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HOST ROCK AND MINERALIZED ORES GEOCHEMISTRY OF ARINEM VEIN, ARINEM DEPOSIT, WEST JAVA – INDONESIA

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ABSTRACT

Geochemically, the major, minor and trace elements play an important role in the various geological processes. The REE characteristics of quartz vein formed during main mineralization stage are representative of mineralization hydrothermal fluid REE compositions. The research concern the integrating geochemistry and mineralogy analyses. It is an ideal method to study the occurrence of gold deposits in the Arinem area. This area is located on the Java island as a part of West Java province of Indonesia. Detail exploration, including some drilling activities, is ongoing to define the gold and base metal reserve as well as the deposit characteristics. Thirty samples from different stage of mineralized body of Arinem vein, altered host rock from different core level, outcrop host rock, Miocene and Pliocene intrusions were analyses for its geochemical composition by using the Induced Couple Plasma (ICP) and Induced Couple Plasma Mass Spectrometer (ICP-MS). Emission Spectrometry was used to extend the lower detection limits and provide a broader spectrum of elements at the Acme Analytical Labortories, Canada. The REE distribution in the altered host rock of the Arinem deposit indicated that the ΣREE enrichment in the altered host rock, with decreasing in its content from the host rock to the mineralized vein. The observed variations in mineralogy and mineral proportions indicate that Au and Ag came into being only during stage II (except for electrum also indicated at stage I), but that sphalerite, galena, pyrite, chalcopyrite and arsenopyrite were deposited during stages I and II.

Keywords : altered host rock, Arinem vein, Geochemistry, Mineralized body, REE.

ABSTRAK

Secara geokimia unsur-unsur utama, sedikit dan jejak (*trace*) memainkan peran penting dalam beragam proses geologi. Karakteristik unsur tanah jarang (*Rare Earth Elements*) dalam urat kuarsa yang terbentuk selama tahap mineralisasi utama merupakan representasi dari komposisi REE fluida hidrotermal. Pendekatan yang diterapkan dalam meneliti hal tersebut meliputi integrasi analisis geokimia dan mineralogi, yang merupakan suatu metode yang cukup ideal untuk mempelajari terjadinya deposit emas di Arinem. Daerah Arinem terletak di wilayah Jawa Barat bagian selatan, Indonesia. Eksplorasi detil, termasuk aktifitas pengeboran, sedang berlangsung untuk menentukan cadangan emas dan logam dasar serta karakteristik deposit. Dalam penelitian ini, tiga puluh sampel telah diambil dari tubuh vein Arinem dengan beragam tahapan mineralisasi dan dari batuan induk terubah dengan tingkatan yang berbeda dari inti ke arah luar, serta dari singkapan batuan induk, dan intrusi berumur Miosen dan Pliosen. Analisis untuk mengetahui komposisi kimia menggunakan *Induced Couple Plasma (ICP)* dan *Induced Couple Plasma Mass Spectrometer (ICP-MS)*. *Emission spectrometry* digunakan untuk meningkatkan batas bawah deteksi dan memberikan spektrum unsur yang lebih luas. Seluruh analisis tersebut dilakukan di laboratorium "the Acme Analytical Labortories", Canada. Distribusi REE pada batuan induk terubah dari deposit Arinem mengindikasikan bahwa terjadi pengayaan jumlah REE dalam batuan tersebut, sebaliknya terjadi penurunan kandungannya pada batuan induk yang mengalami mineralisasi vein. Hasil pengamatan menunjukkan bahwa proporsi mineral dan variasi mineraloginya mengindikasikan bahwa kehadiran Au dan Ag hanya terjadi pada tahap II (kecuali untuk elektrum juga diindikasikan pada tahap I). Sebaliknya sfalerit, galena, pirit, kalkopirit dan arsenopirit terbentuk selama tahap I dan II.

Kata kunci: batuan induk terubah, vein Arinem, geokimia, tubuh termineralisasi, REE.

INTRODUCTION

Geochemically, all the elements of the periodic table have been classified into major, minor, trace and rare earth elements and each of these groups have their own importance. In addition to these broad divisions, the major, minor and trace elements have also been geochemically divided as mobile and immobile elements and these elements play an important role in the various geological processes. Majority of these elements are more or less mobile. It is suggested that the rare earth element in quartz mainly exist in fluid inclusions, so REE characteristics of quartz reflect that of ore-forming fluid in equilibrium with quartz. Therefore REE characteristics of quartz vein formed during main mineralization stage are representative of mineralization hydrothermal fluid REE compositions.

Systematical research, integrating geochemistry and mineralogy, is an ideal to study the occurrence of gold deposits in the Arinem. Therefore, geochemical analyses (including major, minor and trace elements) of mineralized vein and host rocks have been done systematically together with mineralogical investigations, isotopic and fluid inclusions studies. The lack study of the origin of the mineralization source of the search for Arinem deposit previously, require a detail study of the Arinem vein. The present study contains a comprehensive geochemical investigation of the ore and host rock of the Arinem vein from the Arinem deposit.

REGIONAL GEOLOGY

The so-far unexploited mineralization in Arinem deposit, to date has been regarded as low to high sulfidation epithermal quartz vein deposit (Yuningsih et al, 2012; Yuningsih and Matsueda, 2014). Gold exploration in the Arinem area and its surroundings has started since the early 1980s by Antam (Aneka Tambang), the state mining company. Since 1990, detail exploration, including some drilling activities, is ongoing to define the gold and base metal reserve as well as the deposit characteristics.

Arinem area is located on the island of Java as a part of West Java province of Indonesia. The deposit is located at the south of Mt. Papandayan active volcano, about 200 km southeast of the capital city of Jakarta (Fig. 1).

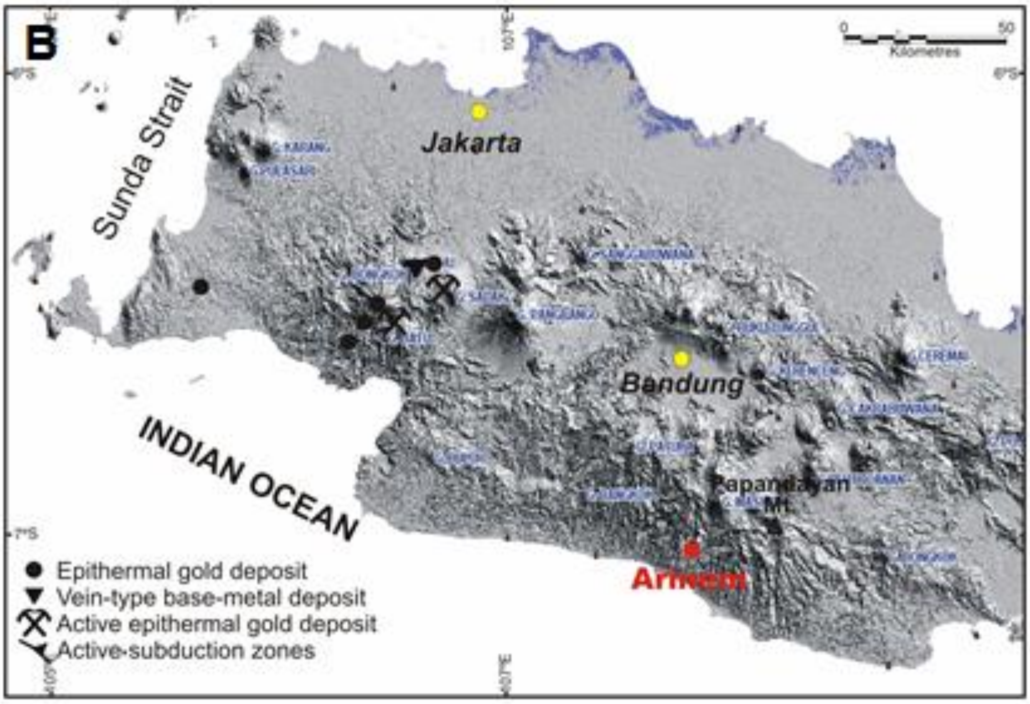

Fig. 1 Morphology of western Java with the distribution of active volcanoes and ore deposits. The location of the Arinem deposit is indicated.

The oldest rocks exposed around the Arinem deposit are andesitic tuff, tuff breccias and aphanitic-porphyritic andesitic lavas. This unit is part of the Late Oligocene to Middle Miocene Jampang Formation (Alzwar et al, 1992) which has been intruded by phaneritic – porphyritic andesitic rocks. Towards the top it was gradually covered by andesitic tuff and tuff breccias which are younger than the Jampang Formation. The volcanic rock of Jampang Formation is host for the mineralization within the area.

METHODOLOGY

Some samples taken from mineralized quartz-sulfide vein and altered host rock of the Arinem vein were prepared for analyses. The elements presented are major, minor, trace and rare earth elements from all the analyzed samples to get detail geochemical features of the mineralized vein body and host rock. Thirty samples from different stage of mineralized body of Arinem vein (See Yuningsih et al, 2012; Yuningsih and Matsueda, 2014), altered host rock from different core level, outcrop host rock, Miocene and Pliocene intrusions were analyses; 16 samples represent a quartz-sulfide vein from different stages and levels, 9 samples represent altered host rock, 1 sample from outcrop of less altered Jampang Formation, 3 samples from Miocene intrusions and 1 sample from Pliocene intrusion.

All samples were clarified by petrographic study, some samples from quartz-sulfide vein were clarified by EPMA, and altered host rock samples by XRD measurement. The geochemical analysis for mineralized vein body, altered host rock and intrusion were carried out at the Acme Analytical Laboratories (Vancouver) Ltd. British Columbia, Canada. The determination had done by Induced Couple Plasma (ICP) and Induced Couple Plasma Mass Spectrometer (ICP-MS) emission spectrometry to extend the lower detection limits and provide a broader spectrum of elements.

RESULTS AND DISCUSSIONS

Major Elements Geochemistry of Arinem Vein

The quartz-sulfide of Arinem vein is characterized by a dominance of SiO_2 ranging from 40.8% to 85.6%, only one sample from stage IB has very low SiO_2 content (10.1%). The Al_2O_3, Na_2O and K_2O contents are low and some samples are under detection limit (< 0.01%). The content of TiO_2 and P_2O_5 are also mostly under detection limit. The CaO contents variable between 0.1 to 10.7% while MnO contents in range 0.02 to 0.4%. Most of the samples contain Fe_2O_3 vary in concentration and Fe_2O_3 enrichment occurs in some samples of the quartz-sulfide veins. Comparing to the altered host rock, the mineralized quartz-sulfide veins are strongly depleted in Al_2O_3, and various but slightly depleted in Na_2O, K_2O, TiO_2 and P_2O_5. The content of the MnO is similar, but Fe_2O_3, MgO and CaO are uneven.

Table 1 Geochemical analysis for major, minor and trace elements composition of selected quartz-sulfide samples of Arinem vein.

Sub stage :	IA	IB	IB	IIA	IIA	IIA	IIA	IIA	IIA	IIB	IIB	IIC	IIC
Level :	265	300	440	265	300	300	300	440	440	440	440	265	265
Sample no. :	2A-18	B.2-47	3A-22	2A-14.2	B.2-50	B.2-16	B.2-15	3A-51	3A-43	3A-92	3A-57	2A-39.2	2A-22
Major Elements :													
SiO_2	59.27	10.12	85.63	75.47	54.49	60.70	58.27	82.97	63.62	64.95	85.96	52.83	40.83
Al_2O_3	0.76	1.87	2.71	4.55	3.25	2.73	2.17	1.13	1.83	0.93	1.24	1.17	2.43
Fe_2O_3	3.97	33.40	5.35	3.54	19.51	8.45	12.69	4.18	10.21	16.24	3.59	10.05	2.88
MgO	1.42	4.08	0.15	0.39	2.66	4.30	1.76	0.15	0.34	1.02	0.13	2.48	0.53
CaO	3.63	10.69	0.20	0.09	0.52	9.44	3.49	0.08	0.22	1.19	0.07	6.82	0.07
Na_2O	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K_2O	<0.01	<0.01	0.01	0.95	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	0.03	<0.01
TiO_2	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.02	<0.01	<0.01	0.13	<0.01	<0.01	<0.01
P_2O_5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.01	<0.01	<0.01
MnO	0.12	0.60	0.09	0.02	0.15	0.44	0.15	0.27	0.30	1.03	0.22	0.26	0.04
LOI	8.30	15.00	4.40	5.50	8.80	8.00	9.10	4.10	8.60	10.10	3.50	9.90	10.50
Sum	77.42	75.74	98.58	90.53	89.32	94.08	87.69	92.83	85.06	95.65	94.67	83.59	57.23
Minor and Trace Elements :													
Cr_2O_3	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.01	<0.002	<0.002	<0.002	<0.002
Ni	<20.00	<20.00	<20.00	<20.00	<20.00	<20.00	<20.00	<20.00	<20.00	<20.00	<20.00	<20.00	<20.00
Sc	<1.00	4.00	2.00	<1.00	1.00	7.00	4.00	<1.00	<1.00	14.00	<1.00	1.00	<1.00
Ba	5.00	2.00	10.00	14.00	2.00	9.00	6.00	7.00	1.00	10.00	6.00	6.00	3.00
Be	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Co	18.30	36.40	5.00	48.20	29.20	11.00	6.50	17.70	16.70	28.00	14.70	13.10	10.40
Cs	0.10	<0.10	0.50	3.10	0.10	0.20	0.20	0.10	0.10	0.20	0.10	0.40	0.10
Ga	5.70	6.40	6.10	10.40	7.20	5.10	9.60	3.40	7.30	2.50	3.70	11.60	23.50
Hf	<0.10	<0.10	<0.10	<0.10	<0.10	0.20	0.10	<0.10	<0.10	0.40	<0.10	<0.10	<0.10
Nb	<0.10	<0.10	0.10	<0.10	<0.10	0.10	<0.10	<0.10	0.10	0.30	<0.10	<0.10	<0.10
Rb	0.30	0.20	0.60	55.40	<0.10	0.40	0.50	0.20	<0.10	0.30	0.20	1.90	0.50
Sn	1.00	<1.00	<1.00	<1.00	<1.00	<1.00	2.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Sr	17.20	48.90	9.90	4.80	10.10	69.80	32.80	3.30	3.90	8.60	3.60	53.60	2.70
Ta	<0.10	<0.10	<0.10	<0.10	0.20	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Th	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.40	<0.20	<0.20	<0.20
U	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	<0.10	<0.10	<0.10
V	<8	38.00	37.00	49.00	50.00	58.00	33.00	21.00	38.00	39.00	16.00	15.00	30.00
W	152.40	5.60	20.90	169.20	11.30	17.60	14.70	35.40	14.20	57.90	49.70	155.50	101.70
Zr	<0.10	1.20	<0.10	<0.10	0.20	4.90	5.20	<0.10	<0.10	14.70	0.50	<0.10	<0.10
Y	0.50	9.30	7.00	<0.10	0.10	5.30	2.40	0.70	0.70	17.90	0.70	1.80	0.40
La	0.30	2.00	3.00	0.20	<0.10	1.50	0.60	0.30	1.10	7.00	0.20	0.20	0.60
Ce	<0.10	4.20	5.90	<0.10	<0.10	2.60	1.20	0.30	0.30	13.90	0.30	0.20	0.30
Pr	0.04	0.70	0.81	0.02	<0.02	0.42	0.20	0.05	0.03	2.03	0.04	0.02	0.04
Nd	<0.30	3.70	4.60	<0.30	<0.30	2.10	1.00	<0.30	<0.30	9.30	<0.30	<0.30	<0.30
Sm	0.07	0.91	0.91	<0.05	<0.05	0.64	0.32	0.06	<0.05	2.55	0.05	0.09	<0.05
Eu	0.04	0.69	0.59	<0.02	<0.02	0.51	0.18	0.08	0.07	2.07	0.06	0.05	0.02
Gd	0.08	1.21	1.23	<0.05	<0.05	0.80	0.36	0.09	<0.05	2.73	0.07	0.20	0.08
Tb	0.01	0.25	0.18	<0.01	<0.01	0.11	0.06	0.02	<0.01	0.38	0.01	0.04	<0.01
Dy	<0.05	1.32	1.11	<0.05	<0.05	0.75	0.40	0.07	0.09	2.59	0.06	0.23	<0.05
Ho	<0.02	0.27	0.25	<0.02	<0.02	0.17	0.09	0.03	0.03	0.52	0.02	0.05	<0.02
Er	0.05	0.88	0.62	<0.03	<0.03	0.47	0.25	0.06	0.07	1.47	0.05	0.13	<0.03
Tm	<0.01	0.13	0.08	<0.01	<0.01	0.07	0.04	0.02	<0.01	0.22	<0.01	0.02	<0.01
Yb	0.06	0.75	0.65	<0.05	<0.05	0.50	0.27	0.05	<0.05	1.54	<0.05	0.16	<0.05
Lu	<0.01	0.11	0.08	<0.01	<0.01	0.07	0.04	0.01	0.01	0.23	0.01	0.03	<0.01
TOT/C	1.43	4.62	0.25	<0.02	0.89	3.82	1.49	0.41	0.64	2.28	0.19	2.49	<0.02
TOT/S	10.96	22.39	3.12	8.34	11.51	3.81	12.54	4.04	10.15	6.09	2.01	11.51	14.35
Σ REE	0.65	17.12	20.01	0.22	0.00	10.71	5.01	1.14	1.70	46.53	0.87	1.42	1.04
ΣLREE	0.45	12.20	15.81	0.22	0.00	7.77	3.50	0.79	1.50	36.85	0.65	0.56	0.96
ΣHREE	0.20	4.92	4.20	0.00	0.00	2.94	1.51	0.35	0.20	9.68	0.22	0.86	0.08
Σ LREE/Σ HREE	2.25	2.48	3.76	-	-	2.64	2.32	2.26	7.50	3.81	2.95	0.65	12.00
Eu/Eu*	1.64	2.02	1.72	-	-	2.19	1.62	3.35	-	2.39	3.12	1.11	-
Ce/Ce*	-	1.64	1.67	-	-	1.53	1.64	-	-	1.79	-	-	-
(La/Yb)N	3.59	1.91	3.31	-	-	2.15	1.59	4.30	-	3.26	-	0.90	-
(La/Sm)N	2.77	1.42	2.13	-	-	1.51	1.21	3.23	-	1.77	2.58	1.43	-
(Tb/Yb)N	0.76	1.52	1.26	-	-	1.00	1.01	1.82	1.32	1.12	0.74	1.14	0.55
Y/Ho	-	34.44	28.00	-	-	31.18	26.67	23.33	23.33	34.42	35.00	36.00	-
Major Ore Elements :													
Mo	7.10	3.50	131.90	0.20	<0.1	1.10	0.40	<0.1	<0.1	2.90	<0.1	41.90	0.90
Cu	3804.10	52754.20	928.90	2892.90	114770.00	3238.40	11091.30	9529.90	15821.50	3339.20	5044.80	5028.60	5060.00
Pb	28448.80	11709.30	3089.70	11.60	300.00	36617.20	23449.80	3885.70	34213.50	12344.80	5560.50	13240.10	157100.00
Zn	167401.00	48121.00	6147.00	106912.00	500.00	14833.00	72997.00	45796.00	84512.00	24725.00	33334.00	115034.00	226300.00
Ni	<0.10	5.50	2.40	0.10	0.50	2.00	2.00	0.60	0.60	7.90	0.60	1.40	<0.10
As	13.20	1158.20	>10000.00	20.60	13.60	289.90	247.80	207.30	45.50	3134.90	17.10	1669.80	4.40
Cd	1287.30	337.20	47.20	1064.70	2.90	112.10	528.70	363.80	587.10	101.70	236.80	885.30	>2000.0
Sb	4.50	23.80	71.20	0.50	1.20	8.00	6.40	2.80	3.40	26.00	0.80	16.30	11.90
Bi	11.60	12.90	0.40	0.60	199.50	12.70	18.30	8.50	21.30	0.20	5.70	2.40	24.70
Ag	30.30	33.10	35.00	2.10	>100.0	66.10	51.40	45.90	60.70	9.70	41.60	12.90	>100.0
Au	1251.90	2290.40	9105.30	91.10	1035.80	2903.60	3612.00	2017.70	4152.50	579.60	17519.20	6965.80	6901.40
Hg	2.52	1.58	0.88	0.67	0.23	3.81	4.40	0.56	0.93	3.32	0.52	1.59	4.50
Tl	<0.10	0.20	0.30	<0.10	<0.10	0.50	0.30	<0.10	<0.10	0.30	<0.10	0.20	<0.10
Se	308.00	154.00	30.00	144.00	116.00	305.00	190.00	78.00	168.00	35.00	49.00	119.00	>500
Te	32.00	16.00	*na*	<5.00	156.00	57.00	53.00	40.00	50.00	14.00	38.00	14.00	209.00

Major elements are in wt%; minor and trace elements are in g t^{-1} except for Cr_2O_3, TOT/C and TOT/S are in wt%; major ore elements are in g t^{-1} excepts for Au is in g t^{-3}

* *n.a* : no analized

Table 2 Geochemical analysis for major, minor and trace elements composition of selected altered host rock samples of Arinem vein with comparison with outcrop Jampang Formation and Miocene-Pliocene intrusions.

	Altered Host rock						Less altered Host rock and Intrusions				
Level	**-60**	**-60**	**200**	**200**	**275**	**300**	**Jampang Fm**	**Miocene Intrusion**			**Plio Intr.**
Sample no.	**BCA-20A-15**	**BCA-20A-1**	**B.3-22**	**B.3-76**	**BCAN 1A-3**	**B.2-66**	**ST**	**GN.SBG**	**GN.HLG**	**GN. BLR**	**GN.WYG**
Major Elements :											
SiO_2	65.27	66.93	42.39	75.06	57.13	75.41	61.97	61.08	60.88	70.06	60.19
Al_2O_3	15.29	8.65	4.92	6.23	15.61	13.36	16.43	16.79	16.46	15.47	16.74
Fe_2O_3	5.80	9.49	27.37	8.95	5.63	1.72	5.38	6.45	5.76	2.62	6.44
MgO	2.27	1.88	3.75	1.75	2.53	0.63	1.54	3.04	2.55	0.82	3.00
CaO	1.77	1.17	0.21	0.19	5.00	0.59	3.42	6.06	5.48	3.24	6.31
Na_2O	0.14	0.03	<0.01	0.01	0.16	0.14	4.59	3.06	3.23	3.89	3.06
K_2O	2.34	1.71	0.06	0.22	2.35	2.31	0.84	1.80	2.21	1.80	1.76
TiO_2	0.74	0.42	<0.01	0.40	0.81	0.58	0.56	0.64	0.61	0.31	0.63
P_2O_5	0.16	0.04	0.01	0.07	0.11	0.10	0.17	0.11	0.11	0.08	0.12
MnO	0.27	0.26	0.22	0.10	0.34	0.05	0.12	0.11	0.10	0.06	0.11
LOI	5.80	9.40	12.90	6.60	10.20	5.00	4.80	0.70	2.40	1.60	1.40
Sum	99.9	99.93	91.78	99.54	99.84	99.92	99.83	99.84	99.82	99.92	99.74
Minor and Trace Elements :											
Cr_2O_3	<0.002	<0.002	<0.002	<0.002	0.002	0.002	0.002	0.003	<0.002	<0.002	0.003
Ni	<20.00	<20.00	<20.00	<20.00	20.00	20.00	20.00	<20.00	<20.00	<20.00	20.00
Sc	25.00	15.00	5.00	9.00	24.00	14.00	13.00	18.00	16.00	5.00	18.00
Ba	201.00	97.00	4.00	11.00	88.00	56.00	111.00	240.00	262.00	221.00	238.00
Be	<1.00	<1.00	<1.00	<1.00	1.00	1.00	1.00	<1.00	<1.00	<1	1.00
Co	12.10	11.80	42.00	15.80	27.90	14.70	9.90	17.30	14.90	4.50	24.30
Cs	9.20	3.50	0.20	0.50	11.30	12.90	1.20	2.80	6.70	4.00	3.10
Ga	16.20	10.20	10.30	8.30	13.90	11.90	15.40	17.90	16.80	14.80	16.50
Hf	2.50	1.00	<0.10	0.50	1.40	1.40	2.90	3.80	4.30	3.40	3.80
Nb	1.00	0.50	<0.10	0.40	0.70	1.00	1.40	3.70	2.60	2.20	3.80
Rb	61.20	50.60	3.40	9.30	92.50	84.70	18.40	89.10	177.20	91.90	77.40
Sn	1.00	<1.00	<1.00	<1.00	1.00	1.00	1.00	6.00	15.00	2.00	1.00
Sr	55.40	27.40	5.00	6.00	49.10	19.90	267.50	268.10	306.80	239.30	247.60
Ta	<0.10	<0.1	<0.10	<0.10	0.10	0.10	0.10	0.30	0.20	0.20	0.30
Th	1.00	0.20	<0.20	<0.20	0.20	0.50	0.70	8.10	16.70	10.40	7.70
U	0.30	<0.10	<0.10	<0.10	0.10	0.20	0.30	1.90	3.10	2.20	1.70
V	115.00	117.00	82.00	76.00	190.00	150.00	82.00	133.00	143.00	30.00	133.00
W	32.50	47.40	9.50	17.30	110.70	131.10	156.90	60.70	67.50	81.40	427.80
Zr	71.00	26.90	1.60	18.90	37.50	35.70	82.50	124.40	129.90	112.70	127.20
Y	21.80	8.90	1.00	4.60	11.40	6.70	24.20	20.70	18.90	13.30	20.50
La	3.90	3.20	0.60	0.90	1.80	1.40	6.90	15.30	15.50	12.80	14.80
Ce	11.10	9.00	0.50	2.20	5.20	4.10	17.20	37.50	38.00	28.50	33.00
Pr	1.71	1.23	0.08	0.42	0.89	0.64	2.65	3.98	4.19	3.03	4.04
Nd	9.30	6.10	0.60	2.40	4.60	3.30	12.30	15.70	16.40	11.20	15.80
Sm	2.75	1.60	0.23	0.73	1.46	1.05	3.39	3.76	3.60	2.28	3.58
Eu	0.48	0.48	0.03	0.21	0.51	0.40	1.05	0.89	0.78	0.64	0.88
Gd	3.34	1.50	0.28	0.83	1.82	1.18	3.66	3.62	3.33	2.06	3.68
Tb	0.61	0.27	0.04	0.12	0.33	0.20	0.64	0.61	0.57	0.34	0.61
Dy	3.55	1.68	0.20	0.89	1.86	1.04	3.89	3.50	3.22	2.13	3.30
Ho	0.76	0.34	0.04	0.17	0.39	0.23	0.80	0.71	0.66	0.42	0.71
Er	2.46	1.01	0.08	0.48	1.20	0.77	2.33	2.03	2.01	1.30	2.14
Tm	0.37	0.16	<0.01	0.08	0.20	0.12	0.37	0.32	0.28	0.21	0.33
Yb	2.29	1.09	0.08	0.47	1.25	0.72	2.43	2.07	1.93	1.50	2.05
Lu	0.37	0.16	<0.01	0.07	0.20	0.13	0.38	0.33	0.29	0.24	0.33
TOT/C	0.39	2.48	0.19	0.17	1.89	0.17	0.49	0.02	0.05	<0.02	0.14
TOT/S	0.38	0.11	18.62	5.47	0.47	0.30	0.02	<0.02	<0.02	<0.02	0.02
Σ REE	42.99	27.82	2.76	9.97	21.71	15.28	57.99	90.32	90.76	66.65	85.25
ΣLREE	29.24	21.61	2.04	6.86	14.46	10.89	43.49	77.13	78.47	58.45	72.10
ΣHREE	13.75	6.21	0.72	3.11	7.25	4.39	14.50	13.19	12.29	8.20	13.15
Σ LREE/Σ HREE	2.13	3.48	2.83	2.21	1.99	2.48	3.00	5.85	6.38	7.13	5.48
Eu/Eu*	0.48	0.93	0.36	0.83	0.96	1.10	0.91	0.73	0.68	0.89	0.74
Ce/Ce*	1.95	2.16	0.83	1.57	1.90	2.02	1.98	2.43	2.41	2.32	2.18
(La/Yb)N	1.22	2.11	5.38	1.37	1.03	1.39	2.04	5.30	5.76	6.12	5.18
(La/Sm)N	0.92	1.29	1.68	0.80	0.80	0.86	1.31	2.63	2.78	3.62	2.67
(Tb/Yb)N	1.21	1.13	2.27	1.16	1.20	1.26	1.20	1.34	1.34	1.03	1.35
Y/Ho	28.68	26.18	25.00	27.06	29.23	29.13	30.25	29.15	28.64	31.67	28.87
Major Ore Elements :											
Mo	0.10	<0.10	0.10	12.30	0.10	2.10	0.10	0.40	0.50	0.50	0.30
Cu	15.00	81.50	77779.80	3284.60	25.70	9.60	13.80	94.90	166.00	59.40	36.70
Pb	7.50	4.60	4540.10	29.00	3.50	5.30	2.10	12.40	38.10	4.70	13.70
Zn	176.00	116.00	7247.00	103.00	54.00	41.00	58.00	41.00	47.00	38.00	60.00
Ni	0.60	4.20	6.30	4.90	4.40	5.60	1.00	4.80	4.20	1.00	4.00
As	4.00	49.30	56.70	20.50	10.90	241.80	10.10	3.20	12.20	22.10	1.50
Cd	<0.10	<0.10	49.20	<0.1	0.10	0.10	<0.10	<0.10	<0.10	<0.10	0.30
Sb	<0.10	0.20	1.70	0.80	0.10	1.20	<0.10	0.30	0.40	0.60	0.20
Bi	<0.10	<0.10	61.50	0.90	0.10	0.10	<0.10	<0.10	0.10	0.20	<0.10
Ag	<0.10	0.2	72.10	2.10	0.10	0.20	<0.10	0.20	0.20	0.10	<0.10
Au	2.60	9.20	536.10	89.30	5.20	22.00	<0.50	2.20	8.00	<0.5	1.60
Hg	0.03	0.11	0.60	0.10	0.01	0.47	<0.01	0.03	0.05	0.01	<0.01
Tl	<0.10	<0.10	<0.10	<0.10	0.10	0.20	<0.10	<0.10	<0.10	<0.10	<0.10
Se	0.80	<0.50	201.00	8.00	0.50	0.60	<0.50	<0.50	0.70	<0.50	<0.50
Te	<1.00	<1.00	53.00	*n.a*	*n.a*	*n.a*	*n.a*	<1.00	<1.00	<1.00	*n.a*

Major elements are in wt%; minor and trace elements are in g t^{-1} except for Cr_2O_3, TOT/C and TOT/S are in wt%; major ore elements are in g t^{-1} excepts for Au is in g t^{-3}

* *n.a* : no analized

Propylitic and argillic alteration zones samples show similar major element content. Most of the altered rocks show low Na_2O, TiO_2, MnO and P_2O_5 contents, variable but low MgO and variable but high SiO_2 and K_2O contents. The Al_2O_3 contents generally almost the same with fresh rock (13.4 to 16.5%) and the SiO_2 contents range from 57.1 to 75.4%. The comparison composition between less altered Jampang Formation with the Pliocene intrusion are depletion of the Na_2O, MgO, CaO, K_2O, & Fe_2O_3; slightly enriched of Na_2O and K_2O; and SiO_2 variable for less altered Jampang Formation. The analyses results for major, minor, trace and rare earth elements of mineralized vein and altered host rock of the Arinem vein are presented in Tables 1 and 2, respectively. Two samples from the alteration zone of the Arinem vein (B.3-22 and B.3-76) have low Al_2O_3 content. They may have been influenced by the presence of strong silica and iron oxide.

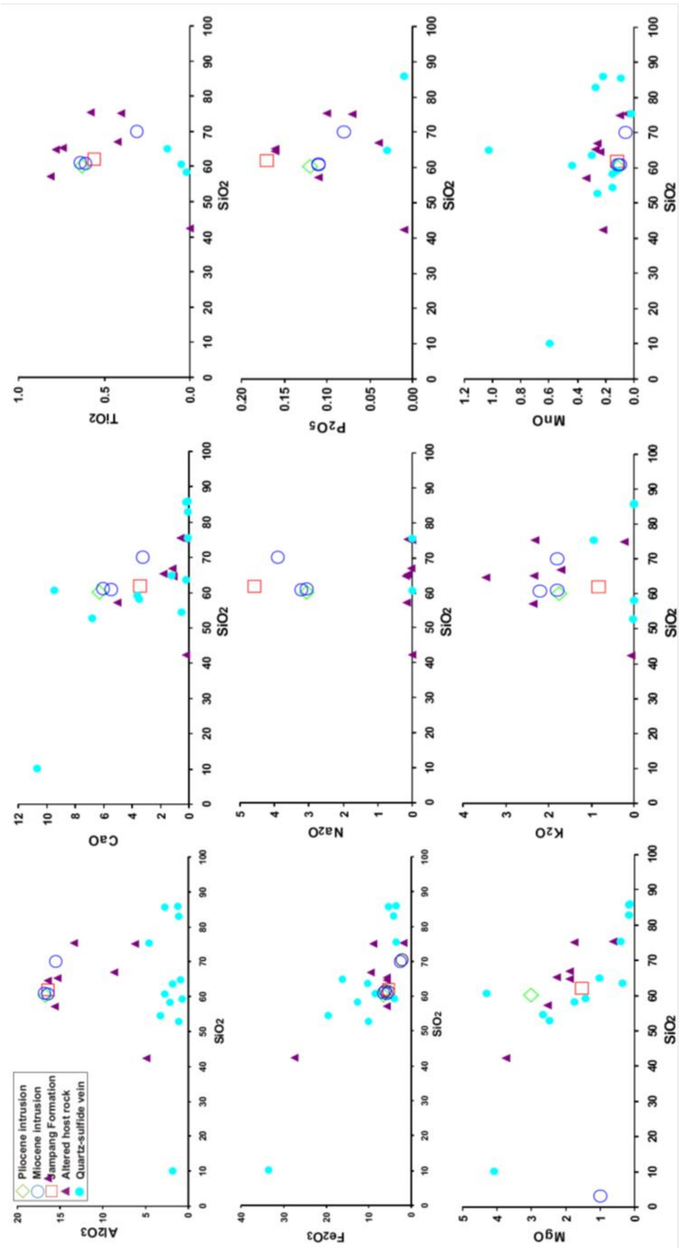

Fig. 2 Relation between the SiO_2 and the major elements content in quartz-sulfide vein and altered host rock of Arinem vein with comparison with less altered Jampang Formation and fresh Miocene-Pliocene intrusions of outcrop samples.

Fig. 2 contains plots of Harker diagram for mineralized Arinem vein and altered host rock. Despite the fact that SiO_2 in some samples might have migrated slightly during the alteration process, the diagrams indicate that: the contents of Fe_2O_3 and MgO increase with decreasing SiO_2 contents both in quartz-sulfide vein and altered host rock samples. Compare to the less altered Jampang Formation, Miocene and Pliocene intrusions, the trend of Al_2O_3 and P_2O_5 of mineralized vein and alteration host rock show similar composition. TiO_2 and K_2O of altered host rock are higher and mineralized vein is lower; Na_2O both altered host rock and mineralized vein are lower; CaO, MgO, Fe_2O_3 and MnO show uneven pattern. The TiO_2 pattern shows the increasing of SiO_2 is follow by the increasing of TiO_2 in mineralized quartz-sulfide vein and decreasing of TiO_2 in altered host rock. Al_2O_3, CaO, K_2O, P_2O_5 and MnO concentrations plotting is unclear. There is no significant difference of the major elements among the different stage of mineralization. The K_2O, P_2O_5, TiO_2 and Al_2O_3 content in altered host rock are both slightly and strongly higher than quartz-sulfide vein.

Minor, Trace and Rare Earth Elements Geochemistry of Arinem Vein

The content of the large lithophile elements (Cs, Ba, Rb and Sr) and the incompatible elements contents are variable comparing to the less altered rocks. The Ba and Rb content in mineralized quartz-sulfide samples are lower comparing to altered host rock samples. Increasing Cs content occur almost in all altered host rock sample but decrease in the mineralized vein. Depleted of Ba occurs in all the mineralized vein and altered zones in a range of 4 to 88 g t^{-1} in altered host rock and in quartz-sulfide vein in a range of 1 to 14 g t^{-1}. Only one altered sample of BCA 20A-15 has high Ba content of 323 g t^{-1}. The Ba content of the less altered Jampang Formation is 111 g t^{-1} and fresh rocks taken from Miocene and Pliocene intrusions around 221–262 g t^{-1}.

The value of the Rb concentration varies within the alteration degree. The average Rb contents are both higher and lower in the propylitic and argillic alteration zones than in the less altered outcrop of Jampang Formation and fresh Pliocene intrusion. The contents of Rb in quartz-sulfide vein are very low, usually less than 2 g t^{-1} only one sample with 55.4 g t^{-1} value. The Sr concentration is lower for all of the mineralized and altered samples (2.7–69.8 g t^{-1}) in comparison with the concentration in the outcrop host rock sample of less altered Jampang Formation, and fresh Miocene and Pliocene intrusions (239.3–306.8 g t^{-1}). However, in general the altered rocks show a high Ba/Rb and Rb/Sr ratios, quartz-sulfide samples show low Ba/Rb ratio but low Rb/Sr ratio.

Similar with Sr, the content of the Zr and Y in both mineralized vein and altered host rock are also depleted comparing to the fresh rock. The content of Ni, Sc, Cs, Hf, Nb, V, and W are depleted with various values. Cobalt (Co) in both vein and altered host rock are enriched, and V is depleted in mineralized vein but enriched in altered host rock. The In contents in mineralized and alteration samples are present in the wide range from 5.0 to 48.2 g t^{-1}. Others trace elements content are similar with the less altered Jampang Formation, and Miocene and Pliocene intrusions. For the Ti group, Hf content is mostly under detection limit but some samples show values up to 2.4 g t^{-1}. The Zr content is variable but low in quartz-sulfide vein (up to 14.7 g t^{-1}), higher in altered host rock (up to 78.7 g t^{-1}). Most of the Ni element is under detection limit and most of samples have a low Cr content.

The Arinem vein data shows the ΣREE abundances between 0.2 to 46.5 g t^{-1} in quartz-sulfide vein but commonly less then 5.0 g t^{-1}. The REE contents in quartz-sulfide vein is almost similar to those in hydrothermal quartz veins of Pongkor (Warmada et al., 2007), or REE in hot spring of Yellowstone (Lewis et al., 1997 and 1998) or ground water and river water (Moller et al., 1998). The ΣREE for altered host rock is between 10.0 to 40.0 g t^{-1}, only one sample has low content of 2.8 g t^{-1} (sample B3-22). In general the ΣREE of the mineralized vein and altered host rock are depleted comparing to the fresh rock. Depletion and enrichment of the REE and the incompatible elements occurs in all the vein and alteration zones. The REE content is low and the pattern is flatter for the mineralized Arinem vein than those for the fresh rocks.

In general, ΣREE in alteration samples shows higher value compare to those in quartz-sulfide vein. It is up to 40.0 g t^{-1} and almost similar to common ΣREE contents in volcanic rock of less altered Jampang Formation (58.0 g t^{-1}) and also other alteration zone of the Bayah (Sukarna, 1999). Tendencies of decreasing in ΣREE in quartz-sulfide vein samples are show by sample from L440 to L200 from stages IA–IIIB (Fig. 3).

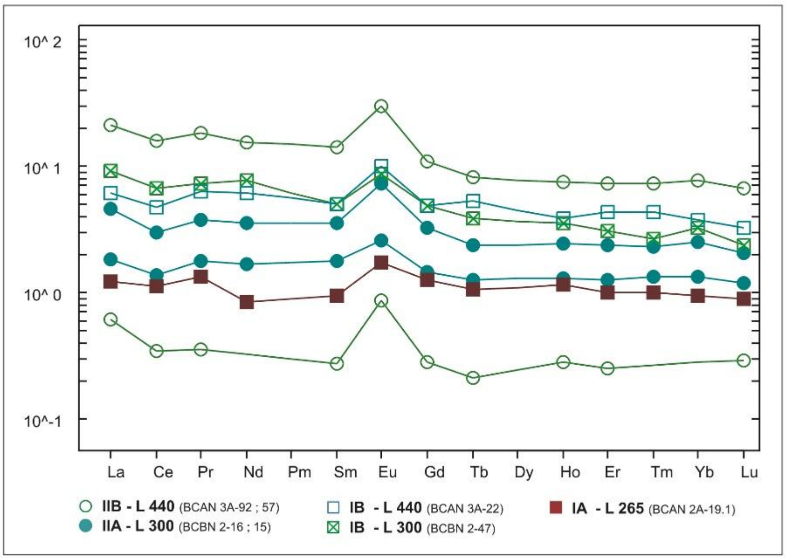

Fig. 3 Rare earth element (REE) patterns of Arinem quartz-sulfide vein.

The ΣREE in the altered host rock are 5 times higher compared to those in quartz-sulfide vein samples (Fig. 4). Some quartz-sulfide samples is mix with clay mineral of altered host rock that resulted high ΣREE (sample no 3A-92/ L440 stage IIB). Some samples of alteration such as samples no. B3-22 and B3-76 are also mix with quartz-sulfide vein and as consequence they have low ΣREE of 2.8 and 10.0 g t^{-1}, respectively.

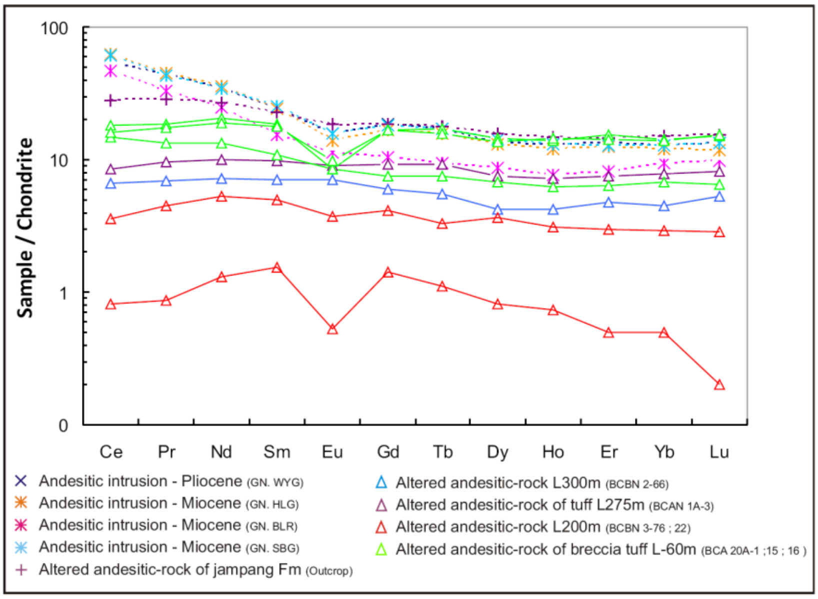

Fig. 4 Rare earth elements (REE) patterns of Arinem altered host rock.

The ∑LREE/∑HREE ratio of the mineralized vein is between 0.7 to 12.0, but mostly more than 2.0. The Eu/Eu* ratio is between 1.1 to 3.4 and Ce/Ce* ratio is 1.5 to 1.8. The ratio of the $(La/Yb)_N$ is between 0.9 to 4.3; $(La/Sm)_N$ is between 1.2 to 3.2; $(TbYb)_N$ is between 0.6 to 1.8; and Y/Ho is between 23.3 to 36.0. The ∑LREE/∑HREE ratio of the altered host rock is lower than mineralized vein, in the range of 2.0 to 2.8. The ratio of Eu/Eu*, $(La/Sm)_N$, and Y/Ho are slightly lower, with ranges of 0.4 to 1.1 (Eu/Eu*), 0.8 to 1.9 $(La/Sm)_N$, and 25.0 to 29.2 (Y/Ho). The ration of the Ce/Ce* in the range of 0.8 to 2.0, $(La/Yb)_N$ ratio in the range of 1.0 to 5.4, and $(TbYb)_N$ ratio of the range of 1.7 to 2.3 are almost similar with the mineralized vein.

The REE data were normalized to their abundance in chondrites according to Sun and McDonough (1989). The elements determined included light REE from La to Eu and heavy REE (HREE) from Gd to Lu. Some samples with quartz-sulfide dominant which are analyzed by LA-ICPMS, shows REE contents are below detection limit. Mineralized vein has slightly negative anomaly of Ce, moderate to strongly positive anomaly of Eu and flat pattern (10^{-1} to 10^{2}).

Altered host rock have flatter pattern with value between 10^{0} to 10^{1}, some show slightly to strongly negative anomaly of Eu. The REE plots of quartz-sulfide vein and alteration host rock are also exhibits variable enrichment in LREE relative to HREE (ΣLREE/ΣHREE = 2.0 to 5.5) only one sample from quartz-sulfide vein (2A-39.2/ stage IIC) has depleted in LRRE (0.7). The less altered andesitic Jampang Formation and andesitic Miocene and Pliocene intrusions have strongly LREE enrichment with slightly negative anomaly of the Eu. The less altered Jampang Formation shows LREE enriched and flatter pattern comparing to andesitic Miocene and Pliocene intrusions which has strongly LREE enrichment.

Major Ore Elements Geochemistry of Arinem Vein

The geochemistry analyses of the major ore minerals concluded gold and silver grades varies from 0.01 (IIA) – 17.52 g t^{-1} (IIB) Au and 2.1 (IIA) - >100 g t^{-1} (IIA & IIC) Ag. The base metal (Cu, Zn and Pb) contents vary from 928.9 (IB) to 114,770 g t^{-1} (IIA), 500(IIA) to 226,300 g t^{-1} (IIC) for Zn, and 11.6 (IIA) to 157,100 g t^{-1} (IIC) for Pb (Table 5.1). Other ore elements are As 4.4 (IIC) to >10,000 g t^{-1} (IB), Sb 0.5 (IIA) to 71.2 g t^{-1} (IB), Cd 2.9 (IIA) to >2,000 g t^{-1} (IIC), Bi 0.2 (IIB) to 199.5 g t^{-1} (IIA), Se 30.0 (IB) to >500 g t^{-1} ((IIC), Te <5.0 (IIA) to 209.0 g t^{-1} (IIC). The sample with highest content of Sb is associated with the highest content of As and the highest content of Se is associated with the highest content of Pb. The content of Mo is up to 131.9 g t^{-1} and until now it is unclear yet the association of the Mo element with ore minerals.

Based on the mineralization stage, the content of the Au, Ag, Te and base metal in the stage I are up to 9.1 g t^{-1} Au, 35.0 g t^{-1} Ag, 32.0 g t^{-1} Te, 5.3% Cu, 16.7% Zn and 2.9% Pb. The Au, Ag, Te and base metal contents in the stage II are up to 17.5 g t^{-1} Au, >100 g t^{-1} Ag, 209.0 g t^{-1} Te, 11.5% Cu, 22.6% Zn and 15.7% Pb. The stage III content low Au, Ag, Te and base metal, as there are up to 0.3 g t^{-1} Au, 22.6 g t^{-1} Ag, 28.0 g t^{-1} Te, 0.9% Cu, 6.7% Zn and 0.4% Pb, respectively (Table 5.1). Samples from the Arinem deposit with high Au content have the lowest REE contents (~2 g t^{-1}). The gold and silver content in the Arinem vein are varies. Relatively low Au and Ag concentration occur in samples from any alteration zone.

Altered host rock, sample B.3-22 is mixed between the altered host rocks (propylitic) with mineralized vein and shows some anomalous value of the ore elements. Sample B.2-66 of altered host rock has high As contents of 241.8 g t^{-1}. Both less altered andesitic Jampang Formation, and Miocene and Pliocene intrusions have very low content of the ore elements except for Cu 13.8 and up to 166 g t^{-1}; Pb 2.1 and up to 38 g t^{-1}; and Zn 58 and up to 60 g t^{-1}. Some trace element also detected in the less altered Jampang Formation, and andesitic Miocene and Pliocene intrusions samples such as Ni 1 and 4.8 g t^{-1}; As 10.1 and 22.1 g t^{-1}. Other elements of Cd (0.3 g t^{-1}), Sb (0.6 g t^{-1}) and Au (8 g t^{-1}) are also detected in the andesitic Miocen and

Pliocene intrusions. Plotting in triangular diagram (Fig. 5) shows the correlation between concentration of the silver-gold-base metal (Zn, Pb, Cu). It is shows that the highest contents of base metal also accompany by the higher content of Au and Ag.

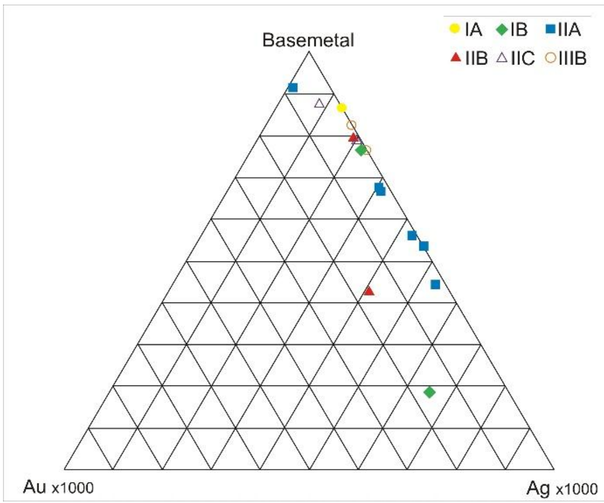

Fig. 5 Au-Ag-base metal correlation of the mineralized Arinem vein.

Variation diagrams for pairs of major ore elements in bulk-ore samples are given in Fig. 6. Positive correlation trends for the element groups Pb-Se-Zn-Cd and Ag-Au-Te point to a mineralogical control of element distribution. The Ag-Au-Te group relates to tellurium- Ag-Au minerals, whereas the Pb-Se-Zn-Cd group relates to base metal sulfides of galena and sphalerite. The As-Sb plot shows a positive correlation distribution, which indicates that the solid solution of As-Sb -bearing minerals is the dominant control for these elements. The Au-Te plot shows a scattered distribution, which indicates that the solid solution of Te-Au-bearing minerals is not the dominant control for these elements.

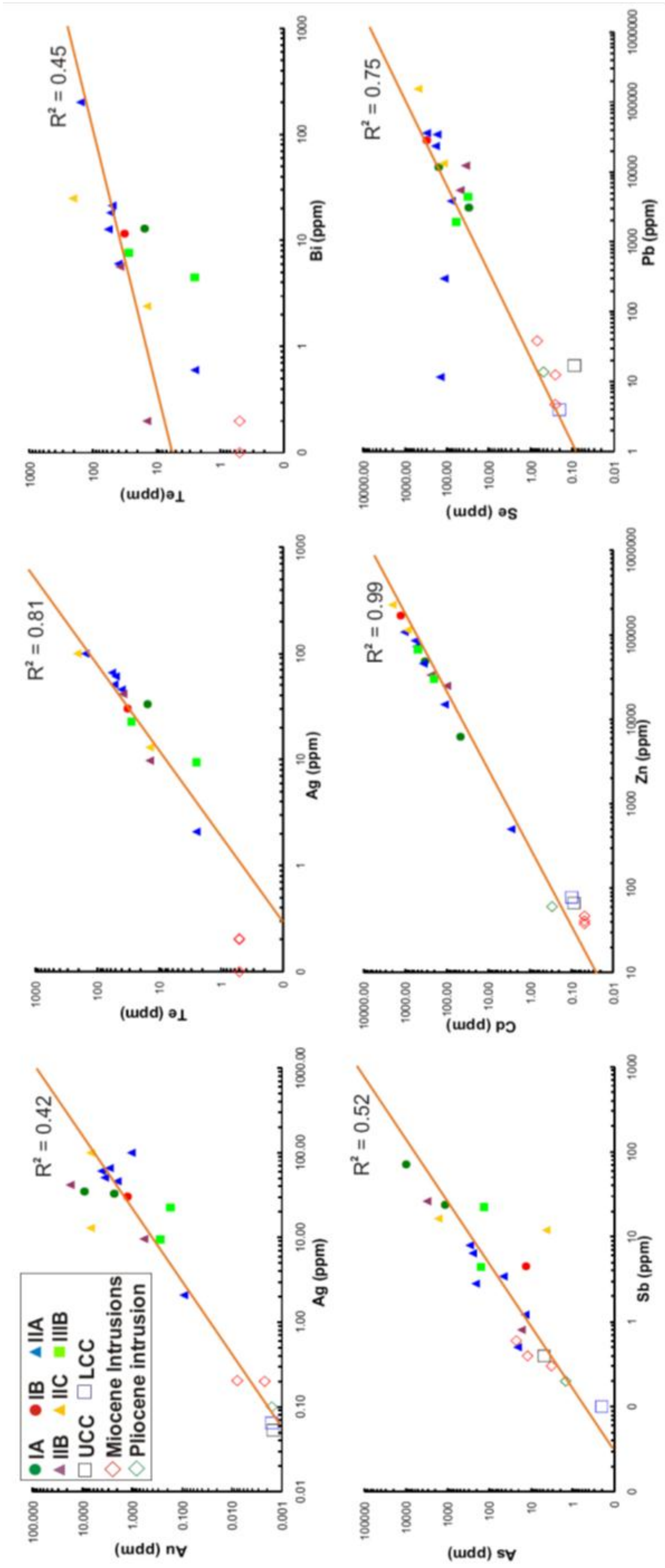

Fig. 6 Variation plots of selected ore-element pairs in bulk-ore Arinem vein samples (in g t^{-1}). Average of upper continental crust (UCC) and lower continental crust (LCC) from various authors are also plotted. Some diagrams show several correlation trends, which tend toward the bulk composition of the bulk continental crust (UCC & LCC).

The As-Au plot also shows a weak positive correlation, with relatively wide variation in As abundance (4.4 to >10,000 g t^{-1} As) compared to the magnitude for Au. The abundance of mercury is very low (0.2 to 4.5 g t^{-1} Hg) and gives a scattered distribution with silver. The correlation trends support the paragenetic observations from ore microscopy, i.e., a chemical and mineralogical trend from the stage I quartz dominated to the stage II base metal rich mineral paragenesis.

The Zn-Cd, Te-Ag, and Pb-Se have very high correlation which concludes that there are some substitutions of Zn by Cd, and Pb by Se as investigated from the petrographic and electron microscope studies. The Te and Ag also have high correlation indicating the occurrence of the hessite, stutzite and petzite. The correlation between Te–Bi and Ag–Au indicating the occurrence of the tetradymite and electrum, respectively. Correlation between As and Sb is reflected by the occurrence of the sulfosalt mineral of enargite and tennantite, and rare substitution of the As by Sb in arsenopyrite. Other ore elements do not shows any regular correlation.

Graphic in Fig. 6 also shows the relation between some ore element in correlation with the upper continental crust (UCC) and lower continental crust (LCC) from various authors (Taylor and McLennan, 1985) to understand the fractionation process of the ore elements. The plotting of the upper continental crust (UCC) and lower continental crust (LCC) in some graphic reflect degree of the differentiated process of the every element relative to value of the bulk continental crust composition.

Several correlation trends tend toward the UCC and LCC composition of the bulk continental crust, or intersect it. The inter-element correlation-trends for Ag-Au-Se suggest a similar process of enrichment for these elements. The position of the bulk continental crust (UCC and LCC) on the extrapolated correlation-trends suggests leaching of these elements from the continental crust with a various degree of efficiency. The base metals are much less enriched over bulk continental crust and indicate a much less efficient process of leaching. The low abundance of mercury in the system (0.2 to 4.5 g t^{-1}) could be a result of the high mobility of mercury.

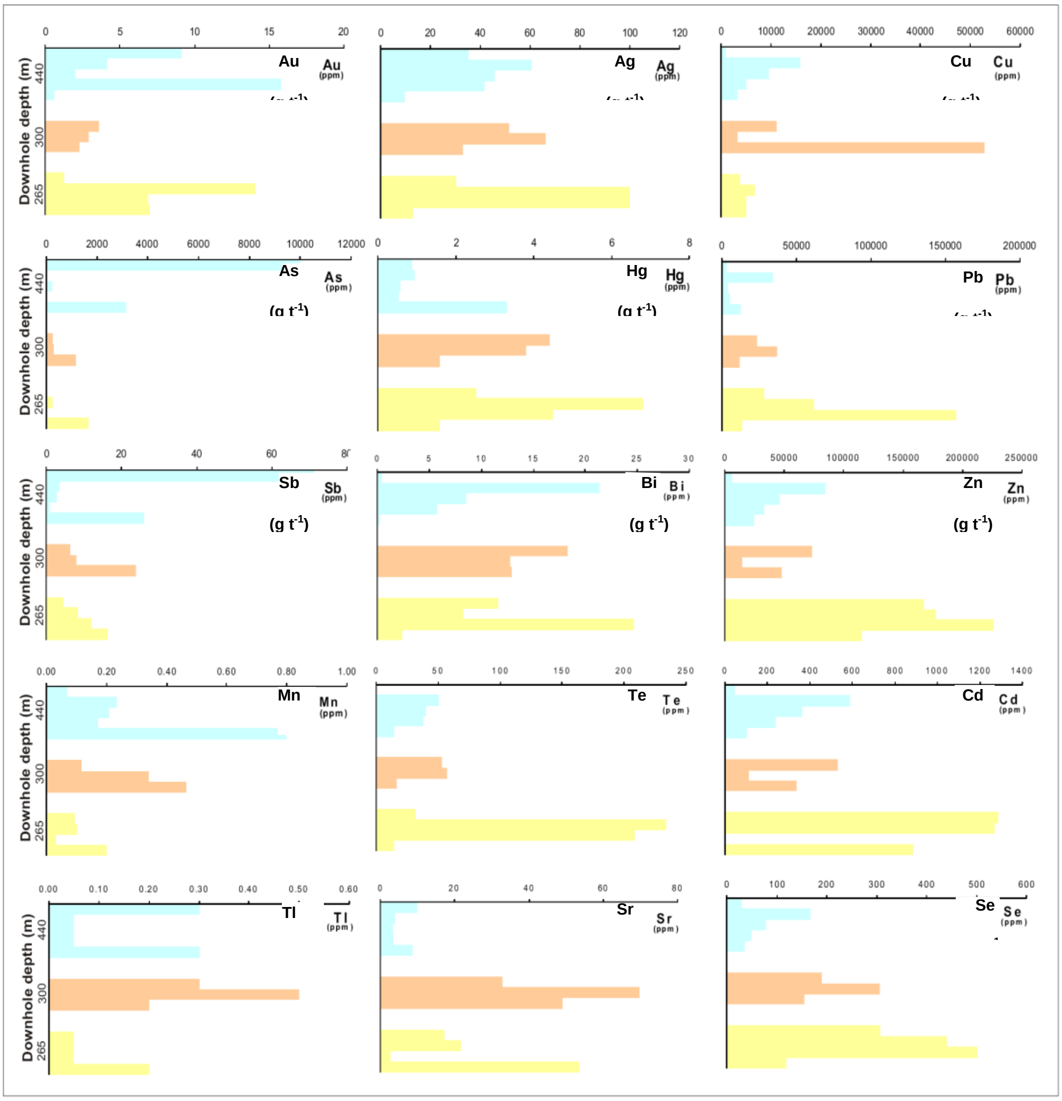

Fig. 7 Selected ore-elements content of the mineralized sulfide-quartz veins from three different vertical levels in the Arinem vein.

The general pattern of elemental concentration changes are well illustrated by the bar graphs (Fig. 7). Gold is highest in the stage IIB sulfide-quartz veins samples of the L440m, and decreases in concentration in stages I and II veins of the L300m to generally less than 5 g t^{-1}. To the deeper part of L265m its concentration is increase. Silver is highest in the sulfide-quartz veins of stage II, where it reaches concentrations of more than 100 g t^{-1}. The concentration of silver tends to be higher in the deeper part. The concentrations of tellurium are similar and follow the pattern of the silver indicating the close occurrence of silver and tellurium.

Arsenic tends to be higher and more consistent in the quartz veins of the shallower level relative to those of deeper part, and it is highest in the quartz veins of the stage IB of L440m (> 10,000 g t^{-1}) which is indicated with the presence of the arsenopyrite. Antimony, although more irregular in concentration essentially follows the same pattern with arsenic. Mercury is vary and occurred in low concentration (<5 g t^{-1}), reaching its highest single sample concentrations in the deeper part of L625m and to shallower level its content is decrease.

The base metals of Cu, Pb, and Zn are present in abundant concentration. The Zn and Pb shows similar pattern which highest at the deeper part and decrease to the shallower part. Zinc is present in consistently measurable amounts with the presence of the cadmium as also shows by the occurrence of the selenium for the lead. The copper show apposite trend with high concentration at the shallower L440m comparing to the deeper part of L265m, although the highest concentration is in the L300m associated with the lowest value of the Zn. The patterns of Tl and Sr concentrations are complex. Concentration of Mn and Bi give a similar pattern with Cu, high in shallower level and low in deeper part with some variation concentration.

Ore contents from altered host rock was conducted from L300m, L275m, L265m, L200m and L (-60m). The patterns of vertical variation in elemental concentration of the wall rocks at Arinem vein are highly irregular and the trends are more difficult to identify. This also because of some samples contains some fragment of quartz vein. The data presented in Fig. 8 are separated into a set of results for samples collected from altered host rock (sharp line), and samples from altered host rock which adjacent to quartz veins or containing quartz stringers (dashed line). Less altered Jampang Formation host rock, and andesitic Miocene and Pliocene intrusions of the outcrop also plotted as comparison (gray color). The lack of the mineralization within the alteration zone of propylitic and argillic also reflect by the geochemical analyses which give very low content of the ore elements. Au, Ag, As, Hg, Pb, Sb, Bi, Zn, Mn, Te, Cd, Tl, Sr and Ag enriched downward, while Cu is uneven.

Fig. 8 Selected ore-element concentrations for altered host rocks from outcrop and five different vertical levels of the Arinem vein. Some samples with dashed red line adjacent to or containing quartz veins are also plotted.

Gold and silver in altered host rock are highest in samples adjacent to or containing quartz veins, whereas As content is almost give a similar pattern with the samples taken from mineralized vein, except for 1 sample from argillic zone give a high content of As (241.8 g t^{-1}). Similar pattern also shown by base metal of Cu, but no for Te, Pb, Zn, and Cd which those are shown the apposite pattern with the mineralized body, with higher content in the shallower level, and lower in deeper part. Different pattern is shown by Se with highest value at the deeper part of L265m. The gold appears to irregularly decrease with depth in the system.

The pattern of the Ag also irregular and the highest value is found in the altered host rocks samples of L200m. Other elements of Mn, Tl and Sr are irregular and give very low contents in all samples. The less altered Jampang Formation, and andesitic Miocene and Pliocene intrusions have very low content of those above elements, except both samples shows higher content of Sr comparing to the altered host rock and mineralized vein. Mn content is similar and slightly lower comparing to the altered host rocks and mineralized vein.

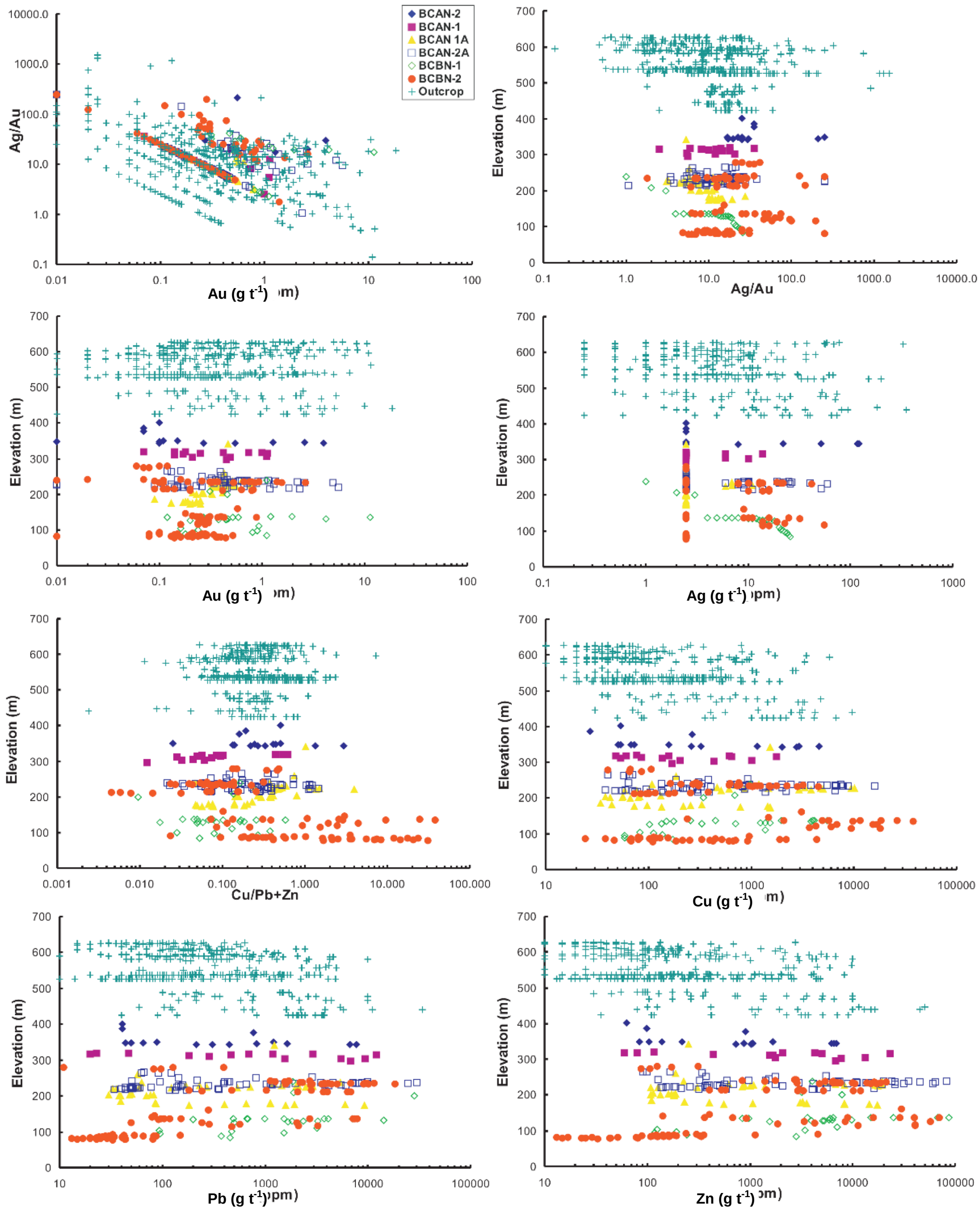

Fig. 9 Variation diagrams of Ag/Au ratio vs. Au value; and Au, Ag and base metal vs. elevation of the Arinem vein (source of data: PT Aneka Tambang).

Assay data for Au, Ag and base metal together with ratio Ag/Au from different elevation also plotted in Fig. 9. The Ag/Au and Au plotted for every elevation indicated the negative pattern correlation. The outcrop and core well data from different elevations shows some trends of the vertical distribution of the ore such as for Au and Ag, they are do not shows any variation from the surface (from elevation ~630 m) to the deeper part (to elevation ~ -80 m). The content of the Au and Ag are relatively constant from the surface to the deeper part, mostly in the range of 0.05 to 10 g t^{-1} and 5 to 100 g t^{-1}, respectively. Rather different with the base metal, which shows to the deeper part the content and grade of the Cu, Zn and Pb are slightly increased. The correlation pattern between Cu and elevation gained from the geochemical analysis of mineralized vein and assay is in apposite manner.

CONCLUSIONS

The low REE contents in quartz-sulfide vein and, by inference, in the hydrothermal fluid, suggest relatively short residence time of the meteoric water aquifer, that is, fast recharge. The partition coefficients of REE in quartz-sulfide of Arinem vein decrease systematically with increasing REE atomic number and same pattern also shows by the host rock of the Arinem vein. The slightly enrichment LREE and depleted HREE pattern of the some samples from the Arinem deposit are probably controlled by the affinity of those elements to cation sites of host minerals.

The REE distribution in the altered host rock of the Arinem deposit indicated that the ΣREE enrichment in the altered host rock, with decreasing in its content from the host rock to the mineralized vein. The trace element data for Arinem vein and altered host rock are show the samples with high ΣREE also have the high elevated Zr abundances, suggestive of contamination by accessory minerals or wall-rock particles.

Positive Eu anomalies in a fluid therefore need a temperature of more than approximately 250ºC, that is, the positive Eu anomaly in most of quartz vein samples reflects higher temperature than recorded during quartz-sulfide deposition and points to deeper fluid-rock interaction at a higher reservoir temperature than it seen in the fluid inclusions trapped at near-surface environment. The positive Eu anomaly in the quartz-sulfide samples could also be due to breakdown of plagioclase in the country rock as seen by hydrothermal alteration of plagioclase in the wall rock and formation of hydrothermal quartz-sulfide. The slightly negative Eu anomaly in the altered andesitic host rock, reflect hydrothermal Eu depletion and complementary Eu enrichment in the fluid.

However, there is also some significant celium (Ce) anomaly exhibit. The negative Ce anomalies are usually typical of marine carbonate and seawater, and reflect oxidation conditions. The low salinity of the Arinem hydrothermal system excludes involvement of seawater, and points to oxidized meteoric water. Comparing to the other deposit in western Java, this phenomenon is similar to the Pongkor and Cikidang deposit, but opposite of the Cibaliung which exhibit high positive Ce anomaly.

The observed variations in mineralogy and mineral proportions indicate that Au and Ag (present within electrum, petzite, argentite, hessite, and stutzite) came into being only during stage II (except for electrum also indicated at stage I), but that sphalerite, galena pyrite, chalcopyrite and arsenopyrite were deposited during stages I and II. The above mentioned observations can be exploited by the difference physico-chemical nature and environment at the deposition time. The relatively high base-metal contents related to a low Au anomaly pattern on geochemical samples reflect the Eh, pH and T-conditions during the ore deposition.

Geochemical zoning patterns at Arinem do not confirm well, in total, to those predicted by the epithermal models or the geothermal analogy, but they do have some regularity, and could with future refinement be tested as predictive tools. The alteration mineral assemblages and physical features of the rocks also appear to be use as guides to vertical and lateral position in the district.

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