HEAVY MINERALS IN PLACER DEPOSIT IN SINGKAWANG WATERS, WEST KALIMANTAN, RELATED TO FELSIC SOURCE ROCK OF ITS COASTAL AREA

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ABSTRACT

Placer deposits are physically accumulated by fluvial and marine processes in coastal area. Thirty six samples were selected from seventy seven samples of seafloor sediment of Singkawang waters. Those samples have been analyzed microscopically for heavy mineral contents. Based on this analysis, the heavy minerals can be divided into four groups: oxyde and hydroxyde, silicate, sulphide, and carbonate.

The source of most heavy minerals in the study area is commonly formed by Felsic igneous rock and finally deposited on the seafloor sediments.

Keywords: heavy minerals, placer deposit, felsic igneous rock, Singkawang

SARI

Endapan letakan secara fisik umumnya terakumulasi oleh proses sungai dan laut. Sebanyak 36 contoh dipilih dari 77 contoh sedimen permukaan dasar laut di Perairan Singkawang. Contoh tersebut telah dilakukan analisis kandungan mineral berat secara mikroskopis. Berdasarkan hasil analisis mineral berat ini dapat dibedakan menjadi empat kelompok yaitu oksida dan hidroksida, silikat, sulfida, dan karbonat.

Sebagian besar sumber mineral berat di daerah penelitian pada umumnya berasal dari batuan beku felsik yang akhirnya diendapkan di permukaan dasar laut.

Kata kunci: mineral berat, endapan letakan, batuan beku felsik, Singkawang.

INTRODUCTION

This study is a part of the marine geology and geophysics investigation and funded by Marine Geology Institute (MGI). The study area is located between 108°48'E – 108°51'E and 0°48'N - 0°51'N in the Singkawang waters (West Kalimantan). It is approximately 1.600 square kilometers area.

The primary objective of this paper is to know the distribution of heavy minerals in the

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sea floor sediment of Singkawang waters and its relation to the source rock, such as felsic rock in south East Asia. The main goal of this study is to invent minerals that possibly valuable to be further developed.

Stratigraphy in the study area (Suwarna, 1993), respectively from the old to the young is as follows (Figure 1):

The Raya Volcanic Formation (Klr), Jura-Early Cretaceous, consists of andesite, basalt, dacite and intrusive rocks, sandstone and mudstone. The characteristics of this formation are : scattered, thick and resistant to erosion, forming many steep hills and islands off the steep coast; *Granodiorite Mensibau (Klm)* is widely Batholith Singkawang formed which tends to be the northwest part of the Peninsula, separated from Batholith Schwaner, intruded the Mt. Raya Formation; *Sintang Intrusive* (Toms) Early Oligocene-Early Miocene, consisting of diorite, quartz diorite, granodiorite, granite, tonalite, quartz gabro, intruded The Bengkayang Group, *Raya volcanic* and Granodiorite Mensibau; predominantly granodiorite and granite, diorite, and Littoral deposits (Qc) consists of mud, sand, and gravel, calcareous locally, and alluvial deposits (Qa) consists of mud, sand, gravel, and plant materials.

Morphologically, Kalimantan Island is in the process of peneplainization with some small remnants. They are formed by weathering of igneous rock, which still cropped out. The peneplain is composed of thick soil in which the minerals derived from. The Singkawang Batholith is the largest intrusive body in the North West coast of Singkawang (Sujatna, et. al, 1985).

METHODS

Thirty-six samples from 77 samples have been selected for heavy mineral analysis (Figure 2). The samples were first analyzed megascopically, and then prepared for grain size analysis (Aryanto, et. al, 2008).

The grain size analysis was done by sieving method to separate grain size fraction and is classified based on Folk (1980). This sieving based on weight percentage to separate each fraction in every sample. Plotting in folk diagram of mud-sand-gravel was done to give the name of surficial sea floor sediment where heavy mineral accumulated.

For heavy mineral analysis, all samples were weighed, and sieved to achieve the grain size fraction of 3 phi (0.125 mm) following the method by Luepke (1984). The heavy minerals with magnetic character were separated by using hand magnetic equipment. On the other hand, for non-magnetic minerals, the separation was done by using bromoform liquid (SG = 2.89). Finally, the result was compared to their mineral abundance in percent (Hartono, 1996).

RESULTS

Result of heavy minerals analysis divided into four groups such as (Table-1):

Oxyde, hydro-oxyde, silicate and carbonate groups. The oxyde group contains magnetite, cassiterite, hematite, and ilmenite. Magnetite (Fe_3O_4) is the most widespread compared to other heavy minerals. In the study area, the formation of magnetite was not related to the granitic rocks. It seems related to the mineral transformation in the primary volcanic and the sedimentary rocks during high grade metamorphism, and transported by river to the sea.

Ilmenite ($FeTiO_3$) in the surficial sediment of the study area has content range between 0.35% - 45%. Ilmenite was found in all samples that had been analyzed. The highest content of ilmenite is 45% in SKWL-10 and SKWL-72 samples of silty sand sediment type.

Cassiterite (SnO_2) was commonly found in the offshore or near Kabung Island, Penata Besar Island, Lemukutan Island and Bajau Cape. The cassiterite usually occurs as a high

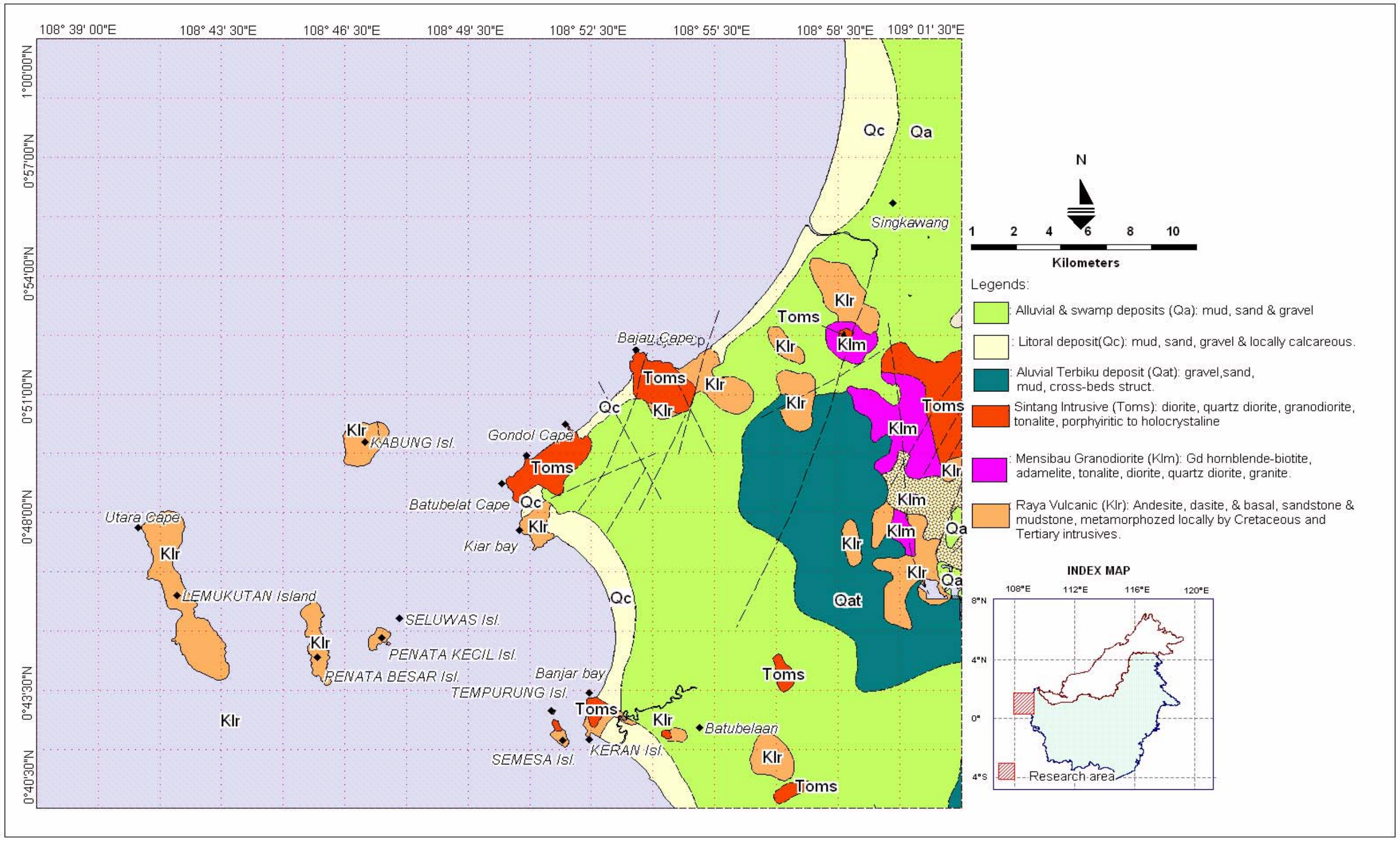

Figure 1 Geological map of study area (Source: Suwarna, 1993)

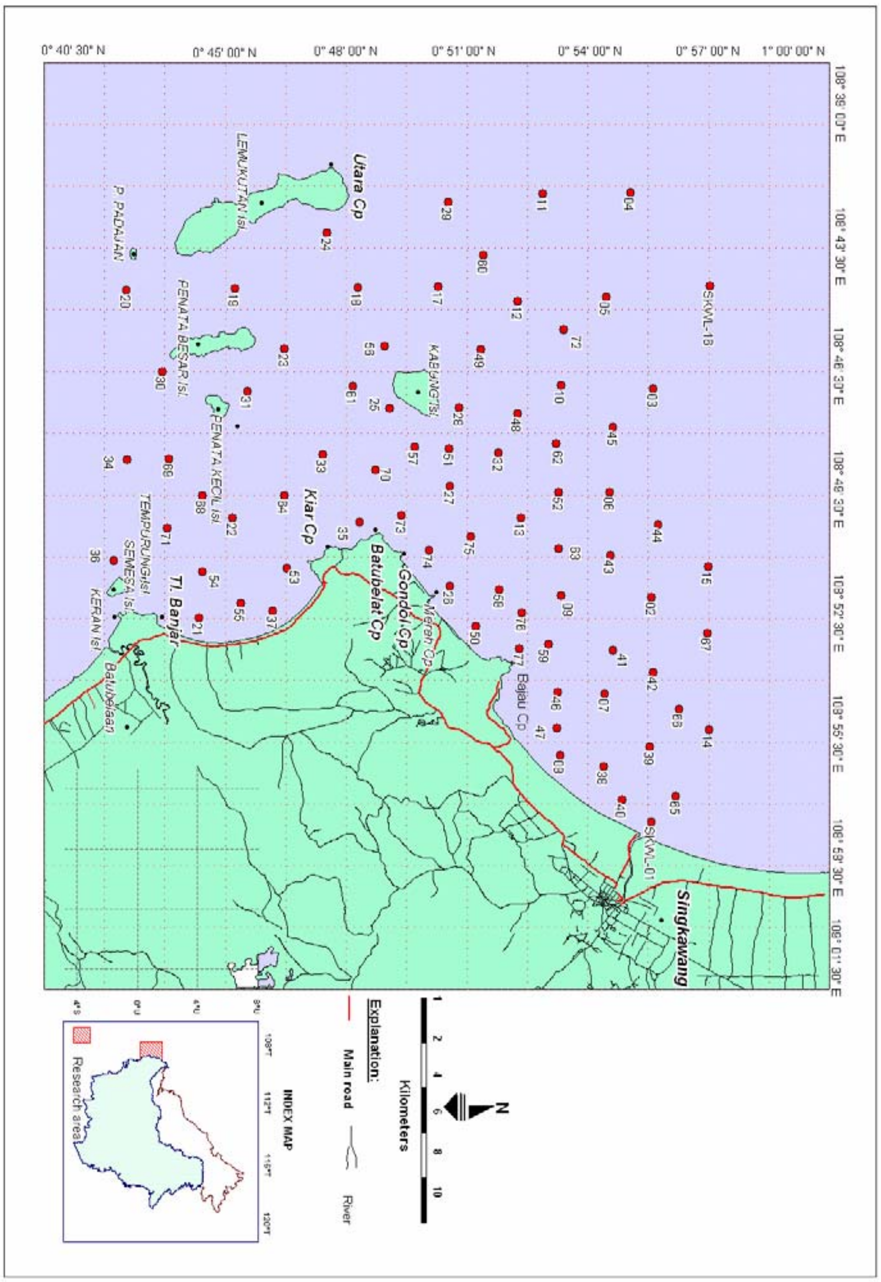

Figure 2. Samples location map of study area

Table-1. Heavy mineral analysis result

	SKWL 05	SKWL 07	SKWL 10	SKWL 11	SKWL 12	SKWL 13	SKWL 18	SKWL 19	SKWL 21
Ilmenite	40	3	45	7.2	Tr	Tr	-	20.0	-
Cassiterite	3.5	Tr	Tr	1.0	-	-	Tr	1.5	-
Hematite	35	12.5	15	10.0	10.5	16.5	7.5	35.0	15.0
Zircon	2	2.5	4.5	0.5	-	Tr	Tr	Tr	-
Tourmaline	2	Tr	2.5	2.0	-	-	-	15.0	-
Epidote	-	-	-	0.5	-	-	-	-	-
Pyrite	Tr	-	-	Tr	Tr	Tr	Tr	-	Tr
Topaz	Tr	1.5	2.5	-	-	-	-	2.5	5.0
Quartz	10	65	25	76.5	85.0	80.0	80.0	21.3	15.0
Carbonate	5	2	1	1.0	3.0	1.0	4.6	0.6	5.0
	SKWL 23	SKWL 24	SKWL 25	SKWL 27	SKWL 28	SKWL 29	SKWL 30	SKWL 31	SKWL 34
Ilmenite	0.5	0.5	Tr	Tr	0.4	25	1	5	Tr
Cassiterite	2.5	-	-	-	-	10	-	5	
Hematite	18.5	8.6	9.5	20.0	19.0	35.0	12.7	40.0	35.0
Tourmaline	0.5	-	-	-	-	-	-	-	-
Epidote	Tr	-	-	-	-	-	-	Tr	-
Pyrite	Tr	Tr	Tr	-	Tr	Tr	Tr	-	4.2
Topaz	-	-	-	-	-	-	-	3.5	-
Quartz	42.2	85.0	84.5	70.0	75.0	22.0	80.0	35.0	55.6
Carbonate	30.1	4.0	4.5	5.0	4.0	4.5	2.5	4.0	1.8
	SKWL 35	SKWL 36	SKWL 38	SKWL 43	SKWL 44	SKWL 45	SKWL 48	SKWL 49	SKWL 51
Ilmenite	5	Tr	Tr	Tr	Tr	Tr	20	0.35	17
Cassiterite	-	-	Tr	-	3.5	Tr	Tr		5
Hematite	3.3	1.3	25.0	5.7	15.0	17.9	22.5	33.6	18.7
Tourmaline	Tr	-	-	Tr	Tr	-	Tr	-	-
Epidote	-	-	-	-	4	-	-	Tr	Tr
Pyrite	Tr	-	Tr	-	Tr	-	-	Tr	-
Topaz	Tr	-	-	-	-	-	-	3.5	1.5
Quartz	55.0	70.3	30.0	85.0	40	80	50	60	16.3
Carbonate	33.3	23.4	40.0	4.3	20.0	0.78	0.7	1.3	35

Table-1. Continued

	SKWL 52	SKWL 56	SKWL 61	SKWL 62	SKWL 68	SKWL 70	SKWL 72	SKWL 74	SKWL 77
Ilmenite	Tr	4.3	20	15	10	Tr	45	5	2
Cassiterite	5.5	6.5	1,25	4.5	Tr	5	15	Tr	10
Hematite	25.9	40.6	40.0	48.0	60.0	30	2.5	40.0	Tr
Tourmaline	-	3.5	0.5	0.0	-	Tr	Tr	-	-
Epidote	-	Tr	Tr	20.0	-	-	-	-	-
Pyrite	-	Tr	Tr	-	Tr	-	-	-	-
Topaz	-	-	-	-	-	1.0	-	-	5.5
Quartz	64.0	11.0	22.5	20.0	10	15	30	25	25
Carbonate	3.5	32.7	15.0	8.0	15.0	40	-	15	10

temperature hydrothermal alteration mineral in the summit of granitic intrusions. As a tin mineral, cassiterite in this study area has been deposited as a placer deposit. The occurrence intensity of the cassiterite is 15% in SKWL-72, its grain shapes, shows orthorhombic crystal system tend to be an irregular form (Aryanto, 2009).

Hematite (Fe_2O_3), in the surficial sediment of the area show content range 1.3% to 60%. Hematite was found in all samples that had been analyzed, the highest content (60%) in SKWL-68 near Penata Kecil island and 48% in SKWL-62 north of Kabung Island.

The silicate group consists of zircon, tourmaline, topaz, and epidote. The most important mineral in this group is zircon. This mineral was found in the north of the study area in low percentage.

Tourmaline ($(Na(Mg,Fe,Li,Mn,Al)_3$ Al_6 $(BO_3)_3$ $Si_{16}O_{18}$ $(OH,F)_4)$, was existed in 14 samples that had been analyzed. Tourmaline commonly originated from pegmatite rock associated with quartz, topaz and cassiterite. It is also associated with lithium, cesium, and

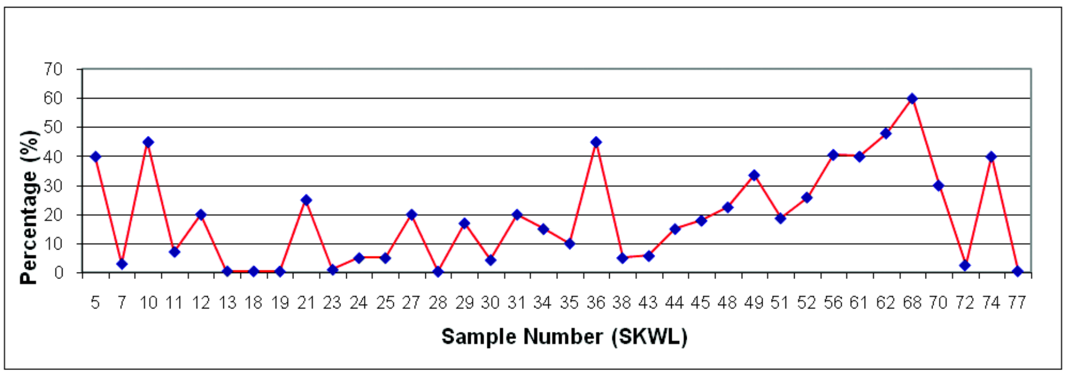

Figure-3. Graphic of hematite mineral content

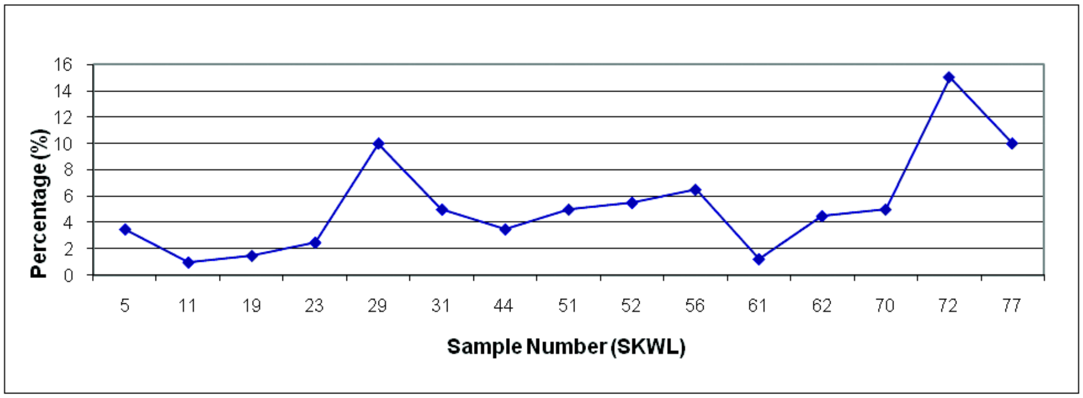

Figure 4. Graphic of cassiterite content

rubidium as rare earth elements. The content of this mineral range between 1% - 15%. The highest content of Tourmaline (15%) is in SKWL-19 (silty sand) and located between Lemukutan and Penata Besar Island of 45 meters water depth.

Epidote ($Ca_2Al_3 (SiO4)_3 (OH)$, was found in 5 analyzed samples. Epidote content range 1% to 4%. The highest content (4%) is in SKWL-44 (silty sand).

Topaz $Al_2(SiO_4)$ $(FOH)_2$, present in 12 samples that had been analyzed. The presence range 1% to 5.5%. The highest (5.5%) is in SKWL-77 of 6 meters water depth in Bajau Cape. It is also found in SKWL-31 of 5% content, located near Penata Besar Island.

Sulphide group is represented by pyrite and is only 1%. Even though this group contains only very low percentage of pyrite minerals, it is important for gold indication. The highest content of pyrite (4.2%) is in SKWL-34 (silty sand).

DISCUSSIONS

All heavy minerals were deposited in surficial sediment of Singkawang waters which derived from felsic igneous rocks. Due to their high specific density, these minerals might be accumulated near the outcrop. The heavy minerals tend to settle at the bottom of the sediment, while lighter minerals were deposited at the top of the seafloor sediment.

Ilmenite minerals are common in the study area. Chemical composition of this mineral consists of Fe 36.8%, Ti 31.6% and O 31.6%. Ilmenite was commonly formed in alkaline source rock of hydrothermal alteration. The high content of ilmenite (45%) is in SKWL-10 and SKWL-72, north of Kabung Island (Figure-2). Those minerals were originated from the primary Raya Volcanic and the metamorphic rocks and found as a marine placer deposit.

Cassiterite mineral represents the existence of granitic rocks which occurs in Kalimantan Island. The distribution of cassiterite contents could be seen in Figure 4. It is interpreted that the source of the cassiterite minerals are derived from eastern part of the study area (Kalimantan mainland). Beside, there are some other origins of this mineral as part of Sintang Granite Intrusive Rock characterized by greisens, high temperature hydrothermal veins and even marine placers. The mineral in all sediments is mined as a tin ore.

Zircon (ZrSiO4) is a silicate mineral group associated with intrusion rock (granites, nepheline, syenite and diorite). The highest content of zircon (10.4%) is in SKWL-56 of 23 meters water depth near Kabung Island and 6% in SKWL-30 south of Penata Besar Island. Its appearance is characterized by ideal forms (tetragonal bipyramid), colorless and the size smaller than zircon in SKWL-56 (Aryanto, 2010).

Magnetite is associated with ilmenite mineral. These marine placer deposits were originated from mineral alteration in the primary Raya Volcanic and the high grade metamorphism sedimentary rock. These minerals might be derived from Lemukutan Island, Kabung Island, and Penata Island.

All chemical process is related to their origin of weathering of igneous rocks (felsic to intermediate rocks). All heavy minerals in surficial sea floor sediment are assumed as the placer deposits. Most heavy minerals are characterized by sub-angular to sub-rounded shapes. It is interpreted that their sources are closed to their deposition; it might sourced from Raya Volcanic in the south (Kabung Island, Lemukutan Island, and Penata Island) and from the east of Kalimantan Island

Table-2. Heavy minerals and source rocks (Pettijohn, 1975)

Heavy mineral	Igneous Rock		Hydrothermal	Metamorphic Rock	
	Mafic	Felsic	Alteration	High grade	Low grade
Augite	x				
Cassiterite		x	x		
Chromite	x				
Hyperstene	x				
Ilmenite	x	x			
Leucoxene	x	x			
Magnetite	x	x		x	
Olivine	x				
Rutile	x				
Serpentine	x	x			
Apatite		x			
Biotite		x	x	x	
Hornblende		x	x	x	
Tourmaline		x	x		
Zircon		x			
Pyrite			x		
Siderite			x		
Columbite		x			

(Sintang Intrusive and Raya Volcanic). Based on Table-2, the source rock of cassiterite, tourmaline and zircon minerals are felsic rock (granite), while the source rock of ilmenite mineral is felsic to intermediate igneous rock such as granite, andesite, and diorite.

CONCLUSIONS

The heavy minerals in the study area could be divided into four groups : oxyde and hydroxyde group containing of magnetite, ilmenite, cassiterite, and hematite; silicate group which consists of zircon, tourmaline, and epidote; sulphide group which is composed of pyrite; and carbonate group containing of carbonate mineral. From those heavy mineral groups only oxyde-hydroxyde, sulphide and carbonate group are not related to the granitic rocks except silicate. Almost all heavy minerals are originated from hydrothermal processes and deposited as placer deposits. The hydrothermal process took place in coastal zone and inland of the study area.

From the point of view of grain shape, sub-angular to sub-rounded in their textures, it could be interpreted that their sources were not far from Raya Volcanic in Kabung, Lemukutan and Penata Island and from the east of Sintang Intrusive and Raya Volcanic.

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REFERENCES

Aryanto, N.C.D., Kamiludin, U., Darlan, Y., Widiatmoko, H.C, Kurnio, H., Setiya Budhi, A., Setiady, D., Dewi, K.T., Permanawati, Y., dan Yulinar; 2008. Laporan Penyelidikan Mineral Kasiterit dan Mineral Ikutannya di Perairan Singkawang, Kalimantan Barat, Puslitbang Geologi Kelautan, *(unpublished).*

Aryanto, N.C.D, 2009. Identifikasi Keterdapatan Kasiterit dalam Sedimen Dasar Laut di Perairan Singkawang dan sekitarnya, Kalimantan Barat, Prosiding PIT IAGI 38, Semarang.

Folk, R.L., 1980. *Petrology of Sedimentary Rocks*, Hemphill Publishing Company Austin, Texas: 182p.

Hartono, 1996. Heavy Minerals and smear slides analysis, *Marine Geological Institute, (Unpublished*).

Luepke, G., 1984. Stability of heavy minerals in sediments, Benchmark papers in *Geology Series*, Van Nostrand Reinhold Company Inc., New York, USA, Vol. 81: 306p.

Pettijohn, F.J. 1975. Sedimentary Rocks, 3 rd ed: NewYork, Harper and Row , Publisher: 487-628.

Sujatna, D.A.D., Wikarno, R., and Hardjadinata, K., 1985. *Granitic rocks of Part of West Indonesia*. Geological Research and Development Centre, Indonesia.

Suwarna, N., Sutrisno, de Keyser. F., Langford, R.P., and Trail, D.S., 1993. Geologi Lembar Singkawang, Kalimantan, Puslitbang Geologi, Bandung.