PS The Case for Geothermal Power in Singapore*

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Abstract

Singapore lies adjacent to a world-class heat flow anomaly (160 mW/m²) centered on the Central Sumatra Tertiary Basin. The heat flow in Singapore is estimated from nearby oil and gas wells to be between 110 and 130 mW/m². Singapore and the neighbouring Malaysian Peninsular have numerous hot springs. Shallow bore holes in a hot spring area in Singapore have geothermal gradients of more than 10 degrees C per 100 m. Application of the Na/K geochemical thermometer gives a mean temperature of 160° C for the reservoir for this hot spring. It is hypothesized that the high head of groundwater in the Central Catchment area in Singapore (120 m above sea level) drives a fresh water lens down to 4 to 5 km depth. TOUGH-2 computer modeling simulates the groundwater flow under Singapore, locates the sea water-fresh water transitions, successfully positions the hot spring area and matches its low salinity. These 2D models show plumes of mixed fresh and seawater with reservoirs at 150° C between 2 and 2.75 km depth in the Bukit Timah Granite and Jurong Formation sediments, respectively. Geothermal water from suitably engineered geothermal reservoirs could be used to power electricity generation, desalination, process heating and district cooling. A feasibility study is required: i.e. more shallow boreholes, deep geophysics and a deep geothermal exploration borehole.

The Case for Geothermal Power in Singapore

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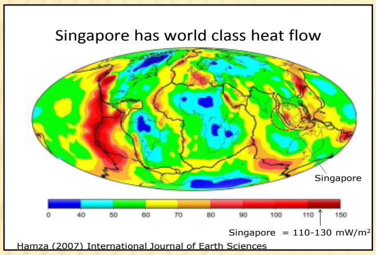

Fig. 1. Singapore lies adjacent to a world class heat flow anomaly

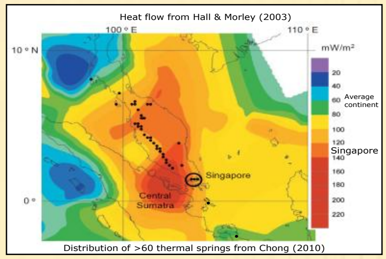

Fig. 2. The heat flow in Singa-pore is ~120 mW/m².

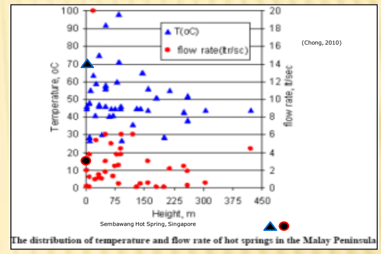

Fig. 3. ~60 thermal springs in the Malay Peninsular.

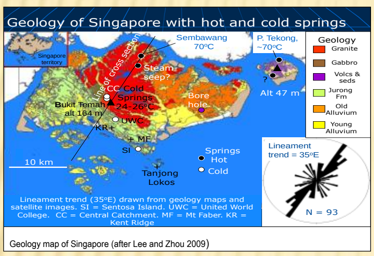

Fig. 4. Two hot and several cold springs in Singapore.

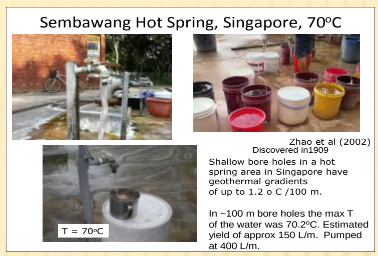

Fig. 5. Sembawang Hot Spring

Results of chemical geothermometers
Temperature in the reservoir

- SiO_2 quartz, Fournier (1973) — 125 °C
- SiO_2 Swanberg and Morgan (1979) — 126°C
- SiO_2 Carmicheal (1989) — 125° C
- Na/K/Ca Fournier and Truesdell (1973) — 166 °C
- Na/K Fournier and Truesdell (1973) — 169 °C
- Na/K Fournier (1979) — 162 °C
- Na/K Truesdell (1976) — 166 °C
- Na/K Santoyo and Diaz-Gonzalez (2010) — 163 °C

Analyses listed in Lee & Zhou (2009)

Fig. 6. geothermal reservoir is 120 -160°C.

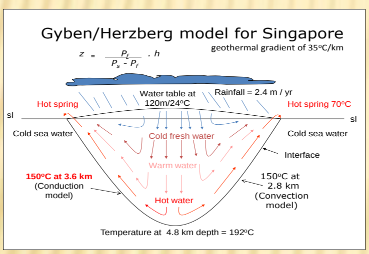

Fig. 7. The high head of ground-water in the Central Catchment (120 m above SL) drives a fresh water lens down to +4 km depth.

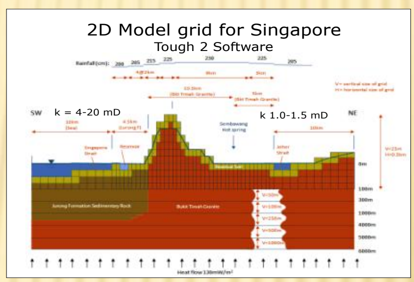

Fig. 8. 2D computer model grid along line of section shown in Fig. 4.

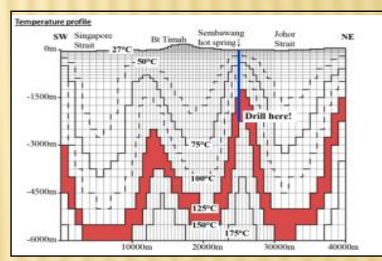

Fig. 9a.

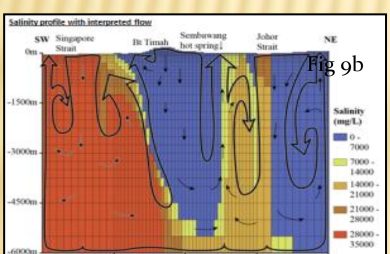

Fig. 9b.

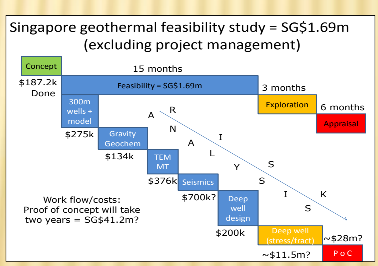

Fig. 10. Feasibility study.

CONCLUSIONS

The geothermal water from suitably engin-eered geothermal reservoirs could be used to power electricity generation,desalination, process heating and district cooling. A feasi-bility study is required: i.e. more shallow bore-holes, deep geophysics and a deep geothermal exploration borehole, as outlined in Fig. 10.

Fig. 9a and b. TOUGH-2 computer modelling locates the sea water-fresh water transitions, successfully positions the hot spring area (Fig. 9a) and correctly predicts its low salinity (Fig. 9b). These 2D models show plumes of mixed fresh and sea water with 150 ° C reservoirs at 2 km depth in the Bukit Timah Granite and 3.5 km in the Jurong Formation.

Reference: Oliver, GJH, Palmer, A, Tjiawi, H. and Zulkefli, F. (2011) Engineered Geothermal Power Systems for Singapore. Journal of the Institute of Engineers, Singapore, Part A: Civil and Structural Engineering, 4, 245-253.