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Estimation of Reservoir Temperature Using Silica and Cationic Solutes Geothermometers: A Case Study in the Tengchong Geothermal Areas

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Reservoir temperature estimation is vitally important for assessing the geothermal exploitation potential of the Tengchong hydrothermal area. In this study, the concentrations of major chemical constituents in geothermal waters sampled from the boiling and hot springs in Tengchong were measured, based on which quartz and cationic solutes geothermometers were used to calculate the subsurface temperatures.Whether a geothermal water sample is in full equilibrium with the reservoir minerals is crucial for the selection of suitable geothermometers. Thus, log (Q/K) diagram and Na-K-Mg triangular diagram were applied to evaluating the equilibrium status between geothermal water and reservoir hostrocks. The results show that the samples RH01, RH03, RH04, RH05 and LL16 were in or very close to full equilibrium with the selected minerals, and Na-K geothermometer is reliable for them. K/Mg geothermometer, instead, is applicable to LP08 and PZH18 whose chemical compositions were adjusted to the shallow reservoir temperatures during their re-equilibrium processes. Generally, cationic solutes geothermometers are unsuitable for the samples SQ20 and RH07 located in the immature water area of the Na-K-Mg diagram, and quartz geothermometer was adopted to evaluate their corresponding subsurface temperatures. According to the reservoir temperature estimation made in this study, there is a high-temperature reservoir with a possible temperature range of 210 to 270 ℃ below Rehai.

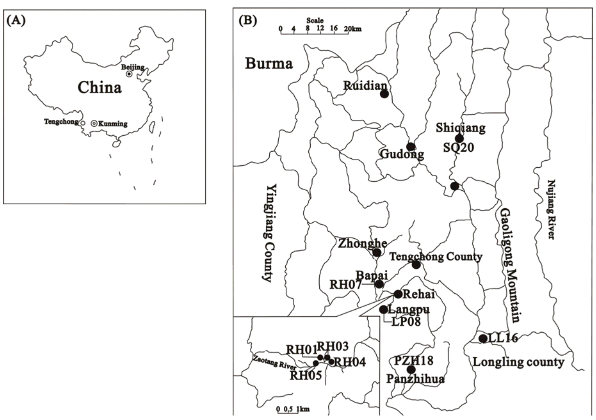

Fig. 1 Simplified map of Tengchong and sampling locations

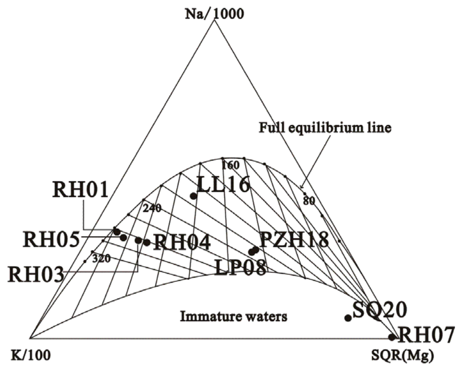

Fig. 2 Triangular Na-K-Mg diagram for geothermal water samples from Tengchong

Key words: chemical equilibrium; geothermometer; geothermal springs; Tengchong; Rehai

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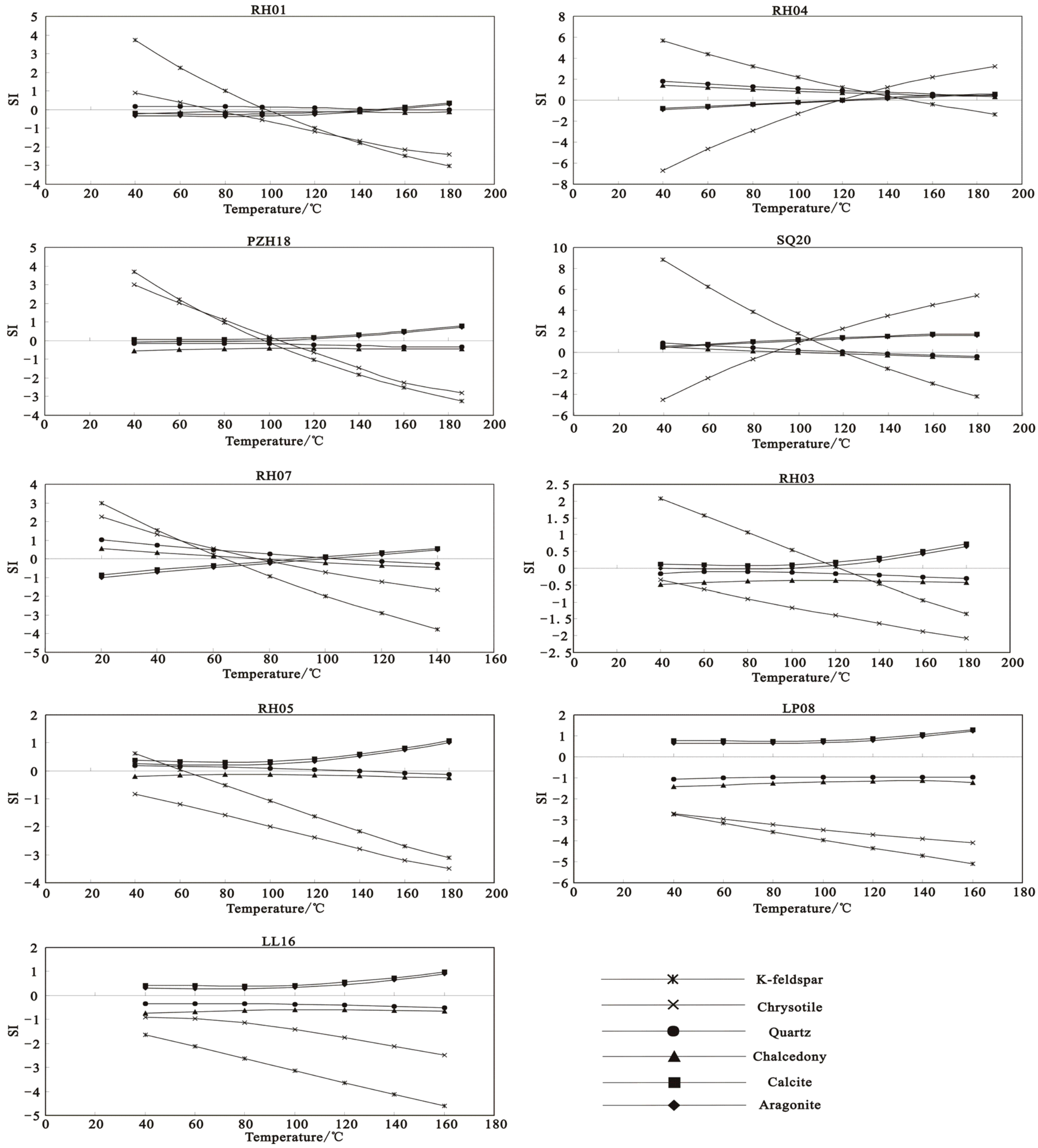

Fig. 3 Log (Q/K)-T diagrams for geothermal water samples

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Table 1 Characteristics of water samples from Tengchong

No.	Location	Date	Sample type	Tem (℃)	pH	Hydrochemical type	EC(μs/cm)
RH01	Dagunguo	2012.07.16	Hot spring	96.6	8.34	Na-HCO_3-Cl	4210
RH03	Huaitaijing-L	2012.07.16	Hot spring	88.0	8.35	Na-HCO_3-Cl	3350
RH04	Huaitaijing-R	2012.07.16	Hot spring	88.0	7.61	Na-HCO_3-Cl	2464
RH05	Gumingquan	2012.07.16	Hot spring	96.0	8.87	Na-HCO_3-Cl	3560
RH07	Bapai	2012.07.17	Hot spring	20.1	7.65	Na-Ca-HCO_3	163.6
LP08	Langpu Dagunguo	2012.07.17	Hot spring	70.0	8.16	Na-HCO_3-Cl	3020
LL16	Banglazhang	2012.07.20	Hot spring	66.0	8.77	Na-HCO_3	1021
PZH18	Xiaotang	2012.07.20	Hot spring	96.0	8.00	Na-HCO_3	1078
SQ20	Shiqiang	2012.07.21	Hot spring	62.0	6.93	Na-Ca-HCO_3	2456

Table 2 Concentrations of major chemical constituents in water samples from Tengchong (mg/kg)

No.	Alkalinity	SiO_2	SO_4^{2-}	Cl-	F	NO^{3-}	Ca	Mg	Na	K	Li
RH01	987.1	700	35.2	725.0	18.2	92.5	0.97	0.02	689.0	122.8	0.00
RH03	770.7	304	20.1	558.6	13.8	19.6	1.54	0.06	538.3	96.8	0.00
RH04	515.2	491	38.3	454.6	8.1	15.4	1.61	0.05	400.4	71.1	0.00
RH05	826.5	483	18.6	651.0	16.1	5.6	1.38	0.03	573.2	107.1	0.00
RH07	75.0	55	8.0	45.0	0.0	14.1	10.33	8.21	9.1	4.9	0.01
LP08	1217.9	150	28.2	336.9	11.7	5.1	3.84	0.98	573.8	55.9	2.89
LL16	505.2	172	38.9	54.5	19.3	0.0	1.36	0.01	203.5	15.2	3.03
PZH18	445.2	244	30.0	83.4	11.7	5.3	1.67	0.13	209.9	19.0	1.44
SQ20	1623.1	79	1.8	82.8	3.3	2.6	70.45	28.08	395.5	68.9	2.03

Table 3 Expressions for different geothermometers

Geothermometer	Expression	
Quartz(a)	$\theta_{SiO_2}℃=\frac{1309}{5.19-\log SiO_2}-273.15$	(1)
Quartz(b)	$\theta_{SiO_2}℃=\frac{1522}{5.75-\log SiO_2}-273.15$	(2)
Na/K(Fournier)	$\theta_{Na/K}℃=\frac{1217}{\log(Na/K)+1.483}-273.15$	(3)
K^2/Mg	$\theta_{K^2/Mg}℃=\frac{4410}{14-\log(K^2/Mg)}-273.15$	(4)

Table 4 Reservoir temperatures calculated using different geothermometers

No.	Location	Temperature/℃			
		Quartz(a)	Quartz(b)	Na/K	K-Mg
RH01	Dagunguo	285.08	250.79	272.10	264.42
RH03	Huaitaijing-L	210.39	192.70	273.04	227.42
RH04	Huaitaijing-R	250.68	224.41	271.64	217.37
RH05	Gumingquan	249.19	223.25	277.15	248.85
RH07	Bapai	106.31	106.44	422.75	52.91
LP08	Langpu Dagunguo	161.17	152.71	214.78	147.08
LL16	Banglazhang	170.21	160.15	193.29	176.87
PZH18	Xiaotang	193.97	179.52	208.63	144.03
SQ20	Shiqiang	124.90	122.32	269.66	101.46

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