Department of Geology
Faculty of Science, Chulalongkorn University

Thermal Exchange from Bangkok Subsoil to Household Air conditioner

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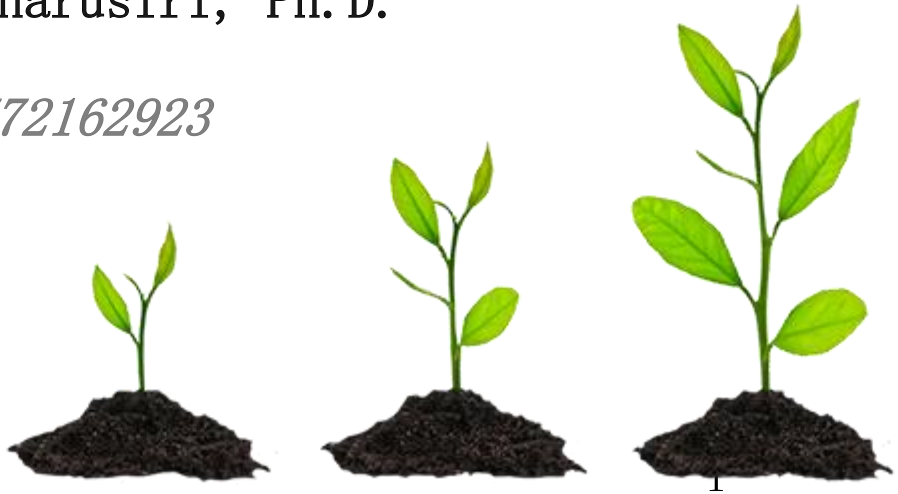


* Seminar II: March 6, 2016

Outlines of my seminar topic

(1) Introduction & Literature reviews

(2) Selected area

(3) Installation

(4) Results

(5) Discussion

(6) Conclusion

Objectives: are to

1. Analyze subsurface temperature in study area;
2. Compare soil profile between Bangkok and study area and
3. Compare energy saving between normal air - conditioner and GSHP

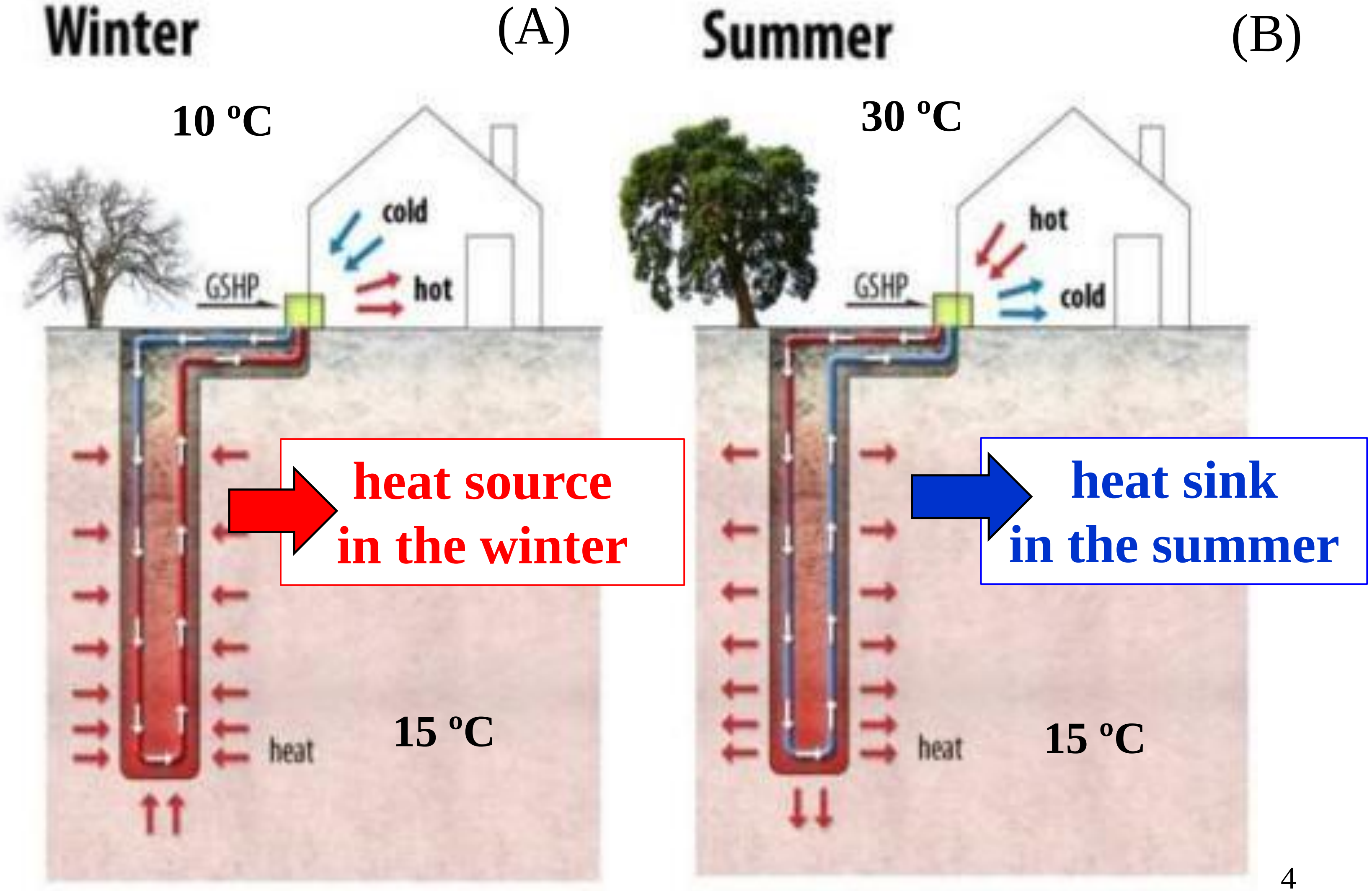
I. Introduction: Literature Reviews

Ground Source Heat Pump (GSHP), also known as Geothermal Heat Pump (GHP), GeoExchange, earth-coupled.

1.1) Fridleifson (2001)

Source: Fridlefson, I.G., (2001), Geothermal energy for the benefit of the people. Renewable and Sustainable Energy Reviews 5: 299-312.

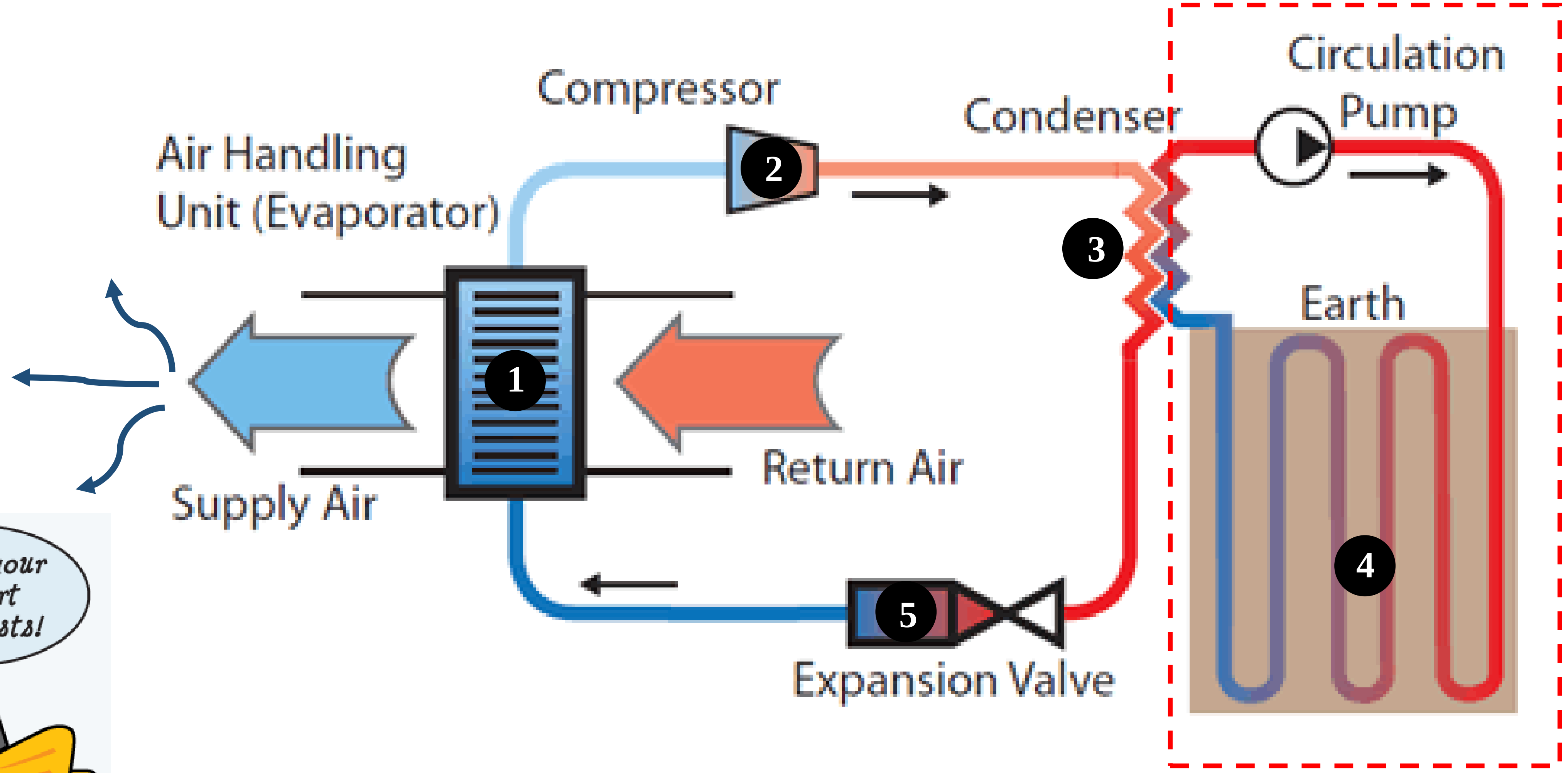
The Ground Source Heat Pump or geothermal heat pump (GHP) system is the heating and/or cooling system that transfers heat to or from the ground.



Source; http://www.kellehers.com.au/wp-content/uploads/Diagram.jpg

Q: How to use GEO heat pump ?

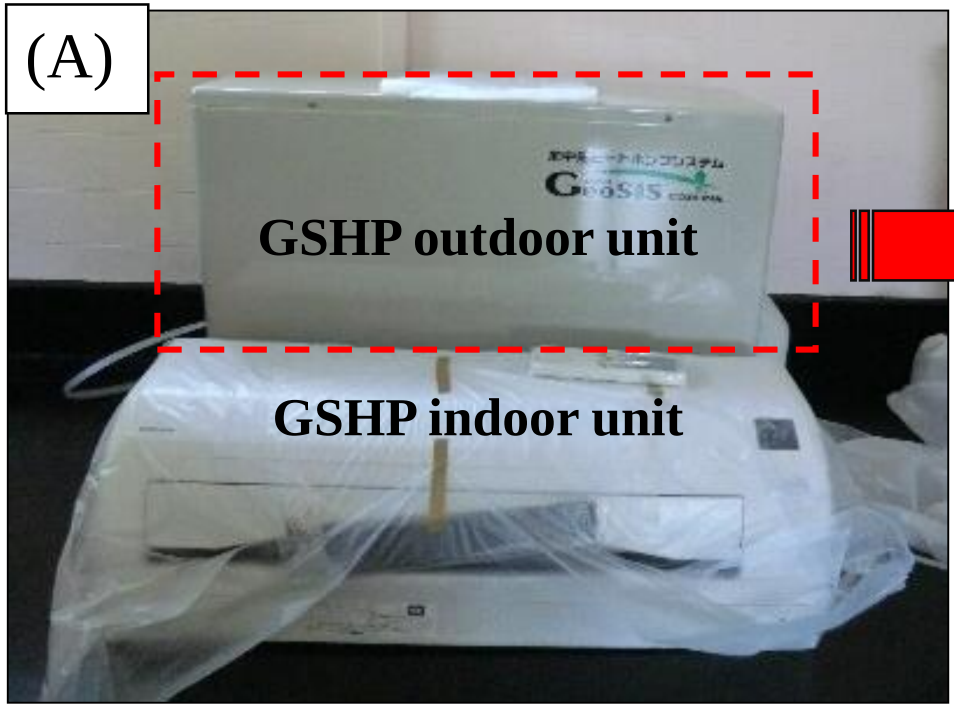
A: Like air-source heat pumps (in normal air conditioners), GSHP uses a reversible refrigeration cycle to provide heating and cooling (dual system).



Source: *https://energydesignresources.com/resources/e-news/e-news-73-ground-source-heat-pumps.aspx*

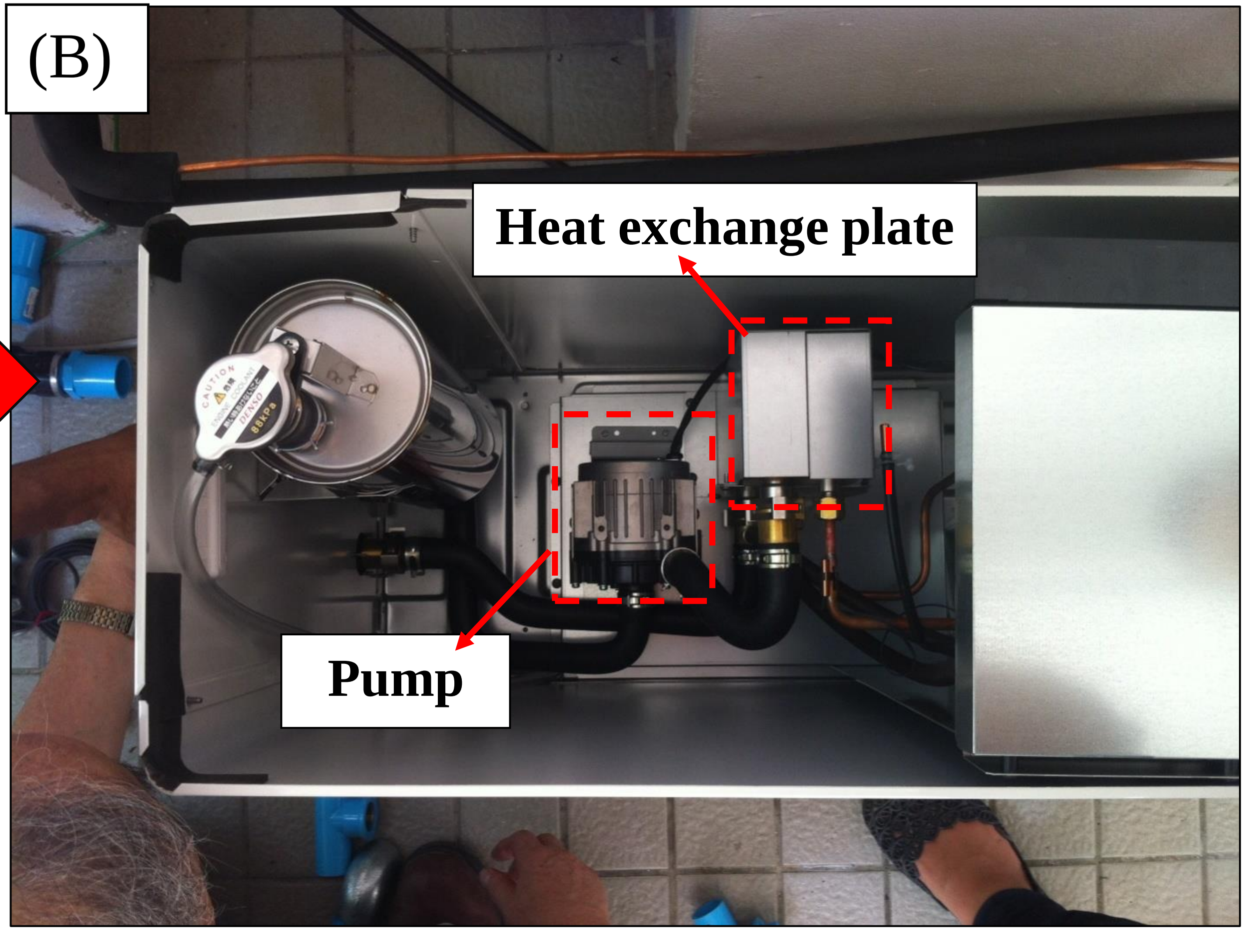
Q: How’s GSHP look ?

A: Like air-source heat pump in the normal air-conditioner, but the difference is that GHSP *does not have a fan coil system*.



GSHP (Chula case)

1 meter



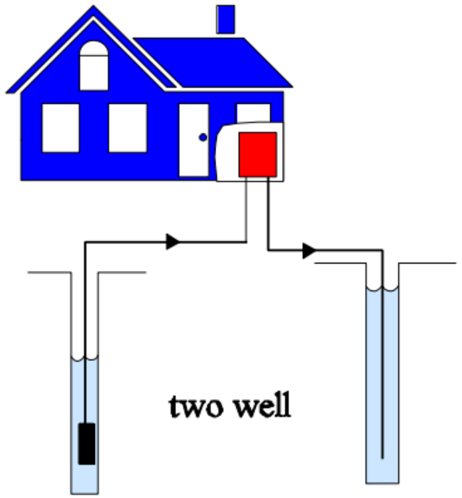
Inside GSHP outdoor unit

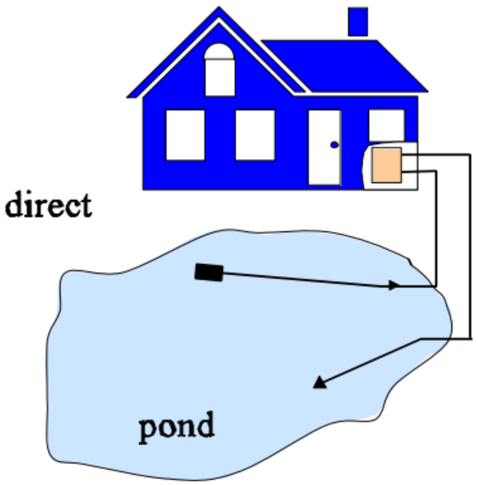
1.2) Lund et al. (2004)

Source: Lund, J., Sanner, B., Rybach, L., Curtis, R., and Hellström, G., (2004), Geothermal (Ground-Source) Heat Pumps - a World Overview, GHC Bulletin, September.

Ground Source Heat Pump (GSHP) or geo-heat pump can be classified on the basis of system installation into closed loop and open loop system.

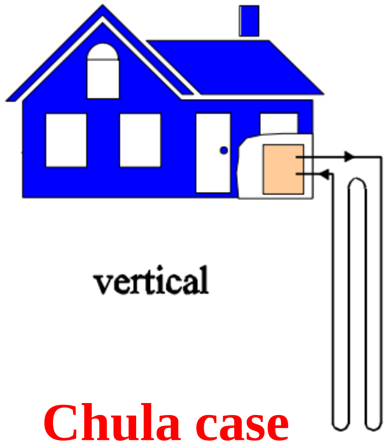
(A) Open loop system



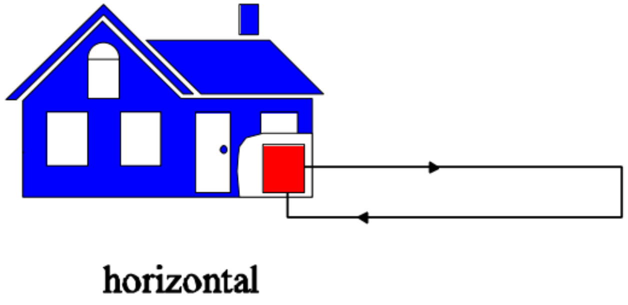


The closed loop systems operated by circulating a water or water/antifreeze fluid through a sealed water-circulating pipe network.

(B) Closed loop system



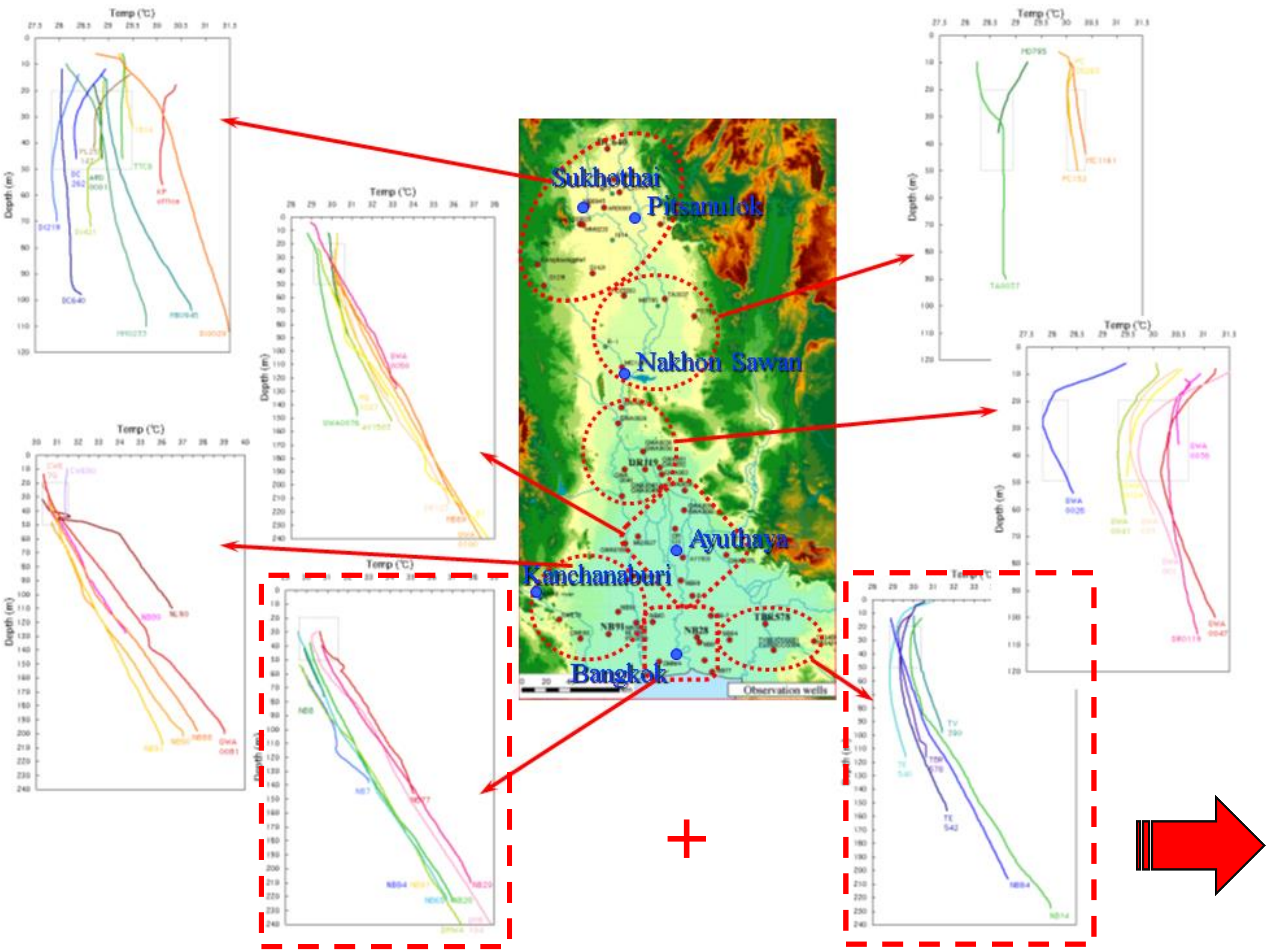
Chula case



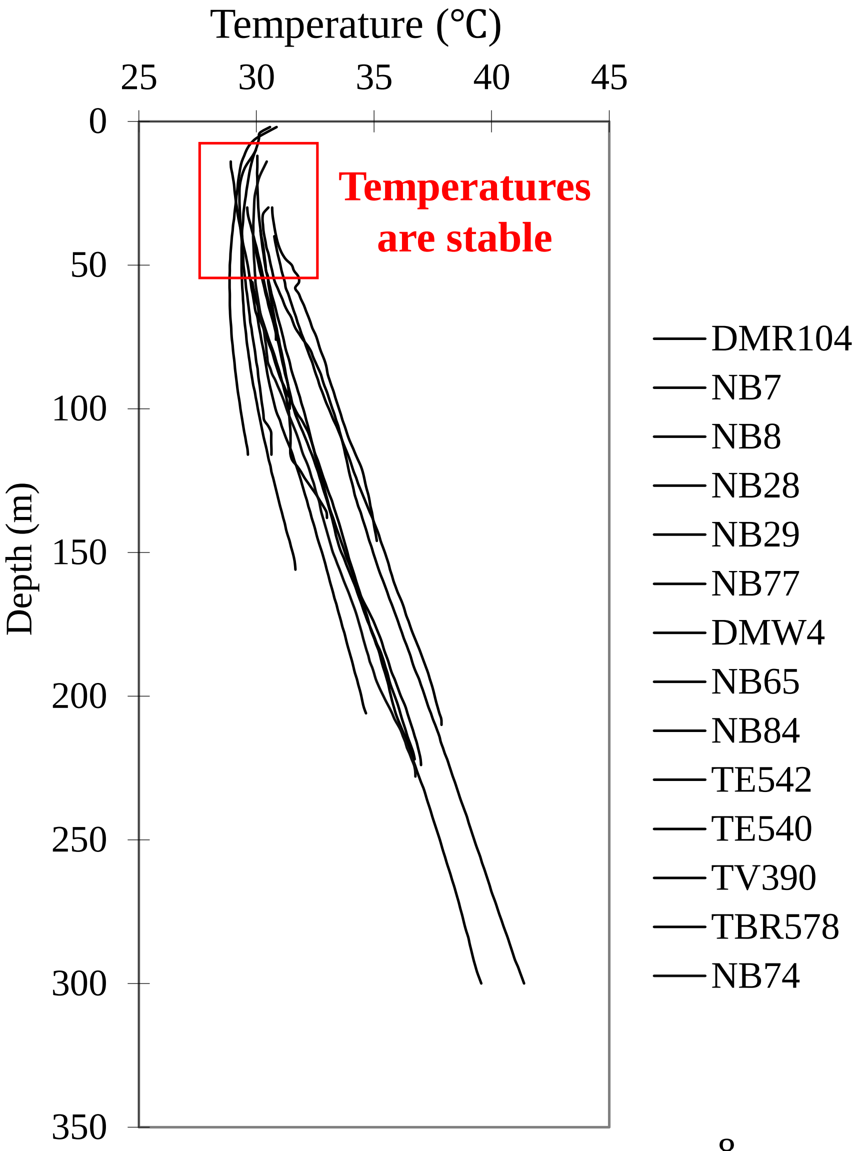
The open loop systems operated by extracting fluid directly from the environment, either as surface water or groundwater.

1.3) Yasukawa et al. (2009)

Source: Yasukawa, K. et al., (2009b), Groundwater Temperature Survey for Geothermal Heat Pump Application in Tropical Asia. Bulletin of the Geological Survey of Japan 60. 9/10: 459-467.

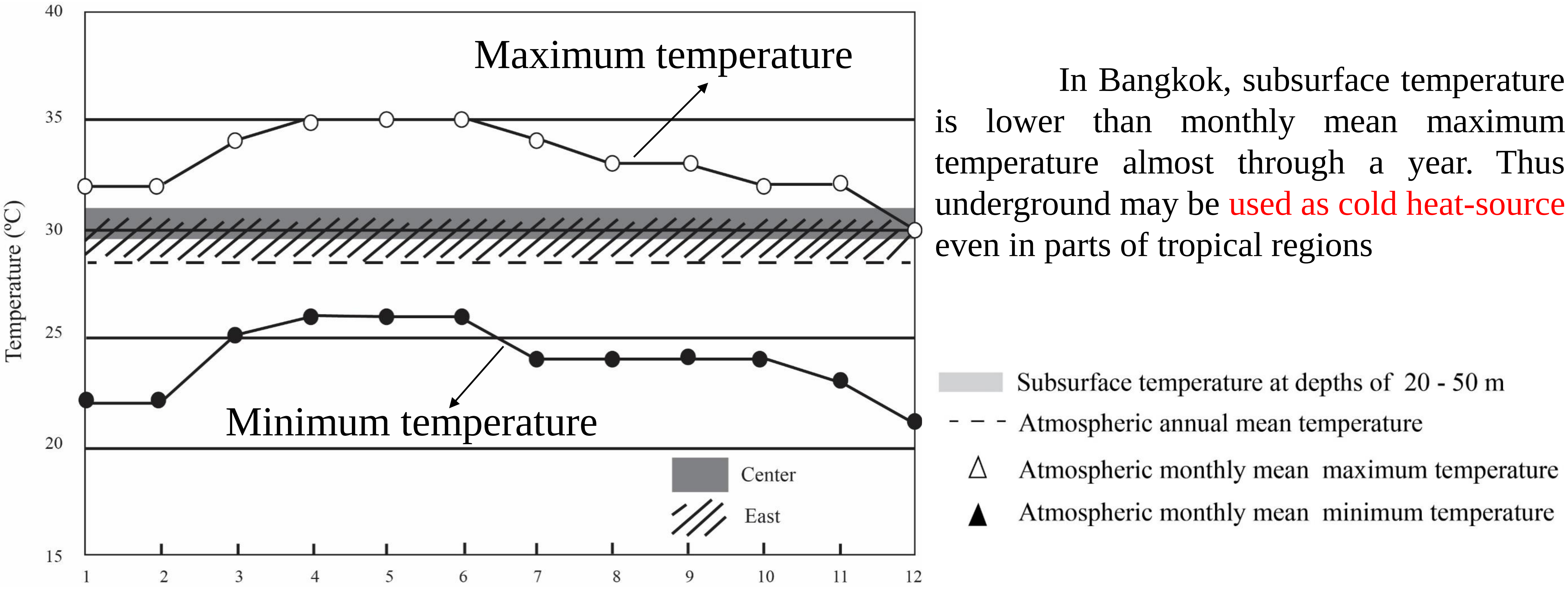


Map of Chao Phraya Plain showing subsurface temperature.



1.3) Yasukawa et al. (2009)

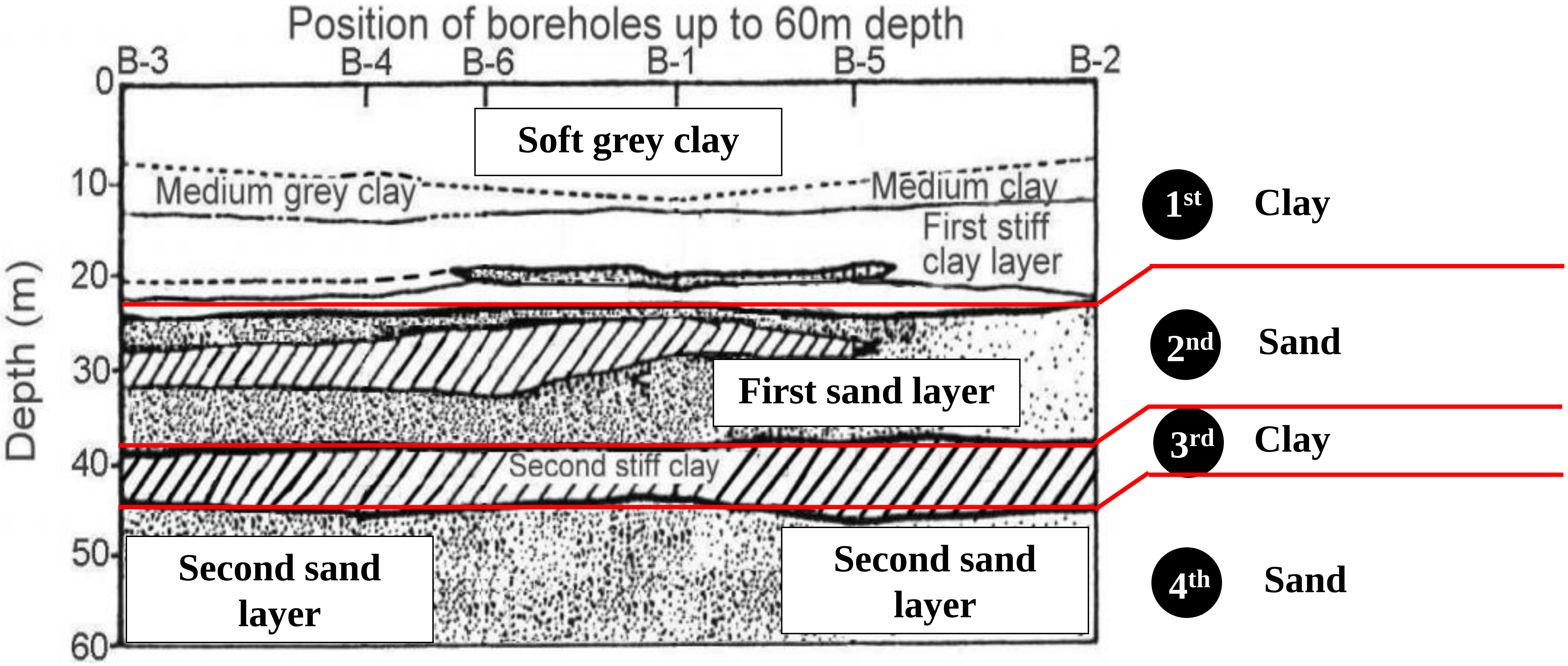
Source: Yasukawa, K. et al., (2009b), Groundwater Temperature Survey for Geothermal Heat Pump Application in Tropical Asia. Bulletin of the Geological Survey of Japan 60. 9/10: 459-467.



In Bangkok, subsurface temperature is lower than monthly mean maximum temperature almost through a year. Thus underground may be used as cold heat-source even in parts of tropical regions

1.4) Balasubramaniam, et al. (2004).

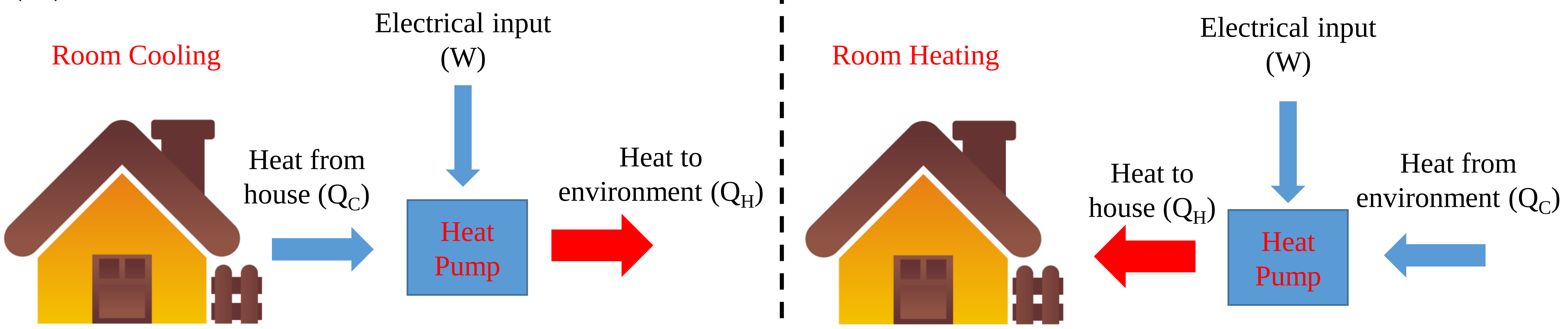
Source: Balasubramaniam, A.S., Oh, E.Y.N., and Phienwej, N. (2004), Bored and driven pile testing in bangkok sub-soils. LOWLAND TECHNOLOGY INTERNATIONAL Vol. a, No. b, pp-pp, date International Association of Lowland Technology (IALT), ISSN 1344-9656.



Typical deep soil profiles at depths 0 to 60 meters.

1.5) Widiatmojo et al. (2017, in prep.)

(A)



$$CoP_{cooling} = \frac{Q_C}{W} = \frac{Q_H - W}{W}$$

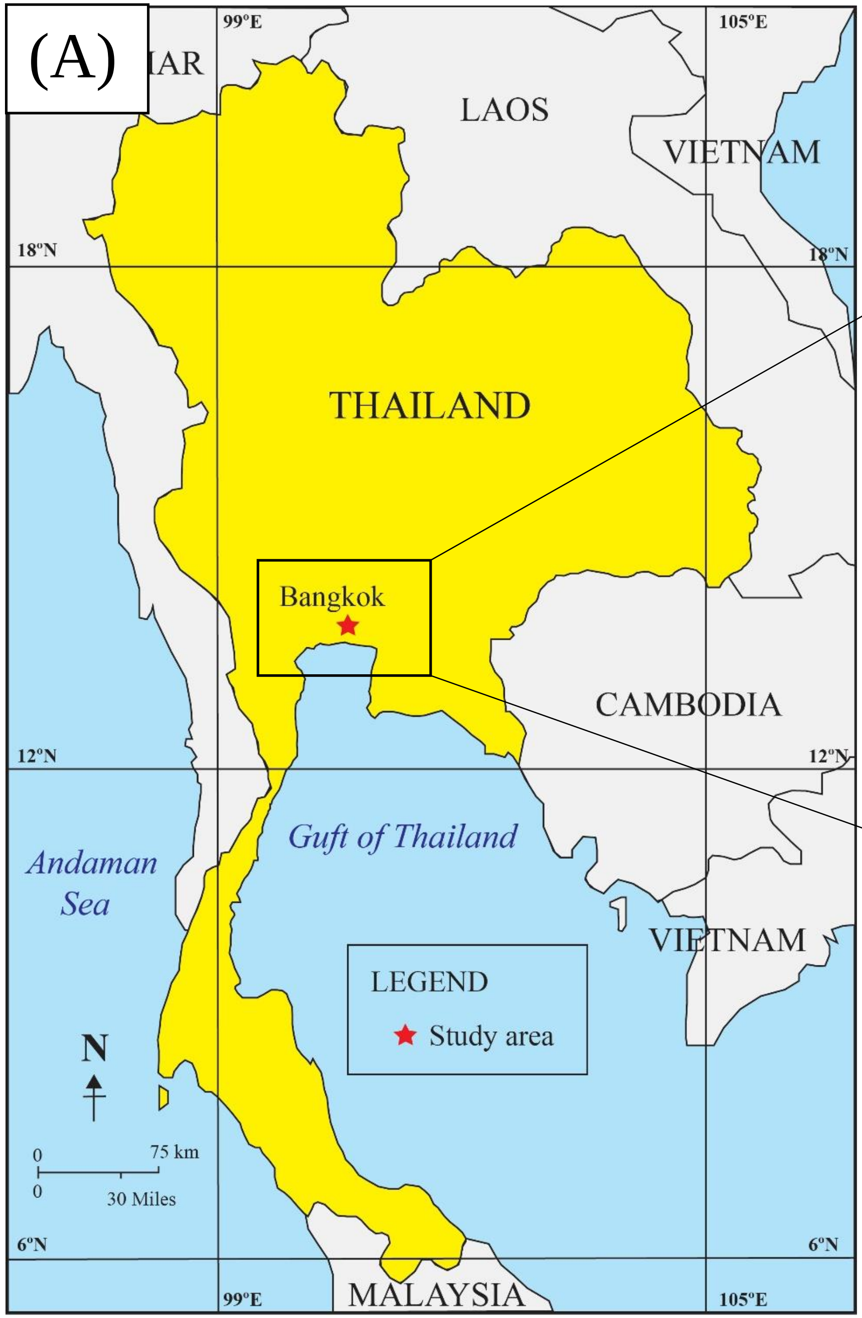
$$CoP_{cooling} = \frac{Q_H}{W} = \frac{Q_C + W}{W}$$

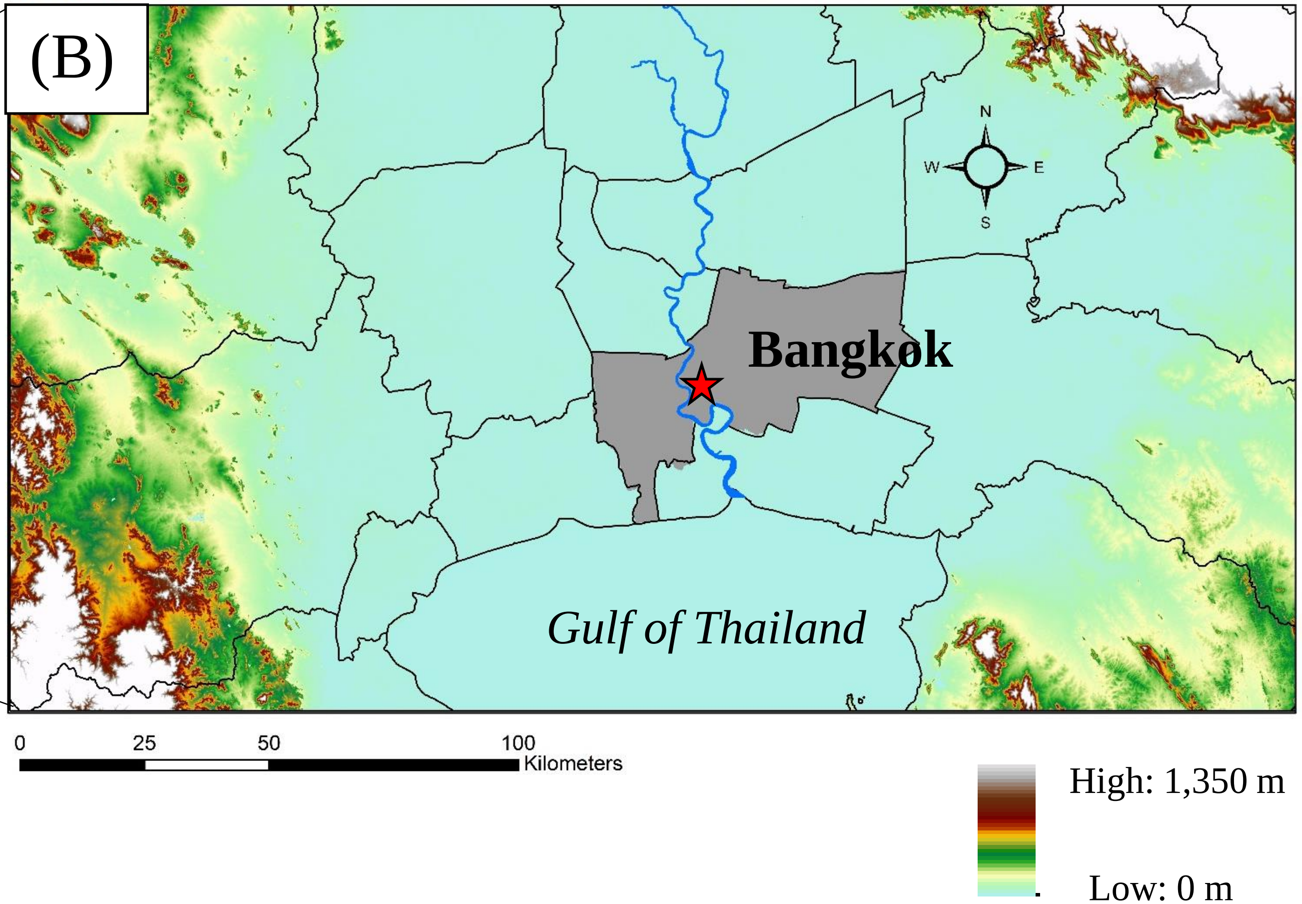
- CoP → ratio between energy transferred for heating or energy removed for cooling to the system input electric energy.

In Thailand

- According to Raksasakulwong (2015)'s report, Prof. Takashima (Akita University) is the first person who introduced GHP to Thailand.
- Kamphaengphet in north-central Thailand is the first place where GHP was installed.
- The research is aimed to extract subsurface energy for GHP,
- Utilization of GHP in Kamphaengphet province was published in Bulletin Geological Survey of Japan, vol. no. 9/10 (whole volume) in 2009.
- However, the amount of energy was not enough to produce GHP system to work successfully.

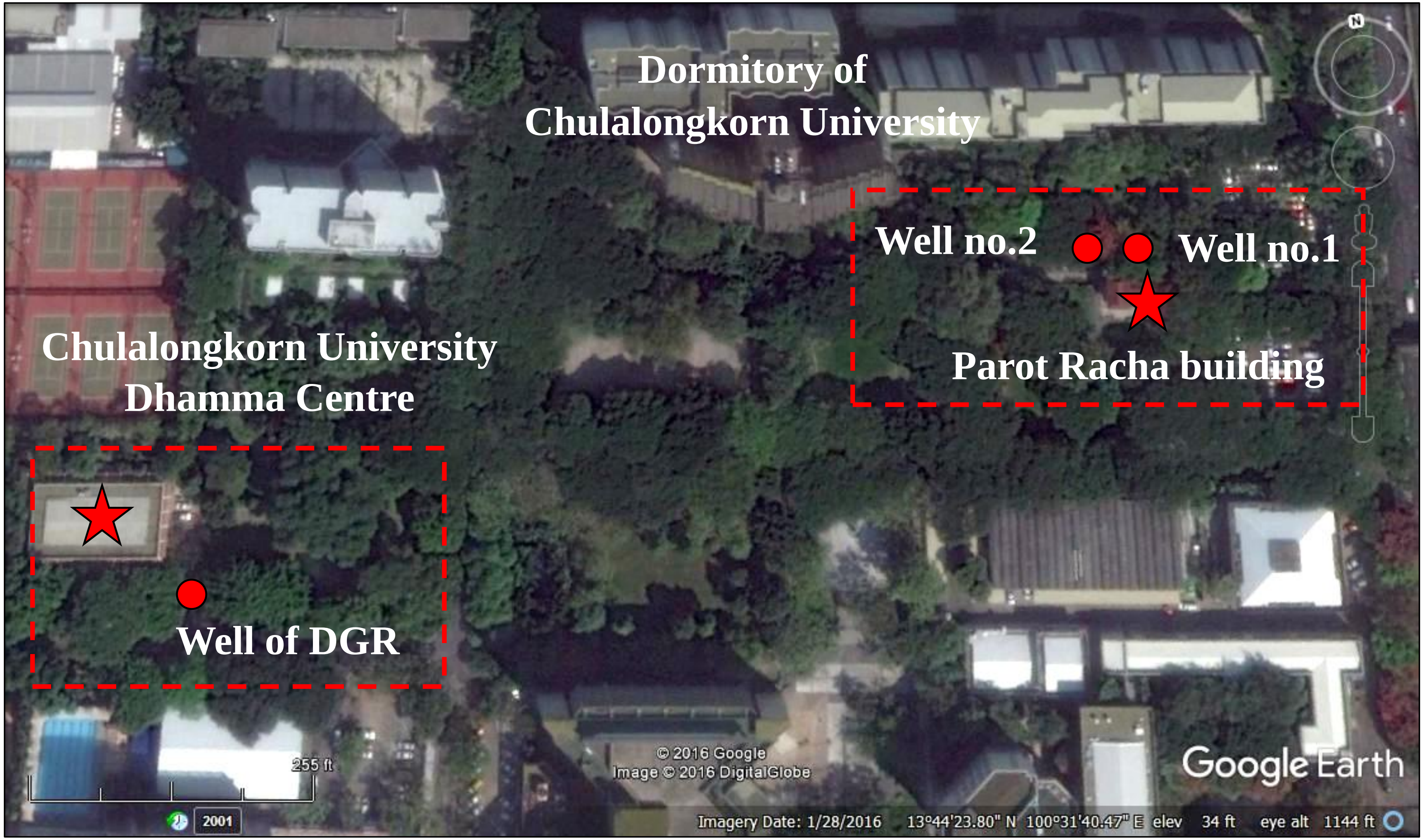
II. Selected area





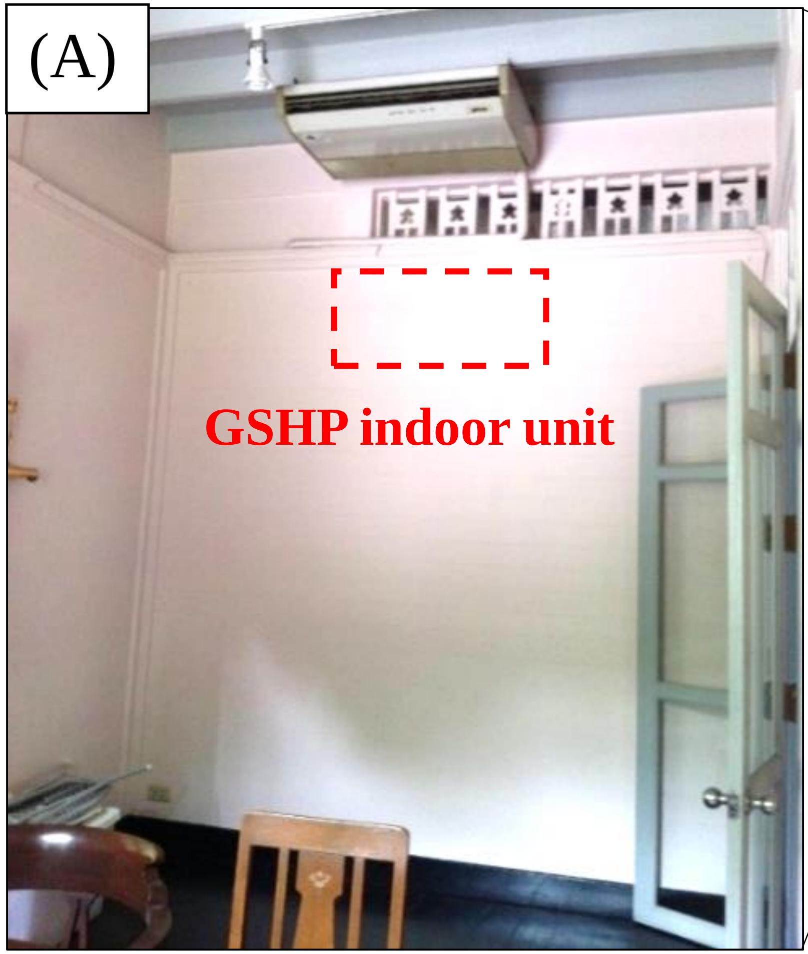
Detail of GSHP system: Index map of Thailand (A) showing the location of Chulalongkorn University (star) in Bangkok (B)

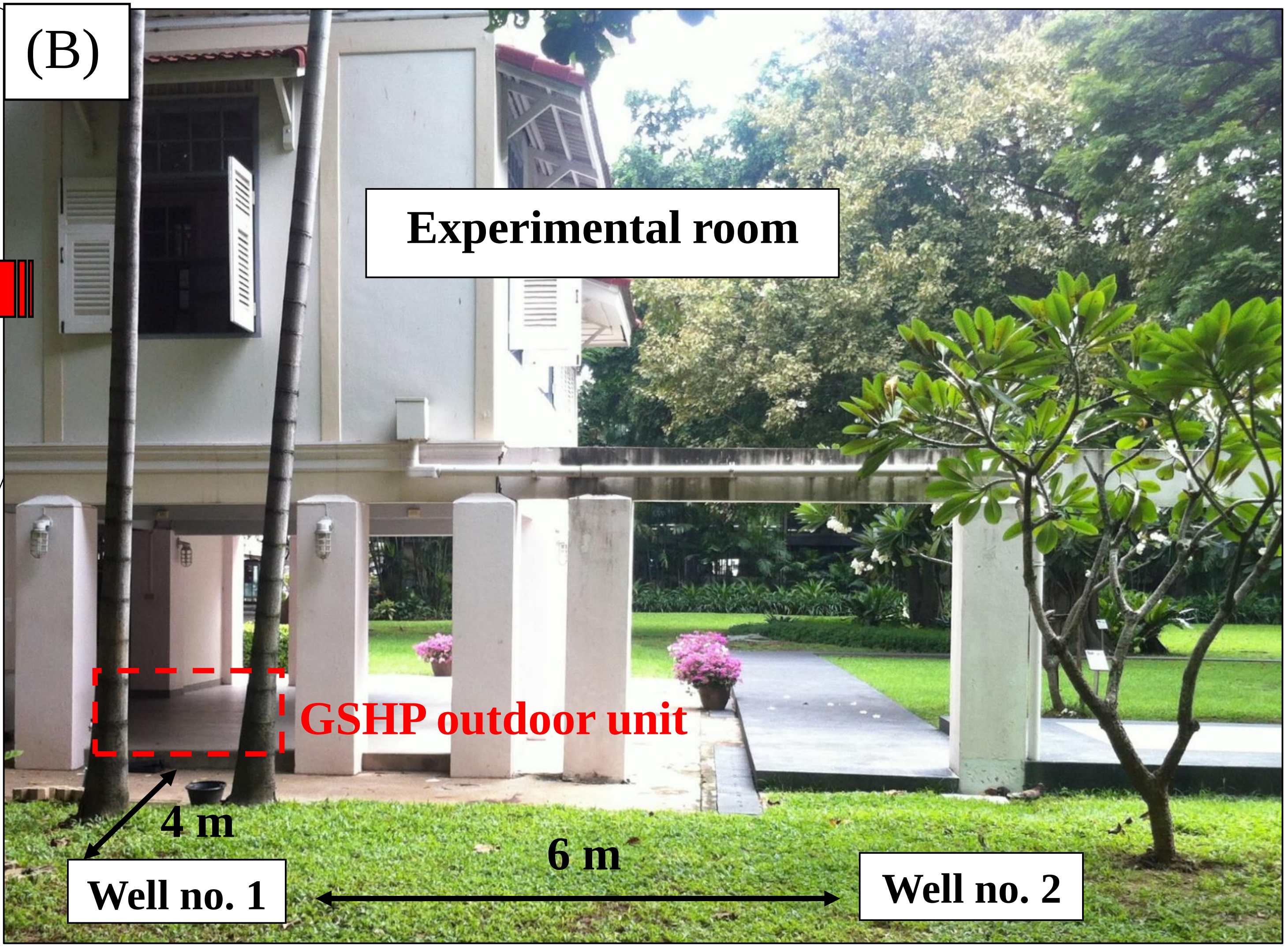
Selected area



Google Earth Map showing the location of Paraot Racha, well nos. 1 & 2 in Chulalongkorn University and the nearest artesian well (Chulalongkorn University Dharma Centre).

Selected area





Remember: *2 units – in-door and out-door*

Experimental room: the second floor of Parot Racha building (2.84 x 4.74 x 3.50 m).

In Bangkok, the land area is very expensive so the best type is the vertical loop to save the land surface.

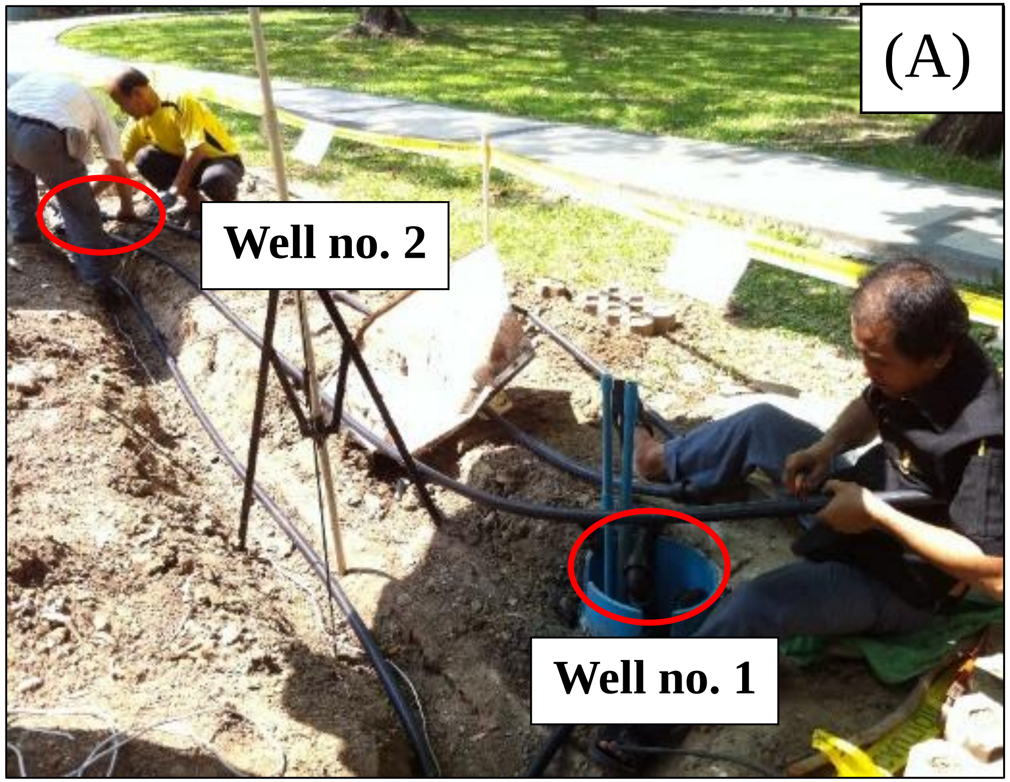
III. installation

Starting with drilling 2 wells (50 m- long) and inserting HDPE pipes in U-shape into these wells.

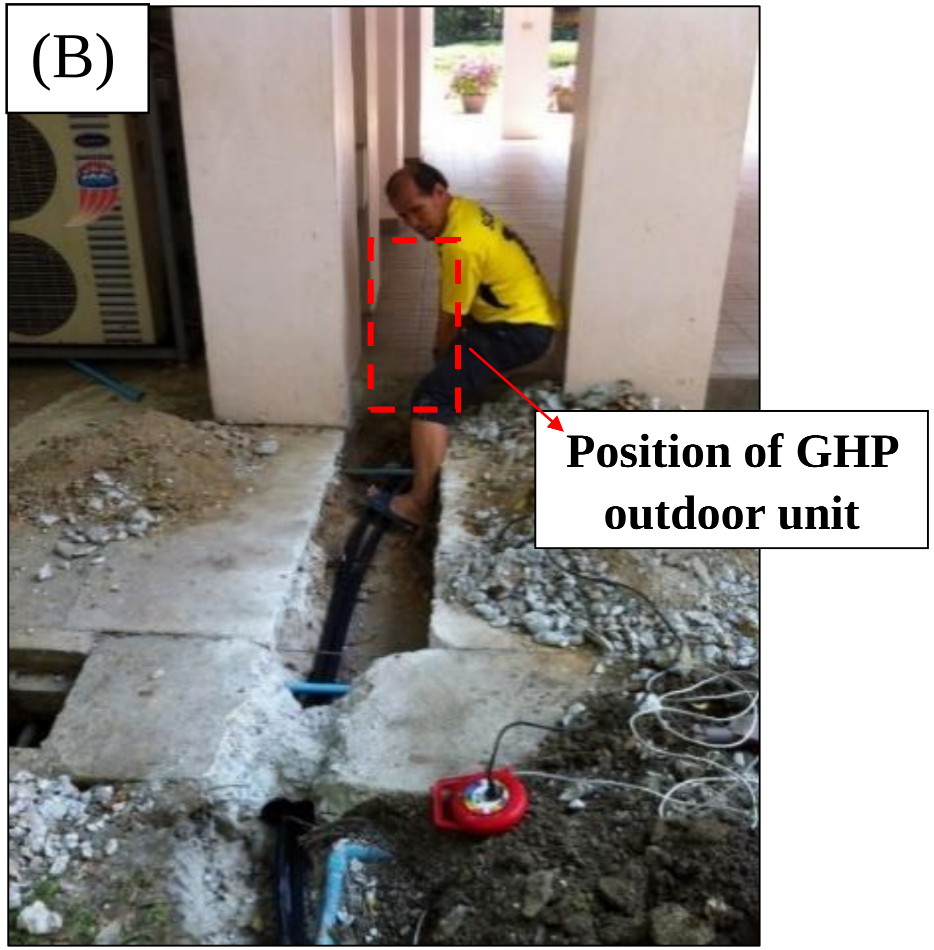
3.1) Drilling

3.2) Pipes setting

3.2) Pipes setting

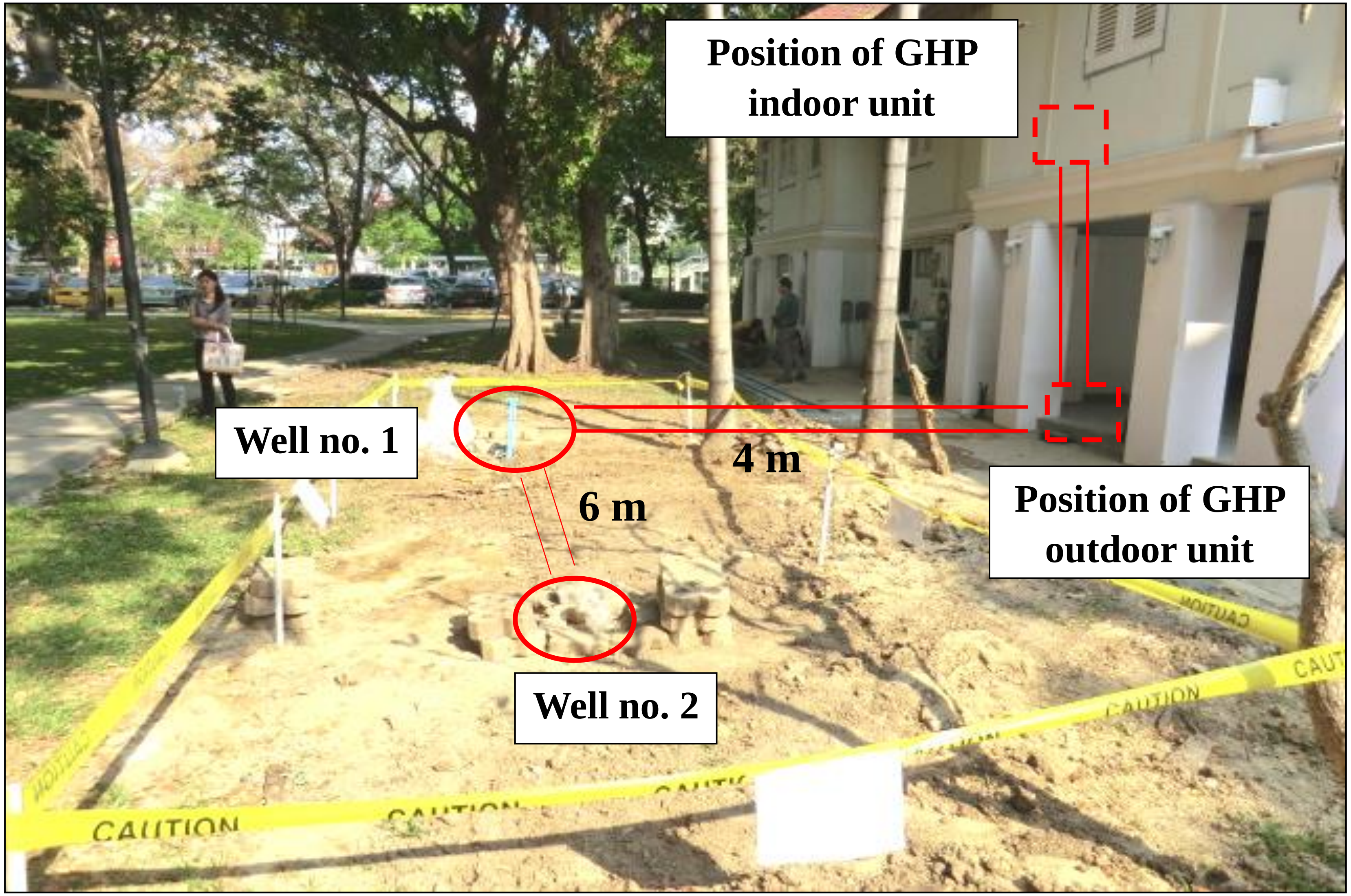


Connecting HDPE pipe of well no.1 to HDPE pipe of well no.2.



Preparing HDPE of well nos.1&2 for connect to GHP outdoor unit.

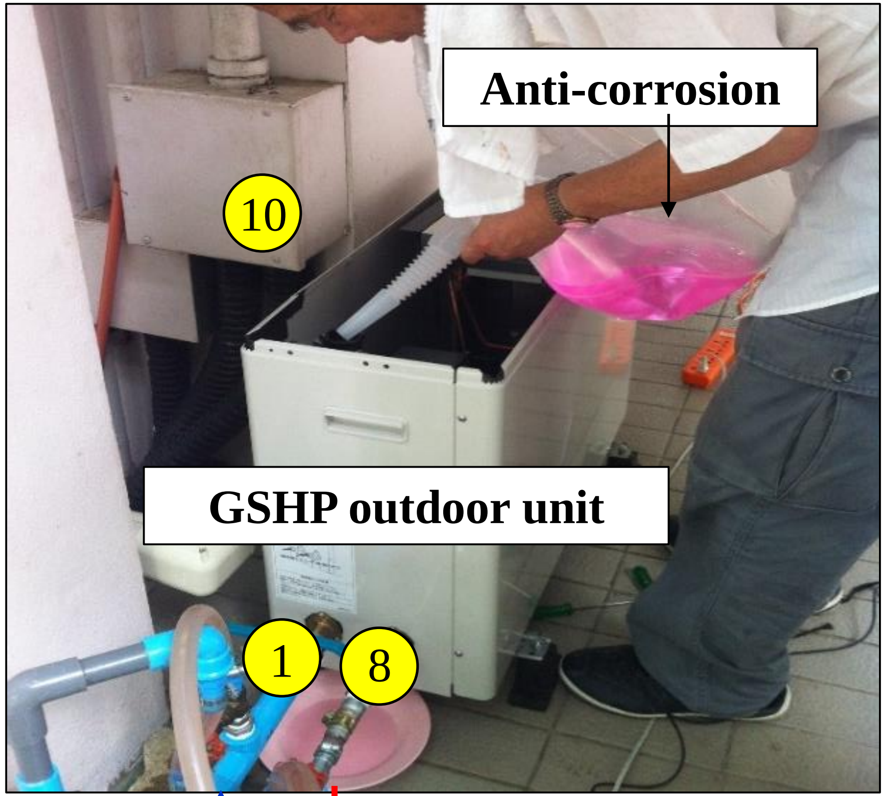
3.3) Landfills



After that filling with local soil into dug wells.

Next step is - connecting inlet and outlet HDPE pipes to the HDPE pipes in both wells and to the GHP outdoor unit. Make sure that there is ***no any leakage***.

3.4) GSHP outdoor unit connecting



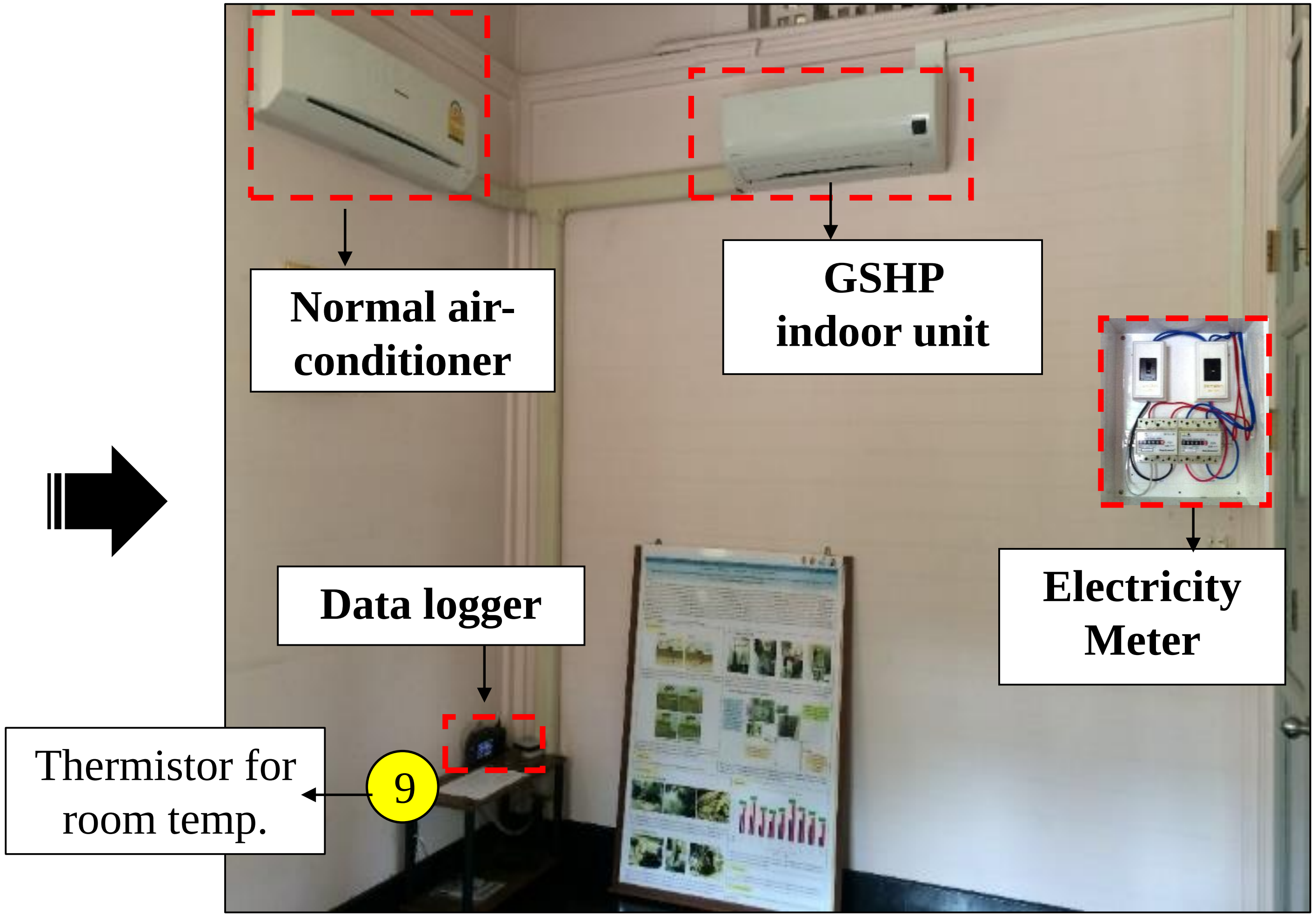
Inlet pipe

Outlet pipe

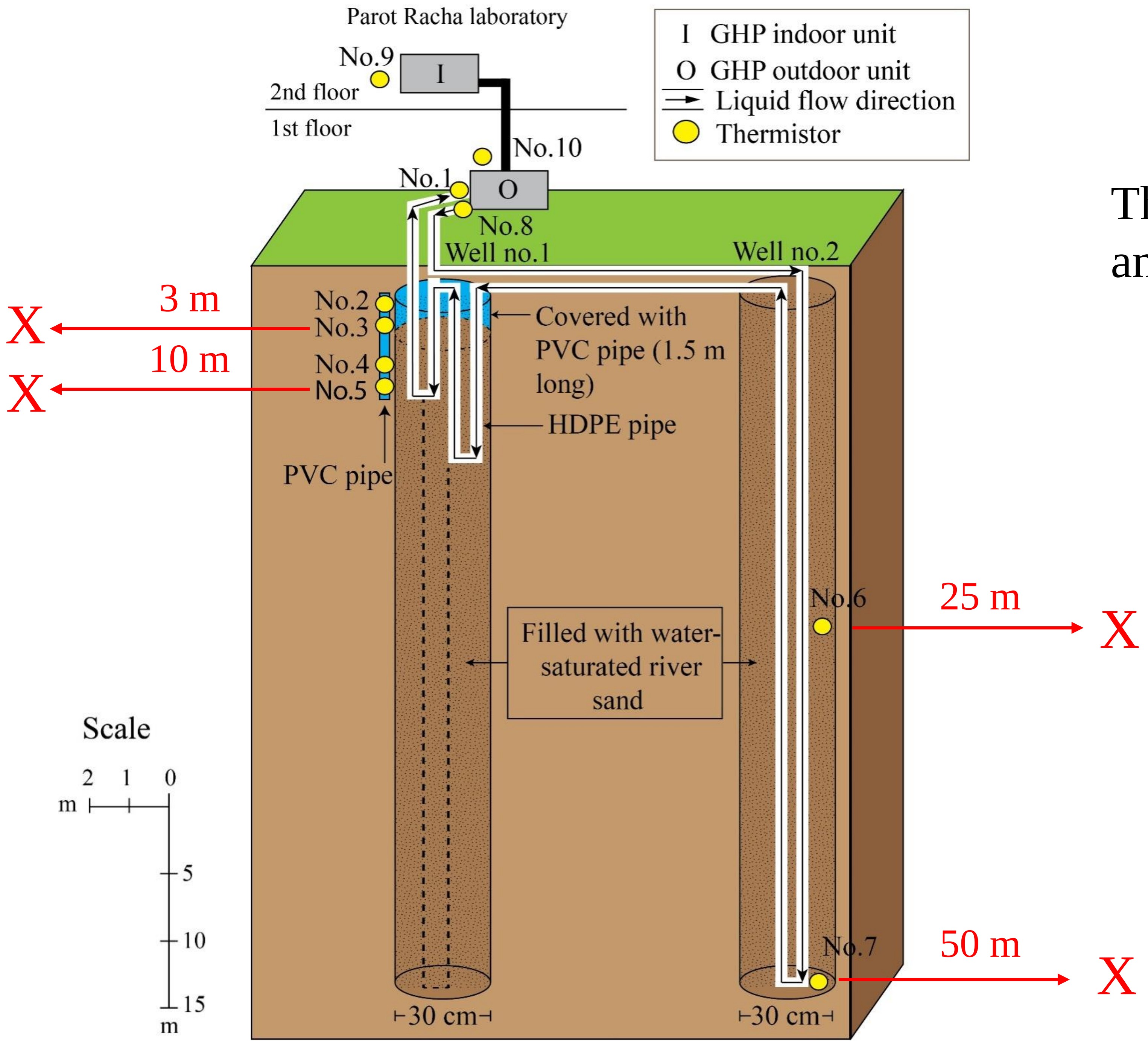
Note: Thermistor no.-
1 = Inlet temp.
8 = Outlet temp.
10 = ATM (outside air) temp.

Finally, connected the GSHP outdoor unit to the GHP indoor unit with data logger, electricity meter in the experimental room.

5. GSHP indoor unit setting



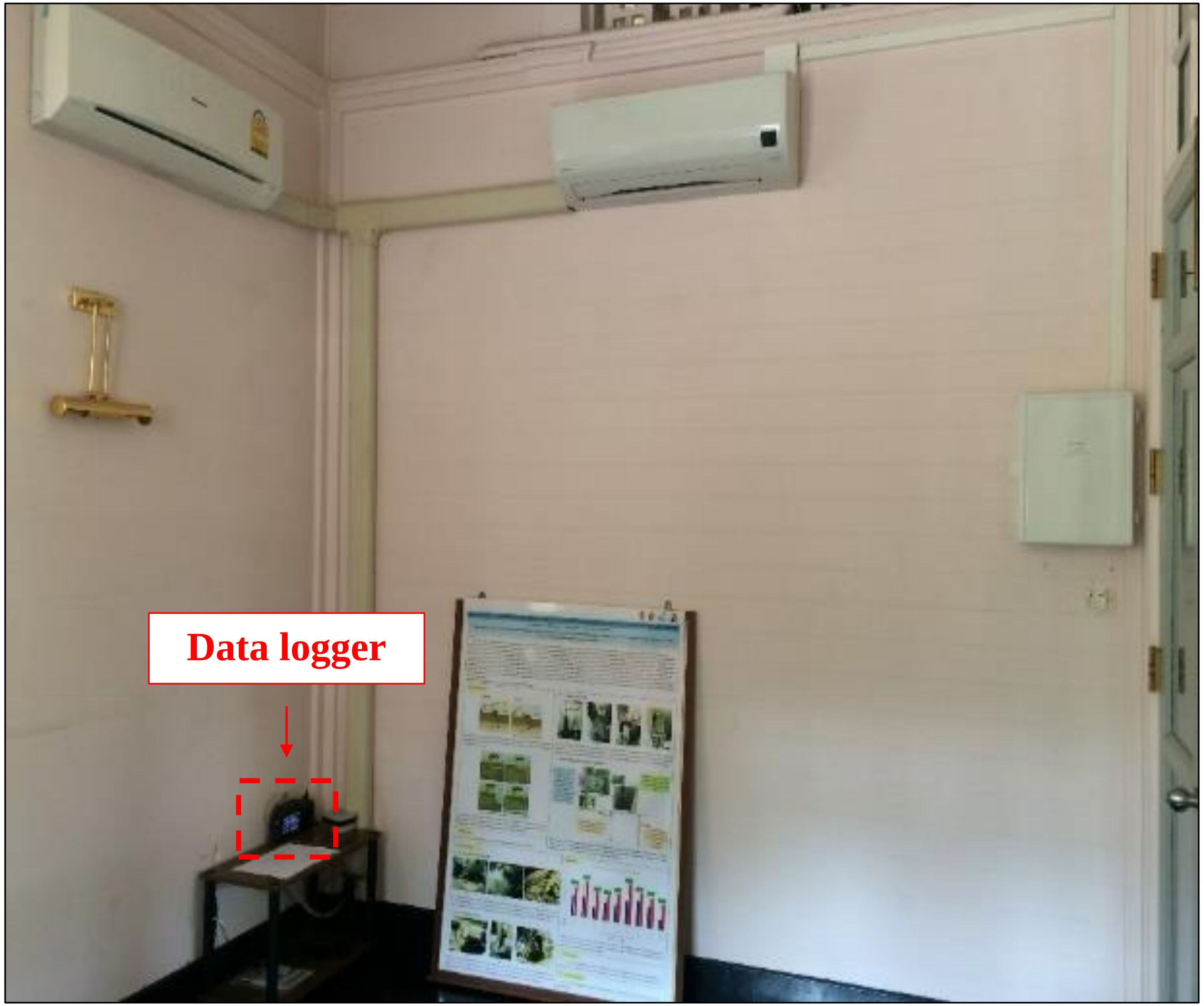
Installation



The circulation pipes stay *without* any leakage.

Schematic installation of geothermal heat pump system at Parot Racha laboratory room.

Note: HDPE pipe in well no.1 was broken. Therefore two new HDPE pipes with the lengths of 10 and 15 meters were inserted and connected to the well no. 2.



Data logger figure in the experimental room

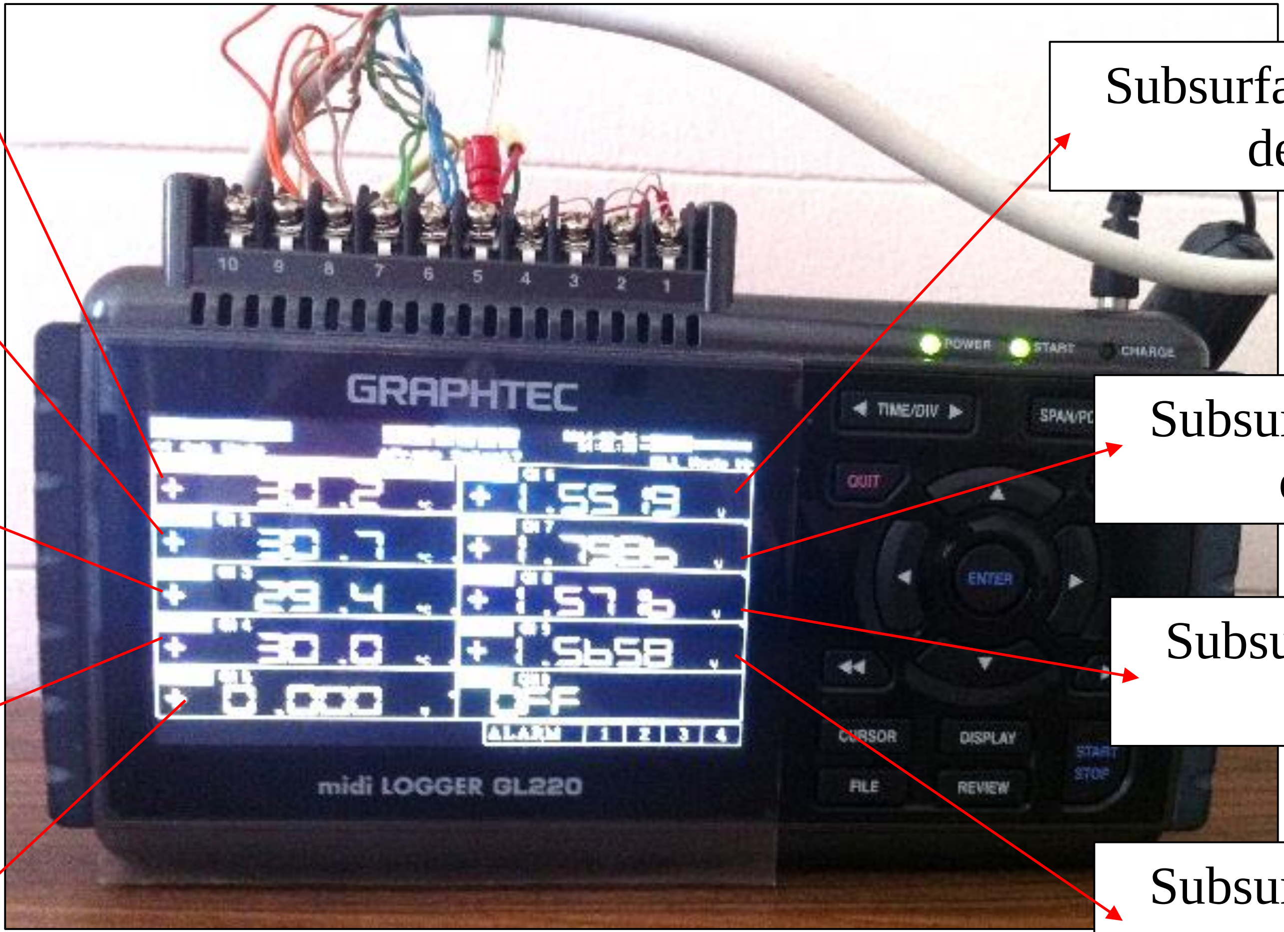
Room temperature

Atmospheric (outside air) temperature

Inlet liquid temperature

Outlet liquid temperature

Flow rate of water circulation



Subsurface temperature at depth of 8 m

Subsurface temperature at depth of 10 m

Subsurface temperature at depth of 3 m

Subsurface temperature at depth of 1.5 m

Recording temperature, humidity and flow rate by **Data Logger** every 20 minutes in 24 hours.

IV. Results

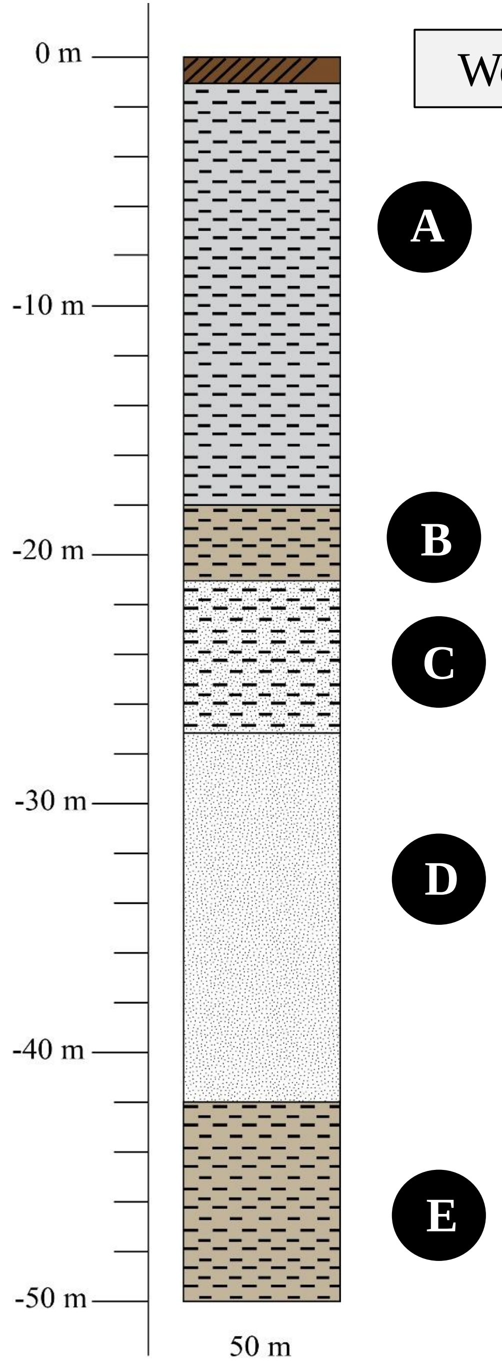
4.1 Cenozoic stratigraphy

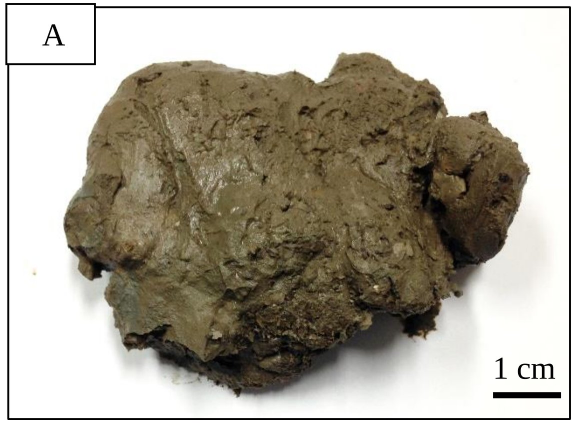
4.2 Temperature and flow rate measurements

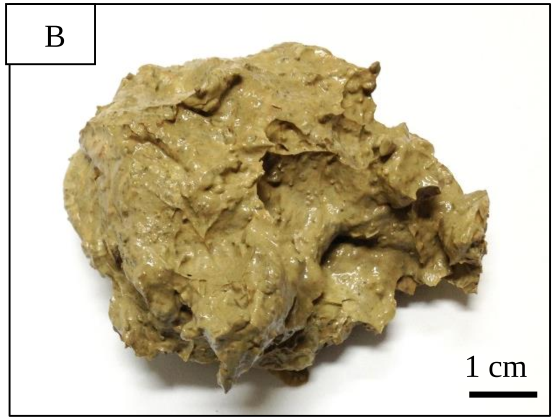
4.3 Energy saving

Results

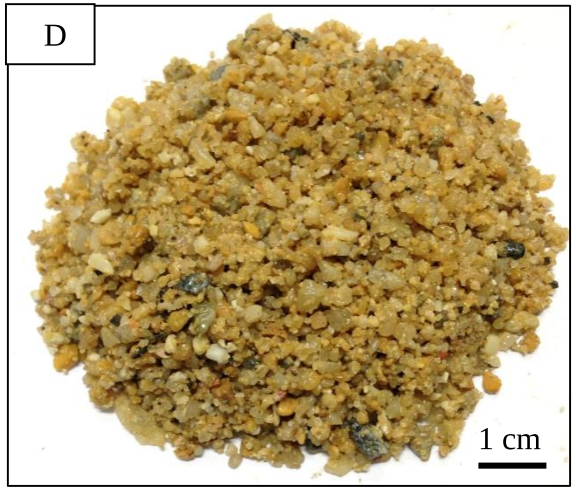
Well no.1

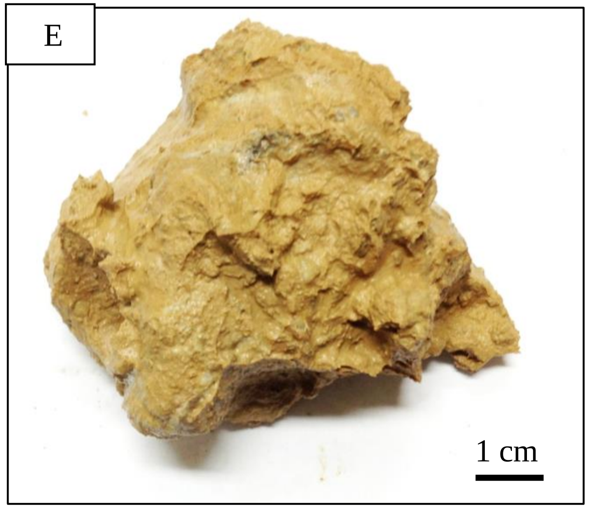


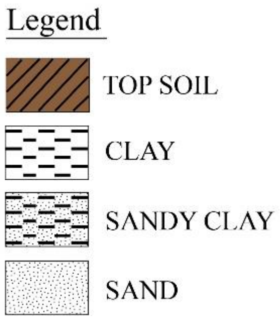




4.1 Based on drilling data, Cenozoic subsurface stratigraphy of the study area was made.

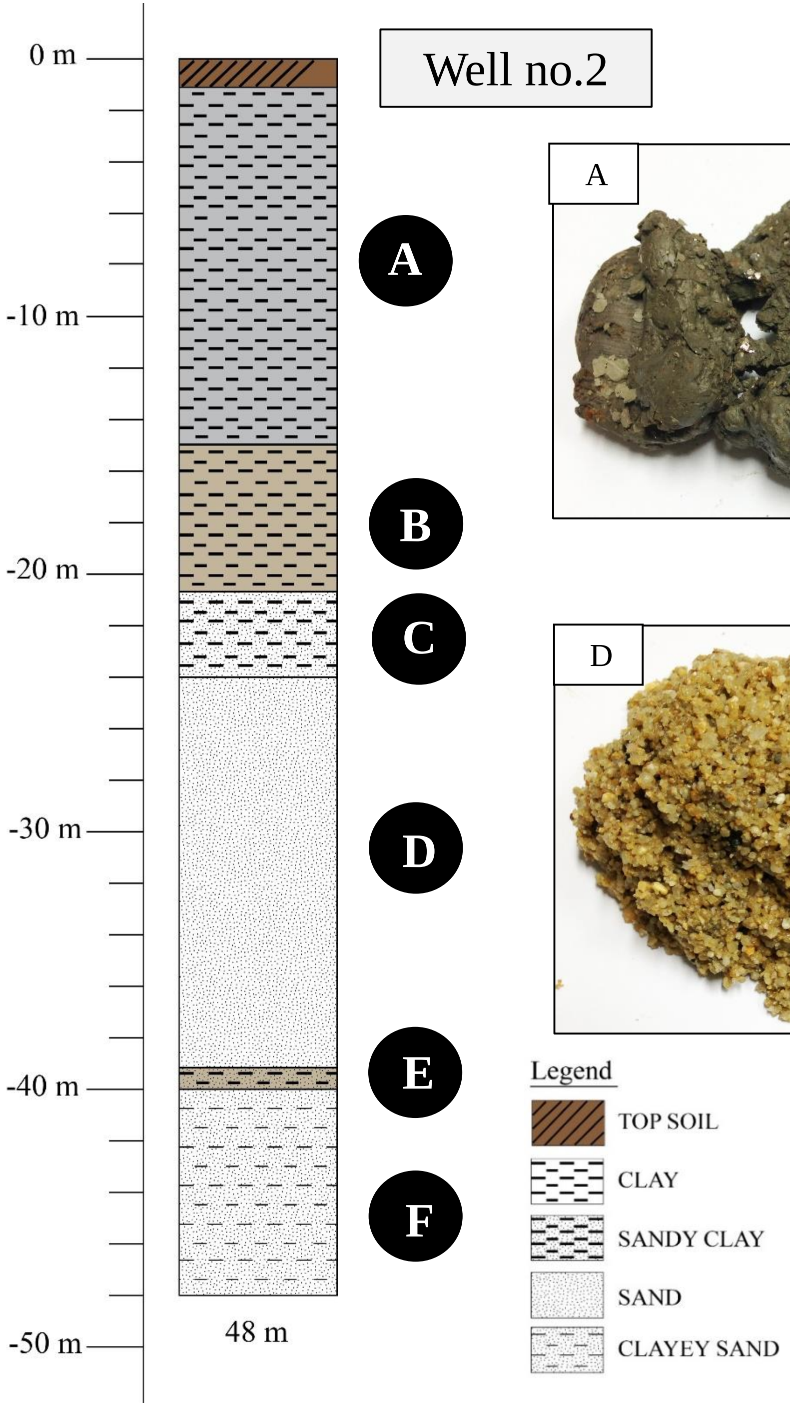


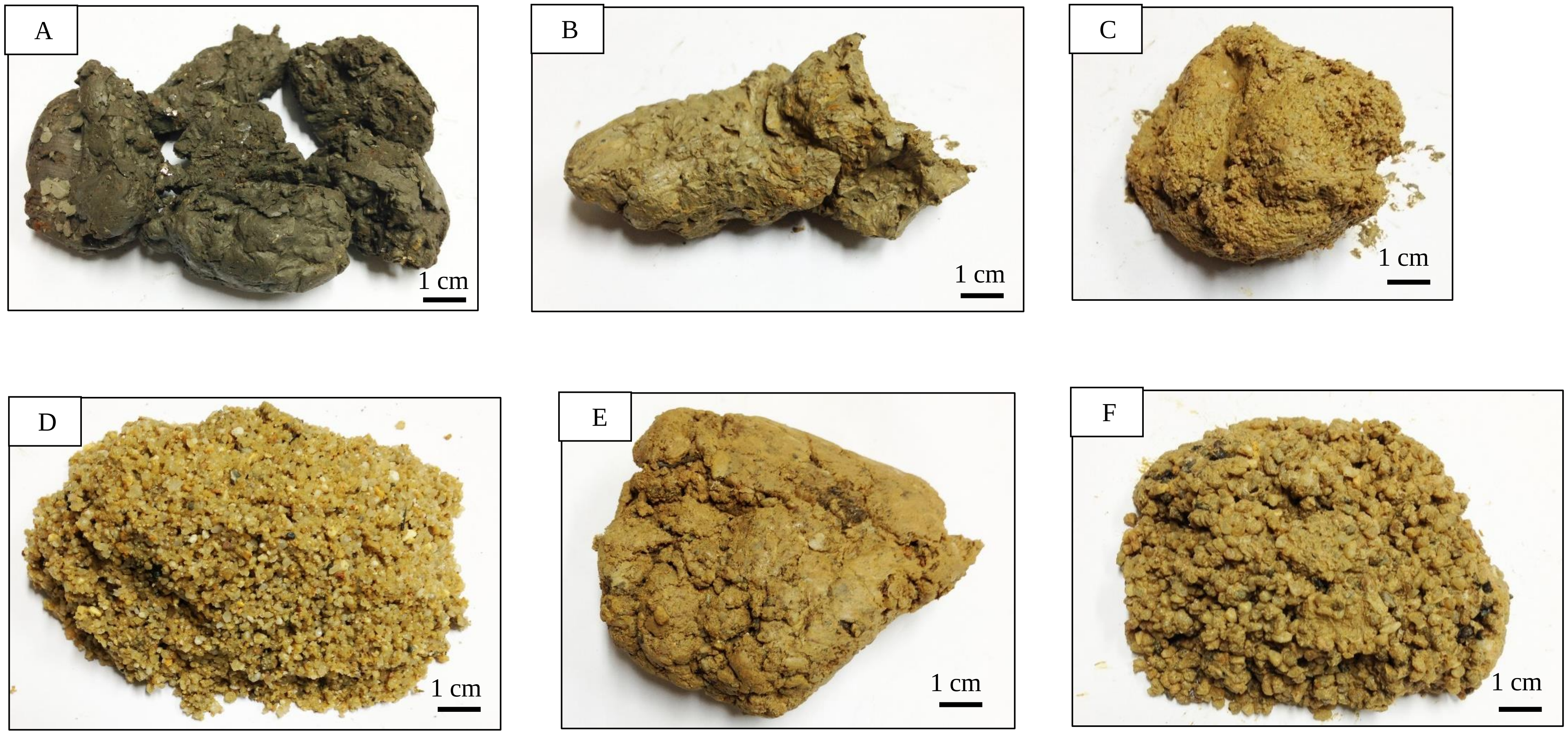




Lithologic log showing lithostratigraphy of Quaternary deposit, well no. 1 at Parot Racha building.

Results

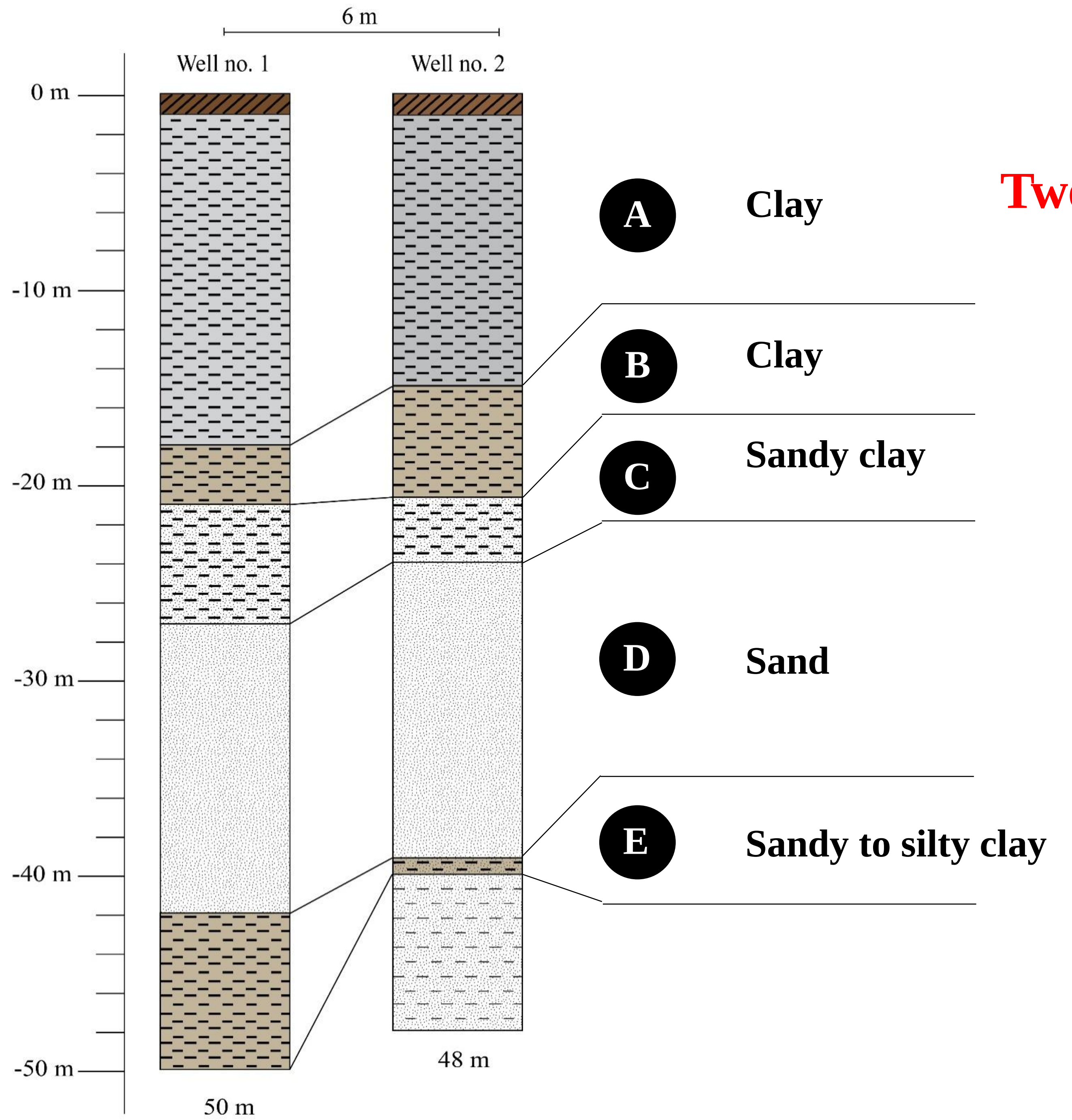




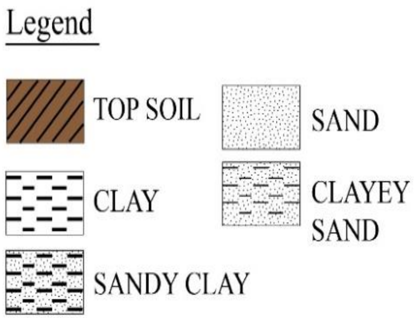
Lithologic log showing lithostratigraphy of Quaternary deposit, well no. 2 at Parot Racha building.

Results

Two well log data shows similar result.



Correlation of 2 lithologic logs in this study show thick sand layers (D) between the overlying and underlying shale or clay.

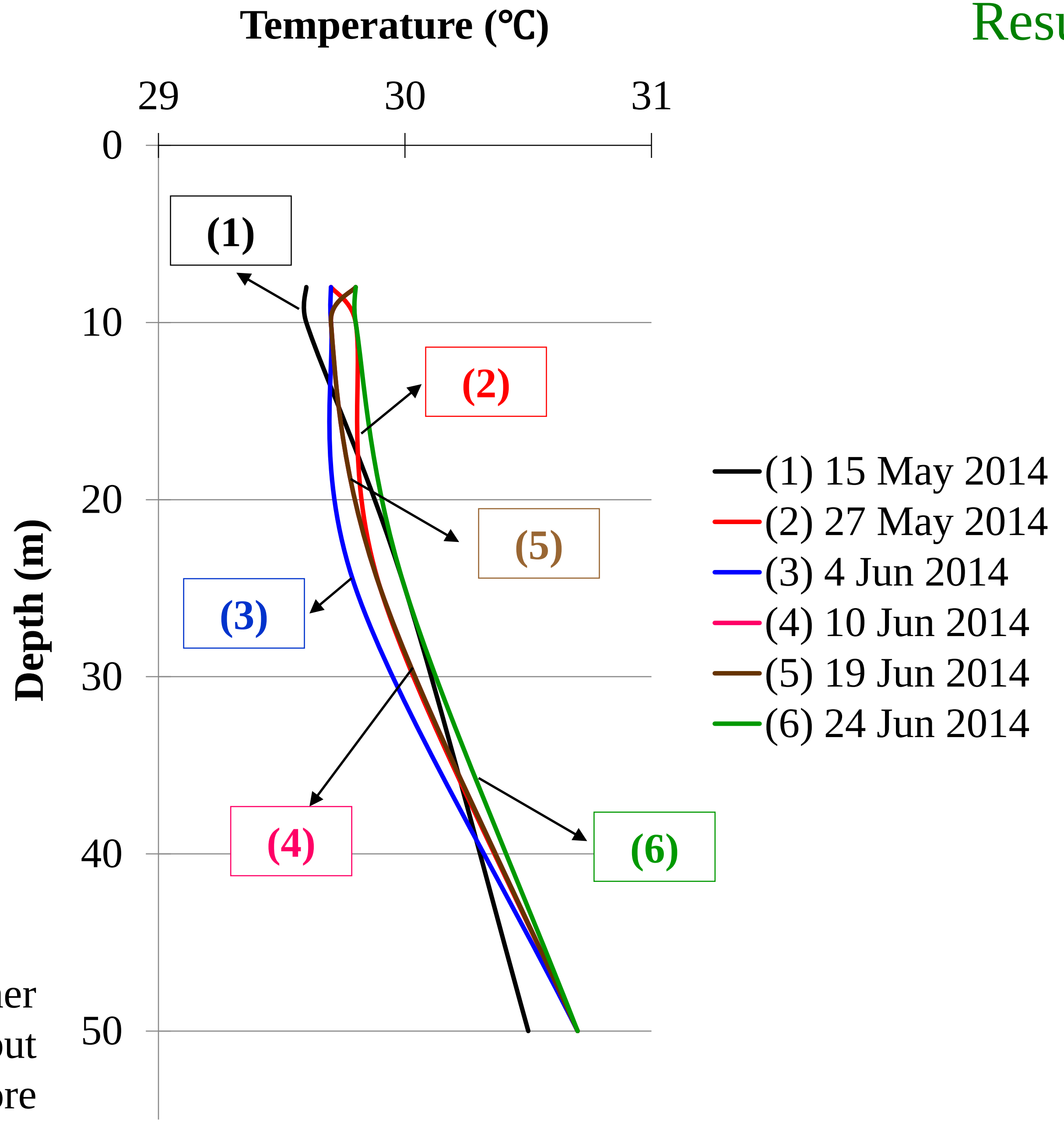


4.2 Temperature measurement

<u>Subsurface temperature</u>

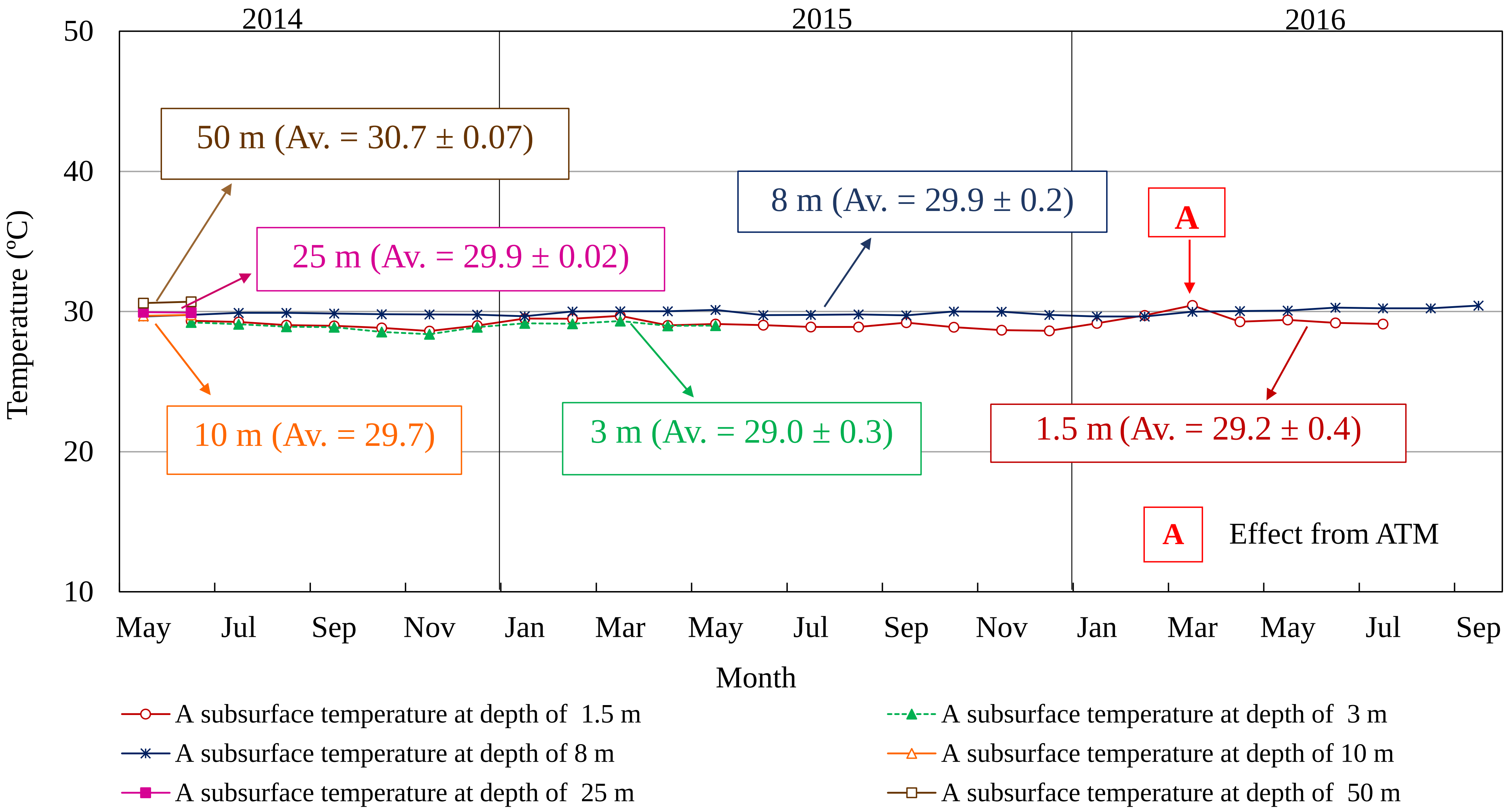
Temperature profiles of observation well nos.1 and 2 at depths of 8, 10, 25 and 50 m.

The graphs show a slight increase in temperatures at depth and are fairly consistent almost all the year.



<u>Note</u> that data logger was installed in August 2014 together with a thermistor at depth of 1.5 m (thermistor no. 2), but thermistors at depth of 10, 25 and 50 m were broken before that.

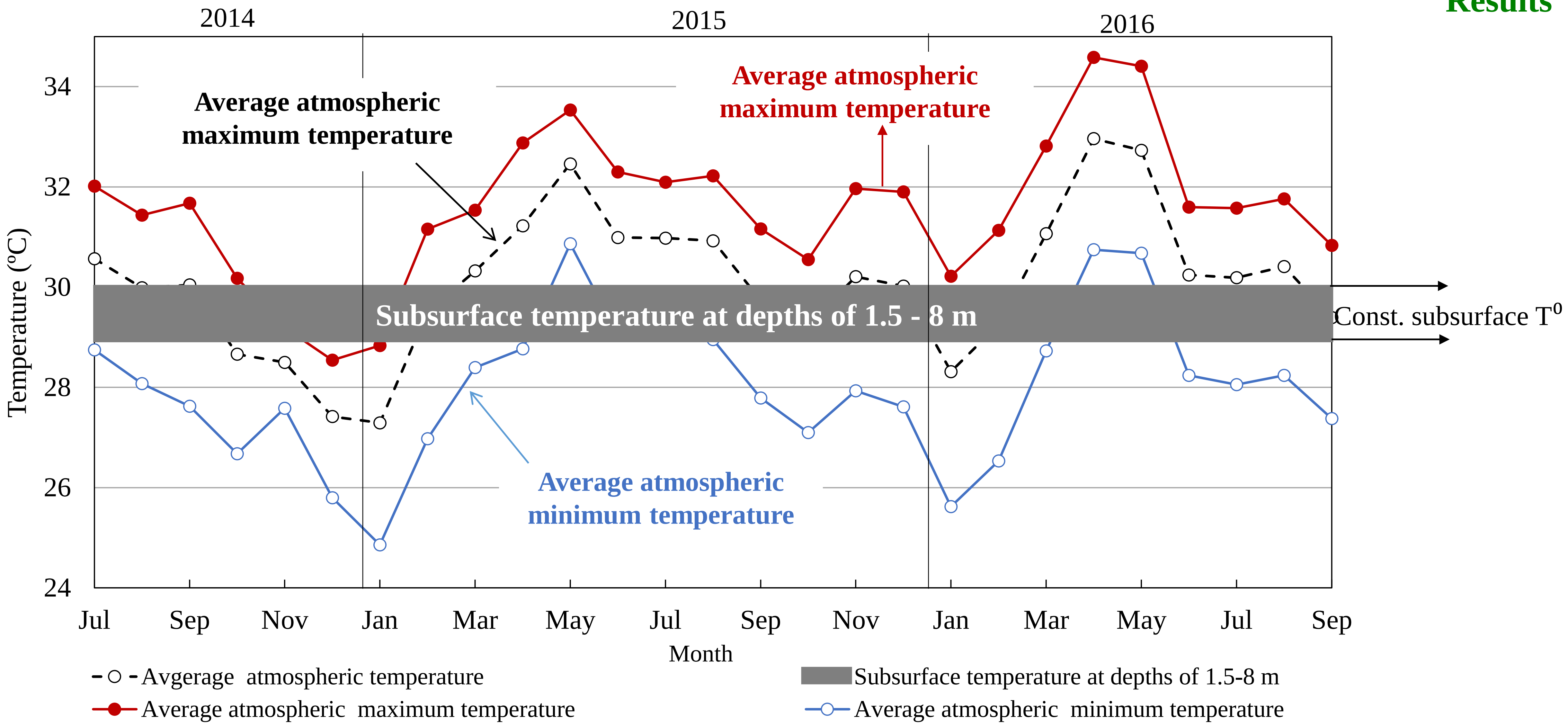
4.2 Subsurface temperature



Average subsurface temperature in long-term measurement at depths of 1.5, 3 and 8 m at Parot Racha Building, Chulalongkorn University from July 2014 to September 2016

4.2 Subsurface temperature

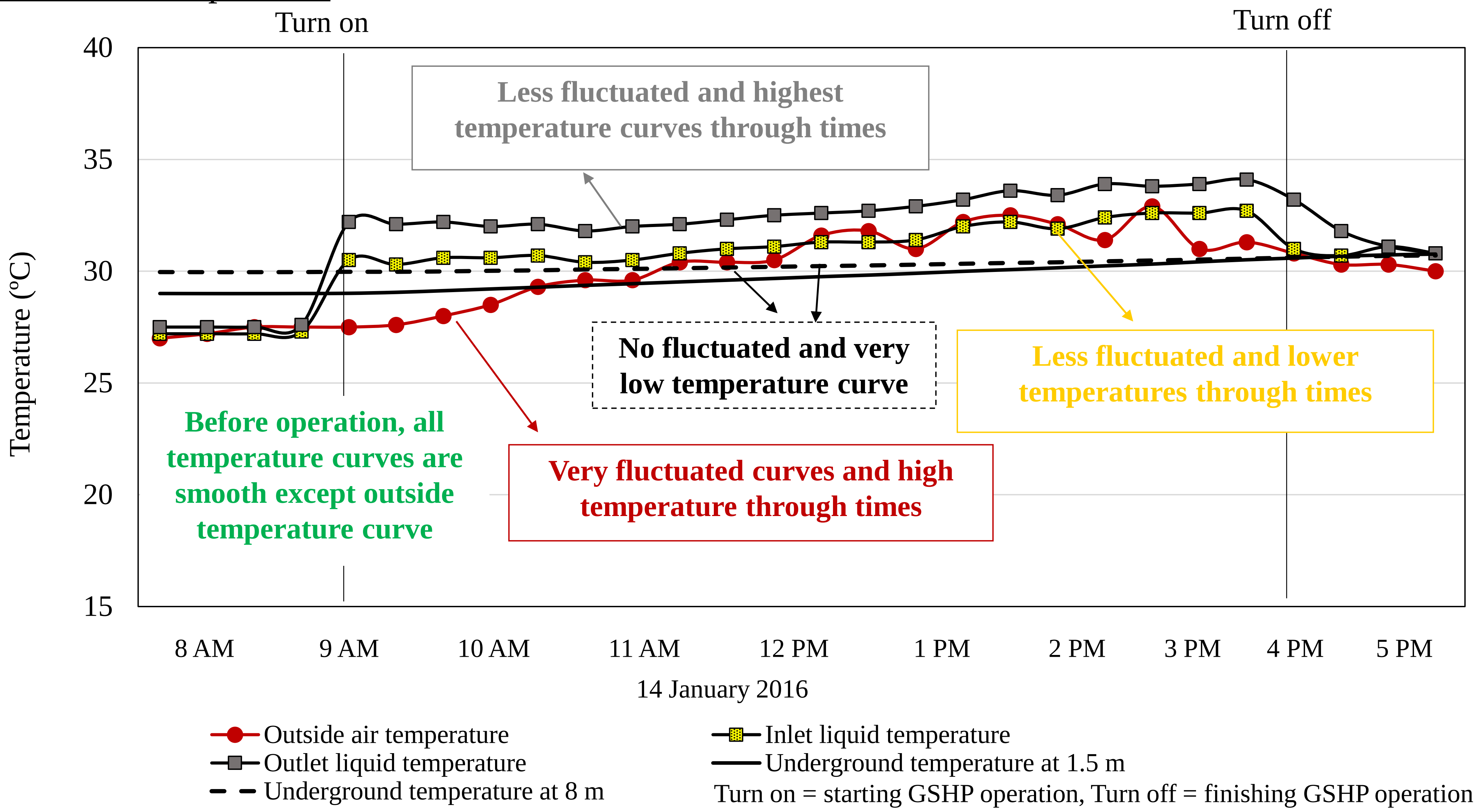
Results



Comparison of atmospheric (outside air) temperatures and subsurface temperatures in long-term measurement at Parot Racha Building, Chulalongkorn University from July 2014 to September 2016.

4.2 Subsurface temperature

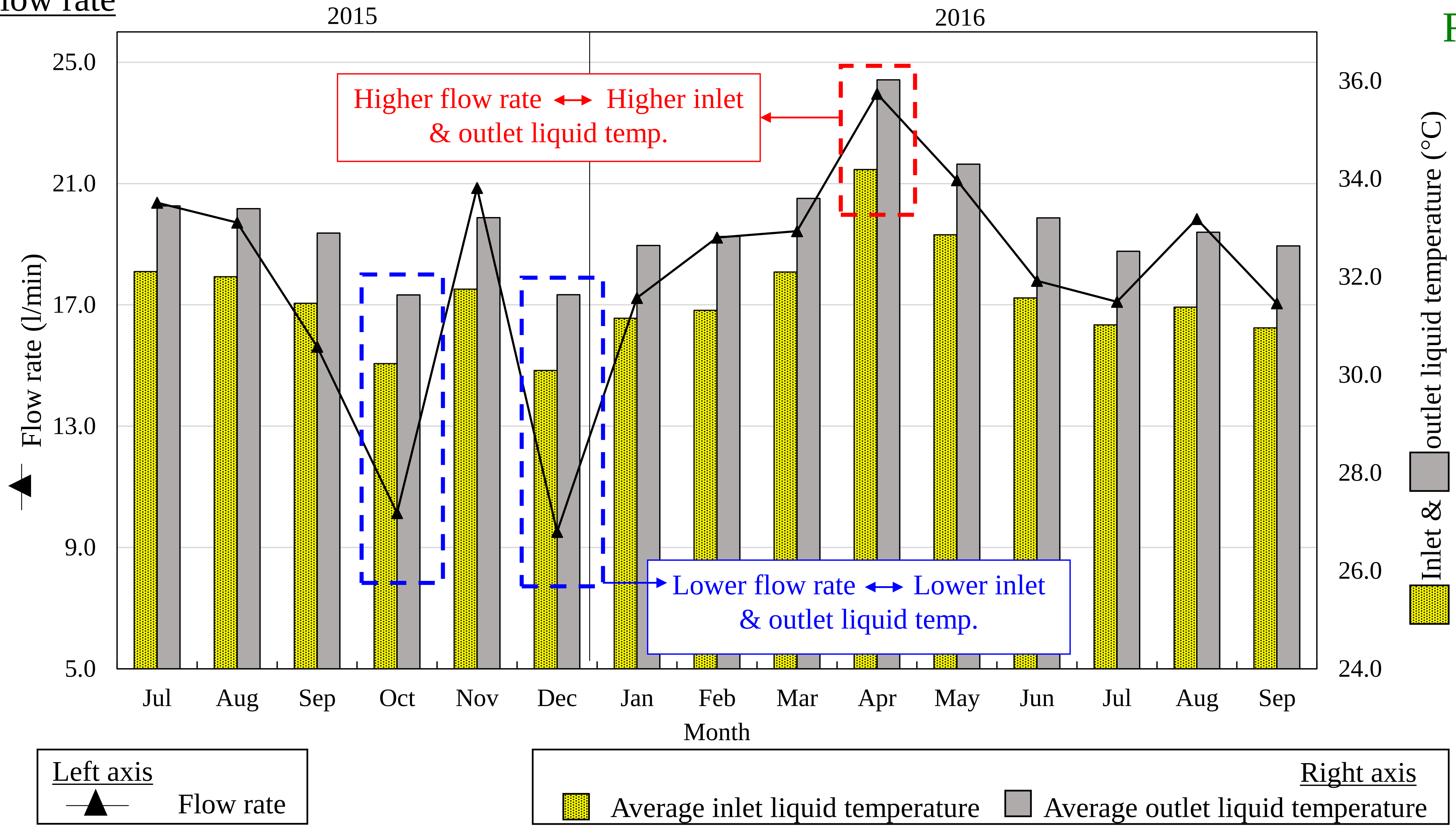
Results



Range of inlet-, outlet-, subsurface- and outside-air temperatures from 8 am to 5 pm of 14 January 2016 showing different styles of temperature excursion.

4.2 Flow rate

Results



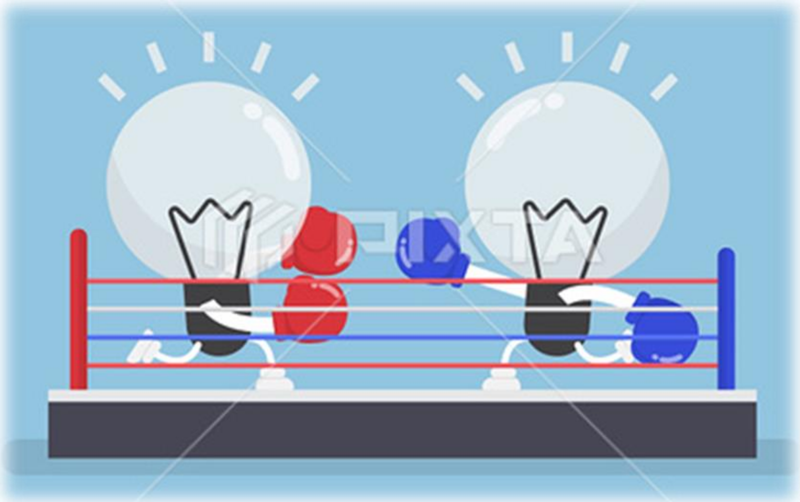
Comparison of flow rate and atmospheric (outside air) temperatures in long-term measurement of GHP during operation from July 2015 to September 2016.

4.3 Energy saving

For convenience, we select 25 ºC for the room temperature and 1-hour operation for both air-conditioners.
Formula for calculation of electricity reducing of GHP as shown in (1).

$$100 - \left[\frac{\text{Electricity consumption of GHP x 100}}{\text{Electricity consumption of AC}} \right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

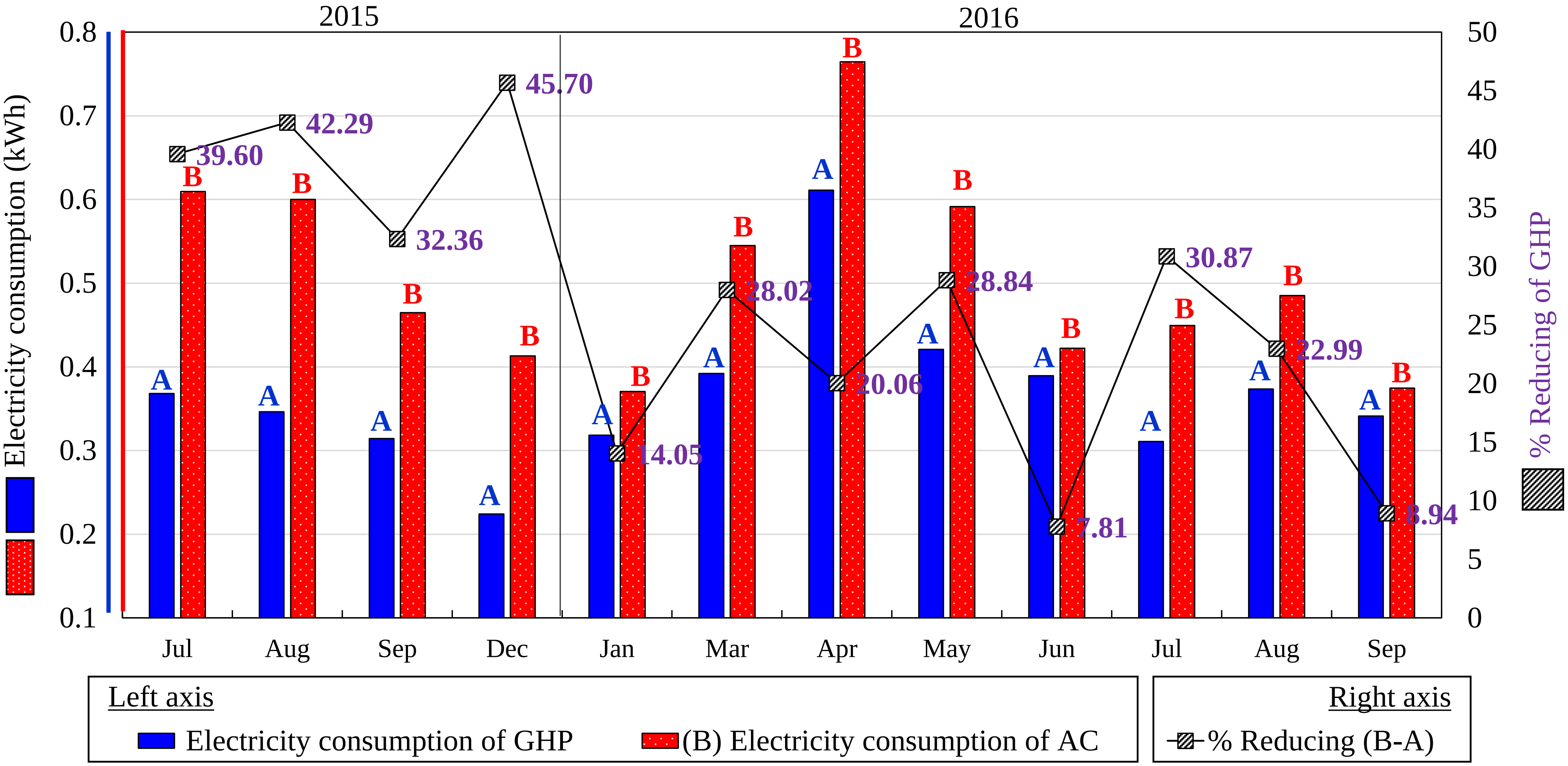
Normal air-conditioner (AC)



GHP

4.3 Energy saving

It is clear that GHP can consume less electricity than the normal air conditioner (AC)



Comparison of electricity consumption between GSHP and normal air-conditioner (AC) t-Test Two –Sample Assuming Equal Variances of atmospheric (outside air) temperature in June 2016

	GSHP	**Normal air-conditioner (AC)**
Mean	30.10939477	30.28533743
Variance	3.582936782	3.574003403
Observations	7	7
Pooled Variance	3.578470093	
Hypothesized Mean Difference	0	
df	12	
t Stat	-0.174002899	
P(T<=t) one-tail	0.432382057	
t Critical one-tail	1.782287556	
P(T<=t) two-tail	0.864764114	
t Critical two-tail	2.17881283	

| t Stat | < t Critical two-tail = *Accept H_0*

t-Test Two –Sample Assuming Equal Variances of Humidity in June 2016

	GSHP	Normal air-conditioner (AC)
Mean	56.5086414	52.17644143
Variance	87.28751638	75.97876063
Observations	7	7
Pooled Variance	81.6331385	
Hypothesized Mean Difference	0	
df	12	
t Stat	0.897034755	
P(T<=t) one-tail	0.19367152	
t Critical one-tail	1.782287556	
P(T<=t) two-tail	0.38734304	
t Critical two-tail	2.17881283	

| t Stat | < t Critical two-tail = *Accept H_0*

V. Discussion

5.1 **Importance of subsurface stratigraphy**

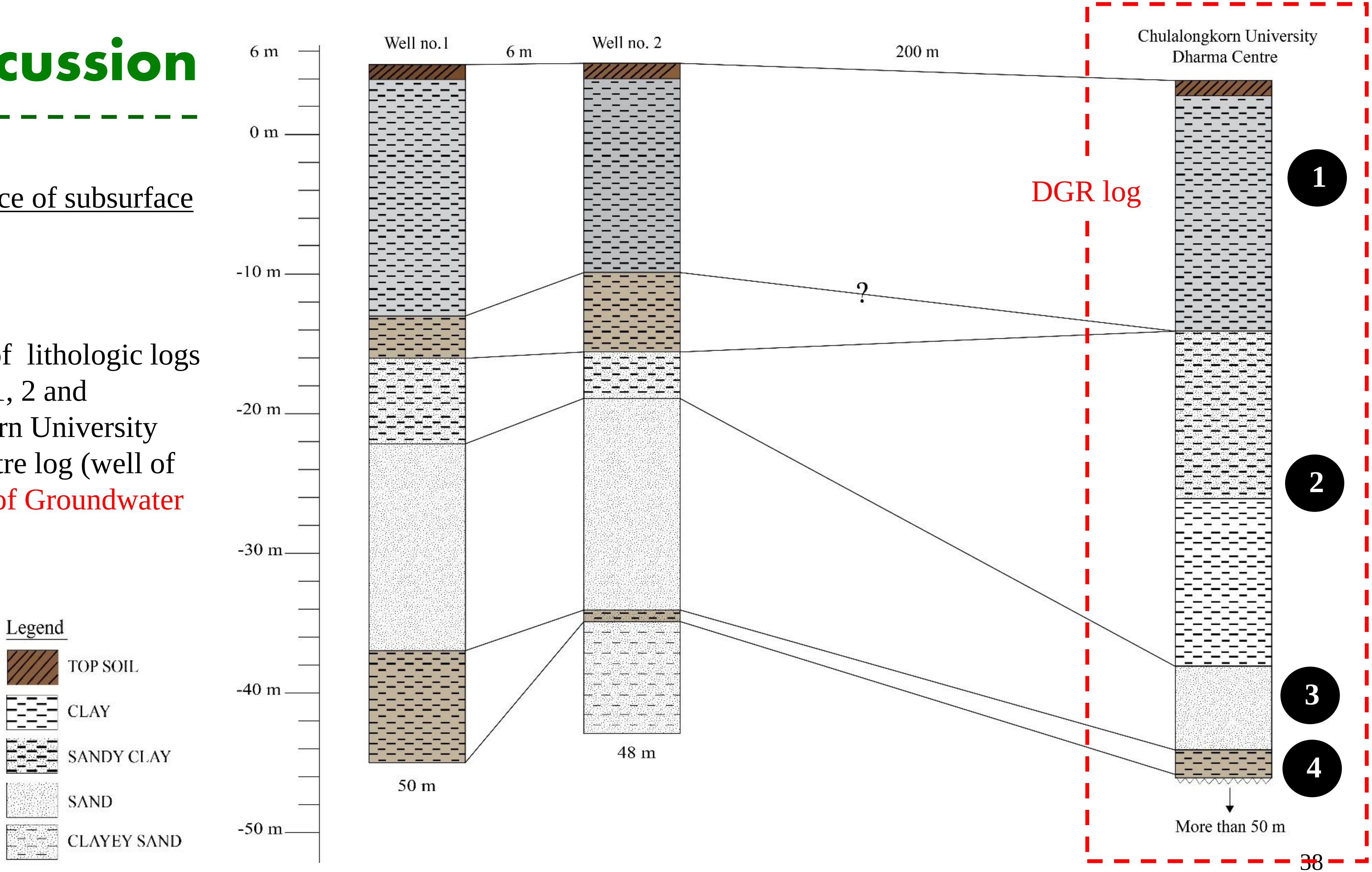
5.2 **Characteristics of subsurface temperatures**

5.3 **CoP**

V. Discussion

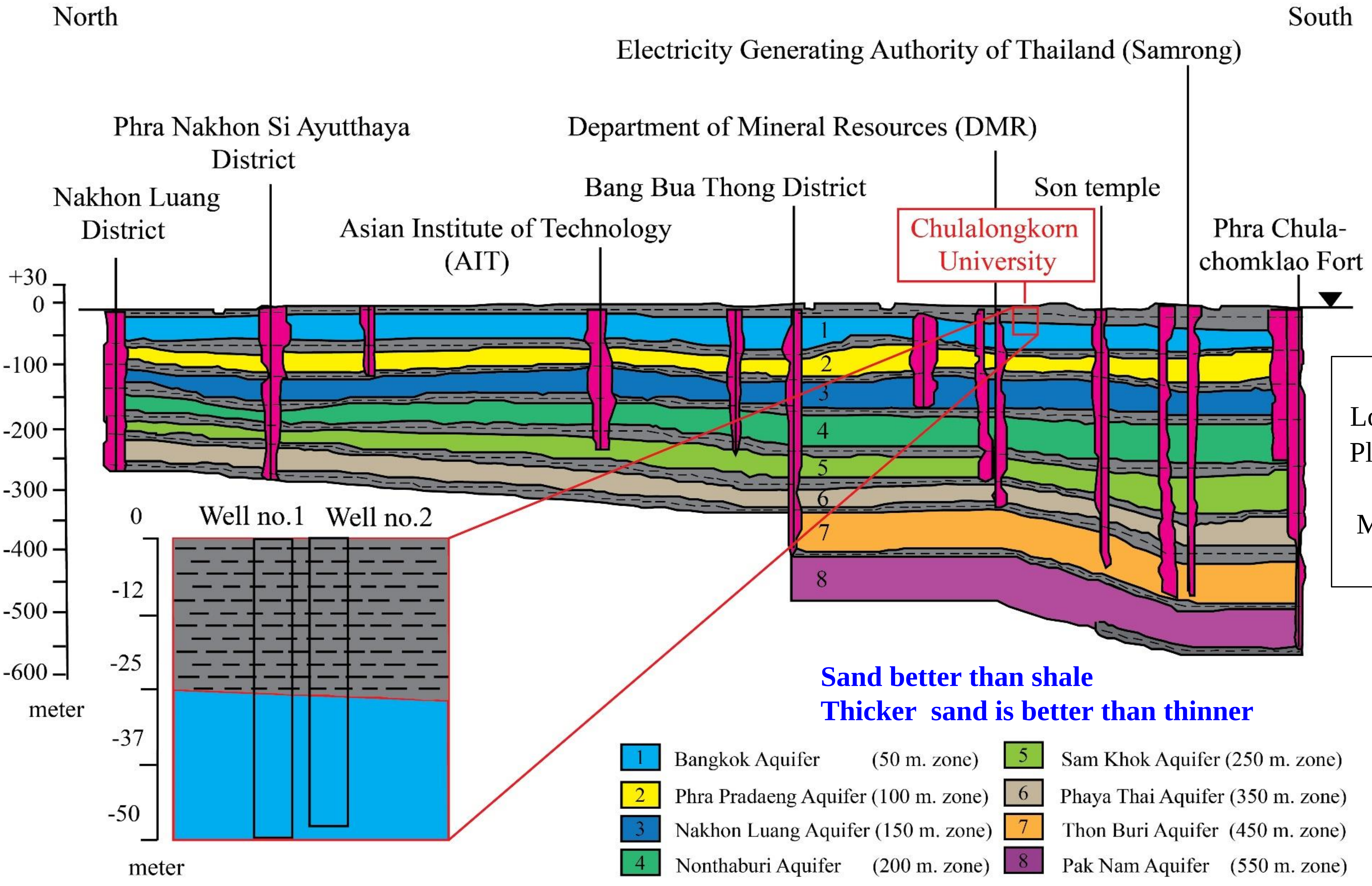
5.1 Importance of subsurface stratigraphy

Correlation of lithologic logs of well nos. 1, 2 and Chulalongkorn University Dharma Centre log (well of Department of Groundwater Resources).



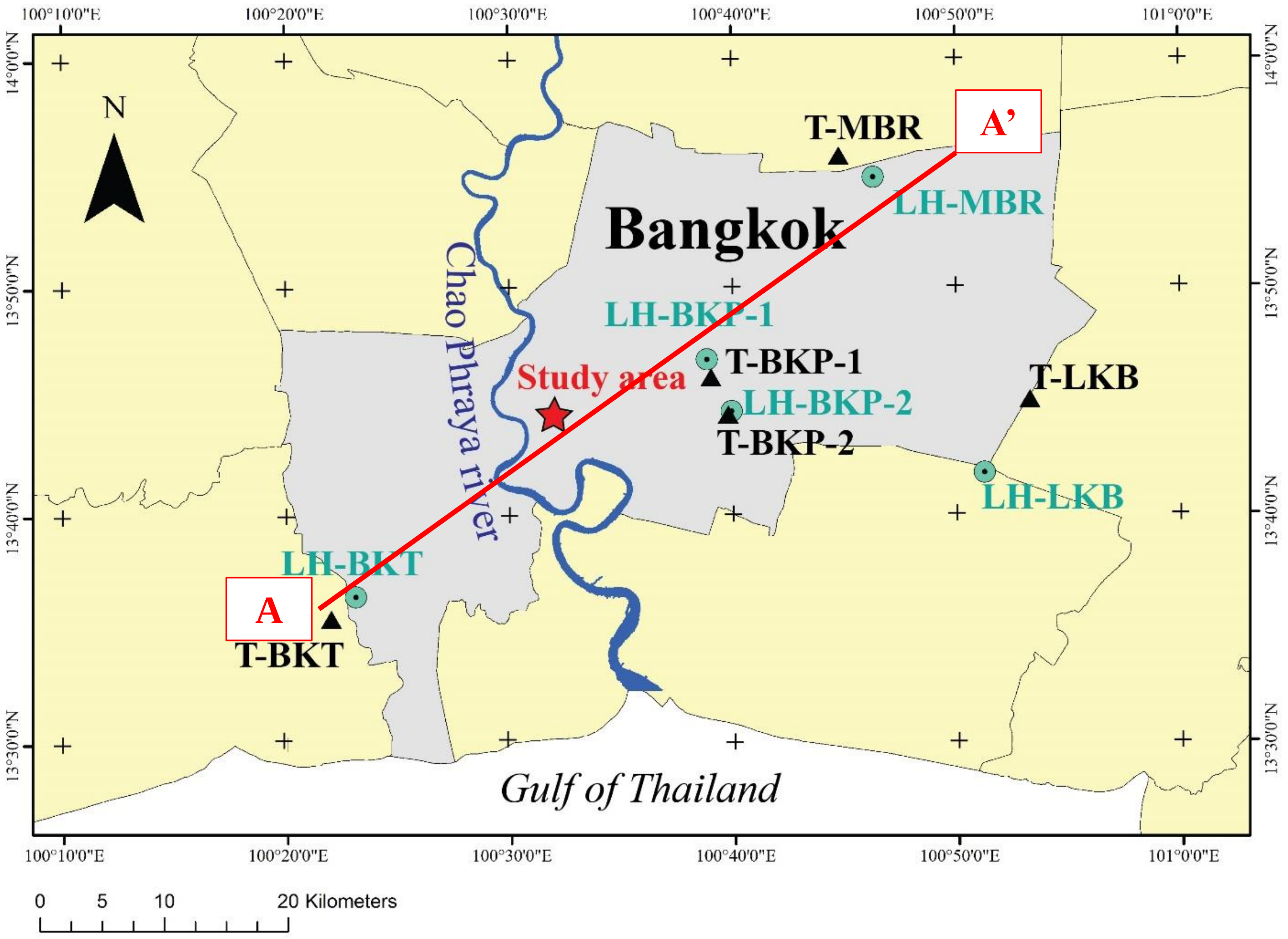
5.1 Importance of subsurface stratigraphy

Discussion



Groundwater of Lower Chao Phraya Plain modified after Department of Mineral Resources (2007).

Sand better than shale
Thicker sand is better than thinner



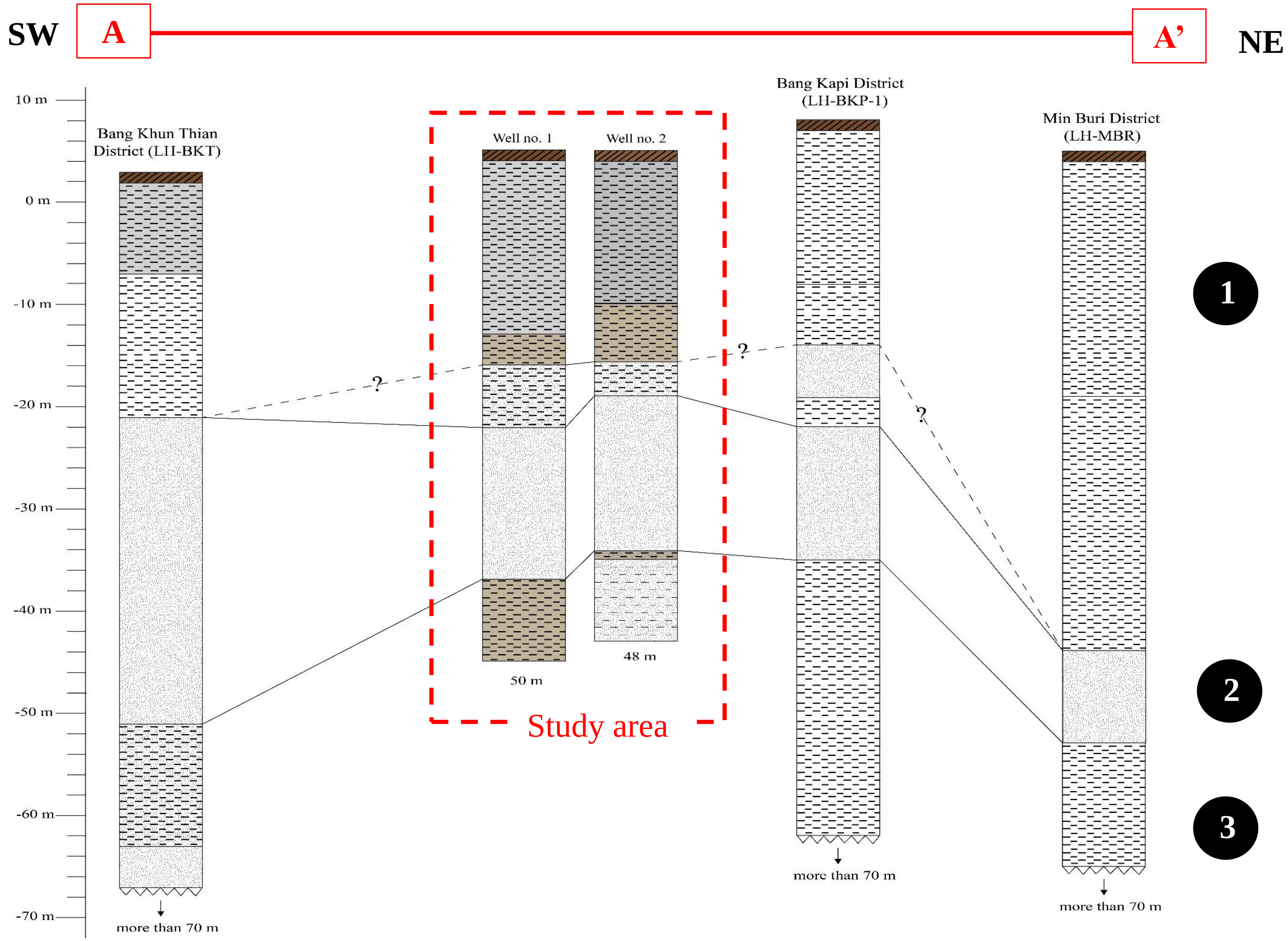
5.1 Importance of subsurface stratigraphy

Legend

- Lithologic log of DGR
- Temperature observation wells
- Cross-section line

Index map of Lower Chao Phraya Plain showing the locations of temperature observation wells around Bangkok (black triangle) and nearest lithologic logs of temperature observation wells (green circle).

Discussion



<u>5.1 Importance of subsurface stratigraphy</u>

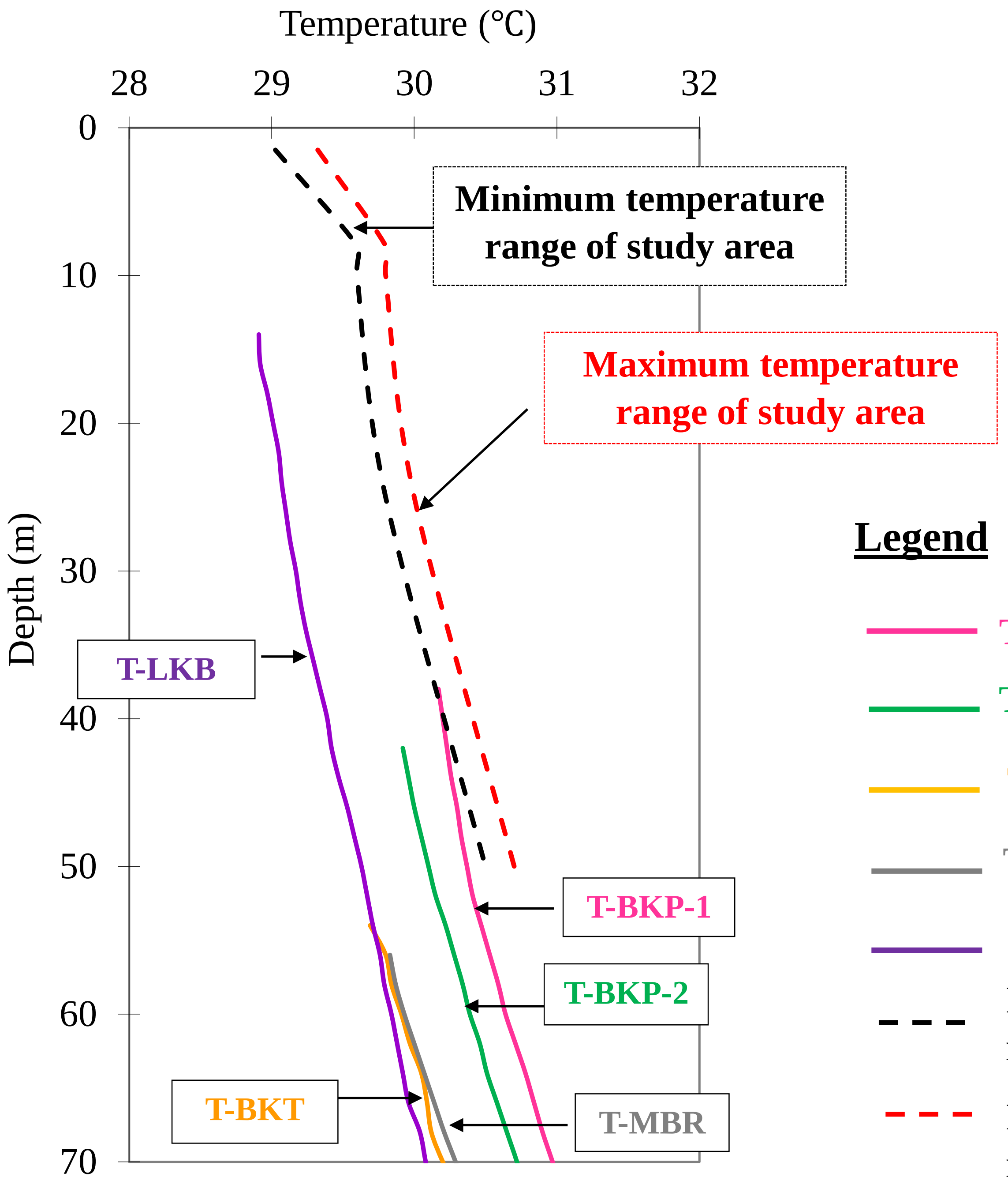
1

Correlation of lithologic logs of well nos. 1, & 2 and lithologic logs of Department of Mineral Resources (DGR): LH-BKT, LH-BKP-1 and LH-MBR.

2

3 *Minburi need more deeper*

Discussion



5.2 Characteristics of subsurface temperatures

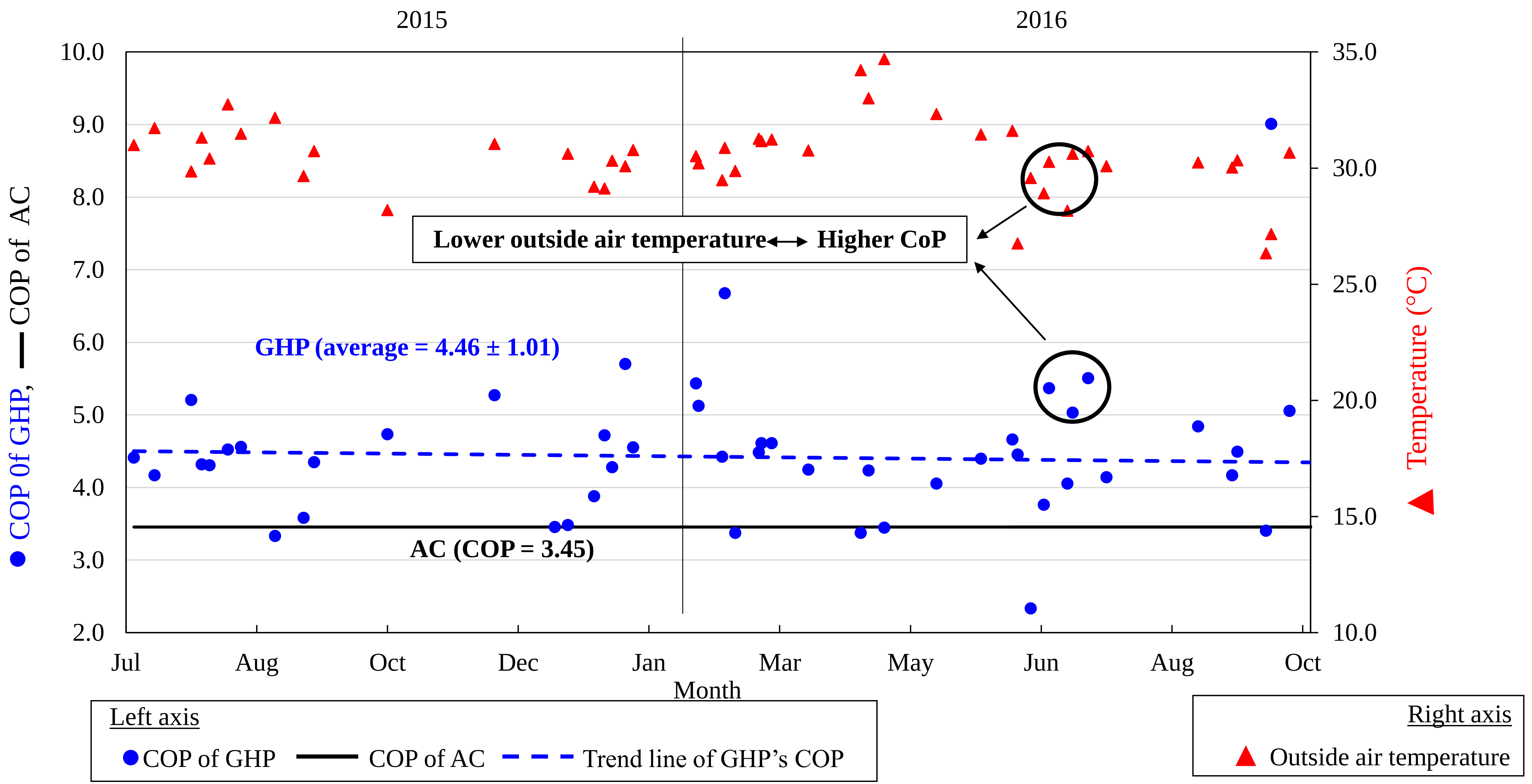
Comparison between well temperature profiles around Bangkok including the study area.

Legend

- T-BKP-1
- T-BKP-2
- T-BKT
- T-MBR
- T-LKB
- Minimum temperature range of study area
- Maximum temperature range of study area

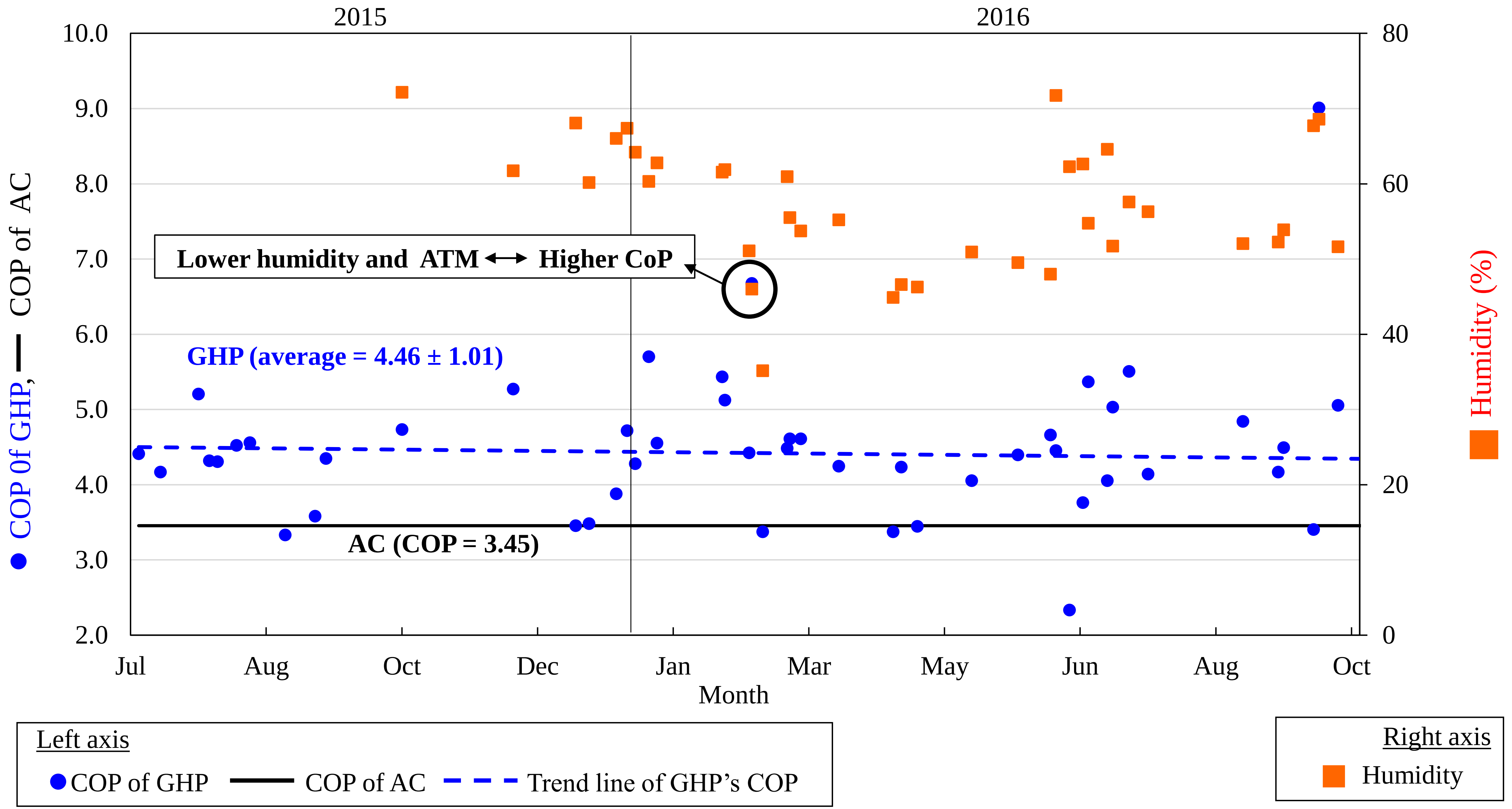
Temperatures tend to increase very slightly at deeper depth

5.3 Coefficient of Performance (COP)---compared with ATM (outside air) temp.



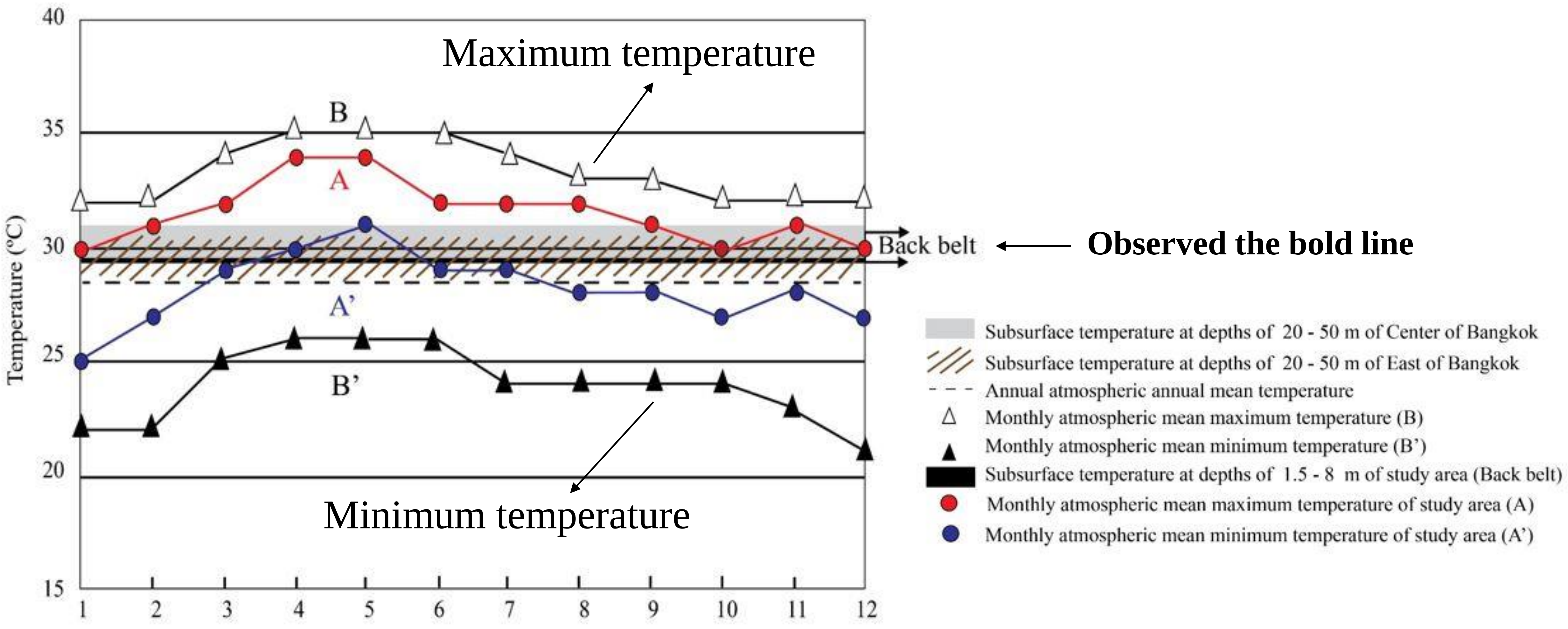
Value of COP of GHP when operating at 25°C in long-term measurement at Parot Racha Building, Chulalongkorn University from July 2015 to September 2016.

5.3 Coefficient of Performance (COP)---compare with humidity



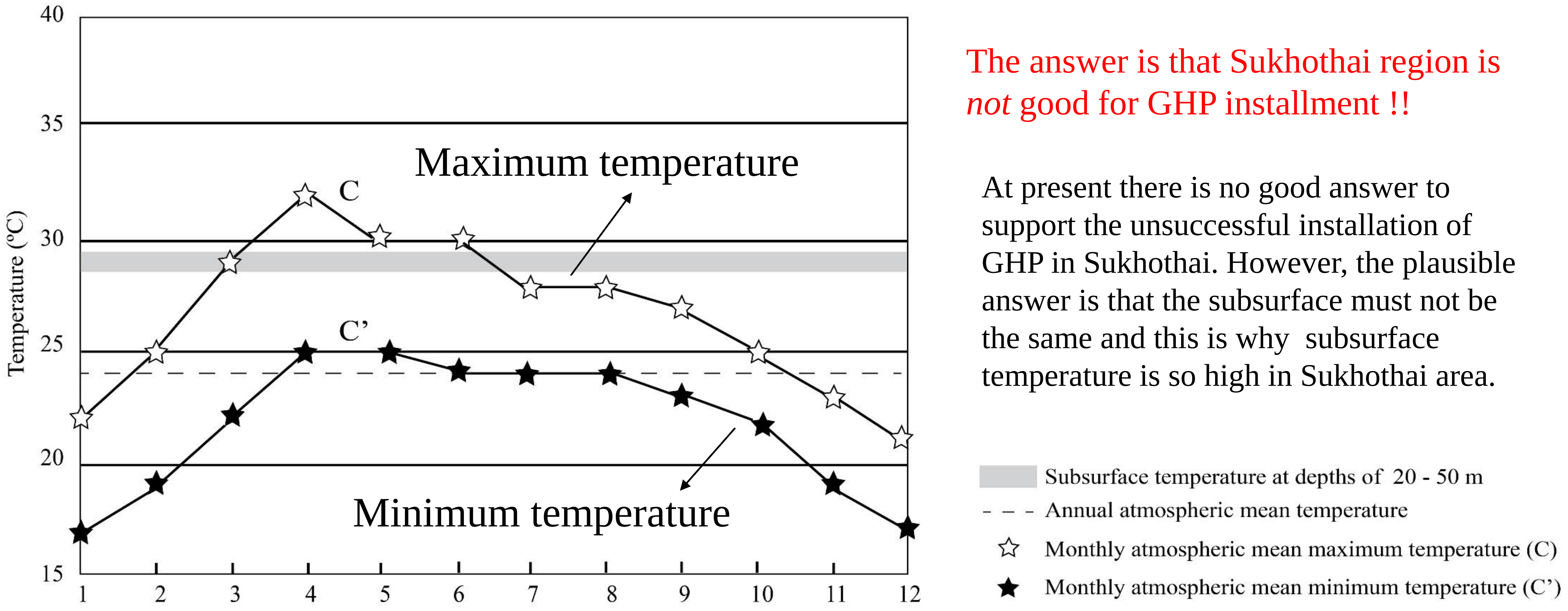
Value of COP of GHP when operating at 25°C in long-term measurement at Parot Racha Building, Chulalongkorn University from July 2015 to September 2016.

5.4 How Bangkok area is good for GHP



Comparison of atmospheric and subsurface temperatures of Bangkok area (modified after Yasukawa et al., 2009).

5.5 Is Sukhothai area good for GHP?



The answer is that Sukhothai region is *not* good for GHP installment !!

At present there is no good answer to support the unsuccessful installation of GHP in Sukhothai. However, the plausible answer is that the subsurface must not be the same and this is why subsurface temperature is so high in Sukhothai area.

Comparison of atmospheric and subsurface temperatures of Sukhothai area (modified after Yasukawa et al., 2009)

VI. Conclusions

- ☺ General control setting temperature is @ 25°C. GSHP system can give high reduction of electricity consumption (kWh) such as *30% in the case of our study* in Bangkok (and many places in other tropical countries) .
- ☺ In normal situation, underground temperature is relatively *stable and always lower* than atmospheric temperature (such as our study in Bangkok case).
- ☺ Data on underground temperature measurement around Bangkok allow the high possibility of using geo heat pump in this Bangkok and nearby area where *subsurface geology is almost the same*.

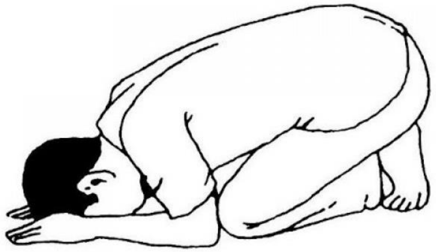
VII. Acknowledgements

The Food and Water Cluster, Ratchadaphisek Somphot Endowment Fund (Prof. Somsak Panha), Chulalongkorn University for grant support to this research work.

Thanks for Assoc. Prof. Chakapan for searching for good laboratory room for GHP instalment.

DGR for providing all the subsurface data.

Geological Survey of Japan (GSJ, Drs. Uchida and Takashima) for providing GSHP instrument.



VIII. About my short abstracts and paper to Conferences & Workshops

1) 5th GEOINDO 2015 International Conference

2) Department of Mineral Resources (DMR) Special talk#2

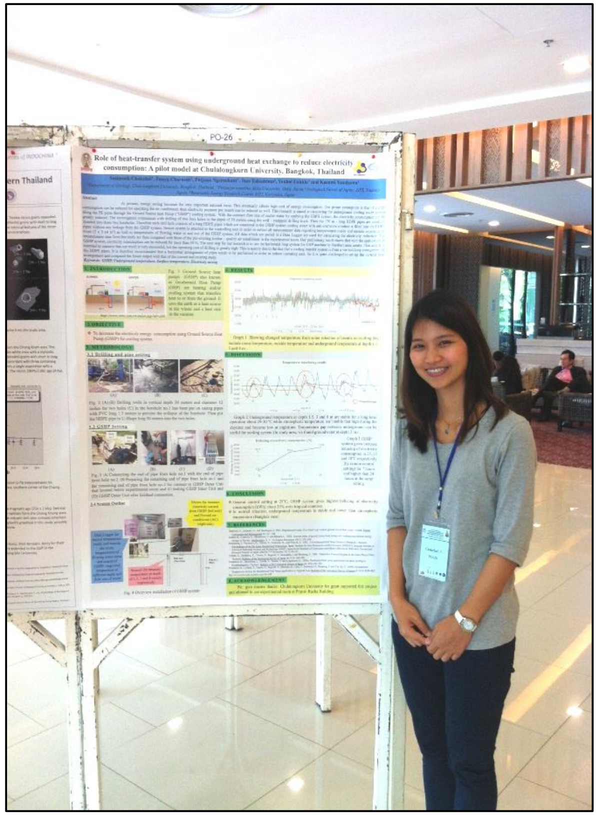
3) The Thematic Session at the 52nd CCOP Annual Session

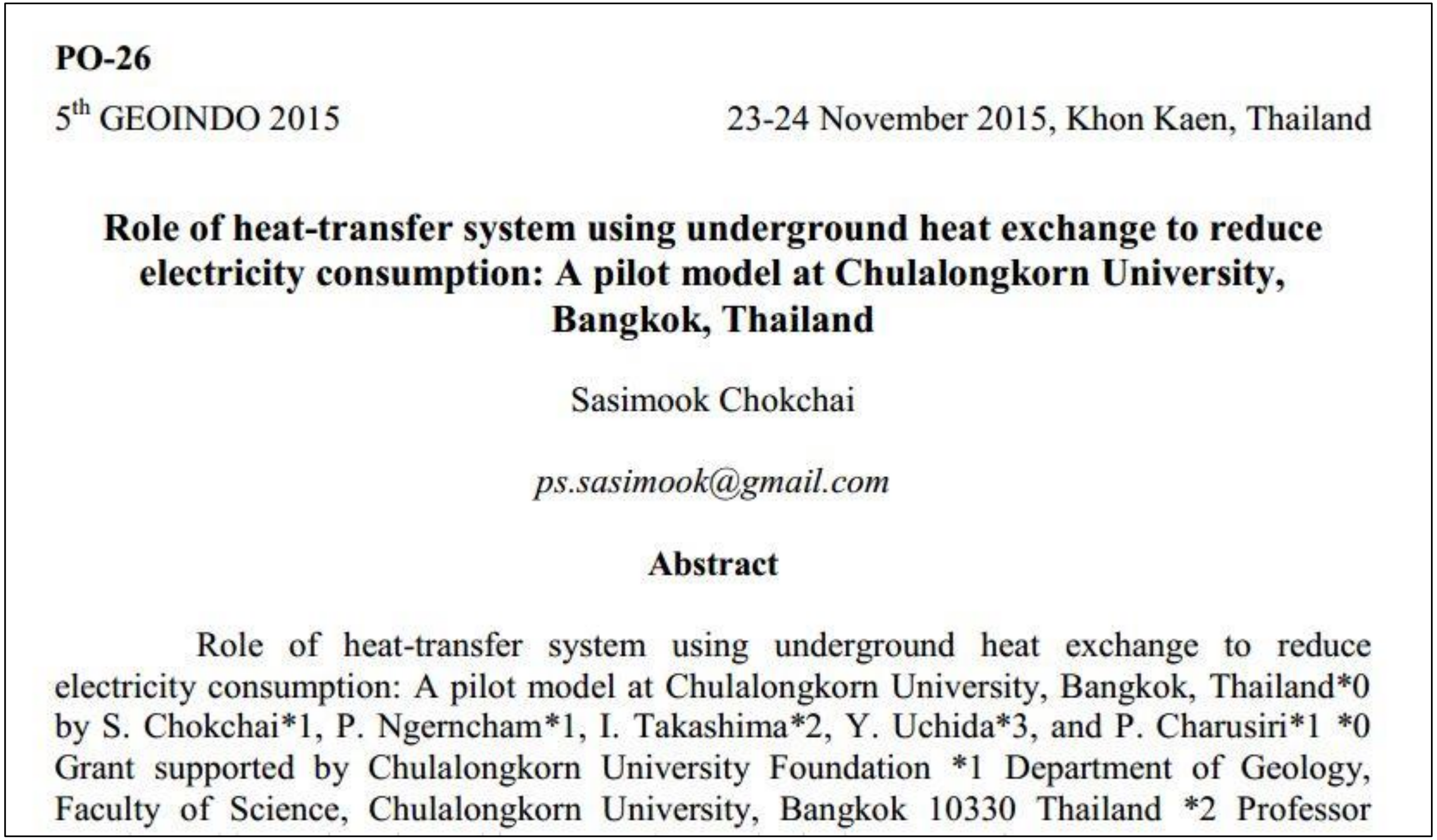
4) The Third Asia Renewable Energy Workshop (3rd AREW)

1) The 5th GEOINDO 2015 International Conference

" Geology, Geotechnology, and Mineral Resources of INDOCHINA "

Technical Conference : November 23-24, 2015, Khon Kaen, Thailand





PO-26

5th GEOINDO 2015 23-24 November 2015, Khon Kaen, Thailand

Role of heat-transfer system using underground heat exchange to reduce electricity consumption: A pilot model at Chulalongkorn University, Bangkok, Thailand

Sasimook Chokchai

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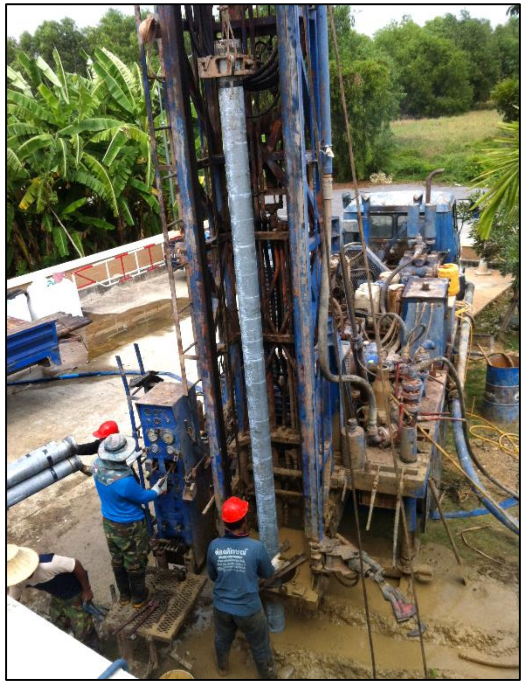
Abstract

Role of heat-transfer system using underground heat exchange to reduce electricity consumption: A pilot model at Chulalongkorn University, Bangkok, Thailand*0 by S. Chokchai*1, P. Ngerncham*1, I. Takashima*2, Y. Uchida*3, and P. Charusiri*1 *0 Grant supported by Chulalongkorn University Foundation *1 Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok 10330 Thailand *2 Professor

2) Department of Mineral Resources (DMR) Special talk#2

February 9, 2016



GSHP system at National Geological Museum, Pathum Thani, Thailand.

3) The Thematic Session at the 52nd CCOP Annual Session

“GEOSCIENCE FOR THE SOCIETY”

1st November 2016, The Berkeley Hotel, Bangkok, Thailand

COORDINATING COMMITTEE FOR GEOSCIENCE PROGRAMMES IN EAST AND SOUTHEAST ASIA (CCOP)

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CCOP-52AS/DIL/ 136

17 February 2017

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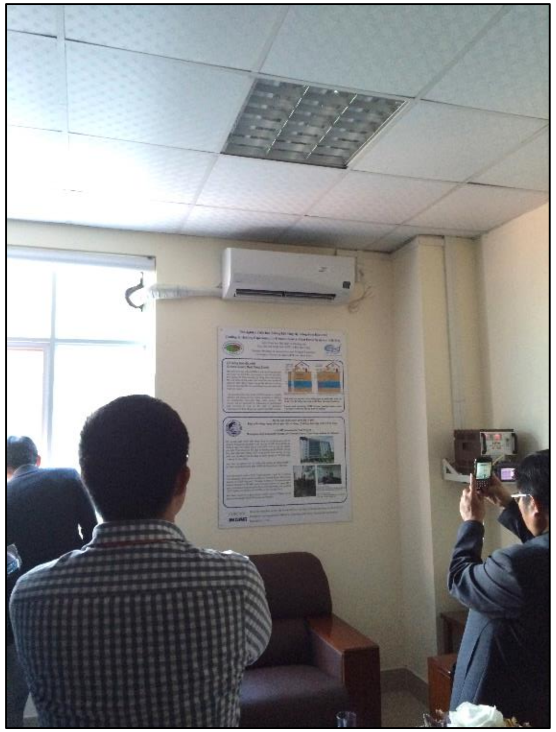
Acceptance Letter:
Full paper of the Thematic Session at the 52nd CCOP Annual Session
“GEOSCIENCE FOR THE SOCIETY”
1st November 2016, The Berkeley Hotel, Bangkok, Thailand

Dear **Ms. Sasimook Chokchai**,

We would like to thank you for the presentation of the thematic paper “**On the New Ground Source Heat Pump in Thailand: A case study at Chulalongkorn University, Bangkok, Thailand**” during the 52nd Annual Session at The Berkeley Hotel in Bangkok,

4) The 3rd Asia Renewable Energy Workshop (3rd AREW)

Hanoi, Vietnam from December 7 – 9, 2016



GSHP system at Vietnam Institute of Geoscience and Mineral Resources (VIGMR), Hanoi, Vietnam.

Thanks a lot for your kind attention

Now times for questions and comments