Geothermal Energy: Case Study Identification Based On Analysis Of Ion Balance And Reservoir Characteristic

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ABSTRACT - Some samples of data from the world's geothermal system consisting of: (1) geothermal systems Padang Cermin (a. Padang Cermin 1, b. Padang Cermin 2, c. Margodadi, d. Wadok, (2) Kawah Ijen (East Java) , (3) Wairakei (New Zealand), (4) Sea water, and (5) Te Aroha (New Zealand). Analysis of ion balance is performed on the fifth geothermal system data stretcher. Analysis triangle ternary diagram (Cl-HCO3-SO4) performed on all the data from the five samples. Ion balance analysis results showed that: (1) showed good hydrothermal system (ion balance value between 0.1 up to 2.19%), (2) shows that the hydrothermal system is not good (the value of the ion balance 47%), (3) showed good hydrothermal system (ion balance value of 1.2%), (4) shows the hydrothermal system that is not good (the value of the ion balance 64%), and (5) indicate that the hydrothermal system is not so good (the value of the ion balance between 8.5%), (Cl-HCO3-SO4) triangle ternary diagram analysis results showed that: (1) produce a type of chloride water reservoir, (2) produces chloride water reservoir types, (3) produces chloride water reservoir types, (4) produce a type of chloride water reservoir, and (5) to produce the type of carbonate reservoir water.

Keyword: geothermal system, Ion balance analysis, (Cl-HCO3-SO4) triangle ternary diagram analysis.

1. INTRODUCTION

The unifying scheme for classifying geothermal system was very simplified classification on hydrologic style [1]. Geothermal fluids have diverse chemical compositions. Many of these chemical differences depend on the sources of recharge waters and the contribution of volatiles from metamorphic or magmatic sources[2]. Fluid composition change caused by the effect the degree of boiling of mixing. Large-scale fluid hydraulic factors, further determine whether a system undergoes fluid convection in the stagnant reservoir. While general trends in fluid chemistry exist for various geothermal environments. It is our task as geochemists to learn the processes which govern fluid compositions and thereby use this information to understand the individual geothermal system.

2. METHODS

The method in this research using: (1) analysis of ion balance, (2) Cl-SO4-HCO_3 and (3) Na-K-Mg chart analysis. Ion balance is the method of checking how good the chemical composition of the geothermal system. In most solutions are the dominant ions Na^+, K^+, Ca^{+2}, Mg^+, Cl^-, HCO_3^-, and SO_4^{-2}. To calculate the value of the formula used Ion Balance:

□Change% = {(□cations+□anions)/|□cations+□anions|}x100

Calculation Cl-SO_4-HCO_3 using the formula:

$S = cCl + cSO_4 + cHCO_3$;

% Cl = (100 cCl)/S and % HO_3 = (100 $cHCO_3$)/S.

Calculation Na-K-Mg using the formula:

$S = cNa/1000 + cK/100 + cMg^{1/2}$

% Na = (cNa)/ 10S and % Mg = (100 c $cMg^{1/2}$)/S. [3]; [4].

3. RESULT

The results of this study are calculation of ion balance and calculation of Cl, HCO3, SO4, Na, K, and Mg concentration in Table 1. While the results of ternary diagrams analysis (Cl-HCO3-SO4) and (Na-K-Mg) are illustrated in Between Figures 1 and 6b.

4. DISCUSSIONS

From Figure 1a. Cl-SO4-HCO3 and NA-K-Mg chart analysis of the geothermal system from spring Padang Cermin 1 (Pc1), indicated that the Padang Cermin 1 geothermal system (Pc1) is chloride water within partial equilibrium. Figure 1b. Cl-SO4-HCO3 and Na-K-Mg chart analysis of the geothermal system from spring Padang Cermin 2 (Pc2), indicated chloride-water system within the immature liquid condition. Figure 1c. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Margodadi Padang Cermin (Mg), indicated carbonated water reservoir condition within partial equilibrium condition. Figure 1d. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Wadok Padang Cermin (Wadok), indicated chloride water reservoir condition situated between partial equilibrium and immature liquid condition. The Padang Cermin geothermal reservoir should be a hight temperature geothermal system if we compare to Wairakei geothermal system New Zealand). The Wairakei Na-K-Mg analysis shows in Figure 1.

Figure 2. Cl-SO4-HCO3 and Na-K-Mg chart analysis of the geothermal system from spring of Kawah Ijin East Java (IjenS), indicated chloride-water system within the immature liquid condition. Figure 3a. Cl-SO4-HCO3 chart analysis of Wairakei geothermal system well (WrkW), and Na-K-Mg chart analysis of Wairakei geothermal system well of (WrkW) and Wairakei geothermal system spring (WrkS), and Figure 3b. Cl-SO4-HCO3 chart analysis of Wairakei system spring (WrkS). indicated the reservoir of Wairakei is chloride water. The liquid condition is a partial equilibrium in the spring, and full equilibrium in the well and the measures temperatures were 99o C in spring and 240ºC in well. The temperature determination using Na-K-Mg chart analysis was consistent with well-measured temperature. Figure 4. Cl-SO4-HCO3 chart analysis of Sea Water (SW), indicated that sea water is rich of chloride altho has much SO4 and HCO3. So that chloride mineral still dominant in sea water. Figure 5. Cl-SO4-HCO3 and Na-K-Mg chart analysis of the geothermal system from Salton Sea well USA (SsUsW), indicated the chloride water and liquid condition of full equilibrium. The liquid condition in full equilibrium so consistent temperature analysis chart of Na-K-Mg with well-measured temperature. For example, the temperature measured the Salton Sea well USA was 330ºC and the Na-K-Mg chart analysis more than 300o C (see Figure 5 and Tabel 1). The other example, the temperature measured the Mirabilis was 245o C and the Na-K-Mg chart analysis closed to well temperature measured (see Figure 6a and Table 1). Figure 6b. Cl-SO4-HCO3 and Na-K-Mg chart analysis of the geothermal system Mirabilis spring Cero Pro Mexico (MvCrS), indicated the chloride water reservoir and liquid condition in partial equilibrium.

Table 1. Data and results of geochemical analysis of sea water and geothermal system of Padang Cermin, Ijen Crater, Wairakei, Salton Sea and Miraviles.

No	Station	C	Na	K	Ca	Mg	Li	B	Cl	SO4	HCO3	%Cl	%Hco	%Na	%Mg	HCO/Cl	Ion Balance
1a	Pc1		1243	93	117	7	15	3	1972	113	306	82,5	49,1	25,8	54,9	0,155	**-0,1**
1b	Pc2		326	72	51	13	8	13	510	15	250	65,8	56,8	7,0	77,5	0,490	**2,2**
1c	Mgd		1545	100	142	13	13	2	2588	52	104	94,3	26,6	25,1	58,6	0,040	**1,4**
1d	Wadok		1166	170	124	7	15	1	2037	68	100	92,4	31,7	21,2	48,0	0,049	**1,1**
2	IjenS	60	1030	1020	3150	680			1675	30	4	98,0	11,8	2,8	69,9	0,002	**71,1**
3a	WrkW	240	1170	167	20	0,01	10,7	26	1970	35	5	98,0	0,8	39,8	3,4	0,003	**-0,2**
3b	WrkS	99	1220	140	30	4,5	14,5	43	2100	30	30	97,2	7,9	25,7	44,7	0,014	**-1,5**
4	SW	4	10760	390	410	1290			19340	2710	140	87,2	4,9	21,3	71,0	0,007	**0,03**
5	SsUsW	330	38400	13400	22010	10			118400	4	140	99,9	97,2	21,9	1,8	0,001	**-3,6**
6a	MvCrW	245	1970	238	73	0,02	5,7	54	3300	36	40	84,0	6,0	43,9	3,1	0,012	**-5,3**
6b	MvCrS	73	1970	79	22	6,5	3,4	48	2600	120	910	71,8	79,7	37,1	48,0	0,350	**-0,7**

CONCLUSION

The fluid compositions should be informed to understand the individual geothermal system, is it chloride water, or acid water or carbonated water reservoirs. We concluded that Na-K-Mg chart analysis with full equilibrium fluid illustrated the consistent temperature with rail temperature well measure. The Padang Cermin geothermal field Pesawaran Lampung Indonesia should be the hight temperature geothermal system refer to Wairakei geothermal system New Zealand.

5. AKNOLEDGMENT

I would like to thanks to Simmons that have product the lecturer book for aNalysis reference and some data that using to be analyzed

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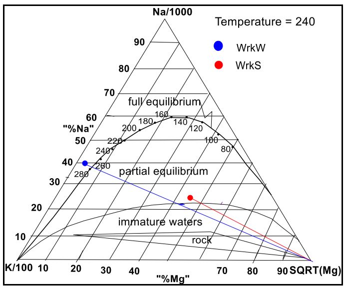

Figure 1. Interpretation from Na-K-Mg chart analysis does determine the temperature of the reservoir. Comparison between the Wairakei spring data analysis (WrkS), and Wairakei well data analysis (WrkW) compare to the good temperature.

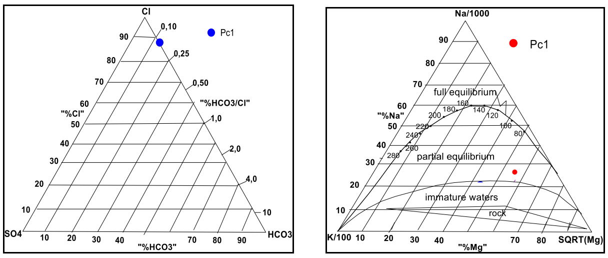

Figure 1a. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Padang Cermin 1 (Pc1)

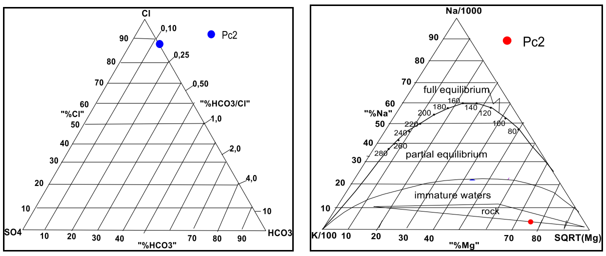

Figure 1b. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Padang Cermin 2 (Pc2)

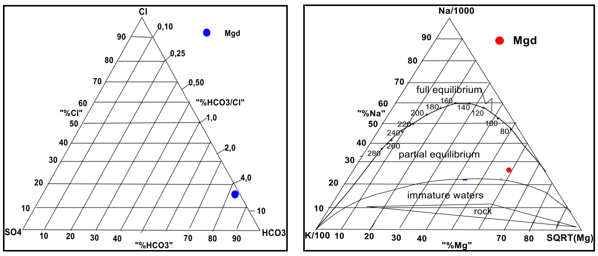

Figure 1c. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Margodadi Padang Cermin (Mgd)

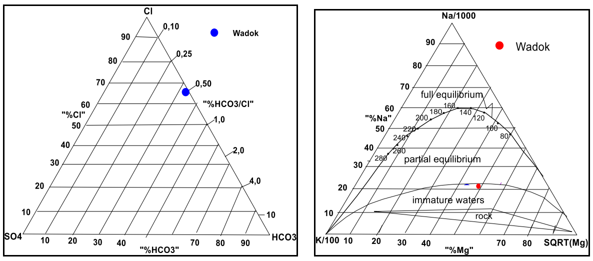

Figure 1d. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Wadok Padang Cermin (Wadok)

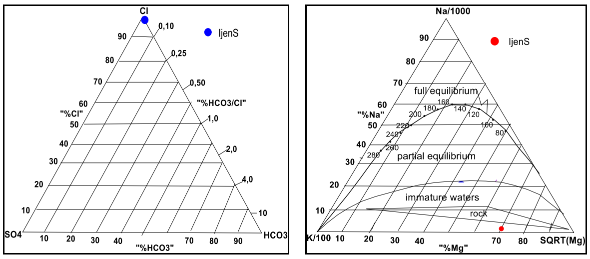

Figure 2. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring of Kawah Ijin East Java (IjenS)

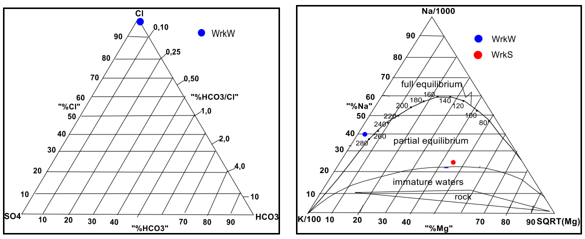

Figure 3a. Cl-SO_4-HCO_3 chart analysis of Wairakei geothermal system well (WrkW), and Na-K-Mg chart analysis of Wairakei geothermal system well of (WrkW) and Wairakei geothermal system spring (WrkS),

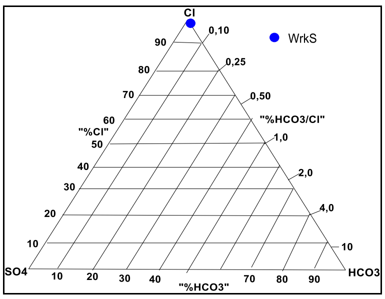

Figure 3b. Cl-SO_4-HCO_3 chart analysis of Wairakei geothermal

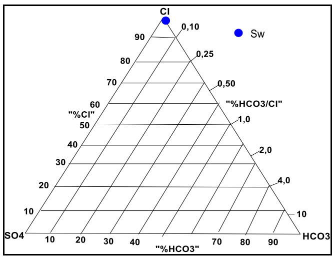

Figure 4. Cl-SO_4-HCO_3 chart analysis of Sea Water (SW), Waairkei system spring (WrkS).

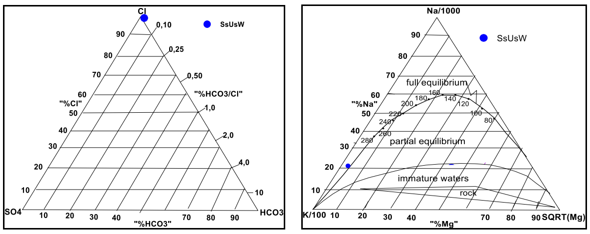

Figure 5. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from Salton Sea well USA (SsUsW)

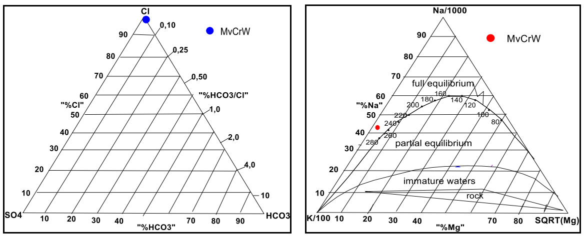

Figure 6a. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system Miraviles well (SsUsW)

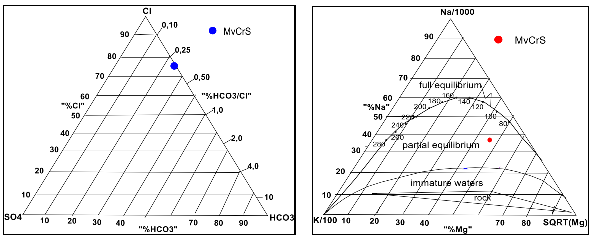

Figure 6b. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system Miraviles spring (SsUsS)