Geophysical features of the Alpine Mediterranean Folded Belt, in the Albanides framework

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Summary

Distribution of gravity, magentic and geothermal fields, and their anomalous features in Albanides onshore and in the Albanian Adriatic Shelf in this paper are presented. There are presented also a hydrographical-geothermal phenomenon in the Albanian Adriatic Sea area, which are correlated with Albanides geological setting.

Key words: Geothermal, Gravity, Heat Flow, Interpretation, Magnetics.

Introduction

The Albanides represent the assemblage of the geological structures in the territory of Albania, and together with the Dinarides at the North and the Hellenides at the South, have formed the southern branch of the Mediterranean Alpine Belt.

Integrated onshore and offshore regional geophysical studies have been performed for the exploration of the Albanides. Seismological studies, gravity and magnetic surveys, reflection seismic lines, geothermal studies, radiometric investigations, vertical electrical soundings and integrated well loggings represent the applied complex of the geophysical investigation. The structural analysis of the Albanides according to the integrated geophysical investigations, in the framework of the integrated interpretation with geological studies results is presented. Integrated oceanographic, hydrographic and hydrological observations and study have been carried out in the Adriatic and Ionian seas, and littoral areas.

Methods

Regional Gravity and Magnetic Mapping of Albanian onshore territory have been performed at the scale 1:200.000. For the western oil and gas bearing regions of Albania have the gravity map of Bouguer Anomaly at scale 1.100.000.

The studies on the geothermal field and evaluation of the geothermal energy in Albania, in the framework of the preparation of "Atlas of Geothermal Resources in Albania", were performed on the basis of temperature logs in the 84 deep oil and gas wells and in 59 shallow boreholes. The temperature was measured with either resistance or thermistor thermometers. The thermal inertia of these thermometers is 5-6 seconds and 3.5 seconds, respectively. Laboratory of Department of Geothermics of the Geophysical Institute, Czech Academy of Sciences, Prague the thermal conductivity of the rocks was determined. The heat-flow density was calculated. Heat-flow density calculations were made for homogenous lithology part of geological sections, according to several models. The temperature maps at 100, 500, 1000, 2000, 3000 meters depths, average geothermal gradient map, heat flow density map and geothermal zones map, by the processed data were compiled. The maps of the Albanian territory have been linked with Greek and Adriatic space ones. Estimation of the geothermal resources of the thermal zones has been performed, based on a volumetric heat content of the model assuming exploitation of geothermal energy by a doublet or a singled wells system.

Oceanographic, hydrographical and hydrological studies are based on multi annual observations in the hydrometric station network since 1958 and on two Albanian oceanographic expeditions "Saranda-1963" and "Patos-1964" in the Southern Adriatic and Northern Ionian. The objects of these studies were: water levels, temperatures and chemical content, formation and circulation of the water mass, wave and wind regimes of the Adriatic and Ionian coastline, water potential and run-off discharge regime of the Albanian Mountainous River System into the Adriatic Sea, suspended material discharge; alluvial granulometric composition, water chemical composition etc.

Analysis and discussions

Seismological studies, regional gravity and magnetic survey data reflect the Earth Crust configuration [Bushati S. 1988, 1997, Frashëri A. et al. 1996, 2004]. Geophysical data reveal that the Earth crust becomes thicker from the central regions of the Adriatic towards Albanides inland. The sedimentary crust has about 10 km thickness in Adriatic seashore and reaches up to 15 km in northwestern regions of Albania. Rocks, with a seismic wave velocity of 5.9- 6.2-km/sec, present the lower part of the sedimentary crust. These rocks have a very consolidated structure. In the Albanides are fixed four of third order trends of the Bouguer anomalies: two maximums two minimums (Fig. 1). The main gravity maximum is extended on the northeastern part of the Albania. The second maximum, which is located in the southwestern part of Albania, has a sub-transversal strike with geological structures of the Ionian tectonic zone. These regional gravity maximums are

attributed to a crust thinning. The second minimum is located in the Alps tectonic zone, by a strike in the SE-NW direction. Generally, the Bouguer anomaly increases from the Adriatic Sea Shelf to the Eastern part of the Albanides. The geological-geophysical profile Albanid 1 presents the decreasing of the depth of roof of the Moho discontinuity in Adriatic Sea region. The Moho discontinuity plunges from 25 km in the central part of the Adriatic Sea to 43- 52 km at eastern part of Albanides. Regional gravity anomalies are caused by a block construction of the crust, which comes out from the results of seismological studies. This tectonic setting of the deep levels of the earth crust in the Albanides finds its reflection even in the distribution of the magnetic fields (Fig. 2). The interpretation of the regional magnetic anomalies shows that the top of the crystal basement plunges toward the littoral of the Albanides up to their central areas.

The tectonic setting of the deep levels of the Albanides Earth Crust and their dynamics has conditioned the geology and tectonic style of Albanides.

Geological and geophysical regional studies, have distinguished the following tectonic zones:

1. Internal Albanides: Korabi, Mirdita, Gashi tectonic zones,
2. External Albanides Albanian Alps, Krasta-Cukali, Kruja, Ionian, Sazani tectonic zones, and Peri Adriatic Depression.

Intensive Bouguer anomalies and very turbulent magnetic field, with weak anomalies (Fig. 1), characterize the ophiolitic belt of the Mirdita tectonic zone in the Internal Albanides. The ophiolitic belt has its biggest thickness about 14 km at its northeastern extreme, in the ultrabasic massif of Kukes. This thickness is reduced up to 2 km towards the west and the southeast. This interpretation is demonstrated a allochton character of ophiolite belt and the covering character of the western contact of ophiolites with the formation of External Albanides. The relations between the Internal and the External Albanides have a nappe character. The separation of the gravity and the magnetic anomalous belts in the central region of the Internal Albanides, at Shengjergji flysch corridor, arguments the presence of Diber-Elbasan-Vlora transversal fault.

A joint characteristic of structural belt in the External Albanides is their westward thrusting, too. Açording to the integrated geological-geophysical studies and deep well data results that two tectonic styles are observed in the Ionian tectonic zone: duplex and imbricate tectonic. Traversal faults have separated the Ionian basin in several blocks. Following limestone top of the south Adriatic basin and Sazani, Ionian and Kruja zones are observed that the limestones of the southern Adriatic basin are extended under the last units. Peri-Adriatic Miocene and Pliocene molasses deposits cover partly the Sazani, Ionian and the Kruja tectonic zones. They are placed trangressively over the older section down to the limestone of the Eocene, creating a two-stage tectonic stage. The molasses post-orogenic deposits have covered transgressively Mirdita and partially Krasta–Cukali tectonic zones in Korça and Burreli basins.

The interpretations of the geological geophysical data lead to a new structural model and tectonic style of the External Albanides. Tectonic zones of the External Albanides have been in compression tectonic regime since upper Jurassic-Cretaceous. Whereas, western part, of Apulian zone and South Adriatic basin, it happens in continuous extension tectonic regime [Meço S. and Alias Sh. 2000]. Overthrusting style of the southeastern part of the External Albanides, with a great southwestward overthrust of the anticline chains, and the presence of the old transversal faults already are well known. Evaporite deposits have been the lubrication substratum during the over thrusting movement. A regional neotectonic phenomenon is also the back thrusting tectonics in the Ionian and Sazani zones. The Albanian sedimentary basin continues even in Adriatic shelf with carbonate and terrigene formations. In the different profiles it is noticed that there exist some local Bouguer and magnetic anomalies in Adriatic shelf [Richeti G. 1980].

Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological setting. The geothermal field is characterized by a relatively low value of temperature. The temperature is 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike. The described geothermal field, with relatively low values of temperature, is a characteristic of the sedimentary basins with a great thickness of sediments. The temperatures in the ophiolitic belt are higher than in sedimentary basin, at the same depth. In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 $mK.m^{-1}$ in the Pliocene clay section in the center of Peri-Adriatic Depression. Elsewhere in Ionian zone, the gradient is mostly 15 $mK.m^{-1}$. The modeling results show that deeper than 20 km is observed decreasing of the gradient (Fig. 3). This change of the gradient is coincided with the top of the crystal basement. In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$ at northeastern and southeastern part of the Albania. After the geothermal modeling, decreasing of the gradient is observed also deeper than 12 000 meters, at the top of the Triassic salt deposits.

The regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map (Fig. 4). There

are observed two particularities of the scattering of the thermal field in Albanides:

Firstly, the maximal value of the heat flow is equal to 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW/m^2 value isotherm is open towards the Adriatic Sea Shelf. Heat flow density values are lower than 25-30 mWm^{-2} in Albanian Alps area.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2. The contours of Heat Flow Density give a clear configuration of ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt is linked with heat flow transmitting from the depth. Ophiolitic belt Heat Flow Density highest value can be explained by the small thickness of the geological section down to the top of crystalline basement, and MOHO discontinuity. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source. In the ophiolitic belt there are some hearths observed of higher heat flow density. Heat flow anomalies are conditioned by intensive heat transmitting through deep and transversal fractures.

Large numbers of geothermal energy of low enthalpy resources are located in Albania. Thermal waters with a temperature that reach values of up to 65.5°C are sulphate, sulphide, methane, and iodinate-bromide types. The Earth crust in the Albanides is interrupted by a system of longitudinal fractures in NW-SE direction and transversal fractures that touch the mantel. The geothermal energy of the Albanides is linked with these deep fractures.

Adriatic Sea Hydrographic-Geothermal Phenomenon

Based on two Albanian Oceanographic Expeditions data have been argumented that the total discharges of the Albanian rivers system in the Adriatic and Ionian Seas have a minimal discharge is 700-800 m^3/s for the hydrological dry years of low precipitation and maximal values 1900-2200 m^3/s for the hydrological wet years of high precipitation (Pano N. 1994). The oceanographically situation of the wet years has been characterized by formation of "The Bridge" of continental water with low salt content and density of the seawaters in the Adriatic Sea. Under “The Bridge” is located also a heat flow density anomaly at the sea bottom (Fig. 4). The “Bridge” direction is corresponds also with the prolongation of well-known Scutary-Pec regional tectonic transversal over the Albanides onshore. This “Bridge” has impact also on the seawater temperature distribution in this area. “The Bridge” includes the surface layer and Levant Intermediate Water (LIW) up to 600 m. depth. This phenomenon has an important influence on dynamics and formation Adriatic Deep Water (ADW).

Conclusions

1. Integrated Geophysical Syrveys have studied Albanides Earth Crust and have distinguished two palaeogeographical units and tectinic zones.
2. The Earth crust in the Albanides is interrupted by a system of longitudinal fractures in NW-SE direction and transversal fractures that touch the mantel.

References

Bushati S., 1988: Regional study of the distribution of gravity field of the Internal Albanides, for tectonics and metallogenic zoning. (In Albanian). M.Sc. thesis. Polytechnic University of Tirana.

Bushati S., 1997: Geomagnetic Field of Albania, Magnetic Map. A Monograph, (In Albanian), Center of Geophysical and Geochemical Investigation, Albanian Geological Survey, 1997.

Frashëri A. and Çermak V. (Editors of chiefs), Doracaj M., Kapedani N., Liço R., Bakalli F., Halimi H., Kresl M, Safanda J., Vokopola E., Jareci E, Çanga B., Kucerova K, Malasi E. 2004. "ATLAS OF GEOTHERMAL RESOUCES IN Albania". Published by Faculty of Geology and Mining, Polytechnic Universioty of Tirana.

Frashëri A., Nishani P., Bushati S., Hyseni A., 1996: Relationship between tectonic zones of the Albanides, based on results of geophysical studies. Peri Tethys Memoir 2: Structure and Prospects of Alpine Basins and Forelands. Mém. Mus. Natn. Hist.nat., 170, 485-511, Paris ISBN: 2-85653-507-0.

Pano N., 1994. Dinamica del littorali Albanese. (In Italian). Atti del 10 Congresso A.I.O.L., Genova, Italy.

Richetti, G.; 1980: Flessione e campo gravimetrico della micropiastra Apula. Boll. Soc. Geol. It., 99, pp. 431-436.

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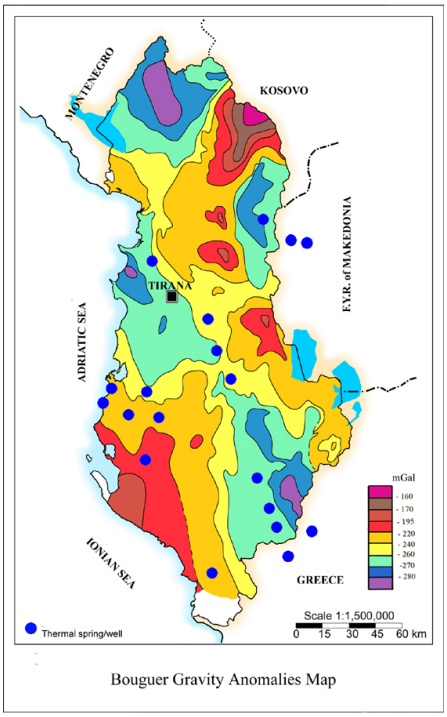
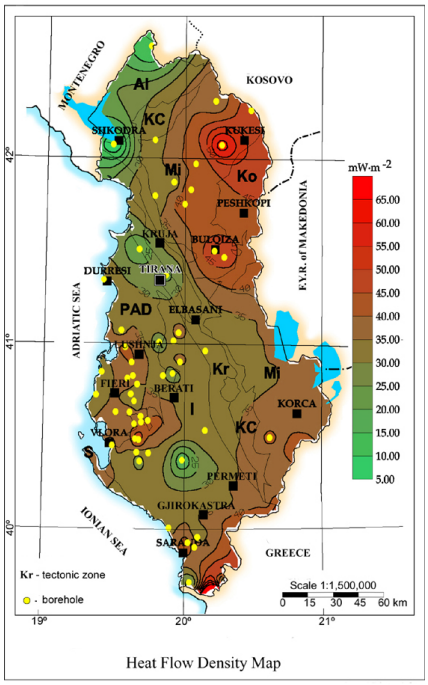
Fig. 3



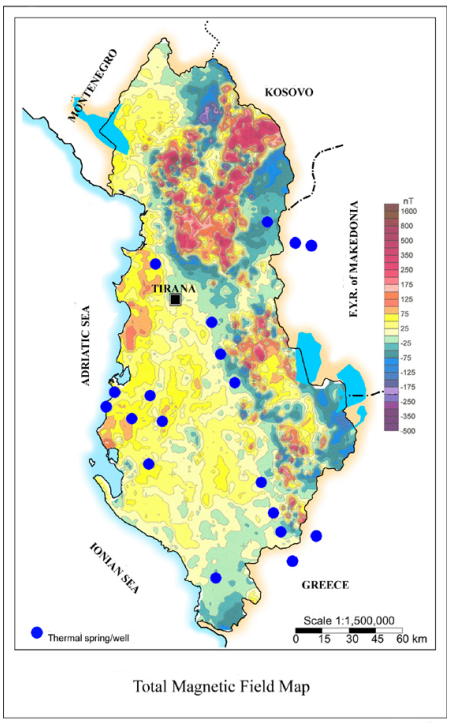
Bouguer Gravity Anomalies Map

Fig.1



Heat Flow Density Map

Fig. 2



Total Magnetic Field Map

Fig. 3

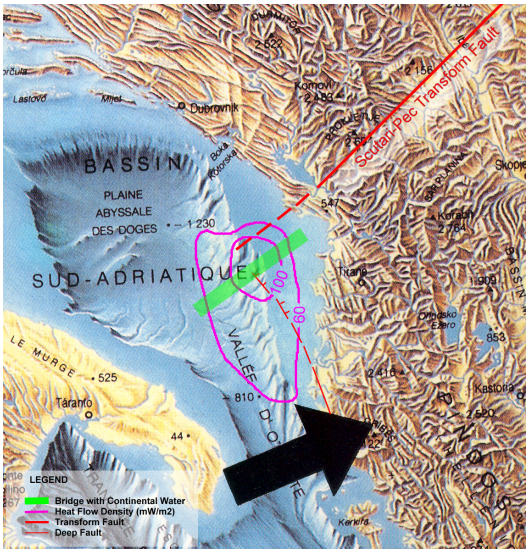


Fig. 4. Correlation of "The Bridge" of continental water Adriatic, Heat Flow Density anomaly and. Scutary-Pec regional tectonic tranvesal fault.