SOME RESULTS OF ASSESSMENT ON GEOTHERMAL POTENTIAL AT THACH TRU HOT WATER RESOURCE IN QUANG NGAI PROVINCE - VIETNAM

LE VINH HONG

Geophysical Division, Geological Survey of Vietnam
Thanh Xuan - Dong Da - Hanoi

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1. ABSTRACT

From 1992 to 1994, on the basis of combination of geochemical, geophysical, geological. and hydrogeological methods, etc., the Geological Survey of Vietnam has carried out a preliminary assessment on geothermal potential of some hot-water resources occurrences in the South of the Country. After summarising tlie work, some prospective geothermal areas have been discovered. Among them, the Thach Tru hot-water resource situated in Moduc district, Quang Ngai province has the open-test potential for the purpose of using geothermal energy to generate electricity.
This paper is presenting some results of a studying of the geothermal potential of Thach Tru hot-water.

2. INTRODUCTION

The Thach Tru thermal area is located approximately 30 km south of Quang Ngai City, 6 km from the coast and just west of the national highway. There are two centres of thermal activity at Thach Tru, located north and south of a small hill (Nui Tho). Both areas are situated within rice fields. The more active area to the south is called Thach Tru and the area to the north is called Tu Son. Tu Son is 1.5 km far from Thach Tru, they are grouped together.
The thermal activities at Thach Tru cover an area of about 500 m² and at Tu Son is 1000 m² and consist of several hotwater springs and shallow pools atop a flat rock.
Temperatures of 69°C and 77°C were measured in the two springs sampled and 81°C in the sediment beneath the pools. The total flow from the Thach Tru area is about 1.5 l/s (see Fig. 1)

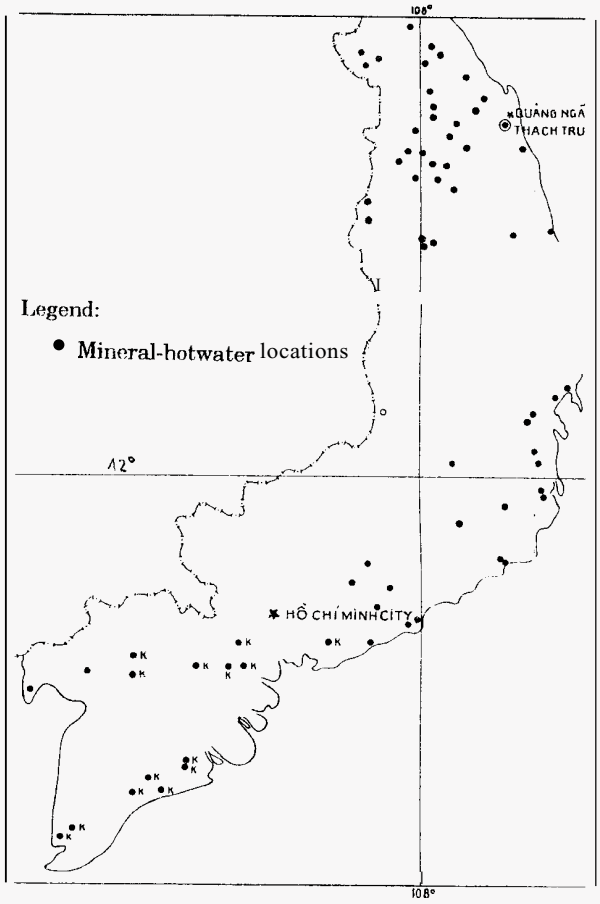


Figure 1. MAP OF MINERAL-HOTWATER RESOURCE in tlie south of Vietnam - scale 1: 5,000,000

3. METHODS OF RESEARCH, RESULTS, DISCUSSIONS

3.1 Geophysics

Geophysical methods have been used to survey in the Thach Tru area include the airborne magnetics and radioactivity at scale of 1:200,000, gravity, radioactivity on the ground. Measure physical characteristics of collected rock samples such as the radioactive concentrations U, Th, K, Thermal conductivity, density.

3.2 Geology

The Geological, hydrogeological mapping at the scale of 1:50,000; rock, water and gas sampling; petrological analysis have been used in the Thach Tru.
The Geological map of Thach Tru area of 1:50,000 scale was established on the basis of a studying and a correlation of the ohtained geological, geophysical results etc. (see Fig. 2).
The thermal activity at Thach Tru occurs on top of a flow, flat-topped outcrop. The outcrop is capped by cemented, sorted, medium grained clastics. Petrographic analysis shows the cement to be pyrite, opal and cristobalite (recrystallised from opal) in one of the two samples collected; and clinoptilolite, opal and cristobalite (recrystallised) in the other. Clinoptilolite and opal indicate neutral to acid conditions at fluid temperatures of less than 150°C and 120°C respectively. They are therefore likely to reflect deposition from historic hydrothermal activity.

3.3 Fluid Chemistry

In the Thach Tru area the chemistry approaches the true Na-Cl character typical of high-temperature magma geothermal systems. Sodium and chloride account for most of the mineralisation (4800-5300 mg/kg TDS) and SO_4 and HCO_3 are relatively minor constituents.
The measured silica concentrations at Thach Tru arc the highest of all the sites investigated. They indicate quartz saturation temperatures of 147-154°C and chalcedony temperatures of 122-131°C. The presence of opal (amorphous silica) in the cemented quartz sands surrounding the hot spring suggests that the springs have been boiling in the past and possibly historically.
('ation geothermometry can be applied with some confidence at Thach Tru because of the relatively mincralised Na-Cl character of

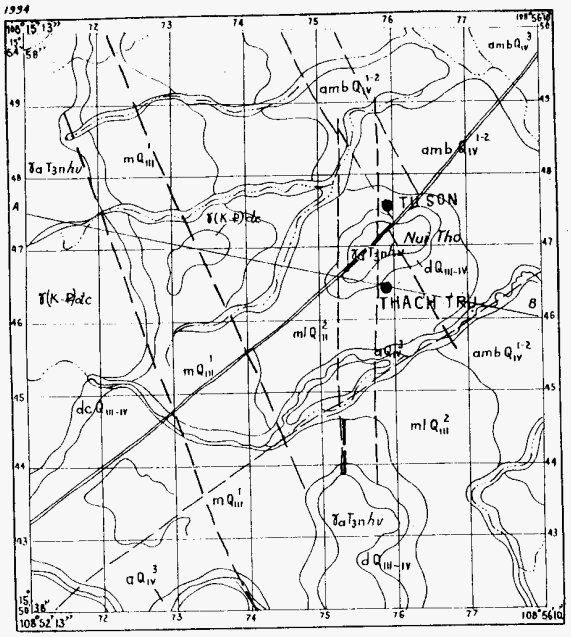
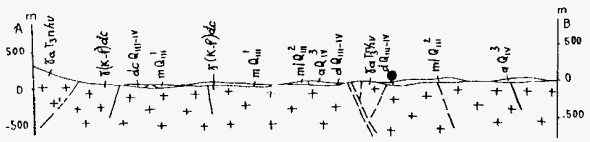


Figure 2. GEOLOGICAL MAP OF THACH TRU AREA (ACCORDING TO GEOLOGICAL, GEOPHYSICAL DATA) scale 1:100,000



GEOLOGICAL SECTION A-B

Legend:

- Q_{IV}^3 **Fluvial** sediments: sand, gravel. pebble. Mixed fluvio-marine-marsh sediments: gray siltstone of peat form.
- Q_{IV}^{1-2} Mixed fluvio-marine-marsh sediments: black-grey, weakly weathered siltstone.
- Q_{III-IV} Deluvial-Coluvial, deluvial sediments: gravel, breccia with a few silts.
- Q_{III}^2 Mixed marine-lagoonal sediments: sand with a few sills intercalated with siltstone lenses.
- Q_{III}^1 Marine sediments: Quarts grewel, pebble, white grey, red-yellow sandstone.
- Veined rocks: opaque fine-grained quartz.
- γ(K-P)dc Deoca complex: granite, porphyritre granosienite.
- γaT3nhv Hai van complex: granite biotite, melanocraticgranite.
- a/b Faults: a- Regional; b- Undetermined.
- Hotwater geothermal Resource.
- Dry stream.

the water. The Na-K geothermomcter of Fournier (1979) and Amorsson et al. (1983) give temperatures up to 160°C and 187°C respectively (see: Table 1-4) while the NaKCa geothermometer give maximum values of 172°C. Overall, geothcnnometry suggests the fluids have equilibrated at teinperatures of 160-180°C, significantly higher than for the other prospects investigated.

The Thach Tru water have a relatively high Mg concentration of 3.5-4.00 mg/kg.

Table 1a. Thach Tru Thermal water: KRTA and GSO Vietnam Survey 1993 Analytical Data

No	Date	Type	Flow L/s	Temp °C	pH	Li	Na	K	Rb	Ca	Fe	Mg	Cl mg/kg	F	Br	SO4	HCO3 (total)	D	δ18O	BAL %	mEq/L	mg/kg
1	27-feb-93	spring	0.5	69	7.50	3.2	1390	71	0.93	360	0.04	3.6	2630	3.7	45	158	60	0.44	126	0.070	2.2	81.0	79.2	4850
2		spring	0.1	77	7.49	3.1	1260	70	0.88	347	0.07	3.5	2560	3.7	45	153	61	0.43	120	0.069	3.3	74.7	77.2	4630
3		outflow	1.0	42	7.99	3.3	1340	73	1.1	371	0.07	3.7	2770	4.1	46	168	60	0.45	123	0.022	4.9	79.5	83.4	4960
4		spring	0.2	54	7.51	3.5	1440	99	1.2	389	0.08	4.1	2910	3.7	51	151	77	0.44	127	0.055	2.2	85.4	87.4	5260
5		spring	<0.1	47	7.27	3.5	1420	94	1.1	389	0.16	4.0	2050	3.8	49	155	76	0.45	136	0.121	4.7	84.4	88.5	5280

Table 1b. Thach Tru Thermal water : KRTA Survey 1 93 Calculated Data

No	Date	Type	Flow L/s	Temp °C	Cl — Li	Cl — Rb	Cl — Ca	Cl — B	Cl — SO_4	Na — K	Na — Ca	T_{Na-K} °C	$T_{Na-K-Ca}$ (A83) °C	$T_{Na-K-Ca}$ (F79) °C	TKM °C	TNa-K-Ca β	TNa-K-Ca °C	TMg °C
1	27-feb-93	spring	0.5	69	161	6818	8.3	1822	45.1	33	7	151	135	165	133	0.33	157	-
2		spring	0.1	77	162	7014	8.3	1815	45.3	31	6	148	142	171	133	0.33	160	-
3		outflow	1.0	42	164	6071	8.4	1877	44.7	31	6	149	140	170	134	0.33	160	
4		spring	0.2	54	163	5847	8.5	2016	52.2	25	6	151	160	187	142	0.33	172	
5		spring	<0.1	47	165	6466	8.6	1999	51.6	26	6	155	156	184	141	0.33	170	-

The fluid chemistry at Thach Tru, indicates deeply circulating nieteoric water with a 15% seawater content and deep temperatures of 160-180°C. Upflow is aligned along a north-south fracture with fluid to the north (at Tu Son) having slightly higher indicated source temperaturcs.

3.4 Origin of The Thach Tru Hotwater Spring

Some spatial relationship between the Neogene/Quaternary basaltic volcanism anti the distribution of the hottest spring in the Thach Tru exist but as noted by Koening (1983), the relationship is a very limited one. Moreover, any genetic relationship between individual volcanic centres and the nearest thermal areas is most unlikely considering the distances involved together with the relatively small magma chambers that develop from basaltic melts.

Table2. Analysis of Gas from Thach Tru Hot spring 4 Sunday 1993

SAMPLE	Date	Sample XSTM		CO_2	H_2S	H_2	H_2 / CH_4 nmoles/mole	O_2	N_2	He	Ar	H_2S	H_2 mmo	N_2 Ie	He	Ar
	27-feb-93	1	0.00	n.d	< 1	-	0.03	9.23	21	954	4.00	11.60	n.d	< 1	0.0	10.3	973	4.45	11.85
Air				0.3	-	-	-	-	210	781	0.0052	9.34							

Table 3. A comparisi n of Analytical Data from KRTA and other Sources

Analyst	date	sample Type	temp °c	pH	Li	Na	K	Rb	Ca	Fe	Mg	Cl	F	Br	SO_4	HCO_3	B	SiO_2	NH_3	ION BAl %	CATS mEq/l	ANS mEq/l
											mg / kg											
Hoppe et al	14-Nov-85	spring	78°	7.04	2.98	1290	68.0		364	0.03	3.04	2590	2.50		143	67		120	0.140	1	76.7	77.3
KRTA	27-Feb-93	spring	77°	7.49	3.10	1260	70.0	1.88	347	0.07	3.50	2560	3.70	45	153	61	0.43	120	0.069	3	74.7	77.2

Table 4. Physical Characteristics of the Pintescabonate Samples at Thach Tru from Geophisical division of Viet Nam 1994.

	Samples No								
	615	615a	615b	615c	615/1	615/1a	615/1b	615/2	615/2a
Density (g/cm^3)	2.30	2.42	2.54	2.56	2.60	2.60	2.26	2.58	2.55
Thercondactivity (w/mk°)	--	2.54	5.06	4.16	2.93	5.06	--	2.54	4.46
Uranium (ppm)	249	7	20	20	7	7	17	5	6
Thorium (ppm)	180	20	28	30	29	5	40	14	22
Potassium (%)	2.1	1.1	0.9	1.0	1.2	1.1	1.3	1.2	0.9

l'he absence of active or recent on-shore volcanism, together with the geology of the individual geothermal prospects, indicates that they are likely to be low to medium temperature systems which have developed in fracture zones caused by faulting in the basement rocks. Deeply penetrating meteoric water is warmed in anormal or 'elevated thermal garden and heat is transferred to the surface by convection.

The Thach Tru thermal watcr is relatively mineralised Na-CI waters where chloride is the major anion.This Spring is located close to the coast and very likely derive their salinity and Na-CI character from a component of seawater. This is supported by veiy low boron content of these waters and high calcium levels, charactcristics typical of thermally altered seawater. Again, tlie low gas contenk suggest little input of magmatic fluid. Isotopic measurements of oxygen, hydrogen and sulphur would help *to* confirm a marine source for these fluids.

Thus, the thetmal waters can be considercd tectonic in origin, having formed through circulation to considerable depth along discrete zones of tectonic fracturing.

Circulation of the waters can bc considered, i.e. with no input of deep connate or magmatic.

3.5 Resource Temperature

Spring temperatures at all the prospects studied in the south of Vietnam were below boiling (the temperatures at outcrop, Tmax=80°C).

Spring geothermometry further supports this view. A number of silica and cation geotheimometer techniques werc used in an attempt to assess deep fluid temperature. The deep temperature at Thach Tru by using cation geothermometry indicates less than 130-140°C.

The chemistty of the watcr at Thach Tru stands out fiom all the sites with indicated dccp temperatures of 160-180°C. A summary of geothennometer temperatures is giving below:

Geothermometer	Author	Temp ("C)
Na-K	Foumier (1979)	187
Na-K	Amorsson *et al* (1983)	160
Na-K	Giggenbach *et al* (1983)	204
Na-K-Ca	Fournnier, 'Truesdell (1973)	172
K-Mg	Giggenbach et *al* (1983)	142

3.6 Thr potential of tlic Thach Tru Geothermal Resource.

The 'Thach Tru Resource assessment is usually seen as a scientific exercise. However it must include some economic consideration.

3.7 The Issue for this study.

The geoscientific evidence is that the resource. with the possihlc exception of Thach Tru, is unlikely to escced 180°C.

Due to the above, at the Thach Tru hotwater resource prospect. a small geothermal steam power plan for regional using could be built.

3.8 Further Exploration.

Based on results obtained from those studies, for further exploration of the geothermal potential at Thach Tru hotwater area, such as a detailed interpretation of aerial photographs including infrared imagery may provide information about the geological controls on the Thach Tru thermal features, should be used in combination with geochemical, geophysical, geological and engineering methods.

4. CONCLUSIONS

- At present, a maximum fluid temperature of 160°C to 180°C is indicated for Thach Tru area *only.*
- The possibility that fluid at a temperature high enough for a small scale electricity generation exists at Thach Tru can not be ruled out.
- Results obtained for an engineering economic analysis show that for electricity generalion at Thach Tru to be economic, it would he necessary to produce fluid at the required temperature of approximately 500m depth.

- On the basis of results indicated above, an exploration well at Thach Tru is considered justified.
- Limited additional geoscientific investigation of the Thach Tru is required in order to identify the most appropriate drilling target(s).

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