

# Thermal Mineral Water Source In Kllokot, Correlated With The Spread Of Seismic Waves In Zone

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## Abstract

The region of Morava e Binçit, where many thermo-mineral springs spring, is located in the seismogenic zone Ferizaj-Viti-Gjilan, of the general seismic classification of our country. Based on the existing seismological data, tectonic maps and geological data, in particular of the Gjilan region in this area, the potentials of geothermal fields are related to the development of tectonics in this area. The built seismic profile, based on information obtained from depths, illustrates all the diamic and geothermal elements of this area. The peculiarities of the earth's crust, in particular of the study area, show that the Gjilan region, in the extension of the wide geothermal area in Morava i Binçit has a structure that is of interest to know about the generation of geothermal energy sources and other groundwater of which are precisely related to the seismic activity of the area. To highlight the relationship between the existence of water, as well as thermo-mineral water and seismic, the data are taken from my dissertation work, as well as from geophysical research conducted in October 2011, using the ABEM seismic apparatus, " Terraloc seismic system - mark 3 ", from the Swedish company, exactly for:" Urban block Baja "where hot water is generally in inversion (inversely) close to the propagation of seismic waves, in this geothermal area. The description provides the definition of the parameters of geological environments with groundwater which environments indicate the values  $\rho$  of seismic velocities  $V_p$  and  $V_s$ , predominant periods and densities  $\rho$  of the amplifying surfaces of Quaternary deposits and unconnected surface layers of Neogene as well as rocks of old geological. In this paper, the results of the study provide data on the near surface waters that emerge in the tectonic structures in the valley, in Kllokot, in the area of junctions of deep fractures and those representative presence filled with tertiary sediments, with heat flux flow. at low speeds where other water sources can be expected.

**Key terms:** Kllokot springs, low speed, layers

## Introduction

Kosovo, as part of the Western Balkans region, is a country rich in geothermal energy. Geothermal zoning, based on the geotectonic structure of the Earth's crust, precisely in Morava i Binçës in terms of geothermal exploitation are quite promising. Kllokot, has a significant geothermal energy potential. The use of this geothermal energy is provided by hot layers of soil, but also by hot waters, with temperatures above  $20^{\circ}\text{C}$  that in this area come to the surface, exactly south-west of Gjilan, at the eastern end of the Municipality of Kllokot.

The healing properties of the mineral waters of Kllokot have been known since the middle of the 19th century. The waters of Kllokot Spa have been used since ancient times, of Dardania, in the time of the Roman Empire, and in the literature there are records for the use of these waters by the Turkish Empire since 1455, etc..

Many physical phenomena can affect the thermal field in the region. Variation of lithology, low -velocity areas, topography of the area lead to an extremely complicated distribution of the geothermal gradient, as well as the distribution of heat flux, which is controlled and dominated by the presence of geothermal waters.

Through this paper we will try to determine the groundwater levels in the layers of horizontal propagation, in correlation with the seismic data of low velocities that show a change in the reduction of P-waves and S-waves, which are the basis of data of special interest in the Kllokot region.

The identification of these inland layers provides valuable information for the study of geothermal fields.

The analysis of low velocity layers allows us to further develop our imagination on the geodynamic and geothermal processes that accompany the accumulation of stresses and swelling of rocks and their release in the form of earthquakes and thermal water sources, precisely in the Klllokot area.

## Methodology

For the specifics of thermo-mineral waters and their correlation with seismicity, the data were collected from my dissertation work with the data of conditions, geothermal, magmatic and structural-tectonic as well as using and determining the water levels from the reports issued for it. All drilled wells in this region, based only on the published data of the seismic risk analysis of the region presented with the transverse profiles of the seismic wave velocity with the compilation of valid data in the territory of Gjilan in particular for the 'Urban Block Baja', by a group of experts IZ I I S, Skopje and N T P ERAMED-Pristina, Kosovo. This comparative methodology can provide final information on the existence of abundant water in the near-surface layers but also in the thermo-mineral ones.

## Geological and seismotectonic characteristics

The Quaternary lowland in Morava i Binçit, extending from Ferizaj, Viti and further towards Gjilan, is surrounded by rock complexes with anticline structure with volcanic composition with low metamorphism, as heat generators. Depression at a young age of formation in the generations of seismically active regional seismic tectonics in Morava i Binçit, is related to the outlines of the system of detachments that intersect the fracture of the direction, Vardar, with the transverse ones, <sup>[1]</sup> represent traffic routes and places where known thermal waters emerge. In the eastern part of the urban area of Gjilan <sup>[2]</sup>, namely the urban block Baje of Klllokot, are present geological formations of volcanic rocks that represent the basic physical-geological characteristics of the area. Referring to the geological map of Gjilan (scale 1: 100000), the marginal resource area in Klllokot 1,2,3, 4, to the north-east, is built by the following geological formations: at the base there are rocks (limestone) of Jurassic (c J<sub>2-3</sub>) covered with alluvial-deluvial Quaternary (a Qh) rocks of clay, gravel-sand, with a thickness of 20 m to 30 m and with fragments of rocks, sand and mud ((dQh) <sup>[2]</sup>.

At their base are Jurassic carbonate rocks (smJ<sub>2-3</sub>) with tectonic mixture with limestone, shale, formation volcanic rocks and Miocene cement clay sediments (m N m<sup>2</sup>), composed of marlstones, clays, sandstone, parts, and lignite. These studies <sup>[3]</sup> showed that the surface terrain is composed of:

- clay, gravel-sand, (CH) High or plastic (CI) at depths 0.4 - 3.0 m,
- clay-sand gravel, at depths of 2.5 - 5.5 m,
- mud-clay clay under high sediments,

The groundwater level ranges between 0 and 4.0 m, while the richest aquifers of thermomineral water are found at shallow depths up to 200 m <sup>[3]</sup>.

## Today's seismic activity of the area

Based on the existing seismological data, tectonic maps and geological data, in the territory of Kosovo, the southeast of Gjilan and its surroundings is defined as a seismogenic area.

This area is distinguished for tectonic disturbances and fractures and their intersection, in which conditions are created for the formation and maturation of thermal waters, as well as their emergence to the surface.

Traces of late volcanic activity in this geothermal area have followed the displacement of the NW-SE terrain, subjected to a new tectonic depression (Morav e Binçës) which is associated with diving along transverse dislocations, which interrupt those of the direction of Vardarite and representing the circulation and exit of the known waters of Klllokot. This fact testifies to the creation of reservoirs and the supply and storage of large quantities of water, since early geological times.

Existence of regional transverse detachments Kaçanik-Gjilan, and Morava e Binçit <sup>[1]</sup>, in the main direction from northwest to southeast with the intersection of the deep Grastik fracture, considered as a

carrier of hydrothermal solutions, the presence of volcanic phenomena and volcanic phenomena thermal, indicate a high seismic activity of the region.

Layers with high heat generating temperatures and low seismic velocities are characteristic of seismoactive and geothermal regions, which directly affect the Earth's crust. As a result of the high temperature, in these areas melting of the material, creation of thermal waters can occur, and consequently, we will have an expansion of the volume of the rocks, which will lead to an increase of vertical or horizontal stresses and, meanwhile, at the birth of seismic activity (Kociaj, 1986; Ormeri, 2010). Precisely for the Kllokot area, seismoactive fractures resulting from compressive stress leading to rock deformation (expansion of rock volume), and the association between tectonics, seismic activity, and geochemical properties of circulating fluids, indicate that these fluids are composed of extracted from rocks, as a result of compressive stress, in this area<sup>[4]</sup>.

Low-velocity P-wave and S-wave seismic data, in correlation with well drilling lithology, to conclude water existence.

## RESULTS AND DISCUSSION

Field observations have found very interesting facts, which help to achieve a more scientific conception of the drainage of these waters to the surface and their relationship with the geotectonic model of depth. To define the parameters of geological environments which environments show local effects different from regional seismic displacements, such as: depth H, values of seismic velocities  $V_p$  and  $V_s$ , predominant periods and densities  $\rho$  of the amplifying surfaces of Quaternary deposits and surface layers unconnected Neogene as well as old geological rocks.

In our study, the area of seismic belt in the part of EVZ, Baja urban block area is of interest, exactly in the eastern part, for which geophysical researches are presented for the analysis of seismicity of transverse profiles by determining the speeds of seismic waves defined on the surface of urban water basins that can also be the basis for the hot waters of Baja.

With reference to the research data of the region, from the study of wave propagation and seismic velocities  $V_p$  and  $V_s$ , as well as their deviation in the result is obtained seismic profiling based on information obtained from depths, illustrating all the diamic and geothermal elements. of this source area (Figure 1), numerous existences of the "Shadow Zone" are observed (in which the P-wave velocity is reduced, based on the data of the seismologist RD Oldham, 1906).

The results are analogous to those offered by the literature of B. Milovanovic, to quote: "the aquifer thermo-mineral waters of the Kllokot springs are located on several levels in tertiary formations and basic formations." With the stable thermo-hydrodynamic regime of Baja waters, as well as the results of drilling, we allow it to be predicted that in the geothermal area of Kllokot, new sources with geothermal energy reserves can be found<sup>[5]</sup>.

The data are from researches performed based on the applications of the refractive (refraction) method with standards of geological environments for determining the values of seismic velocities  $V_p$  and  $V_s$ . Measurements were performed on profiles with a length of 65 to 120 m. The interpretation of the directly measured profiles determines the geological and physical structure of the source terrain of Baja "Kllokot" and the source of Baja "Nena Naile" by also defining the values of seismic velocities  $V_p$  and  $V_s$ , in the description:

The terrain from the RP 1-2 block, which is the thermal source of the Kllokot Bay 1 and 2, has a structure composed of Quaternary and Miocene sediments, as well as Jurassic rocks. At depth (dQh) diluviums - fragments of rock, mud, sand, silt. with a thickness of 20 m to 30 m the velocity of the P waves decreases from  $V_p = 545 \text{ m/s}$  and  $V_s = 240 \text{ m/s}$  instead of  $V_p = 375 \text{ m/s}$  and  $V_s = 110 \text{ m/s}$  with variation  $\Delta V = 170 \text{ m/s}$ . Above 30 m depth in the Jurassic ( $J_{2-3}$ ) layers - in meta-carbonate-marble rocks, the P-wave velocity began to decrease significantly from  $V_p = 3265 \text{ m/s}$  to  $V_p = 2525 \text{ m/s}$  and with  $V_s = 1650 \text{ m/s}$  in  $V_s = 1000 \text{ m/s}$  with variation  $\Delta V_p / V_s = 740 / 650 \text{ m/s}^{(3)}$ . These changes are present in the whole up to 120m, depth and give an understanding of the characteristics of the seismoactive and geothermal regions of the area<sup>(2)</sup>. The changes describe the entire thickness of the rock layer of the Jurassic composition (c J 2-3) where we also find the richest aquifers of thermomineral waters (Milovanović B., 1996), at shallow

depths up to 200m (Figure 1) in the breccia volcanic, porous tuffs, layers of sand, gravel and volcanic-sedimentary limestone with tertiary volcanic-sedimentary formations [2].

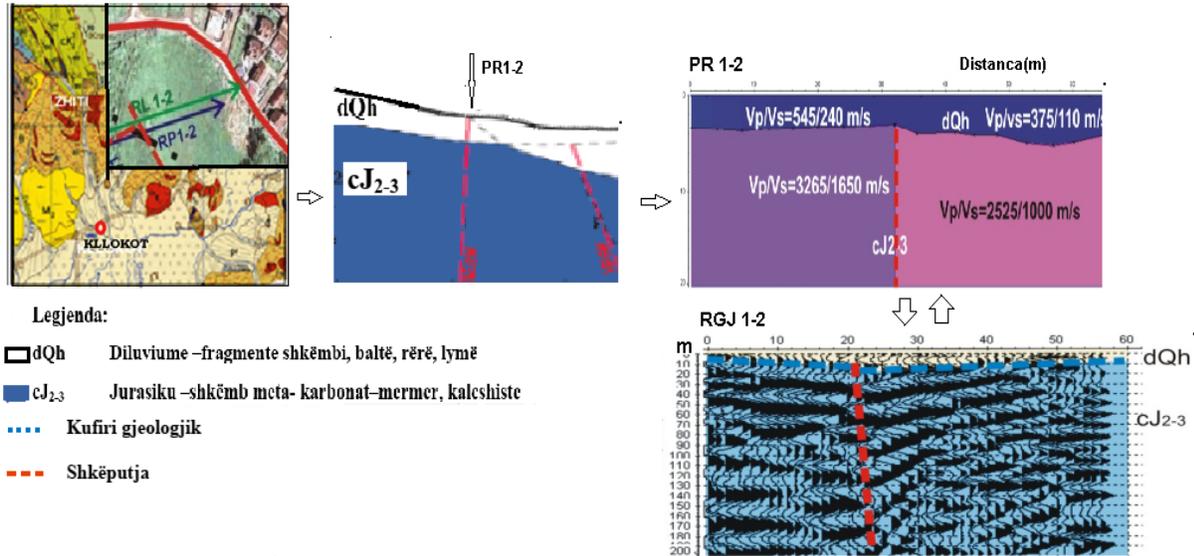


Figure 1. Schematic geological and seismic profiling of the source area of Baja in Killokot 1-2 (modified by A.Zuna)

Although at a distance of several hundred meters, the refractive seismic profile PR1-4, precisely in the source area of Banja “Nëna Naile, interpret alternating changes of lithological composition in the horizontal layers. The area has structure composed of Quaternary and Miocene sediments, as well as the basic rocks of the Jurassic. At depth (dQh) diluviums - fragments of rock, mud, sand, silt, which go with a shallow thickness of 2 m to a depth of 6 m, the velocity of P waves has changes from  $V_p / V_s = 660 / 270$  m / s and  $V_p / V_s = 715 / 320$  m / s with variation  $\Delta V_p / V_s = 55 / 50$  m / s. Significant changes are observed in the Jurassic strata with meta-carbonate-marble, calcareous rocks, where the velocities of P and S waves significantly begin to change from  $V_p / V_s = 1225 / 400$  m / s to  $V_p / V_s = 1200 / 520$  m / s [3]. Significant change of seismic waves has been found to be at the lithological dividing boundary of the Jurassic with a composition of volcanic-sedimentary marbles and diabases and limestones, which form almost the entire layer at a depth of about 450 meters (Proti D.1995, Milovanović B., 1996), where the velocities, based on seismic profiling have value from  $V_p / V_s = 2180 / 850$  m / s to  $V_p / V_s = 2550 / 1020$  m / s with pronounced variation  $\Delta V_p / V_s = 370 / 170$  m / s, in Figure 2

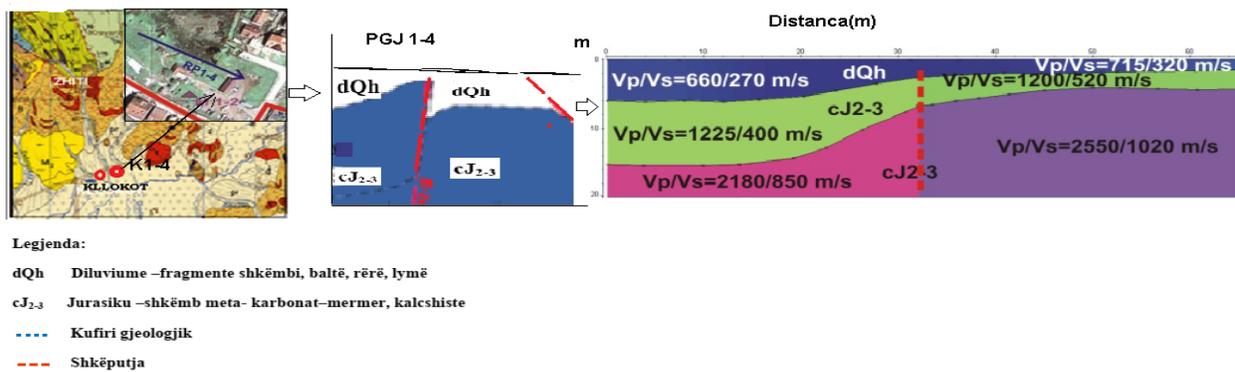


Figure 2. Schematic geological and seismic profiling of the source area of Baja Nëna Naile 1-4 (modified by A.Zuna)

## CONCLUSION

- The tectonic zone of Klllokot is characterized by a strong tectonic-structural development, expressed with anticline structure, in the Quaternary Lowland in Morava i Binçit, surrounded by rock complexes with volcanic composition with low metamorphism, as heat generators.
- Deep buried structures, for the most part, are eroded, which means that for a certain geological time, they are exposed to the surface undergoing a strong erosion, then submerged in depth, being covered by molasses formations and thus turning into water basins with thermomineral possibilities.
- The thermal waters in the Klllokot area correlate in space with low velocity layers.
- In the logic of this discussion from seismic profiles it is understood that along the tectonic zone of Klllokot meet so much mineral and thermo-mineral water, turning it into a hot zone, as well as an opportunity for the discovery of new reserves, mineral and thermo-mineral water
- The heat sources are located in the hot aquifers, up to 100 m (PR 1-2) respectively 450 m ( PR 1- 4 , depth, below the surface of the source area.
- As a consequence of the generated temperature, the existence of low velocity layers should be a source of geothermal energy of hot water which, having a high temperature, can be used as an energy source in this area.
- Following the logic of this discussion from seismic profiles it is understood that along the tectonic zone of Klllokot meet so much mineral and thermo-mineral water, turning it into a hot zone, as well as an opportunity for the discovery of new reserves, mineral and thermo-mineral water

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