STRATIGRAPHICAL NOTES ON THE STANDARD SEQUENCE OF THE UPPER GONDWANAS OF INDIA

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ABSTRACT

Recent additions to the knowledge of the geological history and the floral characters of the various Gondwana members in India necessitate to revise the so far accepted standard sequence of the Upper Gondwana formations. A new scheme based on the geological history and the palaeobotanical characters of the beds is here proposed. The sequence is represented by Mahadeva and Jabalpur series (in the revised sense). The former consists of two stages — Pachmarhi and Denwa, while the latter consists of four floristic zones corresponding to: Parsora, Rajmahal, Nipania and Bhuj.

INTRODUCTION

THE term Gondwana was first introduced by Medlicott in 1872 for certain Indian sedimentaries in his manuscript report of Satpura basin, Madhya Pradesh, but somehow the term did not appear in his published report. It was left for Feistmantel (1876) to revive this term and bring it in print for the first time. Since then, the term has been used widely for similar formations of other countries also. In India, the Gondwana system comprises a group of formations, about 6600 metres thick and were deposited during an era of 200 million years stretching from Lower Permian to Lower-Middle Cretaceous. This group of rocks has been divided into various series and stages, and the relative positions of the stages have been accepted since long. The standard sequence from the Talchirs to the Panchet series (i.e. Lower Gondwanas) is exposed in the Damodar basin while the sequence from Pachmarhi to Bhuj stages (i.e. Upper Gondwanas) is seen in different scattered basins. Careful floral and stratigraphical studies of these various Upper Gondwana members from different basins pose numerous problems in their correlation with the standard sequence which seems to give a misleading picture. In view of these considerations, a new sequence of the Upper Gondwanas is suggested here.

HISTORY

It may not be out of place here to review briefly how these different stages of Upper Gondwana formations have come into use.

The standard sequence has evolved to its present status gradually by the accumulation of evidence from time to time. Feistmantel used Kachh, Jabalpur, Rajmahal, Golapilli and Sriperumatur (in descending order) for the Upper Gondwana sequence as far back as 1876. The different stages of the Upper Gondwana system according to different workers are given in Chart I.

An exhaustive account of the Indian Gondwana formation was proposed by Fox (1931) and the various subdivisions of the Upper Gondwana formations as given by him are accepted till now without major modifications.

OBSERVATIONS

The correlative chart (Chart II) based on earlier available fossil evidence appears to be not accurate. The various series and stages considerably overlap with the result that the correlations proposed are confusing.

Pachmarhi Stage — This group was recognized by H. B. Medlicott from Pachmarhi plateau in the Satpura highlands. These group of rocks are exposed in the Satpuras. The upper portion of undifferentiated Kamthi stage in the Pranhita-Godavari basin is also probably referable to Pachmarhi stage. Underlying the Pachmarhi beds, are the Almod beds (upper portion of Bijoris according to CROOKSHANK, 1936) which were considered as equivalent to Panchet rocks. Pachmarhi rocks are overlain by Denwas (Maleri and Tiki rocks) which are Carnic-Noric in age.

Maleri Stage — This group of rocks is recorded from the Pranhita-Godavari basin and similar rocks are also reported in

CHART I

Table showing the standard sequence of the Upper Gondwana formations of India (according to various workers)

Feist. 1876	Blanford & Medlicott 1879	Oldham 1893	Vredenburg 1910	Cotter 1917	Fox 1931	Wadia 1961
Upper Gondwanas	Upper Gondwanas	Upper Gondwanas	Upper Gondwanas	Upper Gondwanas	Upper Gondwanas	Upper Gondwanas
Kachh	Cutch and	Umia and	Tripetty	Umia	Umia	Umia
Jabalpur	Jabalpur	Jabalpur	Chikiala	Jabalpur	Jabalpur	Jabalpur
Rajmahal			Vemavaram	Kota	Chaugan	
Golapilli	Rajmahal	Rajmahal	Jabalpur	Rajmahal	Kota	Rajmahal
Sripermatur	and Mahadeva	and Mahadeva	Kota		Rajmahal	Kota
			Rajmahal	Lr. Gondwanas		Mid. Gondwanas
			and Mahadeva	Parsora stage	Parsoras	Maleri
			Mid. Gondwanas	and Maleri	Maleri	Mahadeva
			Maleri	stage		(Pachmarhi
			Kamthi	Panchet	Pachmarhi	Panchet)
			Panchet			

The relationship of the Kota and Rajmahal stages is uncertain; possibly the Kota beds are younger than the Rajmahals (Wadia 1961)

CHART II

Correlative Chart of Upper Gondwana formations based on earlier work

Standard Scale	I Pranhita-Godavari	II Satpura	III Son	IV Rajmahal Hills, Bihar	V West Coast
Umia	—	—	—	—	Umia (Bhuj)
Jabalpur	Chikiala	Jabalpur	Jabalpur	—	—
Kota	Kota	—	—	—	—
Rajmahal	—	—	—	Rajmahal	—
Parsora	—	—	Parsora	Dubrajpur	—
Maleri	Maleri	Bagra-Denwa	Tiki	—	—
Pachmarhi	? Upper Kamthis	Pachmarhi	—	—	—

Satpura basin and south Rewa area. The age of these rocks is Carnic-Noric as determined by animal remains.

Parsora Stage — This is exposed in south Rewa and its equivalent is considered to be Dubrajpurs in Rajmahal hills, Bihar. The basal part of the Kota stage of Pranhita-Godavari basin may be the equivalent to Parsora stage. Underlying the Parsora stage are the Tiki rocks which are Carnic-Noric in age. The upper limit of these beds is not well demarcated.

Rajmahal Stage — This stage is known from the Rajmahal hills, Bihar. These rocks lie conformably on the Dubrajpur rocks which are considered as equivalent to the Parsora stage and are supposed to be Rhaetic in age. The age of the Rajmahal stage on the above basis is Lower Jurassic and upwards. Its age had been a controversial problem and it has been assigned varying ages, viz. Probable Middle Jurassic (Halle, 1913; Sahni, 1938; Ganju, 1946) or even Rhaetic (Du Toit, 1927; Seward, 1931), Upper Jurassic (Jacob, 1952). These different assignments are perhaps due to the fact that each author had access to only a few sections and assemblages from different parts of Rajmahal stage and so could not view the problem as a whole. In all probabilities the whole section when considered may range in age from Lower to Upper Jurassic. Further it is to be noted that Nipania flora so far had been included in the Rajmahal flora and about the former, Vishnu-Mittre (1958) observed that " In general composition, the fossil flora of Nipania seems to compare with the fossil flora of Jabalpur and Kota stages of Upper Gondwanas and is therefore to be believed from the upper-most strata of Rajmahal stage." Rajmahal stage includes the period indicated by Kota and Jabalpur stages. In other words, it means the Rajmahal flora indicates a probable Lower Jurassic to Upper Jurassic interval. This picture is quite in contradiction with the so far accepted view.

Kota Stage — The type area of the Kota stage is in Pranhita-Godavari basin and is underlain by Carnic-Noric Maleri stage. About the Kota rocks, King (1881) had observed that " In the middle of the field there does not appear to be any strong separation between the two groups (Kotas and Maleris) — merely a regular passage from red clays series of Maleris by sandstones etc." The author had examined this basin with Shri C. Nageswara Rao and it is considered that the stages Maleri, Kota and Chikiala form a conformable sequence. On the evidence of fish remains, Egerton (1863), assigned Kota stage to Liassic while on the evidence of fossil plants Hughes (1877) observed " We have thus associated in the same group plants of our Indian Jabalpur, Kachh and Rajmahal groups." The Kota stage was considered to be younger than Rajmahal stage on the fossil evidences. But there is a report of Rhaetic plants comprising *Glossopteris*, *Schizoneura*, *Neocalamites* and *Dicroidium* by Nageswara Rao & Shah (1959a) from the basal Kotas. The Kota stage is overlain by the fossiliferous Chikiala stage which is of Upper Jurassic age (Nageswara Rao

& SHAH, 1959b). On the basis of the above considerations, Kota stage ranges in time from Rhaetic to Middle or even Upper Jurassic. This is quite in contradiction than what accepted standard sequence signifies. The contradiction is more so because the Kota stage perhaps occupies a wider time range than what has been indicated in earlier correlative charts. The portion of Kota stage represents Parsora and Rajmahal stages also.

*Jabalpur Stage**— These are known from Satpura and are overlain by Bagra-Denwa rocks which are Carnic-Noric in age. Fox (*l.c.*) while discussing the relationship of Jabalpur and Denwa stages observed that " Mr. Crookshank found the upper Denwas conformably below the Jabalpurs and the relationships of alternate clays and sandstones is so intimate — being a preponderance of a sandstones above and red clays below — that he found it difficult to draw a boundary separating the two groups." It suggests that Jabalpur stage might represent a time from Rhaetic onwards. Matley (1921) remarked that the strata of Jabalpur stage are evidently overlain quite conformably by Lametas and from the evidences available at the time he considered that the beds of Jabalpurs be regarded as of Cretaceous age. Jabalpur flora according to Feistmantel (1876, 1877) is probably intermediate between Rajmahal and Umia beds of Cutch and is believed to be of Upper Jurassic age. About the age of Jabalpurs of Satpura basin, Crookshank (*l.c.*) observed that *Dictyozamites* is equally characteristic of Middle Jurassic and other genera notably, *Nilssonia*, *Taeniopteris* and *Pterophyllum* are rarely found in younger rocks than this, it is clear that the Jabalpur flora is probably Middle or Lower Jurassic age. Recently Sukh Dev (1959) observed that in the microfossils of Jabalpurs, there is an abundance of conifer pollen grains and that of cycadophytes are poorly represented. Bose & Sukh Dev (1960) also reported the Wealden ferns from Jabalpurs of this basin.

Jabalpurs of Son valley have also yielded Wealden ferns (BOSE & SUKH DEV, 1960).

From the above considerations, it is obvious that Jabalpur rocks of Satpura basin occupy a time range from Rhaetic to Lower Cretaceous, i.e. representing Parsora, Rajmahal, Kota and even part of Bhuj stages.

Bhuj Stage — Raj Nath (1932) named the plant beds of Umia as Bhuj stage and assigned a Post-Aptian age.

Feistmantel had assigned a Middle Jurassic age on the floral evidence while the invertebrate fossils associated with these plants beds indicate an age from Upper Tithonian to the Lower Cretaceous (SPATH, 1924-33) to these plant beds.

SUGGESTIONS

Some of the stages represented in the standard sequence, e.g., Rajmahal, Kota and Jabalpur stages are not well defined and they considerably overlap each other. This situation has arisen because these stages in the sequence are taken from disconnected areas of different isolated basins. The relative positions of the stages were mostly on the sporadic assemblages of plant fossils. The ages indicated by such assemblages were assigned to whole group of rocks comprising the stages without proper appraisal of the geological history of the basin. Such age determinations by fossil records got further support by the generally accepted hint that was gathered in those days that the sediments were deposited intermittently and perhaps rapidly at each phase with long periods of relative stagnation during which time in some areas interformational erosion occurred locally (FOX *l.c.*). But as seen in the above observations, the stagnation in the various basins was not to the extent as emphasized, hence a need is felt to revise the earlier standard sequence. In selecting one, the following points should be emphasized:

1. The complete sequence of the Upper Gondwana formations should be from a group of strata occurring in a single basin or at least the maximum thickness of sediments for the whole or major portion of the period involved.

2. It should be possible to subdivide the same into further units and

3. The palaeontological elements should be well represented.

From the available geological information about the various basins, it is known that only two such groups of beds are present — one in Satpura basin and the other, in Pranhita-Godavari basin.

*Chaugan stage has been dropped here on the suggestion of Jacob (1951) and Agarwal (1963). But the presence of Chaugan in Jabalpurs indicates the presence of Kota Horizon in Satpuras.

I-*Upper Gondwanas of Satpura Basin* — The deposition of the Upper Gondwanas began in Middle Triassic time and is represented by Pachmarhi stage in Satpura basin. This stage also forms the basal unit of the Upper Gondwana system. Pachmarhi stage is poorly fossiliferous. It can be clearly differentiated from the underlying Lower Gondwana rocks. Pachmarhi stage is accepted in the sequence since long. Overlying the Pachmarhi stage, is the group of rocks called Bagra-Denwa. The latter are poorly fossiliferous and with mostly animal remains. The age of these rocks is taken as Carnic-Noric. Conformably overlying the Bagra-Denwa rocks is the Jabalpur stage (richly fossiliferous) which contains the Cretaceous elements also. The thickness of Jabalpur rocks is not accurately computed and further there are no indications of any interformational erosion.

II-*Upper Gondwanas of Pranhita-Godavari Basin* — The earliest period of the Upper Gondwana system is represented by probable undifferentiated Kamthi stage with an unconformity at the top. These beds are overlain by Maleri beds which are easily discernible from the underlying beds. Overlying the Maleri stage, are the beds of Kota stage which are lithologically different from the Maleri rocks.

Overlying the Kota stage are the Chikiala sandstones which form the youngest member of the Gondwanas in this basin. The Maleri, Kota and Chikiala rocks form one conformable sequence. The first two members are known for their rich fossil contents. The age of the Maleri stage is Carnic-Noric while the age of Kota stage may range from Rhaetic to Middle or even slightly Upper Jurassic. The Chikiala sandstones are of Upper Jurassic in age.

The stratigraphy in the two basins may be summarised as follows:

European Standard	*Satpura Basin*	*Pranhita-Godavari Basin*
Mid. Cretaceous		
Low. Cretaceous	↑	
Up. Jurassic	Jabalpur	Chikiala
Mid. Jurassic	|	↑
Lower Jurassic	|	Kota
Rhaetic	|	|
Up. Triassic	↓	↓
(Carnic-Noric)	Bagra-Denwa	Maleri
Mid. Triassic	Pachmarhi	? Kamthi

With the present available knowledge, it is seen that in no single basin, the group of rocks are so exposed as to serve a standard sequence for the Upper Gondwanas. The stages Maleri and Kota are known for their fossil contents but stages corresponding to definite Pachmarhi and Bhuj are not recorded from the Pranhita-Godavari basin. The group of rocks in Satpura basin are better suited for the standard sequence but there is one problem, i.e. the thickness of Jabalpur formations known so far is insufficient for the duration of time involved — time from Rhaetic to Lower Cretaceous. The geological history of Satpura basin indicates that the lower horizon might have been deposited in Rhaetic time. But this is not supported at present by the fossil evidence. The absence of such fossil record may be due to many reasons — one of them being, no thorough search for fossils has been made so far. The upper limit of Jabalpur formations is Lower Cretaceous and this finds support by the stratigraphical relationship with the overlying beds and as well as by the fossil record. The thickness of Jabalpur formations needs to be computed properly. The easterly extensions of of Upper Gondwanas in south Rewa have been differentiated partly and Parsora stage is well known for its fossiliferous contents. To avoid confusion, it is suggested that the beds overlying Parsora stage in south Rewa may be referred to as Bansa beds rather than Jabalpurs.

In absence of any definite record of the complete sequence from a single basin, the floristic subdivisions of some part of the Upper Gondwanas (at present based on record from various basins) is being suggested. These may be actually present in Satpura basin but the exhaustive work is required for detailed informations. The sequence consists of two series: Mahadeva and Jabalpur. The former consists of two stages: Pachmarhi and Denwa (Maleri). The latter series consists of 4 floristic zones. These zones are named as Zone A, B, C and D. These are characterised by typical Rhaetic flora in Zone A, abundant cycad flora in Zone B, well represented cycad and conifer flora in Zone C and abundant conifer flora in Zone D. These zones correspond to Parsora, Rajmahal, Nipania and Bhuj respectively and are in conformity with the plant evolution. The standard sequence along with correlation of various

CHART III

Revised General Sequence of Upper Gondwana Formations of India with Correlative Chart

European Standard	Proposed Gondwana Division	Pranhita-Godavari	Satpura	South Rewa	Rajmahal	Mahanadi	West Coast
	Jabalpur Series						
	Zone 'D'						
Mid. Cretaceous Lr. Cretaceous	Conifers abundant (Bhuj)	—	—	—	—	—	Bhuj
	Zone 'C'						
Up. Jurassic	Conifers & Cycads well represented (Nipania)	Chikiala	Jabalpur	Bansa	Nipania	—	—
	Zone 'B'						
Mid. Jurassic Lr. Jurassic	Cycads abundant (Rajmahal)	Kota		—	Rajmahal	Athgarh	—
	Zone 'A'						
Rhaetic	Dicroidium flora (Parsora)			Parsora	Dubrajpur	—	—
	Mahadeva Series						
Up. Triassic (Carnic to Noric)	Denwa stage	Maleris	Bagra-Denwa	Tiki	—	—	—
Mid. Triassic	Pachmarhi stage	? Upper Kamthi	Pachmarhi	—	—	—	—

beds of different basins are tabulated in Chart III.

The upper and lower limits of the individual Gondwana members are not sufficiently well demarcated with respect to time scale. There is a gradual change in sediments in the overlying and the underlying beds and the fossils present in them are of terrestrial nature having a wider-range in time. The difficulty is further enhanced as there are very few marine intercalations in association with the fresh water sediments. Hence a small allowance should be given in considering the age of the individual Gondwana members. The appearance of a newer form should be given more importance than the lingering of the older form in the formations.

The detailed work on the floral studies of individual Gondwana members is being continued and will be published later.

The detailed field and laboratory work on the Upper Gondwana of Satpura and Pranhita-Godavari basins will throw more light on the above problem.

CONCLUSION

The study of the geological history of the various Gondwana stages and the recent contributions in their floral assemblages indicates that some of the stages in the so far accepted standard sequence are not well defined and further these stages overlap each other in time considerably, suggesting a revision of this sequence.

The proposed new sequence is mostly from Satpura basin and at present based on record from various basins. The sequence consists of two series: Mahadeva and Jabalpur. The former consists of two stages, viz. Pachmarhi and Denwa (Maleri). The latter series consists of 4 floristic zones, i.e. zones A, B, C and D. These are characterized by typical Rhaetic flora in Zone A, abundant cycad flora in Zone B, well represented cycad and conifer flora in Zone C and abundant conifer flora in Zone D. These zones correspond to Parsora, Rajmahal, Nipania and Bhuj stages and are in conformity with the plant evolution.

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