Short Note : Mineral Composition of Eocene and Miocene Sandstones in Java Island

Herman Darman[1], Budi Muljana[2] and J. T. van Gorsel[3]
[1]*Shell International EP – Netherlands*
[2]*Geology Department, University of Padjadjaran – Indonesia*
[3]*Geoscience Research / Consultant*
Corresponding Author: herman.darman@shelll.com

INTRODUCTION

A number of studies discuss the mineral compositions of Cenozoic sandstones in Java Island, Some sandstones are dominated by quartz, derived from granitic and/or metamorphic basement terrains or reworked sediments; many others are dominated by lithics and plagioclase feldspars derived from andesitic volcanics. The distribution of these two end-members varies through space and time, and has not been systematically been document for all of Java.

In the first comprehensive study of the geology of Java, Verbeek and Fennema (1896) suggested that most of the Neogene sandstones on Java were erosional products of volcanic rocks, and that quartz-rich sandstones were either of Eocene age or were deposited in the proximity of Eocene rocks.

Rutten (1925), however, studied 110 Neogene sandstones across Java and demonstrated that many of the Miocene sandstones are also rich in quartz, particularly across the northern half Java Island and on Madura Island (Figure 1). These have common 'dusty quartz' and quartz with undulose extinction patterns (both indicative of metamorphic quartz), and were interpreted as clastic material derived from 'old rocks of Sunda-land'. He also observed that grain sizes of Neogene sands generally decrease in Southern direction and that andesitic material is not common before the Late Neogene (probably meaning Late Miocene and younger).

More recent work in West Java by Clements and Hall (2007) and Clements et al. (2012) largely confirmed the patterns established by Rutten (1925):

(1) Sandstones of Eocene and Oligocene age across all of West Java are virtually all quartz-rich, and can be tied to 'Sundaland' Pre-Tertiary granite and-metamorphic basement sources North of Java;

(2) Increase in volcanic detritus in Early Miocene and younger sandstones, particularly in South Java and the axial basins, where all sandstones of this age are typically sourced from the Late Oligocene – Early Miocene "Old Andesites" volcanic arc of the Southern mountains and the Late Miocene- Recent modern arc across the axial zone of Java.

Smyth et al. (2008) provided additional detail on sandstone composition from East and Central Java. They essentially confirm the same patterns as in West Java, but found that some of the Lower-Middle Miocene sediments in the Southern Mountains are quartz-rich, but are composed of volcanic quartz (monocrystalline, clear, often bipyramidal) and are sourced from local acid volcanic rocks.

The purpose of this short note is to contribute to the subject of Java sandstone provenance by summarizing quantitative analyses on sandstone compositions in the recent studies by Muljana & Watanabe (2012), Darman (1991), Siemers et al (1992) and Smyth et al (2008) and provide some additional data points as QFL (Quartz- Feldspar-Lithics) ternary plots.

SANDSTONE GROUPS BASED ON MINERAL COMPOSITIONS

There are two groups of sandstones based on their composition: a) Non-quartz dominated sandstones and b) Quartz dominated sandstones.

Non-quartz dominated sandstones are found in West and Central Java (G & F, Figure 1). Muljana & Watanabe (2012) studied the Miocene Cinambo and Halang formation in Majalengka area, West Java. The quartz composition decreases from the lower to middle Miocene followed by increasing of rock fragment (Figures 2A and 2B). The rock fragment composition was dominated by andesite fragments. These sandstones were deposited when the magmatic and tectonic influences are particularly dominant. The upper Miocene Halang Formation is distinguished by the volcanic content.

Darman (1991, Figure 2C) studied the upper Miocene Halang Formation in the north of Central Java and here the sandstones have a lower quartz content. The majority of the rock fragments are volcanics and are rich in plagioclase minerals. Similar to the Majalengka area, the Halang Formation is a turbidite deposit.

Based on the Dickinson classification diagram (1985, Figure 2D) some of the Lower Miocene sandstone were derived from a recycled orogeny terrain. The upper Miocene Halang Formation sandstones in both Majalengka and Brebes came from a range of sources such as dissected to undissected arc in the south to southeast of the

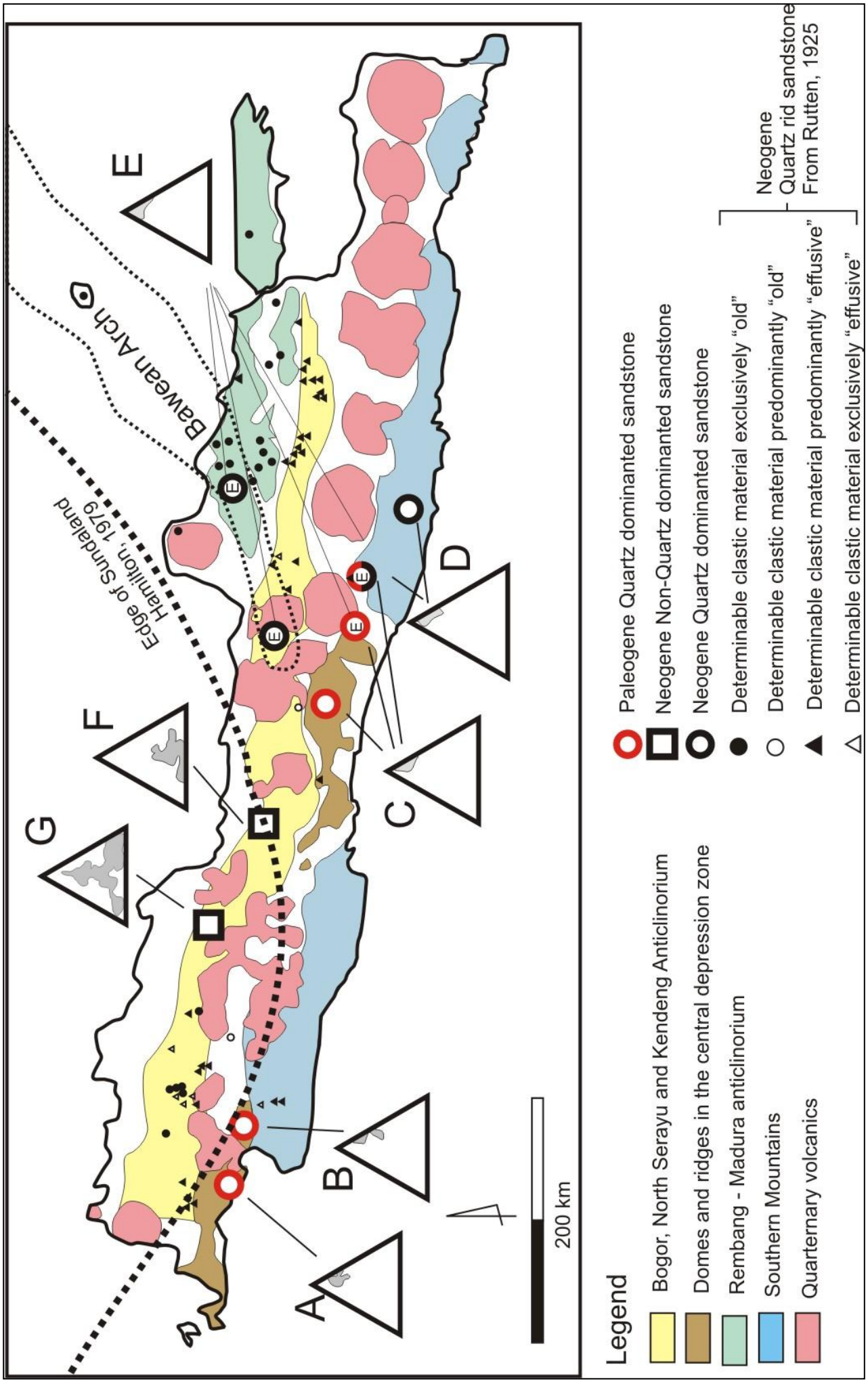


***Figure 1**. Modified physiography map of Java after van Bemmelen (1949), which include locations of sandstone samples with point counting analysis and the. distribution of quartz-rich ("old"; mainly in North) versus volcanics-rich ("effusive"; Southern Mountains and Bogor- Kendeng Troughs) sandstones across Java (Rutten, 1925).*

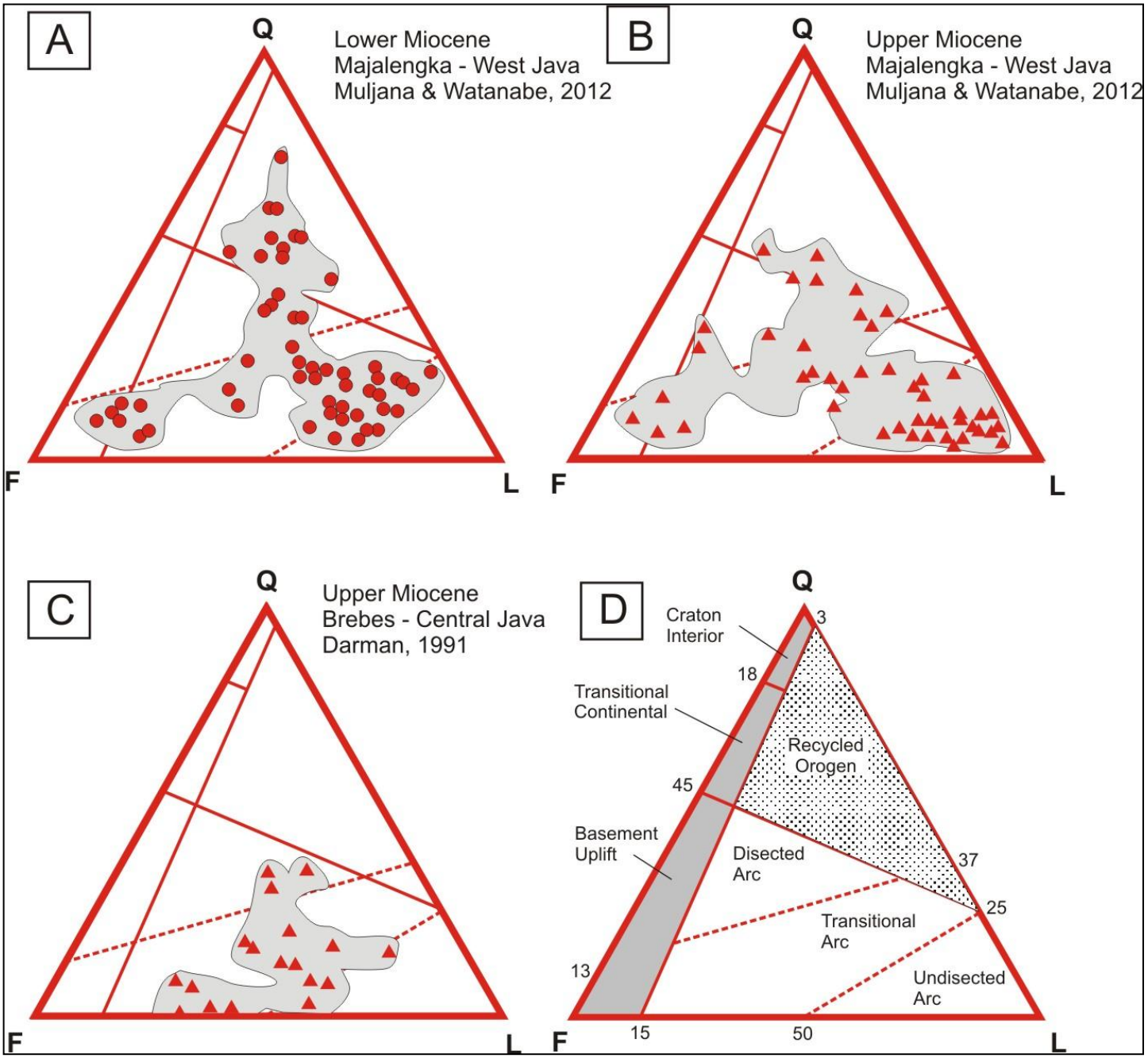


Figure 2. *Quartz, Feldspar and Lithics ternary plot of sandstones from the Halang Formation. A and B are from Majalengka, West Java and C is from Central Java. D is the provenance categories of sandstone based on Dickinson (1985).*

area.

The sandstones compositions of the Bayah Formation (A, Figure 1) and the Walat Formation (B, Figure 1) of SW Java are dominated by quartz (Figure 3). These formations were deposited during Eocene time (Siemers et al, 1992). The outcrop analysis indicated a mix of fluvial and shallow marine sandstones. In Central and East Java, Smyth et al (2008) also found a number of quartz-rich sandstones. The provenance of these sandstones are interpreted as recycled orogen terrain in the north to northeast of the outcrops.

In the southern part of Central Java, Smyth et al (2008) found metamorphic quartz rich sandstone (Figure 4A), deposited in a terrestrial environment during pre-Middle Eocene time, classified as Type 1, in 3 locations (C in Figure 1). These are pre-middle Eocene sandstones and described as metamorphic quartz-rich sedimentary rocks, deposited in terrestrial environment

In the Southern mountains Miocene volcanic quartz-rich sandstones were found in outcrops. Smyth et al (2008) classified these sandstones as Type 2 (Figure 4B), which are located in close proximity to the acid volcanic centers of the Eocene to Lower Miocene Southern mountain arc (Location D, Figure 1). The presence of lignite, channel structures and abundant rootlets, and the lack of marine fauna indicate a terrestrial depositional setting (Smyth et al, 2008).

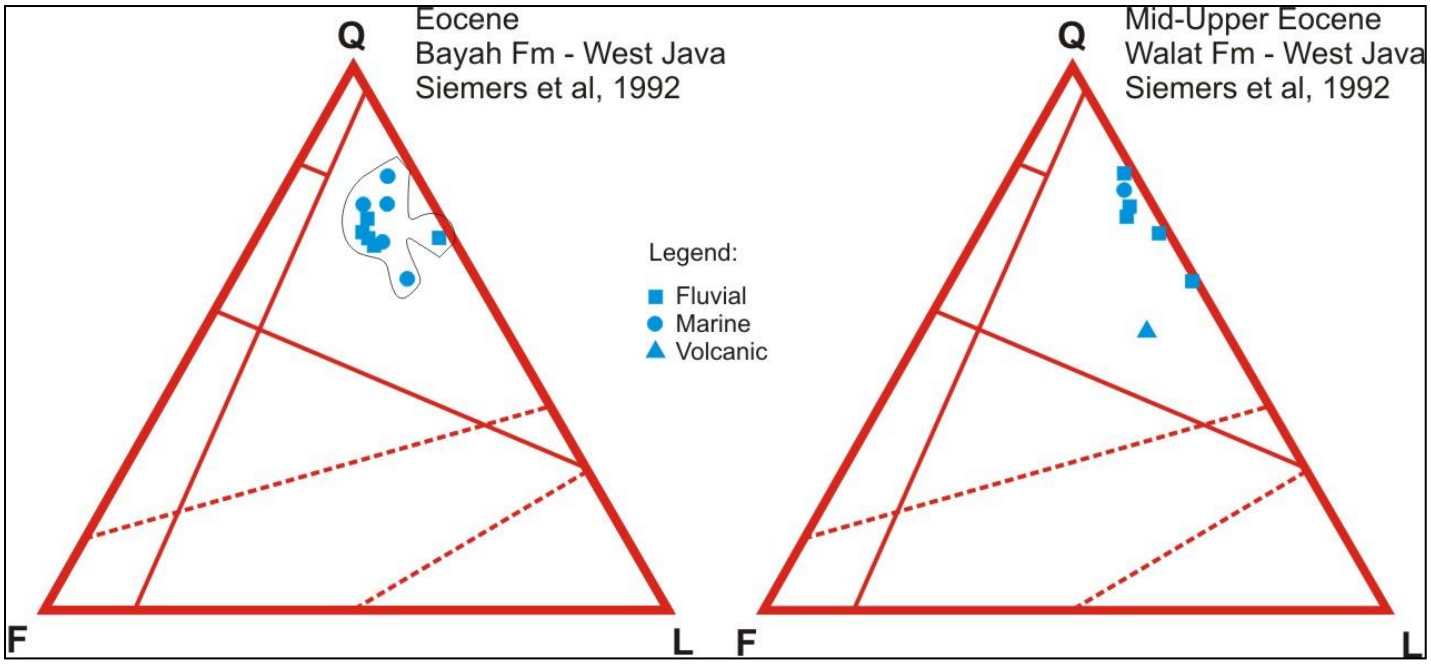


Figure 3. *Quartz dominated sandstones of Bayah and Walat Formation, Southwest Java (Siemers et al, 1992).*

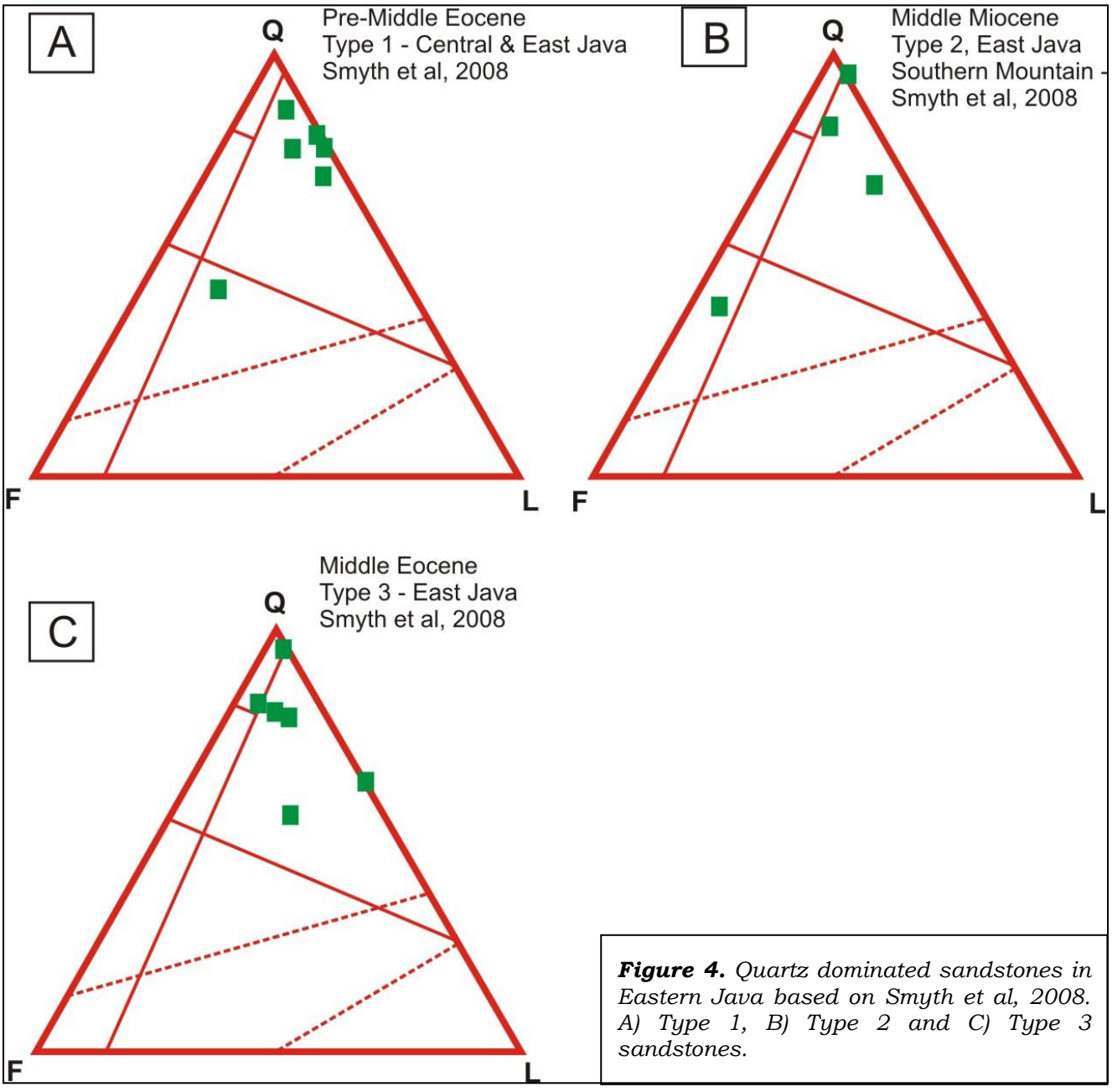


Figure 4. *Quartz dominated sandstones in Eastern Java based on Smyth et al, 2008. A) Type 1, B) Type 2 and C) Type 3 sandstones.*

Mixed provenances of the Middle Eocene to Miocene sandstone (E, in Figure 1) are common in the eastern part of Java. Smyth et al (2008) call these sandstones as Type 3 (Figure 4C). In the Southern mountain area these Type 3 sandstones are Middle Eocene in age, and part of the Nanggulan Formation. Smyth also found quartz-rich sandstone in a small outcrop in the Kendeng Basin, north of Central Java. Although it was found in Miocene Lutut Beds, it has been deposited on the southern margin of the basin and have subsequently been deformed and moved northwards to their present-day position by thrusting (Smyth et al, 2008). Additional Type 3 sandstones are found in Northeast Java, in the Middle Miocene Ngrayong Formation.

These 3 groups of sandstones described by Smyth et al (2008), mainly fall in the "Recycled Orogen" category in the QFL diagram of the Dickinson (1985) classification. Some of the Type 3 sandstones plot in the "Craton Interior" category of provenance. However, the quartz-rich Type 2 sands are clearly of volcanic origin, demonstrating to not rely exclusively on these ternary plots for sandstone provenance interpretation (a point already stressed by Smyth et al. 2003, 2008).

CONCLUSION

Quartz rich sandstones are common in the Eocene interval across Java, in the Miocene of the northern part of Java Island. Feldspar and volcanic rock fragments are more dominant in most other Miocene sandstones.

Sandstones from the Late Miocene Halang Formation in northwest Java are dominated by feldspar and rock fragments. The observation in Majalengka shows the reduction of quartz from the lower to upper Miocene interval.

ACKNOWLEDGEMENT

The authors would like to thank those who contributed to the discussion through personal e-mail or FOSI LinkedIn network: Ma'ruf Mukti, Fadhel Irza, Arif Rahutama and Iqbal Fardiansyah.

REFERENCES

Clements, B., and Hall, R., 2007, Cretaceous to Late Miocene stratigraphic and tectonic evolution of West Java: Proc. 31st Ann. Conv. Indon. Petrol. Assoc. IPA07-G-037, 87-104.

Clements, B., Sevastjanova ,I., Hall, R., Belousova, E.A., Griffin, W.L., and N. Pearson, N., 2012, Detrital zircon U-Pb age and Hf-isotope perspective on sediment provenance and tectonic models in SE Asia. In: E.T. Rasbury et al. (eds.) Mineralogical and geochemical approaches to provenance: Geol. Soc. America Spec. Paper 487, 37-61.

Darman, H., 1991, Geologi dan Stratigrafi Serta Studi Mineralogi Formasi Halang, Daerah Bantarkawung dan Sekitarnya, Kabupaten Brebes, - Jawa Tengah, BSc Thesis.

Dickinson, W. R., 1985, Interpreting Provenance Relations from Detrital Modes of Sandstones, G. G. Zuffa (ed.) Provenance of Arenites *NATO ASI Series*, C 148: D. Reidel Publishing Company, Dordrecht, 333–363.

Muljana, B., and Watanabe, K., 2012, Modal and Sandstone Composition of the Representative Turbidite, from the Majalengka Sub-Basin, West Java: Indonesia Journal of Geography and Geology Vol. 4, No. 1, 3-17.

Rutten, L., 1925, On the Origin of the Material of the Neogene Rocks in Java: Koninklijke Akademie van Wetenschappen te Amsterdam, Proceedings Vol. XXIX, 1, 15-33.

Siemers, C. T., Kleinhans, L. C., and Young, R., 1992, SW Java Field Trip / Core Workshop: Indonesian Petroleum Association Post Convention Field Trip guide book.

Smyth, H., Hall, R., Hamilton, J., and Kinny, P., 2003, Volcanic origin of quartz-rich sediments in East Java: Proc. 29th Ann. Conv. Indon. Petrol. Assoc. 1, p. 541-559.

Smyth, H., Hall, R., and Nichols, G. J., 2008, Significant Volcanic Contribution to Some Quartz-Rich Sandstone, East Java: Journal of Sedimentary Research, v. 78, 335–356.Van Bemmelen, R. W., 1949. The Geology of Indonesia, Vol. 1A, Martinus Nijhof, The Hague

Verbeek, R.D.M., and Fennema, R., 1896, Geologische beschrijving van Java en Madoera: J.G. Stemler, Amsterdam, 2 vols + Atlas, 1135 p.