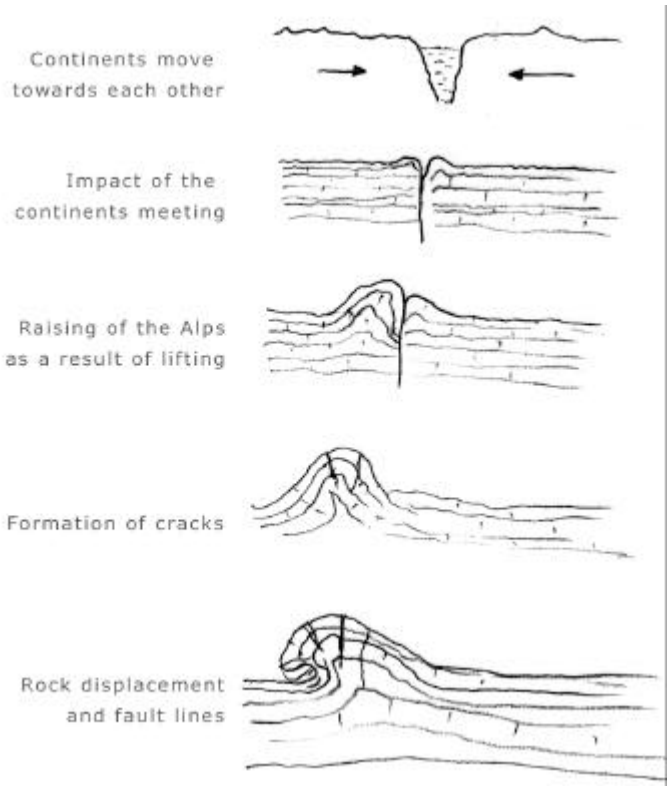
■ EISRIESENWELT

Scientific Background

1. How were the Eisriesenwelt caves formed

The majority of caves in the alpine region are to be found in the limestone mountains, unlike the caves which are formed by lifting (crevice formation), volcanic lava streams or pure water erosion (coastal caves).
In order for caves such as the Eisriesenwelt to be formed, the following conditions must be prevalent:

1.1. Lifting:



During a process of lifting the Alps were formed by rock masses arching up and the resultant tectonic cracks caused the formation of hollow areas in the mountains. Consequently outside influences, especially water, were able to play their part in the formation of the subterranean passages.

Fig. 1 Raising of the Alps

1.2. Composition of the rock:

The composition of the rock plays an important part in the formation of the caves in the alpine region. Extensive cave systems tend to be located mainly in the limestome Alps. Limestone is water-soluble, especially when it comes into contact with rain water which has been enriched with organic material. Consequently the limestone breaks down and dissolves and hollow areas are formed underground. A few million years ago the climate in this region was sub-tropical and the level of solubility was hence higher than it is now.

Fig 2. Formation of arid karst areas , corrosion

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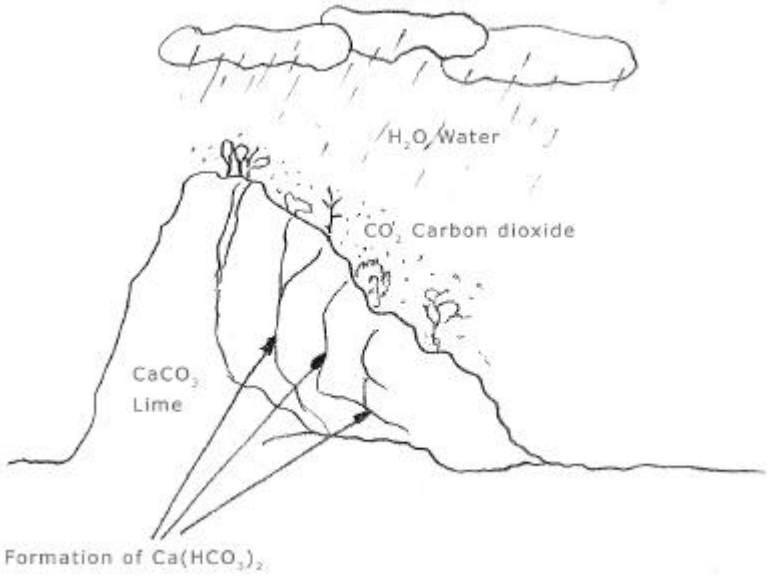


Corrosion is the chemical dissolving of rock (Lime $CaCO_3$) by carbon dioxide (CO_2) und water (H_2O). Pure water has less H+ ions and would not cause lime to dissolve. The introduction of CO_2 from the air and vegetation causes the formation of an aggressive acid :

$CO_2 + H_2O = H_2CO_3$ (carbonic acid).

When this acid permeates the cracks in the limestone it dissolves:

$CaCO_3 + H_2O + CO_2 = Ca(HCO_3)_2$ (=Calcium bicarbonate)

As a result of the limestone dissolving the cracks become wider and the ever-increasing crevices allow greater volumes of water to pass through, which in turn causes greater erosion.

1.3. Water:

The influence of water is visible as erosion. Hollow areas were already present in the rock after the lifting process had created the mountains and in time these subterranean hollow areas became larger and provided channels for rainwater to pass through. Hence the hollow areas which had been present from the early stages were extended mechanically by means of erosion, a process which can be clearly proven in nearly all caves in the alpine region.

The mechanical erosion of rock is further accentuated by the fact that the more water which passes through, the greater the speed with which it flows. This in turn leads to an increase in the amount of material which is washed away. This results in the formation of gorges, shafts and canyons. Es entstehen dadurch Schluchten, Schächte und Canyons. The so-called Kolke are clearly the result of erosion.

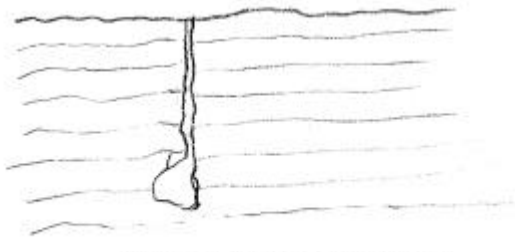


Fig. 3 Erosion

1.4. Incasion:

As a result of this permanent increasing in size over thousands of years, the caves were also subject to the roofs caving in. This process continues until a level of static stability had been reached.

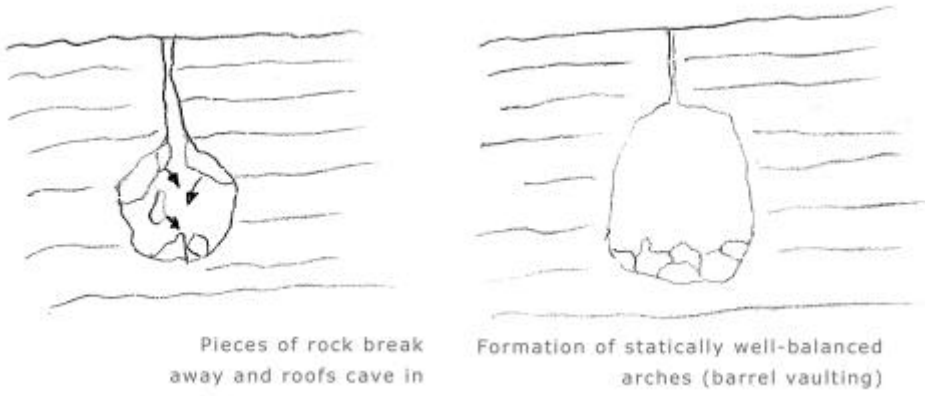


Fig. 4 Incasion

The mechanical erosion of the mountains causes static instabilioty in th erock. Consequently underground hollows and caves are naturally prone to the roofs caving in.

Hence the caves are the result of various factors such as lifting (crevice formation), water-solubility (corrosion) and water erosion. The caves as we see them today are a result of a combination of these factors over a period of thousands or millions of years.

2. Why does ice form in caves?

On the planet earth there is an enormous amount of caves (probably well over one million) but only very few of these are ice caves. A cave is only designated an ice cave if it contains ice formations which remain all the year round.
The Eisriesenwelt is a typical example of dynamic ice caves.

2.1. Different types of ice caves

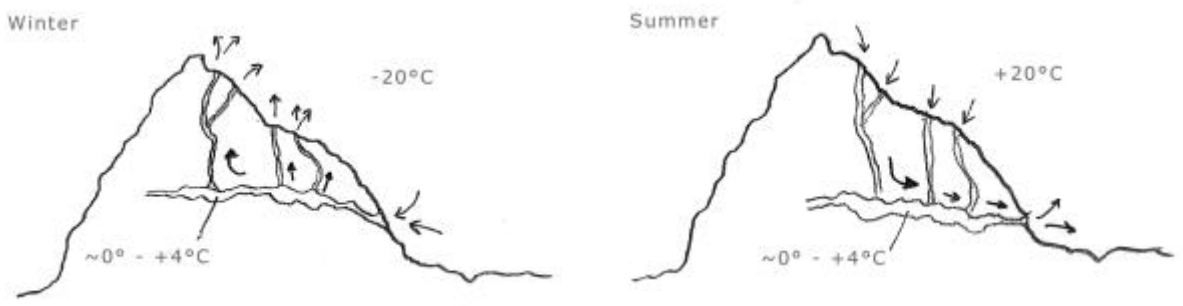
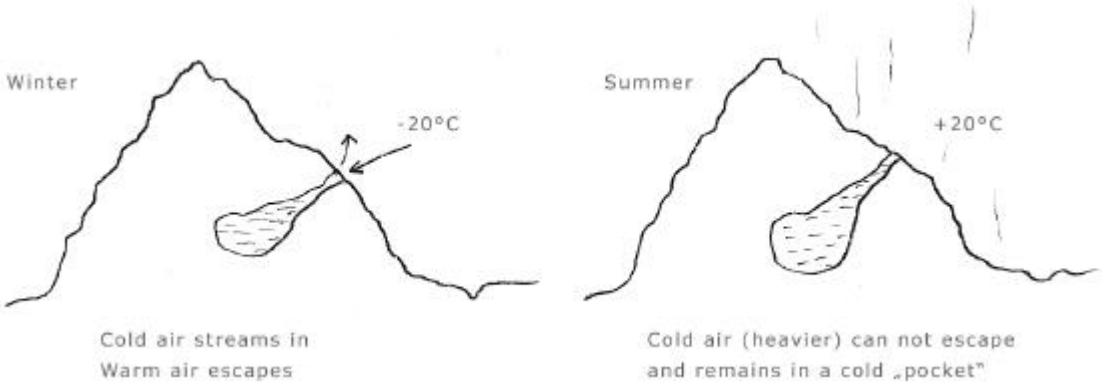


Fig. 5 Dynamic or cyclical ice caves

Fig. 6 Static ice caves



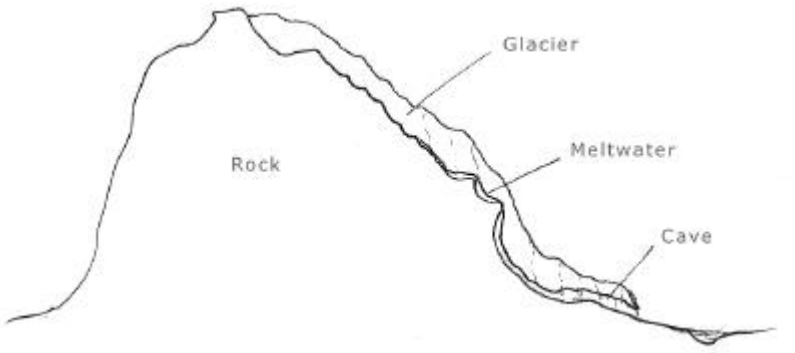
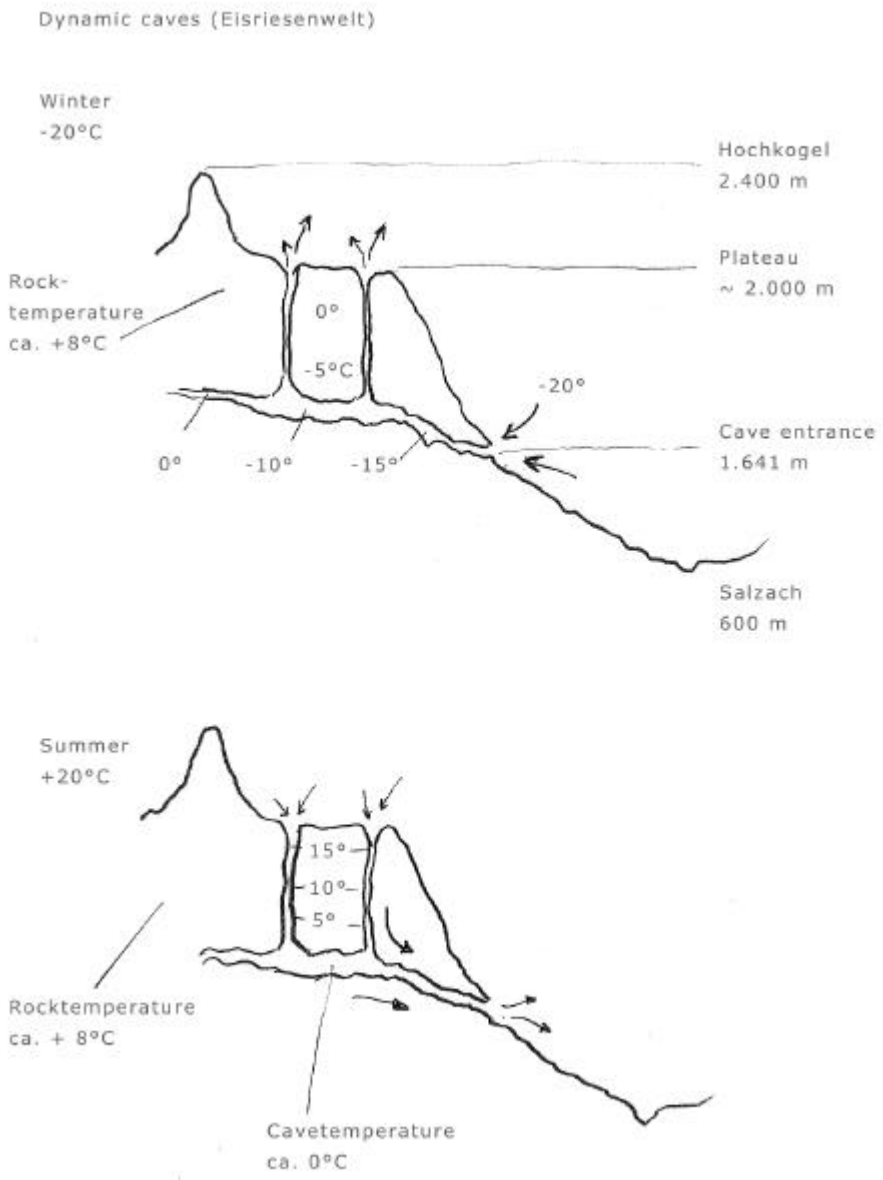


Fig. 7 Glacier caves

2.2. Dynamic or cyclical caves

The basic principle of a dynamic cave is the chimney effect. The requirement for this is that the caves have a system of hollow areas whereby one entrance should be at a relatively low altitude and one exit located at a much higher altitude. In winter, when the outside temperatures are very low, a physical process takes place whereby the relatively warm temperature inside the rock causes a draft which rises up through the cave system. This in turn leads to a radical cooling of the rock surface as a result of the cold air streaming in from outside. This is especially noticeable around the lower entrance. During the summer months the outside temperature is much higher than inside and the opposite effect is the case. The relatively cold air (normal rock temperature is approx. 8 degrees centigrade) causes a downward draft, so that the fairly warm air outside is sucked in to the higher openings. However, on its way down this air has cooled so much that it can no longer warm up the hollow areas in the lower sections. Hence there is a fairly constant temperature around freezing point in the area around the lower entrance, and as a result any water seeping in freezes over (especially meltwater in spring) and ice formations build up.

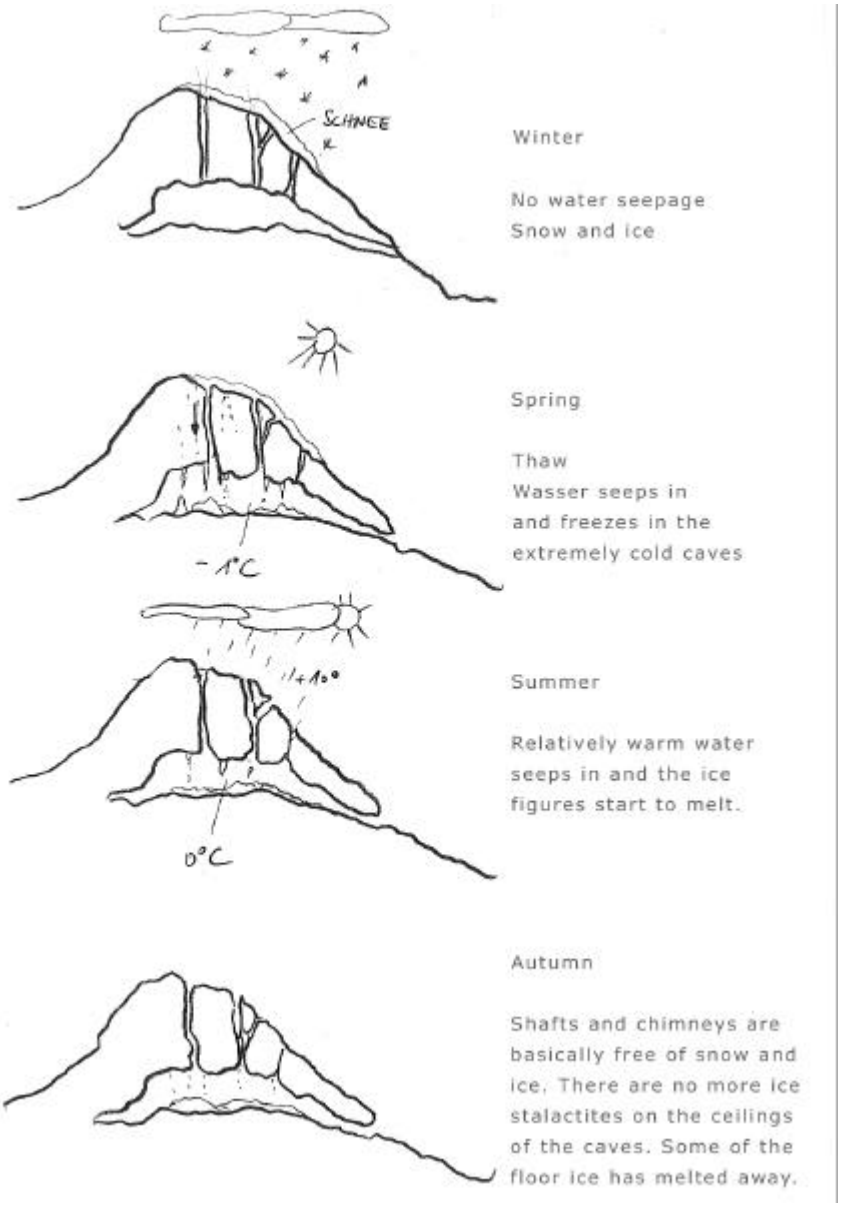
Fig. 8 Chimney Effect / Weathering / Temperature



2.3. Climatic requirements

For ice caves to form there must be sufficient quantities of water available over the right period of time. This means that both temperature and weather must correspond to a strict pattern. In winter the climate must be such that the mountains are sufficiently covered in snow, and in summer the temperature should be high enough to cause the snow to melt but without significant warming of the air which streams into the caves.

Fig. 9 Winter-Spring-Summer-Autumn



2.4. Complex balance of energy

From a scientific point of view the balance of energy in a dynamic cave has still not been completely explained. An exact calculation of the causes of ice formation in caves would necessitate extensive scientific research which has so far not been undertaken. This detailed research would in all probability explain the complex system surrounding the balance of energy.

Energy (measured in calories or joules) is needed, or harnessed, to warm the air. This also works the other way round so that when air is cooled, warmth is released. What is now required is scientific testing of the climatic conditions in caves to determine the total amounts of energy necessary to melt ice or cause it to form. This might also lead us to an estimate of the expected effect of overall global warming. Tests so far have indicated that the warmth produced by visitors to the caves does not significantly alter the total amount of energy.

Other factors which should be considered are the volume and temperature of the water seeping in, the release of energy as a result of the diffusion of ice (evaporation) , air pressure and the nozzle effect.

All over the world only a few caves are the subject of a variety of ongoing tests which can be spread over decades. In the *Eisriesenwelt* tests are at present being carried out to monitor the temperature and wind; so far, however, we do not have sufficient data to put forward a complete theory explaining the specific conditions which can be found in subterranean cave systems.

3. How old is the ice in the Eisriesenwelt?

One question which has always preoccupied people is the age of the ice formations in the ice caves which are to be found in the alpine region. Data from geological and scientific tests on deposits taken from the ice show that the oldest layers of ice in the ice caves of the alpine region (especially the Eisriesenwelt) are approximately 1,000 years old. Bearing in mind that the history of these caves stretches back over 50 to 100 million years, it becomes clear that these ice formations are an extremely recent phenomenon.