Karst terranes and environmental aspects

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Abstract Karst is a complex geological phenomenon that relates to terranes composed of limestone, dolomites, gypsum, halite, or other soluble rocks. Protection of groundwater in karst against pollution is needed because of the high velocity of its flow (several hundreds of thousands of meters per day) and where polluted materials are carried without being filtered. Protection of karstic aquifers against pathogens and rapidly degradable chemicals is carried out for the catchment areas with an estimated delay time of 60 days and for a distance of more than 30 m. Tracer methods have recently become quite useful in karst regions; a tracer may respond as a multiimpulse because of different flow lines, flow velocities, and water aquifers. Therefore, if a total water balance has to be established, nearly all answer-back impulses should be considered.

Key words Karst terranes — Karst erosion — Acid rain

Karst and karstification

Definition

Karst is a complex geological phenomenon that relates to terranes [that are] of very specific hydrological characteristics and are composed of limestone, dolomites, gypsum, halite, or other soluble rocks. Inhomogeneities of the rocks may also play an important role in such a respect. Karstification is an aggregate of geological processes either naturally or artificially in the earth's crust and on its surface due to chemical, physicochemical, and/or under diverse geological and climatic conditions through time and is expressed through the formation of openings, the destruction and alteration of the structure of the rocks, and through the creation of a particular type of groundwater circulation and a characteristic regime of drainage network and characteristic regional topography (Fig. 1).

Concept of karstic erosion by groundwater

Mandel (1965) stated that in the saturated zone of calcareous aquifers, the process of erosion by solution proceeds at a very slow rate and consists essentially of two correlated phenomena: (1) Solution channels are formed and widened in the vicinity of springs where a strong concentration of flow occurs. The solution channels gradually develop in an upstream direction until gradually one giant spring captures the groundwater of an entire calcareous massifs. (2) Throughout the aquifer, an intricate system of solution channels develops, the dominant characteristic of which is its direction towards the outlet. Generally the process should be regarded as the transformation of a more or less isotropic aquifer into a strongly anisotropic one.

The direction of groundwater flow is the determining factor in the karstic development of calcareous aquifers, whereas varieties of lithology, faults, fissures, etc., are only of secondary importance. The preferential directions of flow tend to become "fossilized" and do not necessarily reflect the most recent geological events. From these considerations some practical consequences follow concerning the large-scale exploitation of groundwater from calcareous aquifers.

Karst corrosion

It is the peculiar erosion by dissolution primarily of limestone (and in a broader sense of other rocks readily soluble in water). Jakucs (1977), in his discussion of the concept of karst corrosion, stated that the dissolution of limestone in water may be the result of one or any of the combinations of the following distinct processes.
Pressure

By Karstification Processes

Natural and/or by human activities

Temperature

Water

Gas

Limestones, Dolomites, Sulfates, Chalcides, and other rocks

By erosion
(Corrosion and corrosion)

Karst Phenomena

Stalactites

Stalagmites

Travertines

Corrosion (Chemical)
1) Solution \( \Rightarrow \) Precipitation
2) Ion exchange
3) Sorption (Adsorption \( \Rightarrow \) Desorption)

Non-karstic corrosion of limestone

Whereas the simple physical (carbonate) and chemical (hydrocarbonate) dissolution of limestone may be considered karstic corrosion, corrosive denudation due to other chemical factors comes under the heading of the non-karstic chemical decomposition of limestone. This includes a large number of chemical reactions that take place between limestone and chemical reagents liberated in various types of soil, e.g., the corrosive organic acids produced by the aerobic decay of vegetal and animal substances. The inorganic acids and salts resulting from the biochemical or inorganic processes of weathering in the soil also play an important role in limestone corrosion:

\[
\text{CaCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{CO}_2 \tag{5}
\]

\[
\text{CaCO}_3 + 2\text{HNO}_3 \rightarrow \text{Ca(NO}_3)_2 + \text{H}_2\text{O} + \text{CO}_2 \tag{6}
\]

Cholnoky (1940) stressed the role of \( \text{CO}_2 \) in the soil, and he stated that in the soil there is a continuous process of decay, of slow oxidation, resulting in the formation of carbonic acid gas, which then condenses on the grains of the soil skeleton of an invariably adsorptive nature. Rainfall after a dry spell gives out a “smell of rain”; the characteristic odor of the gases displaced by the raindrops from the surfaces of the soil grains.

A fraction of the \( \text{CO}_2 \) absorbed in water (0.7 percent at 4°C) turns into carbonic acid:

\[
\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 \tag{3}
\]

As soon as the water containing the carbonic acid comes into contact with \( \text{CaCO}_3 \), a reaction occurs to produce calcium hydrocarbonate by dissolution of the limestone:

\[
\text{CaCO}_3 + \text{H}_2\text{CO}_3 \rightleftharpoons \text{Ca(HCO}_3)_2 \tag{4}
\]

\[
\text{CO}_2 (\text{gaseous in the atmosphere}) \rightleftharpoons \text{CO}_2 (\text{absorbed in water}) \tag{2}
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