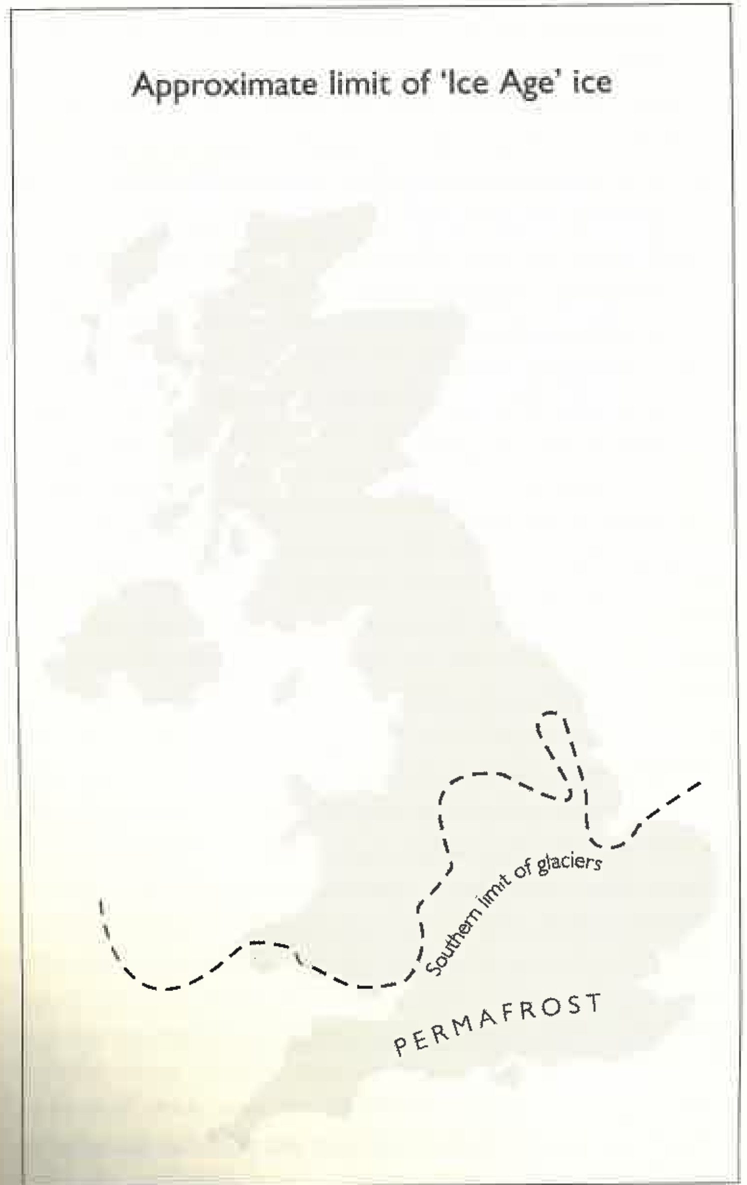
CHAPTER FOUR

The Frozen Landscape

Pleistocene epoch – from 10,000 years to 2.5 million years ago

The glaciations of the last 2 million years or so have probably affected the British landscape more than any other geologically short-lived event in the history of these islands. The Pleistocene 'Ice Age' will dog the pages of this book, popping up as an addendum to the geology of all ages, like a last-minute twist in the plot. There will be many allusions to it and how it has changed the rocks laid down in the landscape we see now. Glaciation, like love, changes everything.

If anything, the principles of uniformitarianism – that the present is the key to the past, to use Hutton's words – had become so well established in geology that proposing the idea of a cataclysmic glaciation was equivalent to defending the concept of a Noachian flood. Widespread glaciation was tainted by the discredited idea of catastrophism and consequently took a long time to be fully adopted. By the 1830s a begrudging acceptance of the role that ice had played in the formation of the landscape found expression in the belief that what we now know as the area of glaciation had been under a very deep sea in which



icebergs had floated down from the Arctic. Through studying the effects of glaciers in his native Switzerland, the geologist Louis Agassiz was, in 1837, eventually able to show the world that the extent of ice in prehistory was much more profound than had ever been thought before.

In Britain, where the glaciers rolled across the landscape, and that can be anywhere north of Ipswich, Oxford, Gloucester and the Bristol Channel, they left behind telltale signs of their presence. Most of upland northern Britain shows these signs: the wide U-shaped valleys that are occupied by misfit streams – tiny watercourses that could not possibly have eroded such a large valley on their own; the knife-edge arêtes that formed when glaciers eroded the U-shape on adjacent valleys or where more than one cirque[1] (formed by the heads of different glaciers on the same mountain) meet; hanging valleys where smaller tributary glaciers met main glaciers, often leaving behind a high waterfall once the ice had gone; and heavily striated rock faces halfway up mountains. Most of these features are so easy to visualise as the products of gargantuan ice flows that they form the backbone of GCSE geography field studies in places like the Pennines, Snowdonia, the Scottish Highlands and the Lake District. It's hard not to wonder why science was so slow to take them on.

Beyond the forms that are normally attributed to glaciation – the U-shaped valleys, cirques and arêtes – there is a truly beneficial one that the ice bequeathed to the Lake District: the lakes themselves. While tarns fill the upland

1. These ampitheatre-like bowls at the head of a glacier are also known as corries in Scotland or cwms in Wales.

corries, features that are just as distinctive occupy the wide, flat-bottomed U-shaped valleys below: ribbon lakes, each one of them produced as a result of meltwater filling a valley floor scooped out by a glacier. Some of the U-shaped valleys hold not one but two ribbon lakes, separated by flat, green fertile areas that are at a premium for farming in such a landscape and are very recent in origin. They represent the consolidation of deltas formed by tributary streams at the point where they enter the lake; the streams drop their loads of sediments just as a river drops its sediment as it enters the sea to form a coastal delta. Over time the deltas grow and, eventually, one large lake is split into two. The deltas also form at the heads of the ribbon lakes for the same reasons and grow downstream over time. Though divided now and separated by two miles of rich farmland, Derwent Water and Bassenthwaite were once one large lake. Glacial lakes with so much alluvium entering them are essentially temporary features and eventually Bassenthwaite will silt up completely. As will all the lakes over time.

For now, the ribbon lakes *are* the Lakes of the Lake District. Windermere, Ullswater, Bassenthwaite and a dozen more long, dark waters arranged under the fells and pikes in a great radial pattern emanating from Scafell that was first noticed not by a geologist, but by William Wordsworth.

> I know not how to give the reader a distinct image of these more readily, than by requesting him to place himself with me, in imagination, upon some given point; let it be the top of either of the mountains, Great Gable, or Scawfell; or, rather, let us suppose our station

> to be a cloud hanging midway between those two mountains, at not more than half a mile's distance from the summit of each, and not many yards above their highest elevation; we shall then see stretched at our feet a number of valleys, not fewer than eight, diverging from the point on which we are supposed to stand, like spokes from the nave of a wheel.[2]

The drainage pattern itself is a superimposed one that lingers from the period immediately before: the Tertiary, which ran from 65 million to 2 million years ago. During the Early Tertiary, the Lake District was uplifted into a dome with its centre near Scafell Pike. Streams radiated from the top and cut first into chalk, a sandstone and then a limestone, finally incising a path down through shales and slates. The chalk was removed first – as it was over the whole of the north-west – followed by the sandstone and limestone, which now form broken concentric rings around the whole Lake District. Having cut through the older rocks in a manner dictated by the young dome, the drainage pattern has endured, with only a few changes, to the present day.

England's Lake District has inspired poets and artists for centuries from Wordsworth in Grasmere and Coleridge at Keswick to the German émigré and Dadaist Kurt Schwitters,[3] who settled in well at Ambleside from 1945,

2. *A complete guide to the Lakes: comprising minute directions for the tourist, with Mr. Wordsworth's description of the scenery of the country, &c. and three letters on the geology of the Lake District*, John Hudson, Adam Sedgwick, William Wordsworth, 1843.

3. While the exact circumstances surrounding his exile are vague, Schwitters may have said something rather uncomplimentary about the Nazi-endorsed art

probably because of his love of mountain scenery. Between Wordsworth and Schwitters, came another 'mountain man' to live by the Lakes, John Ruskin, the nineteenth-century social critic, artist and philosopher. Ruskin harboured a life-long interest in geology every bit as intense as Wordsworth's – even writing about it, especially in regards to its relationship to architecture. He was not so much interested in the creation of the mountains as the ruins that were left behind; he had little patience for deep time, but was instead stimulated by an artistic understanding of the landscape: 'We have to ask then, first, what material there was here to carve; and then what sort of chisels, and in what workman's hand, were used to produce this large piece of precious chasing or embossed work, which we call Cumberland . . .'[4]

The nineteenth century was an age of synthesis for science and, unfortunately for many, that synthesis did not include a strictly literal or biblical version of Creation. This was problematic for many followers of the new sciences as many amateur scientists of the time had theological training and had come to the subjects almost as a hobby. When inductive reasoning was applied to geological problems, God didn't seem to be present in the detail. Like many, Ruskin[5] may have fought shy of accepting all the scientific presumptions

of the time and was wanted for interview – a euphemism if ever there was one – by the Gestapo. He fled Germany in 1936 and his work appeared in the *Entartete Kunst* (Degenerate Art) exhibition mounted by the Nazis to ridicule the Modernists the following year.

4. *Deucalion: Collected Studies of the Lapse of Waves and Life of Stones* (1883), John Ruskin.

5. Like all Victorian polymaths, in drawings and photographs Ruskin's approximate age can be determined by the increasing length of his beard.

of geology, with its impersonal scales of deep time and its increasingly counter-Creation overtones, but he was interested in the landscape and, while a student at Oxford, attended the debates of the Geological Society, including one on the effects of glacier erosion on mountain form. As a consequence, Ruskin's work reads now as an attempt to breathe the mystery back into the landscape, moving dull science aside and reinstating the land with magic.

Eschewing geological time, Ruskin promoted the idea that some geology might be enjoyed for what it is rather than how it formed. 'I do not care, and I want you not to care,' he told his students, 'how crest or aiguille was lifted . . . I do care that you should know . . . in what strength and beauty of form it has actually stood since man was man.' In some cases, however, glaciation has formed landscapes since man was man – particularly during the later glacial periods. Of which, Ruskin would surely approve.

As well as the powerful forces of erosion that glaciers exert, they also deposit the products of that erosion on the landscape. Though its modern name is 'superficial', you are just as likely to hear it referred to by geologists as 'drift' – a hangover from the days when it was believed that icebergs were the chief agent of erosion and deposition. Superficial or drift geology includes a range of some quite substantial forms which I shall give a quick tour of here. All of them are made from the products of glacial erosion: broadly boulder clay or till, a generic name for anything a glacier has ploughed up, partially ground apart and then dumped, unsorted and without any bedding planes. If you live in a part of Britain that was at any time under a glacier, some or all of these forms might be present in your local landscape. Even if you don't live in an upland (and therefore traditionally glacial) area, it's still worth keeping an eye out for glacial features, some of which turn up hundreds of miles from the nearest U-shaped valley.

The most famous of these features are the whale-back hills known as drumlins, rounded hills that often occur in swarms of hundreds with 'blunt' ends that face the origin of the glacier and a long tapered tail on the lee side, very much like the crag and tail structure under Edinburgh Castle and the Royal Mile. The landscape that a swarm of drumlins form is often known by the highly descriptive term 'basket of eggs topography' and can be seen particularly well in Ribbleshead in the Yorkshire Dales or over wide areas of Ireland. Aside from the general principle of streamlining along their long axes on which all agree, the exact formation of these hills is still a subject of research.

Another key feature deposited by all glaciers is moraine, the dredgings of their journey that they push towards their snouts by the conveyor-belt mechanism displayed by all glaciers. The Cromer Ridge along the north coast of Norfolk is one such heap. In an area of the country famed for its low-lying nature, the Cromer Ridge, which is actually the result of two moraines meeting, is a significant feature about 9 miles (14 kilometres) long and rising to a height of 300 feet (92 metres).

East Anglia is covered in drift geology which obscures a lot of the bedrock almost everywhere except at the coast. The region also includes the youngest rocks of our islands, the Quaternary Crags, which, even though they don't contribute any remarkable features to their landscapes, I feel I should mention for the sake of completeness. 'Crag' is an umbrella term for a number of rock types deposited between 3.75 and 1.5 million years ago which range from shelly, pebbly sand to sandy limestones. The oldest of these is the Coralline Crag. Despite its name, which might reasonably lead you to believe that it has something to do with coral, it doesn't – the fossils it contains are of the shared skeleton structures of colonial species of bryozoans. The Coralline Crag is, however, a rare example of a British limestone not produced in a tropical or sub-tropical sea, and is only found in a strip of land less than 2 miles (3 kilometres) wide that runs north-east–south-west for a distance of 11 miles (18 kilometres) from Aldeburgh through Orford Castle, which makes use of the slight eminence of the spot. In this part of the world, even more so than north Norfolk, the 30 feet (9 metres) of relief supplied by the ridge are more than enough to make it stand out, especially when viewed from the River Alde.

Associated with the Coralline but far more widespread is the Red Crags whose chief claim to fame is that they contain the earliest remains in Britain of horses, oxen and elephants. The Red Crags are bursting with more humble fossils of fish bone, sharks' teeth and shells, many of which are from still extant species – the whelks may even look like the ones that can be liberated from a nearby stall, if eating marine snot is your thing.

While glaciers ground down the rock and incorporated it into till, some larger rocks were transported whole, only to be dropped when the ice melted away. These larger blocks – which sometimes appear precariously balanced on the country rock – are known as 'erratics'. In areas of complex glaciation, where glaciers from different areas meet, the erratics can help scientists unravel the sequence of events and what ice came from where. In this way,

erratics perform a vital service to science by providing all the utility of a geological homing beacon.

Scientists believe there have been seventeen cycles of glacial-interglacial periods so far and there are more to come. But while a large area of Britain has been repeatedly inundated by glaciers over the last 2 million years, some areas in the south remained glacier free. They were, however, periglacial in nature and subject to permafrost and seasonal snowcaps. The exact effects of tundra conditions on each landscape differed from one to the next.

As anyone who has had to call out a plumber in icy weather will tell you, repeated freezing and thawing of water in a confined space can be very destructive. Water has a very curious property, in that it expands in volume by 9 per cent as it approaches freezing point. That might not seem a lot but, just as it will cost hundreds of pounds to fix the plumbing if your pipes lack sufficient lagging, in nature it is certainly enough to be able to shatter rock. Freeze-thaw weathering is a periglacial effect that can occur in relatively temperate climates because all it takes is the fluctuation of temperatures around 0°C. The high rocks of the Lake District, Pennines, Grampians, North West Highlands and other upland regions of Britain are still being broken into tiny little pieces by frost shattering. These little pieces tumble down the mountains to form scree or talus slopes, the unconsolidated fans of rubble you find at the foot of cliffs and steep slopes in the mountains.

In the south-west, frost shattering has been active on the moors, helping to break up the granite tors by prising apart the rock along its lines of weakness. The process is slow by human standards, but each thaw allows more water into the crack slightly expanded by the ice and so the process goes on.

In porous outcrops, periglacial conditions allow ice to penetrate into the very fabric of the rock itself and change its nature from porous to impermeable. For example, water normally sinks straight through chalk, so surface water and stream erosion are practically non-existent. In periglacial climates, however, it takes on a different set of properties and it is this change in its physical characteristics which leads to a particular kind of erosion.

Although the South Downs were never covered in glacial ice, the climate was still cold enough to maintain a cap of snow and to keep parts of the soil and chalk frozen the whole year round. In the brief summers the snowfields on top of the Downs would melt and the top layers of soil and chalk would thaw and become heavily saturated while lying over the still frozen impermeable chalk beneath. The waterlogged rock slid down the slope en masse over the solid, frozen rock along with the meltwater from the thaw which added river erosion into the fray. As a result of these periglacial conditions, when the ground eventually thawed at the end of the last glacial period, it left behind steep, V-shaped, dry valleys or coombes. Once there was no permafrost left, rain that fell disappeared into the porous chalk once again.

This is how Devil's Dyke to the north of Brighton formed. The most famous dry valley of them all, Devil's Dyke is approximately 300 feet (91 kilometres) deep and over half a mile (0.75 kilometres) long and is a feature that humans have long found so striking, that we have constantly re-invented our association with it ever since it was formed.

Moving out of the Pleistocene epoch, into the present Holocene – out of geological time to prehistory and history – Devil's Dyke was adapted as a hill fort and, in the Iron Age, like many similar sites, it is likely that all of the grass was removed to reveal the stunning white chalk beneath, to either impress or intimidate travellers through, and occupants of, the valley below.

In Victorian and Edwardian times, a mania for tourism took hold. On Whit Monday in 1893, 30,000 people made their way to Devil's Dyke to indulge themselves in the pleasures of what had been set up as a kind of theme park on the site. While a bandstand and fairground would seem to have little to do with bedrock geology, it was the wide open spaces, fantastic views and feelings of freedom that lay so close to bustling Brighton that drew people up there in the first place. It was, of course, inevitable that dull commerce followed them like a Pennine rambler being stalked by an ice-cream van, but Edwardian tourists were lured at first by the products of the geology, even if they didn't know it.

Visitors today need not fear such a garish state of affairs, as Devil's Dyke has been restored to a natural, managed state. But they will be able to see the remains of a 350-metre-long cable car system that ran across the valley, the course of a funicular railway on the northern slope that extended down to the village of Poynings, and the platform bed from a single-track branch line that ran from Hove. It must have resembled the slopes of Snowdon in minature.

The ice has left its mark on the landscape in geological time, prehistory and history, adding to the evolution of Devil's Dyke as it has added to the evolution of Britain as a whole. The last great glaciation, which finished around

10,000 years ago, was a defining chapter in the formation of Britain, topping and tailing the geology and finally rendering the fine detail of the landscape into a shape we would recognise today.