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Characteristics of Paremba Sandstones in Bantimala Complex: The Implication of Oil Exploration in Eastern Indonesia

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ABSTRACT

This research aims to determine the characteristics and provenance of paremba sandstones as an implication of oil and gas reservoirs potential. Paremba sandstone is a shallow marine sedimentary rock in the Bantimala tectonic complex, which is composed of flysh-type sedimentary rocks, interbedded sandstone, shale and conglomerates. The field data retrieval are using measuring section method. There are 31 thin section samples, including 5 blue day thin section samples for provenance analysis based on the percentage content of monocrystalline quartz, polycrystalline quartz, plagioclase, K-Feldfar and rock fragments. Paremba sandstone lies on the Bontorio River consist of conglomerates, very coarse - fine sandstones, siltstone, claystone and fosilliferous limestone with an almost vertical slope of 70 ° - 80 ° and NW - SE direction. Conglomerates are divided into two types, namely cherty conglomerate which is grayish-red colored, the sizes of the grain are pebble - boulder, open-packing, bad sorting, fragments consists of schist and quartzite, matrix in sandy-silt and cement consists of silica (chert) and grayish conglomerates which is similar to a cherty conglomerate, but it has gray colored and absen of chert. Sandstone have coarse - fine grain sizes, sub-angular - rounded grain shapes, in the form of arkose and litharenite which have flame structures (load cast: sole mark), slump structure, parallel lamination and ripple lamination. The presence of mosaic textures on sandy limestones, epidote in sandstones and graphite shows that paremba sandstones had undergone low-grade metamorphism. Based on the Qm-F-Lt diagram, the Qm-PK diagram and the Qt-F-L diagram, the paremba sandstones are from recycled orogen to interior craters, whose rocks had undergone Lithic recyled, transitional recycled, until quartoze recycled so it is interpreted that paremba sandstone comes from the Recycle orogenic tectonic environment. Petrographic observations of five blueday samples found that two of them had porosity <1% with fracture porosity-type. This is indicates that paremba sandstones are not suitable as oil and gas reservoirs.

Keywords: *Bantimala; Paremba sandstone; Bontorio river; provenance; tectonic; reservoir*

1. INTRODUCTION

The Bantimala complex is located around 60 km northeast of Makassar, South Sulawesi (Fig. 1). The Bantimala complex is the oldest rock complex that occupies the South arm of Sulawesi. Previous study [1] revealed that the complex Bantimala consists of a set allokton rocks which are mixed, tectonically condolencens, and consists of bancuh unit (mélange), high pressure metamorphic unit, paremba sandstones unit, chert "paring" unit, breccia schist unit, and the "Kayubiti" ultramafic unit. The rock set have varies age, from the Trias to the Early Cretaceous. Paremba sandstone is referred to Jurassic Shallow Marine Sedimentary rocks, composed of flish type sedimentary rocks, consists of interbedded sandstone, shale and conglomerates [2]. Paremba sandstones are formed in terrestrial - shallow marine environments, with fossils content composed of ammonite (fuciniceras), gastropods, and brachiopods that are early - middle Jurassic [3]. Paremba sandstones had undergone strong tectonics and imbrication with the early cretaceoseus – trias rock, which forms the complex of the mélange. This study aims to determine the characteristics of paremba sandstones and the provenance of Paremba sandstones.

2. METHODOLOGY

The analysis was carried out using field data and also petrographic analysis, 31 samples were obtained in the field and divided for two analysis, 26 for petrographic incisions and 5 for petrography + bludye. The field data retrieval was carried out along the Bontorio River, it is more or less than 300 meter for measuring section that was measured.

From the results of the analysis it was known that the lithology of the study area consists of sedimentary rocks and metamorphic rocks in the form of green schists. Metamorphic rocks are found at the top of the Paremba Sandstone section based on the stratigraphic position, seen in the position and rock foliation. Paremba sandstone itself consists of chert conglomerates, gray conglomerates, very coarse sandstones, coarse sandstones, medium sandstones, fine sandstones, silt, fossiliferouse limestones and claystone. The rocks relative position is around NW-SE with an almost vertical slope of 70 ° - 80 °.

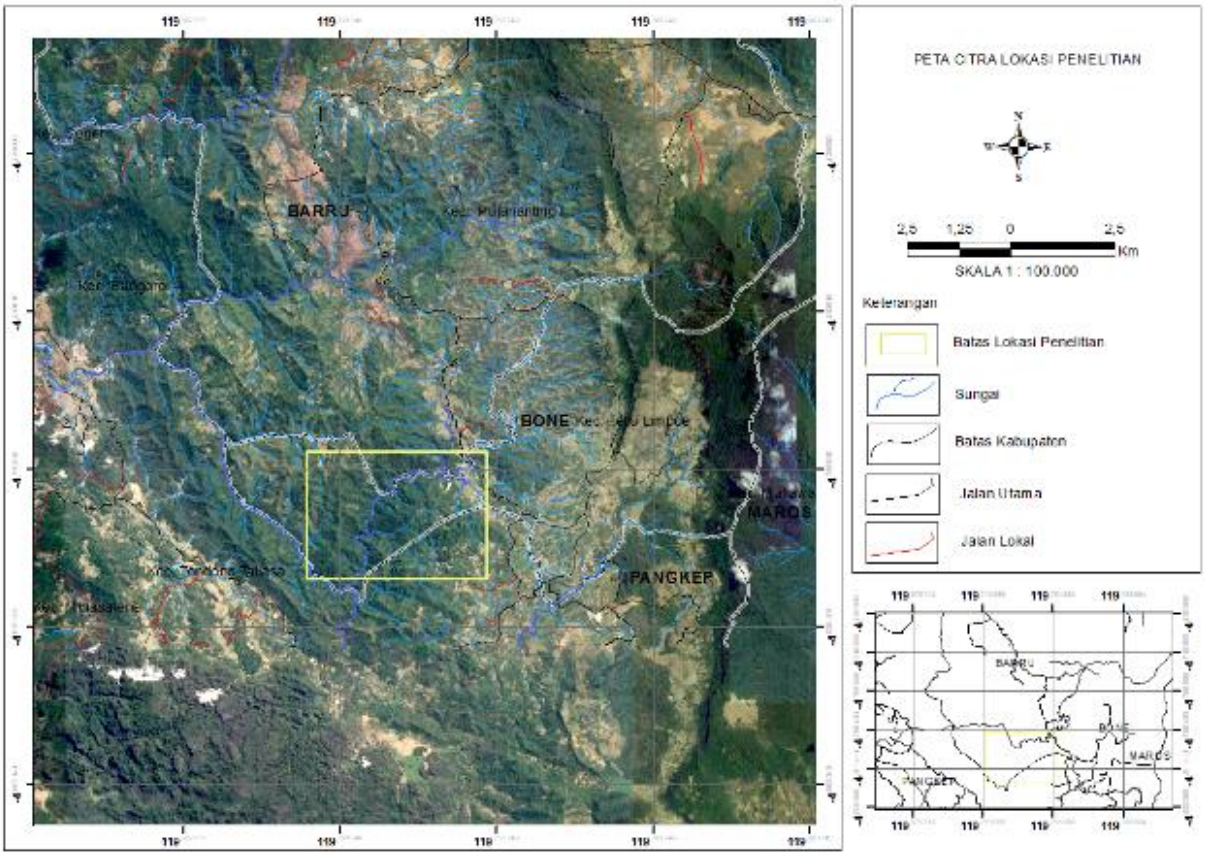

Fig. 1. Map of research location

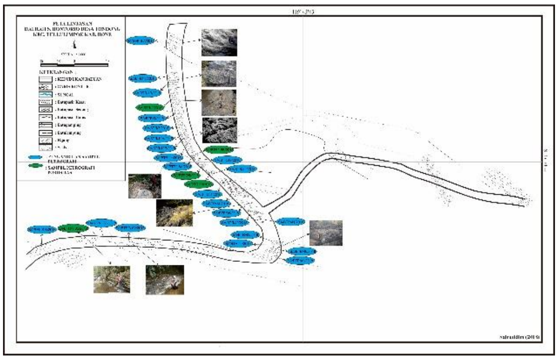

Fig. 2. Profile of Paremba Sandstone

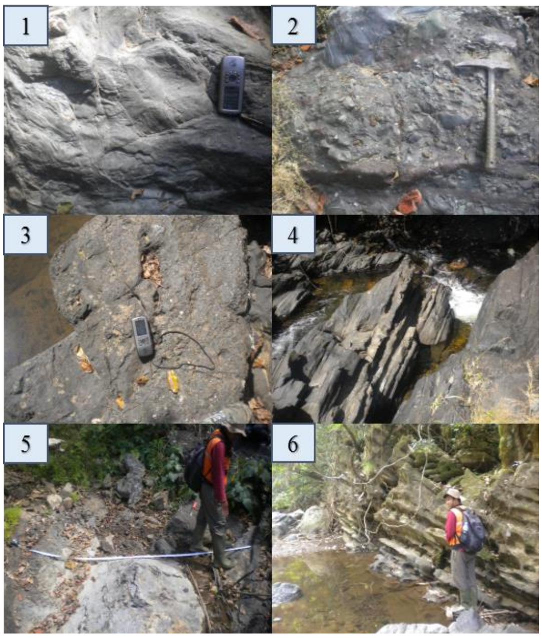

Fig. 3. (1) Photo of megascopis schist outcrop (2) photo of megascopis outcrop of chert conglomerate, (3) Photo of megascopis outcrop of gray conglomerate (4). Photo of megascopis sandstone outcrop, (5). Photos of megascopis outcrops of fossiliferouse limestones, (6). Megascopic photo of limestone

3. RESULT AND DISCUSSION

A. Results

A.1. Litology

Analysis was carried out on 31 rock samples in the paremba sandstone section on the Bontorio River. Sandstones that can be observed in this unit are very fine until very rough in grain sizes, blackish gray in color. angular in shapes and well-divided. The sedimentary structures that can be observed are lenticular, wavy, flame structure and lamination. Compiled mainly by quartz, and contains glauconite, muscovite, and carbonate. Also found graphite minerals which are associated with the mineral calcite indicate that the rock is formed in a metamorphic environment.

Microscopically, the minerals that can be identified in thin section are monocrystalline and polycrystalline quartz, igneous fragments, quartzite fragments, opaque minerals, iron oxide, feldspar, plagioclase, calcite, glauconite, and muscovite. The dominant mineralogy is quartz with a precent content that varies from 40% to 75%. Quartz which can be observed in thin secions can be divided into monocrystalline and polycrystalline. Monocrystalline quartz has a greater grain size than polycrystalline quartz. The presence of polycrystalline quartz reaches 15%.

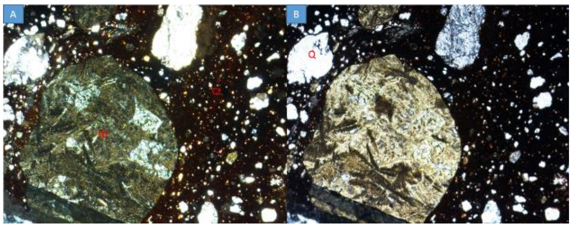

Fig. 4. Photomicrograph conglomerate in ST.1 with composition of rock fragments (rf), quartz and cement in the form of chert (Ct)

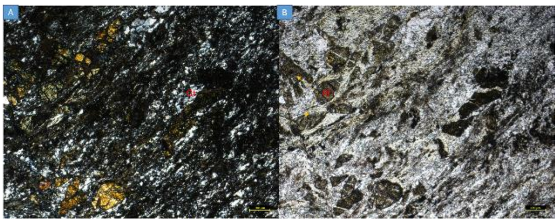

Fig. 5. Photomicrograph conglomerate on ST.2 with composition of rock fragments and cement form of silica.

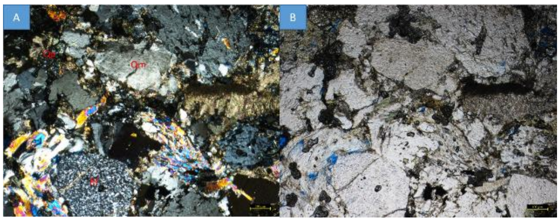

Fig. 6. Very Coarse Sandstone Photomicrograph on ST.49 with the composition of Monocrystalline Quartz, Polycrystalline Quartz and Rock Fragments.

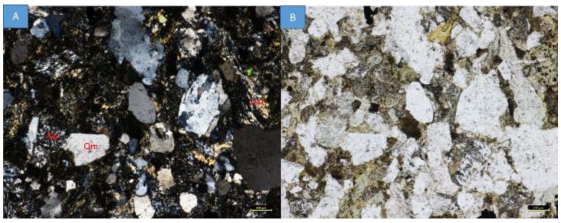

Fig. 7. Coarse Sandstone Photomicrograph on ST.7 with a composition of Monocrystalline Quartz, Polycrystalline Quartz and Calcite.

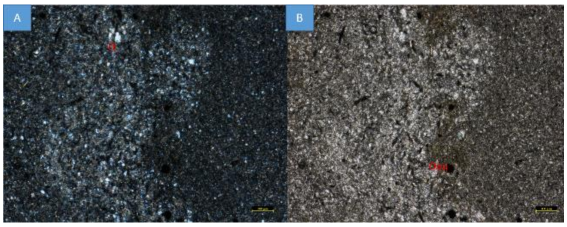

Fig. 8. Fine sandstone photomicrograph at ST. 43 with composition of quartz clay minerals and opaque minerals.

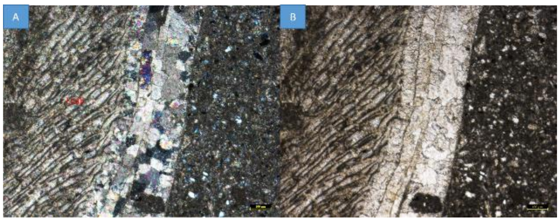

Fig. 9. Photomicrograph of ST.18 fossiliferous limestone with components of macro fossils in the form of rudist walls with age lower cretaceouse.

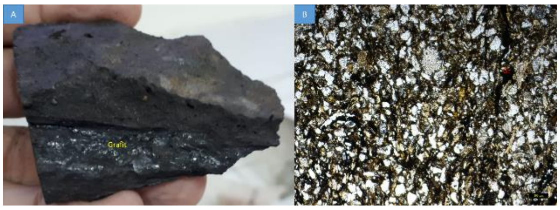

Fig. 10. (A) Photograph of graphite in megascopis at ST station. 19. (B) photomicrograph of Graphite. The presence of graphite indicates rocks formed in a metamorphic environment.

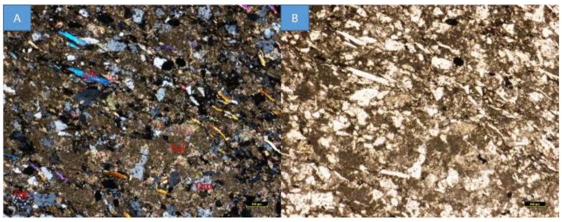

Fig. 11. Photomicrograph of sandy limestone with components of calcite, mica, and quartz minerals. The appearance of the mica mineral alignment is indicated that the rock is formed in a metamorphic environment

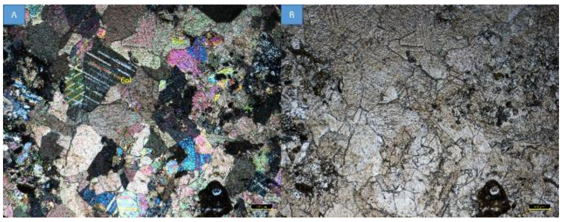

Fig. 12. Photomicrograph mozaic texture on ST. 19 with calcite composition, (curved boundary shape) very typical in marble.

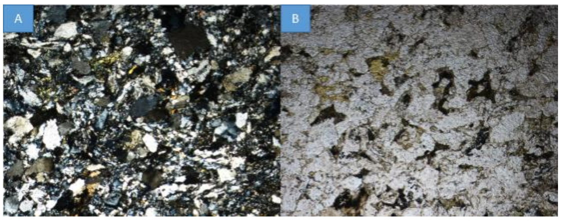

Fig. 13. Photomicrograph of the quartzite structure on ST. 12.Based on the presence of graphite and the structure of metamorphism, it can be interpreted that paremba sandstones on the Bontorio River had undergone a low degree of metamorphism.

Based on Pettijohn's classification [4], thin section samples showed the names of rocks in the form of lithic arenite and sub lithic arenite, and quartz arenite (Fig. 5). Only 2 samples were found included in the arcosic arenit. It can be estimated that these sandstones are deposited in various sediment deposition environments, namely fluvial, delta and alluvial sediments associated with tectonic conditions in the form of active margins, where such of the tectonic conditions are the source of the presence of lithic fragments in the sandstone.

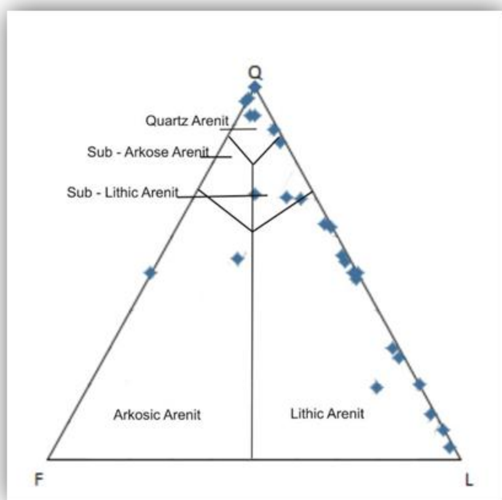

Fig. 14. Ternary Q-F-L diagram paremba sandstone in thin section [4].

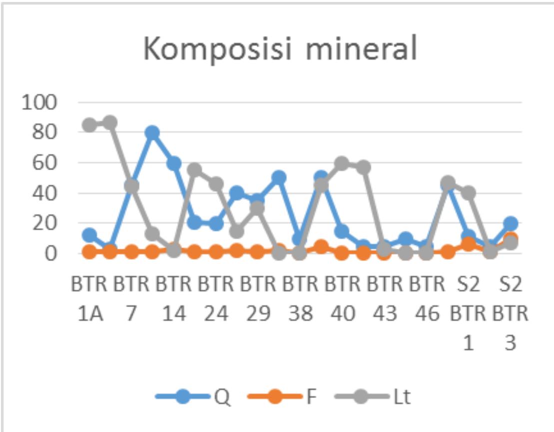

Fig. 15. Comparison of the mineral content of quartz, F, lithic

Based on the histogram in Fig. 14, it can be seen that there is a decrease in lithic content downstream or further away from conglomerate outcrops, but an increase in the composition of quartz minerals. Feldsfar mineral content is very small in number along the outcrop. It can be interpreted that the lithic content which is contained in paremba sandstone outcrops also comes from the same source that found in conglomerates. Although the presence of rijang as cement in red conglomerate rocks could have originated from the environment where the conglomerate was deposited. In general, the amount of minerals such as quartz, lithic and feldfar, experiences a downward trend downstream from the river, this occurs because in the lower part of the paremba section there is an increase in carbonate mineral content in the form of calcite. The three samples obtained in the lower part of the paremba section were all dominated by calcite minerals.

A.2. Stratigraphy

Based on the field data and petrographic analysis, the paremba sandstone stratigraphy on the Bontorio River, sections can be grouped into 3 parts, first is conglomerates and coarse sandstone conglomerates by turns, in the middle part are dominated by coarse sandstone and medium sandstone and few layers of conglomerate, layer of black fossiliferous limestone and a layer of graphite in contacts between limestone and sandstone. In the downstream section, it is dominated by medium sandstone and fine sandstone by turns, and at the end of the section, there are sandy limestones which is take turns with carbonate sandstones. At the Upstream and downstream of the Paremba section are metamorphic rocks in the form of green schists with nonconformity stratigraphic relationships. The sedimentary structure that encountered is a flame structure (load cast: sole mark), slump structure, parallel lamination and ripple lamination. In general, based on the column measuring section and rock position, it can be seen that the paremba sandstone section on the Bontorio River shows a coarsening upward structure, where the downstream sediment particles are increasingly smooth. This structures show more sediment supply and greater energy.

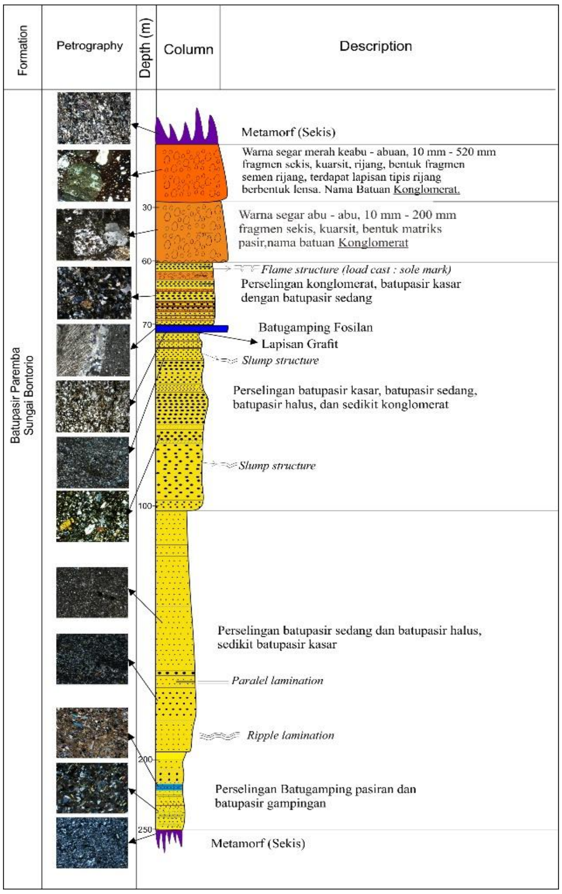

Fig. 16. Paremba Sandstone stratigraphic column on the Bontorio River based on strike and dip.

A.3. Porosity

Porosity analysis was obtained from petrographic thin section observations with the addition of bluedye. From five samples of thin section which added by bluedye were only 3 samples that showed pore, 2 samples did not show any pores because in both samples there are many calcite minerals so that it could be interpreted that the pores contained in these rocks had been filled with calcite minerals. A thin section of rock that shows the presence of pores is generally only 1%. The pore type is secondary pore, which is only in the fractured part of the rock that has experienced strong tectonics. The small number of pores in rocks can occur due to diagenesis increased in rocks, as well as the increased of carbonate mineral content. In general, rocks have been cemented by carbonate minerals so the porosity is very little

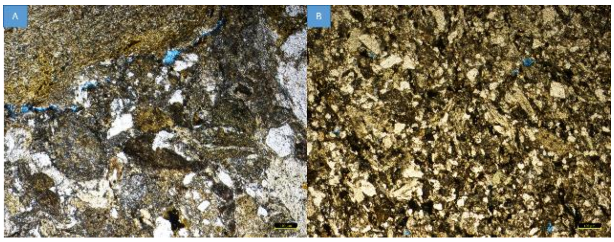

Fig. 17. (A) Photomicrograph of a thin section in ST. 2 (B) Photomicrograph of thin section in ST. 3. With the addition of bluedye.

A.4. Provenance

Quartz composition which is observed in thin sections have varies values from 5% to 86%, with the average values of all thin sections is 20%. The shape of quartz grain is anhedral - subhedral with hexagonal shape. One of the characteristic minerals that can be observed is muscovite (1-5%). Muscovit is one of the minerals which is forming rocks that come from magma, this mineral can also presence in metamorphic rocks. Because of the physical properties of muscovite which are susceptible to chemical weathering, muscovite is rare present in siliciclastic rocks. The presence of hexagonal quartz and muscovite minerals could become characteristic of source rock derived from acid igneous rocks or regional metamorphic rocks (high P & T) [4].

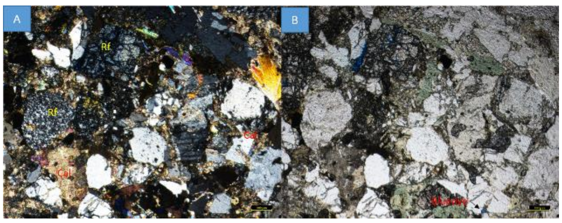

Fig. 18. Photomicrograph of coarse sandstones at ST. 49.B, which shows cemented sediment particles by calcite so that in Fig. B it appears that the pore filled with blueday is very little <1%.

A.5. Tectonic Settings

The study of tectonic settings is done using a plot diagram ternary Qm-F-Lt, Qt-F-L, and Qm-P-K [5]. The plot of the Qt-F-L diagram (Fig. 14) shows the provenance of a paremba sandstone is develop from an recycled orogeneous interior to an undissected arc. The results of the Qm-F-L plot diagram (Fig. 15) show rocks derived from Lithic recyled, transitional recycled, until quartoze recycled.

The plot of the ternary Qm - P - K diagram (Fig. 16) is also use to know in general whether there is an influence of volcanic activity during the deposition of Paremba Sandstone. The plot results show that the tectonic environment is not affected by volcanic activity where the results of the plot show the provenance originating from the continental block.

From the overall results of the ternary diagram, it shows that the Paremba Sandstone originates from a tectonic environment in the form of orogenic Recycle. The results of microscopic analysis show that rocks are dominated by quartz minerals and the matrix and rock fragment are still exist. This shows that source rock is transported relatively far from the source.

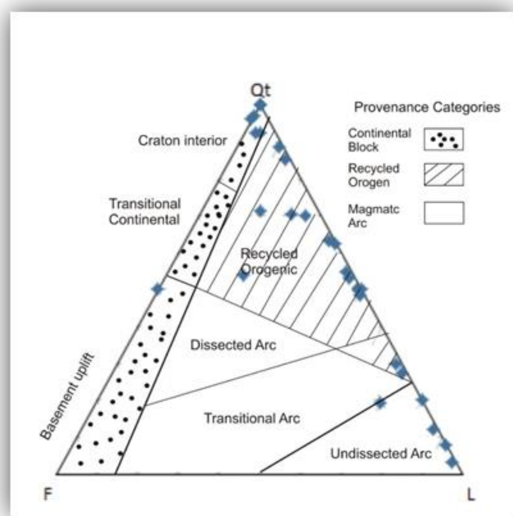

Fig. 19. Qt - F - L, ternary diagram of Paremba Sandstone thin section sample.

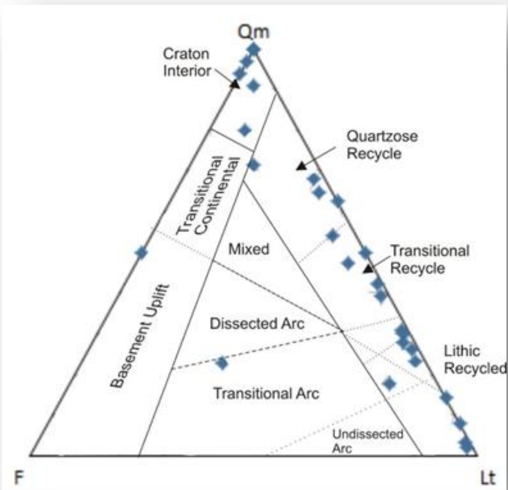

Fig. 20. Qm - F - Lt, ternary diagram of Paremba Sandstone thin section sample.

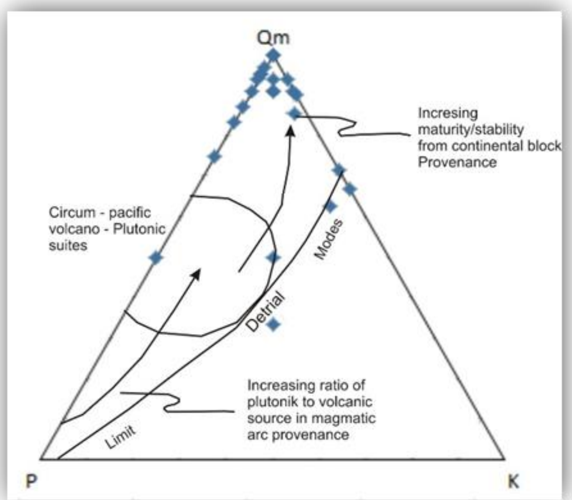

Fig. 21. Qm - P - K, ternary diagram of Paremba Sandstone thin section sample.

B. DISCUSSIONS

Paremba sandstone had undergone a low degree of metamorphism characterized by the presence of epidote and graphite minerals, as well as mineral structures undergoing alignment, so that it can be said that Paremba sandstones are metasedimentary rocks associated with the Bantimala melange complex. Pores presence of only 1% shows that the rock has undergone diagenesis and also some of the pore has been filled with calcite minerals, so the Paremba sandstones on the Bontorio River are not suitable to be reservoir rocks of oil and gas. Based on sediment structure data, the presence of the flame structure (load cast: sole mark), on contact between sandstones and conglomerates shows that the conglomerate position is interpreted to be at the bottom of the crushed alignment with the sandstone. As well as the presence of flanges in the red conglomerate, the conglomerate layer was formed in a chemical environment where flanges can be formed, then because the coarse sediment supply increases so the grey conglomerates that are not flanged are deposited at the upper of red conglomerates, as time goes on the supply sediment diminishes and the deposited sediment becomes finer.

4. CONCLUSION

Based on the ternary plot diagram as well as the analysis of characteristic minerals in thin section samples of Paremba sandstone, it can be concluded that Paremba sandstone is a sedimentary rock with a high degree of maturity with rock types such as lithic arenite, sub lithic arenite, quartz arenite and a little arcosic arenite. The porosity of rocks is generally very little, only about 1%, the pores in rocks have been filled with calcite minerals. Source rocks are the result of recycled orogen undissected arc to interior cratons. The tectonic environment which is related is not influenced by volcanic activity where the result of the plot shows the provenance originating from the continental block.

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