JOIDES Journal

Volume 27, No. 2
Fall 2001

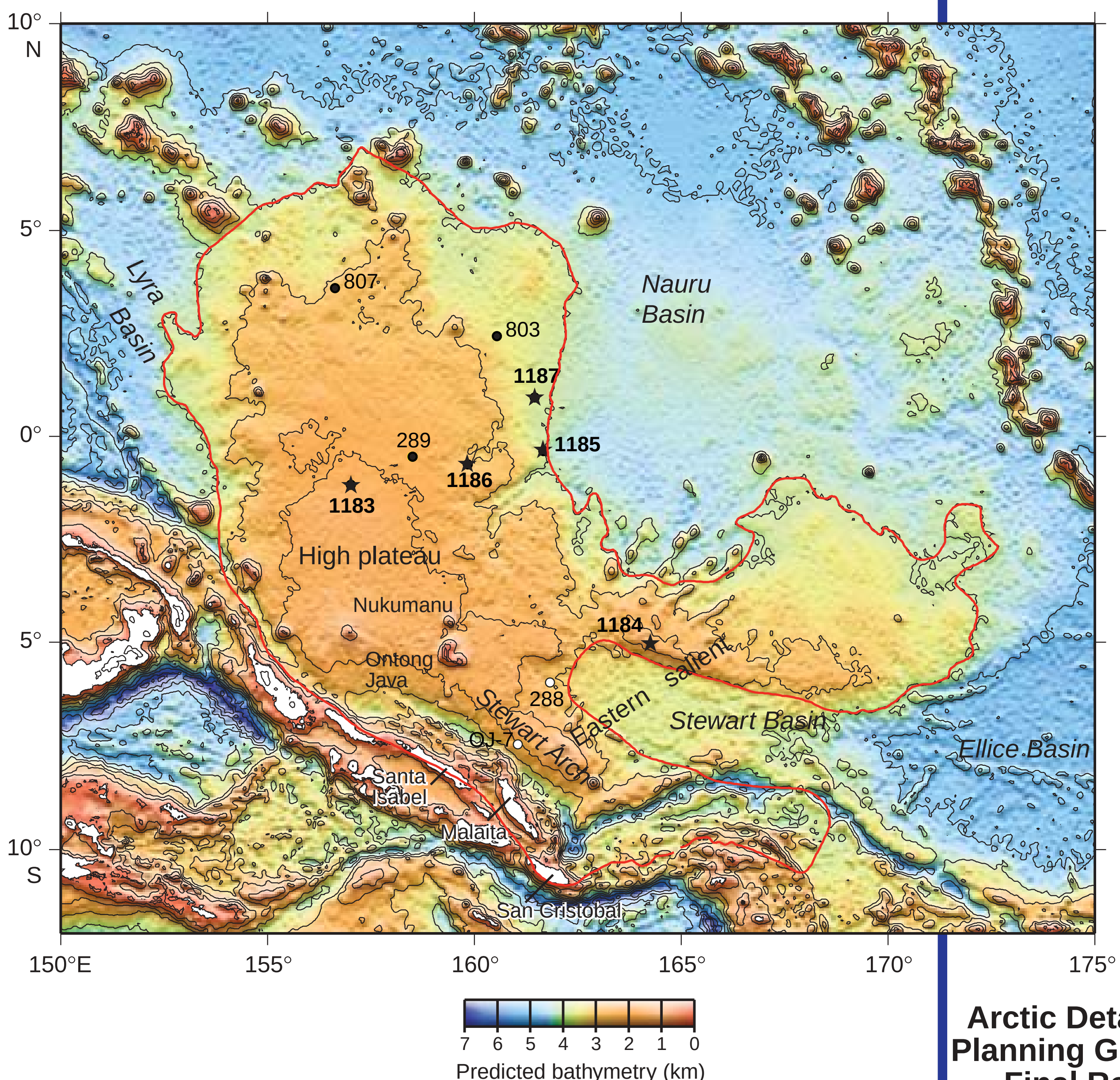
Joint Oceanographic Institutions
for Deep Earth Sampling

In this issue:

Leg 194 Science Report

Leg 195 Science Report

Leg 192: Basement Drilling of the Ontong Java Plateau



Arctic Detailed Planning Group Final Report

Revised Call for IODP Proposals

Plus:
Schedule for FY2003 - The Final Year of ODP Operations

In this issue from pages 2 - 6:

Leg 192 Science Report: Basement Drilling on the Ontong Java Plateau

Figure Caption for the Front Cover Illustration:

Figure 1. *Map of the Ontong Java Plateau showing the locations of sites drilled on Leg 192 (stars). Regional bathymetry is after Smith and Sandwell (1997). The plateau is outlined in red. Black dots = previous ODP and DSDP drill sites that reached basement. White dots = Site 288, which did not reach basement but bottomed in Aptian limestone, and Site OJ-7, which was proposed for Leg 192 but not drilled.*

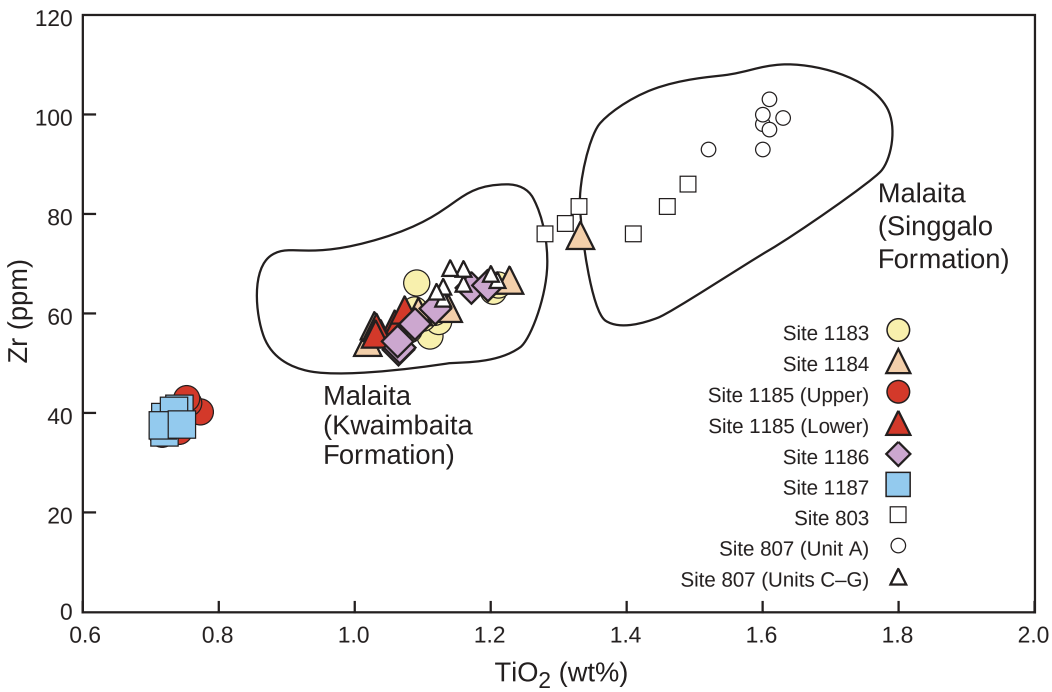
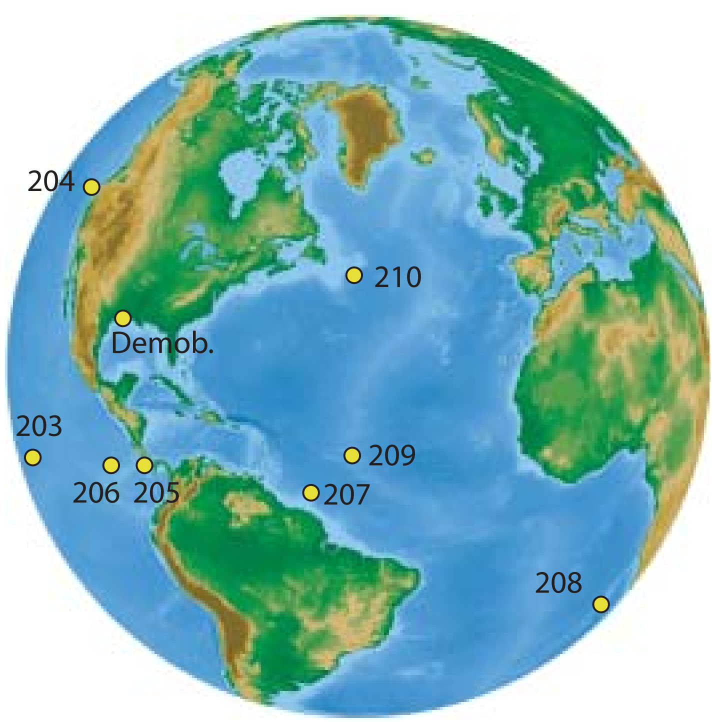


Figure 3*. Zr vs. TiO_2 data for basement rocks recovered at the Leg 192 sites, and ODP Sites 803 and 807. Fields for basaltic lava flows of the >2.7-km-thick Kwaimbaita Formation and the overlying ~750-m-thick Singgalo Formation on Malaita are shown for comparison. [Editor's Note: Figs. 2 and 4 are in the article. on pages 3 and 4.]*

Locations of drilling Legs 203 to 210 in the Pacific and Atlantic Oceans. The final year of ODP operations in 2003, including Legs 206-210 and the tentative demobilization port of Galveston, Texas, was recently scheduled . Details available in in this issue in the article "Scheduling of the FY2003 Drilling Program: The Final Year of ODP Operations" from p. 28-31.



Volume 27, No. 2
Fall 2001

TABLE OF CONTENTS

In this issue:

JOIDES Resolution Operations Schedule: October 2001 - November 2003

Leg	Destination	Port (Origin)	Dates[1]	Total Days[2] (Port/Sea)	Co-Chief Scientists	TAMU Contact
199	Paleogene Pacific	Honolulu	24 October - 17 December '01	54 (5/49)	M. Lyle P. Wilson	T. Janecek
200	H2O Observatory	Honolulu	17 December '01 - 28 January '02	42 (5/37)	R. Stephen J. Kasahara	G. Acton
201	Peru Biosphere	San Diego	28 January - 1 April '02	63 (5/58)	S. D'Hondt B. Jorgensen	J. Miller
202	SE Paleoceanography	Valparaiso	1 April - 1 June '02	61 (5/56)	A. Mix R. Tiedemann	P. Blum
203	Equatorial Pacific ION	Balboa	1 June - 8 July '02	37 (5/32)	J. Orcutt A. Schultz	G. Acton
204	Gas Hydrates[3]	San Francisco	8 July - 6 September '02	60 (5/55)	G. Bohrmann A. Trehu	C. Richter
205	Costa Rica	San Diego	6 September - 6 November '02	61 (5/56)	J. Morris H. Villinger	A. Klaus
206	Fast Spreading Crust	Balboa	6 November '02 - 5 January '03	60 (5/55)	TBN[5]	TBN
	Transit	Balboa	5 January - 13 January '03	8 (2/6)	TBN	TBN
207	Demarara Rise	Barbados	13 January - 8 March '03	54 (3/51)	TBN	TBN
208	Walvis Ridge	Rio de Janiero	8 March - 9 May '03	62 (5/57)	TBN	TBN
209	MAR Peridotite	Rio de Janiero	9 May - 10 July '03	62 (5/57)	TBN	TBN
210	Newfoundland Margin	Bermuda	10 July - 9 September '03	61 (5/56)	TBN	TBN
	Transit	St. John's	9 September - 21 September '03	12 (1/11)	TBN	TBN
	Demobilization[4]	Galveston	21 September - 30 September '03	9 (9/0)	TBN	TBN

2 November 2001

[1] Start date reflects the first full day in port, and is the date of the ODP and ODL crossover meeting. The *JR* is expected to arrive late the preceeding day. Port call dates have been included in the dates that are listed.
[2] Port calls are generally scheduled for 5 days; however, the ship sails when ready.
[3] A mid-leg port call will occur for Leg 204.
[4] Demobilization assumes a seven day (plus 2 day port call) period tentatively scheduled for Galveston.
[5] Check ODP-TAMU website (www-odp.tamu.edu) for staffing updates.

SCIENCE
Leg Reports

ODP

ODP Leg 192: Basement Drilling on the Ontong Java Plateau

John Mahoney [1], Godfrey Fitton [2], Paul Wallace [3], and the Leg 192 Scientific Party

INTRODUCTION

Volcanic oceanic plateaus are the oceanic counterparts of continental flood basalts and thick passive-margin volcanic sequences. Most plateaus were formed in the Cretaceous far from continental lithosphere, and they may reflect a mode of large-scale mantle upwelling commonly attributed to the initial, plume-head stage of hotspot development (e.g., Campbell, 1998), although alternative hypotheses also have been proposed (e.g., Smith and Lewis, 1999; Cserepes and Yuen, 2000). The plume-head model predicts that the great bulk of magmatism is produced from a geochemically ocean-island-like mantle source in a few million years or less. Such rapid outpouring of lava may have substantial effects on climate, oceanographic conditions, and/or the biosphere (e.g., Larson and Erba, 1999). Plateaus can affect subduction patterns, plate motions, and continental growth. In contrast to continental flood basalts, where mantle-source signatures often are overprinted by lithospheric signatures, most oceanic plateaus provide a more clear record of their mantle source compositions and eruption ages. Deep-sea drilling through the thick sediments that blanket plateaus is generally the only way to sample basement crust effectively.

The world's largest volcanic oceanic plateau, the Ontong Java Plateau (OJP), has a surface area of 1.5-1.9 x 10^6 km^2 (similar to that of Alaska), a crustal volume of 4-5 x 10^7 km^3 (e.g., Eldholm and Coffin, 2000), and may represent the largest igneous event of the last 200 m.y. if formed in a single, geologically brief magmatic episode. The principal goal of Leg 192 was to sample acoustic basement at several widely spaced sites on the OJP in order to help establish the range of ages and compositions. Secondary goals were to evaluate the eruptive setting and the possible relationship of plateau emplacement to changes in paleoceanographic and paleoclimatic conditions. During the leg we recovered basement and sediment cores at five sites in previously unsampled areas (Sites 1183-1187; Fig. 1, front cover).

BACKGROUND

The OJP consists of the high plateau in the north and the eastern salient in the east and south (Fig. 1). In many areas, the basement crust is covered with pelagic sediments >1 km thick. Previous drilling on the high plateau penetrated 9 m of basaltic basement at DSDP Site 289, 26 m at ODP Site 803, and 149 m at ODP Site 807. Other basement samples come from subaerial exposures of the plateau's southern edge in the eastern Solomon Islands of Santa Isabel, San Cristobal, and, particularly, in Malaita, where a 3.5-km-thick basement section is exposed (Tejada et al., 2001). Extensive Early Cretaceous lava sequences filling basins to the north and east of the plateau proper are likely to be related to the OJP as, perhaps, is the Manihiki Plateau to the east (see review of Neal et al., 1997).

On Malaita, a >2.7-km-thick pile of uniform, low-K tholeiite known as the Kwaimbaita Formation is overlain by ~750 m of the Singgalo Formation, a slightly more incompatible-element-enriched and isotopically distinct tholeiite. These two basalt types also are present at Site 807 and on Santa Isabel, and isotopically Kwaimbaita-like tholeiitic basalt was recovered at Site 803. ^{40}Ar-^{39}Ar dating revealed that basement in several far-flung locations was formed at ~122 Ma, consistent with plateau emplacement in a geologically brief pulse as predicted by the plume-head model. However, an ~90 Ma eruptive episode

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also was documented at several widely separated sites (see Neal et al., 1997). All ~122 and ~90 Ma lava flows erupted below sea level. Originally shallow or emergent regions may have resulted from the combined effects of emplacement of the OJP's >30-km-thick crust (e.g., Gladczenko et al., 1997) and the transient dynamic uplift predicted by the plume-head model.

DRILLING SUMMARY

Four of five sites drilled during Leg 192 on the high plateau (Sites 1183, 1185, 1186, 1187) yielded pillow and/or massive basalt flows with rare, thin sedimentary interbeds. These sites and three previously drilled basement sites form a transect extending eastward from Site 1183 to Sites 289, 1186, and 1185, northward to Sites 1187 and 803, and then northwestward to Site 807. Figure 2 summarizes water depth, sediment thickness, basement penetration, and igneous rock type and age data for the seven high-plateau sites along the transect. Eastern-salient Site 1184, where a thick volcaniclastic sequence was encountered, lies off the transect 586 km to the southeast of Site 1185. Figure 3 (color plate inside front cover) shows Zr vs. TiO_2 data for igneous rocks analyzed aboard the ship.

Site 1183 is located near the crest of the high plateau. Eruptive activity may have been at its most vigorous here as shallow water or subaerial volcanism. Site 1183 was the only Leg 192 site at which much of the Miocene-Aptian sedimentary succession was cored, since the sedimentary history of the OJP was known from previous drilling. Dominant nannofossil foraminifer chalk, with some intervals rich in volcanic ash (Paleocene to early Eocene, and late Eocene to Oligocene) or chert (middle Eocene), were recovered. Several unconformities were tentatively interpreted to result from calcite compensation depth oscillations coupled with plateau subsidence. We cored 81 m of nonvesicular, tholeiitic pillow basalt, similar to the Kwaimbaita Formation on Malaita, as well as several thin limestone interbeds containing Aptian microfossils.

Site 1184 lies on the northern ridge of the eastern salient. We cored 338 m of vitric lithic tuff, lapilli tuff and lapillistone, representing five subunits, below a Miocene chalk section and a ferromanganese crust. Wood fragments

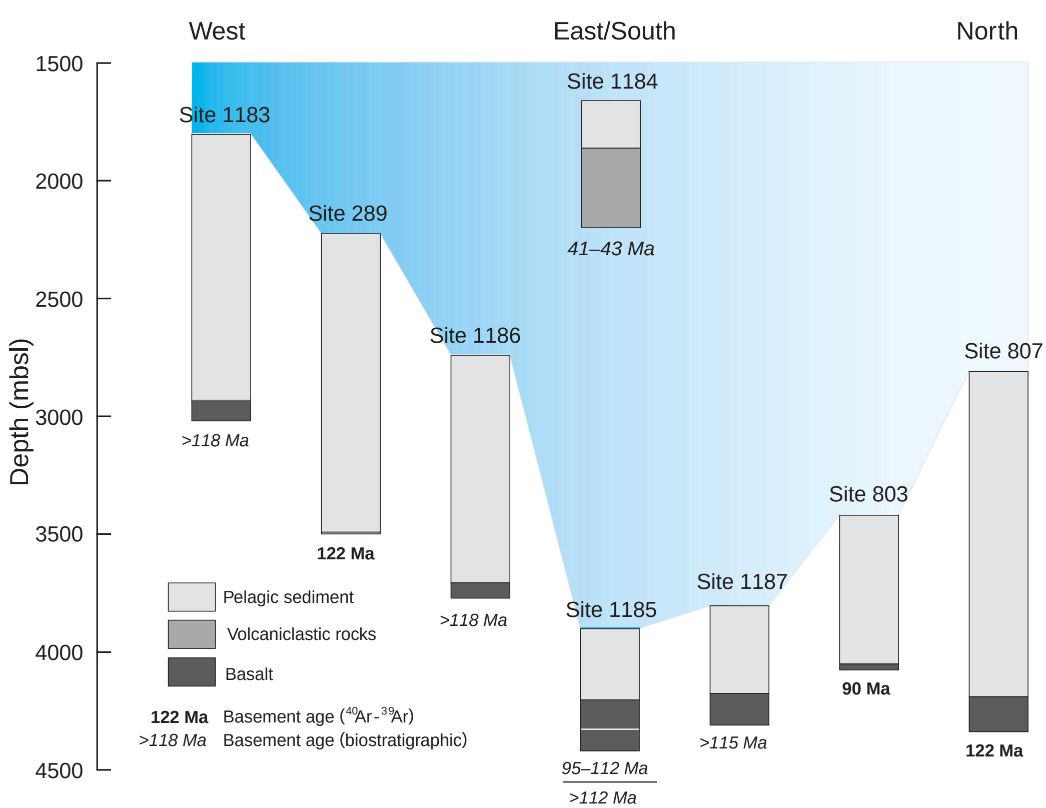

Figure 2. *Stratigraphic sections drilled during Leg 192 and at the three previous DSDP and ODP basement sites on the OJP. Basement ages for the earlier sites are from* ^{40}Ar-^{39}Ar *dating of basalt. Basement ages for the Leg 192 sites are estimated from biostratigraphic evidence.*

were found at four of the subunit boundaries. Glass shards are mostly subangular, blocky and nonvesicular, and armored and accretionary lapilli (Fig. 4) and tachylite clasts are present throughout the volcaniclastic succession. The succession is interpreted as a product of explosive hydroclastic eruptions in a shallow-water to emergent setting. Compositionally, the volcaniclastic rocks are similar to Kwaimbaita-type basalt. Rare nannofossils recovered from some finer-grained tuff intervals suggest a middle Eocene age, but the steep paleomagnetic inclination (-54^o) suggests a much greater age.

Site 1185 is on the eastern edge of the high plateau, where it was postulated that drilling might yield basalt of a different composition and/or age from that on the plateau's crest. We divided the 217-m cored basaltic basement section into upper and lower groups on the basis of lava flow morphology, composition, and nature of alteration. The upper 125 m consists of pillow lavas and two massive flows, and is composed of the most magnesian (8-10 wt. % MgO) and incompatible-element-depleted (e.g. ~0.7 wt. % TiO_2, ~38 ppm Zr) basalt yet found on the OJP. The lower 92 m consists of massive flows of Kwaimbaita-type basalt. Microfossils preserved in thin limestone interbeds suggest a latest Cenomanian to Albian age for the upper group and an Aptian age for the lower group.

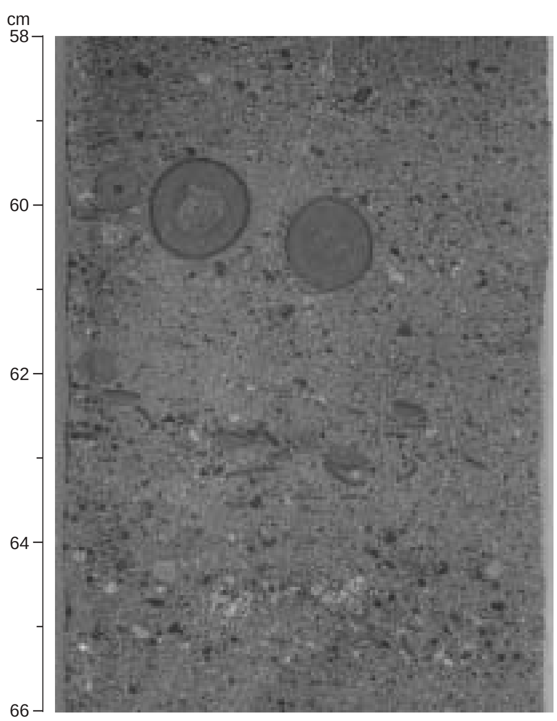

Figure 4. *Accretionary lapilli, both whole (round) and fragmented, in gray lithic vitric tuff. Subunit IIA at Site 1184 (interval 192-1184A-14R-1, 58-66 cm).*

Site 1186, on the eastern flank of the high plateau between Sites 1183 and 1185, was drilled to investigate the very different volcanic stratigraphy at these two sites. A 65-m succession of pillow basalt and massive flows, separated by thin limestone interbeds, was cored. Aptian microfossils from limestone immediately above and within basement suggested that the basalt is the same age as that at Site 1183, and shipboard chemical analysis showed it to be of the Kwaimbaita type. Drilling was terminated to allow time for a fifth site. Site 1186 was the only site logged during Leg 192.

Site 1187 is located near the eastern edge of the high plateau, roughly midway between Sites 803 and 1185. Unlike other high-plateau sites, Site 803 and probably Site 1185 (upper group) contain basalt that is significantly younger than 122 Ma. We cored 136 m of basaltic basement composed of pillow lava and two thin massive flows that is compositionally indistinguishable from the low-Ti, high-Mg basalt forming the upper group of flows at Site 1185. However, late Aptian microfossils in an ~2-cm-thick chalk layer immediately above basement suggest that the basalt is older than that forming the upper group at Site 1185.

PRINCIPAL SCIENTIFIC RESULTS

Basement Ages

It now appears that an immense part of the high plateau was formed in the ~122-Ma event: the central region (Sites 289, 1183, and 1186), northern flank (Site 807), and probably much of the eastern flank (lower 92 m of flows at Site 1185, possibly Site 1187). Basement crust in Malaita and much of Santa Isabel also was formed in this event. With the resolution of existing sampling and dating, the duration of this event could have been as great as ~7 m.y., or much shorter. The central region of the high plateau seems to have been largely unaffected by post-122-Ma eruptive episodes. Evidence for these later episodes is found exclusively around the eastern margins of the high plateau (Site 803, possibly Site 1187 and the upper group of flows at Site 1185) and on the eastern salient (Santa Isabel, Malaita, San Cristobal, Site 1184, and in ash layers at Site 288, at the boundary between the salient and high plateau). Biostratigraphic data for the volcaniclastic sequence at Site 1184 suggest that at least locally significant tholeiitic volcanism may have occurred on the northern part of the eastern salient in the ~41-43 Ma period. However, post-122 Ma magmatic episodes appear to have been volumetrically minor in relation to the ~122 Ma event. This conclusion is one of the major results of Leg 192. In contrast, substantial volumes of magma were emplaced over a period of ~30 m.y. in the southern and central Kerguelen Plateau and Broken Ridge (Pringle and Duncan, 2000).

Petrology and Geochemistry of Igneous Rocks

A fundamental result of Leg 192 is that only Kwaimbaita-type basalt was encountered at Sites 1183 and 1186; it forms the lower 92 m of flows drilled at Site 1185. The lower group of flows (Units C-G) at Site 807 on the northern plateau flank are also of the Kwaimbaita type. Other magma types are present mainly on the margins of the plateau. We conclude that Kwaimbaita-type magmas, likely derived from a very homogeneous and voluminous mantle source, were the most abundant type produced during construction of the upper basement.

An exciting discovery was the low-Ti, high-Mg basalt at Sites 1185 (upper group) and 1187 that requires significantly higher total amounts of partial melting than the Kwaimbaita magma type, that probably represents 18-30% partial melting (e.g., Neal et al., 1997). Understanding the origin of the apparently large volume of such flows on the high plateau’s eastern edge awaits more precise dating, and comprehensive elemental and isotopic data.

By the Eocene, the plateau had drifted thousands of kilometers from its 122-Ma position (e.g., Yan and Kroenke, 1993). Surprisingly, the mantle source of the volcaniclastic rocks at Site 1184 was compositionally similar to that of the Kwaimbaita magma type. Despite the Eocene biostratigraphic age, this similarity argues that the Site 1184 magma mantle source was closely related to the mantle that formed the bulk of the plateau in the Aptian.

Basement Paleolatitude

Estimated basement paleolatitudes at Sites 1183, 1185, 1186, and 1187 are in the 19-25^{o}S range. The estimates are north of the ~35-42^{o}S location suggested for the central high plateau region between 125 and 90 Ma in the plate reconstruction of Neal et al. (1997), and even farther from the present position of the Louisville hotspot (~50^{o}S), proposed by several workers to be the plume that fed the OJP. The amount of true polar wander and the distance the Louisville hotspot has drifted since the Early Cretaceous (if it existed then) are as yet unknown. Presently, in agreement with Nd-Pb-Sr isotopic data for pre-Leg 192 basement samples and the lack of a post-plateau seamount chain corresponding to a plume tail (e.g., Neal et al., 1997; Tejada et al., 2001), the paleolatitude data do not appear to support a Louisville hotspot origin for the OJP.

Site 1184 presents a paradox in that the -54^{o} mean magnetic inclination of the volcaniclastic sequence implies a paleolatitude of ~35^{o}S. This value is much farther south than the ~15-20^{o}S paleolatitude expected for this part of the OJP (e.g., Yan and Kroenke, 1993) if the mid-Eocene biostratigraphic age is accurate. Shore-based ^{40}Ar-^{39}Ar dating may help resolve this as yet unexplained discrepancy.

ERUPTIVE ENVIRONMENT AND PALEOENVIRONMENTAL IMPACT

The volcaniclastic sequence at Site 1184 formed in shallow water but seems to represent magmatism that occurred long after the Aptian phase of plateau construction. Basement rocks at the four Leg 192 sites on the high plateau were emplaced well below sea level, as were those of Sites 289, 803, 807 and all OJP basement sections in the eastern Solomon Islands. The virtually vesicle-free pillow basalt at Site 1183 was probably erupted at a depth of at least several hundred meters. The only evidence that any part of the high plateau was at least briefly shallow or emergent is provided by two thin (<1 m recovered) layers of laminated vitric tuff deposited as turbidites at the base of the Aptian sedimentary sequence at Site 1183, a thin vitric tuff immediately above basement at Site 289 and, possibly, abundant glass shards in Aptian limestone at Site 288. If a large proportion of OJP magmas were erupted under shallow water or subaerially, then the flux of climate-modifying volatiles (particularly SO_2, Cl, and F) to the atmosphere would have been considerable (e.g., Michael, 1999). Our results indicate that most of the plateau formed below sea level, and that its large-scale environmental effects were probably limited.

LEG 192 SCIENTIFIC PARTY

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SCIENCE
Leg Reports

ODP

ODP Leg 194: Sea Level Magnitudes Recorded by Continental Margin Sequences on the Marion Plateau, Northeast Australia

Alexandra R. Isern [1], Flavio S. Anselmetti [2], Peter Blum [3], and the Leg 194 Scientific Party

INTRODUCTION

Carbonate platforms are large geologic structures composed of the remains of calcium carbonate-secreting organisms that can be found in environments ranging from tropical to temperate, and in locations that are free of siliceous sediment to those with significant amounts of terrigenous sediment. Because these platforms are composed of biogenic remains they are sensitive to changes in environmental conditions such as sea level, wind or currents, nutrient content, and water temperature. Thus, the study of carbonate platforms provides fundamental information regarding environmental change in a range of environments. In addition to their high-quality environmental record, carbonate platforms are often important petroleum reservoirs. Therefore, much effort has been expended in both industry and academia to understand the growth, development, and associated diagenetic alteration of carbonate platforms.

From January to March 2001, Leg 194 drilled a series of eight sites through Oligocene-Pliocene carbonate platforms on the Marion Plateau and adjacent slope sediments, located seaward of the south central Great Barrier Reef off northeast Australia (Fig. 1). Primary goals of this drilling were to calibrate an important interval of the global sea level curve and to investigate the influence of paleoceanographic changes on carbonate platform development in a cool sub-tropical environment. Results from Leg 194 provided an accurate estimate of the magnitude of middle Miocene sea level fall,

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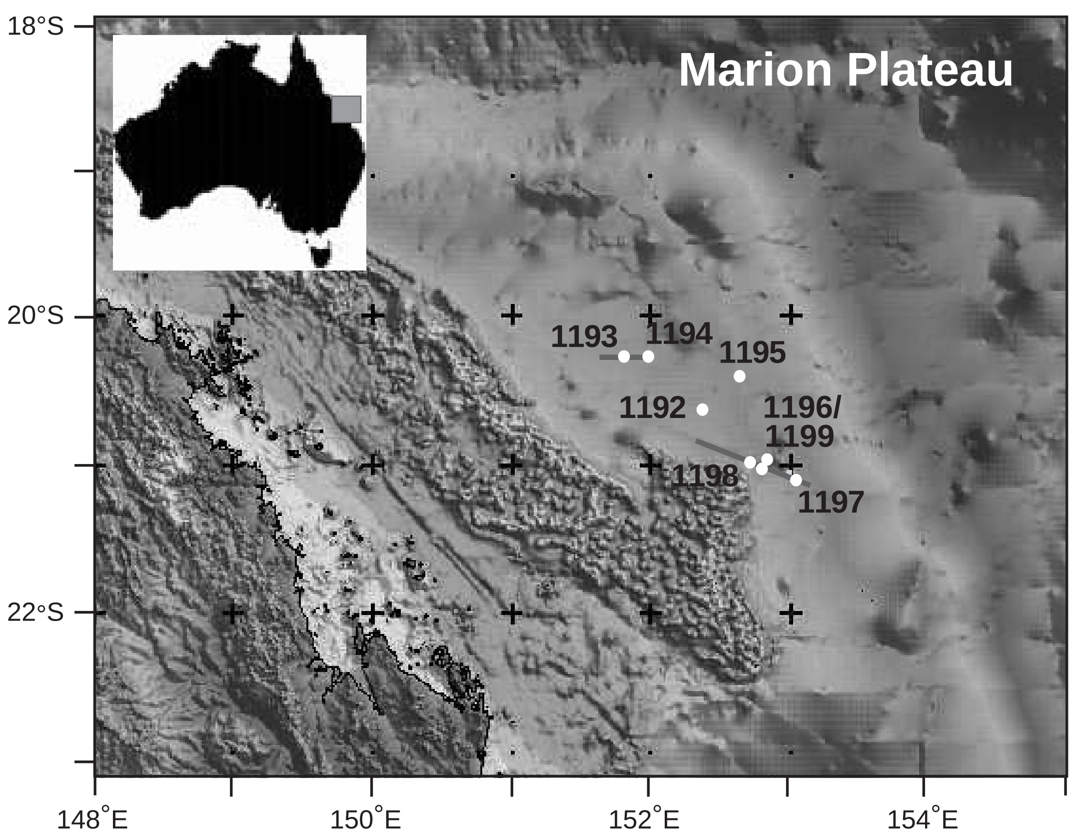

Figure 1. Bathymetric map of ODP Leg 194 drillsites (circles) off northeastern Australia. The location of these sites relative to the Australian continental margin is indicated in the box at upper left. Lines indicate the locations of seismic sections shown in Figures 2 and 3. Bathymetry provided by the Australian Geological Survey Organization.

and indicated that sub-tropical faunal assemblages are capable of building tropical platform geometries. Additional work on recovered sediments will provide important information for constraining paleo-currents in the western South Pacific.

PRINCIPAL SCIENTIFIC RESULTS

Timing of Carbonate Platform Development

The northeast Australian margin is characterized by many carbonate platforms, the most notable and youngest being the Great Barrier Reef (International Consortium for Great Barrier Reef Drilling, 2001). The older Queensland and northern Marion Plateaus were drilled during Leg 133 (Davies et al., 1991). The Marion Plateau (Fig. 1) was selected for Leg 194 drilling as it provided ideal targets for addressing the magnitude of sea level change and evolution of the platform. Seismic profiles and sediments recovered during Leg 194 indicate that the Marion Plateau experienced extensive sub-tropical/cool sub-tropical carbonate platform development over much of the plateau from the early to middle Miocene (Fig. 2; color plate inside the back cover, and Fig. 3).

In the late middle Miocene (~11 Ma), carbonate bank productivity rapidly diminished due to exposure after the major sea level fall from ~11-7 Ma. Platform growth did not reinitiate over most of the area after re-flooding. This is surprising because growth rates of the organisms that construct carbonate platform edifices are high enough to outpace potentially destructive sea-level rises. The death of carbonate platforms and reefs has been termed

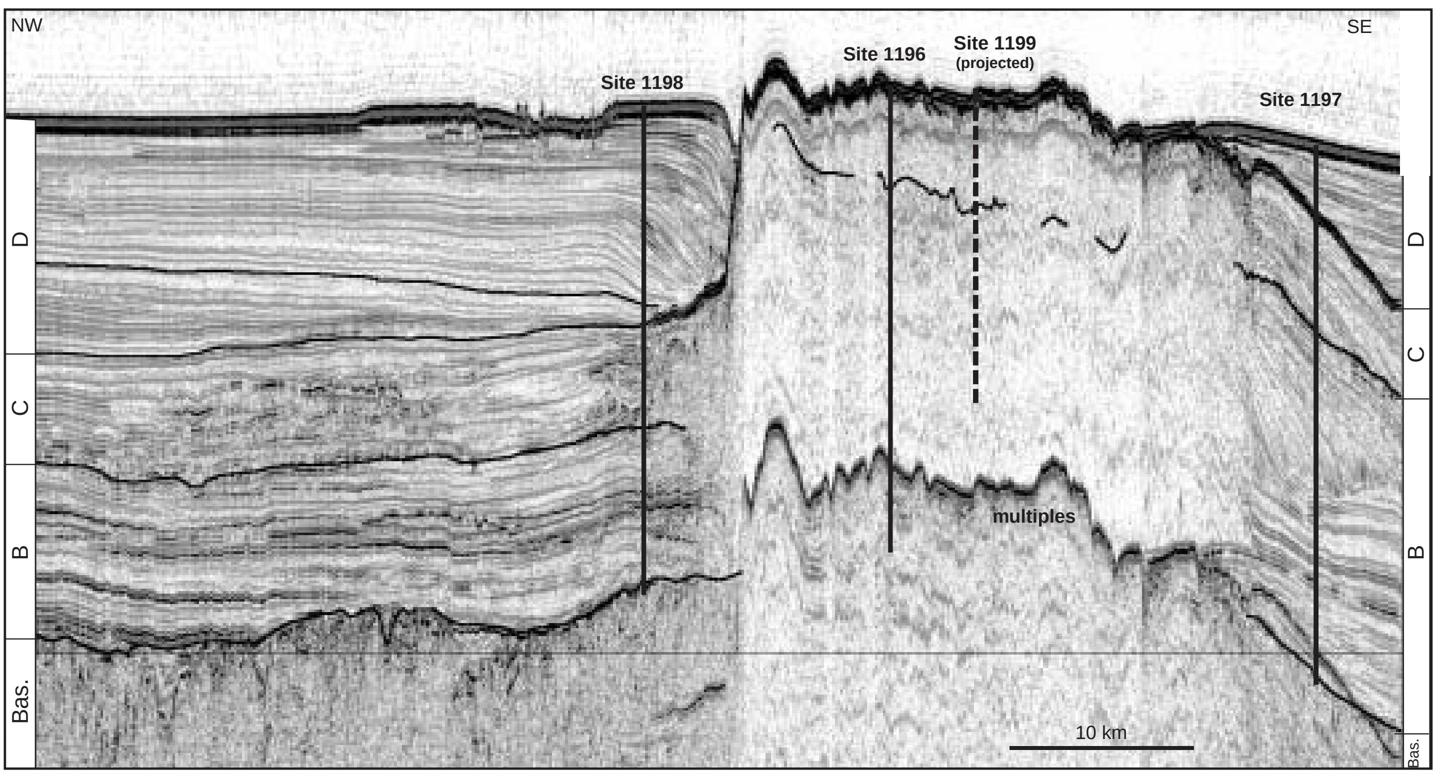

Figure 3. Seismic section along the southern drilling transect; extents of boreholes at Sites 1198, 1196, 1999, and 1197 are shown by vertical lines (see Fig. 1 for locations). Site 1199 is located approximately 5 km northeast of this seismic line and was projected onto the line perpendicularly. Seismic mega-sequences that can be correlated throughout the study area are labeled on both sides of the figure. The seismically transparent, southern carbonate platform can be seen at the center of the figure. This platform is made up of multiple growth phases throughout the Miocene. The platform drowned in the late Miocene to early Pliocene, and current-induced non-deposition has kept its surface nearly free of sediment. This carbonate platform nucleated in a topographic depression or on a carbonate ramp and its subsequent growth was strongly controlled by current flow. The platform architecture is asymmetric, with the upcurrent (left) side being relatively sediment-starved as compared to the downcurrent (right) side.

the "paradox of drowning" (Schlager, 1981). The cause for the demise of the Marion Plateau carbonate platforms remains unclear, but may be due to environmental stress caused by sea level variations in conjunction with reduced sea-surface temperatures (Isern et al., 1996), greatly increased rates of subsidence for the Marion Plateau (Mueller et al., 2000), increased river discharge (Pigram et al., 1992), and increased current activity across the drowning platforms.

Given the progression of the early shallow-water reef systems to the present water depths of the drilling sites (304-420 m), it is clear that postrift thermal subsidence is a controlling factor on long-term accommodation space for platform growth. The postrift subsidence of the region occurs even though unambiguous rift structures are not observed across the plateau.

Calibration of the Global Sea Level Curve

Measuring the magnitude of eustatic sea level fluctuations is a difficult problem whose resolution is essential both for the establishment of an accurate eustatic sea level curve for the Phanerozoic and for the accurate interpretation of sediment sequences on continental margins. Several attempts have been made to determine the amplitude of glacioeustatic fluctuations, including passive-margin sequence stratigraphy (Haq et al., 1987), modeling of sedimentary depositional regimes (Watts and Thorne, 1984), calibration of the oxygen isotope curve (Miller et al., 1987), and analysis of the depositional history of carbonate sediments on atolls (Schlanger and Premoli-Silva, 1986). These analyses often agree on the timing of sea-level changes, but significant differences exist between estimates of the magnitude of these events. A primary goal of Leg 194 drilling was to calibrate an important part of the global eustatic sea-level curve by estimating the magnitude of the major late middle Miocene (N12-N14) sea-level fall using sequence geometries and sedimentary facies from Sites 1193 and 1194 on the northern drilling transect (Figs. 1 and 2).

Drilling at Site 1194 penetrated a lowstand shallow water carbonate ramp of late middle Miocene age that interrupts intervals of deeper water sediments. This sequence was deposited ~12 km from an early-middle Miocene carbonate platform drilled at Site 1193 (Fig. 2). Sequence relationships show that this ramp was deposited subsequent to the top of the platform at Site 1193. In addition, sediments recovered from this ramp at Site 1194 show no evidence of reworking, such as abrasion, and consist of distinctly different faunal assemblages as compared to the adjacent carbonate platform. This evidence rules out the possibility that sediments of the lowstand ramp were derived from the adjacent carbonate platform.

The present-day relief between the top of the platform at Site 1193 and the base of the lowstand system at Site 1194 is 145 m. Shipboard porosity data were used to correct for sediment decompaction resulting from the unloading of post-middle Miocene sediment. Corrections of 7 m at Site 1193 and 56 m at Site 1194 reduced the relief to 96 m. Consideration of paleo-water depths of 30 ± 20 m during the highstand at Site 1193 and 40 ± 10 m during the subsequent lowstand at Site 1194, derived from larger benthic foraminifer assemblages, requires a eustatic fall of 86 ± 30 m. This reconstruction assumes infinite flexural strength of the basement between the two sites (i.e., no differential subsidence). This assumption is supported by the presence of undisturbed sediment characterized by constant dip angles, the short distance and horizontal basement geometry between the sites, and the absence of major faults. The estimated magnitude for the late middle Miocene eustatic fall derived here is agrees with estimates derived from other proxies, but is less than the value of 185 m initially proposed using seismic geometry from this area uncalibrated by drilling data. The estimated magnitude also is greater than estimates from the New Jersey margin. Platform erosion at Site 1193 and overall tectonic subsidence during sea level lowering were not considered. Both effects are likely to be smaller than the error margin of the above estimates and would increase the sea level fall. It is also possible that a record of the lowest sea level was not preserved, cored, or observed at Site 1194. This also would increase the magnitude of the eustatic fall described here.

Strong Seafloor Currents Control Carbonate Platform Development

Most well-studied examples of carbonate platforms in modern environments, such as the Bahamas, have sedimentation patterns that reflect prevailing wind directions. Winds are the dominant energy source, forcing sediment off the platform on the leeward side and leaving the windward side relatively sediment-starved. These wind patterns produce a platform asymmetry with steep windward and gentler leeward slopes (e.g., Eberli and Ginsburg, 1987). This model is commonly used to interpret carbonate platforms observed in the geologic record.

The carbonate platforms off northeast Australia, though morphologically similar to the Bahamas platform, have a differerent developmental history. Interpretations of high-resolution seismic data and cores from Leg 194, along with modern oceanographic data from northeast Australia, show that sedimentation on the Marion Plateau is dominated by oceanographic currents. The influence of these currents, the primary energy source along the platform, on carbonate growth creates an asymmetrical platform geometry where the upcurrent side of the platform is relatively sediment starved and most sediments are deposited in the downcurrent direction (Fig. 3). Furthermore, the dominant sediment shedding direction is opposite that of the prevailing winds but parallel to the principal direction of current flow. These currents likely determine not only the morphology and amount of sediment transported from the platform top, but also the growth potential of the platforms.

The influence of currents is observed today as large sediment drifts on the Marion Plateau surface. A significant benefit of Leg 194 drilling is that continued study of recovered cores will provide a history of the currents off northeast Australia, including changes in strength and flow pattern. These currents are dominated by the East Australian Current, the primary western boundary current in the South Pacific whose development is strongly linked to changes in current flow resulting from the Miocene closure of the low-latitude gateway north of New Guinea. Thus, a better understanding of current flow off northeast Australia will provide additional information to better constrain the closing of this important gateway.

Influence on Platform Architecture of Physical Parameters and Biofacies

The recognition that currents control carbonate platform sedimentation along the Marion Plateau has important implications for the interpretation of carbonate platforms imaged on seismic data. Prior to Leg 194 drilling, seismic data interpretation suggested that the organisms that constructed the platforms of the Marion Plateau were dominated by tropical, warm-water species, including corals. The remains of these warm-water organisms generally form flat-topped platforms with steep sides, as they are dominated by unstable aragonite and high magnesium calcite mineralogy that becomes cemented as it undergoes alteration to more stable calcite mineralogy.

Seismic data show that the platforms on the Marion Plateau are similarly characterized by massive, table-like structures, and yet the recovered sediments from Leg 194 are almost entirely composed of the remains of cool, sub-tropical organisms such as red algae, bryozoans, and larger benthic foraminifers. These calcite-dominated organic remains have a lower diagenetic potential than their aragonite-dominated counterparts in the tropical realm. Despite the reduced cementation potential, the drilled platforms are well cemented. On the slopes, however, reduced cementation resulted in poor recovery. The observation that cool sub-tropical faunal assemblages produce platform geometries that are similar to tropical carbonates suggests that physical parameters, such as current flow and sea level change, may be more important in the establishment of platform architectures than the dominant biofacies.

Fluid Flow

Porewaters from Leg 194 sediments provide clear evidence that seawater is circulating through the carbonate platforms and proximal sediments on the Marion Plateau. Sampling of fluids within the carbonate platforms was not possible due to low core recovery. Water samples taken from sites adjacent to the carbonate platforms show that seawater is being fed through the platform edifices into high-permeability, late Miocene sediments that form an aquifer overlain by ~200 m of low-permeability sediments of Pliocene age. Furthermore, the dolomitization observed in both drilled platforms is in itself indirect evidence for past fluid circulation through these platforms. Dolomite formation on a large scale requires fluid flow to deliver the required magnesium to the precursor calcium carbonate sediments. The timing and mechanisms of this flow and the nature of the fluids, whether normal seawater or hypo- or hyper-saline fluids, are unresolved questions.

Acoustic Basement

Prior to Leg 194, no direct information existed concerning the basement composition of the Marion Plateau. The highly altered volcanic flows and volcaniclastic basement rocks recovered during Leg 194 differ greatly from the metasedimentary rocks drilled on the Queensland Plateau during Leg 133 (Davies et al., 1991). The lack of deformation suggests that these volcanics may have been emplaced during the Late Cretaceous-Paleocene rifting of northeastern Australia from the Papuan Plateau and the Lord Howe Rise. The high intensity and consistent paleomagnetic response of the basement may provide age estimates for both the emplacement of the basalts and the timing of low-temperature alteration. This new information, supplemented with post-cruise analyses, will have important implications for understanding regional tectonics and also for understanding the subsidence history of the Marian Plateau.

LEG 194 SCIENTIFIC PARTY

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SCIENCE
Leg Reports

ODP

Leg 195: Seafloor Observatories and the History of the Kuroshio Current

M. Salisbury [1], M. Shinohara [2], C. Richter [3] and the Leg 195 Shipboard Scientific Party

INTRODUCTION

Leg 195 had three distinct objectives. The first was to install a long-term geochemical observatory at a cold vent in the throat of South Chamorro Seamount, an active serpentine mud volcano in the Mariana forearc which is bringing fluids, mud, metamorphic rocks and mantle xenoliths to the seafoor from the decollement 25 km below (Fig. 1). The second was to install a state-of-the-art borehole seismic observatory almost 600 m below the seafloor in the middle of the Philippine plate to fill an important gap in the International Ocean Network (ION) net. The third was a contingency objective. If time allowed, piston cores were to be obtained at a shallow water site under the Kuroshio Current in order to study climate change in east Asia over the past 1.5 my. Each objective was achieved with remarkable success and scientific surprises.

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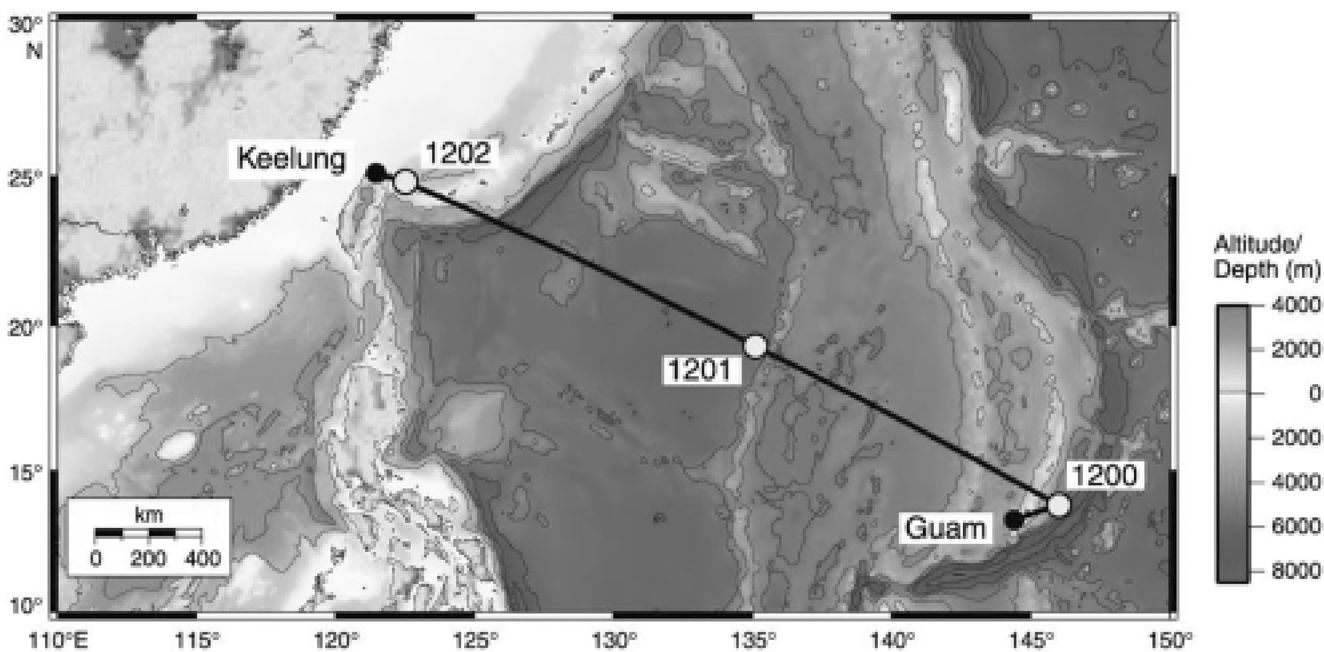
SERPENTINE MUD VOLCANO OBSERVATORY

South Chamorro Seamount, the only known site of active serpentine/blueschist mud volcanism in the world (Fryer et al., 1999), was selected for the installation of a borehole geochemical observatory following the discovery of megafaunal assemblages around low temperature (2-3°C), high pH (12.5) springs on the summit. The drill site was located in the vicinity of mussel beds observed with the *JOIDES Resolution*'s re-entry television system. Although drilling was difficult, the results were stunning. Cores recovered from all six of the holes drilled at Site 1200 consisted of poorly sorted, serpentine mud breccias that were pitch black in color in the upper 20 m and dark blue in the rest of the section. The muds are composed of silty clay-size serpentine minerals derived from the serpentinization of ultramafics, plus accesory glaucophane, spinel, garnet, chlorite and talc derived from the metamorphism of mafic rocks along the decollement. The clasts, which range up to 1 m across, consist of partially to completely serpentinized ultramafics (harzburgite>>dunite>>lherzolite). The whole-rock chemistry of the ultramafics is

Figure 1. Location map of the Phillippine plate and the Mariana forearc showing sites drilled during Leg 195. The geochemical observatory was installed at Site 1200, and the International Ocean Network (ION) seismic observatory was installed at Site 1201. Site 1202 was drilled to study the history of the Kuroshio Current.



consistent with 20-25% melt extraction at some time during arc formation. The dual origin of the mud breccia consituents is revealed in the grit fraction. About 90% of the grit consists of partially serpentinized ultramafics; 10% consists of metabasites, including glaucophane schist, crossite/white mica/chlorite schist, amphibolite schist containing blue-green to black amphibole, and possibly jadeite. These lithologies, especially the blueschists, are indicative of a high P, low T origin, and are interpreted as metamorphosed basic rocks from the descending slab. About 1% of the grit fraction consists of zoned blue sodic amphibole with blue rims and lighter blue-green cores, implying relatively rapid ascent within the rising serpentine muds.

The pore waters from Site 1200 revealed two remarkable phenomena: a deep-sourced fluid believed to be upwelling from the top of the subducting slab 25-30 km below, and a new, low temperature extremophile microbial community that lives in the top 20 m of the sediments and is chemically manipulating its environment to suit its own needs. For most chemical components, the pore water vs. composition profiles for the site represent nearly ideal advection-diffusion curves and the gradients in the top few meters are so steep that they can only be maintained by upwelling from below (Shipboard Scientific Party, 2001). The pore fluids are in equilibrium with brucite and are among the most alkaline ever sampled in the deep sea. The only site known with comparable values is Conical Seamount, a similar mud volcano about 650 km to the north. The pore water is enriched in (mainly carbonate) alkalinity, Na, Na/Cl, K, B, ammonia, methane and C2 through C6 hydrocarbons, components that are virtually absent in depleted harzburgites and therefore require a different source. The pore fluid is highly depleted in Mg, Ca, Sr and Li and has low concentrations of Si, Mn, Fe, Ba and phosphate.

Pore water profiles also reveal that these deep fluids feed an active microbial community that is oxidizing light hydrocarbons from the fluid while reducing sulfate. This is a true extremophile community operating at, and probably driving the pH to, 12.5 to perpetuate its own ecosystem. Sulfate reduction is most active at two levels: microbes in the upper 3 m reduce seawater sulfate that diffuses downward against the upwelling fluid while those at the base of the microbial layer reduce sulfate supplied by the upwelling fluids. Although hydrogen can be produced by serpentinization, organic carbon is virtually absent in depleted serpentinized ultramafics. The microbes must rely on methane and C2 through C6 thermogenic hydrocarbons for their source of organic carbon and ammonia for their nitrogen, both supplied by upwelling fluids. The microbial community intercepts these nutrients and effectively traps and recycles them within the ecosystem, causing an enrichment of carbon in the uppermost sediment. Although the microbes could not be classified aboard ship, frozen samples were taken for shorebased cultivation and ribosomal DNA analysis.

We also accomplished the primary objective at this site, the installation of a Circulation Obviation Retrofit Kit (CORK) geochemical observatory in the conduit of the seamount. Operations were extremely difficult from an engineering standpoint. The mud breccias were so unstable that it took three weeks, two casing strings and nine round trips of the pipe (representing 52 km of pipe in and out of the borehole) to install the observatory a mere 200 m into the seafloor. To complicate matters further, longline gear deployed indiscriminantly by a Japanese fishing fleet out of visual contact became entangled in the drill pipe during the deployment. When we left the site, the debris had been cleared and the observatory, which consists of two osmotic water samplers and an array of thermistors, was fully operational. The first remotely operated vehicle (ROV) visit to recover data from the observatory is planned for the spring of 2003.

BOREHOLE SEISMIC OBSERVATORY

The second major leg objective was to install a seismic observatory in the middle of the Philippine plate in extremely deep water (5.7 km) about 100 km west of the inactive Kyushu-Palau Ridge, an abandoned subduction zone. Site 1201 drilling also was full of surprises.

The Site 1201 section consists of 510 m of Miocene through late Eocene sediments and 90 m of submarine basalt that is transitional between Mid-Ocean Ridge Basalt (MORB) and arc tholeiites in composition. The uppermost sediments are pelagic red clays and cherts with interbedded sandstones and silty claystones, but the rest of the section, from 53-510 mbsf, consists almost entirely of coarse- to fine-grained turbidites composed of detrital volcaniclastic material and traces of reef detritus. Individual turbidite layers range from 10s of m to a few mm in thickness and tend to decrease in thickness and grain size downsection, reflecting a gradual change from low to high energy deposition. The basal 20 to 30 m of the unit consists of interbedded turbidites and reddish tan to chocolate brown claystones deposited in a quiet marine setting. The biggest surprise was the color of the turbidites, which range from almost black to dark greenish gray in the upper half of the unit, where the volcaniclastics are relatively fresh, to Christmas tree green in the lower half. These changes are related to progressive alteration with depth, including the devitrification of glass, replacement of calcic cores of plagioclase by clays, the infilling of voids and vesicles by clays and zeolites in the upper part of the unit, and the entire replacement of volcaniclastic material in the lower part of the unit by smectite, chlorite and zeolites during diagenesis.

This diagenesis has resulted in pore water composition that is unusual for deep-sea sediments. The most striking feature is an extremely large increase in pH, Ca and chlorinity with depth. Whereas seawater is mainly a sodium chloride solution, the altered seawater near the base of the sediments is mainly a calcium chloride solution. Calcium increases to 270 mmol/kg, 27 times the concentration in seawater, by leaching from the volcanoclastics. Similarly, chlorinity increases by 20% owing to the removal of water during the formation of hydrous minerals such as clays and zeolites. The gain in Ca is balanced by the removal of 70% of the Na and the loss of nearly all of the Mg and K from the seawater during the formation of clay, smectite and zeolites. The rise in pH to 10 from the seawater value of 8.1 also reflects extreme alteration. Many of the pore water gradients in the top of the turbidites can only be supported by ongoing reactions, which is consistent with the fact that the volcaniclastics at this level are not yet completely altered. Deeper in the section, however, many of the geochemical gradients approach zero, implying that equilibrium has been achieved and that the geochemistry observed is that of “fossil” pore water.

Shipboard dating was difficult because of carbonate dissolution and fossil dilution by turbidites; however, we obtained a superb paleomagnetic inclination record in the pelagic sediments and a surprisingly good record in the turbidites. Based on these data, it is evident that the basement formed by submarine eruption in deep water near the equator during the Eocene, before 34.3 Ma, in an arc or back arc basin environment. Pelagic sedimentation began in the late Eocene, continued into the early Oligocene to about 30 Ma, and became mixed with and was finally overwhelmed by increasingly thick, coarse and energetic turbidites composed of arc-derived volcaniclastics. The composition and timing of the turbidites is consistent with a source to the east in the Kyushu-Palau Ridge, an arc active from 48 to 35 Ma (Arculus et al., 1995) that only began to subside ~28 Ma. The deposition of turbidites came to an end between the late Oligocene and the early Pliocene, and pelagic sedimentation resumed as subduction and volcanism shifted to the Marianas. Pelagic sedimentation then ceased about 5 Ma, presumably in response to bottom currents caused by a change in bottom circulation.

The principal objective at the site also was accomplished. A state-of-the-art borehole seismic observatory, built by the Japanese for the ION network and identical to one installed in the Pacific on Leg 191, was installed 50 m, or 560 mbsf, into basement. The observatory consists of two three-component digital seismometers, cemented into the basement and connected by an umbilical to battery and recording packages located on the seafloor in the re-entry cone (Figs. 2 and 3, next page). Recording will begin in March 2002 after final electrical connections are made during a visit by the Japanese ROV *Kaiko*.

KUROSHIO CURRENT

The final objective of the leg was to obtain a high resolution sediment section beneath the Kuroshio Current in order to study Quaternary climate change in the western Pacific. Reconstruction of a detailed climate record for east Asia for the last 1.5 m.y. was predicated on the successful drilling of a high sedimentation rate site in the Okinawa Trough, one of the few locations under the Western Boundary Current where the seafloor lies above the Calcite Compensation Depth (CCD) and calcareous microfossils would be preserved. The drilling results at Site 1202 were unexpected and spectacular, as at the previous sites. The recovered section consisted of 400 m of dark silty clays deposited at a rate of at least 3 m/k.y., one of the highest rates ever observed for fine-grained, fossiliferous sediments.

We infer that the section consists of reworked sediments from the Chinese mainland that were delivered to the East China shelf from the Yangtze River. If this inference is correct, the section at Site 1202 is almost ideal for studying climate change associated with glaciation and deglaciation in East Asia during the Holocene and latest Pleistocene. The top 130 m of sediment, recovered with the Advanced Piston Corer, contain excellent paleomagnetic, lithologic and biogenic proxies for climate at extraordinarily high time resolution of <100 years, assuming bioturbation to 20 cm. This resolution should be sufficient, in principle, to study the influence of climate on the rise of Chinese civilization.

LEG 195 SCIENTIFIC PARTY

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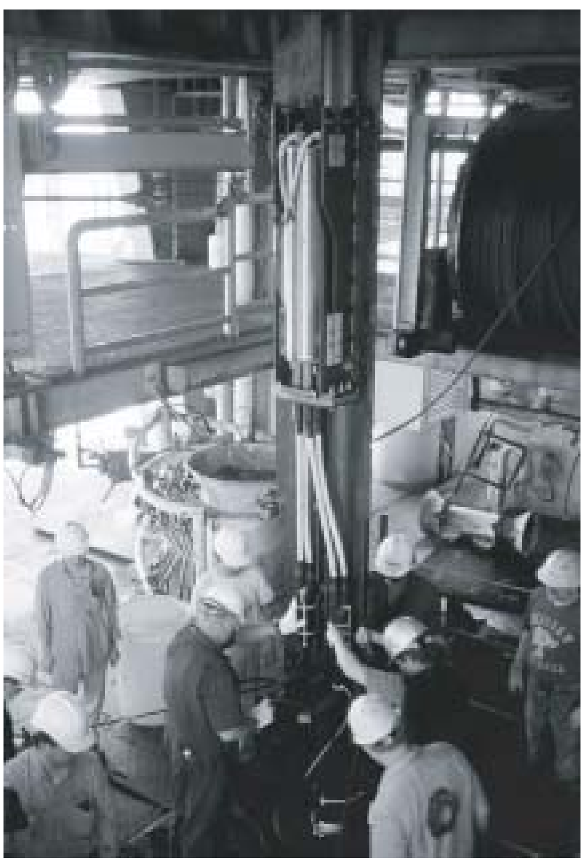

Figure 2 (left). *Leg 195 Sewing Club attaching umbilical cables to stinger during ION seismometer deployment at Hole 1201D.*

Figure 3 (right). *Remotely operated vehicle (ROV) landing platform installed in Hole 1201D; lithium batteries for ION seismometer are on lower level.*

IODP

Arctic Detailed Planning Group (ADPG) Final Report

Jan Backman [1] (Chair, JOIDES Arctic Detailed Planning Group)

EXECUTIVE SUMMARY

Over the past few years, there has been increasing awareness that the Arctic Ocean plays a fundamental role in the global ocean-climate system. Yet a remarkable lack of rudimentary information about this ocean's geologic history is available. Ocean Drilling Program (ODP) Proposal 533, "Paleoceanographic and Tectonic Evolution of the Central Arctic Ocean", directly addresses this critical lack of information. It proposes direct sampling of seafloor rocks and sediments that have accumulated over the Cenozoic and which record the evolution of the Lomonosov Ridge and the Arctic environment. The scientific importance of this proposal was confirmed when it was ranked number one by SCICOM at their August, 2000 meeting. The proposal is one of only a few within ODP that calls for the use of platforms other than the *JOIDES Resolution* (*JR*) because the *JR*, which does not have an ice-reinforced hull, is incapable of entering the central Arctic Ocean.

To better define the operational, logistical, and cost elements of this science proposal, and to develop a project implementation plan, SCICOM constituted an Arctic Detailed Planning Group (DPG) in December 2000. The mandate of the DPG included 15 specific tasks. These were discussed in two meetings (January 31-February 1, 2001 in Stockholm and June 18-19, 2001 in Washington, DC) by DPG members with the advice and guidance of three external consultants secured through Joint Oceanographic Institutions, Inc. (JOI).

We are pleased to report that all tasks in the mandate have been addressed. Our opinion is that, given recent advances in science and technology, an Arctic expedition to accomplish the scientific goals of ODP Proposal 533 is logistically and operationally feasible.

INTRODUCTION

The Working Group was charged by the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) to complete a series of tasks designed to describe the technical, financial and logistical aspects for completing JOIDES Proposal 533, a scientific drilling program in the central Arctic Ocean. The goal was to develop a project plan to conduct Proposal 533 as an ODP expedition, or "leg". This report describes the work of the DPG on a task-by-task basis, based on its members' expertise, the advice of special consultants contracted by JOI, and guidance from other external experts and advisors.

TASK 1. DRILLING: PLATFORMS, RIG AND EQUIPMENT

Platforms

To function in the central Arctic Ocean, the DPG defined the following basic criteria:

1. A drilling platform must be "ice-class" to operate in the central Arctic Ocean (this does not mean that the platform must be able to break ice; it can be towed by, or steam behind, icebreaker(s)).
2. The platform must be equipped with a dynamic positioning (DP) system.
3. The platform must be equipped with a moonpool to enable drilling.

The potential drilling platforms that can fulfill, or that can be modified to fulfill, the above criteria were identified and include:

- Finnish icebreaker/drillship *Botnica* (96.7 m; www.fma.fi), built in 1998. *Botnica*, a DP vessel with a moonpool, is not built for breaking Arctic ice, but can operate in the Arctic Ocean if assisted by ice-breaker(s).
- Canadian-built drilling barge *Sea Sorceress* (114 m; www.caldive.com), built in 1983. This platform was assessed by a marine architect (see JOI report, November 2000: "Alternate Platform Evaluation for ODP 533", Report 99019-01). The DP system requires evaluation to ensure that it could function in Arctic ice. A few other ice-classed Canadian barges exist: *Arctic*

Immerik Kamotik (sister to the *Sea Sorceress), Arctic Tarsuit, Arctic Breaker,* and *Arctic Tuk.* To participate in an Lomonosov Ridge expedition, these platforms would require modifications, either installation of a moonpool or DP, to meet the basic criteria.

Because the *Botnica* meets all criteria without modification, the DPG ranked this platform the highest. Lengkeek Vessel Engineering evaluated the *Botnica* for its suitability as a platform and provided a technical report to JOI.

The *Botnica* has DNV icebreaker class 10; the vessel can enter the Arctic, but it cannot perform heavy icebreaking and can work in the Arctic if supported by heavy icebreakers. *Botnica* has two limitations: she has limited fuel capacity (approx. 30 days) and the moonpool must be modified to protect it from ice damage during transit. Each of these identified limitations can readily be addressed and overcome. The Swedish icebreaker *Oden* has enough fuel capacity to refuel the *Botnica* during the expedition. Lengkeek proposed a moonpool modification that is technically simple and costs $100K.

At the first meeting of the DPG, a third drilling platform option was considered. This option involved the use of the *Oden*, with icebreaker support, as is the case with the other options. This option was evaluated in one of the contracted studies (Seacore Ltd.). *Oden* was assessed to be ill-suited as a drilling vessel primarily because of the limited deck area for handling and storing drillpipe. Consequently, in this final report, the DPG removed the *Oden* as one of the potential drilling platforms.

Drill Rig and Equipment

Several different drill rigs and equipment (drill string, bottom hole assemblies, and sampling / logging tools) are available for installation on the preferred drilling platform. The DPG defined primary requirements for drilling equipment as capable of:

- being mobilized on the selected drilling platform;
- recovering continuous core in mud, and mudstone lithologies;
- sampling to a total depth of 1800 m (water depth and depth below seafloor);
- taking a core with a diameter no smaller than the current ODP size (ca. 5.8 cm).

DPG members recognize the benefit of a drilling system that can handle ODP drill string. This would enable deployment of ODP tools, specifically the advanced piston corer (APC), the extended core barrel (XCB), and possibly the rotary core barrel (RCB), that are the sampling tools of choice for paleoceanographic objectives such as those in Proposal 533. Heave compensation may not be required given Arctic sea conditions.

External evaluation of these systems, and their recommended configuration for each of the proposed drilling platform options, was conducted by Seacore Ltd., under contract to JOI. Their results, in a report to JOI delivered on June 18, 2001, were reviewed by the DPG and incorporated in the following description.

Drill Systems Evaluation

Seacore evaluated a range of drilling systems and found that the C100 and C200 rigs are suitable for either of the two drilling platforms. Of the two, the C200 is preferred because it:

- has greater load capacity (improved pipe length and pullout ability);
- is better able to structurally span the moonpool on either vessel;
- is larger, and thus safer, in terms of work area (sample and drill deck); and
- has an ease of bracing given its more rigid frame.

The DPG recommends the C200 system. The C200 can be used with either the ODP-type drillstring (API 5” diameter) or aluminum drillstring. ODP/TAMU (Texas A&M University) may be able to supply this expedition with two full drill-strings. Furthermore, the drillstring is fully compatible with the coring tools the proponents recommend to meet the scientific objectives. The advantage of aluminum drillstring is that, with some modification, its single bottom hole assembly (BHA) can accommodate a wider range of sampling tools than the ODP BHA. In addition, the wider bore of the aluminum pipe would decrease wireline trip time and speed up operations. The DPG recommends selection of one of these two drillstring options (API or Aluminum) so that the APC, the XCB, and the RCB can be used to meet the paleoceanographic and tectonic objectives of Proposal 533.

Mobilization

The C200 is a containerized mobile drilling system which is deployed by following a simple mobilization and demobilization strategy. Mobilization time is estimated at 4 to 5 days. The containerized system requires little in port other than a suitable berth and adequate cranes. The berth needs to be on a hard-standing quay with a suitable lay-down area to temporarily store the equipment to be installed; a space of 400-600 m^2 is ideal. An ideal crane system will be capable of at least 25 tons capacity and has a radius that will extend to the vessel's moonpool. Dockyard welders also will be needed to secure the base of the rig to the ship and to install sea fastenings.

Shakedown

Seacore evaluated the need for testing the drilling and sampling system and recommended that 1 to 2 days should be dedicated to sea trials. Two options were proposed. One is to schedule trials immediately after expedition mobilization in a location proximal to port. The second option is to test the system on the selected platform, on an opportunity basis, one year or less before the expedition. Opportunities may arise where the combined vessel and drilling system could be used for another project. In this option, ODP would partner with the project to test the coring tools selected (APC, XCB, RCB) at an appropriate site near the location of the contracted work. For example, given other interests that have been expressed, it is possible that this system could be used in the North Atlantic (Rockall, Faroes, and West of Ireland) in 2002.

The DPG recommends that ODP attempt to partner with another project, on an opportunity basis, to test the drilling system on the selected vessel in advance of the Arctic expedition, perhaps in the North Atlantic. This would enable ample testing and would allow time between the test and the expedition for any required modifications.

Coring Time Estimates

Seacore analyzed the times to sample and log the sediment and rock intervals required to meet Proposal 533 science objectives. These times fit well within the planned program time and no modifications are required.

Other Performance Issues

Seacore did not find any major characteristics that would adversely affect the performance of the drilling system on either the *Sea Sorceress* or *Botnica*. However, they provided comparison comments on the two platforms. Because of the size and dimensions of *Botnica's* moonpool, Seacore preferred this platform. This preference is fully consistent with the DPG's priority of platforms.

Downhole Logging

In addition to cores, logging data will help achieve the scientific objectives. Logs will provide *in situ* measurements of physical and chemical properties of the sediments on Lomonosov Ridge for correlation with seismic records, and for use as a continuous paleoceanographic proxy record of climate and environmental change. Logging tools that measure natural gamma, porosity, density, resistivity, acoustic velocity, and magnetic susceptibility are desirable. All of these tools are available from Schlumberger and have been used on the *JR*. Tools on the *JR* are combined into three tool "strings", each about 30 m in length and each requiring about 7 hours of wireline deployment for operations in water depths at the Lomonosov Ridge sites. Seacore determined that this system is compatible with the C100 and C200 rigs.

The DPG received recommendations from ODP's Logging Services Operator on two options to log Lomonosov Ridge: using the ODP Schlumberger tools and using tools from another service provider. Alternate service provider options are included to demonstrate the range of options available for this project. Any logging service provider option requires the following components:

- Sheave and a wireline logging cable at least 2000 m long;
- Logging container for data acquisition and analysis computers;
- Container laboratory and storage space;
- Logging tools, and
- Logging engineer.

The alternative option provides flexibility in terms of logging time and cost, but some service providers may have a limited suite of tool types compared with Schlumberger (Table 1). The DPG recommends that the logging services provider be selected by a bidding and negotiation process. This competitive process could either be incorporated into the drilling services contract or done separately through ODP Logging Services after the drilling contractor has been selected.

TASK 2. WEATHER WINDOW

Optimal ice conditions for icebreaker operations occur during August and early September. Therefore, it is recommended that the program begin during the first week of August (2003). The plan calls for leaving the pack ice 35 days later, in early or mid-September. Transit times to the rendezvous point for starting the drilling leg at the ice edge will vary among platforms, depending on each of their respective mobilization ports.

The DPG envisions a 35-day operation within the pack ice, from the ice edge to the drill sites and back. The 35 days include a 5-day transit from the ice edge at ca. 80°N to the key paleoceanographic sites located near 87°N, 25 days onsite, and 5 days transit back to open waters. Variations in regional ice conditions will determine the optimal location for entering the pack ice which can be anywhere between Svalbard and the Kara Sea, perhaps even the Laptev Sea. Drilling operations of 25 days is considered sufficient to achieve the major scientific objectives of Proposal 533.

TASK 3. ICEBREAKERS

During icebreaking, the prime objective is to transit as quickly as possible through a region with minimal fuel consumption and vessel damage. The strategy, therefore, is to avoid thick ice, follow leads, and identify (and avoid) ice environments that add to the likelihood of vessel damage and increase resistance to vessel passage. Vessels follow courses that may not be straight in order to minimize energy consumption and exposure to damage.

This strategy, to be followed while the vessels are in transit, is in contrast to ice management strategies used when the vessels are configured for drilling operations. Ice management requires direct engagement of difficult ice to ensure that floes do not impact the stationary drilling platform. The ice management vessels must follow the direction of ice movement to ensure that whatever ice approaches is reduced to a tolerable level for the drilling vessel.

The operational strategies of ice transiting and ice management have a significant bearing on the command structure of the operation, planning, fuel consumption, and crew fatigue. The general strategy for ice management, while on station, calls for the largest vessel assigned to break ice to be positioned first, 3-4 km up drift. This distance would provide 2-3 hours of advance notice of ice conditions. This vessel would also break a wide enough swath to allow room for drift direction shifts. The more maneuverable vessel(s) will work inside a 1.5-km radius to manage the ice, reduce it to small floe sizes, and maintain ice-free space around the drilling platform to allow ice to drift past.

These strategies, expert advice from the icebreaker captain and ice management experts

	Schlumberger Slimhole Tools	Example Alternative Wireline "Compact" Tools
Tools	1. Gamma/ porosity/ density/resistivity 2. FMS/sonic velocity	1. Gamma/porosity/ density/sonic 2. FMS-style tool (under development)
Type	Wireline	Wireline or Memory or Thru-bit
Time	23 hr	7 to 12 hr, depen-ding on deployment and type
Cost	$363,000	ca. $200,000

Table 1. *Logging options for the proposed Lomonosov Ridge program.*

at the November 2000 DPG meeting, and subsequent group discussions resulted in two different platform configuration options. “Arctic Armada” Options A and B can meet the scientific objectives of the DPG.

Arctic Armada Option A

The highest ranked and preferred option consists of three vessels: the *Botnica* as the drilling platform and two supporting icebreakers, one of several available 75,000 hp Russian nuclear icebreakers (NIB), and one hunter icebreaker (HIB). Two possible HIBs are the *Oden,* a 24,500 hp vessel that will be provided by Sweden, and the Canadian *Terry Fox,* a quick, highly maneuverable ship capable of breaking and moving smaller floes.

Arctic Armada Option B

This, the second ranked Armada option, is comprised of four vessels. The *Sea Sorceress* will be the drilling platform supported by three icebreakers: a Russian NIB, the *Oden* provided by Sweden, and the *Terry Fox* of Canada. The *Terry Fox* would remain close to the drilling platform to protect the vessel from any impact by bergy bits. This added support for Option B is needed because the *Sea Sorceress* does not have a powerful propulsion system that can aid the DP when small ice (bergy bits) hit the barge. The *Terry Fox* is ideally suited since it was built for this type of work in the Beaufort Sea and inshore Newfoundland.

TASK 4. ICE FORECAST

Ice forecasting is important to select general transit routes. However, the transiting phase through the pack ice is less difficult than the drilling phase, when dynamic positioning of the drilling vessel must be maintained continuously. Therefore, ice forecasting during drilling is essential for making decisions on the relative positions of the vessels ahead of the drilling platform, for deciding optimal icebreaking modes, and for long-term forecasting of the predominant heading of ice movement.

Ice forecasting also is used to establish operating limits for the DP vessel, such as:

- Maximum floe size ice thickness and ice concentration allowable, and
- Minimum width of the open channel that must be maintained around the vessel.

During Beaufort Sea drilling operations, Canadian Marine Drilling (CANMAR), Gulf Canada Ltd. and Imperial Oil Ltd. developed techniques for “managing” ice for their summer and winter drilling operations. These techniques became known as “ice management systems” (Clark et al., 1997).

These systems are built upon a combination of ice monitoring techniques and icebreaking methods such as break or deflect. The systems include techniques for surveying both regional and local ice conditions. Air photographs, obtained by satellites and airplanes, and synthetic aperture radar (SAR), developed by CANMAR in cooperation with the Canadian Centre for Remote Sensing, comprise the basis for regional ice reconnaissance.

Ice management requires precise and reliable ice monitoring systems that include access to satellite imagery (RADARSAT), airborne SAR, helicopter reconnaissance visual observations of local ice conditions, and weather forecasting. The ice monitoring information is used to develop the icebreaking and management operations on a daily basis (e.g., distances from the drill platform, headings for all vessels, whether to break ice or move it away).

On behalf of the DPG, JOI contracted the Swedish Polar Secretariat to recommend a weather and ice monitoring plan and determine the cost of such a plan. This group, in turn, engaged other experts from Russia (AARI, INTAARI, and Northern Sea Route Administration); Finland (Finnish Maritime Administration), and the Swedish Maritime Administration. The completed plan was delivered to JOI on June 18, 2001.

The ice forecasting plan is based on recommendations for planning the expedition, transiting to drill sites, and drilling operations. The most critical drilling operations component requires three different forecasting systems for weather, ice-drift, and ice type/thickness to make the following decisions:

- To select the region and site to drill;

- To decide the time to start drilling; and
- To decide during drilling if and when emergency pull-out is required.

Site Selection and Initiation of Drilling

The forecasting system will be used to identify, at a minimum, a 48-hour window at one of the proposed sites where ice conditions are favorable. Once this has been done, a 3-day forecast for the site will be prepared for wind direction and speed and the distribution of high and low pressure systems. Global positioning satellite (GPS) transmitting units will be placed in a grid pattern on ice floes in the site region to begin collection of real time ice drift, direction and speed measurements. Ice reconnaissance helicopter flights will locate any giant floes or icebergs in the region.

Drilling Operations

During drilling operations, data are needed to guide decisions about the position and operation of the NIB and the HIB. Forecasting during this time will include real time GPS ice drift, plots of ice floe type and thickness drawn from helicopter reconnaissance, and weather forecasts. These data also will provide advance warning of large floes to enable pulling out of the well to wait on ice conditions.

TASK 5. COMMUNICATIONS

The DPG recommends that a communication plan be established that is similar to, if not identical, to the ODP plan. This plan includes the following reports that are the responsibility of the co-chief scientists, the drilling superintendent and the staff scientist:

- Preparation of a daily drilling summary by the operations manager onboard the drilling platform,
- Preparation of a daily ice management summary and forecast, and
- Preparation of a weekly science summary by the co-chief scientists.

These reports should be sent to ODP/JOI, ODP/TAMU, ODP/LDEO (Lamont-Doherty Earth Observatory), and the JOIDES Office daily or weekly, depending on the report, using Maritex transmission. All vessels are equipped for this transmission type. Communication among the Armada will be based on standard high-frequency (HF) radio transmission.

The U.S. National Aeronautics and Space Administration (NASA) used their Tracking and Data Relay Satellite for data exchange with a team of government researchers in the Arctic in 1999. Six satellites flew over the North Pole as the researchers worked on the ice. The DPG recommends that ODP investigate and, if appropriate, request this type of communication for the drilling period in 2003. This would provide full, continuous email and Internet communication for the leg.

In addition to routine reports, this program's vessels would follow their respective emergency communication plans and strategies in the event of an accident. Each vessel recommended here already has plans in place that meet this requirement and have been approved by their national standard associations and external auditors (e.g., Lloyd's Registry).

The plan should remain flexible in order to incorporate the latest technological developments. Many ships will be traveling to the Arctic in the next two seasons, and work will be done on improvening various communication devices. Therefore, this proposed plan should be revised to include newly tested and proven systems. A new Canadian Standards Association standard (S475) also exists that includes multiple vessel operations where one central individual is responsible for management of the flotilla and, therefore, all associated communications. A final communication plan should be developed to this new standard.

TASK 6. CONTINGENCIES

Scientific and operational contingencies must be considered. The ability to achieve the scientific objectives will depend, to some extent, on the severity of the ice conditions.

The proponents have developed an ideal plan to address this need for contingency by including alternate regions for meeting the scientific objectives. The alternate sites are distributed over a 360 nm long and 40 nm wide stretch along the crest of the Lomonosov Ridge. In the event the primary sites have conditions too severe for operations, it is highly likely that one of the other regions, located up to 360 nm away, will have better ice conditions.

Operational contingency plans need to be prepared in order to minimize the impact that unforeseen events might have on the whole operation. Possible scenarios include:

- Loss of drill string;
- Engine breakdown to an icebreaker;
- Serious fire onboard a vessel; and
- Serious injury, illness or loss of life.

Protection against some of these scenarios can be achieved by ensuring that adequate quantities of spares and self-maintenance capabilities are available. For example, a drill string of up to 1800 m in length is needed for successful operations. At least two complete drill strings should be carried in case one is dropped or damaged.

The multi-vessel nature of drilling on the Lomonosov Ridge adds a significant degree of protection against the risks that a vessel may suffer, such as fire or flooding. Vessels will always be nearby to provide assistance in this program. The breakdown of a single icebreaker could force operations to halt by preventing ice management. To minimize this risk, the DPG has proposed only proven, well-maintained, reliable icebreakers for this program.

All of the proposed icebreakers, except the *Sea Sorceress*, have medical personnel and hospital facilities on board to handle medical emergencies; *Oden* and *Botnica* include medical doctors on high Arctic expeditions. Medical emergency evacuation guidelines for transfer of personnel to hospital in 24 hours must be included in the plan. The Northern Sea Route Administration holds this responsibility for the NIBs, and they incur the costs including those for large, long-range helicopters.

A detailed communication plan must be provided that explains all possible emergency strategies that will be followed. It is recommended that a standard Health, Safety and Environment (HSE) plan that is normally used for multiple vessels in the offshore oil industry be developed. In these plans, a Bridge Document is used to define the roles of each vessel and bring them together under one plan.

TASK 7. LIABILITY

Two general types of civil liability must be addressed for all types of operations:

- Loss of life and personal injury; and
- Property claims, such as damage to ships, property, or harbor works.

In a recent development specific to marine operations, the International Maritime Organization (IMO) established a global liability and compensation regime for spills of oil carried as fuel in ship's bunkers. Protection against liability or indemnification is typically carried by ship owners in two forms: (1) establishment of standards and procedures that ensure a high level of performance to reduce risk; and (2) by insurance. Vessels owned by some nation states (e.g., Canada) do not carry insurance because the nation agrees to indemnify without relying on insurance companies.

Once the final vessel selection is made for the Arctic Armada, each of the individual vessel insurance plans should be reviewed to ensure they have adequate limits on liability. Also, the collective or "global" multi-ship program, as defined in a Bridge Document, should be reviewed from a liability perspective to define any additional insurance or HSE procedure guideline requirements.

In summary, the Program's liability protection should be developed under the direction of a project manager by:

- Definition of each partner or vessel owner's risk and their coverage;
- Definition of any global risk and required coverage;
- Definition of any vessel interface risk and required coverage;
- Evaluation of any third party risk and recommended coverage, if required; and
- Specification of the Program's operational and environmental guidelines, following industry and government standards as outlined in Task 8 HSE documents.

TASK 8. ENVIRONMENTAL IMPACT

The proposed program is in international waters where no national environmental regulations apply. However, the Arctic is recognized as a sensitive region of the world and stringent pollution protection procedures must be followed.

An Environmental Impact Statement (EIS) should be incorporated into the charter party agreement. It is suggested that this program follow the new draft IMO guidelines for Arctic operations. We should also look at the very stringent Antarctic rules to ensure that we follow a strict precautionary approach.

ODP, as a US-led program, currently has an EIS on file with the US Environmental Protection Agency (USEPA) that does not include operations in the Arctic Ocean. The EIS must be modified for the Arctic and submitted to USEPA for approval. Modifications should utilize three existing documents:

- New IMO Guidelines for Arctic ship operations;
- Antarctic environmental guidelines for marine operations; and
- The Swedish Polar Secretariat's EIS for *Oden*.

This EIS will establish the environmental component of the program's HSE guidelines that must be included in all subsequent commercial agreements. Insurance providers and governments, if they indemnify, also will require assurance regarding compliance of these guidelines. This assurance is normally achieved by third party surveys and audits (e.g., ABS or Lloyd's Registry) to ensure that all parties, such as ship owners and contractors, are compliant with the agreements.

TASK 9. TO BE ODP OR NOT TO BE ODP?

The advantages of conducting Proposal 533 within a scientific ocean drilling program outweigh any possible disadvantages. The science of Proposal 533 is currently the highest ranked within ODP, and the proposal was written within the ODP framework to optimize the scientific return.

The specific advantages, in terms of science, include:

- paleoceanographic methods developed within ODP are the best in the world for the recovery of a complete sediment record;
- the ODP science operations infrastructure can efficiently deliver the science objectives as well as publish the results; and
- ODP staff experience to plan and conduct paleoceanographic legs cannot be duplicated.

Conducting this program within ODP also has advantages for ODP itself. In ODP's Long Range Plan, both Arctic research and the use of other platforms are highlighted goals. By conducting Proposal 533 within the program, ODP demonstrates that it can deliver the majority of its goals set out in the Long Range Plan. This demonstration is beneficial for all nations to justify new funding in the next program, the Integrated Ocean Drilling Program (IODP). At a recent science planning workshop for IODP (e.g., COMPLEX and APLACON), the Arctic and alternate platforms were again highlighted as essential. The Proposal 533 expedition, if conducted within ODP, will provide the Program with knowledge and experience for conducting mission-specific research in the Arctic and elsewhere that will be essential to a successful IODP.

TASK 10. LABS & DATA

Laboratory environments for Arctic drilling will be highly dependent on the platform chosen for drilling and coring operations. Laboratory needs could span the range from simply packaging up the cores for off-loading at the end of the cruise to a shipboard environment with analytical capabilities similar to those on the *JOIDES Resolution*. Three laboratory scenarios are outlined below. They range from an environment that considers only the most essential laboratory functions to one in which cores are split on the platform. All scenarios assume that no pre-built integral laboratory space is available on the platform.

Essential Laboratory Functions

At a minimum, basic core storage and safety (e.g., hydrocarbon) monitoring are essential. In this scenario, cores would be monitored for hydrocarbons and then properly marked/stabilized/packaged, stored in a climate-controlled container, and transported to a shore-based repository/laboratory at the end of the leg. Three climate controlled containers would be required on the drill platform, including a containerized laboratory with gas chromatographs (and, potentially, Rock Eval and CNS units), a container for core marking/stabilization/packaging, and at least one container for core storage.

Additional Laboratory Functions

Given the efforts put toward the planning and implementation of this leg, and the high scientific interest in this first major drilling effort in the Arctic, a larger suite of laboratory facilities should be considered if space is available. In addition to essential safety and curation functions, additional container-housed facilities for whole-core physical property work with a multi-sensor track, basic micropaleontological age dating, and deep-biosphere analyses could be added.

Split-core Laboratory Functions

The next incremental consideration is that of splitting the cores on the platform for at least one hole from each site. This scenario incorporates the laboratory needs of the previous two scenarios (core curation/storage, hydrocarbon monitoring, whole-core multi-sensor analyses, micropaleontological age dating, and deep biosphere analyses) plus needs for core splitting and core description containers. Core description involves, at a minimum, macroscopic and microscopic descriptions, digital line-scan photography, and split-core spectral imaging. Some of the required equip-ment could be housed in the same container as the whole-core multi-sensor track. Additional chemical/biological and physical property analyses in separate container(s) could be considered on a space availability basis.

Other Considerations

The modular laboratories for an alternate platform environment will likely be supplied or leased by interested investigators. ODP-TAMU does not have the duplicate whole-core and split-core equipment readily available for use on alternate platforms. Most, if not all, of the modular equipment/laboratories outlined above, including core splitters, exist at institutions around the world and have been used on research vessels for years. The instruments or laboratories usually have their own very capable data-capture systems. A standard output format can be specified so the data can be uploaded into the ODP JANUS database at the end of the leg. Commercial, off-the-shelf, or readily available applications could be utilized for core descriptions (e.g., those used by the Hawaii Drilling Project). These packages have the basic information needed for graphical and text-based core descriptions and have a variety of output formats.

Flexibility is the *key* consideration. To the extent possible, all laboratories should be modular, using standard 20-ft shipping containers. This approach would minimize preparations on the platform and mobilization costs.

TASK 11. COSTS

The DPG received cost estimates from operators of all of the platforms. DPG members experienced in managing mission-specific programs prepared the other costs, based on recent experience in the Arctic and elsewhere. For cost estimates that had a range, based on this experience, the highest cost estimate was selected and used. The DPG incorporated the cost submitted in the contracted studies.

The grand total estimated cost for Arctic Armada Option A is approximately \$8.6M (Table 2; next page). Of this total, about \$2M can be considered to be “normal” ODP science operational costs, \$0.9M will be contributed by Sweden as the cost of *Oden*, and some costs will likely be contributed by individual scientists and labs lending laboratory and containers to the expedition. Table 3 (next page) summarizes these contributions; the resulting net total cost is \$5.3M.

Itemized costs for Arctic Armada Option B total approximately \$9.4M (Table 4, next page). Contributions by Sweden and other sources are as in Option A. Table 5 (next page) summarizes these factors; the resulting net total cost is \$6.1M.

TASK 12. EXTERNAL FUNDING

Two potential sources of external funding, one within the framework of ODP and the other completely separate from ODP, would require different strategies for solicitation of support.

Because of the clear advantage of completing this science within ODP, identification of "external" funding that could be achieved within the ODP framework is important. Four such options are:

1. "In-kind" vessel support similar to the contribution from Sweden;
2. Innovative management; i.e., exchange the *JOIDES Resolution* with the *Botnica*

Costs	Explanation of Costs
$ 4,580,000	*Botnica*, *Oden*, NIB day rate total
945,000	Drilling system
440,600	Project managers
400,000	Laboratory equipment
350,000	Sea trial & shakedown
363,000	Downhole logging
306,540	Sub-managers
230,000	Environmental & ice management
160,000	Other drilling & BHAs
150,000	Helicopter sevice
125,000	Container purchase
120,000	Coring tools
100,000	Moonpool modification
90,000	Expedition supplies
68,250	Technical staff
50,000	Container shipping
50,000	Travel to/from port
50,000	Global program insurance
15,000	Planning meetings
5,000	Port call expenses
$ 8,598,390	**Total**

Table 2 (left). *Arctic Armada A Itemized Costs.*

Costs	Explanation of Costs
$5,550,000	*Sea Sorceress*, *Oden*, NIB, *Terry Fox* rates
945,000	Drilling system
440,600	Project managers
400,000	Laboratory equipment
350,000	Sea trial & shakedown
363,000	Downhole logging
306,540	Sub-managers
230,000	Environmental & ice management
160,000	Other drilling & BHAs
150,000	Helicopter sevice
125,000	Container purchase
120,000	Coring tools
90,000	Expedition supplies
68,250	Technical staff
50,000	Travel to/from port
50,000	Global program insurance
15,000	Planning meetings
5,000	Port call expenses
$ 9,360,390	**Total**

Table 4 (right). *Arctic Armada B Itemized Costs.*

Grand Total	$ 8,598,390
Total Science Operations	2,050,390
Sweden Contribution	900,000
Other Contribution	325,000
Net Total Cost	$ 5,323,000

Table 3 (left). *Arctic Armada A Net Costs.*

Grand Total	$ 9,360,390
Total Science Operations	2,050,390
Sweden Contribution	900,000
Other Contribution	325,000
Net Total Cost	$ 6,085,000

Table 5 (right). *Arctic Armada B Net Costs.*

because DSND, Ltd. operates *Botnica* and owns 50% of the *JOIDES Resolution*;
3. Early termination of the third-tier subcontract within the ODP with Offshore Drilling Ltd. and establishment of another contact with DSND Ltd. to supply the drilling platform for Proposal 533; and
4. Request more funding through the ODP Council at a cost of approximately $3M for the US and $750K for each full member (less if associate members contribute).

For truly external funding, the proposal would have to be submitted to the national science funding agencies of the 11 proponents (Sweden, United States, Norway, Germany, Canada and Denmark). A "membership" fee from each of the national agencies should be established, and it is recommended that the proponents set up "rules" for scientific participation similar to the current ODP. A Memorandum of Understanding would be needed to cooperate and obtain access to ODP drilling tools and, potentially, other support services.

The major issues with this approach are (1) the funding agencies are the same as those that now fund ODP; some may have the view that "they already paid at the office", and (2) the timing is tight for getting funds to take advantage of the Swedish contribution in 2003.

TASK 13. LIMITING FACTORS

The two factors that control the program's ability to complete the scientific objectives are not different from any other ODP leg. These factors are (1) limiting the funds that are made available for the equipment and facilities needed to complete the science, and (2) the weather conditions that can restrict drilling operations. For the special case of Proposal 533, budgets are needed for a special platform. However, the DPG has provided recommendations that address this factor (see Task 12). In terms of weather, the limiting factor in the central Arctic Ocean is the sea ice conditions. The proposed location is one of the most favorable in the Arctic Ocean in terms of ice thickness (typically first and second year ice). Also, the DPG has recommended vessel support and alternate sites to ensure that this factor is a very low risk.

The DPG emphasizes that modern science and technology has brought Arctic operations into the realm of normal marine operations. Scientific programs are conducted now from surface ships in the Arctic pack ice each field season, and several trips taking tourists to the North Pole also occur each summer. During the discussion, it was noted that "it's time to dispel the myth that Arctic operations are an insurmountable challenge."

TASK 14. PROJECT MANAGEMENT

The management requirements for Proposal 533 are similar to those of other ODP legs with the addition of ice management expertise. As in the ODP, there should be an overall project manager who oversees the planning of the program and begins efforts, on a full time basis, 2 years prior to leg implementation. This person should have Arctic experience, and a good knowledge of drilling management. The successful candidate would work closely with the co-chiefs and ODP contractors and be responsible for:

- Developing the Requests for Proposals and/or contracts for vessels and services;
- Working with ODP managers to schedule and coordinate their services;
- Developing an HSE plan;
- Overseeing, through contract, the development of an insurance plan once the vessels have been selected;
- Preparing the EIS;
- Coordinating and running necessary planning meetings; and
- Providing routine reports to JOI, JOIDES, NSF, the selected subcontractors and the ODP contractors on all planning activities.

In addition, this planning effort should be supplemented, starting 8 months prior to the beginning of the leg, by contracting the lead expedition managers: a drilling/coring operations manager (this position could be an existing ODP engineer), a science operations manager (this position could be an existing ODP staff scientist), and an ice and vessel manager to oversee subcontractors.

During the expedition, the selected ice and vessel manager would be the head of the expedition in the field, and all other field managers would work under his/her direction. The person selected for this position should have Arctic operational management and multi-vessel drilling expertise. This manager will develop the reporting structure for all field operations. The DPG discussed example management structures, but the selected expedition leader should be allowed the flexibility to develop the best possible field management team and structure.

TASK 15. TIMELINE

The DPG developed a schedule to implement Proposal 533 within ODP (Fig. 1). The major milestones are: a dedicated manager, starting in October 2001; request for bids for vessels and services in spring, 2002; the selection of the expedition manager in April 2002, and vessel selection by September 2002.

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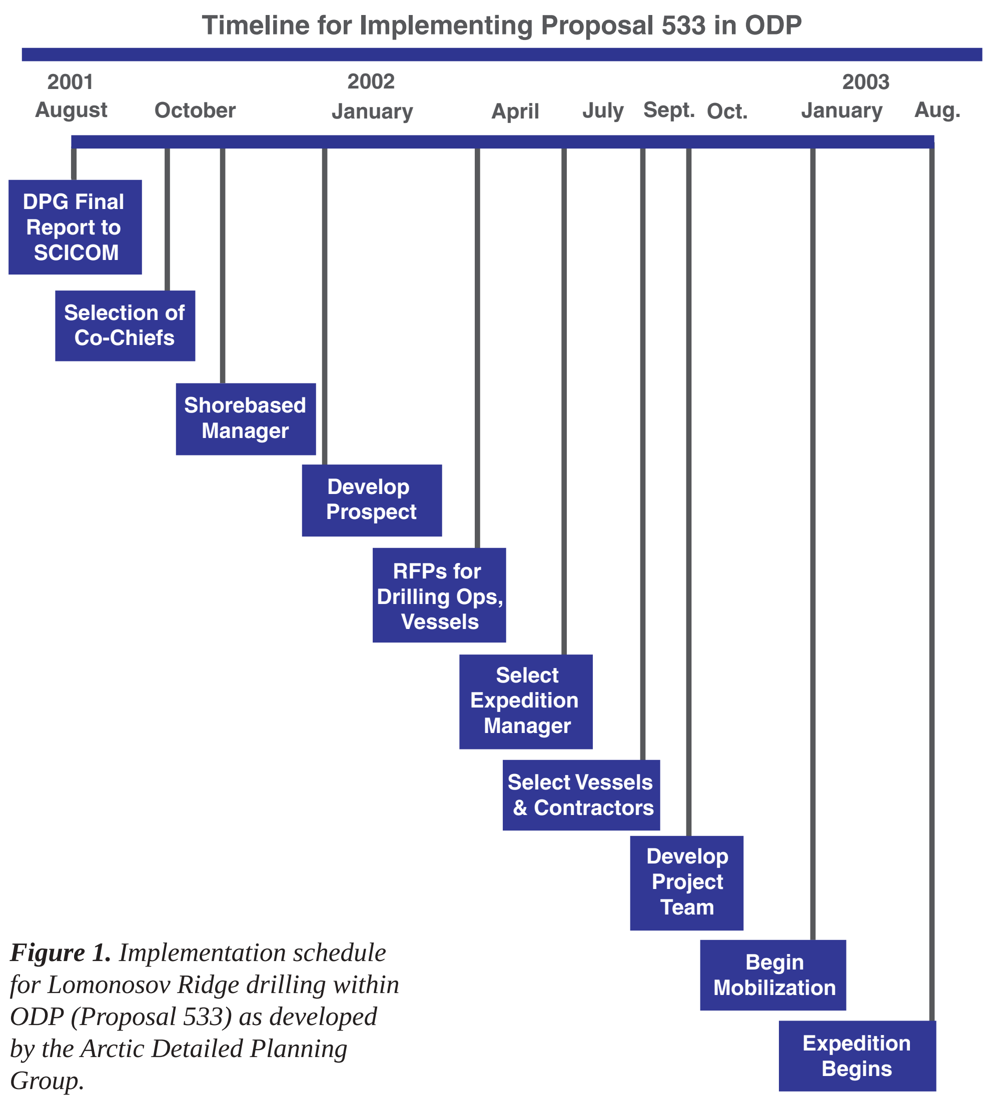

Figure 1. *Implementation schedule for Lomonosov Ridge drilling within ODP (Proposal 533) as developed by the Arctic Detailed Planning Group.*

SCIENCE
FY 2003 Operations Schedule

ODP

Scheduling of the FY2003 Drilling Program: The Final Year of ODP Operations

Keir Becker (Director, JOIDES Office)

THE PROCEDURE

At its August 2001 meeting, SCICOM considered 23 externally reviewed proposals for the final year of ODP operations. Ten proposals were carried forward from the August 2000 meeting, and thirteen proposals were forwarded since then by the SSEPs. The proposals were considered primarily in terms of their relevance to the objectives and priorities of the ODP Long-Range Plan. SCICOM discussions and evaluations were guided by a process mandated by EXCOM in 1998 that includes four principal steps: (1) defining the pool of proposals to be ranked, then thoroughly discussing each one, (2) ranking by signed ballots, (3) selection of ranked proposals to forward to OPCOM for possible scheduling, and (4) acceptance of an OPCOM-recommended schedule by simple-majority SCICOM vote. The final step is formal approval by EXCOM at its January 2002 meeting. This report of the SCICOM-recommended FY2003 schedule should be considered provisional pending EXCOM approval.

Table 1. *Guide to JOI/ODP and iSAS/IODP acronyms used in this article.*

JOI/ODP/iSAS/IODP ACRONYMS

JOI -	Joint Oceanographic Institutions
JOIDES -	Joint Oceanographic Institutions for Deep Earth Sampling
ODP -	Ocean Drilling Program
NSF -	National Science Foundation
JR -	*JOIDES Resolution*
EXCOM -	Executive Committee
SCICOM -	Science Committee
OPCOM -	Operations Committee
ESSEP -	Science Steering & Evaluation Panel - Earth's Environment
ISSEP -	Science Steering & Evaluation Panel - Earth's Interior
PPG -	Program Planning Group
DPG -	Detailed Planning Group
APC/XCB -	Advanced Piston Corer/Extended Core Barrel
CORK -	Circulation Obviation Retrofit Kit
FY2003 -	Fiscal Year 2003
ION -	International Ocean Network
LWD -	Logging While Drilling
MAR -	Mid-Atlantic Ridge
mbsf -	meters below seafloor
MSP -	Mission-Specific Platform
RCB -	Rotary Core Barrel
IODP -	Integrated Ocean Drilling Program
iPC -	interim Planning Committee
iSAS -	interim Science Advisory Structure

REVIEW AND RANKING RESULTS

Proposal reviews were conducted in groups according to major themes of the Long-Range Plan. SCICOM members voted by signed ballots to determine a global scientific ranking of all 23 proposals, including those requiring mission-specific platforms (MSPs). After tabulation and presentation of the rankings, SCICOM decided by consensus to send the top thirteen ranked proposals to OPCOM for development of possible drilling schedules.

Rank	*Proposal*	*Short Title*	
1	533	Lomonosov Ridge	MSP
2	525	MAR Peridotite	
3	559	Walvis Ridge	
4	522	Fast Spread Crust	
5	577	Demerara Rise	
6	519	S. Pac. Sea-Level	MSP
7	557	Storegga Slide	
8	564	New Jersey Shelf	MSP
9	594	Newfound. Margin	
10	548	Chicxulub	MSP
11	575	Gulf of Aden	
12	539	Blake Hydrates	
13	455	Laurentide Ice Sheet	

SCHEDULE OPTIONS FROM OPCOM

OPCOM applied the following criteria in developing alternative schedules for FY2003 *JOIDES Resolution* (*JR*) operations: (1) maximize use of *JR* prior to demobilization in Galveston by September 21, 2003, which allowed scheduling of five normal-length *JR* legs; (2) honor SCICOM rankings to the extent possible, (3) moderate weather constraints (hurricanes, high-latitude winter) lead to scheduling low-latitude programs in winter/ spring and any high-latitude programs in summer. This basically is consistent with rankings and not a serious factor.

OPCOM actually forwarded four schedule options for SCICOM consideration. Each honored the SCICOM rankings by including the top four ranked *JR* programs, and each also included a different North Atlantic program ranked below the top four as the final leg. This approach was motivated by the statistical closeness of rankings beyond the top four *JR* programs, and that scheduling the fifth-ranked *JR* program would entail a significant transit penalty on that leg that could not be avoided owing to the firm demobilization date.

SCICOM RECOMMENDATION: FY2003 *JOIDES RESOLUTION* SCHEDULE

Before proceeding to a vote on the four schedule options, SCICOM thoroughly discussed the relative scientific merits of the four programs being considered for the final leg in the four possible schedule options. The SCICOM voting procedures require only a simple majority for SCICOM to approve a suggested schedule. Members first ranked the four options on individual paper ballots. The option with the Newfoundland conjugate margin program was clearly favored by a majority, and the following schedule option for FY2003 was accepted by unanimous SCICOM motion:

Leg	*Proposal*
206	An in-situ section of oceanic crust spread at superfast rate
207	Demerara Rise: Equatorial Cretaceous and Paleogene paleoceanographic transect
208	Early Cenozoic extreme climates: The Walvis Ridge transect
209	Drilling mantle peridotite along the Mid-Atlantic Ridge from 14º to 16ºN
210	Drilling the Newfoundland half of the Newfoundland-Iberia transect

Each of these five programs has a very strong scientific basis in the Long-Range Plan, as well as in the reports of the PPGs as follows:

Legs 206 and 209 - Architecture of Oceanic Lithosphere PPG;
Legs 207 and 208 - Extreme Climates PPG;
Leg 210 - North Atlantic Rifted Margins DPG.

In addition, the deep holes proposed for Leg 210 address the Long-Range Plan technological goal for establishing holes deeper than 2 km below seafloor.

SCICOM also endorsed an OPCOM recommendation to switch eastern Pacific programs in the FY2002 schedule. The Eastern Equatorial Pacific ION program advances to Leg 203 and the Costa Rica Subduction Factory and CORK program is delayed until Leg 205. The revised FY2002 and recommended FY2003 programs will be presented at the January 2002 EXCOM meeting for final approval.

SUMMARIES OF OBJECTIVES FOR LEGS 206 THROUGH 210

Leg 206: Oceanic Crust Spread at Superfast Rate, Guatemala Basin

The proponents of this leg are D. Wilson, J. Alt, and R. Detrick. Leg 206 is the first of a proposed two-leg program to core and log a complete upper crustal section to gabbros. The site is located in the Guatemala Basin in 15 Ma crust that was formed during a period of superfast spreading (>20 cm/yr) at the Pacific-Cocos plate boundary.

Leg 206 will core the upper section and start a cased reentry hole that would be proposed for further IODP drilling as one of several possible pilot sites for the IODP initiative of a complete crustal penetration. Specific Leg 206 scientific objectives will focus on determining the depth to, and nature of, the dike/gabbro contact or transition zone. Given the fast spreading rate, this transition is expected to be relatively shallow at the site (1300-1800 mbsf), an interpretation supported by site survey seismic data. The drilling plan includes an APC/XCB pilot hole through ~240 m of sediment, an RCB hole ~120 m into uppermost basement, and the main cased hole. The initial casing string in the main hole will extend through uppermost basement to ~350 m beneath the seafloor.

Leg 207: Equatorial Cretaceous/Paleogene Paleoceanographic Transect at Demerara Rise

The proponents of this leg are J. Erbacher, R.D. Norris, and P.A. Wilson. Leg 207 will core a paleoceanographic depth transect on the Demerara Rise on the Surinam margin where the sediments present an ideal target to investigate rapid climate change and mass extinctions in the Cretaceous and Paleogene. These periods encompass the best examples in the geologic record of rapid, wholesale extinctions linked to massive perturbations of the global carbon cycle and extreme changes in Earth's climate.

Specific objectives of Leg 207 include triple-APC holes at four primary sites along a depth transect for high-resolution evaluation of:

- the history of multiple Cretaceous oceanic anoxic events (OAEs) in an equatorial setting;
- response of oceanic biotic communities across a range of paleodepths to extreme perturbations in global climate and carbon cycle;
- key Paleogene events of biotic turnover and/or inferred climate extremes, particularly the Late Paleocene Thermal Maximum (LPTM) and Eocene/Oligocene boundary;
- short- and long-term changes in greenhouse forcing and tropical sea surface temperature response, and
- the role of the equatorial Atlantic gateway opening in controlling paleoceanographic circulation patterns, OAEs, and cross-equatorial heat transport into the North Atlantic.

Leg 208: Early Cenozoic Extreme Climate Transect at Walvis Ridge

The proponents of this leg are J. Zachos, R. Zahn, V. Spiess, N. Schackleton, D. Kroon, T. Herbert, and G. Dickens. Leg 208 also will address Cretaceous and Paleogene extreme climate variations, with a program of high-resolution coring along a depth transect on Walvis Ridge targeting upper Cretaceous and early Cenozoic pelagic chalks and oozes. The Walvis Ridge is an ideal location for obtaining sediment cores for reconstructing early Cenozoic variations in the thermal and chemical characteristics of deep and surface waters in the South Atlantic Ocean.

Five primary sites will be cored with APC/XCB along a depth transect for detailed study of the paleoceanographic variations associated with several prominent episodes of early Cenozoic extreme climate change. These include the LPTM, the Early Eocene Climate Optimum, and the Early Oligocene Glacial Maximum. A fundamental objective is to characterize variations in water mass chemistry and circulation at different depths on orbital time scales in transition across these extreme climate states. Several hypotheses will be tested, including one that calls for a rapid dissociation of methane hydrates as the primary cause of the carbon isotope excursion across the LPTM.

Leg 209: Mantle Peridotites on the Mid-Atlantic Ridge, 14-16°N

The proponents of this leg are P. Kelemen, J. Casey, and M. Cannat. Leg 208 will core and log the upper mantle exposed along a magma-starved segment of the Mid-Atlantic Ridge at 14-16°N. This segment was identified during previous expeditions as an excellent location to test current hypotheses that mantle flow, melt extraction, or both, are focused in three dimen-sions toward the centers of mid-ocean ridge segments, especially at slow-spreading ridges.

Igneous crust is locally absent along the segment to be drilled at several sites, and the structure and composition of the mantle can be determined at intervals over ~100 km along strike. Up to seven primary sites will be sampled and logged, utilizing the Hard-Rock Reentry System, coring depths up to 150 m, and LWD. Primary objectives include characterizing the spatial variation of mantle deformation patterns, residual peridotite composition, melt migration features, and hydrothermal alteration along axis. A secondary aim of the leg is to provide a natural laboratory to test geophysical imaging techniques in a region underlain mainly by partially serpentinized peridotites.

Leg 210: Newfoundland Margin, Non-Volcanic Rift Conjugate

The proponents of this leg are B. Tucholke, N. Driscoll, W. Holbrook, J. Hopper, H.C. Larson, K. Louden, T. Minshull, D. Sawyer, J.-C. Sibuet, S. Srivastava, and R. Whitmarsh. The primary objective of Leg 210 is a deep hole through to basement on the Newfoundland rifted margin in a position exactly conjugate to the Leg 149/173 Iberia Abyssal Plain transect. Thus, the leg will build on prior ODP investigations of continental rifting processes on the North Atlantic margins.

Previous legs on the Iberian non-volcanic margin documented extreme extension with little or no decompression melting of the asthenospheric mantle. In contrast, geophysical studies on the conjugate Newfoundland margin reveal significant cross-rift asymmetries in basement depth, amount of tectonic extension, and other deep structures. These observations raise fundamental questions about the rifting of non-volcanic margins, including the cause and extent of mantle unroofing, the presence or absence of decompression melting, the origin of deep and crustal asymmetry between conjugates, the age-subsidence and strain partitioning history, and the relation of rift events to development of shallow water unconformities and the stratigraphic record. Leg 210 will investigate the composition and subsidence history of the stratigraphic sequence above basement and igneous/tectonic basement contact on the Newfoundland margin, with a cased deep penetration hole and logging through ~2200 m of sediment and ~100 m of underlying basement.

STATUS OF MSP AND UNSCHEDULED DRILLSHIP PROGRAMS

The strong showing of MSP programs, with four in the top ten rankings, is noteworthy, demonstrates the great relevance of MSP science to the Long-Range Plan, and is a strong endorsement of the inclusion of MSP operations in IODP. SCICOM recognized that MSP programs could not be considered for ODP scheduling in addition to the approved FY2003 *JR* operations owing to limitations on ODP program resources. Nevertheless, SCICOM reaffirmed its very strong scientific interest in the highly-ranked MSP programs with two consensus statements and a motion to further the planning effort for the Lomono-sov Ridge program, the top-ranked SCICOM proposal for the second year in a row:

1. SCICOM forwards to iPC the four highly ranked MSP proposals as a SCICOM prioritization should funds become available for MSP drilling very early in IODP.
2. SCICOM recognizes the scientific importance and quality of several proposals intended to achieve high priority ocean drilling objectives using MSPs, and enthusiastically supports these drilling programs as part of a MSP component of IODP.
3. SCICOM endorses the joint JOI/European initiative to set up a Lomonosov Ridge Project Management team.

The IODP interim Planning Committee met during the same week, and iPC members observed the SCICOM process of FY2003 scheduling. The SCICOM response regarding MSP programs was very well received at iPC. With proponents' permission, the majority of ODP proposals (conventional or MSP) which were not scheduled by SCICOM have now been forwarded to the interim Science Advisory Structure for IODP planning.

PLANNING
The Transition Period
ODP IODP

The Joint European Ocean Drilling Initiative (JEODI): Update of Activities in 2001

John Ludden, JEODI Project Leader

The Joint European Ocean Drilling Initiative (JEODI) aims to bring a European component to the IODP. JEODI is a Thematic Network (TN) funded by the European Community (EC) that brings together the major member states involved in scientific ocean drilling.

European geoscientists have experience and skill in using and operating "alternative platform" drilling technologies, now termed Mission Specific Platforms (MSPs) by the Ocean Drilling Program (ODP)/Integrated Ocean Drilling Program (IODP) community. The objective of the JEODI project is to harness these capabilities, as part of the IODP, by the provision of shore-based laboratories and other facilities to handle, process, curate and store core derived from these drilling activities. In addition, JEODI will create a management structure and an outreach program for the new era of the IODP in Europe. Of particular importance is the development of a scientific rationale for drilling, and definition of the technological requirements for scientific drilling in the Arctic Ocean. JEODI also will foster links with related international scientific programs such as the International Continental Drilling Program (ICDP), Inter-MARGINS, InterRIDGE, and IMAGES, and with scientific programs in individual European countries. In particular, research will be proposed for drilling related to the fields of climate change, risks, gas hydrates, deep-offshore resource development, and to ongoing EC projects: DeepBugs, Hydratec, Omarc, Costa, Geomound, Hyacinth, and DGLab Corinth.

The following JEODI activities commenced in 2001:

- *Technology of Mission-Specific Platforms in IODP:* This activity is based on the highest ranked MSPs in ODP: The Arctic Lomonosov Ridge, the West Pacific reef (Tahiti, Great Barrier Reef) systems, the New Jersey margin and the Chicxulub impact crater. JEODI will investigate the best technology to achieve these objectives, and will prepare the operational requirements to be put out to bid with the intention of drilling some of these targets in 2004.

- *A Scientific program for Europe as part of IODP:* This program will in part be dedicated toward the use of MSPs by building on the results of the APLACON conference held in May 2001 in Lisbon. It will also define the specific interests of Europe in an international multiple-platform program.

- *Development of links between IODP and global programs:* The scientific links between programs such as InterRidge, Margins and, in particular, ICDP and IMAGES will be developed as part of this activity. The experience, technology, and tools available from ICDP may be essential in achieving the Mission Specific Objectives of IODP. The definition of a multi-platform global program for IMAGES and other programs studying recent climate change also will be addressed.

- *Scientific challenges of oceanic drilling in the Arctic:* JEODI has developed a ten-year plan for drilling in the Arctic, including site-survey requirements, for climate, tectonic and magmatic objectives to be achieved by scientific ocean drilling. Evaluation of the potential of constructing a vessel with Arctic drilling capability is underway.

- *Europe's role in downhole logging and instrumentation of drillholes:* Europe has played an important role in the ODP logging program. This activity is orientated toward redefining this role in a multi-platform drilling program.

- *Shipboard and onshore laboratory facilities in Europe as part of IODP:* IODP platforms will require mobile laboratory units for specific tasks. In particular, mission specific activities require shore-based laboratories for core description, sampling and curating. The role of his activity is to establish the current state of affairs internationally and define the requirements for Europe as part of IODP.

- *Public relations and communication in Europe for IODP:* This activity for the development of an outreach program for IODP in Europe includes stablishment of links with museums, schools and universities at the undergraduate level.

- *A Management structure for Europe as part of IODP:* European countries currently involved in IODP have stated that they want to join IODP as a single unit, with a significant funding contribution so as to become a major partner with the USA and Japan in IODP. A new management structure is being defined in which links with the US National Science Foundation (NSF) and the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) will be established through an "European Lead agency". A contracting system can be established as part of this structure to provide funds to the European science operators of MSPs and IODP support laboratories in Europe.

JEODI plans to have identified key laboratories and agencies in the initial stage of IODP by late 2002. The official European IODP structure should be in place by Summer 2003.

Drilling using MSPs will start early in 2004, provided appropriate funding is available from the European member countries, IODP and the European Commission.

THE JEODI CONSORTIUM

- Centre National de la Recherche Sciéntifique (INSU), France;
- British Geological Survey (NERC), UK; Federal Institute for Geosciences and Natural Resources. Germany;
- University of Stockholm, Sweden;
- Norwegian Geotechnical Institute, Norway;
- Thule Institute, Finland;
- Geological Survey of Denmark and Greenland, Denmark;
- Science Institute, University of Iceland, Iceland;
- Vrije Universiteit, Netherlands;
- Department of Public Enterprise, Ireland;
- Fonds National de la Recherche Scientifique, Belgium;
- Swiss Federal Institute of Technology-Zurich, Switzerland;
- Consejo Superior de Investigaciones Científicas, Spain;
- Institut de Cooperacao Cientifica e Tecnologica Int., Portugal;
- Consiglio Nazionale delle Ricerche, Italy

More information is available on the Internet at a site in the process of development at
http://www.jeodi.org

Leg 195 Report continued from page 15

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PLANNING
The Transition Period

ODP IODP

Revised Call for Proposals: Integrated Ocean Drilling Program*

iSAS Office

A new international scientific ocean drilling program will begin in October of 2003. The interim Science Advisory Structure (iSAS) of the Integrated Ocean Drilling Program (IODP) is now accepting drilling proposals that make use of the multiple drilling platforms that will be available in this new program.

Proposals to the IODP should address the scientific themes described in the IODP Initial Science Plan (now available at www.iodp.org). The proponents should indicate how the proposed ocean drilling will significantly advance our scientific understanding of Earth processes that are addressed under these broad themes.

The IODP Initial Science Plan calls for the following types of platforms to be available to proponents:

1. A non-riser, dynamically positioned drillship similar to the *JOIDES Resolution*, but with enhanced laboratory facilities, capable of drilling in nearly all oceanic water depths.

2. A state-of-the art dynamically positioned drill ship with riser well control. Initially this ship will be limited to water depths between about 500-2500 m. Drill string length will be approximately 10 km. On-board laboratory facilities will be comparable to those on the non-riser ship (see pages 74-77 of the Initial Science Plan).

3. "Mission-specific platforms" to address scientific problems that cannot be drilled using the two primary drilling platforms. Such missions might include drilling in very shallow waters or in ice-covered areas. Laboratory facilities for these platforms will be considered on a case-by-case basis.

Until the official start of IODP, an interim Science Advisory Structure (iSAS) will accept and evaluate all drilling proposals. Consult the iSAS web site at http://www.isas-office.jp, or contact the iSAS Office directly, for the latest guidelines on preparing and submitting drilling proposals during the interim period. Contact information is given on the opposite page.

Deadlines for electronically submitted proposals are 1 April and 1 October.

* **Note:** The first announcement of 18 July 2001 was revised on 6 September 2001. This revised Call for Proposals accords more closely with the document introduced at the IWG meeting on 12-13 June 2001 in Ottawa, Canada.

Update on the Status of Existing Proposals Forwarded to IODP

iSAS Office

Shortly before the first October 1 proposal deadline, the JOIDES Office sent the files for 60 existing proposals to the iSAS Office. Of these, 32 have already undergone external review, and JOIDES may eventually send the iSAS Office up to eight more proposals pending permission from the proponents. The iSAS Office received new revisions or updates for 11 of the 60 proposals transferred from JOIDES by the October 1 deadline. Finally, and most encouraging of all, the iSAS Office received 11 completely new proposals. In other words, we now have a total of 71 active iSAS proposals, with 22 of them either newly submitted, revised, or updated.

Visit the new iSAS Office Website at http://www.isas-office.jp

- Read abstracts of active IODP proposals
- Download the cover sheet and site forms for your proposal submission

The expanded site also includes
- Proposal guidelines
- Committee and panel members
- Meeting schedules
- Meeting agendas and minutes

Are you organizing a meeting, conference, or workshop of interest to the ocean drilling community? We will include an announcement in the next JOIDES Journal edition if you send us information at least a month in advance of our May 1 and November 1 publication dates.

Announcement!

Attending the Fall 2001 Meeting of the American Geophysical Union?

JOI/USSAC and the AGU invite you to a

SCIENTIFIC OCEAN DRILLING TOWN MEETING

Tuesday, December 11, 2001 from 5:30-7:30pm
Room 132, Moscone Convention Center
San Francisco, CA

You're Invited!

Hear the latest news about ODP and its successor, the Integrated Ocean Drilling Program (IODP), which is slated to begin on October 1, 2003. Scientific community leaders will provide brief updates on ODP and IODP. This is an opportunity to ask questions and voice your opinions. All are welcome.

Refreshments will be served.

Special Issue!

Ancient and Modern Seafloor Volcanogenic Massive Sulfide Deposits

Guest Editors: Peter A. Rona and Zengqian Hou

A Special Issue of the journal "Exploration and Mining Technology"
Volume 8, Nos. 3 and 4, dated July and October 1999, 395pp.
Published March 21, 2001
ISBN 0964-1823

This special double issue is dedicated to the memory of the eminent Russian ocean ridge geologist Sergey Krasnov (1952-1996).

Enclosed papers report, for the first time, new Chinese work on volcanogenic massive sulfide (VMS) deposits, as well as related seafloor hydrothermal research by the international community. The Chinese papers report a surge in exploration for, and discovery of, ancient VMS deposits in P.R. China stimulated by discoveries of active systems at ocean ridges and volcanic island arcs.

The special issue may be ordered from the publisher, the Geological Society of the Canadian Institute of Mining, Metallurgy, and Petroleum, at the following address:
Suite 210, 3400 de Maisonneuve Blvd. W.
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PLANNING
News & Announcements

ODP IODP

Where in the World is the JOIDES Office?

Members of the JOIDES Office have been busy with travel to meetings during the summer and into the fall season. We look forward to seeing some of you in warm, sunny Miami this winter!

The following photos are from a reception in honor of the Ocean Drilling Program, held on October 10, 2001 in the Rayburn Office Building on Capital Hill. The event was hosted by JOI/ODP and U.S. House of Representatives Oceans Caucus. A distinguished group of scientists visited Congressional offices from October 8-10 to educate Representatives and staff members on the scientific advances made during the last fifteen years of deep-sea drilling, and the importance of continued U.S. membership in international earth science initiatives. These veteran ODP participants also presented posters and videos at the reception to a diverse audience from the Washington, D.C., area.

Participants in the "JOI/ODP on the Hill" events, from left to right: Susan Humphris (WHOI), Rob Zierenberg (UC-Davis), Steve D'Hondt (URI), Steve Bohlen (JOI), Ken Miller (Rutgers), Peter Flemings (Penn State), Jerry Dickens (Rice), Nick Pisias (Oregon State), and Kasey White (JOI).

Left photo: *Steve Bohlen, JOI President, explains operations onboard the* JOIDES Resolution *to Rep. Jim Greenwood (R-Pennsylvania), a Co-Chair of the House Oceans Caucus.*

Right photo: *Rep. Tom Allen (D-Maine), a Co-Chair of the House Oceans Caucus, pledges his support to ODP and marine science.*

Betsy Fish, JOI Office Manager, Henny Groschel, JOIDES Journal Editor, and Steve Bohlen, JOI President, discuss the future of deep-sea drilling in front of the IODP booth.

Photos by Robert Wright and Henny Groschel

In this issue from pages 7-11:

Leg 194 Science Report: Sea Level Magnitudes Recorded by Continental Margin Sequences on the Marian Plateau, Northeast Australia

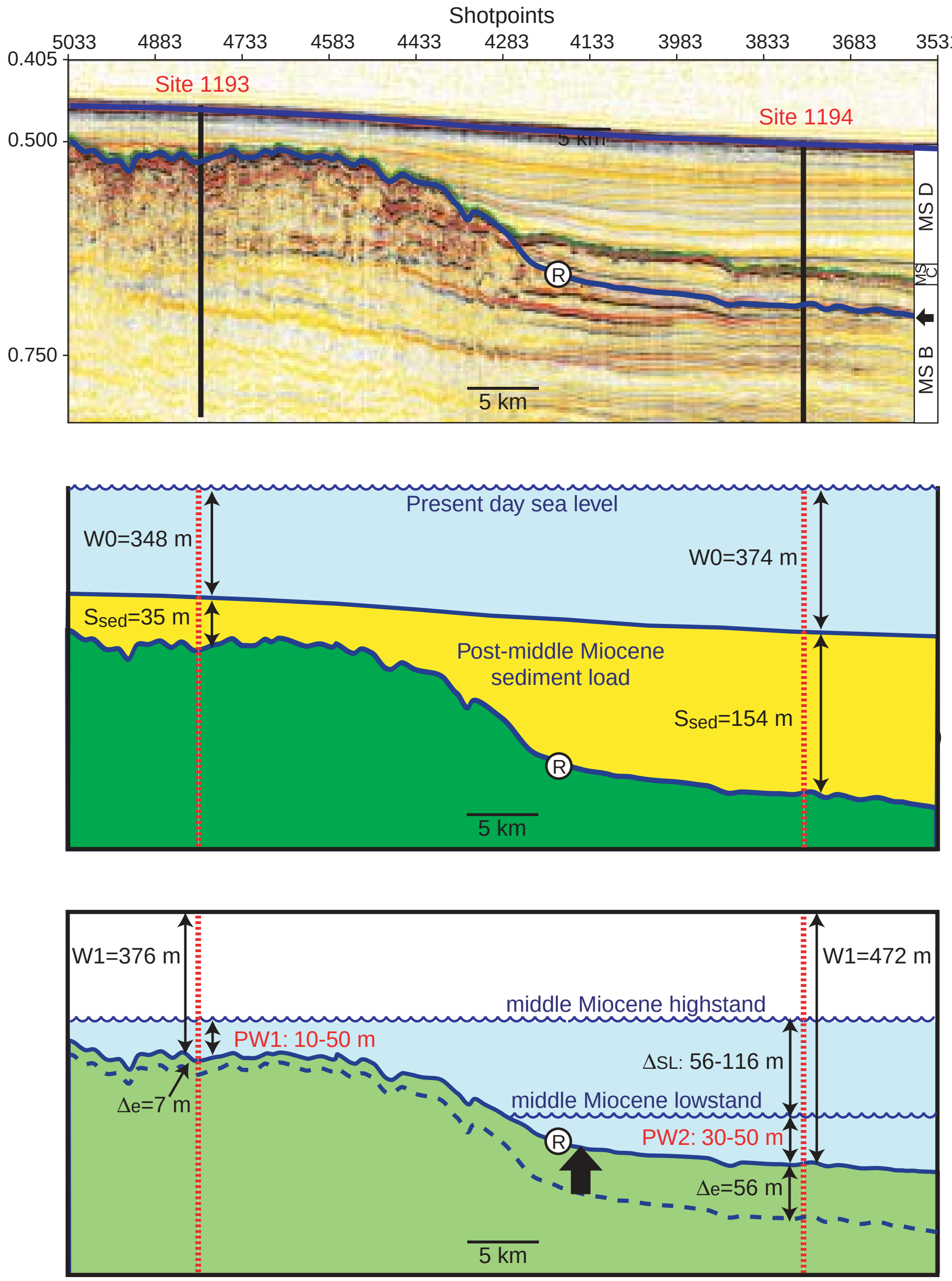

Figure 2. Diagram illustrating the calculation of the late middle Miocene eustatic sea level fall using Sites 1193 and 1194 and assuming infinite crustal strength between the sites (see Fig. 1, in article, for locations). The top panel displays the relevant seismic sequences. The onlapping unit at Site 1194, below the Megasequence B/C boundary and above the onlap surface labeled "R", was deposited during the middle Miocene lowstand, which exposed the platform top at Site 1193. The middle panel is a schematic presentation of the present day configuration. The lower panel shows the geometric adjustment of the relevant sequence boundary (R) as a result of sediment expansion after removal of the post-middle Miocene sediment load. W1 = present day water depth; S = thickness of post-middle Miocene sediment load; PW = paleowater depth estimated from biotic assemblage; Δe= sediment expansion (reduced water depth); and ΔSL = magnitude of eustatic fall. The calculated estimated sea level fall is 86 ± 30 m. *[Editor's Note: Figs. 1 and 3 are in the article on pages 7 and 8]*

ODP CONTRACTORS

Joint Oceanographic Institutions (JOI)

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JOIDES Journal Distribution
1755 Massachusetts Avenue, N.W.
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http://www.oceandrilling.org

JOIDES Office

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Ocean Drilling Program (ODP) - TAMU

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ODP/DSDP Sample Requests
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College Station, TX 77845-9547 USA
Tel: (409) 845-2673
Fax: (409) 845-4857
Email: moy@odpemail.tamu.edu
http://www-odp.tamu.edu

ODP - LDEO

Wireline Logging Services
Logging Information
Logging Schools
Log Data Requests
Borehole Research Group
Lamont-Doherty Earth Observatory
P.O. Box 1000, Route 9W
Paslisades, N.Y. 10964 USA
Tel: (914) 365-8672
Fax: (914) 365-3182
Email: borehole@ldeo.columbia.edu

ODP Site Survey Data Bank

Site Survey Data Submission
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ODP/IODP TRANSITION

Integrated Ocean Drilling Program (IODP)

http://www.iodp.org

Interim Science Advisory Structure (iSAS) Office

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International Working Group Support Office (IWGSO)

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http://www.iodp.org

JOIDES Journal

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