31. LATE PLIOCENE AND QUATERNARY PALEOCLIMATIC CHANGES, INDIAN OCEAN, DSDP, LEG 26

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INTRODUCTION

It is well known that planktonic foraminifera are an excellent tool to use in the reconstruction of paleoclimatic changes. They are especially good as indicators of the Quaternary climate, because Quaternary and Recent faunas are practically the same. Thus, we are able to draw conclusions with respect to Quaternary environments by comparing Quaternary assemblages with Recent ones.

There are different methods for reconstructing paleoclimates using planktonic foraminifera. Detailed descriptions, comparisons, and discussions of these methods are given in Boltovskoy (1973b). The most important methods are (a) utilizing the whole assemblage and (b) using variations in the *Globorotalia menardii* (d'Orbigny) and *G. inflata* (d'Orbigny) ratio. Both methods have their advantages and disadvantages. The most important advantages of the method based on the relationship between *Globorotalia menardii* (d'Orbigny) and *G. inflata* (d'Orbigny) are that it is relatively quick and, although it does not show small details, it exaggerates climatic changes, thus making them more obvious in paleoclimatic curves.

An attempt was made to find material gathered during Leg 26 that was suitable for analysis of Quaternary climatic fluctuations.

MATERIAL AND METHODS

Site 253 was chosen as the best section as far as the Quaternary and upper Pliocene are concerned. It is located at latitude 24°25.65'S and longitude 87°21.97'E, in a water depth of 1962 meters and was drilled in calcareous ooze. The whole Pliocene and Quaternary section was evidently not damaged or disturbed, and extremely abundant foraminiferal tests were found in an excellent state of preservation. The Pliocene/Quaternary boundary was first located at a depth of 5 meters below the bottom surface utilizing the criterion of the *Globorotalia truncatulinoides* (d'Orbigny): *G. tosaensis* Takayanagi and Saito ratio (see details of this method in Boltovskoy, 1973a). This boundary was located at exactly the same place by means of a nannoplankton study. In the lower part of the Quaternary isolated specimens of *Pulleniatina obliquiloculata praecursor* Banner and Blow were recorded. In the underlying Pliocene, typical Pliocene markers, as for example, *Globorotalia crotonensis* Conato and Follador and *G. limbata* (Fornasini), were found.

Eighty-seven samples at 10-cm intervals were taken from the uppermost 9 meters (Core 1) at Site 253. All the samples were washed through a sieve having an average mesh of 0.063 mm (U.S. Sieve Series Mesh No. 230). The volume of each sample was about 5 cc. The residue left was dried and at least 100 specimens of *Globorotalia menardii* (d'Orbigny) complex and *G. inflata* (d'Orbigny), *s.l.* were picked out at random.

In the *Globorotalia menardii* (d'Orbigny) complex *G. menardii* (d'Orbigny), *G. tumida* (Brady), all kinds of transitional forms between these two foraminifers and specimens known as subspecies (or forma) *flexuosa* of the former and latter species were included. Under *G. inflata* (d'Orbigny), *s.l.* included, in addition to typical specimens of this species, those which might be considered by some authors as *G. puncticulata* (Deshayes), as they had more lobulate test and four-five chambers in the final whorl.

PALEOCLIMATIC CURVE

The relationship between *Globorotalia menardii* (d'Orbigny) complex and *G. inflata* (d'Orbigny), *s.l.* was calculated and a paleoclimatic curve was drawn (Figure 1). If these species were equally abundant, the sample was located in the middle. If *Globorotalia inflata* (d'Orbigny), *s.l.* was more numerous than *G. menardii* (d'Orbigny) complex, the sample was put in the corresponding place in the right part of the column, and so on.

The geological ages were based on determinations carried out by Boltovskoy (see Neogene planktonic foraminifera of the Indian Ocean, DSDP, Leg 26, this volume, Chapter 30). However, there is a small difference in the location of the Pliocene/Quaternary boundary in the report cited and in this paper. For the former report only one sample per section was taken. Sample 1-4, 52-54 cm (depth below bottom surface 5 m) was determined as Quaternary and Sample 1-5, 48-50 cm (depth below bottom surface 6.5 m) was considered as upper Pliocene. Consequently, the Pliocene/Quaternary boundary was located at a depth of 5 meters. However, as a result of the present detailed study, the boundary has been located between 5 and 6.5 meters, at a depth of 5.9 meters.

DISCUSSIONS AND CONCLUSIONS

An analysis of the paleoclimatic curve permits the drawing of the following conclusions.

1) The Pleistocene/Holocene boundary lies at a depth of approximately 30 cm below the bottom surface. This location is indicated by the well-pronounced downward decrease of temperature. It is interesting to note that Ericson et al. (1961) for the North Atlantic, and Bol-

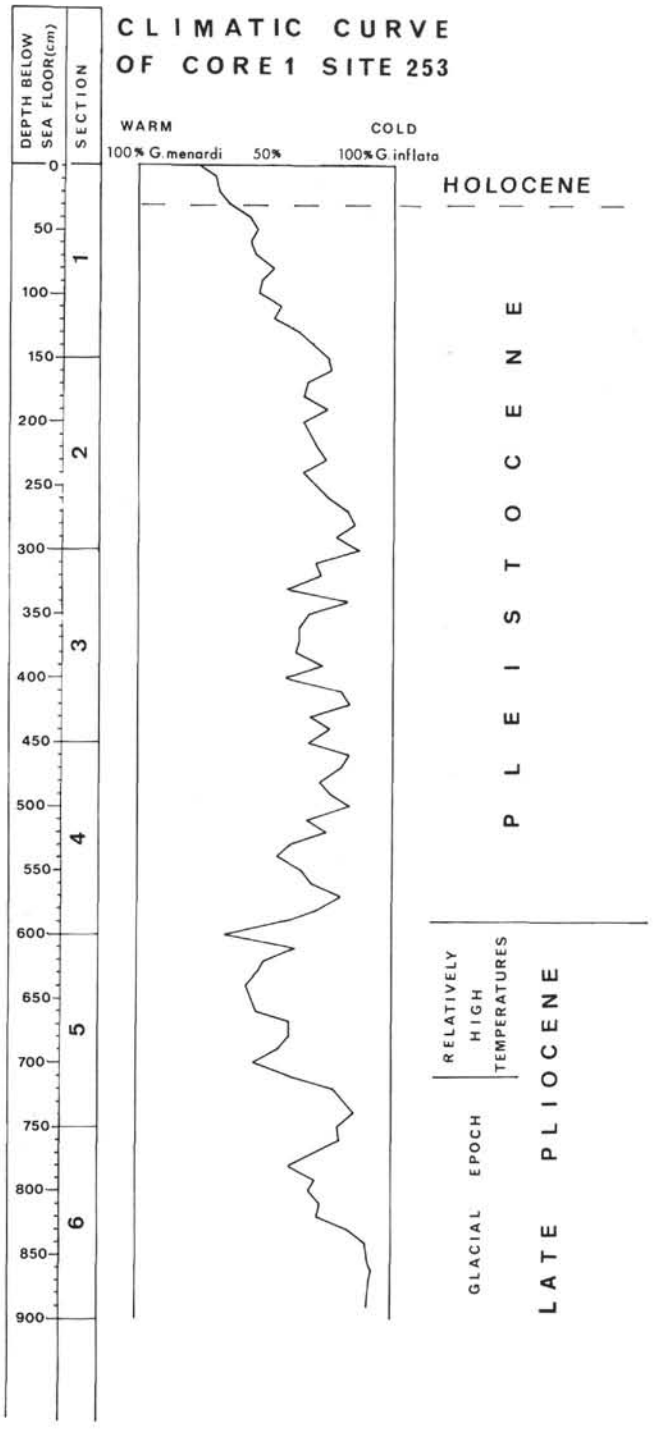

Figure 1. *Climatic curve of Core 1, Site 253.*

tovskoy (1973a) for the South Atlantic determined that the thickness of the Holocene deposits is also about 30-40 cm.

2) The paleoclimatic curve just below Pleistocene/Pliocene boundary shows a rather brief but abrupt temperature increase. A similar brief period of relatively high temperature in the Pliocene was found in the detailed study of piston cores taken in the Southwestern Atlantic (Boltovskoy, 1973a).

3) Below the above-mentioned temperature increase, the lower part of the curve indicates a period of quite low temperature which existed during the late Pliocene. Similarly the late Pliocene period of low temperature was recorded by Boltovskoy (1973a) in the southwestern Atlantic. Kennett et al. (1971) stated that during the upper Pliocene, about 2.13-2.10 millions years ago, a glacial epoch took place in New Zealand. The cold period determined at Site 253 at a depth of 7.10 meters very probably represents the same glacial epoch recorded by Kennett et al. The surface water temperature during that time was somewhat colder than it was during the glacial epochs of Pleistocene.

4) According to Bé (1969), Ruddiman et al. (1970), and Boltovskoy (1973a), the surface temperature of the water is presently warmer than it was about 2000-4000 years ago (represented in the top sample of every core). The present study confirms the conclusion of Boltovskoy (1973a) that the Recent water temperature is also higher than water temperatures during all the interglacial epochs of the Pleistocene, as well as during the warm period in the late Pliocene. As this phenomenon is observed in the South Atlantic and in the Indian oceans, we can conclude that very probably in the whole southern hemisphere (and maybe even in both hemispheres) Recent temperatures are the relatively higher than those present during the late Pliocene and the whole Quaternary.

5) The location of the Pliocene/Pleistocene boundary based on the *Globorotalia truncatulinoides* (d'Orbigny): *G. tosaensis* Takayanagi and Saito ratio is confirmed by a well-pronounced temperature change determined by means of the *Globorotalia menardii* (d'Orbigny) complex: *G. inflata* (d'Orbigny), *s.l.* ratio.

6) The Pleistocene climatic curve clearly shows temperature oscillations. Undoubtedly they correspond to the glacial, interglacial, and interstadial epochs. However, it is rather risky to try to recognize determined epochs on the curve. Site 253 is located in the subtropical zone and in this zone the Pleistocene climatic changes were not as well pronounced as in the temperate zone.

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