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FLUID INCLUSION STUDIES OF THE EPITHERMAL QUARTZ VEINS FROM SUALAN PROSPECT, WEST JAVA, INDONESIA

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Abstract

Sualan prospect is located at Talegong Sub-district of Garut Regency, West Java, Indonesia. The area constitutes calc-alkaline volcanic and volcaniclastic rocks of Tertiary age. The rocks have experienced regional propylitic and argillic alteration. Fluid inclusions from quartz veins were studied in order to constrain the nature, characteristics and evolution of fluids. Microthermometric measurements on fluid inclusion were carried out by freezing and heating experiment. Temperatures of homogenization (Th) and final melting of ice (Tm) were measured for primary, liquid-dominated, two-phase inclusions. The values of Th range from 160°C to 210°C and salinities range from 0.35 to 4.96 wt.% NaCl equiv. Formation temperature of the quartz veins are estimated at 180°C and 190°C and paleo-depth of formation are at 80m and 140m, respectively. Microthermometric data indicates that fluid mixing and dilution were important processes during the evolution of hydrothermal system. Based on fluid inclusion types, microthermometric data, trapping temperature, paleo-depth, texture of quartz and hydrothermal alteration types, quartz veins from prospect were developed under epithermal environment.

Keywords: *Quartz vein, fluid inclusions, microthermometry, salinities, formation temperature, paleo-depth, epithermal, Sualan prospect.*

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1 Introduction

Sualan is one of the epithermal gold prospects in the Garut Regency of West Java, Indonesia (Figure 1). The prospect was recently explored by the Indonesia's state-own mining company, PT Aneka Tambang (Persero) Tbk. An exploration discovering gold mineralization has been conducting recently in the prospect area by detailed geological, geochemical and geophysical investigations.

The Sualan prospect is characterized extensive hydrothermal alteration. Altered rocks belong to volcanic and volcaniclastic rocks of Tertiary age and rock types include andesite lava, lapilli tuff, tuff and polymict breccias. Hypogene hydrothermal alteration includes argillic and propylitic types. Argillic alteration is characterized by quartz ± kaolinite ± illite whereas propylitic alteration is dominated by quartz-chlorite± illite ± smectite assemblages. This research focuses on fluid inclusion studies of quartz vein from the Sualan prospect in order to explore the nature and characteristics of the hydrothermal fluids responsible for hydrothermal alteration.

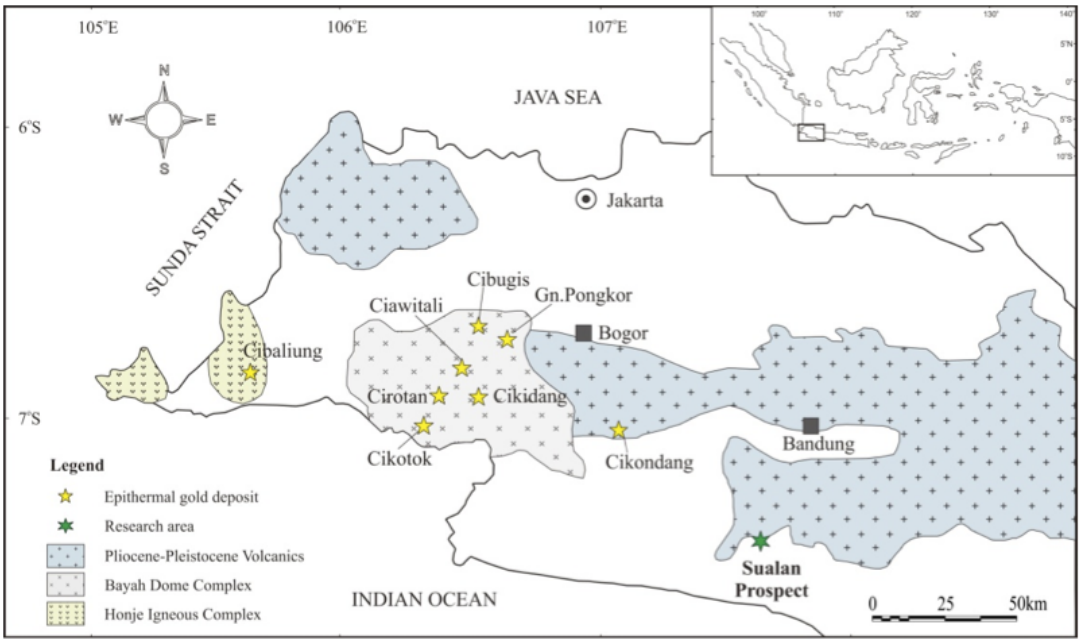

Figure 1: Map of West Java area (Indonesia) showing major epithermal gold deposits and the research location (Sualan prospect).

2 Geologic setting

West Java is a central segment of the Sunda-Banda Magmatic Arc system which was developed during Cenozoic by the subduction of Indo-Australian plate beneath the SE-Asian plate (Soeria-Atmadja *et al.*, 1994). Two distinct magmatic events were recognized within the magmatic arc (Soeria-Atmadja *et al.*, 1994). The early magmatism, occurring during the late Eocene to Early Miocene, has yielded tholeiitic rocks of "Old Andesites" and occupied the southern coast of Java Island (Southern Mountains). The later Neogene (Late Miocene to Pliocene) activities, evolving a magmatic arc, has produced medium- to high-K calc-alkaline volcanic products; basaltic to dacitic rocks, and their intrusive equivalents. Clastics and non-clastics sediments were deposited and intercalated with volcanic rocks throughout the arc. Basaltic to dacitic rocks (with local intrusive) which have resulted from Quatenary active volcanisms cover the older volcanic rocks along the magmatic arc (Soeria-Atmadja *et al.*, 1994; Hamilton, 1979; Hutchison, 1989).

Sualan prospect is located at the Southern Mountains of West Java, a fore-arc region located between the Quaternary volcanic chain and the Java trench. Southern Mountains is a well-known location in West Java area and comprises of Tertiary calc-alkaline volcanic and volcaniclastic rocks of Eocene-Miocene age (Van Bemelen, 1949).

3 Research methods

Hydrothermal quartz veins associated with hydrothermal alteration contain fluid inclusions and samples examined in this study were taken from surface barren quartz veins of argillic alteration zone exposing at two different levels (1217m and 1360m respectively). Quartz occurs as localized fracture-filling vein and generally characterized by comb texture and minor colloform banding. In the samples, fluid inclusions were generally observed and entrapped within the crystalline hydrothermal comb quartz which filled in the fractures of the argillically-altered tuff. Firstly, doubly polished thin-section of about 100μm thickness were prepared from vein quartz samples for preliminary petrographic studies. The shapes, sizes, spatial relationships, and phases within fluid inclusions were determined based on the stan-

dard criteria of Roedder (1984) and Bodnar *et al.* (1985). Then, two samples plates, namely SI-356 and SI-335 containing representative population of fluid inclusions with a primary or most likely primary origin were selected for detailed microthermometric measurements.

The homogenization temperature (*Th*) and, first and final ice-melting temperatures (*Ti* and *Tm*) were measured. In most case *Th* and *Tm* measurements were made on the same fluid inclusions. Microthermometric measurements were carried out by using Linkam TH600 stage at the Department of Earth Resource Engineering, Kyushu University, Fukuoka, Japan. Heating and freezing on fluid inclusions were performed at a minimum cooling/heating rate of one degree per minute and at a maximum rate of 20 degree per minute. Microthermometric data were collected mainly from inclusions which have consistent volumetric liquid-vapor ratios. Temperatures of homogenization were obtained from 54 fluid inclusions and final ice-melting temperatures were collected from 49 fluid inclusions. Fluid inclusion salinity was determined from Tm or freezing point depression (Bodnar, 1993).

4 Fluid inclusion petrography

Fluid inclusions in the quartz are commonly observed as two-phase (L+V) and are liquid-dominated (Figure 2a and 2b). They generally occur along growth zones and isolated planes of the quartz. These fluid inclusions are identified as primary in origin based on their petrographic criteria (Roedder, 1984). Primary fluids inclusions generally made up of more than 90 percent of the total fluid inclusions population. They generally contain 10 to 30% vapor phase by volume (visual estimation). Most primary inclusions were observed as irregular or negative crystal shape with size ranging from 5 to 50 µm and most inclusions were 20µm across. Secondary fluid inclusions also occurred along the healed fractures of quartz.

5 Result and discussion

The measured homogenization temperatures of fluid inclusions in quartz from the Sualan prospect range from 160°C to 210°C. Frequency distributions of *Th* (Figure 3a and 3b) show uni-modal distribution and primary modes occur at temperature range between 180–190°C and 190–200°C. The measurements of first ice-melting temperature range from from -30°C to -39°C with an average of about -30°C. This temperature is consistent with the melting temperature of salt hydrates within the NaCl–H_2O system (Davis *et al.*, 1990). The measurements of final ice-melting temperature range from -0.1°C to -3.0°C with an average of -0.7°C.

The salinities of the inclusions, as calculated from *Tm* (Bodnar, 1993), range from 0.35 to 4.96 wt.% NaCl equivalent with an average of 1.2 wt.% NaCl equivalent. A plot homogenization temperature range versus salinities was used in order to identify the mineral deposit type (Wilkinson, 2001). Sualan fluid inclusions, characterized by low *Th* and low salinities, were plotted in the epithermal deposit field (Figure 4).

Salinities and *Th* data can deduce the complex sequences of fluid processes during the evolution of extinct hydrothermal system. Salinities were plotted against *Th* for the Sualan fluid inclusions and a variation in fluid inclusion salinities with respect to *Th* is apparent on the diagram (Figure 5). Changes in salinities within a limited range of temperature is possibly related to the isothermal fluids mixing and decrease in salinities with slight falling *Th* is possibly related to surface fluid dilution processes (Figure 5). Based on the fluid inclusions types and microthermometric data, no evidence of boiling was observed.

The formation or trapping temperature quartz veins can be estimated from the microthermometric data, especially from *Th*. Under the boiling condition, this temperature generally refers to first peak of histogram distribution of *Th* (Bodnar *et al.*, 1985). In contrast, in non-boiling condition, it can be estimated from the histogram mean. As there is no indication of boiling observed from both fluid in-

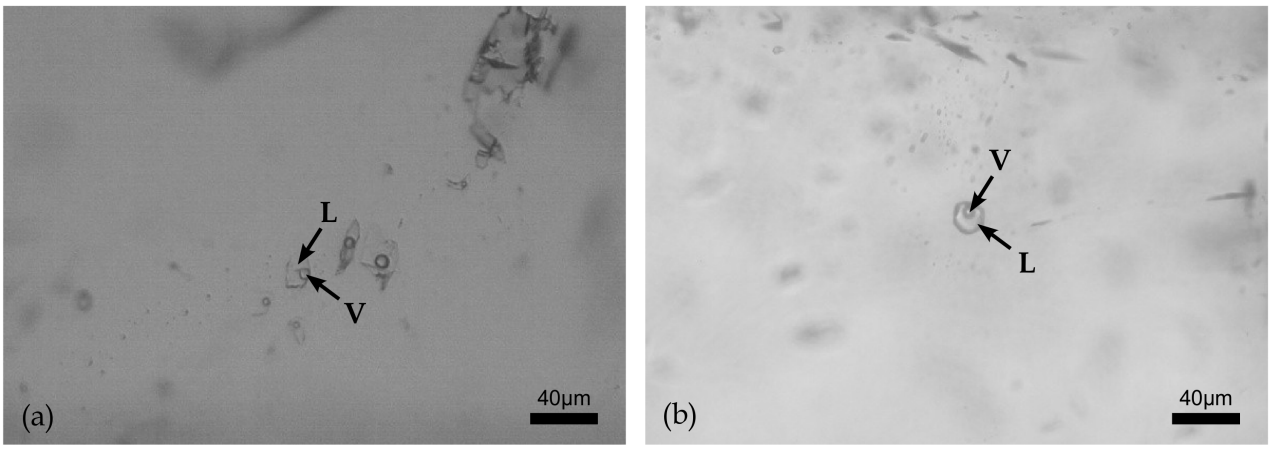

Figure 2: Photomicrograph of (a) a group of two-phase, liquid-dominated primary fluid inclusions entrapped along the growth zone of quartz (b) a single, well-shaped fluid inclusion in an isolated plane of quartz from Sualan prospect. L-liquid; V-vapor.

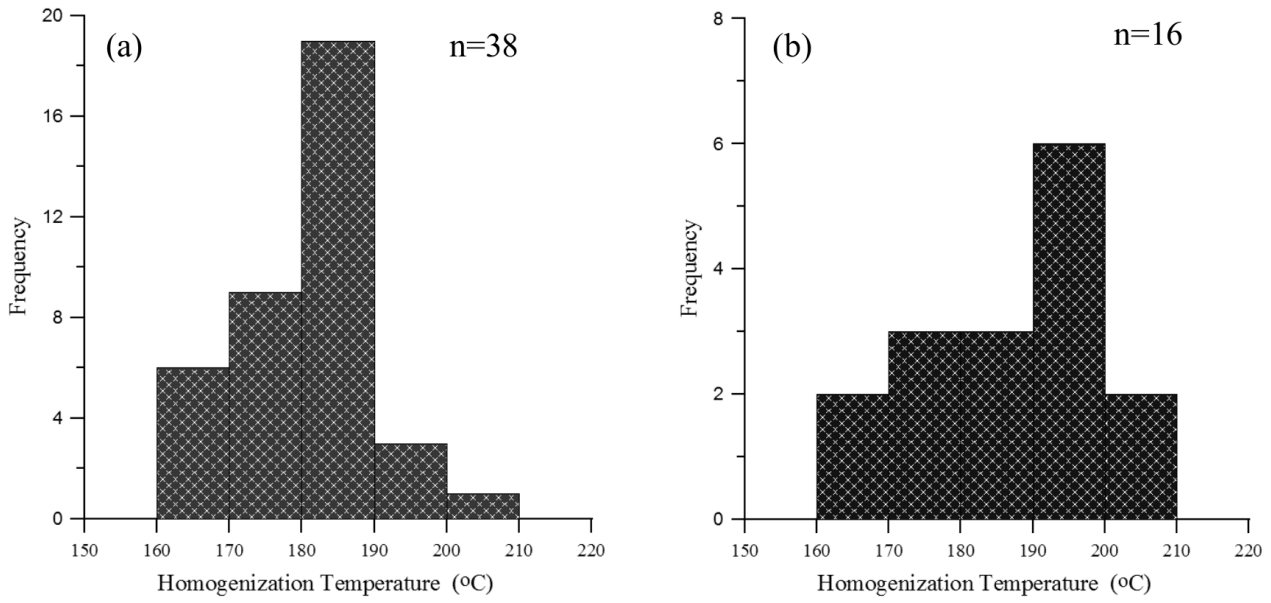

Figure 3: Frequency distribution of homogenization temperatures (*Th*) of primary fluid inclusions in quartz from sample (a) Sl-356 and (b) Sl-335 of Sualan area.

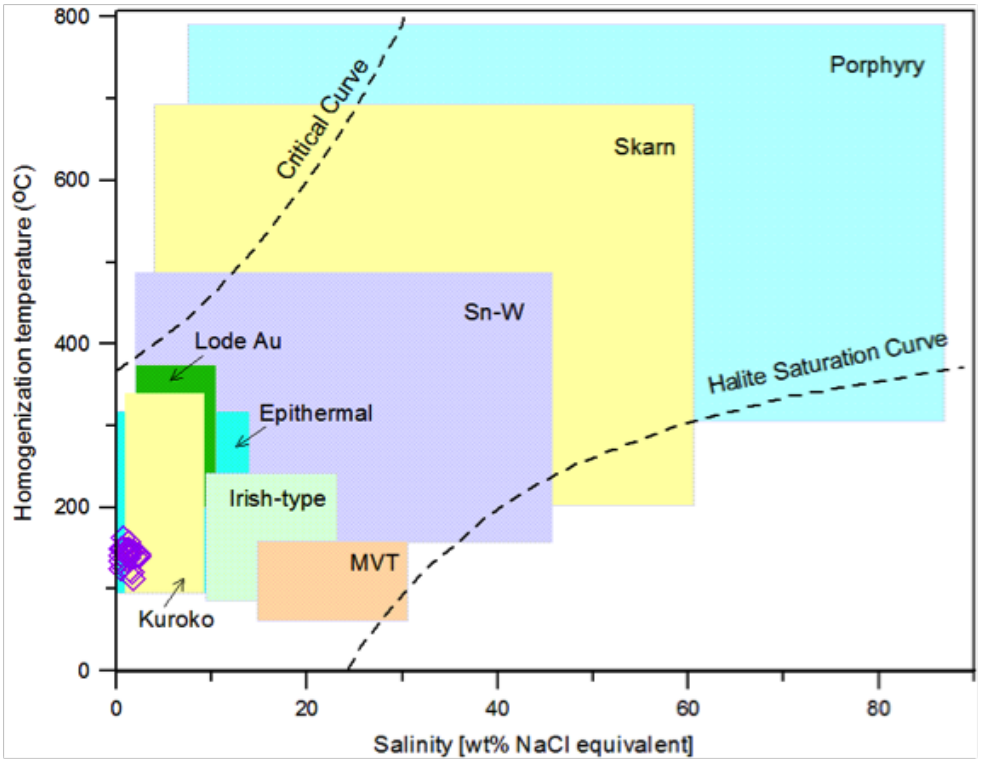

Figure 4: Salinity vs *Th* illustrating typical ranges for inclusions from different types of deposits (Wilkinson, 2001). A plot of fluid inclusions from Sualan prospect is shown and falls within epithermal field.

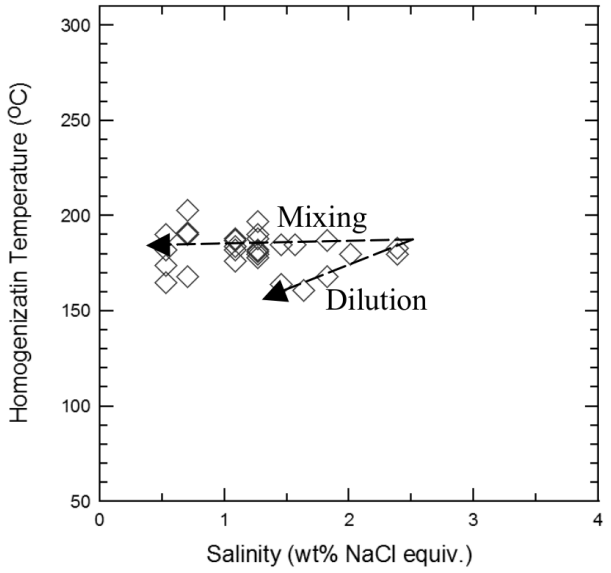

Figure 5: Salinity (wt.% NaCl eq.) vs *Th* diagram for fluid inclusions in quartz from Sualan prospect.

clusion nature and microthermometric data for the Sualan quartz veins and hence, formation temperature is interpreted from the histogram mean of *Th* distribution. It is estimated at 180°C for Sl-356 and 190°C for Sl-335 (Figure 3a and 3b). The formation temperature estimated from the *Th* data can be used to determine the formation depth of the veins. Boiling point curve of Haas (1971) was applied (Figure 6) and the minimum formation depth is estimated at 80m and 140m below the paleo-water table for Sl-356 and Sl-335 respectively.

6 Conclusion

Fluid inclusions from the quartz of Sualan prospect are typically characterized by low *Th* and low salinities. Fluid inclusions are entrapped in the quartz veins which exhibit comb quartz and minor colloform band. Host rocks are hydrothermal altered and characterized by argillic and propylitic assemblages. The homogenization (*Th*) and final melting of

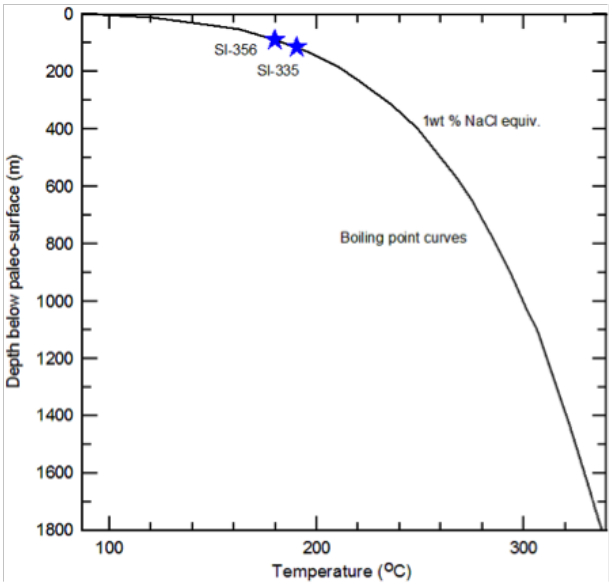

Figure 6: Estimation of formation depth of quartz veins from Sualan area by using the boiling point curve of Haas (1971).

ice (*Tm*) temperatures were measured for primary, liquid-dominated, two-phase inclusions. The values of *Th* range from 160°C to 210°C and salinities range from 0.35 to 4.96 wt.% NaCl equivalent. Formation temperature of the quartz veins are estimated between 180°C and 190°C and paleo-depth of formation are at between 80m and 140m, respectively.

Based on the fluid inclusions types and microthermometric data, formation temperature of vein quartz, paleo-depth, texture of quartz veins that host fluid inclusions and associated characteristics hydrothermal alteration types, it can be concluded that hydrothermal quartz veins in the Sualan prospect were probably developed under epithermal condition and probably related to the low-sulfidation epithermal setting.

Acknowledgement

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References

Bodnar, R.J. (1993) "Revised equation and table for determining the freezing point depression of H2O–NaCl solutions", Geochimica et Cosmochimica Acta 57, 683–684.

Bodnar, R.J., Reynolds, T.J., and Kuehn, C.A. (1985) "Fluid inclusion systematics in epithermal systems", Reviews in Economic Geology 2, 73–79.

Davis, D.W., Lowenstein, T.K., and Spencer, R.J. (1990) Melting behavior of fluid inclusions in laboratory-grown halite crystals in the systems NaCl–H_2O, NaCl–KCl–H_2O, NaCl–$MgCl_2$–H_2O, NaCl–$CaCl_2$–H_2O. Geochimica et Cosmochimica Acta 54, 591-60.

Haas, J.L.Jr. (1971) "The effect of salinity on the maximum thermal gradient of a hydrothermal system at hydrostatic pressure", Economic Geology 66, 940–946.

Hamilton, W.H. (1979) Tectonics of the Indonesian region, U.S. Geological Survey Professional Paper 1078, 345pp.

Hutchison, C.S. (1989) Geological evolution of South-East Asia, Oxford Monographs on Geology and Geophysics, Oxford, UK: Clarendon Press.

Roedder, E (1984) Fluid inclusions, Mineralogical Society of America, Review in Mineralogy 12, 646.

Soeria-Atmadja, R., Maury, R.C., Bellon, H., Pringgoprawiro, H., Polve, M., and Priadi, B. (1994) "Tertiary magmatic belts in Java", Journal of Southeast Asian Earth Sciences 9, 13–27.

Van Bemmelen, R.W. (1949) The Geology of Indonesia, V.F.A. Government Printing Office, The Hague, 732 pp.

Wilkinson, J.J. (2001) "Fluid inclusions in hydrothermal ore deposits", Lithos 55, 229–272.

