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THE APPLICATION AND THE PROGRESS OF GEOTHERMAL ENERGY IN TURKIYE

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ABSTRACT

Energy is becoming the major problem of the whole countries in the world. This is a result of increase in population, industrialization and rise in the living standards. Rapidly increasing energy demand of the world will necessarily be met by fossil, hydraulic energy source, and renewable energies which are geothermal, solar, wind, wave, tides, biogas energies. The most improved one in these new energy sources is geothermal energy.

Geothermal energy is one of the natural energy recourses of Turkiye to add a benefit to decrease the payment of foreign currency depending on fuel oil.

It is one of the inexhaustible resources as hydraulic, solar and wind energy. The geothermal energy is a long life and renewable energy resource compared with fossil fuels as coal, petroleum and natural gas. The geothermal energy is cheaper than those, produced from fossil fuels.

Geothermal energy has lesser and much easily soluble environmental problems in comparison with the ones created by the use of lignite, coal and nuclear sources. Geothermal energy is new, renewable energy. Since it works with nature sources, it is friendly with it. They minimize the threats of acid rain, air pollution and green house effects. It exists locally and has continuity.

The General Directorate of Mineral Research and Exploration (MTA) has carried on geothermal energy explorations in Turkiye. The inventorial works and chemical analyses of the hot springs and mineral waters started in 1962.

Turkiye is situated on Alpine- Himalayan orogenic belt (Fig.1). The presence of the young grabens developed as the result of this orogeny, wide spread volcanism, fumaroles, hydrothermal alterations, existence of more than 1000 thermal and mineral water springs. Some of them have 100°C temperature indicate that Turkey has an important geothermal energy potential (MTA, 1993, Fig.2). Turkiye is the 7th the richest country in the world in geothermal energy potential.

1. INTRODUCTION

Turkiye's land mass is about 814,578 km^2. About 97% of which is situated in Asia, 3% in Europe. The European and Asian sides are divided by the Istanbul Bogazi (Bosphorus), the Sea of Marmara, and the Canakkale Bogazi (Dardanelles). Anatolia is a high plateau region rising progressively towards the east, broken up by the valleys of about 15 rivers, including the Dicle (Tigris) and the Firat (Euphrates). There are numerous lakes and some, such as lake Van, are as large as inland seas. In the north, the eastern Black Sea Mountain chain runs parallel to the Black Sea; in the south, the Taurus Mountains sweep down almost to the narrow, fertile coastal plain along the coast. Turkey enjoys a variety of climates, ranging from the temperature climate of the Black Sea region, to the continental climate of the interior, then, to the Mediterranean climate of the Aegean and Mediterranean coastal regions. The coastline of

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Turkiye's for seas is more than 8,333 km long.

The main principles of environmental policy have been identified as management of natural resources, enabling continuous economic development through protection of human health and natural balance, and leaving a natural physical and social environment to the future generations.

The fundamental objective of energy sector is to supply reliable, inexpensive and high quality energy to all consumer sectors wherever and whenever required at appropriate price and to sustain economic and social development in an environmentally sound manner.

Turkiye is a country aiming at completion of her infrastructure; increase the potential of the industrial sector to complete with the EU countries, to create an informative society and setting up development objectives though the integrations with the developed countries. These target bring together a rapid increase in the electrical energy demand will be twofold between the years 2000 and 2010. The supply and demand projections prepared for the provisions of the increasing energy demand constitute the basic element for the existing energy policies.

2. MAIN GEOTHERMAL FIELDS IN TURKIYE

The first exploration about geothermal energy was started at Balcova-Izmir geothermal field in 1962.Denizli (Kizildere) Geothermal project was carried on as a joint venture project with United Nations Development Programme.

There are 170 geothermal fields in Turkiye. The geothermal regions are distributed along the important active tectonic regions in Turkiye. Their temperatures ranged from 40° to 242°C (Fig.1).

Some examples;

Denizli-Kizildere	242°C
Aydin-Germencik	232°C
Canakkale-Tuzla	174°C
Kutahya-Simav	162°C
Aydin-Salavatli	171°C
Izmir-Seferihisar	153°C
Izmir-Balcova	126°C
Afyon	106°C
Ankara-Kizilcahamam	106°C

Kizildere, Germencik, Simav, Seferihisar, Caferbeyli, Dikili, Tuzla, Golemezli and Salavatli geothermal fields are suitable for electricity production. Among the above-mentioned fields only Kizildere is in use.

The main utilization of the other geothermal energy fields is district heating, green houses, spas and thermal resorts installed for balneology purposes (Table 1). In Turkey, utilization of geothermal energy for direct heat is shown in Table 2 (Batik et al. 2000). The geothermal energy utilization projections in Turkiye in twenty years are as shown on Table 3 (Simsek, 2001).

The exploration activities have been continuing increasingly every year.

2.1. Present Situation Of Geothermal Wells

Up to now 400 geothermal production wells and 300 gradient wells have been drilled in Turkiye. The portion of the wells drilled by MTA in the total number of wells is 305.

Table 1.Capacities in geothermal utilization in Turkiye (January 2001)

Geothermal Utilization	Capacity
District Heating	493 MWt
Balneological Utilization	327 MWt
Total Direct Use	820 MWt
Power Production	20.4 Mwe
Carbon dioxide Production	120.000 tons/yr

Table 3.Geothermal utilization projections of geothermal energy in Turkiye

Years	Power Prod. (Mwe)	Heating (Residences equivalency)	Spa/Others (MWt)
2010	500	500.000 () 500 MWt)	895
2020	1000	1. 250.000 (8300 MWt)	2300

87%of the wells drilled by MTA has been realized in Western Turkiye, 11% in Middle Anatolian and 2% in Eastern Turkiye (Batik et al. 2000).

The temperature distribution obtained from the well outputs in Turkiye is as follows

Table 2. Utilization of geothermal energy for direct heat as January 2001 (H: SpaceHeating, B: Balneology, I:Industrial use, G: Greenhouse heating, *City central heating

Locality	Type	Capacity (MWt)	Energy (TJ/yr)	Capacity Factor
BALIKESIR-GONEN*	H.B.I	32	353.3	0.35
KUTAHYA-SIMAV	H.B.G	58	900.5	0.35
KIRSEHIR	H.B	18	198.7	0.35
ANKARA-KIZILCAHAMAM	H.B.G	30.7	350.32	0.35
IZMIR-BALCOVA-NARLIDERE	H.G	110.4	1357.5	0.35
AFYON-SANDIKLI	H.B	45	496.8	0.35
AFYON	H.G	41.5	470	0.35
NEVSEHIR-KOZAKLI	H.G	13.7	276.104	0.35
AGRI-DIYADIN	H.B	6.3	695.5	0.35
IZMIR-MEDICAL FACULTY HOS	H.B	21.7	239.6	0.35
BALCOVA THERMAL FACILITY	H.B	13.6	150.1	0.35
BOLU	H.B	8	88.32	0.35
AFYON-OMER	H.B	2.5	27.6	0.35
AFYON-ORUCOGLU	H.B	5.7	62.9	0.35
AFYON-BOLVADIN	H.B	1.5	16.6	0.35
AFYON-GAZLIGOL	H.B	5	55.2	0.35
KUTAHYA-GEDIZ	H.B.G	3.94	46.81	0.35
BALIKESIR-PAMUKCU	H.B	2	22.1	0.35
BALIKESIR-SINDIRGI	G	0.4	7.6	0.6
BALIKESIR-EDREMIT	G	9.9	187.36	0.6
BALIKESIR-HISARKOY	H.B	0.12	1.33	0.35
CANAKKALE-EZINE	G	0.3	5.7	0.6
CANAKKALE-TUZLA	G	9	170.33	0.6
CANAKKALE-KESTANBOL	G	0.4	7.6	0.6
DENIZLI-KIZILDERE	G	2.4	45.4	0.6
DENIZLI-TEKKEHAMAM	G	1.8	34	0.6
DENIZLI-GOLEMEZLI	H.B.G	0.28	4.4	0.35
IZMIR-BERGAMA	G	0.4	7.6	0.6
IZMIR-DIKILI	G	2	35.2	0.6
IZMIR-SEFERIHISAR	G	1.06	18.7	0.6
ANKARA-AYAS	H.B	2	22.1	0.35
ANKARA-HAYMANA	H.B	0.1	1.1	0.35
TOKAT-NIKSAR	G	0.14	2.65	0.6
TOKAT-RESADIYE	H.B	0.1	1.1	0.35
AMASYA	H.B	2	22.1	0.35
ESKISEHIR-SAKARIILICA	H.B	0.05	0.55	0.35
GERMENCIK-ALANGULLU	H.B.G	0.8	9.63	0.35
KUTAHYA-SIMAV	H.B	3.6	39.7	0.35
MANISA-SALIHLI	H.B	0.37	4.09	0.35
RIZE-AYDER	H.B	0.29	3.2	0.35
SAKARYA-KUZULUK	H.B	20	220.8	0.35
SAMSUN-HAVZA	H.B	0.07	0.77	0.35
SIVAS-SICAKCERMIK	H.B	0.6	6.62	0.35
URFA-KARAALI	G	15	283.9	0.6
YALOVA	G	0.12	2.27	0.6
YOZGAT-SARAYKENT	G	0.6	11.35	0.6
TOTAL		493.44	6965.104	

Western Turkiye:

Percentage (%)	Temperature (ºC)
1	240-250
2	230-240
2	220-230
5	200-210
11	190-200
5	170-180
2	130-140
7	110-120
3	100-110
21	90-100
5	80-90
8	70-80
7	60-70
9	50-60
7	40-50
5	30-40

Middle Anatolian:

Percentage (%)	Temperature (ºC)
5	90-100
4	80-90
4	70-80
4	60-70
17	50-60
34	40-50
32	30-40

Eastern Turkiye:

Percentage (%)	Temperature (ºC)
6	90-100
6	80-90
6	70-80
16	60-70
16	50-60
38	40-50
11	30-40

Moreover, the first geothermal well was drilled in 1963 and the number of the wells drilled increase after 1982.

As it will be considered, the number of geothermal production wells is too few if compared to the high geothermal potential of Turkiye. Most of these wells have been drilled by MTA and financed by the Governorships, Municipalities and their companies, which constitutes 66.2% and followed by MTA with 16.5 % and 11.7 % Private.

2.2. High Temperatures Fields And Applications

2.2.1. Denizli-Kizildere Geothermal Field

It is the first geothermal field suitable for electricity production. Kizildere is situated the eastern part of Menderes Graben in Western Anatolia. In this field there are two main reservoirs (Figure 3). The first reservoir consists of Pliocene aged limestone. The second reservoir Paleozoic marbles, schistts and quartzites (Simsek, 1985). The geothermal manifestations are fumaroles, fossil thermal springs, and hydrothermal alteration and travertine deposition. The field is ``high temperatures systems in non-volcanic region`` with Larderalla (Italy) in the world classification.

In Kizildere, 23 wells were drilled. The founded reservoirs are at depths between 450-2261 m. with temperature rate of 198-242 °C. The total amount of the geothermal fluid, 140 °C obtained from the production wells is about 1000 tons/hr. Approximately 10% of this fluid consist of steam which is utilized in electricity production. The capacity of the thermal plant is 20 MW. At present, an exact amount of 15 Mwe is produced. In addition to electricity production this energy also utilized in greenhouse heating (6000 m^2) and in the production of dry ice from the CO_2 gas of the steam phase (with a capacity of 120,000 ton/year). Feasibility studies are started to use of wastewater in district heating.

The hot spring and the waters from drilling wells are all dominated by sodium and bicarbonate ions, although sulphate can also reach appreciable amounts.

Scaling is the main problem in Kizildere. This problem is overcome by mechanical cleaning. Scale inhibitor was tried into three wells to prevent scaling. It was not successful because of high production rates and high vibration in the wells. It was also not economic because of high cost.

The other problem is the wastewater, which has high boron concentration. Three reinjection wells have been drilled to solve this problem. One of the well reenjection test result is positive. Reinjection tests are still continued.

2.2.2.Aydin-Germencik Geothermal Field

It is located at the part of Buyuk Menderes Graben in the West Anatolia. In this area the preliminary studies were carried out in 1967. Detailed geological map, hydro geological, geophysical and geochemical studies and drilling tests were implemented (Simsek 1984). Germencik was discovered in 1982 as the second important high enthalpy geothermal field to produce electricty.

Two reservoirs have been explored in this field. The first one is a Neogene conglomerate and the other one is in metamorphic rocks containing gneisses, schists, quartzites and marbles of Paleozoic age (Fig. 4).

Reservoir temperatures are between 203-232° C. Depths of the reservoirs are 285-2398 m and steam ratio is 13-20%. Nine wells were drilled. A well with a depth of 285 m in this field and is one of the shallowest and highest temperature wells in Turkiye. In this geothermal field BRGM (France) and Mitsubishi (Japan) cooperation carried out feasibility study in 1985. Conclusion of this report point out that 2x55 MW capacity of electric power plant will be and also this power plant needs 22 production wells and 11 reinjection wells. For this project, a development plan is under discussion with Ministry of Natural Resources and Energy. The chemical composition of waters from the Germencik field are characterized by Na>Ca>Mg and Cl>HCO_3>SO_4. In comparison to the Kizildere field, the geothermal fluids have higher Na, B, and Cl, but lower HCO_3 and SO_4 contents. Disposed hot water can be used on district heating, greenhouse, drying, canning, textile industry, cooling and balneological purposes.

2.2.3. Canakale - Tuzla Geothermal Field

It is located in Northwestern Anatolia, 80 km southwest of Canakale, 5 km to Aegean sea (Fig. 5). Important and promising results were obtained from geological, geophysical, geochemical studies and gradient drilling in previous years. The first well of 814 m depth was drilled in 1982. In this well steam and hot water mixture was recovered from the first reservoirs at the depths between 333-553 m. in volcanic rocks. Production rate of the well is measured as 130 t/hr, temperature is 173 °C and steam ratio is 13%. Up to now four deep wells were drilled. Expected second reservoir of marbles and metamorphic rocks encountered at 759 m. but could not be tested. These studies are have been continuing. This field is suitable for agricultural uses (heating, greenhouses, drying, etc.) and electrical energy production. In addition to this, geothermal fluid can be used for salt production because of its chemical properties.

2.2.4. Izmir - Seferihisar Geothermal Field

This is located 40 km southwest of Izmir. The spillites of the ``Izmir flysch`` are the main reservoir in the Seferihisar geothermal field (Ester and Simsek, 1975, Fig.6). Two deep exploration and five shallow production wells were drilled. The depths of these wells are 152-1417 m. The higher temperature was measured 153 °C. The flow rate is 100-240 t/h. There are two types waters. The first one is Na/Ca-$HCO_{3\ water}$. Second are Na-Cl waters. The studies have shown that the existing drill holes can produce 8.17x10.000.000 Kcal/hr. thermal energy. This is enough to heat greenhouses of 117,000 m^2. After development of this field the capacity will be enough to heat 3.600.000 m^2.

2.2.5. Aydin - Salavatli Geothermal Field

Aydin-Salavatli geothermal field is located in the middle of Menderes Graben, halfway between Kizildere and Germencik fields. The stratigraphic series of Salavatli geothermal field consist of Menderes Metamorphic and sediments deposited during the Menderes rifting period. Two deep holes were drilled in 1987. They have depth of 962-1510 m. The reservoir temperature is changing between 162-171 °C. This field is suitable for space heating, agricultural purposes, balneology and producing electricity.

2.2.6. Kutahya - Simav Geothermal Field

Simav (Kutahya) is located on the north of Simav city in West Anatolia. The Simav Graben is located on the southwest part of Simav, which is 100 km. Away from the area and generally limited by E-W trending faults (Fig.7). Eynal, Citgol and Nasa geothermal fields are located on northern and western part of the graben (Karamanderesi and Yilmazer, 1984).

Totally nine wells are opened at Eynal, Citgol and Nasa geothermal fields. The depths of these wells are 100-725 m. A deep hole drilled at this field and the founded reservoir is 162°C. It is suitable for the use of electricity production and the use of space heating. The flow rate in this field is about 262 t/hr.

The construction of the Simav District Heating System has started in March 1991. 3200 residences are heated at present and this amount is expected to rise to 6500 when completed.

2.2.7. Izmir-Dikili-Bergama Geothermal Field

It is situated approximately 90 km the north of Izmir. Exploration study has begun in the frame of MTA-JICA (Japan International Cooperation Agency) cooperation in this field. During testing of this field the modern technology was used by deep holes. The well drilled in 1989 has a depth of 1500 m. The temperature of the geothermal activity in Kaynarca area is related to post volcanism of the Sulukaya lava and Kocatepe lava. According to the geothermal gradient survey there are no significant reservoir down to 700 m, to the north of Kaynarca. It is scarcely expected that geothermal reservoir of higher than 200 °C is formed shallower than 1000 m in Kaynarca area.

2.2.8. Izmir-Balcova Geothermal Field

Balcova geothermal field is located to the NE of the Seferihisar field and is at a distance of 10 km. to Izmir (Fig.8). Exploration studies were started in this field in 1963. The oldest unit in the Balcova field is the Upper Cretaceous ``Izmir flysch`` that covers large areas. The flysch consist of sandstones, schists and phyllites and contains lenses of limestones and exotic blokes of serpentinities, diabases and granidiorite. The Neogene units consist of Miocene aged sandstones, clay stones, limestones, Pliocene volcanic (tuff, andesitic lava) and Quaternary alluvium and talus deposits (Yilmazer, 1985). Up to now, nineteen production wells were drilled. The heat energy of 5x1000000 kcal/hr produced from the production wells. The major anions and cations of the waters are, in descending order, HCO_3, SO_4, Cl and Na, Ca, Mg respectively. The hot water has been used to heat the thermal installations of Balcova, some units of Dokuz Eylul University and 9,400 residences in Balcova. Izmir-Balcova Geotermal District Heating System will be the biggest district heating system in Turkiye 15,000 heating capacity.

2.2.9. Afyon-Omer-Gecek Geothermal Field

This field is located on the eastern part of Western Anatolia. The oldest unit in this area is metamorphic rocks of Paleozoic age. These metamorphic rocks start at the base with alternation of micaschists, quartzites and phyllites and are followed by marbles and calcschists the thickness of which reaches 100 m in the Omer-Gecek field (Erisen, 1984). Neogene sediments consist of clay, clayey sand, silt, marl, limestone and silicified limestone. Trachytic tuff and agglomerates and the basaltic lava flows intercalated with the Neogene sediments represent the products of the volcanic activity at Afyon (Fig. 9). Afyon geothermal province is located along the Afyon Graben to the southeast of the Simav graben. Geological studies have revealed the presence of several faults in the area with trends in NE-SW, NW-SE and E-W directions.

In Omer-Gecek area 26 wells have been drilled by MTA since 1971. The reservoir temperature changes in a range of 50-100 ° C. The drilled wells have the total flow rate of about 300 l/s, at the depths of 120-905 m. The hot waters are sodium bicarbonate is sodium chloride type waters.

In Omer-Gecek thermal units, geothermal heating has been applied to 4000 residence, spas and 5000 m^2 greenhouses. Total amount of the heat produced is 2.8x10.000.000 kcal/hr. The water rising through the drill holes created scaling or corrosion problems. Down whole heat exchanges and chemical inhibitors were utilized to overcome these problems.

2.2.10. Manisa - Salihli - Caferbeyli Geothermal Field

Salihli geothermal field is located along the southern boundary fault of the Gediz Graben. The major reservoir of the Salihli field is the Paleozoic metamorphics with secondary porosity developed in connection with the tectonic movements in the area. The conglomerate and sandstone layers of the Neogene sediment comprise the secondary reservoir. A total of five wells were drilled in the field. The highest temperature is 155 °C. The depth of this well is 1189 m. The flow rate this well reaches 2 l/s. The hot waters of Salihli field are sodium bicarbonate and calcium bicarbonate types.

2.3. Low Temperature Applications in Turkiye

There is one low temperature large-scale city heating applications in Turkiye, Kirsehir GDHS.

Kirsehir is a city in the middle of Anatolian region that shows a terrestrial climate. According to the TS 2164, the outdoor design temperature is -12 °C. The system uses 54/57°C geothermal water from artesian wells located within Kirsehir city. The wells are close to the heat plant, thus the investment cost of the transportation line was kept minimum. The discharge temperature is 40 °C.

Kirsehir City distribution network comprises pre-insulated fibreglass pipes. In the return line no insulated pipes were used for economy. Due to characteristics of fiberglass pipe, no heat expansion joints were used. Pipes are kept between two fixed concrete blocks and expansion is stored as stress in the pipes. Branching is done using steel tees. From this connection fiberglass pipe is laid up to the house entrance.

Temperature loss in these pipes is minimum. In larger dimensions, DN 300 and above, it is about 0.1 km.
The equipment used in building stations is self operated temperature and flow control valves, circulating pumps, pressure and temperature gauges.

Heating circulating pumps are divided into three stages. These are low, medium and high temperature pumps. The outdoor average temperature determines which pumps operate. But, supply and return temperatures are always kept the same.

The geothermal water in Kirsehir is corrosive and causes scaling. To minimize these problems, scale inhibitor is injected to the wells. To protect against corrosion fiberglass pipes and titanium plate heat exchangers are used. The system was commissioned partially in 1993 and completed in 1994 with a capacity of 188-residence equivalence and 18 MWt.

Some of the other low temperature geothermal applications;

Gediz spa and motel facilities are heated by 78 °C geothermal fluid since November 1987.

Floor heating system is applied in Havza spa by 54 °C geothermal water.

Rize Ayder thermal curing center is heated with a geothermal water of 54 °C at an elevation of 1700m above sea level.

Two mosques in Haymana are heated by 43 °C geothermal water.

Sivas-Sicak Cermik spa is heated by 46 °C geothermal water.

Afyon Gazligol Spa facilities use 68 °C geothermal water for heating and curing purposes.

Another thermal curing center using low temperature geothermal water is Orucoglu Thermal Resort. 48 °C

3. PROBLEMS ENCOUNTERED IN GEOTHERMAL UTILIZATION

The wastewater and $CaCO_3$ scaling are the most important technical problems encountered during exploration. The other problem is the non-existence of the proper and understandable geothermal energy procedures and laws in Turkey.

3.1. Waste Water Problem

It is created due to chemical pollutant in the produced fluid at geothermal fields. Major chemical pollutants can be due to high salinity and high boron concentration. In addition to this, As, Cl, NH4 and some other ions can be stated as other pollutants. Especially, these pollutants are harmful for agriculture.

3.2. Scaling and Corrosion

This is resulted from decreasing pressure and temperature of discharged fluids. Content of CO_3 in fluids is the main effect on $CaCO_3$ scaling. Calcite deposit is very serious in geothermal fields like Kizildere with high CO_2 content. In order to solve this serious problem, inhibitors, pressure control and exchanger systems are used. Corrosion is being overcome by using epoxy pipe at some fields.

3.3. Legal Problems

One of the most important problems is the lack of laws for geothermal use. The present laws are those used for mining, groundwater and mineral water. They are not applicable and a draft geothermal law has been prepared. If it is enacted the exploration of geothermal energy, it will improve.

4. RESULTS

- The General Directorate of Mineral Research and Exploration (MTA) has carried on geothermal energy explorations in Turkiye since 1962. Aydin-Germencik (232°C), Denizli-Kizildere (242°C), Kutahya-Simav (162 °C), Aydin-Salavatli (171 °C), Canakkale-Tuzla (174°C), Izmir-Seferihisar (153°C), these fields are the suitable for electricity production.

- Turkiye is located on active tectonic belt. The carbonate dominated rocks, which gained secondary porosity and permeability, limestone, marble, conglomerate, granite, andesite, diabase and spilite are reservoirs rocks. The common cap rocks consist of claystone, sandstone, conglomerate and clayey limestone type sedimentary rocks.

- Turkiye is one of the 10 countries with the richest geothermal potential of the world. The potential of geothermal energy, including wells is 2,308 MWt.

- Geothermal energy has a wide utilization area according to different temperatures; its utilization area in Turkiye is mostly district heating. Most of the development is achieved in geothermal direct-use applications by 52.000 residences equilance geothermal heating (493 MWt) including district heating, thermal facilities and 454.470 m^2 geothermal greenhouse heating. 194 spas in Turkey are used for balneological purposes (327 MWt).

- 170 geothermal fields exist in Turkiye, which 500 Mwe power production and 3.500 MWt (500,000 residences) space heating is targeted for the year 2010.

- The geothermal energy is 50-80% cheaper than other energy sources in Turkey.

- Turkiye meets demand of energy with imported oil. Geothermal energy is an important resource in bridging the gap between the energy supply and demand of Turkiye.

- Turkiye's first commercial geothermal power plant installed in Denizli-Kizildere area. The capacity of the plant is 20.4 Mwe. Installation of the electricity power plant in the power of 185 Mwe and total usage of geothermal energy with integrated installations of 2890 MWt in heating (According to the 8th. Development programmed for five years)

- Laws related with the geothermal regulations both in research and utilization of it must be prepared as soon as possible.

- The distribution of geothermal fields in the country indicates conformity to the energy demand in Turkiye. Mainly high enthalpy geothermal fields are located in west and northwest Anatolia where the energy shortage exists. On the other hand, In Central and Eastern Anatolia where the heating energy is needed, and the existing fields are suitable for this purpose with their low enthalpy.

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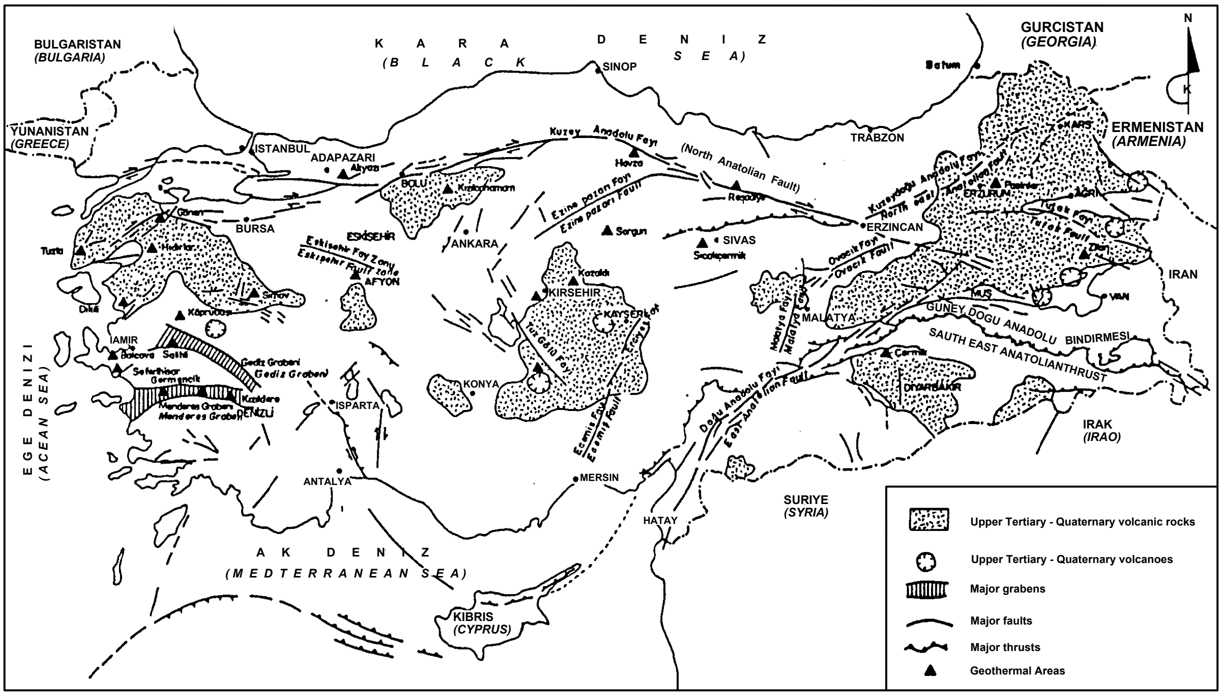

Fig. 1 The Geothermal Fields in Turkey

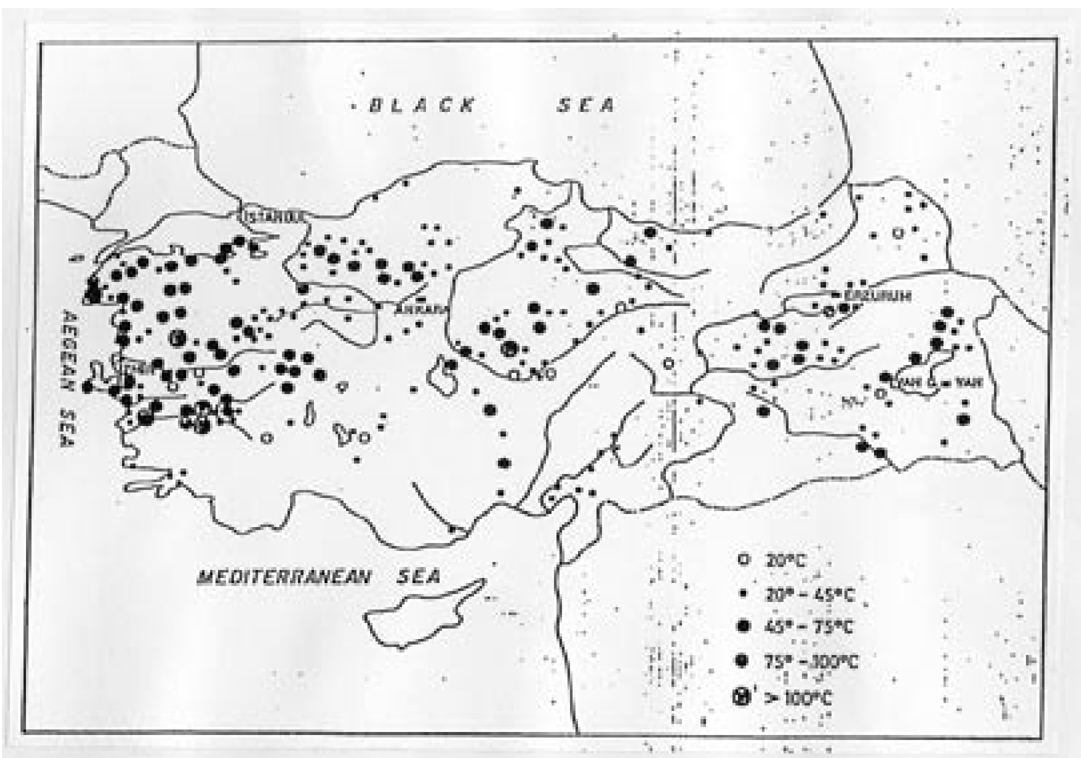

Fig. 2 Distribution of Hot Springs in Turkey

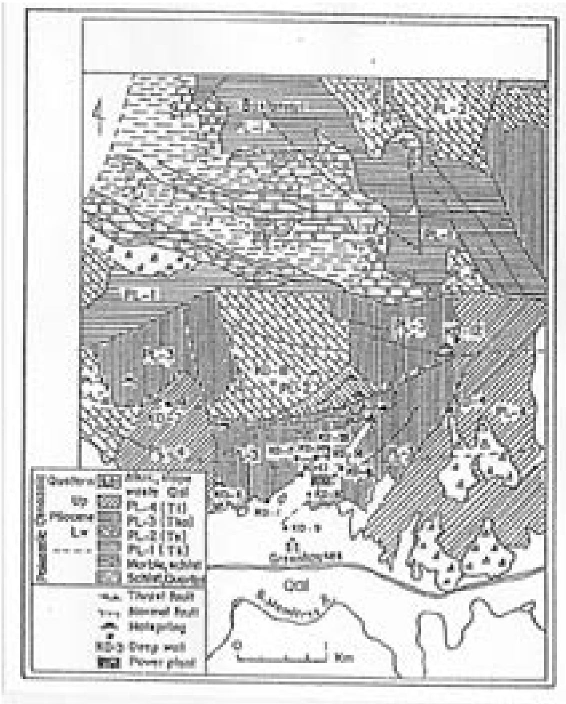

Fig. 3 Geologcal map of the Kizildere geothermal field (from Simsek, 1985)

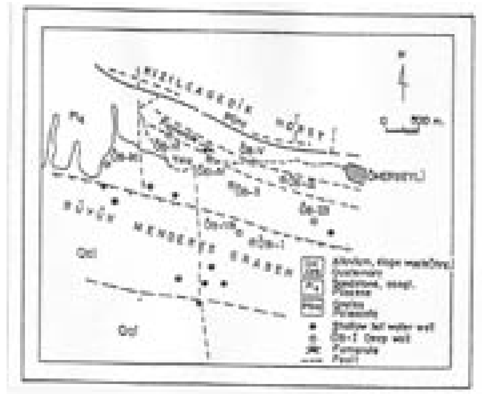

Fig. 4 Simplified geothermal map of the Germencik geothermal field (from Simsek, 1984)

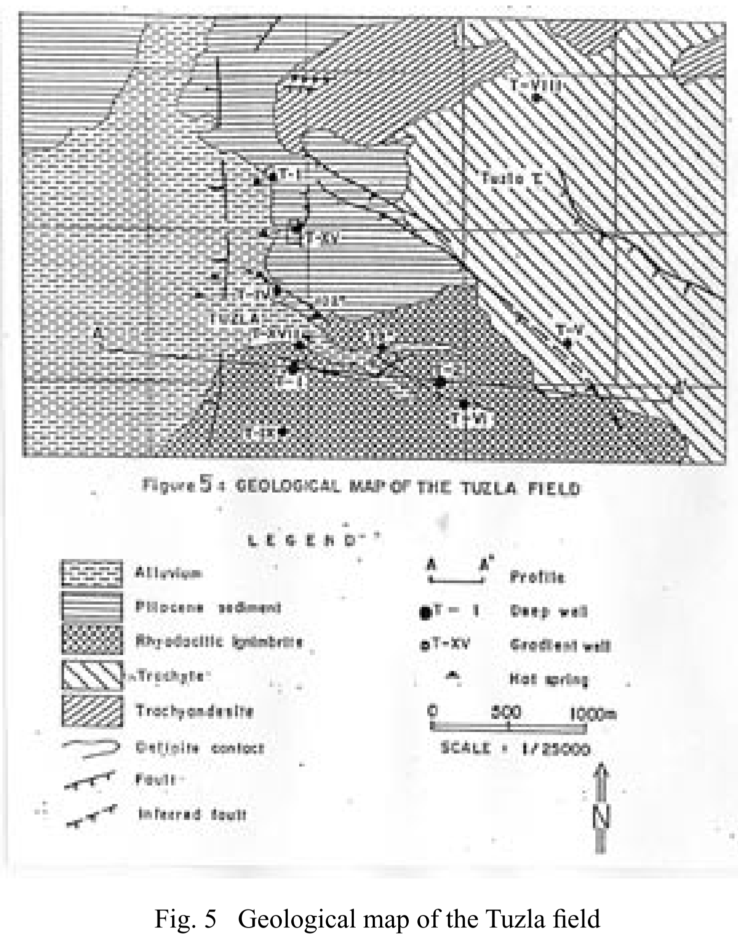

Fig. 5 Geological map of the Tuzla field

Fig. 6 The geological map of the Seferihisar geothermal field (modified from Esder and Simsek, 1975)

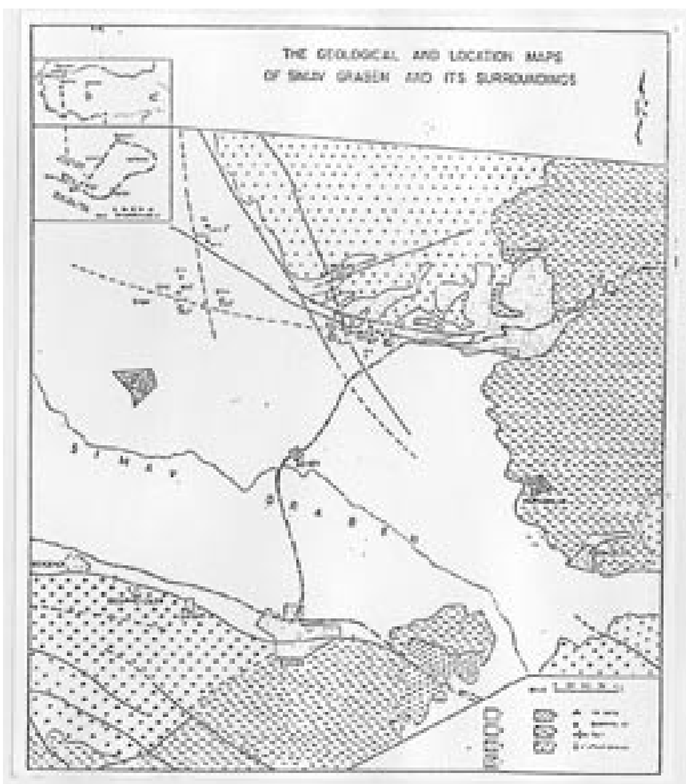

Fig. 7 Geological and location maps of Simav graben and its surroundings

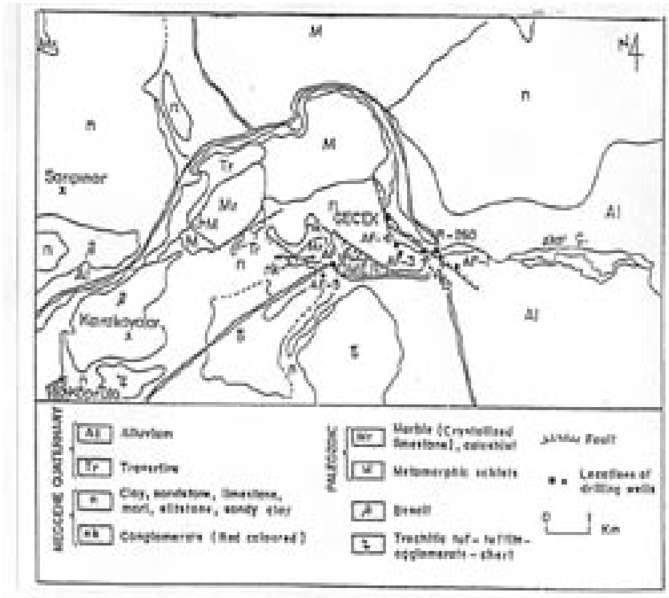

Fig. 8 Distribution of hot-springs and drilling wells in the Balcova geothermal field (from Yilmazer, 1989)

Fig. 9 Geological map of the Omer-Gecek geothermal field (from Erisen, 1984)