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Overview of Gedongsongo Manifestations of the Ungaran Geothermal Prospect, Central Java, Indonesia : a preliminary account

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ABSTRACT

Gedongsongo surface manifestations of the Ungaran geothermal prospect in Central Java, Indonesia, have high temperature properties, 72 - 87^{0}C, 2 – 6 pH and 770 ppm of chloride. The stable isotopic ratios of $\delta^{18}O$ and δD of two adjacent manifestations show a slightly different enrichment. The western part reveals a more magmatic water influence than those of the eastern one. This is supported by the presence of relic manifestations as most occurs in the eastern part; whereas active fumaroles and steaming ground exist at western part.

INTRODUCTION

Ungaran Volcano is located at northern part of the Java volcanic arc (Figure 1). Java itself is developed by the north-south modern subduction system of the Indian oceanic plate and Eurasian continental plate (Hamilton,1979). Ungaran lies within 4 stratovolcanos range, i.e. Merapi, Merbabu, Telomoyo and Ungaran (from south – north; Figure 1). Bemmelen (1949) describes the Ungaran volcano as composed of augite-olivine basalt-andesite (Lower Pleistocene), augite-olivine basalts (upper Pleistocene), augite-hornblende(biotite) andesite (upper Pleistocene and Holocene) and hornblende andesite (Holocene). These three distinct compositions are recognized as the products three of major volcanic eruptions which were separated by two collapses structures (Bemmelen, 1949). This structure type might control surface manifestations at Ungaran.

Some geothermal manifestations appear to surround Ungaran volcano, i.e. Kali Ulo, Diwak, Banaran and Gedongsongo. In this paper, the author focuses on major manifestations that occur at Gedongsongo which is situated at the southern flank of Ungaran summit. An update of manifestation descriptions and fluid origins are described.

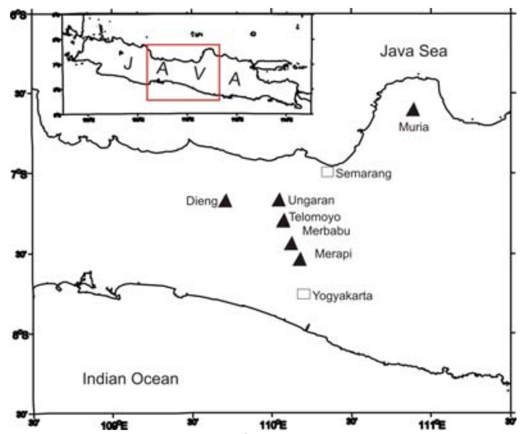

Figure 1: Locality of Ungaran Geothermal Prospect, Central Java, Indonesia

THERMAL MANIFESTATIONS

Thermal manifestations of Gedongsongo are in the form of fumaroles, hot springs and steaming ground. The active thermal manifestations mostly occur in the western part of a small creek on the southern flank of Ungaran summit (Figure 2). Measured temperatures made using a thermistor at the vent of fumaroles (size 0.75 x 0.50 m) reaches 85^{0}C (measured in November 2008) with significant mass flow rate (Nukman, in prep.) The fumarole discharges from steep cliff; whereas steaming ground (45 x 30 m) with similar temperatures coexists in higher topography. This suggests that fumaroles were formed due to heated ground water which in bisected topography (Figure 3). The temperature of hot spring (eastern part) and steaming ground (southern part) reaches about 40^{0}C and 50^{0}C, consecutively.

In the eastern part of the creek exist relic manifestations (Figures 2 & 3). There are many dead trees covered by sulphur and mud. The sulphur odor can be recognized at very close distance, and there are tiny fractures over the ground also covered by sulphuric mud interpreted as relic warm or hot spring channel mouth.

The altered ignimbrite and andesitic rocks reveals a high alteration intensity (0.8 of 1 AI of Browne, 1999) and pervasive silica replacement is also present; there are not many feldspar left. Relic epidote also appears at some outcrops.

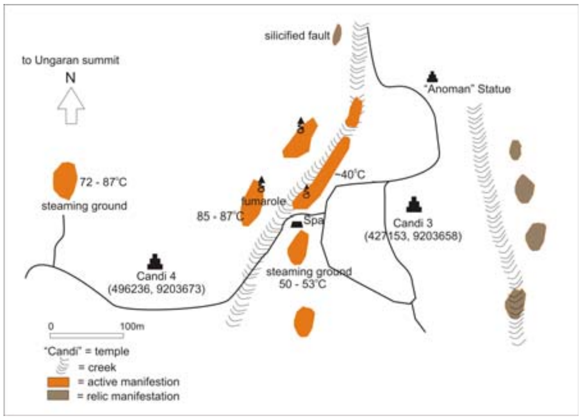

Figure 2: Locality of surface manifestatiosn of Gedongsongo.

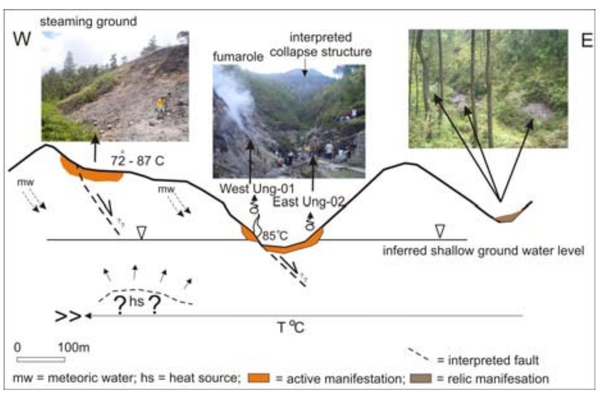

Figure 3: East-west cross-section over Gedongsongo manifestations (detailed explanation described in the text).

The distribution of manifestations shows a N-S alignment (Figure 2), parallel with steep cliff (and small creek) which possibly formed due to a collapse structure or normal faulting as commonly occur in volcanic regions. This permeable structure is considered to control the convective heat transfer. A silicificied fracture indicating a normal fault is found at the relic steaming ground at northern part (Figure 2). There is no relic epidote in this site.

FLUID TYPE AND ORIGIN

Water samples of manifestation were collected, filled in rinsed polyethene bottles, fully filled and sealed to avoid any precipitation prior analysis processes. The chemical constituents were analyzed by the Chemistry Department of UGM (Indonesia) and isotopic constituents were measured by GNS Lower Hutt (New Zealand). The chemical composition is shown in Table 1.

The West Ung-01 sample was collected from fumaroles at the western cliff; the East Ung-01 was collected from hot spring located just a few meters to east of the West Ung-01 location. The chemical contents are plotted on ternary diagram of Cl-SO_4-HCO_3, to identify fluid type, i.e. mature, volcanic, steam heated and peripheral type (Giggenbach,1991). The isotopic composition of water data is plotted in δD versus δ^{18}O diagram and compared to meteoric water line of Craig (1961) to identify fluid origin and process, i.e. meteoric, magmatic, mixing, boiling, vaporization and precipitation (Craig,1961; Truesdell,1977, Ellis & Mahon,1977).

Table 1
Chemical and isotopic constituents (unit: o/$_{oo}$) of Gedongsongo manifestation, Ungaran geothermal prospect, Central Java, Indonesia.

Location	West Ung-01	East Ung-02
pH	2	6.7
Li	0.1	-
Na	91.8	17.6
K	54.3	6.2
Ca	1.1	10.9
Mg	40.4	3.7
Cl	753.3	790.9
SO_4	3008.3	5.7
HCO_3	-	-
SiO_2	411.0	189.6
$\delta^{18}O$	2.68	-8.19
δ D	-9.2	-49.4

local meteoric water (code: cold creek) has : $\delta^{18}O$ = -7.7 , δ D = - 46.6 in o/$_{oo.}$

The West Ung-01 is more sulphate rich water with a significant amount of chloride as illustrated in Figure 4. This composition suggests a mixing process has been occurring in region.

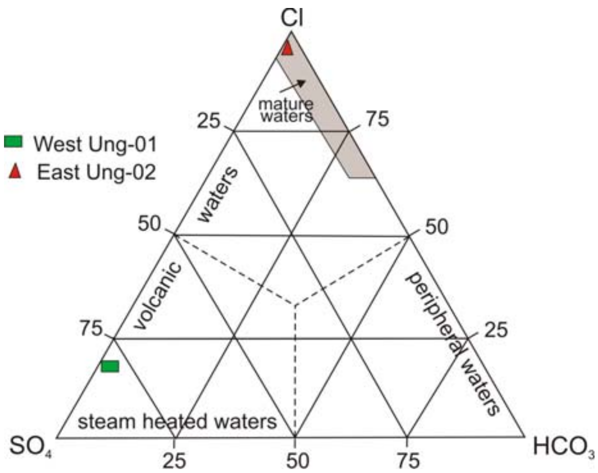

Figure 4: Gedongsongo water type based on SO_4-Cl-HCO_3 ternary diagram of Giggenbach 1991.

The isotope data (Figure 5) is parallel with this interpretation as the West Ung-01 shows enrichment of $\delta^{18}O$ relative to Craig meteoric water line, but does not reaches the magmatic box area where $\delta^{18}O$ is higher (enrichment in ^{18}O content than those ^{16}O as commonly occur at igneous rock and in water reaction contact with magma; Ellis & Mahon, 1977). Although East Ung-02 is classified as mature water type but has depleted $\delta^{18}O$ and lies on the global meteoric water line of Craig (1961).

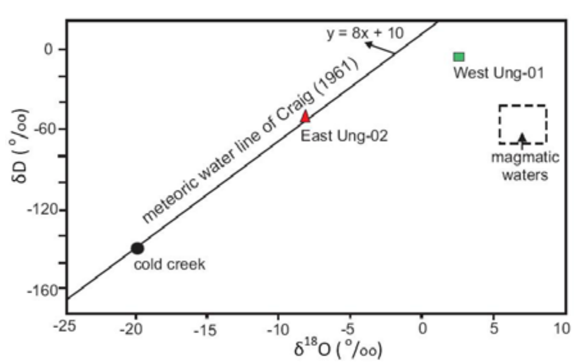

Figure 2: Oxygen isotope positive shift of West Ung-01 relative to meteoric water. The meteoric waterline is constructed based on the global meteoric line of Craig (1961).

DISCUSSION

Gedongsono fluid type is classified as acid sulfate-chloride water which consistent with collapsed structure processes. A slight magmatic fluid influence is recognized in the western part of Gedongsongo, where the active manifesatotions exist; this suggest that a mixing process is occurring in this region. To test this interpretation, we plan additional samples will be collected and analyzed (in particular for isotope) in the near future.

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