GEOTHERMAL SITUATION IN THE AREA OF GREEK ISLANDS AND COASTAL AREA

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1. INTRODUCTION

Geothermal energy is a term that refers to thermal water or steam, which is concentrated at accessible depths (less than 3km) and can be economically exploited.

This kind of energy is the sole renewable source not directly or indirectly connected to solar energy. It is a reliable and always available source: day and night throughout the year. Provided that it is properly implemented, geothermal energy is a sustainable and benign to the environment resource. Since the transfer of geothermal energy far from its source for long distances is not very common or advantageous, its exploitation for local development activities or for the energy self-dependence of isolated areas (e.g. islands) is particularly favorable.

Geothermal energy has been used for centuries for bathing, cooking or even heating pursposes, but it was in the early 1900's that the large-scale utilization commenced. The geothermal uses are commonly divided into two categories: electrical (production of electrical power) and direct uses. The former uses are limited to fluid temperature above 160°C, although temperatures as low as 90°C can still produce electricity in a binary power plant. The high temperature fluids for conventional electricity generation are confined to certain areas of earth, associated with magmatic and seismic activity and young volcanism (e.g. California, Japan, Larderello-Italy and Milos Island-Greece). On the other hand, low-temperature regions, which can be exploited in a wide variety of direct uses, are more widespread and can be found in most countries. The utilization of geothermal energy in principle employs known technology and straightforward engineering, borrowed from the oil (e.g. drilling technology), domestic and power sectors. However, in some cases, dissolved solids or gases in the geothermal fluid complicate the technology.

Despite some misperceptions about its nature, especially concerning its renewability, geothermal energy is considered as a sustainable energy source, which can provide a substantial part of energy needs, especially on a local basis. The abundance of geothermal resources and the improvement of the technology (and consequently the reduction of the capital cost) will allow geothermal energy to participate more actively in the energy sector.

As mentioned above, geothermal energy is a clean energy form. The emission of greenhouse gases is orders of magnitude lower than that from burning fossil fuels. The removal of hydrogen sulfide from high-temperature steam and the re-injection of spent geothermal waters into the ground reduce significantly any potential negative environmental impact.

The aim of this paper is to examine the main characteristics of the geothermal fields in island and coastal areas of Greece emphasizing on those in the Aegean region, and the development of exploration and exploitation activities.

2. CENOZOIC MAGMATISM IN THE WIDER AEGEAN AREA

The magmatism and volcanic activity in Greece took place during Cenozoic. The first records come from East Macedonia and Thrace, during the Upper Eocene, and the most recent ones from Santorini Island, where the eyewitnesses of the last eruption are still alive.

After extensive research, combination and evaluation of all the obtained data, it has been concluded that several magmatic locations exist in Greece, the distribution of which –according to their age-migrate from the north to the south.

This volcanic activity in Greece has been going on continuously without any interruptions. In the islands of North Aegean (Samothraki, Agios Eftstratios, Lesvos) the intense volcanic activity took place between 23,2 and 16,2 Ma ago.

In the Central Aegean (Skyros, Psara, Euobea) the volcanic activity was not extensive and took place in the period between 17,7 and 13,2 Ma ago.

The age of the Eastern Aegean volcanism is 10,7-3,5 Ma.

During the last 5 Ma the intensive volcanism in Greece is divided in two main categories:

A scattered volcanism, which is mostly located in Mt. Vorras and in the southern coasts of Pagassitikos Gulf (6-0,5Ma ago).
The volcanism located along the volcanic island arc of Southern Aegean, from Sousaki to Nisyros Island. The oldest volcanic activity goes 4,7Ma back, while the last historical eruptions of Methana and Santorini were recorded in 282 B.C. and 1950 A.C. respectively. Hydrothermal eruptions have been also recorded in historical times in Milos (16th century) and Nisyros (19th century).

The oldest plutonic formations in North Greece have been traced in Chalkidiki (52-44Ma), Kavala (21Ma) and Samothraki (18,5Ma). The age of the Central Aegean plutonics is 17-8,5Ma, the youngest of which are located in Serifos and the oldest in Ikaria Island.

The deep exploratory oil-wells that were drilled in the Delta of Nestos river (North Greece, between Kavala and Thassos), showed that the tempera-tures of the sediments are over 200°C at depths less than 2000m. This has been considered as an indication of a Middle Miocene plutonic intrusion. Inbedded horizons of ignimbrites were also traced in the Upper Miocene sediments of Kavala basin.The volca-nism in the islands of North Aegean (Samo-thraki, Imvros, Lemnos, Ag. Efstratios, Lesvos) and in the neigh-boring areas of Asia Minor was gene-rated by the active subduction and the extensional decom-pression of the lithospheric mantle (from the collapse of the Alpine orogene), which are considered as the most suitable mecha-nism that generated the magma-tism in this area.

In the area of Central Aegean (Cyclades Islands), a non-extensive and scattered volcanism is located in the islands of Syros, Psara and Chios, while the most extensive outcrops are found in Euobea Island.

Scattered volcanic activity has been recorded in Greece mainly during Pliocene and less in Pleistocene, in the west coasts of Pagassitikos Gulf, the North Euobean Gulf, Mt. Vorras, Strymonas Basin, Antiparos and Psathoura Islands.

The correlation between the Psathoura and Pagassitikos-Euobean Gulfs with the north branch of North Anatolia Fault is evident.

Intense volcanic activity has been taking place in the area of South Aegean Volcanic Arc. In Soussaki, Egina and Poros, the age of the volcanism is Pliocene, while in Methana, Santorini and Nisyros is Quaternary.

In the island complex of Milos, Santorini and Kos-Nisyros, big and complex volcanoes are structured (10-43km^3 above sea level), while the periodical manifestation of large explosive events caused frequent calderic collapses. On the contrary, the effusive activity prevails in the volcanic centers of Saronikos gulf and creates dome and lava flow complexes.

The general geochemical characteristics of these volcanic rocks are absolutely accordant to the products of the volcanic arcs in subduction zones.

The differences in structure and in the explosive behavior between the volcanic centers of western (Saronikos) and central-eastern arc, can be ascribed to the smaller crust thickness as well as to the more intensive extensional tectonic regime of the central-eastern part. Santorini, which is located over the thinner crust zone presents the most explosive behavior.

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The volcanic centers are placed selectively along four normal faults, in Saronikos, Milos, Santorini and Kos-Nisyros.

3. THERMAL REGIME OF THE AEGEAN REGION

Greece, like many other Mediterranean countries (e.g. Italy and Turkey) is "rich" in geothermal energy. This is because the greatest part of the country is located in an area geodynamically very active, as a result of the movement of the African Plate towards the Eurasian one. The Institute of Geological and Mineral Exploration (IGME) has carried out the bulk of geothermal exploration activities in Greece. The first activities started in the early '70s and were mainly focused on areas related to the south Aegean volcanic arc and on central Greece (Sperchios Basin). The evaluation of the geothermal resources was continued in 80's and 90's covering the greatest part of Greece.

The map of Figure 2 shows clearly that the vast majority of the geothermal areas are located in Aegean region (island and coastal areas). This can be explained by the specific geodynamic and tectonic situation in this region during the most recent geological period.

In fact, Greece is part of the southern edge of the Eurasian Plate, which has been fragmented due to the subduction process of the African under the Eurasian Plate. One of the surface effects of this convergence is the creation of an active volcanic belt, which extends from the Gulf of Saronikos via Milos and Thira as far as Nisyros.

This volcanic arc contains geothermal anomaly. The distinctive geodynamic nature of the Aegean area causes considerable seismic activity; the area also exhibits intensive tectonic activity that has a destressing effect in the areas furthest inside the Aegean volcanic arc, which often results in the formation of rift valleys, sometimes involving volcanic activity. The general extension process and the intensive tectonic activity encourage the hot fluids to circulate and uprise, thus forming several thermal reservoirs.

Figure 2 summarizes the heat flow data available or Greece.

The most extensive anomalies occur in conjunction with the active volcanic belt and with the areas affected by the volcanism in the Pliocene-Quaternary. The other major anomaly area in continental Greece is in the region of Macedonia and Thrace and in the North Aegean area (to the islands and the coastal areas). These regions lie in an active back extension area with a thinning lithosphere, which create for that reason an important positive geothermal anomaly. In fact, in this region an intensive extension tectonic activity is present since the Pliocene-Quaternary, which has formed large grabens (e.g., Strymonas Graben) with many hot springs and important subsurface reservoirs of geothermal fluids inside the sediments or basal formations.

4. GEOTHERMAL FIELDS AND THEIR CHARACTERISTICS

In the areas of the active volcanic arc, and especially in Milos and Nisyros, the potential geothermal resources are enormous. Geothermal fluids of 60°C have been found in 20m deep wells. The total potential for power generation in these areas is estimated to exceed 200 MWe. Unfortunately, the 2MWe pilot power plant in Milos, which was in operation only for a short period in the '80s, was hit by technical problems and ceased operation in 1989. Regarding the low temperature potential, the present data yield a potential exceeding 400 MWt proven and 800 MWt probable. The most important explored low temperature areas near the Aegean coasts are located in the basins of Alexandroupolis, Xanthi-Komotini, Nestos Delta, Strymon, Mygdonia, in Sperchios valley and in the island of Euobea.

The geothermal fields under exploration in the Aegean islands and coastal areas are presented in Table 1.

In Lesvos Island, the Greek Public Power Corporation (PPC) has financed an exploration project, in the frame of which several shallow wells were drilled in the area, where the thermal water temperature ranges between 86-92°C. PPC plans to start a drilling program, which will include the construction of 3 new wells about 2km deep, hoping to arrive at the medium enthalpy reservoirs (120-150^0 C) and then

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to install some organic cycle power production plants.

Two 200m deep wells were drilled in Kimolos for the purpose of the desalination project which was realized in the island. The aquifer was found at the depth of 170-200m and its temperature reaches 60°C.

Finally, next to the balneology center of Therma, in Samothraki Island, three shallow wells yielded large quantities of high salinity fluids, the temperature of which is approximately 100°C. Further development plans include construction of a modern Spa center heated by geo-thermal energy.

4.1 Milos Island

Milos is the region where the first geothermal exploration activity in Greece at great depths was set up and carried out. Geologically, the island has Mesozoic metamorphic basement complex consisting of schists, phyllites, quartzites, schistose crystalline limestone (composed of calcite and mica) and marbles. On top of the basement, a Neogene marine transgression unconformity series lies, which is made up of conglomerates, limestone and gypsum. The series is not very thick and does not entirely cover the metamorphic rocks.

Volcanism has given rise to typically calc-alkaline rocks. It began in the Upper Pliocene with large explosive eruptions, which deposited a mainly calctufa-ignimbritic series. Afterwards, the activity became basically effusive, with the formation of domes and flows. The final period of this cycle consisted of renewed explosive eruptions accompanied by secondary rhyolitic lava (0,5 Ma). This was preceded by a long period of lahar deposition, which covered some half of the island.

Milos is marked by a very intensive rigid tectonic activity. The main faults run parallel to the volcanic belt, perpedincular to it and N 60° E. There are frequent vertical dislocations, some of which are notable. Additionally, the island presents an important seismic activity.

Table 1: Characteristics of low-temperature geothermal fields in the area of Aegean

Geothermal Field	Surface area (km^2)	Reservoir Depth (m)	Total Flow Rate (m^3/h)	T_{max} (°C)	T.D.S. (g/L)	Water Type
Aegean Coastal Areas						
Porto Lagos		450	20	38	5	Cl-Na
South Komotini	30	450		40		
Sani-Afytos	6	500-600		38	1-2	
Sousaki	10	80-150	>200	75	40	Cl-Na
Methana	10	100-250		45	40	Cl-Na
Kammena Vourla	5+	50-200	1200	46	8	Cl-Na
Aedipsos	5+	100	400	81	38	Cl-Na
Aegean Islands						
Polychnitos (Lesvos)						Cl-Na
Argennos (Lesvos)	4	10-300	800	86	12	Cl-Na
Stypsi (Lesvos)	10	50-200	200+	95	1-5	Cl-Na
Geras (Lesvos)	2+	20-80	150	40	1-2	$Cl-HCO_3$
Nenita (Chios)	5+	100-400	100	90	4+	Cl-Na
Therma (Samothraki)		40-120	100	100	40	Cl-Na
Milos	50	10-100	200	90	5-30	Cl-Na
Kimolos		170-200	200	60	40	Cl-Na
Santorini	10	50-400		70	30	Cl-Na
Santorini		20-50	200	65	10-40	Cl-Na
Kos		100-400		28		Cl-Na

Thermal activity is nevertheless very limited, consisting of minor springs with maximum temperature of 45°C, fumaroles with temperatures up to 102°C and hot grounds with maximum temperatures of 100°C. From a geological point of view, most of the thermal waters are salty with a pH below 7 (sometimes until 2,5), a relatively high B and NH_4 content and a low NA/K ratio.

On the contrary, the hydrothermal activity is extremely intensive. This has resulted in considerable transformation of the volcanic series into clay products, particularly bentonitic in bigger depth and kaolinitic near the surface. Thus, an excellent impermeable covering layer has been formed, as a result of this self-sealing process. There are a large number of phreatic eruption craters, which affect the volcanic layer, but also the Neogene limestone series as well as the metamorphic ones.

The most violent explosions flung out very large blocs of schist and limestone, so that the diameter of the craters may be up to 600m. Approximately 60 thermometric boreholes were drilled in order to survey the geothermal potential of the island, which indicated temperature gradi-- ents up to 100°C/100m. This information was used for the construction of an approximate gradient map, which delineated the two main areas with particularly high positive anomalies.

The information obtained from the geoelectrical soundings was extremely useful in deciding the locations of the deep soundings.

Two years (1971-1973) were necessary for all the geological, geochemical and geophysical prospecting works to be completed in Milos. By the end of the project it became possible to identify the most promising areas and to site the exploratory and production wells.

At first, two deep exploratory wells were drilled: MZ1 and MA1. At the bottom of the first well (1101m) the temperature was approximately 320°C. The well produced between 60 tn/hour of mixed fluids, with an enthalpy of 450 Kcal/kg. The second well (MA1) encountered temperatures of 318°C at the depth of 1163m. This well also produced mixed fluids with about 56% steam, with an enthalpy of about 345 Kcal/Kg. The flow rate was around 60 tn/hour and the wellhead temperature approximately 240°C. Three more production well +100-1380 m deep, have similar results in temperature, flow rate and enthalpy. The total high enthalpy potential of Milos Island is estimated to 200 MWe.

4.2 Nisyros Island

The island of Nisyros is also part of the volcanic belt. It has a composite volcano with older andesitic volcanic rocks capped by a small caldera, the diameter of which is approximately 4 km.

After the formation of the caldera, a number of dacitic domes formed inside it. There were numerous phreatic eruptions, which in some cases have formed large craters. The most important feature of phreatic origin is a crater inside the caldera, 250m in diameter.

The most recent phreatic eruption occurred in the 19th century. The fumarolic activity inside the caldera is intensive and arrives to 100°C. Several hot springs occur in the island, even on the slopes of the volcano, having a maximum temperature of 55°C.

Nine temperature-measuring wells have been drilled in the island. Two of them, which are located inside the caldera, encountered temperatures until 100°C at the depth of 100m, while one of them produces very low-pressure steam. Inside the caldera two productive wells were also constructed at the depth of 1500m. A geothermal reservoir was found at the depth of 1200-1500m, inside the Mesozoic basal limestones and the volcanic rocks, with temperatures of 247°C and 318°C respectively. The first well found a deeper reservoir at the depth of 1800m with temperatures higher than 400°C, but with high salinity and corrosion effects that produced severe problems to the surface preliminary installations. Thus, this deeper reservoir was cemented. Both wells produced a mixture of steam and water.

The volcanic formations have been subjected to intensive hydrothermal activity, which has considerably reduced its permeability. The geological structures and the geothermal data available so far, indicate that this area has a considerable potential, probably more than 50 MWe.

4.3 Santorini Island

Santorini has a complex volcanic system, which is still active. The oldest volcanic products date back to Late Pliocene. In 1630 B.C. a great eruption took place, which resulted in the formation of the calderic depression that gives the island its current aspect. Various eruptions inside the caldera –the last of which was in 1950- have caused the creation of the small island of Kameni. The volcanic rocks lie on metamorphic basement, which is revealed at the southeastern part of the island.

There are various signs of thermal activity: fields of fumaroles (97°C) in Nea Kameni and hot springs (with maximum temperatures ranging from 50 to 55°C) in Nea Kameni as well as along the inside walls and marginal slopes of the volcano, particularly at the southern edge of the island (Vlychada).

Ten relatively shallow (max 300m deep) temperature-measuring drillholes were constructed in the volcanic series at the northeastern and in the metamorphic series (limestone, schist and a younger granitic intrusion) at the southeastern part of the island. The temperatures that were measured reached 70°Cm, and the temperature gradient was found to be several times higher than the mean one.

4.4 Sousaki

Sousaki lies on the coastal area of Saronikos Gulf, on the northwestern side of the Aegean volcanic arc, 22km from Korinthos. Strymonikos Gulf was formed by a destressing tectonism during Pliocene-Quaternary. The main directions of the tectonic activity run E-W and NW-SE.

The oldest formations (corbonate series and flyschoid structures) are of Mesozoic age and contain ophiolites. They are partially covered by a Neogene series. The volcanic formations date back to the Pliocene and consist of domes and dacitic flows, which are generally of limited extent.

In the area of Sousaki, several examples of hydrothermal activity are evident. In addition, there are fumaroles of low temperature (about 42°C) but rich in CO_2. A temperature-measuring borehole was drilled and recorded 73°C at the depth of 150m. The chemical analyses showed that the fluids had interesting geochemical characteristics and very low Na/K ratios. Five other temperature-measuring soundings carried out in the area indicated high variations in temperature in the first few meters, after which the gradient becomes stable. This was due to the permeability of the layers that were penetrated. The measurements in the existing wells in the region around the hydrothermalised area showed relatively high temperatures (up to approximately 40°C). The geochemical data from these wells suggested temperatures of medium enthalpy in the reservoir.

4.5 Methana Peninsula

The peninsula of Methana is situated in the southern part of Saronikos Gulf. It consists of volcanic formations dominated by lava domes and flows with secondary tuffs and volcanic agglomerates. The type of the formations is characteristic of those of the volcanic arc. The oldest formations probably originated at the beginning of Quaternary, while the youngest come from the eruption of 250 B.C.

There is no real evidence of hydrothermal activity in the area, although there are some hot salt-water springs with temperatures up to 44°C/ The geoche-mical data do not suggest favorable conditions for high enthalpy in “economic” depths.

4.6 Lesvos Island

The island of Lesvos is situated in Northeastern Aegean, inside the volcanic belt and it is partially volcanic. The volcanic activity in this region dates back to the Miocene (16-18 Ma) and is part of the large calc-alkaline and k-rich belt, which encompassed the central part of the Aegean during Tertiary.

The pre-volcanic basement consists of a metamorphic rock series, which emerges mainly at the eastern part of the island. The area was subjected to an extensive Neogene-Quaternary extension tectonic activity. The island is considered to be very “rich” from a geothermal point of view, with hot springs at temperatures around 87,5°C in Polichnitos (the hottest fluids found in Greece).

The geothermal filed of Polichnitos is the most intensive in the island, with 20 hot springs of a total capacity 13-25 lt/sec.

The water is particularly rich in chloride and their salinity is between 11-12 gr/lt. Unfortunately, the 24 temperature-measuring soundings taken, did not provide much information due to the circulation of all the fluids even in small depths. Five production wells were constructed in the area, at the depth of 150m, which encountered reservoirs with 70-95°C fluids. The total flow rate is more than 100lt/sec but the potential of the area is estimated to be much higher.

Another important geothermal area is in Argennos, located at the northern part of Lesvos. The maximum temperatures of the hot springs are around 86°C. The water has a relatively low ratio of Na/K and interesting geochemical characteristics.

Finally, high water temperatures (up to 92°C) have been found in the area Stipsi-Kalloni at relatively shallow depths (150-300 m).

Although there has been no recent volcanic activity in the area, the geothermal anomaly in relatively shallow depths can be attributed to the active tectonism. A recent deeper well given very high flows but the temperature remains at 100^0 C.

4.7 Chios Island

The area of Nenita (Chios Island) has been recently explored. Five exploratory boreholes were drilled and a geothermal reservoir at the depth of 300-400m was identified, having temperatures up to 90°C.

The fluids are rich in salts and circulate in Neogene's sediments or in the "roof" of the limestone Mesozoic formations. Geochemical evidences shows higher temperatures on the deeper basement, that can be connected with an impressive extensional tectonic similar to the near Anatolian coasts.

4.8. Samothraki Island

The northern island of the Aegean Sea is really interesting from geothermal point of view. The Tertiary volcanism and an important granitic intrusion of the same age, together with the neighboring Anatolian fault system, created important geothermal anomalies in the area. Evidences the geothermal interest of the area are provided by the existence of hot springs, of very positive geothermal gradients and mainly the temperatures of three shallow (30-50 m) wells, which were 100°C. Unfortunately, no systematic exploration data exist for this geothermically important island.

4.9 Sperchios Valley

Sperchios Valley actually constitutes a Plio-Quaternary tectonic graben, following the East-West direction. The faults of the southern part of the graben have significant displacements, along which several hot springs emerge, with temperatures between 35-42°C (Thermopyles). The geological formations consist of Mesozoic carbonate series covered by an ophiolitic flysch. The fluvio-deltaic sediments of the graben date from Quaternary, which is actually the formation period of the Valley.

The springs of high flow rate (20lt/sec) are located in Thermopyles. The salinity of the fluids is approximately 6-8gr/lt and their type is sodium chloride and calcium bicarbonate. Nineteen shallow wells were drilled in the area (50-250m deep), and the temperatures they've encountered are medium (~45°C).

Near Ypati, a NH_4 anomaly has been traced. A small diameter exploratory borehole constructed in the area, reveal the existence of a thick alluvial layer (280m) rich in geothermal fluids above the carbonate series. The temperature of the fluids at the bottom of the well (325m) was 52°C. Abundant CO_2 carried the hot water up to 10m above the wellhead.

4.10 Euboea Island

The geothermal area in Euboea Island is located in Aedispsos, at the north-western end of the island. Aedipsos lies over the intersection of two major active tectonic lines (EW and NW-SE) that are responsible for the geothermal anomaly of the area, since they allow the geothermal fluids to circulate and escape to the surface. The hot springs (78,5°C) have formed an extensive travertine plateau. The salinity of the majority of the waters is extremely high (up to 33gr/lt).

5. GEOTHERMAL APPLICATIONS IN THE AEGEAN REGION AND CONCLUSIONS

As 2MWe power plant was installed in 1985 in Milos, but it is not in operation, but it is not in operation due to technical and environmental problems (mainly from the H_2S emission).

Other major applications of geothermal energy in coastal and island areas of Greece are:

Greenhouse Heating in Lesvos, Milos and Nisyros islands with a total installed capacity of ~6MWt.

Geothermal desalination in the islands of Kimolos and Milos. The first has been already completed, while the second has just started.

The heating needs of 2 houses in Milos with DHE are provided by the re-circulation (by natural convention) of "clean" water through a "downhole heat exchanger" (DHE).

The potential for power generation using ORC units in several Aegean islands (Milos, Nisyros, Santorini, Lesvos and possibly Chios) is large and a preliminary estimate is ~20MWe.

Geothermal Heat Pumps: a geothermal heat pump (GHP) system was recently installed in a municipal building in the city of Rodos (140kW rated power), used for both heating and cooling. In addition, a heat pump coupled with ground heat storage uniformity distributed below the building basement) is in operation for heating and cooling an office building of 6000m^2 near the coast of Attica (Athens) by utilising the warm water (36°C) of a nearby well. The heat pump rating is 220 kW.

Bathing and balneology: Thermal spas and bathing centers operate at 56 locations in Greece, almost half of which are located in coastal or Aegean island areas. Certain swimming pools are also heated by geothermal fluid (Edipsos, Aridea). A conservative estimate of the total thermal capacity of the Greek spa resorts is 35 MWt.

In conclusion, the geothermal potential, especially in the islands and coastal areas of Aegean, is big and the prospects are good, although due to technical and economic constraints the degree of exploitation is very limited so far. Most of the highly touristic islands face significant water shortage every year, particularly during summer time, which has negative impacts on tourism. In many cases, geothermal energy can provide the necessary power to desalinate the seawater or even the electric power to cover the needs of the islands.

In addition, the utilization of geothermal heat pumps (or downhole heat exchangers) for heating and cooling seems very attractive and profitable, particularly in the touristic places.

Finally, the direct or indirect use of geothermal fluids for space and swimming pool heating can be extremely beneficial for almost every Spa, since this way the bathing period will be significantly extended.

Furthermore, the important geothermal potential that has been so far discovered can be successfully used for other applications, such as in greenhouses, in the agro-industrial sector, in aquaculture, etc.

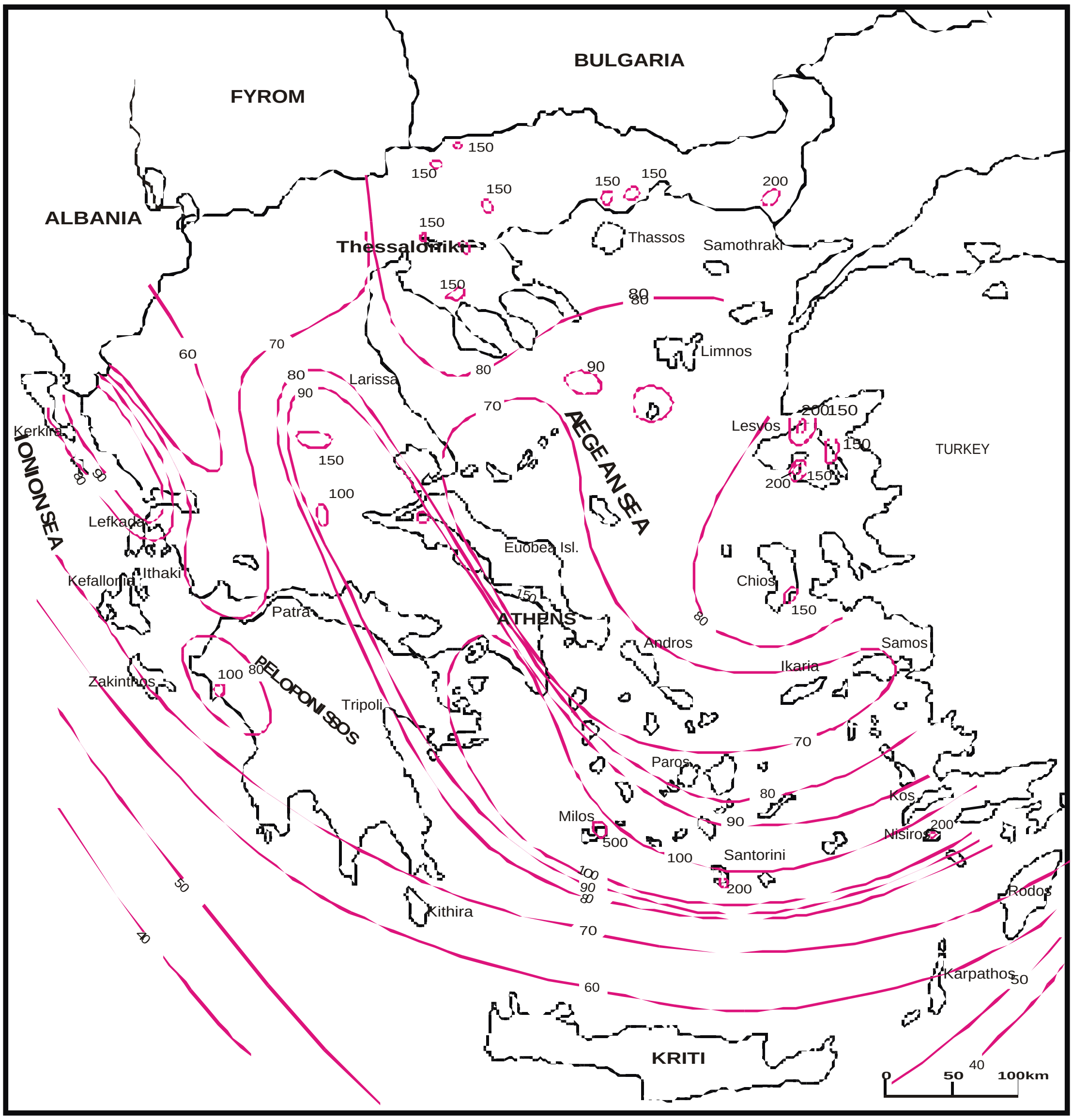

Figure 1: Heat flow density map of Greece

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Figure 2: Geothermal areas in Greec

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