SUPERCONTINENTS OVER THE GEOLOGICAL TIMES

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ABSTRACT

A palaeomagnetic polar wander curve relative to India is prepared for the past 1600–1800 m.y. period. Comparison of this and the corresponding African curve suggests that Gondwanaland assembled only about 800 m.y. ago. The palaeomagnetic data thus suggest that the history of the global surface since the middle Proterozoic times has been characterised by the existence of three supercontinents during different epochs—the Afro-American supercontinent till about 1000 m.y. ago, Gondwanaland from late Proterozoic till late Mesozoic. and the Eurasian supercontinent since the Tertiary times.

1. INTRODUCTION

ONCE crucial question in the postulate of global plate tectonics[1,2] is whether the large scale plate motions, known to have occurred since the late Mesozoic, also took place in the older times. The palaeomagnetic evidence strongly supports this possibility[3]. The palaeomagnetic data from Africa and the South and North Americas, for instance, suggest that these three continents were joined together in a single supercontinent until about 1000 m.y. ago[4]. Since the European data[5] seem to contradict the existence of Pangaea in the Precambrian times, the question now arises whether this Afro-American assembly existed as part of a 'Greater Gondwanaland' or as a separate supercontinent. This is examined here from the palaeomagnetic data for the entire Present-to-Proterozoic interval which are now available for India, summarised below, Australia[6,7], Africa[4,8] and South America[4].

2. THE BIRTH OF GONDWANALAND

The palaeomagnetic poles obtained from the Indian rock formations are summarised in Table I and the corresponding polar wander curve is shown in Fig. 1. The Precambrian part of this is the modification of an earlier[9] polar wander curve and all the available data have been included. The Phanerozoic part of this curve is based on an earlier summary[10] and incorporates the new data[11] available since then. In view of the detailed magneto-stratigraphic correlations[12,13] and agreement with the marine-magnetic[14] and palaeoclimatic[9,15] deductions, this can be considered to be a fairly complete polar wander curve for India for the past 1600 to 1800 m.y. duration.

The Phanerozoic palaeomagnetic data from India and the other Gondwanic continents[3,10,16] are consistent with the Gondwanic reconstructions of du Toit[17] and Smith and Hallam[18]. These reconstructions can therefore be used to study the older palaeomagnetic data from these continents. Accordingly, the Indian polar wander is recomputed for the India-Africa assembly of the latter reconstruction and compared with the corresponding African[8] curve in Fig. 2. This comparison suggests that India and Africa had not assembled in their early and middle Phanerozoic Gondwanic position until about 750–800 m.y. ago. These data also fail to support Piper's[19] claim that the Precambrian

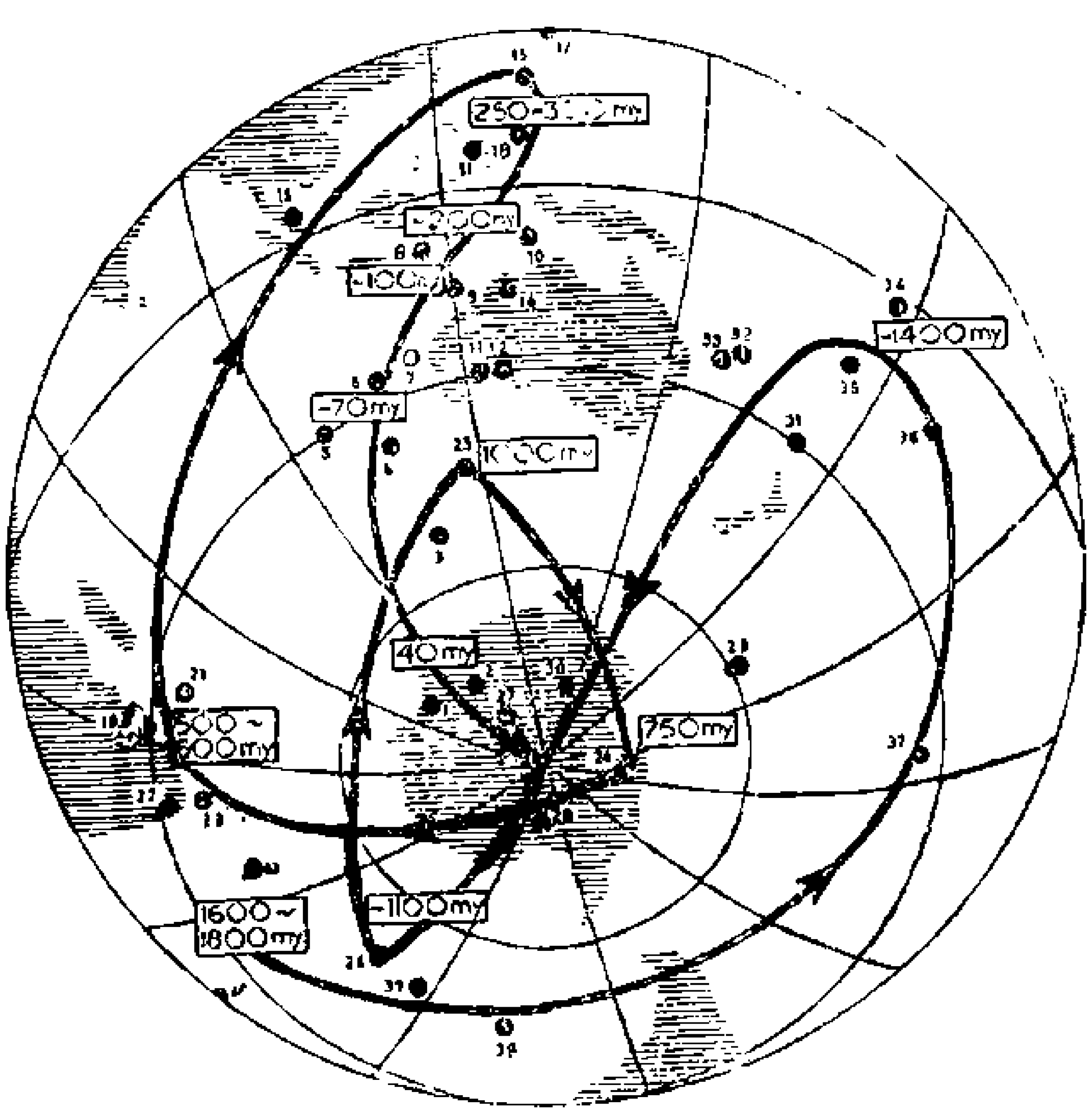

FIG. 1. *Palaeomagnetic polar wander (south pole) path for India,* 1 : Siwalik redbeds ; 2–5 : Deccan traps ; 6–7 ; Tirupathi and Satyavedu sandstones ; 8–9 ; Rajmahal and Sylhet traps ; 10–13 : Pachmarhi, Mangli, Parsora and Himgir sandstones ; 14–16 : Kamthi beds ; 17 : Talchir series ; 18 : Speckled sandstones ; 19 : Salt Pseudomorph beds ; 20 : Purple sandstones ; 21–22 : Rewa and Bhander sediments ; 23 : Kondapalle charnockites ; 24 : Malani rhyolites ; 25 : Mundwara complex ; 26 : Lower Sullavais ; 27 : Kaimur sandstones ; 28 : Upper Pakhals ; 29–30 : Bhima sediments ; 31 : Lower Pakhals ; 32–33 : Cuddapah sediments ; 34–35 : Lower Vindhyans (B.H.Q. and B.H.J.); 36 : Visakhapatnam charnockites-I ; 37–38 : Horahelli and Chitaldurg dykes ; 39 : Visakhapatnam charnockites-II ; 40 : Gwalior lavas ; 41 : Hyderabad dyke.

palaeomagnetic data from the Gondwanic continents favour Carey's[20] assembly of Gondwanaland. When the Australian data[6,7] are also considered, the above deduction is further confirmed in corroboration of the earlier tentative conclusion[21] that India, Africa and Australia came together in the Gondwanic assembly only in the late Proterozoic times. As has been stated earlier, the palaeomagnetic data also suggest that South America and Africa were already joined together at this time[4].

TABLE I

Synopsis of the Indian palaeomagnetic poles

Geological interval and age	Rock suites	Mean pole (south) Latitude	:	Longitude
Tertiary	Siwalik red beds and Deccan lavas	63° S	:	85° E
Late Cretaceous	Deccan lavas and upper Gondwana sediments	27° S	:	106° E
Early Cretaceous-Jurassic	Rajmahal and Sylhet lavas	12° S	:	118° E
Permo-Triassic	Lower Gondwanas and Speckled sandstones	17° S	:	125° E
Permo-Carboniferous	Kamti and Talchir beds	27° N	:	132° E
Cambrian-Late Proterozoic	Salt Range and upper Vindhyan sediments and Charnockites	32° S	:	30° E
About 750 m.y.	Malani rhyolites	78° S	:	225° E
950-1000 m.y.	Mundwara complex	43° S	:	116° E
About 1100 m.y.	Lower Sullavai sediments	49° S	:	341° E
About 1150 m.y.	Kaimur and upper Pakhal sediments	81° S	;	204° E
1200-1300 m.y.	Bhima sediments	68° S	:	172° E
About 1400 m.y.	Lower Pakhal, lower Cuddapah and lower Vindhyan sediments and Charnockites	19° S	:	165° E
1600-1800 m.y.	Charnockites, dykes and Gwalior lavas	37° S	:	346° E

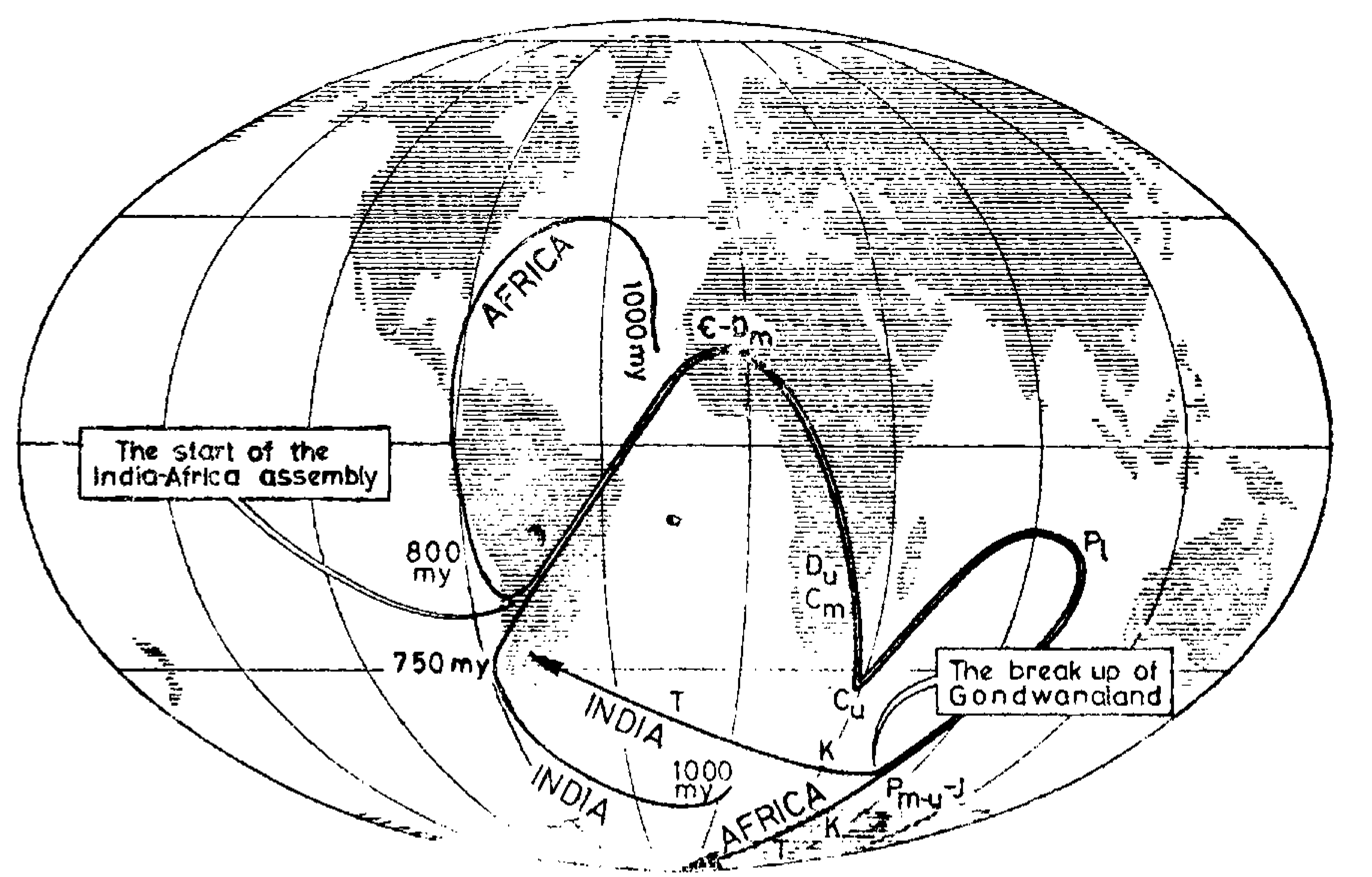

FIG. 2. Comparison of the Indian and African palaeomagnetic polar wander curves. The Indian data, summarised in Fig. 1, recalculated for the India-Africa assembly of the Gondwanic times, *i.e.*, 58·9° clock-wise rotation of India, with respect to Africa, with the rotation pole at 28·9° N; 42·2° E. The African polar wander curve is after Brock and Piper[16].

3. Afro-American, Gondwanic and Eurasian Supercontinents

The Gondwanic supercontinent obviously resulted from the type of convergent plate motions of which Eurasia[3,22,23] is a latter-day example. The history of Gondwanaland can thus be considered in three stages: (*i*) the late Proterozoic formative stage of convergent plate motions, (*ii*) the approximately 700 m.y. long supercontinent stage, and (*iii*) the late Mesozoic fragmentation stage of divergent plate motions. The inference drawn above suggests that the Afro-American supercontinent[4] fragmented, with the separation of North America about 1000 m.y. ago, long before the Gondwanic supercontinent came into being. This is analogous to the later (late Mesozoic) break-up of the latter which preceded the formation of the Eurasian supercontinent. Another common feature of the three supercontinents (Table II) is their crustal volume (about 2·5 billion Km^3).

Table II

Terrestrial supercontinents since middle Proterozoic

Geological Interval	Supercontinent and the constituent continents	Hemisphere occupied	Area (10^6 Km^2)	Crustal volume* (10^9 Km^3)
Since Tertiary	*Eurasia* Europe, Siberia, China, India and Arabia	Northern	55	2·5
Late Mesozoic-Late Proterozoic	*Gondwanaland* South America, Africa, India, Australia and Antarctica	Southern	74	2·6
Till the close of middle Proterozoic times, *i.e.*, till about 1000 m.y. ago	*Afro-America* Africa, South America and North America	Southern	72	2·5

* Average crustal thickness assumed about 45 Km for Eurasia and about 35 Km for the other two supercontinents.

The continental concentrations on much larger scales also appear to have occurred in the geological past. The palaeomagnetic evidence[3] suggests that Pangaea, with a crustal volume of about 4 billion Km^3, existed from the Silurian till the Triassic times. This resulted from the merger of Euramerican and Gondwanic land-masses during this period. In case Siberia indeed joined Europe in the Permo-Triassic[3,22,23], then the Triassic Pangaea must have had the maximum crustal volume (about 4·5 billion Km^3) amongst the supercontinents that have existed on the global surface during the past billion years. Piper *et al.*[4] have also speculated on the possibility of the concentration of all continental crust in one large mass in the middle Proterozoic times.

4. Conclusions

These observations suggest that the growth and dispersal of the supercontinents have been a major feature in the evolution of the global surface. It will be quite interesting, therefore, to examine whether the supercontinents should be considered to be of interinsic importance in the framework of the plate tectonics theory. Studying plate interactions in terms of the Feynman graphs for electron-photon scattering in quantum-electrodynamics appears to be a promising attempt[24] in this direction.

The concentrations of the continental crust in the form of supercontinents, as suggested in the foregoing, does not seem to be an exclusively terrestrial phenomenon however. The Martian surface[25], for instance, is also characterised by a similar feature, *i.e.*, only one supercontinent of rather comparable dimensions.

5. Acknowledgements

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1. McKenzie, D. P., In : *The Nature of the Solid Earth* (Ed. E. C. Robertson and others), 323 (McGraw-Hill, 1972).
2. LePichon, X., Francheteau, J. and Bonnin, J., *Plate Tectonics* (Elsevier, 1973).
3. McElhinny, M. W., *Palaeomagnetism and Plate Tectonics* (Cambridge University Press, 1973).
4. Piper, J. D. A., Briden, J. C. and Lomax, K., *Nature*, 1973, **245**, 244.
5. Spall, H. R., *Earth Planet. Sci. Lett.*, 1973, **18**, 1.
6. McElhinny, M. W. and Luck, G. R., *Geophys. J.*, 1970, **20**, 191.
7. Facer, R. A., *Earth Planet. Sci. Lett.*, 1974, **22**, 44.
8. Brock, A. and Piper, J. D. A., *Geophys. J.*, 1972, **28**, 139.
9. Hasnain, I., Ahmad, N. and Ahmad, R., *PAGEOPH*, 1973, **104**, 537.

10. Bhimasankaram, V. L. S. and Pal, P. C., in *Proc. II UMP Symp.* (Ed. M. N. Qureshy and S. Balakrishna), Hyderabad, 1970.
11. Wensink, H., In : *Implications of Continental Drift to Earth Sciences* (Ed. D. H. Tarling and S. K. Runcorn), Academic Press, 1973, **1**, 103.
12. Pal, P. C., In : *Symposium on Peninsular Shield*, Indian Academy of Geoscience, Hyderabad, 1973.
13. —, *J. Geol. Soc. Ind.*, 1974, **15**, 81.
14. Laughton, A. S., McKenzie, D. P. and Sclater, J. G., In : *Proc. XXIV International Geological Congress*, 1972, **8**, 65.
15. Pal, P. C., *Bull. Nat. Geophys. Res., Inst.*, 1971, **9**, 89.
16. Creer, K. M., *Earth-Science Reviews*, 1970, **6**, 369.
17. du Toit, A. L., *Our Wandering Continents*, Oliver and Boyd, 1937.
18. Smith, A. G. and Hallam, A., *Nature*, 1970, **225**, 139.
19. Piper, J. D. A., In : *Implications of Continental Drift to Earth Sciences* (Ed. D. H. Tarling and S. K. Runcorn), Academic Press, 1973, **1**, 19.
20. Carey, S. W., In : *Continental Drift—A Symposium* (Ed. S. W. Carey), University of Tasmania, 1956, p. 177.
21. Giddings, J., Crawford, A. R,. Embleton, J. J. and McElhinny, M. W., *Geol. Soc. Am. Abstracts with Programs*, **5**, 1973, p. 635.
22. Hamilton, W., *Bull. Geol. Soc. Am.*, 1970, **81**, 2556.
23. Pal, P. C., In : *Proc. Seminar on Geological and Geophysical Studies on Himalayas*, Roorkee University, 1972, (In press).
24. Negi, J. G., Drolia, R. K. and Pandey, O. P., *PAGEOPH*, 1973, **110**, 2070.
25. Carr, M. H., Masursky, H. and Saunders, R. S., *J. Geophys. Res.*, 1973, **78**, 4031.

THE ACTION OF CHLORPROMAZINE ON THE SKELETAL MUSCLE OF FROG

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Abstract

The action of Chlorpromazine on the skeletal muscle of frog when tested under Gaddum superfusion technique was found to be (1) an anticholinergic effect in small doses and (2) a spasmogenic effect in large doses, this spasmogenic effect was not blocked by curare.

Introduction

Chlorpromazine (CPZ) is one of the phenothiazine derivatives widely used in psychiatry and also in the treatment of spastic conditions. The untoward effects of this drug include parkinsonian like symptoms and dyskinetic symptoms which may be mistaken for tetanus, meningitis, poliomyelitis, etc. These symptoms are explained as the effect of the drug on the extrapyramydal system. This work was taken up to find the effect of graded concentration of CPZ on the skeletal muscle.

Materials and Method

Experiments were carried out on the skeletal muscle of frog *Rana tigrina* under Gaddum superfusion technique[4,5]. The ringer solution prepared according to Burn J. H. (1952) was used. The contractions were recorded on a slow moving smoked drum. Acetylcholine chloride (ACH) was used as an agonist in a dose of 1–2 mcg.

CPZ dissolved in distilled water was used in doses of 0·1, 1, 10, 100 ng[†] and 1, 10 and 100 mcg in 0·1 ml volume. The effect of CPZ in higher doses like 100 mcg and above were recorded on a stopped drum. In these experiments ACH was not used as an agonist, and they were repeated in potassium-free, calcium-free, sodium-free ringer solution and the solution containing twice the concentration of potassium ion. Tubocurarine 10 mg/ml was used as a blocking agent.

All drugs were dropped from a tuberculine syringe along with ringer solution. The contractions due to ACH were recorded for 20 seconds. After obtaining a set of submaximal contractions due to ACH, the CPZ was dropped followed by ACH after 20 seconds. The inhibition or potentiation of ACH induced contractions by CPZ was expressed as the height of contraction in mm.

Results

The effects of CPZ on skeletal muscle can be grouped under three headings.

1. Anticholinergic action in doses of 0·1 ng to 10 mcg (Fig. 1).
2. Potentiation of ACH induced contraction in 0·1 ng and 1 ng.
3. A spasmogenic action at 100 mcg and above (Fig. 2),

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