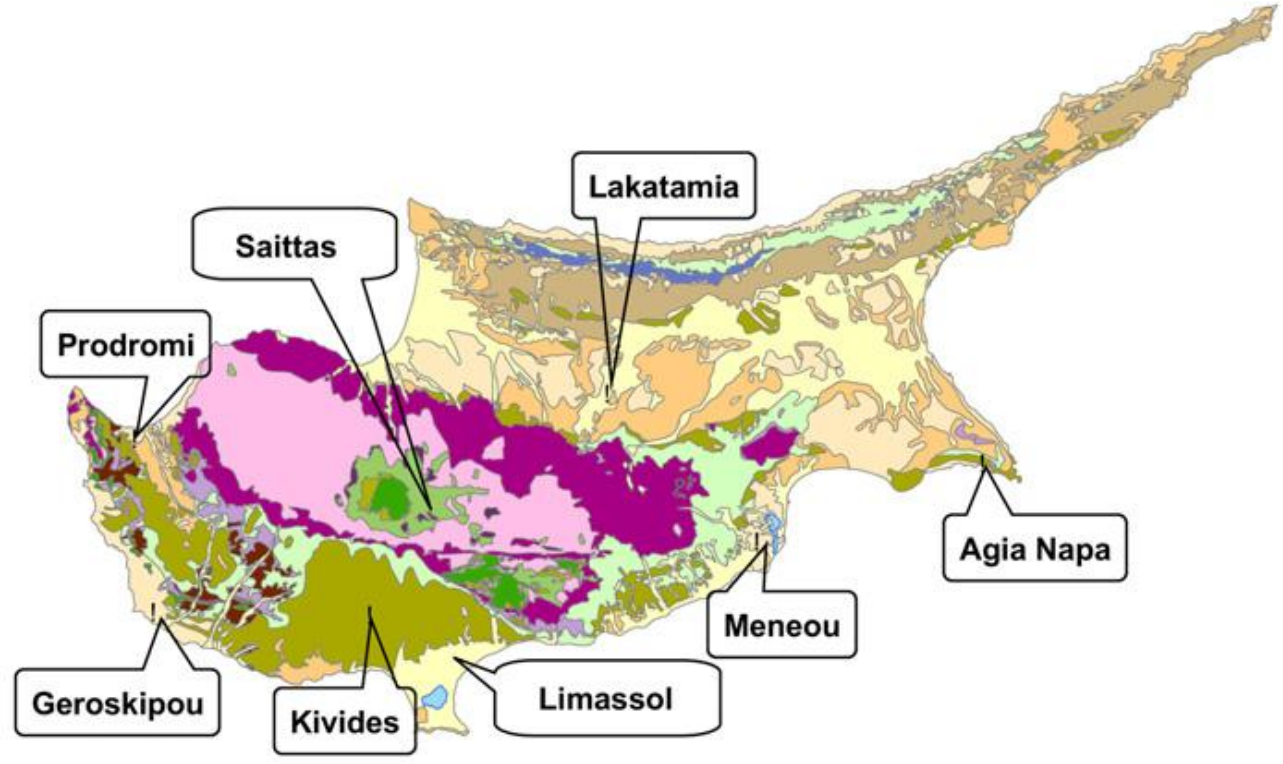
Project: Investigation and determination of the temperature and other ground characteristics in Cyprus, for the use in the design of ground heat exchangers and heat pumps

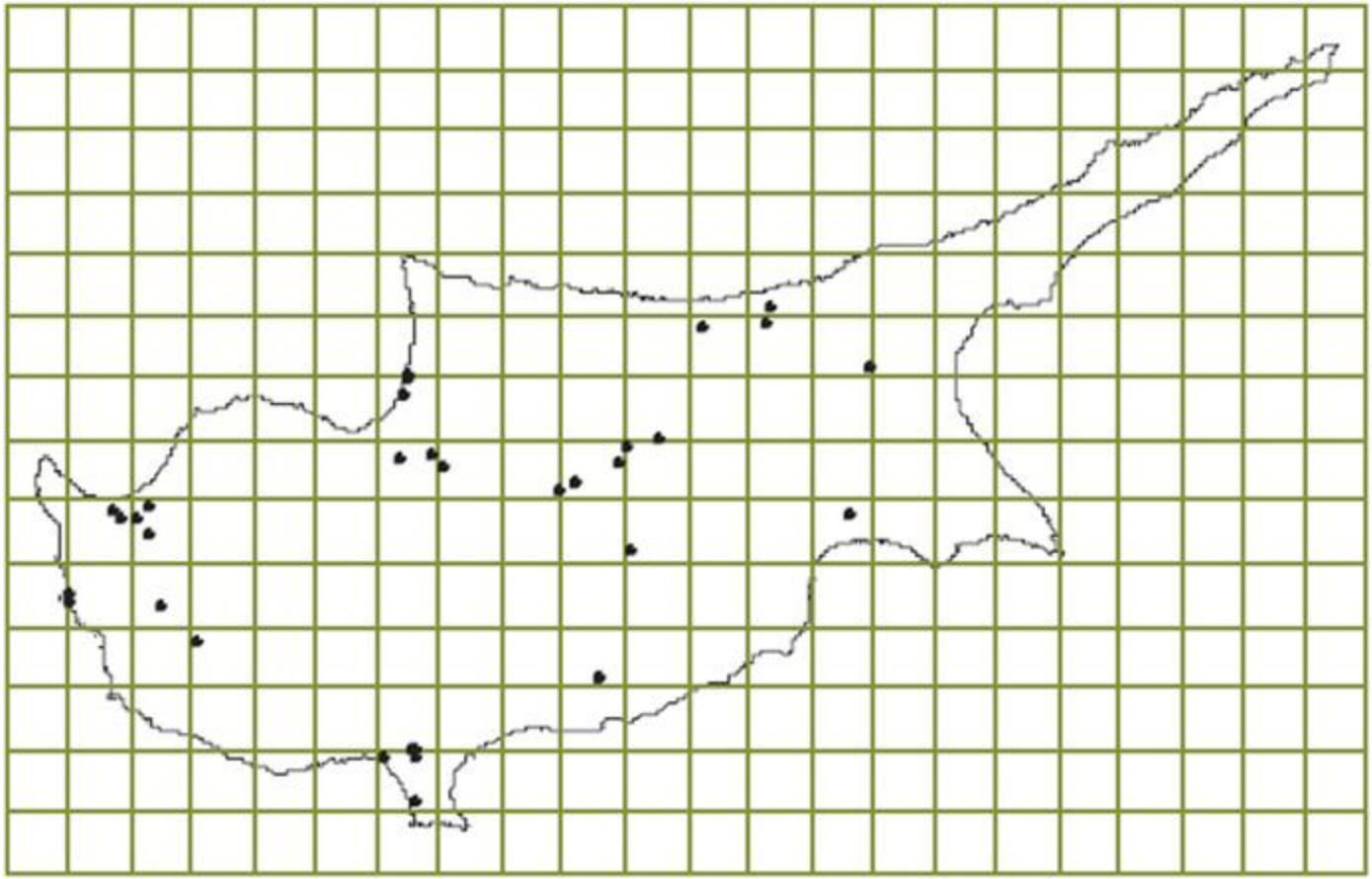
The work was carried out as part of a research project cofounded by the Research Promotion Foundation (RPF) of Cyprus -contract TEXN/EN/0308(BIE)/15-and the European Regional Development Fund (ERDF) of the EU.

Eight boreholes were drilled with depths of 100-180m for investigation

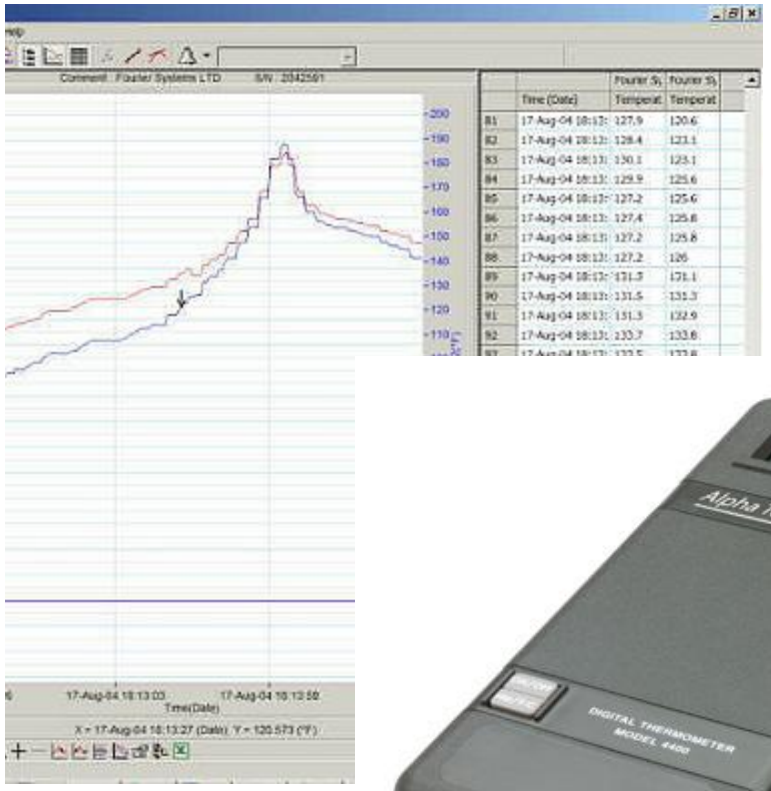


Cambridge 2015

In the geological study an additional number of 33 pre-drilled boreholes were considered. The measurements were made in air and water filled boreholes.



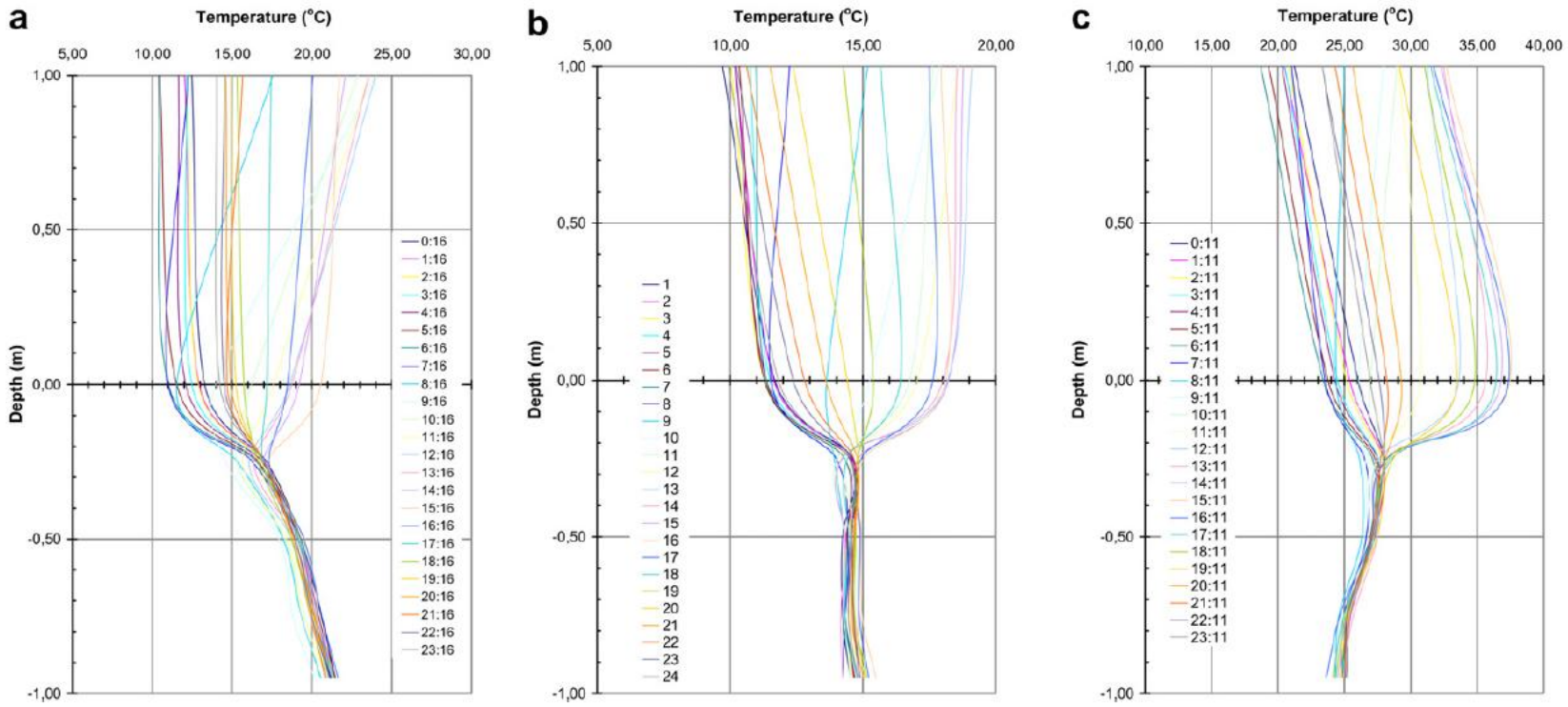
Accuracy 0.5°C



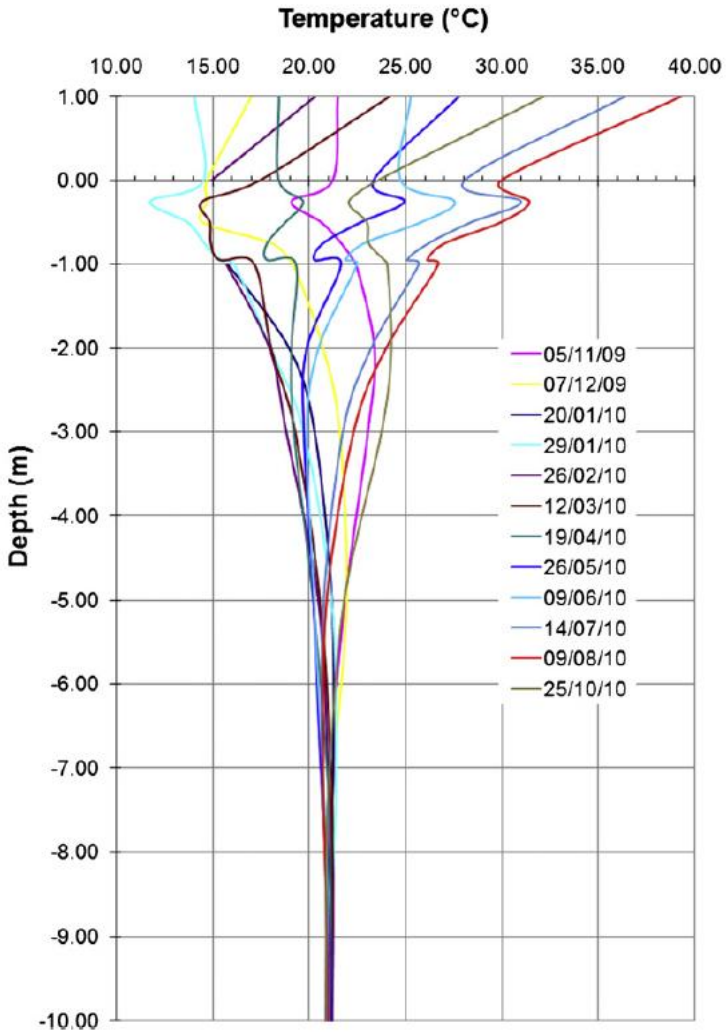
Thermistor accuracy 0.2°C

Table 1
Borehole and equipment installation details.

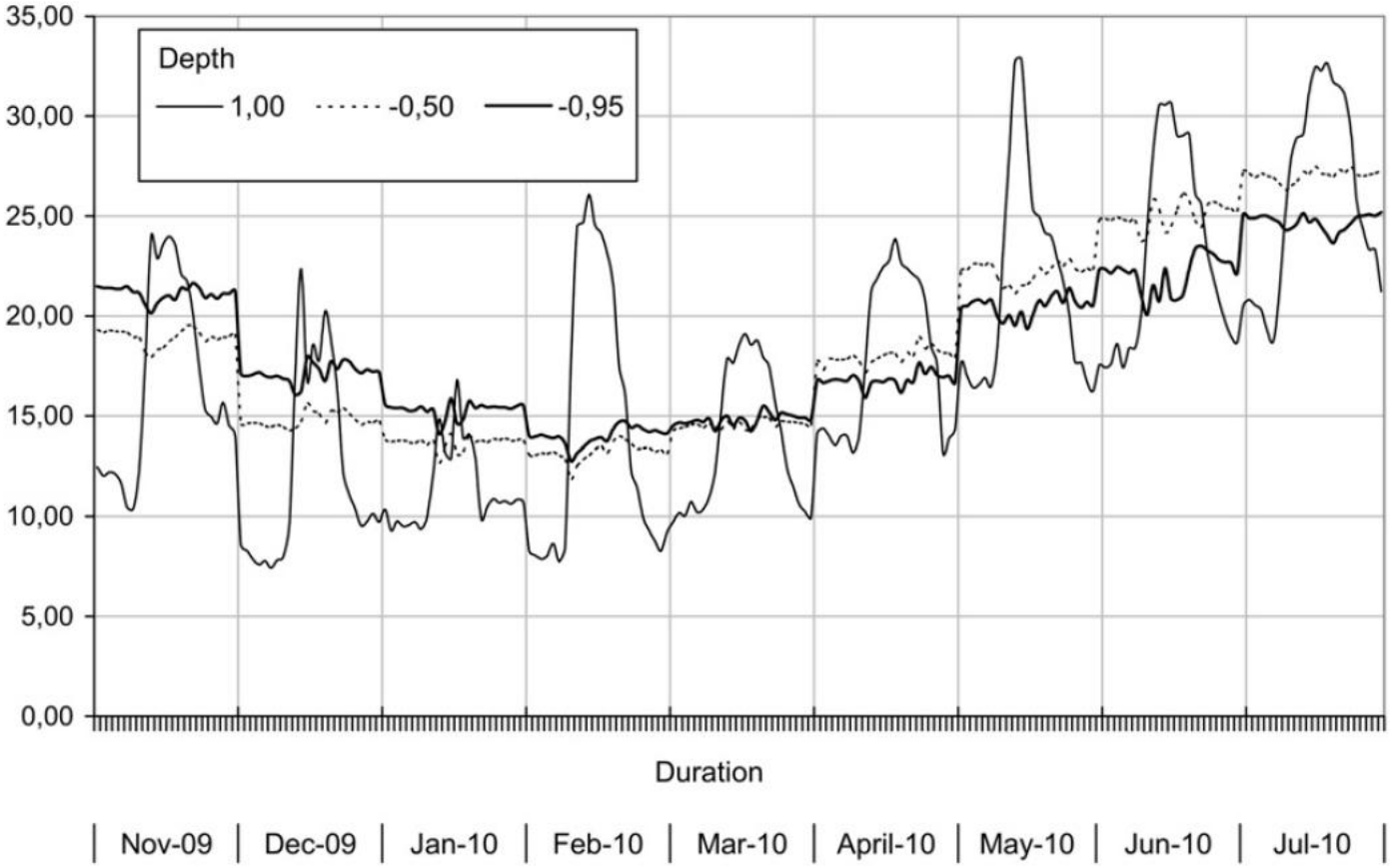
Location	Depth/ Diam (m)	Ground heat exchangers	Filling material	Thermocouple positions (m)
Agia Napa Famagusta	100.5/0.2	PE100, PN16, 32 × 3 mm, 2 U × 100 m	Bentonitic clay	Ambient, 0, 0.25, 0.5, 0.75, 1, 3, 5, 7, 8, 9, 10, 11, 15, 20, 40, 60, 80, 100
Meneou Larnaca	97/0.2	PE100, PN16, 32 × 3 mm, 1 U × 97 m PE100, PN16, 40 × 3 mm, 1 U × 97 m PE80, PN16, 40 × 3mm, 1 U × 97 m	Bentonitic clay	Ambient, 0, 0.25, 0.5, 0.75, 1, 3, 5, 7, 8, 9, 10, 11, 15, 17, 37, 57, 77, 97
Lakatamia Nicosia	160/0.23	PE100, PN16, 32 × 3 mm, 1 U × 160 m 1 U × 100 m	Bentonitic clay and cement	Ambient, 0, 0.25, 0.5, 0.75, 1, 3, 5, 7, 8, 9, 10, 11, 15, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160.
Kivides Limassol	196/0.15	PE100, PN16, 32 × 3 mm, 1 U × 196 m 1 U × 96 m	Bentonitic clay	Ambient, 0, 0.25, 0.42, 0.67, 0.92, 3, 5, 7, 8, 9, 10, 15, 26, 46, 76, 96, 126, 146, 176, 196.



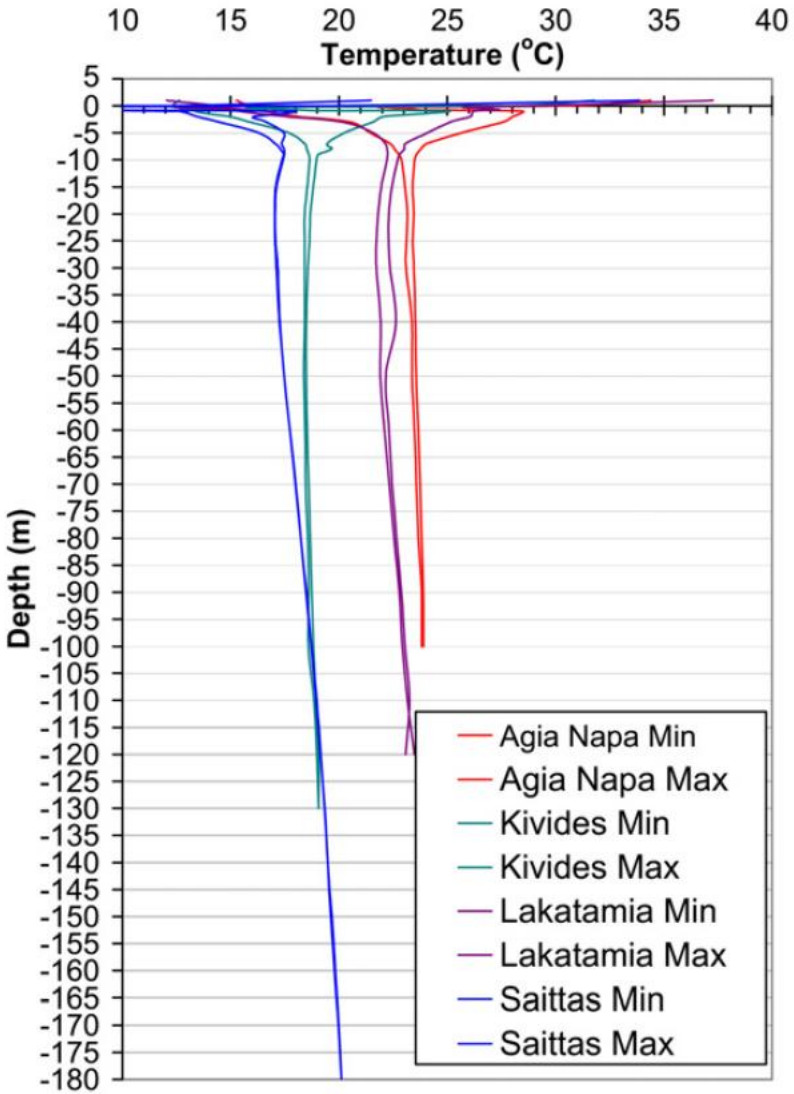
Top layer temperature distribution at Prodromi for (a) 6 November, 2009 [winter], (b) 13 March, 2010 [spring] and (c) 15 July, 2010 [summer].



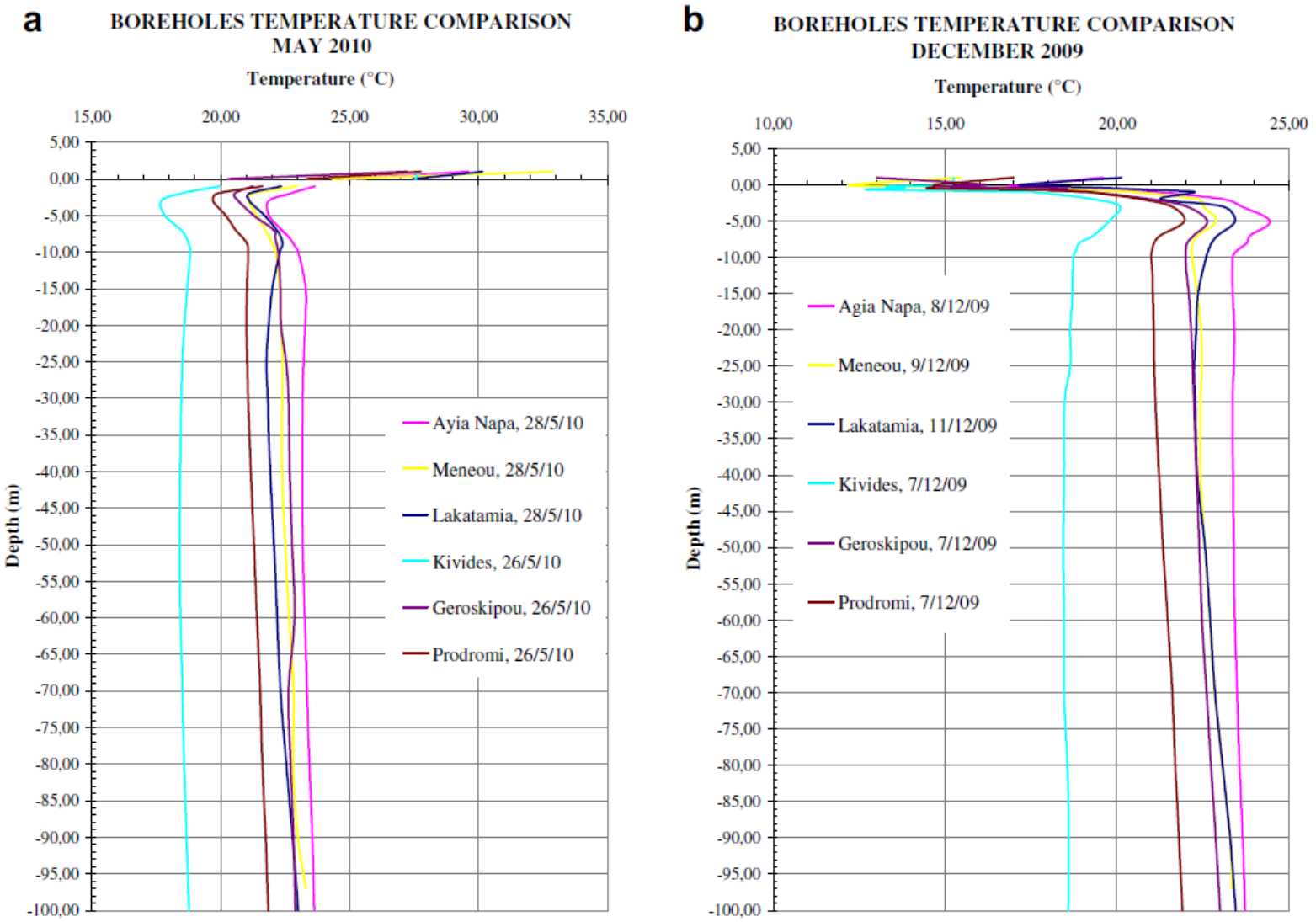
Borehole temperature distribution at Prodromi for the period of one year (November,2009 to October, 2010)



Ambient and ground temperature profiles at Prodromi for the period of November, 2009 to July, 2010

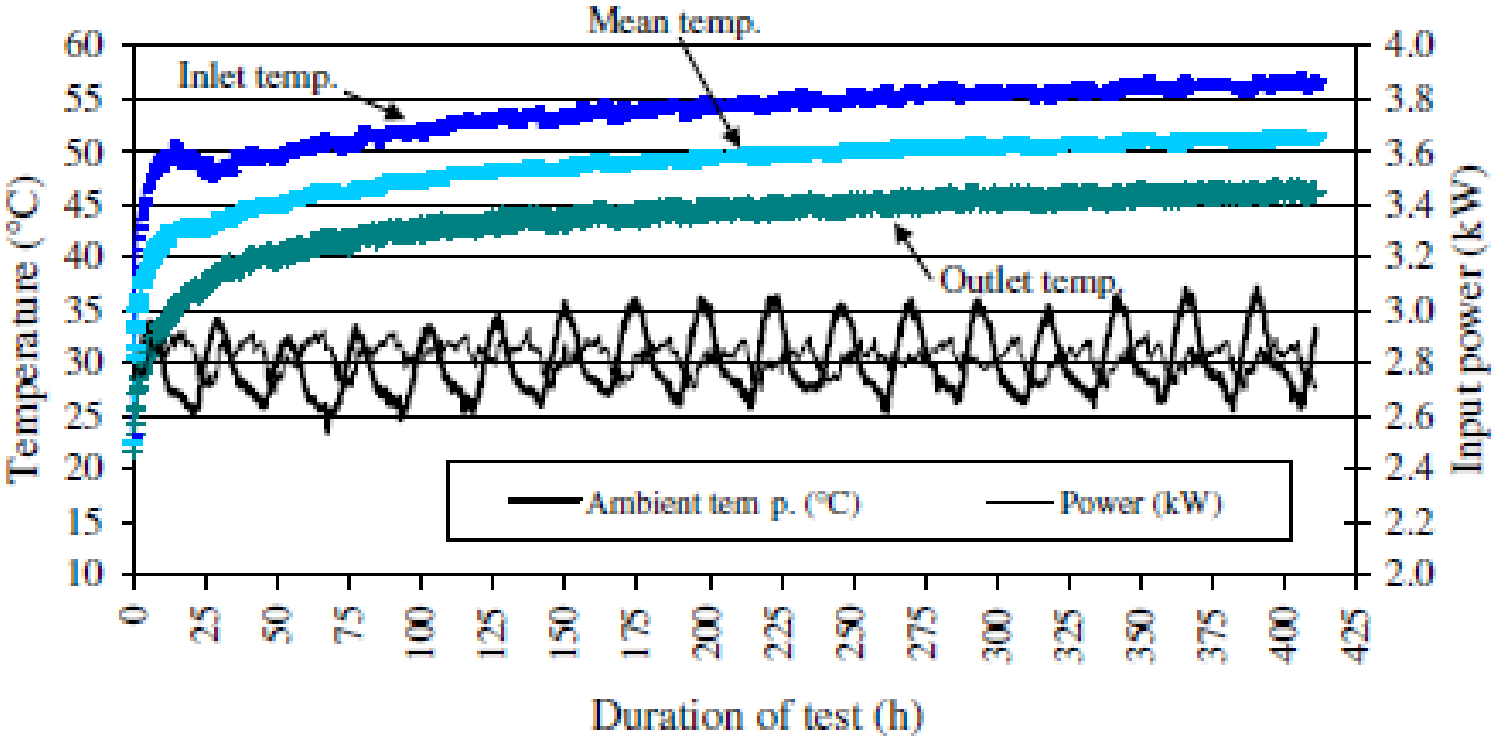


Minimum and maximum ground temperature distribution at Saittas, Kivides, Lakatamia and Agia Napa locations for the period between October, 2009 and 2010.

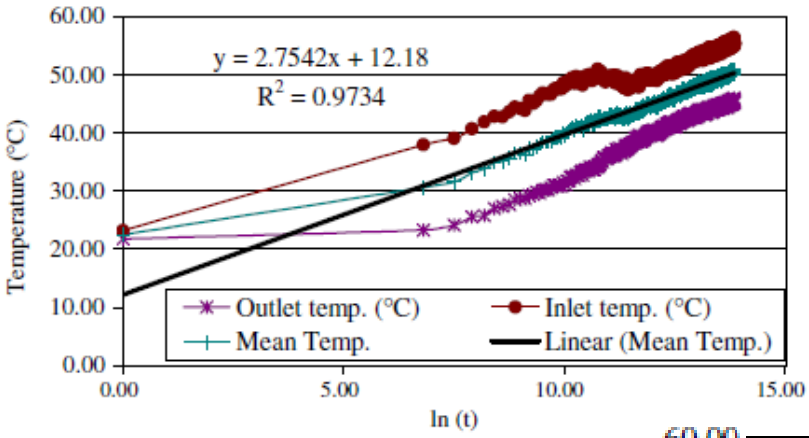


Ground temperature distribution of the boreholes for (a) May, 2010 and (b) December, 2009

Mean fluid temperature, ambient temperature and power input to the system during the line source method test.

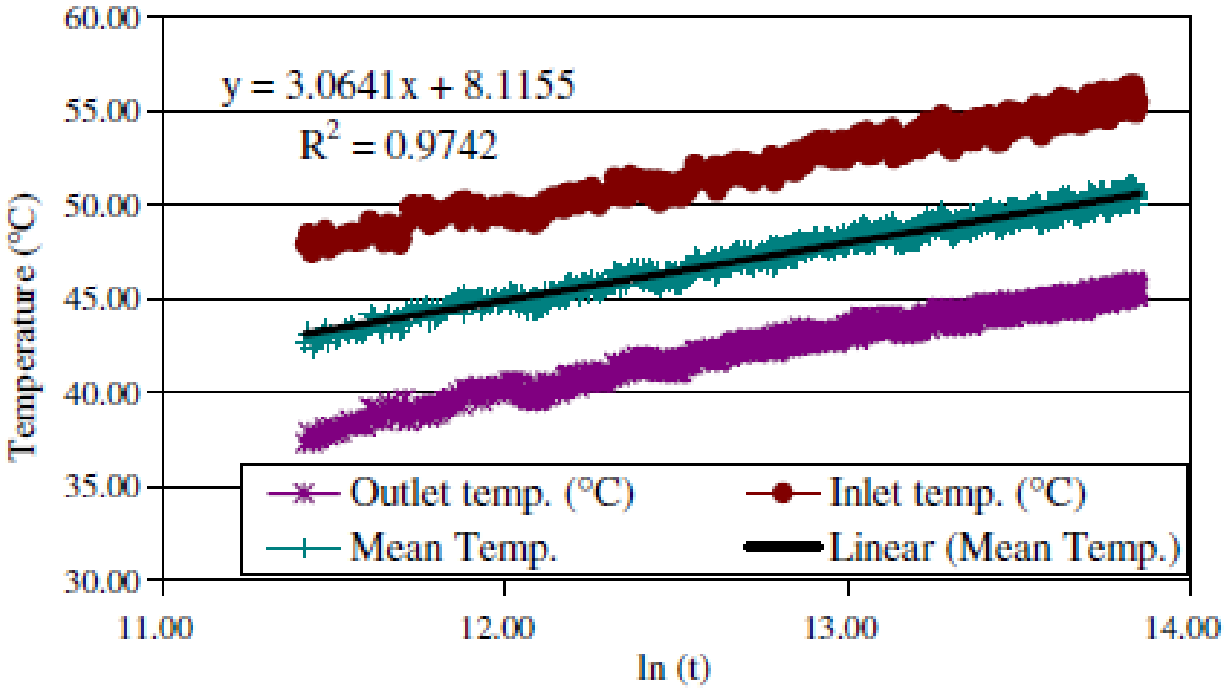


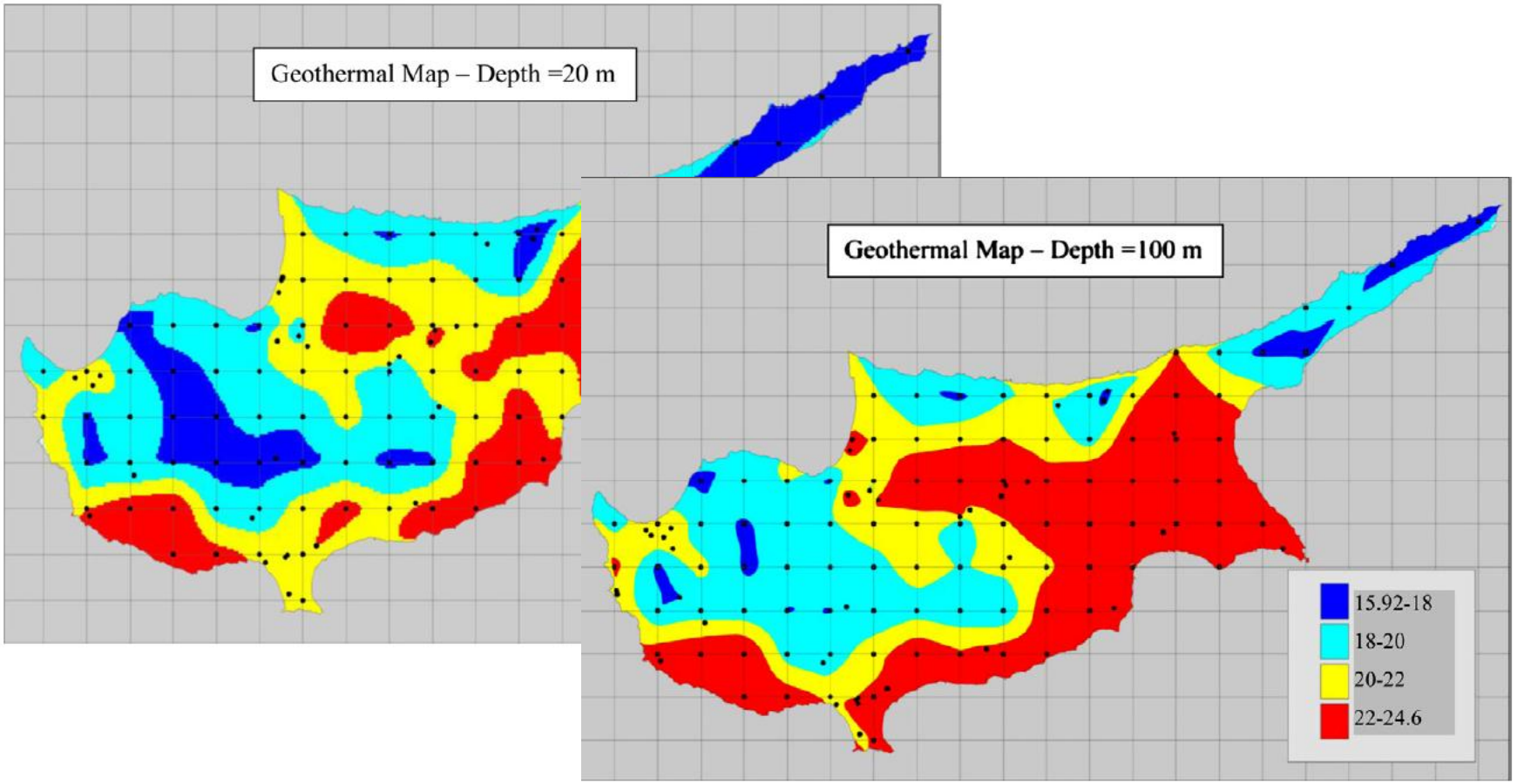
Mean fluid temperature plotted against time logarithm, ln(t) [time in seconds].



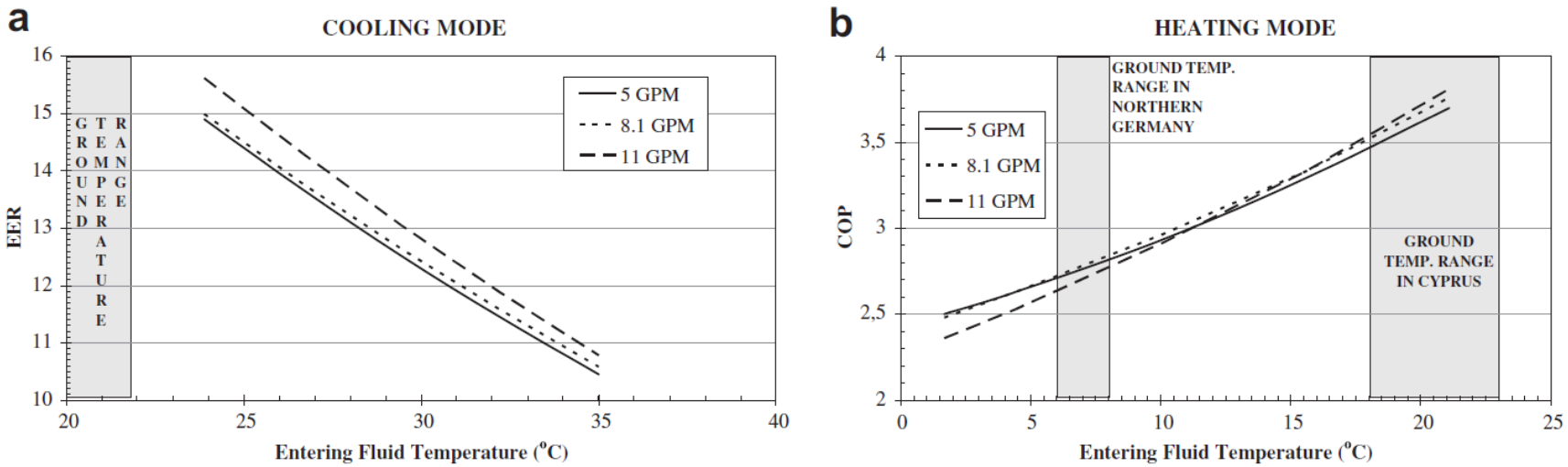
$$T \approx \frac{Q}{4\pi\lambda L}(\ln t)$$

Useful data for satisfying the criterion $at/r^2 \geq 5$





Use of Artificial neural networks for the generation of geothermal maps of ground temperature at various depths by considering land physical properties and configuration



Ground coupled heat pump Efficiencies in respect to the entering fluid temperature for (a) cooling mode and (b) heating mode

General Conclusions:

(a) The temperature of the ground in Cyprus is constant throughout the year and is within the range of 18-23° C.

(b) The GCHP operating conditions vary depending on the manufacturer, the country/region or climate conditions aimed for and the purpose to be used. According to the climatic conditions and the thermal characteristics of the ground, proper pump selection and sizing should be made

(c) The data collected clearly indicate that there is a potential for the efficient use of GCHPs in Cyprus leading to significant savings in power.

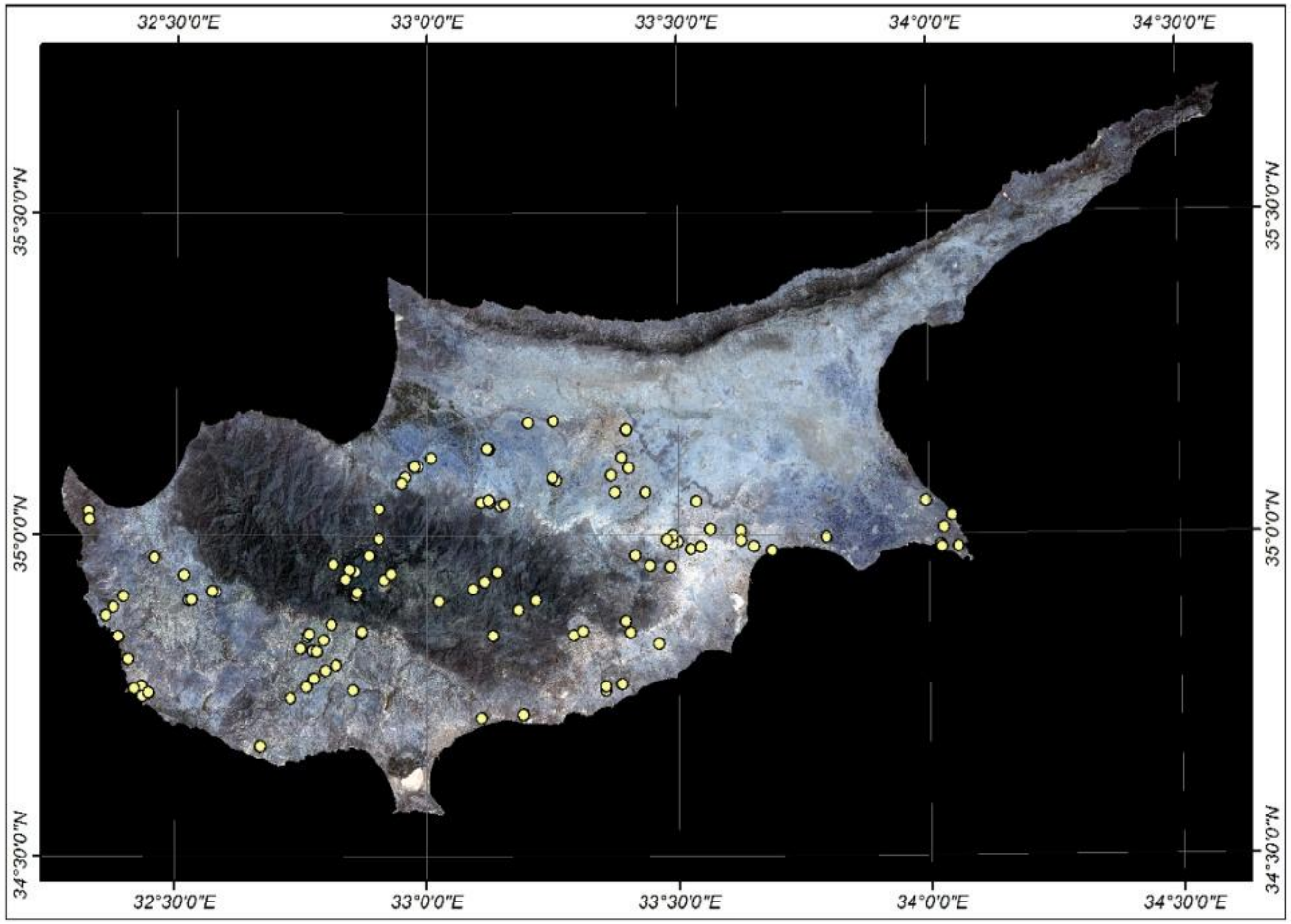
Project: Investigation and determination of the geothermal parameters of the lithologies in Cyprus, for the compilation of the geothermal map of the island (2012-2015)

The work was carried out as part of a research project cofounded by the Research Promotion Foundation (RPF) of Cyprus under contract TEXNOLOGIA/ENEPG/0311(BIE)/01 and the European Regional Development Fund (ERDF) of the EU.

Geological Setting

The island from geological point of view is divisible into four E-W trending, geological terranes: (a) the Kerynia or Pentadhactylos Range, (b) the Troodos Ophiolite complex, (c) the Mamonia complex and (d) the Mesaoria Mesaoria Plain can be also found in many bibliographies as the Circum Troodos Sedimentary Succession

For measuring the thermal properties of the underground in Cyprus geological sampling was carried out. The sites were selected according to the geological formation, the lithology and their geographical Samples were collected from outcrops and to overcome the lack of samples from some formations, samples were also obtained from the drill core archive of the Cyprus Geological Survey. 150 samples were selected as shown in the map.



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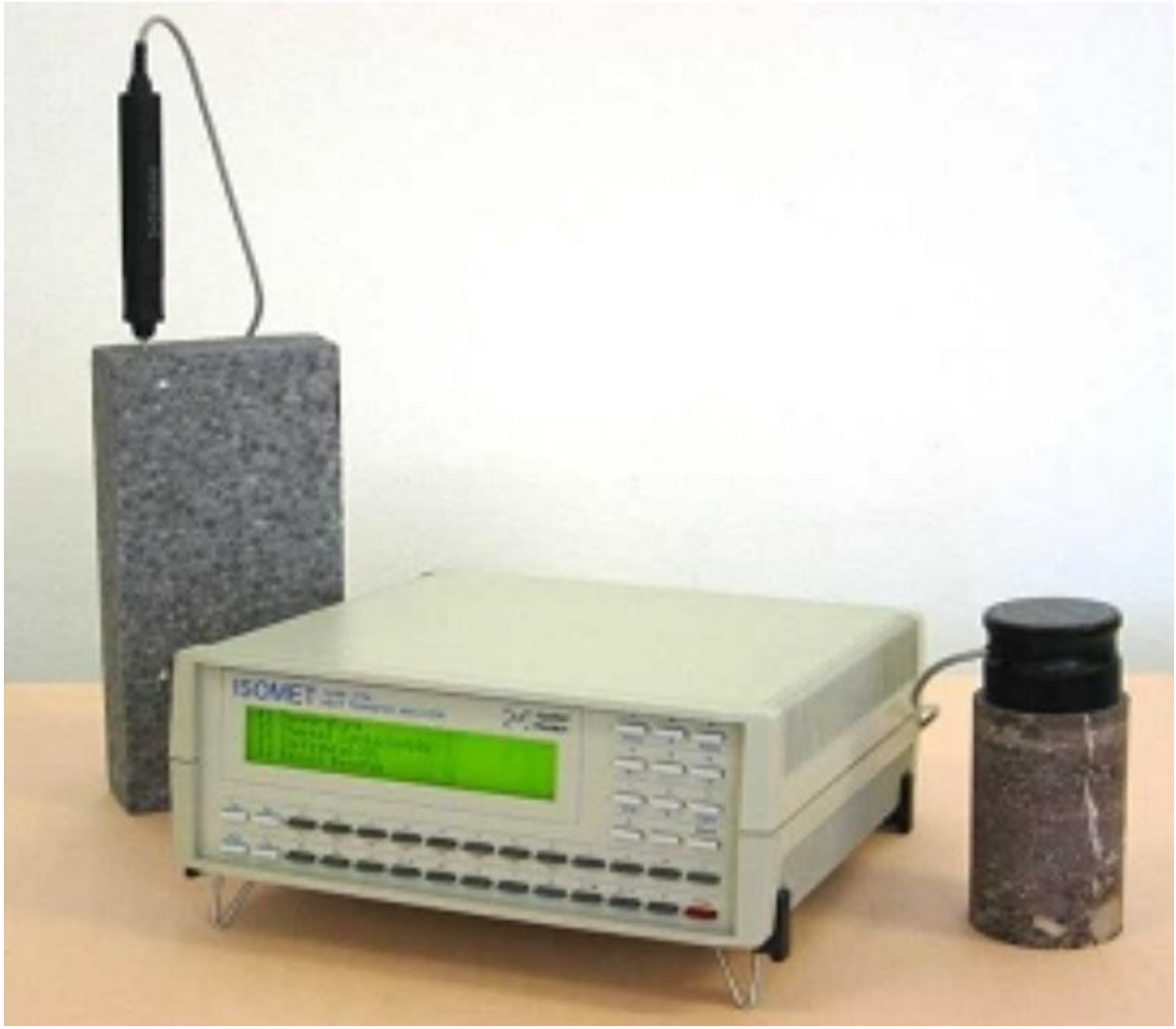


Values of thermal conductivity, thermal diffusivity and specific heat capacity per lithology

	Thermal Conductivity (W/mK)						Thermal Diffusivity x 10^{-6} (m^2/s)						Specific Heat Capacity x 10^{-3} (J/K Kg)						
	DRY			WATER SATUR.			DRY			WATER SATUR.			DRY			WATER SATUR.			
LITHOLOGY	max	min	average	max	min	average	max	min	average	max	min	average	max	min	average	max	min	average	No of tested samples
Basalt	1.5	1.1	1.2	1.5	1.3	1.4	0.9	0.6	0.7	0.9	0.7	0.8	0.7	0.6	0.7	0.9	0.6	0.8	4
Calcarenite	2.0	0.4	1.1	2.1	0.9	1.5	1.2	0.3	0.7	0.8	0.5	0.7	0.9	0.5	0.7	1.0	0.6	0.8	23
Chalk	2.2	0.6	1.4	2.4	1.2	1.7	1.2	0.3	0.8	1.1	0.6	0.9	0.9	0.6	0.7	1.2	0.7	0.9	28
Chert	2.1	1.4	1.7	2.0	1.6	1.8	1.2	0.8	0.9	1.1	0.8	0.9	0.8	0.7	0.7	0.9	0.8	0.9	6
Diabase	2.8	1.0	1.9	3.0	1.1	2.0	1.3	0.6	1.0	1.3	0.6	1.0	0.8	0.6	0.7	0.8	0.7	0.8	9
Dunite	2.4	2.4	2.4	2.3	2.3	2.3	1.1	1.1	1.1	1.2	1.2	1.2	0.8	0.8	0.8	0.7	0.7	0.7	1
Gabbro	2.8	1.8	2.2	3.7	2.2	2.8	1.9	1.1	1.4	1.6	1.0	1.3	0.7	0.5	0.6	0.9	0.7	0.8	3
Gypsum	1.4	1.1	1.3	1.1	0.6	0.9	0.8	0.7	0.7	0.7	0.3	0.5	0.8	0.6	0.7	0.8	0.7	0.8	5
Harzburgite	2.0	1.3	1.7	1.9	1.5	1.8	1.0	0.8	0.9	0.9	0.7	0.8	0.8	0.7	0.8	0.9	0.8	0.8	3
Limestone	2.6	2.6	2.6	2.5	2.5	2.5	1.5	1.5	1.5	1.2	1.2	1.2	0.7	0.7	0.7	0.8	0.8	0.8	1
Marl	0.9	0.5	0.7	1.3	0.7	1.0	0.6	0.3	0.5	0.8	0.5	0.7	1.3	0.8	1.0	1.5	0.9	1.1	9
Microgabbro	1.0	1.0	1.0	1.2	1.2	1.2	1.2	0.6	1.0	1.1	0.6	0.9	0.7	0.6	0.7	0.8	0.7	0.7	4
Olivine-phyric basalt	1.1	0.9	1.0	1.2	1.2	1.2	0.7	0.5	0.6	0.7	0.6	0.6	0.7	0.7	0.7	0.9	0.8	0.8	2
Plagiogranite	3.4	3.4	3.4	3.6	3.6	3.6	1.6	1.6	1.6	1.5	1.5	1.5	0.8	0.8	0.8	0.9	0.9	0.9	1

A catalogue was created showing each sample and its properties

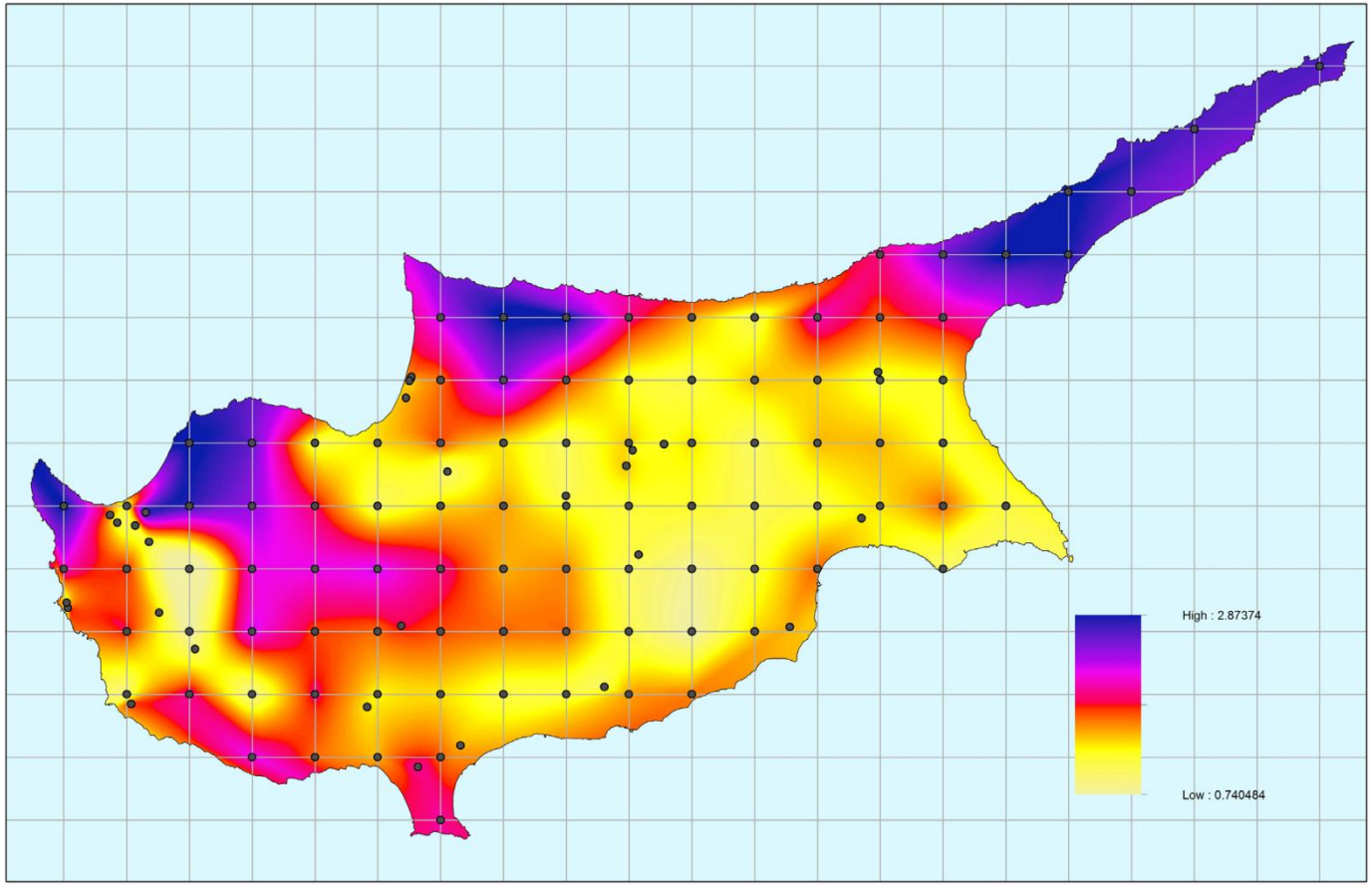
Sample 048

	Dry	Water Saturated	units
Diffusivity x 10^{-6}	0,61	0,76	m^2/s
Thermal Conductivity	1,01	1,44	W/mK
Specific Heat Capacity x 10^{-3}	0,74	0,97	J/K kg
Density x 10^{-6}	2,23	1,96	kg/m^3
Absorption/ Moisture	13,07		%
Formation/Stratigraphic Unit	Pachna		
Lithology	Chalk		

Sample 049

	Dry	Water Saturated	units
Diffusivity x 10^{-6}	0,65	0,60	m^2/s
Thermal Conductivity	1,08	1,16	W/mK
Specific Heat Capacity x 10^{-3}	0,68	0,83	J/K kg
Density x 10^{-6}	2,46	2,35	kg/m^3
Absorption/ Moisture	3,44		%
Formation/Stratigraphic Unit	Volcanic Sequence (Upper Pillow Lavas)		
Lithology	Olive phyric basalt		

Artificial neural networks for the generation of the conductivity map of the ground in Cyprus



Conductivity map for the first 100 m of depth, in dry soil.

THANK YOU FOR

YOUR ATTENTION