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Siluro–Devonian palaeogeographies based on palaeomagnetic observations

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The total amount of palaeomagnetic data for Siluro–Devonian times is sparse and of variable quality, even for the major continents. As such, it is not possible to apply rigid objective criteria to select the most reliable data as this would eliminate virtually all observations. None the less, there is general agreement among most palaeomagnetic workers as to which data are the most acceptable (for example, Livermore *et al.* (this symposium) and Scotese (this symposium)). Theoretically, all such data should be in agreement for any given tectonic unit for any given time, but this is not the case. Hence subjective evaluations must still form a major contribution to apparently objective reconstructions for these times until adequate consistent data are available. The differences between individual assessments then depend on the extent to which other palaeoclimatic, palaeontological or structural constraints are incorporated into the model. The incorporation of such elements further widens the degree of subjectivity involved for such periods of time and inhibits the objective testing of such reconstructions by independent palaeolatitudinal determinations.

The palaeoclimatic evidence is probably the second most reliable factor, but it is not simple to make such assessments. What, for example, constitutes a thick limestone? Such limestone would not accumulate if there was a high argillaceous discharge in the vicinity. In other words, the local palaeogeography can have a drastic effect on the latitudinal extent of any one of these palaeolatitude indicators. Furthermore, the present may not be an ideal key to the past in this instance. While the angle of insolation on the Earth's surface will clearly be related to the latitude, the atmospheric circulation patterns and hence climatic zonations may well have been drastically different in the majority of geological time when there were no polar ice sheets and hence a low albedo at the poles. Under such circumstances, the polar areas would be of low pressure during the summer season as the low angle of insolation would be more than compensated by its duration. It is probably this effect that is largely responsible for the ameliorable climates that are generally considered to have existed during much of the Mesozoic. Such a model would still show latitudinal zonation of climatic belts, but it is probably only near the Equator that these would be directly analogous to the present pattern.

The use of palaeontological criteria can be extremely informative, not merely in terms of assisting in establishing longitudinal relationships, which are not defined on palaeomagnetic grounds alone, but also for an understanding of the nature of the organism being considered. Turner & Tarling (1982) considered the known distributions of the Siluro–Devonian agnathans, particularly thelodonts, in relation to the available palaeomagnetic data. They concluded that the evidence appeared to be more consistent with these having a dispersal pattern that required land connections, that is, they lived predominantly, or even entirely, in fresh or brackish water at low latitudes and were unable to cross ocean barriers. However, such assessments can be largely circular when considering areas for which no reliable palaeomagnetic data are available.

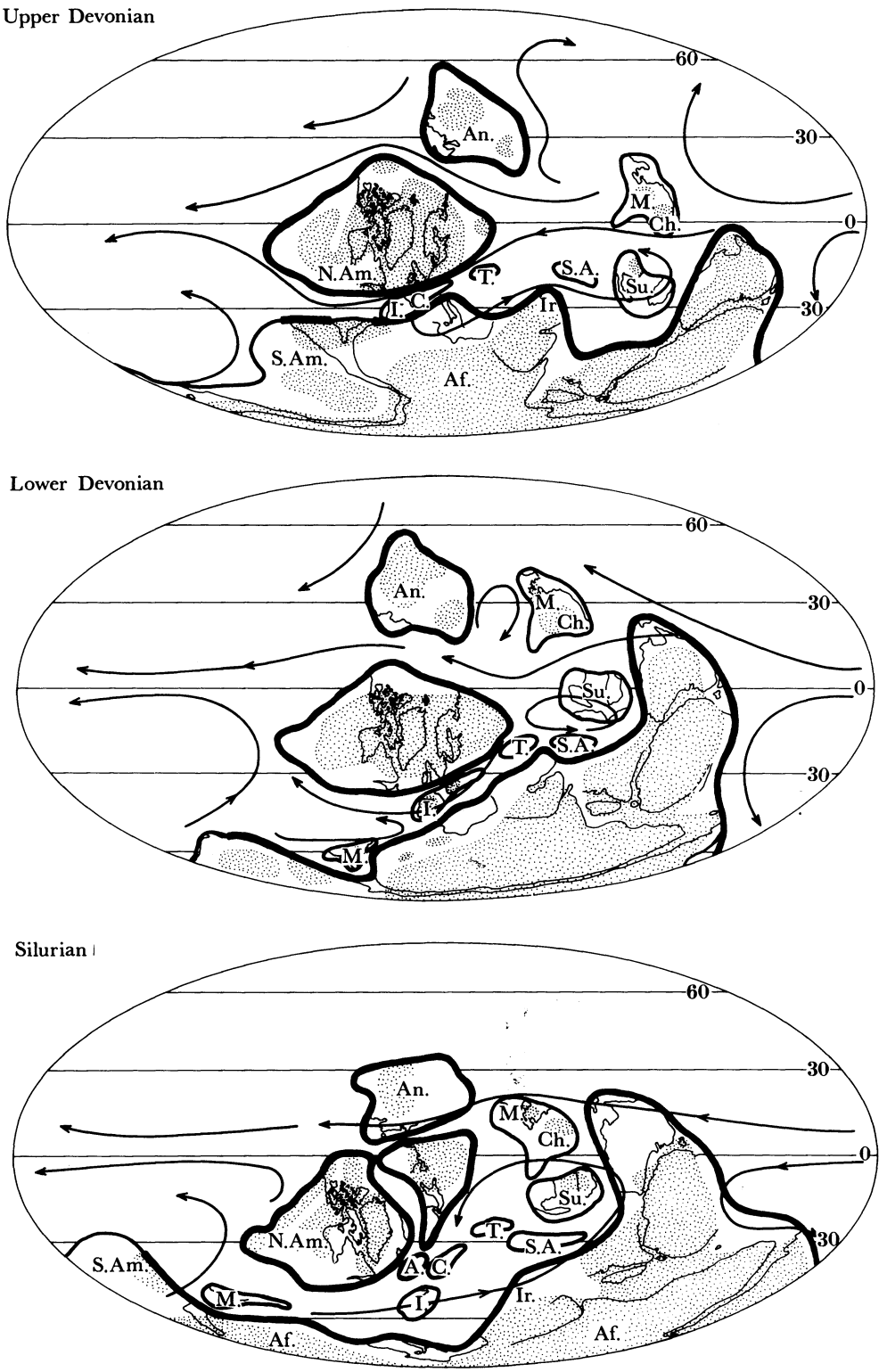

FIGURE 1. Reconstructions for Silurian and Devonian times. Land areas are shown dotted. Ocean currents are purely schematic, based on analogy to present-day oceanic circulation patterns. The heavier outlines indicate areas for which palaeomagnetic controls are available. (After Turner & Tarling 1982).

Continental blocks are labelled as: N.Am., North America, including Kolyma & Greenland excluding Central America, W Cordillera, etc.; S.Am., South America (probably excluding Andean regions); Af., Africa; Ir., Iran; An., Angaraland (Siberia); M+Ch., Manchuria and China (N and S China probably separated); M., Mauretanides and Florida; Su., Sundaland (SE Asia); S.-A., Southern Angaraland (S. Central Asian blocks); T., Tarim; I., Iberia; C., Central Europe; A., Armorica.

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Tectonic restraints clearly limit the areal extent over which individual palaeomagnetic data can be extrapolated, but also provide longitudinal constraints. For example, many of Siluro–Devonian agnathans occur in low latitudes and the early forms could be entirely equatorial and placed so that the Australian forms are directly adjacent to those of the Canadian Arctic. Such a situation would be highly consistent with the known affinities between these two groups, but would not allow for a collision between Africa and North America in the Acadian. The only solution would be for some separation of the Gondwanan continents into eastern and western components, but then there must be evidence for these two parts becoming joined during the late Palaeozoic, and there is no evidence for such a suture. It must therefore be concluded that such a reconstruction is not realistic and other explanations must be sought for such faunal identity.

By using such criteria, it is possible to determine Siluro–Devonian reconstructions (figure 1) which are apparently consistent with most of the palaeomagnetic, palaeoclimatic and palaeontological and tectonic requirements. The data for such reconstructions are discussed more fully by Turner & Tarling (1982) and Tarling (1983), supplemented by some newer data and further consideration of the tectonic units involved. Clearly such reconstructions cannot be considered to be final as considerably more reliable palaeomagnetic data are required. Furthermore, there are clearly palaeobiogeographical problems still present in such reconstructions. Some provinces in the Andes, for example, are inconsistent with these reconstructions, as also for the Carboniferous. The persistence of such anomalies suggests that it was not some abnormal feature of the Malvinokaffric realm, but probably reflects that the Andean area, at least, was not in its present relationship to the South American craton at these times. Such a situation is exactly analogous to the Mesozoic situation for much of Central America, which then lay northwest (present-day coordinates) of the North America craton, but an acceptable solution awaits further palaeontological, tectonic and palaeomagnetic study.

References

Tarling, D. H. 1983 *Palaeomagnetism*, p. 379. London: Chapman and Hall.

Turner, S. & Tarling, D. H. 1982 Thelodont and other agnathan distributions as tests of lower Palaeozoic continental reconstructions. *Palaeogeog. Palaeoclim. Palaeoecol.* **39**, 295–311.

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