CARBONATE SEDIMENTATION AND LITHOGENESIS OF THE DOYA DOLOMITE FORMATION (CALC ZONE OF TEJAM) OF THE BAGESHWAR-KAPKOT AREA, DISTRICT ALMORA, UTTAR PRADESH

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ABSTRACT

The present paper incorporates the various aspects of sedimentation of the Doya Dolomite, which is one of the formations of the Calc Zone of Tejam of the area under study. This is a predominantly calcareous formation, whose lithologic variations/associations and petrographic attributes have been briefly given in the paper.

During most of the basinal history of this formation, the environment embraced chemical conditions. The site of deposition was far away from the mainland, as a result of which, rapid influx of detritus was not possible. The deposition of this formation appears to have taken place under tectonically stable shelf conditions. During some of the earlier periods of the sedimentational history, the environment was biochemically controlled, because of stromatolitic algal photosynthesis. The chemical admixtures like primary silica, iron and pyrite have variedly affected the chemical realm of sedimentation. A low CO_2 content, warm water and oxygenated humid climate, might have predominated during the carbonate sedimentation. However, short-lived periods of restricted circulation, under euxinic conditions, also intervened.

The basin possibly embraced an infra-neritic environment during most of its history. A biostromal suite of some of the earlier parts of the basinal history was, more or less, cyclically repeated by the carbonate—shale suite, during the later parts. The latter suite witnessed euxinic and shale facies, which intertongue with the limestones.

An attempt has been made to elucidate the various stages of lithogenesis, leading to the final lithification, of the carbonate rocks of this formation.

INTRODUCTION

A thick sequence of calc-argillaceous rocks—the Calc Zone of Tejam extends in the northern part of the Almora district. The carbonate rocks of this Zone, which occur in wide spread belts in the northern Kumaon Himalaya, are devoid of recognisable fossils, excepting the algal stromatolites, which are also restricted to certain horizons.

The Bageshwar—Kapkot—Loharkhet area (Text-fig. 1), covering some 500 square kilometres, was mapped and geologically studied in detail for the first time by Misra and Bhattacharya (1972). Bhattacharya (1971) dealt with the petrographic studies of the carbonate rocks around Kapkot. Misra and Banerjee (1968) worked out the geology of the adjoining area, east of the present. The works of Heim and Gansser (1939) and Gansser (1964) give broad outlines of the geology of the entire Kumaon Himalaya on a regional basis.

LITHOSTRATIGRAPHY AND PETROGRAPHIC NOTES

In the area under study, the hitherto unclassified Calc Zone of Tejam (named by Heim & Gansser, 1939), has been subdivided into four formations (Misra & Bhatta-

CHARYA, 1972): (i) Doya Dolomite, the stratigrphically oldest, followed up by (ii) Hatsila Slate, (iii) Kapkot formation, and (iv) Saling Slate. On the basis of the disposition of the sedimentary structures and bedding-cleavage relationship, the Doya Dolomite and the Hatsila Slate appear to be inverted in nature, the latter two formations being in normal position. A thrust, designated as the Kaphauli Thrust by MISRA and BHATTACHARAY (1972), separates these two pairs of formations. The Calc Zone stratigraphically rests on a group of quartzites (which appears to be inverted in the field), exposed in the southern part around Bageshwar—the Berinag group.

The scope of the present paper is confined to the sedimentation and lithogenesis of the Doya Dolomite formation, which is predominantly a carbonate sequence. Text-figure 2 shows the outcrops of this formation and the adjoining rock units. In the present area, this formation is synelinally folded into a huge plunging syncline, along with the overlying and underlying formations. This formation can be correlated with the Gangolihat dolomite (MISRA & VALDIYA, 1961; VALDIYA, 1962; MISRA & BANERJEE, 1968) of the adjoining areas.

The constituents of the Doya Dolomite formation include limestone and dolomite (often with magnesite stringers chert and stromatolites of the genus *Collenia*), and subordinate slates and black carbonaceous slates. A generalised physical succession of the various rock types of this formation, for the northern limb of the syncline, has been shown in Text-figure 3. It must be noted that stratigraphic succession being inverted for this formation, what occurs at the physical top is actually the stratigraphic base and *vice versa*.

Petrographically, the carbonates are mostly composed of calcilutite/dololutite, calcarenite/dolarenite, and rarely dolorudite. Dolomitisation is a common phenomenon. Hematite, magnetite, pyrite, limonite and carbonaceous matter are found disseminated in the carbonate rocks.

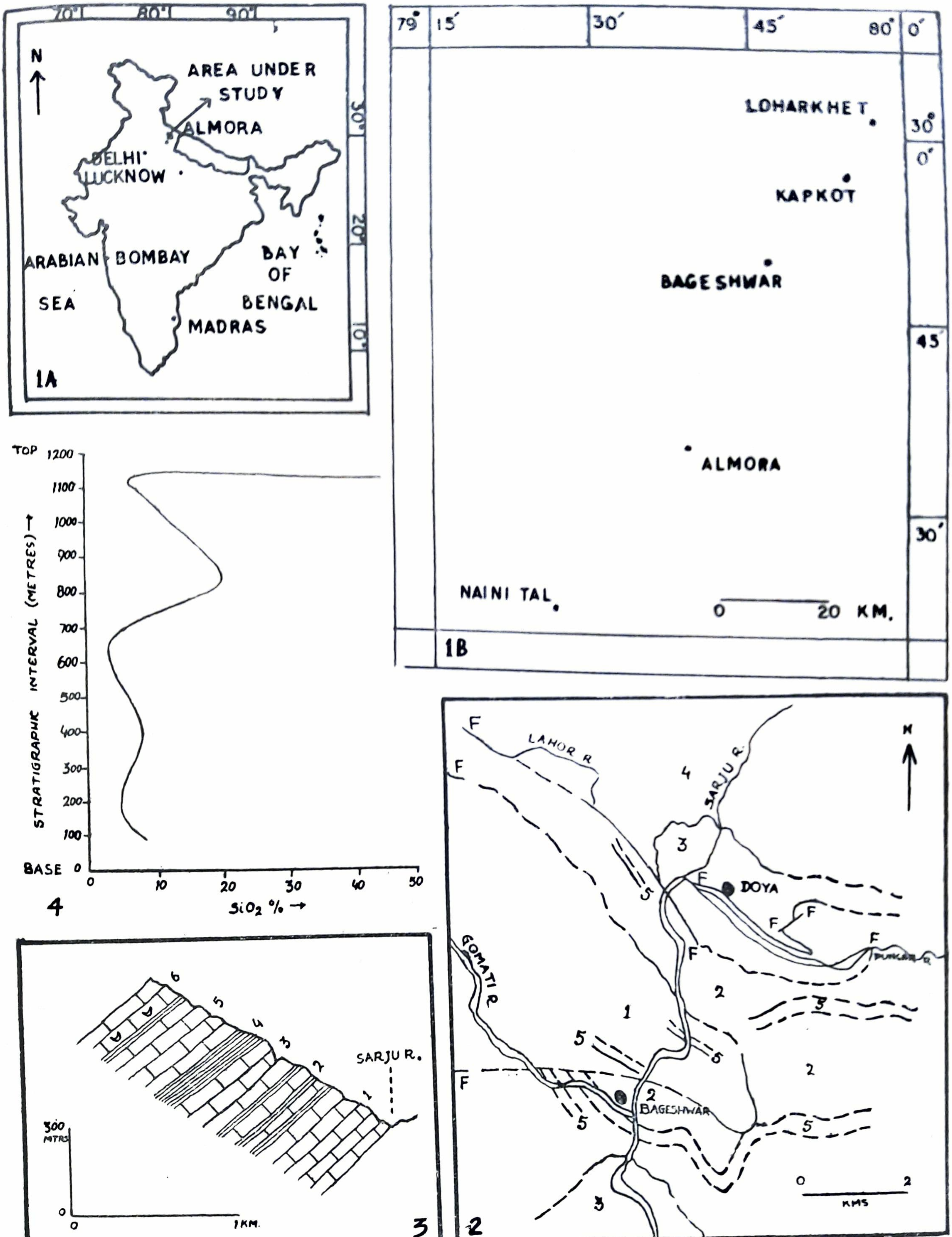
SEDIMENTATION

After the deposition of the rocks of the Berinag group, the basin acquired a somewhat different set-up of environmental conditions. The period of heavy and regular influx of detrital material was not prominent. It became more deeper. The basin, thus, mainly turned to be a site of chemical precipitation. The various aspects of sedimentation of this formation are described below.

THE PHYSICOCHEMICAL REALM

A substantial part of the carbonate rocks of this formation includes micrites or the microcrystalline ooze. They are the product of direct and relatively rapid chemical precipitation out of sea water (FOLK, 1959). They are, thus, the first cycle or autochthonous limestones. They might have also been formed by the mechanical abrasion of the carbonate grains (FOLK, 1959). In short, they are orthochemical constituents, because they are chemical precipitates. The overall uniformity in mineralogical and textural characteristics of these micrites indicates that the intrabasinal chemical activity was not subjected to any (major) change of conditions in the depositional basin. Their deposition indicates that during sedimentation, currents were either absent or not strong enough to winnow away or dis-

5—Bedded Dolomite, often with altered copper pyrites, 6—Dolomite, often with stromatolites and magnesete stringers; 4. Distribution of (primary) silica at different stratigraphic levels of the Doya Dolomite formation. All the samples analysed are siliceous limestones, corresponding to the representative horizons of the formation.



Text-figs. 1-4—1. Location map of the area under study; 2. Distribution of the outcrops of the Doya Dolomite formation. 1—Baijnath Crystallines, 2—Berinag group, 3—Doya Dolomite formation, 4—Hatsila Slate formation, 5—Basic rocks, F—Fault; 3. Cross-section across the Doya Dolomite formation, showing the variations in lithology. 1—Limestone and dolomitic limestone (with chert lenses and magnesite stringers in lower horizons), 2—Interbedded black slates and phyllites, 3—Massive dolomite, 4—Black slates and phyllites, the respective horizons of this formation thus, suggests an oxygenated chemical environment of deposition.

(iii) *Pyrite*—Pyrite, as a chemical sediment, like iron oxides, is also of some importance. It occurs in relatively lower stratigraphic levels of this formation. Formation of pyrite requires acid or weakly basic solutions. According to CHILINGAR, BISSEL and WOLF (1967, p. 244), the occurrence of silica with pyrite suggests that both formed in reducing, low-pH conditions characteristic of the basinal euxinic black limestone and marl facies. They hold that pyrite is confined to some deep water limestone facies, and doubtfully assign its origin to anaeorobic bacterial activity, possibly under euxinic conditions.

CLIMATE

The ocean water might have been warm and the CO_2 content low (perhaps through evaporation or photosynthesis), because these are theideal conditions for carbonate sedimentation. Cold water and abundance of CO_2, on the other hand, promotes dissolution of the carbonates.

The overall lithology of this formation, points to its deposition in oxygenated humid climate, as is indicated by the general lack of evaporites and the related rock types. The repository was an open ocean with free circulation. However, short-lived periods of restricted circulation under euxinic conditions also intervened, as revealed by the presence of the interbedded black slates and the dark coloured limestones.

BATHYMETRIC CONSIDERATIONS

In general, it may be said that during the earlier part of the depositional history, the area embraced a shallow and open intertidal marine environment. Later, the basin encountered short-lived periods of still deeper conditions, as indicated by the presence of argillaceous limestones, which are believed to be of deep water origin. Eventually, a general deepening–the infraneritic environment—followed, till the deposition of the whole of the carbonate sequence was over, which, in turn, gave way to another thick sequence of argillaceous suite—the Hatsila Slate formation.

FACIES RELATIONSHIP

The tectonically stable shelf area of the Berinag--Doya sedimentation, represents a thick orthoquartizite-carbonate suite of rock types. As a result of local, short-lived and lateral variations, in space and time, of the environmental conditions during the Doya sedimentation, some of the lithologic units intertongue and pinch out. A biostromal suite of some of the earlier parts of the basinal history was, more or less, cyclically repeated by the carbonate-shale suite, during the later parts. The latter suite embraced euxinic and shale facies, which intertongue with the limestones. A model of the sedimentary environments, showing the facies relationships, existing in the Doya Dolomite formation, has been shown in Text-figure 5.

LITHOGENESIS OF THE CARBONATES

After processing the petrographic and field data, an attempt may be made to elucidate the various stages of lithogenesis of the carbonates of this formation. The most probable sequence, resulting in the final lithification, is schematically shown in Fig. 6, and is described below.

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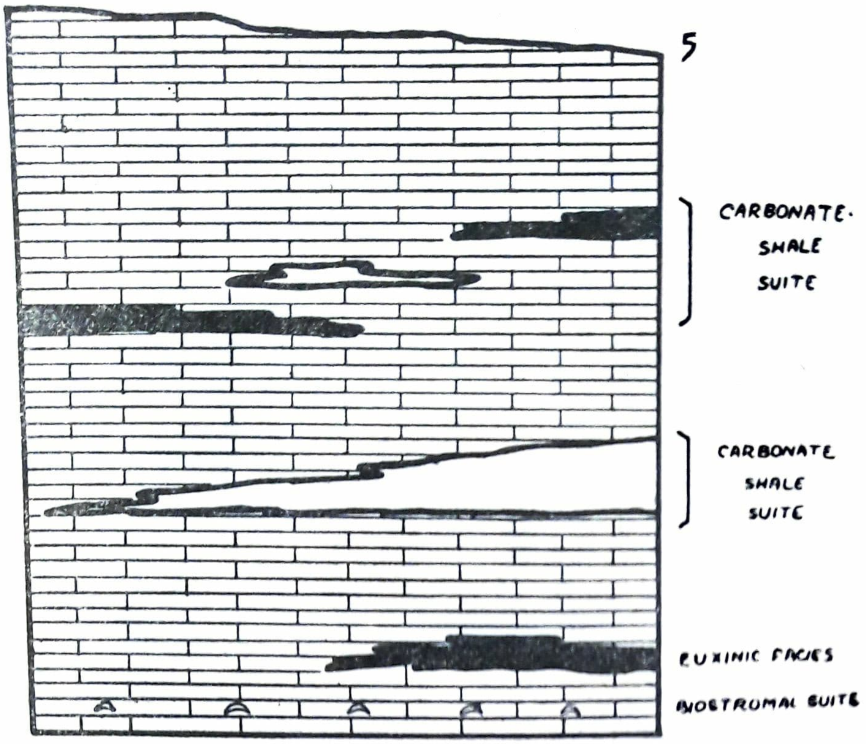

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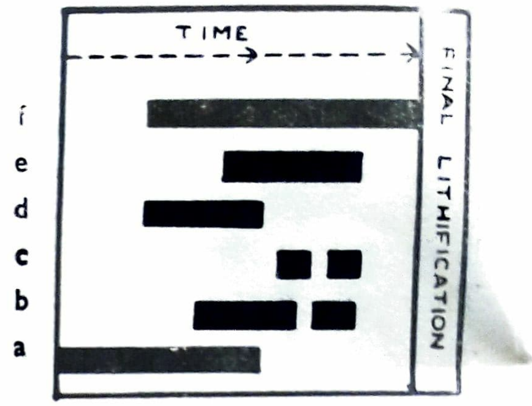

Text-figs. 5-6.—5. A model of the sedimentary environments, showing the facies relationship and the lithologic associations within the Doya Dolomite formation; 6. Tentative schematic diagram showing the stages of carbonate paragenesis of the Doya Dolomite. (*a*) Deposition of $CaCO_3$ and some silica. (*b*) Dolomitisation (partially interrupted by primary silica precipitation). (*c*) Intermittent silica replacement by carbonate. (*d*) Submarine, penecontemporaneous transportation of the carbonate fragments (by currents). (*e*) Partial, short-lived exposure to the wave-base. (*f*) Compaction, leading to the final lithification.

It appears that originally calcite ($CaCO_3$) was precipitated from the sea water. However, studies on the modern carbonates reveal that aragonite ($CaCO_3$), which is a pseudomorph of calcite, and high-magnesian calcite, are the first to precipitate. The former readily, converts to calcite, because of its metastability. This phenomenon is known as 'inversion. For this reason, aragonite is believed to be absent in ancient (especially Precambrian and Mesozoic) carbonates. Precipitation of primary dolomite is still a debatable question, although most of the workers believe it to be of secondary origin. However, petrographic studies reveal that the dolomites of the present area, appear to be the product of dolomitisation that affected the respective horizons.

After the primary deposition of $CaCO_3$, the phenomenon of dolomitisation ensued, which was interrupted by partial (primary) silica deposition. However, the degree of dolomitisation was not uniform—it was, more or less, a case of selective dolomitisation. Thereafter, intermittent, but partial, replacement of silica by the carbonates followed. Penecontemporaneous submarine transportation of the earlier-formed carbonates was active within the basin, and gave rise to the deposition of calcarenites and calcirudites (i.e. the allochemical constituents). While, normal sedimentation was in progress, short-lived periods of partial emergence to the wave base also intervened. Ripple-marked and cross-bedded carbonates are the products of such a situation. At the end, when the sediments settled finally, the phenomenon of compaction—which is one of the most important processes of diagenesis—led the rocks to the final lithification.

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