such recombinants are available it will be possible to explore approaches to forcing the expression of the insulin gene within *E. coli*. Techniques already exist to force transcription of inserted DNA, but whether such transcripts can be faithfully translated is unknown. Even if *E. coli* could be persuaded to synthesise preproinsulin there still remains the problem of processing this to the mature hormone. The use of this technology for the large scale production of insulin may well depend not only on engineering *E. coli* to express the insulin gene but on the development of *in vitro* processing systems. There clearly remains a great deal of work before one can confidently anticipate the commercial production of insulin in *E. coli*, but the first step has been taken. □

Evidence for Earth expansion?

from Peter J. Smith

THE concept of an expanding Earth has been in circulation for several decades now, but has never attracted much interest. If it were not for the historical example of continental drift, it would be tempting to assume that such indifference reflects a correct interpretation of the Earth's behaviour and that expansion is only an illusion in the minds of a handful of enthusiasts. But the temptation should be resisted, at least for the time being. Drift was once regarded as illusory by the majority of Earth scientists; but the idea was kept alive by a few fanatics until proof came at last from outside the field of geology. Geologists, convinced that continental drift was inconsistent with the existing body of geological knowledge, suddenly found their rejected theory confirmed by physicists and were forced to reinterpret their data accordingly.

Of course, it would be dangerous to over-react to history by concluding that the majority must now be wrong about Earth expansion as it would be to re-enact the sort of response which greeted Wegener's suggestion that the continents had drifted. The cases are not precisely analogous. There were serious problems with the pre-drift world view that only drift could resolve, whereas Earth expansion appears to offer no comparable advantages. On the other hand, if proof of expansion is to come at all it is most likely to come, as with drift, from the physicists. Earth scientists may feel they have no need for expansion; but if physicists could show that the gravitational constant has decreased with time, expansion would

have to be accepted and accommodated.

In the meantime, however, there are still occasional attempts to test the expansion hypothesis against purely geological-geophysical data, the latest of which comes from Steiner (*Geology* 5, 313; 1977). Steiner's idea is simple in principle. For an Earth of constant radius, the rate at which the surface area of ocean floor increases at oceanic ridges must equal the rate at which it decreases through subduction. But if the former is greater than the latter the total area of the ocean floor must *ipso facto*, increase; and the most obvious explanation of such an increase would be an expanding Earth.

Unfortunately, as previous attempts have shown, the practice of testing for expansion is invariably much more difficult than the principle. Steiner begins well enough with the map of ocean basin ages produced by Pitman *et al.* (*Geol. Soc. Amer. Map MC-6*; 1974), from which he measures directly the area of floor produced in the three major oceans during each geological epoch and period from the Jurassic to the Holocene. The first conclusion to emerge clearly is that at most times the rates of floor production vary considerably from ocean to ocean but with "a tendency toward negative correlations where a maximal rate of sea-floor spreading in one ocean basin is compensated for by a minimal rate in another". During the Paleocene, for example, the rates in the Indian and North Atlantic Oceans were high compared with those in the Pacific and South Atlantic Oceans; during the Eocene the rate in the Indian Ocean was higher than those in the Pacific and North Atlantic Oceans which were in turn higher than that in the South Atlantic Ocean; and so on.

The existence of such negative correlation indicates that sea floor spreading results from a globally coordinated process, although this no more rules out the possibility of traditional convection than it does the possibility of expansion. Slightly more favourable to expansion (though again not definitive), perhaps, is the fact that the combined rate of ocean floor production for all the oceans together has apparently increased exponentially with time since the Jurassic. Of course, this detected increase could be spurious. The ocean floor data currently available would indicate an increase even if the rate of floor production had always been constant, for the older the sea floor the greater generally is the proportion already subducted. Moreover, the picture is confused by the fact that the map produced by Pitman and his colleagues is incomplete, specifying ages for only about 66% of the deep ocean floor.

To determine the true rate of floor production since the Jurassic, Steiner has therefore had to make estimates of the spreading in unmapped areas during the past 5 Myr, extrapolate the results back in time, and make corrections for differential subduction. The increase in the rate of floor production with time remains, nevertheless, even when these procedures are complete.

As for numbers, Steiner estimates that the average rate of ocean floor production over the past 165 Myr was $2.61 \text{ km}^2 \text{ yr}^{-1}$. He also concludes that the average subduction rate over the same period was only $1.88 \text{ km}^2 \text{ yr}^{-1}$ and that this average too conceals an increase with time. However, the procedure for obtaining the latter figure is, if anything, even more involved than that necessary to determine the average spreading rate; and therein lie two difficulties. The first is the question of credibility. The greater the degree of assumption, extrapolation and 'correction' there is in calculations of this sort, the less convinced the reader will be of the validity of the result and the greater will be the opportunity for picking holes in the argument. This certainly implies no criticism of Steiner, who has done the best he can with the limited data available. In the circumstances, however, it is bound to be difficult to convince those who are predisposed not to believe in Earth expansion.

The second problem, which may only be a special case of the first, is that the more complicated the procedure and the larger the number of mathematical processes involved, the greater will be the errors on the figures obtained. Thus Steiner estimates the errors to be $\pm 15\%$ on the areal production rate and $\pm 20\%$ on the subduction rate. The obvious conclusion to be drawn from the rates themselves is that over the past 165 Myr the area of ocean floor produced was 33% greater than the area destroyed, which interpreted in terms of an expanding Earth would imply a Jurassic palaeoradius of 5,668 km, or 0.89 of the Earth's present radius. The final error on the palaeoradius, however, is $\pm 13\%$. Unfortunately, this is just large enough to allow the figures to be interpreted in terms of an Earth of constant radius even though, as Steiner points out, there is good reason for regarding 5,668 km as a maximum.

So Steiner has come up against the problem that has bedevilled most previous attempts to test the hypothesis of Earth expansion, namely, that the basic data have insufficient resolving power. Through no fault of his own, his analysis is unlikely to convert anyone to a belief in expansion, although equally it will do nothing to discourage those already converted. □

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