

Deep Transboundary Water-Bodies: Exploration & Management in the Pannonian Basin of the Republic of Croatia UNESCO-IAH-UNEP Conference, Paris, 6-8 December 2010

Slobodan Kolbah

INA Naftapljin Oil & Gas Exploration & Producing Company, V. Holjevca 10 000 Zagreb, Croatia,
email: slobodan.kolbah@ina.hr

ABSTRACT

Oil & gas exploration and production information in north Croatia opens the way to delineation and characterization of deep water bodies of the Pannonian basin or the Danube-river basin, most of which are transboundary between Croatia and the surrounding countries.

The importance of this presentation is to improve the understanding of Croatia's deep transboundary aquifers with the information and knowledge from the countries where they are already recognized as well as to point out their existence to the countries where the process of their delineation is in development. There is need for stronger opening of discussion about deep transboundary water bodies. This can be achieved by introducing understanding of deep geology, here obtained by the process of O&G I&P, to point out strategic water reserves and water as a carrier of mineralization and geothermal energy. A more holistic approach to water is also a crucial environmental feature.

Croatia shares a number of deep transboundary aquifers with surrounding countries, and support in the implementation of world standards in the area is important. Countries that have deep transboundary aquifers should assist each other in aligning the national laws, rules and procedures and ensuring institutional capacity in fulfilling the planning, regulation, reporting and information requirements to harmonize with world standards. Multilateral collaboration of experts from abroad, meeting specific local experience and vice-versa is important in the delineation and characterization of these features, and supporting of the process with new knowledge and experience.

The most prolific water bodies are available in reservoirs of fissured massive rocks, especially karst developed carbonates, and most common and widespread are primary porous clastic rocks. According to chemical characteristics we can find potable water very deep in the Basin fill, as well as in the deep burned bedrocks. Delineation of saline and high saline water bodies is important as well as of geothermal aquifers. The results of geological, geophysical, petrophysical and geochemical information from O&G I&P process are an available base for the delineation of deepwater bodies.

Key words: exploration and management, deep transboundary aquifers, Pannonian basin, fresh, mineral & geothermal water.

1. DELINEATION OF DEEP WATER-BODIES

Exploration and management of deep water-bodies, some of which are transboundary in the Pannonian basin of the Republic of Croatia, is an important issue for the country's economy. In the beginning it is important to underline the meaning of deep water body character to distinguish them from ground water-bodies, explored and produced by hydro-geological methods and subsurface catchments. If we use criteria that thermal water temperature should be above 30°C, most of deep water-body will fall in that group. The geothermal situation in the discussed part of Pannonian basin (high geothermal gradient 5°C/100 m, mean surface temperature 11°C) suggests that we can find thermal water under 400 m of depth in tertiary basin areas. Last, but not least criteria is that they are much more isolated from surface waters influence than ground waters, but connections are possible, and here, as in all other cases, we have to bring all criteria and our understanding of certain features together to delineate deep water-body from ground water-body.

Our experience and open questions will meet the aim of the Conference, to bring together leading world experts in the fields of law and water sciences, to discuss approaches for the sound management of transboundary aquifers, in differently developed countries. Management of such aquifers is not an internal issue and has to be harmonized with the neighbors and monitored by the international society, sharing experience and resources. It is from the transboundary aquifers themselves that we have to

learn most, about their natural characteristics and dispositions, and follow those in our management and policies as much as it is possible.

1.1. Geographic and geological presumption

The north part of Croatia is located in the southeast area of the Pannonian basin. This Tertiary sedimentary basin is situated between the Alps, the Carpathian and the Dinaric mountain ranges. The basin water bodies are connected with reservoir rocks developed in the Tertiary and Quaternary sediments sequence. They are mostly, sedimentary clastic and carbonate and below them are buried, in older aquifers, parts of surrounding ranges of Hercinian and Mesozoic consolidation.

1.2. Characterization and classification

The most prolific deep water-bodies are available in massive reservoirs, which are some fissured rocks formations, especially if we deal with mighty carbonates sequences, where karst features are developed. On the other hand, most common and widespread are different sandstone bodies, controlled by primary porosity.

According to chemical characteristics we can find potable water very deep in the basin fill, as well as in the rocks below the basin fill. Delineation of saline and high saline water bodies is also important. Favorable terrestrial heat flow, applied over the deep water-bodies, makes them attractive as geothermal aquifers, a favorable media to tap geothermal energy surplus.

The results of geological, geophysical, petrophysical and geochemical information, together with hydrodynamic testing and production, from oil, natural gas and geothermal water exploration and production are make a substantial base for the delineation of deep water-bodies.

In one case story, an attempt in year 2006 was undertaken, to make a more complete regional picture of a broader area of SW Pannonian basin of North Croatia and SW Hungary, or part of the Danube-river basin. It was attempted to exchange our experience in exploration and production of oil, gas and geothermal water in Croatia with international and Hungarian experience as member of the ICPDR (International Commission for the Protection of the Danube River) which takes part in the work of WFD related expert groups, since 2002, especially in the field of transboundary groundwater bodies.

Criteria for the delineation of water-bodies have been designated on the guidance according to a hierarchical approach, in harmony with the possible lateral and other changes of body characteristics:

- *type of the geological features:*
 - type of reservoir porosity:
 - “karstic” (k) in fractured and karstic type porosity
 - “porous” (p) with primary developed porous

Both of them can be in basin or outcropping position, or mixed basins and mountainous position

- *Containing water temperature above 30°C* in thermal karstic (kt) / porous (pt) water-bodies.
- *subsurface catchments* in:
 - Hydro-geological units in porous / karstic aquifers,
 - Water management units of mountainous region,
- *Large scale upward flow* in the water-bodies of alluvial plains, to make distinction in chemistry and in the sensitivity of groundwater dependent ecosystems.

With this approach, we understand that some deep water-bodies can have hydrodynamic connection with different ground water-bodies.

We have to be wary careful if we claim deep water-bodies to be:

thermal karstic (kt) and
thermal porous (pt)

In that starting attempt it was necessary to make regional unification, simplification and to bring together, sometimes numerous and in some criteria different features. Further on, we deal only with deep water-bodies or deep thermal karst and porous features, hydro-geological objects we left aside. To indicate possible deep water-bodies with transboundary character, we found the results quite satisfactory.

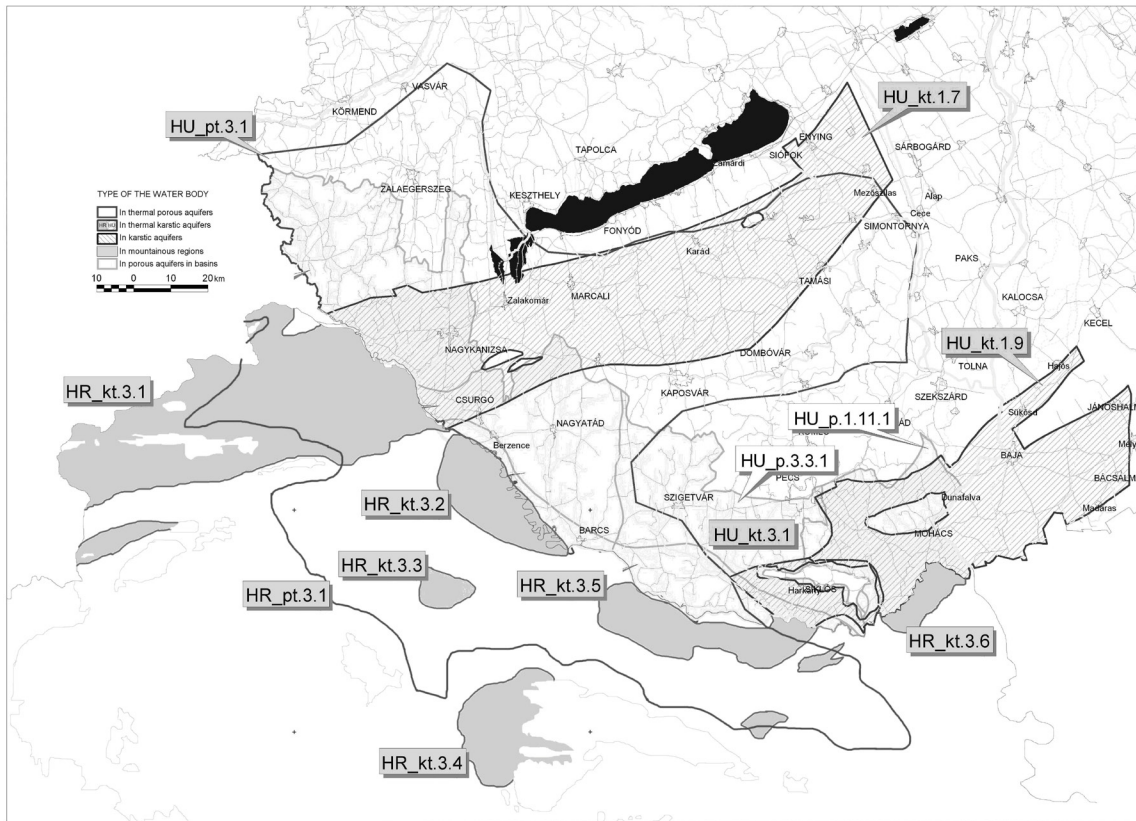


Figure 1. Presentation of important water-bodies along the Croatian – Hungarian border line. At the Croatian side only the deep water-bodies, or thermal karstic and porous aquifers are pointed out and arbitrary transboundary connections with the potentially matching ones on the Hungarian side. From the 8 delineated thermal karstic deep water-bodies 3 are possibly of transboundary character as well as 1 thermal porous deep water-body in the Tertiary Drava basin fill. Later oil and gas explorations result with gas-condensate field discovery in NW part, of the complex Mesozoic-tertiary “karst” water-body HR_kt.3.5, by its transboundary prolongation to the Hungarian side.

2. LEARNING MORE ABOUT DEAP WATER-BODIES

It is from the early sixties that experts at the O&G company INA Naftaplin and the Mining university of Zagreb (Čubić et al., 1995; Jelić et al., 2000 & 2005; Kolbah et al., 2010) have made advances in the understanding of the deep water bodies of the NW Croatia, in connection with oil, gas and thermal water production, and have been continuously reporting at the *World Geothermal Congress*. Numerous geothermal testing and production preparations about deep water –bodies was gradually performed up today (Kolbah et al., 2004, 2007, 2008 & 2009; Pravica et al., 2006; Kulenović et al., 2006; Kurevija et al., 2008 a & b).

An attempt to collect all the experience necessary for further exploration and management of that deep resources in NW Croatia is organized and in great deal produced in the modular project (Kolbah et al., 2006).

Building regional geological solutions makes the basis for understanding all important natural processes necessary to get an idea of how to apply existing abandoned deep wells and other surface infrastructures or drill new facilities and develop technologies in harmony with both deep water-bodies (DWB) and surface environment. Better understanding of that complex issue finally can help in rising confidence in making crossboundary arrangements.

2.1. Scanning the deep water-bodies

Massive and very expensive information left after the intense period of oil, gas and geothermal exploration and production and experienced human resources make possible to do deep structural mapping of the basin conditions, through which we can follow speeding and characteristics of important DWB. Beside their deep geometry and buildup, it help us to fulfill a puzzle of understanding thermodynamic and hydrodynamic processes, carrying together al other important chemical and physical characteristic of active fluid water in first place.

There exist thousands of kilometers of 2D seismic lines and other geophysical information, also 3D seismic shooting on hundreds of wells holds a large amount of information that can be used for our purposes.

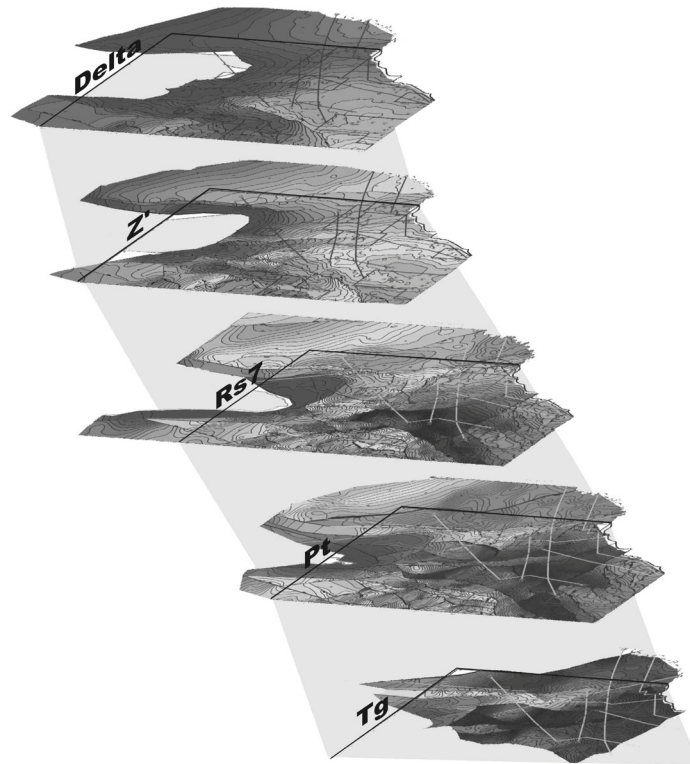


Figure 2. here we can see a mapping scan of most of the important features in the basin: Hercinian consolidated basement (Tg). Pre Tertiary rocks (Pt), mostly Mesozoic, with important carbonate bodies and geological mapping was performed to delineate them. Important sedimentary breakdown in mid Miocene (Rrs) help us to visualize that package of that basin fill, in quite irregular basis some additional important carbonate bodies and core braces formations are controlled in it, here further detailed works have to be done to delineate them. Most of the Pannonian sandstone reservoirs are controlled by thickness between top formation discordance (Z') and top mid Miocene (Rs7). Important Lower Pontian sandstones in same way are controlled by top formation marker (Delta) and top Pannonian marker (Z'). In deeper parts of Drava basins it is important to map top Upper Pontian sequence (Alfa) on which Pliocen and Quaterniar beds are spread.

2.2. Closing a circle

Geological interpretation of deep structures, we can say, starts with putting together elements on cross sections. The obtained results can be presented best on them as well, besides using maps.

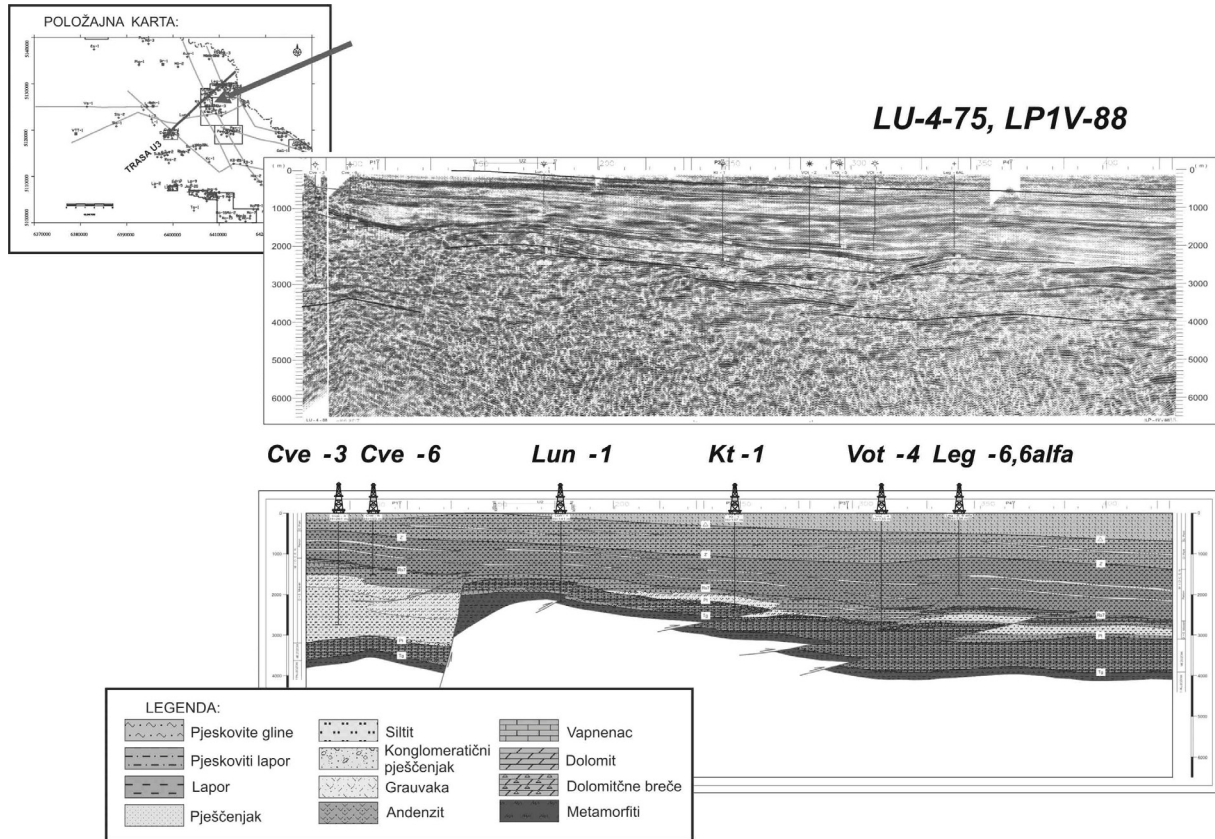


Figure 3. On cross section U2, important geothermal field Lunjkovec –Kutnjak is presented. On the NW end it shows crosboundary character of the main DWB in fractured Mezozoic carbonates, and also in the Tertiary sandstones of the area.

3. DISCUSION

Exploration & management of deep transboundary water-bodies in the Pannonian Basin of the Republic of Croatia have deep roots in Oil & gas exploration and production but its future is geothermal energy and water utilization in harmony with neighbouring countries. So far we discussed case stories from Drava River valley tertiary basin. Same experience we can apply on the border with Serbia, Bosnia and Hecegovina and Slovenia. DWB in Dinarides range of southern Croatia are not discussed here because they need different approach. There is a need for stronger opening of the discussion of deep transboundary water bodies. Transboundary agreements over the DWB can be achieved by introducing mutual understanding of the country’s interest, with great help if both sides accept presented deep geological solution. Same understanding is necessary to protect crucial environmental features.

4. CONCLUSION

Croatia shares a number of deep transboundary water-bodies with surrounding countries. Using their own experience and getting international support creates a good chance to implement high world standards in the area. It is a long way to aligning the national laws, rules and procedures and ensuring institutional capacity in fulfilling the planning, regulation, reporting and information requirements to harmonize with world standards. Multilateral collaboration of experts from abroad, meeting specific local experience and vice-versa is important in the delineation and characterization of these features, and supporting of the process with new knowledge and experience.

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