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THE TETHYAN LEGACY—THE ORIGIN AND DISPERSION OF INDIAN OCEAN ECHINOIDS

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ABSTRACT

Palaeontological evidence suggests that peninsular India has occupied the coral reef belt of the Tethyan region continuously since at least the late Jurassic. This seems to contradict palaeomagnetic evidence of India's supposed translocation from a southern Gondwanaland since the Jurassic. The corals, echinoids and other marine invertebrates of peninsular India appear to be closely related or identical with Eurasian forms continuously since at least late Jurassic times, and to have a tropical, not an antarctic, facies.

INTRODUCTION

THE foundation of our knowledge of the original character of Indian echinoid faunas stems from the researches of Duncan and Sladen (1882-1886), and although various authors have revised or reviewed the subject over the past half-century, the greater part of our information is still to be found in the volumes of *Palaeontologia Indica*, to which Duncan and Sladen contributed. Until about five years ago the picture emerging from these studies was reasonably clear and consistent with other evidence. Now, unfortunately, a serious conflict of evidence from different scientific disciplines confronts us. The purpose of this review is to summarize the opposing theories.

PALAEONTOLOGICAL EVIDENCE

Our knowledge of the echinoid fauna of India based partly on sampling of the species which presently inhabit the northern Indian Ocean, and partly on collections of fossils covering the time-span of some 150 million years, since the mid-Jurassic period. Prior to the Jurassic, marine sediments are lacking, save for Palaeozoic beds, which do not contain representatives of surviving groups. Over the span of time from the mid-Jurassic, the Indian echinoid faunas have consistently presented a tropical aspect, and they comprise groups which are associated with reef corals, and which in fact actually inhabited coral reef environments.

Peninsular India has been an elevated land mass for the past 150 million years, seemingly an island continent. There are marine sediments still surviving, to mark the former existence of a northern coastline, which ran from Cutch, in the north-west, eastward along the present course of the Narbada valley to Baroda. The sea which washed this ancient coast is termed Tethys, and it extended as a shallow epi-continental sea across southern Asia and north Africa to the Mediterranean region. A relatively uniform marine fauna occupied Tethys from Europe in the west to the Himalayan region, in the east, though in the case of the Jurassic, we have Indian sediments preserved only in the Cutch region.

The southern coastline of the Indian island continent is not presently known from Jurassic sediments, but from the Cretaceous onwards we have surviving deposits from the Tiruchirapalli district of southern India. These, too, are richly fossiliferous, and yield information on the nature of the fauna which inhabited the sea to the south of India, presumably the forerunner of the existing Indian Ocean.

It would be both tedious and unnecessary to rehearse here the extensive invertebrate faunas which have been made known from these two coastlines ; the details may be found in the monographs cited in the references at the end of this paper. Instead it may suffice to summarize the distinctive features of the faunas, inso far as they bear on the problem of the origin of the Indian biota today.

During the latter part of the Jurassic period the coral-reef belt of the world was about 60 degrees of latitude in breadth, about the same as today, but it was tilted about 25 degrees towards the north on the Eurasian side of the Earth. For lack of Australasian fossils, we cannot say if there was a similar tilt to the south on the opposite side of the planet ; if there was, then it would imply a difference in the position of the poles, as indeed is postulated by Bain (1963), Fell (1967, 1968), and other writers. Putting aside the question of polar wandering, all data are in agreement that the entire marine faunal assemblages of India for the Jurassic, Cretaceous and Tertiary periods comprise elements of the coral reef zone. The corals themselves are richly represented and they, together with the associated invertebrate phyla, including echinoderms, belong to typical Tethyan genera which ranged from Europe across southern and central Asia, and also in many cases occurred in tropical and subtropical America. It would appear, then, that the subcontinent of peninsular India straddled the coral reef belt, and carried reefs along both its northern and southern coasts. Further, and this is particularly true of the Jurassic of Cutch, and the Cretaceous beds of the Narbada valley, the marine invertebrate fauna of the northern coastline was extremely similar to that of the European Tethys. No author has doubted that northern India at these epochs formed the southern margin of Tethys. During the Cretaceous period the coral reef felt continued to girdle the earth, though not so much tilted as before, for its outliers extended to about 37 degrees south latitude, and to 50 degrees north latitude in Europe. The Tertiary beds which succeed the Cretaceous continue to register tropical faunas, with the reef belt gradually assuming its present direction, symmetrical with respect to the equator and poles. Echinoid genera of modern aspect begin to appear in the beds from the Eocene onwards, at first shared with Europe, later becoming restricted to the present tropical belt. It would appear that these modern genera were original inhabitant of Tethys, but died out one by one in the northern regions of that sea as the earth's climate changed, or as the patterns of circulation in the ocean were altered. This topic has been discussed elsewhere (Fell, 1967). The relevant point here seems to be that the modern Indian echinoid fauna is the lineal discendant of the original Tethyan fauna, and that it owes this heritage to the fact that India has always formed the southern margin of the Tethyan region. After the elevation of the Himalayas at the end of the Tertiary, the realm of Tethys became restricted to the present northern portion of the Indian Ocean. According to Furon (1963, p. 43), the coast of the Indian Ocean was already evident in East Africa by Permo-Triassic times. Lack of sediments presumably explains our inability to detect an Indian Ocean on the Indian subcontinent until the Jurassic. Furon reports that the later Jurassic faunas of Madagascar are very closely correlated with those of Cutch, so this would seem to imply intercommunication between Tethys and the Indian Ocean by late Jurassic time.

The palaeontological picture, then, suggests that India has occupied the northern Indian Ocean continuously since at least late Jurassic times, and that its northern peninsular region has lain near the boundaries of both Tethys and the Indian Ocean. The palaeontology also implies that throughout the 150 million years since the mid-Jurassic, the coral belt of the earth has had approximately the same breadth as it has today, and that India has straddled the reef belt continuously. And it is precisely in these conclusions that palaeontologists now find themselves at odds with geophysicists. I pass now to examine this conflict of evidence.

Geophysical Evidence

On the basis of palaeomagnetic observations, Adie (1965) and Creer (1966) deduce that India formed part of a supercontinent, Gondwanaland, located over or near the geographic South Pole in the early Mesozoic. The supercontinent is inferred to have suffered dismemberment in mid-Jurassic times ; in Adie's version, the process terminated in the Cretaceous. In Creer's view the disruption started about 150-200 million years ago (Triassic to mid-Jurassic). Adie (1965) states that ' India drifted at least 60° of latitude northward in post-Jurassic time.' Bullard (1969) says ' Palaeomagnetic work shows that India has been moving northward for the past 100 million years.' McElhinny (1969) deduces that an India-Madagascar-Antarctica block broke away from Africa between 155 and 100 million years ago, opening up the Indian Ocean for the first time. An India-Madagascar block then separated from Antarctica, and at first drifted southwards, before reversing its course to move northward.

There is some mutual disagreement between these various versions, but all agree that India once lay far to the south of its present position, and that this southern origin is to be dated to Jurassic time. The various versions differ as to time of arrival in its present situation, ranging from ' post-Jurassic ' or Cretaceous to some unspecified time during the last 100 million years. The same authors attribute similar translocations to Australia, except that McElhinny suggests that eastern Australia may have separated from the rest of Australia,and subsequently rejoined it. On the other hand, Audley-Charles (1966) finds ' no evidence to support the contention of continental drift between the continents of Asia and Australia during the Mesozoic, on the contrary all the indications are that the spatial relationships between Asia and Australia have not altered since the beginning of the upper Triassic at least.'

Discussion

I believe that the evidence is rather compelling that the breadth of the coral reef belt has not significantly varied during geological time. If therefore India lay some 60 degrees of latitude to the south of its present position during Jurassic time, it is highly improbable that the Cutch Jurassic marine beds and their included corals could have been formed on the Gondwana basement rock where we now find them. Yet the geological evidence appears to indicate that the Cutch Jurassic beds rest on their original basement (and have not, that is, been overthrust onto Gondwana basement from elsewhere). Similarly, the evidence appears secure that the reef-bearing beds of the succession of Cretaceous sediments at Tiruchirapalli did in fact form on the basement rock where we now find them. So also with the Cretaceous beds of the Narbada. Further, it seems inexplicable that the Cretaceous Narbada

fauna so closely resembles its European Tethyan counterpart if, in fact, these Narbada beds were deposited in some remote and unspecified location in the far southern ocean. There is also inconsistency between the African date for the origin of the Indian Ocean given by Furon (Permo-Triassic) and the inferences of McElhinny. Lastly, it is peculiar, to say the least, that the Tethyan-derived genera and species which inhabit modern Indian seas should have been preceded by closely related congeners or identical genera in early Tertiary Indian sediments laid down in some far southern ocean. It is as if the early Indian corals and echinoids had been forewarned that one day India would be attached to Asia, and that they had better take care to adopt Eurasian characters well in advance of their projected arrival date fifty million years in the future.

If, on the other hand, we accept the palaeontological and the palaeomagnetic data as both equally well founded, then we must conclude that the coral reef belt, and the Tethyan fauna, extended through a breadth of 100 degrees of latitude in Jurassic times, though, strange as this may seem, it was only true of the Indian Ocean region. My own view is that the palaeomagnetic data may have been misinterpreted ; and that it is probable that Jurassic India occupied the same geographic position as modern India. On this view, there is no mystery about the Tethyan heritage of a Tethyan land.

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