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Epithermal Au-Ag Selenides-Tellurides Mineralization of Western Java Deposits

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Abstract
The ore mineralogy of the western most of West Java such as Pongkor, Cibaliung, Cikidang, Cikotok and Cirotan are characterized by the dominance of silver-arsenic-antimony sulfosalt with silver selenides and rarely tellurides over the argentite, whereas the eastern part of West Java including Arinem and Cineam deposits are dominated by silver-gold tellurides. Mineralogical differences between Se-type deposits at Pongkor, Cikidang, Cibaliung, Cisungsang and Cirotan and Te-type deposits at Arinem and Cineam show their different geochemical characteristics. Mineralogical and geochemical differences can be explained by variation of physico-chemical conditions that existed during gold-silver deposition with applying the phase relation between sulfides, tellurides and selenides minerals association in the deposits. The relative values of $f_{Se2(g)}$, $f_{Te(g)}$ and $f_{S2(g)}$ control the actual presence of selenide or telluride minerals within the West Java deposits, which also depend on their concentrations in the hydrothermal fluid. Even though the concentration of selenium in the hydrothermal fluid of Te-type deposits might have been similar or even higher than that in the Se-type, early substitution of selenium in the sulfide minerals prevents its concentration in the hydrothermal fluid to the levels for precipitating selenide minerals. Therefore, early sulfide minerals deposition from reduction fluids will not increase the $f_{Se2(g)}/f_{S2(g)}$ ratio to form selenide minerals in Te-type deposits of Arinem and Cineam, other than selenium bearing sulfide mineral such as Se-bearing galena or Se-bearing pyrargyrite-proustite.

Keywords : aguilarite, fugacity, hydrothermal, naumannite, selenium, substitution, tellurium

Introduction
Java is situated within the Indonesian archipelago at the southern margin of Sundaland and the Eurasian Plate. Sundaland is the continental core of SE Asia. (e.g. van Bemmelen, 1949; Hamilton, 1979) formed by the accretion of blocks to the Eurasian margin, and had been assembled by the Late Triassic. Northward subduction of the Indo-Australia Plate beneath the Eurasian Plate has probably been continuous since the early Paleogene although associated volcanism may not have been. Almost all the rocks exposed on Java are Cenozoic, and they include igneous intrusion, volcanic products, siliciclastic sedimentary rocks and shallow marine carbonate. In place they are significantly deformed. (Clement & Hall, 2007).

Gold mineralisation in Indonesia formed in andesitic arcs which were active for intervals of between 3 and 20 My from the Cretaceous to Pliocene. Fifteen major arcs are identified with a total on land extent of over 15,000 kms. Known orebodies and major prospects are confined to six arcs within the mid-Tertiary to Pliocene age range. In Indonesia these arcs total approximately 7,000 km in length and contain combine historical production and current resources in excess of 2,500 tonnes of gold and 20 million tones of copper.
Individual arcs or segments of arcs are characterized by specific types of mineralisation reflecting both arc basement related to earlier collisions and reversals in tectonic polarity, and erosion level.

The Se-type of western Java mineralization are mostly lie within and on the flanks of the Bayah Dome and in this study represented by Pongkor, Cikidang, Cisungsang, Cirotan and Cibaliung while the Te-type are located more eastern and represented by Arinem and Cineam deposits (Figure 1). Studies of ore mineralogy and geochemistry were carried out within the epithermal ore deposits of western Java by previous authors such as Pongkor (Basuki et al, 1994; Marcoux and Milesi, 1994; Milesi et al, 1999; Sukarna et al, 1994; Sukarna, 1999; Syafrizal et al, 2005; Syafrizal et al, 2007; Warmada et al, 2003; Warmada et al, 2007), Cikidang (Rosana and Matsueda, 2002; Rosana, 2004), Cibaliung (Angeles et al, 2002; Harijoko et al, 2004; Harijoko et al, 2007; Marcoux and Milesi, 1994; Marjoribanks, 2000; Sudana and Santosa, 1992), Cisungsang (Rosana et al, 2006), Cirotan (Milesi et al, 1993; Marcoux et al, 1993), Arinem (Yuningsih et al, 2012), and Cineam (Widi and Matsueda, 1998).

**Result and Analysis**

The dominant opaque minerals from the Se-type deposits are Se- and Se-bearing silver minerals (aguilarite, naumannite, argentite, polybasite and pyrargyrite), electrum and tetrahedrite with various amounts of sulfide minerals of sphalerite, galena, chalcopyrite, arsenopyrite and pyrite. Other ore minerals are found in trace amount. Some rare mineral of Bi- and Sn-bearing minerals such as lillianite and canfieldite occurred in Se-type deposit of Cirotan (Milesi et al, 1993). The Te-type is characterized by the occurrence of hessite, petzite, stutzite, tetradyomite, altaite, tennantite-tetrahedrite and with high amount of sulfide minerals of sphalerite, galena, chalcopyrite and pyrite with occurrences of arsenopyrite.

Rare telluride minerals of hessite and altaite were reported from the Se-type deposit (Harijoko et al, 2007), but until now there are no selenide minerals observed in the Te-type deposits of Arinem, except for the Te-type deposit of Cineam which there is trace of Se-bearing minerals of pyrargyrite-proustite.

The FeS content of sphalerite from the Te-type is generally similar to those of the Se-type mostly in the range of 0.1-2.4 mol% (Se-type) and 0.5-2.0 mol% (Te-type, rare are up to 8.5 mol%). However, the FeS content of sphalerite from massive deposit of the strata bound or massive sulfide with some vein association. Vein size of the Se- and Te-types are various from some meter to more than 5,000 m in length and from some centimeters up to 5 m in width. The gold mineralization ages within this area for the Se-type are mostly of Pliocene and Pleistocene with range from 1.7~2.4 Ma and Late Miocene (11.18 Ma) for Cibaliung deposit. K-Ar ages dating of Te-type indicated the mineralization age are around 8.5~9.9 Ma or Late Miocene, respectively.

Most of the Se- and Te-types deposits in western Java are vein in form. However, the Cisungsang deposit form

![Figure 1. Location and distribution of the Se- and Te-types deposits in the western Java, Indonesia](image-url)
Cisungsang (Se-type) is higher, ranging from 13.6-19.6 mol%, and from Cirotan is between 0.5-26.0 mol% (Milesi et al, 1993). Cadmium content in sphalerite of Se-type is in the range of 0.1-2.0 mol% and in Te-type of Arinem around 0.1-1.0 mol%.

The Ag content of electrum from the Se-type is higher than that from the Te-type, ranges between 22-68 wt% and 14-40 wt%. Some ore minerals from Se-type contain selenium such as in galena up to 1.5 wt%, in acanthite-aguilarite up to 13.5 wt%, in polybasite up to 3.6 wt% (with Te content up to 5.5 wt%). Tellurium content in proustite is in trace amount and in uytenbogaardtite is up to 0.8 wt%. Ore minerals of the Te-type deposit of Arinem contain selenium such as in galena up to 1.9 wt%, in tetradymite 0.1-2.1 wt%, and up to 1.4 wt% in petzite. Geochemical analyses on the bulk vein samples inferred Mn is higher in the Se-type, but low in the Te-type. Bi and Hg are lower in the Se-type comparing to the Te-type deposit.

Fluid inclusions data of quartz indicate that the Se- and Te-types formed over temperature ranges of 160-330ºC and 160-350ºC, with average (shallower to deeper) are around 170-220ºC and 190-270ºC, respectively. The salinity of ore fluids for the Se-type is estimated to have been slightly lower than that for ore fluids of the Te-type. The Se-type has salinity up to 3.4 wt% NaCl equiv. with average less than 1 wt% NaCl equiv. except for the Cirotan deposit it is up to 7.15 wt% NaCl equiv. (Milesi, 1993) and for Te-type is in the range of 0.2-4.3 wt% NaCl equiv. with average ~2 wt% NaCl equiv..

References
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