Precambrian and Lower Cambrian stromatolites of the Lesser Himalaya, India*

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In the lesser Himalayan carbonate formations all known stromatolite assemblages with Lower, Middle. Upper Riphean, Vendian and Lower Cambrian (Tommotian and Lenian) affinities are present. The Lesser Himalaya show spectacular assemblages of Riphean taxa. The Upper Proterozoic (Riphean) carbonate formations can be traced from the north-western (Jammu) to the north-eastern (Arunachal) end of the Lesser Himalaya and are designated by various groups and formations exposed in tectonic windows. The Terminal Proterozoic (Vendian/Ediacaran) and Lower Cambrian (Tommotian and Lenian) stromatolites, carbonates and phosphorites are more or less restricted to the Central sector of the Lesser Himalaya (Krol Belt) in Kumaun, Garhwal and Himachal Pradesh. The Precambrian-Cambrian stratigraphy of the lesser Himalaya has become more interesting since the discovery of the Ediacaran metaphytes (Vendotaenids) and metazoans from the Krol Formation to understand the possible links between the evolution of the metaphytes and metazoans and the decline of the stromatolites across the Precambrian-Cambrian boundary in the Indian subcontinent.

Key-words—Precambrian, stromatolites, Lesser Himalaya, Krol Belt, Ediacaran, Vendotaenids, Precambrian-Cambrian boundary.

INTRODUCTION

TEWARI (1988a; 1989) has made an attempt to assess the biostratigraphic usefulness of stromatolite taxa in Upper Proterozoic and Lower Cambrian carbonates of the Lesser or Lower Himalaya (Text-fig.1) with special reference to Proterozoic-Cambrian boundary. The distribution of stromatolite taxa in time and space across the Proterozoic-Cambrian boundary suggests that only Lower Riphean to Lower Cambrian (Lenian Stage) taxa are found in the Lesser Himalaya (Table 1, Text-fig.2). The Lower Proterozoic (Aphebian/Pre Riphean) stromatolites have not been recorded so far. The Upper Proterozoic (Riphean) stromatolite taxa are widely distributed in the carbonates of the inner Lesser Himalaya. The Terminal Proterozoic (Vendian) and Precambrian-Cambrian boundary stromatolite taxa are found in the Upper Krol and Lower Tal Formations of Mussoorie, Korgai, Niglidhar and Nainital synclines. The Lower Cambrian (Tmmotian to Lenian) taxa are restricted to the Tal Formation of Mussoorie and Korgai synclines. Recently, Ediacaran metaphytes, metazoans and trace fossils have been recorded from the Krol Formation of the Lesser Himalaya (Tewari, 1988b, 1989, 1991c, 1992a; Shankar & Mathur, 1991). The available data on the stromatolites from the Precambrian and Cambrian Lesser Himalaya and Peninsular Indian basins have been reviewed by Kumar (1980, 1984), Tewari (1984b, 1989), Valdiya (1989) and Raha and Das (1989). In the present paper, an attempt has also been made to establish the possible link between the decline of the Riphean stromatolites and the appearances of the Vendian (Ediacaran) metaphytes and metazoans in the Lesser Himalaya.

RIPHEAN STROMATOLITES

The Upper Proterozoic (Riphean) in the north-western Jammu and Kashmir Himalaya is represented by a thick sequence of carbonates known as the Jammu Limestone (Great Limestone) or Vaisnodevi Limestone. For a long time it was considered to be Late Palaeozoic in age (Wadia, 1928). However, the presence of Riphean stromatolites (Singh & Vimal, 1972; Raha, 1980; Tewari, 1984b, 1989) proved it to be Upper Proterozoic. From numerous stromatolite discoveries, Raha (1980), demonstrated that the entire sequence of the Great

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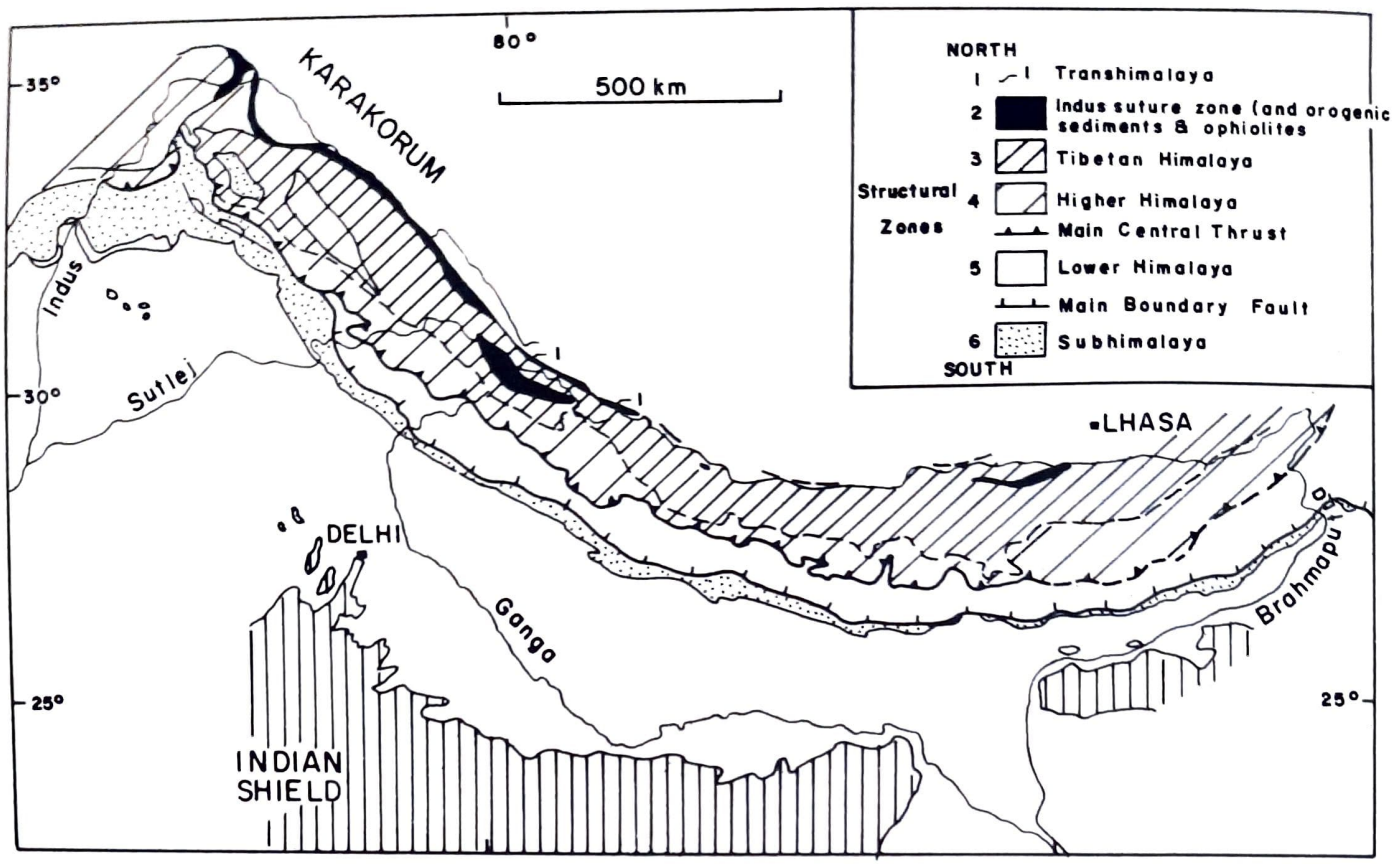


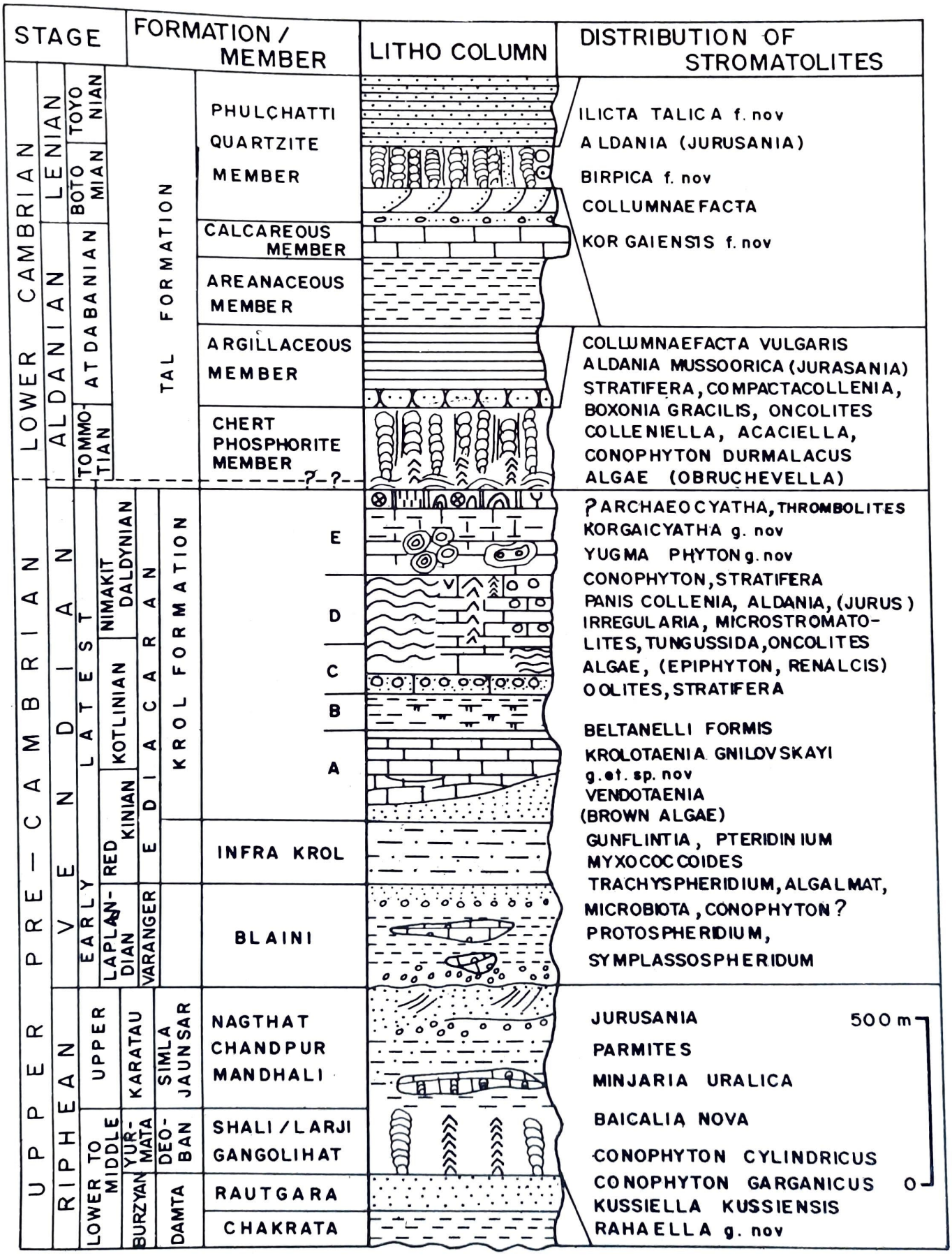
Text-figure 1. Geological map of the Himalaya (after Gansser, 1974). The stromatolites are abundantly found in the Lesser/Lower Himalaya (5).

(Jammu) Limestone is characterised by several levels of Riphean stromatolite taxa. He established a sequence of three assemblages, namely, (I) *Colonnella-Kussiella* assemblage zone, (II) *Colonnella-Conophyton* assemblage zone and (III) *Baicalia* assemblage zone. The two lower zones (I and II) are considered by Raha (1980) to be Lower Riphean in age and third zone as Middle Riphean. Additional studies by the present author (Tewari, 1984b, c, 1989) and Raaben and Tewari (1987) have confirmed the age suggested by Raha (1980).

The Stromatolite assemblage (I) comprises *Kussiella kussiensis* Krylov, *Kussiella* fm. indet., *Omachtenia granesis* Raha, *Platella talwarensis* Raha and also four taxa of *Colonnella* Komar, namely, *Colonnella elongata* Raha, *Colonnella katraensis* Raha, *Colonnella* cf. *C. laminata* Komar, *Colonnella* cf. *C. discreta* Komar.

Table 1. Stromatolite biozonation of Lesser Himalaya, north India (Tewari, 1989)

No.	Biozone	Stromatolite Assemblage	Age
VII	*Ilicta*	*Ilicta talica*. f. nov., *Collumnaefacta korgaiensis* f. nov., *Aldania birpica* f. nov.	LENIAN/TOYONIAN (Lower Cambrian)
VI	*Collumnaefacta-Boxonia*	*Collumnaefacta vulgaris*, *Boxonia gracilis*, *Aldania mussoorica*, *Colleniella*, *Acaciella*, *Compacto-collenia*, *Conophyton durmalacus*, *Conophyton* msp.	TOMMOTIAN (Precambrian - Cambrian (PC/C) Boundary)
V	*Yugmaphyton*	*Yugmaphyton* g. nov., *Minicolumellae*, *Stratifera*, *Conophyton*, *Tungussia* msp.	LATE VENDIAN
IV	*Jurusania-Parmites*	*Jurusania* msp. *Jurusania himalayika*, *Parmites*, *Tungussia*, *Poludia*	UPPER RIPHEAN TO EARLY VENDIAN
III	*Baicalia*	*Baicalia nova*, *Baicalia Chandakia* f.nov., *Minjaria uralica*, *Jacutophyton*	MIDDLE RIPHEAN
II	*Conophyton*	*Conophyton cylindricus*, *Conophyton garganicus*, *Colonnella columnaris*	LOWER RIPHEAN
I	*Rahaella-Kussiella*	*Rahaella* g. nov., *Rahaella elongata*, *Rahaella katraensis*, *Kussiella kussiensis*, *Kussiella vittata*	LOWER RIPHEAN



Text-figure 2. Lithocolumn showing the distribution of Precambrian (Riphean, Vendian) and Lower Cambrian stromatolites, algae and Ediacaran biota.

Although the four taxa named above have been assigned to *Colonnella* Komar, they do not, in fact, have any of the basic characteristics of that group (Komar, 1966) and has been revised by the author (Tewari, 1989).

The four taxa were examined by Dr. V.A. Komar in USSR who has confirmed (V.A. Komar, personal communication, 1986) the opinion of the author that they do not belong to *Colonnella* (Komar, 1966). Tewari (1989) has described these taxa under a new group (form genera), *Rahaella*.

The lowermost part of stromatolite assemblage I biostrome (the *Colonnella-Kussiella* assemblage zone of Raha, 1980) is established here as those beds with *Rahaella* (P1 1; Text-fig. 3). The association also includes *Omachtenia granensis* Raha, which is the smallest size form amongst the group *Omachtenia* Nuzhnov. All these forms are restricted to the lower part of the beds. Above the *Rahaella* assemblage, locally distinctive beds can be recognized and are characterised by the stromatolite *Platella talwarensis* which is specific to this horizon. *P. talwarensis* has affinity with other Riphean taxa of *Platella* Komar, but it also resembles some forms of *Parallelophyton* from the Lower Proterozoic of Karelia, USSR. *P.talwarensis* does not appear in the upper part of the section.

The uppermost part of the first biostrome is characterised by beds of *Kussiella kussiensis* and may be considered as a distinct unit. *K. kussiensis* is the dominant form and other indeterminate forms of *Kussiella* are also present in this biostrome (Text-fig. 3). Slightly higher in the section, separate beds with well developed laminated stromatolites of the supergroup Thyssagetacea Vlasov are found. This supergroup, together with *Kussiella* is characteristic of the Satka asssemblage of the Lower Riphean of the Urals, USSR.

A second biostrome is exposed higher in the section. The horizon is more correctly described as biohermal. As indicated by Raha (1980), the bioherm is characterised by *Conophyton* sp. and *Colonnella* sp., *Conophyton cylindricus* Maslov forms spectacular structures having more than 50 cm in diameter and up to several meters in height (Text-fig. 3). Large *Colonnella* sp. structures, described as *Colonnella riasiensis* Raha, are also present. Some of these stromatolites indeed belong to the group *Colonnella* Komar, but other having inverted conical and cylindric columns are identified as *Conusella regularis* Golovanov and correspond to the diagnosis of *Conusella* Golovanov. A characteristic feature of this association is that the big columns of *Colonnella* sp., *Conophyton* sp. and *Conusella* sp. occur in high dome shaped bioherms. It is also important to note that such bioherms are either found in the same bed or in adjoining beds together with *Gaya* sp. and with large forms of *Paniscollenia* sp. The general aspect of the association of

Plate 1

1. Lower Riphean form *Rahaella elongata* Tewari 1989 from Lower Shali Limestone, Lesser Himalaya showing nature of columns, laminae and microstructure etc. (WIF/A-1360)

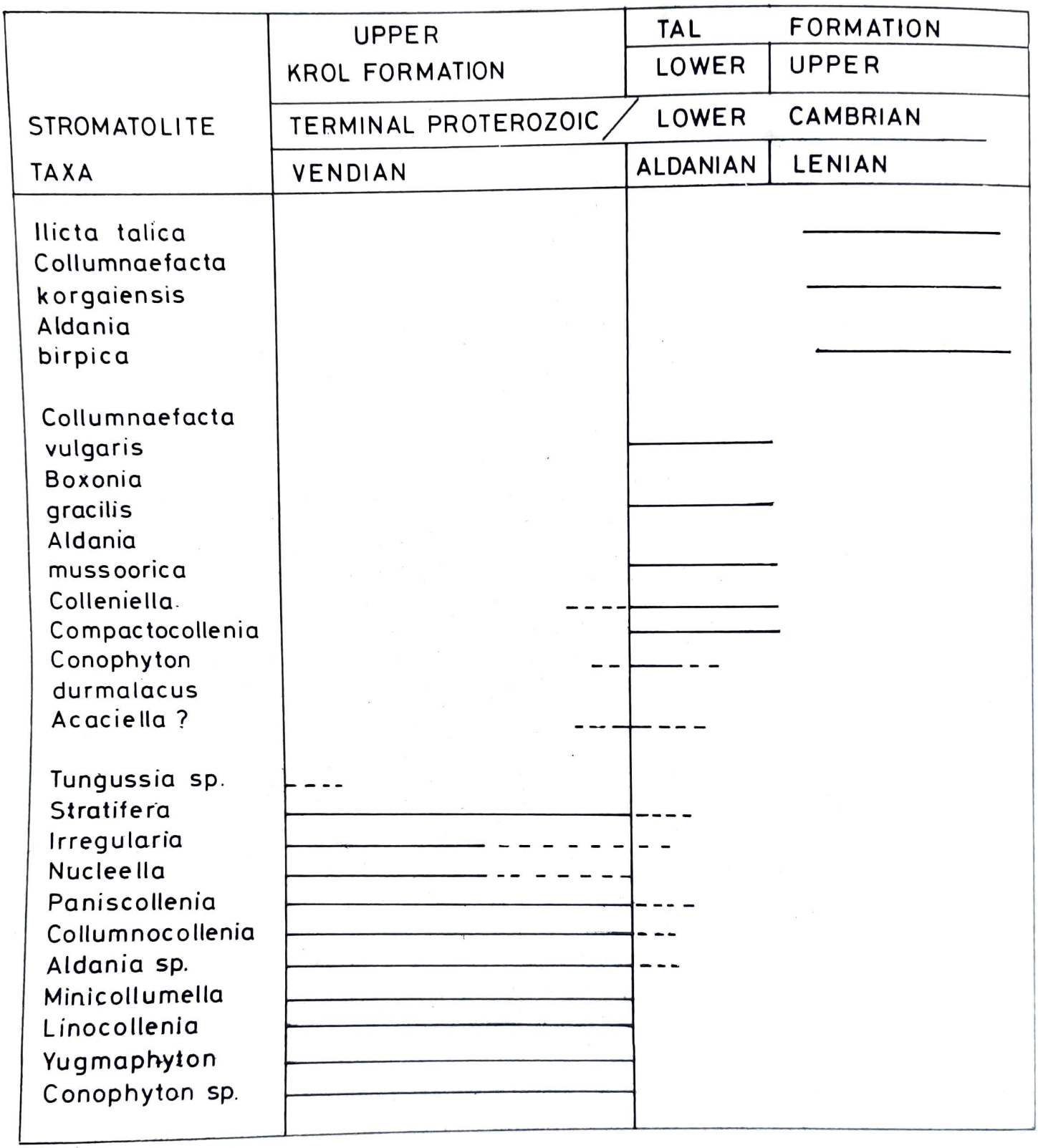
Table 2. Riphean stromatolite time range chart for the Lesser Himalaya (Jammu-Dharamkot-Shali including Shimla and Sataun, Larji-Deoban-Gangolighat Ta Jem Belt)

STROMATOLITE TAXA	PALAEO PROTEROZOIC/ PRE-RIPHEAN/ APHEBIAN FORMS NOT FOUND	MESOPROTEROZOIC		NEOPROTEROZOIC	
		RIPHEAN			
		LOWER	MIDDLE	UPPER	
		BURZYANIAN 1650±50-1350	YURMATANIAN 1350±50-1000±50	KARATAVIAN 1000±50-680 Ma	KUDASHIAN 680-650 Ma
Kussiella kussiensis					
Kussiella vittata					
Kussiella msp.					
Rahaella elongata					
Rahaella katraensis					
Colonnella msp.					
Colonnella columnaris					
Colonnella riasiensis					
Omachtaenia granensis					
Omachtaenia msp.					
Platella msp					
Platella talwarensis			- - - -		
Poludia msp					
Conophyton cylindricus					
Conophyton garganicus			- - - - - - - - -		
Conophyton misrai			- - -		
Baicalia msp.					
Baicalia chandakia					
Baicalia nova					
Baicalia prima					
Jacutophyton msp.					
Svetliella msp.					
Minjaria uralica					
Masloviella columnaris					
Plicatina antiqua					
Nucleella msp.		- - - -	- - - -		
Gongylina differentiata		- -		- - - - - -	
Paniscollenia msp.			- - - - - - - - - -	- -	
Stratifera undata					- - - - - - - -
Conusella msp.			- - - - -	- - - - -	
Parmites concrescens					
Cryptophyton msp.					
Jurusania himalayika					- - - -

the second biostrome is very similar to the Lower Riphean Baikalian association of the southern Urals, Russia.

Biostrome III (*Baicalia* assemblage zone) includes stromatolites of the group Baicalia in its lower part, originally described by Raha (1980) as *Baicalia baicalica* (Text-fig. 3). However, this form species has been now revised by Krylov and Shapovalova (in Raaben & Komar, 1982) as *Baicalia nova*. The revision demonstrated that several forms have been described in the former USSR under the name *Baicalia capricornia* Water 1972. *Baicalia* sp. from Jammu Limestone and *Baicalia nova* from Russia are not identical to *Baicalia capricornia* described from Bangemall Group (Middle Riphean) of Western Australia but are closely comparable. *Baicalia* cf. *B. baicalica* and *Baicalia* f. described from assemblage 4, Jixian system of Sinian suberathem of China

Table 3. Vendian and Lower Cambrian (Krol-Tal) stromatolite time range chart for the Lesser Himalaya



(Zhu Shixing, 1982) is identical to *Baicalia* sp. from Jammu Limestone. *Baicalia* sp. from the Jammu Limestone is similar to *Baicalia nova* Krylov and Schapovalova, described from the Avzyan Series of the southern Ural and *Baicalia prima* Semikhatov from Middle Riphean of Siberia, but does not resemble the type form *Baicalia baicalica* from the Prebaikal region. *Baicalia burra* Preiss described from the Burra Group of Australia resembles *Baicalia* sp. from Jammu Limestone.

The stromatolites from the Jammu Limestone have a very simple microstructure and their gross morphology and branching pattern are very simple and are not bush