Proc. Univ., Bristol Spelaeol. Soc., 1981, 16 (1), 5-10

AN INTRODUCTION TO AUSTRIAN KARST

by
S. R. PERRY

ABSTRACT

The plateaux of the Northern Limestone Alps underwent uplift between Miocene and Pliocene times due to pressure from the Central Alps. The run-off from the Central Alps took a linear northerly direction to the Northern Foreshore. Subsequent dissection separated the plateaux physically and local radial drainage patterns developed. The surface features of the plateaux are dependent on glaciation, solution and weathering. The plateaux show good conditions for cave formation. This has occurred in two major phases, late Tertiary northerly phreatic tunnels and post glacial radial vadose development.

INTRODUCTION

This paper gives an introduction to the karst of Austria, as reviewed by Bauer and Zötl. (1972). It provides a background to the interest the University of Bristol Spelaeological Society is now showing in the Löser plateau of the Totes Gebirge.

Karstifiable rock makes up about one sixth of Austria. Four fifths of the karst area lies in an east-west band of limestone, the Northern Limestone Alps, which lies to the north of the Central Alps. The hardrock Central Alps are separated from the Limestone Alps by the longitudinal rivers: the Inn, the Salzach and the Enns. The Northern Limestone Alps include the High Alps (summits greater than 2,000m.) and to their north the pre-Alps (summits less than 1,500m.). (Fig. 1).

The dominant rocks of the High Alps are the triassic limestones Wettersteinkalk and Dachsteinkalk. Both are fine grained, light coloured, bedded strata up to 1,500m. thick. The pre-Alps contain many less permeable rocks including dolomites and shales. They have suffered greater surface erosion and show rounded hill forms, corroded flat in the Tertiary period (Tertiary denudational plains). The classic features of the High Alps are impressive steep sided, interdigitating plateaux and the corresponding narrow valleys.

THE DEVELOPMENT OF THE LIMESTONE ALPS

The Triassic limestones were subjected to tectonic pressure from the Central Alps and suffered extensive nappe-type folding in the early Tertiary, with overthrusts reaching up to fifty kilometres in a northerly direction. The nappes were corroded by the run-off from the Central Alps and widespread denudational plains were formed. During early Miocene these plains were covered by a several hundred metre thick hardrock gravel blanket (Augensteine) washed from the Central Alps. The Augensteine can still be found, especially in the east of the range and where they have been deposited within caves and fissures by water action (Fig. 2).

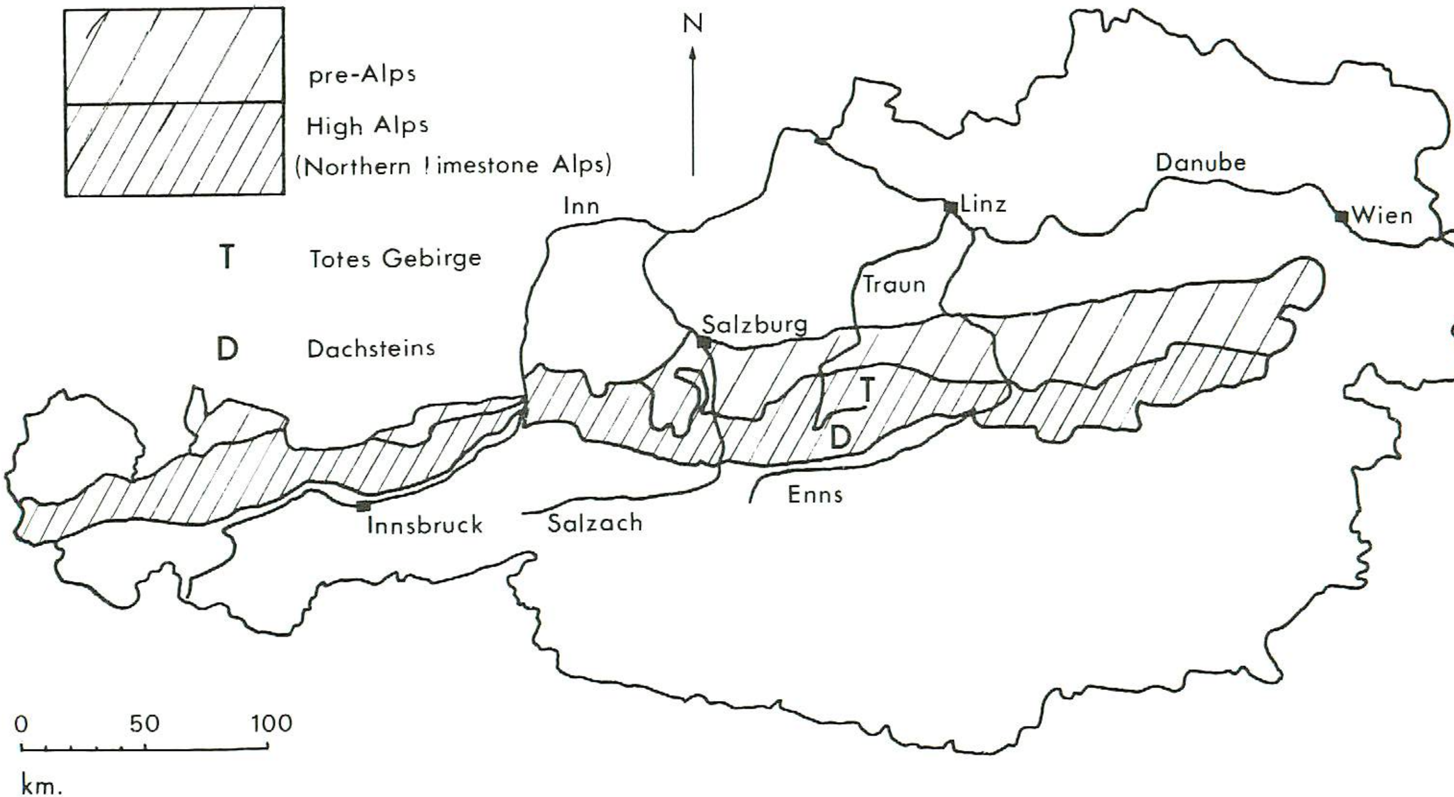

Fig. 1: Austria — The Northern Limestone Alps.

During early Miocene only a few hills would have shown above the Augensteine but with the uplift of the Alps from then to Pliocene times the gravel cover was eroded away and widely extending plateaux were exposed. The plateaux survive as the High Alps, where they are of extensive limestone sequences (Wettersteinkalk and Dachsteinkalk) with low dip. These factors have reduced surface erosion by the development of extensive subterranean drainages. Such areas are termed 'Raxlandshaft' (Raxlandscape).

The Raxlandshaft was dissected by younger tectonic block movements to form the interdigitating plateaux. The subsequent down-cutting of valleys interrupted the previous generally northwards drainage from the Central Alps, which had formed the Tertiary denudational plains and the extensive horizontal phreatic cave systems of Austria. The Limestone Alps were isolated physically from the Central Alps by the Inn, the Salzach and the Enns, which diverted the run-off from the Central Alps to the Danube. This valley formation reached its present extent (and formed a hydrological barrier) by the beginning of the Quaternary period. Subsequent drainage was local to each plateau, with a radial distribution rather than a dominantly northern direction. The final major event was Quaternary glaciation.

The limestone plateaux are most prominent in the isolated massifs of the Steinernes Meer, Tennengebirge, Dachstein, Totes Gebirge and east as far as the Vienna Basin. To the west a mountain chain form, the Northern Tyrolean Alps, formed of steeply dipping Wettersteinkalk and of less spelaeological interest, is continuous with the high alpine dolomite ranges.

SURFACE FEATURES OF THE PLATEAUX

Large karst features such as dolines predate the Quaternary glaciation. The glaciers themselves enlarged surface rifts to gouge out straight narrow ravines several metres deep and up to one hundred metres or more long. These 'Gassenlandschaft' are characteristic of the glaciated plateaux and indicate the network of main faults and joints. Step-like scarps separated by flat beddings, 'Plattenlandschaft', are found in areas of distinctly bedded low-dip limestone, again due to glacial scouring. As the glaciers receded (the Dachsteins still have a glacier which was once 400m. thick) the released water aided the formation of numerous surface-open shafts, usually blocked with surface moraine or glacial scree.

Since the glaciation small features, 'lapies', have developed: fine sharply fluted 'Trittkarren' formed above the tree line (about 1,600m.) and rounded bollard-like 'Rinnenkarren' up to one metre deep formed below the tree line, under soil cover. There is a band of overlap due to the timber line having fallen three to four hundred metres since the thermal maximum. On the bare plateau, where the temperature is low (increasing the carbon dioxide solubility) and precipitation is high, post-glacial erosion is estimated at 15 to 20cm. of limestone. Lower down the vegetation reduces the available water (transpiration) but the acid soil increases the corrosive power of the slightly warmer water. Trittkarren are

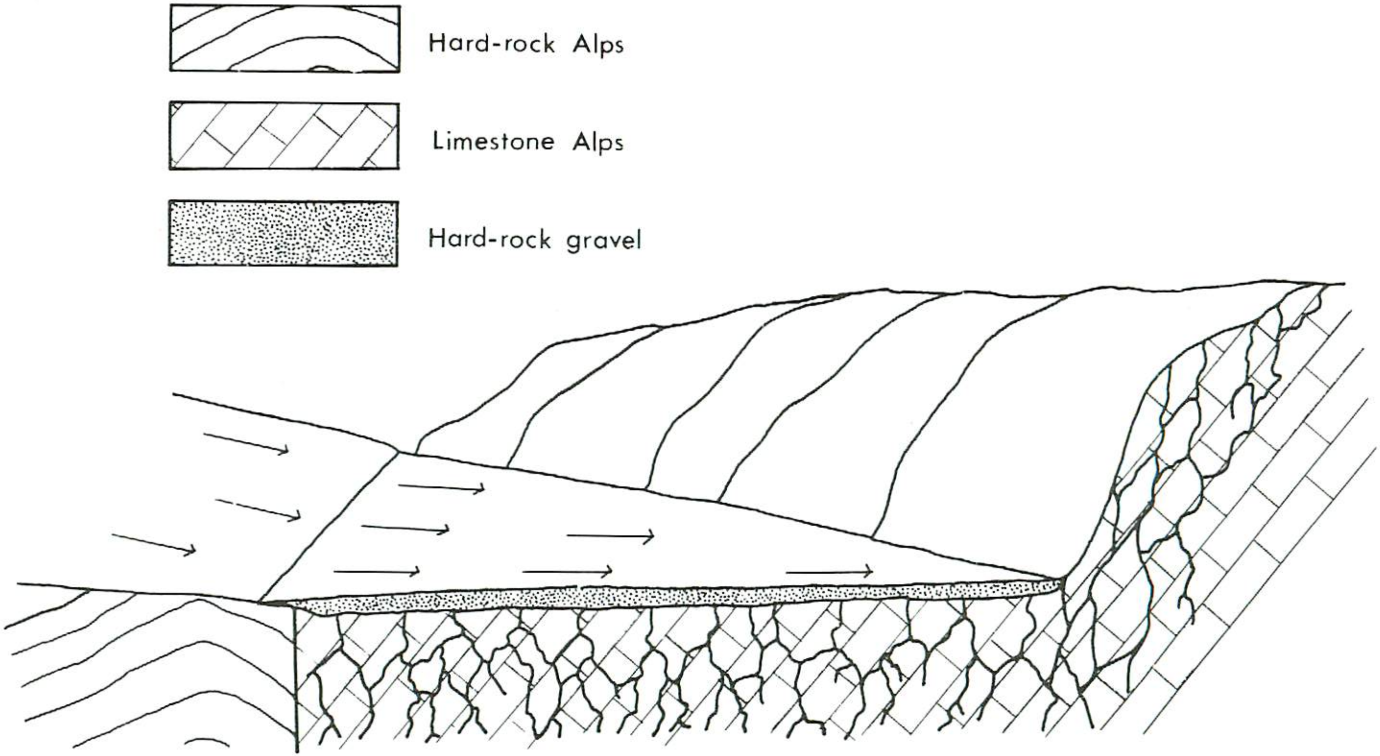

Fig. 2: Formation of denudational plains. Arrows indicate direction of water flow. Network in limestone indicates fissures.

centimetres deep, Rinnenkarren up to one metre deep. Above about 2,200m. frost weathering is sufficient to prevent lapies formation.

HYDROLOGY

The development of an underground drainage system depends on the amount and structure of the bedrock, the surface morphology, the amount and quality of the water having access to the surface, the position of the base level of drainage (potential energy gradient) and the time available.

The tendency to cave formation rather than surface run-off is greatest if the surface is nearly horizontal. High precipitation and carbon dioxide content help. Surface features, such as lapies and Gassenlandschaft, direct water to the bedrock and subterranean drainage will then take advantage of and enlarge the internal weaknesses, with flow directed by the local base level. All the necessary factors including depth of limestone are found *par excellence* in the high plateaux around the Dachsteins, though changes in the parameters since Tertiary times have dictated several phases of cave development.

A limestone mass can be divided according to the drainage conditions in various regions. Highest is a zone of vadose development, where passages are essentially air filled and gravity drives flow and passage formation vertically down planes of weakness, usually joints and faults. At some depth a level of permanent flooding is reached, where flow is dictated by hydrostatic pressure and may travel in many directions to reach the base level. This phreatic zone is limited by the extent of the karstifiable rock. The upper portions of this karst water body will experience the most rapid motion and turnover, and will be the zone of greatest passage formation. This region overlaps with the vadose region in a zone where water level and flow type varies closely with the precipitation. A 9.7km. tunnel through the Schneealp has allowed direct observation of these zones in a Wettersteinkalk plateau to the east of the range.

THE CAVES

The earliest phase of development is evidenced by Liassic deposits within the Tertiary limestone. These pockets are not relevant to the present caves, which divide into phreatic tunnels and precipitous vadose systems. The phreatic tunnels run in a northerly direction, formed by late Tertiary run-off from the Central Alps, before the latter were separated by their longitudinal valley systems. This drainage ran through the Limestone Alps to the base level of the northern foreshore and was associated with the drainage which formed the denudational plains. At this time several large 'poljes' are thought to have sat perhaps 1,000m. above the present plateau.

The phreatic tunnels of the major known caves lie between 1,300 and 1,800m. above sea level. The systems often have several stories denoting successive uplifting of the Alps during their formation, the phreatic tunnels being formed in the upper, rapidly moving layer of the karst water body. The Dachstein Mammut Cave is a classic example with 16.5km. of passage lying at altitudes between 1,250 and 1,500m. The Eisriesenwelt Cave of the Tennengebirge has 42km. of passage between 1,600 and 1,800m.

Late vertical developments, either connected with the horizontal passages, as in the 432m. shaft of the Geldlock, or in separate shaft caves, such as the Gruberhornhohle (854m. total depth), were formed in the isolated vadose zones of the Quaternary plateaux. Much of the water supply was glacial and post-glacial meltwater (i.e. local) and radial drainage patterns were formed with overlapping water systems running centrifugally within the plateau. Vertical connections in the Dachstein Mammut Cave betray their links with the glacier bed above by the moraine deposited at their junctions with the phreatic tunnels.

Spore tests reflect both types of cave form. Radial patterns were found for drainage from the centre of the Totes Gebirge. In contrast drainage from the southern edge of the Totes Gebirge (Tauplitz fault zone) passed 30km. north through the entire massif.

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ADDITIONAL READING

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