Changing Landscapes of the Isle of Man

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Introduction

The Isle of Man is a small mountainous island in the northern Irish Sea basin. The island comprises two upland areas that reach 621 meters at Snaefell separated by the low-lying central valley. There are further lowlands in the south east and the extensive northern coastal plain (Figure 1). The Isle of Man is a fault-bounded block of Cambrian, Ordovician and Silurian slate formed by crustal extension and doming during the late Jurassic and early Cenozoic (Quirk and Kimbell, 1997). Devonian and Carboniferous lithologies form the bedrock geology of the lowlands. Two million years ago climates cooled heralding the onset of the Quaternary - a recent geological epoch associated with high magnitude climate changes from ice ages (glacials) to warm periods (interglacials). During the glacials of the Quaternary successive advances of substantial ice sheets sculpted the landscape of the British Isles. The Isle of Man lies directly in the path of ice sheets advancing from mountains in Scotland and the Lake District, southwards across the Irish Sea, and so would have been covered and sculpted by the erosive power of successive glaciations. During interglacials climates improved to conditions similar to, or warmer than, that encountered in Britain today. Each ice sheet is akin to a large scouring pad advancing across the landscape removing sedimentary evidence of previous events. Consequently as the last Ice Age, the Devensian (80-11.5 kyrs ago)[1], produced an ice sheet that extended far into the southern Irish Sea, covering the Isle of Man, the recent sediments on the island only reflect land-forming processes during and after the Devensian. Early research held that the uplands were an ice-free nunatak during the Devensian (Wirtz, 1953; Cubbon, 1957; Thomas, 1976), but recent estimates of ice thickness indicate that the island was covered during the Devensian glacial maximum (Bowen, 1973; Boulton et al. 1977).

The Quaternary geology of the Isle of Man divides into two suites of deposits – local upland sediments and lowland sediments composed of lithologies foreign to the

[1] 1 kyr = one thousand years

Island (Kendall, 1894; Lamplugh, 1903). The foreign deposits consist of a mixture of diamict floor, drumlin field, ice-marginal moraine, ice-disintegration topography, ice-front alluvial fan, subaqueous fan, sandur and proglacial lake sediments deposited almost exclusively on the northern coastal plain. The uplands are covered with an extensive and almost ubiquitous cover of till composed of locally derived slate, with the thickest deposits (up to 20 metres) on the floors of the main valleys and substantially thinner sequences on steeper slopes and interfluves. Soon after the ice retreated from the island the extensive cover of glacial till was rapidly reworked by periglacial slope processes producing thick sequences of soliflucted till (Thomas, 1985; Dackombe and Thomas, 1985; 1989). The Devensian climate began to warm sharply around 15 kyrs ago, but the transition from glacial conditions to the current warm period (the Holocene) was punctuated by short-lived cooling of the climate, particularly between 13-11.5 kyrs ago before the onset of the Holocene 11.5 kyrs ago. Landforms and sediments set into or overlying the glacial and periglacial deposits reflect land-forming processes during late glacial and Holocene times. Understanding the Manx landscape requires an appreciation of a considerable variety of geomorphological (land forming) processes responsible for the development of the natural landscape.[2]

Devensian glaciation of the Isle of Man

Ice covered the island during the main advance of the Devensian ice age, which commenced after 30 kyrs ago. Ice sheets expanded from Scotland and Cumbria forming a large ice body that at its zenith between 28-22 kyrs ago extended into the south Irish Sea. There is no morphological evidence that ice formed on the Isle of Man, with the smoothed and sculpted upland landscape produced by a large 1000-750 metre thick ice sheet consuming the entire island (Dackombe and Thomas, 1989). During the advance of the icesheet thick sequences of glacial sediments were deposited on the northern coastal plain abutting against the 300 metre high, north facing, faulted escarpment (Figure 1). Further glacial sediments were deposited in the south of the island on the Plains of Malew, where the sediments are sculpted to form drumlins. Drumlins are oval shaped low hills composed largely of glacial sediments smoothed by the flow of the ice. Ice marginal moraine ridges form at the snout of glaciers owing to the tectonisation of pre-existing sediment, the pushing of debris by thrusting ice and through the simple accumulation of debris along the ice margin. Across the northern plain of the Isle of Man there is a series of east-west orientated linear ridges composed of glacigenic sediment that are almost certainly ice marginal moraines or ridges produced by oscillations of the glacier snout as the ice retreated. South of the Bride Hills these retreat or recessional moraines take the form of low amplitude linear ridges.

In places, fluctuations of the ice margin have produced more substantial ridges. The Bride Hills are a suite of ridges aligned east-west across the island. The sediments exposed on the coast at Shellag Point are highly deformed by glacio-tectonism, having

[2] The landscape history of the island has attracted considerable attention during the past five years, which will culminate in the publication of *A New History of the Isle of Man Volume 1 - Evolution of a Natural Landscape* (Chiverrell and Thomas, 2001b). The volume synthesises the wealth of recent research on the Pre-Quaternary and Quaternary geology and geomorphology of the Isle of Man.

been folded and thrusted by the glacier during a minor readvance of the Devensian ice sheet. North of the Bride Hills coastal cliff sections reveal a stacked sequence of glacial tills deposited during and after the ice advance which is responsible for the glaciotectonics. These sediments are believed to be contemporaneous with glacial sediments and landforms at Orrisdale and near Peel. During this readvance the Devensian ice margin was aligned along the west coast of the island as far south as Peel and northwards to the Orrisdale ridge, before veering north-east to the Bride Moraine and offshore into the Vannin Sound (Figure la). There are further ice marginal sediments north of Orrisdale exposed in the cliff sections at Jurby. These sediments and landforms were deposited during further northward retreat of the ice margin to the Jurby ridge (Figure lb). Unlike the earlier glacial sediments, which were deposited in a terrestrial environment, the Jurby succession is subaqueous and was produced by an ice margin dipping its snout into a large ice marginal lake. The dimensions of this lake are unclear, but it was substantial given that there are several metres of glaciolacustrine sediment exposed on the west coast near Killane, beneath Ballaugh Curragh and on the east coast at Dog Mills.

Deglaciation of the Isle of Man

During the later stages of the Devensian the ice margin had already advanced to and retreated from maximum limits. Recent interpretation of the glacial landforms suggests that the ice margin was at the Bride-Orrisdale limits by 18-16 kyrs ago, and so although the uplands and south of the island were ice free the island continued to experience a cold climate until 14.5 kyrs ago. Organic sediments in former kettle hole basins date the timing of the ice margin clearing the island. Kettle hole basins at Jurby Head and Kirk Michael were produced when dead-ice buried within glacial sediment melted and collapsed leaving shallow basins filled with water. Radiocarbon dating of organic sediments from the base of these basins indicates the ice had cleared the island by circa 16.0-15.0 kyrs ago. There are no *in situ* glacial sediments in the Manx Uplands, the hill-slopes and valleys are covered with a mantle of slope process sediments. The thickest deposits occur on the valley floors, and have been incised into by subsequent fluvial activity leaving valley side solifluction terraces (Figure 2). The slope processes responsible for soliflucted till deposits in the upland valleys took place during cold periglacial conditions immediately after deglaciation. Periglaciation is the modification of landscape under a non-glacial cold climate (Ballantyne & Harris, 1993). Frost heave structures and ice wedge casts in the upper layers of glacial sediment pay further testimony to a period with a periglacial climate after deglaciation. Substantial alluvial fans surround the Manx Uplands issuing from the main valleys (Figure 1), and were formed by deposition of vast quantities of sediment as the rivers incised into the soliflucted tills that choked the valleys. The timing and duration of alluvial fan formation on the coastal plain provides a chronology for the main phase of fluvial incision in the Manx uplands. Organic sediments overlying and underlying alluvial fan gravels at Glen Balleira and Ballaugh constrain alluvial fan formation to between 18.0-11.5 kyrs ago. In the uplands, river terraces and alluvial fan surfaces are set into the soliflucted till, and are contemporaneous with the fluvial incision and formation of lowland alluvial fans.

Pollen and beetle fossil records provide further information about the Manx landscape immediately after deglaciation. Organic sediments in kettlehole basins at Kirk Michael and in depressions (pingos) formed by periglacial ground-ice on the Ballaugh alluvial fan (Figure 1c) have yielded pollen diagrams that identify the vegetation changes between 15.0-11.5 kyrs ago (Mitchell, 1965; Dickson *et al.* 1970; Chiverrell and Thomas, 2001). Grasses and sedges, with low frequencies of the open ground herbs sorrel, mugwort, saxifrages, pinks and plantains dominate pollen spectra. Gradually as the climate improved after 14.5 kyrs ago sporadic shrub pollen grains occur, with juniper, crowberry, willow and birch more abundant between 14.5-12.5 kyrs ago. There is a short-lived retrogressive phase where birch, willow and crowberry decline and the open ground herbs are more abundant, which signifies a cooling of the climate between 12.5-11.5 kyrs ago. Beetles provide more precise climate data when present in fossil records, because there are a number of species with specific tolerances of temperature. Consequently subfossil beetle remains have been used to quantitatively reconstruct changes in climatic conditions at the end of the last ice age. Beetle records from the Kirk Michael and Jurby Head kettlehole sediments identify a rapid 10 degree warming of mean summer temperatures circa 14.5 kyrs ago, conditions which persist until between circa 12.5-11.5 kyrs ago when there was a sharp downturn in mean summer temperatures of 10 degree centigrade (Joachim, 1978). In the British Isles the warm period is called the Windermere Interstadial and the subsequent downturn in temperatures is called the Loch Lomond Stadial. The Loch Lomond Stadial ended with a 10 degree warming of mean summer temperatures circa 11.5 kyrs ago and marks the beginning of the current warm period, the Holocene. The vegetation colonisation during the Windermere Interstadial stabilised the landscape of the Isle of Man, with soil development and a cover of open ground herbs and dwarf shrubs. This stabilisation reduced rates of erosion and sediment transfer in the uplands, and so the solifluction activity ceased and much of the fluvial incision probably occurred during the Windermere Interstadial and Loch Lomond stadial. The incision that occurred in upland catchments contributed substantial quantities of fluvial gravel to the mountain front alluvial fans that flank the Manx Uplands.

After the Ice Ages

The Holocene period began 11.5 kyrs ago with a rapid warming of climate. Evidence of the character of the early post-glacial landscape of the Isle of Man is derived from organic sediments in the major peat basins. Pollen data from organic sediments at Ballaugh Curragh, Curragh-y-Cowle, Pollies and the Lhen Trench (Figure 1c) identify the colonisation of the island by vegetation after the last ice age (Innes *et al.* unpublished). Heath-land dominated by dwarf birch, crowberry, heather, juniper and herb-rich grasslands are gradually replaced as woodlands return to the island. Birch woodland expanded 10.7-10.2 kyrs ago, with hazel and pine arriving slightly later 10.2-9.0 kyrs ago as a boreal forest community became established on the island. The Irish Elk *(Megalocerus giganteus)* survived in this developing boreal forest until 10.6-10.2 kyrs ago, according to ^{14}C dates on what is the most recent specimen recorded anywhere in the world (Gonzalez *et al* 2000). Holocene Irish Elk on the Isle of Man were also of smaller dimensions than their counterparts in Ireland in the late glacial period. The boreal forest declined and was succeeded by mixed deciduous woodland as oak and elm returned to the island 8.5-8.1 kyrs ago with hazel continuing to thrive as an understory shrub. Alder joined this mixed deciduous woodland around 8.1-7.7 kyrs ago. The vegetation changes after this point reflect the impact of people on the landscape. During the Mesolithic and Neolithic these impacts take the form of minor reductions in woodland pollen reflecting small scale and temporary clearances. Substantial clearance and cereal cultivation is recorded during the late Neolithic and intermittently throughout the Bronze Age. More substantial clearances affecting the uplands and the northern and central lowlands are recorded during the Iron Age, and witnessed the most substantial removal of woodland from the island. The sequence of vegetation changes ties closely to the detailed archaeological and historical records of human activity on the island, and demonstrates the considerable impact people have had upon the landscape during the late Holocene (Davey, 1999; Innes *et al.* unpublished).

Organic sediments on the northern plain of the Isle of Man also record the sequence of sea level changes during the Holocene. Marine waters influenced currently terrestrial sites at Lough Cranstal, the Lhen Trench and at Phurt, and so are indicative of higher sea levels. Sea level rose rapidly from a low of 55m below OD during the late Devensian as the climatic conditions improved during the Holocene. On the northern coastal plain the raised cliff-line and beach at the Point of Ayre and associated fresh and brackish water lagoonal basins are indicative of higher sea levels 9.0-8.4 kyrs ago. Recent unpublished research has identified further evidence for changes in sea levels on the Isle of Man, with seven regressive and four transgressive sea level changes at Phurt and the Lhen Trench between 7.7-4.4 kyrs ago (Innes *et al.* in prep.). Holocene palaeoclimate data is not abundant on the Isle of Man, with the changes in bog surface wetness recorded in the peat sediment on Beinn-y-Phott providing one of the few proxy archives of climatic fluctuations. The Beinn-y-Phott peat stratigraphy records shifts to a wetter climate after 3.3-2.9 kyrs ago during the Bronze Age, before 2.4-2.2 kyrs ago during the Iron Age and before 1.3-1.2 kyrs ago during the early Medieval Period (Chiverrell *et al.*, 2001). These wet shifts occur at similar times to those recorded in peat sequences elsewhere in the British Isles and provide further evidence for regional climate change.

Alteration of the landscape by people and continued climatic fluctuations albeit on a smaller scale than occurred during the Devensian imply the Manx environment has been changing throughout the Holocene. Rivers have carried out the most significant land-forming processes during the Holocene, and Manx rivers like the Sulby, Neb and Auldyn have produced a suite of river terraces (Chiverrell *et al.* 2001). River terraces are former floodplains abandoned as rivers incise; rivers typically either deposit sediment aggrading the floodplain or incise leaving former floodplain as terraces. Environmental controls on river systems include human activity within the catchment, climate changes or high magnitude events (floods), and these affect whether rivers incise or aggrade. The higher terraces in the Manx uplands date to the late Devensian and are composed of very coarse gravel. During the early Holocene rivers continued to occupy these terraces and were unable to cope with the calibre of material and incise, and so they were either aggrading or quiescent systems. There are younger terraces incised into these early surfaces, but these formed after incision during the last 3000

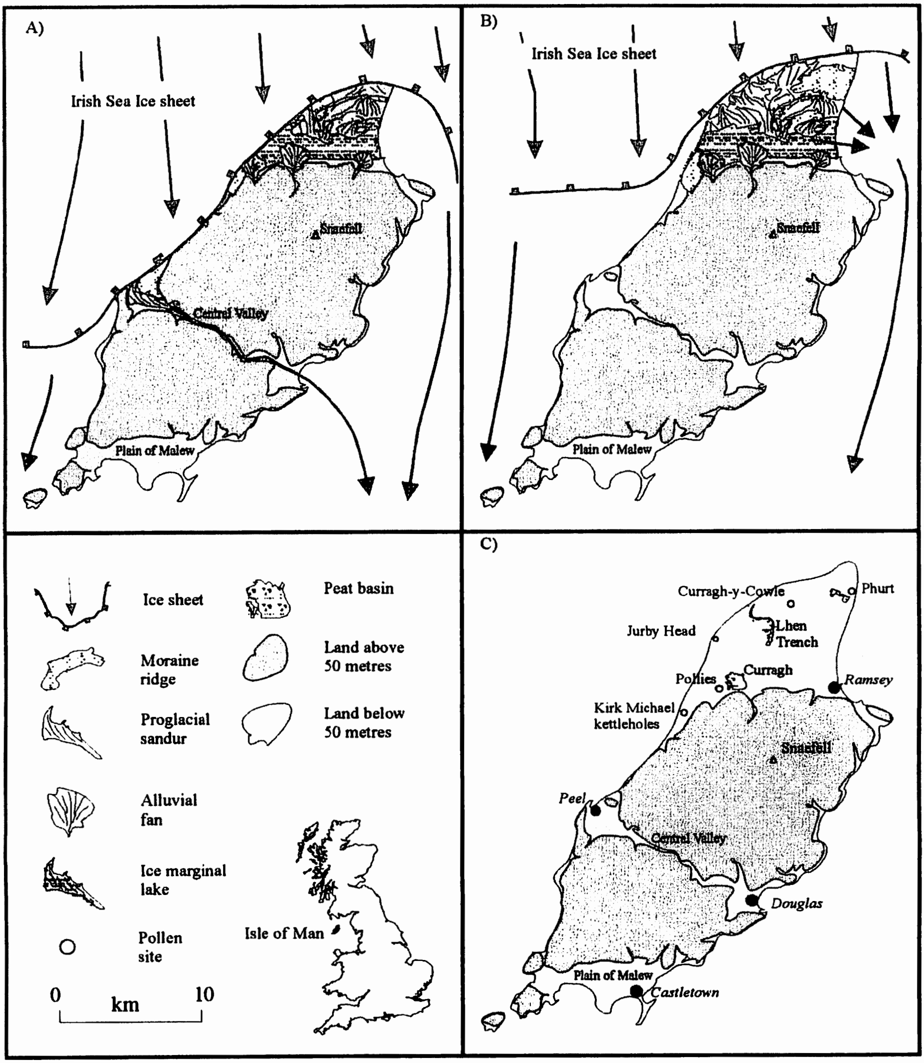

Figure 1: Landscapes of the Isle of Man. a) During the late Devensian whilst the ice margin was at the Orrosdale/Bride limits; b) During the late Devensian whilst the ice margin was at the Jurby limits; c) the locations of late Devensian and Holocene palaeoecological sites.

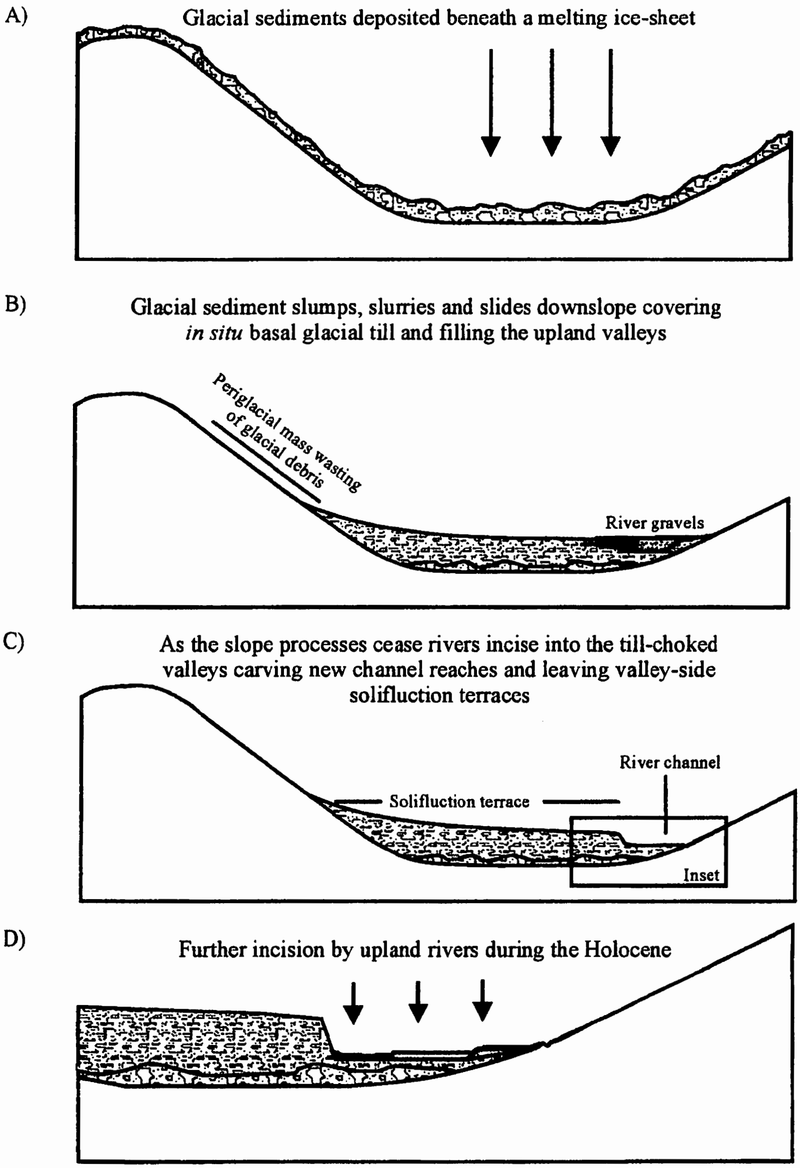

Figure 2: Landscape changes in the valleys of the Manx Uplands. A) on deglaciation 18-16 kyrs ago; B) during the cold periglacial conditions after deglaciation 16-14.5 kyrs ago; C) during warm and cooler conditions 14.5-11.5 kyrs ago; and D) during the Holocene (10-0 kyrs ago).

years of the Holocene. During this time period the rivers have produced between one and and three younger terraces. Increased scale of human activity is the most likely trigger for these phases of increased fluvial activity, given that the fluvial incision is coincident with substantial woodland clearances. However there have been shifts to wetter climatic conditions during the late Holocene and it is possible climate may be triggering fluvial incision. The most likely hypothesis is that fluvial incision has occurred in response to the combined efforts of people and climate.

Synthesis

The rolling uplands and gently undulating lowlands of the Isle of Man reflect the cumulative effects of land-forming processes during and since the last ice age. The drift mantled and smoothed upland hill-slopes are only broken by cliffs flanking the reaches incised by fluvial activity. The fluvial incision has left valley side terraces of solifluction deposits and suites of river terraces. The river terraces reflect the adjustment of river systems during the late Devensian and environmental changes during the Holocene. The lowland landscape is almost entirely an artefact of the last ice age, with the key components of a glaciated terrain characterising the northern plain and the plain of Malew. The evidence for post glacial landscape change is limited to sequences of organic sediments at Ballaugh Curragh and the Lhen Trench, and the Ayres coastal succession. It is the evidence of glacial activity and the glaciated landscape that has always and continues to attract the attention of geologists and geomorphologists, because the island is "an unrivalled field for the study of the conditions that ruled in the northern part of the basin of the Irish Sea during the glacial period" (Lamplugh, 1903).

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