The central Arctic Ocean sediment record: Current progress in moving from a litho- to a chronostratigraphy

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In recent years there has arisen a major controversy surrounding the ages of the sediments recovered from the central Arctic Ocean. Earlier interpretations (Steuerwald et al. 1968; Clark 1970, 1971; Hunkins et al. 1971; Clark et al. 1980) inferred that the rates were very low, and of the order of 0.2 to 0.005 cm/1,000 years. These ages were based primarily upon published *interpretations* of the paleomagnetic polarity records of central Arctic Ocean sediments. These interpretations have been challenged by Sejrup et al. (1984). These authors measured amino acid D/L ratios of planktonic and benthonic foraminifera in core T3-67-11. They interpreted their results to mean that central Arctic Ocean sedimentation rates were 10 to 20 times higher than had been previously reported. These authors pointed out that since the actual paleomagnetics data had only been published from one Arctic Ocean core, the published polarity interpretations could not be fully evaluated. Jansen et al. (1983) and Zahn et al. (1985) have looked at the stable isotopic composition of planktonic foraminifera and the paleomagnetic records from cores to the north of the Fram Strait and within the Norwegian-Greenland Sea and suggested that the low sedimentation rate interpretations previously put forth could indeed be in error.

More confusing still, Macko & Aksu (1986) published the results of an amino acid racemization study of planktonic foraminifera from a central Arctic Ocean core and reached the conclusion that sedimentation rates were low and agreed with the paleomagnetic interpretations.

The major unanswered question that remains in this debate has been just what do the paleomagnetic records from the central Arctic Ocean T-3 dataset look like? This short note will address this question, as well as present a revised chronostratigraphy for the central Arctic Ocean. A more complete treatment of the existing central Arctic Ocean paleomagnetics data will be presented in Jones et al. (in press) and Jones (in press).

Dr. David Clark and his graduate students have made over 7,500 spinner magnetometer measurements on 110 of the 550 cores recovered from the Ice Island T-3 between 1963 and 1974. The quality of this paleomagnetic dataset varies widely from samples analyzed with full stepwise demagnetizations and 6-spin measurements to no demagnetization and only 1-spin measurements. Inclinations had not been calculated for any of these data. The polarity records that have been published from this dataset were based upon the sign (+ = normal/− = reversed) of the inphase Quadrature value.

All of the existing paleomagnetics data from these 110 cores were evaluated and the inclinations calculated. Only those data that had been demagnetized in fields of 50 Oe or greater and that could be placed into the 12-unit lithostratigraphy of Clark et al. (1980) were used in this study. This criteria left a dataset of 14 cores. In addition, Jones et al. (in press) have made over 2,500 cyrogenic magnetometer measurements on three additional cores.

A composite lithostratigraphic section for the central Arctic Ocean was constructed by calculating the median thickness for each of the 12 lithostratigraphic units as defined by Clark et al. (1980) in each of these 550 cores. Special precautions, as outlined in Jones (in press), had to be taken for estimating the true thickness of both the youngest unit M (coretop recovery problem) and the oldest unit A (since records end within this unit the depth to the bottom of unit A cannot be directly measured).

The lithostratigraphic units from each of the 17 cores used in this study were normalized to the composite unit thicknesses, and the paleomagnetics data from each of these cores were stacked and evaluated as a single record. This robust approach was necessary for the following reasons: First, the 5 to 10 cm sampling interval used for most of the spinner magnetometer data causes severe aliasing when looking at any one record. Second, the glacial-marine nature of the sediments results in a number of spurious one-point spikes related to large pebbles that do not reorient with the earth's magnetic field. Third, due to the wide range of demagnetization intensities used, a number of records most likely contain incompletely removed VRM overprints, resulting in a number of artificially shallow inclination values. For this region of the world one can calculate that inclination values should be in excess of 75 degrees. Only those inclination values in excess of 75 degrees are plotted in Fig. 1.

The first change in magnetic polarity occurs 50% of the way into unit K (or 107 cm on the composite section) and is interpreted to be the Brunhes/Matuyama boundary (Fig. 1). There is a weak suggestion of a return to normal polarity between 90% unit K and 10% unit J (120 to 125 cm on the composite), and is tentatively interpreted to be the Jaramillo. However, too much weight should not be placed on this interpretation. A change from reversed to normal polarity is very clearly observed 55% of the way into unit D and a return to reversed polarity occurs 5% of the way into unit A (271 to 311 cm on the composite plot). This interval of normal polarity

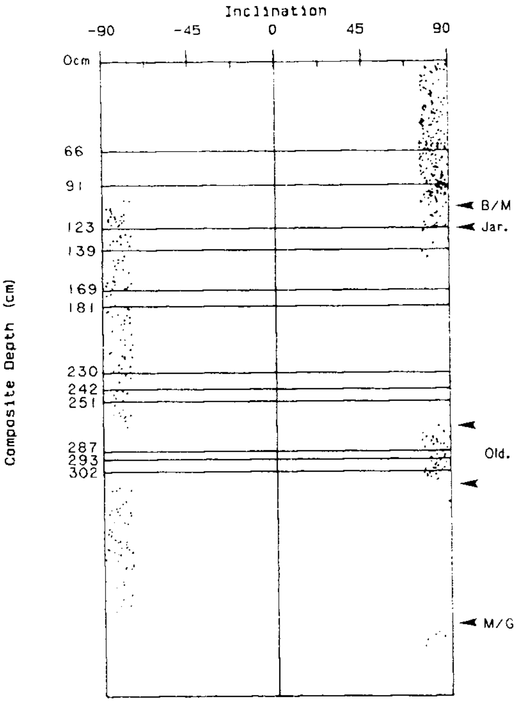

Fig. 1. Composite plot of paleomagnetic inclination data from 17 central Arctic Ocean cores. Only those inclination values greater than 75 degrees are plotted. Composite depths were calculated from the median thickness of each lithostratigraphic unit as found in all central Arctic cores and as defined by Clark et al. (1980). Paleomagnetic polarity interpretation is given on the right. B/M = Brunhes/Matuyama boundary (0.73 My). Jar = Jaramillo (0.90 to 0.97 My). Old = Olduvai (1.67 to 1.87 My). M/G = Matuyama/Gauss boundary (2.48 My). Entire paleomagnetic inclination dataset is presented in Jones et al. (in press) and Jones (in press).

is interpreted to be the Olduvai. At 70% of unit A (418 cm on the composite plot) there is a change in polarity from reversed to normal, which is interpreted to be the Matuyama/Gauss boundary.

Using all of the paleomagnetics and lithostratigraphic data, one can calculate an age for each of the lithostratigraphic boundaries (Fig. 2). The finalized central Arctic Ocean chronology will be presented in Jones (in press). This should be little changed from that presented here but will take into account additional analyses presently being made that are designed to further evaluate those intervals where we have the least confidence (i.e. units J and F).

The major contributions of this work include:

1. This is the first time that the existing paleomagnetics dataset from the T-3 core collection has been thoroughly examined and the data, at least selectively, published. These data clearly show that the first polarity reversal occurs within unit K and suggests a sedimentation rate of approximately 0.15 cm/1,000 years. The other observed polarity changes suggest similar sedimentation rates. These data support the earlier interpretations of low sedimentation rates and disagree with the interpretations of Sejrup et al. (1984). The next step to be taken is for the amino acid racemization data to be reevaluated to understand why they are in disagreement with all other data used to infer sedimentation rates in the central Arctic, including the amino acid racemization data of Macko & Aksu (1986).

2. Although this study supports the notion of low sedimentation rates for the central Arctic Ocean, I propose that the oldest continuously accumulating sediment (i.e. not found below a hiatus) recovered from the T-3 platform is approximately 2.5 million years old, and is not Miocene in age as previously interpreted by Clark et al. (1980). This difference of interpretation is based upon previous workers assuming that

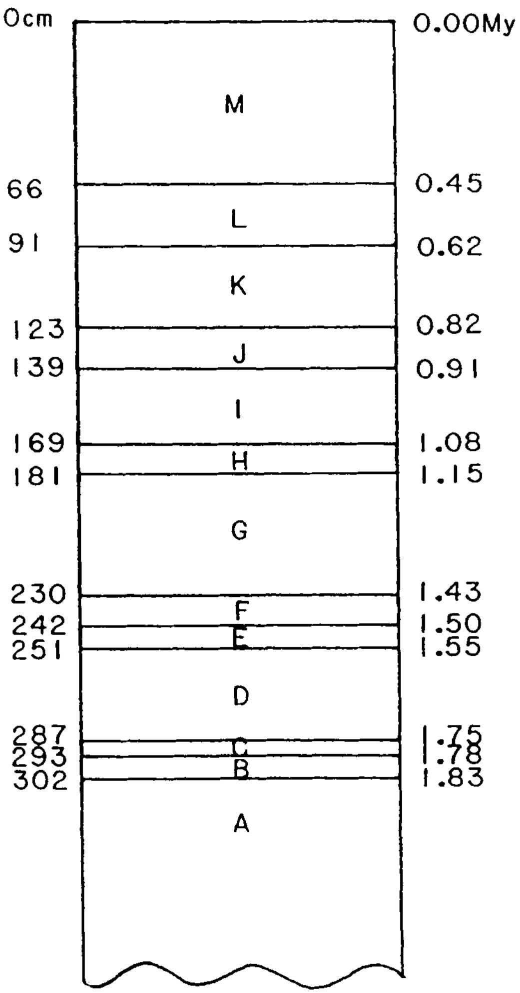

Fig. 2. Composite lithostratigraphic section (units M to A) for the central Arctic Ocean. Scale on the left is the median depth to each of the lithostratigraphic unit boundaries as defined by Clark et al. (1980). Scale on the right is the calculated age for each of the lithostratigraphic boundaries using the paleomagnetic polarity interpretation in Fig. 1.

the interval of normal polarity between 55% unit D and 5% unit A was the Gauss, whereas I have interpreted this interval to be the Olduvai. It must be pointed out that this controversy has not been solved confidently and a detailed discussion of the problem is presented in Jones (in press).

3. Clark et al. (1980) have shown that the lithostratigraphic units M to A occur throughout the Canadian Basin of the central Arctic and these units are easily identified. By calculating the age of each of these unit boundaries it is now possible to place each of the cores from the T-3 collection into a central Arctic Ocean chronology without having to generate a paleomagnetic record for each core.

References

Clark, D. L. 1970: Magnetic reversals and sedimentation rates in the Arctic Ocean. *Geological Society of America Bulletin 81*, 3129–3134.

Clark, D. L. 1971: Arctic Ocean ice cover and its Late Cenozoic history. *Geological Society of America Bulletin 82*, 3313–3321.

Clark, D. L., Whitman, R. R., Morgan, K. A. & Mackey, S. D. 1980: Stratigraphy and glacial-marine sediments of the Amerasian Basin, Central Arctic Ocean. *Geological Society of America Special Paper 181*. 57 pp.

Hunkins, K., Bé, A. W. H., Opdyke, N. D. & Mathieu, G. 1971: The Late Cenozoic history of the Arctic Ocean. Pp. 215–237 in Turekian, K. K. (ed.): *The Late Cenozoic Ice Ages*. Yale University Press, New Haven.

Jansen, E., Sejrup, H.-P., Fjæran, T., Hald, M., Holtedahl, H. & Skarbo, O. 1983: Late Weichselian paleoceanography of the southeastern Norwegian Sea. *Nor. Geogr. Tidssk. 63*, 117–146.

Jones, G. A. in press: *A revised chronostratigraphy for sediments of the central Arctic Ocean.*

Jones, G. A., Clark, D. A. & King, J. in press: *The paleomagnetic record of the central Arctic Ocean.*

Macko, S. A. & Aksu, A. E. 1986: Amino acid epimerization in planktonic foraminifera suggests slow sedimentation rates for Alpha Ridge, Arctic Ocean. *Nature 322*, 730–732.

Sejrup, H.-P., Miller, G. H., Brigham-Grette, J., Løvlie, R. & Hopkins, D. 1984: Amino acid epimerization implies rapid sedimentation rates in Arctic Ocean cores. *Nature 310*, 772–775.

Steuerwald, B. A., Clark, D. L. & Andrew, J. A. 1968: Magnetic stratigraphy and faunal patterns in Arctic Ocean sediments. *Earth and Planetary Science Letters 5*, 79–85.

Zahn, R., Markussen, B. & Thiede, J. 1985: Stable isotope data and depositional environments in late Quaternary Arctic Ocean. *Nature 314*, 433–435.