# ALGAL STROMATOLITES FROM THE KROL FORMATION OF THE MUSSOORIE SYNCLINE, UTTAR PRADESH

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## ABSTRACT

The results of the study of the Algal stromatolites associated with phosphorite occurring in the top most member of the Krol Formation, the Mussoorie Phosphorite Member, which overlies the light grey dolomitic limestones, known as the Upper Krol Limestones, near Mussoorie in the Dehra Dun District of Uttar Pradesh have been recorded in the paper. The types of stromatolites that have so far been recognized from these are: (i) spheroidal or nodular (Oncolithes), (ii) conical cup shaped, (iii) cylindrical columnar branching upwards, (iv) laterally connected columns, (v) cylindrical columnar with detached columns. Excepting the first one which is rounded and without any root, the rest of the structures appear to be varieties of *Collenia*. The significance of the association of these algal stromatolites on the genesis of the phosphorite and the environment of deposition is obvious as the presence of these stromatolites indicate shallow intertidal to subtidal marine condition.

The oncolites present in this horizon appear to have affinity with the Late Palaeozoic to early Mesozoic forms. The columnar forms have to be defined and named properly for distinguishing them from the Proterozoic ones. The type (iv) form compares very well with the form *Malacostroma concentricum* (Gurich) reported from the Mississippian of Belgium (Johnson, 1961).

## INTRODUCTION

ALGAL stromatolites occurring in association with the Mussoorie phosphorite near Mussoorie town, (30°27′30″:78°4′) have already been reported (Raha & Gururaj, 1970). The phosphorite occurs in the synformal Krol Nappé extending from Mussoorie to north of Narendranagar (30°09′30″:78°17′30″), and has recently been designated as the upper most member of the Krol Formation by the author (Raha, 1971). Previously this horizon was thought to be the basal member of the overlying Tal Formation. Five different varieties of stromatolitic structures have so far been identified in 0·5 m thick dolomitic limestone interbedded within the phosphorites.

## GENERAL GEOLOGY

The geological sequence of the area where the algal structures occur is as shown below.

The classification given has been suggested by the author in a recent paper (Raha, 1971) on the basis of the fact that the limestone, chert, phosphorite and black shale are genetically related and occur commonly in association. The Mussoorie Phosphorite Member has been designated as the top most member of the Krol Formation in the Mussoorie area. Within these phosphorites, stromatolitic limestone (dolomite) of 0·5 m thickness has been reported (Raha & Gururaj, 1970).

| | | |
|---|---|---|
| Tal Formation | Gray silty shales and siltstones | |
| Krol Formation | Mussoorie Phosphorite Member | Black carbonaceous shales (2·0 m) |
| | | Phosphorite (1·8 m) |
| | Light grey dolomitic limestone with some argillaceous limestones | Dolomitic limestone with stromatolitic structures (0·5 m) |
| | | Phosphorites (2·5 m) |
| | | Black chert with shales (3·0 m) |

## DESCRIPTION OF THE STRUCTURES

Five different varieties of algal stromatolites have been recognized in this occurrence. Excepting some spheroidal stromatolites occurring near the base of the 0·5 m thick zone, the rest are mostly columnar varieties. Detailed description is given below.

### I. *Spheroidal structures*

(Pl. 1, Fig. 1 & 2)

These are merely spherical to ellipsoidal, plicated and curved bodies. Diameter varies between 0·8 cm and 3·0 cm, but is occasionally as large as 5·0 cm.

A great number of the spheroids show eccentric radial arrangement because of

the shells of accretion being much thicker in one side, which is typical of algal growth (Carozzi, 1961).

The lamellae are formed of dark and light coloured crypto-crystalline calcitic material. The dark colour in the growth lamellae is most probably due to organic material present in them. The thickness of the growth lamellae varies from 75 to 375 microns with an average of 150 microns. The margins of these nodules are crenulated with protuberances. Some isotopic spongy material are occasionally found near the centre of these spheroids. Radial dark lines with light coloured segments are suggestive of growth filaments.

Similar structures have been described by Bradley (1929) from the Green River Formation of U.S.A. Bhargava (1969) has also reported such "algal pisolites" from the Krol E stage of Nigali syncline, H. P. These are "Oncolites" ranging in age from Pre-Cambrian to Recent. But in the geological columns their significant development is found in the upper Palaeozoic to early Mesozoic time and are rare in older rocks.

### II. *Conical cup-shaped structures*

(Pl. 2, Fig. 7 & 8)

These are attached forms rising from base upwards and increasing in diameter in the upper parts like a cup.

The laminae occur as inverted bowls with convexity upwards. The individual structures comprising several laminae varying in thickness from 75 microns to 30 microns measure 0·3 cm to 1·4 cm in diameter and 1 cm to 5 cm in height. Their roots comprise earthy calcitic materials. Thick calcitic bands are also found at times in between the fine laminations. The microstrata are dome shaped with convexity upwards and slightly thinning at the margins. Curvature is higher near the margins. Interspaces between the stromatolites vary from 1 mm to 6 mm and some times it is even 1 cm. The increase in diameter with respect to the height is more, and ratio of the width of the base to that of the top is 1·5 on the average.

These simulate the *Collenia symmetrica* Fenton and Fenton described by Valdiya (1969) from different calcareous horizons of the lesser Himalayas, but sizes are quite small in the present case.

### III. *Cylindrical columnar structures branching upwards*

(Pl. 1, Fig. 1)

Columns of inverted bowls often bifurcate upward. The individual branches are less in diameter than the orignial columns. Constriction near the base of the branches is rare. Branches are more or less of uniform dimensions.

Columns are separated from each other by clastic carbonate material such as pellets, intraclasts and lime-mud. But sometime the columns are pressed together. Width of columns remains more or less constant. The height of the columns vary from 1 cm to 12 cm and the width from 0·5 cm to 2·5 cm. Columns usually originate from Oncolites (Fig. 1).

These resemble *Collenia buriatica* Maslov described by Valdiya (1969) from the calcareous zone of Pithoragarh and the lower Shali limestone.

### IV. *Laterally connected columns*

(Pl. 2, Fig. 3 & 4)

These are composed of stromatolitic microstrata continuing between columns of inverted bowls, thus giving a wavy look to the entire structure. Thickness and other characteristics are more or less similar to the columnar structures described above.

The diameter of individual columns vary between 1 cm to 4 cm with average of 3 cm. The base is polygonal to subrounded.

This form (Pl. 2, Fig. 3) is comparable with the *Malacostroma concentricum* reported from the Mississippian of Belgium (Gurich *in* Johnson 1961, p. 223).

### V. *Cylindrical columns separated by narrow interspaces*

(Pl. 1, Fig. 1; Pl. 2, Fig. 5)

These are non-branching type columns of inverted bowls often originating from calcareous clay pellet or spheroidal stromatolitic structures. Columns are 0·5 to 2 cm in diameter. Normally columns of more or less uniform sizes are associated. Their heights vary from 3 cm to 12 cm. Other characteristics are more or less similar to the other columnar stromatolites. The individual microstratum does not extend much on sides. The interspace is filled with calcareous mud and pellets.

These are similar to *Collenia columnaris* Fenton and Fento described by Valdiya (1969) from the Fawn Limestone, Lower Vindhyan, and excepting that these are the calcareous zone of Pithoragarh, much smaller in size.

## DISCUSSION

The occurrence of stromatolites in association with phosphorites of Mussoorie area was reported for the first time by the author (Raha & Gururaj, 1970) suggesting the mode of origin and nature of the environment of deposition of the phosphorite. Possible algal stromatolites from Krol Limestone of Mussoorie syncline was reported by Mithal and Chaturvedi (1969). The phosphorite-chert-shale association overlying the thick sequence of dolomitic limestones of the Krol Formation has been named as the Mussoorie Phosphorite Member, the top most member of the Krol Formation of Mussoorie syncline, which was earlier considered to be the basal member of the Tal Formation (Raha, 1971).

Most of the stromatolitic structures appear to be varieties of *Collenia*. The different stromatolite bearing horizons in the Himalayas have been correlated by Valdiya (1969) with the stromatolitic horizons of the Vindhyan Group (Up. Precambrian) with the help of the different varieties of *Collenia*. There are reports of Mesozoic fauna, probably of Jurassic age, from the upper part of Tal Formation which overlies the Krol Formation (Pascoe, 1959). There appears no significant break between the Krol and the Tal Formations. On the other hand, the Krol and the Infra-Krol Formations overlie the Balaini Formation which is believed to be equivalent to the Talchir Boulder Bed. Recently, the presence of Coccolithophorids of Jurassic age have been reported by Tewari (1969) from the contact between Krol B & C stages, which is much below the stromatolite bearing zone of the present area. Thus the stromatolite assemblage of the Krol characterized by smaller sizes is definitely much younger in age than those reported by Valdiya (1969). These forms appear to be more akin to Late Palaeozoic and Early Mesozoic forms, particularly the Oncolites. This also suggests the name *Collenia* is insufficient to distinguish the columnar stromatolites and use them as marker of stratigraphic horizon as adopted by Valdiya (1969). In this respect the different nomenclatures adopted by the Russian (Krylov, 1963; Raaben, 1969; Cloud & Semikhatov, 1969), are more useful. Similar classification and nomenclature for the younger forms has not been given much attention, as has been given for the Precambrian ones. However, in the younger rocks development of stromatolites are of restricted nature and the narrow zone with smaller forms in this case may be due to that. The resemblance of type IV with a Mississippian form *Malacostroma concentricum* is quite interesting.

The stromatolitic rocks were macerated for algal spores and pollen, but the results were negative. So we shall have to depend on the other available data for the age of this horizon.

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## EXPLANATION OF PLATES

### PLATE 1

1. Algal stromatolites, spheroidal near base and columnar upwards. Columns originating from nodules and branching upwards.

2. Polished section of spheroidal stromatolites.

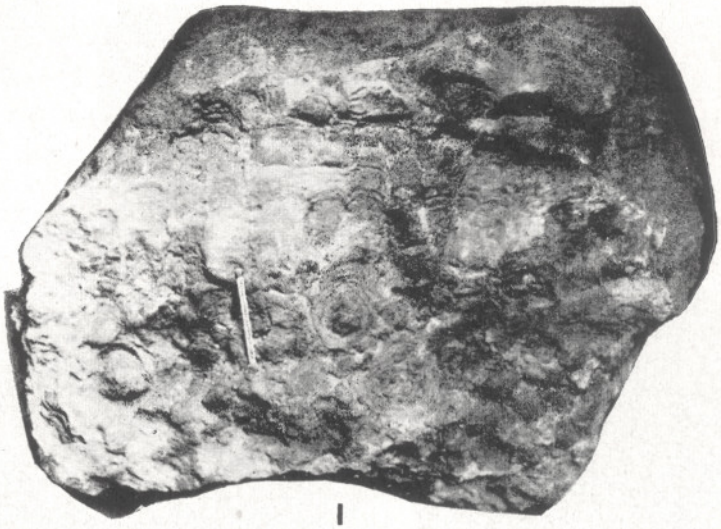
### PLATE 2

3. Laterally connected columnar stromatolites. Dark bank is phosphatic.

4. Columnar stromatolite with columns separated by interspace giving rise upwards to laterally connected stromatolites.

5. Columnar stromatolites separated by narrow interspace filled up with calcareous mud.

6 & 7. Conical cup shaped stromatolites originated from calc. mud.



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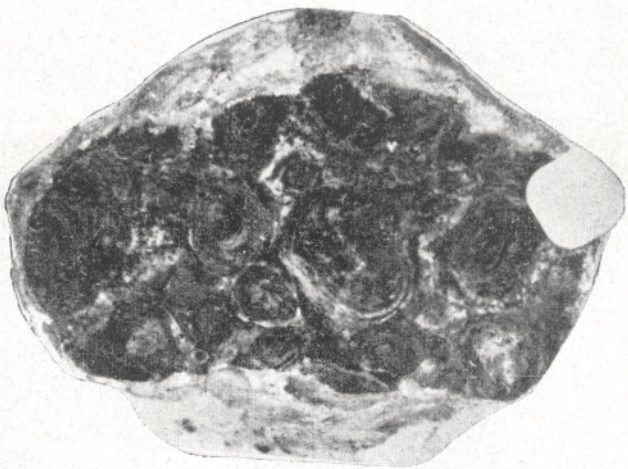

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