Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Geothermal Update Report from Israel 2005

Dov Levitte, Yeshayahu Greitzer

Levitte, D., Israel Geological Survey. 30, Malkhe Israel st., Jerusalem 95501, Israel

Greitzer, Y., Consulting Geologist. 18, Zeitlin st., Tel Aviv 64955, Israel

E-mail address, dlevitte@netvision.net.il

Keywords: deep wells, thermal springs, direct uses, Israel

ABSTRACT

Since the previous geothermal update report from Israel 1999, few new studies concerning Geothermal subjects were published.

Some 430 deep oil and structural wells were drilled in Israel, Most of these wells are abandoned or not in use. The available geothermal information from the majority of these wells was used in preparation of thermal gradients and isotherm contour maps at different depths. Approximately 100 of the above mentioned wells were examined for possible utilization of low enthalpy geothermal energy. Target horizons, possible yields, water salinity and water temperature were estimated.

A number of those wells were selected for utilization in spas based on different chemical composition and salinity concentrations with varying balneological needs.

Since the year 1999 few more of the above mentioned wells were utilized for spa application. At the same period numerous shalow low temperature wells were drilled for fish ponds water supply.

Also the use of geothermal water for agriculture continued scaling up, in the Dead Sea Rift and the southern coastal plainl, for use in greenhouses. Most of this water is pumped from deep water wells.

INTRODUCTION

The main geothermal activity in Israel till 1999 was in utilization of hot water for fish ponds spas and green houses (Fig 1). This trend is still active and increasing. Several geothermal studies were made during the 1970's and 80's (Levitte and Olshina, 1978, 1982, Mazor et al., 1980, Eckstein, 1976, Levitte et al., 1978, Rotstein et al.,1977), Greitzer and Levitte 1995, 1999, Levitte and Greitzer 1996, 1997, , Jaffe, et al (1999). In addition numerous private consulting studies were carried out for utilization of hot and saline waters from abandoned oil wells for spas, some of them in progressive development stage. Numerous shalow low temperature wells were drilled, for water supply to fish culture.

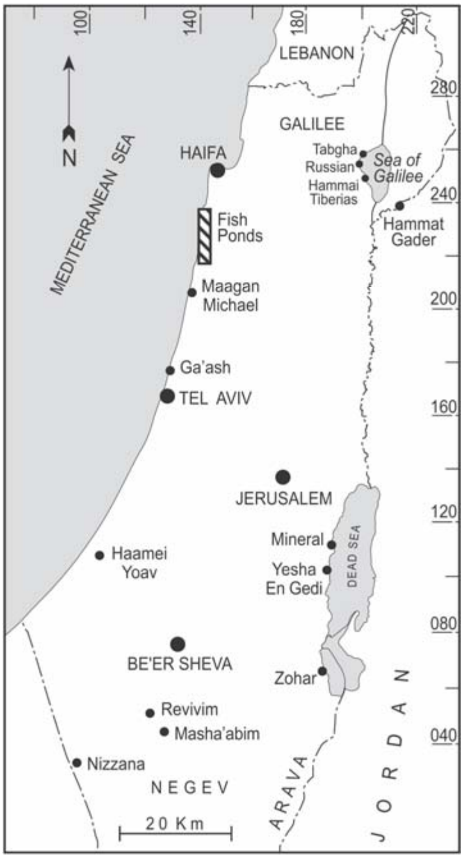

Fig. 1: Location map of Israel.

Geothermal water potential of the Paleozoic-Lower Cretaceous (Curnub formation), Cenomanian – Turonian (Judea Group) and Quaternary aquifers in Israel.

High temperatures water found in deep oil and water wells in Israel suggested the possibility of using geothermal energy for space, agricultural and recreational heating.

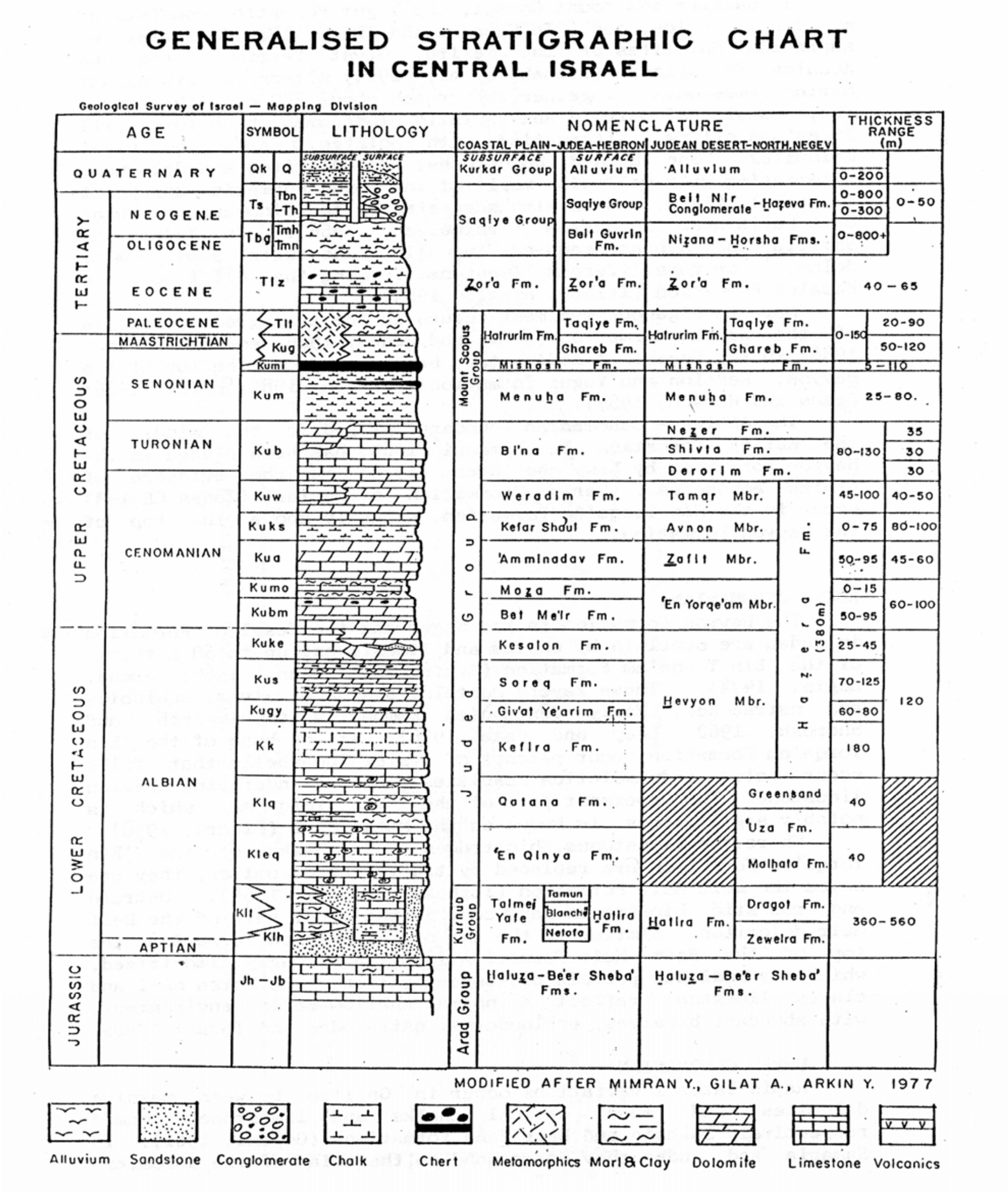

Fig. 2: Generalized Stratigraphic Chart of Israel.

Three main aquifers can be utilized for direct geothermal use in Israel (Fig 2): a deep seated Lower Cretaceous sandstone aquifer (Kurnub Group Aquifer), a moderate depth Cenomanian - Turonian confined aquifer (Judea Group Aquifer) and a shallow Quaternary Coastal aquifer (Coastal Plain Aquifer). The two deeper aquifer (Lower Cretaceous and Cenomanian-Turonian) display moderate to high temperature (30-80°C) while the shallow aquifer (Quarternary Aquifer) displays low temperatures (24-30°C).

The Lower cretaceous deep aquifer is composed mainly of sandstone (Nubien Sandstone). It is a confined aquifer containing fresh and brackish fossil water with a very limited recharge. It is located in southern Israel (Negev and Arrava regions) and the deep subsurface of Judea-Samaria Anticlinorium.

The Cenomanian - Turonian aquifer is composed mainly of limestones and dolostones confine by overlying Senonian - Eocene chalk, marls and clay.

The aquifer is exposed on the Judea-Samaria Anticlinorium and is confined in the western foothills and under the coastal plain.

The recharge area of this aquifer is large and forms one of the two most important aquifers in Israel.

The shallow Quaternary Coastal aquifer (Coastal Plain Aquifer) is composed of sand and sandstones interbeded with loam and thin beds of clay. The aquifer is located along the coastal plain from Sinai peninsula in the south up to the Carmel Mt. In the north. The recharge area of this aquifer is large and forms one of the two most important aquifers in Israel.

Thermal waters for health and recreation

Two types of sources supply thermal waters for health and recreation: (a). water emanating from springs and (b) water pumped from wells

(a). No new data was added about thermal springs in Israel since our report of 1999. It worth to mention again the existing observed hot springs in Israel. All the thermal springs in Israel are located along the Jordan-Dead sea rift which is a part of the the Syrian-African rift. Geothermal phenomena are abundent along this rift. The temperature observed in springs along the Jordan - Dead Sea Rift range between 26°C and 62°C. The largest discharge of thermal water is located in springs around Lake Kinneret (Sea of Galillee).

(b). Many deep drillholes in Israel encountered thermal waters (Fig.1); Negba 1 with a water temperature of 42°C which is utilized by Hammey Yoav Spa. This well is an abandoned structural oil well drilled to a depth of 1916 m which was perforated at a depth of few hundred meters within the limestones and dolostones of the Cenomanian - Turonian aquifer.

Ga'ash 1 (1114 m depth) and 2 (5508 m depth), abandoned oil wells north to Tel Aviv are producing thermal water for the Gaash Spa from Cenomanian-Turonian aquifer and Lower cretaceous aquifer. The Mashaabei Sadde Spa in the Northern Negev uses thermal water from a well tepping the Cenomanian-Turonian Aquifer.

Two large spas (En Geddi and Mineral) utilizing hot water from shallow wells elong the western coast of the Dead Sea in En Geddi area. The thermal waters (42°C) emanate through the Dead Sea Rift forming fault.

Agricultural utilization of geothermal water

Agricultural uses of geothermal water in Israel are divided into two branches: (a) greenhouses, and (b) fish farming.

<u>(a). Greenhouse</u>

The geothermal water here is used for both, space (greenhouses) and ground heating, using brackish water (600-1400 ppm. Cl at a temperature of 35°- 42°C), Since 1999 the utilization of thermal water for greenhouses in the Negev is increasing progressively.. The hot water is supplied by the Nizzana - Mash'abbe Sade well field, located in the northern Negev. These wells tap the Cenomanian-Turonian aquifer at a depth reaching 750 m and yield about 200 cu.m./h. These hot water are exploited by Kibutz Revivim and Moshav Nitsanei Sinai.

Another source of geothermal water in the southern part of Israel is located in the Arrava Valley tapping thermal water from the huge Nubian Sandstone aquifer. The Paran No. 20 deep well (which is the deepest water well in Israel - 1536 m) located in the Central Arrava about 80 km. south of the Dead Sea, draws water from this aquifer at 60°C with a yield of 150 cu.m/h and 600 mg/l Cl. In the Northern part of the Arrava Valley two artesien wells supply thermal waters; En Yahav No. 6 et at a temperature of 43°C and En Ofarim No. 5 at a temperature of 38°C. Shizafon No. 1 well in the southern part of the Arrava Valley was drilled to a depth of 900 m and yields 150 cu.m/h at a temperature of 51°C. (H. Naor et al 2003)

Another well field was developed in the Paran area exploiting the cenomanian–Turonian limestone and dolomite aquifer. The wells are 200 – 500 m deep and their temperatrure is about 30 – 33° C

<u>**(b)**. Fish farming.</u>

Geothermal water for fish farming is used in two regions; one in northern Israel adjacent to the Jordan Valley at Hammat Gader Springs (27°C), and the other along the Mediteranean coast in Atlit-Maagan Michael, utilizing warm brackish water (26°C). The water is supplied by shallow wells of about 30-100 m depth, penetrating the sandstone Coastal aquifer and draw water from the interface zone between sea and fresh water. Same type of wells were drilled in the southern coastal plain for supplying warm water to fish ponds. Since 1999, the supply of thermal water for fish farming in Atlit-Maagan Michael increased significantly.

REFERENCES

Eckstein, Y. (1976). The measurements and interpretation of terrestrial heat flow in Israel.. Isr. Geol. Surv. Report, Hydro/3/76, 170

Greitzer, Y. (1963). Groundwater salinity in the Cenomanian - Turonian aquifer of Central Israel. TAHAL (Water Planning for Israel) P.N. 293. 22 p.

Greitzer, Y. and Levitte, D. (1995). Geothermal update report from Israel. In, World Geothermal Congress, Florence, Italy, May 1995. 3 p.

Greitzer, Y. and Levitte, D. (1999). Geothermal update report from Israel. In, World Geothermal Congress. Kyushu-Tohoku, Japan, May 2000. p. 209-211.

Jaffe', F., Dvorjetski, E. Levitte, D., Massarawieh, R. and Swarieh, A. 1999. Geothermal Energy Utilization in Jordan Valley between Lake Kinneret and the Dead Sea: A View from Antiquity, In Stories from a Heated Earth – Our Geothermal Heritage, R. Cataldi, S. F. Hodgson, J. W. Lund, Eds., Geothermal Resources Council and International Geothermal Association, Davis, CA, USA.

Levitte, D. and Olshina, A. (1978). Geothermal energy potential of deep wells in the southern coastal plain of Israel. Isr. Geol. Surv., Rep. Hydro/9/78, 15 p

Levitte, D., Olshina, A. Wachs, D (1978). Geological and Geophysical investigation in the Hammat Gadder hot springs area. Isr, Geol. Surv. Rep. Hydro/4/78, 58 p.

Levitte, D. and Olshina, A. (1982). The geothermal potential of the Jurassic aquifer in the Ashdod area. Isr. Geol. Surv., Rep. Hydro/2/82, 6 p.

Levitte, D. and Olshina, A. (1985). Isotherm and geothermal gradient maps of Israel. Isr. Geol. Surv., Rep. Hydro/1/85, 94 p.

Levitte, D. and Greitzer, Y. (1996). Geothermal energy in Israel – Update. (Abstract), The Israeli Union for Engineering and Mining science.13th Annual meeting, December 1996.

Levitte,D. and Greitzer,Y.(1997). Geothermal water potential of Cenomanian - Turonian aquifer in Central Israel. IGA News.

Mazor, E., Levitte, D. Truesdell, A. H.,Healy, J. and Nissenbaum, A. (1980). Mixing models and ionic geothermometers applied to warm (up to 60° C) springs: Jordan Valley, Israel. J. Hydrol., 45: 1-19.

Naor, H. , Granit, I., Zuriel, A. (2003). Central Arrava – Update of the hydrological operational status of the aquifers and new wells up to the year 2002. TAHAL Consulting Engeenies, Tel Aviv.

Rotstein, Y., Klang, A. and Levanon, A. (1977). Electrical resistivity survey of Bet She'-Jordan Valleys and lake Kinneret. Isr. Inst. Petrol. Res. and Geoph. Rep. GT/149/74(3)

Meteorological Service of Israel, (1975). Temperature measurments at a depth of 100 cm in various places in Israel. (unpublished data).

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2004 (other than heat pumps)

[1] I = Industrial process heat | H = Individual space heating (other than heat pumps)
C = Air conditioning (cooling) | D = District heating (other than heat pumps)
A = Agricultural drying (grain, fruit, vegetables) | B = Bathing and swimming (including balneology)
F = Fish farming | G = Greenhouse and soil heating
K = Animal farming | O = Other (please specify by footnote)
S = Snow melting

[2] Enthalpy information is given only if there is steam or two-phase flow

[3] Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.004184 (MW = 10^6 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

[4] Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

[5] Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
		Flow Rate (kg/s)	Temperature (^{o}C) Inlet	Temperature (^{o}C) Outlet	Enthalpy[2] (kJ/kg) Inlet	Enthalpy[2] (kJ/kg) Outlet	(MWt)	Ave. Flow (kg/s)	Energy[4] (TJ/yr)	Capacity Factor[5]
Hamat Gader	F	300	27	22				300	198	
Mediteranean Coa	F	1000	26	20				1000	791	
Tiberias	B	20	42	30				20	32	
Hamat Gader 1	B	200	42	32				200	260	
Hamat Gader 2	B	140	42	32				140	185	
Hamey Zohar	B	7	30	26				7	4	
Hamey Yesha	B	10	41	30				10	14	
Mineral	B	20	42	30					32	
Hamey Yoav	B	50	42	32				25	33	
Gaash	B	100	38	28				100	132	
Mashabbe Sade	G	50	42	24				25	59	
Paran Nubian	G	60	60	24				30	142	
Paran C-T	G	100	30	22				75	79	
Nizzana	G	50	38	24				40	74	
En Yahav+Ein Ofa	G	110	45	30				80	158	
TOTAL		2217						2052	2193	

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2004

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]			
District Heating [4]			
Air Conditioning (Cooling)			
Greenhouse Heating		512	
Fish Farming		989	
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]		692	
Other Uses (specify)			
Subtotal			
Geothermal Heat Pumps			
TOTAL		2193	

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology