Taylor, D. W. (1967). Late Pleistocene nonmarine mollusks from the State of Puebla, Mexico. *In* "Annual Reports for 1967 of the American Malacological Union," pp. 76–78.

von Erffa, A., *et al.* (1977). Geologie des Hochbeckens von Puebla-Tlaxcala und seiner Umgebung (Erläterung zu einer Geologischen Karte). *In* "Das Mexiko-project der Deutschen Forschungsgemeinschaft. XI." (W. Lauer, Ed.). Franz Steiner Verlag, Wiesbaden.

HAROLD E. MALDE
U.S. Geological Survey
Denver, Colorado 80225

VIRGINIA STEEN-MCINTYRE
P.O. Box 1167
Idaho Springs, Colorado 80452

Comments on: "Surface Circulation of the Indian Ocean during the Last Glacial Maximum Approximately 18,000 yr B.P." by Warren L. Prell *et al.*

In the cited paper the authors utilize the CLIMAP planktonic foraminiferal biogeography of the Indian Ocean to estimate the sea surface temperature (SST) and the ocean circulation patterns during the last glacial maximum (LGM). Their reconstructions, based on present day foraminifera concentrations and transfer function techniques, yielded differences between the present distribution and the LGM as about −1.5° to −2.0°C averaged over the Indian Ocean and about −5°C along the subtropical West Australian coast.

The data base used in the study contained 42 Indian Ocean core samples which according to the authors is a significant improvement on the CLIMAP (1976) set. It is important to note at this stage that the study was based only upon one form of data, viz. the distribution of planktonic foraminifera. It did not incorporate land-based proxy data. Furthermore, the enhanced core network described in Figure 2 and Table 1 does not contain any core samples north of 19°S and east of 90°E. In other words, the entire northeastern equatorial Indian Ocean in the vicinity of Indonesia and northwest Australia is void of data. However it is the form of the data rather than its distribution that we will emphasize later.

The authors make specific reference to the work of Webster and Streten (1978) by stating ". . . We conclude that the ΔSSTs of 7° to 11°C as suggested by Webster and Streten (1978) (. . . in Table 2 . . .) are highly unlikely in the equatorial Indian Ocean and western Pacific. . . ." This statement appears to be based on an unfortunate misinterpretation of our Table 2 possibly reached by considering the table in isolation of a considerable discussion.

Our primary aim was to produce a picture of the climate of the LGM which was consistent with as many forms of proxy data (marine and continental) as were obtainable. The basic philosophy, to which we still hold, was that a meaningful climate can be achieved only by a synthesis of widespread and diverse data. The task became quite difficult when the data from CLIMAP (1976), subsequently substantiated by Prell *et al.* (1980), appeared to be inconsistent with estimates of the LGM climate in the tropical north of Australasia based on palaeobotanical data summarized (for example) by Bowler *et al.* (1976).

The apparent differences were associated more with the magnitude of the SST than its distribution. Indeed, subsequent reference to Prell *et al.* indicates a substantial correspondence between our proposed climate structure and their ocean temperature distribution. Their evidence of an enhanced Western Australian current during the LGM and the indication of a much cooler SST distribution in the southern central Indian Ocean in summer is completely consistent with our proposed anomalous atmospheric long wave pattern, which seemed to envelope many of the proxy data sets over

much of Australasia. Thus if the CLIMAP data were in error, and that point has not been proven, it is an error in magnitude only and that probably only in the tropical regions.

A major thrust of our paper was an attempt to resolve the apparent paradox presented by the two data sets. Our Table 2 represented estimates of the surface temperature (not sea surface temperature) which would be consistent with the only evidence we have of the ancient structure of the low latitude atmospheric column above the ground, viz. the Mts. Jaya, Sirunki, Inim, and Wilhelm freezing levels which are substantiated by lower elevation proxy climatological data in the same region. Table 1 showed results of the opposite approach: the calculation of the LGM tropical freezing levels inferred from the CLIMAP SST estimates. Via either technique large disparities existed. Unfortunately Prell *et al.* (1980) have interpreted these results as incorrect estimates of the SST at the LGM rather than acknowledging them for what they were: indicators of large differences between major data sets.

We suggested seven possible explanations of the difference. Four could be dismissed because of physical inconsistencies obtained by consideration of present data or the physical laws which control atmospheric structure. The remaining three possibilities were that the interpretations of the land-based glacial and paleobotanical record were incorrect, that the CLIMAP tropical reconstructions were in error, or that the anomalously low snow line on the New Guinea mountain ranges was a result of high frequency (i.e., multiple occurrences per season) incursions of cold air from the south. It was pointed out that our hypothetical long-wave atmospheric pattern for the LGM which would be consistent with the Antarctic ice distribution would also be conducive to the propagation of mid-latitude disturbances northward over Eastern Australia and the Tasman Sea. At that time the question was left open as to what weight one would apply to the three possibilities although we did tend to find some support for the paleobotanical record from its diversity in type and location. Furthermore, some recent evidence from the tectonically raised coral of eastern Papua-New Guinea (Aharon, 1981) does appear to support the contention of lower SST than that indicated by CLIMAP, at least in the western South Pacific Ocean.

We must make one further point regarding the influence regions of individual data points in the interpolation scheme used by CLIMAP. More specifically we are concerned with the reliance of the CLIMAP reconstruction in the western South Pacific Ocean on the two companion cores V28-239 and V28-238 in the vicinity of 3°N, 159°E. Unfortunately these cores were characterized by extremely low sedimentation rates (Shackleton and Opdyke, 1976) which render more difficult the usually confident inferences which may be made with the higher accumulation rate cores (Shackleton and Opdyke, 1976). A number of cores lie to east beyond 170°W from which surface temperature drops of 4°–6°C have been inferred (CLIMAP, 1976). Indeed the *enhancement* of the *surface temperature gradient* presents other problems for the provision of a consistent regional climate in the Western Pacific Ocean. A larger longitudinal temperature gradient does not appear to be consistent with the general aridity of Australia as described by Bowler *et al.* (1976) during the LGM.

We may speculate further on the reconstructions in the Eastern Indian Ocean. We remarked in our paper that the influence of the western Pacific Ocean on the eastern Indian Ocean was probably reduced significantly during the LGM by the closing of Torres Strait. However, the reconstructions of Prell *et al.* (see their Fig. 7) still show the isotherms being almost parallel with lines of latitude to the northwest of Australia even though the only data point lies at 19°S which suggests a temperature drop of greater than 4°C! Possibly the

orientation of the isotherms in the reconstructions comes from the influence in the interpolation schemes of the V28 cores or from the patterns of the present sea surface temperature. Unfortunately, the present isotherm distribution probably relies considerably on an open Torres Strait.

Despite these remarks, it is still our opinion that it is difficult to discern which of the three candidates described above are responsible for the disparity; perhaps all factors may be important to a greater or lesser degree.

There are two main purposes for this letter. First it is to correct the misconceptions of our results presented by Prell *et al.* The second is to reiterate our belief in the use of multiple data sets in any reconstruction process. The CLIMAP data is the only proxy data set with global distribution and consequently it is clearly the most important as evidenced by the diverse uses to which it has been put. However, as there appear to be inconsistencies with other data sets the importance of the CLIMAP data insists that these apparent paradoxes be addressed.

It may be of interest that a conference was held at Howman's Gap in Victoria in February 1981 (the so-called "CLIMANZ" conference) which was attended by many Quaternary workers from Australia and New Zealand. At this meeting the deep sea core data for selected time periods were compared with a wide range of land based proxy data for the Australasian region. The proceedings of this conference will be published later this year and will provide a first step in drawing attention to inconsistencies existing among different data sets at least in this region.

REFERENCES

Aharon, P. (1981). Surface ocean temperature variations during the late Wisconsin stages $^{18}O/16_0$ isotopic evidence from coral reef terraces in eastern New Guinea. *Proceedings of the CLIMANZ Conference*. Australian Academy of Science, Canberra (in press).

Bowler, J. M., Hope, G. S., Jennings, J. N., Singh, G., and Walker D. (1976). Late Quaternary climates of Australia and New Guinea. *Quaternary Research* 6, 359–399.

CLIMAP (1976). The surface of the ice-age Earth. *Science* **191**, 1131–1137.

Prell, W. L., Hutson, W. H., Williams, D. F., Bé, A. W., Geitzenauer, K., and Molfino, B. (1980). Surface circulation of the Indian Ocean during the last glacial maximum, approximately 18,000 yr B.P. *Quaternary Research* **14**, 309–336.

Shackleton, N. J., and Opdyke, N. D. (1976). Oxygen-isotope and paleomagnetic stratigraphy of Pacific Core V28-239 Late Pleocene to Latest Pleistocene, *Geological Society of America Memoirs* **145**, 449–464.

Webster, P. J., and Streten, N. A. (1978). Late Quaternary ice age climates of tropical Australasia: Interpretations and reconstructions. *Quaternary Research* 10, 279–309.

PETER J. WEBSTER
CSIRO Division of Atmospheric Physics
Aspendale, Victoria 3195, Australia

NEIL A. STRETEN
Australian Numerical Meteorology Research Centre
Melbourne, Victoria 3000, Australia

About Pigmy Mammoths of the Northern Channel Islands and Other Island Faunas

In an extensive article on the endemic pigmy mammoths of the Northern Channel Islands, Johnson (1978) concluded that elephants reached the islands by swimming. On the basis of submarine morphology and structure Johnson argued that even during the periods of lowermost sea level no continuous land bridge could have formed between the islands and the California coast. This assumption was shared by Madden (1981) in the ensuing discussion; the same idea is held by other scientists in California.

On geological grounds, however, Johnson's argument to rule out the possibility of a