# A Possible Beach of a Glacial Lake on the Hill of Tillymorgan, Aberdeenshire

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## Introduction

Layers of gravel were seen in trenches on the higher slopes of Hill of Tillymorgan which are interpreted as the beaches of a large lake covering the Insch and Huntly valleys. If accepted as such they would provide additional evidence that this area of North-east Scotland was ice-free during part of the last glaciation.

Wind turbines were installed on the Hill of Tillymorgan in 2016 and, in the trench for the electric cables, a thin layer of gravel was observed, by chance, as the author was walking past to visit the slate quarries at the top of the hill. This layer is about 50cms thick with the upper surface merging with the overlying drift and with a sharp lower contact to underlying sediments. It can be followed for about 10m into the hillside where the base rises and where, eventually, the gravel pinches out (see Photo 1 and Figure 1). It occurs at an elevation of 240m above present day mean sea level (amsl.) at NGR NJ 649 336. A thicker section of similar material was seen further up the track in a small temporary quarry at an approximate elevation of 254 - 256m amsl. Still further up the track towards the turbines more gravel was seen but could not be examined before the trench was filled in. The highest gravel seen was at approximately 240m. Again, below 240m the presence or absence of gravel could not be ascertained because the trench had been backfilled before the site was first seen.

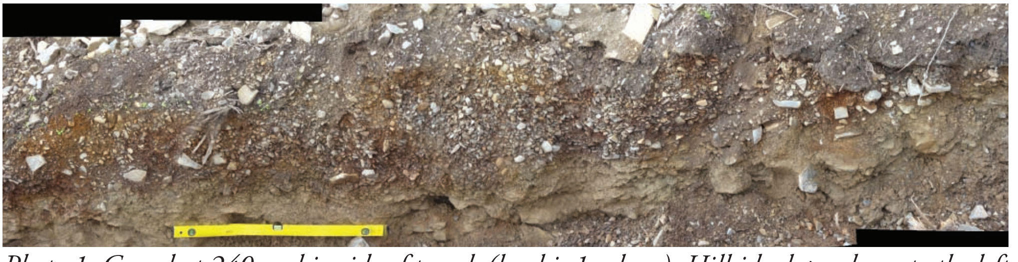

*Photo 1. Gravel at 240amsl in side of trench (level is 1m long). Hillside slopes down to the left and gravel pinches out to the right.*

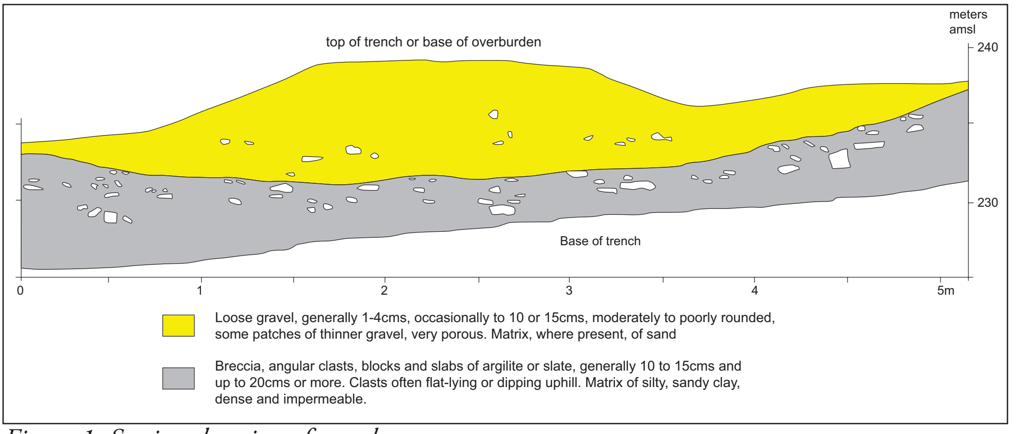


*Figure 1. Section drawing of trench.*

## Nature of the Gravel at 240m

The gravel at 240m amsl was examined closely and sampled. Photo 2 shows how clean and well-sorted this material is. It overlies (just below the ruler) a very different sediment which is a breccia made up of angular fragments of slate in a muddy matrix. On first sight before the section was cleaned up the contact was very apparent because a considerable amount of water was seeping out of the bottom of the gravel over the underlying breccia.


*Photo 2. Close-up of gravel showing the well-sorted beach gravel overlying the ill-sorted and angular breccia underneath.*

The gravel consists of clasts (individual pebbles) of slate and argillite and is very well sorted. Almost all of the clasts are between 10mm and 40mm in diameter with very few bigger than 50mm and none seen above 100mm (see Grain Size Analysis, Figure 2). The clasts would be described as rounded or subrounded (all corners and most faces have been smoothed by abrasion in water), but the very largest and smallest ones tend to be more angular. The small amount of matrix present consists of sand, silt, and mud. The sand is mainly small fragments of slate; no quartz sand was seen.

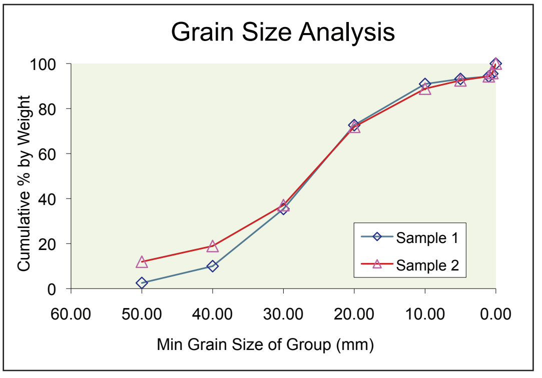


*Figure 2. Grain size analysis. See text for explanation.)*

The grain size analysis (Figure 2) presents the cumulative percentage of the material by weight plotted against the minimum grain size for that fraction. Thus, for both samples, almost 90% of the material has a grain size greater than 10mm, so that for both samples, less than 10% of the material is smaller than this size. Similarly, material larger than 40mm represents 20% of sample 2 but only 10% of sample 1. The steepness of the curves shows that the samples are well sorted. A well-sorted sand typically has a void space of about 30%. The fact that only 10% of this material is less than 10mm means that the spaces between the clasts will be largely empty. As a result the gravel is very permeable and, in the trench, water was seeping out along its lower surface keeping the underlying breccia wet.

The underlying material is very different. It is a breccia, which means that it consists of angular clasts (the corners are still sharp) in a matrix of clay, silt and sand. Clasts are of all sizes up to 20 or 25cms and made of slate and other argillites. They are of the same material as those in the gravel but are of completely different shapes. Also, the void spaces are totally packed with matrix that makes it largely impermeable.

## Local Geology

The maps published by the British Geological Survey show the hill above the site is composed of slates of the Hill of Foudland Pelite member composed of metamorphosed mudstones and silty mudstones. Below the site the Macduff Formation comes in and this is composed of metamorphosed muddy sandstones and siltstones. They are both part of the Dalradian Series and date from about 1000 to 541 million years ago. At the bottom of the hill and across most of the Insch valley various members of the Insch Pluton occur. These are basic and ultra basic rocks intruded between 485.4 and 443.8 million years ago during the Ordovician period.

The Hill of Foudland Pelite member is the material found in the slate quarries at the top of the Hill of Tillymorgan and along the hills to the west as far as the River Bogie and a bit beyond. The Macduff Formation is too coarse and sandy to form slates and this is why the quarries are only found at the tops of the hills and down the north sides.

Over most of the area exposure is poor. The area is covered by young surface sediments which the British Geological Survey describe as 'diamictite'. This term covers a mixture of mud, silt, sand, and larger fragments of rock, all mixed together with little internal structure. Diamictite is usually ascribed a glacial origin and can include glacial till (the material left behind by glaciers) and solifluxion deposits (formed by down-slope movement of material by a continuous freeze/thaw action).

## INTERPRETATION OF SEDIMENTS

Both the gravel and the breccia were deposited during the Pleistocene glacial period (2 million to 10 thousand years ago). This was a time of long and extremely cold winters with brief, warm summers. The prevailing wind direction was from the west or south-west and so the bulk of the precipitation would have fallen over the western hills and as far east as the Cairngorms. Also, easterly winds which now bring snow to the northeast would not have blown over open sea but over ice, so would not have picked up much moisture. Therefore, in the west, precipitation of snow would have been sufficient to overcome summer melting and great thickness of ice and glaciers built up. However, further east winter snowfall would not have been deep enough to survive the warm summers and no ice would have accumulated. With the lack of snow and ice to provide insulation, the ground would have been completely frozen for several hundred meters and so would have been totally impermeable. In summer only the surface would have melted. The melt water being unable to soak away would have turned the surface sediments to mud, which would have flowed slowly downhill under gravity. Under these conditions the resulting sediments were completely mixed and now look like they had been put through a cement mixer. It typically filled-in hollows and rounded off bumps producing smooth, gentle concave slopes. This is referred to as solifluxion and is one of many periglacial processes. It is also commonly the origin of diamictite.

The breccia formed under these annual freeze/thaw cycles under permafrost conditions. Significant movement by water, whether in a river or on a beach, can be discounted because of the lack of sorting, the angularity of the clasts and the presence of matrix filling all the available void space.

The origin of the gravel is more difficult to identify, particularly in view of its elevation at 240m amsl. However, the rounded nature of the clasts and the relative lack of fine grained material would imply steady movement by water in a back and forth manner with a nearby area of deeper water where the fine grained material could end up. The lack of any cross-bedding or other sedimentary structures would imply that the water movement was not in one direction only, but occurred in an oscillating manner. These conditions would not be satisfied by deposition from a river but would be consistent with constant reworking on a beach.

The outline of the lake related to this beach can be seen on Figure 3 where the 250m contour has been highlighted. It would have extended to Bennachie in the south and as far west as Rhynie and the Cabrach. At this elevation it would have extended through both the Glens of Foudland and the valley of the Bogie and so to the area around Huntly and beyond. Note that there are no hills above this elevation to either the north or the east.

The location of this gravel at an elevation of 240m with nothing to the north or east to dam it up is a problem and has to be explained. During the Pleistocene period, continental ice sheets moved out of northern Europe into the North Sea, and at the same time ice flowed from the Spey Valley and the Great Glen through the Moray Firth. As a result the Moray Firth and the North Sea were filled with ice that may have been at least a kilometre thick extending at least to the latitude of Caithness. This could well have provided the eastern and northern limits of the proposed lake

To prove the presence of a lake of this extent needs further evidence of beaches or other features at the same or very similar elevations around its proposed shore line. At the same time as the wind turbines were being built, a gas pipeline was being installed through the valley of Jericho to the west of the A96. Unfortunately this was dug, the pipe installed and the trench back-filled before it could be examined. Hopefully, this pipe will be taken down the north side of the hill in the near future permitting the trench to be examined there.

This beach material is not exposed and cannot be seen at the ground surface. To explain this it is proposed that after the lake drained, freezing conditions continued and any surface manifestation of the beaches were removed by solifluxion processes. In the adjacent field to the south east of the site there is a steep slope at a similar level which may have been a small cliff behind an equivalent beach. Similar features can be seen elsewhere in the Insch valley at a similar elevation; they are not often seen at other elevations. Further exposures of similar beach gravels are likely to be seen only in trenches dug by farmers for drainage work.

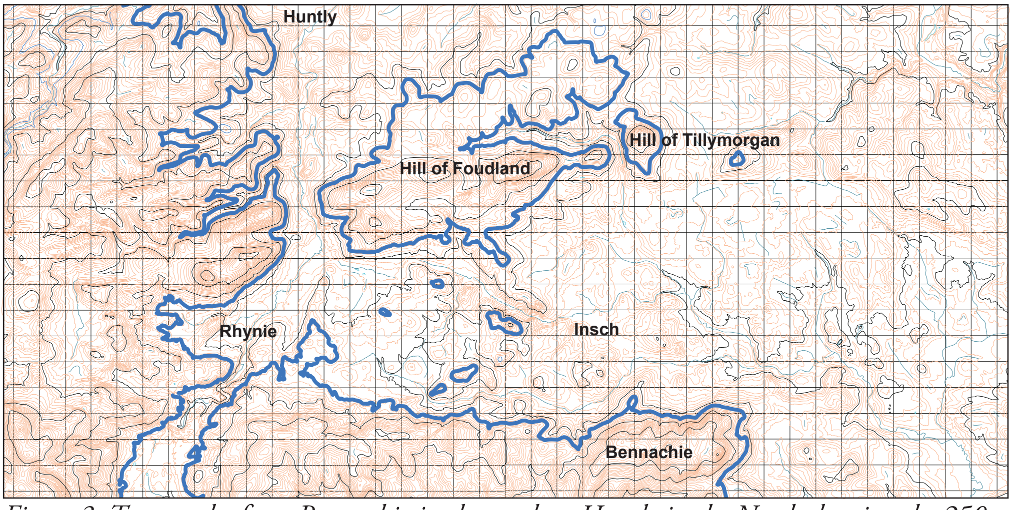


*Figure 3. Topography from Bennachie in the south to Huntly in the North showing the 250m contour - the approximate line of the proposed beach.*

Beaches formed along the edges of glacial lakes are found elsewhere in Scotland. The most famous being the 'Parallel Roads' of Glen Roy. (There is a good visitor site in this glen, the waters of which flow into Glen Spean not far to the east of Fort William.) Here, ice in the Great Glen dammed a lake in Glen Roy that spilled over a series of passes into neighbouring glens. In this instance, the spillways were set in rock, and so the lake level stayed the same for some time. As a result, the beaches are more substantial than the example considered here and can clearly be seen on the neighbouring hillsides.

## The Significance of this Possible Beach

The discussion of whether the North East of Scotland was ice-covered during the last glaciation has gone on since the earliest studies of the region. The arguments were summarised by Clapperton and Sugden (1975) and more recently by Merritt and Leslie (2009). Indisputable glacial tills are found along the coast all around North-east Scotland. From Aberdeen to Peterhead it is red in colour, being derived from ice flowing out from Glenmore over the Old Red Sandstone there. From Peterhead to Fraserburgh and in patches further west along the Moray Firth, it is blue/grey when fresh. It clearly flowed over the Moray Firth as it contains blocks of fosiliferous Jurrassic and Cretaceous rocks and has been proven to exist there by oil drilling. The ice from which these deposits came probably resided in the Great Glen and the Spey Valley. Both these tills are found close to the coast and sometimes appear to have been pushed up over the land from the seaward side. Neither of them are found far inland. It is suggested that ice flowing out from Scandinavia and Northern Europe deflected the ice flowing out from Scotland. This idea is supported by the presence of glacial erratics of Norwegian rocks being found in gravels along the coast.

Arguing for ice-cover over the area, Merritt and Leslie refer to the presence of meltwater channels which were formed by water flowing under glaciers. However, the examples they quote are all close to the coast. They do not refer specifically to any further west than Turriff.

In favour of the lack of ice, Synge (1956) used the presence of tors on Bennachie, rotted bedrock (e.g. the quarry of rotted granite at the Rowan Tree car park, Bennachie) and weathered till. He also argued that the smooth hillsides seen in the area are the result of periglacial processes and not glacial action, which would be expected to leave a more irregular profile with hard rocks protruding.

Against this they all maintain that if the area was ice-free, there should be signs of the presence of large ice-dammed lakes. If present these would have led to the formation of lake-bottom sediments, deltas and beach deposits, none of which they claim to have seen. Thus, if the gravels at 240m, and those seen briefly at higher elevations are accepted as beach deposits, the arguments for an ice-free area in North-east Scotland are strengthened.

## References


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