CURRENT TEMPERATURE STUDIES

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CURRENT TEMPERATURE STUDIES IN KAMOJANG GEOTHERMAL FIELD WEST JAVA INDONESIA

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ABSTRACT

Kamojang geothermal field is located in Garut approximately 42 Km south-east of Bandung city. This area is vapor dominated system and high temperature around 235-250°C. Geographically, the area is located on a series of active volcanoes, such as: G.Rakutak, G.Gandapura, G.Guntur and G.Masigit. This volcanoes series are Quaternary volcanoes about 0.452 to 1.2 Ma. G.Guntur is the most active volcano compared to the surrounding volcanoes until now.

The complex volcanoes around the Kamojang geothermal field as heat source of the geothermal system. The resulting temperature of the magma interacts with the fluid produced alteration rock. Alteration zone in this field are crystobalite-montmorillonite, illite-montmorillonite and chlorite-epidote. By doing thermoluminescence analysis on the rock alteration and comparing with temperature mineral and temperature measurements from wells, it can be seen distribution temperature geothermal until now. Based on the analysis this method indicates that the current temperature in Kamojang geothermal field divided into three, that are: old, medium and young. The young temperatures are expected to contribute good heat on the geothermal systems.

Identify the current of paleo temperature to temperature it now using petrography, X-ray diffraction and thermoluminescence methods. The results of this analysis are expected to be used as consideration in the area development of Kamojang geothermal field.

INTRODUCTION

Kamojang geothermal field located in Garut, West Java Province, which is about 42 km to the southeast of Bandung. Geographically, geothermal field is located in the Quaternary volcanic series lined from west to east. The volcanoes are G.Rakutak, Ciharus Lake, Pangkalan Lake, G.Gandapura, G.Guntur and G. Masigit. G.Rakutak is the older than G.Guntur and both are still active. While the Kamojang geothermal field boundaries limited by several morphologies, ie: G.Gandapura in the east, S. Ciwalirang in northern, western section of Lake Ciharus and S. Citepus in the south.

Kamojang geothermal field is steam dominated with high temperature around 235-250°C. This area was first discovered by the Dutch in 1920 and the early exploration in 1973 with the cooperation between the Government of Indonesia and New Zealand. After 10 years of exploration, this field produces in 1983 to producing 140 MWe, and in 1997 expanded to 220 MWe (Sudarman et al., 1995). This study focused on the study of geothermal temperature distribution obtained from the petrography analysis, X-ray diffraction, fluid inclusion and thermoluminescence. Some of the core and cutting samples from wells KMJ-6, 10, 25, 26, 35, 47, 52,78 and CHR-1 to analysis by the method. By studying the current temperature is expected to learn the history of paleo heat until now.

GEOLOGY OF KAMOJANG GEOTHERMAL FIELD

Robert et al. (1983) and Robert (1987) compiled Kamojang stratigraphy and geology of the area based on the correlation between lithology and lithologic logs of drilling shallow and deep wells. Based on this, the area Kamojang composed by two formations (from old to young) is a Pangkalan and Gandapura Formation. Pangkalan Formation aged 1.2 ± 0.02 Ma which occupies the western part, while Gandapura Formation aged 0.452 ± 0.05 Ma occupies the eastern Kamojang (age dating using the K-Ar method). Whereas according Kamah et al. (2003, 2005) general geology of Kamojang geothermal area and its surrounding composed by volcanic material of volcanoes Pre and Post Caldera. The Pre Caldera volcanic deposits from the old to the youngest are Basalt G.Rakutak, Basalt Dog-dog, Pyroxene Andesite G.Cibereum, Pyroclastic G.Sanggar, Pyroxene Andesite G.Cibatuipis, Andesite Porphyry G.Katomas, Basaltic Andesite Legokpulus and G.Putri, Andesite Lava Pasir Java and Pyroxene Andesite G.Kancing. The Post Caldera formation from old to young are G.Batususun and Basaltic Andesite G.Gandapura, Andesite Lava G.Gajah, Basaltic Andesite G.Cakra-Masigit and Guntur. The Post Caldera formations are unconformity overlaying the Pre Caldera formation.

In geothermal systems, the heat is obtained from magma. In the Kamojang geothermal system, identification of heat source based on gravity and magnetic analysis conducted by Sudarman and Hochstein (1983). From this analysis shows that there is a solid material on the depth (> 2 km), the upper part contained highly-magnetic. According Sudarman (1983), the material is a cooling pluton and diorite composition. This heat interacts with fluids forming hydrothermal alteration rock that serves as a cap rock and reservoir in the Kamojang geothermal system.

METHODOLOGY ANALYSIS

The study was conducted on core samples and cutting some of the well KMJ-6, 10, 25, 26, 35, 47, 52.78 and CHR-1 to be analyzed using petrography analysis, X-ray diffraction and thermoluminescence. Petrography analysis was conducted to identify the structure, texture and composition of the alteration mineralogy, while the X-ray diffraction analysis to determine the type of clay minerals. The thermoluminescence analysis determine age and thermal history of the alteration that occur in the rocks. The secondary data from temperature measurements of wells and fluid inclusion needed to correlate temperature obtained from the mineralogical analysis and thermoluminescence. By knowing the correlation of temperature from this methods are expected to contribute to knowledge about the characteristics of the Kamojang geothermal field based on temperature distribution.

RESEARCH RESULTS

Based on the results of petrography analysis and X-ray diffraction showed that the temperature can be identified from hydrothermal alteration minerals are arranged in mineral alteration zone, ie: crystobalite-montmorillonite, illite-montmorillonite and chlorite-epidote (Figure 3.). While the interpretation of temperature mineral alteration of each zone and can be seen in Table 1.

Crystobalit-montmorillonite zone

This zone is characterized by the presence of crystobalite minerals, montmorillonite, quartz, calcite, anhydrite, gypsum, hematite and pyrite. Minerals are present at elevations above 1000 m asl formed at temperatures below 100^{o}C (Table 1.). Based on the well temperature measurements show that the temperature at this elevation around 100 ^{o}C.

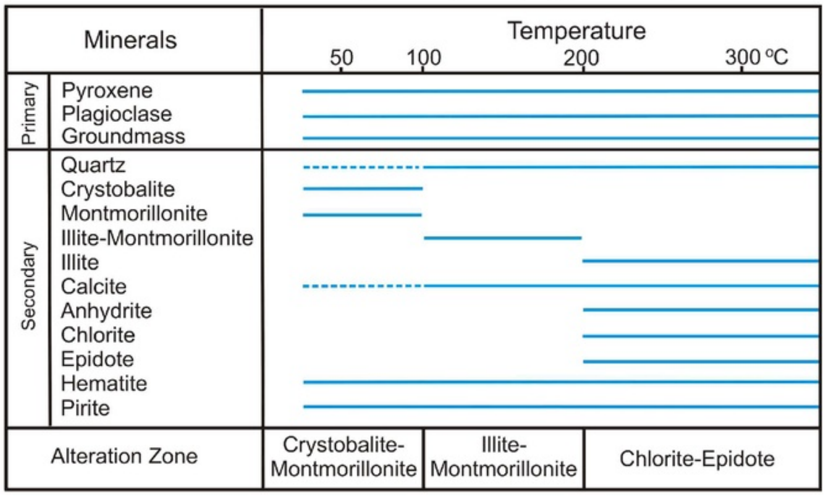
Illite-montmorillonit zone

This zone is characterized by the presence of illite-montmorillonite, calcite, anhydrite, gypsum, hematite and pyrite. Minerals are present at elevations ranging from 1000-600 m asl and the temperature of this zone is based on the formation of crystobalite and montmorillonite minerals ranged between 100-200 ^{o}C (Table 1.). Based on the well temperature measurements show that the temperature in elevation about 100-200^{o}C.

Chlorite-epidote

This zone is characterized by the appearance of chlorite, epidote, zoisit, illite, wairakit, hematite and pyrite. Minerals are present at elevations less than 600 m asl. The temperature of this zone is based on the formation of chlorite and epidote. Minerals are formed at temperatures greater than 200^{o}C. (Table 1.). The results of wells temperature measurements, the temperature in elevation more than 200^{o}C. Results of fluid inclusion temperature measurements at depth 1725 m indicates that the temperature around 245-250^{o}C (Utami, 2000). This zone is the reservoir zone with temperature ranging from 235-250^{o}C (Pertamina, 1995).

Table 1. Mineral index temperature of Kamojang geothermal field



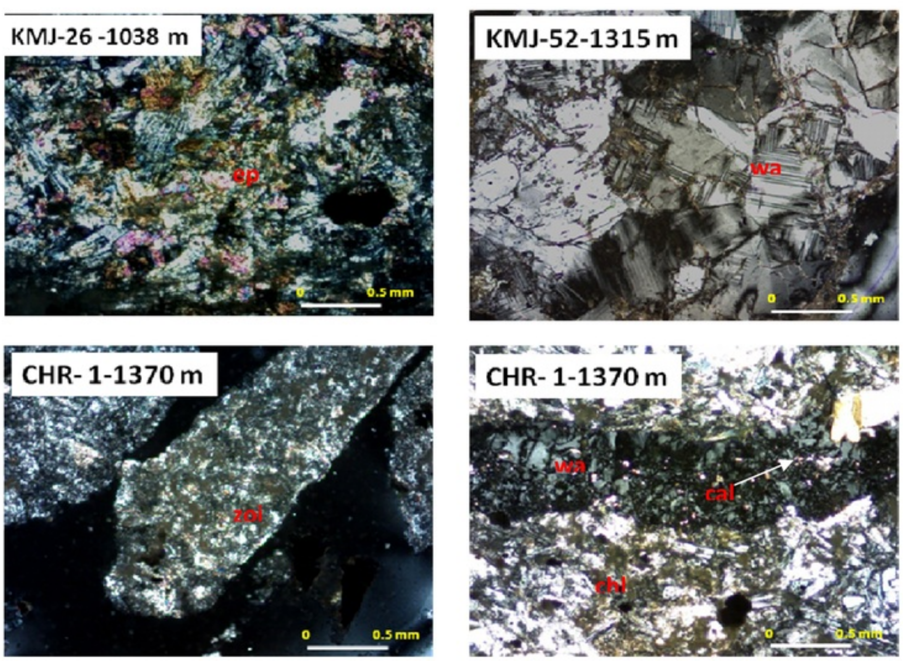


Figure 1. Shows the high temperature alteration minerals, ie: epidote (ep), chlorite (chl), zoisite (zoi), calcite (cal) and wairakite (wai)

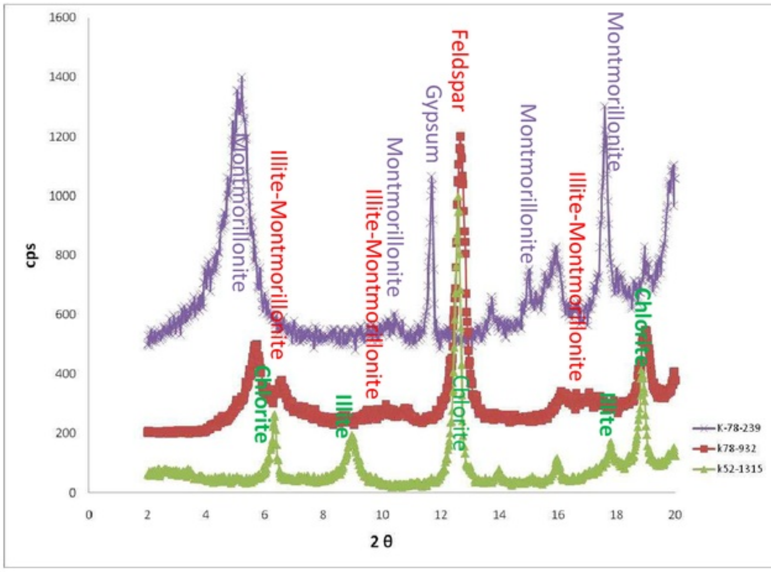


Figure 2. Shows the type of clay minerals, ie montmorillonite, illite and illite-montmorillonite analysis of ethylene glycol in the well KMJ-78 and 52

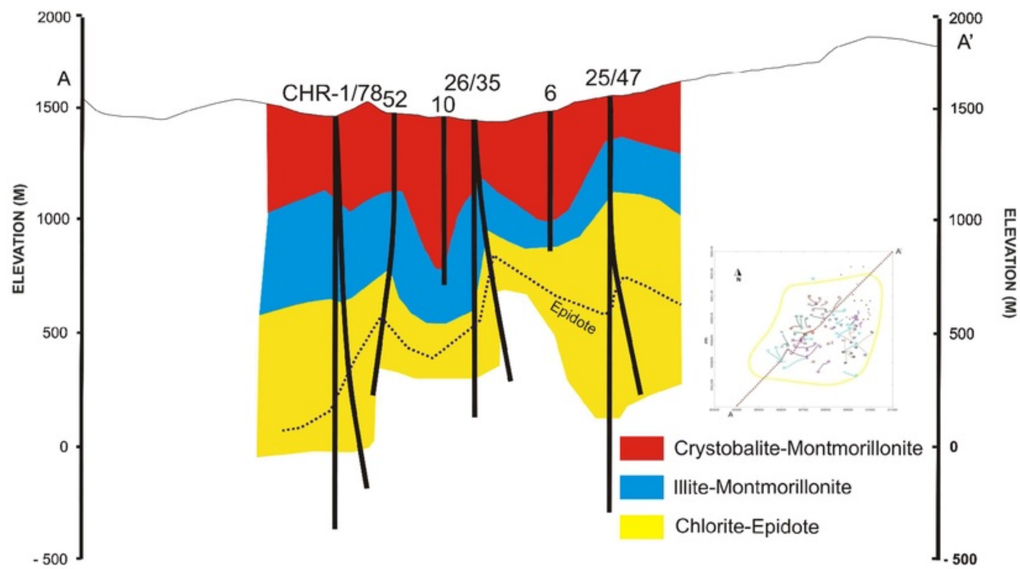


Figure 3. Zonation of alteration mineral at Kamojang geothermal field (section A-A')

Thermoluminescence dating is a method to determine the age of rocks from the Quaternary between 1 ka-1 Ma (Takashima, 2011). This method using quartz or feldspar minerals and can be used in rock alteration (Takashima et al., 2004).

In the study area thermoluminescence method was conducted on rock that contains quartz. This method is used to determine the age of the heat that occurs in alteration rocks. From the petrography analysis of some selected rock samples indicate that the sample of CHR-1 (depth 1250 m), KMJ-10 (depth 1982 feet) and KMJ-78 (depth 1611 m) is the samples that contain the highest percentage of quartz , which is about 50-55% of the total amount of existing mineral alteration. Total quartz is expected to result thermolumniscence age at testing (see Table 2).

Table 2. Total presence of quartz in alteration rock samples results from petrography analysis

Well, depth	Intensity of Alteration (%)	Quartz (%)
KMJ-6, core 2000 feet	85	45
KMJ-10, core 1982 feet	75	55
KMJ-25, core 1377 m	85	40
KMJ-26, cutting 1038 m	85	35
KMJ-35, cutting 759 m	70	25
KMJ-47, cutting 1435 m	85	40
KMJ-52, cutting 1315 m	90	50
KMJ-78, core 1611 m	75	50
CHR-1, core 1250 m	95	35

In thermoluminescence measurements the heat measured up to 400°C. The measurement results obtained forms graphic intensity values against temperature to 400°C, while the relative age is determined by reading the graph. Based on the interpretation of reading the graph, it can be determined relative age thermal history and can be grouped into three, ie: old, medium and young. Samples that have high intensity values are old age, whereas samples with low intensity values showed young age. Old age owned by sample KMJ-10 (depth 1982 feet) with intensity up to 550 thousand. Medium age is owned by the sample KMJ-78 (depth 1611 m) has an intensity of up to 36 thousand, while the young age of the sample CHR-1 (depth 1250 m), which has an intensity of up to 12 thousand. Thermoluminescence analysis results can be seen in Figure 4. Graph patterns do not show a good arch curves, due to the persistence of the mineral impurities such as pyrite and hematite that do not be separated by a magnetic separator.

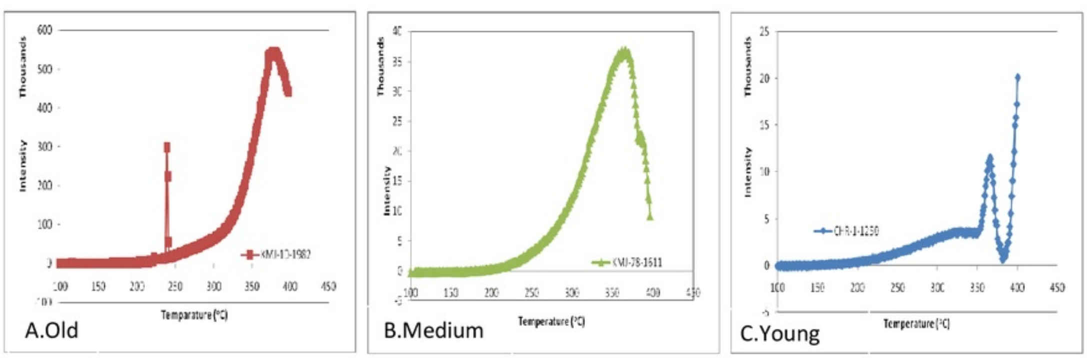


Figure 4. Graph shows the results of the thermoluminescence analysis at temperatures of 400°C

1. DISCUSSION

Results plot of temperature against the interpretation of mineral alteration, fluid inclusion, temperature measurement of wells and themoluminescence analysis, it can be interpreted on the history of heat that occurs in section A-A'(Figure 5.). In the sample KMJ-10 (depth 1982 feet) found illite-montmorillonite minerals, calcite, anhydrite, gypsum, hematite and pyrite. Measured temperatures around 100°C, while the thermoluminescence analysis show relatively old age. This gives the sense that the area is a region that previously is hot (old) and the measured temperature now about 100°C.

In the well KMJ-78 (depth 1611 m) present mineral chlorite, epidote, zoisit, illite, wairakit, hematite and pyrite, whereas the temperature of fluid inclusions identification at a depth of 1725 m shows the temperature is 245-250°C (Utami, 2000). Temperature measurement at the reservoir zone around 202°C and the results of thermoluminesence measurement indicate the medium age. This indicates that the region is going heat.

The sample CHR-1 (depth 1250 m) present mineral chlorite, epidote, zoisit, illite, wairakit, hematite and pyrite, while the measured reservoir temperatures around 228°C. The results of thermoluminescence measurements showed young age. This condition gives the sense that the young age and the heat that occurs is correlated with the heat that occurs in the current reservoir. The heat is required in Kamojang geothermal system.

Based on the analysis above, it can be interpreted that the old heat flows from under well KMJ-10. The heat is interpreted from the older igneous intrusion, while the heat under the wells KMJ-78 and CHR-1 was interpreted come from younger intrusive rocks.

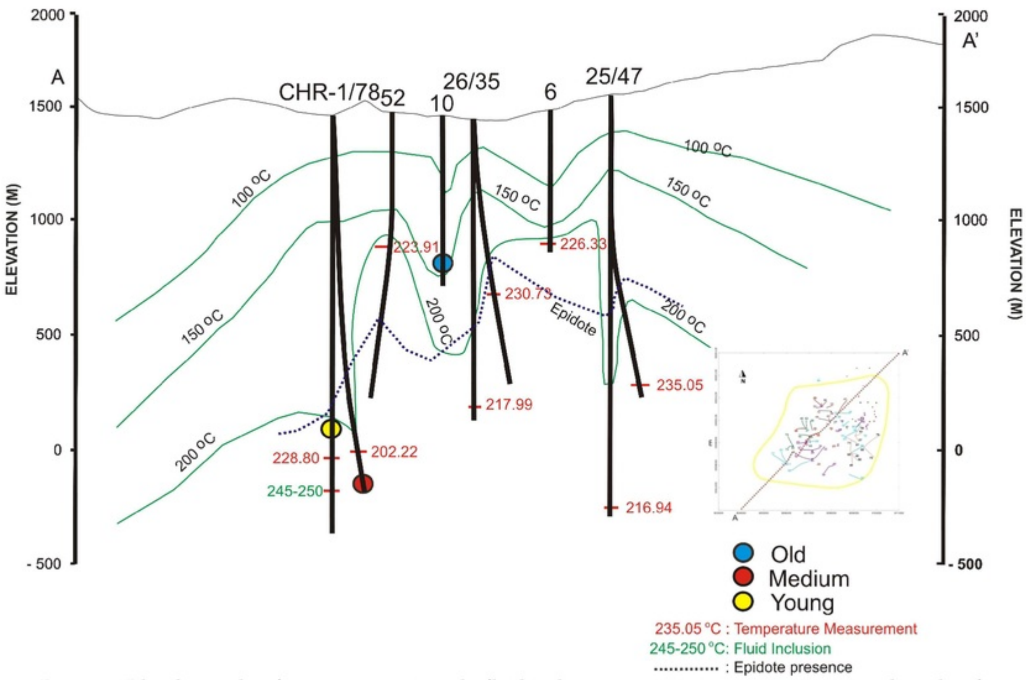


Figure 5. Plot the results of temperature minerals, fluid inclusions, temperature measurement and results of thermoluminescence analysis (old, medium and young)

2. CONCLUSION

Zone of alteration minerals contained in Kamojang geothermal field include: crystobalite-montmorillonite, illite-montmorillonite and chlorite-epidote. Which serves as reservoir zones are chlorite-epidote zone, the temperature of this zone is around 235-250°C (Pertamina, 1995).

Based on the results of measurements of heat up to 400°C on quartz samples indicate that the relative age of heat can be grouped into: old, medium and young. Old age owned by sample KMJ-10 (depth 1982 feet), medium age owned by sample KMJ-78 (depth 1611 m) and the young age of the sample CHR-1 (depth 1250 m).

Based on the analysis above, it can be interpreted that the old heat flows came from under wells KMJ-10. This heat was interpreted came from the older igneous intrusion. The heat source under KMJ-78 and CHR-1 wells interpreted came from the younger intrusive rocks. The history of young heat is highly correlated with the actually measured temperature and reservoir heat. This temperature is needed in the Kamojang geothermal field. By knowing the history of heat is expected to be used to determine the development area of Kamojang geothermal field.

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