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Isotopic composition of modern infiltration water in southern vicinity of Krakow

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Introduction

Water molecules called H2O are actually a diverse isotopic combination of the elements that make them up. Water isotopes are natural tracers used in the study of the hydrological cycle on Earth. Methods using knowledge of isotopic composition have a special place in groundwater research. Isotope analyzes provide unique opportunities to study the resources of these waters, their occurrence and dynamics, impossible to determine or significantly limited using other methods.

Methods

The research concerned young waters of modern infiltration (not older than approximately 70 years). Based on the results of the full isotopic composition of water ($\delta^{18}O$, $\delta^{17}O$, $\delta^{2}H$ and tritium concentration), analyzes were carried out using the $\delta^{18}O$-$\delta^{2}H$, $\delta^{18}O$-$\delta'^{17}O$, $\delta^{18}O$-$\Delta'^{17}O$ and T-$\delta^{18}O$ diagrams. For each of the measurement points, the ratio of summer to winter infiltration in its supply zone was determined. In this case, the summer half-year is the period from April to September and the winter half-year - from October to March.

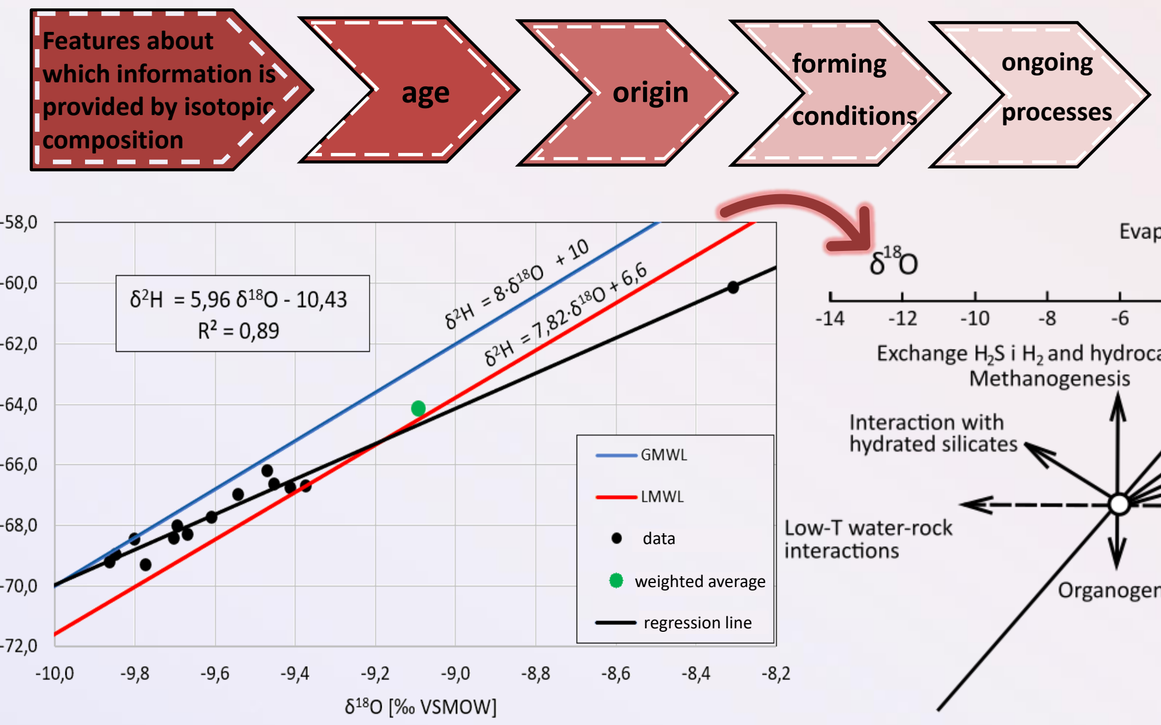

Fig.1. Dependence of the $\delta^{2}H$ value on the $\delta^{18}O$ value in the tested groundwater samples against the background of GMWL and LMWL

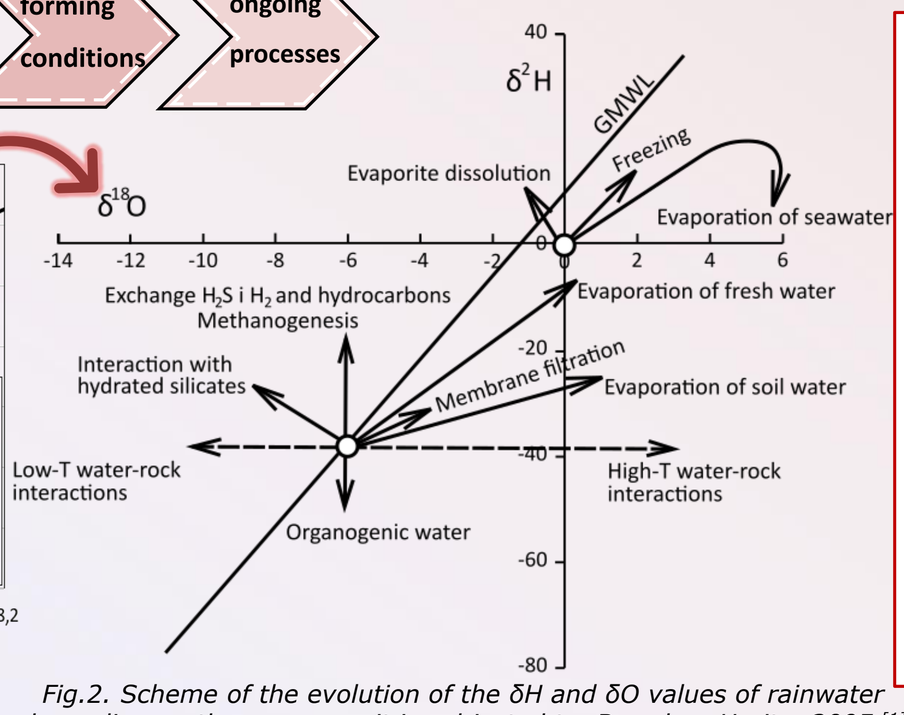

Fig.2. Scheme of the evolution of the δH and δO values of rainwater depending on the processes it is subjected to. Based on Horita, 2005 [1]

Results - southern vicinity of Krakow

The analyzes allowed to prove the presence of partial evaporation of rainwater before its infiltration into the ground and water environment in the southern neighborhood of Krakow (Fig.1, Fig.2). The ratio of summer to winter infiltration in its recharge zone was determined for each groundwater intake. The obtained results are characterized by significant variability within the range of 0.54-0.89 for H isotopes and 0.44-0.60 for O isotopes. The young age of the analyzed groundwater was demonstrated (up to a dozen or so years) without the presence of admixtures of older water.

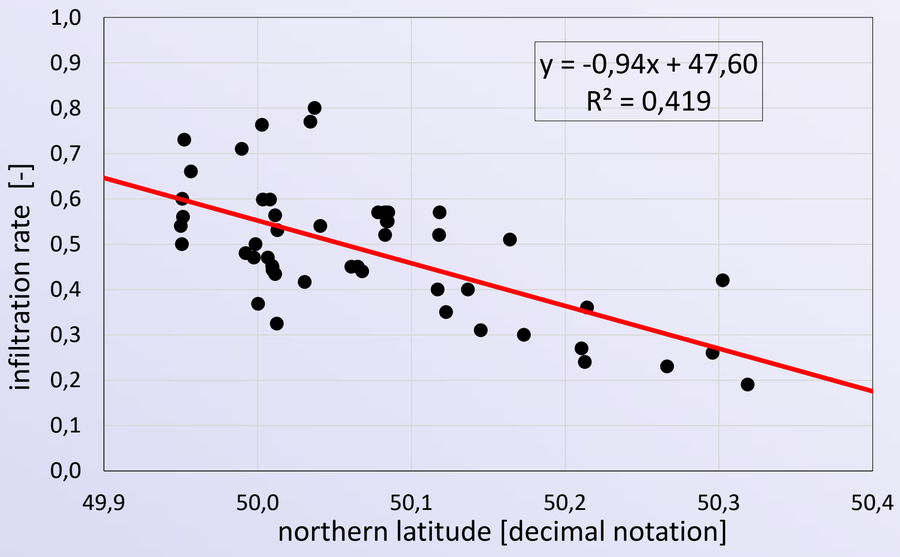

Fig.3. Dependence of the infiltration coefficient on the northern latitude of the measurement point near Krakow. The red line represents a linear regression of the data

Results – vicinity around of Krakow

Based on archival data, the area of analysis of the distribution of infiltration coefficients was extended to include the northern area of Krakow. There was a tendency to assume lower values of the summer to winter infiltration ratio with increasing northern latitude, with a correlation of $R^2 = 0.419$ (Fig.3). For this area, this parameter has values in the range of 0.27-0.89 for $\delta^{2}H$ and 0.19-0.80 for $\delta^{18}O$ with an arithmetic mean of 0.53 and 0.48, respectively (Fig. 4).

One of the most important uses of the infiltration coefficient is tritium methods for simple chamber models. At the beginning of their use, it was believed that effective summer infiltration was practically non-existent. The infiltration ratio α was incorrectly assumed to be 0.05 or even equal to zero[2]. Currently, it is believed that values in the range of 0.4-0.8 do not significantly change the modeling results [3]. However, the presented research shows that this parameter can have a much wider range of values, even in such a small area. This allows for the possibility of questioning such research in the light of the presented analyses.

Conclusions

1. A significant degree of evaporation of rainwater before its infiltration has been proven
2. The values of summer to winter infiltration ratios in the Krakow region are characterized by a significant correlation with the northern latitude of the location of the water intake.
3. In the vicinity of Krakow, the summer to winter infiltration ratio is 0.54–0.89 for H and 0.44–0.60 for O
4. The cause of the observed effect is unknown. It is assumed that the following factors may be of greatest importance: lithology, type of vegetation cover, regional and local climatic conditions, terrain (slope inclination and exposure) [4]. Their combination should be the solution to the problem.

References

[1] Horita J., 2005 *17. SALINE WATERS*. Isotopes in the water cycle
[2] MAŁOSZEWSKI P. & ZUBER A 1982 - Determinig the turnover time of groundwater systems with the aid of environmental tracers I. Models and their applicability. J. Hydrol., 57: 207- 231.
[3] Grabczak J., Małoszewski P., Różański K., Zuber A., 1984 *Estimation of the tritium input function with the aid of stable isotopes,* Catena, vol. 11, nr 2-3
[4] Zuber A., Różański K., Ciężkowski W., 2007 *Metody znacznikowe w badaniach hydrogeologicznych*, Oficyna Wydawnicza Politechniki Wrocławskiej

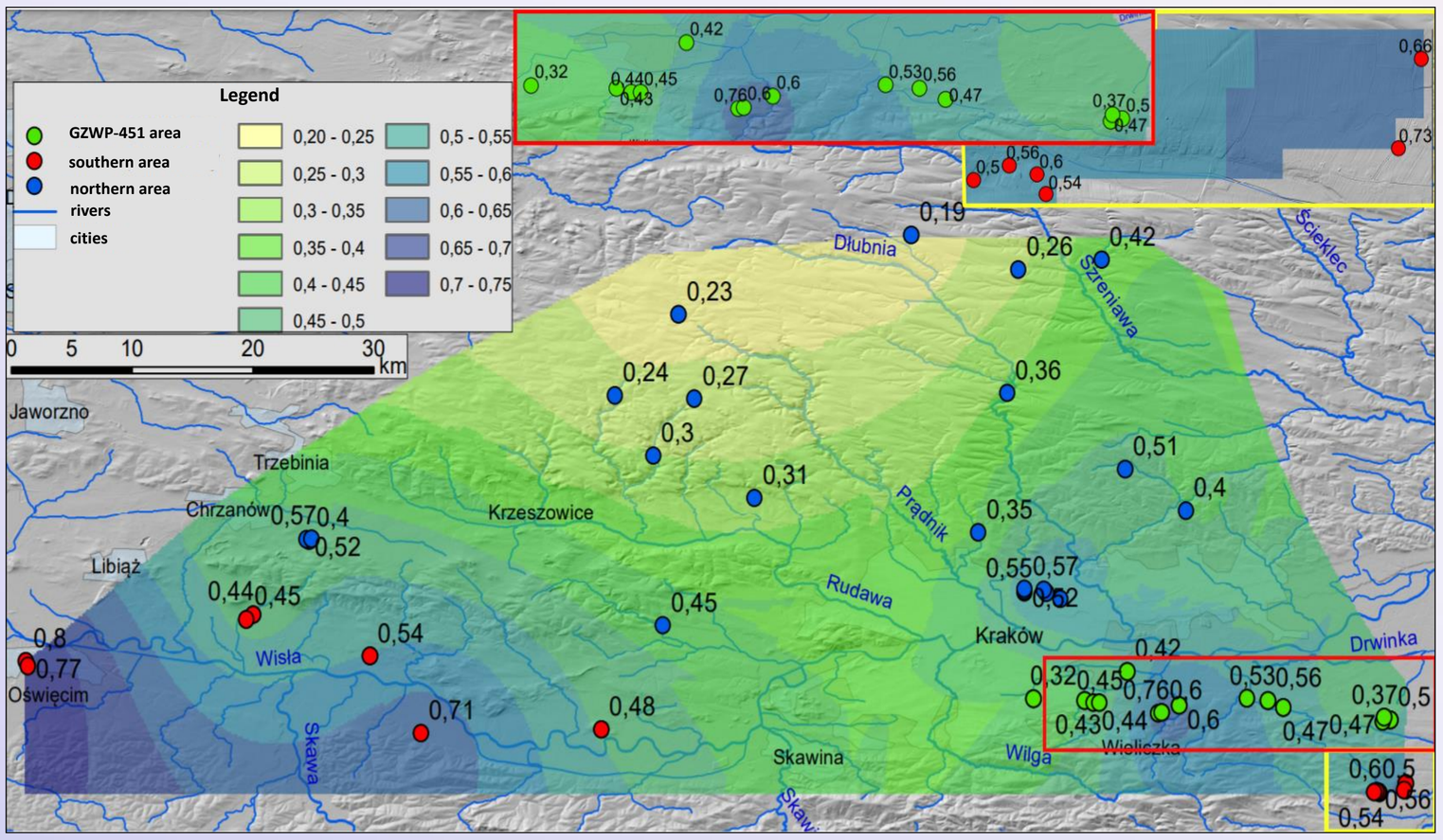

Fig.4. Map of the research area with marked measurement points carried out in the southern and northern neighborhood of Krakow and the area of GZWP 451-Bogucice. The presented infiltration coefficient α values were calculated using the $\delta^{18}O$ value