

IODP Expedition 323:

Pliocene-Pleistocene paleoceanography and climate history of the Bering Sea

Site U1341 Summary

13 August 2009

Background and objectives

The primary objective of drilling at Site U1341 (BOW-14B) was to study high-resolution Plio-Pleistocene paleoceanography in the southern part of Bering Sea at a western flank location of the Bowers Ridge. Previous DSDP coring (Site 188) and other piston core studies in the region documented relatively high sedimentation rates of 100 to 138 m/m.y., respectively, and presence of appropriate microfossils for paleoceanographic studies. The Bowers Ridge is well situated to study the past extent of water mass exchange with the Pacific Ocean through the adjacent Aleutian passes such as Amukta, Amchikta and Buldir Passes. Of particular interest, is to understand the influence of changes in the warm Alaskan Stream water mass that flows into this region and presumably impacted the distribution of the past sea-ice coverage. While the productivity in the Bering Sea in general is very high with respect to the other parts of the global oceans, the expected productivity at this site is lower than the Site U1339 which experienced substantially greater influence from the adjacent Bering Shelf which was subaerially exposed during the glacial low sea level stands. Drilling at this site, located at a relatively deep water depth of 2177 m, should provide us with past intermediate water conditions including the chemical compositions. For example, this site is located just below the modern dissolved oxygen minimum zone (OMZ) which causes the formation of laminated sediments, and slight fluctuations in the intensity or depth of the OMZ should be captured by proxy records of past oxygenation measured at this site compared to other, shallower sites. This site and the shallower drill sites on the Bowers Ridge (Site U1340, 1295 mbsl and U1342, 819 mbsl;) will be used to compare the vertical extent of water mass conditions.

The drill site at the Bowers Ridge can also be used to study the impact of subseafloor microbes on biogeochemical fluxes in the highest surface ocean productivity areas of the

drill sites in the Bering Sea. Organic-fueled subseafloor respiration and its impact on biogeochemistry in such a highly productive region has not yet been quantified. To do this, the Bowers Ridge sediments were used to determine subseafloor cell abundance and subjected to intensive geochemical analysis to investigate the link between the mass and characteristics of subseafloor microbes and the extent of export productivity from the surface ocean.

Operations

After arriving at Site U1341, a positioning beacon was deployed at 2311 hours on 26 July. Three holes were drilled at this site. A complete set of site specific tide tables were provided by the science party for Site U1341 and these were used to make adjustments relative to initial mudline core and for each successive core on each hole. A new continuous APC coring depth record was established when Hole U1341B reached 458.4 m DRF. APC coring totals for Site U1341 include 148 total cores, 1189.4 meters penetrated, 1201.54 meters recovered, for 101% recovery. The time spent on Site U1341 was 170.5 hours or 7.1 days.

Hole U1341A

Hole U1341A was spudded at 0510 hr on 27 July. The first APC barrel recovered 3.04 m of core and an official sea floor depth was established at 2150.9 m DRF. APC coring continued through Core U1341A-20H to a depth of 2334.4 m DRF using non-magnetic coring assemblies and with the FLEXIT orientation tool installed. The non-magnetic coring equipment was changed to the standard APC coring system and coring continued. Coring with the APC system was suspended after Core U1341A-41H with two successive short, incomplete strokes of the core barrel. Overall recovery for Hole U1341A using the APC coring systems was 101% with 364.94 meters recovered.

Hole U1341B

The vessel was offset 20 m east of Hole U1341A. Hole U1341B was spudded at 2245 hr on 28 July. The first APC barrel recovered 8.7 m of core and an official sea floor depth was established at 2150.9 m DRF. APC coring continued through Core U1341B-18H to a

depth of 166.7 m DSF using non-magnetic coring assemblies and with the FLEXIT orientation tool installed. Coring with the APC system was suspended after Core U1341B-56H with three successive short, incomplete short strokes of the core barrel. A new continuous APC coring record was established with continuous piston cores from the mudline to 458.4 m DSF or CSF. The XCB coring system was then deployed from Core U1341B-57X through 71X. The hole was terminated after Core U1341A-71X when the total depth of the hole reached 600.0 m DSF. APC core recovery for Hole U1341B was 102% with 467.64 m recovered. XCB core recovery for Hole U1341B was 88.2% with 126.9 m recovered. Total core recovery was 98.7% with 594.5 m recovered. The coring tools were secured and the hole was swept clean and then displaced with 200 barrels of high viscosity logging mud. There was no fill identified at total depth. The top drive was set back and the drill pipe was tripped to 80 mDSF while monitoring the hole for problems. The end-of-pipe (EOP) was placed at ~ 80.0 m DSF. Rig-up for wireline logging began at 1930 hr on 31 July. Two logging strings were deployed. The Triple Combo reached total hole depth of 600 m WSF and good quality logs were obtained. The second logging string consisted of the FMS-sonic tool. This tool string also reached total depth of 600 m WSF and also obtained good data on both passes. Wireline logging in Hole U1341B was successfully concluded and all logging equipment was rigged down by 1530 hr on 1 August.

Hole U1341C

Operations at Hole U1341C commenced at 1555 hr on 1 August. The vessel was moved 20 m east of Hole U1341B. Hole U1341C was spudded at 1810 hr. The first APC barrel recovered 5.5 m of core and an official sea floor depth was established at 2150.9 m DRF. APC coring continued through Core U1341C-17H to a depth of 147 m DSF using non-magnetic coring assemblies and with the FLEXIT orientation tool installed. Standard steel core barrels were then installed and coring continued through Core U1341C-27H (230 m DSF). Overall core recovery for the APC was 242.06 m (106.2%).

Lithostratigraphy

Three holes were drilled at Site U1341; the deepest, Hole U1341B, reached 604.5 m CSF-A. The sediments recovered are a mix of biogenic and siliciclastic sediments, while volcanoclastic material was of minor importance perhaps reflecting the more distal location of Site U1341 to the Aleutian arc. The most abundant terrigenous grain types are silt-sized feldspar, quartz, clay, mica and rock fragments. Some pebbles are composed of basalt, pumice or scoria, indicating a volcanic source. Dolostones and micron-scale crystals of dolomite occurred in high-concentrations at various depths but particularly at the bottom of Hole U1341B. Authigenic carbonate patches, nodules and layers are light olive gray and olive gray and often characterized by a granular texture and a stronger induration relative to the surrounding sediments. Sediment composed of siliciclastic sediment or mixed lithologies tends to be very dark greenish gray to dark gray, while diatom ooze tends to be dark gray to olive gray to light olive. Boundaries between different sediment colors and/or lithologies are dominantly gradational and bioturbated, but occasional sharp contacts occur as well. Sharp contacts are occasionally coeval with distinct changes in magnetic susceptibility, with higher values corresponding to mixed biogenic-siliciclastic sediments and lower values to diatom ooze. Intervals with thin distinct parallel laminations were relatively rare and confined to the upper part of the record (0-20 m CSF-A). At lower depths, thickly laminated to thinly bedded material with wavy boundaries occurred more frequently. Site U1341 sediments are indicative of low oxygen conditions, as implied by the decrease in benthic foraminifera diversity index below 200 m and by the occurrence of laminated intervals throughout the cores. Also today, an oxygen minimum zone (OMZ) impinges on parts of the western Bowers Ridge.

Two lithologic Units were defined at Site U1341 by a change from alternating diatom silt, diatom clay, and diatom ooze, to solely diatom ooze. The boundary between the two Units, dated at 1.6 Ma is paralleled by a significant change in the intensity of the magnetic susceptibility record (208 m CSF-A at Hole U1341B), in the abundances of calcareous test, and in interstitial water pH and Ca values. The two units are further subdivided into Subunits IA to ID and Subunit IIA to IIE, respectively.

Whole-round density (GRA) correlates well with the abundance of diatoms recorded in smear slide data with a high percentage of diatoms correlating with low GRA values and low siliciclastic components. Diatom ooze may reflect interglacial conditions while mixed diatom-siliciclastic lithologies may reflect glacial conditions. This is consistent with the pattern of biogenic opal mass accumulation rate observed in piston cores from the Bering Sea. Interestingly, the occurrence of sediment intervals rich in nannofossils has been noted.

Biostratigraphy

Core catcher samples from Site U1341 are dominated by highly diverse diatoms together with radiolarian, calcareous nannofossil, foraminiferal and organic walled microfossils with medium to high diversity and preservation ranging from moderate to very good. Biostratigraphic datums are derived from diatom, radiolarian, dinoflagellate, ebridian and silicoflagellate bioevents and show that Site U1341 contains the Early Pliocene to the Pleistocene sediments. However, the presence of early Pliocene species indicates that some reworking has occurred within the top ~20 m.

Cores from Holes U1341A and U1341B exhibit a broadly linear sedimentation rate. Siliceous microfossils show consistent occurrences throughout the section, and are mainly composed of high latitude pelagic species indicating changes to surface water productivity. Calcareous microfossils are mostly confined to the top of the section from around core 250 m CCSF-A for nannofossil, and 280 m CCSF-A for planktonic foraminifers. Thereafter, only sporadic occurrences of calcareous fossils and calcareous cemented agglutinated foraminifers are detected, which may be linked to changes in preservation. Benthic foraminifers are largely characteristic of those found within or near the oxygen minimum zone in high latitude regions. Dinoflagellates consistently occur throughout the section, indicating changes to the productivity and ice cover of the surface waters.

Calcareous foraminifera and nannofossils show greatest preservation in the upper part of the section from about 240 m CCSF. This broadly coincides with the greatest abundances of sea-ice diatoms and radiolarians living in cold and oxygen rich intermediate water mass. As the preservation of carbonate in deep sea sediments is hindered by high productivity and the associated low oxygen in the bottom waters, it appears that the productivity may have been reduced by a direct seasonal sea-ice coverage and an enhanced stratification. Sea-ice diatoms, intermediate water radiolarians, and calcite preservation, all increase markedly again at about 110 m CCSF.

The first occurrence datum (FO) of *Emiliana huxleyi* at 0.29 Ma provided the zonal assignment of calcareous nannofossil Zone NN21 in the upper section of this site. Calcareous nannofossil Zone NN20 and the top of calcareous nannofossil Zone NN19 can only be well constrained in Hole U1341C, establishing an age older than 0.44 Ma.

The late Pleistocene fauna at Site U1341 is dominated by *Neogloboquadrina pachyderma* (sin) and reflect the late Pleistocene cooling on the site. Additional fauna are the subpolar species *Globigerina bulloides*, *Globigerina umbilicata*, and *Neogloboquadrina pachyderma* (dextral) which are appearing in low numbers. Around 2.5 Ma. only the subpolar species are present. Around 60 species of benthic foraminifera were recovered in 140 samples from three holes of this site. Assemblages in the top of the section, from Sample 11H-CC, are of relatively high diversity and abundance, and show affinities to assemblages within or near the oxygen minimum zone in the Sea of Okhotsk and also more common deep water Pacific Ocean species. In the remainder of the holes foraminifers become less abundant, and the agglutinated species *Eggerella bradyi* and *Martinotiella communis* become more important components of the assemblages.

Cores above 41.2 m CSF-A at Hole U1341A are assigned to the *Neodenticula seminae* Zone of 0.3 Ma and younger. This datum was closely matched at Hole U1341B at 37.7 m CSF-A. The following age of 0.9 Ma at Hole U1341A is defined by the last common occurrence (LCO) *Actinocyclus oculatus* at 79.6 m CSF-A. The top of the *A. oculatus* Zone is constrained by the LCO of *Neodenticula koizumii* (1.7 ± 0.1 Ma). The LCO of

Neodenticula kamtschatica at 366.2 m CSF-A at Hole U1341B defines the base of the next biostratigraphic zone at 2.7 ± 0.1 Ma. The age of 3.9 Ma is assigned to between 458.3 and 458.8 m CSF-A by the FO of *N. koizumii*.

The last occurrence of silicoflagellate *Dictyocha subarctios* was found between 50.95 and 60.41 m CSF-A at Hole U1341A. The LO of ebridian *Ammodochium rectangulare* with the age of 1.9 Ma was assigned in between 233.21-241.4 m CSF-A at Hole U1341A and 228.52-238.11 m CSF-A at Hole U1341B. Last occurrence of ebridian *Ebriopsis antiqua antiqua* was found between 328.09 and 332.81 m CSF-A at Hole U1341A and between 325.83 and 335.28 m CSF-A at Hole U1341B. The LO of silicoflagellate *Distephanus jimlingii* lies between 332.71 and 342.26 m CSF-A at Hole U1341A and between 335.18 and 345.78 m CSF-A at Hole U1341B. Silicoflagellate assemblages were mainly composed of *Distephanus speculum*, *D. medianocisol*, and *D. octonarius* in most core catcher samples at both holes.

The radiolarian stratigraphy at Site U1341 spans from the *Botryostrobus aquilonaris* Zone (Late Quaternary) to the *Dictyophimus bullatus* Zone (Middle Pliocene) in the subarctic Pacific. At the bottom of Hole U1341B, the last occurrence (LO) of *Dictyophimus bullatus* (3.8-4.0 Ma) is identified by occurrence of several specimens of the species. Changes in abundances of *Cycladophora davisiana*, intermediate water dwelling species, showed anti-phase patterns with abundances of calcareous microfossils (calcareous nannoplanktons and planktonic foraminifers) at each hole of Site U1341. This suggests the relationship between intermediate water formation in the subarctic Pacific and carbonate preservation. *Cycladophora sakaii* is thought to be an ancestor species of *Cycladophora davisiana*. Occurrences of *Cycladophora sakaii* were very low at Site U1340 (water depth: ca. 1300 m). On the other hand, *Cycladophora sakaii* were constantly found below 100 m interval at Site U1341 (water depth: ca. 2200 m), implying *Cycladophora sakaii* dwelled mainly in deep water below 1000 m water depth.

The polar and sub polar taxa *Islandinium minutum*, *O. centrocarpum*-Arctic morphotype and *Impagidinium pallidum*, that are known to be abundant in regions where sea ice

cover occurs up to 12 months per year and winter sea surface temperature below 0°C, occur only in the upper part of the sequence, starting about 371 m CSF-A. Below 300 m CSF-A, the diversity decreases and the assemblages are dominated by the Protoperidinal *Brigantedinium* spp. and *Trinovantedinium variabile* or by the extinct species *Filisphaera filifera*. *T. variabile* appears below 300 m CCSF-A, and dominates the assemblage of Sample 323-U1341A-60X-CC.

Paleomagnetism

Archive halves of all APC cores recovered at Site U1341 were measured on the three-axis cryogenic magnetometer at 2.5 cm intervals. The natural remanent magnetization (NRM) was measured before (NRM step) and/or after stepwise alternating-field (AF) demagnetization (demagnetization step) in peak fields of up to 20mT. Cores U1341A-1H through U1341A-12H, and U1341C-5H-3 through U1341C-11H-5 were measured at NRM step and 20 mT demagnetization step, and other cores Site U1341 were measured only at 20 mT demagnetization step to keep the core flow. The obtained inclinations average nearly 70° over the entire depth range of the cores, while the site axial dipole inclination is about 72°. The inclinations show several distinct intervals of reversed inclinations that we interpret to be polarity epochs. The declinations, after correction with the FLEXIT tool to orient the declination data with North, suggest that there are multiple polarity intervals in the uppermost 17 cores at Holes U1341A and U1341B. The FLEXIT tool appears to show the declination change of ~180° at the Brunhes/Matuyama boundary in Hole U1341A, but it does not seem to identify older polarity changes (Jaramillo onset or termination) or the Brunhes/Matuyama boundary in Hole U1341B. Within the Matuyama reversed polarity interval approximately a dozen previously identified excursions are discernable. Relative paleointensity variations (CHI or INT/Ms) show a good correlation with benthic foraminifera diversity, which are related to dissolved oxygen contents of the bottom waters. This indicates that extensive reducing conditions near the sediment/water interface especially at the lower half of the hole were responsible for the degradation of paleointensity.

Geochemistry

Undetectable methane, deep SO_4^{2-} penetration, and low values of DIC, alkalinity, NH_4^+ and PO_4^{3-} suggest low present-day microbial activity as compared to Site U1339 despite similar TOC contents. Preliminary model estimates based on the measured DIC profiles suggest that microbial respiration at Site U1341 in the upper 30 m is approximately 20% of the activity estimated for Site U1339. This difference may partly be attributed to differences in sedimentation rates. The major metabolic pathway in the sections studied is organoclastic sulfate reduction, and according to the DIC, alkalinity and sulfate profiles this process is mainly confined to the upper 30 meters.

The most striking feature of Site U1341 is the unusual shape of the DIC, alkalinity and phosphate profiles as well the pattern of the SO_4^{2-} profile. DIC, phosphate and alkalinity profiles indicate either non-steady state caused by recent changes in microbial activity or unusual high net consumption of DIC and PO_4^{3-} in strata below 50 m. The SO_4^{2-} profile suggests a curiously high net consumption in the 300-400 m depth interval despite the lack of CH_4 and the presence of a presumable rather refractory organic carbon pool. It is possible that the interstitial water chemistry still to a large extent shows the overprint by past events such as sulfate removal by extreme high rates of organic matter mineralization during high productivity periods. The present-state IW chemistry thus reflects the transition towards a new steady state.

Microbiology

A total of 73 microbiological samples were collected adjacent to interstitial water whole-rounnds for postcruise analyses for abundance of prokaryotes. Samples were fixed according to the protocol described in “Microbiology” Methods.

Physical Properties

The top ~210 m CSF-A of the sediment section at Site U1341 exhibits rapid, single point excursions to readings >200-400 SI of whole-core magnetic susceptibility measurements (MS). Below this depth MS readings are subdued and rapid deflections to values >100 SI are uncommon except at a depth of ~575 m CSF-A where a broad band of high susceptibility occurs between 565 and 575 m CSF-A. The upper section of rapidly varying and high values is coincident with Lithostratigraphic Unit I. Although ash layers occur in this unit, they are equally abundant in underlying Unit II that displays only background variations in readings. The contrast in the profiles of MS readings between Units I and II is thought to reflect the occurrence in the diatom silt of Unit I of presently unidentified alteration products having magnetic susceptibility properties.

The Gamma ray attenuation (GRA) sensor records a trend of slightly decreasing average values of wet bulk density from a near-surface reading of ~1.35 gm/cm³ to ~1.32 gm/cm³ at the base of Hole U1341B at ~605 m CSF-A. At a depth a ~220 m CSF-A, which is below the transition from Unit I to Unit II, a discernable but small shift to lower density near ~1.25 gm/cm³ is evident. The entire vertical profile of bulk density undulates broadly from average values of ~1.30 gm/cm³ to ~1.45 gm/cm³. The wave-length of fluctuations narrows downhole. Measurement of P-wave velocity by the slow track WRMSL documents a downhole trend of increasing velocity. The gradient of average P-wave velocity values ranges from ~1.51 km/s for near-surface sediment to ~1.56 km/s at the base of the hole at 605 m CSF-A. A slight shift to lower readings (0.02 km/s) appears to occur across the transition from Lithostratigraphic Unit I to Unit II. The low overall gradient in downhole velocity, which is estimated at only 0.08 km/s/km, demonstrates the ability of diatomaceous sediment to resist compaction.

Downhole Natural Gamma Radiation (NGR) readings show spiking to high values >40 counts/s above an undulatory and generally decreasing trend of values from near-surface counts/s averaging ~15 to less than ~5 at the base of Hole U1341B. A shift to slightly lower values is just perceptible near the Unit I and II boundary. The implication of the overall decreasing trend and broad superimposed oscillations is that the clay mineral content decreases irregularly downward, an interpretation that is consistent with the decreasing terrigenous content of the drilled section from the diatom silt of Unit I to the dominantly siliceous ooze of Unit II.

The Moisture-Density (MAD) downhole trend clearly reveals the contrasting density characteristics of the diatom silt of Lithostratigraphic Unit I and the siliceous microfossil ooze of Unit II. The sediment in Unit I shows a higher fluctuation in values ranging from 1.62 gm/cc³ to 1.2 gm/cc³, superimposed on a perceptible but slight increase with depth to the unit's boundary with underlying Unit II. The impression is gained that the lower overall bulk density of Unit II reflects a higher concentration of low-density siliceous microfossils than the diatom silt of overlying Unit I. Just beneath the surface, porosity values average ~80% and the matching water content is ~60 %. At the bottom of Hole U1341B water content decreases only slightly to ~58% and, correspondingly, porosity to ~75%. Similar to the depth profiles of most other physical properties, the downhole distribution of sediment porosity exhibits undulations or excursions to higher and lower values. The downhole variation in grain density is prominently offset, from an average density of ~2.39 gm/cm³ to 2.23 gm/cm³ at the boundary between Units I and II. The average density also decreases with depth from a near-surface value of ~2.50 gm/cm³ to as low as 2.10 gm/cm³ at the base of Hole U1341B. These trends are interpreted as tracking the downhole increase in relative abundance of low density diatoms. The depth distribution of thermal conductivity decreases overall from a near-surface value of 0.85 W/mK to 0.80 W/mK at the base of Hole U1341B. This profile thus parallels the downhole decreasing values of most other physical properties measured on cores recovered at Hole U1341B.

Stratigraphic Correlation

The composite depth scale and splice at Site U1341 is constructed from 0.0-374.40 m CCSF-A (as defined in “Stratigraphic Correlation” section in the “Explanatory Notes” chapter). The splice consists of one continuous splice from the mudline to 141.30 CCSF-A, and two appended “floating” splices, first from 141.3 to 326.43 m CCSF-A and second from 326.44 to 374.40 m CCSF-A. The continuous splice ranges from the top of Core U1341A-1H to Section U1341B-14H-7, 88 cm. The first floating splice ranges from Section U1341B-15H-1, 0 cm to Section U1341A-34H-7, 64 cm. The second floating splice ranges from Section U1341A-35H-1, 0 cm to the base of Section U1341B-39H-7. These appended intervals are supported by wireline logging data compared to core logging of natural gamma radiation. Additional cores below the splice are included in the composite depth framework by appending them with a constant affine value specific to each hole.

The cumulative offset between CSF-A and CCSF-D depth scales is approximately linear. The affine Growth Factor (a measure of the fractional stretching of the composite section relative to the drilled interval) at Site 323-U1341 is 1.06 between 0 and 374.4 m CSF-A. Cores deeper than the spliced interval, i.e. Cores U1341A-41H, and U1341B-40H through U1341B-71X are not tied to the splice, but are appended with a constant affine value of 19.95. Mass accumulation rates in this interval should not be divided by the affine growth factor, because their depths are a linear transformation of drilling depths.

Downhole Measurements

Two downhole logging tool strings were deployed in Hole U1341B to the total depth of 600 m DSF (2750 m DRF): the triple combo and the FMS-Sonic combination. Overall, the caliper of the density sonde on the triple combo tool indicated an enlarged and irregular borehole, with many intervals with hole diameter >20 inches. During the runs, the tool encountered significant drag in many places above 260 m WSF, producing a stick/slip motion that was detrimental to the quality of the data. As a result, the logging speed was increased from 900 ft/hr to 1200 ft/hr and the tools reconfigured to prevent any impact on the vertical resolution of the data.

The readings of the two orthogonal FMS calipers suggest that the borehole section was far from circular, probably elliptical. One caliper read less than 10 inches over most of the lower half of the interval logged, while the other one kept close to ~14 inches, near the limit of its range. The fact that the curves display variability over most of the hole suggests that both sets of arm were making some kind of contact with the formation, possibly with one pad only in some places. The larger hostile environment lithodensity sonde (HLDS) caliper readings show that this single arm caliper was likely following the longest 'axis' of the hole and that the stronger and skinnier arm was actually pushing inside the formation.

The large hole size had an effect mostly on the measurements that require good contact with the formation, namely density and porosity. The very high neutron porosity values above ~275 m WMSF indicate that porosity readings are erroneous above this depth. Similarly, the anomalously low density values between 180 and 210 m WSMF are also indicative of poor tool contact and are also erroneous. Even if the FMS arms seem to have been in contact with the formation over most of the interval logged, this contact was likely only partial in places, resulting in blurry or featureless images in many intervals. It is still possible to identify many fine layers, mostly in the deeper part of the hole.

Logging Unit 1 (80-220 m WSMF) is characterized mainly by decreasing trends with depth in gamma ray and resistivity, accompanied with several high peaks in these measurements. It coincides mostly with Lithologic Unit I, made of diatom ooze and diatom silt. Most of the peaks in gamma ray are related to high uranium content. The coincidence of these higher uranium values with higher resistivity, and to some extent with higher density is an indication that they are due to authigenic carbonate, which was observed at many of these depths. Logging Unit 2 (220-350 m WSMF) is defined by increasing trends with depth in gamma ray and density, while resistivity mostly decreases. Several peaks in gamma ray can be observed in this unit as well, again generally due to higher uranium content and often associated with authigenic carbonate observed in the core. The top of Logging Unit 3 (350-425 m WSMF) is defined by a sharp drop in density at ~350 m WSMF, and by similar changes in gamma ray and

density. Since velocity does not display any significant change at this depth, the change in density is likely responsible for the strong reflector that can be observed in Seismic Line Stk5-1 at 3340 ms two-way travel time. The top of Logging Unit 4 (425-600 m WMSF) is defined by a drop in resistivity, which decreases with depth over the entire unit. It coincides also with an inflection in the overall increase with depth of shear velocity and, to a lesser extent, of compressional velocity.

Formation temperature measurements were successfully made at three depths in Hole U1341A with the APCT-3 tool. The measured temperatures ranged from 4.68 °C at 41.0 m DSF to 11.12 °C at 136.0 m DSF, and fit closely a linear geothermal gradient of 67.8 °C/km. The temperature at the seafloor was 1.95 °C, based on the average of the measurements at the mudline during all the APCT-3 deployments. A simple estimate of the heat flow can be obtained from the product of the geothermal gradient by the average thermal conductivity (0.825 W/m °C) which gives a value of 55.9 mW/m², within the range of previous measurement in the area.