POSSIBILITY OF EXTENDING THE DRINKING WATER SUPPLY FOR THE CONSTANȚA HARBOR

Glicherie CARAIVAN[1], Irina DINU[2], Constantina FULGA[1], Vlad RADU[3]

[1]*National Institute of Marine Geology and GeoEcology – GeoEcoMar, Constanta Branch, 304 Mamaia Blvd., 900581, Constanta, Romania*
[2]*National Institute for Marine Geology and Geoecology - GeoEcoMar– Bucharest, 23 – 25 Dimitrie Onciul, 024053 Bucharest 2, Romania*
[3]*National Institute for Land Reclamation ISPIF Bucharest, 35 – 37 Olteniței Rd, 024053 Bucharest 4, Romania*
e-mail: gcaraivan@geoecomar.ro, irinadinu@geoecomar.ro, costina_fulga@yahoo.com

Abstract. The Constanța Harbor is located along three structural blocks: Constanța, South Constanța and Eforie - Techirghiol, with different hydrogeological characteristics. This paper presents the main sources for drinking water supply of the Constanța Harbor. A new abstraction well was proposed and installed, to intercept the Upper Jurassic – Lower Cretaceous confined aquifer, in the proximity of the Cernavodă - Constanța Fault, in the marine area of the Constanța Harbor platform.

Key words: aquifer, Constanta Harbor, tectonic block, abstraction well

1. INTRODUCTION

Over the years, the water supply of Constanța Harbor has been totally dependent of the water supply of Constanța city. The increase of the drinking water delivery price made the Constanța Harbor Administration evaluate alternatives for drinking water supply from groundwater sources.

All the investigations carried out by now in South Dobrogea were made on land. The marine domain located in the proximity of the coast wasn't investigated, the danger of contamination with salty marine water being raised by skeptics.

The aquifer potential in the Constanța Harbor is evaluated for the first time in this paper, based on geological, structural and hydrogeological data. That is why this approach is a challenge.

2. MATERIALS AND METHODS

Preliminary hydrogeological studies and technical reports for water supply for some industrial or private objectives located in the Constanța area (Fig. 1), were analyzed.

Field investigations were also carried out, in order to achieve additional data concerning water sources.

3. MAIN GEOGRAPHIC FEATURES

The Constanța Harbor domain has been acquired artificially from the sea, by civil engineering works, such as dams and fillings. It extends from the Cape Constanța (Gate 1) to Agigea. Its western boundary follows the base of the marine cliff, previously modeled by the marine hydrodynamic regime, but also bearing the damaging effects of landslides and erosions.

The average elevation is 60 to 70 m, increasing to 80 – 90 m south of the Albeşti Valley. The Constanța Harbor, as coastal zone, belongs to the category of erosion coast lines, with cliff, taken out of the direct influence of the marine hydrodynamic regime, by civil engineering works.

The climate is typically continental, with the sea influence upon a 10 to 15 km wide littoral strip. The average multi-annual temperature is 11.2 ^{o}C. The precipitations are low and unevenly distributed during the year, not exceeding 400 mm/year.

4. REGIONAL GEOLOGICAL FRAMEWORK

The Constanța Harbor and the South Constanța – Agigea area are comprised in the South Dobrogea platform, bound-

Fig. 1 Topographic map with location of the wells F1 – F15; FP - location of the new well; AB, CD hydrogeological cross-sections

ed north by the Capidava – Ovidiu fault (Fig. 2). South Dobrogea has common platform features, with a Pre-Cambrian crystalline basement and a sedimentary cover (Palezoic – Quaternary deposits).

Regional WNW – ESE and NNE – SSW fault systems (Fig. 2) divide the South Dobrogea platform in tectonic blocks with uneven thickness and differing positions of the stratigraphic limits.

In the study area, several geological formations have been identified in outcrops and boreholes, being presented hereafter (Figs. 3 – 5):

The basement, including Arhaic gneisses (Ovidiu Series), Lower Proterozoic high-grade metamorphic rocks (Palazu Series) (Ionesi, 1994) and Upper Proterozoic (Vendian) volcano-sedimentary rocks (Green Schists Formation), is dipping southwards and westwards (Paraschiv *et al.*, 1983).

The sedimentary cover started with thick Mesozoic deposits, followed by thin Sarmatian – Quaternary deposits and has been described in detail by Băncilă, 1973; Dragastan, 1985; Avram *et al.*, 1988, 1997; Dragastan *et al.*, 1998, Dinu et al, 2007.

Mesozoic is represented by locally developped Triassic deposits, consisting of reddish to yellowish or dark sandstones, argillaceous shales, limestones, oolites, breccias and conglomerates.

The Upper Jurassic – Lower Cretaceous carbonate rocks crop out along the Capidava – Ovidiu Fault (Fig. 5).

Upper Cretaceous is represented by conglomerates, sandstones, silty marls (Cenomanian + Turonian) and chalk with concretionary cherts and sandstones and conglomerates in the basal part (Senonian).

The Sarmatian deposits are well represented, being more or less like a continuous layer that covers the eastern part of South Dobrogea. It consists mainly of limestones with some detritic levels.

The Quaternary succession covers most of the South Dobrogea surface. Its formations start with a reddish argillaceous level (Lower Pleistocene), covered by up to 40 m of loess deposits (Middle – Upper Pleistocene). Along the main streams, the recent alluvial sediments are present.

5. STUDY WELLS IN THE CONSTANȚA HARBOR ZONE

The Harbor domain is located on the following tectonic blocks (Fig.2):

- Tectonic block 5 (Constanța), bounded north by the Capidava – Ovidiu Fault, south by the Cernavodă – Constanța Fault, west by the West Constanța Fault, going on in the Black Sea shelf to the east.

  The most representative study wells on this block are F6 Mamaia and F13 METRO 1 Constanța (Figs. 1, 6), that crossed the following litho-stratigraphic succession: 13 m thick Quaternary deposits of sand and silt, 2 to 12 m thick Sarmatian limestones, 42 to 74 m thick Senonian chalky deposits, locally Albian deposits, about 4 m thick and Upper Jurassic deposits, up to 400 m thick.

- Tectonic block 10 (South Constanța), bounded north by the Cernavodă – Constanța Fault, south by the Lazu - Cumpăna Fault, which crosses the Constanța Harbor in the proximity of Gate 6, west by the Palas Fault, and to the east, going on in the Black Sea shelf.

  This block covers a wide part of the industrial zone of Constanța city (Figs. 1, 7). It was investigated by several drinking water abstraction wells: F1 and F2 Brewery, F4 and F11 Oil Factory, F9 Oil Terminal Storage Area 1, F15 Astra Română. These wells crossed the following litho-stratigraphic succession: 13 to 40 m thick Quaternary deposits of loess with local calcareous concretions; 31 to 68 m thick Sarmatian limestones with local clay and sand intercalations; 74 to 175 m thick Senonian deposits of chalk and chalky limestones with local sandstone and clay intercalations; 99 to 320 m thick Upper Jurassic limestones and dolomitic limestones.

- Tectonic block 13 (Eforie – Techirghiol) is bounded north by the Lazu – Cumpăna Fault, south by the Rasova – Costineşti Fault and west by the Techirghiol Fault, going on towards east, on the Black Sea continental platform.

  This block is characterized by the absence of the Upper Jurassic – Valanginian formations. 200 m thick Cenomanian and 200 to 350 m thick Senonian deposits are directly overlapped over the Middle Jurassic and Triassic deposits. The crystalline basement descends in steps towards the littoral zone.

  The tectonic block 13 extends in the southern part of the Constanța Harbor. The study wells crossed the next litho-stratigraphic succession: 21 to 35 m thick Quaternary formations, 30 to 44 m thick Sarmatian limestones, 222 to 244 m thick Senonian chalky formations, 50 to 250 m thick intercepted mainly detritic Cenomanian formations.

6. PRELIMINARY HYDROGEOLOGICAL CONSIDERATIONS

In the study area, three potential water sources have been identified: phreatic water, medium depth groundwater (the Sarmatian aquifer), deep groundwater (the Upper Jurassic – Lower Cretaceous aquifer).

The phreatic aquifer, developed at the base of the loess-like deposits, on the impervious red clay overlapping the Sarmatian limestones, was investigated by the wells F7 and F8 (Fig. 1). Groundwater is mainly potable but the pumping rates at the installation are too low, around 1 l/s. The aquifer discharges through several springs, at the base of the slope between the plateau and the shore. Chemical analyses of samples from these springs show slight influences from the sewerage system.

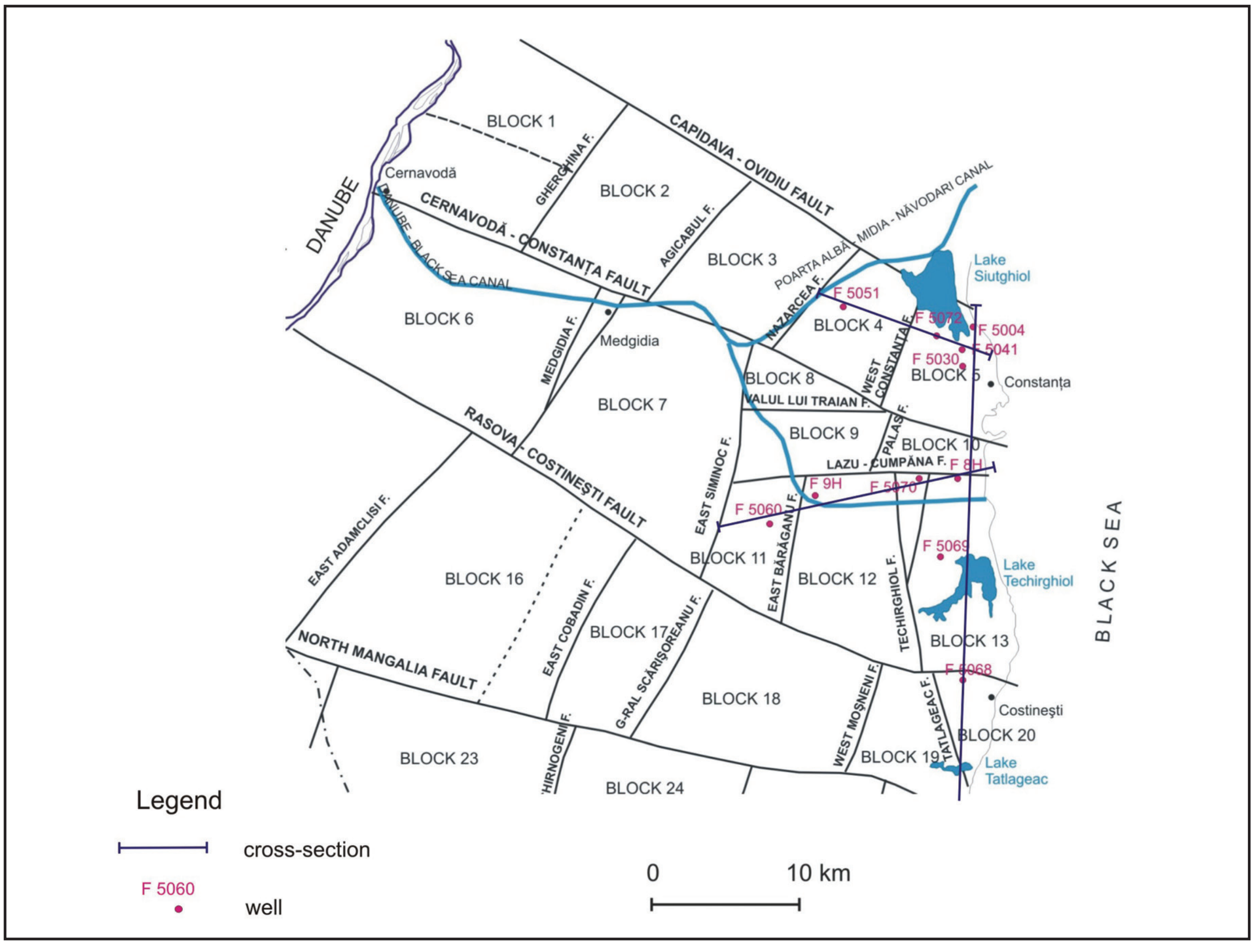

Fig. 2 Sketch of the fault systems and tectonic blocks of South Dobrogea in the study area with the wells used for the cross-sections from Figs. 3-5; similar codes for tectonic blocks as used by Moldoveanu, 1998

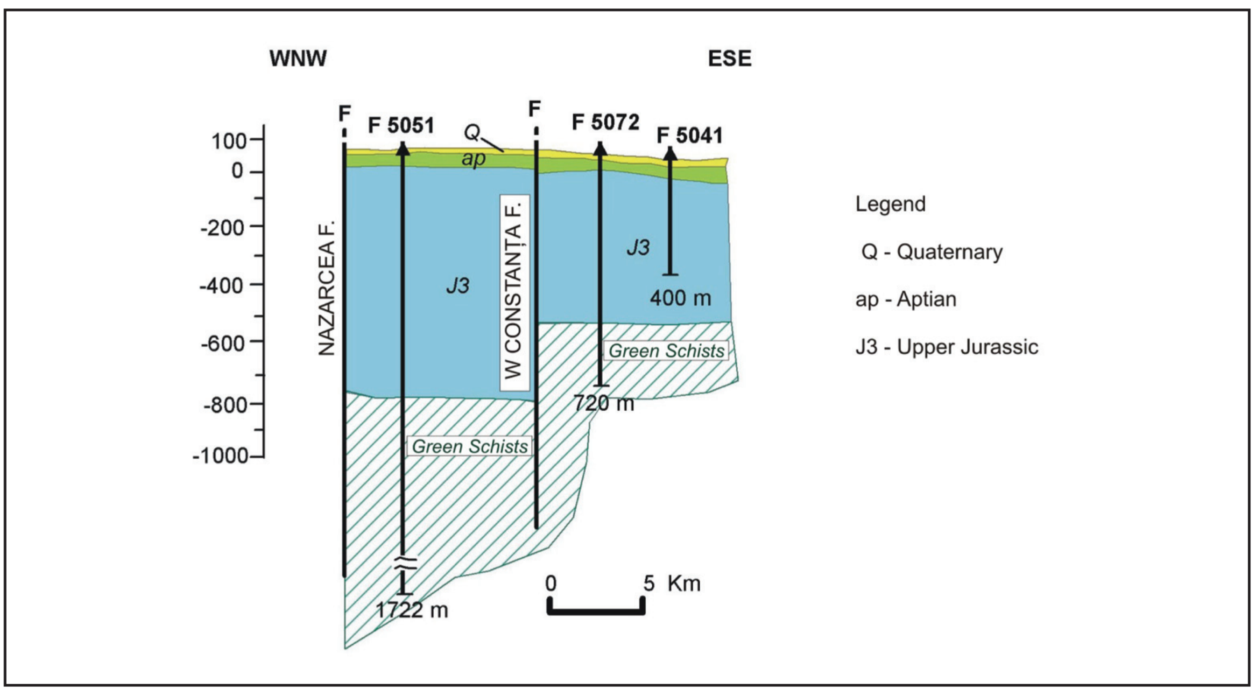

Fig. 3 WNW-ESE cross-section (see Fig. 2)

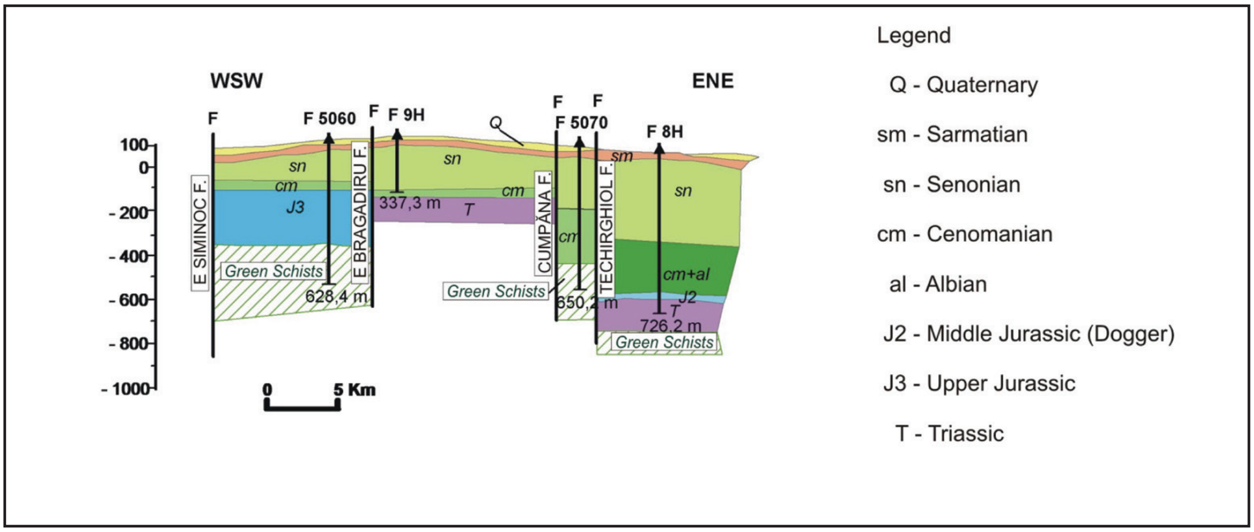

Fig. 4 WSW-ENE cross-section (see Fig. 2), emphasizing the block without Upper Jurassic deposits

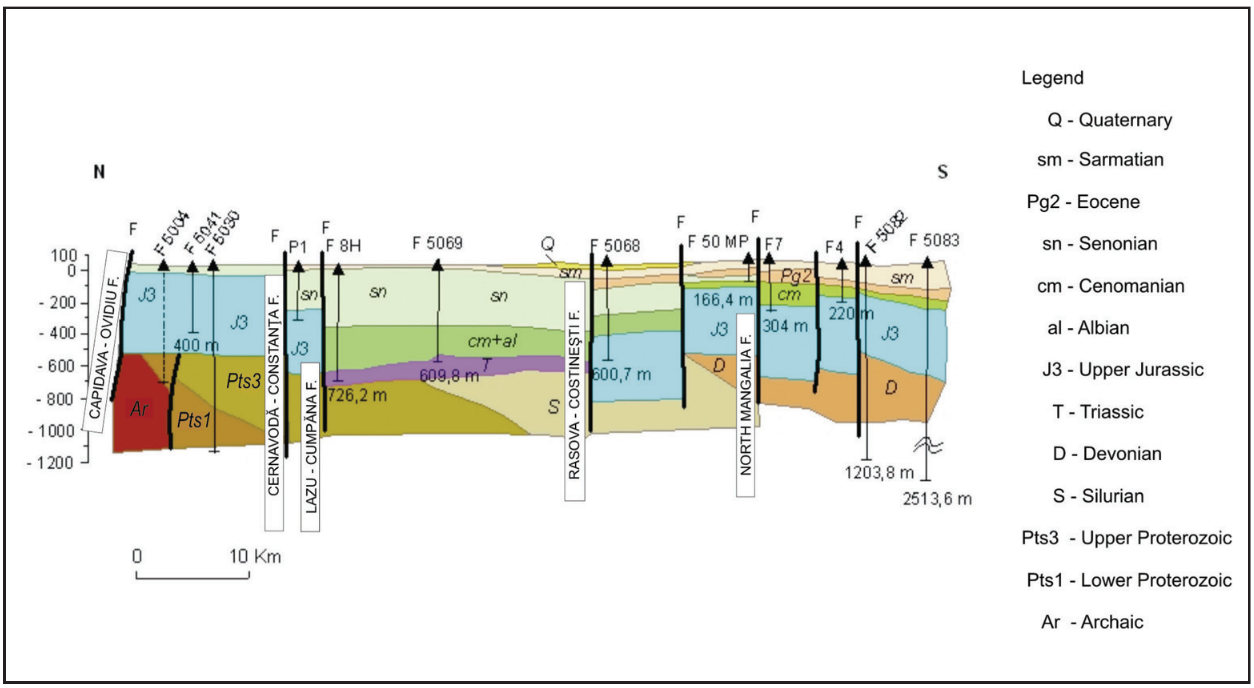

Fig. 5 Regional N-S cross-section (see Fig.2), parallel to the coast line

Thus, both from the quantitative and qualitative points of view, this aquifer is not appropriate as drinking water source.

6.1. The Sarmatian aquifer

In the area of Constanța city, the medium depth aquifer in altered and karstified Sarmatian limestones, is locally covered by bentonitic clay. The thickness of the Sarmatian deposits varies between 2 and 68 m, in the zone of Constanța city, increasing southward, up to 180 m.

The Sarmatian aquifer is not continuous in the study area. Groundwater flow in the Sarmatian limestones is mixed. The aquifer is locally unconfined, in the zones where it is covered by silty loess deposits, or locally confined, in zones where it is covered by clayey loess deposits (Moldoveanu, 1998).

At regional scale, the Sarmatian aquifer is supplied from precipitation on the Bulgarian territory, where the whole structure is outcropping at higher elevations. Before the 1990s, an irrigation system was also in function and afferent losses were increasing the recharge. Starting from 1990, the irrigations were gradually reduced and nowadays they are not used anymore.

The Sarmatian aquifer discharges to the east (Fig. 8), to the Black Sea, and to the Danube – Black Sea canal, which in-

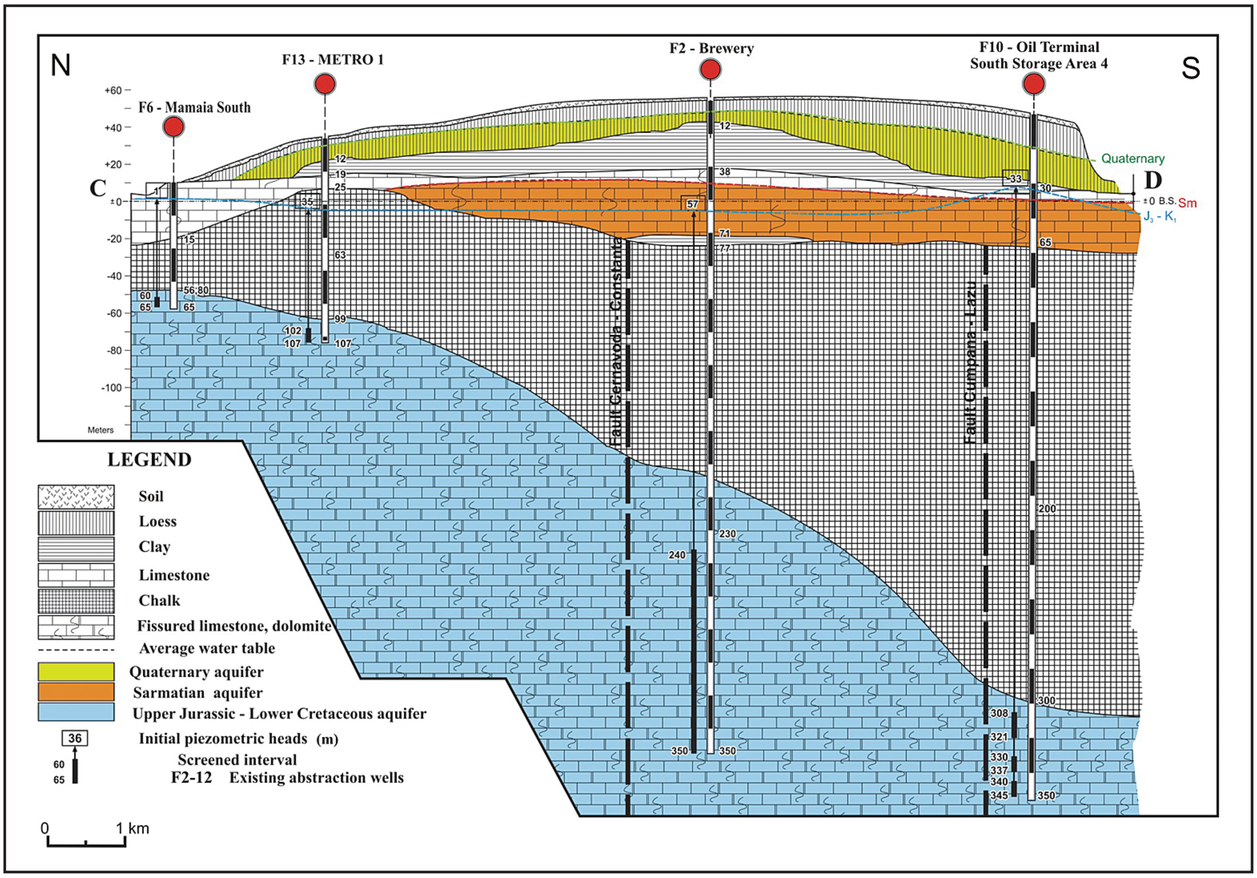

Fig. 6 N-S hydrogeological cross-section (see Fig. 1) through Constanța city

tercepts the Sarmatian formations on the last 5 - 6 km, before reaching the Black Sea. The aquifer also discharges by downward leakage, to the confined Upper Jurassic – Lower Cretaceous aquifer, except for the coastal zone, where the leakage is upward, due to the head difference.

There are abstraction wellfields in the Sarmatian aquifer in the littoral zone and towards the border with Bulgaria.

The transmissivity of the Sarmatian aquifer determined from pumping tests varies between 50 and 3500 m^2/day (Moldoveanu, 1998).

In the Constanța Harbor area, the Sarmatian aquifer was intercepted by 100 to 155 m deep wells, such as F9, F11 and F12. The aquifer is intercepted up to 60 – 65 m deep. It is confined when covered by bentonitic clay and unconfined when the bentonitic clay is missing.

The water table in the abstraction wells from the Sarmatian aquifer is, usually, mainly ascending, with stabilized depths between 34.5 and 36 m. The pumping rates at the installation are between 3.33 l/s (F12) and 6.25 l/s (F11) and the optimal exploitable rates are between 3.64 l/s and 7.84 l/s for a well, the estimated average hydraulic conductivities are between 3.48 m/day and 6.90 m/day, corresponding to 16 to 30 m thick total screened intervals.

From the qualitative point of view, groundwater from the Sarmatian aquifer, from 100 to 155 m deep abstraction wells, exceeds the standard for nitrate content (80 mg/l) and for filtrate residual (over 2000 mg/l). The bacteriological analyses show that the abstraction wells in the industrial zone exceed considerably the standard for total coliforms and fecal coliforms. We also appreciate that in the Harbor zone, the Sarmatian aquifer might be polluted by petroleum products. For this reason, the drinking water supply of the Constanța Harbor shouldn't be provided by the Sarmatian aquifer.

6.2. The Upper Jurassic – Lower Cretaceous aquifer complex

The Upper Jurassic – Lower Cretaceous aquifer complex, located in the limestone and dolomite deposits affected by the regional WNW – ESE and NNE – SSW fault systems mentioned above (Fig. 2), is generally confined. The aquifer can become locally unconfined in the western and northern parts of South Dobrogea, where the Lower Cretaceous deposits crop out (Moldoveanu, 1998). In the southern and eastern parts of South Dobrogea, the deep aquifer complex is separated from the Sarmatian aquifer by the Senonian aquitard consisting mainly of chalk and marl.

The natural boundary of the Upper Jurassic – Lower Cretaceous aquifer is the Capidava – Ovidiu Fault. In the north-

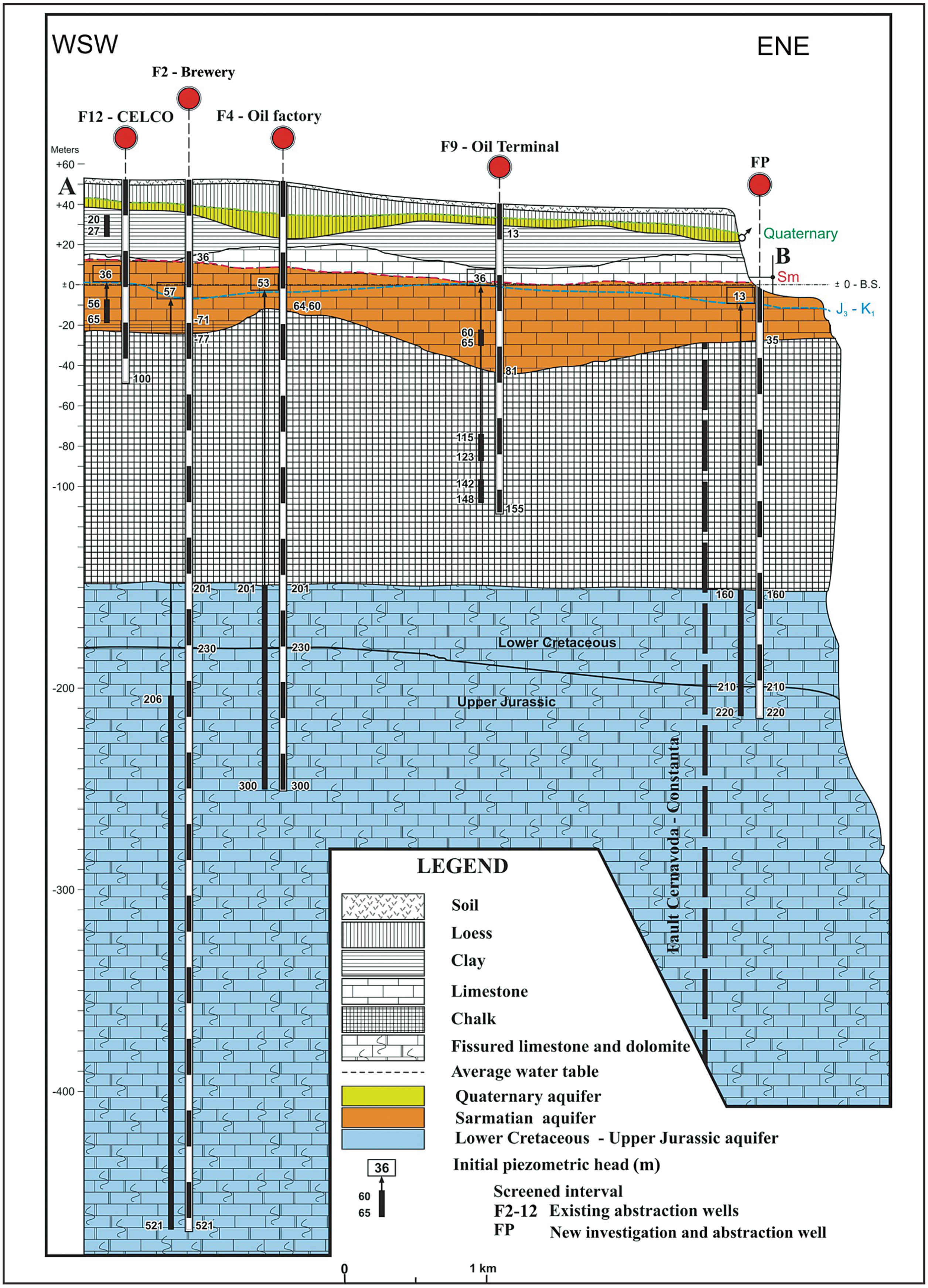

Fig. 7 WSW-ENE hydrogeological cross-section (see Fig. 1) through Constanța city

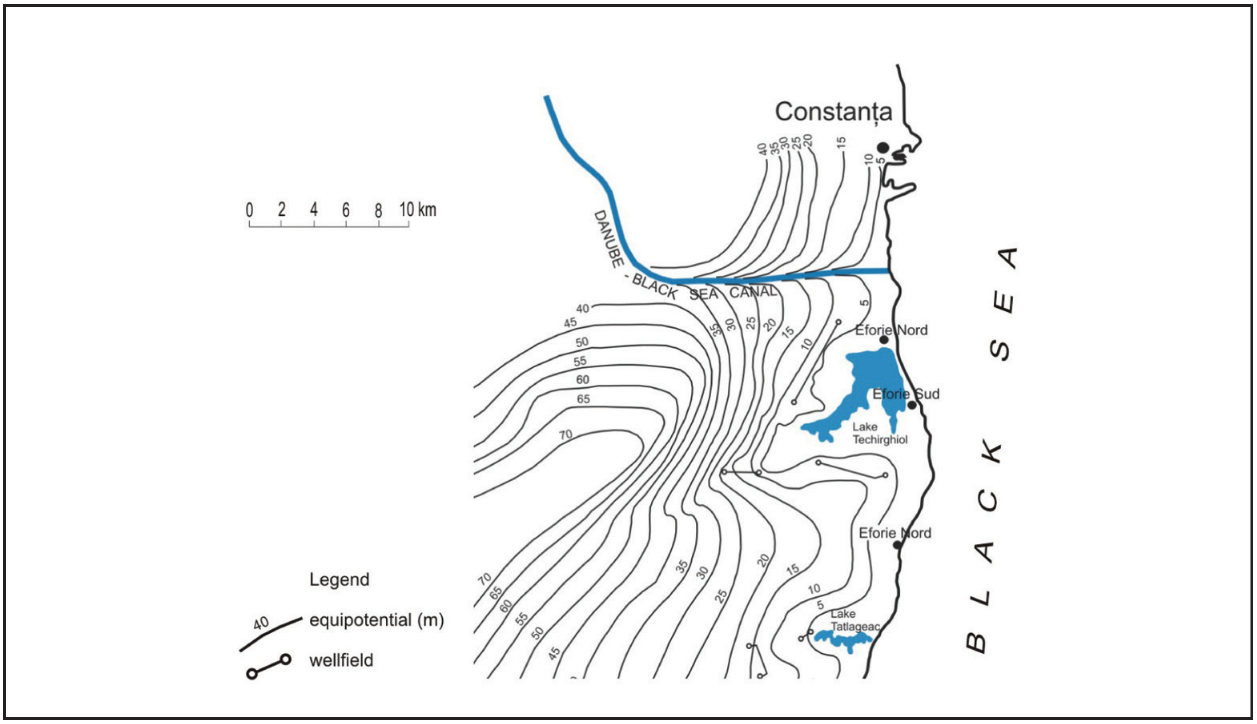

Fig. 8 Piezometric map of the Sarmatian aquifer in the study area (Moldoveanu, 1998 with modifications)

ern compartment of the fault, the Upper Jurassic have low thickness and are overlapped on the Green Schists Formation, with high elevations and low permeability, that make a barrier for the groundwater flow, deviating it towards east (Zamfirescu *et al.*, 1994). Thus, the Capidava – Ovidiu Fault is considered an impervious boundary.

The thickness of the Upper Jurassic – Lower Cretaceous deposits varies between 200 m and more than 1000 m in the northern part. The aquifer geometry is emphasized in Figs. 3-5.

The piezometric heads (Fig. 9) show that the Upper Jurassic – Lower Cretaceous aquifer is supplied from the Bulgarian territory, where the Upper Jurassic deposits crop out (Zamfirescu *et al.*, 2005). The aquifer discharges to the east, to the Black Sea, and also to northeast, in the Lake Siutghiol. The aquifer is also supplied by downward leakage from the Sarmatian aquifer or, in the western part of South Dobrogea, by effective infiltration from precipitation. Along the coast, the piezometric heads of the Upper Jurassic – Lower Cretaceous aquifer are higher than the ones of the Sarmation aquifer, so there is an upward leakage.

The transmissivity of the Upper Jurassic – Lower Cretaceous aquifer determined from pumping tests varies between 10 and 200000 m^2/day (Moldoveanu, 1998).

The most important abstraction wellfields in the Upper Jurassic – Lower Cretaceous aquifer are located in the area of Constanța city. There are also abstraction wellfields in the area of Medgidia city.

This aquifer has been intercepted by means of several wells in the study area, at depths between 57 and 103 m in the tectonic block 5 (F3, F6, F13), at depths around 200 m in the tectonic block 10 (F1, F2, F4, F5) and at depths around 300 m in the tectonic block 13 (F10, F14). The exploitable potential of this karstified aquifer complex is expressed by the differing exploitable rates in the wells mentioned above, reflecting the anisotropic character of the fissuring porosity.

Thus, the abstraction rates at the installation of the wells are around 22 l/s in the tectonic block 5, around 7.5 l/s in the tectonic block 10 and around 6.6 l/s in the tectonic block 13. The optimum abstraction rates vary between 5.5 and 267.3 l/s, while the average hydraulic conductivities vary between 1.84 and 332.73 m/day, corresponding to the screened intervals with total thicknesses between 109 and 154 m.

The water from the Upper Jurassic – Lower Cretaceous aquifer meets the Romanian drinking water standard (Caraivan, 2006). The groundwater quality and the abstraction rates indicate that this aquifer should be used for the drinking water supply of the Constanța Harbor.

7. NEW WELL

Taking into account the geological structure, the hydrogeological conditions and the restrictions generated by the accessibility of the drilling equipments, a first investigation and abstraction well, marked by FP (Fig. 1), was drilled and completed within the Harbor area, close to Gate 5. The technical characteristics of the new well are shown in Fig. 10. This well is sited on the prolongation of

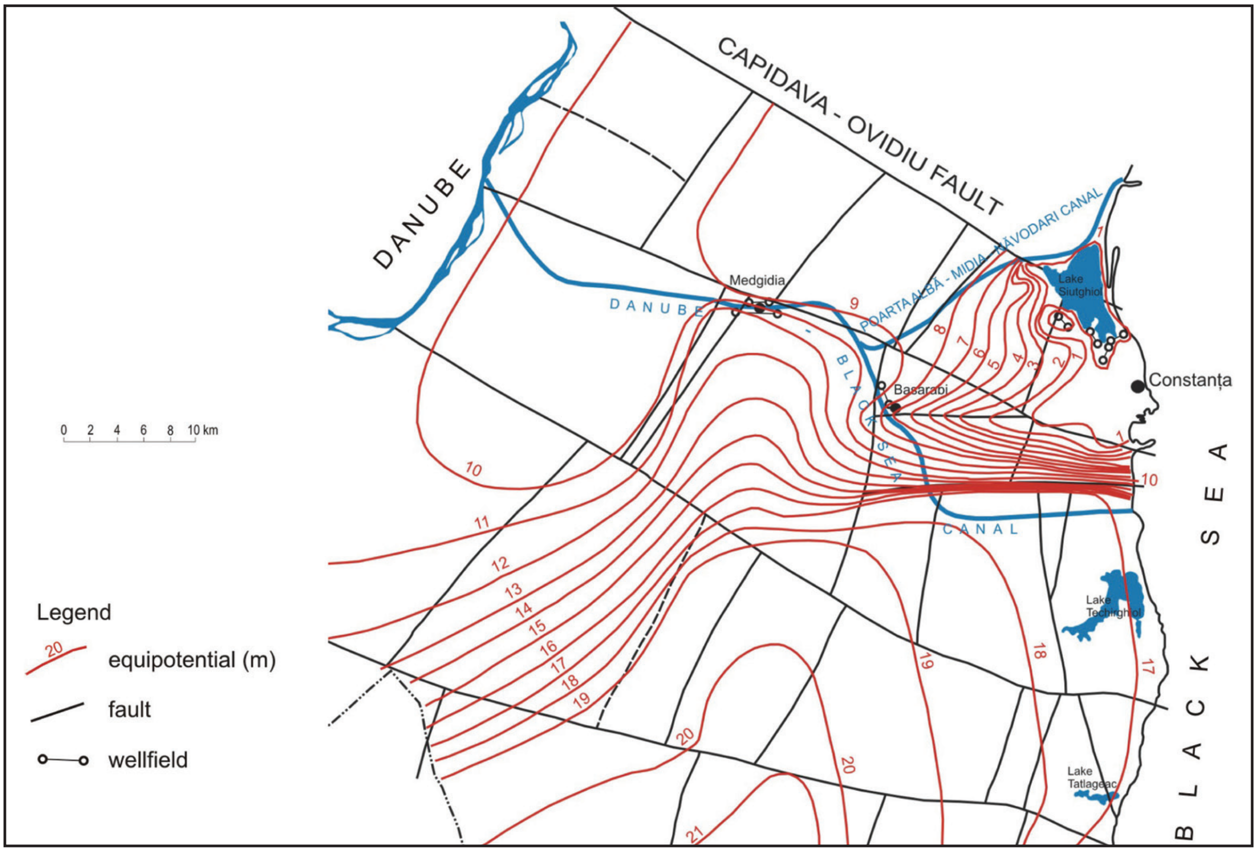

Fig. 9 Piezometric map of the Upper Jurassic – Lower Cretaceous aquifer complex in the study area (Moldoveanu, 1998 with modifications)

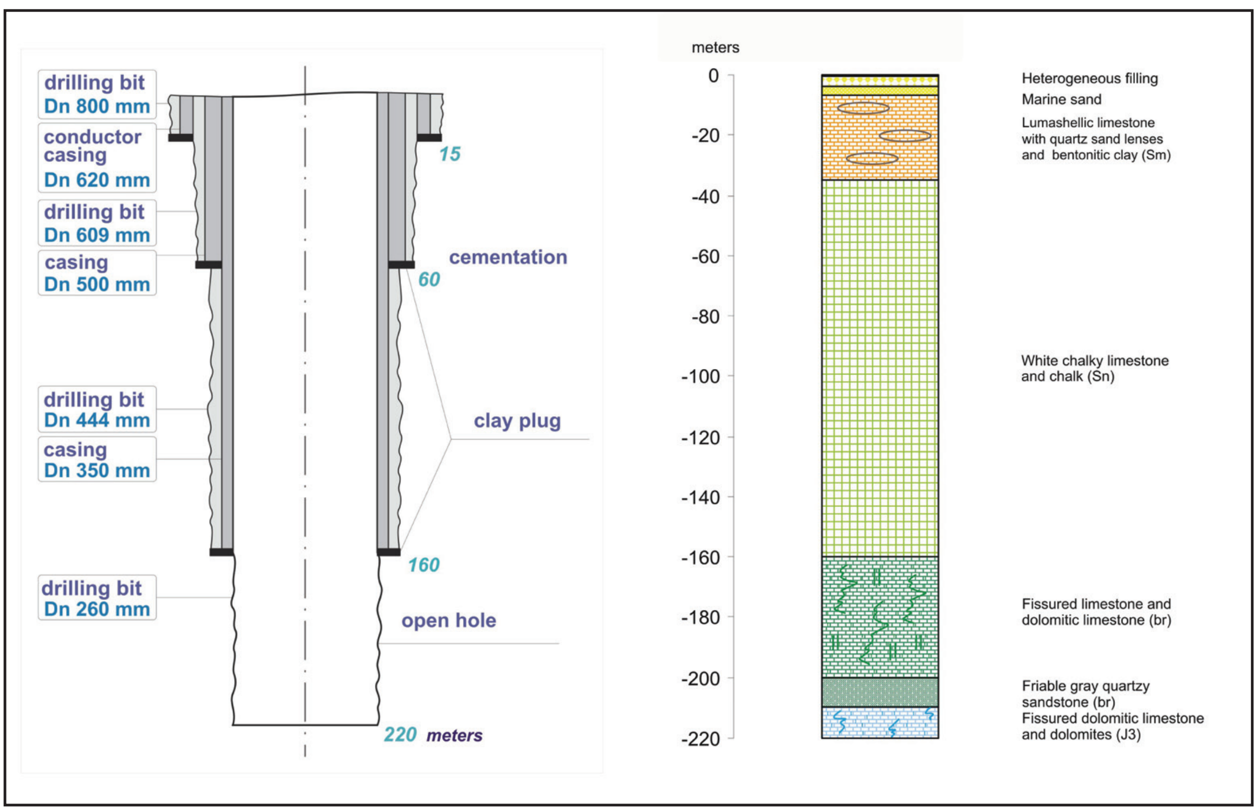

Fig. 10 Sketch of the proposed and implemented construction of the FP well

the Cernavodă – Constanța Fault to the marine domain, supposedly a zone with maximum fissuring. Technical restrictions, such as high voltage networks or buried pipelines have been taken into account when choosing the location of this well.

The drilling works have been designed for an investigation depth of 220 m. The well has been located at the limit between blocks coded 10 and 5 and taps the Upper Jurassic – Lower Cretaceous aquifer. The aquifer is protected by the potential anthropic stress by an aquitard, consisting of Senonian chalk and marl. The depth of the open hole interval is 183 – 212 m and the depth of the piezometric head is 3 m. The hydraulic conductivity is 6.5 m/day and the optimal abstraction rate is 6.92 l/s. The radius of influence of the well is 203 m. There is no interference between the new well and the other wells (Caraivan, 2006).

The chosen location meets the requested conditions for sanitary protection. Groundwater is of drinking quality, with a total hardness of 18.625 German degrees. In order to improve the groundwater quality, the water well system also includes a UV filter.

The Beneficiary is requested to monitor the abstraction rate, the piezometric head and the groundwater quality of the well.

8. CONCLUSIONS

A brief review of the geological framework and of the drinking water sources is presented in this paper. Based on the hydrogeological and technical conditions, a new investigation and abstraction well has been installed in the Constanța Harbor zone, opening the Upper Jurassic – Lower Cretaceous aquifer. This one is more appropriate to be used for the drinking water supply.

This study emphasizes the hydrogeological potential, especially in the zone adjacent to the tectonic blocks 5 and 10, where the Senonian aquitard ensures the protection of the confined aquifer.

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