Chapter 5 Caithness

Introduction

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Geographically, Caithness (Figure 5.1) forms a link between the Orkney Islands and the Northern Highlands. The north-east part of the district is a gently undulating erosion surface *c.* 90–180 m OD developed on the underlying sandstone bedrock, whereas to the south, conglomerates and quartzites form the upstanding hill masses of Morven (705 m), Maiden Pap and Scaraben. The effects of glacial erosion are limited by comparison with the north-west Highlands, and in studies of the Quaternary of Caithness, the glacial deposits have been the principal focus of research. Particular attention has centred on patterns of ice movement, the characteristics of a distinctive shelly till, the interaction between ice of local origin and the external ice that deposited the shelly till, the number and ages of separate glaciations represented in the stratigraphic record and the question of whether or not part of north-east Caithness was ice-free during the Late Devensian.

During the last century the glacial deposits were the subject of numerous papers particularly on account of their content of marine fossils (Busby, 1802; Peach, 1858, 1863a, 1863b, 1863c, 1865b, 1867; Jamieson, 1866; Crosskey and Robertson, 1868c; Brady *et al.,* 1874; Dick, *in* Smiles, 1878; Peach and Horne, 1881c). The abundance of these fossils led to a considerable debate as to whether the deposits were indeed the product of land ice (Croll, 1870a; J. Geikie, 1877) or whether they had been deposited in the sea from icebergs (Cleghorn, 1850, 1851; Peach, 1863a, 1863c; Jamieson, 1866). Caithness also became noted for the number and size of the Mesozoic and Cenozoic erratics found there (Peach, 1859, 1860; Peach and Horne, 1881c; Tait, 1908, 1909; Carruthers, 1911; Crampton and Carruthers, 1914). These erratics were thought to have come from the Moray Firth or the eastern coast of Sutherland and hence supported the interpretation that the last ice movement over most of Caithness was from the south-east towards the north-west (Croll, 1870a; J. Geikie, 1877; Peach and Horne, 1881c) and not, as had been suggested by Jamieson (1866), in the opposite direction.

During this early phase of study of the glacial deposits, the main outlines of the glacial stratigraphy of Caithness were also established. The sequence consisted of a lower till containing erratics derived from immediately inland (Jamieson, 1866; Peach and Horne, 1881c; Crampton and Carruthers, 1914), an overlying till containing the marine fossils and erratics already referred to, and, in the southern and western parts of the county, a local till together with morainic and glaciofluvial deposits (Peach and Horne, 1881c; Crampton and Carruthers, 1914). The superposition of the lower and the shelly tills can be seen at localities such as Baile an t-Sratha (Dunbeath) and Drumhollistan, and an additional lower till may be present at the site of the largest known Mesozoic erratic at Leavad. Significant observations were also made on the periglacial features found on the hills in the south of Caithness (Carruthers, 1911), and the absence of raised shorelines from much of the coast was also noted (Crampton and Carruthers, 1914).

Despite this early interest, little further work has been carried out on the glacial deposits in Caithness until recent years. Various summaries and syntheses of the published evidence were produced (for example, Bremner, 1934a; Charlesworth, 1956; Phemister, 1960; Godard, 1965), but little original work was carried out until that of Omand (1973). He systematized the glacial stratigraphy and named the lower, local till (the Dunbeath Till), the shelly till (the Lybster Till), and the upper local till (the Reay Till); the moraines and glaciofluvial deposits were assigned to the latest Bower stage. No break was noted in deposition between the Dunbeath and Lybster tills, the first being deposited by ice flowing from the south-west and the second by ice from the south-east. This sequence of events is broadly similar to that interpreted for the glacial deposits of Orkney by Rae (1976) (see Chapter 4), which strongly suggests contemporaneity of the glacial phases, as does the sedimentary succession (Sutherland, 1984a). This glacial phase was therefore characterized by initial unimpeded expansion of Scottish ice, but subsequently the ice turned to flow towards the north-west, presumably due to the influence of the Scandinavian ice in the North Sea Basin as originally suggested by Croll (1870a, 1875) (but see below). There is some debate as to whether the Reay Till and the Bower stage represent significantly later glacial events (Peach and Horne, 1881c; Smith, 1968, 1977; Omand, 1973; Flinn, 1981; Sutherland, 1984a) or are essentially

retreat phenomena of the major glaciation (Crampton and Carruthers, 1914; Charlesworth, 1956; Sissons, 1967a). This outline stratigraphy has been confirmed and amplified in southern Caithness by Hall and Whittington (1989).

There is no direct evidence that bears on the age of the glacial deposits in Caithness. No *in situ* organic sediments have been found below or interstratified with the glacial deposits. Radiocarbon dating of the shells within the till has produced only a 'greater than' age (Omand, 1973) and amino acid analyses suggest that the majority of the shells have been derived from deposits of last interglacial age or older (Bowen and Sykes, 1988; Bowen, 1989). Various workers (Smith, 1977; Synge and Smith, 1980; Flinn, 1981; Sutherland, 1984a) have proposed that the shelly till may date from earlier than the Late Devensian and that only the overlying morainic and glaciofluvial deposits in the west and south of the county are of Late Devensian age. Hall and Whittington (1989) and Hall and Bent (1990), however, have argued that there is no evidence for a hiatus between sediments dated to the Lateglacial Interstadial and the underlying glacial deposits, thus inferring a Late Devensian age for the latter.

Overlying the glacial sediments are thicknesses of head and soliflucted till (Omand, 1973; Smith, 1977; Futty and Dry, 1977; Hall and Whittington, 1989). These have been interpreted as supporting the concept of this area being ice-free during the Late Devensian, the area being presumed to be subject to severe periglacial processes at that time. However, the mass-movement sediments may equally reflect early deglaciation as well as further activity during the Loch Lomond Stadial (see Hall and Whittington, 1989). In the south of the county the summits of the quartzite and conglomerate hills above about c 450 m OD are notable for a range of active and fossil periglacial features, including wind and frost-related effects in the hill-top detritus and vegetation (Crampton, 1911; Crampton and Carruthers, 1914).

The earliest known deposits post-dating the last glaciation of Caithness are those at the Loch of Winless (Peglar, 1979), where the initial deposition of organic sediment has been dated to after 13,000 BP. This site has the most detailed published Lateglacial Interstadial pollen diagram in this region of Scotland and it shows certain differences from the north-west Highlands, with the possible local development of tree birch. Further Lateglacial Interstadial pollen records have been described by Hall and Whittington (1989) and by Charman (1990) from the Caithness–Sutherland border.

Apart from the information on the sparse local vegetation from the Loch of Winless, there is little information available on the environment during the Loch Lomond Stadial. It may be presumed, on the basis of inference from neighbouring areas, that certain of the periglacial features at both low level and on the mountain summits in the south of the county were formed or modified at this time, and this is confirmed by the work of Hall and Whittington (1989).

The vegetational development during the Holocene is important in this region for an understanding of the forest history of Scotland and the development of the blanket peat of the Flow Country. Lewis (1906) and Crampton (1911) provided details of vegetation and forest changes represented in the macrofossils preserved in peat sections, including the extensive occurrence of pine stumps in the central and western parts of Caithness. However, apart from the early work of Durno (1958) and the investigation of peat mounds by Robinson (1987), the only detailed pollen analytical work is that from the Loch of Winless. Caithness during the Holocene appears to have been largely treeless, although local, sheltered patches of birch–hazel woodland had developed by 9300 BP. Fossil pine stumps occur within blanket bog in western Caithness (Birks, 1977; Gear and Huntley, 1991) but in the east of the county the sampled pollen values for pine are so low that it seems unlikely that the tree ever grew there. Radiocarbon dating of the pine stumps has shown that the pine forest in Caithness was short-lived, expanding and retreating within a period of about 400 years around 4000 BP (Gear and Huntley, 1991). Clearance of the limited woodland cover in Caithness by Man appears to have started at around 3000 BP.

The Glaciation of Caithness

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The main features of the glaciation of Caithness are illustrated in (Figure 5.1).

The glacial deposits of Caithness vary considerably in their distribution and thickness: typically they attain their greatest thickness in pre-existing valleys, topographic depressions and coastal re-entrants, and are relatively thin on higher

ground and interfluves (Cleghorn, 1851; Jamieson, 1866; Peach and Horne, 1881c; Cramp-ton and Carruthers, 1914; Godard, 1965; Omand, 1973; Hall and Whittington, 1989).

Three main suites of glacial deposits are characteristic of the area (Jamieson, 1866; Peach and Horne, 1881c; Crampton and Carruthers, 1914; Omand, 1973; Hall and Whittington, 1989). These comprise a locally derived till generally occurring west of a line from Reay to Berriedale (Figure 5.1) and deposited by ice originating in the hills of southern Caithness and Sutherland, a distinctive shelly till (often weathered in its upper layers) to the east and derived from offshore in the Moray Firth, and hummocky glacial deposits which locally overlie both till sheets in the main valleys.

Long recognized as a distinctive deposit on account of its abundant shell content, the shelly till, has received considerable documentation. The first known report of marine shells in the Caithness drift was by Busby (1802; cited by Crampton *et al.,* 1914, p. 118). Later, in the course of his energetic travels around Caithness, Robert Dick identified the widespread occurrence of shelly boulder clay, which he explained as a marine deposit associated with sea ice and glaciers (Smiles, 1878). He collected and identified many shells, some well preserved, from the deposits and also recorded the presence of Chalk flints and oolitic limestone clasts. Shells collected by Cleghorn were listed by Smith (1850a) and their arctic character noted (Smith, 1850b). Cleghorn (1850, 1851) thought the till to be a marine deposit and attributed the fragmentary nature of the shells to the feeding habits of catfish! Miller (1847 — see Miller, 1858) first publicized Dick's and Cleghorn's observations, and later exhibited some of Dick's specimens (Miller, 1851).

C. W. Peach added greatly to the knowledge of the fossil content of the till (Peach, 1858, 1859, 1860, 1863a, 1863b, 1863c, 1865b, 1867), listing the remains of 142 species, including molluscs, Foraminifera, bryozoa, sponges and algae. Further details of Foraminifera were provided by Crosskey and Robertson (1868c) and 'Entomostraca' by Brady *et al.* (1874). The most abundant molluscs are *Arctica islandica* (L), *Spisula solida* (L.), *Mya truncata* L., *Turritella communis* Risso, *Tridonta elliptica* (Brown) and *Tridonta borealis* Schumacher (Crampton and Carruthers, 1914).

Interpretations of the glacial sequence in Caithness have centred notably on the patterns of ice movement represented by the different deposits and, more recently, on questions concerning the age(s) of the deposits and the extent of the Late Devensian glaciation.

The first regional synthesis of the glaciation of Caithness was put forward in an important study by Jamieson (1866). He believed the shelly drift to be a marine deposit disturbed and mixed into its present state by drift-ice moving north-west to south-east across the county, which he inferred from striations, the apparent distribution of stoss and lee slopes and the overlap patterns of drift on bedrock in different areas. Chronologically he related the shelly drift to the glacial-marine period or submergence, which he believed followed the main glaciation (see Clava and Nigg Bay) on the basis of the sub-arctic character of its fauna, which he did not appreciate was a derived assemblage. Jamieson (1866) also described up to 20 ft (6.1 m) of reddish-brown clay with boulders (sandstone, quartz, mica-schist and granite) with few or no shells resting on the shelly till at Wick and Keiss.

C. W. Peach reached a different conclusion about the origin of the Caithness till. Revising his earlier ideas of glaciomarine processes (Peach, 1863a, 1863c), he informed Croll in 1868 (Croll, 1870a) that the drift had been formed by land ice moving from the Moray Firth to the Atlantic. Croll (1870a, 1875) supported and elaborated this view, arguing that Scottish ice in the Moray Firth was deflected across Caithness by Scandinavian ice in the North Sea and carried with it shales, Chalk flints and Chalk fossils from the sea bed in its boulder clay. This interpretation was also favoured by J. Geikie (1877), who noted that the striation and till patterns cited by Jamieson for a south-east ice movement were equally explicable in terms of a north-west movement, and the stoss and lee forms were somewhat indistinct. Moreover, an ice movement towards the south-east did not take account of the Chalk and other foreign material in the till. Geikie concluded that the Caithness till was simply an ordinary glacial boulder clay, but with shells dispersed through it.

Using as evidence the patterns of striations, roches moutonnees and the distribution of indicator stones, Peach and Horne (1881c) confirmed the existence of two separate ice streams: local ice moving east-north-east and north-north-east, deflected by external ice moving north-west. They described the characteristics of the till units associated with the separate ice masses and presented a revised species list for the shelly till, noting the general deep-water character of the faunal assemblage. They concluded that both tills were deposited by land ice. Peach and

Horne (1881c) also presented the first detailed account of 'moraines' and gravel in Caithness, although examples near Dirlot had been recorded earlier by Dick (Smiles, 1878). The features largely comprise ridges and mounds of gravel resting on both the local and shelly tills. They are largely confined to the central and north-west part of the county and are generally absent from the east, as noted by Jamieson (1866). Peach and Horne suggested that they were formed by local ice moving out from the hilly ground to the west and reaching a limit near Dirlot, long after the retreat of the Scandinavian ice.

Further confirmation of onshore ice movement was provided by Tait (1908, 1909) and by the location of the famous Leavad and other erratics (Tait, 1909, 1912; Carruthers, 1911; Crampton and Carruthers, 1914; Sutherland, 1920).

Crampton and Carruthers (1914) later showed the moraines and gravels to be more extensive than was previously recognized. From the existence of cross striations away from the zone of confluence of the two main ice streams and the presence of a local till beneath the shelly till at Leavad, they thought it highly probable that local ice advanced across part of lowland Caithness before the external ice reached its full extent. After the latter had waned, the moraines and gravels were deposited by an advance of local ice across part of the area covered by the shelly till with lobes extending to near Thurso and reaching the sea at Wick and Sinclair's Bay.

Bremner (1934a) explained the shelly till of Caithness as the ground moraine of his 'Second Ice Sheet' moving north-west from the Moray Firth to the Atlantic. He suggested that some of the erratic material recognized by Crampton and Carruthers (1914) was carried south-east from the northern Highlands into the Moray Firth by the 'First Ice Sheet', then moved into Caithness by the second. As evidence for a pre-shelly till glaciation he quoted striae patterns and the presence of local till beneath the Leavad erratic. A third ice sheet was indicated by the surface moraines and gravels, and although less extensive than the previous one, it covered 'quite half of the Caithness plain north-east of a line from Lybster to Reay'. Here Bremner was following Crampton and Carruthers (1914). Charlesworth (1956, 1957) largely echoed Bremner's views although he placed the limit of the third ice sheet (his Highland Glaciation) further north than Peach and Horne, in Orkney.

Phemister (1960) reconstructed two separate ice-sheet movements in Caithness from striae orientations. The earlier one, from south-east to north-west, deposited the shelly boulder clay. The later one was to the north as the Scandinavian ice barrier withdrew eastwards and although it must also have transported a shelly till, two separate shelly tills had not been identified. Phemister correlated the northerly ice movement with the so-called Strathmore Glaciation of north-east Scotland and mapped it as extending beyond the Caithness coast. He also noted an early, local ground moraine beneath the shelly till.

Godard (1965) identified three superimposed till sheets in Caithness, reflecting the changing predominance of mainland and Scandinavian ice, and interpreted them in terms of Bremner's triple ice-sheet model (Bremner, 1934a). A lower local ground moraine was overlain by a shelly till deposited by ice moving north-west from the Moray Firth; above was an upper local ground moraine associated with ice from a more southerly direction which extended into Orkney.

Sissons (1965, 1967a) considered that during the last glaciation Scottish ice bifurcated in the Moray Firth due to the presence of Scandinavian ice to the east. One stream moved north-west across Caithness and Orkney, depositing the shelly till. Subsequently, during the so-called Aberdeen–Lammermuir Readvance, inland ice moved north-east across Caithness to a limit of till, morainic mounds and 'mines resting on the shelly till near Dirlot, as identified by Peach and Horne (1881c).

Smith (1968, 1977) proposed a rather different chronology for glacial events in Caithness. He thought that the moraines at Dirlot and near Lothbeg represent the limit of the Weichselian (Late Devensian) glaciation in Caithness and that the shelly till was of Saale ('Wolstonian') age. He noted great depths of shattered bedrock, extensive colluvium at the base of slopes and lack of 'fresh' forms over large parts of the county. However, the one radiocarbon date from the shelly till at Gills Bay (>40,800 BP (Birm–179); Shotton and Williams, 1971) does not necessarily support his argument — as he states (Smith, 1977), it is inconclusive.

From his investigation of the field evidence Omand (1973) suggested there had been three main phases in the glaciation of Caithness. The first is represented in a number of sections, as at Baile an t-Sratha, where a local till (Dunbeath Till) underlies the shelly till, indicating early local glaciation. During the second phase, ice from the Moray Firth was diverted across Caithness by Scandinavian ice in the North Sea Basin and deposited the shelly till (Lybster Till). This ice stream merged with and deflected local inland ice, which deposited an upper local till (Reay Till) identified by Omand west of the shelly till limit. However, the distinction between the two local tills is unclear and, so far as is known, they are not seen together in any section. Probably they are both part of the same till unit, its distribution reflecting variations in the dominance of different ice masses. During the final phase (Bower stage), local ice deposited moraines and gravels as it wasted back more or less continuously in the eastern part of the county. Omand concluded there was no evidence for a separate Lateglacial readvance or a separate till associated with the Bower stage. From the periglacial modification of the tills by solifluction and cryoturbation and from the radiocarbon date cited above, Omand proposed either that the glacial maximum in Caithness was early in the Devensian, or the deposits in Caithness were older, possibly Wolstonian' in age as suggested by Smith (1968). He implied that the latter was more probable since evidence elsewhere in the country supported a Late Devensian ice maximum.

Studies in the central North Sea Basin apparently indicate that Scottish and Scandinavian ice did not coalesce during the Late Devensian (Jansen, 1976; Sutherland, 1984a; Cameron *et al.,* 1987; Sejrup *et al.,* 1987; Nesje and Sejrup, 1988) (see also Lambeck 1991a, 1991b). Thus, as Flinn (1981) and Sutherland (1984a) noted, if the flow of the ice that deposited the shelly till was to the north-west as a consequence of deflection by Scandinavian ice, then the till must pre-date the Late Devensian. However, the assumption that Scandinavian ice is required to produce such a flow pattern may not be warranted; for example, a strong outflow of ice from the Moray Firth might also produce such a pattern (see for example, Hall and Bent, 1990). On the basis of a small number of striations, Flinn (1981) proposed that subsequent to deposition of the shelly till, local ice flowed outwards across the Caithness coast, northwards to Orkney and south-eastwards into the Moray Firth. In contrast, Sutherland (1984a) suggested that much of northern and eastern Caithness may have been ice-free during the Late Devensian. Some support for such a proposal comes from preliminary results of amino acid analyses of shells from the Caithness till, which suggest that the shelly till may relate to glaciation during the Early Devensian (Bowen and Sykes, 1988; Bowen, 1989, 1991). The results also indicate a Late Devensian age for the shelly till at Latheronwheel. This raises questions of whether there might be more than one shelly till or whether sampling elsewhere might have missed younger shells.

Hall and Whittington (1989), working on the stratigraphy of south-east Caithness, have continued the debate. From the field evidence they conclude that the inland till and the shelly till relate to a single glacial episode and, following retreat of the ice in the Moray Firth, there was a late minor advance of the inland ice. Furthermore, from an assessment of several lines of relative age evidence, including the degree of weathering of the tills, periglacial deposits and comparisons with Buchan (see Chapter 8: Northeast Scotland), Hall and Whittington infer that this episode was during the Late Devensian. They conclude that the maximum limit of the Late Devensian ice must therefore have been as far north as the Orkney–Shetland Channel, assuming that the shelly till of Caithness and Orkney is a single lithological unit. Subsequently, Hall and Bent (1990) have elaborated on the model citing additional evidence from a wider area of the Moray Firth and Buchan. They propose that the last Scottish ice-sheet extended northwards across Caithness and Orkney to a limit in the Orkney–Shetland channel, and eastwards across the adjacent shelf to a limit at the Bosies' Bank moraine (Bent, 1986).

Hall and Whittington (1989) also report the presence in south-east Caithness of peat deposits radiocarbon-dated to the Lateglacial Interstadial, which are overlain by Loch Lomond Stadial gelifluction deposits. This evidence is important in demonstrating the significance of periglacial mass wasting in Caithness during the stadial.

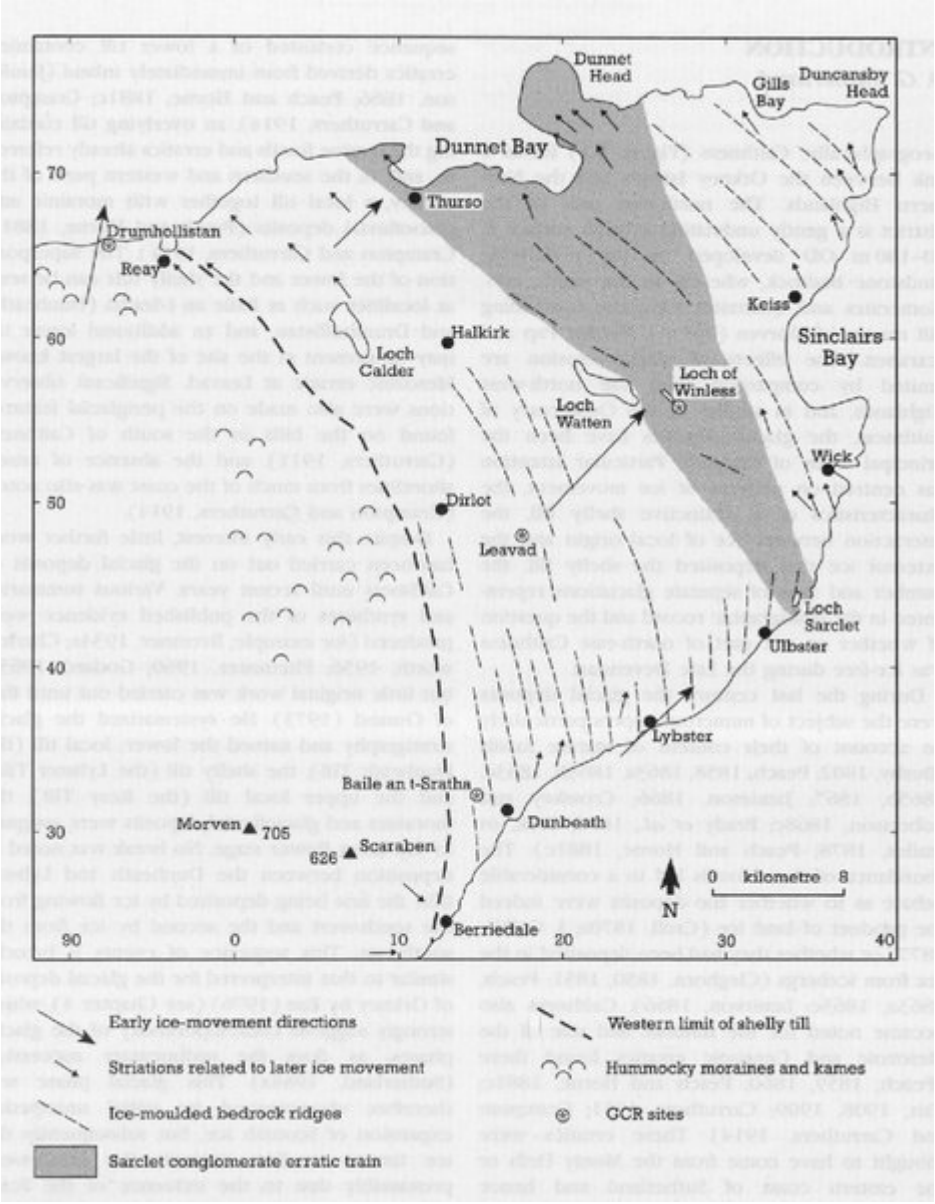
It is clear from the above review that several important questions remain to be answered about the glacial sequence in Caithness. In particular these concern:

1. the position of the Late Devensian ice limit;
2. the direction, age and extent of the last ice movement;
3. the age of the shelly till and its weathering and periglacial modifications;

4. the origin of the shelly till: was it deposited by land-based ice or as a glaciomarine deposit?
5. the age of the local till below the shelly till and its stratigraphic relationships to local till elsewhere;
6. the significance of the moraines and gravels above both the local and shelly tills;
7. the origin and significance of the reddish-brown, stoney clay on top of the shelly till at Wick and Keiss described by Jamieson (1866).

The answers to these questions have an important bearing on a wider scale concerning the extent of the last ice-sheet in northern Scotland and adjacent areas of the North Sea Basin, Orkney and Shetland. Three sites have been selected to represent the main units and features of the glacial deposits of Caithness: Baile an t-Sratha, Drumhollistan and Leavad.

References



(Figure 5.1) Location map and principal features of the glaciation of Caithness, including patterns of striations, ice-moulded landforms, distribution of erratics and shelly till (from Peach and Horne, 1881c; Sissons, 1967a; Sutherland, 1984a).