

**HYDROGEOLOGICAL ASPECTS OF CRETA-
CEOUS LIMESTONE KARST IN WESTPHALIA,
FRG**

**HIDROGEOLOŠKE ZNAČILNOSTI KRASA NA
KREDNIH APNENCIH V VESTFALIJI (ZRN)**

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Izvleček

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Loehnert, E. P.: Hidrogeološke značilnosti krasa na krednih apnencih v Vestfaliji (ZRN)

Izvir Pader v Paderbornu (Zvezna država Severno Porenje - Vestfalija) je glavni iztok iz zbirnega območja, ki ga predstavlja na jugovzhodu ležeči odprti kras paderbornske "Visoke planote". Glavne smeri podzemeljskega toka so znane že skoraj sto let, zahvaljujoč številnim sledenjem. Za vodo ponikalnih potokov, ki so bili pred kratkim sledeni, je dokazano, da se ponovno pojavlja v globokih vrtinah, odkoder dobiva mesto vodo in sicer tako, da iz njih črpajo "ujeto" talno kraško vodo. Skladno s tem je torej ves sistem med seboj hidravlično povezan, kar ima neposredne posledice tako za količine vode v izvirih kot tudi za varovanje pitne vode.

Ključne besede: globoki kraški sistem, prosta/zajezena voda, zgornjekredni apnenci, izvir Pader.

Abstract

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Loehnert, E. P.: Hydrogeological Aspects of Cretaceous Limestone Karst in Westphalia, FRG

The Pader Springs of Paderborn (Federal State of Northrhine-Westphalia) constitute the main outlet of recharge taking place over the open karst High Plateau to the south-east. Principal underground flow directions are known for almost hundred years due to numerous tracer tests. Traced water of losing streams was recently proved to reappear in deep boreholes of the City Works withdrawing groundwater under confined karst conditions. Consequently, the whole system is hydraulically interconnected, with practical implications for both spring discharge and drinking water protection.

Key words: deep karst system, unconfined/confined conditions, Upper Cretaceous limestones, Pader Springs, second largest spring in Germany.

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INTRODUCTION

This paper is aimed at summarising two contributions by the author to the “Classical Karst - International Karstological School”, Lipica, and the International Symposium “Man on Karst”, Postojna, entitled

- Specific karst features in Westphalia (Germany) and
- Interpretation of environmental isotope data in karst waters of Paderborn (Northrhine-Westphalia, Germany), respectively.

Most of the facts and findings presented at these congresses are published but not all of them are in English nor in easily available journals either. It might, therefore, be justified to draw the attention of interested karst's researchers to a small but attractive subject, the aquifer system of Paderborn located in the eastern part of the federal state of Northrhine-Westphalia (Fig. 1). For graphs, diagrams, maps, sections etc., the reader is referred to the list of selected references below.

HYDROGEOLOGICAL SETTING

The karst aquifer system under consideration is located within Upper Cretaceous calcareous sediments at the eastern margin of the bowl-shaped Münster basin which contains marine sediments of up to 1800 m thickness in the centre. Three hundred meter thick of limestones and marlstones of Cenomanian, Turonian and Lower Coniacian age are uplifted along the southeastern margin of the basin forming the Paderborn High Plateau, an area of approximately 300 km². This plateau and parts of the neighbouring Egge Mountain constitute the recharge area of the Pader springs at Paderborn with a discharge rate of 4-5 m³ s⁻¹ as the second largest spring in Germany (after the Aach spring in Swabia).

Typical karst features such as dolines, dry valleys, sinking streams, estavelles etc. are encountered at the high plateau. With respect to underground flow conditions, tectonic faulting and fracturing seem to play a major role. Underground flow paths were delineated by Stille (1903) and subsequent researchers, which represent the paths taken by lost water in stream beds to emerge in the Pader springs. This, however, represents only a minor portion of the recharge, the major portion being derived from rainfall over the plateau area.

The Pader springs including others with smaller discharges emerge along a line which separates the open from the confined system. Northward from this dividing line, the fractured-karstified strata dip beneath impervious clayey-marly sediments of Upper Cretaceous

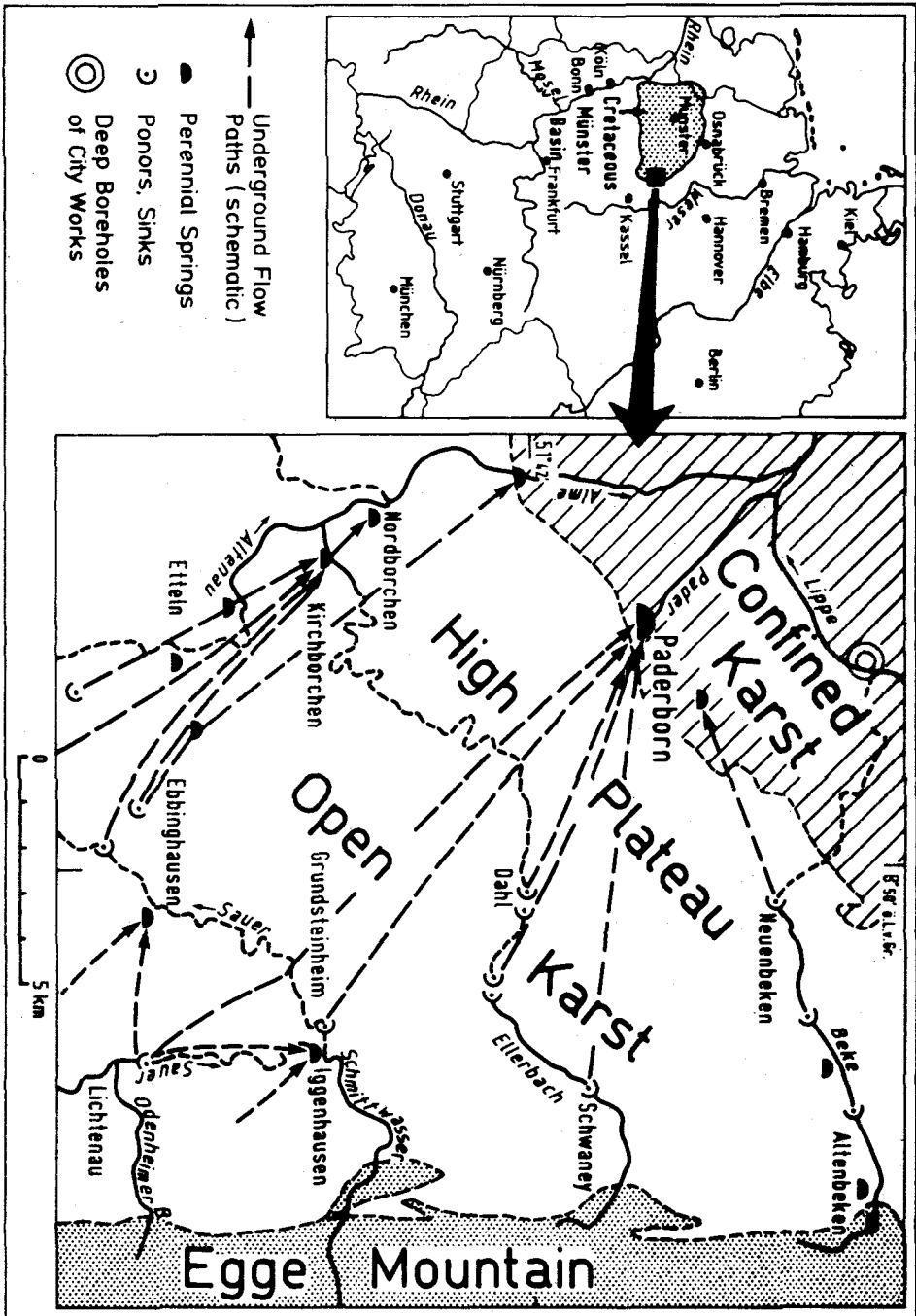


Fig. 1: Location Map.
Sl. 1: Pregledna karta.

age. Beneath this impervious cover, deep boreholes of the City water works abstract roughly 10 million m³ fresh water per year. It has been a point of controversy whether this amount of water could be proved as deficit in the Pader springs. The author of this paper succeeded in proving the interrelationship by applying different techniques, among others, conventional tracing.

PREVIOUS AND CURRENT RESEARCH

Merit is due to H. Stille (1903) who laid the foundations for subsequent researchers in his pioneering work which included dye tracing and a classification of Pader springs. After the second world war the Geological Survey of Northrhine-Westphalia continued to investigate the system by mapping and a variety of tracer tests (Baskan 1970, Koch & Michel 1972, 1984). The discovery of fresh water reserves under confined karst conditions (Hederer 1977) was a boost, which eventually brought about the application of environmental isotopes in deep borehole waters in order to trace their origin and to monitor the equilibrium of the fresh/saline water interface (Geyh & Michel 1974, 1979, 1987). These activities stimulated our own work to a considerable extent.

The author recently reviewed tracing tests executed over almost hundred years in the Paderborn karst system (Loehnert 1992). Since tracers injected in sinks on the high plateau are to be recovered after 3 - 4 days (equal to 100 - 300 m h⁻¹ dominant flow velocity) in many separate Pader springs, the system is ideal to make students familiar with various techniques including discharge measurements and hydrochemical analyses. The latter aspect is particularly of interest because the "Warm Pader spring" located in the western area is enriched in NaCl and this is suspected to be due to a higher share of uprising deep basin brines in accordance with spring discharges. Latest findings by Loehnert & Struffert (1994, in press) employing tritium and oxygen-18 revealed slightly higher calculated residence times for the western springs as compared with the eastern spring waters where injected artificial tracers commonly appear. It is these eastern springs which tend to become turbid after heavy rains (Stille 1903).

CONCLUSIONS

Much research activities were devoted to the Paderborn karst aquifer system but no final conclusions can be drawn yet. Further research is particularly required with respect to the confined section of the system which is hydraulically interconnected with the open section where recharge takes place. Our suggestion is to combine the monitoring of both surface as well as rain waters in the recharge area and groundwaters in the springs and deep boreholes. Promising environmental tracers such as selected chemical parameters (both of geogenic and anthropogenic origin) and isotopes in their variability are to be studied. The karst system, being one of the oldest investigated by a number of researchers in Germany, provides excellent chances for interdisciplinary studies.

SELECTED REFERENCES

- Baskan, M. E., 1970: Hydrogeologische Verhältnisse am Südostrand des Münsterischen Kreidebeckens und im Eggegebirge unter besonderer Berücksichtigung der Karsthydrologie.- Fortschr. Geol. Rheinld u. Westf., 17, 537-576, Krefeld.
- Geyh, M. A. & G. Michel, 1974: Isotopen- und Hydrochemie des tieferen Grundwassers im Raum Paderborn.- Fortschr. Geol. Rheinld u. Westf., 20, 67-78, Krefeld.
- Geyh, M. A. & G. Michel, 1979: Hydrochemische und isotopenphysikalische Entwicklung des Grundwassers in Paderborner Aquifer.- GWF-wasser/abwasser 120 H 12, 576-582.
- Geyh, M. A. & G. Michel, 1987: Grundwasserbewirtschaftung und Isotope.- Z. Dt. Geol. Ges., 138, 261-271, Hannover.
- Hederer, T., 1977: Trinkwasser aus Tiefem Karst der Paderborner Hochfläche.- Paderborn: Schöningh.
- Koch, M. & G. Michel, 1972: Hydrogeol. Karte Kreis Paderborn 1:50.000, Erl., Krefeld.
- Koch, M. & G. Michel, 1984: Hydrogeol. Karte Nordrhein-Westfalen 1:50.000; L 4318 Paderborn, Krefeld.
- Loehnert, E. P., 1990: Beitrag zur Geohydrologie des Karst-Aquifer-systems von Paderborn (Nordrhein-Westfalen) (in German, English abstract).- N. Jb. Geol. Paläont. Abh. 181, 519-530, Stuttgart.
- Loehnert, E. P., 1992: Tracing of the Paderborn karst aquifer system (Westphalia, Germany): A critical review.- Tracer Hydrology, 243-250, Balkema Rotterdam.
- Loehnert, E. P., 1993: New Results on Cretaceous Limestone Karst in Westphalia, Germany.- Hydrogeol. Processes in Karst Terranes (Proceedings of the Antalya Symposium and Field Seminar, Oct. 1990). IAH Publ. no. 207.
- Loehnert, E. P. & F.-J. Struffert, 1994: Umweltisotope in den Quellwässern der Pader (Paderborn, Nordrhein-Westfalen).- Geol. Jahrbuch, Festschrift Neumann-Mahlkau (in press).
- Stille, H., 1903: Geologisch-hydrologische Verhältnisse im Ursprungsgebiet der Paderquellen zu Paderborn.- Abh. Königlich Preuß. Geologische Landesanst. und Bergakademie N. F. H. 38.

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Povzetek

Rezultate hidrogeoloških preučevanj od konca 19. stol dalje lahko povzamemo, kot sledi:

- Globoki kraški sistem, razvit v zgornjekrednih apnencih vzdolž vzhodne meje münsterskega bazena, bodisi odprt (nezajezen) ali zaprt (zajezen), predstavlja v prvem

primeru cono napajanja, v drugem primeru pa odtočno cono, dokazano z izviri in vrtinami. V zadnjih nekaj letih se je skušalo kvantificirati določene tipe kraške talne vode glede na njihove fizikalno-kemijske lastnosti in glede na rezidenčni čas v podzemlju. S temi raziskavami bo treba še nadaljevati tudi v bodoče.