IDENTIFICATION OF PERMEABILITY GEOTHERMAL RESERVOIR IN AN ACTIVE FAULT ZONE

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ABSTRACT

The Indonesian state on the ring of fire is an area that has geothermal potential. The existence of geothermal systems is generally closely related to the activities of volcanism and magmatism. Although producing geothermal systems occur in both compressional and extensional regions of strain in volcanic arcs. Volcanic areas have dominant lithology in the form of igneous rocks, and have complex geological structures. Rocks in the geothermal field are usually volcanic rocks. Which have small primary permeability of the fracture, the rock have a secondary permeability, so that the total permeability becomes larger. Fault is a fracture system that will help rocks have a large total permeability. Another relationship between fault and geothermal heat is that a fault create vertical permeability of a rock. So in the field of geothermal, there is usually a pattern of alignment between the location of a manifestation with the location of other manifestations in a similar fault system.

Keywords: Fault, Geothermal, Permeability, Reservoir

INTRODUCTION

The decrease in fossil energy resources has led to an increase in demand for efficient utilization of unconventional and sustainable energy resources, such as geothermal reservoirs. Additionally, the increasing impact of carbon dioxide has led to the development of geological storage of carbon dioxide. In this context of geothermal development and carbon dioxide storage within a sedimentary formation, one important aspect for the siting of future wells is to locate zones where fluid circulation occurs. Productive heated land reservoirs should have high porosity and permeability, considerable size, high temperatures and sufficient fluid content. Permeability is generated by stratigraphic characteristics and structural.

The high correlation between the presence of geological structures in a region can form the permeability of rocks to circulate due to warming by heat sources. When the fluid circulates in a reservoir, it can form a shielding layer that causes the rocks on the surface to be transformed (clay alteration rocks), in response to the heat pressures from within the earth. On the other hand, the continuous hydrothermal activity can result in a high fracture in the geothermal environment, causing rock formation on deformed surfaces and eventually forming certain morphologies. This environment becomes a single geothermal system. Thus, the geothermal system in the active fault line can be created by environmental permeability factors of rock and hydrothermal activity.

The permeable igneous rocks usually contains fracture zones. Based on the direction, the fracture permeability is divided into two: vertical permeability and horizontal permeability. Fault strongly supports the formation of vertical permeability, because the geothermal fulid can pass to the surface along the fault plane. This is characterized by the presence of surface geothermal. Basically, the development and management pattern of geothermal energy is only based on three main factors, namely temperature, permeability and geothermal fluid (Hanano, 1999).

BARASANGA GEOTHERMAL FIELD

Regionally, structures of Lasusua-Kendari Sheet are faults, fold, and joint. Fault and straightness are generally northwest-northwest directions in the direction of Lasolo fault. Lasolo fault is sinistral slip-sliding fault which allegedly still active until now, as evidenced by the hot springs in Batugamping reefs that aged Holocene on the Fault Line in Southeast Tinobu, precisely in Barasanga District Lasolo. A rising fault is found at Tanjung Labuandala in the south of Lasolo, ie the rock from iolite rocks over the Meluhu Formation rocks. Fault Lasolo is North-West-trending, dividing the Kendari Sheet into two parts. The north-east side of the fault section is called the Hialu Lane and the southwest is called the Tinondo Lane (Rusmana, et al, 1993). Hialu Lane is generally a set of rocks characterized by the origin of Ocean Crust and Tinondo Lane is a set of rocks that are characterized by the origin of continental exposure.

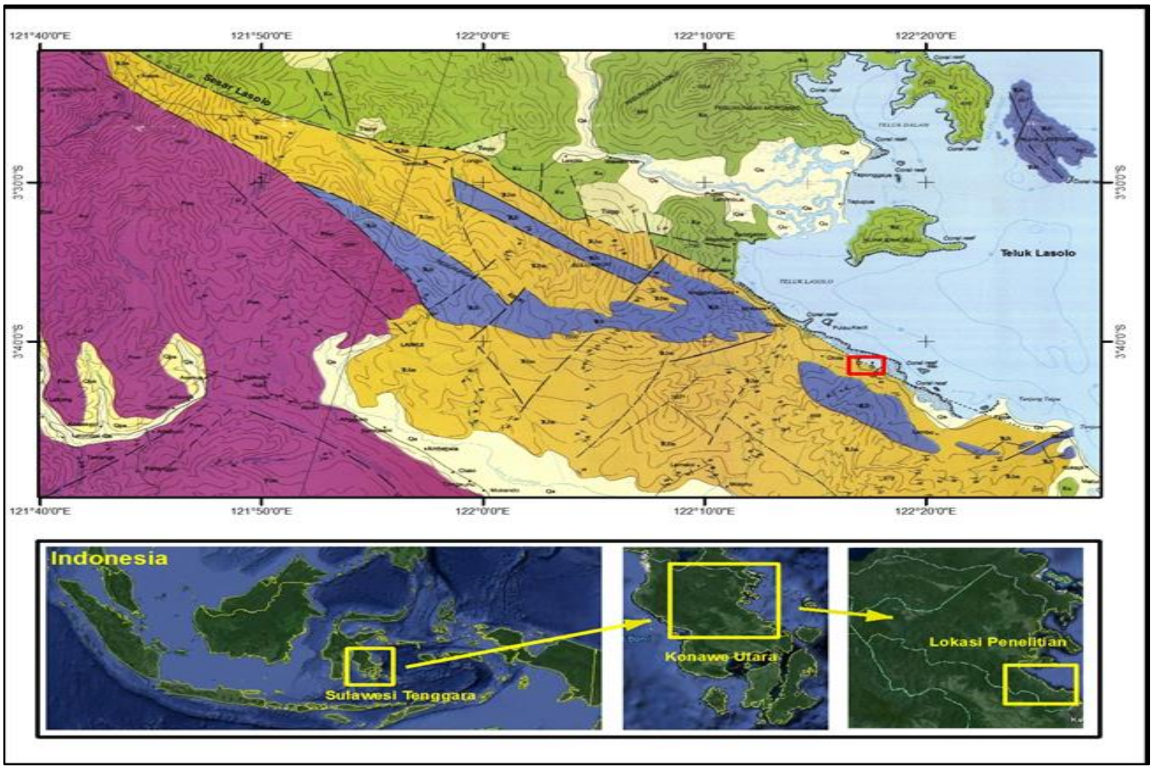

Figure 1: Geological map of the Lasusua-Kendari, Indonesia.

PERMEABILITY

Permeability is important because it is a rock property that relates to the rate at which hydrocarbons can be recovered. Values range considerably from less than 0.01 millidarcy (MD) to well over 1 darcy. A permeability of 0.1 MD is generally considered the minimum for production. Highly productive reservoirs commonly have permeability values in the Darcy range.

Permeability is expressed by Darcy's Law:

$$Q=A\left(\frac{k}{\mu}\right)\left(\frac{\Delta P}{L}\right)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where Q is rate of flow, k is permeability, μ is fluid viscosity, $\frac{\Delta P}{L}$ is the potential drop across a horizontal sample, and A is the cross-section area of the sample. Permeability is a rock property, viscosity is a fluid property, and $\frac{\Delta P}{L}$ is a measure of flow potential.

The basic concept of permeability is closely related to the basic law of fluid flow through porous media, known as Darcy's Law, which is the first empirical law first introduced by Henry Darcy in 1856 (Rivera. J., 1995) Conceptually Rivera (1995) subsequently divides permeability based on its medium to matrix permeability, and fracture permeability. Matrix permeability is generally defined as a single porosity system especially in materials such as rocks whereas fracture permeability is related to a fracture or a series of fractures. The concept of permeability in geothermal is more proportionally oriented to the container, namely primary permeability and secondary permeability (Browne, 1996). Primary permeability includes rocks, contacts of rock layers, unconformity and ancient solution features that are also overall known as stratigraphic approaches. Secondary permeability includes fractures, hydraulic fracturing, joints and hydrothermal leaching.

The search for the permeable zone of the geothermal area reservoir can be performed using structural analysis, stratigraphy, structural and stratigraphic combinations, microearthquakes and drilling. The search for structural signs includes the analysis of the appearance of geothermal symptoms through aerial photography and Landsat imagery, a review of rock distribution patterns and rock contacts and the appearance of regional lineament deployment. Identify potential fault zones through the appearance of symptoms during the drilling process, among others, loss of fluid circulation, powder analysis and rock core, and others. Permeable zone search can also be done by looking at the distribution of microseismicity. The greater the degree of seismicity, the greater the flow of fluid below the surface into the reservoir.

RESULT AND DISCUSSION

The fault zone is usually the most important fracture zone of a geothermal geology. This zone is usually a way out of geothermal fluid to the surface or as a recharge media to catch water from the soil. Fault zone usually consists of 2 parts of the fault core and damage zone (Caine et al, 1996). In the active fault zone (usually frequent earthquakes at that location), the hydraulic conductivity of the fault core usually increases with the increase of the earthquake magnitude (Gudmundsson, 2000). When the fault is inactive, the fault cores are very narrow, but still sufficient to pass the fluid (Gudmundsson, 2000) Damage zone on the fault lies on both sides of the fault core Damage Zone consists of many fractures of varying sizes and usually also the same direction as the main fault.

The geothermal field usually associated with the volcanic landscape, one of the areas that usually has a constituent rock in the form of igneous rock and has a complex geological structure. In relation to geological structures related to geothermal, important geological structures to be considered are fracture structures, especially faults and minor faults (fracture). In the reservoir, the fluid flow in the fracture zone or the minor faults is usually larger and may be almost all in this zone. Fracture is related to the permeability of the reservoir. The magma interactions in igneous rocks usually have very little permeability. Fracture structure is very important because the structure is closely related to the escape of hydrothermal fluid and hydrological cycle. Fracture will make igneous rocks that have this small primary permeability to have a large secondary permeability. So the influence of fracture will cause the total permeability becomes bigger.

Fracture structures are essential for the hydrothermal migration process because they play very important role in the escape of hydrothermal fluid. In the process of passing fluid to the surface, it requires a high permeability.

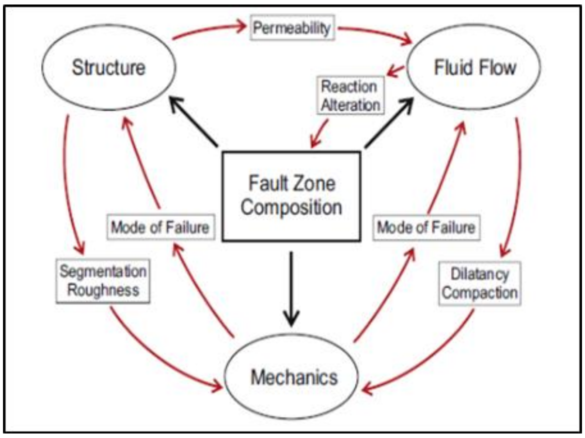

Figure 2 : Flow diagram showing interactions of main topics of structures, mechanics, and fluid flow. Mode of failure refers to whether or not seismic slip occurs (Faulkner, 2010).

The potential for geothermal heat can be identified by the presence of surface geothermal manifestations. One of the controllers on the emergence of such manifestations is the presence of the exit medium or the permeable zone (Hochstein and Browne, 2000). The geological structure of a fracture or fracture zone is one of the permeable zone indications which is an important aspect of geothermal exploration. Its existence is the path to the process of migrating the geothermal fluid (Soengkono, 1999).

Manifestations of surface geothermal occur because of fractures that allow hot fluids to the surface. Fractures can be formed due to the geological structure of the Lasolo fault found in the Baruata Region. Lasolo fault is estimated to be active until now which is marked by the availability of hot springs in Barasanga area (Rusmana, et al., 1993). Structural and stratigraphic combination analysis involves collectively the two elements forming a localized permeable zone such as a combination of fractures with rock contacts or joints with rock contacts or with dissonance. Rocks contact sometimes act as a means of forming a normal fault structure (gravity fault).

Figure 3 : Seepage of hot springs Barasanga.

Refering to the geothermal system that is the availability of heat source, reservoir, Caprock, and water source that is heated the ground water (ground water). This study focuses on the presence of hot water in rock layers in order to obtain geophysical models of subsurface rock layers suspected as layers of hot-water rocks. The first layer at the sounding points G1 and G2 based on field geological conditions and petrographic analysis and guided by the classification table by (Telford, 1990 and Loke, 2004), is an emerging area of hot springs. Presumably in this layer is a limestone (travertine) which has a layer thickness of 1.4 meters and a depth of 1.4 meters with resistivity 266 Ω.m. At the sounding point G1 to the point of sounding G2 with a depth of 2.52 meters and a layer thickness of 1.13 meters is a manifestation formed due to the dissolution process of limestone around due to the hot chemistry of hot springs. Travertine is manifold incoherent travertine is travertine where the material of the preparation is not mutually binding strongly. This layer is medium or hot spring and has a distribution from the West-Northwest until the East to Organize at the point of sounding G1 continuously to the sounding point G2. The presence of a layer of hot-water rocks is thought to be a sandstone with a resistivity value between 20-95m because sandstones have good porosity and permeability so that the ability to absorb and pass water is very good. This layer is a container or place of heating of water sources.

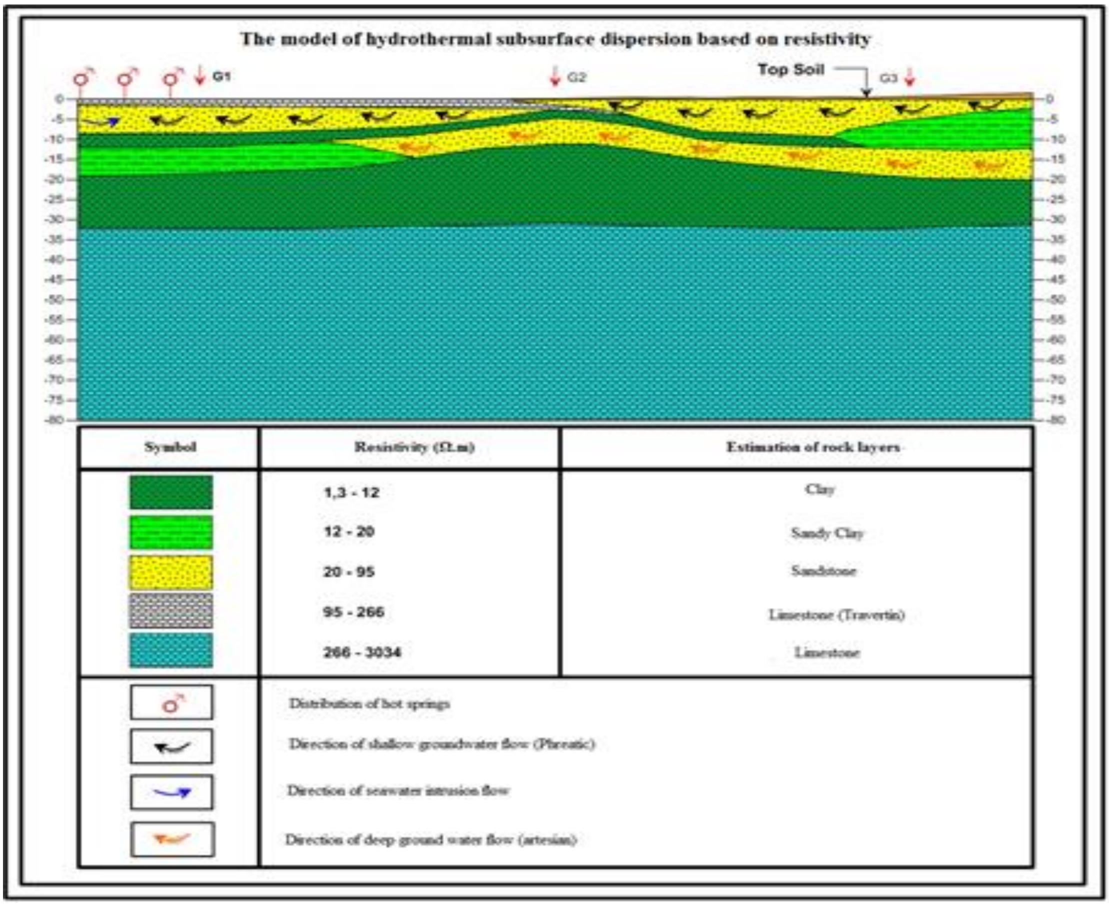

Figure 4 : Model of surface rock distribution of hydrothermal based on resistivity.

Groundwater flowing into the structural zone will be heated and pass through rock zones. The source of heat comes from the activity of geologic structure which is estimated to be active in the form of Lasolo shear fault. The ground water will continue to accumulate and heated, resulting in increased water temperature, increased volume, and increased pressure. Due to the constant pressure, temperature and volume of groundwater from below the Earth's surface due to geological structure activity, the hot fluid suppresses the rocks above it and seeks a breakthrough path to release the pressure. The hot fluid then breaks through the weak zones of the rocks above, resulting in a geothermal heat manifestation in the North-Northeast region.

The existence of manifestations in the Barasanga region in accordance with the results of the analysis of the manifestation of geochemical analysis of the six samples of hot springs that show the type of hot water chloride (chloride). Contains a higher chloride (Cl) element than other elements. And based on the result of physical analysis of hot springs with a surface temperature below 1000^{o}C that is with average about 480^{o}C and manifestation of geothermal in the form of travertine sedimentation is characteristic of the heat source of the non-volcanic area caused by the activity of geological structure in the form of Lasolo shear fault.

CONCLUSIONS

- Manifestations of surface geothermal, estimated to occur due to heat propagation from below the surface or due to fractures that allow the geothermal fluid to flow to the surface.

- Distribution surface rock layers are suspected as sandstone with resistivity values between 20-95 Ω.m from the southwest direction to the north-east of the Sea, with geothermal sources derived from geologic structural activity such as the Lasolo shear fault leading from the East to Northwest.

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