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(Figure 44) Tentative reconstruction of ice margins at the maximum stage of the second major expansion of the Main Late Devensian ice sheet (after Hall and Bent, 1990 and Sejrup et al., 1987). This stage is correlated with the maximum of the 'Dimlington Advance', 18.5–15.1 ka BP (Sejrup et al., 1994).

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(Figure A1.13) Landforms and deposits in and adjacent to the Ugie catchment. A, Ardglassie; B, Blackhills; BB, Ballus Bridge; G, Greenhill; K, Kirkhill; L, Lumbs; Ly, Leys; O, Oldmill; R, Red Loch; SL, Sinclair Hills; W, Upper Waughtonhill; WD, West Dens channel.

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(Plate 4a) Buchan Gravels Formation at Windyhills. a Quartz-quartzite gravel of the Windy Hills Gravel Member at its type locality (P104101) .

(Plate 5a) Flint clasts recovered from the base of the Buchan Ridge Gravel Member in a trial pit on the Moss of Cruden [NK 0253 4024]. Little-worn flints such as these were either derived directly from a former cover of Chalk in the area or from a remanié flint deposit. This evidence suggests that the present terrain lies close to the level of the sub-Cenomanian surface. (a P104122, b P104121).

(Plate 5b) Flint clasts recovered from the base of the Buchan Ridge Gravel Member in a trial pit on the Moss of Cruden [NK 0253 4024]. Little-worn flints such as these were either derived directly from a former cover of Chalk in the area or from a remanié flint deposit. This evidence suggests that the present terrain lies close to the level of the sub-Cenomanian surface. (a P104122, b P104121).

(Plate 8c) Till of the Banffshire Coast Drift Group at Oldmill [NK 0245 4407], showing downward transition from weathered to unweathered diamicton. (P104106).

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(Plate 22) Southern face of Kirkhill Quarry [NK 011 528] in 1979 (P528224). The sands and gravels resting on bedrock belong to the Pitscow Sand and Gravel Formation. The conspicuous pale band at their surface is the podzolic Kirkhill Palaeosol Bed. Periglacial sediments of the Swineden Sand Bed and the Camphill Gelifluctate Bed succeed this. The base of the Rottenhill Till Formation is at shoulder level with the figure. It is weathered towards the top (Fernieslack Palaeosol Bed) and is overlain by the pale coloured Corsend Gelifluctate Bed. The overlying Hythie Till Formation has a sharp erosional base. Note, the deformation structure affecting sediments beneath the till (above and to the left of the figure). Approximately 8 m of sediments are exposed.

(Plate 23) Partially glacitectonised, podzolic Teindland Palaeosol Bed below sandy diamicton of the Woodside Diamicton Formation at Teindland quarry [NJ 297 570]. Luminescence dates of 79 ± 6 ka and 67 ± 5 ka have recently been obtained from the sands overlying the palaeosol bed to the left of the scale card. (P104118). Scale bar showing 1 cm intervals.

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(Plate 27) Sheared lens of the Burn of Benholm Peat Bed within olive grey shelly clay and diamicton (Benholm Clay Formation) in trial pit BBP4, at the Burn of Benholm site north of Johnshaven (Appendix A, 26). The shelly deposits are overlain by red-brown diamicton of the Mill of Forest Till Formation (D4879).

(Table 1) Summary of events preserved in the marine and onshore records in and around north-east Scotland (after Holmes, 1977).

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

(Table 8) Radiocarbon dates from Late-glacial sites in the district.

(Table 9) Geological surveyors.

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(Table A1.2) Lithostratigraphy of the Teindland area.

(Table A1.3) The lithostratigraphy at Castle Hill, Gardenstown.

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(Table A1.6) Lithostratigraphical units at Kirkhill and Leys Quarries.

(Table A1.7) Radiocarbon dates from sites in the Philorth valley (after Smit.

(Table A1.8) Lithostratigraphy at Camp Fauld.

(Table A1.9) Lithostratigraphy in the vicinity of Ellon, Leask and Slains.

(Table A1.10) Lithofacies associations at Mill of Dyce Pit.

(Table A1.11) Sedimentary facies at Strabathie (after Thomas,1984).

(Table A1.12) Pollen count from the Nether Daugh Pits.

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

(Table A1.15) Stratigraphy of the Knockhill Wood site.

(Table A1.16) Outline pollen count from Knockhill Wood.

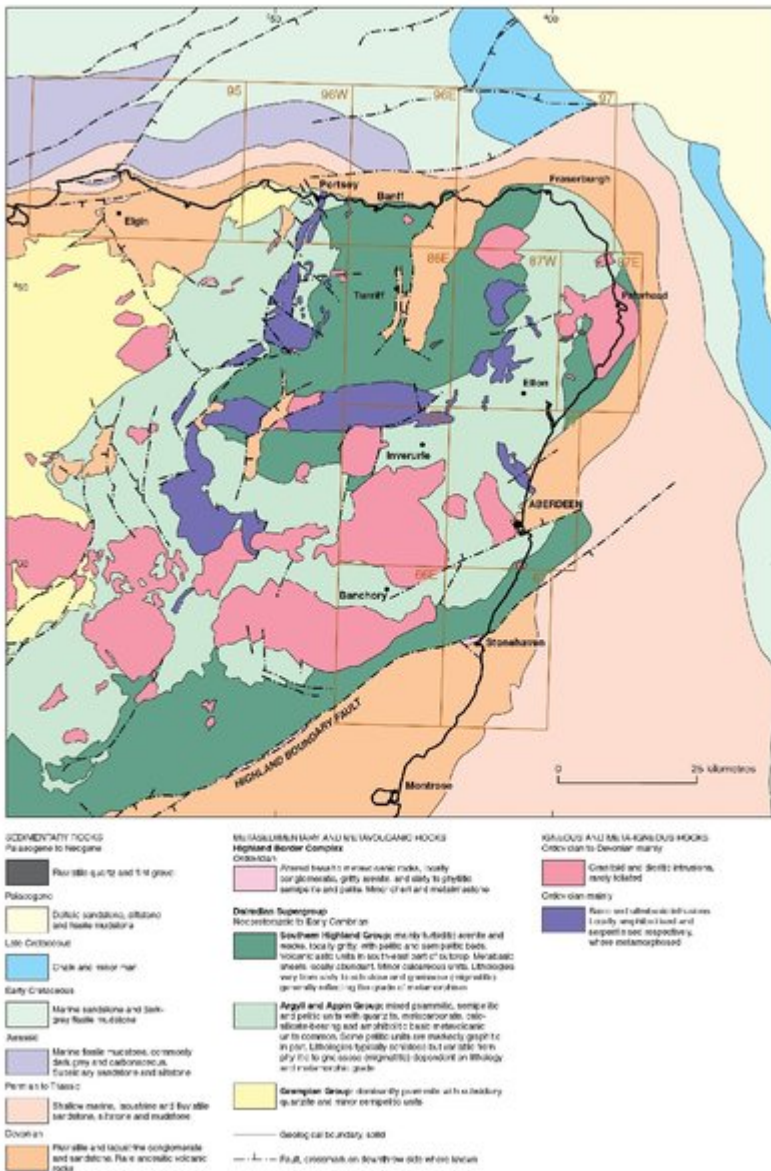
(Table A1.17) Lithostratigraphy in the vicinity of the Burn of Benholm.

(Table A2.1) Sand and gravel resource assessment surveys in north-east Scotland: primary data sources.

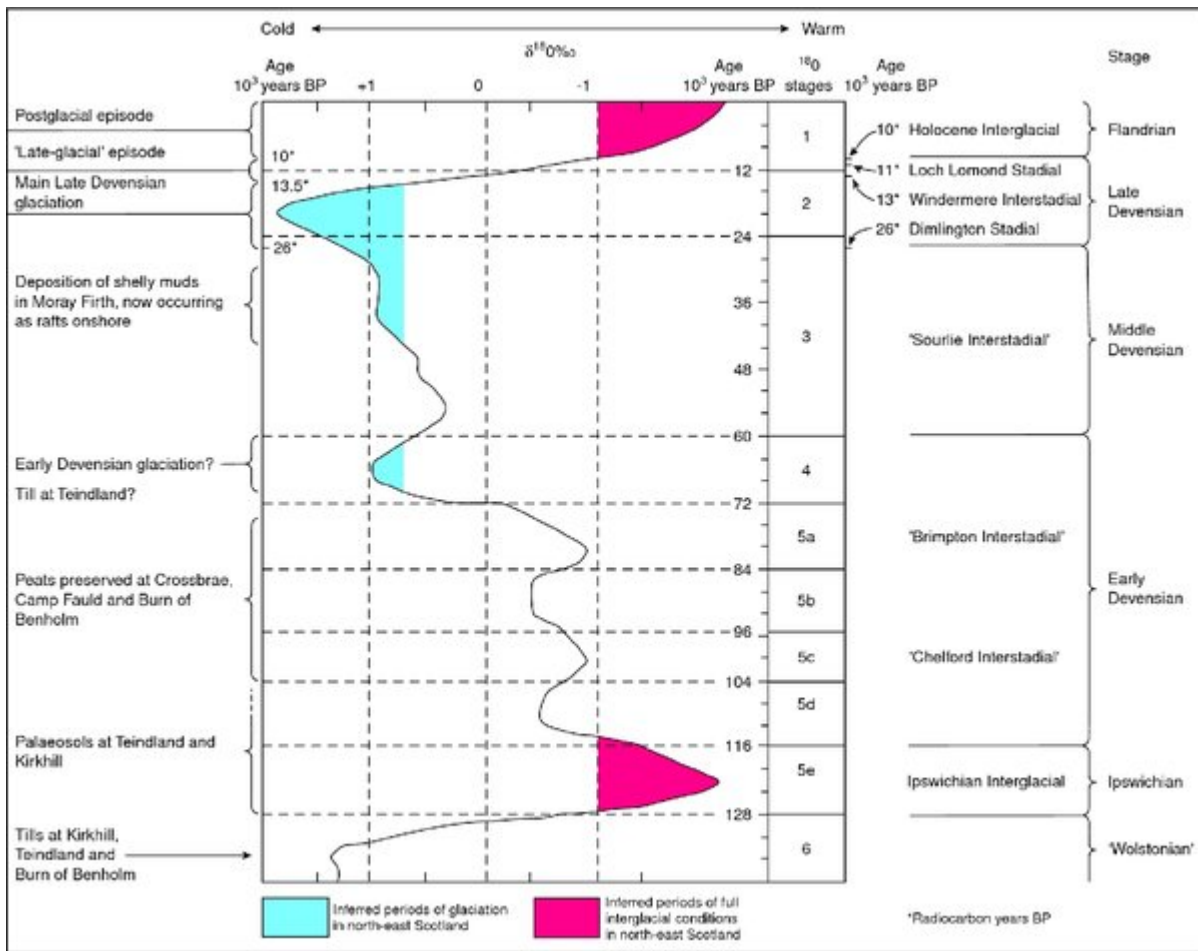
(Table A2.2) Summary results of mechanical and physical testing of naturally occurring gravels from north-east Scotland.

(Front cover) Cover photograph: Crovie Village (D6116). Sandstones and conglomerates of the Lower Devonian Crovie Group crop out on the foreshore and are down-faulted against Dalradian rocks of the Macduff Slate Formation that form the headland at the far end of the village. The landslip scar beyond the red telephone box exposes fine-grained deposits of the Kirk Burn Silt Formation of the Banffshire Coast Drift Group.

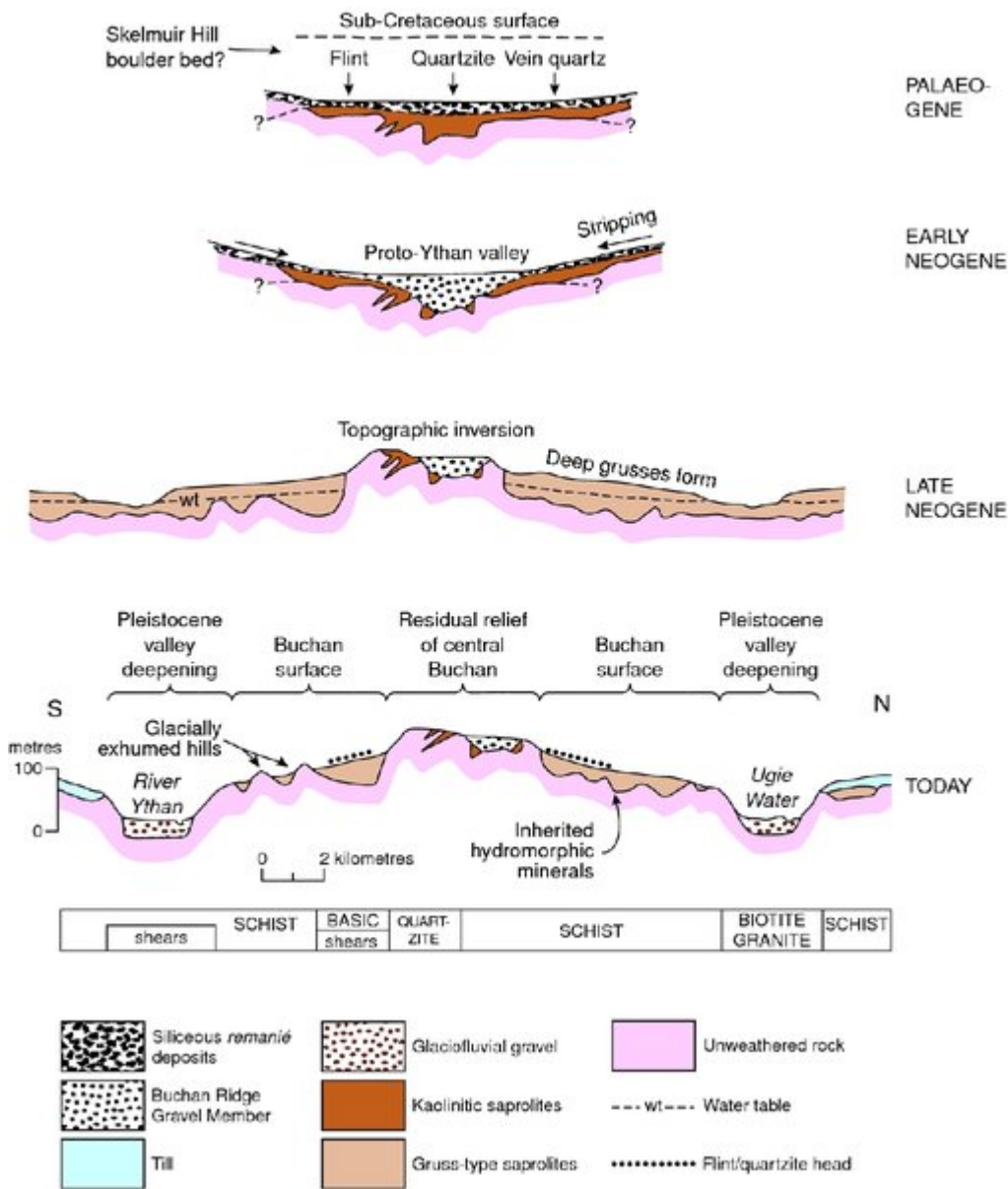
[References](#)



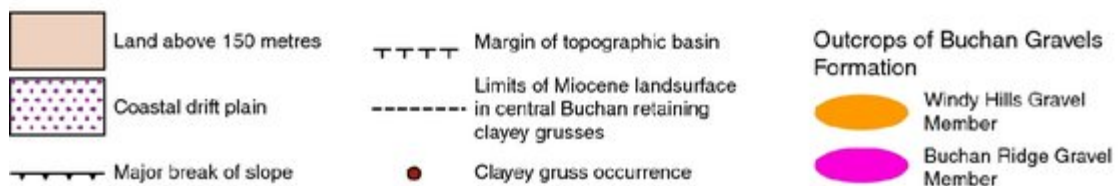
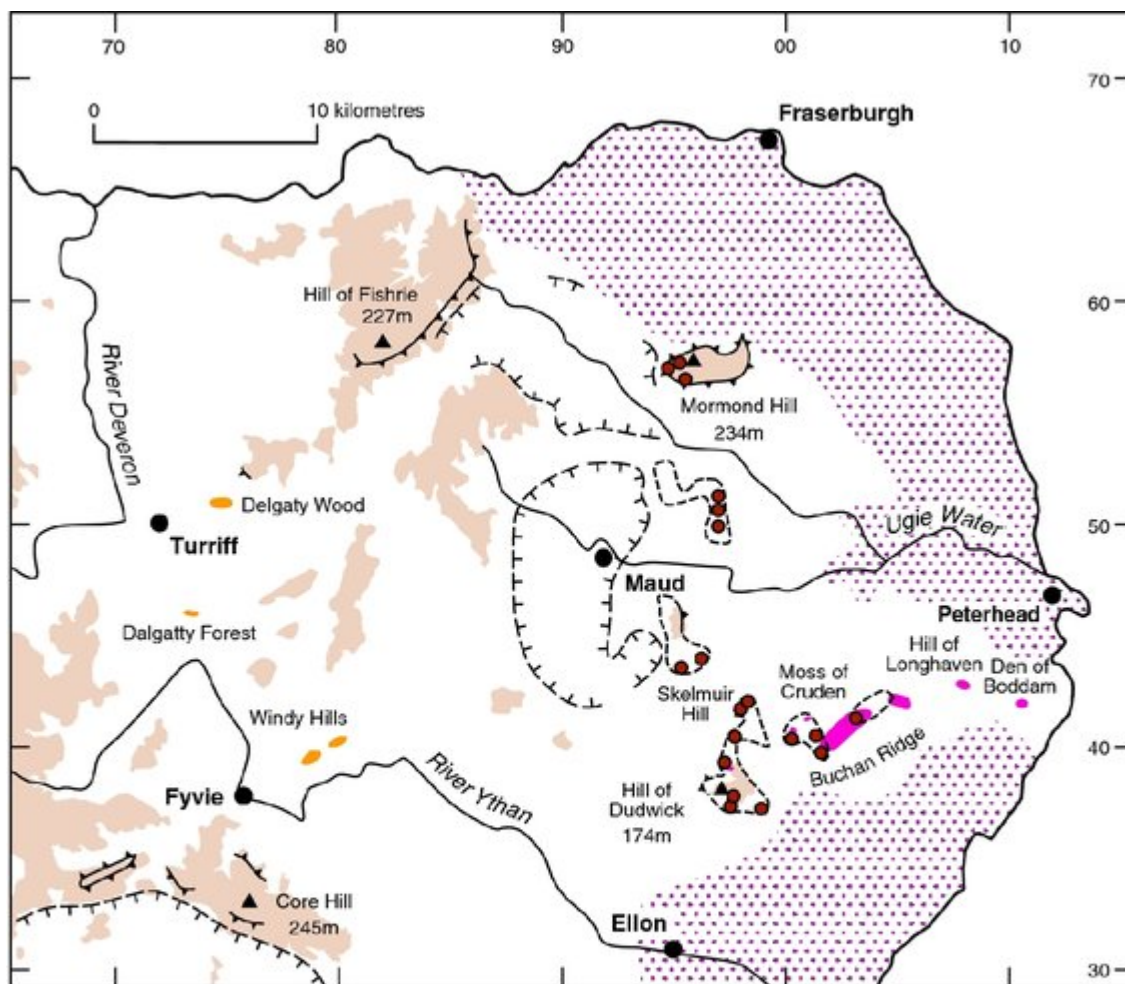
(Figure 2) Solid geology of the district.



(Figure 7) The 'SPECMAP' oxygen isotope curve for the last glacial—interglacial cycle (after Imbrie et al., 1984) with climato-stratigraphical stages and selected events in north-east Scotland.



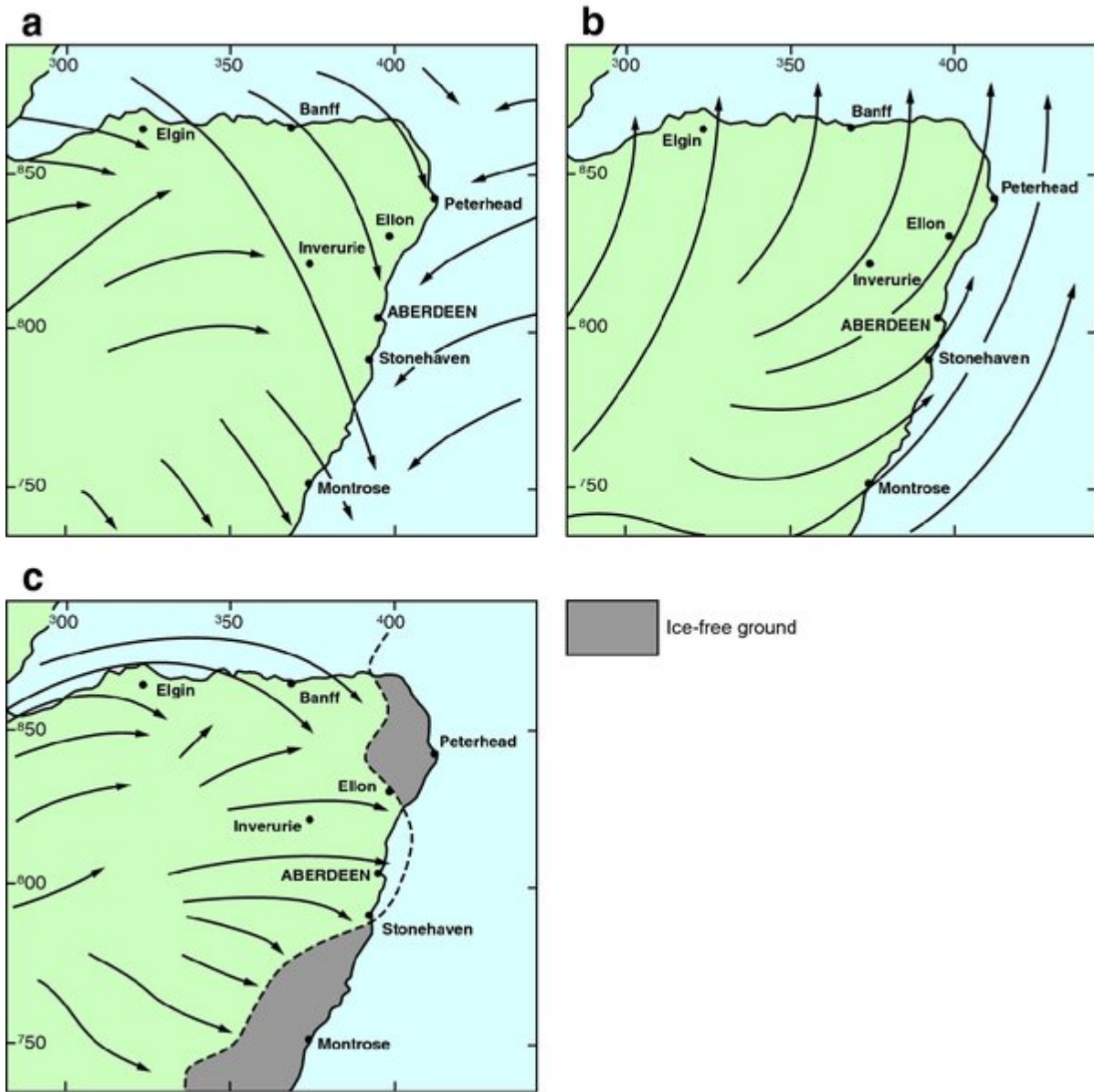
(Figure 20) Summary of Cainozoic relief development in central Buchan (after Hall, 1987).



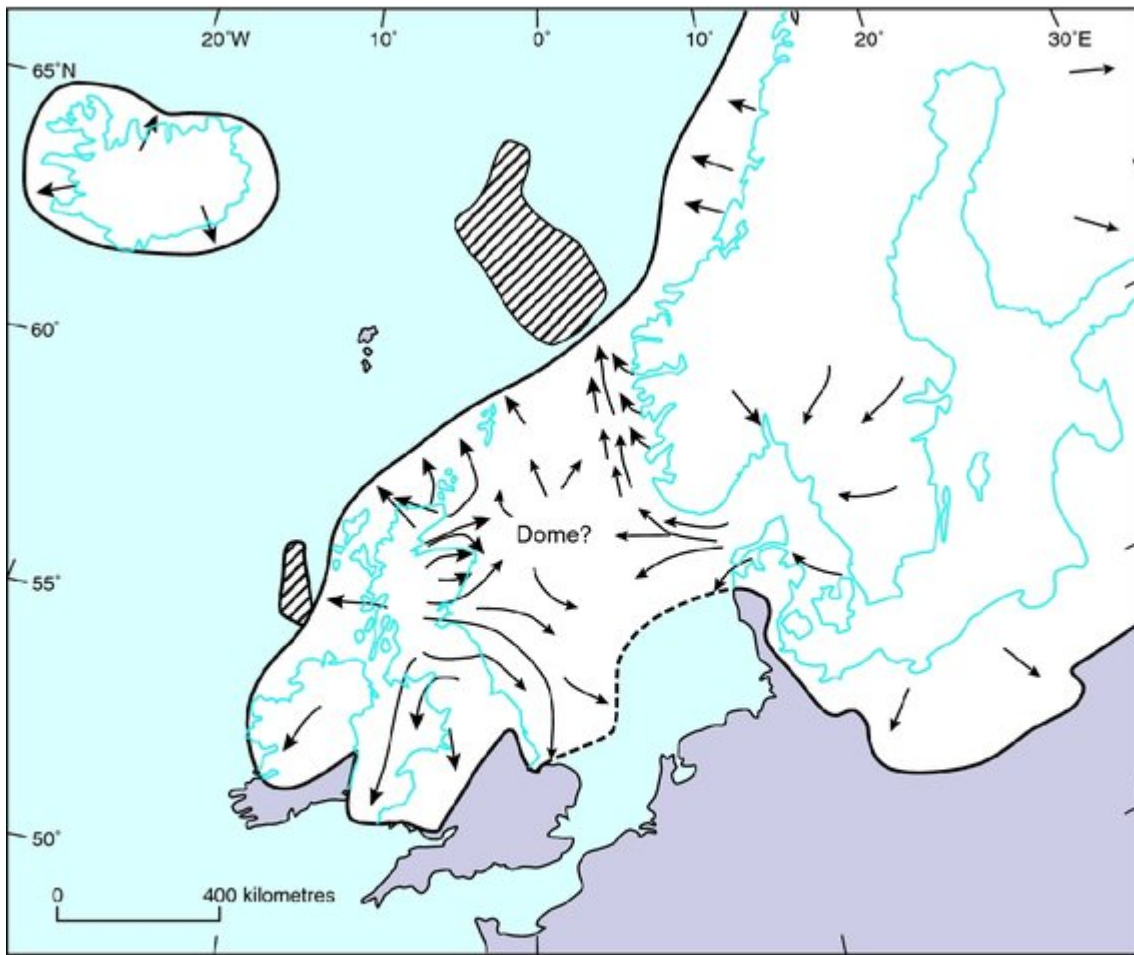
(Figure 22) Distribution of Miocene land surface and major topographical features (after Hall, 1985).



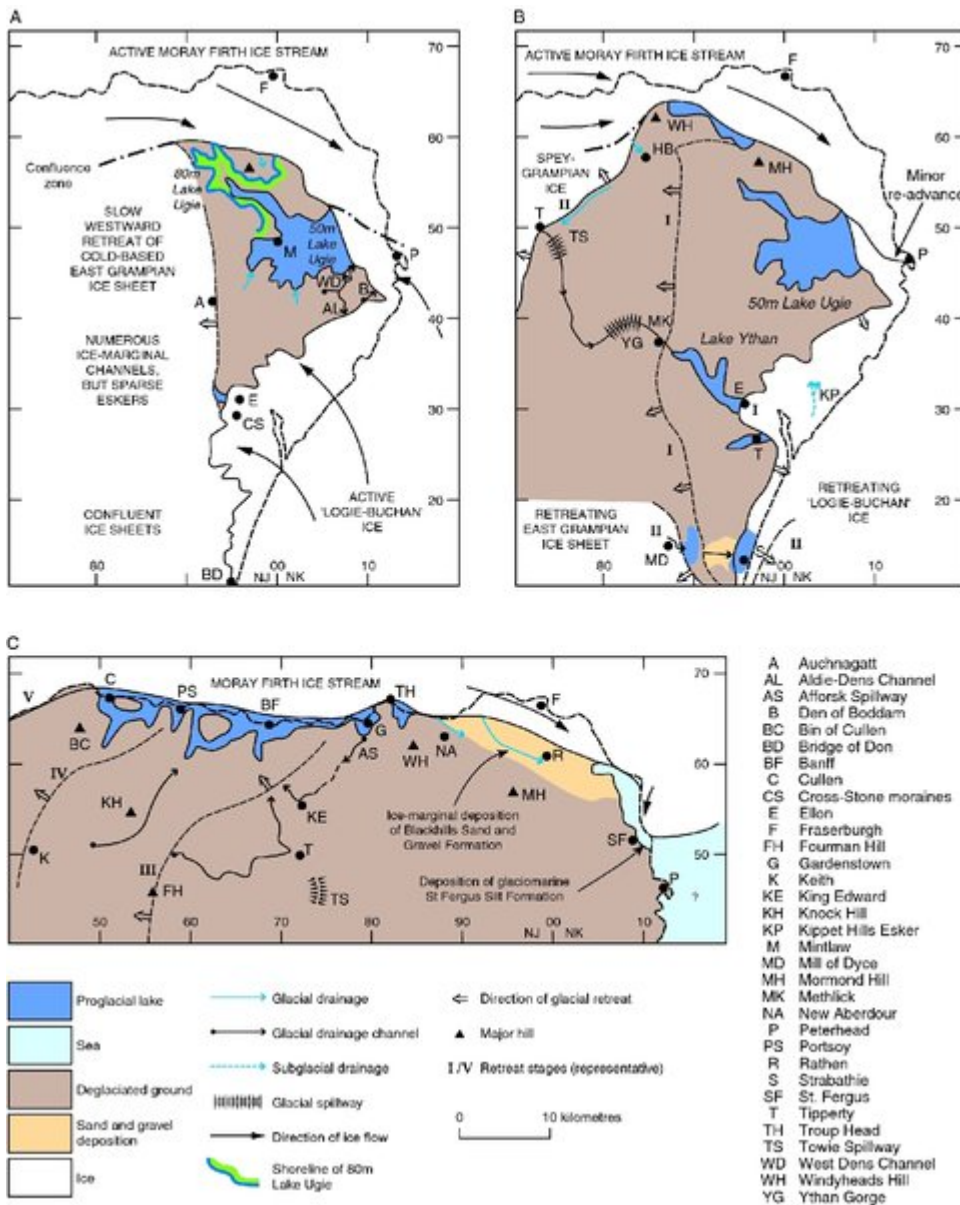
(Figure 36) Patterns of ice flow deduced by Jamieson (1906). a Deposition of Indigo Till b Deposition of Lower Grey Boulder Clay c Deposition of Dark Blue Boulder Clay and Red Clay Series d Aberdeen Re-advance.



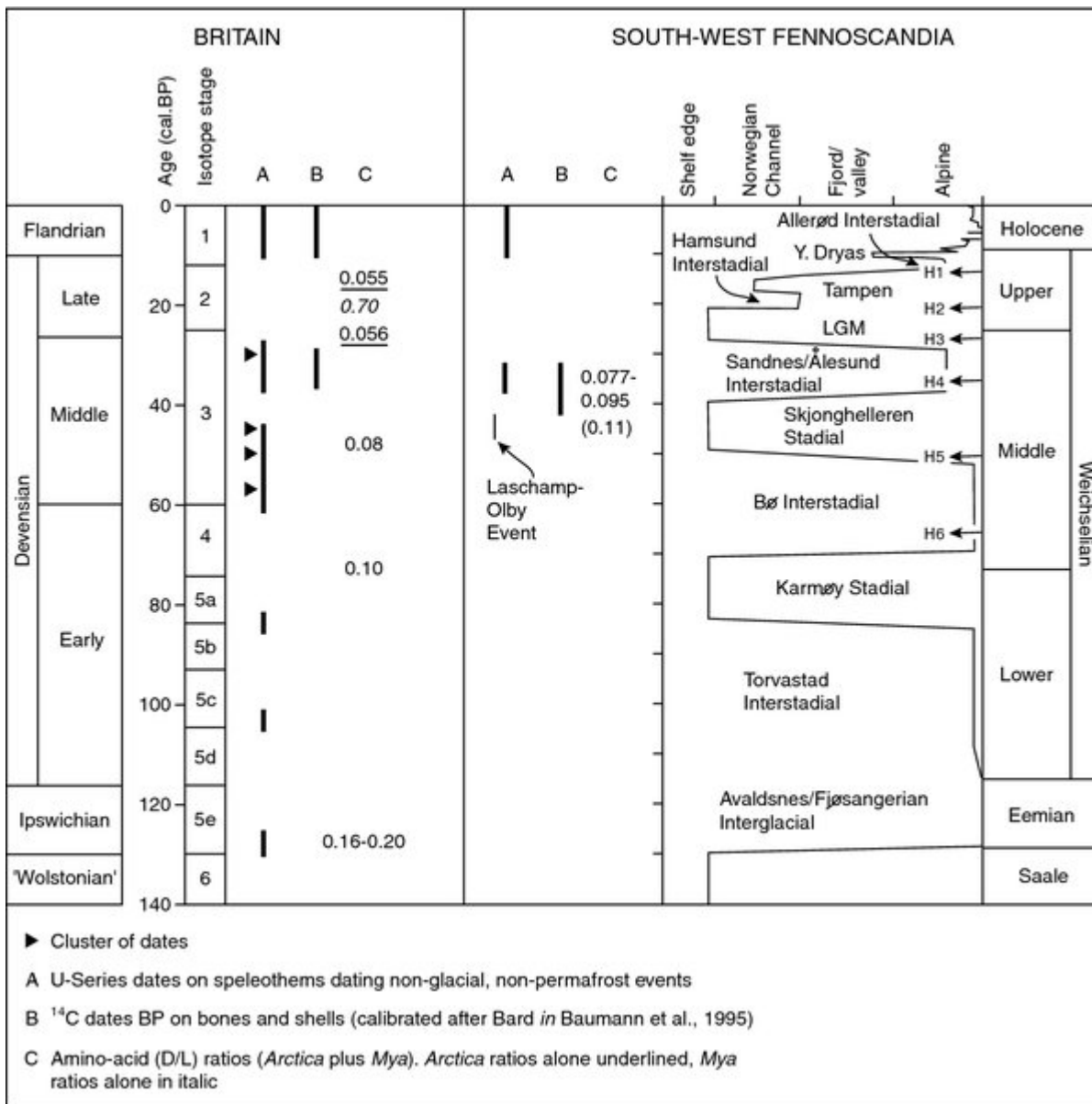
(Figure 37) Patterns of ice flow deduced by Bremner (1943).



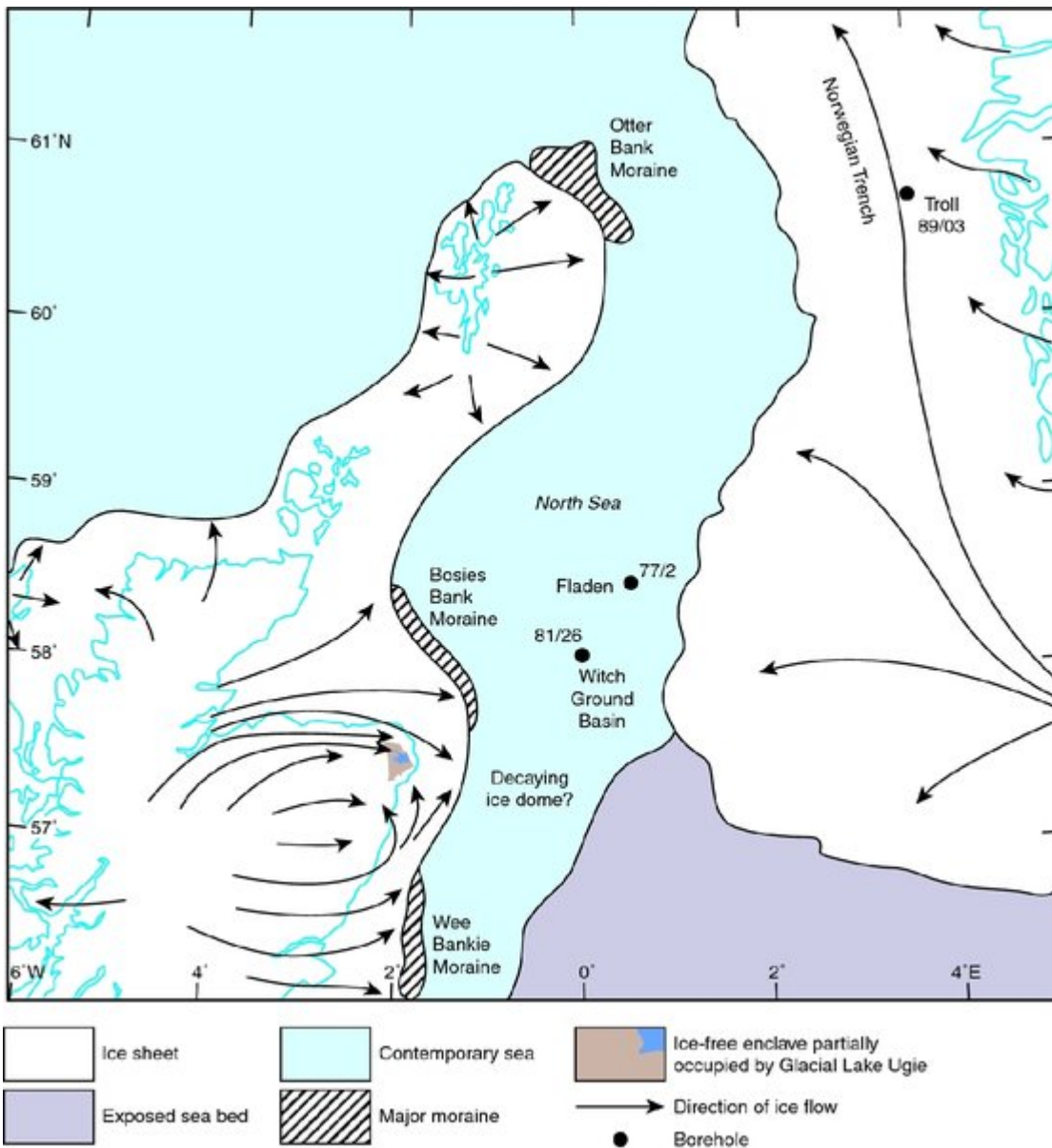
(Figure 41) Reconstruction of the maximum extent of the Main Late Devensian—Weichselian ice sheets (28—22 ka BP) showing possible location of former ice streams (modified from Sejrup et al., 2000).



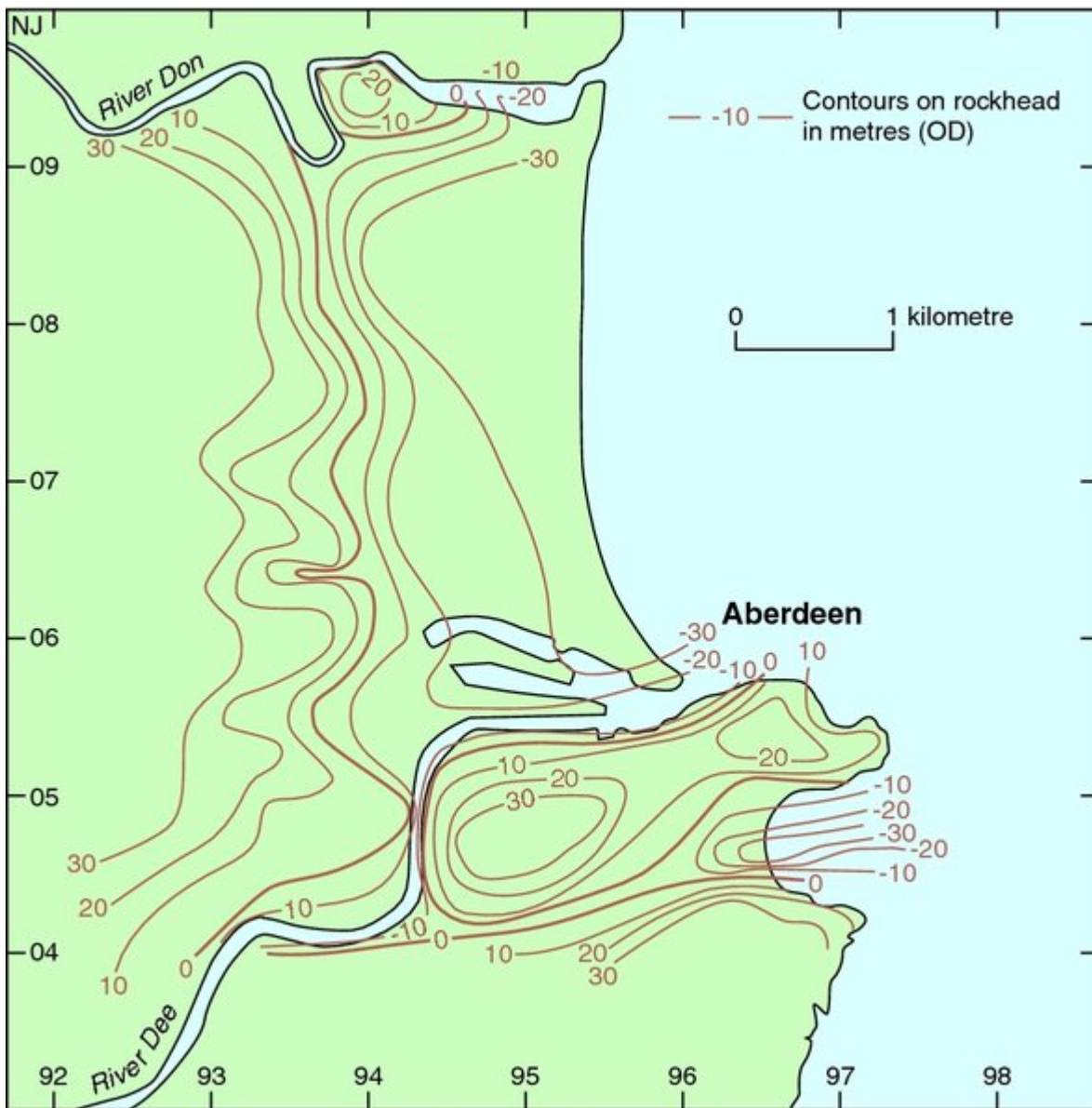
(Figure 42) Tentative reconstructions of former proglacial lakes in north-east Scotland. a Creation of '50 m' Lake Ugie shortly after the maximum of the second major expansion of the Main Late Devensian ice sheet (after 18 ka BP) and following the earlier ponding of the 80 m' lake. Widespread glacial over-riding of glaciolacustrine deposits occurred east of Lake Ugie. b Parting of East Grampian and 'Logie-Buchan' ice with the formation of Lake Ythan. c Diachronous ponding along the Banffshire coast and glaciomarine incursion around St Fergus at about 15 ka BP.



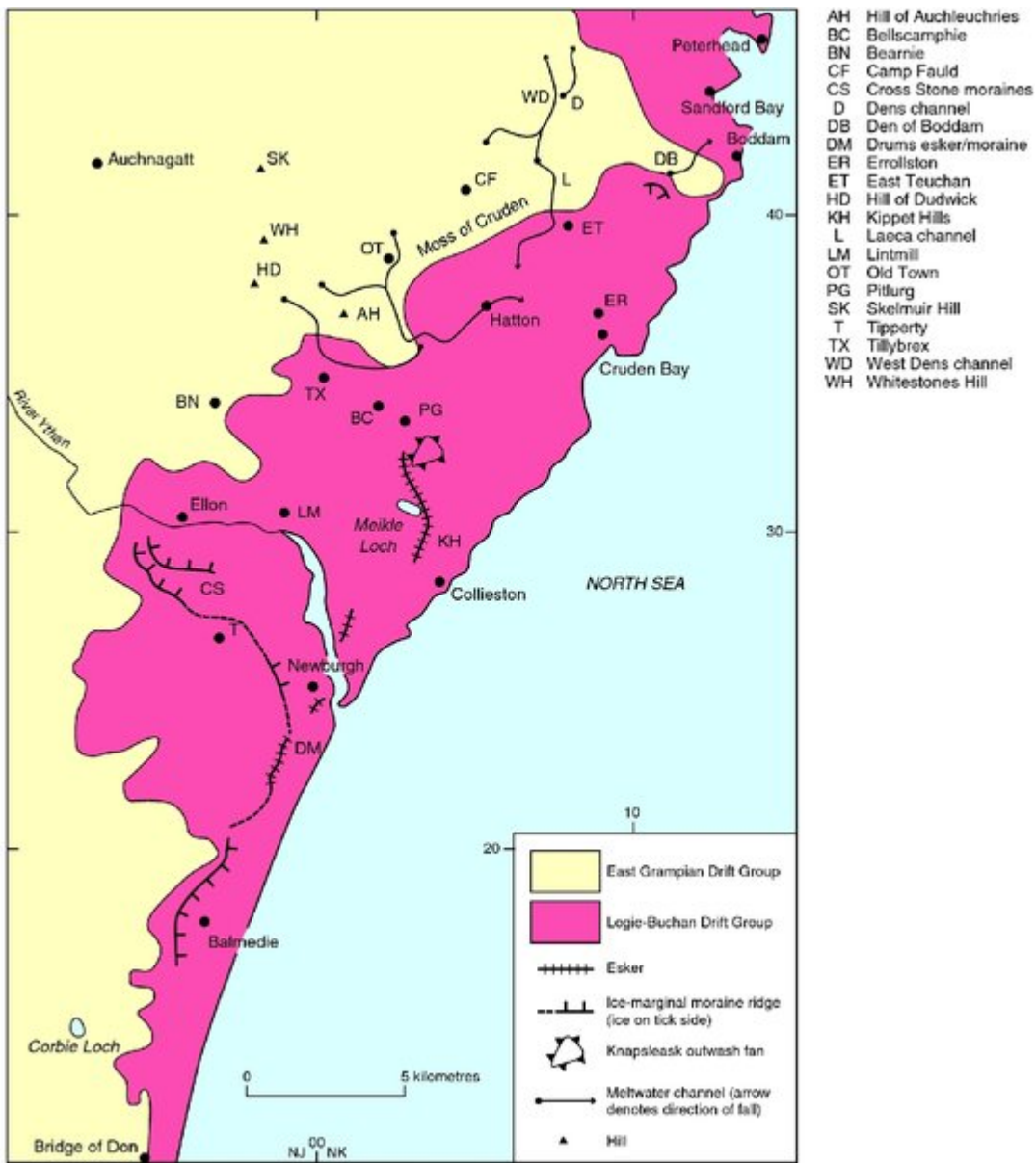
(Figure 43) Devensian—Weichselian events in Britain and south-west Fennoscandia (after Peacock and Merritt, 1997; Sejrup et al., 2000). Norwegian data from Baumann et al. (1995) and Mangerud et al. (1981). D/L amino-acid ratios corrected according to Miller and Mangerud (1985). British data from Baker et al. (1995), Bowen (1989), Gordon et al. (1989), Lawson and Atkinson (1995) and Miller et al. (1987).



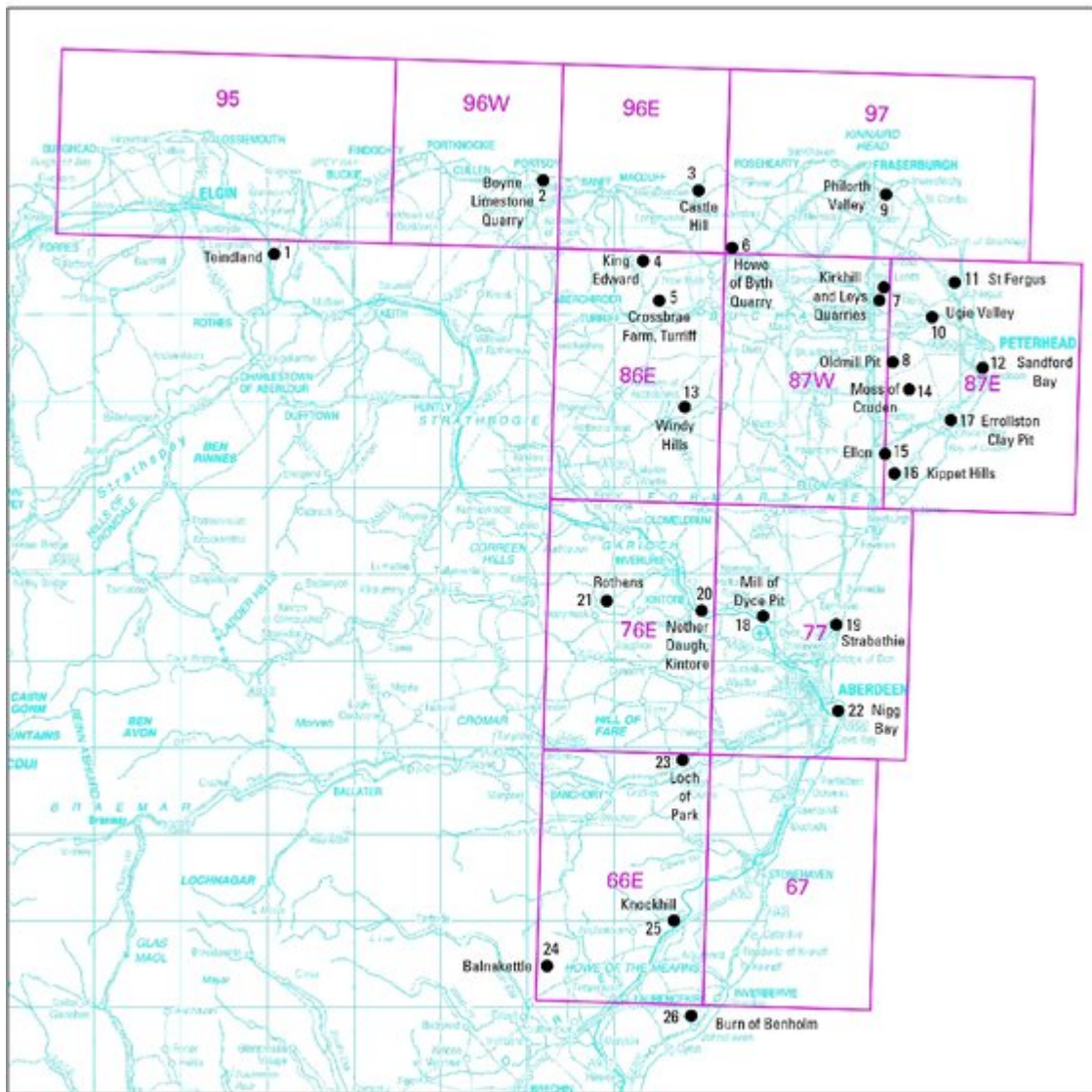
(Figure 44) Tentative reconstruction of ice margins at the maximum stage of the second major expansion of the Main Late Devensian ice sheet (after Hall and Bent, 1990 and Sejrup et al., 1987). This stage is correlated with the maximum of the 'Dimlington Advance', 18.5—15.1 ka BP (Sejrup et al., 1994).



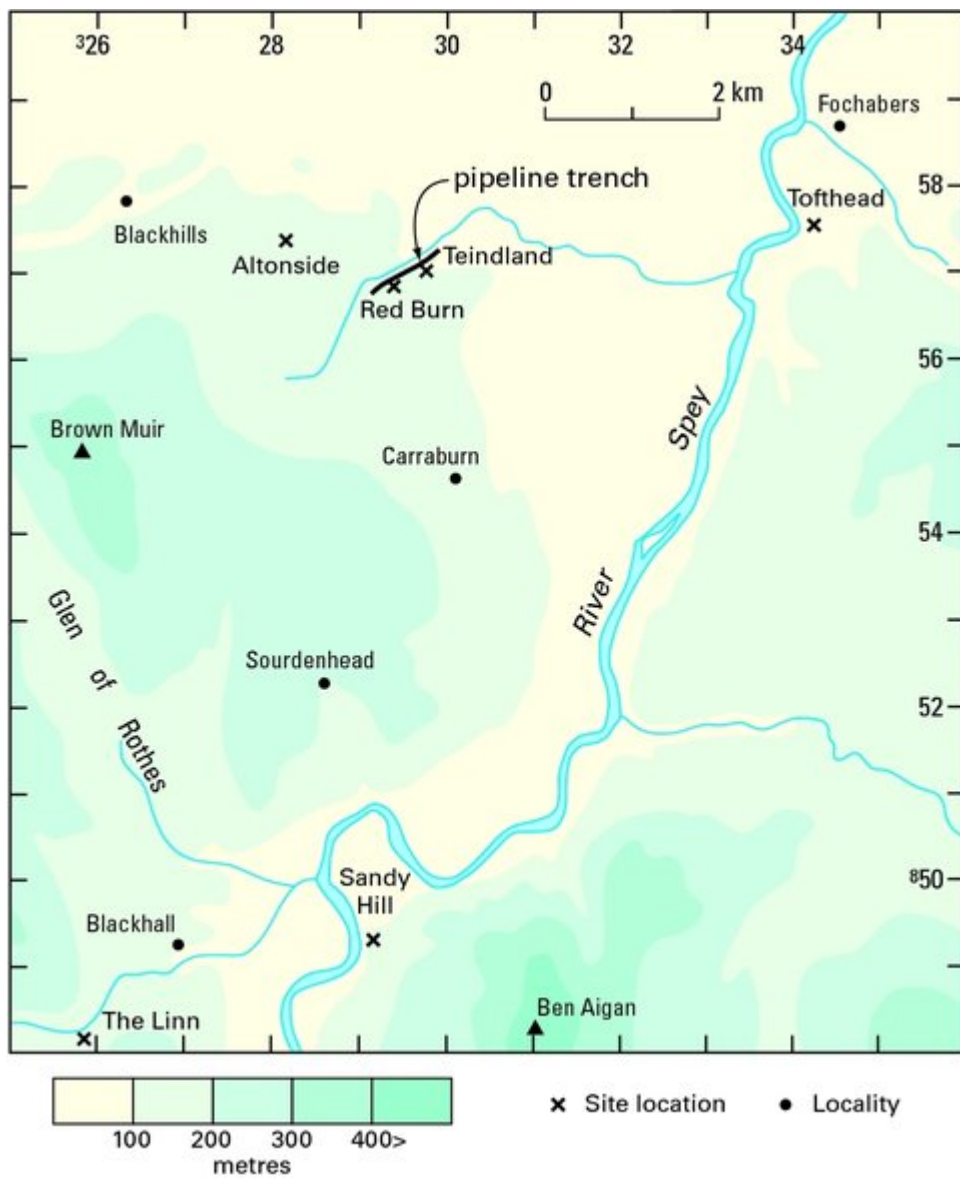
(Figure 46) Contoured rockhead surface beneath the City of Aberdeen (after Munro, 1986).



(Figure 50) Distribution of the Logie-Buchan Drift Group and related features.

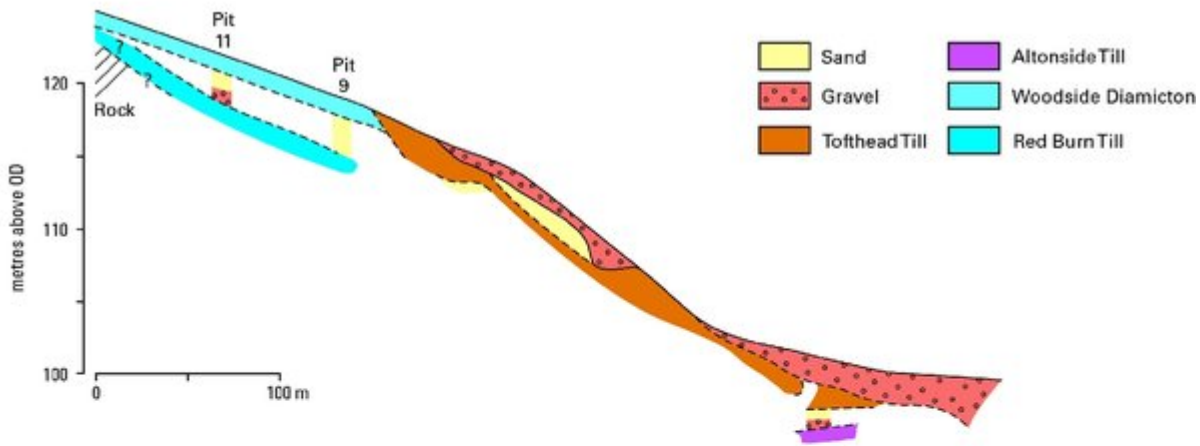


(Figure A1.1) Locations of sites described in Appendix 1.

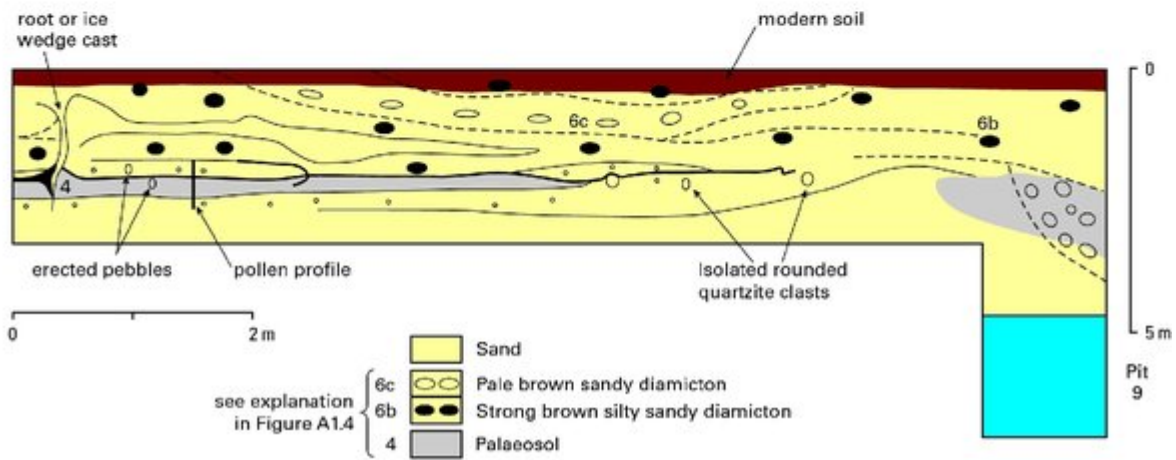


(Figure A1.2) Location of sites in the vicinity of Teindland (after Hall et al., 1995a).

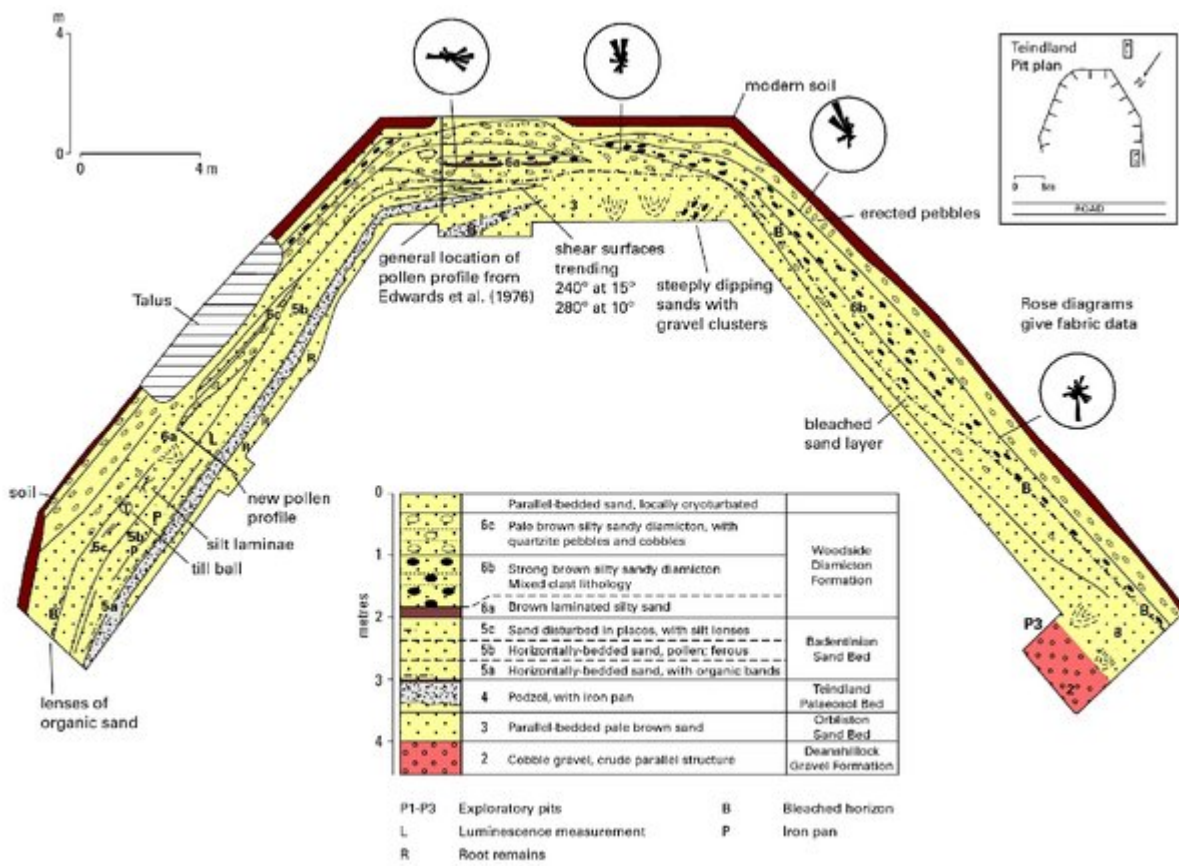
a Transect along pipeline trench located in Figure A1.2



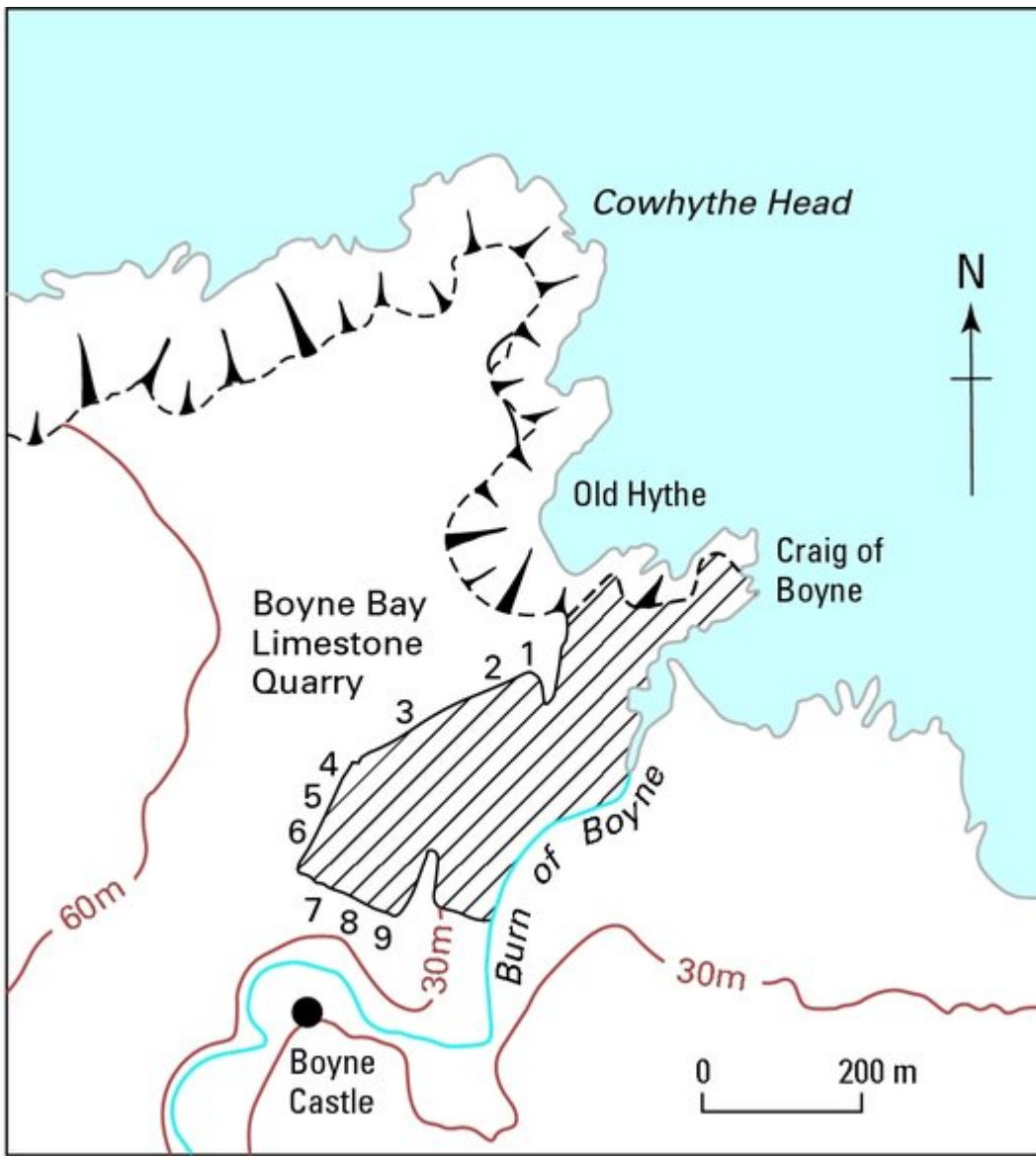
b Red Burn section (pollen site)



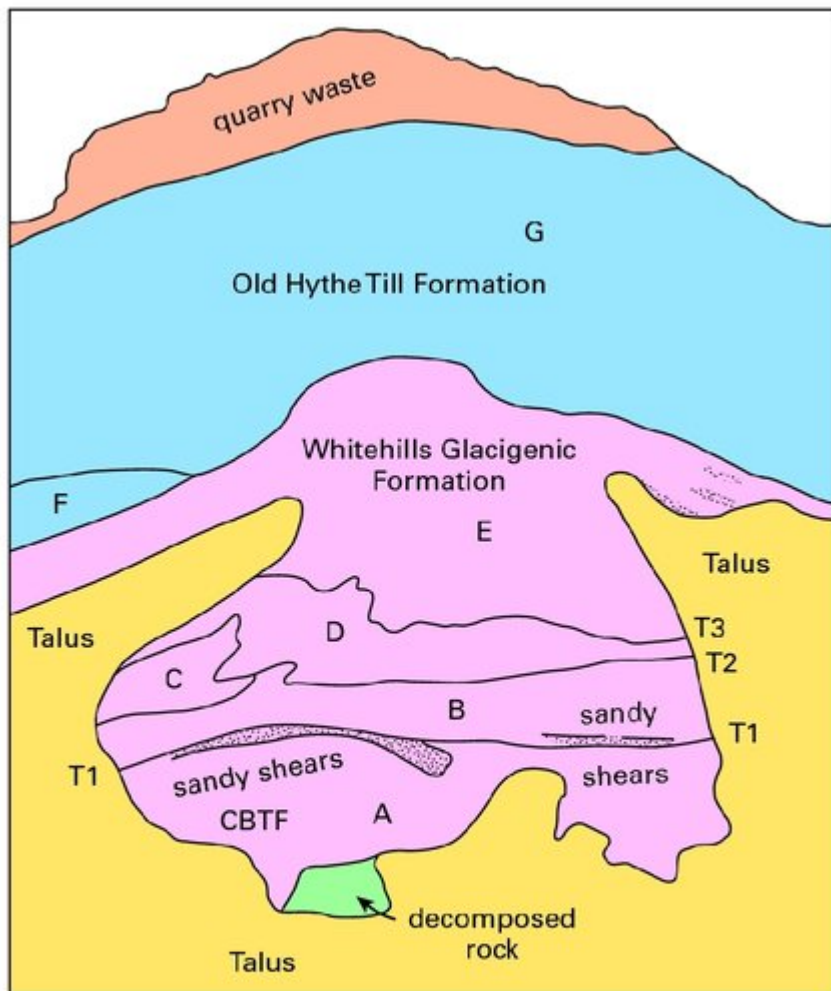
(Figure A1.3) Lithostratigraphy at Red Burn (after Hall et al., 1995a).



(Figure A1.4) The original Teindland pollen site (after Hall et al., 1995a).



(Figure A1.5) The location of the Boyne Limestone Quarry (after Peacock and Merritt, 2000a).

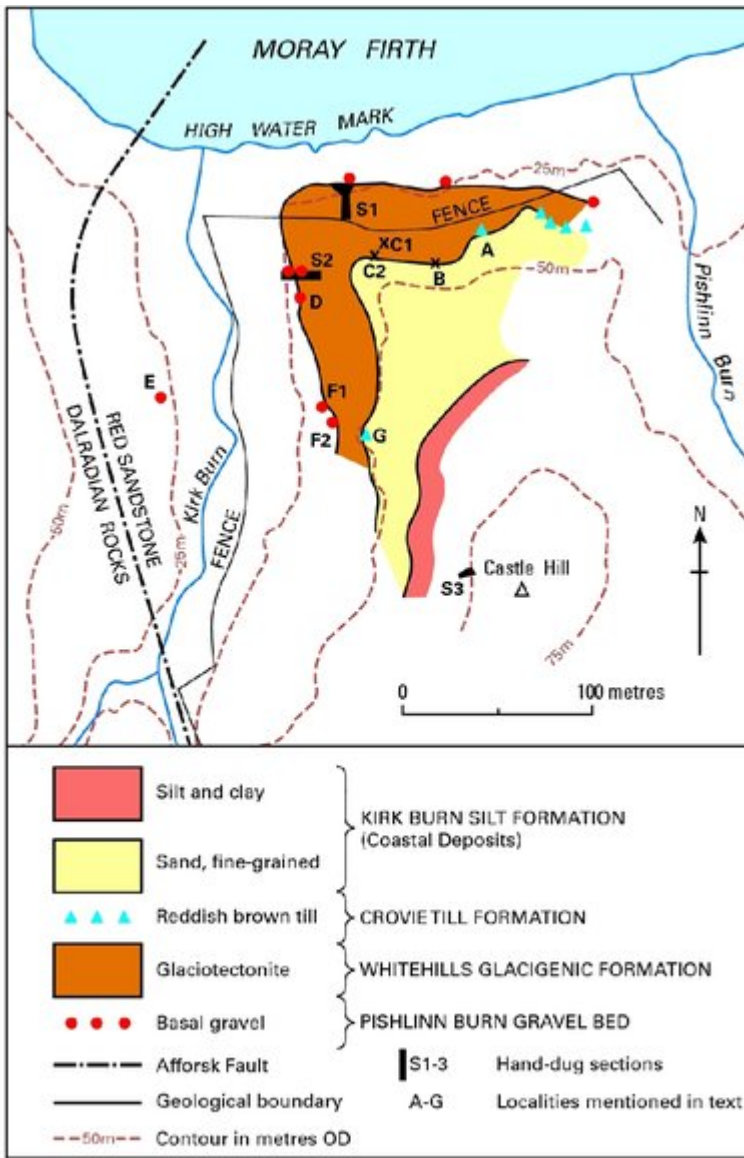


A-G Units, described in the text

T1-T6 Shear surfaces

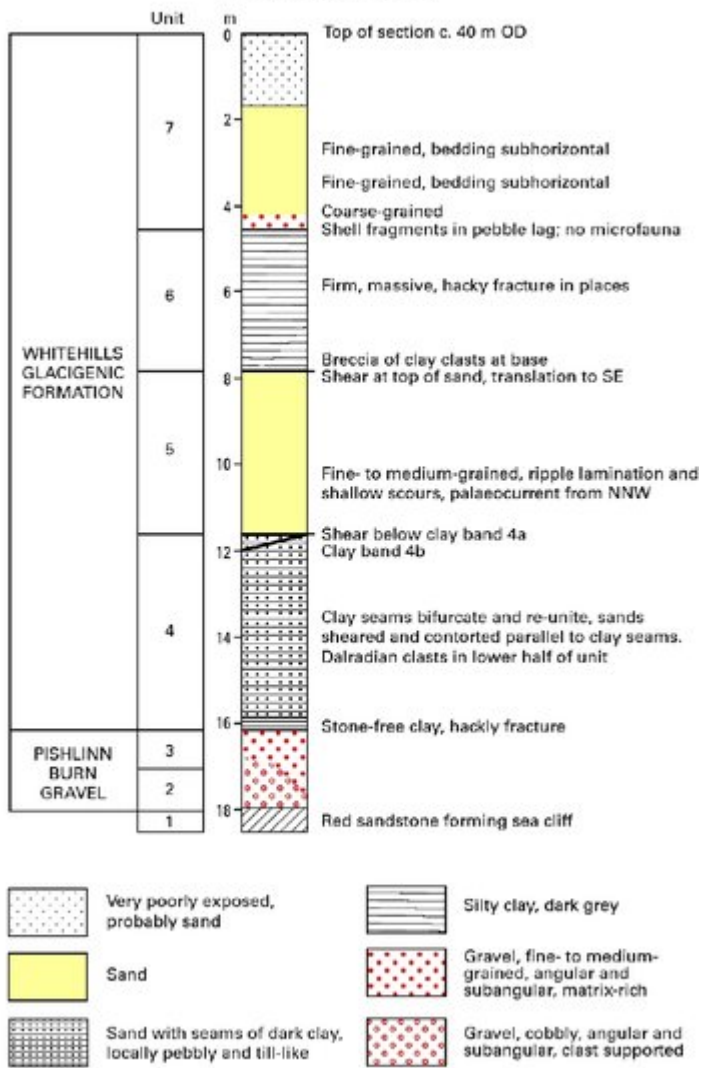
Section about 12 m high

(Figure A1.6) The glacial sequence at locality 1, Boyne Limestone Quarry (after Peacock and Merritt, 2000a).



(Figure A1.7) Map of Castle Hill, Gardenstown (after Peacock and Merritt, 1997).

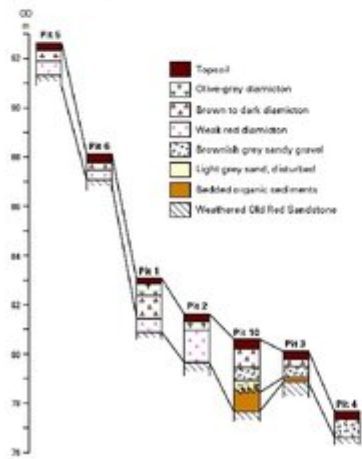
Section S1 [NJ 7935 6442]



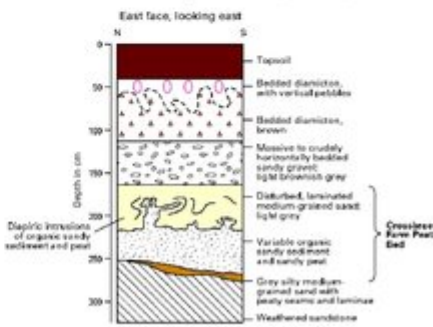
(Figure A1.8) Lithological log of Section S1 at Castle Hill (after Peacock and Merritt, 1997).



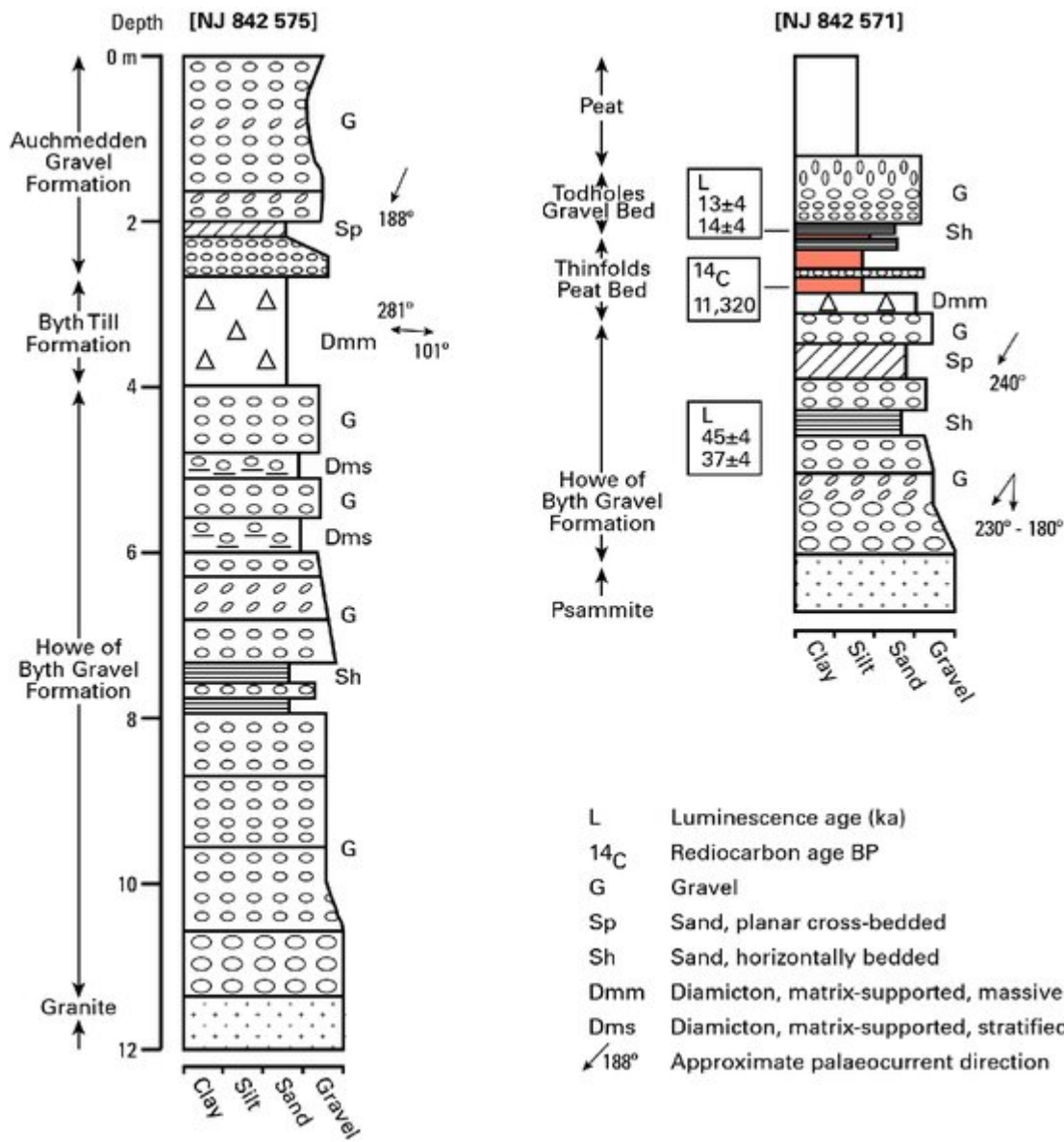
b Transect constructed from excavations dug in 1992



c Log of Site B (Pit 10)

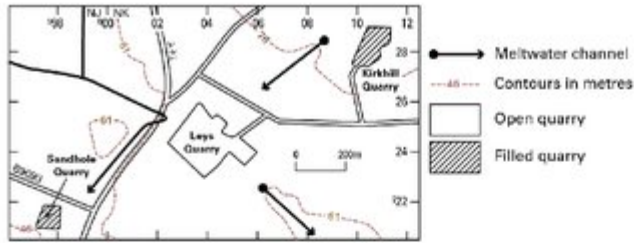


(Figure A1.9) Crossbrae Farm site (after Whittington et al., 1998).

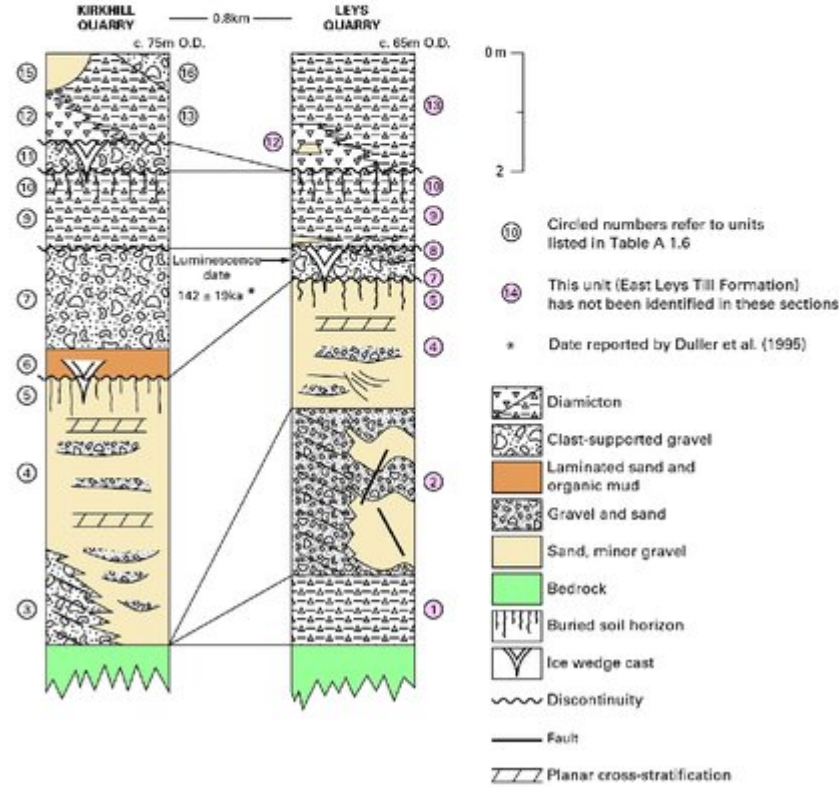


(Figure A1.10) Graphic logs and lithostratigraphy of representative sections at the Howe of Byth sand and gravel quarry (after Hall et al., 1995b).

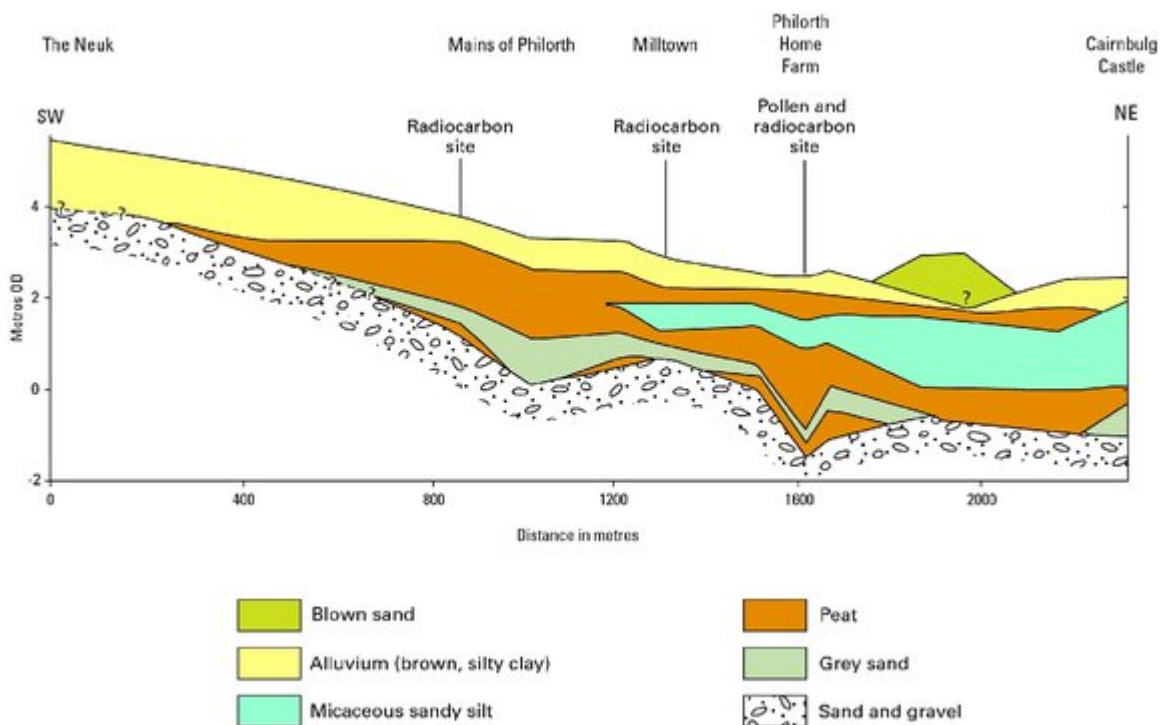
a Location of Kirkhill and Leys quarries (Sheet 87W)



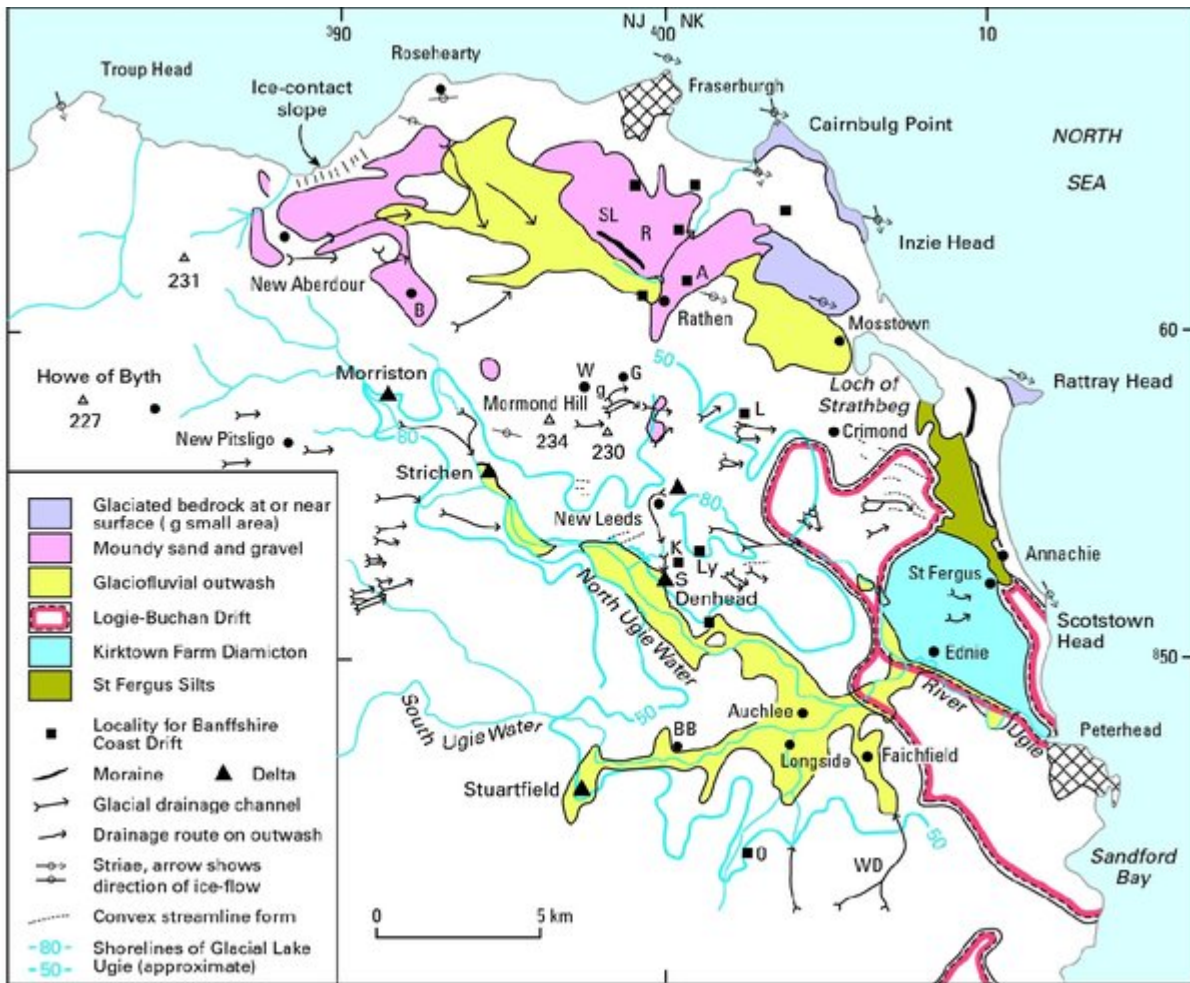
b Generalised logs and stratigraphical sequences



(Figure A1.11) Generalised lithological sequences at Kirkhill and Leys quarries.

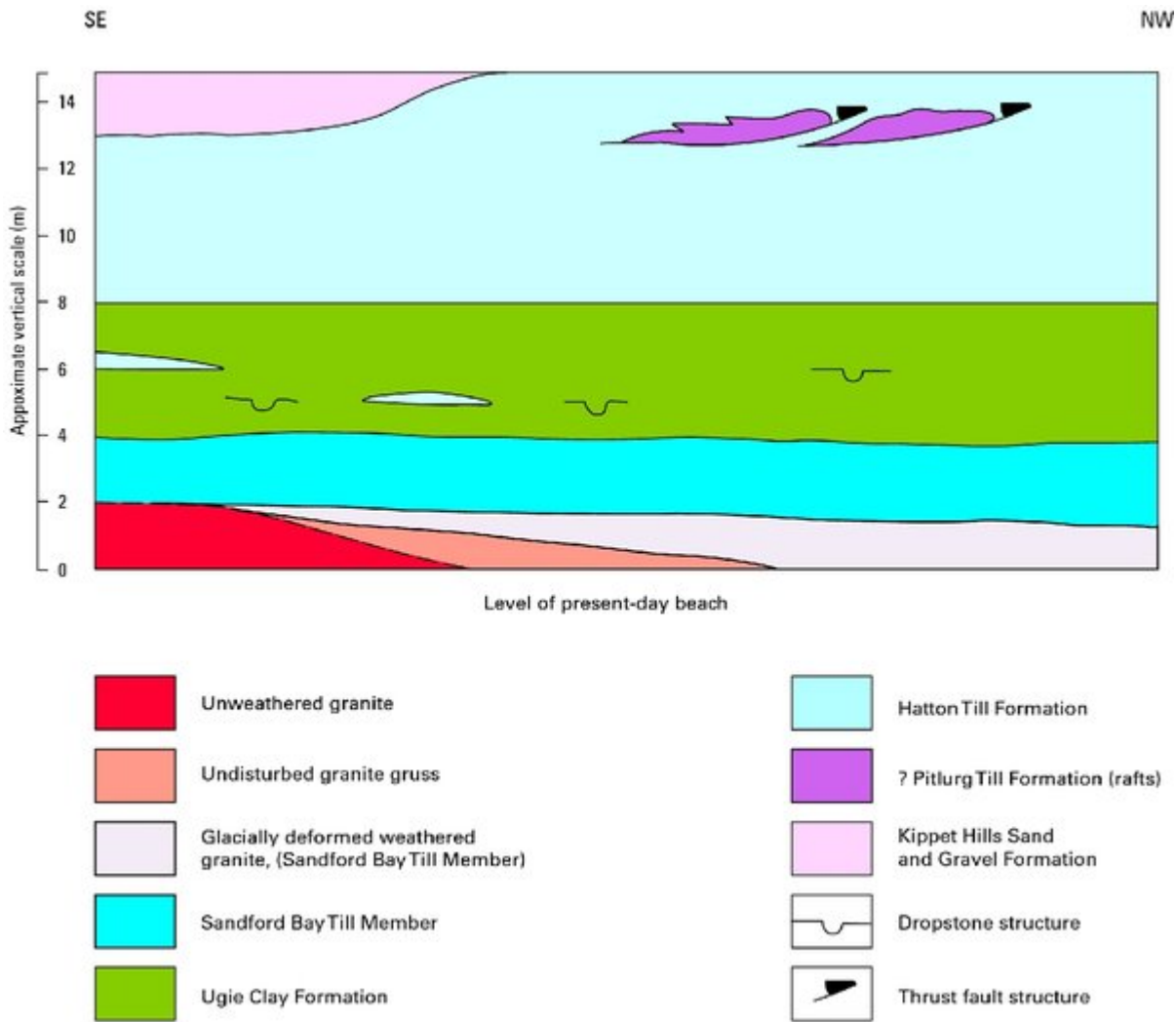


(Figure A1.12) Generalised transect along the lower Philorth valley showing radiocarbon and pollen sites used in the construction of the local Holocene sea level curve (after Smith et al., 1982).

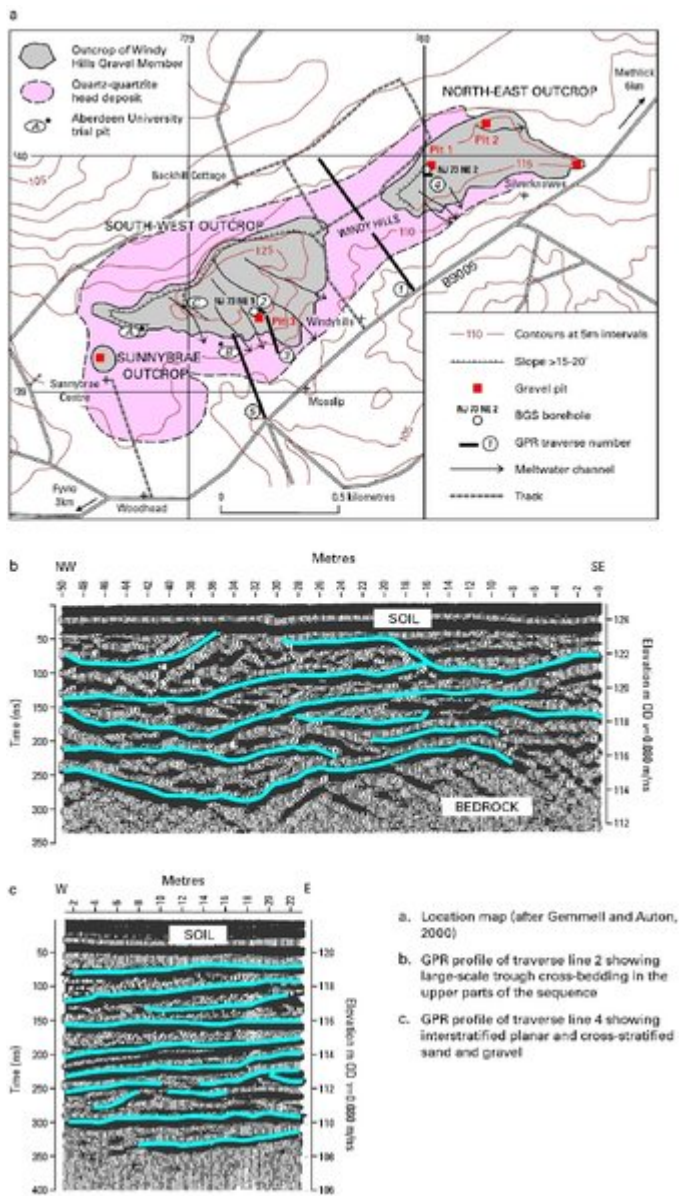


(Figure A1.13) Landforms and deposits in and adjacent to the Ugie catchment. A, Ardglassie; B, Blackhills; BB, Ballus Bridge; G, Greenhill; K, Kirkhill; L, Lumbs; Ly, Leys; O, Oldmill; R, Red Loch; SL, Sinclair Hills; W, Upper Waughtonhill; WD, West Dens channel.

(Figure A1.15) Localities at St Fergus (after Peacock, 1999). See (Figure A1.13) for general location of the St Fergus Silt Formation.

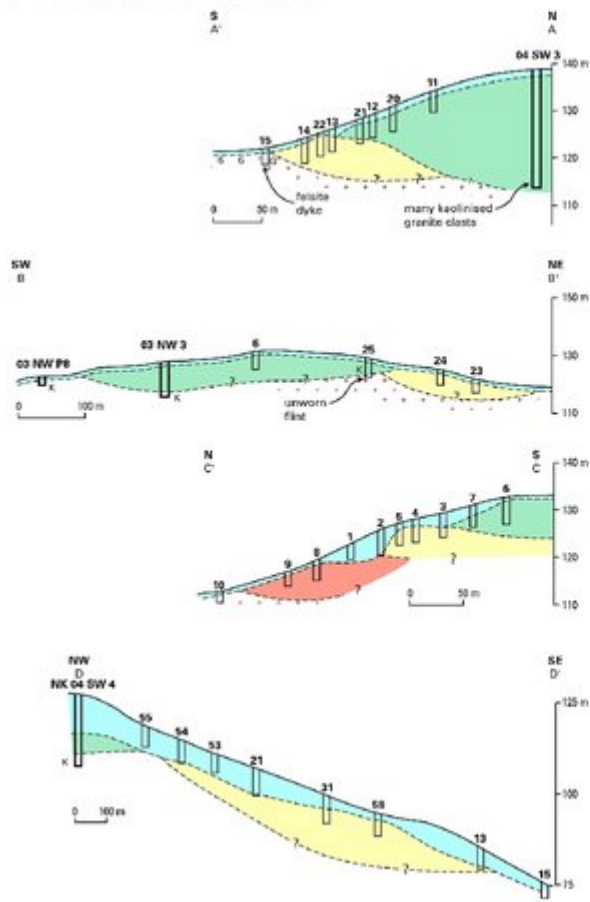


(Figure A1.16) Schematic stratigraphical relationships in the Sandford Bay area, based on cliff sections near Sandford Lodge [NK 125 434] and in the Invernettie road diversion [NK 120 447].

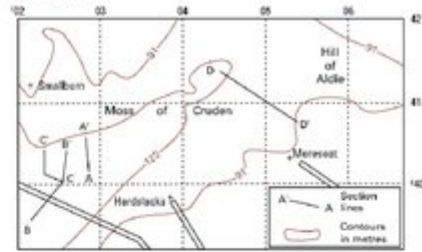


(Figure A1.17) The principle outcrops of the Windy Hills Gravel Member of the Buchan Gravels Formation near Fyvie.

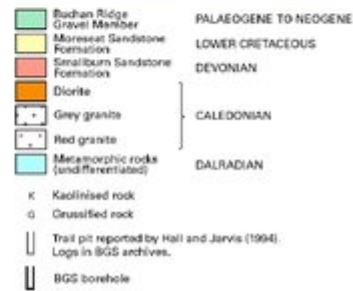
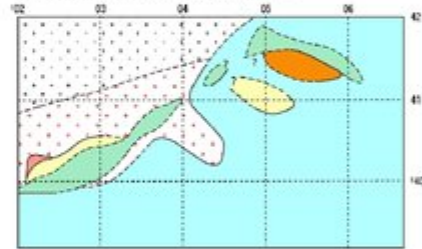
a Transects across the Moss of Cruden



b Locality map

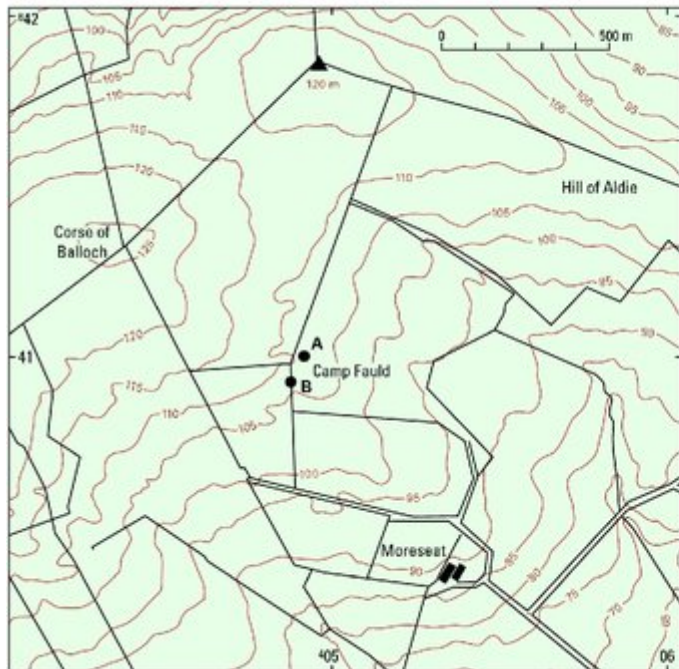


c Subdrift geological map showing outliers of the Smallburn and Moresett Sandstone formations, and the Buchan Ridge Gravel Member

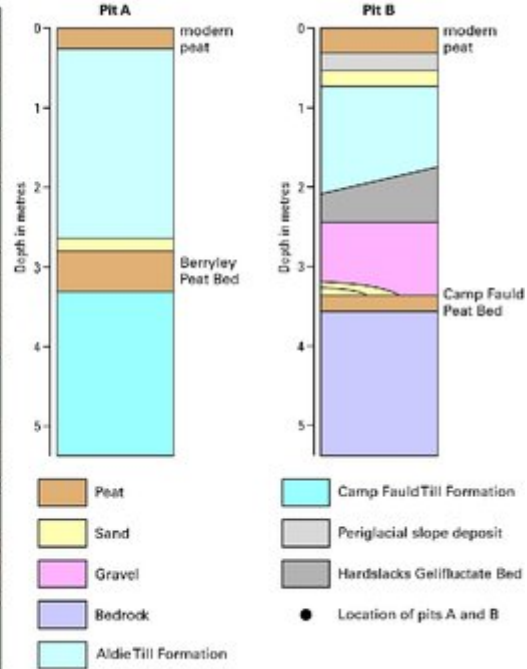


(Figure A1.18) Investigations on the Buchan Ridge (after Hall and Jarvis, 1994).

a Locality map

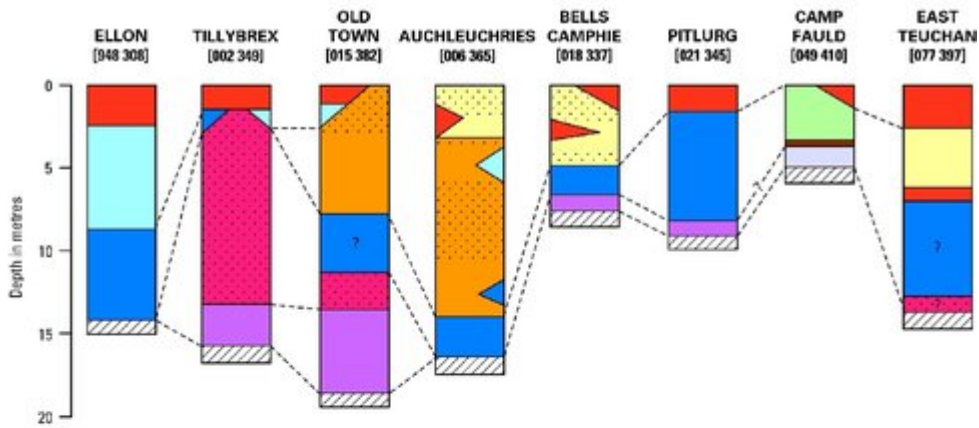


b Pit logs

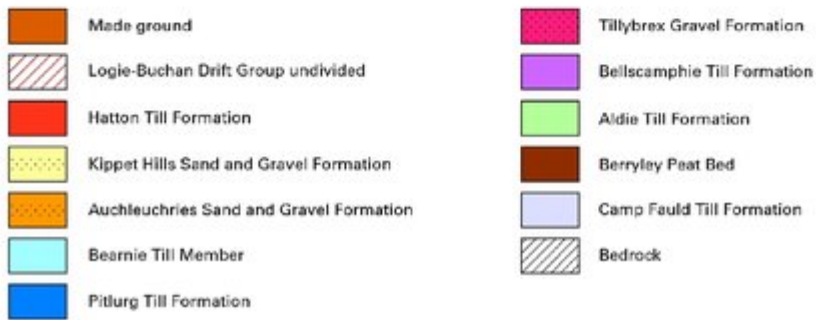
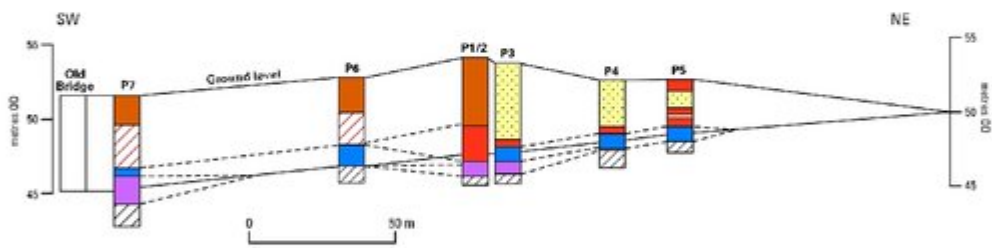


(Figure A1.19) Camp Fould site (after Whittington et al., 1993).

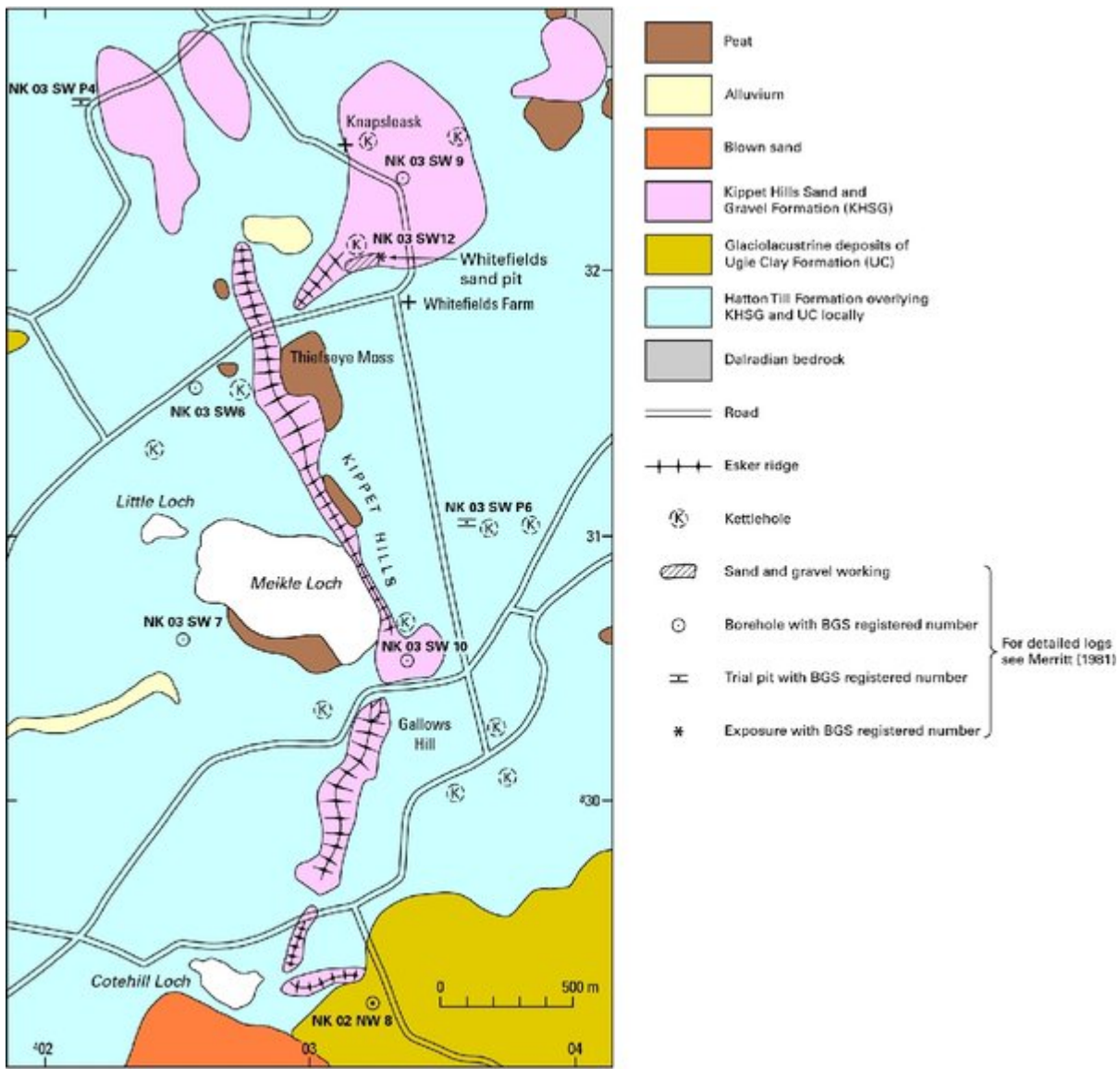
a Logs of representative sections/boreholes located on Figure 50



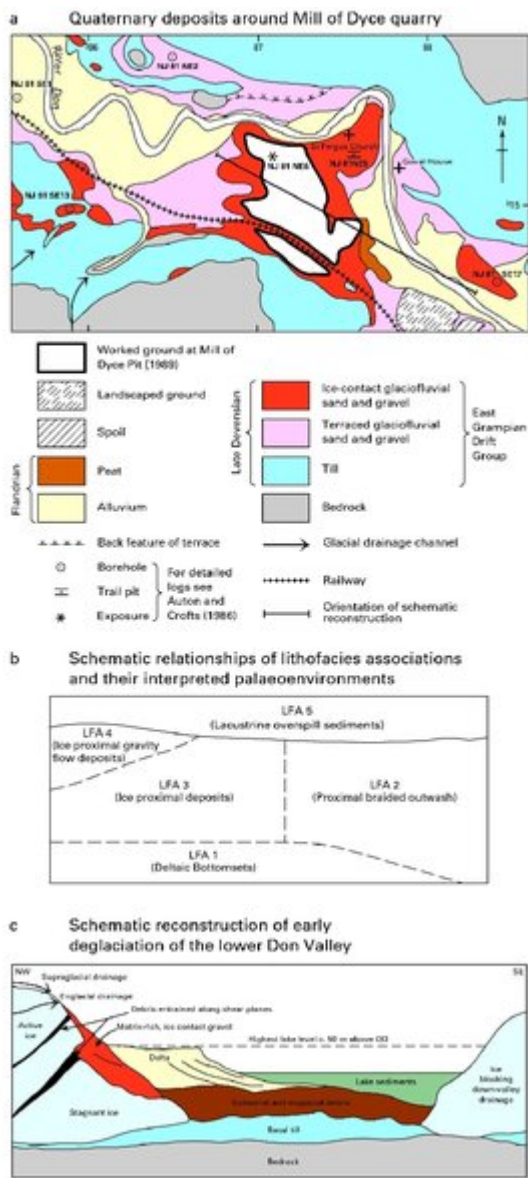
b Transect along Bellscamphie railway cutting



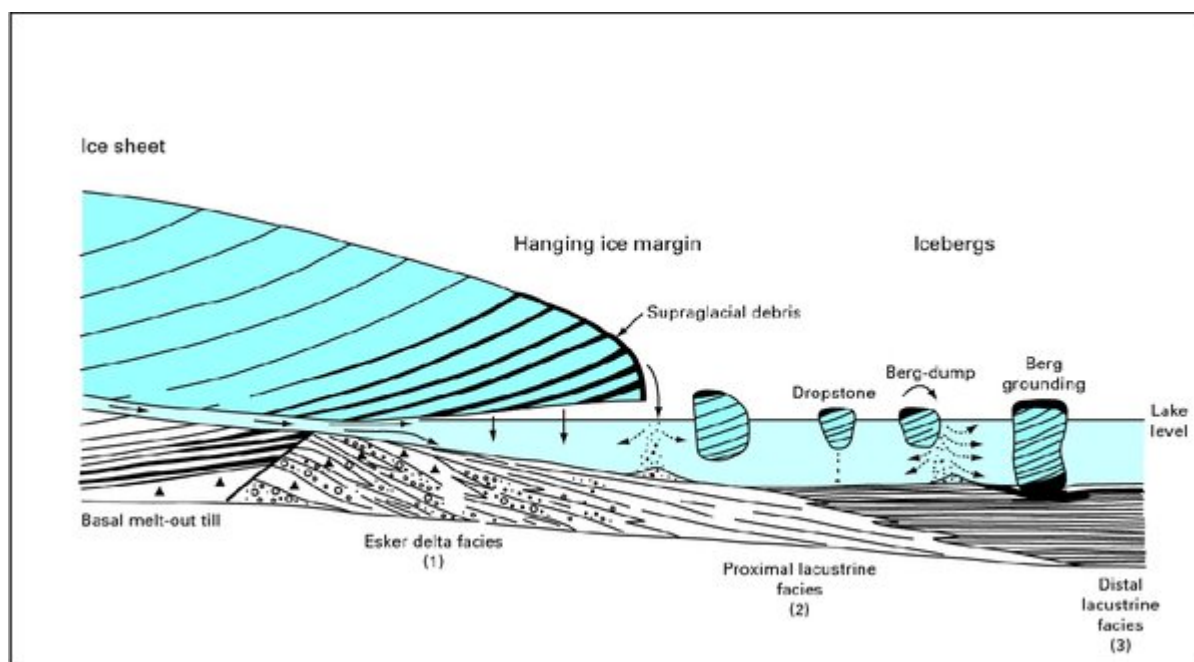
(Figure A1.20) Schematic logs and correlations in the Ellon area (after Hall and Jarvis, 1995).



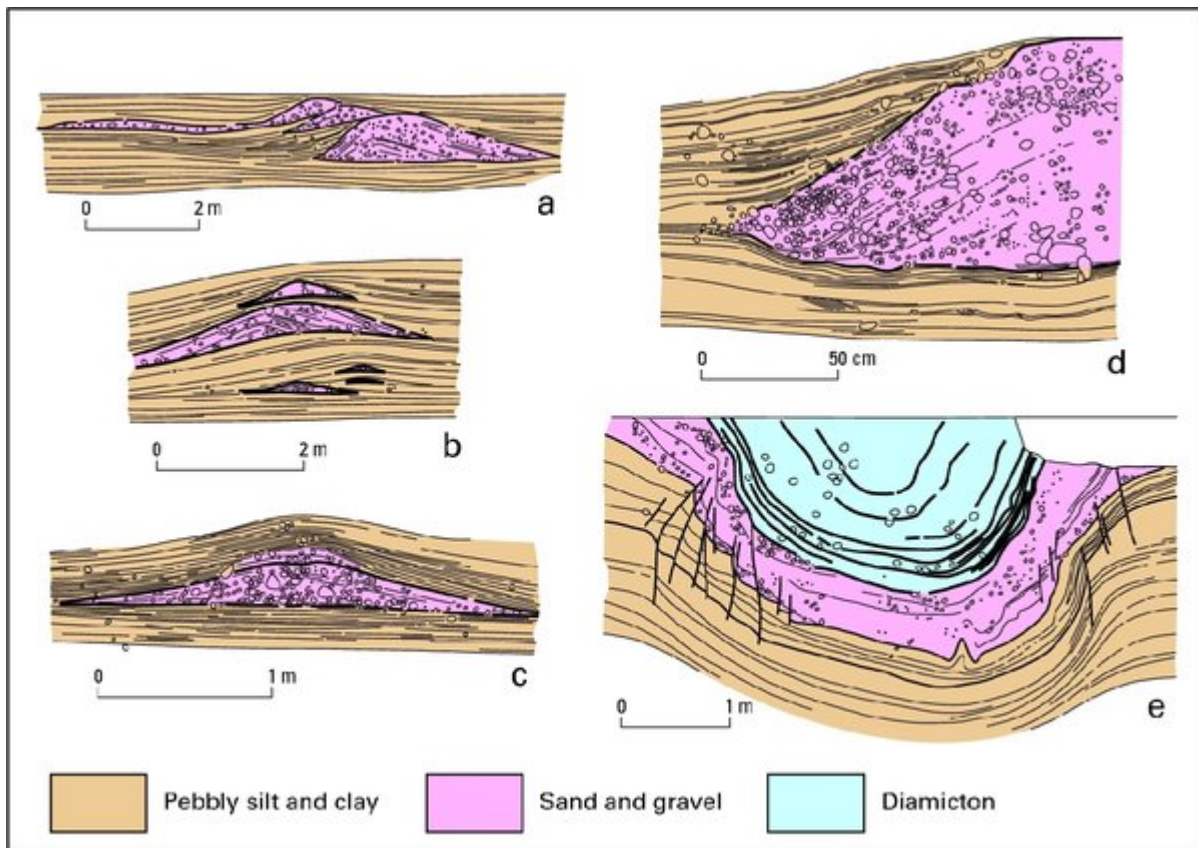
(Figure A1.21) Quaternary deposits and landforms of the Kippet Hills area.



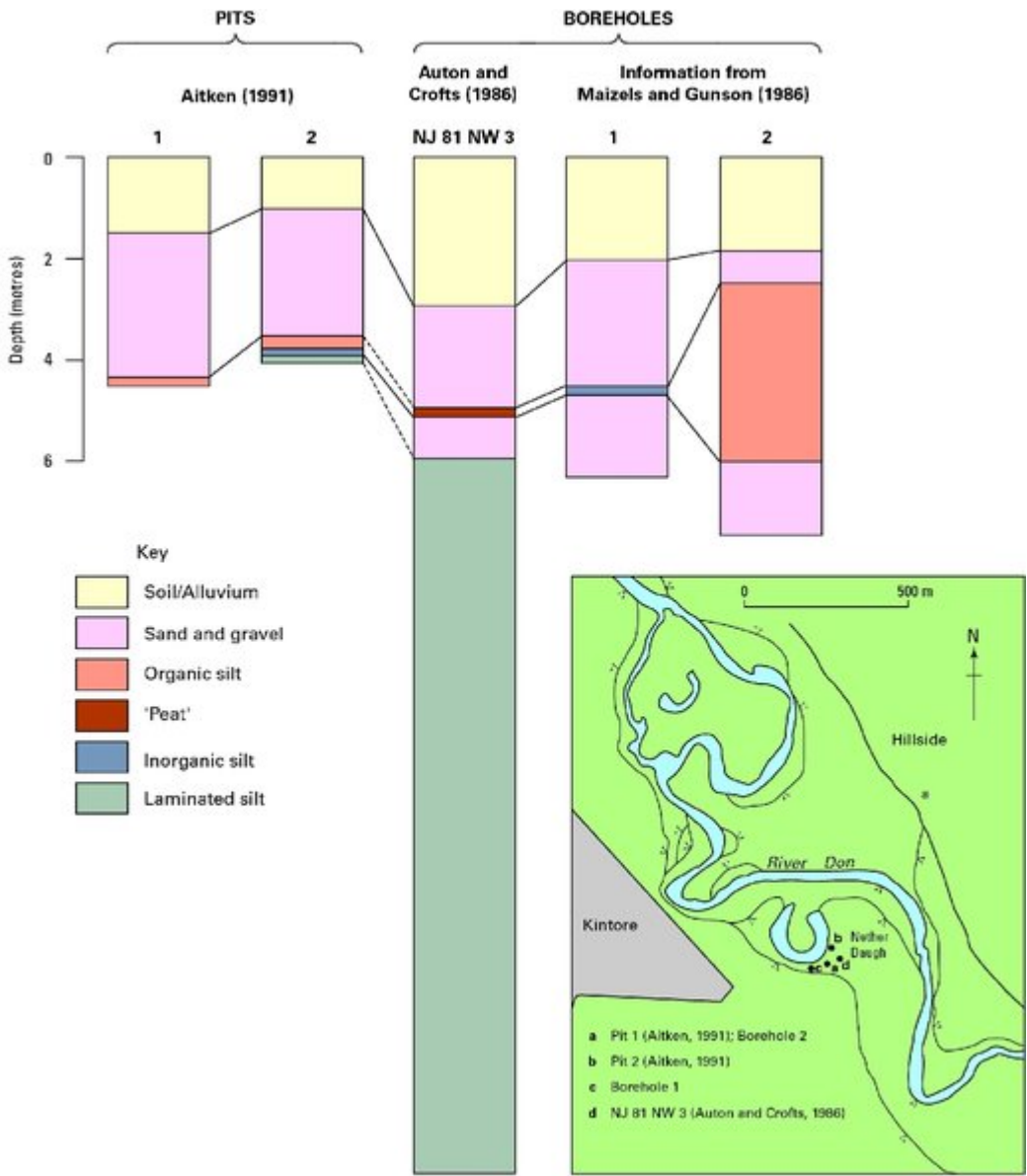
(Figure A1.22) Mill of Dyce sand and gravel quarry and the deglaciation of the lower Don valley.



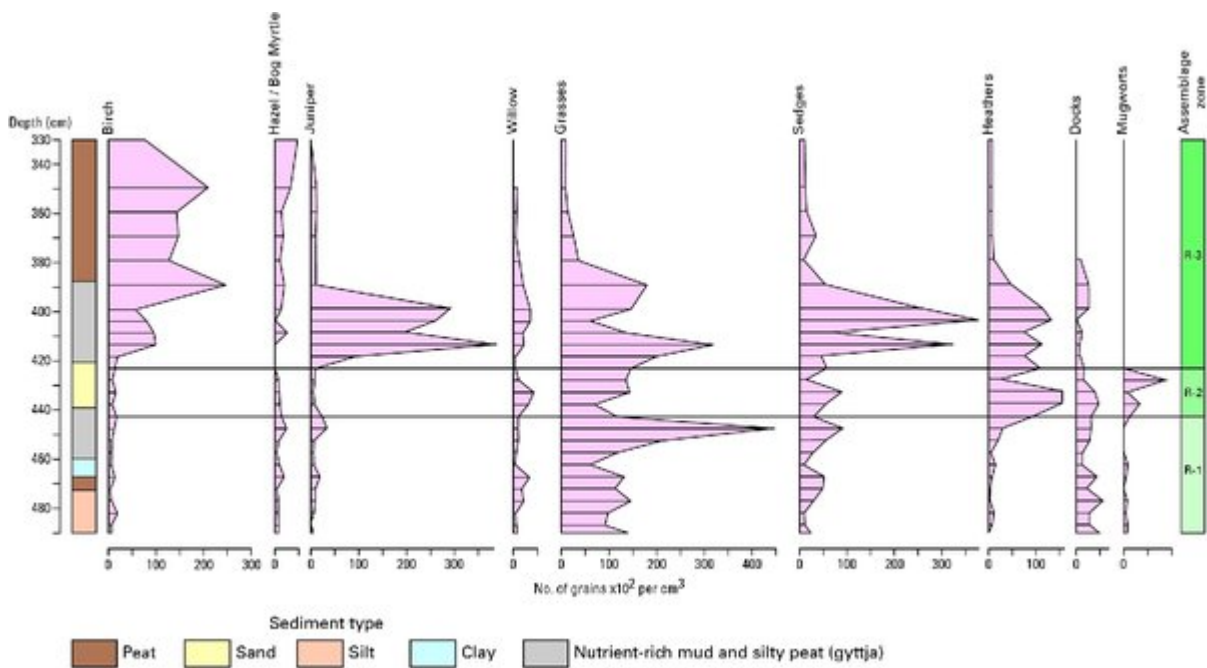
(Figure A1.23) A palaeoenvironmental model of the Strabathie subaqueous esker-delta (after Thomas, 1984).



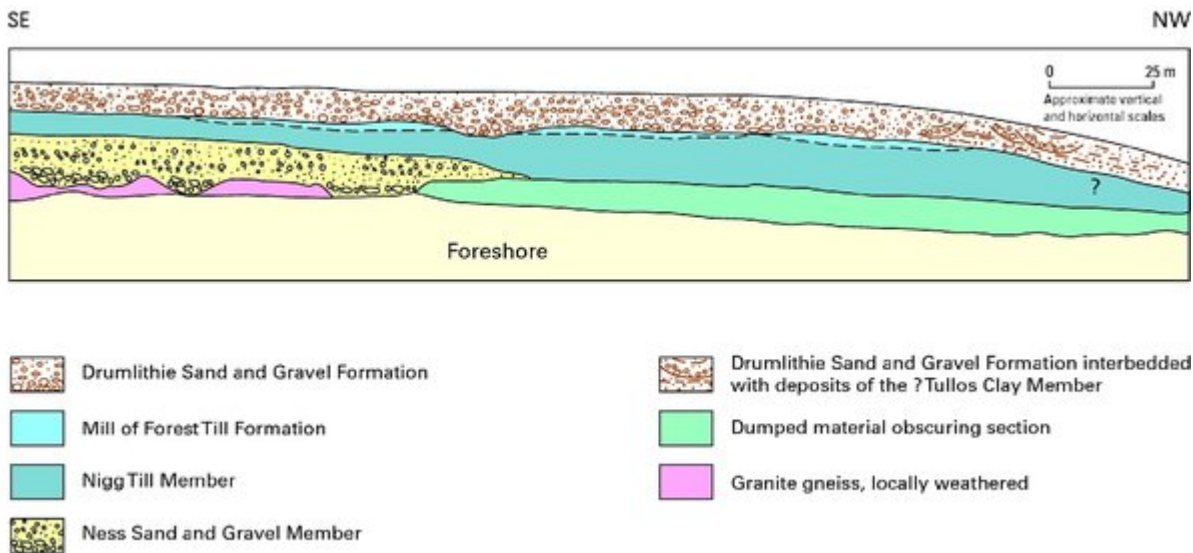
(Figure A1.24) Iceberg dump and grounding structures at Strabathie (after Thomas, 1984). a—d dump structures; e grounding structure



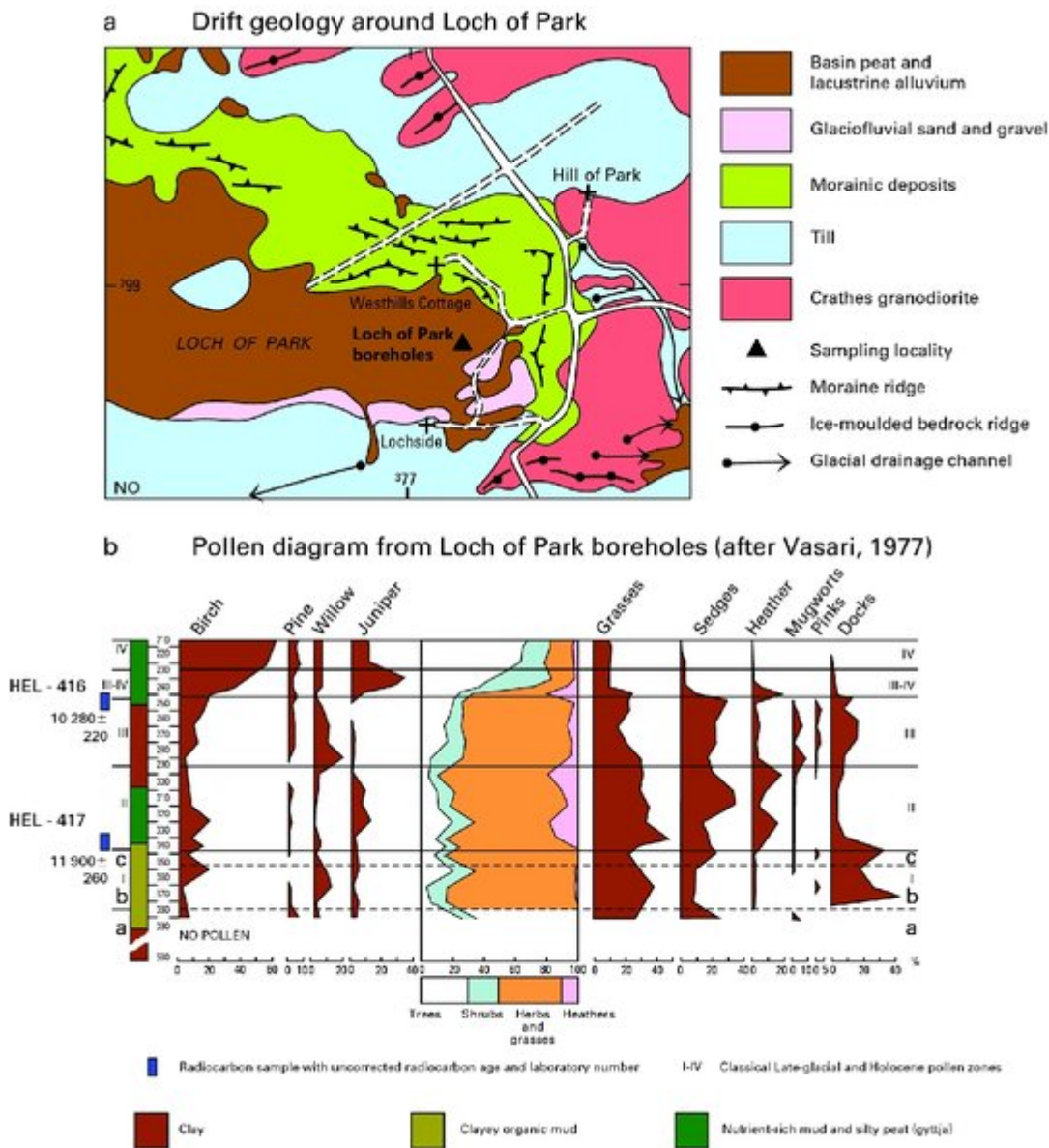
(Figure A1.25) Lithostratigraphy at the Nether Daugh site.



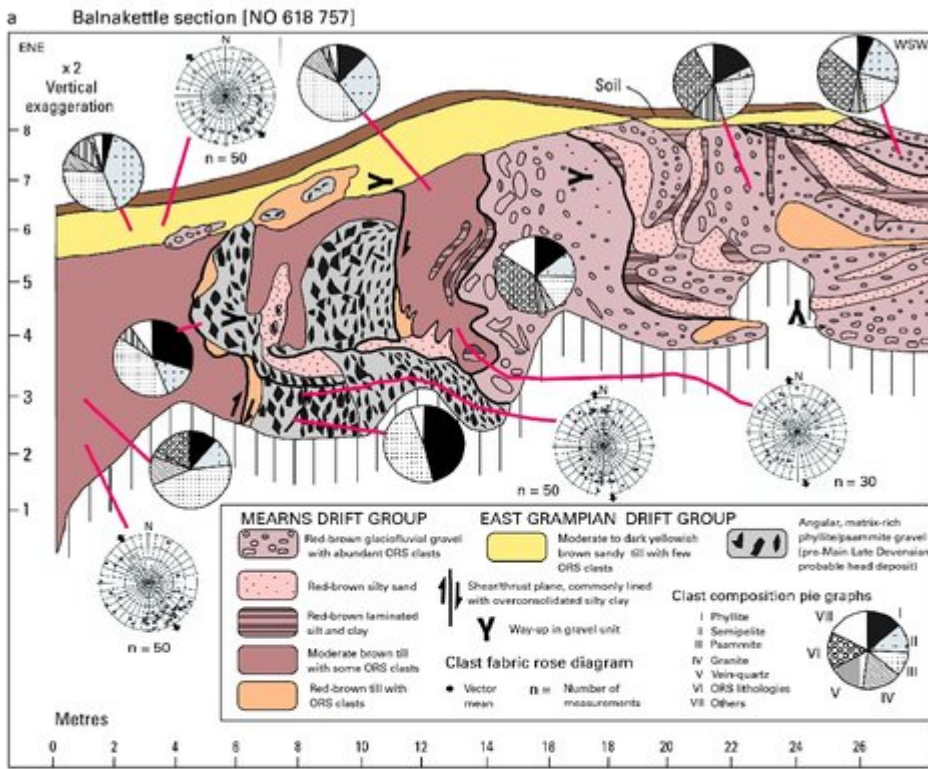
(Figure A1.26) Absolute pollen diagram of selected taxa from Rothens (after Aitken, 1991).



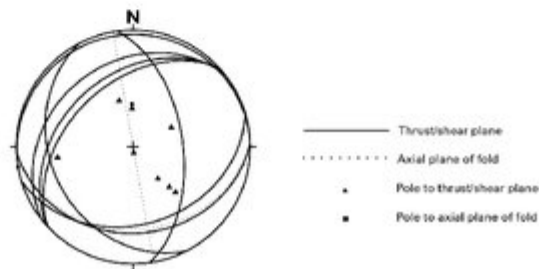
(Figure A1.27) Stratigraphical relationships of deposits at the Nigg Bay cliff section in 1977—80 (not to scale and partially schematic).



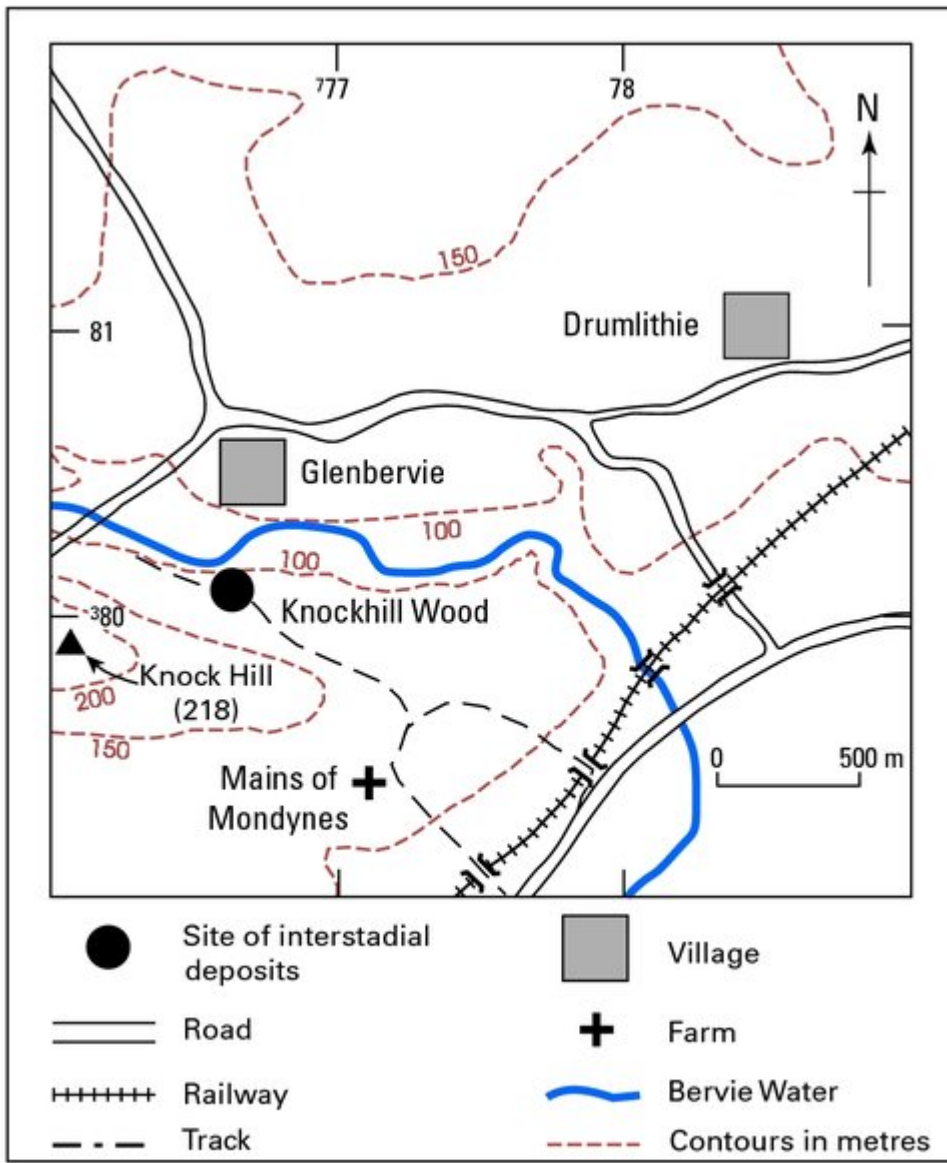
(Figure A1.28) Loch of Park locality, near Banchory.



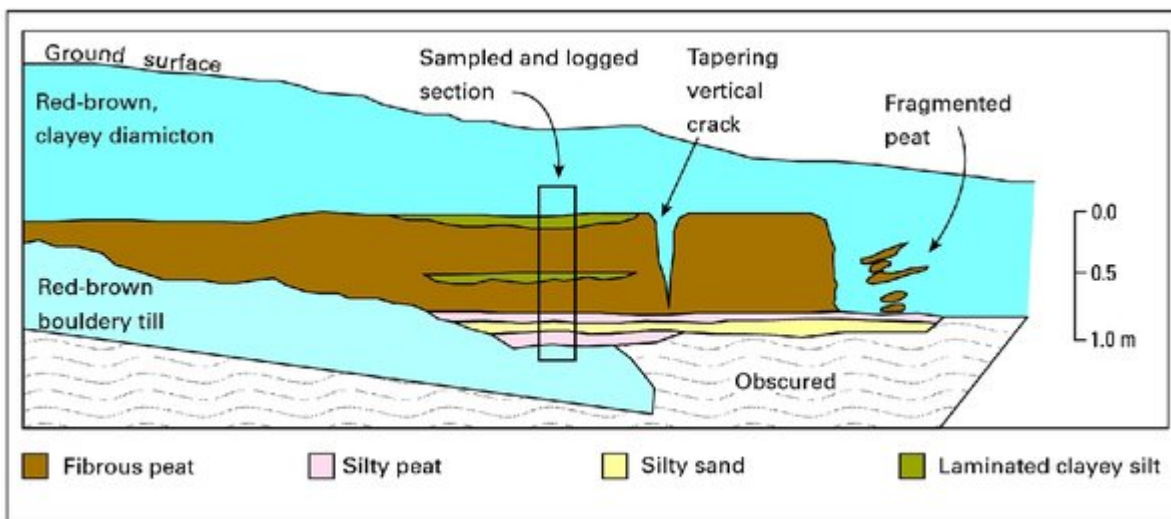
b Deformation structures at Balnakettle
(Lower hemisphere projection)



(Figure A1.29) Stratigraphy and structure of the Quaternary sediments at Balnakettle.



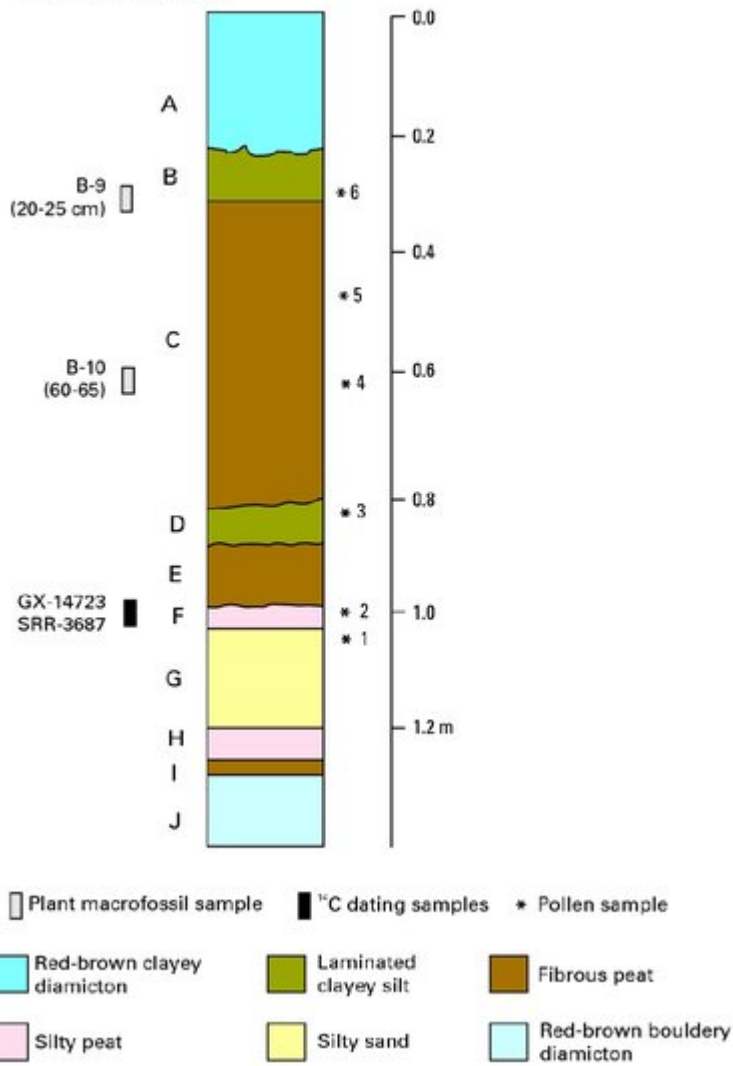
(Figure A1.30) Location of Knockhill Wood site.



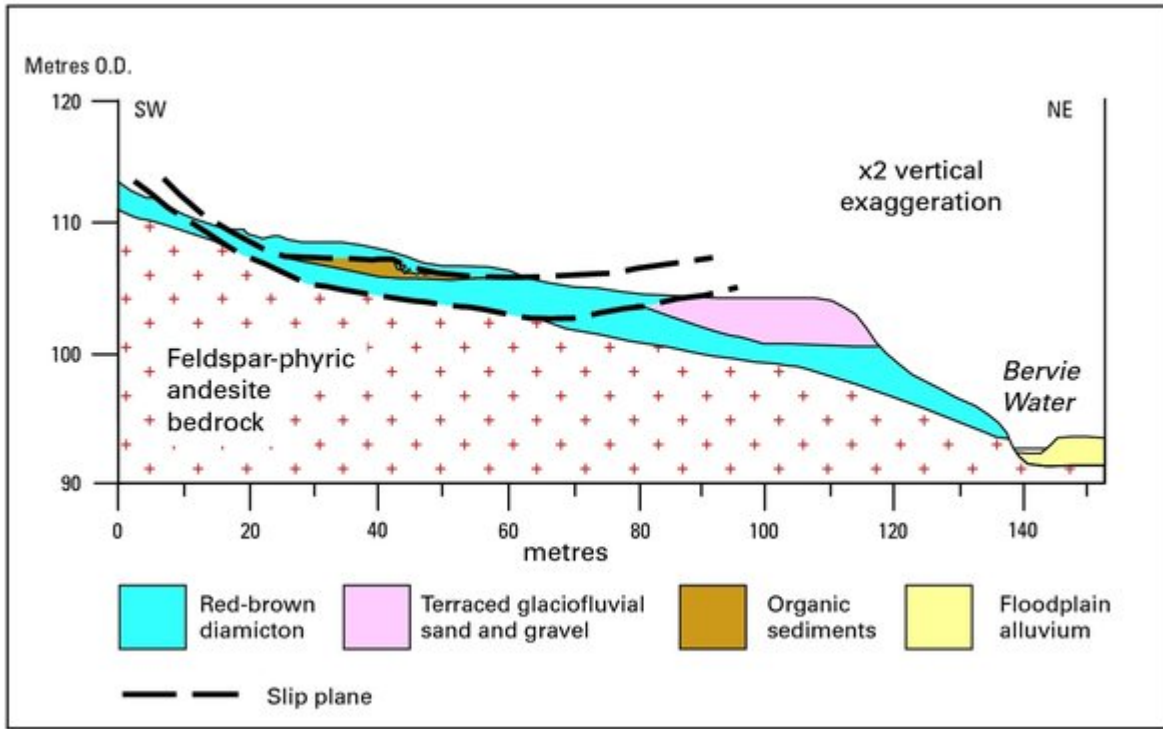
(Figure A1.31) Sketch transect of the Knockhill Wood exposure showing the relationship between the organic and glacial sediments.

KNOCKHILL WOOD SECTION, GLENBERVIE
 [NO 7667 8012]

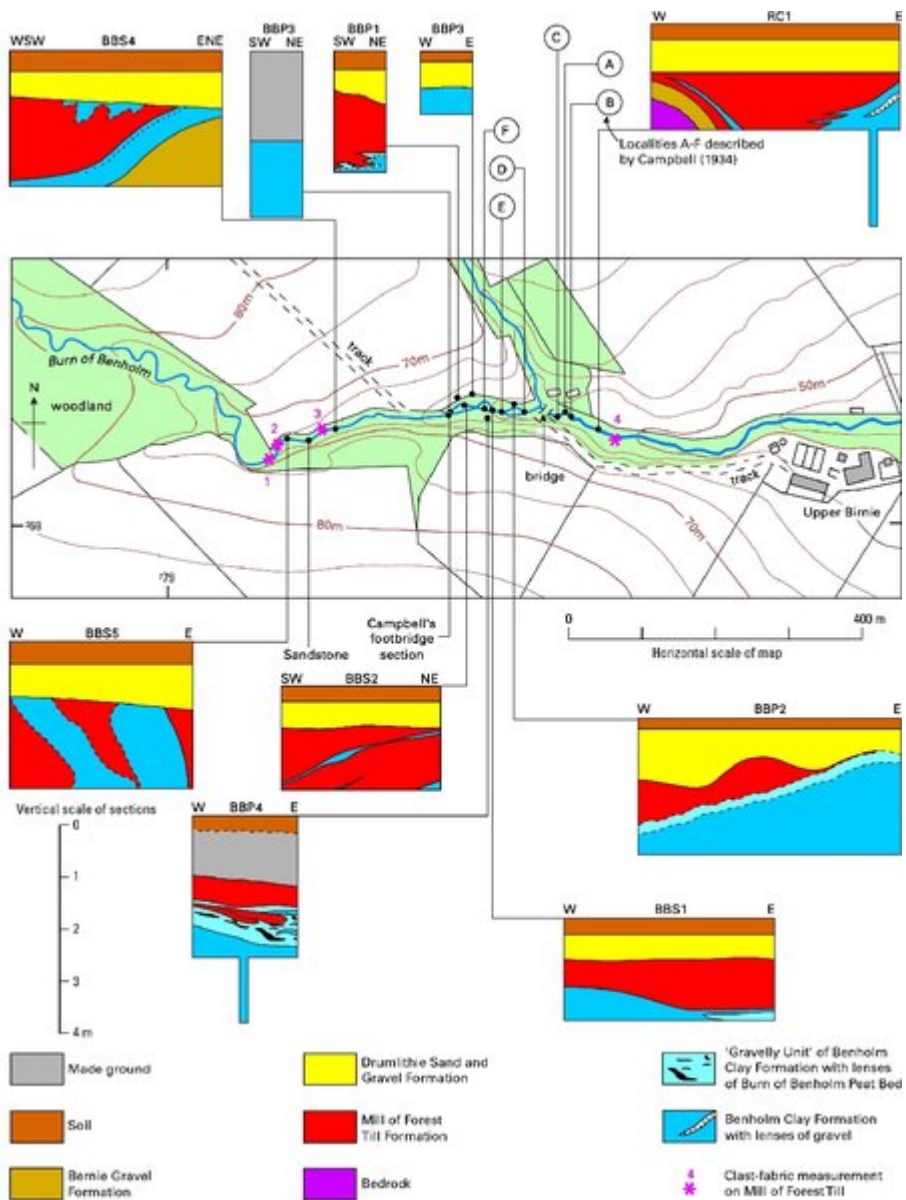
Surface level: 112.38m



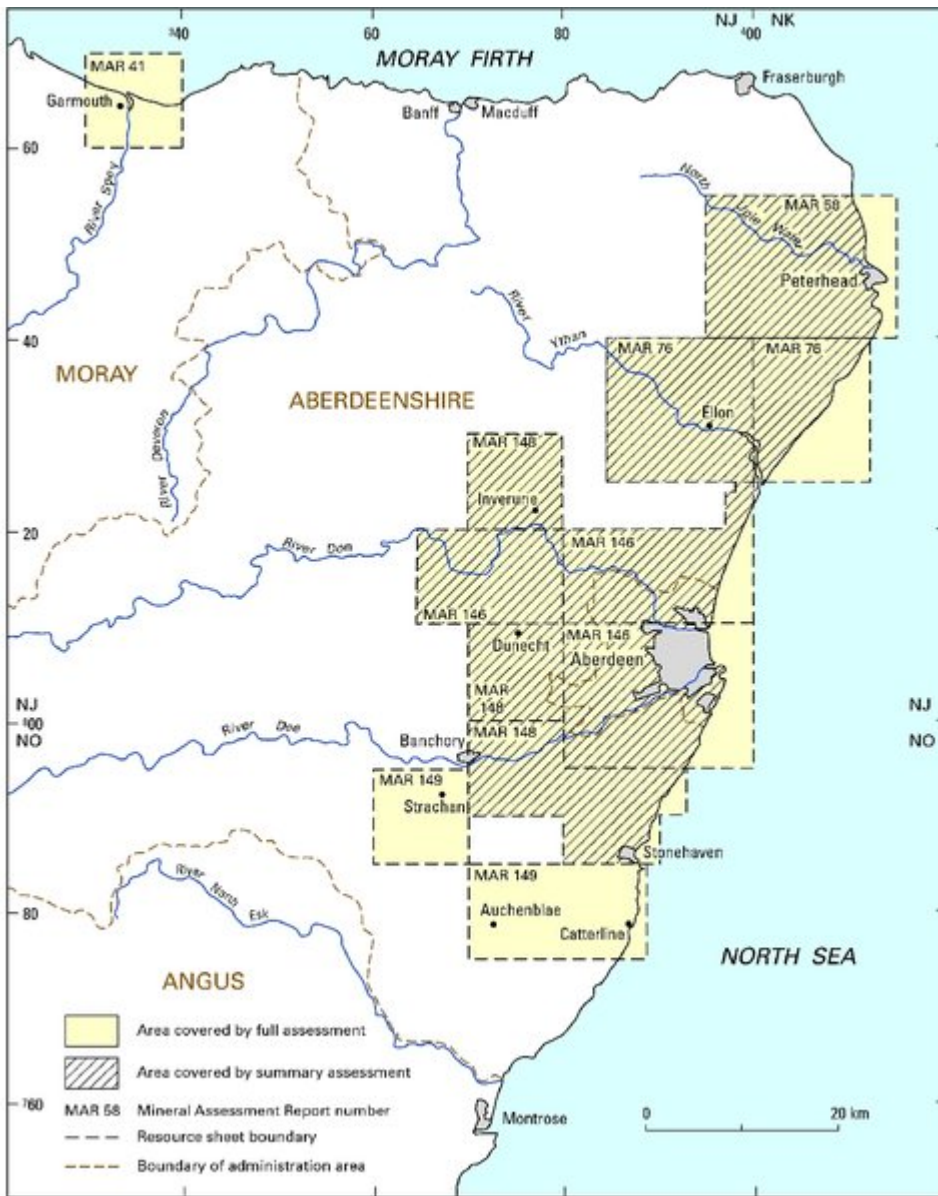
(Figure A1.32) Graphic log of the organic sequence at Knockhill Wood.



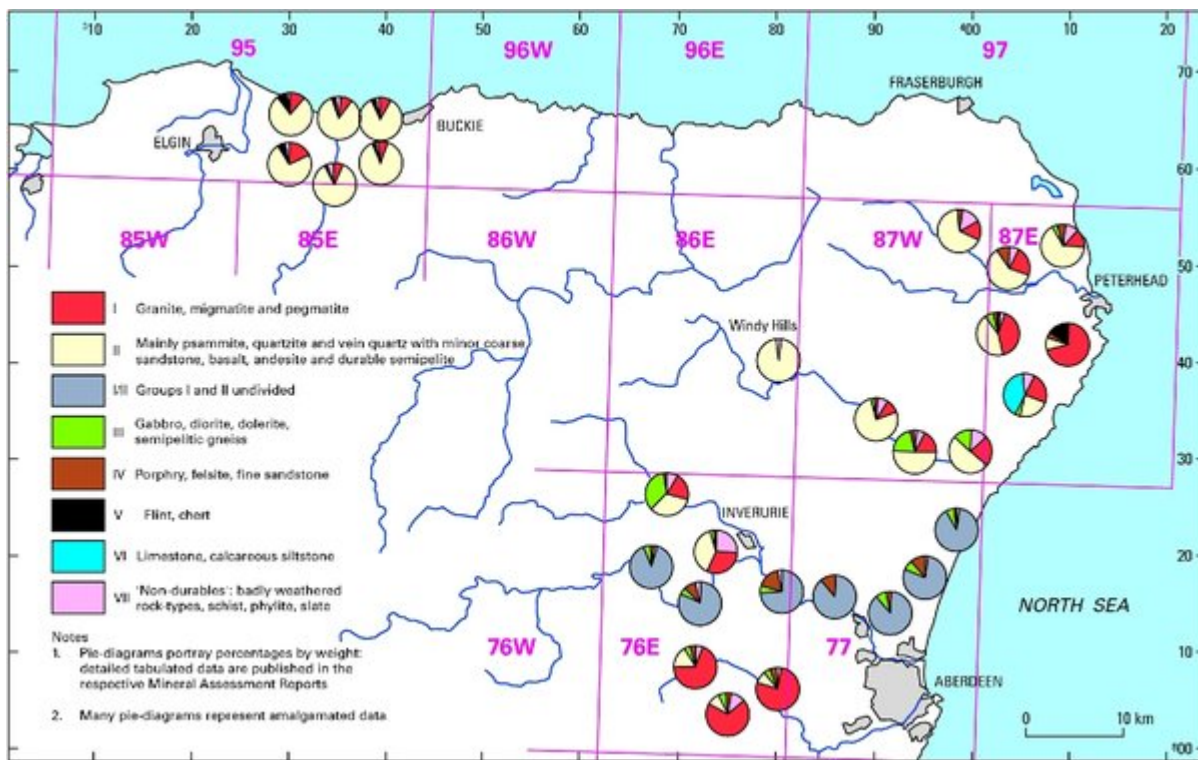
(Figure A1.33) Postulated form of the landslide Knockhill Wood.



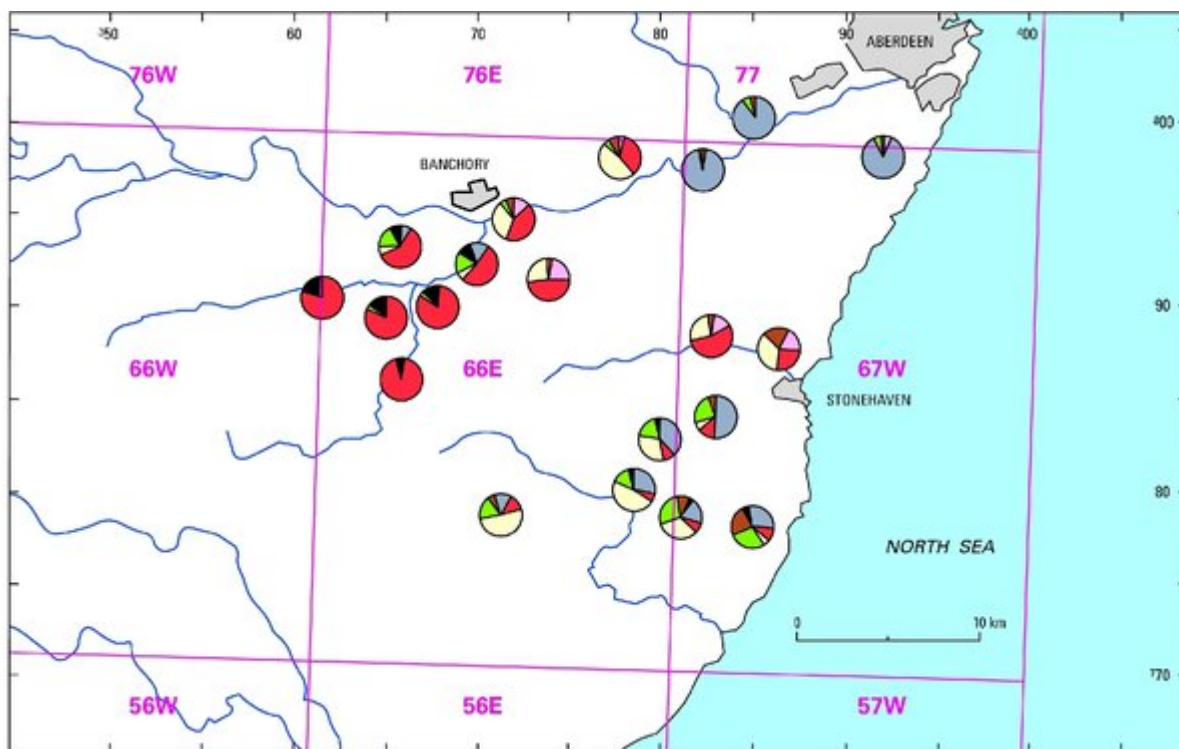
(Figure A1.34) Excavations and measured sections at the Burn of Benholm.



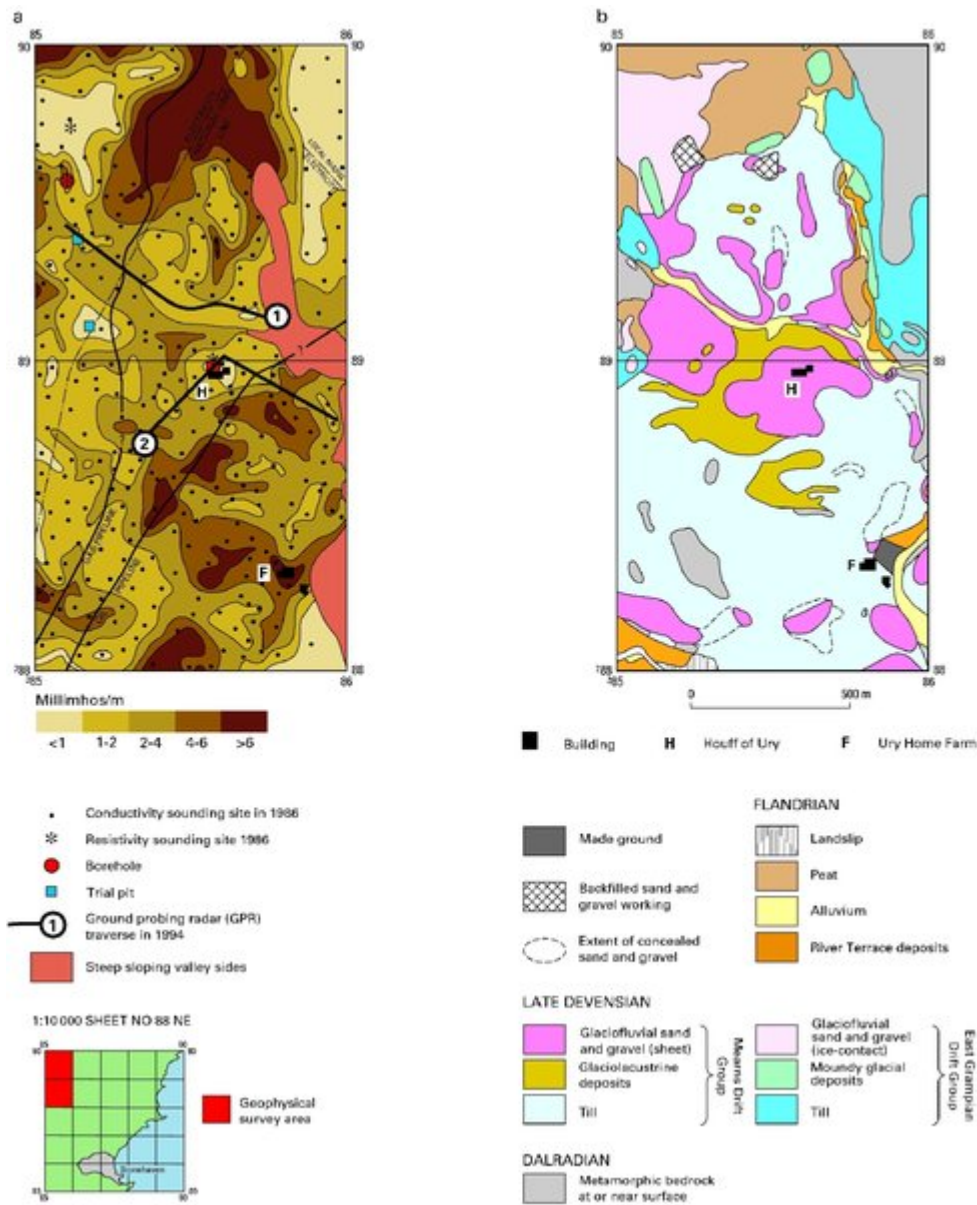
(Figure A2.1) Sketch map showing the location of published sand and gravel resource assessment sheets and administrative areas in north-east Scotland.



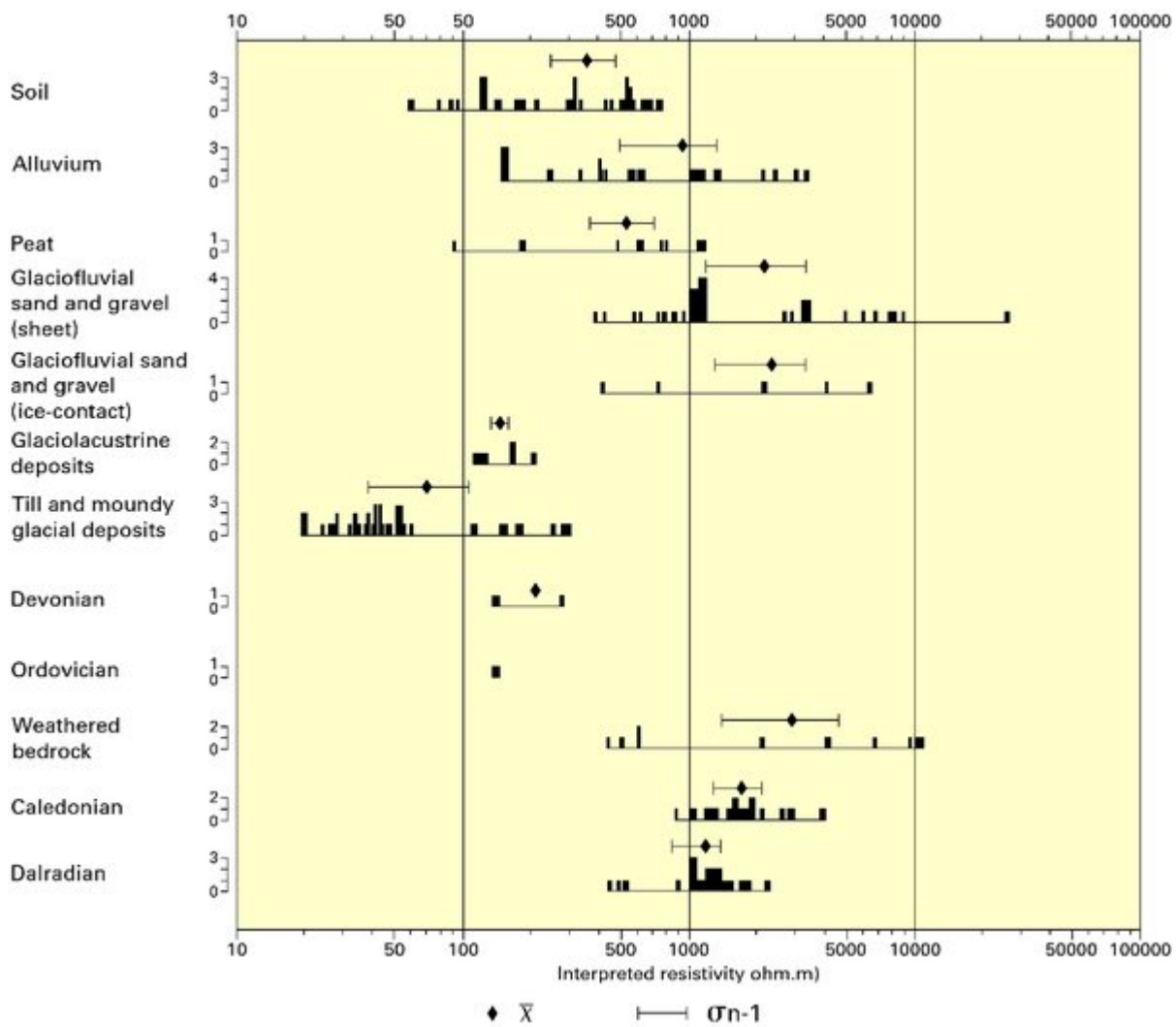
(Figure A2.2) Composition of workable gravel deposits between Elgin and Aberdeen.



(Figure A2.3) Composition of workable gravel deposits south of Aberdeen.

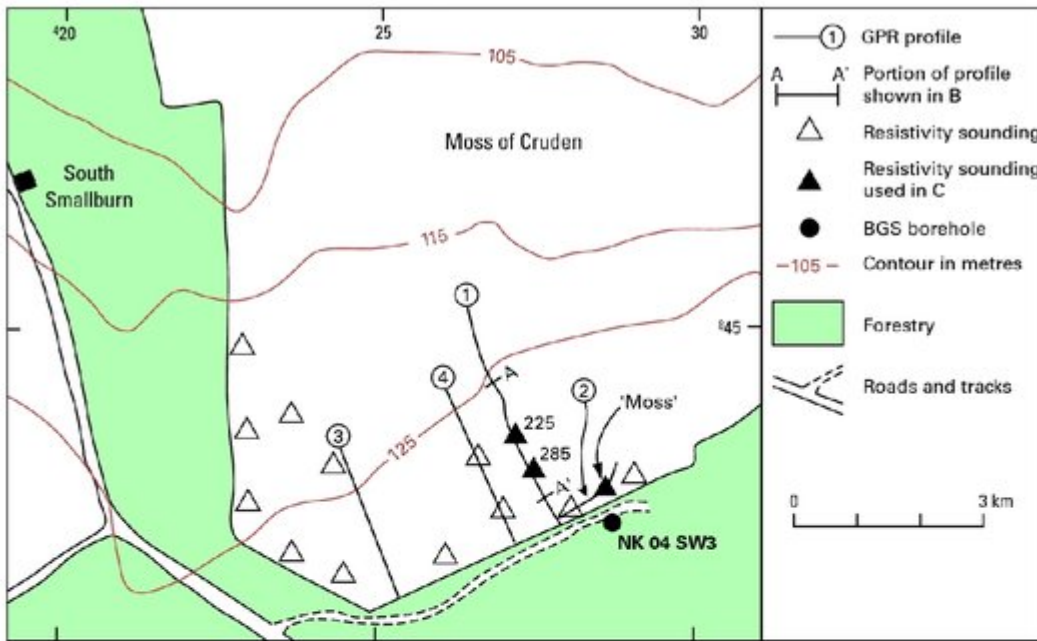


(Figure A3.1) Houff of Ury area. a Contoured ground conductivity values and location of GPR traverses in the Houff of Ury area b Geological map of the contact between the East Grampian and Mearns drift groups in the Houff of Ury area, based on geological mapping, conductivity surveying and ground resistivity soundings

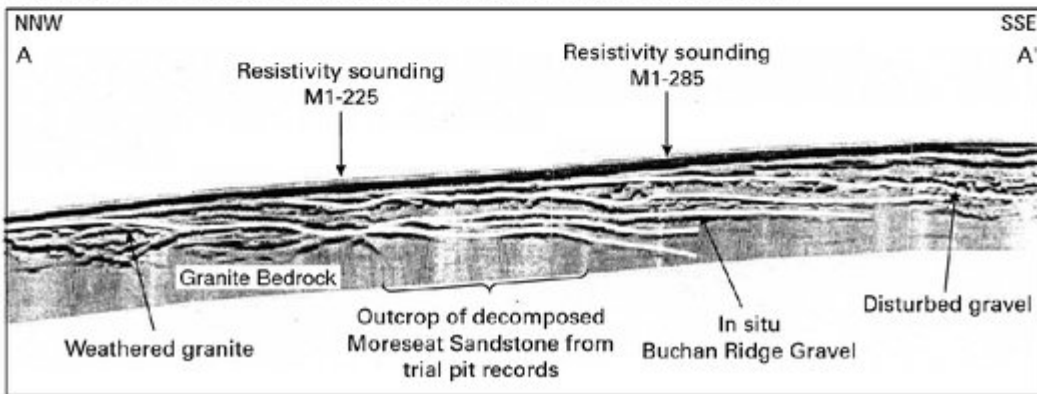


(Figure A3.2) Frequency distribution of interpreted resistivity values from the Banchory- Stonehaven sand and gravel resource sheet area (Auton et al., 1988).

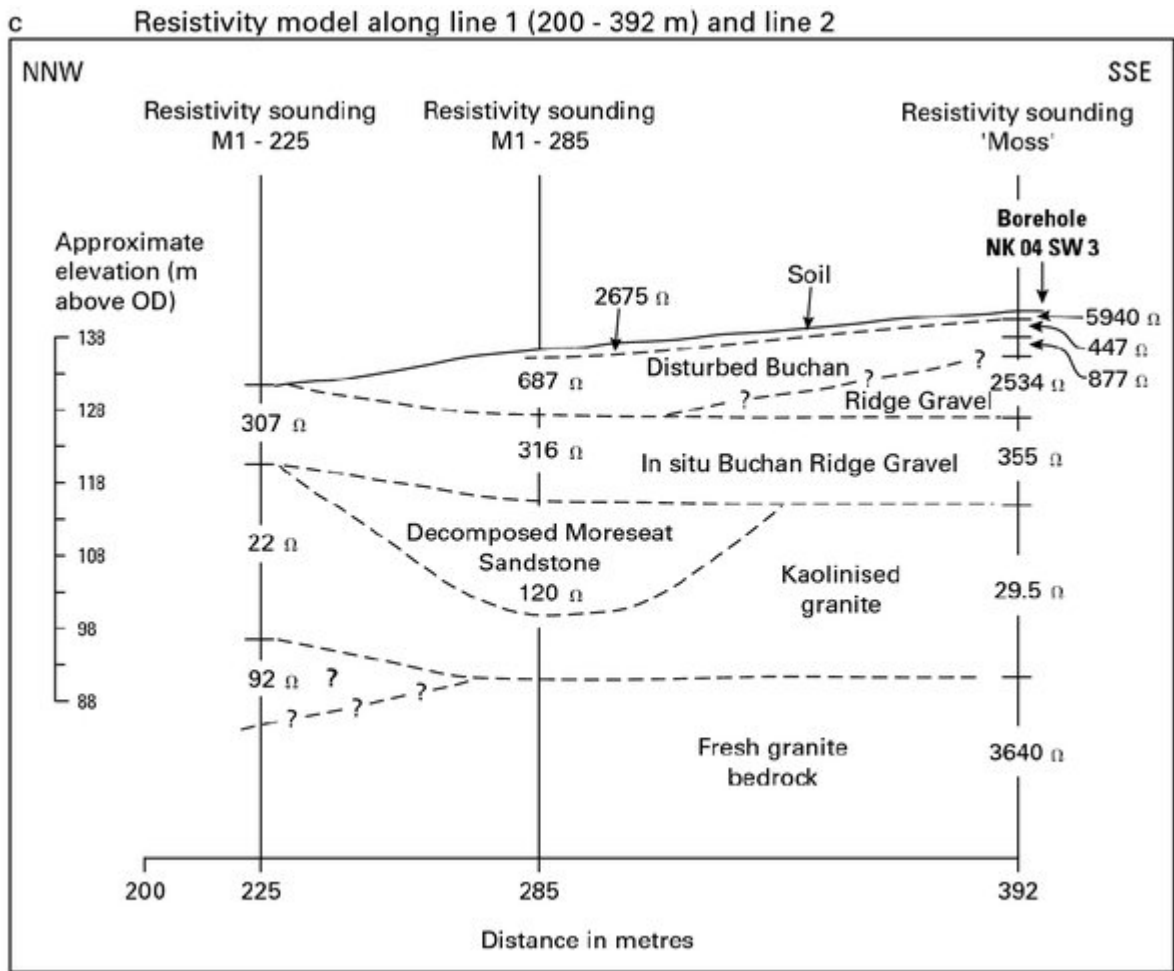
a Location of GPR traverses and resistivity soundings on the northern slope of the 'Buchan Ridge' at the Moss of Cruden



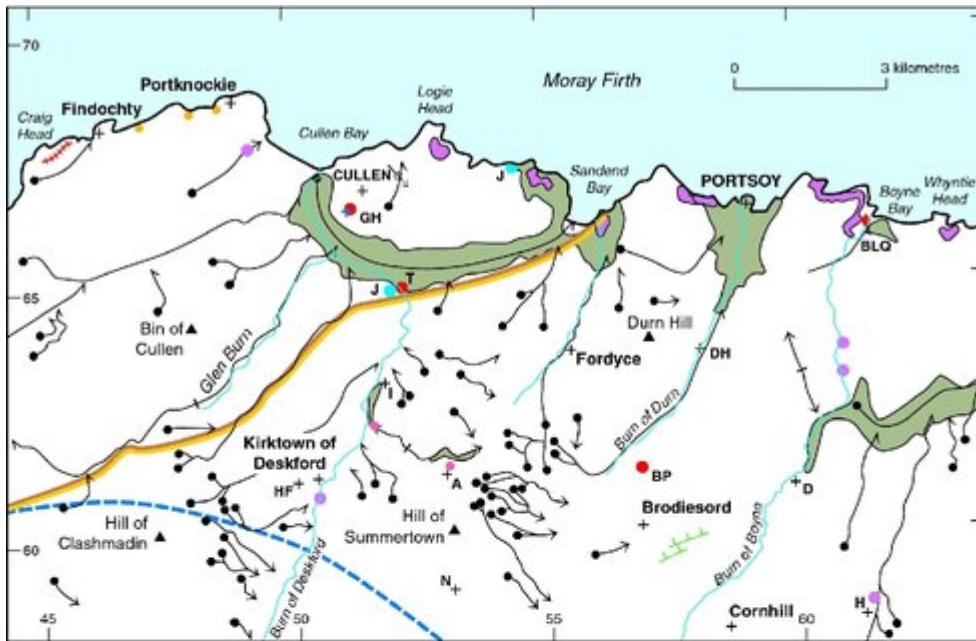
b Interpreted GPR profile (50 MHz) along part of line 1 (162-342 m)



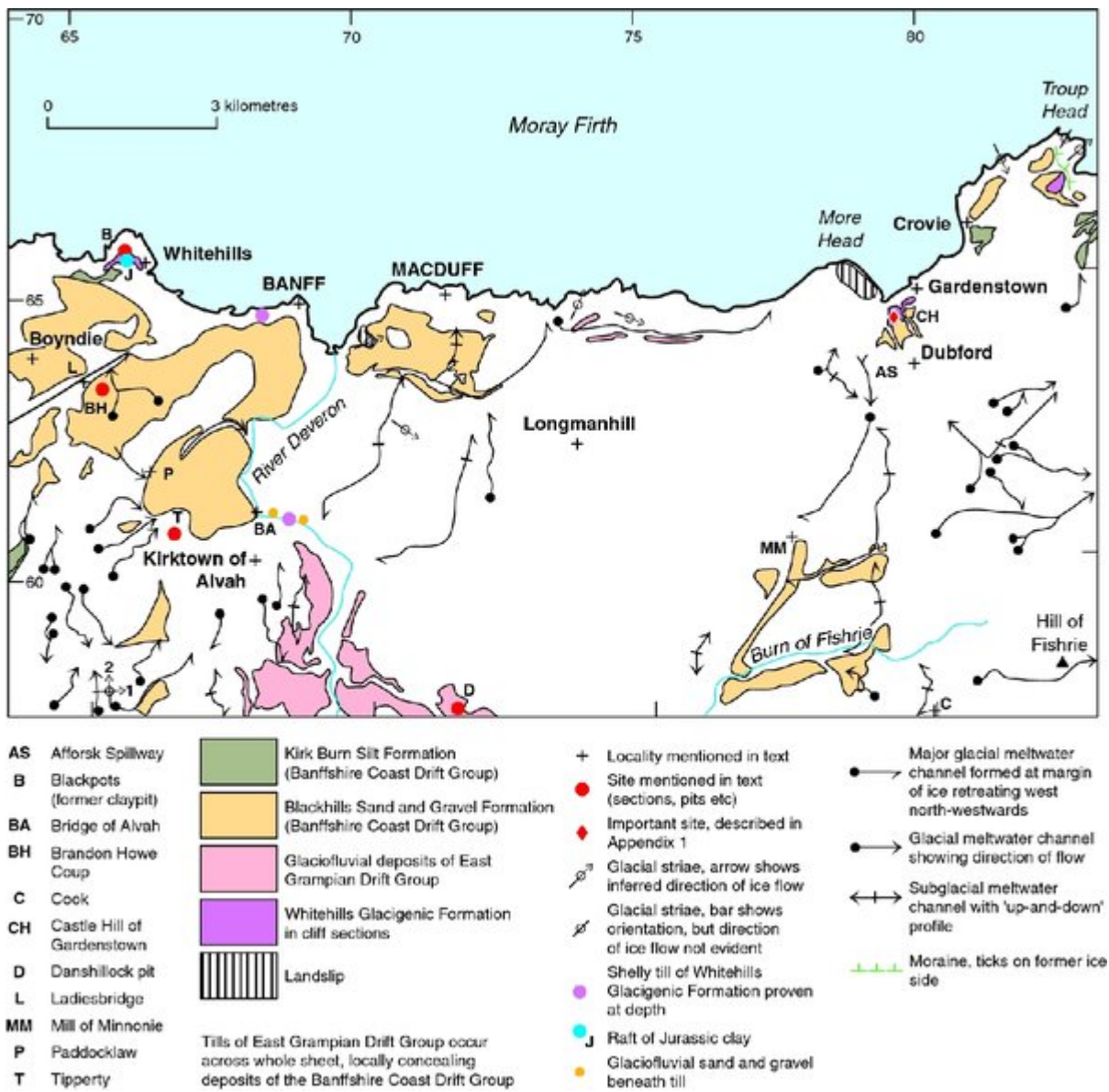
(Figure A3.3) Buchan Ridge. a Location of GPR traverses and resistivity soundings on the northern slope of the 'Buchan Ridge' at the Moss of Cruden b Interpreted GPR profile (50MHz) along part of line 1 (162–342 m).



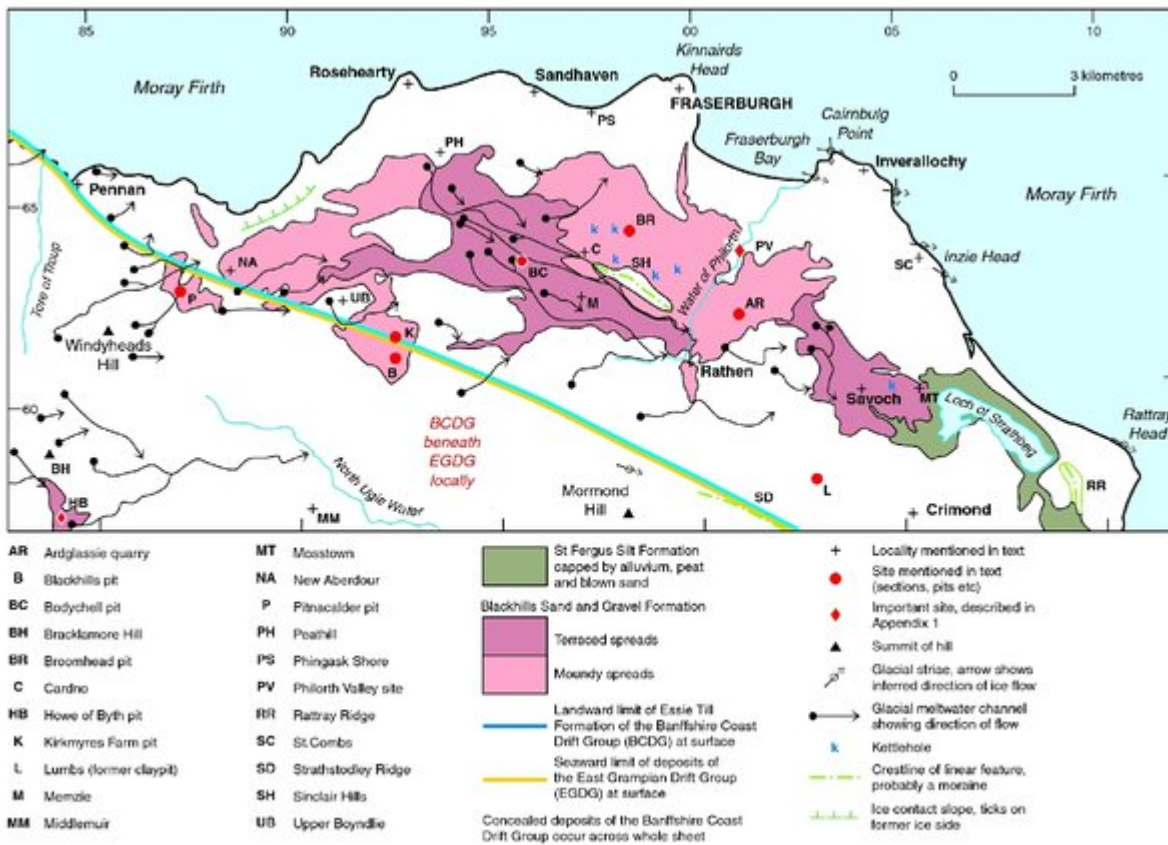
(Figure A3.3c) Buchan Ridge. Resistivity model along line 1 (200-392 m) and line 2



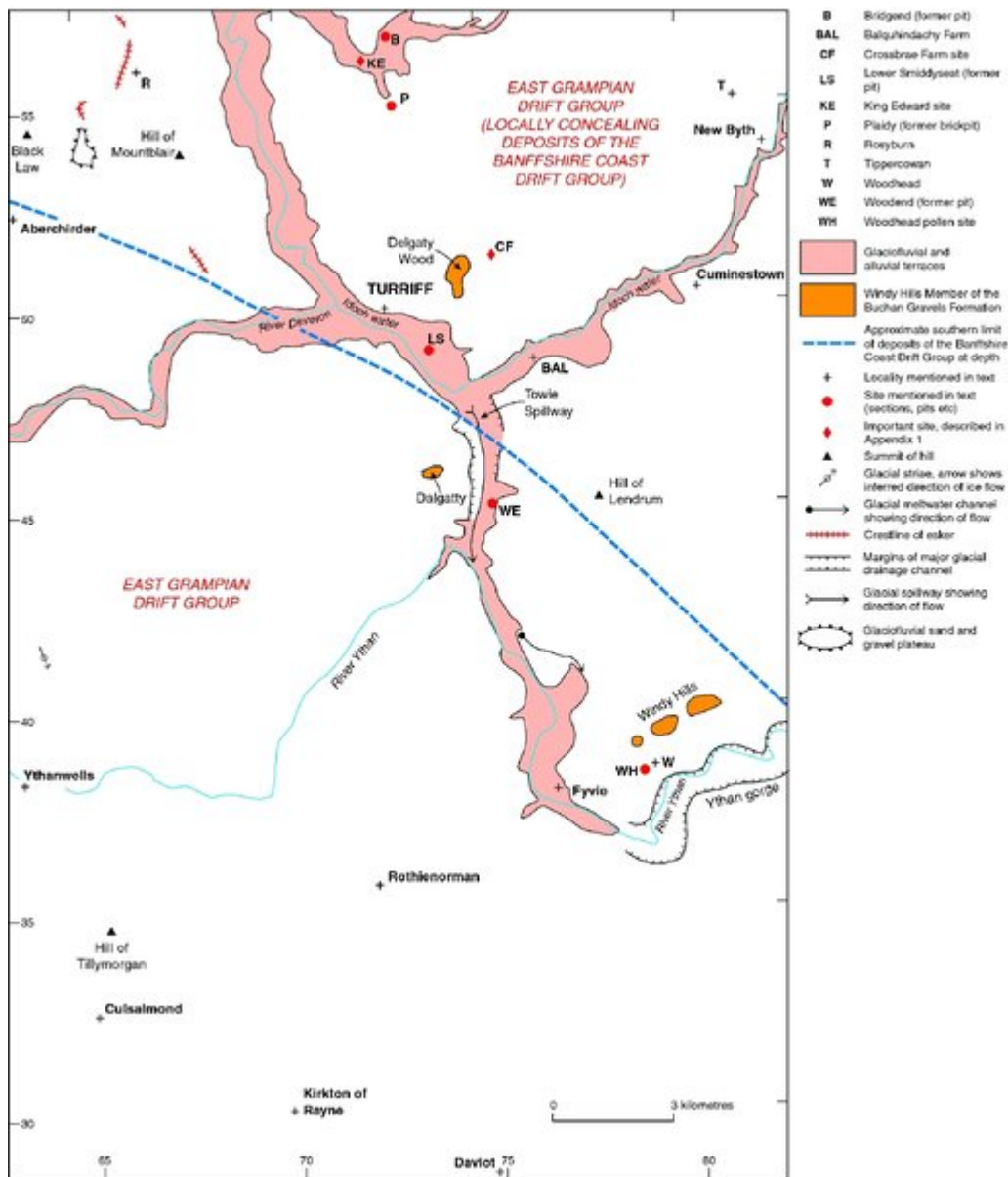
(Map 2) Glacial and glaciofluvial features and the distribution of glacial deposits on Sheet 96W Portsoy.



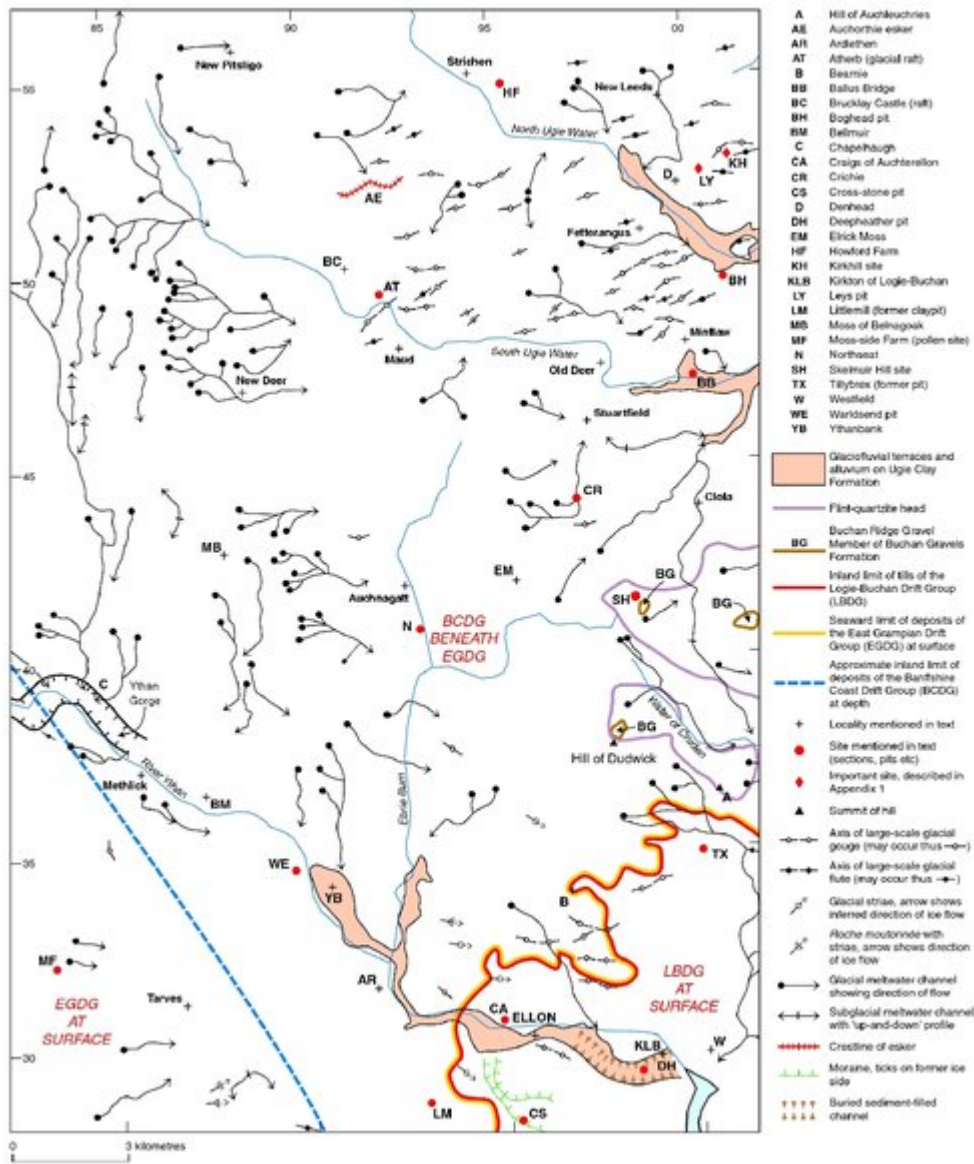
(Map 3) Glacial and glaciofluvial features and the distribution of glacial deposits on Sheet 96E Banff.



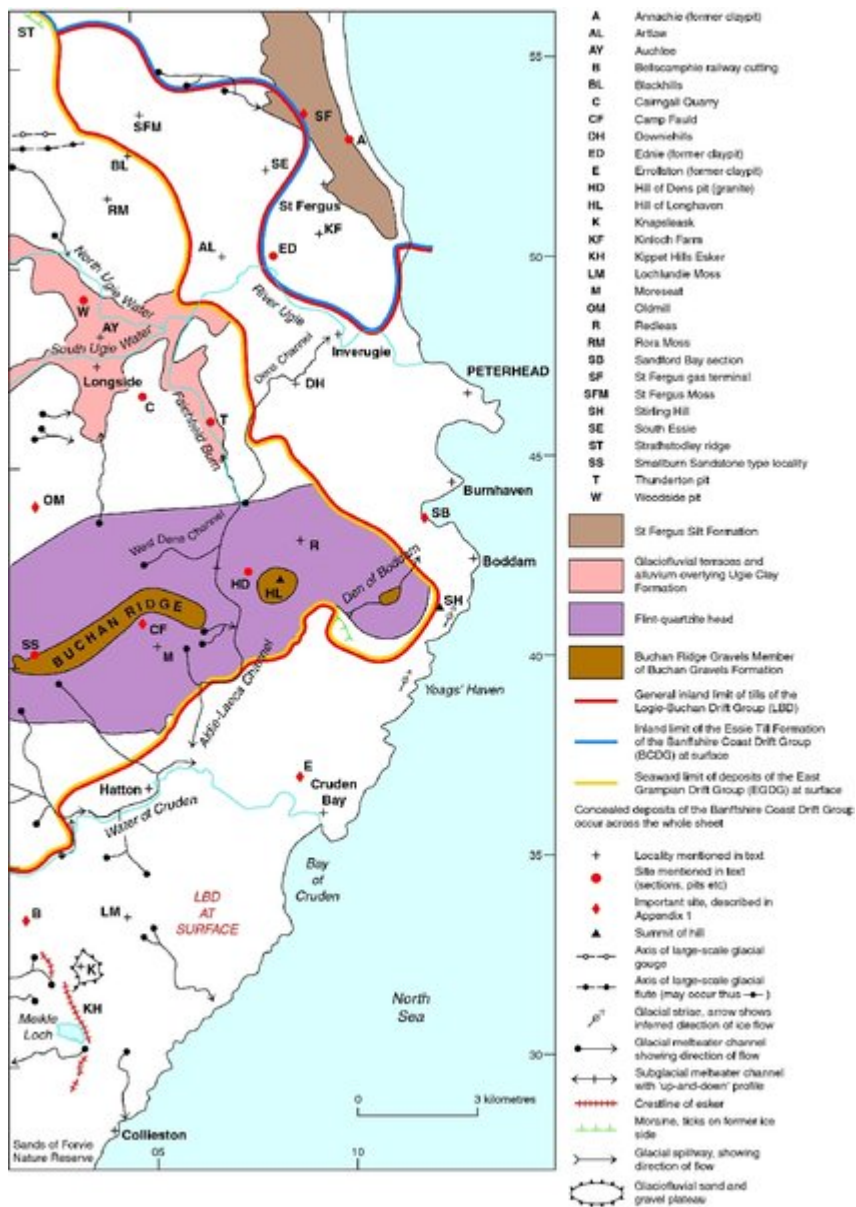
(Map 4) Glacial and glaciofluvial features and the distribution of glacial deposits on Sheet 97 Fraserburgh.



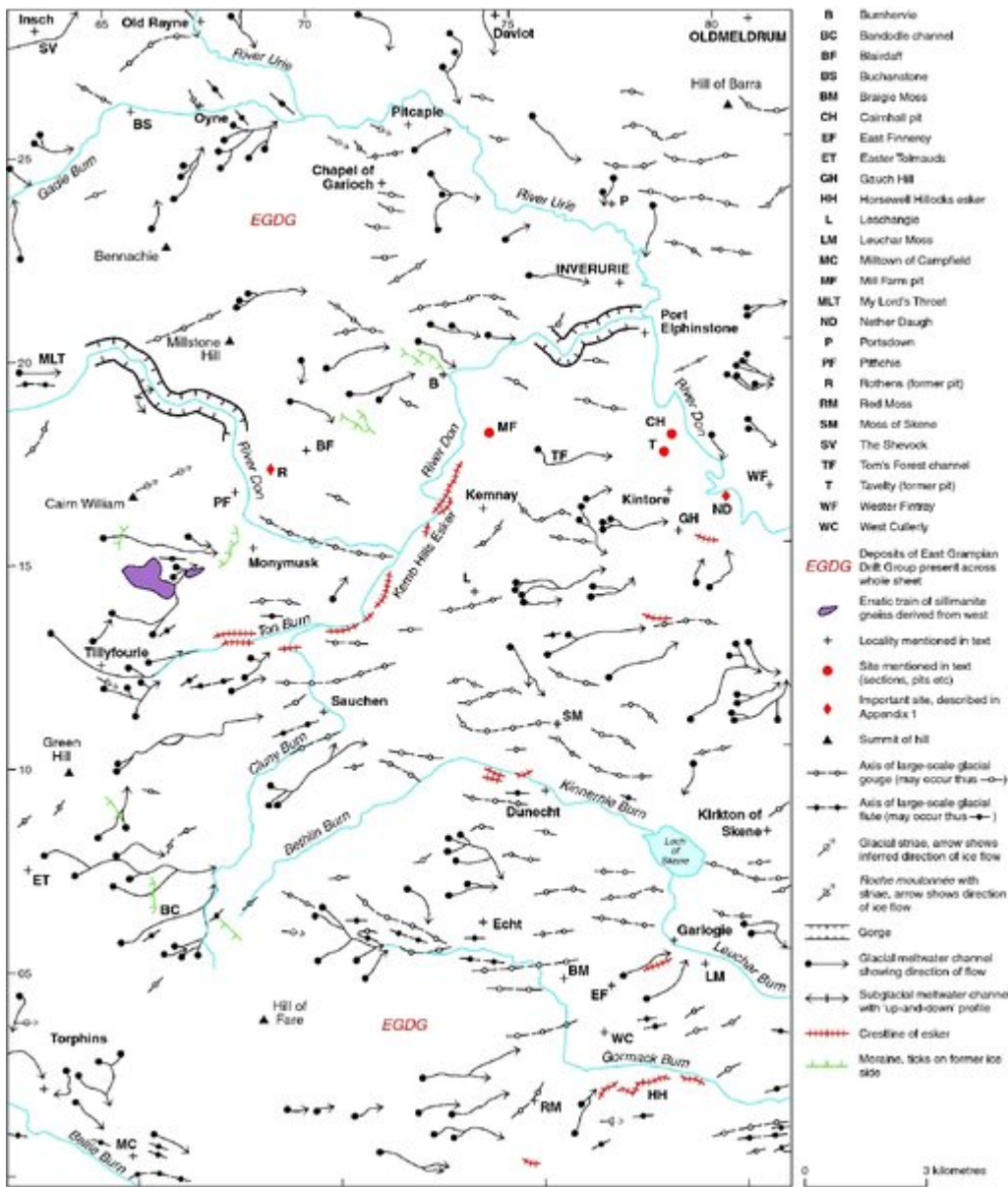
(Map 5) Glacial and glaciofluvial features and the distribution of glacial deposits on Sheet 86E Turriff.



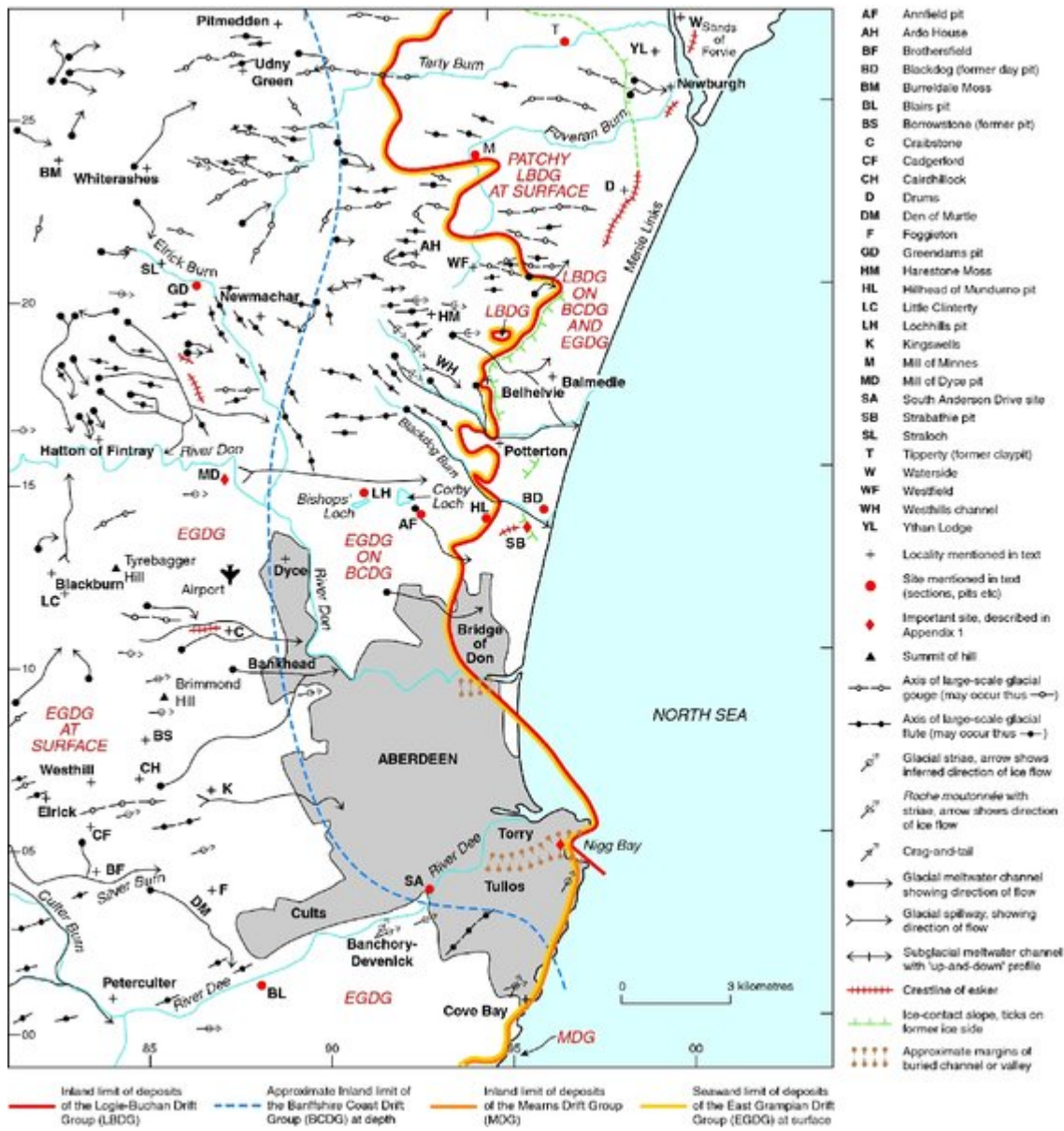
(Map 6) Glacial and glaciofluvial features and the distribution of glacial deposits on Sheet 87W Ellon.



(Map 7) Glacial and glaciofluvial features and the distribution of glaciogenic deposits on Sheet 87E Peterhead.



(Map 8) Glacial and glaciofluvial features and the distribution of glaciogenic deposits on Sheet 76E Inverurie.



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



(Map 11) Glacial and glaciofluvial features and the distribution of glacial deposits on Sheet 67 Stonehaven.



(Plate 4a) Buchan Gravels Formation at Windyhills. a Quartz-quartzite gravel of the Windy Hills Gravel Member at its type locality (P104101)



(Plate 5a) Flint clasts recovered from the base of the Buchan Ridge Gravel Member in a trial pit on the Moss of Cruden [NK 0253 4024]. Little-worn flints such as these were either derived directly from a former cover of Chalk in the area or from a remanié flint deposit. This evidence suggests that the present terrain lies close to the level of the sub-Cenomanian surface. (a P104122, b P104121).



(Plate 5b) Flint clasts recovered from the base of the Buchan Ridge Gravel Member in a trial pit on the Moss of Cruden [NK 0253 4024]. Little-worn flints such as these were either derived directly from a former cover of Chalk in the area or from a remanié flint deposit. This evidence suggests that the present terrain lies close to the level of the sub-Cenomanian surface. (a P104122, b P104121).



(Plate 8c) Till of the Banffshire Coast Drift Group at Oldmill [NK 0245 4407], showing downward transition from weathered to unweathered diamicton. (P104106).



(Plate 15) The Kippet Hills Esker looking northwards from Broom Hill [NK 0332 3058], near Collieston. Meikle Loch occupies a large kettle hole beside the esker, which is capped by red clayey diamicton typical of the Logie-Buchan Drift Group. The esker merges northwards into an outwash fan at Knapsleask (D2791).



(Plate 17b) Glacial rafts. b Attenuated, fractured and sheared lenses of sand within the Whitehills Glacigenic Formation at the Boyne Limestone Quarry (P104124).



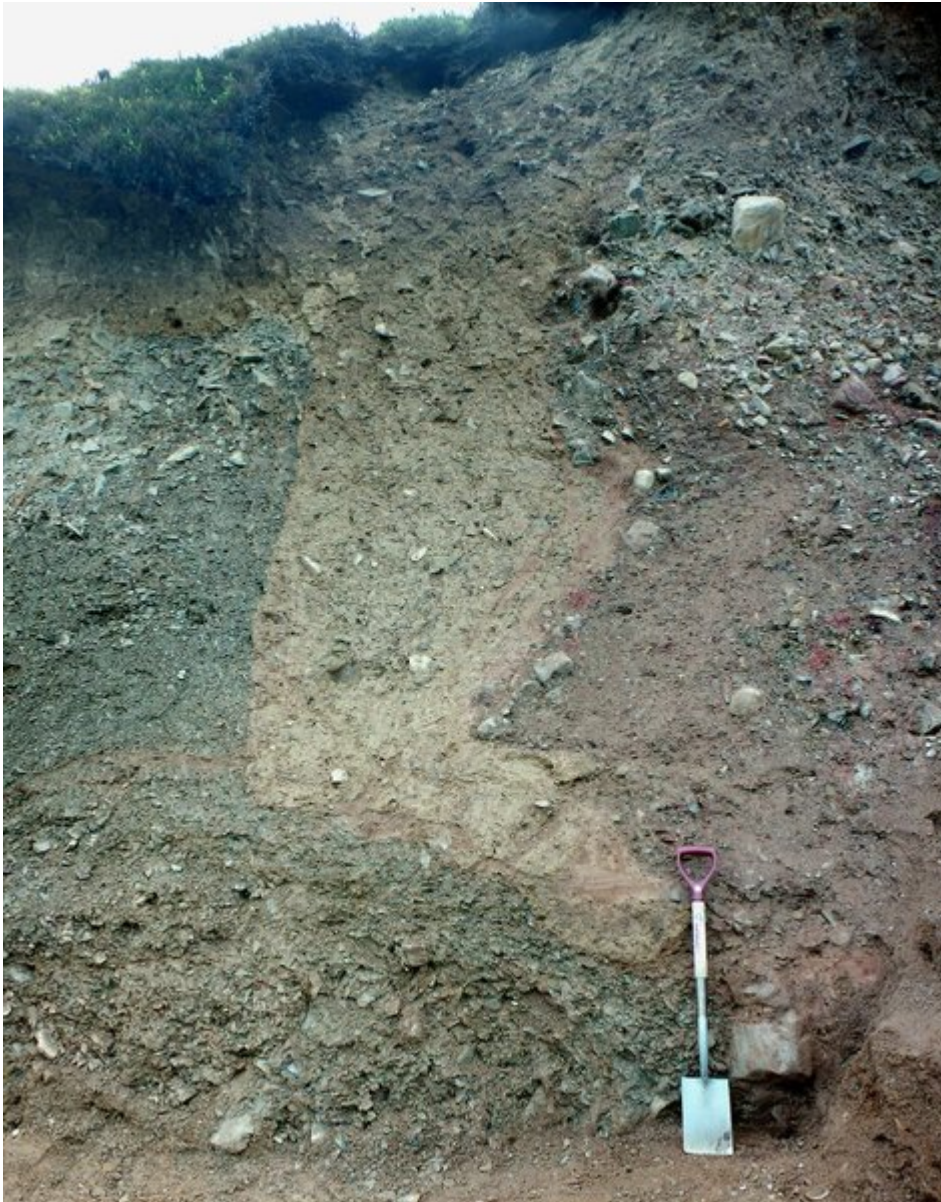
(Plate 22) Southern face of Kirkhill Quarry [NK 011 528] in 1979 (P528224). The sands and gravels resting on bedrock belong to the Pitscow Sand and Gravel Formation. The conspicuous pale band at their surface is the podzolic Kirkhill Palaeosol Bed. Periglacial sediments of the Swineden Sand Bed and the Camphill Gelifluctate Bed succeed this. The base of the Rottenhill Till Formation is at shoulder level with the figure. It is weathered towards the top (Fernieslack Palaeosol Bed) and is overlain by the pale coloured Corsend Gelifluctate Bed. The overlying Hythie Till Formation has a sharp erosional base. Note, the deformation structure affecting sediments beneath the till (above and to the left of the figure). Approximately 8 m of sediments are exposed.



(Plate 23) Partially glacitectonised, podzolic Teindland Palaeosol Bed below sandy diamicton of the Woodside Diamicton Formation at Teindland quarry [NJ 297 570]. Luminescence dates of 79 ± 6 ka and 67 ± 5 ka have recently been obtained from the sands overlying the palaeosol bed to the left of the scale card. (P104118). Scale bar showing 1 cm intervals.



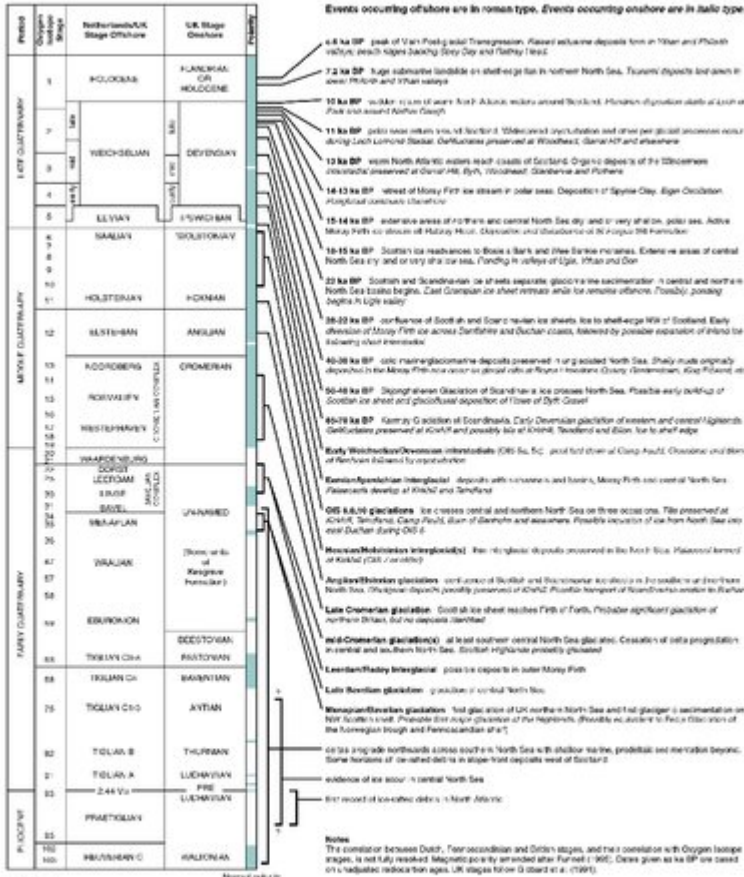
(Plate 24) Attenuated rafts of sand and brecciated dark grey pebbly clay within the Whitehills Glacigenic Formation at Oldmill pit [NK 0243 4389]. Greyish brown diamicton of the Banffshire Coast Drift Group caps the section above a metre-thick unit of grey, sheared sandy diamicton (a penetrative glacitectorite). The ice that overrode the sequence flowed towards the left (east-south-east) (P104119).



(Plate 26) Glacitectonised sequence at Balnakettle, north-east of Fettercairn. Till and gravel of the Mearns Drift Group are tectonically intercalated with older (pre- Late Devensian) head gravel composed of angular clasts derived from local Dalradian pelitic and semipelitic bedrock. The top of the tectonised sequence is truncated by a till of the East Grampians Drift Group, formed during a local re-advance (P100707).



(Plate 27) Sheared lens of the Burn of Benholm Peat Bed within olive grey shelly clay and diamicton (Benholm Clay Formation) in trial pit BBP4, at the Burn of Benholm site north of Johnshaven (Appendix A, 26). The shelly deposits are overlain by red-brown diamicton of the Mill of Forest Till Formation (D4879).



(Table 1) Summary of events preserved in the marine and onshore records in and around north-east Scotland (after Holmes, 1977).

Oxygen Isotope Stage	Teindland/Eigin	Boyne Limestone Quarry/Keith	Gardensloven/Bayfil	Byth/Crossbrae	Kirkhill/Leys	Peterhead/Cruden	Ellon/Fyvie	Aberdeen	Banchory	Stonehaven
Flandrian Holocene 1										
Lock Lomond Stadial 2a		Garra Hill Gelfluctate Bed		Tadwaite Gravel Bed		Woodhead Gelfluctate Bed				
Windermere Interstadial 2b		Garra Hill Peat Bed		Thorncliffe Peat Bed		Woodhead	Mill of Dyce Peat Bed	Loch of Park dyke bed	Glenbervie Peat Bed	
Urnfield Stadial 2c	Uggle Clay Formation	Kirk Burn Silt Formation	Kirk Burn Silt Formation			St Fergus Silt Formation				
	Blackhouse Till Formation	Arnhuch Till Member	Arnhuch Till Member	Coarsebrae Gelfluctate Bed	Mosses Gelfluctate Bed	Uggle Clay Formation	Uggle Clay Formation	Quandina Sand & Gravel Formation	Lashburn Sand & Gravel Formation	Draxholm Sand & Gravel Formation
		Blackhilts Sand & Gravel Formation	Blackhilts Sand & Gravel Formation	Auchmodden Gravel Formation	Kirkhill Church Sand Formation	Eske Till Formation	Kapel Hills Sand & Gravel	Old Dye Silts Formation	Old Dye Silts Formation	Uy Silts Formation
	Tadwaite Till Formation	Old Hybla Till Formation	Coarse Till Formation	Byth Till Formation	East Lays Till Formation	Natton Till Formation	Natton Formation	Mill of Forest Till Formation	Banchory Till Formation	Mill of Forest Till Formation
					Hybla Till Formation	Sandford Bay Till Member	Bearnie Till Member	Wigg/Kingswells Till member		
							Auchnuchrois Sand & Gravel Formation	Arce Sand & Gravel Member		
							Don Burn Till Member			
Early Late Devensian glaciation										
	Alverdale Till Formation	Whitliff's Gelfluctate Formation	Whitliff's Gelfluctate Formation		Corrie Diamicton Formation	Reife or Oldmill	Pitburg Till Formation	Anderson Drive Diamicton Formation		
				Howe of Byth Gravel Formation	Corried Gelfluctate Bed					
			Pollock Burn Gravel Bed			Alde Till Formation	Manchlocks Gelfluctate Bed			
5a-c	Badenoch Sand Bed			Coarsebrae Fine Peat Bed		Sampla Peat Bed				Burn of Berwick Peat Bed
6a-c										
	Teindland Palaeosol Bed	Truncated palaeosol			Fernieback Palaeosol Bed					
	Orribloun Sand Bed					Blackrock Farm Sand Bed				
6f	Diemen/Bood Gravel Formation			Coarsebrae Till Formation	Roberton Till Formation	Camp Fiddell Till Formation		Pitburg Till in part		Berwick Clay Formation
	Red Burn Till Formation	Crags of Boyne Till Formation			Shel Lays Sand & Gravel Formation			Dybbre Sand & Gravel Formation	Ballanquhain Till Formation	Green Gravel Formation
					Clunhill Gelfluctate Bed					
					Wendoch Sand Bed					
7f					Kirkhill Palaeosol Bed					
8f					Phobers Sand & Gravel Formation					
					Kirkhill Gelfluctate Bed					
					Corried Gravel Formation					
					Lays Till Formation					

References Hall et al. (1995) Sheet 809 Godwin and Willis (1955) Peacock and Merrit (2003) Sheet 362 Peacock and Merrit (1997) Hall et al. (1995) Wilkinson et al. (1998) Connell and Hall (1987) Sheet 872 Connell and Hall (1987) Whittaker et al. (1982) Sheet 879 Connell and Hall (1987) Hall and JARA (1983) Berman (1931, 1940) Milne (1977) MUIR (1988) Mulhock (1977) Sheet 982 Vassal (1977) Sheet 67 Auton et al. (2000)

NOTE: In general, minimal ages are shown. For example, Coarsebrae Gelfluctate Bed may be OIS 2c to 4, Anderson Drive Diamicton may be OIS 6, Kirkhill Palaeosol Bed may be OIS 8 or 11. All Peat and Palaeosol beds are assigned to the group of the underlying or enclosing deposit. Indicated units are informal; they have not been entered into the BGS Lexicon.

Central Grampian Drift Group East Grampian Drift Group Banffshire Coast Drift Group Logie-Buchan Drift Group Means Drift Group Dated unit

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

Site	Grid reference	Laboratory number	Age (years BP)	Dated material and setting	Reference
Roths cutting	NJ 277 498	Beta-85532	11 110 ± 70	peat under remobilised till	Appendix 1
Carral Hill, Keith	NJ 444 551	Q-104	10 808 ± 230	peat under remobilised till	Godwin and Willis (1959)
Carral Hill, Keith	NJ 444 551	Q-103	11 098 ± 235	peat under remobilised till	Godwin and Willis (1959)
Carral Hill, Keith	NJ 444 551	Q-102	11 308 ± 245	peat under remobilised till	Godwin and Willis (1959)
Carral Hill, Keith	NJ 444 551	Q-101	11 888 ± 225	peat under remobilised till	Godwin and Willis (1959)
Carral Hill, Keith	NJ 444 551	Q-100	11 358 ± 300	peat under remobilised till	Godwin and Willis (1959)
Woodhead, Fyvie	NJ 788 384	SRR-1723	10 780 ± 50	peat under remobilised till	Connell and Hall (1987)
Howe of Byth	NJ 822 571	SRR-4830	11 320	peat beneath gravel	Hall et al. (1995)
Moss side, Tarves	NJ 833 318	I 6969	12 200 ± 170	peat under remobilised till	Clapperton and Sugden (1977)
Loch of Park	NO 772 988	IHEL-416	10 280 ± 220	kettlehole infill	Vasari and Vasari (1968)
Loch of Park		HEL-417	11 900 ± 260	kettlehole infill	Vasari and Vasari (1968)
Mill of Dyce	NJ 8713 1496	SRR-762	11 550 ± 80	kettlehole infill	Harkness and Wilson (1979)
Mill of Dyce	NJ 8713 1496	SRR-763	11 640 ± 70	kettlehole infill	Harkness and Wilson (1979)
Glenbervie	NO 767 801	CX-14723	12 460 ± 130	peat under remobilised till	Appendix 1
Glenbervie	NO 767 801	SRR-3687a (humic)	12 305 ± 50	peat under remobilised till	Appendix 1
Glenbervie	NO 767 801	SRR-3687b (humic)	12 340 ± 50	peat under remobilised till	Appendix 1
Britzieshill Farm	NO 7936 7918	SRR-587	12 390 ± 100	peat under remobilised till	Auton et al. (2000)
Rothens	NJ 638 171	SRR-3803	10 680 ± 100	kettlehole infill	Appendix 1
Rothens	NJ 638 171	SRR-3804	11 640 ± 160	kettlehole infill	Appendix 1
Rothens	NJ 638 171	SRR-3805	11 760 ± 140	kettlehole infill	Appendix 1

(Table 8) Radiocarbon dates from Late-glacial sites in the district.

Ashcroft, WA	WAA
Auton, CA	CAA
Barrow, G	GB
Berridge, NG	NGB
Campbell, R	RC
Carroll, S	SC
Crofts, RG	RGC
Duncan, IG	IGD
Edwards, LT	LTE
Fettes, DJ	DJF
Fletcher, TP	TPF
Golledge, N	NG
Gould, D	DG
Grant-Wilson, JS	JSCW
Harris, AL	ALH
Highton, AJ	AJH
Hinxman, LW	LWH
Horne, J	JH
Irvine, DR	DRI
Kneller, BC	BCK
Leslie, AG	AGL
Linn, J	JL
May, F	FM
McCourt, WJ	WJM
McLean, F	FM
Mendum, JR	JRM
Merritt, JW	JWM
Munro, M	MM
Murdoch, WM	WM
Peacock, JD	JDP
Read, HH	HHR
Redwood, SD	SDR
Ross, DL	DLR
Skae, HM	HMS
Smith, CG	CGS
Stephenson, D	DS
Thomas, CW	CWT

(Table 9) Geological surveyors.

Sheet No	Name	Scale of Survey	Surveyor	Date
67	Stonehaven	1:10 560	DRI	1876-82
		1:10 560	GB	1893-95
		1:10 560	RC	1913-26
		1:10 000	CAA, SC, RGC, DG, JWM, CWT	1984-95
66E	Banchory	1:63 360	HMS	1878-82
		1:10 560	DRI	1878-82
		1:10 560	GB	1893-95
		1:10 000	CAA, SC, RGC, DG, AJH	1984-94
96E	Banff	1:10 560	JH, JSGW	1879-81
		1:10 560	HHR	1918
		1:10 000	JDP	1987
		1:10 000	TPF	1993-96
86E	Turriff	1:10 560	JH, JSGW, LWH	1880-84
		1:10 560	HHR	1917-19
		1:10 000	WAA, AGL, MM	1978-81
		1:10 000	DC, CWT	1988-92
96W	Portsoy	1:10 560	JH	1880-82
		1:10 560	HHR	1916-18
		1:10 000, 1:10 560	TPF, DG, JRM, SDR, DS	1987-89, 1996-97
95	Elgin	1:10 560	JL, JSGW	1877-80
		1:10 560/1:10 000	NGB, ALH, FM, JDP	1961-63
86	Huntly	1:63 360/1:10 560	JH, JSGW, LWH	1880-84
		1:10 560	HHR	1917-19
97	Fraserburgh	1:63 360/1:10 560	JSGW	1879-80
		1:10 560/1:10 000	DJF, JRM, JDP, CGS, CWT	1981
87W	Ellon	1:10 560	JSGW, DRI	1880-81
		1:10 560	HHR	1930
		1:10 000/1:10 560	WAA, IGD, LTE, BDK, AFL,MM	1980s
		1:10 000	DLR	1977-78
		1:10 000	JWM	1995
77	Aberdeen	1:10 560	DRI, JSGW	1880-82
		1:10 000	FM, WMM	1972-77
		1:10 000	CAA, RGC, NG, JWM, DLR, CGS	1984-2000
87E	Peterhead	1:10 560	JSGW	1880-81
		1:10 560/1:10 000	DJF, JRM, JDP, CGS	1981
		1:10 000	DLR, WJM	1976-78
		1:10 000	JWM	1986
76E	Inverurie	1:63 360/1:10 560	DRI, HMS, GB	1879-95
		1:10 000	CAA, DG, AJH, JWM, DLR, CGS	1985-96

(Table 10) Survey history of geological maps.

Geological sheet	Number of boreholes
95 Elgin	796
96W Portsoy	28
96E Banff	63
97 Fraserburgh	138
86E Turriff	11
87W Ellon	298
87E Peterhead	641
76E Inverurie	474
77 Aberdeen	1805
66E Banchory	554
67 Stonehaven	686

(Table 11) Number of boreholes on each geological sheet.

Site number	Site name	Site characteristics and significance
1	Teindland	Long sequence; 4 tills; Ipswichian palaeosol; luminescence dated sand
2	Boyne Limestone Quarry	Mesozoic rafts; glaciectonites; 3 tills one shelly;
3	Castle Hill, Gardenstown	Whitehills Glacigenic Formation with OIS 2/3 shells Mesozoic rafts; glaciectonites; 3 tills one shelly; Whitehills Glacigenic Formation with OIS 2/3 shells; capped by glaciolacustrine Kirkburn Silt Formation
4	King Edward	Rafted OIS 3/4 shelly deposits
5	Crossbrae Farm, Turriff	Early Devensian peat bed; gelifluctates
6	Howe of Byth Quarry	Windermere Interstadial peat; OIS 2 till; OIS 3 gravel (luminescence dated)
7	Kirkhill and Leys quarries	Longest sequence in region; 2 palaeosols; 5 gelifluctate beds; three 100 ka cycles represented (3 tills)
8	Oldmill pit	Mesozoic rafts; glaciectonites; 2 tills, old gravel
9	Philorth valley	Estuarine deposits and peat; Holocene sea level change
10	Ugie valley	Glacial Lake Ugie and possible mid OIS 2 readvance; tundra polygons
11	St Fergus	Raised OIS 2 glaciomarine silts and late readvance; tundra polygons
12	Sandford Bay	Logie-Buchan Drift Group deformation tills and clays on 'local' till with sparse Norwegian erratics
13	Windy Hills	Neogene quartzite gravels; tills and gelifluctates; GPR traverse
14	Moss of Cruden	Devonian Smallburn Sandstone Formation outlier Lower Cretaceous Moreseat Sandstone Formation outlier Neogene Buchan Ridge flint/quartzite gravels Camp Fault; Early Devensian peat bed, 2 tills
15	Ellon (Bellscamphie)	'indigo' shelly till; long sequence with 4 tills
16	Kippet Hills (Slains)	Esker; Logie-Buchan Drift Group; early Pleistocene shells
17	Errollston Clay Pit	Logie-Buchan Drift Group deformation tills and clays
18	Mill of Dyce pit	Deglaciation of lower Don valley; deltaic sequence
19	Strabathie, Bridge of Don	Deltaic sequence formed during parting of ice streams
20	Nether Daugh, Kintore	Meander infill; late Holocene environmental change
21	Rothen, Monymusk	Kettle hole infill; Late-glacial sequence
22	Nigg Bay, Aberdeen	Long sequence including elements of four drift groups
23	Loch of Park, Banchory	Late-glacial to Holocene pollen sequence
24	Balnakettle, Fettercairn	Tectonised sequence; late readvance of East Grampian ice
25	Knockhill, Glenbervie	Windermere Interstadial peat bed under landslipped till
26	Burn of Benholm	Red till on Early Devensian peat on shelly diamicton

(Table A1.1) Sites described in Appendix 1.

Unit	Name proposed in this publication	Original name in Hall et al. (1995a)	Depositional environment	OIS
9	Waterworks Till Formation*	Waterworks Till	Glacial	2
8	Tofthead Till Formation*	Tofthead Till	Glacial	2
7	Altonside Till Formation†	Altonside Till	Glacial	?2
6	Woodside Diamicton Formation*	Teindland Till	Glacial	4
5	Badentinian Sand Bed*	Teindland Upper Sand	Lacustrine ?	4/5a
4	Teindland Palaeosol Bed*	Teindland Buried Soil	Soil formed late in interglacial period	5e
3	Orbliston Sand Bed*	Teindland Lower Sand	Glaciofluvial	6
2	Deanshillock Gravel Formation*	Teindland Gravel	Glaciofluvial	6
1	Red Burn Till Formation†	Red Burn Till	Glacial	6

* CENTRAL GRAMPIAN DRIFT GROUP

† BANFFSHIRE COAST DRIFT GROUP

(Table A1.2) Lithostratigraphy of the Teindland area.

Unit	Lithostratigraphical unit	Lithology	Thickness m
5	Kirk Burn Silt Formation*	Glaciolacustrine silts and clay	>19
4	Crovie Till Formation†	Reddish brown till	0–0.8
3	Whitehills Glacigenic Formation*	Silt, sand and grey clayey diamiction	<18.0
2	Pishlinn Burn Gravel Bed†	Gravel, cobbly towards base	<1.5
1	Old Red Sandstone	Red sandstone	> 10

* Banffshire Coast Drift Group

† East Grampian Drift Group

(Table A1.3) The lithostratigraphy at Castle Hill, Gardenstown.

Modern Name*	Jamieson (1865)	Gardenstown/Gamrie	King Edward
<i>Antalis entalis</i>	<i>Dentalium entalis</i>	x	x
<i>Amauroopsis islandica</i>	<i>Natica islandica</i>	x	x
<i>Aporrhais pes-pellicani</i>	<i>Aporrhais pes-pellicani</i>		x
<i>Boreotrophon clathratus</i>	<i>Trophon clathratus</i>	x	x
<i>B. clathratus</i> var. <i>gunneri</i>	<i>T. clathratus</i> var. <i>gunneri</i>	x	x
<i>B. truncatus</i>	<i>Trophon truncatus</i>	x	x
<i>Buccinum undatum</i>	<i>Buccinum undatum</i>	x	
<i>Colus gracilis</i> }	<i>Fusus propinquus</i>	x	x
<i>C. howsei</i> }			
<i>Epitonium groenlandicum</i>	<i>Scalaria groenlandica</i>		x
<i>Lacuna vineta</i>	<i>Lacuna divaricata</i>	x	x
<i>Oenopota pyramidalis</i>	<i>Mangelia pyramidalis</i>	x	x
<i>O. turricula</i>	<i>Mangelia turricula</i>	x	x
<i>Polinices nanus</i>	<i>Natica marochiensis</i>		x
<i>P. pallida</i>	<i>Natica pallida</i>	x	x
<i>Tectonatica clausa</i>	<i>Natica affinis</i>	x	x
<i>Tachyrhynchus reticulata</i>	<i>Mesalia reticulata</i>		x
<i>Turritella communis</i>	<i>Turritella unguina</i>		x
<i>Tectura virginea</i>	<i>Tectura virginea</i>	x	
<i>Acanthocardia echinata</i>	<i>Cardium echinata</i>	x	x
<i>Anomia ephippium</i>	<i>Anomia ephippium</i>	x	
<i>Arctica islandica</i>	<i>Cyprina islandica</i>	x	x
<i>Macoma balthica</i>	<i>Tellina balthica</i>	x	x
<i>M. calcarea</i>	<i>T. proxima</i>	x	x
<i>Mya truncata</i>	<i>Mya truncata</i>		x
<i>Mytilus edulis</i>	<i>Mytilus edulis</i>	x	
<i>Serripes groenlandicus</i>	<i>Cardium groenlandicum</i>	x	x
<i>Spisula elliptica</i>	<i>Mactra solida</i> var. <i>elliptica</i>	x	
<i>Tridonta borealis</i>	<i>Astarte borealis</i>	x	x
<i>T. montagui</i>	<i>Astarte compressa</i>	x	
<i>Yoldia limatula</i>	<i>Leda limatula</i>		x
<i>Yoldiella lucida</i>	<i>Leda lucida</i>		x
<i>Zirphaea crispata</i>	<i>Pholas crispata</i>	x	x

* For authors of species see Lubinsky (1980); Macpherson (1971) and Smith and Heppell (1991)

† The bivalve *Timoclea ovata* has been reported from Gardenstown/Gamrie (Peacock in Sutherland 1993b).

(Table A1.4) Mollusca from shelly deposits of the Whitehills Glacigenic Formation.

New name	Old name	Age
Peat (unnamed)	Peat (un-named)	OIS 1
Todholes Gravel Bed*	Todholes Gravels	Loch Lomond Stadial
Thinfolds Peat Bed*	Byth Peat	Windermere Interstadial
Auchmedden Gravel Formation*	Auchmedden Gravels	OIS 2
Byth Till Formation†	Byth Till	OIS 2
Howe of Byth Gravel Formation*	Byth Gravels	OIS 3 ?

* Banffshire Coast Drift Group

† East Grampian Drift Group

(Table A1.5) Lithostratigraphy at the Howe of Byth.

Unit	Deposit as originally named	New names	OIS
16	Kirkhill Gelifluctate 5	Manse Gelifluctate Bed*	2
15	Kirkhill Upper Sands	Kirkhill Church Sand Formation*	2
14	East Leys Till	East Leys Till Formation*	2
13	Kirkhill Upper Till	Hythie Till Formation†	2
12	Corse Diamicton	Corse Diamicton Formation*	2?
11	Kirkhill Gelifluctate 4	Corsend Gelifluctate Bed†	4?
10	Kirkhill Upper Buried Soil	Fernieslack Palaeosol Bed†	5e
9	Kirkhill Lower Till	Rottenhill Till Formation†	6?
8	Leys Upper Sands and Gravels	West Leys Sand and Gravel Formation†	6?
7	Kirkhill Gelifluctate 2/3	Camphill Gelifluctate Bed†	6
6	Kirkhill Organic Muds and Sands	Swineden Sand Bed†	6?
5	Kirkhill Lower Buried Soil	Kirkhill Palaeosol Bed†	7?
4	Kirkhill Lower Sands and Gravels	Pitscow Sand and Gravel Formation†	8?
3	Kirkhill Gelifluctate 1	Kirkton Gelifluctate Bed†	8?
2	Leys Lower Gravels	Denend Gravel Formation†	8?
1	Leys Till	Leys Till Formation†	8?

* Banffshire Coast Drift Group

† East Grampian Drift Group

(Table A1.6) Lithostratigraphical units at Kirkhill and Leys Quarries.

Location	Details of sample	Altitude (metres OD) of sample at contact with minerogenic layer	Age (¹⁴ C years BP)	Laboratory number
Philorth Home Farm	Bottom 2 cm of peat above micaceous sandy silt	1.48	5700 ± 90	SRR-1660
Philorth Home Farm	Top 2 cm of peat below micaceous sandy silt	0.82	6300 ± 60	SRR-1661
Milltown	Bottom 2 cm of peat above micaceous sandy silt	1.81	5140 ± 60	SRR-1686
Milltown	Top 2 cm of peat below micaceous sandy silt	1.11	6095 ± 75	SRR-1687
Mains of Philorth	Top 1 cm of peat below brown silty clay	2.59	4760 ± 60	SRR-1655
Mains of Philorth	Bottom 2 cm of peat above grey sand	1.51	6150 ± 250	SRR-1656
Mains of Philorth	Top 2 cm of peat below grey sand	1.47	6885 ± 90	SRR-1657
Mains of Philorth	Bottom 2 cm of peat above grey sand	1.40	7510 ± 120	SRR-1658
Mains of Philorth	Top 2 cm of peat below grey sand	1.34	8465 ± 95	SRR-1659

(Table A1.7) Radiocarbon dates from sites in the Philorth valley (after Smit.

Unit	Deposit as originally named	New names	Age
6	Aldie Till	Aldie Till Formation [†]	OIS 4 ?
5	Periglacial slope deposit	Hardslacks Gelifluctate Bed [†]	OIS 4 ?
4	Sand and gravel	Un-named sand and gravel [†]	
3	Camp Fault Peat B Camp Fault Peat A	Berryley Peat Bed [†]	OIS 5a or c
2	Brown sand with sparse quartzite clasts	Moreseat Farm Sand Bed [†]	OIS 6 ?
1	Camp Fault Till	Camp Fault Till Formation*	OIS 6 ?

* Banffshire Coast Group

† East Grampian Drift Group

(Table A1.8) Lithostratigraphy at Camp Fault.

Lithostratigraphical unit	Lithology	Thickness m	Age
F Hatton Till Formation*	Red (10R 4/6) calcareous clayey silty diamicton, locally interbedded with Unit E	1–2.3	OIS 2
E Kippet Hills Sand and Gravel Formation*	Pinkish grey sand and gravel with dolomite and calcareous mudstone clasts, and shell fragments	up to 5.0	OIS 2
D Bearnie Till Member of Hythie Till Formation†	Dark grey sandy diamicton with clasts of local provenance and material reworked from Unit C	up to 2.7	OIS 2 ?
C Pitlurg Till Formation‡	Very dark grey to dark grey (7.5YR N3) slightly calcareous clayey silty diamicton with Jurassic clasts and fossils	up to 7.0	OIS 2 ? in part OIS 6 ?
B Tillybrex Gravel Formation†	Weathered gravel with clasts of psammite and flint	up to 11	>OIS 6 ?
A Bellscamphie Till Formation†	Strong brown (7.5YR 5/4) non-calcareous, sandy silt matrix diamicton	up to 2.1	>OIS 6 ?

* Logie-Buchan Drift Group

† East Grampian Drift Group

‡ Banffshire Coast Drift Group

(Table A1.9) Lithostratigraphy in the vicinity of Ellon, Leask and Slains.

Lithofacies Association (LFA)	Main sediment types	Stratification	Palaeocurrent directions	Other structures
5	Medium- to coarse-grained sand with scattered pebbles	Small-scale planar cross-bedding	~	~
4	Mixture of diamicton, boulders, gravel, sand and silt	Crude bedding in diamicton and boulder gravel, ripples and cross-bedding in sand, pebble and cobble stringers	~	Chaotic upright open folds, slumps and normal faults
3	Poorly sorted matrix-rich boulder gravel, pods of open-work gravel, minor sand lenses	Crude, discontinuous bedding with cobble and pebble lags, minor planar, ripple and trough cross-bedding in sandy units	Towards 066° (imbrication in open-work gravel)	Vestigial folds
2	Poorly sorted matrix-rich gravel; subordinate interbeds and lenses of sand, open-work gravel	Crude, some horizontal bedding, erosional bases in matrix-rich gravel; imbrication in open-work gravel	Towards 119° (gravel imbrication)	Possible frost-wedges; steep, tight to open folds in gravel (dips up to 80°)
1	Fine- to medium-grained sand; minor silt	Planar cross-bedding, climbing ripples, horizontal bedding, large-scale trough cross-bedding; horizontal lamination in silt	Towards 090° and 100° (climbing ripples); towards 152° (planar cross-bedding); towards 040° (trough cross-bedding)	~

(Table A1.10) Lithofacies associations at Mill of Dyce Pit.

Facies	Description
1 Esker delta	Wide range of coarse-grained sediments with rapid vertical and lateral variations. Deposits include cross- and planar-laminated sand, pebbly sand, and clast-supported pebble, cobble and boulder gravel, all intercalated with lenses and wedges of diamicton
2 Proximal lacustrine	Laminated silt, cross-stratified and massive sand; fine-grained gravel occurring down-dip of Facies 1
3 Distal lacustrine	Laminated and massive clay, silt and sand, interstratified with thin, rhythmic alternations of clay and silt, or silt and sand (passing with transitional contact south westwards into Facies 2)
4 Diamicton	Massive, stony, red-brown diamicton with significant proportions of silt and clay, locally capping the proximal lacustrine facies

(Table A1.11) Sedimentary facies at Strathvie (after Thomas, 1984).

	Percentage total dry land pollen	
	Pit 1	Pit 2
<i>Betula</i>	15.4	13.2
<i>Pinus</i>	1.1	1.8
<i>Quercus</i>	0.6	0.9
<i>Alnus</i>	14.3	11.0
<i>Corylus/Myrica</i>	12.0	11.0
<i>Salix</i>	2.3	1.3
Gramineae	26.3	30.4
Cyperaceae	15.6	26.0
Ericales	9.4	6.4
Caryophyllaceae	0.6	1.3
<i>Epilobium</i>	1.1	
Umbelliferae	0.6	
<i>Polypodium</i>	0.6	0.4
<i>Sphagnum</i>	5.2	0.8
<i>Filicales</i>	3.1	3.4

(Table A1.12) Pollen count from the Nether Daugh Pits.

Species	Head	Thorax	Left elytron	Right elytron	No. ^a
CARABIDAE					
<i>Trochus quadricornis</i> (Sch.)		1	1		1
<i>Eumeloides fovealis</i> (Pz.)	1			1	1
<i>Pterostichus strenuus</i> (Pz.)		1		1	1
<i>Agonum fuliginosum</i> (Pr.)	11	15	9	10	15
<i>Draconus</i> sp.			1		1
DYTISCIDAE					
<i>Hydroporus</i> sp.	1				1
<i>Hydroporus foveolatus</i> (L.)	4	3	3	3	4
<i>Hydroporus</i> sp.		1			1
<i>Agabus/Hydrophilus</i> sp.	F	F	F	F	F
<i>Rhysanus/Acilius</i> sp.			F	F	F
<i>Colymbetes foveatus</i> (L.)			1	1	1
HYDROPHILIDAE					
<i>Hydrophilus</i> sp.	1	2	1	1	2
<i>Ceryon</i> sp.	1	1			1
<i>Hydrophilus foveatus</i> (L.)			1		1
<i>Laccobius minutus</i> (L.)	1	1	4	3	4
HYDRAENIDAE					
<i>Gastrophysus</i> sp.				1	1
<i>Hydraenus nigerrimus</i> (Kug.)	1	1	1	1	1
<i>Limonius</i> sp.		1			1
STAPHYLINIDAE					
<i>Lesteva</i> sp.	1				1
<i>Stenus coarctatus</i> (L.C.)			1	1	1
<i>Stenus</i> sp.	10	8	12	10	12
<i>Lathrobium thymumipes</i> (Fab.)	1	2	2	2	2
<i>Lathrobium</i> sp.	1		1	1	1
<i>Gabrus</i> sp.	1				1
<i>Quedius</i> spp.		2		1	2
<i>Tachysporus isolatus</i> (Erich.)				1	1
<i>Tachinus confusus</i> (Gron.)	1	2	1	4	4
<i>T. latro</i> (Gron.)	3	3	4	7	7
Aleocharinae gen. et sp. indet.	49	70	59	52	70
SCARABAEIDAE					
<i>Aphodius sphaerulatus</i> (Pz.)	1		1		1
SCIRTIDAE					
<i>Cyphus</i> spp.	12	12	24	26	24
ELMIDAE					
<i>Eolus parallelipipedus</i> (Muller)	1	2	2	2	2
ELATERIDAE					
<i>Selenosomus incanus</i> (Gyll.)		1		1	1
CANTHARIDAE					
<i>Cantharis</i> sp.	2			1	2
NITIDULIDAE					
<i>Nitidulus</i> sp.			1		1
CRYPTOPHAGIDAE					
<i>Atomaria fuscomela</i> (Herbst.)			1	2	2
LATHRIDIDAE					
<i>Fucinus thymovorus</i> (Oliv.)		1			1
CHRYSOMELIDAE					
<i>Derocera</i> sp.			1		1
<i>Phyllotreta sericea</i> (L.)	4	1	2	2	4
<i>Chrysolina foveolata</i> (Scop.)	1	1	1	1	1
<i>Phyllotreta</i> sp.			1		1
APIONIDAE					
<i>Apion</i> sp.	1	2	1		2
CURCULIONIDAE					
<i>Phyllotreta proserpina</i> (Gredler)		1	1	1	1
<i>Eoryphidius pyrenaeus</i> (Scudder)	7	4	2	1	7
<i>Necaris foveolatus</i> (L.)	1				1
<i>Leucoderes pubescens</i> (Stephens)	1	2	2	1	2

(Table A1.13) Coleoptera from Nether Daugh (Pit 2).

Nigg unit	Member	Formation	Drift Group
5	Tulloch 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.

Unit	Lithology	Description	Thickness (m)	Depth (m)
A	Landslipped till	Diamicton , stiff, clayey, slightly sandy; moderate reddish brown, 'flecked' with red. Clasts angular to subangular, gravel including decomposed andesite. Slightly irregular gradational base	0.25	0.25
B	Clayey silt	Clayey silt , with sand laminae and thin wisps of peat. Light olive-grey to pale reddish brown. Sharp planar base	0.05	0.30
C	Fibrous peat	Peat , fibrous, compact, with pronounced colour banding on freshly exposed face. Colour ranges from moderate yellowish brown, through dusky yellowish brown to black. Slightly irregular base	0.51	0.81
D	Clayey silt	Clayey silt , micaceous, with fine sand and some peat fragments. Dark yellowish brown to moderate greyish red. Uneven base	0.07	0.88
E	Fibrous peat	Peat , fibrous, dark yellowish brown to dusky yellowish brown	0.10	0.98
F	Silty peat	Peat , silty, laminated, moderate grey	0.06	1.04
G	Sand	Sand , silty and clayey, medium- to coarse-grained, greyish red. Some small peat lenses incorporated towards the base	0.16	1.20
H	Silty peat	Peat , silty and clayey, moderate olive-grey	0.05	1.25
I	Fibrous peat	Peat , fibrous, dark yellowish brown to dusky yellowish brown	0.02	1.27
J	Till	Diamicton , firm, sandy and silty, moderate reddish brown. Clasts rounded to well rounded, large cobbles and boulders derived from Old Red sandstone conglomerates	0.15+	1.42

(Table A1.15) Stratigraphy of the Knockhill Wood site.

Sample	Depth (cm)	Trees		Shrubs/dwarf shrubs			Grass	Sedges	Herbaceous taxa							Aquatics	Spores									
		<i>Betula</i> (birch)	<i>Pinus</i> (pine)	<i>Corylus</i> (hazel)	<i>Salix</i> (willow)	Ericaceae (heather)	<i>Empetrum</i> (crowberry)	Gramineae	Cyperaceae	Compositae: Liguliflorae (daisy)	Compositae: Tubuliflorae (daisy)	Caryophyllaceae (pink)	Cruciferae (brassica)	<i>Epilobium</i> (willowherb)	<i>Ranunculus</i> (buttercup)	<i>Rumex</i> (dock)	<i>Thalictrum</i> (meadow-rue)	<i>Artemisia</i> (mugwort)	<i>Myriophyllum</i> (water-milfoil)	<i>Potamogeton</i> (pondweeds)	Filicales	<i>Lycopodium</i>	<i>Lycopodium selago</i>	<i>Sphagnum</i>	Indeterminate	
6	25-30	1	1		1	2	28	54							10		1								165	2
5	45-50	1			1	1	14	75	1		1	1												4	1	12
4	57-67	1					14	65	1	1	3	4			3	1						5				3
3	81-84	1	1		4		26	34	4	19	1	2		2	2	2			1			10				4
2	97-104		2	1	4		32	34	1		1	11	1	1	3	4	2		3			11				3
1	101-107		2		7		28	34	1			12	1	1	8				1			7				6

Analysis by MJC Walker, University of Wales, Lampeter, 1989
Pollen sum = 100 land pollen

(Table A1.16) Outline pollen count from Knockhill Wood.

Lithostratigraphical unit	Lithology	Typical thickness (m)
Drumlithie Sand and Gravel Formation*	Rounded cobble gravel	up to 1.20
Mill of Forest Till Formation*	Stiff, moderate reddish brown, sandy clayey stony diamicton, containing clasts derived from the Devonian bedrock of Strathmore	up to 1.30
Burn of Benholm Peat Bed†	Peat and humic clay as sheared lenses in overlying till and underlying clay	up to 0.15
Benholm Clay Formation‡	Stiff, olive-grey, calcareous, silty clay and clayey diamicton; with well dispersed clasts and fragments of marine shells, including <i>Arctica islandica</i> (L.). Clasts include basalt, gneiss, troctolite, limestone (including chalk), shale, flint and jet, as well as Lower Old Red Sandstone lithologies	up to 3.00
Birnie Gravel Formation‡	Moderate brown, clayey gravel	up to 3.00
Bedrock	Andesite	

* Mearns Drift Group

† Logie-Buchan Drift Group

‡ East Grampian Drift Group

(Table A1.17) Lithostratigraphy in the vicinity of the Burn of Benholm.

Mineral Assessment Report name, number and date	Area (km ²)	1:25 000 resource sheets	Boreholes	Trial pits and natural sections	Resistivity soundings	Sampled workings
Garmouth (41) [1979]	54	1	57	31	0	3
Peterhead(58) [1981]	258	1	67	19	0	11
Ellon (76) [1981]	343	2	61	39	0	15
Aberdeen (146) [1986]	660	3	77	72	0	17
Inverurie, Dunecht, Banchory & Stonehaven (148) [1988]	398	2	54	81	43	38
Strachan, Auchinblae & Catterline (149) [1990]	274	2	38	55	22	35
Total	1987	11	354	297	65	119

(Table A2.1) Sand and gravel resource assessment surveys in north-east Scotland: primary data sources.

Test	Garmouth MAR 41	Peterhead MAR 58	Ellon MAR 76	Aberdeen MAR 146	Inverurie Stonehaven MAR 148	Strachan Auchenblae Catterline Mar 149	Combined mean
Aggregate Impact Value	71* (11-18)†	23 (16-38)	22 (14-31)	28 (22-34)	25 (17-32)	27 (19-31)	24 (11-38)
Aggregate Impact Value Residue	-	-	-	35 (29-43)	35 (26-52)	33 (26-41)	34 (26-52)
Aggregate Crushing Value	19 (13-20)	-	-	-	20 (16-24)	-	20 (13-24)
Aggregate Crushing Value Residue	-	-	-	-	39 (34-48)	-	39 (34-48)
Ten percent Fines Value	-	190 (95-270)	170 (120-280)	170 (120-230)	-	150 (95-240)	170 (95-280)
Relative Density (oven dried basis)	2.57 (2.53-2.60)	2.50 (2.45-2.54)	2.59 (2.51-2.63)	2.58 (2.52-2.62)	2.55 (2.51-2.62)	2.53 (2.44-2.63)	2.55 (2.44-2.63)
Relative Density (surface dried basis)	2.60 (2.57-2.62)	2.56 (2.51-2.59)	2.68 (2.58-2.66)	2.62 (2.56-2.67)	2.60 (2.56-2.68)	2.59 (2.53-2.73)	2.60 (2.51-2.73)
Apparent Relative Density	2.65 (2.64-2.66)	2.66 (2.60-2.76)	2.71 (2.64-2.75)	2.67 (2.62-2.70)	2.69 (2.62-2.82)	2.69 (2.59-2.99)	2.68 (2.59-2.99)
Water Absorption (%)	1.1 (0.7-1.6)	2.1 (1.7-2.4)	1.8 (0.9-2.9)	1.3 (0.8-1.6)	2.0 (1.1-2.9)	2.2 (0.9-4.8)	1.8 (0.7-4.8)
Inferred Drying Shrinkage‡ (concrete) (%)	0.054 (0.044-0.063)	0.071 (0.064-0.077)	0.066 (0.048-0.088)	0.056 (0.046-0.063)	0.070 (0.052-0.088)	0.075 (0.047-0.126)	0.065 (0.044-0.126)
Measured Drying Shrinkage (concrete) (%)	-	-	-	0.048 (0.039-0.054)	0.040 (0.040-0.065)	0.055 (0.040-0.073)	0.051 (0.039-0.073)

Note: * Averaged results; these are listed fully in each of the six Mineral Assessment Reports.
† Figures in parentheses refer to the range of results.
‡ It is emphasised that the 'inferred' drying shrinkage values quoted for concrete are obtained indirectly. They are probably anomalously high.

(Table A2.2) Summary results of mechanical and physical testing of naturally occurring gravels from north-east Scotland.

Cainozoic geology and landscape evolution of north-east Scotland



(Front cover) Cover photograph: Crovie Village (D6116). Sandstones and conglomerates of the Lower Devonian Crovie Group crop out on the foreshore and are down-faulted against Dalradian rocks of the Macduff Slate Formation that form the headland at the far end of the village. The landslide scar beyond the red telephone box exposes fine-grained deposits of the Kirk Burn Silt Formation of the Banffshire Coast Drift Group.