

## Preliminary Review of Geothermal Fluids Characteristic At Back Arc Basin In Kampar-Kuantan Singingi, Riau Province and Tanjung Jabung Timur, Jambi Province, Indonesia

Anna Yushantarti

Center For Mineral, Coal, and Geothermal Resources, MEMR  
Jl Soekarno Hatta 444, Bandung, Indonesia  
untuk.anna@gmail.com

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### ABSTRACT

Kampar-Kuantan Singingi, Riau Province and Tanjung Jabung Timur, Jambi Province, Sumatera are ones of non volcanic geothermal areas at back arc basin, in central Sumatera basin (Riau) and South Sumatera Basin (Jambi), Indonesia. The geothermal manifestations are only hot springs (Kepanasan, Gunung Sahilan, Sungai Pinang, Pandan Sejahtera, and Bandar Jaya). The temperatures are about 46.8-64.5°C with neutral pH. In general the structure of the area followed the pattern of regional structure of Sumatera island trending northwest-southeast and the lithology of the area dominated of sedimentary rocks and alluvial. All of them are bicarbonate type and immature waters but only Kepanasan hot springs reached partially equilibrium. The temperature of geothermal reservoir is about 138°C (Kepanasan), 90°C (Gunung Sahilan), 83°C (Sungai Pinang), and . 100°C (Geragai), These areas are classified into low to medium temperature.

### 1. INTRODUCTION

Geothermal areas in Indonesia are associated with various type of geological environments and of course consequently having various type of systems. By December 2017, about 342 geothermal locations have been identified, where Sumatera has 98 geothermal areas, resources of 6651 MWe, reserves of 6912 MWe, and installed of 452 MWe (Center for Mineral, Coal, and Geothermal Resources, 2017). This study describes the preliminary review of non volcanic geothermal fluids characteristics at back arc basin in Kampar-Kuantan Singingi (Riau), and Tanjung Jabung Timur (Jambi). There are several oil field that operated at these area : Riau (Bangko, Duri, Dumai, etc) and Jambi (Geragai, Tanjung Jabung Timur)

Kampar and Kuantan Singingi are in Riau Province, while Tanjung Jabung Timur is in Jambi Province, Sumatera island, Indonesia (Figure 1). Kampar-Kuantan Singingi, Riau is located in Central Sumatera Basin, while Tanjung Jabung Timur, Jambi is located in South Sumatera Basin. Tectonically, they are at back arc basin and could be categorized in non volcanic geothermal area. Indonesia non-volcanic geothermal systems have not been utilized as a source of electrical energy, because of the lack of understanding for the non-volcanic geothermal system. Hall (2002) showed based on heat flow map at Sundaland region, these areas are having good enough of heat flow about > 120 mWm<sup>2</sup> compared to the others area (Figure 2).

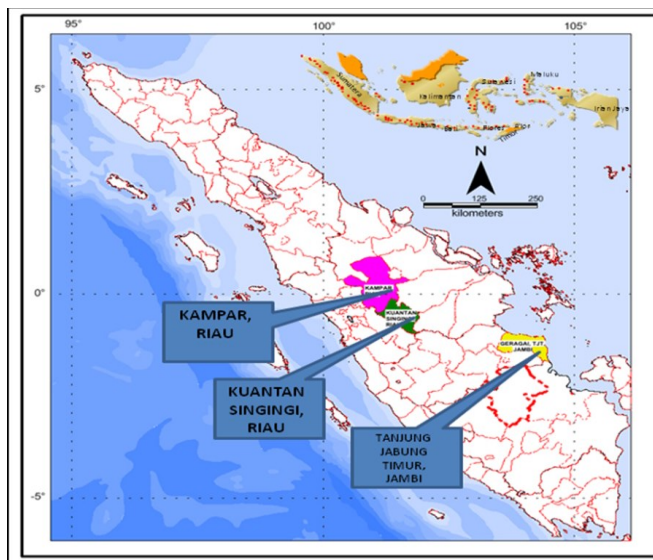


Figure 1: Map Location of Geothermal Selected Area in Riau and Jambi

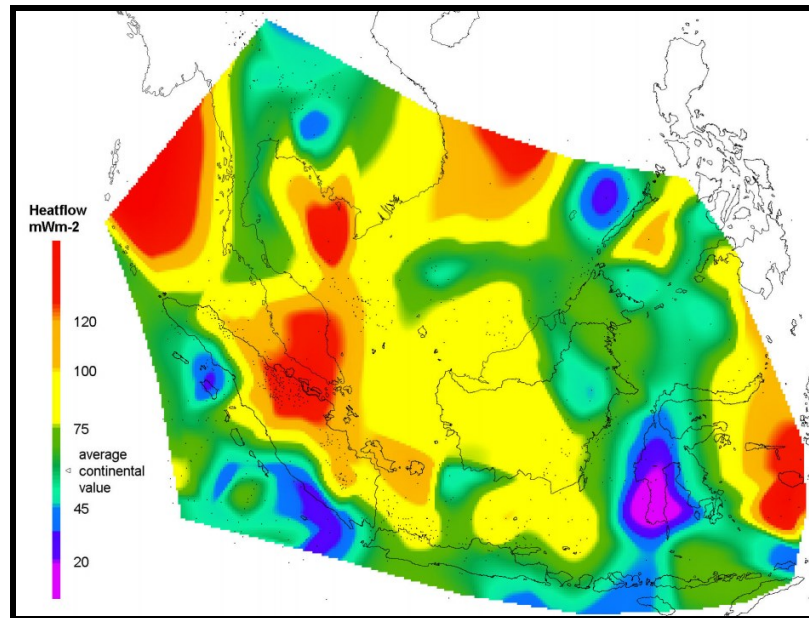


Figure 2: Map of *Heat Flow for Sundaland region* (Hall, 2002)

## 2. GEOLOGY IN A BRIEF

Based on geology regional of Pekanbaru and Lubuksikaping (Clarke, et.al, 1982) and Solok (Silitonga and Kastowo, 1995), Kampar and Kuantan Singingi are consisted of sedimentary rock, intrusive rock, and alluvium aged Pra Tertiary until Quarternary. In general the structure of the Kampar and Kuantan Singingi area followed the pattern of regional strucre of Sumatera island trending northwest-southeast.

Regional geology in Tanjung Jabung Timur is dominated by sedimentary rocks, volcanics rocks, intrusion, and alluvial that formed Pra Tertiary to Quarternary according to regional geological map of Jambi and Muaro Bungo (Simandjuntak, et. al, 1994)

## 3. THERMAL MANIFESTATIONS

The thermal manifestations are only hot springs, for this paper, the discussion only focus for 3 (three) zone hotsprings in Kampar-Kuantan Singingi, Riau and 4 (four) zone hot springs in Tanjung Jabung Timur, Jambi.

### 3.1 Kampar Thermal Manifestations

There are 2 (two) hot springs: Kepanasan and Gunung Sahilan.

#### 3.1.1. Kepanasan Hot spring

It is located at Sinamanenek village, Kampar Regency, coordinat on 0°46' 58.4458"N, 100°45' 11.4936"E, and elevation 45 masl. The physical characteristics are having highest temperature of hot spring about 64.5 °C at atmospheric temperature 31.7 °C, pH 8.27, flow rate 1 l/s, the highest conductivity about 1335 µS/cm, no smell or sinter deposit around the hot springs.

#### 3.1.2. Gunung Sahilan hot spring

It is located at Gunung Sahilan village, Kampar Regency, coordinat on 0°1' 36.4562"N, 101°21' 29.1254"E, and elevation 34 masl. The physical characteristics are having highest temperature of hot spring about 50 °C at atmospheric temperature 30.5 °C, pH 8.02, flow rate 0.5 l/s, conductivity about 503 µS/cm, no smell or sinter deposit around the hot springs

### 3.2. Kuantan Singingi Thermal Manifestation

There is only one warm spring at Kuantan Singingi, namely Sungai Pinang warm spring.

#### 3.2.1. Sungai Pinang warm spring

It is located at Sungai Pinang, Kampar Regency, coordinat on 0°35' 10.686"S, 101°24' 56.5801"E, and elevation 85 masl. The physical characteristics are having highest temperature of hot spring about 49.7°C at atmospheric temperature 28.3°C, pH 7.22, flow rate 0.5 l/s, conductivity about 300 µS/cm, no smell or sinter deposit around the warm springs.

### 3.3. Tanjung Jabung Timur Thermal Manifestations

There are 4 (four) thermal manifestations: Pandan Sejahtera-1, Pandan Sejahtera 2, Pandan Sejahtera 3, and Bandar Jaya hot springs. The Pandan Sejahtera-1, 2, and 3 are close each others about 50-100 m.

#### 3.3.1. Pandan Sejahtera 1, 2, and 3 hot springs

It is located at Geragai, Tanjung jabung Timur Regency, coordinat on 1°9' 1.1427"S, 103°40' 32.3949"E, and elevation 9 masl. The physical characteristics are having temperature of hot spring about 55.46-61.5 °C at atmospheric temperature 30.1°C, pH 6.90-7.53, flow rate 0.5/s, conductivity about 395 µS/cm, no smell or sinter deposit around the hot springs

#### 3.3.2. Bandar Jaya warm spring

It is located at Rantau Rasau, Tanjung Jabung Timur Regency, coordinat on 1°10' 37.86"S, 104°5' 7.2489"E, and elevation 4 masl. The physical characteristics are having temperature of warm spring about 39.21°C at atmospheric temperature 26.58°C, pH 6.50, flow rate 1 l/s, conductivity about 444 µS/cm, no smell or sinter deposit around the warm springs.

## 4. CHARACTERISTIC FLUIDS

There are 9 samples of hot springs and 2 samples of surface water taken during the research in 2015 and 2016. The chemical analysis of the water samples is shown on Table 1. The results of hot spring analysis was only low concentration if compared with the others result analysis of hot spring at volcanic areas around the world. The composition of Kampar and Kuantan Singingi hot springs, Riau are dominated by HCO<sub>3</sub> (75-647 mg/l), chloride ion (21-115 mg/l), and Na (125-303 mg/l), while SiO<sub>2</sub> only (12-15 mg/l). Kepanasan-2 hot spring has the highest chloride ion (115 mg/l) compared to the others hot springs. Tanjung Jabung Timur hot springs have lower concentration rather than Riau hot springs, even though the temperatures are similar.

### 2.2 Classification of the Fluids

The type of all hot springs in Riau and Jambi (Figure.3) based on the Cl-SO<sub>4</sub>-HCO<sub>3</sub> diagram, are bicarbonate type with neutral pH. This could be an indication of dilution process. They are similar with the cold waters type which are also bicarbonate type. Based on Cl-Li-B diagram (Figure 4), Sungai Pinang hot springs fall into Li zone, while the others are plotted between Cl and B zone. Based on Na/1000-K/100-Mg<sup>0.5</sup> diagram, Kepanasan and Gunung Sahilan hot springs fall into the partial equilibrium zone and the others are immature waters. It is an indication that reaction between fluids and reservoir rocks were mixed with surface water.

**Table 1: Water Result Analysis in Kampar-Kuantan Singingi-Tanjung Jabung Timur Area**

Keterangan	pH	Conductivity (µS/cm)	Temperature (°C)	B	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	Li <sup>+</sup>	F <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	HCO <sub>3</sub>	
				mg/l									
KAMPAR-KUANTAN SINGINGI, HOT SPRINGS, RIAU	Kepanasan-1	8.27	721	64.5	0.73	1.53	182.31	4.29	0.03	1.02	22.84	0.71	457.08
	Kepanasan-2	7.96	1335	53.6	2.22	4.01	303.05	7	0.04	1.1	115.76	1.32	647.18
	Kepanasan-3	7.71	163	39.9	0.18	3.12	23.55	4.35	0.02	0.09	2.17	12.74	75.32
	Gunung Sahilan	8.02	503	50,0	0.36	0.35	125.45	1.06	0.01	0.64	21.26	1.69	225.85
	Sungai Pinang-1	7.22	300	49.7	0.11	11.35	26.99	8.26	0.08	0.33	1.74	28.62	152.08
	Sungai Pinang-2	7.07	280	45.7	0.11	10.15	25.72	6.89	0.06	0.28	1.32	24.52	140.6
TANJUNG JABUNG TIMUR HOT SPRINGS, JAMBI	Pandan Sejahtera-1	7.23	304	61.5	0.05	5.19	40.72	11.84	0.01	0.11	3.56	0.28	194.88
	Pandan Sejahtera-2	7.4	300	61.48	0.15	5.91	40.4	11.02	0.01	0.11	3.36	0.27	192.13
	Pandan Sejahtera-3	7.64	305	55.46	0.15	5.86	40.42	11.07	0.01	0.11	3.49	0.37	194.52
	Bandar Jaya	6.28	382	39.21	8.15	3.18	70.52	14.75	0.01	0.37	2.77	0.19	255.98
RAIN OR SURFACE WATER	Cold Spring Kepanasan	6.86	43	31.5	9.96	0.16	2.43	0	0.01	0	2.32	1.94	3.11
	Geragai Rain Water	5.98	3	28.5	0.1	0.3	0.73	0.57	0.01	0.01	0.11	0.23	10.43

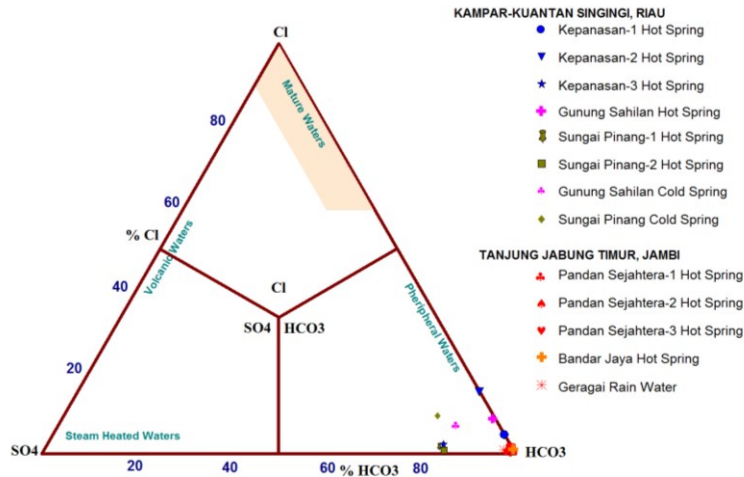


Figure 3: Cl-SO<sub>4</sub>-HCO<sub>3</sub> Ternary Diagram

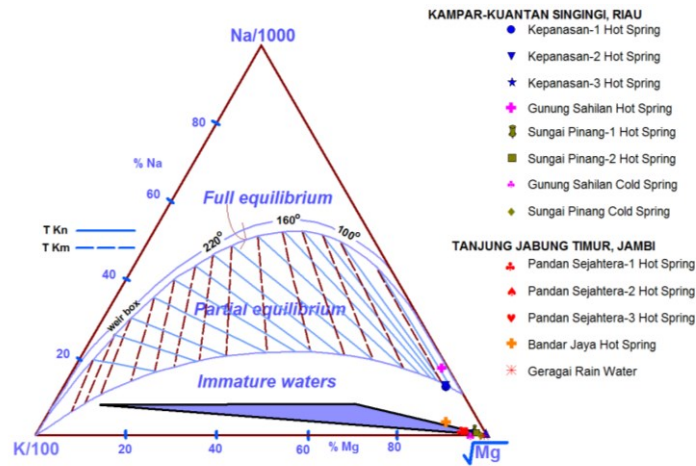


Figure 4: Na-K-Mg Ternary Diagram

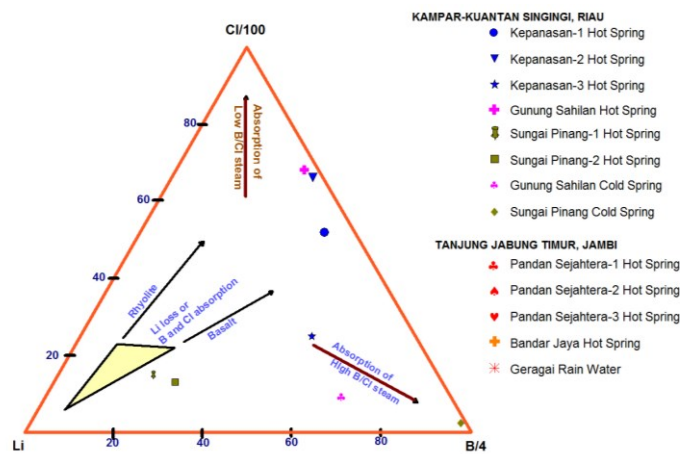


Figure 5: Cl-Li-B Ternary Diagram

### 2.3 Geothermometry

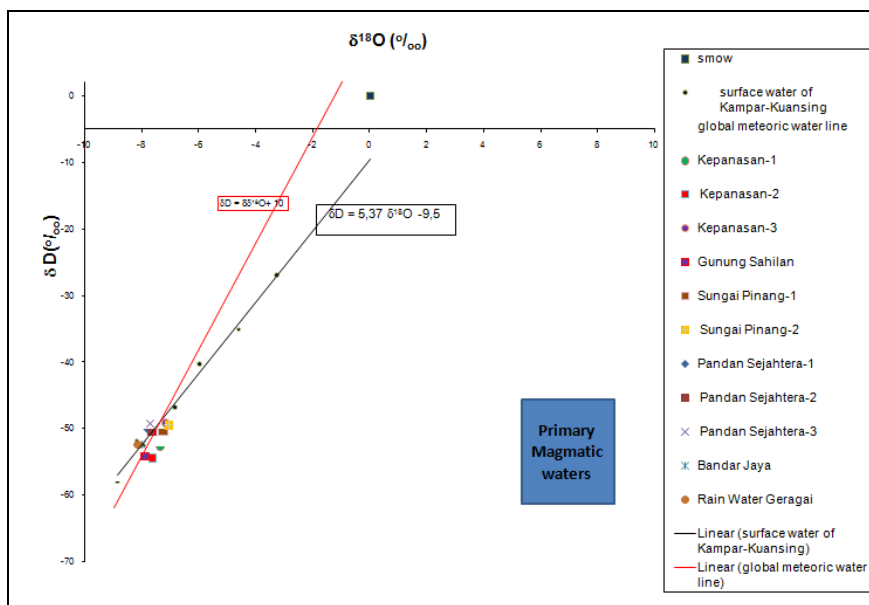
The prediction of reservoir temperature is calculated with seven different geothermometer equations (Tabel 2). The calculation result that shown in Table 2, since the temperature of manifestations relative low to medium, the silica geothermometers seems not to realistic. Kepanasan and Gunung Sahilan hot springs are plotted in partial equilibrium zone, so it will have a realistic result of prediction temperature with Na-K (Giggenbach) and they have 138°C (medium temperature) for Kepanasan and only 90 °C for Gunung Sahilan (low temperature). The others hot springs seems little bit difficult to get a realistic result, for these case, Pandan Sejahtera has about 98-101°C and Sungai Pinang has about 78-83°C from Na-K-Ca (low temperature),while Sungai Pinang and Bandar Jaya could be approach from silica geothermometer about 90-92°C (low temperature).

**Table 2: Geothermometry in Kampar-Kuantan Singingi-Tanjung Jabung Timur Geothermal Area**

Sampel Hot Spring	Quartz cond	Quartz adiabatic	Na-K-Ca	Na/K Fournier	Na/K Truesdell	Na/K (Giggenbach)	K/Mg (Giggenbach)
Kepanasan-1	54	61	131	118	71	138	70
Kepanasan-2	54	61	130	117	70	137	70
Kepanasan-3	47	55	94	276	265	287	62
Gunung Sahilan	48	56	94	69	19	90	55
Sungai Pinang-1	50	57	83	336	351	341	62
Sungai Pinang-2	48	55	78	319	325	325	59
Pandan Sejahtera-1	91	93	101	329	341	335	79
Pandan Sejahtera-2	99	100	101	321	329	327	76
Pandan Sejahtera-3	95	97	98	322	329	328	76
Bandar Jaya	90	92	163	290	284	299	91

### 2.4 Isotope

Stable water isotope data plot in global meteoric water line and local meteoric water sampel which approached by local groundwater and surface water samples (Figure 6.). It could be an indication that it is meteoric water origin. Several isotope of hot springs near to local meteoric water line, it could be an indication that the contributions of deep fluids is minor, but for hot spring Kepanasan and Gunung Sahilan are more positive than local waters, this could be an indication that geothermal fluids has been enriched with <sup>18</sup>O because of rock-water reactions at depth (Nicholson, 1993).



**Figure 6: Water Isotopes Diagram**

## 6. CONCLUSION

Preliminary Review of Geothermal Fluids Characteristic At Back Arc Basin In Kampar-Kuantan Singingi, Riau Province and Tanjung Jabung Timur, Jambi Province, Indonesia shows that the hot springs are neutral pH, only having the highest temperature of about 64.5°C (Kepanasan hot spring), the concentration of water analysis tend to be low to medium concentration, and geothermal manifestations are only hot springs, they are Kepanasan, Gunung Sahilan, Sungai Pinang, Pandan Sejahtera, and Bandar Jaya. They are bicarbonate type, immature waters, except for Kepanasan and Gunung Sahilan are plotted in partial equilibrium. The isotop waters shows more positive  $^{18}\text{O}$  for Kepanasan and Gunung Sahilan only, while the others are very close to the sampel of local ground water or rain water. Only Kepanasan has medium temperature of reservoir about 138°C (Na-K) and the rest are low temperature of reservoir.

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