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Ocean Drilling Program's Research Intensifies as End Nears

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The Ocean Drilling Program (ODP), an international partnership of scientists and research institutions organized to explore the Earth's evolution and structure, provides researchers around the world access to a vast repository of geological and environmental information recorded far below the ocean surface in sea floor sediments and rocks. The Joint Oceanographic Institutions, Inc. manages ODP under contract with the National Science Foundation. Like all good things, however, even the ODP—widely hailed as one of the best examples of international cooperation in all of geosciences—must come to an end.

As ODP approaches its scheduled end in 2003, the geological and geophysical community is reaffirming its commitment to scientific ocean drilling with a surge of strong proposals focusing on the themes described in the ODP Long-Range Plan. That surge of proposals has intensified the competitive process by which Joint Oceanographic Institutions for Deep Sea Sampling (JOIDES) evaluates such proposals. JOIDES schedules ODP drilling programs annually at the summer meeting of its Science and Operations Committees. At the summer 2000 meeting, 30 proposals were considered for scheduling in FY 2002 (October 1, 2001 – September 30, 2002) and a more efficient overall sequence for FY's 2001–2002 was endorsed. The revised 2001–2002 schedule is presented in Table 1, and the sites to be cored are shown in Figure 1. There are many opportunities to participate in ODP drilling legs through 2002.

Further information on these opportunities is available at http://www.odp.tamu.edu/sciops/cruise_application_info.html. As ODP nears its end, community excitement and concrete planning are accelerating for a follow-on Integrated Ocean Drilling Program (IODP) that will utilize more than one drilling platform, with drilling beginning approximately a year after the end of operations. Many of the themes of ODP drilling have been brought forward and further developed in the documents that justify IODP, and it is expected that many of the proposals that JOIDES cannot schedule in ODP will be forwarded to IODP for further consideration. Details about the planning effort for IODP are available at http://www.iodp.org.

All of the ODP programs scheduled for 2001–2002 directly address principal scientific themes set out in the ODP Long-Range Plan (LRP). In fact, the schedule includes programs addressing all six of the principal LRP themes, which are:

- Understanding Earth's changing climate (Legs 198, 199, and 202);
- Causes and effects of sea-level change (Leg 194);
- Sediments, fluids, and bacteria as agents of change (Legs 195, 196, 203, and 204);
- Earth's deep biosphere (Legs 201 and 204);
- The transfer of heat and materials to and from Earth's interior (Legs 195 and 203); and
- Investigating deformation of the lithosphere and earthquake processes (Legs 195, 196, 197, 200, and 205).

The schedule is particularly strong in programs relating to two of the three initiatives described in the LRP: (a) understanding natural climate variability and the causes of rapid climate change, by coring the sedimentary record as expressed in key locations throughout the Pacific Ocean basin; and (b) in situ monitoring of geological processes, by installing or preparing holes for subsequent installation of long-term observatories. These initiatives are planned for 6 of the 2001–2002 legs, and 2 types of observatories will be used. Broadband seismic installations (Legs 195, 200, and 205) at sites selected by the International Ocean Network (ION) and Ocean Seismic Network (OSN) will be top-priority locations for global seismic imaging of Earth's interior. "CORK" (Circulation Obviation Retrofit Kit) and "Advanced CORK" hydrogeological observatories (Legs 195, 196, and 203) that seal long-term sensors in the formation in locations with active subsurface fluid flow will be used to study the fluid flow processes, the fluids and the properties of the formation that control the flow, and the linkages between fluid flow and tectonic processes. The "CORK" involves just one seal, at the top of the hole, while the "Advanced CORK" uses multiple seals to separately isolate different zones in the formation. Specific objectives for 2001–2002 are summarized below, leg by leg.

Leg 194: Marion Plateau–Neogene Sea Level

Leg 194 is investigating the variations and magnitude of sea-level changes recorded in continental margin sequences on Marion Plateau, Northeast Australia. Marion Plateau, now capped by carbonate platforms, is one of a number of continental fragments formed during Cretaceous rifting in the western Coral Sea. The drilling strategy utilizes the stratigraphic relationship between early to middle Miocene and late Miocene second-order highstand carbonate platform complexes to determine the

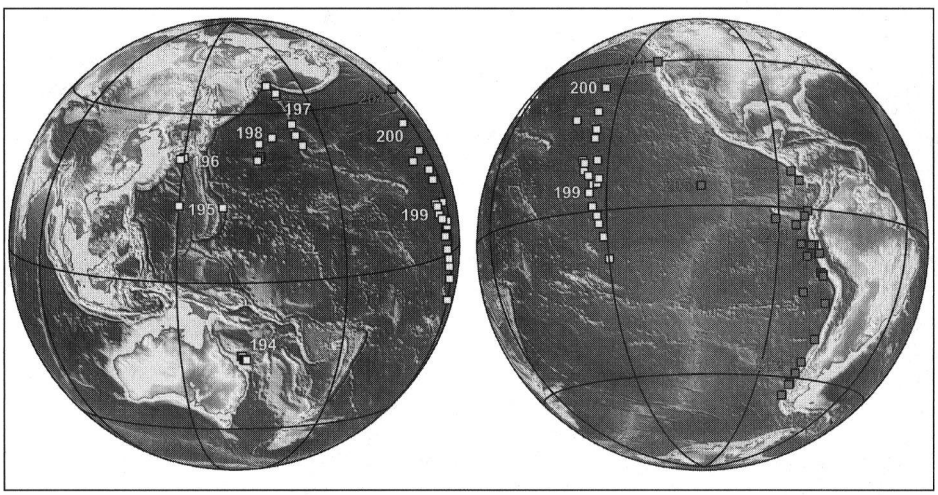

Fig. 1. Legs and drill sites planned for the Ocean Drilling Program's JOIDES Resolution in 2001–2002. Original color image appears at the back of this volume.

absolute magnitude of the middle Miocene N12-N14 sea-level fall based on a shift in the locus of carbonate platform deposition in response to the sea-level change. The sites lie along a strike line on a single structural element, so thermal subsidence of the platform should have affected all of them equally, enabling the first accurate measure of the amplitude of the mid-Miocene sea-level fall.

Table 1. Projects scheduled for drilling by the *JOIDES Resolution* during 2001–2002.

Leg	Project	Port (Origin)	Dates
194	Marion Plateau – Neogene Sea Level	Townsville	January 6 – March, 5, 2001
195	South Chamorro Seamount/West Pacific ION	Guam	March 5 – May 3, 2001
196	Nankai Subduction Zone – Phase II	Keelung	May 3 – July 2, 2001
197	Hawaiian Hot Spot – Emperor Seamounts	Yokahama	July 2 – August 28, 2001
198	Shatsky Rise – Extreme Warm Climates	Yokahama	August 28 – October 24, 2001
199	Paleogene Equatorial Pacific Paleoceanography	Honolulu	October 24 – December 17, 2001
200	H2O Seismometer Emplacement	Honolulu	December 17 – February 7, 2002
201	Deeply Buried Microbes – Peru Margin	Panama City	February 7 – April 8, 2002
202	Southeastern Pacific Paleoceanography	Valparaiso	April 8 –June 7, 2002
203	Costa Rica Subduction Factory	Panama City	June 7 – August 6, 2002
204	Gas Hydrates at Hydrate Ridge	San Francisco	August 6 – October 4, 2002
205	Equatorial Pacific ION	San Francisco	October 4 – November 9, 2002

Leg 195: South Chamorro Seamount/West Pacific ION

Leg 195 will undertake two different projects. First is an exploration of geochemical, tectonic, and microbiological processes in the intermediate depths of an active subduction factory at South Chamorro Seamount. A CORK will be installed to study these processes over the long term. Second, a seismometer will be placed in the Philippine sea floor as part of ION. South Chamorro Seamount, on the Mariana forearc, is a serpentine mud volcano that brings up material derived from a region of high-pressure, low-temperature metamorphism. Leg 195 should help us better understand 1) the processes of mass transport and geochemical cycling in subduction zones and forearcs of non-accretionary convergent margins; 2) the variability of slab-related fluids within the forearc environment as a means of tracing dehydration, decarbonation, and water/rock reactions in the subduction and supra-subduction zone environments; 3) the metamorphic and tectonic history of non-accretionary forearc regions; 4) the physical properties of the subduction zone as controls over dehydration reactions and seismicity; and 5) the nature of biological activity associated with deep-derived subduction zone material.

The second part of Leg 195 is devoted to placing a long-term seismic observatory. The ION had proposed two sites in the western Pacific as a contribution to the Global Seismic Network, which still lacks coverage in large areas of the oceans. The two western Pacific sites are designed to aid the study of earthquake dynamics, the dynamics of the subducting plates, the formation of island arcs, and how these processes relate to mantle convection. The first seismometer was successfully placed during Leg 191 in the summer of 2000; the Leg 195 emplacement is the second of the sea-floor seismic observatories in this part of the Pacific. Both of these observatories are to be connected to nearby telecommunications cables in the future.

Leg 196: Nankai Subduction Zone–Phase II

The Nankai program is designed to investigate hydrogeologic, diagenetic, and tectonic processes in an accretionary prism where a thick section of clastic sediment is being accreted. Leg 196 is the second of a two-leg program, which began with Leg 190 coring operations on two transects up the prism off Shikoku Island. Leg 196 will be devoted principally to logging-while-drilling (LWD) and installation of Advanced CORK hydrologic observatories. LWD will be used to assess the density, porosity, resistivity, and sonic velocity structure at three sites near the toe of the "Muroto" transect cored during Legs 131 and 190. Advanced CORKs will then be installed in two of these sites: Site 808, which penetrates frontal thrust, decollement, and subducting oceanic crust, and a reference site 15 km seaward. The latter installation is planned to include a Japanese broadband seismometer, which will greatly enhance study of the linkages between plate boundary tectonics and fluid flow in the accretionary prism.

Leg 197: Hawaiian Hot Spot–Emperor Seamounts

Assuming a fixed-hots pot frame of reference, the bend in the Hawaiian-Emperor chain has often been cited as the best example of a change in plate motion. Alternatively, the bend might be a record of the motion of the Hawaiian hot spot relative to the Pacific lithosphere. Four lines of inquiry support the latter view: global plate motions predicted using relative plate motion data; spreading rate data from the North Pacific basin; mantle flow modeling utilizing geoid and seismic tomographic constraints; and new paleomagnetic data from the Emperor chain. The best available paleomagnetic data suggest that Pacific hotspots may have moved at rates comparable to those of lithospheric plates in Late Cretaceous to early Tertiary times (81–43 Ma). Leg 197 will test the hypothesis of southward motion of the Hawaiian hot spot by drilling five seamounts of the Emperor trend. The principal objective is to moderately penetrate the basement (150–250 m) to obtain samples suitable for radiometric age and paleomagnetic paleolatitude determinations.

Leg 198: Shatsky Rise–Extreme Warm Climates

The mid Cretaceous (Barremian-Turonian) and early Paleogene were characterized by some of the most equable climates of the Phanerozoic and are among the best-known ancient "greenhouse" climate intervals. In addition, these intervals contain some of the most abrupt and transient climatic changes in the geologic record, including the Late Paleocene Thermal Maximum (LPTM); the mid-Maastrichtian event, when the sources of deep water appear to have shifted from low to high latitudes; and the early Aptian oceanic anoxic event. These transitions involved dramatic changes in oceanic circulation, geochemical cycling, and marine biota. The proposed drilling plan is designed to address the long-term transition into and out of "greenhouse" climate as well as the abrupt climate events. Leg 198 will investigate these changes in the Cretaceous and Paleogene by means of a depth transect on Shatsky Rise, a plateau emplaced in equatorial latitudes in the central Pacific at the end of the Jurassic.

Leg 199: Paleogene Equatorial Pacific Paleoceanography

The complex system of equatorial currents is one of the most persistent and clear traces of wind-driven circulation in the ocean and gives rise to a narrow band of equatorial upwelling. During the Neogene, the rain of debris from the equatorial upwelling zone in the Pacific Ocean built a mound of up to 500 m of calcareous and siliceous sediments on the Pacific crust as it moved beneath the equator. The existence of such a mound is less obvious in older sediments. Leg 199 will collect a transect of Paleogene sediments in the eastern Pacific Ocean centered on the approximate positions of the equator at 50–60 Ma and at 35–40 Ma. Three related questions will be addressed by this transect: what has been the long-term history of the intensity of atmospheric circulation; what has been the latitudinal movement of the intertropical convergence zone (ITCZ)—a key indicator of the relative temperature gradients in the northern and southern hemispheres; and what has been the history of hydrothermal activity during the Eocene and how might it relate to either warm climates or chert formation?

Leg 200: Preparation for H2O Seismometer Emplacement

Leg 200 will case and core a hole into the basement at the Hawaii-2 Observatory (H2O) site in the eastern Pacific, one of the high priority sites for the Ocean Seismic Network because of the large gap in regional seismic coverage. The site is very close to the existing H2O seafloor observatory installed on the Hawaii-2 cable, so it will provide a unique opportunity for real-time, continuous monitoring of geophysical and geological experiments. Plans are being developed for installation of a broadband seismometer in the H2O hole and connection to the H2O observatory using

wireline reentry sometime after Leg 200 drilling. Very little drilling has been attempted in crust that is representative of moderate age like that at the H2O site (45–50 Ma), so the cores will be of great interest in understanding geochemical and geophysical evolution of "normal" fast-spreading oceanic crust.

Leg 201: Deeply Buried Microbes–Peru Margin

This program will document how supplies of organic carbon and electron acceptors shape the distribution and activity of microbial communities buried in deep-sea sediments. The *JOIDES Resolution* will drill a series of sites along the Peru Margin and in the eastern equatorial Pacific. The questions to be answered include: Are different sedimentary geochemical regimes characterized by different microbial communities, or merely by different degrees and kinds of community activity? How does the flow of electron acceptors through deep sediments affect community structure and sediment chemistry? And, to what extent do past oceanographic conditions affect microbial communities now buried in deep-sea sediments?

Leg 202: Southeastern Pacific Paleoceanography

The primary objective is to assess changes in surface intermediate, deep, and bottom water mass interaction between the South Pacific and the Southern Ocean. The subsurface flows—important elements of the global thermohaline circulation, influence the heat, salt, oxygen, and nutrient balances of the entire Pacific Ocean and may trigger global climate feedback associated with heat transport and the carbon cycle. To explore these effects, Neogene and older sediments will be recovered along latitudinal and depth transects of the Cocos, Carnegie, Nazca, and Chile Rises in the southeast Pacific.

Documentation of changes of the Peru-Chile Current will facilitate the study of the northward advection of cold upper-ocean water and upwelling of subsurface water along the eastern boundary of the Pacific Ocean. Specifically, this study will test hypotheses on: 1) global thermohaline circulation and the linkage of global oceans through the Antarctic; 2) the interaction of the eastern boundary and equatorial currents and their role in the long-term oceanic carbon dioxide balance; 3) the role of biological productivity on modifying subsurface water masses near the eastern boundary; 4) mechanisms of Southern Hemisphere wind changes (as reflected in boundary current advection) to changing glacial, orbital, and greenhouse gas forcing; and 5) the response of the ocean to the opening of the Drake Passage, closing of the Panama Isthmus, and uplift of the Andes.

Leg 203: Costa Rica Subduction Factory

Leg 203 will build on previous drilling off Costa Rica to test existing models and develop an understanding of the processes associated with the seismogenic zone and the workings of the subduction factory. The focus is to investigate the hydrology, sediment dynamics, and geochemistry of this margin by recovering oceanic basement rocks in a lower plate reference site and by monitoring fluid flow, temperature, and geochemistry there and at two sites through the decollement. Two or three of these sites will be instrumented with CORK or Advanced CORK hydrogeological observatories. Two additional sites are to be drilled a short distance into the basement close to the deep penetration basement site to determine the fluid flow direction within the basement.

Leg 204: Gas Hydrates at Hydrate Ridge

There are a series of goals set for Leg 204 to promote understanding of gas hydrates. The source region for gas and the physical and chemical mechanisms of hydrate formation will be compared in two distinct sedimentary and tectonic environments: the older sediments of the accretionary complex, where massive hydrates and associated authigenic carbonate are found near the seafloor, and the younger, well-stratified sediments of the adjacent, rapidly filling slope basin.) Estimates of hydrate volumes and underlying free gas content will be calibrated and determined with geophysical remote sensing techniques. A better understanding of these properties is needed to map hydrate distribution regionally between drill sites. Geochemical tracers, physical properties measurements, and microstructural analysis will be used to determine whether the variations in BSR and subBSR reflectivity observed in seismic data result from tectonically induced hydrate destabilization, as inferred from seismic reflection data. An understanding of the geochemical effects of hydrate formation will be developed to identify paleo-proxies for methane release that can be used to integrate the geologic data into climate models and understand the possible role of massive, catastrophic hydrate destabilization on global change. The porosity and shear strength of hydrated and underlying sediments will be determined to evaluate the relationship between hydrates, fluid flow, and slope stability. The distribution of methanogenic and methanotrophic bacteria will be quantified in the sediments to evaluate their contribution to hydrate formation and destruction and related sediment diagenesis.

Leg 205: Equatorial Pacific ION

A cased, cemented hole is to be drilled and fitted with a re-entry cone in the Equatorial Western Pacific to support a site selected by the ION and the OSN for long-term geophysical observatories. The installation, to be done later using wireline re-entry, is planned to include triaxial broadband and high frequency seismometers and a broadband hydrophone suspended in the water column near the SOFAR channel. The observatory will be attached to a buoy with satellite communications to return data daily to established data centers.

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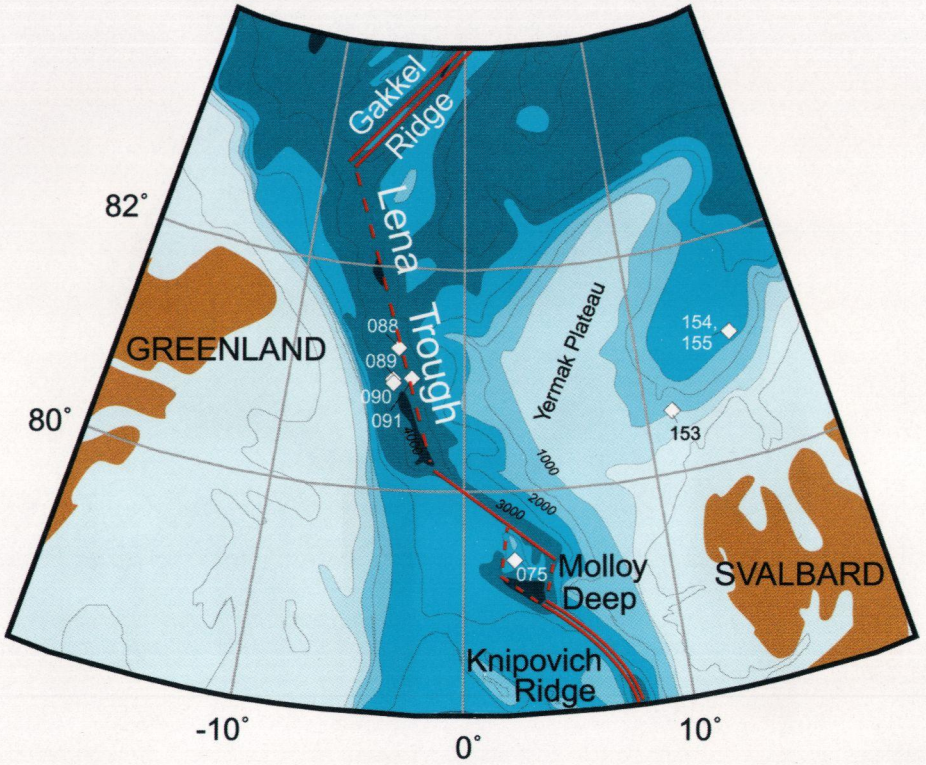

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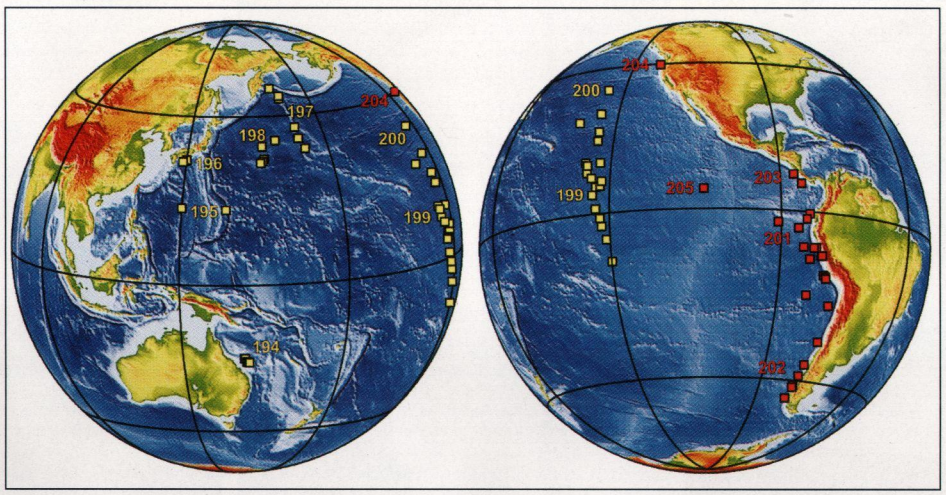
Fig. 2. Sample locations from cruise ARK XV/2 of Polarstern. *Locations of spreading axes are marked in red.*



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