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CHEMICAL CHARACTERIZATION OF GEOTHERMAL WATERS FROM WEST FIELD OF ROMANIA. III. STRUCTURAL RELATIONSHIP BETWEEN CHEMICAL PROPRIETIES OF THE GEOTHERMAL WATERS AND THE CONTACT ROCKS FROM ORADEA AND FELIX BATH

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ABSTRACT

This study makes a comparative analysis between geothermal waters preceded from collector basin of Oradea and Felix Bath. The conclusion after this study is that both geothermal waters reservoir have a common origin, it were formed in the Cretaceous and the Triassic Acvifer, dropped from Apuseni Mountains to Oradea and mounted to Felix Bath. Water composition was determined in relationship with the neighboring rocks structure, using dosage method and spectral method.

Also, this study briefly presents the importance and the utilization of these thermal waters in watering cure.

INTRODUCTION

The two geothermal water collector basins, Oradea and Felix Bath, which are in discussion, are situated in the western part of Romania, in the West Field. Between these two places is a distance of about 6 km. Geothermal waters from Oradea basin are taking refuge in a collector of Triassic age, being placed at a depth of 2000-3000 m. In this case water temperature is variable, having 80-120^{o}C. This collector basin is formed by carbonates rocks, mainly dolomite and limestone with small intercalation of clays and anhydrite.

Felix basin is situated in the eastern part of Oradea town; it is of Cretaceous age and formed also by carbonated rocks, in majority limestone. The depth of this collector is between 80-120 m, while its variable temperature is about 29-45^{o}C.

RESULTS AND DISCUSSION

In present paper we want to bring more experimental arguments regarding the relationship which exists between the two geothermal collector basins and their common genesis.

One hypothesis on the origin of these waters maintains the idea that they are the results of meteoric water infiltration from Apuseni Mountain. [5] To understand this fact, is important to say that the geological structure of those mountains is very close to that on the two collectors.

Age of these waters, determined by using the hard isotope of hydrogen, is more than 35000 years, fact which supports the previously mentioned hypothesis. [4] Triassic basin (2000-3000 m) and warmed water mounts on some local earth tears with obviously tendency to come on the surface straight of Felix Bath.

Making chemical determination and some correlation we have tried to found out experimentally proves in this hypothesis advantage.

As we have saw in previously papers, Oradea's geothermal waters have a mineral content about 1 and 1,5 g/l, thus being framed in the category of sulfate-carbonate-calcium-magnesia waters. From the ions contained by these kind of substances we have found the next intervals of concentration values:

$[SO_4^{-2}]$ = 350 - 850 mg/l; $[HCO_3^{-}]$ = 150 - 400 mg/l; $[Ca^{+2}]$ = 140 - 250 mg/l and $[Mg^{+2}]$ 40 - 75 mg/l. [2] This composition is perfectly according is the taking refuge rocks structure.

As we have saw in previously papers, Felix's geothermal waters have a mineral content about 0,5 and 0,8 g/l, thus being framed in the category of carbonate-sulphate-calcium-magnesia waters. From the ions contained by these kind of substances we have found the next intervals of concentration values: $[HCO_3^{-}]$ = 325 - 500 mg/l; $[SO_4^{-2}]$ = 100 - 300 mg/l; $[Ca^{+2}]$ = 100 - 175 mg/l and $[Mg^{+2}]$ = 20 - 40 mg/l. [3]

In **fig.1** are presented the rock stratum against depth. Triassic stratum, which is situated at Oradea at the depth between 2000 and 3000 m, is formed by carbonate rocks of dolomite and limestone type, with small clay intercalation, concordant to stratum graphic section, executed at the Oradea 1715 drilling.

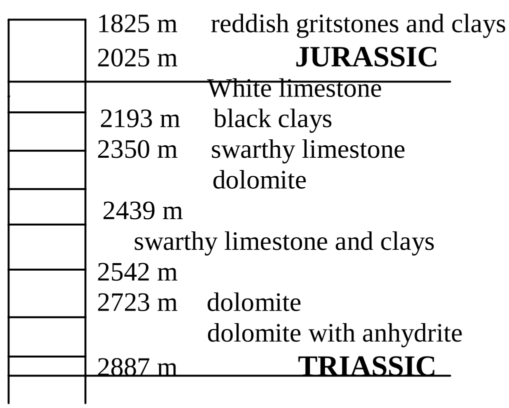

Fig. 1

Stratum graphic section executed at the Oradea 1715 drilling.

As it showed in **table 1**, the main characteristic of studied Triassic rocks is the high content in carbonates. Remarkable is the absence of alkali ions, which however appears in waters because of clay intercalation. Silica is spread in all stratums, but in the Jurassic gritstone has a value of 80,56%. In the last stratums, sulphur concentration is very increased because of sulphate. The stratum has major influence on the structure of geothermal water. From this collector basin, geothermal waters follow roughly the chemical characters of neighbouring rocks with which are in contact.

For example, the influence of anhydrite is considerable, in some waters the concentration ion being beyond 800 mg/l.

Natural waters found carbonate rocks in their ascendant way towards the hot hearth of collector; so, their take place a dissolving process, in closed system, and some ions such as bicarbonate, calcium and manganese are accumulated. The contact with some clay intercalation determinates the presence of chloride and alkali ions, in small quantities. In final phase of known evolution, these waters meet anhydrite and solve the calcium sulphate.

Table 1.
Chemical composition of extracted rocks at Oradea 1715 drilling.

m	2011	2220	2354	2560	2799
Mn	0,59	0,62	0,64	0,77	0,58
Al_2O_3	4,96	6,20	3,78	1,40	11,1
S	1,74	0,65	0,69	0,61	1,25
SiO_2	80,6	30,0	15,6	13,5	35,9
As	0,01	0,01	0,01	0,01	0,02
Fe	2,65	3,51	2,19	1,42	4,18
CaO	1,66	18,8	22,4	25,9	9,58
MgO	1,19	0,21	8,70	15,2	0,44
Cu	0,06	0,04	0,04	0,04	0,03
Zn	0,07	0,02	0,08	0,08	0,03
P_2O_5	0,05	0,11	0,14	0,03	0,15
CO_2	2,43	22,2	34,5	36,2	15,8

Silicate existence in all mineral stratums determines its presence in geothermal waters. It comes out that exists an enough evidently proportionality between water temperature and silica concentration. In **table 2** are shoved the concentrations of siliceous dioxide in tree different collectors: Triassic, Cretaceous and Pannonian.

Fournier [1] experiences had demonstrated that amorphous silica is solved at 0^{o}C, and, at the same time with temperature increasing, per and crystalobalite, calcedonies and quartz are beginning to be solved.

Table 2
SiO_2 concentration against the temperature

Sources	Depth (m)	Temp. at bottom	Water temp. [^oC]	[SiO_2] mg/l
RT	-	-	27	12
402C	400	-	35	31
4008T	1200	-	37	34
4087C	150	-	39	34
IC	75	-	40	41
ChP	300	-	45	20
4003C	60	-	45	39
4078P	1000	-	47	52
BC	47	-	48	40
CiP	700	72	49	20
PP	2300	94	55	82
603P	900	-	56	33
ChiP	1000	-	56	36
ChişP	1000	89	58	41
TP	1100	-	60	60
605	-	-	65	50
4081T	2500	74	65	56
4045P	1300	63	68	60
4006T	2400	-	78	75
4004T	2300	-	80	75
4058P	1300	-	86	89
4767T	3200	-	86	89
4005	2500	-	90	87

This reason determined us to try to found a relationship between water temperature and silica concentration. The phenomena was studied on a number of 25 sources of geothermal waters belonging to Triassic (T), Cretaceous (C) and Pannonian (P) collectors, situated in Bihor area. Figure 2 presents the corresponding diagram.

It can be seen from graphic that all the points are situated around two straight. On the straight with smaller slope figured geothermal waters from Oradea and Felix basins. Pannonian geothermal waters with all others chemical; and physical proprieties are represented by points on other straight.

In conclusion, the contains from geothermal waters can be used as temperature indicator, with the condition that the water type studied to take part from same basin or at least, from related basins.

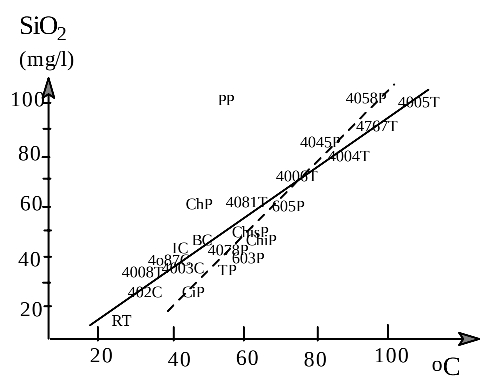

Figure 2
Dependence of silica concentration against temperature.

The fact that the points, which represent geothermal waters, are situated on the same straight is proving their common origin. Following the evolution of these waters in time and space, we can see that bicarbonate waters have been past in bicarbonate-sulphate waters, and than, in sulphate-bicarbonate or sulphate waters.

Following the evolution of geothermal waters from Triassic collector basin and its ascendant remove to Cretaceous collector situated in Felix Bath region, represents a special a special interest. It was presumed that acvifer system of Felix Bath is supplied by a series of earth tears because an ascendant moves from Triassic collector. According with this affirmation is the structural unit of these two types of waters.

A graphic representation using the correlation diagram of majority ion concentrations against the mineral containing is showed in fig. 3.

From the previously diagram we can observe some conclusion.

- The level of chloride ions has an undeveloped tendency to increase in the same time with the mineral containing; practically, the chloride concentration remains constant.

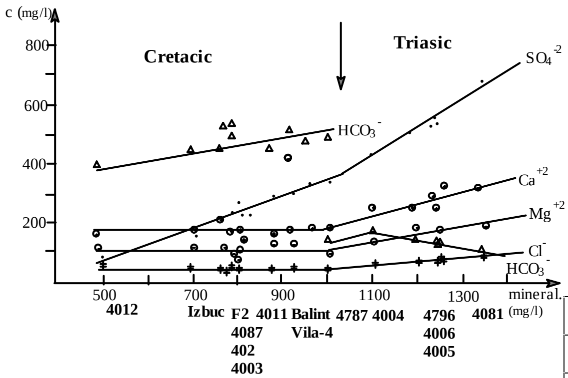

Figure 3
The variation of majority ions concentrations against the mineral containing

- Calcium and magnesium level are continuously increased against the mineral containing, without any interruption when the water pass from the Cretaceous collector to the Triassic basin.
- The level of sulphate ions continuously increases against the mineral containing. The increase is more pronounced in Triassic collector.
- Bicarbonate ions have the most interesting behaviour. The concentration of this ion is increased in Cretaceous collector, in the same time with the mineral containing, but in the moment of passing in the Triassic collector, its concentration decrease suddenly; practically the curve is breaking.

We have made emission gamma spectra for a number of for rocks samples and a residual sample after evaporation. Three rocks tested in these analyses were taken at different depth from Apuseni Mountains and one rock was taken from the surface. Water specimen was collected from Oradea waters. Spectra obtained are presented in figure 4. As we can observed from these spectra, a structural unit exists for the rocks, according with the composition of solvated ions in geothermal waters.

The content of radionuclides in geothermal waters from Triassic collector is presented in **table 3.**

Table 3
The content of radionuclides in geothermal waters from Oradea basin

4004	4005	4006	4081	4767
Radon (Ci/l . 10^{10})				
3,23	6,26	4,77	4,89	3,04
Radium (pCi/l)				
39,35	40,47	68,22	60,30	23,00
Uranium (g/l . 10^{6})				
5,76	15,13	7,96	7,32	6,50

In the first place, Triassic collector geothermal waters radioactivity is due to the presence of ^{226}Ra and ^{222}Rn. Gamma debits dosages are situated in the limits of natural radioactivity stock.

Cretaceous collector geothermal water content in radionuclides is **presented in table 4.**

Table 4
The content of radionuclides in geothermal waters from Felix basin

Izbuc	F-2	4003	Balint	402
Radon (Ci/l . 10^{10})				
4,53	2,57	2,28	1,30	0,89
Radium (pCi/l)				
1,32	2,74	2,04	4,95	1,52
Uranium (g/l . 10^{6})				
2,64	-	6,60	2,70	-

A difference in ^{226}Ra and ^{222}Rn content is obviously at a zone analysis of these waters. So, in Oradea area, where the waters have a bigger thermally and depth, water radon content is for 4 times more than in Felix waters, and radium is for 20 times more.

CONCLUSION

Experimental results obtained by us bring more arguments to support the hypothesis that geothermal waters from both acvifers have a common genesis. These waters come from infiltration waters that are warmed in Triassic collector from Oradea and than mounts on some local earth tears to Felix Bath where come out, at the surface, with a remarkable modification of their mineral content.

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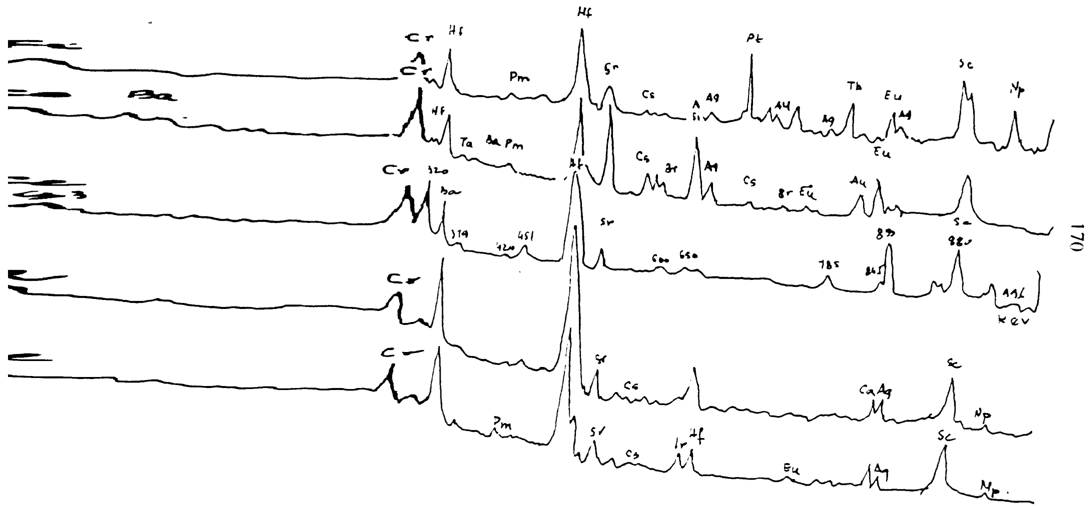

Figure 4.

Emission gamma spectra for a number a for rocks sample and a residual sample after evaporation.

1. Felix, depth 360 m; 2. Water from Oradea;3. Felix, depth 703 m; 4. Zece Hotarea; 5. Felix, depth 149 m;