Geothermal manifestations linkage with the Siulak Fault segment in Kerinci

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Abstract

Geothermal manifestation on the Sungai Medang and Semurup, Kerinci Regency appear along the Sumatran Fault System. Geological setting as well as this are interesting things to understand from the linkage between of them. To know this process, it is necessary to understand the fault structure mechanism and the presence geothermal features manifestations. The aim of this research in addition to understanding the linkage between of them, which comprehend the fault mechanism of the fault structure, so as to know the role of the fault structure in the appearance of geothermal features manifestation. Geothermal manifestation in Sungai Medang has geothermal features manifestation surface including hot spring, hot pool, geyser dome, hydrothermal alteration rock, sinter silica, and carbonate sinter. The fault structure measured and analysis on the eastern part of Siulak Fault segment of the Sungai Medang was found to be a normal right slip fault, but western part of Siulak Fault segment on the Semurup which strike-slip fault and normal right slip fault. The existence of geothermal features manifestation surface in fault zone of Siulak Fault segment is evidence that, the role of faults is as a controlled by apeear geothermal manifestation. The fault structure mechanism is the result of dextral movement of Siulak Fault which forms a pull-apart basin. This basin is single fault-bend basin as one master fault of active segment. The fault regime stress analysis obtained direction compressional force is trending north-northwestern and south-southeastern. This regime stress is locally stress on Sungai Penuh Basin.

Keywords: *Geothermal manifestation, Semurup, Sungai Medang, Siulak fault*

I. INTRODUCTION

The Sumatran Fault is an active fault structure from the Middle Miocene to the present which is associated with geothermal manifestations along Barisan Range [1]. There is consequence by the spreading of the Andaman Sea which responds to the touch collision of the Australian plate towards the eastern part of the Sundaland [2-4]. These have numerous implications for the existence of energy resource potential in Sumatra, particularly geothermal energy potential surface manifestation [1-2]. Sumatran Fault and Barisan Range are a geological formation with dynamic geology interchanging, that have occurred since the Early Miocene to the present [5-6]. The fault system is a fault segmentation that forms a pull-apart basin, which is overstep fault-bend basin and single fault-bend basin [7-9]. There is including Siulak Fault segment which forms a Sungai Penuh Basin in the Kerinci, Jambi Province.

The fault structure formation of pull-apart basin in Kerinci "Sungai Penuh Basin" by Siulak fault segment the linkage to geothermal features surface manifestation, such as geothermal manifestation in the Sungai Medang and Semurup. The presence of geothermal features manifestation on the surface at these two locations is the key that there is a geothermal system in the area, and it is believed to hava a close linkage with the fault system of Siulak Fault segment. Therefore, it is necessary to understand the characteristics of the geothermal fluids and also the fault mechanism formed.

Geothermal manifestation on Sungai Medang and Semurup, into Kerinci Regency are in the Barisan Range with Quaternary volcanic complexes (Figure 1). Inverstigation on digital elevation model and integrated to surface geothermal surface in there area, it is indicated that the linkage geothermal manifestation to Siulak Fault. The understanding about

geothermal manifestation required geological investigation and analyzed of structural geology mechanism [8-10]. One of the steps in the geothermal exploration of determination permeable zone on geothermal resource is understanding fault structure mechanism by considering geothermal feature

Metamorphic (Ja), Siguntur Limestone (Js), Peneta Metasediment (KJp), Siulak Limestone (Ksl), Siulak Sedimentary and Volcanic Rocks (Ks), Bandan Volcanic (Tb), Hulusimpang Volcanic (Tomh), Kumun Tuffaceous Sedimentary (Tmk), Granitoid Miocene (Tgr), Sheared basalt (Tpb), Sungaipenuh Granitoid (Tpgds), Rhyo-Andesite Volcanic (QTv), manifestation characterized.

The research area is composed by stratigraphy formation which consisting of old to younger sequence formation that is Granitoid Jurassic (Jgr), Asai

Pengasih Tuffaceous Sedimentary (QTp), Patahsambilan Volcanic (Qvp), Malintang Volcanic (Qvm), Old Kerinci-Tujuh Volcanic (Qokt), Tujuh Volcanic (Qvt), Kunyit-Raya Volcanic (Qvkr), Kerinci Volcanic (Qvk), Debris Avalanche Volcanic (Qvtd), and Alluvium (Qv) (Figure 1).

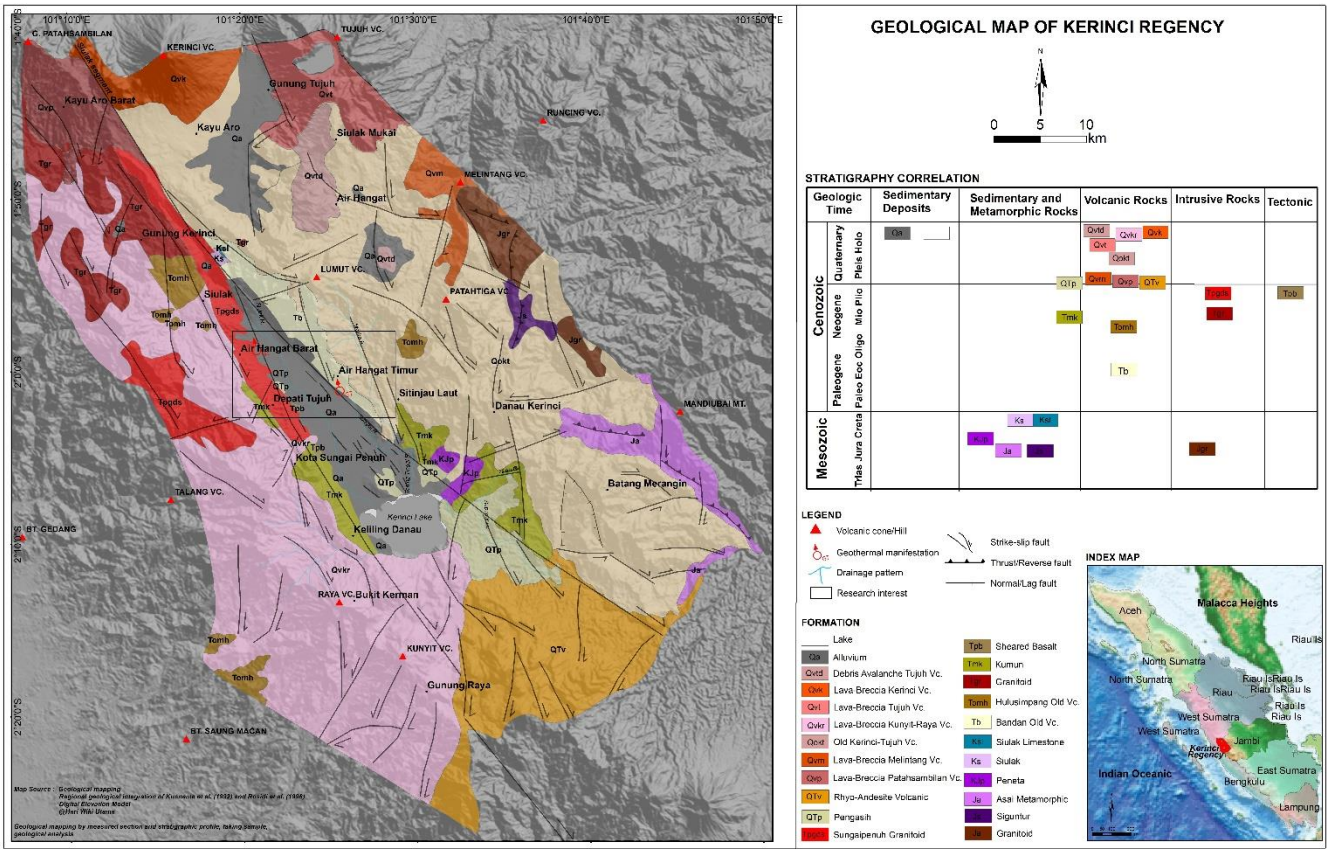

Figure 1. Geological map in the research area which area of interest (black rectangle). The area is associated with geothermal surface feature manifestations and Sumatran Fault of Siulak segment which is surrounded by Quaternary volcanic complex of Barisan Range [8-12]

The evidence geological setting on the geothermal manifestation area to make it important to fault structure measured which descriptive, kinematics, and dynamic. Structural geology analyzed and geological interpretation will help geological model of the geothermal system. One of the geological methods that can be used determine of surface geological setting and vertical structure geology interpretation.

Therefore, the aim of this research is comprehend the relationship geothermal features surface manifestation to fault structure mechanism. So that, can be estimate the permeable zone of geothermal system in an area. The most important point is the information and database from this research can be used as guidance for geothermal exploration further.

II. MATERIALS AND METHODS

This research begin with interpretation and analysis of detailed surface expression of Digital Elevation Model imagery. The used to show that research area have structural lineament on Sungai Penuh Basin.

Volcanic complex morphology was clearly observed which have relatively radial sentripetal and sentrifugal drainage pattern the associated with fault system, whereas morphology surrounding as consequence of tectonics orogenesis Barisan Range the continued of strike-slip movement formed of pull-apart basin.

Rock outcrops form the basis research comprises alternating to deformation outcrop datas along Siulak Fault segment on the Sungai Penuh Basin. The field datas were measured fault structure directly on the eastern segment and western segment of the basin. Then field analysis the tentative result analyzed. The data retrieval about two (2) segment fault datas structures, which were fault plane and striation on slip plane. The two segments on the geothermal manifestations covering the Sungai Medang (eastern segment) dan Semurup (western segment). It is the equipped lithology datas the related to stratigraphy composed.

This paper is separately stages into field observation of measured fault displacement and the studio work. The field observation including structural datas collection, such as fault plane and striation; rake and trend of fault line on slip plane of the Sungai Medang and Semurup geothermal manifestations (Figure 2). Studio work including structural analysis, stereographic model, and correlation to field datas and integration tectonics setting [13-16].

In the field, structural data collection was directed towards acquiring data concerning the orientation of planes and structural features. Measurement of plane orientation was critical point since the outcrop displayed opposite dip direction. Measurement of structural features in the research including of fault plane and striation properties. Every measured datas must recheck and crosscheck toward other structural datas. In the studio, structural analysis is employed to know direction of stress of the research area. It should further our understanding in constructing and comprehend the structural models [16].

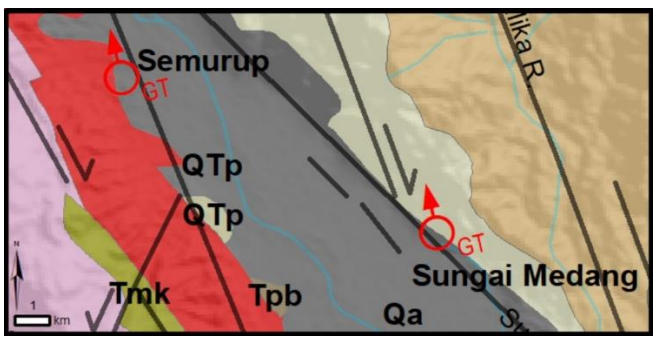

Figure 2. The detailed surface geothermal manifestation on the Sungai Medang and Semurup. This location is a place for measuring fault structures in geothermal area. The regional area see Figure 1

Regime stress analysis would be interpreted to comprehend the probability of geological phenomenon that show in the outcrop. Structural analysis using stereographic models for simplify the fault characterized. Integration result structural analysis to geologic regional setting the related event tectonic, that obtain result structural analysis to close or almost the similarly toward displacement zone. It is for understanding structural mechanism the related geological phenomenom.

III. RESULTS AND DISCUSSIONS

The stratigraphy on the Sungai Medang geothermal manifestation consist of andesitic lava of volcanic product of Bandan Formation. Some of andesitic lava has been altered to form geothermal or hydrothermal alteration to form of argillic type (montmorillonite, kaolinite, smectite, illite) and little bit of propylitic type (chlorite, calcite), and silica sinter. The Semurup geothermal manifestation has stratigraphy composed by Pengasih Formation are bounded by Sungai Penuh Granitoid. More than half of them have altered of hydrothermal alteration to form argillic type (kaolinite, montmorillonite, and smectite), travertine of carbonate sinter, and also silica sinter.

In this research the structural data measured on Siulak Fault segment of twenty (20) datas collections data divided into ten (10) datas on the eastern segment of Sungai Medang geothermal manifestation and ten (10) datas on the western segment of Semurup geothermal features manifestation. The data data collection includes of fault plane, striation, and equipped with fault properties (Table 1).

The features of the fault structure on the surface associated with geothermal manifestations are based on the fault plane and fault line structures, that have been measured at both locations of geothermal manifesattions (Table 1). The existence of damage fault zones, such as mylonite, gouge fault, which are evidence of the existence of geological structure.

Table 1. Fault structure data collecting on the Sungai Medang geothermal manifestation and Semurup geothermal features

No	Fault Plane	Fault Line	Fault Classified
1	N138°E/65°	30° WNW	Normal right slip fault
2	N130°E/70°	15° WNW	Normal right slip fault
3	N135°E/64°	20° WNW	Normal right slip fault
4	N130°E/68°	25° WNW	Normal right slip fault
5	N133°E/65°	28° WNW	Normal right slip fault
6	N133°E/65°	27° WNW	Normal right slip fault
7	N132°E/65°	30° WNW	Normal right slip fault
8	N131°E/70°	17° WNW	Normal right slip fault

9	N134°E/65°	18° WNW	Normal right slip fault
10	N138°E/65°	25° WNW	Normal right slip fault
11	N338°E/65°	08° ESE	Strike-slip fault
12	N330°E/70°	19° ESE	Normal right slip fault
13	N335°E/70°	10° ESE	Strike-slip fault
14	N332°E/70°	15° ESE	Normal right slip fault
15	N336°E/70°	09° ESE	Strike-slip fault
16	N338°E/70°	08° ESE	Strike-slip fault
17	N337°E/70°	10° ESE	Strike-slip fault
18	N335°E/70°	18° ESE	Normal right slip fault
19	N336°E/70°	22° ESE	Normal right slip fault
20	N338°E/70°	20° ESE	Normal right slip fault

Note: No. 1-10 (Sungai Medang), 11-20 (Semurup), WNW (West Northwestern), ESE (East Southeastern)

Geothermal manifestation on the Sungai Medang near geothermal on Sungai Tutung and Semurup have characteristic of surface manifestations (Table 2). The data is only measured and tested for the direct physical properties of geothermal manifestation at the locations. The measurement made include water temperature, air temperature, pH, type of geothermal manifestation. All measureements were repeated three times to determine the trend of the physical characteristics of the geothermal manifestations.

Table 2. The measurement results of geothermal features on the Sungai Medang and Semurup, Kerinci

No.	Sample Location	Water T (°C)	Air T (°C)	pH	Manifestation Features
1	Sungai Medang-1	50.2°C 49.4°C 52.5°C	26.4°C 25.7°C 26.4°C	7.8 7.9 8.0	Hot spring manifestation and hot pool, clarity water, little bit of silica sinter around the spring, several spots area were identified oxidation, little bit sulphur
2	Sungai Medang-2	80.4°C 81.6°C 82.5°C	30.2°C 29.5°C 29.4°C	7.7 8.1 8.3	Hot spring manifestation, clarity water, residual silica/silica sinter around the spring, several spots area were identified oxidation, little bit sulphur, sulphur smells, associated with hydrothermal alteration rock
3	Sungai Medang-1	47.4°C 50.5°C 47.5°C	27.3°C 25.4°C 26.1°C	7.7 7.8 7.7	Hot spring manifestation, clarity water, little bit of silica sinter around the spring, several spots area were identified oxidation, little bit sulphur,
4	Semurup-1	82.5°C 87.7°C 92.8°C	30.5°C 30.7°C 30.4°C	7.2 7.2 7.3	Hot pool and hot spring manifestation, clarity water, deposit of silica sinter on pool surrounding, little oxide, sulphur smells and the associated with hydrothermal alteration rock
5	Semurup-2	82.5°C 80.4°C 82.8°C	30.5°C 30.7°C 30.4°C	7.2 7.2 7.3	Hot pool and hot spring manifestation, clarity water, deposit of silica sinter and carbonate sinter on pool surrounding, little oxide, sulphur smells and the associated with hydrothermal alteration rock
6	Semurup-3	-	-	-	Geyser dome has residual silica the altered of tuffaceous sedimentary and lava altered, it has experience geothermal fluids shrinkage

Note: The detailed location see Figur 1 and Figure 2

The integration of fault structure data analysis and geothermal features manifestation characteristic of the Sungai Medang, then a stereographic diagram can be made to analyzed of the fault mechanism (Figure 3)

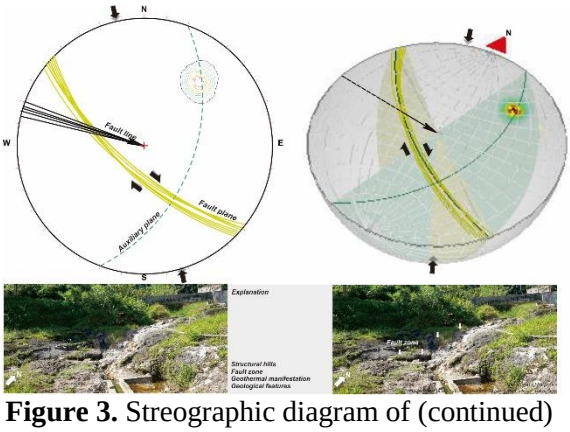

Figure 3. Streographic diagram of (continued)

(Continued text previous) Sungai Medang to understand fault mechanism. Modeling using Dips 7.0 application

The analysis of fault structure data on the Semurup geothermal manifestation, so that a fault structure diagram can be made using modeling in Dips 7.0 software application (Figure 4).

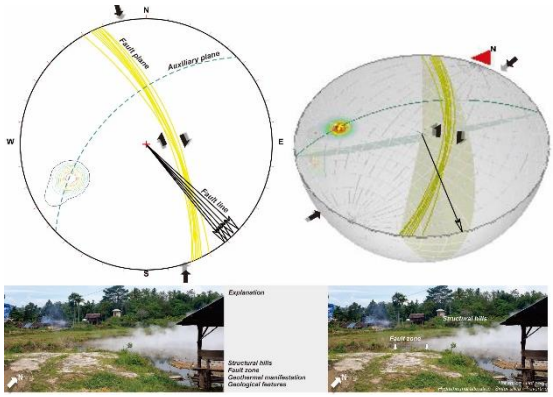

Figure 4. Semurup fault structure of streographic diagram for understanding fault mechanism

Fault structure analysis on the Sungai Medang obtained the regime stress of compressional structural regime is north-northwestern and south-southwestern (N345°E and N165°E) with fault plane range of N130°E/70° - N138°E/65° (see Figure 3 and Table 1). This location is dominated by rormal right slip fault.

On the Semurup has data analysis obtained regime stress of compressional force is south-southeastern and north-northwestern (N 165°E and N 345°E) with fault plane range of N332°E/70° - N338°E/70° (see Figure 4 and Table 1). At this location there are strike-slip fault and normal right slip fault. The fault regime stress analysis obtained direction compressional force research area is trending north-northwestern and south-southeastern. This fault mechanism is influenced by the movement of the Siulak Fault segment. This regime stress is locally stress on Sungai Penuh Basin.

The presence of fault structure from the Siulak Fault segment plays an important role in the appear of geothermal features surfacemanifestation on the Sungai Medang and Semurup. The role can be seen from the emergence of geothermal manifestation, such as hot spring, hot pool, geyser dome, and hydrothermal alteration rock along the fault zone. If attention to the fault movement (see Figure 3 and Figure 4) which is a normal right slip fault eastern part of the Siulak Fault (Sungai Medang), meanwhile the strike-slip fault and normal right slip fault on the western part of the SIulak Fault (Semurup). The meaning in both fault segments of this fault structure have the similarly fault characteristics, but only distinguished by the direction of the fault plane (see Table 1). The regime stress is from north-northwestern and south-southeastern indicates that the fault formation in the two segments is really influenced by the Sumatran Fault System (SFS) from the Siulak Fault segment, which moves dextral fault which is connected with the Sungai Penuh Basin formation [8-10].

The Sumatran Fault has been active since Middle Miocene until now as a consequence of the rifting Andaman Sea in the northern part of Sumatra Island [14-15]. The rifting is influenced by touch collision of Australian plate to eastern margin of Sundaland Oligo-Miocene [14-15]. Previous research it was faound that the movement of the Sumatran Fault System, where the western segment moves in a north-nrothwestern direction, while the eastern segment is relatively passive [15]. This explanation must be take into account the different active faults in each segment of the Sumatran Fault, for example Sungai Penuh Basin has one master fault of the Siulak Fault the forming of single fault-bend, while on the Singkarak Basin controlled by more than one master fault, which Sianok Fault, Sumani Fault, and minor segment of Singkarak Fault the forming a overstep basin [8,15-16]. Both of basin type are pull-apart basin, but only distinguished by the master fault. The segmentation of the Sumatran Fault is believed to be the influence of the basement configuration and rock resistance characteristic. Especially in this Siulak Fault segment besides the appear of geothermal features manifestations, there is also a basin of Sungai Penuh basin the associated with volcanic cone, such as Kerinci Volcanic, Tujuh Volcanic, Raya Volcanic, Kunyit Volcanic, and Patahsambilan Volcanic.

IV. CONCLUSIONS

Geothermal manifestation in Kerinci "Sungai Penuh Basin" appear on the Sungai Medang which is part of the eastern segment the Siulak Fault, meanwhile geothermal manifestation on the Semurup on the western part of the Siulak Fault segment.

The emergences of geothermal manifestations in these two locations in the the Siulak Fault segment. The geothermal manifestation is hot spring, hot pool, hydrothermal alteration rocks, geyser dome, deposit of sinter silica and carbonate sinter.

The fault regime stress analysis obtained direction compressional force is trending north-northwestern and south-southeastern. This fault mechanism is influenced by the movement of the Siulak Fault segment. This regime stress is locally stress on Sungai Penuh Basin.

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