

# Sandstone Provenance Study in Wonoregoro, Boyolali Regency, Central Java

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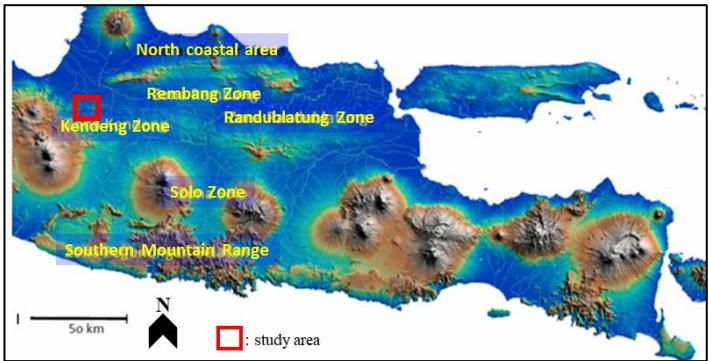
**Abstract.** Wonoregoro is part of western Kendeng Zone, the depocenter of North East Java Basin that is mainly filled with thick pelagic and volcanoclastic sediments. Sandstones lithofacies is presence within the research area and may act as a useful tool to reach the aim of this research, which is to determine the provenance. The research has conducted field observation, petrographic analysis on seven thin sections of sandstones from the field, and bathymetry interpretation from benthic foraminifera. Overall, the sandstones are predominantly composed of lithic components (72.73%-88.05%) and significant matrix (25%-50%), thus classified as lithic greywacke. The combination of quartz-feldspar-lithic (QFL) and the heavy minerals composition suggest that the sandstone provenance in research area is a product of Oligo-Miocene volcanic of southern mountain range.

## 1 Introduction

Wonoregoro is part of western Kendeng Zone as shown in Fig. 1. This zone is the depocenter of North East Java Basin. The basin itself is the back-arc basin of uplifted Southern Mountain Range of Java during the Oligo-Miocene, mainly filled with thick pelagic and volcanoclastic sediments [1]. Nevertheless, sandstones lithofacies is presence within the study area. The occurrence of sandstone might be a useful tool to determine the provenance of the sedimentary rock in the area, which become the aim of this research. Since most published research took place at the eastern part of Kendeng zone [2,3] it has become the more reason to conduct this research, which may represent the western margin of Kendeng Zone.

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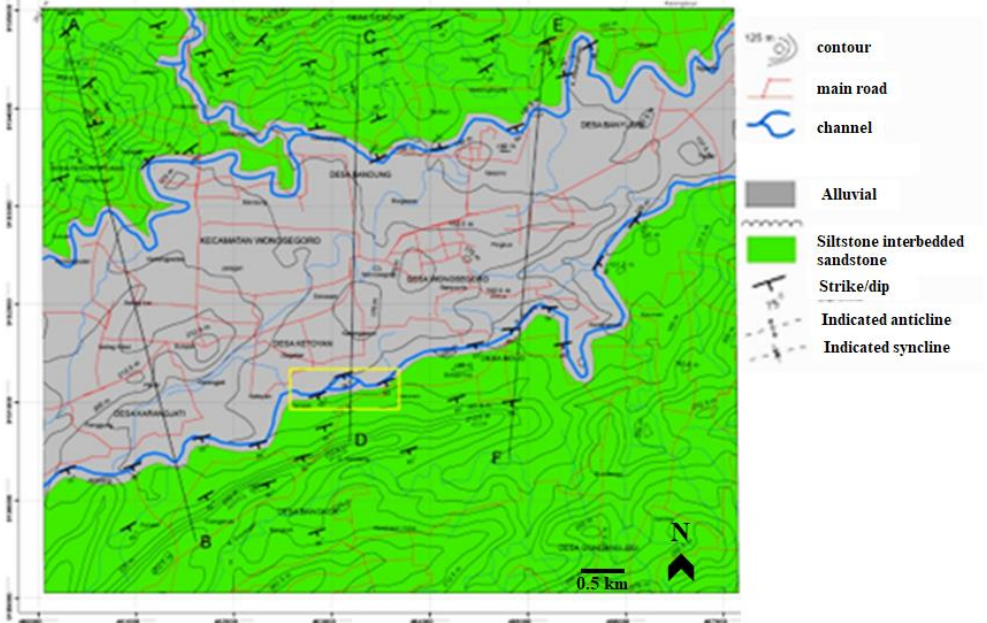
**Fig. 1.** Physiography of central and eastern Java (zonation referring to van Bemmelen, 1949).

There are several attributes of sediment or sedimentary rocks in order to conduct provenance study, for instance, grain-size, degree of weathering, extent of diagenetic development [4]. It is also well known that provenance can provide a fruitful information to do reconstruction of the geological process.

2 Methodology

2.1 Field Observation and Sampling

The field observation area is along Serang River within Wonosegoro, Boyolali regency. During this step, field samples are also collected. There are 7 sandstone samples to conduct petrography analysis and 6 samples for biostratigraphy analysis, the location sample collecting is shown in Fig. 2.



**Fig. 2.** The observation area map, where the yellow box is the location of samples collected for further analysis

## 2.2 Petrography Analysis

There are two purposes in running this method, which are to obtain 1) the percentage of light minerals (quartz, feldspar, and lithic); and 2) the heavy minerals (biotite, hornblende, pyroxene, and hematite) from Kerek Formation samples. The first petrographic analysis is conducted by preparing seven samples from the field into thin sections and then observed under polarized microscope. Each section is divided into at least 300 grid to count the distribution of light minerals. The results are projected onto the QFL ternary diagram [5]. The second analysis is utilizing reflected light on ground sample to determine and count at least 300 heavy minerals.

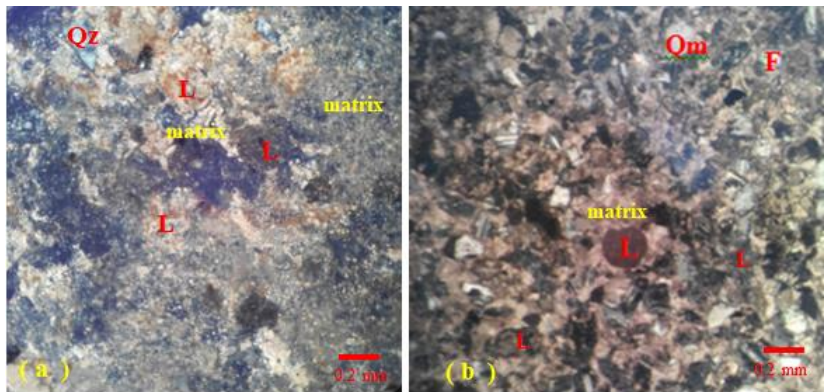
## 2.3 Biostratigraphy Analysis

Archimedes Six sandstone samples were prepared into grains to undergo biostratigraphy analysis. The grain samples were observed under reflected lights to determine benthic foraminifers. The distribution of determined species is used to define the zonation of bathymetry of each sample, based on the Blow 1969 classification [6].

## 3 Results and Discussion

The lithology in the studied area, generally consist of siltstone interbedded sandstone. The siltstone is grey and contents of carbonates material. the sandstones that found several times interbed, has a wide range thickness of thickness, from 5 cm up to 2 m, which is actually thickening upwards the rock formation. Hence, the coarsening upward stacking pattern is determined from this formation. A specific sedimentary structure is identified within the sandstones, which most likely is the Tc section of Bouma sequence, where convolute at lower part and ripple at the upper part (Fig. 3), and at the uppermost of the sandstone layer is lamination (Td section). This structure is evidence of turbiditic mechanism involved in the sedimentation process that usually happened at a slope land morphology. Where the presence of benthic foraminifera (Fig. 4) in the sand is a strong prove of marine depositional setting. The zonation of bathymetry (Table 2) also suggests that this lithofacies is deposited in a middle neritic zone. The described characteristic of this lithology has become the justification to interpret that siltstone interbedded sandstone from research area is equivalent to Kerek Formation (referring to the regional geology from [7;8]).

Overall, the samples are predominantly composed of lithic, ranging from 72.73% (BM-16, Fig. 2.a) up to 88.05% (BM-06, Fig. 2.b). Besides the quartz-feldspar-lithic (QFL) constituent, presence of matrix is significant in the samples as well, ranging from 25% to 50%, thus, classified as lithic greywacke. As for heavy minerals, there are four minerals identified from samples, which are biotite (as the dominant constituent; up to 72.26%), hornblende, pyroxene, and hematite. The distribution of light minerals is provided in Table 1, where the heavy minerals distribution is shown in Table 2.



**Fig. 3.** Thin sections (a) BM-16 and (b) BM-06 shows the dominance of lithic component in the sandstones. L: lithic, Qz and Qm: quartz, F: feldspar

**Table 1.** Light minerals distribution of sandstone in Wonosegoro

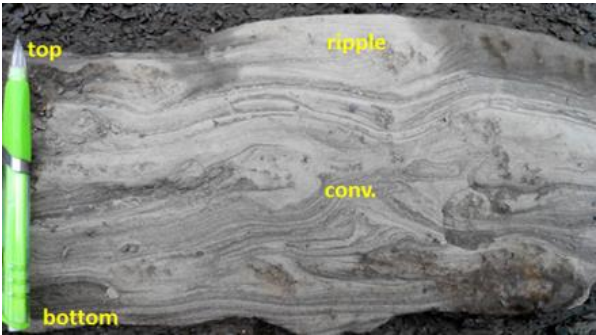
Sample	Mineral (grain)			Total grain	Mineral distribution (%)			Class [9]
	Lithic	Quartz	Feldspar		Lithic	Quartz	Feldspar	
BM-03	272	49	14	335	81.19	14.63	4.18	lithic greywacke
BM-16	256	53	43	352	72.73	15.06	12.22	lithic greywacke
BM-15	281	44	22	347	80.98	12.68	6.34	lithic greywacke
BM-04	277	40	29	346	80.06	11.56	8.38	lithic greywacke
BM-12	313	28	16	357	87.68	7.84	4.48	lithic greywacke
BM-06	302	33	8	343	88.05	9.62	2.33	lithic greywacke
BM-07	287	52	47	386	74.35	13.47	12.18	lithic greywacke

**Table 2.** Heavy minerals distribution of sandstone in Wonosegoro

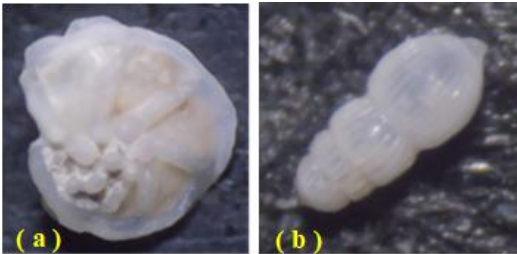
Mineral	Heavy mineral distribution (%)				
	BM-01	BM-07	BM-04	BM-03	BM-15
Biotit	72.26	75.53	67.30	66.33	71.38
Hornblende	19.51	18.13	19.68	22.00	18.65
Pyroxene	2.13	2.42	4.76	4.33	4.50
Hematite	6.10	3.93	8.25	7.33	5.47

**Table 3.** Bathymetry zonation of sandstone in research area

Species	Tidal Zone	Neritic Zone			Bathyal Zone			Abyssal Zone
		Inner	Middle	Outer	Upper	Middle	Lower	
<i>Cibicides sp.</i>								
<i>Textularia sp.</i>								
<i>Buliminella sp.</i>								
<i>Uvigerina sp.</i>								
<i>Eggerella sp.</i>								
<i>Nonionella sp.</i>								



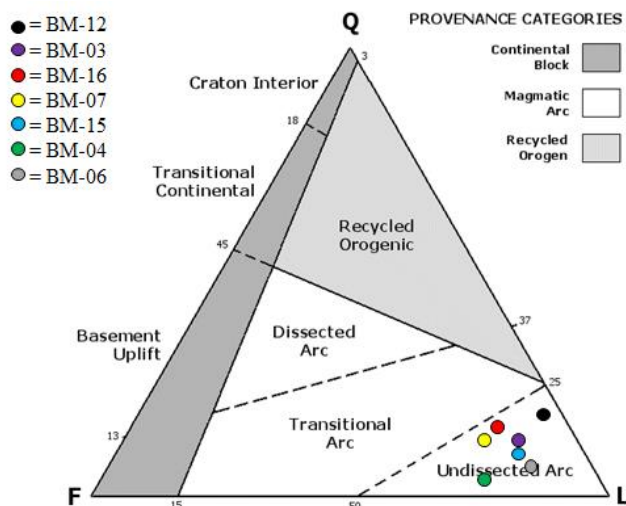
**Fig. 3.** Outcrop sample of sandstone in studied area that shows typical structure from Bouma sequence



**Fig. 4.** Some of the benthic foraminifera found from sandstone samples that are used to interpret the bathymetry.

The QFL distribution is projected in the QFL ternary diagram (Fig. 5) suggested that provenance of sandstone in research area is from magmatic arc, specifically the undissected arc part. The association of heavy minerals found in the sandstone is a typical of intermediate or andesitic magma type [10] that formed the provenance.

Magmatic arc province is consisting of volcanic highs on active island arcs along the continental margin, and some parts have not form volcanic plugs are known as the undissected arc [5]. Regarding to the regional geology and previous study [7,8], the magmatic arc mentioned from the ternary diagram most likely be referred to the Oligo-Miocene southern Java mountain range that does not developed volcanic plug.



**Fig. 5.** The projection of sandstone constituent from the field in QFL ternary diagram, which suggests that all samples has provenance from undissected arc

## 4 Conclusion

Sandstone of Serang River, Wonorego, which represent the Kerek Formation from the western Kendeng Zone, is classified as lithic greywacke. The combination of QFL in the sandstone shows suggests provenance from magmatic arcs, specifically the undissected arc, where the magma composition is andesitic (intermediate). Thus, this provenance is a product of Oligo-Miocene Volcanic in the southern Java mountain range.

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