommends that a proper Angstrom shatterbox be purchased ($7k - $8K) and that the cracked vessel be replaced ($5k) or repaired ($3k) in time for Leg 134 (89-31).**

Computers: Standard Plots (all members)

At the first SMP meeting, the panel decided that standard software templates should be developed for each shipboard lab in order to reduce duplication by shipboard scientists and to improve the efficiency of data output for Vol A. However, the panel discussed more general issues of data handling and data presentation which apply to all of the shipboard labs. M. Mottl noted that although standard plots exist on the Vax system for geochemistry, the scientists opted to use the Mac and the PC for data presentation. I. Gibson noted that flexibility is required. The panel agrees that there are minimum requirements for data handling as follows:

a) an easy transfer capability from the Vax to either the Mac and/or the PC environment;
b) flexible software packages available for spreadsheets, database applications, and plotting; and
c) where the same plot is generated each leg, standard plotting templates should be available on PC or Mac supported software packages.

D. Graham reported that with the installation of the Ethernet network onboard, requirement (a) will be met. The panel reviewed each lab with respect to these requirements. The labs which require the most improvement in this area are the micropaleontology and the XRD/XRF labs.

Shipboard data input for micropaleontology is not yet computerized; quadruple forms are still in use. This strongly inhibits use of micropaleo data in the database. TAMU is working on adapting the micropaleontological database program CHECKLIST; however, this program is not suitable for direct data entry. Its application is producing and plotting range charts. **TAMU should place highest priority for software on the development of a computerized form to replace the current quadruple forms.** The computerized version should have the following attributes:

- user-easy shipboard data entry in the database
- spelling checker to eliminate discrepancies
- customized forms for each major microfossil group
- compatibility with CHECKLIST
- dataentry should be available both via keyboard at the microscope and using a forms menu

The XRD/XRF laboratory does not yet have file transfer from VMS to a PC-based or Mac-based system. This requires duplicate data entry. **Data transfer from VMS to the micro environment should be developed and implemented for the XRD/XRF lab.**

In summary, SMP recommends the following actions by TAMU related to computers and data:

(1) where the same plots are generated for each leg, standard plot templates should be developed using Mac and PC plotting software;
(2) a variety of software with manuals that provide flexible data manipulation such as spreadsheets, databases and graphics packages should be available for Mac and PC environments;
(3) develop data entry software as described above for the micropaleontology lab; and
(4) provide data transfer from VMS XRD/XRF files to the Mac and PC environments (89-32).

III Sedimentology and Visual Core Descriptions (all members)

J. Baldauf began the discussion with a presentation of TAMU's proposed modifications to the dreaded Barrel Sheets. At present much of the data that is entered on these sheets is done by hand. Not only is this a repetitive exercise, errors are easily incorporated into the data set when copied manually from one medium to another. TAMU's proposed modifications include: presentation of the entire visual core description; removal of the smear slide data; include graphic lithology, structure and core disturbance; show sample locations with code designations for each lab or data type; present quantitative colour data; include down core plots of physical properties and allow for space for downhole logs, if appropriate. **SMP endorses and encourages these proposed changes to the Barrel Sheets.**

M. Leinen was unable to attend the meeting, her report on benchtop XRD for the sedimentology lab is deferred until the next SMP meeting. R. Jarrard (LDGO-BHRG) noted that on leg 124E with a scientist and a dedicated technician, 1 XRD and 1 XRF analysis was completed per core. Other methods for bulk mineralogical analyses were discussed. However, the panel needs more information on these techniques. **Action: M. Rhodes will report on infrared and other methods for bulk mineralogy to the next SMP.**

J. Baldauf and D. Graham reported that TAMU is working on a core video scanner. **Action: TAMU report to next SMP on status of the video scanner.**

Image analysis of smear slides was reported by A. Richards. Researchers at the Univ. of Miami may have the most advanced approach. **Action: A. Richards to follow the developments at Miami and report to next SMP.**

K. Moran presented the new method for digital core colour analysis used at Bedford Institute. The method uses an 'off the shelf' product manufactured by Instrumar Engineering Ltd. The product is a hand held spectrophotometer which uses a xenon flash as a light source and an array of light sensitive detectors which receive light after a prism separates the light into a wavelength spectrum in the range of 400 to 700 nanometres. The method may be applicable to ODP. **Action: K. Moran to present comparative Munsell and digital colour analysis at the next SMP.**

The panel discussed the hard rock visual core description computer method at our first meeting. We agree that **TAMU should begin the development of a sedimentological visual core description computerized form to be compatible with the new developments in the Barrel sheets (89-33).**

The panel re-emphasizes the importance of our recommendation made at the first meeting which states: the evaluation of the smear slides should not be broken down into absolute percentages; rather the percent composition should be represented by descriptive terms which represent ranges of percent compositions (89-20).

The topic of improvements to sedimentology and visual core description was not completed at this meeting and should be reviewed again, as a high priority at the next SMP meeting.

IV Requirements of Downhole Logging and Shipboard Measurements: Data Integration/Analyses (P. Worthington)

P. Worthington presented a summary of the recommendations made by DMP's physical properties working group which met on 17 August 1987 (attachment #2) One philosophy of the working group is that for each downhole measurement, there should be an equivalent shipboard measurement and that laboratory data should be obtained at restored temperatures and pressures where possible. Presently there are no examples from shipboard operations which meet this philosophy. The panel agrees generally with the philosophy of the working group; however, are cautious about suggesting complete duplication of each measurement because of scale problems, measurement interference among instruments, and cost/benefits. The panel discussed possible equivalent measurements which can be accomplished by supplementing the current physical property laboratory suite. The most obvious addition to the lab is the measurement of natural gamma spectrometry **(Action: Moran research and report to next SMP).** Other additional measurements include induced gamma with pulsed or accelerated source **(Action: I. Gibson research and report to next SMP)** In addition, the panel suggested that additional downhole measurements could be made to link logs to core using magnetic susceptibility. At present the shipboard scanned measurement of magnetic susceptibility is being used to correlate between holes. H. Tokuyama reported that a downhole magnetometer/magnetic susceptibility tool has been developed in Japan (attachment #3). **Action: J.P. Valet to monitor French and Japanese tool development and report status of application of this tool to ODP hole-size and vertical resolution in sediments.**

Other issues which were presented by Worthington are:

- how representative are the properties of one hole at, for example, a lithosphere site?
- should samples be tested at their in situ temperature and pressure?
- with the addition of the formation microscanner to the suite of logging tools, we may be able to better locate the core samples in the hole.

P. Worthington also suggested that the two panels (DMP and SMP) should hold a joint meeting in order to define the requirements for directly linking downhole measurements to shipboard measurements. SMP agrees that we need to proceed with this effort as a high priority and a joint meeting would be appropriate in one year. A. Richards recommended that we prepare a framework for the joint meeting in order to basically define available technologies. An outline of this framework is attached (#4). **Action: D. Graham to prepare ODP technology database using Richards' outline for review at the next SMP meeting.**

V SGPP Report on Fluids Sampling (H. Elderfield)

H. Elderfield presented the concerns of SGPP regarding the need for new or modified procedures for fluid sampling. A report which details these concerns is attached (#5). These concerns are directed toward the panel's highest priorities, sedimented ridge crests and accretionary prisms.

The SGPP's concerns about methods specifically relate to sample squeezing and to the method(s) for obtaining uncontaminated pore fluid samples, i.e. the Barnes\Uyeda Tool (WSTP) and the Pressure Core Barrel (PCB). Because the geochemistry lab now has an AA, trace element analysis can be done. However, the squeezers require titanium sleeves in order to eliminate contamination. **SMP fully endorses this request and, as we discussed at our first meeting (89-1), SMP agrees that it would be advantageous to have available a few non-plastic squeezers to minimize contamination.** Titanium should be considered first, and if the material is too weak, other materials which will not cause contamination for trace element analysis should be considered. **Action: M. Mottl to investigate possibility of using titanium squeezers. SGPP also requests that ultra-centrifugation be available for pore fluid extraction in the upper 200 metres. SMP, again, fully endorse this request (89-1).** In addition, SGPP echoes our request that a greater flexibility in whole round sampling be adopted (89-1). J. King noted that, although we agree that more flexible sampling is required, there is danger in loosing whole core scanned data if these samples are cut from the core at the catwalk. Whole round samples which do not require immediate attention/analyses should be removed from the core just prior to splitting.

H. Elderfield also presented the concerns of SGPP regarding the WSTP. M. Mottl noted that WSTP may only have a "bad" reputation because of one failure. In general, the tool works well and is only limited by sample size and the strength of the probe. P. Worthington also noted that DMP has discussed improvements to the tool, one of which is strengthening the probe. It was agreed that the PCB is also required in order to acquire larger volumes of pore fluid samples and for gas analyses. The PCB was successfully tested on the engineering leg (refer to attachment #6); however, there is as yet no procedure for handling the sample on deck. Engineering development for sample handling will require two separate methods which have different requirements:

1. for fluids/gas compositional analysis; and

2. for determination of physical properties at in situ pressures.

SMP agrees that the first method may be more easily accomplished and should be considered first, with the Cascadia/Vancouver Is. Leg as the operational goal. The primary requirement is separation (squeezing) of fluid from solids within the barrel. The second technique requires either transfer of the sample to a pressure chamber or measurements of some properties directly in the cell (e.g. thermal conductivity, acoustic velocity, resistivity). **Action: TAMU Engineering group representative attend next SMP meeting to discuss methods of PCB sample handling.**

VI Underway Geophysics (J. Mutter)

Data Acquisition
LDGO loaned their high speed streamer to TAMU for onboard testing. Because the fire which occurred onboard now limits the maximum ship speed to 10 knots, tests could not be fully performed. D. Graham thought that the streamer was required back at LDGO shortly. However, J. Mutter thought otherwise. If the streamer is not yet required at LDGO, it should remain onboard for tests following the drydock.

Processing
SIOSEIS (as recommended by T. Shipley, attachment #7) was used successfully during Leg 127 for post processing. However, real-time processing is not yet happening onboard. **Action: TAMU to report on the status of real-time and post processing at the next SMP meeting.** Also, scientists on Leg 130 should be encouraged to fully test and report on the processing capabilities of the current system.

Real-time Navigation
D. Graham reported that they had visited URI and Lamont to discuss JOIDES RESOLUTION navigation requirements. Subsequent to the visits, they sent out an RFP for the provision of a real time navigation system. They received bids back from 4 groups with a lowest bid of $250,000. Because the costs were high, the acquisition is on hold. **Action: TAMU to provide RFP to Mutter, Tokuyama and Whitmarsh for review prior to the next SMP meeting. Mutter, Tokuyama and Whitmarsh to present proposed recommendations at the next SMP meeting.**

VSP
P. Worthington presented a history of DMP's recommendations on VSP (summary attached #8). DMP had recommended that VSP's should not routinely be done on the ship. Although DMP agrees that there are major benefits achieved when VSP's are run, their main concern was that there was not an appropriate level

of support for tool acquisition and for data processing, which could possibly be achieved with a 'national VSP laboratory'. J. Mutter pointed out the JOI/USSAC supported workshop on VSP and ODP recommended the formation of a "US National VSP Laboratory" and that VSP's should become an integral part of ODP science (see Executive summary, attach #9). Although the deployment of the tools for VSP should be evaluated by DMP, the data acquisition and processing is an SMP concern; consequently the two panels play a joint role. SMP agrees that the VSP is the only direct tie between seismic reflection data and well log data. **SMP suggests that DMP reconsider their recommendation after reviewing the recommendations of the JOI/USSAC workshop. SMP re-emphasizes their recommendation that _if_ VSP becomes a routine (i.e. a zero offset VSP is run at each site where a sonic log is collected) part of the program, underway geophysical operations should be integrated with the VSP program (89-9).**

VII Upcoming Legs (K. Moran)

J. Baldauf presented the schedule for upcoming legs. The upcoming leg which has requested special shipboard measurements is Leg 131 to Nankai Trough. SMP reviewed the recommendations made by the Working Group on Fluid Regimes of Accretionary Wedges. K. Moran presented a framework for shipboard measurements which can be used in deciding what measurements are appropriate for the ship. Measurements fall into the following categories:

1. Standard (routine) tests and procedures that are required on all recovered core samples.
2. Non-routine measurements which must be performed onboard because of degradation/changes to the sample with time. Equipment for these measurements fall into two categories:
    a. ODP available
    b. Supplied by the shipboard scientist
3. Non-routine measurements which should be done onshore because it is either very specialized or very labour-intensive. Equipment for these measurements fall into three categories:
    a. ODP available at TAMU
    b. Located at individual scientists' institution
    c. Equipment supported by JOIDES or member countries, but located at a designated institution or university.

The Working Group recommended that equipment should be available onboard for matrix permeability. SMP agrees that this equipment falls into the 3a and 3b categories. The equipment is too specialized and labour-intensive for routine use onboard. M. Langseth (PCOM) confirmed this by commenting on the results of Leg 128. The equipment was set up onboard for Leg 128, but was not used. However, the equipment is presently operational at TAMU and can be used for post-cruise testing of whole round samples. If whole rounds are removed for this testing, they should be sealed in the plastic liner with wax and stored in salt water until tested onshore.

Recommendations were also made for testing samples onboard for 'seismic' velocity under in situ pressure. SMP agrees that this type of measurement falls into the 3b or 3c category. This equipment is very specialized and can be performed post-cruise, if appropriate sample handling and storage is carried out.

An upgrade to the thermal conductivity device was also recommended and this action has been completed by TAMU.

Modifications to the whole-round sampling policy were also recommended and SMP agrees as stated in the minutes of our Feb., 1989 meeting. However, consideration should be given to when the whole rounds are removed in the core flow and should be removed after the MST.

The Working Group also recommended use of the PCB, which was discussed earlier under the SGPP report heading and will be reviewed at the next SMP meeting. It was noted by A. Richards that a pressure core barrel has been successfully used by a group of researchers at TAMU. **Action: J. Baldauf to invite a representative from TAMU to discuss their experience with pressure core barrels and to present current research on gas hydrates.**

An anelastic strain relaxation (ASR) device was recommended by the Working Group for estimates of relative maximum/minimum stress direction. B. Whitmarsh reported that the instrumentation for this measurement is simple; however the results from Leg 123 are not yet fully understood. R. Jarrard suggested that given the limited number of downhole measurements of stress direction from the BHTV, this measurement may be quite valuable. Since ASR must be performed immediately after sample recovery, the measurement falls into category 2b at present and should be considered for 2a following the results of Leg 131 to Nankai Trough. **Action: K. Moran to investigate the equipment to be used on 131 and report at the next SMP meeting.** SMP discussed and noted that for true stress direction, core orientation is required.

Structural fabric analysis was also recommended by the Working Group. Some possible methods are X-Ray fluoroscopy, X-Ray tomography, and direct core photocopy. The high technology methods need further review by SMP. For hard rock core recovery, the photocopy method (as used by KTB) should be implemented. **SMP recommends that TAMU purchase a photocopier and adapt it for photocopy of whole core rock samples (89-34).** The method should follow that of KTB. **Action: A. Richards investigate the high technology methods and report at the next SMP meeting.**

VIII Guidelines for Radioisotope Use Onboard JOIDES RESOLUTION

PCOM requested that SMP provide satisfactory guidelines for the use of enriched stable or radioactive isotopes onboard the Resolution. SMP agrees that guidelines are required. However, in order to define guidelines appropriate to the program, SMP requires a better understanding of the priority of the science which requires radioisotopes onboard. SMP requests input from SGPP, OHP, TECP, and LITHP on what scientific objectives require the use of these substances and their relative ranking. SMP also needs additional information on the results of radioisotope use on Leg 128, information on the how clean was the Sedco/BP 471 upon delivery to the program, and the current guidelines used by member country oceanographic institutions. **Action: All SMP members forward their respective institution/member country guidelines to K. Moran; J. Baldauf report on the "cleanliness" of the ship at the next SMP meeting and the results of Leg 128 radioisotope use; and K. Moran to solicit thematic panel input on scientific requirements/ranking.** With this information SMP will draft guidelines for approval by PCOM.

IX Review and Status of ODP Sampling Tools

K. Moran reviewed the results of Leg 124E. An ODP Development Engineering representative was unable to attend with regrets. SMP outlined issues which should be discussed with a representative at the next meeting. These issues are:

- PCB sample handling requirements
- XCB/Hard rock core orientation (status)
- Sonic core monitor (status)
- APC core recovery/disturbance
- APC temperature sensor (status)

X Next Meetings

SMP is striving to hold every other meeting at TAMU. In addition, I. Gibson recommended that SMP overlap with IHP. **SMP requests the next meeting to be held at ODP/TAMU on 6-7 March, 1990.** IHP is meeting 7-8 March at TAMU. In addition, the panel discussed the need to meet at a port of call as recommended by PCOM in our mandate. At present, 55% of the panel membership have not been on the ship. Consequently, we feel that it is imperative for the panel to visit the ship. **SMP requests our fourth meeting be held in Brisbane following Leg 133 (tentative dates 11-13 Oct 1990).** In order to address the requirements of full integration of downhole and shipboard measurements, a three day meeting is requested, allowing for a one day joint meeting with DMP.

XI The chair thanked our host, John Mutter, for making the arrangements for the meeting and for his quick response to the blackout by providing light. Thanks were also extended to Xenia Golovchenko for arranging lunch and a tour of the Borehole Research Group facility. The meeting was adjourned at 1700, 3 October.

Attachment #1

Shipboard Measurements Panel
Second Meeting
2-3 October 1989
Lamont-Doherty Geological Observatory

Agenda

I Welcome and Introduction

II Minutes of Last Meeting and Business Arising:

Paleomagnetics (King)
Physical Properties (Moran)
Computers: Standard Plots (All members)
Micropaleontology (Thomas)
Petrology (Rhodes)

III Sedimentology and Visual Core Description

IV Requirements of Downhole Logging and Shipboard Measurements: Data Integration/Analyses (Worthington)

V SGPP Report on Fluids Sampling (Elderfield)

VI Underway Geophysics (Mutter)

VII Upcoming Legs

VIII Guidelines for Radioisotope Use Onboard JOIDES RESOLUTION

IX Review and Status of ODP Sampling Tools

X Next Meeting(s)

Physical Properties Working Group

A physical properties working group met on 17 August 1987 with PCOM approval. Group comprised P.F. Worthington, R. Carson, and M. Salisbury of DMP and P. Jackson (UK), D. Karig (Cornell) and E. Taylor (TAMU/ODP). Group proposals were adopted by DMP as follows.

DMP Recommendation 1987/21

"(A) Physico-mechanical properties (laboratory) data should be gathered in accordance with the following philosophy:

- for each parameter measured downhole there should be a corresponding laboratory measurement on board ship; this would provide improved calibration and interpretation;
- laboratory data should be obtained at restored in situ conditions where possible;
- laboratory data should be three-dimensional where appropriate to take account of anisotropy.

Two types of data should be measured:

- scanning, eg. GRAPE, PWL, of whole core
- detailed, eg. resistivity, velocity, on plugs

Detailed measurements should be integrated with parallel investigations on same material in sedimentology, geochemistry, etc.

In pursuit of these objectives, the following technical developments are needed.

SCANNING: multisensor facility comprising GRAPE (available), PWL (available), magnetic susceptibility (under development) and natura gamma spectral (new development). Seek modular enhancements by addition of ultrasonic sensor to assess core quality and correlate with downhole measurements.

DETAILED: instrumented pressure cell for compressional and shear velocities and resistivity (new development). Fluid cell for pore water resistivity (upgrade of existing geochemical facility). Constant-flow permeameter (under development). XRF (available but under threat) must be reactivated. Anelastic relaxation monitor (new development).

[These developments complement the existing gravimetric/volumetric determination of density and porosity, thermal conductivity measurements, cryogenic magnetics, consolidation tests, and vane shear tests, facilities for which already exist. The Hamilton Frame would become redundant.]

(B) Physico-mechanical properties (in situ) data should be gathered in accordance with the GEOPROPS PROBE principle: pore pressure, permeability, porosity, strain, stress.

(C) Sampling methodology should be improved as follows:

- core orientation, absolutely vital that routine downhole technology be developed;

- multiscanning of whole core to recognise intact material and guide point sample selection; this would be enhanced by an ultrasonic caliper/imager in the multisensor system;

- point sampling (plugs) to be taken prior to splitting;

- during structurally important legs, identify fabric and split perpendicular to it.

(D) Priorities for acquisition/development

(1) Downhole core orientation; feasibility study to investigate available methodology

(2) Geoprops Probe 1

(3) Seismic/Resistivity cell with pore water resistivity

(4) Anelastic relaxation facility

(5) Spectral gamma sensor/ultrasonic sensor; feasibility study for incorporation into multisensor array.

(E) A subgroup of DMP members be formed with special responsibility for physical properties, to advise the programme through DMP on physical properties matters.

(F) It is imperative that a dedicated technician be available for physical properties measurements on board ship."

（接続図と説明）

完全自動・一体化した残留磁気測定・交流消磁・帯磁率異方性測定システム

A3

新妻信明・小山真人（静岡大理）

FULL-AUTOMATIC PORTABLE SPINNER MAGNETOMETER COMBINED WITH AF DEMAGNETIZER AND MAGNETIC SUSCEPTIBILITY ANISOTROPY METER

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We describe a new combination system for paleomagnetic measurement, into which the following four instruments are incorporated: a ring-core-type flux-gate spinner magnetometer, an alternating field (AF) demagnetizer, an ARM superimposer, and a magnetic susceptibility anisotropy meter (Figure 1).

The system is composed of the following mechanisms or circuits:

① a ring-core sensor and its driving circuits (an activator and a lock-in amplifier),

② a sensor holder incorporated with three sets of coils, which are utilized for AF demagnetization, ARM overprinting, and susceptibility anisotropy measurement, respectively,

③ a mechanism for sample rotation and resetting for 6-spin measurement, using a pair of non-magnetic ultrasonic motors and motor drivers,

④ a magnetic shield case,

⑤ a demagnetizing current generator and a power amplifier,

⑥ a regulated current source for ARM overprinting and magnetic susceptibility anisotropy measurement,

⑦ a central controller and I/O interfaces (a personal computer, a digital voltmeter, a GP-IB interface, an I/O board and peripheral circuits).

In this system, the whole measurement process is controlled by the central computer, which executes the sample rotation and reset during 6-spin magnetization measurement, the ON/OFF and wave-form control of demagnetizing current during stepwise AF demagnetization, and the ON/OFF control of DC magnetic field during ARM overprinting or susceptibility anisotropy measurement.

The noise level of the magnetometer corresponds to 1×10^{-8} kA/m (emu/cc) of 30 cc sample for 10 times stacking measurement. The maximum field intensity of the AF demagnetizer is 50 mT. The total weight of the system is only about 35 kg, which is light enough for field use.

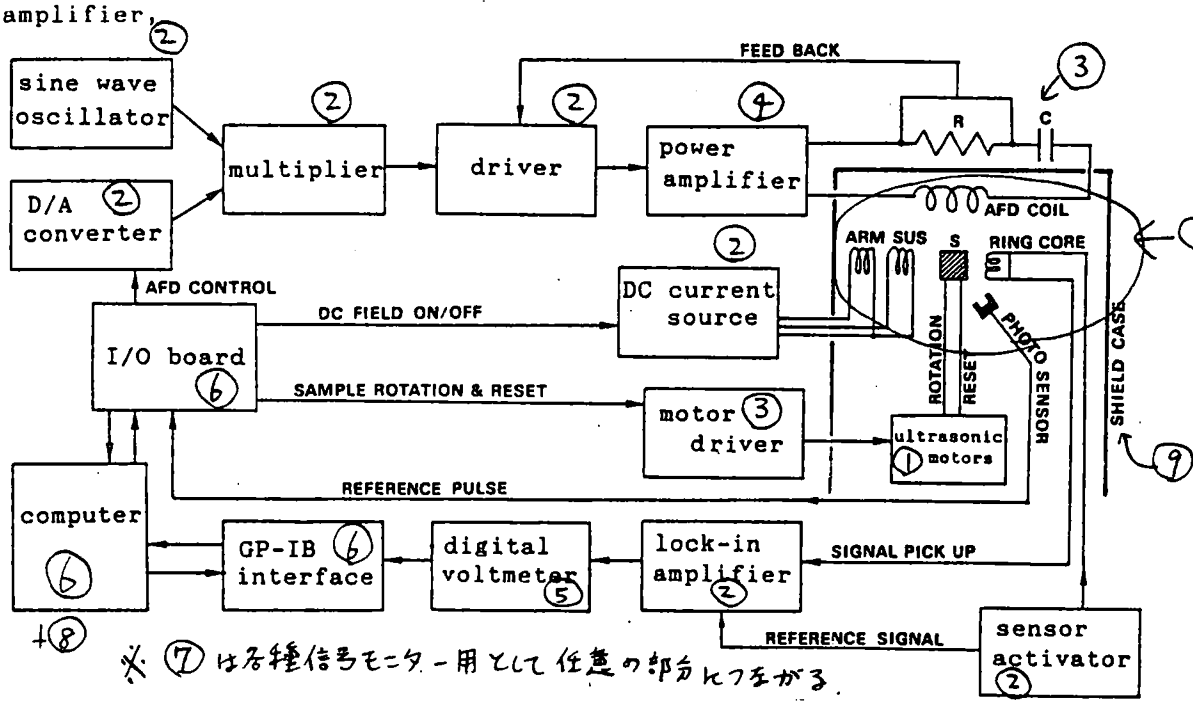

Fig. 1 Block diagram of the system. AFD: alternating field demagnetization; ARM: coil for overprinting of anhysteretic remanent magnetization; SUS: coil for magnetic susceptibility anisotropy measurement; S: sample; R: resistor (0.5 Ω); C: capacitor (1 μF); RING CORE: ring-core-type flux-gate sensor.

①〜⑨はリストの方の番号と一致

Attachment #4

Specification Sheet for SMP/DMP Technologies

I Instrument
- A) Name
- B) Manufacturer
- C) Price

II What is measured?
- A) Directly
- B) Indirectly
- C) What are the assumptions to the measurements?

III Scientific Importance of Measurement
- A) General
- B) Specific

IV Operational Use
- A) Current ODP Shipboard
- B) Off-the-shelf availability
- C) Modifications required for ODP use
    1. Who is capabable of making these modifications?
    2. Approximate cost of modifications

V Specifications
- A) Range of measurements/units
- B) Accuracy; Precision
- C) Maximum water depth
- D) Operational temperature range
- E) Technical support required to operate/maintain
- F) Size

VI Impact of this measurement on current routine shipboard operations
- A) Can the measurement fit into current core flow (SMP) or current downhole combinations (DMP)
- B) What current measurements will be enhanced by the addition of this measurement?
- C) What current measurements will be degraded by the addition of this measurement?

VII Suitability relative to scientific need
- A) What scientific objectives can be met?
- B) What are the technological achievments?

VII Include other relevant comments

Attachment #4

Scientific Objectives: Requirements for Technological Developments

Proposed Joint SMP/DMP Meeting

I Definition of scientific objective
- A) General
- B) Specific

II Definition of required technologies to meet the objectives
- A) Current practice
- B) Required measurement
  1. Range
  2. Accuracy
  3. Precision
  4. Environmental variables (temp., pressure)
  5. Resolution
     - i vertical
     - ii lateral

III Development status and schedule
- A) Under development
  1. < 1 yr to prototype
  2. 1-2 yr to prototype
  3. > 2 yr to prototype
- B) Not under development
  1. Can be done with existing technology
  2. Cannot be done (include explanation)

IV Development cost
- A) Fully known (i.e. lump sum acquisition)
- B) Partially known (estimate)
- C) Not known (include explanation)

REPORT ON SAMPLING OF FORMATION FLUIDS IN THE OCEAN DRILLING PROGRAM

Draft Report of the Sedimentary and Geochemical Processes Panel
(Prepared by Sub-Committee of P.Froelich, H.Elderfield & F.Prahl)

For Discussion: Shipboard Measurements Panel Meeting
Lamont, October 2-3, 1989.

PROLOGUE: STATEMENT OF THE PROBLEM

SGPP is concerned that the effort to understand fluid circulation, composition, and chemical interactions in sedimented ridges and accretionary prisms will require a dedicated effort by ODP to quickly modify and perfect new fluid sampling techniques and procedures. This short paper addresses the shortcomings of present methods, and briefly reviews those parameters which are of highest priority for any sampling protocol.

Ideally, formation fluids must be recovered with their in situ compositions, temperatures, and pressures unaltered. Gas compositions are critical in accretionary prisms (volatile hydrocarbons, CO2, CH4, noble gases, H2S), particularly in clathrate zones. Chemical contamination of transition metals must be eliminated in order to obtain valid fluid compositions in zones where metalogenesis processes are important (sedimented ridges). Samples must be demonstrably free of artifacts due to entrainment of drilling fluids. Since no one procedure is capable of accomplishing all these goals to produce rapid down-hole fluid chemical compositions, we believe that successful marriage of a modified shipboard sampling protocol with the new pressure core barrel may accomplish most of our goals. However, this committee is uncertain of the plans that ODP has for the PCB and wishes to be kept abrest of its development and testing via a direct link between the engineers/staff scientists most closely linked to this project, and the members of this sub-committee.

SHIPBOARD VS IN SITU SAMPLES

These procedures, as presently practiced onboard JOIDES Resolution, have deficiencies. Shipboard sampling of wholerounds

(Manheim-Sayles method), cut and squeezed immediately after core retrieval, can not provide reliable gas compositions nor eliminate artifacts due to pressure effects on solution-solid equilibria. However, in principle, shipboard squeezing can, with minor modifications, eliminate (or at least test for and minimize) temperature- and redox-artifacts. Squeezers composed of titanium (rather than stainless steel) eliminate contamination due to the iron-alloy metals and the formation of surficial FeS surface phases that can sequester other metals from anoxic fluids. Careful temperature control of the squeezers prior to loading and squeezing can eliminate most temperature artifacts. By cutting, transferring, and loading wholerounds under an inert atmosphere, most redox artifacts can be minimized, provided a suitable rapid and reliable means of cutting and transferring whole-rounds on deck can be designed. Thus shipboard squeezing, with a few simple modifications, can generate much valuable high resolution down hole information. It has the advantage of being ship-time efficient (no additional wire-time is required). It has the disadvantages of being shipboard labor intensive and inappropriate for gases or other constituents with severe pressure artifacts.

In situ sampling has the advantage of being the only practical means of eliminating artifacts due to depressurization and is thus critical for obtaining information on gas compositions, particularly in clathrate zones. The present design of in situ sampler (Barnes tool) relies on separation of fluids from the formation at the bottom of the hole and can return samples without temperature and pressure artifacts on solution chemistry. However, this tool is ship-time inefficient, returns only one sample per wire-trip, has proven unreliable, and massive failure risks the entire hole. Chief Scientists are thus reluctant to employ this tool until after the final (bottom) objective is reached. In addition, it does not recover a sample of the formation from which the fluid was obtained, and can only be adapted to return either gas samples, or uncontaminated transition-metal samples, but not both at the same time.

The newly-designed pressure core barrel (PCB), while still in development, could potentially return to the ship a sample of the formation and its fluids and gases under in situ pressure and without contamination (if constructed of titanium). It is also potentially temperature-controllable, so that it is capable of recovering gas and fluid compositions without PT-artifacts. It has the disadvantage of returning only one sample per wire trip, but has the advantage that multiple lock-on chambers can be employed to separate the core material under in situ conditions into various subsamples for different purposes. We believe that the PCB contains the seeds of a reliable in situ sampling device that has the best chance of providing reliable data.

In the following paragraphs, we address (1) improvements in shipboard methods and protocols and (2) development of the pressure core barrel. Other features of SGPP's concerns for fluid sampling (packers, high-temperature sampling, instrumented holes) are contained in the SGPP White Paper.

IMPROVEMENTS IN SHIPBOARD METHODS AND PROTOCOL

1. Squeezers should be composed of titantium to eliminate Fe-alloy contamination problems. (Designs have been forwarded to ODP and the process is underway.)

2. Shipboard technicians should be instructed to pre-refrigerate squeezers at in situ temperatures in a T controllable refrigerator prior to loading and squeezing. Some knowledge of the thermal gradient expected in each hole will be required.

3. ODP should consider alternate methods of separating pore fluids from sediments onboard ship, particularly for the upper 200 m of high porosity sediments such as those encountered on legs 113, 114, 119, and 120. For example, Ultra-centrifugation (gimbaled) inside a walk-in reefer has the advantage of being potentially amenable to controlling temperature- and redox-artifacts in some types of sediments.

4. Abandon the 1/2 round sampling strategy. (In effect.)

5. All PW samples should be cut at the rail as soon as the core is on deck. This committee will design a simple and appropriate strategy for retaining the initial redox state of shipboard wholerounds for future considerations and testing.

PRESSURE CORE BARREL

ODP ACTION: This sub-committee requests that ODP provide SGPP with design drawings and text outlining the intended capabilities of the PCB through its various phases of development. Our aim is to assist ODP in perfecting a device that best addresses the overall requirements of an in situ sampler.

This committee has only recently become aware of the PCB, and is not abrest of developments by ODP. The highest priority mission for the PCB should be the recovery of gas compositions under in situ pressures since no other means is currently available. Secondary missions should be the capability (1) to separate fluids from the solids at in situ temperatures and pressures, (2) to hold the solids at in situ temperatures and pressures for microbiological and physical properties measurements, and (3) to enable manipulations of a split of the sample through the use of a variety of lock-on transfer chambers. We envision the ultimate development of a number of use-specific PCB's and lock-on chambers, some with remote sensing capabilities to measure veolcity, density, thermal and electrical conductivity, etc.

under in situ conditions, others with the capability to add tracers or withdraw gases, solutions, or solids.

1. Can the PCB (Phase III and beyond) be constructed from titantium to eliminate Fe-alloy contamination and H2S-Fe interations ?

2. Thermal control: During testing and deployment of Phase I and II, the thermal history of the sediment contained inside the PCB should be monitored to determine the temperature history of the recovered interval: Is the device sufficiently thermally insulated (or have a high enough thermal inertia) to limit the temperature rise to less than 2 deg C over the time interval between coring and transfer to a T-controlled environment ? If not, how can better thermal ballast be accomplished ? Will the use of Ti be better or worse ?

3. A similar PCB has been developed by Dr. Rick Jahnke (Skidaway Inst. Oceanography) which uses the internal overpressure to "self-squeeze" (separate the fluids from the solids) through ports segmented along the barrel. Can the ODP-PCB be designed to contain one such port (perhaps as an ancillary end cap) so that fluid samples can be obtained ? Alternatively, can a PCB be designed as a giant squeezer ?

Attach to minutes
A6

LEG 124E
PRESSURE CORE SAMPLER
PCS - 124E

TEST RESULTS

* DEPLOYED THREE TIMES - ONCE INSIDE DP, TWICE IN FORMATION
* CORE SAMPLES RECOVERED ON BOTH ATTEMPTS
* FULL HYDROSTATIC PRESSURE RECOVERED TWO OUT OF THREE TIMES
* REASON FOR IS[illegible] PRESSURE IDENTIFIED (ACCUMULATOR REDRESSING PROBLEM)
* DOWNHOLE MECHANICAL FUNCTION WAS FLAWLESS
* DEPLOYMENT/REDRESSING VASTLY IMPROVED OVER PREDECESSOR

DESIRED IMPROVEMENTS

* ACCUMULATOR IMPROVEMENT TO ELIMINATE REDRESSING BETWEEN RUNS
* INCREASED FLOW TO CUTTING SHOE
* IMPROVED CORE REMOVAL - EXPENDABLE CORE BARREL OR CORE LINER
* REPLACE O-RING TRASH SEAL WITH TEFLON TO REDUCE DRAG

PHASE II - DEVELOPMENT PLAN

* MODIFY TOOL TO ALLOW CORE TRANSFER UNDER PRESSURE
* DEVELOP PRESSURE/TEMPERATURE CONTROLLED LAB CHAMBER

Attachment 7

INSTITUTE FOR GEOPHYSICS
THE UNIVERSITY OF TEXAS AT AUSTIN

8701 Mopac Boulevard · Austin, Texas 78759-8345 · (512) 471-6156 · Telex: 910-874-1380 UTIG AUS

April 25, 1989

Dr. Kate Moran
Three Fathom Harbour
Rural Route 2
Nova Scotia
CANADA

Dear Kate:

I have read with interest your panel's report on underway geophysics. I would like to offer a few comments on one aspect of the problem — the Masscomp. The basic functions of the Masscomp are not very well understood by SMP or ODP. The University of Texas (P. Stoffa) contracted (about 8-months salary to Wiederspahn) to provide ODP with our Highres system (written by M. Wiederspahn for me), about 8 functions from Stoffa's Process system, and provide data logging for underway geophysics. The existing system needs significant improvements.

The 'Masscomp system' consists of these three separate components.

1. Highres. This program controls digitization (done on a front-end board of the Masscomp) and output to a disk file and in SEGY format to tape. The software is specific to the Masscomp hardware which does the digitization. The installed ODP system is no longer current. The system has evolved over the last few years to satisfy my purposes. I currently have a complete system which was last used for a month on the R.V. Washington in Dec88/Jan89. I am satisfied with its performance and quality control which includes some realtime statistical and screen displays. I plan no further program development. It certainly could use better documentation, though I consider it adequate in its present form. It does require that the operator be familiar with digitizing/filter/gain issues as well as the Unix operating system.

2. Process. This software was intended for realtime processing, or post-processing and display. Only a very small subset of processes were ever promised to ODP. I do not consider it adequate for ODP purposes.

3. Data Logging. I believe that this system works as designed. It was not developed to include realtime navigation processing and display.

I replaced Process with Sioseis on my Masscomp several years ago. This software was developed by Paul Henkart at Scripps. It has numerous features which make it attractive for single channel processing, particularly realtime processing, but it supports a full range of multichannel processing (though rather plain vanilla options, which I would consider a plus for ODP needs). Some of these useful realtime features have to do with methods to window the data (for small computer efficiency) while at the same time allowing for changes in deep water

Attach. 7

delay settings. I am pleased with the debugged version of Sioseis now running on my Masscomp. Henkart continues to provide maintenance to users on a cost basis.

Processing speed is dependant on record lengths, sample lengths and computational complexity of the processes being preformed. I have never had a problem keeping up with realtime processing and display when filter and displaying a two second window of 1 mill data every 10 sec with my Masscomp which includes a small Masscomp supplied AP. However, the Masscomp was chosen 5 years ago as the best machine to provide digitizing under the control of a computer. At the time, the next best alternative was a DFS 5.

I have used the Masscomp to collect 8 channels of 4 mill data. It is able to edit, sort, nmo, stack, filter, agc, display at a 24 sec shot rate in realtime. Optimizing realtime processing requires an understanding of how the software works to make good use of a small machine like a Masscomp (eg. where does it do FFT's, how long are they, do they fit in the AP or not; how do the gain functions work, some are severely computation intensive, others not). The ODP machine, like mine, is pretty slow by recent standards, but I expect mine to be around for several more years, and frankly it is adequate.

I have not had any experience with Sierraseis, nor have I been able to locate anyone who has. In the long run, it will likely be the best system, but it will require at least modest changes to run efficiently in realtime on the Masscomp (should the Masscomp be kept) and a realtime data transfer module will need to be written. It will not replace the functionality of Highres.

I would consider potential action items:

A. 1. have the new Highres installed on the ODP machine(1-m programers time)
   2. have Sioseis, which I believe ODP already owns, modified and installed on the ODP machine, including use of the ODP owned AP for filtering (1-m programers time)
   3. have a seminar/orientation on how to make prudent use of the existing computation speed.

B. 1. install Sioseis and Sierraseis on the shipboard VAX
   2. consider a larger realtime machine

I realize that the Masscomp is only one of a number of issues which SMP is concerned with in the underway geophysical lab. Viewed within the context of the larger issues of realtime navigation display, the seismic acquisition problems may be better handled as part of some larger scale solution.

Sincerely yours,

Thomas H. Shipley

Thomas H. Shipley
Senior Research Scientist

cc: L. Garrison, A. Mayer, ODP
T. Davies, M. Wiederspahn, P. Stoffa, UTIG
R. Moberly, PCOM
P. Henkart, SIO

8. Vertical Seismic Profiling   A8-1

Becker recounted a recent USSAC meeting at which a policy on VSP was sought. An earlier JOI-USSAC workshop on VSP had recommended:

(i) VSP should become an integral part of ODP science;

(ii) zero-offset VSP should be done at all ODP sites;

(iii) offset VSP should be done for specialized applications;

(iv) tool improvements are needed;

(v) a U.S. national VSP laboratory should be established.

USSAC did not accept (v), instead preferring integration with the JOIDES structure. USSAC sought guidance from DMP on items (i)-(iii) and in respect of USSAC responding to item (iv) by providing money for tool acquisition by LDGO or an appropriate subcontractor.

Panel noted that there is already a single component VSP tool on board ship. Three component tools would provide significantly improved data but processing to extract the extra information may be expensive and difficult. Anderson commented that three similar tools are needed for regular use in order to provide back-up and allow for breakdowns.

DMP Response

(1) VSP should be run only in response to scientific needs: zero offset VSP should not be a standard operation on board ship.

(This re-affirms earlier DMP position)

(2) Minimum tool acquisition for ODP use is three separate three-component VSP tools for adequate back-up.

(3) If such a three-component facility is provided, LDGO Borehole Geophysics Research Group is the logical tool operator for tool maintenance, deployment and data archiving.

(4) Availabilty of three separate tnree-component tools would simplify the logistics of offset VSP planning.

(5) Adequate funding is needed for tool acquisition, operation and data archiving.

(6) With these tools there is potential for considerable financial loss in terms of lost tools and lost hole.

(7) Rough cost estimates are at least $200,000 for the three tools and $50,000 per year for operation. Replacement of lost tools would be additional.

Vertical Seismic Profiling (VSP)

PCOM Question

"Should VSP be a routine experiment on board ship and what is its scientific return?"

DMP Response

Application of VSP should depend on its relevance to the scientific objectives, its priority rating vis-a-vis other measurements and experiments, the existence of a science-driven commitment to its application, and the subsequent dedication of resources/effort for processing and interpretation.

The scientific returns of VSP include:

- detection of reflectors beneath the drill bit;
- measurement at a scale which is closer to geophysics;
- three-dimensional information;
- data from uppermost 70 m of sediment which is currently not logged;
- potentially better porosity characterisation in some basalts/carbonates.

DMP is prepared to encourage appropriate initiatives for VSP deployment including:

- scientific proposals;
- JOI-USSAC workshop on VSP;
- USSAC offer to fund acquisition of VSP capability;
- establishment of technical support within an approved institution.

DMP Recommendation 1987/2

VSP should not be a routine experiment on the ODP drill ship.

Attachment 9

I. EXECUTIVE SUMMARY

The potential role of Vertical Seismic Profiling (VSP) and other borehole seismic experimentation within the Ocean Drilling Program (ODP) was examined by a group of twenty-eight specialists, including academic marine and land-based seismologists, logging specialists, industry scientists and contractors at a two-day workshop sponsored by JOI/USSAC (see Appendices I and II). The venue was the Colorado School of Mines. The group achieved consensus on the following, which are presented here as recommendations for the development of a vigorous VSP program that would significantly enhance the scientific return of ocean drilling.

1. VSPs should become an integral part of ODP science because of their unique ability to:

   a) provide a direct tie between the drilled section, logged properties and surface seismics

   b) determine formation velocity structure

   c) determine anisotropy and heterogeneity, and resolve structural images in complex settings

   d) predict structure beneath the drill bit.

2. ZERO-OFFSET VSPs should be performed at all sites in structurally simple settings where sonic logs will also be run.

3. OFFSET VSPs such as walk-away VSPs, oblique seismic experiments, or single-offset VSPs should be performed for specialized applications in structurally complex settings. High density coverage of geophysical data is essential to the success of these experiments.

4. Substantial improvements in tools and analysis capabilities must be accomplished to ensure a viable program. These include:

   a) broad-band tuned source arrays

   b) three-component tools

   c) multi-element vertical arrays of geophones and hydrophones

   d) computer processing and modeling capability at sea and on shore.

5. A "U.S. National VSP Laboratory" should be established to carry out VSPs as required by the U.S. science community, coordinate development of VSP technology and analysis, and assist in specialized borehole seismic experiments.