Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia Earth and Planetary Science 6 (2013) 30 – 37
Procedia
Earth and Planetary Science

Geochemical Characteristics of Host Rocks of Polymetallic Epithermal Quartz Veins at Soripesa Prospect Area, Sumbawa Island, Indonesia

Win Khant[1,3], I Wayan Warmada[1], Arifudin Idrus[1],
Lucas Donny Setijadji[1], Koichiro Watanabe[2]

[1]Department of Geological Engineering, Gadjah Mada University, Indonesia
[2]Department of Earth Resource Engineering, Kyushu University, Japan
[3]Department of Geology, Banmaw University, Myanmar
Corresponding author: winkhant1995@gmail.com

Abstract

The Soripesa prospect area is located at Maria village, Wawo district, Bima region in the eastern part of Sumbawa Island, Indonesia. This area is a part of Cenozoic Calc-alkaline volcanic inner Banda-Sunda Arc. There have five main polymetallic epithermal quartz veins in the Soripesa prospect area, namely, Rini vein, Jambu air vein, Dollah vein, Merpati vein, and Arif vein. The dominant lithology is a lithic-crystal tuff of andesitic and dacitic composition and bedded limestone. Major oxides and trace elements were analysed using X-Ray Fluorescence (XRF) to identify the host rock geochemistry. The main veins are hosted by andesitic and andesitic/basaltic volcanic host rocks. Major elements compositions are affected by alteration. Based on the trace element data, host rocks of all veins were formed in the volcanic arc basalt (VAB) and island arc basalt (IAB) tectonic setting. Host rocks of Rini vein contain higher amount of precious and base metal elements (Zn, Cu, Pb, and Ag.etc.) than those of other host rocks.

Keywords: Soripesa prospect area, lithology, tectonic setting, mineralization

INTRODUCTION

The Soripesa prospect area is located at Maria village, Wawo district, Bima regency, West Nusa Tenggara Province, Sumbawa Island, Indonesia. The prospect area is previously owned by PT Bima Baruna Raya Mining (BBRM) and PT Sumbawa Timur Mining. These companies have observed Au-Ag deposit and base metal mineralization. At present, PT Bima Putera Minerals (Indomining Group) has a Mining Permit for those deposits. The prospect area is mainly occupied by andesitic and dacitic volcaniclastic rocks and small portion of Tertiary bedded limestones. There have five main veins in the Soripesa prospect area including Arif vein, Dollah vein, Jambu Air vein, Merpati vein, and Rini vein, trending nearly north-south. The main ore minerals are chalcopyrite, azurite, malachite, sphalerite and galena forming as polymetallic epithermal quartz veins.

Soripesa prospect area is located in the eastern part of Sumbawa Island and in the eastern part of Sunda-Banda arc (Neogene). Sunda-Banda arc is the longest in Indonesia, extending from North Sumatra through Java, Bali, Lombok, and Sumbawa, to east Damar. Tectonic setting and genesis of vein host rocks are important for ore depositions. The purpose of this paper is to confirm the rock types, tectonic setting, and to identify their mineralization potential and the genesis of host rocks of polymetallic epithermal quartz veins in the Soripesa prospect area, East Sumbawa, Indonesia.

TECTONIC SETTING AND REGIONAL GEOLOGY

The Sumbawa Island forms as a part of the Cenozoic Calc-alkaline volcanic inner Sanda-Banda arc, which is still active up to present. Sunda-Banda island arc is a volcanic arc formed by the interaction of plate subduction slab in the form of Indo-Autralia with Asian plate. The shape of the island arc is now being modified in the east due to collision with the Australian–New Guinea continental margin, including West Flores to East Sumbawa and Alor (Hamilton, 1979). Figure 1. shows the tectonic setting and location map of the Sumbawa Island, Indonesia.

The East Sumbawa area is largely underlain by andesitic to basaltic lava and breccia of the Lower Miocene, with intercalations of tuff and limestone, and fresh pyroclastic sequences (Nana and Aswan, 1978). This sequence is overlain in parts by dacitic tuff and bedded limestone of the Middle Miocene. These units have been intruded by numerous small to medium bodies in the Middle to Upper Miocene including andesite, dacite, diorite, trachyte and syenite (Fig. 2). A signature type of epithermal and porphyry copper mineralization can be recognized in those rock units.

The northern part of Sumbawa Island is dominated by the eruptive products of the active Tambora and Sangeang volcanoes, comprising of lahar, volcanic bomb and lapilli. Sumbawa Island, regionally, is intersected by NW-SE and NE-SW trending structures. However, the formation of quartz veining, alteration and mineralization at Soripesa Prospect are related to the N-S faulting (Noya *et al.*, 2009).

SAMPLING AND ANALYTICAL METHODS

X-ray Fluorescence (XRF) Analyses

Nine samples are selected for X-ray fluorescence analyses. All selected representative samples were collected from the host rocks of polymetallic epithermal veins. Major and trace element data were obtained by XRF analysis using a Rigaku RIX-3100 Serial VR 25006 X-ray fluorescence spectrometer at the Earth Resources Engineering Department, Kyushu University, Japan. Samples were crushed by vibration mill and heated by electronic furnace about 3 hours to get LOI (Loss of Ignition)

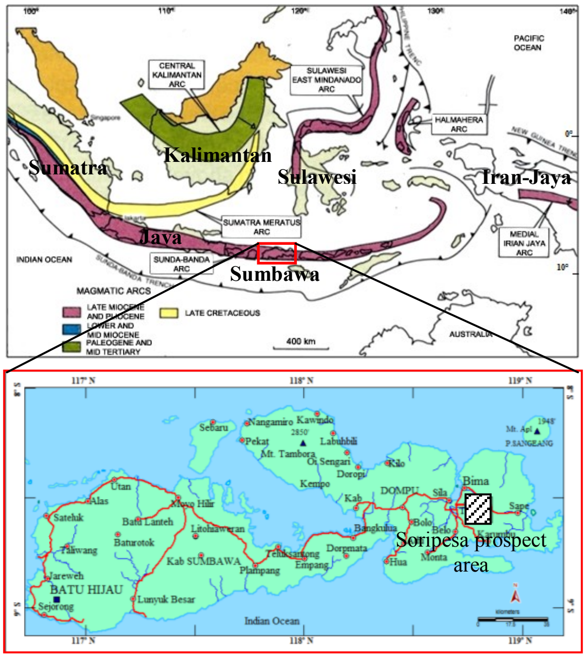


Figure 1. Location map of Sumbawa Island and Soripesa prospect area within the Sunda-Banda magmatic arc (modify after, Carlile and Mitchell, 1994).

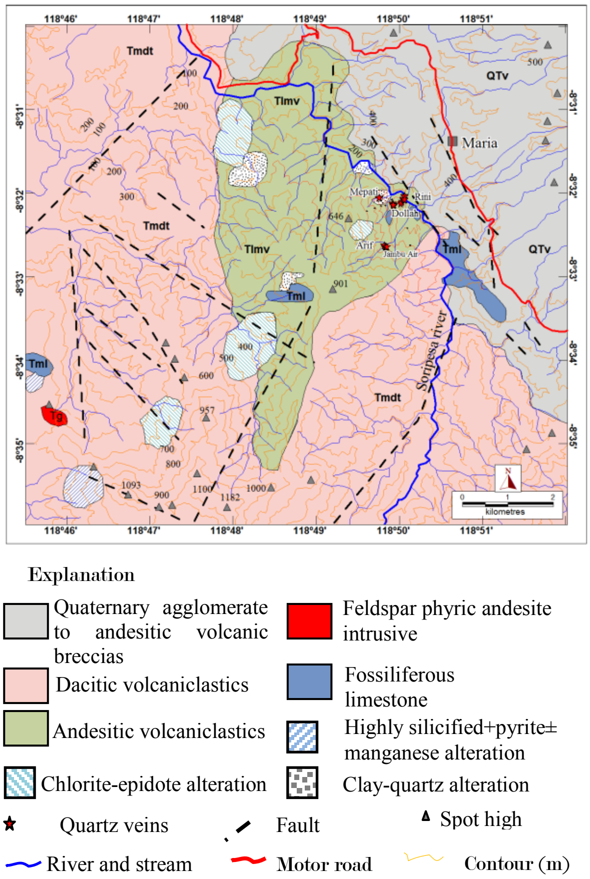


Figure 2. Geological map of the Soripesa prospect area and surrounding area. (modified after Noya *et al.*, 2009)

HOST ROCK GEOCHEMISTRY

Major Elements

The major element compositions of host rocks were determined by X-ray fluorescence (XRF) analysis. The major element data are given in Table 1 together with their modal and normative compositions. The host rocks of the polymetallic epithermal quartz veins have a considerable spread in major element values. The range for SiO_2 is from 48.99 to 75.96 wt% and for the other elements' $A1_2O_3$ 8.79-17.52; FeO as total iron 1.52-12.07; TiO_2 0.52-1.47; MnO 0.01-0.85; MgO 0.37-9.03; CaO 0.14-19.5; Na_2O 0-1.52 and K_2O 0.01-3.24. Some host rocks samples such as DV5, RAH, and MV3 increase the content of SiO_2 because of alteration effect. On the diagram (SiO_2-Na_2O+K_2O), host rocks therefore are plotted in basalt, andesite, dacite, and rhyolite fields, respectively, based on the SiO_2 content (Fig. 3). The volcanic rock classification therefore was estimated and identified by using a diagram that contains the major element (TiO_2) and trace elements (Zr, Nb, and Y). In the Nb/Y versus Zr/TiO_2 diagram (Fig. 4), the host rocks of all veins show high Zr contents and are falling in the fields of basaltic andesite and andesite.

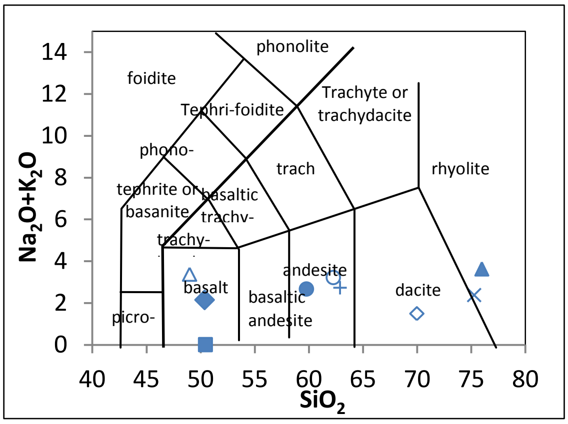


Figure 3. Volcanic rock classification plot diagram ((Na_2O+K_2O vs SiO_2) (after Le Bas *et al*., 1986).

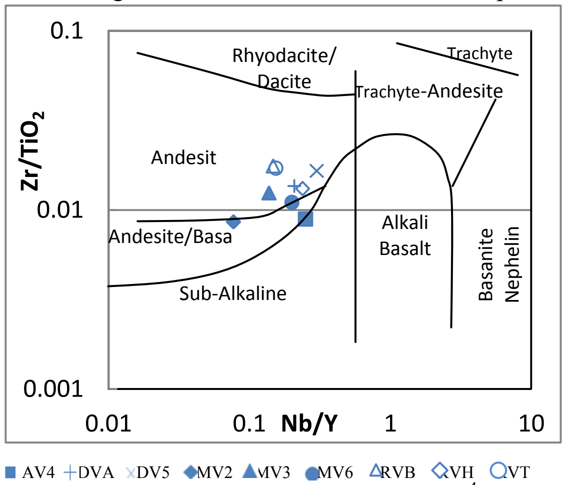


Figure 4. $Zr/TiO_2 \times 10^{-4}$ vs Nb/Y diagram of Winchester and Floyd (1977).

Tabpe 1. Major element compositions (mass%) of host rocks near epithermal quartz veins from the Soripesa prospect area

Sample	SiO_2	TiO_2	$A_{l2}O_3$	K_2O	Na_2O	CaO	MgO	MnO	FeO	P_2O_5	H_2O	TOTAL
AV4	50.44	1.47	14.71	0.01	0	19.50	0.40	0.85	11.15	0.03	1.12	99.68
DVA	62.87	0.89	14.37	2.68	0.05	5.94	2.98	0.21	6.33	0.08	3.17	99.57
DV5	75.27	0.52	8.97	2.36	0.02	0.93	3.03	0.29	4.80	0.07	2.80	99.06
MV2	50.37	0.91	16.85	2.09	0.06	0.14	9.03	0.72	12.07	0.10	6.18	98.52
MV3	75.96	0.77	13.47	3.24	0.39	0.14	0.37	0.01	1.65	0.02	3.27	99.29
MV6	59.76	0.68	16.15	2.64	0.03	0.29	7.44	0.68	7.05	0.05	4.48	99.25
RVB	48.99	0.88	17.52	2.23	1.15	5.47	7.41	0.50	9.40	0.10	4.44	98.09
RVH	69.97	0.98	8.79	0.86	0.64	2.85	5.64	0.24	6.61	0.09	2.96	99.63
RVT	62.25	0.80	12.47	3.16	0.06	5.46	4.35	0.44	7.10	0.08	2.90	99.07

Tabpe 2. Trace element compositions (ppm) of host rocks near epithermal quartz veins from the Soripesa prospect area. (BDL = below detected limit)

Sample	*Pb*	*Zn*	*Cu*	*S*	*Zr*	*Y*	*Ba*	*Sr*	*Rb*	*W*	*Mo*	*Sn*	*Sb*	*As*	*Cd*	*Hg*	*Au*	*Ni*	*Co*	*Cr*	*V*	*Cl*	*Bi*	*Ag*	*Nb*	*U*	*Th*
AV4	216	799	97	483	131	16	2	1038	BDL	35	3	BDL	9	56	25	BDL	BDL	BDL	BDL	56	311	13	3	BDL	4	2	BDL
DVA	329	826	1231	22	121	24	919	282	59	61	1	BDL	3	55	BDL	BDL	BDL	3	2	10	197	21	3	8	5	4	BDL
DV5	4840	1075	1974	105	86	10	407	71	66	29	BDL	3	13	615	8	2	BDL	1	4	BDL	113	42	4	56	3	BDL	BDL
MV2	5	432	33	13521	78	26	221	21	47	49	BDL	BDL	2	9	2	5	BDL	BDL	5	23	241	24	2	10	2	BDL	2
MV3	47	16	0	6381	96	29	199	37	61	10	BDL	7	4	9	BDL	BDL	BDL	3	10	6	208	16	10	2	4	BDL	5
MV6	166	474	22	5956	75	10	355	19	63	48	3	1	6	38	BDL	1	BDL	3	9	17	169	30	2	5	2	BDL	4
RVB	7612	1502	3549	67	155	34	800	301	52	45	BDL	BDL	8	1015	3	2	BDL	1	33	7	198	67	4	5	5	BDL	BDL
RVH	53	2422	339	53	129	21	244	101	18	40	BDL	5	8	17	1	2	BDL	17	22	25	131	80	BDL	3	5	3	4
RVT	5302	394	889	129	137	26	740	373	74	53	1	BDL	2	695	8	BDL	BDL	1	13	BDL	157	44	5	180	4	BDL	BDL

Trace Elements

Trace element compositions of the host rocks of all veins are listed in Table 2. Ratio and index of some trace elements can be used quantitatively to describe the difference in trace elements from different type of host rocks. To some degree, this difference might reflect the degree of magma crystallization as well as source regions.

Pearce (1982) has proposed TiO_2 versus Zr and Cr versus Y diagrams to discriminate basalts from mid-oceanic ridge island arc and within plate settings. In these diagrams, the host rock samples are plotted in the field of MORB (Fig. 5a and b). However, the outlined MORB field overlaps the fields of island arc basalts and within plate basalts. Thus, Cr vs Y plots of host rock samples in the diagram (Fig. 5b) can also be treated as to plot both in the IAB and WPB, indicating their transitional nature between the two settings or between MORB. It is also possible that the overlap is due to the involvement of sub-continental lithosphere in magma genesis as pointed out by Watters and Pearce (1987). In the Zr and TiO_2 plot diagram (Fig. 5a), most host rock samples are shown in the field of the VAB (volcanic arc basalt) and MORB setting. But, there have no samples in the MORB field in figure (5a).

The relationships of Nb, and Y with Zr are shown in Fig. 6a and 6b. The Zr/Y and Zr/Nb ratios of these host rocks are much higher in comparison with the primitive mantle (Sun and McDonough, 1989) indicating their enriched source characteristics of the elements. Zr/Nb has been widely used to discriminate between enriched and depleted sources (Le Roex et al., 1983). The Zr versus Nb plots of volcanic host rocks of all veins suggest their derivation from moderately enriched source (Fig. 6).

Abundances of compatible elements such as Rb decrease with increasing fractionation as measured by the abundance of an incompatible element such as Zr, whereas the abundances of incompatible elements such as Rb, Zn, and Sr increase continuously with fractionation. Binary plots of Zr and selected trace elements (Rb, Zn, Ba, and Sr) are presented in figure (7).

Ore-forming Elements

The abundance of ore elements and incompatible elements (mineralization agent) in rocks is one of the important criteria to evaluate the potential of mineralization: the higher these elements in rocks, the greater the mineral potential. It is also a necessary criterion to define potential source ore-rock. We can see clearly that the main ore forming elements are Pb, Cu, and Zn. Comparing to the host rocks. The order of ore-forming elements abundance (ppm) in host rocks of Arif vein is: Sb 9, Pb 216, As 56, Mo 3, Zn 799; in host rocks of Dollah vein: Sb 8, As 332, Mo 0.5, Pb 2500, Cu 1500; in host rocks of Merpati vein: As 18, W 49.48, Cu 42.75, Bi 31.84, Sb 6.54, Mo 6.25, Ag 4.49, Sn 3.62, Pb 1.47, Au 1.28; and host rocks of Rini vein: As 57.04, W 49.48, Cu 42.75, Bi 31.84, Sb 6.54, Mo 6.25, Ag 4.49, Sn 3.62, Pb 1.47. These data

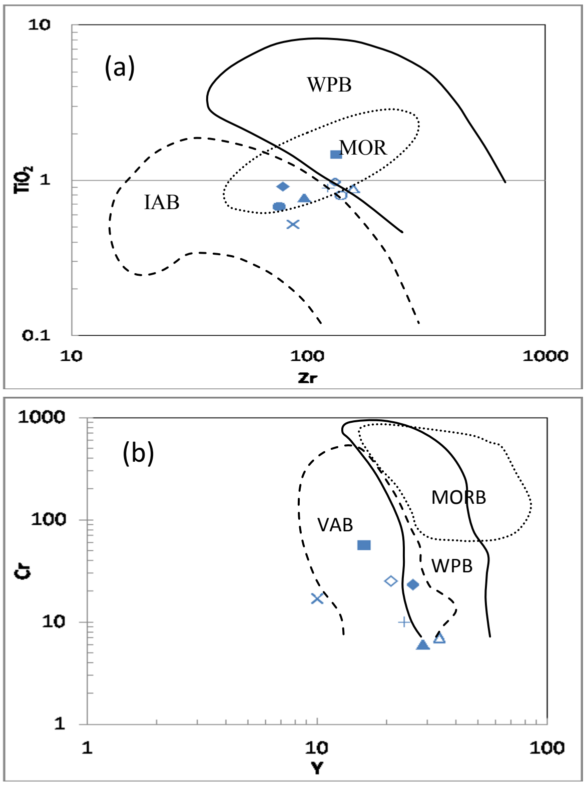


Figure 5. Binary diagrams for the tectonic setting of the volcanic host rocks from the Soripesa prospect area. (a) Zr vs TiO_2 (Pearce, 1982) and (b) Cr vs Y (Pearce, 1982). MORB: Mid-Oceanic Ridge Basalt, IAB: Island Arc Basalt, WPB: Within-Plate Basalt, VAB: Volcanic Arc Basalt.

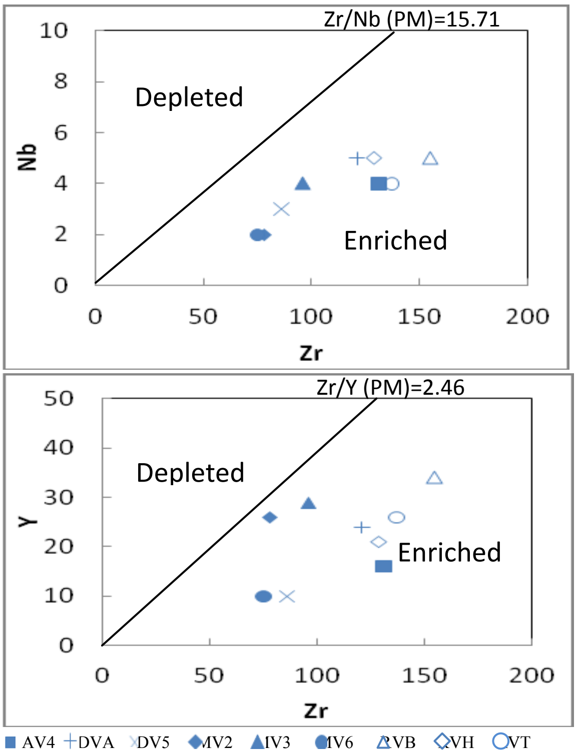
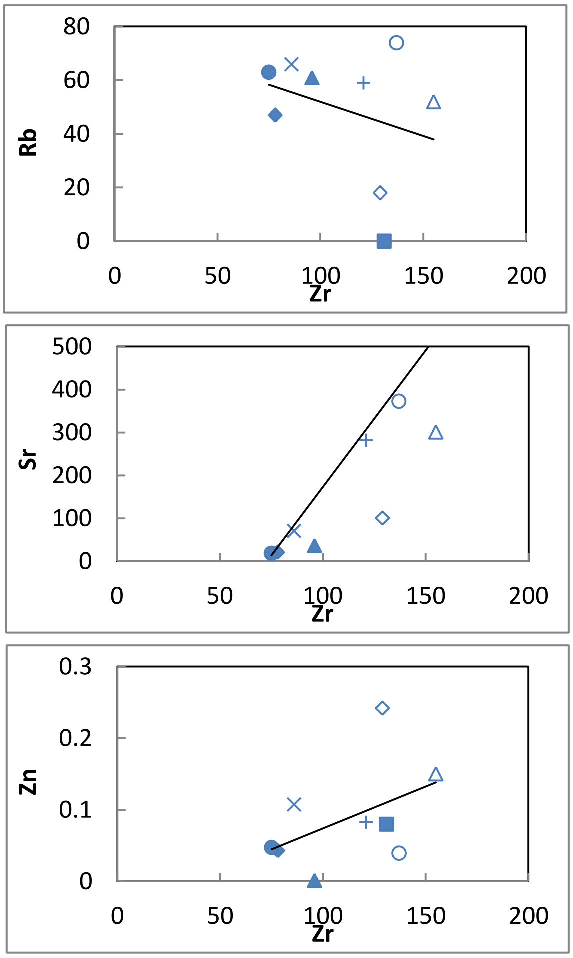


Figure 6. Plots of Zr versus (a) Nb and (b) Y for volcanic host rocks showing the less mobile nature of these elements and illustrating the sensitivity of these element ratios to source composition. Primordial mantle ratios after Sun and McDonough (1989).



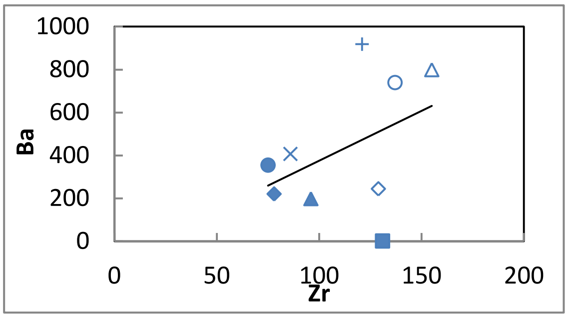


Figure 7. Variation in Rb, Zn,Ba, Sr, and Zr (all in ppm) for volcanic host rocks near epithermal quartz veins from the Soripesa prospect area

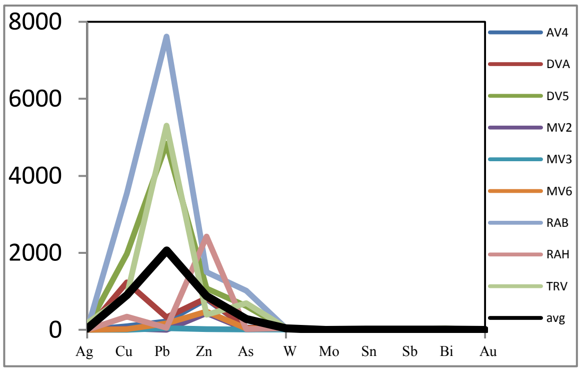


Figure 8. Ore-forming elements compositions of the host rocks.

indicate that host rocks of Rini vein have higher content of ore forming elements than other host rocks suggesting the Rini vein has the highest potential. Host rocks of Merpati vein contain lesser ore elements in both variety and quantity than the other host rocks and, therefore, has the lowest potential of mineralization.

CONCLUSIONS

The Soripesa prospect area is located in the eastern part of Sumbawa Island, Indonesia. Recently, according to tectonic setting, Sumbawa Island is a part of Cenozoic Calc-alkaline volcanic inner Sunda-Banda Arc. The arc has been largely formed by northward subduction of Indian oceanic crust. Most host rocks of all veins in the Soripesa prospect area are andesitic, dacitic, and andesitic/basaltic volcaniclastic rocks. According to geochemistry data, host rocks of all veins at the Soripesa prospect area are in andesitic and andesitic/basaltic fields. Host rocks therefore may be formed on medium to thicker continental crust above subducting lithosphere. Based on the trace element data (Zr, Y, Cr, and Ti), most of the vein host rocks indicates that they formed in volcanic arc basalt (VAB) and island arc basalt (IAB) tectonic setting. The Zr versus Nb plots of volcanic host rocks of all veins suggest their derivation from moderately Zr enriched source. Binary plots of Zr and selected trace elements (Rb, Zn, Ba, and Sr) suggest that the host rocks were formed from fractional crystallization processes. Based on the ore forming elements, host rocks of Rini vein is the highest potential mineralization. But, host rocks of Merpati vein contain lesser amount of ore elements and have a lowest potential of mineralization.

ACKNOWLEDGEMENTS

Firstly, we would like to thank to JICA for their financial supporting. Second, we are thankful to Indomining Group for their permission to collect samples and finally, many thanks to Geology Laboratory, Kyushu University, Japan for making analyses.

REFERENCES

Carlile, J.C., and Mitchell, A.H.G., *Magmatic arcs and associated gold and copper mineralization in Indonesia.* Journal of Geochemical Exploration 50. 91-142 (1994).
Ewart, E., *The mineralogy and petrology of Tertiary–recent orogenic volcanic rocks with special reference to the andesite–basaltic composition range*. In: Thorpe RS, Ed. Andesites. New York, John Wiley and Sons: 25–87 (1982).
Irvine, T.N., and Baragar, W.R., *A guide to chemical classification of common volcanic rocks*. Can. J. Earth Sci. 8, 523–548 (1971).

Le Roex, A.P., Dick, H.J.B., Erlank, A.J., Reid, A.M., Frey, F.A., and Hart, S.R., *Geochemistry, mineralogy and petrogenesis of lavas erupted along the south west Indian ridge between the Bouvet triple junction and 11 degrees east*. J. Petrol. 24, 267–318 (1983).

Le Bas, M.J., Le Maitre, R.W., Streckeisen, A., and Zanettin, B., *A chemical classification of volcanic rocks based on the total alkali–silica diagram.* J. Petrol. 27, 745–750 (1986).

Noya, Y., Effendhy, O., Hamdan Z., Abidin, and Pakaya, Y., *Geological background and economic prospect of the Soripesa deposit, eastern Sumbawa*. Proceeding pit IAGI Semarang, 2009. The 38th IAGI annual Convention and Exhibition Semarang, 13-14, October (2009).

Pearce, J.A., *Trace element characteristics of lavas from destructive plate margins,* in: Thorpe, R.S. (Ed.), Andesites. Wiley, London, pp. 545–548 (1982).

Sun, S.S., and McDonough, W.F., *Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes*, in: Saunders, A.D., Norry, M.J. (Eds.), Magmatism in the Ocean Basins Geological Society of London Special Publications, 42, pp. 313–345 (1989).

Watters, B.R., and Pearce, J.A., *Metavolcanic rocks of the La Ronge Domain in the Churchill Province, Saskatchewan: geochemical evidence for a volcanic arc origin*, in: Pharaoh, T.C., Beckinsale, R.D., Richard, D. (Eds.), Geochemistry and Mineralization of Proterozoic Volcanic Suites Geological Society, Special Publications, 33, pp. 167–182 (1987).

Winchester, J.A., and Floyd, P.A., *Geochemical discrimination of different magma series and their differentiation products, using immobile elements*. Chem. Geol. 20, 325–344 (1977).