All about Caves

Caves are natural cavities in rock. Several types of cave are found in New Zealand; sea caves, lava caves and solution caves.

Sea Caves

Sea caves are common in rocks along New Zealand's coasts. Waves repeatedly pounding the rock forces water into tiny cracks. The cracks gradually enlarge. Although sea caves can be of impressive size, they are rarely very long.

Lava Caves

Lava caves are found in cooled basaltic lava flows. Auckland is built on a field of basaltic volcanoes and has a number of lava caves. Some can be seen on Rangitoto Island, and the largest is the Wiri Lava Caves in South Auckland.

Lava caves begin as open lava canyons, through which lava moves from the vent of the volcano to the advancing toe of the lava flow. Although the lava may be as hot as 1200°C, the surface of the flow cools rapidly. A crust forms over the flow, crating a lava tube. If the lava drains out of the tube at the end of the eruption, a lava cave is left behind. Entrances, known as skylights, are created by the partial collapse of the cave roof.

Solution Caves

In New Zealand solution caves are formed in limestone (such as at Waitomo Caves) and in marble (found in the mountains of the Nelson region). The calcium carbonate ($CaCO_3$) that these rocks are composed of readily dissolves in acid, allowing solution caves to form. Carbonic acid (H_2CO_3) is produced naturally when carbon dioxide from the atmosphere is dissolved in rainwater.

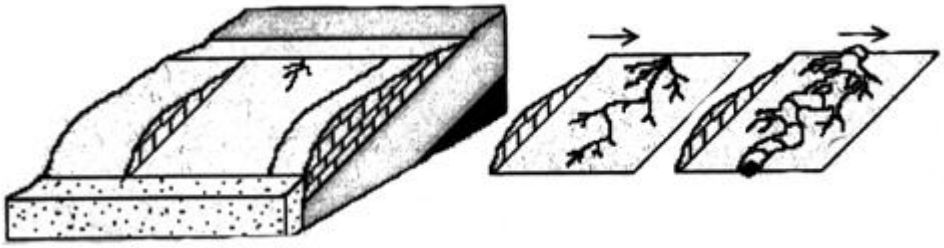
$$\mathbf{H_2O + CO_2 \Leftrightarrow H_2CO_3}$$

Although this acidic water will dissolve calcium carbonate, it is so weak that it is still fine to drink. When solid calcium carbonate comes into contact with carbonic acid, it is dissolved, forming calcium (Ca_2^+) and bicarbonate (HCO_3^-) ions in solution.

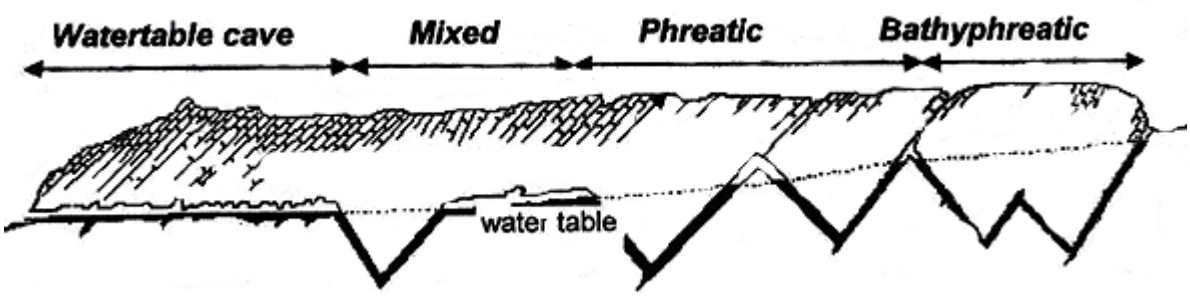
$$\mathbf{CaCO_3 + H_2CO_3 \Leftrightarrow Ca_2^+ + 2HCO_3^-}$$

Soils have much higher concentrations of CO_2 than the atmosphere. They accumulate CO_2 that is released by plant roots, bacteria and fungi. Water percolating through soils absorbs additional CO_2 and becomes more acidic than rainwater. However this water quickly becomes saturated with $CaCO_3$ dissolved from the soil and fragments of the limestone below. This water is not significant in the formation of cave passages in limestone, but is very significant in the reverse process, the deposition of speleothems. Cave passages are formed by less acidic, but unsaturated water running off the land during storms, or from streams which drain non-carbonate rocks flowing onto the limestone.

Caves begin as a tiny network of water filled tubes which slowly extend along the **fissures** (such as bedding planes, joints and faults) in limestone from an input point (i.e. a stream running onto the limestone) to an output point (i.e. the edge of the limestone in the valley). These tubes are called **proto-caves** and grow as the limestone is dissolved away. The path the tubes will take is a balance between the shortest and steepest route, and the path of least resistance. As water cannot pass through limestone except along fissures in the rock, the path of least resistance is determined by the number and openness of these fissures. In rock that has a high number of open fissures the pattern of proto-caves will be straighter and less branched. One tube grows at the expense of the others and eventually reaches the output, forming a ***cave conduit***. The water now flows along the cave conduit and may eventually enlarge it into a cave of enterable dimensions. The diagram below shows a proto-cave extending down a single bedding plane and enlarging into a cave.



When water goes underground at several points, more complex caves occur. The type of cave formed is dependent on the number of fissures present and their openness. This is shown in the diagram below in which the number of fissures decreases from right to left.

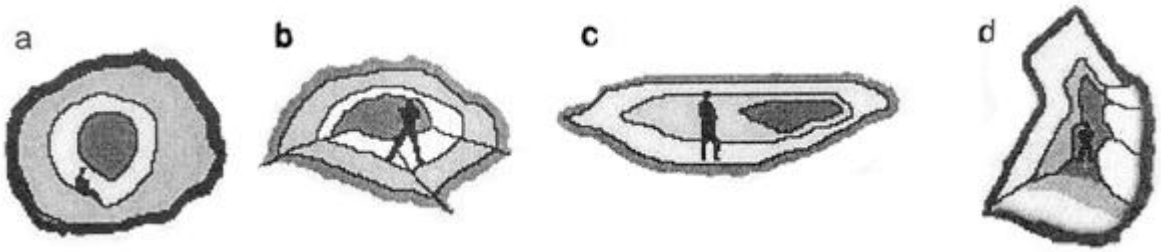


Where there are few fissures, ***bathyphreatic*** caves are formed. These caves make a single pass under the ***water table*** (the level below which the rock is saturated with water). As the number of fissures increase, ***multiple loop phreatic*** caves form under the water table. The water table eventually falls to the tops of these loops, which become air filled. Where the number of fissures is very high, direct, low gradient routes form, known as ***water table caves.*** When these passages become large enough, the water table is lowered into them, forming ***canal*** passages. Most caves are combinations of the different types.

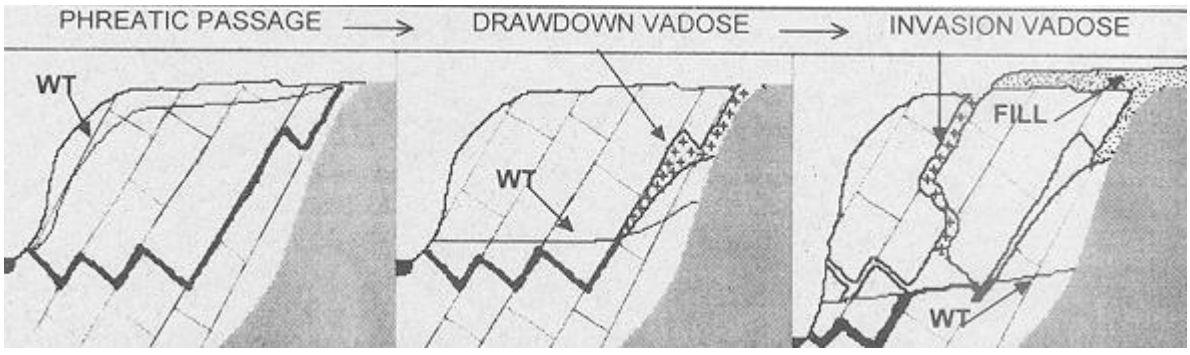
Multiple level caves form where a new output has been created, for instance by a river cutting down into its valley. The new output may be directly below the old spring, or it may also move sideways. The cave stream may simply cut down into the floor

creating a drawdown vadose canyon, or a whole new system of phreatic passages may form in the same manner as the original cave.

Phreatic passages are created under the water table and are completely filled with water during their formation. When they first form they have a circular cross-section of they may be elongated parallel to the fissure they form along if it is relatively open. As the passage develops the entire perimeter is eroded. The diagram below shows some phreatic passage shapes. Where the geology is uniform or the water flow is very fast, circular cross-sections develop (a). If the passage is being eroded slowly and the rock is uniform, the original shape of the fissure can control the shape of the passage (b, c,). If the rock is not uniform, its properties may change between beds, and the passage cross-section can become very irregular (d).



Vadose passages are partially air filled and form after the water table (WT) has been lowered. ***Drawdown vadose*** passages are guided by the earlier phreatic passages, which are often visible in the roof (e). ***Invasion vadose*** passages are created by new streams invading limestone in which the water table has already been lowered by a previous phase of cave development. They tend to be steeper than drawdown vadose passages, often being systems of vertical shafts. Waterfalls produce circular shafts which are usually modified by spray attacking weaknesses in the walls. Parallel sided shafts form where broken rock is removed from faults. ***Domepits*** are fluted shafts with a symmetric dome at the top. They form where slower moving water flows as a film down the walls of a fissure.



As only the bottom and sides of the passage are eroded, vadose passages have the form of trenches or canyons (e, g, h). The size of vadose caves is a product of the size of their streams and the duration of the erosion. Large chambers can form when streams undercut the walls and remove the resulting fallen rocks (f). The deepest vadose caves are found in mountainous areas.

Caring for Caves

Many caves in New Zealand are used for tourism and recreation. Caves and their formations take many thousands of years to form. The fragile cave environment is easily damaged and changed as soon as it is entered by people. People cause changes to the atmosphere, the animal and plant life, the water flow, the speleothems and the cave itself. Obvious impacts in wild caves are broken speleothems, litter, and mud smeared on walls and speleothems. Less obvious is the compaction of the floor sediments which affect the caves hydrology and fauna. Even organic mud moved through a cave by cavers can affect the cave ecosystem. In tourist caves body heat from large numbers of people can raise the air temperature causing the speleothems to dry out; their breathing can alter the caves CO_2 balance causing corrosion of speleothems, and lint and flakes of skin accumulate as dust. Many tourist caves have been altered to allow access.

The best way to preserve our caves is for all those that use them, from tourist operators to school groups, to learn about caves and how people affect them. Caves are fragile places and must be treated with care and respect. Take nothing but your memories, break nothing but the silence, and leave nothing but footprints (and only if you can't help it).