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OUTLOOK ON PALEOCLIMATE CHANGES IN ALBANIA.

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ABSTRACT

In the paper there are presented the results of inversion of thermologs data for the ground surface temperature history in Albania. The analysis presented in paper is based on 4 thermoplots, from different regions of Albania. The wells are located in Sedimentary Basin of Albania, at the field region in the west of Central Albania and in the ophiolitic belt in the mountainous region of the northeast Albania. Based on inversion data, it results that 3.5 centuries ago in Western Albania the climate was warmer. Later a cooling of 1^{o}C occurred, until 1 century ago. During the 20th century an increase of 1^{o}C is observed. Inexpressive climate warming in the second half of this of this century is observed in Northwestern Albania. This warming mainly after the second half of the 20th century is presented also by meteorological data. The warming has caused its impact on country climate, water systems and ecosystems of the Albania.

Keywords: Ground Surface Temperature, Paleoclimate Changes, Paleoclimate Reconstruction, Thermolog,

INTRODUCTION

Albania lies in a subtropical zone. It is a Mediterranean country. Winter is relatively short and mild, humid near the seaside areas. Summer lasts very long and it is hot and dry. To the east, in the mountain areas, the climate is Mediterranean mountainous. There, the temperature is lower than in seaside zones and the raining decrease. Sunshine varies from 2560 hours per year in Tirana, down to 2046 hours in Kukesi City. Average yearly temperature varies from 16.5^{o}C in Vlora City, 11.8^{o}C in Kukes and 7.0^{o}C in the northern area of the Albanian Alps. In Albania the rainfall is about 1430 mm a year. Albanian Alps is one of the most humid territory in Europe, up to 3094 mm a year rainfalls (Albanian Climate, 1978, Boriçi, M. and Demiraj, E. 1990, Mici, A. et al 1975).

The climate in Albania varies from a region to the other, according to the location compared with the seaside, to the seasons, years, and centuries. The ground temperatures are conditioned by geographical position of the area, area's geology, ground lithology, dynamics of the underground waters, meteorological conditions, and season.

The Albanides represents the assemblage of the geological structures in the territory of Albania. Two major peleogeographic domains form the Albanides: the Internal Albanides in the eastern part and the External Albanides in the western part of Albania. The Internal Albanides are characterized by presence of the immense and intensive tectonised ophiolitic belt, which is displaced from east to west as overthrust nappe. The External Albanides was developed out of the western passive margin and continental shelf of the Adriatic plate. The geological section of Albanian Sedimentary Basin is more than 12000 m thick.

The Earth crust in Albanides is interrupted by a system of longitudinal fractures in NW - SE direction and transversal fractures, that touch even the mantel. With deep fractures are linked geothermal energy of the Albanides.

Maximal geothermal gradient in this Basin has a value of 21.3 mK/m. These gradients change from one formation to others. Geothermal gradient increases up to 25 mK/m in the ophiolitic belt of the Inner Albanids. Heat flow density has its highest values of 42 $mW.m^{-2}$ in the Albanian Sedimentary Basin and 60 $mW.m^{-2}$ in ophiolitic belt (Cermak, V. et al 1996, Frasheri, A. and Cermak, V. et al. 1995, Frasheri, A. 1993, 1996).

Analyzing some thermoplots of different wells in Albania, it resulted a useful information to evaluate the paleoclimate changes until a thousand years ago. This information of the Ground Surface Temperature history, according to thermoplots in Albania, is analyzed in this paper.

MATERIAL AND METHODS

The study of geothermal field of Albania has been carried out based on the temperature logging in the oil and gas deep wells located in the Albanian Sedimentary Basin, also in boreholes in the ophiolitic belt. These wells, with a depth of 50 m to 6700 m, are located in different geological situations (Cermak, V. et al 1996, Frasheri, A. and Cermak, V. et al. 1995, Frasheri, A. 1993, 1996).

Paleoclimate reconstruction has performed by estimation of the ground surface temperature changes at the past T (z=0,t)=Ts (t), $-t_o \le t \le 0$, according to the present distribution of the temperature at the depth $T(z, t=0) = T^e(z)$, recorded in the borehole. Temperature distribution T (z, t) was evaluated by solving of the know problem (Dimitriev B.I. et al. 1997):

$$\frac{\lambda(z)}{a^2(z)} \cdot \frac{\partial T}{\partial t} = \frac{\partial}{\partial z}\left(\lambda(z)\frac{\partial T}{\partial z}\right) + j(z), \quad for\ -t_o \le t \le 0,\ 0 \le z \le H,$$

$$T_z(z, t=-t_o) = T_{St}(z),$$

$$T(z=0,t) = T_S(t),\ T_S(t=-t_o) = T_{St}(z=0) = T_o,$$

$$\lambda \frac{\partial T}{\partial z}\Big|_{z=H} = q,$$

$$\left[T_{St}\right]_{z_n} = 0,\ \left[\lambda \frac{dT_{St}}{dz}\right]_{z_n} = 0$$

Where: temperature-conductivity coefficient $a^2(z)$, heat-conductivity $\lambda(z)$ and heat sources j(z) are changes with the depth $0<z<\infty$. The parameters a(z), $\lambda(z)$, j(z), and heat flow density (q) at the depth must be determined by measurements. The beginning temperature distribution function $T_{St}(z)$ is determined by a condition of $T(z,t=0)=T^e(z)$.

Ten thermoplots were used for inversion of the ground surface temperature history. For the analysis presented in this paper we have chosen 4 thermoplots, in different regions of Albania. Well Ko-10 it is located in Sedimentary Basin of Albania, at the field region in the west of Central Albania (Fig. 1). Wells Vl-1127, Gurth-595, Krasta-1 and Ragam-168 are located in the ophiolitic belt, in the mountainous region of the northeast of the Albania. The temperature inversion for paleoclimate reconstruction done by Dr. V. Cermak and Dr. Jan. Safanda (Vl-1127, Gurth-595, Krasta-1, Ragam-168) and Prof. Henry Pollack (Ko-10 well), using Dr. P. Z. Shen software program, adopted after GST inversion technique proposed (Frasheri, A. 1995, Frasheri, A., Cermak, V. and Safanda, J 1999).

The results of this inversion of the ground surface temperature history are correlated with the data of air and ground temperatures, which are recorded in Meteorological Stations (1, 2, 9, 10). In the event of not being able to make a full comparison of the whole time of the ground surface temperature history, we consider this test as valuable also for the last decades, for which there are hydrometereological instrumental data. For this correlation three stations are chosen Tirana in Central Albania, Fier at Western area and Kukes in Northwestern region of Albania (Tab; 1; Fig. 1) (Albanian Climate, 1978, Boriçi, M. and Demiraj E. 1990, Gjoka, L. 1990, Mici, A. et al 1975, the data for 1985-2000 after Mustaqi V.).

Location of the Meteorological Stations Tab 1

Station	Coordinates		Altitude (m)	Area
	φ_N^o	λ_E^o		
Tirana Airport	41° 20'	19° 47'	88.9	Central Albania
Kukesi	42° 25'	20° 25'	354.2	North-Eastern Albania
Fieri	40° 44'	19° 31'	12.0	Western Albania

RESULTS AND DISCUSSION

The thermoplot of Kolonja-10 deep well, which is located in field's Western region of Albania, temperature trend and residual temperature anomalies are shown in fig. 2 (Frasheri, A. 1995).

According to these data, climate reconstruction of the thermal field is presented in fig. 3. As it is seen in this figure, from the beginning of the 20th century the seaside region of Albania is warmer. The average increase in the temperature is about 1 ^{o}C. To the contrary, from the XVth century until the end of XIXth it has cooled about 1^{o}C. Pre-1500 Mean Ground Surface Temperature is equal to the To=17.9 ^{o}C. First five centuries of the second millenium are characterized by a warming of 1^{o}C. In this way, climate in the seaside field's part of Albania is characterized by increase and decrease alternations of the temperature. These alternations have lasted for five centuries. Change of the average yearly temperature has not been over 1^{o}C.

Fig. 4,5 shows a GST history according to Vl-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes, which are located in the mountainous regions of Northeast Albania. Some nonessential changes are observed in these regions as to the warming trend of the 20th century.

To correlate data of GST history according to geothermal studies with the data of hydrometeorological observations, there are analyzed data from three stations that we had in disposition. These stations are located in field regions (Tirana and Fier) and in mountainous regions of Albania (Kukes), where the investigated wells are situated. Fig. 6 presents graphics of yearly average temperature of the air and ground at depth of 20 cm and 40 cm in Tirana Meteorological Station. As well known, Tirana is located in Central Albania. During 1985-2000 there is presented only the average annual air temperature, because of lack of data of the soil temperature (fig. 7). In general, by the end of 20th century, in all Albania is observed a warming of climate. Warming trend it is observed in the air and the soil in all Albanian territory (Fig. 7, 8). The warming trend, in particular after seventy years, clearly shows these graphics**.** The meteorological data shows that the warming trend is not a monotone one. In short intervals are observed cooling and warming (Fig. 8). The meteorological studies have verified this phenomenon, too. It has been consisted that: "Around the 1980's a warming trend is observed" (2, 8). The warming period, in the field regions of Albania, is accompanied with a decrease in the rainfalls (Fig. 9).

This warming is part of the global Earth warming during the second half of XX century. Its impact has been observed in some directions. There are two main directions:
Firstly, with decaying of the rainfalls is observed decreasing of the water resources of the country, of surface's and underground waters.
Secondly, temperature augmenting has caused increasing of the evaporation in the water systems. Consequently in the river system, reservoirs, wetlands, lakes and lagoon system has been observed thermal stress. In very beautiful ecosystems of Albanian lagoon as Narta, Karavasta, Kune-Vaini and Micro Prespa Lake etc. thermal stress has its impact, first of all on the biodiversity.

CONCLUSIONS

Based on the results of inversion of the thermologs data, recorded in deep wells and boreholes, for the evaluation of the ground surface temperature GST history, we have arrived in following conclusions:

1. The climate in Western field's regions of Albania was warmer 3.5 centuries ago. Later a cooling of 1^{o}C occurred, until 1 century ago. During the 20th century an increase of 1^{o}C is observed.
2. Temperature records in Northwestern Mountainous region of Albania confirmed inexpressive climate warming in the second half of this of this century.
3. This warming, mainly after the second half of the 20th century, is demonstrated also by meteorological data.

4. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes of Albania. Impact it is observed first of all on the biodiversity.

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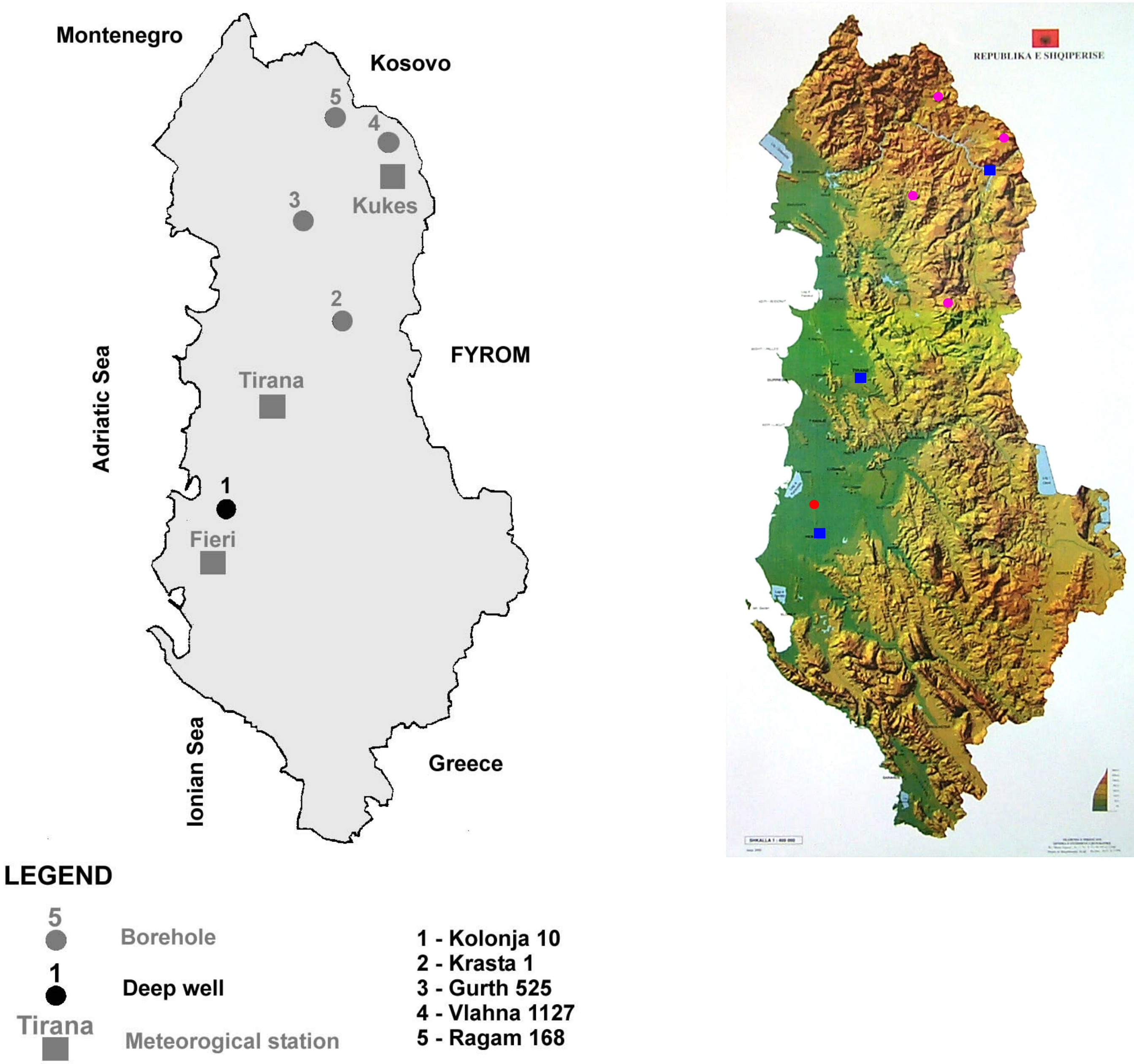

Fig. 1. Map of Albania and location of the Kol-10, Vl-1127, Gurth-595, Krasta-1 and Ragam-168 wells and Tirana, Fier and Kukes Meteorological Stations.

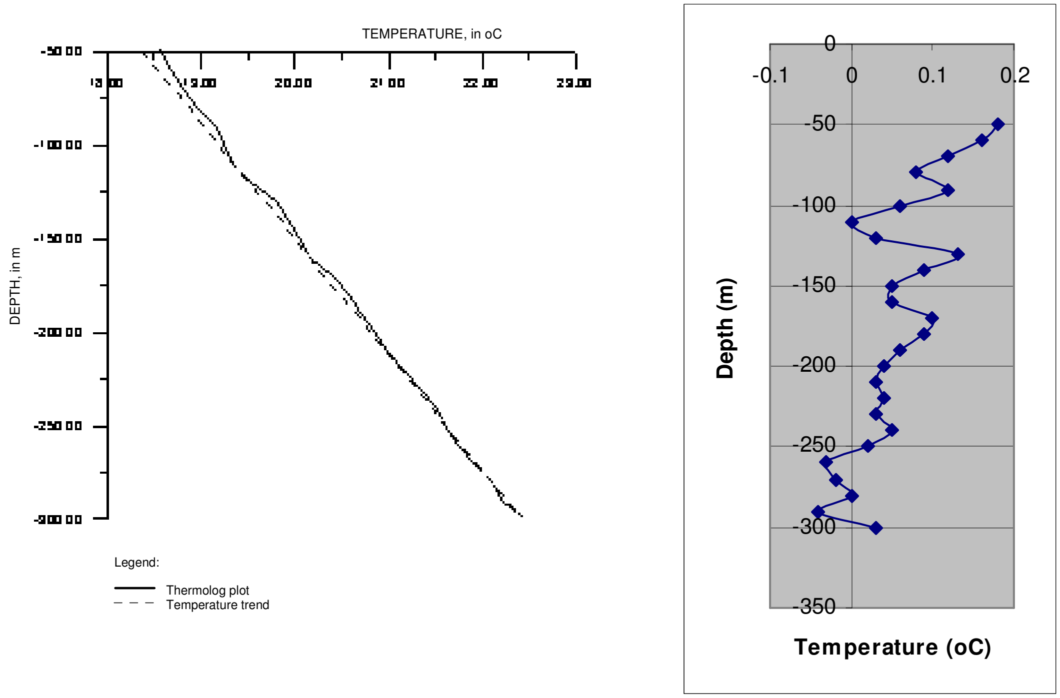

Fig. 2. Thermoplot of Ko-10 well in field Western region of Albania.

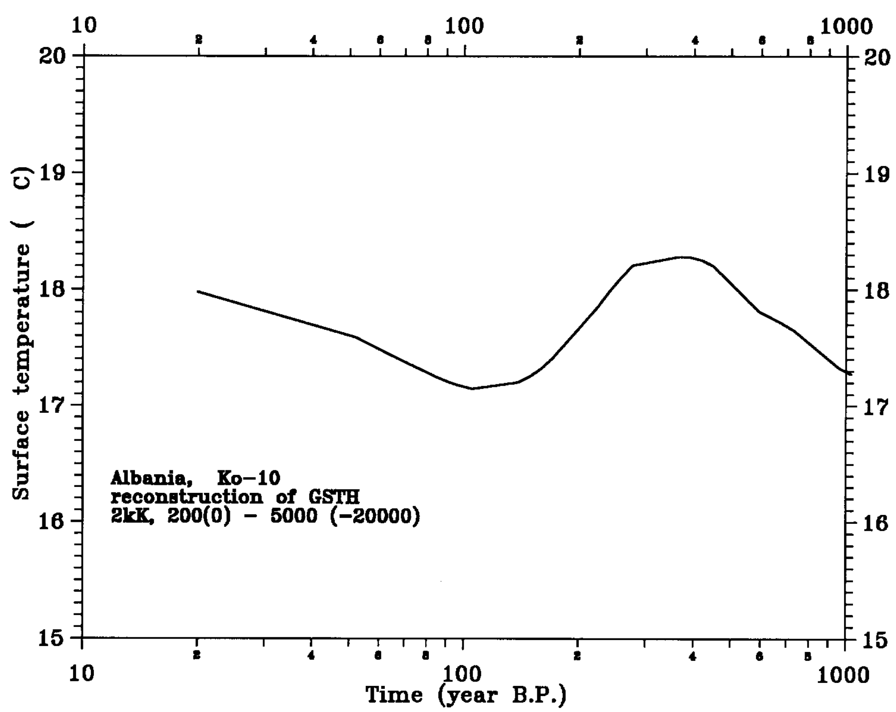

Fig. 3. Ground surface temperature history according to thermoplot of Ko-10 well (according to the Prof. H. Pollack calculations)

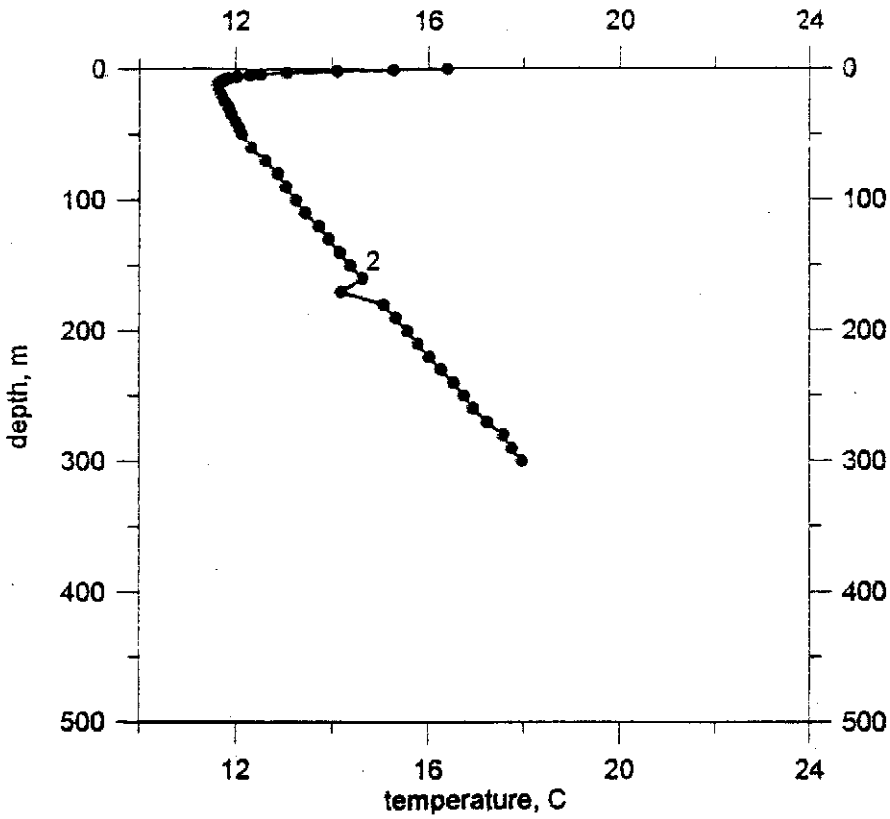

Fig. 4. Thermolog of Vl.-1127 borehole, located in mountainous northwestern region of Albania

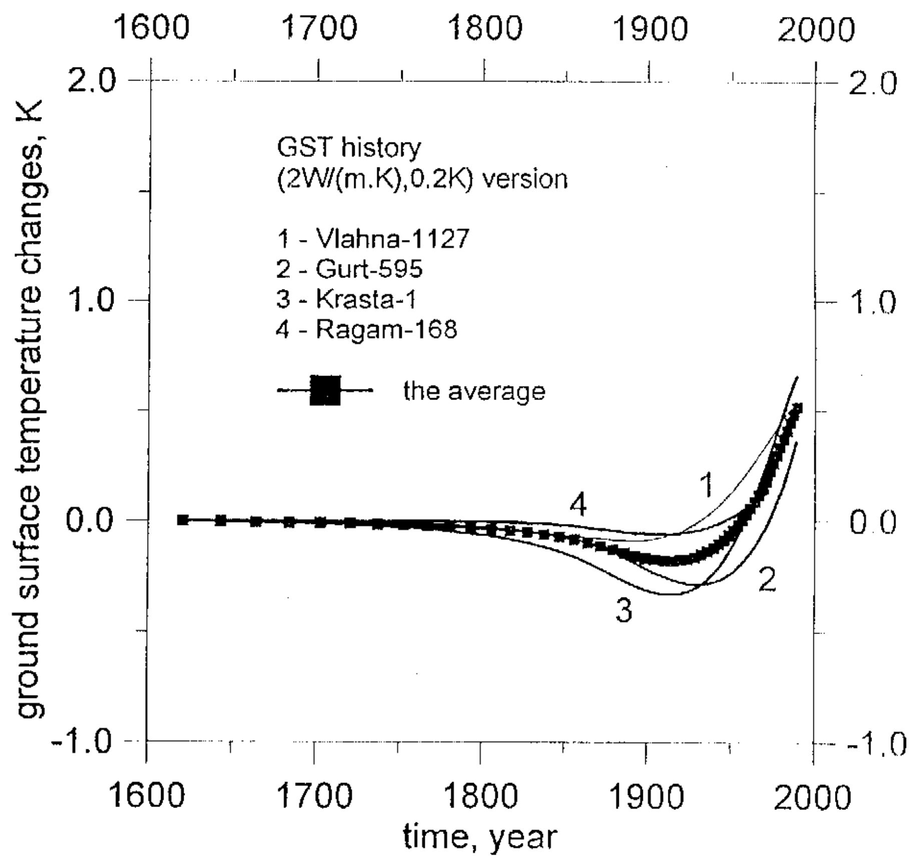

Fig. 5. Ground surface temperature history according to thermoplot of Vl.-1127, Gurth-595 and Krasta-1 boreholes (According to the Dr. Cermak, V. and Dr. Safanda, J. calculations).

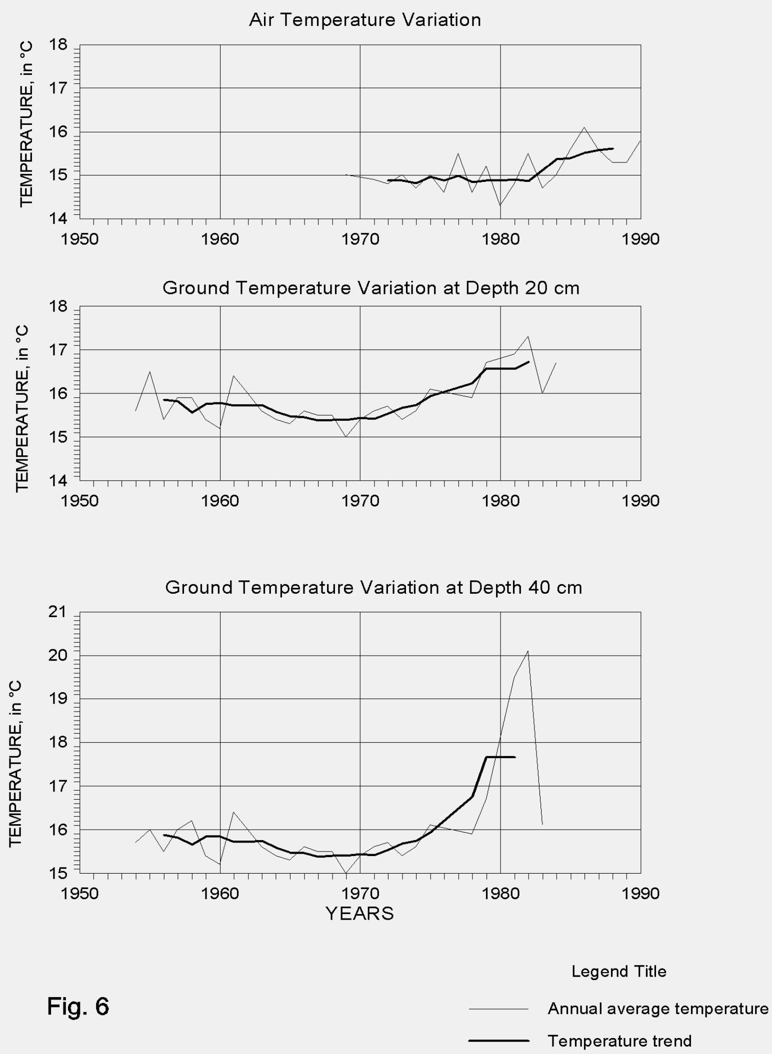

Fig. 6. Air and Ground Average Annual Temperature Variation at Tirana Meteorological Station.

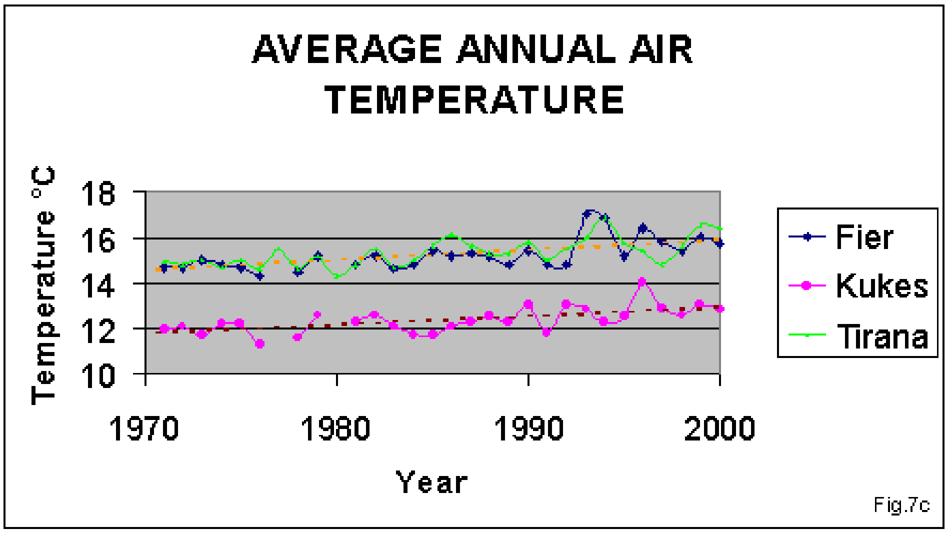

Fig. **7**. Air Average Annual Temperature Variation at Tirana, Kukes and Fier Meteorological Stations.

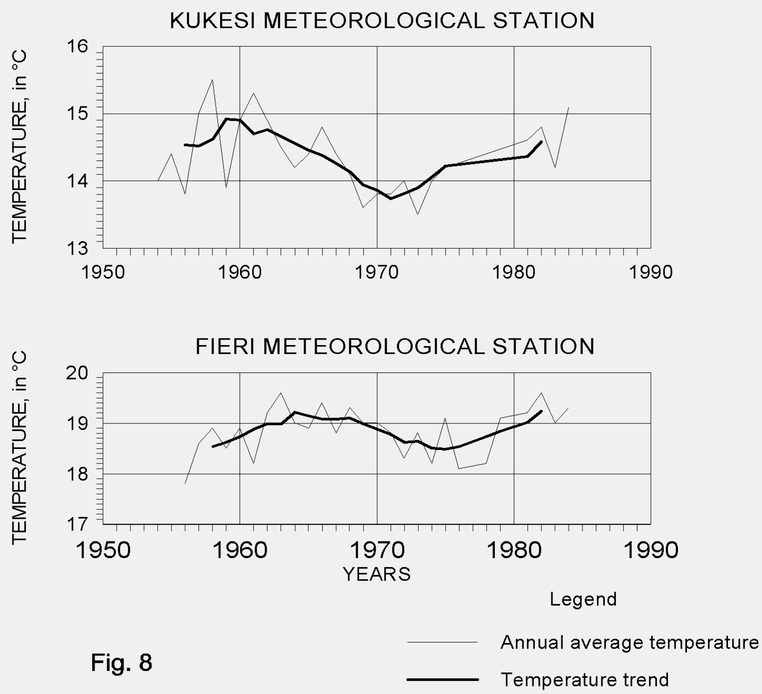

Fig. 8. Ground Surface Average Annual Temperature variation at Kukes and Fier Meteorological Stations.

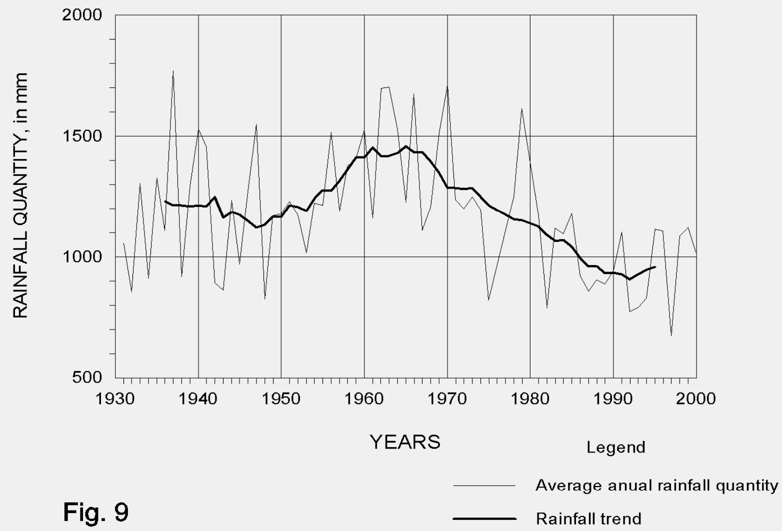

Fig. 9. Average Annual Rainfall Quantity, Tirana Meteorological Station.