IODP Expedition 323:

Pliocene-Pleistocene paleoceanography and climate history of the Bering Sea

Site U1343 Summary

27 August 2009

Background and objectives

The primary objective of drilling at Site U1343 (Proposed Site GAT-4C) was to study high-resolution Pliocene-Pleistocene paleoceanography at a location that is proximal to the gateway to the Arctic Ocean, that is closer to the current seasonal sea ice limit, and that, because of its 2 km water depth, will provide information regarding the history of mid-depth water in the Aleutian Basin. This site is located at a topographic high clearly separated from the Bering Shelf. Hence, it is anticipated to receive less supply of reworked terrigenous sediments from the shelf during the interglacials or the subaerially exposed land during the glacials than a location directly downslope of the Bering Shelf.

Site U1343 is in the area of high biological productivity called the "Green Belt." The Green Belt is formed by the Bering Slope Current (BSC), which originates from the Alaskan Stream water that flows into the Bering Sea through the western Aleutian Islands. The water that enters the Bering Sea moves eastward along the Aleutian Islands and consequently encounters the Bering Shelf. The BSC is at ~300 m and its flow is forced to turn to the northwest once it meets the slope and shelf; eddies and instabilities in its flow cause upwelling along the shelf break. Moreover, tidal mixing causes further vertical mixing of the water masses along the BSC, enhancing biological productivity within the "Green Belt," a zone adjacent to the northwest trending shelf break where high primary productivity in the surface waters and high organic carbon accumulation at the seafloor are taking place. Because of the expected high organic carbon supply to the seafloor, especially during the interglacial sea level highstands, it is possible that the oxygen minimum zone (OMZ) expanded down to the depth of this site during the past. In order to compare the vertical extent of water mass conditions across the basin, and relate the OMZ to paleo-productivity, the records from the shallower drill sites on the Bowers Ridge (Site U1340, 1295 m; Site U1342, 818 m;) as well as the other slope sites will be

used. This site is also located close to the maximum extent of the present day seasonal sea-ice cover. Thus, it is expected that at the water surface, this site had been covered by the seasonal or perennial sea ice during the glacial low sea level lowstands.

The drill site in the gateway region to the Arctic Ocean can also be used to study the impact of subseafloor microbes on biogeochemical fluxes in the highest surface ocean productivity areas of the Bering Sea drill sites. Organic-fueled subseafloor respiration and its impact on biogeochemistry in such a highly productive region have never been quantified previously. To do this, the drilled sediments in the gateway region were used to determine subseafloor cell abundance and to investigate the link between the mass and characteristics of subseafloor microbes and the extent of export productivity from the surface ocean.

Sedimentation rates at this site were not previously known due to the lack of piston cores. However, approximately 180 m/m.y. have been observed at Site U1344 (Proposed Site GAT-3A) in an earlier site survey piston core study. Thus, prior to drilling, the recovery of the Pleistocene to the Pliocene sections was expected at this site.

Operations

Five holes were cored at Site U1343. Hole U1343A was cored with the APC system and drilled to 201.5 m DSF. Hole U1343B was dedicated to microbiology and cored to 35.5 m DSF. Hole U1343C was cored with the APC system to 234.2 m DSF. Only a single mudline core was taken at Hole U1343D and a decision was made to attempt another mudline core for stratigraphic correlation. Hole U1343E was cored with the APC and XCB systems to 744.3 m DSF. The XCB system had to be used for Cores U1343E-42X to 45X, where we encountered dry sediment and retrieved a destroyed core liner (42X), and for the deepest cores U1343-50X to 83X. The shallower interval cored with the XCB system coincided with a bottom simulating reflector (BSR). Generally, coring was routine except for biogenic methane encountered in the cores, which complicated the curation of all cores at this site. APC coring totals for Site U1343 include 98 cores, 860.4 m penetrated, 859.8 m recovered, for 99.9% recovery. XCB coring totals for Site U1343

include 37 cores and 360.6 m penetrated, 318.14 m recovered for 62.8% recovery. Total cored interval for Site U1343 was 1221.0 m, with 1178.23 m of core recovered for a 96.5% total recovery. The time spent on Site U1343 was 6.7 days.

Hole U1343A

Hole U1343A was spudded at 0305 hr on 7 August. The first mudline core recovered 5.5 m of sediment and the calculated seafloor was 1962.4 m DRF. APC coring continued through Core U1343A-22H to 201.5 m DSF using non-magnetic coring assemblies. Temperature measurements were taken on Cores U1343A-5H, 9H and 14H with the APCT3 temperature tool. Core orientation was taken on all cores with the FLEXIT orientation tool, but the data were lost when the computer running the download software was accidentally switched off during the FLEXIT operations, causing the program to lose its synchronization with the tool. Overall recovery for Hole U1343A using the APC system was 101.2% with 203.86 m recovered.

Hole U1343B

The vessel was offset 30 m north and Hole U1343B was spudded at 2240 hr on 7 August. The first mudline core recovered 6.85 m of sediment and the calculated seafloor was 1962.4 m DRF. Both contamination testing methods, per-fluoro-methyl-cyclohexane (PFTs) and microspheres, were deployed. A total of four APC cores were recovered for microbiological sampling to 35.5 m DSF. Average APC core recovery for Hole U1343B was 97.4% with 34.56 m recovered.

Hole U1343C

The ship was offset 30 m west from the prospectus site position. The APC was deployed and Hole U1343C was spudded with the APC at 0305 hr on 8 August. The first mudline core recovered 7.2 m of sediment and the calculated seafloor was 1964.2 m DRF. APC coring continued through Core U1343C-26H to 234.2 m DSF using non-magnetic coring assemblies. Overall recovery for Hole U1343C using the APC coring system was 98.7% with 231.04 m recovered.

Hole U1343D

Hole U1343D was spudded 30 m south of Hole U1343C at 0135 hr on 9 August. Based on the stratigraphic correlation of the first and only core, Hole U1343D was terminated at 0135 hr. Overall recovery for Hole U1343D using the APC coring system was 100.0% with 8.5 m recovered.

Hole U1343E

There was no offset from Hole U1343D. Hole U1343E was spudded at 0215 hr on 9 August. The first core barrel recovered 8.2 m of core and an official seafloor depth was established at 1967.5 m DRF. APC coring continued through Core U1343E-15H using standard steel core barrels. At Core U1343E-16H the non-magnetic barrels were put in service and were used for the rest of the hole. Coring with the APC system was suspended after Core U1343E-41H was pulled with a ruptured core liner. Core U1343E-41H had to be hydraulically pressed out of the core barrel. This coincided with a BSR observed in the seismic data. The core was also noticeably drier and harder at this depth. The XCB coring system was then deployed from Core U1343E-42X through 45X with good recovery. The APC coring system was then put back in service for Cores U1343E-46H to 49H. At that time we began to get partial strokes of the piston and were having to drill over every core. The XCB system was re-deployed and coring continued through Core U1343E-83X to 744.3 m DSF. The coring tools were secured and the hole was swept clean and then displaced with 200 barrels of prepared high viscosity logging mud. There was no fill identified at total depth. Two logging strings were deployed. The triple combo string reached total depth of 745 m DSF and good quality logs were obtained. The second logging string consisted of the FMS-sonic tool, which reached total depth of 745 m DSF and also obtained good data on both passes. Wireline logging in Hole U1343E was successfully concluded and all logging equipment was rigged down by 0745 hr on 13 August. APC core recovery for Hole U1343E was 100.3% with 381.86 m recovered. XCB core recovery for Hole U1343E was 88.3% with 318.41 m recovered. Total core recovery for Hole U1343E was 94.47% with 700.27 m recovered.

Lithostratigraphy

Sediments at Site U1343 are primarily composed of silt with varying amounts of clay and diatoms, and minor amounts of sand, ash, foraminifers, calcareous nannofossils, and sponge spicules. The sediment is predominantly dark/very-dark greenish grey to dark/very-dark grey. One lithologic unit is defined at this site spanning the early Pleistocene to the Holocene. Six laminated intervals are observed and can be correlated between the holes based on lithologic, reflectance and magnetic susceptibility data. Unit I encompasses a time period comparable to Unit I defined at the Bowers Ridge Sites U1340 and U1341. However, Site U1343 is distinct by having a higher proportion of siliciclastic grains and a higher occurrence of sand-sized grains. This is probably related to the location of this site on the continental slope and the relative proximity to the source of terrigenous sediments. During glacial sea level lowstands, and in particular during early stages of deglaciations, significant amounts of coarser-grained detrital material might have been mobilized from the exposed Bering Sea shelf and redeposited further down the continental slope. Unlike Site U1339, drilled previously on the slope at Umnak Plateau, volcaniclastic material is a minor component of sediment at Site U1343 because it is more distant from the Aleutian arc. There is a shallow sulfate–methane transition zone and abundant methane in the sediment column at Site U1343, like the other slope sites. Benthic and planktic foraminifera encrusted with yellow minerals were common, and often coincided with samples in which authigenic carbonates were found. Association of authigenic carbonates and apparent overgrowths implies that authigenic carbonates nucleated on the foraminifer tests. In this case, the stable isotope records from this site are potentially contaminated by the isotopic signature of the overgrowths, however, pristine foraminifer shells were also observed, and the generation of uncontaminated isotope stratigraphies should be possible after careful screening for authigenic carbonates.

Biostratigraphy

The composite age model derived from all five holes shows that the sediment record recovered in Site U1343 spans the last 2.0 to 2.4 m.y., yielding a broadly linear trend in sedimentation rates, with values around 26 cm/k.y. for the upper 400 m CCSF that

increase to around 56 cm/ky. for the lower 350 m CCSF. Siliceous, calcareous and organic fossils show greatest abundances in the upper 300-250 m CCSF relative to the section below. In the upper section all microfossil groups show distinct large and frequent oscillations indicating fluctuations in the sea-ice cover and productivity in the upper water column, and in the deep-water environment. Distinct changes in the general trend of abundances and/or assemblage composition were observed in all major microfossil groups, which occur either gradually or abruptly between 200 and 300 m CCSF (0.8 to 1.1 Ma). Thus the changes are linked to the Middle Pleistocene Transition (MPT). Benthic foraminifers indicate high frequency changes in bottom water oxygen content over the entire sequence, probably related primarily to surface water productivity, but possibly also to bottom water ventilation changes and methane seeps. The cooling trend observed after the MPT is reflected in the increase of abundances of sea-ice dinoflagellate and diatom taxa and in the decrease of the predominance of pelagic/open water conditions, as reflected in the decline of the subpolar planktic foraminifers and of the diatom species *Neodenticula seminae*.

The occurrence of calcareous nannofossil *Emiliania huxleyi* at the base of Core U1343A-3H assigns an age for this core to the calcareous nannofossil Zone NN21, which is defined by the FO datum of *E. huxleyi* (0.29 Ma) to the present. However, the occurrence of a barren interval below this level has made impossible to constrain the FO of *E. huxleyi* and the boundary with Zone NN20. The LO datum of *Pseudoemiliania lacunosa* (0.44 Ma) in Sample U1343A-12H-7W, 46 cm, which defines the upper limit of calcareous nannofossil Zone NN19, is well constrained as it takes place within an interval rich in calcareous nannofossils. While the trace amount of planktic foraminifer *Neogloboquadrina atlantica* (sinistral) with the LO (2.4-2.5 Ma) is present, the age derived by this taxon appears too old when compared to other datums. Benthic foraminiferal assemblages have a similar species composition to assemblages from Site U1339, and within or near the oxygen minimum zone in the Sea of Okhotsk. High frequency variation in oxygenation is apparent throughout the section, but initial results show generally higher oxygen indicators such as *Elphidium* cf. *batialis* and *Islandiella norcrossi* are dominant from in and below Core U1343E-24H.

The LO datum of diatom *Proboscia curvirostris* (0.3 Ma) and the LO datum of *Thalassiosira jouseae* (0.3 Ma) were observed at ~70 to 77 m CSF-A in the three holes at Site U1342. This is consistent with results from Site U1339 at the Umnak Plateau. The cored interval above the LO of *P. curvirostris* (0.3 Ma) is assigned to the *Neodenticula seminae* Zone (NPD12). The interval between last common occurrence (LCO) datum of *Actinocyclus oculatus* observed at 296.4 m CSF-A and the LO datum of *P. curvirostris* at 69.4 m CSF-A in Hole U1343E is assigned to *P. curvirostris* Zone (NPD11). The interval below this datum above the FO of *Neodenticula koizumii* is *A. oculatus* Zone (NPD10). The FO of *P. curvirostris* (1.85±0.1 Ma) was defined in Sample U1343E-50X-CC and assigned to the age in the *A. oculatus* Zone. The LO of *Pyxidicula horridus* (1.9-2.0 Ma) was estimated in Core U1343E-61X. The LCO of *N. koizumii* (2.1 Ma) was observed at Sample U1342E-77X-CC. The interval between this datum and the bottom of Hole U1343E is assigned to the *N. koizumii* Zone (NPD9). The LO of silicoflagellate *Distephanus octonarius* (0.2-0.3 Ma) is estimated to be between 64.0 and 74.9 m CSF-A. The LO of *Dictyocha subarctios* (0.6-0.8 Ma) is estimated to be between 196.2 and 205.35 m CSF-A (Hole U1343C) and between196.1 and 205.45 m CSF-A (Hole U1343E). The bottom age at Hole U1343E is younger than 2.5 Ma due to the absence of ebridian *Ebriopsis antiqua antiqua*. In Sample U1343E-27H-CC, relatively warm water taxa belonging to *Dictyocha* spp. are observed in high numbers (30%), indicating a possible increase of the subarctic Pacific water entry into the Bering Sea. Six radiolarian datums common in the subarctic Pacific were identified at this site. The LO and FO datums of *E. matuyamai* (0.9-1.5 Ma and 1.7-1.9 Ma, respectively) were identified in samples from Hole U1343E. In the upper 250 m CSF-A changes in dinoflagellate assemblages are observed, indicating varying conditions in surface waters from the conditions with high productivity and upwelling to the conditions with pronounced sea-ice cover. Such a high variability above 250 m CSF-A is also observed in pollen and spore abundances, suggesting changing vegetation in adjacent land masses as well.

Paleomagnetism

The Brunhes/Matuyama boundary is clearly identified at Holes U1343A, U1343C and U1343E between 180 and 185 m CSF-A, and both the termination and onset of the Jaramillo subchron were identified below this. Deeper in the section, while inclination tends to cluster around normal polarity values making it difficult to identify polarity zonation, the top boundary of the normal polarity zone at around 292 m CSF-A has been tentatively identified as the termination of the Cobb Mountain subchron. The paleointensity variation has quite large amplitude and obviously shows a coherent change with the magnetic susceptibility suggesting that the NRM intensity has been largely influenced by environmental changes.

Geochemistry

Interstitial water SO_4^{2-}, DIC, PO_4^{3-} and NH_4^+ concentration profiles indicate that the sediments at Site U1343 are characterized by high rates of carbon turnover as compared to the sites at Bowers Ridge. Values are, in general, at least one order of magnitude higher than at Site U1342 on Bowers Ridge. Profiles of CH_4 and SO_4^{2-} suggest that sulfate reduction is largely driven by CH_4 diffusing into the sulfate zone. The SO_4^{2-} profile is nearly linear in the top 8 m CSF-A, indicating no significant consumption there. The CH_4 flux into the SO_4^{2-} zone, as calculated from the concentration gradient between 8-11 m CSF-A, is approximately 50-60% of the SO_4^{2-} flux into the sulfate–methane transition zone (SMTZ). Hydrogen sulfide is also at a maximum in the SMTZ. The ratio between autotrophic and organoclastic sulfate reduction is higher at Site U1343 than at the Bowers Ridge or Umnak Plateau sites. A relative high flux of Ca^{2+} into the SMTZ further stresses the importance of anaerobic methane oxidation (AOM) which commonly leads to the formation of $CaCO_3$. The Ca^{2+} flux into the SMTZ is approximately 35% of the methane flux, indicating that an equivalent fraction of the DIC produced through AOM is deposited as $CaCO_3$.

The curvature of the NH_4^+ profile suggests NH_4^+ production from organic matter degradation throughout the sediment column. This is confirmed through preliminary modeling exercises, and suggests organic matter degradation and hence microbial activity

even at depths below 400 m CSF-A. Organic matter degradation also leads to the accumulation of DIC and PO_4^{3-} in the interstitial water. The accumulation of these species, however, is much lower than predicted from the NH_4^+ profile assuming steady state and a constant ratio between C, N and P of remineralized organic matter. This suggests both production and consumption of DIC and PO_4^{3-} in the sediment. Consumption of these species is most likely due to formation of apatite and calcium carbonates (e.g., dolomite). The pore water profiles suggest that rates of net consumption of PO_4^{3-} is highest between 180-200 m CSF-A, and net DIC consumption is highest between 300 and 350 m CSF-A.

The decrease in salinity and pore water chloride concentrations indicates freshening of the pore fluids with depth. A possible explanation for this trend is the dissociation of gas hydrates during core recovery, which release freshwater and cause depletions in dissolved ion concentrations. Alternatively, decreases in pore water salinity and chloride concentrations can result from meteoric water input, clay membrane ion filtration and clay mineral dehydration.

Microbiology

Samples for abundance of prokaryotes were collected adjacent to interstitial water whole-rounds in sections cored using the APC. High resolution sampling took place in the microbiological dedicated cores from Hole U1343B as well as samples taken one per core to APC refusal at Hole U1343A. Additional samples were taken from XCB Cores U1343E-78X to 80X to evaluate cell abundance and community structure in the deepest portion of Hole U1343E. PFT analyses performed on all cores at Hole U1343B and in the deeper cores at Hole U1343E show no contamination from the drill fluid. Samples from all cores were fixed. These analyses will assist with understanding the global distribution and abundance of subseafloor life in a highly productive oceanic regime. A special focus will be directed toward the function of Archaea in the sulfate reduction zone, the sulfate–methane transition zone and the methanogenesis zone.

Physical Properties

Downhole from the upper ~10 m CSF-A, wet bulk density increases slightly from an average reading of ~1.60 g/cm^3 to ~1.65 g/cm^3 at ~100 m CSF-A. The average value below this depth, although oscillatory, does not seem to change until ~360 m CSF-A, the calculated depth (~360 m) of the BSR, where a shift to a lower average of ~1.60 g/cm^3 occurs. This shift coincides with the change from APC to XCB coring and the consequent recovery of drilling-disturbed core sections. The measured magnetic susceptibility exhibits cyclicity from lower values averaging ~20-25 SI units to higher readings of about 250 SI units. Peak readings, which are roughly separated by 30-50 m, are prominent to a depth of ~360 m CSF-A. Below this depth the wavelength increases and average values decrease.

Sonic velocities, Vp and Vs, recorded by the downhole FMS-sonic logging tool, increase with depth from a near-surface value of ~1550 m/s to ~1840 m/s at the bottom of Hole U1343E at ~744 m CSF-A. Three gradients of increasing Vp can be recognized: the first gradient extends down to ~360 m CSF-A increasing at ~110 m/s/km, the second extends from 360 to 520 m CSF-A increasing at ~550 m/s/km, and the third gradient extends from 530 to ~744 m CSF-A increasing at ~890 m/s/km. NGR counts generally track abundance of clay minerals and their absorbed radioactive nuclei. Evidently, at Hole U1343E, higher bulk density sediment is also richer in clay and other siliciclastic minerals. Siliceous microfossils that resist compaction and sediment consolidation are not the dominant component constructing the stratigraphic section. Perhaps because of this circumstance NGR readings appear to track compaction-driven densification of clay-rich beds, an observation that is consistent with the progressive downhole increase in logging-tool measured Vp-velocities.

In a general way, cores collected above the BSR at ~360 m CSF-A exhibit higher variability of thermal conductivity values and these are also the most gas-disrupted sections measured. Cores collected below the transition at ~520 m CSF-A to higher carbonate bearing, Vp velocity, and bulk density, display the highest range of thermal conductivity values. Average values of discrete-sample density increase downward at

Hole U1343A from near-surface measurement of ~1.50 gm/cm^3 to near 1.70 g/cm^3 at ~100 m CSF-A. Below this subsurface level, the average MAD bulk density changes little. Similar profiles of water (moisture) content and sediment porosity are recorded at Holes U1343A and U1343E. Near-surface porosity is ~70%, noticeably lower than that measured at Sites U1339 (~80%), U1340 (~75%), U1341 (~78%), and U1342 (~80%). This difference can be ascribed to the lower overall content of siliceous microfossils constructing the sedimentary section. Porosity (and water content) decreases sharply downward to ~60% at ~80 m CSF-A, below which porosity only gradually decreases to ~56 % at ~744 m CCSF-D. Average grain density seems to show three density-fluctuating groupings: an upper group from the seafloor to ~100 m CFS-A of average density ~2.68 g/cm^3, a middle group between ~100 and 540 m CFS-A averaging ~2.65 g/cm^3, and a basal group that shifts to a lower density of ~2.55 g/cm^3 at ~540 m CFS-A but increases farther downward to 2.70 g/cm^3 at 744 m CFS-A.

Stratigraphic Correlation

The composite depth scale and splice at Site U1343 is constructed from 0 to 779.18 m CCSF-A. The splice consists of one complete and continuous interval from the mudline to 270.47 m CCSF-A. The continuous splice ranges from the top of Core U1343C-1H to U1343E-29H-7, 79 cm, and below this, there are appended cores ranging from Core U1343E-29H-1, 0 cm to U1343E-83X-7, 31cm, (779.18 m CCSF-A) with a constant affine value of 35.62 m. Within the splice, the composite CCSF-A depth scale is defined as the CCSF-D depth scale. CCSF-D rigorously applies only to the spliced interval. The cumulative offset between CSF-A and CCSF-D depth scales is nonlinear. The affine growth factor at Site U1343 between 0 and 36.4 m CSF-A is 1.03. At greater depths all cores have an affine growth factor of 1.15. Calculation of mass accumulation rates based on the CCSF-A or CCSF-D scales should account for the affine growth factor by dividing apparent depth intervals by the appropriate growth factor for the depth interval. After dividing by the growth factor (accounting for the different depth intervals) this scaled depth scale should be referred to as CCSF-B. Mass accumulation rates calculated for the interval of appended cores deeper than the spliced interval, should not be divided by the affine growth factor because their depths are a linear transformation of drilling depths.

Downhole Measurements

Two tool strings were deployed in Hole U1343E: the triple combo and the FMS-sonic combination. While both runs indicate an irregular hole, in particular above 430 m WSF, all the calipers show that the tools were making contact with the formation over most of the interval logged, suggesting that the overall quality of the data is good. While the HLDS caliper suggests that the tools were making good contact between 300 and 360 m WSF, and that the hole was even smaller than the nominal bit size in part of this interval, the density and neutron porosity data in this interval seem questionable. The anomalously low density readings between 307 and 322 m WSF, and the very high neutron porosity values between 300 and 360 m WSF suggest that the tool was not properly measuring formation properties. Comparison with the density measurements made with the GRA track sensor on cores recovered from Hole U1343E, and with moisture and density (MAD) measurements made on samples from Site U1343, shows a generally good agreement, except in this interval, where logging data are significantly lower than core measurements.

Logging Unit 1 (100-330 m WMSF) is characterized mainly by a steady increase with depth in velocity, while the other log data remain mostly uniform despite some variability such as in the gamma ray. The velocity increase at the bottom of logging Unit 1 is likely responsible for the strong reflector that can be observed at 2860 ms two-way travel time in the seismic data. A synthetic seismogram was produced using a wavelet extracted from the seafloor reflection in traces adjacent to shot point 350 and Site U1343 in Line Stk-1. While it was speculated that this reflector might be a BSR indicating the existence of gas hydrate overlying free gas, there was no conclusive indication from the logs supporting the occurrence of gas hydrate. However, slightly higher velocity and resistivity trends and lower dipole waveform amplitudes above the reflector, as well as low chlorinity values measured on several interstitial water samples, suggest that some amount of gas hydrate might be present. Logging Unit 2 (330-510 m WMSF) is defined by slightly decreasing trends with depth in resistivity, and by gamma ray values slightly higher than the shallower and deeper units. The top of logging Unit 3 (510-745 m WMSF) is defined by a drop in gamma ray and an increase in V_p and a change in the trends of all the logs. The

gamma ray, potassium, thorium, density, resistivity, V_p, V_s logs all display higher amplitude and lower frequency variability than in the upper units, suggesting a significant change in the deposition history and rates. A dolostone that was recovered in this unit can be recognized in the FMS images.

The APCT-3 tool was successfully deployed three times in Hole U1343A. The measured temperatures ranged from 4.34°C at 43.5 m DSF to 8.53°C at 129.0 m DSF, and fit closely a linear geothermal gradient of 49.0°C/km. A simple estimate of the heat flow can be obtained from the product of the geothermal gradient by the average thermal conductivity (0.985 W/m°C), which gives a value of 48.2 mW/m^2, within the range of previous measurement in the area.

Sedimentation Rates

Very high sedimentation rates were observed throughout the drilled depths at Site U1343. From the seafloor to the top of Jaramillo subchron (0.998 Ma; 267.6 m CCSF-A) sedimentation rates were relatively constant within the range of 25 to 29 cm/ky. An increase in the rate to 46 cm/ky was observed between the top and the bottom of the Jaramillo subchron (1.072 Ma; 302.0 m CCSF-A). Further down to 407.7 m CCSF-A, or 1.55 Ma as indicated by the LO of the dinoflagellate *F. filifera*, sedimentation rates are ~21 to 25 cm/ky. Sedimentation rates increase to 54-58 cm/ky between 408 and 716 m CCSF-A. The age at this depth is estimated at 2.1 Ma by the LCO of the diatom *Neodenticula koizumii*.