New Zealand Mid-Tertiary Stratigraphical Correlation

The apparent absence of certain stratigraphically important planktonic Foraminifera from the Australian and New Zealand Tertiary rocks has made it difficult to correlate these sequences with the more tropical Tertiary sequences[1]. A recent examination of rocks from the North Auckland region of New Zealand has yielded what appears to be a warmer water fauna.

One of the most important short-ranging species in the well-documented Trinidad Oligocene–Miocene section is *Globorotalia kugleri* Bolli[2]. In New Zealand, Hornibrook[3] recorded possible specimens of this species from the Kopuku section, south of Auckland City, from rocks of Otaian age. A few Otaian samples from North Auckland have yielded definite specimens of *G. kugleri*. Samples slightly older than this have yielded specimens of *Globigerina ciperoensis ciperoensis*.

The initial appearance in time of *Globigerinoides trilobus* (Reuss) has until recently been placed at the base of the Awamoan stage[4]; but there is slight evidence that it may start a little earlier than this, possibly in the top of the Otaian[3]. This level would be approximately equivalent to the top of the *G. kugleri* zone in Trinidad (Fig. 1).

New Zealand stages (ref. 5)	Trinidad zones (ref. 2)	New Zealand stages
Awamoan, Hutchinsonian, Otaian, Waitakian	*C. stainforthi*	Awamoan
	C. dissimilis	Hutchinsonian
	G. kugleri	Otaian
	G. ciperoensis ciperoensis	Waitakian
	G. opima opima	Duntroonian
	G. ampliapertura	Whaingaroan

Fig. 1 Correlation of the New Zealand stages with the planktonic foraminiferal zones of Trinidad

Eames, Banner, Blow and Clarke[5] have correlated the Waitakian–Awamoan rocks in New Zealand with the *stainforthi* zone of Trinidad. The recent discovery of definite *G. kugleri* in Otaian rocks shows that this is completely wrong. There is therefore very little evidence for their hypothesis, which shows a large disconformity below the Waitakian Stage in New Zealand.

With further work, now in progress in New Zealand on the Tertiary planktonic Foraminifera, it is hoped to establish a more accurate correlation of the Tertiary with rocks elsewhere.

D. Graham Jenkins

New Zealand Geological Survey,
Lower Hutt, New Zealand.

[1] Jenkins, D. Graham, *Micropal.*, **6**, 345 (1960).
[2] Bolli, Hans M., *U.S. Nat. Mus. Bull.*, **215**, 97 (1957).
[3] Hornibrook, N. de B., and Schofield, J. C., *N.Z. J. Geol. Geophys.*, **6**, 38 (1963).
[4] Hornibrook, N. de B., *N.Z. Geol. Surv. Pal. Bull.*, **34** (1) (1961).
[5] Eames, F. E., Banner, F. T., Blow, W. H., and Clarke, W. J., *Fundamentals of Mid-Tertiary Stratigraphical Correlation* (Camb. Univ. Press, 1962).

PHYSICS

Charge Transfer associated with Temperature Gradients in Ice

The deviation at temperatures above −7° C from the theoretical value for the charge transfer produced by temperature gradients in ice is shown to be a surface phenomenon.

Recent calculations[1] predict that when a steady temperature difference ΔT is maintained across a uniform specimen of pure ice a potential difference of magnitude $V = 2\Delta T$ mV is developed between its ends. This equation was tested by applying temperature gradients to cylinders of pure ice and was verified for temperatures below

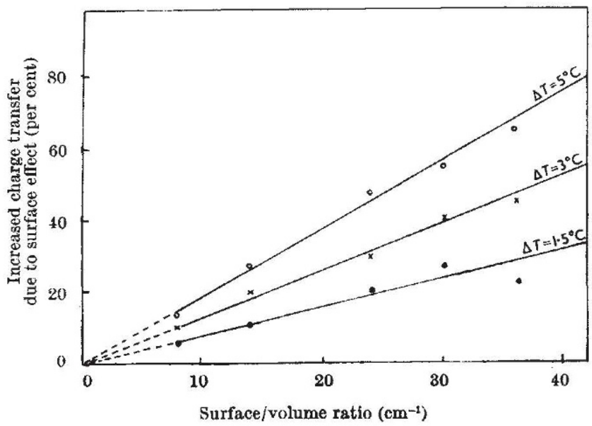

Fig. 1. Effect of the surface-volume ratio on the potentials developed across ice by steady temperature gradients (temperature of colder end of ice cylinder = −7° C)

−7° C. Above this temperature, however, the measured potentials were greater than those predicted.

In order to discover whether the accentuation of the potentials developed across the ice as the temperature of its warmer end approached 0° C was a surface-dependent phenomenon or not, the experiments were repeated for cylindrical specimens of ice of different surface-volume ratio. Curves obtained of V against ΔT for different values of this ratio are shown in Fig. 1. It is seen that as the ratio increases so does the divergence from the theoretical value. Although the accuracy of these experiments was not very great it is evident from the figure that if the straight lines are extrapolated back to zero surface-volume ratio they tend to pass through the origin, that is, showing that the divergence at high temperatures is solely a surface phenomenon, corresponding to an additional transport of charge along a surface layer having a larger variation of conductivity with temperature than the bulk ice. It is not possible to calculate the thickness of such a layer, since both its conductivity and its concentration of mobile ions are unknown.

Weyl[2] has suggested that the molecules on the surface of ice are disarranged and that this distortion extends a finite thickness into the ice. The thickness and adhesive properties of this 'liquid layer' vary with temperature in a similar manner to the divergence of the temperature-gradient potentials from the foregoing equation, but at present there is no direct evidence connecting these two surface properties of ice.

J. Latham

Department of Physics,
Manchester College of Science and Technology,
Manchester, 1.

[1] Latham, J., and Mason, B. J., *Proc. Roy. Soc.*, A, **260**, 523 (1961).
[2] Weyl, W. A., *J. Coll. Sci.*, **6** (5), 389 (1951).

Epitaxial Growth of Silicon by Vacuum Sublimation

Single crystal layers of silicon up to several μ thick have been deposited on to a heated single crystal silicon substrate from a sublimating source. We believe we can grow good epitaxial crystals at a lower growing temperature than previous experiments[1] by reducing the growth rate in a good vacuum free from contamination.

Silicon slabs of about 18 mm × 1·5 mm × 0·5 mm and 18 mm × 3 mm × 0·5 mm were used as the source and the substrate, respectively, with which preferably {111} planes were used. They were cut, polished, etched and cleaned before they were fixed to tungsten rods with tantalum clips so as to face the widest surfaces about