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Origin of mineral and thermal waters

title: **Verification of conceptual model of the Budapest karstwater regime by environmental isotopes**

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INTRODUCTION

Conceptual models describing the working mechanism of thermal karstic reservoirs around Budapest were developed and verified by geological, hydrological, hydraulical, geothermal, water quality and isotope hydrological data. Results of detailed environmental isotope (^{14}C, ^{3}H, $\delta^{2}H$, $\delta^{18}O$ and $\delta^{13}C$) studies accomplished in this project are presented.

CONCEPTUAL MODEL

Natural spring (of 20 to 65°C) activity occurs at the border of the Buda-Pilis Mountains close to the Danube River (the regional karstic base level of this area) along tectonic lines. These springs are mixtures of a colder component arriving directly from the nearby mountains and of a warm component from the pressured, confined part of the karstic aquifers where the overlying clayey sediments determine the flow-paths. By reaching the deepest point of the flow-path (at the boundary of Mesozoic basement) the flow moves towards the springs where it enters the surface, after some mixing with cold or lukewarm karstic waters.

VERIFICATION OF MODEL BY ENVIRONMENTAL ISOTOPES

$\delta^{2}H$ and $\delta^{18}O$ data of more than 90 wells and springs are close to Meteoric Water Line ($\delta^{2}H = 8.4 \cdot \delta^{18}O + 12.3$ [‰]) proving that both cold and warm components originate from precipitation fallen in the Buda-Pilis Mountains. $\delta^{2}H$ and $\delta^{18}O$ of the cold component (–70 and –9.5‰ respectively) is similar to the annual mean of precipitation while of the thermal component is lighter down to –95‰ and –12.5‰. These data indicate that the temperature at the infiltration of warm component was 2 to 8°C lower than today, i.e. the termalwater is „Ice-age" groundwater.

^{14}C groundwater ages of thermal component, are more than 10 thousand years (estimated by $\delta^{13}C$ correction), supporting the Ice-age origin. Both ^{14}C and stable isotope data prove that the cold component is younger to be infiltrated in the Holocene ages. In case of springs the ^{14}C "ages" are fictitious because of the mixing process and are characteristic of the mixing rate.

Vulnerability of the thermal karst regime was investigated by tritium (^{3}H) data. Karst water of the thermal wells is tritium less (<0.5 TU) i.e. protected against the modern (after 1952) anthropogenic pollutions. On the other hand greatest part of the springs contains detectable tritium originating from the fresh, shallow local groundwater, so the thermal karstic springs along the Danube River can be considered as the most sensitive spots of flow regime. The thermal waters are used only for balneo-therapeutical and mineral water bottling purposes and are under very strict management.

TDIC (Total Dissolved Inorganic Carbon) content (mainly free CO_2) grows via temperature in Budapest thermal karst regime. Origin of surplus CO_2 (post volcanic or metamorphic) was investigated by $\delta^{13}C$ and chemistry data. Using equations of isotope dilution and mass balance the intercept of the $\delta^{13}C_{measured}$ via 1/TDIC represents the $\delta^{13}C$ of the surplus CO_2. The intercept was found as +3‰ indicating metamorphic origin at temperature higher than 200°C. Volcanic origin of surplus CO_2 can be excluded because these gases are characterized by more lighter (–5 to –7‰) $\delta^{13}C$.

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