Gondwana Research xxx (2009) xxx–xxx

Contents lists available at ScienceDirect

Gondwana Research

journal homepage: www.elsevier.com/locate/gr

Discussion

Comment on “Illawarra Reversal: the fingerprint of a superplume that triggered the Pangean break-up and the end-Guadalupian (Permian) mass extinction” by Yukio Isozaki

Jason R. Ali

Department of Earth Sciences, University of Hong Kong, Pokfulam Road, Hong Kong, China

ARTICLE INFO

Article history:
Received 13 July 2009
Received in revised form 15 July 2009
Accepted 9 November 2009
Available online xxxx

Keywords:
Kiaman
Superplume
Emeishan
Permian
Siberian Traps

1. Introduction

Recently Isozaki (2009) has tried to explain how a series of catastrophic events which occurred on the surface of the planet over a 30 Ma period straddling the Permo-Triassic boundary were driven by deep Earth processes. The starting point for his hypothesis is the core. Perturbations of “stable” activity within the outer core, possibly due to it being penetrated by large volumes of subducted lithospheric slab that had accumulated in the lower part of the mantle, resulted in two ostensibly coeval events: (i) an upward-ascending superplume being generated at the core–mantle boundary (CMB), and (ii) an instantaneous major change in the geomagnetic field's configuration, from a fixed polarity state with an assumed high-intensity, to a low-intensity system in which field reversals took place on a more “normal” 10^5–10^6 years. The superplume is considered to have risen rapidly through the ~2300 km-thick lower mantle whereupon it began heating the base of the upper mantle (iii). Within a geologically short period a number of geographically-linked upper mantle plumes formed and rose to the Earth's surface resulting in extensive mafic volcanism (iv). The devastating impact on the biota was principally a consequence of the increased cosmic radiation reaching the Earth's surface as a result of the weakened geomagnetic field (v). It is thought that the radiation would have enhanced the cloud-cover (Svensmark, 2007), which when combined with the increased gases and aerosols associated with the eruptive activity would have contributed to the solar-heat shielding and, hence, to a “plume winter” (vi). A protracted period of global-ocean anoxia stressed the biota even further (vii).

There are, however, problems with the proposed extinction scenario.

2. Geomagnetic aspects

First, if the principal driver for the plume winter and, hence the extinction, was the substantially enhanced incoming cosmic radiation (caused by the reduced geomagnetic-field flux) following the Kiaman's superchron termination, should not the biotic response have been more rapid? As it is, there was an approximately three million-year hiatus between the end-Kiaman reversal and the mid-Capitanian extinction. This suggests that the geomagnetic field was not the principal causal mechanism; possibly it was more of an “exacerbating factor”.

Second, a fundamental assumption made by Isozaki is that the geomagnetic field during superchrons is somewhat stronger than it is for other times. Two references are cited to support this claim (Kutzner and Christensen, 2002; Maruyama and Santosh, 2008) but neither draws upon geomagnetic paleointensity data to demonstrate the case. Whilst the available geomagnetic paleointensity data-suite hints at the geomagnetic field being stronger during the Kiaman, as compared to the period which followed it (e.g., Biggin and Thomas, 2003), such a notion is a long way from being “accepted knowledge”. Indeed recent works have identified both low- and anomalously high-strength fields within the superchron (Garcia et al., 2006; Cottrell et al., 2008).

DOI of original article: 10.1016/j.gr.2009.11.003.
E-mail address: jrali@hku.hk.

1342-937X/$ – see front matter
doi:10.1016/j.gr.2009.11.005

3. Timing of volcanism

For the volcanism aspect of the Isozaki's hypothesis to have any validity, it must be possible to show that (i) it is no older than 265.8 Ma, and (ii) at the localities where this criterion is met there is sufficient time between the superplume beginning its ascent from the CMB and the surface magmatism commencing. With regards to the latter, it is worth noting that one of the most influential plume models, the "Campbell–Griffiths" (e.g., Campbell, 2005), estimates this process to take ~100 Ma. At 7 Ma, Van Keken's (1997) figure is appreciably less; Farnetani and Samuel's (2005) "spout plume" is thought to travel at 10–12 cm/year, and would thus make the journey in around 25 Ma. Irrespective of the estimate differences, the critical point is that a non-negligible period of time is required to get a plume from the CMB to the Earth's surface, which is almost certainly >10 Ma.

3.1. Timing of volcanism: Oslo Rift, Oman, northern India, offshore Western Australia, North China block

Apart from the effusive activity associated with the SW China Emeishan large igneous province (see below), a key argument in Isozaki's model is that mantle–plume volcanism also occurred in the Oslo Rift, and at Oman, northern India, offshore Western Australia and the North China block.

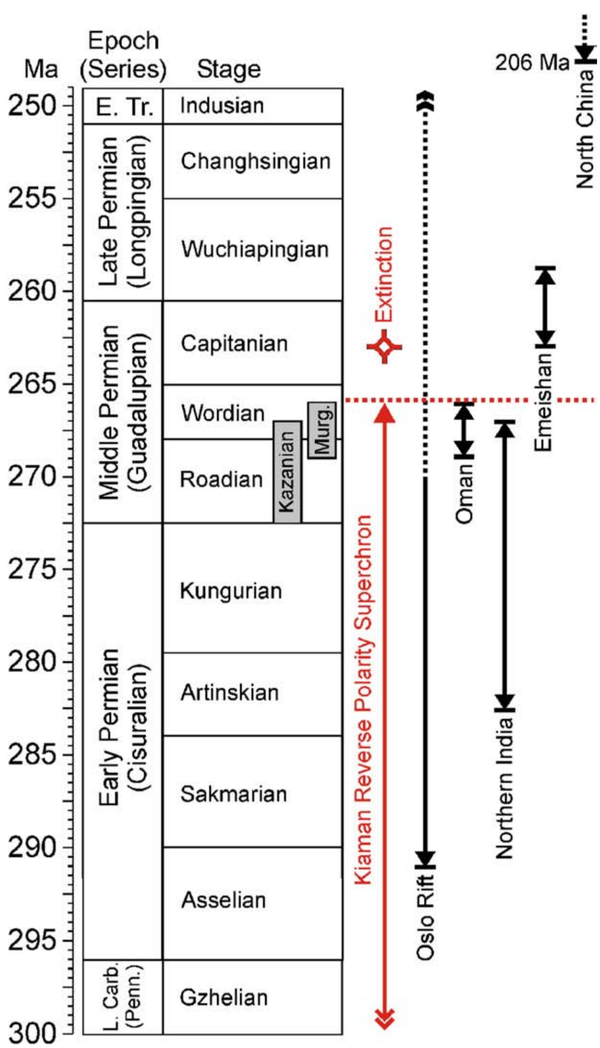

Fig. 1. Geological time-scale showing the ages of the various phenomena and LIPs referred to by Isozaki (2009). The scale and stratigraphic nomenclature follow Menning et al. (2006).

One of Isozaki's two support references for the Oslo Rift magmatism was Larson et al. (2008). That work indicates that the first basalt flows were erupted in the Late Carboniferous–Early Permian (291 ± 8 Ma), whilst the bulk of the magmatism spanned "Stages 3 and 4" (from 6), the latter mainly between 288 Ma and 270 Ma (Fig. 1) (activity continued until the Early Triassic, but it was very much the waning stage).

For Oman, Isozaki drew upon Rabu et al. (1990). Those authors briefly described two locally-developed volcanic units, both within the Saiq Formation. Based on the fusulinid fossil content of a carbonate which sits atop the lower volcanic series and envelops the upper package, the units were considered to have been erupted in the middle to late Murghabian which, based on Menning et al. (2006), would make them ~266 Ma (Fig. 1).

No reference was cited by Isozaki (2009) for the age of the northern India Panjal Traps and the correlative formations now in Tibet and Nepal. The available literature, however, indicate that the effusive activity there pre-dated 265.8 Ma: the Nar–Tsum spilites in southern Tibet and the Bhote Kosi basalts in central Nepal date from the Sakmarian–Roadian (Garzanti et al., 1999), whilst the NW India Panjal Traps date from the Artinskian–Kazanian (Chauvet et al., 2008). Using the Menning et al. (2006) time-scale, it is clear that the volcanism in northern India had terminated by ~267 Ma (Fig. 1); more critically, it could have started well before then at 282–287 Ma.

Supposed Permian–Triassic age basalts have been identified in a borehole offshore Western Australia (e.g., Veevers and Tewali, 1995). It must be noted, however, that the source of this information was Le Maitre (1975) who reported a simple petrographic study of some "probable Mesozoic age" basaltic drill chips from the Edel No. 1 Petroleum Well. My survey of the literature indicates that there is no evidence for a Permo-Triassic mafic LIP offshore Western Australia. One explanation for the Edel well basalt fragments is that they were erupted as a result of the Early Cretaceous break-up of India and Australia, and are thus correlative with the SW Australia Bunbury Basalts (e.g., Coffin et al., 2002).

Although a North China block LIP is portrayed on the paleogeographic map of Isozaki (2009, Fig. 3), no mention is made of it in the text, nor is a reference cited. Fortunately, Isozaki (2007) provides some information: Yang and Woolley (2006). From that work, three localities could realistically be incorporated into Isozaki's model: Datong (40.0°′N, 113.0°E), Huanglongpu (34.3°N, 110.0E) and Huayangchuan (34.0°N, 110.2°′E), their respective age dates being 229 Ma, 206 Ma and 181 Ma.

3.2. Timing of volcanism: Emeishan

For more than a decade the Emeishan Basalts have been temporally correlated with the end of the Guadalupian series (260.5 Ma), when a major biotic crisis was thought to have occurred (e.g., Wignall, 2001). New studies, however, indicate that although the onset of volcanism and the extinction were synchronous, they date from the middle Capitanian stage, ~263.0 Ma. This is based on detailed stratigraphic studies of ostensibly conformable Maokou Limestone/Emeishan Basalt contacts in sections in the northern and eastern LIP. There, the lithological boundary can be 2–3 full conodont biozones older than the end of the Guadalupian (e.g., Ali et al., 2002; Wignall et al., 2009).

3.3. Summary of the timing data

Volcanism in the Olso Rift, Oman, northern India and Emeishan cannot be related to the end-Kiaman superplume. The effusive activity either pre-dates the event (Oslo, Oman, India), or is so temporally close to the episode (<3 Ma; Emeishan), that there would have been insufficient time between the plume beginning its ascent from the CMB at 265.8 Ma and the start of volcanism. The so-called Western Australia LIP can be disregarded; it is more likely of Early Cretaceous

Please cite this article as: Ali, J.R., Comment on "Illawarra Reversal: the fingerprint of a superplume that triggered the Pangean break-up and the end-Guadalupian (Permian) mass extinction" by Yukio Isozaki, Gondwana Res. (2009), doi:10.1016/j.gr.2009.11.005

age. Only the North China block volcanic rocks could conceivably be linked to the event, but the volumes of material that were either erupted or emplaced as shallow-level intrusive bodies are almost inconsequential.

4. Conclusions

Isozaki has proposed an all-encompassing model linking events which happened ~265.8 Ma in the deep Earth (termination of the Kiaman superchron, formation of a superplume at the core–mantle boundary) to various catastrophic surface processes (large-scale volcanism) and phenomena (mass extinctions) that occurred a short time later in the Middle Permian through Early Triassic. Unfortunately, detailed scrutiny of the data indicates significant problems with aspects of the hypothesis such that it can probably be considered falsified. With regard to explanations for the mid-Capitanian (not end-Guadalupian) and end-Permian killing episodes, until proven otherwise, it is probably best if they are rooted in scenarios linked respectively to the formation of the Emeishan Basalts and the Siberian Traps.

Acknowledgements

Paul Wignall and Scott Bryan kindly reviewed drafts of the manuscript. Aspects of this work were funded by a Hong Kong Research Grants Council award (HKU700204).

References

Ali, J.R., Thompson, G.M., Song, X.Y., Wang, Y.L., 2002. Emeishan basalts (SW China) and the 'end-Guadalupian' crisis: magnetobiostratigraphic constraints. Journal of the Geological Society of London 159, 21–29.

Biggin, A.J., Thomas, D.N., 2003. Analysis of long-term variations in the geomagnetic poloidal field intensity and evaluation of their relationship with global geodynamics. Geophysical Journal International 152, 392–415.

Campbell, I.H., 2005. Large igneous provinces and the mantle plume hypothesis. Elements 1, 265–269.

Chauvet, F., Lapierre, H., Bosch, D., Guillot, S., Mascle, G., Vannay, J.C., Cotten, J., Brunet, P., Keller, F., 2008. Geochemistry of the Panjal Traps basalts (NW Himalaya): records of the Pangea Permian break-up. Bulletin de la Societe Geologique de France 179, 383–395.

Coffin, M.F., Pringle, M.S., Duncan, R.A., Gladczenko, T.P., Storey, M., Müller, R.D., Gahagan, L., 2002. Kerguelen hotspot magma output since 130 Ma. Journal of Petrology 43, 1121–1139.

Cottrell, R.D., Tarduno, J.A., Roberts, J., 2008. The Kiaman Reversed Polarity Superchron at Kiama: toward a field strength estimate based on single silicate crystals. Physics of the Earth and Planetary Interiors 169, 49–58.

Farnetani, C.G., Samuel, H., 2005. Beyond the thermal plume paradigm. Geophysical Research Letters 32 Article No. L07311.

Garcia, A.S., Thomas, D.N., Liss, D., Shaw, J., 2006. Low geomagnetic field intensity during the Kiaman superchron: Thellier and microwave results from the Great Whin Sill intrusive complex, northern United Kingdom. Geophysical Research Letters 33 Article No. L16308.

Garzanti, E., Le Fort, P., Sciunnach, D., 1999. First report of Lower Permian basalts in South Tibet: tholeiitic magmatism during break-up and incipient opening of Neotethys. Journal of Asian Earth Sciences 17, 533–546.

Isozaki, Y., 2007. Plume winter scenario for biospheric catastrophe: the Permo-Triassic boundary case. In: Yuen, D., Maruyama, S., Karato, S., Windley, B.F. (Eds.), Superplume: beyond plate tectonics. Springer, Dordrecht, pp. 409–440.

Isozaki, Y., 2009. Illawarra Reversal: the fingerprint of a superplume that triggered Pangean breakup and the end-Guadalupian (Permian) mass extinction. Gondwana Research 15, 421–432.

Kutzner, C., Christensen, U.R., 2002. From stable dipole towards reversing numerical dynamos. Physics of the Earth and Planetary Interiors 131, 29–45.

Larson, B.T., Olaussen, S., Sundvoll, B., Heeremans, M., 2008. The Permo-Carboniferous Oslo rift through six stages and 65 million years. Episodes 31, 52–58.

Le Maitre, R.W., 1975. Volcanic rocks from EDEL no. 1 petroleum exploration well, offshore Carnarvon basin, Western Australia. Journal of the Geological Society of Australia 22, 167–174.

Maruyama, S., Santosh, M., 2008. Models of snowball Earth and Cambrian explosion: a synopsis. Gondwana Research 14, 22–32.

Menning, M., et al., 2006. Global time scale and regional stratigraphic reference scales of Central and West Europe, East Europe, Tethys, South China, and North America as used in the Devonian–Carboniferous–Permian Correlation Chart 2003 (DCP 2003). Palaeogeography, Palaeoclimatology, Palaeoecology 240, 318–372.

Rabu, D., Le Metour, J., Bechennec, F., Beurrier, M., Villey, M., Bourdillon Jeudy de Grissac, C., 1990. Sedimentary aspects of the Eo–Alpine cycle on the northeast edges of the Arabian Platform (Oman Mountains). In: Robertson, A.H.F., Searle, M.P., Ries, A.C. (Eds.), The geology and tectonics of the Oman region: Geological Society of London Special Publication, 49, pp. 49–68.

Svensmark, H., 2007. Cosmoclimatology: a new theory emerges. Astronomy and Geophysics 48, 18–24.

Van Keken, P., 1997. Evolution of starting mantle plumes: a numerical and laboratory models. Earth and Planetary Science Letters 148, 1–11.

Veevers, J.J., Tewali, R.C., 1995. Permian–Carboniferous and Permian–Triassic magmatism in the rift zone bordering the Tethyan margin of southern Pangea. Geology 23, 467–470.

Wignall, P.B., 2001. Large igneous provinces and mass extinctions. Earth-Science Reviews 53, 1–33.

Wignall, P.B., Sun, Y.D., Bond, D.P.G., Izon, G., Newton, R.J., Védrine, S., Widdowson, M., Ali, J.R., Lai, X.L., Jiang, X.L., Cope, H., Bottrell, S.H., 2009. Volcanism, mass extinction, and carbon isotope fluctuations in the Middle Permian of China. Science 324, 1179–1182.

Yang, Z.M., Woolley, A., 2006. Carbonatites in China: a review. Journal of Asian Earth Sciences 27, 559–575.

Please cite this article as: Ali, J.R., Comment on "Illawarra Reversal: the fingerprint of a superplume that triggered the Pangean break-up and the end-Guadalupian (Permian) mass extinction" by Yukio Isozaki, Gondwana Res. (2009), doi:10.1016/j.gr.2009.11.005