Geological Report on the Pollatomish Landslide Area, Co. Mayo

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Report Contents

Executive Summary

The Geological Survey of Ireland (GSI) is a line division of the Department of Communications, Marine and Natural Resources, and is the national earth science organisation. A major landslide occurred in the Pollatomish area of North Mayo on the night of Friday 19th of September, 2003, during a period of very heavy rainfall. The landslide resulted in considerable damage to roads, bridges and property and the evacuation of over 40 families from their homes. GSI contacted Mayo County Council after the initial emergency period to seek permission to visit the area and examine the phenomenon. This internal report, which is compiled for GSI records, consists of a geological and topographic description of the area, based on the site visit, including comment on the landslide event and its probable cause. It is the opinion of the authors that while the geology of the area contributed to the event, that the critical factor was the extent of heavy rainfall on the night, coming after a long dry summer, resulting in instability of the peat and extensive failure of the slopes.

1 Introduction

The landslides that are the subject of this report occurred in the Dooncarton Mountain area of Pollatomish in North Mayo, on the west coast of Ireland, some 12 kilometres east of the town of Belmullet and 55 kilometres north of the town of Westport (Fig.1).

Geological Survey of Ireland (GSI) staff, Ronnie Creighton and Koen Verbruggen, visited the landslide area on Tuesday 30 September.

Prior to the visit a detailed desk study of the geology of the area had been undertaken, using geological maps, aerial photography and GIS. The desk study also included a review of relevant digital mapping held at the GSI offices in a project specific GIS (Geographic Information System). This included Ordnance Survey of Ireland (OSI) topographic coverage at 1:50,000, the OSI 50m DEM (Digital Elevation Model), Orthophotography and GSI 6":1 mile historic mapping and 1:100,000 bedrock geology mapping (Figs 2 & 3). This was done to ascertain if there were any geological factors relevant to the occurrence of the landslides. On the visit a walkover survey was done of a part of the landslide area to examine the landslides themselves and any geological exposures.

This report includes a description of the geology of the Pollatomish area, including any impacts the geology may have had on the slope failure. In addition some observations are made on the landslides themselves. The report focuses solely on the geology of the area and does not include any engineering observations or conclusions on the landslide mechanisms. Some comment is made on possible causes but these are not based on detailed field survey or an engineering assessment.

This is an internal GSI report which is intended to assist in the construction of a database on landslides, bogflows and rock falls in Ireland. Copies of this report will be provided to the Area Engineer for Mayo County Council, Mr Paddy Mahon, as well as to Tobin Environmental Services, consultants to Mayo County Council on this issue.

2 Bedrock Geology

The bedrock or solid geology of the Dooncarton area is described in the Geological Survey of Ireland publication "Geology of North Mayo", by Long et al. (1992), which includes a geological map of the area at 1:100,000 scale. The local geology consists of metamorphic rocks over 400 million years old, belonging to the "Dalradian Supergroup", and dominantly made up of altered sedimentary rocks, schists and sandstones with some thin marbles. A number of geological faults occur in the area, including within the steep Dooncarton Mountain. However the area is tectonically stable and there is no evidence for any recent movement on any of these structures, which are likely to have last moved over 200 million years ago. These faults and all of the geology is best exposed in coastal sections west and north of Dooncarton Mountain, and has been extrapolated across the hillier ground where exposure is poor. In more detail the local geology consists of the following rock types, grouped into a number of formations (see Fig 2).

Group	Formation	Rocktypes	Location
Inver Group	Inver Schist	Graphitic, semi-pelitic schists and marbles	Upper Slopes Dooncarton, Barrnacuile, Gortbrack
Inver Group	Ballybeg Park Limestone	Calcareous schists & marble.	Upper Slopes Dooncarton, Barrnacuile, Gortbrack
Inver Group	Doon-na-Dell Schist	Semi-pelitic (silty) schists	Upper Slopes Dooncarton, Barrnacuile, Gortbrack
Appin Group	Pollacappul FMn.	Calcareous, graphitic and semi-pelitic schists	Middle Slopes Dooncarton Hill
Erris Group	Srahlaghy Quartzite Fmn.	Massive pale coloured quartzites	Middle Slopes Dooncarton Hill
Erris Group	Benmore Fmn.	Psammites (Metamorpic sandstones)	Lower Slopes of Dooncarton Hill, Pollatomish
Erris Group	Broadhaven Fmn.	Psammites (Metamorpic sandstones)	Lower Slopes of Dooncarton Hill, Pollatomish

Dooncarton Mountain also contains an igneous intrusive rock, which is metamorphosed to metadolerite.

The faults in the area are low-angle reverse faults or thrusts, which have emplaced younger rocks onto older rocks. The movement on these faults is interpreted to have occurred during a series of mountain building events, called the Caledonian-Appalachian orogeny, over a 200 million year period, but which ended 400 million years before present. While there is some evidence for reactivation of these earlier structures during the Hercynian Orogeny (c.200 million years ago) elsewhere in Ireland, there is no evidence for any more recent fault reactivation in this area. Faults are orientated at a low angle, less than 40 degrees, to the northerly and easterly facing slopes that have failed, and dip towards the south and south west. As such they are at close to right angles with the failed slope and thus far less likely to fail than a fracture at a low angle or sub-parallel to the slope surface.

The role of the bedrock geology in the landslide event is critical but indirect. The presence of the high ground and slope profile is controlled by the underlying geology, the folding and faulting of which has resulted in the current relief. The different hardness of adjoining formations, such as hard metamorphosed sandstones and more easily weathered schists, has resulted in the stepped profile of the hillside. A north-south fault line, which may contain material which is easier to erode than the surrounding rocks, forms part of the course of the stream flowing into the bay at Pollatomish. Another important factor is that these rock types are all highly impermeable, being tightly cemented and compact, thus have a high run off rate during rainfall compared to more permeable rocks such as younger limestones or sandstones.

3 Topography

The Pollatomish area is dominated by the upland area of Dooncarton Mountain. The summit height is about 260m above sea level at the site of the radar mast. There is a secondary summit just to the east at 242m. The ridge extends further to the west towards Gortbrack with summit heights here of 250m and 233m. The land drops steeply on all sides, towards the coast on the east and north sides, and to the interior river valley on the south side of Dooncarton Mountain.

To the north of Pollatomish, the mountain slope drops steeply almost to the coast on the west side of Sruwaddacon Bay, there being only a narrow coastal strip, where the road is located, at an elevation of 10m to 15m above sea level. To the north of the mountain at Glengad there is a wider coastal strip at elevations of 10m to 20m above sea level. Bedrock outcrops all around the coastline with the exception of the area at the mouth of Sruwaddacon Bay.

The steeper, very rocky slope on the north side of the mountain below the summit may represent an old corrie backwall where there has been accentuated erosion by ice during the Ice Age. The slope profiles vary along the mountainside as determined from the 10m contours on the aerial photograph, but for much of the length there is a relatively even slope between the 50m and 150m contours. Above the 150m contour the slopes steepen considerably towards the ridge crest. It was in this area that the landslides were initiated. Also, above the cemetery and some distance to the north and south of it, the slope steepens between approx. 40m and 100m above sea level.

Surveying by the engineering consultants will have established the slope profiles in detail.

Five main streams drain the mountain area, as defined on 1:50,000 Sheet 22. The principal one is the river which rises on the south side of the summit and enters the sea at Pollatomish beside the cemetery. Moving north from Pollatomish a stream enters the sea at the mouth of Sruwaddacon bay. Another stream flows north to sea at Glengad. Two further streams drain the mountain to the west and southwest. In addition several other gullies drain the mountain between these more major water courses. Much of the rainfall and the resultant landslide material was channelled into these streams and caused considerable damage to property, the roads, and bridges.
The erosive power of this water is well seen in the overdeepened gorges in the streams north of the cemetery where they cross the road.

4 Quaternary Geology

Quaternary Geology is concerned with the unconsolidated sediments (clays, sands, gravels, etc.) overlying the bedrock, and their morphology on the landscape. These sediments and the resultant landscape are the result of depositional and erosional processes taking place during the Glacial (Ice Age) and Postglacial Periods up until the present day.

The Quaternary Geology of this part of County Mayo has not yet been mapped in detail. Therefore there are only very general maps available of the distribution of sediments overlying the rockhead.

The Pollatomish area was glaciated at some stage during the last glacial period in Ireland, termed the Midlandian, which ended some 10,000 years ago. It is not known at what stage of the Midlandian Cold Period (ca. 100,000 to 10,000 years ago) the icesheet advance over the north west part of County Mayo occurred. The ice advanced northwest from the Irish Midlands, breached through the Nephin mountain range and spread out across the lower ground lying to the west of the mountains. In general the drift deposits in this part of County Mayo are fairly thin and consist mainly of a weathered glacial till or boulder clay containing stones of the underlying Dalradian rocks, quartzites and schists. There is little glacial sand and gravel in the region. In the postglacial period an extensive cover of peat developed over the Erris region.

In the area of Dooncarton Mountain and the villages of Pollatomish and Glengad there is a thin cover of glacial sediments and indeed many areas which are drift-free. As stated above, the area has not been mapped in detail so the exact extent of drift cover cannot be confirmed with any certainty. Peat bog lies directly on the bedrock in many places and certainly does on the higher slopes.

It is possible that the upper parts of Dooncarton Mountain were never glaciated (Synge, 1969), the icesheet only reaching a certain height on the slopes of the mountain which is defined by the "drift limit" or the elevation above which no glacial sediments occur. The walkover on the slopes above the cemetery suggests that the drift limit in this area is somewhere between 50m and 100m above sea level.

An exposure on the side of the high road to Barnacuille directly above the cemetery shows a very sandy glacial deposit with small angular to sub-rounded stones. The high sand content probably reflects the lithology of the underlying quartzites and schists, ie. dominated by sand grade particles. This sandy deposit is suggestive of an ice-marginal location for deposition where there has been some degree of sorting by water underneath the ice. On top of this sandy facies there is a layer of head or a colluvial deposit this consists of stones of the underlying schistose bedrock set in a sandy clay matrix. The deposit is very stony and the stones have a preferred orientation or fabric pointing downslope, indicating that sediment has moved downslope. This may have happened towards the end of the Ice Age when periglacial conditions prevailed. There was no ice cover but a very cold Arctic-type climate with extensive permafrost conditions. Alternate freezing and thawing would result in considerable movement of sediment downslope.

No other exposures in the Pollatomish or Glengad area were examined. Reconnaissance mapping by Synge (Synge, 1968) suggested that the steeper mountain slope behind Glengad may have been the backwall of a very old corrie where there had been a local build-up of snow and ice. Remnant hummocks or moraines of this local ice flow were identified downslope near the coast.

An extensive peat cover overlies the bedrock at higher levels. The scars at the back of the slides indicate that this cover was relatively thin, in the order of 1m to 2 m thick on average.

Given the limited extent, particularly their absence on the higher ground, and the limited thickness of the glacial deposits in the area, it is not felt that they were a contributory factor to the occurrence of the landslides. The material that moved in the landslide process was composed of peat, stones and a sandy clay, the latter two being eroded from the weathered bedrock surface underneath the peat.

5 The Landslides

The landslides occurred on almost all the slopes around Dooncarton Mountain. These included the slopes extending from Pollatomish to Glengad facing the sea, the valley head and western slopes of the river valley south of the summit, and on the slopes of the valley to the west of the summit. In these last two locations there was no immediate threat to any houses or farm buildings. The severe havoc was caused between Pollatomish and Glengad.

On the day of the GSI visit, the whole area was viewed from the road and up at the Radar Station. In addition a walkover survey was done in Zone B (as defined by the consultants) from the high road at the end of the houses up the hill to the landslides and then along the slope at that level and back down to the cemetery.

Some twenty plus landslides occurred. They are practically continuous along the slope from Pollatomish northwards to Glengad. There are individual landslides but also groups of coalescing landslides. They occur just below the crest of the ridge where the slope steepens considerably at elevations of 180m to 200m.

In the area of the walkover, the backwall of the slides shows the typical crescentic shape in plan and has a vertical face of 0.5m to 2.0m of peat. Tears in the peat are seen on the margins of some slides. The slip surface has developed at or close to the interface between the peat and the underlying bedrock. This surface is extremely smooth and difficult to walk on, the peat having been smeared and moulded on the bedrock surface. It also exhibits striations or scratches in the downslope direction where coarser material has scored the peat. At a number of the failure surfaces examined a “hard pan” surface was exposed at the base of the peat, this is a mineral (iron and manganese) rich clay layer that forms close to the rock/subsoil interface within the lower part of the subsoil. As a semi-continuous and relatively smooth surface, which would be both impervious and resistant to root growth, it appears to have provided a ready slip surface at the base of the peat. At the lower end of the slip surface there are frequently dumps of the eroded peat and rock. These have been overtopped by the rush of water carrying the smaller peat hags further down.

The extensive distribution of debris all along the slope would suggest there was some sort of sheet flow down the mountain slope at the height of the storm. Further down the slope this surface water was then channelled into the stream gullies which then became overdeepened thus causing further erosion and damage down near the base of the slope.

6 Cause of the Landslides

The underlying geology can be ruled out as the primary causal factor in triggering the landslides. While geological faults occur in the area the underlying bedrock is tectonically stable. Also there are no drift deposits in which lines of weakness could have developed.

It is also the view of the GSI that the construction of the Radar Station on Dooncarton, the operations of Enterprise Energy Ireland, or overgrazing were not contributory factors in the occurrence of the landslides.

It is believed that an exceptionally heavy rainfall event combined with the condition of the peat bog and the very steep slope location resulted in this disaster occurring. During the very hot and dry summer the peat dried out considerably, it contracted somewhat in volume, and cracks developed in the peat surface and probably within the mass of the peat. This unusual physical structure of the peat meant that the rainfall could penetrate quickly to the base of the peat and generate a type of sheet flow, which would cause a slip surface to develop at the interface with the bedrock. The nature of this slip surface, as described above, suggests that this set of conditions happened very quickly creating a downslope force of considerable momentum to dislodge so much debris.

7 Conclusions

Although this may be considered a freak event due to exceptionally heavy rainfall, it does draw attention to the possibility of other such slope failures occurring in other parts of Ireland where similar conditions pertain. Each event whether it be landslide, bogburst or rockfall, are unique events due to a particular set of circumstances. However such geohazards need to be documented to build up a database of past events so that risk assessment can be undertaken. This could then lead to steps to mitigate against potential risks. It is the intention of the GSI as the national earth science agency to create this database of geohazard events and examine the feasibility of carrying out geological hazard vulnerability mapping.

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Appendix - Maps

Figure 1. General location of Pollatomish area, in north Mayo.
Figure 2 1:100,000 scale Geology of the Pollatomish area against 1:50,000 topography.
Figure 3. Geology and 270 deg. relief shaded DEM of the Pollatomish Area.

Fig. 1. General location of Pollatomish area, in north Mayo.

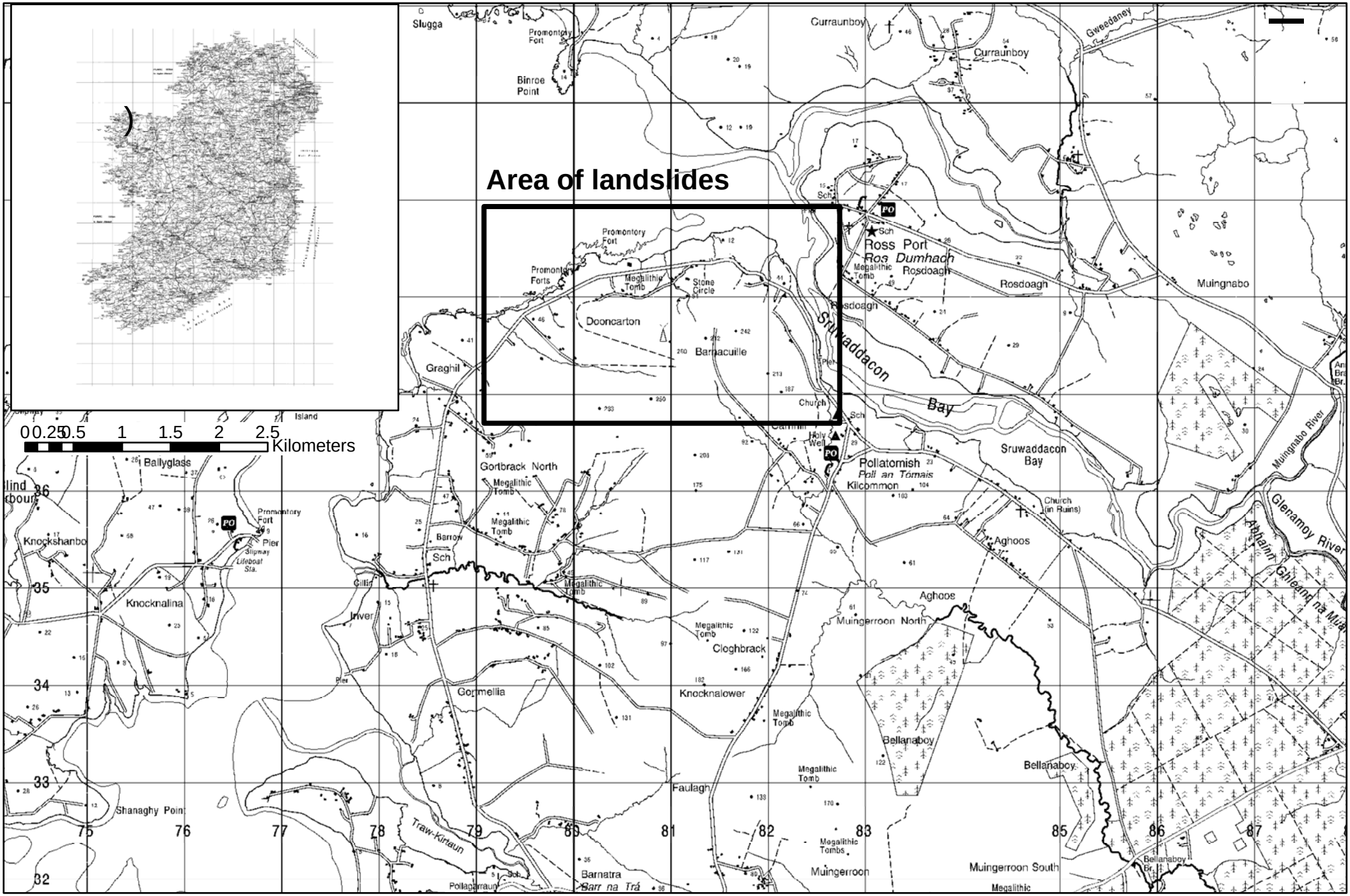

Figure 2. 1:100,000 scale Geology of the Pollatomish area against 1:50,000 topography.

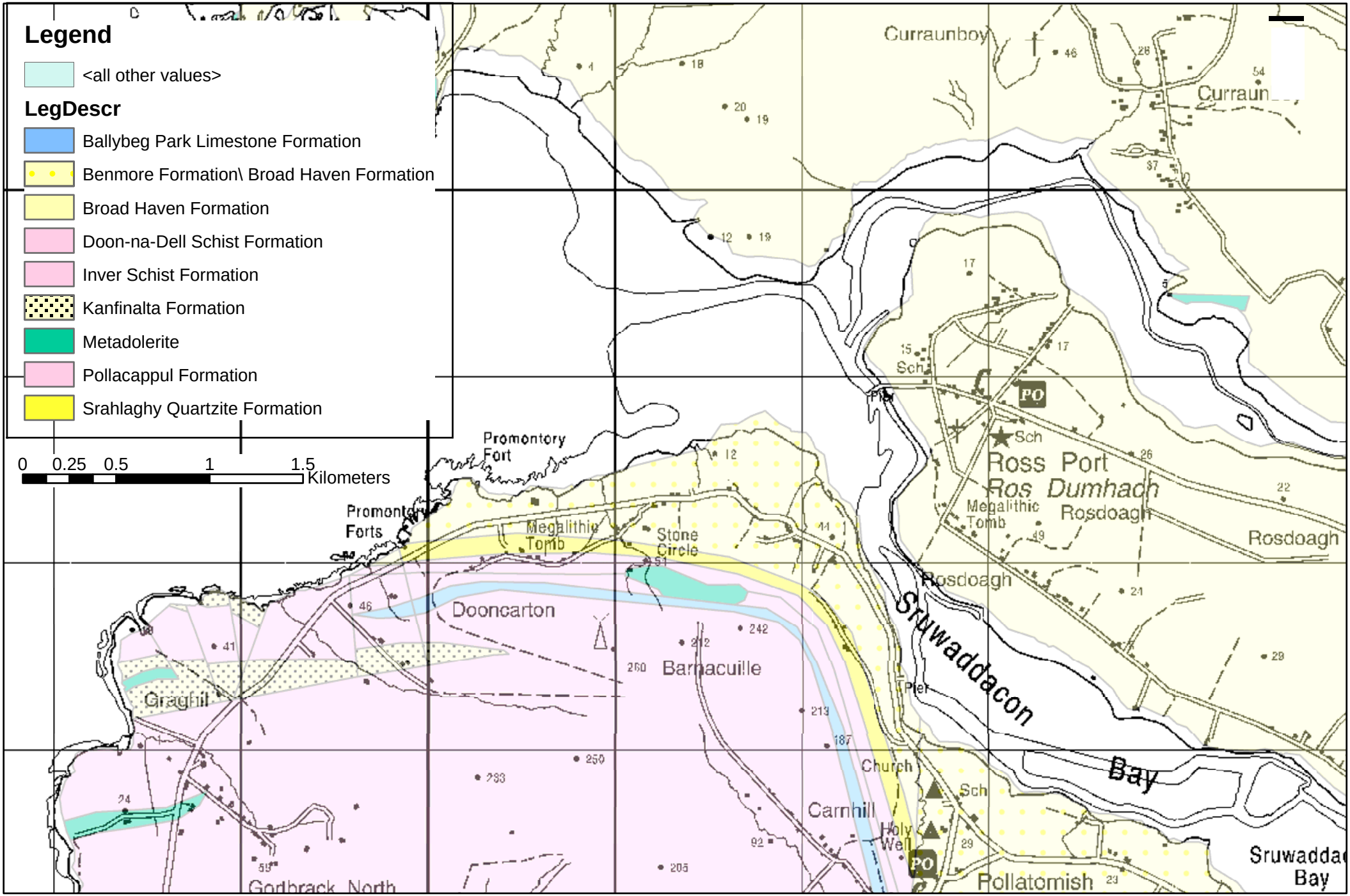

Fig 3. Geology and 270 deg. relief shaded DEM of the Pollatomish Area.