The Occurences of Heavy Mineral Placer at Kendawangan and Its Surrounding, West Kalimantan Province

Keterdapatan Mineral Berat Plaser Kawasan Pantai dan Lepas Pantai di Kendawangan dan Sekitarnya, Provinsi Kalimantan Barat

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ABSTRACT: The main objective of this study is to identify and to determine the variation of heavy mineral placer composition in the sediment of Kendawangan coastal, offshore and its surrounding area. Sediment samples were taken from 18 locations, comprised of 12 samples from offshore and 6 samples from coastal area. For this analysis the heavy metals were identified and analyzed using isodynamic separator and binocular microscopic. The result indicates that heavy minerals consist of zircon, cassiterite, rutile, ilmenite, topaz, chalcopyrite, epidote, pyrite, hematite, hornblende and magnetite. Cassiterite and zircon are found in all sediment samples from all locations, and it is potential to be further developed.

Keywords: Heavy minerals placer, Zircon, Cassiterite, Kendawangan, West Kalimantan

ABSTRAK: *Tujuan penelitian ini adalah untuk mengidentifikasi dan menentukan variasi kandungan mineral berat plaser pada sedimen pantai dan lepas pantai Kendawangan dan sekitarnya. Sampel sedimen diambil dari 18 lokasi yang terdiri atas 12 sampel sedimen lepas pantai dan 6 sampel sedimen pantai. Analisis dilakukan dengan menggunakan isodinamik separator dan mikroskop binokular. Hasil analisis menunjukkan bahwa mineral berat terdiri atas zircon, kasiterit, rutil, ilmenit, topas, kalkopirit, epidot, pirit, hematit, hornblende, dan magnetit. Kasiterit dan zircon juga dijumpai pada sampel sedimen di semua lokasi yang dianalisis dan berpotensi untuk dikembangkan lebih lanjut.*

Kata kunci: *Mineral berat plaser, Zirkon, Kasiterit, Kendawangan, Kalimantan Barat*

INTRODUCTION

The accumulated collection of heavy minerals from its source to depositional environment is affected by several factors such as weathering levels between the source rock and the sedimentation environment, mechanical abrasion during transportation, sorting properties and diagenesis process (Morton and Hallsworth, 1999; Morton and Chenery, 2009; and Bateman and Catt, 2007)..

According to Friedman and Sanders (1987), the natural effect of the heavy mineral availability in sediments were affected by the presence of native rock minerals, unless on heavy mineral results of a secondary process, which was originally a decomposition of other minerals. This mineral is present in the form of new mineral in particular mineral groups. The purpose of this heavy mineral analysis is to eliminate all these variables mentioned above, except lithological source region and the necessary hydraulic factors. Thus, the origin of the sediment can be found by comparing the heavy mineral assemblages that are present in the sediment. This can be done by collecting heavy minerals contained in the sediment rock which are considered to be the source of these sediments.

Several types of heavy minerals are often found in sediments and showing a variation of heavy mineral contents (Table 1). Sedimentation is the influx of sediment load into a particular marine environment through the medium of water. Sedimentation in coastal environments is often termed as materials which are concentrated in a mass of water, either in the form of organic and inorganic materials (Pickard, 1967).

Study area is in a coastal environment where the sediment supply is considerably high. High sediment supplies come from land through streams. Human activity in the upstream particularly watersheds clearings which increase surface erosion is a major factor that enhance the sediment supply to the ocean (Pickard, 1967).

Boggs (1992) stated that the composition of sands can be expressed by its chemical composition. Chemical analysis will provide a feature or "bench mark" for studying the origins of final product sediments. Geochemical analyzes are necessary to study the mass balance and flow of material in the earth's evolution as a whole. Other techniques used in the analysis of sorting the composition of geochemistry in sedimentary rocks (Basu and Molinaroli, 1989).

Coastal sand deposits may contain various mineral associations mainly dependent on the surrounding geological environment (Jensen and Bateman, 1981). The identification of minerals in sediment samples of sand will show the different types of rocks that present in a particular area. Analysis of mineral provenance reflect the composition of different environments.

The purpose of this study is to obtain the heavy mineral composition in sediment samples of Kendawangan coastal and offshore and its surrounding area, West Kalimantan Province. Kendawangan coasts of the study area are located at the west side of West Kalimantan, where boundaries of the east side is Bengkayang, the west and north sides is Natuna Sea and the south is Mempawah Regency.

Zircon, cassiterite, rutile and ilmenite has economic values at the study area. While the sulfide minerals such as pyrite minerals are used as an indicator of the presence of sediment hydrothermal porphyry and epithermal type (Berger et al., 2008). Furthermore, Subiantoro et al. (2012) has identified the potency of radioactive mineral in Kendawangan area. They found radioactive mineral in zircon and monazite form, which is composed of uranium, thorium, and REE

Administratively, the study area belongs to the Ketapang district. Geographically the research area located at coordinates of 110 2'– 110 7'E and 2 20' - 2 40' S. The study area is about five hundred square kilometers (Figure 1). Ketapang can be reached from Pontianak as the capital city of West Kalimantan Province with about 225 kilometers distance.

General geological condition of study area is a part of Ketapang Geological Map Sheet 1414 Scale 1: 250 000 (Rustandi and de Keyser, 1993). The oldest lithology of this area is composed of Kerabai volcanic rocks in Gunungapi Kerabai Unit (Kuv), located in the lowlands. Generally it is composed of andesite, basalt, dolerite, trachite, andesite, rhyodacite, dacite and rhyolite. Pyroclastic rocks are ash, lapilli, crystal and crystal tuffs and lithic, volcanic breccias and agglomerates. Lithologies units is end of Cretaceous to Paleocene. Above Kerabai Volcanic Rocks is Ketapang Complex (Ke), composed of quartz sandstone, siltstone and shale. The age of this rock is Jura to Cretaceous. The upper most layers is alluvium (Qa) which consists of clay and sand, and is often associated with other heavy minerals such as ilmenite, monazite, rutile and xenotime (Figure 2).

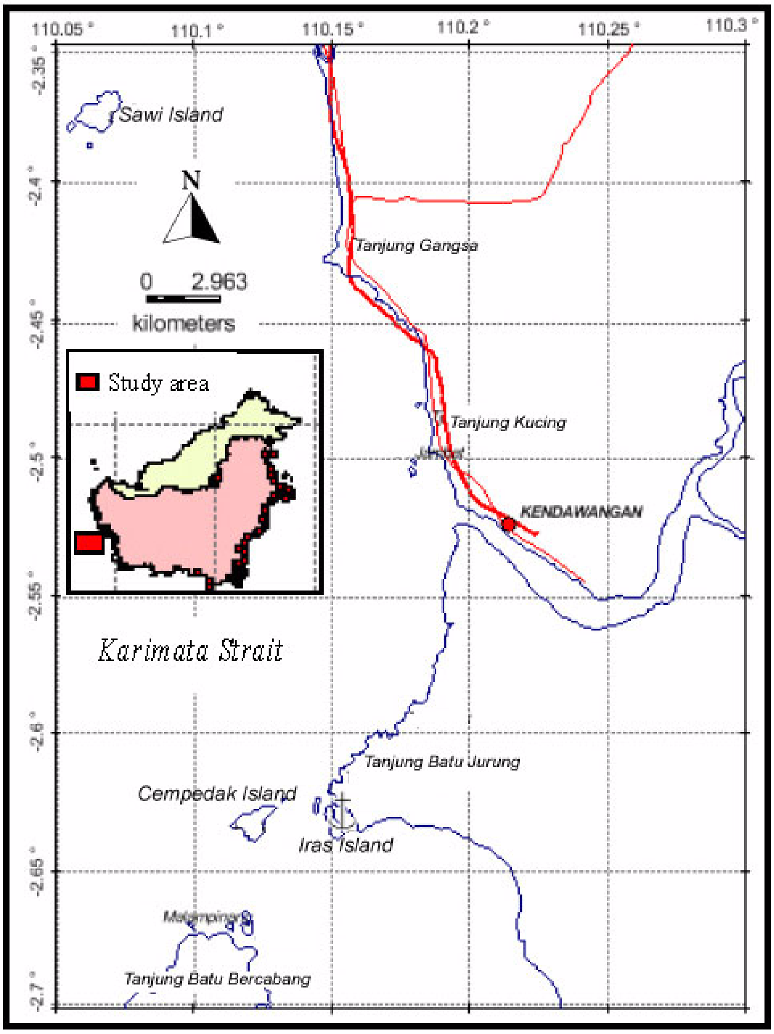


Figure 1. Location of the study area

METHODS

Eighteen sediment samples have been collected from surface Kendawangan and vicinity area. The sediments were analyzed by wet method and dry method. Wet method was carried out by using liquid bromoform as heavy mineral separation tool (SG 2890 kg/m^3). Dry method is conducted for coastal samples using isodynamic separators. The purposes of these analyses are to separate the heavy minerals from light minerals and to estimate the percentage of each mineral concentration.

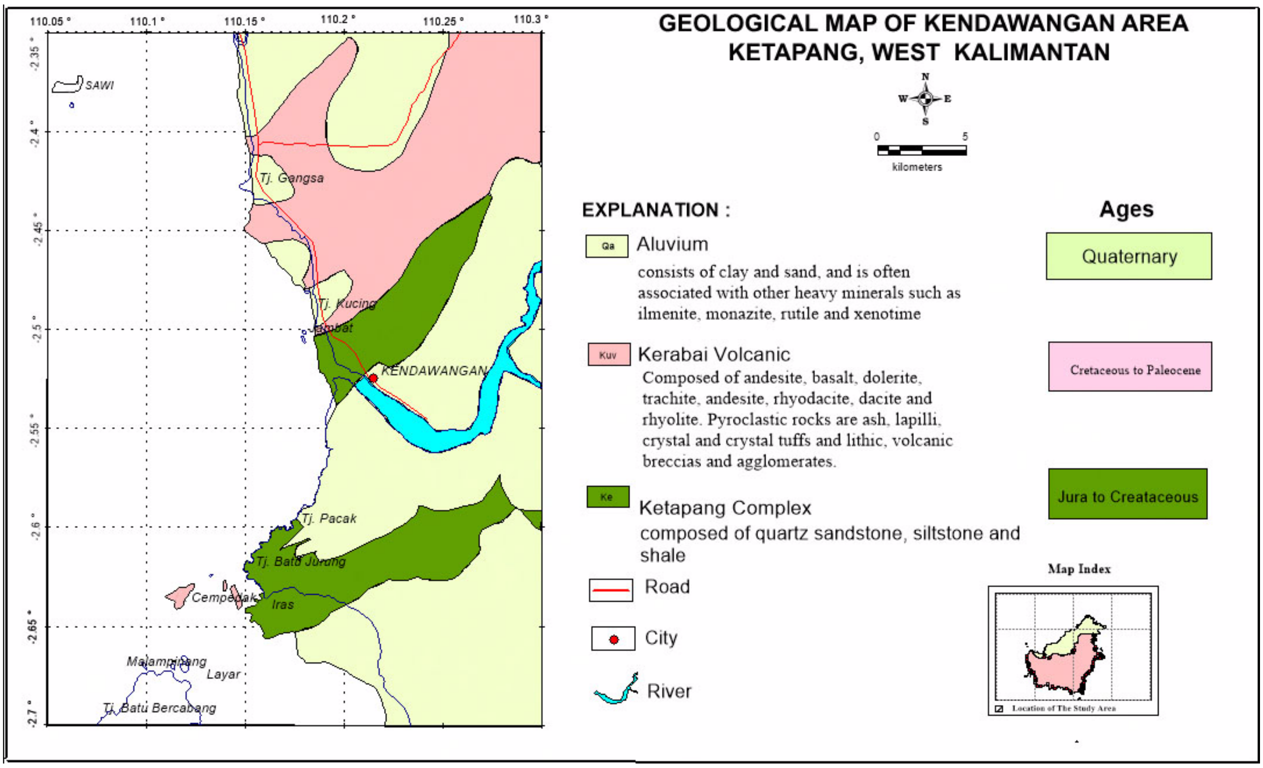


Figure 2. Geological map Kendawangan area, West Kalimantan, (Rustandi and de Keyser 1993).

RESULTS

Heavy mineral data analysis of 18 sediment samples that distributed on 12 sea floor and 6 coastal areas are presented on Table 1. Megascopically, this metasediment consists of blackish brown in color and rough textures. Petrographic analysis data of the hard rock samples represented on figures 3. Petrographic analysis on two granite samples derived from outcrop on KP-05-A and KP-05-B. KP-05-A composed of quartz (25%), feldspar (8%), Phylosilicate (5%), Tourmaline (1%), iron-oxide (40%), Fe-rich clay minerals (10%), clay mineral (6%), and KP-05-B consists of lithic fragments (5%), Quartz (1%), Quartz (63%), Sericite (25%) and Opaque (6%).

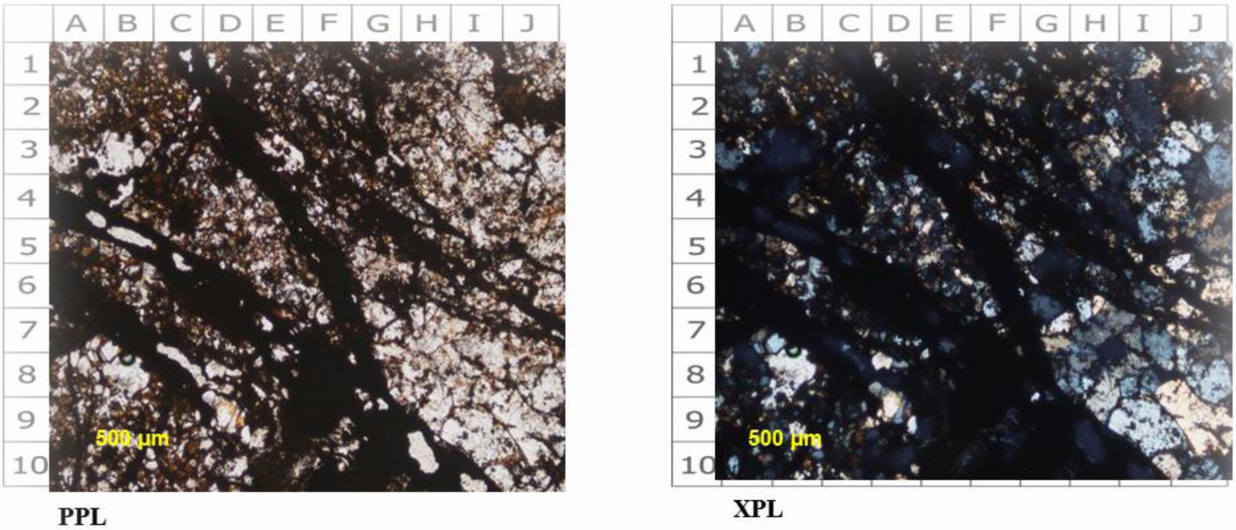
Heavy minerals consist of zircon, magnetite, hematite, epidote, tourmaline, cassiterite, alanite, pyrite, xenotime, monazite, apatite, thorite, rutile, silimanite, and hornblende. Those heavy minerals demonstrate different abundance at each sample location (Table 1). Heavy minerals are not found in samples which are composed of quartz, this might be related to transport and deposition process of sediments. Heavy minerals that are distributed widely at the research area including zircon, topaz, epidote and rutile.

Cassiterite (SnO_2), this mineral range from 0.3 to 15%. The presence of high intensity is found in KG 07 locations on gravelly sand sediments at the north-southwest of Tj. Batujurung (Figure 4). Tin (Sn) as the main constituent element of cassiterite is found in most coastal and offshore sediment samples which ranged from 0.1 to 0.5% (Table 1). The highest content of Sn is found in sediment samples of Tg. Pecak (KG-07).

Hematite (Fe_2O_3) is found in most sediment samples. The highest abundance intensity of hematite is 24%, found in sediment samples at the west Tanjung Pacak waters (KG-10). In the western Tanjung Batu Jurung waters (KG-07) the intensity of hematite is about 20%.

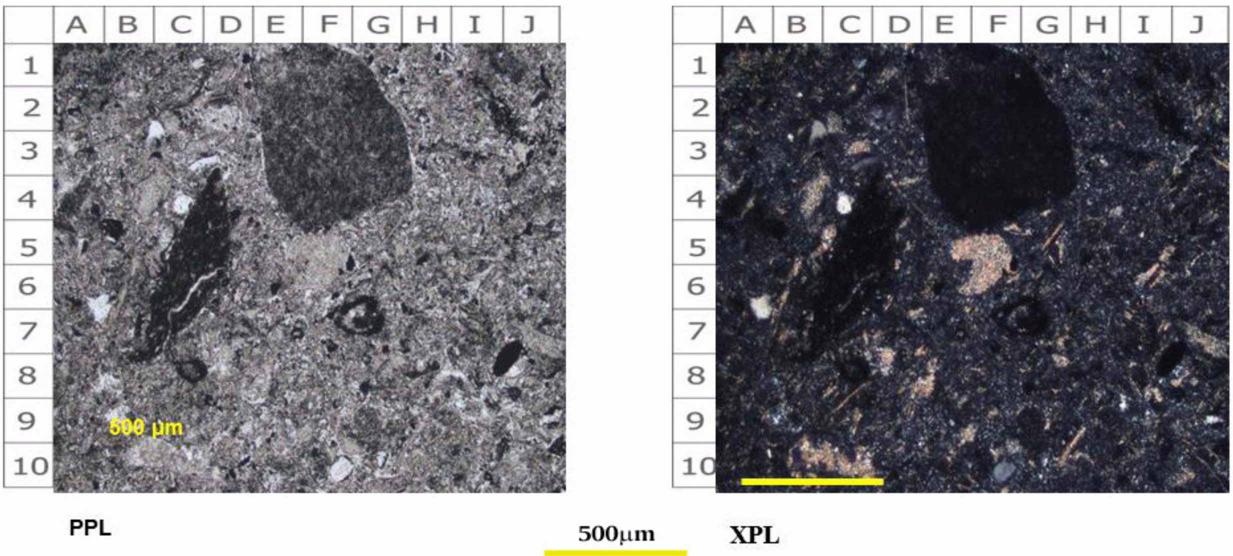
Zircon ($ZrSiO_4$), zircon is associated with granitic magmatic intrusive rocks, nepheline, syenite and diorite (Herman, 2007). Beach and sea floor sediments contained of zircon between 1 and 25.6%. The highest intensity of zircon is found on sediment samples at the beach side of Kendawangan River (KP-11). While in the surface sediment sample at 11 meters water depth (KG-07) the abundance of zircon is about 20%. Moreover, the intensity of Zr element ranged from 1 to 25.6 % (Table 1). The highest content of Zr (25.6 %) is found on sediment sample at the mouth of Kendawangan River (KP-11). On sediment sample of west coasts (KG-07) the intensity of Zr is about 20 %.

Magnetite (Fe_3O_4) is formed from the mineral iron mineral alteration. The highest intensity of this mineral is 5.98% on sediment sample of Tanjung Gangsa coast (KP-02). The intensity of magnetite on gravelly sediment sample of Cempedak Islands at 20m water depth (KG-08) is about 2%.



KP-05-A; Altered rock show siliciclastic crsytals whit clay groundmass (B2, E2) characterized by gradual grain size changes (cataclastic texture) from lower right is coarser (I9, J10) to upper left (finer); (A1, B2), and they are latter cut by fractures and cracks that are infilled by allochtonous Fe-oxides/hydroxides (D2, F6) and quartz secondary crystals (H10)

Rock Name : Iron-rich cataclastic rock



KP-05-B These pictures show sericite and secondary quartz replacement of feldspar (F7), lithic fragments (F2) and glassy groundmass (E5,F8). Sericite pseudomorphs after glass shards and primary mineral (feldspar?)

Rock Names : Sericite-quarrtz altered vitric tuff

Figure 3. These pictures show siliciclastic crystals that show gradual grain size changes (cataclastic texture) from the lower right (coarser) to upper left (finer), fractures and cracks are filled by allochtonous Fe-oxides/hydroxides rock in locations KP-05 and KP-05-B around Tanjung Gangsa Coast. These pictures show siliciclastic crystals that show gradual grain size changes (cataclastic texture) and they are later cut by fractures and cracks.

Table 1. Heavy Mineral Occurrence at Coastal and Offshore Sediments (%)

NO.	CODE SAMPLE	KP 01	KP 02	KP 03	KP 05	KP 09	KP 11	KG 02	KG 03	KG 07	KG 08	KG 10	KG 17	KG 20	KG 29	KG 33	KG 35	KG 39	KG 41
1	Zircon	17.90	3.50	19.48	18.75	6.20	25.60	1.50	2.00	20.00	1.00	2.30	5.00	14.00	5.00	2.50	4.00	5.90	2.50
2	Magnetite	5.18	5.98	0.15	4.68	5.25	12.00	-	-	2.00	2.00	-	-	-	-	-	-	-	-
3	Hematite	2.65	16.20	1.04	7.24	0.59	5.11	-	35.00	20.00	20.00	24.00	15.00	-	-	-	-	-	-
4	Epidote	0.41	1.33	1.87	1.50	1.20	1.30	7.30	-	2.50	0.10	3.50		5.00	5.00	6.00	6.00	7.00	4.00
5	Casiterite	2.71	8.77	0.31	8.77	3.50	1.20	1.00	2.60	15.00	0.30	3.50	1.20	4.50	4.00	3.50	5.50	5.10	8.50
6	Alanite	0.87	1.40	1.50	1.80	1.20	-		-	-	0.30	-	-	-	-	-	-	-	-
7	Pyrite	2.18	1.66	1.09	1.56	0.65	3.10	-	-	0.50	0.50	-	2.10	-	-	-	-	-	-
8	Xenotime	0.90	1.40	2.50	1.00	1.30	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Monasite	5.40	1.50	1.50	1.50	1.17	-	3.30	-	3.50	1.30	3.20	2.00	-	-	-	-	-	-
10	Apatite	1.40	0.50	1.20	0.50	0.60	-	-	-	2.00	2.00	-	30.00	4.50	3.00	4.00	4.50	5.00	7.00
11	Thorite	1.20	1.50	2.00	1.70	2.30	1.60	-	-	1.50	0.90	-	-	-	-	-	-	-	-
12	Rutile	12.40	14.83	8.63	7.24	22.30	9.85	11.30	-	5.00	2.00	3.00	4.70	5.00	6.00	4.00	7.00	8.00	7.00
13	Ilmenite	8.10	6.48	8.54	6.00	5.00	-	-	45.00	-	0.30	2.00	-	-	-	-	36.00	-	-
14	Hornblende	1.00	1.48	0.89	1.00	1.00	-	1.32	-	2.00	0.30	2.00	-	2.00	1.00	3.00	2.00	4.00	6.00
	TOTAL	62.30	66.53	50.70	63.24	52.26	59.76	25.72	84.60	74.00	31.00	43.50	60.00	35.00	24.00	23.00	65.00	35.00	35.00

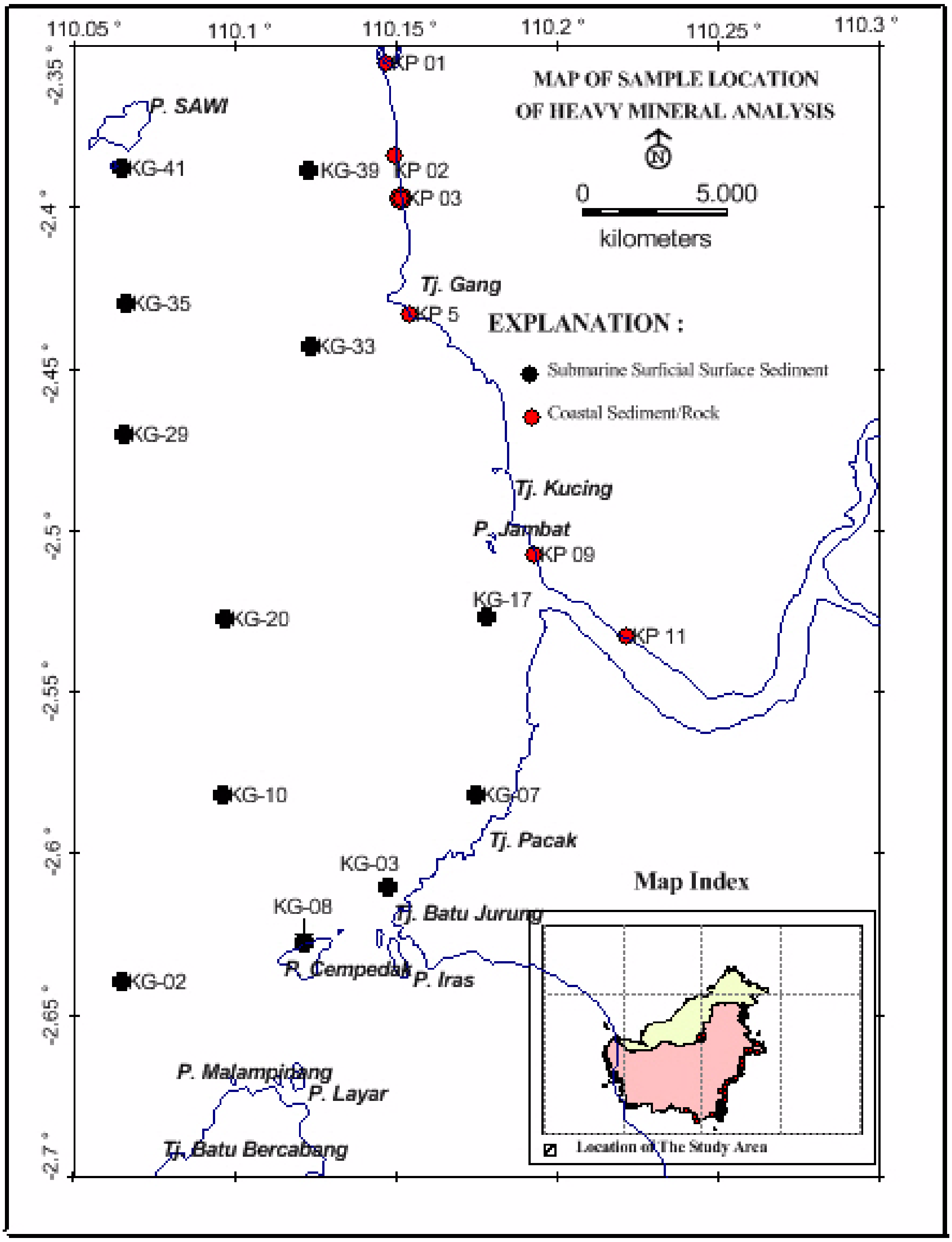


Figure 4. Sample Location at Coastal and Offshore Area Kendawangan (Setyanto et al., 2015)

Alanite (Ce, Ca, Y)$_2$(Al,Fe^{2+},Fe^{3+})$_3$(SiO$_4$)$_3$(OH), is found about 1.8% on sediment sample of the beach Tanjung Gangsa (KP-05). This mineral is only found on gravelly marine surface sediment sample of Cempedak Island waters (KG-08) at 20 m water depth (0.3%).

Pyrite (FeS$_2$), the highest intensity of pyrite (2. 18% and 2.1%) are found in Tanjung Gangsa (KP-01) and on gravelly muddy sand around Kendawangan River (KG-17) at 6m water depth, respectively.

Xenotime (YPO$_4$), This mineral is found only at the beach samples. The highest intensity (2.5%) is found on beach sediments at Tanjung Gangsa (KP-03). This mineral is not found on offshore sediment samples.

Monazite (Ce, La, Nd, Th) PO$_4$, the highest intensity of monazite is 5.4%, observed on marine sediment samples of Cempedak Island (KP-01 and KG-07). At 11m water depth around Cempedak Island this mineral is found on silty sand sediment with intensity 3.5%.

Apatite $Ca_5(PO_4)_3(OH, F, Cl)$, the highest intensity of apatite (30%) is found on sediments of Kendawangan river (KG-17, 6m water depth). In marine sediment, the highest intensity is found in KP-01 (1.4%).

Thorite (Th,U) SiO_4, on beach sediment sample, the highest intensity of thorite (2.3%) is found at the Tanjung Kucing (KP-09), and offshore sediment samples of the Layar Island (KG-07, 1.5%). This mineral is accumulated on silty, and sandy sediments at 11m water depth.

Rutile (TiO_2), the highest intensity of rutile are 22.3% and 8%, observed around the coast of Tanjung Kucing (KP 09), and sediment sample of Tanjung Gangsa coast (KG 39), respectively. This mineral is accumulated in muddy gravelly sand at 4m water depth.

Ilmenite ($FeTiO_3$), the occurrence intensity of this mineral in sediment samples of both Tanjung Gangsa (KP 03) and Iras Island (KG 03) is similar (8.54%). It is accumulated in marine gravelly sand at 20m water depth.

Hornblende, $(Na,Ca)_2(Mg,Fe,Al)_5(Al,Si)_8O_{22}(OH)_2$, the occurrences intensity of hornblende in sediment sample of Tanjung Gangsa (KP 08) is 0.3%, while in that of Sawi Islands (KG 41) is 6%. It is accumulated in gravelly sand at 3m sea water depth (Table 1).

DISCUSSION

The heavy mineral in the research area occurred in varying types and value at each sample location, particularly in the coarse fractions of the coastal sediments. In addition, there are also several samples contained no heavy minerals, and generally composed only by quartz. This might be related to the formation of the sediment which were transported and deposited in low energy environment, resulting the accumulation of only light mineral.

In relation to the potential economic heavy mineral deposits in the research area zircon and cassiterite minerals are considered as economic mineral deposits with its associated minerals are rutile and ilmenite. While the sulfide mineral of pyrite is used as an indicator of epithermal type (Boggs, 1992) which provided economical mineral deposited.

The intensity of cassiterite on the marine sediment range between 12.31% - 15%, occured in KG 07 sample (11m sea water depth) on a gravelly sand sediment located in the north-southwest of Tj. Batujurung. The heavy metal analysis also indicates high intensity of cassiterite on the beach, which resulting the occurrence of element Sn (the main constituent of cassiterite) in all beach and offshore sediments. Therefore, the result of analysis shows that the high content of cassiterite (Sn) is generally contained in the sediment of Kendawangan River.

The intensity of the mineral zircon on the coast is very abundant, indicated by relatively high content of the element zirconium (Zr) as the main constituent of the mineral zircon. The rare elements analysis on six coastal sediment samples, indicate that the percentage of Zr ranged between 1 and 25.6 %. The highest percentage (25.6 %) is found at the mouth of S. Kendawangan (KP-11) and off the west coast (KG-07) with percentage 20%.

In general, most of the rocks in the study area have been undergone further altered. The indication of this alteration observed in the field is the reddish colour, the occurence of secondary quartz veins mineralized, pyrite, and chalcopyrite as well as chlorite, biotite and clay minerals. This appearance can be observed based on petrographic observations, which in general, demonstrate weak level process of alteration. The process of hydrothermal alteration in the research area partly as a result from a diorite intrusion.

On the coast, the result exhibits the opposite condition, indicated by low percentage of hematite. This suggest the occurrence of post-deposition oxidation to reduction of minerals from the hydrothermal solution.

CONCLUSIONS

Heavy minerals occurred in the study areas are Zircon, magnetite, hematite, epidote, tourmaline, cassiterite, alanit, pyrite, xenotime, monazite, apatite, thorite, rutile, silimanite, and hornblende. The occurrence of secondary minerals such as chlorite, biotite and clay minerals suggest the indication of alteration process. Zircon and cassiterite which are found in Kendawangan can be classified as a potential economic mineral, thus generate curiosity for further investigation.

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