DIAGENETIC FEATURES OF PALEO LAGOONAL REEF OF TACIPI AREA, SOUTH CELEBES

By :

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Abstract

Limestone outcrops of the Tacipi area is an ideal carbonate platform part of Neogene East and West Sengkang Basin that are located in the south part of Sulawesi, precisely in western of Bone city. The limestones of this area, outcropping mainly on the north-south oriented hills such as Temapole, Anadara, Tamping, Lappa, etc., are the best reef example in the Tacipi area, as the reef itself, its debris and detritus can be distinguished in the field. Throughout the ridges and pinnacle in Tacipi field the limestones are predominantly homogenous boundstones on the top and detrital bioclastic packstones with local grainstones, and wackestones at the bottom. There are four major reef zonation indentified pacth reef, barrier reef, fore reef and lagoon. The extensive freshwater leaching of fossil fragments and calcareous cement give the preservation of biomouldic and vug pore spaces.

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Introduction

The Tacipi carbonate platform is a part of Neogene East and West Sengkang Basin that are located in the south part of Sulawesi, precisely in western of Bone city (Fig.1). Topographically the basin is low lying area close to sea level. The Sengkang basin is bounded by Latimojong Mountains to the north which are composed of Cretaceous flysch sediments (Sukamto, 1982). The Bone Mountains form the southern boundary of the Sengkang basin where Neogene sediments rise to outcrop.

East Sengkang Basin

The basin is formed during the Early to Middle Miocene with north-south axis of sedimentation. Up to 1800 m of Middle Miocene sediment are preserved unconformably overlain by late Miocene reef limestones (Sukamto, 1982; Grainge & Davies, 1983). The development of reef indicates a relatively stable shallow marine environment, compared to deep water through postulated in the West Sengkang Basin.

Tacipi Formation is equivalent with the Tacipi Member of Sukamto (1982). This Tacipi Formation can be subdivided into two units, the lower interval consisting of interbedded limestones and calcareous mudstones, informally called unit B and an upper reef limestone called unit C. The base unit B comprise generally fragments of limestone enclosed calcareous grey mudstones. The upper unit C consists of homogenous bioclastic packstones with occasional grainstones. The reefal bioclasts have been extensively modified by diagenesis but appear to consist mainly of coral and encrusting algae. Walanae Formation extends across both the East and West Sengkang Basin and crops out around their margins and along the Walanae fault zone (Fig.1).

The data from outcrop and hand specimen of Tacipi field is the key to understanding the formation of carbonate platform and its facies of research area. Although several facies are identified through study of conventional slab samples of hand specimens. More detail facies identification and its delineation are supported by thin section analyses.

Tacipi Limestones

The top and base of Tacipi Formation are represented by distinct north-south lineation of geomorphological features, especially in southern area of East Sengkang Basin. The limestones of this area, outcropping mainly on the north-south oriented hills such as Temapole, Anadara, Tamping, Lappa, etc., are the best reef example in the Tacipi area, as the reef itself, its debris and detritus can be distinguished in the field.

The Reef Facies

The hill ranges of Anadara, Temapole and Lanca (Fig. 2) are occupied by topographical pinnacles and ridges of massive, partly hard and chalky coral reef limestones. They consist of mostly large clusters of coral knobs or branches, up to 25 cm in diameter, in a micritic to calcarenitic cement. Encrusting algae are common, but not as abundant as coral.

Throughout the ridges and pinnacle in Tacipi field the limestones are predominantly homogenous boundstones on the top and detrital bioclastic packstones with local grainstones, and wackestones at the bottom. Bioclasts are mainly of branching finger-like corals, bivalves and calcareous algae with gastropods, foram and echinoderms. Generally the size of bioclast varies from fine to coarse grained and large coral fragments are common.

Corals and algae are the main reef building organisms. They frequently found still in growth position. Molds of large gastropods and shells are associated within the reef complex. The reef ridges and pinnacles

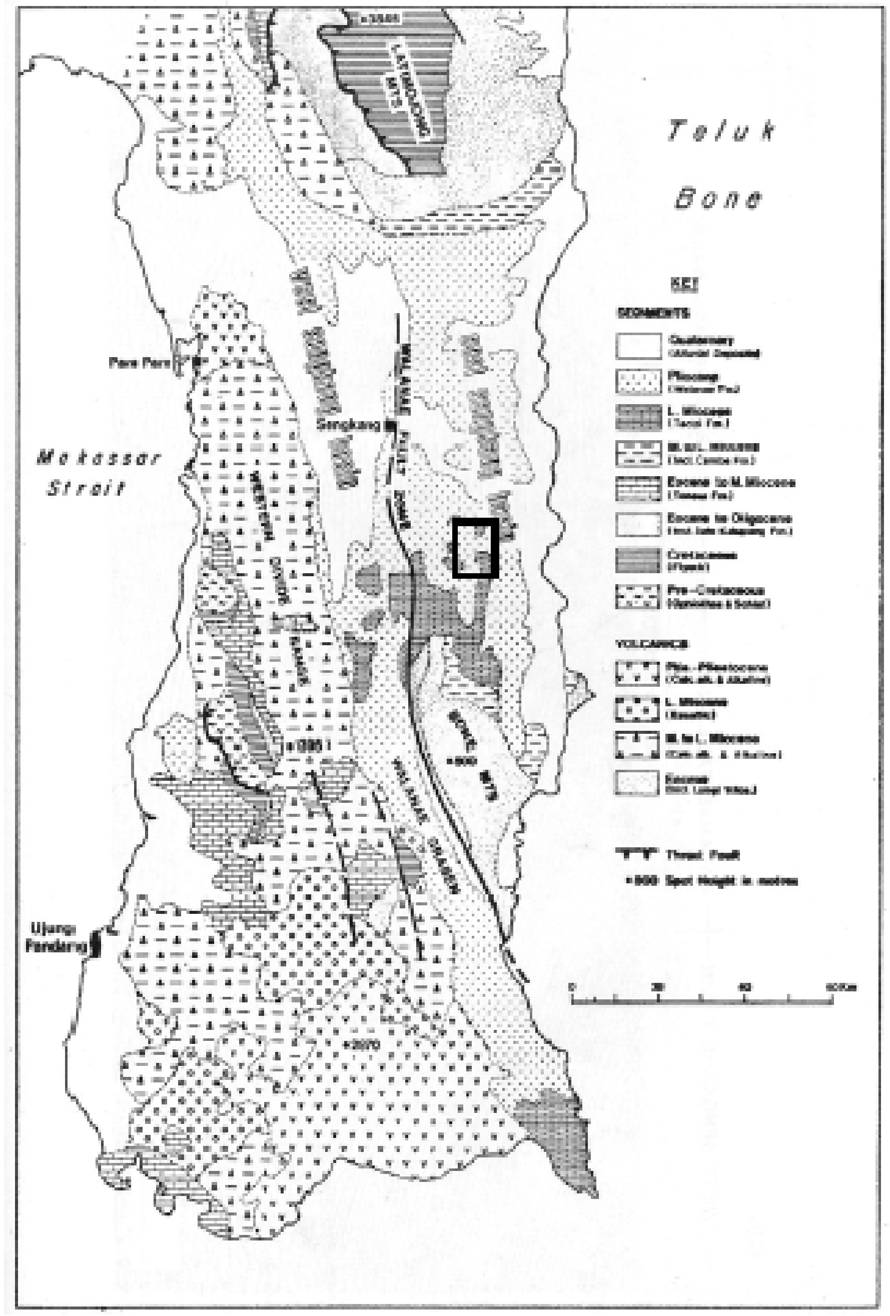

Fig. 1: Regional geology of southern arm Celebes (Sukamto, 1982). Research area is shown by open square and located in the East Sengkang Basin.

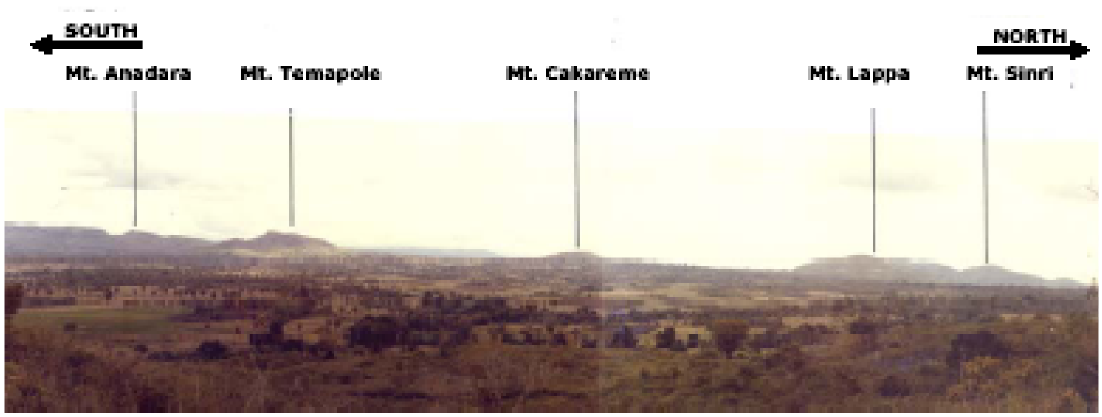

Fig. 2: Ridges and pinnacles morphology of the western part Tacipi carbonate field. On the foreground is relatively flat inter-reef area. Photograph from the eastern ridges.

rises 50 – 100 m above the normal surface levels of the hill tops. The lower part of the hills are surrounded by reef debris to calcarenitic facies, forming an inter-reef deposit (Fig. 3). The pinnacles of Temapole and Tajong in western and the ridges of Carebu in eastern are extremely rich in corals, generally head and branching corals. Calcareous algae and corals in growth position is abundant, embedded in a micritic cements which are partly altered to sparry calcite due freshwater cementation (Fig.4). In river Jaling, southern of Carebu village, and Temapole hill, a characteristic reef facies occurs, which has been found elsewhere in all ridges or pinnacles of Tacipi area.

The Reef Debris Facies

This facies surrounded the lower part between the reef ridges. It is characterized by a changeable facies of rudstones-packstones, wackestone and mudstones. Rudstones-Packstones facies occur as reef debris which present generally surrounded the middle of the slope of a ridge or pinnacle (Fig. 5), whereas wackestone and mudstone layer distributed in the lower slope. Rudstone is a breccia facies which associated with reef debris. Fragments are badly sorted, angular to subangular, 3 mm to 30 mm in diameter and embedded mainly by wackestone – packstone facies (Fig. 6). The limestone fragments are mixture of coral, algal, foram, molusc, and echinoid which can be interpreted as facies of flanked growing reef (Fig. 3).

Algal foraminiferal limestones occur as irregular pockets of and mainly associated with reef building as broken debris cemented by micrite and sparry calcite. The detrital limestone bank occurring in Jompie village and surrounding ridges of Sappewalie and Tamping. The limestone banks are about 2 m to 5 m thick, consisting of detrital and show slightly bedded structure. These banks are overlying mostly the lower slope of reefal facies and can be found more wider distributed in the southern direction (Fig. 6). These detrital limestones comprise generally of larger forams such as Camerinide and Lepidocyclina, planktonic and bentic forams as well as fragments of molusc, coral and algae. The reefal and their surrounded bedded bioclastic limestones contain larger foraminifera species such us Lepidocycina.

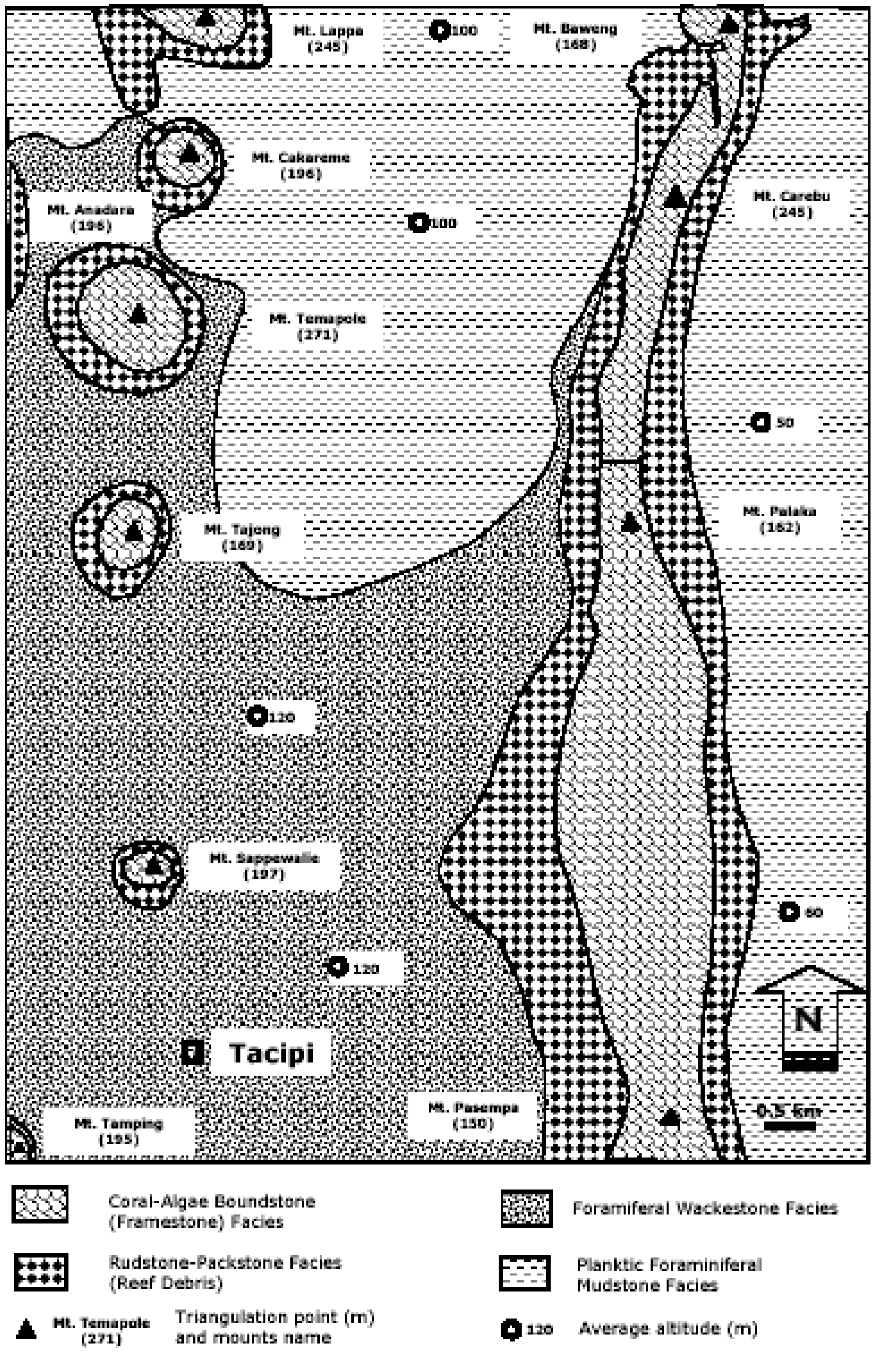

Fig. 3: Simplified carbonate facies map of Tacipi area.

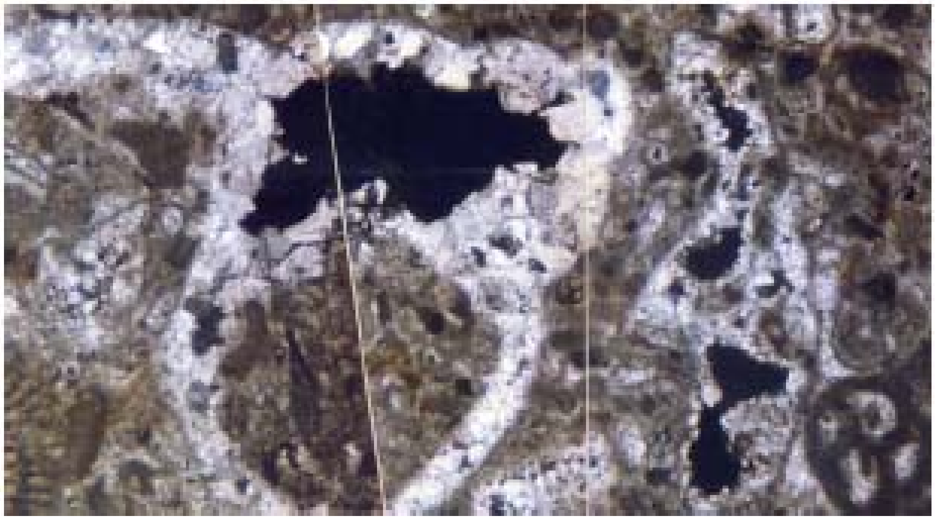

Fig. 4: Mouldic porosity and blocky spar cementation on gastropode. Photo base is about 7 mm long.

Fig. 5: Bedded limestone outcrop of rudstone-packstone facies or reef debris facies

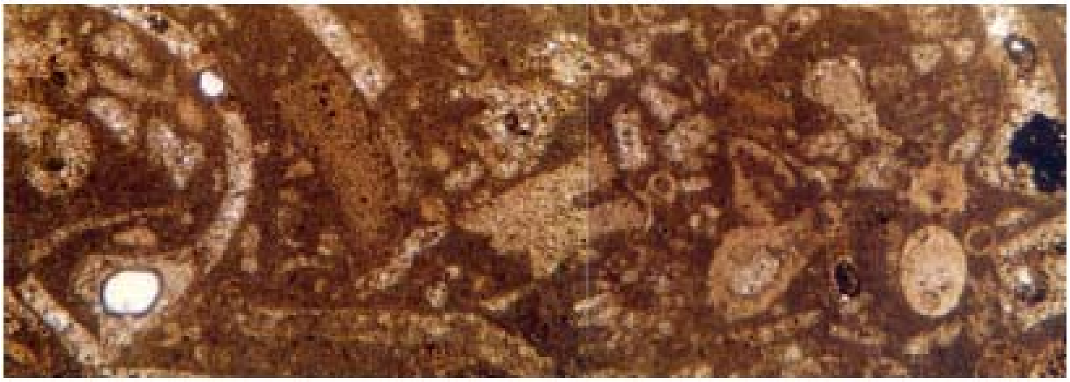

Fig. 6: Rudstone sample under microscope showing various reef materials as bioclastic fragments which are enclosed by wackestone groundmass. Photobase is about 10 mm long.

Wackestone and mudstone facies in lower flank of reef buildup contain mainly planktic foraminifera. Micropaleontological age dating from Globigerinoides extremus and Globorotalia tumida give a range between N18 and N19 or Upper Miocene – Lower Pliocene age.

Diagenetic Features

The limestones are off-white to buff in colour and are friable with vuggy appearance in outcrop and hand specimen. Occasionally, there are intervals which are completely calcite cemented. Detailed petrographic studies of outcrop and handspecimen from the Tacipi field have established the main diagenetic processes that have affected the limestones. The main diagenetic features are :

- The extensive freshwater leaching of fossil fragments and the preservation of biomouldic pore space.
- The widespread occurrence of intact micrite envelopes and lack of stylolites, indicating the limestone has not undergone compaction.
- The predominance of blocky calcite cement suggesting freshwater phreatic zone cementation (Fig.4).
- The rare occurrence of dolomite, which only occurs as a minor replacement of micrite.

Porosity Development

The porosity in the Tacipi limestone is almost exclusively biomouldic, resulting from the leaching of originally aragonitic bioclasts. The porosity of the limestones is therefore largely a function of the distribution of these bioclasts, their size and the extent to which they have been leached. Subsequent freshwater calcite cementation has reduced this biomouldic porosity and permeability in places by blocking narrower interconnection between vugs (Fig.7). Ocasionally the leached porosity is completely occluded by calcite cement. The origin of this cemented zones are not clear, but they may represent palaeo water tables where more extensive cementation occurred in the freshwater phreatic zones than in the overlying vadose zone. Visible porosity estimation shows an average porosity of over 30 percent. To the reef flanks which are mainly located in lower area, bioclast size decreases slightly and is matched by a decrease in average visible porosity.

Fig. 7: Vuggy and mouldic porosity which partly blocked by sparry calcite. Photographed in cross polar position with gypsum comparator. Photo base is about 10 mm

Reef Zonation

The four major reef zonation indentified were:

1. Patch reef this facies are distributed in the western belt, where some relative north-south trend isolated hills such as Lappa, Cakareme, Temapole, Tajong , Sappewalie and Tamping characterized by abundant reef and reefal facies on the top (Fig. 8). These isolated hill chains adjacent immediately with deeper water environment. These reef probably grew up more faster than barrier reef in the eastern part. The reef growing my be relatively uninterrupted as is shown by perfect changes from reef core to reefal or bioclastic facies.
2. Barrier reef occurs in eastern ridge from Curu Baweng hill in the north until Pallaka hill in the south. This barrier reef is developed by vigorous head, brain and branching corals and encrusting algal which created a rigid framework and persistent against high energy water environment. Coral algae framework can be classified as boundstone (Dunham, 1962) or especially as framestone (Embry and Klovan, 1971). The ubiquitous presence of carbonate mud and the open or spar-filled original porosity in this facies illustrates also the high energy reef environment. Virtually all the effective porosities seen are moldic, or solution enlarge moldic and fracture as well as vug porosity which all of them classified as post depositional or secondary porosity.
3. Fore reef facies are characterized by high percentages of fine grained planktonic foramineral rich lime mud, mainly range between mudstone to wackestone of Dunham carbonate classification (Dunham, 1962). Small fragments corals, algae, echinoid spikes, shell, and gastropods enclosed by very fine – fine grained lime groundmass indicate clearly detrital origin from upper reefal facies and open marine environment.
4. Lagoon facies might be expected as a “mélange” of larger foraminifera, green and red algae, and echinoid spikes that enclosed by terigenous clay groundmass. This facies present in western part of Temapole, Cakareme and Lappa where they western flanks are shallow water transition between marine and terrestrial environment.

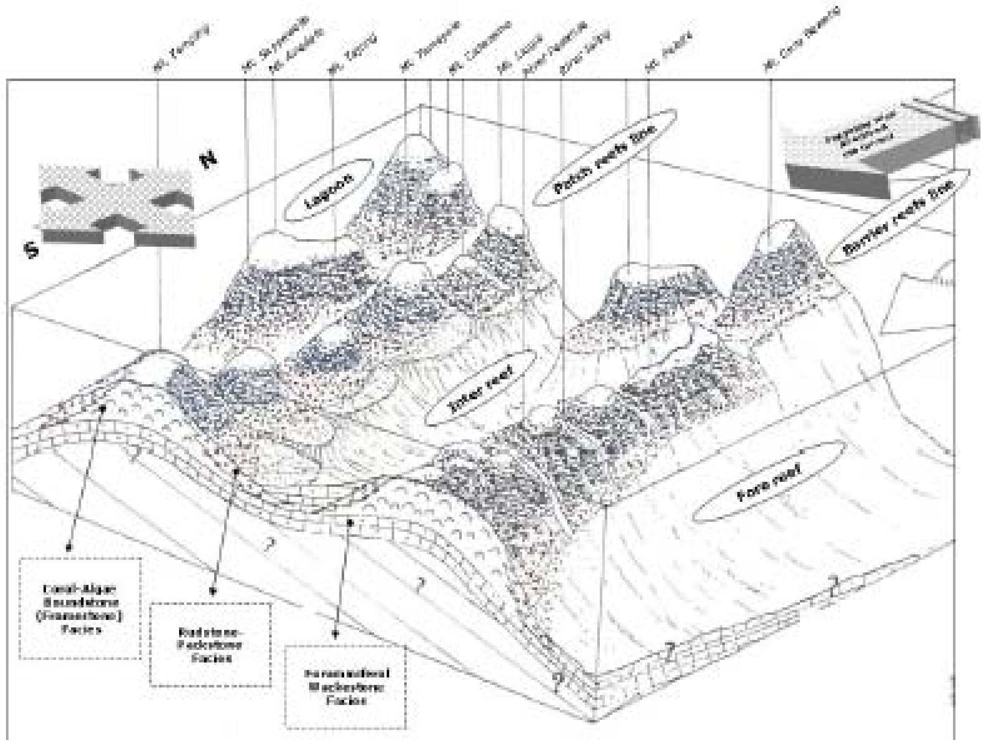

Fig. 8: Hypothetical block diagram showing paleo-environment of reef complex of Tacipi area. Talus or reef debris distributed more extensive in the southern part due north-south wind trend and sea current. Patch reefs are distributed between Temapole and Tamping, whereas barrier reefs between Curu Baweng and Pasampa river.

CONCLUSION

The Tacipi limestone area is underlain by a Pre Miocene basement high which probably controlled the site of initial reef growth. The limestones this area are interpreted as reef buildups, composed mainly of reef derived detritus underlain by a thin interbedded section of mudstone

and limestone which mark the initial transgression and establishment of reef growth. Reef growth was centered along north-south trending ridge between Mt. Lappa – Mt. Tamping in the western belt and Mt. Curu Baweng to Jaling river in the eastern belt. The reef complex developed on an elevated platform and cemented bioclastic talus material was periodically transported into the deep water off-reef environment. Evidence of deep water environments are seen in the lower slope of hills Tamping, Temapole and Anadara where there are a reduction of skeletal material and abudance of planktonic forams.

The carbonate facies which may be identified in the Tacipi Formation are fore reef, barrier reef, patch reef, and lagoon. A good resolution for shoreline identification was made base on observation of texture, structure and composition in outcrops and hand specimens. The rocks show a clearly defined open sea, barrier reef and lagoon and patch reef association which can be identified in the field and laboratory. The setting of these reefs which associated with top of the ridges (e.g.

Temapole- and Curu Baweng- hill) are classified as “high energy” whereas in the bottom “low energy” environment. The porosity type and its distribution are controlled by primary and secondary, however secondary porosity type plays more important role in reservoir development.

Fluctuation in sea level during deposition exposed the limestone to extensive freshwater leaching. Termination of reef growth probably took place at different times throughout the basin, and was caused essentially by an increased rate of subsidence.

The major phase of diagenesis occurred during or soon after deposition of the limestones when at least parts of the reefs and associated sediments were intermittently exposed. Pervasive water leaching, probably mainly in the vadoze zone, was extensive. Concomitant with the leaching, freshwater leaching, fresh water flushing also resulted in the formation of meniscus cements in the vadose zone and blocky cements in the phreatic zone. Exposure of the reef also caused fracturing and an extensive ramifying network of veins formed which were possibly enhanced by further dissolution. The fractures were in many places connected with large biomouldic pores and both were subsequently infilled by vadose carbonate silt.

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