Chapter 5 The Quaternary of South Wales

Introduction

Studies of coastal and cave stratigraphic sequences particularly in Gower (Chapter 3) and south-west Wales (Chapter 4) have provided the most detailed evidence about the Middle and Late Pleistocene and its sub-division in southern Wales (for example, Bowen 1970a, 1973a, 1973b, 1974, 1984). Elsewhere in Dyfed, the Brecon Beacons, Black Mountains, the South Wales Coalfield and the Vale of Glamorgan particular details of the Late Pleistocene and Holocene history provide further complementary evidence. A prominent theme of past studies has been attempts to delimit the maximum extent of the Late Devensian ice-sheet. Another theme relates to the upland areas of South Wales, particularly the Brecon Beacons, which exhibit a range of glacial and periglacial landforms that provide evidence for Late Devensian and especially Devensian late-glacial environmental events and conditions. A number of sites within the region has also yielded important data for reconstructing Holocene palaeoenvironments.

Events pre-dating the Ipswichian Stage

With the exception of landforms such as erosion surfaces and tors, which have evolved in response to processes operating over long timescales (Brown 1960; George 1974; Battiau-Queney 1980, 1984), the oldest evidence for the Pleistocene in South Wales is generally held to be the deposits of the 'Older Drift' (Bowen 1970a, 1974). It has long been believed that glacial deposits of the 'Older Drift' were younger than the *Patella* Beach of Gower (George 1932), but in recent years it has been demonstrated that the raised beach in fact post dates the 'Older Drift' (Bowen 1970a, 1973a, 1973b, 1974, 1984). Bowen (1973a, 1973b) argued that only derived, redistributed 'Older Drift' glacial sediments overlie the raised beach, having been reworked into this position by periglacial processes during the Devensian Stage.

'Older Drift' glacial deposits occur, for example, in west Gower and in the Vale of Glamorgan. These consist of both Irish Sea and Welsh glacial deposits, and they exist in areas outside the limit of the Late Devensian ('Newer Drift') glaciation (Charlesworth 1929; Bowen 1970a, 1973a, 1973b, 1981a, 1981b). They are sometimes characterised by considerable dissection in comparison with more coherent deposits of the Late Devensian, although those in west Gower cannot be distinguished in this way.

Much is owed to the work of the Geological Survey Officers (for example, Strahan and Gibson 1900; Strahan and Cantrill 1904; Strahan 1907a, 1907b, 1909; Strahan *et al.* 1907, 1909, 1914; Dixon 1921) who established the details of glaciation in South Wales. They showed that two ice-sheets had traversed the region: one from the Irish Sea Basin with erratics from as far afield as Scotland, the Lake District and North Wales, and another from the Welsh uplands. Strahan and his colleagues (and later T N George in Gower) demonstrated that 'Older Drift' ice crossed south-west Dyfed (Pembrokeshire) from the north-west, and moved in an easterly direction along the Bristol Channel, impinging on west Gower and parts of the Vale of Glamorgan. At Pencoed, in the Vale of Glamorgan, Strahan and Cantrill (1904) described shelly deposits with igneous Irish Sea erratics, underlying Welsh glacial deposits. They demonstrated that this Irish Sea ice had carried erratic boulders to the Vale of Glamorgan as far east as Cowbridge and possibly beyond. Details of this extensive Irish Sea glaciation in the region were further elaborated by Griffiths (1937, 1939, 1940) who applied heavy mineral analyses and plotted erratics trains to ascertain the provenance of the drifts. He concluded that, over much of South Wales, the Irish Sea and Welsh ice masses had been coeval. Using similar evidence, Bowen (1970a) delimited six provinces of glacial drifts — Irish Sea, Central Wales, Brecknockshire, Glamorgan, mixed Irish Sea and Central Wales drift, and mixed Irish Sea and Glamorgan drift — see (Figure 13). It is generally held that South Wales was entirely submerged beneath the Irish Sea and Welsh ice-sheets in 'Older Drift' times.

Bowen *et al.* (1985) and Bowen, Jenkins and Catt (unpublished) have shown that parts of the 'Older Drift' are of different ages in south-west Gower: with mixed provenance Irish Sea and Welsh drift succeeded by a Welsh drift delimited by a moraine at Paviland. Estimates of their ages in comparison with an oxygen isotope scale are made by Bowen *et al.* (1985).

Recent work in the Vale of Glamorgan and a reexamination of the 'Storrie erratic collection' from Pencoed (Strahan and Cantrill 1904) have confirmed the former presence of Irish Sea ice in the area (Donnelly 1988) — see also Chapter 2. Donnelly noted that the Irish Sea glacial sediments were probably extensively reworked by Welsh ice in the Late Devensian. Unfortunately, these drifts are no longer exposed in the Pencoed and Ewenny areas, although British Geological Survey boreholes record their presence.

The Ipswichian Stage

Other than for the coastal margins of South Wales, where raised marine and terrestrial cave sediments occur, evidence for temperate (interglacial) conditions is generally sparse. Possible evidence for the Ipswichian Stage comes from relict soils preserved in areas unaffected by the Late Devensian glaciation, on the ground previously glaciated by the 'Older Drift' ice-sheet (Bowen 1970a, 1973a, 1973b, 1974). Such soils have been described from the Vale of Glamorgan (Crampton 1960, 1961, 1964, 1966c), parts of south Gower (Ball 1960; Clayden 1977a, 1977b) and south Pembrokeshire. Such palaeosols are an important element of the coastal sequences around Gower, where they have been reworked as colluvial deposits, analogous to the 'limon rouges' of Mediterranean lands (Bowen 1966, 1970a). Where these palaeosols occur as surface features, they provide assistance in defining areas not glaciated by Devensian ice. They are represented in the GCR site coverage by the colluviated facies of the coastal sections — see Chapter 3.

The Devensian Stage

Evidence for Early and Middle Devensian conditions is also confined to areas beyond the limit of the Late Devensian ice-sheet, and it is only represented by colluvial and head deposits widely exposed around the coast and in cave sequences (for example, at Long Hole and Bacon Hole Caves, Gower). It is reasonable to assume that comparable head and colluvial sequences also exist inland, but they have not yet been recognised. The long sequence described by Bull (1975, 1976) from Agen Allwedd Cave near Llangattock may cover much of the Devensian.

The South Wales end-moraine

An incidental but pre-eminent theme in investigations of the Late Pleistocene in South Wales is the delimitation of the extent of Late Devensian ice. Since Charlesworth (1929) first defined the 'Newer Drift' limit, the South Wales ice margin has been the subject of several revisions (Charlesworth 1929; Griffiths 1940; Wirtz 1953; Mitchell 1960, 1972; Lewis 1966b; Bowen 1970a, 1973a, 1973b, 1974, 1981a, 1981b; George 1970; John 1971a) — see (Figure 14).

The most significant differences between these reconstructions have arisen from different methodology. For example, Mitchell (1960, 1972) used an East Anglian stratigraphical model amplified by work in Ireland and argued that the raised beaches around Wales were principally of Hoxnian age, thus making it implicit that they were overlain by deposits of both Saalian and Devensian age. Mitchell (1960) and Synge (1963, 1964) concluded that the majority of glacial sediments in Wales were of Saalian age, with Late Devensian Welsh ice only forming a limited ice cap in the uplands, and Irish Sea ice only impinging along the North Wales coastal margin. In contrast, faunal (Bowen 1970a, 1973a, 1973b, 1974) and amino acid evidence (Bowen *et al.* 1985; Bowen and Sykes 1988) suggests that most of the raised beach outcrops are probably of Ipswichian age. Principally on the basis of coastal lithostratigraphy, Bowen (1970a, 1973a, 1973b, 1974) and John (1970a) in Pembrokeshire, for example, have shown a more extensive Late Devensian glaciation in Wales than Mitchell (1960, 1972) — see (Figure 14).

The Late Devensian ice limit: south-east Wales

In south-east Wales morphological evidence for the margin of the ice-sheet is well developed. Prominent moraines and areas of hummocky terrain were widely deposited by ice from Mid Wales and Breconshire, and Charlesworth's (1929) limit, drawn to coincide with the southern limit of continuous drift mapped by the Geological Survey, has been relatively little modified by subsequent workers. Lewis (1966a, 1966b) argued for little more than a Late Devensian cirque glaciation in the South Wales uplands, extending to valley glaciation in parts of the Usk Valley (the 'Breconshire

end-moraine'), but it was subsequently demonstrated that Late Devensian ice was extensive in the uplands. For example, Ellis-Gruffydd (1972, 1977) argued that glacial striae and erratics showed that the entire Old Red Sandstone escarpment had been submerged beneath the 'Breconshire ice-cap'. Ice from this dispersion centre flowed north into the Usk Valley (Williams 1968a); west through Cwm Dwr to join Mid Wales ice moving down the Tywi Valley; and south across the South Wales Coalfield, to the limits reconstructed by Bowen (1970a, 1973a, 1973b, 1974) (Ellis-Gruffydd 1977).

A powerful stream of ice from the uplands moved eastwards in the Brecon area; it bifurcated near present day Llangorse Lake, sending branches north-east into the Wye Valley and south-east into the Usk Valley (Williams 1968a; Lewis 1970b). Part of this Usk glacier probably coalesced with glaciers from the eastern Coalfield (Welch and Trotter 1961) to form a piedmont lobe extending offshore between Newport and Cardiff (Bowen 1970a). The relationship of Late Devensian ice to buried channels in the lower Usk region has been discussed by Williams (1968b). Ice moving northeast into the Wye Valley probably only overtopped the Black Mountains escarpment (Hay Bluff) locally, and the Usk glacier moved almost due east near Crickhowell to terminate near Lianfihangel–Crucorney where it formed a large moraine.

The Late Devensian ice limit: central South Wales

Farther west, a similar pattern is repeated, with Late Devensian Welsh ice from the Glamorgan uplands moving south and south-east into the Vale of Glamorgan. Although moraines associated with this ice were developed locally, the maximum limit is frequently marked in the Vale by extensive areas of hummocky terrain, for example, around Pyle, Margam and Llanilid (Bowen 1970a). Deposits in the Llanilid area were recently examined by Donnelly (1988) who upheld the established Late Devensian maximum limit (Bowen 1970a), and discussed the relationship of these deposits to the 'Older Drift' Irish Sea deposits of the Vale of Glamorgan. Late Devensian events near Pontypridd were discussed in detail by Harris and Wright (1980).

Evidence of Late Devensian glaciation in Swansea Bay is well established (for example, Strahan 1907a; Trueman 1924; Charlesworth 1929; Jones 1931a, 1931b, Griffiths 1939; Bowen 1970a; Al-Saadi and Brooks 1973; Culver 1976; Anderson 1977; Anderson and Owen 1979; Culver and Bull 1979). The Nedd (Neath), Tawe (Swansea) and Alan Valleys acted as major outlets for Welsh ice from the uplands. This ice coalesced to form a large piedmont lobe in Swansea Bay. Late Devensian glacial sediments mark part of the western limit of this lobe in eastern Gower (for example, George 1933a; Bowen 1970a; Campbell 1984) — see Langland Bay (Rotherslade). Comparable glacial sediments occur in association with a series of over-deepened rock basins in the Neath and Swansea Valleys (Al-Saadi and Brooks 1973; Anderson and Owen 1979; Culver and Bull 1979). These basins may have formed by preferential ice erosion along major fault zones (for example, the Neath Disturbance) and pre-glacial river courses. Lacustrine deposits associated with wastage of the ice have been described from these basins and their offshore extensions (Culver and Bull 1979). They are truncated and succeeded, over large areas of Swansea Bay and its coastal fringes, by the marginal marine deposits of the Holocene transgression (Godwin 1940b; Culver and Bull 1979). Although the maximum Late Devensian ice limit lies offshore, the Neath, Swansea and Alan Valleys contain lacustrine deposits, kame terraces and halt-stage moraines; evidence for sequential ice wastage, as the ice-sheet thinned into individual valley glaciers (Charlesworth 1929; Hughes 1974; Anderson and Owen 1979; Culver and Bull 1979). A minimum age for the Late Devensian glaciation of the area is given by Pollen Zone I deposits recovered from a kettle hole (now destroyed) at Bryn House, Swansea (Trotman 1963).

In areas adjacent to Carmarthen Bay, some drifts contain both Irish Sea erratics and heavy minerals, but they are dominantly of Welsh origin (Griffiths 1940). Griffiths suggested that deposits in this region had lithological characteristics of the 'Older Drift' mixed Irish Sea and Welsh provinces, but had been substantially reshaped by 'Newer Drift' Welsh ice, which had only been weakly developed in the area. Subsequent workers (for instance, Bowen 1965, 1970a, 1980b; Campbell 1984) have discussed the evidence for Late Devensian ice streams moving into Carmarthen Bay from basal ice-sheds farther north, for example, in the Mynydd Sylen and Cross Hands areas (Cantrill *in* Strahan et *al.* 1907). This Welsh ice flowed along the valleys of the Tywi, Gwendraeth Fawr and Gwendraeth Fach. Upper layers of ice moved almost due south, providing important evidence for a considerable ice gradient and substantial central Wales ice cap in Late Devensian times (Strahan *et al.* 1907; Bowen 1970a; Campbell 1984). This evidence, together with important lithostratigraphic constraints provided by coastal sequences in west Gower (Chapter 3) and in the Carmarthen Bay

coastlands (Chapter 4) have been used to revise Charlesworth's (1929) 'Newer Drift' limit in this area (Bowen 1970a) — see (Figure 14).

The Late Devensian ice limit: south-west Wales

West of Carmarthen, the delimitation of the Late Devensian maximum ice limit has also been revised. Charlesworth (1929) restricted 'Newer Drift' Irish Sea ice to northern Pembrokeshire where he identified ice marginal overflow channels in the Fishguard district and end-moraine deposits between Newport and Cardigan. Morphologically similar accumulations at Banc-y-Warren and near Tregaron were used to indicate large ice-free areas in Pembrokeshire and western Carmarthenshire (Dyfed) — see (Figure 14). The Fishguard (Gwaun-Jordanston) meltwater channels have since been reinterpreted as subglacial in origin (Bowen and Gregory 1965; Bowen 1967), and they indicate a more extensive Late Devensian glaciation in the area than envisaged by Charlesworth (1929).

Remains of pingos are well developed in Wales (Figure 1) and numerous examples have been described — from Llangurig in Mid Wales (Pissart 1963, 1965; Trotman 1963), from the Cledlyn and Cletwr Valleys in south-west Wales (Watson 1971, 1972; Watson and Watson 1972, 1974; Handa and Moore 1976), and from northern Carmarthenshire, around Llanpumpsaint and Pontarsais (Bowen 1974). Their widespread occurrence in south-west Wales both inside and outside Charlesworth's (1929) 'Newer Drift' limit was believed by Watson (1972) to invalidate this limit. He argued that such features were only found in high densities outside the limit of the Late Devensian glaciation, by analogy with pingo densities in the Yukon. Their occurrence in south-west and Mid Wales together with other periglacial features, was used as an argument to substantiate ice-free areas during the Late Devensian — see Chapter 6. Others, however, have argued that the fossil pingos simply demonstrate the occurrence of areas of former permafrost subsequent to deglaciation of Late Devensian ice (Bowen 1973a, 1973b, 1974; Handa and Moore 1976).

The area also provides important evidence for geomorphological conditions in south-west Wales during the Late Devensian. Significant periglacial modification to the tors of Preseli and the Trefgarn area is thought to have occurred (John 1970a, 1973) when they lay close to, but south of, the maximum ice limit. The Preseli Hills are thought to have formed a barrier to Irish Sea ice in the area (Bowen 1973a, 1980a, 1984). The survival of tors as significant landscape features, particularly in glaciated areas, has been a longstanding geomorphological problem. Tors and other indicators of periglacial conditions at the Stiperstones in Shropshire have also been used as evidence in the argument that locally elevated areas escaped engulfment by Late Devensian ice in the Borderlands (Rowlands and Shotton 1971; Goudie and Piggott 1981). Sites with tors and associated weathering products, may provide useful information regarding the long term, pre-glacial evolution of the landscape of south-west Wales (Battiau-Queney 1980, 1984).

Upland landforms

Striking examples of landforms associated with glacial erosion and deposition have long been known from the South Wales uplands (Symonds 1872; David 1883; Reade 1894; Howard and Small 1901), and accounts of these features were given by the Geological Survey (for example, Robertson 1933). The distribution of the principal erosional and depositional landforms of the region was also given by Bowen (1970a) and Groom (1971); and the pre-Devensian late-glacial evolution of the uplands has been discussed widely (for example, Richardson 1910; Robertson 1933; North 1955; Thomas 1959; Lewis 1966a, 1966b, 1970a, 1970b; George 1970; Ellis-Gruffydd 1972, 1977). Cirques and Devensian late-glacial landforms including moraines and protalus ramparts are well developed in the Brecon Beacons, particularly at Cwm Llwch, Craig Cerrig-gleisiad and Mynydd Du (Black Mountain).

The significance of these landforms is that they show widespread cirque glaciation and snowpatch formation in the uplands during the Younger Dryas. The dating and interpretation of these features have been assisted by a number of pollen stratigraphic and radiocarbon dating studies (for example, Trotman 1963; Walker 1980. 1982a, 1982b).

Lewis (1966a, 1966b) gave the first detailed descriptions of the moraines and protalus ramparts of the Brecon Beacons. From their morphology, he inferred that their formation occurred during two separate periods in the Devensian late-glacial. On the basis of earlier pollen work in the region (Hyde 1940; Bartley 1960a; Trotman 1963) the older

moraines and ramparts were assigned to Pollen Zone I (Older Dryas), and the newer ones to Pollen Zone III (the Younger Dryas) (Lewis 1966a, 1966b). Later studies of the moraines and protalus features in the Brecon Beacons by Ellis-Gruffydd (1972, 1977) and Walker (1980, 1982a, 1982b) showed that most of the features had formed during the Younger Dryas.

Ellis-Gruffydd (1977) mapped 27 moraines and protalus features of varying morphological complexity at 23 locations along the Old Red Sandstone escarpment. Recent pollen analytical studies in the Brecon Beacons by Walker (1980, 1982a, 1982b) have provided evidence to support a recrudescence of glacier ice in the region during the Younger Dryas.

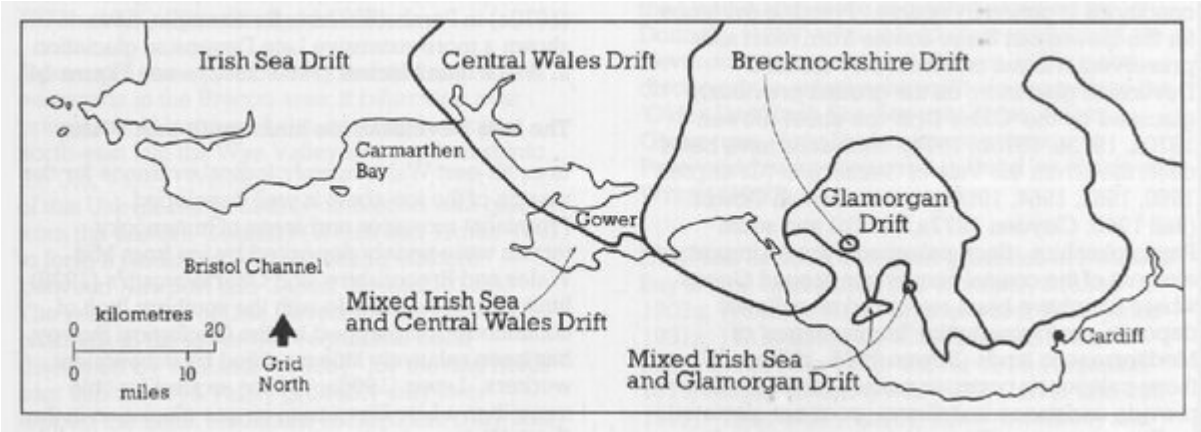
Devensian late-glacial and Holocene environmental history

A major theme in South Wales has been the use of pollen assemblage biostratigraphy to reconstruct Devensian late-glacial and Holocene environmental conditions. Hyde's (1940) study at Ffos Ton Cenglau (on the Pennant Measures escarpment) produced one of the first pollen diagrams in Wales. About the same time, Godwin (1940b) integrated the earlier observations of Strahan (1896), von Post (1933), Hyde (1936), George (1936) and George and Griffiths (1938) into a comprehensive account of marine and related sediments in the Swansea Bay area. He established that the Holocene transgression in the bay occurred during the later part of the Boreal (Pollen Zone VI) and was interrupted by minor regressive phases when peat beds formed. Many of these peat beds have been recorded at other sites around the coast as these were later correlated by radiocarbon dating (Godwin and Willis 1961).

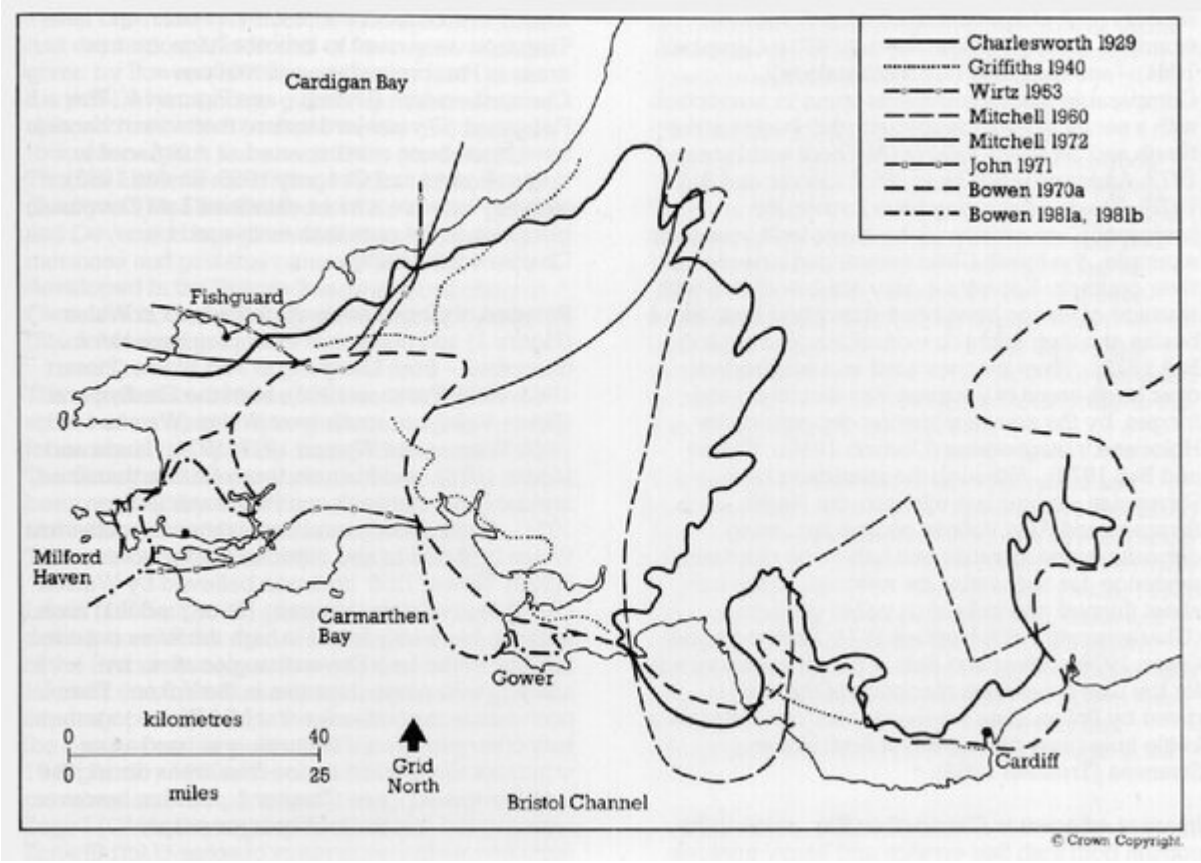
The first Devensian late-glacial sequence described in South Wales was that at Rhosgoch Common (Bartley 1960a, 1960b). Subsequently, Trotman (1963) studied sequences at Bryn House (Swansea), Cwmllynfell (near Brynamman), and Waen Du (near Llangattock), and provided an outline of Devensian late-glacial and Holocene environmental history for the region. The sequence extending back to Pollen Zone I in a kettle hole at Bryn House (Trotman 1963) provided evidence for ascribing local glacial deposits to the Late Devensian (Bowen 1970a).

Further aspects of Holocene vegetational and environmental history have been widely discussed (for example, Seymour 1973; Moore 1975a; Handa and Moore 1976; Evans 1977a; Slater and Seymour 1977; Evans *et al.* 1978; Walker 1980, 1982a, 1982b; Chambers 1981, 1982a, 1982b, 1983; Smith and Cloutman 1984; Seymour 1985). Traeth Mawr, Craig Cerrig-gleisiad. Cwm yr Eglwys (Dinas) and Esgyrn Bottom, the Cledlyn Valley and Cwm Nash provide a framework for reconstructing and interpreting Holocene palaeoenvironments in the region.

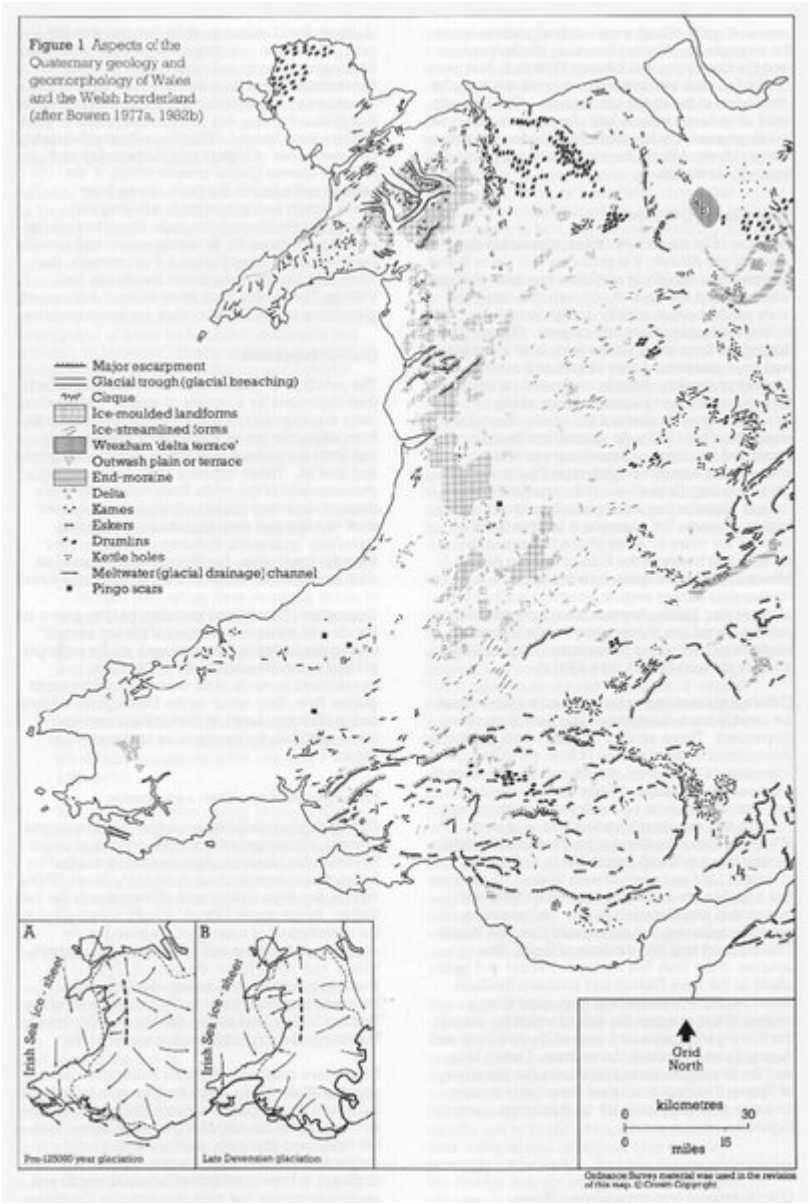
References



(Figure 13) Drift provinces of South Wales (from Bowen 1970a)



(Figure 14) Some suggested Late Devensian ice limits in South Wales (from Bowen and Henry 1984; Campbell 1984)



(Figure 1) Aspects of the Quaternary geology and geomorphology of Wales and the Welsh borderland (after Bowen 1977a, 1982b)