Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Albanian Progress on Geothermal Usage, 2015-2019

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Keywords: Geothermal, temperature, heat exchanger, cascade, integral, combined, direct use.

ABSTRACT

Albania, though a small country, could be considered rich in natural resources, including fossil fuels and renewable energy. Part of the renewable resources is the geothermal energy, so far not used at all for its energy potential, but only for its health and curative values. The aim of this paper is to show the efforts and progress towards the use of geothermal as a source of energy supply.

1. INTRODUCTION

During the reporting period Albania has approved several laws;

- *Law No. 124/2015 "On Energy Efficiency"* whose aim is to: Compile regulatory and national policies on promotion and improvement of the energy efficiency with primary focus on energy saving, supply reliability and removal of barriers on the electrical energy market; Setting of National Target regarding the energy efficiency; Increase of competition between different operators.
- *Law No.116/2016 "On the Energetic Performance of the Buildings"* whose aim is to: Establish the legal framework regarding the energetic performance of the new buildings, considering the local and climatic conditions, buildings comfort as well as cost effectiveness.
- *Law No. 7/2017 "On Promotion of the Renewable Energy Resources usage"* whose aim is to: To promote the generation of the electrical energy from the renewable resources of energy; Decrease the import of the organic fuels, greenhouses gases emissions & environmental protection; Promote the development of the electrical energy market, generated from the renewable resources as well as the regional integration; Support the diversification of the energy resources; Support the rural and remote areas development by improving their energy supply.
- *DoCM No. 179, dated 28.3.2018 "On Approval of the National Action Plan on the Renewable Energy Resources, 2018-2020".*

2. GEOLOGY BACKGROUND

Albania is a small country, only 28 787 km^2 in surface area, ~ 4,500,000 inhabitants, and is situated in the southwestern part of the Balkan Peninsula. This paper provides some details on the electricity generation, geothermal energy, resources, geological features, and geothermal reserves. Surface manifestations of geothermal resources are found throughout Albania, ranging from the region of Peshkopia in the northeast, where hot springs with water temperature are about 43°C and an outflow above 14 l/s are found, through the central part of the country with different sources (including the springs of Llixha-Elbasan) with temperatures above 66°C, to the Peri-Adriatic depression (see Figure 1), which has a number of wells drilled for oil & gas exploration, producing water with temperatures around 40°C, at variable yields. The thermal water in Albania is only used for balneology. This form of use dates back from early times in history, or from the time of the Roman Empire (i.e. the Sarandaporo's thermal baths).

The geothermal fluids, in springs and wells, of Albania are located in three zones: Kruja, Ardenica and Peshkopia (Frashëri et al. 2004). The three zones differ from each-other by the geological characteristics and thermo-hydrogeological features, as shown in Figure 2. They are related with the regional tectonic and the seismological activities.

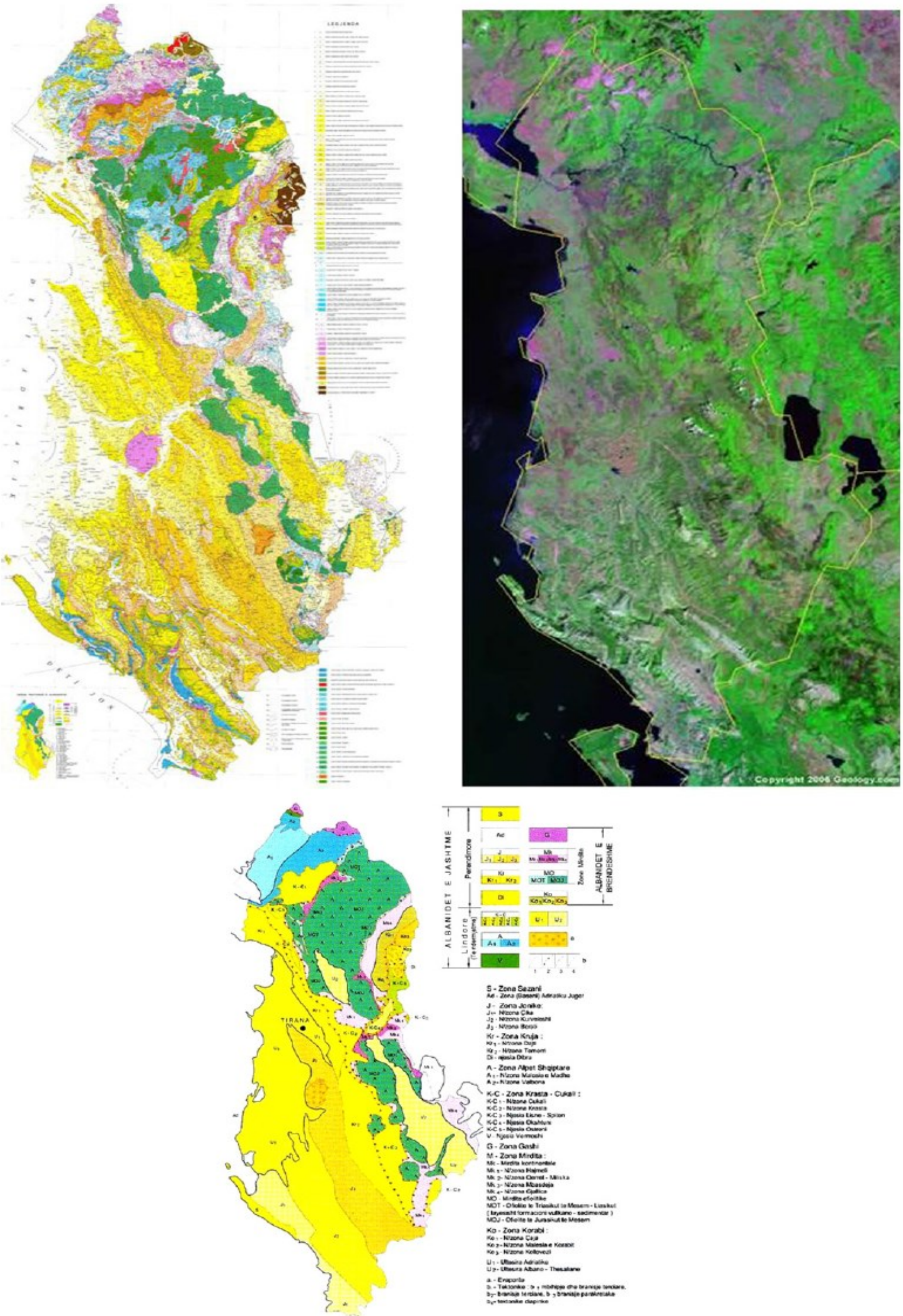

Figure 1: The map of Albania

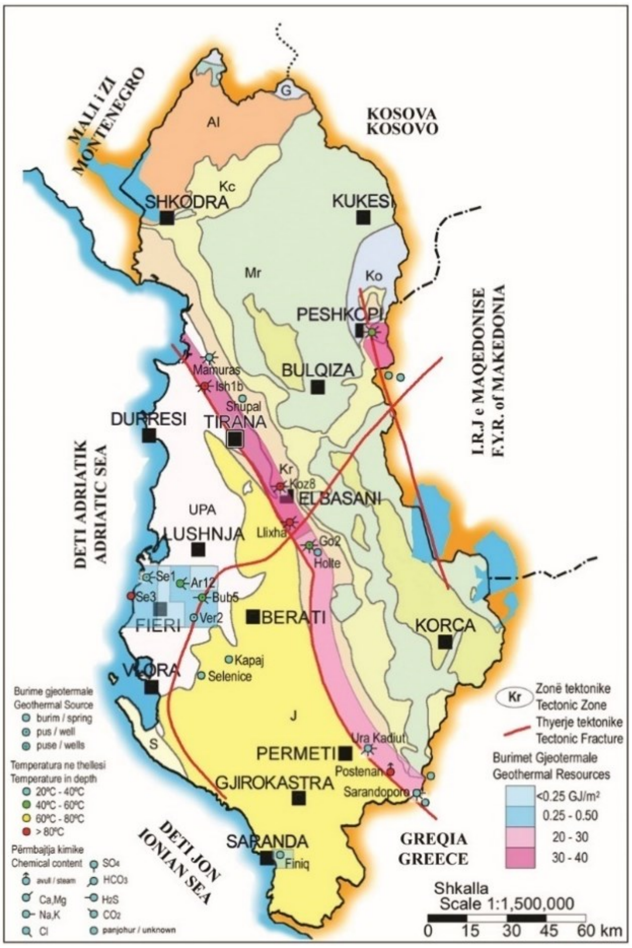

Figure 2: Geothermal map of Albania

The main geothermal springs of Albania and some technical data on them, are presented in the Table 1 (Frashëri et al. 2004).

Table 1: Geothermal springs of Albania

No	Spring and location	Temperature (°C)	Coordinates		Yield (l/s)
			Latitude (N)	Longitude (E)	
1	Mamurras 1 & 2	21÷22	41°42'24"	19°42'48"	11.7
2	Shupal	29.5	41°26'9"	19°55'24"	<10
3	Llixha, Elbasan	60	41°02'	20°04'20"	15
4	Hydraj, Elbasan	55	41°1'20"	20°5'15"	18
5	Peshkopia	43.5	41°42'10"	20°27'15"	14
6	Katiut Bridge, Lëngarica, Përmet	30	40°14'36"	20°26'	>160
7	Vronomer, Sarandaporo, Leskovik	26.7	40°5'54"	20°40'18"	>10
8	Finiq, Sarandë	34	39°52'54"	20°03'	<10
9	Holta Creek, Gramsh	24	40°55'30"	20°33'36"	>10
10	Postenan, Leskovik	Steam source	40°10'24"	19°48'42"	N/A
11	Kapaj, Mallakastër	16.9÷17.9	40°32'30"	19°39'30"	12
12	Selenicë, Vlorë	35.3	40°32'18"	19°39’30”	<10

Along the second half of the XXth century in Albania, there has been very intensive drilling for oil and gas exploration. During the drilling, some of the wells "accidentally" blew out "hot water" or brine. Table 2 present all "geothermal wells" of Albania as well some important technical data about them (Frashëri et al. 2004).

Table 2: Geothermal wells of Albania

No	Well	Temperature (°C)	Coordinates		Yield (l/s)
			Latitude (N)	Longitude (E)	
1	Kozani 8	65.5	41°06'"	20°01'6"	10.3
2	Ishmi 1/b	60	41°29'2"	19°40'4"	3.5
3	Letan	50	41°07'9"	20°22'49"	5.5
4	Galigati 2	45÷50	40°57'6"	20°09'24"	0.9
5	Bubullima 5	48÷50	41°19'18"	19°40'36"	
6	Ardenica 3	38	40°48'48"	19°35'36"	15÷18
7	Semani 1	35	40°50'	19°26'	5
8	Semani 3	67	40°46'12"	19°22'24"	30
9	Ardenica 12	32	40°48'12"	19°35'42"	
10	Verbasi 2	29.3			1÷3

The aquatic potential of Albania has the following main characteristics (Frashëri et al. 2004):

- The volume of the underground water is estimated to be in the range of 12.8 km^3;
- The underground water flow width is estimated to be in the range of 295 mm;
- The average modulus of the underground water yield is estimated to be in the range of 9.5 l/(s*km^2)

The groundwaters of Albania make up 31% of the total aquatic reserves of the country. Thus far, the geothermal resources have been used only for their balneological values and unfortunately not at all for their energy potential. Albanian geothermal fluids have temperatures up to the lower limits of the middle enthalpy. With the exception the Postenani steam spring, which gives hope to find resources with temperatures in the range of 80°C.

2.1 Kruja geothermal zone

Kruja geothermal zone represents a zone with large geothermal resources, as shown in Figure 3. The Kruja Geothermal Zone extends over a length of 180 km from the Adriatic Sea in the North, down to the Southeastern area of Albania, and further S-E to the Konitza area in Greece (Frashëri A. et al. 2003, Fytikas M.D. and Taktikos S. 1993). The geothermal aquifer is represented by a carstified neritic carbonate formation with numerous fissures and micro fissures. Three boreholes produce hot and mineralized water, Ishmi - 1/b (Ishm - 1/b), Kozani - 8 (Ko - 8) and Galigati - 2 (Ga - 2). Thermal springs of the Llixha Elbasani spa are located about 12 km S of Elbasani city (Frashëri et al. 2004).

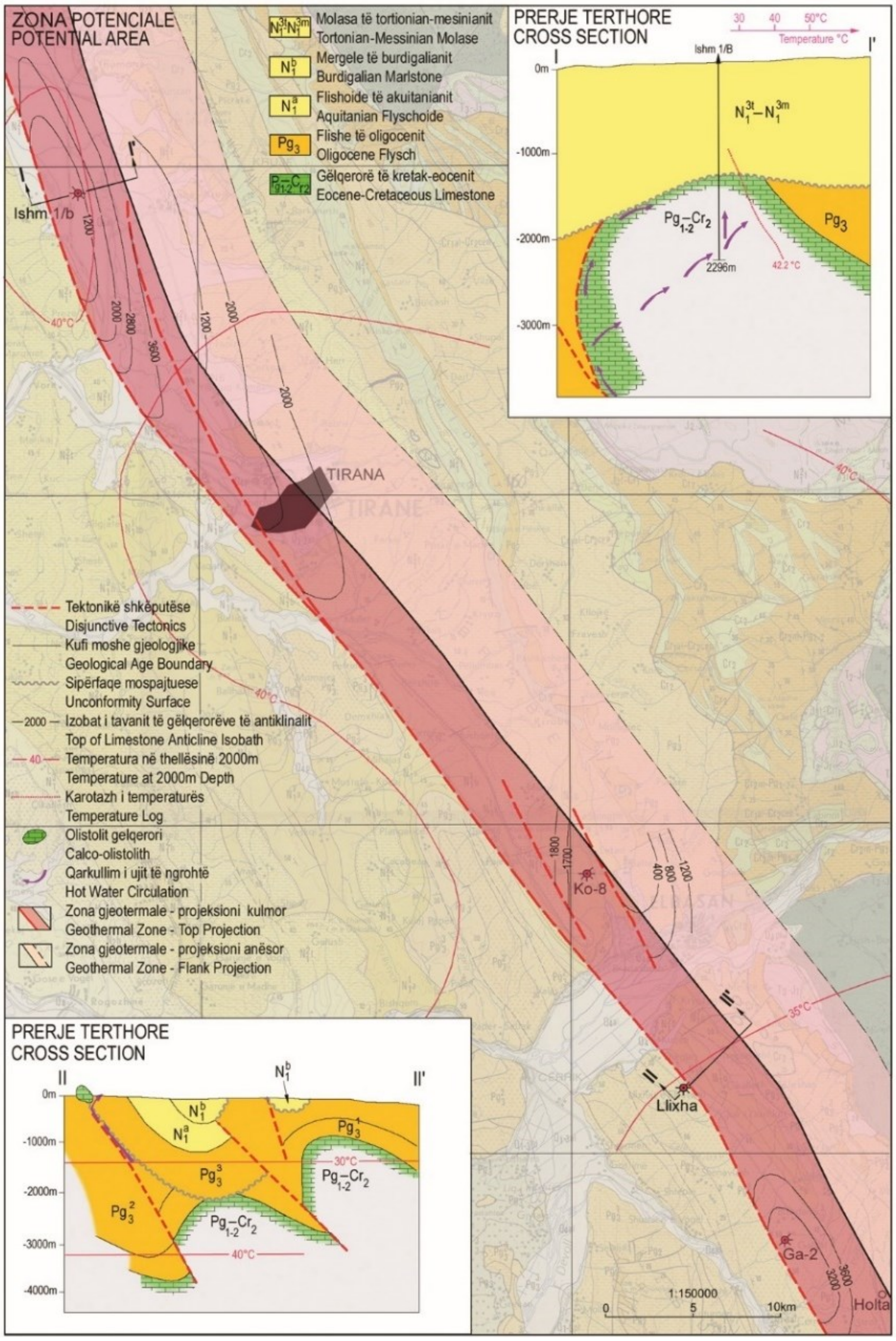

Figure 3: Kruja geothermal zone map

The Ishmi - 1/b is the northernmost borehole of Kruja geothermal field, about 20 km NW of Tirana. Ishmi 1-b well was drilled in the upper part of the fissured and karstified limestone in 1964. The borehole intercepts the limestone section at 1300 m depth and continues through more than 1000 m of carbonate strata. Effective porosity is less than 1% and the permeability ranges from 0.05 - 3.5 mD. The hydraulic conductivity of the limestone section varies between 8.6×10^{-10} - 8.8×10^{-8} m/s and the transmissivity ranges from 8.6×10^{-7} - 8.5×10^{-5} m^2/s. The Kozani - 8 well was drilled in 1989 and is located 26 km SE of Tirana. It encounters limestone strata at 1819 m, penetrating 10 m into the section. Hot water has continuously discharged from the Ishmi-1/b and Kozani - 8 boreholes at rates of 3.5 l/s and 10.3 l/s, respectively, since the end of drilling operations in1964 and 1988, respectively. Galigati-2 borehole is located on a hill, about 50 km SE of Tirana. At depth of 2800 m, it discloses an 85 m thick limestone section. Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320° of azimuth. All of them are connected with the main regional disjunctive tectonics of Kruja zone. Thermal waters flow out through the contact between the conglomerate layer and the calcolistolith layer, as showed in Figure 4 (Frashëri et al. 2004).

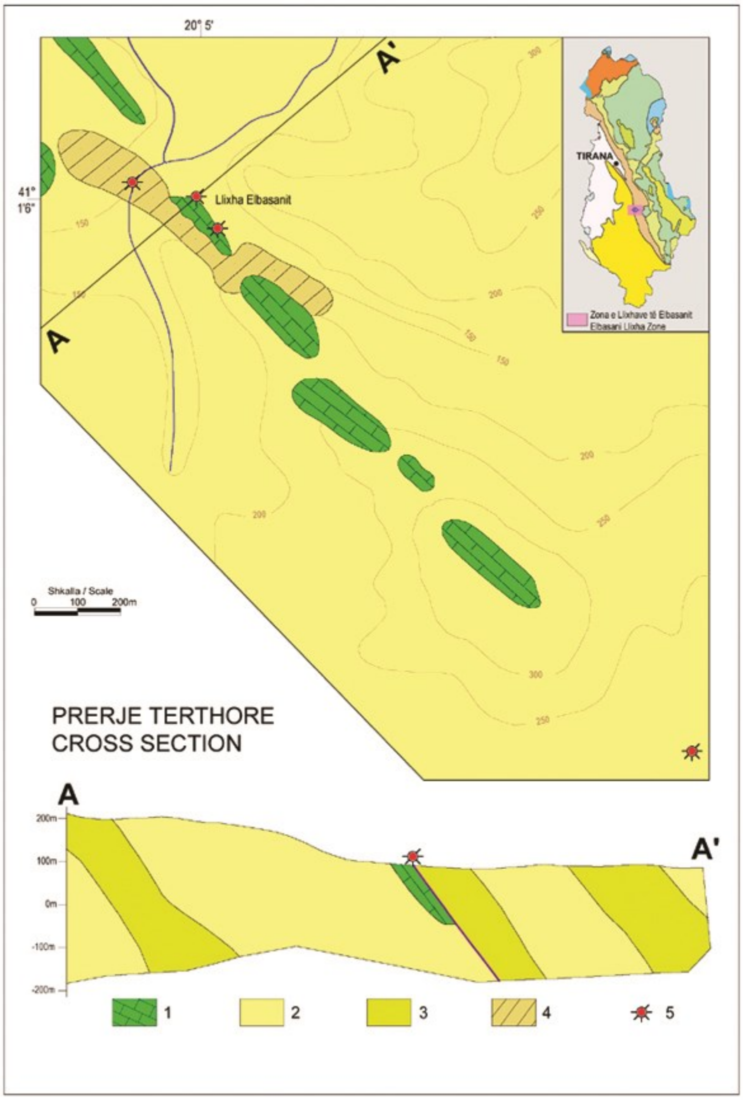

Figure 4: Geological map of the Llixha Elbasan springs

In this area, the reservoir is represented by the Llixha limestone structure. These springs have been known since before the Second World War. Surface water temperatures in the Tirana-Elbasani zone vary from 60°C to 65.5°C. In the aquifer top in the well trunk of Kozani - 8 the temperature is 80°C. Hot water has a salinity of 4.6-19.3 g/l. Elbasani Llixha water contains Ca, Na, Cl, SO_4, and H_2S (Avgustinsky et al., 1957) while in the Tirana-Elbasani, thermal waters are of Mg-Cl type. They contain the cations Ca, Mg, Na and K, as well as the anions Cl, SO_4, and HCO_3 with pH to 6.7-8 and density of 1.001 - 1.006 g/cm^3. Elbasani Nosi Llixha water has the following formula (Avgustinsky V.L. 1957):

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}SO^{4}_{38}}{Na_{46}Ca_{35}}$$

Wellhead temperatures in the Tirana-Elbasani zone vary from 60 - 65.5°C. The temperature at the top of aquifer reaches 80°C in the Kozani-8 hole. According to the temperature logs in Ishmi - 1/b and Galigati - 2, temperatures at depth in the carbonate section are 42.2°C and 52.8°C, respectively. The difference between the temperature of thermal water gushing at the surface and of the limestone section at depth shows that a mixture of waters from different depths and temperatures has occurred. The Lëngarica river thermal springs, near of the Vjosa River Valley, Postenani steam springs and the Sarandaporo springs can be found south of the Kruja geothermal area. Thermal water flows out from the contact between the Eocene fissured and carstified limestones and the flysch section. The steam flows from tectonic fault. On both sides of the Lëngarica River, shores are located Bënja thermal springs, well known from the Roman era, as showed in Figure 5. These waters are much different. They do not contain H_2S, CO_2 and are a factor of 7-9 times less mineralized than waters from the Tirana-Elbasani zone. The mineral water of these springs is drinkable. Water temperature is 29°C. Yield is 30-40 l/s (Frashëri et al. 2004). Nearby the Albanian-Greek border is located Sarandaporo's thermal spring with mineral drinkable water, the temperature is 27.6°C and yields more than 40 l/s. Geothermal springs at Kavasila in Greece is located in southern part of Sarandaporo riverside. Kavasila thermal springs and Sarandaporo in Albanian side are springs belong to a single geothermal system, on the northern side it continues with the steam springs of Postenan Mountain in Leskovik and Bënja geothermal springs of Përmet. Table 3 shows the fluids temperature measured with different geo-thermometers.

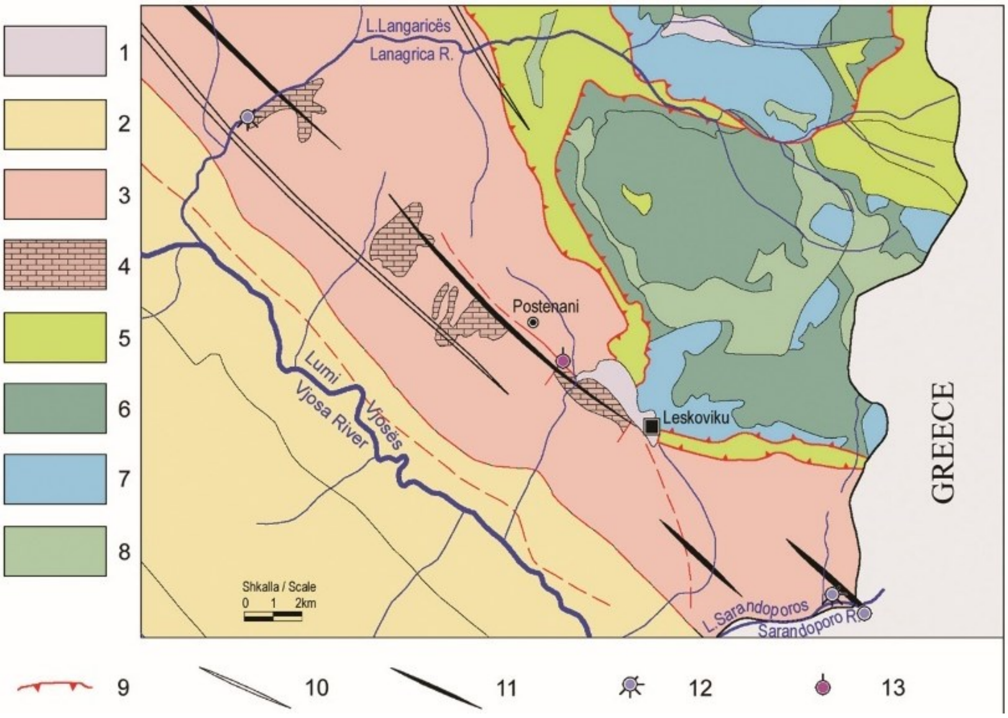

Figure 5: Lëngarica spring geological map

Table 3: Kruja zone springs temperatures

Geo-thermometer	Llixha Elbasan springs	Mamurrasi springs	
		Spring 1	Spring 2
Fournier	254	241	220
Truesdell	235	184	191
Na+Ka+Ca	143	130	132

The Kruja geothermal area concentrates most geothermal resources in Albania. The most important resources, explored until now, are located in the Northern half of Kruja Geothermal Area, from Llixha-Elbasan in the South, to Ishmi north of Tirana. For the Tirana-Elbasani subzone heat in place (Ho) is 5.87 x 10^{18} - 50.8 x 10^{18} J, identified resources (Hi) are 0.59 x 10^{18} - 5.08 x 10^{18} J, while the specific reserves range between values of 38.5-39.6 GJ/m^2. The second subzone, Galigati, has lower concentration of resources 20.63 GJ/m^2, while geothermal resources amount to 0.65 x 10^{18} J. These reserves have been extrapolated for this whole subzone up to the Albanian-Greek border (Frashëri et al. 2004).

2.2 Ardenica geothermal zone

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs, as shown in Figure 6. The Ardenica geothermal area is situated 40 km N of Vlora within the Peri-Adriatic Depression. It's comprised of the molasses Neogene brachy anticline Ardenica, the Semani anticline, the northern pericline of Patos-Verbasi carbonate structure, and the overlying Neogene molasses. The Ardenica geothermal area is intercepted by the Vlora-Elbasan-Dibra transversal fault. The Ardenica geothermal reservoir comprises sandstone sections of Serravalian, Tortonian and Pliocene age. These sandstone layers are composed of coarse, medium and fine grains. Effective porosity of the aquifers is about 15.5% and the permeability reaches 283mD. Hydraulic conductivity is 4.98 m/s and transmissivity have a value 8.9 x 10^{-5} m^2/s. These reservoir properties translate into an output of 5-18 l/s. Hot water discharges from the boreholes Ardenica-3 (Ard-3) and Ardenica-12 (Ard-12), both situated in the Ardenica brachy anticline, Semani – 1 (Sem - 1) and Semani - 3 (Sem - 3) boreholes in the Semani anticline structure, in the Verbasi - 2 (Ver - 2) drilled in the Patosi monocline and the Bubullima - 5 (Bub - 5) borehole that intercepts the carbonate section of the Patos-Verbasi structure. At the surface, the boreholes discharge waters at temperatures of 32-67°C. Water flows into these boreholes at depth intervals of 1200 ÷ 1700 m (Ard - 3), 1935-1955 m (Ard - 12), 2250-2275 m (Sem - 1), 2698-2704 m and 3758 m (Sem - 3), 875-1935 m (Ver - 2) and 2385-2425 m (Bub - 5). Ardenica thermal water is Ca-Cl type, with 21.2 mg/l iodine, 110 mg/l bromide and 71 mg/l boric acid, and has a formula:

$$M_{58.8}\frac{Cl_{98}}{Na_{86}}$$

Electrical resistivity and SP logs in the Ardenica –12 and Semani - 1 boreholes, show that the sandstone section has a thickness of 445-1165 m. As an example, these geophysical logs for the Ardenica - 12 borehole are shown together with the temperature log and lithologic column. It is clearly shown that the aquifer temperatures are higher in the sandstone layer than above or beneath it. At the wellhead, temperatures are 32°C for Ardenica - 12 well, 35°C for Semani - 1 well, 38°C for Ardenica - 3 well and 67°C for the well

Semani - 3. However, the temperature in the aquifers at depth of 1935-1955 m is 45.8°C. Ardenica reservoir has energy reserves in the range of 0.82 x 10^{18} J. Resources density varies from 0.25-0.39 GJ/m^2. The boreholes have been abandoned from a long time and await renewed investments to be converted into geothermal exploration (Frashëri et al. 2004).

2.3 Peshkopia geothermal zone

Peshkopia geothermal zone is located in the Northeast of Albania, in the Korabi hydrogeologic zone, Figure 7 (Çollaku A. et. al 1992). At distance of two kilometers east of Peshkopia, water at 43.5°C flows out of a group of thermal springs on a river slope composed of flysch deposits. Some of the springs yield flow rates up to 14 l/s. Occurrence of these springs is associated with a deep fault at the periphery of a gypsum diapir of Triassic age that has penetrated Eocene flysch, which surrounds it like a ring. These springs are linked with the disjunctive tectonic of seismic-active belt Ohrid Lake-Dibër, at periphery of the gypsum diapir. This tectonic belt links the Banjishte and Kosovrasti thermal springs, which are located in the North Macedonian territory, close to the Albania-North Macedonia border (Frashëri A., Pano N. 2003, Micevsky E. 2003).

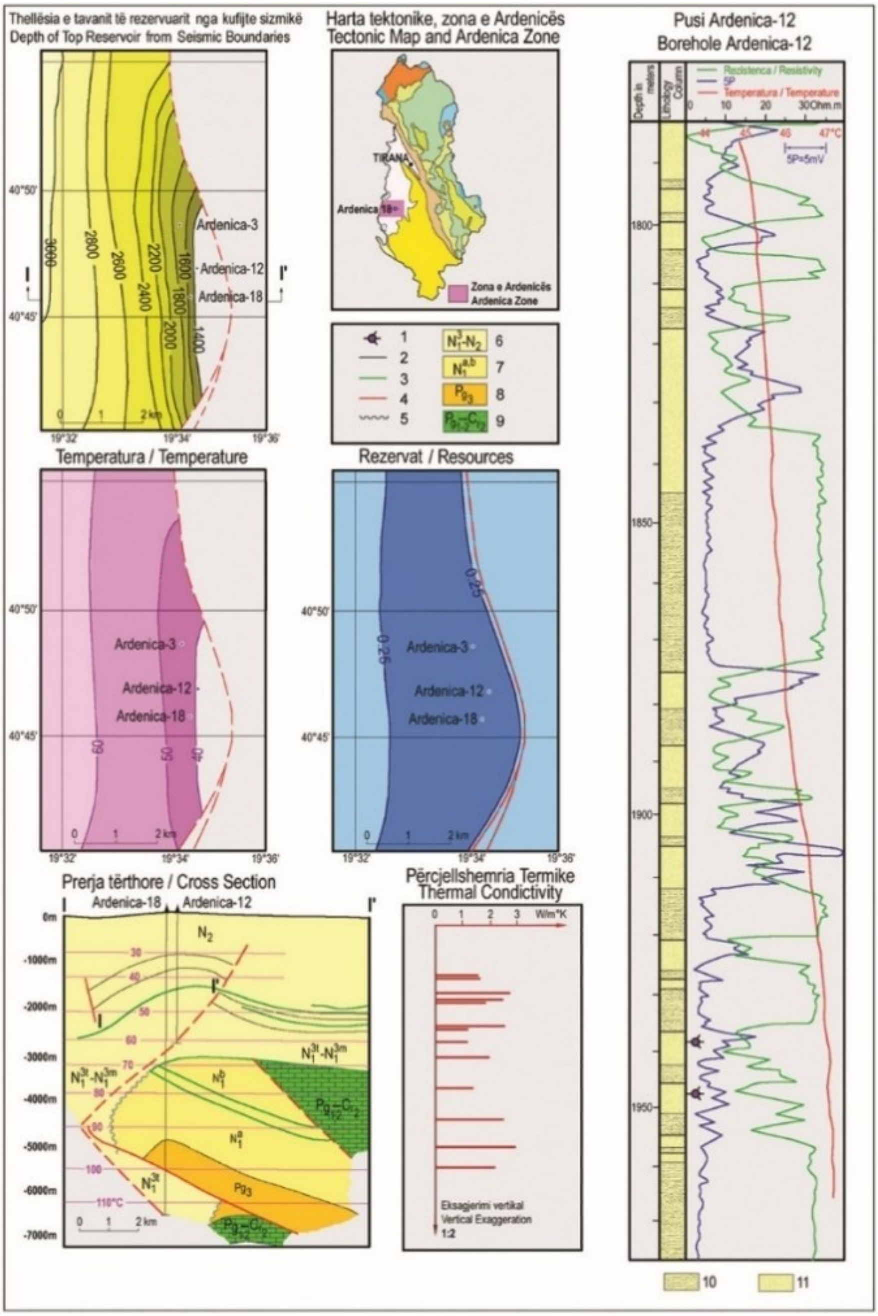

Figure 6: Ardenica geothermal zone map

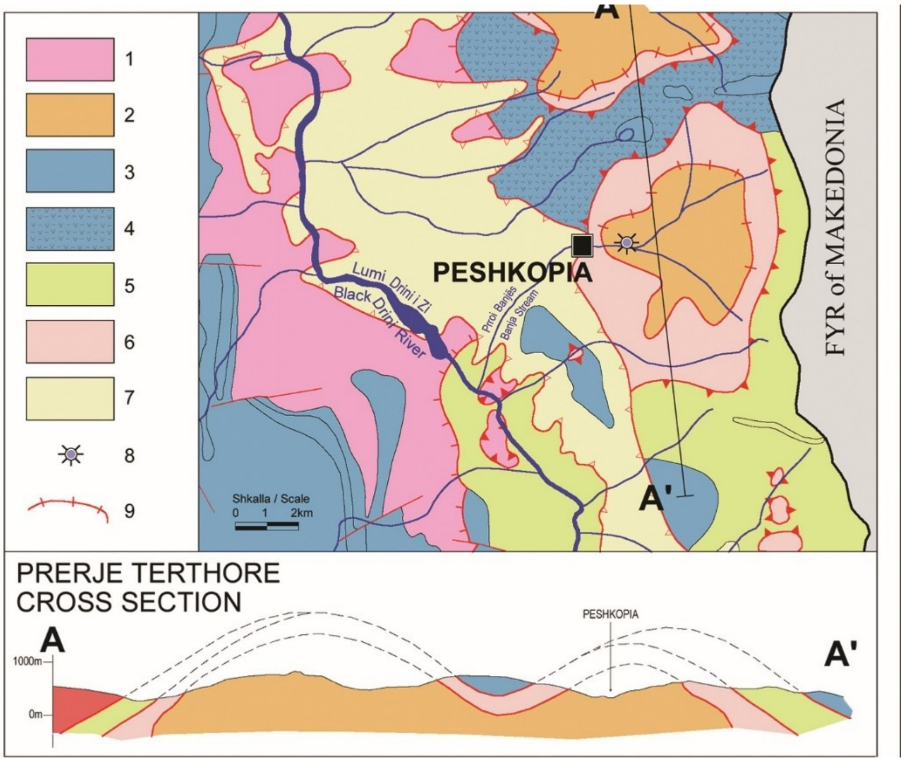

Figure 7: Peshkopia geothermal zone map

Evaporite diapir extends vertically over 3-4 km (Kodra A. et al. 1993) and comprises the main aquifer of this geothermal system. The occurrence of thermal waters is connected with the low circulation zone always under water pressure. Where gypsum plunges, under the level of free circulation zone, the presence of H_2S can be detected in the water. The thermal waters are of sulphate-calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H_2S. Their chemical formula is (Avgustinsky V. L. 1957):

$$H_2S_{0.0495}M_{4.4}\frac{SO_{56}^{4}}{Ca_{65}}$$

In the riverbed, outcrops of anhydrides and gypsum are located, also with a big yield of cold mineralized water springs, sulphate-calcium type. The temperature is 12°C. Different geothermometers indicate the reservoir temperatures are 140 - 270°C. Considering the regional geothermal gradient, temperatures of 220°C would be found at depth of 8 - 12 km. However, the gypsum diapir represents e high thermal conductivity body focusing heat from its surroundings. Therefore, water could become warmer at shallow depths, suggested by the geothermal gradient. Water temperature, big yield, stability, and also aquifer temperature of Peshkopia Geothermal Area, are similar with those of Kruja Geothermal Area. For this reason, the geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana-Elbasani area (Frashëri et al. 2004).

3. DISCUSSION

It is obvious that Albania has much to do for a deeper understanding, assessment and utilization of the Geothermal Resources. The private investments are not yet attracted by its use; therefore, the authorities should consider ways to incentivize and promote the development of this sector. Although significant progress has been done toward the completion of the legal framework to promote the usage of the Renewable Resources of energy in Albania, more should be done regarding the financing of such projects.

4. FUTURE DEVELOPMENTS AND INSTALLATIONS

Attracted from the high energetic values of Llixha Elbasan springs as well as of the water gushing from Kozani 8 well, a private investor has started the preparation of the preliminary design for their use, however it is very difficult to make any accurate and reliable estimation on the time when shall start and the respective completion date.

5. ACKNOWLEDGMENTS

This paper goes in memory of Prof. Dr. Alfred Frashëri, the pioneer of the Geothermal Energy in Albania, a man who did herculean efforts to promote its usage for the energy potential, the promotor of the law on "Renewable Energies" in Albania.

6. SUMMARY

In the past five years in Albania, regarding the Geothermal Energy, unfortunately progress have been made mostly on the legal basis. Three laws and one DoCM have been approved paving the road toward its utilization. Although the geothermal regime of the country does not seem to promote and support energy generation via the conventional schemes, still it shows significant potential on the direct use. The limited number of units (heat pumps) installed as of today proofs that still the country is only on the first steps of its use. It

remains to the Albanian authorities and to financial institutions to create a portfolio with the clear aim of incentive the sector. Otherwise it shall be at the mercy of sporadic investments of small investors/donors, and limited to the health purposes, but never reaching the real potential that country has.

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APPENDIX 1 GEOTHERMAL UTILIZATION

Table 1: Present and planned production of electricity

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2019	0	0	97	0	2,283	7,629	0	0	0	0	2,380	7,629
Under construction in December 2019	0	0	0	0	557.8	2,435	0	0	0	0	557.8	2,435
Funds committed, but not yet under construction in December 2019	0	0	0	0	1,204	5,391	0	0	50	0	1,254	5,391
Estimated total projected use by 2020	0	0	97	0	4,045	15,455	0	0	50	0	4,192	15,455

Table 2: Geothermal (ground-source) heat pumps as of 31 December 2019

Locality	Ground or Water Temp. (ºC)	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type	COP	Heating Equivalent Full Load (Hr/Year)	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
Tirana (Pallati i Kulturës)	18	500	2	Water-Water	4.06	4960	N/A	N/A
Tirana (Twin Towers)	16	1200	6	Water-Water	4.06	4960	N/A	N/A
Shkodra (Peter Mahringer High School)	13	180	2	Ground-Water	N/A	N/A	N/A	N/A
Korça (Kindergarten)	12	22.7	1	Water-Water	3.9	5230	N/A	N/A
TOTAL		1902.7	11		12.02	15150		

Table 3: Summary table of Geothermal Direct Heat Uses as of 31 December 2019

Use	Installed Capacity (MWt)	Annual Energy Use (TJ/yr = 10^{12} J/yr)	Capacity Factor
Individual Space Heating	N/A	N/A	N/A
District Heating	N/A	N/A	N/A
Air Conditioning (Cooling)	N/A	N/A	N/A
Greenhouse Heating	N/A	N/A	N/A
Fish Farming	N/A	N/A	N/A
Animal Farming	N/A	N/A	N/A
Agricultural Drying	N/A	N/A	N/A
Industrial Process Heat	N/A	N/A	N/A
Snow Melting	N/A	N/A	N/A
Bathing and Swimming	N/A	N/A	N/A
Other Uses (specify)	N/A	N/A	N/A
Subtotal	N/A	N/A	N/A
Geothermal Heat Pumps	1.9027	10.3773258	0.183351669
TOTAL	1.9027	10.3773258	0.183351669