XXXVIII IAH Congress

Groundwater Quality Sustainability
Krakow, 12–17 September 2010

Extended Abstracts

Editors:
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University of Silesia Press 2010

abstract id: **281**

topic: **4**
Mineral and thermal water

4.2
Origin of mineral and thermal waters

title: **Flow pattern and water ages in thermal system of Podhale Basin, southern Poland, as deduced from environmental tracers**

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keywords: Podhale Basin, thermal waters, environmental tracers

Fissured and karstified Eocene and Mesozoic carbonate formations of the Podhale Basin represent the largest reservoir of renewable thermal water in Poland. They outcrop in the Tatra Mts. at altitudes of 1000–1800 m and deep to the north under the flysch formations. The main direction of flow is to the north for abt. 15 km, to the impermeable formations of the Pieniny Klippen Belt, where it is divided and diverted to the west and east, and next to the south to the Danube watershed in Slovakia. The temperature ranges from abt. 20°C near the outcrops to abt. 85°C at the most northern wells. The thermal water is exploited for heating (wells BA1 and BA2) and recreation (wells BA1, BA2, Z1, Z2, BU and SZ). For a better understanding of the flow pattern and water age, environmental isotopes ($\delta^{18}O$, $\delta^{2}H$, ^{3}H, ^{14}C, $\delta^{13}C$) have been used since early seventies and recently also gaseous tracers (He, Ne, Ar and SF_6) under the grant No N 525 402334 from the Ministry of Science and Education.

The C^{14} data of thermal waters range between 37 to 0 pmc with $\delta^{13}C$ from abt. 5 to 0‰; evidently exhibiting the influence of isotopic exchange with carbonate minerals, which makes the quantitative dating rather impossible. The $\delta^{18}O$ and $\delta^{2}H$ are similar to those of modern waters in springs and cold waters in wells situated near the Tatras, with several exceptions characterized by shift of $\delta^{18}O$ to heavier values, which are caused by isotopic exchange with carbonate minerals (Fig. 1). The isotopic composition of water in the Z1 well has become variable after the start of exploitation, which suggests changes in inflows to that well from different karstic channels. The isotopic altitude effect was estimated from the data of springs and wells within the Tatras area. For $\delta^{2}H$, the mean altitude of recharge area reads: $h(\delta^{2}H)$ (m a.s.l.) = $-69.1 \cdot \delta^{2}H - 4054$, with the uncertainty of about 100–200 m (Zuber et al., 2008).

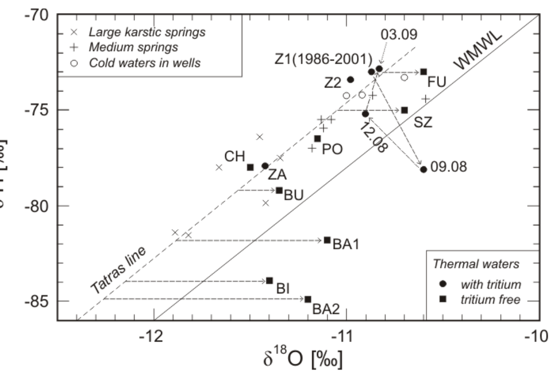

Figure 1. Isotope composition of the investigated waters with indicated shifts (horizontal lines) of $\delta^{18}O$ from the local meteoric line (see text in relation to changes in the Z1 well).

The most negative $\delta^{2}H$ values of thermal waters are close to those of large springs (Fig. 1), which may suggest their Holocene age. However, these most negative values are observed in the farthest wells whereas close to the recharge area, the $\delta^{2}H$ of thermal waters are similar to those of medium springs (Figs 1 and 2) indicating the low altitude recharge. Thus, the most negative $\delta^{2}H$ values of thermal waters observed in BI, BA1 and BA2 wells most probably result from recharge under cooler climatic conditions. Very high He excess contents and negative noble gas temperatures (NGT) derived from Ne and Ar concentrations (Fig. 2) are in agreement with such interpretation. The lack of ^{14}C with $\delta^{13}C$ values close to 0‰ in these three wells also confirms that hypothesis qualitatively.

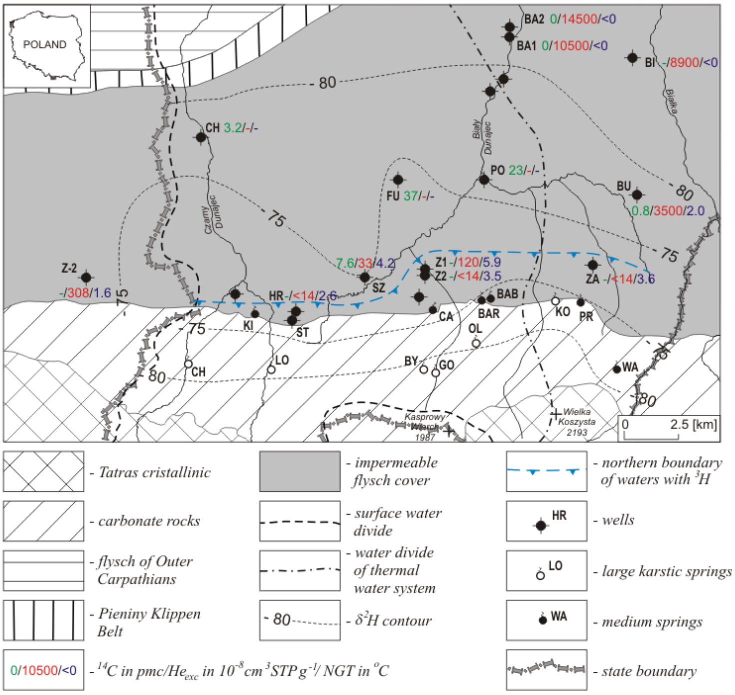

Figure 2. Environmental tracers in the Tatras and thermal waters of Podhale Basin.

According to all tracer data shown in Fig. 2, the oldest waters exist in the north-eastern part of the basin, whereas in the western part, the exchange of water is faster by one to two orders of magnitude. Such flow pattern, unexpected from the hydraulic conductivity values, probably results both from the presence of karstic channels in the western part enhancing regional permeability, and from obstacles to horizontal flow caused by fault zones in the eastern part.

REFERENCE

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International Association of Hydrogeologists

AGH University of Science and Technology

2-vol. set + CD
ISSN 0208-6336
ISBN 978-83-226-1979-0