Site 22 Nigg Bay, Aberdeen

The superficial deposits exposed in the Nigg Bay section (Map 9), to the south of Aberdeen city, represent a classic sequence that has been used extensively to establish the sequence of Pleistocene glaciations in the Aberdeen district, and more widely in north-east Scotland. Jamieson (1882b) provided the first detailed description of the succession. Others, principally Bremner (1928), Simpson (1948, 1955) and Synge (1963) subsequently added detail and debated the interpretation of the sequence. The reader is referred to Gordon (1993c), who reviews the long history of research on the site. This account focuses on describing and interpreting the deposits, and establishing the local lithostratigraphy (Table A1.14).

Although the deposits exposed at Nigg Bay provide evidence of a complex sequence of glacial and deglacial events affecting the Aberdeen area, they do not record all of them. Evidence from the lower Dee valley, and from recent gas pipeline trenches and road excavations to the west and north-west of Aberdeen city are also described here as they provide an important record of earlier events not represented in the section at Nigg Bay.

Nigg Bay Section

The Nigg Bay section, which occurs on the south side of the bay [NJ 965 045], is over 200 m in length and up to 20 m high (Figure A1.27). Since the mid-1970s material dumped at the base of the cliff has obscured most of the lower unit in the stratigraphy and allowed slumping and vegetation growth on the upper part. However, at present all of the main units are visible.

The exposed deposits only represent the uppermost 20 m of a 60 m-thick succession that occupies a broad buried valley lying between Torry and Tullos Hill (Map 9). The valley might have been a former course of the River Dee (Simpson, 1948), but evidence from borehole logs (Monro, 1986) and geophysics (Law, 1962) indicates that, within the broad feature, a narrow gorge-like channel cut into bedrock descends to 40.5 m below OD beneath the bay (Figure 46). This channel has an apparently irregular 'up-and-down' long profile suggesting that it was cut by subglacial meltwaters. Its excavation predates the drift succession at the site.

Borehole logs show that the channel is filled with about 30 m of drift, mainly till with subsidiary gravel and sand bodies (Munro, 1986). The till is described as grey or grey-brown in colour, suggesting that it was deposited by ice that advanced from the west or north-west. It is possible that the uppermost till units of the buried sequence correlate with the grey till seen in the cliff section, but they may have been deposited during an earlier event (see below).

The following account is based on the descriptions of Jamieson (1882b), Bremner (1928), Simpson (1948) and Synge (1963), augmented by observations made by E R Connell since the mid 1970s. The formal lithostratigraphy is established here. Four main units can be recognised in the cliff section above bedrock, which comprises granite-gneiss and is locally weathered.

Unit 1 Ness Sand and Gravel Member

This unit, up to 9 m thick, comprises coarse (locally bouldery) gravels and sands passing upwards into sands with minor gravel beds. Clast types are dominated by local metamorphic and igneous rocks, but they also include very sparse Norwegian erratics (rhomb-porphyry and larvikite) and ultrabasic rocks from the Belhelvie mass north of Aberdeen. Flint has been found recently in the gravel, as have a number of clasts of greyish brown diamicton (some of them 'armoured'). A single unarmoured clast of red diamicton has also been found in the gravel close to the junction with the overlying till.

Interpretation Recent sedimentological and palaeocurrent analyses indicate that the sands and gravels were deposited by meltwater flowing north-eastwards.

They have been assigned to the Lochton Sand and Gravel Formation of the East Grampian Drift Group on account of their dominantly local clast composition (Synge, 1963). However, the presence of ultrabasic clasts derived from the north

(Bremner, 1928), sparse Norwegian erratics (Read et al., 1923; Bremner, 1928) and sparse flints makes them sufficiently distinctive to be named here as the Ness Sand and Gravel Member. The clasts of greyish brown diamicton are of interest in that they resemble the overlying grey till in both texture and mineralogy. It seems likely that some clasts were introduced into the meltwater deposit directly by the ice mass that eventually deposited the grey till, whereas others may be derived from older till deposits in the area. The clast of red diamicton possibly originated from an older red, Old Red Sandstone-derived till once present in the area. The ultrabasic clasts, Norwegian erratics and flints were all probably reworked from older deposits when ice advanced into the area from the north-west, north or north-east.

Unit 2 Nigg Till Member

This unit, up to 10 m thick, typically comprises a very dark greyish brown to dark greyish brown (2.5Y 3/2–4/2), hard, sandy, silty diamicton containing predominantly local metamorphic and igneous clasts.

Interpretation This thick deposit of lodgement till rests unconformably on the underlying sands and gravels. Its base dips gently northward and it possibly correlates, in part, with the uppermost till units preserved in the buried channel. The unit is assigned to the Banchory Till Formation of the East Grampian Drift Group on account of its clast composition, which is dominated by local metamorphic and igneous types, and its strong north-easterly clast fabric (compare with Synge, 1963). It was deposited by ice that flowed down the Dee valley from accumulation centres in the Grampian Mountains.

Unit 3 Mill Of Forest Till Formation

Though it is absent locally, this unit ranges up to 5 m thick. It is typically a reddish brown (5YR 4/4), hard, sandy, diamicton with mostly Old Red Sandstone-derived clasts.

Interpretation The gradational transition between this unit and the underlying grey till suggests that both were deposited during the same glacial stage. The content of Old Red Sandstone-derived clasts and north-north-easterly clast fabric (Jamieson, 1882b, 1906; Synge, 1963) of the red diamicton indicate it was deposited by ice flowing northwards from Strathmore along the coast, at a time when the Dee valley ice had receded westward. The absence of Permo–Triassic material and of Early to Mid Pleistocene shells indicates that the unit should be correlated with the Mill of Forest Till Formation of the Mearns Drift Group rather than the Hatton Till Formation of the Logie-Buchan Drift Group, which occurs immediately to the north of Aberdeen. While generally less than 2 m thick in the section, the till is known to be up to 5 m thick in nearby boreholes and excavations.

Unit 4 Drumlithie Sand And Gravel Formation

Coarse gravels (locally bouldery) and sands pass northward into interbedded sandy gravels and sands with laminae and beds of red silt and clay. The gravels contain numerous Old Red Sandstone-derived clasts. The upper part of the unit displays a range of periglacial features, including cryoturbation structures, frost cracked clasts and possible ice-wedge casts. The unit is between 2.5 and 6 m thick.

Interpretation These glaciofluvial outwash deposits contain a similar erratic suite to the underlying red till and were almost certainly deposited from the ice that laid down that till. Simpson (1948, 1955) originally linked this unit with the moundy ice-contact gravels containing a similar erratic assemblage and thin beds of red diamicton at, for example, Balnagask (immediately north of Nigg Bay) and Loirston (some 3 km to the south-south-west). All were deposited during the southward retreat of the same ice mass. However, Jamieson (1865, 1874, 1882b, 1906), Bremner (1928, 1934a, 1938, 1943) and later Synge (1956, 1963) all concluded that the sediments formed part of a moraine that marked the limit of what Synge termed the 'Aberdeen Readvance'. Synge (1963) sited evidence for a gravelly till and 'faulting and overthrust structures' at the northern end of the Nigg section, which he considered were formed at the exact margin of the re-advance.

Recent work has not been able to confirm Synge's description of till and glacitectonic structures, but suggests that any deformation and faulting is more likely to have resulted from melt-out of buried glacier ice. Simpson (1948) also recorded a range of load, deformation and fault structures in the fine-grained sediments to the west of Nigg. Some may have

formed by slumping of sediment from the adjacent valley sides whereas others may have resulted from having been deposited on top of melting buried ice.

Mapping of glaciofluvial sediments and landforms in the Aberdeen district, and farther afield in north-east Scotland, led Clapperton and Sugden (1975, 1977) and Murdoch (1975, 1977) to strongly support Simpson's (1948, 1955) interpretations. The mapping identified continuity of glaciofluvial landform elements across the boundaries of the supposed 'Aberdeen Readvance'. As a result, the sediments and landforms of the coastal zone around Aberdeen are now interpreted as having been deposited during the westerly retreat of the East Grampian ice sheet and the southward retreat of the coastal ice that deposited the Mill of Forest Till.

Unit 5 Tullos Clay Member

Recent exposures indicate that the sands and gravels of unit 4 tend to fine northward as originally suggested by Simpson (1948). He also recorded extensive deposits of red and khaki-coloured clays, silts and sands in excavations and boreholes up to 1 km west of the Nigg section. No fossils were recovered from the deposits, but Simpson suggested that they could be glaciomarine in part. Nearby at the former Torry claypit (to the north of Torry and approximately 1.5 km west-north-west of the Nigg section), Jamieson (1858) described a similar sequence of fine-grained sediments and recorded bird and fish remains (Peacock, 1999). These appear to confirm a glaciomarine influence and the deposits are named here as the Tullos Clay Member of the Ugie Clay Formation.

Summary

All the stratigraphical units exposed at Nigg Bay are believed to relate to the Main Late Devensian glaciation of the area (Clapperton and Sugden, 1977; Murdoch, 1977; McLean, 1977) (Table 7). The stratigraphy of the exposed sequence at Nigg Bay indicates a strong flow of ice north-eastwards from the Grampian Mountains along the Dee valley. This advance led to deposition of the outwash gravels and sands of the Ness Sand and Gravel Member and the thick unit of till, the Nigg Till Member. It is unclear if the thick till sequence preserved in the buried channel at Nigg Bay relates in part to this advance of Grampian ice, or an earlier advance of unknown age, or to both. The 'exotic' clasts in the Ness Sand and Gravel Member gravels are probably reworked from older deposits in the area. As the East Grampian ice receded, southerly sourced ice transported Old Red Sandstone material from Strathmore (and immediately offshore) into the Aberdeen area. The same ice stream also deposited the Logie-Buchan Drift Group sediments farther to the north. Retreat of this ice mass resulted in the deposition of both moundy ice-contact deposits and sheet-like spreads of the Drumlithie Sand and Gravel Formation throughout the district.

Sections west and north-west of Aberdeen

Important sections in the lower Dee valley are included here as they record events that were earlier than those interpreted from the Nigg Bay section.

Bremner (1934a) has recorded important sections in excavations for the Anderson Drive segment of the Aberdeen ring-road, near Bridge of Dee [NJ 927 037] (Map 9). At the base of the sequence he descibed a 'dark shelly boulder clay' containing arctic shells, many of which were striated. Unfortunately he provided no further information on this deposit and more recent investigations have failed to rediscover it (McLean, 1977). Although no Norwegian erratics were found in the deposit by Bremner (1934a), he speculated that it might have been deposited directly by Scandinavian ice, or more probably, by Scottish ice forced back onto the coast by Scandinavian ice in the North Sea (Figure 37). Hart (1941) reported limited textural and mineralogical data from the Anderson Drive deposit that suggest that it is of distinctly different provenance to the Benholm Clay Formation at Gourdon (see Site 26 Burn of Benholm). However, Hart's data indicates some textural affinity with the Jurassic to Lower Cretaceous derived diamictons within the Banffshire Coastal Drift Group. Consequently, the deposit is here formally named the Anderson Drive Diamicton Formation of that group.

In the ring-road excavations recorded by Bremner (1934a), the dark shelly boulder clay was apparently overlain by 'grey boulder clay with characteristic erratics from the north-west' (from the Belhelvie, Barra Hill and Huntly basic igneous

masses). Unfortunately, he did not describe the exact relationship between the tills. It is possible that erosion of a unit similar to this one provided the ultrabasic erratics recorded in the lower gravels of the Nigg Bay exposure, and that such a unit could be preserved within the thick sequence infilling the Torry–Tullos buried channel.

During the 1970s, extensive gas pipeline trenches to the west and north-west of Aberdeen provided important information on the local Quaternary sequence. Murdoch (1975, 1977) and McLean (1977) described two distinct and superimposed till units in this area. The lower till was dark brown (10YR 3/4) or locally blue grey (5PB 3/2) where gleyed (Munro, 1986). It was fine grained and possessed a strong south-easterly clast fabric. Erratics derived from outcrops to the north-west were also commonly recorded within this unit, which is patchily distributed and generally preserved only in bedrock depressions.

The lower unit is overlain by a much more laterally extensive unit of grey brown (10YR 5/5–7.5YR 4/5) relatively sandy till (Munro, 1986). Clast fabrics in this upper unit are less strongly clustered than in the underlying till, but display easterly or north-easterly orientations. The till contains abundant clasts of red granite to the east of the Hill of Fare granite. In 1998, an excellent exposure in a road excavation [NJ 879 062] near Kingswells, to the west of Aberdeen, revealed both tills in superposition. The lower of these two tills is here named the Den Burn Till Member and the upper the Kingswells Till Member, both of the Banchory Till Formation. It is probable that the Den Burn Till Member correlates with the 'grey boulder clay' reported by Bremner (1934a) overlying the Anderson Drive Diamicton in the ring-road excavations. The Kingswells Till Member is probably the lateral equivalent of the Nigg Till Member in the Nigg section. Both tills seen in the Kingswells exposures would now be described as lodgement/deforming-bed tills.

Murdoch (1977), McLean (1977), Munro (1986) and Auton and Crofts (1986) found evidence that the upper grey-brown till was interbedded with the coastal red till units (Mill of Forest and Hatton till formations) at a number of sites suggesting that deposition of both units occurred close together in time. Both Murdoch (1977) and McLean (1977) were of the opinion that the upper till unit was a supraglacial facies of the lower till. However, based on the evidence of distinct clast assemblages and fabrics, Sutherland (1984a) and Auton and Crofts (1986) concluded that both were basal tills and related to different glacial events.

Summary

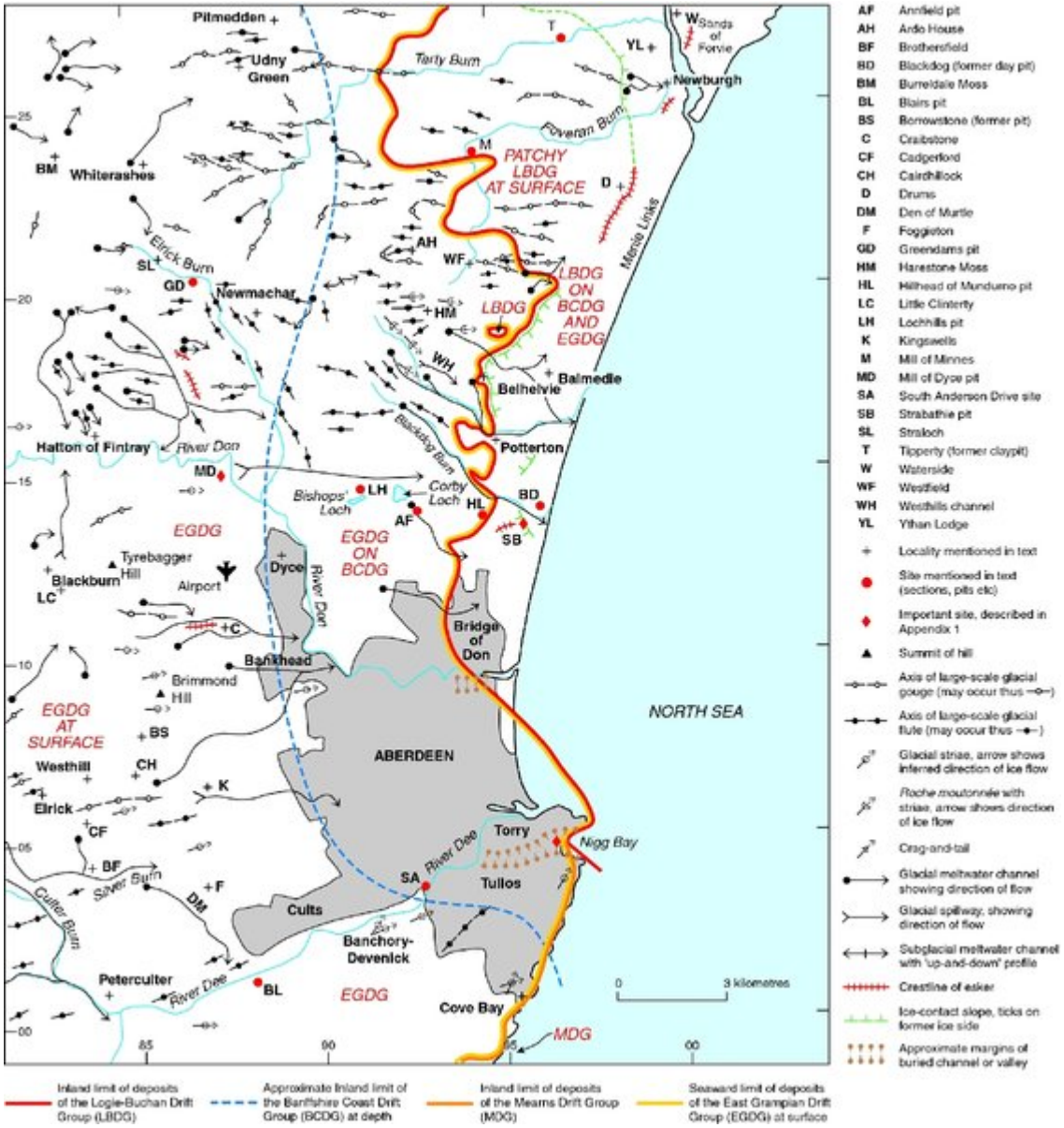
The exposures in the lower Dee Valley and to the west and north-west of Aberdeen record important evidence of the pattern and relative timing of glacial advances. Evidence is present for ice advance from the north (Anderson Drive Diamicton Formation) and north-west (Den Burn Till Member). These sediments probably predate the deposits exposed in the Nigg Bay section and may, in part, provide sources for the 'exotic' clasts recovered from the Ness Till Member gravels. Later a strong ice flow from the west and south-west deposited the extensive Nigg and Kingswell till members. These tills grade up into, or are interbedded with, Old Red Sandstone-derived tills in the coastal zone and indicate some contemporaneous deposition. As no weathering horizons, soils or peat beds have been recorded interstratifed with the tills and gravels of the Aberdeen area, all units are considered to date from phases of the main Late Devensian glaciation (Clapperton and Sugden, 1977; Murdoch, 1977; McLean, 1977; Munro, 1986). However, some till units present in the buried channel at Nigg may date from earlier events. Radiocarbon dates from peat and lacustrine sequences younger than the glacigenic sediments in the area (see Site 21 Rothens, Monymusk, Site 18 Mill of Dyce Quarry and Site 23 Loch of Park) indicate that the region was finally deglaciated prior to 11 640 or 11 900 BP.

(Table A1.14) Lithostratigraphy at Nigg Bay and in the vicinity of Aberdeen.

Nigg unit	Member	Formation	Drift Group
5	Tullos Clay	Ugie Clay	Logie-Buchan
4		Drumlithie Sand and Gravel	Mearns
3		Mill of Forest Till	Mearns
2	Nigg Till	Banchory Till	East Grampian
	Kingswells Till	Banchory Till	East Grampian
	Den Burn Till	Banchory Till	East Grampian

Ness Sand and Gravel	Lochton Sand and Gravel	East Grampian
	Anderson Drive Diamicton	Banffshire Coast

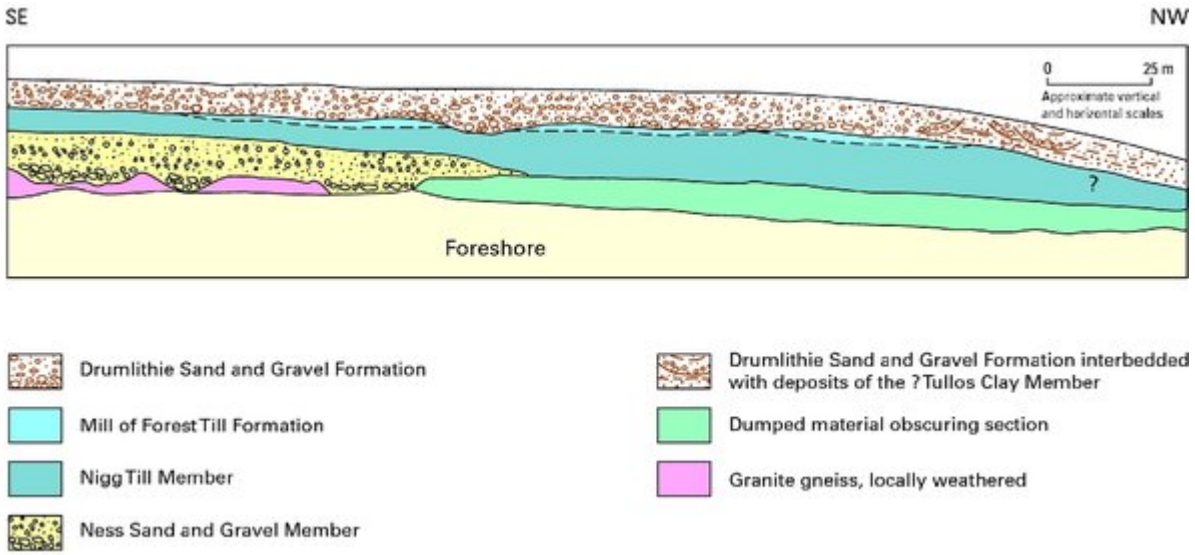
References



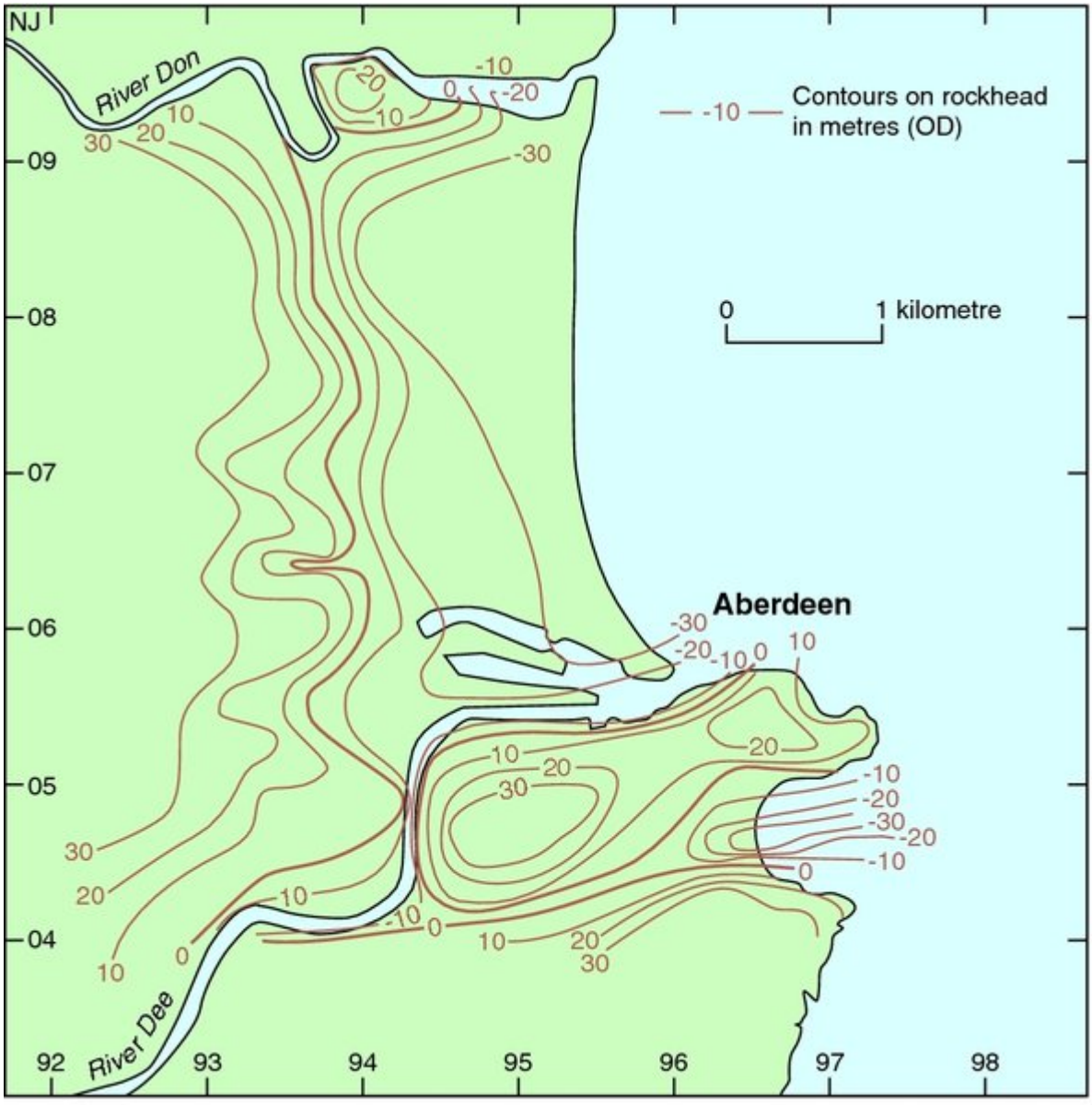
(Map 9) Glacial and glaciofluvial features and the distribution of glacigenic deposits on Sheet 77 Aberdeen.

Nigg unit	Member	Formation	Drift Group
5	Tullos Clay	Ugie Clay	Logie-Buchan
4		Drumlithie Sand and Gravel	Mearns
3		Mill of Forest Till	Mearns
2	Nigg Till	Banchory Till	East Grampian
	Kingswells Till	Banchory Till	East Grampian
	Den Burn Till	Banchory Till	East Grampian
1	Ness Sand and Gravel	Lochton Sand and Gravel	East Grampian
		Anderson Drive Diamicton	Banffshire Coast

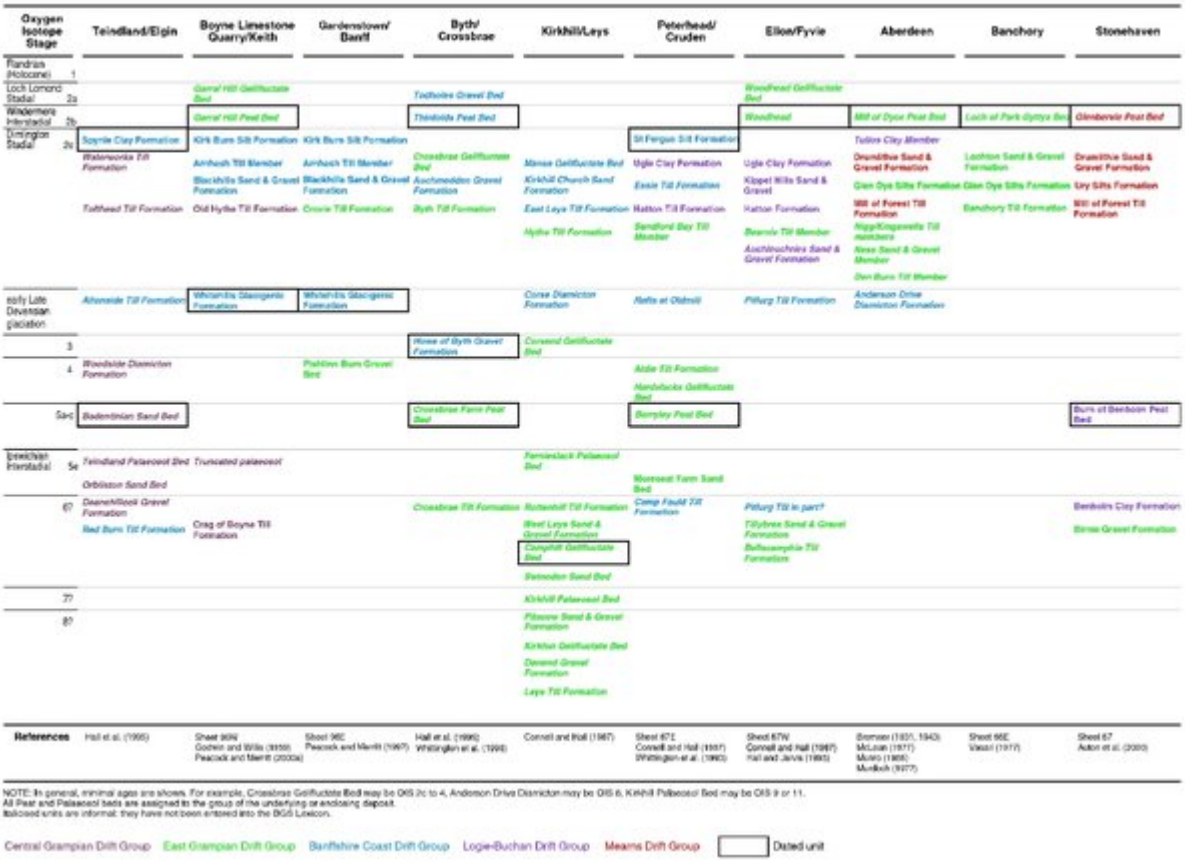
(Table A1.14) Lithostratigraphy at Nigg Bay and in the vicinity of Aberdeen.



(Figure A1.27) Stratigraphical relationships of deposits at the Nigg Bay cliff section in 1977—80 (not to scale and partially schematic).

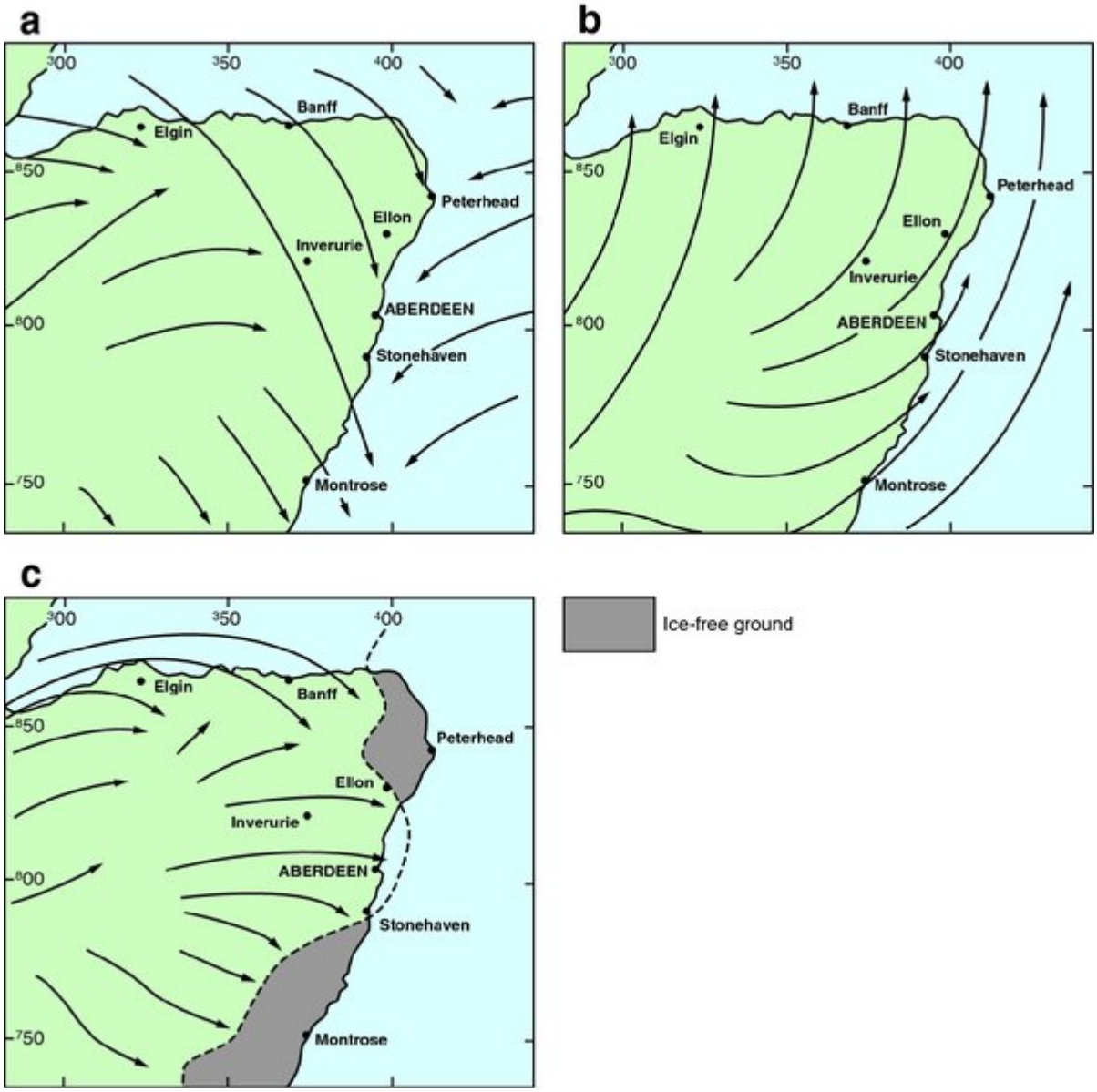


(Figure 46) Contoured rockhead surface beneath the City of Aberdeen (after Munro, 1986).



NOTE: In general, minimal ages are shown. For example, Crossbrae Golfluctate Bed may be OIS 2c to 4, Anderson Drive Diamicton may be OIS 6, Kirkhill Palaeosol Bed may be OIS 9 or 11.
All Peat and Palaeosol beds are assigned to the group of the underlying or enclosing deposit.
Italicised units are informal: they have not been entered into the BGS Lexicon.

(Table 7) Correlation of lithostratigraphical units in north-east Scotland.



(Figure 37) Patterns of ice flow deduced by Bremner (1943).