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MAGNETC, GRADIENT TEMPERATURE AND GEOCHEMISTRY SURVIE S WITHIN PASEMA AIR KERUH GEOTHERMAL AREA EMPAT LAWANG DISTRICT, SOUTH SUMATERA PROVINCE INDONESIA ABSTRACT The Pasema Air Keruh geothermal area situated within the Empat Lawang District, Sumatera Selatan Province. Magnetic, gradient temperature and geochemistry survies conducted within that area, in 9 June 2012. The magnetic and the gradient temperature were not analysed zet. The geochemical analysis using the geothermometer and geoindikator, doe to determine the reservoir characteristic and temperature.

The first geothermal exploration activities in Empat Lawang District Sumatera Selatan Province were carried out in the Penantian hot spring field Air Keruh Sub District and Airklinsar hot spring field Ulu Musi Sub District. The discharge test measurements show that chemical composition of the reservoir water was analyzed by standard methods and subsequently classified using Cl-SO4, HCO3 triangular diagram. A Na-K-Mg triangular diagram was used to classify waters according to the state of equilibrium at given temperatures. The geothermal waters are of chloride water type and from a relatively old hydrothermal system.

Thermal fluid is in equilibrium with reservoir rocks. The chemical geothermometers were used to predict subsurface temperature. The calculated temperatures using Na-K geothermometers and Na-K-Mg geoindikcator is more than 300oC. However, compare with measured temperature furthere. Key word: geochemical, geothermometer, geoindicator, geothermal Empat Lawang 1. INTRODUCTION The Empat Lawang geothermal field is located on one of the major tectonic belts of the Fault Sumatera System. In addition to this, there are volcanic areas spread throughout the country. Therefore, the country has many hot springs with a variety of temperatures ranging up to 98oC.

The hot springs are located mainly on major active fractures and volcanic areas one of which is Penantian and Airklinsar. The Penantian and Airklinsar is one of the prospective areas in Empat Lawang District Sumatera Selatan Province for geothermal exploration which was initiated by Virgo Team are the first in June 2012. The map location is shown in Figure 1. The Empat Lawang geological extends elongated the Fault Sumatera System between the Bengkulu and Sumatera Selatan. The Penantian and Airklinsar geothermal field is located near the Gunung Kasih Massif, which is Paleozoic in age.

This Massif is mainly composed of metamorphic schists, marble and granite, and forms the basement of the geothermal area covered by Tertiary Proceedings - ICP2012 ISBN: 979-95620-2-3 Page 129 volcanic-sedimentary units assumed to be cap rock. The rocks of the Empat Lawang are divided into ten zones that are characterized in Figure 2. The geothermal manifestation spreads throughout an area including boiling hot springs, travertine and swampy areas formed by hot water emergence and leakage. The results of chemical analysis of hot and cold water samples have been evaluated for fluid using Giggenbach diagrams. 2.

CHEMICAL COMPOSITIONS OF THE WATERS The geochemical study is based on discharge water samples collected from the discharge of two hot water springs. These samples were collected in M June 2012. Samples were untreated and included acidified water. Chemical analyses of Na, K, Ca, Mg, B, Li, and SO4 were carried out in the site laboratory of Lampung University (Bandar Lampung), and the SiO2 pH, Cl, HCO3, in laboratory of Sriwijaya University (Palembang). Li, Cl and B are conservative elements in the geothermal system. They are fixed in fluid phase and have not equilibrated. The conservative elements are the best geoindicators of the origin of the geothermal system.

B/Cl ratio and Cl-Li-B ternary diagram were used to indicate the source of the fluid. A plot of the relative concentrations of Cl, Li and B is shown in Figure 3. All geothermal waters have high Cl content relative to Li and B, indicating that they are from an old hydrothermal system and that fluid migrated from the old basement rock. 3. CLASIFICATION OF THE THERMAL FLUIDS The average chemical compositions of the geothermal water from the Penantian and Airklinsar are presented in Table 1.

The discharge water from Airklinsar hot water are of the chlorate type with alkaline pH (6-7) and with total dissolved solids in range the of 400- 700 mg/kg. A Cl are predominate cations with concentration more than 600 mg/l respectively, whereas Mg is present only in trace (0.4-2 mg/l). In contrast, hot waters discharged from Penantian hot spring are neutral (pH-6-7) and concentration of sulfate and carbonate ions are lower.

The chemical compositions of the waters were classified on the basis of major ions using the Cl-SO4-HCO3 triangular diagram of Giggenbach (Figure 3). All samples plot to area of mature waters and can be classified as Cl-rich geothermal water which formed by the interaction of geothermal fluids with the host rock and dilution with low salinity water at depth (White and Muffler, 1971). The Empat Lawang possesses great potentiality for the utilization of geothermal energy.

The region has been centre of attraction to a number of visiting national scientists, encouraging them to collect and analyze geothermal water samples at different localities on a sporadic basis. One of such studies has determined the temperature and reservoir characteristic. 4. ESTIMATION OF THE RESERVOIR Even though the above table suggests that none of the springs have a huge mass flow rate, a number of springs emerging in the vicinity could have lowered the flow rate.

Water containing chloride concentration more than 100 ppm. No high concentration of silica is observed relative to discharge temperature in all spring waters. The waters at Airklingsar lying in this region have relatively high chloride, suggesting that the waters are fairly mature as indicated by the Giggenbach's diagram of concentrations of the major anions, Cl, SO4 and HCO3. This is illustrated in Figure 3. Proceedings - ICP2012 ISBN: 979-95620-2-3 Page 130 Table 1.

Geochemical data from Penantian and Airklingsar hot spring Sampel Na K Ca Mg B Li SO4 HCO3 SiO2 Cl Penantian 15 9 31 0,4 6 0,3 228 190 64 119 Airklingsar 32 9 133 2 17 0,2 340 61 50 664 5. SUBSURFACE TEMPERATURE ESTIMATION Chemical geothermometers are used in order to estimate the reservoir temperature. The important criteria for chemical geothermometer application to thermal spring are the pH, temperature and discharge rate of the spring. Some of them give unreliable results such as either lower than spring temperature or extremely high temperature.

These equations are based on geothermometers for chalcedony and quartz, which assume hat these minerals used in geothermometers, are not in equilibrium with rock – water interaction in reservoir. The silica and cation geothermometers were used for the evaluation of subsurface temperature for discharges (Table 1). The Source of temperature equations: T–measured temperature, T: Na-K– Fournier and Truesdell (1973), T: Na-K – Giggenbach (1988), TFournier (1977) were used. These give reservoir temperatures ranging from 211o to 251C.

The Na-K geothermometer of Giggenbach (1988) suggested reservoir temperature in the range of 331oC – 429 oC and Fournier (1977) suggested reservoir temperature in the range of 271-289oC which is higher than measured temperature. The Na-K-Ca geothermometers (Fournier and Truesdell (1973)) predict anomalously high reservoir temperature (326oC – 438 oC). The Na-K-Mg triangular diagram shows the equilibrium between the geothermal fluids and rock and reservoir temperature (Figure 4).

By considering the diagram presented in Figure 5, the Kozakli hot springs plot in the immature water part, so using the chemical geothermometers is not reliable according to the theory used to establish the diagram. In this Na-K-Mg diagram all the samples have not gained equilibrium with rock, presumably due to fast circulation of luid through the rock fractures. This causes the water to be mmature, considering the ion exchange processes that, equilibrium has not been reached yet with rock minerals because of circulation flow.

Figure 4 shows that samples from studied geothermal wells fall on the full equilibrium line, suggested attainment of the (Airklinsar) and 350oC (Penantian) 3. CONCLUSION The geothermal waters discharged from Airklinsar of the Empat Lawang geothermal field are of chlorate type with a high concentration of Cl. Chemical compositions of reservoir waters indicate that the reservoir is located in the liquid dominant zone and geothermal waters come from an old geothermal system. The water composition from Penatian Empat Lawang is carbonate and sulphate.

Thermal fluid is in equilibrium with reservoir rocks, which can be the product of water-rock interaction at high temperature. Common geothermometers have been used for estimating the subsurface temperature. The results from Na-K geothermometers and Na-K-Mg geoindikcator, indicate that the reservoir Proceedings - ICP2012 ISBN: 979-95620-2-3 Page 131 temperature. The calculated temperatures using Na-K geothermometers and Na-K-Mg geoindikcator is more than 300oC. However, compare with measured temperature furthere. Figure 1. The map location of the Penantian and Airklinsar geothermal field. Figure 2.

The geological map of the Penantian and Airklinsar geothermal field. Proceedings - ICP2012 ISBN: 979-95620-2-3 Page 132 Figur 3. The diagram of the Penantian and Aklinsar reservoir characteristic. Figur 4. The diagram of the temperatures of the Penantian and Aklinsar geothermal reservoir.

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