preliminary results indicate a closer correlation to $R_{mo}\%$ than that of $T(\gamma P_{NH}/\gamma P_P)$. This may be due to more accurate measure of heating as P_{EO} measures confining pressure, reproducible in closed system laboratory studies. Effective overburden pressure can be determined at the levels of the sample taken for measurement of vitrinite reflectance.

The high coefficient of correlation of Fig. 1*b* has demonstrated that the combined effect of heat and pressure, especially overpressure, influences increase in vitrinite reflectance for values of R_{mo} less than 1.50%. Pressure has a determinative role in this combination, because of its influence on thermal conductivity of the geological section containing the vitrinite.

Figure 2 and equation (3) indicate that the thermal conductivity of shale in a thick continuous shale section will be the same for a given effective overburden pressure irrespective of its depth. This will be true for any area of uniform heat flow and will be the same whether the shale is overpressured or not,

Heat and time have been related to coalification and increase in vitrinite reflectance. In Fig. 1*a* and *b* the values of vitrinite reflectance are for the same samples, so the time-factor does not have to be considered in this comparison. Nevertheless, the comparison has important implications for the significance of time in coalification processes. The amount of time available for heating may influence the final state of maturation of vitrinite, coal or other hydrocarbons. From the excellent correlation of Fig. 1*b* it can be inferred that the time-factor in relation to precision of vitrinite reflectance estimates for given temperatures and pressures, is of limited significance on a geological scale and is likely to be critical only for a short period.

Further investigation of the combined effect of heat, pressure, thermal conductivity of sediment, and time in natural, geological conditions will improve understanding of the increase in reflectance of vitrinite. The resulting data should also provide a more sound basis for interpretation of the role of natural physical processes in the maturation of all types of organic matter in terms of physical chemistry.

R. A. McTavish

Continental Oil Company Ltd,
116 Park Street,
London W1, UK

Received 16 May; accepted 25 November 1977.

1. Teichmüller, M. & Teichmüller, R. in *Coal and Coal-bearing Strata* (eds Murchison, D. G. & Westcoll, T. S.) 233–267 (Oliver and Boyd, Edinburgh, 1968).
2. Ammosov, I. I. *C.R. 6ème Congres Int. Strat. Geol. Carbonifere* **2**, 403–415 (1970).
3. Lopatin, N. V. & Bostick, N. H. *Reprint Ill. Geol. Surv. 1974–Q*, 1–16 (1974).
4. Gretener, P. E. *Bull. Can. petrol. Geol.* **17**, 255–259 (1969).
5. Timko, D. J., Fons, L. C., Grittman, W. K. & Rees, F. B. in *Abnormal Subsurface Pressure, A Study Group Report 1969–1971*, 20–30 (Houston Geological Society, Houston, 1971).
6. Fertl, W. H. *Abnormal Formation Pressures* (Elsevier, Amsterdam, 1976).
7. Hottman, C. E. & Johnson, R. K. *J. petrol. Technol.* **17**, 717–723 (1965).
8. Wichmann, P. A. *Trans. III Europ. Form. Eval. Symp.* S1–S15 (1974).
9. Dowdle, W. L. & Cobb, W. M. *J. petrol. Technol.* **27**, 1326–1330 (1975).
10. Jones, P. H. *J. petrol. Technol.* **21**, 803–810 (1969).
11. Lewis, C. R. & Rose, S. C. *J. petrol. Technol.* **22**, 11–16 (1970).

Rejecting evidence of Gothenberg geomagnetic reversal in New Zealand

MORNER and Lanser[1], in 1974, gave evidence that the Gothenberg Geomagnetic Event had been discovered in New Zealand. The report was made prematurely, being based on remarks by Topping[2] in an address at the INQUA Congress in Christchurch, New Zealand, 1973. Further investigations, detailed here, show that the presumed evidence for the Gothenberg reversal was unsound.

Topping's presumption was based on measurements of palaeomagnetic polarities in 16 andesite boulders taken from two adjacent localities in a lahar. The lahar is between 9,540- and 12,450-yr-old (ref. 2) and is located at Bruce Road on the northwestern side of Mount Ruapehu, National Park, New Zealand. Eleven of the boulders displayed reversed polarities, and Topping concluded that this was sufficient to prove that the lahar was hot when it flowed, and the boulders had not cooled to below their Curie temperatures until after the lahar had come to rest. The independently determined age of the lahar, based primarily on ^{14}C measurements[2], indicated correlation of the implied reversed geomagnetic field with the Gothenberg Event. If correct, this would have been the first record of the Gothenberg Event in the Southern Hemisphere, and in view of its importance more thorough investigation was obviously needed.

Therefore an additional 16 oriented boulders of andesite were taken from one of Topping's localities. Two, three or four samples, at different distances between the outer surface and centre, were taken from each boulder, and polarities were measured with a spinner magnetometer.

Only a few samples had been magnetically cleaned by Topping. They showed no sign of instability after thermal demagnetisation at 150 °C, and Topping assumed that the magnetisations of all his sample boulders were stable. The following more rigorous cleaning tests confirm that Topping's assumption was correct.

Samples from three of the newly collected boulders were thermally demagnetised step by step at 50° intervals between 100 °C and 600 °C, and samples from two others were a.c. demagnetised at peak field intervals of 10 mT up to 50 mT. Directional changes were negligible up to 500 °C for thermal demagnetisation and up to 50 mT for a.c. demagnetisation. The palaeomagnetic stability index of Briden[3] was applied and confirmed these observations. From these stability indices a peak field of 10 mT was chosen as best for a.c. cleaning and a maximum temperature of 300 °C for thermal cleaning. The remaining samples were cleaned at either of the above values, approximately half by each method.

The magnetisation directions of samples from each individual boulder are in good agreement with one another. This shows that the material in each boulder was at rest while cooling from the Curie temperature.

The magnetisation directions of individual boulders seem to be random, showing that their natural remanent magnetisation (NRM) could not have been acquired by cooling after coming to rest in the lahar mound.

After cleaning, the mean inclination for all the boulders was $-10°$ with a standard deviation of 35°, and the mean declination was 132° with a standard deviation of 72°. A *t*-test shows that the inclinations and declinations are randomly distributed at the 95% confidence level.

It is thus concluded that the volcanic material composing the boulders acquired its thermoremanent magnetisation (TRM) by cooling in a stable magnetic field before the boulders were involved in the lahar flow. During the lahar flow the rocks were below their Curie temperature, and when they came to rest were magnetically oriented in random directions. They therefore do not record a geomagnetic field direction and are not suitable for testing the existence in the Southern Hemisphere of the Gothenberg Reversed Event.

J. C. Sukroo
D. A. Christoffel

Physics Department,
Victoria University of Wellington,

P. Vella
W. W. Topping

Geology Department,
Victoria University of Wellington,
Wellington, New Zealand

Received 10 October; accepted 6 December 1977.

1. Morner, N. A. & Lanser, J. L. *Nature* **251**, 408 (1974).
2. Topping, W. W. thesis, Victoria Univ. Wellington (1974).
3. Briden, J. C. *J. geophys. Res.* **77**, 1401 (1972).