OCEAN DRILLING PROGRAM

LEG 141 PRELIMINARY REPORT

CHILE TRIPLE JUNCTION

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ABSTRACT

During Leg 141 of the Ocean Drilling Program *JOIDES Resolution* occupied five sites off the coast of southern Chile between 12 November 1991 and 12 January 1992. Leg 141 investigated the tectonic and geologic processes involved in the subduction of a mid-ocean ridge, the thermal and hydrological effects of ridge subduction on the overriding plate, the geology and tectonics of one possible example of ophiolite formation and emplacement, and the chemistry of sub-seafloor frozen gas hydrates.

At Sites 859 and 863, holes drilled into the base of the trench slope 0 and 30 km respectively from the subducting ridge showed similar thermal gradients but different degrees of lithification of the sediment, and different levels of hydrothermal activity. The transition from subduction accretion to subduction erosion during ridge subduction was documented at these two sites.

Cores from Sites 860 and 861 in the middle and upper slope region of the Chile Trench forearc yielded records of complex depositional patterns and tectonic uplift of the forearc prior to ridge subduction. These sites also yielded data showing the decrease in temperature gradient landward from the trench, and the associated decrease in the rate of hydrothermal circulation.

All four sites in the forearc showed traces of hydrocarbon gases that have migrated long distances up the subduction zone. No gas hydrates were recovered, even in the pressure core sampler, but inorganic geochemical anomalies in interstitial fluids from the sediments indicate that gas hydrates were present before drilling and probably occupied approximately 25% of the pore space.

Cores from Site 862 on the Taitao Ridge demonstrated the ridge's oceanic crustal affinity and helped constrain models for its origin, with important implications for ophiolite genesis models elsewhere.

INTRODUCTION

Scientific ocean drilling during Leg 141 was focused on the study of the processes related to the subduction of mid-ocean-ridge spreading centers. The Chile Trench, located between about 45°40'S and 47°00'S, is the site of a collision between the Chile Ridge spreading center and the Chile Trench subduction zone (Herron et al., 1981; Cande and Leslie, 1986; Cande et al., 1987). The intersection of the spreading ridge and the trench forms a ridge-trench-trench triple junction involving the Antarctic Plate, the South American Plate, and the Nazca Plate. The Chile margin triple junction region is one of only two presently active examples of the subduction of a mid-ocean ridge, a tectonic event that has occurred numerous times around the convergent margins of the Pacific basin.

Ridge-trench collisions are likely to leave distinctive structural and stratigraphic signatures in the geologic record of the overriding plate, including (1) rapid uplift and subsidence of the arc and forearc (DeLong and Fox, 1977; DeLong et al., 1978, 1979), (2) high levels of regional metamorphism and elevated thermal gradients, (3) a hiatus in arc magmatism, (4) anomalous near-trench and forearc magmatism (Marshak and Karig, 1977), and (5) localized subsidence and extensional deformation of the forearc in the region of the collision (Herron et al., 1981; Barker, 1982). Alteration, diagenesis, and perhaps mineralization of forearc materials can also be expected, driven by the hot fluids venting from the subducting spreading ridge.

Leg 141 had three primary objectives: (1) to study the geological, geophysical, and geochemical processes involved in a ridge-trench collision, including the vertical-motion history and mass movement of the forearc in the collision zone; (2) to investigate the mechanism of possible ophiolite formation and emplacement in the Chile margin triple junction region; and (3) to investigate the geochemistry of frozen gas hydrate compounds present in the near-surface sediments of the region that are manifested in seismic reflection profiles as bottom-simulating reflectors (BSRs).

Sites 859, 860, and 861 together form a dip transect across the forearc region (Fig. 1). Sites 863 and 859 form a strike transect that includes the present-day triple junction. Site 862 is located on the Taitao Ridge, approximately 25 km south of the triple junction. The Taitao Ridge is a bathymetric high that forms a promontory extending out from the landward trench slope south of the collision zone, and the ridge may represent a fragment of oceanic crust in the process of emplacement into the South American continental margin.

DRILLING OBJECTIVES

The drilling objectives for the Chile margin triple junction region focused on the effects of ridge subduction. Geophysical studies suggest that the major effect of the collision is that tectonic erosion, manifested by rapid subsidence of the forearc, dominates the processes acting along the margin before the ridge crest arrives at the trench, and culminates in a period of rapid tectonic erosion when the ridge is subducted, followed by a period of subduction accretion that "rebuilds" the forearc. The basic objectives of the drilling program were to test this subduction erosion model and explore the mechanisms responsible for subduction erosion. Specific scientific questions include:

1) What are the *timing, rates, amplitude, and regional extent of vertical motion* within the forearc that result from the ridge-trench collision?
2) Where is the *seaward limit of continental crust* along the Chile margin forearc in the vicinity of the ridge-trench collision?
3) What are the *nature, petrology, distribution, and chemical affinities for near-trench volcanism* associated with the ridge-trench collision?

Answers to these questions were sought during Leg 141 through determining the ages, depositional environments, and lithologies of the forearc rocks in this region.

SITE 859

Drilling at Site 859 (proposed site SC-3) achieved almost complete penetration of a small accretionary wedge at the leading edge of the South American forearc basement (Fig. 2). The accretionary wedge is composed of a uniform suite of fine-grained terrigenous clastic sediment of late Pliocene age and is overlain by a thin lower-trench-slope cover sequence of Pleistocene age. The main source area of the sediment is the nearby Andean volcanic arc and crystalline basement. Glacial rock flour makes a significant contribution to the sediment.

Two lithologic units were identified at Site 859:

- Unit I, 0 to 10 meters below seafloor (mbsf): upper Pleistocene clayey silts and silty clays, with abundant radiolarians and diatoms.
- Unit II, 10 to total depth (TD, 476 mbsf): divided into two subunits:
  - Subunit IIA, 10 to 235 mbsf: uniform Pleistocene and upper Pliocene clayey silts and silty clays.
  - Subunit IIB, 235 mbsf to TD (476 mbsf): upper Pliocene silty claystones and clayey siltstones.

The sediment at Site 859 is terrigenous. The source of the sediment is the nearby Andean crystalline basement and the volcanic arc. Perhaps the most marked feature of the cored material is its uniformity, both in facies and mineralogical composition. The boundary between Subunits IIA and IIB is well defined by a transition zone between 216 and 235 mbsf, and is diagenetic, consisting of a prominent discontinuity in the degree of lithification. The abundance of silt-sized non-weathered feldspar and the occurrence of fresh detrital biotite indicate the absence of pronounced chemical weathering, and along with silt-sized quartz, the feldspar and biotite are the contribution of glacial rock flour to the sediment. The Matuyama/Brunhes paleomagnetic reversal was detected at a depth of about 30 mbsf, the Gauss/Matuyama reversal at 300 mbsf, and the Gilbert/Gauss reversal at about 400 mbsf. The Pleistocene cover sediments are folded, with axial orientations perpendicular to the direction of plate convergence. Below 200 mbsf, the Pliocene sediments show signs of pervasive brecciation and shearing and constitute "broken formation" (Broken formation was described by Hsu, 1968, as "A body of broken strata which contains no exotic blocks and which, regardless of its broken state, functions as a rock stratigraphic unit" and the use of the term has been reviewed by Raymond, 1984.).

Benthic foraminifers indicate a middle to lower bathyal depositional realm. This is compatible with deposition on young and therefore buoyant oceanic crust prior to offscraping and accretion. Temperate to subtropical conditions in the late Pleistocene followed a cold-water marine paleoenvironment in the early Pleistocene. Cold water dominated throughout the late Pliocene, interrupted by three short periods of temperate water conditions. A new and surprising result of the biostratigraphic studies is the identification of a temperate to subtropical marine paleoenvironment during the late Pleistocene. There is some evidence from radiolarian and foraminifer fauna for coastal unwelling both during the Pliocene and Pleistocene.

Physical properties were measured on structurally intact subspecimens of the core. The most important discoveries here are high average grain densities (2.8 g/cm^3) and low porosities (an average of 48% near the mud line, decreasing to an average of 15% at 470 mbsf with wet water contents consequently as low as 5% at 470 mbsf). Anomalously high porosities were found in the intervals 200 to 240 mbsf (up to 55%, 20% above local background) and 380 to 420 mbsf (up to 37%, 15% above local background).

Chemical analysis of interstitial-water samples and water sampler temperature probe (WSTP) samples show a pronounced chlorinity and salinity minimum between 30 and 70 mbsf. This may represent a dilution of pore fluids with fresh water liberated by the decomposition of gas hydrate. The chlorinity profile does not show diffusion gradients, suggesting that gas hydrate decomposition was triggered by drilling and that the gas hydrates are stable *in situ*. In this case, approximately 25% of the pore volume may be filled by gas hydrates. An additional chemical discontinuity was intersected around 240 mbsf. This is a zone of marked increase in Ca, a matching decrease in Mg, and a minimum in alkalinity in interstitial water. With no dolomitization present, this chemical signature is characteristic of a fluid resulting from the alteration of oceanic basement. Low K contents corroborate this interpretation.

Headspace and vacutainer analyses of gases trapped in the core liner indicate a microbial, biogenic gas source in the upper part of the sedimentary section at Site 859. A significant component of thermogenic gas is evident from the analyses of the cores in the lower part of Hole 859B. Contents of solid organic matter are lower than 0.5% throughout, and generally there is a low degree of maturity. The thermogenic gas component must have migrated to its present location, probably from deeper, hotter parts of the accretionary prism downdip in the subduction zone.

Downhole temperature measurements reveal a geothermal gradient of roughly 200°C/km for the upper 50 mbsf. Below this sub-bottom depth the temperature profile is extremely irregular, and includes a zone of temperature decrease between 130 and 220 mbsf. At 240 mbsf a downhole temperature of 62°C was recorded, which may relate to an ambient rock temperature of 42°C and hot fluids entering the borehole in a very narrow sub-bottom-depth range. Wireline logs in Hole 859B show disturbances in the temperature of the downhole mud column in positions that roughly correspond to the WSTP measurements. Temperatures of the mud at TD were approximately 50°C, constraining an overall thermal gradient of 100°C/km.

Sonic velocities in the upper part of Hole 859B are 1.8-2.2 km/s with a smooth downward increase. Between 180 and 250 mbsf they vary irregularly between 1.6 and 2.2 km/s. Below 250 mbsf there are variations between 2.3 and 2.8 km/s, with a smooth downhole increase.

SITE 860

Drilling at Site 860 (proposed Site SC-2) penetrated and sampled the seaward flank of a forearc basin and the underlying accretionary wedge (Fig. 2). The ages of both the forearc-basin strata and the deformed accretionary wedge range from Quaternary to early Pliocene; the Quaternary sediments consist of 12 to 15 m of Quaternary slope hemipelagic material overlying the older units. The Pliocene age of this portion of the accretionary wedge is identical to that drilled at Site 859. The time of formation of the accretionary wedge at these sites corresponds to a period of rapid uplift and shallowing of paleo-water depths on the shelf in this region.

Three lithologic units were identified at Site 860:

- Unit I: 0 to 87.7 mbsf: Quaternary to upper Pliocene clayey silt to silty clay with nannofossils, with graded silt and sand interbeds, and one 10-m-thick massive sand unit at base.
- Unit II: 87.7 to 242.5 mbsf: upper Pliocene through lower Pliocene claystone to silty claystone (lapilli bed), plus sandstones and thin conglomerate beds.
- Unit III: 242.5 to 617.8 mbsf: divided into two subunits:
  - Subunit IIIA: 242.5 to 309.8 mbsf: upper Pliocene through lower Pliocene clayey siltstone, silty claystone, ± nannofossils, plus sandy silty claystone with thin conglomerate beds.
  - Subunit IIIB: 309.8 to 617.8 mbsf: upper Pliocene through lower Pliocene gravel, clayey siltstone, silty claystone ± nannofossils plus sandy silty claystone in three intervals, and thin conglomerate beds.

Lithologic Unit I is interpreted to be the result of mixed hemipelagic sedimentation and high- and low-density distal (fine-grained) turbidites. The hemipelagic proportion decreases downhole. The massive sand unit that defines the base of Unit I is the result of a single grain-flow depositional event. Lithologic Unit II is characterized in its upper section by hemipelagic sedimentation, mixed with mud turbidite deposition. Sediments of Unit II also exhibit evidence of traction transport and reworking by bottom-current flow. The upper section of lithologic Subunit IIIA is characterized by hemipelagic and fine-grained turbidite depositional units, with the lower section of this subunit composed of high-density, fine-grained turbidites with signs of reworking. Subunit IIIB exhibits a grain-flow event accompanied by background hemipelagic deposition in its upper section, with successions of high-density fine-grained turbidites in its lower section. Subunit IIIB also shows signs of bottom-current reworking. Lithologic Unit III contains at least five repetitions of sedimentary sequences. This is likely the result of imbrication by thrust faults.

Diatoms were moderately well preserved in mud-line cores at Site 860 but were sparsely abundant between 10 and 150 mbsf. Below 150 mbsf there were no diatoms. Radiolarian abundances were similar to those of diatoms, with many intervals void of specimens. However, 80% of core-catcher samples at Site 860 contained foraminifers, and 87% of core-catcher samples contained benthic foraminifers, providing a basis for both biostratigraphic age determinations and paleowater-depth estimates.

Paleowater-depth determinations from benthic foraminiferal analysis indicate that Site 860 was uplifted during the Pliocene. The upper 60 m of the drilled section was deposited in outer shelf/upper bathyal water depths. From approximately 60 to 435 mbsf, paleowater depths were upper bathyal to lower bathyal. Below about 435 mbsf, paleowater depths were lower bathyal to abyssal.

Three structural domains are defined at Site 860:

1) 0 to 100 m: near-surface slump deformation;
2) 100 to 420 m: thrust stack; and
3) 420 m to TD: broken formation and stratal disruption.

Faults are inferred at sub-bottom depths of 310, 520, and 580 mbsf, with less certain indications of two other faults at 240 and 420 mbsf. All bedding laminations below 420 mbsf are deformed or sheared. Bedding above 420 mbsf is shallowly dipping 10° to the southeast in oriented advanced piston corer (APC) cores.

The thrust faults must be flats or shallow ramps at this location and have large (hundreds of meters) offsets to produce the observed stratal repetitions and simultaneously maintain the shallow bedding dips recorded in the cores.

Two deformation styles occur within the broken formation at Site 860:

1) zones with deformation bands with random orientations; and
2) zones with deformation bands with flat-lying orientations and reverse offset.

Style 1 occurs between shear zones and reflects bulk deformation of rock bodies bounded by those shear zones that allows the blocks to change shape during slip on non-planar faults. Style 2 is composed of the shear zones themselves, with deformation occurring by simple shear. The cementation in the deformation bands is different from that in the host rock, and varies with sub-bottom depth. Perhaps this reflects fluid flow along the deformation bands.

The upper 200 m at Site 860 contains biogenic hydrocarbon gas, while below 200 mbsf the gas has a clear thermogenic component. There was virtually no methane in the top core, and in deeper cores the methane level was relatively constant at approximately 10,000 ppm to TD. The first appearance of ethane occurred at 60 mbsf, and propane first appeared at 250 mbsf.

Inorganic geochemical trends do not display typical equilibrium profiles at Site 860. Sulfate quickly drops from seawater values to near 0 mM above 60 mbsf, but then maintains a level of about 5-10 mM to TD. Chlorine decreases below 100 mbsf, and has local minima at 140, 200, and 360 mbsf. The chlorine profile might reflect relict hydrate formation, which would increase the chlorinity of water not incorporated into the hydrate. Other explanations include freshwater transport from land along subsurface aquifers, or fluid migration from downdip along thrust faults.

Bulk-density measurements on discrete samples show a local bulk-density minimum at 100 mbsf. Grain density shows a local increase at 40-50 mbsf, the same interval that contains a peak in magnetic susceptibility, suggesting that high-density and strongly magnetic minerals may be concentrated at this depth interval. Site 860 displays a compaction profile more typical of marine sediments than did Site 859.

A combination of the ADARA piston-core shoe and WSTP/Uyeda *in-situ* temperature measurements established a geothermal gradient of about 140°C/km in the upper 70 m of Hole 860B, but one apparently reliable measurement of 11.5°C at about 130 mbsf suggests that the gradient is about 30°C/km below about 70 mbsf.

Logging attempts at Site 860 were hampered by poor hole conditions and mechanical problems with both the drill string and the logging tools. As a result, the only logging data acquired at Site 860 are sonic-velocity data from 70 to 185 mbsf, resistivity measurements over the same interval, and Lamont temperature-tool data measured inside the drill pipe from 70 to 607 mbsf.

Sonic data show a relative high-velocity interval at 120 mbsf. The bottom-hole temperature was 26°C, establishing an overall geothermal gradient of about 38°C/km for the drilled interval, in general agreement with discrete *in-situ* temperature measurements.

SITE 861

Drilling at Site 861 (proposed Site SC-1) penetrated and sampled forearc basin strata on the middle trench slope (Fig. 2). These strata are underlain by deformed sediments that may represent the eastward extension of the accretionary wedge intersected at Sites 859 and 860.

Three lithologic units were identified at Site 861:

- Unit I, 0 to 43.8 mbsf: Quaternary silty clays and clayey silts, containing nannofossils.
- Unit II, 43.8 to 351.9 mbsf: divided into two subunits:
  - Subunit IIA, 43.8 to 208.9 mbsf: silty clays and clayey silts of Pleistocene and late Pliocene age, containing intercalations of silt, sand, and gravel layers.
  - Subunit IIB, 208.9 to 351.9 mbsf: upper Pliocene claystones and graded siltstones with intercalations of matrix-supported conglomerates.
- Unit III, 351.9 to 496.3 mbsf: lower through upper Pliocene hard silty claystone to clayey siltstone.

The depositional environment of Unit I is interpreted to be one of hemipelagic sedimentation, interrupted by inflow of turbidites. The sediments of Unit II were deposited in an environment more proximal to the source area than the sediments of Unit I, as suggested by the presence of coarser clastics and intraformational conglomerates in Unit II. A transitional boundary exists between Subunits IIA and IIB. The boundary is not identified by a marked change in rock composition, facies, or depositional environment, but is coincident with a downhole increase in the degree of lithification. The sediments of Unit III reflect fine-grained hemipelagic sedimentation with very distal turbidites.

Microfossil preservation in the sediment at Site 861 is poor, but improved with respect to that at Sites 859 and 860. Pleistocene ages were determined for samples from the upper 65 m. One age constraint indicates an age of 1.02-1.07 Ma in the interval of 50-60 mbsf. However, only 10 m below this depth, at 69.5 mbsf (bottom of Core 141-861C-8H), the boundary between foraminifer Zones N22 and N21 was identified, suggesting an age of 1.9 Ma. From 69.5 to 425 mbsf, there is a long and apparently continuous section of late Pliocene age. Below 425 mbsf, the sediments are of early Pliocene age, documented by foraminifer Zone N19/N20.

A reliable correlation of biostratigraphic and magnetostratigraphic data can be made for the Pleistocene section. The Matuyama/Brunhes paleomagnetic reversal was detected at about 40 mbsf, and the Jaramillo event near the end of the Matuyama Chron was recorded at about 50 mbsf. Below this level, a reliable correlation to the geomagnetic reversal sequence is not possible. A distinct positive magnetic-susceptibility anomaly was found at about 45 mbsf. This anomaly correlates with a high-density, perhaps magnetite-bearing, sand layer.

The sediments recovered at Site 861 can be subdivided into three structural domains. Domain I (0 to 210 mbsf) has horizontal to gently inclined bedding, with the development of an incipient fissility in clay-rich materials below 150 mbsf. Domain II (210 to 390 mbsf) has gently to moderately inclined sedimentary beds, and isolated deformation bands exist. Domain III (390 to 496.3 mbsf) has the characteristics of "broken formation," with abundant deformation bands and stratal disruption, similar to the structural associations found in the lower sections at Sites 859 and 860.

Porosities of the sediments show an almost linear downhole decrease from an average of 60% near the mud line to about 35% at TD. Anomalously low porosities are found associated with sands near 45 mbsf, and a small downhole offset toward lower porosities is observed at the boundary between lithostratigraphic Subunits IIA and IIB (208.9 mbsf). Grain densities show a constant downhole average of 2.75 g/cm^3. *P*-wave velocities between about 1.8 and 2.0 km/s are found in cores recovered from 250 to 350 mbsf, and between about 2.1 and 2.45 km/s in cores from 460 to 490 mbsf.

Chemical analysis of interstitial water and WSTP samples gives no indication of the presence of stable gas hydrates in the form of salinity and chlorinity minima. Generally, interstitial waters at Site 861 are more saline than seawater, with a maximum of 15% above seawater near TD. Calcium contents are lower than seawater, perhaps indicating calcium scavenging in the entire section by the formation of authigenic calcite. A marked discontinuity in calcium content is found at 200 mbsf. A maximum in magnesium content at 60 mbsf probably relates to volcanic ash found in the section at this depth. Sulfate contents are zero or very low, with 10%-15% of seawater concentrations found below 200 mbsf. Boron and potassium profiles suggest that there is a sink for these two elements below 200 mbsf.

Headspace and vacutainer analyses of gases trapped in the core liner provide evidence for a dominantly biogenic gas source down to 200 mbsf. Below this depth, the methane/ethane ratio drops to values between 100 and 1000, indicating a component of thermogenic gas in the sediment. The composition of gases and condensates here is very similar to those in the deeper parts of Holes 859B and 860B. Total organic carbon contents are generally lower than 0.5%, except in the upper 20 mbsf, where total organic carbon contents are between 0.5% and 1.0%. The solid organic matter is immature and has a terrigenous source. The coincidence of immature solid organic matter and thermogenic gaseous hydrocarbons again indicates that the latter have migrated from deeper in the subduction zone.

Downhole temperatures determined with the WSTP and ADARA tools down to 250 mbsf show an almost linear downhole increase, defining a bulk temperature gradient of about 55°C/km at Site 861. Downhole logging could not be attempted at Site 861 due to an emergency abandonment of the site. Very rough weather conditions at that time made the deployment of a free-fall funnel impossible, and therefore Hole 861D could not be reoccupied.

SITE 862

Site 862 (proposed Site SC-6) is located near the crest of the Taitao Ridge, a prominent bathymetric high that juts out from the South American continental margin approximately 25 km south of the present location of the Chile margin triple junction (Fig. 3). Because of the close proximity of the Taitao Ridge to the Taitao ophiolite, exposed 20 km to the east on the Taitao Peninsula, and marine geophysical data that suggest that the Taitao Ridge is of oceanic affinity, the Taitao Ridge was anticipated to be of oceanic origin and in the process of accretion to the Chile Trench forearc. Drilling at Site 862 confirmed that the Taitao Ridge is underlain by mafic igneous material of oceanic affinity, but the apparent youthful age of the Taitao Ridge, less than approximately 2 Ma, and the recovery of likely andesitic materials from the ridge, indicate that the origin and tectonic evolution of the Taitao Ridge is more complex than originally hypothesized.

Two lithologic units were identified at Site 862:

Unit I, 0 to about 23 mbsf: silty clay that grades to clayey silt and silty fine sand with clay, grading to claystone and silty claystone, and sandstone. Hydrothermal alteration of the sediment cover occurs immediately above basement.

Unit II, about 23 mbsf to TD (102.1 mbsf): apparently intercalated submarine basalt and andesite flows with scattered sediment interbeds.

Unit I represents the thin sediment cover that blankets the Taitao Ridge. One core recovered the depositional contact between Unit I sediment and Unit II igneous basement, and shows a clear 2-cm-thick hydrothermal reaction zone in the basal sediment. In Unit II, igneous fragments display vesicular glassy chilled margins that can occasionally be observed to grade to variolitic plagioclase textures. Recognition of intersertal, subophitic, and ophitic textures suggests that a range of depths within cooling units was recovered.

The olivine/pyroxene ratio observed in thin sections was used to distinguish igneous compositions. Hornblende phenocrysts often display pristine borders where they abut against plagioclase phenocrysts, but are altered where they border the groundmass. This suggests that the hornblende is a primary phase in the magma chamber from which this material erupted. High silica contents imply that some eruptive units are of rhyolitic composition. Shipboard X-ray analysis indicates a bimodal distribution of igneous compositions.

Drilling may have recovered a sequence of interlayered basalt and rhyolite flows, but due to the small size (diameter of less than 4 cm) of many of the recovered igneous fragments, the order of pieces in the core liner may no longer reflect the original stratigraphy. What is clear, though, is that the basement of the Taitao Ridge is likely composed of both basaltic and rhyolitic eruptive materials.

Foraminifer and radiolarian assemblages date the uppermost 1 m of the sedimentary sequence to the Pleistocene to Holocene. Biostratigraphic ages for the rest of the sequence are only constrained to the Neogene. Paleowater-depth estimates from benthic foraminifers bracket the present depth of the Taitao Ridge.

All sediment samples from the Taitao Ridge exhibit a strong, normally polarized magnetic overprint. Alternating-field (AF) demagnetization did not isolate the depositional remanence, but samples from the lowermost 10 m of the sediment section display multiple overprints (possibly related to hydrothermal activity) and trend toward positive inclinations during demagnetization, strongly suggesting a reversed depositional polarity. Whole-core demagnetization of the rest of the sedimentary sequence resulted in magnetic inclinations around 30°-35° shallower than expected, from which normal overprinting on a probably reversed depositional remanence can be inferred. The apparently uniform reversed depositional polarity and the Pleistocene age of the uppermost part of the sequence bracket the age of the sediment cover to the Matuyama Chron, less than about 1.7 Ma. This is younger than the age inferred for oceanic crust at the off-axis distance of the Taitao Ridge based on the southward extrapolation of marine magnetic anomalies identified farther north. It also appears that there is a hiatus on the ridge spanning the Brunhes Chron, or that that part of the sequence was not recovered.

Deformation of the sediment section at Site 862 is dominated by structures related to normal faulting. Both faults and bedding are commonly mineralized, providing dramatic planar markers for structural analysis. The local topography surrounding Site 862 is very steep, suggesting that gravity sliding may be an important element of the deformational driving force. Boudinage of sand layers implies some degree of brittle behavior of the sediments, suggesting that deformation post-dates lithification to a large extent. No igneous samples were recovered in original orientation, so no structural analyses could be performed on those lithologies.

The total organic carbon content of the sediment section at Site 862 never exceeds 0.25%. CPI analysis indicates that all sediment samples are highly mature, as does the presence of some gasoline-range hydrocarbons. The high level of thermal maturity in such young, thin sediments that have never been deeply buried indicates deposition on hot volcanic basement, followed by vigorous hydrothermal activity. This relationship supports the inference that the Taitao Ridge cannot be much older than its sediment cover.

The seismic velocity of the sediment drilled is about 1600 m/s throughout the thin sequence, and both bulk density and grain density are constant downsection. Similarities in these properties suggest that the sediment at Site 862 is of similar provenance to that at Sites 859 and 861.

The inferred Pliocene age of the Taitao Ridge is younger than the 3-4-Ma age of the Taitao ophiolite on land. Hence, it is unlikely that the Taitao Ridge represents an offshore extension of the ophiolite onshore. In addition, the Taitao Ridge may be at least 0.5 m.y. younger than the age of the oceanic crust at its off-axis distance from the spreading ridge, as predicted by marine magnetic anomalies farther north. This implies that the Taitao Ridge may be the result of off-ridge volcanism, perhaps related to "leaky transform" extension along the Taitao fracture zone immediately before and/or during ridge subduction. Alternatively, the extensional deformation of the Taitao Ridge may be associated with the Chile Rise, suggesting a possible on-axis volcanic origin for the Taitao Ridge. Either model for the origin of the Taitao Ridge is consistent with the ridge's current attachment to either the Antarctic Plate or the South American Plate.

SITE 863

Site 863 (proposed Site SC-5) is located at the base of the trench slope of the Chile Trench at the point where the Chile Ridge is being subducted (Fig. 4). Fluids and heat emanating from the spreading ridge were expected to have produced extensive mineralization and elevated thermal gradients in the overlying sediment at Site 863. While evidence of fluid flow, cementation, and mineralization was recognized in the sediment section drilled at Site 863, the temperature gradient was not as steep as anticipated. The temperature gradient at Site 859 was similar to that of Site 863, despite being approximately 30 km north of the triple junction.

Two lithologic units were defined at Site 863:

- Unit I, 0 to 104.4 mbsf: silt- and clay-sized sediment, both lithified and unlithified. Divided into three subunits:
  - Subunit IA, 0 to 3.9 mbsf: Quaternary unlithified, undeformed silty clay and clayey silt, with minor sand.
  - Subunit IB, 3.9 to 46.6 mbsf: upper Pliocene unlithified, sulfide/organic-rich silty clay to clayey silt, with minor sand.
  - Subunit IC, 46.6 to 104.4 mbsf: upper Pliocene lithified silty claystone to clayey siltstone, with minor sandstone.
- Unit II, 104.4 to 742.9 mbsf: upper Pliocene sandstone and bioturbated siltstone, with sandy silty claystone.

Drilling recovered a sequence composed of Quaternary unlithified, undeformed silty clay to clayey silt, with a minor sand component, deposited as slope cover on the more intensely deformed sediments of the accretionary wedge. Strongly deformed upper Pliocene sulfide/organic-rich silty clay to clayey silt with steep to vertical bedding, deformation bands, and broken formation underlies the slope cover, and represents the uppermost strata involved in the deformation associated with ridge subduction. Diatoms and radiolarians are poorly preserved at Site 863, except in APC cores. Only the most robust foraminifer forms are preserved. The entire drilled section at Site 863 is late Pliocene or younger.

Deformation near the top of the hole is dominated by reverse faults, with offsets larger than the scale of the core. One well-developed flower structure, with fault strands with both reverse and normal offsets, was recovered. These faults cannot be restored by a two-dimensional reconstruction in the plane of the core face; their restoration requires an oblique strike-slip component of motion, suggesting that other fault zones which display reverse and normal offsets in the plane of the core face may actually accommodate an oblique component of motion.

Hole 863B was drilled for 640 m in a direction nearly parallel to bedding, penetrating approximately 60 m of section. The vertical bedding first appears at about 265 mbsf and extends to TD. Many well-developed slickenlines indicate normal offsets on faults. Normal faulting dominates the most recent deformation. Some faults contain secondary calcite mineralization bands

1-2 mm wide, commonly showing slickencrysts. Quartz-pyrite mineralization also occurs along faults. These observations suggest that fluid flow and mineralization along the fault surfaces were synchronous with deformation.

Multishot orientation of APC cores allows the referral of structures to the geographic coordinate system: both bedding and faults strike northwest-southeast in these cores, at a large angle to both local topographic slopes and to the plate-convergence direction. This orientation may reflect strike-slip faulting in the forearc, extending to within 5 km of the base of the trench slope. The entire forearc may represent a broad shear zone that takes up trench-parallel plate motion. The strike-slip component of plate motion in this region is about 20 mm/yr (Chase, 1978). Such a rate distributed over the 160-km-wide forearc implies strain rates of about 4×10^{-15} s^{-1}.

Inorganic geochemical observations suggest that four geochemical zones are present at Site 863. From the seafloor to 60 mbsf, a zone of sulfate reduction is typical of microbial hemipelagic diagenesis. A methanogenic layer exists between about 60 and 147 mbsf, where the calcium content drops to 20% of that of seawater. This zone is completely different from layers above and below. In the zone from 147 to 400 mbsf, as in the uppermost layer, sulfate diagenesis is the dominant process, but apparently there is no active pyrite production. A diffusion profile upward from approximately 400 mbsf is recognized in this depth interval. Another zone of methanogenesis is present between 400 and 490 mbsf.

Below 490 mbsf, fluids comprise a strongly alkaline brine: chlorine contents are up to 15% above those of seawater; pH increases to 10.5 in the lower 150 m of the hole; and calcium reaches concentrations up to 150 mM, suggesting nearby reactions with basalt.

Organic geochemical data define a biogenic gas zone from about 70 to 125 mbsf and a zone dominated by thermogenic gas likely from about 350 mbsf to TD. Other intervals had very low hydrocarbon gas content. The vertically bedded sequence drilled at the bottom of Hole 863B likely represents a preferential migration pathway for hydrocarbons originating at depth or a zone of hydrocarbon preservation.

The overall temperature gradient in the upper 250 m at Site 863 is 80°C/km to 100°C/km. Superimposed on this gradient are (1) a low-temperature anomaly at 30-60 mbsf, corresponding to both a sulfide-rich zone and a change in the porosity; and (2) a zone of steep temperature gradient from about 200 to 240 mbsf.

Early-stage deformation of the sandstone at Site 863 was primarily compressive, with reverse/thrust faulting dominant in the cores. This deformation is likely to be related to frontal accretion of these turbidites following deposition in the Chile Trench. Uplift and tilting of the sedimentary strata were probably a result of the subduction of the steep topography of the ridge itself. The latest phase of deformation recognized in the cores, high-angle normal faulting, including the reactivation of preexisting reverse faults, reflects the subsidence of the forearc immediately following ridge subduction.

SUMMARY

The deformation sequence at Site 859 indicates that subduction erosion has not yet begun. Regional uplift, likely due to early Pliocene subduction accretion, has affected the entire forearc in the region of Sites 860 and 861. The lack of Quaternary sediment incorporated into the thrust system at Site 859, however, may mean that subduction accretion at that location has ceased and that this segment of the margin is in transition from accretion to erosion. Site 863 sediments are undergoing extensional deformation as the latest phase of their deformational history. This, together with observations from seismic reflection images, strongly indicates that subduction erosion is taking place at Site 863. Thus, the transition from subduction accretion to subduction erosion along the Chile Trench in this region occurs over a distance along strike of about 30 km, and over time periods of about 3 m.y.

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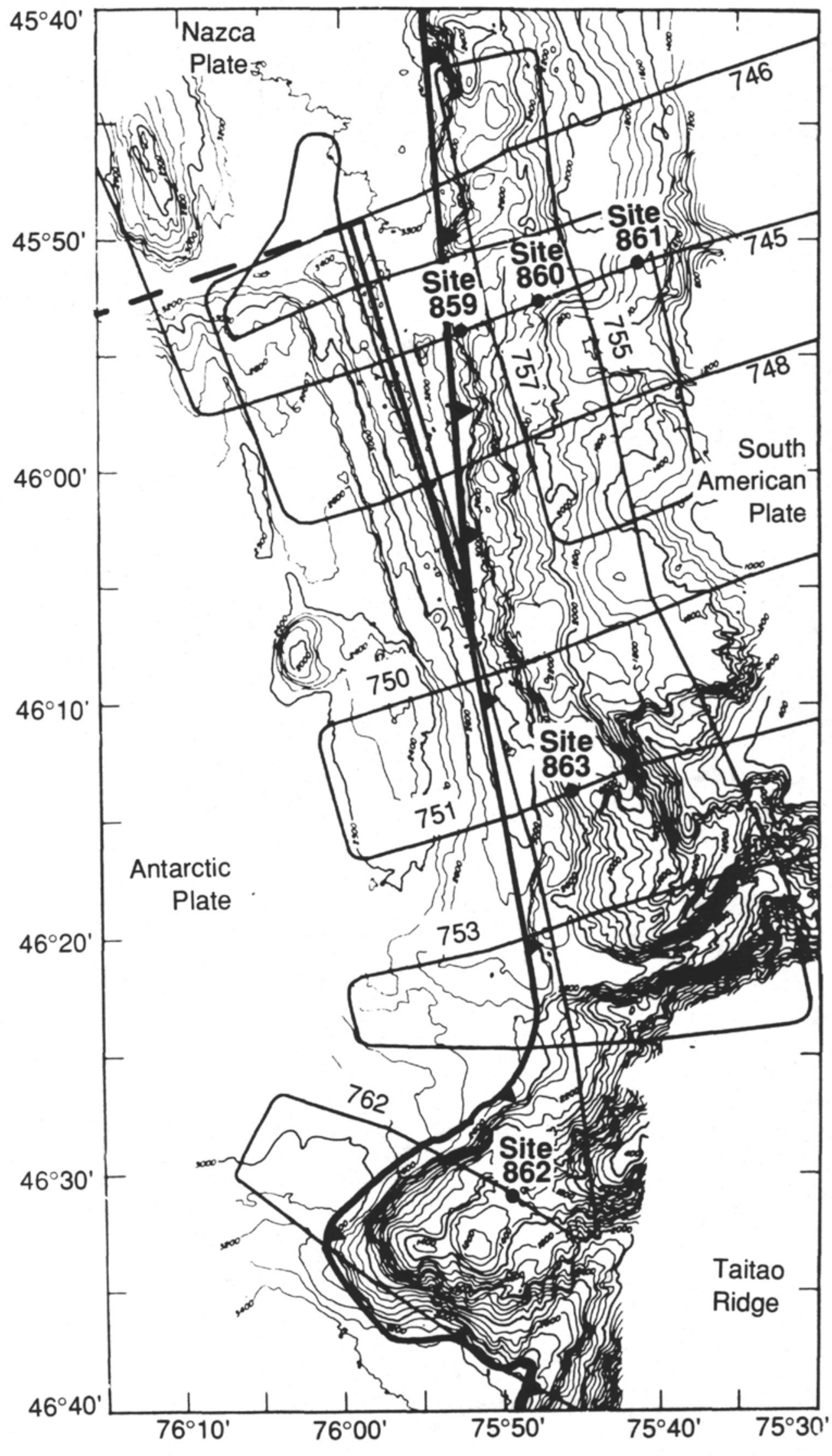


Figure 1. Bathymetric map of the Chile triple junction region showing the locations of Sites 859 through 863, occupied during Leg 141.

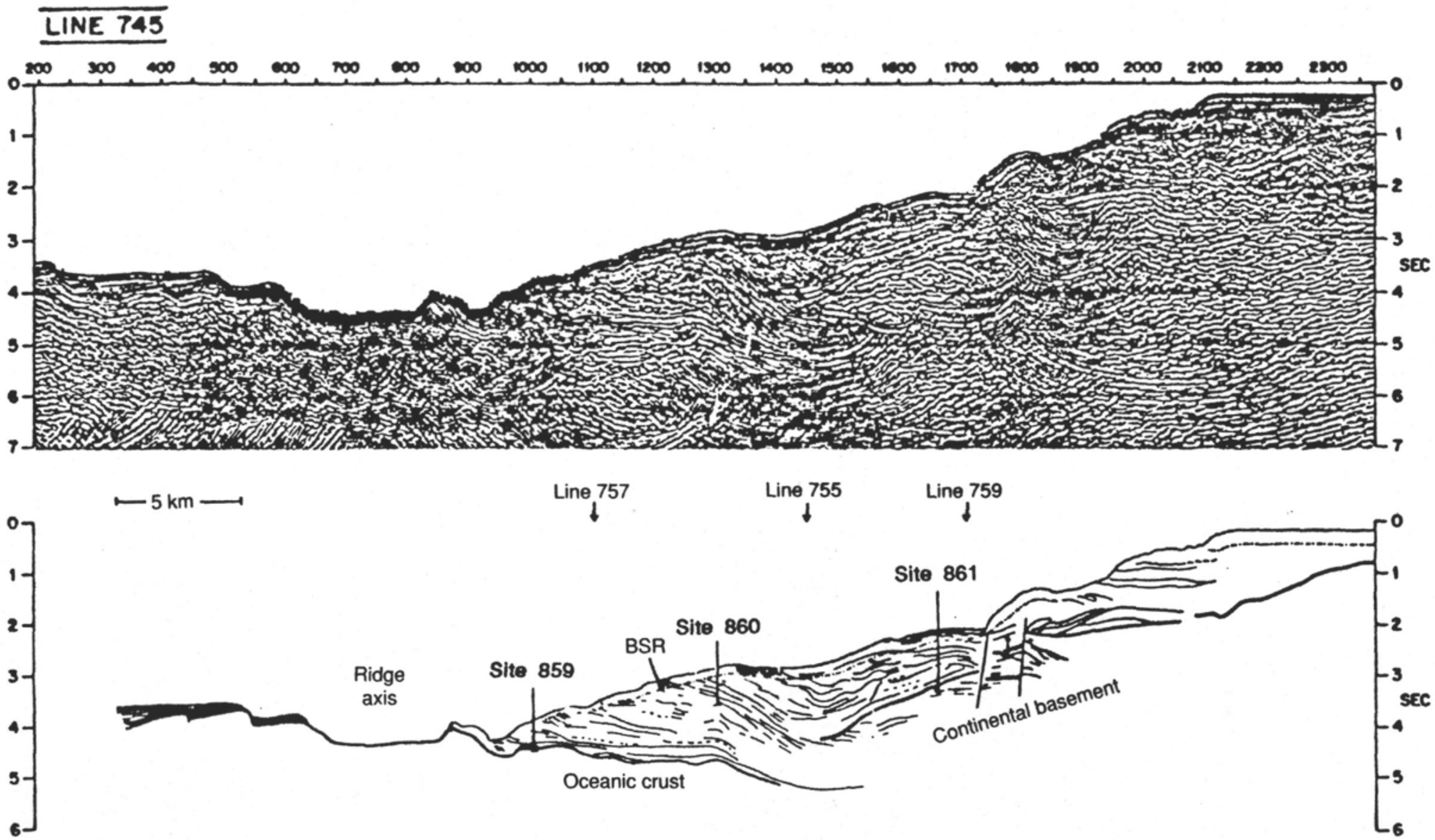


Figure 2. *R/V R. D. Conrad* Seismic Line 745, showing the locations of Sites 859, 860, and 861.

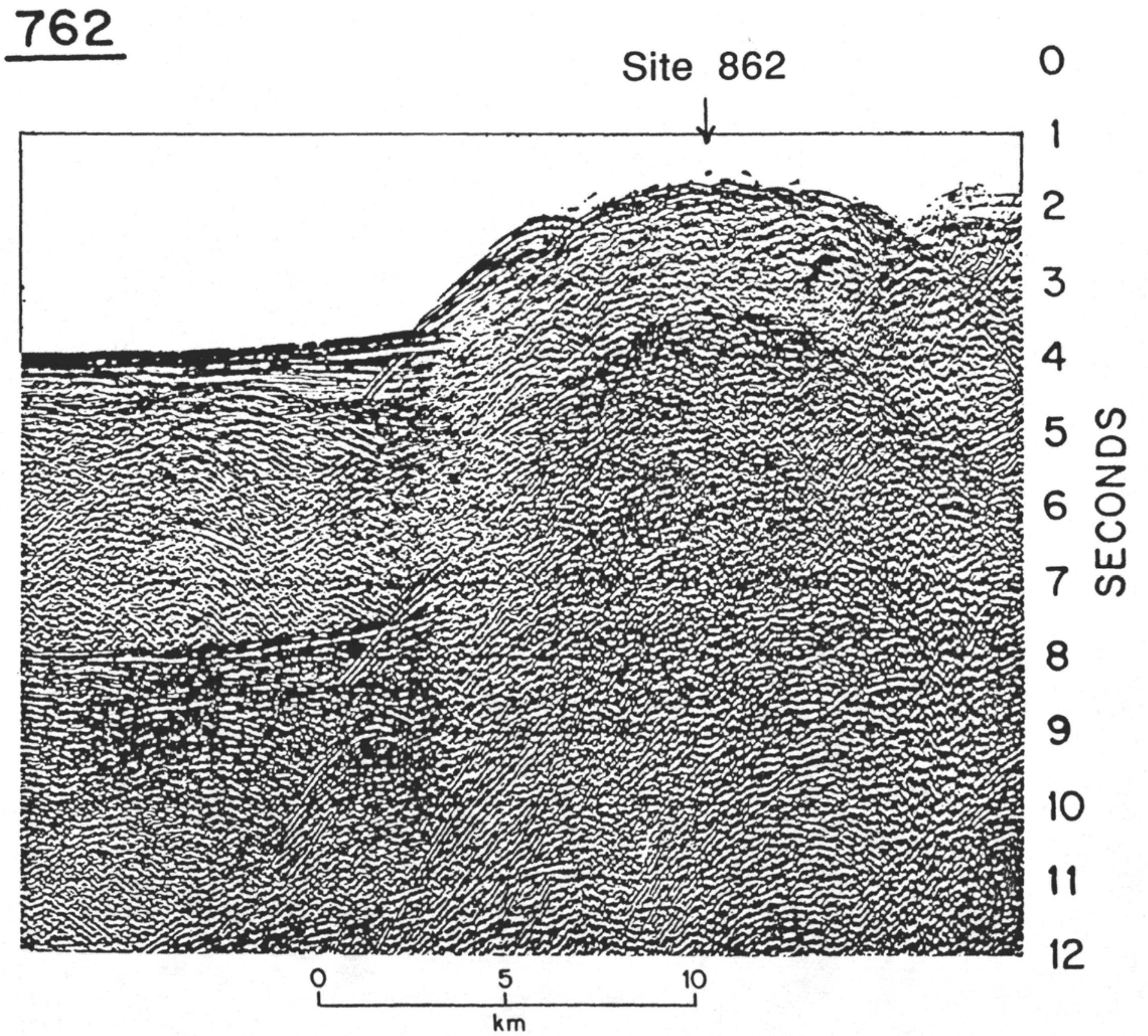


Figure 3. *R/V R. D. Conrad* Seismic Line 762, showing the location of Site 862.

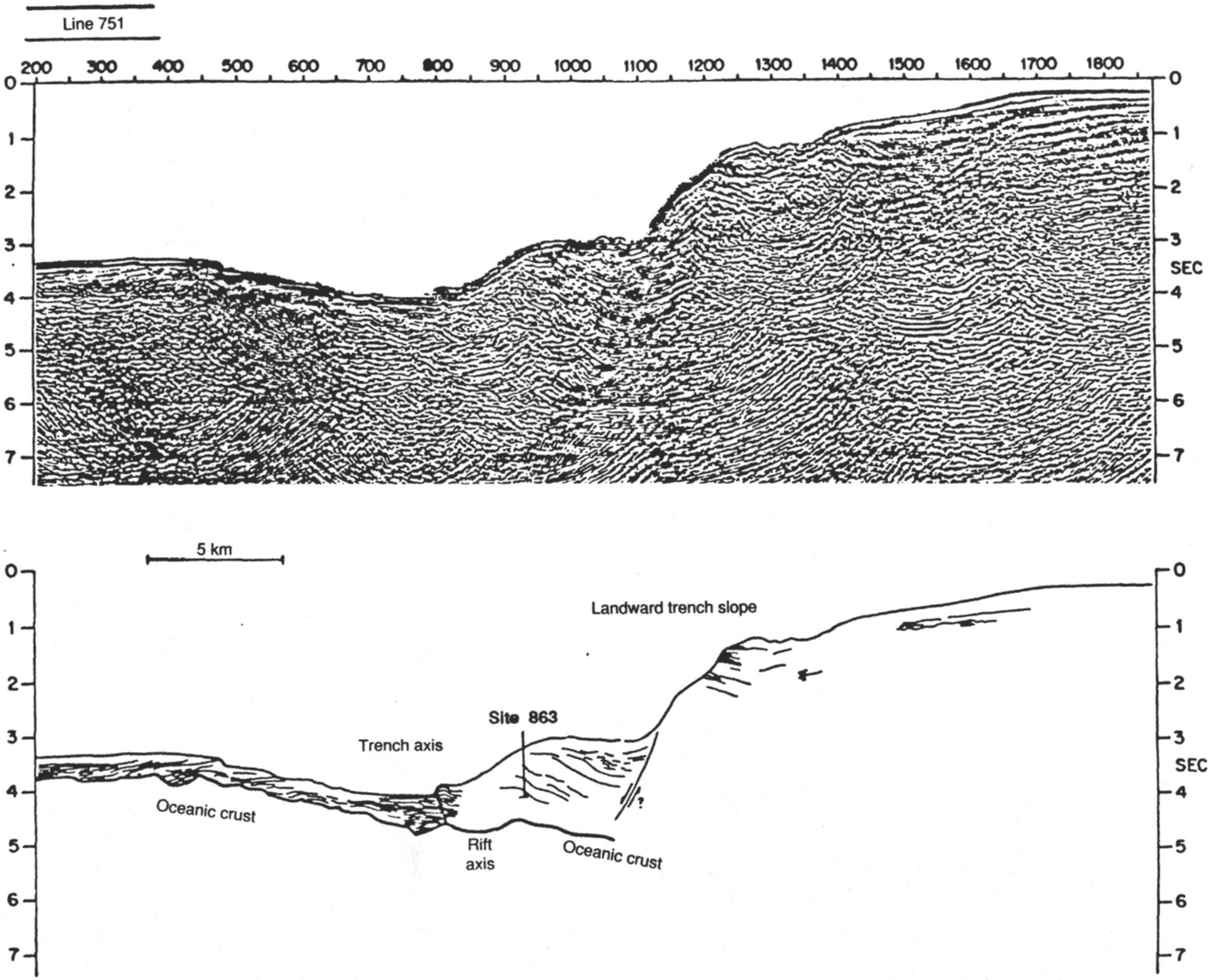


Figure 4. *R/V R. D. Conrad* Seismic Line 751, showing the location of Site 863.

OPERATIONS REPORT

The following operations and engineering personnel were aboard *JOIDES Resolution* for Leg 141 of the Ocean Drilling Program:

ODP Operations Superintendent:	Dave Huey
ODP Development Engineer:	Scott McGrath
ODP Development Engineer:	Mark Robinson
Schlumberger Engineer:	Chris Wood

INTRODUCTION

Leg 141 drilled in a unique tectonic area along the coast of southern Chile, where an active spreading ridge is subducting under the South American continent. The area was expected to present significant sampling and drilling challenges. High geothermal gradients and probable zones of hydrothermal activity made the downhole collection of fluid and gas samples a priority. Pre-cruise plans included the collection of *in-situ* fluids and the measurement of temperature with the water sampler temperature probe (WSTP), as well as the use of the pressure core sampler (PCS) to capture methane hydrates at hydrostatic pressure. The PCS was designed to eliminate the depressurization effects of normal core-retrieval processes that result in the loss of smaller pieces of frozen material through sublimation. In addition to these downhole-sampling challenges, collision tectonics were expected to produce unstable hole conditions.

Leg 141 officially began when *JOIDES Resolution* dropped anchor in Balboa Harbor, Panama, at 1000 hr (local time; 1500 UTC) on 12 November 1991, and ended in Valparaiso, Chile, at 1750 hr (2050 UTC) on 12 January 1992. On the way to the first site, the vessel stopped briefly in Valparaiso to pick up scientific supplies and to exchange some passengers. On two separate occasions during Leg 141, operations were interrupted for medical evacuations of shipboard personnel to Puerto Quellón, Chile.

During Leg 141, the drill ship occupied 5 sites and drilled 13 holes. A total of 2514.8 m of sediment and rock was penetrated, with 1018.79 m of core recovered in 284 cores. Logs were collected in holes at Sites 859, 860, 861, and 863. Hole 863B was reentered via mini-cone and deepened after changing core bits. Table 1 presents coring statistics for all holes drilled during the leg, Table 2 is a detailed breakdown of time expenditures, and Figure 1 is a simpler description of time distribution.

Some notable events and achievements of Leg 141 include the following:

- Successful deployment of six different specialized coring systems: APC (advanced piston corer), XCB(extended core barrel), XCB/FC (extended core barrel/flow control), PCS (pressure core sampler), MDCB (motor-driven core barrel), and RCB (rotary core barrel);
- Deployment of six non-coring downhole data-gathering devices (other than logging tools): ADARA APC temperature tool, WSTP (water-sampler temperature probe), Uyeda heat-flow probe, Tensor orientation tool, Eastman multishot camera tool, and SCM (sonic core monitor);
- Full operation of three developmental systems: MDCB, PCS, and SCM;
- Penetration of three pronounced bottom-simulating reflectors (BSRs), without recovery of any solid hydrates with either the PCS or conventional core barrels; and
- Severance of one bottom-hole assembly irretrievably stuck in a keyseat.

PANAMA PORT CALL

Port call at Balboa Harbor, Panama, was short and uneventful. Routine ODP logistics/operations shipments were on- and offloaded, and Sedco equipment was received. The offgoing scientists, technicians, and ship's crew were discharged and replaced by Leg 141 and transit-only personnel. A full load of fuel was bunkered, and some port-call maintenance was performed by Sedco. A Baker-Hughes team inspected all the 5-in. and 5-1/2-in. drill pipe in the rackers, resulting in the removal of several joints of 5-in. pipe from the drill string.

TRANSIT FROM PANAMA TO VALPARAISO AND VALPARAISO PORT CALL

JOIDES Resolution departed Port Balboa, Panama, at 1600 hr local time (2100 UTC) on 15 November 1991 for Valparaiso, Chile, and arrived at anchor on 25 November at 0700 hr local time (1000 UTC; local Chilean time is used throughout the rest of the Operations Report). The 2628-

nmi transit was accomplished in about 9.5 days at an average speed of 11.5 kt in fair to moderately rough seas.

The 7.25-hr port call in Valparaiso provided the opportunity to exchange personnel and take on additional freight. After completing customs and immigration formalities, exchanging part of the technical crew, embarking the remaining scientists, disembarking several scientists and Sedco personnel for medical reasons, and embarking a small load of freight, the ship departed Valparaiso Harbor at 1400 hr on 25 November 1991, the same day it arrived.

SITE 859 (PROPOSED SITE SC-3)

The 803-nmi transit from Valparaiso Harbor to the start of the site survey was completed in 73 hr at an average speed of 11.0 kt. *JOIDES Resolution* arrived at the location for the pre-site survey for Sites 861, 860, and 859 (proposed Sites SC-1, SC-2, and SC-3 respectively) at 1500 hr on 28 November 1991.

The vessel then ran an east-to-west confirming seismic line over the three proposed sites, dropping a 14-kHz Datasonics commandable/releasable beacon at each site as it was passed. Each of the sites was accurately located and the beacons were dropped at these sites at 1657, 1727, and 1819 hr, respectively.

Hole 859A

The seismic gear was retrieved, and the ship returned to the beacon at proposed site SC-3 to begin operations at Site 859. The vessel was steadied over the beacon at 2030 hr on 28 November 1991, and makeup of the bottom-hole assembly (BHA) was begun. A conventional APC/XCB BHA was assembled with a standard 11-7/16-in. roller-cone bit.

Bottom was confirmed in the first mud-line APC shot at 2753.3 meters below sea level (mbsl). Cores 859A-1H and -2H were taken without incident. Stiff formation at unexpectedly shallow depths resulted in partial strokes and shattered liners for Cores 859A-3H, -4H, and -5H.

Cores 859A-3H, -4H, and -5H were oriented via both the normal Eastman Multishot camera tool and a new, electronic Tensor orientation tool. Comparison of the results of these tandem measurements demonstrated that they were identical between the tools to within 1° of arc. Also included in the APC coring deployments were ADARA heat-flow cutting shoes. The ADARA instrumentation worked well, but the measurements were not valid due to apparent movement of the cutting shoe within the sediment during the equilibrium wait period. WSTP runs were made with the old Uyeda-temperature electronic package, since the new WSTP deck electronic-interface box could not be made to work.

The XCB system was used for Cores 859A-6X and onward except when the PCS was deployed (Cores 859A-9P, -12P, -15P, and -21P). The first two PCS attempts did not recover *in-situ* pressure due to operator error. Cores 859A-15P and -21P most likely did collect samples at hydrostatic pressure, although the technique used to measure the trapped pressure on deck was not suitable to confirm this. No significant gases or evidence of methane hydrates were discovered in either of the two "successful" PCS cores. Due to slow XCB penetration, the hole was abandoned at 146.4 mbsf. The bit cleared the rotary table at 2330 hr, 1 December 1991, ending Hole 859A.

Hole 859B

The ship was offset 20 m to the northwest while the RCB BHA was made. The hole was spudded at 0800 hr, 2 December 1991, after the driller detected seafloor at 2760 mbsl. (Later logging in Hole 859B suggested that the tag depth was low, the driller having failed to detect soft sediments at about 2754 mbsl, essentially identical to the depth assigned to Hole 859A.)

The hole was drilled with a center bit to 52 mbsf, and three spot cores were taken in an attempt to recover material missed by the coring in Hole 859A. The spot cores were recovered with 3.86, 5.84, and 9.67 m of sediment. A WSTP run at 71.3 mbsf yielded a valid temperature measurement, but no water sample, due to filter clogging. The center bit was used again as the hole was deepened to 140.0 mbsf to begin continuous coring. Penetration was slow through the sticky, firm formation; drilling 60 m required 5.5 hr, including wireline and connection time. The WSTP was deployed in temperature-only mode five additional times as the hole was drilled but apparently successfully measured *in-situ* temperature only twice.

Routine RCB coring began at 140.0 mbsf and ended at a total depth (TD) of 476.1 mbsf, where coring operations were terminated due to time constraints. Over the deeper sections of the hole, the bit deplugger was dropped three times and successfully deplugged the throat of the core bit when mud in the throat inhibited core recovery.

No solid methane hydrates were recovered from Holes 859A or 859B, although seismic evidence and geochemical evidence suggest that some clathrates were present in the formation. Gas contents of the cores were continuously monitored in the cores that exhibited trapped gas pockets (most of the cores). Some gas expansion, but no violent degassing, of the cores on deck was observed. Gas chromatograph (GC) analysis of vacutainer samples revealed very large concentrations of methane, but also significant portions of C2 and C3 (as high as 163 and 65 ppm, respectively), plus small concentrations (up to 7 ppm) of hydrocarbon gas species C6 and above. Microscopic globules, which would fluoresce under ultraviolet light, were detected in Core 859B-27R, indicating the presence of hydrocarbons. The globules were examined by extract techniques and determined to be condensed, low-molecular-weight hydrocarbons. The presence of these hydrocarbon indications was sufficient to require a further clarification from ODP headquarters on the acceptability of continued drilling at this site. Authorization was received via Marisat, and operations continued without interruption.

After drilling operations ceased and prior to logging, a wiper trip was conducted. No ledges or bridges were detected during the downward portion of the wiper trip. Rigging of the geophysical tool string began at 2330 hr on 6 December 1991. The sonic tool was turned off because the tool string appeared to contain too many tools for the telemetry capability. Uphole logs (minus the sonic data) were recorded from TD (463.6 mbsf) to the base of pipe (42.3 mbsf). The Lamont temperature tool appeared to have flooded, and only 12 min of data were recovered from the first run.

A sonic tool string consisting of the sonic, caliper, and natural gamma-ray tools was run in order to get downhole velocity data in Hole 859B. Logs were recorded from 469.7 mbsf to the base of the pipe at 43.6 mbsf.

The formation microscanner (FMS) tool string was run from 460.5 to 38.7 mbsf. A second pass was made from 460.5 to 28.0 mbsf.

To take advantage of the excellent weather conditions, a vertical seismic profile (VSP) using the well seismic tool (WST) was conducted next. The seismic source was a 400-in.^{3} water gun, hung from the side of the ship. The WST was rigged with the Lamont temperature tool and lowered to 461.1 mbsf. Eight seismic stations were attempted, but because of enlarged hole conditions, clamping of the tool was successful at only four stations. Temperature measurements were taken at 11 additional stations during this run.

The geochemical tool string was run last. On the first pass, the hole was logged from near bottom (455.6 mbsf) to the base of the pipe (30.1 mbsf) in open hole, and 15 m into pipe. Logging was completed with a second pass, recorded from 202.7 to 30.1 mbsf in open hole, and 11 m into pipe.

After the pipe cleared the mud line, the ship was moved toward Site 860 with thrusters and hydrophones down while the drill string was pulled. The end of pipe was on deck at 1730 hr on 8 December 1991, ending Hole 859B.

SITE 860 (PROPOSED SITE SC-2)

Transit over the 3.3 nmi from Site 859 to Site 860 (proposed site SC-2) began as soon as the pipe cleared the mud line at Hole 859B, at 1115 hr on 8 December 1991. The 14-kHz Datasonics commandable/releasable beacon had been dropped during the site survey prior to operations at Site 859 and was activated at 1830 hr on 8 December 1991, beginning operations at Site 860.

Hole 860A

While still in slow-motion transit from Site 859, the bottom-hole assembly (BHA) for the next hole was assembled, including a large cutter PDC drag bit (10.125 x 3.80 in.) and required subs to allow MDCB operations (if appropriate formation was found). A newly developed anti-clog valve, part of the new XCB/FC coring system, was also included in the BHA.

Water depth over the beacon was 2113 mbsl according to the precision depth recorder (PDR). Several hours were spent feeling for bottom until it was discovered at about 2159 mbsl, according to a somewhat uncertain driller's tag. One overfilled APC core was taken, which did not satisfactorily establish the depth to the mud line. The pipe was pulled up 7 m to try again, ending Hole 860A at 0250 hr on 9 December 1991.

Hole 860B

The next APC core established mud line at 2157.1 mbsl. APC coring proceeded for seven cores at which point the core barrel could not be extracted with 130,000 lb overpull. The barrel was washed over for 3 m and then pulled free with the sand line. The final four APC cores failed to achieve full initial stroke, but each recovered a core more than 8.5 m long, suggesting that either the core barrel continued to work its way into the formation after the initial stroke or the extra core was flow-in material sucked in when the barrel was extracted from the formation.

The PCS was deployed for Core 860B-8P but did not capture any core sample. The PCS did actuate correctly and was retrieved with pressure inside at 3791 psi, about 540 psi over hydrostatic pressure at bottom-hole depth.

The remainder of the hole was drilled with the XCB to 617.8 mbsf. The XCB coring efforts were moderately successful, although core recovery was sometimes poor and the penetration rate was slow.

The PCS was deployed for Cores 860B-13P and -18P in an attempt to recover *in-situ* gas hydrates thought to be present in sufficient quantities to account for a BSR seen on the seismic records. Core 860B-13P captured 0.61 m of core (total core capacity for the PCS is 0.86 m) and retained pressure on deck of 3012 psi, about 300 psi less than hydrostatic pressure. The gases analyzed from Core 860B-13P did not confirm the presence of solid gas hydrates *in situ*. Core 860B-18P proved to be the first of four deployments of the PCS during which frustrating mechanical failures inhibited the recovery of cores and *in-situ* pressure in this hole, as well as in the upper section of Hole 861C.

The WSTP tool was deployed routinely after about every third core down to 155 mbsf. In general, good water and temperature samples were obtained until the formation became too stiff to allow insertion of the probe tip without the sediments cracking.

Ten XCB cores were taken using the new XCB/FC system, which uses special, flow-regulated core barrels. The XCB/FC deployments were spaced throughout the hole. The pressure-flow characteristics of the special barrels were very close to computer-model predictions, and the regulator function apparently worked as designed to inhibit clogging of the cutting-shoe water jets. Unfortunately, this response characteristic did not produce the desired improvement in quality or quantity of recovered core. Recovery for the 10 XCB/FC cores ranged from 0 to 8.93 m with an average of 15.9% recovery. The standard XCB was deployed 59 times and averaged 31.9% recovery over the hole.

All of the cores recovered contained hydrocarbon gases, and most showed signs of expansion in the liners. Vacutainer samples were taken whenever possible and analyzed for gas composition. Methane was the predominant gas, but significant quantities of heavier molecular-weight hydrocarbon gases were also found, including species above C6. When these compounds were identified and the C1/C2 ratio dropped to below 500, it was presumed that the gases had migrated to their present location from a thermally mature source an unknown distance from Site 860. Drilling operations ceased after Core 860B-41X (357.7 mbsf) in accordance with standard Pollution Prevention and Safety Panel (PPSP) policy. Guidance was requested from PPSP on the decision to further deepen the hole. Authorization to continue drilling was received via Marisat, and coring resumed. The PCS was deployed for Core 860B-42P in a final attempt to capture a core at *in-situ* pressure conditions in the hope of getting some measure of total gas content *in situ*. This attempt was frustrated by a mechanical failure of the complex PCS latching system.

Quantities of heavy hydrocarbon gases detected in the shallowest cores dropped off deeper in the hole. Hydrocarbons did not play a role in the decision to stop drilling in the hole.

The SCM system was tested briefly (with Cores 860B-64X, -66X, and -68X) and performed well. Minor software problems on deck were corrected, and three runs were completed in which the downhole electronic monitoring unit accurately tracked and recorded core entry.

A multishot drift survey of the hole was taken at 100-m intervals during recovery of Core 860B-70X. The inclination of the hole slowly increased with depth to a maximum of 4° at the bottom of the hole. The hole was terminated at 617.8 mbsf, when the co-chief scientists determined that the continental basement target might not, in fact, be present below Site 860. By that time, significant hole problems were beginning to crop up, including 22 m of fill following the last core.

Logging operations began at 1630 hr on 15 December 1991, with a mud sweep and full-length wiper trip. Reaching the lowermost 126 m of the hole required rotation and circulation during the downward portion of the wiper trip to clean out fill and minor bridges. An aluminum go-devil was pumped down to lock open the lockable float valve. The first logging run, the Quad combo, was attempted without the side-entry sub (SES). It was stopped by a bridge at 188 mbsf, and logging was achieved only from that point to the logging depth of the bit (55 mbsf). When the tools were pulled into the BHA they encountered an obstruction assumed to be an unlocked float valve. With some effort, the tools were recovered undamaged.

The SES was picked up and placed in the drill string in order to achieve more access to the hole for the remainder of the logging program. The bit was run to 615 mbsf while the abbreviated logging tool string was run through the pipe. Upon lowering, the tool string became stuck in the BHA. While working the logging line and drill pipe in response to the stuck tools, the logging line was apparently overrun, resulting in the line being parted just above the cable head. Efforts to recover the logging tools from the BHA were unsuccessful, and the drill string was pulled. The logging tools were recovered intact when the BHA reached the deck. The bit cleared the rotary table at 0300 hr on 17 December 1991, ending Hole 860B.

The trip out of the hole and the very short transit to the next site were conducted at night and in poor weather. Accordingly, the beacon at Site 860 was not released. Plans were made to return to Site 860 to collect the beacon after completion of operations at the next site.

SITE 861 (PROPOSED SITE SC-1)

The 3.5-nmi transit from Site 860 to Site 861 (proposed site SC-1) was accomplished in DP mode, with the thrusters and hydrophones down, while tripping out of Hole 860B. The seismic survey and beacon drop had already been carried out during the combined site survey prior to operations at Site 859. Operations at Site 861 commenced at 0300 hr on 17 December, when the 14-kHz Datasonics commandable/releasable beacon was activated, and dynamic positioning for Hole 861A began.

Hole 861A

The PDR depth measured at the site was 1690 mbsl, but bottom was tenuously felt by the driller at 1672 mbsl, and an initial APC core shot to a depth of 1677.5 mbsl returned full and failed to reveal a clear mud line. Consequently, the bit was pulled above the seafloor, ending Hole 861A at 1015 hr on 17 December, in preparation for another mud-line-verification core.

Hole 861B

The drill pipe was lifted 5 m and another APC core was taken. This core barrel was also full, with no mud line recovered. The bit was pulled clear of the seafloor again, ending Hole 861B at 1045 hr on 17 December.

Hole 861C

The drill pipe was lifted an additional 6 m and a successful mud-line APC core finally established mud line for the site at 1663.5 mbsl. Piston coring continued through Core 861C-10H, where partial stroke and 110,000 lb overpull defined the refusal depth. Both the ADARA temperature tool and the Tensor orientation tool were used on all APC cores after Core 861C-2H with mixed success, although the tools themselves functioned well. Heavy heave conditions caused at least two APC barrels to suffer pre-sheared pins, but the cores recovered did not show ill effects.

Routine XCB coring continued down to Core 861C-41X at a depth of 353.1 mbsf. Recovery and penetration rates during XCB coring were fair to good, and continuation of coring in that mode preserved the option of using the PCS and heave-decoupled WSTP. These tools would permit optimum investigation of geochemical features in the upper 300-plus m of the sediment column, including hydrates assumed to be present because of a strong bottom-simulating reflector (BSR) evident on the seismic records.

The PCS was deployed four times, at 71.0, 170.2, 220.1, and 248.3 mbsf. The choice of depths was not optimum because repeated trouble-shooting efforts were required between deployments to determine the cause(s) of mechanical actuation failures, which resulted in the tool being recovered with the pressure chamber open. The tool did actuate on the last two runs and captured some pressure, but at significantly less than hydrostatic levels (115 and 190 psi). Both runs also recovered full cores (0.86 m or more), but the analyses of gases taken from the cores did not confirm the presence of hydrates or offer any substantial new information about *in-situ* gas chemistry.

The WSTP (with old Uyeda electronics) was deployed five times in both water-sampling and temperature-measurement modes and six times as a temperature probe only. Five good water samples were obtained, and temperature results appeared to be very reliable until the final three temperature runs, in which measurements were questionable. It is thought that the probes cracked the formation upon insertion during these unreliable runs.

As at Sites 859 and 860, hydrocarbon gases in Hole 861C were common in all cores, and cores composed of the softer sediments expanded slightly in the liners. Some heavy hydrocarbon species were observed (C4 and C6), but not at significant levels. The C1/C2 ratio, as determined in vacutainer samples, declined steadily until leveling at about 600.

Hole 861C was arbitrarily terminated at 353.1 mbsf in order to change to the RCB coring system for deep penetration to the projected depth of continental basement (1200 mbsf). The drill string was pulled, and operations at Hole 861C were completed when the bit cleared the rotary table at 1530 hr on 20 December.

Hole 861D

The vessel was offset 20 m northwest, and a standard RCB BHA was assembled, complete with drilling jars. The pipe was run in with a center bit in place in the outer core barrel, and Hole 861D was spudded at 2015 hr on 20 December 1991. Drilling with the center bit continued to 342.3 mbsf, where the center bit was replaced with an RCB, and coring began. A bit deplugger was dropped twice after netting zero recovery for Cores 861D-3R, -4R, and -5R. Both times a clay plug was removed, but it seemed to reappear between core-barrel deployments. Sidewall scraping during heavy heave conditions probably contributed to the bit-plugging problem. However, the problem disappeared as suddenly as it had appeared, and RCB coring was conducted with good results to Core 861D-16R at 496.3 mbsf. High seas produced heave conditions on 21 December very nearly at the heave compensator's stroke limit, but operations continued without any interruption forced by the weather.

At 1330 hr on 22 December, a medical-evacuation emergency was declared by the ship's surgeon, who had been treating the UDI Second Engineer for lung-related illness for several weeks. The doctor determined that an immediate evacuation to the nearest medical facility was necessary in the interest of the crewman's health. The local ship's agent arranged for us to rendezvous with a pilot boat and doctor in the sheltered waters of the Gulf of Corcovado off Puerto Quellón, Chile. No helicopter or small boat was available to serve as the evacuation vehicle because of the distances and weather conditions.

Consequently, Hole 861D was terminated, and the drill string was pulled. The option to deploy a mini-cone was rejected, based on the danger to personnel, with high seas washing the main deck at the time of the evacuation. The beacon was also left behind, since weather and sea conditions made recovery dangerous and unlikely to be successful. Plans were tentatively made to return to Sites 860 and 861, where beacons had been abandoned, during the transit from Puerto Quellón to the next site if weather conditions permitted.

TRANSIT TO PUERTO QUELLON

The drill string was pulled and the entire selection of drill collars was laid down in the main-floor collar racks in preparation for a bad-weather transit north along the coast over some 200 nmi to Puerto Quellón. The vessel departed Site 861 at 2100 hr on 22 December. The transit to the med-evac rendezvous was uneventful, as the heavy rolls expected from the broadside swells were not as bad as feared. The rendezvous took place on schedule at 1500 hr on 23 December, with a minimum of red tape.

SITE 862 (PROPOSED SITE SC-6)

The ship returned south along the coast to Sites 861 and 860, where the two previously unreleased beacons were recovered. The ship then proceeded to the waypoint for the start of the pre-site survey for Site 862, and deployed seismic gear. Two passes over the target area were required to select an optimum drill site where maximum sediment thickness was available. Operations at Site 862 began at 1642 hr on 24 December 1991, when a 14-kHz Datasonics commandable/releasable beacon was dropped. The ship immediately returned to the beacon location to begin dynamic positioning. The drill collars were picked up to make up an APC/XCB/MDCB BHA.

No more than 100 m of sediment was expected over basement; at least 60 m of sediment was considered desirable to spud the hole effectively. The PDR water-depth measurement indicated firm seafloor and maximum available sediment thickness at 1239 mbsl, but both PDR and apparent driller's tag were misleading. Four APC water cores were taken before the mud line was located at 1268 mbsl.

Hole 862A

Four APC cores were taken with some difficulty. Full stroke was achieved on the first two cores but the second required 100,000 lb overpull for extraction from the sediment. The third APC core did not achieve a full stroke and overpulled to 60,000 lb. The fourth, and last, APC core penetrated less than a meter and defined the piston-coring refusal point.

The coring mode was changed to XCB, and a single core attempt ended in a broken XCB cutting-shoe spacer sub when the core barrel encountered hard rubble at 21.1 mbsf. Both the cutting shoe and broken half of the spacer sub were left in the hole along with the core catcher and any core that had been captured. The junk in the hole ended any further possibility of deepening in this particular spot, so the bit was pulled above the seafloor to start a second hole. The bit cleared the mud line at 0615 hr on 25 December 1991, ending Hole 862A.

Hole 862B

The vessel was offset 10 m to the southeast, and Hole 862B was spudded with an XCB and washed to 17.5 mbsf. Recovery in the wash barrel was 0.26 m of highly disturbed sediment overlying rocky cobbles. Three additional XCB cores were laboriously taken in what appeared to be a rubble zone with some clay and gravel constituents. Recovery ranged from 0.75 to 4.12 m, and the core material was composed of roller stones that did not appear to have been trimmed or recently fractured. One TC-insert XCB cutting shoe had its cutting structure obliterated, and two others suffered significant damage. Torquing in the hole was severe, and cuttings consistently packed-off the annulus around the bit or drill collars when flow rates were too high or held constant for more than a few minutes. Fill in the hole became a serious problem, amounting to 8 m after Core 862B-4X. The rate of penetration in Cores 141-862B-3X and -4X was as slow as 3 m/hr, and additional time was spent cleaning out fill to reach the bottom of the hole.

Since it was apparent that the objective of reaching and sampling solid basement was unlikely to be achieved at this location with XCB technology, the hole was terminated and the pipe was pulled in order to change over to the rotary core barrel (RCB) coring method. The MDCB was not deployed because it is not possible to clean out fill without simultaneously starting the MDCB. The hole was abandoned, the pipe was tripped, and the hole officially ended when the bit reached the drill floor at 2030 hr on Christmas Day.

Hole 862C

The vessel was offset 100 m to the southeast before starting Hole 862C in the hope of finding less rubble. The RBI C-4 RCB roller-cone bit was run to bottom, and the hole was spudded at 1239.0 mbsl. The hole was initially washed to 40 mbsf, where coring began. The sediment cover proved to be slightly thicker at this location, as rapid penetration was achieved to about 85 mbsf, although core recovery over this zone was very low, consistently less than 5%.

At 0100 hr on 26 December, just prior to spudding Hole 826C, operations were suspended for 30 min as an unidentified vessel on a collision course for *JOIDES Resolution* did not respond to normal radio hailing. Eventually a response was received to hails in Spanish, and the ship, seagoing tug *R-Lenga*, identified herself as a local work boat for servicing lighthouses. Her errand and approach were not adequately explained, but she changed course after approaching to within 0.2 nmi and eventually left the area.

RCB coring continued into the same rubble-dominated zone that had been encountered at a slightly shallower depth in Hole 862B. Total recovery in seven cores was just over 2%. The recovered material was composed entirely of hard-rock roller stones. As in Hole 862B, severe torquing and fill created difficult coring conditions and caused very slow progress toward more solid basement.

At this time, the UDI crane operator badly cut several fingers on his left hand while using a table saw. The ship's surgeon ordered an immediate medical evacuation in order to get him to a micro-surgery center soon enough to possibly save one or more of his damaged fingers.

Therefore, Hole 863C was terminated after eight cores at a TD of 102.1 mbsf at 0000 hr on 27 December. The drill string was pulled, and the ship got under way for Puerto Quellón to rendezvous with the same Chilean immigration and medical personnel who had been aboard only 2 days earlier. The beacon at the site was abandoned because the weather was too rough to offer any possibility of a successful after-dark beacon recovery.

SECOND TRANSIT TO PUERTO QUELLON

After leaving Site 862, the ship proceeded up the Chilean coast for 240 nmi to Puerto Quellón and transferred the injured crane operator to the Chilean agent and medical authorities. The 200-nmi trip south to the start of the pre-site survey for proposed site SC-5 was completed in 18 hr.

SITE 863 (PROPOSED SITE SC-5)

The site survey was routine, and a 14-kHz Datasonics commandable/releasable beacon was dropped at 0245 hr on 29 December 1991, beginning operations at Site 863 (proposed site SC-5). The seismic gear was retrieved and the ship returned to the beacon location but found the beacon signal too erratic for reliable positioning. A second commandable/releasable beacon was dropped and used for dynamic positioning at Site 863. The malfunctioning beacon was recovered two days later during routine coring operations.

Hole 863A

An APC/XCB BHA was made, with auxiliary subs required to allow for the deployment of the MDCB.

The PDR reading showed the seafloor to be at 2487 mbsl, but mud line was established at 2575.9 mbsl, 88.9 m deeper than the PDR estimate.

Six APC cores were attempted, but it was obvious the sediment was too stiff for effective deep APC work when Core 863A-2H experienced a 50,000-lb overpull for extraction. APC Cores 863A-2H through -6H failed to stroke completely and suffered overpull of 40,000-55,000 lb. The Tensor electronic orientation tool was used to orient Core 863A-3H, but failed due to erratic battery behavior. The old Eastman multishot camera tool was used to orient Cores 863A-4H through -6H.

After repeated partial strokes and declining recovery through six cores, the point of APC refusal was reached, and the coring mode was changed to XCB. Coring with XCB continued from Core 863A-7X at 56.1 mbsf through Core 863A-31X at 297.3 mbsf, with intermittent success. Core recovery was generally low, due to a tendency for core block and/or because the formation was dominated by poorly cemented sands, which proved to be virtually impossible to recover. A distinct change in lithology was encountered at about 80 to 90 mbsf, where sand became much more prominent.

The WSTP was deployed in Hole 863A after every third core. Below 150 mbsf only the smaller temperature probe was deployed. At 268.4 mbsf the temperature probe apparently did not insert into the sediment, as the formation was too stiff.

Following Core 863A-31X, a WSTP temperature probe was lost when a stop-piece on the colleted delivery system backed off, leaving the probe and about the lower third of the delivery system in the hole. Although the 11.7-m fish was tagged inside the BHA, three attempts to retrieve it were unsuccessful, and the hole had to be abandoned. The pipe was pulled to the seafloor, ending Hole 863A at 1430 hr on 1 January 1992.

Hole 863B

The vessel was offset 10 m east to start Hole 863B to continue coring to the target depth of 700 mbsf. A center bit was pumped in place and the hole was washed to 297.3 mbsf, the termination depth of Hole 863A. Penetration rates and torque response of the bit during drilling were normal, so it was assumed at the time that the bit had not suffered any significant damage.

Coring was resumed using the XCB, but problems ensued immediately. The first three XCB cores were recovered completely empty, showing no signs of even making contact with the formation, much less sampling it. It was assumed that the core barrels were not landing and latching in the BHA for unknown reasons, although it was clear that the center bit used to drill the upper portion of the hole had latched normally. A bit deplugger was dropped and recovered and showed indications of proper land and latch-in. An ADARA temperature shoe was made up to a modified XCB barrel and lowered into the sediment in an attempt to get both a final *in-situ* temperature measurement and a push-core sample. Neither effort was successful, as the ADARA shoe programming faltered, causing the tool to stop sampling prematurely. The push-core was not present, and again, the tools did not show signs of having come into contact with the formation.

Core 863B-4X was cut with an extended XCB cutting shoe and consisted of 7.16 m of well-trimmed core. Two more XCB cores were attempted, and recovery was low due to core jamming after a partial core had been acquired. No reason for the failure to recover core on the first three XCB attempts was found. At this point, the formation was becoming tough enough to cause significant damage to the tungsten carbide-insert cutting shoes in use.

In the hope of achieving higher quality cores and discharging a JOIDES Planning Committee (PCOM) testing mandate, the MDCB coring system was used for the next two cores. Both deployments were mildly successful in terms of core recovery and almost completely successful in terms of testing the latest version of the MDCB. Despite recovering good cores with the MDCB, it was clear that the scientific objectives of the hole could not be achieved in the time available at the speed of net penetration possible with the short (4.5 m) MDCB system. Thus, the MDCB was retired. One further XCB core was cut before coring was terminated, and the pipe was tripped in order to switch to the RCB system.

Before tripping out of the hole, a mini-cone (free-fall funnel, FFF) was dropped around the pipe and into the hole. The pipe was tripped to the deck, and a 12-drill-collar BHA was assembled with a standard 9-7/8-in. roller-cone bit, plus a mechanical bit release and Hydrolex drilling jars. The pipe was tripped back to bottom, and the Colmek TV was run in on the VIT frame.

The reentry was difficult. Despite having a mini-mud skirt and three flotation balls on tethers, all designed to make finding the cone easier, the FFF proved very difficult to identify. After 5 hr, the correct hole was identified and reentered.

Coring in Hole 863B was resumed using the RCB. After four cores with lackluster recovery, similar to the disappointing XCB results, a formation change to fine-grained siltstone and sandstone with near-vertical bedding planes wrought a dramatic improvement in core recovery, which remained high through the rest of the hole. A drift survey was taken at 100-m intervals and revealed a dogleg, with drift angles increasing from 2° off vertical at 75 mbsf to at least 9° at 175 mbsf, and then going back to 3° to 5° deeper in the hole.

Coring was terminated after Core 863B-49R at 742.9 mbsf, when time for drilling operations expired and the original depth target for the site had been surpassed. A wiper trip was made only over the lower half of the hole, since the upper half had been in good shape when re-entered 3 days earlier. The hole was circulated clear, and the bit was released 10 m off bottom with a routine activation of the mechanical bit release.

While the pipe was being pulled to logging depth, it began to drag and then became thoroughly stuck, with the end of pipe at 231.1 mbsf. Conditions strongly suggested that the BHA was tightly wedged in a keyseat. After attempts were made to free the pipe with no success, the string was hung off with about 30,000-lb down-load, and logging operations began. It was hoped that heave cycles pushing down the pipe during two days of logging would free the BHA from the keyseat.

Four runs were made. The geophysical tool string (spectral gamma ray, sonic, caliper, resistivity, and Lamont temperature tools) was run first. The tool string hit a constriction in the pipe at approximately the sea floor (2564.6 mbsl), but passed through when the drill pipe was pulled up enough to remove the bow in the pipe. Downgoing logs were recorded from 232.0 to 734.8 mbsf, less than 10 m above TD at 742.9 mbsf.

The geochemical tool string was run second. On the first pass, the hole was logged from near bottom (734.0 mbsf) to base of pipe (232.0 mbsf) in open hole, and 232.0 m into pipe. The second pass was recorded in open hole from 549.1 to 232.0 mbsf.

The FMS tool string was rigged up and lowered to maximum logging depth (738.1 mbsf). During the first upward pass, the Schlumberger computer malfunctioned when the tool string was at 290.0 mbsf. The tool string was lowered back 50 m, and data were recorded to pipe (232.0 mbsf). A second pass was made with the FMS tool string over the entire open hole.

The fourth run was made with the lithoporosity tool string (spectral gamma-ray, neutron porosity, and lithodensity tools) from 732 mbsf to the base of pipe. Temperature measurements were also taken at six 10-min stations (three in pipe; three in open hole). The final logging run in Hole 863B ended at 2200 hr on 8 January 1992.

At the end of logging operations, the pipe was still firmly stuck in the keyseat and would not budge. With all other options exhausted, a Schlumberger severing charge was assembled and run in to the transition joints immediately above the BHA. The pipe was severed cleanly. The string was immediately free, and the pipe was pulled clear of the seafloor and tripped to the deck, passing through the rotary at 1100 hr on 9 January 1992, officially ending site operations for the leg. As the pipe was pulled, the beacon was released and recovered routinely in fair daylight conditions.

With extra time in hand for the return voyage to Valparaiso, the ship proceeded 17 nmi south to Site 862 to collect the beacon that had been abandoned there. Release and recovery were straightforward, and at 1505 hr on 9 January, the vessel began the transit to Valparaiso.

FINAL TRANSIT TO VALPARAISO

The final downhole and beacon recovery operations had proceeded ahead of schedule, leaving more than adequate time to steam to Valparaiso to meet the scheduled arrival time of 0600 hr on 13 January 1992. Although the original intention was to proceed at a modest speed to save fuel, this plan was dropped in lieu of proceeding at full speed to achieve an early arrival. This would allow extra time either at anchor or at a dockside berth to remove the drilling and reentry equipment from the forward drill-collar racks to the riser hold in preparation for the loading of a massive amount of equipment for the diamond coring system (DCS) leg about to begin. The ship arrived in Valparaiso harbor at 1750 hr on 12 January 1991, officially ending Leg 141.

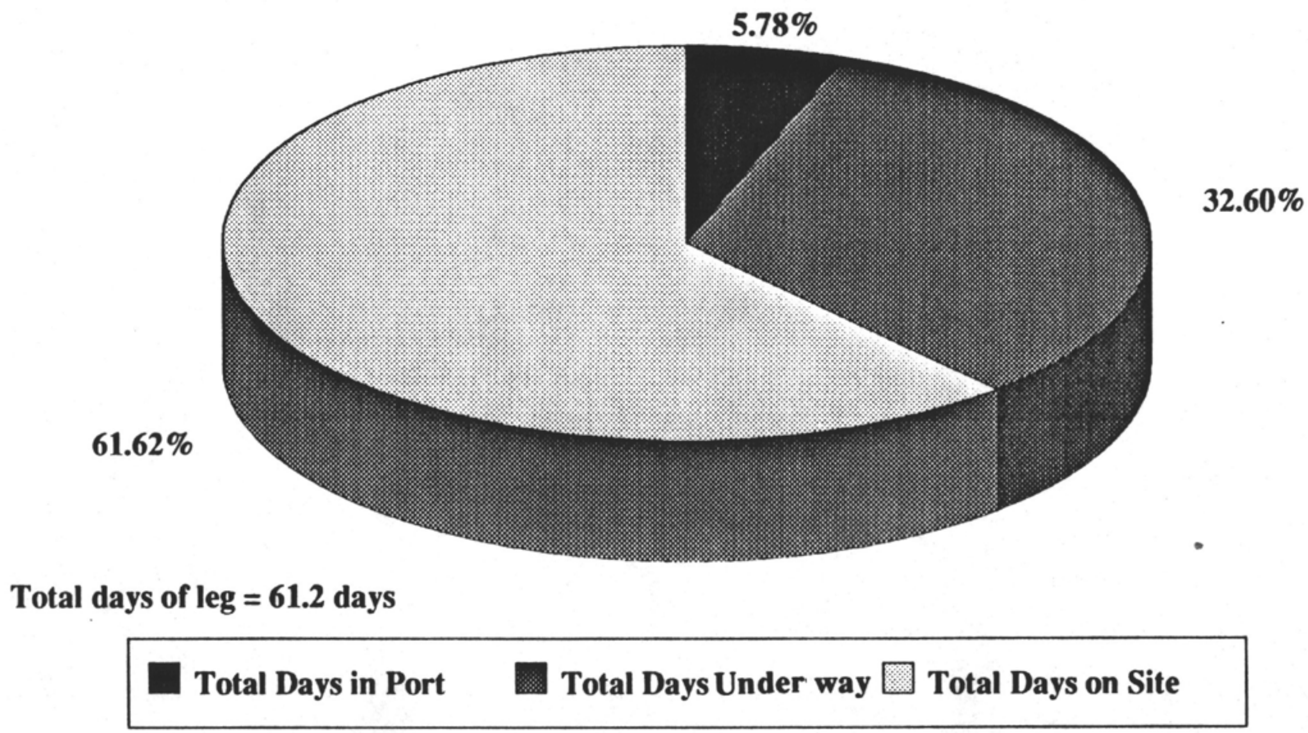
Table 1.
SITE SUMMARY

Hole	Latitude	Longitude	Water Depth (meters)	Number of Cores	Interval Cored (meters)	Core Recovered (meters)	Recovery (percent)	Interval Drilled (meters)	Total Penetration (meters)	Time on Hole (hours)	Time on Site (days)
859A	45 53.761S	075 51.165W	2753.3	21	145.0	53.56	36.9%	1.5	146.5	77.3	
859B	45 53.720S	075 51.339W	2760.0	38	365.0	169.67	46.5%	111.1	476.1	162.0	
		Site Totals:		59	510.0	223.23	43.8%	112.6	622.6	239.3	10.0
860A	45 51.972S	075 45.101W	2157.1	1	8.4	9.78	116.4%	0.0	8.4	8.3	
860B	45 51.972S	075 45.101W	2157.1	70	617.8	225.83	36.6%	0.0	617.8	192.3	
		Site Totals:		71	626.2	235.61	37.6%	0.0	626.2	200.6	8.4
861A	45 51.025S	075 41.531W	1663.5	1	9.5	10.00	105.3%	0.0	9.5	7.3	
861B	45 51.025S	075 41.531W	1663.5	1	9.5	9.92	104.4%	0.0	9.5	0.5	
861C	45 51.025S	075 41.531W	1663.5	41	353.1	202.17	57.3%	0.0	353.1	76.8	
861D	45 51.008S	075 41.499W	1663.5	16	154.0	40.65	26.4%	342.3	496.3	53.5	
		Site Totals:		59	526.1	262.74	49.9%	342.3	868.4	138.1	5.8
862A	46 30.475S	075 49.603W	1286.3	5	22.1	21.45	97.1%	0.0	22.1	13.5	
862B	46 30.475S	075 49.603W	1280.0	3	25.4	6.07	23.9%	17.5	42.9	11.0	
862C	46 30.509S	075 49.566W	1239.0	7	62.1	1.38	2.2%	40.0	102.1	30.8	
		Site Totals:		15	109.6	28.90	26.4%	57.5	167.1	55.3	2.3
863A	46 14.210S	075 46.371W	2575.9	31	297.3	75.39	25.4%	0.0	297.3	83.8	
863B	46 14.210S	075 46.371W	2575.9	49	445.6	192.91	43.3%	297.3	742.9	188.5	
		Site Totals:		80	742.9	268.30	36.1%	297.3	1040.2	272.3	11.3
		Leg Totals:		284	2514.8	1018.78	40.5%	809.7	3324.5	905.6	37.7

Table 2.
OPERATIONS RESUME

Total Days (12 November 91 to 12 January 92)	61.3
Total Days in Port	3.5
Total Days Under Way	20.0
Total Days on Site	37.8
Stuck Pipe/Downhole Trouble	0.4
Tripping	4.3
Other	0.5
Drilling	1.7
Coring	22.7
Re-Entry	0 4
Logging/Downhole Science	7.4
Fishing & Remedial	0.2
Repair Time (ODP)	0.1
Development Engineering	0.0
Repair Time (Contractor)	0.0
W.O.W.	0.0
Casing and Cementing	0.0
Total Distance Traveled (nautical miles)	5212.5
Total Distance in Transit (nautical miles):	5190.0
Average Transit Speed (knots):	11.1
Total Miles Surveyed:	22.5
Average Speed Survey (knots):	8.0
Number of Sites	5.0
Number of Holes	13.0
Total Interval Cored (m)	2514.8
Total Core Recovery (m)	1018.7
% Core Recovery	40.5
Total Interval Drilled (m)	809.7
Total Penetration	3324.5
Maximum Penetration (m)	742.9
Maximum Water Depth (m from drilling datum)	2760.0
Minimum Water Depth (m from drilling datum)	1239.0

FIGURE 1.
LEG 141
TOTAL TIME DISTRIBUTION



TECHNICAL REPORT

The following ODP Technical and Logistics personnel were aboard *JOIDES Resolution* for Leg 141 of the Ocean Drilling Program:

Laboratory Officer:	Bill Mills
Assistant Laboratory Officer:	Don Sims
Marine Laboratory Specialist/Yeoperson:	Michiko Hitchcox
Marine Laboratory Specialist/Curatorial Representative:	Lorraine Southey
Marine Computer Specialists/System Managers:	Ed Garrett Matt Mefferd
Marine Electronics Specialist:	Roger Ball
Marine Electronics and Downhole Tools Specialist:	Bill Stevens
Marine Laboratory Specialist/Photography:	Shan Pehlman
Marine Laboratory Specialist/Chemistry:	Chieh Peng Ken McCormick
Marine Laboratory Specialists:	Mary Ann Cusimano "Gus" Gustafson Robert Kemp Jeff Millard Monica Sweitzer Chun-Yeung Yan

INTRODUCTION

Leg 141 began on 12 November 1991, when *JOIDES Resolution* docked in Balboa, Panama. On 15 November, *JOIDES Resolution* departed from Panama for a 10-day transit to Valparaiso, Chile, where some passengers and freight were exchanged in a brief port call. On 24 November *JOIDES Resolution* left Valparaiso with a crew of 108 people, including 48 scientists and marine specialists. Before leaving Valparaiso, two scientists, one who had made the transit and another who had just joined the ship at Valparaiso, departed the ship for medical reasons. On 23 December and again on 28 December, drilling operations were suspended to evacuate ship's personnel for medical reasons, and the ship made a transit to Puerto Quellón, Chile, to deliver the afflicted personnel to shore-based medical authorities. Leg 141 ended on 12 January 1992 in Valparaiso, Chile, after 61 days at sea.

PORT CALL: BALBOA, PANAMA

On 12 November 1991, *JOIDES Resolution* docked in Balboa, Panama, ending Leg 140. Technical staff moved aboard that afternoon and completed a routine crossover. During the remainder of the 4-day port call, we discharged all Leg 140 cores and freight, and loaded new supplies. Philips Electronics made the only service call during the port call. Their service representative spent 3 days installing and aligning the recently overhauled XRD goniometer.

TRANSIT PROJECTS

Transits provide a very important break from the normal coring routine. During the Leg 141 transit from Panama to Chile, the technical staff had time to cross-train, to complete needed equipment maintenance, and to work on special projects. Newer marine specialists became more familiar with their equipment and lab methods. In the Chemistry and X-ray labs, marine specialists trained on newly installed equipment and prepared for work at upcoming sites.

Other marine specialists began preparations for downhole experiments. They rigged the 400-in.^{3} water gun and hydrophone for vertical seismic profiling, modified the gas-sampling manifold on the PCS, and prepared the WSTP for special He-isotope sampling.

At the request of the Science Operations Manager, we held an informal workshop to discuss the future of the Chemistry Lab. Leg 140 and Leg 141 marine chemistry specialists, two Lab Officers, the Supervisor of Technical Support, and Leg 141 chemists, including a former staff scientist, attended the workshop.

Other ODP departments took advantage of the transit time. Administration sent personnel to complete the annual government equipment inventory. The Engineering department conducted classes on the PCS for the drill crew, scientists, and marine specialists. They also conducted tests on the MDCB and the new Tensor orientation tool. Personnel from the Computer Services Group, working with the marine computer specialists, installed a new ethernet system in the Core Lab.

LAB OPERATIONS

In general, lab operations were routine, with special emphasis placed on downhole measurements and geochemical sampling. Table 1 summarizes the lab analyses performed on Leg 141.

Underway Geophysics

We collected geophysical data on five transit lines. Marine specialists routinely collected bathymetric data on all transit lines and magnetic data only on the longer transits to and from the Chile triple junction drilling area. We used two 80-in.^{3} water guns during all site surveys. GPS was used to navigate all geophysical lines. The Shipboard Environmental Data Acquisition System (SEAS) bathymetric and meteorological data were collected routinely on all transits and on-site.

Computing: Ethernet and Scratch Server Installation

To increase data-transfer rates between the VAX and PCs/MACs, the computer specialists upgraded the localtalk network to an ethernet system during the transit. Also, they installed a 1.2-gigabyte scratch server. The new system has performed well and is noticeably faster.

Downhole Tools

WSTP Spread Sheet

An Excel spread sheet was developed to convert resistance, measured by the Uyeda temperature recorder, to temperature values. The spread sheet contains all the latest thermistor coefficients (in protected cells) and will convert and plot resistances as entered.

Downhole-Temperature Measurements

To support the objectives of this leg, the scientists placed special emphasis on the collection of downhole water and temperature measurements. We ran the new ADARA temperature tool on most APC cores. This system was a pleasure to use, taking 17 temperature measurements with only one failure.

Also, we used the WSTP tool extensively for taking water samples and collecting temperature measurements in softer formations (17 samples). The "temperature only" version of the WSTP tool was used in harder formations with moderate success (19 measurements).

Pressure Core Sampler (PCS)

As part of the hydrate studies, we deployed the PCS 12 times in an attempt to capture hydrates under hydrostatic pressure. Out of 12 runs, 6 runs yielded core, and 2 runs provided gas samples, but only one run recovered both core (no hydrates) and hydrostatic pressure.

Tensor Orientation Tool

We successfully tested the new electronic core orientation tool (called the Tensor tool) this leg. The Tensor tool is a downhole surveying tool using the latest in magnetometer technology and data-acquisition hardware. The current version, purchased for preliminary testing, cannot measure inclination. With its successful deployment, this tool and future tools will be modified to measure both inclination and orientation.

Chemistry Lab

New Weighing Programs

As part of the effort to replace the Pro 350's, a new balance control program (named WT) was developed for the Macintosh computer. There are two versions of this program. One version controls the Cahn 29 electrobalance and can be run from any Mac with a serial port. The second works on a Mac SE with a National Instruments analog board. Both programs have the same features as the older Pro 350 versions but now use a statistical approach to determine final weight. The user can now select the precision and confidence level before weighing. As the program averages weights, a "running" Student's T test is calculated and used to determine when weighing should stop. The user can save the raw weights in a text file and then load them into a spread sheet for further statistical treatment.

GeoFina Hydrocarbon Meter

The new GeoFina Hydrocarbon Meter was installed during the transit, but it was used very little during Leg 141. We purchased the instrument to measure S1 and S2 peaks and to back-up the Rock-Eval instrument.

Core Lab

During Leg 141, new bearing rails were installed on the super saw, but after a few days of use they were as scored as the old ones. New supply boxes were built for the catwalk.

During Leg 142 the core lab will undergo extensive modifications in order to accommodate additional analytical equipment and to improve core flow in the lab. In preparation for renovations scheduled for Leg 142, we relocated the ship's chill-water lines and added a new 208V circuit in preparation for relocating the cryomagnetometer in Valparaiso.

Subsea Shop

After several years of planning and construction, the Subsea Shop is finally ready for the American Bureau of Shipping certification in Valparaiso. We completed installation of all supply air ducts, the A/C, the furniture, and the electrical services during Leg 141. The ship's mechanic relocated the subsea camera winch controls to the Subsea Shop. The core techs greatly appreciated his efforts when they were able to stay dry and warm during a reentry at Site 863.

Storeroom Improvements

We installed six new cages under the gym, which immediately reduced unauthorized checkouts of critical supplies to zero. Also, the storekeeper added 24 new shelves to the shelving units in the Lower 'Tween and Hold Storerooms. With these additional shelves, supplies are more efficiently and logically arranged, and storage capacity has increased 30%. All lab supplies and lab-equipment spares are now located in the (cleaner) Lower 'Tween Storeroom. Paper and office supplies are in the Hold Storeroom.

PHYSICAL PLANT

Core-Receiving Platform

To prevent the accidental lifting of the core-receiving platform when the crane is moving drill collars, the support braces have been "trapped" in their sockets.

Drill and Chill Water

The ship's engineers installed check valves to the core-lab drill-water supply. This will prevent the drill water from reversing flow and will make the meter readings more reliable. Also, they installed a flow-control valve to the User Room A/C to help balance chill-water use in the core lab.

Regulated Power

The regulated power on the Fo'c'sle Deck (RP-62) failed twice during the leg. The ship's electricians discovered that a lug to the bus bar had worked loose, causing intermittent arcing. The lug was tightened and the problem thus resolved.

Table 1.

LABORATORY MEASUREMENT SUMMARY, LEG 141

Sites:	5	
Holes:	13	
Meters cored:	2514.8	
Meters recovered:	1018.8	
Number of samples:	6286	
Samples analyzed:		
	Physical properties, density, and velocity:	621
	MST:	1000 m
	Cryogenic magnetometer:	appr. 1000 m
	Spinner magnetometer:	203
	Rock-Eval:	127
	$CaCO_3$:	588
	Inorganic carbon:	588
	Organic carbon:	162
	Total carbon:	162
	Gas/GC:	143
	Water chemistry:	172
	XRF major and trace:	44
	XRD:	362
	Thin sections:	4
Underway geophysics:		
	Total transit:	5,213 nmi
	Bathymetric data:	4,544 nmi
	Magnetic data:	3,900 nmi
	Seismic data:	22.5 nmi
Downhole tools:		
	Heat-flow measurements (WSTP):	25
	Heat-flow measurements (ADARA):	25
	WSTP water samples:	14
	PCS:	12 runs; 6 core samples, 2 gas samples