

The Conturines Cave in the Dolomites and the Alpine climate of the last 70,000 years. Reconstruction of the climate based on fossilized vertebrate remains from caves.

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Published | 23.10.2025

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Published by

Museum Burg Golling
Markt 1
5440 Golling an der Salzach
Austria
office@museumgolling.at
www.museumgolling.at

Abstract

The Conturines Cave (Ander dles Conturines) in the Val Badia Dolomites (Italy) is the highest bear cave in the world. Due to its wealth of fossil remains of cave bears and cave lions, it is the most important climatic witness to the so-called »Alpine cave bear period«, which largely, but not completely, corresponds to the geological term »Middle Würm«. Cave bears were herbivores and fed mainly on leaves and herbs, such as those found in mixed deciduous forests. The altitude of the Conturines Cave (2,775 m) suggests that the upper limit of the mixed forest, also known as the »beech limit«, was many hundreds of meters higher during the time of the cave bears than it is today. The findings of fossil bones of subtropical-tropical animals such as hyenas, lions and leopards in alpine caves confirm this statement, as do over 80 ¹⁴C age determinations of cave bears from alpine caves. However, the oxygen isotope curve from Greenland's ice cores does not correspond with these results.

Kurzfassung

Die Conturineshöhle (Ander dles Conturines) in den Gadertaler Dolomiten (Italien) ist die höchst gelegenen Bärenhöhle der Welt. Aufgrund ihres Reichtums an fossilen Überresten von Höhlenbären und Höhlenlöwen stellt sie den wichtigsten klimatischen Zeugen für die sogenannte »Alpine Höhlenbärenzeit« dar, die weitgehend, jedoch nicht vollständig, mit dem geologischen Begriff »Mittelwürm« übereinstimmt. Höhlenbären waren Pflanzenfresser und ernährten sich hauptsächlich von Blättern und Kräutern, wie sie im Laubmischwald vorkommen. Die Höhenlage der Conturineshöhle (2.775 m) lässt darauf schließen, dass die Obergrenze des Mischwaldes, auch als »Buchengrenze« bezeichnet, während der Zeit der Höhlenbären viele Hundert Meter höher lag als in der Gegenwart. Die Funde von fossilen Knochen subtropisch-tropischer Tiere wie Hyänen, Löwen und Leoparden in alpinen Höhlen bestätigen diese Aussage ebenso wie über 80 ¹⁴C-Altersbestimmungen von Höhlenbären aus alpinen Höhlen. Die Sauerstoffisotopen-Kurve aus Grönlands Eisbohrkernen zeigt jedoch keine Übereinstimmungen mit diesen Ergebnissen.

1 | A sensational discovery

The discovery of the Conturines Cave in 1987 by the hotelier and mineral collector Willy Costamoling from Corvara was a milestone in climate research in the Alps. The cave is located on the eastern flank of Piz Conturines (3,064 m) in the municipality of Enneberg. Willy Costamoling not only found a cave with rich stalactite jewellery, but also numerous fossil skulls and bones of cave bears. The special feature of this cave is its geographical location: the cave entrance is situated at an altitude of 2,750 m in an area now devoid of vegetation, 300 m higher than the previous leader, the Drachenloch near Vättis (Switzerland) at an altitude of 2,427 m. This makes the Conturines Cave the highest bear cave not only in the Alps, but in the whole world. For scientists, the bear discovery in the Conturines Cave is not only a sensation, but also a basis for calculating the former climate in the Alps.

2 | Cave bears as climate witnesses

Cave bears were pure herbivores. This is evident from the shape of the lower jaw, the wear marks on the cheek and incisor teeth and the low levels of the carbon isotope ^{13}C . The wider surroundings of the cave would not provide sufficient food for any large herbivore today and that is what they were, the cave bears: pure herbivores that lived mainly on the leaves of deciduous trees and herbs. This is evident from the shape of the lower jaw, from the wear marks on the cheek and incisor teeth and from the low levels of the carbon isotope ^{13}C (RABEDER & FRISCHAUF, 2016). The vegetation on the eastern flank of the Conturines today belongs to the alpine altitudinal zone and consists of grasses, dwarf shrubs and cushion plants. This area can therefore be excluded as a food source for cave bears. However, the subalpine altitudinal zone between the tree line and mixed forest is also characterized by tree, shrub and dwarf shrub vegetation, which is not suitable for cave bears. Even in the high mountains, the cave bears fed mainly on the leaves of deciduous trees, as they grow today in sparse mountain forests below the beech line at 1,200 to 1,300 m above sea level. It can therefore be assumed that the beech line at the time of the cave bears was either close to the cave entrances or higher. This makes it possible to calculate how high the average temperatures in the vicinity of the caves were at that time compared to today.

3 | Hibernation as an adaptation to mountain life

Cave bears bridged the vegetation-free winter period by hibernating in caves for a long time. By lowering their body temperature and reducing all bodily functions, they used the energy stored in form of fat as sparingly as possible. This was the only way the bears could survive the winter months, when there was no food available.

4 | Data situation

The basis for the climate reconstruction of the Alpine cave bear period (65–25 ka = 65,000 to 25,000 years before present) is the large amount of absolute dating of cave bear bone samples from around 50 caves in the Alps. More than 200 age values and many »older than« values (> 50,000 years) are available (DÖPPES et al., 2011, 2018; PACHER & STUART, 2008) which are supplemented by 50 molecular »age estimates« and 25 uranium-thorium values. While the last two dating methods are less precise, they suggest the Alpine cave bear era started well before the 50,000-year ^{14}C dating limit (NAGEL et al., 2023).

5 | Historical revue

The first palaeontological excavations in high mountain caves were carried out in the Drachenloch (2,450 m) near Vättis, Switzerland and in the Schreiberwandhöhle (2,250 m) on the Dachstein, Upper Austria. Kurt Ehrenberg, the head of the Schreiberwand cave excavation, recognized the problem of

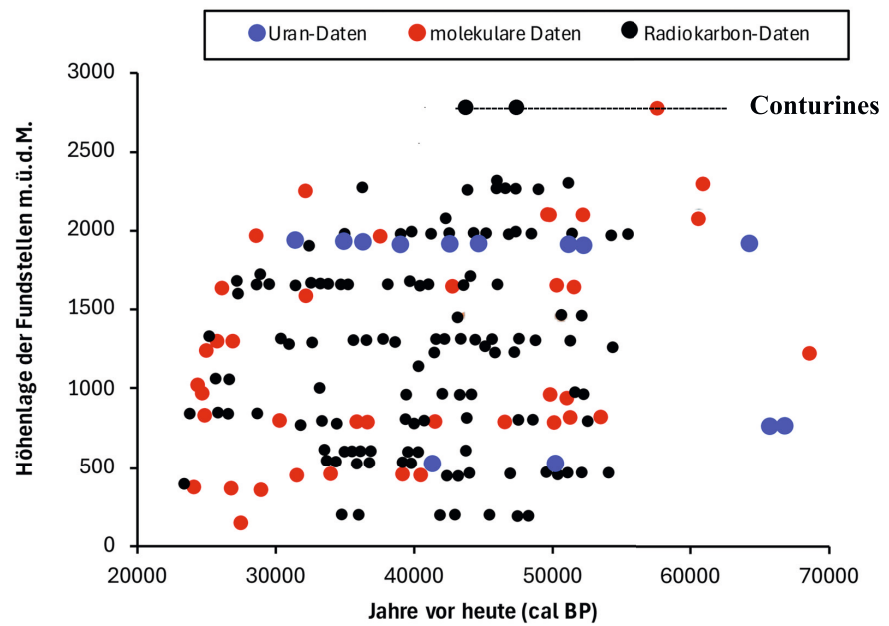


Fig. 1 | Absolute age values of cave bear bones from the Middle Würm of the Alps in relation to the altitude of the sites. The finds from the Conturines Cave are absolute extreme values (DÖPPES et al., 2019; HILLE & RABEDER, 1986; NAGEL et al., 2019).

feeding cave bears at this altitude as early as 1926 and wrote: »Selbst, wenn wir annehmen, daß damals in 2200 m Verhältnisse geherrscht hätten, wie wir sie heute im gleichen Gebiet etwa in 1800 m antreffen, wäre die Höhle noch immer erst knapp an der Baumgrenze gelegen gewesen. Auch dann hätte es in ihrer Umgebung noch keine üppige Vegetation reichliche Nahrung geboten« (»Even if we assume that conditions at 2,200 m would have prevailed at that time, as we find them today in the same area at about 1800 m, the cave would still only have been just at the tree line. Even then, there would not have been abundant food in the surrounding area«, EHRENBURG & SICKENBERG, 1929). As there was no possibility of absolute dating at the time of this excavation, this realisation went unnoticed. The opinion published by Othenio ABEL (1914) that the cave bears were pure herbivores also received little attention at the time. Modern research has not only confirmed this view but also clarified it.

5.1 | Palaeontological excavations in the Ramesch Bone Cave (1,960 m)

The palaeontological excavations in the Ramesch Bone Cave between 1979 and 1984 brought about the first decisive change in our knowledge of the Alpine paleoclimate. In accordance with prevailing theories around 1980, the excavators initially believed that the numerous bones found in this cave belonged to bears inhabiting the last major interglacial period, specifically the Riss-Würm Warm Period (= Eem: 130,000 to 115,000 years ago). They would therefore be too old for the radiocarbon method, because this method only allows values up to around 50 ka (= 50,000 years before today).

Researchers from the Institute for Radium Research and Nuclear Physics and the Institute for Palaeontology in Vienna collaborated to date bone remains from Ramesch Cave using the newly developed uranium series method (HILLE & RABEDER, 1986). The surprise was great when it was shown that the fossil-bearing sediment package from the Ramesch-Knochenhöhle (Ramesch Cave) provided absolute age data ranging from around 150,000 to 31,000 years before today. Samples were taken from the black clay at the bottom of the profile and dated, yielding values between 150,000- and 118,000-years BP, which suggests a chronological assignment to the Riss-Würm Warm Period.

Most of the profile falls within the »Middle Würm« period, dated between 64,000 and 31,000 BP. The Middle Würm is a period between around 65,000 and 30,000 years ago and until then was only considered an »interstadial« with temperatures that were significantly above the values of the subsequent glacial period (»Würm High Glacial«) but just as significantly below today's level. However, this is exactly what K. Ehrenberg had already recognized during the excavation in 1926 (see above): »under interstadial conditions, the cave environment [...] would not have offered abundant food« (EHRENBURG & SICKENBERG, 1929).

6 | Excavations in the Conturines Cave

Only one year after the publication of the »Ramesch Monograph« (HILLE & RABEDER, 1986) the Conturines Cave was discovered by the hotelier and mineral collector Willy Costamoling from Corvara. This cave contained a large amount of fossilized cave bear remains as well as lion jaw remains. The cave entrance lies at an altitude of 2,775 m above sea level, making it the highest cave bear and cave lion site in the world (RABEDER, 1991). Naturally, the question of the geological age of these fossils immediately took center stage. Initial attempts using the radiocarbon method failed because the collagen content (= protein compounds in fossilized bones) was too low. It was not until around ten years later that two ^{14}C dates of around 44,000 and 48,000 years ago were obtained, and it was only a few years ago that a molecular date of almost 58,000 significantly extended this time span. Due to its extreme altitude, the Conturines Cave became a new reference point for estimating alpine temperatures in the Middle Würm. Today, vegetation sufficient for cave bears would only exist about 1,500 m lower than the current cave environment, which is now free of vegetation. The estimated temperature difference between today and the Middle Würm Warm Period is almost +10 °C: $(1,500 \text{ m} \times 0.65/100 = 9.75 \text{ °C})$. The altitude-dependent temperature gradient in the Alps is 0.65 °C, which means that the average temperature decreases by around 0.65 °C per 100 m of altitude.

Paleontological excavations were carried out between 1988 and 2001. Due to the altitude and the long ascent, they were very arduous, strenuous and costly because the transport to and from the site was only possible with the help of helicopters. The yield of skulls and bones was remarkable: almost all of them came from a cave bear species that was described as *Ursus ladinicus* in 2004 (RABEDER et al., 2004) and formed the basis for intensive research to this day. New discovery of a cave lion tooth: Among the large number of individual bear teeth, an incisor of an adult cave lion was also discovered. Previously, the presence of the cave lion was proven by a fragment of the upper jaw, which came from a young individual (RABEDER, 1991).

7 | Research since 2018: Conturines bears as key witnesses of climate change

Due to the omnipresent climate debate, the research results on the cave bears of Conturines Cave have once again been placed at the center of Alpine climate history. Because of the large differences in the research results between the high Alps and the Greenland ice sheet, some Quaternary geologists have criticized the Conturines Cave data for the climate history of Europe.

On the one hand, attempts were made to make the cave bears of the Conturines much older and to »shift« them to a distant interglacial in order to adjust the cave bear age to the $^{18}\text{O}/^{16}\text{O}$ curve (SPÖTL et al., 2018): eleven analysed bone samples only yielded »older than ages« between > 46,400 and > 50,600 years. From this the obviously wrong conclusion was drawn that the cave bear remains do not date from the cave bear period (Middle Würm, 30,000–60,000 years ago) but from the last interglacial (130,000–115,000 years) and would therefore be three times older. However, a new ^{14}C date (43,600 years ago) and a genetic age (59,700 years) have now shown that the Conturines Cave was inhabited by cave bears at least between 60,000 and 44,000 years ago. In the highest bear caves in the Northern Alps (Schneiber-Cave, Schreiberwand-Cave, and Hennenkopf-Cave, Bärenfalle, Potentialschacht and Ramesch-Cave), the cave bear period is documented by numerous ^{14}C and DNA data from 60,800 to 30,000 years before present. The chronological position of the high alpine cave bears is therefore much better established than it was seven years ago.

Unfortunately, all data on high-altitude bear caves in relation to the climate of the recent past has been ignored. The motto »exaggerate and conceal« is a sad reality not only in the so-called »mainstream media« but also in governmental publications, e.g. from the Austrian Academy of Sciences and the Central Institute for Meteorology and Geodynamics (AUER et al., 2014).

A report (SPÖTL et al., 2011) on the dating of a stalagmite in the Höllloch cave system in Allgäu, Bavaria, is relevant to this topic. Thirteen calcite samples were measured using the U/Th method and yielded ages between 62,000 and 37,000 years old, which corresponds to a period entirely within

the »Alpine cave bear period«. The authors concluded that the climate at that time was much colder than it is today, contradicting the biology of alpine animals. However, the results of paleontological research based on fossilized vertebrate remains, which have been published numerous times, were completely ignored.

8 | Mountain formation and climate

Shortly after the discovery of the Conturines Cave, various geologists also discussed the possibility that the cave bears had originally lived at a much lower altitude and only recently reached the present altitude of almost 2,800 m due to the tectonic upward movement of the Alps (up to 5 mm per year). This hypothesis is contradicted by the orientation of the rich stalactite decoration, which dates from the time before the cave bears and corresponds to today's vertical direction (RABEDER, 1991) a tectonic uplift would have caused the stalactites to be inclined. The period between the geologically youngest cave bear remains in the Conturines Cave (around 40,000 years ago) would only amount to 200 m in altitude with an uplift of 5 mm per year, which would correspond to a warming of around 1.3 °C. The migration of subtropical mammals into the Alpine region cannot be explained by tectonics, but only by climate change.

9 | The oxygen isotope curve and the cave bears

The course of the climate in the Pleistocene was characterized by alternating warm and cold periods. This has been generally known for more than 130 years (PENCK & BRÜCKNER, 1909). Since the emergence of the political hypothesis of »man-made climate change«, the question of the climate of the recent geological past has taken on a different dimension of interest. This is because many proponents of this hypothesis are of the opinion that the climate in Europe, and thus also in the Alps, has not been as warm as it is today for around 125,000 years – since the end of the Riss/Würm Warm Period. This view can probably be explained by the course of the oxygen isotope curve, which has been determined several times from drill cores of the Greenland ice sheet (Fig. 1) and is usually used uncritically as a paleo-thermometer. In seawater, the ratio of the heavier but rarer oxygen isotope ^{18}O (only about 0.2%) to the lighter isotope ^{16}O (99.8%) is relatively increased by the accumulation of glacial ice at the poles and in the mountains, because the ^{18}O is »discriminated« in terms of quantity against the ^{16}O during cloud formation and during rain or snowfall. Cold periods with large accumulations of global ice are indicated by high $^{18}\text{O}/^{16}\text{O}$ values, warm periods by lower values. Climate fluctuations in the past can be reconstructed using drill cores from the sea floor and inland ice.

The extent of the temperature changes in the terrestrial area can only be deduced to a very limited extent from the amplitudes of the $^{18}\text{O}/^{16}\text{O}$ curve, as the course of the climate curve drastically shows. The temperature values resulting from the curve are mainly estimated from the $^{18}\text{O}/^{16}\text{O}$ ratio of the shells of marine microfossils (e.g. planktonic foraminifera). A direct transfer to terrestrial conditions is obviously not advisable because it leads to completely wrong results. This is impressively demonstrated by the comparisons between the values of the oxygen curve and the palaeontological data of late Pleistocene vertebrates from Alpine caves (Fig. 1, 3).

10 | Reconstructing the climate

How many degrees Celsius were the average temperatures in the cave bear era above today's? No one can tell us better than the bears of the Conturines cave: they lived from around 60,000 to at least 44,000 years ago in an environment that today consists only of rock, rubble and snow, but which was covered with deciduous trees back then. The beech-fir boundary at that time was about 1,400 m higher than today, the average summer temperatures were 9 to 10 °C higher than today (calculated from the altitude-temperature gradient of 0.65 °C/100 m). The amount of precipitation in the high mountains was sufficient for the growth of mixed deciduous forests, whereas in the lower regions of the Alpine foothills it was much lower, which even led to desertification (NAGEL et al., 2023).

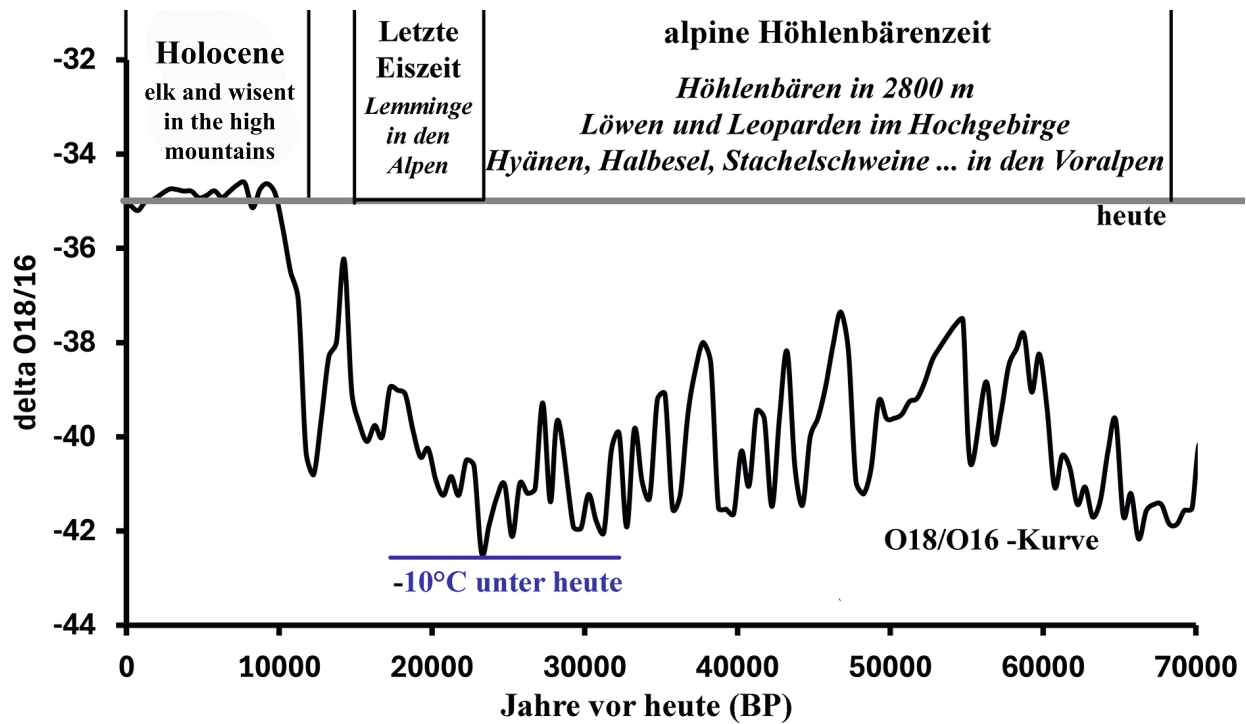


Fig. 2 | Section of the $^{18}\text{O}/^{16}\text{O}$ oxygen isotope curve from the Greenland ice sheet (North Greenland Ice Core Project NGRIP, 2004, compared with palaeontological data from fossil vertebrate remains from Alpine caves, according to (ANDERSON et al., 2004; AUER et al., 2014). The use of the ^{18}O oxygen curve leads to the conclusion that the climate in Europe was always colder than today between the end of the Eemian (= Riss-Würm) warm period 125 ka ago (= 125,000 years before today) and the beginning of the Holocene warm period (about 10,000 years ago). This statement is in stark contrast to the absolutely dated remains of cave bears, lions and leopards from high alpine bear dens and of subtropical species such as hyenas, half donkeys etc. from the foothills of the Alps.

However, there are similarities for the period of the high glacial (approx. 25,000 to 15,000 years before today). Following the isotope curve's lowest point around 30 ka, arctic-adapted animals like mountain and collared lemmings colonised the Alps. During this period, the climate in the foothills of the Alps must have been 10 °C colder than today's; this can be estimated from the climate under which the lemmings live today in Northern Europe and Northern Asia (annual mean temperature < 0 °C). This climate estimate is also confirmed by the dated finds of marmots in low-lying caves, e.g. in the Mehlwurm Cave (390 m) in the Vienna Basin (NAGEL et al., 2023).

For the subsequent warm phase, known as the »hamster period« (approx. 15,000 to 11,000 years ago), the occurrence of fossilized hamster remains in caves at different altitudes in the Alps still poses a puzzle. Today, hamsters live in forest steppes and in (human-influenced) steppes of the temperate zone with summer temperatures above 17 °C on average. At the edge of the Alps, their distribution area ends at an altitude of »below 350 m« with annual precipitation of less than 700 mm.

11 | Confirmation by subtropical immigrants, fossil hippos in Rhine valley gravels and the Milankovitch curve

11.1 | Subtropic immigrants

Confirmation for the high temperatures in the Middle Würm of the Alps comes from the dating of subtropical elements in alpine caves: Remains of cave hyenas, lions and leopards have so far been found in numerous alpine caves (DÖPPES & RABEDER, 1997; PACHER & STUART, 2008; PACHER & RABEDER, 2016, 2018). Radiocarbon dates show that the hyenas and their prey such as half donkeys and steppe bison lived in the Alps at least in the period between 41 ka and 50 ka and probably also 50,000 years ago. The cave hyenas hardly differ in bone structure and genetically from the spotted hyenas still living in Africa today, which were historically always restricted to tropical and subtropical dry areas, so it seems obvious that the fossil hyenas also lived in a climate in the Alps that was about 10 °C warmer and much drier than today's climate (LINDENBAUER et al., 2018; NAGEL et al., 2019).

11.2 | Fossil hippos

Further confirmation of the once high temperatures in Central Europe was recently provided by the age determination of around thirty hippopotamus bones recovered from sand and gravel pits in the Rhine valley, which were found to be between 48,000 and 30,000 years old. Hippos are thermophilic herbivores that today only live in Africa. Fossilized occurrences in Central Europe have been known for a long time, but until recently it was assumed that they died out during the last great interglacial period 115,000 years ago. The current dating of finds from various gravel pits in the Upper Rhine Graben refutes this assumption and provides further confirmation for the cave bears of the Alps (ARNOLD et al., 2025).

11.3 | Milankovitch curve

The widely recognized »Milankovitch curve« (insolation curve), which was derived from the Earth's orbital parameters, provides further evidence. For the Alpine cave bear period between 65,000 and 30,000 years ago, summer temperatures were calculated that were considerably higher than those of today (DÖPPES & RABEDER, 1997; PACHER & STUART, 2008; PACHER & RABEDER, 2016, 2018). The Conturines Cave is not the only site which, due to its extreme altitude, gives us evidence of a high temperature in the Middle Würm. Fossil-bearing bear caves are found across the major karst plateaus of the Northern Alps, regions that currently have sparse vegetation. These so-called »plateau bears« (KAVCIK-GRAUMANN et al., 2023) would not find food on the barren karst plateaus today, so they too can serve as climate witnesses. The most important bear dens are located on the following plateaus (from east to west):

Hochschwab: Potentialschacht (2,070 m, KAVCIK-GRAUMANN et al., 2022)

Totes Gebirge: Ramesch-Knochenhöhle (1,960 m, HILLE & RABEDER, 1986), Brieglersberghöhle (1960 m, RABEDER et al., 2005), Salzofenhöhle (2,005 m, DÖPPES & RABEDER, 1997)

Dachstein: Schreiberwandhöhle (2,250 m, RABEDER et al., 2019), Schottloch (1,980 m, KAVCIK-GRAUMANN et al., 2023)

Tennengebirge: Bärenfalle (2,100 m, KRUTTER et al., 2020)

Steinernes Meer: Hennenkopfhöhle (2,070 m), Schneiberhöhle (2,300 m, DÖPPES et al., 2024)

12 | Material and methods

The material used for age determination consists exclusively of fossil bones and teeth from vertebrate species that can be described as climate-relevant due to their diet and/or their current distribution area. The preservation of bone substance, especially collagen, is due to the special conditions in caves: constant temperature, which corresponds approximately to the annual average of the entrance environment, eternal darkness, high humidity. Collagens are protein compounds whose carbon is used for age determination (^{14}C method) and which contain DNA sequences from which species affiliation can be precisely determined. All age determinations can be repeated with fresh sample material.

12.1 | Radiocarbon method

Most age data from fossil bear remains were obtained using the radiocarbon method (also known as the ^{14}C method) in the following international laboratories (with laboratory code): Beta Miami, CAMS Livermore, ETH Zurich, Gr Groningen, Hv Hannover, KIA Kiel, Lyon, MAMS Mannheim, Oxa Oxford, RIDDL Latvia, Ua Uppsala, UBA Belfast, Utc Utrecht, VERA Vienna. Due to the short half-life of 5,730 years, the range of the radiocarbon method only goes back to around 50,000 years before today.

12.2 | Molecular ages

The so-called molecular dates go back much further. These are »age estimates« based on DNA analysis data that agree surprisingly well with the ^{14}C data (DÖPPES et al. 2024; NAGEL et al., 2019; SHAPIRO

et al., 2011). The molecular ages of the cave bears of the Alps come from GRETZINGER et al. (2019), FORTES et al. (2016) and F. ALBERTI (University of Potsdam).

12.3 | Uranium-series dating

The surprising realization that most of the cave bear remains date from the Middle Würm Period (approx. 65,000 to 25,000 years before present) is due to the uranium series data from the Ramesch-Cave (HILLE & RABEDER, 1980). Although the ages determined in this way have been confirmed by over 200 radiocarbon dates (DÖPPES et al., 2019), the uranium series method is hardly used anymore because it has been found that the uranium content can vary within a bone sample.

12.4 | Taxonomic identification

Taxonomic identification of fossil bones and teeth is typically straightforward using morphological analysis. With DNA analysis, however, it is also possible to check the genetic correspondence to relatives living today, such as the »cave« lion, »cave« leopard or »cave« hyena. This can clarify the question of whether the genetic differences were so great that a completely different diet and way of life appears possible and that, for example, the cat and hyena species living today only in the tropics and subtropics could also have lived under high alpine or arctic conditions or whether the former climate was considerably warmer than today (DÖPPES et al., 2019, 2024; KAVCIK-GRAUMANN et al., 2023; NAGEL et al. 2019).

13 | The »cave paleontological climate curve« of the Alps

The age data of fossil vertebrates from alpine caves published almost 40 years ago (HILLE & RABEDER, 1986) have been denied by most Quaternary geologists and climatologists to this day. They show that the remains of cave bears from high alpine caves do not come from the large interglacials such as Riss/Würm (130,000 to 115,000 years before today) or even from the even older interglacials (e.g. Mindel-Riss, over 200,000), but from the so-called »Middle Würm« between approx. 65,000 and 30,000 years BP (DÖPPES et al., 2011, 2019). The cave paleontological climate curve is based on absolute age data of climatically significant fossil vertebrate remains from extremely located caves in the Alps. The data points of the curve (Fig. 3) are created from the absolute age of the sample (mean values) and the estimated temperature difference compared to today. For the warm periods, it is the highest-lying caves that contain these fossils; for the cold periods, it is the lowest-lying sites. The curve connects the points that show the highest or lowest temperature values per time unit.

14 | Presumed causes

The rhythmic astronomical movements of the sun, moon and planets, which are described by the Earth's orbital parameters (obliquity, eccentricity and precession), are thought to be the main factors behind the major climate changes. The two major warm phases of the last 70,000 years, the cave bear period and the Holocene, coincide with the rhythm of the solar radiation curve (also known as the »Milankovitch curve«), as does the cold phase of the last major glaciation, which – judging by the fossils – brought Arctic climate conditions to the Alpine region. Smaller climate fluctuations such as the »Younger Dryas Period« and the »Little Ice Age« cannot be proven by cave fossils.

15 | Conclusion

The analysis of almost 300 chronological data from taxonomically determined bone samples from 88 caves at altitudes between 190 m and 2,775 m revealed that the alpine climate of the last 70,000 years fluctuated on average from -10 °C below to +10 °C above today's average values. The warm phases together (cave bear period: 41,000 years, hamster period: 4,000, and elk-wisent period: 4,500 years) lasted around 50,000 years, while the cold phases together (lemming period: 8,900 and »Younger Dryas«: 1,000 years ago) only lasted around 10,000 years. The warm periods were therefore around

Fig. 3 | Cave paleontological climate curve of the Alps, determined from the absolute ages of bone samples from caves in comparison with the Milankovitch curve, calculated from the parameters of the Earth's orbit, and with the $^{18}\text{O}/^{16}\text{O}$ oxygen isotope curve measured from an ice core in Greenland. After HILLE & RABEDER (1986) and AUER et al. (2014). Abbreviations: DL1 and DL 2 ... data gap 1 and 2.

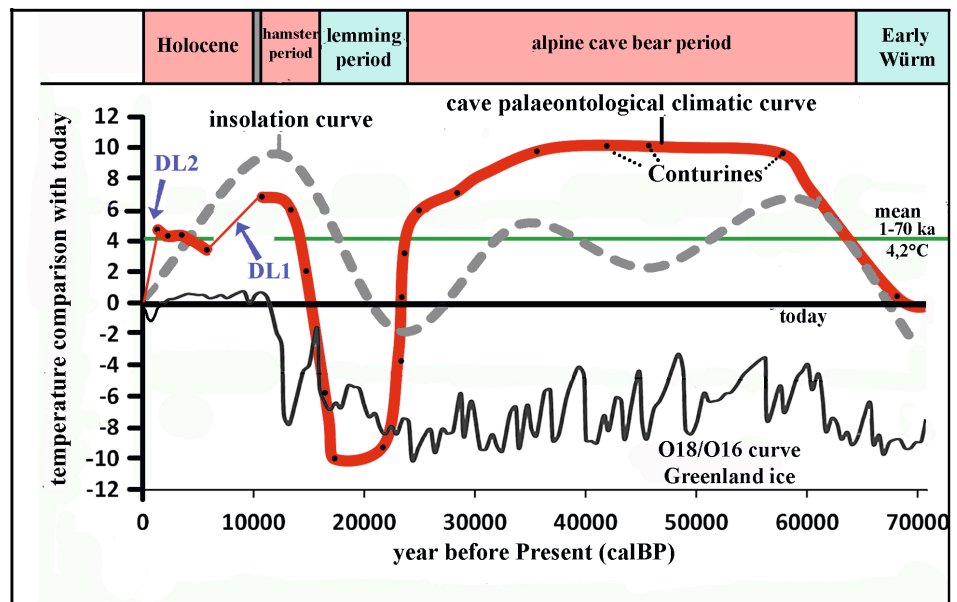


Fig. 4 | The Conturines Cave (2,775 m) in the eastern flank of Piz dles Conturines (3,064 m) is now located in a vegetation-free scree cirque that offers no food for herbivores. Cave bears of the species *Ursus s. ladanicus* have inhabited this cave for at least 20,000 years. During this time, cubs were born there, the bears found food in the surrounding area and many died in the cave (Photo: Gerhard Withalm)



five times as long as the cold periods. The average temperature in the Alps over the last 70,000 years was about 4.2 °C above the current average. The results also showed that the so-called oxygen isotope method, also known as the glaciological thermometer, is only partially suitable for reconstructing the warm phases in the Alps, while the Milankovitch curve, which is based on changes in the Earth's orbit parameters, largely agrees with the data from fossil vertebrate finds in the Alpine caves.

16 | Outlook

It is to be hoped that at some point the many »climate prophets« will adapt their predictions about the future climate to the scientific data and findings. There are numerous speculations and models for the probable climate change in the coming decades and centuries. Looking back to the recent geological past would change these models significantly. Unfortunately, the message that the Conturines Cave brought us is still being ignored today.

17 | Acknowledgement

The excavations in the Conturines Cave were funded by the Bolzano Monument Office, the University of Vienna, the Austrian Academy of Sciences, and Willy Costamoling, who discovered the cave.

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