ON THE ENVIRONMENT OF DEPOSITION OF BERINAG QUARTZITES, GANAI-GANGOLIHAT AREA, DISTRICT PITHORAGARH, U. P.

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ABSTRACT

The Berinag Quartzites, the younger group of the Zone of Badolisera of HEIM AND GANSSER (1939) is studied. These are purely arenaceous group of rocks represented by fine to coarse grained orthoquartzites with minor amount of amphibolite, green phyllites and chlorite schists. On the basis of the sedimentary structures present, it is concluded that the lower part of Salia Formation of MISRA AND KUMAR (1968) represents beach-sandy tidal flat environment of deposition. The persistent boulder bed in the upper part of Salia Formation, represents a fluvial deposit formed by fast moving coastal rivers. The middle lithostratigraphic formation, the Ganai Formation, represents a period of extensive igneous activity having several volcanic flows, with intermittent deposition in beach environment. The youngest lithostratigraphic formation, the Simal Formation, was deposited in a beach-coastal sand dune environmnt. The absence of heavy minerals, except tourmaline and zircon, is characteristic of the Berinag Quartzites. Even zircon and tourmaline are present in very meagre quantity, especially in the Simal Formation. The absence of other heavy minerals in these quartzites is due to the fact that these were absent in the source rock i.e., orthoquartzites. Thus, the provenance of the entire Berinag Quartzites is orthoquartzites (possibly the Central Crystallines) which was situated not far from the area of deposition. The Berinag Quartzites represent a coastal sand deposit, in which the subsidence kept pace with the sedimentation. The sea was never deep for more than a few meters during the entire period of deposition and the sediments were derived from the same source. This may be the product of prograding sequence of a regressive sea.

INTRODUCTION

Overlying the Calc Zone of Pithoragarh, the Berinag Quartzites constitute an important and well defined lithostratigraphic group of the sedimentary zone of Badolisera of Lesser Himalaya of Kumaon, U. P. These are purely arenaceous rocks represented by fine to coarse grained orthoquartzites, amphibolites, green phyllites and chlorite schists. They attain a huge thickness of *ca* 2000 m in Pithoragarh District, U. P. (SAFAYA, 1976). These quartzites have attracted the attention of many workers since the work of MISRA AND VALDIYA (1961) and VALDIYA (1962) who considered the entire sedimentary zone, north of the North Almora Thrust, as inverted and contended that the sedimentary zone represented the lower limb of a mighty recumbent anticlinal fold thrusted from north to south.

This assumption of inversion puts the Berinag Quartzites as the oldest horizon of the Zone of Badolisera. Due to the absence of any definite fossils except the occurrence of stromatolites in the Calc Zone of Pithoragarh, this assumption could not be verified conclusively. The inversion theory was largely based on the convexity of the stromatolite laminae. Later workers followed this theory (MISRA & KUMAR, 1968 ; MISRA & BANERJEE, 1968). However, there is another view which considered the sedimentaries as normal (HEIM & GANSSER, 1939 ; GANSSER, 1964 ; RAM JI, 1976). BANERJEE (1975) also modified his earlier view and considered that the entire sedimentary zone as normal with, of course, some local inverted sequences.

For the present work the sedimentaries have been taken as normal which place Berinag Quartzites as the younger and the Calc Zone of Pithoragarh as the older group of the Zone of Badolisera.

In this paper an attempt has been made to record the sedimentary structures in the Berinag Quartzites and on this basis an attempt has been made to reconstruct the environment of deposition. The area of investigation lies in the toposheets 53 O/14 and 62 C/2 of Survey of India. The important villages of the area are Ganai and Gangolihat.

GEOLOGICAL SETTING

The Berinag Quartzites constitute an important and distinct lithostratigraphic group of the Zone of Badolisera of Heim and Gansser (1939) which occupy vast region in the Central Sector of Lesser Himalayas. These sedimentaries are bounded by two thrusted masses. In the north is the Central Crystallines and in the south is the Crystalline Zone of Almora. The entire sedimentary zone is tightly folded into a series of east-west trending plunging anticlines and synclines.

In the present area, the sedimentaries of the Zone of Badolisera are subdivided into two groups, the Calc Zone of Pithoragarh and the Berinag Quartzites, in which the former overlies the latter. The Berinag Quartzites are further subdivided into three lithostratigraphic formations by Misra and Kumar (1968) (Table 1). They have also discussed the structures of the area. These quartzites are in the form of a doubly plunging syncline (Fig. 1). This syncline is variously named as Simal Synform by Misra and Kumar (1968) and Lamkeshwar Syncline by Ram Ji (1976).

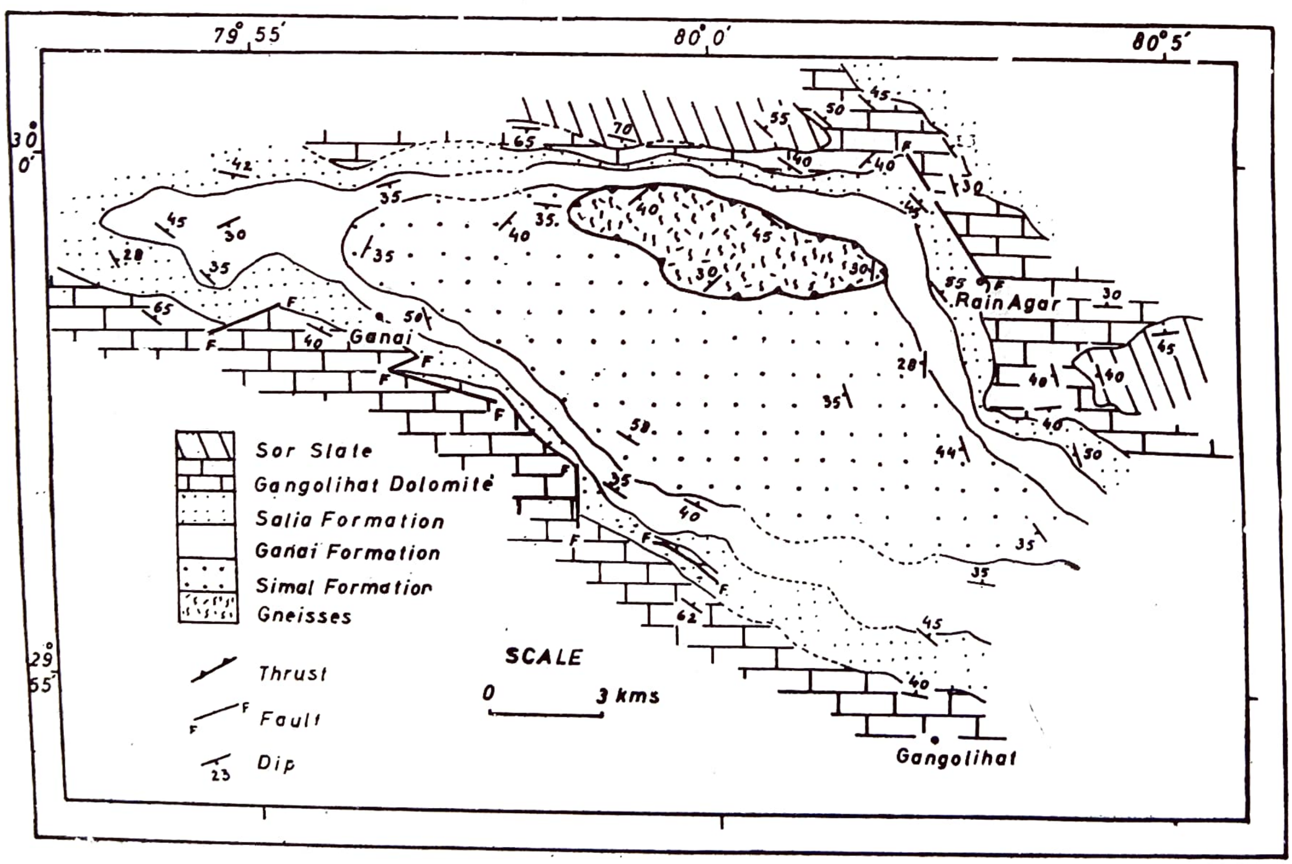


Fig. 1—Geological map of Ganai-Gangolihat area, U. P.

In the central part of the area, the quartzites are overlain by augen gneisses which belong to the Crystalline Zone of Almora. These augen gneisses are also in the form of

Table 1

Group	Formation	Lithology	Environment
Berinag	Simal Formation	Medium to coarse grained orthoquartzites with subordinate chlorite schist and amphibolite.	Coastal sand-beach complex
Quartzites	Ganai Formation	Amphibolites, tuffs, phyllites and fine to medium grained orthoquartzites	Beach
	Salia Formation	Boulder bed Fine to medium grained orthoquartzites with phyllites and amphibolites	Fluvial Beach—sandy tidal flat
Calc Zone of Pithoragarh	Gangolihat Dolomite	Dolomites, dolomitic limestone, stromatolitic limestone with crystalline magnesite and slates	Lagoon-tidal flat
	sor Slate	Slates and protoquartzites	Tidal flat lagoon
		—THRUST—	
Crystalline Zone of Almora	Ratgaria Gneisses	Augen gneisses	

a plunging syncline and constitute a tectonic klippen. The contact between the underlying quartzites and gneisses is taken as thrusted.

LITHOLOGY

The main lithology of this enormously thick succession of rocks is fine to coarse grained orthoquartzites in which 95 to 98 per cent is made up of subangular to subrounded quartz grains cemented together by silica. Sorting is poor to good. The heavy minerals are very rare. Only tourmaline and zircon are recorded. In the Simal Formation tourmaline is almost absent. In opaque minerals hematite and magnetite are recorded.

The boulders, pebbles and cobbles, which are seen in orthoquartzitic matrix, are also made up of orthoquartzites.

The amphibolites, green phyllites and chlorite schists which are present in minor amounts are considered as volcanic equivalent of basic volcanic flows. At places in the green phyllite, bands of relict amygdales can be identified.

SEDIMENTARY STRUCTURES AND ENVIRONMENT OF DEPOSITION

Salia Formation

It is made up of white to light grey orthoquartzites with very minor intercalations of amphibolites, green phyllites and chlorite schists. In the lower part of this Formation the main bedding type is parallel lamination with low angle discordances. The other sedimentary structures are small scale cross bedding, small scale ripple bedding, wave and current ripples, washed ripples and double crested wave ripples (Pl. 1, Fig. 5). At Dasaun Thal where thin silty and shaly bands are developed within orthoquartzites, small scale current bedding, small scale ripple bedding and parallel bedding are the most dominant bedding types. Herringbone structure is well developed which is considered as the characteristic structure of tidal flat environments dominated by tides (Pl. 1, Fig. 3). The other sedimentary structures are mud gals, mud cracks and wave and current ripples (Pl. 1, Fig. 6).

This can be concluded that the lower part of this formation indicates a beach sandy tidal flat environment of deposition.

The middle part shows parallel lamination with low angle discordances, mega ripple bedding and small scale cross bedding. Very large scale mega ripple bedding (Pl. 1, Fig. 1) is the dominant bedding type. Current and wave ripples are also seen. This part must have been deposited in a tidal channel like environment where large scale mega ripple bedding could develop.

In the upper part, the bedding is faintly recognizable and beds appear as massive or very thickly bedded. This massive character may be deceptive in the absence of heavy minerals and clay fractions. Because, even if the bedding is present it is not recognizable in the field. However, poorly preserved parallel lamination with very low angle discordances can be recognized. This part might have been deposited in a beach environment. At the uppermost part of this horizon a persistent band of a boulder bed is seen in which boulders of orthoquartzite are embedded in a matrix of a milky white to light grey orthoquartzites. The cobbles and pebbles are subangular to subrounded. The boulder bed may be the product of fluvial processes deposited by fast moving currents of coastal rivers. The subangular nature of cobbles and pebbles indicate that these were transported not far from the source.

GANAI FORMATION

It is dominantly made up of amphibolites, phyllites, tuffs and subordinate orthoquartzites. The orthoquartzites are interbedded with volcanic rocks which are metamorphosed to amphibolites, phyllites and chlorite schists. The orthoquartzites show parallel lamination with low angle discordances. Perhaps these quartzites were also deposited in a beach environment.

SIMAL FORMATION

This is the thickest formation made up almost exclusively of coarse grained orthoquartzites with occasional thin pebbly bands. These are interbedded with chlorite schists and amphibolites. The orthoquartzites are massive or show well developed parallel lamination, small scale cross bedding and mega ripple bedding. Both trough and planar cross stratifications are profusely developed. Some of the mega ripple bedding shows graded foreset laminae in which the coarser material is in the upper side. Normal graded units are also seen. The cross bedded units show low angle discordances. Some of the low angle discordances show convexity upwards (dune cross lamination of REINECK SINGH, 1973) (Pl. 1, Fig. 4). In few sequences the foreset laminae is making angles between 30°—40° (Pl. 1, Figs. 7-8). In such sequences shaly horizons are surprisingly absent. These units are better sorted. The heavy mineral placers are recorded which are made up of opaque minerals (hematite and magnetite).

The cobbles and pebbles, made up of orthoquartzites and rarely of phyllites, are distributed sparingly in Simal quartzites making a bimodal distribution of grain size.

The Simal Formation was perhaps deposited in a beach like environment. However, some sequences which show better sorting, absence of clay fractions, very high angle of foreset laminae and dune cross bedding, are coastal sand dune deposits. The bimodal distribution due to cobbles and pebbles and some lenticular pebbly horizons in these quartzites indicate mixing of two energy levels. It appears that these pebbles and cobbles must have been brought by coastal rivers and were redeposited by coastal waves.

Thus, the entire thickness of Simal Formation represents a coastal sand deposit. Since the sands, located above the sea level, were exposed to wind activity and also to fluvial agencies this resulted in the modification of sands into low dunes and some river channel deposits. According to GRIPP (1968) coastal dunes develop on stable and specially on prograding shores. Coastal dunes occupy broad zone as wide as 9 kms as in southern Pacific coast.

According to REINECK AND SINGH (1973) in case of the prograding coasts, which are so common in the geological record, the major part of the sand has to be brought in by the rivers.

VALDIYA (1968) has suggested a littoral or beach in stable shelf environment for Berinag Quartzites on the petrographical evidences. However, the bimodal distribution, i.e., textural inversion of FOLK (1959) in these quartzites (i.e., Simal Formation), he ascribed due to the occasional turbulence created possibly by storm.

It can be concluded that after the deposition of Gangolihat Dolomites there was a change from carbonate tidal flat environment to environment suitable for the deposition of terrigenous clastic sediments. The entire thickness of the Berinag Quartzites represents coastal sand deposits predominantly beach coastal sand dune complex which was modified both by tidal currents and coastal rivers,

Heavy Minerals

The heavy minerals of the Berinag quartzites are studied by Kumar (1967, 69). Only zircon and tourmaline are recorded from these quartzites, in which tourmaline is almost absent from the Simal quartzites. The zircon and tourmaline are the most stable minerals in the stability order of heavy minerals (Folk, 1959). The absence of other heavy minerals (except zircon and tourmaline) is quite intriguing. Since the environment of deposition of these quartzites is taken as coastal sand deposit there was every likelihood for the preservation of placers deposits of these heavy minerals but these are surprisingly absent. There can be two reasons for the absence of other heavy minerals from these orthoquartzites:

(1) The heavy minerals suggest that these orthoquartzites are highly matured and only ultra stable minerals could survive the long history of transportation and abrasion. All other heavy minerals were destroyed during this process.

(2) These deposits suggest a second cycle of deposition. All the boulders, cobbles and pebbles except a few which are made up of green phyllites (metamorphosed igneous rock) are made up of very matured orthoquartzites, which indicate orthoquartzite as the source rock for the Berinag Quartzites. The source rock was a matured orthoquartzite in which only tourmaline and zircon were present as heavy minerals. In the second cycle of deposition the heavies were further depleted and during the deposition of Simal Formation only zircon could survive.

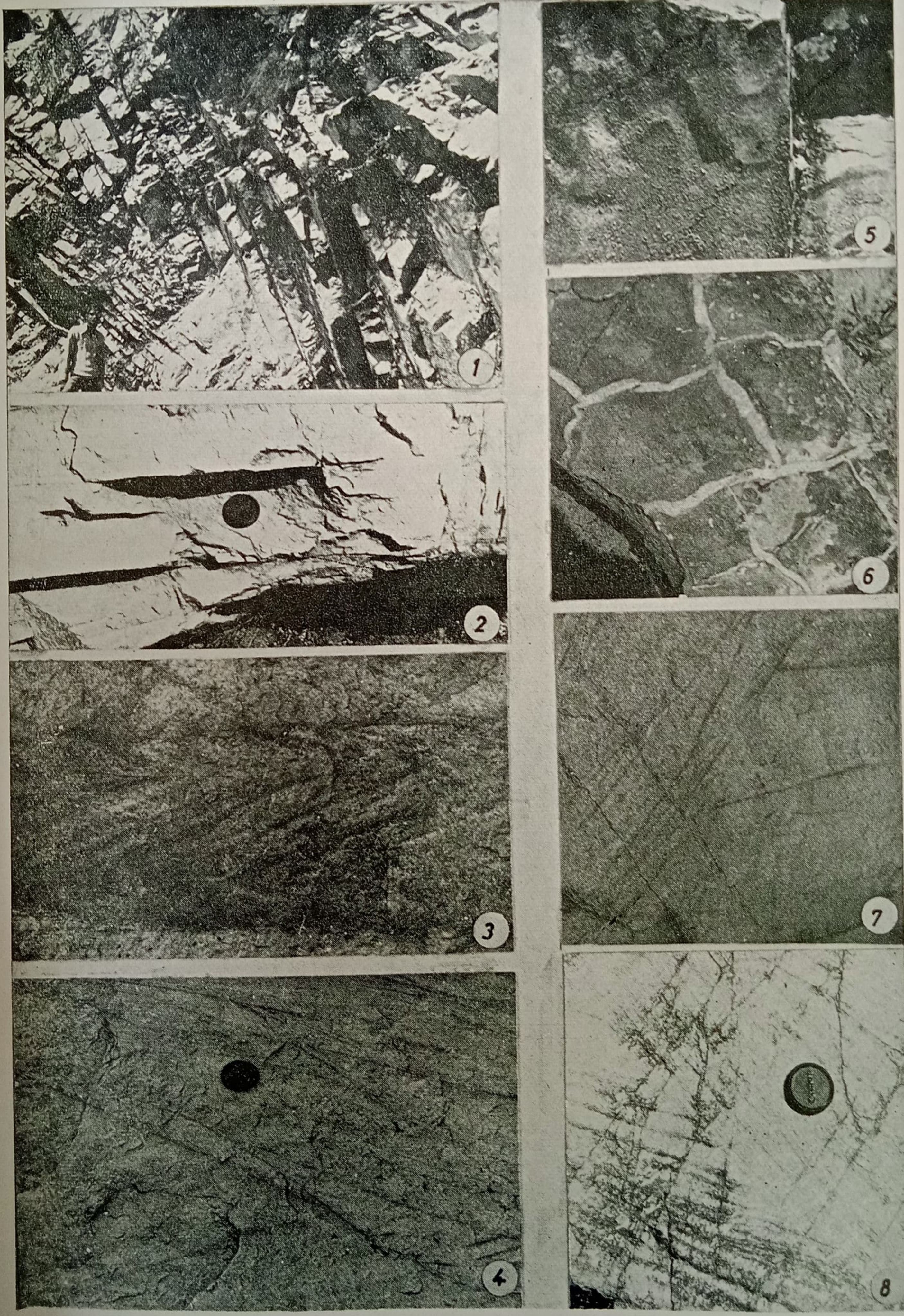
Thus, this can be suggested that the source rock for the Berinag Quartzites was matured orthoquartzites possibly the Central Crystallines and the provenance for the entire period of deposition remained the same. This can also be said that there is no possibility of getting any placer mineral deposits in these orthoquartzites. These orthoquartzites are not matured quartzites in the conventional sense but represent a second cycle of deposition from the orthoquartzitic source area.

Igneous Activity

The Berinag orthoquartzites are interbedded with amphibolites, green phyllites and chlorite schists, which are considered as metamorphic equivalent of basic volcanic rocks. These are especially abundant and conspicuous in the Ganai Formation. It appears that the volcanic activity started during the Salia Formation times and reached maximum development during the deposition of Ganai Formation. But during the deposition of Simal Formation the igneous activity considerably diminished. The entire thickness of Berinag Quartzite took place in a very shallow coastal environment. It appears that the volcanic flows took place near the coast most probably above the sea level, i.e. on land. A few pebbles and cobbles of green phyllites in the Simal Formation bear testimony to this fact which were deposited along with other clastic material near the coast.

Sedimentary Tectonics

About 2000 m thick sequence of Berinag Quartzites is a product of a very shallow coastal environment in which the water was never deep for more than a few meters and this continued for the entire period of deposition with little variation. These deposits were modified by wind and fluvial agencies. The subsidence kept pace with sedimentation. The source was not far from the area of deposition and the rivers which brought the sediments continued to do so during the entire period of deposition. All this suggests that the sedimentation of Berinag Quartzites took place on a stable platform area, and is the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product of prograding sequence of a regressive sea. At the same time the volcanic flows indicate rather unstable tectonic conditions. But this association is typical of Precambrian terrains (SINGH, 1978). According to FOLK (1968) the orthoquartzites (quartzarenite) derived from the reworked sediments require no period of stability and can be formed under any tectonic framework. In such rocks the maturity is generally low and they are characterised by many textural inversion.

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REFERENCES

BANERJEE, D. M. (1975). Stratigraphy of Bageshwar area, a reinterpretation. *Himalayan Geol.* **5** : 348-359.

FOLK, R. L. (1959). *Petrology of sedimentary rocks.* Hem. phillis. Austin.

GANSSER, A. (1964). *Geology of the Himalayas.* Interscience Publishers, New York.

GRIPP, K. (1968). Zur jüngsten Erdgeschichte von Hörnum/Sylt und Amrum mit einer Übersicht über die Entstehung der Dünen in Nordfriesland. *Die Kuste* **16:** 76-117.

HEIM, A. & GANSSER, A. (1939). Central Himalaya. *Mem. Soc. Helv. Sci. Nat.* **73**(1) **9**.

KUMAR, S. (1967). Structure, stratigraphy and petrology of the rocks of Daniya area, districts Almora-Pithoragarh, U. P. *Unpublished Thesis submitted to Lucknow University.*

KUMAR, S. (1969). Sedimentological studies of the quartzites of the Zone of Badolisera, districts Almora-Pithoragarh, U.P. *56th Indian Sci. Congr.* Part III.

MISRA, R. C. & BANERJEE, D. M. (1968). Sedimentological studies in the Calc Zone of Pithoragarh, U. P. *Publs. Adv. Cent. Study Geol.*, Panjab Univ., Chandigarh **5** : 131-147.

MISRA, R. C. & KUMAR, S. (1968). An outline of stratigraphy and structure of Badolisera area, Pithoragarh-Almora districts, U. P. *Publs. Adv. Cent. Study Geol.*, Panjab Univ. Chandigarh **5** : 89-100.

MISRA, R. C. & VALDIYA, K. S. (1961). The Calc Zone of Pithoragarh with special reference to the occurrence of stromatolites. *J. geol. Soc. India* **2** : 252-270.

RAM JI (1976). Stratigraphy and structure of the Garhwal Group in parts of Almora and Pithoragarh, districts, U. P. *in Himalayan Geology Seminar,* New Delhi.

REINECK, H. E. & SINGH, I. B. (1973). *Depositional sedimentary environments.* Springer-Verlag, Heidelberg.

SAFAYA, H. L. (1976). Magnesite deposits of Kumaon Himalaya, U. P.—Depositional environment, genesis and economic utility. *in Himalayan Geology Seminar,* New Delhi.

SINGH, I. B. (1978). Some problems concerning the study of sedimentary rocks in the Precambrian. *Geophytology* **8** (1) : 10-18.

VALDIYA, K. S. (1962). An outline of the stratigraphy and structure of southern Pithoragarh, U. P. *J. geol. Soc. India.* **3** : 27-48.

VALDIYA, K. S. (1965). Petrography and sedimentation of the sedimentary zone of southern Pithoragarh, U. P. Himalaya. *D. N. Wadia Comm. Vol., Min. Metall. Inst. India.* 521-543.

VALDIYA, K. S. (1968). Origin of the magnesite deposits of southern Pithoragarh, Kumaon Himalaya, India. *Econ. Geol.* **63** : 924-934.

EXPLANATION OF PLATE 1

1. Large scale mega ripple bedding, middle part of the Salia Formation, Ganai-Seraghat motor road.
2. Parallel lamination in the upper side and low angle discordances in the lower side, middle part of the Salia Formation, Ganai-Seraghat motor road.
3. Herringbone structure in the Salia Formation, Dasaun Thal $\times\frac{1}{4}$.
4. Small scale current bedding. Upper part shows sand dune cross bedding with convexity upwards, the Simal Formation, Gangolihat-Berinag motor road.
5. Washed ripples in the Salia Formation, Ganai-Seraghat motor road.
6. Mud cracks in the Salia Formation, Dasaun Thal $\times\frac{1}{6}$.
7. High angle cross bedding in the Simal Formation, near Nag on Gangolihat-Berinag motor road.
8. High angle cross bedding in the Simal Formation, near Nag on Gangolihat-Berinag motor road.