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A Theological Study on the Karst Water

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Abstract : Karst water was defined as "Water which fills the cavities of the earth continuously and is only subject to gravity and hydraulic pressure." Karst springs are water outlets from karst-hydrologically active cavities in water-soluble rocks, whether they are on the surface or within the earth. Karst springs behave so differently that the general principles of classification for all springs can be applied to them with a few exceptions. Firstly, classification according to the outflow; perennial springs, periodic springs, rhythemically springs, episodically flowing spring. Secondly, classification according to geologic and tectonic conditions; bedding springs, fracture springs, overflow spring, ascending spring.
key word : Karst water, Karst spring, Karst Barre, Perennial springs, Periodic springs, bedding springs, fracture springs, overflow springs

I. Introduction

Keilhack(1917) uses groundwater to embrace all deep water. But already in 1925 Ule writes : "…water in loose soils indeed occupies such a special postition that we ... do not wish to apply the term groundwater also to the water in the open joints of rocks". At the congress of the International Association for Scientific Hydrology held in Washington in 1939 groundwater was defined as "water which fills the cavities of the earth continuously and is only subject to gravity and hydraulic pressure. ... The term groundwater does not depend on whether the concerned parts of the earth's crust are loose or firm, whether they are weathered or unweathered, whether they lie close beneath the earth's surface or at greater depths. Cavities which contain groundwater may be of very different sizes..., no upward limit has been determined for the size of a cavity."

Keller(1962) makes the following critical comment of the above : "In limestone and gypsum water behaves quite differently than in other rocks." In Austria there is even the rule : "Water in open joints and joints(joint water)...shall not be called groundwater". This definition shows unmistakably the influence of the karst landscape frequent in Austria, which deeply preoccupies hydrogeologists. It may be mentioned that the water supply of Vienna draws large amounts of karst water out of the Raxalpe, Hochschwab and the Schneealpe. On the

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other hand Thurner(1967) adds to the Austrian definition : "From the hydrological point of view there exists no principal difference, for pores are just as much cavities as are join ts, open joins, etc."

Practical and legal requirements are fundamental in the DIN definitions ; these do not always satisfy scientific knowledge completely. Some of the conditions for karst groundwater which, compared with the DIN definition, are more restrictive are :

1. The coherent groundwater surface is missing, In its place there are individual water levels at greater distances from one another which cannot be integrated into one geometrically comprehensible surface.

2. The karst water-body does not move forward as a whole, but in individual streams(tube-flow). In spite of their connections they are frequently hydrologically in dependent of one another.

3. As a result of tube-flow no uniform potential surfaces are to be found in the phreatic zone ; there are individual ones.

4. The diameter of karst-hydrologically active cavities can measure from a few millimeters to tens and hundreds of meters. For this reason also the vmin karst groundwater is higher to the power of ten than groundwater in pores and joints when the pressure gradient if the same.

5. Similar differences in size are also prevalent in networks of cavities.

In conclusion it can be said that the term ground water means water as defined by the International Association for Scientific Hydrology. It is divided into three different types according to the size of the pores, or cavities, and their interrelationships as well as according to the resultant manner of movement of the water.

II. Underground Water

The main characteristic of a karst landscape is underground drainage in a karstifiable rock. Other types of landscape show underground drainage, also, such as when streams ooze away in valley-fill. Thurner(1967) emphasizes that water in loose rock is not karst water.

Precipitation seeping away crosses the zone of seeping water and reaches the zone of water saturation, the groundwater, from which it again emerges at an appropriate place as a spring. There is a high degree of water accumulation in gravels and sands but a low degree of it in hard rocks, on the other hand, when the reservoir consists of joints; in karst there are great variations.

In the initial phase of karstification karstifiable rocks do not behave very differently from insoluble, hard rocks. They are as such impermeable, and only by means of the joints do they become permeable. Limestone and dolomite are brittle and form tight networks of joints after being exposed to only slight stress.

The case with unkarstifiable hard rocks is similar. This network of joints favors the penetration of water and joint groundwater is formed first; this can be equated with the phreatic zone. It extends to very close to the earth's surface. When the interstices are widened. karst hydrological activity sets in and the upper limit of the water-saturated zone sinks. The latter finally comes under the directinfluence of the base level, or shallow karst forms with its watercourses on the impermeable underlying bed. The zone of seeping water has reached its greatest thickness. It corresponds to the vadose zone.

The seeping water gathers in underground water-courses which are called autochthonous, since their water originates in the karst area itself. Water which comes from outside the karst area it called allochthonous. Such is carried into the karst area by surface water systems such as the Reka and the Pivka in Slovenia. Usually they disappear into the underground on reaching the karst or shortly afterwards. Because the loss of water is gradual, this may occur almost unnoticed until the river bed is left dry, e.G., the outflow of the Malham Tarn in Yorkshire(Sweeting, 1972) and the seeping away of the Danube. More rarely allochthonous water enters the underground through a spectacular cave gate, e.g., the Reka *entering* the Mahorciceva Jama , the front cave of the Skocjanske Jame (Slovenia). There can be no doubt that the Reka reaches the phreatic zone and presists in it for the long stretch up to the mouth where it flows out as the Timavo at Duino south of Monfalcone. Nevertheless it keeps its individuality as proved by experiments using various means of water-tracing. One of the best-known examples is the seeping away of the allochthonous Danube between Immendingen and Friedingen. The water disappears in narrow open joins in the Malm limestone and flows underground along various paths to the Aach spring which is 11.7-18.3 km distant, depending on the point of seepage. The speeds of flow measured are between 304 and 422 m/h(Batsche et al., 1970)

A significant portion of the underground Danube flows under phreatic conditions; this was corroborated by diving experiments in the Aach Pot. During such an experiment a vadose cave system was reached at a rather great distance from the spring ; this was an earlier phase in the development of the Danube's underground course.

Ⅲ. "Karst Barre"

The French term karst barre refers to a small area of karst which is surrounded by impermeable rock. There is no comparable term for this phenomenon in English. The water is dammed up in the karst, which thereby belongs mainly to the phreatic zone. The deep karstification is proof of the validity of Davis'(1930) and Thrailkill's (1968) the ories concerning water-courses running through the depths.

Corbel(1957) describes the characteristic example of the quarry of Harehope(County of Durham, North Pennines, England). Limestone is separated from its surroundings by a fissure intrusion. An allochthonous river used to cross the terrain until recently without seeping through. Work in the quarry removed the barrier. Shortly afterward water broke out 30m below the surface while at the same time the river dried up. This is only possible if karst-hydrologically active cavities were already in existence at this time. Simultaneously cave passages were discovered which had become dry. The fact that they had not been completely filled in gives evidence of flowing karst water at this depth during the phreatic phase.

Ⅳ. Blocked Karst

Blocked karst is a common occurrence in periglacial regions with permafrost. In the cold periods of the Pleistocene the water froze in well-developed karst and karst hydrological activity was blocked. In the place of underground drainage there was surface drainage which, aided by frost weathering, formed valleys foreign to karst in karst that was previously water-free;and this in a relatively short time. A good example of this is the dry-valley karst of the Swabian Alb. "subcutaneous caves"(Ciry, 1959) were formed above the permafrost on terrain with a southern exposure during thawing.

Blocked karst is widespread in central and eastern Siberia. Popov etal.(1972) set the thickness of the permafrost at 20-50m in the south, at 300-600 min the north. The maximum depth at which there is thawing is as low as 2.5m in the south, in the north it is only 1.2m. The karst springs are small and in the region of Rybinsk they show around 5 l/s, in Angara-Lena Trough up to 100 l/s. This is an indication of the low intensity actual karstifving processes have under permafrost conditions. The development of underground cavities is correspondingly slow and, also only takes place when an actual circulation of water can setin.

Under the permafrost there can occur extensive, slow convection flows. Warm water from the depths rises into the higher regions and is cooled off as it approaches the permafrost, whereby corrostion due to cooling takes place. When the cold water parts sink and become warmer the result should be limestone depositing. Sufficient observations have not yet been made of such processes and their effects.

V. Karst Springs

Karst springs are water outlets from karst-hydrologically active cavities in water-soluble rocks, whether they are on the surface or within the earth (cave springs). There are scarcely any other characteristice which apply to them alone. The same lime contents, the same amounts of discharge and the same temperatures can be found in other springs as well. Springs emerging from rocks which are permeable, but practically insoluble and therefore nonkarstifiable (volcanic tuffs, lava, etc.) are exempted from this definition.

In Westermann's Encyclopedia of Geography(1970, p.948) stands ; "Cave(karst)springs" springs ofter with a very strong discharge, in karstilied regions." Schmidt(1928) writes: "Karst springs originate when the underground water of karst regions reaches the surface. Karst springs are usually large and can immediately turn millwheels."

Karst springs can be large, but there are many small ones. Cave springs do not always emerge on the surface. Therefore these definitions are no longer satisfactory.

O. Lehmann(1932) spoke of the "karst-hydrological contrast" when referring to the contrast between the innumerable seepage points in karst for precipitation and melted snow, and the comparatively few karst springs in the karst area and along its margins.

Out of the profusion of interstices originally available, selective corrosion creates a network of water-courses. More and more of these become inactive so that, as a result, tere is a concentration of water in only a few of them.

In the early phases of an underground karstified area only marginal parts of the karst water-body are oriented toward a spring;the main part remains undifferentiated as a central karst water-body which passes its water on to the marginal sections. With increasing karst-hydrological activity the catclunent area of individual springs reaches deeper and deeper and the more efficient tap the others. Thus the smaller karst springs are gradually eliminated. The more advanced underground karstification is, the smaller the number of springs and the larger the average discharge from them.

If the springs are fed from the phreatic zone, the discharge of the lower springs increases at the cost of the higher ones. The faster outflow causes the karst water level to area of Holloch comprises 22 Km^2, and when the water level is normal this water emerges only in the Schleichender Brunnen.

Another special aspcct of the karst-hydrological contrast is that a stream entering the underground frequently flows out again from very different springs situated a great distance from one another, e.g., in the Dachstein and in the Toten Gebirge.

Ⅵ. Conculsion

Karst springs behave so differently that the general principles of classification for all springs can be applied to them with a few exceptions.

1. Classification according to the outflow.
a) perennial springs
b) periodic springs
c) rhythemically flowingsprings, so-called intermittent springs, ebb and flow springs
d) episodically flowing springs, e.g., Hungerbrunnen.

2. Classitfication according to geologic and tectonic conditions
a) bedding springs
aa) contact springs at the contact of an underlying, impermeable bed and a capping, permeable ond
ab) springs on bedding joints inside the permeable rock;usually small
b) fracture springs out of open (widened) joints
c) overflow springs drain a phreatic zone with an impermeable base which sinks in toward the mountain
d) ascending springs, when the outflow is heavy these are also called vauclusian springs after the original of the type : Fontaine de Vaucluse east of Avignon

To these types of spring there can still be added individual types which do not fit so easily into a general scheme : subaqueouskarst springs (sublacustrine and submarine); karst springs can also be found in the underground in every form: cave springs. The question whether water which does not energe on the earth's surface can be termed a spring can be answered by the fact that the visual impression in a cave is just as unmistakable as on the earth's surface. Karst springs which have been covered by boulders or by gravel betray their presence by the considerable flow of water. Small karst springs unger loose material can, however, not be distinguished from talus springs. In karst are as springs which flow out of a valley fill may also be effusions of groundwate r-decisions as th classification must be made on the basis of chemistry and temperature. Estavelles function alternately as sinks and as karst springs, thus they are also temporary springs. O. Lehmann(1932) interprets them as relieving an underground stream during high water, Grund sees them as emerging groundwater, Depending on the conditions one or other of the two opposing opinions is correct.

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