JOIDES Tectonics Panel Meeting
University of Washington
Seattle, Washington
5-6 June 1986

Panel members present:	Darrel Cowan (USA), Chairman Karl Hinz (FRG) David Howell (USA) Jeremy Leggett (UK) Kazuaki Nakamura (Japan) Robin Riddihough (Canada) Francois Roure (France) Peter Vogt (USA) Jeff Weissel (USA)
In attendance:	Christian Auroux (ODP) Tony Mayer (JOIDES) Paul Robinson (PCOM) Eli Silver (afternoon of 5 June; WPAC)
Absent:	K. Becker B. Marsh

AGENDA

1. Minutes of previous meeting
2. Reports from liaisons and guests
3. Western Pacific drilling plan
4. Nominations of Co-chief scientists
5. TECP membership and liaisons
6. SW Indian Ocean fracture zone proposal
7. Thematic objectives in the Pacific (CEPAC area)
8. COSOD-II
9. Next meeting

EXECUTIVE SUMMARY
TECTONICS PANEL MEETING
5-6 June 1986
University of Washington, Seattle
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1) TECP EVALUATION OF WESTERN PACIFIC DRILLING PLAN

The nine-leg program as it stands partially addresses TECP's key thematic interests in the region. The Bonin-Mariana and Vanuatu legs especially are well designed and relevant to arc, back-arc, forearc, and collisional problems. Three less satisfactory aspects of the plan are: First, it does not sufficiently attack the general problem of collision. Second, the drilling in Lau Basin is chiefly devoted to petrological and geochemical questions and doesn't address tectonic issues such as extension, the nature and evolution of arc foundations, and collision. Third, a better case needs to be made for how proposed drilling in the South China Sea relates to the kinematics and mechanics of extension.

In response to a request by WPAC, we reconsidered four proposed legs: Japan Sea, Nankai, Zenisu, and S. China Sea. Of these four, Japan Sea and Nankai have the highest priority from a thematic standpoint; S. China Sea has the lowest.

TECP requests that WPAC re-evaluate existing proposals that treat collisional processes and consider expanding existing legs or adding new legs to fully address the problem. Specifically we ask WPAC to reconsider or evaluate: Louisville Ridge or Ogasawara Plateau, and Ontong-Java Plateau. Ontong-Java should be considered as a place to identify the basement of a plateau, and possibly, with better documentation, as a place to study a major collision.

2) THEMATIC OBJECTIVES IN THE PACIFIC (CEPAC AREA)

We view the following tectonic issues as a global thematic interest. They have a high priority in addition because they can be better addressed by drilling in the Pacific than in any other region:

- Dating the oceanic crust for models of relative plate motion
- Hot spots and guyots for constraining absolute plate motions
- Lithospheric flexure (Hawaiian moat)
- Oceanic plateaus (nature and age of basement.

The Ontong-Java plateau is an obvious target to consider in Melanesia.

3) NOMINATIONS OF CO-CHIEF SCIENTISTS

SWIRFZ: von Herzen
MAKRAN: Leggett, Cowan
RED SEA: Cochran, Baecker, Pautot, Bonatti
KERGUELEN I: Schlich, Falvey
KERGUELEN II: John Anderson
INTRAPLATE/90°E(N): Curray, J. Peirce, Sclater
BROKEN RIDGE/90°E(S): Weissel, Duncan, Gradstein
ARGO-EXMOUTH: von Rad, Gradstein, Exon

MINUTES

The meeting began at 8:45 a.m.

Cowan welcomed the new member from France, Francois Roure, and guests from PCOM and JOIDES.

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

Paul Robinson and Tony Mayer reviewed the meeting held at Lamont the previous week. Following are items of particular interest to TECP. Bill Coulbourn has replaced Hussong as one of our two liaisons from PCOM. COSOD-II will be held in Strasbourg in July 1987 and sponsored by ESF. The JOIDES office will move to Oregon State University in October and be headed by N. Pisias. R. Kidd is leaving ODP and he will be replaced by Audrey Meyer.

Mayer summarized the science plan for Leg 112 (Peru forearc). An expanded schedule of 52 drilling days is planned; 36 devoted primarily to tectonics and 12 to paleoenvironmental issues. There are possible safety problems with a deep hole at site #3.

Mayer also reported the drilling plan in the Indian Ocean. For each leg, the prime target is listed first, followed by an alternative: 115 (SWIRFZ; SWIRFZ); 116 (Red Sea; Intraplate deformation/ 90°E); 117 (Neogene I; Makran); 118 (Makran; Neogene I); 119 (Kerguelen I); 120 (Kerguelen II); 121 (Broken Ridge/90°E-south); 122 (Intraplate; Argo/Exmouth); 123 (Argo/Exmouth; ?). The Somali deep hole is not in the drilling plan.

PCOM appointed non-voting liaisons from regional panels to TECP. This decision differs slightly from the recommendation of the panel chairmen's meeting to appoint voting liaisons. They are: ARP -Sibouet; CEPAC - Scholl; SOP - LaBrecque; WPAC - Silver; IOP - none as yet. PCOM also appointed TECP members as non-voting liaisons to regional panels: Vogt to ARP; Hinz to SOP; Leggett to IOP; Nakamura to WPAC; Riddihough to CEPAC. Further changes: Becker is moving from TECP to lithosphere; Ian Delziel was named to replace John Ewing, and Tony Watts will replace Jeff Weissel, effective October 1986. PCOM also expressed concern that TECP is not paying enough attention to the problems of plate kinematics and historical reconstruction of oceanic plates; we may consider supplementing our membership in this area.

Robinson emphasized several times what PCOM wants from TECP: our assessment of outstanding global tectonic problems that can be addressed by drilling and our recommendations as to the regions where this can best be accomplished.

2.2 ODP

Auroux gave an illustrated review of Leg 107 drilling in the Tyrrhenian Sea. Key results bearing on the origin of marginal basins and evolution of passive margins are: The opening of the Sea has been diachronous; there apparently has been no organized single spreading center; there is some evidence for the diapiric rise of serpentinized ultramafic rocks; and Messinian deposits in this area accumulated in shallow water.

2.3 ARP

Howell represented TECP at the April meeting in Barbados. They will propose a series of workshops to define future drilling targets in the South Atlantic, Caribbean, N. Atlantic, Mediterranean, and C. Atlantic. ARP requests TECP to discuss tectonic objectives in the Atlantic and offer our recommendations for a general drilling strategy.

2.4 WPAC

Nakamura reviewed the WPAC recommendations for drilling plans in the Western Pacific, using the tabulation provided in the minutes of the WPAC Miami meeting and the "First Prospectus for Western Pacific Drilling" which Cowan distributed at this meeting. He asked us to address specifically the questions posed to TECP in the minutes concerning drilling proposals for Nankai, Japan Sea, S. China Sea, and Zenisu.

3. WESTERN PACIFIC DRILLING PLAN

Both PCOM and WPAC want our reaction to the 9-leg drilling plan proposed by WPAC and adopted by PCOM subject to evaluation by the thematic panels. In addition, WPAC asked in their minutes that we reconsider Japan Sea, S. China Sea, proposals concerning arc-continent collisions, Zenisu, and Nankai, and by implication, give a thematic blessing or explain why we do not. Cowan proposed that each target or proposal as listed above be discussed in turn in the context of a general thematic issue (back-arc basins, collision, clastic-dominated accretionary prisms). In each case, relevant proposals were summarized and reviewed at length. Below is a brief summary of key points raised about each target, followed by a synopsis of our general views and recommendations on the entire science plan.

3.1 Japan Sea

The key proposal by Tamaki et al. was reviewed, and Nakamura presented recently acquired detailed magnetic data. They reveal coherent magnetic anomalies that will undoubtedly prove useful for tectonic reconstructions if they can be dated. There is still controversy about when and how fast the Japan Sea opened, and about the significance of peculiar crustal thicknesses in oceanic basins.

3.2 South China Sea

Two proposals were summarized and discussed extensively: one by Hayes et al. dealing with the general problem of evolution of passive margins, and a French proposal for dating oceanic crust in the central part of the Sea to elucidate its kinematic history. There was widespread concern that the Hayes proposal is not specific enough about which models for extension or for the thermomechanical evolution of passive margins will be tested by drilling. Moreover, it was not clear how data from only the northern margin of the basin could be used to evaluate models. More information on the conjugate margin and its possible bearing on the problem is required. Substantial interest in the kinematic history of spreading in a "dead" basin was expressed.

3.3 Collisions

Howell first reviewed our rationale for endorsing this general issue. Although we suggested some possible drilling targets at our Miami meeting, we hoped (and still do) that proposals concerning a variety of possible examples will be continuously evaluated. Cowan asked Silver to summarize another example of a collision-related process in the eastern Sunda system involving backthrusting of accreted material and backarc thrusting. He plans to revise his existing Sunda proposal to focus on these more explicitly collision-related problems. Other examples of collisions that were discussed include the Ogasawara Plateau, Louisville Ridge, Taiwan/Manila trench, and Palawan-Sulu Sea.

We discussed the Kroenke et al. proposal (received after the February Miami meeting) for the Ontong-Java plateau. Most of the sites are devoted to establishing the nature and origin of the basement - questions definitely worth pursuing. Only one site, OJ-6, is supposed to address the effects of collision by drilling through a thrust along which part of the plateau was emplaced onto the arc massif. The panel felt that the seismic data in the proposal do not adequately define either the overall tectonic setting of OJ-6 or the putative thrust.

3.4 Zenisu Ridge

On Friday morning, we continued with a thorough review of this target. Although there was a general acceptance of Zenisu Ridge as an example of intraplate shortening of oceanic crust and of possible incipient subduction (in front of an active trench), a couple of panel members felt that the available seismic records, as presented in the drilling proposals, do not convincingly document that shortening has occurred. Further discussion centered on whether drilling the tilted sediments on the west (back) side of the ridge could successfully date the history of uplift.

3.5 Nankai trough

It was pointed out that the Nankai accretionary prism is an example of the general category of "clastic-dominated prisms" which form where thick (about 2 km or greater) sections of hemipelagites and turbidites are partly scraped off along a decollement. There was extensive discussion about where the origin and evolution of such prisms rank in our overall thematic priorities. Nankai is exceptionally well surveyed and can be tied into an on-land subduction complex. We debated whether drilling should be focused near the toe and aimed at reaching the decollement at all costs, or whether an upslope transect should be included. It was repeatedly mentioned that Nankai is one of several clastic prisms in the entire Pacific region and must be compared with Manila, Aleutians, and Cascadia.

After the review summarized above, Cowan asked each panel member in turn to comment on: (1) Whether the nine-leg science plan, as adopted by WPAC and PCOM, satisfactorily addresses the three key thematic objectives outlined in our recent position paper; and (2) His views on the thematic interest and priority of the specific targets discussed above.

Below is the Chairman's distillation of these individual comments.

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TECP EVALUATION OF SPECIFIC LEGS (AS REQUESTED BY WPAC):

a. JAPAN SEA: Our consensus is that the drilling as outlined in the prospectus will contribute important information on the evolution of marginal basins in general, and further insight into obduction. Drilling results can be usefully compared to those from another marginal sea formed by fast, diachronous rifting of continental crust, the Tyrrhenian Sea. It is still unclear how recently acquired magnetic data may modify models for fast opening in concert with rotation of the Japanese Islands.

b. SOUTH CHINA SEA: In our opinion, the Hayes proposal does not explicitly state which models of lithospheric extension or of thermomechanical evolution of passive margins can be tested, nor does it sufficiently describe how data acquired from the proposed transect can uniquely test such models. We do feel, however, that drilling in the South China Sea may profitably address thematic issues (e.g. lithospheric extension) if more data from the Southern conjugate margin are integrated into the proposal. It is arguable whether the continent-ocean boundary is definable or accessible to the drill in the region. If it is, its nature (composition, structure, physical properties) is of interest. A minority feels that drilling ocean crust in the center of the basin is of interest from a kinematic standpoint.

c. NANKAI: The panel feels that drilling on this well-surveyed margin may contribute important insights into the development of clastic-dominated accretionary prisms. In this regard, it is essential that every effort be expended to penetrate through the decollement into the sediments being subducted. Remaining drilling time might then be apportioned among the fore-arc basin sites. Pending the results of the upcoming workshop on physical properties, a minority feel that the main thrust of the leg

should be downhole measurements in a lower-slope site. The panel recognizes that Nankai is very similar to the clastic-dominated Cascadia prism, on which deep decollement-penetrating holes have been recommended. At this point, TECP strongly endorses such deep holes in prisms, and for this reason we downgrade the proposed conventional transect of shallow holes along the Manila trench.

d. ZENISU: An opportunity to document a possible example of ocean-plate shortening seaward of an active trench. Seismic reflection data in the proposal do not substantiate the shortening hypothesis; better records imaging the underthrust oceanic crust are required. Dating the uplift, using tilted sediments on its western flank, is the most important objective.

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TECP EVALUATION OF GENERAL SCIENCE PLAN:

The nine-leg program as it stands partially addresses TECP's key thematic interests in the region. The Bonin-Mariana and Vanuatu legs especially are well designed and relevant to arc, back-arc, forearc, and collisional problems. There are three less satisfactory aspects of the plan. First, it does not sufficiently attack the general problem of collision. Collision-related objectives are included in only the Vanuatu and Japan Sea legs (D'Entrecasteaux and Okushiri targets, respectively). Second, the drilling in Lau Basin is chiefly devoted to petrological and geochemical questions and doesn't address tectonic issues such as extension, the nature and evolution of arc foundations, and collision (Louisville Ridge). Third, a better case needs to be made for how proposed drilling in the South China Sea relates to the kinematics and mechanics of extension. Of the four legs discussed above, this one has the lowest priority from a thematic standpoint; Japan Sea and Nankai the highest.

TECP requests that WPAC re-evaluate existing proposals that treat collisional processes and consider expanding existing legs or adding new legs to fully address the problem. Specifically we ask WPAC to reconsider the Louisville Ridge or Ogasawara plateau collisions. Also, the forthcoming proposal by Silver for the E. Sunda area will need to be considered for addition. Most important, TECP views Ontong-Java as an attractive place to identify the basement of an important oceanic plateau and possibly to study a major collision. We ask WPAC to evaluate Ontong-Java on both accounts, although the existing proposal needs to be revised to include better documentation of collisional structures that are accessible to the drill.

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4. NOMINATIONS OF CO-CHIEF SCIENTISTS

SWIRFZ: von Herzen
MAKRAN: Leggett, Cowan
RED SEA: Cochran, Baecker, Pautot, Bonatti
KERGUELEN I: Schlich, Falvey
KERGUELEN II: John Anderson
INTRAPLATE/90°E(N): Curray, J. Peirce, Sclater
BROKEN RIDGE/90°E(S): Weissel, Duncan, Gradstein
ARGO-EXMOUTH: von Rad, Gradstein, Exon

5. TECP MEMBERSHIPS AND LIAISONS

5.1 Instrumentation, Downhole Measurements, Physical Properties

Keir Becker has moved off TECP to LITHP. S. Bell will attend one of our meetings per year as a non-voting liaison from DMP.

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RECOMMENDATION TO PCOM:

As a replacement for Becker, we nominate either of two experts in physical properties: Dan Davis (SUNY Stony Brook), or Chi-Yuen Wang (Berkeley).

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5.2 Liaisons

Cowan asked all of the TECP members that PCOM named as non-voting liaisons to regional panels if they were willing to serve. Vogt, Hinz, Nakamura, and Riddihough said yes; Leggett is considering it.

We discussed whether all of the liaisons from regional panels should attend our meetings, and how frequently. We prefer to invite them individually on an ad hoc basis depending on our upcoming agenda (i.e. no need for an ARP representative if all we're going to discuss is the Pacific).

5.3 ESF

Cowan received a letter on 5 June from van Hinte asking us to specify what kind of person (i.e. specialty) we would like to have ESF appoint at their Oslo meeting 16-17 June. Our first choice is a global stratigrapher-geohistorian, preferably van Hinte himself or someone like him. Second choice is a modeller of intraplate stress, like R. Wortel. Cowan will telex this information to van Hinte.

5.4 Kinematics

Robinson mentioned that PCOM is concerned that plate kinematics (plate reconstructions, history of oceanic plates) isn't receiving enough attention, and they ask us to consider nominating a new member in this area. TECP feels that kinematics are more than adequately represented by two existing members, Riddihough and Vogt.

6. SW INDIAN OCEAN RIDGE FRACTURE ZONE

Robinson and Mayer asked us to consider whether tectonic issues are adequately addressed in a revised drilling proposal (89/B) by Dick et al. for the fracture zones. Cowan had distributed copies the day before. There was expectably a general concern about the potential rubble problem and the lack of site surveys. It is mandatory before drilling to know where spreading centers intersect the fracture zone and to know the distribution and thickness of sediment. Hinz offered to try to include an

MCS line or two across candidate fracture zones on his next trip across the Indian Ocean. The panel agreed that any data, in addition to that provided by the site survey, will be useful. If the site survey is successful and drilling is conducted as proposed, the consensus of TECP is that potentially useful information, relevant to the tectonic evolution of fracture zones, will be obtained.

7. THEMATIC OBJECTIVES IN THE PACIFIC (CEPAC AREA)

Another important goal of this meeting was to refine the preliminary list of thematic objectives formulated at our last meeting in Miami. In addition, PCOM is particularly interested at this time in thematic issues that can be addressed in Melanesia, because this region is sort of an overlap between WPAC and CEPAC. Mayer presented a summary of 6, 9, and 12 leg drilling campaigns formulated at CEPAC's last meeting, although all recognized that proposals are flooding in and the lists will undoubtedly change.

	6-leg	9-leg	12-leg
EPR	3 legs	3	3
Bering paleoenv	1	1	1
Atolls/guyots	1	1	1
Old Pacific	1	1	1
N Pacific paleoenv/ paleoplates	-	2	2
J de Fuca sed. ridge crest	-	1	1
Chile TJ/paleooc	-	-	2
Hawaiian moat	-	-	1

Mayer noted that the EPR drilling should be thought of as its own special program of oceanic-lithosphere drilling.

Cowan asked members absent in Miami and new members to state what they saw as key general objectives in the region. Vogt emphasized the problems of absolute and relative plate motions that can be attacked by dating anomalies and crust in quiet zones and by drilling and dating hotspot traces and guyots. Roure and Leggett found the Hawaiian moat intriguing as a study of lithospheric flexure. Hinz is interested in the S. Pacific as a place to study the stages of Gondwana breakup.

After further discussion we generated a new statement of thematic objectives, presented below. The first four are clearly defined and have our highest priority at present. The others need further discussion and evaluation.

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IMPORTANT THEMATIC OBJECTIVES IN THE PACIFIC

We view the following tectonic issues as of global thematic interest. They have a high priority in addition because we feel they can be better addressed by drilling in the Pacific than in any other region:

1. Dating the oceanic crust, especially where characterized by M-series anomalies or magnetically quiet zones. These data are critical for establishing and testing models of relative plate motion and calibrating the magnetic time scale.

2. Hot spots and guyots: new information, which can only be provided by drilling, is essential for constraining absolute plate motions.

3. Lithospheric flexure: A unique experiment concerning the flexural rigidity of the crust can be conducted by drilling in the Hawaiian moat.

4. Oceanic plateaus: The nature and age of the basement of plateaus are still outstanding tectonic problems.

Items 1, 2, and 3 collectively bear on the general problem of eustacy.

Several other thematic issues also appear interesting at this time, but we are still considering whether they can be adequately addressed by drilling and, if so, how the Pacific compares with other regions:

- Clastic-dominated accretionary prisms
- Transcurrent continental margins
- Structures in oceanic crust (volcanotectonic features, ridge crests, fracture zones, propagating rifts, fossil ridges)
- Ridge-trench interactions and collisions
- Geochemistry of descending sediments and superjacent volcanoes

With regard to Melanesia, item 4, and the Ontong-Java Plateau in particular, is an obvious issue for consideration at this time. CEPAC may find other attractive targets in Melanesia bearing on objectives 1 and 2.

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Our next major goal is to produce a white paper giving our rationale for emphasizing these objectives. Cowan assigned each item in the above lists to a panel member, who will prepare a draft for distribution prior to our next meeting in October or November. At that meeting we will finalize a list of objectives and a white paper for PCOM.

8. COSOD-II

This conference is scheduled for 6-10 July 1987 in Strasbourg. Mayer and Cowan reminded panel members that prior to COSOD-II, TECP may be asked to prepare another white paper identifying our prime thematic interests on a truly global scale.

9. NEXT MEETING

Our major constraint is to finalize our position paper on the Pacific before the Winter PCOM meeting, which may be held in early December. We will hold our next meeting either during the last two weeks of October, or the week of November 3. Riddihough invited us to meet in Ottawa, and Hinz in Hanover.

The meeting adjourned at 5:30 p.m. on 6 June.

THEMATIC OBJECTIVES IN THE WESTERN PACIFIC
JOIDES Tectonics Panel
May 1986

At our February 1986 meeting, we recommended that drilling in the western Pacific be focused on three tectonic problems: the origin and evolution of island arcs; the nature of active collisions; and the development of back-arc basins. Of the myriad attractive tectonic problems that could be studied in this region, we selected these three because they meet the following criteria. First, they are clearly issues of global thematic importance. Second, we feel that the western Pacific is the best place in the world to address these particular issues. Finally, we feel that drilling alone can answer specific questions related to these tectonic problems.

The following remarks, presented from our global perspective as a thematic panel, summarize our reasons for advocating these objectives.

I. The Rationale for Island Arc Drilling in the Western Pacific

The origin and evolution of magma within the earth stand squarely at the heart of deciphering the evolution of Earth itself. Of all magmatic provinces, island arcs offer the best possible natural laboratory within which to decipher the physical and chemical evolution of magma. Unlike all other areas, the greatest depth of magma formation is limited to be at or above the subducting plate. Moreover, the source material is either normal mantle peridotite or subducted oceanic crust or mixtures thereof, and the thermal regime of the entire region is reflected in the heat transfer of magmatism itself. In addition, the timing of the events of subduction, incipient volcanism, volcanic-center migration, and magmatic flux provides truly fundamental constraints on the mechanics of separation and ascension of magma. Purely geochemical studies in the way of phase equilibria, bulk chemical composition, and isotopic signatures can only be understood when properly viewed through the context of the mechanics of magmatism. Island arcs offer our only hope of clearly understanding large scale magmatic processes. The arcs that are best suited to unravel such problems and that are accessible to drilling are in the western Pacific.

A detailed accounting through time of the mass and composition of all materials associated with arc evolution (magmatic flux, volatile flux, hydrothermal fluids in the forearc, and flux of downgoing oceanic crust and sediment) and also of the isostatic response of arcs on a regional basis provides the fundamental boundary conditions governing all arc processes. The most critical element of such a menu is time. Although old arcs span much time, their heavy blanket of sediments, pyroclastics, and lavas greatly obscures sampling this history. Arcs must be studied early in their evolution to answer most all of the important themes at issue.

Arcs of the critical age for analysis are Izu-Bonin, Mariana, Scotia, and Tonga-Kermadec. Accessibility and operating conditions essentially preclude Scotia, especially when considered in light of land-based follow-up studies. The overall Mariana-Bonin arc system is ideally suited to tackle nearly all of the essential problems, and Tonga covers what is left. Possibly only in studying the correlation between arc magma composition and downgoing plate

composition does another arc, the Aleutians, offer a better perspective. What follows is a list of the principal thematic issues with a few words highlighting, where necessary, their importance and position within more global issues.

Themes in arcs and forearc regions

1) Arc evolution (structural, volcanic), beginning, timing, periodicity, magma transport
   - Allows entire problem of magma production, mechanics of ascension, and wall rock chemical interaction to be assessed, and allows quantitative evolution of intimate coupling of downgoing plate and arc plate (i.e. segmentation, fracture zones, etc.).

2) Nature of arc igneous/metamorphic basement
   - Are granodioritic plutons also characteristic of incipient volcanic fronts? Is the broad submarine arc ridge or welt of MORB type material produced during the initial breakoff and plumage of the lithosphere, or is it arc magma? What thermal regime is reflected in the metamorphic grade of these rocks?

3) Thermal regimes (isostatic response)

   - The very major question of the deep thermal regime of subduction and magmatism can be largely answered by knowing the thermal regime of the forearc, and this couples with the visco-mechanical isostatic regime which further constrains the nature of the arc lithosphere.

4) Fluids, their budget and chemistry

   - Do fluids from dehydration of the downgoing plate travel back up the oceanic crust and erupt in the forearc, carrying base metals stripped from the oceanic crust at high pressure? Are these the fluids that form forearc ore deposits?

5) Intra-arc structure (rotations, etc.)

   - What are the timing and mechanics of major structural readjustments with the arc itself? Are these driven by regional or local forces?

6) Forearc dynamics, seamount offscraping, "cold volcanoes" (i.e. diapirs)

   - Are cold forearc volcanoes a principal means of transporting and redistributing debris from the top side of the downgoing plate? What is the thermal-rheological regime associated with these features; what are the deformation rates; is the process selective of material type?

7) Boninites, relationship to ophiolites

   - Are ophiolites sections shaved off in forearcs? Are boninites continually produced in the forearc region, or only early in arc development? Is there a progression from boninites to more typical arc magmas?

8) Relations of arc chemistry to plate chemistry

- Are regional variations in downgoing plate (oceanic crust ± sediment) chemical composition reflected in the composition of the lavas of the volcanic front?

9) Isostatic response of lithosphere to loading at different stages of arc/backarc evolution

- How thick is the arc lithosphere? Does it thin or thicken with time? Can the rates of isostatic adjustments of volcanic centers and arc crustal blocks be measured through sedimentation history and then be inverted to learn of lithosphere evolution?

II. The Rationale for Drilling along Collisional Plate Margins in the Western Pacific

A growing body of geologic data indicates that mountain systems along continental margins are composed of discrete fault-bounded, crustal fragments, commonly referred to as tectonostratigraphic terranes. These terranes may represent dislodged and repositioned pieces of the local continental margin, or they may be truly exotic fragments such as volcanic arcs, seamounts, and even slivers of distant continental margins. The accreted terranes are commonly surrounded by and immersed in a sedimentary melange, but deeper crustal exposures demonstrate discrete tectonic contacts between the crystalline bodies. Several lines of evidence can be interpreted to show that continents are growing at a rate of ca. 1 km^3/yr while continental accretion on a global scale is expanding continental margins at a rate of ca. 2.5 km^3/yr. The 1 km^3/yr of new growth represents the addition of first-cycle volcanic island arcs and seamounts while the remaining 1.5 km^3/yr constitutes the accretion of recycled continental debris (graywacke) and pelagic carbonate and chert.

The best area to study the processes of collision is in the western Pacific where young arcs with thin sediment carapaces are now colliding with a diverse array of oceanic features. Nowhere else are collision processes so clearly shown and so unobstructed by complicated tectonic relations or thick sediment cover. For geologists to understand continental growth and the dynamics within tectonic collages such as the Cordillera, Caledonides, and the collapsed Tethyan margin (to name but a few), it is critical to investigate a variety of accretionary settings in the western Pacific.

A complicated array of collision styles is exemplified in the western Pacific: (1) Ocean crust colliding with volcanic arcs (thin sediment cover as in Tonga, thick sediment cover as in New Zealand and Japan, and even active ridges as part of the ocean crust as in the Woodlark ridge/Solomon arc system); (2) Continent or continental fragments colliding with volcanic arcs (Palawan with Philippine archipelago, Australia with Timor); and (3) Ocean crust colliding with ocean crust (intraplate shortening as inferred for the Mussau and Zenisu ridges).

Attendant with these varying collision styles are a number of boundary conditions that are equally variable; (1) The angle of collision (perpendicular, oblique to almost parallel, e.g., on the southside of the Aleutians, the angle of collision covers the whole spectrum along strike, whereas, the

New Hebrides arc shows principally orthogonal collisions, and the Tonga arc is affected largely by oblique subduction/collision); (2) The oceanic crust involved in the collision may be either old or young. (Off of Japan, Kuriles, and Tonga, the crust is old while along the south side of the Solomon arc, the crust is young.); (3) The shape of the so-called indentor may vary from linear (Louisville ridge) to broad and equant (Ontong Java) to a single seamount (Erimo); and (4) The crustal thickness of the indentor may be thin or thick (Loyalty ridge contrasted with Ontong Java). And finally, the stages of collision vary from incipient obduction such as Okushiri ridge to the opposite extreme where dispersion and crustal fragmentation prevail such as in the Banda Sea.

Understanding the kinematics and dynamics of these collisional processes will require a wide range of disciplines and research strategies. Nonetheless, ODP drilling is an appropriate tool to investigate a number of critical aspects of the collision process. Drilling:

1. Establishes whether or not parts of the colliding mass are accreted
2. Provides constraints on the timing of collision event(s)
3. Opens windows to appraise changes in physical properties and amounts of strain associated with a collision event
4. May reveal large-scale deformational features such as thrust faults
5. Makes it possible to observe varying stages of diagenesis or metamorphism related to collisions
6. Permits an opportunity to relate vertical tectonic responses to a collision event

From the multitude of possibilities to study collision phenomena in the western Pacific, we have selected four sites where we believe the prospects of good holes are combined with a range of targets covering many of the styles and boundary conditions discussed above. Our recommendations are:

1. D'ENTRECASTREAUX COLLIDING HEAD-ON WITH THE NEW HEBRIDES ARC
2. LOUISVILLE RIDGE SLIDING ALONG AND IMPINGING ON THE TONGA ARC
3. THE EFFECTS OF ONTONG JAVA AMALGAMATING WITH SOLOMON ARC
4. OKUSHIRI RIDGE OBDUCTING ONTO JAPAN

III. The Rationale for Drilling in Western Pacific Back-arc Basins

The global thematic issue that might profitably be addressed by drilling in back arc basins is lithospheric extension. Like continental rift zones and passive continental margins, back-arc basins originate through lithospheric extensional processes. An immediately obvious question is whether the extension of island arc lithosphere (ultimately to form a back-arc basin) differs significantly from extension of continental lithosphere (which may lead ultimately to normal seafloor spreading). ODP has drilled, or will drill, holes at a number of passive continental margins (New Jersey, Galicia, Norway, Exmouth Plateau) to focus on lithospheric extension problems, so it seems that extension of arc lithosphere is a novel problem that can be addressed by drilling in back-arc basins of the Western Pacific.

The whole issue of lithospheric extension has been revitalized recently, with the recognition by Wernicke and other structural geologists that large scale extension in the Basin-and-Range province is mainly accommodated by normal slip on low-angle detachment surfaces rather than by wholesale

stretching and thinning of the lithosphere, a concept popularized by McKenzie. We now have two schools of thought with their proponents: Lithospheric extension via a simple shear (detachment) mechanism, and extension via pure shear (stretching and thinning). The most important difference between the two concepts is that the location of maximum thinning of the mantle is laterally offset from the location of maximum crustal thinning in the detachment model. A likely result is the development of asymmetric patterns of structure, sedimentation, heat flow, and gravity anomalies over the extended lithosphere that would be difficult to explain using a stretching and thinning model unless special conditions are assumed.

The Western Pacific provides a wealth of opportunity for studying extension of arc lithosphere with ODP drilling. Drilling establishes boundary conditions (timing, kinematics, temperatures) that are essential for developing or testing models of extension. Best results are likely in the simplest tectonic situations. For this reason we advocate drilling extensional domains in demonstrably intra-oceanic arcs. We are therefore limited to the following locations:

1) Bonin arc
2) Coriolis trough

} active island arc rift zones

3) Lau basin
4) Mariana trough

} Rifted arc fragments with active back-arc spreading

To be properly effective, ODP drilling must be preceded, or accompanied by thorough deeply-penetrating MCS surveys in order to examine whether master detachment surfaces are present in these extensional domains. Gravity, heatflow, and SeaBeam/Seamarc surveys may also be required to properly locate drill sites.

The detachment model also predicts surface, or near surface exposure of deep-seated rocks, which is consistent with the recovery of metavolcanic rocks and gabbros in the Mariana trough, and upper amphibolite grade mafic mylonite from the Sorol Trough (east of Yap Island). Thus if extension of arc lithosphere occurs by slip on detachment surfaces, a window into the plutonic foundation of island arcs may be available for drilling without requiring large amounts of penetration.