Interaction between fresh and therapeutic groundwater in exploitation conditions based on one year H, O, and S isotope and chemical observations of selected wells (Carpathians, SW Poland)

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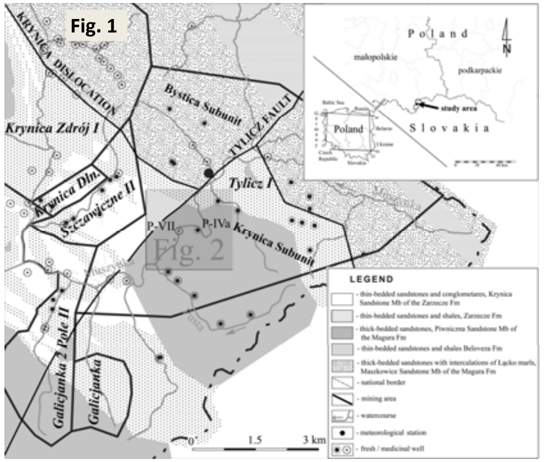
Study area

The research area is a part of the Polish Other Carpathians (Beskidy Mountains, Beskid Sądecki), located in Poprad River Valley, around the Tylicz Village (fig. 1). Geologically this area is located in the Magurska Nappe (flysh Paleogene formation - shales and sandstones of different thickness). The flysch formations cover older Mesozoic and Paleozoic mudstones, sandstones and carbonates, while on the surface occur Quaternary porous, mainly alluvial, sands and gravels. Flysch and alluvial sediments are mainly collector of groundwater. Other Carpathians, including Tylicz region, is also one of the most important Polish region of different types of therapeutic water drainage. In study area the most common are shallow circulation origin carbonated groundwater (containing CO_2) but also occur mineral groundwater without CO_2 represented by studied well P-VII, probably connected with deeper part of the aquifer. Hydrochemical and hydrodynamical processes of forming of groundwater resources in this area and relations between fresh and medicinal groundwater and water pumping impact, are still the subject of discussion.



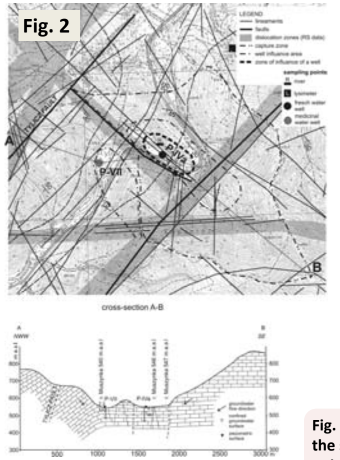


Fig. 1. and Fig. 2. Geological settings of the study area and details of sampling points location

Purpose

Complicated terms of water circulation in the flysch mountain catchments make it necessary to search for effective methods of its analysis in exploitation conditions. The main goal of the study was understanding processes of interaction between therapeutic (HCO3-Na type, mineral) and fresh groundwater in flysch aquifer on the basis of case in Tylicz region (Carpathians, SW Poland). Reliable approach for therapeutic water protection is pivotal task which remains without answer in Polish and European regulations.

Methods

In the study area were selected **5 sampling points** represented: groundwater (**P-VII** well - **HCO_3-Na type medicinal mineral water**, **P-IVa** well – **HCO_3-Na-Ca** type **fresh water**), **surface water** (Muszyna River), **infiltration water** (lysimeter) and **precipitation water** (rain gauge) (fig. 2, fig. 3). Samples from these 5 points were collected every month from April 2014 to February 2015.

Conclusions

The study demonstrated the usefulness of systematic and continuous isotopic, especially $\delta^{34}S(SO_4^{2-})$ and $\delta^{18}O(SO_4^{2-})$, analysis as an important complement to other chemical, isotope and hydrodynamic studies. Due to sustainable fresh groundwater resources management it is recommended not use simplified rules and limited extraction in area of fresh and mineral water coexistence without isotopic, chemical and hydrodynamical analysis.

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Results

Based on chemical (Na^+, K^+, Mg^{2+}, Ca^{2+}, HCO_3^-, Cl^-, SO_4^{2-}) and isotopic research ($\delta^{18}O(H_2O)$, $\delta^2H(H_2O)$, $\delta^{34}S(SO_4^{2-})$, $\delta^{18}O(SO_4^{2-})$ and hydrodynamic data, it was found that studied fresh and mineral groundwater demonstrate different origins and circulation ways (fig. 4, fig. 5, fig. 7). Fresh groundwater resources probably integrally were formed in the catchment (modern infiltration origin) and from precipitation to drainage area was impacted only by local factors. Chemical and isotope composition of mineral groundwater indicated that its resources was formed in deeper part of aquifer us an effect of glacial infiltration origin (fig. 6). Additionally, during the observation period there were no evidences for mixing of these waters with fresh groundwater during their exploitation.

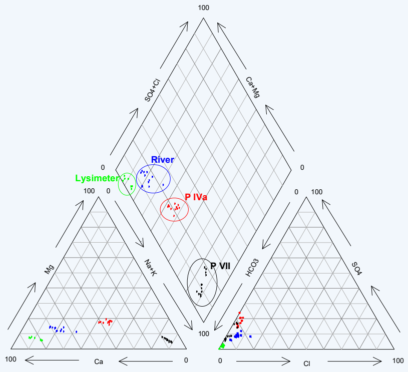

Fig. 3. The basic composition of studied water on the Piper diagram presents diversity of its hydrogeochemical facies

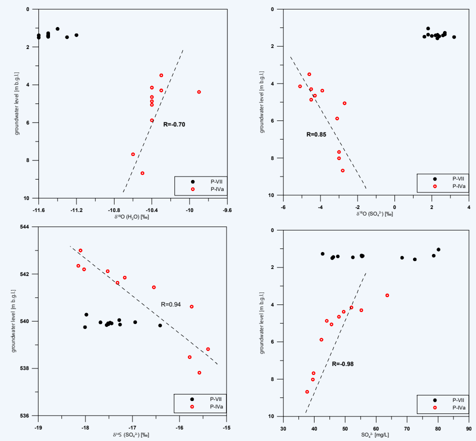

Fig. 4. Relationship between selected isotope and chemical parameters and groundwater level in P-IVa and P-VII wells

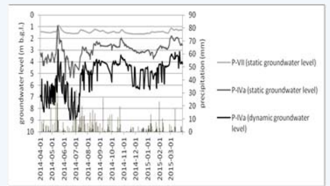

Fig. 5. Groundwater level fluctuation in P-IVa and P-VII wells

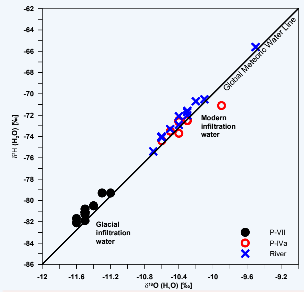

Fig. 6. Relationship between $\delta^{18}O(H_2O)$ and $\delta^2H(H_2O)$ in studied groundwater (P-IVa, P-VI) and river

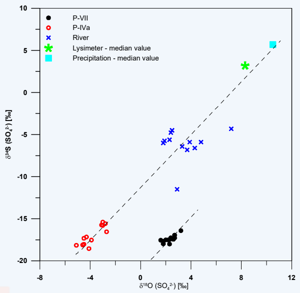

Fig. 7. Relationship between $\delta^{34}S(SO_4^{2-})$ and $\delta^{18}O(SO_4^{2-})$ of water from research points