Fluid Geochemistry Characteristics of Cipari and Wanareja Hot Springs, Cilacap, Central Java

by Yoga Ariwibowo

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Aribowo Y and Nugroho A

Geological Engineering Department, Diponegoro University J. Prof. Soedarto, SH Semarang

ABSTRACT

Wanareja Geothermal manifestation (Cipari and Wanareja hot springs) indicating the existence of geothermal system. Surface temperature of each springs ranged about 41,8^{0}C-42,3^{0}C and pH near neutral about 6.5 -7.5. There are question about the area: are the manifestation area is a part of Mount Slamet/Guci geothermal system or a part of different system, so, to answer the question it need the evaluation of some parameters such as geological condition and fluid chemistry characteristics. The two hot springs has analyzed to figure out the type of fluids, concentration and configuration of geoindicator and tracer elements, and to calculate fluid geothermometry if the fluid type eligible.

The results of fluid chemistry analysis are: principles anion Cl-SO4-HCO3, Cipari springs: Cl: 2390 ppm, SO4: 1,24ppm, HCO3: 41,07 ppm, Na 1046 ppm; Wanareja springs: Cl: 3580 ppm, SO4: 0 ppm, HCO3: 2470 ppm, Na: 2750 ppm and so both springs are bicarbonate waters with a significant chloride content. The ^{2}H and ^{18}O isotope analysis result are Cipari spring -28,25/mil; -2,92/mil, and Wanareja spring -30,12/mil; -3,86/mil, and the analysis of Cl-Li-B ternary diagram shows low ratio of Boron to Chloride.

Based on principles anion analysis, Cipari and Wanareja springs indicating a chloride water, but the high Na-Cl concentration also indicating a brine/formation water. The difference of the two springs is low HCO3 of Cipari and high HCO3 of Wanareja spring, so it is interpreted as the difference influence of meteoric water as Wanareja more influenced by meteoric water than Cipari, and the interpretation is supported by fluid isotope data which is show that Cipari spring plotted in field of formation water, and Wanareja spring plotted in field of formation water but near the meteoric water line. Based on the geoindicator and tracer data, the occurence of Cipari Wanareja geothermal manifestation interpreted as a different system that have no direct relationship with Mount Slamet geothermal system, but more influenced by sedimentary system.

INTRODUCTION

Physiograpicaly, the manifestation area lies between western part of South Serayu Mountains and eastern part of West Java Southern Mountains (figure 1).

Most of Northern and Western part of study area have a hilly landform with the elevation vary about 80-508 m above sea level. The hilly landform formed by Tertiary sedimentary rocks, which has folded and faulted by tectonic processes. Recent geomorphic/ exogenic process is denudation. Most of southern and middle part have a plain landform, which lithologically consist of alluvial deposit from local fluvial system.

There are some hot/warm springs occure around Cipari (named Banyugaram hot spring) and Wanareja (near Central Java and West Java Province border) with surface temperature ranged about 40oC.

The occurence of those thermal manifestations indicating the existence of geothermal system around Cipari-Wanareja area, but the questions remains are which kind of geothermal system, and how are the relationship of the system with nearest geothermal system (Mount Slamet geothermal system), are there a volcanic related geothermal system or sediment related geopressured system? are there a connected system or a separated system with Mount Slamet geothermal system.

OBJECTIVES

The objectives of the study are to identify the type of fluids on the manifestation area based on principles anions concentration and distribution, to identify the chemical behavior of fluids, and determine the origin or source of each fluids by analyze the presence and distribution of the tracer or geoindicator dissolved in the thermal fluids such as Na, K, Mg, B, Li, and the deuterium (H^2) – O^{18} isotope ratio. The interpretation

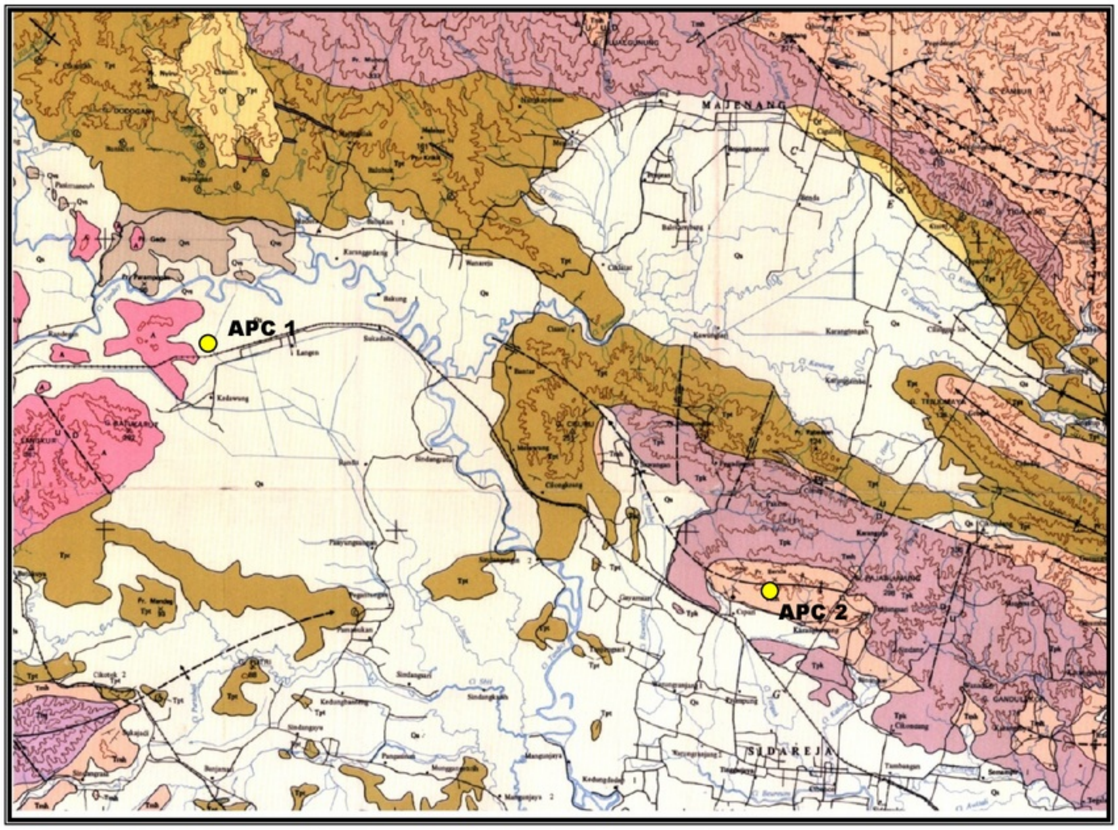

Figure 1: Geological map of Cipari area and the location of warm springs

of fluid origin and chemical behavior expected to be guidance to determine the type of geothermal system and the relationship with nearest system.

GEOLOGY OF STUDY AREA

The geology configuration on the study area consist of Halang, Kumbang, Tapak Formation, and the youngest lithology is aluvial deposit.

Halang Formation (Tmh)

Turbidite sedimentary rocks consist of Tuffaceous sandstone, conglomerate, marl, and claystone; andesitic breccia at the lower part. sandstone mostly wacke, and deposited as turbidites in upper bathyal zone. Structures commonly recognized in the unit are gradded bedding, parellel lamination, convolute lamination, flute casts, and load casts, suggesting a deposition an open marine environment by turbidity currents. locally foraminifers and molluscs are found. Pressumably, a Middle Miocene-Early Pliocene age.

Kumbang Formation (Tmpk)

Andesitic to basaltic volcanic breccia, lava flows, dykes, and tuff; tuffaceous sandstone and conglomerate with thin stringers of magnetite sand intercalations. Comonly, the unit is massive and compact. The age is presumed to be Late Miocene-Early Pliocene. Interfingered with Halang Formation and overlies unconformably the Kalipucang Limestone unit, with maximum thickness is about 2000 m thinning to the east.

Tapak Formation (Tpt)

Greenish grey coarse grained sandstone in the lower part, gradually grading upward into finer greenish grey sandstone with some grey to yellowish sandy marl intercalation. At the upper part, alternating calcareous sandstone and marl contain brackish to marine molluscs, tending to show an Early-Middle Pliocene age. Depositional environment is interpreted to be a tidal zone. Thickness is up to 500 m.

Alluvial deposits (Qa)

gravels, sands, and grey clay deposits, deposited along the flood plains of big streams. Black stinky mud of swamp deposit is also recognized, about 5 m thick. (Kastowo and Suwarna, 1996)

RESEARCH METHOD

The research methods are fluids sampling and chemical analysis of thermal fluids with main objects analyzed are the concentration distribution of principal anions (Cl, SO4, HCO3), principal chemical compound act as geoindicators and tracers such as Na, K, Mg, Li, B, SiO2, and the deuterium (^{2}H) and ^{18}O isotope ratio.

The anions ratio plotted on fluid type ternary diagram to determine the source or origin of fluids, so the characteristic of geothermal system could be predicted. The other compounds also analyzed and interpreted using ternary diagram to predict chemical behavior of thermal fluids related to subsurface fluid-rocks interaction.

RESULTS

The Cipari warm spring (APC1) occure in the sedimentary rock of Halang Formation, which have sandstone-silt lithology. There are one warm spring with average surface temperature about 42°C. The fluid has high salinity that characterize brine water that might be related to the formation water and the occurence of the warm spring. The chemical composition of Cipari warm spring contain high sodium (1046 ppm) high chloride (2390 ppm) and low bicarbonate (41,07 ppm) and little sulphate anion (1,24 ppm, see table 1).

Table 1: Chemical Composition of Cipari area warm springs

Springs	Chemical Composition (mg/kg)					
APC1	pH	Ca	Mg	Na	K	Li
	7,44	667,6	0,54	1046	15,77	0,03
	B	SiO2	NH3	Cl	SO4	HCO3
	8,5	17,10	6,25	2390	1,24	41,07
APC2	pH	Ca	Mg	Na	K	Li
	6,64	375,6	153	2750	175,92	4,3
	B	SiO2	NH3	Cl	SO4	HCO3
	4,56	105,03	18,7	3580	-	2470

The Wanareja warm spring (APC2) chemical character are similar to Cipari warm spring, with high concentration of sodium and chloride (2750 and 3580 ppm), but relatively high bicarbonate concentration (2470 ppm) and no sulphate anion exist.

The principal cation such as Ca, Mg, sodium, and potassium concentration in both warm springs relatively different in ratio. Cipari warm spring (APC1) containing 667,6 ppm Ca, 0,54 ppm Mg, 1046 ppm sodium, and 15,77 ppm potassium, where APC2 has 375,6 ppm Ca, 153 ppm Mg, 2750 ppm sodium, and 175,92ppm potassium

The stable isotope analysis (deuterium (^{2}H) and ^{18}O) resulting a similar concentration of deuterium but quite different ^{18}O concentration (see table 2)

Table 2: Stable isotope analysis result

No	Sample	δ^{18}O /per mil	δ^2H /per mil
1	C2/APC2	-3,86	-30,12
2	C1/APC1	-2,92	-28,25

DISCUSSION

The chemical composition of APC1 water indicating the influence of formation water/brine as if water type ternary diagram plotted APC 1 in the chloride water corner (see fig. 2). The APC1 water could not be interpreted as chloride water that mean reservoir origin fluid due to high concentration of sodium and chloride indicating a formation water source.

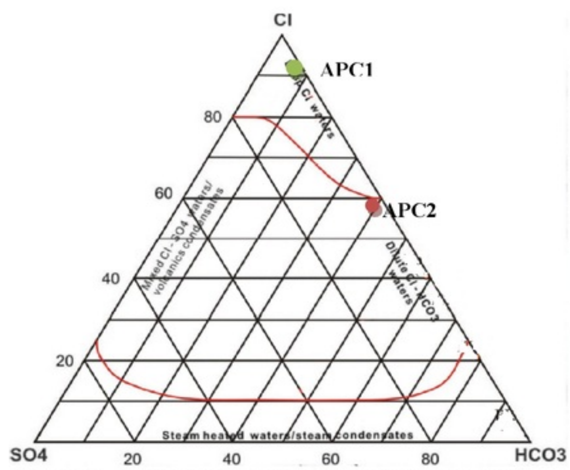

Figure 1: Water type ternary diagram with principal anions as end member

The high bicarbonate concentration in APC2 interpreted as influence of meteoric water but still APC2 characterized as formation water origin, based on higher concentration of sodium and chloride than APC1. The stable isotope analysis confirmed the interpretation as APC1 plotted in formation water area and APC2 plotted still in formation water area but mostly closer to the meteoric water field (fig. 3). As APC1 and APC2 interpreted as formation water origin, thus not represent the equilibrium state on reservoir, so the water not eligible to predict reservoir condition.

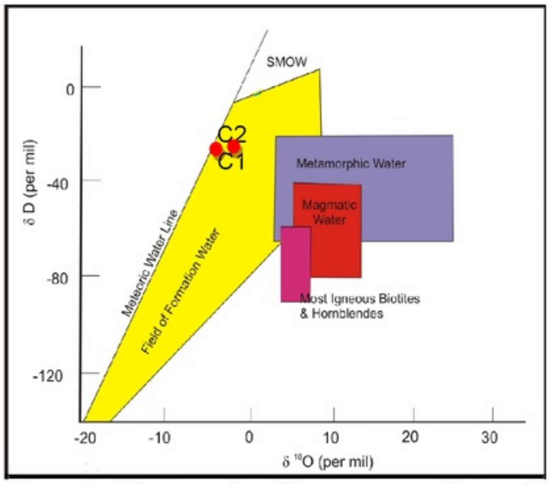

Figure 3: Plotting of stable isotope analysis of APC1 and APC2

Based on Na-K-Mg ternary diagram plot (fig.4) APC1 placed on full equilibrium line and APC 2 on immature field, it confirm that APC2 are formation origin water.

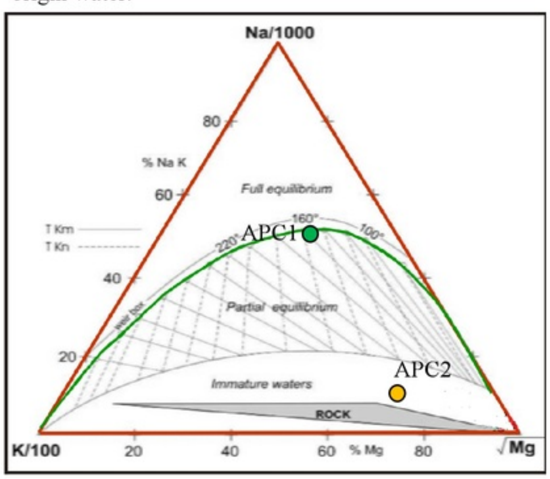

Figure 4: Plotting of APC1 and APC2 on Na-K-Mg ternary diagram

Cl-Li-B ternary diagram (fig.5) plotting APC1 and APC2 on Cl area confirm that the water have volcanic-macmatic origin, as a result of magmatic gas absorbtion with low B/Cl ratio. Low ratio of B/Cl indicating common fluid-rock process on outflow zone, resulting dissolution of minerals of the rocks passsed over by thermal fluids.

Based on all geochemical analysis, the Cipari geothermal manifestation area interpreted as part of geopressured system, and not directly related to volcanic system in Mount Slamet. The occurence of Cipari warm springs interpreted have relationship to sedimentary rock system and NW-SE geological structure trend that passing trough suthern border of West Java and Central Java.

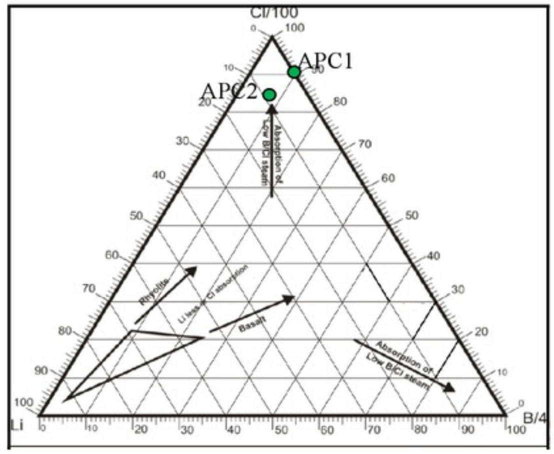

Figure 5: Plotting of APC1 and APC2 on Cl-Li-B ternary diagram

REFERENCES

Fournier, Robert O. 1989. *Water Geothermometers Applied to Geothermal Energy*. USA: US Geological Survey.

Giggenbach, WF. 1988. *Chemical Techniques in Geothermal* Exploration. New Zealand: Chemistry Division, DSIR, Private Bag.

Mahon K, and Ellis, AJ. 1977. *Chemistry and Geothermal System*. Orlando: Academic Press Inc.

Marini, Luigi. *Geochemical Techniques for the Exploration and Exploitation of Geothermal Energy*. Genova – Italy: Dipartimento per lo Studio del Territorio e delle sue Risorse, Università degli Studi di Genova.

Nicholson, Keith. 1993. *Geothermal Fluids,* Chemistry *& Exploration Techniques*. Berlin: Springer Verlag, Inc.

Strelbitskaya, Svetlana. 2005. *Interpretation of Chemical Composition of Geothermal Fluid From The Geothermal Field of Baransky Volcano, Iturup Island, Russia,* Geothermal Training in Iceland 2005.

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