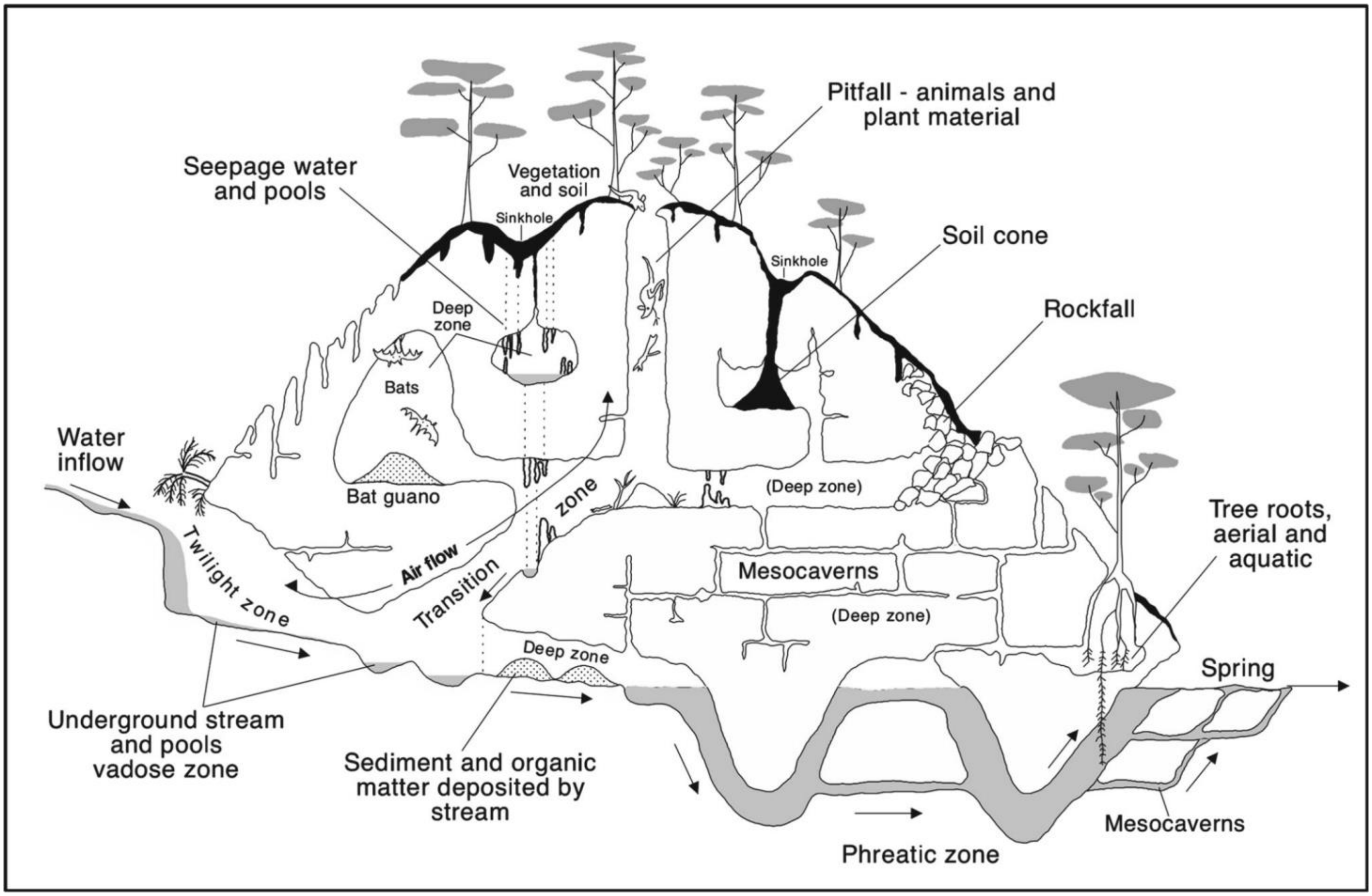
A schematic of fluvial karst system



This figure shows schematic section of a fluvial karst system showing a variety of subterranean voids and their various degrees of inter-connectivity by water and air flow that in turn influences the movement of energy, materials and organisms as well as the extent of the twilight, transition and deep zone environments. Other subterranean habitats have similar attributes working at different temporal and spatial scales but largely lacking the large open conduits (caves) typically found in karst. Reproduced with permission from Eberhard and Humphreys (2003).

Source: Eberhard, S.M. (2023). Cave Fauna. In: Webb, J., White, S., Smith, G.K. (eds) Australian Caves and Karst Systems. Cave and Karst Systems of the World. Springer, Cham. (pp.329-376) https://doi.org/10.1007/978-3-031-24267-0_23

Soil loss in karst areas

In karst areas, soil loss occurs both on land surface and in underground space because the dissolution of soluble bedrock connects the surface and underground environments. Here we present phenomena of karst soil loss, evidence of underground soil loss (USL), and photos of various USL pathways. The materials utilized herein are sourced from the internet, books, articles, and our fieldwork.

Karst soil loss in Cerro del Hierro, SW Spain

by Aitor Fdez-Ceballos on 17 May 2014 (distributed via WIKIMEDIA COMMONS)

The photograph from a Special Area of Conservation in Spain is a good example of how karst soil loss exposes limestone pinnacles while soil erosion removes the residual soil mantle, producing a rugged landscape of bare rock, collapse features, and patchy vegetation. It illustrates the fragility of soil in protected karst systems such as Cerro del Hierro, where even limited disturbance can accelerate soil erosion.

More importantly, this photograph implies that some of the soil loss may be occurring through karst fissures and cavities. The open joints and voids in the limestone likely act as conduits for the downward transfer of fine sediment, contributing to the discontinuous red soil mantle and leaving limestone pinnacles exposed within an increasingly depleted soil matrix.

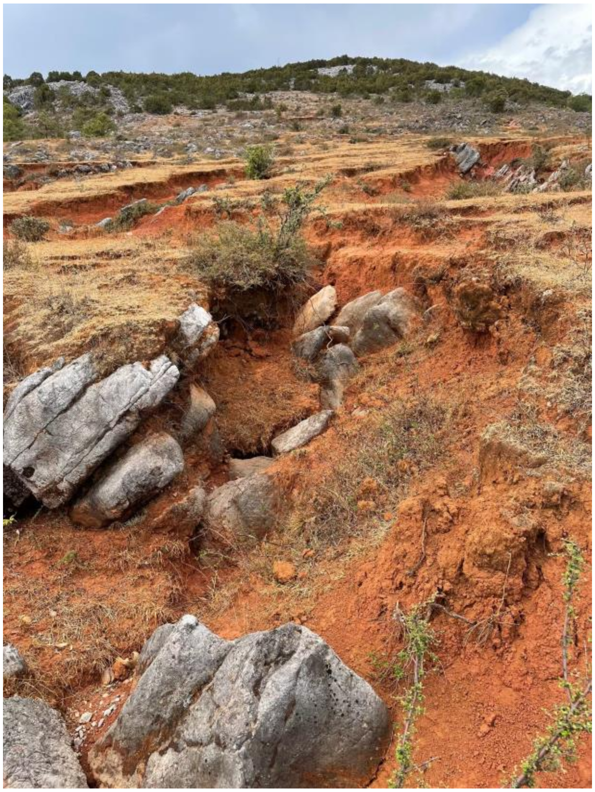
Exact location (-5.7765 W, 37.9197 N)

Karst soil loss-rocky desertification in Yanyuan, Sichuan, SW China

by Shukun Xing on 21 April, 2026 (Faculty of Geographical Science, Beijing Normal University)

The provided images from Yanyuan, Sichuan, vividly illustrate the severe ecological challenges of soil erosion and karst rocky desertification that plague SW China's karst regions. The image displays clear evidence of gully erosion, which quickly take away the soil by concentrated water flow during rain events. The removal of the soil layer exposes the barren bedrock, leading to the creation of a rocky, water-scarce, "desert-like" landscape with low biological productivity.

Exact location (101.3028 E, 27.6460 N)



Accelerated underground soil loss in Mammoth Cave, USA

by Bpluke01 on 9 June 2022 (distributed via WIKIMEDIA COMMONS)

This photo shows ruins of an abandoned saltpeter mine inside Mammoth Cave. Active during the early 19th century due to a saltpeter shortage during the War of 1812.

Mammoth Cave is the longest known cave system in the world, located in south-central Kentucky ofthe United States. The cave system has formally been known as the Mammoth–Flint Ridge Cave System since 1972, when a connection was discovered between Mammoth Cave and the even longer system under Flint Ridge to the north. As of 2025, more than 426 miles (686 km) of passageways had been surveyed, over 1.5 times longer than the second-longest cave system, Mexico's Sac Actun underwater cave. New discoveries and connections add several miles/kilometers to this figure each year.

(https://en.wikipedia.org/wiki/Mammoth_Cave_National_Park)

Accelerated underground soil loss via sinkhole in Guangxi, SW China

Source: Lei, M., Zhou W., Jiang X., et al. (2022). Atlas of Karst Collapses (Page 56), Advances in Karst Science, Springer Nature Switzerland AG, https://doi.org/10.1007/978-3-030-92912-1_4.

This photograph shows a karst farmland landscape affected by sinkholes, located in Fenjie, Yinlin, Guangxi. The sinkholes collect runoff and may function as conduits for the downward movement of fine sediment into the underground. And the underground soil loss through sinkholes is expected to be accelerated when cultivation has disturbed the soil surface and increased the availability of loose sediment.

Exact location (110.967 E, 21.767 N)

Evidence of underground soil loss in karst regions

In karst systems, solution pores, pipes, fissures, sinkholes, karst windows, shaft, and cave entrances act as openings or vertical conduits linking the land surface with the underground cave and river network. If periodic surface runoff washes sediment into these openings, then the cave and underground river network is functioning as a subsurface sink for surface material, which cannot be detected by the current surface monitoring system

Soil creeping slickenside at rock-soil interface in Guizhou, SW China

Source: Zhang, X. B. , Bai, X. Y. , & He, X. B. . (2011). Soil creeping in the weathering crust of carbonate rocks and underground soil losses in the karst mountain areas of southwest china. CARBONATES AND EVAPORITES, 26(2): 149-153.

The paper by Zhang et al. (2011) presents evidences for underground soil losses in the karst mountain areas of SW China, particularly in regions underlain by pure carbonate rocks. The images show field observations of direct soil-bedrock contact and the scratches in the weathering crust of carbonate rocks due to the downward movement of soil: (a) Direct earth–bedrock contacts in the weathering crust; (b) scratches on the surface of an earth crumb; (c) scratches shown by polarizing microscope. Numerous and close scratches were observed in the lower parts of laterite layers and at the interfaces between the layers and the underlying bedrocks in the weathering crust profiles of carbonate rocks in Pingba and Huaxi.

Exact location (106.45 E, 26.45 N)

Storm-induced collapse of a sinkhole in Guangxi, SW China

Source: Lei, M., Zhou W., Jiang X., et al. (2022). Atlas of Karst Collapses (Page 96), Advances in Karst Science, Springer Nature Switzerland AG, https://doi.org/10.1007/978-3-030-92912-1_4.

Thirty-seven cover-collapse sinkholes occurred at Maohe village, Guanxi, China, in May 2012 during and after a heavy rainfall event. Accompanied with these collapses were 11 donut-shaped subsidence areas and sixty-eight earth fissures. The cover-collapse sinkholes were in circular or elliptical shape on the surface and cone shape in the vertical profiles. The largest sinkhole had a long axis of 70 m and short axis ranging from 12 to 38 m, and a depth of greater than 4 m. The smallest sinkhole had a diameter of 1.2 m and a depth of 5 m. The impact area encompasses more than 40,000 m^2. The voids in dolomite and overburden determined locations of these collapses, whereas the drastic groundwater level change determined time of these collapses. The average measured groundwater level was more than 11 m higher than the yearly average groundwater level. Dramatic rise in groundwater levels could cause hydrofracturing and hammer effects on the soils, thus accelerating the subsurface soil loss.

Exact location (109 E, 24 N)

Clay-rich soil cone in a karst cave in Guizhou, SW China

provided by Jianghu He on 26 July 2021, State Engineering Technology Institute for Karst Desertification Control, Guizhou Normal University

The photographs from a field investigation work of our group show a clay-rich soil cone within a karst cave at Anshun, Guizhou. In karst caves, such deposits commonly form when eroded soil is transported downward through cave entrances, fissures, shafts, or sinkhole-fed conduits and accumulates underground, recording subsurface soil loss as part of the broader erosion process. We used ^{137}Cs tracer technique, high frequency online monitoring, and UAV survey to investigate the source of these sediment deposit in the cave. The results show that the soil materials deposited in caves came from surface soil that mainly transported by runoff from the cave entrance, rather than through fissures above the caves (He, 2023).

He, J., Cao, Y., Zhang, K., Xiao, S., Cao, Z. (2023). Soil loss through fissures and its responses to rainfall based on drip water monitoring in karst caves. J. Hydrol. 617, 129000.

https://doi.org/10.1016/j.jhydrol.2022.129000

Exact location (105.5819 E, 25.8081 N)

Sediment cones and tree roots in Sand Cave at Naracoorte, S Australia

Photo by Steve Bourne. **Source**: Reed, E. (2023). Vertebrate Fossils in Australian Caves: Underground Archives of Past Biodiversity. In: Webb, J., White, S., Smith, G.K. (eds) Australian Caves and Karst Systems. Cave and Karst Systems of the World. Springer, Cham. (pp.297-312). https://doi.org/10.1007/978-3-031-24267-0_21

This photo shows a big sediment cone and tree roots in Sand Cave at Naracoorte. The deposits are composed of surface sediments accumulating as cones beneath cave entrances (Forbes and Bestland 2007). **The sediment cone and tree roots together indicate a strong vertical connection between the land surface and the cave interior.** Surface sediments can be transferred downward through cave entrances, fissures, and other solution openings, accumulating as a cone beneath the entry point. The presence of tree roots descending from the roof further confirms that the cave is connected to the overlying soil and vegetation cover. The cave therefore records underground soil loss, where eroded surface material is transported into underground during storms and periodically redistributed downslope by water flow.

Forbes, M. and Bestland, E. (2007). Origin of the sedimentary deposits of the Naracoorte Caves, South Australia. Geomorphology, (86), 369-392.

Exact location (140.7972 E, 37.0357 N)

A soil Cone in Fox Cave at Naracoorte, South Australia

Photo by Ken Grimes. **Source**: White, S.Q. (2023). Otway Basin. In: Webb, J., White, S., Smith, G.K. (eds) Australian Caves and Karst Systems. Cave and Karst Systems of the World. Springer, Cham. (pp.189-200). https://doi.org/10.1007/978-3-031-24267-0_12

This photo shows a large sand cone of predominantly quartz sand occur at the base of solution pipe entrances in several caves. Most sediment has been washed into the caves by periodic inflows from surface runoff, and lag deposits of rock and bone have formed on the sediment surface where water flows have removed finer material. This deposit therefore records underground soil loss. Since the sand is derived from the overlying soil or regolith, it can be interpreted as evidence of underground soil loss in the karst environment.

Exact location (140.8070 E, 37.0592 N)

Deep underground sand dunes in Son Doong cave, Vietnam

by Urs Zihlmann from Zug, Switzerland (distributed on 15 June 2018 via https://urszihlmann.com/story/son-doong/)

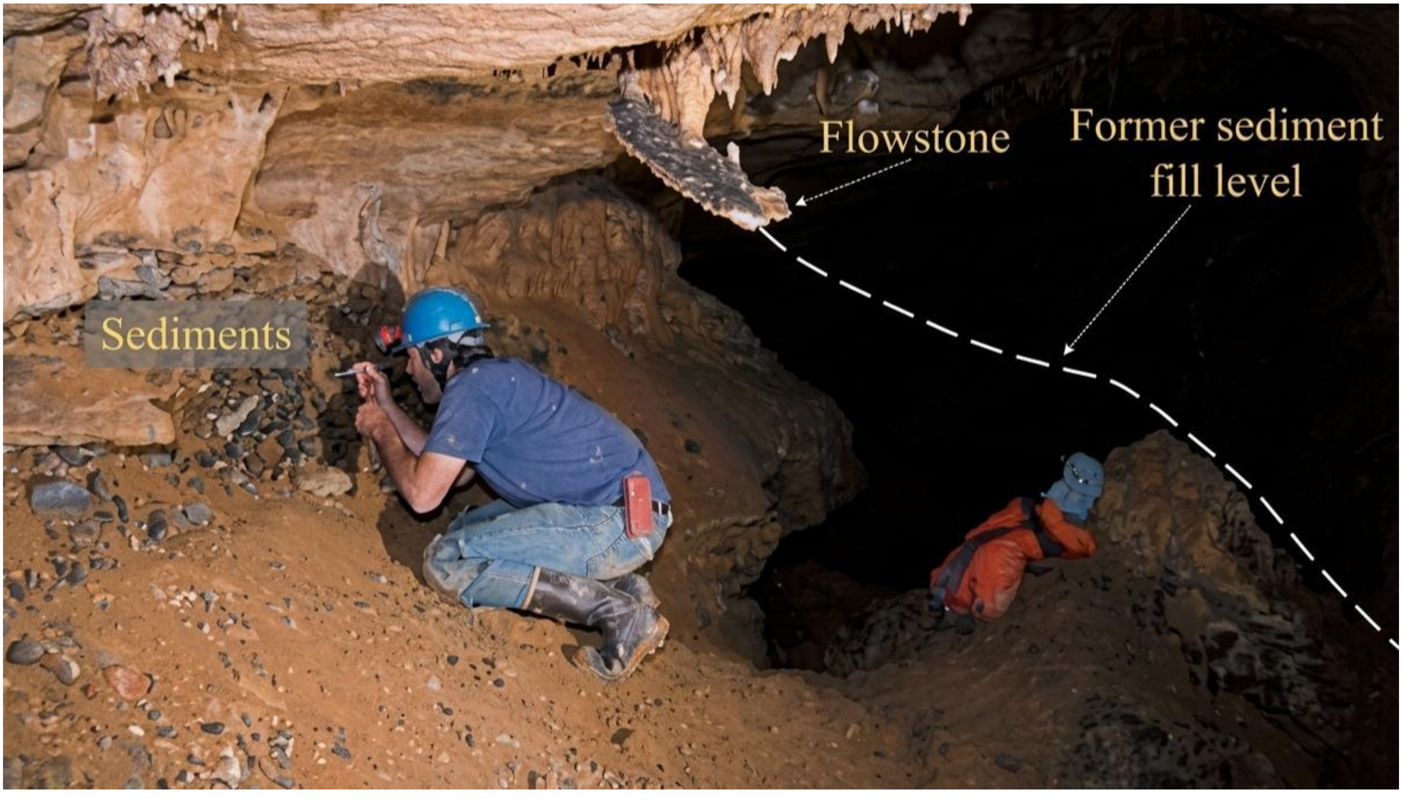
This photo shows underground sand dunes on the way to <Great Wall of Vietnam> in Son Doong cave, located in Phong Nha-Kẻ Bàng National Park in Vietnam. Son Doong Cave is approximately 9km long. Within its caverns lie a jungle and a river, and the cave is large enough to fit a 40-storey skyscraper inside. The main chamber is more than 5 kilometers long, 200m high, and 150m wide. It is so large that it has its own climate, and clouds have even been known to form within it. The cave inside has some of the tallest known stalagmites, which are around 80 meters tall.

Exact location (106.2875 E, 17.4572 N)

Episodic infilling and removal of sediments in a karst cave, USA

This photo shows episodic infilling and removal of sediments is commonly observed in caves. In this section of Windy Mouth Cave (West Virginia, USA), a diamict was almost completely removed after being covered with flowstone. The dotted white line highlights a high-water mark where the cave was once nearly filled with sediment. This indicates a period of high-energy inflow and deposition from external sources. To the left, the exposed cross-section shows poorly sorted material. Fluvial cave sediments often consist of "allochthonous" soil and rock fragments (clastic sediments) from the surface, such as silts, sands, and gravels. The label "Flowstone" points to a layer of calcium carbonate that formed on top of the previous sediment level. In geology, the presence of speleothems (like flowstone) interbedded with or capping clastic layers is a classic sign of alternating periods of surface-driven flooding and quieter, drip-water deposition.

Source: SASOwSKy, I. D. (2007). Clastic sediments in caves–imperfect recorders of processes in karst. Acta carsologica, 36(1).



Soil and vegetation in the entrance of Son Doong cave, Vietnam

by Urs Zihlmann from Zug, Switzerland (distributed on 15 June 2018 via https://urszihlmann.com/story/son-doong/)

The image shows the entrance of Son Doong Cave in Vietnam, which is renowned for being the world's largest cave. The scene in the photograph appears to show green vegetation and soil accumulation near the cave entrance, where light and water are able to penetrate. The presence of soil and vegetation in the entrance of cave suggest that there is likely hydrological activity occurring between the surface and the underground system, which could contribute to soil loss into the karst cavities.

Exact location (106.2875 E, 17.4572 N)

Karst USL pathways

Karst pores

There are two or even three types of porosity in karst aquifers: intergranular pores in the rock matrix, common rock discontinuities such as fractures (fissures) and bedding planes, and solutionally-enlarged voids such as channels and conduits developed from the initial discontinuities. Whereas groundwater flow in the matrix and small fissures is typically slow and laminar, flow in karst conduits (caves) is often fast and turbulent.

Karst micro-pores in SW France

by Lamiot on 13 April 2016 (distributed via WIKIMEDIA COMMONS)

The photograph was taken at "Gorges (small canyon) of the Ciron" downstream from the "bridge of the Trave" in Préchac (Gironde, France). It shows a limestone surface densely marked by small karst pores, visible as rounded pits and irregular cavities. These features were formed by the gradual dissolution of carbonate rock by slightly acidic water, probably enhanced by humic acids and prolonged moisture in the shaded gorge environment. The result is a honeycomb-like microrelief that illustrates small-scale karst weathering on the rock surface.

Karst macro-pores in Longtan Cave in Guizhou, SW China

by Qihua Ke on 14 Aug, 2024

This photo show macro-pores in limestone of Longtan Cave in Tianhetan scenic area in Guiyang.

Karstified fissures (grike, gryke, crevice, crack, solution slots)

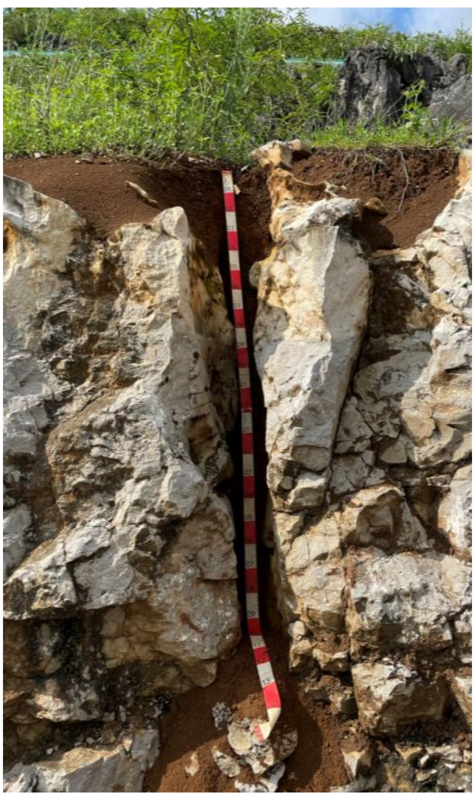
Karstified fissures are natural fractures, joints, or bedding planes in soluble bedrock (limestone, dolomite, gypsum) that have been enlarged by the dissolving action of acidic groundwater along a pre-existing fracture in bedrock. These conduits, which can range from narrow gaps to large, sediment-filled cavities, are essential components of karst landscapes, facilitating rapid underground water flow, high permeability, and increased vulnerability to groundwater contamination.

Karst fissures in Guizhou, SW China

provided by Jianghu He on 20 Aug 2021, State Engineering Technology Institute for Karst Desertification Control, Guizhou Normal University

These photographs, taken from Anshun, Guizhou, show vertical epikarst fissures developed in limestone. The fractures have been widened by carbonate dissolution and partly infilled by residual soil, demonstrating the close coupling of karstification and soil erosion. Rather than remaining as a continuous surface mantle, fine soil is preferentially transferred into joints and cavities by infiltrating water, indicating downward soil loss into the subsurface as well as surface erosion.

Exact location (105.6709 E, 25.6582 N)



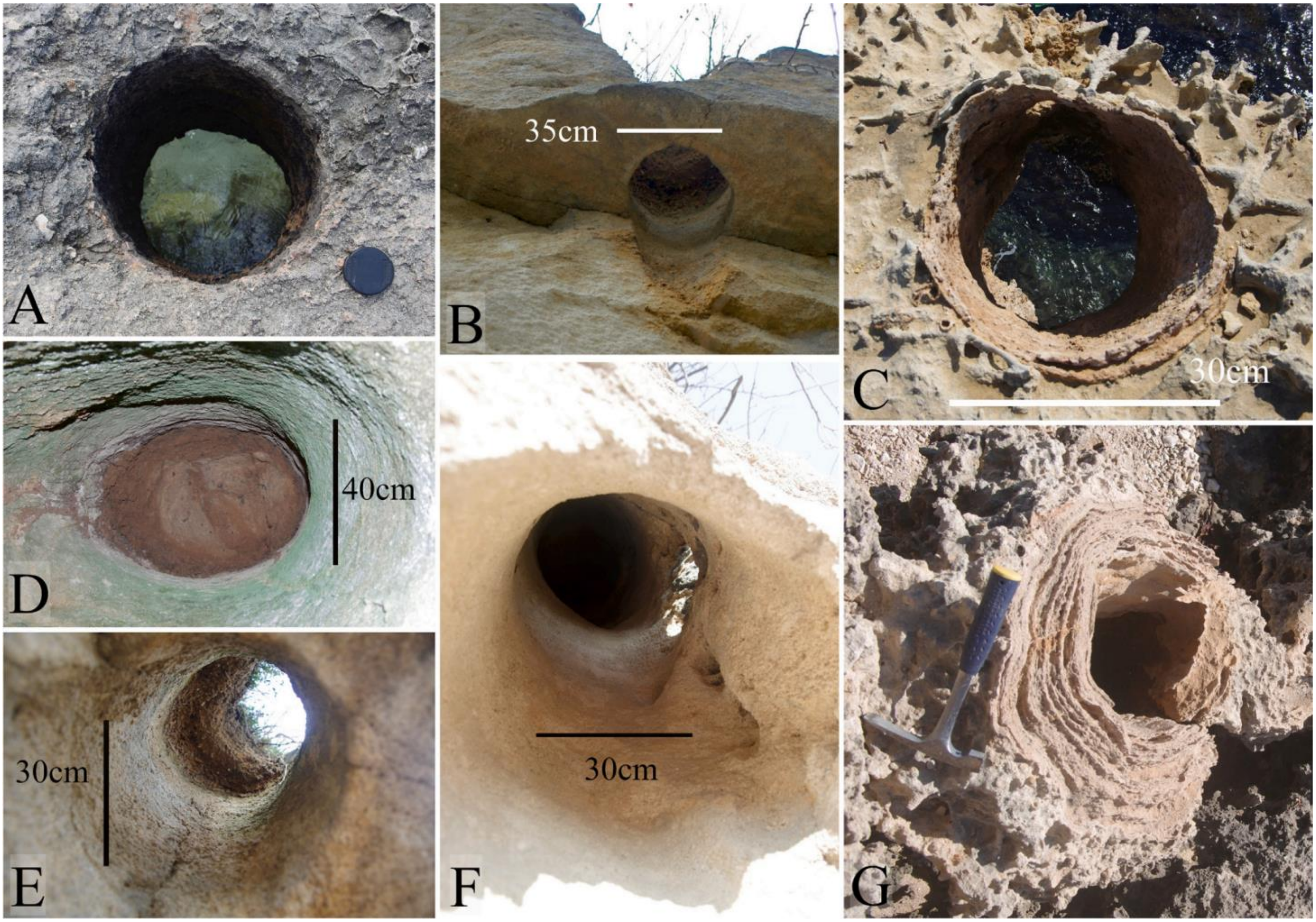
Karst pipes (solution pipes, solution tubes)

Karst pipe is a tubular cavity formed by dissolution projecting as much as several metres down from the surface into karst rocks and often filled with earth, sand, gravel, breccia, etc. The pipes have a range of widths, averaging about 0.5 m, but can be smaller than 0.2 m or over 1 m, although the wider ones tend to be less regular, and some may be due to coalescence of several smaller pipes. Depths are typically 2-5 m, but they can be up to 20 m deep and some may connect with underlying caves.

Solution pipes around the world

Source: Lipar, M., Szymczak, P., White, S. Q., & Webb, J. A. (2021). Solution pipes and focused vertical water flow: Geomorphology and modelling. Earth-Science Reviews, 218, 103635.

This photo shows pipe cross sections: A & C – Plio-Pleistocene calcarenite in Apulia, Italy; B, D, E & F – Miocene calcarenite in Smerdyna, Poland; G – Pleistocene calcarenite at Cape Perron, Perth, Australia. Note that some pipes are rim-free (e.g., D, E) while some have well-developed rims (e.g., C, G); in the case of G, almost filling the pipe, which could be an indicator of pipe senescence.

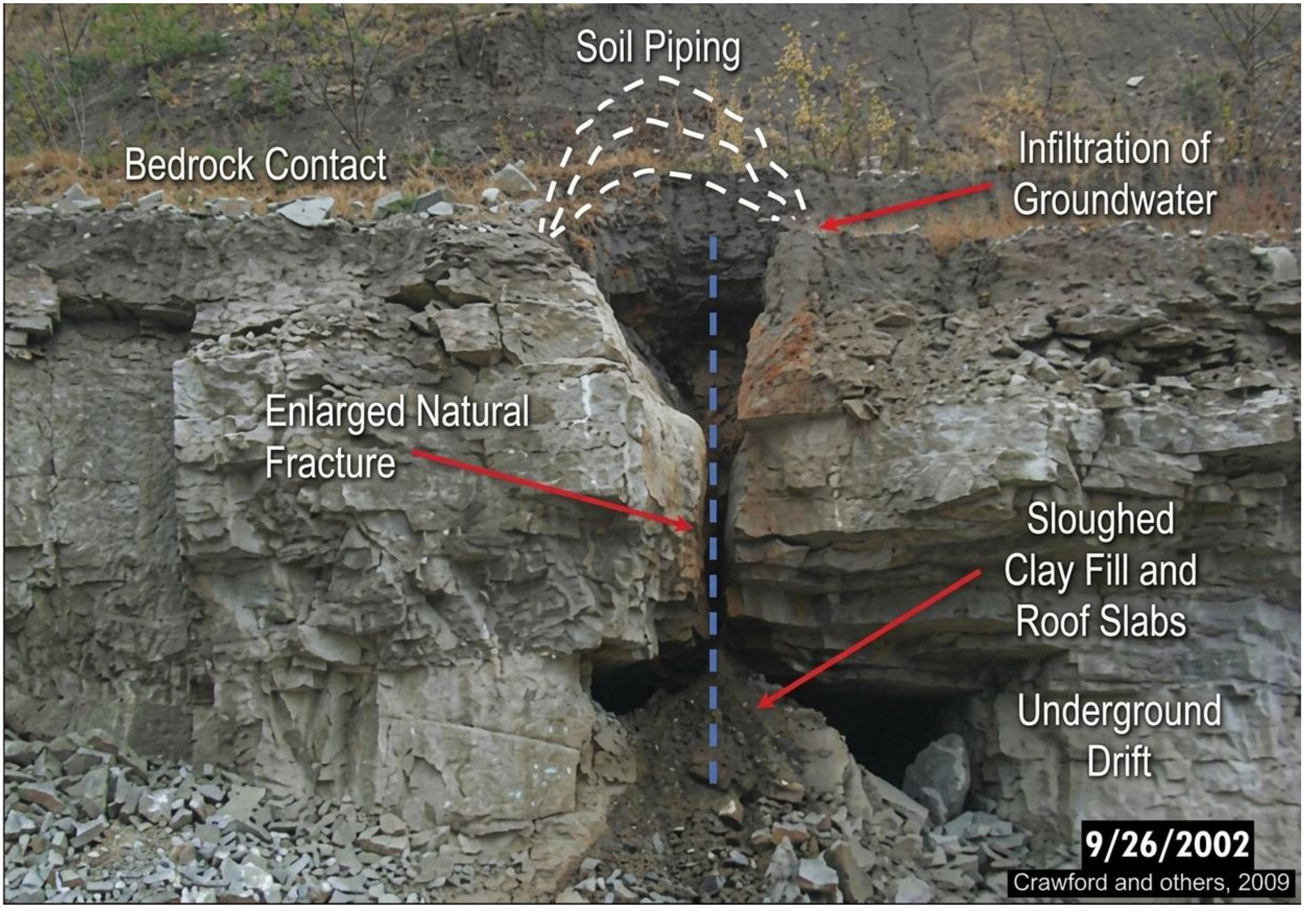


A solution pipe in Virginia, USA

Source: Lace, M.J., Anderson, R.R., Kambesis, P.N. (2021). Iowa Caves and Karst. In: Brick, G.A., Alexander Jr., E.C. (eds) Caves and Karst of the Upper Midwest, USA. Cave and Karst Systems of the World. Springer, Cham. https://doi.org/10.1007/978-3-030-54633-5_4

This photo shows dissolution causes piping in gypsum as viewed in the U.S. Gypsum Old Mill Meadows Quarry. Soil piping and downward sediment leakage along an enlarged bedrock fracture, illustrating subsurface soil loss into an underground void in a karst setting.

Exact location (-78.3003 E, 39.0217 N)



Karst vertical shaft (karren well, pit)

Karst vertical shafts, often called natural wells, pits, or abîmes, are deep, steep-sided, or vertical openings in karst landscapes that extend from the surface downwards, often connecting to underground stream systems. They are primary vertical drainages formed by the dissolution of carbonate rock (limestone or dolomite) along joints or fractures, acting as significant conduits for water to move from the surface into the underground aquifers. (https://en.wikipedia.org/wiki/Karst).

A karst vertical shaft in Wulong, Chongqing, SW China

Source: Vertical Cave Karst Landscape. (2020). In: Chen, A., Ng, Y., Zhang, E., Tian, M. (eds) Dictionary of Geotourism. Springer, Singapore. https://doi.org/10.1007/978-981-13-2538-0_2661

An entry pit in Cave Canem, Iowa, USA

Source: Lace, M.J., Anderson, R.R., Kambesis, P.N. (2021). Iowa Caves and Karst. In: Brick, G.A., Alexander Jr., E.C. (eds) Caves and Karst of the Upper Midwest, USA. Cave and Karst Systems of the World. Springer, Cham. https://doi.org/10.1007/978-3-030-54633-5_4

Sinkhole (doline, ponor, shakehole, swallow hole, swallet, cenote, Tiankeng)

A sinkhole is a depression or hole in the ground caused by some form of collapse of the surface layer. The term is sometimes used to refer to doline, enclosed depressions that are also known as shakeholes, and to openings where surface water enters into underground passages known as ponor, swallow hole or swallet. A cenote is a type of sinkhole that exposes groundwater underneath. Sink and stream sinks are more general terms for sites that drain surface water, possibly by infiltration into sediment or crumbled rock. Most sinkholes are caused by karst processes: the chemical dissolution of carbonate rocks, collapse, or suffosion processes. Sinkholes are usually circular and vary in size from tens to hundreds of meters both in diameter and depth, and vary in form from soil-lined bowls to bedrock-edged chasms. Sinkholes may form gradually or suddenly, and are found worldwide.

Source: https://en.wikipedia.org/wiki/Sinkhole

A sinkhole near Trieste, NE Italy

by **Giuliana Rossi** on 14 March 2021 (distributed via imaggeo.egu.eu), Ist Naz Ocean Geof Sper -OGS, Trieste, Italy

A sinkhole, in the Classic Karst (near Trieste, close to the border with Slovenia), in a rare walk in the Covid-19 lockdown period. The sense of attraction toward the bottom of the sinkhole is given by the grass, probably below the heavy snow until a few days before.

Exact location (13.8562 E, 45.6673 N)

Kızören Sinkhole in Central Anatolia, Turkey

by **Onur Cem Yoloğlu** on 22 March 2023 (distributed via imaggeo.egu.eu)

Kızören sinkhole is a large natural sinkhole, located in Konya Province in Central Anatolia, Turkey. The sinkhole is a funnel-shaped hole, approximately 228 meters in diameter and 171 meters deep. The sinkhole is a popular tourist attraction and has become a site for scientific research due to its unique geological features and historical site. Kızören Hanı, which is just next to Kızören sinkhole, is a historic caravanserai built in the 13th century during the Seljuk Empire period, which served as a stopping point for caravans travelling along the Silk Road.

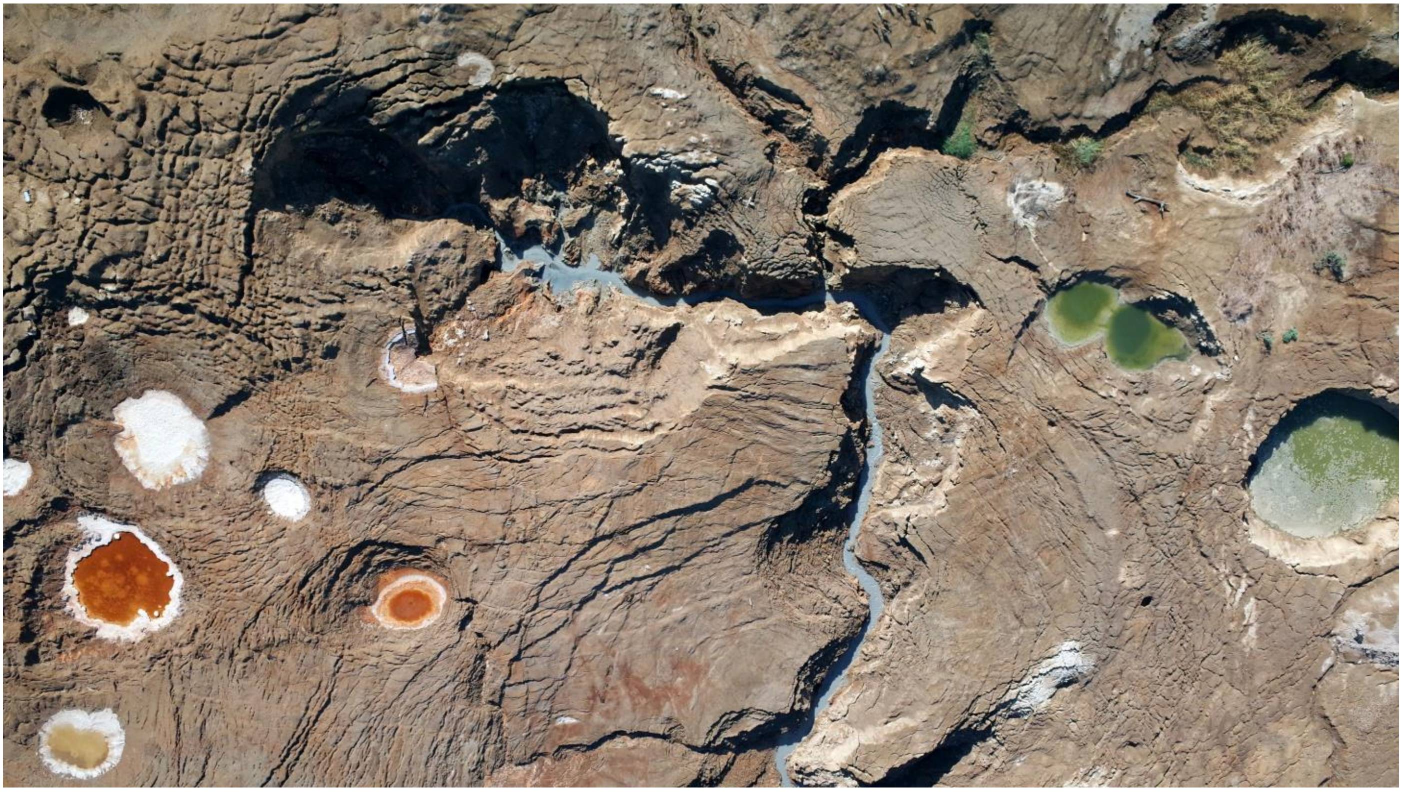
Exact location (33.1855 E, 38.1748 N)

Aerial view of sinkholes and depressions at the Dead Sea

by **Djamil Al-Halbouni** on 21 October 2014 (distributed via imaggeo.egu.eu), GEOMAR - Helmholtz Centre for Ocean Research, Kiel, Germany

Aerial photo of the former lake bottom of the Dead Sea, taken from 150 m altitude by a ground controlled Helium balloon. The regression of the water leaves an extensive mud-flat and a lot of salt. An increasing sinkhole development occurs in this area due to dissolution processes in the underground. On the image one can distinguish a fresh-water source, a recent canyon and ellipsoid sinkhole structures with varying colors due to the composition of the water. Reddish colors indicate iron oxides, greenish reflect under-saturated water and whitish are the margins of sinkholes formerly filled by salt-water. At the lower margin the balloon holding person and the cord can be seen. Aerial photo analysis enables the development of detailed, high-resolution topographic models and change detection, which helps to better understand background processes and formation of such natural sinkhole phenomena and to develop a hazard assessment for the region.

Exact location (35.5325 E, 31.3156 N)



Karst Window (Karst fenster)

A karst window, also known as a karst fenster, is a geomorphic feature found in karst landscapes where an underground river is visible from the surface within a sinkhole. In this feature, a spring emerges, then the discharge abruptly disappears into a sinkhole. The word fenster is German for 'window', as these features are windows into the karst landscape. The term is used to denote an unroofed portion of a cavern which reveals part of a subterranean river. A complex system of caves, known as karst topography, evolves from the effects of water erosion on carbonate rocks such as limestone, dolomite or gypsum. "A karst fenster is caused by a caving in of portions of the roof of a subterranean stream, thus making some of the underground stream visible from the surface". Theories in the creation of karst topography and karst fensters involve vadose water above the water table, and deep-circulating phreatic water (water in the zone of saturation) eroding away subsurface rock. Karst fensters may also form because of weathering from above.

Source: https://en.wikipedia.org/wiki/Karst_window

A karst window as a cave entrance in Tennessee, USA

by Dave Bunnell on 13 July 2014 (distributed via WIKIMEDIA COMMONS)

This is in the main entrance of Snail Shell Cave in Tennessee. It is a Karst Window entrance, where a collapse has occurred into the middle of a cave stream passage. Here you are in one arm of the passage looking into the other arm. The cave extends for long distances each way with flotation required in much of it.

Exact location (-86.5361 W, 35.7826 N)

Karst cave (solutional cave, solution cave)

A solutional cave, solution cave, or karst cave is usually formed in a soluble rock like limestone, of which calcium carbonate ($CaCO_3$) composes. Being the most common type of cave, it can also form in other rocks, including chalk, dolomite, marble, salt beds, and gypsum. Limestone dissolves under the action of rainwater and groundwater charged with H_2CO_3 (carbonic acid) and naturally occurring organic acids. The dissolution process produces a distinctive landform known as "karst", characterized by sinkholes and underground drainage. Solutional caves in this landform—topography are often called karst caves.

The largest and most abundant solutional caves are located in limestone. Limestone caves are often adorned with calcium carbonate formations produced through slow precipitation. These include flowstones, stalactites, stalagmites, helictites, soda straws, calcite rafts, and columns. These secondary mineral deposits in caves are called "speleothems".

Source: https://en.wikipedia.org/wiki/Solutional_cave

Huanglong Cave in Hunan, South China

by Brookqi in November 2008 (distributed via WIKIMEDIA COMMONS)

Huanglong Cave (simplified Chinese: 黄龙洞; pinyin: huánglóng dòng; lit. 'yellow dragon cave') is a karst cave located in Wulingyuan District, Zhangjiajie City, Hunan, People's Republic of China and a national 4A rated scenic area. Covering a total area of 48 ha (120 acres), the cave system extends to 15 km (9.3 mi) in length and is divided into dry and wet levels. There are four levels, thirteen chambers, three underground waterfalls, two underground rivers, three pools, ninety-six passages, as well as an underground lake. The largest chamber in the cave is 4,000 m^2 (43,000 sq ft) and the highest of the three waterfalls is 50 m (160 ft) high. The guided tour through the cave lasts about two hours and includes a boat ride down one of the underground rivers.

Source: https://en.wikipedia.org/wiki/Huanglong_Cave

Križna jama Cave in Slovenia

by **Peter Huber** on 30 October 20153 (distributed via imaggeo.egu.eu)

The Križna jama Cave on the east side of the periodic Cerknica Lake is primarily famous as a rich site of bones of the extinct cave bear, ursus speleus. The eight kilometer long cave is full of drip-stone decorations and also boasts 50 underground lakes separated by sinter barriers through which crystal clear water flows.

Exact location (14.4673 E, 45.7455 N)

Ice caves in high altitude karstic areas

by **Renato R. Colucci** on 30 December 2015 (distributed via imaggeo.egu.eu), Dept. of Earth System Sciences and Environmental Technology. CNR-ISMAR, Trieste, Italy

High altitude karstic environments often preserve permanent ice deposits within caves, representing the lesser-known portion of the cryosphere. Despite being not so widespread and easily reachable as mountain glaciers and ice caps, ice-caves preserve several information about past environmental changes and paleoclimatic evolution. Since their main characteristics is to have ground-ice older than 2 years, many authors are prone to consider ice-caves as sporadic permafrost phenomena. Here, from the "Vasto ice-cave" looking at th enetrance in the Canin-Kanin massif (2587 m a.s.l.) in the Julian Alps in the exceptional December 2015 with extremely dry conditions. Almost no snow on the ground in one of the most snowy areas of the Alps having mean annual precipitation higher than 3300 mm.

Exact location (13.4517 E, 46.3701 N)

Karst spring

A karst spring or karstic spring is a spring (exsurgence, outflow of groundwater) that is part of a karst hydrological system. Because of their often conical or inverted bowl shape, karst springs are also known in German-speaking lands as a Topf ("pot") which is reflected in names such as Aachtopf (the source of the Radolfzeller Aach) or Blautopf (the source of the Blau river in Blaubeuren). Karst springs often have a very high yield or discharge rate, because they are often fed by underground drainage from a large catchment basin. Because the springs are usually the terminus of a cave drainage system at the place where a river cave reaches the Earth's surface, it is often possible to enter the caves from karst springs for exploration. Large karst springs are located in many parts of the world; the largest ones are believed to be in Papua New Guinea, with others located in Mediterranean countries such as Bosnia and Herzegovina, Croatia, Turkey, Slovenia, and Italy.

A main feature of karst springs is that water is rapidly transported by caverns, so that there is minimal filtering of the water and little separation of different sediments. Groundwater emerges at the spring within a few days from precipitation. Storms, snowmelt, and general seasonal changes in rainfall have a very noticeable and rapid effect on karst springs.

The properties of karst springs make them unsuitable for the supply of drinking water. Their uneven flow rate does not support a steady rate of consumption, especially in summer when there is lower discharge but higher demand. In addition, poor filtering and high hardness mean that the water quality is poor.

Source: https://en.wikipedia.org/wiki/Karst_spring

La Fosse Dionne spring in France

by Pline on 8 May 2012 (distributed via WIKIMEDIA COMMONS)

La Fosse Dionne is one of the largest karst springs in France, situated in the center of the town of Tonnerre (Burgundy) at the base of a limestone plateau. The town was created around the spring. In 1758 the spring pool was converted into a lavoir with a semi-circular enclosure and a hierarchy of water channels. It is fed by the rainwater on the surrounding hills as well by at least one subterranean river. The average flow rate is 311 litres per second, but in periods of flood (such as on 15 March 2001) it can reach 3000 litres per second. The average flow varies between 87 litres per second in August and 619 litres per second in January (https://en.wikipedia.org/wiki/Fosse_Dionne).

Exact location (3.9706 E, 47.8566 N)

Gorghe spring in Umbria region, Italy

by **Nicola Morgantini** on 10 January 2010 (distributed via imaggeo.egu.eu), ARPA - Umbria (Italy) - Regional Environmental Protection Agency, Perugia, Italy

Gorghe karst spring in Monte Cucco massif. Monte Cucco is characterised by the presence of a wide (>30km) and deep (-930 m) karst system, the Monte Cucco Cave. The Gorghe spring represent a temporary groundwater outflow of the karst system (Umbria- Central Apennines).

Exact location (12.7554 E, 43.3443 N)

Sinking stream (losing/disappearing/influent stream)

A **sinking stream**, **losing stream**, **disappearing stream**, **influent stream** or **sinking river** is a stream or river that loses water as it flows downstream. The water infiltrates into the ground recharging the local groundwater, because the water table is below the bottom of the stream channel. This is the opposite of a more common **gaining stream** (or **effluent stream**), which increases in water volume farther downstream as it gains water from the local aquifer. Losing streams are common in arid areas due to the climate, which results in huge amounts of water evaporating from the river generally towards the mouth. Losing streams are also common in regions of karst topography where the streamwater may be completely captured by a cavern system, becoming a subterranean river. For example, the Danube River disappears in the Danube Sinkhole between Immendingen and Möhringen in an area of karst.

Source: https://en.wikipedia.org/wiki/Losing_stream

A sinking stream in the Liuchong River in Guizhou, SW China

The most significant feature depicted in Fig. 2 is the presence of three under-mountain passages (sinking streams) that the Liuchong River traverses within the reservoir domain. These sinking streams are characterized by irregular closed cross-sections formed through the dissolution of soluble rocks, creating underground flow passages and complex hydraulic conditions.

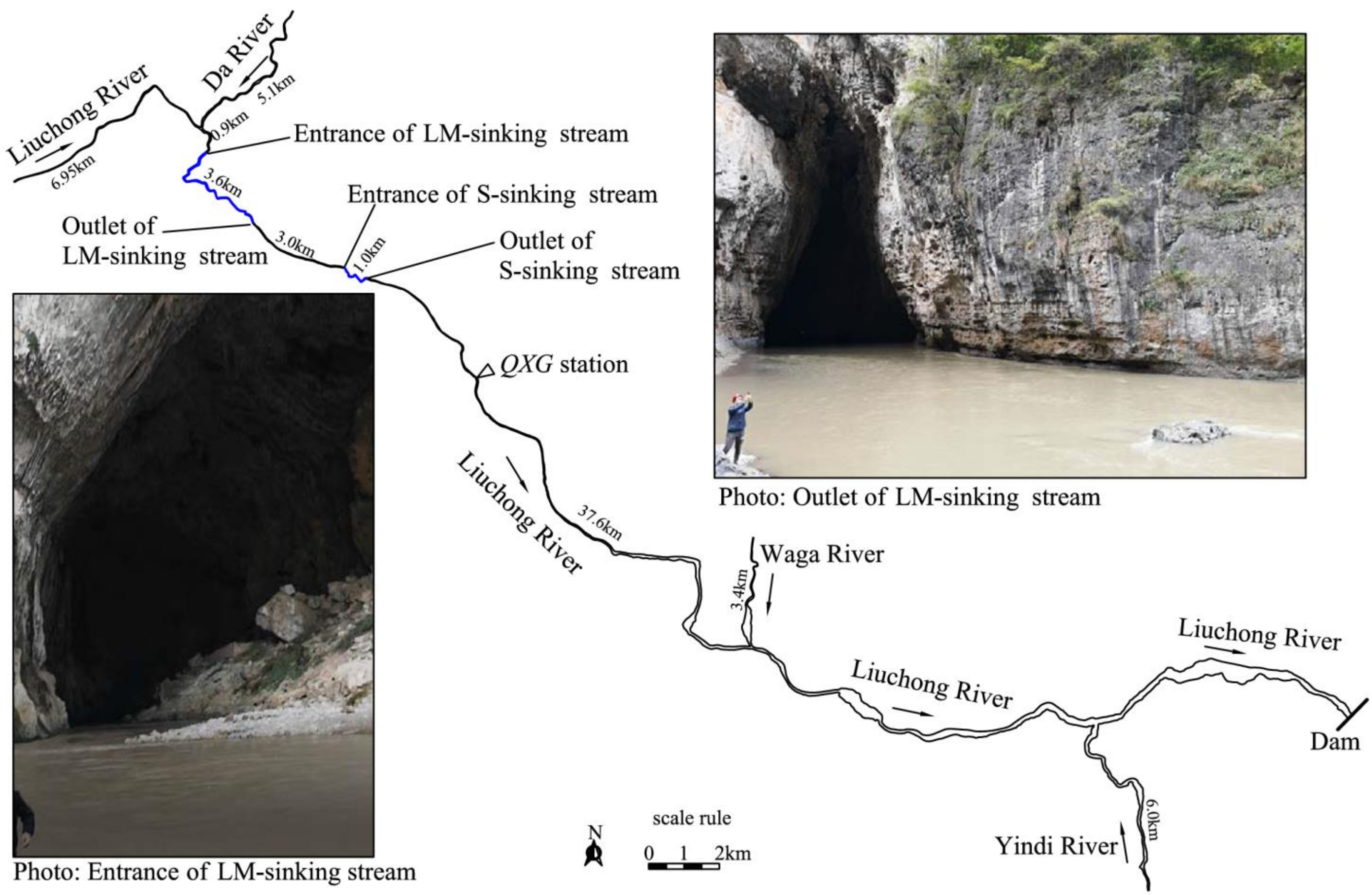


Fig. 2. Study area: the karst river with sinking streams, the dendritic river networks of the Jiayan Reservior.

Source: Hu, D., Li, S., Jin, Z., Lu, S., & Zhong, D. (2021). Sediment transport and riverbed evolution of sinking streams in a dammed karst river. Journal of Hydrology, 596, 125714. (Our research group)

The sinking Risle River in Normandy, Northern France

by Stanzilla on 31 July 2012 (distributed via WIKIMEDIA COMMONS)

On July 30 2012, the Risle disappears into a ponor between Ajou and La Houssaye (Eure, France). It runs underground for 12 kilometres. The river was here 7m wide before it fell into this ponor, on the right side of this picture.

Exact location (0.7889 E, 48.9866 N)

Subterranean river

A subterranean river (also known as an underground river) is a river or watercourse that runs wholly or partly beneath the ground, one where the riverbed does not represent the surface of the Earth. It is distinct from an aquifer, which may flow like a river but is contained within a permeable layer of rock or other unconsolidated materials. A river flowing below ground level in an open gorge is not classed as subterranean. Some natural rivers may be entirely subterranean, collecting in and flowing through cave systems. In karst topography, rivers that originate above ground can disappear into sinkholes, continuing underground until they reappear on the surface downstream, possibly having merged with other subterranean rivers. The longest subterranean river in the world is the Sistema Sac Actun cave system in Mexico.

Source: https://en.wikipedia.org/wiki/Subterranean_river

The Tongtian Underground River in Guangxi, SW China

by unknown photographer on 10 April 2026 via https://us.trip.com/moments/detail/pingguo-3062-144139696/

The Tongtian River (Chinese: 通天河) in Pingguo County, Baise, Guangxi, known as "Asia's No.1 Underground River", is a stunning, natural, 3 km-long subterranean river with navigable boat tours. This is a secret realm beneath the earth. Boarding a boat, you'll experience a geological feast spanning billions of years. The waterway narrows and widens intermittently, with stalactite clusters gradually emerging in the interplay of light and shadow, creating a dreamlike scene. The cave maintains a constant temperature of about 18°C year-round, making it an ideal summer retreat.

Underground lake

An underground lake or subterranean lake is a lake underneath the surface of the Earth. Most naturally occurring underground lakes are found in areas of karst topography, where limestone or other soluble rock has been weathered away, leaving a cave where water can flow and accumulate. Natural underground lakes are an uncommon hydrogeological feature. More often, groundwater gathers in formations such as aquifers or springs. The largest underground lake in the world is in Dragon's Breath Cave in Namibia, with an area of almost 2 hectares (5 acres); the second largest is The Lost Sea, located inside Craighead Caverns in Tennessee, United States, with an area of 1.8 hectares (4.4 acres). An underground lake is any body of water that is similar in size to a surface lake and exists mostly or entirely underground; though, a precise scientific definition of what may be considered a "lake" is not yet well-established. Underground lakes could be classified as either "lakes" or "ponds", depending on characteristics of size, such as exposed surface area and/or depth.

Source: https://en.wikipedia.org/wiki/Underground_lake

Neuron underground lake, SE Albania

by Marek Audy on 13 February 2025 (distributed via WIKIMEDIA COMMONS)

This photo shows the southern quarter of the gigantic thermal lake Neuron on the bottom of the Atmos Cave.

Lake Neuron (Albanian: Liqeni i Neuronit) is an underground thermal lake near Leskovik in Albania. Discovered by scientists in 2025, it is the world's largest known underground thermal lake with a volume of 8335 m³ and its dimensions 138 m×42 m, located 127 metres (417 ft) underground. Water in the Neuron Lake has a temperature of 26 °C. The cave's formation is unusual, as the lake's mineral-rich water contains hydrogen sulfide, which oxidizes upon contact with air, producing sulfuric acid that continuously transforms limestone into soft gypsum.

Source: https://en.wikipedia.org/wiki/Lake_Neuron

Exact location (7.4258 E, 46.2569 N)