

EXECUTIVE SUMMARY  
TECTONICS PANEL MEETING  
29-31 October 1986  
Geological Survey of Canada, Ottawa

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1) RECOMMENDATIONS CONCERNING MAKRAN LEG

TECP endorses an abbreviated (half-leg) drilling program at proposed sites 2, 3, 4, and 5, which are designed to penetrate thrust ramps. These holes will address the following thematic problems: (i) the temporal and spatial development of imbricate thrusts; (ii) the pressures, chemistry, and migration of fluids in a mud-dominated prism; and (iii) the physical properties of variably consolidated muds.

2) RECOMMENDATIONS CONCERNING DRILLING IN OCEANIC CRUST TO TEST MODELS OF ARC MAGMATISM

We strongly support a series of shallow holes (~20m penetration) in oceanic crust descending beneath arcs, rather than a single deep hole (~500m) as advocated by LITHP.

3) EVALUATION OF WPAC "SECOND DRILLING PROSPECTUS"

We rank ordered nine drilling legs based on their overall attractiveness from a thematic standpoint: Bonin-1 (1); Nankai (2); Japan Sea (3); Bonin-Mariana-2 (4); Banda-Sula-S. China (5); Vanuatu (6); Nankai hole dedicated to physical property measurements (tie for 7); Lau Basin (tie for 7); Sunda backthrusting (8).

4) PRELIMINARY HIGH-PRIORITY THEMATIC OBJECTIVES IN CENTRAL & E. PACIFIC

Well defined global problems that should be profitably addressed by drilling in this area are (not listed in rank order): (i) Age of oceanic crust; horizontal kinematics of ocean plates; (ii) Vertical motions and flexure of oceanic lithosphere; (iii) Ridge-trench interactions; (iv) Geochemical relations between descending oceanic crust and superjacent volcanoes; (v) Determining subduction rate by drilling trench sediment.

JOIDES Tectonics Panel Meeting  
Geological Survey of Canada, Ottawa  
29-31 October, 1986

Panel members present: Darrel Cowan (USA), Chairman  
Ian Dalziel (USA)  
Dan Davis (USA)  
Karl Hinz (FRG)  
David Howell (USA)  
Kenneth Hsu (ESF)  
Jeremy Leggett (UK) (29-30 October)  
Bruce Marsh (USA)  
Kazuaki Nakamura (Japan)  
Robin Riddihough (Canada)  
Francois Roure (France)  
Peter Vogt (USA)  
Tony Watts (USA) (30 October)

In attendance: Christian Auroux (ODP)  
Nik Piasias (PCOM)  
Paul Robinson (PCOM) (30-31 October)  
Jean-Claude Sibuet (ARP)  
David Scholl (CEPAC)  
Brian Taylor (WPAC) (29-30 October)

AGENDA

1. Minutes of previous meeting
2. Reports from liaisons and guests
3. Makran: Length and scope of leg
4. Responses to LITHP proposal for deep holes in ocean crust
5. Fracture zones
6. Report on Workshop on Physical Properties of Marine Rocks
7. Evaluation of WPAC "Second Drilling Prospectus"
8. Discussion of thematic objectives in C. & E. Pacific
9. Report on April 1986 workshop on future drilling in the S. Pacific & Antarctic
10. Next meeting

## MINUTES

The meeting began at 9 a.m.

Cowan welcomed Dalziel, Davis, and Hsu, our new panel members, and guests from other panels, PCOM, and ODP.

### 1. MINUTES OF THE PREVIOUS MEETING

The minutes of the last meeting were approved without changes.

### 2. REPORTS FROM LIAISONS AND GUESTS

#### 2.1 PCOM

Nik Piasias reminded us that the JOIDES office is now at Oregon State. USSR is scheduled to join ODP in January. Red Sea drilling will be dropped from the Indian Ocean schedule if clearances are not received by January. TECP should inform PCOM at the January meeting of any required engineering so it can be considered for the FY 1988 budget. PCOM and EXCOM are concerned about allegations of vested interest (by proponents of proposals) on some panels and urged panels to take care. Piasias also urged TECP to state specifically how drilling can address its high-priority thematic objectives.

#### 2.2 ODP

Christian Auroux reported on Legs 109 and 110 and said that the RESOLUTION just finished drilling on 504B.

#### 2.3 ARP

Jean-Claude Sibuet reported that the ARP is recommending five workshops to formulate drillable problems well ahead of the return of the drillship to the Atlantic. The first, on the S. Atlantic, will be held in April 1987. ARP requests TECP input with respect to thematic objectives preferably after this meeting and before the first workshop. Cowan said that the Atlantic would have to be considered in our next meeting, because of time constraints.

#### 2.4 WPAC

Kazuaki Nakamura reported that at their last meeting WPAC produced a second drilling prospectus, with their top 11 legs listed in order of priority. The main change from the first prospectus is that

Vanuatu has dropped to number 9, because of uncertainty over data availability. They are waiting our reaction to the second prospectus.

## 2.5 CEPAC

Dave Scholl said that CEPAC very much wants to meet jointly with TECP, Jan. 12-16 at Scripps, just before PCOM. He described the new "culling" procedure adopted by the panel. There are basically 3 categories:

- Marks 1.0-2.5 - accepted for further consideration
- 2.6-3.0 - accepted for further consideration if modified
- 3.1-4.0 - eliminated

On this basis CEPAC produced a list of proposals, in order, scoring <3.0. Juan de Fuca mid-valley was top; for others see CEPAC report. A straw-vote identified their most highly favored "drilling packages." Atolls and guyots were top; for others see CEPAC report.

CEPAC is waiting avidly for TECP input. Robin Riddihough, who also attended as liaison, also stressed this need.

## 3. MAKRAN LEG: LENGTH AND SCOPE

Cowan had received a letter from PCOM forwarding criticism of the proposed leg by the Indian Ocean Panel. We are asked to address whether a whole (albeit short) or half-leg should be drilled. Leggett reviewed the basic framework of the margin and the proposed drilling sites. Important thematic problems that can be addressed here include: 1) Fluid escape: Makran has a BSR, which would provide interesting comparisons to the methane-poor Barbados toe in terms of fluid regimes. The temperature and pressure of fluids could also be measured; 2) The compaction and deformation history of mud-rich sediments (porosity, fabrics); 3) The rate of accretion and uplift. Slope deposits are much better defined on the Makran margin than on Barbados, but uncertainty about the fossil content of the sediments means we may not get a handle on paleobathymetry and biostratigraphy; 4) Contrast in lowermost slope vs. upslope deformation. Compared with Barbados, the Makran offers the opportunity to look at a linked series of ramps; 5) Comparison of offshore and onshore record: the latter is much more extensive than that of Barbados. Leggett summarized the advantages of Makran drilling: Good opportunity for physical-property measurements; shallow water; good drilling conditions predicted; and a

simple structural framework for linked thrusts and ramp anticlines. And the disadvantages: BSR, but holes can reach objectives shallower than the BSR; short lead time for MCS processing; question whether amount of processed MCS will be adequate; uncertainty over biostratigraphic zonation.

Cowan excused Leggett from the room while the panel formulated its recommendation to IOP and PCOM.

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#### TECP Consensus

TECP notes that the Makran accretionary prism is distinct from other prisms because it is dominated by terrigenous muds (cf. hemipelagic and pelagic muds in Barbados Ridge), moderate convergence rates (~ 5 cm/yr; cf. 2 cm/yr on Barbados Ridge); and well-defined ramp anticlines, probably related to imbricate thrusts, that define a fold-and-thrust belt structural style. We endorse an abbreviated (half-leg) drilling program at sites 2, 3, 4, and 5, which will penetrate postulated thrust ramps and that may address the following thematic problems:

- (1) The temporal and spatial development of imbricate thrusts. Do thrusts progressively develop at the toe of the slope and then become inactive, or are thrusting and contraction active throughout the submerged part of the prism? In this regard, drilling results can be compared with results of field studies in the exposed, onshore part of the prism that indicate massive, out-of-sequence thrusting. TECP recognizes that this objective can be more easily achieved if: a) high-quality MCS data that define the geometry of thrust-related structures are acquired; and b) it is demonstrated that sediments at the proposed sites can be zoned biostratigraphically.
- (2) The pressures, chemistry, and migration of fluids in a mud-dominated prism; physical properties of variably consolidated muds.

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TECP then discussed a letter from R. Duncan concerning drilling on the Mascarene Plateau. He has access to volcanic rocks from two industry wells, which he feels would greatly increase the benefit of the three basement sites in the original one-half leg proposal. TECP noted the new data, but decided not to comment unless requested to do so by PCOM.

#### 4. RESPONSE TO LITHP PROPOSAL FOR DEEP HOLES IN OCEAN CRUST

PCOM asked TECP to evaluate a new proposal by LITHP to drill the holes seaward of the Bonin arc, and in the Argo abyssal plain, deep into basement--500m into oceanic crust in the case of the Bonin site. The purported goal is to acquire geochemical data useful for understanding the origin of magmas in adjacent arcs. Cowan asked Bruce Marsh to review this topic for the panel. He emphasized the importance of understanding the geochemistry of oceanic crust going into subduction zones. In terms of understanding mixing paths on  $^{143}\text{Nd}/^{144}\text{Nd}$  vs.  $^{87}\text{Sr}/^{86}\text{Sr}$  discrimination diagrams, the arc processes are more-or-less understood, but the composition of the crust going in (in terms of variations arising from weathering, hydrothermal alteration) is not. But in his view, a systematic approach to sampling in a number of holes would be better than one deep hole. In fact, just 10m would be enough. Bruce feels deep holes waste the opportunity of additional insights into the arcs concerned, and that little is gained from the tremendous investment in time required for a 500m hole in basement. Another problem is that the extent of exposed arc lavas is not as great in the Bonins as in the Aleutians.

TECP decided that Bruce Marsh should draft a letter to PCOM and LITHP on this issue.

#### 5. FRACTURE ZONES

PCOM had specifically requested TECP to ask itself whether fracture zones are receiving enough attention in the program. Karl Hinz emphasized some of the numerous problems that MCS surveys over fracture zones routinely expose. Peter Vogt outlined the limited returns that have come from submersible studies.

A wide-ranging discussion followed. Several panelists felt that if good proposals emerge, there would be support for them. Peter agreed to review fracture zone problems and report back. Ken Hsu recommended that the appropriate COSOD-II working group be asked to address drilling in fracture zones.

#### 6. REPORT ON WORKSHOP ON PHYSICAL PROPERTIES OF MARINE ROCKS

Dan Davis reported on the USSAC Workshop on Physical Properties and Mechanical State of Marine Rocks, held at Cornell 26-28 June (report will be circulated soon). The idea was to open a discussion about a possible hole

dedicated to physical properties, and of procedures for improving the ways in which physical-property data can be generated more meaningfully in the program.

One key approach favored by several panelists might be a pair of holes, one cored and logged conventionally, one immediately next to it, cored with the Navidrill, with whole core segments preserved in wax for subsequent measurements.

Further discussion was deferred until Karig's proposal for a Nankai hole dedicated to physical properties comes up under agenda item 7.

## 7. EVALUATION OF WPAC "SECOND DRILLING PROSPECTUS"

PCOM had asked whether TECP thought the 10-1/2 leg plan of WPAC was spread too thin geographically, and whether in a 9-leg plan more time should be spent addressing selected thematic issues in fewer geographic areas. Brian Taylor, the chairman of WPAC, also solicited our response to three specific questions: How we rated the Hayes proposal to drill in the South China Sea; how we ranked Nankai with respect to other accretionary prisms in the Pacific; and how we thought the overall process of accretion could be addressed by the drill. He stressed that WPAC urgently needed a clear indication of how we rank the proposed legs from a thematic standpoint.

A long discussion followed, focused on the S. China Sea and general thematic issues.

### 7.1 South China Sea Passive margin

Dennis Hayes had submitted to PCOM a justification for passive margin drilling on the north margin of the SCS. Two sites from his proposal are part of a package ranked 4th by WPAC, but these (SCS 7 & 5) are on the oceanic crust.

Ken Hsu presented a justification for drilling here because of the implications for both passive margins AND Tethyan history. Dalziel echoed Hsu's comment and said data on the stratigraphy and subsidence history of this margin would be valuable for understanding the evolution of the Andean margin. Additional justifications would be the youth of the basin (permitting a clearer assessment of stretching models than is possible in the Atlantic), and the regional problems it would solve (exact age of the oceanic crust). If Hsu were designing a drilling program, he would also put sites on the southern margin. The point about no

ODP drilling of conjugate margins was made. Because of the complexities of collision between the Reed Bank/Dangerous Grounds block (sliver of ancient China rifted off when the SCS opened in the ? Oligocene) and Palawan, several panelists questioned the suitability of this area for the first conjugate drilling.

Brian Taylor opined that the SCS drilling should not be held hostage to its suitability - or lack thereof - for conjugate drilling.

Tony Watts raised the concern that the setting of the proposed sites with respect to deeper-level crustal structures is not yet as clear as on some other margins. Also, the industry data just to the north of the proposed northern SCS transect is not on the table. Brian Taylor responded that we are three years away from drilling; industry may be more forthcoming if it knows ODP is going to the area. Watts made the point that were a deep industry hole in the shelf to be married with one of the proposed SCS holes to basement, we could obtain very significant subsidence information. We should avoid at all costs a transect of holes that stopped short of the basement.

The majority view, he feels, is that the real modeling problems will be solved in the Atlantic.

Leggett asked whether other panelists shared his own reservations: 2 hours re-examining a difficult decision we made at a previous meeting, with essentially the same data on the table, in the face of a strong Lamont lobby. Several did. Voting was deferred until other items on drilling prospectus were considered.

## 7.2 Accretionary prisms

Darrel Cowan reviewed diverse objectives that could be addressed by drilling in clastic-dominated prisms and suggested that the most important thematic problems at this stage are the structure of the decollement-zone and the changes in physical properties in situ that accompany the subduction and accretion of sediments at deep levels in a prism. He advocated both the proposal by Taira for deep drilling through the decollement at the Nankai trough, and a Karig's proposal for a companion hole to be dedicated to the measurement of physical properties and acquisition of whole round core for later study. The Nankai sites have the advantages of: a deep target that can still be reached by the



drill, and an extensive grid of high-quality MCS data that beautifully image geometrically simple fold-and-thrust belt structure. In comparison to Nankai, drilling in the Aleutian or Cascadia prisms is downgraded because the decollement and subducted section is excessively deep. Costa Rica might be an eventual back-up, but the structural geometry is not as clearly imaged as on the Nankai and Cascadia seismic profiles.

Francois Roure expressed the reservation that Nankai drilling would not reveal much beyond what we learned on Leg 110 off Barbaros. Leggett supported the dedicated hole and thought Nankai is the best margin for extensive physical-property measurements. There is apparently still uncertainty over whether the ODP drilling, and an NSF-funded two-ship ESP site-survey cruise, will be located as specified in the Taira proposal, or over Site 583 (Leg 87).

### 7.3 Collisions

Brian Taylor reviewed the options for drilling in collisional settings and mentioned that a new proposal concerning the collision of the Ogasawara Plateau is imminent. He was interested in how TECP thought the collisional process could be studied with the drill. Dave Howell emphasized that the effects of a collision are extraordinarily large-scale and wide-ranging, in both space and time, and that a sustained and comprehensive drilling program in a variety of settings is needed to study a collision. Hsu noted that determining the age of crust in small basins is important for evaluating models. Specific areas discussed included Vanuatu, the Louisville Ridge, Ontong-Java Plateau, and Sulu-Negros-Palawan region.

### 7.4 Lau Basin

Taylor and Scholl reviewed a brand new drilling proposal advocated by a six-nation ad hoc working group. Most proposed drilling addresses backarc-spreading processes; one general site would penetrate outer forearc basement on the Tonga Terrace.

In order to respond to WPAC's urgent need for our thematic prioritization of proposed legs, it was suggested that we rank-order drilling targets by voting. Candidates included not only the legs on the WPAC drilling prospectus, but also the South China Sea transect, a Nankai physical properties

hole, and additional legs at any of the geographic locations already on the prospectus. Each panel member was asked to rank order nine potential legs on the basis of their thematic attractiveness. In the tabulation, nine points were awarded to each first place ranking; 8 to each second place, and so on; a leg which did not appear in a panelist's list received 0. Thirteen panelists voted. The results are tabulated below:

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TECP RANK-ORDERED DRILLING LEGS IN THE WESTERN PACIFIC

Rank	Leg (whole or part)	Votes
1	Bonin-1	90
2	Nankai	72
3	Japan Sea	68
4	Bonin-Mariana 2	64
5	Banda-Sulu-S. China	57
6	Vanuatu	49
7 (tie)	Nankai (physical properties)	39
7 (tie)	Lau Basin	39
8	Sunda Backthrusting	35

The consensus of TECP is that drilling all of the above legs will make an outstanding contribution to the solution of global thematic problems.

It is also the consensus of TECP that the following legs or targets are of a distinctly lower priority from a thematic standpoint:

S. China Sea transect	21
Zenisu Ridge	19
*Vanuatu - 2nd leg	8
*Bonin-deep hole in ocean crust	8

(NB: Legs marked with an asterisk don't appear on the WPAC Prospectus but were included by one or more panel members in their list of 9).

Note also that we did not include Great Barrier Reef among the legs to be ranked. Although we recognize the potential importance of drilling here from a tectonic standpoint, we have as a panel, never discussed or evaluated the proposal.

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8. THEMATIC OBJECTIVES IN THE CENTRAL & EASTERN PACIFIC

At our June 1986 meeting in Seattle, we identified several thematic issues of global importance that we

felt could profitably be addressed by drilling in this region. Some issues were clearly of higher priority; others needed more discussion (see minutes for a list). We also agreed to prepare a White Paper for PCOM and CEPAC summarizing our rationale and recommendations. Certain panel members were asked to prepare and distribute a draft of their section in advance of this meeting so we could discuss the issues in Ottawa.

Each of the thematic issues was summarized in turn by its "proponent" and then discussed by the entire panel. Subsequently, we attempted to re-prioritize the thematic problems by selecting two simple categories reflecting whether a topic was of high or low priority. Within each of these groups we established the "maturity" of the problem: How well is it identified, based on existing proposals, and how satisfactorily will drilling resolve it? Rather than summarize the entire discussion on each topic, the thematic issues and their "proponents" are listed below in two groups.

#### GROUP A: HIGH PRIORITY

##### Mature problems:

- . Dating oceanic crust; horizontal kinematics of ocean plates Peter Vogt distributed a draft of his section of the White Paper
- . Vertical motions and flexure of oceanic lithosphere. Tony Watts reviewed the evidence that seamounts induce flexure of the lithosphere. Some questions were raised about how the linear trend of the Hawaiian archipelago might affect flexure and whether an isolated seamount elsewhere in the Pacific might be a better place to drill. The need for datable sediments in the moat was recognized.
- . Ridge-trench interactions. Roure recommended drilling where the Chile rise intersects the trench to address a variety of problems concerning this tectonic process.
- . Relation between descending oceanic crust and sediments, and superjacent volcanoes. The panel agreed with Marsh's recommendation that crust in front of arcs must be sampled and completely analyzed, preferably in a series of shallow holes distributed along and in front of an arc such as the Aleutians.
- . Subduction rate. Kazu Nakamura outlined a simple but elegant way to determine rates by dating horizontal and tilted sediments in a trench.

Immature problems:

- . Oceanic plateaus. Karl Hinz emphasized that although the identity of basement on plateaus is an outstanding problem, merely drilling a deep hole through volcanic caps isn't the answer. Holes should be intelligently sited based on their relation to plateau structures. More and better MCS data are needed.
- . Structures in oceanic crust. Robin Riddihough stressed that although the Pacific is replete with excellent candidates, it is premature to select targets until they have been surveyed with new, and still-developing, ocean-floor surveying techniques (e.g. SEAMARC).
- . Deformation and physical properties deep within accretionary prisms. Cowan concluded that deep holes on the Nankai prism, if successful, could address outstanding problems concerning the structural styles and changes in physical properties deep within a clastic-dominated prism. Hsu, Dalziel, and others wish to leave the door open for even deeper drilling, perhaps on the Cascadia margin, regardless of results at Nankai. Scholl pointed out that there are a host of other problems concerning the evolution and architecture of convergent margins - e.g. structure and vertical tectonics of forearc basins, nature of the "backstop" of the prism - that could be addressed by drilling, but the consensus of TECP is that these are less important than probing the deep levels of a prism.

GROUP B: DISTINCTLY LOWER PRIORITY

- . Transcurrent margins. Howell reviewed several problems, some of local interest, that could be addressed offshore California. The panel felt that the one with potentially the most global significance concerns refined dating of the Neogene change from convergence to transform motion. Submarine fans are also an attractive target, but Hsu proposed, and the panel agreed, that SOHP should have the responsibility for evaluating and endorsing drilling on fans.

The next step is for each proponent to revise his draft for the White Paper in light of discussions at this meeting. Cowan will contact proponents, assemble a draft of the complete document, and distribute it for panel review prior to our next meeting. It is hoped we can approve the

document then and expeditiously distribute the final White Paper to PCOM and CEPAC in the late Spring.

9. REPORT ON APRIL 1986 WORKSHOP ON FUTURE DRILLING IN THE S. PACIFIC & ANTARCTIC MARGIN

Ian Dalziel selected items from the workshop report that were of tectonic interest and gave us an illuminating review of the present and past tectonics of southern S. America, the Scotia Sea, and Antarctic Peninsula.

10. NEXT MEETING

We had a request from CEPAC via Scholl that our next meeting be a joint one with CEPAC in January, just prior to the PCOM meeting. There was little enthusiasm among TECP panel members for such a joint meeting so soon after this one, especially since we are still formulating our thematic recommendations. We left the door open for a future joint meeting; meanwhile, enough communication can be accomplished through our liaisons and the upcoming meeting of panel chairmen. ARP, via Sibuet, asked that we meet to formulate tectonic priorities in the Atlantic before their first workshop scheduled in April. TECP would rather not endorse any particular objectives at this early stage; rather, we encourage ARP to come up with their drilling targets independently.

We will schedule our next meeting, sometime in the Spring, to be in advance of the Spring PCOM meeting. Ian Dalziel offered to host the meeting at the Institute of Geophysics, University of Texas at Austin, pending a check with the local management.

Cowan asked if someone would substitute for Leggett at the next meeting of the Indian Ocean Panel; no one volunteered. Dave Howell agreed to attend the December WPAC meeting as a substitute for Nakamura, who is unable to go.

The meeting adjourned at 12:30 p.m. on 31 October.