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Outline and joint characterization of Transboundary geothermal reservoirs at the western part of the Pannonian basin

Ágnes Rotár-Szalkai[a,*], Annamária Nádor[a], Teodóra Szőcs[a], Gyula Maros[a], Gregor Goetzl[b], Fatime Zekiri[b]

[a] *Geological and Geophysical Institute of Hungary, 1143 Budapest, Stefánia 14., Hungary*
[b] *Geological Survey of Austria, 1030 Wien, Neulinggasse 38., Austria*

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A B S T R A C T

The compilation of harmonized geological and geothermal models and maps at the W-ern part of the Pannonian basin, covering parts of Hungary, Slovenia, Austria and Slovakia made it possible to delineate potential geothermal reservoirs at regional scales, which are often cut-cross by country borders. Altogether 18 types of potential geothermal reservoirs were identified as a combination of their lithology (Upper Pannonian porous sediments, Miocene sedimentary rocks with intergranular and/or double-porosity, basement fractured crystalline Palaeozoic rocks, and basement fractured [partly karstified] Mesozoic carbonate rocks); temperatures (50, 100 and 150 °C); and hydrogeochemical character of the stored fluids. All identified reservoirs were delineated and shown on maps and the various categories were briefly characterized in terms of their porosity type, hydraulic connections, hydrogeochemistry, as well as utilization potentials. The maps outline prosperous regions for future project developments for various utilization purposes (balneology, direct use, combined heat and power), but most importantly create the basis for a harmonized cross-border management of deep geothermal resources shared by neighbouring countries in the Pannonian basin.

1. Introduction

The Pannonian basin extending across eight countries in Central and Eastern Europe is well-known of its good geothermal potential (Dövényi and Horváth, 1988; Lenkey et al., 2002; Szanyi et al., 2009; Horváth et al., 2015) due to its favourable geological conditions, being rich in thermal water which is widely used for recreational-balneological purposes as well as in the agriculture sector, and to a less extent in district heating (Nádor, 2014; Rman et al., 2015; Nádor et al., 2016; Goldbrunner and Goetzl, 2016; Fendek et al., 2016; Rajver et al., 2016; Oudech et al., 2016; Samardzic and Hratovic, 2016; Gavriliuc et al., 2016; Zikovic et al., 2016). Much of the large geothermal aquifers of this deep sedimentary basin determined by regional geological structures are shared by neighbouring countries and significant basin-scale cross-border groundwater flow occurs (Szőcs et al., 2015; Tóth et al., 2016). Therefore unfavourable effects of excessive thermal water production (e.g. significant depressions in the hydraulic head, drop of temperature and/or yield, changes in water chemistry due to altered groundwater flow patterns) might affect more distant parts of the geothermal aquifers, perhaps being situated in another country. Such negative changes in the quantity and/or quality of some thermal water aquifers with a cross-border impact have already been observed at various parts of the Pannonian basin (Nádor et al., 2012; Szanyi and Kovács 2010; Tóth et al., 2016; Rotár-Szalkai and Ó Kovács, 2016). This is partly due to the high share of balneological use with a single well production scheme, partly to the fact that many of the direct use applications lack reinjection doublets. Furthermore the deep-lying thermal water aquifers are hydraulically connected to the overlying shallow unconfined cold water aquifers in many cases that are intensively used for drinking water supply (Tóth et al., 2011, 2016).

The Renewable Energy Action Plans (NREAP-s) of most of the Central European countries, but especially of Hungary, Slovenia, Austria and Slovakia foresee a 3–3,5 folds increase of geothermal heat production from 2010 to 2020 ((COM, 2015) 293). From the resource side, the abundant availability of thermal groundwater can fulfil this increased demand in theory, however to implement these ambitious goals, the sustainability of various production scenarios and technologies needs to be tested which requires an elementary knowledge on the spatial distribution and main characters (porosity, permeability, temperature, chemistry of stored waters) of the hydrothermal reservoirs.

* Corresponding author.
E-mail addresses: szalkai.agnes@mfgi.hu (Á. Rotár-Szalkai), nador.annamaria@mfgi.hu (A. Nádor), szocs.teodora@mfgi.hu (T. Szőcs), maros.gyula@mfgi.hu (G. Maros), gregor.goetzl@geologie.ac.at (G. Goetzl), fatime.zekiri@geologie.ac.at (F. Zekiri).

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These information are also essential for the regular update on the quantity and quality of the (thermal) groundwater bodies in the frame of the River Basin Management Plans required by the Water Framework Directive, where a special attention is paid to the assessment of natural hydrogeological units irrespective of political borders. In addition to fulfil the information required by these EU policies, a general knowledge on extent and main characters of the potential geothermal reservoirs are required by any further management issues, e.g. site selection of new projects, release of additional production licences, etc.

In the case of large, extended transboundary geothermal aquifers with multiple users having cumulative impacts by their thermal water abstractions, it is of utmost importance to have a joint and regional understanding of the reservoir dimensions and properties irrespective of state borders in order to guarantee sustainable production levels. Although the basic types of geothermal aquifers and their extension at basin scale are relatively well known in the Pannonian basin (Almási, 2001; Tóth and Almási, 2001; Tóth, 2009; Tóth et al., 2016), clarifications of the same reservoirs vary in the neighbouring countries resulting from using different geological nomenclature for the same formation, different understanding of the thermal water flow systems, dissimilar models of the subsurface temperature field, etc. Moreover these hydrothermal reservoirs have not been categorized and characterized yet in a uniform way from a point of view of potential future uses according to their depths, temperatures, chemistry of stored fluids, etc.

The Central Europe Programme funded TRANSENERGY project aimed to support a harmonized and integrated thermal groundwater and geothermal energy utilization management among Hungary, Slovenia, Austria and Slovakia at the western part of the Pannonian basin (Fig. 1), and as such to provide a good example for other regions sharing transboundary geothermal aquifers (Nádor et al., 2013; Rman et al., 2015). This area is characterized by an advanced use of known thermal groundwater resources: in 2010 altogether 307 active geothermal wells operated in this territory, managed by 149 users (Rman et al., 2015). The most abundant type of use is balneology in all four countries (more than 100 users altogether). Although the outflow temperature is relatively low (majority is in the range of 20–60 °C), the low share of energy production is noticeable. Individual space heating of less than 20 spa resorts exist mostly in the Danube basin in Slovakia and in the Mura-Zala basin in north-east Slovenia. Only a dozen of boreholes are used to supply thermal water for the heating of greenhouses in Hungary, Slovakia and Slovenia, while the number of geothermal district heating systems is even less (Lendava is Slovenia, Galanta is Slovakia, Vasvár in Hungary). The status of the current uses also stresses the need to identify potential geothermal reservoirs of higher temperatures in the area, which can be utilized for direct use and/or possibly for power generation in the future.

A novel methodology of outlining and characterizing large transboundary hydrothermal reservoirs based on harmonized geological, geothermal and hydrogeological data, maps and models from four countries has been elaborated and is presented in this paper. The recognized reservoirs and their classification is the first step and may serve as a basis for future estimations of their existing geothermal potentials and quantification of recoverable thermal energy resources, as well as distinguishing between prosperous and non-prosperous areas for future project developments.

2. Settings

The investigated area of 47,700 km^2 covers the western part of the Pannonian basin and encompasses the eastern parts of Austria, north-west Hungary, south-west Slovakia and north-east Slovenia. The studied territory is mainly a lowland area of the Styrian-, Mura-Zala-, Vienna- and Danube basins with some smaller hilly regions, surrounded by the Eastern Alps in the west, the Western Carpathian Mountains in the north, and the Transdanubian Range in the east (Fig. 1).

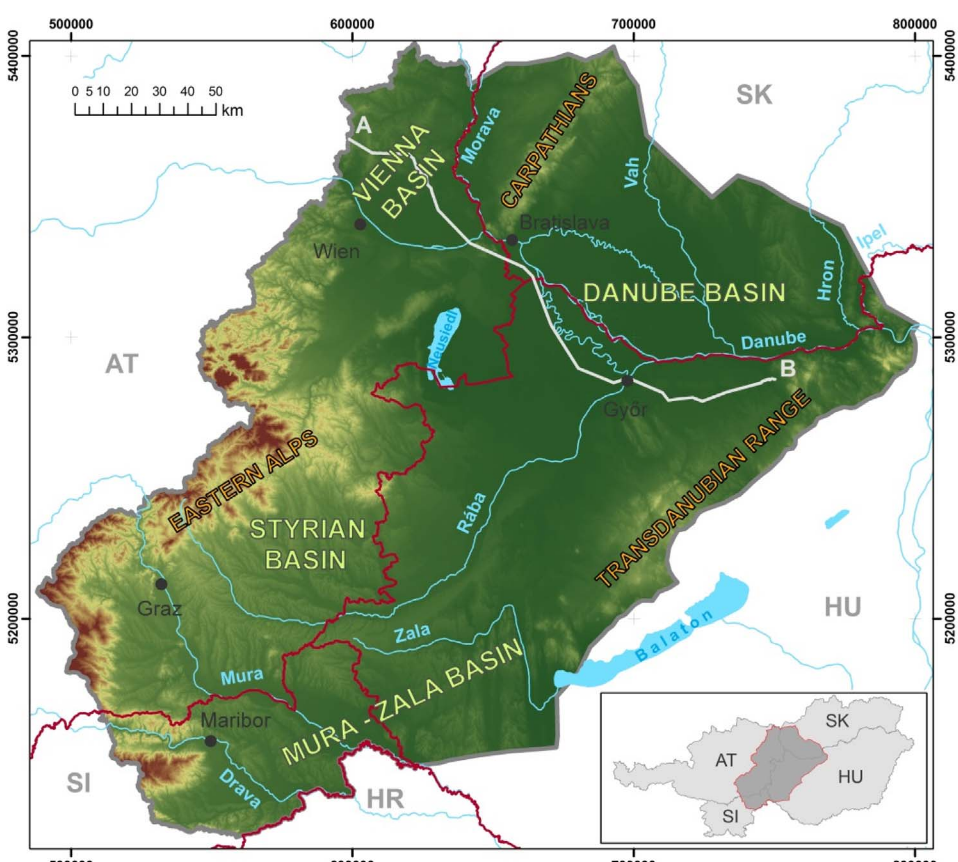

Fig. 1. Location of the study area with the track of the geological cross-section shown on Fig. 2.