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Some Physical Properties of Gedongsongo Steaming Ground, Central Java, Indonesia

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ABSTRACT

A shallow temperature measurement at steaming ground of Gedongsongo manifestation, Ungaran Geothermal Prospect, shows that high thermal gradient occurs at 5 – 30 cm. This shows that a conductive heat transfer zone and low thermal gradient occur deeper (30 – 80 m), which implies a convective heat transfer zone. Some physical rock parameters such us bulk (wet) density, porosity, and saturation of liquid were also measured. These parameters would be an input to a heat loss assessment of the field.

1. INTRODUCTION

Ungaran Volcano lies at northern part of the Java volcanic arc (Figure 1). Hamilton (1979) describes that Java is developed by the north-south modern subduction system of the Indian oceanic plate and Eurasian continental plate. Early geological description was noted by van Bemmelen (1949).

The main manifestation of Ungaran Geothermal Prospect is a fumarole with steam jet inclination 15-20º. This fumarole is surrounded by 30 x 18 m of steaming ground. This manifestation is formed at bisected topography (Fig.3). Steaming ground with higher temperature exists at the upper hill. The hydrology issue is considered to control this different character of manifestation.

Previous research in this area shows a significant different fluid ^{18}O and D isotope at adjacent manifestations separated by a small creek (Figure 2), i.e. west and east block (Nukman, M. 2008). The west block is considered to have more magmatic influences since there is an enrichment of ^{18}O isotope.

The layered laharic breccias is exposed at out at southern part of main manifestation. The bearing of this layered laharic breecia is N 276ºE/19º (Fig. 2 & 3), and the jet inclination of fumarola is in 15-20º which shows that the jet is likely controlled by the bed rock layered laharic breccia which acts as fluid conduit (Fig. 3).

2. METHODOLOGY

One of the purposes to measure the physical properties of steaming ground over the geothermal area is to estimate the heat output of the field. Benseman (1959) describes the measurement of the heat loss over steaming ground by a device known as calorimetry. The later researcher began not only using devices over the steaming to estimate the heat output but also considering the soil parameters of the ground, i.e. Hochstein and Bromley (2005), which shows more a comprehensive measurement approach.

Temperature survey at Gedongsongo was conducted using thermocouple K-Type with error reading 0.1ºC, the probe is made of stainless steel to avoid any corrosion. The temperature was measured at 5, 20, and 80 cm depths. Three strongly altered thermal soils were sampled at depth 20 – 30cm from the surface of the steaming ground. The physical properties i.e., porosity, saturation of liquid, bulk (wet) and dry density, were determined. Hochstein and Bromley (2005) notes that these parameters are related in equation below:

$$c_{eff} = \frac{c_p(1-\emptyset)\sigma_p + c_f \emptyset S_1 \sigma f}{\sigma_w} \qquad \text{.....................eq.1}$$

where c_{eff} = effective thermal capacity per unit mass (J/kg.C) and σf is fluid density (kg/m^3).

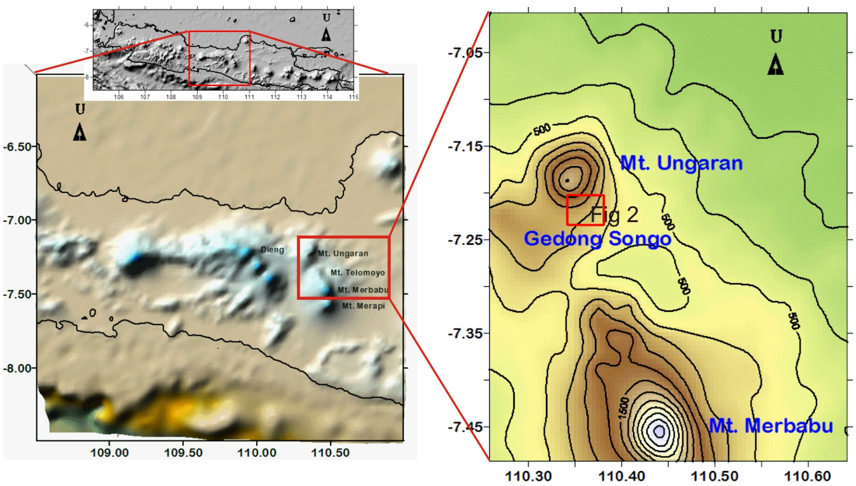

Figure 1: Locality of Ungaran Geothermal Prospect, Central Java.

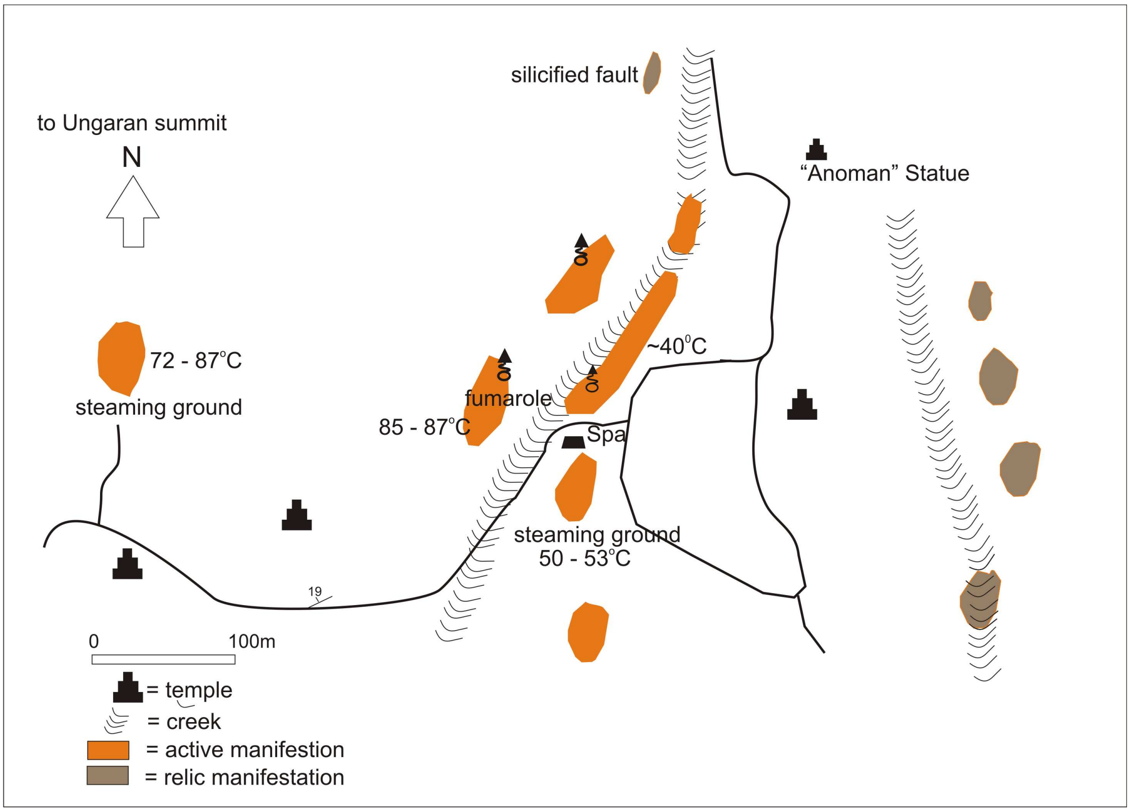

Figure 2: The map sketch of Gedongsongo manifestation. The bright colour is active manifestation and the dark one is relic. Note that the laharic breccias layer is exposed at southern part, N 276^{0}E/19.

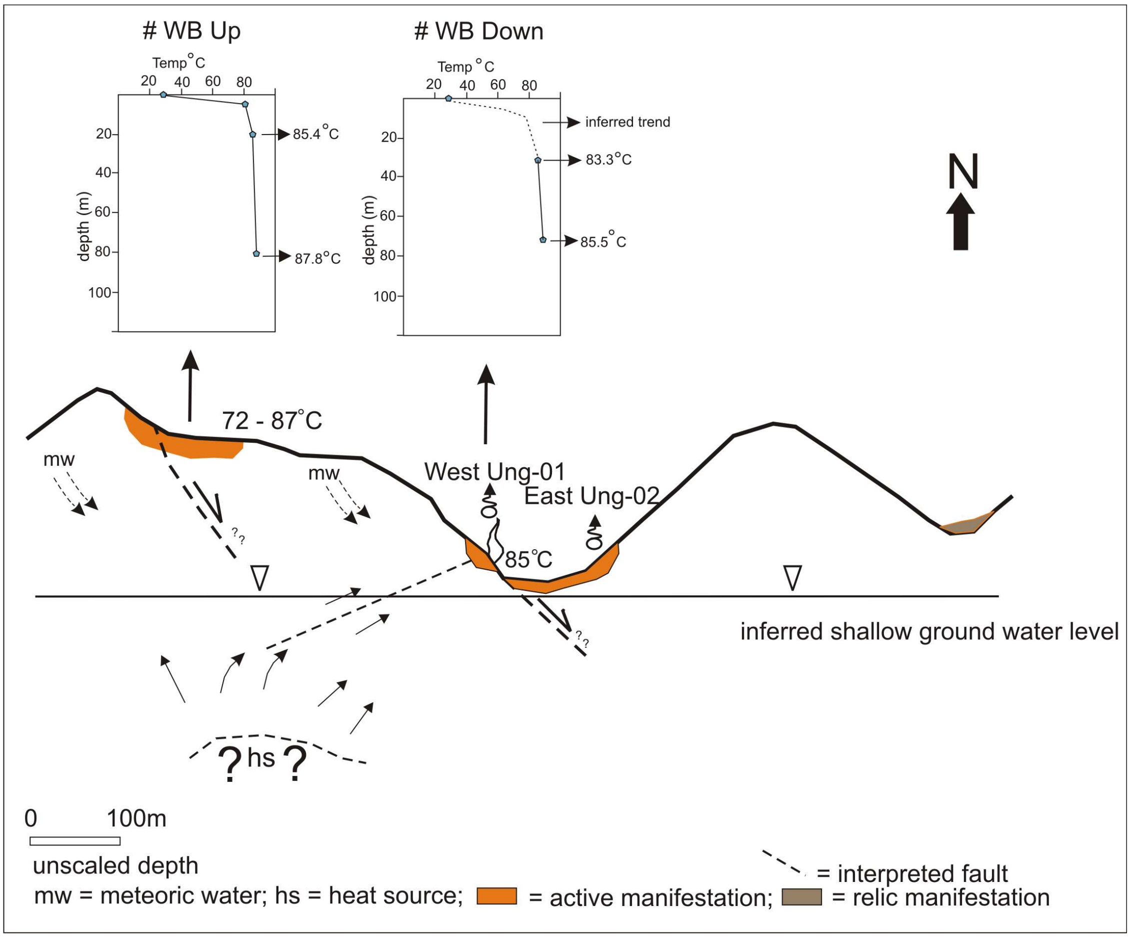

Figure 3: W-E cross section over Gedongsongo manifestation. Shallow temperature measurements (was taken in 27 May 2009, early summer) shows a relatively higher temperature at the uphill, where the steaming ground exist with thicker covered soil.

2. RESULT

The wet density and particle density of the soils from the manifestation at the bisected topography (lower area) shows a similar trend, i.e. in range of 940 – 960 kg/m^3 of particle density; 1600 - 1880 kg/m^3 of wet density, 0.16 – 0.2 of saturation liquid. In contrast, the equivalent parameters in the steaming ground at high elevation shows higher value than those of the lower one (bisected topography), i.e. 1470 kg/m^3 of particle density, 2030 kg/m^{3}of wet density and 0.1 of saturation liquid. The porosity of the soil at the lower area shows a lower value, i.e. 0.41 – 0.49, than those the upper one, i.e. 0.27. The fluid density at 80ºC is 971.8 kg/m^3 (steam table of Roger & Mayhew 1993).

The shallow vertical gradient at 5 – 30 cm is 0.27ºC/cm, and the deeper gradient show more constant value, i.e. 0.05ºC/cm, which is in the depth interval of 30 – 80 cm. The higher thermal gradient shows a conductive heat transfer zone and the lower one shows a convective heat transfer zone. The effective thermal capacity (c_{eff}) parameter could be derived from those physical value based on Eq. 1.

3. DISCUSSION AND PLANS

The lower density (both wet and dry) and porosity of the soil sample on the lower area (bisected topography) of the west block of Gedongsongo thermal area are possibly correlated with the bedrock. The bedrock texture is still observable, i.e. laharic breccias with angular shape of the fragment composed of andesite and pumice with less clay. These types of outcrops do not exist on the manifestation at the higher elevation of the west block due to a thicker covered soil which has more clays as a product of alteration processes.

The effective thermal capacity value of this manifestation is one of three parameters (i.e. thermal diffusivity and wet density) that can be used to calculate thermal conductivity. The conductive heat flux also can be estimated by considering its thermal conductivity and the thermal gradient (Hochstein, 2005). The construction of a modified thermal diffusivity device is unfinished yet; hence those important parameters could not be presented here. More soil samples are required than the current one in order to fill a statistical requirement.

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