

# ON THE UPPER LIMIT OF THE GONDWANA SYSTEM

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## INTRODUCTION AND SHORT HISTORY

I BEGAN the investigations on the stratigraphy and palaeontology of the Jurassic rocks of Cutch in the year 1927. These investigations, carried out in the field as well as in the laboratories, led me to investigate into the problem of the upper limit of the Gondwana system.

Wynne and Fedden divided the Jurassic rocks of Cutch into an upper and lower series. Their 'upper series' comprised the plant-bearing rocks (Palaeozamia beds) and their 'lower series' the marine fossil-bearing rocks of the earlier workers. But the results of the study of the Cephalopods by Waagen (1871, 1873, p.i) and of the stratigraphical relations of the rocks in the field by Stoliczka, during his short visit for that purpose in 1872, resulted in the establishment of four groups known as the Patcham, Chari, Katrol and Umia groups in ascending order.

The Patcham, Chari, Katrol and lower part of the Umia of these workers correspond to the 'lower series', and the upper part of the Umia to the 'upper series' of Wynne. Waagen came to the conclusion that Patcham was equivalent to the Bath group, lower and middle Chari to the Kelloway group, upper Chari and lower Katrol to the Oxford group, upper Katrol to the Kimmeridge group and Umia to the Tithon group. The beds at the Ukra hill, in the extreme west of Cutch, yielded some Cretaceous forms and were, therefore, assigned to that age. Subsequently R. D. Oldham (1893, p. 217) and Vredenburg (1910, p. 87) had expressed their views regarding the relative ages of these groups. The main modifications introduced by Oldham, on the basis of Stoliczka's field notes, over Waagen's view were, firstly, the enlarging of the term Umia to include the Cretaceous beds at Ukra hill also, and secondly, assigning the upper Umia beds of Waagen, i.e. his middle Umia, to doubtful Wealden age and thirdly, assigning the Cretaceous beds at Ukra hill to upper Neocomian. Vredenburg, agreeing with R. D. Oldham in the extended use of the

term Umia, introduced the following changes: Firstly, the upper Chari was assigned to Oxfordian; secondly, the lower Katrol to Sequanian; thirdly, Tithonian was omitted and the lower Umia was assigned to Portlandian and Neocomian; fourthly, upper Umia of Waagen, i.e. middle Umia of Oldham, to Barremian; fifthly, the Cretaceous beds were assigned to Aptian.

## RECENT RESEARCHES

The recent researches on the Jurassics of Cutch began after a lapse of nearly half a century, as Waagen's work of 1873 was practically the last contribution on this subject.

'Umia' of Raj Nath, i.e. Lower Umia of Waagen — In the division of the Umia group, Dr. Spath has followed Waagen, and has adopted two subdivisions, i.e. Umia ammonite bed and upper Umia plant (and *Trigonia crassa*) beds. But the present writer, on the basis of field evidence, has divided the lower Umia of Waagen into five divisions: (1) barren sandstones and shales, (2) the Three green oolitic beds which have yielded the Tithonian ammonites, (3) barren sandstones, (4) *Trigonia* beds and (5) barren rocks.

The Three green oolitic beds of Raj Nath (i.e. the basal Umia ammonite bed of Dr. Spath), which are separated from the underlying Katrol beds by a great thickness of barren sandstones, and from where he collected all his Umia ammonites, have yielded *Micranthoceras* and all the numerous *Virgatosphinctes*, a form so dominant in the Umia beds. According to Dr. Spath (1933, p. 798) the Umia beds are of lower Tithonian age, as in Madagascar *Micranthoceras* occurs with *Hildoglochiceras kobelli*, a Portlandian form, while in Mexico *M. microcanthum* is associated with *Proniceras* and *Durangites* which are almost certainly younger than *H. kobelli*. Moreover, he thinks that there is nothing in the Umia fauna that indicates the upper Tithonian age.

The *Trigonia*-bearing beds overlie the Three green oolitic beds and are separated by a thickness of 200-300 ft. of intervening sandstones. Kitchin has recorded the occurrence of the following forms of *Trigonia* from the Umia group. These forms are grouped here into two sets: (1) those forms which are from such localities where, according to the present writer, the *Trigonia*-bearing beds overlie the Tithonian beds, (2) those forms which are from such localities whose stratigraphical position is not very definite as yet.

1. From localities where the *Trigonia*-bearing beds overlie the Tithonian beds:

- Trigonia parva* Kitchin — S.E. Ghuneri  
*Trigonia crassa* Kitchin (abundant) —  
 N.E. Ghuneri, Haroda, N.E. Umia  
*Trigonia cardiniiformis* Kitchin—Ghuneri  
*Trigonia retrorsa* Kitchin — N.E. Ghuneri,  
 N.E. Umia, Haroda  
*Trigonia spissicostata* Kitchin—N.E. Umia  
*Trigonia dubia* Kitchin — N.E. Ghuneri,  
 Haroda  
*Trigonia V-scripta* Kitchin—N.E. Ghuneri  
*Trigonia recurva* Kitchin — N.E. Ghuneri,  
 N.E. Umia.  
*Trigonia mamillata* Kitchin—N.E. Ghuneri  
*Trigonia ventricosa* (F. Krauss)—N.E. and  
 S.E. Ghuneri, Haroda, N.E. Umia  
*Trigonia pulchra* Kitchin — S.E. Ghuneri

2. From localities whose stratigraphical position is not very definite as yet.

- Trigonia tenuis*, Kitchin—Kukrooa, Adooi,  
 east of Chobaree Wamka, north-east of  
 Jara  
*Trigonia smeei* J. de C. Sowerby — Kuk-  
 rooa, east of Chobaree Shahpur, W.  
 Trummo  
*Trigonia trapeziformis* Kitchin — S.E.  
 Trummo  
*Trigonia remota*, Kitchin — S.E. Habbye,  
 Kass Scarp.

The age of the *Trigonia*s of the first set would, therefore, be at least upper Tithonian, if we accept, according to Dr. Spath, the lower Tithonian age for the underlying Umia ammonite beds, i.e. the Three green oolitic beds. But if we take into account the time interval represented by the barren sandstones, occurring in between the two fossiliferous horizons, the age of the *Trigonia* beds would be at least lower Cretaceous. This

conclusion finds support from the observations of Kitchin (1903, p. 3) who, on the basis of the study of the *Trigonia*s from Cutch, stated: "Though none are identical with European forms, one, *Trigonia ventricosa* Krauss, which is common also in the Uitenhage beds, is a representative of an essentially Cretaceous section of the *Trigonia*ae; moreover, it bears a very strong resemblance to the Cretaceous *T. tuberculifera*, described by Stoliczka from Southern India. There are other *Trigonia*ae occurring with *T. ventricosa* which likewise bear a Cretaceous aspect; one of these is referable to the same section of the genus as *T. ventricosa*, while the other may be classed with the *Pseudoquadratae*, a small group exhibiting characters which are usually associated with a Cretaceous facies. . . It seems most probable that in the Oomia Mollusca we are dealing with a passage fauna which, while retaining a partially jurassic aspect, was characterised also by the presence of types which marked the incoming of a true cretaceous facies. It is not improbable that such an intermingled fauna may have lived in this region at a time when wealden strata were being deposited in Europe. Such an opinion as this was expressed by Stoliczka on his return from work among the rocks of the Cutch Series."

The *Trigonia*-bearing beds are overlain by a considerable thickness (at least 1,000 ft.) of barren rocks.

*Ukra Beds and Bhuj Series* — The present writer (RAJ NATH, 1932), on the basis of structural evidence, places the upper division of Umia of Waagen including the *Zamia* beds, i.e. the 'upper Jurassic series' of Wynne, over the Aptian beds of Ukra hill, and has named them the Bhuj series. Thus, according to him, there is an unconformity between the Katrol and Bhuj series, the latter apparently lying directly over the former in the field. He holds that an interval of non-deposition, or even of erosion, occurred before the rocks of the Bhuj stage were deposited on the Katrol beds. The presence of this unconformity revealed by the present writer finds further support from the following observations of Dr. Spath (1933, p. 737) — ". . . Mr. Smith has now found a Katrol ammonite (*Aulacosphinctoides* sp., p. 529) in the bank of a lake two miles north of Bhuj; and since the embankment was made up of material dug from the bed of the tank (Chhota Rudra

Mata tank) only a few feet deep, it shows that the Middle Katrol beds here come almost to the surface. Again, two miles north of Ler, on the surface of cultivated fields, weathered Lower Katrol Perisphinctids have been picked up..." To my mind the occurrence at Nurrha, in the Katrol stage, of plant fossils having a very strong floral relationship with the Bhuj plant fossils, is due to this unconformity.

As, according to the present writer, the Bhuj series are post-Aptian, he is of opinion that they are not older than middle Cretaceous; they may be slightly younger.

#### UPPER LIMIT OF THE GONDWANA SYSTEM

The significance of the plant-bearing beds (i.e. the Bhuj series of Raj Nath = the 'upper Jurassic' series of Wynne) for fixing the upper limit of the Gondwana system because of their association with the marine fossiliferous beds was realized as early as 1868 (T. OLDHAM, 1869, p. 31). Their importance from this point of view has remained unchanged during all these years, but their stratigraphical position has remained unsettled up till now.

In the earlier stages even the mode of association of the plant-bearing beds (regarded as terrestrial) with the marine (Jurassic) fossiliferous beds was uncertain. Captain Grant left it doubtful; while W. T. Blanford (1867, p. 17) believed that the plant-bearing rocks were actually intercalated with the marine Jurassic rocks. Wynne arrived at the conclusion "that a very few and very imperfect remains of plants do occur in layers distinctly intercalated with the truly marine beds, and have probably been drifted into these localities from shores adjoining the seas in which the mollusca, now found fossilized in these beds, then existed. But as a whole the beds in which the well-marked '*Palaeozamia*' (now called *Ptilophyllum*) occurs are decidedly younger than those containing the truly Jurassic Ammonites and other characteristic fossils; and that they constitute an upper zone, but belonging to the Jurassic period" (T. OLDHAM, 1869, p. 31).

The question of the age of the plant beds has been still more controversial than their mode of association. The conclusions arrived at range from Bathonian to middle Cretaceous. The evidence, on which the age of

the plant-bearing beds has been based, falls into two categories:

- (i) direct evidence based on the plant fossils contained in them; and
- (ii) indirect evidence based on the invertebrate fossils contained in the beds stratigraphically older or younger than the plant beds.

In the earlier years the plant beds of Cutch were regarded as equivalent to Rajmahal (WYNNE, 1869, p. 51) on the basis of a few forms of *Ptilophyllum* (like *Ptilophyllum cutchense*, *P. acutifolium*) found common at the two places. But Feistmantel (1876 a, p. 34), as a result of the study of the several fossil floras of India, including those from Cutch, did not agree in identifying the horizon of the Cutch with that of the Rajmahal. He assigned the Cutch horizon to middle Jurassic (Bathonian) and Rajmahal to lower Jurassic.

The evidences of the second category, though indirect, are regarded as more reliable because of the invertebrate fossils contained in the beds associated with the plant beds. On the basis of the ammonites contained in the Umia ammonite beds, taking them as immediately older than the plant beds, they are referred to uncertain post-Tithonian age by Waagen (1873, p. i), and to upper Tithonian age by Dr. Spath (1933, p. 865). On the strength of results obtained by Kitchin (1903, p. 3; 1913) from the study of *Trigonia* and on the similarity of the marine Umia beds to the Uitenhage series of South Africa, they are referred to lower Cretaceous by Cotter (1917, p. 23). This view is still accepted in recent publications (Fox, 1931; Fox *et al.*, 1940, pp. 71-77).

After the discovery of beds of the Aptian age in Cutch by Stoliczka, the plant beds were then regarded as occurring between the limits of two marine beds, one of Tithonian age and the other of Aptian age. They were consequently referred to Wealden by Stoliczka, Wealden or even Neocomian by W. T. Blanford (1878, p. 119), doubtful Wealden by R. D. Oldham (1893, p. 217), and as Barremian by Vredenburg (1910, p. 87).

The Bathonian, or an even lower age, as favoured by the plant fossils, was at great variance with the age, anything between upper Tithonian to lower Cretaceous, indicated by the invertebrate fossils. This discrepancy between the two evidences—from the plant and from the animal remains—which

Feistmantel aptly calls 'palaeontological contradiction', led to a long controversy between him (1876, 1876 a) and W. T. Blanford (1876, 1878).

Coming to recent researches, the present writer (RAJ NATH, 1932, p. 173), as mentioned in the foregoing pages, has assigned the plant beds to the post-Aptian age. In other words, the Umia stage of the Gondwana system is post-Aptian, probably of middle Cretaceous age.

The discovery of a silicified palm wood which was collected from the plant beds by the party from Banaras and which has been described and named as *Palmoxylon mathuri* by Prof. Sahni (1932, p. 322), now solves this 'palaeontological contradiction' by providing evidence of their higher age on the basis of plant fossils themselves, as the range of Palmae is from upper Cretaceous to Recent.

The flora of the plant beds already contained elements differing widely in age, and the new find is an addition to the list. This feature may be to some extent characteristic

of the flora itself but, in the opinion of the present writer it is to a large extent due to want of recognition of horizons in the plant beds.

The Bhuj series is of great thickness, but a considerable portion of this series over a large area has been eroded away, so much so, that at some places inliers of the underlying Katrol beds occur in the areas occupied by the Bhuj series (viz. at Chhota Rudra Mata tank only two miles north of Bhuj). The series is more or less horizontal, and unfortunately the elevations of the localities were not taken into consideration in the study of the plant fossils from this series. In the light of these observations, I believe that the Bhuj series consists of at least three horizons, viz. *Zamia* beds at the bottom, *Ptilophyllum* beds at the middle and *Palmoxylon* beds at the top. As expected, the uppermost beds of the Bhuj series — the *Palmoxylon* beds — occur as remnant patches, only on the top of the isolated hills of igneous intrusives, standing in the midst of the plain occupied by the lower horizons of the Bhuj series (RAJ NATH, 1942).

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