GEOTHERMAL SYSTEM IDENTIFICATION BASED ON ANALYSIS OF ION BALANCE $Cl\text{-}SO_4\text{-}HCO_3$ AND NA-K-Mg CHART ANALYSIS

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Key word: geothermal system, Ion balance analysis, ($Cl\text{-}HCO_3\text{-}SO_4$) triangle ternary diagram analysis.

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) Wairakey (New Zealand), (4) Sea water, (5) Salton Sea (USA), and (6) Meraviles Cero Prito (Mexico). Analysis of ion balance is performed on the fifth geothermal system data stretcher. Analysis triangle ternary diagrams (Cl-HCO3-SO4) and (Na-K-Mg) performed on all the data from the six samples.
Ion balance analysis results showed that: (1) The Padang Cermin geothermal system showed good hydrothermal system (ion balance value between 0.1 up to 2.19%), (2) the Kawah Ijen geothermal system shows that the hydrothermal system is not good (the value of the ion balance 47%), (3) The Wairakey (New Zealand) showed good hydrothermal system (ion balance value of 1.2%), (4) The sea water is not hydrothermal system. (5) The Salton Sea (USA), indicate that the hydrothermal system is good (the value of the ion balance is 3.6%). (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.

INTRODUCTION

The univying scheme for classifying geothermal system was very simplified classification on hydrologic style (Suharno, 2012). Geothermal fluids have diverse chemical compostions. Many of these chemical differences depend on the sources of recharge waters and the contribution of volatiles from metamorphic or magmatic sources (Giggenbach, et. al., 1983). Fluid compositon change caused by effect the degree of boiling of mixing. Large scale fluid hydrolic factors, further detemine whether a system undegoes fluid convection in stagnant resevoir. While general trends in fluid chemestry exist for various geothermal environments. It is our task as geochemists to learn the processes which goven fluid compositions and thereby use this informatioan to understand individual geothermal system.

METHODS

The method in this research using: (1) analysis of ion balance, (2) Cl-SO4-HCO3 and (3) Na-K-Mg chart analysis. Ion balance is the method to checking how good the chemical composition of the geothermal system. In most solutions are the dominant ions Na +, K +, Ca + 2, Mg +, Cl-, HCO3-, and SO4-2. To calculate the value of the formula used Ion Balance:

$$\Delta Change\% = \left\{ (\Sigma cations + \Sigma anions) / |\Sigma cations + \Sigma anions| \right\} X100$$

Calculation Cl-SO4-HCO3 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 $\% Mg = (100\ c\ cMg^{1/2})/S$.
(Simmons, 1998; Suharno, 2013).

RESULT

Hasil penelitian ini berupa hasil perhitungan ion balance dan perhitungan kandungan konsentrasi Cl, HCO_3, SO_4, Na, K, dan Mg dalam Tabel 1. Sedangkan hasil analisis ternary diagrams (Cl-HCO3-SO4) dan (Na-K-Mg) diilustrasikan pada antara Gambar 1 dan 6b.

DISCUSSIONS

From Figure 1a. $Cl\text{-}SO_4\text{-}HCO_3$ 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 cloride water within partial equilibrium. Figure 1b. $Cl\text{-}SO_4\text{-}HCO_3$ and Na-K-Mg chart analysis of the geothermal system from spring Padang Cermin 2 (Pc2), indicated cloride water system within immature liqide condition. Figure 1c. $Cl\text{-}SO_4\text{-}HCO_3$ and Na-K-Mg chart analysis of the geothermal system from spring Margodadi Padang Cermin (Mgd), indicated carbonat water resevoir condition within partial equilibrium condition. Figure 1d. $Cl\text{-}SO_4\text{-}HCO_3$ and Na-K-Mg chart analysis of the geothermal system from spring Wadok Padang Cermin (Wadok), indicated cloride water resevoir condition situated between partial equilibrium and immature liquide condition. The Padang Cermin geothermal resevoir sould be hight temeperature geothermal system if we compair to Wairakei geotherma lsystem New Zealand). The Wairakei Na-K-Mg analysis shows in Figure 1.

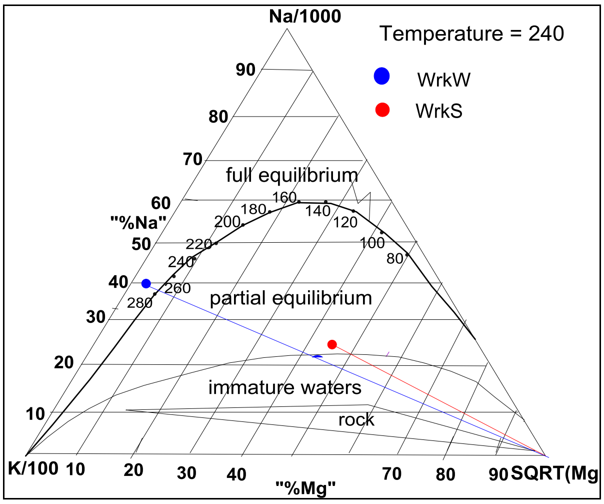

Figure 1. Interpretation from Na-K-Mg chart analysis doe to determine temperature of the resevoir. Comparation between

the Wairakei spring data analysis (WrkS), and Wairakei well data analysis (WrkW) compare to the well temperature.

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), indicated cloride water system within immature liqide condition. 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), and Figure 3b. Cl-SO_4-HCO_3 chart analysis of Wairakei system spring (WrkS). indicated the reservoir of Wairakei is cloride water. The liquid condition are partial equilibrium in the spring and full equilibrium in the well, and the measures temperatures were 99^o C in spring and 240^o C in well. The temperature determination using Na-K-Mg chart analysis was consitent with well measured temperature. Figure 4. Cl-SO_4-HCO_3 chart analysis of Sea Water (SW), indicated that sea water is rich of cloride oaltho has many SO_4 and HCO_3. So that cloride mineral still cominant in sea water. Figure 5. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from Salton Sea well USA (SsUsW), indicated the cloride water and liquid condition of full equlibrium. The liquid condition in full equilibrium so consistent temperature analysis chart of Na-K-Mg with well mesured temperature. For example, the temperature measured the Salton Sea well USA was 330^o C and the Na-K-Mg chart analysis more than 300^o C (see Figure 5 and Tabel 1). The other example, the temperature measured the Miraviles was 245^o C and the Na-K-Mg chart analysis closed to well temperature measured (see Figure 6a and Tabel 1). Figure 6b. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system Miraviles spring Cero Prito Mexico (MvCrS), indicated the cloride water reservoir and liquid onditian in partial equilibrium.

CONCLUSSION

The fluid compositions sould be inform to understand individual geothermal system, is it cloride water, or acid waoter or carboat water reservoirs. We are shoulb be conclud that Na-K-Mg chart analysis with full equilibrium fluid illusstrated the consistent temperature with rial temperature well measure. The Padang Cermin geothermal fild Pesawaran Lampung Indonesia, sould be the hight temerature geothermal system rifer to Wairakei geothermal system New Zealand.

AKNOLEDGMENT

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

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Tabel 1. Data dan hasil analisis geokimia dari sea water dan geothermal system Padang Cermin, Kawah Ijen, Wairakei, Salton Sea dan 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**

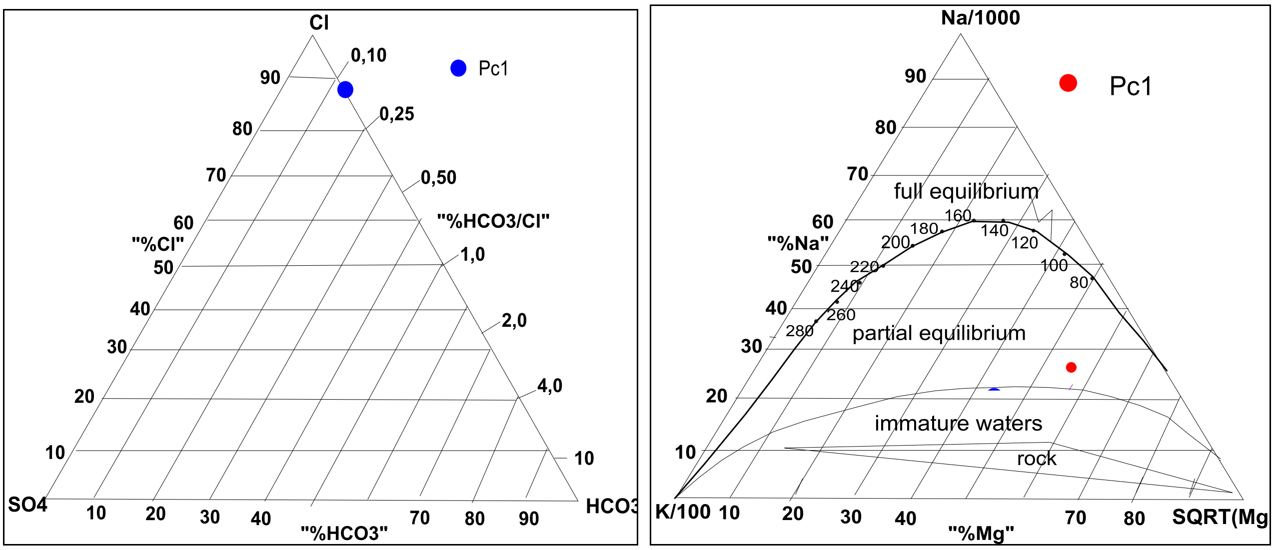

Figure 1a. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Padang Cermin 1 (Pc1)

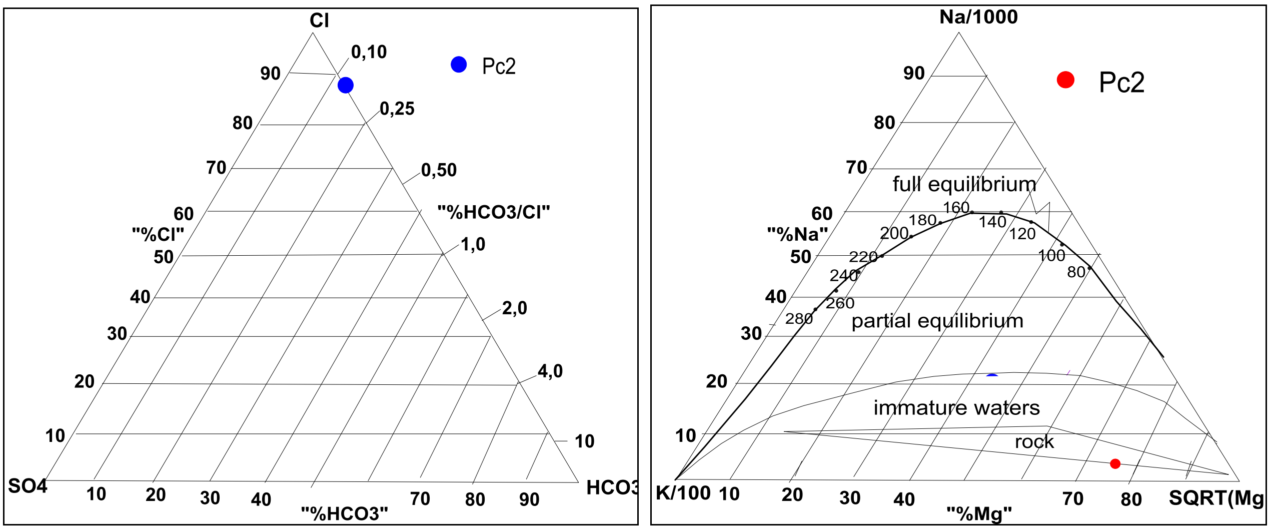

Figure 1b. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Padang Cermin 2 (Pc2)

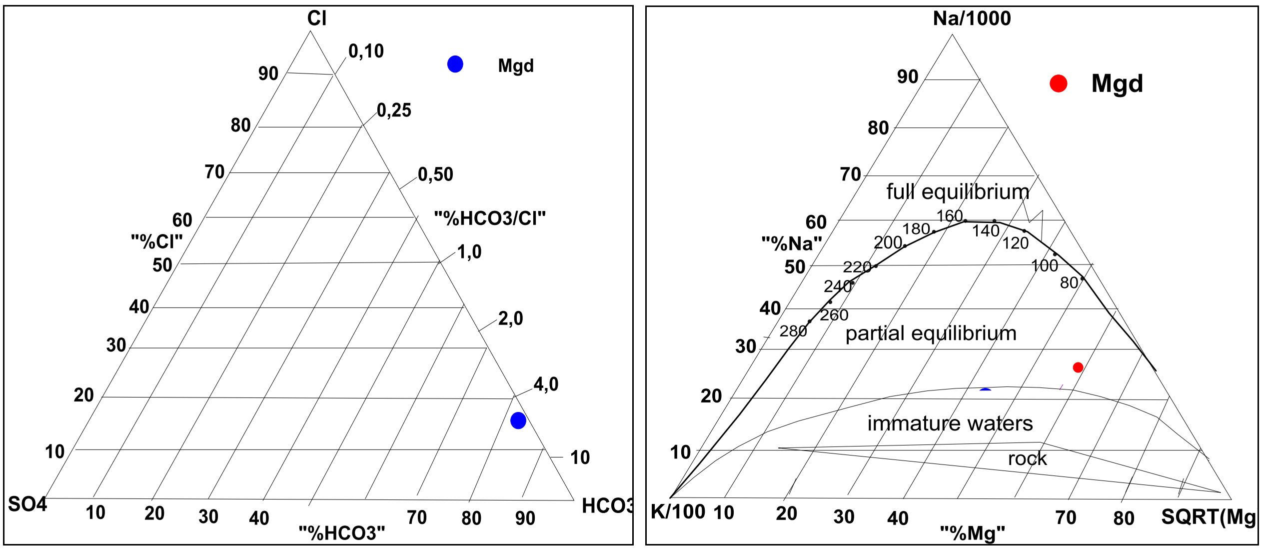

Figure 1c. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Margodadi Padang Cermin (Mgd)

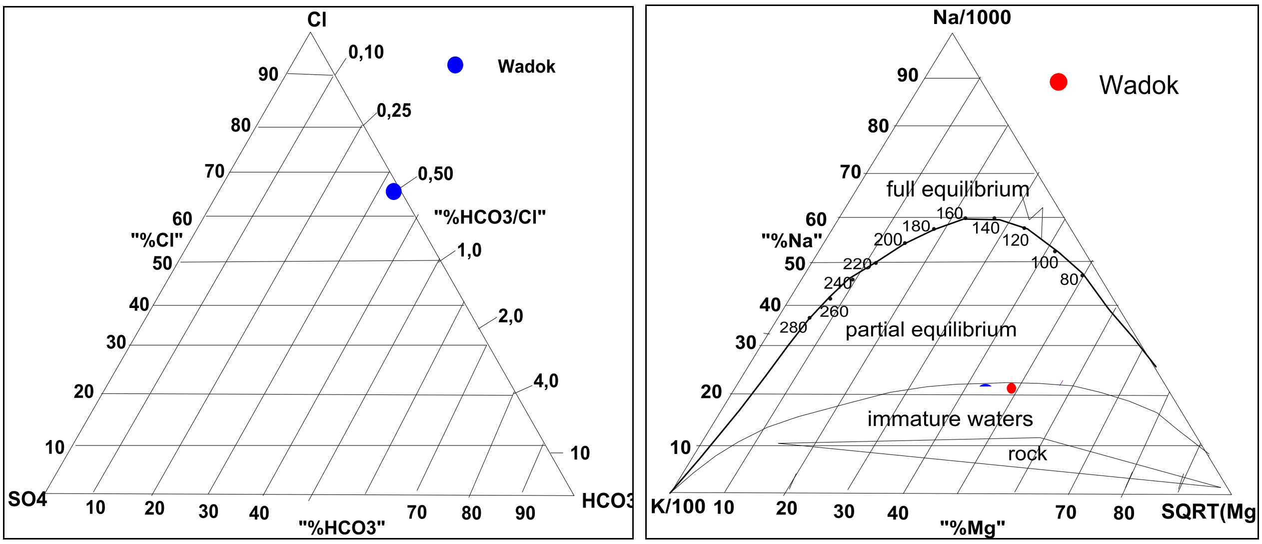

Figure 1d. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring Wadok Padang Cermin (Wadok)

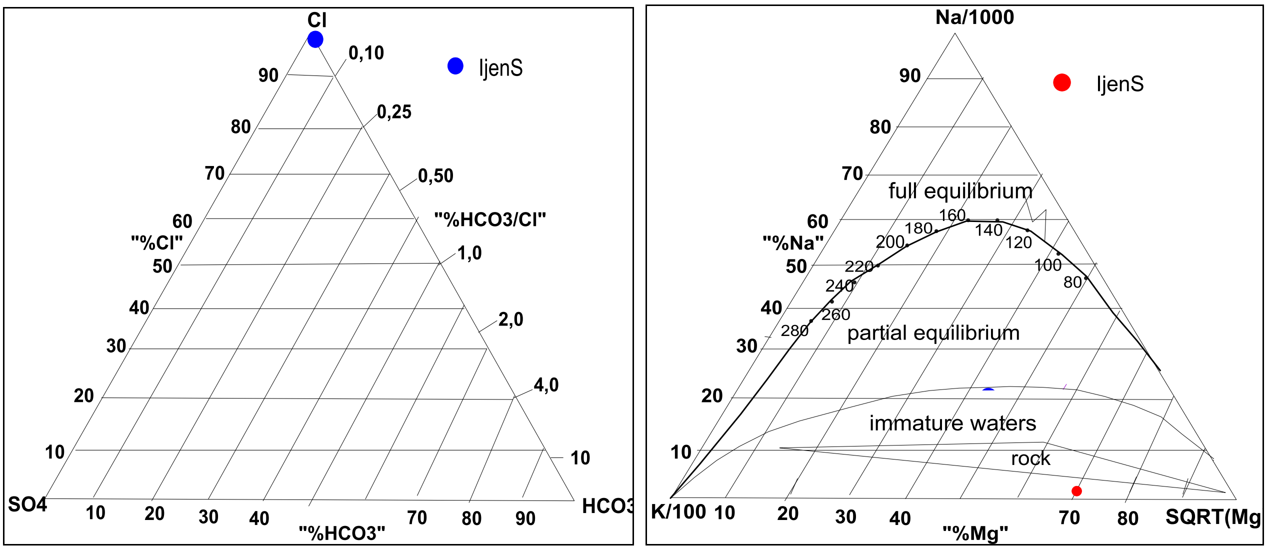

Figure 2. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from spring of Kawah Ijin East Java (IjenS)

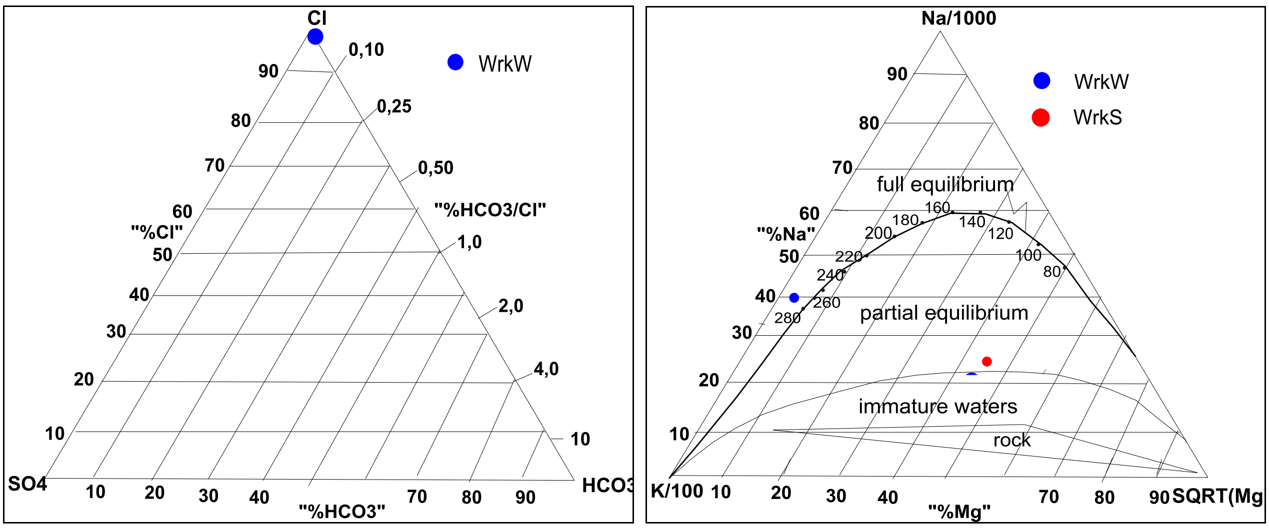

Figure 3a. Cl-SO_4-HCO_3 chart analysis of Wairakei geothermal system well (WrkW), and Na-K-Mg chart analysis of Wairakei geothermal system well of (WrkW) and Wairakei geothermal system spring (WrkS),

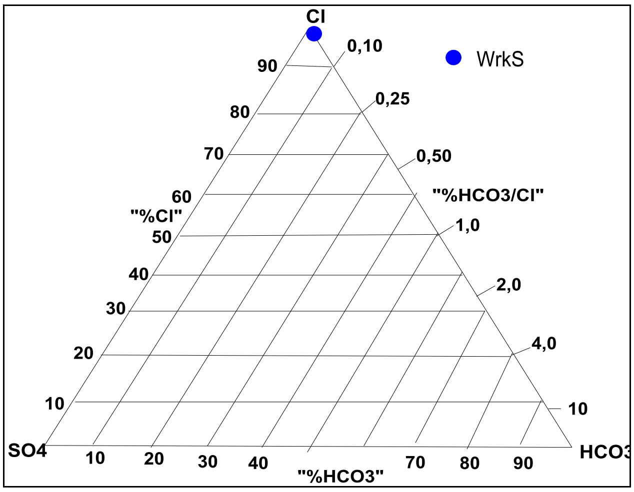

Figure 3b. Cl-SO_4-HCO_3 chart analysis of Wairakei geothermal system spring (WrkS).

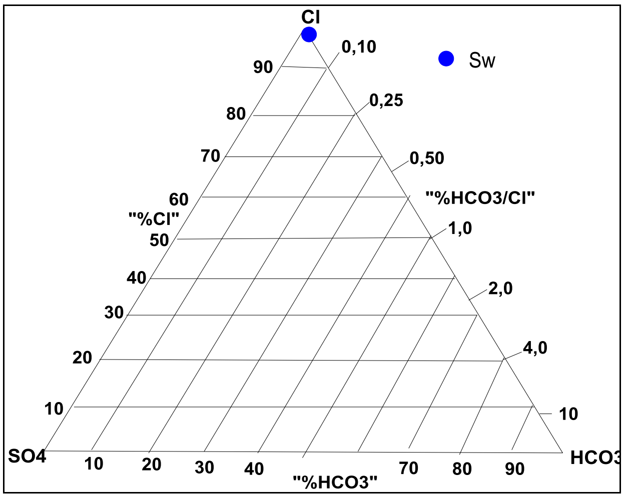

Figure 4. Cl-SO_4-HCO_3 chart analysis of Sea Water (SW).

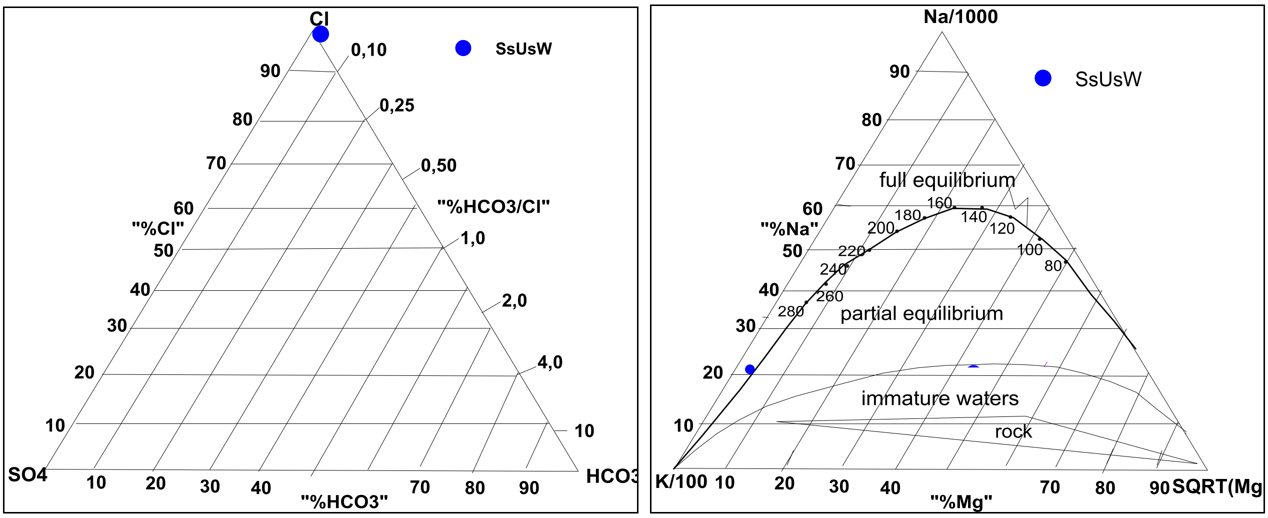

Figure 5. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system from Salton Sea well USA (SsUsW)

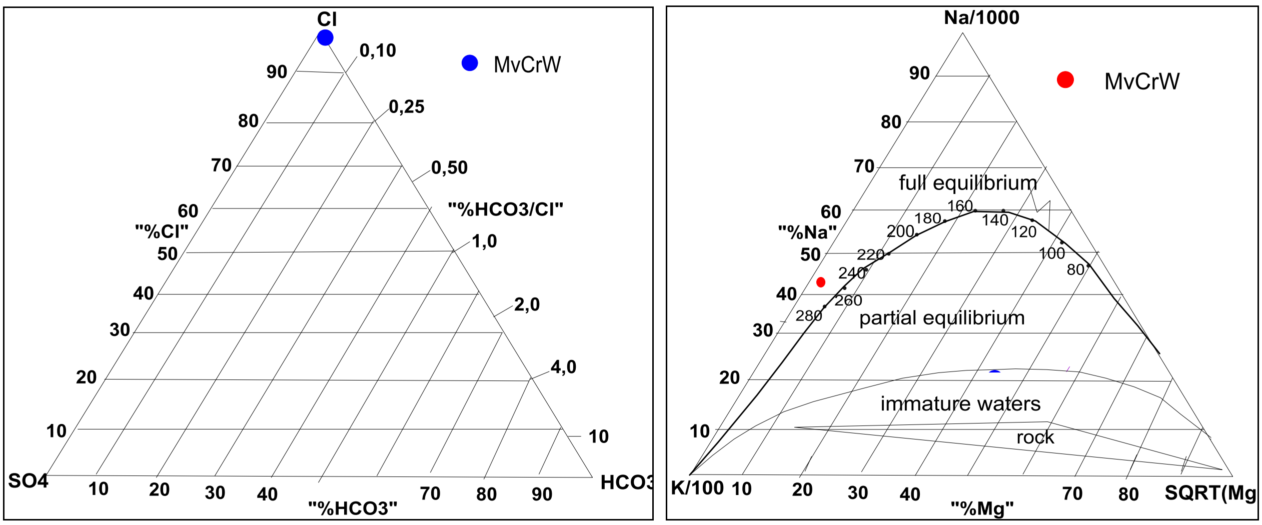

Figure 6a. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system Miraviles well (SsUsW)

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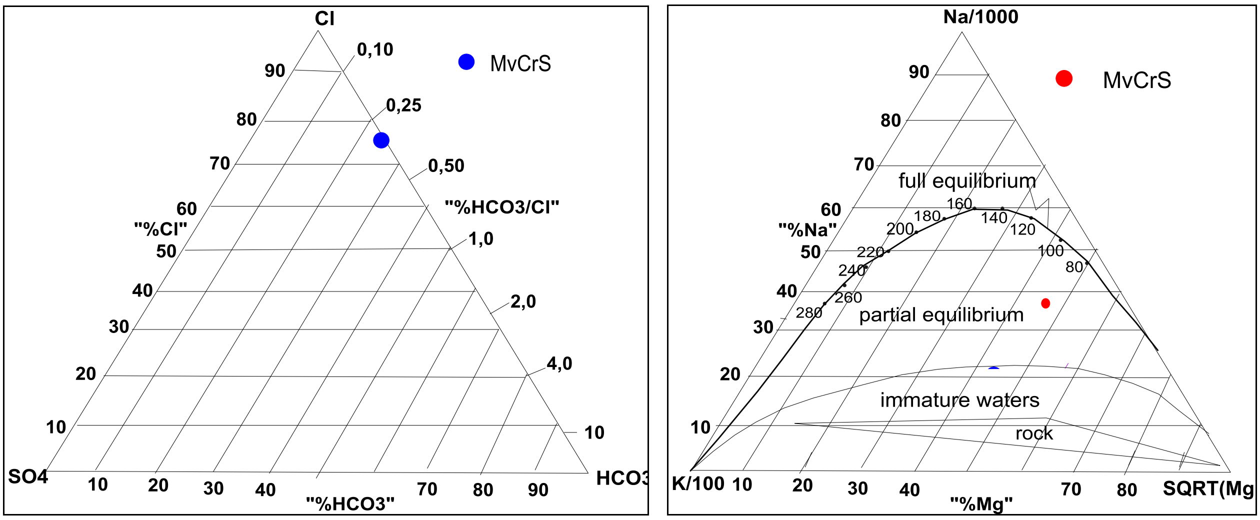

Figure 6b. Cl-SO_4-HCO_3 and Na-K-Mg chart analysis of the geothermal system Miraviles spring (SsUsS)