Site 3 Castle Hill, Gardenstown

At this key site, glaciolacustrine silts and sands of the Kirk Burn Silt Formation (formerly 'Coastal Deposits') overlie a glacigenic sequence that comprises glacio-tectonites (Whitehills Glacigenic Formation) overlain by a thin till (Crovie Till Formation) and underlain by gravel (Figure A1.7). The glacitectonites, which were apparently emplaced by ice moving from seawards, include rafts of marine sand in which sedimentary structures are preserved, the rafts being separated by shears. Amino-acid epimerisation ratios from specimens of *Arctica islandica* collected from one raft suggest that the emplacement of the glacitectonites post-dated the early part of Oxygen Isotope Stage 3 (about 60–45 ka BP).

Castle Hill [NJ 795 642] has long been a focus of geological interest, particularly as it yielded cold-water marine molluscan remains some 25 to 50 m above sea level (Prestwich, 1837; Chambers, 1857; Miller, 1859; Jamieson, 1906; Read, 1923). More recent work (Peacock, 1971; Sutherland, 1984b, 1993b) has shown that the upper part of the succession comprises the sediments of a glacial lake that possibly drained southwards through the Afforsk channel [NJ 788 630], on Sheet 96E (Map 3). Following re-examination, the lower part of the succession is now recognised as dominantly glacigenic (Peacock and Merritt, 1997).

The succession of superficial deposits on part of the north face of Castle Hill is shown in (Table A1.3) after Peacock and Merritt (1997).

Pishlinn Burn Gravel Bed

The Pishlinn Burn Gravel Bed (Figure A1.7), sections S1, S2 and localities D, E, F1 and F2 is a poorly sorted, matrix- to clast-supported gravel consisting predominantly of angular to subangular fragments of Dalradian slaty, turbiditic arenite and semipelite, with sparse well-rounded pebbles of red sandstone. It is interpreted as a water laid or mass movement deposit in which the Dalradian clasts have been reworked from former talus slopes to the west and redeposited by glacial or glaciofluvial action, possibly including rafting.

Whitehills Glacigenic Formation

The Whitehills Glacigenic Formation at sections S1 and S2 contains a basal unit of sand a little over 2 m thick with dispersed pebbles and subsidiary lenses and seams of clay ((Figure A1.8) unit 4). Unit 4 is characterised by pervasive shearing and attenuation of both sandy and clayey lithologies, with the truncation of folds by a glacitectonic lamination in sand, and the formation of anastomosing seams of diamicton due to subhorizontal shearing and rafting. A raft of the Pishlinn Burn Gravel occurs in section S2. These are the features of a 'Type A' glacitectonite in which the passage of overriding ice has resulted in penetrative deformation and high strain (compare with Benn and Evans, 1996).

The overlying units in Section S1 (Figure A1.8) are thickly interbedded sand and silty clay, bounded in places by sand-lined shears. Some of the sand beds retain sedimentary structures in the form of ripple lamination, and unit 7 is a fining-upward succession in which a pebble lag at the base is overlain by 10 to 20 cm of coarse sand with rounded shell fragments. Strata similar to units 5 to 7 apparently occur in the poorly exposed ground between the top of unit 7 and the base of the Crovie Till Formation, and there is another probable lag deposit of gravelly sand with shell fragments at Locality C1 (Figure A1.7). This has yielded a molluscan fauna of boreo-arctic aspect including the bivalve *Arctica islandica* and the temperate foraminifer *Elphidium crispum*. The characteristics of the sediments from unit 5 to near the base of the Crovie Till Formation (shears bounding some of the units, but the retention of sedimentary structures) suggests that these are paraautochthonous rafts of marine strata in which deformation is nonpenetrative (Type B glacitectonites of Benn and Evans, 1996). However, there is a thin (0.6 m) band of dark diamicton immediately below the Crovie Till Formation, which suggests a return to conditions of high strain.

Crovie Till Formation

The reddish brown till of the Crovie Till Formation itself is a gravelly sandy clay diamicton, up to 0.8 m thick, with clasts of Dalradian rocks and sparse, well-rounded pebbles probably derived from Old Red Sandstone conglomerate. It is only present locally, and where absent, the Whitehills Glacigenic Formation is directly overlain by the Kirk Burn Silt Formation.

Kirk Burn Silt Formation

The Kirk Burn Silt Formation on Castle Hill comprises up to 30 m of nonfossiliferous deposits, the lower beds being predominantly fine-grained sand, the upper being silt, clay and fine-grained sand. Some of the sand is coarsely laminated and interbedded on a scale of 0.1 to 0.3 m (Peacock, 1971; Sutherland, 1984b; Merritt and Peacock, 1997). Ferruginous concretions occur in places. Ripple bedding, slump folds and dewatering structures have been seen near the summit of the hill, and Sutherland (1984b) reported cross-lamination in the lower sands with foresets dipping south-eastwards. He also reported that a specimen from near the base of the deposit contained 14 per cent organic matter and a sparse pollen assemblage dominated by grains of *Pinus*. Peacock (1971) suggested that the deposits of the Kirk Burn Silt Formation here, and along a long stretch of the Banffshire coast, were deposited in a glacial lake that was dammed by ice in the Moray Firth, and which drained southwards through the Afforsk meltwater channel ((Figure 42), (Map 3)). This channel, however, is one of a suite, some of which are now known to predate the deposition of the Whitehills Glacigenic Formation (see Site 4 King Edward). The possibility must therefore be considered that the lakes were held up by ice to the south as well as in the Moray Firth, and that they drained generally eastwards to the North Sea.

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

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

- *East Grampian Drift Group
- **Banffshire Coast Drift Group

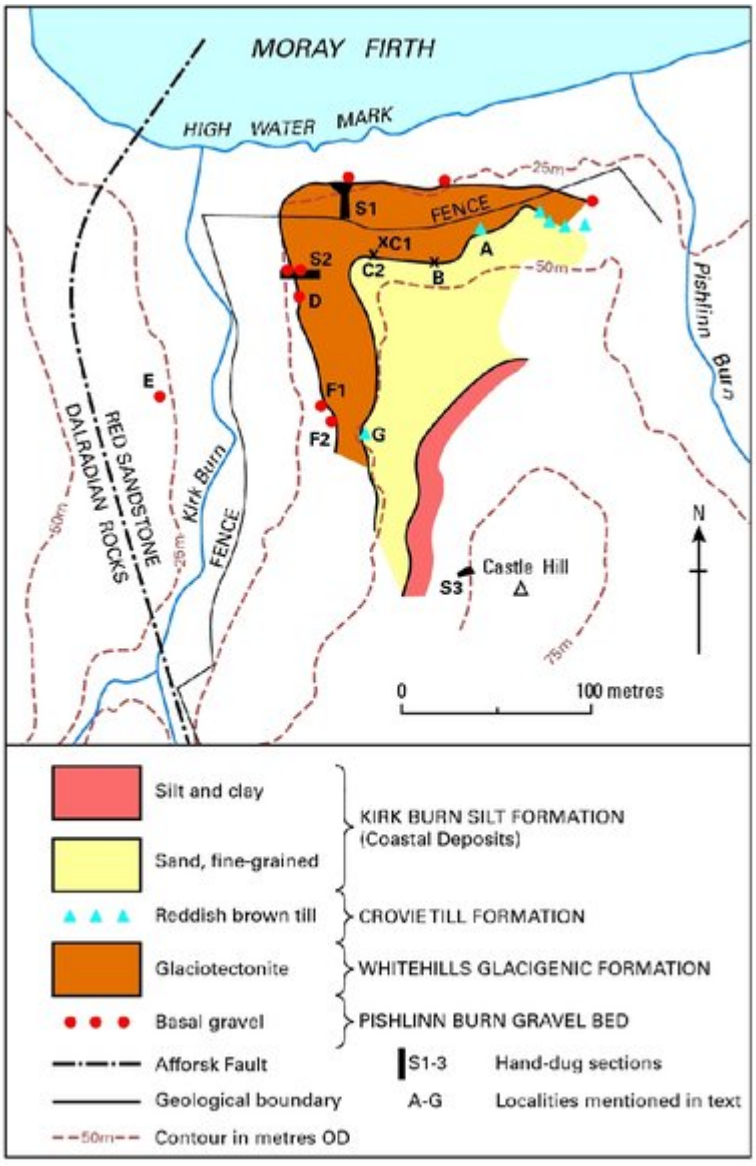
(Table A1.4) Mollusca from shelly deposits of the Whitehills Glacigenic Formation.

Modern Name*	Jameson (1865)	Gardenstown/Gamrie	King Edward
Antalis entalis	*Dentalium entalis*	x	x
Amauropsis islandica	*Natica islandica*	x	x
Aporrhais pes-pelicani	*Aporrhais pet-pelicani*		x
Boreotrephon clathratus	*Trophon clathratus*	x	x
B. clathratus var gunneri	*T clathratus var. gunneri*	x	x
B. truncatus	*Trophon truncates*	x	x
Buccinum undatum	*Buccinum undatum*	x	
Coles gracilis }	*Fusus propinquus*	x	x
C howsei }			
Epitonium greenlandicum	*Scalaria groenlandica*		x
Lacuna vincta	*Lacuna divaricata*	x	x
Oenopota pyramidalis	*Mangelia pyramidalis*	x	x
O. *turricula*	*Mangelia turricula*	x	x
Polinices nanus	*Natica marochiensis*		x
P pallida	*Natica pallida*	x	x
Tectonatica clausa	*Natica affinis*	x	x
Tachyrhyncus reticulata	*Mesalia reticulata*		x
Turritella communis	*Turriteila ungulina*		x

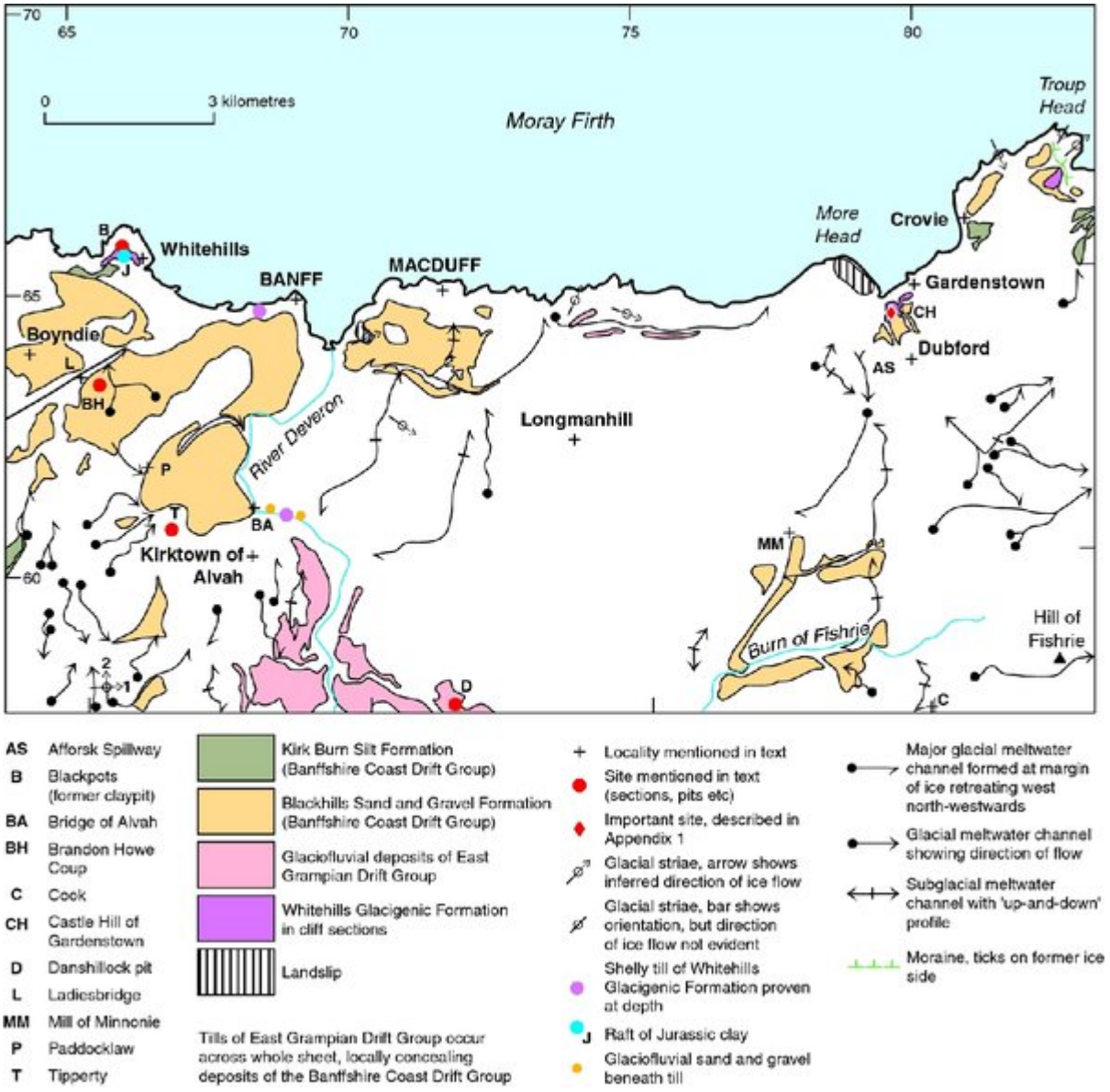
Tectura virginea	*Tectura virginea*	x	
Acanthocardia echinata	*Cardium echinata*	x	x
Anemia ephippium	*Anomia ephippium*	x	
Arctica islandica	*Cyprina islandica*	x	x
Macoma balthica	*Tellina balthica*	x	x
M. calcarea	*T. proxima*	x	x
Mya truncata	*Mya truncata*		x
Mytilus edulis	*Mytilus edulis*	x	
Serripes groenlandicus	*Cardium groenlandicum*	x	x
Spisula elliptica	*Mactra solicla* var. *elliptica*	x	
Tridonta borealis	*Astarte borealis*	x	x
T montagui	*Astarte compressa*	x	
Yoldia limatula	*Leda limatula*		x
Yoldiella lucida	*Leda lucida*		x
Zirphaea crispata	*Pholas crispata*	x	x

- For authors of species see Lubinsky(1980); Macpherson (1971) and Smith and Heppell (1991)
- † The bivalve *Timodea ovata* has been reported from Gardenstown/B38Gamrie (Peacock in Sutherland 1993b).

References



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

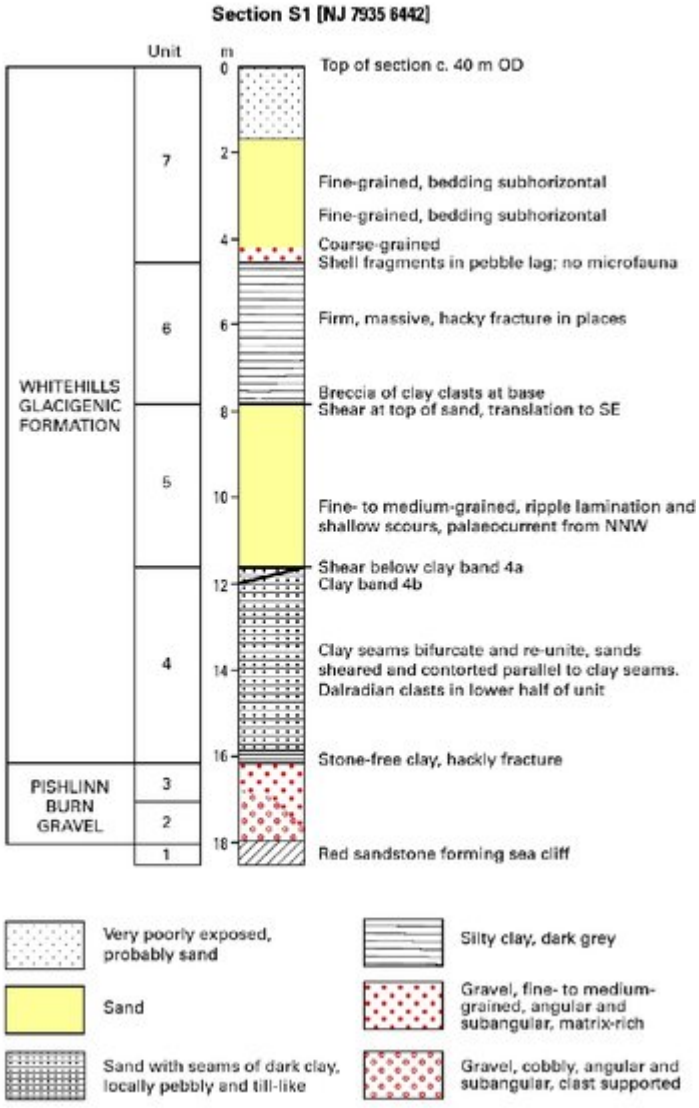


(Map 3) Glacial and glaciofluvial features and the distribution of glacigenic deposits on Sheet 96E Banff.

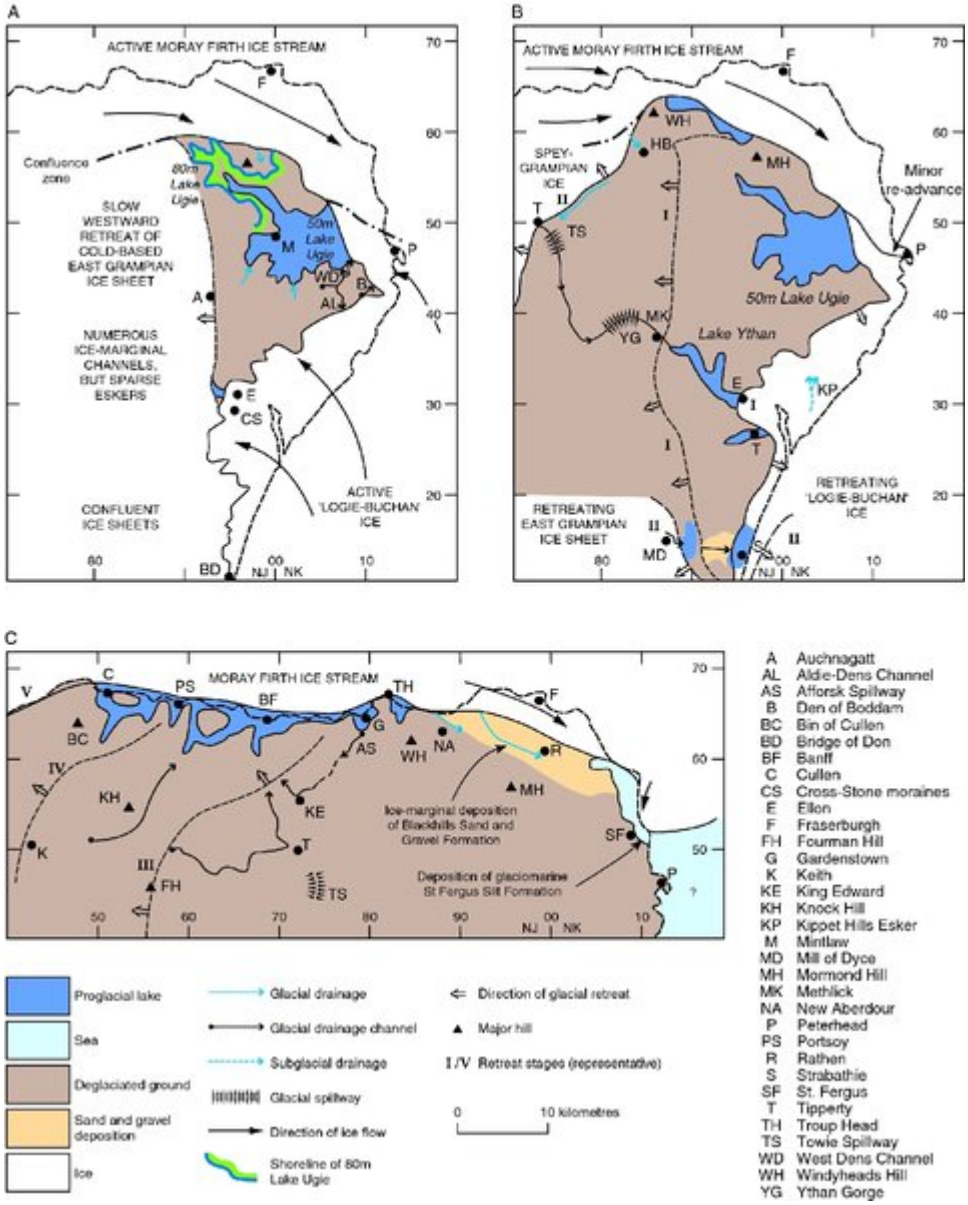
Unit	Lithostratigraphical unit	Lithology	Thickness m
5	Kirk Burn Silt Formation*	Glaciolacustrine silts and clay	>19
4	Crovie Till Formation†	Reddish brown till	0–0.8
3	Whitehills Glacigenic Formation*	Silt, sand and grey clayey diamiction	<18.0
2	Pishlinn Burn Gravel Bed†	Gravel, cobbly towards base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



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



(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 occured 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.

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