OOLITES FROM THE THALKEDAR DOLOMITE FORMATION (LATE PRE-CAMBRIAN) AND THEIR SIGNIFICANCE IN DIAGENESIS

S. KUMAR AND R. KUMAR

Geology Department, Lucknow University, Lucknow–226 007

ABSTRACT

The oolites of the Thalkedar Dolomite of the Calc Zone of Pithoragarh are studied. On the basis of the composition and internal structure, the oolites are classified into five types ; concentric oolites, siliceous oolites, composite oolites, radial oolites and sparry oolites. These oolites have been subjected to diagenetic changes and the following sequence is observed ; (1) Recrystallization, (2) Dolomitization, (3) Early silicification and (4) Late silicification (Epidiagenetic silica). On the basis of the presence of oolites, the environment of Thalkedar dolomites is discussed.

INTRODUCTION

In recent years much attention has been given to the areas of carbonate sedimentation, which are extensively studied in the Carribbean Sea, the Mediterranian Sea, the Persian Gulf, the Gulf of Mexico and other areas. These studies helped in better evaluation of the presence of oolites in the ancient rocks which have been considered as a reliable indicator of the physical parameters as well as chemical milieu of the depositional medium.

The Thalkedar Dolomite is a thick succession of rocks well exposed in the southern part of Pithoragarh District, U. P. It constitutes a well defined lithostratigraphic formation of the sedimentaries of the Calc Zone of Pithoragarh. The lithology of this formation is represented by micritic dolomites, stromatolitic dolomites and siliceous dolomites and slates. The present paper records for the first time a well developed oolitic horizon from the middle part of this formation. An attempt has been made to study these oolites in thin section in detail and on this basis the environment of deposition and diagenetic changes of these dolomites have been discussed.

GEOLOGICAL SETTING

The Calc Zone of Pithoragarh belongs to the sedimentaries of the Zone of Badolisera of Heim and Gansser (1939), which occupies a vast area in the Pithoragarh-Almora Districts, U. P. Valdiya (1962, 1968) has subdivided the sedimentaries of the Zone of Badolisera into two groups, viz., the Berinag Quartzite and the Calc Zone of Pithoragarh. The Calc Zone of Pithoragarh has been further subdivided into 4 lithostratigraphic formations (Table 1).

Thalkedar Dolomite

The Thalkedar Dolomite Formation attains a huge thickness of several hundred metres around Gurna (Fig. 1). It is best exposed on Gurna-Ghat motor road. A well preserved 1 m thick oolitic horizon is recorded in the middle part of this formation. The litholog showing oolite bearing horizon is shown in Fig. 2. The sedimentary structures

Table 1—Lithostratigraphic succession of the Calc Zone of Pithoragarh (Modified after Valdiya (1968)

ZONE OF BADOLISERA		Berinag Quartzites	Orthoquartzites and amphibolites
ZONE OF BADOLISERA	CALC ZONE OF PITHORAGARH	Gangolihat Dolomite	Lower member comprises massive dolomites and dolomitic limestones development of both columnar and stratified stromatolites (*Conophyton garganicus-Baicalia-Colonella* assemblage). It includes the lentiform deposits of magnesite. The upper member consists of tuffaceous purple phyllites and light coloured dolomites
ZONE OF BADOLISERA	CALC ZONE OF PITHORAGARH	Sor Slate	Olive green, brown, grey and black slates with orthoquartzites and subordinate argillaceous dolomitic limestone
ZONE OF BADOLISERA	CALC ZONE OF PITHORAGARH	Thalkedar Dolomite	Siliceous dolomite, dolomitic limestones and slates, with well developed stratified stromatolites *Stratifera* and *Gongylina*
	CALC ZONE OF PITHORAGARH	Rautgara Quartzite	Brown and greyish pink protoquartzite and purple green and brown slates
— — — North Almora Thrust — — —			
		Crystalline Zone of Almora	Porphyrites, schists, quartzites and gneisses

associated with this part of the formation are parallel bedding with low angle discordances, small scale ripple bedding, stromatolitic dolomites with occasional algal mat horizon, ripple marks and mud cracks. The stromatolites associated with this horizon are stratified stromatolites *Gongylina* and *Stratifera* (Kumar & Kumar, 1977). According to Hoffman (1976) the stratified stromatolites indicate low tidal/current scour. Thus, the sedimentary structures and the stromatolites indicate a supratidal to high intertidal environment of deposition which must have been subjected to intermittent aerial exposure as borne out by mud cracks.

Oolites

On the basis of internal structure and composition, the Thalkedar oolites have been classified into 5 types which range in diameter from 0.3 to 1.1 mm. Their relative

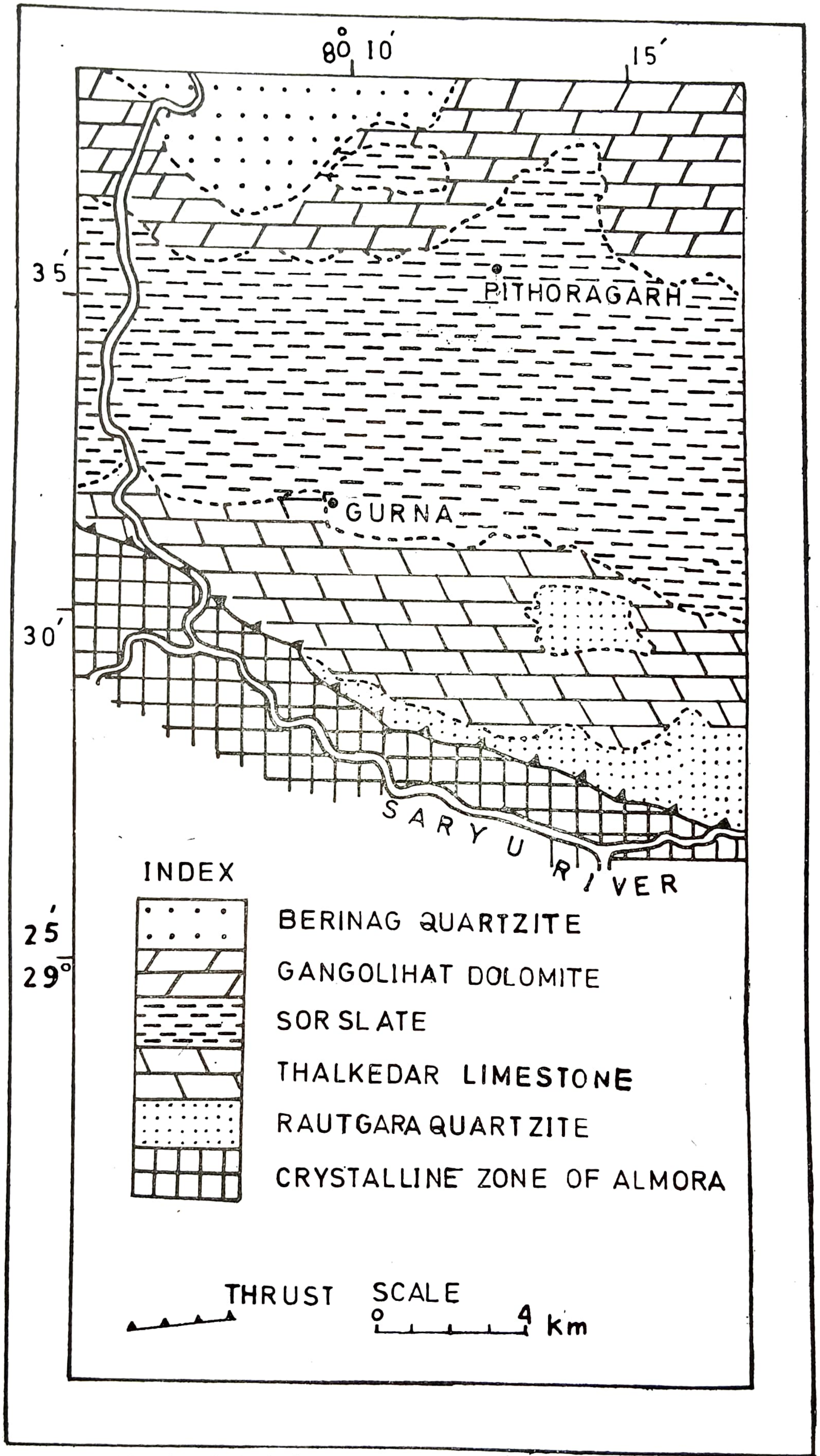

Fig. 1. Geological map of Gurna area (After Valdiya, 1962).

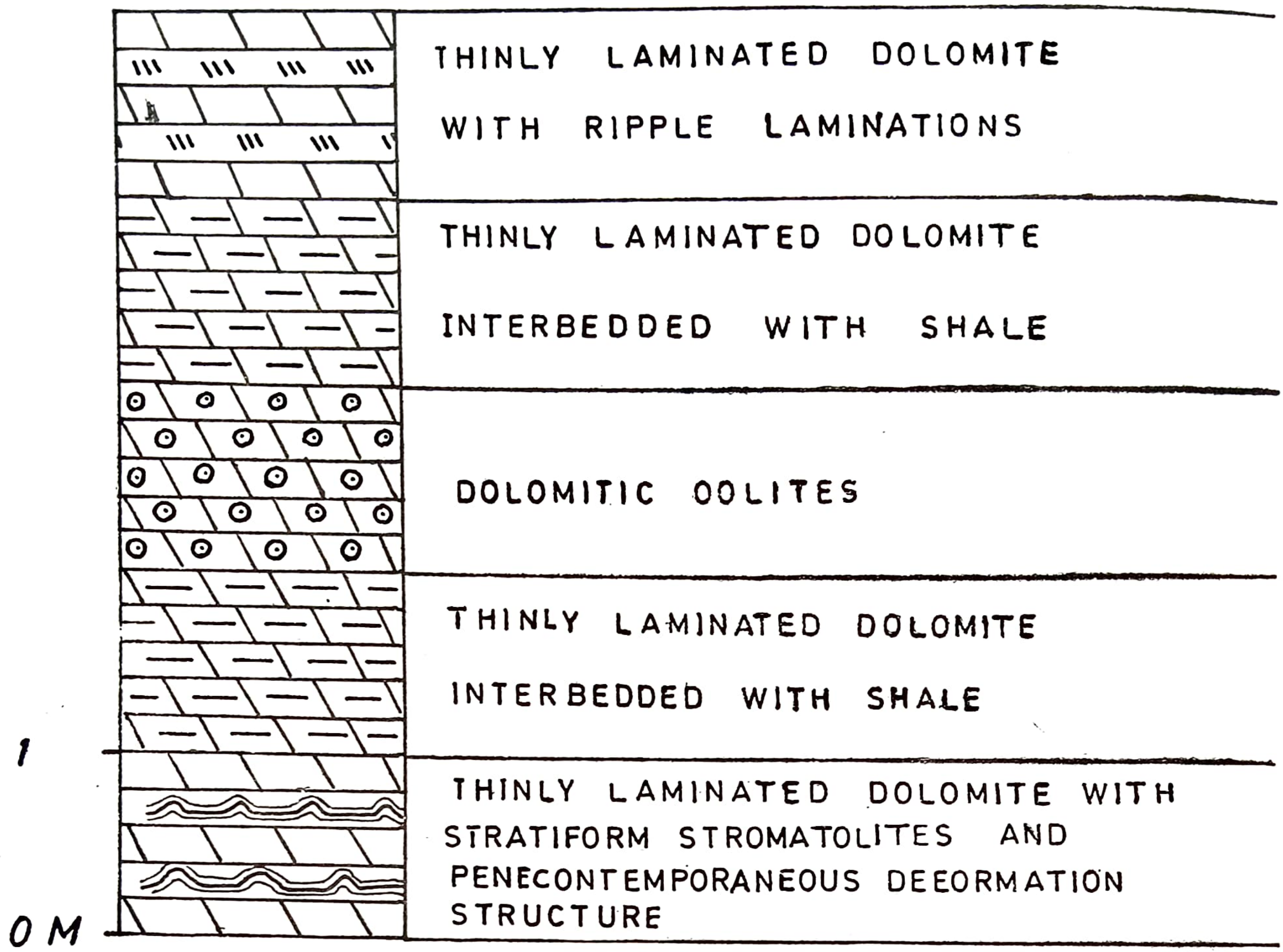

Fig. 2. Litholog of oolite bearing horizon, Thalkedar Dolomite.

abundance is given below on the basis of the counting of more than 300 oolites in thin sections :

1. Concentric oolites .. .. 50 %
2. Siliceous oolites .. .. 30 %
3. Composite oolites .. .. 5 %
4. Radial oolites .. .. 7 %
5. Sparry oolites .. .. 8 %

The relative abundance of the different sizes of oolites of various composition and texture are shown in Fig. 3.

1. *Concentric Oolites*

The concentric oolites (Pl. 1, Fig. 2 ; Pl. 2, Fig. 3) show successive concentric rings and may or may not have a nucleus. The maximum concentric rings recorded are 32. Oolites are mostly circular and a very few are elliptical in shape. More than 90 % of the oolites have a nucleus, which is circular, polyhedral or oblate in shape. The nucleus is made up of aggregates of fine to coarse grains of dolomite. The concentric texture of the envelope results from a superposition of extremely thin individual layers, corresponding to successive phases of accretion separated by phases of interruption. The concentric oolites range in diameter from 0.3 to 0.8 mm. They are generally large with an average equatorial diameter of 0.59 mm.

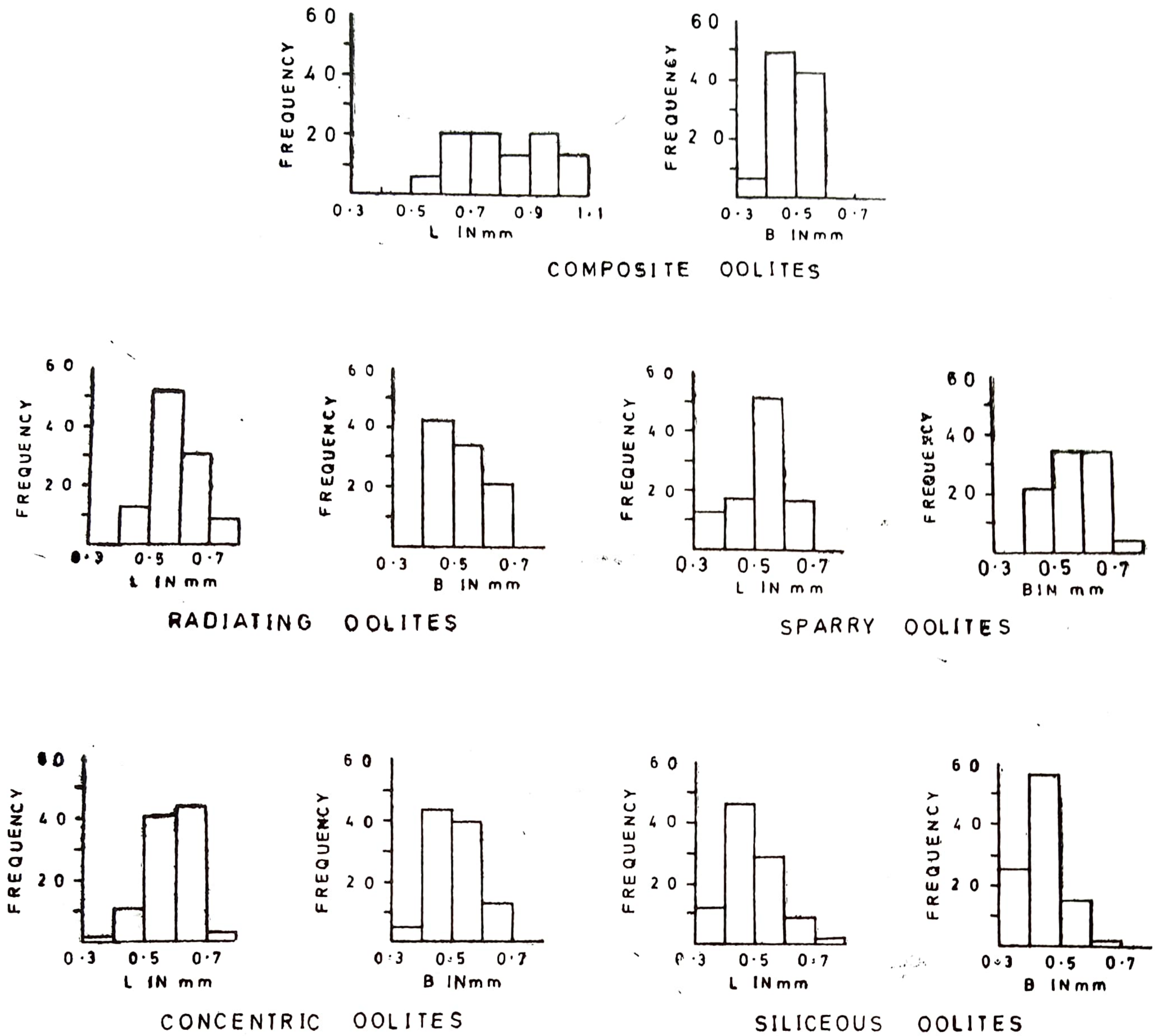

Fig. 3. Histogram showing relative abundance of different sizes of oolites.

2. *Siliceous Oolites*

Some oolites are completely silicified and show no distinct features (Pl. 1, Figs. 2, 3). They are made up of micro-crystalline to cryptocrystalline silica. They mostly consist of concentric rings and a central nucleus of variable size but these concentric rings are not clearly individualized and therefore show no distinct internal structure. Silicification of the carbonate oolites varies in degree from partial replacement of nucleus and/or concentric layers (Pl. 1, Fig. 1) to complete replacement of both (Pl. 1, Fig. 3). Micro texture and structure in siliceous oolites are rarely preserved. They range in diameter from 0.3 to 0.8 mm. The average equatorial diameter is 0.49 mm.

3. *Composite Oolites*

Sometimes oolites are joined to each other through an extension of one of them and consist of a common envelope (Pl. 1, Fig. 4). They are mostly concentric oolites which are joined to each other. The other features are similar to cencentric oolites. They range in length from 0.5 to 1.1 mm. and in breadth from 0.3 to 0.6 mm. The average equatorial diameter is 0.81 mm.

4. *Radial Oolites*

The oolites showing radial structure (Pl. 2, Figs. 1, 3) contain alternating spokes of finely crystalline and microcrystalline dolomite. These alternating spokes are 8—16 in number. The radial texture is of diagenetic secondary origin as indicated by the fact that certain radial fibres extend outside the envelope, encroaching on the matrix (CAYEUX, 1935 ; in CAROZZI, 1960). Radial oolites are circular to subcircular in shape and range in diameter from 0.4 to 0.8 mm. They are nearly always smaller than the concentric and sparry oolites and have an average equatorial diameter of 0.57 mm.

5. *Sparry Oolites*

The sparry oolites (Plate 2, Figs. 2, 3) appear to have resulted from the partial recrystallization of the concentric and radial oolites. The typical sparry oolites possess an internal microcrystalline texture. Sometimes nucleus is also seen. These oolites are circular to subcircular in shape and range in diameter from 0.4 to 0.8 mm. They have an average equatorial diameter of 0.62 mm.

DIAGENESIS

In the study of fossil oolites it is assumed that the original composition of the oolite was either of aragonite or calcite (MC GANNON JR., 1975). This assumption is in accordance with the findings based on the study of recent oolites. Thus, in the present work it is also assumed that the oolites were originally made up of aragonite or calcite and these were subjected to diagenetic process of dolomitization and silicification.

Dolomitization

The oolites were originally made up of concentric layers of aragonite or calcite. These oolites have been completely dolomitized thus showing no evidence of original composition. The process of dolomitization has partly or completely destroyed the concentric texture of the oolites (Pl. 2, Fig. 3) through the development of dolomite rhombs along their boundaries with dolomicrite groundmass. However, the individuality of the oolites can still be seen in some of them. In others the oolites are transformed into microgranular globules (Pl. 2, Fig. 2) which differ from the surrounding dolomicritic groundmass only by the small size of the dolomite granules.

Silicification

In thin section, the siliceous oolites are similar in shape, size and texture with the other oolites. Presence of dolomicrite nucleus and the microcrystalline and finely crystalline silica in outer layers (Pl. 1, Fig. 1) indicate that these oolites are formed by silica replacement of carbonate oolites. Where the silica is microcrystalline many details of the original fabrics are preserved (Pl. 1, Fig. 2) and when silicification has produced a fine to medium crystalline textured chert the structural details of the original rock are lost (Pl. 1, Fig. 3). In certain cases partial silicification caused an exclusion of iron which has been reprecipitated in the adjacent carbonate and appears as small cubic euhedra of magnetite (Pl. 1, Fig. 2). In the final stage of silicification isolated pseudomorphs of microcrystalline quartz are found embedded in the dolomicritic matrix. These pseudomorphs of quartz replace fine to medium crystalline textured chert.

Diagenetic Sequence

The oolitic horizon of the Thalkedar Dolomite clearly provides evidences for diagenetic changes which have taken place in these rocks. The Thalkedar oolites have been classified into 5 types, i.e., concentric, radial, siliceous, sparry and composite. It appears that all the minerals forming the oolites owe their origin to authigenesis. Authigenesis includes dolomite replacement of calcite and/or aragonite, silica replacement of dolomite, and finally, replacement of chert and dolomite by drusy quartz in the form of veins. Thus, every mineral present appears as an authigenic replacement of every other mineral.

It is assumed in the following interpretations that all the oolites were originally made up of aragonite or calcite (FRIEDMAN, 1964 ; SWETT, 1965 ; KAHLE, 1974) with or without a microcrystalline calcareous matrix. Since there is no evidence to know the original composition of the oolites, this assumption is imperative for the reconstruction of the different stages of diagenesis. The Thalkedar oolites also show the development of radial pattern. EARDLY (1938) and CAROZZI (1962) implied the idea that radial structure of Great Salt Lake ooids is diagenetic and that the radial structure is due to recrystallization of aragonite to calcite. These ideas have been thought to be applicable to marine ooids also (WILLIAMS, TURNER & GILBERT, 1955 ; DUNBAR & RODGERS, 1957). However, KAHLE (1974) concluded that radial structure is due to recrystallization of aragonite to aragonite and not to calcite. In the absence of any evidence of calcite or aragonite in the Thalkedar oolites by analogue it seems that the radial pattern has developed during the recrystallization of calcareous oolites which were later subjected to dolomitization and silicification. Sparry oolites, which are made up of microcrystalline dolomite, appear to have resulted from recrystallization and dolomitization of the concentric and radial oolites. These recrystallized and dolomitized oolites have been subjected to silicification producing a dense chert and finally quartz. The pseudomorphs of quartz are characterized by preservation of the rhombic outline of replaced dolomite. KHARKWAL AND BAGATI (1974) have also reported the presence of pseudomorphs of quartz in dolomicritic matrix from the carbonate rocks of the Krol Formation and explained this phenomenon by selective silica replacement of earlier recrystallized dolomite. Besides silica of diagenetic origin, epidiagenetic silica is sometimes observed in thin section in the form of vein cutting through the chert and dolomite (Pl. 2, Fig. 4).

These interrelationships of the various authigenic replacement may be summarized in the following sequence which will account for all of these diagenetic fabrics :

1. Recrystallization
2. Dolomitization
3. Early silicification
4. Late silicification (Epidiagenetic silica)

Environment of Deposition

On the basis of the presence of stratified stromatolites and the primary sedimentary structures, it is concluded that the environment of deposition of the middle part of the Thalkedar dolomites is supratidal to high intertidal of a carbonate tidal flat. However, the presence of oolites which show very high degree of sphericity and very good sorting as well as almost complete absence of intraclasts, suggest a very consistent and moderate energy at the site of deposition. Thus, this does not correspond well with the conclusion drawn from the other sedimentary features including stratified stromatolites. These features suggest a low energy environment which was subjected to intermittent subaerial exposure as borne out by the presence of well developed mud cracks. The most logical site of deposition appears to be supratidal zone.

Thus, this may be suggested that the oolites must have been formed in the open sea in the intertidal zone and were brought and dumped in the supratidal zone by the storm generated wave/current. The absence of bedding feature within the oolitic dolomite is perhaps due to very rapid rate of deposition or dumping, such that the waves or currents could not get enough time to form bedding. The formation of oolite in an open sea can be ascribed to the same process as suggested by CAROZZI (1960).

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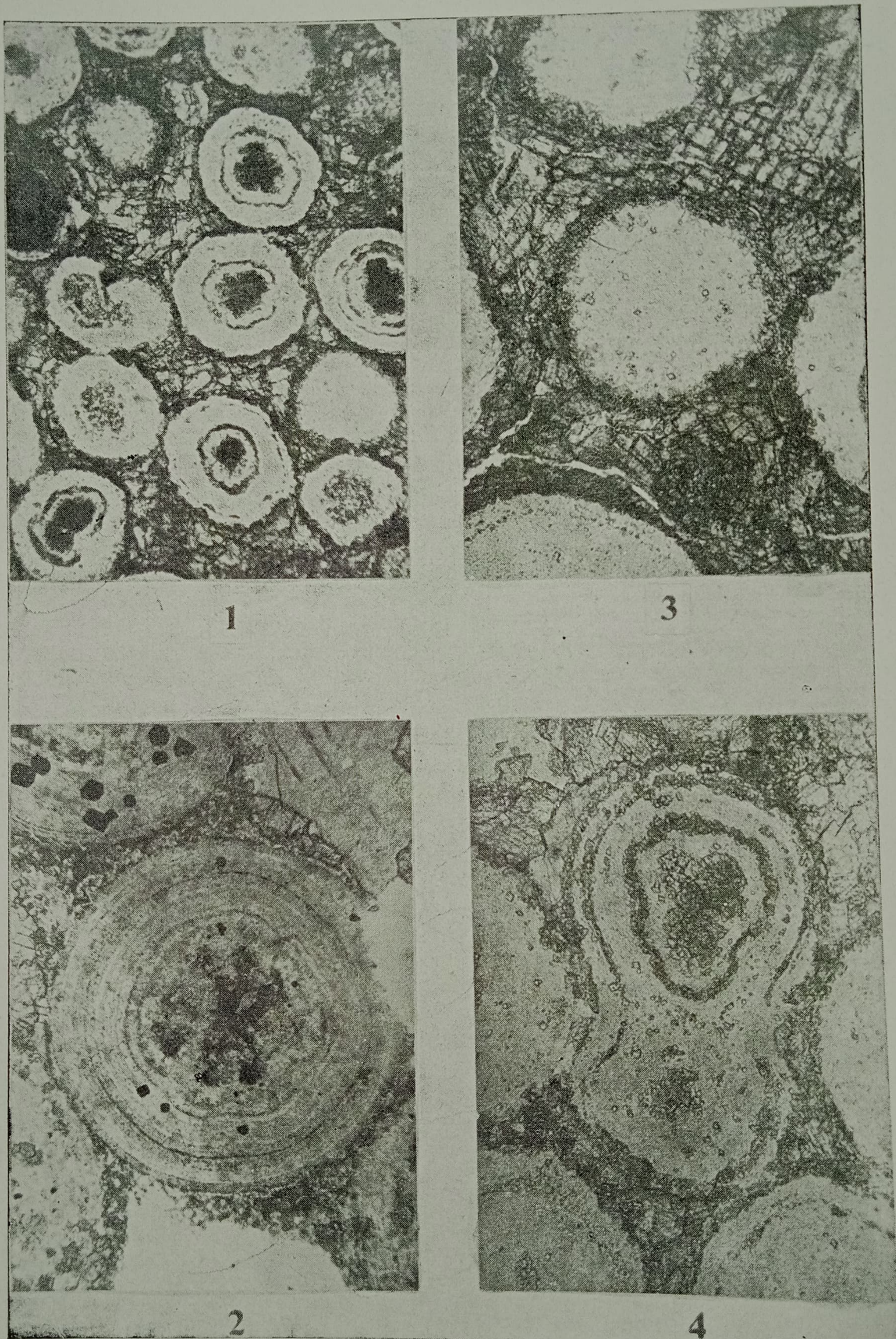
EXPLANATION OF PLATES

PLATE 1

1. Partially and completely silicified oolites seen in Sparry dolomitic cement, ordinary light. ×27.97.
2. A completely silicified concentric oolite with a nucleus, ordinary light. ×55.50.
3. Silicified oolite showing no internal structure, Ordinary light. ×55.50.
4. Partially silicified composite oolite, Ordinary light. ×27.97.

PLATE 2

1. Radial oolites showing development of spokes, Ordinary light. ×55.50.
2. Sparry oolite, Ordinary light, ×55.50.
3. Partially replaced concentric oolite. Ordinary light. ×55.50.
4. A vein of quartz replacing the siliceous oolite, Crossed Nicols. ×55.50.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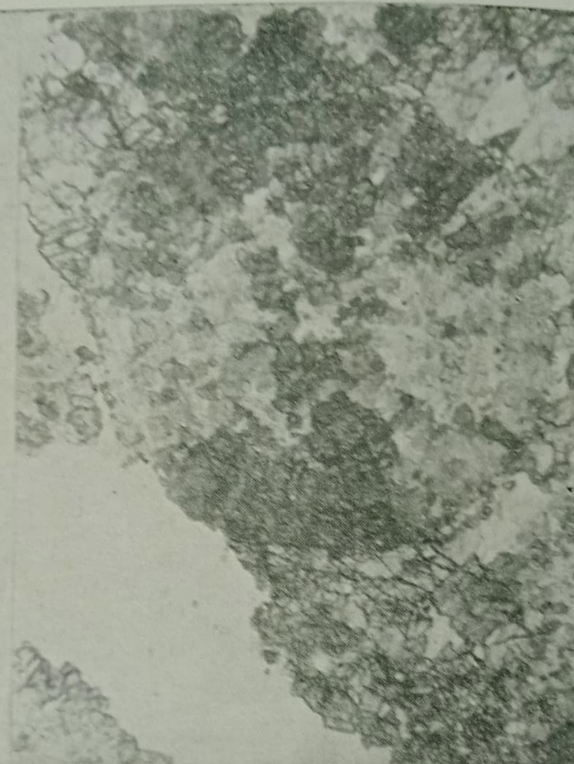

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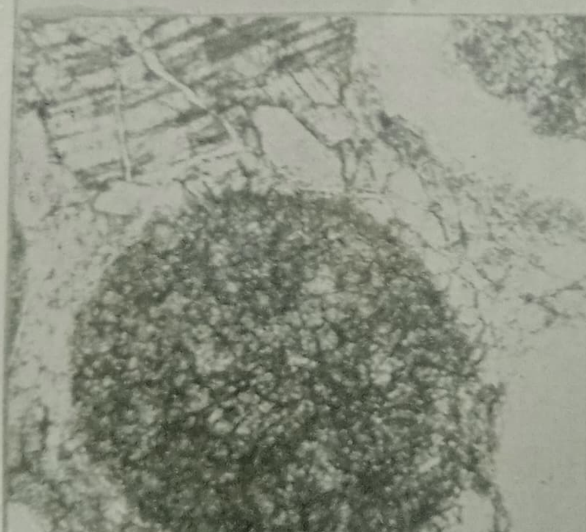

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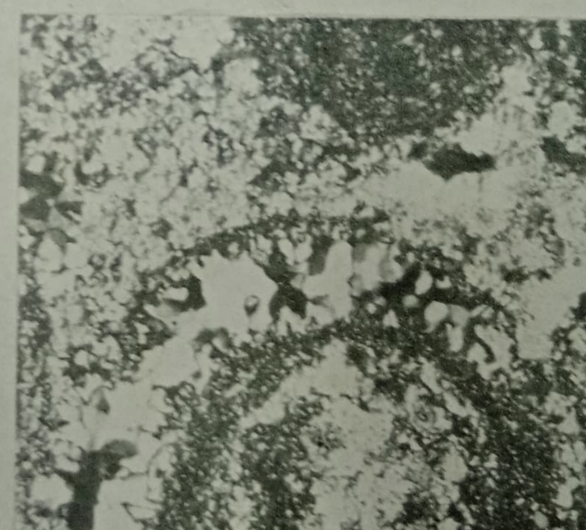

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