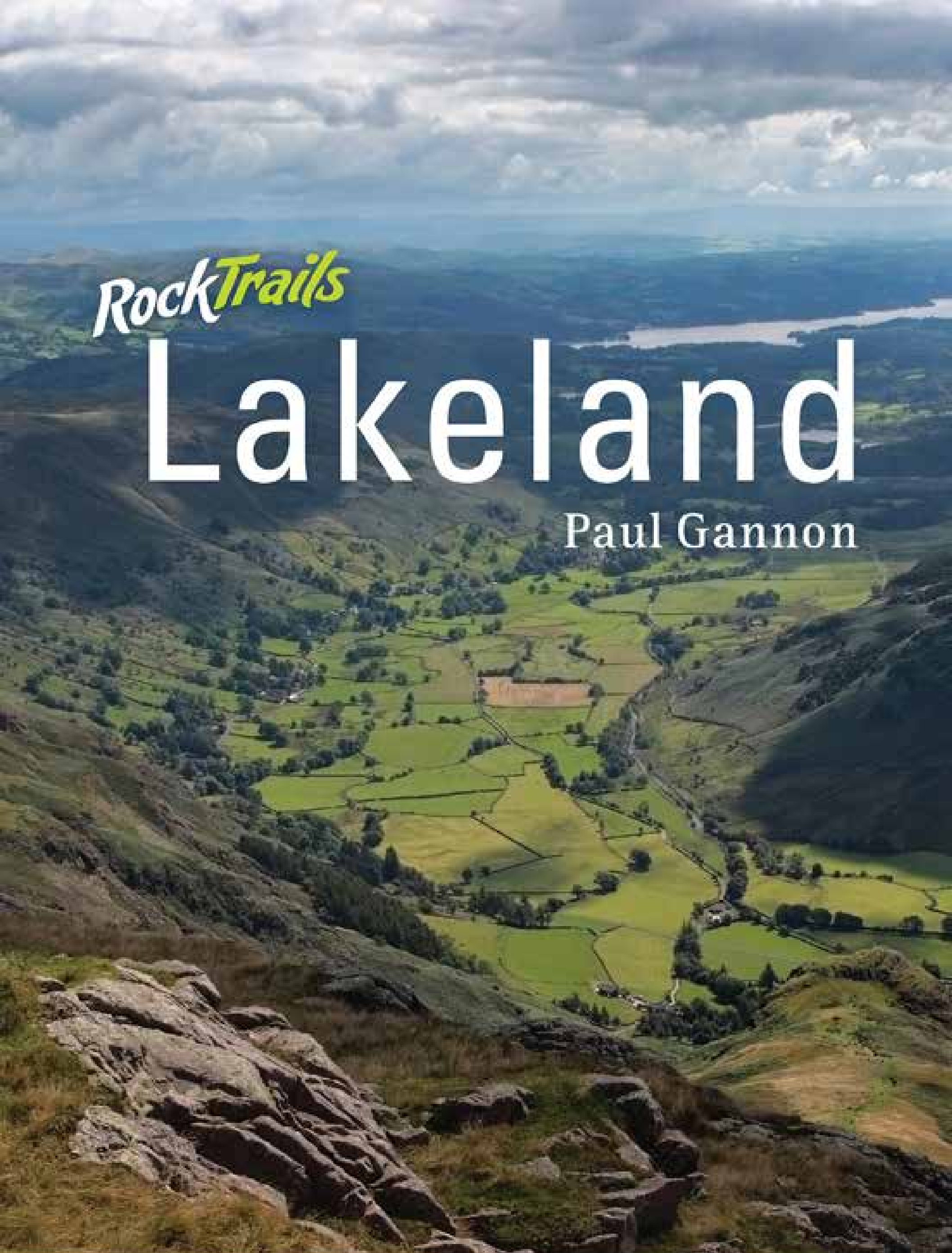
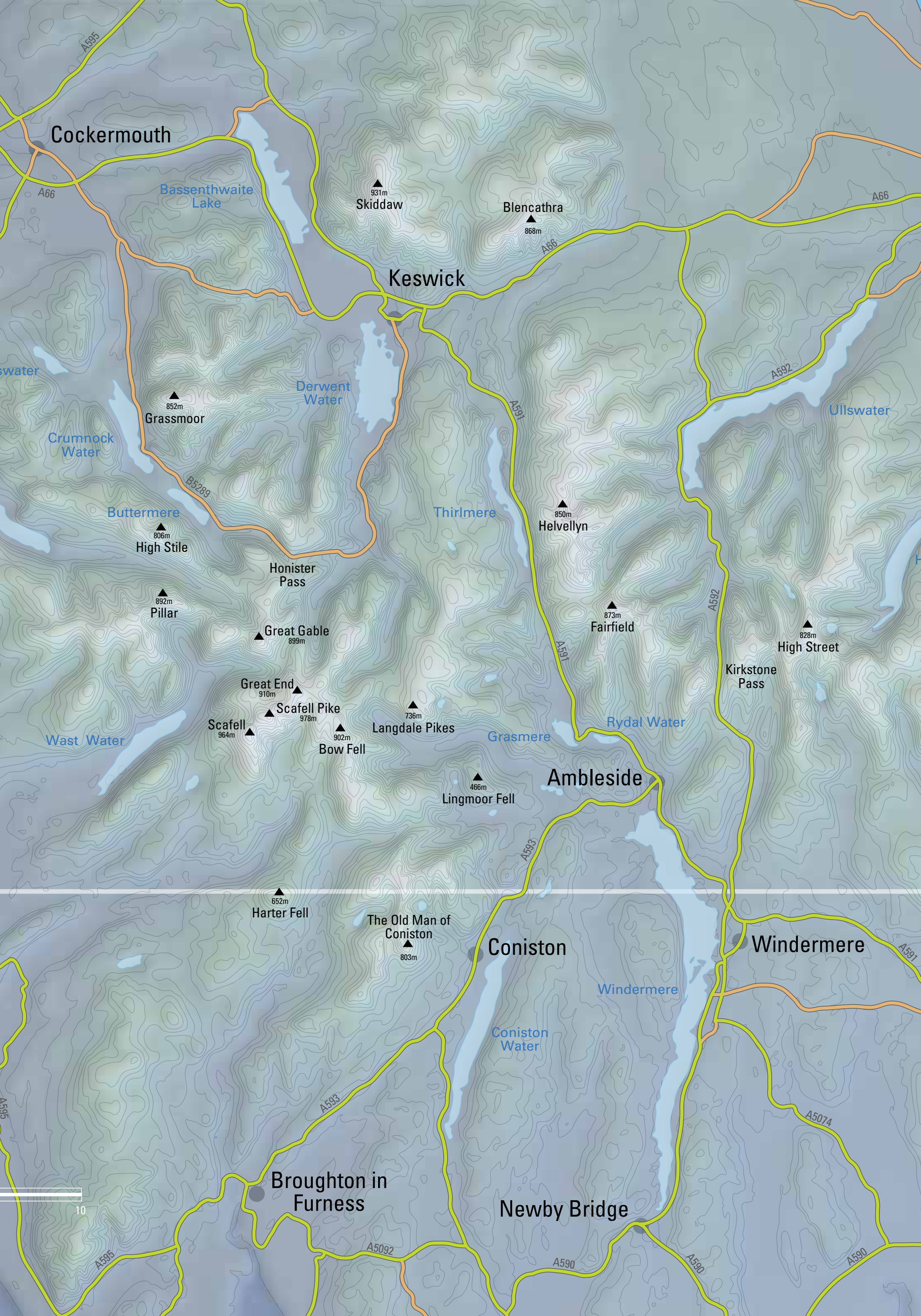


Rock Trails

Lakeland

Paul Gannon

A HILLWALKER'S GUIDE TO THE GEOLOGY & SCENERY



Cockermouth
A595
A66
Bassenthwaite Lake
931m
Skiddaw
Blencathra
868m
A66
Keswick
A66
swater
852m
Grassmoor
Derwent Water
A591
A592
Ullswater
Crumnock Water
B5289
Buttermere
806m
High Stile
Thirlmere
850m
Helvellyn
Honister Pass
892m
Pillar
Great Gable
899m
873m
Fairfield
A591
A592
828m
High Street
Kirkstone Pass
Great End
910m
Scafell Pike
978m
736m
Langdale Pikes
Scafell
964m
902m
Bow Fell
Wast Water
Grasmere
Rydal Water
Ambleside
466m
Lingmoor Fell
A593
652m
Harter Fell
The Old Man of Coniston
803m
Coniston
Windermere
A591
Windermere
Coniston Water
A595
A593
A5074
Broughton in Furness
10
Newby Bridge
A595
A5092
A590
A590
A590

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Reg, Debbie, Roland, Barbara;
Charlie, Antony.
Lakeland lovers all.

Classic Lakeland scenery – a glacial valley carved into tough volcanic rock. Upper Langdale from Rosset Pike.

Contents

Introduction

The Lake District is England's best-loved mountain landscape. It has long been celebrated by poets and writers, adored by fellwalkers and tourists, and venerated by connoisseurs of scenic natural landscapes. The raw compelling beauty of its long narrow lakes, steep-sided valleys and soaring fells has drawn a multitude of visitors over the last three centuries or so. Many of the twelve million people who today visit the area each year do so in order to trek up and down the steep fellsides. They follow in the footsteps of many earlier visitors as well as many generations of inhabitants.

Some of those many fellwanderers wonder why the landscape looks like it does. What created this spectacular tension between fell and valley, rough craggy ridge and smoothly sloping fellside, flat valley floor and hummocky low land, ribbon-shaped valley lake and tiny, rounded mountain tarn?

Photo 0.1 Scafell Pike and Scafell, seen from Esk Pike.

This book aims to help fellwalkers and other visitors answer these questions. The book is in two parts. The first records the fascinating story of how colliding continents, violent volcanoes, irresistible mountain-building forces and intensive glaciation combined to shape the landscape we see nowadays. I attempt to explain why these volcanoes occurred, what sort of rocks they created and how to recognise signs of mountain-building and glaciation on the fells and in the valleys. The second part of the book contains fifteen recommended walks of differing levels of difficulty, with a wide variety of geological features, allowing you to enjoy consistently excellent views of the best of Lakeland's wonderful natural scenery.

Photo 0.2

Pike o' Blisco. Lakeland's popular mountain scenery is the creation of fire and ice.

Great pleasure can be had from walking the fells by appreciating something of the combined influence of volcanoes, glaciation and erosion on the present-day landscape. The book concentrates on what you can see as you walk, without recourse to a hand lens or other special tools. The aim is to enable the reader to identify major and minor features in Lakeland and elsewhere. The landscape is the product of many different forces and factors. Identifying and unravelling these is an endlessly fascinating pastime for the landscape lover.

While geology is fascinating, it relies on a complex scientific terminology. My aim has been to minimise the use of jargon to aid the hillwalker's understanding. This has meant some simplification of the jargon and a pruning of the detail to a minimum. However, I'm afraid we will still have to deal with a minimal set of terms such as 'plate tectonics' and 'fissure-vents', 'magma' and 'intrusive' rocks and 'ice sheets' and 'moraines'.

Geological jargon, when first used, is set in single quotes (e.g. 'lava'). Although many of these terms are defined in the Glossary, I have also sometimes assumed that the meaning is often obvious from the context. In a few cases single quotes have also been used to identify everyday idiom, such as a 'blob' of magma.

While reading the book, the reader may well find it useful to have a large scale map of the Lake District (such as the OS Touring Map 3 1:63,360 or the Harvey 1:40,000) to hand. Both these maps convey a good impression of the topography and will assist in locating the places mentioned in the text (with the help of the index of place names at the back of the book which includes grid references).

CHAPTER 4

Making Mountains

The convection currents within the mantle continued to drive the two tectonic plates carrying Avalonia and Laurentia towards one another, even after the Iapetus oceanic plate had been fully subducted. The result was a collision of continents and the building of the Caledonides, a massive mountain range which included the mountains of the Lake District.

This mountain range is named after the Scottish Highlands which were created at the same time and in the same way, as were the Welsh mountains, those of Scandinavia and, on the eastern flank of northern America, the Appalachians.

We saw in the last two chapters how the collision of the Iapetus oceanic plate with the Avalonia continental plate had led to subduction of the oceanic plate and the generation of

Photo 4.1 The view north from Scafell, depicting the rugged heart of Lakeland's mountainous scenery (Great Gable, centre right).

volcanic activity. Something similar had happened in the west, where the Iapetus Ocean was also subducted under the Laurentian continental plate, again leading to volcanic activity.

When the oceanic plate had been fully squeezed underground by the converging continental plates, the continents were crumpled up against one another. The solid layers of rock making up the continents were subjected to enormous forces over a very long period of time. As previously pointed out, the plates move only a few centimetres a year. Over several million years, however, this amounts to considerable distances of 20 to 100 kilometres every million years.

We know from experience that rock is likely to shatter if subject to a sudden force, say from being struck hard with a hammer – it is brittle. However, when rock is subject to long but relentless pressures it can behave very differently. It behaves in a 'ductile' fashion, that is it can fold and even flow (as also happens in the mantle to create convection currents).

The collision of the continents was initially fairly restrained. The outer parts of the continents, the thin continental slope and volcanic 'island arcs' met first and began to fold and crumple. Then the main, much thicker, parts of the continents were driven closer to each other. The rocks piled unrelentingly into one another, crushing and buckling the weaker rocks more than the tougher rocks, but all were affected. The area where the continents meet gets

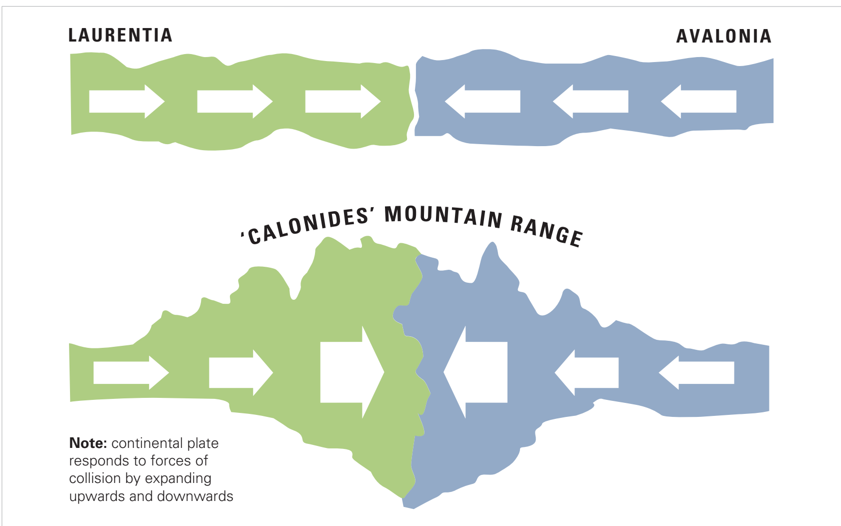


Diagram 4.1 | Continental plate collision.

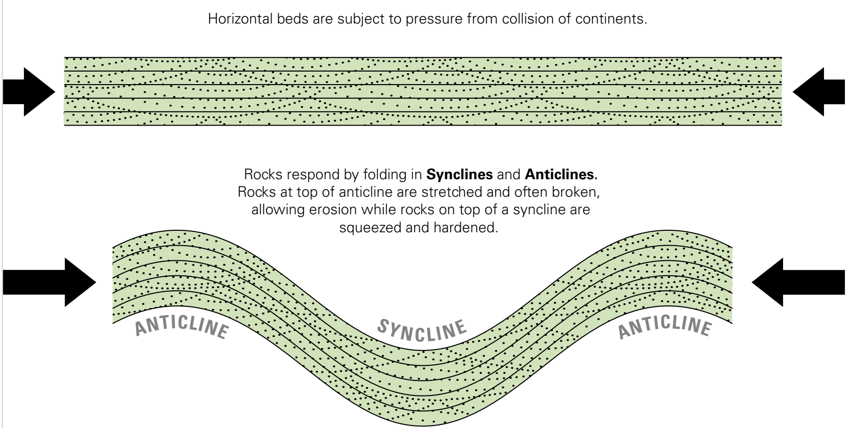


Diagram 4.2 | Synclines and anticlines.

progressively thicker, pushing up some of the rocks into massive mountain ranges (and also thickening downwards to an even greater extent than upwards). Faults are reactivated or created anew and sometimes, as happened with the Skiddaw Group rocks, deeper layers of rock were thrust up on top of newer layers. The intense pressure and heat caused some melting of the lowest part of the plate to become molten magma that then rose, if at all, only some way up through faults before getting stuck and cooling to become granite (a thick-grained 'rhyolitic' rock). The heat also 'cooked' some of the rocks causing chemical changes, and the enormous pressures generated and imposed on the rock turned fine-grained rocks into slate. These last two effects are known as types of 'metamorphism' where rocks are transformed in their state in some way.

The beds of rocks were folded into dips ('synclines') and rises ('anticlines') that can sometimes be detected into today's scenery. Some were shattered (most likely along existing fault lines) and others thrust above one another, even turned upside down. We can see this process of mountain-building happening today before our very eyes in the Himalayas (a result of India impinging on Asia) and in the closer to home Alps (a result of the clash of Africa with Europe).

Powerful pressures were exerted close to the continental edges including, of course, the area that became Lakeland. The sedimentary Skiddaw Group rocks were softer and less able to resist the pressures exerted by the collision than the harder volcanic rocks of the Borrowdale Volcanic Group (BVG). The result was that the Skiddaw Group rocks were intensely folded and broken up with major sections thrust upwards above younger rocks along fault lines. The evidence for this can be discerned in places, especially in Gasgale Gill and on Hopegill Head and Whiteside, the ridge which forms the northern side of the gill. The thrust line is clearly visible at the base of Gasgale Crags, high up the valley side (see Walk 1).

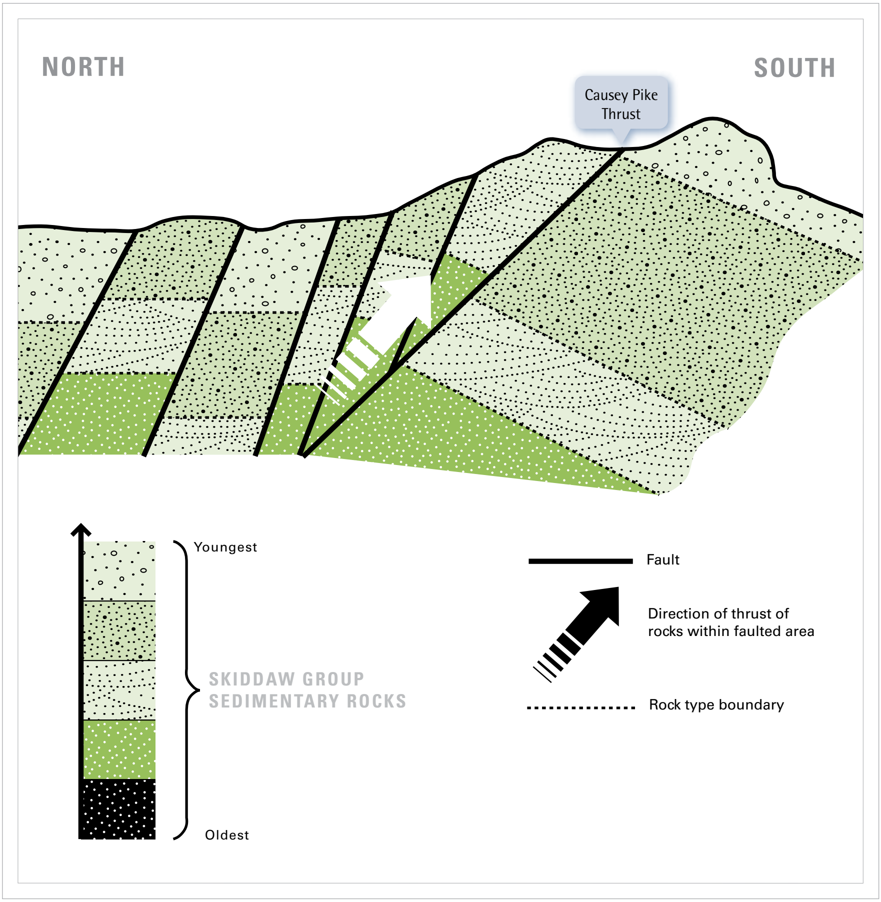


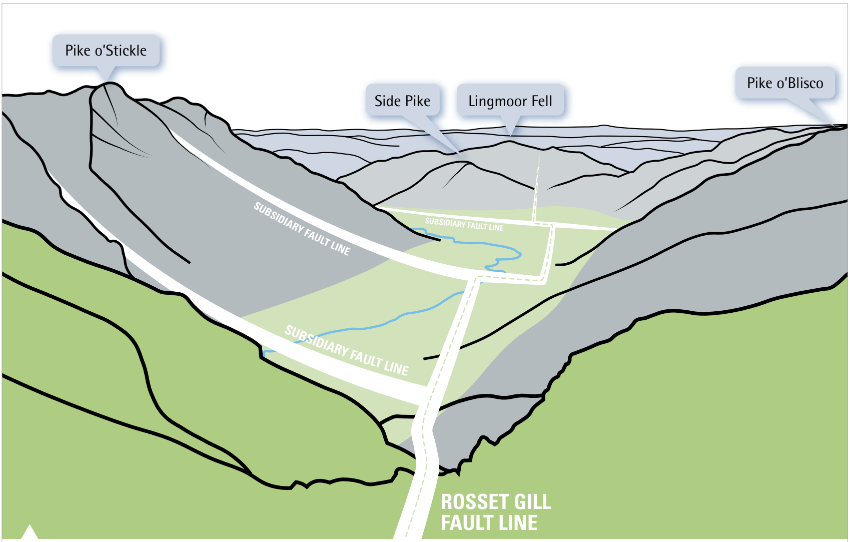
Diagram 4.3 | Folding and thrusting in Skiddaw Group rocks.

Photo 4.2 | Syncline in Skiddaw Group sedimentary rocks exposed on the summit of Hopegill Head.

Photo 4.3 | Small-scale folding in Skiddaw Group sedimentary rocks, Whiteside.

It is also possible to spot in places some of the folds in the rocks and the several anticlines and synclines that run across the Hopegill Head/Whiteside ridge. Indeed, just a few metres west of the summit of Hopegill Head, it is possible to look back up to the summit along the ridge line to see that the top-most rocks are the base of a syncline (see Photo 4.2). The Gasgale Thrust can also be detected further east, cutting through Hopegill Head, Grisedale Pike and the ridge that heads into Hospital Plantation.

Another major thrust line is known as the Causey Pike thrust and runs right across the district. It trends from west-south-west to east-north-east from Crummock Water (on the southern slopes of Rannerdale Knots, Wandope, Sail and Scar Crag) before heading north through the summit of Causey Pike, then resumes a west-south-west to east-north-east trend, eventually petering out near Swinside (south-west of Keswick). Two further thrust



Viewed from The view from Rosset Gill along the line of Mickleden towards Lingmoor Fell.

Diagram 4.4 & Photo 4.4 | Looking along the line of the Rosset Gill fault from Rosset Gill, along Langdale towards Lingmoor Fell. The line of the fault can just be seen as a dark streak on Lingmoor Fell.

faults are found a bit further north-west between the Gasgale Thrust and the present-day town of Cockermouth.

It's worth pointing out that when rocks are folded into anticlines and synclines, the rocks on the top of an anticline are stretched, being on the outer side of a curve, while the topmost rocks of a syncline are compressed (and vice versa for the underside rocks in each case). The stretching of the topmost rocks on an anticline weakens them and cracks them open, giving a head start to the forces of erosion, opening up the lower layers of rock to eventual exposure on the surface. On the other hand, the topmost rocks of a syncline are compressed and thus hardened, making them more resistant to erosion.

This leads to the counter-intuitive effect of anticlines often (but not always) being found in well-eroded areas and synclines often (but not always) being found at the higher points (such as on the summit of Hopegill Head, as seen in Photo 4.2). Both Scafell and Snowdon, the respective highest points in their own regions, are centred close to synclines created by mountain-building forces along calderas created by volcanic activity which took place along those ancient faults – lines of tectonic weakness..

The Scafell syncline trends from north-east to south-west and accounts for the general tilt of bedding that is often seen in rocks in the area (for example on Bowfell as seen on Walk 6). This is a wide and fairly shallow syncline, not a sharp and closely spaced one as seen in the sedimentary Skiddaw Group rocks. This is because the volcanic rocks were more resistant and could better withstand the forces generated by the collision of the continents. Another major syncline, the Ulpha syncline, cuts across often rolling moorlands of Ulpha Fells to the south.

The great pressures exerted by continental collision also caused up and down movements along re-activated ancient faults and on new ones. One particularly important fault, the Rosset Gill fault, runs right against the general trend from north-west to south-east. Its effects on the landscape are obvious in many areas, from Ennerdale, Aaron Slack, Esk Hause, Rosset Gill, Mickleden and across the south-western flank of Lingmoor Fell.

Other major faults run through Eskdale, Upper Langdale, Whillan Beck, Greendale, Greenburn, Grassguards, Baskill, Park Gill, Stockdale, Coniston and Brathay. Sideways earth movements of up to 75m are not unusual (for example, on the Broad Stand fault on the south-east of Scafell) and up to 900m in a few instances (on the Great Langdale Fault). Elsewhere, there have been vertical earth movements along faults of as much as 500m in the granite areas (see below) and among the southern sedimentary rocks.

The faults can often be traced in the landscape over a range of features that together form a longish line. The Eskdale fault runs up through Eskdale, the Wrynose pass and Little Langdale area until it terminates on the Coniston fault zone. It cuts through the granites exposed in the area as well as the Borrowdale Volcanic Group rocks. Some of the Lower

BVG rocks are displaced vertically against one another in the Hard Knott/Wrynose area, with the rocks on the northern side of the fault about 70m lower than their equivalent on the southern side. These faults have often been the site of later deposition of metallic minerals, later mined for copper and lead (see Chapter 8).

The Coniston Fault zone is another of the major fault structures in Lakeland, stretching some 40km from north to south. Major features are spread along the fault zone, including the valleys of St John's in the Vale, Thirlmere (rising to a high point at Dunmail Raise), the valley of the Rive Rothay to Grasmere (another high point at the shoulder between Loughrigg Fell and Silver Howe) and down to and beyond Coniston Water. This major fault zone is believed to have been 're-activated' around 250 million years ago, becoming the site of later earth movements.

The slightly curved Grassguards fault runs from just south of Grassguards Gill, Long-house Gill and Brown Pike. This is thought to be the northern limit of the basin created by the final eruptions of the Upper BVG rocks, the Duddon Basin Succession. The vertical movement along the fault is over 500m, with the rocks to the north of the fault line being lower than those to its south.

As well as the major faults, there are scores of minor ones where earth movements have been less catastrophic, but have still contributed to the shaping of the present day landscape, resulting in minor crags and shallow hollows. These often occur in complex patterns as earth movements along faults have shunted softer and harder rocks into complex arrangements. The faults themselves have also been exploited by forces of erosion, especially ice, to create gullies and valleys.

Photo 4.5

Piers Gill on Scafell Pike.

Photo 4.6 Tilted rocks seen on Bowfell.

One consequence of all these earth movements along fault lines has been to smash the rocks on either side of the fault and to create what geologists call a 'fault-breccia'. These can be up to 100m wide and during the ice ages provided weak points along which glacial ice could carve deep gullies into the rock. This is a common feature of the Lakeland landscape. Such gills are seen on Walk 3 (following Piers Gill on Scafell Pike) and Walk 6 (following Hell Gill on Bowfell, Walk 5, descending Aaron Slack between Great Gable and Green Gable on the line of the Rosset Gill fault).

The folding, tilting and faulting during the mountain-building episode have had a considerable effect on the shape of the landscape that we see today. The great tilt of the rocks forming the Scafell syncline are often quite easy to see, such as on Bowfell or the Langdale Pikes (see Photos 4.7 and w7.7).

Another consequence of the forces generated by continental collision, the creation of slate, has less immediate effect on the topography. The very great pressures generated by the collision of the continents squeezed the tiny minerals making up the fragments of deposited particles in sedimentary rocks. This caused the minerals to change their positions so that they all ended up with their flat faces lined up in the same plane; what is called the 'cleavage plane'. These rocks then split easily along the cleavage planes, producing slate. Some of this slate is worth extracting for roofing or building material, but only a small proportion of it.

Photo 4.7 View of Crinkle Crags and Bowfell. The general tilt of the beds from upper left to lower right is clearly visible, as are deeply incised glacial meltwater channels along fault lines.

The finer the mineral grains (as found in mudstones), the more effectively that good cleavage planes are created and the more likely the rocks are to produce good slate. Slightly bigger mineral grains (as found in siltstones) are less likely to produce good slate, but may well still display cleavage. Coarser mineral grains (as found in sandstones) may not produce any cleavage at all.

I wrote a few paragraphs above that the creation of slate has a less immediate effect on the landscape than thrusting, folding and faulting. However, slate does have consequences for scenery in the longer term. First, cleavage planes in general tend to provide a form of weakness which can be exploited by the forces of erosion. Second, slate is attractive for human use and has led to the development of slate quarries which have left pretty conspicuous effects on the landscape and in the style and colour of the buildings of the area. As the extraction of saleable slate usually involves the quarrying of up to nine or ten times as much unusable slate material, it also involves the creation of large waste tips near slate quarries and mines.

It is worth noting that slate is indeed mined as well as quarried. It is often assumed that a mine in the Lakeland area must be the site of metal extraction, but this is not necessarily the case. Slate is, or has been, mined at Honister and on the southern flanks of Loughrigg Fell, Coniston and elsewhere. Several old slate mines are passed when walking along Loughrigg Terrace, leaving only waste tips and bigger or smaller mine entrances. The waste tips are worth looking at (with very great care if you are tempted to clamber up onto them) for small lumps of the beautifully bedded rocks of the Seathwaite Fells formation.

The story of the collision of the continents does not end there. Underlying the whole area are believed to be substantial sheets of an intrusive rock: granite. The biggest concentrations of granite are thought to have been intruded about 450 million years ago. Some smaller areas (such as the granite around Shap) were probably intruded later, towards the end of the mountain-building events, possibly when the lowest extension of the continental plate during downward thickening of the plate was turned into molten magma.

Granite is a large-grained rock, a feature that arises because of its slow cooling low down in the Earth's surface. It is also a rhyolitic, light-coloured rock (often pinkish in colour). Although such granite is believed to lie underneath the whole of the Lake District it is only exposed in a few places, mainly to the west (see Walks 11 and 14). Where it does crop out, it generally produces a low, rolling moor-like landscape that is found in places such as Ulpha Fell and Birker Fell.

The presence of granite under much of the Lakeland area is inferred from 'gravity anomaly' readings performed by geophysicists with sensitive gravity measuring devices. The results

Photo 4.8 Looking out from a slate mine entrance on Loughrigg Fell, now closed to the public because of recent rock falls.

led them to believe that the granite formed a single massive blob (a 'batholith') underlying the whole Lakeland area. This presented them with a problem, in that this blob would have had to have been far, far greater in mass than all the erupted material. However, according to the theory of volcanic systems and continental plate collision, this could not really be the case as granite is thought to be produced in comparatively small volumes at the end of the cycle, not in vastly greater amounts.

The interpretation of the magnetic anomaly readings has been revised and it is thought today that the granite consists of separate sheets intruded between layers of rock ('laccoliths'). The combination of the sheets plus their sandwich filling of sedimentary or volcanic rocks are now thought to give the same type of gravity anomaly reading as a single granite mass.

The mountain-building era lasted for several million years, eventually drawing to a close some 300 million years ago. By then, the area had been shaped into part of the Caledonides. This was a massive range of mountains, at least as high as the Alps and possibly even as high as the Himalayas. The very process of crushing and twisting the rocks into such mountains had, at the same time, the effect of opening the rocks up to erosion.

Photo 4.9 | Granite outcrop, Low Rigg; High Rigg in the right background.

Photo 4.10 | Birker Fell: granite topography with tuff terrain of the central fells in the distance.

In the millenia since then, the area has at times been above sea level and sometimes below it. When it was above sea level, it was subject to erosion. When it was below sea level it was subject to deposition of sediments and thus, over time, to the creation of new rocks.

Few traces of those new rocks are left (except for some mineral deposits in fault zones) as they have been fully eroded away. For instance, it is believed by many geologists that during the era known as the Cretaceous, there must have been such widespread deposits of sediments that the whole of Britain would have been covered by chalk. This white rock only now outcrops in southern and eastern England and, if geologists are correct, it has been entirely eroded away from the rest of Britain including the Lake District. The same may also apply to other rocks.

The overall course of events has been the erosion of rock in the area, slowly exposing the deeper and deeper layers of rock, uncovering the ancient layers of the Borrowdale Volcanic Group rocks and the even earlier sedimentary rocks of the Skiddaw Group. The net effect of earth movements and erosion has been to expose, along the surface of the Earth, a slice through what was originally a vertical layer of rock, bringing to our attention the oldest through to the youngest rocks of the area.

This process took place about three hundred million years. It is of course impossible to appreciate fully what such long periods of time actually mean. Castlerigg stone circle is about 5,000 years old. At roughly the same time, stone axes were being hewn out of the volcanic rocks of the Langdale Pikes. Both are 'pre-history', reaching way back before even any retained folk memories let alone written records. However, 5,000 years is nothing, a mere momentary twinkle, compared with 3 million years (let alone 300 million). The net result is that we really have little or no idea what the landscape looked like a long time ago.

The last ice age ended about 10,000 years ago and was only the latest of a long run of ice ages that stretches back somewhat more than a million years. We will look in the next chapter at what the ice age did to the landscape and at the multiplicity of features that it produced. However, as to the original shape of what the glaciers did their work on, we have really very little to go on.

A few hints are gained from the gentle curving slopes of the eastern flank of the Helvellyn range or the summit area of High Street. These are probably surviving pre-glacial surfaces and suggest that the millions of years of erosion since the events described in the last chapter and this chapter left a rounded upland plateau area with gentle slopes and shallow valleys. These dips probably followed the course of present day valleys by and large. However, the scenery was probably nothing like the landscape we know and love today with its sharp plunging slopes and deep glacial trenches.

Walk #1

Gasgale Gill & Hopegill Head

START		LANTHWAITE GREEN 159 207 (BUSES SERVE BUTTERMERE)
FINISH		CIRCULAR ROUTE
TIME		5 HOURS+
GRADE	NAVIGATION	●●●○○
	TERRAIN	●●●○○
	SEVERITY	●●●●○

This walk takes you through and over some of the most dramatic of the scenery created by the sedimentary rocks that dominate the northern and north-western fells, collectively known as the Skiddaw Group. Skiddaw Group rocks make up popular peaks such as Grasmoor and Causey Pike, as well as Skiddaw and Blencathra on the Skiddaw massif.

Gasgale Gill & Hopegill Head

I have picked this walk to introduce the Skiddaw Group for several reasons. The Skiddaw Group rocks in themselves are not overly exciting, lacking features that make for easy identification (indeed geologists point out that the Skiddaw Group sedimentary rocks look very much like some of the sedimentary rocks found within the Upper Borrowdale Volcanic Group). However, on this walk you encounter a wide range of geological features, including the line of a major 'thrust' fault, bedding, slumped bedding, slaty cleavage and folded rocks. These features come with excellent views and good walking.

The walk follows two outstanding scenic gems: the intensely enclosed atmosphere of Gasgale Gill, especially in its lower reaches, and the fantastically airy ridge walk between Hopegill Head and the western end of Whiteside. Both are expressions of important geological structures and processes.

Gasgale Gill partly follows the line of a fault, while on the valley slopes to the north of the beck there is a major thrust fault. Along the ridge top there is evidence of convoluted bedding due to intense folding and thrusting of the rocks. Right on top of the ridge, just below the summit of Hopegill Head, you can see the axis of a syncline in the rocks. The ridge line is also a boundary between two different 'formations' within the Skiddaw Group. There is also indirect evidence of a massive underground intrusion of granite.

The Skiddaw Group used to be known as the Skiddaw Slates. While the Skiddaw Group is made up of a variety of sedimentary rocks, many of which display slaty cleavage, not all of them do so. Even those Skiddaw Group rocks which have been affected by cleavage are not worked commercially. The slate extracted from Lakeland quarries is taken from sedimentary rocks interleaved between the volcanic rocks of the Borrowdale Volcanic Group. So, although the rocks seen on this walk are 'slaty', they are not exploited for slate.

The walk starts by going up Gasgale Gill (a deep etching into the mountains on either side), Hopegill Head and Whiteside to the north and Grasmoor to the south. (Those starting from Buttermere could instead miss out Gasgale Gill and reach Hopegill Head via an ascent of Grasmoor.) The Gill is easily viewed from the surrounding high land, especially between Hopegill Head and Whiteside. Although many of the macro-features can be seen from above, a walk through the Gill is an entrancing alternative approach showing an all too often neglected aspect of the geology and scenery of the area.

From the start point, head roughly west up an obvious track towards the start of Gasgale Gill, aiming for the footbridge at 163 209. Cross the footbridge and turn right to follow the lower level path into the narrow entrance to the gill with the beck on the right. Initially the gill is very steep-sided, pressing in almost canyon-like, providing a highly atmospheric start to the walk. The narrow valley is almost claustrophobic in intensity especially when the beck is in spate and it is difficult to avoid having one's attention drawn back and forth between the speeding waters and the looming crags overhead (see photo w1.1). Some minor scrambling is necessary at the beginning in one or two places and care is needed, but any slight difficulties are soon over.

Photo w1.1 Gasgale Gill, with smooth slabs exposed on one side of the valley (looking downstream).

Photo w1.2 Gasgale Gill, with rough, craggy edges exposed on the other side (looking upstream). Hopegill Head is in the centre distance.

The crags on either side of the gill are tilted in the same general direction, from lower left to upper right as you turn round and look back down the valley. This can be seen in the different shape of the outcrops on either side in this narrow section. To the right (south) the beds are exposed, tilted at about the same angle as the slope and leaving a smooth surface. However on the left, a cutting across the beds is exposed, leaving a craggy surface as each has been broken roughly through. This is illustrated in photos w1.1 and w1.2; note, however, that photo w1.1 is looking downstream while photo w1.2 is looking upstream.

In this narrow section, keep an eye on the outcrops to the left. Bedding can clearly be seen in some of the rocks forming the lower parts of the crags above. In some places the bedding has clearly slumped, the result of earthquakes causing downwards sliding of still not fully solidified beds of sedimentary deposits.

After a while the gill opens out, losing its deep canyon-like aspect due to a shallowing of the valley sides, especially on the southern side below the glacial corrie and cliffs of Dove Crag below Grasmoor. This is caused by the changing underlying geology with softer rocks being exposed in the widened area of the valley.

Higher up the gill, the side walls again begin to close into a sharp V-shape and there is an obvious knick point at a rock step across the beck, producing a waterfall. Here is a good point to turn around, if you haven't already done so, to look down the valley towards Gasgale Crags on the right. The base of the crags marks the line of a major thrust fault, the Gasgale Thrust, that we will mention again later on when talking about several linear features running through the gill.

Shortly after resuming the upward slog you arrive at Coledale Hause, a complex col linking Crag Hill and Grasmoor to the south and Hopegill Head and Grisedale Pike to the north. In good weather there is no real navigational challenge in finding the track up Sand Hill, a prominence just below Hopegill Head, and on to the summit.

The summit of Hopegill Head (sometimes known a Hobcarton Pike) is a fantastic view-point, with ridges heading directly off to the west (Whiteside), north (Ladyside Pike, see photo 1.7) and east (then bearing north-east) to Grisedale Pike. Other mountain ridges roll off in the distance.

If the weather permits, the summit is an excellent viewpoint at which to stop and study the sedimentary landscape around you. However, in windy conditions this is an exposed spot and shelter can be hard to find.

Studying the surrounding hills, it is possible to see that the general trend of the landscape is roughly south-west to north-east, with ridge lines running from the Buttermere-Crummock Water valley to that of the River Derwent. There are some secondary arms running north/north-west, but in general the trend of the hills lies across the direction from which the mountain-building pressures came 300 million years ago. The underlying tilted and folded beds have been cut across to produce the present fells, like solid waves. In general these waves, expressed as the long, narrow-ish ridge lines which provide such super walking in the north-western fells of Lakeland, reflect the tilt of the beds: the north-western slopes run up the bedding and the south-eastern slopes cut down through the beds.

Looking west along the ridge towards Whiteside (photo w1.3), two different formations within the Skiddaw Slates make up the northern and southern slopes. The ridge itself and the southern slope, down to Gasgale Gill, is part of what is known as the Kirkstile Formation, consisting of beds of mudstone, siltstone and sandstone. The rocks on the slope to the right of the ridge are known as the Loweswater Formation of sandstones originally laid down in water and subject to slumping caused by earthquakes. The Loweswater Formation rocks come again to the surface near the Gasgale Beck and form the slope running up to Grasmoor for a short distance.

Photo w1.3 Looking west along the summit ridge from Hopegill Head towards Whiteside.

About 10m west of the summit, on the very ridge line, some evidence of folding of the rocks is exposed. There are clear signs of bedding and slaty cleavage. If you get down close to the rocks and look back up them to the summit, you can see that there is clearly a syncline (or downward fold) in some of the rocks (see photo 4.2). In fact, a complex set of anticlines and synclines runs through this area from east to west, some coming up through Gasgale Gill and onto the summit of Hopegill Head and the crags below Sand Hill.

The gill was cut in pre-existing drainage channels by powerful glaciers in (geologically) recent times compared with the ancient mountain-building episodes. However, it is possible that some of the slopes that can be seen from here (e.g. the summit area of Grasmoor and Causey Pike), are probably remnants of the pre-glacial surface that have survived above the valleys we see today.

Looking back down into Gasgale Gill, and starting with the slopes below Grasmoor, the glacial corrie below Dove Crag is quite clear (photo w1.4). The corrie is not very deeply etched, nor does it contain a lake. When temperatures began to rise towards the end of the ice age, this north-westerly located corrie was one of the first to see its glacier melt away. It thus remains fairly undeveloped compared with, say, Blea Water on High Street where the ice melted much later.

Less obvious is a series of linear features including an anticline which runs through the northern end of the Dove Crag, a set of very closely spaced anticlines and synclines which run up to and through Sand Hill and Hopegill Head and others which cut through Gasgale Crags.

One major feature is indirectly visible: the line of the Gasgale Thrust we saw earlier on exposed Gasgale Crags below Whiteside on the northern side of the valley. This continues through just north of Hopegill Head and the northern slopes of Grisedale Pike.

A great wedge of lower (and thus older) beds of the Kirkstile Formation (slumped and folded siltstone and sandstone) has been thrust upwards here to rest against younger beds of the same formation (siltstone and mudstone) as a result of mountain-building forces when the beds of sedimentary rocks were folded. The cohesion of the rocks was destroyed, creating both the complex set of anticlines and synclines in this area as well as the Gasgale Thrust fault. (There is another major thrust fault, the Causey Pike Thrust, which runs just about 1.5km to the south.)

The thrusting here has caused older sedimentary rocks, which form the northern slopes of Hopegill Head and Whiteside, to have been shoved up above the newer rocks which form the southern slopes running down to the beck.

Another geological feature is also indirectly and indistinctly visible, a 'metamorphic aureole'. This marks the limit of the area of rocks heated and toughened by the intrusion, well below ground level, of a mass of molten rhyolitic magma which slowly cooled to form granite. Heat radiated up through rocks in contact with the hot intruded magma, toughening them.

Photo w1.4 | Grasmoor and Gasgale Gill: the immature glacial corrie can be seen in the upper centre left of the photo above the green slopes.

The limit of this effect is marked by a line on the southern side of the valley, running from just south of Coledale Hause roughly along the base of the crags opposite where you are, via the northern edge of Dove Crag and along to the narrow entrance to Gasgale Gill which you earlier walked through. Indeed, this metamorphic aureole largely explains why the gill is gorge-like at the beginning and then widens out. The toughened rocks to the south of the line have been carved into crags below Grasmoor which is nearly 100m higher than the surrounding fells, whereas the softer rock north of it, running up to the beck, has been more easily eroded into shallower slopes.

All of this is quite a lot to take in from one spot, but it's worth getting it all sorted out before carrying on along Whiteside. There are some other features which will attract the attention, not least the marvellous views along this great ridge walk which lasts for 1.6km.

Try to observe the different rock types as you walk along the ridge, noting especially the cleavage which is clearly seen in places. There seems to be no pattern to the different directions of the cleavage in the various outcrops which lie at all sorts of angles, even vertical. This is the result of the complex patterns of folding and thrusting which has distorted the original patterns.

Photo w1.5 View back along the ridge from Whiteside to Hopegill Head (top right).

Further along the ridge, especially in Gasgale Crags, you can see more examples of the slumping and folding of bedding as well as more cleavage. In some places you can see examples of both bedding and cleavage in the same rock exposure, but these two features can sometimes be difficult to distinguish (see photos 1.4 and 4.3). Again it is all but impossible to work out any pattern to the tilt of the bedding due to a complex of anticlines and synclines cutting through the crags, roughly running from east to north-west.

Eventually this delightful ridge walk must come to an end and, after reaching the western summit of Whiteside, there begins a steep descent through numerous interesting outcrops where further examples of bedding and cleavage can be seen. At about 1690 2158 (well to the east of the footpath marked on the OS map) the track crosses the Gasgale Thrust fault line and, by looking back up the gill from the edge of the crags, you can see the line running along the base of Gasgale Crags. The terrain also becomes a bit smoother and noticeably less craggy from here on.

Continue to descend until you reach the footbridge crossed at the start of the walk and, after crossing it, walk the short distance from there to the finish point at Lanthwaite Green. Alternatively, if returning to Buttermere, do consider taking in Rannerdale Knots if you have the energy.