THE THERMO-MINERAL WATERS FROM THE HÂRȘOVA – VADU OII AREA, CONSTANȚA COUNTY

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Abstract. The artesian well F1 drilled by the Hârşova City Hall in the northwestern part of the city intercepted on the 80-150 m depth interval the thermal mineral water aquifer in the Hârşova - Vadu Oii area, confirming the historical data related to this aquifer. The chemical and biological analyses of the water in the well attest to the fact that the water is maintaining its chlorosodic and sulfurous character of water, being recommended for curative purposes.

Keywords: thermo-mineral water**,** Hârșova – Vadu Oii.

Rezumat. Apele termo-minerale din zona Hârșova – Vadu Oii, județul Constanța. Puțul artezian F1, forat de Primăria Hârșova în partea de nord-vest a orașului, a interceptat pe adâncimea de 80 – 150 m acviferul de ape termo minerale din zona Hârșova - Vadu Oii, confirmând șirul de date istorice referitoare la acest acvifer. Analizele chimice și biologice ale apei din puț atestă faptul că acesta își menține caracterul de apă clorurată și sulfuroasă, care este recomandată în scop curativ.

Cuvinte cheie: ape termo-minerale, Hârșova - Vadu Oii.

INTRODUCTION

The Hârșova – Vadu Oii thermo mineral waters are located north of Hârșova Town, in the Constanța County, on the right bank of the Danube River, in a flat relief area, with altitudes below 40 m. Access is possible through the Vadu Oii-Constanța road.

The geology in the study area is represented by the basement and Jurassic, Cretaceous and Quaternary sedimentary deposits (Fig. 1). Here **the basement** consists of Green Schists of Upper Proterozoic Age, represented by silty shales, feldspatic grit stones with clay, grit stones and well lithificated, hard, compact, dark green quartz conglomerates. In the study area the Green Schists are folded, tilted to 35 degrees to the W and SW, as in the Hârșova 63 well. The basement does not outcrop anywhere in the area, but it was intercepted by the Hârșova 63 well at a depth of 34.2 m. The Hârșova 5095 well located 140 m west of "Privalul Puturosu" intercepted the Green Schists at a depth of 129 m (VASILESCU & PÂRVU, 1967). Eight km west of Hârșova, on the left bank of the Danube River, at "Piua Petrii", the 403 well intercepted the Green Schists at a depth of 498 m. (CONSTANTINESCU & CROITORU, 1968). Another well, drilled 6 km downstream (NW) of Hârșova, entered the Green Schists at a depth of 203 m (PRICĂJAN, 1985).

The succession of mesozoic sedimentary layers that have been intercepted in the wells of the study area is described below (Fig. 1).

The Jurassic deposits referred to as the Casimcea formation are to be found as follows:

- At the base Lower Oxfordian represented by massive to bedded red breccias of silicified limestone clasts;
- Above, Lower Oxfordian consisting of hard, white limestones with chert nodules;
- On top of it, Upper Oxfordian is represented by white, bedded, ammonite bearing with some chert nodules;
- Covering Oxfordian, Kimmeridgian deposits consist of white fossiliferous bioclastic limestones.

The Cretaceous is represented by Aptian deposits accumulated in the continental environment. Aptian sediments occur as patches with reduced thickness, consisting of boulders, conglomerates, gravels, sands and kaolin, polychrome clays.

In the low area north of Hârșova Town, **Quaternary deposits** are 34.2 m (Hârșova 63 well) and 70 m (Hârșova 5095 well) thick. They are loose, uncemented and consist of alternating gravel and coarse, gray sand. Genetic types of Quaternary deposits covering the entire area from Hârșova to the East are diluvium-proluvium (BANDRABUR et al., 1968). These loess deposits, dusty-sandy in nature, are macro-porous and contain calcareous concretions. Sometimes they have clay, bricky layers, which are paleosols. The loessoid diluvium deposits come from the washing of the primary loess, followed by their deposition at the base of the slopes, while the proluvium deposits are the torrent slurry cones. They date back to the Middle – Upper Pleistocene. In the Danube meadow, the Upper Holocene alluviums consist of sands and clay sands, 10-15 m thick (Fig. 2).

The Hârșova area is situated in **Central Dobrogea**, North of the Capidava-Ovidiu Fault on a Dobrogea-type basement of the Moesian Platform, consisting of Green Schists (Green Schists Block). To the N-E of the Capidava-Ovidiu Fault, the Proterozoic foundation of Green Schists is affected by two other faults, parallel to this one: Hârșova – Tașaul Fault and Horia-Pantelimonu de Sus Fault. The Hârșova – Tașaul Fault is situated 8 km N-E from the Capidava-Ovidiu Fault, passing through the Danube meadow, south-west from Hârșova, near the town and to the west of Ghindărești. The geological area on which Hârșova is situated is higher than the southern one, which is delineated by the Capidava-Ovidiu Fault. Horia-Pantelimonu de Sus Fault is located 5 km northwest from the Hârșova-Tașaul Fault and its north-eastern section is lower compared to that on which Hârșova is situated (Fig. 1).

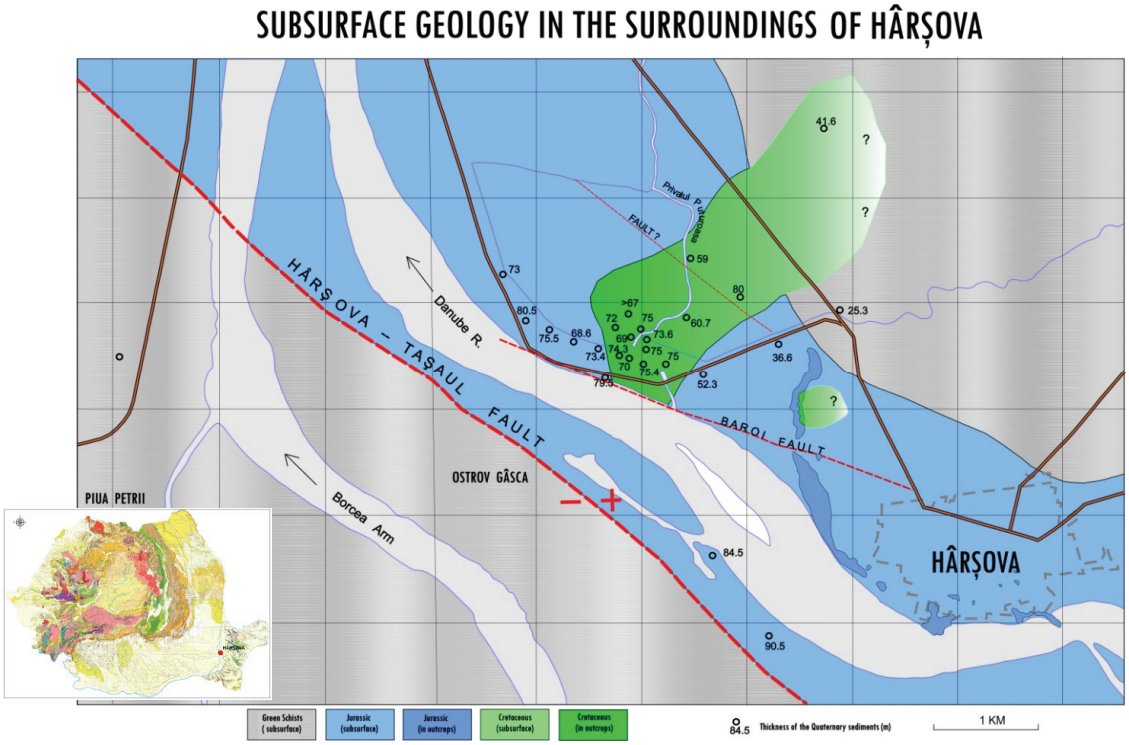

Figure1. Map with wells that intercepted the aquifer area Vadu Oii - Hârșova and thickness of Quaternary sediments intercepted (original; BALTRES, 2014). The map from the left corner is the geological map of Romania with the Hârșova location (source - Geological Institute of Romania).

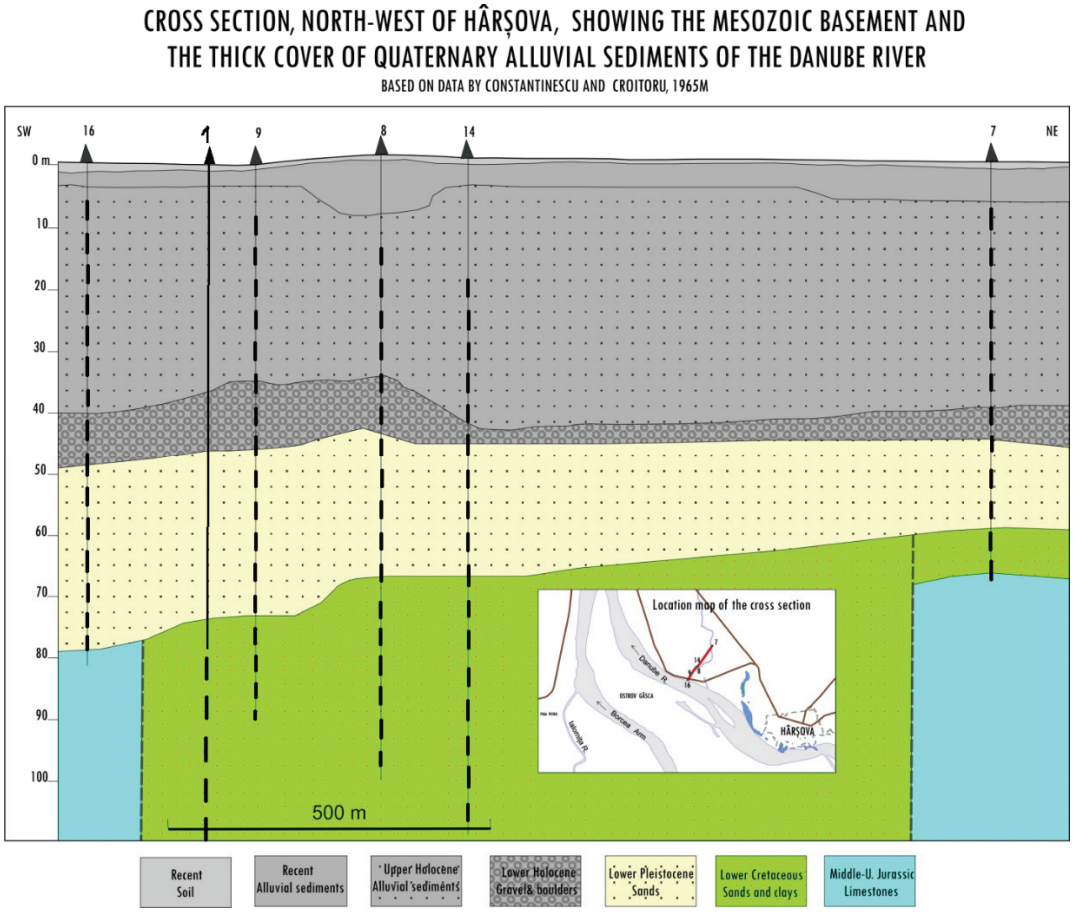

Figure 2. Geological section in the north-west of Hârșova, indicating the depth at which Mesozoic deposits were intercepted, over which were deposited the Quaternary alluvial deposits of the Danube River (BALTRES & PERȘA, 2014);
F1 was drilled in 2013, it is artesian.

The thermo mineral waters from Hârşova have been studied since the 1970s. During the period 1961–1966 numerous boreholes were drilled by I.P.G.G. (Enterprise of Geological and Geophysical Prospections) to the West of the Puturosu canal and in the Danube meadow between Hârşova and Vadu Oii, and by I.S.P.H. at Ostrovul (Islet) Gâsca. Based on these data, CONSTANTINESCU & CROITORU elaborated a report in 1965, and FERU (1971). During the period 1978 – 1983 five other hydrogeological wells were drilled outside Hârşova – Vadu Oii, on the left bank of the Danube River. Their depth was between 163 m and 270 m. The depth of productive layers is in some cases between 60 and 140 m, and in other cases between 160 m and 236 m. The flow rate registered for these wells varied between 5.5 l/s and 8.4 l/s. The registered temperatures range between 18 and 42ºC. Based on total mineralization and H2S content, water was diagnosed as chlorosodic and sulphurous, with a total mineralization up to 2700 mg/l and dissolved H2S up to 57 mg/l.

In 1979, based on data from the well F1 ISLGC by Conclusion 52-89 / 15 June 1979, the substance "chlorine, sulfurous thermal waters with temperatures of 23 - 420C" was approved as an exploitable resource. The flow rate corresponding to the C1 reserve is 432 cubic meters/day, and the extracted reserve is 432 cubic meters/day. The available reserve can be used as spa, for cure and recreation purposes.

MATERIAL AND METHODS

In 2013, the Hârşova Town Hall drilled a new water supply well for the town, but it turned out that the water extracted from this well is geothermal (Fig. 3). On this occasion BALTRES & PERŞA (2014) prepared a hydrogeological report regarding the thermal mineral waters in the Hârşova - Vadu Oii area, whose results are presented in this article. The report includes, besides new detailed maps and cross-sections in the Hârşova - Vadu Oii area, the integration of new data acquired from the well with historical hydrogeological data.

Figure 3. Artesian well F1 Hârşova drilled in 2013 (original).

In 2013, the Hârşova Town Hall, through S.C. Fluid Service performed a new drilling (F1 Hârşova), which is artesian and confirms the existence of the geothermal resources highlighted since the seventies. The depth of the well is 150 m, and the aquifer was intercepted from 80 m to 150 m deep. The filter diameter is 250 mm. In order to determine the hydrogeological parameters of the aquifer, experimental tests through pumping were carried out by S.C. Fluid Service, obtaining the results given in Table 1.

Table 1. Hydrogeological parameters of F1 Hârşova well.

Drilling	Flow rate (l/s)	Drop-down level S (m)	Height of discharge (m)
F1 Hârşova well – aquifer layer interception	3.0	Artesian well	+ 7 m
F1 Hârşova well – stage I	11.4	4.5	-

In June 2014 a water sample was taken from the F1 Hârșova well, and chemical analyses were performed in the laboratory of S.C. Prospectiuni S.A. Spectroscopy's of atomic absorption, potentiometry, volumetry were used as assay techniques. The results of these analyses are given in the Table 2.

Table 2. Chemical analysis of the water sample collected from F1 Hârșova.

Ions	Units	Detection limit	Value
pH		0.1	7.19
Conductivity	µS/cm	0.5	4170.0
Chloride (Cl^-)	mg/l	0.5	1078.0
Sulfate (SO_4^{--})	mg/l	2	160.1
Bicarbonate (HCO_3^-)	mg/l	3	381.3
Sodium (Na^+)	mg/l	0.01	599
Potassium (K^+)	mg/l	0.01	29.85
Calcium (Ca^{++})	mg/l	0.01	153.0
Magnesium (Mg^{++})	mg/l	0.01	61.0
Carbon dioxide (CO_2)	mg/l	3	31.68
Dry residue 180ºC	mg/l	0.1	2420.0
Soluble dry residue (calculation)	mg/l	3	2610.65
Total dissolved salts	mg/l	0.1	3169.0

The bacteriological indicators from the water sample taken from F1 Hârșova well have been analyzed by the National Institute for Research and Development for Industrial Ecology (ECO-IND) Bucharest. The result is that no bacteria have been found in the water, confirming the previous recommendations that thermo-mineral water can be used for balneological purposes. As a result, the Hârșova Town hall intends to submit for funding a project proposal for a spa complex that is about to use these waters.

RESULTS AND DISSCUTIONS

The aquifer of thermo mineral waters is a confined aquifer, which is ascending or artesian in some places. In the Hârșova – Vadu Oii area, which is located to the north-west of Hârșova, about 2 km from the town, more than 22 wells intercepted two types of deposits: on top alluvial complex of the Danube River, and below karstified Jurassic, (or Cretaceous) limestones. Thus, nine of the wells only intercepted the upper layers, and the rest had filters both for Quaternary and Jurassic deposits.

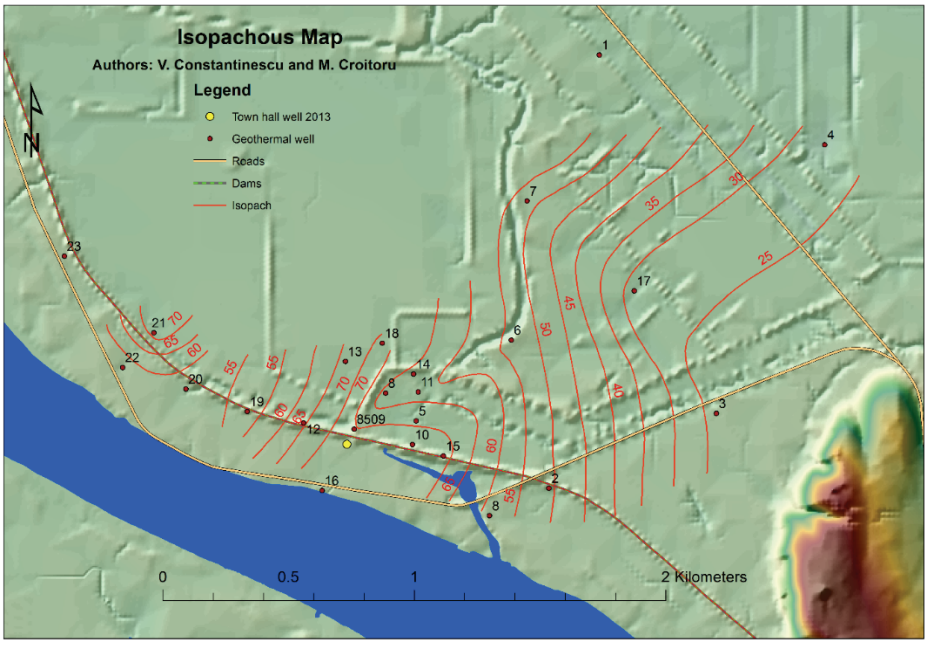

Figure 4. Isopachous Map of Alluvial deposits of the Danube in Hârșova – Vadu Oii area, redrawn by Perșa; With yellow is F1 Hârșova artesian well that was drilled in 2013.

The thickness of the Danube alluvial deposits that host geothermal waters varies from 70-75 m towards the Danube and gradually decreases to 20-25 m eastward (Fig. 4). Between the aquifer and the river there is a direct connection and the existence of impermeable or poorly permeable layers in the alluvial complex determines the ascending nature of the aquifer. The thickness of impermeable layers, which consist of dusty, fine sands, fine clay sands and sandy clay, varies between 2 and 22 m. Based on data from the wells drilled in the seventies, an isopach map

(CONSTANTINESCU & CROITORU, 1968) was elaborated, indicating the spatial extent of the aquifer. The thickness of the aquifer layers increases proportionally while getting closer to the Danube and decreases eastward, as the distance from the river increases.

The hydrostatic levels identified through drilling are found at depths ranging between 0.50 m and 5.80 m, which are lower in areas where clay, dusty, silty sediments are thicker. Three of the wells drilled in the seventies and the one drilled in 2013 are of artesian nature. The wells that intercepted only the alluvial complex have an ascending character, and the artesian character is observed in the wells which undergo the influence of Danube's raised level and flooding surrounding areas, so it is more prominent in the wells located near or even in the thalweg of the river. The data obtained through pumping indicate good permeability and a great discharge capacity of the alluvial complex. Filtration coefficients for the well F8 are around 48 m/24 h. The artesian character is reported mainly in the wells which intercept karstified Jurassic limestones. An example is well F22, which was of an ascending nature when intercepting alluvial deposits. When the well intercepted the Jurassic layer, at depth of 80.5 m, it became artesian.

The high water temperatures of the aquifer from Hârșova - Vadu Oii area are due to their mixture with hyperthermal waters from the depth, which circulate through the cracks and karstic voids belonging to Cretaceous and Jurassic limestone as well as on lines of fracture.

Regarding the origin of hot waters coming from the depth, it is considered that they are of vadose origin. Infiltrating into limestone, they reach the depth where their temperature rises according to the geothermal gradient, and when they come into contact with dislocation lines, they head to the surface where they take the form of hidden artesian waters in the alluvial deposits.

The geothermal gradient at Hârșova has values of 3.5-4 degrees at 100 m (GHENEA et al., 1980) and, according to BUTAC & OPRAN (1985), even higher values of 4-5 degrees at 100 m. To some extent these high values can explain the water temperatures corresponding to the Hârșova - Vadu Oii aquifer. In the boreholes located in the east, values between 11.30^0C and 16^0C were recorded, while in the wells to the west, in areas bordering the Danube, temperatures range between 36^0C and 42^0C. High water temperatures were recorded in the wells from "Ostrovul Gâsca", which intercepted the limestones. There, the measured temperatures were 45^0C (well 12) and 39^0C (well 33).

The results of the chemical analysis performed in 2014 confirms the historical values and show that one characteristic of the geothermal waters from Hârșova -Vadu Oii area is represented by the high values of total dissolved salts (3169.0 mg/l), predominantly sodium and chloride ions. To a lower degree, one can find bicarbonate ions (HCO_3^-), calcium (Ca^{++}), magnesium (Mg^{++}) and sulphate ($SO4^{--}$) plus ions of bromine (Br^-), iodine (I^-) and free gases, such as carbon dioxide (CO_2) and hydrogen sulfide (H_2S). The presence of Cl^- and Na^+ in large quantities in the groundwater is due to their mixture with hot mineral waters that come from depth (CONSTANTINESCU & CROITORU, 1968).

The hydrogen sulfide comes from the water flowing through the upper layer of green schist. Pyrites, which are commonly found in a dispersed form in the green schists, are oxidized according to the following reaction, resulting into hydrogen sulfide and limonite:

$$2FeS_2 + 4\ H_2O = 4H_2S + Fe_2O_3 + O$$

Considering the temperatures and chemical composition of groundwater in the Hârșova-Vadu Oii area, waters are characterized as chlorine, sulfurous thermo-mineral waters, with low salt concentration.

In terms of temperature, they are categorized as mesothermal waters.

CONCLUSIONS

The drillings that have intercepted the aquifer in the Hârșova - Vadu-Oii area have been carried out over the years in several stages and have provided information on the succession of the strata hosting the aquifer, on the hydrostatic level of the soil, the hydraulic characteristics of the aquifer, temperature and chemical composition of thermal mineral water, etc.

In 2013 with the occasion of drilling a new well by the Hârșova town hall, IGR representatives had the opportunity to reconsider and confirm the historical data. The following were observed, *inter alia*:

- The F1 Hârșova well, drilled by the Danube right bank, is artesian.
- The water temperature of the new well has a value of 40 ° C.
- Water has a chlorosodic and sulfurous character, as it has been characterized in the past.
- The thickness of the permeable deposits intercepted in F1 Hârșova corresponds with the thickness of the aquifer as resulting from the Isopach map. Thus, the older data based on which the map was elaborated are validated.

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