THE ANDRASSY GEOTHERMAL PROSPECT IN SABAH, MALAYSIA

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SUMMARY - This surface-based geothermal study was conducted in the Andrassy prospect in Tawau, Sabah. The current state of geothermal activity was assessed through reconnaissance and geochemical study. All fieldwork was carried out fiom February 2000 – February 2001. Fifteen active manifestations were documented. These manifestations range from 43.3" to 78.2°C in temperature and 6.01 to 7.12 in pH. They appeared to be NW aligned, suggesting structural control. The geothermometry results gave calculated reservoir temperature in the range of 180° to 238°C, suggesting that power generation via binary cycle is possible.

1. INTRODUCTION

There are no active volcanoes in Malaysia; the remaining features of active volcanism are hot springs and mud volcanoes. Nonetheless, a radiometric age of only 27,000 years was reported for the pyroclastics in the Tawau area and the basalts that issued from fissures in the Mostyn area are apparently considered very young (Leong, 1974). In 1976, minor seismicity was experienced in Darvel Bay region, showing that tectonic activity still persists (Studt & Mahon, 1979).

Geothermal manifestations are fairly wide spread in Malaysia. According to Abdul Rashid (1990), there are more than 60 reported hot springs in Peninsular Malaysia. In East Malaysia, there are 14 localities exhibiting geothermal manifestations; seven in Sarawak (MGD ,2000) and another seven in Sabah (Liau & Yan, 1998). Of these seven localities in Sabah, six were located in the Semporna Peninsula and another in Poring; thus there are two geothennal areas in Sabah. According to Studt and Mahon (1979), the Semporna Peninsula prospect has a better potential for power generation compared to the Poring prospect, which is currently a famous recreational centre for both local and foreign tourists (Chong & Mohd. Noh, in prep). A brief history on geothermal researches in Sabah is available in the work of Chong (2001). In the past year, the Tawau Hills Park hot springs were described in considerable detail (Chong *et. al.*, 2000; Chong & Mohd. Noh, 2000).

In this paper, the authors present aspects of the more promising Andrassy prospect, which is a part of a MSc thesis (Chong, 2001). Prior to our study, the Andrassy prospect was last assessed in 1989 (Lim et. al., 1991) and it was reported to have the most diverse geothermal manifestations in Malaysia, in reference to Apas 4. Other than Apas 4, Apas 5, a huge mud pool, is also a relatively unique geothermal manifestation in Malaysia. In general, manifestations found in this prospect include hot springs, pools of hot water and mud pools.

2. PHYSICAL SETTING

The Andrassy prospect is located some 25 km fiom Tawau town, encompassing an area of 15 km^2, 1,380 – 1,385 kmN and 4,785 – 4,788 kmE of equator (DNM, 1975 & 1985). It is a hilly terrain. The Tawau Hills Park, a conservation area, is on its northwest edge. At the southeast edge there are the oil palm and cocoa estates; in the middle lies the Andrassy Forest Reserve. Liau and Yan (1998) describe the geology of this area; in simple terms, dacitic agglomerate occurs in the northwest half and dacitic lava and tuff occur in the southeast half.

Meteorologically, the prospect area receives an annual rainfall of more than 2500 mm per year and has an average temperature of 26.7°C (DMS, 2001). No wildlife of special conservation interest has been reported to date. The primary forest, which can be seen clearly from the aerial photographs (DNM, 1995a & 1995b), is restricted to Tawau Hills Park boundary. Secondary forest is found in the Andrassy Forest Reserve; it was previously a logging area in the 1970s. The rest of the area is planted with cocoa and oil palm; cocoa is however being phase out slowly for economic reasons. Wild rattans are found fairly distributed in the secondary forest. Deer and wild boar are hunted in the primary-secondary forest boundary.

3. GEOTHERMAL MANIFESTATIONS

Geothermal manifestations in the Andrassy prospect are limited to hot springs, pools of hot water and hot mud pools. In general, there are two groups of localities where the surface manifestations present. The first one being the Apas 1 – 4 (in Apas Kiri 2 area) and the second one is the Apas 5 (in Apas Kiri 3 area). Apas 1 – 4 consists of mainly groups of hot springs. Apas 5 is situated about 1.5 km north of Apas 4 and is self-isolated at the riverbank of Apas Kiri 3 River. .

Table 1: pH and temperature of each geothermal manifestation in Andrassy prospect.

Location	Temperature °C	pH
Seepage 1 (S1)	69.8	6.15
Apas 1a	75.5	6.02
Apas 1a (ii)	75.8	6.02
Apas 1b	74.7	6.01
Apas 2a	43.0	7.12
Apas 2b	DU	DU
Apas 2c	69.3	6.05
Apas 2d	52.4	6.40
Apas 2e	56.1	6.13
Apas 2f	51.5	6.69
Seepage 2 (S2)	48.6	6.74
Apas 3	53.9	6.62
Apas 4a	78.2	6.75
Apas 4b	77.0	6.06
Apas 4c	72.9	NA
Apas 5	60.6	6.70

DU: Spring dried up
NA: Not analysed

The pH values and temperature readings of each locality are given in Table 1. Manifestations at the Apas Kiri 2 area have a pH range of 6.01 – 7.12 and a temperature range of 43.3 – 78.2°C. Apas 5, in the Apas Kiri 3 area, has a pH of 6.70 and a temperature of 60.6°C. Based on measurements made at the mid point of the Apas Kiri 2 River, the pH is 7.27 – 7.76 and the temperature is 26.6 – 26.8°C. Throughout the course of field study, five new hot springs were found and mapped, two in Apas 1, two in Apas 2 and one in Apas 4. The Apas 2b spring was found to be no longer active.

3.1 Apas Kiri 2 Area

Geothermal manifestations in the Apas Kiri 2 area appeared to be NW aligned, agreeing with the photolineaments drawn by Lim (1989), indicating structural control. The geothermal fluids are acid and near neutral and mild in H_2S smell. Apas 4a has the highest temperature of 78.2°C.

Apas 1 and Apas 2 are mainly hot springs with each uniquely having seepage oozing out from the riverbed. A1a and A1a(ii) in Apas 1 are newly documented. A2b, in Apas 2, were found no longer active; however, A2e and A2f are newly documented. The springs in Apas 2 emerged from the boulders, other geothermal discharge in this prospect emerged from the ground, mostly travertine terrace. Apas 3 is simply a mud pool of 5m x 8.5m (at its widest cross section) in size and is surrounded by bushes.

Apas 4 is also known as the "Old Steaming Ground", measured 96.2m (NW-SE) and 71.6m (NE-SW) at its widest cross section. It can clearly be detected from aerial photographs of 1:25,000 scale. Geothermal manifestations present here included mud pools, hot bubbling pools and hot water spouts.

There are two important conical structures in Apas 4 that distinguish this site fiom other sites in the Andrassy prospect. Both are located at the northern part of Apas 4. This part of Apas 4 is the most active. Moving further north, one will encounter a stretch of mud pools fencing up the northern perimeter of Apas 4. These mud pools appeared to be semi-hardened on top but soft at bottom (like wet cement). The semi-hardened top layer cannot support much weight; it actually collapsed and had the researcher down about 1.5 feet while measuring the size of Apas 4a. The mud was about 70°C and has a mild H_2S smell. The mud pools could have been deeper further north where water saturation was much higher. Pools of hot water dot the terrace of Apas 4; they are widely spread especially in the middle section of Apas 4. Nonetheless, there is one that is exceptionally greenish and another one with exceptional bubbling. To the southern part of Apas 4, where the jeep track crossed through, is the newly labelled Apas 4c. The authors believe that it deserves some special attention for monitoring purposes.

3.2 Apas Kiri 3 Area

There is only one manifestation in Apas Kiri 3 area, the Apas 5 mud pool. It is located 1.5 km north of Apas 4; it can be identified from aerial photographs though not very clearly. It is pear-shape and situated at the tributary of Apas Kiri 3 River and a stream. To the north, the mud pool appears connected to the stream on the west and to the Apas Kiri 3 River on the east. This connection on the west allows the water fiom the stream to mix with the geothermal fluid; however, the connection on the east seems to be an outflow of Apas 5 towards Apas Kiri 3 River.

The size of Apas 5 mud pool was estimated to be 40m (W-E) wide and 50m (N-S) long. The most active part of the pool was at its south where a pH of 6.69 – 6.72 and temperature of

60.3 – 61.1°C was measured. The most active part of the pool appeared to be steamy and the smell of H_2S was apparent, though not very strong. The only way to survey the Apas 5 is to walk on the fallen-rotting trees. Its ground appeared to be like the mud pools at the northern perimeter of Apas 4a and some parts resemble Apas 4c. The depth of the mud excluding the water level at the most active part of the pool was measured as 0.63m; the mud has a strong smell of H_2S.

4. GEOTHERMOMETRY

The results on sodium, potassium, calcium, magnesium and silica analysis are as presented in Table 2. It is observed that the chemical content of the geothermal fluids fiom Apas la, lb, 4a and 4b appeared to be in the same range. The Apas 3 geothermal fluid has a lower concentration of each parameter analysed, this is probably due to the dilution fiom the ascending cool ground water. This is not surprising as Apas 3 is situated on lower level relatively to Apas Kiri 2 River. These results suggest that all the thermal fluids mentioned above originated from the same source.

Table 2: Geochemistry analysis results. All readings are in ppm.

Location	Na	K	Ca	Mg	SiO_2	Si
Apas la	720	86.7	821.2	15.9	74.3	34.7
Apas lb	719	82.3	779.5	14.2	71.5	33.4
Apas 3	525	66.7	549.2	10.7	58.7	27.4
Apas 4a	854	91.4	770.6	16.2	78.7	36.8
Apas 4b	770	94.8	832.4	16.8	79.6	37.2

The calculated subsurface temperature results are as summarised in Table 3. It seems that the Na/K and Na-K-Ca geothermometers calculated temperatures are in good agreement with each other and are logical values for a medium enthalpy hydrothermal system in the Andrassy prospect. Somehow, the Na-K-Ca Mg corrected geothermometer calculations give erroneous negative subsurface temperatures that are illogical thus not considered here.

Table 3: Subsurface temperature results.

Location	Type of geothermometers (°C) Na/K (Fournier)	Na/K (Truesdell)	Na-K-Ca
Apas la	233	208	183
Apas 1b	229	203	181
Apas 3	238	215	184
Apas 4a	223	[illegible]	180
Apas 4b	236	211	186

The Na/K (Fournier) and Na/K (Truesdell) geothermometers gave Apas 3 the highest subsurface temperature of 238°C and 215°C respectively. **But,** according to the Na-K-Ca geothermometer, Apas 4b has the highest subsurface temperature of 186°C. Nonetheless, if we were to consider the dilution factor of Apas 3 geothermal fluid, then perhaps all the highest geothermometers calculated temperatures would go to Apas 4b. However, this is not an issue, as these figures remain estimates. The important finding is that all these figures are well above the minimum temperature required for power generation via binary cycle.

The different calculated figures of each unique geothermometers at each location should all be considered as different parts of the reservoir may have different temperatures. **Though** these estimates may seem to be of little use now, they will be of powerful use in reservoir modelling in near future.

5. THEWAYFORWARD

The next stage of research should be locating suitable drilling sites via a geophysical resistivity study then followed by exploratory drilling. The exploratory drilling is important to assess the reservoir capability of supplying the inflow required by the power plant. An example of systematic geothemal energy exploration study is available in the work of The World Bank Group (2000a). Should the inflow requirement be fulfilled, it would be worthwhile to construct a demonstration plant to assess the reservoir reliability instead of constructing the actual production plant directly.

In the authors opinion, not many or may be no Malaysian company will be willing to invest in the exploration of the Andrassy prospect. Firstly because the capital cost is very high and the return rate is relatively slow. Secondly, there is little or no guarantee of success. The World Bank Group (2000b) discussed some of the recent economic issues. Blair *et. al.* (1982) discussed in detail the investment decision-making and commercial development of geothermal energy.

In order to encourage the private sector to participate in geothermal energy development in the Andrassy prospect, the authors suggest that the Malaysia government should start the project. The project can come under the rural or regional electrification program in the Ninth Malaysian Plan. Once the exploratory drilling has proven the resource to be reliable for power generation, the private sector will then be more interested and more willing to invest in the rest of the project. The Malaysia government can also develop the geothermal power plant first and later sell or contract the plant to a private company. Should the company generating the electricity differ from the power utility owner, an energy sales contract or joint-operation contract could be written and solve the matter.

6. OPTIONS OF DEVELOPMENT

The authors believe, in order to make full use of the geothermal resource in the Andrassy prospect, development should not be confined to power generation alone, but should include a variety of other geothennal related developments. The more diversified the geothermal development the better.

The Andrassy prospect itself can be considered as an open classroom. The geothermal manifestations are of educational value especially to earth science students. Such manifestations are also a rarity in Malaysia; therefore it could have some tourism value. In addition, the Andrassy prospect has the potential of being the Malaysian geothermal educational centre as its manifestations are the most diverse in Malaysia to date. Perhaps all we need to do is to build some infrastructure in the Apas Kiri 2 area, and this site could develop into an edu-tourism centre – the first option.

The second option is to utilise the geothermal fluid for direct uses. With some simple engineering, the Apas Kiri 2 area can be developed into a geothermal recreational centre such as the successful model at Poring Hot Spring Park (Chong & Mohd. Noh, in prep). If we were to develop it into a tourism centre, the isolation of the site can be demotivating factor (Ti, 1994), but it is good to note that the Poring Hot Spring Park is also isolated yet successful. With the aid of heat exchangers, the earth heat can be utilised to assist the agro-industry processes in the Andrassy estates. For instance hot water is needed to clean the palm oil fruits. Cocoa drying via space heating can be a good idea too as it rains almost daily in Andrassy.

The third option is simply to generate electricity from the hot geothermal fluid available in the Andrassy prospect. Unlike the first two options, this option still requires further geothermal study and there is little or no guarantee of success.

Assuming the power generation project is a success, the fourth development option is a state of the art ideal geothermal development that combines all three options mentioned above. It is based on the concept of geothermal cascading utilisation. Thermodynamically, the geothermal fluid will be used for power generation and then will be further utilised in the agro-industry processes or for recreational purposes before being reinjected at .specific point on the periphery of the reservoir. Should this option be practicable, the Andrassy prospect will be a good centre for geothermal education.

As a *summary,* the first option of development is the easiest and the second, third and fourth options are more difficult to achieve. Should the power generation project be unsuccessful there is no good reason not to realise the first option, in particular because Universiti Malaysia Sabah can utilise the Andrassy geothermal area for its academic purposes. By all means the authors support the geothermal development in the Andrassy prospect (done in the manner which is environmental friendly).

7. CONCLUSIONS

The geothermometry results suggest the presence of low-medium enthalpy hydrothermal resource in this prospect. The potential uses of this resource are as discussed in the previous section. In reference to power generation development, a detailed geophysical study is required to locate suitable drilling sites. For this, we will need funding from both local and foreign counterparts. In Malaysia, where fuel is relatively cheap and certain, acceptance towards the relatively unknown geothennal energy is still at a very low level. Nonetheless, we hope to be able to develop this resource in future.

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