GEOTHERMAL EVALUATION FOR THERMAL FLUIDS OF HELWAN SPRINGS EGYPT

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ABSTRACT

Thermal waters ascending from geothermal systems may cool due to conduction of heat to the surrounding rocks, mixing with cooler water, boiling, or by a combination of these factors .
New springs started flowing on November 1991 during road works. After 12 October 1992 earthquake the total discharge of Helwan springs reached more than 400 m^3 /h with a measured temperature range between 23 –32^o C.
Applying geothermometery to Helwan Springs, suggested that reservoir temperature is between 80 ^{o} C and 160 ^{o} C. This increases the importance of developing new ways to use such large amount of water which is currently wasted by discharging to the sanitary system. (Figure1)

1-INTRODUCTION

On November 12 th ,1991 a new spring started to flow in street No. 16, Helwan district during road work. Few days later another spring started to flow in street No 5. Both springs are located about 500 m Southeast Helwan Sulphur bath. This bath is fed by a large sulphur spring in the central part of the district which have been used for curing skin disorders since 7 th century.

On October 12 th, 1992, after an earthquake (5.3 on Richter scale), many springs started flowing at other sites. Water temperature of Helwan Springs range between 23 –32 ^{o} C. In 1969, discharge of Helwan sulphur springs varied between 20 m^3 /h and 47.1 m^3 /h (El Ramly, 1969). In 1992, the total discharge of the existing springs in Helwan reached more than 400 m^3 /h. Most of these water is discharged to sanitary system. Total dissolved solids and major cations and anions concentrations exceed the WHO 1971 maximum permissible limit for drinking water.

2- DIFFERENT ASPECTS CONTROLING SPRINGS

Helwan District is located east of Nile River south of Cairo , where, the predominant rock type in contact with the groundwater is limestone. Helwan District lies east of the seismically active Gabel Qattrani-Dahshour area.

During recent years three events of spring birth associated with seismic activity had been recorded; first on June 26 th, 1962, second on March13 st, 1969, and third immediately after October 12 th , 1992 earthquake.

2.1. Climatic Conditions

Helwan district occupies a portion of northern part of Egypt which lies within the extremely arid belt, where the average annual rain fall is less than 40 mm. Prior to the present aridity, wet climatic conditions were dominant as pointed out by the large number of well branched drainage lines which dissect the area and by the presence of several springs within the area. The area is characterized by a hot summer and a warm winter. The highest mean maximum temperature was 37.1C^o in August 1988 and the lowest mean minimum temperature in January 1981 was 5.5 ^{o} C in Helwan Meteoric station. (during 1980-1990 period).

2.2. Topography, Rock Types and Main Structures.

Topographically the area characterized by a low relief and a gentle slope from east to west. Most geomorphic features within the area of study were shaped during wet climate in the past, where the present arid conditions has contributed much to the lowering of land and retreat of slopes. Because, neither the wet and the arid climates has contributed for any length of time, no genuine karst topography has developed within the study area
(Said, 1954). The deep circulating of spring water through limestone, the biological activity and the presence of CO_2 in the soil are all reasons responsible for erosion and weathering of carbonate rocks and generation of some karst feature under the Helwan area. Rocks exposed in the study area are all of sedimentary origin and range in age from Middle Eocene to Recent. Eocene rocks constitute the most common outcrops in the study area. and mainly made of limestones, marls and dolomites rarely mixed with clastics .

Helwan district lies southwest Cairo- Suez structural belt and is mainly affected by faulting and slightly by folding. Faulting is the main structural feature , there is three sets of faulting
NW-SE (main system affecting the area), E-W and NE-SW, all these faults are normal faults. The strata are generally horizontal and the average dip ranges from 1^o. to 2^o. In the vicinity of faults, the beds are locally dragged, the dip may reach 30^o
(Farag & Esmail, 1950). Beside faults, at least two sets of important joints are dissecting the limestone all over the area E-W and NW-SE

Folding was only produced in consequence of the bending of beds along fault lines or in the rock downthrown sides of faults. Neither true anticlines nor synclines of organic origin are present (Farag and Ismail, 1955)

2.3. Surface Water System

The surface water system includes Nile River and irrigation channels and seasonal water courses including drainage basins occupying the eastern part of the area.

2.4. Groundwater system

Aquifers of the study area from top to bottom are

- Quaternary Aquifers

a-Holocene aquifers in this area is composed of Nile silt, clay and sand with a thickness ranges between 10 m to 14 m. The main sources of recharge are the direct downward infiltration from the irrigation channels.

b-Pleistocene aquifers composed of silts, graded sands and gravels with total thickness ranges between 50 m. to 80 m. The main recharge source of groundwater is the vertical water seepage from irrigation channels and the Nile River. (Attia, 1954).

- Tertiary Aquifers

a-Pliocene aquifer mainly composed of fine to medium sands, clays, and calcareous and argillaceous sediments . During 1992 in piezometers tapping this aquifers, water level was less than that of the Eocene fractured limestone aquifer and more than that of the Quaternary aquifer and Nile River. This indicates that the main source of recharge to Pliocene aquifer within the study area is upward leakage from Eocene fractured limestone aquifer and the downward seepage of water from irrigation channels and drains.

b-Eocene Aquifer
The fractured Eocene limestone has a wide distribution on the surface and in the subsurface of the Helwan district. Abedel Daiem 9 1971) has expected that the most ideal Eocene sections within the area range between 400m. To 800m.and overlay unconformable Cretaceous Nubian Sandstone aquifer. Secondary porosity is much more common in the area than the primary porosity. Eocene fractured limestone aquifer displays karst features, which has lead to the formation of several springs within the area. These springs are fed by upward water leakage from the underlying major Nubian sandstone aquifer through fissures, cracks, underground channels and fault planes. Limestone porosity was clear at the caliper log of several piezometers.

3. SUBSURFACE TEMPERATURE

The mean air temperature in Helwan district is about 21.6 ^{o}C taking into account warnings definition(1976) of a hot spring as the one being 8.3 ^{o} C above mean air temperature, Water temperature of Helwan springs need to be at least 30 ^{o} C in order to be classified as thermal springs
Various chemical geothermometers have been developed to predict reservoir temperature in geothermal fields. In up flow zones below hot springs or shallow drill holes, cooling of water may occur by coduction boiling and/or mixing with cooler water. Silica geothermometers and cation geothermometers ac suggested by different authors have been used to predict subsurface temperature for Helwan springs. Solution- mineral equilibria were also been used as another approach to geothermometery introduced by Reed and Spycher (1984)

3.1. Silica geothermometers

Fournier (1973, 1977) suggested two geothermometers one for quartz and another for chalcedony both with no steam loss. The first suggests 122 ^{o} C. subsurface reservoir temperature temperature. The second suggests 94 ^{o} C. (Table1)

3.2. Cation geothermometers

Three cation geothermometers were been applied to eleven samples (Table1). The 1st was Na-K geothermometers introduced by Fournier (1979) a suggesting temperatures as high as 144 ^{o} C. and as low as 89 ^{o} C. The second by Giggenbach (1988) for
Na-K suggesting temperatures as high as 177 ^{o} C. and as low as 110 ^{o} C.
Na-K-Ca by Fournier et al, (1973) suggested temperature as high as 116 ^{o} C. and as low as 72 ^{o} C. It is to be noticed that suggested temperature. are higher after the October earthquake indicating the increase of up flow from the deep reservoir due to the earthquake

3.3. Solution-mineral equilibria.

An aqueous speciation program Watch (Arnorsson et al., 1993) has been used to construct mineral equilibria diagrams. suggesting 95 ^{o} C. as subsurface temperature by anhydrite, fluorite and chalcedony. Also, SOLVEQ program by Reed and Spycher (1984) has been used to construct mineral equilibria diagrams suggesting 130 ^{o} C. as subsurface temperature by brucite, anhydrite, and quartz.

4. DISCUSSIONS AND CONCLUSIONS

Silica geothermometers have been applied to only one sample analysis reported to Helwan mineral spring by El Ramly(1969), suggesting 122 ^{o} C for quartz geothermometers and 94 C^{o}. for calcedony. Aqueous speciation program Watch (Arnorsson et al., 1993) and SOIVEQ (Reed and Spycher , 1984), have been used to construct diagrams of mineral equilibria using the same water analysis. Watch suggested 95 ^{o} C for subsurface temperature and SOIVEQ suggested 130 ^{o} C for subsurface temperature. The highest recorded surface temperature was 36.1 ^{o} C (El Ramly , 1969). This can be explained by conduction and the mixing of hot water through the up flow zone by cooler water from shallow aquifers. As water moves from the deep aquifer, Nubian sandstone, it changes from sodium bicarbonate water to sodium chloride. Two samples taken from piezometer hole No. 9 and street No.5 spring before and after October 1992 earthquake reveal subsurface temperatures as low as 80 ^{o} C and as high as 163 ^{o} C using cation geothermometers only as silica was not analyzed in these samples (Table1).It is also noticed that the suggested subsurface temperature is higher in both the piezometer and the new spring after the earthquake.

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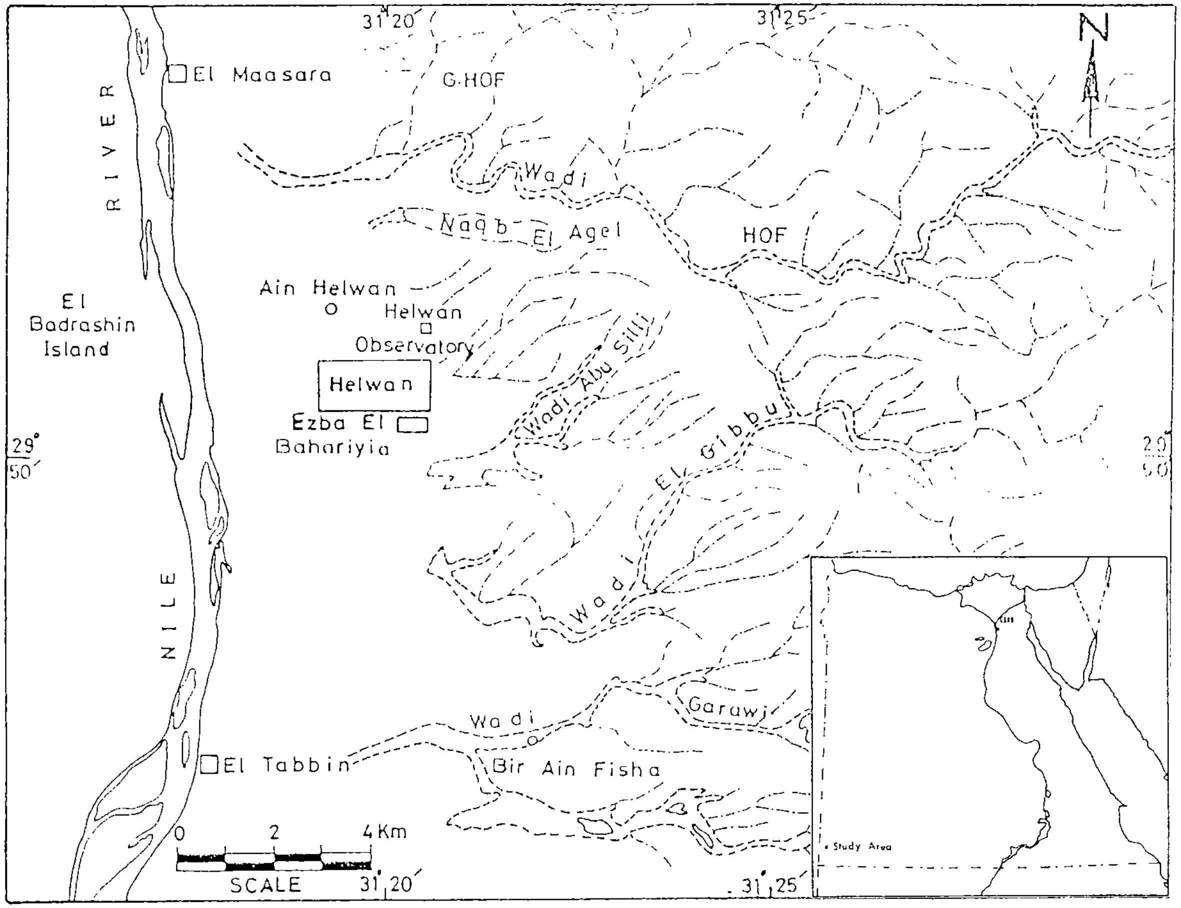

Figure 1 : Location Map

Table 1 : Subsurface temperature calculated by different geothermometers

Name	Date	T.D.S	t1 (°C)	t2 (°C)	t3 (°C)	t4 (°C)	t5 (°C)
Helwan mineral spring	1969		122	94	96	117	77
Piezometer No.1	28/5/92		N.C.	N.C.	89	110	72
Piezometer No.2	26/4/92		N.C.	N.C.	109	130	86
Piezometer No.3	9/2/92		N.C.	N.C.	110	130	86
Piezometer No.5	4/3/92		N.C.	N.C.	128	148	98
Piezometer No.9	26/4/92		N.C.	N.C.	133	153	100
Piezometer No.9	30/10/92		N.C.	N.C.	144	163	107
Street 5 spring	21/6/92		N.C.	N.C.	100	121	80
Street 5 spring	30/10/92		N.C.	N.C.	118	139	91
Street 16 spring	26/4/92		N.C.	N.C.	117	137	90

N.C. : not calculated as there is no silica analysis.
t1 : Fournier 1973 quartz geothermometers
t2 : Fournier 1977 chalcedonygeothermometers
t3 : Fournier 1979 a Na-K geothermometers
t4 : Giggenbach 1988 Na-Kgeothermometers
t5 : Fournier etal. 1973 Na-K-Ca geothermometers