Petrographic Analysis of Rocks in Tanah Puteh and Pulai, Gua Musang, Kelantan.

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Abstract. Gua Musang, Kelantan is well known with diversity of rock associations and also rich in mineral resources such as gold and feldspar according to the existence of active mining sites in this area. The diversity of rock associations in Pulai and Tanah Puteh, Gua Musang have been identified and sampled for this study. The objectives are to determine the mineral association and its composition in various rock types as well as its distribution within these areas. Rock and soil samples have been collected for further analyses using petrography and geochemical analysis respectively. Limestone, tuff, shale, chert, phyllite are amongst of the rock types that have been sampled in this study area. The properties of mineral association in the thin section samples (from the rock samples) have been observed in details using optical microscope. Meanwhile, the results of x-ray fluorescence (XRF) analysis for selected samples have shown that the SiO_2 were ranging between 66 to almost 80 wt.%, and Al_2O_3 varied from 17 to nearly 26 wt.%. The correlation of the mineral composition from chemical analysis are found in accordance with the mineral existence based on the petrographic studies on selected thin sections from Pulai and Tanah Puteh.

1 Introduction

Gua Musang which located in the southern Kelantan is the largest district in the state of Kelantan. It quite well known with diversity of rock associations and also rich in mineral resources such as gold and feldspar according to the existence of active mining sites in this area. Most of the gold mines here are from placer deposit type and contributed 10% of the annual gold production in Malaysia [1]. Katok Batu Mine is one of the examples for gold mineralization that occur along shear zone of intrusive body (Senting Granite) and Permian metasedimentary rocks [1, 2]. Aside from metallic minerals, this area also rich with industrial minerals such as feldspar and clay based on the existence of a quarry in Tanah Puteh, Pulai, Gua Musang. Thus, it is important to study the petrography of rock assemblages within this area in order to recognize the occurrences of mineral deposit. The characteristics of mineral association need further understanding for future exploration purposes. Geochemical analysis was also carried out to determine the chemical characteristics together with petrography studies. X-Ray Fluorescence (XRF) was applied to determine major element and validating

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the mineral's existence. In addition, Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS) analysis and optical microscopic analysis were used to determine the relationship between mineral association and its composition.

1.1 Geological setting

Kelantan is located within the Central Belt of Peninsular Malaysia, bordered on the west of sediment and meta-sediment while on the east consists of granite from the Main Range. Main Range Granite is dominated on the western part of Gua Musang stretching along western of the state boundary of Perak and Pahang while Boundary Range is distributed on the east part of Gua Musang. Gua Musang Formation consists of argillaceous and calcareous rock interbedded with volcanic along with minor arenaceous rocks. The argillaceous of Gua Musang Formation dominantly consists of shale, siltstone, mudstone, slate and phyllite. Carbonate facies can be found as extensive facies in Gua Musang Formation [3].

Sedimentary and metasedimentary rocks found in the centre of Kelantan, is bordered by the Main Range granite on the west and the Boundary Range granite on the east. Ulu Lalat (Senting) batholith, Stong Igneous Complex and Kemahang pluton are the windows of the granitic intrusives within the central zone that have a north-south trend and the continuation up to north Pahang. Boundary Range granite in the east is overlain by the coastal alluvial flat of Sungai Kelantan [4,5,6]. Lower Paleozoic is the oldest rock that outcropping as a northerly-trending belt bordering the foothills of the Main Range and extending eastward up to Sungai Nenggiri. The rocks are mainly metapelites with minor volcanic fragments and slight arenaceous and calcareous intercalations. In the eastern side, Permian volcanic-sedimentary rocks occur extensively and overlying the Lower Paleozoic sequence in southwest Kelantan while the Taku Schist (pre-Triassic), dominates the central north Kelantan [6,7].

Some of the hydrothermal veins are controlled by the structure caused by granite intrusion. Around the intrusive bodies, low temperature contact metamorphism is formed in the shear zones. The quartz veins with low in sulphides, percolate through these sheared zones and cross-cut the volcanic sedimentary rocks [8] and granitoids [1]. The fractures, cracks and bedding of the sedimentary rocks have been infilled with the quartz veins. The hydrothermal solutions travel upwards along the granitoid shear zones to the surface. The hydrothermal veins possibly originate from deeper levels. The intrusive rocks also show sign of gold mineralization especially in the shear zones. This characteristic also can be observed at Katok Batu and Panggong Besar mine in Gua Musang, Kelantan. Generally, the gold mineralization is concentrated in the Triassic and Permian metasedimentary rocks together with volcanic rocks [2].

2 Methodology

2.1 Sampling

Sampling was conducted around selected area in Pulai and Tanah Puteh, Gua Musang, Kelantan (Figure 1 and 2). Geological map from Mineral and Geoscience Department Malaysia (JMG) was used to aid in the selection of the sampling area. Rocks and soils are targeted for sampling. Approximately 500g-1000g of soils are collected together with rock sample and the sampling locations are shown in yellow point as marked in Figure 2.

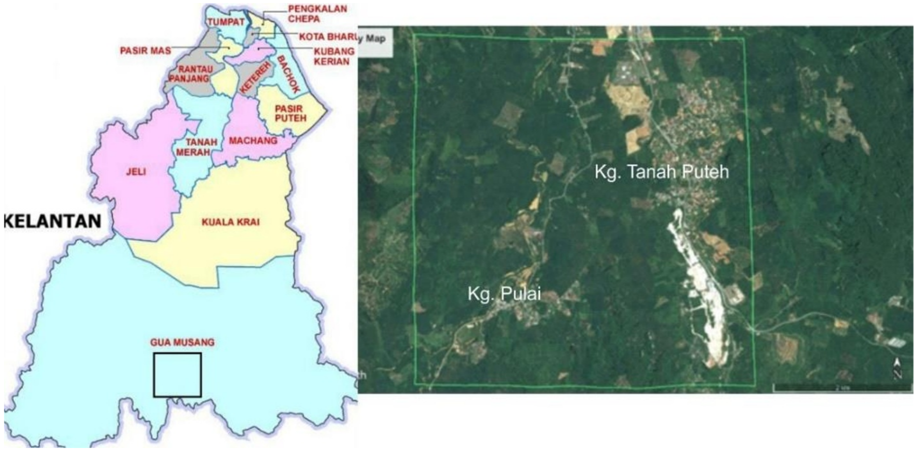

Fig. 1. (*Left*) Map of Kelantan, small box inside represents study area in Gua Musang. (*Right*) Box of study area in Kg. Tanah Puteh and Kg. Pulai from Google Maps.

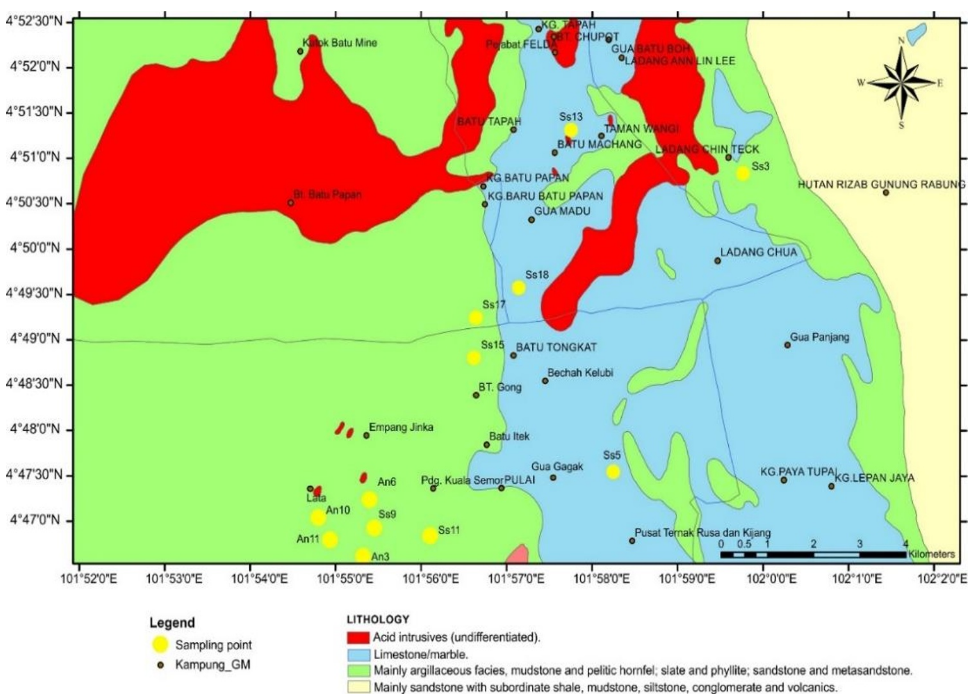

Fig. 2. Geological map of study area in Gua Musang.

2.2 Petrographic analysis

Six hand specimens represent the rock types were selected within the study area and sent to Universiti Kebangsaan Malaysia (UKM) laboratory for thin section preparation in order to proceed for mineralogical and petrography purposes. The optical polarised microscope was used to investigate the mineral presence and distribution in the samples.

2.3 Chemical snalysis

X-Ray Fluorescence (XRF) was used to determine the major elements composition and mineral identification within 5 selected samples respectively. The selected samples were sent for analysis at Physic Laboratory in Universiti Sains Malaysia (USM) Penang. The variation of element composition for each sample and its correlation to the petrographic analyses can be further understand.

3 Result and discussion

3.1 Field observation and sample description

Based on fieldwork observation, limestone body is distributed on the North-East of Gua Musang area and majorly found as karst or hill (Figure 3a). Karst limestone consists of calcium carbonate ($CaCO_3$) and found abundance as the isolated steep hills limestone. The structure sometimes is difficult to be seen as it is covered by vegetation. The alluvial or red soil are found covering the surface in most location. However, several limestone boulders are found scattering within the alluvial or top soil (Figure 3b). This formation obviously can be seen when there have soil excavation or road construction especially along the main road/highway in this area.

Tuff also exists in Pulai (Figure 3c) with fine-grained size and white in colour. The tuff consists minerals of quartz, feldspar, calcite and a small amount of sericite and chlorite. The tuff potentially formed from chemical deposition of calcite or calcium carbonate. Feldspar and clay minerals are quite abundant and potentially resulted from the weathering of rock associations around karst (Figure 3d). Feldspar and kaolinite can be found mainly distributed along the main road near to Kampung Tanah Puteh. In addition, this location also has an active feldspar quarry and can be observed clearly as the white areas in google earth map (see Figure 1).

Meanwhile, meta-sediment presents in the study area as phyllite, shale and slate. Meta-sediment is the oldest rock in the sequence age in early Triassic. Phyllite found in the study area has dark gray colour and fine-grained size (Figure 3e). Phyllite outcrop is easily break off in a blocky shape. As for the slate, it has fine-grained size with whitish colour. However, slate in some area has been weathered but still show it distinct cleavage. Shale was found in weathered condition with blackish colour. Weathered mudstone with clay association (Figure 3f) can easily break into powder and fine particles.

Small sized of iron nodules can be found associated together in some alluvial areas. In deeper alluvial or topsoil, boulders of limestones are found scattered (Figure 3g). Limestone consists of fine-grained size and vary in colour ranging from dark grey to white. Two types of limestone found in the study area are carbonaceous limestone which is dark grey in colour (Figure 3h) and white limestone (Figure 3i). The white limestone commonly originates from the chemical reaction where the calcium carbonate precipitate from the marine water and fresh water. As for the carbonaceous limestone, it forms from biological origin and the dark colour basically represents its composition resulted from the presence of magnesium and iron elements.

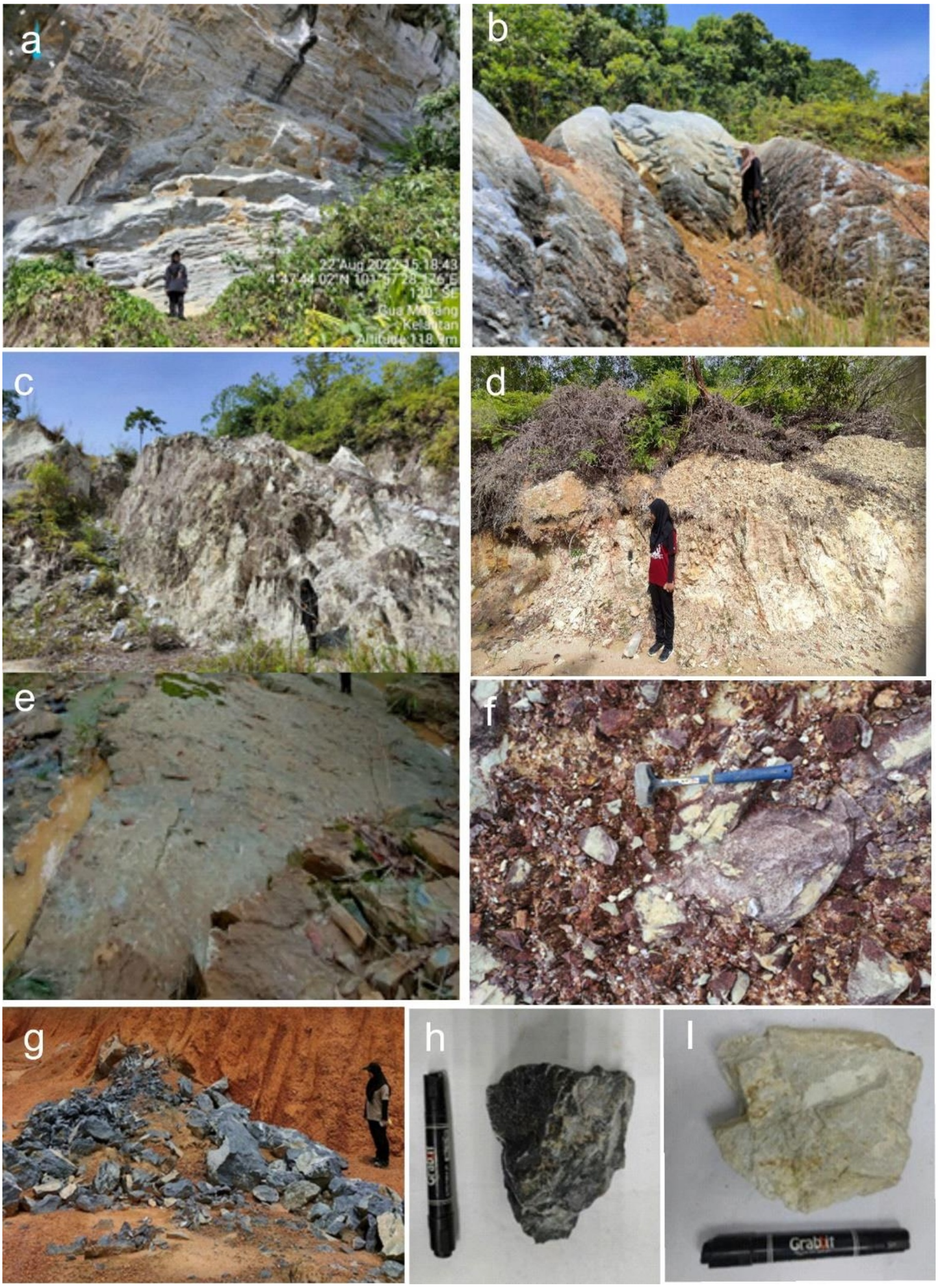

Fig. 3. Several rock associations that can be found within the study area in Pulai, Gua Musang, Kelantan. (a) Karst lithology is quite abundant typically consists of limestone (b) Limestone boulders in various size are scattered within the alluvial resulted from weathering (c) Tuff also overlay together within the assemblages. (d) Sandstone and feldspar are found together in certain area. (e) Outcrops of phyllite in the rubber plantation in Pulai (f) Red mudstone together with the slate are weathered and easily break into small pieces (g) Dark grey limestone is found scattered within the soils as boulders and outcrops (h) Hand specimen of carbonaceous limestone (blackish) (i) Hand specimen of white limestone, this limestone can be found close to the river and several places around the study area.

3.2 Petrography analysis

Six thin section samples from several rock types in study area have been observed under optical microscope for details study on mineral associations. Based on the petrography analysis, the main mineral associations are quartz and feldspar followed by clay minerals, mica, calcite and etc. Table 1 represents the petrographic analysis of selected thin section samples from several rock types and its mineral distribution under microscope observation. The percentage of composition is counted referring on the mineral presence in the thin section sample.

Table 1. Mineral percentage/composition based on petrographic analysis for selected samples from Pulai (AN) and Tanah Puteh (SS).

Samples	Mineral (%)						Remarks
	Quartz	Feldspar	Clay	Calcite	Mica	Opaque	
AN3	30	20	20	10	10	<5	Phyllite
AN6	20	30	20	10	5	<3	Mudstone/ sandstone
AN11	40	20	10	10	2	2	Rhyollite
SS5	40	30	15	10	3	1	Tuff
SS9	30	10	5	> 50	2	<2	White limestone
SS17	25	10	5	> 50	2	>5	Dark grey limestone

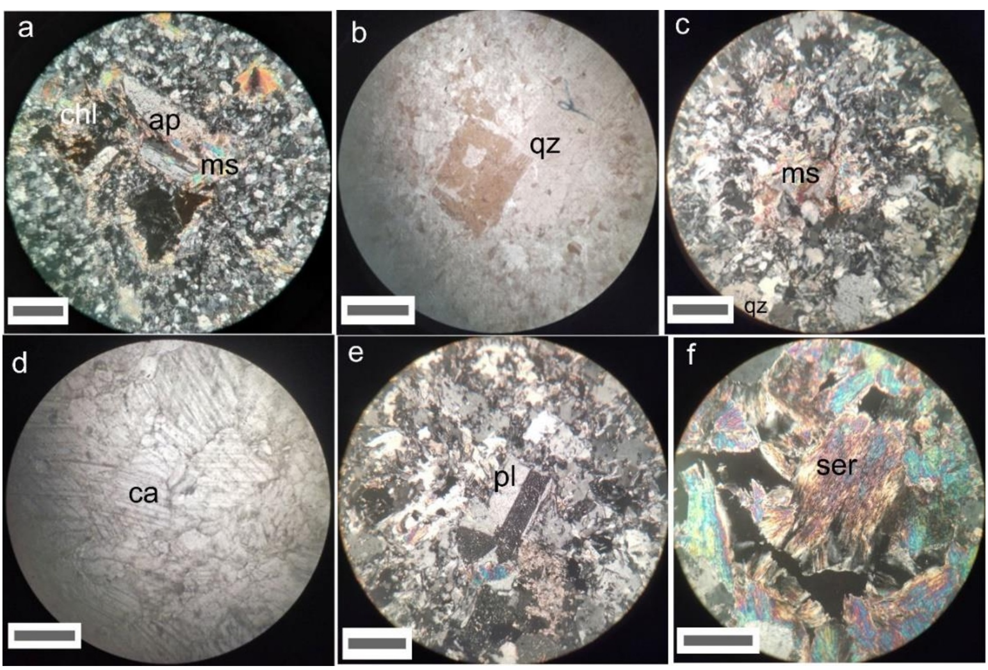

Fig. 4. Photomicrographs of selected rock samples from Tanah Puteh and Pulai, Gua Musang (a) apatite, muscovite and chlorite are found in quartz association under crossed polarized, XPL (b) quartz phenocryst in sample AN11 (rhyolite) (c) muscovite with flaky textures and tabular crystal (d) polysynthetic glide twins of calcite in sample SS9 (e) simple twin (Carlsbad twin) of feldspar can be seen in the middle of SS17 under XPL (f) sericite in crossed polarized (XPL) replacing the feldspar grain. (chl:chlorite, qz:quartz, bt:biotite ms:muscovite, ca:calcite, pl:plagioclase, ser:sericite). Scale bar = 0.2 mm.

Quartz basically colorless in PPL (plane polarized light) but show undulose extinction in XPL (crossed polarized light). In phyllite, quartz or silica occurs as microquartz and calcedonic quartz replacing grains cement and matrix. The mineral associations of biotite, muscovite and chlorite are found scattered within it (Figure 4a). Meanwhile, a phenocryst of quartz can be seen in groundmass of rhyolite (sample AN11, Figure 4b). Muscovite exhibits flaky textures with tabular crystal in tuff groundmass. (Figure 4c). It normally has cleavage in one direction.

Calcite and quartz are sometimes mixed and blended together in limestone. Polysynthetic twinning of calcite is quite common especially in sample SS9 (Figure 4d). Rhombohedral cleavage showed at two intersecting lines at oblique angles and easily identified by its colourless appearance, moderate to low relief and grey extinction colour under microscope. Feldspar grains are generally large and form in tabular shape. Feldspar especially sanidine can be identified as a clast within the matrix. Few phenocrysts of sanidine in a groundmass of phyllite can be observed from the simple twinning (Carlsbad twin) under crossed polars for the K-feldspar (Figure 4e). Sericite can also be found interlocking between it and some grain of K-feldspar is spotted with the replacement of sericites that pseudomorph the previous mineral (Figure 4f). Clay minerals always found accompanied both feldspars that may be resulted from the alteration [9, 10].

Mudstone and sandstone are also found within the argillite lithology. AN6 is a sample that represent the sandstone and the reddish colour in the thin section (AN6) can be observed clearly within the matrix under the optical microscope using both PPL and XPL as shown in Figure 5. The variety of the grain size can be seen within the assemblages that have large grains minerals of quartz and feldspar. The matrix basically consists the mixture of fine particles of clay, mica, sericite and chlorite.

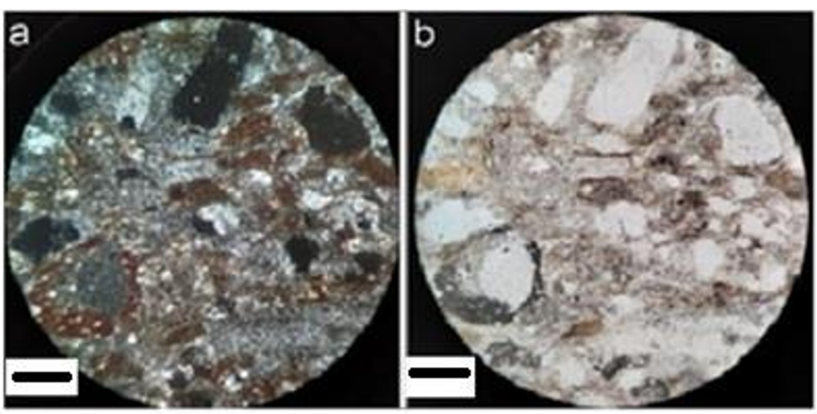

Fig. 5. Photomicrographs of mudstone (AN6) (a) Quartz in various shape and size under crossed polarized lense, XPL (b) similar spot in Fig. 5a but under plane polarized, PPL. Scale bar = 0.2 mm.

3.3 XRF analysis

Table 2 shows the major elements of five selected samples from XRF analysis represent Tanah Puteh and Pulai, Gua Musang, Kelantan. The SiO_2 concentration is within 66 to almost 80 wt.%, while Al_2O_3 within range of 13% to 26 wt%. Composition of Fe- oxides is very little for those samples and majority weight less than 1 wt.% except for sample SS9 and SS17. The others elements such as MgO, CaO and TiO_2 are exist as trace only.

Table 2. XRF analysis of five samples from Pulai (AN) and Tanah Puteh (SS).

Samples	Elements composition in oxide (wt.%)						
	SiO_2	Al_2O_3	K_2O	MgO	Fe_2O_3	CaO	TiO_2
AN10	67.76	25.97	3.47	-	1.92	-	0.41
AN11	79.18	16.01	3.79	0.63	0.30	0.09	-
SS5	79.70	16.85	2.83	0.62	-	-	-
SS9	71.43	21.62	3.93	-	2.32	0.12	0.15
SS17	66.77	17.98	0.87	-	12.27	0.26	1.31

4 Conclusion

As conclusion, the lithology in Pulai and Tanah Puteh are ranged from limestone, meta-sediment, tuff, argillite, shale and phyllite. Petrographic analysis on thin section samples have shown majority of mineral existence are from quartz, calcite, mica and feldspar. This also similar with XRF analysis that shown the composition of SiO_2 has the highest percentage with the range of 66 to almost 80 wt.%. Clay appears in the very fine particles mixed with others fine mineral grains as the matrix of the sample especially for mudstone. The mineral composition from geochemical analysis also in line with the mineral association based on petrography studies.

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References

1. S.H. Goh, G.H. Teh, and W. F. W. Hassan, Geol Soc Malays Bull **52**, 129-135 (2006).
2. K. S. Ariffin, Earth Sci., 313–342 (2012).
3. K. R. Mohamed, N. A. M. Joeharry, M. S. Leman and C. A. Ali, Geol Soc Malays Bull **62**, 131–142 (2016).
4. I. Metcalfe, J. Asian Earth Sci. **76**, 195-213 (2013).
5. C. S. Hutchinson and D. N. K. Tan, The Geol Soc Malays. (2009).
6. T.T. Khoo and B. K. Tan, The Geol. Soc. Malays, 253-290 (1983).
7. MacDonald, Geol. S. Malays Memoir **10**, 202 (1968).
8. K. Yao, B. Pradhan and M. O. Idrees, J. of Sensors, 1-8 (2017).
9. M. Gogoi, R. K. Sarmah, T. P. Goswani, B. N. Mahanta, R. Laisham, H. Saikia and B. Oza, J. Sedimen. Env., Springers, 1-23 (2021).
10. B. Velde and A. Meunier, Springer (2008).