Chapter 7 Inverness area

Introduction

D.G. Sutherland and J E Gordon

The Inverness area comprises the lowlands along the Moray Firth coast from the Dornoch Firth to east of Nairn, the upland areas of the hinterland and the glaciated valleys extending to the west and south-west, including the Great Glen (Figure 7.1). The principal focus of research on this area has centred on the evidence for the last ice-sheet, the pattern of deglaciation and the changes in relative sea level that both accompanied and followed the ice wastage (Auton, 1990a; Firth, 1990a). Until recently, only one deposit was known to pre-date the Late Devensian, the high-level shelly clay at Clava. However, the discovery of possible Hoxnian deposits at Dalcharn and probable Early Devensian interstadial deposits at a site on the Allt Odhar, both associated with multiple till successions, together with detailed reinvestigation of the Clava succession, has enabled the development of a provisional stratigraphy extending back to the Anglian (Merritt, 1990a).

The Inverness area was glaciated during the Pleistocene by one of the major ice streams flowing out from the Highlands, receiving ice from the mountains both to the north and the south of the Great Glen. The pattern of striations indicates that the ice generally moved towards the north-east during the later phases of glaciation (Merritt, 1990a) and was channelled into the inner Moray Firth, beyond which it diverged and flowed back on to the land in both Caithness (Chapter 5) and in Buchan (Chapter 8). As discussed for other regions, such an ice-flow pattern may have occurred on more than one occasion during the Pleistocene. On the higher ground between the Rivers Nairn and Findhorn, there is evidence for an earlier southwards ice-movement in the form of striations aligned north–south and the transport of Middle Old Red Sandstone erratics from source areas around Loch Ness and the inner Moray Firth (Horne, 1923; Merritt, 1990a).

Early work in the area recorded the presence of many glacial features including striations, erratics, moraines, glaciofluvial deposits and terraces (Jamieson, 1865, 1874, 1882b, 1906; Fraser, 1877, 1880; Aitken, 1880; Milne Home, 1880a; MacDonald, 1881; Cameron, 1882a, 1882b; MacDonald and Fraser, 1881; Wallace, 1883, 1898, 1901, 1906; Mackie, 1901; Peach *et al.,* 1912; Horne and Hinxman, 1914; Hinxman and Anderson, 1915; Horne, 1923), as well as a high-level (*c.* 150 m OD), shelly clay at Clava (Fraser, 1882a, 1882b; Horne *et al,* 1894). In the Geological Survey Memoirs (Peach *et al.,* 1912; Horne and Hinxman, 1914; Hinxman and Anderson, 1915; Horne, 1923), three phases of glaciation were recognized: a period of maximum glaciation in which the whole landscape was covered by ice moving out from the mountains to the west and south, a period of confluent valley glaciers as the higher hills became ice-free and a final valley-glacier period accompanied by the formation of moraines. In the area south of the Moray Firth, ice-dammed lakes formed as the ice retreated (Horne, 1923). Later, Bremner (1934a, 1939c) and Charlesworth (1956) developed similar ideas on ice recession and glacial lakes. The effects of glacial erosion have been variable across the area, generally being greater in the west than in the east. To the east of the Great Glen, pockets of deeply weathered bedrock have survived glaciation, as at Clunas, providing a link with the more extensive occurrences of this phenomenon in north-east Scotland (see Chapter 8). More recent studies of glaciofluvial landforms in mid-Strathdearn (Young, 1980) and in the adjacent Dulnain and Spey valleys (Young, 1977b, 1978) indicate that the ice-sheet wasted largely *in situ.* The pattern locally, however, may be quite complex. In the middle Findhorn valley (see below), Auton (1990b) identified six stages involving both downwasting and recession and also the formation of an ice-dammed lake.

In the inner Moray Firth area and in the valleys to the west, a series of ice-sheet recessional stages was proposed by Kirk *et al.* (1966), J. S. Smith (1966, 1968, 1977) and Synge and Smith (1980). Readvances or stillstands were recognized at Ardersier, Alturlie, Kessock, Englishton, Muir of Ord, Balblair-Contin and Garve. However, reassessment of the evidence by Firth (1984, 1989a, 1989b, 1990a) led him to propose an alternative model of progressive ice recession without significant interruptions.

Evidence for pre-Late Devensian deposits occurs at three sites in the Inverness area. At Dalcharn, an organic deposit containing pollen of interglacial affinity forms part of a complex glacigenic succession observed in two separate exposures (Merritt and Auton, 1990; Walker *et al,* 1992). The organic deposit, which contains lenses of compressed peat of infinite radiocarbon age and appears to have been cryoturbated and glaciotectonically disturbed, overlies weathered outwash gravels, which in turn rest on till. Above the organic deposit are two distinct formations of lodgement till, each comprising three separate members. Pollen analysis of the peat (Walker, 1990a) indicates the development of pine forest with birch, alder and holly, which appears to reflect an interglacial episode. The pollen record is similar to that from Fugla Ness in Shetland, which has been assigned to the Hoxnian, although such a correlation is now considered insecure (Lowe, 1984). At present, therefore, it is not possible to provide a firm age for the Dalcharn deposits (Walker, 1990a; Whittington, 1990; Walker *et al.,* 1992).

The second pre-Late Devensian deposit occurs in a section along the Allt Odhar, where a layer of compressed peat containing pollen of interstadial affinity forms part of a succession of glacigenic deposits (Merritt, 1990c; Walker *et al.,* 1992). The peat rests on gravel, which in turn overlies a weathered till. Above the peat is a succession of interbedded paraglacial deposits and till. Pollen analysis (Walker, 1990b) indicates a vegetation–climate cycle involving a succession from birch woodland with juniper and willow, through a phase of expansion of grassland and heathland, to an open landscape of species-poor grass and sedge communities. The peat has yielded an infinite radiocarbon date (Harkness, 1990) and a uranium series date of 106 ka +11/–10 ka, the latter placing the deposit in Oxygen Isotope Substage 5c (Walker *et al,* 1992). The pollen and insect evidence also support an interstadial rather than an interglacial origin for the deposit (Walker *et al,* 1992).

At Clava there is a high-level shelly clay. Originally discovered by Fraser (1882a, 1882b), this deposit was subsequently examined in detail by a committee of the British Association (Horne *et al.,* 1894) in the context of the debate about the existence of a major interglacial submergence of the British Isles. The majority of the committee considered the deposit to be in place and to result from such a submergence, but this was disputed (Bell, 1895a, 1897a). Later publications tended to emphasize the likelihood of the shell bed being a glacial erratic (Sissons, 1967a; Peacock, 1975b). More recently Sutherland (1981a) has suggested that the deposit is indeed *in situ* and results from a marine transgression consequent upon isostatic depression in front of an expanding Scottish ice-sheet. However, reinvestigation of the site led Merritt (1990b) to conclude that the deposit is an erratic of marine sediments, transported by the Late Devensian ice-sheet from the Loch Ness basin.

The direction of movement of the last ice-sheet is well-illustrated by the transport of erratics from within the Highlands to the lower ground of the shores of the Moray Firth (Horne, 1923; Sissons, 1967a; Smith, 1977; Synge and Smith, 1980). Notable among these is the Inchbae augen-gneiss, fragments of which can be traced eastwards from its outcrop to the north-west of Ben Wyvis across the Black Isle and into the coastlands of Moray (Mackie, 1901; Peach *et al.,* 1912; Sutherland, 1984a). It is of interest that there is a distinct upper limit to these erratics on Ben Wyvis (Peach *et al.,* 1912), raising the possibility that the summit of this mountain was ice-free at the time of the maximum extent of the last ice-sheet. The major flow of ice emerging from the Great Glen is also reflected in the transport of erratics in an easterly direction (Horne and Hinxman, 1914; Horne, 1923; Bremner, 1934a; Peacock *et al.,* 1968).

The most striking landforms in the Inverness area relate to the period of deglaciation of the last ice-sheet. Particularly notable in this connection are the deposits at Ardersier and the sequence of glaciofluvial sediments that extends from Torvean at the mouth of the Great Glen at Inverness, through Littlemill to Kildrummie (Harris and Peacock, 1969; Smith, 1977; Synge and Smith, 1980; Firth, 1984). The deposits at Ardersier have been associated with a readvance of the last ice-sheet (J. S. Smith, 1968, 1977; Synge, 1977b; Synge and Smith, 1980), but this interpretation has been questioned by Firth (1984, 1989b). The esker and kame terraces at Torvean are outstanding landforms, among the largest examples of their type of Scotland, whilst the Flemington Esker at Kildrummie is one of the longest continuous such features in Scotland. Associated with such glaciofluvial deposits are meltwater channel systems, particularly on the higher ground and across spurs and interfluves. Young (1977b, 1980) has mapped the intricate sequences of channels in the valleys and hills to the south of Inverness, and a complex sequence of channels crosses the watershed between the Domoch Firth and Cromarty Firth in upper Strathrory. Further elements in the suite of glaciofluvial deposits that resulted from the last deglaciation are outwash terraces, which are found in many of the valleys of the region. Along the River Findhom, near the Streens Gorge, there is an extremely complex sequence of terraces (Young, 1980). This sequence was initiated during de-glaciation and evolved still further during the Lateglacial and Holocene (Auton, 1990b).

Around the coasts the progressive ice wastage resulted in the formation of a series of raised shorelines (see Ardersier and Munlochy Valley). These are isostatically tilted towards the northeast, each successively younger shoreline extending farther west and having a lower gradient than its predecessor (Synge and Smith, 1980; Firth, 1984, 1989a). Shorelines also formed around Loch Ness at this time (see Dores and Fort Augustus), and were considered by Synge (1977b) and Synge and Smith (1980) to be marine, and part of the coastal sequence of shorelines. Firth (1984, 1986) has re-mapped these features and considers that there was no connection with the sea and that the shorelines are lacustrine in origin. As such, they are among the clearest former lake shoreline deposits in Scotland.

At the time of deglaciation, and continuing into the Lateglacial Interstadial, fossiliferous marine sediments were laid down in the sea lochs and along the coastal fringe. These have been studied in boreholes (Peacock, 1974a, 1977a; Peacock *et al.,* 1980) and, to date, no equivalents of the Errol beds (see Chapter 15 below), otherwise widely distributed on the east coast of Scotland, have been found in the inner firths of the Inverness area (Peacock, 1975c). This may suggest relatively late deglaciation of this area, although there is no dating evidence available to support such an idea.

There has been little investigation in the Inverness area of the Lateglacial Interstadial terrestrial environment. Pennington *et al.* (1972) and Pennington (1977a) provided details of pollen and other analyses carried out at Loch Tarff in the extreme south-west of the region. Following an initial phase of pioneer vegetation with species such as *Rumex* and *Lycopodium selago,* which are characteristic of disturbed, skeletal soils, there occurred a period of dwarf-shrub tundra with increased representation of *Empetrum.* A brief period of reduced *Empetrum* values then occurred, which may be correlated with the Older Dryas period of increased climatic severity between 12,000 and 11,800 BP. Thereafter there was a marked expansion *of Empetrum,* which was accompanied immediately prior to the onset of the Loch Lomond Stadial by a peak in juniper pollen. This period of *Empetrum* dominance corresponds to the major part of the Lateglacial Interstadial and represents a time of soil stability and increasing acidity as is also confirmed by the diatom assemblages contained in the sediments.

The events of the Loch Lomond Stadial left a strong imprint on the scenery of this area, most particularly in the south-west, which was invaded by glaciers flowing out from the ice-field of the western Highlands. Major outlet glaciers flowed along the Great Glen to terminate near Fort Augustus (see below) and along lower Glen Moriston. This latter glacier flowed across the exit to Coire Dho (see below) damming a lake and resulting in the production of an outstanding suite of landforms relating both to the ice-dammed lake (shorelines and cross-valley moraines) and to the drainage of the lake (water-swept bedrock and meltwater channels) (Sissons, 1977b).

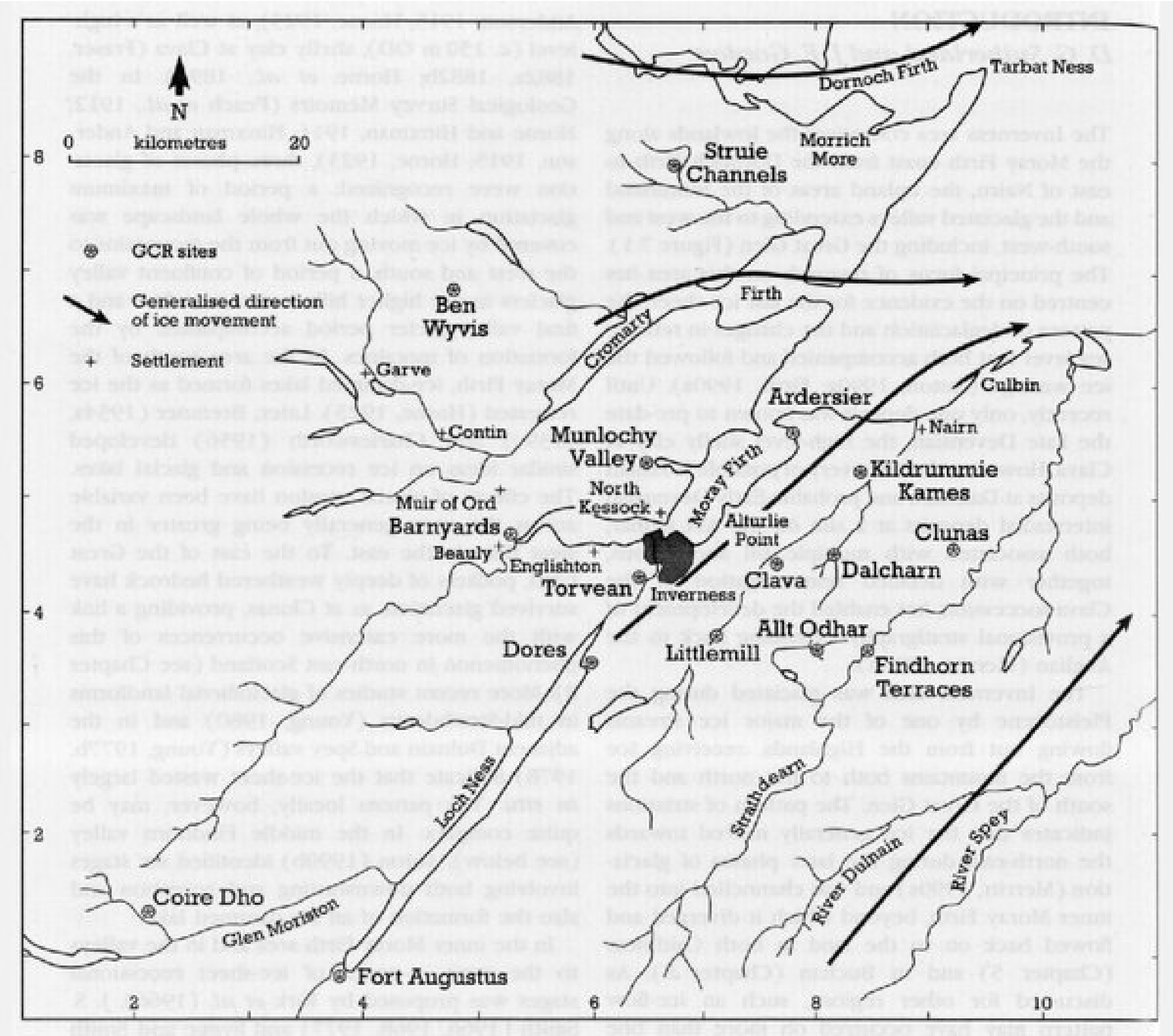
Sissons (1979c) also suggested that certain of the deposits at Fort Augustus related to a *jökulhlaup,* when the ice-dammed lake in Glen Spean and Glen Roy (see Chapter 10) drained catastrophically during the decay phase of the Loch Lomond Readvance. He suggested that this raised the level of Loch Ness several metres and that the resultant flood and corresponding erosion of the glaciofluvial sediments in the Ness valley resulted in the construction of a major fan at Inverness, producing the narrows between Inverness and Kessock (Sissons, 1981c). Firth (1984, 1986) accepted the broad outline of Sissons' hypothesis, although he suggested modi fications to details, such as the position of the ice front at the time of the supposed *jökulhlaup* and the precise nature of the changes in the level of Loch Ness accompanying the flood. In proposing this dramatic sequence of events, Sissons (1981c) also suggested that a marine erosion surface, which he identified underlying Holocene deposits at the head of the Beauly Firth and reaching an altitude a few metres above present sea level, was the equivalent of the Main Lateglacial Shoreline of the Forth valley.

Periglacial processes would have been active, particularly on the mountains during the Loch Lomond Stadial, and the large-scale, sorted ground features on Ben Wyvis may have received their final fashioning at this time, although the cover of frost-weathered debris on the summit area of that mountain may date from the early phases of deglaciation or, if the mountain was not in fact covered by the last ice-sheet, from the fully glacial part of the Late Devensian and earlier (Ballantyne, 1984; Ballantyne *et al.,* 1987).

There has been little study of the changes in the Holocene terrestrial environment of this region, although considerable work has been done on the evolution of the coastline. In the inner firths, Haggart (1982, 1986, 1987, 1988b) and Firth and Haggart (1989, 1990) have shown, by study of sites such as that at Barnyards, that during the early Holocene sea level initially fell, reaching a low some time after 9000 BP, then subsequently rose during the Main Postglacial

Transgression to culminate, between 7100 BP and 5800 BP, in the formation of the Main Postglacial Shoreline. The subsequent fall in sea level to its present level is not securely dated, but several distinct shorelines were formed during this period, as is illustrated by the sequence of estuarine flats at Munlochy Valley (Firth, 1984). Elsewhere in the area, Holocene raised shoreline features are well-developed (Ogilvie, 1914, 1923; J.S. Smith, 1968, 1977; Comber, 1991; Hansom, 1991) and include shingle ridges (Dornoch Firth, Tarbat Ness, Spey Bay and Culbin) and sand beach ridges (Morrich More).

[References](#)



(Figure 7.1) Location map of the Inverness area and generalized directions of ice movement.