Chapter-VII

Microfacies

and

Depositional Environment
INTRODUCTION

Microfacies analysis involves petrographic study of carbonate rocks under the microscope. It is the most important of the various levels of observation possible in the broad field of carbonate petrography. The analysis helps in the interpretation of depositional environment through identification of different carbonate particles, which form and grow in different depositional and diagenetic environments. This interpretation becomes meaningful when petrography is combined with detailed stratigraphic control. Comparison is then made with depositional models constructed on the basis of the study of Holocene sediments.

The concept of depositional interpretation of microfacies was evolved by Cuvillier and Schurmann (1951-1969). During this period an excellent review of the importance of the concept was published by Fairbridge (1954). Earlier works on carbonate microfacies employed, mainly, the paleontological criteria. Flugel (1972) added sedimentological criteria to the basic paleontological approach and described several basic types of microfacies. Excellent illustrations of some of the basic microfacies were given by Horowitz and Potter (1971).

The present petrographic study of carbonate rocks of Lameta Formation carried out through thin-section analysis, mainly
concern the microfacies analysis as well as their textural, compositional and diagenetic characteristics. The samples were stained with Alizarin Red ‘S’ following Friedman’s (1959) technique for differentiating calcite and dolomite.

**MAJOR TEXTURAL CONSTITUENTS**

The major constituents of carbonates can be divided into allochems (framework grains), sparry calcite and micrite (Folk, 1962). The framework grains comprise bioclasts, ooids and intraclasts. Terrigenous admixture is present in most of the samples.

**Bioclasts**

Bioclasts are extremely rare in the Lameta Formation and that too as ghosts due to dolomitization. The various types of bioclasts that have been identified include, ostracods, gastropods, calcispheres and algae.

**Ostracods**

Ostracods and their fragments occur in the Lower Limestone member of Lameta Formation at the Pat Baba and Lameta Ghat localities of Jabalpur area. The Ostracod fossil occurs in fine dark carbonate mud matrix and is internally filled by micrite.

**Gastropods**

Gastropod shells are easily identifiable by their characteristic outlines. The fragments and individual chambers
have been reported from the Lower Limestone member at the Chui Hill locality. The chambers are separated by dark fine-grained micrite walls and are internally filled by micrite (Plate VIA).

**Calcispheres**

Calcispheres have been found in the Lower Limestone member from the Lameta Ghat locality. They are confined to a single bed and occur as small spherical to oval bodies filled with drusy cement (Plate VIB).

**Foramenifera**

The 'ghosts' of foramenifera occur in the Lower Limestone bed at the Lameta Ghat locality. They represent miliolids (?) whose chambers are filled with micrite. The chambers are separated by thin micrite walls.

**Algae**

Algae occur in both the Lower and Upper Limestones and form their major constituent. Thin section study reveal an algal mat (Plate VIC,D) structure in the Lower Limestone and algal fragments in the Upper Limestone (Plate VIE). The algal mat embed a number of quartz grains and intraclasts of different sizes. However, due to recrystallization to fine-grained dolomite most of the original structures have mostly been masked.
PLATE-VI

Photomicrographs of the limestones of Lameta Formation, Jabalpur area, Madhya Pradesh.

A. Gastropod chambers separated by dark fine-grained micrite wall internally filled by micrite (Pat baba)-100X.

B. Probable calcispheres filled by drusty cement in the limestones of Lameta Formation (Sivni Tola)-100X.

C. Algal mat in the limestone of Lameta Formation (Sivni Tola)-100X.

D. Algal mat in the limestone of Lameta Formation (Sivni Tola)-100X.

E. Algal fragment in the limestone of Lameta Formation (Lameta Ghat)-100X.
Non-skeletal grains

Non-skeletal carbonate grains are those which are not of biogenic origin. In the Lameta Formation ooids and intraclasts constitute non-skeletal grains.

Ooids

Thin sections reveal ooids in the Lower Limestone of at the Lameta Ghat section. These have been replaced by dolomite resulting in masking of the original ring and radial structure (Plate VIIA). However, some of these ooids display partially radial-concentric structure. The nuclei of these ooids are generally micrite grains (Plate VIIB,C). Chanda (1967) has also reported scanty ooids in the limestone from Lameta Ghat section.

Intraclasts

Intraclasts are fragments of penecontemporaneous, generally weakly consolidated, carbonate sediment that have been eroded from adjoining parts of sea bottom and redeposited to form new sediment (Folk, 1962). They have firm boundaries with rounded outline indicating that they originated in a high energy environment from erosion of already lithified carbonate sediments. They are thought to form usually by low tides allowing wane attack on exposed, mud cracked carbonate flats. The intraclasts in the limestones occur as encrusted lumps (Plate VIID).
PLATE-VII

Photomicrographs of the limestones of Lameta Formation, Jabalpur area, Madhya Pradesh.

A. Ooids masked due to dolomitization in the Lameta Formation (Lameta Ghat)-100X.

B. Ooids with concentric rings in the limestone of Lameta Formation (Lameta Ghat)-100X.

C. Ooids with concentric rings in the limestone of Lameta Formation (Lameta Ghat)-100X.

D. Encrusted lump in the limestone of Lameta Formation (Bara Simla)-100X.
Sparry Calcite

This type of calcite generally forms grains or crystals of 10 micron size or more and is distinguished from microcrystalline calcite by its clarity as well as coarser crystal size (Folk, 1962). Bathurst (1971) distinguished sparry calcite by the intercrystalline boundaries in the sparry mosaic which are made up of plane interfaces and characterized by enfacial junctions. In the studied carbonate rocks sparry calcite occurs as pore-fillings and as rims along the grains of quartz.

Micrite

Micrite is a microcrystalline calcite material finer than 4 micron (Folk, 1962). Micrite is thought to form by rapid chemical or biological precipitation of aragonite ooze and its subsequent recrystallisation and inversion to calcite. Leighton and Pendexter (1962) defined micrite as consisting of particles less than approximately 31 microns. Bissel and Chilingar (1967) employed the term “micrite” for material, whether crystalline or fine grained, which is 50 micron or smaller in diameter. In the present study Leighton and Pendexter’s definition has been followed.

DESCRIPTION OF MICROFACIES

On the basis of thin section studies of the carbonate rocks different microfacies were identified. The basis of microfacies is
the dominant textural constituents. The microfacies identified are as follows:

1) Micrite
2) Dismicrite
3) Dolo-oosparite
4) Intramicrite
5) Biomicrite
   a) Calcisphere bearing micrite
   b) Ostracod bearing micrite
   c) Gastropod bearing micrite
   d) Algal micrite

1) **Micrite**

This microfacies occurs in the lower part of the Lameta Formation. It consists of homogenous and structureless aggregate of microcrystalline calcite grains less than 31 microns in size. They appear subtranslucent and brownish in low magnification but under high magnification individual grains can be discerned and appear irregularly round and equant.

2) **Dismicrite**

This microfacies is also confined to the lower part of the Lameta Formation. It is composed mainly of micrite with minor amount of spar developed in patches (fenestral fabric). The terrigenous content present in this microfacies is mostly quartz
grains. Calcite is also present occasionally as thin streaks of irregular shape.

3) Dolo-oosparite

This microfacies was encountered in the Lower Limestone beds of Lameta Ghat section. The whole rock has been partially dolomitized resulting in the masking of the internal structure of the ooids. However, in one thin-section a number of ooids are preserved displaying radial-concentric structure. The surrounding sediment is also dolomitized.

4) Intramicrite

This microfacies occurs in the carbonate rocks of Chui Hill and Bara Simla. The microfacies comprise mainly micrite with a few large to small grains of intraclasts. The latter are also micritic but appear darker in comparison to surrounding matrix. These resemble the encrusted lumps of aggregate grain types.

5) Biomicrite

This microfacies occurs in the upper part of the Lameta Formation. The microfacies comprise mainly micrite. The other minor constituents include terrigenous admixture, bioclasts and spar.

Micrite is homogeneous and does not show pelleting or clotting. It is occasionally recrystallized to microspar. Terrigenous
admixture is of fine sand to silt size. The following sub-facies have been identified in this facies.

a) *Calcisphere bearing biomicrite*

This occurs in the lower part of the Lameta Formation. It contains mainly micrite and minor bioclasts with small amount of quartz.

The micrite grains are generally less than 10 microns in size. The bioclast comprise calcispheres and a few unidentified bioclasts. Calcispheres present are mostly of unwalled variety and are recrystallized ranging in size from medium silt to fine sand. Terrigenous admixture, mainly quartz, occurs as medium to coarse silt size particles.

*b) Ostracod bearing biomicrite*

This microfacies occurs in the lower part of the Lameta Formation. It has been identified in the Pat Baba and Lameta Ghat areas. The microfacies consists of dominant micrite and ostracods with small amount of quartz silt.

The micrite is homogenous and structureless. Ostracods occur as disarticulated valves with recurved margins. Terrigenous admixture is mainly quartz silt.

c) *Gastropod bearing biomicrite*

This occurs in the lower part of the Lameta Formation. It is composed mainly of micrite, bioclasts and minor amount of terrigenous admixture.
The gastropods are preserved as single chambers filled with micrite and mostly replaced by dolomitization. The terrigenous mixture present is in the form of quartz silt.

d) Algal micrite

This microfacies occurs in the Lameta Ghat and Chui Hill sections. It has mainly micrite, algal mats and fragments and minor amount of terrigenous admixture.

The algae are mainly in the form of algal encrustations. The terrigenous admixture present is in the form of quartz silt or fine sand size.

DEPOSITIONAL ENVIRONMENTS

The microfacies identified in the present study point to the possibility that both the limestone units of the Lameta Formation represent algal boundstones. The evidence of the presence of other biota including calcispheres, gastropods, ostracods and doubtful foraminifera (? Miliolids) reflect deposition in shallow marine conditions. Chanda (1967) is also of the opinion that both the limestone units of the Lameta Formation were deposited in shallow water conditions since algae present in these limestones require sunlight for photosynthesis. Though algae can flourish upto a water depth of about 70 m. however, they are prolific in shallower parts of the shelf. The evidences of reworking of the limeclasts (rounded to well rounded intraclasts) and their oxidation suggest shallow water conditions for their genesis.
Shallow water conditions are also reflected by the presence of ooids in one of the samples of these limestones. Chanda (1967) also reported one grain of oolite from these limestones. Association of terrigenous quartz fragments in the algal mats suggests that these were trapped by the living algae during their input in the basin.

Micrites are mostly cryptocrystalline and partially replaced by sparry calcite or cryptocrystalline dolomite. The fenestral fabric developed in these micrites suggest their deposition in the inter-tidal and subtidal environments whose sediments are prone to such diagenetic changes during intermittent subaerial exposure of the deposition substratum. Bathurst (1980) suggested the origin of fenestral fabric as a result of cementation and subsequent deformation and reworking of a succession of submarine crusts, which results in the development of the cavities in the intercalated, less cemented carbonate muds. Presence of crinkly-laminate algal mats and millimeter thick laminates and typical feeding and protective burrows also reflect the subtidal environments. These environments are also characterized by the presence of large-scale erosion channels of various depths as have been observed by Chanda (1967) in the limestones of the Lameta Formation.
Carbonate aggregate grains first observed in Bahamas (Illing, 1954) are known to be of three types, i.e., grapestones, botroyoidal lumps and encrusted lumps. Similar “encrusted lumps” occur in the Lameta Formation. These lumps have smoother outer surface and internal voids. Presence of extensively bored and micritised grain aggregates suggests agglutination of carbonate grains by Mg-calcite formed by encrusting organisms (miliolid and ophthalmid foraminifera, etc.) and Mg-calcite formed in the mucilinage sheaths of Cyanophyceae living on the substrate (Flugel, 1982). Under prolonged calm conditions, subtidal algal mats cover these aggregate grains and result in the precipitation of micritic cement by boring algae. The genesis of aggregate grains takes place in the subtidal and inter-tidal shallow-water environments with restricted circulation, about 10 m water depth (Flugel, 1982). Presence of ooids suggests a change of high water energy to weak turbulence or a general change in sedimentary conditions (e.g., Winland and Mathews, 1974). Present analogues of aggregate grain lumps occur in shallow brackish water of the tidal zones (Monty, 1967).

On the basis of the study of microfacies and textural elements, it is suggested that these limestones were formed under varying hydrodynamic conditions of shallow marine environments. These environments represent inter-tidal and subtidal conditions,
however, these appear to have been intermittently switched over to the calm water conditions favouring formation of aggregate grains or to highly agitated environment favouring ooids formation.