Snowdon (Yr Wyddfa)

Highlights

One of the first areas studied for its glacial features, this site shows numerous classic large, medium and small-scale examples of erosional and depositional landforms associated with glacial conditions, particularly in the Devensian Stage. Many moraines and protalus ramparts date from the last, Younger Dryas, cirque glaciation of Snowdonia.

Introduction

The mountain area of Snowdon contains a wide range of glacial and periglacial landforms of exceptional interest. The large spectacular features of glacial erosion (cirques, aretes and troughs) were among the first in Britain to be described, and they have few parallels in Wales. Numerous fine examples of medium-scale, ice-sculptured features include rock steps and roches moutonnées. Further enhancing the interest of the area, particular around Llyn Llydaw, are many well developed, small-scale erosional features such as glacial striae and friction cracks. This assemblage of erosional forms is also accompanied by depositional landforms, particularly moraines and protalus ramparts. Although many of the latter have been assigned to the Younger Dryas, others may relate to wastage of the Late Devensian ice-sheet. Therefore, in addition to providing classic landform examples, the Snowdon area is important for interpreting patterns of mountain glaciation and deglaciation in north Wales.

The area was one of the first in Britain to be investigated with respect to the Glacial Theory, with studies by Bowman (1841), Buckland (1842), Darwin (1842) and Mackintosh (1845). It was not, however, until the work of Ramsay (1860, 1866, 1881) that the impact of glaciation in the area gained general acceptance (for example, Kidson 1888, 1890; Kendall 1893; Marr and Ache 1898; Daykins 1900; Jehu 1902; Davis 1909, 1920; Dewey 1918; and Carr and Lister 1948). Since these early studies, the area has become a classic ground for geomorphologists, with major studies by Seddon (1957), Embleton (1962, 1964a), Unwin (1970, 1973, 1975), Gray (1982a), Gray and Lowe (1982) and Gemmell *et al.* (1986). The area has also been described in texts by Williams (1927), Smith and George (1961), Johnson (1962) Ball *et al.* (1969) and Addison (1983, 1987). Ball and Goodier (1970) described the distribution of features associated with periglacial activity in Snowdonia, and Ince (1981, 1983) has reconstructed the late-glacial and Holocene vegetational history of the area using pollen analytical methods.

Description and interpretation

The Snowdon GCR site comprises a series of cirques radiating from the summit of Snowdon and representative sections of the spectacular glacial troughs in the Llanberis and Gwynant Valleys — see (Figure 36).

Large-scale features of glacial erosion

Processes of glacial erosion have cut the Snowdon massif into a horn with large cirques radiating from a central point. The Crib Goch and Crib-y-ddysgl and Yr Wyddfa to Y Lliwedd aretes are fine examples of the precipitous slopes developed in glaciated uplands. Indeed, probably only the broad-shouldered ridge extending north from Snowdon remains to give any impression of a pre-glacial land surface — see (Figure 36).

The cirques within the site are generally complex in plan, with the concept of a cirque stairway clearly exemplified in Cwm Dyli (Embleton and King 1968). Here, the 'Snowdon Horseshoe' defines the eastern basin of the Snowdon massif; the aretes of Crib Goch and Y Lliwedd encircling the largest glacial excavation of the massif (Addison 1983). Unwin (1970) recorded twenty five cirques in the Snowdon area, including Cwm Dwythwch to the north, although problems of definition may have led to an over-estimate of the total number. Many of the cirques are illustrative of the continuum of features described as cirque troughs and complexes (Gordon 1977). Little lithological control has been identified, although there is a significant orientation, probably climatically controlled, of secondary cirques (Unwin 1973).

Early in the development of the Glacial Theory, the Llanberis Pass was identified as a major glacial trough cut through the Snowdonian massif. Buckland (1842) described this as one of the finest examples of glacial erosion he had seen, comparable to landforms in the Alps. The GCR site includes part of the narrow trough extending from Pen-y-Pass to Llyn Peris GCR site, although the landform as a whole extends north-west as an 8 km long rock basin containing Llyn Peris and Llyn Padarn. The breaching of the Snowdonian uplands at Pen-y-Pass, the modern-day watershed, shows that the dispersal centres of North Wales ice-sheets, at various times in the Pleistocene, lay south of the Snowdon and Glyderau massifs (for example, Greenly 1919; Addison 1983).

The Gwynant Valley is a spectacular U-shaped trough (Johnson 1962), into which ice from the Snowdon Horseshoe flowed, This valley is separated from Cwm Dyli by an impressive rock lip, leaving what is perhaps best described as a 'hanging cwm' (Embleton 1962). The precipitous slopes of Gallt-y-Wenallt make this one of the most impressive features of glacial erosion in North Wales.

Small-scale features of glacial erosion

Small-scale features of glacial erosion are developed within the Snowdon massif. The widespread development of striated bedrock surfaces, particularly within the Llanberis Valley, led to Ramsay's (1860) early study of ice movement directions within the area. More recently, similar features have allowed a large-scale reconstruction of patterns of such movement over Snowdonia (Gemmell *et al.* 1986).

Small-scale glacial erosional features are, however, particularly well preserved in areas where bedrock surfaces have been protected from Holocene weathering, beneath for example, lake waters. Reductions in lake levels at Llyn Llydaw have revealed exceptionally fresh examples on the bedrock of ice erosion (Gray and Lowe 1982); excellent examples of abrasion and smoothing, with streamlined and striated bosses indicating a general easterly direction of former ice movement, can be examined. Roches moutonnées with clearly plucked facets are also visible. The importance of this particular area, however, lies in the small-scale features of subglacial erosion, including plastically-moulded forms (p-forms), well known from Scandinavia (Dahl 1965; Gjessing 1965) and North America (Gilbert 1906; Bernard 1971a, 1971b, 1972), but whose formation has yet to be adequately explained (Embleton and King 1975a). Other small-scale erosional features were noted (Gray and Lowe 1982), including grooves and channels and sichelwannen, possibly formed by subglacial meltwater, as well as friction cracks, gouges and striae. Gray *et al.* (1981) and Gray and Lowe (1982) have suggested that two dominant sets of crossing striae measured in Cwm Llydaw and adjacent areas can be related to different directions of ice movement: one set related to ice flow during the last recorded ice advance, during the Younger Dryas, the other to an earlier glacial event.

Depositional landforms

Glacial depositional landforms are well known (for example, Darwin 1842; Ramsay 1860; Kidson 1890; Kendall 1893; Marr and Adie 1898; Daykins 1900; Jehu 1902; Williams 1927). Recent work has elaborated the distribution of these landforms but it has also raised questions concerning the processes responsible for their formation.

The first systematic mapping of moraines in Snowdonia was by Seddon (1957) who examined the palaeoclimatic factors responsible for their distribution. Pollen analyses made from cores in peat bogs both inside and outside the moraine arcs (Godwin 1955; Seddon 1962), led Seddon to argue that the moraines had formed during two separate phases — at some stage during the retreat of the Late Devensian ice-sheet and again during the Younger Dryas (*c.* 11,000 –10,000 BP). Unwin (1970) subsequently studied the distribution of cirques and cirque moraines using multi-variate analysis. He grouped the moraines into an older series of diffuse forms and a younger series of fresh forms; he further sub-divided both groups into glacial moraines and protalus ramparts. Unwin considered the older series features to have been formed during a readvance of ice in Pollen Zone I or during a recessive stage of the Late Devensian ice-sheet, and the younger series features during the Younger Dryas.

More recently, the depositional landforms of Snowdonia, including the Snowdon massif, were remapped and described in detail by Gray (1982a). In all, he mapped evidence for thirty five cirque glaciers, with glacial limits based on the distribution of end-moraines, boulder and drift limits and the down-valley extent of hummocky moraine. Detailed mapping

in the region also indicated the presence of sixteen protalus ramparts, reflecting the former presence of semipermanent snowbeds down to altitudes of 150m OD. Within the main Snowdon massif, Gray inferred the presence of six former cirque glaciers which he believed had formed during the Loch Lomond Stadial (Younger Dryas). Many of the landforms mapped by Gray cannot be classified simply as 'moraine' or 'protalus rampart'. Many limits are marked by diffuse bouldery or hummocky terrain, and several features are of complex origin; for example, the outer part of the large arcuate ridge in Cwm Tregalen (Figure 36) may be glacial in origin but the inner rim accumulated as a protalus feature by gravity sliding of debris (Gray 1982a).

Dating of moraines and protalus features

Relatively few of the glacial limits thus far identified (Unwin 1970; Gray 1982a) have been dated by radiocarbon and/or pollen analysis. Gray (1982a) suggested that a Loch Lomond Stadial age (Younger Dryas) is likely for the mapped cirque moraines in Snowdonia on the basis of stratigraphic and pollen investigations from the general area (for example, Godwin 1955; Seddon 1962; Burrows 1974, 1975; Crabtree 1970, 1972). However, only Ince's (1981, 1983) study from Cwm Llydaw provides confirmatory dating for moraines actually within the Snowdon GCR site. Radiocarbon dates and pollen analyses of basal samples inside the mapped cirque glacier limits at Cwm Llydaw (Gray 1982a) show that organic sedimentation commenced at *c.* 10.000 BP. This contrasts with sites at Clogwynygarreg and Llyn Goddionduon (Ince 1981) outside the mapped cirque glacier limit, where organic sedimentation began earlier, in the Devensian late-glacial. Collectively, these data provide strong constraints on the dating and extent of the last cirque glaciation of the uplands which occurred during the Younger Dryas. Such evidence is entirely consistent with recent studies in Scotland (for example, Sissons 1976, 1979; Gray and Lowe 1977).

Gray (1982a) generally doubted the widespread existence of pre-Loch Lomond Stadial (Younger Dryas) moraines (the older series of Unwin) in Snowdonia, but the nearby GCR site at Cwm Dwythwch provides evidence for such an 'older', large cirque moraine (Seddon 1962), with a typical late-glacial sequence behind.

Holocene environmental and vegetational history

Pollen studies at Cwm Llydaw (Ince 1981, 1983) provide a detailed record of vegetational and environmental changes during the Holocene. The record shows that after c. 10,000 BP the recently deglaciated uplands were colonised by grassland and open-habitat plant taxa. These early herbaceous communities were then invaded by juniper and birch, which were in turn replaced by birch and hazel woodland and, eventually, by forests of birch, pine, oak, elm and alder (Ince 1983). Altitudinal factors ensured the survival of many open-habitat taxa in the uplands throughout the Holocene. Deteriorating environmental conditions and human interference during mid to late Holocene times resulted in the gradual decline of forests in the uplands and the development of the open-grassland and heathland communities which characterise the area today (Ince 1981, 1983).

Periglacial landforms and features

Periglacial processes have been of major importance in shaping the Snowdonian landscape. Many landforms, types of patterned ground and other features attributable to frost-action, occur within the region. The range and scale of such features in the Snowdon site is not so great as in the Carneddau, but individual landforms and features are discussed by Ball and Goodier (1970) who mapped their morphology and distribution. These include widespread scree slopes of suggested late-glacial age (Ball 1966), a solifluction terrace and an indurated till horizon in Cwm y Llan (Fitzpatrick 1956; Ball and Goodier 1970), and impressive block screes in the Llanberis Valley near Pont-y-Gromlech where individual boulders the size of a small house occur.

Snowdon is important for a wide range of glacial and periglacial landforms. In particular, the site shows the best examples in Wales of large-scale landforms of glacial erosion, including a classic central horn surrounded by a group of radiating cirques abruptly divided by aretes. This assemblage comprises some of the most spectacular glaciated topography in Wales, and indeed Britain, ranking favourably with parts of the Scottish Highlands in terms of intensity of erosion. In this respect, Snowdon contrasts markedly with the adjacent massif of Y Glyderau where the cirques show pronounced structural alignment, and to the Carneddau massif farther east where classic features of glaciation are less

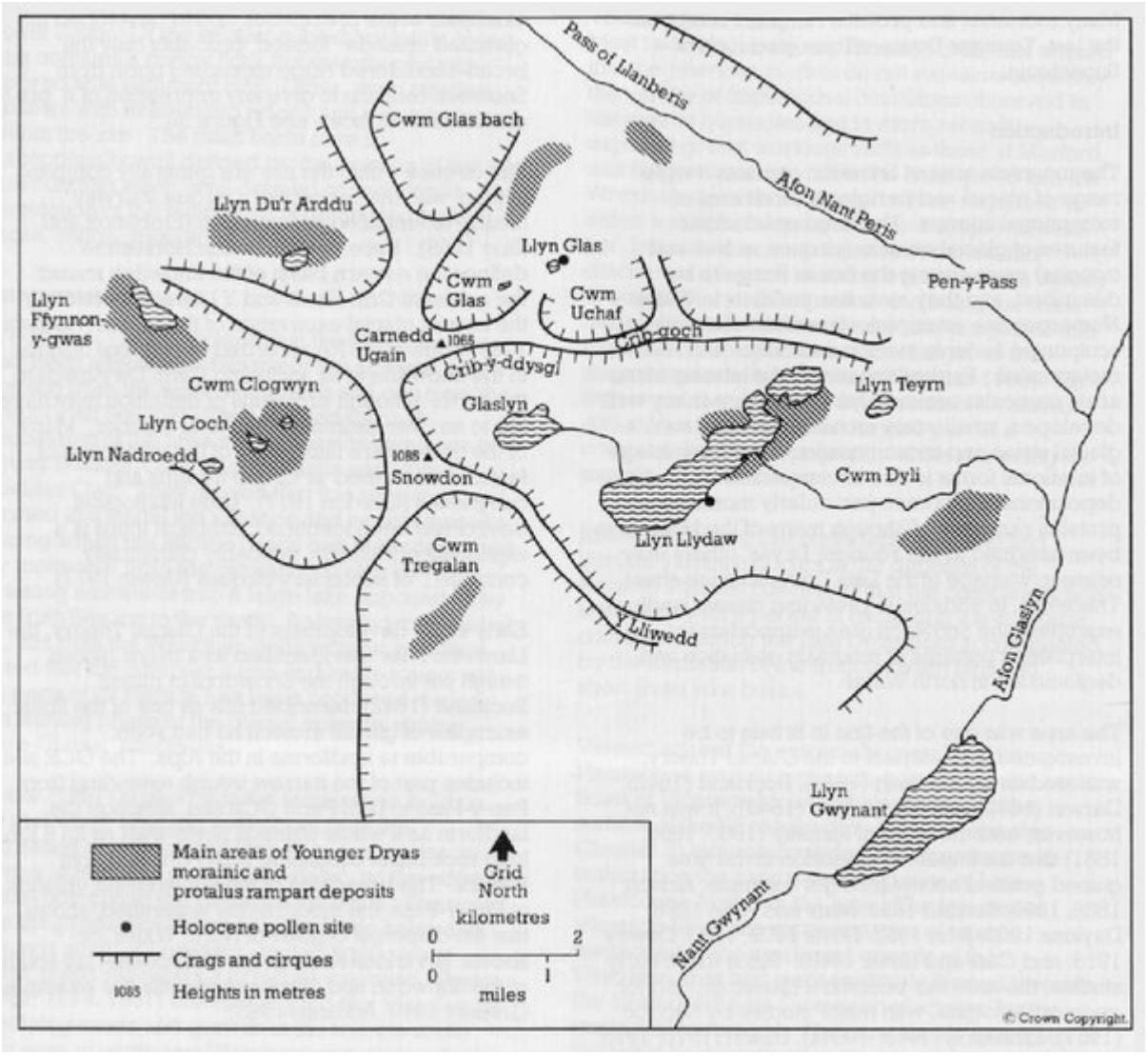
sharply defined and where the generally broad-shouldered landscape shows an unparalleled range of periglacial landforms and features. Of the Snowdon cirques, Cwm Dyli (the Snowdon Horseshoe) is a particularly fine example of a complex cirque with steep rock walls enclosing a series of lake basins and a varied assemblage of Younger Dryas moraines. These moraines indicate that the whole staircase from Glaslyn to the lip of Cwm Dyli was probably occupied by a single glacier — the largest Younger Dryas glacier in Snowdonia. The moraines also clearly demonstrate a recessional phase of this glacier as it retreated from Cwm Dyli towards Cwm Llydaw. Organic deposits from the site have helped in dating the moraines to the Younger Dryas, and the deposits also preserve an important record of vegetational changes in upland Wales during the Holocene. Cwm Dyli is also important for a wide range of well developed small-scale features of subglacial erosion, which help in determining the former directions of ice movement within the cirque during various glacial advances.

The spectacular large-scale landforms of glacial erosion here are some of the finest in Wales and were important for establishing the Glacial Theory in Great Britain. The site is also noted for a wide range of medium and small-scale glacial erosional forms as well as extremely varied depositional landforms. In particular, the site displays an outstanding assemblage of Younger Dryas moraines. The geomorphological interest of the site is enhanced by well developed periglacial landforms and by deposits which preserve important records of Holocene vegetational and environmental changes in upland North Wales.

Conclusions

Yr Wyddfa (Snowdon) displays internationally important landforms of glacial erosion and glacial deposition. These figured prominently in the debate and ultimate acceptance of the Glacial Theory in the British Isles a century and a half ago. Evidence for a glacier advance which only lasted for a thousand years, between 11,000 and 10,000 years ago, is important because it was caused by changes in the circulation in the North Atlantic Ocean. This information, together with cold-climate landforms and deposits, and evidence from pollen which shows climatic change, is important for reconstructing changes in climate over a wide area, and contributes to theories about future changes in climate.

References



(Figure 36) Snowdon (Yr Wyddfa): principal landforms