THE FOSSIL ASSEMBLAGE FEATURES OF LIMESTONE AND CLASTIC SEDIMENTARY ROCK IN LULUT AREA, CILEUNGSI DISTRICT, BOGOR, WEST JAVA

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ABSTRACT

The geological mapping for limestone and clastic sedimentary rock in Lulut area was conducted. The study area was composed of claystone, siltstone, sandstone and limestone intercalations of Jatiluhur Formation formed within neritic setting in Middle Miocene age. This section interfingers with rich coral and algae limestone of Klapanunggal Formation.

Larger foraminifera (Milliolids, Nummulites spp., *Amphistegina* spp., *Operculina* spp., *Cycloclypeous* spp.), *globigerinids, calcareous red and green algae, corals, Mollucs and Brachiopods shell fragments were recorded in biogenic limestone. The marine invertebrata fossil assemblages (Molluscs, Brachiopods) as well as shallow marine trace fossils (skolithos, cruziana) were recorded in calcareous claystone, siltstone, sandstone and bioclastic limestone. Planktic and small benthic foraminifera assemblages were found in fine clastic sedimentary rock.*

The identified larger foram, globigerinids, coral and calcareous algae assemblages associated with invertebrate shell fragments can be indicated age and environmental of limestone. Based on the fossil assemblages and morphology characteristics of the study area, the limestone was formed in back-reef zones (northern part, at Bagogog-Cilalay); reef-crest (central part, at Pasir Bali, Kutalingkung, Sibancana, Kuari D); and fore-reef zones (southern part, at Cileungsi, Ciseah). In the southern part, claystone interlaminations and intercalations are commonly recorded. The reef complex grew in Tertiary age within neritic zone.

Some index planktic foraminifera (*Globigerinoides primordius, Globigerinoides ruber, Globorotalia continousa, Globorotalia siakensis, Globorotalia mayeri, Hastigerina siphonifera* and *Orbulina suturalis*) *recorded in carbonaceous clastic sedimentary rock indicated that sedimentary rock of Jatiluhur sections deposited within Middle Miocene Zones N.9 to N.14. Benthic and planktic foraminifera assembalges in the sections indicated that the sediments were deposited in neritic setting. This is supported by the appearance invertebrate fossils and trace fossils.*

Keywords*: Lulut, foraminifera, invertebrata fossils, trace fossil, Middle Miocene, neritic*

INTRODUCTION

The distribution of limestone resources near or at the earth's surface occupies over 10% of the continental areas. The limestone usually be used as raw material industry (cement, fertilizer, glass, purifier, pulp, paper filler) besides raw building materials. The limestone deposits in Indonesia is very potential. In West Java, there are about 672.820 ton from total 28.678 billions ton in Indonesia. Suandi (1990) reported that the limestone deposits in Lulut area reachs about 101.00 millions ton.

In other hand, study of limestone and clastic sedimentary rock is contribute to examine time and the depositional environments in which these deposits form. Together with tectonic concept, study of the lithology allow us to develop an understanding their geologic history and evaluate their economic significance.

The study area is located closed to Lulut Village, Cileungsi District, Bogor Regency (Fig.1) PT. Indocement Tunggal Prakarsa Tbk. is carrying the limestone resources in raw material industry.

This study on fossil was conducted to figure out the characteristic of macro, micro and tracefossils founded in limestone as well as clastic sedimentary rocks in Lulut area; to interpret when, and in what kind environment the rock was formed.

REGIONAL GEOLOGY

Physiographically, the study area occupies in Bogor Zone which is characterized by typical of east-west folds and faults morphology of Neogene sedimentary rocks of Miocene age (van Bemmelen, 1949).

Regional geology northern area of Bogor has been studied by Effendy (1986). The lithology in study area grouped into :

a. Jatiluhur Formation (Tmj) – marl and clay shale, and quartz sandstone intercalations, increasing sandy toward the east.
b. Klapanunggal Formation (Tmk) mainly consist of thick massive reef limestone with large foraminifera and other fossils including molluscs and echinoderms. Limestone interfingers with Jatiluhur Formation; in the eastern part of area, thickness about 500 m (van Bemmelen, 1949 and Anonymous, 1973). In a cross section thickness maybe more than 800 m.
c. Breccia and lava from Gunung Kencana and Gunung Limo (Qvk) consist of block of andesitic tuff and andesitic breccia with abundant pyroxene phenocrysts and basaltic lava
d. Alluvium

Folds (anticline and syncline) and faults (strike-slip and normal faults) indicated regional and local tectonic activity.

METHODS

In the geological mapping, we observed the outcrops, measured and described the lithology includes the biogenic structure sediment (trace fossils) and macrofossils. The sample was collected from many observation stations.

In laboratory analysis, the samples were prepared and identified using a microscope. The 11 thin section limestone samples were observed to figure out the features of larger and smaller foraminifera, coral, alga and organism shell fragments. The 21 residual fine clastic sedimentary rock samples were analyzed to identify appearance of foraminifera.

In this study, some basic methods were adopted for fossil identification, among all: Adams & Mackenzie (1998), Moore and Kaesler (2000) for invertebrate macrofossils; Cushman (1959) for larger foraminifera; Postuma (1971), Saito *et al* (1981), Kennett & Srinivasan (1983) and Bolli & Saunders (1996) for planktic foraminifera; van Marle (1991) for benthic foraminifera; and Boggs (2006) for trace fossils.

RESULT

Stratigraphy

The lower section of Jatiluhur Formation is built dominantly by clastic sedimentary rocks of claystone, siltstone and sandstone with some of thin limestone intercalations. It seem to be dominant occured in the southern part of the study area, closed to the Cileungsi river. The upper section consists mainly of limestone with the clastic siltstone, claystone and sandstone intercalation. It almost occupies in the central and northern part of the study area. The clastic dan biogenic limestone of Klapanunggal Formation spread around Bagogog, Cilalay, Pasir Bali, Kutalinglung, Sibancana, Kuari D, Cilengsi dan Ciseah (Table 1 and Fig.2).

Invertebrate Fossils

The marine invertebrata fossils assemblage, such as *Molluscs (Gastropods, Pelecypods), Brachiopods*, *Coelenterata (anthozoa – tetracoralia or rugosa, hexacorallite or zoanthariata, tabulata)* were found in organic clastic and biogenic limestones as well as clastic sedimentary rocks.

1. *Molluscs*

Molluscs occupy habitats ranging from the deep ocean to shallow waters in moist terrestrial niches.

a. *Gastropods,*

Gastropods shells are nearly all made wholly of aragonite, although there are a few with mixed mineralogy, comprising an outer layer of calcite and an inner layer of aragonite. Shell structure are cross-lamellar. In the samples, there are a thick-shelled gastropods; in a number of places a trace of crossed-lamelar structure is visible. Adams & Mackenzie (1998) reported that Gastropods occur throught the Phanerozoic, but are most abundant in Mesozoic and Cenozoic sediments.

b.*Pelecypods* (= *Bivalves*)

All have shells composed of two piece known as valves. In the most, the valves are of similar size. The shells vary greatly in size, color and ornamentation. Bivalve shells can be wholly aragonite, wholly calcite or a mixture of the two, and shell structures also vary. Wall structure are foliated, prismatic, crossed-lamelar and homogeneous. In the sample, there are shells with fairly well-preserved structures from dominating calcite shells, thick-shelled bivalve; outlined by a thin dark line probably a micrite envelope.

Lamellibranchiata can be identified, as bivalve with two flat, lamelliform gills on each side of the body.

According to Adams & Mackenzie (1998), this taxa are being present in marine environments since the Cambrian and in non-marine environments since the Carboniferous.

1) *Brachiopods*

Articulate brachiopods have calcite cells and thus the primary wall structure was preserved in samples. The shells identified by the large pedicle valve, smaller brachial valve and their attachment. The wall is impunctate, fairly thick made a foliated layer consisting of fine fibres or prisms arranged with their long axes at a low angle to the lenght of the shell wall. Some pseudopunctate have spines on both valves. Adams & Mackenzie (1998) reported that this taxa are major contributors to the bioclastic content of shallow marine limestone, especially in Palaeozoic.

3) *Coelenterata*

The scleractinian coral, with hard parts composed of aragonite was recorded in the limestone. Larger pieces can be recognized from their size and gross morphology. Adams & Mackenzie (1998) observed corals from Cenozoic limestone.

Algae

The calcareous dark red-brown algae, exhibit many different external forms, such as encrusing, nodular and branching, segmented types, show fine cellular structure were founded in limestone. Some alga are cylindrical branched, segmented, with a poorly preserved internal structure, but apparently having walls of microgranular or finely fibrous carbonate. They are classified as red algae. Adams & Mackenzie (1998) reported that coralline algae are being especially abundant in Cenozoic reefs and associated environment. There was also found plants with numerous branches, the stem is calcified with its central cell cavity surrounded by smaller cortical cell cavities. They are classified as green algae. Adams & Mackenzie (1998) found it in fresh or brackish water environment.

Foraminifera

The foraminifera are almost entirely marine animals, though a very few live in brackish or even fresh water. They are single-celled animals belongin to Protozoa. It developed a test, either of agglutinated foreign material, or of chitin, or of calcareous material secreted by the animal it self (Cushman, 1959).

Larger benthic foraminifera associateed with small form planktic foraminifera which have calcareous test, are dominantly calcitic, were well-preserved in limestone of Klapanunggal Formation.

1) Larger benthic foraminifera

According to taxonomic method by Cushman (1959), some larger benthic foraminifera can be identified.

a. *Milliolids*

Foraminifera belonging to the Suborder Miliolina have test wall structure is described as porcelaneous, and it has a distinctive appearance, being yellow or brown when viewed with plane-polarized light and showing anomalous low birefrigence with polars crosses, sometimes characterized by lost and walls appear micritic, as shown in Fig. 3(b) and 4(b). Adams & Mackenzie (1998) reported that the miliolids are dominantly a Mesozoic and Cenozoic group. Scholle (1978) recorded Milliolids are especially common in slightly restricted back-reef or bank facies.

b. *Nummulites* spp.

Test compressed, small, trigonal or suborbicular in plan. Surface papillate. Embryonic apparatus excentric in position, composed of two equal or subequal chambers, around which there are several chambers whose features are intermediate in character between the embryonic and the usual equatorial chambers. The early chambers may be distinctly spiral in arrangement, later growth mostly on only a segment of the periphery, and thereby producting a triangular outline, or cyclical, but greater on one than on the other side of the nucleoconch. A spiral canal and interseptal canals are present. Equatorial chambers rhomboid or elongate hexagonal. A net of canals in the chamber walls. Lateral chambers well-developed. Pillars present; terinating in surface papillae. They are disc-shaped and have a hyaline wall composed of radial calcite, individual crystal being orientated with their long axes at right angle to the wall, as shown in Fig. 4(a). Cushman (1959) observed *Nummulites* spp. in Oligocene-Miocene sediment.

c. *Amphistegina* spp. d'Orbigny, 1826

Test usually lenticular, trochoid, often involute on the dorsal side in the adult, ventral side with supplementary chambers more or less irregularly rhomboid. Sutures with a pronounced angle. Wall calcareous, finely perforate, without a true secondary canal system. Aperture small, ventral, the wall granular about the opening (Fig. 5). *Amphistegina* spp. occur in the Eocene to Recent sediment (Cushman, 1959).

d. *Operculina* spp. d'Orbigny, 1826

Test billaterally symetrical, planispiral, complanate, usually all coils visible from the exterior, earlier coils sometimes involute, chambers undivided, periphery with thickened marginal cord. Wall calcareous, perforate, smooth or ornamented with bosses. Aperture single, at the base of the apertural face, median, as shown in Fig. 6(a) and 6(b). Cushman (1959) found this taxa in Lower Cretaceous to Recent material.

e. *Cycloclypeous* spp. W.B. Carpenter, 1856

Test in the young of the microspheric from like *Operculina*, early chambers simple, later chambers annual, divided by radial portions into rectangular chamberlets, test discoidal and much compressed (Fig.8). According to Cushman (1959), *Cycloclypeous* spp. lives in Tertiary to Recent.

2) Planktic foraminifera

In limestone of Klapanunggal Formation, the planktic forms belong to the Suborder Rotaliina were identified as smaler rounded *globigerinid* from, show the arrangement of chambers and relatively thick, perforate test walls. The chambers are empty.

In many fine clastic sedimentary samples of Jatiluhur Formation (claystone, siltstone and sandstone intercalations), some planktic foraminifera taxa were recorded. Planktic foraminifera fossils can be identified, among all: *Globigerina venezuelana* Hedberg, *Globigerinoides altiaperturus* Bolli, *Globigerinoides diminutus* Bolli, *Globigerinoides obliquus obliquus* Bolli, *Globigerinoides primordius* Blow & Banner, *Globigerinoides ruber* (d'Orbigny), *Globigerinoides trilobus immaturus* LeRoy, *Globigerinoides trilobus sacculifer* (Brady), *Globigerinoides trilobus trilobus* (Reuss), *Globoquadrina altispira altispira* Cushman & Jarvis, *Globoquadrina dehiscens* (Chappman, Parr & Collins), *Globorotalia continuosa* Blow syn. *Neogloboquadrina continuosa* (Blow), *Globorotalia mayeri* Cushman & Ellisor, *Globorotalia obesa* Bolli, *Globorotalia siakensis* (LeRoy), *Hastigerina siphonifera* (d'Orbigny), *Orbulina suturalis* Bronnimann and *Orbulina universa* d'Orbigny.

There are some planktic index fossils can be recognized in the assemblages are : *Globigerinoides primordius* Blow & Banner (Bolli & Saunders, 1996), *Globigerinoides ruber* (d'Orbigny) (Bolli & Saunders, 1996), *Globorotalia continousa* Blow (Blow, 1979), *Globorotalia siakensis* (LeRoy) (Postuma, 1970) Blow, 1979), *Globorotalia mayeri* Cushman & Ellisor (Bolli, 1966; Bolli & Saunders, 1996), *Hastigerina siphonifera* (d'Orbigny) and *Orbulina suturalis* Bronnimann (Blow, 1979).

Based on identification of planktic foraminifera reffered to Postuma (1971), Saito et al (1981), Kennett & Srinivasan (1983) and Bolli & Saunders (1996), the features of index fossil are:

a. *Globigerinoides primordius* Blow & Banner

Test low trochospiral, unequally biconvex. Equatorial profil elongate, equatorial periphery distinctly lobulate, axial periphery rounded. Wall perforate, surface pitted. Chambers inflated, subglobular, arranged in two to three whorls, three and a half to four chambers in the final whorl, increasing rapidly in size as added. Sutures of the spiral and umbilical side depressed, radial to slightly curved. Surface on final chambers finely hispid. Umbilicus small, narrow. Primary aperture interiomarginal, umbilical, a low to medium arch, bordered by faint rim. A single small, secondary sutural aperture is present on spiral side. This species

b. *Globigerinoides ruber* (d'Orbigny)

Test medium, low to high trochospire, equatorial periphery distinctly lobulate, axial periphery broadly rounded. Chambers highly inflated, spherical, arranged in three and half to four whorls; with three subspherical chambers in the final whorl, increasing moderately in size, are distinctly separated. Sutures on spiral and umbilical side subradial to radial, distinctly depressed. Surface coarsely perforate, surface pitted. Umbilicus narrow. Primary aperture interiomarginal, umbilical, with a medium arched opening bordered by a rim. Secondary / supplementary sutural apertures, small, situated opposite sutures of earlier chambers. This species is distributed stratigraphycally in Late Middle Miocene Zone N.15 to Recent, widely distributed in warm subtropical to tropical waters.

c. *Globorotalia continousa* Blow

Test low trochospiral, equatorial periphery lobulate, axial periphery rounded, chambers subspherical to ovate, four in the final whorl, increasing rapidly in size. Sutures on spiral and umbilical sides radial, depressed. Surface coarsely pitted. Umbilicus narrow, deep. Aperture interiomarginal, umbilical-extra-umbilical, a rather low arch bordered by a distinct rim. This species is distributed stratigraphically in Early Miocene (N.4) to Late Miocene (N.16) within tropical to cool subtropical waters.

d. *Globorotalia siakensis* (LeRoy)

Test very low trochospiral, equatorial periphery lobulate; axial periphery broadly rounded, Wall rather coarsely perforate, surface smooth. Chambers inflated, subglobular, slightly embracing, arranged in about three whorls. The five to six chambers of the last whorl increase regularly in size. Sutures on spiral and umbilical side radial, depressed. Umbilicus fairly narrow to deep. Aperture interiomarginal, extraumbilical-umbilical, a fairly narrow, elongated arched opening, bordered by a faint lip or rim.

e. *Globorotalia mayeri* Cushman & Ellisor

Test very low trochospiral, inflated. Equatorial periphery lobulate. Axial periphery broadly rounded. Wall rather coarsely perforate, surface smooth. Chambers inflated, subglobular, arranged in about three whorls. The five to six chambers of the last whorl increase regularly in size. Sutures on spiral side slightly to moderately curved, depressed. On umbilical side radial depressed. Umbilicus fairly wide and deep. Aperture interiomarginal, extra-umbilical-umbilical, with a large, high arch, bordered by a lip or rim.

f. *Hastigerina siphonifera* (d'Orbigny)

Test planispiral in adult stage, trochospiral in early stage, evolute. Equatorial periphery distinctly lobulate, axial periphery rounded. Wall perforate, surface finely pitted, may be slightly hispid. Chambers globular to subglobular, arranged in about three and a half whorls. The five to six chambers of the last whorl increase rapidly in size. Sutures radial, depressed. Aperture in later stage interiomarginal, equatorial, a broad arch, bordered by a faint rim.

g. *Orbulina suturalis* Bronnimann

Test almost globular, early stage trochospiral. Wall distinctly perforate, surface moderately pitted. Chambers spherical. The much inflated final chamber not entirely enveloping the early part of the test. Transitions from forms in which the last chamber envelope about 75% of the earlier part to forms in which the earlier chambers are only just visible have been observed. Primary aperture interiomarginal, umbilical in the early globigerine stage; in the adult areal with small openings, which are scattered over the wall of the last chamber. Small sutural secondary openings are present in the suture separating the last chamber from the penultimate and earlier chambers.
Biostratigraphycally, the appearance these index fossils shown that the sections deposited within Middle Miocene Zones N.9 to N.14

According to taxonomic description by van Marle (1991), in the fine sediment some benthic foraminifera was identified, among all: *Ammonia beccarii* (Linnaeus), *Amphistegina lessonii* d'Orbigny, *Bolivina* spp., *Elphidium crispum* (Linnaeus), *Eponides* spp., *Gyroidina orbicularis* d'Orbigny, *Gyroidina neosoldani*, *Lenticulina* spp., *Nodosaria* spp., *Nonionella* spp., *Operculina ammonoides* (Gronovius), *Planulinoides* spp., *Pseudonodosaria aequalis*

(Reuss), *Quinqueloculina* spp., *Textularia sagitulla* Defrance, dan *Uvigerina peregrina* Cushman. The foraminifera assemblages were indicated that the sediment rocks were deposited in neritic setting.

Trace Fossils

The burrowing, boring, feeding and locomotion activities of organism can produce a variety of trails, depressions, and open burrows and borings in mud or semi-consolidated sediment bottoms. Filling of these depressions and burrows with sediment of a different type or with different packing creates structures that may be either positive-relief features, such as trails on the bases of overlying beds, or features that show up as burrow or bore fillings on the tops of the underlying mud bed. Burrows and borings commonly extend down into beds; therefore, these structures are not exclusively bedding-plane structures. Tracks, trails, burrows, borings and other structures made by organisms on bedding surfaces or within beds are known collectively as trace fossils, also referred to as ichnofossils, or lebenspuren (Boggs, 2006).

The various kind of trace fossils assemblages in clastic sedimentary rock (claystone, siltstone and sandstone) in the study area can be grouped in *Skolithos* and *Cruziana*. The appearance of this trace fossils had particular significance to paleoenvironmentsl study.

1) *Skolithos* is characterized especially by vertical, cylindrical or U-shaped burrows. Diversity of this trace fossils is low and few horizontal structure are present. This trace-fossils was established for trace that occur in soft ground sand marine surface in beach with high water energy, but it may grade seaward into shallow shelf environment (Boggs, 2006).
2) *Cruziana* is characterized by a mixed association of vertical, inclined and horizontal structures. Boggs (2006) observed that this typical soft ground sand, silt and clay marine in lagoon and shelf with medium to low water energy trace fossils are commonly occur within subtidal zone bellow wave base but above strom wave base.

The bioturbations is charactized the sediment was built within shallow marine setting.

DISCUSSION AND CONCLUSIONS

Fossils assemblages features (the appearance of larger benthic and small planktic foraminifera, besides *molluscs, brachiopods, coelenterata*, calcareous red and green algae), supported by morphology characteristics identified that the limestone was formed in Tertiary age within back-reef zones (at the northern part/Bagogog-Cilalay), reef-crest (at central part / Pasir Bali, Kutalingkung, Sibancana, Kuari D) and fore-reef setting (southern part / Cileungsi, Ciseah). The significant appearances shallow marine invertebrate fossils (*molluscs, brachiopods*) and trace fossils (*skolithos*, *cruziana*) characterized the back-reef.

Coelenterata associated with foraminifera, *molluscs* (*gastropods*, *pelecypods*) and algae grew the coral reef-crest. The planktic foraminifera in limestone with claystone interlaminations and or intercalations characterized the fore-reef within neritic bathymetric zone. The environmental condition changes were recorded by fossil associations.

Some index planktic foraminifera (*Globigerinoides primordius, Globigerinoides ruber, Globorotalia continousa, Globorotalia siakensis, Globorotalia mayeri, Hastigerina siphonifera* and *Orbulina suturalis*) can be identified in carbonaceous clastic sedimentary rock. Biostratigraphycally, the appearance these index fossils shown that the sedimentary rock of Jatiluhur sections deposited within Middle Miocene Zones N.9 to N.14.

The lower section of Jatiluhur Formation are built dominantly by clastic sedimentary rocks of Middle Miocene age claystone, siltstone and sandstone with some of thin limestone intercalations. The upper section consists mainly of bioclastic limestone with siltstone, claystone and sandstone intercalation. On the basis of the appearance of planktic and benthic foraminifera, molluscs and brachipods, besides trace fossils, the clastic sedimentary rock was formed within neritic zone.

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Table 1. Stratigraphy of the study area

Era	Period	Formation	Lithologic Symbol	Description
Quatenary	Recent	Alluvium		Sand, gravel, pebble, loose
Tertiary	Miocene	Klapanunggal		Bioclastic limestone, well sorted, larger benthic & planktic foram, corals, algae
		Jatiluhur		Claystone and sandstone interlaminations Claystone: brownish black, carbonaceous Sandstone : grey, fine to coarse grained, well sorted, subrounded, porous, parallel laminations

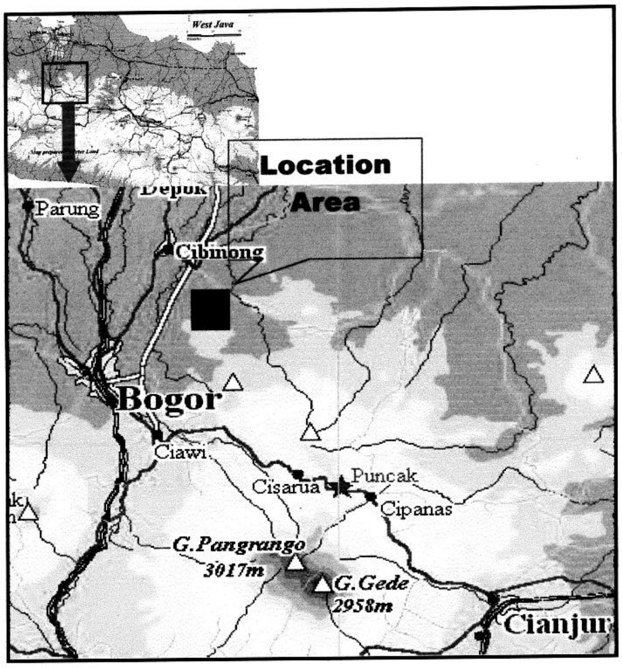


Figure 1. Location area

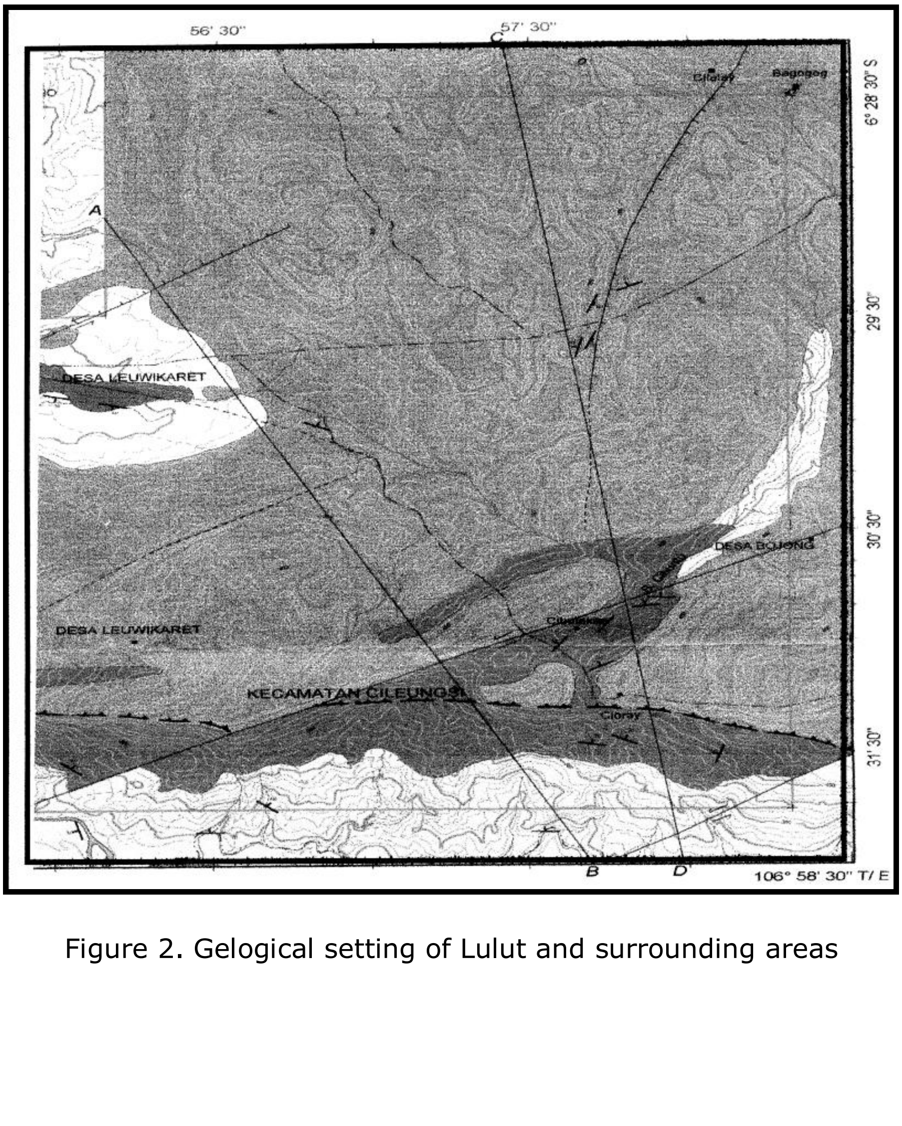
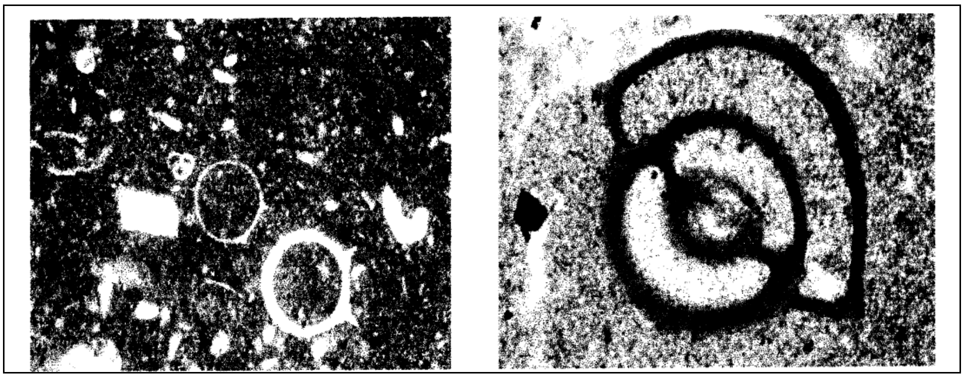
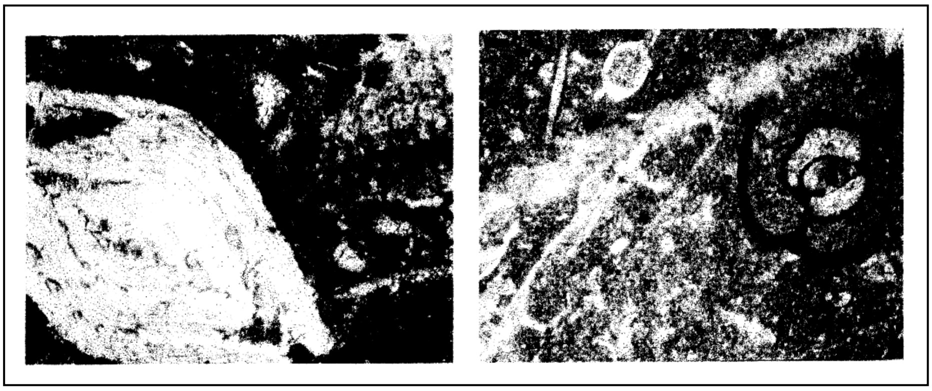


Figure 2. Gelogical setting of Lulut and surrounding areas



(a) (b)

Figure 3. Planktic foraminifera *Orbulina universa* and *globigerinid* form (a); Miliolids benthic foraminifera (b) in mudstone (Sample: 83)



(a) (b)

Figure 4. *Nummulites* sp. (a) and Miliolids Benthic Foraminifera (b) in Wackstone (Sample: 198-3)

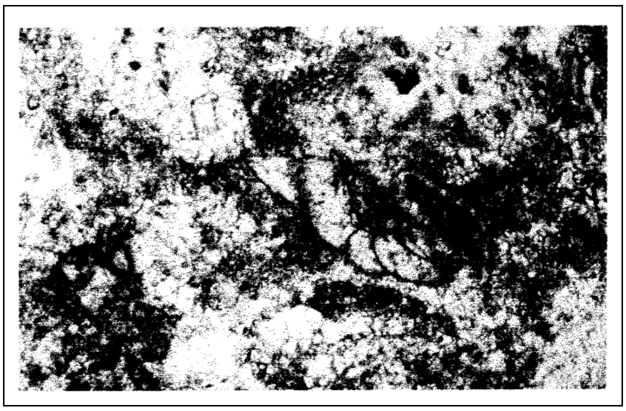
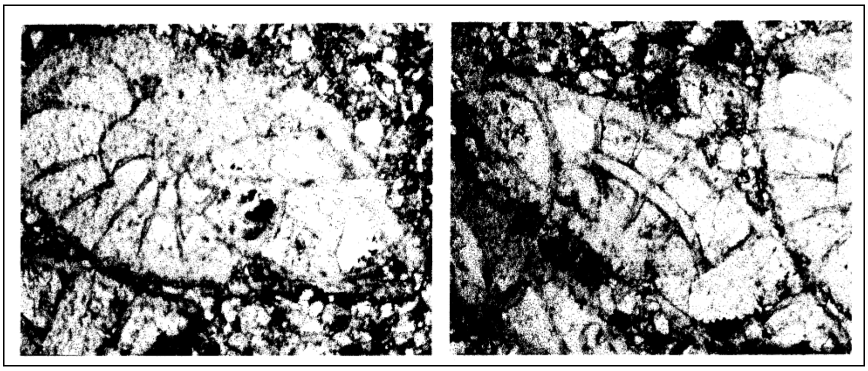


Figure 5. *Amphistegina* sp. in wackstone (Sample: 198-4)



(a) (b)

Figure 6. *Operculina* sp. (a and b) in packstone (Sample : 240-1)

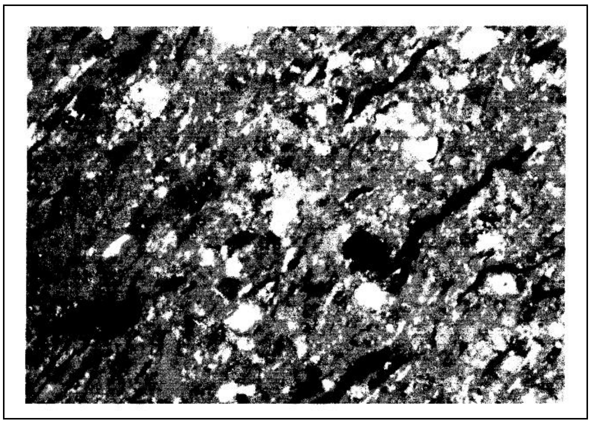


Figure 7. Non calcareous mudstone, lamination, with Illite, Quartz, Feldspar and Carbonaceous (Sample : 256-1)

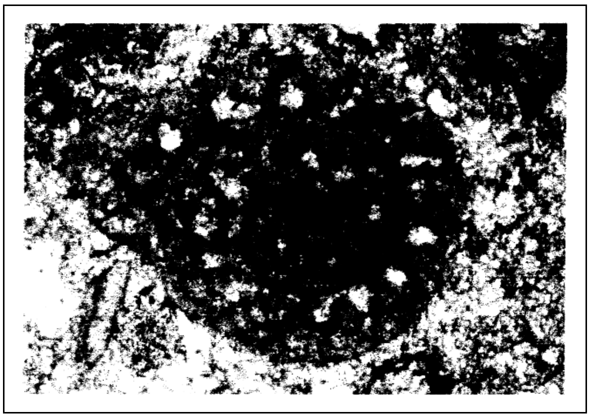


Figure 8. *Cycloclypeous* sp. in packstone (Sample: 156-2)