Discussion on Ordovician palaeogeography of Siberia and adjacent continents

Journal of the Geological Society 1996; v. 153; p. 329-330
doi: 10.1144/gsjgs.153.2.0329

Notes

Journal of the Geological Society, London, Vol. **153,** 1996, pp. 329–330. Printed in Northern Ireland

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Journal, Vol. 152, 1995, pp. 279–287.

Ian W. D. Dalziel & Luis H. Dalla Salda write: In their interesting paper on 'Ordovician paleogeography of Siberia and adjacent continent', Torsvik *et al.* (1995) comment on the hypothesis of possible Laurentia–Gondwana collision during the Ordovician put forward by Dalla Salda *et al.* (1992*a, b*) and amplified by Dalziel *et al.* (1994). Torsvik and his colleagues agree with us that the palaomagnetic data do permit our 'alternative palaogeographic approach' of juxtaposition and collision between the two continental masses in mid-Ordovician times as well as their 'archetypal' scenario with its 3000–4500 km of intervening oceanic lithosphere (Torsvik *et al.* 1995, p. 284 and figs 11d–f). We appreciate their taking time to analyse our approach, and would like to comment briefly on their objections to our model.

(1) Our 'tight fit' of Laurentia and Gondwana for mid-Ordovician times (Dalziel *et al.* 1994, fig. 3) is said to indicate 'unabridged faunal exchange' between the two continents that is not supported by the marine faunal data (Torsvik *et al.* 1995, p. 285). In fact we propose not just a tight fit, but Alpine-style continent–continent collision. The presence of a latitudinal mountain range thousands of kilometres long and of Alpine proportions, is hardly compatible with exchange of marine faunas between the juxtaposed continents.

(2) Faunas indicative of 'deep margins' in the early Ordovician are implied to contradict our model (p. 285). Yet India and Asia were separated by deep water until just prior to their collision, and the presently colliding Australia and Asia are still in part separated by the nearly 6000 m deep North Australia Basin.

(3) The fact that the Taconic Orogeny in the Canadian Maritimes and New England involved arc–continent collision in no way precludes the involvement of a second continent as stated (p. 285). A Laurentia–Gondwana collision would unquestionably have been as complicated as the Alpine collision between Europe and Africa or the present Australia–Asia collision, with several arcs, back-arc basins, aseismic ridges, and intervening microcontinental fragments involved. Although not apparent in fig. 11e of Torsvik *et al.*, the geometry of the suggested mid-Ordovician collision (controlled by the Taconic and Famatinian piercing points) leaves Newfoundland and New England outside the immediate zone of continent–continent collision (Dalziel *et al.* 1994, fig. 3). We have no reason to take issue with well-established models about the Taconic orogen, merely to place them in a possible 'alternative' palaeogeographic setting.

(4) Contrary to the suggestion that the Devonian Period would be the most likely time of transfer of a Laurentian terrane to South America (p. 285), is the fact that the Cambrian–Lower Ordovician platform carbonates of the Precordillera are stratigraphically overlain in part by Upper Ordovician strata of glacial origin (Peralta & Carter 1992). Given the low paleolatitude of Laurentia during late Ordovician times and the total absence of glaciogenic strata of that age from its craton, this indicates that the Precordilleran terrane was transferred to Gondwana during the Ordovician Period (Dalziel 1993; Dalziel *et al.* 1994) as also concluded in a recent biostratigraphic analysis of the Precordillera and the Appalachians (Astini *et al.* 1995).

Finally, we would like to point out that the 'alternative approach' to Ordovician palaeogeography explains much about North American geology south of New England, and about western South America, that the 'archetypal scenario' does not even address. Here we refer *inter alia* to the otherwise puzzling apparent truncation of the Taconic orogen in Georgia and Alabama, the origin of the Ouachita embayment, the Laurentian fauna of the Precordillera, the nature and northward termination of the Famatinian orogen, and the mid- to late Palaeozoic initiation of Andean orogenesis. We submit that the new approach, springing from the hypothetical role of Laurentia as the 'keystone' of the early to mid-Neoproterozoic Rodinian supercontinent (for review see Dalziel 1995), offers answers without seriously violating the basic premises on which the more traditional one is based.

10 July 1995

T. H. Torsvik, J. Tait, V. M. Moralev, W. S. McKerrow, B. A. Sturt & D. Roberts reply: On the South American craton, the early Palaeozoic rocks show facies consistent with cold water environments: generally clastic sediments with low diversity faunas. By contrast, the distribution of the Palaeozoic rocks in the Andean orogen is clearly complex; many different warm and cold water facies occur in adjacent exposures suggesting that sequences, once deposited far apart, are now adjacent (Ramos *et al.* 1986). Some of the Andean terranes have facies and faunas closely comparably with North America, while others have affinities with Gondwana (exactly analogous with the exotic Permian and Mesozoic facies of the far-travelled terranes in the Western Cordillera of North America). These facts do not lead us to change the views expressed previously (Torsvik *et al.* 1995).

It is important that this theme is fully discussed, and we are grateful to Dalziel and Dalla Salda for their remarks. We respond to their four particular comments as follows.

(1) We do not find it reasonable to expect the faunas of Laurentia and Gondwana to be separated for much of the Ordovician if the two continents are contiguous. A mountain range produced by a collision might be expected to act as a barrier to faunal migration for a short time, but not for tens of million of years. If the faunas cannot circumnavigate the mountains, some breaks in continuity of the range would surely develop with time.

(2) While deep margins are certainly not restricted to ocean-facing margins, some correlation cannot be denied.

(3) In the Taconic Orogeny of Laurentia, there is only evidence for an arc–continent collision (McKerrow *et al.* 1991; van der Pluijm *et al.* 1995,); there is no indication of a second continent being involved.

(4) The first exchange of non-marine faunas between Laurentia and Gondwana occurs in the Emsian (late Early Devonian), at the time of the Acadian Orogeny (Scotese & McKerrow 1990; Young 1990). This still seems to us the most probable time for a transfer of terranes from North to South America.

Finally, we would point that our differences with Dalziel & Dalla Salda are ephemeral. They will no doubt be resolved with further research.

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Scientific editing by David Snyder.