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Surface Manifestation in Wapsalit Geothermal Area, Buru Island, Indonesia

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ABSTRACT

The Wapsalit geothermal manifestation is located in Buru Island Indonesia. Geological stratigraphy of the area is even dominated by Paleozoic metamorphic rock. This study is focused on alteration study compared to the type of fluid geochemistry of manifestations. The manifestations consist of hot springs, hot ground, steaming ground and altered rocks. The manifestations are distributed along Waekady River and controlled by Waekedang oblique fault. The temperature of manifestations reaches 94°C. Base on mineral analysis, altered minerals are found such as illite and alunite. These minerals are hardly interpreted as result of hydrothermal alteration since the country rocks are metamorphic.

1. INTRODUCTION

Indonesia has many possibilities to develop energy resources, especially geothermal energy resources. The geothermal resources in eastern Indonesia were dominantly found not in volcanic areas like in western Indonesian. New explorations of geothermal fields were based on geological research conducted by Center of Geological Resources in 2005. Results of the report were used to discover geothermal manifestations with highly temperature hot springs and large altered areas to conduct preliminary research. This paper will hopefully bring an abstract of geothermal surface manifestations and geochemistry of the Wapsalit geothermal field in Buru Island (Figure 1).

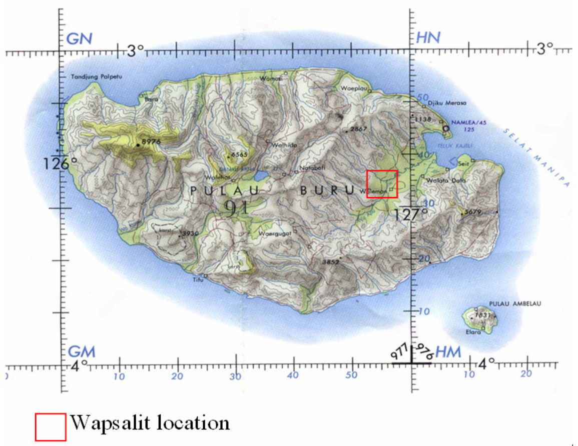

Figure 1: Wapsalit geothermal area, Buru Island.

2. GEOLOGY

The regional setting of Buru Island is on the western part of the Mollucas Archipelago. Geologically, Buru Island was formed of Pre-Tertiary non-volcanic facies on the outer arc like Tanibar – Kai – Seram. The Sorong transform fault affects the geological setting on Buru Island, which is active in association with movement of the Australian plate to the north. The Wapsalit geothermal area is located in the central southern portion of Buru Island, and was formed by sedimentary and metamorphic processes in a medium terrain. Metamorphic rocks are characterized by low grade metamorphism including slates, phyllites and quartzites. Green schist and arkose was found in the west side of the manifestation. The boundary between metamorphic rock and sediments (sandstone and clay) was found in Metar as an unconformity. The NNW-SSE Waekedang transform fault serves as a conduit to transport geothermal fluid to the surface to form Wapsalit hotspring. An altered zone has the same trend as the NNW-SSE Waemetar transform fault that implies connection to Metar hotsprings.

3. MANIFESTATION

Geothermal manifestation appear in Wapsalit geothermal field as hotsprings, hot ground, steam vents, sulfur and salt deposit and altered zones. Manifestations are spreading around Wapsalit River and another was found in Waemetar River, 2.5 km away to the east. Wapsalit-1 hotspring has a temperature range of 98.8 – 101.3°C with pH 9.28, a flow rate of 0.5 L/s. The spring appears along fractures in the metamorphic rock, where steam vents constantly. Alteration is found in rock surrounding the spring that is white to reddish brown in color. Within a range of about 80 x 50 m, there is a strong smell of sulfur gas, and sinter silica appears in many places near the discharge of the Wapsalit-1 hotspring. Hot ground temperature ranges between 85 − 98°C. Physically, the fluid of the hotspring, is clear with much bubble gas. Wapsalit hotspring–2 has measured temperatures between 99.2 – 101.6°C with pH 8.82, and flow rate of 2 L/s, the area of discharge is about 60 x 50 m with muddy fluid, a weak sulfur scent, bubble gas and spreading sinter silica. Altered mineral colours are white, black, and brown. Wapsalit hotspring-3 has a temperature of 99.6°C with pH 6.62, and a flow rate of 5 L/s. The water is clear with no sulfur scent identified, and sinter silica is observed covering the metamorphic rock. Metar hotspring is located in Waemetar River, it has temperatures between 63 and 65°C with pH 7.05, flow rate of 0.5 L/s. The spring appears between boulders of alluvium, the fluid is clear with bubble gas and oxidized surrounding hotspring. No alteration or sulfur scent was noted.

4. ALTERATION

There are eleven locations where rock alterations ware observed surrounding the manifestation of Wapsalit hotspring and steam vents of the Wapsalit River (Figure 2). A variety of altered rock colors ranging from white to brownish–black are representative of high intensity hydrothermal fluid that affected the host rock. Quartz veins were observed in phyllite with sizes about 1 to 4 cm with a thin silica sinter on the top surface of the metamorphic rock; iron oxide are much like sinter.

Altered rocks were analyzed with Portable Infrared Mineral Analyzer by Central of Geological Resources and results of altered clay mineral assemblages like dickite, kaolinite, illite, halloysite, mica, opal and alunite, others are Teflon (Table 1). Distribution of altered minerals show an argillic to advanced argillic altered zone (Corbett and leach, 1998). Argillic type was shown by appearance of halloysite, dickite, kaolinite and advance argillic was shown by appearance of kaolinite, dickite, allunite, opal and mica like muscovite.

Table 1: Alteration analyzed in Wapsalit geothermal area.

Code	Altered Minerals
W25A1	muscovite, dickite, kaolinite
W25A2	muscovite, illite
W25A3	muscovite, illite
W25B1	muscovite, halloysite, illite
W25B2	muscovite, kaolinite, halloysite
W25B3	illite
W25C	muscovite, opal
W25D	illite
W25B	illite
W25E	Muscovite
W25F	Illite, alunite

Argillic type was dominantly formed by clays with low temperature, pH acid to neutral and low salinity hydrothermal fluid. Advanced argillic type occurred as a result of predominantly acid hydrothermal fluid like sulphate water. These mineral assemblages occur as tabular near – vertical zones formed from condensed acid magmatic vapors in porphyry environment and affect the oxidized steam condensates.

5. GEOTHERMAL FLUIDS CHARACTERISTIC

The Wapsalit hotspring appears to be a discharge of meteoric water in the Wapsalit River as does the Metar hotspring. Water accumulated at depth, was heated by convective flow from the heat source, and flowed upwards to the surface in Wapsalit hotspring, with a basic pH 9.0 to 9.50. Hotspring temperature ranges between 99°C to 102°C.

Plotting of hotspring chemical elements (Table 2) indicates that all Wapsalit and Metar fluids are placed in the HCO_3 corner, which means that the geothermal water is bicarbonate below the influence of meteoric water. However, it is inappropriate to plot all of Wapsalit hotspring waters in full equilibrium with water on the Na-K-Mg triangle diagram, which would mean that the water came from deep water as main fluid reservoir. In the Cl–Li–B triangle plot both Wapsalit and Metar are placed in the middle of volcanic and sedimentary environment and they form in one geothermal system (Figure 3).

Figure 2: Distribution of manifestation and alteration mineral in Wapsalit geothermal area.

Table 2: Chemical analyzed of Wapsalit hotspring geothermal area.

Parameter	Wapsalit-1	Wapsalit-2	Wapsalit-3	Metar
pH	9.4	9.1	9.3	7.2
Na	1234	1216	1101	686
K	75.2	76.8	60	28.8
Li	6.8	6.9	5.2	2.8
Ca	0	0	0	16.8
Mg	0.02	0.02	0.01	3.41
Fe	0.02	0.03	0.03	0.21
Al	0	0	0	0
CO_3	637.16	407.55	499.19	0
As	0.2	0.1	0	0
NH_4	2.73	5.64	4.73	9.09
HCO_3	1540.08	2001.79	1532.35	1816.64
Cl	228.67	232.19	182.34	105.54
SO_4	40	40	50	1
B	33.58	35.08	25.51	15.28
F	2	3	1	1
SiO_2	328.24	323.87	248.15	73.46
Conductivity	4500	4360	4300	2330

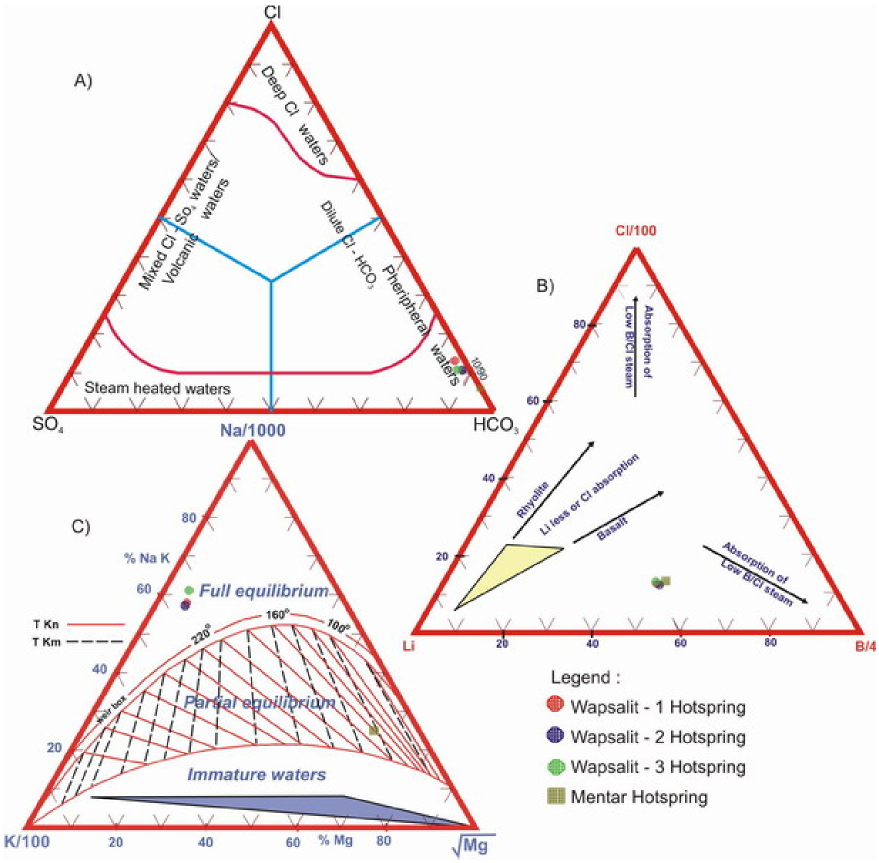

Figure 3: Triangle plot of chemical analyzed Wapsalit hotspring.

6. DISCUSSION

Illite and halloysite occur altered veins and vugs with an origin of plagioclase. Kaolinite and dickite were replace an origin mineral of feldspar but also fill in veins and vugs. Alteration is influenced by pH of the fluid fluid in low temperature conditions, associated with quartz, opal, alunite and pyrite. Some indicate a high sulphidation type deposit.

Muscovite occurs as major alteration mineral that relates to intrusion associated with kaolinite–illite. Kaolinite in this geothermal field could be associated with fumaroles and native sulphur deposits that formed above the paleowater table and related to condensation or oxidation of gases (H_2S) formed during supergene. Appearances of illite was used in as a geothermometer which indicates temperatures of about 200-300°C. Related to illite–muscovite conditions, which were associated with peripheral upper parts of intrusion related system.

A high CO_2 concentration was predicted in the Wapsalit hotsprings by relating the near surface condensation of steam in geothermal fluids, to the deep chloride water that mixed with meteoric water and boiled, making condensation of CO_2. The high temperature of hotsprings with spreading hot ground may occur due to a fast flow of hydrothermal fluid to the surface, where steam-heated water boiled at the water table than produced hot ground and steaming ground. An alteration zone happens as the hot fluid contacts the wall rock, which leads to dissolved rock minerals and the leaching process. Acidic steam and chloride water causes extensive leaching in the surface lithologies, which produces the silica residue as silica sinter. The basic pH of hotsprings causes a greater influence in the sedimentary and metamorphic rock that comprise the Wapsalit geothermal area.

7. CONCLUSION

In the Wapsalit geothermal field it is interesting to observe geothermal manifestations including hotsprings, hot ground, steam vents, sulfur and salt deposit, silica sinter and alteration zones, which are present along the Wapsalit River. Alteration zones are classified as argillic to advanced argillic horizens and high temperature, bicarbonate geothermal fluid is characteristic of the three main Wapsalit hotsprings. Geothermal fluids are characteristic of deep reservoirs that shown the full equilibrium water and appear at the surface by influences of steam heated and metamorphic rock.

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