Platform for Projecting of Integrated and Cascade Use of Geothermal Energy of Low Enthalpy in Albania

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Abstract: *Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:*

- ***Kruja geothermal zone*** *represents a zone with bigness geothermal Identified resources in carbonate reservoirs, $5.9x10^8$-$5.1x10^9$ GJ,*
- ***Ardenica geothermal zone*** *is located in the coastal area of Albania, in sandstone reservoirs.*
- ***Peshkopia gjeotermal zone*** *at northeastern area of Albania. Several springs are located in disjunctive tectonics of the gypsum diapir.*

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

- ***Use*** *of the heat flow of shallow geological section for heating and cooling of the buildings. Integrated exploitation of the geothermal energy must realize by integrated scheme of geothermal energy, heat pumps and solar energy to fulfill.*
- ***T****hermal sources of low enthalpy are natural sources or wells in territory of Albania. They represent the basis for a successful use of modern technologies for a complex and cascade exploitation of this energy, achieving an economical effectiveness:*

1. SPA clinics for treatment of different diseases and hotels for ecotourism.
2. The hot water for heating and sanitary waters of the SPA and hotels, greenhouses and aquaculture installations.
3. Extract of the chemical microelements from thermal waters.

- *Use of deep abandoned oil and gas wells as "Vertical Earth Heat Probe".*
  Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun.

Keywords: Geothermal Energy, Thermal Water, Geothermal Gradient, Heat Flow, Direct Use of Geothermal Energy

1. INTRODUCTION

In Albania, rich in geothermal resources of low enthalpy and mineral waters, new technologies of direct use of geothermal energy are still untouched. Actuality, there are many geothermal, hydrogeological, hydrochemical, biological and medical investigations and studies of thermal and mineral water resources carried out in Albania. The results of the geothermal studies carried out in Albania are presented in "Atlas of Geothermal Resources in Albania" [5]. The hydrogeology and geothermy of the natural springs with thermal waters and the geological structures with high water temperature have also been investigated. Generally, these investigations and studies are separated each from the other. Their information has been served for evaluations of the geothermal resources in Albania, in regional scale. According to results of these new studies, the evaluation for the perspective level of the best areas in country has been selected. After these evaluations is possible to start programmed the investments in these areas. Integrated exploitation and cascade direct use of the geothermal energy will realize by integrated scheme [2, 4, 6]. This scheme has an environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme). Cascade scheme should be used to fulfill the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.

Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people. These investments will be profitable in a short period of time.

2. GEOTHERMAL ENERGY RESOURCES IN ALBANIA

2.1. Methodic

The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections. Temperature maps have been drawning for different levels of up to 3000m depth [3, 5]. Geothermal gradient, heat flow density and geothermal resources maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped [1, 3, 5]. The study of the possibility of exploitation of abandoned deep oil wells as "Vertical Earth Heat Probes" has already begun.

2.2 Geothermal Features

The Albanides form an integral part of the southern branch of the Mediterranean Alpine orogen. They are subdivided in two zones: the Internal and the External Albanides. The geology of Albanides creates the premises for the research and exploitation of natural geothermal energetic resources [3, 5].

The greatest heat flow density with a value of 42 $mW \cdot m^{-2}$ is found in the center of the Preadriatic Depression (Fig. 1). In the east of the ophiolitic belt heat flow density reaches values of up to 60 $mW \cdot m^{-2}$.

The temperature at a depth of 100m ranges 6.7 to 18.8°C, in average 16.4°C (Fig. 2) and at a depth of 500m from 21 to 27.7°C.The

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temperature ranges up to 105.8°C at a depth of 6000m. In the central part of the Preadriatic Depression, there are many deep oil wells where the temperature reaches up to 68°C at a depth of 3000m.

The geothermal gradient has the highest value about 18.7 $mK \cdot m^{-1}$ in the center of the Peri Adriatic Depression. Elsewhere the gradient is mostly 15 $mK \cdot m^{-1}$. In the south of the country the geothermal gradient has low values 11.5-13 $mK \cdot m^{-1}$. Towards the northeastern and southeastern regions of Albania, over the ophiolitic belt, the geothermal gradient increases, reaching the value of 23.5 $mK \cdot m^{-1}$.

2.3. Geothermal Areas and Reservoirs

In Albania there are many thermal springs and wells of low enthalpy (Fig. 3, Tab. 1) [1, 3, 5, 8].

Table 1 Thermal water sources and wells in Albania

Type of the source	Location	Temperature, (°C)	Salt, (mg/l)	Yield, l/sec
Natural Spring	Llixha Elbasan, Peshkopi, Krane (Sarande), Langaric (Permet), Shupal (Tiranë), Sarandoporo (Leskovik), Postenan (Leskovik) Tërvoll (Gramsh), Mamurras (Tiranë).	21-60	0.3-26	10-40
Deep wells	Peri Adriatic Depression and in the Kruja tectonic zone	29.3-65.5	1-19.3	0.9-18

Thermal water springs and wells are mainly located near of the regional tectonic fracture zones. Generally the water circulates through carbonatic rocks and sandstones of the anticlines and evaporitic beds at the depth of 800-3000m. The water of these springs contains salt, absorbed gas and organic matter. They are sulfide: methane, iodine-bromium and sulfate types. Thermal sources are located in three geothermal zones (Fig. 3):

- Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Identified resources in carbonate reservoirs are $5.9x10^8$-$5.1x10^9$ GJ,
- Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.
- Peshkopia gjeotermal zone is located at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

3. DIRECTIONS FOR THE EXPLOITATION OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers following directions for the direct use of geothermal energy, which is unused until now. This exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy [2, 4, 6].

Firstly, space heating and cooling using ground heat by the Borehole Heat Exchanger (BHE), in the shallow (about 100 m depth) boreholes.

Secondly, thermal sources of low enthalpy and of maximal temperature up to 80°C. These are natural sources or wells in a wide territory of Albania, from the South near Albanian-Greek boundary to Northeast districts in Diber Region.

Thermal waters of springs and wells in Albania may be used in several ways:

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because not only the good curative properties of these waters but also springs are situated in nice places near sea side, mountains or Ohrid Lake. An the present some SPA, with a primitive technology, worked in some geothermal springs and wells in Albania.
2. The hot water can be used also for heating of hotels, clinics and tourist centers, as well as for the preparation of sanitary hot water used there. Near these medical and tourist centers it is possible to built the greenhouses for flowers and vegetables, and aquaculture installations.
3. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of creams for the treatment of many skin diseases as well as for beauty care products. From these waters it is possible to extract sulphidric and carbonic gas. It is possible to built installations for processing of mineral waters.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a "Vertical Earth Heat Probe". The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 $mK \cdot m^{-1}$. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. Near of these wells can be build greenhouses.

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun. Based on the above analysis, for the best area selected, a Feasibility Study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

4. ALBANIAN GEOTHERMAL ENERGY MARKET

Successfully of the direct use of the environmental friendly geothermal energy has necessity for a market analyze. Objectives of market study are as following:

- Evaluation of present status of geothermal development in Europe, particularly in Balkan countries, regarding promotion activities, results, application, barriers for market penetration, legal and financial framework, etc.
- Comparison of present status between the different Albanian regions.
- Identification of the attitude and feelings (awareness, knowledge, preference, etc.) for the target groups towards geothermal energy.
- Identification of the attitude and feelings of the target groups towards environmental aspects of geothermal energy.
- Evaluation of the outcome of promotion methods adopted by EU and national institutions.
- Formulation of proposals for effective promotion strategies for geothermal energy in Albania.

4.1. Space heating and cooling

The energy crisis prevailing in the Albania, the increased demand in energy for heating and cooling of premises. Actually, the electric energy consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania [8]. The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump represents a modern system for space heating and cooling (Lund J. 2005, Rybach L. and Sanner B. 2005, Sanner B. 2004). Two types of shallow heat sources exist: ground heat and underground waters heat. Consequently two kind of technology is possible to applied:

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (closed loop),

Secondly: underground water system – Geothermal Heat Pump (open loop).

In order to make use of this renewable geothermal energy and environmental friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes in Tirana [4]. It will contribute in solving the problematic issue of heating and cooling of premises in Albania.

Heat quantity, temperature at Earth surface, and geothermal gradient in shallow geological section, are conditioned by geographical location, geomorphological conditions, ground and bedrocks lithology, specific heat and humidity, season and weather. According to the multi annual meteorological surveys result that in average is 140,000 calory.cm^{-2} heat from solar radiation of the ground during the summer at the plane areas of the Albania. Heat quantity reaches 120,000 calory.cm^{-2} at noertheaster mountains regions [7].

The distribution of the temperature at the depth 100m is presented in Fig. 2. Temperature in subsurface ground at littoral area varies from 16.60^{O}C to 18.80 ^{O}C, averagely 17.80 ^{O}C. In the western plane-hilly area the temperatures have a minimal values 17.15 ^{O}C to 18.41 ^{O}C, and average. In hilly-mountains regions the temperature is 6.70 ^{O}C up to 18.60 ^{O}C, with average temperature is 14.75 ^{O}C. In the Tirana field, the temperature is 15.5 ^{o}C, up to logging depth 31 m, in the Quaternary deposits (Fig. 4) [5]. Ground geothermal energy has heated the underground water reservoir. Tirana underground water basin have a temperatures 14-15 ^{o}C for the Quaternary gravel layer water and 15-16^{o}C for Quaternary sandstone layers waters. Consequently, concluded that water of the underground basin present a heat source for the geothermal pumps.

4.2. Consumers for geothermal energy & thermal water (SPA heating, tourism, drinking water, aquaculture, agriculture)

At the present, some SPA, with a primitive technology, worked in geothermal springs and wells in Albania: Lixha Elbasani, Bilaj Balneological Center (Ishmi 1/b well), Peshkopia (Diber district) SPA, Sarandaporo (Leskovik Disrict) SPA, Langarica-Ura Kadiut (Permeti District).

The oldest and important is Elbasani Llixha SPA, which located about 10 km south of Elbasani city and 61 km in southeast of Tirana The proximity with highways creates great possibilities for Elbasani Lixha SPA to be a nice place. This area may be frequented by a large number of people from different Balkan and European countries. These thermal springs from about 2000 are known years ago. According to historic data, in Elbasani Llixha thermal springs there has been an inn, near of the old road "Via Egnatia" that has passed from Durresi to Constantinople. There are seven spring groups that extend like a belt with 320^{o} azimuth. Surface water temperature is about 60^{o}C and yield in total 15 l/sec. Springs have constant hot water yield and temperature for a long period of time. These data are evidence of a stable thermo-hydrodinamic reservoir regime.

Actually, is not a thermal waters law in Albania, last years has been prepared the draft of the law.

All seven groups of the springs in Llixha Elbasani and Kozani-8 well geothermal area will have the possibilities for modern complex exploitation. The beautiful landscape of Elbasani Lixha area will be not only for medical treatment but also as tourist place. This area located near of the very know Ohrid Lake pearl or mountains Gjinari, with their fantastic forests and nice climate. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of "Mother Theresa" Rinasi (Tirana) Airport, near of the Adriatic coastline and Kruja - Skendergeg Mountain. There are all the possibilities for the echo-tourism development: thermal water, Ishmi beach at the Adreatic Sea , and mountain's area.

Benja and Sarandaporo thermal water areas and Postenani steam springs are located near of the beautiful Vjosa River valley. Peshkopia geothermal springs area is located near of the Korrabi Mountain, higher mountain in Albania (2753m). The beautiful landscape of Vjosa valley, near Albanian-Greek border, and Peshkopia area near of the Debar region in Macedonia, will be not a thermal water bearing place for medical treatment but also as tourist place.

4.3. Geological risk, financial possibilities to cover geological risk

No geological and financial risk for the exploitation of thermal water of geothermal springs and wells in Albania.

4.4. Traffic connections: roads, railways, navigation, and possibilities for transport of heavy goods.

The Ishmi-1/b well is located in Ishmi area and represents the northernmost geothermal well of the Kruja geothermal area. It is located in 20 kilometers NW of Tirana (near of "Mother Theresa" Tirana Airport). By national road communication, Ishmi 1/b well is connected with Tirana, Tirana Airport, Durresi and Shkodra cities.

Kozani-8 well is located 35 kilometers southeast of Tirana, on hill's area. Well connected by 1.7 km road with Tirana-Elbasani national road, and highway "Corridor 8" Durresi-Elbasan-Skopje. One km from Kozani 8 well located Saint George Vladimir Monastery.

Elbasani Llixha SPA is located about 12 km south of Elbasani city and 61 km in south-east of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi-Skopje- Sofia- Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor.

Peshkopia geothermal springs are connected with Tirana by national road (182 km).

Benja-Langarica, Postenani and Sarandaporo geothermal springs areas are located near of the national road Tirana-Permeti (about 217 km)-Konitza (Greece).

5. THE AIMS AND OBJECTIVES OF THE PLATFORM FOR DIRECT USE OF THERMAL WATERS OF LOW ENTHALPY

5.1. The aims of the platform

To examine, demonstrate and disseminate the positive technical and financial aspects of transfer and utilization of innovative geothermal energy technologies in Albania, which will have a direct impact in the development of the regions by increasing their per capita income and at the same time ameliorating the standard of living of the people.

5.2. Objectives:

Integrated exploitation and cascade direct use of the geothermal energy has proposed. The objectives of the platform:

- Country Geothermal Energy and mineral water resources evaluation.
- In-situ detailed investigation of the pre-selected zones with high energy potential and consumers geothermal source, where will installed demonstrative unit.

Among others this task will be concerned with intentions of users-thermal load inspections, initial energy balance analyses, thermal characteristics of individual users, technical geothermal data collection, and examination of existing technology. It is necessary to select the thermal applications, which correspond to the local needs. The following will be defined:

a) In situ consideration of geothermal physical-chemical parameters and potential.
b) Thermal load demands for space heating for each end-user of geothermal sources: dwellings, geothermal SPA, greenhouses, geothermal pools and bathing, aquaculture, mineral waters production, and extraction of the micro-elements and natural salts
c) Energy balance between different end-users,
d) Technologies to be applied
e) Preliminary design of the geothermal energy exploitation system
i) Definition of thermal demands
k) Energy conservation, and
l) Economic evaluation of thermal energy (space heating and hot water production installation cost, life cycle, energy product cost, pay back period). This evaluation must based on actual market prices for equipment, construction etc.

Based on the above analysis, for the best area selected, a feasibility study must performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative technology of direct use of geothermal energy applications in that area.

Environmental protection and preserving level must improve, to well assist the echo-system protection of thermal and mineral water source areas. Among other subjects this phase will focus mainly on examination of the nature of the geothermal fluid, environmental impact of the geothermal fluids during their utilization and disposition, and selection of the most acceptable environmentally methods for the disposal of the geothermal fluids.

The concrete detailed design for the implementation phase of the Platform necessary to be prepared.

- Task 1. Demonstrative units (pilot plants) will be constructed, monitored and finally demonstrated: SPA, with 30-40 beds, for the medical treatment, heating installation in the buildings, greenhouse for the flower and for the legumes, thermal pool for tourists, installation of equipment for extraction microelements and natural salts.
- These demonstrative units will assist in the promotion of the new innovative technology application. The proposed schemes represent an integrated scheme and cascade scheme for exploitation of geothermal energy geothermal energy, heat pumps and solar energy to fulfill. This scheme has an environmental benefit by using renewable energies. Cascade scheme should be used to fulfill the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.
- Task 2: A promotion and tourist agency will be organized. This agency will prepare the reclaims and booking of the rooms for Albanian and foreign patients.

6. GATHERING INFORMATION MATERIAL AND KNOWLEDGE DISSEMINATION IT IS VERY IMPORTANT ELEMENT OF UTILIZATION OF GEOTHERMAL ENERGY

Information material concerning the general principles of geothermal application and new technologies will be prepared and gathered: booklet and posters will be published. For further dissemination of the results of this projects will organize days of open conferences, workshops, seminars, TV and radio-emissions, pamphlets, posters, and summer school.

Establishment of communication channels with local users: Local authorities, Market and Technical Chambers, and investors, is programmed.

7. SIGNIFICANCE OF THE PROPOSED PLATFORM AND ITS EXPECTED ACHIEVEMENTS

The proposed platform has great importance for Albania. It creates the scientific knowledge base for evaluation of natural wealth of geothermal energy and mineral waters in Albania. These data will be used to evaluate and select the rich areas in country. In these areas it is possible to start the investment for direct use of geothermal energy. Very important is transfer of new methods for R&D and evaluation of geothermal water resources, modern technologies and unit equipment for thermal waters exploitation in Albania. Technical and organizing base for modern hotel SPA construction will be created. The tourism will be developed. New modern studying technologies must disseminate in scientific and business community of country. Environmental protection and preserving level will be improved, to assist the echo-system protection of thermal and mineral water source areas.

8. CONCLUSIONS

1.Albania has the resources of geothermal energy of low enthalpy, which is possible for integrated and cascade direct use as an alternative energy.
2. Resources of the geothermal energy in Albania are;
a) Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.
b) Heat of subsurface ground, with an average temperature of 16.4°C and depth Earth Heat Flow.
3. Construction of the space-heating system, using shallow borehole heat exchanger (BHE)-Heat Pumps systems present the most important direction of the use of geothermal energy in Albania.

9. REFERENCES

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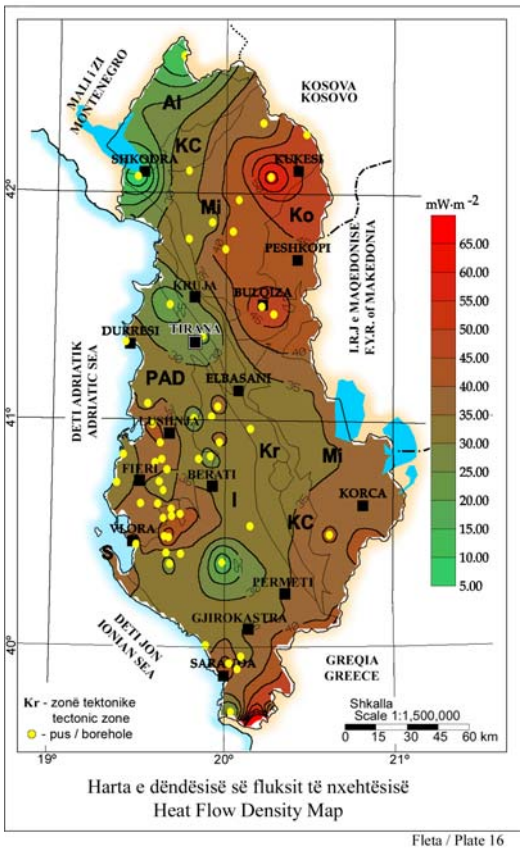

Fig. 1 Heat Flow Density Map of Albania

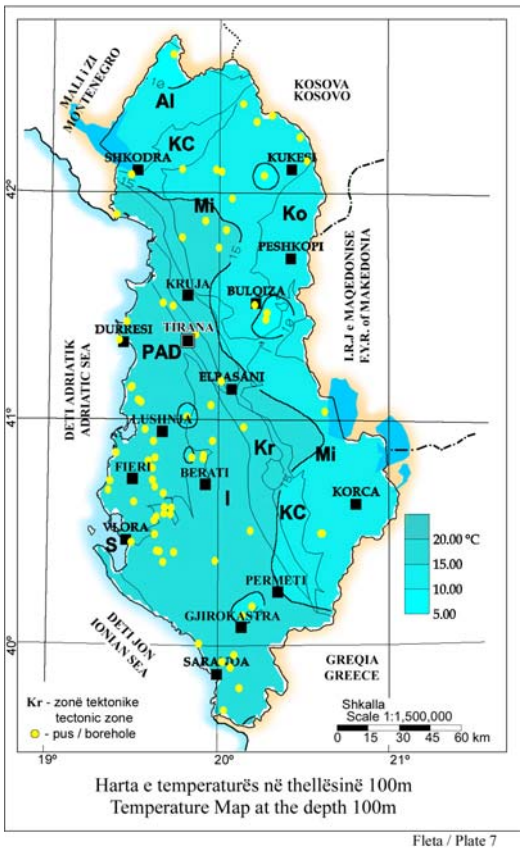

Fig. 2 Temperature Map of Albania, at the depth 100m

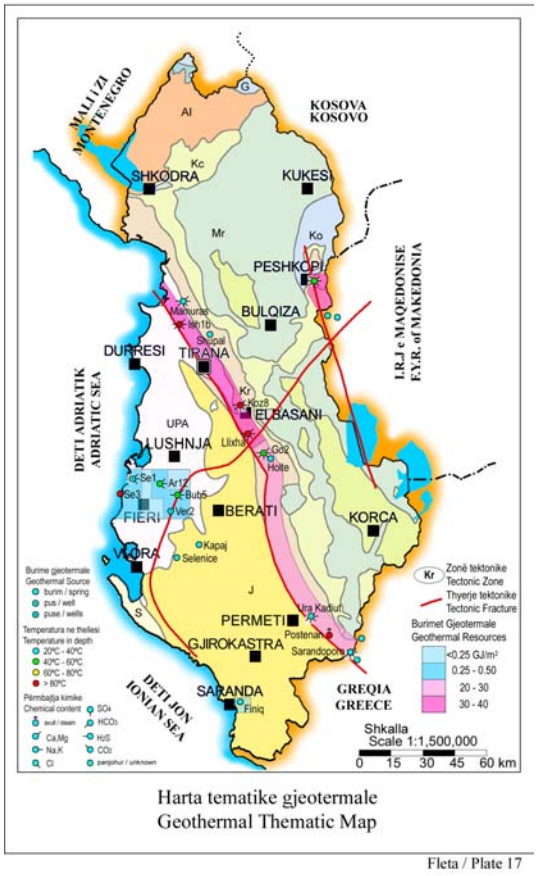

Fig. 3 Geothermal Zones in Albania

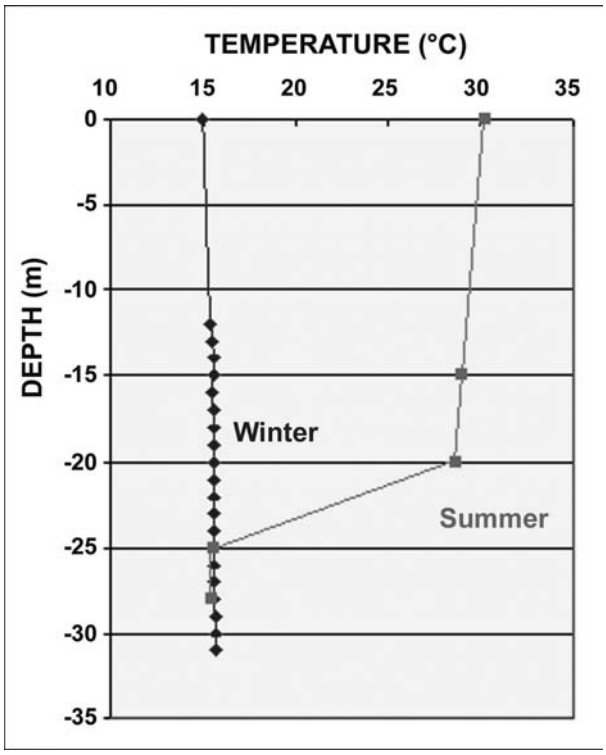

Fig. 4 Thermolog of the Rinasi borehole