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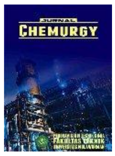

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KARAKTERISTIK GEOKIMIA PADA MATA AIR PANAS DI DESA BATU LEPOQ DAN PANGADAN, KECAMATAN KARANGAN, KABUPATEN KUTAI TIMUR, PROVINSI KALIMANTAN TIMUR

GEOCHEMICAL CHARACTERISTICS OF HOT SPRINGS IN BATU LEPOQ AND PANGADAN VILLAGES, KARANGAN DISTRICT, EAST KUTAI REGENCY, EAST KALIMANTAN PROVINCE

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Abstrak

Kecamatan Karangan di Kabupaten Kutai Timur, Provinsi Kalimantan Timur, merupakan lokasi titik potensi panas bumi di Desa Batu Lepoq dan Pangadan. Sumber air panas ini merupakan bukti kekayaan geologi daerah tersebut, karena tidak ada gunung berapi aktif di pulau tersebut. Penelitian ini bertujuan untuk menganalisis kondisi karakteristik fisik dan geokimia air panas. Model konseptual sistem panas bumi dikembangkan untuk mengetahui potensi panas bumi suatu daerah. Data geokimia fluida dari sampel lapangan diolah menggunakan metode geokimia. Hasil penelitian menunjukkan bahwa kesetimbangan berada pada zona air belum matang, dengan sumber utama fluida panas berasal dari air meteorik yang dipanaskan oleh geopressure. Suhu reservoir satu-satunya pada sistem panas bumi Desa Pangadan diperkirakan 193o±10°C, yang diperoleh dengan menggunakan geothermometer Gigginbach 1988.

Kata Kunci: Batu Lepoq, Geokimia, Geotermometer, Air Panas, Pangadan, Sistem Geotermal

Abstract

The Karangan District in East Kutai Regency, East Kalimantan Province, is identified as having geothermal potential in the villages of Batu Lepoq and Pangadan. The presence of hot springs in these locations underscores the area's rich geological features, despite the absence of active volcanoes on the island. This study aims to analyze the physical and geochemical characteristics of the hot springs. A conceptual model of the geothermal system was developed to evaluate the geothermal potential of the area. Geochemical data from field samples were analyzed using geochemical methods. The findings indicate that the equilibrium lies in the immature water zone, with the primary source of the hot fluid being meteoric water heated by *geopressure. The temperature of the sole reservoir in the Pangadan Village geothermal system is estimated to be 193^0±10°C, as determined by the 1988 Giggenbach geothermometer.*

***Keywords**: Batu Lepoq, Geochemistry, Geothermometer, Hot Springs, Pangadan, Geothermal Systems.*

1. INTRODUCTION

East Kutai is one of the districts in East Kalimantan Province which has a lot of unique and rich geology, especially its natural resources. This district has almost all of its territory explored as a mining area. One of the unique things about this district, which directly borders Kutai Kartanegara Regency, is that it has several geothermal potential points (Geothermal) like hot springs which can still be studied in more depth. From existing studies and evidence of its manifestation, Kalimantan Island shows that geothermal heat can be present even in areas that do not have active volcanic phenomena (Meilani, 2019).

Based on the results of several previous studies regarding the geothermal energy of Kalimantan Island, which is generally dominated by hot water of the Bicarbonate and sulfate type with medium temperature, it is located in the zoneimmature water (Meilani, 2019). Batu Lepoq Village and Pangandan Village are the locations where hot springs are found (hot spring) that appear on the surface originating from a geothermal source.

The geochemical characteristics of geothermal fluids can be used to initially estimate the geothermal system in the research area. Using Ci-SO ternary classification4- HCO3in determining the type of hot water (Nicholson, 1993). Then classify based on the Na-K-Mg ternary diagram for the equilibrium process that occurs when the water below the surface experiences heating and dissolution of compounds in the rocks below the surface (Giggenbach, 1998) and the origin of the fluid using the Ci-Li-B diagram (Giggenbach, 1998). Apart from using three ternary diagrams, you can use isotope analysis to determine the characteristics of subsurface hot water. The geochemical components used are the natural isotopes 18O and 2H from water molecules. Geothermometers are also used to obtain temperature estimates in subsurface reservoirs.

2. REGIONAL GEOLOGY

The research area, specifically the Karangan District, including Batu Lepoq Village and Pangadan Village, lies within the tectonic framework of the island of Kalimantan. This region is bordered by the South China Sea and Sulu Sea to the northwest and north, and by the Java Sea and the Makassar Strait to the south and southeast. According to references on the tectonic framework of eastern Kalimantan, the area comprises sedimentary basins, including the Kutai Basin and Tarakan Basin, and the Mangkabayar Ridge on the easternmost part, which is bordered by the Makassar Strait. Batu Lepoq Village and Pangadan Village are generally part of the Mangkabayar Ridge tectonic section, located to the east and directly adjacent to the Tarakan Basin to the north and the Basin (Biantoro, 1992).

The research site is included in the Mauaralasan Sheet Regional Geological Map (Sukardi, 1995). According to this map, the research area is situated in the Maluwi Formation. The coordinates for the first observation location, the hot springs in Batu Lepoq Village, are 582950 E, 149172 N, and for the second location, the Ampanas hot springs in Pangadan Village, are 582065 E, 133126 N, based on the UTM time division (Figure 2).

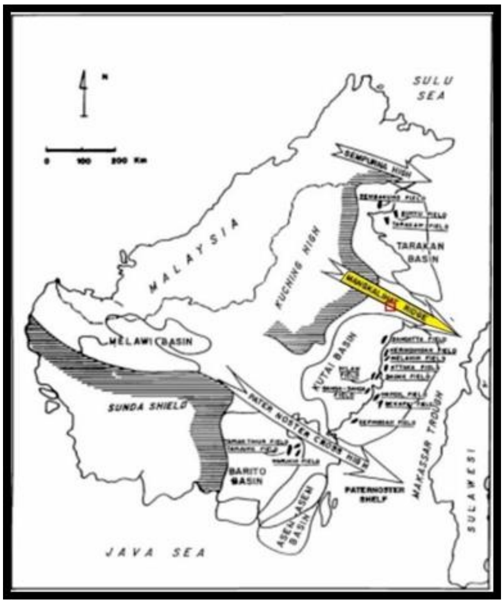

Figure 1. Tectonic system of the research area

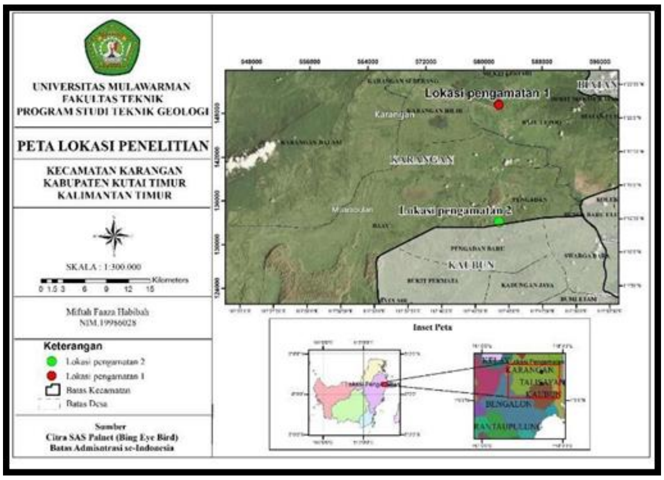

Figure 2. Research Location Map

3. RESEARCH METHODOLOGY

3.1 Collecting Data Method

The data collection method was carried out by taking primary data in the form of hot water samples at two points, namely at the first observation location in Batu Lepoq Village and for the second location in Pangadan Village which is located in Karangan District, East Kutai Regency, East Kalimantan Province. Geochemical samples of manifestation fluids in the Geothermal Fields in Batu Lepoq Village and Pangadan Village which include the results of measurements of temperature, pH, color, odor, Total Dissolved Solid (TDS), cation and anion content, and stable isotopes using this sampling technique are Rubber Seal (unfiltered)After that, it is taken into a bottle and filtered Filtered (filtered). Then samples of rocks around the observation location were taken to carry out geological identification or description.

3.2 Data analysis method

The analytical methods employed in this study include geochemical analysis, geothermometer analysis, and petrographic analysis. Geochemical and geothermometer analyses were conducted through laboratory tests, including IC, ICP-MS, Isotope, and ICP-OES tests. Petrographic analysis was performed on thinly sliced rock samples observed under a polarizing microscope at 4X and 10X magnifications.

4. RESULT AND DISCUSSION

The lithological conditions in the research area in Batu Lepoq Village consist of limestone, specifically identified as Framestone based on the classification by Embry and Klovan (1991). In Pangadan Village, the lithology is classified as Lepidocyclina Packstone, according to Embry and Klovan's (1991) classification. Limestone is the predominant lithology at both research locations.

The physical characteristics of the hot water in the research area vary between the sampling points. The sample from the first location in Batu Lepoq Village was not taken directly from the hot spring, resulting in a temperature of 48 °C. In contrast, the sample from the second location in Pangadan Village, taken directly from the hot spring, had a higher temperature of 51 °C. The water at the first location is clear, whereas at the second location, it is clear but slightly cloudy. The odor also differs between the locations: the first location has no distinctive smell, while the second location has a strong sulfur odor. The pH value of the water at the first location is slightly acidic at 6.9, compared to 8.3 at the second location. The total dissolved solids (TDS) in both locations are less than 1000 ppm, with the first location having a TDS of 466 ppm and the second location 769 ppm. Additionally, the physical characteristics of the hot water at both locations were observed. The following table summarizes the characteristics of the hot water at the two locations **(Table 1)**.

Table 1. Characteristics or Physical Properties of Hot Water at Both Observation Locations

Description	**Description**	**Description**
Batu Lepoq Village	**Batu Lepoq Village**	**Batu Lepoq Village**
Pangadan Village	**Pangadan Village**	**Pangadan Village**
Coordinates: X=582950, Y=149172	Coordinates: X=582950, Y=149172	Coordinates: X=582950, Y=149172
Coordinates: X=582065, Y=133126	Coordinates: X=582065, Y=133126	Coordinates: X=582065, Y=133126
Type of Manifestation: Hot water	Type of Manifestation: Hot water	Type of Manifestation: Hot water
Type of Manifestation: Hot water	Type of Manifestation: Hot water	Type of Manifestation: Hot water
Sample Type: Water	Sample Type: Water	Sample Type: Water
Sample Type: Water	Sample Type: Water	Sample Type: Water
Elevation: 26.10 m		
Elevation: 40 m	Elevation: 40 m	Elevation: 40 m
Sample Collection Time: 11:40 WITA	Sample Collection Time: 11:40 WITA	Sample Collection Time: 11:40 WITA
Sample Collection Time: 17:46 WITA	Sample Collection Time: 17:46 WITA	Sample Collection Time: 17:46 WITA
Date: March 8, 2023	Date: March 8, 2023	Date: March 8, 2023
Date: March 8, 2023	Date: March 8, 2023	Date: March 8, 2023

Then, after knowing the elements of anions, cations and isotopes, calculations are carried out balance. If the results balance below 5% of the water sample can be investigated further according to Iswahyudi (2017). Geochemical analysis uses water samples taken from the research location, namely Batu Lepoq Village with code (APDBL) and Pangadan Village with code (APDPANG) **Table 2.**

Table 2. Anion and cation analysis table at the research location.

Anions and Cations		
Element	**Mg/L or ppm**	
	APDBL	**APDPANG**
δ18O	- 7.38	- 7.31
δ2H	- 41	- 45.57
Na	30.38	43.88
K	4.82	2.64
Ca	27.28	32.79
Mg	18.99	17.6
Cl	11.56	28.08
SO4	20.25	5.56
F	0.22	0.2
HCO3	224.87	234.75
NO3	2.87	0.96
Li	Not detected	Not detected
B	Not detected	Not detected
Charge Balance	- 1.29	2.93

The type of hot water at the research location is included in the bicarbonate hot water type with a value of 224.87 ppm at the Batu Lepoq Village and Pangandan Village locations at 234.75 ppm. which indicates that this water has been transported and associated with the side support (Nicholson, 1993). Both hot spring locations are located in the peripheral water or water dominated zone. The hot spring fluid in the peripheral water zone experiences a lot of mixing with meteoric water and CO2from geothermal sources (Mnjokava, 2007). This is supported by field data. A neutral to slightly alkaline pH of around 6.9 to 8.3. Apart from pH, the temperature at both locations has a water temperature that is not too hot. The diagram used uses the Cl-SO4-HCO3 ternary diagram (Giggenbach, 1988) **(Figure 3).**

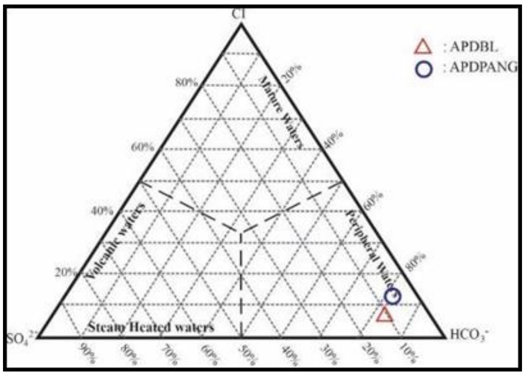

Figure 3. Hot Water Type Plot Results for Both Observation Location

Then the calculations carried out are to calculate the fluid balance of the two water samples in immature waters. Immature water is a zone where it is indicated that the reservoir rock is located at high pressure and temperature. Then, before it rises to the surface, it is diluted by mechanical water so that it is rich in Mg or dominant Mg. The plotting results show that immature water can be seen in the diagramNa-K-Mg ternary (Giggenbach, 1988) **(Figure 4).**

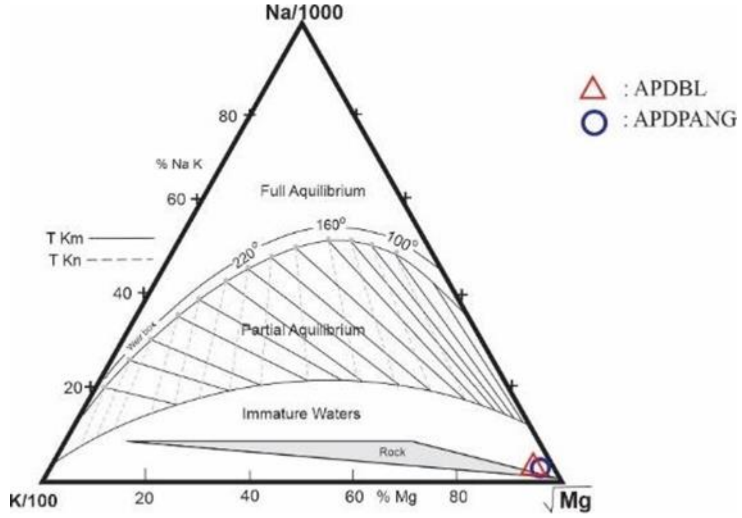

Figure 4. Hot Water Fluid Equilibrium Plot Results for Both Observation Locations

The origin of the fluid used utilizing the Cl-Li-B element can provide information regarding the origin of the fluid and the dilution of the hot spring fluid. The results of the patterning show that the dominant element is chloride (Cl) with a value of 100 percent at each location. can be seen at **(Figure 6)**. The elements Lithium (Li) and Boron (B) were not detected due to the suspicion that there was a lot of mixing (mixing) that occurs between hot fluids and meteoric water and the distance the fluid migrates to the location of the manifestation where samples are taken for investigation. So the concentration or presence of the elements Lithium (Li) and Boron (B) is very small or cannot be read according to Giggenbach, 1991 in Ariwibowo. Then go into "absorption of low B/Cl steam". This shows that the two hot waters are very little influenced by volcanic activity (far from the heat source of a geothermal system at depth), this can be interpreted that the hot water comes from shallow surface water which has been mixed a lot (Tala, 2020) **(Figure 5).**

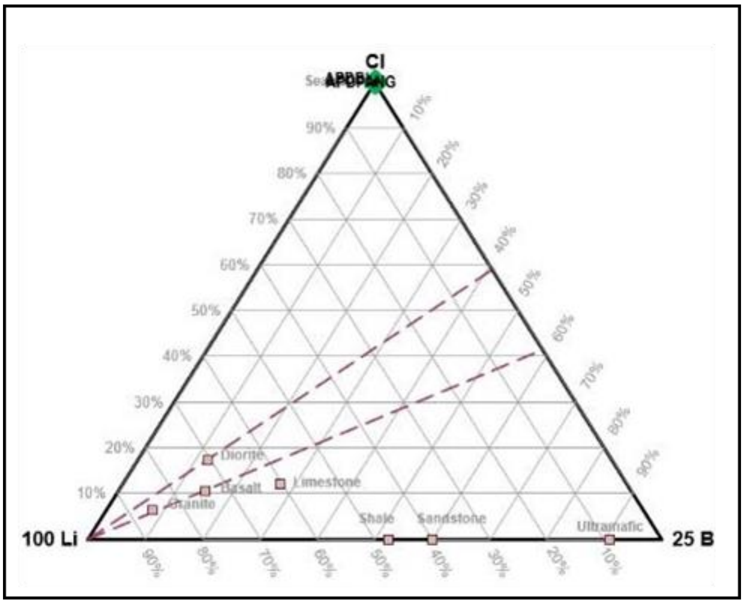

Figure 5. Plot Results on Ternery Diagrams to Determine Fluid Origin

Based on the B/Cl ratio of hot water samples found in Batu Lepoq Village and Pangandan Village, with low values, this ratio is close to the line on the B/Cl ratio graph, indicating that the origin of the fluid comes from the same reservoir (Nicholson, 1993) **Figure 6**.

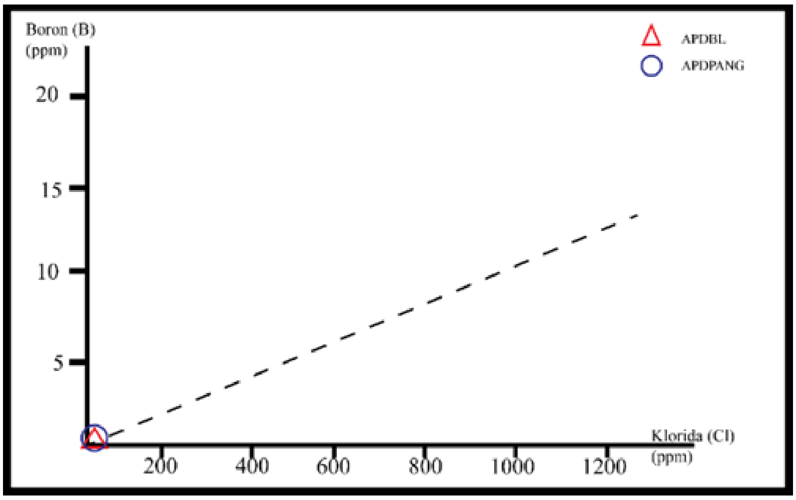

Figure 6. B/Cl diagram

The hot water in the research area of Batu Lepoq Village indicates that the hot water comes from surface water which is influenced by meteoric water which is dominantly mixed into the hot water at the research location **Figure 7.**

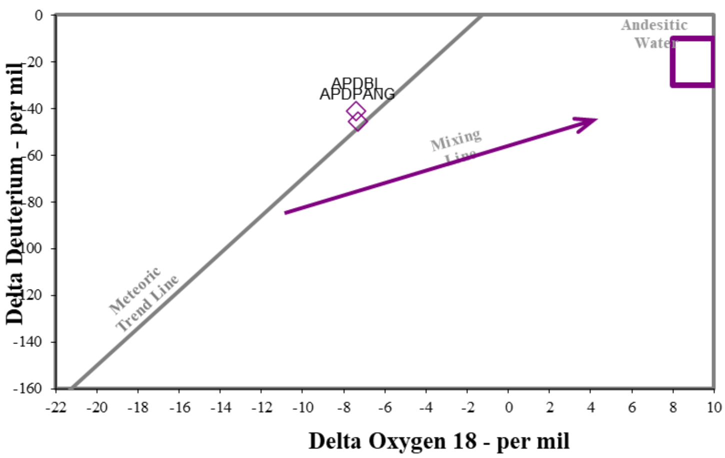

Figure 7. Graph of stable isotope values of deuterium and Oxygen 18

Geothermometer analysis utilizes the elements Na, K, Ca and Mg which are then entered into equations in **Table 3**

Table 3. Geothermometer

Na-K-Ca	**Na/K Fournier 1979**	**Na/K Truesdell 1976**	**Na/K Giggenbach 1988**	**Na/K Tonani 1980**	**Na/K Nieva & Nieva 1987**	**Na/K Arnorsson 1983**	**K/Mg Giggenbach 1986**	**Kode**
56	260	243	272	286	246	247	45	**APDBL**
40	177	139	195	168	165	148	34	**APDPANG**

In this context, the geothermometer method is used to estimate the reservoir temperature in a geothermal system. However, in this research, there are several aspects that need further review.

One of these is the appropriate sampling at the hot spring source. Consequently, the sample taken from the first location, which is APDB in Batu Lepoq Village, cannot be used to estimate the reservoir temperature because the sample was taken from a place far from the source, thus not representing the actual reservoir temperature.

For the second location, the APDPANG sample can be calculated using several geothermometer methods, one of which is based on the ion content of Na and K. This method is used because the Na-K geothermometer is adapted for estimating reservoir temperatures in the range of 180-350°C. At the location in Pangadan Village, after analysis, the temperature was found to range from 139-195 °C. Based on Table 2, the temperature that falls within the Na-K geothermometer approach, according to the equation by Giggenbach (1988), indicates a reservoir temperature of 195 °C with ±10°C

Petrographic analysis using thin sections of the rock taken, at the first location. After laboratory observations, this BGBL sample showed that the mineral cassite dominates and there is also a preserved reef fossil body of quite large size. After carrying out microscopic observations. With the presence of micrite (6C) of 15.7% and sparite (3B) of 65.9% of the total microscopic composition in **Figure 8**, the name of this rock is Framestone based on (Embry & Klovan, 1991). At the second location, after petrographic observations, the name Lepidocyclina Packstone was obtained. Due to the presence of Foraminifera fossils in the form of Lepydocyclina sp in (1E, 5E), which dominates in this sample as 72.7% skeletal grains, then 21.2% micrite and 6.1% sparite (4D) which fill the inter-skeletal grains in this limestone. From the composition of this BGPANG sample, the name Lepidocyclina Packstone was obtained. Based on classification (Embry and Klovan. 1991). Then the mineral cassite also fills the cavities. Can be seen at **Figure 9.**

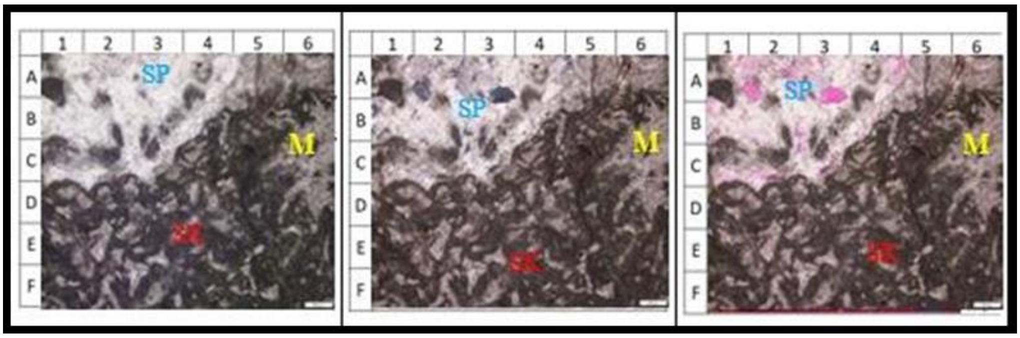

Figure 8. First Location Thin Incision

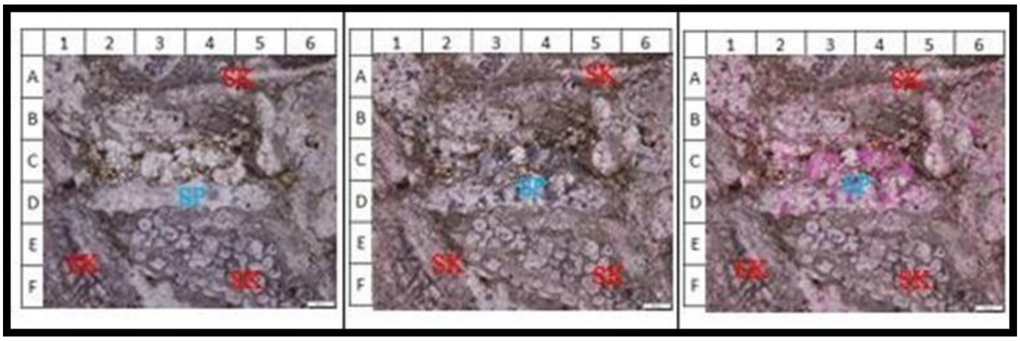

Figure 9. Second Location Thin Incision

The creation of a conceptual model of this geothermal system in this research is based on the results of analysis of geomorphology, lithology, physical characteristics of water and geochemistry of hot water. The local geological structure also plays a major role in the presence of hot water manifestations according to (Hutauruk, 2023). The hot fluid pathway at the second location in Pangadan Village is also controlled by a structure in the form of a fault as evidenced by the presence of a destruction zone (brecciation) in the direction of N176°E It is from this route that the hot fluid in the reservoir can come out to the surface and create the manifestation of hot water.

Then, the type of hot water which is bicarbonate hot water can be assumed to originate from carbonate rock reservoirs which are supported by the natural landscape around the research location, namely karst and also from regional geology which is part of the Maluwi Formation. However, geochemical analysis of hot water cannot provide detailed information regarding the condition of the reservoir below the surface (Goldscheider, 2010). This requires additional research to ensure that the reservoir originates from carbonate rocks. Making this model uses the principle that carbonate rock reservoirs and reservoirs in karst areas are usually hypogenic karst, in this case the water relies on gravitational forces and also the secondary porosity of the carbonate rock itself as a storage place for hot fluids (Goldscheider, 2010).

5. CONCLUSION

Can be concluded that:

a. The two points of this study location are mainly limestone. The Batu Lepoq Village research area is Framestone limestone. Pangadan Village's Lepidocyclina Packstone lithology.

b. Batu Lepoq's hot water was not directly in the hot spring. Therefore, its temperature was 48 °C, while Pangadan's was 51 °C since it was taken immediately at the hot spring. In Batu Lepoq the water is clear, while in Pangadan bit murky. Pangadan smells strong sulfur, although Batu Lepoq does not smell. Batu Lepoq's water pH is 6.9, slightly acidic compared to Pangadan's 8.3. Batu Lepoq has 466 ppm TDS and t has 769 ppm.

c. Water type based on analysis of Cl, SO4, and HCO3, where HCO3 dominates, shows that both places have bicarbonate hot water. Based on the chemical equilibrium of the two areas, the Mg value is high, indicating immature water that has not been heated or in touch with the source rock. According to Cl-Li-B analysis, the hot water in both research locations comes from the same reservoir and has the same B/Cl ratio. The isotope graphic shows that the water is meteoric because it is near the meteoric line. For the first location, the reservoir temperature cannot be determined because the sample was not taken directly from the hot spring source. However, for the second location in Pangadan Village, the reservoir temperature is approximately 195°C based on the equation by Giggenbach (1988).

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