COMMENTS ON "PLATE TECTONICS WITH FIXED CONTINENTS: A TESTABLE HYPOTHESIS – II" by P. D. Lowman, Jr.

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IT IS always refreshing to encounter new ideas that challenge orthodoxy, and the hypothesis recently advanced by Lowman (1986) is no exception. This is especially so since the hypothesis is readily testable: by future VLBI, satellite laser ranging and seismic observations according to Lowman, although we consider that the necessary data are extant, in the form of Mesozoic and Tertiary (if not Palaeozoic) palaeomagnetic measurements.

Lowman proposes that while sea-floor spreading may be a valid ingredient of the plate-tectonic model, continental drift is not. In fact, Lowman contends that continental drift is incompatible with a number of lines of evidence, including compressive stress on passive (trailing) margins, absence of low-velocity zones under cratons, plate-driving mechanisms and palaeomagnetism. With regard to the last of these, Lowman cites our observation (Embleton and Schmidt, 1979) that the PreCambrian apparent polar wander paths (APWP) for the better-studied cratonic areas, show remarkable similarities with the continents left in their present-day locations, rather than assuming some *a priori* continental reconstruction. While we adhere to our earlier conclusion, that these relationships represent a conflict with plate tectonics *sensu stricto,* during PreCambrian times, we should caution against extrapolating this conclusion to the present time. We specifically noted that for much of the Phanerozoic "the paleomagnetic data are only satisfied by reconstructing continents to form super-continents (for example, Gondwanaland); even Pangea may have existed during the Late Palaeozoic/Early Mesozoic" (Embleton and Schmidt, 1979). Two aspects of these APWP relationships need emphasizing. The first is that they do not require relative continental motion for the PreCambrian; and the second is that, following Phanerozoic continental drift, the continents have returned to their original relative locations. What Embleton and Schmidt (1979) argued for, was a transitional phase from PreCambrian tectonics to present-day plate tectonics. Schmidt and Embleton (1980) examined the PreCambrian APWP assuming a small Earth, but this was only one of many possible models. A small Earth provided a convenient explanation for continents having been fixed with respect to each other, but it is also possible that a modified, non-random form of plate tectonics has operated. It should be emphasised too, that the construction of PreCambrian APWP is fraught with errors, not just in pole positions, but also in pole ages. For PreCambrian rocks, age errors of 2-3% yield uncertainties of 40-60 million years. Clearly, the details of PreCambrian APWP are unlikely ever to be defined as well as are Mesozoic and Tertiary APWP, but the problems to be solved in PreCambrian geology are an order of magnitude larger than the problems with Mesozoic and Tertiary geology, and ought to be soluble with correspondingly rudimentary APWP.

Palaeozoic APWP, while better-defined than PreCambrian APWP, are likewise prone to pole position and age errors. This is particularly so for the less intensively-studied Gondwana continents, and interpretations of continental distributions throughout the Palaeozoic are controvertible. However, it seems that these sources of error ought to be minimal for studies of Late Palaeozoic assemblages; thus, it is perhaps not surprising for Lowman to take the view of the Permo-Carboniferous Pangea B reconstruction (Morel and Irving, 1981), as he does. While it is clear that the Late Paleozoic paleomagnetic data require some form of supercontinent (see for instance Irving, 1977; and Irving and Irving,

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1982), the details of the reconstruction are open to uncertainty, because of the indeterminacy of the longitude problem in palaeomagnetism, and the assumption of a geocentric axial dipole (fully discussed by Merrill and McElhinny, 1983, pp. 79-84 and 167-177). These are secondary problems, however, but Lowman highlights them with particular reference to Pangea B "to cast doubt on the validity of palaeomagnetic evidence" (Lowman, 1986, p. 72). It seems inconsistent to us to accept the PreCambrian data, yet reject the better-constrained Late Paleozoic data. Nevertheless, the greatest travesty Lowman commits is to ignore the vast wealth of paleomagnetic data from Mesozoic and Tertiary rocks, for which pole-position errors and age uncertainties are relatively insignificant. The most appropriate data set to assess the probability of present-day continental drift is that from the Mesozoic and Tertiary rocks.

For instance, consider the Mesozoic pole positions from the Gondwana continents plotted in Fig. 1 (from Embleton and Schmidt, 1977). Fig. 1a shows the close group of Late Triassic—Early Jurassic paleomagnetic poles, plotted with respect to Africa, after reconstructing Gondwanaland (Smith and Hallam, 1970). These poles are very scattered if the continents are left in their present-day positions. In fact, Fig. 1b shows the amount of scatter (reflecting continental drift) that occurred between the Early Jurassic and the Cretaceous. Poles marked K are considerably dispersed, indicating that for the Cretaceous the Gondwana configuration is no longer appropriate. Likewise, the Early and Mid-Tertiary pole-positions for these continents can only be brought into alignment by allowing continental drift. This is also true for the northern continents (see Irving, 1977, for instance). Bearing this in mind, along with the fact that poles from rocks of Latest Tertiary age yield an average position indistinguishable from the Earth's present spin axis (Merrill and McElhinny, 1983, p. 169), it is very difficult to deny the reality of continental drift.

Literally thousands of Mesozoic and Tertiary paleomagnetic poles irrefutably support the Wegenerian concept (Wegener, 1924) of a supercontinent (Irving and Irving, 1982), yet Lowman chooses to highlight two aspects of current paleomagnetic research yet to be verified or otherwise, and which do not reflect the present consensus. Paleomagnetism is an active field of research, and it is to be expected that there are differences of opinion between various groups on certain arcane points; but there is one point that all paleomagnetic groups agree upon, and that is the necessity of continental drift as an integral part of plate tectonics. Lowman will have to put forward a much more cogent argument to rebut the paleomagnetic evidence for continental drift. In particular, the Mesozoic and Tertiary data demand recognition.

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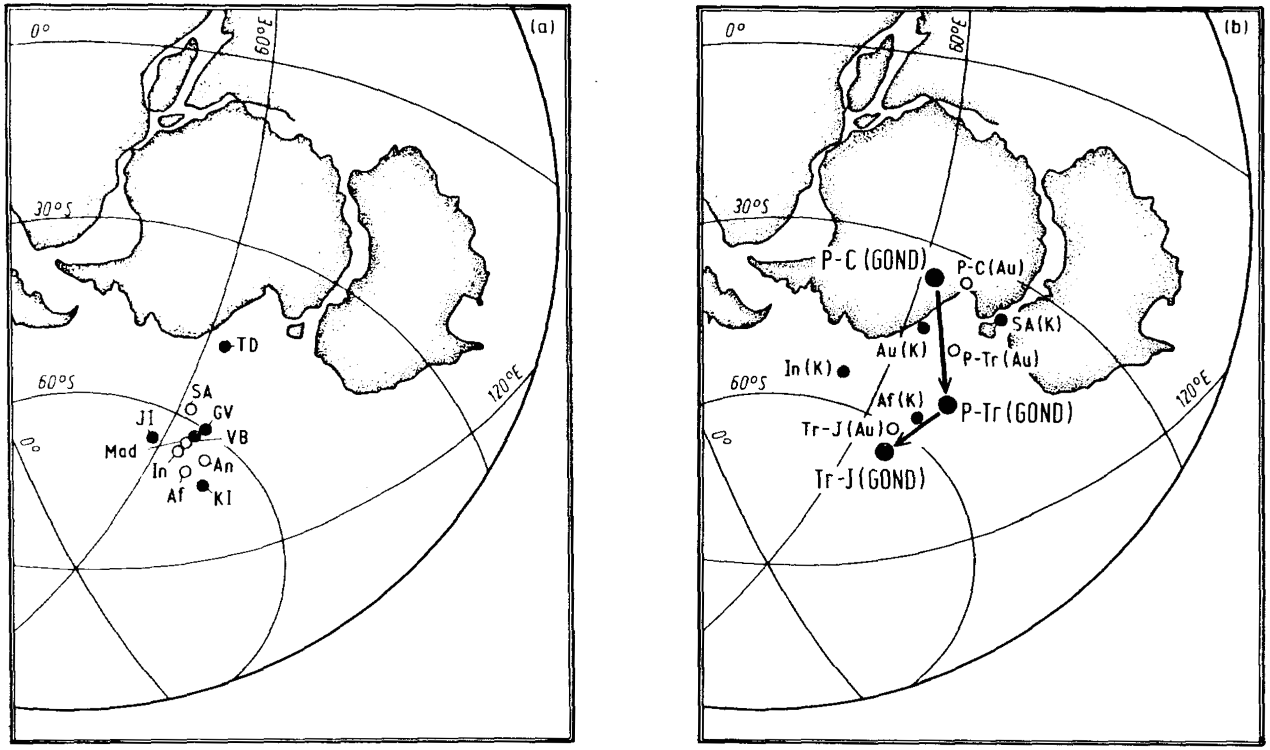

Fig. 1. Palaeomagnetic pole positions for the Gondwana continents plotted with Africa in its present geographic location, following Smith and Hallam (1970).

(a) Late Triassic-Early Jurassic poles. Open circles are mean pole-positions for Africa (Af), South America (SA), India (In), Madagascar (Mad), and Antarctica (An), while the full circles are individual poles for Australia (after Embleton and Schmidt, 1977).

(b) Common apparent polar wandering (APW) for Gondwana continents from the Permo-Carboniferous (P-C) to the Late Triassic-Early Jurassic (Tr-J) (Embleton and Schmidt, 1977). The Gondwana mean pole-positions are shown by the large full circles joined by the solid lines, while the equivalent Australian (Au) pole-positions are shown as open circles. Smaller full circles marked K represent Cretaceous poles. These last poles are scattered, and are interpreted to indicate that Gondwanaland disintegrated between the Early Jurassic and the Cretaceous.