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Geochemical Characteristics of Three Hot Springs from Western Thailand

Thiwat Rattanawong[1], Raphael Bissen[2], Waraporn Kumpairoh[1], Sakonvan Chawchai[1,3,*]

[1] MESA Research Unit, Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand

[2] Department of Mining and Petroleum Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok 10330, Thailand

[3] Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand

[*] Corresponding author: Email: sakonvan.c@chula.ac.th

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Abstract

At present a total of 118 hot springs are distributed throughout Thailand. Several studies with a focus on high-temperature hot springs related to geothermal resources were conducted in the northern and southern parts of the country. Geochemical data, however; especially isotopes of medium-to-low temperature hot springs are still scarce. Geochemical water analyses and isotope studies can provide crucial information for the future economical development of the hot springs, such as reservoir temperature, water source and quality. This study aims to investigate the chemical composition and stable isotopes ($\delta^{18}O$, δD) of three hot spring waters from western Thailand; Hin Dad, Bor Klueng and Ban Samorthong (surface water temperatures of 40-50 °C). The chemical type of the hot spring waters from Ban Samorthong and Bor Klueng are alkaline-carbonate, while Hin Dad hot spring is a calcium-carbonate type with high amount of sulfate, which is related to bedrock. Based on the silica geothermometer, reservoir temperatures are 65-90 °C. The stable isotopes $\delta^{18}O$ and δD of all hot spring waters suggest a recharge with meteoric waters. The three hot springs are well-known for public water recreation and health therapy. Bor Klueng, the least developed of the three hot springs is used by locals as a source of drinking water. Regarding toxic elements, Ban Samorthong hot spring has high fluoride (F^-) (14.84 mg L^{-1}); while Hin Dad hot spring shows concentrations of lead (Pb^{2+}) (0.07 mg L^{-1}) and Bor Klueng of Pb^{2+} (0.02 mg L^{-1}), and F^- (4.35 mg L^{-1}) which are above drinking water limits and might lead to health problems. In conclusion, the examination of elemental compositions and stable isotopes ($\delta^{18}O$, δD) of the three hot springs contributes to a better understanding of reservoir temperatures and recharge and can be beneficial for the natural resource development of medium-low temperature hot springs in Thailand.

Keywords: Water chemistry; Medium-low temperature hot springs; Western Thailand; $\delta^{18}O$ and δD isotopes

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Introduction

Hot springs (or thermal springs) can be found around the world and are a natural resource, which can be developed for tourism or be a source of geothermal energy. The potential use of hot springs largely depends on temperature and volume of the reservoir as well as the amount of waterflow within the reservoir [1]. Hot springs are well-known as geothermal resources in over 80 countries with geothermal utilization in 58 countries. Even low enthalpy thermal springs can be used for supporting geothermal power plants [2-5].

In Thailand, 118 hot springs have been found in the northern, western, eastern and southern parts of the country (Figure 1; [6-7]). The Department of Mineral Resources (DMR) has surveyed (surface temperature, pH and fluoride content) hot springs throughout Thailand and divided them into two types: (1) hot springs related to or originating from igneous rock fractures; (2) hot springs found in sedimentary rock layers overlying a granitic basement reservoir [6, 8]. Their surface temperatures are specific to certain regions and range between 40-100 °C: (1) hot springs in northern Thailand have the highest surface temperatures with >80 °C, (2) hot springs in southern Thailand have medium temperatures between 60 and 80 °C and (3) hot springs in western and eastern Thailand have the lowest surface temperatures between 40 and 60 °C. The usage of hot springs in Thailand mainly depends on their surface temperature; high-temperature hot springs are usually used for generating electricity and drying processes; medium-temperature hot springs are used for tourism and agriculture; and low-temperature hot springs are used for water supply, as recreational area and health therapy (Figure 1).

During the last decade, sixteen high-temperature hot springs in Thailand were investigated in detail by the Department of Groundwater Resources regarding their potential use as alternative energy source, and chemical properties were analysed, e.g. pH, total dissolved solids (TDS), anions (CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, F^-, NO_3^-) and compound cations (SiO_2, Na, K, Li, Ca, Mg, Fe, Mn, Zn, Cu, Cd, Pb, Al, As). The concentrations of Na-K-Ca and SiO_2 were used to calculate reservoir temperatures following Fournier (1973) and Arnórsson (1983) [9-10]. Five hot springs in northern and southern Thailand exhibited potential for a use as geothermal energy source. However, only hot springs in Chiang Mai (surface temperature >80 °C) were developed to produce electricity with a current production of 150-250 kWh a^{-1}, with new power plants under development [7, 11-14]. Previous studies of hot springs were focused on a naturally-occurring health hazard in drinking-water resources in northern Thailand due to high fluoride content [15]. In southern Thailand (Ranong, Surat Thani and Phang Nga Provinces), hot springs were examined with geological and geophysical methods, e.g. magnetotelluric, resistivity and gravity survey [16-18]. Kapong hot pring in Phang Nga Province has been recently investigated in detail with geophysical methods and geochemical water analyses [19]. In eastern Thailand, hot springs from Chanthaburi have been reported having high pH values (9.0), and exhibiting reservoir temperatures of 77-98 °C [20].

Although, most high-temperature hot springs in Thailand have been studied based on geophysical and geochemical methods regarding heat source, potential use and possible hazards, the medium- and low-temperature hot springs still lack data. In western Thailand, Bor Klueng hot spring (Figure 2) in Ratchaburi Province has only been investigated for the diversity of bacteria and notably high sulfur contents [21]. Hin Dad hot spring (Figure 2) in Kanchanaburi has been studied by resistivity survey together with electrical imaging for tourism management and subsurface exploration [22]. Another location with a lack of information is Ban

Samorthong hot spring (~200 km northeast of Hin Dad; Figure 2). Despite all these investigations, published geochemical data for western Thailand is unavailable. However, the availability of geochemical and hydrogeothermal data is important for the prospective economic development of hot springs.

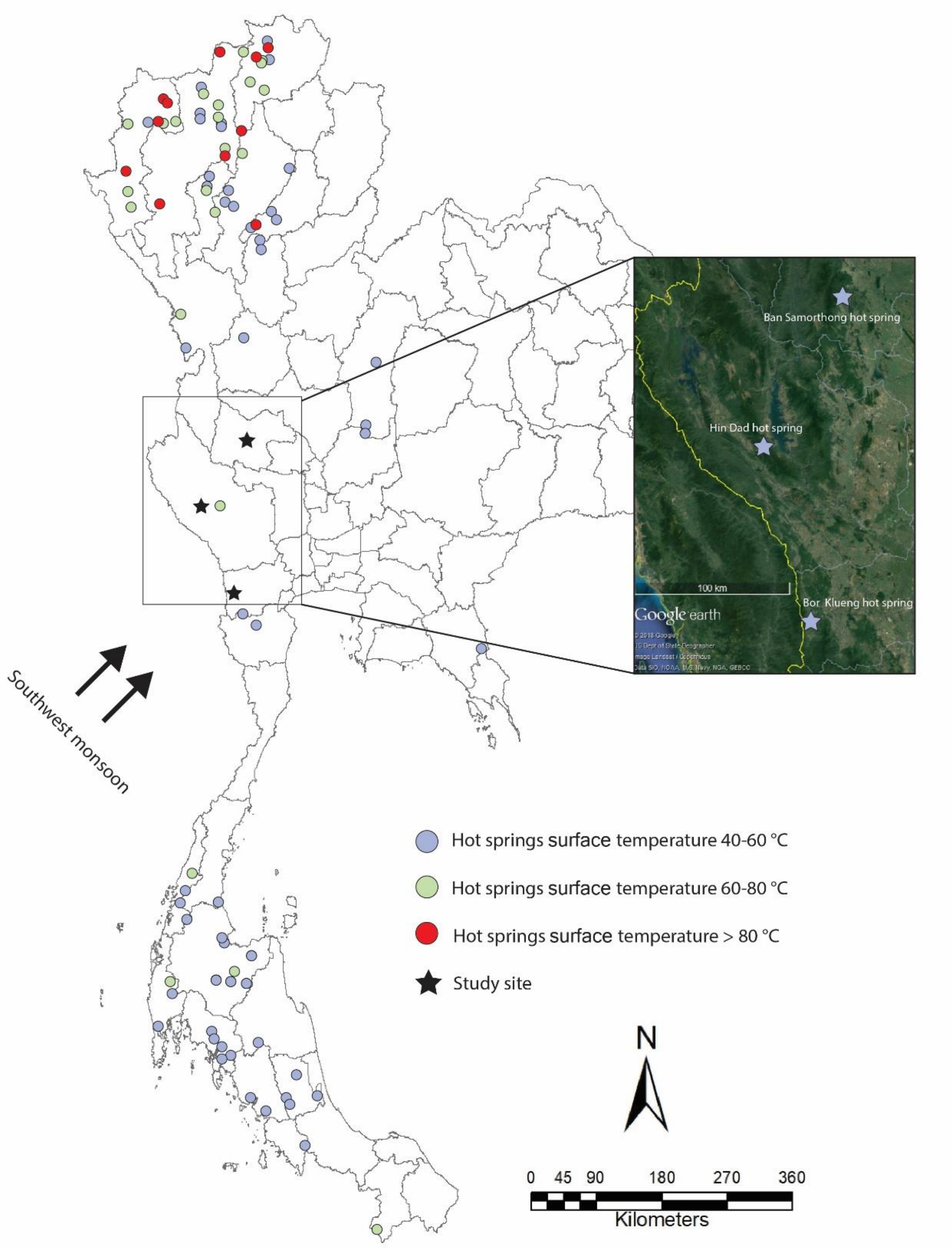

Figure 1 Map of Thailand showing hot spring locations based on Raksaskulwong (2005) and Ramingwong (2000) [6-7] and the study sites.

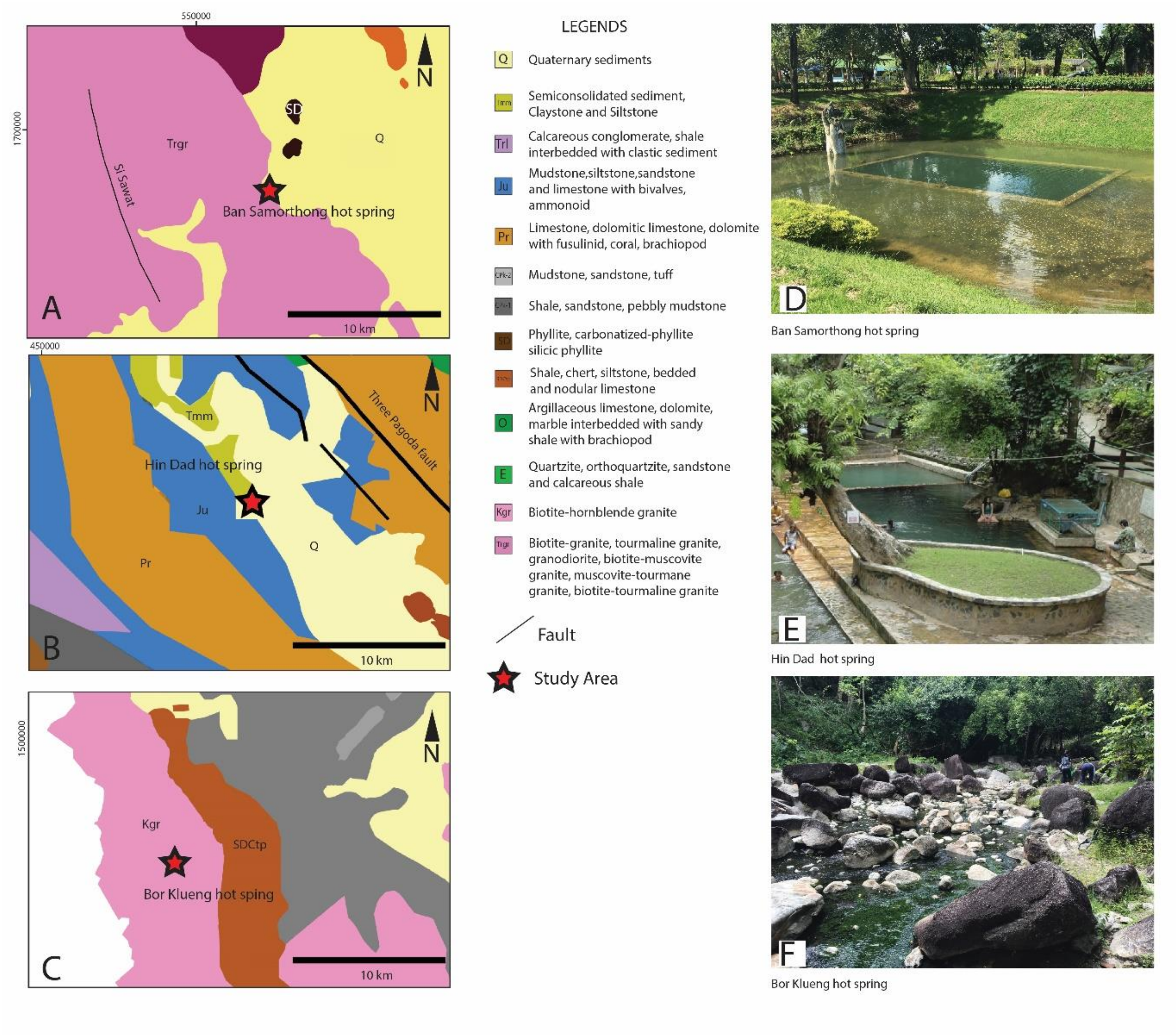

Figure 2 Geological map (modified after Department of Minerals Resources, 2007 [21-22]) and sampling locations of (A, D) Ban Samorthong, (B, E) Hin Dad and (C, F) Bor Klueng hot springs.

In this study, we examine elemental compositions and stable isotopes ($\delta^{18}O$, δD) of Bor Klueng, Hin Dad, and Ban Samorthong hot springs in western Thailand (Figure 1). The elemental composition is discussed in the context of the geological setting to delineate their possible variations in composition, providing insight into reservoir temperatures and water quality. Also, the $\delta^{18}O$ and δD isotopes are used to identify the source of water for each hot spring and lead to a better understanding of their nature.

Regional setting

The three study sites are located in western Thailand (Figure 2); Bor Klueng hot spring in the Suan Phueng District, Ratchaburi Province (13°31'09.4" N and 99°14'44.5" E), Hin Dad hot spring in the Thong Pha Phum District, Kanchanaburi Province (14°37'29.8" N, 98°43'33.6" E), and Ban Samorthong hot spring in the Huai Khot District, Uthai Thani Province (15°20'31.2" N and 99°30'54.6" E). While Hin Dad and Ban Samorthong are water plumes and well developed for tourism, Bor Klueng hot spring is a natural hot stream (~10 m wide) which originates from an open fracture in granite (Figure 2).

In western Thailand, hot springs are located nearby and along the fault lines of the Three Pagodas fault with fewer hot springs along the fault lines of the Sri Sawat fault [19, 21]. The large scale Three Pagodas fault group consists of NW–SE striking, sinistral strike slip faults with a length of at least 700 km, from the Mawlamyine District of Myanmar across central Thailand to south of Bangkok, where it enters the Gulf of Thailand [23]. Based on seismic and remote sensing data, Three Pagodas and Sri Sawat are considered to be active fault zones [24-25].

In terms of geology, Bor Klueng hot spring is situated in unit Kgr (Figure 2C), which consists of biotite-hornblende granite, muscovite granite, and porphyritic granodiorite, 10 km to the west of the Three Pagodas fault. Hin Dad hot spring is located in unit Q (Figure 2B), a quaternary alluvium sediment. The nearest rock units are Ju and Pr; Ju consisting of mudstone, siltstone, sandstone, and limestone, while Pr consists of limestone and dolomitic limestone interbedded with chert. Hin Dad hot spring is in the vicinity of a minor fault of the Three Pagodas fault group, ~ 5 km in a northeastern direction. Ban Samorthong hot spring is located within unit Trgr (Figure 2A), a Triassic granite. This granite has a coarse texture with orientated grains of feldspar, muscovite, tourmaline and quartz. This hot spring is located ~4 km north-east of a minor fault of the Sri Sawat fault group.

The climate of the study area is influenced by the southwest monsoon during summer (May-October) which brings warm and moist air from the Indian Ocean toward Thailand causing abundant rainfall, while the northeast monsoon causes drier conditions during winter (November-February). Between March and May, additional precipitation is probable due to tropical cyclones.

Material and methods

A total of 9 hot spring water samples were collected in October 2017 from the three study sites. At Ban Samorthong, water samples were pumped up from a groundwater well at a depth of 30 m. At Bor Klueng and Hin Dad, water samples were collected from pools, the source of which are water plumes with water reaching the surface through fractures. Surface temperature, pH and electric conductivity (EC) were measured in the field by AquaPro Water Quality Tester and portable pH meter Oxi 325-B Oximeter (WTH; water test hand-bag). All water samples were filtered through 0.2 μm membranes before bottling. Polyethylene plastic bottles were used to collect the samples, avoiding any contaminants. Reagent quality HNO_3 was added to the samples for metal ion analysis. For the SiO_2 analysis, the water samples were diluted 1:10 using deionized water to prevent the precipitation of SiO_2.

The water samples were analyzed by ion chromatography to measure cations (Na^+, K^+, Mg^{2+}, Ca^{2+}, Si^{4+}) and anions (F^-, Cl^-, Br^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, HCO_3^-), using mix-standards from Sigma-Aldrich (89886 and 89316). Elements exhibiting low concentrations (Ba, Fe, Cu, As, Pb, Zn and Cd) were measured by ICP-MS, using the multi-element calibration standard 2A from Agilent Technologies (8500-6940). All water samples were analyzed at the Department of Geosciences, National Taiwan University, Taiwan.

For isotopic analysis ($\delta^{18}O$ and δD), the samples were collected in polyethylene bottles with no chemical agents added and subsequently measured by PICARRO cavity ring-down spectrometer (L2130-i Isotopic H_2O) at the Thailand Institute of Nuclear Technology laboratory, Thailand. Isotopic results are reported as relative (per mill, ‰) to the international standard Vienna Standard Mean Ocean Water (VSMOW). The measurement precision for $\delta^{18}O$ and δD are 0.1‰ and 0.5‰, respectively.

Results and discussion

1) Hydrochemistry

Hin Dad hot spring water has the highest EC of 835 and TDS of 760 mg L^{-1}, followed by Ban Samorthong and Bor Klueng hot springs (Table 1). Hin Dad hot spring also has the highest concentrations of major cations and Ca+Mg > Na+K, while Ban Samorthong and Bor Klueng have concentrations of Na+K > Ca+Mg (Figure 3). At all of the three study sites, the anions present in the highest concentrations are HCO_3^- > SO_4^{2-} >> Cl^- >>> NO_3^-. At Hin Dad the major cations and anions are Ca^{2+} and HCO_3^- and CO_3^{2-}. These ions come from the dissolution of calcareous rocks. Dissolved Ca and Mg contribute to the water hardness. While water at Bor Klueng and Ban Samorthong are soft, Hin Dad with 151.97 mg L^{-1} of Ca^{2+} is classified as hard water (www.usgs.gov). The SO_4^{2-} content in Hin Dad hot spring water is considered high with 125 mg L^{-1}. Based on the geological setting, calcareous rocks (limestone) are dominant at the Thong Pha Phum District around Hin Dad Region (Figure 2B). At Ban Samorthong and Bor Klueng the major cations and anions are Na^+, K^+, HCO_3^- and CO_3^{2-}, which suggest an alkali carbonate water or deep groundwater influenced by ion exchange. In addition, the concentrations of Na^+, K^+, and F^- at Ban Samorthong and Bor Klueng hot spring are higher than at Hin Dad. The weathering of silicate minerals (e.g. mica and feldspar) is a common source of dissolved Na and K, that are dominant in felsic rocks around both Ban Samorthong and Bor Klueng (Figure 2A, C).

Table 1 Hot spring water chemistry

Study sites	**Bor Klueng**	**Hin Dad**	**Ban Samorthong**	**Health-based guideline by the WHO**
Temperature (°C)	52.0	42.2	53.7	-
pH	7.82	7.56	8.10	-
EC (S m^{-1})	0.024	0.084	0.051	-
Ca^{2+} (mg L^{-1})	10.85	151.97	3.24	-
Mg^{2+} (mg L^{-1})	0.97	24.44	0.06	-
Na^+ (mg L^{-1})	29.37	12.49	109.38	200 mg L^{-1}
K^+ (mg L^{-1})	8.41	3.48	4.76	-
Ba^{2+} (mg L^{-1})	0.06	0.16	0.06	1.3 mg L^{-1}
Fe (mg L^{-1})	0.06	0.07	0.04	-
Cu (mg L^{-1})	0.003	0.001	0.00	2 mg L^{-1}
As (mg L^{-1})	0.011	0.008	<0.001	0.01 mg L^{-1}
Pb (mg L^{-1})	0.02	0.07	0.01	0.01 mg L^{-1}
Zn (mg L^{-1})	0.27	0.61	0.17	3 mg L^{-1}
Cd (mg L^{-1})	<0.001	<0.001	<0.001	0.003 mg L^{-1}
HCO_3^- (mg L^{-1})	112.89	463.75	233.67	-
SO_4^{2-} (mg L^{-1})	3.58	125.43	15.92	500 mg L^{-1}
Cl^- (mg L^{-1})	4.16	2.81	6.37	250 mg L^{-1}
F^- (mg L^{-1})	4.35	0.76	14.84	1.5 mg L^{-1}
NO_3^- (mg L^{-1})	1.02	0.51	0.62	50 mg L^{-1}
SiO_2 (mg L^{-1})	29.20	20.80	38.20	-
TDS (mg L^{-1})	181	760	382	-
δ D (‰)	-43.44	-33.85	-54.79	-
$\delta^{18}O$ (‰)	-7.08	-5.56	-8.14	-

Remark: Values presented are the average values of 3 samples.

Table 2 Percentage distribution among species of Ba, Fe, Cu, As, Zn and Cd compounds

Component	Species name	Bor Klueng	Hin Dad	Ban Samorthong
Ba^{+2}	Ba^{2+}	96.51	62.96	89.33
BaF^{+}		0.06	-	0.20
$BaCl^{+}$		0.02	-	0.02
$BaSO_{4(aq)}$		1.45	33.22	5.98
$BaNO_3^{+}$		0.02	-	0.01
$BaCO_{3(aq)}$		0.32	0.33	1.24
$BaHCO_3^{+}$		1.61	3.46	3.21
Fe^{+2}	Fe^{2+}	81.38	44.42	63.39
$FeOH^{+}$		13.98	2.01	23.09
$Fe(OH)_{2(aq)}$		0.06	-	0.22
FeF^{+}		0.30	0.03	0.80
$FeSO_{4(aq)}$		2.92	50.86	10.26
$FeHCO_3^{+}$		1.35	2.68	2.23
Cu^{+2}	Cu^{2+}	2.60	2.01	0.70
$CuOH^{+}$		18.16	4.65	10.01
$Cu(OH)_{2(aq)}$		15.12	1.00	17.77
$Cu_2(OH)_2^{+2}$		0.40	0.01	-
$Cu_3(OH)_4^{+2}$		0.02	-	-
CuF^{+}		0.05	-	0.44
$CuSO_{4(aq)}$		0.09	2.18	0.11
$CuCO_{3(aq)}$		62.66	87.79	68.25
$CuHCO_3^{+}$		0.22	0.61	0.12
$Cu(CO_3)_2^{-2}$		0.69	1.76	3.03
AsO_4^{-3}	As^{5+}	88.19	-	0.04
$HAsO_4^{-2}$	As^{3+}	11.79	78.36	93.45
$H_2AsO_4^{-}$	As^{5+}	11.79	21.64	6.51
Pb^{+2}	Pb^{2+}	5.03	2.95	1.44
$PbOH^{+}$		18.65	4.17	10.66
$Pb(OH)_{2(aq)}$		0.18	0.03	0.18
PbF^{+}		0.16	0.02	0.16
$PbCl^{+}$		0.03	0.01	0.01
$PbSO_{4(aq)}$		0.28	5.79	0.35
$Pb(CO_3)_2^{-2}$		0.73	1.42	3.42
$PbCO_{3(aq)}$		69.66	74.36	80.57
$PbHCO_3^{+}$		5.29	11.25	3.21
Zn^{+2}	Zn^{+2}	55.50	36.77	30.12
$Zn(CO_3)_2^{-2}$		0.02	0.04	0.16
$ZnOH^{+}$		23.94	4.19	27.56
$Zn(OH)_{2(aq)}$		3.09	0.51	6.09
ZnF^{+}		0.37	0.04	0.69
$ZnCl^{+}$		0.02	-	0.02
$ZnSO_{4(aq)}$		1.67	37.14	4.09
$ZnCO_{3(aq)}$		13.06	15.73	28.60
$ZnHCO_3^{+}$		2.32	5.57	2.66

Table 2 Percentage distribution among species of Ba, Fe, Cu, As, Zn and Cd compounds (*continued*)

Component	Species name	Bor Klueng	Hin Dad	Ban Samorthong
Cd^{+2}	Cd^{2+}	81.79	39.95	57.38
	$CdOH^{+}$	2.71	0.35	4.03
	CdF^{+}	0.35	0.03	0.85
	$CdCl^{+}$	0.98	0.32	1.06
	$CdSO_{4(aq)}$	2.87	46.25	9.13
	$CdHCO_3^{+}$	3.42	6.06	5.09
	$CdCO_{3(aq)}$	7.84	6.96	22.20
	$Cd(CO_3)_2^{-2}$	0.023	0.04	0.27

Remark: Values presented are the % of total concentration

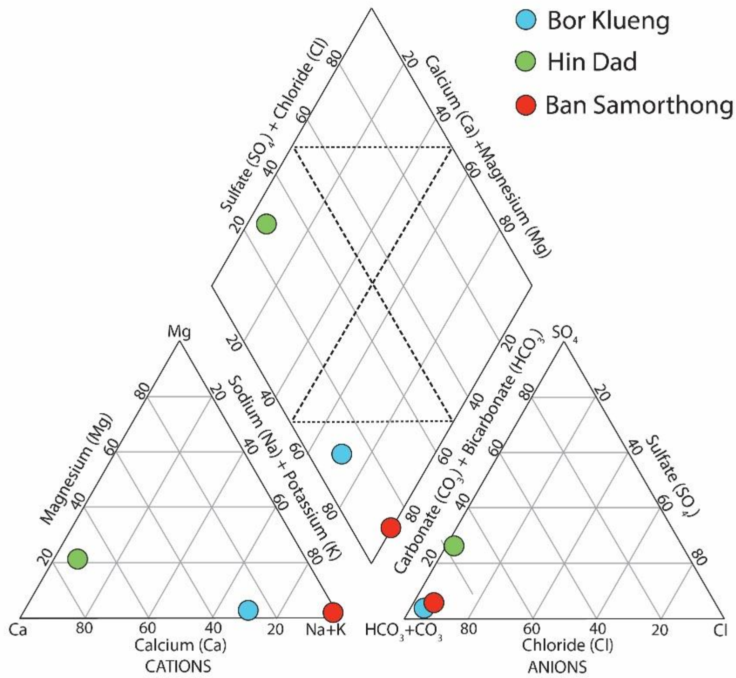

Figure 3 Piper diagram of all hot spring water samples.

In addition, the computer programs MINTEQ (https://vminteq.lwr.kth.se/) was used to calculate the speciation for the prevailing conditions (T, pH, Eh, and ion contents). The speciation results (Table 3) show that Ba, Fe, Cu, Pb, Zn and Cd are in oxidation state II (Ba^{2+}, Fe^{2+}, Cu^{2+}, Pb^{2+}, Zn^{2+}, Cd^{2+}) at all three locations. At Hin Dad 78% of As is present in the form of As^{3+} and 93% at Ban Samorthong. Only at Bor Klueng, 88% of As are in oxidation state V (As^{5+}). Regarding toxic elements, Bor Klueng and Ban Samorthong exhibit fluoride (F^{-}) contents exceeding the WHO limits for drinking water. In addition, Bor Klueng and Hin Dad exceed the limits for lead (Pb^{2+}).

Minerals such as micas (biotite, muscovite), amphiboles (hornblende) and fluorite (CaF_2) are reported to be among the sources of fluorine in rocks [15, 26-27]. Biotite and hornblende are present in the granite bedrock at Bor Klueng and Ban Samorthong. The high F^{-} levels in water from hot springs are probably due to the chemical weathering of fluoride-bearing minerals, which happens upon contact with the hot water.

Hin Dad and Bor Klueng are part of the western metallogenic province in Thailand, while Ban Samorthong is part of the central metallogenic province. Lead and fluorite deposits can be found in all three provinces, as hydrothermal vein deposits and/or stratiform deposits (Ordovician limestone, Kanchanaburi). Thong Tha Phum District exhibits a high potential for Pb-Zn deposits. Common minerals are galena (PbS) and cerrusite ($PbCO_3$). A lower pH also contributes to the mobility of Pb ions.

2) Reservoir temperature

Hot spring water samples were plotted in the Na-K-Mg ternary diagram (Figure 4). The Na-K-Mg diagram can provide a comparison of the temperature dependence of the Na/K ratio of geothermal water with the K/Mg ratio. This elemental ratio is controlled by the equilibrium between geothermal water and a mineral assemblage composed of albite (Na-feldspar), orthoclase (K-feldspar), muscovite and clinochlore (Chlorite group). The diagram (Figure 4) can be used to classify water as fully equilibrated with rocks, partially equilibrated (mixed), or immature at given temperatures [28]. Our results show that the hot springs at Bor Klueng and Hin Dad are immature waters, which suggests a mixing of groundwater and meteoric water. Only Ban Samorthong hot spring water samples are partially equilibrated. The water samples of Ban Samorthong, which were pumped from 30 m below ground surface, indicate a partial dissolution of surrounding rocks and mixing with the hot spring water.

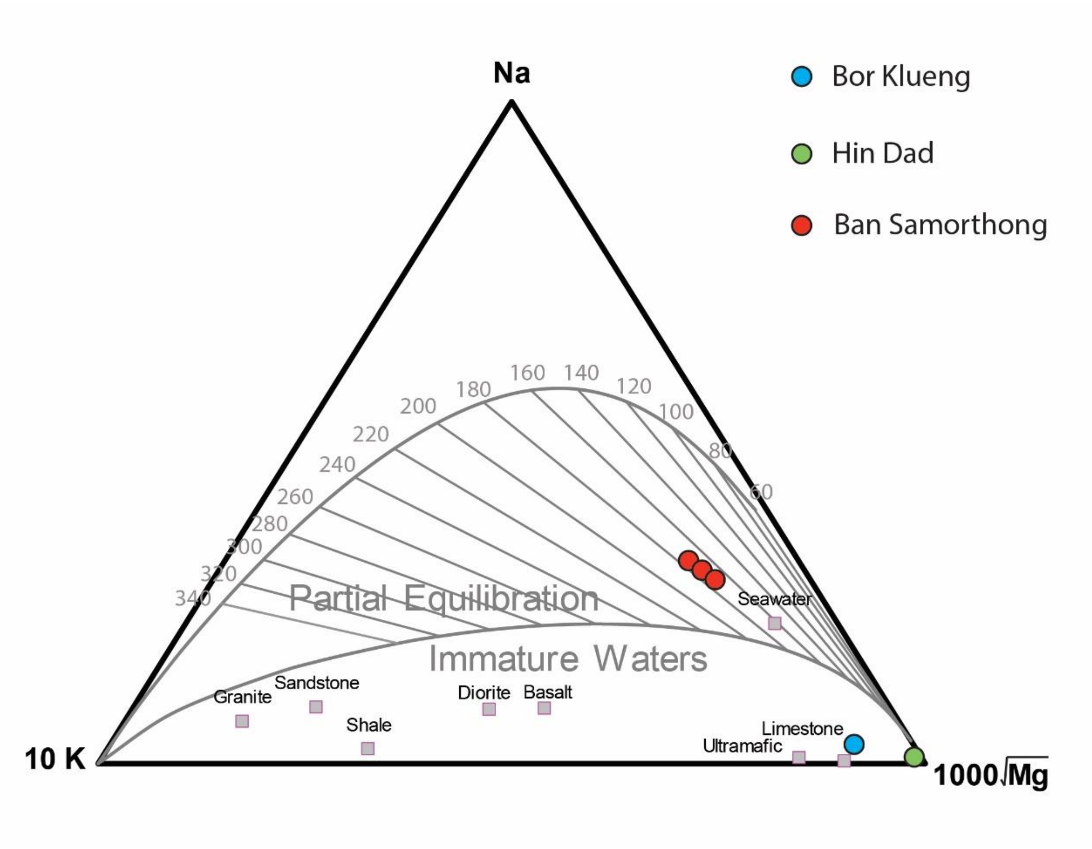

Figure 4 Ternary diagram Na-K-Mg$^{1/2}$ [28] for the three hot spring water samples.

Based on the amount of dissolved SiO_2 and the surface temperature, the silica solubility curve indicates the SiO_2 is present in the form of quartz at all three hot springs. At low temperatures, the ratio of Na/K is mostly affected by mineral dissolution and might not be at equilibrium yet [28]. In this study, the reservoir temperatures are calculated using the equations of Fournier (1977); quartz-no steam loss and quartz-after steam loss [29]. At Ban Samorthong, water samples were pumped from a groundwater well at a depth of 30 m, and assumed "no steam loss". At Bor Klueng and Hin Dad, water samples were collected from pools. Their sources are water plumes with water reaching the surface through fractures. Consequently, we assume for both sites "maximum steam loss". The calculated reservoir temperatures were ranging from 65-70 °C at Hin Dad, 78-82 °C at Bor Klueng and 90-92 °C at Ban Samorthong (Table 3).

At the present time the three hot springs are mainly used as recreation area by locals and tourists. However, their temperatures are promising with regard to a potential future use for electricity generation via low-temperature resources systems (www.climeon.com). A combination of geochemical data and geophysical methods can lead to a better understanding of the hot springs. The use as an energy source could prove to be extremely useful for small-scale industries/businesses (e.g. drying process, heat pump system).

3) Stable oxygen and hydrogen isotopes

The δD and $\delta^{18}O$ values of each hot spring are plotted and compared to the global meteoric water line (GMWL, $\delta D = 8\,\delta^{18}O + 10$) [30] and the local meteoric water line (LMWL) at the nearest locations (Figure 5). In this study, we reconstructed the LMWL from precipitation data (2015-2017) of two rain stations, in the Kanchanaburi and Nakhon Sawan Provinces. The local meteoric water lines of both stations are lower than GMWL (Figure 5).

The δD and $\delta^{18}O$ isotopes of Ban Samorthong have the lowest values, δD of -54.79 ‰ and $\delta^{18}O$ of -8.14 ‰, followed by Bor Klueng hot spring (δD of -43.44 ‰ and $\delta^{18}O$ of -7.08 ‰), and the highest values (δD of -33.85 ‰ and $\delta^{18}O$ of -5.56 ‰) at Hin Dad hot spring. The data plotted mostly within the GMWL (Figure 5), suggesting a precipitation-related water source. Bor Klueng water isotopes values plot slightly above the GMWL line. The differences in isotope values for each hot spring can be due to continental effects, e.g. distance from the coast and altitude (the further from the coast the lower the values, the higher the altitude the lower the values and vice versa). Ban Samorthong hot spring, farthest from the western coast, has the lowest values. The distance of Hin Dad and Bor Klueng hot spring from the ocean is similar, but there is a difference in altitude between the two locations of c. 100 m, with Hin Dad at c. 100 m and Bor Klueng at c. 200 m above mean sea level (MSL).

Table 3 Reservoir temperatures calculated using silica geothermometer

Mineral	Equations	References	Temperature (°C)		
			Bor Klueng	Hin Dad	Ban Samorthong
Quartz-no steam loss	$t(°C) = \frac{1309}{5.19 - \log S} - 273.15$	Fournier (1997) [29]	78	65	90
Quartz-after steam loss	$t(°C) = \frac{1522}{5.19 - \log S} - 273.15$	Fournier (1997) [29]	82	70	92

Remark: S represents silica concentration as SiO_2 in mg kg^{-1}.

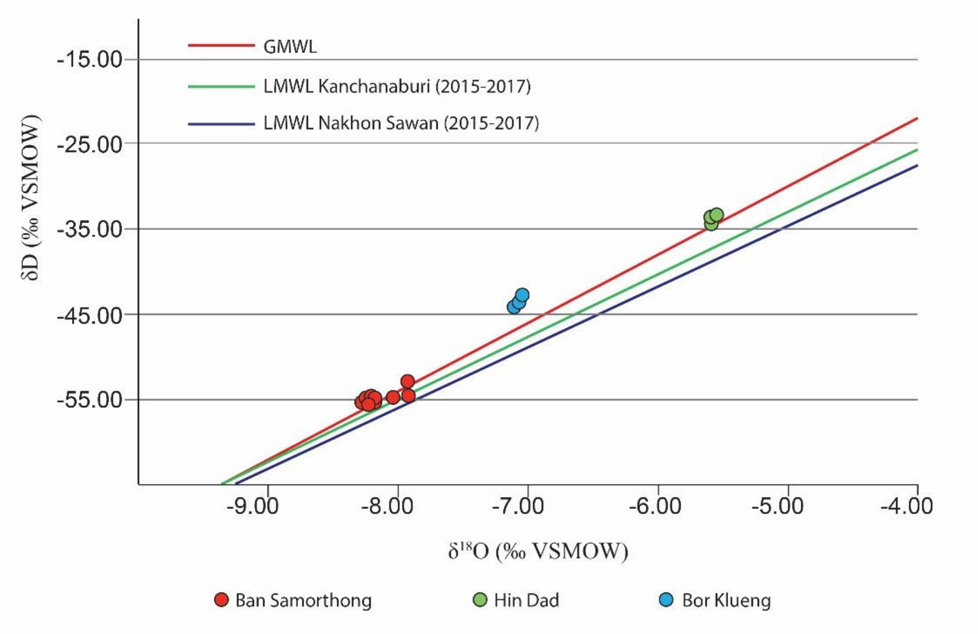

Figure 5 Plot of δD values versus $\delta^{18}O$ values of three hot springs. GMWL represents the Global Meteoric Water Line [30] and LMWL represents the Local Meteoric Water Line of the two nearest stations in Kanchanaburi and Nakhon Sawan.

Conclusions

Three selected hot springs from western Thailand exhibit different geochemical characteristics and can be divided into 2 types: (1) $Na\text{-}K\text{-}HCO_3$, Ban Samorthong and Bor Klueng and (2) $Ca\text{-}HCO_3\text{-}SO_4$, Hin Dad. Each of them features slight differences in elemental compositions which are due to their initial water composition and the interaction with the surrounding rocks. Based on silica geothermometer, the reservoir temperature for Ban Samorthong was calculated to be 90 °C, 82 °C for Bor Klueng and 70 °C for Hin Dad. The temperatures are promising with regard to a potential future use for electricity generation via low-temperature resources systems. Local precipitation is the main recharge water for the three hot springs, accordingly, the stable isotopes of the water samples plot closely to the global meteoric water line in a δD and $\delta^{18}O$ diagram. Different isotope ratios at each hot spring are a result of location and altitude. In conclusion, geochemical information of the three hot springs from western Thailand can be used as a database for development of medium-low temperature hot springs and as a guideline for further hydrological and geothermometry studies in the area.

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