CHAPTER 1

The Yorkshire Dales

Tony Waltham and David Lowe

White limestone scars terracing the hillsides, great expanses of bare limestone pavement, streams that sink into the ground, deep pothole shafts peppering the high benches, and the extensive networks of caves passages that lie beneath the fells. These are just some elements of the Yorkshire Dales karst. Though not the only significant karst terrain in Britain, it has more than its share of the best developed and best known limestone landforms. The Dales region has the country's longest cave system and the greatest expanses of glaciokarst, whereas the deepest cave and the largest gorge lie elsewhere. A combination of the spectacular and the beautiful makes the limestone country of the Dales strikingly significant in terms of its geomorphology and its landscape values.

Karst is just one element of the terrain that characterises the Yorkshire Dales. The limestone scars and the steep-sided glaciated valleys combine to make the area one of the most scenic parts of England. Its National Park extends over an area about 40 km square, with the landscapes of its southern half dominated by limestone outcrops. The area, commonly known simply as the Dales, is a distinctive block within the central Pennine Hills, with its rivers draining to both the west and east coasts of England.

Though the karst region is generally referred to as the Yorkshire Dales, it includes the Ease Gill valley that lies in tiny slices of both Lancashire and Cumbria; this therefore lies outside the National Park, which keeps within the county boundary (Fig. 1.5). The surface karst in Ease Gill is largely unspectacular but it overlies multiple complex cave systems that have now been linked to become part of the Three Counties Cave System (named as such because it also extends beneath the county boundary into Yorkshire). At times the less formal and more relaxed term, the Dales, is perfect to describe what many would claim is the finest area of karst and caves in Britain.

Geography of the Dales

Within the Yorkshire Dales, the more spectacular and extensive karst, and most of the larger caves, are contained within an area known as the Craven Uplands. This is the belt of limestone country that is dominated by the Three Peaks of Ingleborough, Pen-y-ghent and Whernside and also extends eastwards to Malham and Wharfedale. Wide limestone benches lie at altitudes around 400m and summits rise above the karst to about 700m. Towards the southwest the Uplands overlook the Craven Lowlands, which generally lie below 200m, and the margin between the two areas is the great step in the terrain marking the line of the Craven Faults.

The Yorkshire Dales, by Tony Waltham and David Lowe
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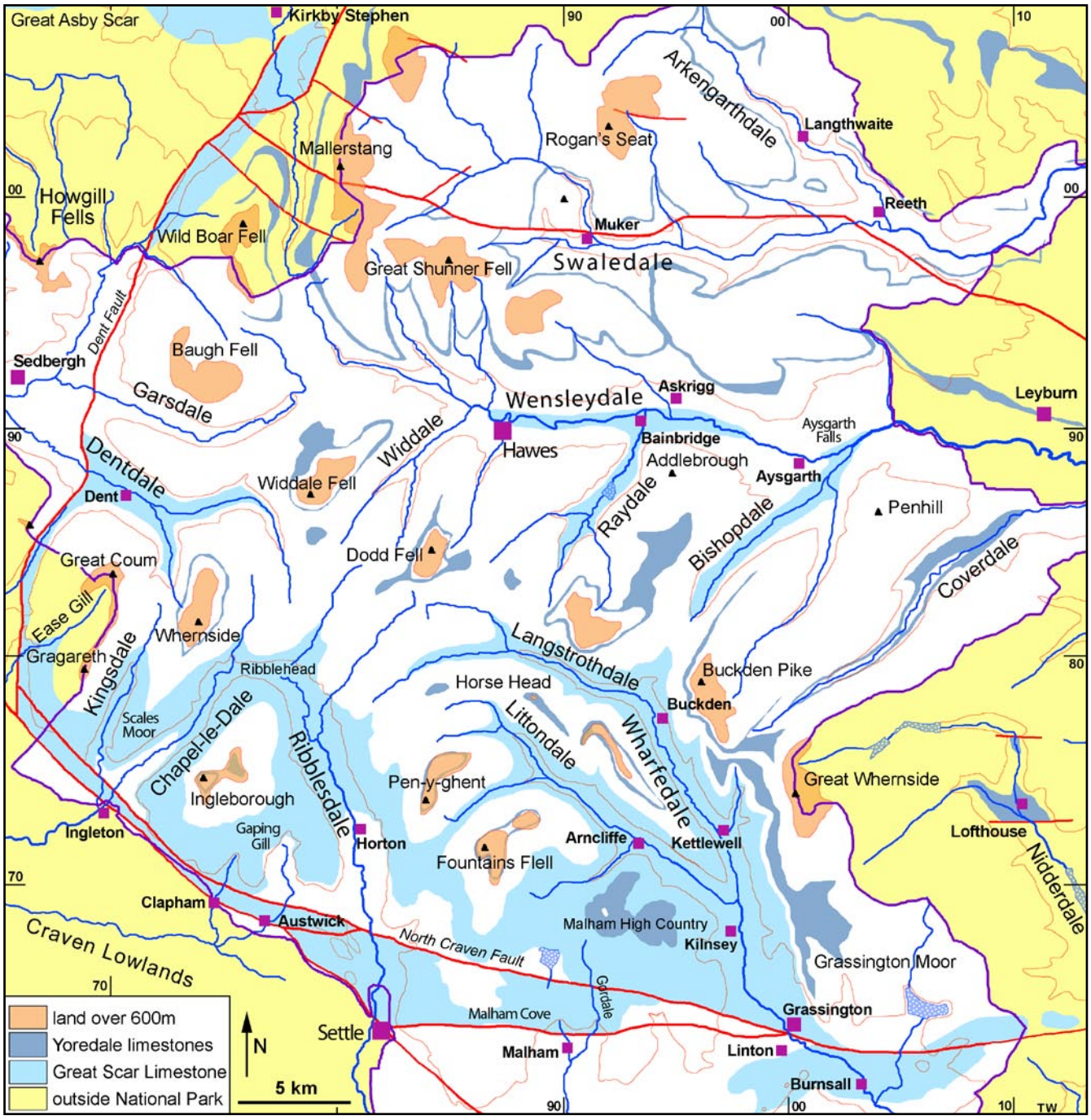
Geology of the limestone

The Craven Uplands are just the southern, slightly upturned edge of the Askrigg Block, an ancient geological structure that has helped to define the elements within the landscape of the Yorkshire Dales. This largely fault-bounded block is a positive feature that has been upstanding relative to its neighbouring terrain for a substantial part of geological time. It still stands high above the Craven Lowlands towards the southwest, but its other boundaries are more subdued. In the north it is bounded by faults that cross the Pennines through the lower ground of the Stainmore Gap, its western edge is also faulted, where adjacent higher ground includes the Howgill Fells, and in the east the edge of the Block dips gently away beneath younger rocks beyond Nidderdale.

Perhaps the most significant aspect of the Askrigg Block's history is that around 350 million years ago, in Carboniferous times, it formed a shallow shelf sea that was almost surrounded by deeper-water basins. Carbonates were deposited on that shelf to form the limestones that are now host to most of the caves and karst of the Dales. Along the southern margins of the Askrigg Block, a thick limestone

***Figure 1.1**. Ingleborough standing above the limestone benches that are interrupted by Chapel-le-Dale and Kingsdale (TW).*

***Figure 1.2**. Stalactites in Pippikin Pot (photo: Mark Shinwell).*



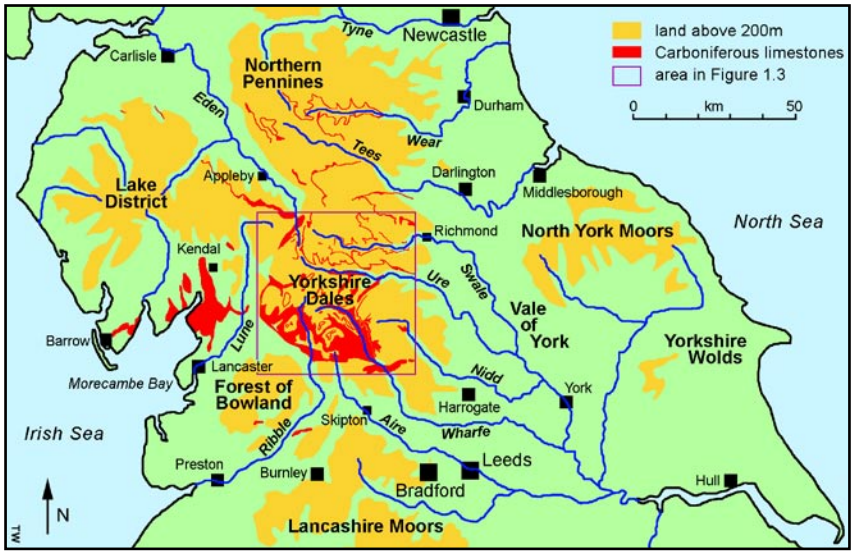


Figure 1.3. *Extent of the karst across the Yorkshire Dales; the only Yoredale limestones marked are those with significant caves and karst; all the marked outcrops are of the Main Limestone, except across Grassington Moor, Nidderdale and Coverdale (Middle Limestone) and on the Malham High Country (where the lower Yoredale limestones are contiguous with the Great Scar Limestone); contours are at 300m and 600m.*

Figure 1.4. *Location of the Yorkshire Dales astride the north-south chain of the Pennine Hills, within the heart of northern England; the areas of Carboniferous limestone marked are only those with significant known karst.*

Figure 1.5 *(opposite). Limestone pavements on the main benches around Ingleborough, with Pen-y-ghent rising in the distance (TW).*

The Great Scar Limestone

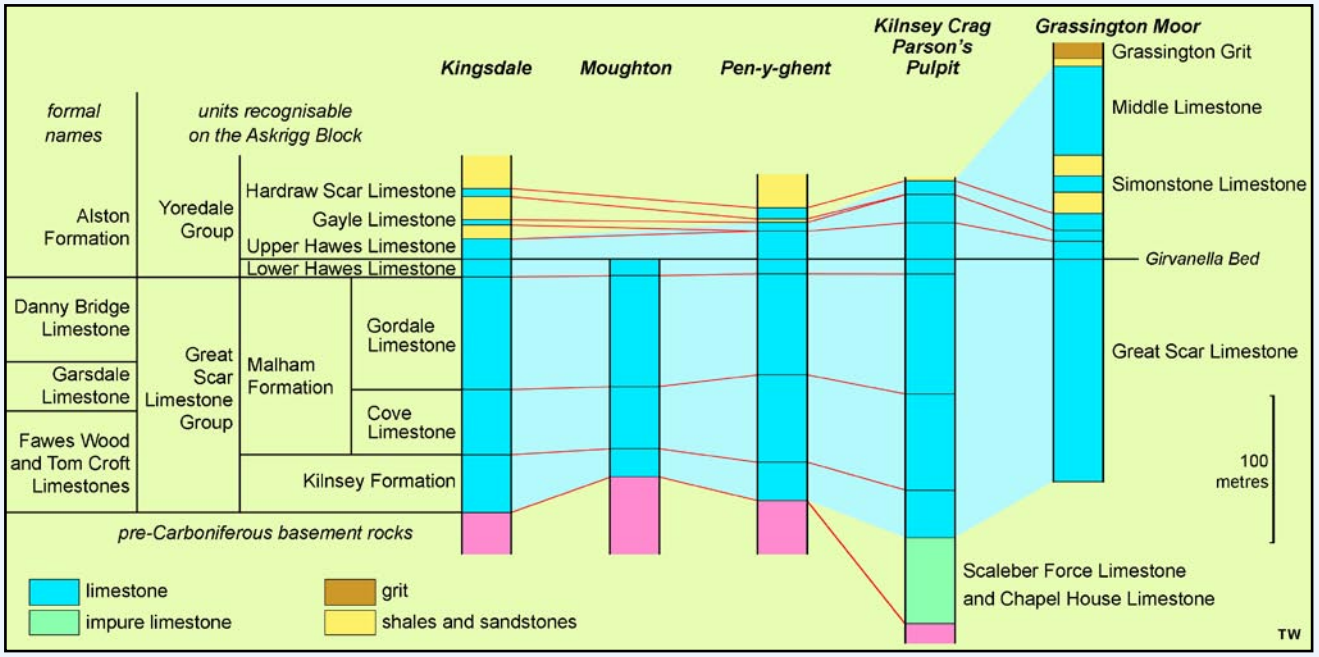
The major karst landforms and most of the larger cave systems in the Yorkshire Dales are developed on and within a major unit of strong, largely pale-coloured limestone that is informally known as the *Great Scar Limestone*. Though this unit is readily recognisable in terms of its related geomorphology, it is less clearly defined in geological terms. This is because, although it everywhere includes the formally-defined Great Scar Limestone Group, it locally extends upwards to take in one or more of the younger limestone beds that lie within the Yoredale Group.

Within the Dales, the Great Scar Limestone Group presents a consistent and distinctive appearance. In contrast there is considerable lateral and stratigraphical variation within the lower part of the overlying Yoredale Group, reflecting the changing and contrasting environments in which its original sediments were deposited. In its classic form a typical Yoredale cyclothem includes basal marine limestone, overlain in turn by marine shale, sandstone, seatearth and coal. However, in some areas the clastic rocks are virtually absent, and one or more of the Yoredale limestone beds can be in continuity with each other and with the underlying Great Scar Limestone Group.

The Carboniferous Limestone stratigraphy is described in Chapter 2, but within subsequent chapters the terms *Great Scar Limestone* or *the limestone* are used to refer to the Great Scar Limestone Group along with whichever overlying limestone beds exhibit similar lithologies and are essentially in continuity. Across the western Dales this includes the Lower Hawes Limestone, which is everywhere lithologically similar to the underlying limestones. Farther east the informal *Great Scar Limestone* unit includes some or all of the Lower Hawes, Upper Hawes, Gayle and Hardraw Scar limestone beds, reflecting the absence of significant intervening

shale and sandstone. In the diagram below, the geomorphological unit that contains the main elements of the Dales karst and caves is enclosed by the pale blue background. On Grassington Moor this extends up to the Middle Limestone to recognise that streams sinking into this limestone at Mossdale Caverns and Langcliffe Pot pass through intervening shales and sandstones to enter the underlying Great Scar Limestone (see Chapter 7). The Girvanella Bed is a generally-thin nodular limestone that forms a marker band near the top of the main limestone sequence (see Chapter 2)

This informal use of the term *Great Scar Limestone* is intended to provide a sensible approach to describing the broad geological context of the karst geomorphology without the need to become immersed in the finer details of stratigraphy. The diagram shows the formal stratigraphical names, which are derived from the Sedbergh area, and relates these to names that are more recognisable and applicable to the limestones that contain the Dales' main karst and caves on the southern part of the Askrigg Block.



sequence is exposed, and this hosts the main areas of the Craven Uplands karst that are centred on Ingleborough and Malham. Farther north on the tilted block these beds lie buried beneath younger rocks.

Most of the Dales karst and caves have formed on and within the Great Scar Limestone, which takes its name from the rock scars along the sides of all the Craven Dales, from Kingsdale across to Wharfedale. This limestone is largely a pale grey or cream in colour, but it weathers to a white surface patina that makes it so very distinctive as a landscape feature. It is generally between 150 and 200m thick, and hosts all the deeper caves. Above the Great Scar Limestone, the Yoredale Group is a mixed rock sequence dominated by impermeable shales. These gather the run-off from rainfall and snowfall to form streams that flow into the caves in the Great Scar. The Yoredale sequence also includes another set of limestone beds. Though nowhere more than about 50m thick individually, these Yoredale limestones contain their own caves and support their own karst, notably in the northern dales where the Great Scar Limestone is buried deep beneath the surface.

Complications occur locally, where some of the Yoredale limestones are contiguous with the Great Scar Limestone, notably in and around Wharfedale, and the geomorphological unit that forms the karst does not match any single term that is geologically correct (see box). The geological map and key in Figure 1.5 are simplified to indicate the areas of limestone outcrop that can be distinguished by their karst geomorphology.

Climate

The climate of the Yorkshire Dales is temperate and oceanic, dominated by frontal systems and associated depressions that sweep in from the southwest and provide copious amounts of relief rainfall when they meet the Craven Uplands. Weather records from the Malham Tarn Field Centre (Burt and Horton, 2003) are reasonably representative for most of the Dales karst, and provide a 40-year sequence of data (Table 1.1). Temperatures rise to daily means of only around 15°C through the summer months of June to September, and ground frosts strike on nearly half the nights of the year. Snow lies on the fells for an average of 35 days of each winter, but for longer on the summits, and for less time on the dale floors where it rarely persists for longer than a week.

***Figure 1.6**. Wharfedale in winter (TW).*

***Figure 1.7**. On pasture in Ribblesdale, sheep walk past a reed-filled shakehole where water drains into the limestone beneath (TW).*

On average, every other day in the Dales can be described as rainy, with more than a millimetre of precipitation, and the rainfall is spread very evenly through the year. The weather over the Dales karst can hardly be described as harsh, but it is a notable event when cave streams either drop to levels that open sumps or decline in flow to give the cave divers good visibility in placid waters; and summer storms always bring the risk of major flooding underground.

Countryside

Grassland dominates the landscape of the Yorkshire Dales. The wide-open fells, broken by limestone scars but with only rare stands of trees, create much of the character of the Dales. Even the dale floors are dominated by a mixture of rough pasture and nurtured meadows, with very little that goes under the plough. The open grassland dictates the style of farming, almost entirely devoted to hill sheep and cattle, but it also owes much to the sheep that have grazed it for thousands of years and remain very effective at keeping down any growth of shrubs and trees. Adding to the character of the grasslands are the dry stone walls, built of local limestone or sandstone, which form dense networks on every dale floor and continue more widely spaced over even the highest fells.

Though the farming has a major visual impact on the landscape of the Dales, it provides only a foundation to the Dales economy. The largest part of the economy is related to tourism in and around the many villages and small towns within the Yorkshire Dales National Park. The Park encompasses most but not all of the karst, and its major visitor attractions include some of the karst landforms. Malham Cove and Gordale Scar earn ‘honey-pot’ status with

Mean annual air temperature		6.9°C
Mean coldest month	January	1.5°C
Mean warmest month	August	13.0°C
Lowest recorded temperature	(February 1986)	–13.0°C
Highest recorded temperature	(August 1990)	28.2°C
Nights per year with ground frost		145
Mean annual rainfall		1502.4 mm
Mean wettest month	December	167.0 mm
Mean driest month	May	90.6 mm
Wettest recorded month (October 2000)		328.9 mm
Driest recorded month (April 1980)		2.5 mm
Rainy days (>1 mm rainfall) per year		180

***Table 1.1**. Selected statistics of the climate recorded at Malham Tarn between 1961 and 2000 (after Burt and Horton, 2003).*

Figure 1.8. *The open expanse of grassland on a loessic soil over the limestone, in Dowkabottom, above Littondale (TW).*

Figure 1.9. *Hardraw Force, the highest of the many waterfalls in Wensleydale (TW).*

the numbers of people they attract on a fine summer weekend. Waterfalls are always an attraction, and the Dales have many, nearly all formed where streams cascade over strong beds of limestone. There are also three show caves, White Scar Cave, Ingleborough Cave and Stump Cross Caverns, each with its own character, for those who wish to venture underground in relative comfort. But there is far more to the Dales, and the combination of stone-built villages dating from the 1700s, dry-stone walls tracing up the dalesides, and the wild open fells above provides some of the most visually pleasing countryside in Britain. The National Park thrives on the proceeds of its undoubted scenic value (Waltham, 2007).

Mining, mainly for lead ore, was a major industry, in Swaledale and Wharfedale in particular, but a peak of activity around 1800, when the miners found their way into some significant caves, declined to nothing at all after about 1980. Its place in the local economy has been taken only in part by quarrying, both for limestone and for the older

Quaternary chronology

As many Quaternary events are diachronous, dates in the table on the right are best estimates from a variety of sources that are applicable to a timeline for the Yorkshire Dales. All dates are in years counted back from 2000 (so expressed as b2k) derived from the Greenland ice cores back to about 48 ka and then from correlations with radiometrically dated lavas and tephras. Calibrated carbon years are effectively the same, as they are linked to the ice-core years but are expressed as years before 1950. Ages in uncalibrated carbon years are younger by about 1600 years at 12 ka and by about 3500 years at around 40 ka. MIS are Marine Isotope Stages (see Chapter 3). There is ongoing debate over the cold phases of the 'Wolstonian', as the type locality may be of a different age, but no better names have yet been agreed for these intervals.

A chronology of the late Quaternary, in the table below, has dates in years BC or AD, or in thousands of years BP (meaning Before Present at the year 2000). The starts of the archaeological periods are diachronous, and these quoted are applicable to the Yorkshire Dales. The last glaciation of the Dales region extended over about 27–16 ka, but was diachronous between valleys and uplands during both advance and retreat.

MIS	*start*	*British terms*	*other terms*	
1	11.7	Holocene		
2	27.5	Late Devensian	Weichselian, Würm	Late Pleistocene
3	59		Upton Warren IS	
4	73	Middle Devensian	cold	
5a	77		Brimpton IS	
5b	90	Early Devensian	cold	
5c	100		Chelford IS	
5d	114	Early Devensian	cold	
5e	126	Ipswichian	Eemian	
6	186	Late 'Wolstonian'	Saalian, Riss	Middle Pleistocene
7	245		Aveley IG	
8	303	Middle 'Wolstonian'		
9	339		Purfleet IG	
10	362	Early 'Wolstonian'		
11	423	Hoxnian	Holsteinian	
12	478	Anglian	Elsterian, Mindel	
13	540			Early Pleistocene
20–14	814	Cromerian		
62–22	1750	Beestonian	Bavelian, Günz	
	2588	Pleistocene start		

MIS	*start*	*stage*	*sub-divisions*	*archaeology*
1		Holocene	Neoglacial = Little Ice Age : AD 1500 – 1800 Medieval Climatic Optimum : AD 900 – 1300 Atlantic : 8.0 – 5.0 ka	Medieval Period AD 400 Romano-British Period AD 100 Bronze Age 2600 BC Neolithic 3900 BC
	11.7		Pre-Boreal and Boreal : 11.7 – 8.0 ka	Mesolithic 9600 BC
2		Late Devensian	Loch Lomond Stadial = Younger Dryas : 12.8 – 11.7 ka Windermere Interstadial = Lateglacial Interstadial : 14.7 – 12.9 ka Last Glacial-Interglacial Transition : 14.7 – 11.7 ka	Palaeolithic from about 45 ka
	27.5		Last Glacial Maximum = Dimlington Stadial : 26 – 19 ka	

***Figure 1.10**. Landsat image of the southern part of the Askrigg Block, in false colour; the more lush plant cover, notably along the cultivated land of the dale floors, shows as brown, and forestry plantations show as dark brown; some of the bare limestone shows in a pale blue tint. As the sun direction is from the south, the north sides of the hills and the south sides of the valleys are in deep shadow. In this image, Ribblesdale lies top to bottom down the centre, with the triangular mass of Ingleborough on its left; Barbondale is in the top left corner; Littondale and Wharfedaleare on the right and converge just off the image.*

and generally harder rocks that lie beneath it in Chapel-le-Dale and Ribblesdale. The number of quarries has declined, but the few large survivors are important employers, and the remaining limestone quarries have little impact on the karst. Extraction of water-worn rockery stone from the limestone pavements was destructive in the past, but this has now ceased completely.

Geomorphology of the Dales

Most of the karst landforms that now occur in the Dales limestones have developed their recognisable morphological features within about the last million years. The same applies to most of the caves, which were no more than very narrow fissures when their evolution is traced back more than the same million years or so. The history of both the surface landforms and the caves therefore spans much of the Quaternary, when the Dales landscape evolved by fluvial erosion that was interrupted by multiple interludes of glacial activity. The chronology of the Quaternary (see box on the previous page) is now reasonably well constrained, not least by the data that have been derived from datable stalagmites in the Dales caves (see Chapter 10).

The dales themselves are fine examples of glaciated troughs with U-shaped profiles that are closest to perfection in Chapel-le-Dale and Wharfedale. However they were occupied by discrete valley glaciers only for short periods during growth and decay of the ice sheets. For much longer periods, ice covered the entire area of the Yorkshire Dales, and ice erosion on the limestone benches above the dales left the bare rock surfaces that were subsequently etched by erosion to become limestone pavements. Elsewhere, the ice deposited and then over-ran thick layers of rock debris and shaped it into the distinctive mounds that are the drumlin fields; those around Ribblehead are among the best developed and best known in Britain, purely as glacial features, unrelated to the karst. Meltwater also provided a powerful erosional force, both beneath the ice sheets and during each phase of deglaciation, and the gorges that it carved have survived in the limestone terrains where they have not been degraded by subsequent fluvial erosion. The impact of the Quaternary ice sheets is apparent throughout the landscape, and the pavements, gorges, dolines and caves combine to create within the Yorkshire Dales a glaciokarst of international significance.

***Figure 1.11**. Kettlewell village, on the floor of the glaciated trough of Wharfedale, seen from the limestone bench on its east flank (TW).*

***Figure 1.12**. The drumlins at Ribblehead, seen beyond the track of the Settle to Carlisle railway that traverses the Dales karst (TW).*

Caves in the Dales

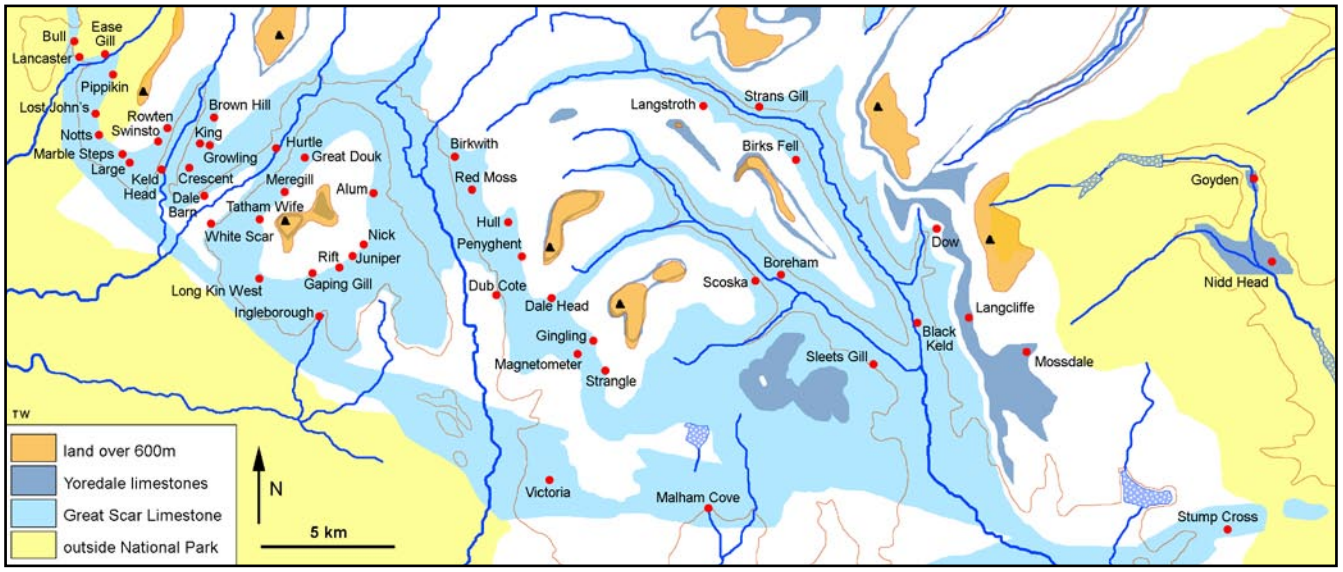
With nearly half the total number of caves currently recorded in Britain, and nearly half the combined length of known cave passage, the Yorkshire Dales karst is a notable cave region. Most of the major caves are in the western half of the Craven Dales (Fig. 1.15), compared to fewer in the east and hardly any known caves in the largest block of limestone, northeast of Malham Tarn. Though depths reached in the Dales caves appear insignificant on a world scale (Georgia's Krubera is nearly ten times as deep), the longest (the Three Counties Cave System) is about number 25 in a list of the world's longest caves. The Dales caves have atmosphere and appeal; their clean-washed streamways descending staircases of waterfall shafts offer sheer spectacle, as well as sport that can be both challenging and enjoyable. And where the active stream caves intersect old and abandoned high-level passages, a caver can walk through silent galleries some of which are beautifully decorated by calcite stalactites and stalagmites.

Many of the Dales caves are known as potholes, or just as pots. Both terms refer primarily to a cave that opens on the surface as a vertical shaft, whereas many that are entered through roughly horizontal passages are named as caves. Confusingly, some caves continue with deep underground shafts and some potholes have extensive passages below their entrance shafts; the name of a feature is no indication of its overall dimensions, but generally refers only to the nature of its entrance. And many others of the great Dales cave systems are just named as holes, which is purely descriptive, avoids any inferences about depth, and casts no aspersions on the spectacular qualities of their underground passages.

***Figure 1.13. M**ain streamway in Lancaster Hole (photo: Paul Deakin).*

***Figure 1.14**. Cow Pot, an open pothole 23m deep from daylight, first descended by the Yorkshire Ramblers in 1899 (photo: Mark Shinwell).*

***Figure 1.15**. Locations of some of the more important caves in the Dales, including most but not all of the longer and deeper systems; at the western end of the karst, all the caves from Bull Pot (of the Witches) to Large Pot are now parts of the Three Counties Cave System.*



Exploration of the caves

Excepting the opening up of Ingleborough Cave in 1837 (Craven, 1999), serious underground exploration in the Dales began only in 1892, when members of the Yorkshire Ramblers' Club enjoyed a golden age, needing only to walk up onto the pristine limestone benches to descend innumerable open potholes and caves (Craven, 2007). This burst of activity was prompted partly by the fact, a shock to local pride, that the great shaft of Gaping Gill was first descended completely by a passing Frenchman in 1895. However, with heavy rope ladders and no private cars, every weekend's caving was a major expedition, journeying out from their home town of Leeds. Only after 1918 were many more clubs formed, each to provide the team effort and the then essential pool of expensive equipment. Notable were the Craven Pothole Club, the Bradford Pothole Club and the British Speleological Association, with the latter eventually making the lion's share of major discoveries, including some caves that were seriously challenging to explore, especially with the equipment available at the time (Craven, 2001).

The same clubs continued activities after 1945, and were joined by many others. The Northern Pennine Club and the Northern Cave Club each began long series of notable and difficult explorations, while the Red Rose Cave and Pothole Club began a protracted and productive involvement with the caves of Ease Gill. The most successful new club was the University of Leeds Speleological Association, which since the 1960s has made numerous spectacular discoveries and also set new standards in producing the cave surveys that are an invaluable scientific output from sporting cavers.

Huge improvements in diving equipment and the introduction of single rope techniques have revolutionised caving to the extent that major new discoveries continue to be made within the Dales. Members of the Cave Diving Group have explored vast lengths of underwater cave passage behind the main resurgences. Meanwhile, no longer needing to rely upon club funds to provide expensive equipment, many cavers have taken to working with groups of friends. One such group, the Misty Mountain Mud Mining Corporation, specialises in digging out the mud and debris that have choked many cave passages over time, and their major success has been in forging some of the missing links that finally made the Three Counties Cave System a reality. This and all the other major caves in the Dales are described and discussed in Volume 2 of this book.

***Figure 1.16**. Stalagmites in Pippikin Pot, Leck Fell, of the type invaluable for dating by their content of uranium isotopes (TW).*

Cave research

Beyond the cave surveys that are produced by every team that discovers a new cave and are invaluable as a basis for various scientific studies, there has been relatively little systematic research within the Dales caves. This is partly because their potentially cold, wet and hostile environment is not conducive to slow and painstaking observation and recording. Archaeological excavations and biological collecting are generally the least restrained because they mostly take place in the entrance zones. The exception in terms of research deep in caves has been the collecting of suitable stalagmite samples for radiometric dating. Laboratory analysis of specific isotopes produced during uranium decay has provided reference age values that have supported establishment of an outline cave development chronology (see Chapters 7 and 10). Scope for future research lies in applying improved and novel dating techniques, and in studying the stable isotopes within stalagmites in order to elucidate data on palaeoclimates. Alongside the laboratory work, detailed geological and geomorphological mapping in some of the larger but slightly more accessible cave systems will continue to provide the evidence required to interpret the evolution of the caves and the surface landforms.

None of the techniques of isotope science, or the results of their application, was available when the predecessor of this volume was published nearly 40 years ago (Waltham, 1974). That so much has changed, and that so much progress

***Figure 1.17**. Straw stalactites in the half-submerged tube of Boreham Cave's high-level passage, discovered by, and still only accessible to, cave divers (photo: Dave Ryall).*

has been made, warranted the preparation of this book. Not only has cave research advanced to new levels of vision and understanding, but the output of chronological data has given caves, in the Dales and elsewhere, a greater prominence in wider studies of the evolution of Britain's landscapes.

Karst adjacent to the Dales

Whereas the Yorkshire Dales region is the prime concern of this book, there are significant caves and karst landforms in many adjacent limestone areas.

The Yoredale limestones continue northwards beyond the Dales and thicken along the Northern Pennines, where they form long narrow outcrops along the flanks of major valleys (Fig. 1.5). The more important of their scattered caves merit a Chapter in Volume 2.

West of the Pennines, Carboniferous limestones form the bedrock in a large area on and around the Arnside peninsula, on the eastern side of Morecambe Bay, but the greater proportion of this is lowland covered by thick glacial and alluvial sediments. Karst is developed only in and on fault-bounded blocks of higher ground, where the limestone pavements include many that are extensive and particularly well developed (see Chapter 5). Between some of the pavements, wetlands floor basins with underground drainage that distinguishes them as the only poljes in Britain (Gale, 1981, 1984, 2000) and maze caves were developed at past water tables in their marginal limestone bluffs (Ashmead, 1974; Waltham *et al*., 1997). On the north side of the bay, the limestones of Furness are notable for large karstic collapse features known as sops that were filled with high-grade iron ore, which has been extracted in its entirety (Rose and Dunham, 1977; Moseley, 2010); a few small caves lie in the flanks of the various limestone hills (Brook *et al*., 1994). On both sides of the bay, small caves have yielded important bone deposits and other archaeological material (Smith, 2012; Wilkinson *et al*., 2011).

The same limestones extend northwards as an incomplete fringe around the older rocks of the Lake District (Fig. 1.2). South of Appleby, the low escarpment of Great Asby Scar has the most extensive of many well-developed limestone pavements (Waltham *et al*., 1997).There are just a few caves recorded along the narrow discontinuous outcrop towards the northwest, and also in limestone around Whitwell in the Forest of Bowland (Brook *et al*., 1994).

***Figure 1.18**. Limestone pavement at Holmepark Fell, one of many extensive pavements east of Morecambe Bay (photo: Simon Webb).*

***Figure 1.19**. A newly collapsed doline on the gypsum at Ripon, in the Vale of York (TW).*

East of the Pennines, karst landforms are developed to a limited scale on various units of younger and weaker rocks. The narrow escarpment of Permian dolomitic limestone, extending from south of Harrogate to north of Darlington, has small-scale underground drainage on its dip slope, and Smeaton Pot and Farnham Cave have the longest known passages (Gibson *et al*., 1976; Lowe, 1978; Speight, 1987). At Knaresborough, the same limestone is cut through by the River Nidd gorge, which contains tufa springs known as the Petrifying Well and some adjacent cave dwellings (Cooper and Burgess, 1993). Permian gypsum, in beds with a parallel outcrop just to the east of the dolomitic limestone, have few visible karst features, except where subsiding and collapsing dolines have caused major damage to buildings and infrastructure, notably in Ripon (Cooper, 1986, 2005).

Across the Vale of York, the ooidal limestones of the Late Jurassic Corallian Group have the best of the karst features in the North York Moors. Beneath the floor of Bransdale, Excalibur Pot has more than 1600m of passages, including a long streamway and multiple high-levels (Douthwaite and Ewles, 2010). It is the only long cave currently known

***Figure 1.20**. The stream passage in Excalibur Pot, in the Jurassic limestones of the North York Moors (photo: Gary Douthwaite).*

Figure 1.21. *The Main Chamber the Gaping Gill Cave System with Fell Beck in full flood forming an unusually large waterfall from daylight (photo: Paul Deakin).*

beneath the Moors, but is probably indicative of many more caves yet to be discovered in the Corallian limestones. The nearby Kirkdale Cave, developed at a similar horizon, has a small maze of abandoned bedding passages, which gained significance when Ipswichian bone deposits were excavated from them (Boylan, 1981; McFarlane and Ford, 1998). Farther west, the scarp edges of the Hambleton Hills, also formed in Jurassic rocks, are noted for their many Windypits, with vertical shafts that descend into deep and long fissures and rift passages; however these are primarily landslip fissures where dissolutional enlargement has been minor or negligible (Cooper et al., 1976; Gibbs and Stewart, 2003; Murphy and Lundberg, 2008.).

The Chalk surface of the Yorkshire Wolds has a well developed fluviokarst with numerous dry valley systems (Waltham et al., 1997), but no caves are recorded within it, other than sea caves, most notably at Flamborough Head.

Though the eastern part of Yorkshire contains a host of contrasting karst landforms within its various soluble rocks, none compares to the spectacular glaciokarst and extensive cave systems of the Dales.

References

Ashmead, P, 1974. The caves and karst of the Morecambe Bay area. 201-226 in Waltham, *op. cit.*

Boylan, P J, 1981. A new revision of the Pleistocene mammal fauna of Kirkdale Cave, Yorkshire. *Proc. Yorks. Geol. Soc*., **43**, 253-280.

Brook, D, J Griffiths, M H Long and P F Ryder, 1994. *Northern Caves 3: The Three Counties System and the North-west*. Dalesman: Lancaster, 287pp.

Burt, T P and B P Horton, 2003. The climate of Malham Tarn. *Field Studies*, **10**, 635-652.

Cooper, A H, 1986. Subsidence and foundering of strata caused by the dissolution of Permian gypsum in the Ripon and Bedale areas, North Yorkshire. *Geol. Soc. Spec. Publ*., 22, 127-139.

Cooper, A H, 2005. Remediation of a sinkhole over gypsum in Ripon, UK. 272-276 in T Waltham, F Bell and M Culshaw, *Sinkholes and Subsidence*, Springer: Berlin.

Cooper, A H and I C Burgess, 1993. Geology of the country around Harrogate. *Mem. Brit. Geol. Surv*., Sheet 62.

Cooper, R G, P F Ryder and K R Solman, 1976. The North Yorkshire windypits: a review. *Trans. Brit. Cave Res. Assoc.*, **3**, 77-94.

Craven, S A, 1999. A history of cave exploration in the Northern Pennines, United Kingdom, up to 1838. *Cave Karst Science*, **26**, 53-59.

Craven, S A, 2001. The British Speleological Association (1935–1973) and its founder Eli Simpson: with particular reference to activities in the northern Pennines of England. *Cave Karst Science*, **28**, 99-112.

Craven, S A, 2007. History of cave exploration in the Northern Pennines of England: the work of the clubs 1892–1945. *Cave Karst Science*, **34**, 23-32.

Douthwaite, G and M Ewles, 2010. Excalibur's hidden secrets. *Descent*, 213, 20-22.

Gale, S J, 1981. The geomorphology of the Morecambe Bay karst and its implications for landscape chronology. *Zeitschrift Geomorphologie*, **25**, 457-469.

Gale, S J, 1084. Quaternary hydrological development in the Morecambe Bay karst, northwest England. *Norsk Geografisk Tidsskrift*, **38**, 185-192.

Gale, S J, 2000. *Classic landforms of Morecambe Bay*. Geographical Association: London, 48pp.

Gibbs, J and R Stewart, 2003. *Moorland caver: a guide to the caves and windypits of the North Yorkshire Moors*. JMG: Cleveland, 76pp.

Gibson, R, M Bliss and R Shackleton, 1976. Caves of the Magnesian Limestone. *J. Yorks. Subterranean Soc*., 1, 9-22.

Lowe, D J, 1978. Farnham Cave, a rift cave in the Magnesian Limestone. *Trans. Brit. Cave Res. Assoc*., **5**, 23-28.

McFarlane, D A and D C Ford, 1998. The age of the Kirkdale Cave palaeofauna. *Cave Karst Science*, **25**, 3-6.

Moseley, M, 2010. The metalliferous mines of Cartmel and south Lonsdale. *British Mining* (Northern Mines Research Society), 89, 104pp.

Murphy, P J and J Lundberg, 2008. Uranium series dates from the Windypits of the Noth York Moors: implications for late Quaternary ice cover and the timing of speleogenesis. *Earth Surface Processes Landforms*, **34**, 305-313.

Rose, W C C and K C Dunham, 1977. Geology and hematite deposits of South Cumbria. *Econ. Mem. Geol. Surv. G. B*., Sheet 58.

Smith, I R, 2012. Kirkhead Cavern, Kent's Bank Cavern and Whitton's Cave near Allithwaite: geology, sediments and archaeology. 98-102 in H J O'Regan, T Faulkner and I R Smith (eds), *Cave Archaeology and Karst Geomorphology in North West England: Field Guide*. Quaternary Research Association: London.

Speight, A, 1987. Smeaton Pot. *Caves and Caving*, 35, 33-35.

Waltham, A C (ed.), 1974. *Limestones and Caves of North-west England*. David and Charles (for British Cave Research Association): Newton Abbot, 477pp.

Waltham, T, 2007. *The Yorkshire Dales Landscape and Geology*. Crowood: Marlborough, 224pp.

Waltham, A C, M J Simms, A R Farrant and H S Goldie, 1997. *Karst and Caves of Great Britain*. Chapman & Hall (for Joint Nature Conservation Committee): London, 358pp.

Wilkinson, D M, H J O'Reagan and J Thorp, 2011. Dogs, scouts and cavers: a history of archaeological excavation at Dog Hole Cave, Haverbrack, Cumbria, UK. *Cave Karst Science*, **38**, 125-130.

Figure 1.22*. The main passage in Sleets Gill Cave is dry and abandoned except when it fills to the roof in times of flood; its size may be taken as an indication that there are many more caves awaiting discovery in the great block of limestone between Malham and Littondale (TW).*