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CHEMICAL CHARACTERIZATION OF GEOTHERMAL WATERS FROM WEST FIELD OF ROMANIA. V. GEOTHERMAL WATERS FROM CENTRAL ZONE OF FIELD

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ABSTRACT

Chemical characterization of geothermal waters of Pannonian System from central region of Western Plain of Romania is presented in this paper. Both constituents like: Cl-, NO2-, NO3-, HCO3-, CO32-, SO42-, PO43-, Ca2+, Mg2+, Na+, K+ and microelements were found in these waters by using various methods. Based on the chemical composition these geothermal waters could be classified as bicarbonate-sodium-chloride waters. This work is a comparative study with Oradea geothermal area.

INTRODUCTION

The studied region presents hydrogeologic complications. This fact involves the necessity of studying the geothermal aquifer located in permeable deposits of the Upper Pannonian in a general relation with the entire region.The Lower Pannonian situated to the south of Crişul Repede river is considerate equivalent with the Moesian one. The geological formations of this stratigraphic zone are formed by an alternation of marna sands with lenticular stones.

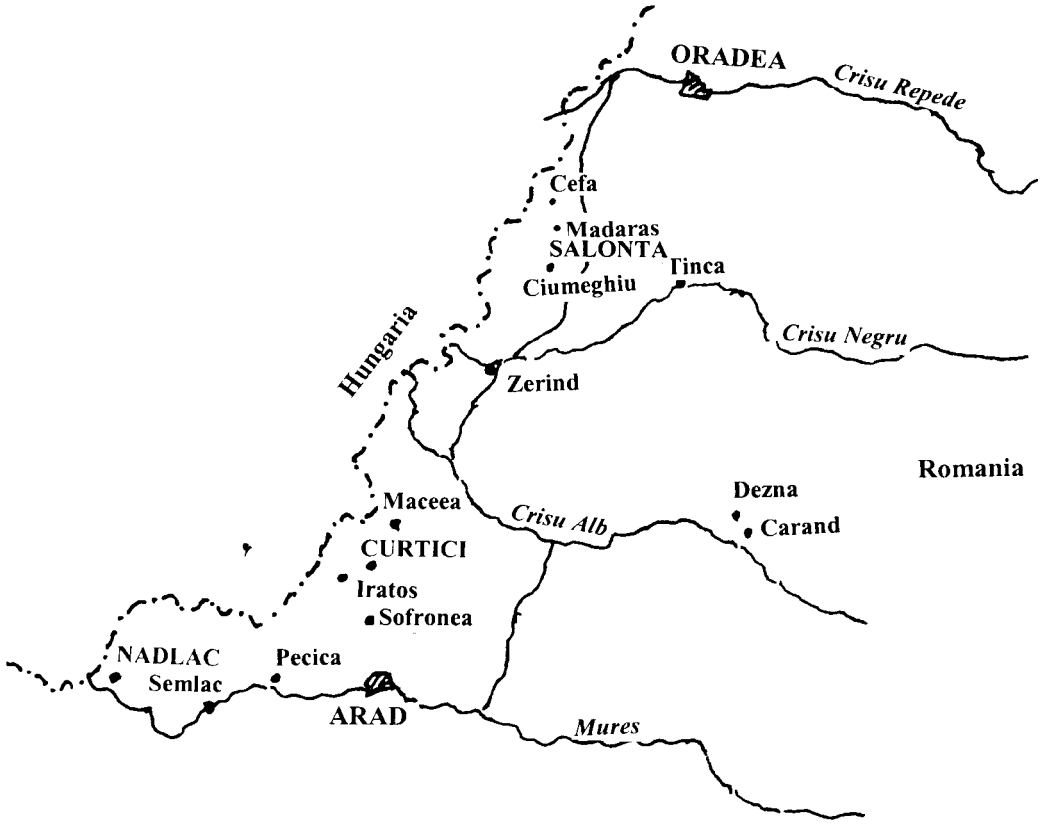

Figure 1. The distribution of the studied wells

By some authors the Upper Pannonian is formed only by pontian formations and by other authors is a multi-layered aquifer constituted by ponțian, roman and dacian formations. The south zones starts with complex homogenous pelite sands and to the north intrusive sand form the basement complex.The quaternary deposits are widely presented in this region and due to their lithography constitution they have a special importance from the hydrogeological point of view. Generally the cuaternar is represented by three types of formations: a) alluvial deposits formed by old and new alluviums of Crişul Repede, Crişul Negru and Crişul Alb rivers (these alluviums represent the constituents of the rivers meadow); b) the gravitational formations are represented by detritus, gravel soil, sloping soil; they have enhanced especially at the border zone or very close to the border; c) the mixed genesis formations are made by red clay with ironmanganese intrusions and piedmont deposits.Besides the lithologic and petrographic variety the region presents very complex tectonic structures as well. The soil texture has implications both on hydrogeological conditions and especially on the entire sedimentary deposits.Waters penetration through the permeable rocks depends on the petrographic nature of these rocks and their tectonic level. The aquifer layers are well developed in the most recently alluviums from the meadows of the rivers from the Western Plain of Romania. A general characteristic of phreatic layers is that they have a great contribution on feeding by vertical infiltration the deep aquifers.The deep layers of the aquifer have been increasing through all the permeable directions included in the stratigraphic column starting by the alliterated bed on the surface of crystalline from the basement to the Pleistocene level.Due to special conditions, the deep layers of the aquifer are mostly represented by thermal aquifers or mineralized thermal aquifers. [1, 6, 7]

RESULTS AND DISCUSSIONS

The studied region is delimitated to the north by Crisul Repede river and to the south by Mures river. There were taken for study the following geothermal wells: Ciumeghiu 4678 and 4668, Salonta 1705 and 4667, Cefa 4776, Madaras 4777, Tinca 4621 and 4622, Carand 4660, Dezna F-1, Sofronea 1660, Semlac 4639, Iratos 4638, Socodor 4669, Arad 1672, 1658, 4662 and 1578, Nadlac 4672, Curtici 4771 and 1667. [5] The distribution of these wells is shown in Figure 1The results of the chemical analysis are presented in Table 1 and the chemical composition of the major components from the geothermal waters, in meq%, in Table 2. As seen from the Table 2, taking in account the cations, all these geothermal resources with a few exceptions have high sodium content. From the point of view of the anions it is still available the rule established for the northern part of the Western Plain that waters are very strong bicarbonate or chloride. The results are presented in the triangular diagram from the Figure 2. Water from Salonta, well 4667 presents the general characteristics of Pannonian Colector, being very strong bicarbonate, low chloride and very strong sodium type. On the other side the geothermal water from Salonta, well 1706 is far from the general rule, being strong chloride, low bicarbonate and very strong sodium type.The geothermal wells: Cefa 4776 and Mădăras 4777 are very close to very strong sodium-bicarbonated water type. The Tinca basin presents similar characteristics.The geothermal water from Carand well 4660 and Dezna F-1 probably have another origin because they have a very low mineralisation and they are strong bicarbonate, low chloride and presents a very high sodium content.The general rule of waters from Pannonian Colector is also recorded for the geothermal waters from wells: Sofronea 1660, Iratoş 4638 and Socodor 4669.The geothermal basin from Arad has a modified chemical composition and tends to chloride type of water in the following order: 4662, 1658, 1578 and 1672.Changes in chemical composition of geothermal waters were studied for four wells. The results are shown in Table 3. They could be observed not significant changes in the chemical composition. The changes could be the result of some pressure drops which accidentally happen at different feed zones. [5] Regarding the content of microelements they can notice the presence of boric acid in all the studied wells. The boric acid concentration is more than 100 mg/l in Salonta-Ciumeghiu basin. An interesting phenomenon is the systematic presence of phosphate, nitrite and nitrate anions, which were not recorded in geothermal waters from Cretaceous and Triassic basins. [2, 3]

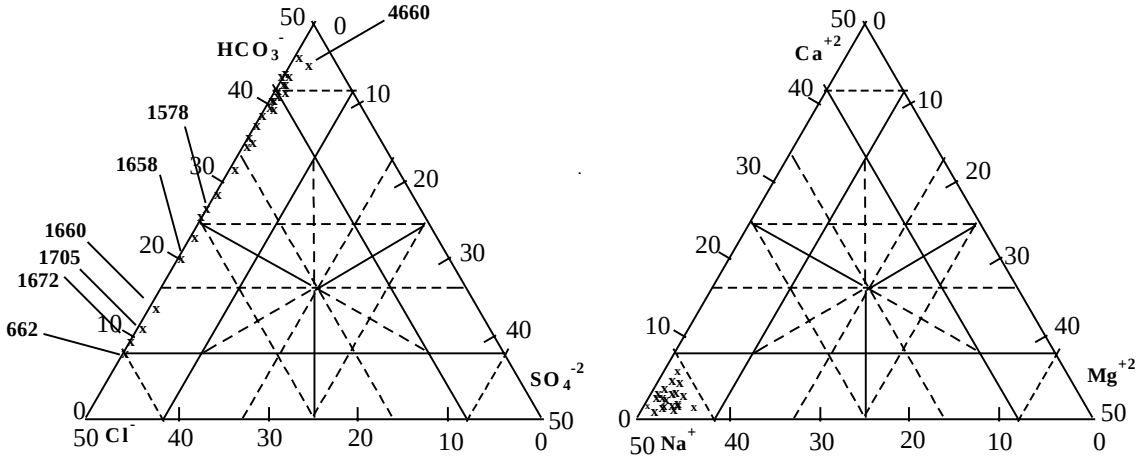

Figure 2: The triangular diagram with the distribution of ions in geothermal waters

CONCLUSIONS

The data obtained from the chemical study indicates that the characteristics are almost the same like those for the northern part of the Western Plain of Romania. Geothermal waters are rich in bicarbonate and sodium ions, but they also have a significant content of chloride. The mineralisation of these waters is between 1000 mg/l and 5000 mg/l, except well 4660 Carand and F-1 Dezna with a mineralisation of about 500-600 mg/l and well 1705 Salonta with a mineralisation higher than 10000 mg/l.

They remark the presence of boric acid in the whole studied area, the highest concentration has reached in Salonta-Ciumeghiu basin. Organic compounds are presented as well. This could be due to the contact of geothermal waters with hydrocarbons.

An interesting fact is the systematic presence of phosphate, nitrate and nitrite ions, which appear only very seldom in geothermal water from the northern part of the Western Plain and in Triassic and Cretaceous Collectors.

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Table 1 Chemical composition of geothermal waters in the reasearch area

		4776	4777	4321	4322	4667	1705	4668	4676	4660	F - 1	1660	4673	4638	4669
pH		7.49	7.41	7.00	7.09	7.40	7.01	7.29	7.62	7.00	7.00	6.90	7.05	6.65	7.05
Cond	µS/cm	1250	1500	-	6000	8700	20000	7000	6750	710	780	2800	4500	3800	3500
Residue	mg/l	716	830	2614	3610	5068	9360	5680	5021	455	434	1300	2191	1695	1834
Hardness	^{o}G	2.18	1.48	11.60	43,75	2.80	17.76	2.27	2.27	2.69	14.28	1.26	4.00	1.65	1.13
anions															
[Cl^{-}]	(mg/l)	56,73	82,97	312,00	319,14	638.28	4471.15	668.80	342.18	21.27	10.63	159.57	992.88	354.60	134.74
	(meq/l)	1.590	2.337	8.799	8.799	17.998	125.948	18.783	9.650	0.600	0.300	4.495	27.968	10.000	3.800
[NO_2^{-}]	((mg/l)	a	a	a	a	a	0.20	a	a	0.04	0.04	0.15	0.14	0.08	a
	(meq/l)	-	-	-	-	-	0.004	-	-	0.002	0.002	0.003	0.003	0.001	-
[NO_3^{-}]	(mg/l)	0.26	0.21	-	0.07	0.54	-	0.17	0.25	a	a	0.26	0.06	0.19	0.28
	(meq/l)	0.004	0.003	-	0.001	0.009	a	0.003	0.004	-	-	0.005	0.001	0.003	0.004
HCO_3^{-}	(mg/l)	809.77	803.29	2318.40	3581.26	3134.07	1967.29	3577.93	3436.97	349.73	401.07	1098.00	640.50	1220.00	1677.50
	(meq/l)	13,275	13,619	38.006	58.709	51.393	32.251	58.654	56.344	5.733	6.575	17.568	10.248	19.520	26.840
[SO_4^{-2}]	(mg/l)	a	a	7.70	u	55.54	78.58	58.43	61.89	39.91	61.72	4.53	13.17	11.93	6.99
	(meq/l)	-	-	0.160	-	1.149	1.637	1.217	1.289	0.831	1.266	0.095	0.276	0.250	0.147
[PO_4^{-3}]	(mg/l)	0.61	0.44	-	a	u	a	a	a	0.20	a	0.75	a	0.56	a
	(meq/l)	0,016	0,014	-	-	-	-	-	-	0.006	-	0.024	-	0.016	-
Total	**(meq/l)**	**14.896**	**15.523**	**49.965**	**67.700**	**70.551**	**159.840**	**78.657**	**67.287**	**7.171**	**8.162**	**22.190**	**38.220**	**29.78`1**	**30.786**
Cations															
[NH_4^{+}]	(mg/l)	3.40	3.53	8.00	6.73	4.46	9.66	10.30	8.87	2.47	1.64	2.80	5.00	2.80	7.50
	(meq/l)	0.189	0.195	0.444	0.374	0.259	0.537	0.572	0.493	0.137	0.091	0.154	0.275	0.154	0.412
[Na^{+}]	(mg/l)	320.00	335.00	980.00	1100.00	1550.00	3500.00	1800.00	1465.00	130.00	60.00	450.00	800.00	650.00	670.00
	(meq/l)	13.931	14.562	42.608	46.826	67.391	152.174	78.261	63.956	5.652	3.609	19.565	34.783	28.161	29.130
[K^{+}]	(mg/l)	3.50	3.50	38.50	61.50	50.00	55.81	33.00	33.00	11.00	10.00	20.00	40.00	20.00	30.00
	(meq/l)	0.089	0.090	0.985	1.573	1.279	1.782	0.844	0.844	0.281	0.256	0.511	1.023	0.511	0.767
[Ca^{+2}]]	(mg/l)	15.03	10.22	41.30	168.54	13.33	125.00	18.47	18.47	12.42	58.72	4.41	16.83	5.61	5.31
	(meq/l)	0.750	0.510	2.061	8.401	0.665	3.120	0.922	0.922	0.620	2.930	0.220	0.841	0.280	0.265
[Mg^{+2}]	(mg/l)	0.36	0.26	25.30	96.43	4.07	37.61	a	a	5.13	26.39	2.80	7.17	3.77	1.70
	(meq/l)	0.030	0.020	2.080	7.937	0.335	3.023	-	-	0.340	2.168	0.230	0.590	0.310	0.140
[Fe^{+2}]	(mg/l)	0.40	0.14	0.50	2.70	0.52	0.20	0.17	0.90	0.15	0.90	0.39	0.27	0.46	0.30
	(meq/l)	0.014	0.005	0.018	0.097	0.019	0.007	0.007	0.032	0.005	0.032	0.014	0.009	0.016	0.001
Total	**(meq/l)**	**14.985**	**15.385**	**48.192**	**65.208**	**69.987**	**161.643**	**80.608**	**66.247**	**7.035**	**8.086**	**20.673**	**37.521**	**29.532**	**30.725**
[SiO_2]	(mg/l)	28.50	30.00	62.00	67.00	53.00	33.00	106.00	146.00	80.00	25.00	33.00	38	32.00	50.00
[HBO_2]	(mg/l)	2.98	5.67	22,20	17.60	104.20	89.40	61.60	163.00	a	a	9.46	7.87	16.44	7.87
o. c.	(mg/l)	38.24	21.40	-	6.00	171.25	85.41	217.41	114.94	2.79	1.85	60.29	51.98	19.01	84.95
Phenols	(mg/l)	0.53	0.39	-	a	10.00	4.10	38.00	18.57	a	a	1.48	2.02	1.34	4.30
Mineral.	(mg/l)	1241.54	1275.21	3844.7	5420.96	5544.81	10367.90	6332.82	5676.53	571.32	656.60	1768.10	2561.89	2318.44	2602.84

		1672	1658	1578	4662	4672	4771	4671	1667	1654	1675	1677	1547	1663	
pH		8.00	7.40	8.00	7.40	6.90	8.05	7.00	7.60	6.90	6.60	7.40	6.20	7.20	
Cond	µS/cm	6000	4550	2500	6900	5000	2480	2700	2880	2600	2450	2500	30150	7200	
Residue	mg/l	3327	2142	1313	3299	2335	1398	1378	1417	1293	1382	1261	16995	5540	
Hardness	°G	10.85	4.90	6.30	7.20	2.38	1.65	0.89	0.86	1.82	1.12	1.31	31.50	5.38	
anions															
$[Cl^-]$	(mg/l)	1702.08	833.31	390.06	1666.62	744.60	548.93	141.84	113.47	74.46	74.46	85.10	9042.30	120.56	
	(meq/l)	48.000	23.500	11.000	47.000	20.675	15.480	4.000	3.199	2.097	2.097	2.397	254.713	3.400	
$[NO_2^-]$	((mg/l)	0.09	0.08	0.08	a	0.09	0.10	0.08	a	0.08	0.24	a	0.03	a	
	(meq/l)	0.002	0.002	0.002	-	0.002	0.002	0.002	-	0.002	0.008	-	0.001	-	
$[NO_3^-]$	(mg/l)	0.33	0.12	0.03	0.03	0.36	0.43	0.21	0.54	0.21	0.13	0.06	a	0.43	
	(meq/l)	0.016	0.002	-	-	0.006	0.007	0.004	0.009	0.004	0.089	0.001	-	0.007	
HCO_3^-	(mg/l)	705.89	965.58	834.23	639.20	1250.50	1283.44	1159.00	1411.78	1220.00	1427.54	1329.28	4733.53	4052.69	
	(meq/l)	11.572	15.780	13.676	10.315	20.080	21.040	18.544	23.143	19.620	23.402	21.791	77.599	66.437	
$[SO_4^{-2}]$	(mg/l)	a	a	10.00	a	20.16	a	12.34	a	12.34	42.82	15.63	14.81	18.14	
	(meq/l)	-	-	0.214	-	0.423	-	0.256	-	0,294	0.892	0.326	0.308	0.379	
$[PO_4^{-3}]$	(mg/l)	0.18	0.26	0.21	a	a	0.47	0.62	a	0.62	a	0.64	t	t	
	(meq/l)	0.006	0.008	0.007	-	-	0.015	0.019	-	0.019	-	0,202	-	-	
Total	(meq/l)	**59.596**	**39.350**	**24.899**	**57.315**	**41.114**	**36.540**	**22.821**	**26.638**	**22.821**	**24.391**	**25.596**	**332.621**	**70.223**	
Cations															
$[NH_4^+]$	(mg/l)	3.18	2.40	2.10	5.05	4.66	2.76	2.11	3.23	2,14	1,57	2.22	13.00	8.33	
	(meq/l)	0.177	0.133	0.117	0.280	0.256	0.153	0.116	0.179	0.117	0.086	0.122	0.722	0.463	
$[Na^+]$	(mg/l)	1275.00	850.00	500.00	1250.00	900.00	830.00	500.00	600.46	470.00	550.00	540.00	7300.00	1500.00	
	(meq/l)	55.435	36.936	21.739	54.348	39.130	35.652	21.739	26.107	20.307	23.913	23.472	317.391	65.217	
$[K^+]$	(mg/l)	6.00	6.00	4.00	5.00	30.00	5.00	20.00	-	30.00	40.00	20.00	100.00	80.00	
	(meq/l)	0.153	0.153	0.102	0.128	0.676	0.128	0.511	-	0.762	1.023	0.511	2.537	2.046	
$[Ca^{+2}]]$	(mg/l)	25.85	15.63	25.05	26.65	10.72	3.81	4.11	2.40	4.11	3.31	2.20	58.91	16.83	
	(meq/l)	1.290	0.780	1.250	1.330	0.536	0.190	0.206	0.118	0.206	0.165	0.110	2.940	0.839	
$[Mg^{+2}]$	(mg/l)	31.43	11.29	12.16	15.08	3.89	0.36	1.40	2.27	2.26	4.38	1.26	101.05	13.13	
	(meq/l)	2.585	0.969	1.000	1.241	0.320	0.030	0.115	0.186	0.186	0.360	0.104	8.310	1.080	
$[Fe^{+2}]$	(mg/l)	0.67	0.78	0.32	0.75	0.15	0.67	0.32	1.35	0.54	0.28	0.14	0.15	0.37	
	(meq/l)	0.024	0.028	0.011	0.027	0.005	0.024	0.011	0.048	0.019	0.010	0.005	0.005	0.013	
Total	(meq/l)	**59.664**	**39.019**	**24.219**	**57.354**	**40.923**	**36.177**	**22.698**	**26.638**	**21.499**	**25.428**	**24.580**	**331.925**	**69.658**	
$[SiO_2]$	(mg/l)	30.44	26.50	27.12	23.50	48.00	32.00	39.00	43.00	-	36.00	-	44.00	-	
$[HBO_2]$	(mg/l)	15.00	25.00	8.00	20.51	8.10	7.14	10.65	11.95	12.74	13.43	-	47.38	156.94	
o. c.	(mg/l)	21.99	43.98	26.33	39.50	107.82	46.15	51.09	57.51	45.44	83.30	13.93	0.43	13.00	
Phenols	(mg/l)	1.65	1.90	1.30	0.93	7.05	2.05	1.27	1.48	1.17	0.53	0.63	a	a	
Mineral.	(mg/l)	3796.14	2733.96	1803.46	3642.36	3021.29	2705.11	1856.03	-	-	2149.76	-	21407.80	5810.48	

Table 2. The content of main ions from geothermal the Pannonian collector basin located in the central part the Western Plain of Romania, in meq/l .

Nr. crt	Sursa	$[Cl^-]$ (%meq)	$[HCO_3^-]$ (%meq)	$[SO_4^{-2}]$ (%meq)	$[Na^+]+[K^+]$ (%meq)	$[Ca^{+2}]$ (%meq)	$[Mg^{+2}]$ (%meq)
1	4776	11.84	44.56	-	46.78	2.50	0.10
2	4777	7.53	43.87	-	47.62	1.66	0.06
3	4321	8.80	38.03	0.16	45.23	2.14	2.16
4	4322	6.50	43.36	-	37.11	6,44	6.05
5	4667	12.75	36.42	0.81	49.05	0.47	0.24
6	1705	39.40	10.09	0.51	47.62	0.96	0.93
7	4668	7.86	37.28	0.77	49.07	0.57	-
8	4676	7.17	41.87	0.96	48.18	0.69	-
9	4660	4.18	39.97	5.79	42.17	4.40	2.42
10	F-1	1.84	40.28	-	23.90	18.12	13.40
11	1660	10.13	39.58	0.21	48.56	0.53	0.56
12	4673	36.59	13.41	0.36	47.71	1.12	0.79
13	4638	16.79	32.77	0.59	48.54	0.47	0.52
14	4669	6.17	43.59	0.24	48.65	0.43	0.23
15	1672	40.27	9.71	-	46.58	1.08	2.17
16	1658	29.86	20.05	-	47.53	1.00	1.24
17	1578	22.09	27.46	0.43	45.09	2.58	2.06
18	4662	41.00	9.00	-	47.49	1.16	1.08
19	4672	25.14	24.42	0.51	48.63	0.65	0.39
20	4771	21.18	28.79	-	49.45	0.26	0.04
21	1667	6.00	43.88	-	49.00	0,21	0.35
22	1654	4.59	42.99	0.64	49.00	0.48	0.43
23	1675	3.96	44.17	1.68	49.03	0.03	0.70
24	1547	38.289	11.51	0.05	48.19	0.44	1.25
25	1663	2.42	47.30	0.27	48.28	0.60	0.77

Table 3. Change in time of the chemical composition of geothermal waters (meq/l)

	1997	1998	1999	2000	2001	Mean
4777 MADARAS						
Cl^-	2,48	2,51	2,33	2.20	2.18	2.35
HCO_3^-	14.60	14.30	15.06	13.75	13.59	14.36
SO_4^{-2}	-	-	-	-	-	-
$Na^+ + K^+$	16.15	16.12	16.48	15.85	14.74	15.88
$Ca^{+2} + Mg^{+2}$	0.52	0.47	0.50	0.50	0.56	0.51
4776 Cefa						
Cl^-	1.35	1.26	1.24	1.05	-	1.22
HCO_3^-	13.32	12.92	12.72	11.39	-	12.59
SO_4^{-2}	0.26	0.26	0.06	0.02	-	0.15
$Na^+ + K^+$	13.49	13.27	13.13	12.09	-	12.99
$Ca^{+2} + Mg^{+2}$	0.92	0.96	0.60	0.60	-	0.77
4668 Ciumeghiu						
Cl^-	-	20.00	18.50	-	18.78	19.39
HCO_3^-	-	58.26	60.37	-	58.65	59.57
SO_4^{-2}	-	1.04	1.07	-	1.22	1.06
$Na^+ + K^+$	-	78.61	78.14	-	79.00	78.80
$Ca^{+2} + Mg^{+2}$	-	0.69	1.16	-	1.80	0.97
1672 Arad						
Cl^-	46.09	48.50	46.00	47.77	48.23	42.32
HCO_3^-	10.78	11.57	10.74	11.32	11.56	11.19
SO_4^{-2}	-	-	-	-	-	-
$Na^+ + K^+$	59.26	61.43	58,98	59.78	60.09	59.91
$Ca^{+2} + Mg^{+2}$	2.55	2.82	2.77	2.46	2.98	2.72