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| RESEARCH ARTICLE

Preliminary Study of Accretion Complexes of Mangilu Area, Pangkep Ragency South Sulawesi

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| ABSTRACT

The exposure of Mesozoic rocks in the Mangilu area, both as a result of tectonic deformation in the form of mélange, low-high degree metamorphism and deep-sea sediments (flysch, radiolarian cherts, and sediment flow in the form of olistostrome), which formed in the subduction zone indicates complex accretionary rocks. The purpose of this study is to identify and study the accretionary complex trace rocks of the Mesozoic era. The method used in this study was field observation, including collection of geological data, tectonic deformation, rock groups and laboratory analysis (petrography). In general, the accretion complex is divided into 2 categories, namely a). oceanic volcanic groups and sediments of the oceanic crust; b). terigenous sediments from continents with sialic beds. The oceanic volcanic group consists of gabbro, diabase, dolerite, pillow and hyaloclastic lava, and oceanic sediments consist of radiolarian chert and mali limestone. The terigen sedimentary group consists of flysch type sandstones and olistostrome flow sediments with components in the form of granite, granodiorite, dacite and diabase. Other components found in autoclastic breccia rocks in the Mangilu area consist of metaperidotite, serpentinite, quartzite and metachert. Based on the Oceanic Plate Stratigraphy (OPS) arrangement, the autoclastic breccia rocks in the Mangilu area consist of bottom up, namely ultramafic/serpentinite, gabbro, diabase, pillow basaltic lava, hyaloclastic, radiolarian chert, mali limestone and flysch sediments. The mixing of rocks originating from oceanic plates with continental plates in autoclastic breccias indicates that the Mesozoic accretion complex in the Mangilu area has experienced strong deformation in the form of thurst in the Tertiary era.

| KEYWORDS

Accretion complex, autoclastic breccia, Mangilu

| ARTICLE INFORMATION

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1. Introduction

The exposure of Mesozoic rocks in the Mangilu area is related to the imbrication of the Pangkajene thrust fault (Sukamto, 1982), both rocks resulting from tectonic deformation in the form of mélange, high-low degree metamorphism and deep-sea sediments such as flysch, radiolarian chert and olistostrome. The characteristics of these rock groups indicate their formation in subduction zones accompanied by the development of accretionary prisms.

When a mixture of autoclastic breccia components of various types and sources is examined, it can reveal the long history of the formation of the Mangilu accretion complex, starting from the expansion of the ocean floor, subduction on the continental margin accompanied by deformation, seamounts in the oceanic crust to the mixing of rock components in autoclastic breccias.

In general, according to Isozaki Y and Kimura G (1992), accretion complexes are grouped into 2 categories, namely a). oceanic volcanic groups and sediments from the oceanic crust in the form of gabbro, diabase, dolerite, pillow lava, hyaloclastic, radiolarian chert, and metamorphic limestones; b). terrigenous sediments from continents with sialic beds such as flysch type sandstones and olistostrome granitic. Other components in the Mangilu accretion complex are deformed rock blocks such as metaperidotite, sepentinite, quartzite and metachert, which complement the constituent components of *Oceanic Plate Stratigraphy* (OPS).

The mixing of Mesozoic rock components in the Mangilu autoclastic breccia in the thrust zone can be interpreted as an indication of the occurrence and exposure of autoclastic breccias by thrust faults in the post-Upper Cretaceous or Tertiary?

Accretion Complexes (ACs), namely the accumulation of rock blocks in the subduction zone area from various rock types and sources, with the main characteristics being the presence of OPS (Oceanic Plate Stratigraphy) and thrust imbrication structures, Isozaki Y and Kimura G (1992).

The study location is located in the Mangilu area, Pangkep Regency, South Sulawesi (Figure 1).

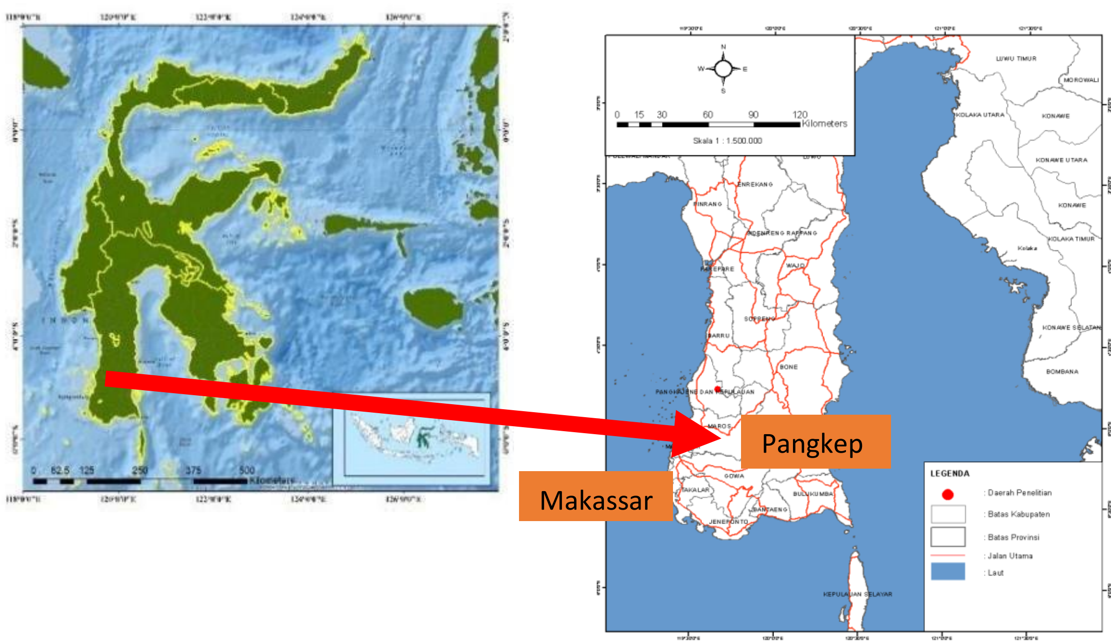

Figure 1. Map of the Research Location for the Mangilu area, Pangkep Regency, South Sulawesi

2. Research methods

The research method used in this study is field observation, including collection of geological data, tectonic deformation, rock sampling and laboratory analysis in the form of petrography. The petrographic analysis is emphasized determining the name and the internal textural structure of the rock, which is related to the degree of deformation and the type of rock.

3. Result and Discussion

The geological phenomena recorded by the outcrops of the Mesozoic and Cenozoic rock groups provide important information in the geological and tectonic settings of the Mangilu area, which is part of the Bantimala complex.

3.1 Geological and Tectonic Framework

The lithology unit of the Mangilu area, which consists of mélange, olistostrome, Rijang Radiolaria, Balangbaru Sandstone, autoclastic breccia, Mallawa Sandstone and Tonasa Limestone, can be described as follows (Kaharuddin et al., 2022, Hasanuddin, et al., 2022), Figure 2

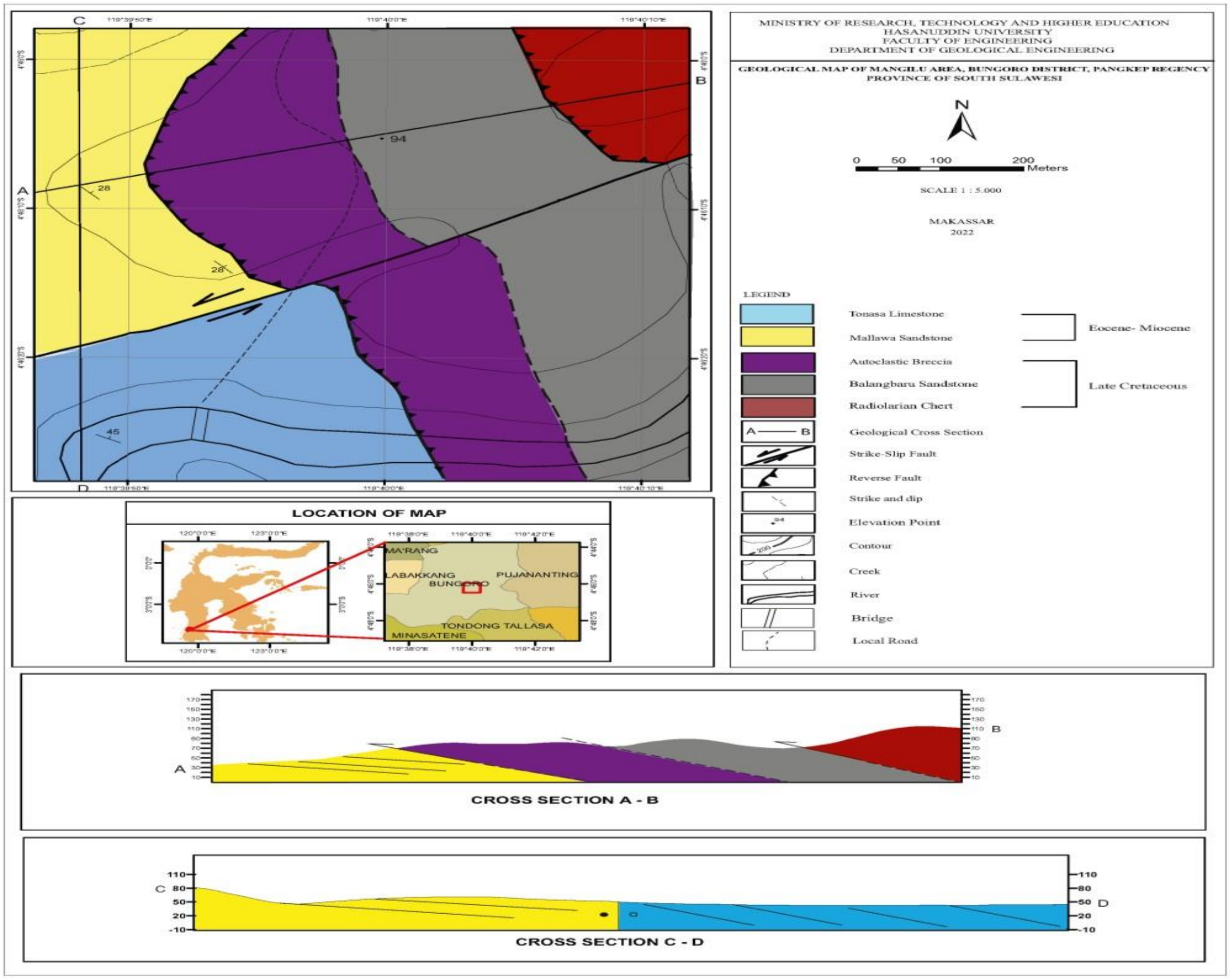

Figure 2. Geological map of the Mangilu area (Hasanuddin et al., 2022).

a. Melange

Mélange, as the bedrock of this area, consists of the Broken Formation and Melange Autoclastic Formation. Broken formations are tears or joints in deformed rock with rock components/blocks without displacement (Festa et al., 2010, 2016) occurring in green schist and metaperidotite (Figure 3). Mélange autoclastic is composed of blocks of blue schist, eclogite, green schist, granulite, amphibolite, quartzite, metachert and mataperidotite, boudin/lensis form with tectonic texture, measuring 30 cm - 1000 cm. The rock blocks are surrounded by green schist foliation and a matrix of flares (Figure 4). In mélange, there are associations of deformed, folded and altered diabase rocks. It is exposed at the junction of the Pangkajene River, Pateteyang River and Cempaga River.

b. Olistostrome

The olistostrome or mélange sedimentary is above, and the tectonic slice contacts the mélange below it (Kaharuddin et al., 2022). In contrast to the olistostrome in the Bantimurung area in Tondongtallasa, where the olistolith is dominant in the oceanic crust (Kaharuddin et al., 2017; Kaharuddin, 2020). the olistostrome of the Mangilu area is dominated by olistolith (Abbate et al., 1970) granite, granodiorite, followed by chert, claystone, metalimestone/marble with a tecttonite texture, covered by matrix and claystone, olistolith granite and granodiorite with augen deformation structures (Kaharuddin et al., 2022), (Fig. 5).

Figure 3. Outcrops of Broken Formation from Melange on the Pangkajene river

Figure 4. Outcrop of Autoclastic Melange tectonic texture in the Cempaga river.

c. Rijang Radiolaria

Rijang radiolaria Upper Cretaceous age exposed in the Pangkajene River, Cempaga River and Pateteyang River, has experienced strong deformation in the form of upright folds, joints and some boudin structures (Figure 6)

Figure 5. Olistostrom (X) selice tectonic contact with the lower Melange Broken (Y) in the Pangkajene river (Kaharuddin, et al, 2022).

Figure 6. Radiolaria (X) Chert Outcrops Lower Olistostrome(Y) contacts on the Cempaga river

d. Balangbaru sandstone

Balangbaru sandstone of the Upper Cretaceous age includes flysch type sediments consisting of alternating sandstones, siltstones, conglomerates and shales, as well as chert inserts (Sukamto, 1982). The position of the rock layers between N 340oE/45o-N 5oE/75o shows symptoms of deformation in the form of systematic joints, boudin, broken scale structures and microfolds due to overpressure (Figure 7).

e. Mallawa sandstone

Mallawa sandstone, including Tertiary rocks of Paleocene-Eocene age (Sukamto, 1982), which were positioned as autochthonous blocks/foot walls by the Pangkajene thrust so that their conditions have also been deformed, there are even symptoms of position reversal where bed breccias are at the top in the contact zone of Mesozoic rocks (Balangbaru sandstones). Malllawa sandstone consists of quartz sandstone, claystone, marl and calcarenite containing foraminifera fossils, there are coal inserts, and some are altered to form kaolin (Figure 8).

Figure 7. The Balangbaru Sandstone Outcrop reveals a scale structure in the Pangkajene river (Kaharuddin, et al, 2022).

Figure 8. Outcrops of Mallawa Sandstone (X) in contact with an autoclastic breccia (Y) in the Mangilu area

f. Batugamping Tonasa

Batugamping Tonasa has also been deformed by the Pangkajene thrust in the form of joints and boudin symptoms and fault breccias. Including Tertiary rocks of Early Eocene-Miocene age (Figure 9).

g. Autoclastic Breccia

Breksi Autoklastik those exposed in Mangilu were formed by tectonic and structural deformation processes, did not experience transport media but were formed by crushing or fragmentation of rock layers in the Pangkajene thrust fault zone during the pre-Upper Miocene. Shows a flasher structure with the alignment of rock blocks from southeast to northwest (N 325oaE). The rock component consists of rock blocks measuring around 0.1-10 meters consisting of schist, quartzite, marble, chert and metachert, greenstone, serpentinite, plagioclase peridotite, gabbro, diabase and dolerite, pillow lava, hyaloclastic, Balangbaru sandstone and cataclastic breccias with fragments of sandstone, quartzite, marble and shale (Hasanuddin et al., 2022).

The rock blocks show a tecttonite texture in the form of broken, slickenside, bending, crushing, lensing and flasher, and some have been altered with the minerals chalcopyrite and calcite (Figure 10).

Figure 9. Tonasa Limestone Outcrops with boudin structures in the Pangkajene river (Hasanuddin, et al. 2022)

Figure 10. Autoclastic Breccia outcrop showing the structure of flarer and serpentinite blocks (X) in the Mangilu area

Convergent tectonics that has occurred since the Mesozoic era formed the subduction of oceanic crust into the continental plate accompanied by tectonic deformation, which will produce high-grade metamorphic rocks in the form of blue schist, eclogite, granulite, green schist, marble, quartzite and amphibolite (Zulkarnain, 1999). In line with the formation of these metamorphic rocks in the subduction zone under the accretionary prism, mélange, diabase and olistostrome were formed during the Jurassic period. Then in the Upper Cretaceous period followed the formation of Radiolaria Rijang, Balangbaru Sandstone.

Outcrops of high-grade metamorphic rocks associated with low-grade, mélange, ultramafic, olistostrome granitic are the result of deformation of the oceanic crust subduction system into the continental margin plate during the Jurassic to Early Cretaceous, around 114-132 million years ago (Zulkarnain, 1999).

From thermobarometric calculations of garnet-glaukofan, it shows a temperature of 580o-640oC and a pressure of 18 -24 Kbar (Miyazaji et al., 1996) at a depth of 65 - 85 km. The results of plotting the mélange block in the geotectonic diagram and spider diagram on trace elements and rare earth, as well as petrographic observations, show that the mélange protolith was formed in the MORB, OIB tectonic environment (Kaharuddin, 2020) while from the Granite olistolith Mangilu is in the Active Continental Margins (ACM) of the toleite and calc-alkaline rock series (Kaharuddin et al., 2022).

3.2 Karakteristik Litologi Kompleks Akresi Mangilu

The Mangilu Accretion Complex is composed of a mixture of rock groups resulting from convergent tectonic deformation in subduction zones (Kusky, 2013; Izosaki and Kimura, 1992); accretion occurs starting from the center of the ocean floor expansion with Mid-Oceanic Ridge Basalt (MORB), carbonate and chert, and Ocean Island Basalt (OIB) from seamounts and pelagic sediments to the subduction zone where metamorphic rocks, mélange and terigen sediments are formed in the form of flysch and gravity flow type sediments (Sukamto, 2011) in the form of sandstone and olistostrome (Figure 11).

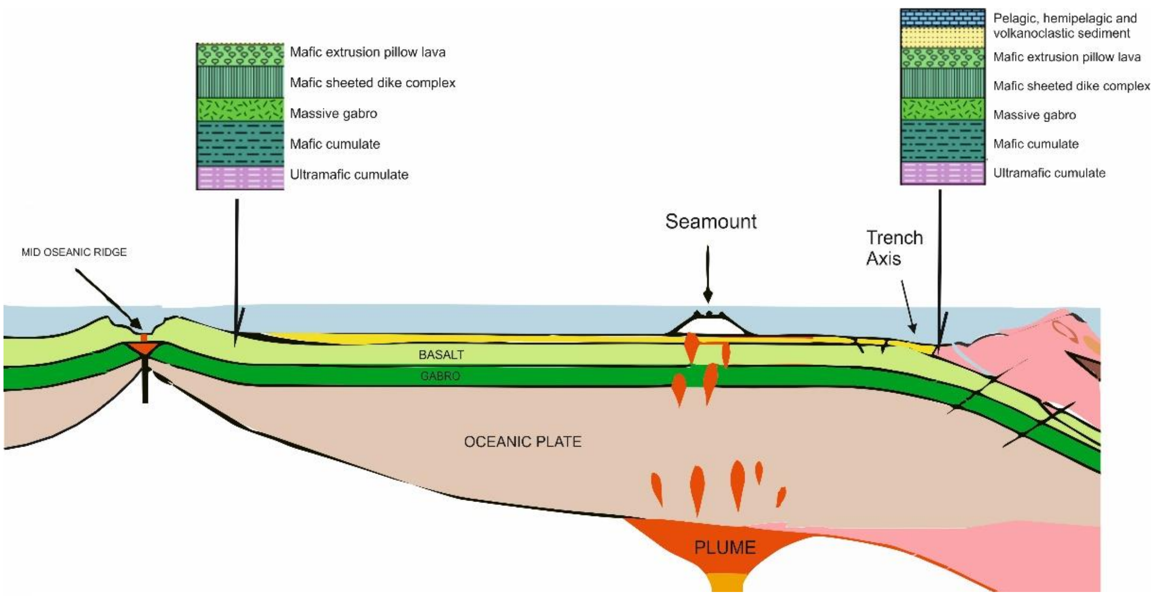

Figure 11. Oceanic Plate Stratigraphic Cross Section, migration of rock components from the center of Expansion (MOR) to the continental margin subduction zone, adopted from Kusky. T.M, et al. (Hasanuddin, et al. 2022).

Accretion from this rock group is arranged in a perfect oceanic plate stratigraphic order (OPS) in subduction zones on the continental margin. In general, accretion complexes, according to Isozaki Y and Kimura G (1992), are grouped into 2 categories, namely:

a. The oceanic crust group is an oceanic volcanic component consisting of greenstone, pillow lava (basal, diabase and dolerite) from the Ocean Island Basalt (OIB) seamount, and pelagic sedimentary components such as radiolarian chert which has partially metamorphosed into quartzite and limestone which turns into marble.
b. A group of sediments of the onshore origin or tertigenous sediments consisting of the flysch type Balangbaru Sandstone and gravity flow type turbidite sequences in the form of olistostrome granitic (Kaharuddin, 2022).

The base component of the oceanic plate stratigraphy (OPS) is serpentinite, the cumulative peridotite is plagioclase and gabbro peridotite. The appearance of mélange with components of green schist, blue schist, quartzite and marble is related to the exclusion of Pangkajene imbricated thrusts from the inside of the subduction zone on the continental margin.

Based on the structure and occurrence, the accretion complex is divided into 3 types (Isozaki Y and Kimura G, 1992), namely:

a. *Coherent-type* consists of *sediment-dominant subtype* and *oceanic volcanics-dominant (Oceanic Island Basalt)*
b. *Olistostrome-type* consists of *high pressure block-free subtype* and *high pressure block-bearing subtype*
c. *Serpentinite mélange-type*; keeping-keping blok serpentinite high P/T metamorfik

Based on the characteristics and structure of the Mangilu Accretion Complex, including the type of olistostrome accretion with the composition of its components, a mixture of sedimentary material from the Oceanic Plate Stratigraphy (OPS) component and the coherent type accretion component. Based on the type of component, the exposed olistostrome in Mangilu is divided into 4 types, namely:

a. Olistostrome with high pressure (olistolite) fragments (serpentinite, silisified and quartzite) exposed in the Pateteyang River (Figure 12).
b. Granik olistostrome with boudin or lensis granite olistolite, exposed in the Pangkajene River (Figure 13)

Figure 12. Olistostrome outcrop with serpentinite, silisified high-pressure olistolith and quartzite (X) contact with Chert Radiolaria (Y) in the Patteteyang river.

Figure 13. Granitic Olistostrome Outcrop in the Pangkajene River

a. Granodioritic olistostrome with granodiorite, dacite and diabase olistolite exposed in the Cempaga and Pateteyang Rivers (Figure 14)

b. Carbonatic olistostrome with olistolite of limestone, claystone, dacite and chert, bound to a scale claystone matrix, exposed in the Pateteyang River (Figure 15)

Figure 14. Granodioritic Olistostrome Outcrop in the Cempaga river

Figure 15. Outcrops of Carbonatic Olistostrome, limestone olistolith (X) embedded in scale claystone (Y) in the Cempaga river.

The presence of Ocean Island Basalt (OIB) components and carbonate rock associations is a characteristic of olistostrome type accretion in the trench zone of ancient seamounts (Isozaki and Kimura, 1992).

In the Balangbaru terigen flysch rock formation there are conglomerate lenses (with basal, claystone and limestone fragments), limestone fragments, coral fossils and coal lenses as an indication of avalanche material from the shallow sea into the deep sea trench in the form of gravity sliding as part of the olistostrome.

The Mangilu Accretion Complex was exposed by the Pangkajene imbricated fault faulting as many as three faults so that the stratigraphic setting is more complicated and complex (Sukamto, 1982). Even the Pangkajene fault, which passes through Mangilu in a southeast-northwest direction, forms and reveals the autoclastic Mangilu Breccia, which ascends/rides in a thrusting manner over the Tertiary rocks of the Mallawa Sandstones and Tonasa Limestones in the Neogene or pre-Upper Miocene (Hasanuddin et al., 2022).

3.3 Tectonic Implications and Structure

The outcrops of rock groups in the Mangilu Accretion Complex are sourced from high-low degree metamorphic rocks, mélange, trough deposits, Rijang Radiolaria, olistostrome granitic gravity flow deposits and flysch type sediments, Balangbaru Sandstones can be interpreted as subduction of oceanic crust into the continental margin plate at the time Early Jurassic-Cretaceous where the Mangilu Accretion Complex was built Wakita et al. 1994; 1996; Yamada et al., 2009 and Setiawan et al., 2014).

Autoclastic breccia rocks containing rock blocks components from Mid-Oceanic Ridge Basalt, Ocean Island Basalt from seamount components, pelagic sediments from radiolaria and metalimestone, and terigen sediments in the form of Balangbaru flysch type sediments can show an oceanic plate stratigraphic component (OPS) as a rock constituent of the Mangilu Accretion Complex which has undergone tectonic abrasion by the Pangkajene thrust.

Polylithic autoclastic breccia exposed in the Pangkajene thrust zone between Rijang Radiolaria and Balangbaru Sandstones as a hanging wall with Mallawa Sandstones and Tonasa Limestones as foot walls (Figure 2).

Mixing of rock components between Mesozoic rock groups in Autoclastic Breccia and deformation and brecciation occurs in the Tertiary rocks of Mallawa Sandstone and Tonasa Limestone, as well as the alteration in Autoclastic Breccia and Mallawa Sandstone from hydrothermal trachite rocks of Upper Miocene age (Sukamto, 1982), it can be interpreted that the containment fault or the Pangkajene thrust occurred during the pre-Upper Miocene which formed the Mangilu Autoclastic Breccia.

4. Conclusion

Based on the results of the study, the following conclusions were drawn:

1. The high-low grade metamorphic block components mixed in melange consist of blue schist, green schist, eclogite, granulite, quartzite, marble and amphibolite, indicating traces/fossils of subduction in the Mesozoic Age
2. Presence of ultramafic rock groups (MORB), dyke Basalt, Ocean Island Basalt, metalimestone, Balangbaru Sandstone (Flysch), a group of Ocean Plate Stratigraphy (OPS) rocks formed at the center of the oceanic division (Mid-Oceanic Ridge)) migrate up to the trench where accretionary prisms form
3. Based on the characteristics and structure of the Mangilu Accretion Complex, it belongs to the olistostrome type of accretion with the composition of its components a mixture of sedimentary material from the Ocean Plate Stratigraphy (OPS) component and the coherent type accretion component. Based on the type of component, the exposed olistostrome in Mangilu is divided into 4 types, namely: olistostrome with high pressure fragments (olistolith), olistostrome grantik, olistostrome granodioritik and olistostrome carbonatic
4. The combination of outcrops of high-low and melange degree metamorphic rocks with Ocean Plate Stratigraphy (OPS) rock groups in autoclastic breccias in the Mangilu area, showing traces of the Mesozoic Accretion complex exposed by the Pangkajene thrust in the Neogene Age

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Conflicts of Interest: The authors declare no conflict of interest.

References

[1] Abbate E., Bortolotti V., and Passerini P. (1970). Olistostromes and Olistoliths, Benchmark Papers in Geology, *66*, Stroudsburg, Pennsylvania. 86 - 110.
[2] Festa A., Pini G.A., Dilek Y and Codegone G. (2010). Mélanges and mélange-forming processes: A historical and new concepts Int. Geology Rev., *52*, 1040-1105.
[3] Festa A., Ogata K., Pini G.A., Dilek Y., and Allonso J.L. (2016). Origin and significance of olistostrome in the evolution of orogenic belts: A global synthesis, Gondwana Research 39, 180-203.
[4] Hasanuddin, K., Syam B., Maulana-Baso R. and Aisyah-Bidara N. (2022). Petrological Study Of Autoclastic Breccia Formation in Mangilu Region, Pangkep South Sulawesi Province. PIT IAGI ke 51 Tahun 2022 Makassar, Sulawesi Selatan.
[5] Isozaki Y and Kimura G. (1992). Distribution, Characteristics, Definition and Origin of accretionary complex, Evolving Earth Symposium.Okazaki 17.
[6] Kaharuddin-Haerany S , Asri J, Sahabuddin J, Muh. F W and WIra P (2022). Tectonic Deformation and Its Implications for Geological Disasters; Case Study of Mangilu Area, Bantimala Complex Pangkep South Sulawesi Province, PIT IAGI 51 Tahun 2022 Makassar, Sulawesi Selatan.
[7] Kaharuddin-Imran, A.M., Abdullah C.I., and Jaya A. (2017). Olistostrome and the Mesozoic tectonic of the Bantimala Complex, South Sulawesi MATEC Web of Conferences *102*, 04011 (2017) SICEST 2016. http://dx.doi.org/10.1088/1755-1315/235/1/012043.
[8] Kaharuddin, (2020). Olistostrome and its Implications for Mesozoic Tectonics of the Bantimala Complex, Pangkep District, South Sulawesi Province. Disertation of Engineering Faculty, Hasanuddin University, Makassar.
[9] Kusky T.M, Windley-Safonova I., Wakita K., Wakabayashi J., Polat A. and Santosh M. (2013). Recognition of ocean plate stratigraphy in accretionary orogens through Earth history: A record of 3.8 billion years of sea floor spreading, subduction, and accretion, Gondwana Research, 501-547.
[10] Sukamto R., (1982). Geologi Lembar Pangkajene dan Watampone Bagian Barat, Sulawesi, P3G (Departemen Pertambangan dan Energi), Bandung.
[11] Setiawan N.I., Osanai Y., Nakano N., Adachi T., Yonemura K., Yoshimoto A., Setiadji L.D., Kaharuddin, and Wahyudiono J. (2014). Geochemical characteristics of metamorphic rocks from South Sulawesi, Central Java, South and West Kalimantan in Indonesia ASEAN Eng. J. Part C 3 Number 1, ISSN 2286-8150. 107-127.
[12] Sukamto R. (2011). Peek Geologic Development of South Sulawesi Area from Mélange Complex of Bantimala, Geologic Tours Guide of Bantimala, ITB, Bandung.
[13] Wakita K., Munasri-Sopaheluwakan J., Zulkarnain I., and Miyazaki K. (1994). Early Cretaceous Tectonic Events Implied in the Time-log Between the Age of Radiolarian Chert and its Metamorphic Basement in Bantimala Area, South Sulawesi, Indonesia, Research Article, Bandung, Indonesia.
[14] Wakita K., Sopaheluwakan J., Miyazaki K., Zulkarnaen I., and Munasri, (1996). Tectonic of the Bantimala Complex, South Sulawesi, Indonesia, Tectonic Evolution of Southeast Asia, London.
[15] Yamada Y., Yamashita Y., and Yamamoto Y. 2(009). Submarine landslide at subduction margins: Insights from physical models Tectonophysics, 484, 156-167.
[16] Zulkarnain I. (1999). Cretaceous tectonic events of the Bantimala area, South Sulawesi - Indonesia: Evidence from rock chemistry J. Tek. Mineral *2*, Bandung.

Appendices

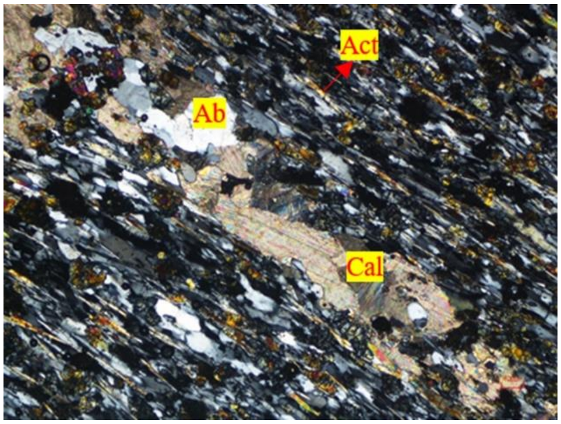

Figure16. Photomicrograph of muscovite-chlorite-quartz schist

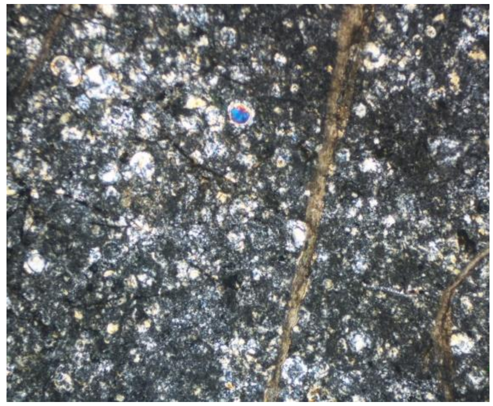

Figure 17. Photomicrograph of radiolarian chert

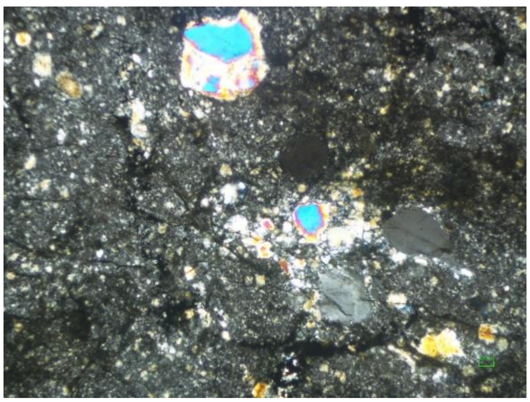

Figure 18. Photomicrograph of graywacke

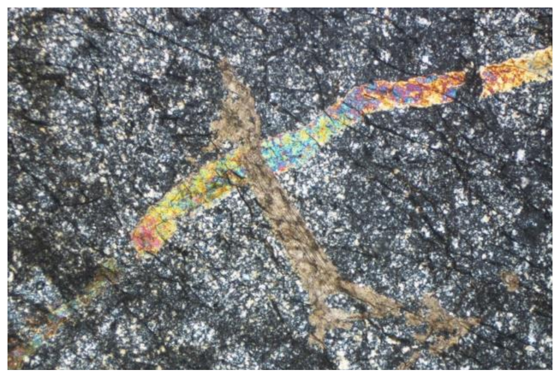

Figure 19. Photomicrograph of quartzite

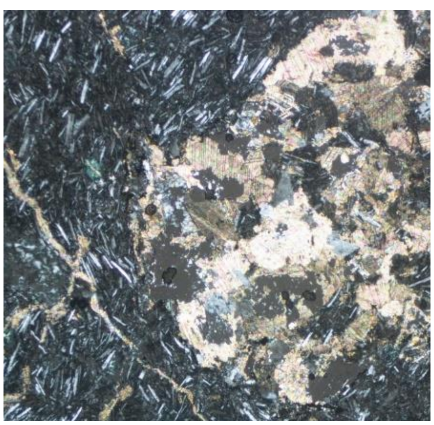

Figure 3. Photomicrograph of pillow lava with amygdaloidal structure filled with calcite.

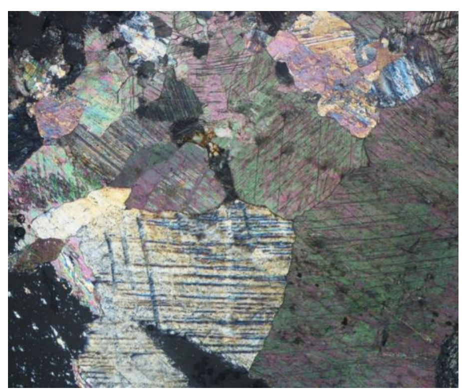

Figure 21 Photomicrograph of plagioclase peridotite