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STROMATOLITIC PHOSPHORITES OF FAR WESTERN NEPAL

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सारांश

पश्चिम नेपालको मध्य हिमालयमा पहिलो पल्ट डोलोमाईट चट्टानमा स्ट्रोमाटोलाईट युक्त फोस्फराईट भेटिएको छ। यो थोरैमात्र गहिरो सागरीय वातावरणमा फोस्फेट जम्मा भएर बन्न गएको देखिन्छ। प्रस्तुत लेखमा स्ट्रोमाटोलाईट युक्त फोस्फराईटको रासायनिक बनावट तथा पेट्रोग्राफी बारे चर्चा गरिएको छ।

ABSTRACT

The stromatolitic phosphorites are found for the first time in the Lesser Himalayan carbonate formations of Far Western Nepal. The phosphorites are confined to the cherty dolomite member which is a part of a thick succession of slate, limestone and dolomite. This paper deals with the petrography of the stromatolitic phosphorite and their chemical composition. The shallow marine environment of phosphate deposition is indicated.

INTRODUCTION

Phosphate exploration in Nepal was introduced by R. P. Sheldon who visited some parts of Western Nepal where the concentration was found very low (Sheldon, 1967). After the visits of Indian phosphorite occurrences, the possibilities of their being present in Nepal was infered (Sharma, 1967) and the investigations carried out in Western Nepal showed a content of less than 10% P_2O_5 in nodules (Sharma, 1968).

Afterwards, the south-eastern Nepal Himalaya was explored where the phosphate content was reported up to 30% P_2O_5 in nodules (Kazitsyn, 1970) and up to 10% in 1 m rock thickness from Takure village (Kazitsyn, 1973). Prospecting works carried out by the author in the region to the north of Main Boundary Thrust (MBT) from Mechi River in the east to Arga Khanchi district in the west reveal less than 5% P_2O_5 in 0.5–1m rock thickness (Bashyal, 1973, 1974, 197,5 1976). Detail investi-

gation showed that the clastic phosphate grains are associated with volcanic tuff and pebbly shale (Bashyal, 1978, 1980).

So, now the search for the ancient phosphorite was carried out in the metasedimentary units of Far Western Nepal Himalaya from where the phosphatic stromatolite sample in floats of Janpri khola (Bajhang district) was reported (Dikshit, Pers. comm.). Still more the metasedimentary units of Nepal continue across the border into Kumaun Lesser Himalaya where the Precambrian Gangolihat Dolomites containing stromatolites are poorly to moderately phosphatic (Valdiya, 1972), and the Precambrian rocks of Udaipur and Rajasthan (India) contain stromatolitic phosphorite deposits (Banerjee, 1971).

The study area, nearly 4000 sq. km. lies between the rivers Mahakali and Seti of Far Western Nepal Himalaya in Dandeldhura, Baitadi, Darchula and Bajhang Districts. The crystalline and metasedimentary units from Dandeldhura in the north to MBT in the south were described and correlated to that of Kumaun (Bashyal, 1981). The stromatolites were reported from the carbonates of Kali Gad (Nakajima and Pradhan, 1979) and these carbonates can be correlated to Syaldanda Formation of Sharma (1980).

GEOLOGICAL SETTING

Bajhang and Baitadi Metasedimentary Complexes in the Lesser Himalaya of Far Western Nepal are traceable for 50 to 70 km from Mahakali River forming the border with Kumaun in west to Seti River in east. The metasedimentary rocks (exposed in tectonic windows) are thrust over by the crystalline rocks (Fig. 1). The area is structurally complicated by many folds, thrusts and transverse faults. The stromatolitic phosphorite horizons occur among the thick succession of slate, limestone and dolomite of Chamlia and Baitadi Carbonate Formations.

Baitadi Carbonate Formation

Confirmably overlies Patan Slate (Table 1) and is composed of coloured slates interbedded with green sandstone and various quartzites with cross-bedding structures. The lower most member of the formation is represented by non-phosphatic stromatolite bearing dolomite and limestone. Whereas the middle part consists of a thick succession of limestone, dolomite and black slate. The upper part, the Dhik Gad stromatolitic member, contains magnesite bands up to 10m thick and stromatolitic phosphorite beds up to 4m thick.

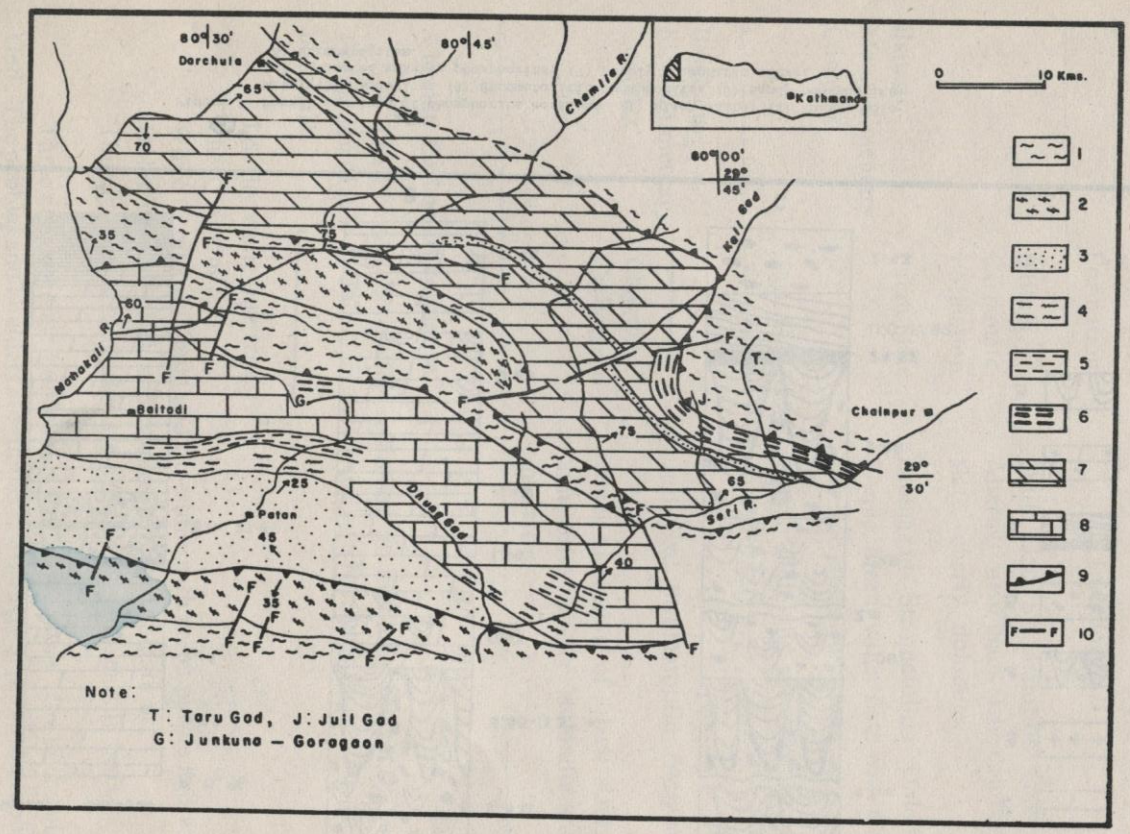


Figure 1: Geological map of Far Western Nepal. (1) Phyllite and quartzite with amphibolite; (2) Mica schist and gneiss; (3) Purple shale and green sandstone; (4) Dhung Gad stromatolitic dolomite; (5) Black slate; (6) Stromatolitic phosphorite; (7) Chamlia Carbonate Formation; (8) Baitadi Carbonate Formation; (9) Thrust; (10) Fault.

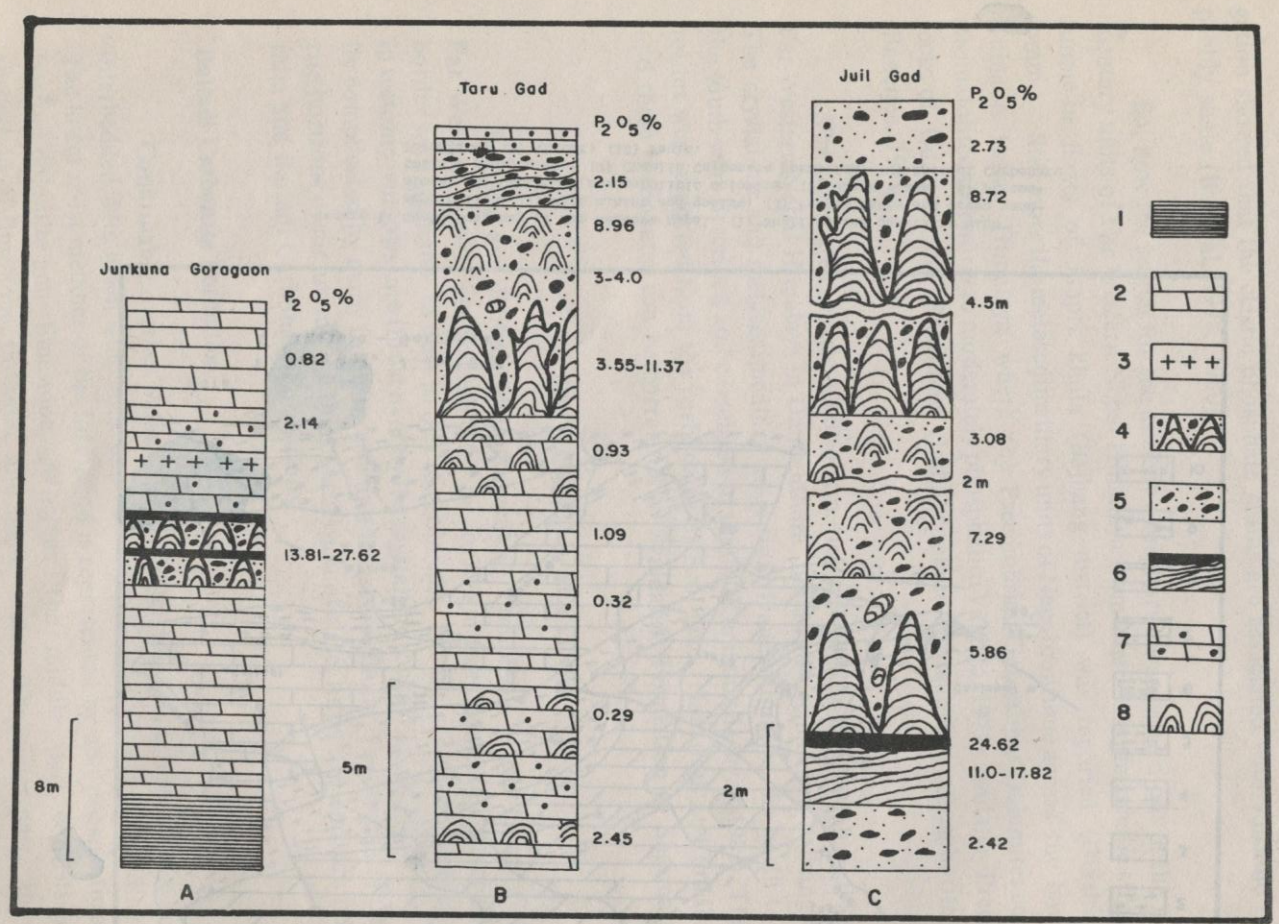


Figure 2: Detail sections of phosphorite horizons. (1) Black slate; (2) Cherty dolomite; (3) Magnesite; (4) Stromatolitic phosphorite; (5) Sandy phosphorite; (6) Laminated massive phosphorite; (7) Feebly phosphatic rocks; (8) Stromatolites.

Table 1 Lithological Succession of Metasedimentary Complexes.

	Formation	Lithology
	Baitadi Carbonate Formation	Dhik Gad Stromatolitic *Phosphorite.* Alternation of black slate, coloured limestone and slate, cherty dolomite.
Baitadi Metasedimentary Complex	Patan Slate	Dhunggad Stromatolitic Dolomite Purple, green, voilet slate with white, dark quartzite and green sandstone
	Taru Gad Shale	Purple shale and green sandstone
		Unconformity
Bajghang Metasedimentary Complex	Chamlia Carbonate	Juil Gad Stromatolitic *Phosphorite.* Thick succession of black slate, coloured slate, limestone, cherty dolomite and locally white quartzite.

Chamlia Carbonate Formation

The Chamlia formation is similar in lithology to that of Baitadi Carbonate Formation (Table 1) and is characterised by a rhythmic succession as follows (top to bottom):

Locally white quartzites;
Cherty dolomites;
White to pink dolomite and limestone with green purple and voilet slates;
Dolomite with black and calcareous slate laminations;
Thinely laminated black slate with basal conglomerate beds.

Three conglomerate beds were noted at the basal part of the black slate in Taru Gad. The pebbles and boulders are similar in lithology to the stratigraphically underlying cherty dolomites thus indicating a sedimentation gap.

Juil Gad stromatolitic phosphorite, exposed in upper part of the field succession to the south of Darchula-Paribagar Thrust, are confined to the cherty dolomites. The

columnar stromatolites observed in Taru Gad, Juil Gad and Khet indicate the reverse field succession.

PHOSPHORITE OCCURRENCES

The stromatolitic phosphorites were discovered, for the first time, in Dhik Gad of Baitadi district and Juil Gad of Bajhang district. The limestone, dolomite and the black chert of the region, at places, are feebly phosphatic. The phosphorite horizons located were traced at a few streams and hill sections. The detail sections together with the chemical composition are described below.

A. Baitadi Area

Along Dhik Gad, a tributary of Chamlia River, the stromatolitic phosphorites with magnesite, yielding up to 10% P_2O_5, were observed in the floats of the stream. The outcrop located at Junkuna village extends up to Goragaon for a distance of 2km.

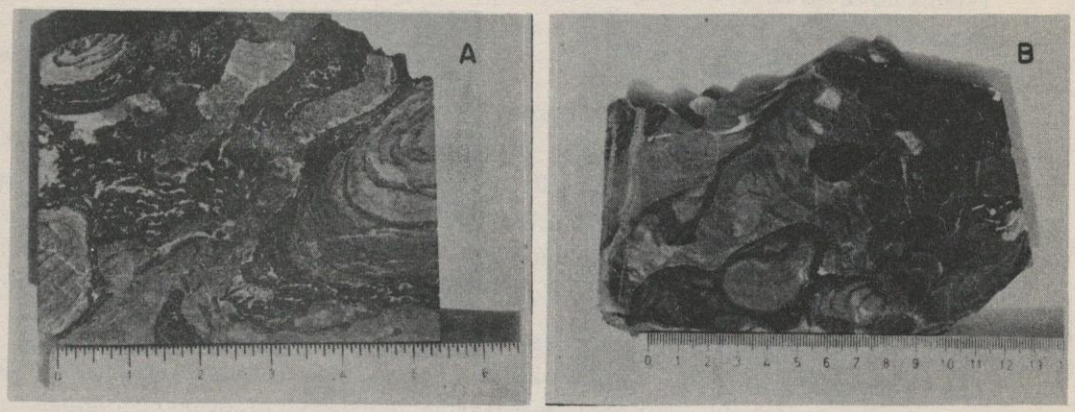
Massive stromatolitic phosphorite bed, more than 4m thick, is confined among cherty dolomites (Fig. 2 A). The stromatolites are highly phosphatised along their marginal parts and the internal algal structure is composed of thin alternations of white dolomite and black phosphate material (Fig. 3 A). The intercolumnar spaces of the stromatolites are filled by sandy type of phosphorite composed of framgments and pellets of phosphate and chert in a carbonate matrix. Phosphate content varies from 10 to 15% P_2O_5.

On the track near Goragaon, the laminated massive phosphorite consists of thin layers of black phosphate (less than 1mm thick) and white-gray cherty dolomite (up to 6 mm thick). The phosphorite bed, 4m thick, contains up to 21 % P_2O_5.

B. Bajhang Area

The phosphorite horizon of Bajhang area is traceable for more than 25km from Paribagar near Seti River in the east to Goichan village in the west. Detail sections were studied in Taru Gad and Juil Gad.

The phosphorite bed in Taru Gad is located 500 m upstream from Jhiri village. The bed dips moderately with 30° to 40° towards north, total thickness of phosphatic rocks is more than 32m. Lower part of the horizon is composed of feebly phosphatic cherty dolomite with magnesite. The stromatolites gradually become more



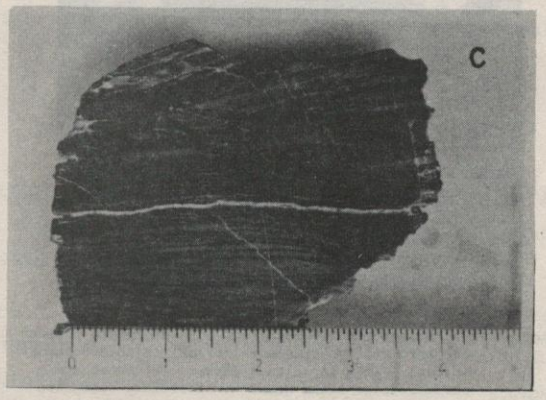
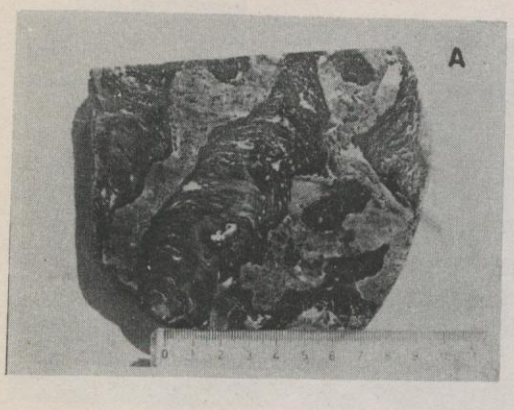


Figure 3: (A) Stromatolites highly phosphatised along the marginal parts, Junkuna, Baitadi;, (B) Intercolumnar space of stromatolites filled by phosphate pellets and fragments (black), Taru Gad; (C) Cross - laminations of phosphate (black) and dolomite (white-gray), Khet village.



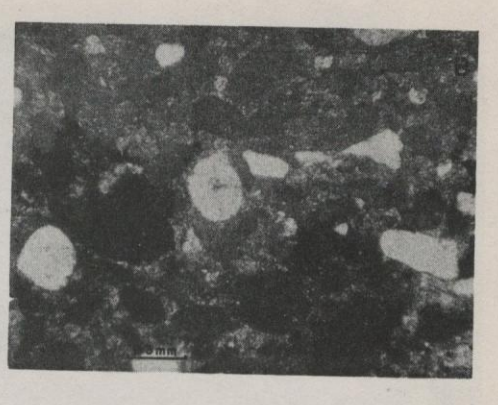


Figure 4: (A) Phosphatic stromatolites with phosphate pellets and stromatolite fragments (black) in intercolumnar spaces. Float in Kalanga River; (B) Phosphate pellets (black) and quartz (white) in a carbonate matrix; Juil Gad; (C) Algal structure with quartz inclusions of laminated massive phosphorite. Juil Gad.

frequent upward and develop into nearly a 6m thick bed of stromatolitic phosphorite containg up to 11.37% P_2O_5 (Fig. 2B). Intercolumnar spaces of the stromatolites are filled by sandy type of phosphorite composed of phosphate pellets and fragements with quartz in a carbonate mass (Fig. 3 B).

Similar phosphate rocks occur in the eastern slope of Khet village and near left tributary of Juil Gad. Here the stromatolitic phosphorite, nearly 15m thick, occurs among sandy phosphorite beds (Fig. 2). Besides other modes of coccurrence, the laminated (0.85 m thick) and massive (0.20m thick) types of phosphorite occur at the base of the stromatolite bed. Cross laminations were visible even in a hand specimen (Fig. 3 C) and the rock contains up to 24.62% $P_2 0_5$.

Towards west the phosphorite horizon was traced and infered at Ramala and Kotila villages, Kadachaur stream and Goichan village. The phosphate pellets and stromatolite fragments in the intercolumnar spaces of the highly phosphatic stromatolites are characteristic in these parts (Fig. 4 A) which contain 18–19% $P_2 0_5$ in average. Flat-pebble conglomerate was found in Kadachaur stream.

Chemical analyses, of some samples show that the stromatolitic phosphorites of the region are poorly to moderately phosphatic ccontaining 10 to 15% $P_2 0_5$ in average.The massive and laminated type of phosphorites are richer yeilding up to 24% $P_2 0_5$ (Fig. 2).

Petrography

The general term "collophane" is used for the phosphate material. The term "sandy" is applied for those phosphorites containing dark phosphate pellet and fragment visible even with naked eyes.

The algal structure in the phosphorites is represented by thinly layered alternation of fine dark collophane and white cryptocrystalline dolomite. Tiny carbonate, quartz and organic inclusions are present in the algal structure. Along the margins, the rounded carbonate grains are replaced by collophane (Goragaon). Sometimes the chert and collophane form the algal structure (Taru Gad).

Petrographic study reveals that the sandy type of phosphorite is composed of pellets and fragments of collophane, carbonate pellets and quartz grains embedded in a fine to medium crystalline dolomite (Fig. 4 B). The collophane pellets, rounded to subrounded of 0.3 mm diameter in average, are present together with elongated blade-like (0.55 mm long) and irregular shaped fragment (3mm).

Massive and laminated phosphorites are composed of thin cross-laminated white medium grained carbonate and brownish yellow to dark collophane (Fig. 4 C). Collophane, locally exhibiting the algal structure, contains tiny grains of carbonate and clastic quartz.

CONCLUSION

The stromatolitic phosphorite horizons of Baitadi and Bajhang area are located in cherty dolomite member of the carbonate formations comprising of a thick succession of black slate, limestone and dolomite. A close association of phosphate and stromatolite is noted as in the Precambrian Gangolihat Dolomite of Kumaun Himalaya (Valdiya, 1972), Precambrian phosphorite of Udaipur, India (Banerjee, (1971) and Cambrian phosphorite of Georgina Basin, Australia (Southgate, 1980). The stromatolites of the present area resemble in their morphological features to the phosphatic stromatolites found in Chandak, Marh, Bisabjer and Range Office of Pithoragarh, belonging to *Collenia columnaris* and *Baicalia baicalica,* which are analogous to Middle Riphean (1260 to 1000 m. y.) stromatolites of USSR (Valdiya, 1969.)

Cross-bedding in the phosphorite and the presence of flat-pebble conglomerate indicate the shallow water condition agitated by waves or tides which may have affected the phosphatic stromatolite columns. Thus many spalled-off angular, elongated and stromatolitic fragments occur in the sandy phosphorite. Well rounded to subrounded collophane pellets occurring in sandy phosphorite indicate constant agitation, probably, by waves. It is suggested by many workers that the benthic algae flourish prolifically in warm and shallow marine environment, particularly, in intertidal zones.

From the economic point of view, further prospecting work is warranted to determine the extension, thickness and grade of the phospherite. The phosphorites known at present are poorly to moderately phosphatic and 4m to 6m thick. The algai bioherm may be of swelling and pinching nature. However the recent research and development of an alternate technology of nitrogen-phosphate in a small scale industry (Le Sieure, 1979; Mio. Eng., 1979) should be evaluated for the phosphorite occurrences of Far Western Nepal.

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