BABEȘ-BOLYAI UNIVERSITY
FACULTY OFGEOGRAPHY

PHD THESIS

Mineral water resources on the western slopes of South Harghita Mountains and their capitalization opportunities

- Summary -

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TABEL OF CONTENTS

1. GENERAL ASPECTS

1.1 Introduction

We consider as a paradox the fact that at the beginning of the XXIst Century there is still not enough quantitative information concerning certain types of resources. Most of the researchers in natural science are often concentrated upon the detailed and sophisticated analysis, trying to keep up with the scientific progress and still one can see how restrained is the knowledge about the subsurface resources which worth to be exploited. The case is the same for the Romanian natural mineral waters.

During the last years in Romania there have been published many studies and researches concerning the mineral waters. But we have to highlight the fact that all the articles process the data of the most known springs or the analysis of few springs and then they give a description of the whole area. No one has been trying the description and the complete inventory of all the mineral waters in a certain area.

This work pretends to be an exhaustive study as far as possible concerning the mineral water resources from the South-Western part of Harghita Mountains and it tries to intercept aspects concerning their location, physical and chemical characteristics, their therapy properties, their economic value and other essential elements also within the context of elaborating some sets of local and areal capitalization scenarios.

The results presented in this study were obtained after having measured/mapped 44 rivers, from their confluence to their spring and after having walked for about 600 km in the period of September 2012 - May 2013.

The reason of choosing this subject is based on two aspects: (1) the contradiction between the greater and greater importance given to this praiseful resource in other countries and the reduction of its exploitation in Romania (2) the will to provide an updated, exact and complete image concerning the potential of the mineral waters available in an area where this resources are only partially exploited and the knowledge about them is incomplete, especially from the quantitative point of view.

Thus we decided to make a study describing all the mineral springs in the investigated area and their detailed description, by providing some data acquired by the same measuring method used for all the cases. The measured data shall be available for the large public on a web page in order to be used in various purposes (economic, administrative etc.). At the same time we want this work to represent a starting point for further researches.

This research has also the purpose to make the reader aware of the great number of natural mineral water springs that Transylvania has and to point out the importance of the new investments in this field in order to significantly improve the exploitation degree for this valuable resource.

The investigated area, the South-Western part of Harghita Mountains is remarked by an exceptionally valuable potential of mineral waters. The mineral springs in this area are connected to volcanic activities which took place about 21 – 0.03/0.01 million years ago along the internal line of the Carpathians starting from the Bükk Mountains in Hungary, extending towards the South of Poland, the North and the Center of Slovakia and having the last segment in the Romanian Eastern Carpathians: Harghita Mounts (Lexa et al., 2010).

The Southern part of Harghita Mountains, the last volcanic edifices of the Eastern Carpathians , active between 5 and 0.03/0.01 million years ago, might be characterized by the abundance of post-volcanic phenomena such as carbonated mineral springs.

Mineral water springs appear as post-volcanic phenomena due to the minerals and gases dissolved in water. Underground, the meteoric water most often assimilates the carbon dioxide running between the payers and by washing the magmatic rocks it dissolves different minerals thus getting to generate multiple types of mineral water.

The work is structured as follows:

The first chapter represents the introductive part of the thesis and it has as a purpose to get the reader familiarized with the studied field, presenting its most important geographical characteristics. At the same time, it defines the subject to be analyzed and also the research methodology.

The second chapter aims the history of mineral water research by going through the bibliography from the eighteenth century till now. There shall be presented the most important books and articles containing information about the springs from the South-Western area of Harghita Mountains and also the legal provisions recently appeared.

The third chapter called "Cunoștințe generale legate de geneza apelor minerale" [General information concerning the mineral water genesis] treats the problem of the volcanoes from the South Harghita Mountains, phenomenon generating the actual appearance of the post-volcanic phenomena and which by the structure of the created layers has a strong influence upon the mineral water characteristics. There shall be also presented the spring genesis, the obtained information representing the starting point of the field research.

The fourth chapter is designated to present the 92 mineral springs mapped on the South-Western part of Harghita Mountains during the field research that represent the totality of mineral water resources in the area. The spring description is based on the personal observation made in field and on the physical and chemical parameters measured on this occasion. Here, besides the detailed description of certain springs characteristics generally presented in previous works, we have proceeded to the description and characterization of a number of 32 springs discovered and analyzed during the field observation. This is why we appreciate that this chapter is the most representative from the point of view of the new and consistent personal contributions.

The fifth chapter is dedicated to the introduction in the Romanian literature of the cold water “geysers” by presenting the actual phenomena in the valley of the Chirui river.

The sixth chapter aims to classify the mineral springs according to their location in the geologic environment and also according to the physical and chemical characteristics using the Cluster analysis. In both of the cases there are emphasized seven classes presenting different results.

The seventh chapter is designated to get the actual national exploitation of mineral waters compared to other European countries. There shall be emphasized the developed projects, the actual exploitation and promotion and also the official development plans in this field.

The eighth chapter is presenting our ideas for the capitalization opportunities of the mineral water resources based on the field observations and on the spring characteristics considering the successful solutions applied by other European countries. By emphasizing the therapy, touristic and industrial potential, we wish that the mineral water resources on the South-Western part of Harghita Mountains shall be studied by more detailed research for a proper exploitation in future.

In **Chapter nine** there are listed the most important conclusions took during the research and presented in detail in chapters 1-8.

1.2. Delimitation of the studied area

For the procedure of delimiting the studied area we have considered geologic, geographic and hydrographical criteria.

The South-Western and Southern limits of the studied area correspond to the limit of the volcanogenic-sedimentary layers of the surface.

On the East side, the limit corresponds to the line of the watershed separating the water basins turning towards the Ciuc Basin from the ones belonging to the Baraolt Basin.

On the North-West we have considered the limit of the South area of Harghita Mountains based on the determination made by László Attila in his doctoral thesis having the title "Studiul geologic al structurilor vulcanice din partea sudică a Masivului Harghita" [The Geological Study of the Volcanic Structures in the South Harghita Mountins] (1999).

The hydrographical aspects were essential in including the rivers from their spring to their confluence. We think it is important not to cut in two the basins for geographic or mapping reasons.

The determined area has a surface of 342 km^2 and it partially includes the hydrographical basins of Vârghiş, Cormoş and Baraolt.

1.3. Used methods

Generally the springs appear along the valleys. So the springs' identification needs a mapping of all the valleys from the confluence to the spring along all the investigated area. On the South-Western part of Harghita Mountains there were mapped the significant permanent valleys, meaning 44 rivers on different lengths belonging to the hydrographical basins of Vârghiş, Cormoş and Baraolt. Thus in the autumn of 2011, in the autumn of 2012 and in the spring of 2013 there have been identified 92 carbonated mineral water springs along the rivers.

In order to identify the precise location of the springs, there has been used a Garmin CSx 60 GPS, a navigation unit meant for the field use. This GPS is equipped with a bathometric altimeter and it presents the position in geographical coordinates.

Determination of physical and chemical parameters by the method of analysis

The description of springs implies the following aspects: name, hydrographical basin, information concerning the location, origin, activity, description of the apparition form, the spring endowment, vulnerability to certain risks, the geological environment, physical and chemical parameters and other observation. The measurements were concentrated upon the most important physical and chemical parameters. These are the following: discharge, temperature, electric conductivity, TDS (Total Dissolved Solids as mineralization), pH, carbon dioxide and hydrogen carbonate, calcium, magnesium, total iron, chlorides. Among the contamination indicators there are the nitrates, ammonium and phosphates.

In order to measure the **temperature, the electrical conductivity, the TDS, the pH,** it has been used a multi-parameter portable device equipped with electrodes, Thermo Orion 5 Star.

The content of carbon dioxide and carbonate hydrogen was measured by the method of classical analytical chemistry with pipettes. In order to measure the concentration of dissolved **carbon dioxide** there have been used water stamps, a solution of sodium hydroxide of 1N concentration and phenolphthalein in liquid. In order to measure the concentration of **hydrogen carbonate** we use the water sample, chloride acid of 1N concentration and methyl orange in liquid.

The main cations and anions (**calcium, magnesium, chloride**), respectively the **ammonium and phosphates** were measured by a reflectometer, Merck RQFlex plus 10. The determination of concentration in chemical elements and substances is made by using test strip Merck that must be wetted with the water sample and introduced into the device.

In order to determine the concentration of the **nitrate** it has been used a Nitacheck 404 reflectometer. The measurement was made using the Merck test strips which were wetted with the water sample and introduce in the device.

The determination of **total iron** concentration was made by the colorimetric method using an Aquaquant Merck kit. We have to mention that using this method we cannot obtain exact results.

If the concentration of one parameter has passed the possible range of measurement, we have diluted the water sample with distilled water and the result was multiplied proportionally according to the dilution.

For the case of Forajului Pâlpâitor [Blinking Drilling] from the valley of Chirui river, the measurements concerning the discharge, temperature, electrical conductivity and dissolved carbon dioxide content were made with one hour frequency (measurements hourly during the entire cycle). The hydrostatic pressure was measured with the Dataqua DA-S-LTRB 118 device at the depths of 10 and 20 m.

2. MINERAL WATER AS A POST-VOLCANIC PHENOMENON

The word post-volcanic phenomenon refers to the totality of natural processes shown in the neighbor areas of an inactive volcano. They consist in the delivery of thermal energy and volatile substances in the area of volcanic rocks long time after the volcanic activity and they represent the effects of cooling and disaggregation of profound magmatic chambers (Szakács, 2010). The constant manifestations on the surface area include thermal anomalies and thermal springs, gas emanations (the carbon dioxide or the hydrogen sulfide), carbonated mineral water springs and the corresponding deposits (Szakács, 2010). Where these post-volcanic manifestations are intense there has formed the so called mofetta “aureola” in the Eastern Carpathians (Airinei &Pricăjan, 1972). According to Pricăjan (1982), the gas emanations are rare in the area of the actual eruptive but they are more frequent and intense in the neighbor areas of the volcanic mountains and they are fewer in the far areas. In order to explain the mineral water genesis we have to consider several agents: the water origin, the water circuits between the layers, the crossed geological structure, the origin of the dissolved elements and the mechanism of solubility (Kisgyörgy & Kristó, 1978; Bányai, 1957).

As far as we got, there isn’t any integral cadastre/database of the mineral water resources for the area of eruptive mountains. Bányai J. (1934b) approximates their number over 2000, Pricăjan (1972) speaks about over 1000 springs in Harghita county and Szakács (2010) also, estimates a number of thousands for the entire territory of the mofetta aureola.

3. MINERAL WATER SPRING ON THE SOUTH-WESTERN PART OF HARGHITA MOUNTAINS

In order to make an inventory of mineral water springs it has been started from the works describing in detail their situation (as localization and physical and chemical properties) emphasizing those having as authors Kisgyörgy Z. (1975), Szász Á. (2005) and Jánosi Cs. et al. (2009). The information provided by them was compared to the reality in the field during several itineraries having as purpose the validation of data in the mentioned bibliographical sources, the discovery of new sources and also the description and the determination of physical and chemical characteristics of the springs.

The tables below include the list of mineral water springs in the studied area being noted the springs described by the mentioned authors and also the springs found and mapped by personal investigations. In the tables we have used the signs "+" and "-" referring to the inventory ("+") or non-inventory ("-") of a certain spring. By the sign "!!!" we have marked the springs not noted in the literature and thus they can be considered and new springs of mineral water discovered by the author and they are described for the first time in this work.

Tabelul 1. Lista izvoarelor de apă minerală din bazinul hidrografic al pârâului Baraolt

Nr.	Numele apei min.	Kisgyörgy Z., 1975	Szász Á., 2005	Jánosi Cs., 2009	Czellecz B., Szász Á., 2012-2013
	Pârâul Șopotul				
1	Izv. Súgó	+	+	+	+
2	Izv. Súgópataki	-	-	+	-
3	Izv. nr. 2 din pâr. Șopotul	-	-	-	**+ (!!!)**
4	Izv. Köveshegyi	+	+	+	+
5	Izv. nr. 3 din pâr. Șopotul	-	-	-	**+ (!!!)**
6	Izv. Mihály András	+	+	+	+
7	Izv. Magyaros Alji	+	Dispărut	+	-
8	Izv. Pihenői	+	Dispărut	-	-
9	Izv. în amonte de Mihály A.	-	-	-	**+ (!!!)**
10	Izv. Muhási	+	-	+	-
	Pârâul Șarpele				
1	Izv. Rezes	+	+	+	+
2	Izv. Nádasalji/ Izv. nr. 2 din pâr. Șarpele	+	+	+	+
3	Izv. nr. 3 din pâr. Șarpele	-	-	-	**+ (!!!)**
4	Izv. Veress Dezső	+	Dispărut	+	-

Nr.	Numele apei min.	Kisgyörgy Z., 1975	Szász Á., 2005	Jánosi Cs., 2009	Czellecz B., Szász Á., 2012-2013
5	Izv. Nagyágsorki	-	-	+	-
6	Movila feruginoasă cu apă min. nr. 1	-	-	-	**+ (!!!)**
7	Movila feruginoasă cu apă min. nr. 2	-	-	-	**+ (!!!)**
8	Movila feruginoasă cu apă min. nr. 3/ Izv. Fenyősorri	+	+	+	+
9	Movila feruginoasă cu apă min. nr. 4	-	-	-	**+ (!!!)**
10	Movila feruginoasă cu apă min. nr. 5	-	-	-	**+ (!!!)**
	Pârâul Uscat				
1	Izv. din pârâul Uscat	nu este menționat	nu este menționat	nu este menționat	**+ (!!!)**
	Pârâul Lung	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	<u>Pârâul Bradul Mare</u>				
1	Izv. Kőrises 1/ Bolond	+	+	+	+
2	Izv. Kőrises 2/ Foraj vechi din pâr. Bradul	+	+	+	-
	Foraj hidrogeol. nou	-	-	-	**+ (!!!)**
3	Izv. Tamásné	+	+	-	+
4	Izv. Balló	+	-	-	-
5	Izv. Zöld Pál	+	-	-	-
6	Izv. Érces	+	+	+	+
7	Foraj hidrogeol. vechi din Bodvaj	+	+	+	+
8	Szonda 439	+	+	-	Disp.
9	Izv. Nagyfenyősi, Buzgó	+	-	+	+
	Pârâul Bradul Mic				
1	Izv. Kisfenyősi cu captare	+	+	+	+
2	Izv. Kisfenyősi fără captare	-	-	-	**+ (!!!)**
	Pârâul Mic Pietros				
1	Izv. Györgykovácsloki 1	+	Dispărut	+	+
2	Izv. Györgykovácsloki 2	+	Dispărut	+	+
3	Izv. Györgykovácsloki 3	+	Dispărut	+	+
4	Izv. Györgykovácsloki 4	-	-	+	-
5	Stațiunea balneară a lui Elek Apó	+	Dispărut	+	Dispărut
	Pârâul Érces (Minereu)				
1	Caverna cu apă min. nr. 1	+	+	+	+
2	Caverna cu apă min.nr. 2	-	+	+	+

Nr.	Numele apei min.	Kisgyörgy Z., 1975	Szász Á., 2005	Jánosi Cs., 2009	Czellecz B., Szász Á., 2012-2013
3	Caverna cu apă min.nr. 3	**-**	**+**	**+**	**+**
4	Izv. în aval de caverne nr. 1	**-**	**+**	**+**	**+ (!!!)**
5	Izv. în aval de caverne nr. 2	**-**	**-**	**-**	**+ (!!!)**
6	Izv. în aval de caverne nr. 3	**-**	**-**	**-**	**+ (!!!)**
7	Izv. în aval de caverne nr. 4	**-**	**-**	**-**	**+ (!!!)**
8	Izv. în aval de caverne nr. 5	**-**	**-**	**-**	**+ (!!!)**
9	Izv. Istenkasi	**+**	**-**	**+**	**-**
10	Izv. Gyöngyerdő alatti	**+**	**-**	**-**	**-**
	Pârâul Pietros				
1	Izv. Kövespataki	**+**	**+**	**+**	**+**
	Pârâul Ulmul				
1	Izv. din pâr. Ulmul	**+**	**-**	**+**	**+**
2	Izv. Pista	**-**	**-**	**-**	**+ (!!!)**
3	Izv. Kicsi Pista	**-**	**-**	**-**	**+ (!!!)**
	Pârâul Baraolt				
1	Izv. Rezes	**+**	**+**	**+**	**+**
2	Bazinul Rezes/Baia lui Nea Mackó	**-**	**-**	**+**	**+**
3	Izv. Alszegi	**+**	**+**	**+**	**+**
4	Izv. Dimény Ágnes	**-**	**+**	**+**	**+**
5	Izv. Boér	**+**	**+**	**+**	**+**
6	Izv. vizavi de Boér	**-**	**-**	**-**	**+ (!!!)**
7	Izv. Ágya	**-**	**-**	**-**	**+ (!!!)**
8	Izv. Róka, Omlás	**+**	Dispărut	**+**	**+ (!!!)**
9	Izv. vizavi de Omlás	**-**	**-**	**-**	**+ (!!!)**
10	Izv. Szikra	**+**	**+**	**+**	**-**
11	Izv. Báger	**-**	Dispărut	**+**	**+**
12	Izv. Sapkás/Gáteri	**-**	**-**	**+**	**+**
13	Izv. vizavi de Gáteri	**-**	**-**	**-**	**+ (!!!)**
14	Izv. Ágostonhídi	**+**	**+**	**+**	**+**
15	Izv. Szénáskerti 1	**+**	**+**	**+**	**+**
16	Izv. Szénáskerti 2	**+**	**+**	**+**	**+**
17	Izv. Pető	**+**	**+**	**+**	**+**
18	Izv. Meggyespusztai	**+**	**-**	**+**	**-**
19	Izv. Ángyélikai	**+**	**+**	**-**	**-**
20	Izv. superior din pâr. Baraolt	**-**	**-**	**-**	**+ (!!!)**

Nr.	Numele apei min.	Kisgyörgy Z., 1975	Szász Á., 2005	Jánosi Cs., 2009	Czellecz B., Szász Á., 2012-2013
	Pârâul Țiganul				
1	Izv. Cigánylábi 1	**+**	**+**	**+**	**+**
2	Izv. Cigánylábi 2	**-**	**-**	**-**	**+ (!!!)**
3	Izv. Cigánylábi 3	**-**	**-**	**-**	**+ (!!!)**
	Pârâu afluent stâng al p. Baraolt, în aval de confluența cu p. Țiganul	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	Pârâul Negru				
1	Izv. Feketepataki	**+**	**-**	**-**	fără ape min.
	Pârâul Pietros, afluent al pâr. Negru	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	Pârâul Pietros, afluent al pâr. Baraolt	nu este menționat	nu este menționat	nu este menționat	nevizitat
	Pârâul Herman	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	TOTAL	**42**	**29**	**44**	**57**

Tabelul 2. Lista izvoarelor de apă minerală din bazinul hidrografic al Cormoșului

Nr.	Numele apei min.	Kisgyörgy Z., 1975	Szász Á., 2005	Jánosi Cs., 2009	Czellecz B., Szász Á., 2012-2013
	Pârâul Cormoș				
1	Izv. Hámori	**-**	**-**	**+**	**-**
2	Izv. Faluborvize	**+**	**-**	**+**	Dispărut
3	Izv. Laji	**-**	**-**	**-**	**+ (!!!)**
4	Izv. Nagy Dezső/Péteri/ Faluvégi faköpüs	**+**	**+**	**+**	**+**
5	Izv. Kőalatti	**-**	**-**	**+**	**-**
6	Izv. Szejkésvíz	**-**	**-**	**+**	**-**
7	Izv. Szájváni	**+**	**-**	**-**	Disp.
	Pârâul Coșagul				
1	Izv. Kiskósági	**+**	**-**	**+**	**+**
Nr.	**Numele apei min.**	**Kisgyörgy Z., 1975**	**Szász Á., 2005**	**Jánosi Cs., 2009**	**Czellecz B., Szász Á., 2012-2013**
	Pârâul Gherend	nu este menționat	nu este menționat	nu este menționat	fără ape min

Nr.	Numele apei min.	Kisgyörgy Z., 1975	Szász Á., 2005	Jánosi Cs., 2009	Czellecz B., Szász Á., 2012-2013
	Pârâul Șolomaș	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	Pârâul Cuvoso				
1	Izv. Kuvaszói	+	+	+	+
	Pârâul Păstrăvilor	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	Pârâul Dobrota	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	Pârâul Alb	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	Pârâul Lugoj	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	Pârâul Fierarul				
1	Izv. Kovácspataki I. 1/ Izv. Ángyélikai	+	-	+	+
2	Izv. Kovácspataki I. 2	-	-	+	-
3	Izv. Kovácspataki II. 1	+	-	+	+
4	Izv. Kovácspataki II. 2	-	-	+	-
	Pârâul Molidul				
1	Izv. Fenyős	+	+	+	+
2	Izv. nr. 2 din pâr.Molidul	-	-	-	**+ (!!!)**
3	Izv. Hályagi	+	+	+	+
4	Izv. nr. 4 din pâr.Molidul	-	-	-	**+ (!!!)**
	Pârâul Creanga Mică				
1	Izv. Kiságpataki	+	-	+	+
2	Izv. Bojtorosi	+	-	+	+
	Pârâul Mina Roșie	nu este menționat	nu este menționat	nu este menționat	nevizitat
	Pârâul Pietros	nu este menționat	nu este menționat	nu este menționat	fără ape min.
	Pârâul Aurul				
1	Izv. Farkasmezői 1	+	-	+	+
2	Izv. Farkasmezői 2	+	-	+	Disp.
3	Izv. Aranyosi	+	+	+	+

	Pârâul Mohoi				
1	Izv. Muhari	+	+	+	+
Nr.	**Numele apei min.**	**Kisgyörgy Z., 1975**	**Szász Á., 2005**	**Jánosi Cs., 2009**	**Czellecz B., Szász Á., 2012-2013**
	Pârâul Mic și Mare Alb				
1	Izv. Egres	+	+	+	+
2	Izv. Benzi alatti	+	+	+	+
3	Izv. Vincze	+	+	+	+
4	Izv. nr. 4 din pâr. Alb	-	-	-	**+ (!!!)**
5	Izv. Csorgó	+	+	+	+
6	Izv. Medvebarlangi	+	-	+	-
7	Izv. nr. 6 din pâr. Alb	-	-	-	**+ (!!!)**
8	Izv. nr. 7 din pâr. Alb	-	-	-	**+ (!!!)**
9	Izv. nr. 8 din pâr. Alb	-	+	-	+
10	Izv. Szikszai	+	-	+	Dispărut
11	Izv. Széncsűri	+	-	+	Dispărut
	Pârâul Holoșag				
1	Izv. Szonda	+	+	+	+
2	Izv. Halasági	+	+	+	+
3	Izv. Korsós	+	+	+	+
	TOTAL	**25**	**14**	**29**	**26**

Tabelul 3. Lista izvoarelor de apă minerală din bazinul hidrografic al Vârghișului

Nr.	**Numele apei min.**	**Kisgyörgy Z., 1975**	**Szász Á., 2005**	**Jánosi Cs., 2009**	**Czellecz B., Szász Á., 2012-2013**
	Pârâul Vârghiș	în afara arealului studiat	în afara arealului studiat	nu este menționat	fără ape min.
	Pârâul Curio	în afara arealului studiat	în afara arealului studiat	nu este menționat	fără ape min.
	Pârâul Pietros	în afara arealului studiat	în afara arealului studiat	nu este menționat	fără ape min.
	Pârâul Chirui				
1	Izv. Festő	în afara arealului studiat	în afara arealului studiat	+	+
2	Foraj hidrogeol. Lobogó	în afara arealului studiat	în afara arealului studiat	+	+
3	Foraj de cercetare	în afara arealului studiat	în afara arealului studiat	+	-
4	Izv. în fața cabanei	în afara arealului studiat	în afara arealului studiat	+	+
5	Izv. în grădina cabanei	în afara	în afara	+	+

		arealului studiat	arealului studiat		
6	Bazinul în grădina cabanei	în afara arealului studiat	în afara arealului studiat	+	+
Nr.	**Numele apei min.**	**Kisgyörgy Z., 1975**	**Szász Á., 2005**	**Jánosi Cs., 2009**	**Czellecz B., Szász Á., 2012-2013**
7	Izv. Rebeka	în afara arealului studiat	în afara arealului studiat	+	+
8	Izv. Principal	în afara arealului studiat	în afara arealului studiat	+	+
	Pârâul Ilosa	în afara arealului studiat	în afara arealului studiat	nu este menționat	fără ape min.
	Pârâul Uscatul Mic și Mare	în afara arealului studiat	în afara arealului studiat	nu este menționat	fără ape min.
	Pârâul Hoților				
1	Bazinul Dumbrava Harghita	în afara arealului studiat	în afara arealului studiat	+	+
	Pârâul Alb, afluent al pr. Hoților	în afara arealului studiat	în afara arealului studiat	nu este menționat	fără ape min
	TOTAL	**-**	**-**	**9**	**8**

Comparing the real circumstance in the field reconstituted by our own research with the reports from the bibliographic references we can see that Kisgyörgy Z. (1975) reports a total number of 67 springs, Szász Á. (2005) mentions 43 active springs and 9 mineral water springs disappeared and Jánosi Cs. (2009) mentioned a number of 82 mineral springs in the studied area. During the personal investigations on field, in order to elaborate this study, there have been mapped 92 mineral springs.

The mapping of the rivers has been made with great precision and as a consequence other springs besides those presented in the last column do not actually exist. From the 92 mapped springs, 32 may be considered as personal discoveries and these are described for the first time in this work.

4. THE COLD WATER "GEYSER" FROM THE VALLEY OF CHIRUI RIVER

The hydrogeological drilling from Băile Chirui represents a particular case among all the mapped sources. It can be considered a special one even among the previously described drillings by its artesian and intermittent nature.

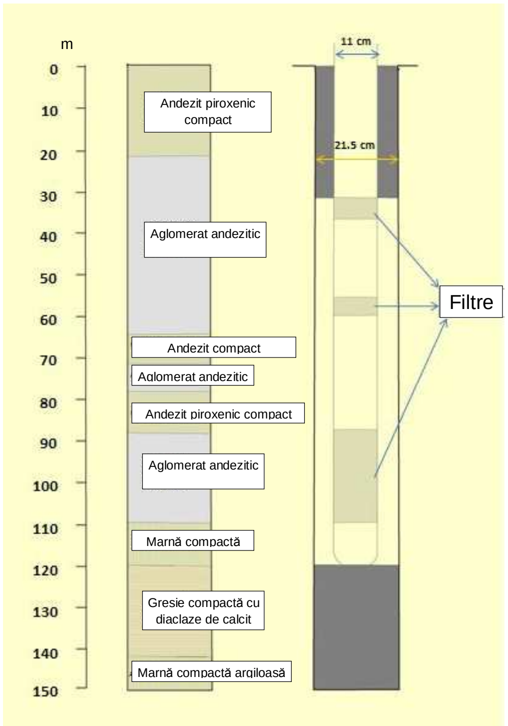


Fig. 1. Profil geologic al forajului H503
(Sursa: Raport geologic Geolex S.A.)

Fig. 2. Erupția apei din sondă
(Sursa: Czellecz B., 2009)

Similar phenomena were described all over the world but their number is reduced. Due to the similarities with the geysers, this phenomenon received the name of "cold water geyser". Still, we consider that the name of geyser might be wrong and this is why we recommend the name of "geysering well".

According to the literature these phenomena are in fact hydro-geological drillings and they are characterized by the successive active and non-active phases. In the active phase we can speak about a water eruption generated by the flux of the carbon dioxide and the non-active phase is characterized by the up-going movement of the water inside the drilling tube. The length of the active and non active phases is usually identical.

Between 2007 and 2009, by the measurements made, one tried to determine the length of the active and non active phases and their constant. The measurements concerning certain physical and chemical parameters had as a purpose the identification of the phenomenon characteristics.

Just one set of data, collected in March 2009, observed an entire cycle of the drilling. The rest of partial measurements correspond to those registered during the complete analysis. Thus it has been identified an entire cycle of 51 hours having the active phase of 38 hours and the non active phase of 13 hours.

The role of the carbon dioxide in the system running is emphasized in fig. 4. It can be seen a growth of dissolved gas content once the water is returning back to the tube and also its reduction before the eruption. These changes are connected to the gas bubbles release before the eruption described in all the elaborated theories. But we have to mention also the flux of the free gases which probably has a more important role than the dissolved gases released from the water.

The subsequent measurements were made in 2013 and they are concentrated upon the water discharge, electrical conductivity, hydrostatic pressure and the functioning of the system.

The measurement's results show that the range of data concerning the hydrostatic pressure may be used to describe and characterize a drilling cycle. In the non active phase the water level in the tube presents a continuous growth that might be observed by the growing of the hydrostatic pressure. When the water passes the top of the tube the hydrostatic pressure is grossly reduced and starts the eruption with maximum level. The pressure reduction may be explained by the upwards movement of the free gas bubbles going to the surface area. The eruption level is slowly reduced during the following hours and then it is set to a certain level. About 3 hours before entering into the tube we can see an oscillation of the eruption level that may be observed also by the deep hydrostatistic pressure changes. When the time approaches to retire, these changes happen more and more often and with greater and greater level differences. By these oscillations we have identified a new phase in the drilling, namely the mini-cycles characterized by a succession of weaker activities and stronger ones, represented by the changes of the eruption level (fig. 5.). The retiring of the water in the tube is made quickly, in a few minutes. By the water retiring into the tube the hydrostatic pressure slightly reduces. The lack of gross reduction of this parameter may be explained by the gas bubbles existing in that moment. Once it is retired, at a certain depth, the water level starts to grow again.

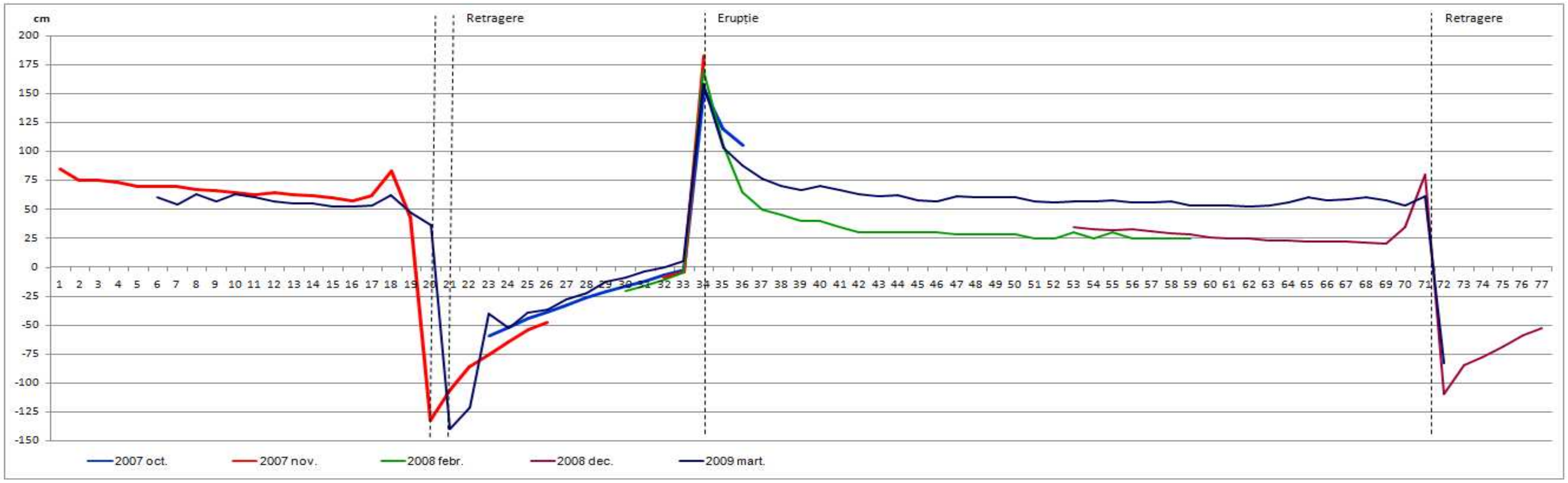


Fig. 3. Succesiunea fazelor active și inactive exprimată prin nivelul apei față de gura sondei

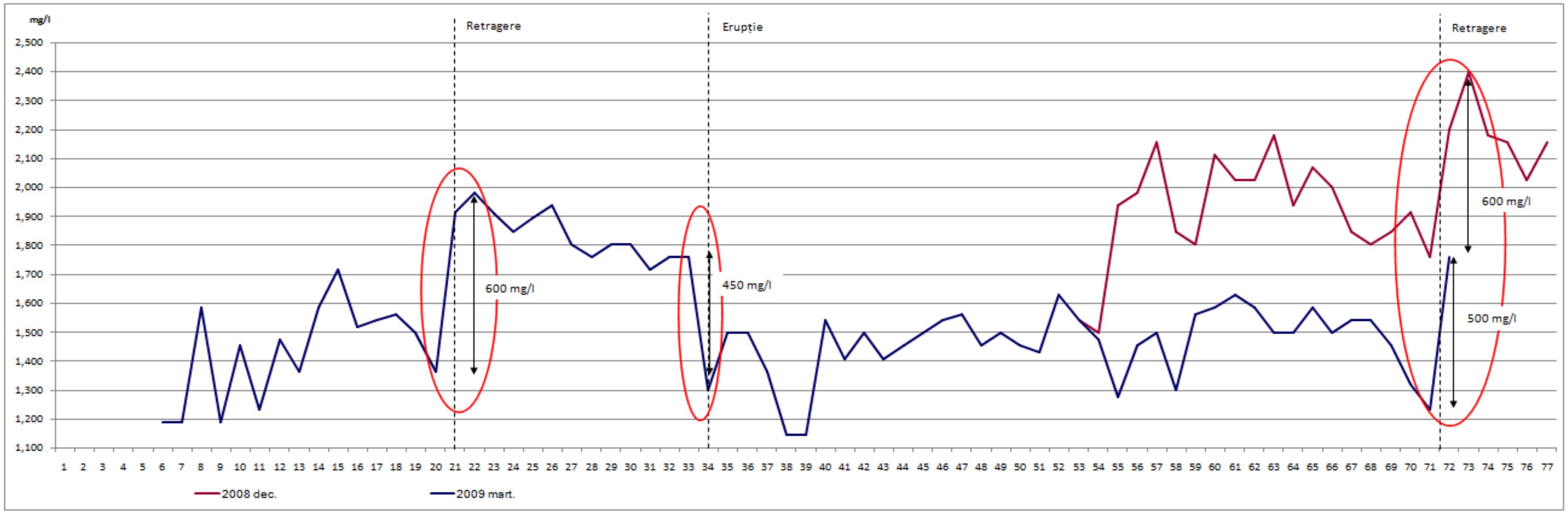


Fig. 2. Schimbările conținutului de dioxid de carbon dizolvat în apă în diferitele faze de activitate ale forajului din Chirui

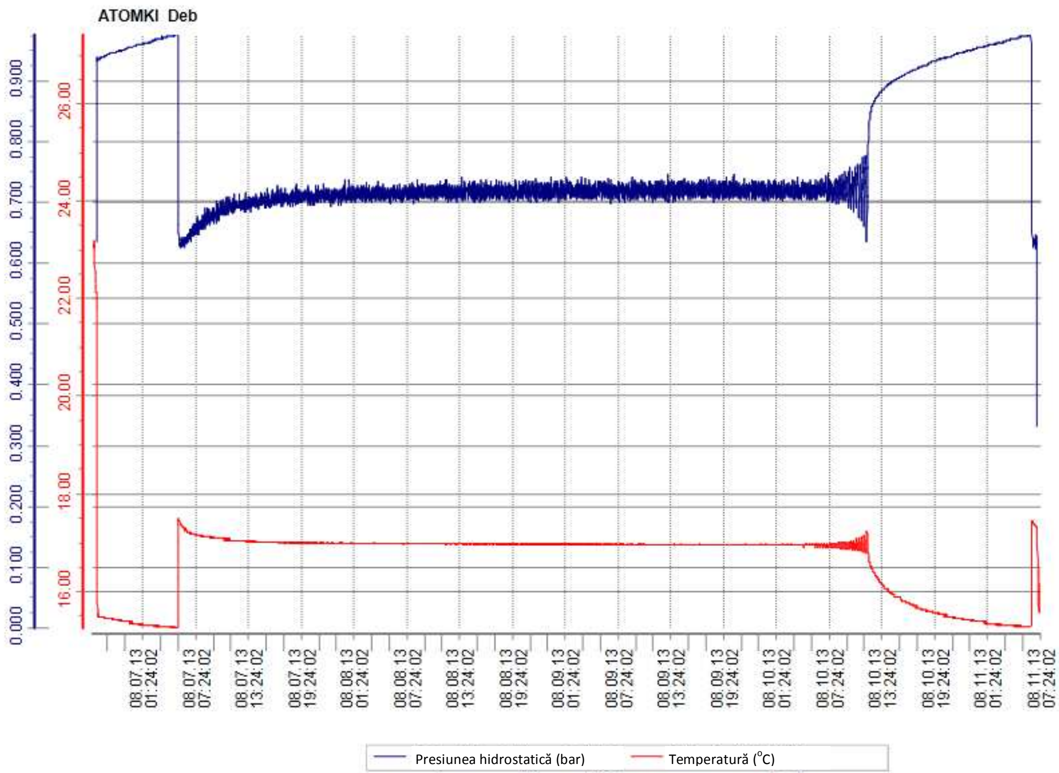


Fig.5. Schimbările presiunii hidrostatice, ale temperaturii și ale debitului (linia verde) în cursul unui ciclu al forajului (august 2013)

Concerning the water electrical conductivity (registered in 2013) we can see a general rhythm that can be observed every 25 - 30 hours. Between the minimal and maximal values of conductivity we can see a difference of about 400 microS/cm (fig. 6.). This difference can be considered a significant and unusual one because it is not a change from an active phase to an inactive one. So we suppose that the change is caused by the system provision from another source, from another water bad (aquifer) with different characteristics of the water.

Being an extremely rare phenomenon on Terra, the existence of such a “cold water geyser” in Chirui shall entitle its touristic and economic exploitation. We should be interested also to the water quantity brought to the surface (1845.5 m^3 during one cycle).

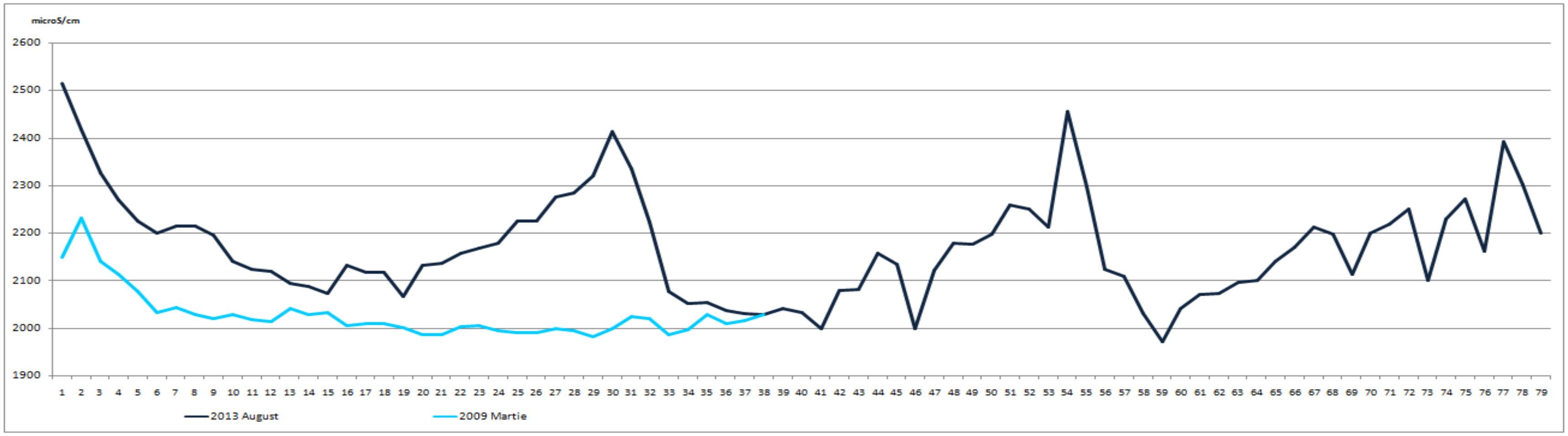


Fig.6. Valorile conductivității electrice înregistrate de-a lungul întregului ciclu al forajului în 2009 și 2013

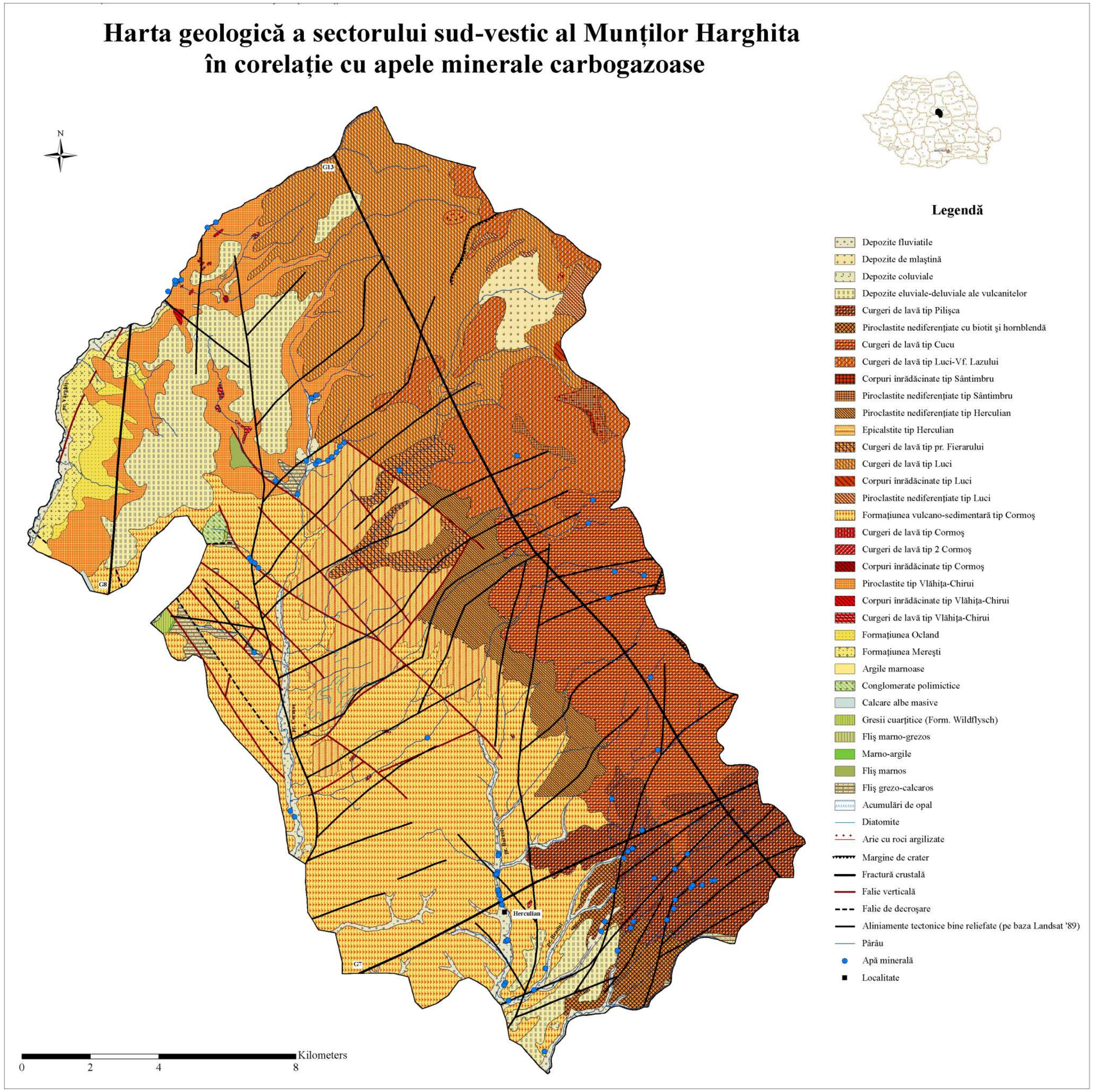
5. CLASSIFICATION OF MINERAL WATER SPRINGS ACCORDING TO THE PHYSICAL AND CHEMICAL CHARACTERISTICS

5.1. The chemical composition of mineral waters related to the geological structure

The springs have been analyzed according to the geological structure existing on the surface in the area where mineral waters appear. Thus the spring data is interpreted in groups of seven categories as follows: (1) springs in the area of Volcanogenic Sediments of Chirui Type, (2) springs in the contact area between the Chirui and Cormoş Formations, Herculian Epiclastics and calcareous flysch, (3) springs from the area of Volcanogenic sediments of Cormoș type, (4) springs from the contact area between the lava flows of Luci-Lazu type, Fierarul and Cucu type, (5) springs from the lava flows of Cucu type, (6) springs from the lava flows of Pilișca type, (7) springs from the contact area between the Formations and lava flows of Pilișca type and the eluvial- diluvial volcanoclastic deposits.

5.2. Classification of mineral waters by the Cluster analysis (made exclusively according to the physical and chemical characteristics)

According to the similarities of the physical and chemical characteristics, the mineral water springs can be grouped in seven classes – four great classes and three smaller ones. In the Cluster analysis there were introduced 103 cases with 8 variables. The cases represent the mineral springs and the eight variables are the temperature, the electrical conductivity, the TDS, the pH, the carbon dioxide content, the hydrogen carbonate content, the calcium and magnesium content. Twelve cases were introduced twice and they appear as having different entry data, acquired in 2011 and 2013, respectively 2012 and 2013. This step has as purpose to check if the springs defined according to two sets of data belong to the same class or not.



I. Izvoarele din zona Formațiunii vulcanogen-sedimentare de tip Chirui

II. Izvoarele din zona de contact dintre formațiunile vulcano-sedimentare de tip Chirui, de tip Cormoș, epiclastite de tip Herculian și formațiuni de fliș grezo-calcaros

III. Izvoarele din zona Formațiunii vulcanogen-sedimentare de tip Cormoș

IV. Izvoarele din zona de contact dintre curgerile de lavă de tip Luci-Lazu, de tip Fierarul și de tip Cucu

V. Izvoarele din zona curgerilor de lavă de tip Cucu

VI. Izvoarele din zona de contact dintre curgerile de lavă de tip Cucu și de tip Pilișca

VII. Izvoarele din zona de contact dintre piroclastitele și curgerile de lavă de tip Pilișca și depozitele eluviale-deluviale ale vulcanitelor

Fig.7. Harta geologică a sectorului SV al Munților Harghita și repartiția izvoarelor minerale în corelație cu rețeaua de falii (Sursa: hărțile geologice 1:50000 elaborate de IGR, modificate pe baza lucrării lui László A., 1998)

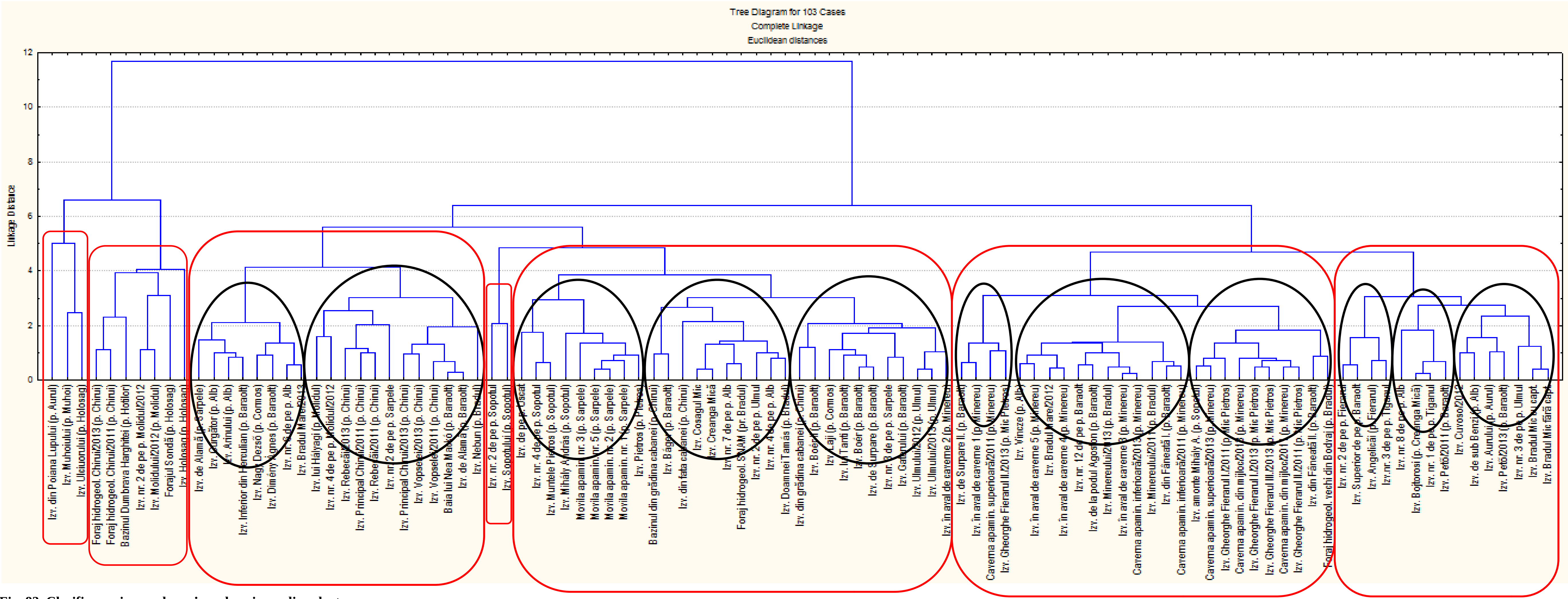


Fig. 83. Clasificarea izvoarelor minerale prin analiza cluster

Tabelul 4. Valorile parametrilor măsurați caracteristice fiecărei clase formate după analiza cluster

	Temp. (^oC)	**pH**	**TDS (mg/l)**	**Ca^{2+} (mg/l)**	**Mg^{2+} (mg/l)**	**CO_2 (mg/l)**	**HCO_3 (mg/l)**
Clasa I.	9.1, 9.1, 10.7	6.36, 6.3, 6.57	1903, 1257, 1288	246, 495, 355	135, 98, 79	2134, 1584, 1276	2562, 2318, 2196
Clasa II.	9.8-10.5, 15.5- 16.5	6.2, 6.4-6.6	900-1100, 1300-1500	115-125, 175, 260	60-65, 80-90	800-1000, 1550 - 1750	1403, 1700 - 1770, 2250 - 2650
Clasa III.	**III.a.** 9 - 10.5 **III.b.** 9.5 - 10, 11 - 12	**III.a.** 5.6 - 5.8 **III.b.** 5.8 - 5.6, 6.2 - 6.6	**III.a.** 300 - 550 **III.b.** 600 - 750	**III.a.** 90 - 125 **III.b.** 80 - 100	**III.a.** 15 - 35 **III.b.** 30 - 50	**III.a.** 1600 - 1800, 2100 - 2200 **III.b.** 1400, 1700 - 2000	**III.a.** 420 - 670 **III.b.** 730 - 880, 950 - 1100
Clasa IV.	4.4, 7.7	7.22, 7.39	494, 695	74, 77	2 , 17	946, 1425	610, 885
Clasa V.	**V.a.** 9 - 10, 11 - 11.5 **V.b.** 9 - 10, 14 - 15 **V.c.** 11 - 13, 14 - 15	**V.a.** 6.1 - 6.8 **V.b.** 5.6 - 5.8, 6 - 6.3 **V.c.** 5.7 - 6	**V.a.** 180 - 300 **V.b.** 220 - 330, 400 - 410 **V.c.** 270 - 340, 360 - 430	**V.a.** 25 - 30, 40 - 50 **V.b.** 47 - 77 **V.c.** 40 - 60, 70 - 90	**V.a.** 3 - 8, 13 - 15 **V.b.** 10 - 25, 30 - 40 **V.c.** 10 - 20, 25 - 30	**V.a.** 610 - 660, 1000 - 1200, 1430 - 1540 **V.b.** 660 - 880, 1050 - 1250 **V.c.** 1100 - 1300, 1400 - 1670	**V.a.** 244,300 - 400 **V.b.** 300, 480 - 550 **V.c.** 420 - 550, 580 - 610
Clasa VI.	**VI.a.** 13 - 13.5 **VI.b.**10.5 - 11.5, 12 - 12.5 **VI.c.** 13.5 - 14.5, 16 - 17	**VI.a.**5.2 - 5.6 **VI.b.**5.1 - 5.4, 5.6 - 5.7 **VI.c.**5.3 - 5.6	**VI.a.** 190 - 210 **VI.b.** 200 - 300 **VI.c.** 180 - 230	**VI.a.** 20 - 30, 55 - 60 **VI.b.** 30 - 40, 50 - 60 **VI.c.** 25 - 30, 40 - 45	**VI.a.** 5 - 15 **VI.b.** 8 - 20 **VI.c.** 5 - 15	**VI.a.** 700 - 800 **VI.b.** 1650 - 1850 **VI.c.** 1200 - 1400, 1700	**VI.a.** 300 - 430 **VI.b.** 300 - 400, 480 - 520 **VI.c.** 300 - 370
Clasa VII.	**VII.a.** 6 - 7 **VII.b.** 6.5 - 7.1 **VII.c.** 6.5, 8.5 - 10	**VII.a.** 4.7 - 5.4 **VII.b.** 4.9 - 5.2 **VII.c.**5.1 - 5.4, 5.5 - 5.9	**VII.a.** 35, 70 - 80 **VII.b.** 35 - 45, 120 - 125 **VII.c.** 125 - 150, 210 - 280	**VII.a.** 10 - 15 **VII.b.** < 5, 11 - 20 **VII.c.** 20 - 35, 40 - 50	**VII.a.** < 5 **VII.b.** < 5 **VII.c.** < 5, 7 - 13	**VII.a.** 1850 - 2020 **VII.b.** 1120 - 1270 **VII.c.** 1400 - 1500, 1650 - 1750	**VII.a.** 60 - 90 **VII.b.** 61, 183 **VII.c.**200 - 250, 300 - 360

6. ACTUAL SITUATION IN CAPITALIZATION OF THE MINERAL SPRINGS IN HARGHITA MOUNTAINS

6.1. The actual capitalization of mineral waters in Romania compared to other European countries

According to the statistics of the European Union, Romania is not between the first countries concerning the mineral water resources. We suppose that this is from the following reasons: 1. the statistics are made according to the number of bottling companies and to the number of spas and health resorts; 2. there is no unitary documentation about the mineral water resources on the European territory; 3. deficiencies concerning the adequate exploitation of mineral waters in Romania.

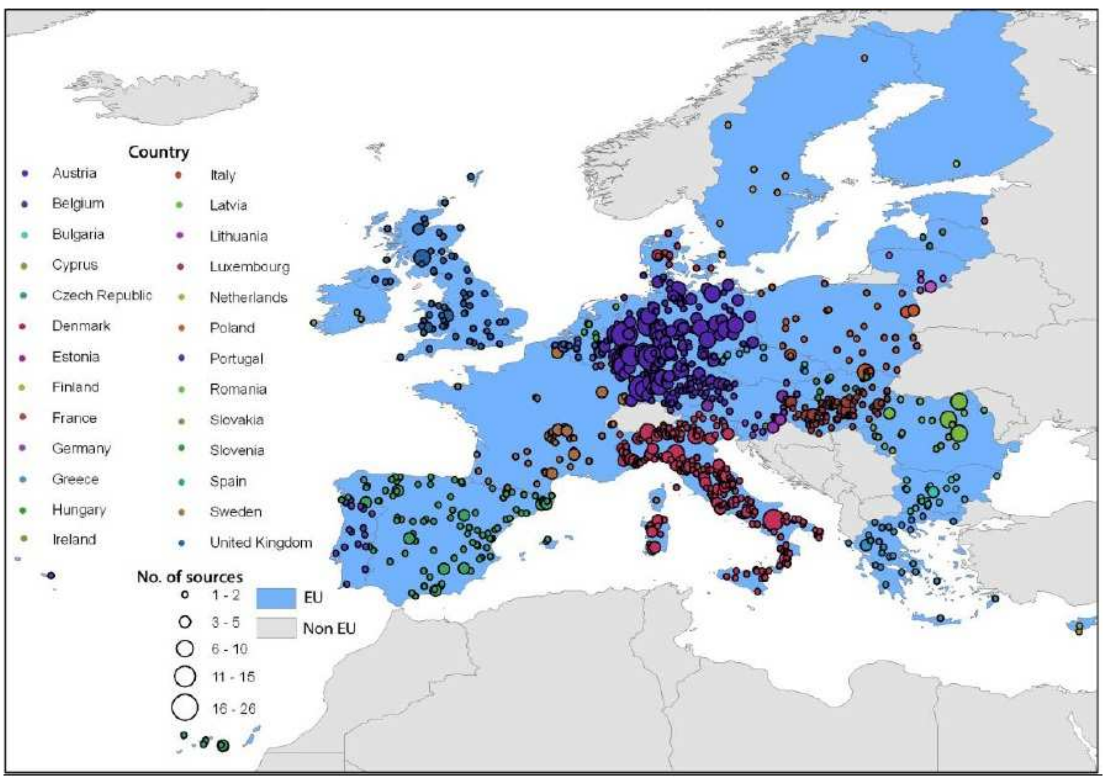


Fig. 94. Distribuția surselor de apă minerală recunoscute în cadrul Uniunii Europene - sursa datelor din Jurnalul Oficial al UE pe baza Articolului 1 din Directiva 2009/54/EC (Harta: Nobajas i Ganau, 2013)

6.2. The actual situation of mineral waters promotion in the Harghita and Covasna counties

Attempts of promoting the mineral water resources can be observed by the decisions and budget assigned by the local councils like the Harghita and Covasna County Council and by the ONG actions.

Harghita and Covasna are beneficiaries of the Operational Regional Program 2007-2013, Priority Axe 5 (Sustainable development and tourism promotion), the operation Developing and consolidating the internal tourism by supporting the promotion of specific products and marketing activities. The project has a total value of 1.037 million RON and it contents the following activities:

- mineral water promotion by participating to exhibitions,
- mineral water promotion by electronic media,
- mineral water promotion by marks,
- activities of mineral water promotion by publishing.

The dead line of the project is July 31, 2015 (source: County Council of Harghita). If we compare the promotion techniques of mineral waters in Hungary and Romania one may conclude a more efficient running of the Hungarian projects, treated with more attention and earnest by the authorities.

6.3. Initiatives concerning the mineral waters capitalization in Harghita and Covasna Counties

The Phare Program RO2006/018-147.04.01.01.01.03.12 “Drumul Apelor Minerale” from 2006 may be considered a good initiative in order to exploit the mineral waters in Romania. The program was meant to rehabilitate the areas of health resorts in 14 localities of Covasna and Harghita Counties in order to promote and develop the balneal tourism in the area. The program running between 2006 and 2011 did not satisfy the expectations and the rehabilitation actions were not satisfactory. According to the Ministry of Regional Development and Public Administration the project works were ended in September 2011.

The problem concerning the mineral waters capitalization was emphasized by the vice-president of the International Association of Hydrologists, Florin Zamfirescu in 2007 within the annual conference of mineral waters. He ascertains that “In Romania there isn’t an integrated management for the subsurface water resources. Here, the management of the subsurface waters is divided between the Ministry of Environment for drinking waters and the Ministry of Economy for the mineral waters. This makes that in a divided resources administration there are national problems…” (Green Report Magazine, 2007).

6.4. New projects concerning the mineral waters capitalization

There are future initiatives of developing and exploiting the mineral springs and heath resorts (the report “Analysis of Business Opportunities in the Centre Area from the perspective of sustainable development” drawn by the University Petru Maior of Târgu-Mureș upon the request of the Ministry of Education, Research and Innovation within the Sectorial Operational Program for the Development of Human Resources 2007-2013; Strategy of Regional Development 2014-2020, Priority Axe 5 – Tourism Development – drawn in 2013 by the Agency for Central Regional Development in Alba Iulia; The National Strategy for Sustainable Development of Romania, *Horizons 2013-2020-2030* (the Romanian Government, the Ministry of Environment and Sustainable Development in partnership with the Program of the United Nations for Development, the National Centre for Sustainable Development)). Still, we have to mention that the failure of the finalized projects where the state authorities were involved through the local and regional councils, puts under a question mark the success of the future projects.

Because of the problems observed in the development attempts of the country officials, we appreciate that the satisfactory results can be obtained only by private investments and by a unified promotion with national and international professional marketing techniques.

7. RECOMMENDATIONS FOR THE CAPITALIZATION OF MINERAL WATER RESOURCES

7.1. Recommendations for the exploitation of the springs due to their discharges

Most often the natural springs have a reduced discharge fluctuating generally between 0.002 l/s and 0.3 l/s. As for the drillings the discharges are greater, usually more than 1 l/s. The following graphics present the discharge distribution for different springs. The sources with great discharge are presented in a separate graphic. The discharges were measured for 59 sources from a total number of 92 springs.

The drilling from Chirui is not represented on the graphic because of its much greater discharge compared to the other springs. This drilling produces an average volume of 5.34 l/s. It is very unusual the significant volume produced by the Minereul Spring (Izv. Minereului), because such a great discharge is not characteristic for natural springs.

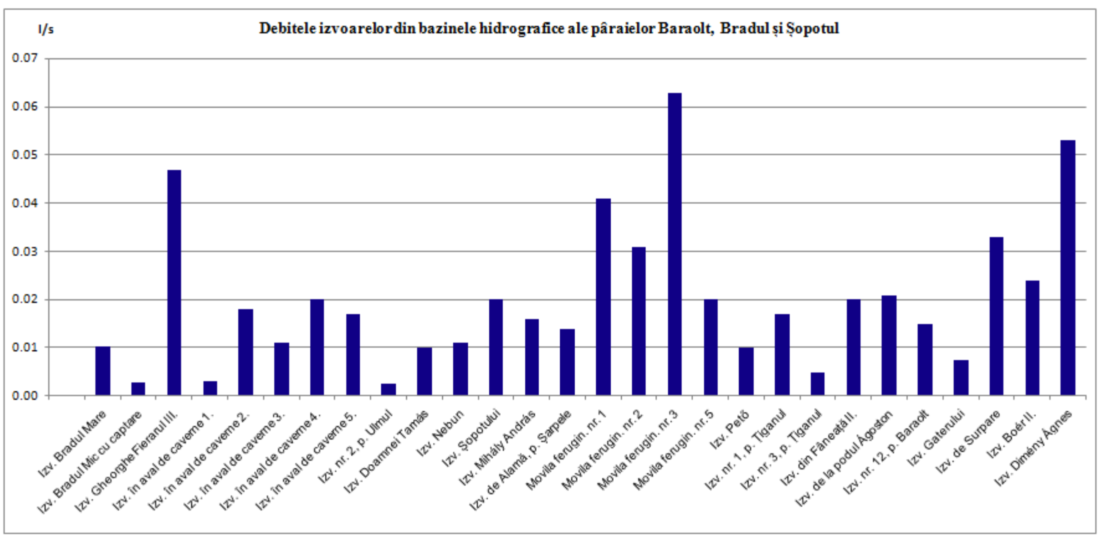


Fig. 50. Debitele izvoarelor minerale naturale aflate în bazinele hidrografice al pâraielor Baraolt, Bradul și Șopotul

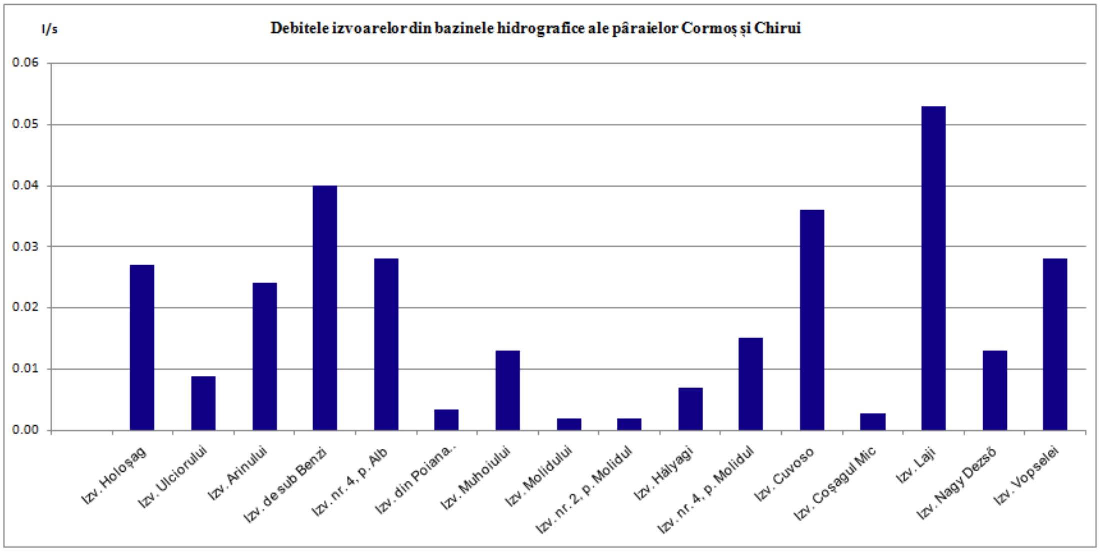


Fig. 61. Debitele izvoarelor minerale naturale aflate în bazinele hidrografic ale pârâurilor Cormoş şi Chirui

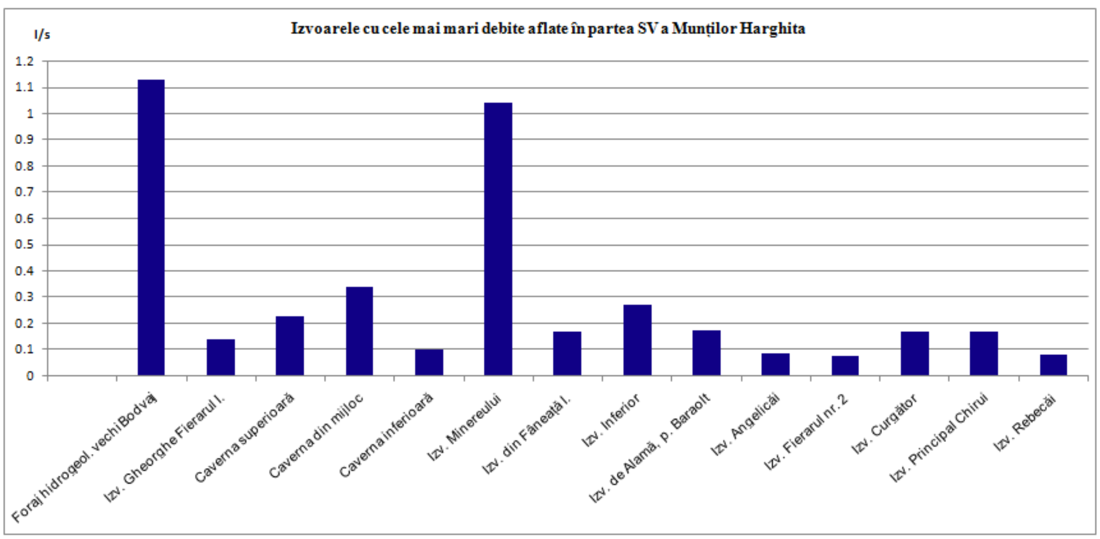


Fig. 12. Izvoarele minerale de pe partea sud-vestică a Munților Harghita caracterizate prin cele mai mari debite

If we make a calculation of all the discharges listed in the graphics we obtain a value of 3.72 l/s in the basin of the Baraolt river (fig. 10.), a value of 0.47 l/s in the basin of the Cormoş and Chriui rivers (fig. 11.) and a value of 4.19 l/s for the sources with greater debits (fig. 12.) to which is added the discharge of the drilling from Chirui. In this way it is obtained a total discharge of 13.72 l/s, which means a volume of **1185.4 m^3 mineral water lost every day.** This value emphasizes the available resources in the underground aquifers of the South-Western part of Harghita Mountains, wasted almost entirely.

In order to exploit the mineral waters in balneal purposes we propose a more detailed research to establish the therapeutic effects of these waters. For the bottled water, the hydro-geological research is compulsory. During these measurements, one has to consider the idea of sustainable development which supposes a moderate exploitation according to the National Strategy of Sustainable Development in Romania, *Horizons 2013-2020-2030* and ensuring the locals access to sources. The water can be bottled industrially but it should include also medicinal bottled waters as well.

According to the data of the National Society of Mineral Waters (SNAM) the production of mineral water presents a reduction during the last five years, which reflects also the evolution of mineral water consumption in Romania. But the export shows promising values in certain cases (Dumitrescu & Beldescu, 2012).

According to the data provided by the Romanian Centre for Trade and Foreign Investment Promotions, the markets in Bulgaria and Italy became the most open for the Romanian brands. Still, the greatest export is to the Moldavian Republic. But there are many market registering significant growths of requests during the last years: Poland, Vietnam, Chile, Mexico, South Korea, Azerbaijan, Kazakhstan, Belarus, Ukraine, Panama, Malta, Indonesia and Brasilia. For the moment, Romania is not among the providers of these markets.

7.2. The most valuable springs for therapeutic use

In the previous subchapter we have chosen 20 mineral springs from the 92 mapped on the South-Western part of the Harghita Mountains, as being the most favorable for the human consumption and external use and which may represent the subject of more detailed studies concerning their therapeutic effects. The most promising springs for therapy are those located in the basins of Cormoş and Chirui rivers.

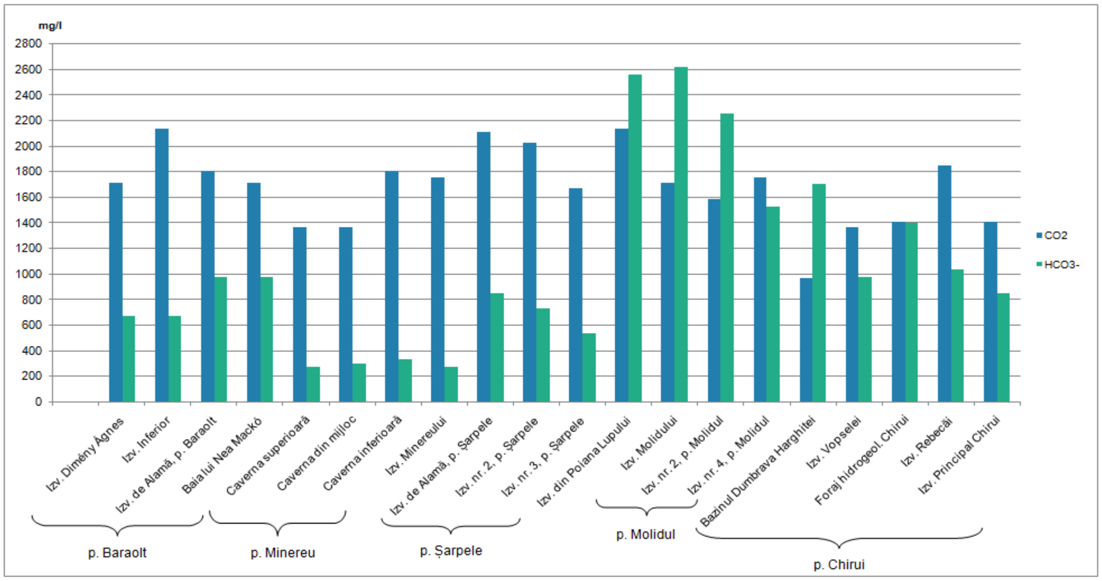


Fig. 13. Conținutul de CO_2 și HCO_3 al izvoarelor cu potențial terapeutic

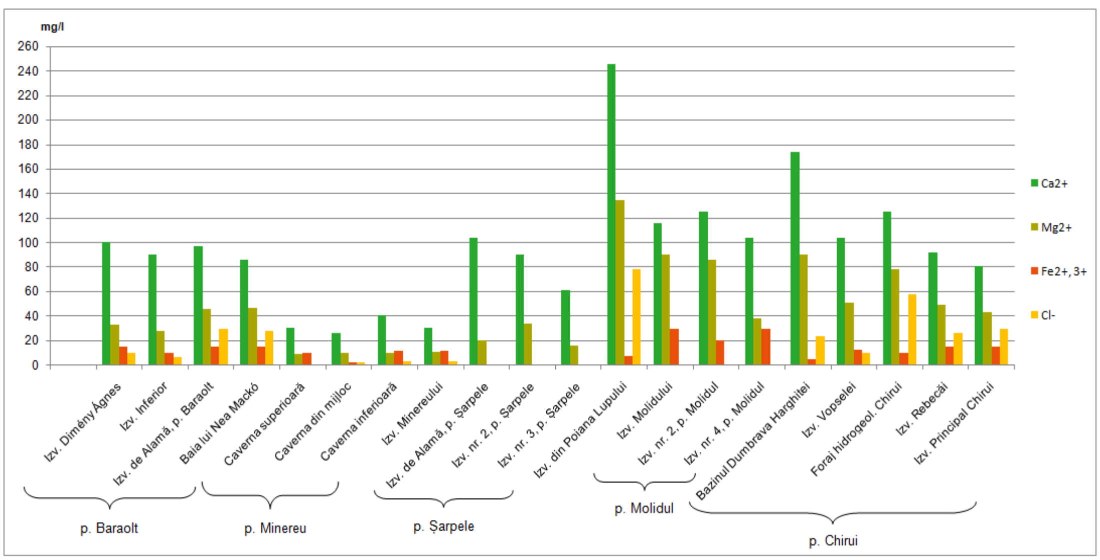


Fig.14. Concentrația celor mai importante macro- și microelemente ale izvoarelor cu potențial terapeutic

Besides the sources from the basin of Şarpele [The Snake] river, all the sources can be accessed from the good forest roads. The best accessibility is for the springs of Chirui and the springs in the area of Herculian village. The springs in the basin of Minereu river can be accessed on a concrete road up to a point where the rest of the distance, a couple of hundred meters, is walked.

On the first place in multiple criteria is the Spring from Poiana Lupului but the other springs of this area do not have enough favorable characteristics.

A more favorable area may be the river of Molidul where three sources have benefic effects upon the body and they are some tens of meters far from each other.

The next spring area having a therapy potential is represented by the Chirui valley. Here there are five sources of mineral water.

On the fourth place is the Herculian area where four sources are considered as promising for internal and external cures. The attempts of exploiting these sources are observed nowadays. Next to the Inferior Spring there is a small station with an external basin and facilities for interior baths. These baths are used without medical observation by a reduced number of visitors. The Bath of Nea Mackó was recently renovated but the therapeutic effects are not scientifically known.

The fifth place is for the area of mineral water Caverns. These springs do not have a high mineralization but thanks to their cave shape and to their iron oxide mud sources, they represent a touristic attraction.

The last area with mineral waters having a certain therapeutic potential may be considered the area of the Snake river. The strong points of this location are the proximity of iron oxide mud sources and the high content of carbon dioxide in the springs. The disadvantage of the location is the fact that the springs can be reached only by walk.

The analysis made above had as a purpose to choose some locations with mineral waters worth to be studied in detail from a therapeutic point of view. According to the data previously mentioned, we conclude that **the valley of Chirui river, the valley of Molidul river, the mineral water Caverns area** and also **the area of Herculian village** may represent favorable locations for the medical tourism development thanks to the therapeutic mineral waters, after a set of scientific research made by the specialists.

7.3. Exploitation of mineral springs from a recreational point of view

The mineral sources might be introduced in the touristic or educational routes. Our proposition is that the routes should not concentrate only upon the mineral sources but they should offer various objects and activities comprising multiple elements characteristic to a certain area. As a consequence it is recommended that the interest points on the rout imply, besides mineral water sources, botanical protected areas, different natural geological forms, geological forms from the mining industry, specific hydrographic elements, areas for picking forest fruits etc.

Many natural element of geologic, geomorphologic, hydrologic, biologic origin may serve for the outdoor education. Among these is the great variety of mineral springs which, besides the status of drinking water may offer an enrichment of geographic, hydro-geologic and chemical knowledge. The region offers the opportunity to taste several types of mineral water on a restrained area.

Besides the actual elements of touristic potential we have to mention the mountain site represented by the volcanic edifices, site points, tablelands (information boards), forest areas, thick and deep valleys, representing important elements of touristic attraction (fig. 15.).

Fig. 7. a. Vedere panoramică de pe Muntele Cucului spre Depresiunea Baraoltului.
b. Vedere panoramică spre Muntele Pilișca (Foto: Czellecz B., 2012)

The tablelands (information boards) may be very important during a route so, their placement is essential. But we have to call the attention upon the importance of a unitary development. The touristic routes to be projected and set up must be carefully projected, choosing the most favorable places from the point of view of the accessibility and also of the main objective placement. The information panels have to include written information in multiple languages and the attraction elements have to be represented on the maps.

Recreational and adventure parks are other opportunities for touristic development in a region where a part of the services could be focused on the mineral water resources. As in the previous case, the parks need multiple services in order to offer different ways of spending free time as agreeable as it may be.

The hydro-geologic drilling in the Chirui area could become an attractive element, having the characteristic of a cold water “geyser” with eruptions up to a high of 2 m, eruptions that can be admired at a certain range of time.

8. CONCLUSIONS

We consider that the most important result of this research is the inventory of all the mineral water springs on the South-Western part of Harghita Mountains. Even if there were more similar researches (Bányai et al., 1957; Kisgyörgy, 1975 and Jánosi et. al, 2009), the information provided does not reflect the entire reality and does not include all the mineral water sources.

On the investigated area of 340 km^2 there are 92 sources of mineral water along 23 rivers from which 89 are natural mineral springs and 3 are hydro-geological drillings. In all the cases there have been made measurements using the same analysis method. There were analyzed 12 physical and chemical parameters for all the sources: free gases liberation, temperature, pH, electrical conductivity, total mineralization, mineral salts, content of carbon dioxide, content of HCO_3, concentration of calcium and magnesium and content of nitrates and ammonium. The discharge was measured for 59 sources, the content of chlorides was measured for 64 cases, the content of iron was measured for 70 cases and the phosphates were analyzed only near the localities in 19 cases. The sources locations were described mentioning the geographical coordinates and the height where they appear. The precise localization of the springs is presented on 23 topographic maps and on one geological map.
Among the 92 investigated sources a number of 32 are new, being described for the first time in this work.

The results of the analysis concerning the mineral waters

There has been made the classification of mineral springs according to the geological layers on the surface, next to the sources and based on the physical and chemical characteristics using the Cluster analysis. The obtained classes according to the characteristics do not always correspond to the classes defined according to the distribution of the superficial geological layers. The origin of the springs is often influenced also by the presence of tectonic fractures. For both of the cases came out seven classes presenting different results but in both cases we concluded that the springs' characteristics are more influenced by the local agents. The mineral springs do not get similar characteristics thanks to the general characteristics of a certain region from the geologic and geographic point of view and so we cannot make a general statement based on the characteristics of certain sources.

Table 10. Comparative analysis of the classes of mineral sources according to two different methods

	Cluster analysis results		The results of classification based on the area geology
Class I.	One source from each of the basins of **Holoşag, Aurul and Muhoi** rivers. They are characterized by a very high mineralization and high level of carbon dioxide.		The sources from the area of volcanogenic sediments Form such as Chirui. This class groups all the sources in the basin of the **Chirui** river. They are characterized by uniformity, with high mineralization and high content of carbon dioxide for the active sources. In the case of the degenerated sources there are registered lower values of the parameters.
Class II.	Certain sources from the basin of **Chirui** river, certain sources from the basin of **Molidul** river and the rest of the springs in the basin of **Holoşag** river. They are characterized by a high mineralization and high level of carbon dioxide.		The sources in the contact area between the Volcanic sediments forms such as Chirui, such as Cormoş, epiclastic sediments such as Herculian and calcareous flysch forms. This class groups the sources from the basin of **Holoşag**, **Aurul**, **Muhoi** and **Alb** rivers. They are characterized by a high content of carbon dioxide. We cannot make a general statement for the mineralization.
Clasa III.	Two sources from the **Şarpelui [Snake]** basin, certain springs from the basin of the **Alb** river, a source from each hydrographic basin of **Cormoş and Bradul Mare** rivers, three sources from the basin of **Baraolt**, the rest of the sources from the basin of **Molidul**, the rest of the active springs from the basin of **Chirui river**, one source from the inferior course of **Bradul** river**.** They are characterized by a little lower mineralization than the previous classes and a high level content of carbon dioxide.		The sources from the area of volcanic sediments form such as Cormoş. This class groups all the sources situated along the inferior course of the rivers **Baraolt**, **Cormoş**, **Bradul**, **Şopotul**, the sources on the river **Molidul**, the sources from the basins of the rivers **Cuvoso and Coşagul Mic**. We cannot make a general description.
Class	The first two springs on the river		The sources from the contact area

IV.	**Șopotul**. They are characterized by a medium mineralization, low content of carbon dioxide and high (neutral) pH.		between lava flow such as Luci-Lazu, such as Fierarul, and such as Cucu. This class groups the sources from the hydrographical basins of the rivers **Creanga Mică and Fierarul**. Except the Creanga Mică spring, they could be characterized by a very low mineralization and high content of carbon dioxide.
Class V.	The source on the river **Uscat**, three sources in the basin of the river **Șopotul**, five sources in the basin of the river **Șarpele**, the source on the river **Pietros**, three sources (degenerated) from the basin of the river **Chirui**, six sources on the river **Baraolt**, the springs along the rivers **Coşagul Mic and Creanga Mică**, two sources on the river **Alb**, two sources on the inferior course of the river **Bradul** and one source from the basin of each of the rivers **Cormoş** and **Minereu**. They are characterized by a medium content of carbon dioxide, low mineralization and a slightly acid pH.		The sources from the area of lava flows such as Cucu. This class groups all the sources along the superior courses of the rivers **Baraolt**, **Țiganul**, **Bradul Mare** and **Bradul Mic**. The sources from the hydrographic basin of the river Baraolt are characterized by a high content of carbon dioxide and very low mineralization. The springs from the hydrographic basin of the river Bradul are characterized by a high content of carbon dioxide but with a mineralization a little bit higher than the previous case.
Class VI.	Five sources on the river **Baraolt**, almost all the sources along the river **Minereu**, all the sources on the river **Mic Pietros**, one spring on the river **Alb**, the spring on the river **Bradul Mare**, two sources in the basin of the river **Bradul**, one spring along the superior course of the river **Șopotul**. The sources are characterized by a low mineralization, an acid pH and medium to high content of carbon dioxide.		The springs from the area of lava flow such as Pilişca. This class groups all the springs along the rivers **Șarpele** and **Mic Pietros**, two sources on the superior course of the river **Șopotul**, the spring on the river **Uscat** and a source in the basin of the river **Bradul**. We cannot offer any general description.
Class VII.	All the springs along the superior courses of the rivers **Fierarul**, **Baraolt** and **Țiganul**, one source on the superior course of the river **Creanga Mică**, all the springs in the basin of the river **Bradul Mic**, the spring on the river **Cuvoso**, two sources in the basin of the river		The springs from the contact area between the pyroclastites and the lava flows such as Pilişca and eluvial-diluvial volcanic deposits. This class groups all the springs from the hydrographic basins of the rivers **Minereu** and **Ulmul**, one spring on each of the rivers **Bradul** and **Pietros**,

	Alb, one spring in each basin of the rivers **Aurul** and **Ulmul**. The springs are characterized by a very low mineralization, high content of carbon dioxide and a very acid pH.		three sources in the basin of the river **Șopotul**. We cannot make a general description.

From the table above we can see that the geology of the area may provide characteristics similar to the springs only in one case out of seven presented above. Concerning the springs in the hydrographic basins of the rivers Holoşag, Aurul and Molidul we can speak about a restrained area because of which the geological and geographical environment is very similar to each other. For the springs along the superior courses of the rivers a general characteristic can be given because of their localization in a geological environment with compact layers. Thus, because of the circulation in a short time and due to the inefficient dissolution of different types of rocks we cannot have different characteristics of the springs. They are characterized by a very low mineralization and by a high content of dissolved carbon dioxide. There are also other springs having similar characteristics with the ones presented above but situated in a different geological environment. By the Cluster analysis these springs are grouped together.

Capitalization of the mineral waters

The great variety of the springs and also their great number leads to the need of exploiting them. Consequently, considering the therapeutic effects and the mineral water discharges and their accessibility, there have been chosen four favorable areas of development and there are indicated the setting and investment actions: the valley of the river Chirui, the valley of the river Molidul, the area of mineral water caverns from the hydrographic basin of the river Bradul and the region of the locality Herculian.

The touristic attraction of the valley of the river Chirui is determined by the presence of the “cold water geyser”. The Blinking Drilling by its unusual activity may be considered a “natural” curio. Similar phenomena on the Earth were described during the last decade and there are about 15 drillings. We are talking about hydro-geological drillings the activity of which is characterized by the successive active and non active periods. The active periods are manifested by a continuous eruption of the water and the non active periods by the movement of the water column in the tube. While most of these phenomena are generally characterized by a short time of activity (maximum two hours), the Blinking Drilling presents a longer activity, of 38-78 hours. By more detailed research focused on the determination of the running principle of the system we shall succeed in setting the exact time when the drilling activity goes from one phase to another.

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