Aspects of the last Ice Age in Ireland

Part I: Glaciations, their processes and investigating ice flows

When it is considered that the Earth is 4.6 billion years old it is obvious that the Irish landscape has undergone huge changes within that time. The geological processes which have operated on the Irish landscape over these billions of years are extremely varied and complex, hence the records of these processes that are left in the surface form of the landscape and their underlying rocks are extremely complicated and fragmentary and difficult to decipher. To understand the landscape in its current form we must realise that various large scale, global events have been more important than others, and though geological processes (*e.g.* the action of rivers and the sea, peat formation) are still operating today in Ireland these have only a minor effect on the overall landscape. The last mega-geological event to have affected the Irish landscape is the last **ice age**, or **glaciation**. This occurred between 73,000 and 10,000 years ago and had a huge effect on our landscape and geology, being the final shaping action over the majority of our countryside. This article looks at the effect this ice age had with respect to the causes of the Ice Age, processes of ice erosion and deposition, and ice flow indicators.

The article will focus initially on the processes by which the ice works on the landscape and causes great changes to everything it meets, as well as some of the indicators we see today which tell us of past ice flows in Ireland.

Why did we have an ice age?

Since the beginning of the Earths History the surface temperatures of the Earth have undergone huge variations, varying from intensely hot conditions to intense cold. These alternating hot and cold lasted for hundreds of millions of years. For example, we know that at the time of the dinosaurs the Earths surface temperatures were high and the Earths climate as a whole was essentially a tropical one. At present, and for the last 50 million years or so, we have been in a time when the temperatures are quite cold as a whole, therefore we are in a kind of global ice age. 50 million years ago Western European climate was sub-tropical. Temperatures have cooled gradually since then and about 2 million years ago the configuration of ice at the poles was pretty much as it is today. Within the last two million years the extent of ice at the poles has fluctuated greatly, extending at some times into the mid latitudes and beyond. It was during these time periods that ice engulfed Ireland bringing with it ice age effects and processes to this country.

Why does the ice at the poles 'grow' and engulf Ireland every now and then?

There are three factors which contribute to the development of glacial conditions in Ireland every few thousand years (Figure 1). These are all related to the Earths position and geometry as an orbiting planet in the Solar System.

The **first factor** is known as the '**eccentricity**' effect. As the Earth orbits the sun, its orbit is not perfectly circular but resembles that of an ellipse, or stretched out circle. This means that over a cycle of 100,000 years the orbit brings the Earth further away from the sun when the elliptical orbit is at its most 'eccentric'.

Being further away from the sun at these times obviously means we don't get as much heat from the sun. This has huge effects on Earth surface temperatures as a whole.

The **second attribute** is known as the '**tilt**' effect. The Earths axis is tilted and the northern hemisphere leans towards the sun in June and away from it in December. The angle of tilt is not stable either meaning the Earth 'leans' towards the sun more at some times than it does on others. This means that if the tilt angle is higher the temperature range may be greater. Approximately every 41,000 years, the tilt is closest to vertical. Sunlight then strikes the poles at a sharper angle, and seasonal variations in temperature are reduced.

The **third factor** is the '**wobble**' effect. The Earths axis wobbles like a spinning top, wobbling along a circular path every 23,000 years. This means that in the case of the northern hemisphere its summer occurs either when the Earth is furthest from the sun on its elliptical orbit, or when it is closest.

These three cycles combined means that the Earth goes through predictable sequences of temperature variations which, when combined and leading to a reduced global temperature, mean that snow and ice do not melt in the mid-to-high latitudes causing glacial conditions. The greatest and longest lasting ice ages occur when all three cycles coincide.

How does the ice collect and flow?

We all know that when snow falls it collects on the landscape but in today's climate usually melts in a matter of hours. Not so during glacial conditions in Ireland. Every few thousand years conditions cause the Earths temperature to fall as a whole which means that snow may not melt in all localities: if snow begins to accumulate it forms a compact, icy substance called **firn** or **neve**. This can further compact as accumulation increases and when this material attains a depth of 50m or so it begins to flow as blue glacier ice. This ice flows similar to the manner wet concrete flows. As the ice flows over its substrate small pieces of rock and soil over which it flows become stuck to the base by freezing on and are therefore 'plucked' from their resting place and incorporated into the base of the glacier. This makes the base of the glacier more grating and it can further erode the underlying material, just as coarse sandpaper will on wood. Therefore by **'plucking'** and **'abrasion'** processes the glacier ice continues to erode everything it passes over, smoothing and polishing underlying rock and picking up material in its basal layers.

In this way rock and soil debris get incorporated into the glacier and can be carried far from their source. Rock material carried in this way is known as erratic material and the individual rocks are known as **erratics**. The erratics may be small pebbles or sand grains forming soil or subsoil or may be large cobbles or boulders strewn across the landscape (Figure 2). The distinction of 'erratic' is the fact that they are resting on a bedrock dissimilar to their own rock type *e.g.* sandstone blocks resting on an area of limestone bedrock.

What was the geometry of the last ice sheet in Ireland?

During the last glaciation ice covered the entire country was covered by ice except for possibly a small area in west Limerick and north Kerry. The ice was moving all the time in the manner outlined above, and was up to 1,000m thick in places. Obviously, the erosive power of an ice sheet one kilometer deep on the underlying landscape was phenomenal. Only our highest mountains peaks stuck up above the ice as **nunataks** (Figure 3) so everything under this level was scoured, planed, smoothed or bulldozed, and in most cases then covered by the massive amount of debris that were left by the ice after it retreated.

The Irish ice sheet was not one great mass of ice but contained a number of independent domes and small ice caps which coalesced to form one overall ice sheet (Figure 4). These domes had ice which radiated out from their centres and moulded the countryside under them. As the ice domes started to melt they retreated in on themselves and huge amount of glacial meltwater was released. The centres themselves moulded the landscape in such a way that we can reconstruct their geometry by looking at certain ice flow indicators in the landscape.

Ice flow indicator 1: Striae.

Striae are scratches into bedrock which are formed by small pieces of rock or soil protruding from the base of the ice scratching the rock underneath them and leaving a groove mimicking ice flow (Figure 5). They are usually found on smooth outcrop surface where the rock has been polished by the abrasive ice. They are remarkably consistent features and many striae may be seen side by side on one small outcrop. They are also found on bedrock under subsoil and if you dig a hole deep enough to hit bedrock not only may the striae be seen, but the very rocks at the base of the subsoil which caused them as this subsoil was emplaced by the glacier all those thousands of year ago!!

Ice flow indicator 2: Roche moutonnees.

Roche moutonnees are asymmetric bedrock bumps or hills with polished up-ice faces and jagged down-ice faces. The polished face is a result of ice abrasion on a bedrock obstruction at the base of the ice and the jagged face a result of plucking. They occur at a variety of scale and may be less than 1m to several hundred metres across.

Many bedrock outcrops in Ireland look polished and on close inspection it is seen that they have jagged faces too, therefore with some detective work we can infer ice flow direction by simply examining bedrock outcrop at most localities.

Ice flow indicator 3: Drumlins.

Drumlins are oval shaped hills which are often blunt at the up-ice end and elongated at the down-ice end, with a thinning tail. They are thus streamlined with their long axes in line with ice flow direction. This characteristic shape gave the feature its name which is derived from the Irish *droimnín* (small, round-backed hill).

They occur mostly in clusters, or swarms, and are usually tens of metres wide and a few hundred metres long. Their long axes parallel ice flow direction. Sometimes they have rock cores. In many counties (*e.g.* Cavan and Monaghan) lakes often occupy poorly drained, interdrumlin areas.

References.

Benn, D.I. and Evans, D. J.A., 1998. Glaciers and Glaciation. Arnold, London. 734 pages.

Warren, W.P. and Ashley, G.M., 1994. Origins of the ice-contact stratified ridges (eskers) of Ireland. *Journal of Sedimentary Research*, A64 (3): 433-449.

Figure Captions:

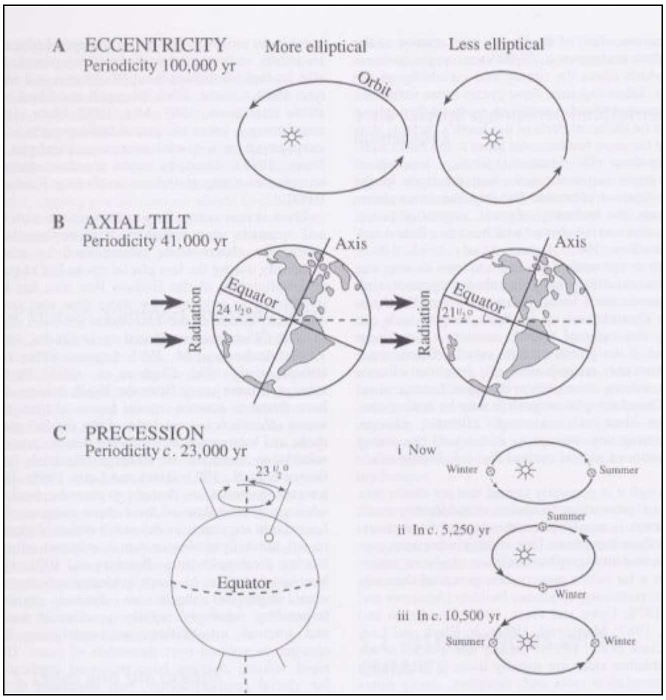

Figure 1: Cyclical variations in the Earths orbit affecting the amount of solar radiation reaching the surface. From Benn and Evans (1998).

Figure 2: Erratics of sandstone in area of limestone bedrock, Oldcastle, County Meath.

Figure 3: Nunatak protruding above Vatnajokull Ice Sheet, Iceland.

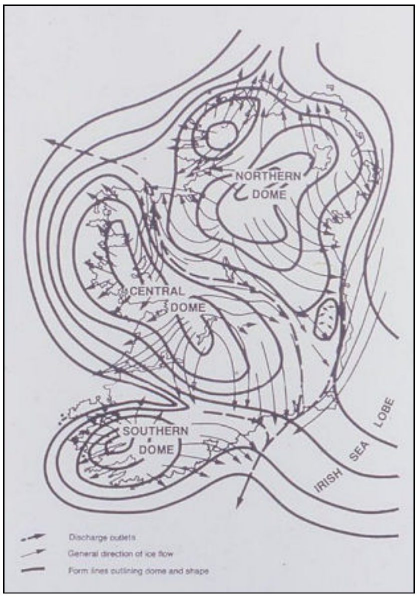

Figure 4: The extent and configuration of ice in Ireland during the most recent ice age here (from Warren and Ashley, 1994).

Figure 5a: Striated rock outcrop in Iceland

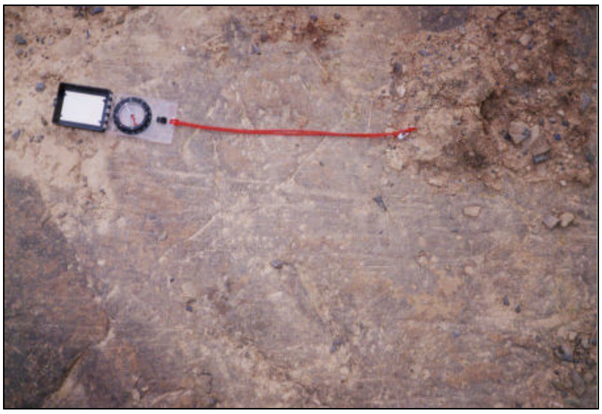

Figure 5b: Striae at Mandistown, north Meath

Figure 6: Slieve Snaught in the Derryveagh Mountains, Donegal. The knob of rock on the right flank of the mountain is a striking roche moutonnee. Ice flow was from left to right.

Figure 7: A drumlin at Aclare in north Meath. Flow was right to left, note the streamlined shape of the hill.