ON THE OCCURRENCE OF STROMATOLITES IN THE KROL FORMATION OF NAINITAL AREA AND ITS IMPLICATIONS ON THE AGE OF KROL FORMATION

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ABSTRACT

A well-developed stromatolite assemblage of *Conophyton garganicus–Baicalia baicalicu–Colonella* sp. is recorded for the first time from the upper Krol sediments of Nainital area. This is a characteristic assemblage of Proterozoic (middle Riphean) in India, U.S.S.R. and Australia. The age of Krol is thus late Precambrian, and is correlated with calc zone of Pithoragarh, Shali limestone, Deoban limestone, Vindhyan and Aravalli sediments. The stromatolites of Krol sediments are also associated with phosphorite and galena mineralization.

INTRODUCTION

KROL formation is an important lithostratigraphic unit of the lesser Himalaya, and is made up of essentially limestone and dolomite. Medlicott[1] proposed the name Krol formation for the sequence of dolomite, limestone, shale, and marl of the Krol hill near Solan, which was later investigated in detail by Pilgrim and West[2], Auden[3] and others. Krol succession in Nainital area makes a major syncline and represents south-eastern extremity of Auden's Krol belt, and was first studied by Middlemiss[4]. Later Pal and Merh[5], Pande[6], Fuchs and Sinha[7] made detailed stratigraphic and structural studies in Nainital area.

During the course of a sedimentological study of Krol formation of Nainital area, some well-developed stromatolites have been recorded in the upper Krol dolomites of Nainital area. This paper presents data on these stromatolites.

KROL FORMATION OF NAINITAL AREA

Krol sediments in Nainital area are 700–800 m thick; the upper Krol sediments (Krol C, D and E of Auden) represent dominantly algal mat deposits, together with oolitic limestone, tidal flat succession of sandstone and shale. Algal mats and branching stromatolites are recognized in these sediments by Fuchs and Sinha[7]. The algal mat deposits of Krol sediments show algal mats with smooth laminations, algal mats with contorted and corrugated laminations, algal mats with fenestral structure, loferite, oncolite dolomite, bird's eye dolomite. These facies represent deposition in a protected bay in intertidal to supratidal zone. The facies is comparable to algal mat facies of Shark bay (Davies[8]). Associated with algal mat deposits are also a few horizons with well-developed columnar stromatolites. In this paper two of such horizons are discussed.

(A) *Horizon of* Conophyton garganicus *and* Colonella *sp.*

Within a sequence of black limestone showing algal balls, oncolites, algal mats, there are horizons showing *Conophyton garganicus* and *Colonella* sp. There are *ca.* 50 cm thick horizons made up of *Colonella* sp. in which laminae are continuous. Within this unit *Conophyton garganicus* is developed. These thicker limestone units alternate with 5–15 cm thick shaly limestone units made up of small *Colonella* sp. colonies.

SYSTEMATIC DESCRIPTION

Supergroup—Conophytonida, Group—*Conophyton*, Form—*Conophyton garganicus* Koroljuk, 1963 (Figs. 1, 2).

Colonies are conical to subcylindrical (height 10–25 cm and diameter 4–8 cm) showing conical internal laminae. Circular to elliptical in cross-section. In longitudinal section a prominent axial zone is developed, where the thickness of dark laminae is distorted, while the thickness of light bands remain relatively constant. The dark laminae are smooth to lenticular. Within the laminae galena is present.

(B) *Horizon of* Baicalia baicalica

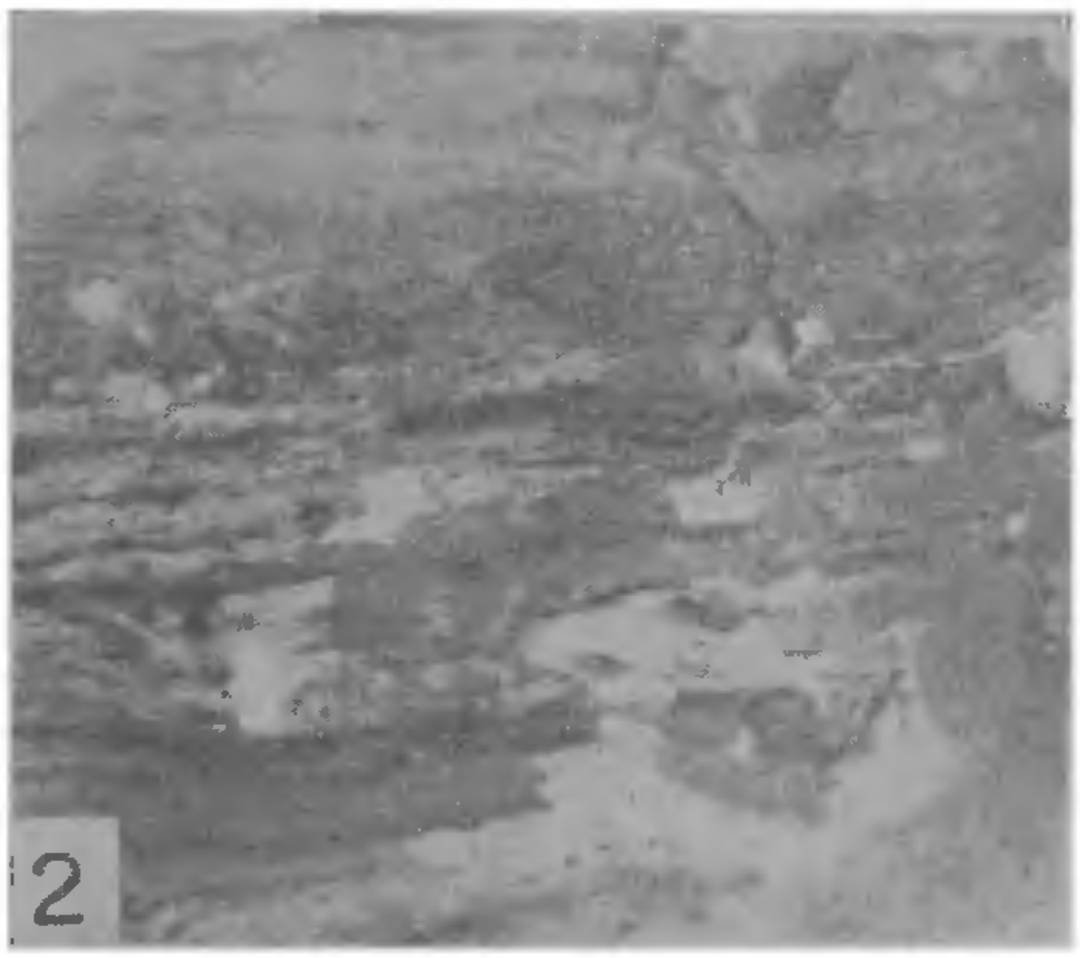
This is a 1 m thick horizon of stromatolitic limestone showing dark coloured elongated stromatolites showing branching characteristics, and abundant oncolites. It is underlain by a calcareous shale showing tidal bedding, and overlain by algal mat dolomite, showing faintly crenulated laminae with well-developed lamellar fenestrae.

SYSTEMATIC DESCRIPTION

Supergroup—Tungussida, Group—*Baicalia*, Form—*Baicalia baicalica* Krylov (Figs. 3, 4).

Colonies tuberous, making angle of a few degrees to 90° with the horizontal. Height 10–20 cm,

width 2–6 cm, branching in the form of dichotomous thinner columns. Margins of the column uneven or rugged. Laminae are non-enveloping, convexity of the laminae moderate to flat. Boundaries of dark laminae are gradational.



FIGS. 1–2. Fig. 1. Longitudinal section of *Conophyton garganicus*, showing well-defined axial zone, × 1. Fig. 2. Longitudinal section of *C. garganicus* showing arrangement of laminae, × 1.

Remarks.—The columns of *Baicalia baicalica* have not grown erect, but on a horizontal plane. Such growth of *Baicalia baicalica* is also present in Bhander limestone (Vindhyan) of Satna area (unpublished data), and is most probably due to hypersaline conditions. These stromatolites are phosphate bearing.

AGE OF KROL FORMATION

Age of Krol formation is highly disputed, mainly due to absence of any well-defined fossil assemblage. Most of the fossils and pollen and spores reported so far by various workers are of questionable stratigraphic value. Oldham[9] and most of the later workers assigned a presumed Permo-triassic age to Krol, because the underlying Blaini formation has been correlated with Talchir boulder bed, though without any fossil evidence.

FIGS. 3–4. Fig. 3. *Baicalia baicalica* colony. One div. of scale = 1 cm. Fig. 4. Section of *B. baicalica* showing internal structure. The laminae are fairly convex, and dark and light laminae possess gradational contact, × 1.

Sitholey *et al.*[10] and Lakhanpal[11] give Permo-triassic age to Infrakrol, while Ghosh and Srivastava[12], Sah *et al.*[13] give Triassic age to lower Krol. Tewari[14] assigns a Jurassic age, while Mittal and Chaturvedi[15] give a Permian to

Lower Cretaceous age; Sinha[16] also gives an upper Jurassic to lower Cretaceous age. However, Fuchs in Fuchs and Sinha[7] report that Infrakrol/Krol sediments yielded only primitive plant remains of no stratigraphic significance, and correlates Krol with Shali and assigns a Precambrian age. Gundu Rao[17] also reports Precambrian oncolites from Krol (identified by Mrs. Zhuravleva). Valdiya[18], based on palaeontological studies of Kalia[19], gave Permian age to Tal, and a lower Palaeozoic (Devonian) age to Blaini–Krol succession.

Thus, it is evident that no well-defined faunal and floral assemblage has been reported from the Krol sediments. In the present study a well-defined stromatolite assemblage of *Conophyton garganicus*, *Baicalia baicalica* and *Colonella* sp. has been recorded. This stromatolite assemblage has been considered a characteristic assemblage of Proterozoic (middle Riphean) of U.S.S.R. and Australia (Walter and Preiss[20]). In India this association has been reported from Gangolihat limestone and Vindhyan sediments, which are considered to be middle Riphean (Valdiya[21], Kumar[22], Kumar and Tewari[23]).

Singh and Tangri[24] reported *Conophyton* (?) and *Colonella* assemblage from Blaini formation and assigned a middle Riphean age. Singh[25] further suggested that Nagthat–Blaini–Krol–Tal succession is Precambrian in age, and lesser Himalaya is northern part of Indian shield. This find of Riphean stromatolites from Krol formation of Nainital further strengthens the contention of Singh[25].

Correlation

Conophyton has been reported from several Indian rocks, *e.g.*, Lower Vindhyan (Valdiya[21]; Kumar[22]); Bijawar (Krishna Murti[26]), Jammu limestone (Raha and Shastri[27]), Calc zone of Tejam (Bhattacharya[28]), Gangolihat dolomite (Kumar and Tewari[23]). However, except for Kumar[22], Kumar and Tewari[23] none of the workers made a study of internal laminae in thin section, which is essential in identification of stromatolites on generic and specific level.

Kumar and Tewari[23] report *Conophyton garganicus–Baicalia baicalica* assemblage from Gangolihat dolomite. Thus Krol formation can directly be correlated with Gangolihat dolomite of Calc zone of Pithoragarh. Nevertheless, the Krol formation can tentatively be put time equivalent and correlated to Calc zone of Pithoragarh, Shali limestone, Deoban limestone, Vindhyan sediments, and Aravalli phosphates, on the basis of presence of *Conophyton* sp. and *Baicalia* sp. in these rocks.

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