A BRIEF HISTORY AND INVENTORY OF THE THERMOMINERAL RESOURCES OF THE BĂILE HERCULANE RESORT

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Abstract. The notion of mineral water has evolved significantly over time, at the beginning of studies referring only to waters used for therapeutic purposes in spa treatments. Later, the research expanded to include all groundwater and surface waters that possess specific chemical or physical properties beneficial for various applications. The complex properties, -chemical and physical-, specific to mineral water deposits have led to the development of medical spa facilities and, by extension, of the spa tourism. In order to be recognized as a thermomineral resource, the mineral water springs are subject to comprehensive geological, hydrogeological and medical studies. Even though the origin of the thermomineral waters remains a subject of scientific debate, early studies (18th century) proposed various theories regarding their genesis, from the juvenile water reserves to mixtures of karst and thermal waters). In the mid-20th century, several researchers such as I. Popescu-Voițești and V. C. Papiu explored the origin of these waters, concluding that they are of meteoritic type or have been modified by rock-water interactions. The role of thermal waters in shaping the balneological identity of the Băile Herculane resort is particularly significant, with numerous studies highlighting the dissolution of minerals from the surrounding rocks and the geothermal gradient as key factors in the mineralization process. This research aims to provide a brief historical overview of the discovery and exploration of thermomineral resources in the Băile Herculane resort, as well as to inventory all of these resources. This paper completes the discussion on the origin and classification of thermomineral waters, while also emphasizing the importance of these resources in the development of modern therapeutic spa practices.

Keywords: spa, thermomineral resources, springs, treatment, Băile Herculane resort.

Rezumat. Un scurt istoric și inventariere al resurselor termominerale din stațiunea Băile Herculane. Noțiunea de apă minerală a evoluat semnificativ în timp, la începuturile studiilor referindu-se doar la apele utilizate în scop terapeutic în tratamentele balneare. Ulterior, cercetările s-au extins pentru a include toate apele subterane și de suprafață care posedă proprietăți chimice sau fizice specifice, benefice pentru diverse aplicații. Proprietățile complexe, -chimice și fizice-, specifice zăcămintelor de apă minerală au condus la dezvoltarea facilităților balneare medicale și, prin extensie, a turismului balnear. Pentru a fi recunoscute ca resursă termominerală, izvoarele de apă minerală sunt supuse unor studii geologice, hidrogeologice și medicale ample. Chiar dacă originea apelor termominerale rămâne un subiect de dezbatere științifică, studiile timpurii (secolul al XVIII-lea) au propus diverse teorii privind geneza lor, de la rezervele de apă juvenilă până la amestecuri de ape carstice și termale. La mijlocul secolului al XX-lea, mai mulți cercetători precum I. Popescu-Voițești și V. C. Papiu au explorat originea acestor ape, concluzionând că sunt de tip meteoritic sau au fost modificate prin interacțiuni rocă-apă. Rolul apelor termale în conturarea identității balneologice a stațiunii Băile Herculane este deosebit de semnificativ, numeroase studii evidențiind dizolvarea mineralelor din rocile înconjurătoare și gradientul geotermal ca factori cheie în procesul de mineralizare. Această cercetare își propune să ofere o scurtă prezentare istorică a descoperirii și explorării resurselor termominerale în stațiunea Băile Herculane, precum și să inventarieze toate aceste resurse. Această lucrare completează discuția despre originea și clasificarea apelor termominerale, subliniind totodată importanța acestor resurse în dezvoltarea practicilor balneare terapeutice moderne.

Cuvinte cheie: stațiune balneară, resurse termominerale, izvoare, tratament, stațiunea Băile Herculane.

INTRODUCTION

The concept of mineral spa water has had several meanings over time. Initially, as mineral waters were considered underground or surface waters that could be used for therapeutic purposes, in spa treatment (BERLESCU, 1996). Later, spa treatment waters were called curative waters, while the concept of mineral waters expanded, encompassing all underground and surface waters that, due to their chemical or physical qualities, can be used in the spa treatment, the bottling industry or for the extraction of salts or gases (POVARĂ & MARIN, 1984). The notion has broadened its scope, because in the spa cure, in addition to underground or surface mineral waters, some peloids (therapeutic muds) are used, so that the complex of natural factors of balneary cure is called therapeutic mineral substances (PONTA et al., 2013). These mineral water deposits, due to their specific chemical and physical qualities, have favored the development of medical spa units and, implicitly, of spa tourism. A mineral water deposit becomes a balneary hydromineral value only through the certification of geological - hydrogeological and medical - balneary studies.

The origin of thermomineral waters still remains unclear. The first investigations were carried out over two centuries ago. A dissertation about the Băile Herculane resort, signed by Pascalis Caryophilus and entitled "De thermis Herculanis nuper in Dacia detectis", dates back to 1737, as well as Alessandru Popoviciu's work "Băile lui Ercule și scaldele de la Meedia", published in 1871 (GĂMAN, 2019). The first important scientific work is that of the geologist I. Popescu – Voitești (1921), who attributes the hot springs to the supply of juvenile water. In 1960, another geologist, V. C. Papiu, considers the water of the thermal springs to be of meteoric origin, and A. Pricăjan (1972) considers that it is originally a mixture of karst water and thermal water. I. Povară (1998) assume that the water in the system is of meteoric origin, but was modified by water-rock interaction during its descent, heating, and ascent (POVARĂ, 1998). The study of waters, regardless of their position, is included in the hydrogeological or balneological works, which, in addition to the analyses by components, major elements (temperature, precipitation, winds), demonstrate in particular “that the

mineralization of water – an important state in the hydrographic landscape of the regions – is essentially due to the dissolution of the rocks through which it circulates, and its temperature is determined by the geothermal gradient and the radioactivity of the acidic rocks" (MUNTEANU et al, 1986). It is important to mention the primary role of the thermal water resources of Băile Herculane in shaping and developing the spa character of the resort (SPÂNU, 2012).

The purpose of this research is to develop a brief history of the discovery of thermomineral resources in the Băile Herculane resort and at the same time to inventory them.

MATERIAL AND METHODS

In developing this research, the analysis of bibliographic sources regarding the history of the appearance and classification of thermomineral resources in the Băile Herculane resort was taken into account - works presenting the history of thermal research in the region, geological research analyzing the chemical composition of thermal waters, studies regarding balneotherapy and the efficiency of thermal waters for various ailments etc. Field trips were carried out to identify the thermomineral sources according to the classification available (VELCEA, 1971). Finally, an inventory of these resources was carried out and a map of the location of the main groups was developed using the QGIS tools.

RESULTS AND DISCUSSIONS

***The exploited mineral water deposits*.** The thermomineral waters are located in two hydrodeposits, one located in the Jurassic limestones and granites at the base of the Cerna graben, the other in the Jurassic limestones of the Cerna synclinorium. The waters from the two hydrodeposits are connected by the transverse faults of the Cerna graben (PRICĂJAN & AIRINEI, 1981). The deposit is exploited through 24 known sources, of which 16 are natural springs and 8 are opened through wells. The wells have depths ranging between 280 m (Neptun well) and 577.5 m (Traian well). A. Pricăjan has identified the main 12 springs: Cross of Ghizela, «Șapte Izvoare», Scorillo well, Hercules I, Hygieia, Apollo II, Diana I + II, wells 1 + 4, «Izvorul de ochi», «Izvorul de stomac», Traian well and Decebal well.

The thermomineral springs together provide a flow rate of 6500 l / 24 h, and the thermal water is used in the treatment pools. From a hydrochemical point of view, Cl^-, Na^+ and Ca^{2+} ions predominate in the water; the water is chlorosodic, bromoiodated or iodated – sulfurous, with a total mineralization between 1.0 and 8.5 g / l (Dumitrascu, 2011). The degree of mineralization of the thermomineral waters increases from north to south, and the chemical composition varies from spring to spring (PRICĂJAN, 1999). Hydrogen sulfide is found in concentrations of up to 60 mg / l, which explains the characteristic smell in the area. The intense blue or milky white color of the substrate, determined by cyanobacteria and, respectively, by sulfobacteria of the genus *Beggiatoa*, should not be ignored. Cristescu I. (1996) emphasized that the analysis of thermomineral waters revealed the predominant presence of Cl, Na, Ca ions, to which are added elements such as lithium, strontium, titanium, cobalt etc. The free and dissolved gases are nitrogen (65 – 90% of the total), oxygen, carbon dioxide and methane, present especially in the Diana IV, V springs and in Decebal.

According to the chemical composition, CRISTESCU (1996) identifies four groups of thermomineral springs:

1. **Chloro-sodium, bicarbonate, weakly sulfurous springs** (Șapte Izvoare on the right bank, the left bank and the artesian spring from the Scorillo borehole). These have a mineralization of 500 - 2600 mg / l, in composition being predominant sodium chloride, calcium sulfates and calcium bicarbonates. The hydrogen sulfide content is weak (4 - 5 mg / l), but they are among the most radioactive springs in Romania.

2. **Chloro-sodium, bicarbonate, calcium springs** (Hercules I and Hygieia), springs with a higher content of chlorides, calcium bicarbonates and magnesium and with up to 80 mg / l calcium and magnesium sulfates. Due to the total mineralization of 600 - 3500 mg / l they are comparable to the springs at Băile Felix.

3. **Chlorosodium, bromoioduric, weakly sulfurous springs** (Apollo I, II and Hebe), contain hydrogen sulfide between 15 and 44 mg / l, sodium and potassium chlorides up to 1500 mg / l, calcium and magnesium sulfates up to 110 mg / l, bromine and iodine 1 – 3 mg / l. Mineralization can reach 2800 mg / l.

4. **Chlorosodium, bromoioduric, sulfurous springs** (Diana I – V, Neptun I – IV, Venera, Traian, Decebal and boreholes 4578 – 4579), that have an increased content of hydrogen sulfide (from 30 mg / l in the Diana spring to 60 mg / l in the Traian spring), sodium and potassium chlorides (3500 – 4780 mg / l) and calcium and magnesium sulfate (114 – 214 mg / l).

The thermalization of the current circulating water is determined by hot waters with or without supersaturated vapors, originating from great depths, transported to the surface through the fault system (STOICESCU, 1982). The high mineralization is determined by the mixture of infiltration waters with reservoir waters (from structures whose existence is proven both by the specific chemistry and by the presence of natural gases such as methane, ethane and other higher methane homologues). According to this model, the Herculane thermomineral deposit is formed and regenerated permanently, with the involvement of three components: the infiltration waters along the Cerna Valley, the reservoir-type waters and the hot waters, with or without vapors, from deep areas.

***The thermomineral springs and therapeutic indications*.** According to the geographical criterion, chemical composition and degree of radioactivity, the thermomineral springs in Băile Herculane are divided into five groups: Șapte Izvoare, Hercules, Diana, Neptun and Traian (Fig. 1).

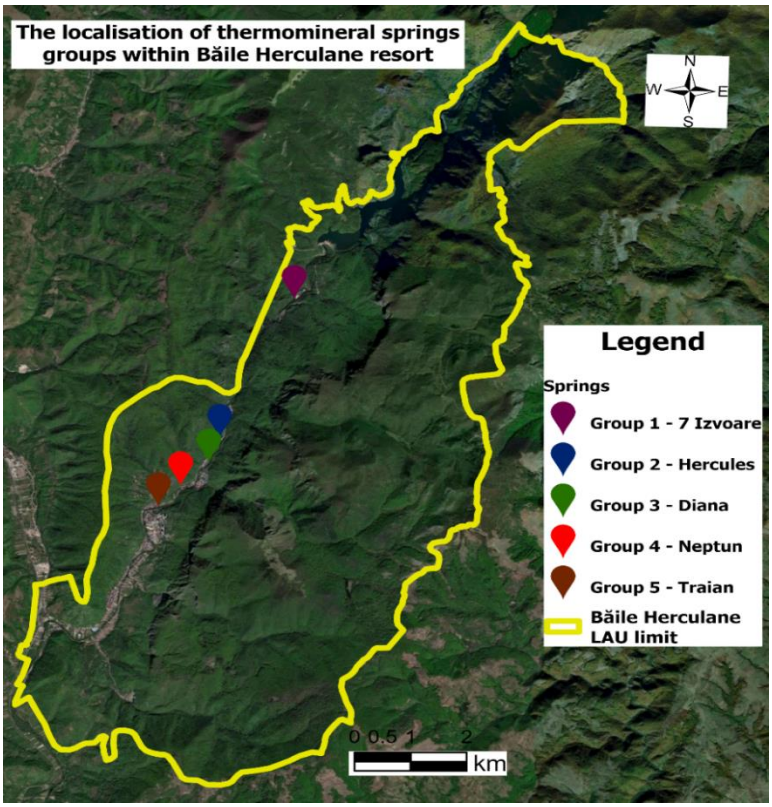

Figure 1. The location of groups of thermomineral springs in Băile Herculane (original).

Currently, they are used in nine treatment bases, with a cumulative flow of 25.75 l / s, the others flowing freely into the Cerna. There are another 9 artesian springs obtained by drilling, with a cumulative flow of approximately 30 l / s (NEGREA & NEGREA, 2002) .

Group I: Şapte Izvoare is located upstream of Băile Herculane, on the DN67D road, km. 3 – 4 and includes 2 groups of natural springs and 2 artesian boreholes (Fig. 2).

Figure 2. The thermal water pool in the Șapte Izvoare area (original).

1. The Stânca Ghizelei spring is located on the left bank of the Cerna, near the Stânca Ghizelei, it is an artesian spring, created by drilling up to 1201 m deep, the water comes from the level of 620 - 1200 m, from limestone, the flow

rate is 7 l / s, the temperature is 34 - 38.5˚C, the total mineralization is 0.3 - 0.7 g / l, the radioactivity is 0.7 - 11.1 Rn. Chemical composition: bicarbonate, calcium, sodium chloride water, it is used for the outdoor thermal pool, built in 1977.

2. Trei Izvoare Calde is located on the right bank of the Cerna, at km 4 of the DN67D road and is a spring with three natural sources, with a flow rate of 0.08 - 0.5 l / s in the spring no. 1, 0.17 - 0.2 l / s in the spring no. 2, 0.2 – 1 l / s in the spring no. 3, with temperature between 36.5 – 53.5˚C, and a total mineralization of about 4.4 – 6.9 g / l. Chemical composition: bicarbonate, sodium chloride water; the springs are captured, but not currently used.

3. Șapte Izvoare (La Gropan) are located on the left bank of the Cerna River, at km 3 of the DN67D road, there are four natural outlets, captured in a concrete basin, under the road; the flow rate is variable depending on the season, between 0.1 – 6.64 l / s, with temperature 35 – 40˚C, total mineralization 0.6 – 1.14 g / l, the highest in this group of springs; radioactivity 0.3 – 65.6 Rn (pCu / l). Chemical composition: sodium chloride, bicarbonate, sulfurous water, hydrogen sulfide is 14.05 mg / l. Locals have used them since ancient times, and currently open-air baths are made.

4. Scorillo spring is located on the left bank of the Cerna, at km 3 of the DN67D road, it is an artesian spring, created by drilling in 1969 - 1970, the water comes from the level 60.4 - 549.5 m, from granite; the flow rate is 1.23 - 2.91 l / s, with a temperature of 50 - 54˚C, total mineralization 0.6 - 0.9 g / l, radioactivity 0.2 - 20.4 Rn. Chemical composition: sodium chloride, calcium, hypotonic and weakly sulfurous water; it is dried up, currently unexploited.

Group II: Hercules is located in the northern sector of the resort, between the Roman Hotel and the Apollo Bath and includes 6 natural captured springs (NEGREA & NEGREA, 2002).

1. Hercules I spring (Roman Bath) is located on the right bank of the Cerna River, in a cave behind the Roman Hotel; it is a natural spring; the flow rate is 18.8 - 96.4 l / s, with a temperature of 15 - 54˚C, oscillating depending on the season, total mineralization 0.9 - 3.5 g / l, depending on the flow rate, radioactivity below 4.2 Rn. Chemical composition: chloride-sodium and calcium water. It was used before the Roman conquest, and is currently used to supply the baths in the saline section of the Roman Hotel, the Neptun Baths (under renovation) and the thermal pool near the Cerna Hotel; the water has beneficial effects in inflammatory rheumatism, in diseases of the peripheral vessels, the respiratory tract and the nervous system (STOICESCU & MUNTEANU, 1976).

2. The Hygieia spring (from the Greek goddess of health) is located on the right bank of the Cerna, 30 m downstream from the entrance to the Roman hotel, it is a natural spring, included in a fountain together with the neighboring spring, Hercules II, the flow rate is 0.10 – 0.22 l / s, with a temperature of 40 – 44˚C, total mineralization 1.4 – 3 g / l. Chemical composition: chloride-sodium, calcium, hypotonic and weakly sulfurous water, radioactivity 17.4 Rn. The water was used in internal cures for digestive and urinary diseases. Today the spring is dry, and the gate is closed.

3. Hercules II spring is located on the right bank of the Cerna, next to the Hygieia spring, it is a natural spring, the flow rate is 0.06 – 0.11 l / s, with a temperature of 27.5 – 46˚C, total mineralization 2 – 2.7 mg / l. Chemical composition: sodium chloride and calcium water, radioactivity 4.5 Rn. The water was used in internal treatment, currently the spring is dried up.

4. Despicatura springs (Alfa and Beta) are located on the right bank of the Cerna, 55 m downstream from the entrance to the Roman hotel, it is a natural spring, emerging in two different places of the Despicatura Cave, the water of each spring is captured, feeding a small dam lake; the cumulative flow rate is 0.3 – 16.7 l / s, the temperature is 49 – 51˚C in the Alfa spring and 50 – 53˚C in the Beta spring, total mineralization 1.8 – 3.4 g / l. Chemical composition: sodium chloride and calcium water, radioactivity 4 - 114 Rn. The water was used in the pre-Roman period, the Romans captured it to supply their thermal baths, but currently the springs have dried up.

5. Apollo II spring is located on the right bank of the Cerna, it is an artesian spring; the flow rate is 4.4 – 6.5 l / s, temperature 52 – 56˚C, total mineralization 2.4 – 3.9 g / l. Chemical composition: sodium chloride, calcium and weakly sulfurous water, radioactivity 9.8 Rn. It is used to supply the Apollo Baths.

6. Apollo I spring is located on the right bank of the Cerna River, 110 m downstream from Apollo II spring, it is an artesian spring, captured in the Apollo Bath building, through a 7 m deep well; the flow rate is 3.35 – 6 l / s, temperature 42 – 55˚C, total mineralization 2.73 – 4.40 g / l. Chemical composition: chloride-sodium, calcium and sulfurous water, radioactivity 1.38 Rn. It supplies Apollo Bath, like Apollo II spring, and is recommended for treating diseases of the musculoskeletal and circulatory system, as well as for some skin diseases.

Group III: Diana is located between Hercules Square and Diana Bath, it includes 3 springs, one of which is a borehole (NEGREA & NEGREA, 2002).

1. Diana I and II springs are located on the right bank of the Cerna, downstream of Hercules Square, they are two natural springs located in a small cave, captured and sent through a pipeline to the Diana spa pavilion; the flow rate is 0.10 - 1.67 l / s, temperature 46 - 55˚C, total mineralization 5.6 - 5.8 mg / l. Chemical composition: chlorous-sodium, calcium, hypotonic, brominated and sulfurous waters, radioactivity 35.5 - 205.0 Rn. It supplies the Diana bath for the treatment of rheumatic diseases.

2. Diana III spring is located on the right bank of the Cerna River, near Baia Diana. It is an artesian spring drilled in 1958, and the water rises from a depth of 50 – 260 m; the flow rate is 0.04 – 0.05 l / s, with a tendency to decrease until it dries up, the temperature is 53 – 62˚C, the total mineralization is 2.8 – 4.2 g / l. Chemical composition: thermosulfurous, chlorosodic, calcium, hypotonic water, radioactivity 0.20 Rn. It is used in internal treatment for digestive and respiratory system diseases, urticaria and allergies, sinusitis, and in external treatment for the treatment of chronic degenerative rheumatism.

3. The Hebe Spring is located on the right bank of the Cerna River, at the southern end of Hercules Square, near the Stone Bridge with the Antiques Gallery (Covered Bridge), it is a natural spring captured in a collector well, right inside the Hebe Bath; the flow rate is 0.10 – 0.74 l/s, low and variable, the temperature 22 – 33˚C, the lowest in the Diana group, the total mineralization 3.16 g/l. Chemical composition: chlorous-sodium, calcium, hypotonic and sulfurous water. It is used inside the Hebe Bath, in external treatment, for the treatment of peripheral nerve disorders and inflammatory rheumatism; it is also intended for use in internal treatment.

Group IV: Neptun is located downstream of the Hercules Hotel and includes more springs, of which 3 are drilled, on the right bank of the Cerna and one on the left of the river, springs with the highest content of hydrogen sulfide (NEGREA & NEGREA, 2002).

1. Neptun I spring is located on the right bank of the Cerna, downstream of the Hercules Hotel, it is an artesian spring through drilling practiced in 1894 at 276 m; the flow rate is 3.6 - 6 l / s, temperature 45.5 - 55.5˚C, total mineralization 3.7 - 5.6 g / l. Chemical composition: chloride-sodium, calcium, hypotonic and sulfurous water, radioactivity 4.2 - 36.4 Rn. It supplies the treatment base of the Hercules and Roman hotels and is used in external cures for the treatment of rheumatic diseases, certain skin and respiratory diseases.

2. Neptune II Spring (Izvorul de stomac, Anteu, Iosif) is located on the right bank of the Cerna River, next to Neptune I Spring. It is a natural spring, captured inside a well, located on the riverbank, in an elaborate construction, through which it descends 4 m; the flow rate is 0.1 – 0.2 l / s, depending on the season, the temperature is 40 – 54˚C, the total mineralization is 5.7 – 6.4 g / l. Chemical composition: sodium chloride, calcium, hypotonic, sulfurous water, radioactivity 35.9 – 207.4 Rn. It is used both in internal treatment for the treatment of gastric, hepatic, pancreatic diseases, diabetes mellitus and allergies, sinusitis and rhinitis, and in external treatment for the treatment of chronic degenerative rheumatism.

3. Neptune III Spring (Izvorul de Ochi, Argus) is located on the right bank of the Cerna River, opposite Neptune II Spring, it is a natural spring, captured in a concrete fountain in the Brancoveanu style; the flow rate is 0.02 – 0.18 l / s, quite low, the temperature is 49 – 55˚C, total mineralization 4.7 – 6.2 g / l. Chemical composition: sodium chloride, calcium, hypotonic, sulfurous water, radioactivity 6 – 196 Rn. It is used in external cures for the treatment of ophthalmological conditions.

4. Neptune IV Spring is located on the right bank of the Cerna River, next to Neptune I Spring, it is a spring drilled in 1968 to supplement Neptune I Spring and has the same hydrochemical characteristics as the latter.

5. Venera Spring is located on the left bank of the Cerna River, downstream of the pedestrian walkway near the Hercules Hotel (Podul Pieței), it is a natural spring captured in 1929; the flow rate is 0.09 – 0.54 l / s, low, temperature 32 – 40˚C, total mineralization 5.9 – 7 g / l. Chemical composition: chloride-sodium, calcium, hypotonic, sulfurous water, radioactivity 407 Rn, the highest in the Neptune group. It was used to supply the Venera Bath, in the treatment of gynecological and musculoskeletal disorders, but currently the bath building is abandoned, ruined, and the spring discharges underground into the Cerna River.

Group V: Traian is located downstream of Podul Roșu and includes 2 drilling springs on the left side of the Cerna. The Decebal drilling and those started in 1976 at the Slaughterhouse and Lime Factory constitute reserves for the future (NEGREA & NEGREA, 2002).

1. Traian Spring is located on the left bank of the Cerna, near Podul Roșu, it is an artesian spring, drilled at 575 m in 1969; the flow rate is 4.5 - 5.6 l / s, temperature 54 - 62˚C, total mineralization 6.14 - 7.54 g / l. Chemical composition: chloride-sodium, calcium and sulfurous water, it is the spring with the most constant chemical composition of all the thermomineral springs at Băile Herculane, radioactivity 17.7 - 117 Rn. It supplies the Diana, Dacia and Domogled hotels.

2. Decebal Spring is located on the left bank of the Cerna River, in Vicol Park, it is an artesian spring, drilled at 597.7 m in 1969; the flow rate is 1.67 – 2.20 l / s, temperature 32.5 – 39.5˚C, total mineralization 5.8 – 7.4 g / l.

The thermomineral water treatments. Thermomineral waters from Băile Herculane have therapeutic qualities that recommend them in the treatment of a wide range of conditions, but they are contraindicated in others that we will specify later.

The main therapeutic factor encountered is sulfur, which is present both in mineral waters and in the emanations, and which practically constitutes the basis from which the development of the types of treatments is started (STOICESCU & MUNTEANU, 1976).

The balneary cure carried out in all resorts of this kind in the world is of three types and consists of:

- *prophylactic cure* – is addressed to all people who do not suffer from any type of condition, this being recommended to be carried out over a period of at least 7 days of treatment. Prophylaxis practically consists of procedures to maintain the tourist's current health status and to prevent possible conditions (ALUCULESEI & NISTOREANU, 2014);

- *therapeutic cure* – is intended for people who already suffer from a condition, the tourists in question being considered patients of the treatment base. The therapeutic cure is initially recommended by the specialist doctor or the family doctor, who, based on the investigations carried out, will issue a referral ticket to a specialized clinic for personalized treatment. This type of treatment has no adverse effects, practically contributing to the improvement of the health status of the patient in question;

- *recovery treatment* – is perhaps the most difficult treatment method because it is addressed exclusively to people who have undergone interventions and need a recovery period. It is used especially in the case of improving the

sequelae resulting from a vascular accident, an orthopedic intervention or any surgical procedure. This type of treatment is prescribed exclusively by the specialist doctor, based on extremely precise documentation, and most often the involvement of a third party is required, in the most frequent cases this being a companion.

Internal and external treatments are those that make up the types of treatment highlighted previously and which are frequently complemented by other procedures, specific nutrition and rules of behavior indispensable during the treatment.

The therapeutic qualities of thermomineral waters. The thermomineral waters of Băile Herculane are extremely complex in terms of their composition (STOICESCU & MUNTEANU, 1976; ROȘCA et al., 2016). The effects that their compounds have are very diverse, have important effects on the human body and refer to:

- **the thermality** – acts on blood circulation, causing a change in nutritional exchanges in the body;
- **the sulfur** – is the most important element in the mineral content of the sulfurous thermal waters of Valea Cerna. Dissolved in deep thermal waters, the sulfur in this area has a greater power to penetrate and diffuse into the body during the baths. It is beneficial in treating diseases of the circulatory, locomotor, respiratory, and skin systems, has antiseptic, hyperemissive, desensitizing and anti-inflammatory action;
- **the thermal waters are lower in sulfur, but radioactive** – produce beneficial effects on circulation, improve heart activity through skin and coronary vasodilation, in parallel with a decrease in pulse and blood pressure;
- **the thermal waters are rich in calcium** – have a calming, sedative effect and are indicated for nervous system disorders.

Complementary therapeutic procedures. As previously mentioned, balneary treatment is one of the most complete and complex, justified by the possibility of undertaking several procedures at the same time or succeeding the initial ones with others (BERLESCU et al., 1975; TEIXEIRA & GOMES, 2021). The following can be easily highlighted:

- *hydrotherapy* – consists of various types of showers, baths, sauna, partial infusions, dry and wet wraps;
- *electrotherapy* – is performed by aerosols with or without ultrasound, partial or general light baths, diadynamic currents of different frequencies, with and without pulses, rectified, interferential and medium-frequency currents, infrared, partial and general ultraviolet, short waves, ultrasound, galvanization, ionization, etc.;
- *medical physical culture and treatment through gymnastics and movement* – consist of individual or group physical exercises, outdoors and in pools, stretching, massage, ergometric bicycle, shower massage, mechanotherapy, field treatment, aerobic gymnastics;
- other treatments: *apitherapy, acupuncture, eye installations, Aslan geriatric treatment* etc.

CONCLUSIONS

Taking into account the elements presented in this study - the historical and geological analysis of the thermomineral resources in the Băile Herculane resort, the classification and exploitation of water sources, it results that the importance of thermomineral waters is extremely important in the medical and spa tourism development (ZAHARIA, 2019). At the same time, the systematic monitoring of the resources and implicitly their continuous research, are considered essential if reference is made to the aspect of sustainable development of spa tourism. Considering the geographical criterion, the complex and diverse chemical character, as well as the degree of radioactivity, the current classification of the thermomineral resources in the analyzed resort was reached.

The five main groups: Șapte Izvoare, Hercules, Diana, Neptune and Traian, are made up of multiple springs that, through their unique therapeutic benefits, serve to treat various ailments. Among the most significant discoveries are waters with high levels of hydrogen sulfide, especially in the Diana and Traian springs, which are often used for their anti-inflammatory and analgesic effects. It is important that the spa resources and the resorts of this kind in the country to return to the attention of the relevant authorities, which should invest in this renewable wealth and in the modern treatment facilities. Spa tourism should be perceived as a continuous source of income for authorities and stakeholders, because it addresses to all categories of tourists (through multiple spa treatments - prophylactic, therapeutic or recovery), but also because it does not present seasonality, and can be practiced any time of the year (MINISTERUL TURISMULUI, 2014).

The results obtained from this study can guide future efforts to develop more precise therapeutic protocols, based on the specific chemical profiles of each spring, but also on the patient's or tourist's own pathology (if we refer to prophylaxis). The Băile Herculane resort, one of the most important spa destinations in Romania, can thus become a valuable destination for spa tourism and implicitly also for the medical tourism, taking into account that the waters are protected and used efficiently and that the options offered by the spa facilities are as diverse as possible (PRIMĂRIA BĂILE HERCULANE, 2020).

In conclusion, Băile Herculane's thermomineral resources are integral not only to the local ecosystem but also to the economic and health sectors, with continued research and sustainable exploitation offering significant benefits for both local communities and visitors alike.

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