The origin of Northern Thailand geothermal systems as indicated by isotopic hydrogeology

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Abstract

Fang, San Kamphaeng, Pa Pae and Mae Chan are among the five highest potential geothermal resources in Thailand. Their systems are similar in character of hot-water dominated type, high pH, with sodium carbonate species and are associated with granitic rocks. The investigated isotopic elements were tritium, deuterium and oxygen-18. The deuterium and oxygen-18 values suggest the origin of water may have been derived from local precipitation, possibly from somewhat higher altitudes. Small numbers of tritium unit present in these water indicate a short period of circulation as groundwater of these thermal fluids or mixing with low-tritium hot fluids.

Extended Synopsis

Over sixty hot springs localities are scattered throughout Thailand. The surface temperatures of discharged hot water range from 40° to 100° C. Most of these hot springs are associated with granitic rocks of various ages and thus, limitted the hot spring areas to the northern and western granitic belts of Thailand. Among these, five highest potential areas which their inferred chemical geothermometer range from 170°-200°C are located in the north, they are San Kamphaeng, Fang, Pa Pae and Mae Chaem of Chiang Mai Province and Mae Chan of Chiang Rai Province (Figure 1).

Isotopic hydrogeochemical study were performed on San Kamphaeng, Fang, Pa Pae and Mae Chan geothermal systems on three isotopic species, oxygen-18, deuterium and tritium[1, 2, 3] and unpublished data (Table 1 Ratanasthien and Louvat, 1987). The isotopic results of oxygen-18 and deuterium show isotopic ratio lie close to the meteoric line. The results of those thermal water are trending toward negative value. The more positive value of surface and shallow groundwater in the same area could indicate the origin of thermal fluid may have been derived from meteoric water of somewhat higher altitude.

Tritium isotopic analysis indicate the thermal water contain small tritium value. The data from Fang, Pa Pae and Mae Chan show slightly higher value than those of San Kamphaeng. When compare with the surface runoff the results show that the thermal water in these areas are essentially very young and derived from local precipitation possibly from somewhat higher altitudes. The lower tritium unit of San Kamphaeng system than the others could be attributed either to the longer period of groundwater (meteoric origin) circulation before being heated up and discharged as hot springs and/or a different mixing ratio between deep and shallow groundwater.

Geochemical characteristics of these geothermal systems are similar. They all are characterized as hot-water dominatedtype with sodium-bicarbonate species. Surface and groundwater as well as thermal fluids discharged as hot springs or from exploratory drilling wells show over long periods of time the chemical compositions varying within narrow limits and containing small amounts of dissolved solid. The observations also show a seasonal fluctuation in concentration on some chemical species in thermal water such as sodium, potassium, calcium and bicarbonate suggesting that these geothermal systems represent secondary reservoirs. They occur above or at the perimeters of the main reservoirs of sodium-bicarbonate-fluoride water where the principal primary reservoir of sodium-fluoride might extend to the depth of several kilometers. The formation of sodium-bicarbonate-fluoride water is believed to be the result of interaction between the descending calcium-magnesium-bicarbonate meteoric water and sodium-fluoride dominated thermal water. Calcium and magnesium have been removed from the system by the deposition of fluorite and magnesium clay minerals such as chlorite which have been found associated with most of the hot springs. Consequently, the ascending hot water iscertainly dominated by the less reactive or easily dissolved species such as sodium, bicarbonate, and some excess fluoride ions. The mixing zone between the hot sodium-fluoride water and heated meteoric water is easily recognizable by fluorite formation and intensive rock silicification due to a rapid decrease in reservoir temperature. This causes the precipitation of silica and resulting in theformation of a self-sealing barrier, controlling the direction of the flowwater and chemical equilibrium. The system is stable within certain limitsof chemical composition unless ithas been disturbed by seismic waves. Insuch circumstances, abnormally high concentration of some particular ions such as fluoride, chloride, sodium, etc. are expected.

The heat source of Thailand geothermal systems are not clearly understood. The association with granite, which influences their chemical composition, could not conclude whether the water in the reservoir heated

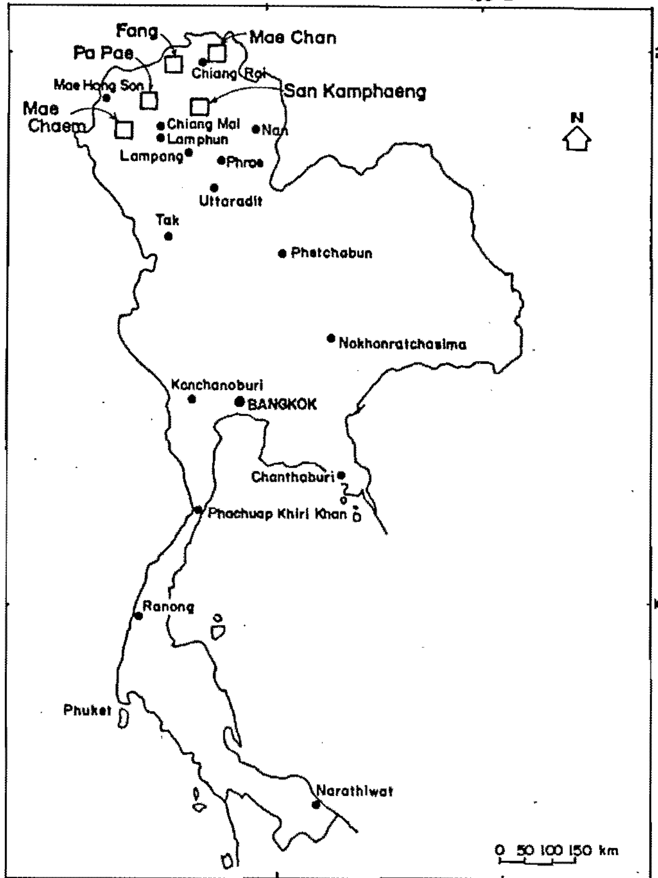

Fig. 1 Five highest geothermal potential areas in northern Thailand.

Table 1 Chemical data (in meq/l) of hot springs, cold springs, stream and shallow groundwater in San Kamphaeng, Fang, and Mae Chan geothermal areas.

CODE	Temp.	Oxy-18	Deut	Trit	pH	Ca	Na	K	Mg	Cl	SO_4	HCO_3	Si	F
Thermal water														
CM-6	98.0	-7.45	-52.4	4.9	8.88	0.01	6.17	0.33	0.00	0.70	0.09	5.03	12.67	1.08
CM-7	78.0	-6.96	-48.0	0.0	7.54	0.01	6.17	0.34	0.00	0.36	0.26	6.67	13.02	0.97
CM-8	102.0	-7.39	-48.1	0.8	8.38	0.01	6.26	0.33	0.00	0.57	0.12	6.11	13.24	1.03
CM-9	97.0	-7.48	-53.0	0.9	8.27	0.01	6.04	0.28	0.00	0.37	0.11	6.89	11.81	0.93
CM-10	64.0	-7.63	-47.7	1.6	7.98	0.03	6.00	0.26	0.00	0.50	0.08	6.70	11.39	0.91
CM-11	97.0	-7.59	-52.3	1.4	7.96	0.01	6.26	0.34	0.001	0.39	0.05	6.66	13.31	1.00
CM-17	99.5	-7.70	-55.0	0.6	8.04	0.04	5.57	0.26	0.01	0.34	0.70	4.43	13.88	1.03
CM-18	95.0	-7.85	-57.0	0.8	8.01	0.08	5.52	0.28	0.01	0.34	8.94	4.23	13.88	1.12
CM-27	96.0	-8.46	-60.1	0.0	8.56	0.01	4.87	0.24	0.00	0.33	0.07	3.85	14.66	1.13
CM-28	98.0	-8.28	-58.6	0.0	9.10	0.01	5.22	0.25	0.00	0.38	0.08	3.18	15.80	1.21
CM-29	97.0	-8.42	-60.4	0.3	8.74	0.00	4.96	0.23	0.00	0.49	0.12	3.26	15.37	1.26
CM-30	95.0	-8.37	-61.6	0.6	9.06	0.01	4.78	0.23	0.00	0.41	0.15	3.56	14.23	1.06
CM-31	95.0	-8.52	-61.8	0.3	8.16	0.01	4.61	0.00	0.00	0.45	0.13	2.59	14.21	1.21
CM-32	97.5	-8.45	-61.6	0.3	8.29	0.01	4.74	0.00	0.01	0.48	0.15	4.89	18.08	1.05
CM-33	90.0	-8.60	-61.9	0.1	8.36	0.01	4.43	0.00	0.00	0.48	0.10	3.43	14.80	1.13
CM-34	98.0	-8.45	-60.6	0.0	8.69	0.11	4.78	0.00	0.03	0.40	0.14	2.54	15.37	1.26
CM-36	100.0	-8.44	-62.9	0.5	8.45	0.01	3.93	0.23	0.00	0.37	0.02	3.98	16.37	1.13
Cold spring, stream and shallow groundwater														
CM-1	28.0	-8.00	-48.7	1.7	5.41	0.03	0.01	0.04	0.07	0.07	0.01	0.19	1.57	0.01
CM-2	38.0	-8.04	-54.7	0.7	5.85	0.26	0.10	0.11	0.28	0.02	0.01	1.30	1.85	0.02
CM-3	27.3	-5.69	-41.8	9.0	6.93	2.59	0.45	0.02	3.45	0.04	0.02	10.39	;5.55	0.06
CM-5	28.0	-7.25	-47.3	7.9	6.78	2.26	0.27	0.02	1.76	0.05	0.03	4.92	5.55	0.01
CM-12	28.5	-6.52	-45.8	7.3	7.05	3.96	0.37	0.02	2.17	0.04	0.21	7.33	4.04	0.02
CM-13	28.0	-5.56	-39.7	8.2	7.97	3.21	0.26	0.03	1.92	0.02	0.2	6.03	3.59	0.03
CM-16	24.0	-6.73	-44.2	7.8	7.40	0.42	0.23	0.04	0.25	0.06	0.03	1.21	1.88	0.01
CM-19	26.0	-7.98	-57.1	10.4	6.40	0.61	0.17	0.05	0.26	0.02	0.35	1.19	2.19	0.01
CM-20	26.5	-6.79	-48.9	11.7	6.61	0.76	0.26	0.03	0.26	0.04	0.00	1.48	2.59	0.01
CM-25	24.5	-8.27	-57.4	7.2	7.24	7.65	0.11	0.05	0.83	0.01	0.12	6.82	0.28	0.01
CM-26	26.0	-5.92	-38.4	9.1	6.70	3.10	0.41	0.06	0.64	0.02	0.44	3.90	2.31	0.01
CM-35	22.0	-8.50	-61.1	8.6	7.81	0.28	0.10	0.00	0.12	0.01	0.01	7.70	2.02	0.01

up by steam and gases from hydrothermal fluids, or by a long term heat transfer produced from chemical reaction, fault movements, or radioactive disintegration. These principal reservoir thermal waters are not considered to be hydrothermal fluids, products of magmatizaion, because they contain only a small proportion of typical hydrothermal elements such as boron and chloride. These reservoirs are considerably deeper than the thermal spring waters, which are believed to be ascending from secondary reservoirs. Small amounts of calcium and magnesium, sometimes absent in hot spring fluids compared with ordinary groundwater, indicate that the resident time of interaction must have been long enough for neoformation and separation of new minerals. The high surface temperature of hot springs and small number of tritium content could suggest that the hot waters may be very young or high degree of mixing by meteoric water, and suggest that the water inthe secondary reservoir underwent an intensive heat-transfer by considerable amount of heat from the primary reservoir.

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References

KRTA (Kingstone Reynolds Thom and Allardice Ltd.), 1977, Reconnaissance survey of the geothermal resources of northern Thailand stage 1, Report (Exploration), unpublished report.

Ramingwong, T., and others, 1985, 1980-1981 Geochemical Data of Five Highest Potential Geothermal Systems in Northern Thailand : Fang, San Kamphaeng, Mae Chan, Pa Pae and Mae Chaem; Report submitted to EGAT, 88 p.

Ratanasthien, B., and others, 1985, Water Qualities of Geothermal Fluids from San Kamphaeng and Fang Geothermal systems, A Final Report Submitted to EGAT, 249 p.