Residential excursion to N.E Ireland

Exploring the Paleogene Volcanoes of NE Ireland.

Friday 2nd – Monday 5th Sept 2016.
Leader: Dr. Fiona Meade participants 10

Friday 2nd September
Report by Maggie Donnelly

Our group met up in the sunshine, outside the Lough and Quay Hotel, Warrenpoint at 1.30 pm. Unfortunately, our numbers were, at this stage, seven – one member had had to cancel, one's car had broken down in Belfast and two were still on the ferry having had to return to Cairnryan because of a sick passenger!!

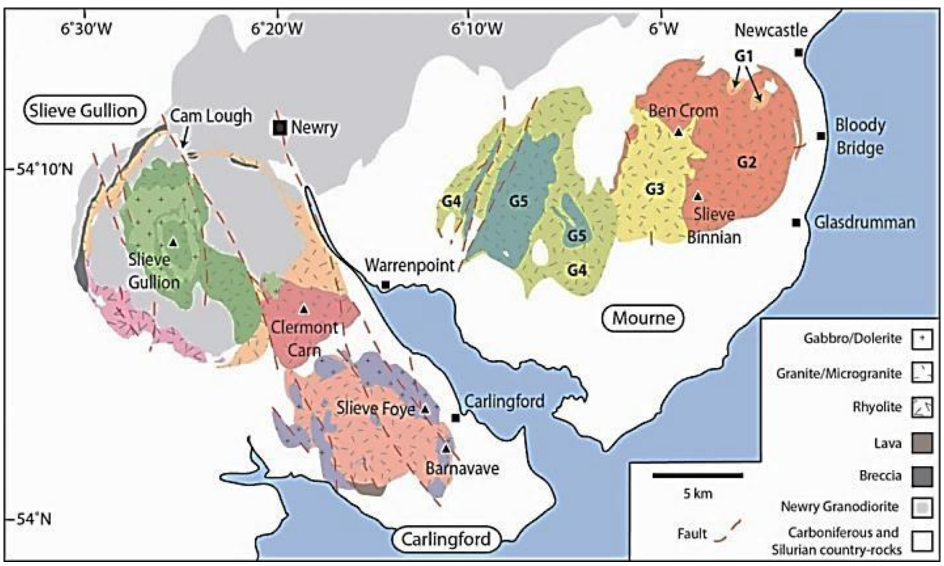

Figure 1. Geological map of the Mourne, Gullion and Carlingford igneous centres, after Cooper & Johnston in The Geology of Northern Ireland (2004)

Our leader, Dr Fiona Meade, gave us an introduction to the geology of the region from an excellent vantage point at the end of the pier. Across Carlingford Lough were the hills of the Carlingford Igneous Centre and the village of Carlingford tucked in by the shore, behind us to the east were the Mourne Mountains with a coastal plain stretching out at the base, and to the northwest lay the Slieve Gullion Ring Complex (Figure 1). We were in the 'Southern Uplands-Longford Down' terrane in which the country rock was Ordovician-Silurian – originally turbidites, accumulated on the floor of the Iapetus Ocean. Here they were more distal than in the Southern Uplands, and so much more finely grained. As the Iapetus closed, the sediments had been compressed, tightly folded and metamorphosed to greenschist facies. The Iapetus suture lay about forty km to the south. Around 400 Ma the Newry granodiorite was emplaced.

During the Carboniferous Ireland lay on a shallow coastal shelf where the sediments were transformed into limestone. From our position we could clearly see this extending coastal slope which gave rise to the words of the song – 'where the mountains of Mourne sweep down to the sea'. About 65 Ma, a plume head impinged on the base of the Earth's crust, stretching it, producing volcanism, the North Atlantic Igneous Province and the opening of the Atlantic Ocean. Although the British and Irish Palaeogene Igneous Province lay at the south eastern edge of the NAIP, about 1000 km from the plume head, the thinned lithosphere of the Mesozoic Basins, aided by pre-existing crustal faults, directed magma migration. The central complexes arose at intersections of ancient Caledonian lineaments – terrane boundaries and the basement highs of the major Basins. Lava eruption began about 64 Ma (Skye, Antrim lava fields) from central igneous complexes in Skye, Carlingford, Mull and Rum, and waned about 58 Ma. A second phase took place around 56 Ma and the Mourne granites were intruded into the Carboniferous rocks. Magma sitting in large chambers at depth for long periods of time allows fractional crystallisation, but here the volcanism is known as 'bimodal' – basic and acidic intrusions/extrusions form, but very few that are intermediate (andesitic). It seems that a large amount of crustal melting occurred producing rocks rich in silica (granitoids).

The area was first mapped in 1925 by J. E. Richey[3] during his six week summer holiday. He identified five separate granite intrusions: G1 – G3 in the Eastern Mournes, G4, 5 in the West, and proposed a 'ring dyke' model, but this interpretation has now been revised by Stevenson (2007) using work by Hood[4] (1981) and Gibson[5] (1984) on grain size, mineralogy, petrology and his own work on mineral lineations. He suggested a laterally 'inflated laccolith model' in which the granites were intruded diagonally from the SE to higher crustal levels in the NW, as a series of individual sills, each underneath and 'jacking up' the preceding one(s), so that the oldest is at the top. The different granites can be identified by their contact zones, and by differences in their weathering and petrology.

We drove along the Mourne Coastal Route to Kilkeel, then to the Head Road for the Silent Valley and the gate of the park, J 3096 2046, where we collected detailed maps of the walking trails and sites of particular interest, before continuing up to a large car park near the café and visitors' centre. The latter had excellent displays concerning the geology, engineering works, flora and fauna of the Silent Valley – a perfect location from which to take in the 'big picture' of the Mourne granites. The Silent Valley reservoir was built in the early 20th Century to increase the water supply for the rapidly growing population and industry of Northern Ireland. An area of 9,000 acres in the Mourne Mountains (with high rainfall) was bought by Belfast Water Commissioners – now owned by Northern Ireland Water. Work to dam the Kilkeel River started in 1923, and the project completed in 1933. However, problems arose because the valley floor was covered in a thick layer of glacial deposits – large boulders had been mistaken for bedrock while in fact the base of G3 granite was at a much greater depth.

We continued the short distance to the Silent Valley reservoir and dam (Figure 2) where the scenery was stunning in the beautiful sunshine). Slieve Binnian borders the eastern side of the reservoir, and high on its flank the boundary between the G2 (older) and G3 (younger) granites can clearly be seen.

Figure2. Silent Valley Reservoir, with the overflow spillway

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Margaret Greene

After taking several photos, we proceeded north about 600 m to the Slieve Binnian Tunnel, J 3090 2275, dug 3.6 km (1949 – 1952) through the Slieve Binnian granite to take water from the Annalong River in the adjacent valley, and so to increase the water supply

The tunnel was mapped before being concrete-lined revealing a host of minor intrusions, and suggesting that these many dykes are probably typical of the whole intrusive complex.

Continuing along the trail we arrived finally at the Ben Crom Dam, (J 3343 2546, 5 km from the park entrance) which towered majestically above us**.** We then had to climb up **'hundreds'** of **steep** steps to where we could walk along the road on the top of the dam – the view was spectacular!

Figure 3. Slieve Binnian Tunnel Maggie Donnelly

We resisted the temptation to head for the large quarry in G3, southeast of the. dam, J 3126 2518, as it is now not easily accessible, the rock surfaces are no longer fresh, the floor is often water-filled and strewn with rock fall debris – in fact it is dangerous!

Completed in 1957, the dam contains the reservoir between mountains which clearly display the contact between the G2 (older) and G3 (younger) granites along the western side (Figure 4). We ventured through the western gate on to the slope for a close look at the granite and to collect a few samples. After all this, we returned to the trail (finding our two members who had been delayed on the ferry!) and down to the café for a resume of what we had seen. To our disappointment, it was now past five o'clock and the café was closed!

We then set off westwards for about 400 m through trees and across open grassland to our final locality, the Mourne Wall, J 3012 2107. On the way we saw a beautiful glacial valley in the distance) and passed the site of 'Watertown' where the dam builders lived during its construction. We also experienced a completely different aspect and view of the Valley and Slieve Binnian. The Mourne Wall which encloses the Silent Valley Park catchment, is up to 2.5 m high, about 1 m thick and 35 km long, and runs over 17 mountain peaks (Figure 5). Built of granite blocks, using the dry stone wall technique, between 1904 and 1922, it could be seen stretching off both north and southwards across the valley and up the precarious slopes of Slieve Binnian to the east. We reached a style and were able to climb onto the wall, taking numerous photos.

Finally, after a **really** good afternoon 'on the rocks', we made our way back to the cars, and back to the hotel for dinner, where we found our last missing member – we were now a completed party of 10 plus leader.

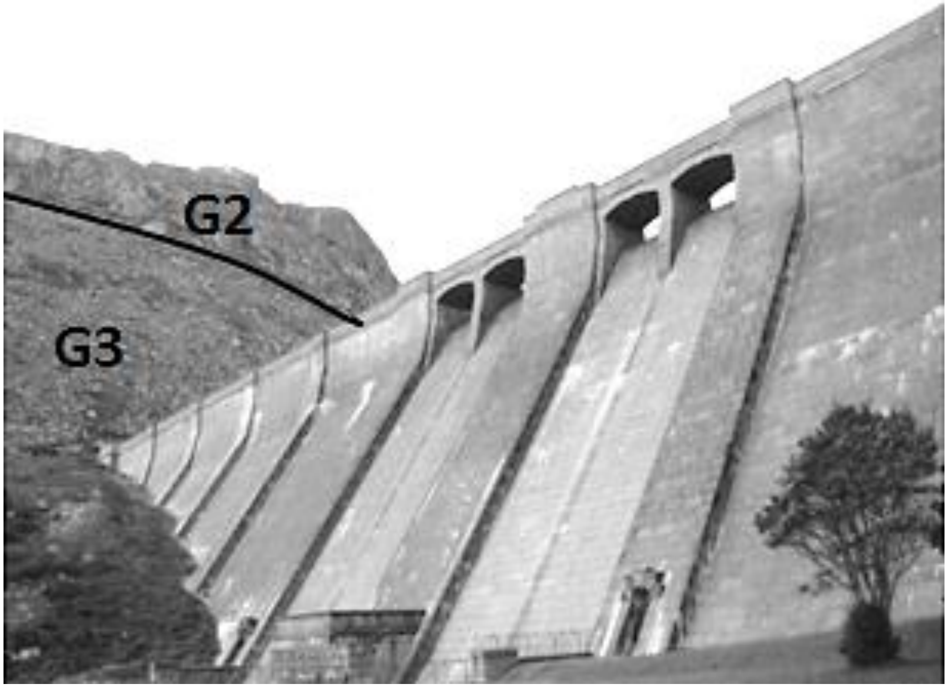


Figure 4. Ben Crom Dam and the two granites

Maggie Donnelly


Figure 5. The Mourne Wall.
Maggie Donnelly

Sat 3rd Sept
Report by: *Seonaid Leishman, Margaret & Phil Greene*
"Bouldering" and Regional metamorphism"

This morning we examined the effect of the Western Mourne granites on the surrounding country rock – the Longford-Down metasediments. The section is exposed in the Bloody Bridge River just south of Newcastle, so named after a massacre of the Irish Rebellion of 1841 when the river ran red. The route is known as the Brandy Path because it was used by smugglers taking goods from the coast up over the Mourne Mountains. Our very wet morning began on the beach examining the metamorphosed greywackes, the equivalent of the Southern Uplands Hawick Group.

'Bouldering' in the river.
Seonaid Leishman

The fine-grained siltstones and mudstones were laid down distally, far out in the Iapetus Ocean, from eroding island arcs, and so include volcanic minerals such as iron, colouring the weathered rock red. During closure of the Iapetus the rocks were metamorphosed to greenschist facies and folded isoclinally with a small dip striking NE – SW, producing green, grey and black layers.

On the river section several groups of young folk were 'bouldering', getting very wet, while we tried to keep at least our feet dry. Across river there was a section through glacial moraine, very poorly sorted with huge boulders so probably laid down as an outflow. We started to climb up through the metamorphic aureole, the result of the Mourne granite intrusion, which would have been at a temperature of 800^0 C. Here the contact is with G2. G2 is more fractionated than G1 and movement was from the SW so that younger granites were thrust under older. G1 through to G5 were emplaced over a 2Ma period. The plume head was situated beyond Skye so that the Mournes activity was on the edge, 1000 km from the centre. As a result, this volcanism could only have happened at terrane boundaries and where the crust is thinner. The layered metasediments began to show the effect of baking, converting to hornfels which is striped pale (quartz and carbonate) and dark (biotite rich). Near the edge of the aureole the granite is finer grained having cooled more quickly. It had little time to contract and so has no joints. Further up the mountain, in the middle of the intrusion, the granite stayed molten for longer allowing the crystals of feldspar, quartz and biotite to grow bigger. This coarse grained granite was quarried for Belfast cobbles. During intrusion, the hornfels would have become almost plastic and is crosscut by veins. Blocks have been fractured from the aureole, trapped in the magma and begun to melt. The granite is crosscut by tuffisite veins where fumaroles of gas, released by dehydration, focused on a zone, fracturing it and depositing material. When the country rock has organic content the gas will contain carbon dioxide and methane which in this case, could have contributed to the K – T extinction! It was still pouring with rain when we returned to the cars so a very pleasant lunch stop was made in the Galley café in Annalong!

Tuffisite vein
Seonaid Leishman

"Mixing and mingling" and the Glasdrumman composite cone-sheet.

After lunch we went down to the beach at Glasdrumman. It had stopped raining! The country-rock of Longford-Down metasediments is heavily folded like a rumpled carpet. Here it is cut by a cone sheet, one of a swarm related to the Western Mourne Centre. This is a form of dyke which intruded via an inward-dipping conical fracture. It is concentric to the granites and dips to north and west.

Heavily folded metasediments.
Seonaid Leishman

The cone sheet developed during an inflationary period and compares with the sills at Drumadoon and on Bute. It was the conduit for two types of intrusion. The margins of the dyke are basaltic and the centre quartz –feldspar rhyolite. Interestingly there are no internal chilled margins so both magmas must have been intruded at the same time, interacting during transport *and* once emplaced. The crystals of feldspar and quartz are rounded so they were not in equilibrium.

The hotter basalt on either side heats and lubricates the thicker more crystalline rhyolite in the centre, allowing it too to flow and produce magma mixing and mingling. This can result in an intermediate zone of darker hybridised rhyolite i.e. dacite. However, traversing south to north along the beach (this has to be at lowish tide) we saw many variations on this theme – basaltic enclaves in the rhyolite and vice versa, producing leopard-print rock. The lava lamp effect! There was also an occasional xenolith of the metasediment. At the northern end, the dyke narrowed and, as the flow rate was constant, the rhyolite and basalt are completely mixed due to turbulence. A dyke such as this may only have operated for a few days! What an amazing exposure and what an amazing day!!

Basalt and rhyolite mingling *Seonaid Leishman*

Our amazing leader *Seonaid Leishman*

Sun 4th Sept

Report by: Rhona Fraser

Carlingford Igneous Centre

Sunday's excursion to the Carlingford Igneous Centre required an hour's long drive via Newry and the crossing of the Irish border despite being only a mile across the water from Warrenpoint. Today's weather was wall to wall sunshine. Carlingford Igneous Centre, which is thought to represent the roots of a large central volcano active around 62 – 66 million years ago, consists of two main intrusions, a microgranite ring dyke with a gabbro infill (i.e. a lopolith if you are a proper geologist).

Both of these intrusions are crosscut by swarms of basaltic cone sheets. The centre shows bimodal magmatism, typical of the North Atlantic Province with granite/rhyolite – gabbro/basalt and no rocks of intermediate composition. Our first locality was just before the bridge into Carlingford village and showed contact between the underlying Silurian Longford-Down meta-siltstone and the basaltic cone sheet (Figure 1 –ugh!!! A picture of me but it does show the contact). There was also a very attractive information board explaining the geology.

Figure 1. Metasediment and cone sheet contact at Carlingford. *Rhona Fraser*

The main part of the day was climbing to the edge of the igneous centre via the well-marked Tain Way. The different geology of Slieve Foye was immediately obvious compared to the rounded granite Mourne Mountains as the Foye gabbro is extremely resistant to erosion and forms steep angular crags.

Figure 2. Slieve Foye and Tain Way. *Rhona Fraser*

Lunch was taken around the Slate Rock where in a very short distance we could see the local country rock which is the Carboniferous Carlingford limestone basal conglomerate (Figure 3), porphyritic basalt cone sheets (Figure 4) and the aureole between them (Figure 5)

Figure 3. Carboniferous Carlingford Limestone basal conglomerate. *Rhona Fraser*

Figure 4. Basalt cone sheet along the side of Slate Rock. *Rhona Fraser*

Figure 5. Hornfels basal conglomerate – compare wit
Figure 3. *Rhona Fras*

Basaltic magma can be as hot as 1200^{0} C, far hotter than granite, so when it is intruded into adjacent sedimentary rock such as the conglomerate, the latter starts to melt with siltstones forming hornfels and limestones marble. As the cone sheet intrudes it inflates, thus potentially cracking and deforming the local rock. The basaltic cone sheet which could be traced along the north slope of the hill consisted of varying amounts of plagioclase feldspar crystals in a basaltic groundmass. . At times the rock consisted of over 90% phenocrysts which would have made it too thick to flow (Figure 6).

Figure 6. Basalt of cone sheet-packed

Rhona Fraser

Figure 7. Microgranite blocks with veining with
with phenocrysts gabbro on summit...and Maggie for scale!!!! . *Rhona Fraser*

After lunch we continued up to the col between Slieve Foye and Barnavave where we reached the contact between the microgranite ring dyke and the overlying gabbro. After the Carlingford volcano ceased erupting about 59 million years ago the region remained geologically active for some time producing large strike slip faults across the area which formed clefts on the ridges. One such defile, our last locality, showed the contact between the knobbly gabbro on top and large blocks of micro granite beneath. The latter was often cut by microgranite veins, the theory being that these were formed by hotter and therefore more liquid parts of the intrusion.

After completion of this most enjoyable and hot day the only thing for it was ice creams back at Carlingford. Then, because some of the party were leaving us, Fiona was presented with a 'thank you' gift, and thanked profusely and most sincerely for leading us on such a fascinating and amazing field trip.

<u>Mon 5th Sept</u>

Report by: Muriel Alexander

Our final visit was to Slieve Gullion and the Slieve Gullion Ring Complex which lie to the west of the Mourne Granites and north of Carlingford. On the previous evening we had driven to Black Mountain and from the height of Clermont Cairn had viewed the spectacular scene of Slieve Gullion and the almost complete ring complex of low hills surrounding it. These were formed by the collapse and erosion of the volcano that was active in the Palaeocene, 60 Ma. Now we were setting off for a much closer view.

We drove on a traverse west through Newry and then on country roads until we turned into a car park on our right which overlooked Cam Lough, J0376 2411. From here Slieve Gullion towered above us across the loch and on looking northwards, we could identify a fault which formed the loch and valley in which we were standing. In the distance this fault had cut the ring dyke and moved the edges dextrally about 2 km apart, almost NW to SE, on either side of the loch.

With fewer cars we returned a short distance to a quarry, J 0362 2458, where the ring dyke was well exposed, sliced through, and with the surrounding rock also exposed. The ring dyke was formed in the Palaeocene by the inflation, then collapse of the roof of the magma chamber under the volcano, causing magma to be forced up the cracks encircling it. We spent some time here identifying the lighter coloured microgranite of the ring dyke on the left, dipping outwards and arched over and the darker metamorphosed sedimentary rock into which the dyke had been intruded. The contact is known as the ring fault down which the rocks above the now empty magma chamber had collapsed. To the right on the quarry wall we found 400 Ma Devonian Newry granodiorite which is also seen in the low area between Slieve Gullion and the ring dyke. On the floor of the quarry some loose rock showed black tuffisite veins cutting through the microgranite. These were caused by gases escaping to the surface during intrusion. After much discussion and hunting around for the ideal specimens we returned to our cars.

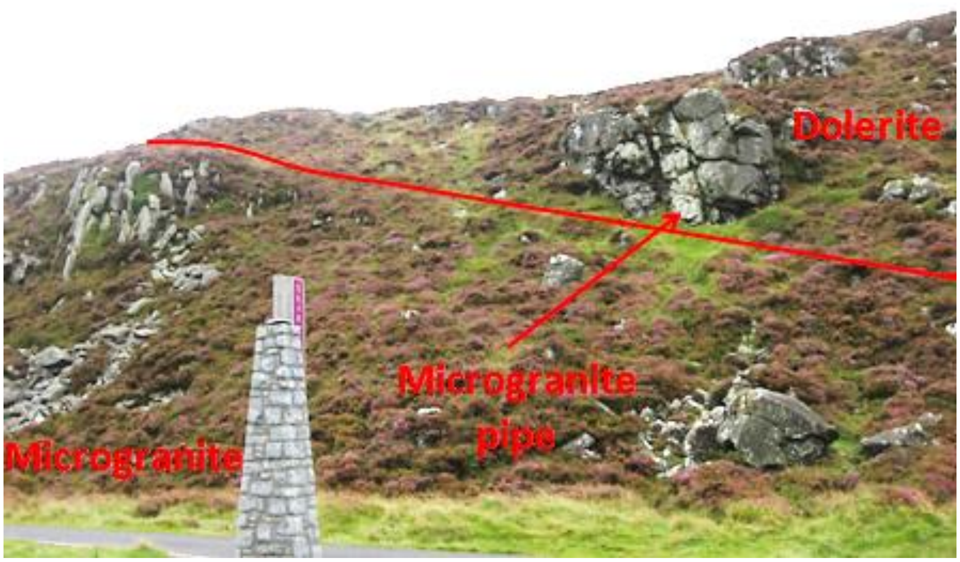
Cam Lough Quarry. *Rhona Fraser*

Cam Lough Quarry. *Maggie Donnelly*

The final location was the Slieve Gullion summit car park, J0181 2003. As we drove up the forest road we looked over at the microgranite of Black Mountain where we had stood the previous evening. This was produced towards the end of the volcanic activity and we again observed where the granodiorite is found on the low ground towards the ring complex. We then continued on to our last stop at the summit car park. Here on the hillside we saw at least two sloping bands of rock, the lower one being lighter grey and lumpy, a felsic microgranite, with a much darker, denser sheet of mafic gabbro above. This is the ‘Central Layered Complex’ which in total, is formed of thirteen layers – again a ‘bimodal’ model. A large mafic magma had been injected into the south western granodiorite of the Newry Igneous Complex during the Palaeocene. Fractionation of this basalt and melting of the surrounding granodiorite and metasedimentary crust would have produced more silicic melt. These mafic and felsic melts were then emplaced as alternating sheets, becoming dolerite and microgranite, to form the ‘Central Layered Complex’. Lastly, there was a microgranite pipe, created where the less dense felsic magma rose up through the partially solidified denser gabbro. A very interesting information board described this igneous activity.

Geology over, we now headed back down to the Forest Park Courtyard and gathered in the café where we enjoyed lunch and said a BIG THANK YOU to Fiona for spending time with us and for a really happy, interesting and thought provoking weekend.

View at summit the car park.   *Maggie Donnelly*



Our group at the summit car park. *Rhona Fraser*

References

1. **Dr Fiona Meade**. Geological Society of Glasgow autumn field excursion. Exploring the Paleogene volcanoes of NE Ireland, 2^{nd} – 5^{th} Sept 2016. **Unpublished Excursion Guide.**

2. **Ed I, Mitchell, 2004.** The Geology of Northern Ireland: Our Natural Foundation. *Geological Survey of Northern Ireland.*

3. **Richey, J. E., 1927.** The structural relations of the Mourne Mountains (Northern Ireland) *Quarterly Journal of the Geological Society of London*, **83**, 653-88.

4. **Hood, D. N., 1981.** *Geochemical, petrological and structural studies on the Tertiary granites and associated rocks of the eastern Mourne Mountains, Co Down, Northern Ireland.*
Unpublished Ph.D. thesis, Queen's University, Belfast.

5. **Gibson, D., 1984.** The *petrological and geochemistry of the western Mournes granites, Co Down.*
Unpublished Ph.D. thesis, Queen's University, Belfast