THE GONDWANA SYSTEM OF INDIA AND THE VERTEBRATE LIFE HISTORY IN THE LATE PALEOZOIC

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ABSTRACT.—New investigations in the geological history of Asia, especially of Siberia, China and Mongolia give a new idea of the distribution of the Gondwana sediments.

Despite certain hypotheses, the supposed great northern Paleozoic continent—Laurasia, in its Asiatic part, was a region of sedimentation of Gondwana facies. It seems probable that, in the Paleozoic, the climatic zones occupied an essentially different position, from those of the present time. The equatorial zone was situated more or less athwart the recent equator, between some present West-European meridians.

The "northern" zone of temperate climate (i.e., the region of Gondwana facies) lay almost meridionally (in recent sense) from North of Asia to Australia and Antarctica.

The geographic situation of India and the discovery of some early tetrapod localities in the Indian Gondwana-System determines the significance of India as a connective link between Asia and the southern continents.

Paleontological investigations and excavations of the Indian localities of the Paleozoic Tetrapoda may solve some very interesting problems of the history of the Earth and Life.

THE enormously thick continental sediments, rich as a rule, in vegetable detritus, coal and ironstone, which are common in the Southern continents (South Africa, Australia, South America and the Antarctica) have for a long time been called "Gondwanian sediments", after the ancient land of the Gonds in India. It is in India that these deposits, which are so characteristic in the Southern continents, would seem to make an irruption into the Northern Hemisphere. This fact compels us to consider that the Indian Peninsula is a fragment of the gigantic Paleozoic southern continent—Gondwanaland, a fragment which moved northward.

The Gondwana continent counterpoised Laurasia, another great Paleozoic continent. It consisted of the northern continental shields of North America and Asia forming a single vast strip of Paleozoic land stretching from East to West.

In the 1920's, A. Wegener succeeded in giving a very clear explanation of the similarity of the sediments by the theory that these primaeval masses split up and drifted apart.

This was supported by the fact that Tillites (ancient glacial sediments in the basal layers of the Gondwanian sediments in all countries where these sediments are developed) were to be found in all parts of Gondwana. The Upper Paleozoic glaciation of Gondwanaland was a more convincing confirmation of Wegener's conception of the original unity of all the blocks of the Southern continents which later drifted far apart. The continental Upper Paleozoic sediments of Laurasia, which are of the same age as those of Gondwanaland, were first studied in North America and Europe. They are quite different from the Gondwanian sediments in the lower parts of their sections. It is only towards the middle of the Trias that the continental sediments become similar both in the northern and southern continents.

The Upper Paleozoic sediments of Laurasia bear no traces of glacial facies. They are distinguished by strong coalification in their Upper Carboniferous division, which in Gondwanaland is composed of glacial facies. Their coaliferous sediments do not resemble the coalbearing strata of Gondwanaland. They are the facies of tropical Carboniferous forests alternating with red-coloured strata of lagoon sediments coloured by ferroxide. The Permian sediments of Laurasia, which contain coal only in regions with remnants of the Carboniferous are represented by the same red-coloured rocks.

The Cordaital and Glossopteris flora of Gondwanaland bear features of a higher organisation, adaptation to more continental conditions and a cool climate.

The difference between the land vertebrates of the two great continental regions is no less important, despite the fact that the asynchronism of Laurasian and Gondwana faunas makes an accurate comparison difficult. In Laurasia, we deal with early Permian Tetrapoda : with an abundance and variety of Amphibia and a large number of archaic reptiles—Cotylosaurs and Pelycosaurs.

Among the late Permian Gondwana faunas the Amphibia are rare and belong only to the group of Labyrinthodontia.

The reptiles belong in the main to the higher Synapsids—(mammal-like reptiles), their number and variety in the Gondwana deposits being striking. The mammal-like features of the reptiles from the Gondwanian facies are considered to testify the proximity of their habitats to the cold regions of the Late Paleozoic glaciation.

Such a distribution of the facies, flora and fauna in Laurasia and Gondwanaland made it necessary either to accept Wegener's theory as to the northward shifting of parts of Gondwanaland or to assume that large changes took place in the position of the earth's axis. At the present time precise conceptions of the physics of the Earth have led to the complete rejection of the theory that the continents are dirfting. The conception of the change in the position of the Earth's axis, is the only acceptable one that can explain the movement of the climatic belts of our planet in the course of geological history. Despite the astronomer's objections to this hypothesis their position is becoming weaker every year under the stress of new geological data. Glaciations were caused by a number of factors, the intensification of the solar radiation which coincided with the rising of great parts of the earth-crust (F. Hoyle's theory), being of major importance.

The development of paleontology has greatly changed our conceptions in regard to the fauna of land vertebrates in the Upper Paleozoic, the investigations conducted by Russian paleontologists having played no small part. During the last 25 years numerous localities with new forms of Amphibia and reptiles have been found in the European part of the U.S.S.R.

It was discovered that there had existed a rich fauna of the Late Paleozoic mammal-like reptiles in the centre of the assumed Laurasiatic continent. These reptiles were typical of Gondwanaland.

In the basal horizons of the Russian Upper Permian the early mammal-like reptiles found are similar to ancient synapsids of North America.

Lower Permian localities recently found in North Kazakhstan (Tersakkan) are absolutely similar to the Red Beds of North America (Clear Fork), as to the fauna of Tetrapoda, the type of their preservation and facies of the sediments.

In India, China, Indo-China, and quite recently in Central Siberia in the Tunguska basin, anomodonts, the typical Gondwanian Theromorphs, have been found though not from the Permian but Trias. Traces of Gondwanian Permian Theromorpha in the form of single unidentified bones, have been discovered in the Upper Permian part of the enormous continental strata of the Kuznetsk basin.

In Soviet Asia—in the Kuznetsk and Tunguska basins, as well as in Central Asia (Outer and Inner Mongolia)—the development of enormous areas of continental coalbearing strata of the Angara type has been reported. The Angarian sediments have all characteristics of the Gondwana system of India and Southern continents and a flora similar in their advances in adaptation to

cool climate with Cordaites and Glossopteris-like Zamiopteris. In one of the "islands" of such sediments, in the Kenderlyk Lower-Permian series of Eastern Kazakhstan, the traces of tillites (ancient glacial sediment) have been found in the base of the section. The greatest part of sediments in Asia, that are similar to those of the Gondwana System corresponds to the lower section of the Permian period and rather seldom, to the Upper Permian. In the areas, where continental sedimentation continues into the Trias (Western and Central China, possibly, the Tunguska basin), land vertebrates and typical Gondwanian flora can be found (big Anomodonts, Procolophonids, Theriodonts).

In almost all lower Permian series of the Gondwana type in Soviet Asia no localities of land vertebrates have been found yet. Preliminary investigations of the enormous masses of the Lower Permian sediments, discovered by a Soviet palaeontological expedition under my guidance on the territory of the Mongolian People's Republic (Outer Mongolia), did not detect any remnants of land vertebrates, though there are facies which are favourable for conservation.

No locality of land vertebrates has been discovered in Permian strata of the Kuznetsk and Tungus basins, enormous in size of the areas of development ; they rise to thousands of cubic kilometres of continental rocks. Even if we take into account that the investigations which have been conducted up to now are very insufficient in scope, one should admit that the continental strata of the Gondwana type lacked certain general conditions for the conservation of Tetrapods.

In regard to the conservation of land vertebrates, the Lower Permian strata of Asia are similar to the Lower Permian Ecca series, the latter being widely developed in the Southern continents, especially in Africa. They are enormous sediments with coal, having been greatly enriched by vegetable detritus. Despite the fact that sections of the Ecca series are well exposed in the dry steppes of South Africa, the bones of reptiles have been discovered only in two cases.

Massive beds of sandstones, schistose clays and pseudo-conglomerates having a great amount of fossil wood are rather often found in the Ecca series. The continental Lower Permian sediments in Kenderlyk (Kazakhstan) or in Nojan Somon, Sutai Hure and Tzetzerleg (Mongolian People's Republic) should be considered as the sediments of this very type, which are characterized by great variability in facies and abundance of large stems of cordaites. Coal-bearing Gondwana sediments of the Damodar series in India especially in their Lower Permian division (the Barakar section) have still greater likeness to the Ecca series. In the Barakar section land vertebrates are encountered. It is reasonable to postulate the presence of considerable accumulations of remains, forming real localities. The Permian localities of India have not been sufficiently studied or excavated. An investigation of the Lower Gondwana localities of India will make us understand a strange phenomenon : why the red coloured deltaic deposits in the Red Beds of North America, that are poor in organic vegetable material, contain so may localities of land vertebrates, while the deltaic sediments of the Gondwana facies of Asia and Africa being abundant in carbonized organic materials, are almost lifeless in enormous masses of sediments.

It seems difficult to believe that there was no fauna of land vertebrates in Asia and Africa in the lower Permian. The fauna of Carboniferous and Lower Permian amphibians and reptiles in the western part of Laurasia is too abundant and diverse to put forward such a supposition. A striking "emptiness" of thousands of square kilometres of the Lower Permian strata of Asia and southern continents cannot well be considered accidental. The Lower Permian strata of North America, having localities of tetrapods represent peculiar sedimentation areas in the coastal depression limited by the barrier reefs of the sea and filled with deltaic deposits. During the period of the Upper Permian red coloured sediments found along the western side of the Ural range there existed big barrier reefs separating the zone of sedimentation from the high sea. It is noteworthy that the reefs, that came into existence in Cis-Oural later than in America, formed a vast area of bone-bearing red coloured sediments, similar to the Red Beds of the U.S.A. from

the facial point of view, but they contain the fauna of archaic Amphibia alongside with the Gondwanian reptiles. The relict forms are represented by the survivals of the archaic reptiles of the Red Beds of North America (Caseids, Captorhinids, Batrachosaurs).

In the Lower Permian Gondwana sediments, we should possibly search for other types of localities in comparison with those formed in the red coloured aft-reef facies of the Laurasian sedimentation zones.

The fauna of somewhat more "continental" nature is to be expected here, it is biologically similar to the mammal-like reptiles which appeared later on in numerous localities of southern continents. Asia has not revealed to the scientists the enigma of its ancient life yet, but we have already approached the point which will lead us to a solution of these secrets. The first thing that should be done is to investigate the Lower Permian localities of India, as they are now the only localities that can be used as a guide among boundless masses of the "dead" Gondwana deposits.

The importance of the Gondwana sediments in the major problems of Earth's history is reflected in one more fact. There seems no doubt that the difference between coal-bearing sediments of Gondwana and red-coloured sediments of Laurasia is in the main due to the sedimentation in different climatic belts. The Laurasian Permian facies are of tropical character, and their location in coastal areas behind the enormous barrier reefs supports the idea that they have been formed in a warm climate.

Gondwana sediments have all signs of a zone of moderate climate with dark coloured rocks prevailing due to hypooxide iron salts and organic substances in them. The former conception of two great Paleozoic continents—Laurasia and Gondwana—as the continents of cold and tropical climate, is not supported by any new facts of geological investigations of Asia. On the contrary, the entire eastern part of Laurasia—that is the modern Asia—(Central, Nothern and Southern)—is distinguished by a vast distribution of the sediments of the Gondwana type, sometimes with the layers of glacial deposits. It is possible that the number of the latter will increase due to further investigations. The probable conclusion is that the distribution of the zones of moderate climate and the tropics at the end of the Paleozoic period (the Lower Permian) was very different from what it was thought to be in the thirties.

It seems possible that the development of the Gondwana facies was due to their proximity to the Polar zones but with enormous mountain-forming elevations of vast areas of the Earth's crust that served as accumulators of glacial masses during the period of the warming-up of the Sun. The Gondwanian facies have been accumulating in the zones of sedimentation, which bordered such elevations, while low continents, in the coastal regions of warm seas, gave sediments of tropical, Laurasian type.

It is obvious that the conception of Laurasia as a single Paleozoic continent in a warm climatic zone should be rejected. We consider Asia as an area of predominant Gondwana facies and it can be counterpoised to Europe and North America, as areas with the predominance of Laurasian facies, which should be called Eurolaurentian (Europa+ Laurentia) facies of the continental Upper Paleozoic.

Thus we inevitably come to the notion that the distribution of climatic zones in the Upper Paleozoic period did not at all resemble the distribution existing now, and this fact is reflected in the distribution of the Gondwanian and Eurolaurentian continental facies. In the Paleozoic period a "vertical" distribution of the climatic zones should exist, with the equator being located approximately perpendicularly to the modern one. Such a location of the equator explains the distribution of the Gondwanian facies in the form of enormous belts which are spread along the meridians from North Asia to to the Antarctic, through India, Africa and Australia.

The equatorial belt stretched along the red-coloured (Eurolaurentian) sediments of the warm climate from the locations in Middle Kazakhstan through Cis-Oural and Europe to the Red Beds of the U.S.A.

It is noteworthy, that this hypothesis coincides with the supposed locations of

the poles and the equator in the Paleozoic calculated on the basis of "fossilized magnetism" of the sediments in the U.S.A. and Britain. These investigations enable us to establish the location of the magnetic poles and then, geographical poles of the Earth by means of determining the orientation of magnetic elements in the rocks. The American reports, which are, in my opinion, more accurate, state that in the early Paleozoic period the North Pole was located in the equatorial part of the Modern Pacific Ocean, and in the late Paleozoic period—in the eastern region of modern Asia, on the latitude of the Himalayas. No doubt it is still impossible now to determine the exact position of the climatic zones and the inclination of the Paleozoic equator to the modern one. It is obvious, however, that the "vertical" distribution of climatic zones is not a speculation but a theory which to a certain extent, reflects the true state of things. It is of great importance for the understanding of the general course of geological history and the development of land life in those distant times of the Upper Palaeozoic period.

In elaborating this problem, India is of paramount importance. Its powerful continental Palaeozoic sediments are a bridge between enormous areas of the Gondwana facies in the Central and Middle Asia and those in southern continents.

Undoubtedly, the common efforts of Indian and Soviet scientists to investigate the Gondwana-System and especially Lower Permian sediments, their palaeogeography, facies, flora and land fauna will lead to the solution of this important and interesting problem.

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