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HYDRODYNAMIC STUDY OF RECHARGE CONDITION OF BUDA KARST SYSTEM CONSIDERING HYDROGEOCHEMICAL DATA

SUMMARY OF Ph.D. DISSERTATION

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INTRODUCTION

Budapest with its historically known thermal waters plays an important role in economy of the country. Overexploitations connected to the coal mining during the 1960-1990 years caused a considerable drawdown in the karst system (Alföldi L. et al. 1980; Liebe P. & Székely F. 1980; Böcker T. et al. 1981; Lorberer Á. 1986, Alföldi L. and Kapolyi L. 2007). Decrease of pressures and water levels resulted in changing of geochemical quality and quantity of thermal springs. Therefore, to avoid the increasing environmental threats in the future, there is a need to study the cold-warm karst system as an integrated regime and to achieve it a 3-D numerical groundwater flow model was constructed.

The previously constructed models of the area (Heinmann Z. and Szilágyi G. 1977, Kovács Gy. et al. 1979, Csepregi A. 2007) deal with evaluation of recharge, overexploitations connected to the coal mining and the temporal changes of other karst-water withdrawal. To achieve those goals 2D one or two-layer models were enough. The model constructed in this thesis considers the different hydrogeological layers and different geological zones in these hydrogeological layers to evaluate the spatial changes and variations of geochemistry and pressures in the cold-warm karst system.

The goals of the thesis were:

- Carry out an integrated hydrogeological-hydrogeochemical evaluation on the Buda Thermal Karst System based on archive hydrogeological, hydrogeochemical, and environmental isotope data;
- Characterize the flow system of the area by constructing a 3D steady-state model, which is able to describe the zonebudget, potential levels and transport processes (the model is capable to manage the different hydrostatic layers with different geological zones);
- Calibrate the flow model by the measured water levels and stable isotope data;
- Clarify the main flow paths that were specified by 3D model by using hydrogeochemical data.

METHODS

To achieve the aims of the thesis, firstly I considered the theoretical methods to quantify the potential levels of descending (cold) and of ascending (hot) flow systems respect to the density distribution. The quantified potential-levels of warm side, were used to draw the potentiometric map of ascending (hot) flow system. This quantification has been demonstrated main flow directions of karst system.

I constructed a 3D numerical steady state flow model by using Visual Modflow Pro software. The flow system was simplified to two aquifer systems, the uncovered shallow aquifer and the semi-covered regional karst aquifer, which were separated by Pelogene-Neogene aquitard complex layer. The model successfully constructed the main flow paths of the area and the recharge, discharge and zonebudget conditions. The model was calibrated by karst water level, water-table levels and environmental isotope data.

The exactness of the 3D flow model was verified by evaluation of geochemistry of water. Cluster analysis was applied to classify the similar objects to the respective categories. Furthermore, several graphs of measured main cations, anions and stable isotopes of karstwater were plotted to check the reliability of cluster groups, the spatial distribution of objects and the main flow paths of the region.

SUMMARY AND THESES

1 – To hydrogeochemically evaluate the thermal karst system I have separated the flow system into two vertically different density flow systems: cold side (descending and gradually geothermally heated flow system) and warm side (ascending and slightly cooling flow system). By theoretical consideration, I have quantified the hydraulic potential levels of each measurement point in the two different density flow systems, which clarify the consequence of lifting force between two different temperature and density flow systems or ascending of thermal water toward the warm-lukewarm springs.

2 – I constructed a 3D numerical steady state flow model of the area. Infiltration conditions were determined by using the 1:100 000 scale covered geological map (published by MÁFI). The model deals with two aquifers, the uncovered shallow aquifer (shallow local flow system) and the semi-covered regional karst aquifer (regional karst flow system) as one unique system.

3 – By computing the water balance or the waterbudget of the area, 75% of the total infiltrated water drains to the surface as a local system. The 19% of the total infiltrated water (51967 m^3/day) directly infiltrates through the uncovered karst. The 5% of the total infiltrated water (14332.1 m^3/day) flows through the Paleogene-Neogene complex aquitard layer to the main karst layer. Finally 223.66 m^3/day water flows through the deepest not karstified fresh carbonate layer to the main karst layer. So, 66523 m^3/day (51967 m^3/day + 14332.1 m^3/day + 223.66 m^3/day) or 25% of total infiltrated water discharges from the regional main karst system through the springs or-wells of the thermal-karst. The computed values confirms the total discharge of wells and springs with temperature above 15 °C (67000 m^3/day) reported by Göltz B. 1982.

4 – By computing the budget of the Paleogene-Neogene complex aquitard layer, which is located between the two aquifers, it was splitted into the upper and lower zone. I quantified that 42% (5552.9 m^3/day) of infiltrated water of the Paleogene-Neogene layer flows toward the karst system through the edge of the upper zone layer and the rest 58 % (7779.2 m^3/day) flows toward the lower zone, despite the fact that last one has a significant contact area with the main karst layer. This fact reflects the sensitivity of the thermal system to the infiltrated pollution through the edge of upper zone of the covering sediments.

5 – I calibrated the model by $\delta^{18}O$ and ^{14}C data as indicator elements. The results of the ^{18}O transport modeling represent the old water of deep wells in the center and southern part of Budapest filtrated during the interglacial time. These results confirm the correctness of the concept of the model independently of hydraulic heads and discharges data.

6 – The ^{14}C transport modeling indicates that the residence time of the old water in the flow system is about 30 000 years, which confirms the result of the $\delta^{18}O$ transport modeling processes.

7 – The results of the geochemical analysis of thermal waters proved the increasing presence of younger water in the flow system toward the thermal springs (10% to near 50%) in the central zone of Budapest. The young waters firstly originate from the uncovered carbonate area (recharge area) as shallow intermediate flow system and secondly from the edge of the covering sediments, the last one is quantified in thesis 4. It confirms the sensitivity of the thermal springs to the infiltrated pollution in the central zone of Budapest.

8 – The geochemical analysis of waters of south Budapest wells proved the probability of the upward flow from south of Budapest (Csepel II. well) toward the thermal springs (Gellért springs). Evaluation of $\delta^{18}O$, ^{14}C and $\delta^{34}S$ data proved that the presence of younger water is

the result of infiltration from the edge of the upper part of the covering sediments, which was also supported by zonebudget results.

Complex hydrogeological, hydregeochemical and isotope hydrological studies provide useful results to evaluate and to quantify the 3D model of the regional groundwater flow system with waters with different temperature and density.

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