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**Permo-Carboniferous Life Provinces, with Special Reference to India\***

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AT the recent meeting in Amsterdam (Sept. 2–7, 1935) of the Sixth International Botanical Congress, the inter-relations of the Late Palaeozoic floras were discussed by various geologists and palaeobotanists. After Professor T. G. Halle's Presidential Address to the Palaeobotanical Section, Professor A. C. Seward, F.R.S., opened the discussion with remarks on the "Nature and significance of geobotanical provinces". He dealt, *inter alia*, with the difficulties attending a decipherment of the records of the rocks, particularly those connected with the climatic implications of extinct forms of plant life. Perhaps the most striking observation in this masterly discourse, characteristic of a man of Professor Seward's authority and experience, was that today he knew less about the value of fossil plants as tests of climate than he did forty-three years ago, when he wrote his well-known Sedgwick Prize Essay for the year 1892. Among others who followed with papers on various aspects of the problem, was Professor Halle himself, who discussed the relation between the Late Palaeozoic floras of Eastern and Northern Asia (pp. 227–228).<sup>1</sup> Professor R. Kräusel of Frankfurt a.M. spoke on the distribution of the Devonian flora. Professor W. Gothan of Berlin dealt in two papers with the interrelations of the Permo-Carboniferous life provinces (pp. 226; 242–244). Professor W. J. Jongmans of Heerlen discussed the distribution of synchronous floras with special reference to the movement of the poles and of continental blocks (pp. 239–242). Professor A. Renier of Brussels offered remarks on stratigraphical correlations in and between the geobotanical provinces (pp. 244–245). Lastly, the present writer read a paper on the *Glossopteris* flora of India and its phytogeographical relations (pp. 245–247), of which a summary is given below.

Immediately after the Amsterdam Congress, an international gathering of about eighty geologists and

palaeontologists met in Heerlen (Sept. 9–12) for the Second Congress of Carboniferous Stratigraphy under the auspices of the Geologisch Bureau of the Nederlands. Here we had the advantage of the presence of the veteran geologist Dr. W. A. J. M. van Waterschoot van der Gracht, Mr. D. N. Wadia of the Indian Geological Survey and other geologists interested in tectonic problems connected with Asia. Among many interesting and important items on the programme, Professors Jongmans and Halle presented their Amsterdam papers again under these new auspices, and in this connection the writer also had the privilege of discussing that part of his paper which dealt with the relations of the Indian Gondwana flora with those of Siberia and China.

As the space allotted for the advance abstracts of the Amsterdam Congress was necessarily limited, and as the full paper will be delayed in publication, I propose to give below an extended summary in the hope that it may be of interest to readers of *Current Science*. The full paper will appear in the *Proceedings of the Indian Academy of Sciences* for 1936.

It is generally agreed that towards the end of the Palaeozoic era there existed four more or less well-defined botanical provinces. In the southern hemisphere there was the Gondwana continent, with its very characteristic *Glossopteris* flora. This flora also extended into India, which now lies north of the Equator. Gondwanaland was separated by a great Mediterranean Ocean, the Tethys, from the other three provinces which had more or less distinct floras of their own. These were, *firstly*, the Arcto-Carboniferous province, inhabiting the area now occupied by parts of Europe and eastern North America; *secondly*, the province of the *Gigantopteris* flora, developed in parts of western North America and in China, but extending south into Sumatra; *thirdly*, the Angara province, stretching eastwards from near the Ural Mountains as far as the Pacific Coast, and southwards as far as the Tarbagatai Range, within a few degrees north of Kashmir. The floras of these three northern provinces have more in common with each other than any one of them has with the

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\* Published in *Curr. Sci.*, Vol. IV, December 1935, p. 385.

<sup>1</sup> These page references are to the *Proc. 6th Internat. Bot. Congr.* (Sec. PB), Amsterdam, 1935, Vol. II.

Gondwana flora. Their geographical relations are best understood by viewing the globe from the Arctic pole.

It is noteworthy that both the Arcto-Carboniferous province and the *Gigantopteris* province are cleft longitudinally into two blocks each, the blocks of each pair being separated by wide oceans, the Atlantic in the one case, the Pacific in the other. But towards the pole the two halves of each province tend to approach each other, although their actual meeting has not yet been proved. In Eurasia, the Angara flora is wedged in between the other two floras. In its affinities, so far as they are understood at present, the Angara flora is perhaps the most interesting of all, because it contains elements of all the other three floras in addition to a large proportion of genera and species peculiar to itself. The synthetic nature of the Angara flora is perhaps best understood if we look at the globe from, say, the Altai Range: Angara Land is then seen to occupy a central position, as one amongst the four life provinces. Lastly, the *Glossopteris* flora, although containing stray elements of the "northern" type, is for the most part a distinct assemblage, strongly characteristic of the southern hemisphere. This province is perhaps best seen from the southern pole, although from there India goes out of the view.

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It remains to add that while the above ideas were arrived at independently I owe the original impetus for them to certain suggestive remarks made by Professor Hale, in his classical memoir on the Shansi flora,<sup>7</sup> where he drew attention to the close proximity of the Indian and Chinese floras and hinted that this anomalous position may have had something to do with the tectonic features of the intervening region. The above hypothesis would also explain the apparent anomaly of two climatically distinct floras lying, as they now do, athwart the same latitudes. There need not, therefore,

be any serious difficulty, at least on geographical grounds, in accepting the idea that while the "Arcto-Carboniferous" flora (including its Sino-Sumatran phase) was developed in a relatively warm and humid climate, the *Glossopteris* flora was essentially a temperate flora.

In reply to an enquiry my esteemed friend Mr. Wadia also wrote to me that he thought a N.-E. tongue of the Indian horst had much to do with the acute southward bend of the Assam mountains into Burma. To him and to Dr. F. R. Cowper Reed, I am indebted for references to geographical literature on this aspect, which showed that the problem has already received attention from many geologists. To mention only the most recent instance, I learned that the idea of Assam as a resistant pivot, round which the far eastern block probably drifted south-westwards into its present position, has also been recently expressed on geological grounds by M. Fromaget,<sup>8</sup> Director of the Geological Survey of Indo-China. Lastly, it was gratifying to find that at the Amsterdam Congress Professor Jongmans expressed ideas essentially similar to those presented in my paper, read the same day.

With so much concurrence on the essential points, I think that we may feel satisfied about the stability of our main conclusions. About ten years ago, in an essay on a broad survey of the "Southern Fossil Floras",<sup>9</sup> I said that it was the scattered distribution of the previously glaciated areas of Gondwana Land that provided the main support to Wegener's hypothesis: palaeobotany did not seem to me at the time to lend any clear evidence in favour of it. The Carboniferous glaciation of the southern hemisphere still appears to me to be the main pillar on which Wegener's idea rests. But I now feel that palaeobotanical considerations, such as those set forth above add another, though modest, support to this remarkable theoretical edifice, at least so far as concerns the movement of continental masses through wide ranges of latitude and longitude.

<sup>7</sup> Halle, T. G., "Palaeozoic plants from Central Shansi," *Palaeontologia Sinica*, 1927, Ser. A. 2, (i), 288-290.

<sup>8</sup> Fromaget, J., *Essai sur l'évolution paléogéographique de l'Indochine, etc.*, Hanoi, 1934.

<sup>9</sup> Sahn, B., *loc. cit.*, 1926, 233.