USING ALUMINUM DATA: IMPLICATIONS ON GEOCHEMICAL MODELING

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ABSTRACT

In the quest to determine if measured aluminum values is in fact necessary in evaluating geochemical data, two particular studies were conducted. Results have shown that employing actual aluminum concentrations using SOLVEQ gave the most positive results. The first study estimated reservoir temperatures of three wells (MG30D, M

G24D and MG43D) from the EDC Leyte geothermal field using the FixAl method and actual aluminum concentrations while the second is a calibration study to test aluminum sensitivity using SOLVEQ and Watch 2.4 softwares on CN-1, a production well in BacMan. Both papers yielded conclusions in favor of the method using measured values of aluminum by SOLVEQ among the FixAl method and using arbitrary aluminum values by Watch 2.4. Nevertheless, the FixAl method is still recommended in reservoir fluid reconstruction by both studies in the absence of laboratory analysis for aluminum.

Currently, the EDC laboratories have no capability yet for trace aluminum analysis on geothermal water samples although validation of methods is on-going. To reinforce the information provided by the above-mentioned projects, studies using more data from wells with known mineralogy and complete chemistry as well as comparison with measured temperatures of feed zones or its closeness to other geothermometers are suggested.

Keywords: aluminum, FixAl method, SOLVEQ, Watch 2.4

STUDIES TESTING THE SIGNIFICANCE OF APPLYING MEASURED ALUMINUM CONCENTRATIONS IN GEOCHEMICAL DATA EVALUATION

The two papers presented below agree that incorporating measured aluminum values in softwares such as SOLVEQ can provide more accurate evaluation in multicomponent chemical equilibration calculations of mineral equilibria.

1. COMPARISON OF RESERVOIR TEMPERATURES FROM THEORETICAL CHEMICAL GEOTHERMOMETRY USING THE FIXAL METHOD AND MEASURED VALUES OF ALUMINUM

Three production wells from Mahanagdong, Leyte, Philippines characterized as waters of neutral, low-enthalpy (MG30D); neutral, mid-enthalpy (MG24D) and acidic, high-enthalpy

(MG43D) were chosen for the experimental study. SOLVEQ was then used to simulate the numerical models. Forced equilibration was applied for MG30D and MG24D with microcline and with kaolinite for MG43D. The minerals assigned on the log (Q/K) versus temperature plots were those indicated in the petrological reports of each well and those commonly used as geothermometers in Philippine geothermal systems suggested by Reyes (1990). A ±5 tolerance in temperatures at log (Q/K) = 0 was employed to improve the approximations and models.

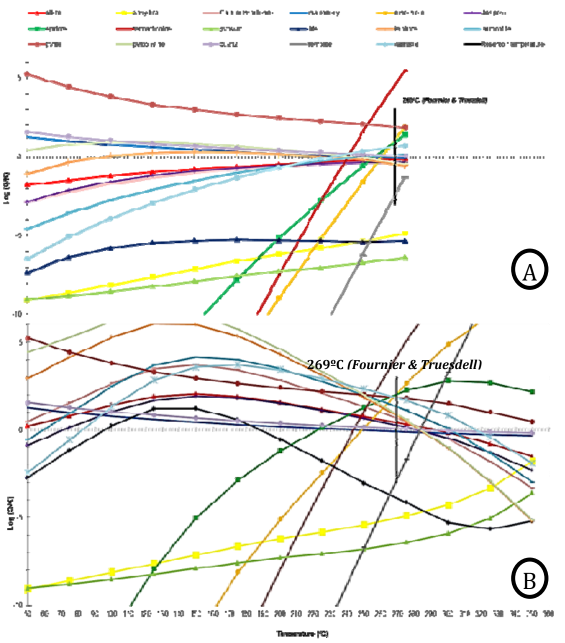

Figure 1: Saturation indices vs temperature plots of MG30D using FixAl method (A) and using an actual concentration of Al (B)

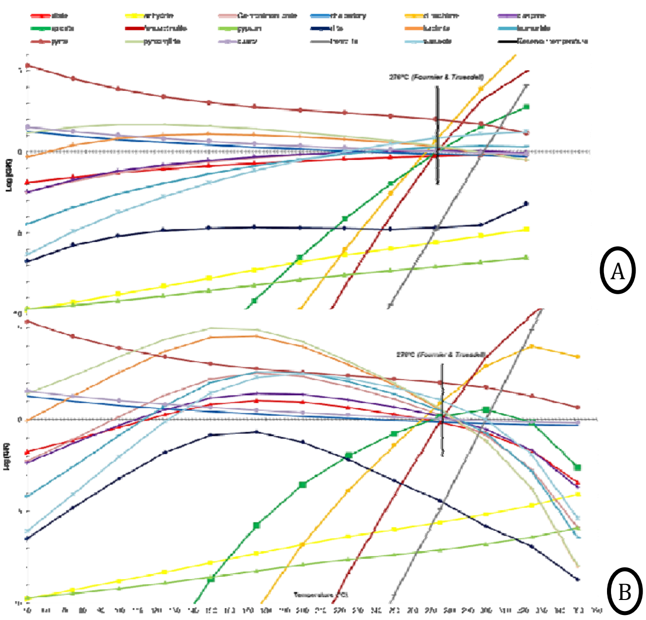

Figure 2: Saturation indices vs temperature plots of MG24D using FixAl method (A) and using an actual concentration of Al (B)

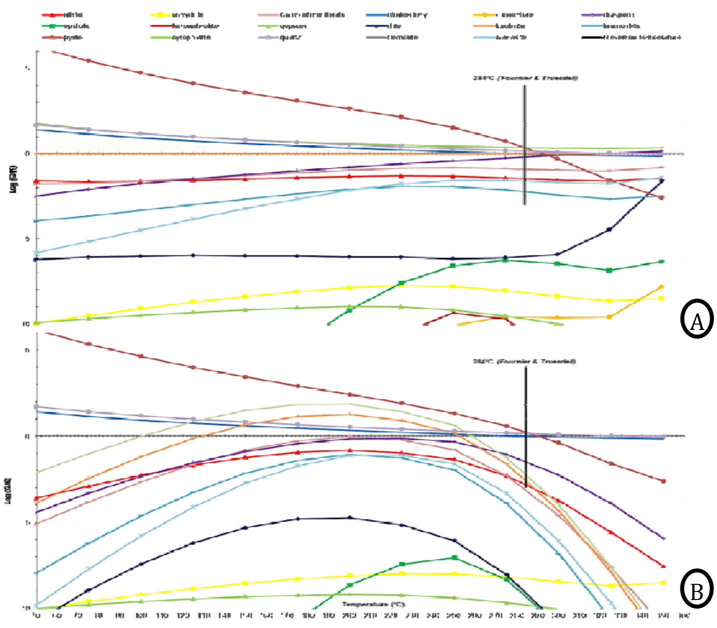

Figure 3: Saturation indices vs temperature plots of MG43D using FixAl method (A) and using an actual concentration of Al (B)

Both techniques presented for each well gave comparable number of converging minerals at a specified temperature range. The method using actual aluminum concentrations for the near-neutral and acidic types of fluid nevertheless gave nearer estimates or minor temperature differences when matched with the calculated reference temperatures by Fournier and Truesdell (1973) than the FixAl method.

Table 1: Difference of the final estimated temperatures calculated by the method of Pang and Reed (1984) with the temperatures calculated from Na-K-Ca geothermometry by Fournier and Truesdell (1973)

Well names	Methods	Final estimated temperatures (°C)* using the ±5 tolerance intervals	Calculated reservoir temperatures (°C) based on Fournier and Truesdell (1973)**	Difference (°C)
MG30D	FixAl	245-255 (5)	269	14-24
	measured Al	270-280 (5)		1-11
MG24D	FixAl	230-240 (4)	276	36-46
	measured Al	270-280 (5)		4-6
MG43D	FixAl	280-300 (2)	284	4-16
	measured Al	280-290 (2)		4-6

*Final estimated temperature of each method refers to the temperature which has the smallest difference from the reference temperatures and where the most number of minerals converged. The number of converging minerals is indicated in parentheses.
**Automatically computed by SOLVEQ.

The identity of minerals converging in the method using measured aluminum results were realistic of waters containing neutral and acidic types of fluid though they were not fully equivalent with the minerals enlisted on petrological reports.

2. Preliminary Results of Aluminum Sensitivity Calibration using SOLVEQ-XPT and Watch 2.4 Softwares

Located at the Bacman geothermal field, the CN-1 production well has been characterized as having shallow acid and deep neutral-pH, low-enthalpy fluids based on historical data. It initially discharged a mature (equilibrated), neutral and liquid-dominated fluid. However after several years of discharge, mixing with high-sulfate, cooler and acidic fluid was noted. In plotting log (Q/K) versus temperature, only certain minerals common to SOLVEQ and Watch 2.4 databases were preferred for clarity and ease of assessment. Aluminum was forced to equilibrate with microcline according to studies by Pang and Reed (1998) and Palandri and Reed (2001) wherein microcline is suitable for hydrothermal systems with pH between 5.5 and 9 and >6, respectively.

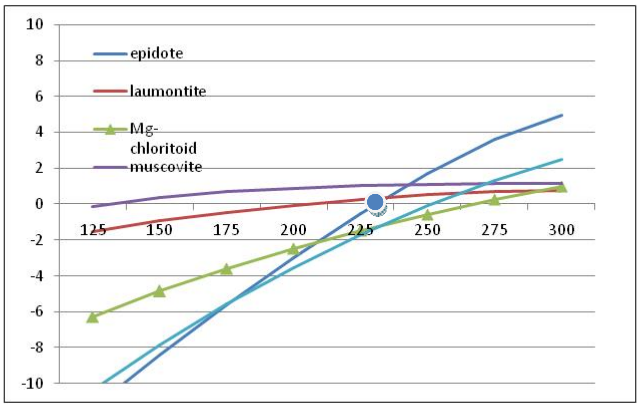

Figure 4: Saturation index vs temperature plot of CN-1 using SOLVEQ FixAl to microcline

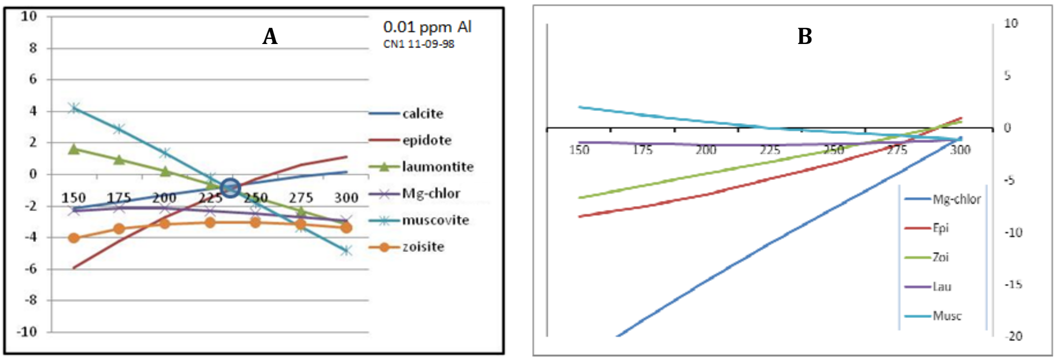

Figure 5: Saturation indices vs temperature plots of CN-1 using SOLVEQ (A) and Watch 2.4 (B) softwares at 0.01 mg/L Al concentration

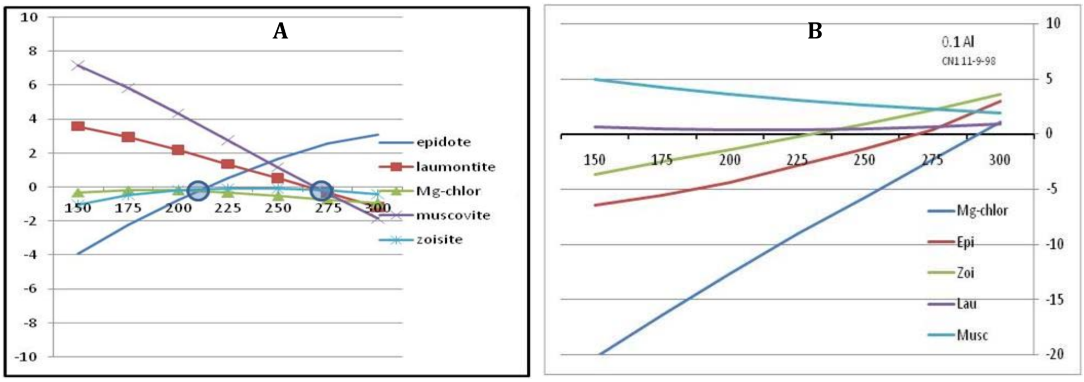

Figure 6: Saturation indices vs temperature plots of CN-1 using SOLVEQ (A) and Watch 2.4 (B) softwares at 0.10 mg/L Al concentration

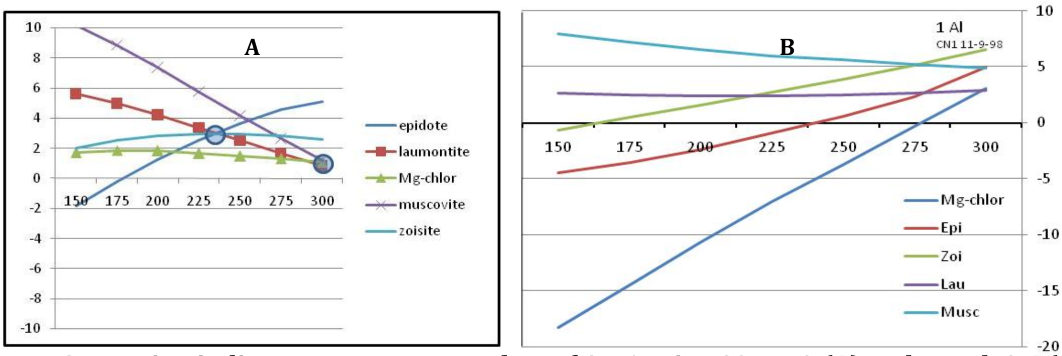

Figure 7: Saturation indices vs temperature plots of CN-1 using SOLVEQ (A) and Watch 2.4 (B) softwares at 1.0 mg/L Al concentration

The number of mineral curves that nearly crossed the zero log (Q/K) horizontal line at the same temperature, or the number of minerals that co-existed in equilibrium for almost all the plots, was not substantial, two to three was the maximum in most cases.

Table 2. Summary of estimated temperatures by SOLVEQ and Watch 2.4 softwares using numerous Al concentrations

Well name	Software	Al concentration (mg/L)	Estimated temperatures (°C)	Calculated reservoir temperature*(°C)
CN-1	SOLVEQ	0.01	237	270
	Watch 2.4		-	
	SOLVEQ	0.10	210 and 270	
	Watch 2.4		-	
	SOLVEQ	1.0	237 and 300	
	Watch 2.4		-	

*with cooler inflow of ~200°C

Using the SOLVEQ-FixAl method, the resulting temperature of convergence is at ~230°C, where epidote and laumontite minerals are in equilibrium with each other. The relatively low temperature of convergence seems reasonable considering the cooler (high SO_4) fluid inflow in the well; T_{quartz} for this sample is ~228°C while T_{NaK} is 265°C. No convergence was noticeable for all graphs when Watch program was used though a shift of curves is evident above the saturation index line equal to zero.

Based on the initial results, SOLVEQ with FixAl is recommended in reservoir fluid reconstruction (in the absence of laboratory analysis for trace aluminum). However, FixAl is dependent on the assumed mineral assemblage in the reservoir; in the absence of such data, e.g. exploration areas, thermal spring data; actual aluminum data are necessary for more accurate subsurface evaluation. Thus, development of analytical method for aluminum trace analysis in geothermal fluid must be pursued.

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