The mechanisms of karstification

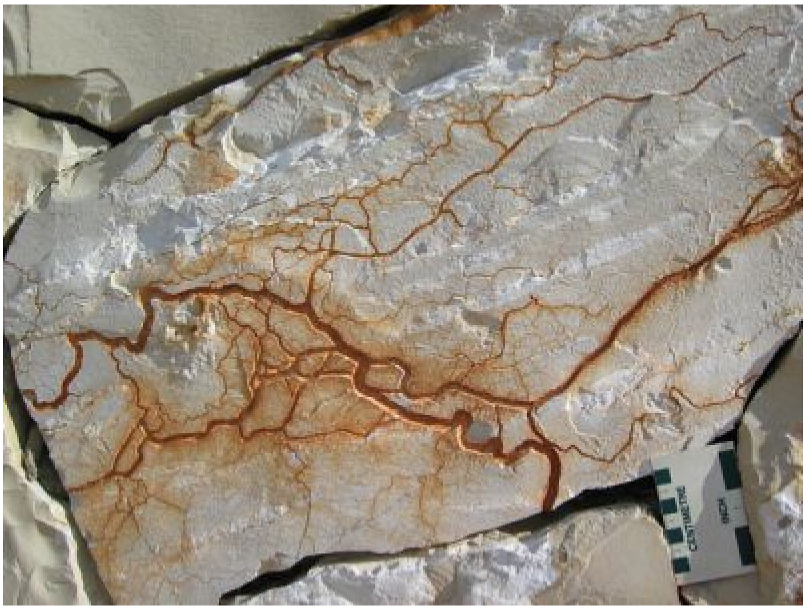

Figure 1. Network of cracks and root marks in the epikarst. [Source: © M. Bakalowicz]

At the very beginning of its appearance on the surface of continents, the rock has very low permeability, which does not facilitate water infiltration. This permeability is mainly ensured by pores and cracks, sometimes and very locally by open fractures in accordance with the orientation of the stresses that generated them. Mechanical actions related to decompressions, plant roots, etc., widen the natural discontinuities near the surface (Figure 1), which promotes infiltration. Two mechanisms are at the basis of karst formation: the flow of water into the carbonate rock and the dissolution of carbonates by acidic water [1], characterizing the **karstification potential** (KP). KP is defined by two factors: the "engine" of groundwater flow and the "solvent", which allows the dissolution of the rock by groundwater, and thus the expansion of some of the initial voids [2].

The **engine** is commonly gravity. The stronger the potential **hydraulic gradient** between the recharge surface and the emergence, the easier the groundwater flow will be, and therefore the more efficient the transport and disposal of dissolved materials. To gravity can be added a gradient of density, related to the mixture of fresh water and salt water (in the case of coastal aquifers), or of temperature due to the mixture between thermal water and fresh water.

The most common **solvent** is rainwater and all surface water that infiltrates, made acidic by the dissolution of CO_2, which is highly soluble in water. The infiltration water takes on CO_2 and becomes sufficiently acidic to dissolve the carbonate rocks at depth [3]. It transports and disperses CO_2 underground, permanently maintaining its dissolving power. The Earth's atmosphere contains little (partial pressure of CO_2 : 0.035%) and rain dissolves about 30 mg/L of calcium carbonate $CaCO_3$. But life in soils produces a lot of CO_2 that accumulates there until it is 100 times more abundant than in outdoor air (pCO_2: 2 to 4%), allowing the dissolution of 250 to 350 mg/L of $CaCO_3$.

The more water and CO_2 infiltrating, the faster the karstification process is. The amount of water infiltrating is determined by precipitation on the recharge area and by any surface runoff that is lost to carbonate rock after sinking on impermeable ground. This amount of water therefore depends on the climate and the geometry of the reservoir. The partial pressure of CO_2, determined by the vegetation cover and air temperature, also depends on the climate. Other solvents have been identified in the interaction of groundwater with deep-seated gases, such as H_2S and hydrothermal CO_2, or in the freshwater-salt water mixture. These solvents are at the origin of particular forms and organizations of voids and drainage of karst aquifers, such as hydrothermal karst and coastal karst [4].

Different independent approaches show that a conventional network of karst conduits is built in a few tens of thousands of years, i.e. faster than a river network [5]. As a result, karst is very sensitive to geological events that may change the base level and the original permeability of the rock. All karst specialists now agree that all carbonate formations have been karstified to varying degrees over geological time [6].

References and notes

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