Cold Gondwana, warm Tethys and the Tibetan Lhasa block

ALLÈGRE *ET AL.*[1] suggest that there is a climatic and hence palaeolatitude paradox implied by late Carboniferous glacial deposits and early Permian warm Cathaysian floras, both being present in the Lhasa block of southern Tibet. To account for this paradox they claim that, if it formed part of Carboniferous Gondwanaland, the Lhasa block must have detached in the early Permian.

Allègre *et al.*[1] also question, without offering evidence, the interpretation of the Carboniferous Damxung–Linzhu pebbly slates as tillites. I have never seen these deposits but it seems significant that in many of these Asian blocks proposed as parts of eastern Gondwanaland[2], pebbly mudstone facies of late Carboniferous age have been identified and interpreted as glacial marine diamictites (Fig. 1). Cameron *et al.*[3] explain the lithological characteristics of these pebbly mudstone deposits by the reworking and turbiditic redeposition of ice-rafted sub-glacial or fluvioglacial debris. They explain the presence of limestone with warm water faunas towards the top of the 'pebbly mudstone' by an amelioration of the climate. However, Smith *et al.*[4] show that Australian Gondwanaland moved closer to the South Pole from mid-Carboniferous to early Permian times, which would not favour climatic amelioration of eastern Gondwanaland.

The explanation of the climatic paradox may be that during mid-Carboniferous times southern Tibet was well within (<600 km) the cold continent of eastern Gondwanaland. By the postulated removal of central Tibet and Indochina[2], the Lhasa block became, in early Permian times, part of the newly rifted continental margin of Gondwanaland, suddenly invaded by the warm waters of the new ocean, Tethys II, that was spreading across the early Permian tropics.

The postulated rifting of southern Tibet from Gondwanaland in the mid-Jurassic (Fig. 1) correlates with the evolution of the north-west Australia margin[5]. Using the late Cretaceous palaeolatitude of 15°N for the Lhasa block, proposed by Allègre *et al.*[1], implies a spreading rate of ~7 cm^{-1} yr for 50 Myr if the Lhasa block were rifted from north-west Australia (~15°S) in the mid-Jurassic (170 Myr). That spreading rate compares closely with India following a similar path at 10 cm yr^{-1} for the first 30 Myr then 5 cm yr^{-1} for the next 40 Myr (ref. 6).

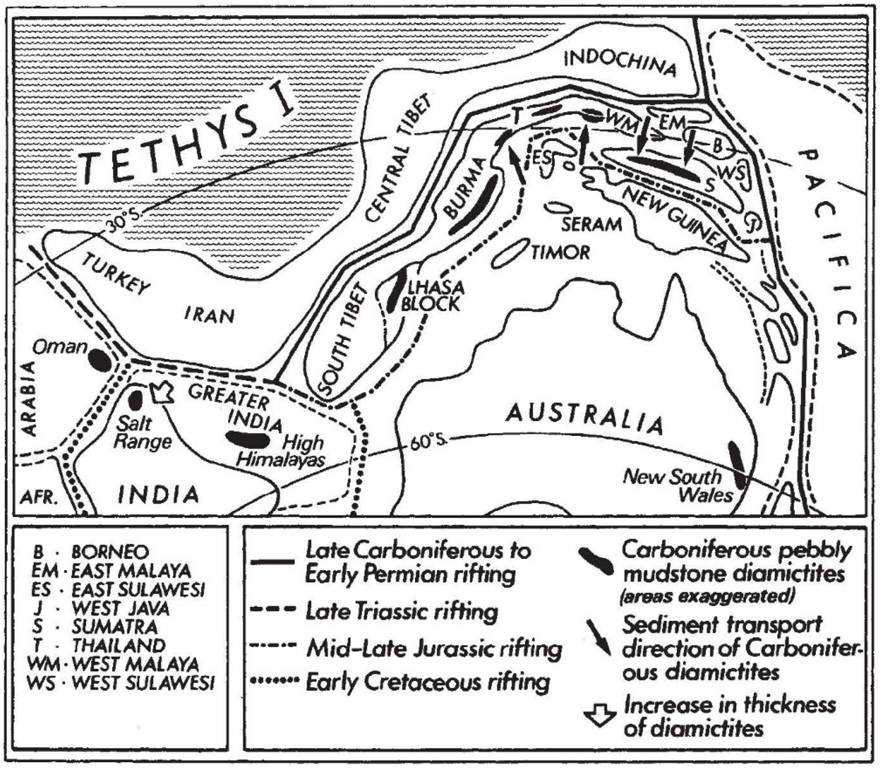

Fig. 1 Correlation of the late Carboniferous marine glacial pebbly mudstones (diamictites) of the eastern part of greater Gondwanaland. The qualitative reconstruction[2] is based on the Antarctic–India–Australia assembly of ref. 4. Present coastlines or outlines are for reference only. The shapes of the Asian fragments originating in greater Gondwanaland have been modified by tectonic deformation[7] since they left Gondwanaland. The original shapes have not been reconstructed here but some allowance for crustal shortening has been made. Late Carboniferous marine glacial diamictite data for Sumatra, Malaya, Thailand, Burma, New South Wales, High Himalayas are from ref. 3. Oman glacial marine diamictites are plotted from ref. 8. The western Salt Range diamictites described by Teichert[9] may be early Permian rather than late Carboniferous. Location of Pacifica and late Carboniferous to Permian and late Triassic rifting are after ref. 2, Jurassic rifting after ref. 5. Early Cretaceous rifting and latitudes are plotted after ref. 4.

M. G. AUDLEY-CHARLES

Department of Geology,
University College London,
Gower Street,
London WC1E 6BT, UK

1. Allègre C. J. *et al. Nature* **307**, 17–22 (1984).
2. Audley-Charles, M. G. *Nature* **306**, 48–50 (1983).
3. Cameron, N. R., Clarke, M. C. G., Aldiss, P. T., Aspden, J. A. & Djinuddin, A. *Proc. Indones. petrol. Ass. 9th A. Conventn* 149–187 (Indonesian Petrology Association, Jakarta, 1980).
4. Smith, A. G., Hurley, A. M. & Briden, J. C. *Phanerozoic Paleocontinental World Maps* (Cambridge University Press, 1981).
5. Pigram, C. J. & Panggabean, H. *Nature* **301**, 231–234 (1983).
6. Molnar, P. & Tapponnier, P. *Scient. Am.* **236**, 30–41 (1977).
7. Maddox, J. *Nature* **307**, 9 (1984).
8. Williams, G. T. & Whitmore, R. J. *Sci. Technol Newslett.* **57**, 3 (1983).
9. Teichert, C. *Neues Jb. Geol. Paläont, Abh.* **129**, 167–184 (1967).

ALLÈGRE *ET AL.* REPLY—Audley-Charles has commented on two distinct aspects of our paper: the Carboniferous versus Permian climatic paradox and the late (late Jurassic) rifting of the Southern Tibet (Lhasa) block. Before answering these comments, we should point out that the hard core of our observations[1] concerned the central and southern parts of the Lhasa block for periods, in general, after the late Jurassic. Thus Audley-Charles has focused on that part of our data which, both in space and time, certainly needs further study.

Yet, several lines of evidence strongly argue against a late drift of the Lhasa block: (1) The Rhaetian (~200 Myr) flora of the Linzhu basin is identical to the Rhaetian flora from Laurasia and quite distinct from the coeval Gondwanian flora. (2) The ammonoid fauna from the Upper Anisian (~220 Myr) from the Lhasa block seem to be related more closely to those of the European Alps than to those of the Himalayas[2]. (3) The Bangong–Nujiang suture zone which separates southern Tibet (Lhasa block) from northern Tibet (Quantang block) is probably of mid-Jurassic age, as indicated by low-