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RESEARCH ARTICLE

Continental Sediments of Cinambo Formation in the Bogor Trough West Java, Indonesia

Abdurrokhim *, Iyan Haryanto

Department of Geoscience, Faculty of Geological Engineering, Universitas Padjadjaran, Indonesia.

* Corresponding author : abdurrokhim@unpad.ac.id
Tel.:+62-822-6103-1000
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Abstract

Volcanoclastic sediments commonly represent low quality reservoir facies, since volcaniclastics are composed largely of reactive and unstable minerals that leads to the destruction of porosity by cementation and compaction processes. During the Neogene time, although the Bogor Trough largely infilled by volcaniclastic deep-water deposits, the arenites that delivered from continental in the north actually still contributed as sequel Paleogene deposits.

This manuscript intends to discusses the Neogene provenance of continental sediments into the Bogor Trough. The samples are taken from sandstone beds of the Cinambo Formation at Cilutung River in Majalengka. Quartz-rich sandstones are better potential reservoirs in term of quality in hydrocarbon exploration of sub-volcanic region in this area.

Keywords: Volcanoclastic, Bogor Trough, Hydrocarbon exploration,

1. Introduction

The most characteristic of Neogene sedimentary rocks in the Bogor Trough is turbidity volcanoclastic deposits, with the oldest exposed unit in Majalengka area is the Cinambo Formation. The formation developed during Middle Miocene, and consists mudstones dominated facies with locally interbedded with sandstones, calcareous sandstones, limestone and tuff (Djuri, 1995; Isnaniawardhani et al., 2020; Martodjojo, 2003). Bogor Trough, Neogene E-W elongate deep in center part of West Java, was distributed from Bogor City in the west through Kuningan City in the east, that then called with Serayu Basin in Central Java (Martodjojo, 2003; Sujanto & Sumantri, 1977).

Martodjojo (2003) and Sujanto & Sumantri (1977) explained that Bogor the Trough was established at early Neogene and infilled largely by volcanoclastic sediments in deep-water settings. The sediments mostly were delivered from the south that known as Southern Mountains. Little information described that the trough received mixing source of volcanoclastic from the south and continental materials from the north, as sequel deposits of Paleogene sediments (cf. Abdurrokhim & Ito, 2013; Clements & Hall, 2011).

This manuscripts reports the sediment characteristic of continental source into the Bogor Trough during Neogene time, taken from samples of Cinambo Formation sandstone beds at Cilutung River in Majalengka. Continental source sediments is crucial for reservoirs potential of subvolcanic hydrocarbon exploration in this area.

2. Geologic setting

Cinambo Formation is representing Middle Miocene sediments infills into the Bogor Trough in Majalengka area. It is the oldest exposure of sedimentary rocks in this area. Bogor Trough in West Java was spaced to Serayu and Kendeng deeps in Central and East Java (Satyana & Armandita, 2004). The trough is seated in the southern margin of Sundaland (Fig. 1A), developed in response of frontal subduction between Eurasian Plate in the north and Indian Plate in the south, that created the subduction along Java Trench (Hall, 2011; Hall & Morley, 2004; Metcalfe, 2017). Bogor Trough, the Neogene deep in front of subduction, was basically a foreland deep due to trust loading of up-tilted Southern Mountains (cf. Martodjojo, 2003), infilled largely by volcanoclastic materials.

The Bogor Trough in West Java, an area of where largely consist of volcanoclastic deep-water are bounded respectively in the north by shallow marine and carbonate deposits of NW Java Basin, in the west by paralic and shallow marine deposits of Banten Block and in the south by proximal volcanoclastic and carbonate deposits of Southern Mountains. , shallow marine deposits of Northwest Java Basinal area, and shallow marine to paralic deposits of Banten Block to the south, north, and west, respectively. Quaternary deposits of alluvial and volcanic are also elsewhere covered those deep-water deposits. (Fig. 1B).

Cinambo Formation in the study area (Fig. 2) consists sandstones, mudstones and conglomerates, characterized by mudstone dominated facies in the lower part then that changes gradually into sandstones dominated facies in the upper most part. The formation was developed in the deep-water setting during Middle Miocene (Isnaniawardhani et al., 2020).

Cinambo Formation is overlaid by Late Miocene Halang Formation conformably, which is divided into breccia member in the lower part and sandstones member in the upper part. Locally, the upper part of Halang Formation changes into mudstone dominated facies of Subang Formation. Age of Halang Formation is Late Miocene, and developed in the deep-water settings (Isnaniawardhani et al., 2020).

Stratigraphic units of the Bogor Tough are generally typified by transgressive Paleogene deposits of fluvial to shallow marine, and regressive Neogene deposits of deep-water to fluvial deposits. Paleogene deposits are predominately continental source sediments, while Neogene deposits are dominated by volcanoclastic sediments.

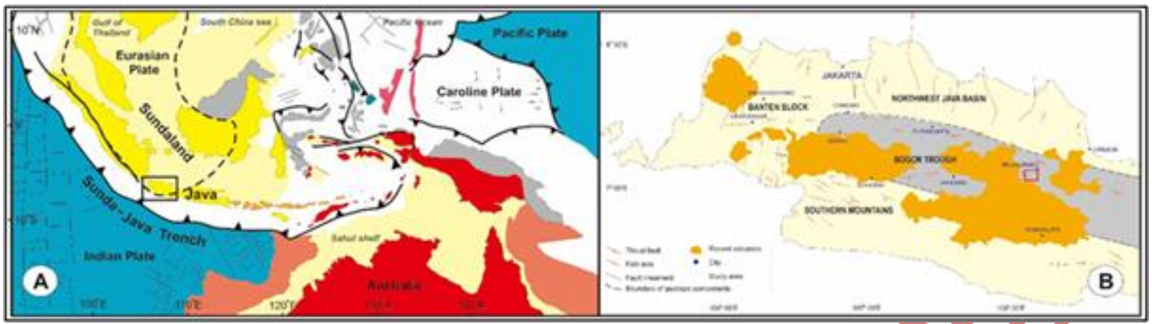

Fig. 1 (A) Tectonic frameworks of Indonesian region, represents the Sunda–Java Trench where the Australian plate subducts beneath Eurasian continent to the north. The Sundaland seated on the southern margin of this Eurasian continent (Hall, 1996). (B) Tectonic elements of West Java, E-W elongate of Bogor Trough in the center part through the east. Red rectangular indicated the study area in the center part of Bogor Trough. Modified mainly after Martodjojo (2003) and Satyana & Armandita (2004)

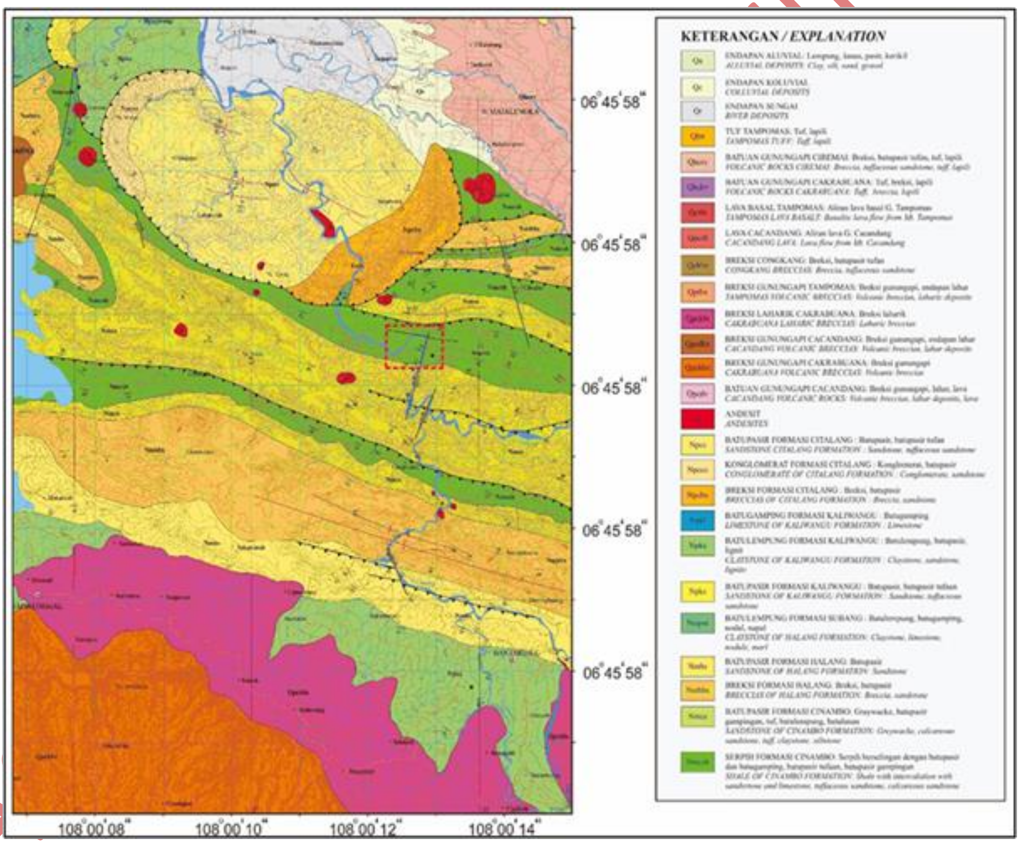

Fig. 2. Geological map of Majalengka Area (Isnaniawardhani et al., 2020), shows relatively E-W Neogene deposits distribution, following folds and trust system in this region. Rectangular red dot is the study area, part of the oldest stratification of Cinambo Formation.

3. Data and method

In the study area, Cinambo Formation was exposed in the wall and floor of Cilutung River and tributaries. It is is typified by mudstones and sandstone. Mudstones are claystone, siltstone and locally thin to very thin-bedded of fine- to very fine-grained sandstones. Interbedded locally with with thick- to very thick-bedded sandstones, gravelly mudstones and slump (Fig. 3). Petrographic samples are taken from fine- to coarse-grained turbidite sandstones, typified by graded-bedding, parallel and cross rippled-lamination beds (Fig. 4).

Sandstone samples are blue dye impregnated during thin section preparation for porosity identification. Polarizing petrographic microscope is using for mineral identification and frameworks composition, fabric orientations, cementation, and porosity development. Schematic flowchart of source rock research of Neogene sediments infill into the Bogor Trough is detailed in Fig. 5.

Fig. 3. Outcrop photograph of the Cinambo Formation that exposed at Cilutung River. The formation represents mudstones dominated facies, locally thin- to thick-bedded sandstones intercalations. Circled figure for scale.

Fig. 4. Turbidite sandstones reveal graded-bedding, parallel-lamination and cross-rippled-lamination sedimentary structures of classical turbidite with the sandstones grain-size are various from fine–medium.

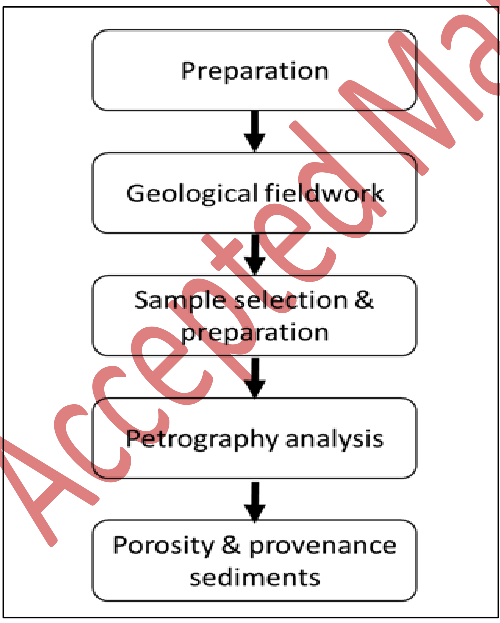

Fig. 5. Research flow chart of sediments characteristic of the Cinambo Formation

4. Results

Sandstones of Cinambo Formation are mostly poorly sorted, fine- to very coarse-grained, thin- to very thick-bedded with sharp basalt contacts and top. The sandstones are developed in response to turbidity currents. Petrographic thin sections showing that the sandstones are mostly having poor sortation, compound of more than 15% matrixes. Fine- to medium-grained of frameworks minerals with dis-organized micro-breccia features embedded within matrixes (Fig. 6). Only one sample is arenite (Fig. 7.).

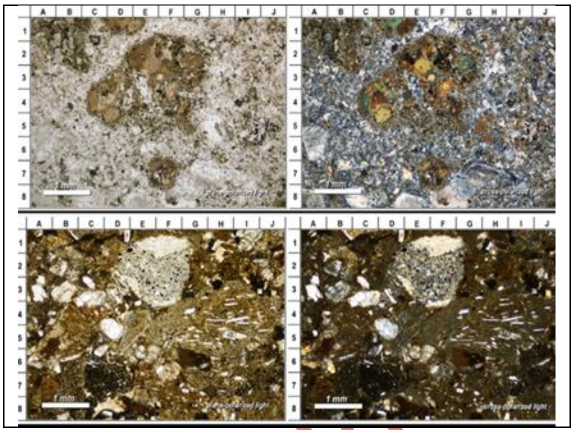

Fig. 6. Thin section photograph of sandstone samples representing lithic wacke, consists of volcanic rock fragments (E4, F7 for upper photograph, E2, I5 for lower photograph) and others mineral such plagioclase (H7 for upper photograph, D5 for lower photograph), and amphibole (H5 upper photograph). Matrix in between grains is mostly delivered from fine-grained volcanic materials

Lithic fragments are dominating the composition of framework as its commonly reported of Neogene sedimentary rocks in the Bogor Trough. It is majority consisting of volcanic materials. Fine-grained sedimentary rocks are locally also observed. Authigenic minerals, such as clay mineral, commonly found to substituted feldspar and rock fragments. Cements filled the pores in between the grains are clay and carbonate minerals (Fig. 7).

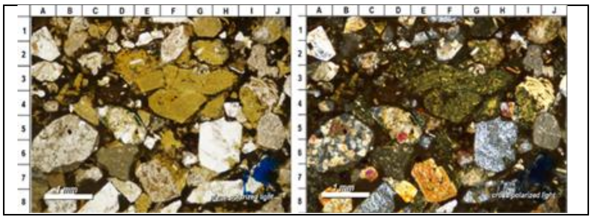

Fig. 7. Thin section photograph of lithic arenite representing monocrystalline quartz (A2, F2, H6), rock fragments (B6, F4, G2, J1) and feldspar (F7). Authigenic clay in between grains is argillaceous matrix of volcanic materials (D4)

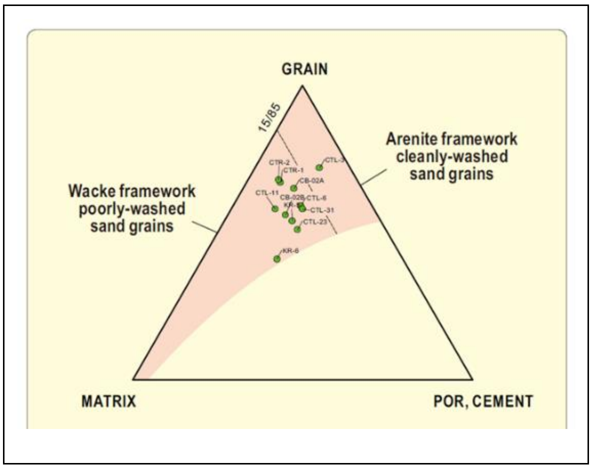

Fig. 8. Ternary diagram of grain, for framework compositional table calculation, matrix and cements

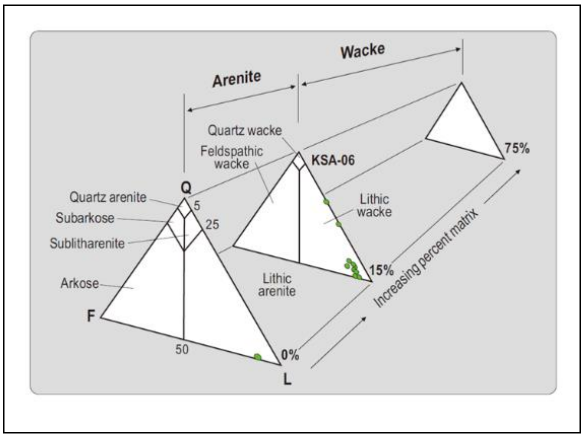

Fig. 9. Ternary diagram of Cinambo samples represent that the samples mostly contain muddy facies.

The domination of quartz-rich materials is only observed from two sandstone samples, CB-02A and CB-02B. The samples revealed undulating, segmenting extinction and lamellae deformation textures. Quartz minerals are more than 40% of framework composition, dominated by monocrystalline quartz that indicating of continental source provenance. Then the sandstones are called quartz wacke sandstones (Fig. 7). Rock fragments, consists of fine-grained sedimentary rocks and metamorphic rocks, are also observed in small quantity. Likewise, feldspar, chlorite, epidote and mica. Cement, filled the pore in between grain, are dominated by calcite another clay bond. (Fig. 7). Sandstone framework composition of Cinambo Formation samples are listed in table 1, while the ternary diagram is shown in Fig. 8.

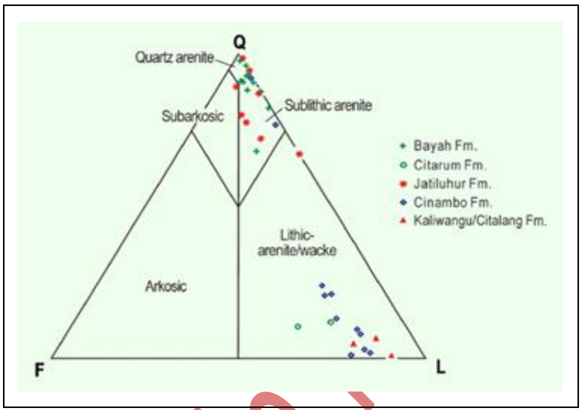

Fig. *10*. Ternary diagram of some stratigraphic units in the Bogor Trough. Bayah Formation is the only Paleogene, while others are Neogene deposits

Table. 1. Petrographic examination sheet

No	Sample ID	Qm %	Qp %	K-F %	P %	Ls %	Lm %	Lv %	Quartz total	Feldspar total	Lithic total	Matrix %	Cement %	Porosity %	Grain contact	Cement phase	Pore origin
1	KR-6	10	0	0	8	2	0	28	10	8	30	43	21	5	point, meniscus, long	chlorite, minor calcite	intraparticle dissolution, molds, shrinkage of matrix
2	KR-5	15	0	0	10	3	0	35	15	10	38	30	14	10	concavo-convex, suture	calcite, chlorite, sericite	intraparticle dissolution, molds
3	CB-02A	53	1	0	1	1	0	3	54	1	4	18	5	8	long, concavo-convex	calcite, chlorite, sericite	molds, fractured grains
4	CB-02B	40	0	0	1	9	0	2	40	1	11	26	10	5	point, meniscus, long	clay minerals, chlorite, calcite, sericite	intraparticle dissolution, molds, shrinkage of matrix
5	CTR-1	5	1	0	8	5	0	40	6	8	45	20	2	5	point, meniscus, long	clay minerals, chlorite, calcite, sericite	intraparticle dissolution, molds, shrinkage of matrix
6	CTR-2	8	0	0	13	5	0	40	8	13	45	23	3	5	long, concavo-convex	clay minerals, chlorite, calcite, sericite	intraparticle dissolution, molds, shrinkage of matrix
7	CTL-6	5	0	0	8	3	0	45	5	8	48	22	11	10	long, concavo-convex	clay minerals, chlorite, calcite, sericite	intraparticle dissolution, molds, shrinkage of matrix
8	CTL-23	12	0	0	8	6	0	30	12	8	36	29	20	5	long, concavo-convex	clay minerals, chlorite, calcite, sericite	intraparticle dissolution, molds, shrinkage of matrix
9	CTL-3	2	0	0	10	15	0	40	2	10	55	8	8	10	long, concavo-convex	clay minerals, chlorite, calcite, sericite	intraparticle dissolution, molds, shrinkage of matrix
10	CTL-31	1	0	0	8	5	0	42	1	8	47	20	11	10	long, concavo-convex	clay minerals, chlorite, calcite, sericite	intraparticle dissolution, molds, shrinkage of matrix
11	CTL-11	1	0	0	10	0	0	40	1	10	40	25	6	5	long, concavo-convex	clay minerals, chlorite, calcite, sericite	intraparticle dissolution, molds, shrinkage of matrix

5. Discussion

Bogor Trough developed at earliest Neogene, signed by volcanoclastic sediment infills into the trough from Southern Mountains. Both areas, Bogor Trough and Southern Mountains in West Java, are dominated by volcanoclastic turbidity deposits, where the proximal facies are commonly found in Southern Mountains area, while in the Bogor Trough are more distally facies.

Sandstone beds of volcanoclastic deposits in the Bogor Trough mostly contain muddy facies (Fig. 9), due to turbidity processes during depositional. The quality of volcanoclastic sandstones reservoir is primarily controlled by history of diagenetic. Because the composition of volcaniclastics are largely consisting of reactive and unstable minerals have high potential for extensive changes during burial diagenesis, especially leads to the destruction of porosity by cementation and compaction processes (Mathisen & McPherson, 1991).

Fortunately, the Bogor Trough was also infilled by quartz-rich sediments of continental source from the north, that delivered since Paleogene. This feature is observed from ternary diagram of some formation units in the trough (Fig. 9). Since the Bogor Trough was actually still infilled from continental source sediments from the North and volcanoclastic source from the South during Neogene, the reservoir potential of siliciclastic deposits better developed to the northern part. The existence of arenite sandstones in the Bogor Trough decreases during the Neogene, especially in the southern and center part of Bogor Trough, but not in the northern part (Fig.10).

6. Conclusion

Sediments source rock of Cinambo Formation could be grouped into: (1) volcanoclastic sediments, which was sourced from Southern Mountain, and (2) continental sediments, which was sourced from Sundaland. The dominance of quart-rich sediments from two samples of sandstones confirmed that continental sediments source from the north was not interrupted to continue delivering the materials to the Bogor Trough since Paleogene time.

The potential siliciclastic sandstone reservoirs of Neogene deposits are supposed to be developed better in the norther area of the Bogor Trough in the hydrocarbon potential exploration of subvolcanic in West Java.

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