SOIL MERCURY SURVEY AT MAKAROYEN VILLAGE IN KOTAMOBAGU GEOTHERMAL FIELD, NORTH SULAWESI, INDONESIA

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ABSTRACT

Kotamobagu geothermal field is one of the prospective geothermal development in North Sulawesi, Indonesia. The soil mercury survey were conducted in Kotamobagu, mainly within Makaroyen village, on the foot of Ambang Mountain. Concentrations of soil mercury (soil Hg), were measured for 20 sampling points in the area of 1.0 km EW and 1.0 km NW with elevation around 1000 m above sea level. High concentrations of soil mercury, 2920 to 17900 ng/g soil, were mainly measured in the northeast and east of the study area whereas lower concentrations to the centre, south and to the west. High concentration of soil mercury 14900 ng/g soil and above it was detected in the northeast and east of the area Makaroyen village. The presence of flow path of high temperature fluid and heat source is expected below the areas with high concentrations of soil mercury.

Keywords*: Kotamobagu, Survey, Potency, Geothermal Field, Soil Hg*

INTRODUCTION

Kotamobagu geothermal field lies on the southern slope of Ambang Volcano in North Sulawesi Province, Indonesia, 200 km to the southwest of Manado city, capital of the province. The field has been proved to be one of the geothermal prospects in Indonesia (Hochstein and Sudarman, 2008). PT. Pertamina Geothermal Energy (PT.PGE) has conducted reconnaissance and feasibility studies in Kotamobagu and concluded that the field has high potential for power generation. PT. PGE also conducted a research on environmental impact upon development and issued a document related to the environmental impact, which is one of the requirements by Indonesian government for starting geothermal development project in Kotamobagu.

In geothermal exploration, geochemical methods such as soil air gas surveys have been recognized as an excellent tool to find the locations of subsurface heat source and of faults or fractures that act as pathway for geothermal fluid (Koga, 1984). For example, mercury (Hg) is one of the volatile materials found in fumarole gas. It is transferred directly upward from a heat source by advection of geothermal fluid and by diffusion as well (Koga and Noda, 1975; Varekamp and Buseck, 1983).

In this study, we have carried out soil air gas surveys including soil Hg. The area for soil mercury survey mainly lies within Makaroyen village and the area is covered by mainly house of local people and paddy field and wild grassing with elevation around 1000 m above sea level. The area survey is choosing at Makaroyen village because in this area had crossed of fault by direction northeast to southwest. In this area of 1.0 km EW and 1.0 km NW, we measured soil Hg concentrations.

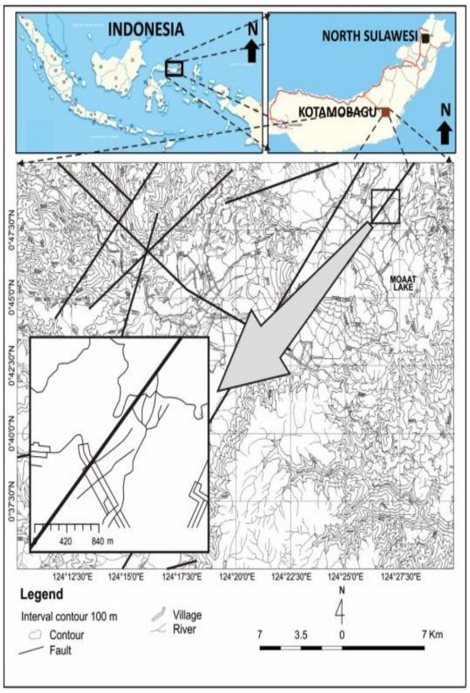

Figure 1: Located Of Survey

GEOLOGY

Geological Setting

Survey area locates in the Eastern Kotamobagu city mainly lies at Makaroyen village on the slope of Ambang Mountain (Fig. 1). The lithology consist of the Tertiary and the Quaternary rocks. Tertiary sedimentary rocks consist of shale and sandstone with intercalation of limestone and chert, and are overlain by Tertiary and Quaternary volcanic rocks. The Tertiary volcanic rocks are products of Old volcano consisting of breccia, tuff and andesitic lava, dacite and rhyolite. Ambang Volcano and Lake Deposits of Quaternary overlain the Tertiary volcanic rocks in Liberia village. Ambang volcanic unit consists of tuff, agglomerate, lahar, lava, and sulfur deposit within a crater of Ambang volcano. Southern side of Ambang Volcano, Lake Deposits unit consist of grey clay stone, plant remnants and lignite. The survey area partly locates within tuff pumice. Geological map is shown in Fig.2 with cross section and lithologies.

Geological Structure

Fault in Kotamobagu had directions northwest to southwest, northeast to southwest and west to east. Fracture with direction west to east which is crossing the sedimentary rocks controls the appearance of Pusian and Bakan hot springs (PT.PGE, 2005). Fracture with direction northwest to southeast controls the appearance of Lobong hot spring. Fumaroles appearances are controlled by fracture, with direction northeast to southwest (PT.PGE, 2005).

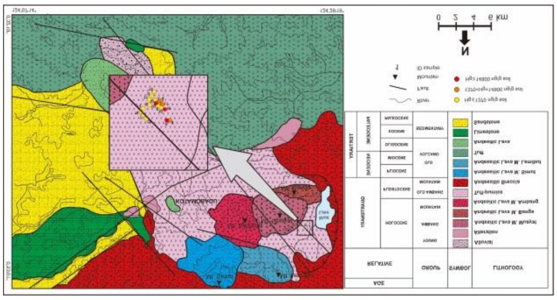

Figure 2: Geological Map

MEASUREMENT METHODS

Soil mercury was measured at 20 points, mainly in Makaroyen village (Fig.1). The measurements were made at intervals from 50 to 200 m. Concentration of soil mercury was measured at each point where the hole of 60 cm depth and 5 cm diameter was made by hammering steel pipe into the ground. Soil sample was collected from the bottom of the hole. Soil samples were air dried for a week, then pulverized for analysis of adsorbed Hg on soil. Hg on soil was analysed for mercury with Atomic Absorption Spectrometer (Mercury SP3 Nippon Instruments Co.) in laboratory.

RESULTS AND DISCUSSION

The cycle ranged for soil mercury was determined by cumulative frequency method. Data was divided into a couple of groups that can be approximated with a straight line. One cycle of the straight line suggests presence of one population of soil air gas (Klusman, 1993).

The soils Hg data are plotted for cumulative frequency and concentrations in Table 1 and Figure 3. As shown in the figure, the data can be divided into three groups and are approximated by three straight lines in the three ranges below 1370, between 1370 and 14900 and above 14900 ng/g soil. This suggests that three populations of soil Hg present in the field. Figure 3 shows concentration distribution of soil Hg. The concentrations of soil Hg range from 78 to 17900 ng/g soil. Figure 1 and 4 shows soil Hg concentration distribution with circles of different colour that represents there concentration groups. High concentrations of soil Hg with range from 2920 to 17900 (ng/g soil) were measured mainly in the east and northeast of the area (sample 5, 6, 17, 18, 19) and relatively low concentration in the center, northwest and the west (sample 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 20).

Results of soil air gas survey are summarized in Table 1 and Figures 3 and 4.

Table 1: Soil Hg Concentrations (ng/g soil)

ID	Coordinate						Hg	Temp in Hole	Ambient Temp.
Sample	North			East			(ng/g soil)	(°C)	(°C)
1	0	48	9.4	124	26	56.3	1370	28.4	24.9
2	0	48	9.4	124	26	56.3	1370	25.2	25.7
3	0	48	10.9	124	26	55.4	696	24.8	25.7
4	0	48	8.2	124	26	55.3	830	27.5	25.2
5	0	48	7.2	124	26	57.7	2920	28.5	24.9
6	0	48	22.4	124	27	4.2	14900	27.8	28.9
7	0	48	22.1	124	27	1.9	1170	24.5	26.9
8	0	48	18.0	124	26	44.0	78	23.7	25.8
9	0	48	10.5	124	26	48.8	280	23.9	24.8
10	0	48	3.2	124	26	50.6	277	24.0	23.7
11	0	48	6.4	124	26	53.0	194	24.5	24.0
12	0	48	6.0	124	26	48.3	151	24.2	23.2
13	0	48	21.0	124	26	46.2	218	27.7	24.6
14	0	48	12.9	124	26	43.9	329	24.6	23.7
15	0	48	15.7	124	26	42.1	88	24.8	24.0
16	0	48	0.1	124	26	52.2	497	27.9	24.1
17	0	48	12.4	124	26	57.7	5060	28.5	23.6
18	0	48	9.9	124	26	58.6	15500	30.7	24.2
19	0	48	13.7	124	27	0.4	17900	26.7	24.8
20	0	48	9.0	124	26	53.6	393	24.9	24.2

Concentrations of Soil Hg shown in Fig. 3 as below:

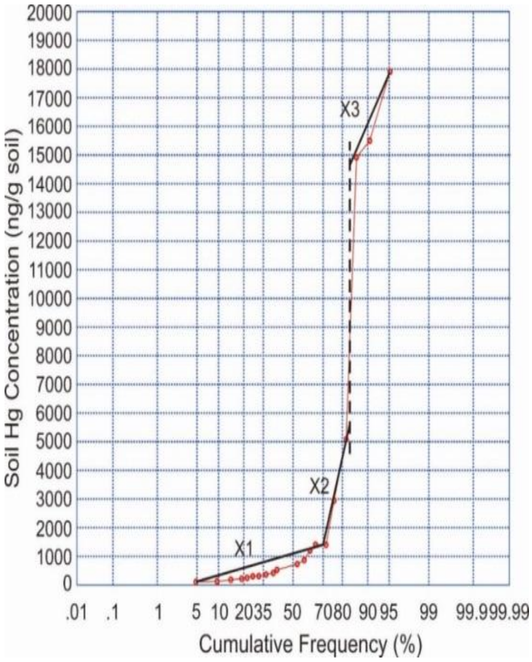

Figure 3: Soil Hg Concentrations (%)

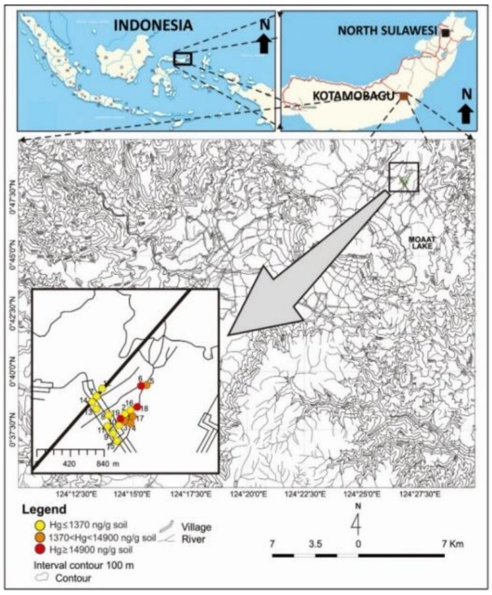

Figure 4: Sampling Point Of Soil Air Gas in Kotamobagu

Concentrations of Hg, were measured for 20 sampling points in the area of 1.0 km EW and 1.0 km NW. High concentrations of soil Hg, 14900 to 17900ng/g soil, were mainly measured in the northeast and east of the study area. Concentrations of soil Hg, below of 1370 ng/g soil were measured in the centre, south and west of study area.

High concentration of soil Hg 14900 ng/g soil and above it was detected in the northeast and east of the area Makaroyen village. The presence of flow path of high temperature fluid and heat source is expected below the areas with high concentrations of soil Hg.

CONCLUSION

Soil air gas survey was conducted at 20 points at Makaroyen village in the Kotamobagu geothermal field, North Sulawesi Indonesia. High concentrations Hg were detected in the northeast and east of the survey area. This implies the presence of high temperature heat source or a flow path of high temperature fluid below this area.

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