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Characteristic and Provenance of Talang Akar Formation Sandstone, Sukamoro Area, South Sumatera

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ABSTRACT

The Sukamoro area, Banyuasin Regency, South Sumatra, is an area that reveals a lot of surface geological conditions of the Talang Akar Formation, such as sandstones. Sandstone is used as an object of research because of its relatively common abundance, high resilience, and compact physic. Generally, the material that makes up sandstone comes from the previous rock. This study aims to determine the characteristics of sandstones and the origin of sediments originating from the Sukamoro area. Studying the origin of clastic sedimentary rocks can later explain the composition and geological evolution of the source area. Previous research in the Sukamoro is focused more on paleontological analysis, where foraminifera fossils were not found in carbonate samples. The Provenance study uses a descriptive-analytical method of surface data which is then integrated with petrographic data. Integrating petrographic data from sandstones using a sandstone framework composition triplot (Zhang modification, 2016). The results of this study will offer significant new insights into the tectonic setting of the South Sumatra Basin, particularly the Sukamoro Region. Provenance analysis results show that the sandstones of the Talang Akar Formation originate from the Magmatic Arc and Recycle Orogen.

Keywords: *Talang Akar Formation; Provenance; Sukamoro; Recycle Orogen; Magmatic Arc*

ABSTRAK

Daerah Sukamoro, Kabupaten Banyuasin, Sumatera Selatan, merupakan daerah yang banyak mengungkap kondisi geologi permukaan Formasi Talang Akar, seperti batupasir. Batupasir digunakan sebagai objek penelitian karena kelimpahannya yang cukup umum, serta tingkat ketahanannya yang tinggi dan fisik yang kompak. Umumnya material penyusun batupasir berasal dari batuan sebelumnya. Penelitian ini bertujuan untuk mengetahui karakteristik batupasir dan asal sedimen yang berasal dari daerah Sukamoro. Dengan mempelajari asal usul batuan sedimen klastik nantinya dapat menjelaskan komposisi dan evolusi geologi daerah sumber. Penelitian sebelumnya di daerah Sukamoro lebih banyak terfokus pada analisis paleontologi, dimana tidak ditemukan fosil foraminifera pada sampel karbonat. Studi Provenance menggunakan metode deskriptif analitis dari data permukaan yang kemudian diintegrasikan dengan data petrografi. Pengintegrasikan data petrografi dari batupasir menggunakan triplot komposisi kerangka batupasir (modifikasi Zhang, 2016). Hasil studi ini akan menawarkan wawasan baru yang signifikan mengenai tatanan tektonik Cekungan Sumatera Selatan, khususnya Kawasan Sukamoro. Hasil analisis provenance diperoleh bahwa batupasir Formasi Talang Akar berasal dari Magmatic Arc dan Recycle Orogen.

Keywords: *Talang Akar Formation; Provenance; Sukamoro; Recycle Orogen; Magmatic Arc*

INTRODUCTION

The Talang Akar Formation is one of the South Sumatra Basin's hydrocarbon-producing reservoirs. This basin is filled by two distinct sources in the paleo highs of the eastern and western portions. The lower portion of the Talang Akar consists of coarse-grained sandstone, while the upper portion restricts sandstone and shale intercalation[1]. The Talang Akar Formation is made up of deltaic sandstones, siltstone, and shale. As the formation ascends, a fluvial-deltaic sediment type at the base changes into a marine sediment condition. The Gritsant Member comprises coarse-to-very coarse sandstones intercalated with shale and lignite and has a thickness between 200 and 550 meters. The uppermost 300 meters are composed of typically medium-grained sandstones intercalated with shales or lignite (a transitional constituent).

Sukamoro area, Banyuasin Regency, South Sumatra, is the area for the research study. This area reveals the surface geological conditions of the Talang Akar Formation, such as sandstone. Sandstone is used as an object of research because of its abundance, which is quite common, and its resistance level is high and physically compact. Generally, sandstone constituent materials come from previous rocks[2]. Sandstone is a sedimentary rock generally composed of clastic material or the result of erosion of source rock [3][4][5]. It can originate from land to marine depositional environments. Sandstones are composed of minerals, both those classified as stable, such as quartz and zircon, or other minerals classified as unstable such as feldspar, as well as lithic or rock fragments, which are also precipitated during the transportation process. The amount of mineral content in the sandstone is inseparable from the stability of the mineral itself, as well as the mineral content in the source rock. Thus, sandstone mineral content can indicate provenance by considering their abundance of sedimentary detritus grains[5][6]. According to Samir M Zaid[7], studies of the provenance of clastic sedimentary rocks frequently seek to elucidate the composition and geological evolution of sediment source regions and to constrain the tectonic setting of the depositional basin.

This study aimed to determine the sandstone's characteristics and origin of sediment from the Sukamoro area. Previous studies in the Sukamoro area mainly focused on paleontological analysis, where foraminifera fossils were not found in the carbonate sample. Based on pollen fossils, it is interpreted that the depositional environment is transitional[8]. According to Sasmita et al[9], The Talangakar sandstone's provenance can vary due to geography, the rate of accommodation development, and the demand for the materials that supply the basin. The provenance of Mendah village, which is part of the South Palembang subbasin, is the Arc Orogen source, with a high concentration of lithic, that developed as an Undissected Arc[9]. The provenance of the Jambi Subbasin is characterized by continental block tectonics. Compositions of sandstone compounds originating from various provenances Terranes governed by plate tectonics are typically contained within discrete and distinct domains. In pursuance of the above objectives, we integrate petrographic data from the sandstone with triplots of sandstone framework compositions (Zhang’s modification) [10][11]. The results of this study will offer significant new insights into the tectonic setting of the South Sumatra Basin, especially the Sukamoro Area.

LITERATURE REVIEW

Provenance

The Dickinson diagram model (1979) determines the type of provenance [6]. According to Dickinson and Suczek's (1979) plotting diagram, the tectonic control of the original rock can be determined by looking at its mineral composition, specifically its quartz (Q), feldspar (F), and rock fragments (L) concentration[12][13][14]. However, in 2016, Zhang et al. changed the provenance diagram model created by Dickinson and Suczek (1979), where identification is made more deeply by focusing on the primary content of sandstones and QFL mineral characteristics (Quartz, Feldspar, and Lithic). According to Zhang et al. (2016), modification of the provenance diagram is divided into three types[11]. The first discusses the tectonic circumstances based on quartz, lithic, and feldspar proportions. Second, it describes the deposition area's circumstances based on the

monocrystalline quartz, feldspar, and lithic content. Lastly, provenance is determined by polycrystalline quartz, lithic volcanic rock, and sediment lithic.

METHOD

The methodological approach is analytical descriptive, using surface data to observe outcrops and geological features such as lithology, sedimentary structure, texture, and composition. Samples are also used for laboratory examination. Small incisions were made in the chosen rock samples for additional petrographic investigation and provenance study (see Figure 1). Petrographic analysis was carried out to determine the mineral composition contained in the sample rock. Petrographic analysis using a microscope so that the smallest minerals can be seen. The mineral composition contained in the rocks was then observed to determine the characteristics of the sandstones from the Sukamoro area.

Provenance analysis was carried out by plotting the mineral composition into a triplot of sandstone framework compositions. The tectonic control of the original rock can be determined by looking at its mineral composition, specifically its quartz(Q), feldspar(F), and rock fragments(L)[12][15]. The provenance diagram used differs from the diagram used in the previous study. This study, using a modified provenance diagram by Zhang et al[11]. Zhang et al. modified the origin diagram model previously created by Dickinson and Suczek (1979), in which relief is carried out in greater detail by concentrating on the predominant sandstone and QFL mineral content. The integration of petrographic data from sandstones with the triplot composition of the sandstone framework (Zhang modification) represents a departure from previous research techniques. This method is anticipated to allow for a more precise description of the tectonics and depositional conditions. This is considered to be more comprehensive because it employs monocrystalline quartz, feldspar, and lithic content to determine depositional conditions, and polycrystalline quartz, lithic volcanic rock, and sedimentary lithic to manage rock source conditions.

The Talang Akar Formation comprises sandstone lithology throughout the study area. In order to determine the origin of the sandstones of the Talang Akar Formation, samples of fresh sandstone were collected. The distribution of observation locations includes 13 locations, including BP-1, BP-2, BP-3, BP-4, BP-5, BP-6, BP-7, BP-8, BP-9, BP-10, BP-11, BP-12, and BP-15 (see Figure 2).

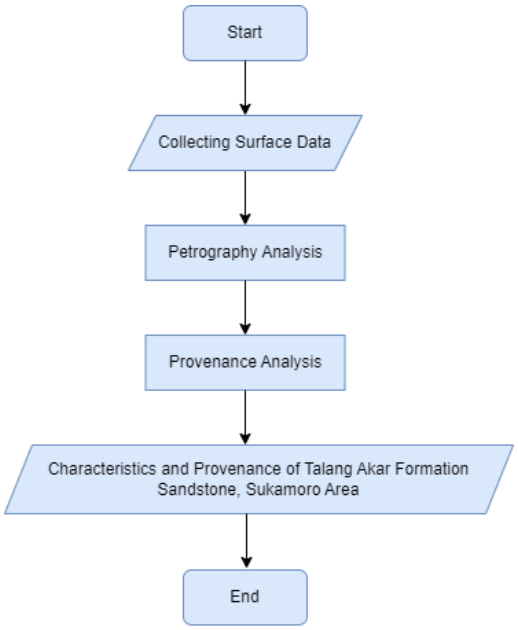

Figure 1. Flow chart of analysis characteristics and provenance of the Talang Akar sandstone, Sukamoro area.

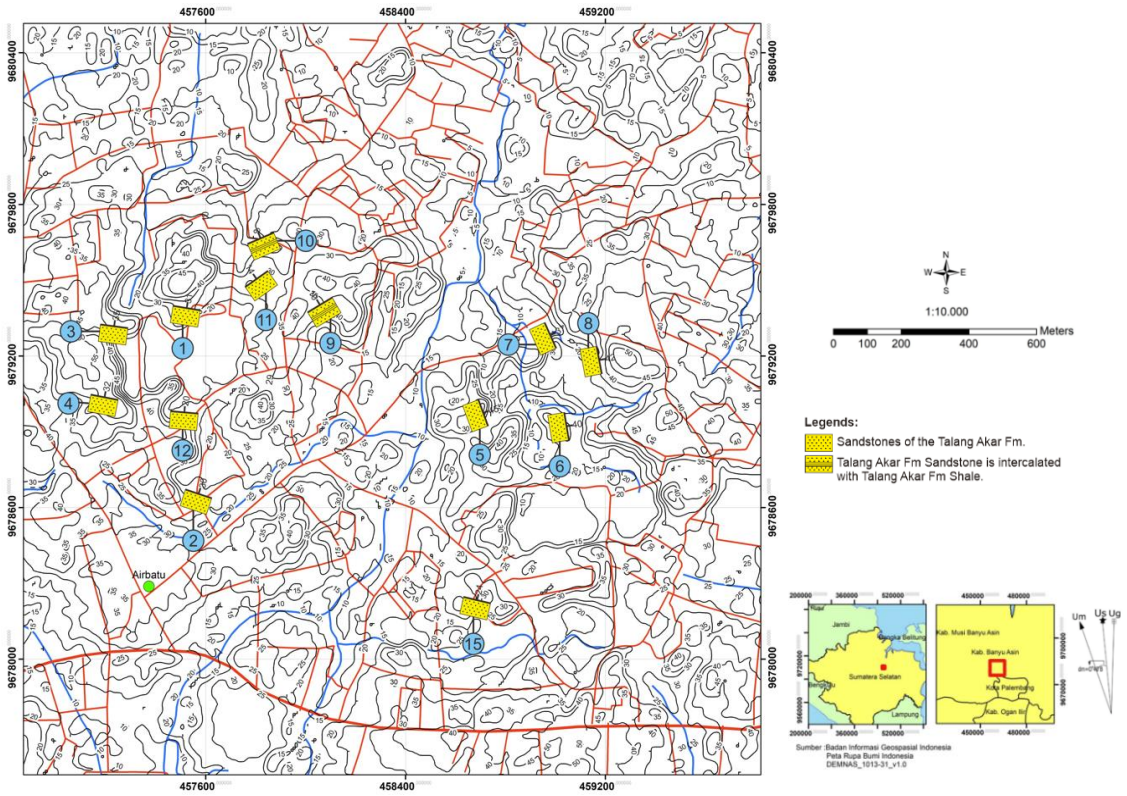

Figure 2. Track map observation of Sukamoro Area

RESULTS AND DISCUSSION

Sandstone characteristics of Talang Akar Formation

Based on the results of direct observations on the 13 sandstone outcrops found, it is known that the dominant sandstones are bright white and fresh in color and, when weathered, are brownish-white. They also have a grain shape classified as subrounded with good sorting (well sorted) to moderately sorted closed packaging. In addition, sandstones composed of fragments, matrix, and cement in silica are classified as having poor porosity and permeability with a sedimentary structure dominated by parallel bedding. In addition, the sandstone samples analyzed have grain shapes varying from coarse to fine sand. In more detail, samples BP-1, BP-2, BP-3, and BP-4 have coarse sand grain sizes, and samples BP-5, BP-6, BP-7, BP-8, BP-9, BP-10, BP-11, BP-12, and BP-15 have the size of a fine grain of sand.

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Petrographic characteristic of Talang Akar Formation Sandstone

The sandstones of the Talang Akar Formation contain a reasonably uniform composition, namely fragments in the form of quartz divided into monocrystalline and polycrystalline quartz with a percentage of both ranging from 2% - 36% and 1.5% - 6.5%, feldspar, which is also divided into alkaline feldspar (such as orthoclase) and plagioclase feldspar with a total percentage of both around 2.5% - 32.75%, then rock fragments which include sedimentary lithic (3% - 34.5%) and volcanic lithic (2.5% - 9%) and in one sample there is calcite (9%) and biotite (3% - 7%). Furthermore, the matrix is a pseudo matrix, micrite, silica, and cement dominated by silica, clay, and carbonate (see Table 1). Feldspathic Wacke, Lithic Wacke, Lithic Arkose, Sublitharenite, Litharenit, and Arkosic Arenite are the sandstones in the research area (Classification Pettijohn, 1975)[16] (see Table 2).

Table 1. Percentage of sandstone constituent materials of the Talang Akar Formation before normalization

Sample ID	Quartz		Feldspar	Vulcanic Lithic	Sediment Lithic
	Mono	Poly			
BP-1	12,5	5	28,5	7	4
BP-2	8	2,25	32,75	4,5	10,5
BP-3	2	6,5	26	5,5	22
BP-4	9,5	-	29	2,5	20
BP-5	26	-	14	5,5	7
BP-6	32,5	-	11	9	3
BP-7	34	3	9	7	3
BP-8	36,5	2,5	10	4	11
BP-9	21,5	7,5	21,5	3,5	6,5
BP-10	26,75	-	2,5	3	10
BP-11	26,5	3,25	11,5	8	9
BP-12	13,25	-	18	16,25	4,5
BP-15	11	-	-	3,5	34,5

Table 2. The Naming of rocks using petrography

Sample ID	Rock Name	Sample ID	Rock Name
BP-1	*Feldspatic Wacke*	BP-8	*Sublitharenite*
BP-2	*Feldspatic Wacke*	BP-9	*Feldspatic Wacke*
BP-3	*Lithic wacke*	BP-10	*Lithic Wacke*
BP-4	*Feldspatic Wacke*	BP-11	*Arkosic Arenite*
BP-5	*Lithic Arkose*	BP-12	*Litharenite*
BP-6	*Sublitharenite*	BP-15	*Lithic Wacke*
BP-7	*Sublitharenite*		

Characteristic of the Provenance Sandstone of the Talang Akar Formation

Based on the results of Modified Zhang et al. (2016) plotting diagrams, when viewed from the Qt-F-L and Qm-F-Lt content of the rocks, the sandstones of the Talang Akar Formation in the Sukamoro Area are mostly from Recycled Orogen and Magmatic-Arc (see Figure 3). Magmatic arc provenance is indicated by BP-1, BP-2, BP-3, BP-4, and BP-12. Whereas Recycled orogen was shown by samples BP-5, BP-6, BP-7, BP-8, BP-9, BP-10, BP-11, and BP-15. This is influenced by total quartz mineral content, which is more dominating than feldspar minerals and lithic rocks, both mono quartz and poly quartz in each sample. The magmatic arc of the tectonic setting is inseparable from the activity of the Sumatran subduction zone as a result of the convergent subduction of plates, namely the Indo-Australian plate, which subducts under the Eurasian plate northward in the Early Cretaceous to the Late Cretaceous which stretches across the island of Sumatra and south of the island of Java[17].

In addition, based on the mono quartz content (Qm-F-Lt), the Modified Zhang Diagram plot et al. (2016) results specifically demonstrate that the Transitional Magmatic-Arc (BP-1, BP-2, BP-3, BP-4, B-12) to Mixed Provenance (BP-5, BP-6, BP-9), Quartzose Recycled (BP-7, BP-8, BP-10, BP-11), and Lithic Recycled (BP-15) are the origins of the dominant sandstones from the Talang Akar Formation (see Figure 4). This shows that lithic material, either in the form of plutonic or volcanic lithic, has had the most influence on the rock, followed by mono quartz.

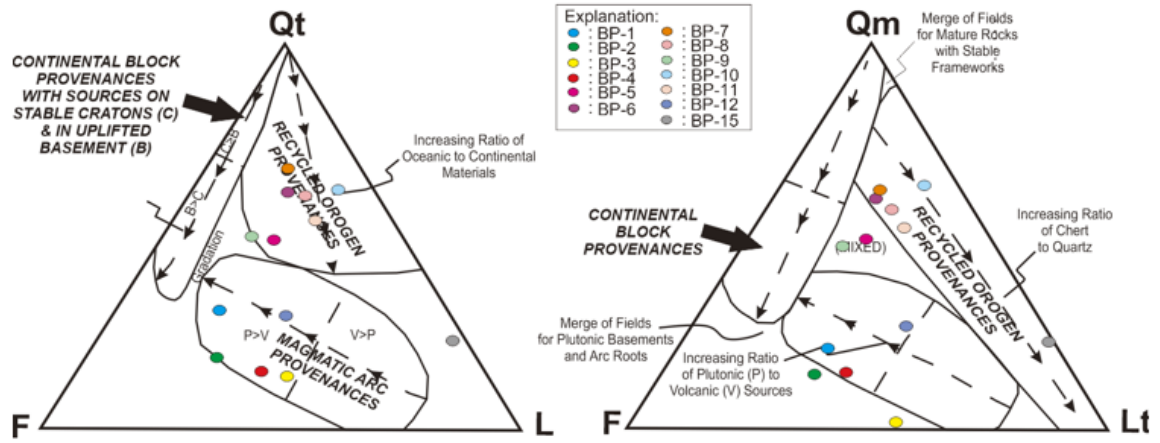


Figure 3. Plotting results of the Talang Akar Formation Provenance Diagram (Qt-F-L and Qm-F-Lt) (Modified Zhang et al., 2016)

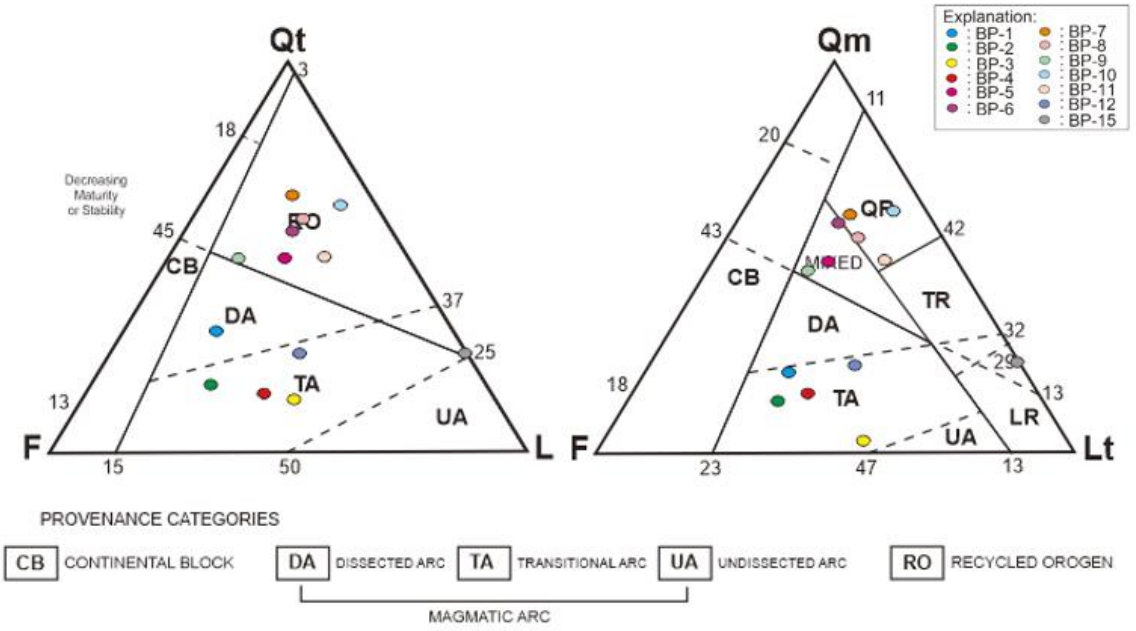
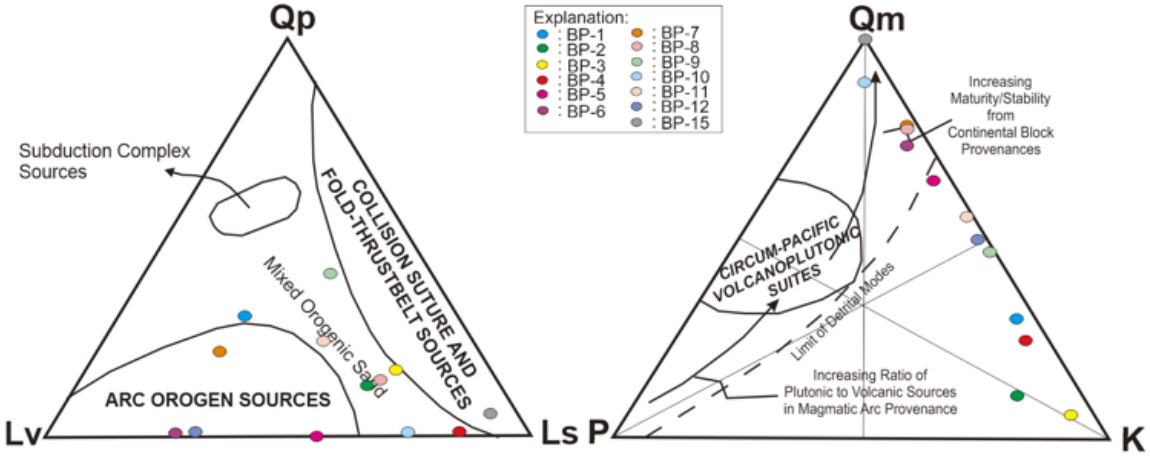


Figure 4. Results of the Sub-Zone Provenance Diagram (Qt-F-L and Qm-F-Lt) Sandstone Samples of the Talang Akar Formation (Modified Zhang et al., 2016)

Additionally, based on the percentage of polycrystalline lithic determined by the Qp-Lv-Ls content, the Talang Akar Formation sandstone fragments in the study area are primarily sourced from Mixed Orogenic Sources (BP-1, BP-2, BP-3, BP-4, BP-9, BP-10, and BP-11), and partially from the Arc Orogen Source (BP-4, BP-6, BP-7, and BP-12) (see Figure 5a). The Collision Suture and Fold-Thrust Belt are where the source is shown on BP-15. Due to the almost equal amounts of polycrystalline quartz, sedimentary lithic, and volcanic lithic present, Mixed Orogenic Sands produce detritus that is still influenced by provenances from the Subduction Complex Zone, Collision Orogen, and Arc Orogen. However, compared to sedimentary lithic and polycrystalline quartz, detritus from Arc Orogen Sources contains a greater proportion of volcanic lithic particles. As a result of the rock that was initially formed in the collision zone of two continental plates by subduction activity, where the character is dominated by the content of sedimentary lithic fragments, the Collision Suture and Fold-Thrustbelt are characterized by an abundance of sedimentary lithic fragments. According to the monocrystalline proportions, the dominant sandstones of the Talang Akar Formation in the Sukamoro Area have not undergone stability or maturation, whereas some Recycled Orogen provenances have undergone stability or maturation (Figure 5b).



(a) (b)

Figure 5. a) Plotting the provenance diagram Qp-Lv-Ls Sandstone Samples of the Talang Akar Formation shows that the dominant source comes from arc-orogenic sources and mixed orogenic sand (Modified Zhang et al., 2016), b) Plotting the provenance Qm-P-K diagram, showing the dominant rocks have not experienced an increase in stability or maturity, and some have experienced an increase in stability or maturity from the Continental Block Provenances

The provenance of the Sukamoro region differs from what Sasmita stated[9]. In the current study, Magmatic Arc and Recycled Orogenic are more prominent in the Sukamoro region. This may be due to the fact that the samples used in earlier studies originated from a region of the Continental block with fewer lithic mineral characteristics than quartz and feldspar minerals. Mendah area in South Palembang Basin dominates the Undissected Arc. In contrast, the current study utilized data samples that were more widely dispersed in the Sukamoro region. Variations in the presence of quartz(Q), lithic(L), and feldspar(F) minerals result in Magmatic arc and Recycled orogen dominating tectonic conditions. The presence of monocrystalline quartz(Qm), feldspar(F), and lithic(L) in the Sukamoro region reveals the depositional conditions of the region, which vary to demonstrate mixed, magmatic arc, and orogenic arc states.

CONCLUSION

According to petrographic analysis, the sandstones of the Talang Akar Formation contain a wide variety of compositions, including fragments in the form of quartz, divided into monocrystalline and polycrystalline quartz with percentages ranging from 2%–36.5% and 1.5%–6.5%, feldspar, which is also divided into alkaline feldspar (such as orthoclase) and plagioclase feldspar, with percentages ranging from 2.5%–32.75% In addition, the matrix is composed of a pseudo matrix, micrite, and cement, which are predominated by silica, clay, and carbonate. So, after naming the rocks, the Talang Akar Formation sandstones in the research region consist of Feldspathic Wacke, Lithic Wacke, Lithic Arkose, Sublitharenite, Litharenite, and Arkosic Arenite. According to the classification of the original rock tectonic setting, the sandstones of the Talang Akar Formation in the Sukamoro and Surrounding Areas are predominately derived from magmatic arcs and recycled orogen. Magmatic arc are shown by BP-1 (in the dissected arc sub-zone), BP-2, BP-3, BP-4, and BP-12 (indicate magmatic arc tectonic settings with transitional arc sub-zone). Recycled Orogen are shown by BP-5, BP-6, BP-7, BP-8, BP-9, BP-10, BP-11, and BP-15.

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