Cheddar Gorge

[ST 46 53]–[ST 48 54]

Highlights

Cheddar Gorge is perhaps the single best known karstic feature in Britain and provides a spectacular example of a limestone gorge fed by a system of dry feeder valleys. The morphology of the gorge and the associated well-dated caves, provides a unique insight to its geomorphic evolution over the last million years. It demonstrates the results of episodic fluvial erosion in a karst terrain, which was left dry when the surface drainage disappeared underground into caves.

Introduction

Cheddar Gorge extends approximately 2 km eastwards from Cheddar village and forms the downstream portion of an extensive dry valley network which once drained most of the Mendip plateau (Figure 5.8). Above Black Rock three dry valleys form part of the dendritic network feeding into Cheddar Gorge. These represent particularly good examples of dry valleys incised into the Mendip plateau. Below Black Rock the gorge is far more precipitous and is entrenched to 120 m deep into the limestone where it descends steeply towards the flank of the Mendip Hills at Cheddar village. Many caves exist in the side of the gorge and are described in Barrington and Stanton (1977) and Irwin and Jarratt (1992).

The origins of the gorge have been the subject of much discussion since the early 1800s (Dawkins, 1862; Winwood and Woodward, 1891; Callaway, 1902; Reynolds, 1927; Stride, A.H. and Stride, R.D. 1949; Ford and Stanton, 1968; Trudgill, 1977; Smith, 1975a, b, 1977), with several theories including cavern collapse, earthquake activity, and incision by a periglacial meltwater river being put forward. Only the last of these now carries any credence. Recent work by Atkinson *et al.* (1978), Atkinson *et al.* (1986), Smart *et al.* (1988b) and Farrant (1995) has focused on the morphology and dating of both the swallet caves and the caves exposed in the gorge, which has led to a better understanding of the geomorphic history of the gorge, and enabled it to be set in a chronological framework.

Description

Cheddar Gorge is entirely incised into the Carboniferous Limestone succession on the southern flank of the Mendips. Above the gorge the main valley continues south-east from Black Rock, towards Cheddar Head where it widens, becomes more open and divides again. From Black Rock, the northern tributary splits and extends up Velvet Bottom and the Longwood valley, as far the modern stream sinks at Longwood swallet and the other Charterhouse caves, which lie at the contact of the limestone with the Lower Limestone Shales on the south side of the Black Down pericline.

The Longwood–Cheddar valley is the best example of the relationship between the stream sink, dry valley and resurgence (Figure 5.8). The upper dry valleys descend gently from the plateau surface at an elevation of around 245 m to Black Rock, where the gradient increases markedly. Over the next 2 km the floor descends over 130 m to an elevation of 20 m at the resurgence (Figure 5.10).

The rock exposed in the gorge is mainly the Clifton Down Limestone, although some Hotwells Limestone crops out in the cliffs of the downstream part. The limestone dips at about 20° to the south and is cut by a major joint set trending NNW–SSE which has a strong influence on the cliff morphology and on the caves. The cliffs on the south side reach heights of 120 m, and are dominantly vertical, mainly aligned on the strong joints, and broadly stable because the dip is away from the gorge and into the cliffs. The northern side is less steep, because the southerly dip facilitates bedding plane slip and the formation of steep bedding plane slabs. The cross-section of the gorge is therefore an asymmetric V-shape, typical of fluvial excavation (Figure 5.9). Its floor meanders between rock buttresses whose pattern is at least in part orientated by the major fractures which also determine the profiles of the main limestone walls. The gorge is now dry, except in major floods such as that of July 1968 (Hanwell and Newson, 1970), and the drainage is entirely underground, the water resurging at the Cheddar Risings at the foot of the gorge.

In the gorge walls are a number of caves, the most important of which are the Gough's Cave complex, clustered around the resurgence at the foot of the gorge, and Reservoir Hole. Many of these contain stalagmites which have been dated by uranium-series and electron spin resonance methods. Stalagmites in the upper parts of Gough's Cave give uranium-series ages around 235 ka (Farrant, 1995). A scalloped flowstone in Great Oone's Hole above yielded uranium-series ages around 375 ka (Farrant, 1995), but an electron spin resonance date for some of the same flowstone yielded an age of 1060 ka (Smart *et al.,* 1988); the latter is probably an overestimate, reflecting uncertainties in the dosimetry. It is apparent that the Gough's main bore was abandoned by around 120 000 years ago. Uranium dates from Reservoir Hole show the upper cave levels had been abandoned by 350 ka. The gorge shows many classic features of a fluvially excavated valley. These include a steep long profile, a recognizable V-shaped cross-section, a clear relationship to normal fluvial valleys, lack of any collapse debris, knickpoints including a conspicuous one at Horseshoe Bend, and a large alluvial fan dissected by the modern streams at the foot of the gorge.

Interpretation

Cheddar Gorge is Britain's largest and most spectacular karst gorge. It provides a particularly fine and easily accessible example of fluvial erosion in a karst landscape, although this was not always thought to be the case. The earliest theories on the formation of the gorge were put forward by Dawkins (1862) who suggested that it was formed as a result of cavern collapse. This was also the view held by Winwood and Woodward (1891) in an account of a Geologists' Association field excursion to Mendip. Later, Callaway (1902) noted the joint-controlled nature of the gorge and concluded that it must have been formed by a subterranean stream. Reynolds (1927) was one of the first to suggest that the gorge was cut by a surface river. The last advocates of the collapsed-cavern theory were Stride, A.H. and Stride, R.D. (1949), although this myth is still often perpetuated in many modern geological texts. Thus Cheddar Gorge is probably Britain's most frequently misinterpreted geomorphic feature.

It is possible that some subaerial fluvial excavation took place before karstification had developed sufficiently to divert drainage underground. However, this process cannot have played a major role as the gorge truncates older high-level caves. Ford and Stanton (1968) demonstrated that the gorge must have been formed by a subaerial stream, pointing to the difference between the gorge's long profile and that seen in the stream caves. They also noted that the gorge has often cut cleanly through existing cave passages. Additionally, they stressed the disparity between the immense volume of the gorge and that of even the largest Mendip caves such as GB and Lamb Leer. Cavern collapse can only have played a minor, if not trivial role in the gorge formation. A useful summary of the different theories on the origins of the gorge is published in Smith (1975a).

The commonly accepted view is that Cheddar Gorge was incised over the last million years by a subaerial meltwater river during periglacial periods, when underground drainage was restricted (Smith, 1975a). Extensive mass movement and solifluction, coupled with development of permafrost during glacial periods led to the blocking of the swallet caves with ice and frozen mud and the establishment of surface drainage. Due to the nature of the Mendip plateau, the steepest stretches were at the valley mouth, where incision was therefore the greatest. Cheddar Gorge is the largest of the gorges on the Mendips because it drained the bulk of the plateau and because its lower end was lower than those elsewhere, thus maximizing its erosive power. Each successive periglacial episode caused renewed incision of the gorge, while during the interglacial periods, underground drainage was renewed and the gorge became dry, except under conditions of major flood. A late Pleistocene fauna in several of the valley floor caves (Tratman, 1975; Currant, 1987) shows that the gorge had reached almost to its present floor level by early Devensian times.

Erosion of the softer Jurassic and Triassic rocks along the southern flank of the Mendips during interglacials enabled each successive reactivation of the valley to work from a lower level, thus creating a series of knickpoints in the gorge which receded upstream through time (Barrington and Stanton, 1977). The knickpoints have been correlated on geomorphic grounds with a series of erosional benches along the southern flank of Mendip (Ford and Stanton, 1968). However, these erosional benches may not accord with the former positions of base level; Stanton (1985) reinterprets them as random associations of stratimorphic flats. These knickpoints may also correlate with a series of abandoned cave levels in the Gough's Cave system (Ford, 1965b; Ford and Stanton, 1968; Stanton, 1985; Farrant, 1991). The cave levels relate to a succession of past stable resurgence positions (Figure 5.10); they may also correlate with levels in the swallet caves to the north, but more dating evidence is needed before conclusions can be drawn.

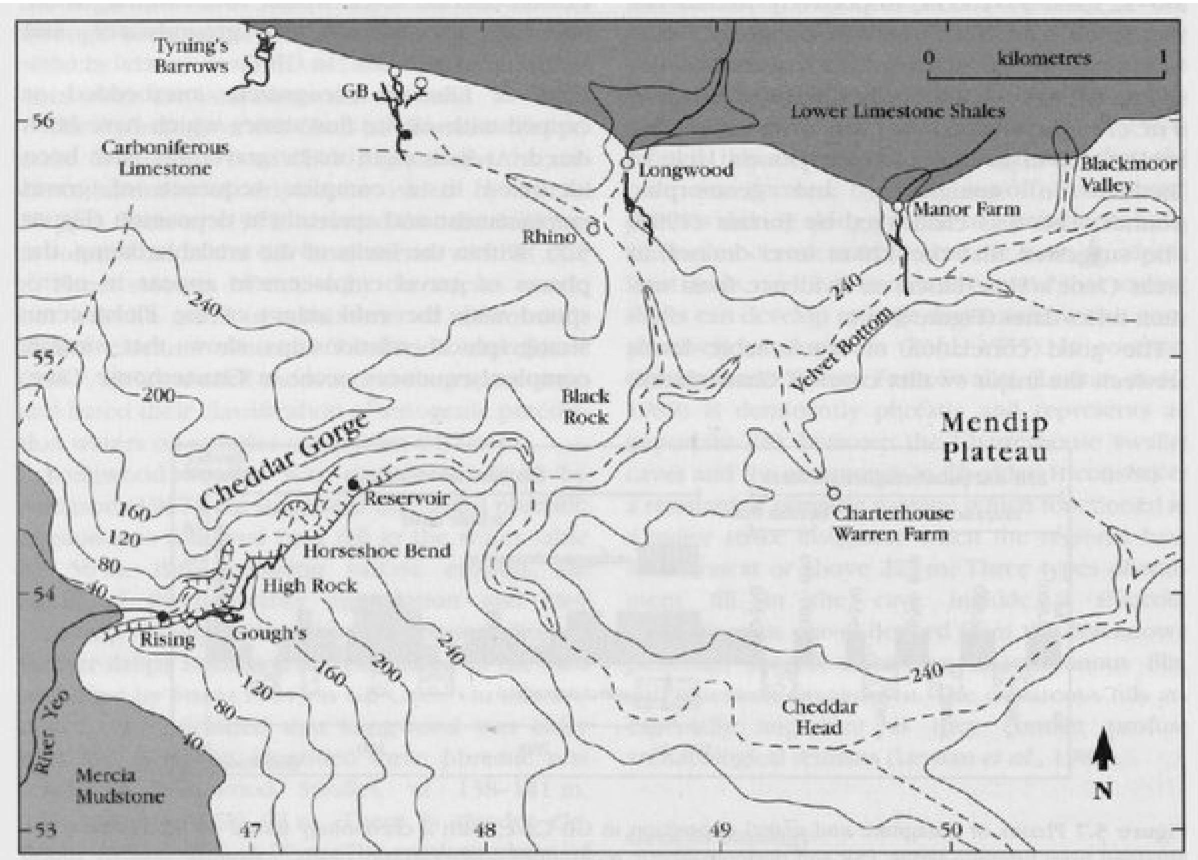
Recent work has concentrated on defining the rate of excavation of the gorge, its development through time, and how it relates to the climate fluctuations during the Pleistocene. By dating the caves and relating their morphology to former stages in the evolution of the gorge, Atkinson *et al.* (1978) and Farrant (1991, 1995) have shown that the lower section of the gorge has been incised at an average rate of 0.25 m

Extrapolation of this rate up to the plateau surface suggests incision of the gorge began approximately a million years ago. With refinement of a chronology it may prove possible to ascertain the relative importance of periglacial erosion and temperate fluvial erosion, but low resolution of the older dates makes this very difficult for the earlier phases of the gorge's history. The large number of dated stalagmite samples from extensive associated caves makes this one of Britain's best documented karst gorges.

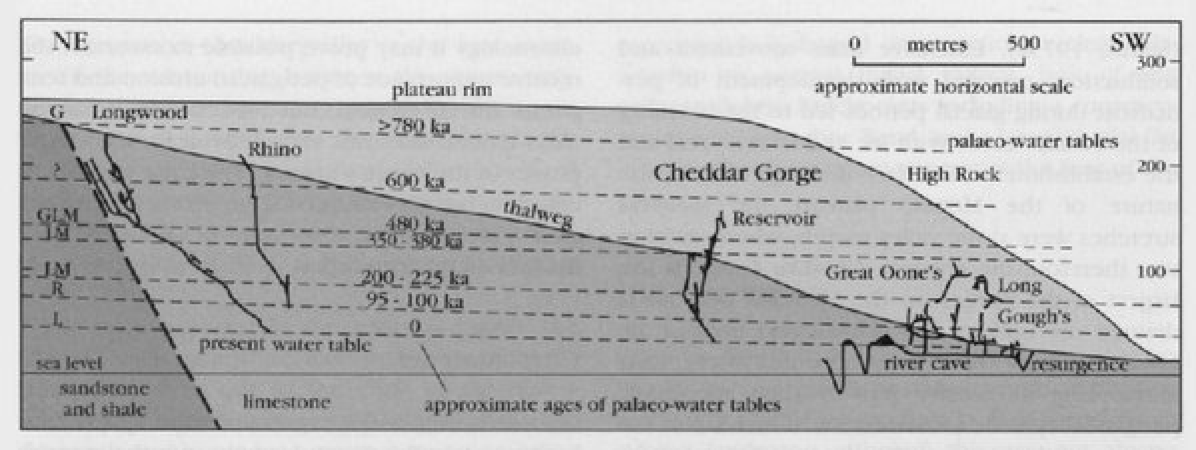
Conclusions

Cheddar Gorge is the largest and most spectacular karst gorge in Britain, and is unique in that a series of well-dated caves in the gorge walls have enabled its geomorphic evolution to be deduced. Although often wrongly cited as a collapsed cavern, it is a fine example of fluvial erosion in a karst landscape, left dry by the onset of underground drainage. Cheddar clearly shows the relationship between the gorge and the dry valleys which feed it, while the abandoned and active caves show the relationship between surface and underground features in a limestone karst.

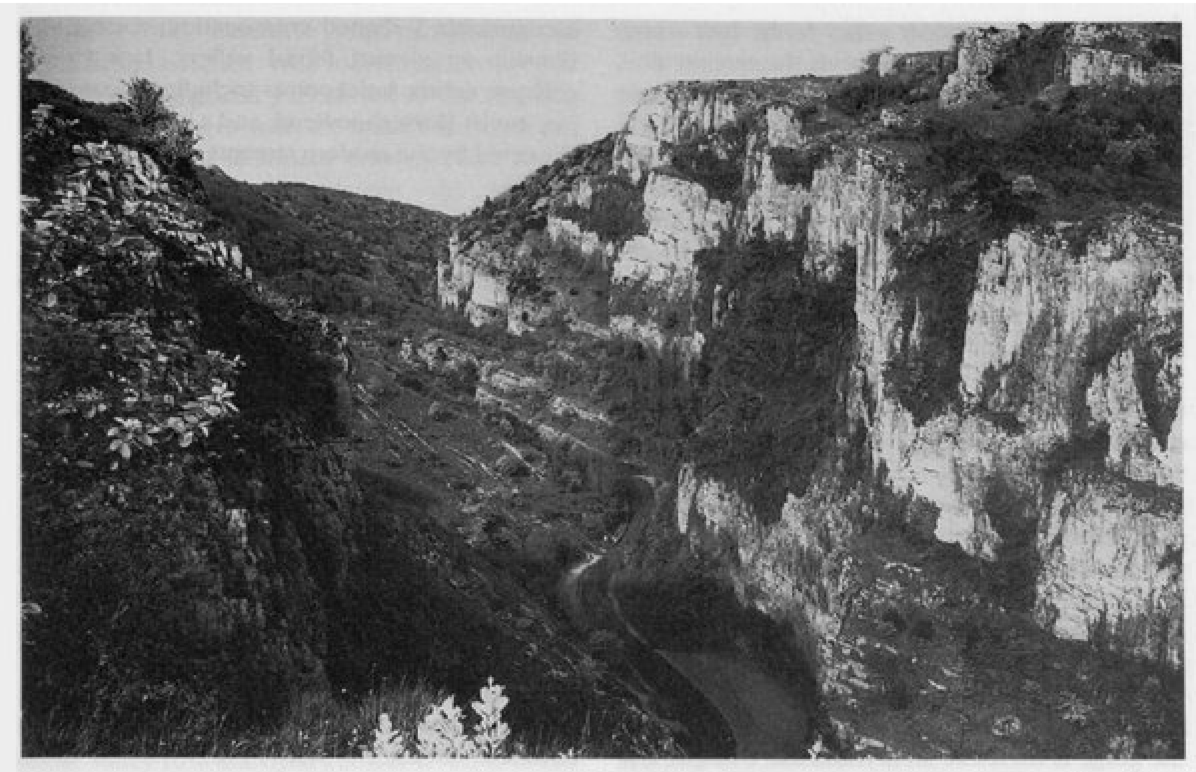
References



(Figure 5.8) Map of Cheddar Gorge and the lower part of its dry valley system reaching across the karst to the edge of the Mendip Plateau.



(Figure 5.10) Long profile of Cheddar Gorge up into the Longwood Valley, with the caves beneath. Each palaeo-water table is recognized from cave and surface morphology, and is dated from the sediments in associated cave passages at both the swallet and resurgence ends of the system. The water tables steepen greatly in the sandstone and shale, but are marked beyond the limestone only to label the caves in which each is recorded (G = GB Cave; L = Longwood Swallet; M = Manor Farm Swallet; R = Rhino Rift). The horizontal scale is distorted by the projection, and the vertical scale is exaggerated three times (largely after Stanton, 1985; Farrant, 1995).



(Figure 5.9) Cheddar Gorge, looking upstream from the northern rim opposite High Rock. The limestone dips to the right, ensuring the stability of the cliffs on the right, while the left slope is cut back almost to the dip of the bedding planes. (Photo: A.C. Waltham.)