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32. *DATA REPORT:* ^{14}C DATING OF SEDIMENT OF THE UPPERMOST CAPE FEAR SLIDE PLAIN: CONSTRAINTS ON THE TIMING OF THIS MASSIVE SUBMARINE LANDSLIDE[1]

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ABSTRACT

Six ^{14}C-age measurements of the carbonate fraction of sediments sampled from Ocean Drilling Program (ODP) Leg 164 Site 991 are reported. These samples straddle the most recent sole of the Cape Fear Slide. These data indicate that a hiatus occurs at 2.06 mbsf that separates sediments with ^{14}C ages ≤10 ka from those with ages ≥26.9 ka. The hiatus corresponds with a stratigraphic boundary between soft, undisturbed sediment above and firmer, yet disturbed sediment below, and is believed to correspond with the most recent activity on the slide.

BACKGROUND

A number of continental margin slumps have been linked to the dissociation of gas hydrates (Carpenter, 1981; Paull et al., 1991; Kayen and Lee, 1993, Rothwell et al., 1998). The stability of gas hydrates in the sediment column may be strongly influenced by changes in sea level (Carpenter, 1981; Schmuck and Paull, 1993; Paull et al., 1996). A lowering of sea level will cause a downward shift in the base of gas hydrate stability, thus stimulating the decomposition of gas hydrates. This process adds water and gas into sediment pore spaces, weakening sediment strength and inducing slope failure. Thus, correlation between the frequency of slumping activity relative to sea-level positions could be expected. Comparison of ^{14}C ages to sea-level history at a number of slide sites may provide insight into the potential connection of submarine landslides to hydrate instability.

Cape Fear Slide

The Cape Fear Slide is a massive submarine landslide (~100 m thick, 25 km wide, and involving about 5000 km^2 of area) located on the continental margin off of North Carolina (Embley, 1980; Cashman and Popenoe, 1985; Popenoe et al., 1993). This slide occurred in a region of prevalent gas hydrates (as indicated by the regional presence of bottom-simulating reflectors [BSR's]) and active diapirism. Both the emplacement of the diapirs (Dillon et al., 1982; Cashman and Popenoe, 1985; Popenoe et al., 1993) and potential sediment instability due to gas hydrate decomposition (Carpenter, 1981; Schmuck and Paull, 1993) have been suggested as mechanisms for this slumping event. Although the Cape Fear Slide is one of the more thoroughly studied mass-wasting events, both the cause and the timing of the slide are still uncertain (Paull et al. 1996).

One of the objectives for drilling over the Cape Fear Diapir (Sites 991, 992, and 993) was to investigate the timing of deformation. Sediments from Sites 991 and 992 recorded complicated deformation and several internal hiatuses between 2.06 and 47 mbsf at Site 991 (Paull, Matsumoto, Wallace, et al., 1996). At Site 991, however, a distinct contact, which was taken to be the sole of the most recent slide event, was identified at 2.06 mbsf.

METHODS

The upper few core sections from Sites 991, 992, and 993 were reinspected in the Ocean Drilling Program (ODP) Core Repository in Bremen, Germany. The location of a lithologic discontinuity between undisturbed soft sediments and firm sediments exhibiting signs of distortion was re-established at 2.06 mbsf at Site 991 (Paull, Matsumoto, Wallace, et al., 1996). Site 991 is located between the headwall of the slide and the crest of the diapir (Paull, Matsumoto, Wallace, et al., 1996).

Six sediment horizons from the upper two core sections of Site 991 were selected for ^{14}C age dating (Table 1). Samples, with volumes of ~5 cm^3, were obtained from 1-cm-thick zones centered on the depths reported in Table 1. Five samples were collected from above the contact and one below (Fig. 1). Special care was given to avoid material from the outer walls or the cut face. Also, the sediments immediately above (~3 cm) the contact were avoided, because they might be contaminated by older material reworked during the slide event. Similarly, material within 15 cm of the obviously burrowed hiatus surface was also avoided for fear that younger carbonates might be reworked downward (Fig. 2).

The samples were sent to the National Ocean Sciences Accelerator Mass Spectrometry (AMS) Facility at the Woods Hole Oceanographic Institution. The CO_2 from the carbonate fraction was extracted from the samples by acidification. The bulk carbonate in these samples was dominated by nannofossils. The CO_2 carbon was reacted with an Fe/H_2 catalytic reductant and converted into graphite for ^{14}C/^{12}C measurement. Measurements of the δ^{13}C were made on a VG Optima mass spectrometer at the AMS facility in Woods Hole and were used to normalize the fraction of modern carbon to National Bureau Standards (NBS) Oxalic Acid I. The percent of modern carbon and the reported ^{14}C-ages follow the convention of Stuiver and Polach (1977) and Stuiver (1980). Radiocarbon ages are calculated using a $t_{1/2}$ of 5568 yr.

RESULTS

Calculated ^{14}C ages of the five samples collected from the undisturbed soft sediment above the "soft-firm" contact we have interpreted as the sole of the most recent slide, range in age from 3800 to

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Table 1. ^{14}C age data obtained from the carbonate fraction in Hole 991A samples.

Core, section, interval (cm)	NOAMS sample-ID	Depth (mbsf)	^{14}C age (radiocarbon years)	Modern carbon (%)	$\delta^{13}C$ (‰ PDB)
164-991A-					
1H-1, 31-33	OS-9737	0.33	3,800 ± 25	0.6232 ± 0.0021	1.68
1H-1, 91-93	OS-9741	0.93	5,670 ± 30	0.4936 ± 0.0019	1.87
1H-1, 121-123	OS-9739	1.23	440 ± 35	0.4483 ± 0.0019	1.96
1H-2, 12-13	OS-9740	1.63	9,080 ± 35	0.3230 ± 0.0015	1.53
1H-2, 52-53	OS-9742	2.03	10,000 ± 60	0.2875 ± 0.0021	1.10
1H-2, 71-72	OS-9738	2.22	26,900 ± 110	0.0354 ± 0.0005	1.29

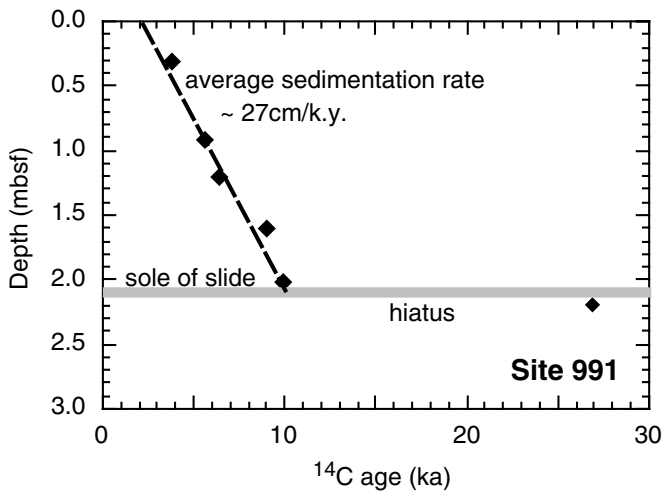

Figure 1. Depth vs. ^{14}C age for the uppermost 3.0 m at Site 991. These ^{14}C ages indicate a hiatus between 10 and 27 ka.

10,000 radiocarbon years (Table 1). These data (Fig. 1) indicate continuous sedimentation at Site 991 over most of the Holocene. A linear fit to this data indicates a sedimentation rate of 27 cm/k.y. This sedimentation rate compares well with other ^{14}C data that have been collected in the region (Paull et al., 1996). The sixth sample, which came from firm sediments beneath the sole of the slide (at a depth of 2.21 mbsf), has an age of 26,900 radiocarbon years.

DISCUSSION

Making accurate determinations of the age of a slump-related hiatus is complicated by both uncertainties in the sedimentology and in the dating techniques. However, the measured ^{14}C ages of the samples that straddle the inferred hiatus between 2.03 (3 cm above) and 2.21 mbsf (15 cm below) spans between 10 and 27 ka (Fig. 1). This age bracket encompasses the interval associated with the Pleistocene sea-level lowstand between ~12 and 28 ka (Shackleton, 1987). Links between continental margin slumping and the last glaciation have been inferred elsewhere (e.g., Walker and Massingill, 1970; Bugge et al., 1988; Evans et al., 1996; Rothwell et al., 1998). Lowered sea level during glacial maximums is a potential mechanism for gas hydrate decomposition at the base of the gas hydrate–stability zone resulting in destabilization of continental margin sediments (Carpenter, 1981; Paull, et al., 1991; Popenoe et al., 1993).

CONCLUSIONS

Carbon-14 dating of sediments from Site 991 indicates that a hiatus at 2.06 mbsf, which separates soft, undisturbed sediments above from firmer sediments showing signs of distortion below, spans from 10 to 26.9 ka. These data constrain the timing of the last major activity on the Cape Fear Slide to a time span generally consistent with the last sea-level lowstand.

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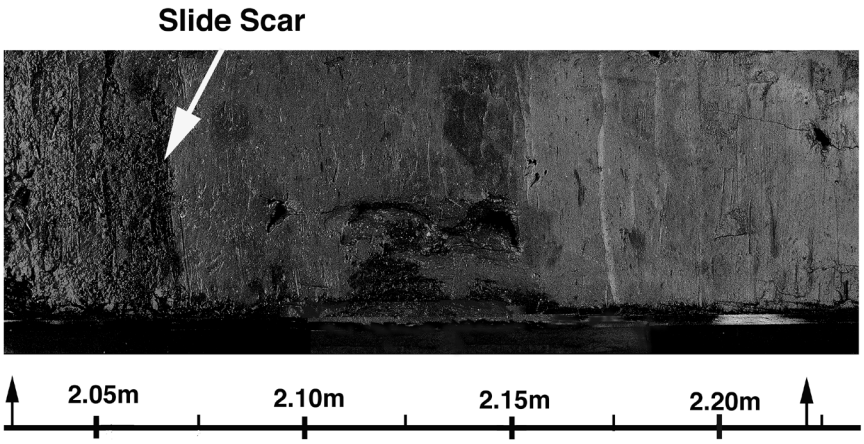

Figure 2. Core photograph showing the contact between overlying undisturbed sediments and sole of the uppermost slide scar at 2.06 mbsf in Section 164-991A-1H-2. The location of the two samples that straddle the sole of the slide are identified with arrows. Sampling was avoided directly beneath the sole of the slide because of the mottled sediment, suggesting bioturbation.