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Springs as indicator of geotectonic disturbances

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SUMMARY

The main object of research in this publication is the springs considered in the development system of the regional structural geology of the Carpathians. In specific theoretical and practical examples it proved that the springs can be indicators of linear faults. The effectiveness of combining field methods with remote methods for detecting geological explosive disturbances and fracturing of the local substrate has been proved. The prospects and directions for further research are shown.

Introduction

Even at the time of the emergence of preventive ideas of man about the geological and structural structure of our planet and the processes that occur there springs were considered (this day) as a kind of “hydrogeologic windows into aquifers” (Stevens et al., 2011). During the period of active development of modern geology (in the late XIX - early XX century), spring was the subject of conducting regional geological surveys and hydrogeological studies (if they are availability on the territory). Accordingly the development of scientific and technical means and the application of modern research methods, water sources have lost their original scientific significance. However, areas with increased complexity of engineering and geological conditions (in particular, mountainous areas), the places of natural groundwater exit to the surface are an integral part (and sometimes the only tool) of the complex of geological surveys.

Methods of investigation

In fact, many springs appear on the contacts of various suites or in zones of tectonic disturbances. Although the Quaternary sediments mask the places where water emerges, nevertheless, when mapping the sources, obtain valuable material of geological structure of the study area. According to the location system of springs (often with wetlands), geophysicists possibility conclusions about the tectonic structure of the territory.

In the latter half of the XX century according to the results of special regional studies, it was proved that the linear arrangement of the source system of the watercourse can be a geomorphological indicator of geological faults and fracture of the local substrate (Raskatov, 1972). Due to the fact that the source of the watercourses is the springs - speaking of morphographic methods, the place and role of the springs in structural geology should be highlighted.

In practice, the place of the natural release of groundwater to the day surface might not always detected remote sensing. Therefore, the application of field research methods and determining the localization of water sources in place is necessary. In the process of conducting research, we used data from field observations conducted by Polish scientists in the framework of the Chornogory massif about 100 years ago (Swiderski, 1937) and modern monitoring studies were carried out by specialists of the Carpathian National Natural Park (Kravchynskyi et al., 2019).

Data processing and analysis was carried out using stock materials (Geological map), satellite images of Google Earth and general and special purpose software (Exel and Mapinfo Professional).

A regional assessment of the relationship of water sources with tectonic features was carried out: in Poland (Janusz S., Pociask-Karteczka J., 2017), USA (Hobba WA, JR., Fisher DW, FJ Pearson, JR., JC Chemerys, 1979), Iran (Fatemeh Rezayi, Omid Asadi Nalivan, Sara Ayobi Ayoblu, 2017), Ukraine (Yakovlev V.V., Ananyev S.N., 2013), Russia (Sorokina A.T., 2006), etc.

Results of investigations

The research area we covered is outlined by the Carpathian National Natural Park - the first and largest (area of 504.95 km^2) of Ukraine's national natural parks, which is located in the south eastern part of the Ukrainian Carpathians (Ivano-Frankivsk region). Regional accounting and inventory of springs is one of the annual environmental activities carried out by inspectors and scientists of the park (Kravchynskyi et al., 2019).
In a comprehensive analysis of the monitoring results of the springs in the upper part of the Prut River basin near the village of Vorokhta, it was found that the groundwater discharge points No. 10-12 coincided with the strike of the regional geological fault identified early in the 60s XX century (Figure 1).

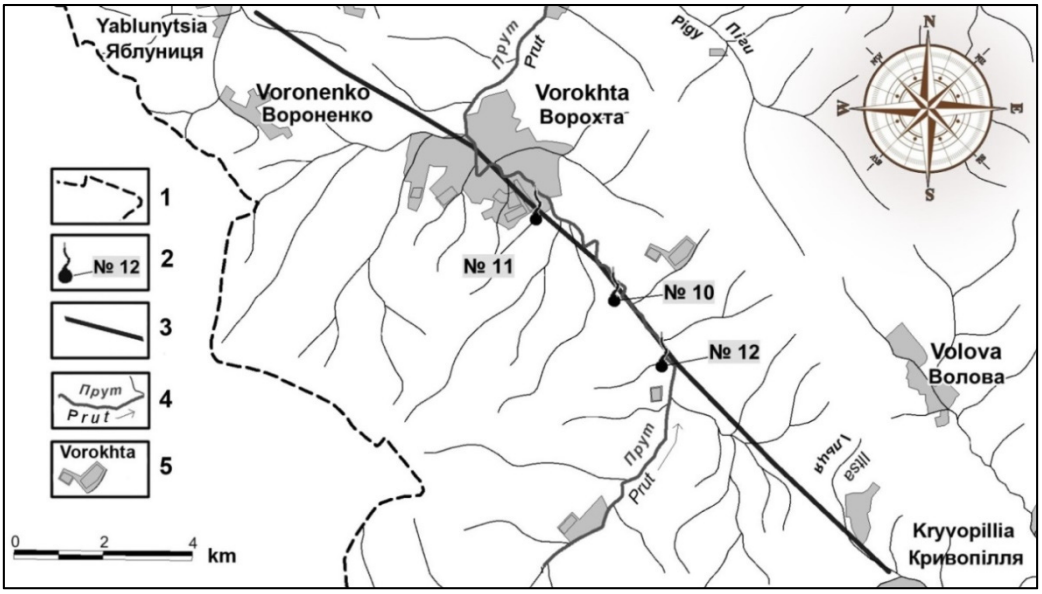

Figure 1 *The location scheme of the springs along the reliable line of tectonic contact in the Vorokhta region on the territory of the Carpathian National Natural Park: 1 - the border of the Carpathian National Natural Park; 2 - spring and his numerical order; 3 - tectonic fault (according to the Geological map); 4 - river; 5 – locality*

Nevertheless the localization of natural sources possibly to be reflect the manifestations of local geological and tectonic disturbances that are not intended for regional geological or tectonic maps. Comparing the results of field surveys within Mykulychyn village (Yaremchansky city council, Ivano-Frankivsk region) with the data of satellite images, we revealed a linear stretch of several water sources here. Further more detailed studies revealed the similarity of the evaluating parameters and properties of these natural objects: water-resource potential, mode and physico-chemical parameters (temperature, chemical composition). Thus, there is possible assumed that a geological-tectonic disturbance, about 1 km long, linearly extending from the northwest to the southeast (Figure 2).

In the autumn-winter period, a smaller thickness of snow is often observed in places along the marked line in comparison with the higher sections in the same weather conditions. This effect is an informative confirmation of the presence of a deep geological and tectonic disturbance, which elevated geothermal anomalies certain to be observed.

The third fact of the local tectonics features that we have determined may be a partial coincidence of the strike of a discontinuous disturbance of the local substrate with the linear distribution of the lower boundary of the forest, which according to (Raskatov, 1972) is due to the influence of the tectonic structure.

In hydrographic terms, the geological and tectonic disturbance identified by us reaches the Kisnyi stream (the right tributary of the Prut River). Further study of the predicted strike section made it possible to see in the water stream and valley a clear boundary of changes in rock lithology and in streamway configuration and the presence of thresholds (Figure 2).

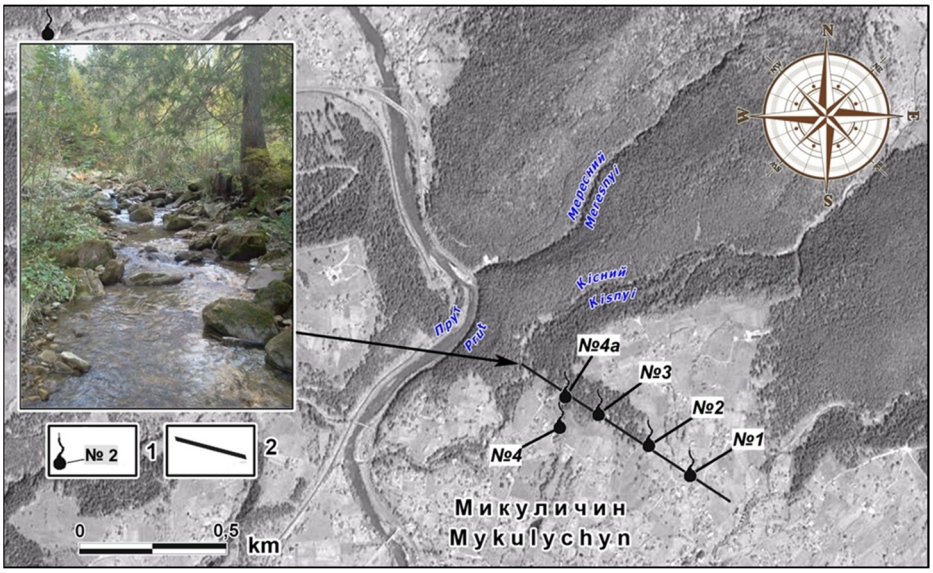

Figure 2 *Identification of a possible tectonic fault according to the location of spring in the village of Mykulychyn, Ivano-Frankivsk region: 1 - spring and his numerical order (spring No. 4a - a long-standing well, No. 4 - a modern functioning water intake); 2 - probable tectonic fault identified according to the location of the springs*

In addition, observations in the area in the spring (Figure 2) showed that a sharp change in meteorological conditions (especially before a significant thunderstorm) is preceded by a slight decrease in the groundwater level and, accordingly, a decrease in the debit of the spring. During periods of some phases of the moon, the opposite effect was noted - "tides," that is, a short-term increase in the level of groundwater and point discharge. Thus, it is possible specific geodynamic aspects in the system of the geological phenomenon of the spring.

For a more detailed study of the indicator relationships of springs with geological and tectonic disturbances, a systematic analysis of the results of detailed field studies conducted about 100 years ago (Swiderski, 1937) using modern approaches, methods and tools was carried out.

The research area is located on the north-eastern slopes of the Chornogory massif of the Ukrainian Carpathians and, covering an area of about 75 km^2, extends from the source of the Prut River to the source of the Pogorilets River.

The process of conducting structural-linear analysis of the territory consisted of two aspects. In the first case, a river network was used (the sources of rivers and streams, sometimes river bends, etc.) with the localization of springs. Other geomorphological features of the likely general stretching of lineaments in the territory with the location of the springs were considered.

The highest density of springs is observed at the source of a river of the Prut River. In many cases, lineaments are drawn along the sources of rivers and streams along two-three (less often four-five points), which are not identify tectonic disturbances.

However, when analyzing the location of the springs, which are often located on the same line, the lineaments stand out more clearly and at a greater distance (Figure 3). A similar situation is observed in the second case. Geological and tectonic disturbances identified by the results of other geomorphological features are predominantly northeastern and often coincide with the direction of part of the riverbed of the main streams. According to (Raskatov, 1972), the straight sections of the rivers are mainly due to the influence of the tectonic structure, the springs, which are thus located, can also be an indicator of local geological and tectonic disturbances.

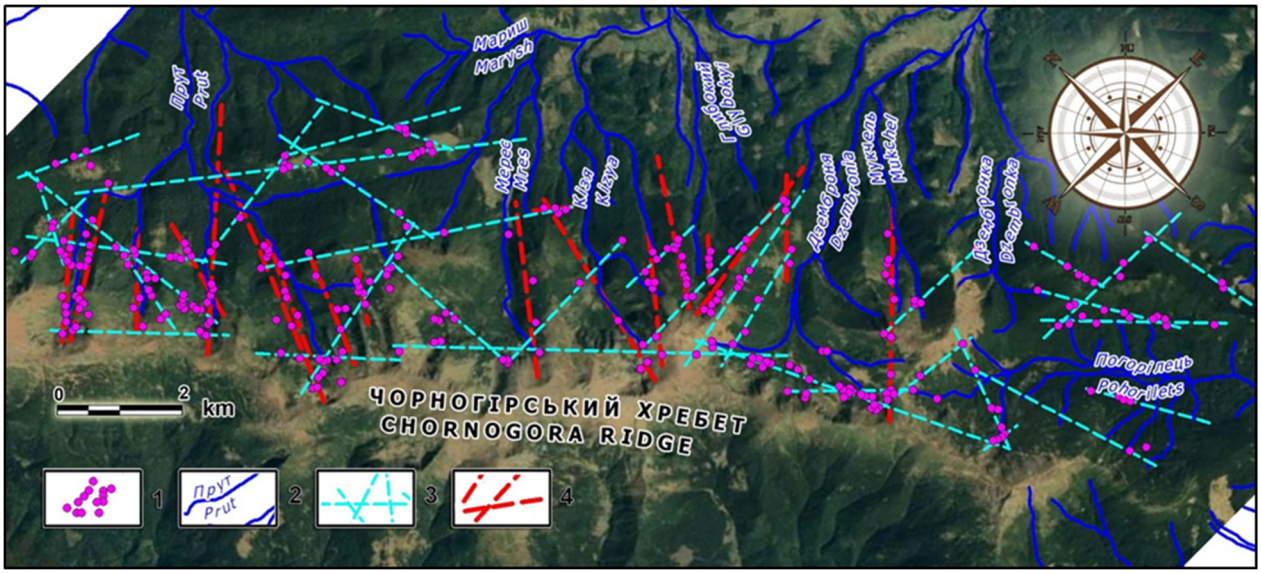

Figure 3 *The lineament analysis of the territory of the Chornogory massif in the territory of the Carpathian National Natural Park: 1 - springs; 2 - river and its name; 3 - lineaments identified by the interpretation of the river network and the localization of springs; 4 - lineaments identified according to geomorphological analysis of the territory and location of springs*

Conclusions

This study has shown the importance of studying (especially in afield) springs for the development of regional structural geology in the aspect of identifying geological and tectonic disturbances (including mildly expressed geomorphological).

The springs are often linear and may be a criterion for identifying a probable tectonic fault without using additional indicators and terrain characteristics. The results are more accurate and effective in combination with other indicators (hydrographic elements, geomorphological features of the territory, etc.).

An analysis of the results of expeditionary studies and a review of specialized literature allows the distribution of springs in the Carpathian National Natural Park are not only linearly, but like ring structures, which should be given special attention in the future.

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