A PRELIMINARY ACCOUNT OF THE FRAMEWORK GRAIN COMPOSITION AND PROVENANCE OF THE LOWER TERTIARY SANDSTONE OUTCROPPED IN THE OMBILIN BASIN, CENTRAL SUMATRA

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ABSTRACT

The outcrop findings of the inverted Basin fill in the Ombilin Basin Central Sumatra, provides a new opportunity for research into provenance and sediment dispersal system. Sandstone samples were taken for petrographic examination from the Eocene Brani Formation, the Oligocene Sawahlunto Formation and the Miocene Ombilin Formation.
Major diagenetic features such as compaction, cementation, replacement and grain deformation are commonly present in all samples, but however they exhibit a different intensity level and variation in detail to each formation.
Metamorphic rock fragment, marble rock fragment and plagioclase grain are the distinctive grain types (petrographic classes) of the Brani Formation sandstone. Petrographic classes that characterize the overall populated sandstone of the Sawahlunto Formation consist of undulosed monocrystalline quartz and lithic chert. Petrographic classes that characterize the overall populated sandstone of the Ombilin Formation comprises sedimentary rock fragment (authigenic grain and intrabasinal clast) and lithic volcanic. In terms of parental rock assemblage, it is identified that the provenance (parental rock) of the sand grain in the three formations are possibly sourced from five rock assemblages: A). Pre Tertiary Extrabasinal sediment and volcanic; B). Pre Tertiary Extrabasinal Metamorphic; C). Extrabasinal contemporaneous volcanism; D). Intrabasinal contemporaneous sediment; E). Pre Tertiary Extrabasinal granitoid pluton.

Keywords: *Tertiary sandstone petrography, Provenance, Ombilin Basin*

ABSTRAK

Singkapan batuan Tersier hasil tektonik inversi dari cekungan ombilin di Sumatra Tengah menyediakan peluang bagi penelitian provenance dan sejarah pola dispersal sedimen. Sampel batupasir Tersier Bawah untuk pemeriksaan petrografi diambil dari Formasi Brani, Formasi Sawahlunto dan Formasi Ombilin.
Sampel batupasir menunjukkan sifat umum diagenesa pada ketiga formasi, ditandai oleh kompaksi, sementasi, replacement dan deformasi butiran. Variasi detail dan intensitas diagenesa masing-masing berbeda pada ketiga formasi.
Kelas petrografi yang menjadi penciri batupasir Formasi Brani adalah butiran fragmen batuan metamorf, fragmen marmer dan plagioklas. Kelas petrografi yang mencirikan Formasi Sawahlunto adalah kuarsa monokristalin, dan fragmen rijang. Sedangkan kelas petrografi yang menjadi penciri batupasir Formasi Ombilin adalah fragmen batuan volkanik dan fragmen batuan sedimen intabasinal. Dari perspektif kumpulan batuan muasal, maka provenance batupasir ketiga formasi tersebut ditafsirkan berasal dari lima kelompok asosiasi batuan: A). Kelompok sedimen dan volkanik ekstrabasinal Pra Tersier; B). Kelompok ekstrabasinal metamorf Pra Tersier; C). Kelompok ekstrabasinal volkanik yang sejaman; D). Kelompok intrabasinal sedimen yang sejaman dan; E). Kelompok granit pluton Pra Tersier.

Kata Kunci: Petrografi batupasir Tersier, Provenance, Cekungan Ombilin

INTRODUCTION

The outcrop findings of the inverted Basin fill in the Ombilin Basin provides a new opportunity for research into sediment dispersal system (Figure 1.). The formation and evolution of the Ombilin Basin is controlled by the Latest Mesozoic orogenesis, therefore, it is possible that rich information related to the Early Cenozoic sedimentation can be obtained from depositional records in the Ombilin Basin. In the Ombilin type of setting, tectonics exerts the main control on topography and determines sediment flux from catchments (Figure 2.).

Sandstone petrography is a powerful tool for deciphering both the composition of source terrains and the geotectonic setting, in which ancient terrigenous deposits formed. Sand composition is also sensitive to other factors involved in the clastic sediment system, and valuable information about climate, relief and transport can be obtained from the framework composition of sandstones. All of this information is crucial for any basin analysis and may help distinguish boundary surfaces and the internal anatomy of unconformity-bounded units of the basin fill. Thus, detrital facies are useful for analyzing depositional sequences and, consequently, the organization and develop of the clastic sedimentary record of the basin filling.

In general, the objective of the current study is directed: 1). to reveal and examine the framework sand grain of the Brani Fm., Sawahlunto Fm., and the Ombilin Fm; 2). to find out the petrographic class that define the compositional variation and grouping; 3). to infer the sand provenance and basin fill history (Figure. 3).

METHOD

Outcrop samples were collected from several exposures along roadcut and rivercut during fieldwork (Figure 4.). Samples were routinely collected from all facies recognized within the Brani, Sawahlunto and Ombilin Formations. Sample numbers and stratigraphical location are put on the composite sedimentary 1og.

In order to elucidate the petrography and provenance of those above formations, 50 samples were examined. The petrographic procedure permits an examination of framework composition according to the 'traditional' method (Pettijohn, 1957). In addition, by examining diagenetic alterations (e.g. epimatrix, pseudomatrix, dissolution of framework grains) into account, the original framework composition of the sediment can be restored. Key indices for framework composition were used to plot samples in ternary diagrams as QFL.

Regional Geology

The Ombilin basin is a Tertiary sedimentary and structural basin located on the crest of the Bukit Barisan Range in Central Sumatra (West Sumatra Province). The basin is well know for its Tertiary coal resources (Figure 1.). The southern part of the basin is well exposed, while the northern part is covered by Quaternary tuffs. The exposed part of the basin is 27 km wide and 60 km long, trending in the direction of the Sumatra Trend.

Present tectonics show the basin to be asymmetric, being rather gentle on its western side, presumably bounded by normal basement faults, and fairly steeply folded in the eastern part, with pre-Tertiary rocks overriding the Tertiary strata along a reverse fault; the Takung Fault. Sets of normal and strike-slip faults also dominate the basin. The Pre-Tertiary consist of Carboniferous Limestones (Kuantan Formation), Permian volcanics (Silungkang Formation), and Triassic sedimentary strata (Tuhur Formation) which were intruded by granites and granodiorites.

Pre Tertiary Stratigraphy

In terms of provenance study, it is important to aknowledge the frame of the Pre Tertiary stratigraphy (Figure 2.), since the Pre Tertiary represented the major basement for the Tertiary basin in the Ombilin area, from those the sedimentary detrital will be deliberated in the subsequent Tertiary sedimentation and all related basin fill processes.

The following stratigraphic frame summarizes the result of many previous authors as have been presented on the book edited by Fletcher & Yarmanto (1993).

The pre-Tertiary framework of Sumatra consists of a mosaic of continental and oceanic microplates accreted in the Late Triassic when the Mergui, Malacca, and East Malaya microplates were joined together to form the Sunda Craton. Further accretion followed during late Mesozoic times involving the Woyla Terrains.

The Ombilin Basin is largely floored by meta-volcanics and meta-sediments of the Mergui accretionary terrain. The pre-Tertiary sedimentary succession is commonly intruded by Upper Triassic granites at several locations around the basin.

Lower-Upper Carboniferous Kuantan Formation

The Kuantan Formation is a remnant of the Mergui pre-Tertiary accretionary terrain. It is divided into the Phyllite and Shale Member, Limestone Member, and Lower Member. The Phyllite and Shale Member consists predominantly of reddish to dark brown shales and phyllite which are slightly schistose. It contains thin intercalations of dark grey slate, quartzite, siltstone and chert. This member is also reported to contain lava flows with compositions ranging from basalt to andesite.

The Limestone Member is a massive, white to grey limestone grading into marble. Within the limestone, thin intercalations of slate, phyllite, siliceous shale and quartzite are reported.

The Lower Member consists predominately of light grey to reddish brown quartzite and quartz sandstones with intercalation of phyllite, siliceous slate, shale, volcanic rocks, chloritized tuff, conglomerates, and brown chert. The Lower Member is reported to be tightly folded in several localities with common quartz veining.

Permian Silungkang Formation

The Silungkang Formation is part of the Woyla pre-Tertiary accretionary terrain. It has been separated into a "Lower and Upper part" and a Limestone Member. The Lower Part is predominately hornblende andesite, augite andesite and meta-andesite with thin intercalations of tuffs, limestones, shales and sandstones. The Upper Part consists of arenaceous limestone, calcareous sandstone, and shale with minor intercalations of agglomeratic tuffs. Augite andesite and basalt flows are interbedded with the sedimentary sequences and reported to be locally chloritized.

The Limestone Member is massive, hard, medium to dark grey with thin intercalations of shale, sandstone and tuff.

Mid-Late Triassic Tuhur Formation

The Tuhur Formation is divided into two members and sporadically outcrop west of the Trans Sumatra Fault Zone. The Slate and Shale Member consists of medium to dark grey slate, shale and marl with intercalation of brown chert, radiolarite, black silicified shale and thin layers of metamorphosed greywacke.

The Limestone Member consists of poorly bedded, sandy limestone and massive, fossiliferous, conglomeratic limestone. Selected beds display pebbles containing fusulinids derived from Permian limestones. These are interbedded with slates and shales.

Pre Tertiary Intrusives

Pre-Tertiary sedimentary rocks of the Mergui and Woyla accretionary terrains were intruded by granites, granodiorites, quartz diorites, and quartz porphyries of various ages. Radiometric dating indicates an Upper Jurassic to Cretaceous age for most outcrops. However, samples have

been dated from Permian to Quaternary.

Tertiary Stratigraphy
Early Eocene Sangkarewang Formation

The Sangkarewang Formation is one of the most widespread formations observed in outcrop throughout the Ombilin Basin. The Sangkarewang Formation is a thick sequence of brownish, dark grey to black, finely laminated, papery, organic rich shales. Interbedded within the shales are fine to medium grained feldspathic sandstones. Structurally the finer grained sediments are often characterized by slump structures and commonly faulted and folded into tight isoclinal folds.

The Sangkarewang Formation was deposited in a lacustrine environment. Age dating of the Sangkarewang Formation is based on the presence of Musperia radiata and Scleropagus which indicates Paleogene to early Eocene deposition.

The paleogeography of the Ombilin Basin during the Eocene is depicted as a relatively low lying, closed basin floor accumulated up to 1500 meters of typical organic rich lacustrine sediments. These sediments rapidly thinned towards the basin margins where they coalesced with alluvial fan and debris flow sediments which contributed conglomeratic and breccia material from up-thrown fault blocks where basement was exposed.

Early-Mid Eocene Brani Formation

The coarse grained Brani Formation consists of fanglomerates and debris flow sediments deposited along active basin bounding faults from late Paleogene? to middle? Eocene. No palynomorphs or age determinant microfossils have been recovered from the Brani Formation. It has been age dated by its interfingering with lateral and overlying stratigraphic units.

The Brani Formation is dominated by clast supported, poorly sorted, fanglomerates of pebble to boulder size. Clast composition varies and is dependent on the basement rock on which they were deposited on or near. They are predominantly reddish brown to purple with mottling indicating the presence of rootlets or burrows. Individual fanglomerate sequences of the Brani Formation generally fine upward, and are commonly capped by sandstones and argillaceous siltstones. Style of sedimentation indicates these deposits are fanglomerates and debris flows are a result of rapid uplift along the flanks of newly formed grabens.

Early-Mid Oligocene Sawahlunto Formation

The Sawahlunto Formation is late Eocene to early Oligocene in age and unconformably overlies Sangkarewang, Brani and basement terrains where observed along the western portion of the Ombilin Basin. Recent work suggests the Sawahlunto Formation from Oligocene to lower Miocene on the basis of Cassoretitriletes vanraadrhooveni (Lyqodium scandens).

The Sawahlunto Formation is a fining upward sequence deposited in a flood plain or mire type depositional environment. The base of the sequence consists of grey, fine to medium grained, well sorted sandstones. Sands commonly have an erosional base and are interbedded with finer grained siltstones, clays, and coals. This sandstone rich basal sequence is overlain by ripple laminated, carbonaceous, siltstones and shales. The entire sequence is capped by a series of interbedded grey mudstones, coal, and organic rich shales.

The formation appears to be widespread with coal seams developing along both the eastern and

western portions of the basin. This suggest that the topographic relief of adjacent basements highs during the late Eocene to early Oligocene was low.

Oligo-Miocene Sawahtambang Formation

The Sawahtambang Formation of Oligocene to Early Miocene outcrops at many localities in the southern and western portions of the basin. Excellent outcrops of stacked, cross bedded channeled sands form one of the best exposed examples of braided stream fluvial sediment.

The Sawahtambang Formation is characterized by a thick massive sequence of cross bedded sandstones, mostly quartzose to feldspathic. Shales and siltstones are only locally developed.

Sandstones sequences are light grey to brown, fine to very coarse grained with occasional pebble interbeds. Individual sand sequences consist of very poorly sorted, subangular, hard, quartz grains.

A typical sequence of the Sawahtambang Formation consists a series of depositional cycles, each has an erosional base overlain by imbricated pebbles, cross bedding and parallel lamination with a fining upwards sequence. Within the coarse grained sands, lenses of trough shaped cross bedding area common. No fossils or palynomorphs have been analyzed from the Sawahtambang Formation. All age dating has been based on its relative position between the underlying Sawahlunto Formation and overlying Ombilin Formation. Thus, an Oligocene age is assumed.

Early-Mid Miocene Ombilin Formation

The Ombilin Formation lies conformably on the Sawahtambang Formation and represents the first major marine incursion into the area. The Ombilin Formation consists of grey, silty to slightly sandy, moderately calcareous mudstones with common carbonaceous material. Interbedded with mudstones are off-white to white, very fine to fine grained, calcareous, glauconitic sandstones and soft, off-white, calcareous siltstones. Thickness of Ombilin Formation varies dramatically in different portions of the basin.

The stratigraphic equivalent to the Ombilin Formation in the central Sumatra Basin is the Telisa Formation. It forms part of the Lower Miocene transgression which inundated most of Sundaland. There appears to have been low relief islands of basement terrain in the neighborhood and localized volcanic activity. Evidence for this can be seen in the high percentage of greenish grey volcanogenic sands observed in outcrop in the northern portion of the basin.

RESULTS

Lithologic Finding & Lithofacies Subdivision

Brani Formation, Sawahlunto Formation and Ombilin Formation have a common lithologic facies. These Formations consisted largely of 4 lithofacies, as follow:

1) Conglomerate facies
2) Breccia Facies
3) Coarse Grained Sandstone facies
4) Fine Grained Sandstone facies.

The conglomerate facies is characterized by the presence of reddish coloured, grain supported fabric, poorly stratified and sharp erosional bases. The size of gravel clasts is largely well sorted and range from pebble to small cobble.

The gravel framework comprises subrounded to rounded quartz vein fragment, chert and limestone. The maximum thickness of this facies is approximately 560 m. The gravel clast imbrication has a NE-SW orientation. This facies is attributed to terrestrial ephemeral stream deposits.

The breccia facies is characterized by the presence of brown colours. The size of gravel clasts is largely poorly sorted and range from pebble to cobble. The gravel framework comprises angular to sub angular igneous and sedimentary rock fragments. The maximum thickness of individual bed is approximately 25 m. The gravel clast imbrication has a NE-SW orientation. This facies is attributed to terrestrial ephemeral stream deposits.

The coarse grained sandstone facies comprise sandstones and subordinate conglomerate intercalations, the sand beds are commonly characterized by lateral grading into conglomerate. It is characterized as well by dark brownish yellow colours and shows structureless-poorly well bedded sand beds with common sharp erosional bases. The sand grain is primarily composed of poorly sorted very coarse graied sands, sub angular to rounded grain shape. Gradded beds and trough cross stratification were occassionally observed to indicate a channel related deposits.

The fine grained sandstone facies comprises interbedded sandstone, siltstone, claystone and common conglomerate. An overall sandstone bed shows yellowish grey to yellowish brown colours. It is characterized by well stratified with paralel laminated plane bed and cross laminated sand and common concretionary nodule. Thin laterally impersistent coal seam and coal lenses are occasionally observed. Sharp erosional bases are common. The framework grain is characterized primarily by the presence of very fine to medium sand size. Disarticulated mollusc fragments, planktic tests and benthic foraminifera are evident. This facies is attributed to the interdistributary bay and the adjacent abandoned channel with distinct tidal influences.

General Remarks of the Sandstone Petrology and Composition

Based on the examination of the petrographic samples taken from the three formations, in general the sandstones could be divided into two groups of textural frame, namely arenite sandstone and subwacke sandstone, feldspar garin is scarcely found, moreover the lithic class of these group is characterized by the presence of rock fragment, primarily metamorphic rocsk fragment and cherty fragment. The types of sand grain contact is predominated by long, concavo-convex and suture contacts, represent advance diagenetic stage and severe compaction (Figure 5, Figure 6, Figure 7.).

According to the Pettijohn (1975) classification scheme, the sandstone could be classified into 4 groups, namely: A). Lithic Arenite sandstone; B). Lithic Graywacke sandstone; C). Subarkosic sandstone and; D). Feldsphatic Wacke sandstone (Figure 8).

Diagenetic Features

Major diagenetic features such as compaction, cementation, replacement and grain deformation are commonly present in all samples, but however they exhibit a different intensity level and variation in detail to each formation.

Diagenetic modification in the Brani Formation is characterized by the presence of compaction and partial dissolution in quartz and rock fragment; calcite cementation and replacement in association with clay matrix intergrowth; grain deformation as revealed by the segmented extinction in quartz crystal and grain fracturing.

Diagenetic modification in the Sawahlunto Formation is characterized by the presence of compaction and partial dissolution in quartz and volcanic rock fragment; calcite cementation and replacement

in association with secondary quartz overgrowth and matrix recrystalization (epimatrix); grain deformation as revealed by the segmented and undulosed extinction in quartz crystal and grain fracturing filled with calcite veinlet.

Diagenetic modification in the Ombilin Formation is characterized by the presence of compaction and partial dissolution in quartz, metamorphic rock fragment and volcanic rock fragment; calcite cementation and replacement in association with secondary quartz overgrowth and matrix recrystalization (epimatrix), fine undifferentiated rock fargment were replaced by authigenic mica and chlorite; grain deformation as revealed by the segmented and undulosed extinction in quartz crystal and squeezed ductile rock fargment forming pseudomatrix between grains.

Modality of the Sand Grain Composition

Brani Formation Sandstone

Petrographic samples taken from the matrix of intercalated breccias and conglomerate were analysed, since they represent allogenic sand sized detritus. The sandy matrix in breccias is characterized by prominent sodic plagioclase that is possibly derived from older Pre Tertiary granitoid basement high that can be found elsewhere in the vicinity of the basin. A petrographic comparison has been carried out between sodic plagioclase observed in granite sample and allogenic plagioclase found in the sandstone to check the possibility of their provenance.

The sandy matrix in the conglomerate is dominated by marble rock fragment, schistose metamorphic rock fragment and undulosed monocrystalline quartz. Plagioclase grain present in smaller quantity than found in the former breccia matrix. The sandy matrix of the conglomerate is possibly derived primarily from metamorphic terrane consisted low grade metamorphic rock and marble.

The sand framework taken exclusively from the sandstone of Brani Formation consists primarily of prominent metamorphic rock fragment, undulosed monocrystalline quartz, marble fragment and common chert clast, whilst plagioclase is scarce.

Modal analysis of the sandstone has revealed petrographic classes that characterize the populated sandstone of the Brani Formation. Metamorphic rock fragment, marble rock fragment and plagioclase grain are the distinctive grain types (petrographic classes) of the Brani Formation sandstone.

Sawahlunto Formation Sandstone

The sandstone composition of the Sawahlunto Formation is characterized by prominent metamorphic rock fragment, lithic chert and undulosed monocrystalline quartz. Petrographic classes that characterize the overall populated sandstone of the Sawahlunto Formation consist of undulosed monocrystalline quartz and lithic chert. The present of volcanic rock fragment is gradually increased upsection, but however, this grain type does not typify an overall sandstone of the Sawahlunto Formation, since its occurrence is merely impersistent in the upperhalf stratigraphic interval of the formation.

Ombilin Formation Sandstone

Sandstone composition of the Ombilin Formation is dominated by lithic volcanic (volcanic rock fragment) and fine grained sedimentary rock fragment (green pellet) and subordinate plagioclae grain showing subangular to subrounded grain shape.

The volcanic rock fragment is characterized primarily by the presence of lathwork plagioclase

microlith, the affinity of this type of lithic volcanic is commonly associated with the intermediate to acidic volcanics.

Petrographic classes that characterize the overall populated sandstone of the Ombilin Formation comprises sedimentary rock fragment (authigenic grain and intrabasinal clast) and lithic volcanic.

Sandstone Provenance

In terms of parental rock assemblage, it is identified that the provenance (parental rock) of the sand grain in the three formations are possibly sourced from five rock assemblages: A). Pre Tertiary Extrabasinal sediment and volcanic; B). Pre Tertiary Extrabasinal Metamorphic (metasediment); C). Extrabasinal contemporaneous volcanism; D). Intrabasinal contemporaneous sediment; E). Pre Tertiary Extrabasinal granitoid pluton. It is supported by the the regional setting that source for sediment into basin has possibly derived largely from The Pre Tertiary formations namely Carboniferous Kuantan Formation, Permian Silungkang Formation, Triassic Tuhur Formation and Pre Tertiary Pluton.

There are complicated factors contribute to ultimate sedimentary provenance. The strong controll of provenance may come from parental rock, basin setting, paleogeography (sedimentary environment) and sedimentary delivery system.

Regarding to the key grain types of the Brani Formation sandstone that is characterized by metamorphic clast and marble fragment, thereby its provenance could be attributed to the more local sourced where the sediment delivery system was associated with the basin forming tectonic activity. This is also indicated by the nature of the deposit, which is dominated by the slope related deposit, such as sieve deposit of the alluvial fan system and coarsed grain colluvial sediment, represent a textural immature stage.

Based on the facies analysis, the sedimentation setting associated with the provenance of the Sawahlunto Formation is originated from braided alluvial, characterized by the presence of ephemeral stream with gentler angle of repose. This type of basinal setting provided such a long distance sediment delivery system and sedimentary mixing induced by resedimentation of the temporary sediment storage in alluvial system. This recycling process, recurrent transportation and re-entrainment of the sediment were responsible for the sediment mechanical sortation, thereby polymineral grain of the rock fragment could be disintegrated into quartz and other monomineral grain types.

Major provenance for the sandstone of the Ombilin Formation is originated from the sedimentary mixing between an extrabasinal source associated with the influx of volcanic material derived from the contemporaneous volcanic eruption during sedimentation and an intrabasinal source originated from reworking authigenic material derived from marine environment.

Quartz Grain Typology

Apart from simple distinction between monocrystalline and polycrystalline types, petrographic finding has distinguished an internal variation and different type of the quartz grain. Monocrystalline quartz commonly represents undulatory extinction with deformation lamellae to indicate deformation processes, whilst polycrystalline quartz is composed of more than three microcrystals with polygonized intracrystal boundary.

The typology of quartz grain internal fabric could be attributed to the parental source of detritus and hence provided a greater assist in provenance interpretation. Based on

30 petrographic samples from the three formations, four types of quartz grain typology are clearly evident: 1). plutonic quartz with common non-undulosed extinction with trapped tiny inclusions; 2). brittle-ductile deformed quartz grain with deformation lamellae and segmented extinction; 3). low grade metamorphic quartz, commonly polycrystalline with suture-mosaic intrlocking contact and; 4). micro crystalline quartz, mostly represented by chert fragment.

Textural Maturity and Sedimentary Environment

Textural maturity concept has an important role in interpretation of the sandstone provenance. Homogeneity of sortation and shape of grain can provide a descriptive scale to identify a degree of effectivity and enviromental selection during transportation and sedimentation of grain.

Brani Formation

Estimated volume percentage of the conglomerate matrix ranges between 1.6%-18%, comprises ferroan oxide and carbonate (calcite), whlist clay mineral in the matrix is scarcely observed. The sand framework is consists primarily of metamorphic rock fragment and microcrystalline of cherty fragment.

On the other hand, volume of the breccias matrix reach a percentage of 16% at maximum, comprises prominent clay luthum with subordinate ferroan oxide and carbonate. The sand framework is dominated by the presence of angular plagioclase grain.

Sawahlunto Formation

Estimated volume percentage of the matrix ranges between 0.2%-24.25%, the finest constituent is primarily comprises ferroan oxide and sericite with subordinate clay mineral. The sand frame predominated by the presence of quartz, metamorphic rock fragment, chert and occasionally sedimentary rock fragment. Plagioclase grain is present in smaller quantity than the other major petrographic class (0.1%-8%).

The shape of the sand grain is characterized by the presence of prominent angular grain, apart from minor rounded grain. According to those textural description, the sand from Sawahlunto Formation could be attributed to the sub mature textural stage.

Ombilin Formation

Estimated percentage of the matrix volume ranges between 3%-24%, and consists largely of variegated clay minerals. On the other hand, the sandstone framework is characterized by the presence of undifferentiated fine grained sedimentary rock fragments and lithic volcanics. The majority of these grain shape are from angular to rounded with poor to well sorted sand grains. According to these textural and compositional evidence, the sandstones were considered to represent immature stage.

The second important framework grain is plagioclase, which is range between 1%-10%, characterized by angular to subrounded shape. Detrital green pellets and carbonaceous swirl are also evidence, observed on several occasion. These grains to indicate marginal marine or neritic sedimentary environment.

Degree of Maturity and Sand Composition

Apart from the textural maturity, the concept of compositional maturity of the sand grain framework could be used and evaluated as one of provenance indicator. The presence of high stable and ultra stable grain may indicate more mature composition than those with unstable grains. The ubiquitous quartz grain is one of maturity index of composition, since

its durability and can pass over two recycle of deposits.

Compositional mature stage is represented by the sandstone of the Oligocene Sawahlunto Formation. Quartz grain as a stable light mineral is more abundant in Sawahlunto Formation than in the Brani and Ombilin Formations. The sediment of the Ombilin Formation has been recycled from older sedimentary rock, this process has eliminated the less stable mineral grains to be deposited in the subsequent priod of sedimentation.

Compositional submature stage is represented by the sandstone of the Eocene Brani Formation, since it has a greater number of lithic metamorphic than quartz grain. This stage indicates a mixing of local short distance detrital source with minor contribution from recycled sediment from te older sedimentary strata.

Compositional Immature stage is represented by the sandstone of the Miocene Ombilin Formation. The sand composition of the Ombilin Formation is dominated by less stable sedimentary rock fragment and lithic volcanic. Detrital of lithic sediment is normally stem from the contemporaneous exposure of the first cycle sedimentary source, whilst the volcanic fragment could be supplied by the contemporaneous volcanism during the sedimentation of the Ombilin Formation.

CONCLUSION

The three Tertiary formations consisted largely of 4 lithofacies: Conglomerate facies, Breccia Facies, Coarse Grained Sandstone facies and Fine Grained Sandstone facies.

The overall sandstones from the three formations could be divided into two groups of textural frame, namely arenite sandstone and subwacke sandstone. According to the Pettijohn (1975) classification scheme, the sandstone could be classified into 4 groups, namely: Lithic Arenite sandstone; Lithic Graywacke sandstone; Subarkosic sandstone and Feldsphatic Wacke sandstone.

Diagenetic modification in the Brani Formation is characterized by the presence of compaction and partial dissolution in quartz and rock fragment; cementation and replacement. Diagenetic modification in the Sawahlunto Formation is characterized by the presence of compaction and partial dissolution in quartz and volcanic rock fragment; cementation and replacement and matrix recrystalization (epimatrix). Diagenetic modification in the Ombilin Formation is characterized by the presence of compaction and partial dissolution in quartz, metamorphic rock fragment and volcanic rock fragment; cementation and replacement and matrix recrystalization (epimatrix).

Metamorphic rock fragment, marble rock fragment and plagioclase grain are the distinctive grain types (petrographic classes) of the Brani Formation sandstone. Petrographic classes that characterize the sandstone of the Sawahlunto Formation consist of undulosed monocrystalline quartz and lithic chert. Petrographic classes that characterize the overall populated sandstone of the Ombilin Formation comprises sedimentary rock fragment (authigenic grain and intrabasinal clast) and lithic volcanic.

In terms of parental rock assemblage, the provenance (parental rock) of the sand grain in the three formations are possibly sourced from five rock assemblages: A). Pre Tertiary Extrabasinal sediment and volcanic; B). Pre Tertiary Extrabasinal Metamorphic; C). Extrabasinal contemporaneous volcanism; D). Intrabasinal contemporaneous sediment; E). Pre Tertiary Extrabasinal granitoid pluton.

Major provenance of the Brani Formation sandstone could be attributed to the more local sourced where the sediment delivery system

was associated with the basin forming tectonic activity. Major provenance of the Sawahlunto sandstone is originated from a long distance sediment delivery system and sedimentary mixing induced by resedimentation of the temporary sediment storage in alluvial system.

Major provenance for the sandstone of the Ombilin Formation is originated from the sedimentary mixing between an extrabasinal source associated with the influx of volcanic material derived from the contemporaneous volcanic eruption during sedimentation and an intrabasinal source originated from reworking material derived from marine environment.

Compositional mature stage is represented by the sandstone of the Oligocene Sawahlunto Formation. Compositional submature stage is represented by the sandstone of the Eocene Brani Formation, since it has a greater number of lithic metamorphic than quartz grain. Compositional Immature stage is represented by the sandstone of the Miocene Ombilin Formation. The sand composition of the Ombilin Formation is dominated by less stable sedimentary rock fragment and lithic volcanic.

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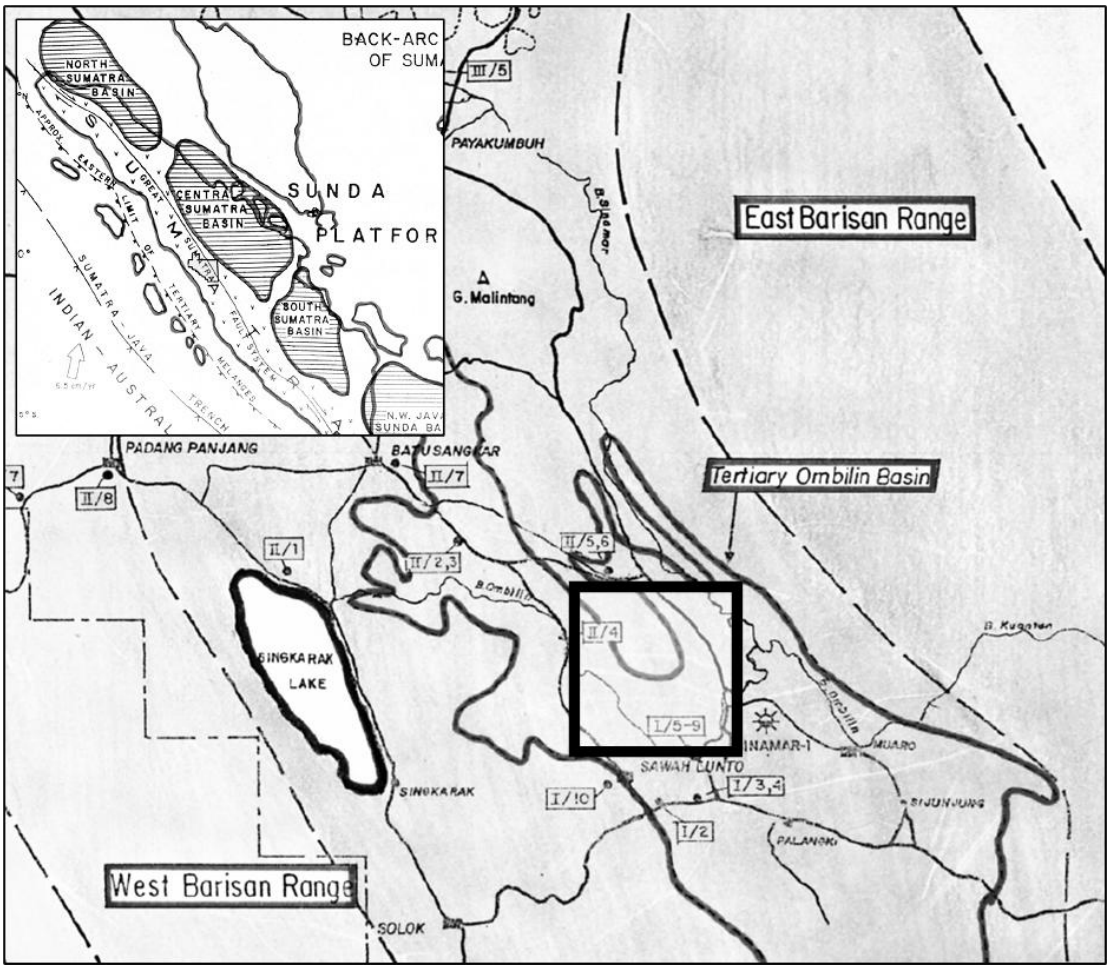

Figure 1.

Map depicting the location of Ombilin Basin, shaded box is location of the current study (modified after Fletcher &

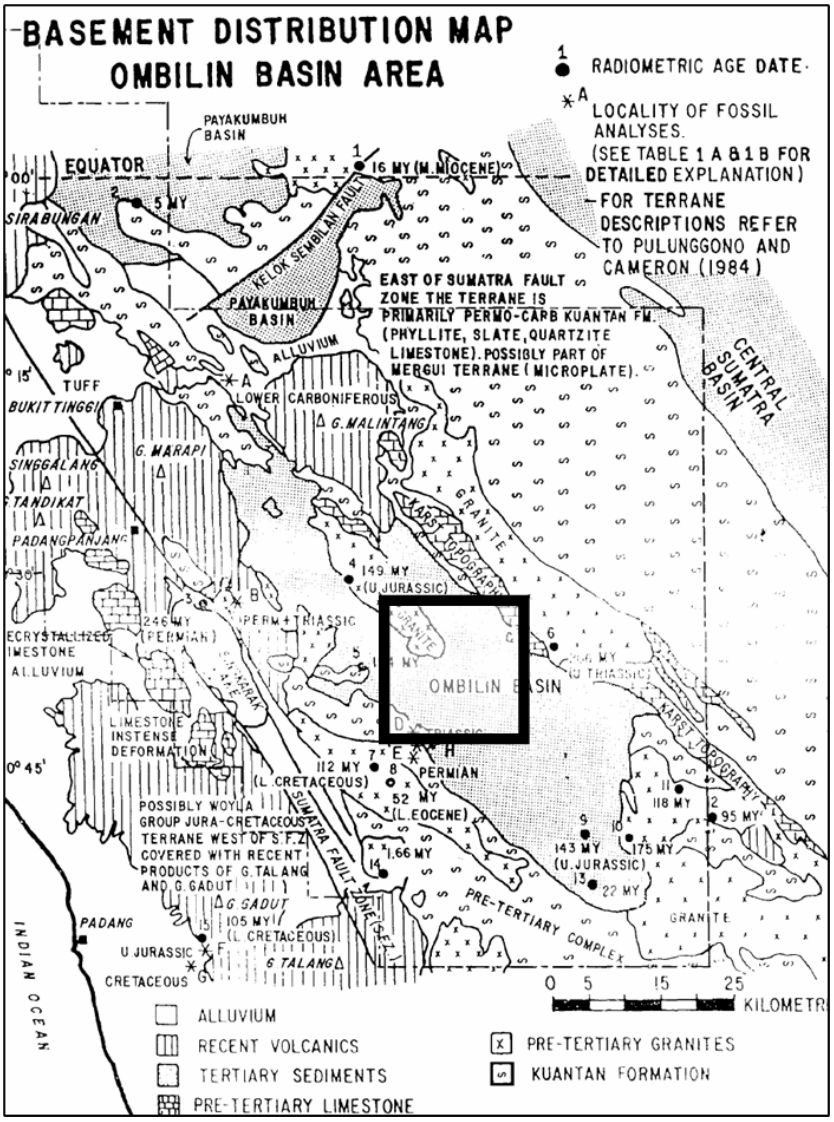

Figure 2.

Map depicting the location of Pre Tertiary basement exposure, shaded box is location of the current study (modified after Pulunggono & Cameron, 1994)

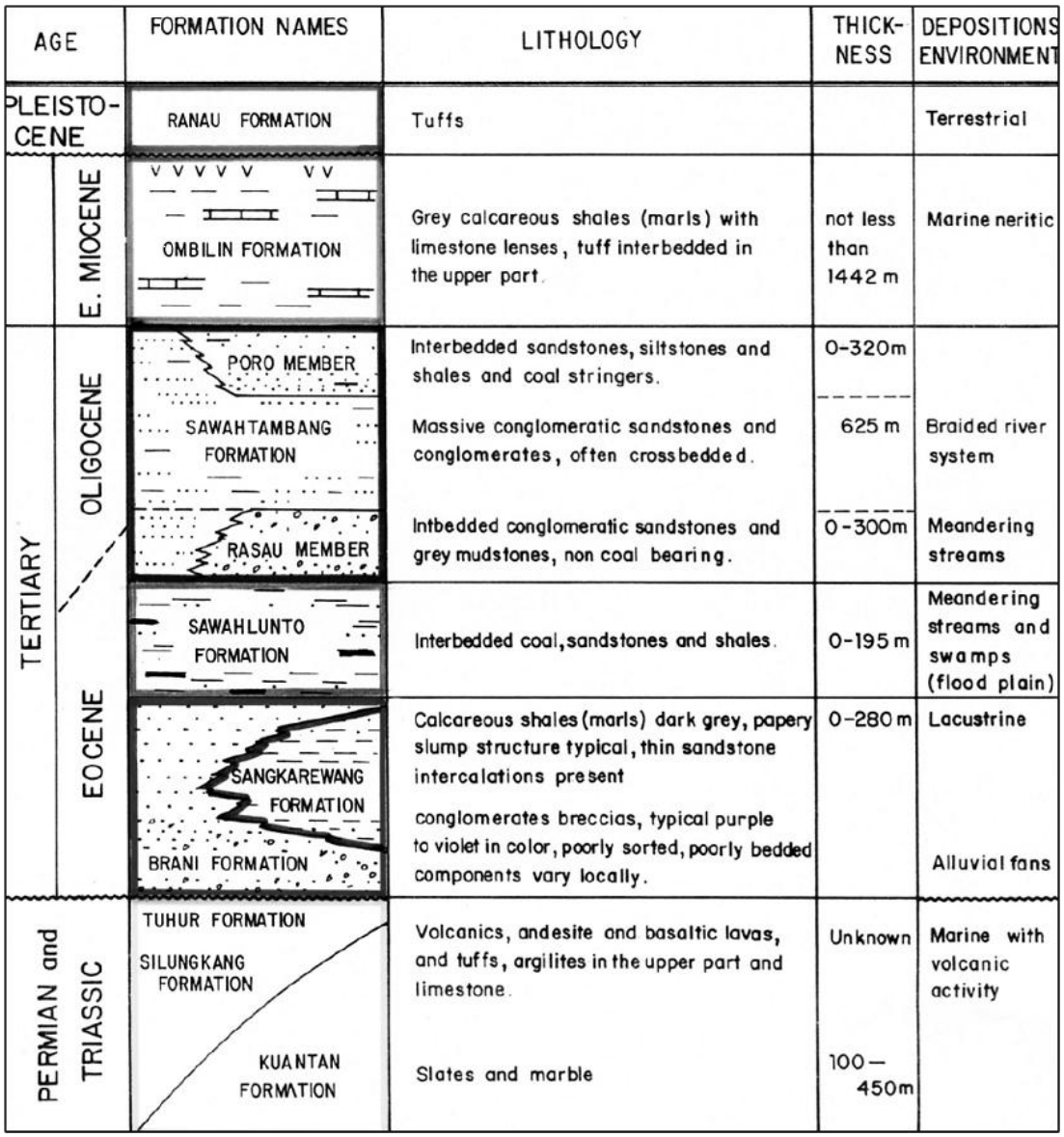

Figure 3.

Regional stratigraphic framework of the Ombilin Basin, sandstone samples were taken from the Brani Formation, Sawahlunto Formation, and the Ombilin Formation (modified after Fletcher & Yarmanto, 1993)

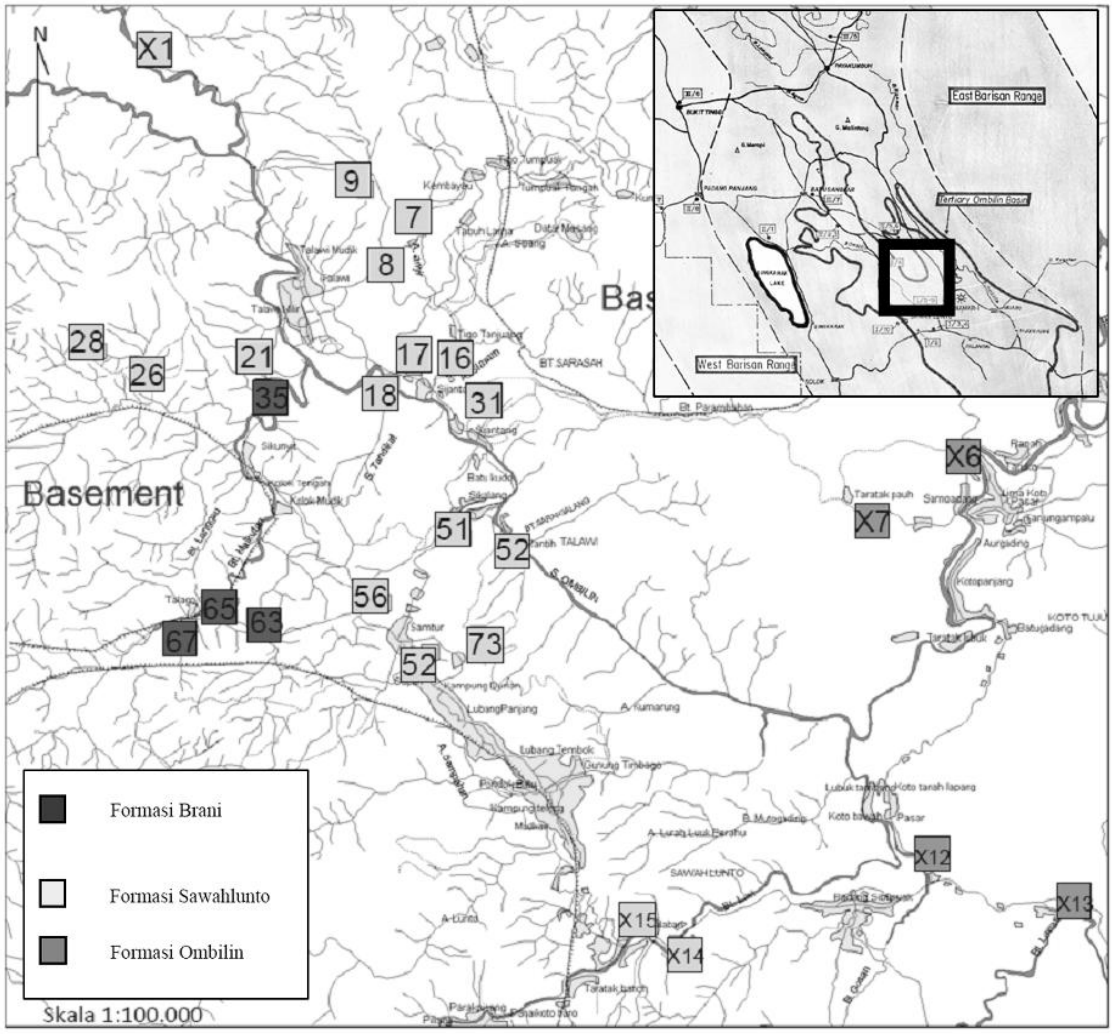

Figure 4.

Map showing distribution of the Brani, Sawahlunto and Ombilin Formations, small boxes with number are the location of hand specimen sampling (Yeni, 2009)

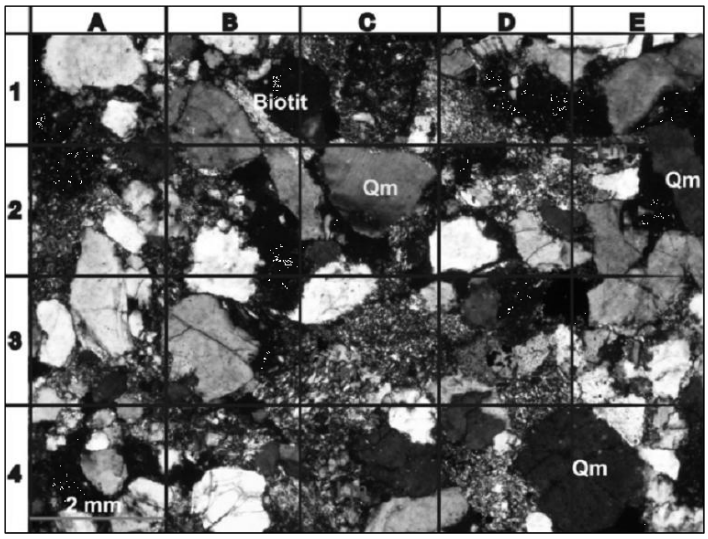

Figure 5.

Microphoto represent a typical sandstone of the Brani Fm., the sample is characterized by suture grain contact (E-3), point contact (A-3), long contact (B-1) and concave-convex contact (C-3), pseudomatrix (C-3,D-2) due to squeezed and broken grain, and common allogenic mica (B-1)

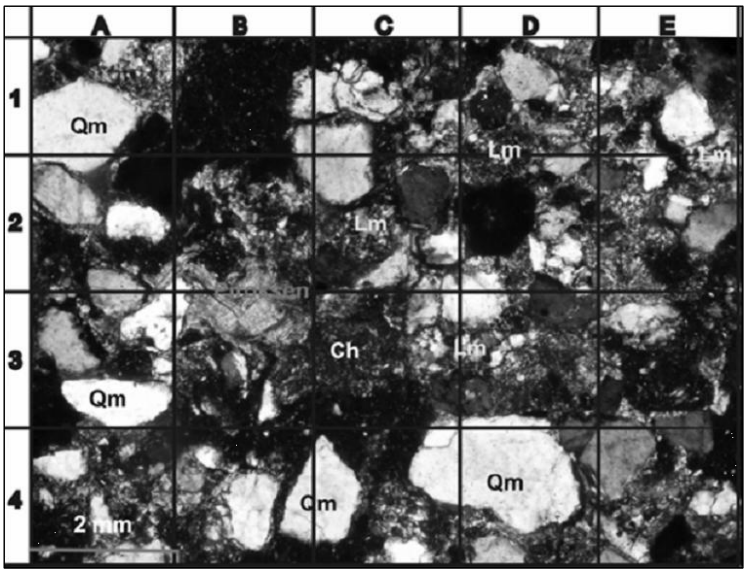

Figure 6.

Microphoto represent a typical sandstone of the Sawahlunto Fm., the sample is characterized by the presence of suture contact (D-3), concave-convex contact (A-2) and long contact (B-4), several grain outline represent corroded texture (C-2, D-4), its composition is dominated by monocrystalline quartz and rock fragment

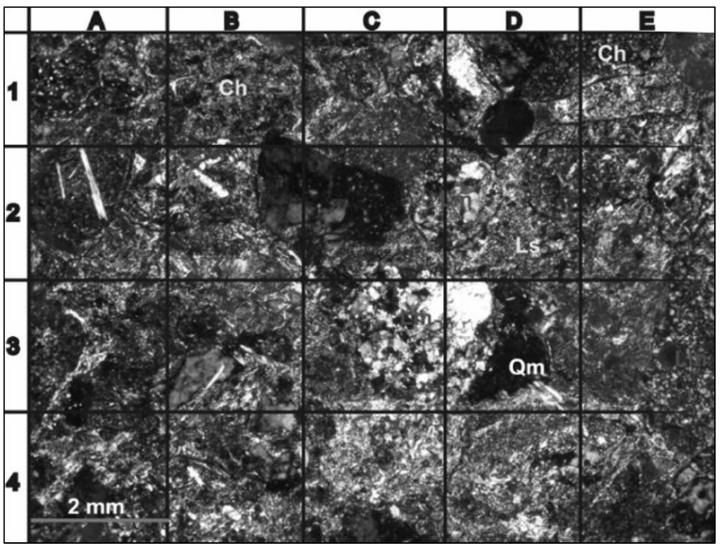

Figure 7.

Microphoto represent a typical sandstone of the Ombilin Fm., the sample is characterized by the presence of *suture contact* (C-3)*, long contact* (A-2)*, point contact* (D-1) and *concave-convex contact* (B-2), an overall grain contact showing corroded texture, the sand composition is dominated by fine grained volcanic rock

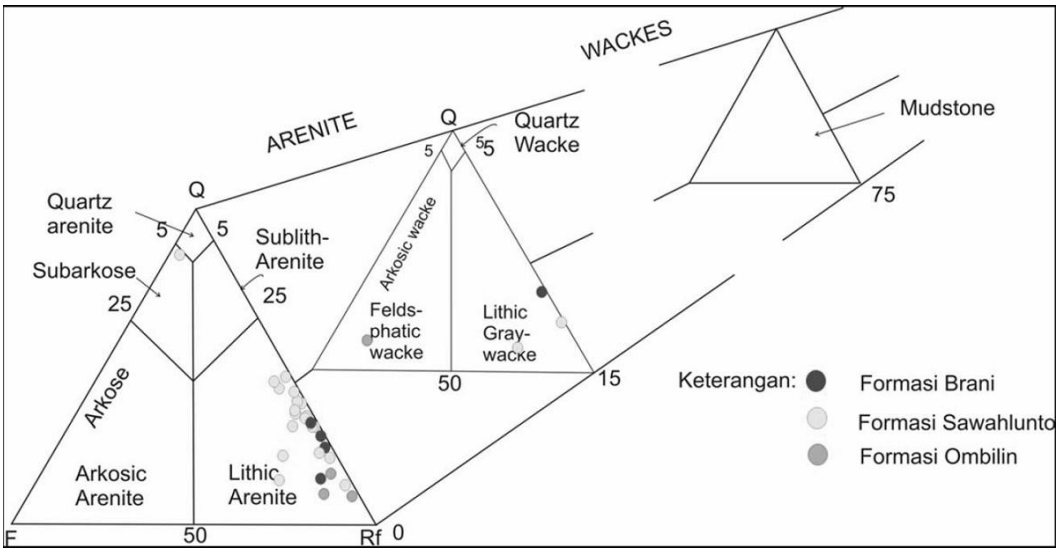

Figure 8. Sample distribution in the ternary QFL field for the sandstone of the three formations, the diagram shows indistinct clustering trend of the three formation, the textural framewrok of the whole sample is divided into arenite and subwacke textural group