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RESEARCH ARTICLE

Provenance Analysis Based On Petrographic Samples On EXIA-1 Well, Banggai Basin, East Sulawesi, Indonesia

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Abstract

The structure of Exia is composed of Miocene built-up carbonates formed by shear faults. The buildup carbonate feature in the Exia prospect can be seen from the high elevation surrounded by lows with an NNE-SSW and NE-SW trending. The MA-1, SE-1, MI-1 wells are several wells in the Tiaka and Senoro Fields which are proven to have large gas reserves. Tiaka Field is located to the west of the Exia Well, while Senoro Field is to the northeast. The study used primary data from the Exia-1 well in the form of cutting samples. The wet and dry cutting samples were further processed into thin section. This thin section is then carried out for petrographic, XRD, and SEM analysis. Tomori Formation starts from the deeper environment FZ1 upwards to the shallower FZ5 –FZ6 (reef) with open marine and restricted areas. The allochem that composes the limestone at The Matindok Formation consists of red algae fragments and benthic forams which indicate the facies zone of formation in FZ 4 (slope). In the upper Mantawa Formation, it is still quite clear the presence of large forams indicating a reef association environment (FZ5-FZ6), but the presence of a large number of planktonic forams indicates a deeper depositional environment / slope, so it is possible that large forams were transported from a shallower environment. The Kintom Formation have rock provenance ranging from continental blocks in the interior of the craton to a recycled orogeny section of recycled quartz zone.

Keywords: Provenance, Banggai Basin, Tomori Formation, Tectonic Setting, Petrography, Facies Zone

1. Introduction

1.1 Sub Introduction

The Exia structure located between the Tiaka and Senoro structures. The main reservoir is in the Upper Miocene Mantawa reef carbonates. The second reservoir is in the limestones of the Tomori Formation. The Exia structure is located on the Banggai micro continent shelf, precisely offshore foreland. Tectonically this structure is not deformed.

The structure of Exia is composed of Miocene built-up carbonates formed by shear faults. The buildup carbonate feature in the Exia prospect can be seen from the high elevation surrounded by lows with an NNE-SSW and NE-SW trending. This structure is located along the tectonically complex eastern extent of Sulawesi. The Block includes part a collision complex formed during the Miocene (Hasanusi and Petricola, 2006).

The MA-1, SE-1, MI-1 wells are several wells in the Tiaka and Senoro Fields which are proven to have large gas reserves. Tiaka Field is located to the west of the Exia Well, while Senoro Field is to the northeast.

Paleo-high structure in the Exia structure can be seen from the cross section that passes through the Exia-1, MA-1, and BO-1 wells. The carbonate members of the Mantawa reef which are members of the Minhaki Formation are composed of porosity formed by inter-granular and vuggy carbonate components. The same type of reservoir was also found in wells BO-1, MA-1, MI-1 and SE-1, with porosity between 15 – 30%. The results of the seismic inversion analysis on the reservoir in Exia-1 are considered to have better porosity quality than reservoirs in other wells. Seismic inversion data in the Mantawa interval indicates a low impedance character which implies a good porosity, so it is concluded that the carbonate reef members of the Mantawa Formation of the Minahaki Formation in the Exia-1 structure are predicted to have good porosity.

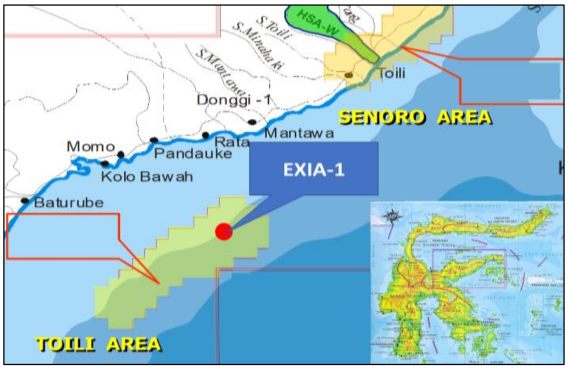

Fig 1. The location of the Exia-1 Well is between the Tiaka and Senoro structures.

Lithological succession in the Banggai-Sula Basin is divided into 4 groups, namely Pre Mesozoic-Succession (Basement), Mesozoic Succession, Tertiary Carbonate Platform, and Quaternary Deposit (Surono and Sukarna, 1995). The four groups are divided based on lithological association, fossil content and lithological succession.

The Pre-Mesozoic succession is composed of metamorphic, basement, granitic, and volcanic Mangole (Figure 2). The metamorphic basement in this group is composed of slate, schist, and gneiss which may have been deformed during the Upper Paleozoic Period (Garrard, et al, 1988). Banggai granite is composed of granite intrusion with high abundance of orthoclase, granodiorite, quartz diorite, microdiorite, porphyry syenite, aplite and pegmatite. This granite is formed from the Late Permian to Triassic based on six K-Ar mica, two K-Ar hornblende and Rb-Sr feldspar (Piagram and Surono, 1985). Mangole volcano is composed of sub-aerial, layering and alteration. In this section the lithology consists of rhyolite, dacite, ignimbrite, lithic tuff and breccia, and indicates an age of 210 million years (Sukamto, 1975).

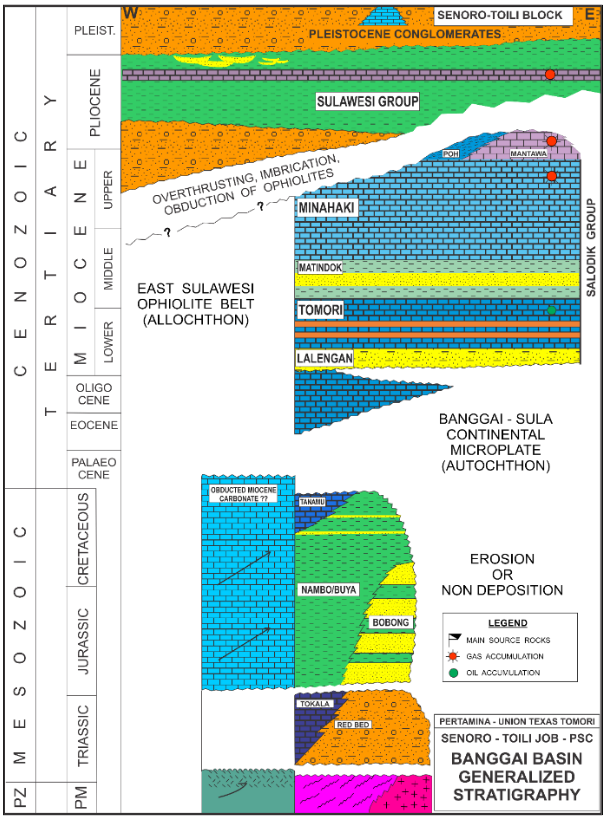

Fig 2. Stratigraphy of the Banggai Basin (BPPKA, 2006)

At the top of the basement are the Menanga Formation, Bobong Formation, Buya Formation and Tanamu Formation which are included in the Mesozoic Succession. The Menanga Formation is composed of crystalline limestone and metasedimentary rocks (schist and phyllite) with quartzite insertions. The next layer is not in harmony with the Early Jurassic Age layer and the depositional environment is in the shallow sea which produces coarse-sized clastics in the Bobong Formation known as the Kabau Formation (Figure 2).

The Tertiary Carbonate Platform consists of the Pancoran Formation and the Salodic Group which override the older successional units asynchronously (Figure 2). The Salodik Group is divided into three units, namely the Tomori Formation (formerly known as the Lower Platform Limestone Unit), the Matindok Formation (clastic and coal units), and the Minahaki Formation (Upper Platform Limestone Unit). Locally, the patch reef of the Tomori Formation is widely dolominated (Hasanusi et al., 2012). Based on biostratigraphy analysis, depositional history of post collision sediment started at the end of Late Miocene. During this time, a sea level rise occurred, and deposition of the Kintom Formation took place in a deep marine at upper bathyal setting (Abimanyu, 1990). At the Miocene age, it is indicated that there is an unconformity based on nannoplankton studies. The unconformity occurred in the Late Miocene age, equivalent to 10.606 Ma–8.20 Ma, with a duration of 2.406 million years (Nurhidayah, et. Al, 2024).

The Quaternary deposits overlapped with the tertiary carbonate platforms. In the Peleng Formation there are reef limestones which are interpreted to have formed during the Pliocene in a shallow marine environment and recent deposits of mud, silt, sand and gravel associated with swamps, rivers and beaches (Garrard, et al, 1988). The Celebes Mollasse, especially the shale facies act as top and bottom seal of some reservoir in this area, mainly in onshore (Kurniawan, et.al., 2017). Based on stratigraphic analysis, the Celebes Molasse was deposited in a marine environment, generally outer sublittoral to upper bathyal.

Foraminifera assemblages show that shallowing and deepening of the basin has occurred repeatedly due to collisional tectonic processes in the eastern Sulawesi arm (Kurniasih et.al., 2021). The collision tectonic phase occurred at least from the Middle Miocene to the upper part of the Middle Miocene. Some minor tectonic extensions, however, occurred in this phase. Subsequently, the extension tectonic phase occurred until the Holocene. Based on Wilson (2002), Carbonate sedimentation in the region spanned the Tertiary, occurred in the full range of plate tectonic settings and in a diversity of depositional settings. The location and development of equatorial carbonates was commonly influenced by clastic influx, tectonics, eustasy and oceanography. Extensive carbonate platforms were best developed on shelves with limited clastic input or on isolated bathymetric highs.

Satayana et, al,. (2011) on his research related to prospective petroleum plays in Banggai Basin stated that Large gas fields have been discovered in the Neogene reefal carbonates of the Banggai platform. Gas has been produced from the late Miocene reefs of the south arm of onshore Sulawesi and their prospectivity continues offshore into the Gulf of Bone. Mesozoic petroleum plays are prospective in deeper parts of the Gorontalo, Buton and Banggai Basins. Based on source rock analysis shows that there are possibilities to find mature Mesozoic source rock due to high level of maturity based on Ro and Tmax analysis (Santy, 2016).

The petroleum system has been working on the Exia structure with good reservoir quality so the Exia-1 well was drilled. The drilling results were declared a dry hole, so an evaluation of the cause of the well failure was required. One of the analyzes that needs to be carried out is to carry out a provenance analysis on the Exia-1 Well. The purpose of this provenance analysis is to determine the lithology, facies zone and provenance of the rocks penetrated in the Exia-1 well.

2. Methodology

Exia-1 well with TD 9907 ft MD penetrated until Tomori Formation. Grupa-1 well encountered Biak Formation (1750-2376 ft MD), Kintom Formation (2376-7127 ft MD), Mantawa Formation (7127-8450 ft MD), Minahaki Formation (8450-9164 ft MD), Matindok Formation (9164-9289 ft MD) and Tomori Formation (9289-9907 ft MD). Based on cutting data, oil show found at Mantawa Formation 7127-8418 ft MD (1291 ft), Minahaki Formation 8580-8610 ft MD (30 ft), Tomori Formation 9288-9670 ft MD (382 ft).

The study used primary data from the Exia-1 well in the form of cutting samples. Cutting samples obtained in the form of wet cutting samples and dry cutting samples. Wet cutting samples are cutting samples that are directly taken and obtained during the drilling process without being cleaned, washed, and dried. The dry cutting samples came from the same sources as the wet samples, but had been cleaned and dried. These samples were taken from Mantawa Formation up to Tomori Formation. Total samples are 60 samples varied from Mantawa, Matindok, and Tomori Formation.

The wet and dry cutting samples were further processed into thin section. This thin section is then carried out for petrographic, XRD, and SEM analysis. The petrographic analysis aims to determine the characteristics of rock samples in the study area such as texture, structure, and mineral composition of the rocks that make up the rocks, as well as to enhance and classify rocks optically.

XRD analysis was carried out to determine the distribution of minerals, especially clay minerals. The distribution of known clay minerals will be an indicator in determining the stages of diagenesis of clay minerals. Determination of diagenesis is supported by SEM data which can be seen from the presence of clay minerals as a result of diagenesis. In addition, XRD data will be integrated with petrographic results to determine the provenance of the research well rock. Petrographic analysis was carried out to determine the type and percentage of minerals, followed by a provenance analysis using the provenance classification according to Dickinson and Suzcek (1979).

3. Results and Discussion

3.1Analysis of Rock Facies and Diagenesis

The division of the facies zone (FZ) for carbonate rock formations (Tomori, Minahaki, and Mantawa Formation) uses the Wilson Facies Zoning rimmed carbonate platform type (Figure 3). This was based on the tectonic setting. The most suitable platform type is the rimmed type which is characterized by the presence of a barrier and a restricted zone.

In general, the zone division in this model consists of deep sea (FZ 1) slope-shelf (FZ 2,3,4) platform margin (FZ 5-6) interior platform (FZ 7,8,9) and partially subaerial zone (FZ 10), where each FZ characterizes specific depositional environmental conditions, due to differences in depth and circulation patterns of seawater, so that they will have different texture characteristics and associations of constituent components (especially bioclasts).

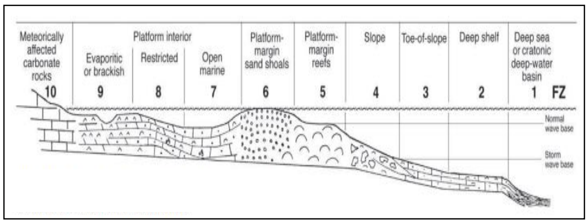

Fig 3. Zoning of Facies Rimmed Carbonate Platform (Wilson, 1975).

The lower part of the Tomori Formation, at a depth of 9860 – 9900 ft, clastic limestone appears, the facies is dolomitic packstone-wackestone, with allochem components in the form of bioclasts which have been partially replaced by micrite and sparite, but can still be recognized from their geometry. The components of the bioclast consist of coral shards, algae shards, and benthonic/plangtonic forams. The composition is carbonaceous shale, with fine grain size, showing a laminate, dark gray color. The diagenesis process in the form of microbial micritization is quite intensive, neomorphism from micrite to microspar is also quite intensive so that the texture and original components of the rock are not very visible (Figure 4). Another diagenetic process observed was minor dolomitization. Based on the texture and composition of the constituents, it is interpreted that limestone is formed in the facies zone (FZ) 4-5 (slope to platform margin reef).

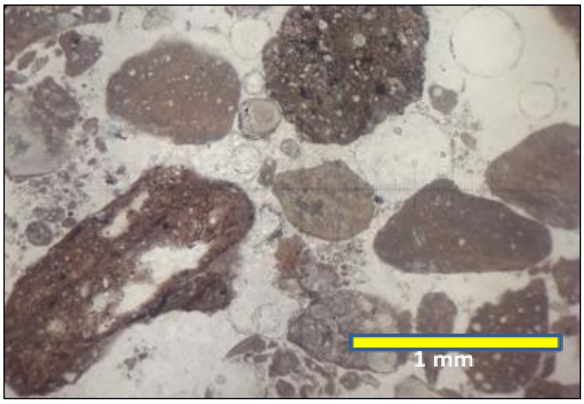

Fig 4. Thin section Figure from depth 9890Ft

At a depth of 9700 - 9800 ft, in this zone the rock is in the form of fine-grained clastic limestone, wackestone-mudstone, with the main constituent components in the form of carbonate/micrite mud, microspar/sparicalsite, and a few shells of organisms in the form of planktonic and benthic foram shells which have been largely altered. (Figure 5). The diagenesis process that occurs is in the form of micritization both biogenic and mechanical to form carbonate mud followed by replacement/neomorphism of micrite into microspar. Another observed diagenesis process was in the form of quite intensive dissolution followed by the filling of large enough crystalline calcite. Based on the texture and composition of the constituents, it is interpreted that limestone is formed in the facies zone (FZ) 3-4 (slope to toe of slope).

Fig 5.Thin Section image from 9800ft showing small trace of foraminifera (F) dan crystalline calcite (C).

Analysis of samples in the depth range of 9600 – 9680ft is dolomitic limestone facies because the presence of dolomite is quite abundant associated with oil stain (Figure 5), while the original constituent components are not very recognizable because most of them have undergone intensive diagenesis into micrite, sparite, and dolomite (Figure 6). Diagenesis features observed were pressure dissolution, recrystallization of calcite, and moderately intensive dolomitization, which is thought to have occurred in a burial diagenesis environment, where dolomite formation is associated with fracture zones and pressure dissolution along with oil stain formation. Based on the texture and composition of the constituents, where most of the original texture has been converted into crystalline calcite and dolomite, the depositional facies at this depth could not be determined.

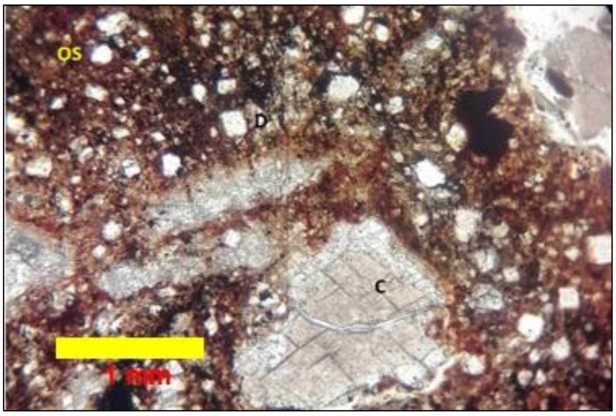

Fig 6. Dolomite (D) Associated with Oil Stain (OS) at 9680 ft.

In general, the Matindok formation at this depth consists of fine sandstone-silt-clay fragments with a mixture of carbonate fragments, with the abundance of carbonate fragments varying at each depth, from 10 to 30%. Carbonate fragments in the form of red algae fragments, shells of planktonic and benthic forams. Diagenesis processes that play a role in the sedimentary rocks of the Matindok Formation are recrystallization and compaction of clastic sedimentary fragments as well as mycritization and neomorphism of carbonate rock fragments. at a depth of 9240 ft identified the presence of dolomite (Figure 7) as a result of diagenesis in burial environments.

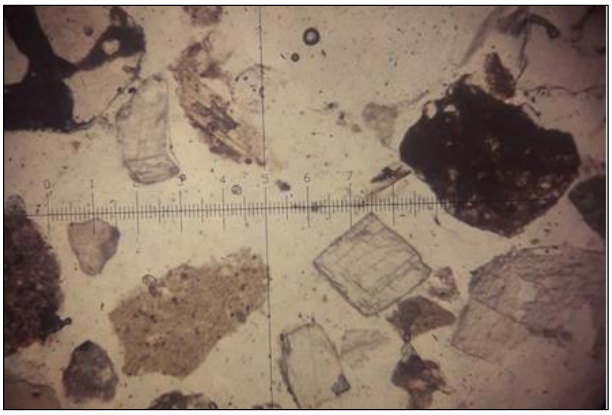

Fig 7. Thin section sample from Matindok Formation at 9240ft.

The Tomori Formation at a depth of 9300 – 9560 with carbonate rock samples shows the presence of shale fragments and metamorphic fragments (phyllite/slate) (Figure 8). The recognizable components of carbonate rocks are large foram shells (lepidocyclina) and encrusting algae. The features of diagenesis that can be recognized are micritization that occurs in marine phreatic environments, pressure dissolution and grain fracturing in burial environments. Based on the texture and composition of its constituents, it is interpreted that limestone is formed in the facies zone (FZ) 4-5 (slope to platform margin reef).

Dolomite began to be observed in the incision starting at a depth of 9400 (slightly) and the most abundant at a depth of 9680, where the presence of dolomite was associated with oil stains (Figure 6), with carbonate components that were still recognizable in the form of large and small foram remnants which had been largely replaced.

Dolomite can be formed due to the increased concentration of Mg in three diagenesis conditions; at the beginning of sedimentation in evaporite environments (high evaporation, usually characterized by association with ooids), in diagenesis mixing environmental conditions (zones of mixing meteoric water and seawater, usually characterized by association with intensive dissolving features), and burial diagenesis environments (usually associated with burial features). Burial pressure in the form of grain fracture, pressure dissolution, and seam dissolution).

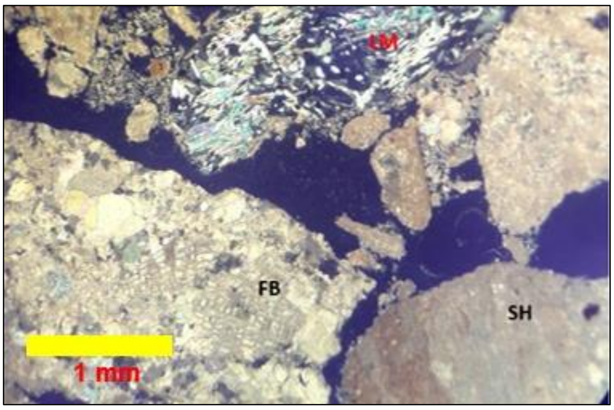

Fig 8. Thin section sample at 9340ft showing fragments of shale (Sh), metamorphic rock (Lm), dan large foram (FB).

In all samples, in general, traces of dissolution diagenesis were observed, but have been replaced by crystallization of calcite and dolomite. Traces of intensive dissolution which are features of meteoric conditions in the form of vug and channeling were not found. Diagenesis products associated with dolomite in the form of dissolution seam filled with oil stain (Figure) and shell fracture indicate that the environment for dolomitization is burial.

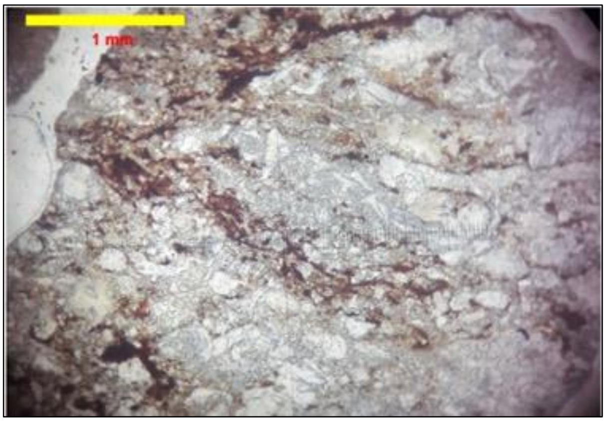

Fig 9. Dissolution seam and grain fracture associated with dolomitization at a depth of 9600 ft.

In general, the Matindok Formation is in the form of shale composed of fine-sized quartz (Q) fragments (less than 0.3 mm), carbonate (K) in the form of microspars, and clay minerals are fine, and at the bottom (9240 depth) dolomite is found (Figure 10).

The appearance of the fragments in the incision is drill cutting fragments that do not entirely represent the rock constituent fragments, the fragments which appear as sedimentary lithic (LS) are fragments of the Matindok shale. From the intervals represented by the depths of 9180, 9210, and 9240, a pattern can be seen, where in general the grain size of the sediment tends to be coarser, which is in line with the increasing abundance of quartz, as well as the larger the size of the quartz. The carbonates in this formation not only exist as fragments but also act as cement.

The presence of dolomite at a depth of 9240 also confirmed the results of chemical analysis which showed the presence of MgO and CaO which was quite significant at this depth. Based on the textural interpretation, the formation of dolomite is probably controlled by burial factors, not Mg input by groundwater under exposed conditions near the surface.

The shape of the quartz grains that make up the shale is still relatively angular, so that it is interpreted in the transportation and deposition process that it has not been intensively abraded due to the relatively close distance of the source. The presence of monocrystalline quartz in relatively significant quantities in the shale indicates the source rock is granitic-granitoid composition, while the presence of carbonate indicates the influence of the carbonate source from the older formation (Tomori).

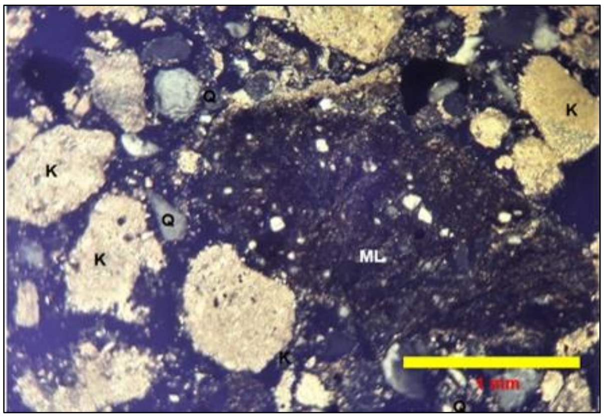

Fig 10. Thin Section at 9180ft.

The lowest part of the Minahaki Formation, at a depth of 9120 ft, is clastic limestone with a mixture of clastic sedimentary materials (clay and silt fragments), and the higher you go, the more there is a tendency for more allochem fragments/carbonate grains, and the lower the carbonate mud matrix fraction, so that in general gradual change and also alternation from wackestone to packstone-grainstone is seen. The limestone composition allochem consists of red algae fragments and benthic forams (Figure 11) which indicate the facies zone of formation in FZ 4 (slope) based on the Wilson model with modifications. The diagenesis process observed in the form of micritization and neomorphism, dissolution and filling of most of the dissolution results, which indicates the marine and meteoric diagenesis environment. At South Seno Field , Minahaki Formation is characterized by carbonate ramp morphology with mouldic and intercrystalline microporosity (Yumansa, et, al., 2023).

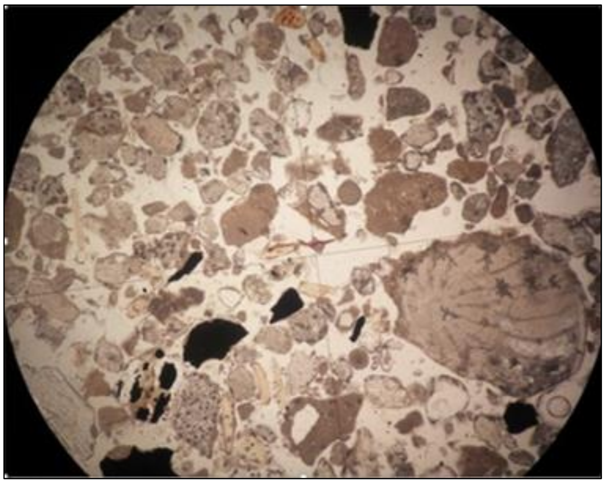

Fig 11. Thin section from the Minahaki Formation reveal the presence of red algae fragments.

The Mantawa Formation is composed of limestone lithology which in general has undergone very strong diagenesis so that only a few constituent components can still be recognized, including large foraminifera fragments and small benthic and planktonic foraminifera (Figure 12). At the top, it is still quite clear the presence of large forams that indicate a reef association environment (FZ5-FZ6) based on the Wilson model with modifications, but the presence of a large number of planktonic forams indicates a deeper depositional environment/slope, so it is possible that the large forams were transported from a different environment. shallower. The diagenesis process that stands out at the bottom is the formation of large calcite crystals that show perfect bidirectional cleavage, so it is interpreted as the result of filling/replacement of cavities resulting from dissolution and fracture in meteoric environmental conditions to burial, where the presence of deformed calcite crystals in the sample depth 7600-8000 ft indicates rock deformation. At a sample depth of 7150 ft (top Mantawa) showing the process of converting the total carbonate constituent components into micrite and sparite, at a depth of 7180 ft, some of the original components can still be recognized in the form of large forams and small forams. On Another field, characterized by reefal build-ups morphology and leached and vugular macroporosity pore-type (Yumansa, et, al., 2023)

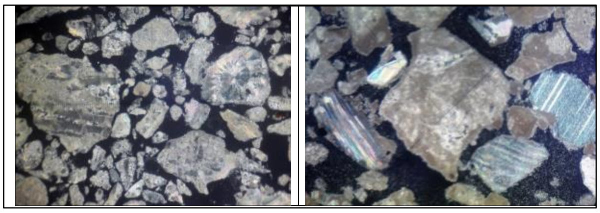

Fig 12. Rock sections of the Upper (left) and Lower (right) Mantawa Formation showing the presence of crystalline foram and calcite fragments.

In general, the rocks that make up the Kintom Formation consist of alternating fine sandstone-silt-shale, where the components of the sandstone consist of monocrystalline quartz (Qm), polycrystalline quartz (Qp), lithic (L), and feldspar (F), as well as a mineral matrix. clay (Figure 13). Shale layers are generally composed of lithic, clay minerals and a few fine quartz fragments.

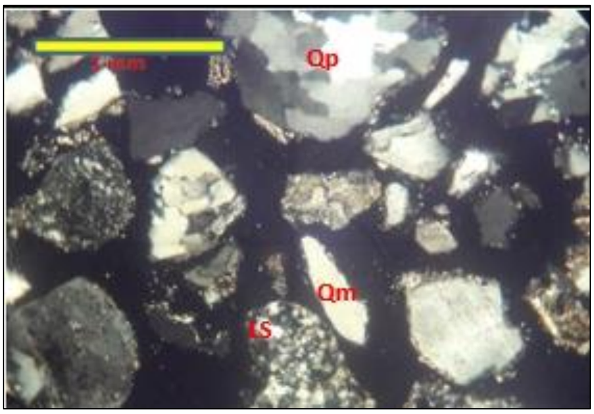

Fig 13. Thin section sample at 4030ft.

3.2 The Tectonic Setting Analysis

Based on several samples showing significant abundance and grain size of sand fragments, a provenance analysis was performed using the point counting method, taking into account the number/abundance of quartz (Q), feldspar (F) and lithic (L) grains. Provenance analysis can only be carried out on some samples from the Kintom Formation, because other formations are carbonate, while the Matindok Formation is generally shale, so it does not meet the requirements for point counting analysis.

The results of the calculation of the abundance of QFL (table 1) show that the percentage of quartz in general is quite dominant (more than 70%) with a little feldspar and 11-25% lithic. Polycrystalline quartz is generally identified with an abundance of less than 10%.

Based on the plotting of the Suczek & Dickinson triangle diagram (Figure 14) in general most of the sandstone samples show provenance of recycled orogen origin, which is interpreted as a Banggai microcontinent block that was uplifted due to collision with the East Sulawesi Ophiolite Belt in Late Miocene, granite part of the Banggai microcontinent block exposed on Peleng Island. The presence of polycrystalline quartz indicates that the erosion that occurred also involved metamorphic rocks older than granite, where what was exposed on Banggai Island was mica schist.

Table 1. The Results Of The Calculation (Point Counting) Of The Grain Fragments Composing The Sandstone

Depth	Q Total		Q Mono		Q Poli		Feldspar		Lithic	
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
4030	122	74,5	108	65,6	13	7,9	6	3,6	36	21,9
5020	134	70,5	116	61,5	18	9,5	8	4,5	48	25
5830	106	80,3	95	71,8	11	8,4	3	2,3	23	17,4
6160	96	85	87	77	9	8	4	3,5	13	11,5
6490	113	78,4	105	72,9	8	5,5	4	2,8	27	18,8
6820	94	100	87	91	7	9				

The QFL diagram shows the Kintom Formation rock depths of 4030, 5020, 6160 and 6820 having rock origins from continental block section of the craton interior and recycled orogeny section of quartzone recycled.

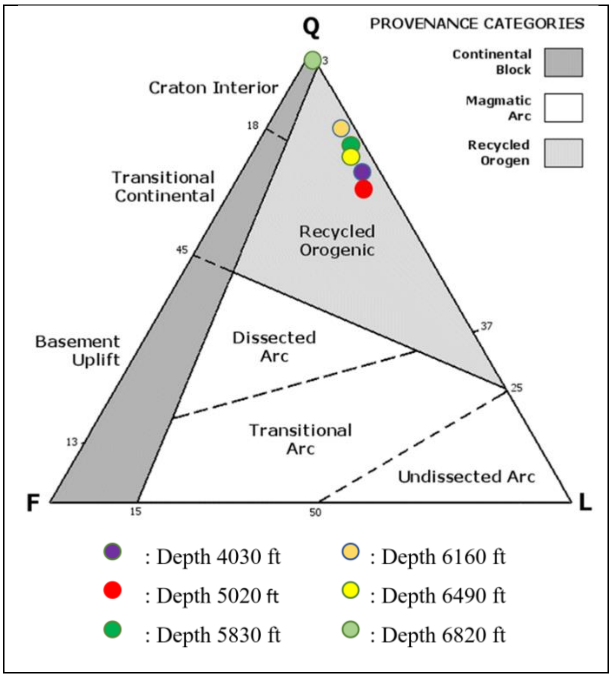

Fig 14. Ternary Diagram Quartz-Feldspar-Lithic.

4. Conclusion

The Tomori Formation is generally composed of clastic, fine-grained limestone (wackestone-packstone), bioclast components that can still be recognized are generally planktonic and benthic foram fragments. The average composition of XRD is 14% clay, 67% carbonate, 3% quartz and 19% other minerals. The features of diagenesis that developed were microbial micritization in marine diagenesis environments, micrite neomorphism into microspars, dissolution followed by replacement in bioclasts generally in meteoric diagenesis environments, and grain fracturing with pressure dissolution in burial environments. Minor dolomitization is seen starting at 9540ft depth, and intensifies at 9600-9680 depths, where dolomite is always associated with the oil stain-fracture zone. Dolomitization was also seen from SEM-EDS, high MgO of about 21% at a depth of 9740 ft. The facies zone of the Tomori Formation starts from the deeper environment FZ1 upwards to the shallower FZ5 –FZ6 (reef) with open marine and restricted areas.

The Matindok Formation is in the form of shale-mud with a mixture of carbonate (foram, red algae) and siliciclastic (sand – shale) fragments. The average composition of XRD is 33% clay, 41% carbonate, 4% quartz and 25% other minerals. SEM EDS shows the surrounding quartz block contains illite and kaolinite sheets, a small amount of carbonaceous cement and micrite spheres. The allochem that composes the limestone consists of red algae fragments and benthic forams which indicate the facies zone of formation in FZ 4 (slope).

The lowest part of the Minahaki Formation, 9120 ft deep, is clastic limestone with a mixture of clastic sedimentary materials and the higher you go, the more allochemic fragments there are, and the lower the carbonate mud matrix fraction. XRD is 19% clay, 66% carbonate, 2% quartz and 15% other minerals. Dolomitization was also seen from SEM-EDS, high MgO of about 5% at depths of 8500 ft to 8520 ft.

The Mantawa Formation is based on a thin section composed of skeletal grain in the form of a large foramic shell that is almost changed, a matrix of micrite, and cement in the form of sapricalcite spread from a depth of 7150 ft – 8000 ft. Sufficiently large crystalline calcite emerges from a depth of 7330ft. The results of XRD analysis of the Mantawa Formation showed an abundance of 10% clay minerals, 74% carbonates, 2% quartz and 12% other minerals. Dolomitization is also seen from SEM-EDS, the MgO content is about 2% at a depth of 8370 ft. In the upper Mantawa Formation, it is still quite clear the presence of large forams indicating a reef association environment (FZ5-FZ6), but the presence of a large number of planktonic forams indicates a deeper depositional environment / slope, so it is possible that large forams were transported from a shallower environment.

The Kintom Formation has a depth of 5440 to 6820 ft. The mineral composition described is based on 2 parameters, namely fragments and matrix. The fragments consist of quartz minerals (polycrystalline and monocrystalline) and lithic sediments, while the matrix consists of feldspar and clay minerals such as sericite and kaolinite minerals.

The Kintom Formation which is characterized by rock constituent fragments at the bottom is dominated by lithic, the higher up the more quartz, with a lot of polycrystalline quartz at the top showing a pattern of change in the provenance from volcanic arc (shown by lithic dominance) to continental (quartz dominance) and slightly dissected arc, indicated by the abundance of polycrystalline quartz. The QFL diagram shows that the Kintom Formation rock depths of 4030, 5020, 6160 and 6820 have rock origins ranging from continental blocks in the interior of the craton to a recycled orogeny section of quartzone recycled. Meanwhile, this affinity indicates that the tectonic setting is at the plate margin with a convergent mechanism and within the plate body (within plate) of oceanic or continental crust. In addition, alkaline affinity also shows that at the subduction boundary the magma series position is far from the subduction zone.

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