INDONESIAN MINING JOURNAL Vol. 17, No. 3, October 2014 : 122 - 133

MINERALIZATION OF THE SELECTED BASE METAL DEPOSITS IN THE BARISAN RANGE, SUMATERA, INDONESIA (CASE STUDY AT LOKOP, DAIRI, LATONG, TANJUNG BALIT AND TUBOH)

MINERALISASI CEBAKAN LOGAM DASAR TERPILIH DI BUKIT BARISAN, SUMATERA - INDONESIA (STUDI KASUS DI LOKOP, DAIRI, LATONG, TANJUNG BALIT DAN TUBOH)

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ABSTRACT

Three types of base metal occurrences discovered along the Barisan Range, Sumatera are skarn, sedex and hydrothermal styles. The skarn styles include Lokop, Latong and Tuboh, while Dairi and Tanjung Balit belong to sedex and hydrothermal deposits, respectively. The Lokop deposit is dominated by galena with minor pyrite and is hosted within interbedded meta-sandstone, slate, phyllite, hornfels and quartzite of the Kluet Formation. The Skarn Latong deposit consists of galena with minor sphalerite and chalcopyrite with skarn minerals of magnetite, garnet and calcite. It is hosted within the meta-limestone of the Kuantan Formation. The Skarn Tuboh deposit is dominated by sphalerite with minor galena, pyrite, manganese, hematite and magnetite. It is hosted within interbedded meta-sandstone and meta-limestone of the Rawas Formation. The Dairi deposit belongs to the sedimentary exhalative (sedex) type. It is hosted within the sedimentary sequence of the Kluet Formation. Two ore types known are Julu and Jehe mineralization. The Julu mineralization referring to as sediment exhalative (sedex), was formed syngenetically with carbonaceous shale. Ore mineralogies consist of galena, sphalerite and pyrite. The deposit was formed within the temperature range of 236-375°C with salinity ranges from 9,3-23% wt.NaCl. The Jehe mineralization which belongs to the Mississippi Valley-Type, is hosted within dolostone of the Jehe Member. Ores comprise galena, sphalerite, pyrite, chalcopyrite, tetrahedrite and tenantite. The deposit was formed at temperature range from 193-400°C with salinity up to 38.2% wt.NaCl. The Tanjung Balit deposit belongs to the hydrothermal mineralization. The deposit is hosted within the sedimentary sequence of the Silungkang Formation. Ores consist of chalcopyrite, galena and sphalerite with minor gold and silver. Hydrothermal minerals such as silica, illite, montmorillonite, pyropilite, muskovite, siderite, diaspor, dickite, magnesite, chlorite, carbonate, rhodochrosite, analcime, alunite, smectite, ankrite, calcite, dolomite, sericite and zeolite are common found. The Tanjung Balit mineralization is formed at the temperature range from 185-350°C and belongs to meso-epithermal type.

Keywords : kluet, sedex, skarn, base metals

Received : 12 December 2013, first revision : 28 April 2014, second revision : 25 August 2014, accepted : October 2014

SARI

Tiga jenis logam dasar yang dijumpai sepanjang Pegunungan Bukit Barisan, Sumatera, adalah cebakan skarn, eksalasi sedimen and hidrotermal. Jenis skarn termasuk Lokop, Latong dan Tuboh, sedangkan Dairi dan Tanjung Balit masing-masing termasuk eksalasi sedimen dan hidrotermal. Cebakan Lokop didominasi oleh galena dengan sedikit pirit and terdapat dalam perselingan batupasir meta, batusabak, filit, batutanduk dan kuarsit dari Formasi Kluet. Cebakan Latong mengandung galena dengan sedikit sfalerit dan kalkopirit terdapat dalam batugamping meta dari Formasi Kuantan. Mineralisasi berbentuk lapisan, lensa dan kantong serta berasosiasi dengan mineral skarn berupa magnetit, garnet dan kalsit. Cebakan Tuboh didominasi oleh sfalerit dengan sedikit galena, pirit, mangan, hematit dan magnetit. Cebakan Tuboh terdapat dalam batugamping-meta dari Formasi Rawas. Cebakan Dairi termasuk jenis eksalasi sedimen (sedex). Mineralisasinya terdapat dalam runtunan batuan sedimen dari Formasi Kluet. Ada 2 jenis mineralisasi yang dapat dibedakan, yaitu Julu dan Jehe. Mineralisasi Julu yang digolongkan ke dalam eksalasi sedimen, terbentuk singenetik dengan serpih karbonan. Mineralogi bijih terdiri dari galena, sfalerit dan pirit. Mineralisasi berupa lapisan dengan ketebalan mencapai hingga 8 m. Cebakan Julu terbentuk pada kisaran temperatur dari 236-375°C dengan kegaraman berkisar dari 9,3-23% berat NaCl. Sebaliknya, mineralisasi Jehe termasuk jenis Missisippi Valley-Type dan terdapat dalam dolomit dari Anggota Jehe. Mineralisasi terdiri dari galena, sfalerit, pirit, kalkopirit, tetrahedrit dan tenantit. Cebakan Jehe terbentuk pada kisaran temperatur dari 193-400°C dengan kegaraman mencapai 38,2% berat NaCl. Cebakan Tanjung Balit termasuk jenis hidrotermal, yang terdapat dalam runtunan batu sedimen dengan sisipan tuf Formasi Silungkang. Mineralogi bijih terdiri dari kalkopirit, galena, sfalerit, dan sedikit emas dan perak. Cebakan ini berupa urat dan tersebar. Mineralisasi diikuti oleh mineral ubahan seperti silika, ilit, monmorilonit, pirofilit, muskovit, siderit, diasfor, dikit, magnesit, klorit, karbonat, rodokrosit, analsim, alunit, smektit, ankerit, kalsit, dolomit, serisit dan zeolit. Cebakan Tanjung Balit terbentuk pada kisaran temperatur 185-350°C dan termasuk jenis meso-epitermal.

Kata kunci : kluet, eksalasi sedimen, skarn, logam dasar

INTRODUCTION

It is well known that the economic reserves of base metals (Pb-Zn-Cu) in the world almost come from the sedimentary process. Almost 2/3 of world base metal reserve is extracted from sediment hosted deposit/sedimentary exhalative deposits/sedex) (MacIntyre, 1995; Large, 1977; Goodfellow et al., 1993). Research development of base metal deposits have resulted in several types of base metal deposits in the world such as " Irish Type", "Mississipi Valley Type", "Sedex" and "Broken Hill Type", and volcanogenic massive sulphides (Stanton, 1972; Large, 1977; Ridler and Shilt, 1974).

In Indonesia, such deposits are randomly distributed in Sumatera, Kalimantan, Sulawesi and other small islands (Machali et al., 1987; Sukirno, 2006). However, only some of them have been investigated, especially in Sumatera Island, i.e., Dairi Pb-Zn deposit at Sopokomil village, Karo Regency, North Sumatera ((Noya et al., 2002; Sinaga, 2006); Latong deposit at Siabu District, Madina Regency, North Sumatera (Hakim et al., 2005; Hakim, 2003); Lokop Pb-Fe deposit at Lokop District, East Aceh Regency (Sukirno, 2006), Tanjung Balit Pb-Cu-Zn deposit, Pangkalan District, Limapuluh Kota Regency, West Sumatera (Elhami, 2008; Abidin, 2008; Rizal, 2006) and Tuboh deposit, Lubuk Linggau, South Sumatera (Abidin, 2010), as shown in Figure 1. Indication of such deposits is also found at Painan, Pesisir Selatan Regency; Aek Pawan, Sayur Matinggi District, South Tapanuli Regency, North Sumatera and Lubuk Turop prospect, Gunung Tua District, South Tapanuli and Langkat, Sumatera Utara; Singkil Regency and Blengkejern (Gayo Alas), Aceh; Gunung Batu prospect, Abai Pb-Fe deposit, Solok Selatan Regency, West Sumatera (Abidin, 2008; Abidin and Baharuddin, 2008; Abidin and Harahap, 2007; Abidin and Purnama, 2006; Rizal, 2006; Sunarya et al., 1985). The deposits are associated with sedimentary sequence of the Pre-Tertiary Tapanuli Group, granites and monzonite.

The aim of this paper is to describe the differences among the Lokop, Latong, Toboh, Dairi and Tanjung Balit deposits, i.e., geology, mineralogy and genetic models.

METHODOLOGY

Data of this paper are compiled during research work carried out by the Center for Geological Survey (CGS) formerly the Geological Research

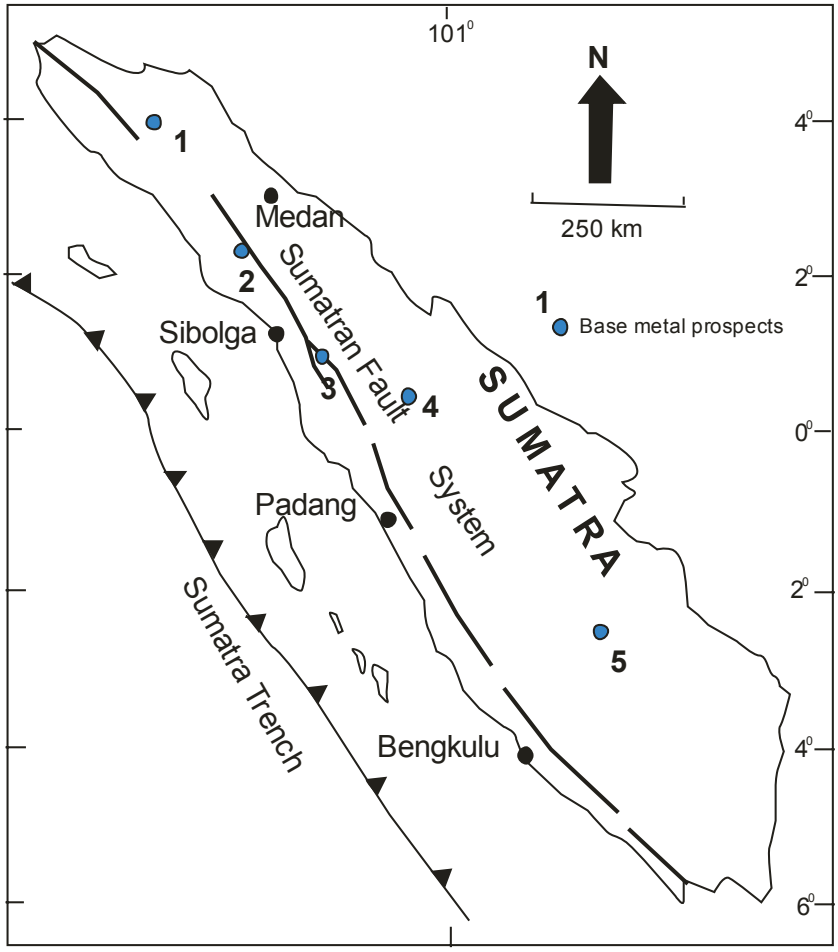

Figure 1. Distribution of selected base metal deposits in Sumatera.
1. Lokop; 2. Dairi; 3. Latong; 4. Tanjung Balit; 5. Tuboh

and Development Centre (Abidin and Suyono, 2004; Abidin and Suwarti, 2005; Noya et al., 2002; 2004; Hakim et al., 2005; Bambang and Yudawinata, 2001; Sinaga, 2006; Baharuddin, 2004; Harahap et al., 2009). During the field work, selected samples were collected. Laboratory work including polished section, petrography and mineral analysis (Cu, Pb, Zn and Au) (AAS) were carried out by Geollab, CGS.

TECTONIC AND GEOLOGIC SETTING

Regional Tectonic Setting

Like most other islands in Indonesia, Sumatera forms a complex tectonic setting (Katili and Hehuwat,1967; Tjia,1977; Hamilton,1979; Hutchison, 1994; Barber and Crow, 2000). A subduction process between the Thetis Ocean and the Sundaland basement has resulted in a mixing rock both originated from oceanic and continental areas (Katili, 1973; Hamilton, 1979; Pulunggono and Cameron, 1984; Hutchison, 1994; 2007). Magmatic and volcanic activities as well as the structural collision, have significantly contributed to control an ore formation in the area.

Pre-Tertiary regional tectonic scheme of Southeast Asia has been constructed by several authors (Hamilton, 1979; Cameron et al., 1980; Daly et al., 1991; Pulunggono and Cameron, 1984; Metcalfe, 1996; 1998; Barber et al., 2005; Hartono, 2002). Three terains have been classified (Hutchison, 1994), i.e., West Sumatera Terrain (Cathaysian), Sinoburmalaya (Gondwana) and East Malaya (Cathaysian). The study area is located within West Sumatera Terrain within the western part of the Barisan Zone with base metals indication (Machali et al., 1997; Sunarya

et al., 1985). The Sinoburmalaya Terrain, which contains quartz sandstone and glacial deposit, forms as a Gondowana and is bounded by West Sumatera Terrain as “Medial Sumatera Line” of Sumateran Fault Zone. The East Malaya terrain, which is characterized by the presence of Lower Permian fusulinid limestone and Permian volcanic rocks, extends to Indochina and South China and is bounded by the Sutura Benton-Raub and Sinoburmalaya Terrains.

Regional Geology of the Base Metal Deposit in Sumatera

Pre-Tertiary basement rocks in Sumatera, which is exposed along the central spine of the Barisan Mountains, extend along the length (500 km) of the island that is parallel to the southwest coast, as illustrated in Figure 2. To the northeast and southwest, the basement is overlain by Tertiary to recent sedimentary and volcanic rocks, including the products of recent volcanic activities follows the NW-SE trend of the Barisan along the whole length of the island.

Carboniferous metasediments and carbonate rocks assigned to Tapanuli Group are the oldest rocks exposed in the area and were formed as the basement of the Sumatera mainland (Cameron et al., 1980). This group is formally further divided into two formations, namely the Kluet Formation and Kuantan Formation and two undifferentiated rock units (Undifferentiated Permo-Carboniferous rocks and Undifferentiated Mesozoic and/or Palaeozoic Strata) (Cameron et al., 1982; Clarke et al., 1982; Rock et al., 1983). The Kluet Formation is mainly composed of metaarenites and argillites, while the Kuantan Formation comprises slates, metaquartzose arenites, quartzite and wackes. A carbonate rock is part of the meta-clastic sediments forms layers and lenses both in the Kluet and Kuantan Formations. The undifferentiated Permo-carboniferous comprises conglomeratic metawackes, metaarenite and slates and the undifferentiated Mesozoic-Palaeozoic Strata comprise metavolcanics, slate and limestone. This group is unconformably overlain by the Permian Peusangan Group (Rock et al., 1983), which consists of Silungkang and Telukido Formations.

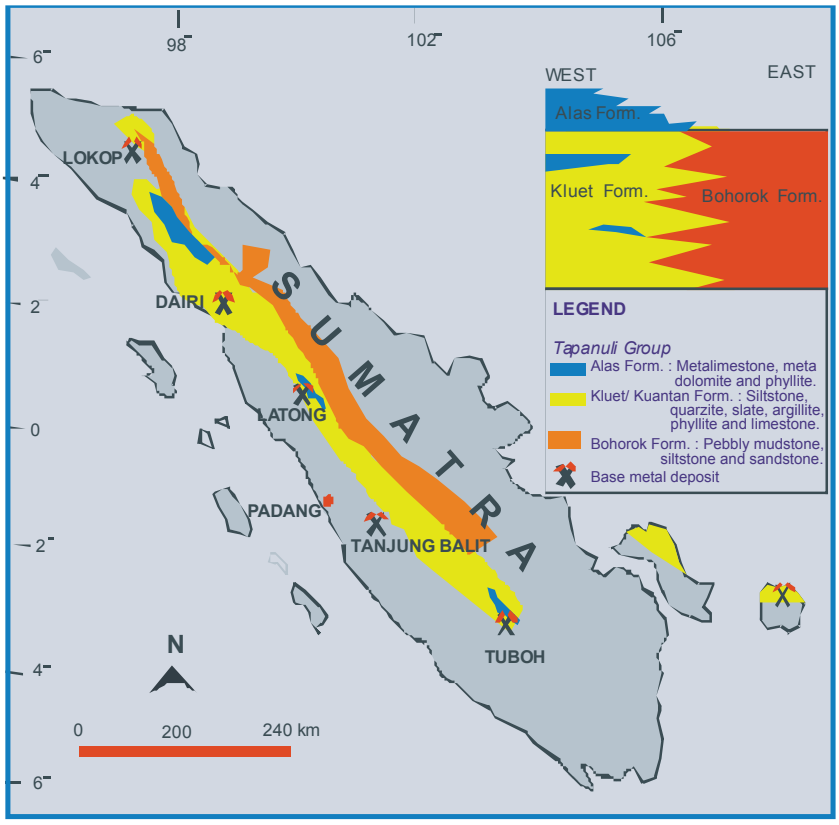

Figure 2. Map showing the distribution of the Pre-Tertiary Tapanuli Group in Sumatera (Clarke et al., 1980)

The Silungkang Formation includes limestone, basic metavolcanics, metatuffs and volcaniclastic sandstone (Hartono, 2002). In contrast, the Telukkido comprises pyritic feldsphatic metaquartzose arenites and argillite with thin coals and plant remains. These two groups in fault contact with the Woyla Group and intruded by Paleozoic to Mesozoic Granitoids. The Woyla Group in this region formed as an oceanic assemblage, which is composed of serpentinites, amphibolitised gabbros, pillow basalts, hyaloclastites, cherts and deep sea sediments, interpreted as imbricated segments of ocean floor and its underlain mantle (Cameron et al., 1980).

All these Paleozoic and Mesozoic groups and the granitoid are unconformably overlain by Tertiary sediments and intruded by the granite to granodiorite of Tertiary ages.

The oldest Tertiary rock unit is Pematang and Sibolga Formations of Oligocene age. They are uncorformably overlain by Miocene Kampar and Gadis Groups, respectively. The Middle to Late Miocene igneous and volcanic rocks intrude and also cover these two groups. The old Tertiary rocks are covered by Pliocene to Holocene volcanic rocks.

Geology of Prospect Areas

In general, the rock units of the prospect area belong to the Tapanuli Group (Figure 2). Age of the formation ranges from Early Carboniferous to Middle Permian (Cameron et al., 1980; Clarke et al., 1982). The group was intruded by some granite Batholiths of Permo-Triassic-Cretaceous age. Brieftly, geology of each prospect includes Lokop, Dairi, Latong, Tanjung Balit and Tuboh will be dicussed in more detailed.

In Lokop prospect, the deposit is still hosted within the Pre-Tertiary Kluet Formation. However, the knowledge of geology is very limited. In the field, the exposures of the Kluet Formation in the area have been strongly weathered. The litohological units observed are phyllite, meta-sandstone and quartzite. Pb-Fe deposit is encountered whithin the weathered rocks (Abidin and Harahap, 2007).

The Dairi deposit (Figure 3) is occupied by Pre Tertiary sedimentary sequence referring to as Kluet Formation (Aldiss et al., 1983; Sinaga, 2006). The Kluet Formation in this area is divided into Dagang Beds Member (Dairi Prima Mineral) and Julu Silty Carbonacous Shale Member (Her-

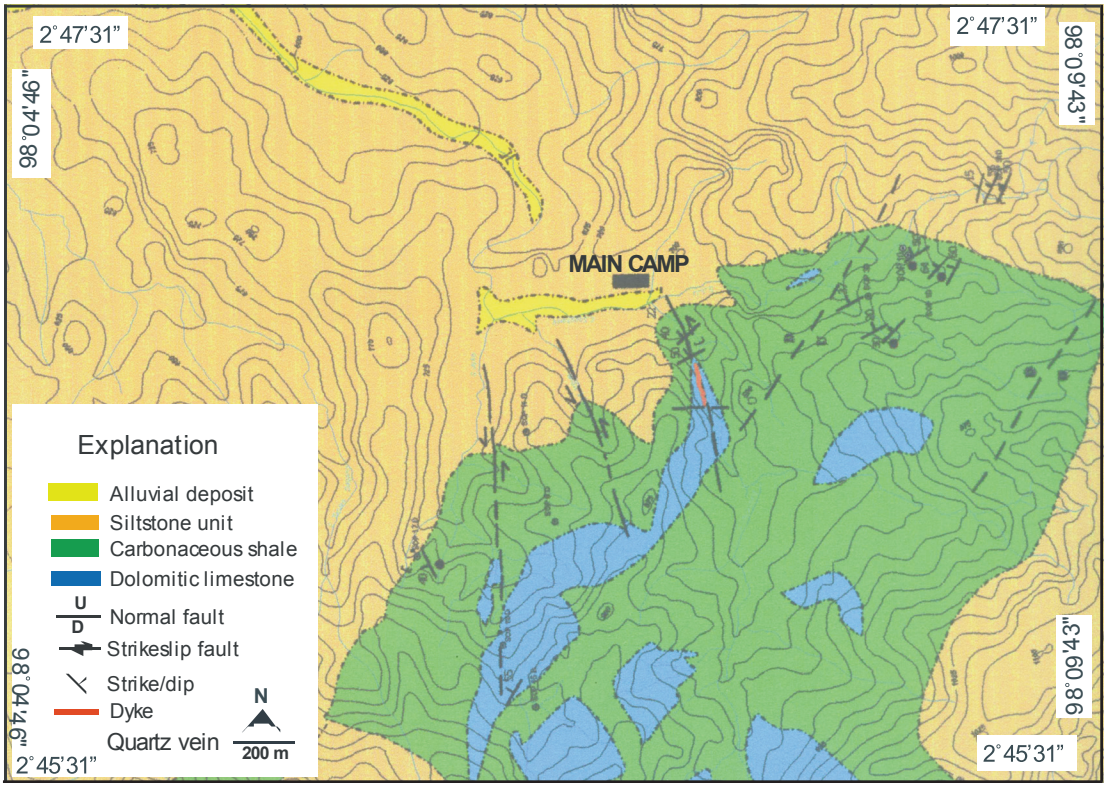

Figure 3. Simplified geological map of the Dairi prospect (Suharsono and Suwarna, 2002)

ald Resources Ltd., 2001). The Dagang Beds Member consists of interbedded sandstone and siltstone unit. while the Julu Silty Carbonaceous Shale Member comprise silty carbonaceous shale; dolomitic limestone. The lower unit of the Kluet Formation is dolostone (The Jehe Dolostone). Locally, it is brecciated with quartz and calcite veins (1-2 cm) filling fractures. Pyrite, sphalerite, galena and chalcopyrite are commonly found.

The schematic geology of the Latong deposit (North Sumatera) is shown in Figure 4). Lithology of the Latong deposit comprises bedded, turbidite type, low-grade metamorphic rocks, wake sandstone, marble, quartzite, slate and phyllite) (Hakim et al., 2005). In general, in places, these rocks have been folded and faulted. The age of the unit is assigned to be Early Permian-Late Carbonaceous (Aldiss et al., 1983; Noya et al., 2002).

In contrast, In Tanjung Balit (West Sumatera), the deposit is hosted within the Pre-Tertiary Silungkang Formation (Rocks et al., 1983; Agus and Mangara, 1984; Elhami, 2008; Abidin, 2008; Hartono, 2002).

The schematic geology of the Tanjung Balit deposit is shown in Figure 5. It is composed of interbedded metasandstone, claystone, shale, slate and volcanics. Polymetallic minerals such as Pb, Zn, Cu and minor Au are found with these rocks.

The Tuboh deposit is hosted within the Rawas Formation (Figure 6) (Suharsono and Suwarna, 2000; JICA, 1987). It was previously referred to as the Asai Formation (van Bemmelen, 1949).

The Silungkang Formation at Tanjung Balit Prospect.

The lithology of the Rawas Formation is dominated by metasandstones, limestones, phyllites and slates with minor fine tuffs and thin andesite lavas The age of this formation is correlated with the Asai formation, i.e, middle Jurassic to Lower Cretaceous (JICA, 1987). Rocks of the Rawas Formation have been partly undergone thermal

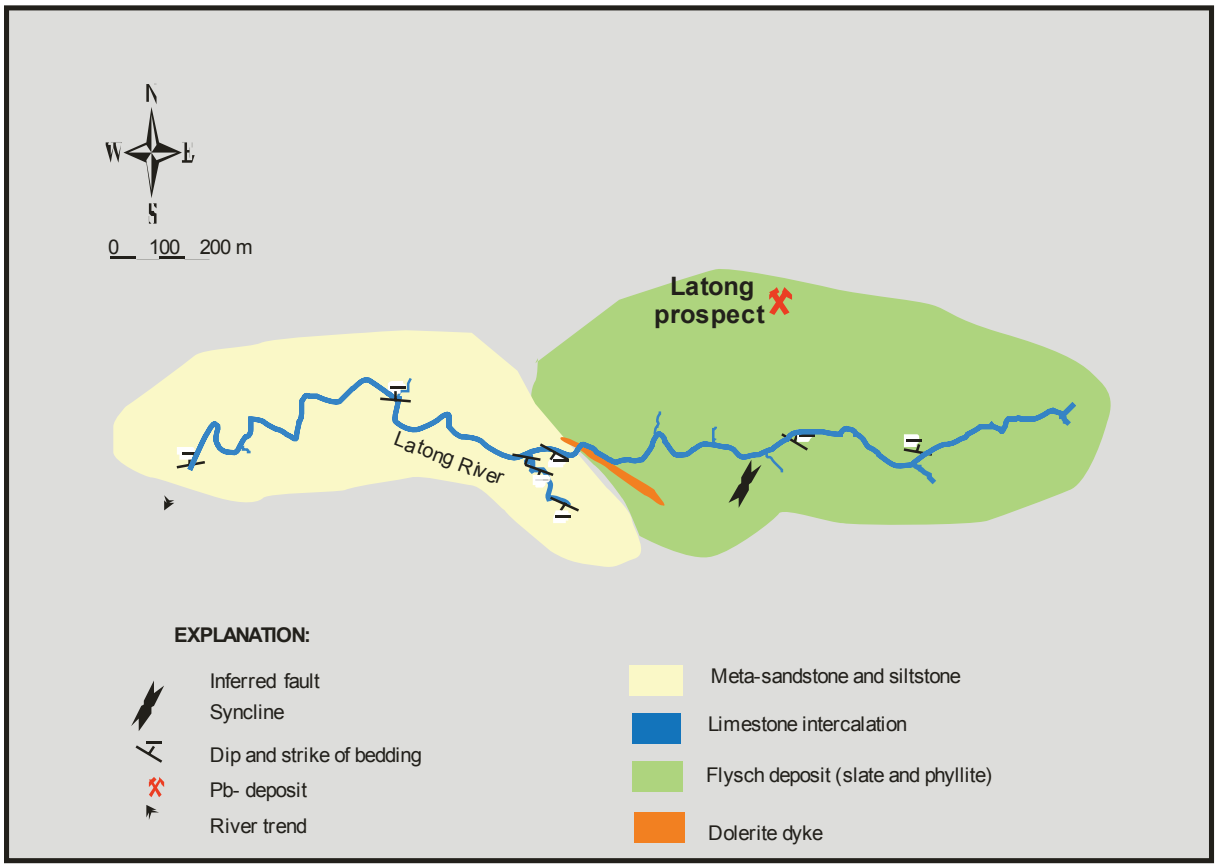

Figure 4. Geology of the Latong Deposit (Hakim et al., 2005)

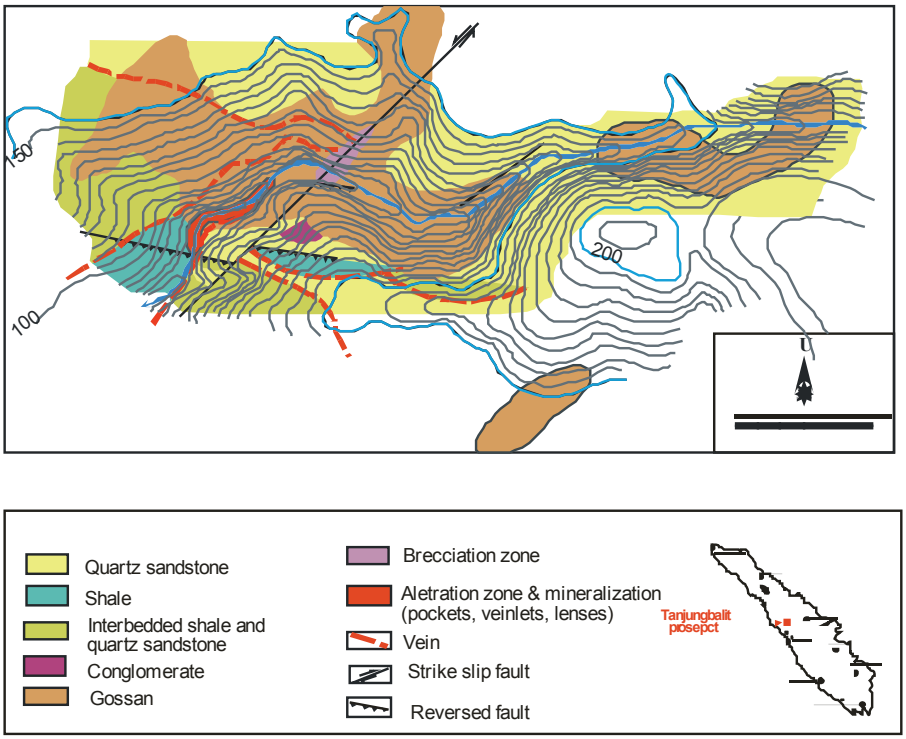

Figure 5. Schematic geological map of the Tanjung Balit (Agus and Mangara, 1984)

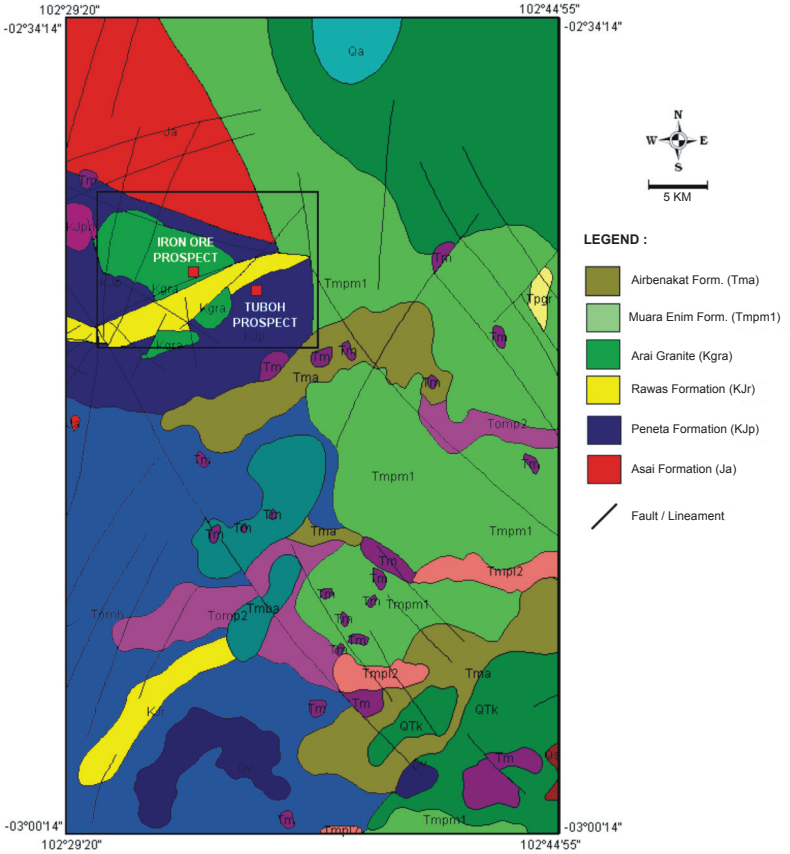

Figure 6. Map showing the geology of the Tuboh prospect (Suwarna et al., 1993)

metamorphism due to the Arai granite intrusion (Abidin, 2010). Mineralization (Zn, Pb, Cu) is associated within the Rawas Formation.

RESULTS AND DISCUSSION

Result

Base metal deposits found in the Barisan Range, Sumatera are Tuboh deposit (South Sumatera), Tanjung Balit deposit (West Sumatera) (van Bemmelen, 1949; JICA, 1987; Agus and Mangara, 1984) and Lokop deposit (Aceh) (Cameron et al., 1980; Crow and van Leeuwen, 2005; Abidin and Harahap, 2007). Subsequently, similar deposits were also discovered in Dairi deposit, Karo Regency (North Sumatera) (Herald Resources Ltd., 2001; Digdowirogo et al., 2000; Noya et al., 2002; Sinaga, 2006), Latong deposit, Madina Regency (North Sumatera) (Noya et al., 2004; Sinaga, 2006; Hakim et al., 2005; Harahap et al., 2014 in progress).

In Lokop deposit, ore mineralogy comprises mostly massive lead with minor pyrite. The content of Pb within the massive ore (up to 90%) with little pyrite (Abidin, 2006). The Lokop deposit is believed due to the emplacement of the Lokop Granite into the Kluet Formation (Cameron et al., 1982).

The Dairi deposit, which is located in Karo Regency, North Sumatera, also hosted within the sedimentary sequences of the Kluet Formation (Herald Resources Ltd., 2001; Digdowirogo et al., 2000; Sinaga, 2006). Two types of base metal mineralization are found in the area, i.e., Sediment Exhalative (sedex) of Julu and Mississippi Valley-Type (MVT) of Jehe (Sinaga, 2006). The Julu mineralization was formed syngenetically with carbonaceous shale originated from carbonaceous slate (Sinaga, 2006). Ore mineralogy consists of galena, sphalerite and pyrite. The ore styles belong to stratiform/beddings and veins. The distribution of ores from the top to the bottom of the vein are dominated by massive laminated sulphide ores of galena, sphalerite and pyrite. The deposit is possibly formed due to submarine fan deposits (Sinaga, 2006). The Julu mineralization was formed at temperature range of 236-375 °C with salinity ranges from 9,3-23% wt.NaCl (Sinaga, 1996).

The Jehe mineralization hosted within dolostone of the Jehe Member and Bongkaras (Sinaga, 2006). The ore is associated with quartz vein crosscutting with bedding. It is also characterized by the presence of crackle breccia and ore matrix breccia. Comparing to the earlier, the ore body consists of more various metals such as galena, sphalerite, pyrite, chalcopyrite, tetrahedrite, tenantite dan minor argentite. The deposit was formed at temperature ranging from 193-400ºC with salinity up to 38,2 % wt. NaCl (Sinaga, 2006).

In the Latong deposit, mineralization is in the form of lensoids, veins and pockets that replaced limestone. Ore mineralogy of the deposit consists of mainly galena with minor pyrite, sphalerite and chalcopyrite. Results of selected samples indicate that the content of galena (80%), sphalerite (10%) chalcopyrite (3%) and the rest is pyrite and supergene minerals (covelite) (Hakim et al., 2005). The Latong deposit was formed due to the emplacement of granite batholite known as Penyabung granite surrounding area (Sukirno, 2006; Aldiss et al., 1983). This batholite intruded the calcareous rocks of the Kuantan Formation, produced a contact metamorphisme between both rocks. Pheneumatolitic process took place and formed the Latong skarn deposit.

In Tanjung Balit, the deposit is in the form of layer, veins and disseminated faetures within meta-siltstone/tuff horizon of the Silungkang Formation. It belongs to polymetallic minerals of lead, sphalerite and silver with minor chalcopyrite, marcasite, magnetite, pyrite and chalcosite. Result of analysis of some selected samples indicates that the contents of Pb (60%), sphalerite (30%), chalcopyrite (10%) with minor pyrite, silver and gold (Abidin, 2008). The deposit is followed by a complex hydrothermal mineral alteration such as silica, illite, montmorillonite, pyrophylite, muscovite, siderite, diaspore, dickite, magnesite, chlorite, carbonate, rhodochrosite, analcime, alunite, smectite, ankerite, calcite, dolomite, sericite and zeolite. The alteration mineralogy belongs to silicification, prophylitic, argillic and advanced argillic types.

The Tuboh deposit is situated at approximately 3.5 km south of the Rawas River, i.e., Tuboh River, Musi Rawas Regency, South Sumatera. Ore mineralogy consists of sphalerite, galena, chalcopyrite, pyrite, hematite, manganese. Mineralization styles are characterized by veins

and layers. Skarn mineralogies are composed mainly of hedenbergite and subordinate amount of garnet, as well as accompanied by alteration minerals of siderite, chlorite, epidote, calcite and quartz (JICA, 1987). The Tuboh deposit was formed due to the effect of the Arai Granite intrusion (Abidin, 2010).

Discussions

As described above, several known base metal deposits have been discovered along the Barisan Range, Sumatera, i.e., Lokop (Aceh), Dairi and Latong (NS), Tanjung Balit (West Sumatera) and Tuboh (South Sumatera). Although they are found within the same area (i.e., Barisan Range), style of the base metal mineralization is different from one deposit to the others. From the data discribed above, so far three proposed styles of deposits are suggested, i.e., skarn/replacement, sedex and hydrothermal processes. The skarn types include Lokop (Aceh), Latong (North Sumatera) and Tuboh (South Sumatera) deposits. Late stage magmatic processes (Lokop Granit, Penyabungan Batholith and Arai Granite respectively) (Cameron et al., 1982; Aldiss et al., 1983; JICA, 1987) resulted in base metal bearing hydrothermal fluid penetrated the calcareous rock. Phneumatolitic process replaced the calcareous rock of the Kluet, Rawas Formation and deposited ore minerals of lead and pyrite.

The Dairi deposit indicates a different style to those of Lokop, Latong and Tuboh deposits. The Dairi merely hosts within the meta-sediment of the Kluet Formation, and it is not associated with any intrusive rocks. Therefore, the Dairi is grouped into a sedimentary exhalative style (sedex). Sedex defined as any deposit of which is associated with sedimentary process. Mineralization in sedex is formed syngenetically with the sedimentary deposition (MacIntyre, 1995; Sinaga, 2006; Noya et al., 2002). In Dairi deposit, two ore bodies of Julu and Jehe mineralization have been recognized. The Julu mineralization is characterized by the temperature homogenization (Th) ranged from of 236-375°C and salinity ranges from 9,3-23% wt.NaCl (Sinaga, 2006). The Th in Julu is slightly constant i.e., 236-375°C. These temperatures could be formed due to the formation of submarine fan in the Julu. The higher salinity of the Julu mineralization could be explained due to the presence of other chloride brines within the fluid, such as Na-K-Ca-Mg and other components.

The Jehe mineralization hosted within dolostone of the Jehe Member (Herald Resources Ltd, 2001). The ore is associated with quartz vein crosscutting with bedding. It is also characterized by the presence of crackle breccia and ore matrix breccia. Comparing to the earlier, the ore body consists more various metals such as galena, sphalerite, pyrite, chalcopyrite, tetrahedrite, tenantite dan minor argentite. The deposit was formed at temperature ranging from 193-400ºC with salinity up to 38.2% wt. NaCl (Sinaga, 2006). Again, the fluid within the Jehe mineralization contains chlorides such as those found in the Julu mineralization.

Finally, the hydrothermal mineralization is formed due to the igneous body intruded the younger rocks as a host rock. A late magmatic process has reacted with ground water/meteoric water resulting in a metals rich-host rocks and is formed vein types/disseminated mineralization. Tanjung Balit deposit is one example of this type (Abidin, 2008; Elhami, 2008). Fluid inclusion measurements within quartz veins indicate that the homogenization (Th) range from 185-350ºC from secondary inclusion (Abidin, 2008). From the presence of alunite, ore mineralogy as well as higher temperature range of the secondary fluids suggest that the deposit may belong to meso-epithermal types. The differences of Tanjung Balit with the other deposits are quite contrast. The main differences are the present of complex hydrothermal alteration (silicification, prophylitic and argilic alteration). Such alteration is not found at the Dairi deposit but some are found in Skarn types (Latong and Tuboh).

CONCLUSIONS

Several types of base metal occurrences have been discovered along the Barisan Range, Sumatera, i.e., skarn, sedex and hydrothermal types. Such deposits include Lokop (NAD), Latong (North Sumatera) and Tuboh (South Sumatera). Dairi belongs to sedex type while Tanjung Balit is hydrothermal style. All of which are hosted within pre-Tertiary sediments. All of which are hosted within pre-Tertiary sediment of Kluet (Dairi and Lokop), Kuantan (Latong), Silungkang (Tanjung Balit) and Rawas Formations (Tuboh).

Lokop mineralization is characterized by the subordinate of Pb (up to 80%) with minor pyrite.

Mineralization is in the form of veins, pockets and boulders and belong to the skarn type, is hosted within the rock sequence of slate, phyllite, quartzite and metasandstone of the Kluet Formation. The origin of such deposit is possibly related to the Lokop granit with respect to Kluet Formation. The Latong deposit is hosted within the metalimestone of the Kuantan Formation. Mineralization such as galena, sphalerite and chalcopyrite with skarn minerals of magnetite, garnet and marble form as layer, lensoid and pockets. The Latong deposit was formed due to the intrusion of Penyabungan granit within the Kuantan Formation. The Tuboh deposit consisting of sphalerite, galena with minor chalcopyrite and pyrite, is vein types. Skarn mineralogies are hedenbergite, garnet, siderite, epidote and marble. The deposit is classified into distal skarn (exoskarn) where the orebody hosted within the Rawas Formation due to the Arai granite.

The Dairi deposit is hosted within the sedimentary sequence of the Kluet Formation. Two types of mineralization known are Julu and Jehe. The Julu which belongs to the Sediment Exhalative (sedex) was formed syngenetically with carbonaceous shale. Ore mineralization comprises massive laminated sulphide ores of galena, sphalerite and pyrite. The ore styles belong to stratiform/ beddings and veins. The genetic model of the Julu mineralization is possibly formed due to submarine fan deposits within the temperature range of 236-375 °C with salinity ranges from 9,3-23 % wt.NaCl. In contrast, the Jehe mineralization belongs to the Mississippi Valley-Type (MVT). It is hosted within dolostone of the Jehe Member of the Kluet Formation. The ores are associated with quartz vein crosscutting with bedding. The Jehe mineralization contains more various metals than the Julu mineralization. The deposit was formed at temperature ranging from 193-400ºC with salinity up to 38.2 % wt. NaCl.

The Tanjung Balit deposit is the example of the hydrothermal type found along the Barisan Range, Sumatera. It is hosted within the Silungkang Formation. Mineralization consists of sphalerite, galena, chalcopyrite, gold and silver. Styles of ore are veins and disseminated features. The Tanjung Balit mineralization is followed by various hydrothermal alteration. The deposit which is characterized by polymetallic minerals was formed within the temperature ranging from 185-350ºC. It belongs to meso-epithermal types due to The presence of alunite suggesting the deposit my belongs to meso-epithermal type.

ACKNOWLEDGEMENTS

The writers thank to Prof. Dr. H. Z. Abidin and many previous investigators who have supplied data and reports to finish this paper. Acknowledgements are also to the members of field team who working together in some areas.

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