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THE SOURCES OF GEOTHERMAL ENERGY IN ALBANIA

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ABSTRACT

The results of geothermal investigations in Albania are treated in this article. The aim of this paper is to present the possibilities for the extension of energy resources in Albania through the use of geothermal energy. Geothermal investigations in the past three years have shown that possibilities for the exploitation of the geothermal energy exist in Albania. The ways of exploitation of this kind of energy are also given.

1. INTRODUCTION

Albania is a mountainous Mediterranean country with numerous natural energy resources. There are many rivers flowing from the mountains where seven hydro-power plants have been built, with an installed power of 1427.1 MW (Frasheri N., 1994) There are about 20 oil and gas reservoirs under exploitation in Albania, producing about 1.2 Mt oil (Albanian Encyclopedic Dictionary, 1985); but within the last years, the production has decreased, and in 1999 only about 340 Kt of oil were extracted. There are tens of coal mines in Albania, with an output of over 2 Mt coal in 1984 and 214.6 Kt of coal in 1993.

The Albanian energy system is mainly based on electricity produced by hydropower plants. The climate of Albania is a typical Mediterranean one, with a hot and dry summer. This climate can periodically prevent the hydroelectrical system from producing power at capacity (based on the water resources of Albania).

In the present conditions of a new Albanian market economy, together with the transformations in the management of existing energy system, the study of other energy sources has begun. There are great possibilities to use other sources of energy, such as solar (about 129.3 $Kcal \cdot cm^{-2} \cdot year^{-1}$). In the coastal areas the average wind speed is about 2.8-3.8 $m \cdot sec^{-1}$ (Climate of Albania, 1978). There are many regions where the wind speed is several times greater than that in the above-mentioned regions. This is another important source of energy.

In Albania, there are also many thermal water springs and wells of low enthalpy with a temperature of up to 65.5°C, which indicates that it is possible to make use of the geothermal energy.

2. GEOLOGICAL FEATURES

The Albanides form an integral part of the southern branch of the Mediterranean Alpine orogen. They are subdivided into two zones: the Internal and the External Albanides. The Internides are formed by the Mirdita ophiolite nappe, which is separate from the oceanic Subpelagonian Trough (Geological Map of Albania, scale 1:200,000, 1984) Geological and geophysical studies carried out in the External Albanides and in the Adriatic Sea display distinct structural belts, which are related to different tectono-stratigraphic units. From East to West the External Albanides consist of the Krasta-Cukali isopic zone, the Kruja zone, the Ionian zone and the Sazani zone. The Albanian Alps zone is located in northern Albania.

A 1500m thick sequence of Cretaceous to Paleogene neritic carbonates and 5km of Oligocene flysch characterizes the Kruja zone. Locally, a Tortonian continental sandstone facies lies unconformably on a variety of older strata.

The Ionian zone is made up of a thin-skinned fold and thrust belt which is detached from the basement at the level of Permo-Triasic evaporites. Late Triassic and Early Jurassic neritic limestone and dolomites contain cherts. Oligocene and Aquitanian series are developed into flysch and flyschoid facies.

At the base of Burdigalian to Serravalian series, in the clay-marl series of present molassic facies, an angular unconformity is developed.

The Preadriatic Depression is filled with continental and deltaic Miocene and Pliocene series. Serravalian sandstones and clay lie unconformably on deformed older strata and are themselves involved in compressional structures.

Generally, carbonate rocks are fissured and karstified, thus forming important groundwater reservoirs (Dakoli, H., et al. 1981, Hydrogeological Map of Albania, scale 1:200,000, 1985, Eftimi R. et al., 1989).

In the western part of Albania, there are two artesian basins: the Adriatic and Tirana basins. The sandstone aquifers of the Tortonian deposits generally have a low permeability (the medium specific yield of the wells is about 0.04-1 $l \cdot s^{-1} \cdot m^{-1}$.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal fields and the natural thermal water springs and wells. The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were

carried out in 145 deep wells, in boreholes, and in mines, at different hypsometric levels.

The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees.

The chemical composition of the waters was determined. The output of the springs and wells and their hydrogeology was evaluated.

Geothermal studies were extended all over the territory of Albania. In the western regions, where oil and gas reservoirs are situated, the temperature has been recorded in about 120 wells. In the northeast and southeast regions of Albania, about 25 boreholes have been studied together with eight thermal water springs for which the chemical analyses were also carried out.

4. RESULTS

The results of the geothermal studies are presented in maps using contour lines. Temperature maps have been drawn for different levels of up to 5000m depth. Geothermal gradient maps and heat flow density maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped. The water basins with higher average temperature than that of mean ambient in one of the regions have been studied as well.

An investigation has begun into the possibility of exploitation of abandoned deep oil wells as "Vertical Earth Heat Probes" (Frasheri A., Bakalli F., 1995) has already begun.

5. DISCUSSION

The geology of the Albanides defines the regional possibilities for the research and exploitation of natural geothermal energy resources (Frasheri A., et al., 1995. Frasheri A. & Bakalli F., 1995). The greatest heat flow densities are found in the center of the Preadriatic Depression, where the value is 42 $mW \cdot m^{-2}$, and in the east of the ophiolitic belt, where heat flow density reaches values of up to 60 $mW \cdot m^{-2}$ (Fig. 1).

The temperature varies from a minimum of 12°C at a depth of 100m 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 isotherm runs in a direction that fits that of the strike of the Albanides. The configuration of the isotherm is the same down to a depth of 6000m. With increasing depth, the zones of highest temperature align in a direction southeast to northwest, towards the center of the Preadriatic Depression and even further towards the northwestern coast.

The geothermal gradient reaches ~18.7 $mK \cdot m^{-1}$ in the center of the Preadriatic Depression. Elsewhere the gradient is mostly 15 $mK \cdot m^{-1}$ (Fig. 2). In the south of the country the geothermal gradient has low values 11.5-13 $mK \cdot m^{-1}$. The lowest gradient value of 7-11 $Mk \cdot m^{-1}$ is found in the deep synclinal belts. Towards the northeastern and southeastern regions of Albania, over the ophiolitic belt, the geothermal gradient increases, reaching the value of 23.5 $mK \cdot m^{-1}$.

6. GEOTHERMAL AREAS AND RESERVOIRS

In Albania there are many thermal springs and wells of low enthalpy. Their water temperatures reach values of up to 60°C (Fig. 3). Table 1 presents some data on the water temperature for such springs.

These thermal water springs are mainly near zones of regional tectonic fractures. Generally the water circulates through carbonatic rocks of the structures and evaporitic beds at some kilometers of depth. The water of these springs contains salt, absorbed gas and organic matter. They are sulfide: methane, iodine-bromine and sulfate types.

In many deep oil and gas wells, there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2). These waters come from different depth levels (800-3000 m) of limestone reservoirs (wells 1, 2, 3, 4) and sandstone reservoirs (wells 5, 6, 7 and 8).

Presently, the thermal waters of the springs 1, 2, 4, and 6 and wells 1, 2, 3 in Albania are used only for health purposes. These waters could be used for heating purposes and greenhouses as well.

7. DIRECTIONS FOR THE EXPLOITATION OF GEOTHERMAL ENERGY IN ALBANIA

The geothermal situation in Albania offers two directions for the exploitation of geothermal energy, which has not been used so far.

- **First,** thermal water springs and wells of low enthalpy
- **Second,** 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 an average value of about 18.7 $mK \cdot m^{-1}$. At 2000m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. This "Vertical Earth Heat Probe", by means of water circulation, is coupled with the heat transfer from the surrounding rocks downwards, to be finally recovered in the tubes (Hoffman F., et al., 1993).

8. CONCLUSIONS

In Albania, there are several geothermal energy sources that can be used. Such geothermal energy sources are natural thermal water springs and deep wells with a temperature of up to 65.5°C. Deep abandoned oil wells can be used as "Vertical

Earth Heat Probe". The use of geothermal energy in Albania must start as soon as possible, in the framework of a separate project, after the compilation of the geothermal resource "Atlas of Albania" in February 1996.

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Table 1 THE THERMAL WATER SPRINGS IN ALBANIA

N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in $l \cdot s^{-1}$
1	Llixha Elbasan	60	0.3	0
2	Peshkopi	5-43	9	10
3	Krane-Sarande	34		<10
4	Langareci-Permet	6-31		>10
5	Shupal-Tirana	29.5		10
6	Sarandoporo-Leskovik	26.7		>10
7	Tervoll-Gramsh	24		>10
8	Mamurras-Tirane	21	26	>10

Table 2: THE OIL AND GAS WELLS THAT HAVE SELF-DISCHARGE OF THERMAL WATER

N°	Well Name	Temperature in °C	Salt in $mg \cdot l^{-1}$	Self-discharge, in $l.sec^{-1}$
1	Kozani-8	65.5	4.6	10.4
2	Ishmi 1/b	64	19.3	4.4
3	Galigati 2	45-50	5.7	0.9
4	Bubullima 5	48-50	35	
5	Ardenica 3	38		15-18
6	Ardenica 12	32		
7	Semani1	35		5
8	Verbasi 2	29.3		1-3

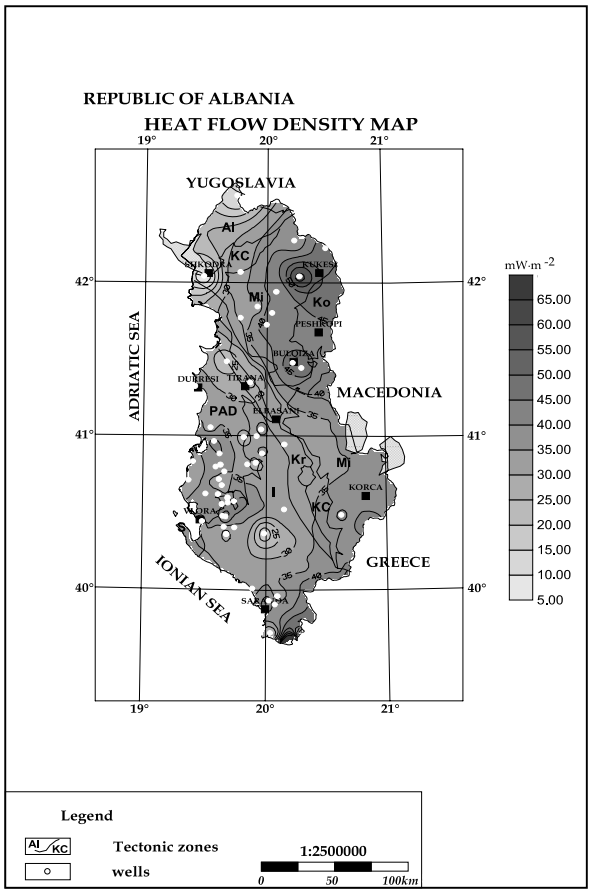

Figure 1.Heat Flow Density Map.

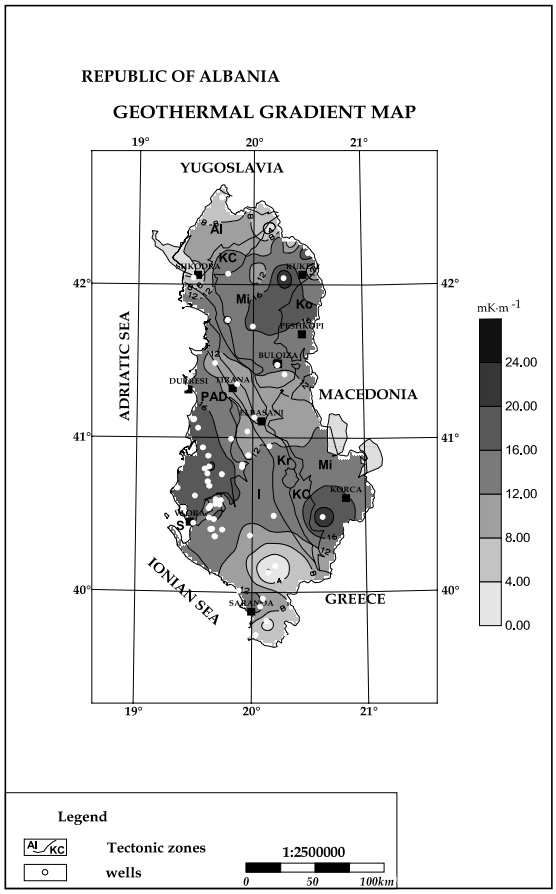

Figure 2. Geothermal Gradient Map.

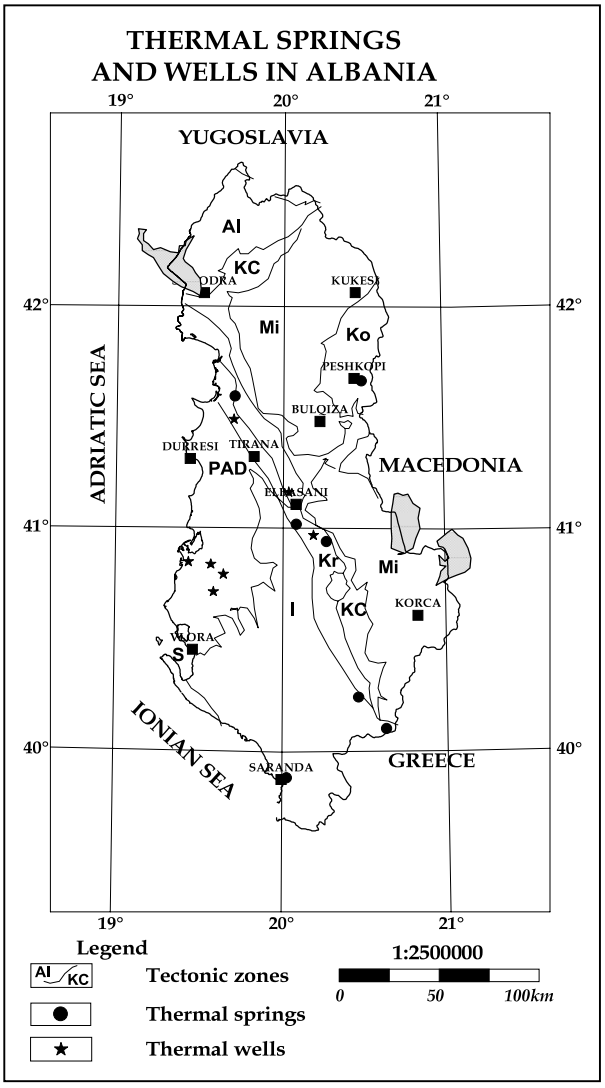

Figure 3. Thermal Springs and Wells.