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OSL Dating Supports "High" Sedimentation Rates in Central Arctic Ocean

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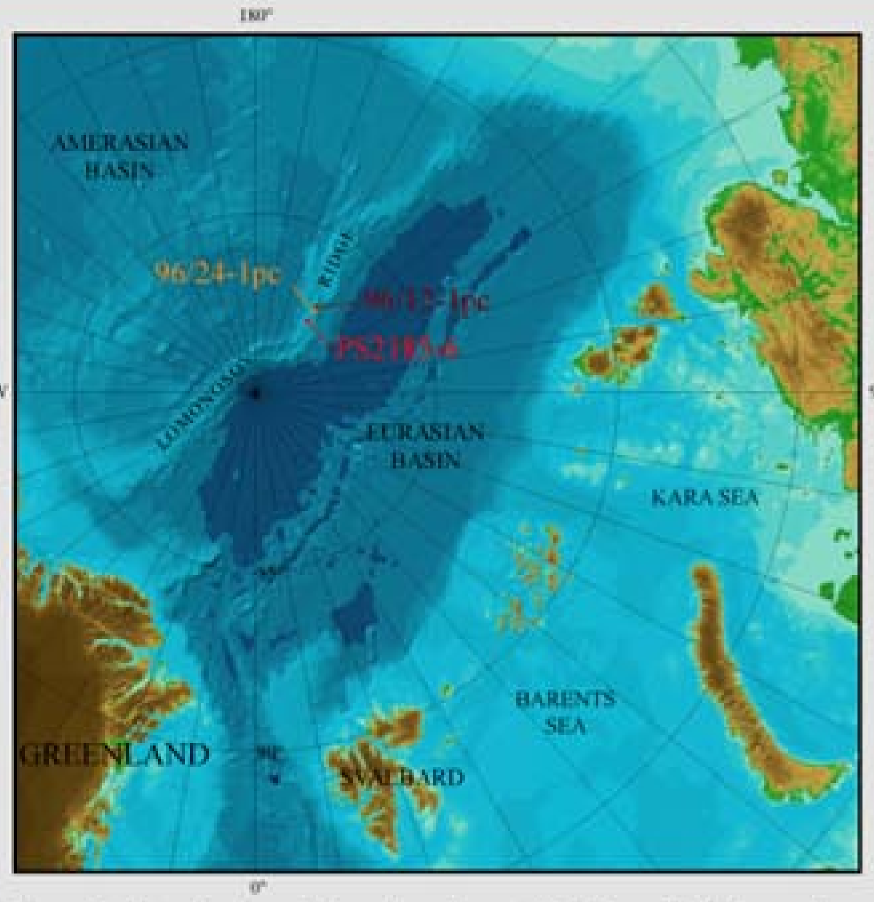


Figure 1. Map showing the location of cores 96/12-1pc, 96/24-1pc and PS2185-6.

The Achilles heel of Arctic paleoenvironmental reconstructions

The study of past climates relies on the accuracy of the age models used. The establishment of accurate age-depth relationships for sediment cores retrieved from the Arctic Ocean is associated with great difficulties and uncertainties, and there is much debate about how to derive a reliable chronology. Indeed, the chronology of Arctic Ocean sediments may be regarded as the Achilles heel of Arctic paleoenvironmental reconstructions. For example, on the crest of the Lomonosov Ridge the geophysical data indicate undisturbed sedimentation presumed to be favorable to studies of the Arctic paleoenvironment. Using cores from this area, sedimentation rates have been proposed, ranging from mm/1000 years (typical for deep-seared clay facies) to several cm/1000 years (average modern deep-sea sediments)(Fig. 1 and 2). This one order of magnitude uncertainty in chronology is clearly unsatisfactory.

A new approach to constrain the Pleistocene chronology of Arctic Ocean sediments has been suggested by Jakobsson et al. [2000]. They argue that variations in manganese concentration and sediment color with depth provide a proxy for glacial-interglacial variability. This approach was used to correlate Arctic deep-sea cores to low latitude $\delta^{18}O$ glacial-interglacial cyclicity, thereby permitting the construction of an age model (Fig. 4). Their model yields a sedimentation rate curve with two distinct intervals, each rather linear in character. The first interval from MIS 1 to 4 shows an average sedimentation rate of 2.8 cm/ka, whereas the second interval, from MIS 5 to the Brunhes/Matuyama boundary, shows an average rate of 0.5 cm/ka.

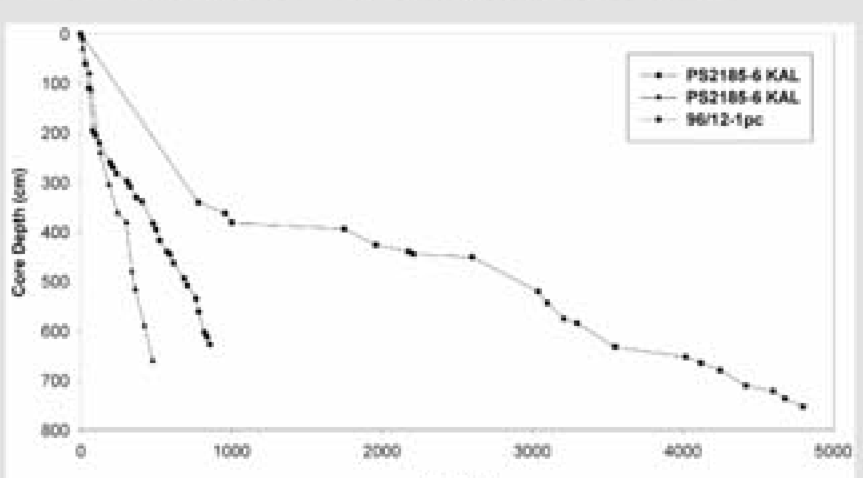
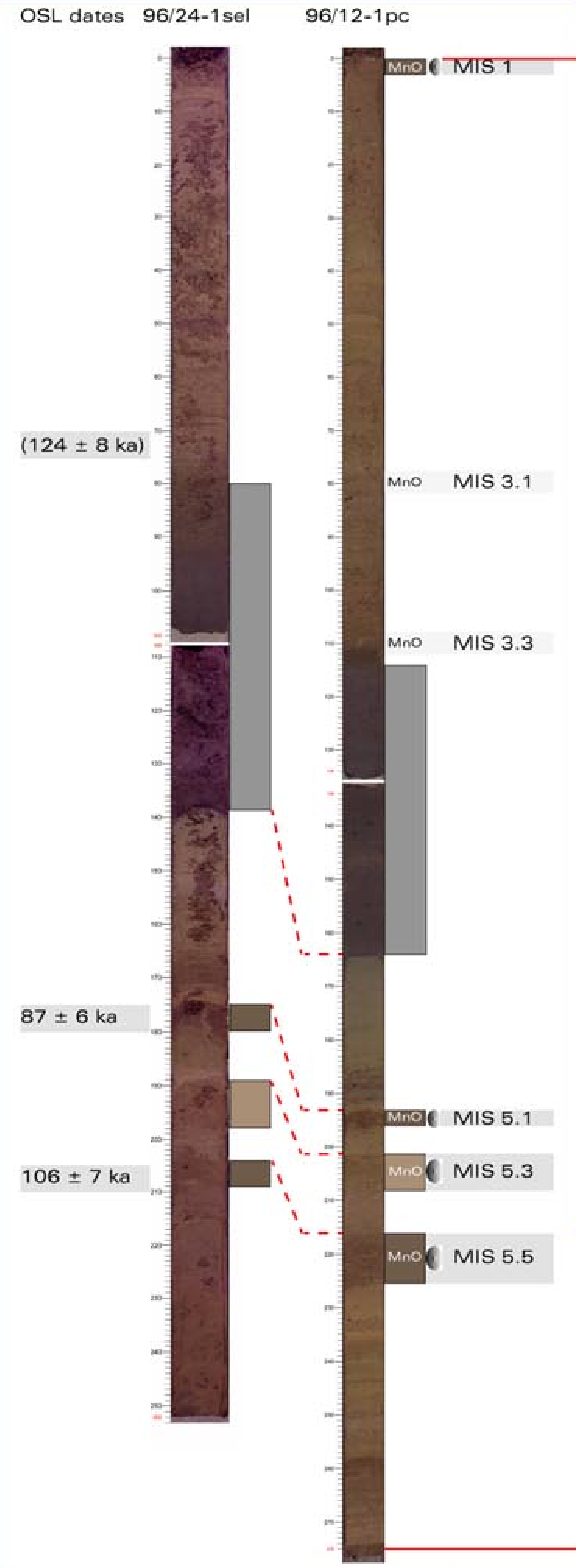


Figure 2. Two alternative age-depth relationships for core PS2185-6 vs. core 96/12-1pc. The excursion scenario [Frederichs, 1995] for core PS2185-6 is plotted with squares and the true reversal boundary scenario [Frederichs, 1995; Spielhagen et al., 1997] with triangles.



Legend

Nannofossil occurrence

MnO Chemical measurements indicate MnO enrichment

MIS Marine Isotope Stage

Dark gray sediment unit

Dark brown, mottled, sediment unit

Medium brown, mottled, sediment unit

Figure 3. Lithostratigraphic correlation between core 96/24-1sel and 96/12-1pc. OSL dating of three samples has been carried out in core 96/24-1sel and the results are shown in the left column.

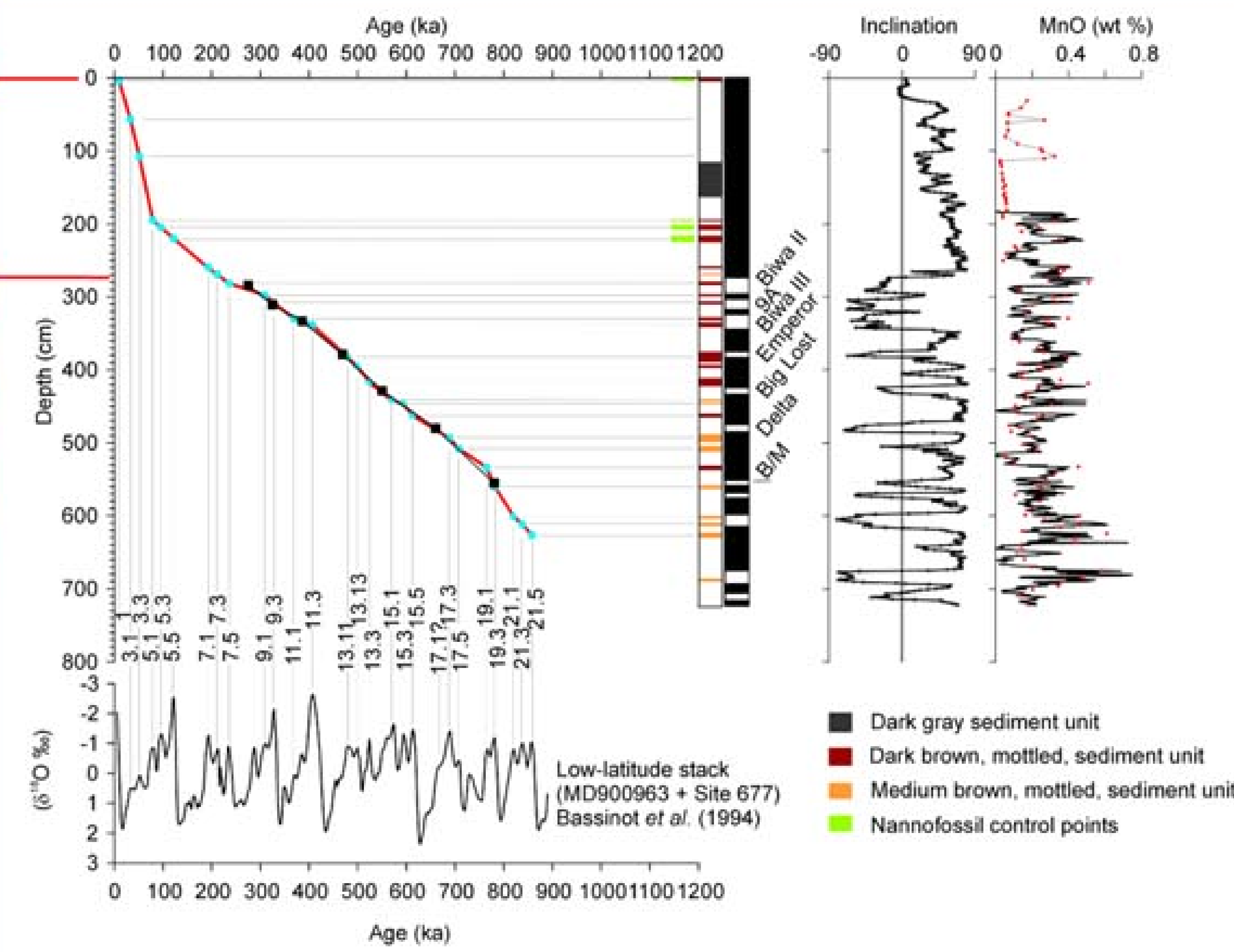


Figure 4. Age-depth diagram of the entire core 96/12-1pc showing the relationship between ages of inferred geomagnetic excursions and correlation between MnO-color cycles and oxygen isotope variations in marine core MD900963, site 677.

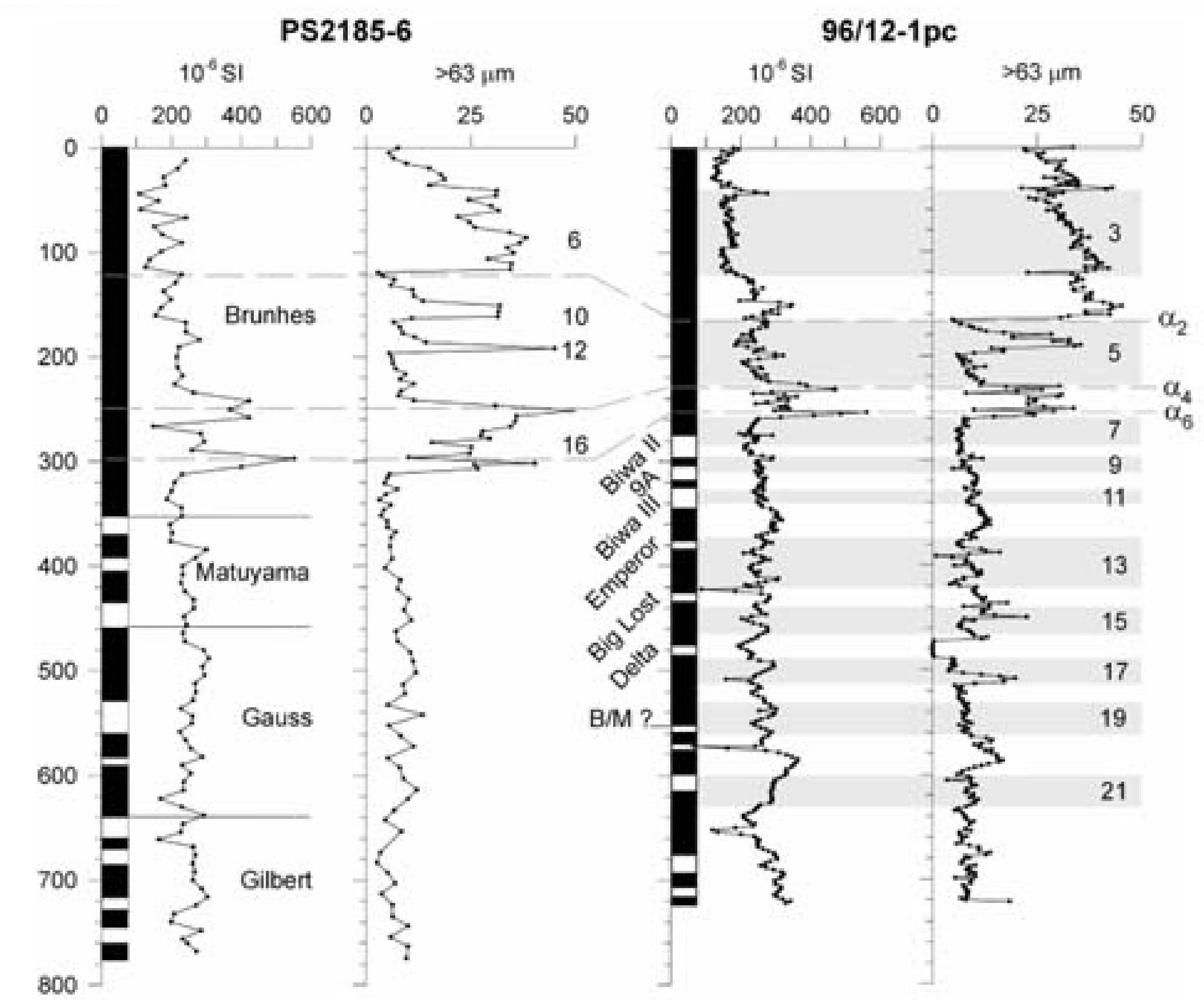


Figure 5. Stratigraphic correlation between core PS2185-6 [Spielhagen et al., 1997] and 96/12-1pc based on selected features in magnetic susceptibility (α) and grain size (>63 µm) [Jakobsson et al., in press]. The Marine Isotope Stages are inferred as well as the interpretation of the geomagnetic stratigraphy in the two different interpretations of the chronology of the Lomonosov Ridge sediments.

Optically Stimulated Luminescence (OSL) Dating

Luminescence dating offers an independent absolute age control for clastic sediments. This technique uses the build up of a trapped electron population in natural minerals such as quartz as a chronometer. The electron population is initially set to zero by daylight exposure during transport (by wind, water or ice), and then begins to build up with time, because of exposure to naturally occurring radiation. The technique is widely used in terrestrial deposits, and is now providing the chronological foundation for much of our understanding of the last glacial cycle in Arctic Eurasia (see Boreas volume 26, 1999). The typical age range of the method is from recent times back to about 150 ka. The technique has had limited application in marine cores, primarily because oxygen isotopes and ^{14}C have been the preferred methods at lower latitudes. Nevertheless, recent work on marine Eemian (MIS 5.5) material from Denmark has proved very encouraging with a mean age for 26 samples of 113 ka.

OSL dating of core 96/24-1sel from the Lomonosov Ridge

In order to further test the age model by Jakobsson et al. [2000], OSL dating has been carried out on core 96/24-1sel, raised from 980 m water depth on the Lomonosov Ridge in the central Arctic Ocean during the expedition Arctic Ocean 96 with Swedish ice breaker Oden. This core has been correlated to nearby core 96/12-1pc, which in turn has been correlated to core PS2185-6 raised from Polarstern during the ARK-VIII/3 expedition (Fig. 3 and 5). This allows us to compare our preliminary OSL results with the previous established chronologies in the cores PS2185-6 [Speilhagen et al., 1997] and 96/12-1pc [Jakobsson et al. 2000].

The preliminary results from two of the three OSL dated samples from core 96/24-1sel supports the interpretation that the sedimentation rate in the central Arctic Ocean is of the order of cm/1000 years. The sample from the stratigraphic position identified as MIS 5.5 (205-210 cm) yielded an age of 106 ±7 ka and the sample from MIS 5.1 (175-180 cm) yielded 87 ±6 ka. The third sample was taken from a location in the core with a high input of IRD (70-75 cm). The OSL date of this sample is far too old for its stratigraphic location in the core, which most probably is a result of the dominantly ice rafted sediment and insufficient light exposure before sedimentation.

References

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