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THE ALLOCHEMICAL CONSTITUENTS AND ENVIRONMENT OF DEPOSITION OF GANGOLIHAT DOLOMITE, KATHPURIA CHHINA AREA, ALMORA DISTRICT, U. P.

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ABSTRACT

The Oolites, interclasts and pellets are the main allochemical constituents of the lower part of the pre-Cambrian Gangolihat Dolomite, Kathpuria Chhina area, district Almora, Kumaon Himalaya, U. P. The petrographic stained sections reveal that these rocks are made up of predominently dolostone. Chemical analysis, insoluble residue, X. R. D. and D. T. A. studies confirm the dominance of dolomite. Two microfacies viz., Oosparite and intrasparite have been recognized. The allochems show various stages of diagenetic modifications. The sequence of diagenetic events is discussed.

The Gangolihat (Dolomite) Formation is a product of subtidal-protected intertidal flat environment. The Oosparite and intrasparite microfacies of Gangolihat Formation suggest high energy wave dominated (agitated) shallow warm marine environment.

INTRODUCTION

Allochemical constituents or "allochems" are chemically or biochemically precipitated grains within the basin of depositions. These are not simple chemical precipitate but have a higher order of organization and have suffered some transportation (Folk, 1959). Allochems are dominant constituents of carbonate rocks. Folk (1959) has described four principal types of allochems viz., Oolites, intraclasts, fossils and pellets.

The Gangolihat Dolomite is youngest Formation of the Calc Zone of Pithoragarh in Almora-Pithoragarh districts. The main lithounits are dolomite, limestone, dolomitic limestone, stromatolitic dolomites, intraformational conglomerate, oolitic-intraclastic dolomite, slates, lenses of magnesite, phosphatic stromatolitic dolomite and phyllites. Kumar and Tewari (1978a, b) and Tewari (1981) have studied the stromatolites and oolites from Gangolihat Dolomite. The statistical studies and diagenesis of oolites has already been described by Kumar and Tewari (1978, b). Oolites and intraclasts, the dominant allochems of Gangolihat Dolomite form the subject matter of the present study (the fossils are not found in Gangolihat Dolomite, except stromatolites and microbiota).

PREVIOUS WORK

Allochemical constituents of Oolitic-intraclastic rocks have been studied with special reference to their genesis and environmental significance ranging in age from Precambrian to Recent all over the world. Modern oolites are studied in the Mediterranean sea, Florida, Bermuda Island, the Bahama bank, the Persian Gulf, Gulf of Mexico (Laguna Madre), Carrab-

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bean sea and Gulf of Aqaba, Red sea (Friedman, 1964, Friedman *et al.*, 1973). The oolites suggest marine environment but fluvial and lecustrine oolites are also not uncommon. The quiet water oolites are rather rare in geological literature.

The intraclastic oolitic carbonate rocks have attracted many sedimentologists to Peninsular and Himalayan sedimentary basins of India. In Lesser Himalaya the oolites, intraclasts, algal pisolites, oncolites and the fossil fragements are the main allochems of Krol-Tal Formations of the Krol belt. (Kharakwal and Kumar, 1970, Kharkwal and Bagati, 1974, Bassi and Vatasa, 1971, Bhargava, 1969, Patwardhan and Ahluwalia, 1975, Gundu Rao, 1969, Singh *et al.* 1980, Pal and Srivastava, 1981).

Petrography, diagenesis and environmental significance of allochems has been dealt in Precambrian inner Lesser Himalayan carbonate rocks from Jammu to Sikkim-Bhutan and Nepal Himalaya (Chadha, 1976; Nautiyal *et al.*, 1952; Valdiya, 1965; Dixit, 1970; Misra and Kumar, 1968; Misra and Banerjee, 1969; Bhattacharya, 1971; Kumar and Tewari, 1978 a, b; Kumar and Kumar 1980; Mukherjee and Chaudhary, 1975; Upreti and Merh, 1979).

GEOLOGICAL SETTING

Table 1 shows the lithostratigraphic succession of the Calc Zone of Pithoragarh in Almora-Pithoragarh area (Kumar and Kumar, 1980; modified after Valdiya, 1968). These metasedimentaries are bound in the north by Main Central Thurst and in the South by North Almora Thurst and designated as Zone of Badolisera by Heim and Gensser (1939) and Gansser (1964). Valdiya (1962) classified them as older Berinag Quartzite thurst over youger Calc Zone of Pithoragarh. In the present area, Gangolihat (Dolomite) Formation is overlying the Sor (Slate) Formation and underlain by Berinag Quartzite without any inversion of these lithounits. (Kumar and Tewari, 1978, a, b; Bhattacharya and Joshi, 1979).

Table 1—Lithostratigraphic Succession

Berinag Quartzite	Orthoquartzites and amphibolites.
Gangolihat (Dolomite) Formation.	Lower member comprises massive dolomite and dolomitic limestone showing development of both columner and stratified stromatolites *Concophyton garganicus—Baicalia—Colonnella* assemblage. It includes lentiform deposits of magnesite. The upper member consist of tuffaceous purple phyllites and light coloured dolomites.
Sor (Slate) Formation	Olive green, brown grey slates with orthoquartzite and subordinate argillaceous dolomitic limestone.
——————— North Almora Thurst ———————	
Almora crystalline	Schists and gneisses

A meter thick oolitic intraclastic band is found associated with stromatolitic dolomite in the lower part of the Gangolihat Dolomite near the contact with Sor (Slate)

Formation in Kathpuria Chhina area, Almora district. The detailed litholog (Fig. 1) shows the association of sedimentary structures and oolitic bands.

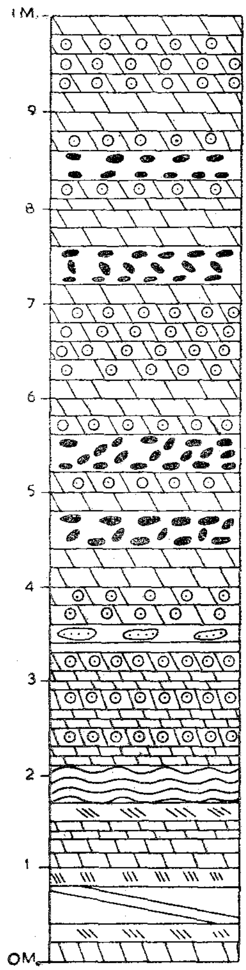

Fig. 1. DETAILS OF I METER OOLITIC LIMESTONE BAND LOCALITY – KATHPURIA CHHINA, ALMORA, U. P.

LABORATORY STUDIES

Petrography

Petrographic thin sections of oolitic intraclastic dolomite were scanned. Chemical staining was done by Alizarine Red S solution following Friedman (1959) for identification of calcite and dolomite. Dominance of dolomite is recorded. The oolites and intraclasts are made up of dolomite and cemented by sparry dolomite. Following Folk's (1959) classification two microfacies viz., Oosparite and intrasparite are recognized. The detailed petrography is discussed while describing diagenesis of intraclasts and oolites. The presence of dolomite in the rock is confirmed by chemical analysis, X.R.D. and D.T.A. studies.

Differential Thermal Analysis (D.T.A.)

The D.T.A. curves for some representative samples of Gangolihat Dolomite and

Oolitic band have been obtained by Hall D.T.A.–O2 Model. The studies were carried out in atmosphere using chromel alumel thermocouple and $\alpha-Al_2O_3$ as reference. The heating rate was kept 10°C per minute.

Two endothermic peaks were recorded at 750°C (range 680°C-820°C) and 875°C (range 840°C-910°C) in the D.T.A. curves (Fig. 2). D.T.A. confirms the presence of dolomite mineral in the rocks as predominant constituent.

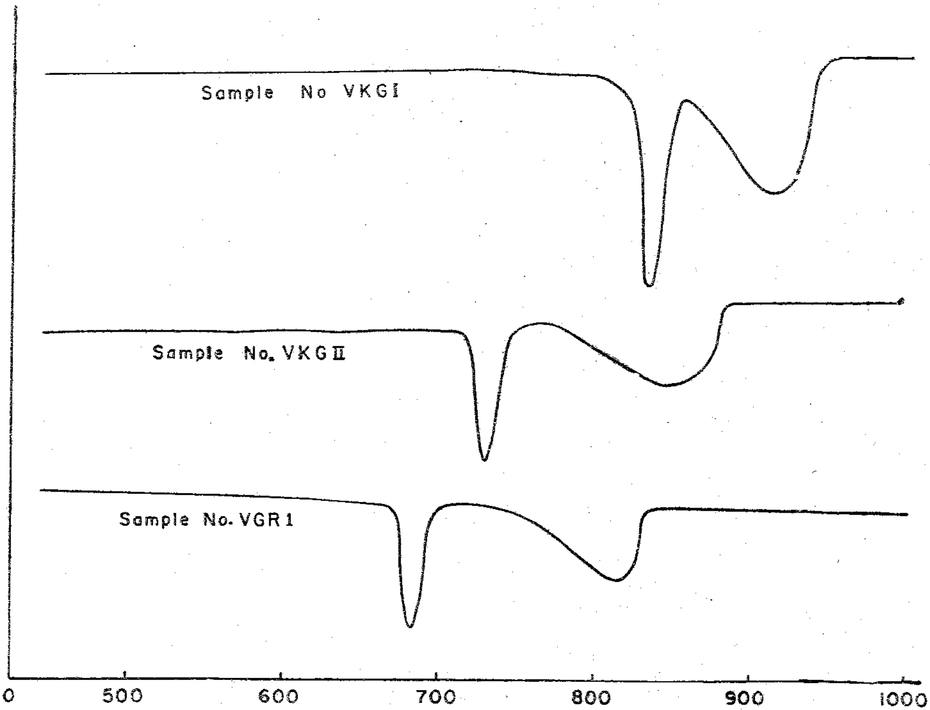

Fig. 2. D.T.A. curves of Gangolihat Dolomite, Kathpuria Chhina area, Almora.

Insoluble residues

Insoluble residue study of some representative samples were made. Non carbonate residue was obtained after HCL treatment by dissolving a few grains of powdered sample. The sand fraction was studied under binocular microscope for insoluble residues. Quartz and chert are the dominant constituents of insoluble residue. Some opaque minerals are also found.

ALLOCHEMICAL CONSTITUENTS

Allochems are framework of rock that include oolites, shells, intraclasts and pellets cemented by sparry calcite/dolomite cement. These rocks are equivalent to well sorted terrigenous clastics and represents similar structures and textures. The allochems have been brought together by strong waves to winnow away and microcrystalline ooze that otherwise might have accumulated as a matrix and the interstitial pores have been filled by directly precipitated sparry calcite cement.

The petrography and diagenesis of the allochems (intraclasts and oolites) is given below :

INTRACLASTS

The term intraclasts was introduced by Folk (1959), for fragments of penecontemporaneous, usually weakly consolidated carbonate sediment that have been eroded from adjoining parts of the sea bottom and redeposited to form a new sediment (reworked within the area of deposition).

The intraclasts of the area under study forms about 23% of the allochemical constituents. The intraclasts are made up of dolomite and range in size from 0.28 mm to 20 mm. The intraclasts are rounded to subrounded (Plate I, i), flat, elongated and slab like in shape (Plate I, a, e). The angular and abroaded intraclasts (Plate I, b, f, j) are also recorded. The intraclast of earlier cycle is sound as nucleii in some composite oolites which represents second cycle of sedimentation (Plate I, k). The internal structure of intraclasts is completely destroyed during the process of diagenesis. The authigenic silica is found around the intraclasts (Plate I, a, c). The secondary epidiagenetic silica veins cutting across the oolites and intraclasts (Plate I, l) represents a late silicification stage. The intraclasts show partial to complete recrystalization (Plate I, l, g).

OOLITES

Carozzi (1960) defined oolite as a spherical or sub spherical body, 0.25 to 2 mm in diameter of any composition usually displaying a nucleus around which at least one concentric layer has been deposited by an accretion process.

The oolites of the present area constitute 75% of the allochemical constituents. Kumar and Tewari (1978 b) have described them in detail. Further studies of these oolites by the present author suggest that they are algal oolites and some of the forms have been identified. A brief description of oolites is given here.

CONCENTRIC OOLITES are circular and elliptical in shape with a nucleus (Plate I, d). The concentric rings are formed due to accretionery growth.

CONCENTRIC CUM RADIAL OOLITES are ellipitical to circular in shape and the radial texture is superimposed over concentric pattern. (Plate II, a, b).

COMPOSITE OOLITES are formed by recycling from the earlier oolitic-intraclastic rock in which the concentric and radial oolites are joined and surrounded by a common envelope (Plate I, k, II, d).

SILICEOUS OOLITES are formed by partial and complete replacement of original carbonate oolites by silica (Plate I, j, Plate II, e).

PSUDO OOLITES AND PELLETS are rounded to ellliptical in shape and without any internal structures. These form only two percent of allochems.

DEFORMED OOLITES are found associated with intraclasts. (Plate II, f).

CRESCENT SHAPED oolites are found associated with concentric and radial oolites. (Plate II, i).

Following Z. Zhuravelva, 1964 (in Raaben and Zabrodin, 1972) these algal oolites are recognized as *Osaqia monolamellosa* (Plate II, d). *Radiosus* (Plate I, d, h; Plate II, a, b, g). A new form *Radiosus radialis* (Plate II, c) has also been identified.

DIAGENESIS OF INTRACLASTS AND OOLITES

The diagenesis of oolites have already been described by Kumar and Tewari (1978 b) in detail. However, a brief history of diagenetic events is discussed here. The oolitic intraclastic rock show recrystallization followed by dolomitization and two phases of silicification i. e. early silicification and late silicification. These processes have oblitrated the oolitic texture partially (Plate II, g and h) to completely (Plate II, e).

RECRYSTALLIZATION is the first stage of diagenesis in Gangolihat Dolomite which is represented by oolites and intraclasts. The original micrite (aragonite or calcite) has been completely recrystallized and the radial pattern (Plate II, a, c) is the result of recrystallization. The intraclasts also show partial to complete recrystalization (Plate I, b, g). The authigenic growth of silica forming a ring like structure around intraclast is a diagenetic phenomenon (Plate I, a, c).

DOLOMITIZATION has obliterated the concentric and radial textures of the oolites and show development of dolomicrite which have been followed by replacement of dolomite by silica (Plate II, g, h). During early silicification stage the original carbonate oolites are replaced by silica. The replacement is partial to complete. The concentric structure retained where the silicification was rapid and has been completely lost where the process was slow (Plate 1, j and Plate II, e). The microveins of microcrystalline silica (epidiagenetic silica) cutting across the oolites and intraclasts (Plate I, l) represent late silicification stage.

ORIGIN OF THE "ALLOCHEMS" AND THEIR ENVIRONMENTAL SIGNIFICANCE

The intraclasts are reworked fragments of semi consolidated carbonate sediment and formed by low tides allowing wave attack on exposed mud flats. The recycling of intraclasts from oolitic intraclastic rock of earlier cycle supports the reworking hypothesis for the origin of the intraclasts.

The oolites are formed by accretion process of calcium carbonate around a nucleus of mud aggregate, fossil or quartz grain. The modern oolites suggest an agitated high energy environment for them. The fossil oolites (Oosparite) are also formed in tidal channel (Illings, 1954) which suggest a high energy environment. The degree of sorting of oolites also indicates vigorous current action (Folk, 1959). Such an agitated environment is possible in shallow warm marine environment in intertidal zone of a carbonate tidal flat where the oolitic accretion is very active. However, Simone (1981) in her review of ooids has questioned the attribution of oolites to typical high energey environment.

The intraclasts and oolites reflects the spectrum of sedimentation and environment of deposition of Gangolihat Dolomite. Kumar and Tewari (1978 a, b) on the basis of columnar and stratified stromatolites suggested a tidal flat environment (Protected intertidal mud flats and low energy supratidal zones) of deposition for Gangolihat Dolomite. The palaeoenvironmental interpretations based on the study of allochems are discussed below.

The fine grained calcareous sediments were being deposited at shallow depths in protected calm water Gangolihat basin. Such calm water environment prolonged for a long time and the environment was very favourable for growth and metabolic activity of micro-organism and blue green algae (Cyanophyta) to form stromatolites. The prolific growth of stromatolites is found in lower part of Gangolihat Dolomite. The presence of *Conophpton* and *Colonnella* suggest that the basin was protected from strong waves or currents. The oolites were formed in this intertidial environment where oolitic accretion was favourable and warm water was also available for supersaturation. The prolonged calm water condition was suddenly interrupted by storms or strong waves which is a common phenomenon in tidal flat environment. (Reineck and Singh, 1973). Such wave attacks were periodic and produced fragments from semi-consolidated calcareous mud which was produced by turbulent agitations of water in high energy environment. These fluctuations brought the broken fragments into highly wave agitated sites where they were subjected to wave action and abrasion. These rounded to subrounded (intraclasts) were finally deposited in the new high energy environment.

The recycling of the intraclasts and oolites (composite oolites)suggest that they have been derived from oolitic-intraclastic rocks of earlier cycle. The redeposition of earlier formed allochems suggest fluctuations in environmental energy in a tectonically active Gangolihat basin.

The co-existence of concentric cum radial structure in oolites has been explained by most of the workers as diagenentic processes based on the study of Recent Bahamian Ooids which have radial structure. The fibrous radial structures made up of calcite in ancient oolites supposed to be formed by the diagenesis of Bahamian type ooids made up of aragonite. Recent researches (Loreau, 1973 in Simone, 1981; Simone, 1981) suggest that radial fibrous structures can be formed in low energy environments commonly in sheltered intertidal zones However, the present author suggest a secondary origin to these structures.

There is striking similarity in palaeobasinal conditions of Gangolihat Dolomite with intraclastic dolomite of Kali Gandaki Valley, Central-West Nepal (Upreti and Merh, 1979). These two Formations show same environmental conditions for oolitic-intraclastic rocks and development of stromatolites. Tewari (1981) has correlated Gangolihat Dolomite of eastern Kumaon Himalaya with intraclastic oolitic-stromatolitic dolomite of Central West Nepal. The continuation of different litho-tectonic units of Kumaun Lesser Himalaya of India has been traced accross the Kali river into Western Nepal. (Personal communication, Ramesh Bahsyal, Deptt. of Mines and Geology, Kathmandu, Nepal).

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EXPLANATION OF PLATES

PLATE 1

Fig. 1. (a) Elongated intraclast showing authigenic growth of silica forming a ring like structure around intraclast (x 46 crossed nicols).

(b) Abraded intraclast showing partial recrystallization (x 23).

(c) Authigenic silica rims around intraclasts (x 23).

(d) Concentric oolite with dolorhomb as nucleus (x 46 crossed nicols).

(e) Flat, slab like intraclasts (x 23).

(f) Angular intraclast with concentric and radial oolites (x 46).

(g) Intraclast showing recrystallization (x 23).

(h) Concentric and radial oolites and intraclasts (x 23).

(i) Rounded to subrounded intraclasts (x 46).

(j) Subangular intraclast (x 46) associated with siliceous oolite showing partial replacement of carbonate oolites.

(k) Composite oolite with intraclast of earlier cycle as nucleus (x 46).

(l) The secondary (epidiagenetic) silica veins cutting across the oolites and intraclasts (x 23).

PLATE 2

Fig. 2. (a) Concentric cum radial oolite showing recrystallization. Radially arranged sparry dolorhombs up to the outer margin of the oolites (x 56).

(b) Concentric cum radial oolite. The radial fibres does not extend up to outer margin (x 56).

(c) Concentric cum radial oolite superimposed over concentric rings extend outside the envelope of rings and encroaching on the matrix (x 56).

(d) Composite surrounded by a common envelope (x 56).

(e) Siliceous oolites showing complete replacement of original carbonate oolites. (x 28.3 crossed nicols).

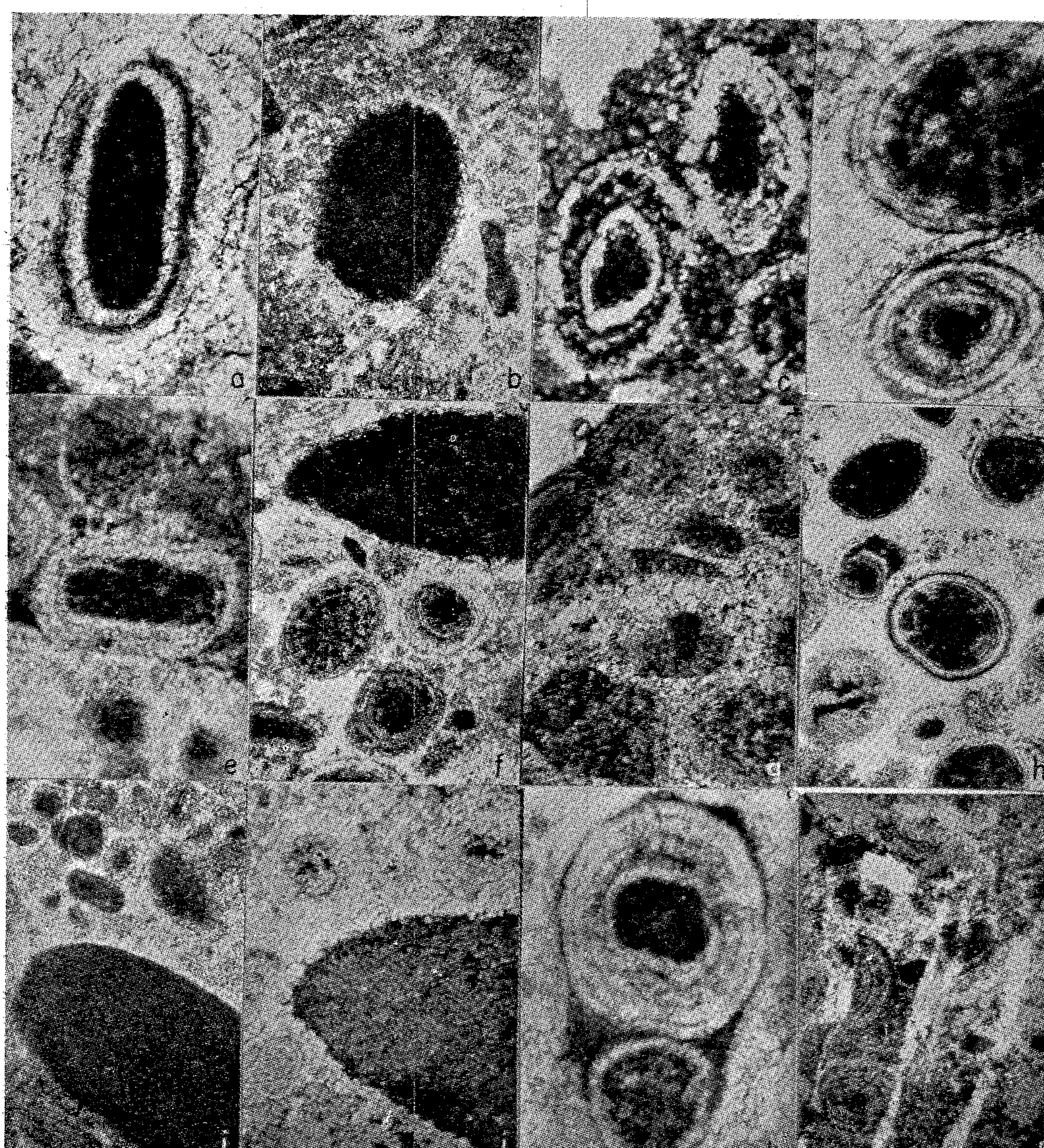
(f) Deformed oolite associated with intraclast (x 28.3).

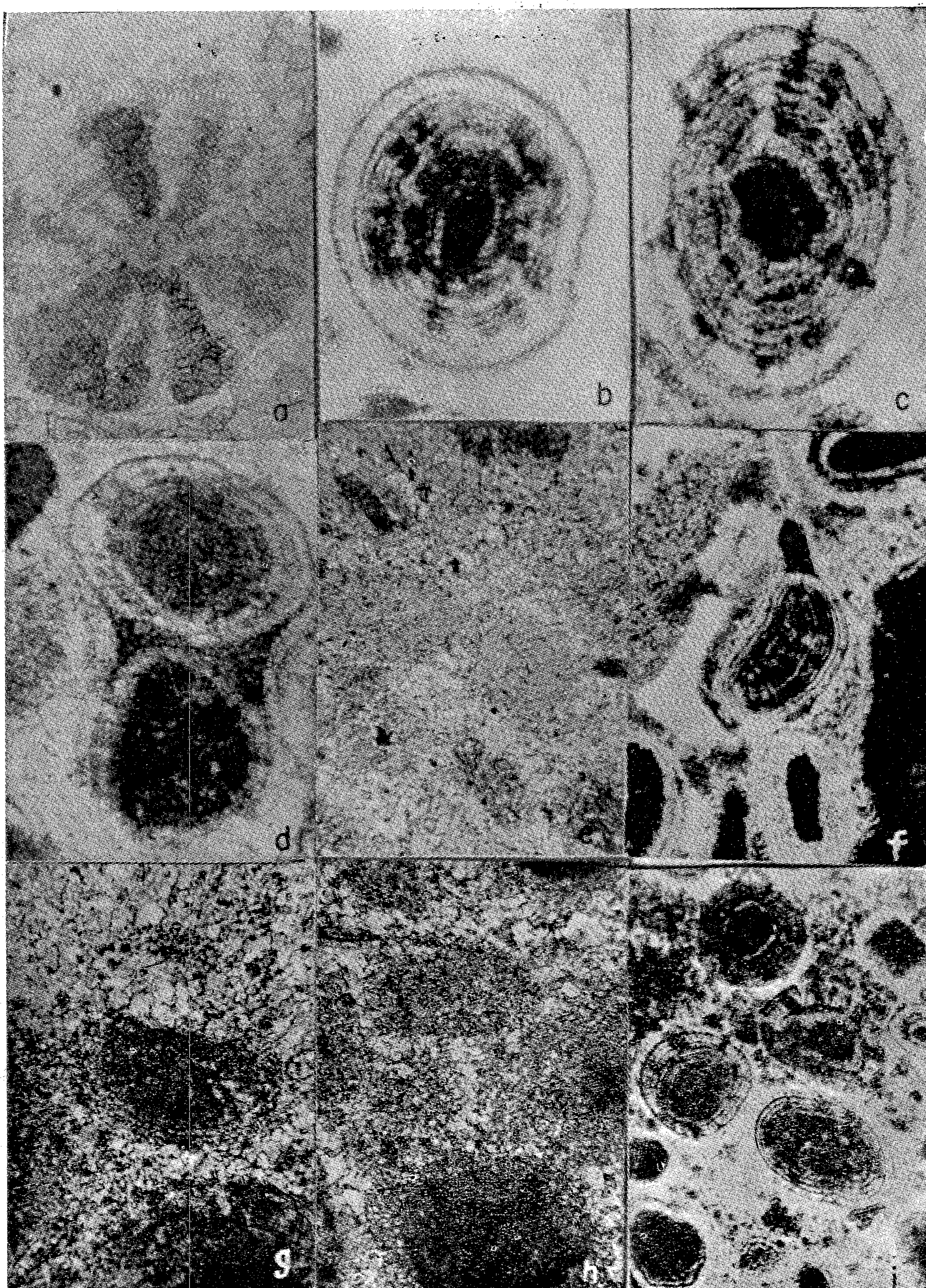
(g) The concentric and radial texsure of oolite is partially obliterated by dolomitization (x 56, crossed nicols).

(h) The dolomite is being replaced by silica (x 56 crossed nicols).

(i) Crescent shaped oolite associated with concentric and radial oolites (x 28.3).

PLATE—1

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