Pb-Zn-Ag DEPOSITS AT TANJUNG BALIT, LIMAPULUH KOTA REGENCY, WEST SUMATERA

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ABSTRACT

A Pb-Zn-Ag deposit located at Tanjung Balit, Limapuluh Kota Regency, West Sumatra, is hosted within the meta sedimentary rocks of the Tapanuli Group. The lithology consists of interbedded shale, meta sandstone, slate and phyllite (Kuantan Formation). The deposit is in the form of veins, veinlets and disseminated. The thickness of veins ranges from few centimeters up to 5 meters. In places, some ore bodies are conformable with the host rocks. The main ores are lead, sphalerite, chalcopyrite, pyrite and silver with minor marcasite, magnetite, chalcosite and gold. Hydrothermal mineral assemblages consist of silica, illite, monmorillonite, pyrophyllite, muscovite, siderite, diaspore, dickite, magnesite, chlorite, carbonate, rhodochrosite, analcime, alunite, smectite, ankerite, calcite, dolomite, sericite and zeolite. Fluid inclusion measurements of secondary inclusions within quartz veins indicate that the homogenization temperature (Th) ranges from 185 - 350°C. The presence of alunite, higher content of base metals as well as higher temperature range of the secondary fluids suggests that the deposit may characterize a high suphidation epithermal type.

Keywords : Tanjung Balit, Tapanuli Group, fluid inclusion, high sulphidation epithermal

SARI

Cebakan Pb-Zn-Ag, yang terletak di Tanjung Balit, Kabupaten Limapuluh Kota, Sumatera Barat, terdapat dalam batuan metasedimen, Kelompok Tapanuli. Batuan Kelompok Tapanuli ini terdiri atas perselingan serpih, metasedimen, batusabak dan filit (Formasi Kuantan). Cebakan ini berbentuk urat, urat tipis, dan tersebar. Ketebalan urat berkisar dari beberapa cm hingga 5 m. Mineral bijih utama yang dijumpai berupa timbal, sfalerit, kalkopirit, dan perak dengan sedikit markasit, magnetit, pirit, dan kalkosit. Mineral ubahan hidrotermal terdiri atas silika, ilit, monmorilonit, pirofilit, muskovit, siderit, diasfor, dikit, magnesit, klorit, karbonat, rodokrosit, analsim, alunit, smektit, ankerit, kalsit, dolomit, serisit, dan zeolit. Pengukuran inklusi cair inklusi sekunder dalam urat kuarsa menunjukkan temperatur homogenisasi berkisar dari 185 - 350°C. Kehadiran alunit, tingginya kandungan logam dasar, serta tingginya temperatur (inklusi sekunder) menunjukkan cebakan Pb-Zn-Ag di Tanjung Balit ini mencirikan tipe epitermal sulfida tinggi.

Kata kunci : Tanjung Balit, Grup Tapanuli, inklusi cair, epitermal sulfida tinggi

INTRODUCTION

Although Pb-Zn-Cu-Ag ores has been known in Balung Village during the Dutch Colonialism (van Bemmelen, 1949) but no information about similar deposit (Pb-Zn-Cu-Ag mineralization) at Tanjung Balit was mentioned. The deposit is found in the junction of Mahat and Left Marang Rivers and belongs to Tanjung Balit village, Pangkalan District, Lima Puluh Kota Regency, West Sumatera (Figure 1). This prospect is located within Longitude & Latitude (N 00 10 381; E 100 48 941). Plateau. Nucl. Tracks Radiat. Meas.17(3) : 301-307.

The presence of base metal Pb, Zn and Ag along the Barisan Range, Sumatera such as Lokop (East Aceh), Dairi and Latong (North Sumatera), Tubo (South Sumatera) and Bukit Besi (West Sumatera) have been recorded by many authors (van Bemmelen, 1949; Rock *et al*., 1983; JICA, 1986; Herald Resources Ltd., 2001; Crow and van Leeuwen, 2005; Abidin and Harahap, 2006 and 2007).

The deposits are commonly hosted within the pre-Tertiary rocks of the Tapanuli Group, *i.e*. Kuantan or Kluet Formation. The type of deposits are classified into sedex (sedimentary hosted), skarn and hydrothermal types. Sedex (sedimentary exhalative) is defined as sediment-hosted deposit that was formed from the discharge of hydrothermal fluids onto the sea floor (Goodfellow *et al*., 1993). The main economic minerals of sedex deposit are lead and sphalerite. In Sedex type, ores are deposited in the continental margin environments or fault-controlled basins and troughs. The ore fluids could be derived from exhalative centres occuring along these faults within the basins. Biogenic reduction of seawater sulphate mostly controlled the deposits. The deposit forms as lensoid shape, layers, beds and massive. Almost 2/3 of world base metal reserve is extracted from sediment hosted deposit/sedimentary exhalative deposits/Sedex) (MacIntyre, 1995).

Hydrothermal Pb-Zn deposits are formed due to the deposition of the late stage fluid of intrusive body known as hydrothermal fluids that penetrated the host lithology. Pb-Zn hydrothermal deposits are commonly associated with high sulphidation epithermal deposit (Corbett and Leach, 1995). Within the skarn type mineralization, the responsibility for the source of ores is a pluton that occurs near the area. The fluid replaced the calcareous rocks (limestone) as the host rocks (Sawkins, 1990). So far, the deposits which belong to the sedex type are Dairi prospect (Herald Resources Ltd., 2001) while others belong to both skarn and hydrothermal types. Pb-Zn-Ag deposit at Tanjung Balit may belong to hydrothermal style of high sulphidation epithermal system.

Although several deposits are present, no deposit is exploited, except that at Tanjung Balit which is mined by trenching and collecting the ore while stripping the overburden. At the moment, many investors (mining companies) are interested in exploring such deposits.

The area of Tanjung Balit prospect is approximately 300 hectares and is now owned by the PT. Berkat Perkasa (local property). Up to now, the area has been explored in detail including drilling, trenching and soil sampling in order to evaluate the ore values. The deposit is hosted within the interbedded meta sandstone, slate, filit, siltstone and claystone. The ore is in the form of veins, veinlets either conformable/ stratiform or unconfomable with the bedding of the rocks.

This paper is to study the hydrothermal alteration, mineralogy and paleo-temperature of Pb-Zn, Cu, Ag depositv at Tanjung Balit area, Limapuluh Kota Regency, West Sumatera.

ANALYTICAL METHODS

Selected samplings of both mineralized and unmineralized rocks have been undertaken during the research project held by Geological Survey Institute in 2006. All samples have been screened for mineral and ore compositions, alteration and paleo-temperatures. Sample treatments have been analyzed at the Geollab (GSI) using XRD (PW3040/x0X'Pert PRO), ASD (*Portable Analytical Spectral Devices*) and Fluid Inclusion Stage. The result of the analyses is shown in Table 1, 2 and 3.

Figure 1. Location map of the study area.

Regional tectonic setting

Sumatera Island, which is a product of the oblique subduction of Hindia Plate with the Sundaland has a complex tectonic setting (Hamilton, 1979; Hutchison, 1980; Barber *et al*., 2005). A complex tectonics, structure, lithology as well as mineralization are collaborated along the Barisan Mountain in Sumatera Island. Therefore, many researchers are interested in studying this region in order to solve the geological problems. A subduction process has resulted in mixing rocks both originated from oceanic and continental areas (Hamilton, 1979; Pulunggono and Cameron, 1984). The emplacement of magmatic and volcanic activities as well as the structural features has greatly attributed to control an ore formation in the area.

Tectonic setting of Sumatera has been compiled by many authors (Hamilton, 1979; Hutchison, 1980; Aspden *et al*., 1982; Barber *et al*., 2005). As shown in Figure 2, tectonic elements of Sumatera comprise three domains (Barber *et al*., 2005), *i.e*. West accretionary complex, volcanic arc and basins. The Sumateran Fault Zone is located within the Pre-Tertiary basement complex (Sundaland fragment) while the basin is dominated Quaternary-Recent sediments and volcanics.

Table 1. Result of XRD Analyses of Altered Samples from Tanjung Balit

Sample No. / Mineral alter	06YE 02a	02b	04	06	07	08	09	10	13	14a	16	17	20b	20c	21	022	023	024	025
Actinolite		x																	
Anglesite											x								
Chalcopyirite										x									
Chalcosite												x							
Crystobalite														x					
Diaspore													x						x
Geothite													x			x			
Galena	x	x	x	x	x	x	x				x						x	x	
Illite			x					x	x										
Kaolinite			x																
Magnesite					x														
Montmorilonite									x										
Muscovite															x				
Phlogopite								x							x				x
Pyrite		x	x	x	x	x	x		x	x	x							x	x
Quartz		x	x		x	x		x		x		x	x	x					
Rhodokrosite												x							
Rutile																			x
Sphalerite					x	x													
Siderite					x		x												
Sphangolite												x							
Troilite					x			x											

Table 2. Result of ASD Analysis of Altered Samples from Tanjung Balit

No. Sampel / Mineral alter	06YE 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Ankerite																					x			
Analcime																					x			
Alunite																							x	x
Chlorite							x											x						x
Clinochlore											x									x		x		
Carbonate												x			x									
Calcite													x											
Diaspore			x																					
Dickite				x	x					x	x	x	x	x	x	x	x	x	x	x				x
Dolomite													x											
Hematite							x	x		x	x	x	x	x		x	x	x						
Illite	x	x	x	x	x	x	x	x			x	x	x	x	x									x
Kaolinite		x				x	x		x			x	x		x	x	x		x	x		x	x	x
Monmorillonite		x	x		x				x	x	x							x	x	x	x	x	x	
Muscovite	x					x	x				x	x		x										
Magnesite						x																		
Pyrophylite	x						x			x		x	x	x	x									
Siderite		x																x						

Table 3. Result of Fluid Inclusion Measurement

Sample No.	Type Incl.	Size/Shapes	Tm	Th (°C)	Remarks
06YE014a	Secondary	<0.5μ	-	285.1-350	4 times meas.
06YE15a	Secondary	<0.5μ	-	>185	
06YE27a	Secondary	<0.5μ	-	26.5-242.0	3 times meas.

Note :
Meas. = measurement

Regional Geology

Pre-Tertiary basement rocks in Sumatera, which is exposed along the central spine of the Barisan Mountain, extend along the length (500 km) of the island parallel to the southwest coast (Figure 3). To the northeast and southwest, the basement is overlain by Tertiary to recent sedimentary and volcanic rocks, including the products of recent volcanic activity follows the NW-SE trend of the Barisan along the whole length of the island. Tapanuli Group is the oldest rocks exposed in the area and is formed as the basement of the Sumatera mainland (Sartono and Sinuraya, 1985; Aspden *et al*., 1982; Cameron *et al*., 1980; Pulunggono and Cameron, 1984). This group is formally further divided into 3 formations (Kuantan, Kluet and Bahorok Formations) (Rosidi *et al*., 1976; Cameron *et al*., 1982b; Aldiss *et al*., 1983) plus two undifferentiated units (Undifferentiated Permo-Carboniferous rocks and Undifferentiated Mesozoic and/or Paleozoic Strata). Both Kuantan and Kluet Formations are mainly composed of similar rocks of slates, metaquartzose arenites, quartzite, wackes, metaarenites and argillites (Silitonga and Kastowo, 1975; Rosidi *et al*., 1976). Carbonate rock is part of the meta-clastic sediments form layers and lenses both in the Kuantan and Kluet Formations. The Bahorok Formation comprises interbedded quartz sandstone, greywake, and conglomerate. The undifferentiated Permo-carboniferous comprises conglomeratic metawackes, metaarenite and slates and the undifferentiated Mesozoic Paleozoic Strata comprising metavolcanics, slate and limestone. This group is unconformably overlain by Permian Peusangan Group which is broadly divisible into two formations: Silungkang and Telukkido Formations (Rosidi *et al*.1976; Cameron *et al*., 1980). The Silungkang Formation composes of limestone, basic metavolcanics, metatuffs and volcaniclastic sandstone (Fontains and Gafoer, 1989). In contrast, the Telukkido Formation comprises pyritic feldsphatic metaquartzose arenites and argillite with thin coals and plant remains (Rock *et al*., 1983). These two groups in fault contact with the Woyla Group and intruded by the Paleozoic to Mesozoic Granitoid. The Woyla Group in this region formed as an oceanic assemblage which composes of serpentinites, amphibolitised gabbros, pillow basalts, hyaloclastites, cherts and deep sea sediments, interpreted as imbricated segments of ocean floor and its underlying mantle (Cameron *et al*, 1980; Rock *et al.,* 1983, Kastowo *et al*., 1978). The three groups and the granitoid are unconformably overlain by sediments and intruded by the granite to granodiorite of Tertiary ages. These Paleozoic and Mesozoic rocks are in fault contact with Ultrabasic rocks, and intruded by Cretaceous Granite. The whole of Pre-Tertiary rocks are acting as a basement rock, and unconformably overlain by Tertiary and Quarternary rock units. The oldest Tertiary rock unit are Pematang and Sibolga Formations of Oligocene age (Aspeden *et al*., 1982). They are uncorformably overlain by Miocene Kampar and Gadis Groups respectively (Aspeden *et al*., 1982). The Middle to Late Miocene igneous and volcanic rocks intruded the older rocks and also cover these two groups. The old Tertiary rocks are covered by Pliocene to Holocene volcanic rocks.

Figure 2. Tectonic domains of Sumatera (Barber *et al*., 2005).

District geology

A simplified geological map of the Tanjung Balit area is shown in Figure 4 (Taufik & Pohan, 1984). The main lithology comprises interbedded meta-quartz sandstone, siltstone, shale and conglomerate. Meta-quartz sandstone is light grey, fine-medium grained;

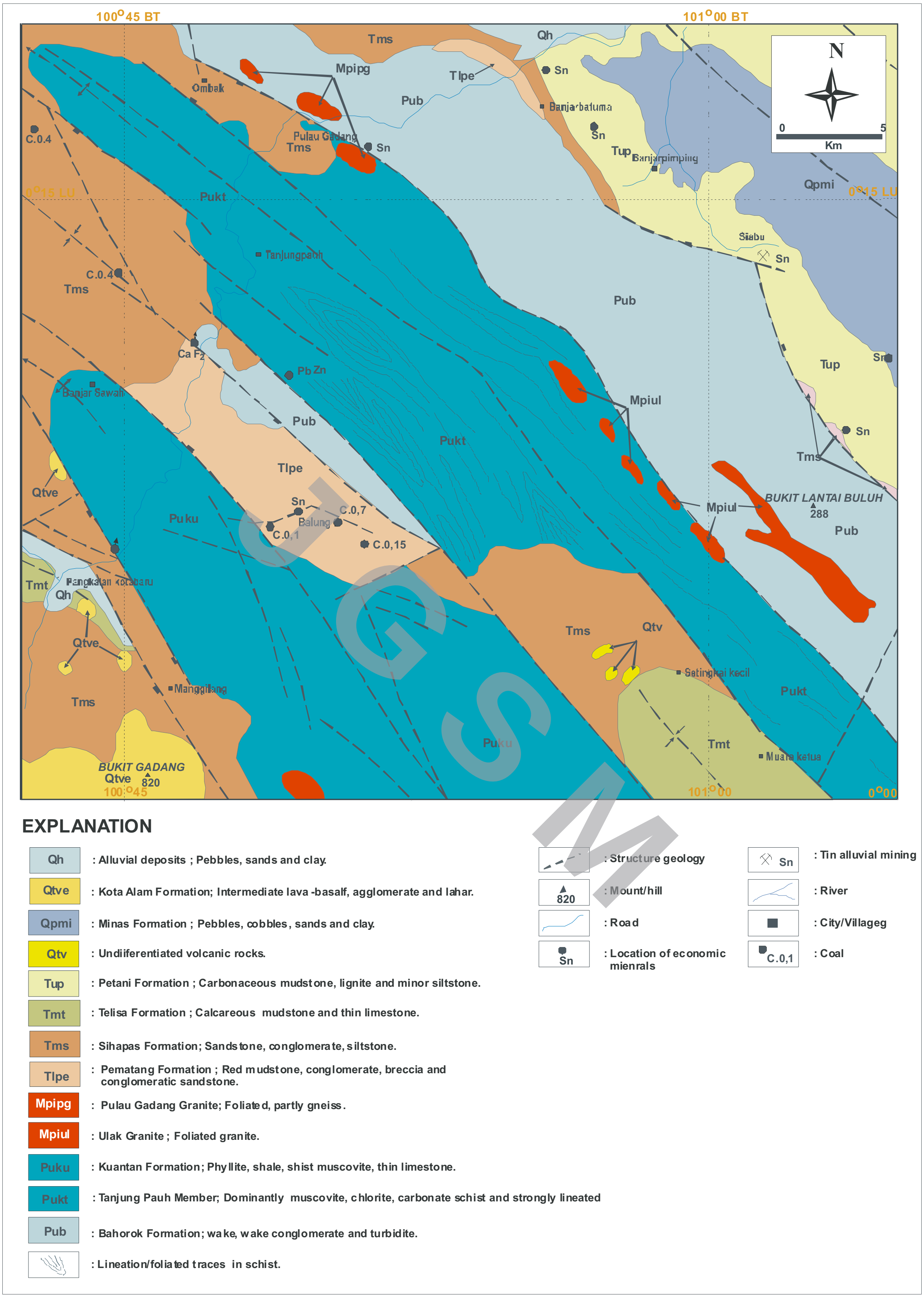

Figure 3. Regional geological map of the Tanjung Balit area (Rosidi *et al*., 1976).

showing thinly beds (5-10 cm) up to massive and is altered to some degree and strongly oxidized. Cross-cutting and stratiform quartz veins are seen within these rocks. Shale is grey, strongly weathered and altered while siltstone is light grey, soft, strongly weathered (Figure 5a). Conglomerate is dark grey, polymict, with 2-7 cm in diameter components of igneous rocks, sediments, and quartz.

Petrographical studies of selected samples show that the rocks are moderate to strongly altered and strongly weathered. In general, minerals detected are quartz, serisite, zeolite, clay minerals and opaque minerals. So far, the fresh rocks observed under microscope is only slate, consisting of low grade metamorphic minerals such as sericite and muscovite with additional of quartz and opaque minerals (Figure 5b).

Hydrothermal alteration

A total of 19 and 24 samples respectively have been analyzed for hydrothermal alteration using XRD and ASD methods (Table 1 and 2). Minerals identified using XRD are kaolinite, illite, monmorillonite, phlogopite, diaspore, rutil, muscovite, spinel, crystobalite, quartz, spangolite, rhodochrosite, anglesite, pyrite, galena, sphalerite and chalcosite. While using ASD, are silica, illite, monmorillonite, pyrophyllite, muscovite, siderite, diaspore, dickite, magnesite, chlorite, carbonate, rhodochrosite, analcime, alunite, smectite, ankerite, calcite, dolomite, sericite and zeolite. Some selected mineral alteration assemblages are shown in Figure 6A and 6B. These minerals are well distributed within altered rocks (claystone, siltstone, sandstone, shale and slate).

Mineralization

The main ore body found in the area is a polymetalic Pb-Zn-Cu-Ag. It is in the form of veins, veinlets and disseminated features within the host rocks. The veins range from few cm to 50 cm thick either conformable to the beddings or crosscutting veins (Figure 7a). In general, the direction of veins is N110E (Djaswadi & Sukirno, 1981), *i.e.*, similar to the direction of Sumateran Fault Zone. The vein consists of massive ores or a quartz vein with ores (Figure 7b). Additional ores such as pyrite, chalcopyrite, marcasite, chalcosite, magnetite and Pb- oxides are also found.

Galena, which is light grey in colour, massive, showing “triangular pits”. Some of which are folded and faulted due to deformation (Figure 7c). The galena is either as massive veins or associated with quartz veins, cavity fillings (Figure 7d), or replacing the gangue minerals. Sphalerite is dark grey, disseminated and uncrystallized (Figure 7d), replacing galena or pyrite and cavity fillings and contains blebs of chalcopyrite. Chalcopyrite is yellow, uncrystallized; commonly found within sphalerite as ”chalcopyrite disease” due to partial replacement of sphalerite by chalcopyrite (Eldridge *et al*., 1988). Pyrite is pale yellow, disseminated feature, vein/veinlets. Magnetite is dark grey, veinlets, crosscuting vein within galena. Marcasite is dark yellow, good cleavage and replaced galena and pyrite. Silver is difficult to identify except using AAS analysis (66-2364 ppm, Taufik & Pohan, 1984).

Fluid inclusions

A 3 mm thin section was prepared in GSI -Laboratory. A total of 4 samples have been measured (Table 3). Before measuring, it is firstly observed under a polarized microscope to identify the individual inclusions. Samples are measured under Fluid Inclusion Microscope Stage at GeoII Lab, GSI. In this measurement, only secondary inclusions are available. The size of inclusion ranges from <0.5 micron, bipase and irregular crystals. First melting temperatures (Tm) and the salinity of the fluids are unable to calculate. However, homogenization temperatures calculated from selected secondary inclusions range from 185° - 350°C.

DISCUSSIONS

Pb-Zn-Cu-Ag mineralization in Tanjung Balit area is hosted within metasediments of the Kuantan Formation. The rocks include claystone, siltstone, shale, slate and phyllite (Rosidi *et al*., 1976). These rocks have been experienced hydrothermal alteration. Most of them are altered from weak to strong alteration forming silicification-subprophylitic-argillic-advanced argillic assemblages. Silicification is characterized by the dominantly silica; the subprophylitic alteration are composed of mineral assemblages of silica, chlorite, siderite, calcite, ankerite, rhodochrocite, dolomite, chlino-chlor and dolomite. The argillic assemblages are characterized by the presence of illite, monmorillonite, smectite, dickite, kaolinite, analcime and magnesite. The advanced argillic alteration is the presence of diasphore, pyrophyllite, mica, alunite-haloysite-silica. These mineral are disseminately distributed within slate, meta-sandstone/siltstone, shale and veins.

Hydrothermal mineral assemblages in the Tanjung Balit area are almost similar to those in Bonjol area (Abidin and Harahap, 2007). The differences are the presence of secondary Cu minerals such as anglesite, spangulite and chalcosite in the Tanjung Balit. The alteration characters of the secondary hydrothermal minerals indicate that the Tanjung Balit deposit may belong to a high sulphidation style (HS) (Corbett and Leach, 1995). As a matter of fact, the Tanjung Balit deposit contains polymetallic minerals (mainly base metals) consisting of galena, sphalerite, silver, pyrite and chalcopyrite with additional supergene minerals such as hematite, jarosite and guthite.

Fluid inclusion measurements within the quartz veins show that the homogenization temperatures range from 185°-350°C (all inclusions are secondary). Those higher temperatures (up to 350°C) are regarded as a high sulphidation system (Berger and Henley, 1989).

As a whole, on the basis of ore mineralogy, hydrothermal alteration assemblages as well as temperatures, the Pb-Cu-Zn-Ag mineralization in Tanjung Balit may characterize a high sulphidation epithermal style.

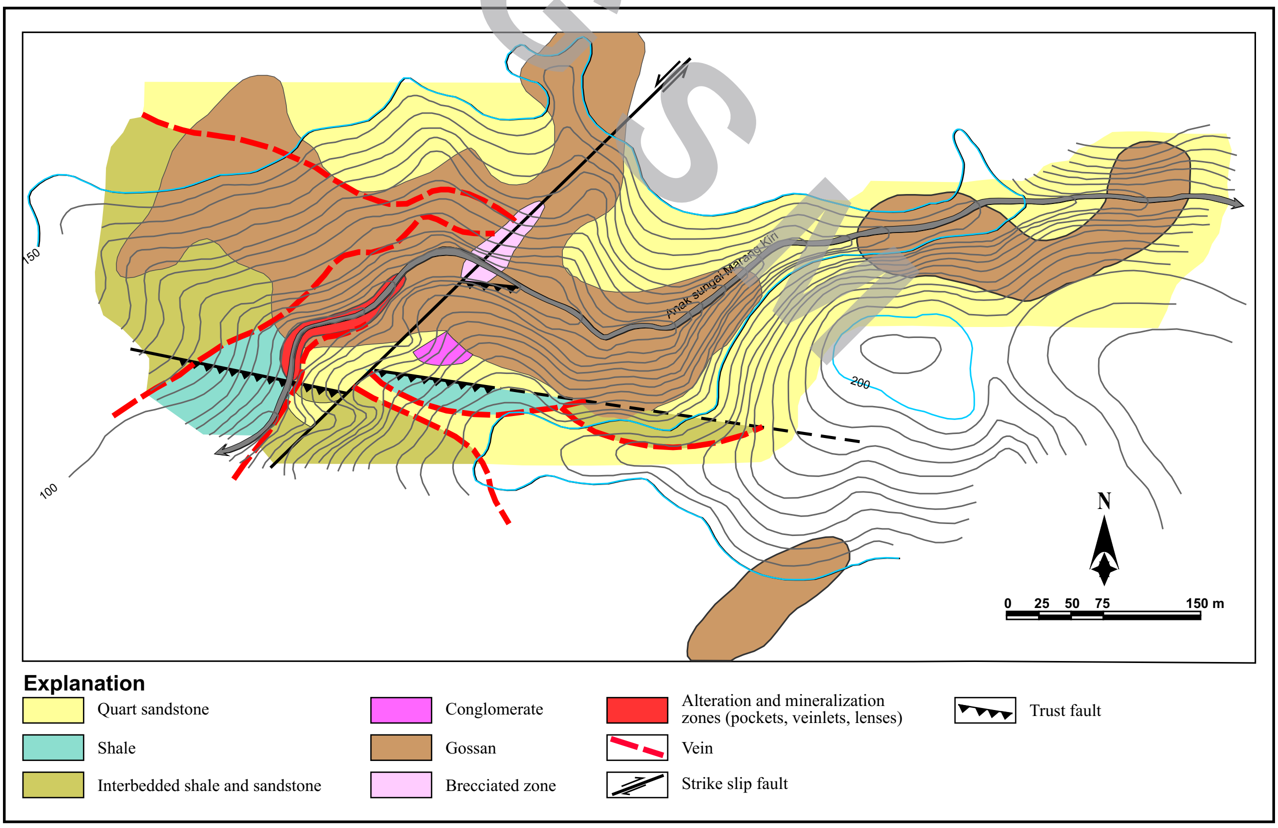

Figure 4. Simplified geological map of the Tanjung Balit area (Taufik & Pohan, 1984).

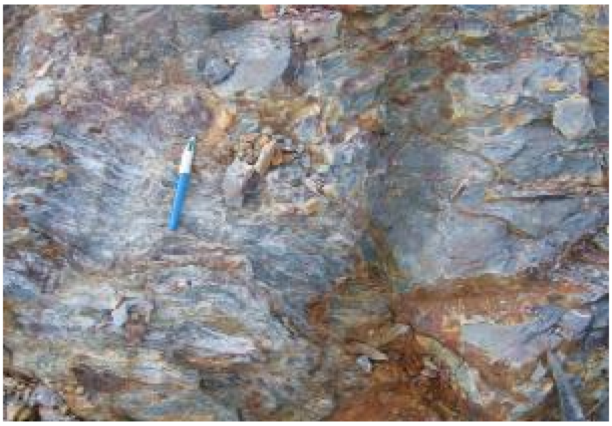

Figure 5a. Shale and claystone in Tanjung Balit area.

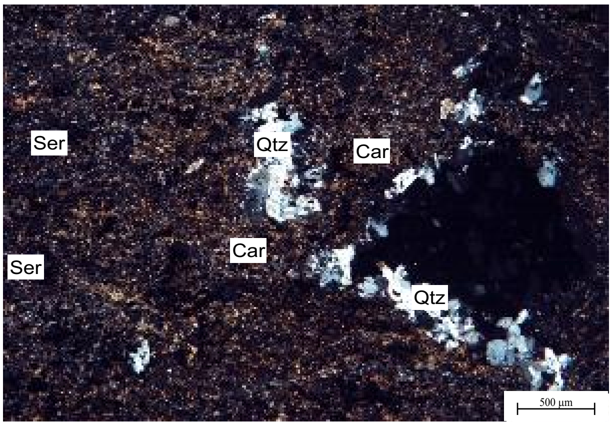

Figure 5b. Microphotograph showing sericite (Ser), carbonate (Car) and quartz (Qtz) within slate.

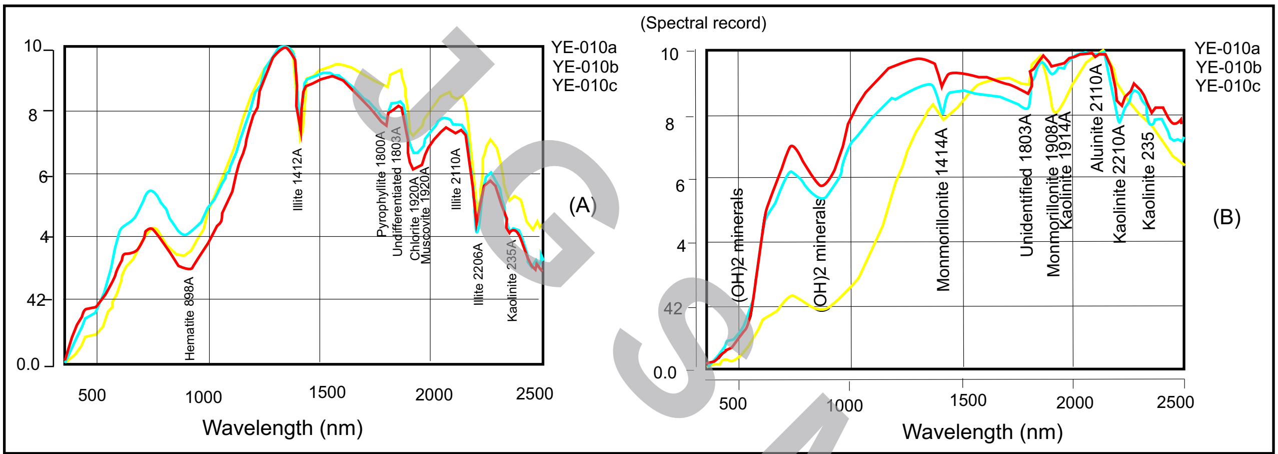

Figure 6. Graphic distribution of selected hydrothermal mineral assemblages showing pyrophyllite, illite, kaolinite using XRD analysis (A) and alunite, monmorillonite and kaolinite using ASD analysis (B).

Figure 7a. Cross-cutting Pb- veinlets within meta sandstone.

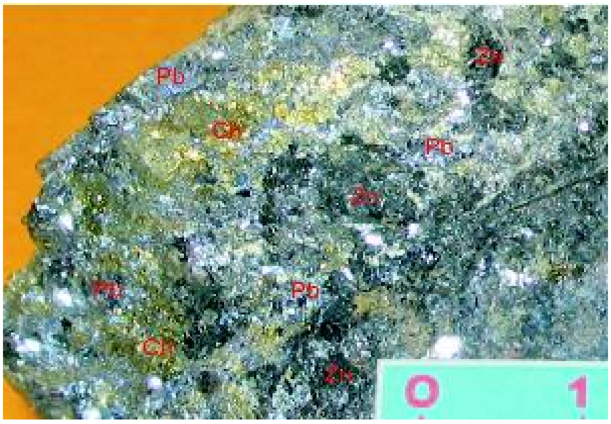

Figure 7b. Massive ore of galena (Pb), sphalerite (Zn) and chalcopyrite (Ch).

Figure 7c. Microphotograph showing folded Pb-ore and quartz (Qtz).

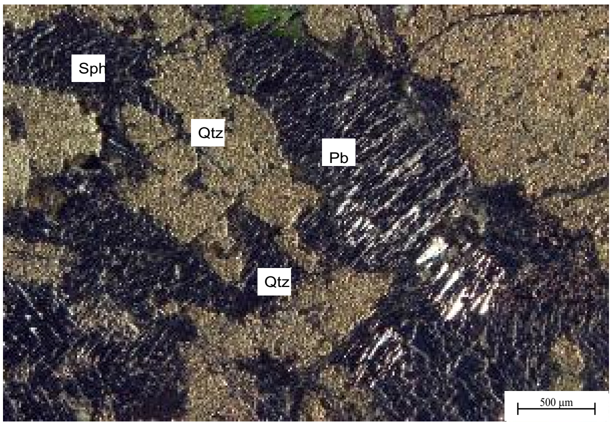

Figure 7d. Microphotograph showing. Pb-ore and sphalerite (Sph) cavity fillings in quartz (Qtz)

CONCLUSIONS

The Pb-Zn-Cu-Ag mineralization in Tanjung Balit is hosted within the Tapanuli Group of Kuantan Formation. The deposit is hosted within interbedded quartz sandstone, greywacke and interbedded shale, meta sandstone, slate and phyllite. The deposit belongs to the polymetallic mineralization where the major ore are lead, sphalerite, chalcopyrite and silver with minor magnetite, marcasite, chalcosite and gold. Base metallic minerals are rich in the deposit. Various hydrothermal alteration assemblages (silicification, sub-prophilitic, argillic and advanced argillic) have been identified. The silicification is dominated by quartz while sub-prophylitic zone is silica, chlorite, siderite, calcite, ankerite, rhodochrocite, dolomite, chlino-chlor and dolomite; the argillic assemblage is illite, monmorillonite, smectite, dickite, kaolinite, analcime, magnesite and the advanced argillic is the alunite, diasphore, pyrophyllite, mica, haloysite and silica. The deposit was formed by the temperature ranging from 185-350C (secondary inclusions within quartz vein). On the basis of ore mineralogy (high base metal contents), alteration mineralogy (alunite, diasphore, pyrophyllite, mica, halloysite and silica), the Pb-Zn-Cu-Ag deposit in Tanjung Balit may have a similarity to high sulphidation epithermal type.

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