# Special Proceedings of the Reading Geological Society

# Field visit to Antrim, NI
# 15th-22nd September 2012

East Prospect of the Giant's Causeway, watercolour by Susanna Drury, 1739 (Ulster Museum)

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**Editors; David Ward and Chris Fone**

## Introduction

The Reading Geological Society organises a week long field meeting every two years, the main intention being that the meeting should take the members to areas which are impossible to visit during the one and three day visits that are regularly undertaken, and secondly that do not involve too much travel or carbon consumption. The lead time to plan such an expedition is about 18 months, hence work started in early 2011. Eventually 20 members attended the meeting, a number which gave great satisfaction to the organisers.

Accommodation – always a challenge in organising field meetings – was excellently provided by the Half Way House hotel at BallyGally.

The Society was extremely fortunate in finding Dr Philip Doughty, the retired Curator of Geology at the Ulster Museum, who offered to provide a detailed itinerary, also leaders who all turned out to be of International standard. The leaders all provided comprehensive handouts, even to the extent of individual copies of the excellent "A Geological Excursion Guide to the Causeway Coast" These handouts helped greatly in the field, but were heavily consulted by members in their contributions to this Report.

The area covered by the visit stretched from Ramore Head in the NW, along the Antrim Coast to Larne, and two further sections at Donaghadee. The geology examined ranged from the Silurian at Donaghadee– where the intricacies of terranes, accretionary prisms and subtle folding were revealed, through the Triassic-Jurassic boundary at Larne, where palaeontology and fossil earthquakes were studied, to the magnificent sills and lava flows of the Antrim Basalts. The Giants Causeway, of course, was probably the highlight of the week, but very closely followed by Garron Point, where the rotational failure in the Jurassic-Cretaceous-Tertiary sandwich was extraordinary.

This Report was written by the members – each of whom was allocated a half day – and was edited by Chris Fone and David Ward, who made corrections where needed to the geology and the minimum amount of changes to the English, so that the style of the writers was maintained.

Thanks are due to many people who contributed to the success of this visit – to Philip Doughty, for organising the Leaders, to the Leaders individually, to Chris Fone, Carole Gregory and Edmund Shirley for assistance to the organiser and finally but far from least, to the members who attended and supported the event.

*David Ward, Field Meetings Secretary, Reading Geological Society*

## Members who attended the Antrim visit.

Robin Birtley
Ann Marriott
David Riley.
Clare Fone
Chris Fone
Edmund Shirley
Howard Rose
Christine Moore
David Price
Hilary Jensen
Kit Brownlee

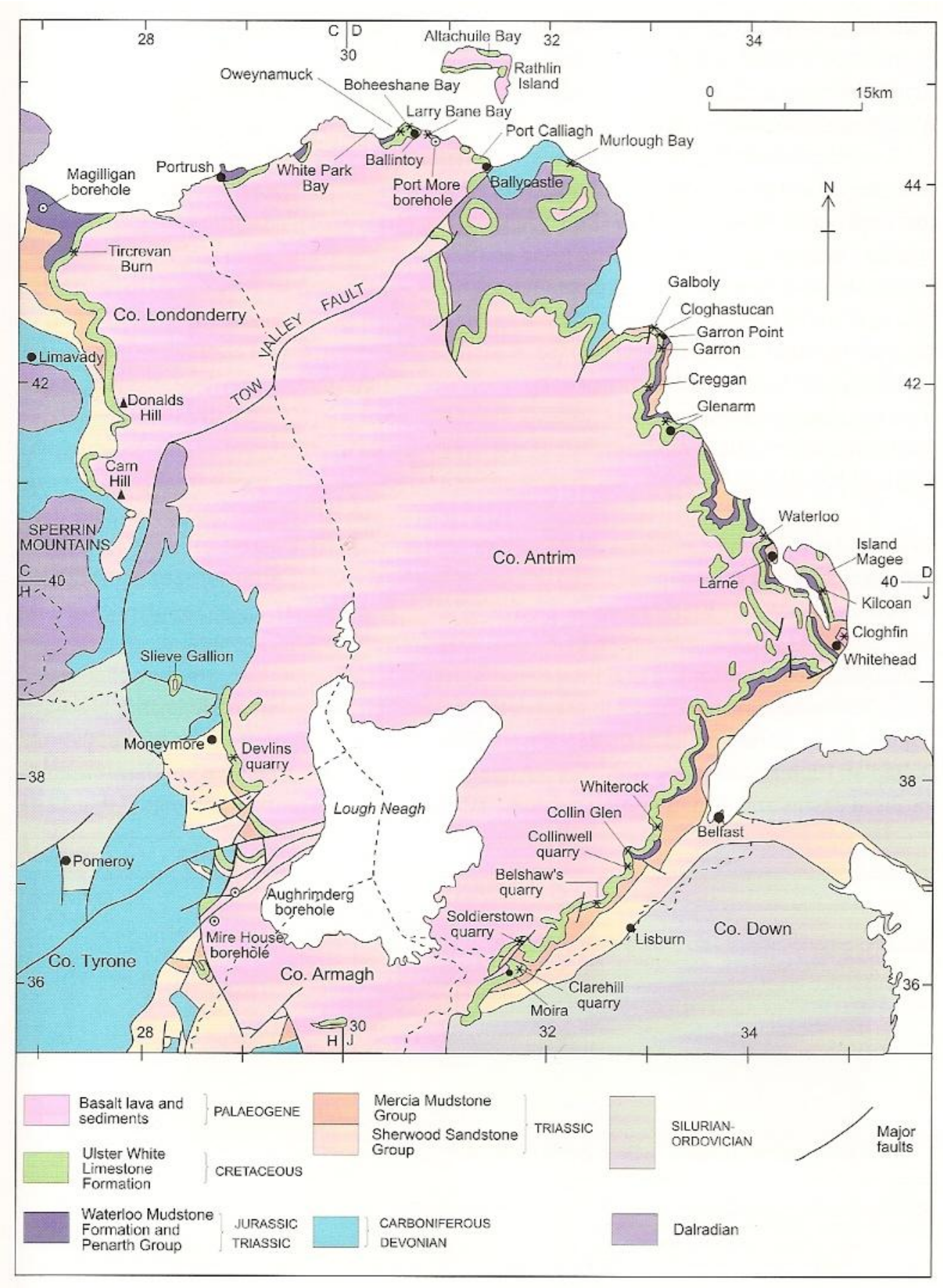
Roger Lloyd
John Hurst
Ricki Bull
David Ward
Elaine Butler
Jeffrey Taylor
Susan Taylor
Susan Barr
Barbara Barrett
Christine Hooper
Robin Hooper

**Group picture on The Giant's Causeway, Antrim (not on this photo are Christine Moore and Kit Brownlee)**

**A wet occasion at Garron Point with Philip Doughty (not on this photo are Christine Moore, Hilary Jensen, Kit Brownlee, Susan Barr, Robin Hooper, Chris Hooper [taking photo])**

**Final evening celebrations with geological themed hats supplied by Susan Barr (Robin Hooper was the photographer)**

## Geological Map of North-East Northern Ireland




Source, 'The Geology of Northern Ireland, our natural Foundation' – Geological Survey of Northern Ireland, pg 151

**Saturday morning, September 15th – the journey to Ballygally**

I was delighted to be invited by David Riley to join this geological field trip; a “first” for me. I always wanted to be a member of a rock group! As the new boy, I was keen to be involved in the half-day reporting procedure but I recognised that my limited geological knowledge was a constraint, so I was relieved when David Ward allocated this time slot to me since it addressed the journey from Gatwick to the hotel in Antrim. The only stratum involved was flying at 25,000 feet! By the end of the week, I felt that I had been accepted into the fold.

The weather at Gatwick South Terminal at 7am was sunny with little wind; the temperature was a pleasant 12C. This was a good omen for the week ahead. My hold baggage check-in was quickly completed and I proceeded to the security check. I made the tactical mistake of putting my trowel in my rucksack, which was my cabin luggage. The X-ray machine detected this tool and I was summoned to explain myself. After a few minutes spent describing the essential nature of this implement for my important geological investigations during the coming week to the security officer, and persuading him that I had no intention of using it as a weapon, the confiscation was averted. (Ironically, I had no occasion to use the trowel during the field trip, and masquerading as an expert geologist was, at best, a “white lie”!) The next adulteration was the mandatory march through the bright lights and musack of the duty-free shopping area in order to reach the central lounge; that really was a liberty too far! I settled on a quiet seat and at 7.45am, David Riley joined me and we mused on the week ahead. At 8.10am, the departure gate (no. 6) for our Flybe flight BE962, scheduled departure time 8.50am, was declared so we made our way there. The glitz of the central lounge quickly deteriorated into a musty, dingy, long corridor, half of whose width was blocked off for maintenance work so passengers were moving in both directions in a restricted space. Chaos! In the gate 6 departure lounge, David introduced me to David Ward and several other members of our party (20 in total) who were also assembled there were pointed out to me. I expressed some surprise at the number of ladies in our party, a statement from which I made a diplomatic withdrawal later in the week!

At 8.40am we started boarding the aircraft, an Embraer E195 twin turbofan jet-engined machine. The leather seats were comfortable with plenty of leg room. After a long taxi and a wait in the take-off queue, we were airborne at 9.12am. From the right-hand side of the aircraft, landmarks such as the O2, Olympic Park and the Square Mile in central London could be easily seen; however beyond the Midlands, cloud cover prevented the point at which we left the English mainland from being observed (on the return journey, we re-joined the mainland over Merseyside).



At 9.50am, the aircraft started its descent into the George Best Belfast City Airport where it landed at 10.15am. After disembarkation formalities and collecting our hold baggage, we were met by the driver of Kirkwood Coaches, which was to provide our transportation for the week ahead. We were all aboard the coach at 10.45am, and we proceeded out of the airport complex and via the M2, M8 and A2 (Causeway Coastal Route) roads to Ballygally, a small, north-facing coastal village.

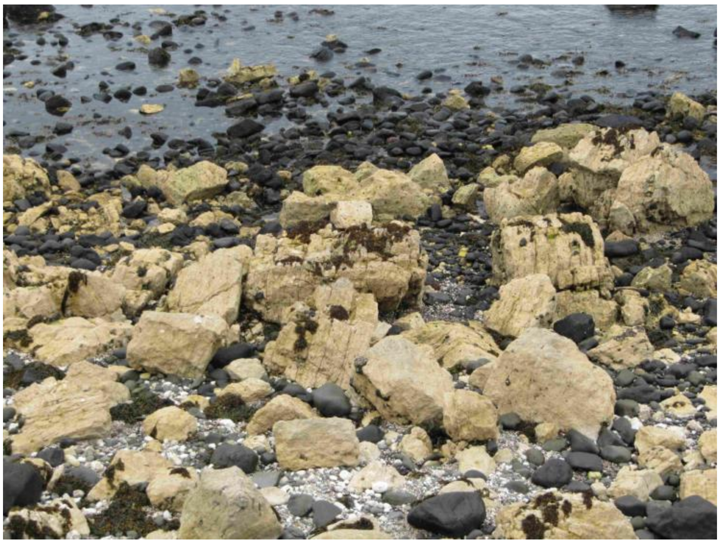

The Halfway House Hotel was situated about 1km west of the village on the A2 road, where we arrived at 11.30am and we were welcomed by Philip Doughty, the main expert leader for our field trip. Philip was due to be our expert leader for the whole week but unfortunately he was unwell and instead he had arranged for several of his expert colleagues to be leaders for selected days during our trip. A final itinerary for the field trip, with named expert leaders for each day, was distributed to all members of the group. We checked into our rooms and congregated in the bar for a snack lunch at 12.15pm.

*Report and photos by Robin Birtley*

**Saturday afternoon, September 15th – Ballygally north**

After a quick lunch we were keen to explore the coastal geology outside the front of our hotel, just north of Ballygalley. Some of our party went south and some north, along the beach and A2 road.

The A2 wanders along the coast and was built in the 1830s to link up the coastal villages. For much of the way it runs on a raised beach, about 8m above the current sea level. Although the sea level rose after the last ice age the land rose even faster due to the removal of the huge pressure from the ice sheet, up to a km thick.
The loose rocks on the shore are dominated by two types, one white (limestone) and one almost black (basalt); hence it is sometimes known as the black and white coast (photo). Their origin is revealed by the generalised vertical section of this part of the coast (see diagram below).



The 'white limestone' is the same formation as upper chalk in southern England but much harder and denser due to the filling of the voids with calcite. This process was discussed in detail later in the week. The limestone is sufficiently hard to form pebbles on the beach, although many had been bored by creatures in recent times (see photo left). Following a period of erosion basalt lava flowed over a landscape similar to the Downlands in southern England; about 60 million years ago. The basalt preserved the chalk by preventing erosion and reducing its solution by percolating water.

The cliffs are unstable due to the presence of the Waterloo mudstone below the chalk. Above the road we observed a jumble of fallen rocks and debris (see photo below on page 10). Later in the week we studied the larger landslips further north, including classical

rotational slips. Some of the larger slips occurred soon after the disappearance of the last ice sheet, about 13, 000 years ago, when the removal of the ice, supporting the cliffs, caused huge slips of the chalk and basalt lava over the soft mudstone below.

Our walks along the beautiful coast wetted our appetite to learn more about the exciting geology during the coming week.

*Report and photos by David Riley*

**Saturday afternoon, September 15th – Ballygally south**

The flight from London, Gatwick to Belfast took about 1.15 h, then via a small coach 19 members of the Reading Geological Society were driven a short distance through Antrim north to the Halfway House Hotel, Ballygally – (our base for the week). We were met by the friendly greetings of Philip Doughty who had kindly organised for us the itinerary and leaders for the week. Philip joined us for lunch and would be leading us on one of the visits later in the week.

As a short introduction to the geology he explained that the basal rocks were a continuation of the Grampian and Midland Valley Terranes of Scotland. To the north of Ballygally we would see the Dalradian metamorphic rocks, the red Triassic rocks of what was originally referred to as the Upper Keuper Marl, the Jurassic Lias and the Cretaceous Chalk. Philip explained that the Wealden rocks of the early Cretaceous are absent from Northern Ireland, either eroded or perhaps not deposited in the first place. These rocks had then been overlain in the Palaeogene by the Antrim Basaltic sequence which was pointed out as the rocks on Ballygally Head, visible to the south (see photo left). To the east were two small offshore islands called the Maiden Rocks, one with a lighthouse, and these were Palaeogene Dolerite rocks.

Following lunch the first stop was to disentangle our 'flight legs' by taking a walk across the road outside the Hotel to the sand and boulder beach! A mixture of pebbles was examined, one piece of chalk (White Limestone in Northern Irish literature) contained a section of a Belemnite (see photo right). Most of the group then walked south toward Ballygally village and across its boulder-strewn beach as the tide was low. The boulders were up to 2.5 m size and were typically a very hard Chalk with flint layers or Basalt.

Some of the basalt had small amygdales containing zeolite minerals; Sue Taylor found one with attractive needle-like crystals of the zeolite, Natrolite. Near the Ballygally slipway large boulders had been deposited as 'Armour protection', one tall block with an imaginative shape had been painted with an animal's face which we later learnt was the Ballygally 'polar bear'.

On the way back to the Hotel for dinner we met Robin and Chris Hooper, who were extending their motor home trip around Ireland to include our geology field trip.

*Report and photos by Clare Fone*

**Sunday morning, September 16th – Carrickarade – Leader Dr Paul Lyle**

We all set off from The Halfway House Hotel in our coach on our first full day of geology, meeting our leader for the day at the National Trust car park in Larrybane Bay on the north Antrim coast. The highlight in the morning was to be a visit to Carrickarade Island; this is spelt more commonly as Carrick-a-Rede but originates from the Gaelic 'Carraig-a-Rade' and the spelling used in this report will follow that more commonly used in the geological literature. The journey was about 1 hour, during which the weather changed from bright sunshine to heavy showers, a cycle that remained with us for the rest of the day.

Our leader, Dr Paul Lyle and his wife welcomed us at the NT car park, about 0.5 km east of Ballintoy village and took the opportunity to give an overview of the geology at Carrickarade on the coach during one of the heavy showers which were driving-in from the west. Early in the Palaeogene, about 60 Ma, the split between the Eurasian and North Atlantic plates (proto North Atlantic) started impacting on what was to become the Irish and west Scottish coasts. The separation was initiated by stretching and rifting in the continental crust, the first phase of which was an explosive volcanic environment at points along the fissures, followed later by basaltic lava eruptions, rather like we see occurring in present-day Iceland. The lava eruptions appeared to occur in two separate time periods separated by a relatively dormant period when weathering was able to produce vegetation and a soil horizon. The lava production periods are called the Lower Basalt Formation and the Upper Basalt Formation with the period between referred to as the Interbasaltic Formation.

The surface geomorphology at the start of the volcanism was a vegetated, undulating Karst surface on the Upper Cretaceous chalk, which in Northern Ireland was much less porous and much harder than the chalks in southern England as a result of a 2nd phase of crystallisation in the rock matrix. It is formally referred to as the White Limestone in Northern Ireland.

With the sun appearing we left the comfort of the coach and started walking east along the cliff footpath. Paul then gave us an overview of the geology and history of Larry Bane Bay.

At the western extremity of the Bay, Larry Bane Head, a quarry had cut into the White Limestone and was worked in the 19th and 20th centuries, primarily as a source for agricultural lime production. Adjacent to the car park and National Trust buildings were the remains of another quarry, this time working the Dolerite Sill that formed a commanding cliff to the south (see photo left). It was unusual to have sills in the Lower Basalt Formation, which are normally extrusive lava layers, but here the

Knocksoghey Sill had intruded and was probably linked to Sheep Island offshore of Larry Bane Head. Paul explained that all the basalts in Antrim had the same mineralogical proportions and throughout had no change in the magnetic pole alignment. This made it very difficult to differentiate between basalt exposures over Antrim but supported the evidence that the period of volcanicity was only over a relatively short 1 to 2M year period.

Looking east our main objective was visible; the volcanic vent, which comprised an agglomerate of ash and boulders, was the base of Carrickarade Island and had been protected from erosion from the sea by a ring of dolerite sheet dykes. These were quite visible from our stop location. Paul explained that seaward, to the north, a major E-W fault, called the Ballintoy Fault, existed and which had dropped the land section rocks about 100 m. This fault was probably a reactivated PreCambrian or Cambrian fault and was interesting in that it didn't follow the normal NE-SW trends of the typical Caledonian faulting.

We then walked to the famous rope bridge that gives access to the island itself; it is about 30 m above the sea and straddles a narrow gap, quite a challenge in a strong breeze! Apparently there is a history of a rope bridge at this location for over 350 years, giving access to an ideal fishing location (see photo left). On the Island Paul explained the location and background behind the small volcano of Carrickarade. The volcanic vent was approximately 600 m diameter and most of it on the mainland, with only the northern quadrant making up the island. A series of dolerite dykes formed a protective outer carapace to the main vent and these were visible to the west and east (see photo below left) on the mainland cliffs as well as the edge of the island. The vent itself was an agglomerate of ash and boulders (mostly rounded); the boulders being mainly basalt but Chalk and Lias material are also found in the agglomerate. This material was quite visible in the steep cliffs of the mainland and those forming the gap traversed by the rope bridge (see photo below).

The small volcanic vent was one of a series of vents along the north Antrim coast and represented the initial phase of volcanicity, before the main basalt lava eruptions, occurring along an old pre-existing fault that was reactivated by the rifting tensions caused by the opening of the Atlantic. The explosive nature of this initial phase was initiated by the magma’s reaction with ground water in the chalk karst terrain existing at the time.

Paul explained that the subsequent basalt lava flows that covered the area could be compared with the Iceland fissure eruptions of the present day and whilst they covered a large area of Antrim, they thinned out quickly to the north of the current coastline. By studying the occurrence of zeolites in the Iceland basalts it was discovered these nearly exclusively occurred in the lower flows and not in the later upper fissure flows. In this part of Antrim the basalt is all zeolite-rich and by making a correlation with Iceland it has deduced that as much as 600/700 m of volcanic material has been eroded from the region since the Palaeogene period.

We then made the return journey across the rope-bridge and back to the National Trust car park, taking cover from the occasional shower blowing in from the west. Lunch, purchased earlier on route to the north coast, was eaten on the coach or, by some weather-resistant members, in the picnic areas around the adjacent NT buildings.

*Report and photos by Chris Fone*

**Sunday afternoon, September 16th – Ballintoy – Leader Dr Paul Lyle**

The focus of the afternoon was to examine the Cretaceous chalk outcrops and faulting surrounding the basalts.

Locality 1: Ballintoy Harbour car park
The Causeway basalts are limited at the north and south by faults; Ballintoy harbour lies on one of these E-W faults: to the south lie the chalks and to the north lie the basalts which have been down-faulted. The chalks are exposed on the landward side. Above the sea cave, bedding within the chalk is clearly visible to the south side, but the fault line is seen above the cave, and brecciated chalk is visible to the north.

It is known that Lias clay lies underneath the chalk under the car park, however this is now concealed in this locality. Looking along the length of the harbour it is clear that the harbour has been formed along a fault as chalk is visible on the south and basalts on the north.

Moving easterly along the coast, the chalk can be seen to dip at about 15 degrees; this is explained as “fault drag” where rocks at the edge of a fault are dragged in the direction of movement of the fault.

Locality 2: Bendoo plug
Past the harbour can be found the Bendoo plug. This is a doleritic intrusion within the chalk a few hundred metres across, which has been fully exposed leaving a steep black cliff, showing contraction joints. Some metamorphosed chalk was visible. During our visit, the actual contact was obscured by sand, but we were informed that it is occasionally fully exposed and was at most 0.5 m thick; it is thought therefore to have been formed by a single event, as continuous eruption over extended periods can cause more extensive metamorphism. Basalts (dolerite is a coarse-grained basalt) are also known to absorb water form their surroundings which would limit the effects. Observations of similar sized intrusions in Hawaii are known to cool in 10-15 years.

Locality 3: Beach west of Ballintoy harbour
On the west side of the harbour we were able to inspect the downfaulted basalts on the beach. Large expanses of ashes were exposed, weathered green due to the formation of chlorite. Two formations of basalts were visible, underlain by a clear red band of varying thickness (see photo left). The latter is formed of buried ashes. It was explained that vesicles tend to accumulate at the top and bottom of cooling lavas, and these could be seen above the red band; they were infilled by zeolites, which are known to form at 300-500 degrees C.

Locality 3: Coast path west of Ballintoy
Looking towards the sand can be seen a raised Pleistocene beachline, and behind an old sea cliff. The leader explained that this formed as a result of sea level rises after the loss of the ice sheets, but before the land rose again (see photo right).

Rotated chalk blocks line the coast, due to the existence of the Lias clay beneath which allows rotational sheer (see photo below). The fractures within the chalk allow the formation of springs due to its increased permeability, and these are found at the junction with the Lias clays.

Locality 4: White Park Pay, east end
A small amount of Lias was found exposed on the beach, however due to the tide it was not possible to investigate in detail; this was overlain by some basal conglomerate visible in the cliff above.

Further along on the beach was a boulder about 0.8 m in diameter. This is a green microgranite containing a sodium amphibolite called Riebeckite, and is one of the best examples of erratics from Ailsa Craig (its only known source regionally). There followed a discussion of the location and direction of movement of ice sheets in Ireland. The existence of these erratics on the Antrim coast shows that the Scottish ice sheet expanded into Ireland at least once; the Irish ice sheet is thought to have had its greatest thickness in the counties south of Antrim, and this section of coast was therefore affected by both.

*Report by Edmund Shirley. Photos by Edmund Shirley and Chris Hooper*

**Monday morning, September 17th- Cushendun – Leader David Ward**

Where coordinates are quoted they are given with respect to the Irish Grid described in 1965. The 4 figure coordinates shown below give lengths to the nearest 10 metres. The first four digits are eastings and the second four digits are northings

A) Cushendun Foreshore

We first visited a coastal location at Cushendun (coords 3250 4334). At this point there is a weathered and wave worn narrow, rock outcrop of low relief in the foreshore; the shoreline is aligned here approximately NNE-SSW. There is a terrace of houses fronted by a narrow service road close to sea level behind the foreshore and the width of the outcrop between the service road and tidal line is only about 10m. There is no beach sand here but limited deposits of light coloured beach sand do occur nearby to the south.

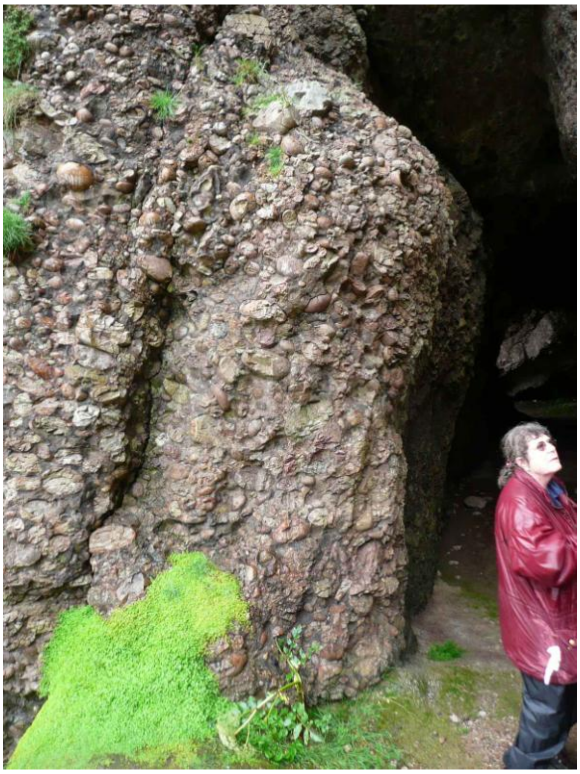
The predominant rock in the outcrop is a grey green, fine to medium grained, deformed, metamorphosed sandstone with narrow quartz veins; this is said to be a Dalradian schist of likely Precambrian age (see grey rock in photo above). The Northern Ireland geological map (solid, 2nd Edition, 1997) shows this outcrop to be the shoreline limit of the Glendun Formation, described as a metamorphosed series of sandstones (psammites), shales and mudstones (pelites) with quartz segregations. In tectonic terms this Formation is part of the Southern Highland Group terrane better known on the Scottish mainland to the east.

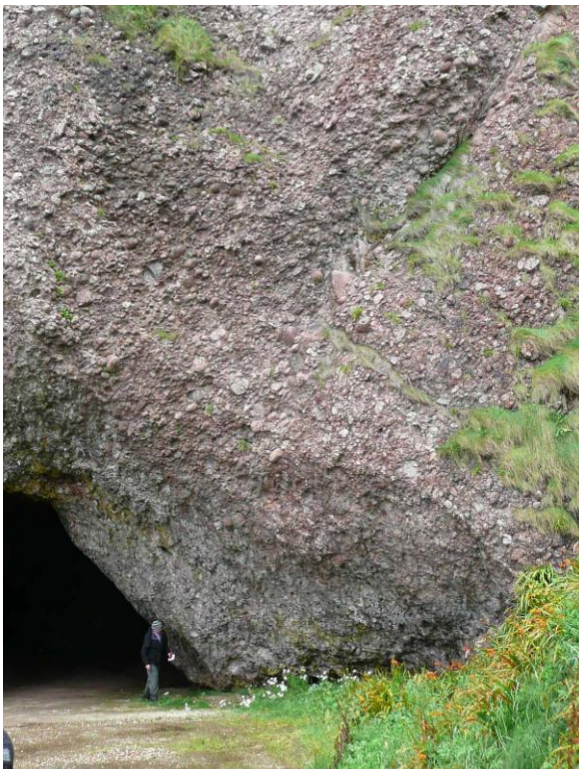
There is a conspicuous intrusion, striking approximately NW-SE, within the Dalradian formation at this point. The intrusion appears as a dyke in the present orientation, about 5m wide with a steep dip to the SW (see pink rock in photo above). This intrusion has a dark pink cast; it is generally fine to medium grained with frequent small phenocrysts but it has also swept up occasional large clasts of the host schist during its injection. The contact with the Dalradian on both sides appears to be tight without clear alteration zones. The appearance could suggest the dyke is a dacite in intrusive form, i.e. a granodiorite, and the map shows an extensive occurrence of granodiorite about 2 km to the NW. The age of the intrusion must be less than the Dalradian so it probably appeared during the Cambrian or Ordovician periods.

B) Cushendun Conglomerates

A short walk southeastwards through the village took us to the impressive coastal headland of conglomerate cliffs (3252 4325) and their easily entered sea caves. The floors of the caves are close to but higher than present sea level so indicating a change in sea level in the past. Seen from below the height of the headland appears to be of the order of 20m above present sea level and it continues inland towards the south west.

The conglomerate is a chaotic assemblage of cemented, generally rounded clasts of up to about 500mm in size, many of which have exposed fractured faces. Some of the clasts are said to be quartzitic but they also include red sandstones, tuffs and schists. Interlaminations of coarse sandstones and mudstone also occur. These are clearly high energy torrent deposits placed in different flood events. There are no fossil remains so the age is uncertain but the Geological Survey of Northern Ireland names them as part of the Cross Slieve Group





and a formation time in the lower Devonian period. There are other views which speculate they could have been placed in much later Triassic times.

*Report and photos by Howard Rose*

**Monday afternoon, September 17th- Cushendall – Leader David Ward**

Sites visited. OS map of the area, Bally castle sheet 05 1: 50 000


1. Hill viewpoint at Clady on the A2 183m looking south west into Glendun------ to see overall glaciation effects
2. Cushendall Town viewpoint to see spur Lurigethan left by glaciers cutting Glenballyemon and Glenariff
3. Coastal Valley sides of Glenariff showing vegetation bands, seen from Red Bay lifeboat station car park.
4. Cushendall beach site at Limerick point Red Bay to view porphyry, schist and sand beds
5. Roadside site south of Red Arch on the A2 past Redbay pier----- to view caves on raised beaches

The viewpoint (see photo left) over Glendun ---- was reached by parking in a lay-by at Clady and going through a metal farm gate. One could appreciate the moorland terrain of heather, peat bog, tussocks of grass and boulders making walking difficult to the outcrop overlooking Glendun.

The glens have all been glaciated over 2 million years by a series of glaciers and ice sheets. They are classic U shaped valleys. Several streams now form V shaped and hanging valley tributaries into the glens.

Site 2. In the town one can see the spur of Lurigethan which was carved on each side by two glaciers cutting Glenballyemon and Glenariff (see photo right).

Site 3. The view across the bay from the lifeboat station at Red Bay shows the changes in vegetation caused by the underlying geology. The moorland plateau with poor acid soils on the dolerite, the green meadows of the chalk soils in the mid-section and the poorer soils on the lias at sea level can be easily picked out. Horsetails are abundant on this poor lias soil and it is not economic for farming (see photo left).

Site 4. The beach site was reached by walking through a housing estate where all the roads were called Dalradia. There is no clear access from the lifeboat station car park through the caravan site. The beach site at Cushendall is 8 km south of the morning site at Cushenden. There were many similarities and some differences. The discussions continued on the origin of the features of the beaches.

Agreement was reached that these rocks were laid down in either Triassic or Devonian times, but the clasts are of Dalradian - PreCambian to Ordovician age. These beaches are one of the few sites along the coast where the dolerite plateau igneous rocks and the hard white chalk deposits have been worn away and multiple faults have lifted the lower stratigraphic sequences to ground level.

* *Dalradian in geology describes a series of metamorphic rocks, typically developed in the high ground which lies southeast of the Great Glen of Scotland. This was the old Celtic region of Dál Riata (Dalriada), and in 1891 Archibald Geikie proposed the name Dalradian as a convenient provisional designation for the complicated set of rocks to which it is difficult to assign a definite position in the stratigraphical sequence.*

*In Archibald Geikie's words, "they consist in large proportion of altered sedimentary strata, now found in the form of mica-schist**, graphite-schist, andalusite-schist, phyllite, schistose grit, greywacke and conglomerate, quartzite, limestone and other rocks, together with epidiorites, chlorite-schists, hornblende schists and other allied varieties, which probably mark sills, lava-sheets or beds of tuff, intercalated among the sediments. The total thickness of this assemblage of rocks must be many thousand feet." The Dalradian series includes the "Eastern or Younger schists" of eastern Sutherland, Ross-shire and Inverness-shire, the Moine gneiss, as well as the metamorphosed igneous and sedimentary rocks of the central, eastern and southwestern Scottish Highlands. The series has been traced into the northwestern counties of Ireland. The whole of the Dalradian complex has suffered intense crushing and thrusting.   Source wikapedia*

*** The schists constitute a group of medium-grade metamorphic rocks, chiefly notable for the preponderance of lamellar minerals such as micas, chlorite, talc, hornblende, graphite, and others. Quartz often occurs in drawn-out grains to such an extent that a particular form called quartz schist is produced. By definition, schist contains more than 50% platy and elongated minerals, often finely interleaved with quartz and feldspar. Schists can contain garnets.  Source wikapedia*

There are intrusions of porphyry *** dykes and evidence of xenoliths of Dacite**** (see photo below).

**** Porphyry is a variety of igneous rock consisting of large-grained crystals, such as feldspar or quartz, dispersed in a fine-grained feldspathic matrix or groundmass. The larger crystals are called phenocrysts. In its non-geologic, traditional use, the term "porphyry" refers to the purple-red form of this stone, valued for its appearance.*


*The term "porphyry" is from Greek and means "purple". Purple was the color of royalty, and the "Imperial Porphyry" was a deep purple igneous rock with large crystals of plagioclase. This rock was prized for various monuments and building projects in Egypt, Imperial Rome and Europe. Source wikapedia*

*****Dacite: Dacite is an extrusive igneous rock. Dacite lava is most often light gray, but can be dark gray to black. Dacite lava consists of about 63 to 68 percent silica ($SiO_2$). The principle minerals that make up dacite are plagioclase, quartz, pyroxene, or hornblende. Dacite generally erupts at temperatures between 800 and 1000 degrees C., and is one of the most common rock types associated with enormous Plinian-style eruptions.*
*Source* *http://vulcan.wr.usgs.gov/LivingWith/VolcanicPast/Notes/dacite.html*)

Intrusions of igneous rocks into sedimentary sandstones, laid down in desert conditions, further layers of ash and lava, have been subject to metamorphic forces of temperature and pressure and then weathered, faulted and folded many times which gives a complex puzzle to try to unravel. These rocks have been buried at depth of up to 10 km and it was a rare opportunity to see them uplifted to beach level at Cushenden and Cushendall.

They now appear as a conglomerate of porphyry and Dalradian schists, cobbles and boulders interspersed with sand lenses (see photo left). The largest boulders at this site were 600mm, not as large as the Cushenden caves site. The stones appeared more altered and the crystals devitrified.

The group considered the similarities and differences of the deposits:

| | |
|---|---|
| Cushenden site morning | Cushendall site afternoon |
| Boulders larger | Boulders smaller |
| Sheared pebbles and boulders | No apparent sheared stones |
| Stones more rounded | Stones more oval |
| Cementing material finer grained, both dark red sandstones | Cementing material coarser grained |
| Small sand lenses | Larger visible sand lenses |
| No quartz or basalts found | Quartz and basalt found |
| Possible some chatter marks on the rocks indicating they are worked by water | No chatter marks – wind driven only? |

It was clear that the strata of the rocks had been re-worked by wind, weather and perhaps water and washed into beds of conglomerate and sand and cemented by pressure over a long period.

Photograph (see page 18) showing comparative typical size and shape of porphyry beach pebbles. The Cushenden pebbles had larger feldspar crystal.  The Cushendell pebbles were typically smaller and asymmetric, the crystals also smaller or missing.

The group considered how these conglomerates had been assembled. One theory was they had been blown or washed by flash floods or sandstorms into deep wadis in desert conditions. Another theory was they had been tumbled off a continental shelf.  The differences in the deposits could be explained by the multiple faults in the region which fits with the beaches being formed in similar conditions but at different times.

Site 5 – Nanny's caves. There is no easy parking access to the roadside caves. There were originally six caves in the Triassic sand and mudstones of Red Bay. It is accepted that the caves were created by the sea when the beach levels were higher after the last ice age. The sea levels were higher and rising due to the extra volumes of melted ice and the land was recovering and lifting from the removal of the weight of ice too.  For a sufficient period the beach levels were 3.5 – 10 m higher than they are at present.  At this time the caves were formed and the raised beach can be seen at many sites on the coast. Many sections of the coast road are built on the raised beach. The photograph (see lower photo page 19) shows a small cave forming in the wave cut notch and also shows the very poor lias soils with primitive horsetails growing. (Pteridophytes, Equisetopsida, growing since Devonian times.)

*Report and photos by Christine Moore*

**Tuesday, September 18th – Murlough Bay and Ballycastle Bay – Leader Dr Peter Millar**

Loughaveema (Sheet 05 D207360)

The first stop was by the A2 where the lake Loughaveema is sited in a sub glacial melt water channel which runs north into the Carey Valley (see photo left). This channel is part of a series of channels that developed at the time of the decay of an ice sheet centred on Lough Neagh after the Last Glacial Maximum in Northern Ireland, 15,000 BP. The lake was the source of myths and legends as it cyclically empties and fills rapidly. It was empty on this occasion and channels cut into the peat were visible in the larger part of the lake basin to the east of the road (see photo right) Later in the week it was completely full. To the north of the lake there is an outlier of Cretaceous Ulster White Limestone Formation capped with Lower Antrim Basalt. The lake area was originally mapped as chalk and it was assumed that the fluctuating levels of the lake were due to seepage through the Ulster White limestone, a very hard and calcite rich form of chalk and the seepage was mostly through joints. It was thought that these are periodically blocked with peat, controlling the drainage of the lake. However, recent investigation shows that the lake occupies a depression in the Dalradian formed as a result of the sub glacial streams flowing northwards; the chalk only underlies the northern edge. Hence the more likely reason for these fluctuations of water level is the slow seepage through the underlying glacial gravels in the melt water channel. From the Earth Science Conservation Review of sites in Northern Ireland "Groundwater seepage of this type along partially buried portions of melt water channels may be more important that hitherto realised in the control of water levels within glaciated terrain."

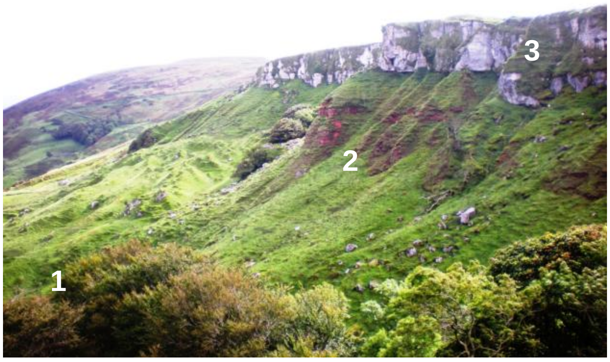
The second stop was briefly to look at the Carey Valley itself. (Sheet 05 D166398). From the road, it was possible to identify a Gilbert-type delta structure formed when the lower Carey valley was flooded. Vast amounts of debris were carried sub-glacially down the melt water channel and formed a delta when entering the flooded valley. As the water level fell it left a series of terraces and deltas, indicative of a stepped series of reductions in water level.

Murlough Bay (Sheet 05 D190418)

The first stop was a view point along the coast to east and west. First Dr Millar talked about the three basement terranes of Northern Ireland:-

- the Central Highlands (Grampian) terrane consisting of basement rocks of Dalradian (Neoprotozoic-Cambrian) bounded in the south by the Fair Head-Clew Bay Fault a south westerly extension of the Highland Boundary Fault in Scotland.
- the Midland Valley terrane bounded in the north by the Fair Head-Clew Bay and to the south by the Southern Upland Fault. It is mostly covered by Upper Palaeozoic, Mesozoic and Palaeogene rock.
- the Southern Uplands-Down-Longford terrane bounded in north by the Southern Upland Fault and to the south, the Iaptus Suture Zone. This is characterised by Ordovician and Silurian greywackes and shales, stacked up as an accretionary prism (more about this with Bernard Anderson at Donaghadee).

Murlough Bay is within the Central Highland terrane with basement of Dalradian overlain by rocks of Carboniferous age.




The view to the east (see photo left) shows Dalradian in the lower part of the cliffs (ref 1). The Sherwood Sandstone (Triassic) lies unconformably above (ref 2) but the unconformity was obscured by extensive landslips. Above that is the Ulster White Limestone (ref 3). Between these upper two outcrops is an interval of 150M years; elsewhere in Northern Ireland the Lower Jurassic (Liassic) is present but here the whole of the Jurassic is missing. On the far skyline is the Dalradian of the exhumed landscape that forms Highland Border Ridge, the Triassic tapers out against this ridge.

The view to the west (see photo right) is dominated by the Fair Head Sill, a dolerite intruded into Carboniferous, Triassic and Cretaceous sequences and is the same age as the Antrim Plateau Basalts. Fair Head Sill is a complex intrusion of many columnar jointed sills inter-fingering into the sedimentary strata; it is inclined to the south and thins to the east and south. The maximum depth is about 85m. This could be seen more clearly later on in this excursion.

The second and further stops were on the beach. At the eastern end of the beach the

Dalradian schists were examined in detail (see photo left). These are highly metamorphosed siltstones and sandstones formed in the Grampian orogeny and detailed examination showed cleavage at a high angle to the bedding and Dr Millar demonstrated how this was related to folding. To the east, at Torr Head, the bedding is inverted and large nappe structures have been mapped. Numerous quartz veins were observed and in Omagh, the veins in the Dalradian are mined for precious metals by the Galantas Gold Corporation.

Walking back along the beach to the west, there was a marked change to dull reddish sandstones and shales mapped as the Ballycastle Group, in the Lower Carboniferous. The Carboniferous is down faulted to the north by the Great Gaw Fault which runs east-west along the foreshore from Murlough Bay through Fair Head to Ballycastle Bay. The down throw is as much as 400m. These are interpreted as deltaic deposits being coarse grained immature sandstones deposited in the faulted syndepositional basin. Elsewhere, in Ballycastle for example, there are coal seams in these beds. Examination of the sandstones indicated that there are bands of pebbles of white quartzite eroded from the quartz veins in the Dalradian schists which form the exhumed surface of the Highland Border Ridge. We also observed nodules of iron oxide in the coarse sandstones.

Continuing westwards volcanic rocks interbedded with the sandstones outcropped on the beach and also formed the offshore rocks and small islets to the north. These are the result of contemporaneous vulcanicity at this time. Basalts and an ash layer were examined. One outcrop had been originally mapped as pillow lavas and the general consensus of the group was that this was correct (see photo left).

At the bottom of the road leading to the car park, was a large lump of dolerite from the overlying Fair Head sill; this was lying such that the columns in the olivine dolerite could be seen in cross-section (see photo right). Dr Millar then discussed the Fair Head sill intrusion. The jointing makes the dolerite susceptible to weathering by ice expansion and there were vast scree slopes below the cliffs. The position of the conduit was not known, but probably lay to the north, the sill itself thickens northwards and is now cut off by marine erosion. The view to the west clearly showed two sills, the upper is the Fair Head sill and the lower is the Binnagapple sill, separated by about 10 metres of Carboniferous shales. Below them is the former Arches coal mine within the Carboniferous.

The final stop was at the top of the cliffs where the extreme eastern edge of the sill just fingering into the chalk could be seen, the contact showing signs of contact metamorphism in the chalk.

*Report and photos by Hilary Jensen*

The coach then took us to Ballycastle where Dr Millar explained the geology and history of the attempts to mine the coal seams in the Carboniferous beds of the region. We examined an adit entrance and a significant dolerite dyke, then spent a period on the beach looking at examples of fossil wood in the sandstone beds exposed on the foreshore (see photo top left on page 23).

Dr Peter Millar escorted us back to Ballygally where we thanked him for leading another fantastic day.

*Report extracted from RGS Newsletter No 190 – November 2012, report and photo by Chris Fone*

**Wednesday morning, September 19th - Portrush – Leader Ian Enlander**

Our guide for the day was Ian Enlander, an employee of the Northern Ireland Environment and Heritage Service where he was a member of the Earth Science Team. Our first activity would be to examine the Portrush dolerite sill. Later we would visit Dunluce Castle, an impressive old structure dating from the 13th century.

Portrush Sill - On arrival at the foreshore at Portrush we examined the Jurassic deposits of Lower Lias age. These rocks were well bedded and were clearly of sedimentary origin. We could observe numerous fossils on the surface. In particular there were numerous examples of Ammonites (see photo below). Magma had intruded into these lower lias rocks to form the Portrush sill. The sill was thought to be over 40m thick in parts and had intruded widely over the surrounding area. We could see the interface between the sill and the overlying lias over a short 20m stretch of rocks (see photo above with pen lying on the sill roof). The hot magma had baked the Lower Jurassic Lias deposits which were now brittle and were effectively indurated. These altered rocks were perhaps a metre thick and were termed hornfels. We were told that the Middle and Upper Jurassic deposits were never deposited in this part of Ireland and there was an unconformity in deposition between the Lower Lias and the Cretaceous white limestone representing 10 million years. The age of the Lower Lias could be inferred from the ammonite fossils found (see photo right). There were also numerous limpets which tended to dissolve away the rock to which they were attached leaving distinctive markings (see photo top left on page 24)

Fossils here were also a key part in the development of the science of geology. An

interesting historical controversy between the Vulcanists and the Neptunists had at one time raged around the interpretation of these fossils. The Neptunists put forward the theory that all rocks had been deposited from the Ocean by a process of chemical deposition. The living creatures that died clearly fell to the bottom and were embedded in the rocks to become fossils. The Vulcanists on the other hand maintained that igneous rocks were at one time molten and could not therefore contain fossils. The Vulcanists generally got the better of the argument but the Neptunists riposted that the Portrush ammonites were clear evidence that these rocks, being of igneous origin, favoured the Neptunist theory. No one at the time was able to point out that these rocks were merely altered or metamorphosed sedimentary deposits and that there was no inconsistency in the Vulcanists' position.

Visit to Dunluce Castle - Dunluce Castle, home to the Earls of Antrim, had its origins in the 13th Century and had been rebuilt again in the 17th century. It's defensive position mattered more to the builders than the unstable structure it was built on. Legend has it that the kitchen collapsed into the sea and only the kitchen boy survived. We were interested in the nature of the rather rubbly breccias on which the castle was built. Some clasts were huge, up to 5m in diameter. It was clear that a volcanic event had breached the surrounding Ulster White Limestone Formation. A view of the dark lavas adjacent to white limestones, taken from the Castle Bridge is shown above. It was thought that a mass of ejected volcanic material had fallen back to form the basaltic agglomerate (see photo right). It was not clear how wide the neck of the volcano had been. One vertical vent wall was exposed 60m East of the mouth of the Dunluce burn. The white Limestones were of Cretaceous age while the volcanic vent events occurred in the Palaeogene.

*Report and photos by Roger Lloyd*

**Wednesday afternoon, September 19th - The Giants Causeway – Leader Ian Erlander**

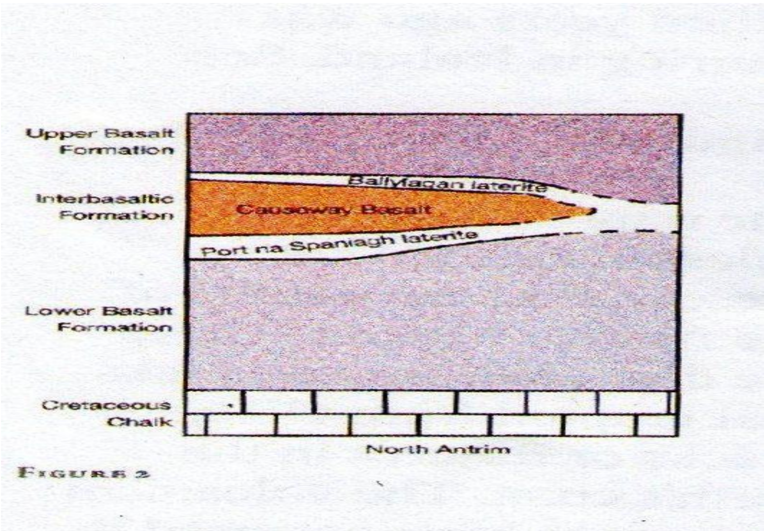
Above the top of the Ulster White Limestone Formation lies the Antrim Lava Group (early Palaeogene ~60million years BP). The Giant's Causeway site has exposures of the lower levels of this group, from the Lower Basalt Formation to the third lava flow of the Causeway Tholeiitic Basalt (contains a higher level of silica than olivine basalt).

On the descent from the visitors centre, a feature rising from the sea on the left, called the Camel's Back, is a dolerite dyke intruded into the Lower Basalt which possibly fed the platform basalts of the Upper Basalt Formation. Emplacement of dykes like this was facilitated by the 2-3% of crustal stretch due to the rifting of the North Atlantic.



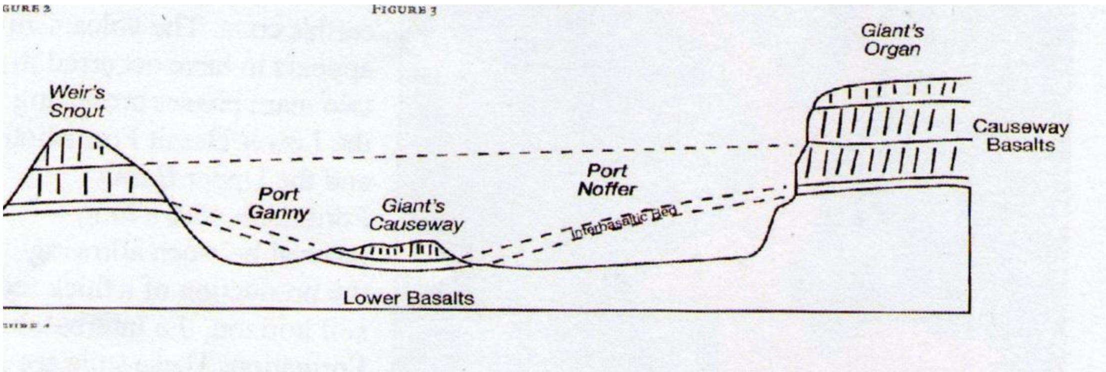
Descending further, an outcrop of Lower Basalt is seen to be covered by a purple/red/grey material that dips steeply towards the Causeway (see photo above left). This is a laterite, (Port na Spaniagh member) that was formed on the weathered upper surface of the Lower Basalt during a lengthy period of volcanic inactivity. The basalt surface featured deep valleys with highly weathered soils depleted of alkaline and silica materials to leave a soil rich in goethite and bauxite (1-10m) which was an economical mining prospect and led to ~ 400 adit mines around Northern Ireland for the extraction of iron and aluminium ores which were shipped to Cumbria for processing.

Around the corner and lower is a good outcrop of Lower Basalt that shows 'onion' weathering, where physical and chemical weathering has developed rounded boulders from the original basalt blocks (see photo above right).



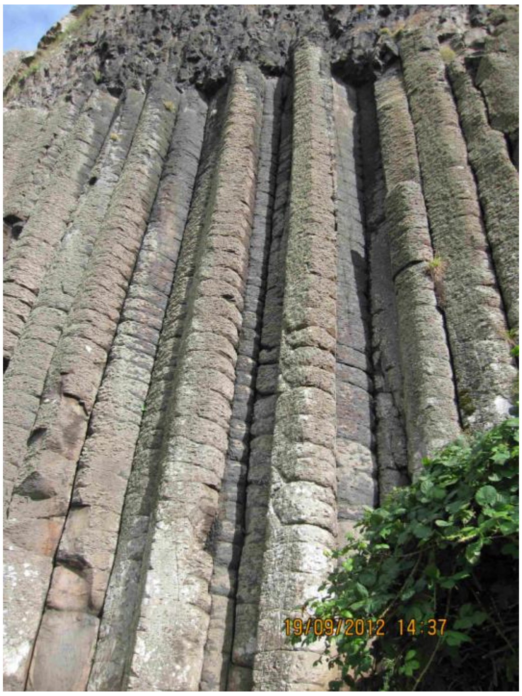

Localised volcanic activity in north Antrim produced the Interbasaltic Formation that sits on the weathered Lower Basalt. This formation is contained between the Lower and Upper Basalts and includes the Port na Spaniagh laterite on the lower surface and the Ballylagan laterite (the weathered surface of the final Interbasaltic flow) on the upper surface.

There are six flows in the Interbasaltic formation of which the lower three are exposed at the Causeway site. The first flow erupted to fill a valley on the Lower Basalt weathered surface and form a deep pond of lava (between 30-100m deep) which then cooled slowly from beneath and rather more quickly from above due to the presence of water on the upper surface (lake/river?).




The immediate chilled contact at the base (with red soil layer plus vegetation) produced a thin layer of a rubbly bottom followed by the 3-7 sided irregular polygonal, but mostly hexagonal columns of basalt.

The upper cooling front from the surface was affected by the presence of water which descended down 'master joints', ~ 5m scale, which led to deformation of the columns to produce smaller curved structures. The cooling fronts from the top and bottom met to give a lower 'colonnade' with an upper 'entablature' (named by the Russian geologist S.I. Tomkeieff). Further cooling then produced the horizontal 'ball' and 'socket' joints, all clearly visible in these photographs below.

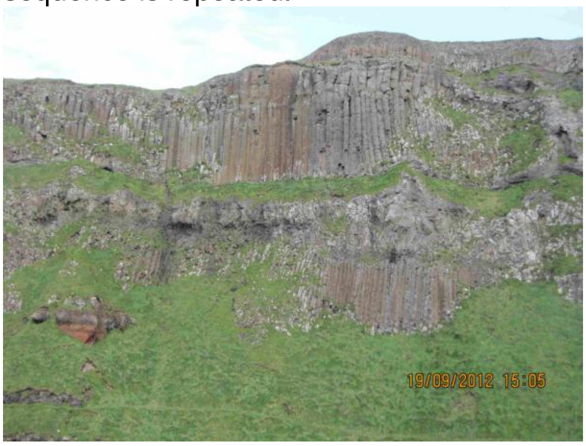

Following the path around Port Noffer, another fine example of the colonnade and entablature of the first flow is found at the Giant's Organ, which is topped by a grassy ledge lying between flow 1 and flow2 (see photo right). Although the columns look symmetrical there are obvious imperfections which were incorporated into the total structure.

Continuing northwards after the 'Organ', the Port na Spaniagh laterite (up to 5 m deep) is once again exposed with good examples of the 'Giant's eye' – highly weathered rounded basalt blocks lying within the laterite layer (see photo top left on page 27).


The secondary mineral talc and remnant columnar structures were also found in this layer.

Just around the headland (going east) between Port Noffer and Port Reostan is a dolerite dyke which runs from below sea level up to the top of the promontory and shows bifurcation at the path level.

The path in Port Reostan was blocked but still allowed a fine view of the first two flows of the Interbasaltic formation at the 'Amphitheatre'. The photograph below left shows a glimpse of the Port na Spaniagh beneath the colonnade of the first flow. Above the colonnade is the entablature (see photo below right) followed by a grassy section before the sequence is repeated.





After a steep climb out of Port Reostan, with its fine views of the Causeway, David Ward thanked Ian Enlander for his excellent explanations and guiding.

*Report and photos by John Hurst*

**Thursday morning, September 20th – Larne Foreshore – Leader Dr Mike Simms**

Dr Mike Simms is the Curator of Paleontology and Meteorites in the Department of Natural Sciences at the Ulster Museum. His interest and expertise include the Triassic/Jurassic coastline of Antrim.

William Bald Memorial - William Bald was the engineer who led the building of the 40km. coast road along the Antrim Coast from Larne to Cushendall, between 1832 and 1842. The road allowed access to the Antrim Glens and enabled communication and trade along the coast via road rather than their previous reliance on the sea route to Scotland for trading. Bald used the original level of the raised beach, formed c. 8500-6000BP, as the platform for his road, a novel approach as previous plans had been to build the road inland. He also blasted parts of the cliffs in order to obtain additional stone for the road. It was a great achievement for its day, costing £37,140 – some £12,000 over budget, and remained largely unchanged until the 1960's.

Travelling towards Larne - Mike pointed out the formations at Ballygally Head NW535629 where a massive dolerite intrusion formed columnar shapes, larger in 'diameter', but not as extensive, nor as impressive as those on the Giants' Causeway. Looking out into the bay the small islands called the Maidens were visible, also dolerite, with the one to the north looking so much like a battleship that it had been torpedoed by the Germans in the Second World War.

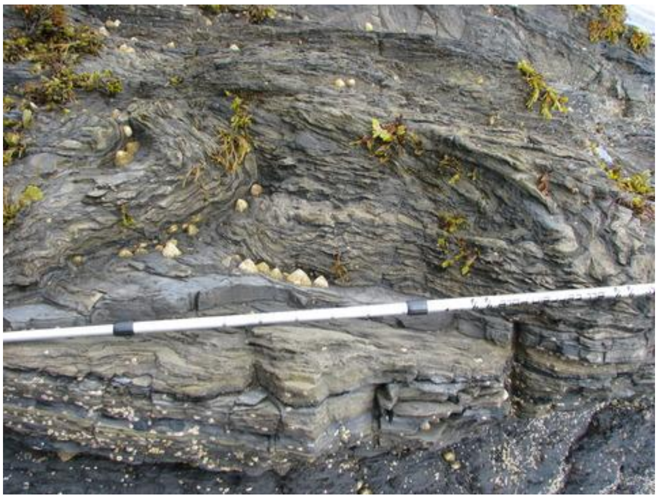
Larne, Waterloo Bay – D409037 NW5558 and NW5657. The shore below the promenade at Waterloo Bay, Larne, is the best place in Northern Ireland to see the transition from the latter Triassic to the early Jurassic. Two sedimentary basins subsided in the early Triassic – the Larne- Loughneagh basin here and the Rathlin trough, separated by a high ridge at Murlough Bay, tilting 25° N.

Mercian mudstone, a red non-marine deposit that underlies this area was laid down 240-230 Ma. The greenish-grey siltstones of the Collin Glen Formation were seen in the cliff at the southern end of the area. Microscopic dinoflagellates can be found in the Tea Green Marl within the Mercia Mudstone. This layer was deposited in water, probably brackish, possibly within a lagoon. As the sea level rose, salinity increased leading to shallow lagoons.

As one moves northwest along this section of the coast, the deposits change to those of the Penarth Group (approx. 15m thick). The lower part of this group, the Westbury Formation, is dominated by dark shales in which are found sandstone and pyrite (see photo left). When sampled it is consistent over distance, here 7m but over the UK always 5-10m thick. The darkness of the shales derives partly from the organic matter and partly from the pyrite which when finely divided gives a black rather than silver colour. Within the laminated layers of the shale can sometimes be found a lumpier layer with tubular burrows. In these 'lumpier' layers enough oxygen was available for burrowing creatures to live. The formation of these shale layers could have been in sea water as shallow as 5-7m with a small tidal range. Dr. Simms explained that in this scenario anoxia would increase under quiet conditions, allowing the black shale layers to be laid down. A storm affecting the area would then bring in oxygen and sand that would also bring life into the area and allow it to flourish, only to disappear again as the conditions quietened.

Certain layers of the black shale, however, do contain fossil scallops and other fossils of smaller bivalves, although never in the same bedding plane. Variations in salinity may explain this: at 3.5% salinity (the norm) diversity of life is found in sea water. When the salinity increases to 3.7% or decreases to 3.2% most creatures will die. There are organisms that will survive 1.75%; where this is the case they thrive because none of their predators have survived. It is likely that a combination of the two explanations account for the fossils found in the occasional black shale layer.

Above the Westbury Formation, a bit further north on the beach, there is an abrupt change to a paler unit (originally sand and mud) of the Lower Cotham Member with variation in its strata – contorted folds of varying orientation, bedding plane slickensides, some stretch and shear along cracks and a 'mangled' appearance indicate a period or instance of the churning up of about 3.8m (vertically) of soft sediment (see photo top left on page 29). Dr. Simms suggested that the cause of this deformation was consistent with a tsunami arising from a seismic event, possibly caused by asteroid impact, of which evidence has not yet been found. He discussed the idea that the stretch and shear could have happened later but



showed that there was no evidence of sedimentary movement adjacent to this area and this fact indicates that the churning occurred as a result of one event. Succeeding this is an area of rippled strata just below which are found cracks filled with the sand, continuous with the sand beds. At the top of these cracks, the age is estimated at 200 Ma.

Moving north along the beach, the grey silty mudstones of the upper Cotham Member follow. In the first few metres of this layer usually only a few bivalves are found, although an ichthyosaur skeleton was found here by a mature student, Brian McGee, from Queen's University in 1999 (There's hope for us all!). Most British ichthyosaurs have come from slightly younger rocks; this is older, though poorly preserved as the rocks had been baked by heat and the bones scattered, perhaps by currents. As one continues north, crinoids and then ammonites appeared, giving clues as to the increasing salinity of the area and to the T-J Boundary.

Triassic-Jurassic boundary c.200 Ma - Mike looked in vain for the disused sewer pipe which helped demarcate the boundary of the Triassic-Jurassic periods. Unfortunately it had been removed. The rocks in this area (the Blue Lias) are similar on both sides of the timeline. However at the end of the Triassic after a mass extinction only one or two lineages of ammonites were left and then even these disappeared. They re-appeared in abundance at the beginning of the Jurassic. Usually the appearance of *Psiloceras planorbis* points to the beginning of the Triassic. Mike suggested that a more accurate distinction would be when the next three ammonites appeared, since ammonites are a mobile species and it was possible that *Psiloceras* had existed in small groups during the time of 'disappearance.'

*Psiloceras* in this area measures no more than 10mm diameter, but the peculiarity of this section is that the muds are 'cooked,' indicating that they have been laid down close to a vent or heat source. When looking for this heat source, the only visible possibility here was a small dyke which did not appear to be a good candidate.

*Report and photos by Ricki Bull*

**Thursday afternoon, September 20th – Antrim Coast Road – Leader Philip Doughty**

Coast Road at Carnfunnock Country Park 154 562 - The development of the Coast Road by William Bald in 1832-42 was a major undertaking, eased somewhat by a raised beach which ran most of the way from Larne to Cushendall. The road was built on this and then turned inland to cross to Ballycastle. It had a major benefit to the villages and mines in the North in that it provided the first overland route to Larne, where smelters required the ores.

The Jurassic along the coast is represented only by the Lias sequence, consisting of grey, plastic clays, which are overlain directly by the Chalk and basalts. These load the Lias sediments to the extent that they are extruded from beneath the Chalk whenever there is a space for them to escape. This clay movement has produced major roadbuilding problems all along the Antrim coast where this sequence is exposed, resulting in uplift of road surfaces as blocks suffer circular rotation and cliff falls when the Chalk and basalts are made unstable.

Following a series of rockfalls in 1967, £575,000 was spent in repairs and modifications – one of which involved burying the “best outcrop of fossiliferous Lias” at Garron Point under a rock and concrete cover. Road repairs and cliff work are a regular requirement as the rocks continue to move.

Ballygally Head 384 080 - The Ballygally headland consists of an approximately circular dolerite plug showing massive columnar jointing on the seaward side right against the road – the columns are 1-2 m across and 15-20 m tall and were an attraction to rock climbers, now stopped because of the risk of falls directly onto the road.

Scawt Hill is the hill NW of Ballygally, 3 km distant and 378 m high, resulting from a volcanic neck inserting itself through the Chalk and now forming a plug of dolerite. Prof Tulley studied the reactions of the basalt with the chalk here and identified a suite of minerals of intermediate composition between the two, including the minerals Scawtite, Portlandite and Larnite.

Disused Quarry at Whitebay 327 153 - This quarry in the cliff face at road level shows the Larry Bane Chalk – here about 5 m thick and sandwiched between the upper Ballintoy and the lower Boheeshane Chalks – all under the basalts. The original surface of the Chalk shows rounded tops reminiscent of the Downs of S England, valleys and solution features submerged by many layers of broken brown, weathered basalt. In some of the eroded basin surfaces of the chalk a red deposit was visible; this is Northern Ireland’s equivalent of ‘Clay with Flints’, the clay in this case derived from the decomposition of volcanic ash that had fallen in the early phase of volcanicity.

Although the weather had closed in we left the coach during a short break in the rain to examine the rocks in detail (see photo above). Fallen blocks of Chalk contained belemnites, while tipped Lias clay contained small ammonites and various bivalves. Many lumps of pisolitic iron ore, derived from the weathering of the basalts and now present as laterites, were scattered across the area, presumably having fallen from the red bands between the lava flows above.

Glenarm 313 155 - This small village has the Eglington Quarry on the N side which works the Chalk for fillers, pharmaceutical additives and white lining material for marking roads – a European wide usage. The Chalk – otherwise the Ulster White Limestone – is far harder than the English equivalent, due to being strongly cemented by calcite while it was being laid down, not, we were told, by subsequent processes.

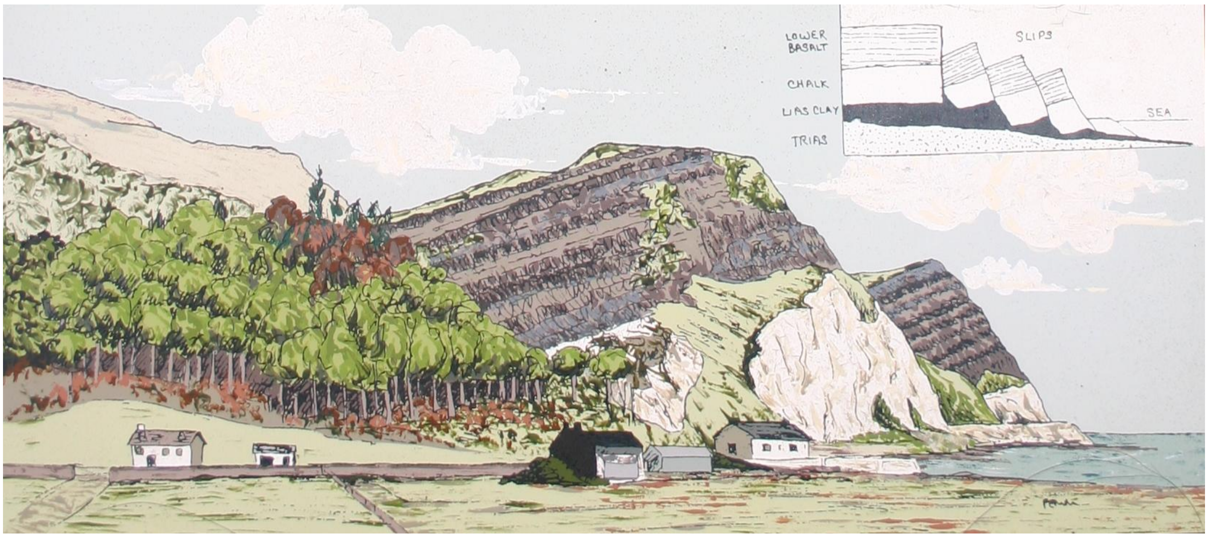
Above and to the N of Glenarm is the former hamlet of Straidkilly, roughly translated as “the village of slips”. It appears that no one lives there now!

Half a km to the N of Glenarm, the grey Lias mud could be seen accumulating behind the retaining wall on the shore side of the road and in places, oozing over it.

Carnlough 286 175 - Major quarries, now disused, on the Londonderry Estate behind Carnlough were worked in the 19th and 20th centuries for lime making, fluxes and whiting with the products exported to Scotland, where on the W coast there are no limestones available for this purpose. A railway ran from the quarries to the harbour, crossing the Coast Road on a bridge built of the local Chalk. The bridge remains in apparently good condition, as does the harbour wall made of the same material, with regularly interspersed blocks of basalt, achieving a chequered effect.

Another local industry was the manufacture of ammonia from an, apparently, ammonia rich peat. This business operated from 1904-08 but it is very unclear why the peat should contain ammonia. The party speculated that it might be guano, or a guano rich peat.

Garron Point 303 243 - The view from the car park just south of Garron Point shows that the headland consists of 3 major blocks of Chalk overlain by a thick, 30m cap of layered basalt. Each block has revolved away from the coast in classic ‘rotational failure’ mode aided by the Lias clay underneath, which both lubricates and extrudes to allow the blocks to move (see diagram below taken from the local site plaque). Major publications, including Holmes’s Principles of Physical Geology carry pictures of this feature, such is its status.




This movement results in lifting of the foreshore and Coast Road (see photo left); creates instability in the rocks themselves allowing material to be dislodged and therefore fall; and in the disruption of underground services. The rotation cannot be stopped, so periodic road repairs are carried out and netting has been attached to the cliff face to catch falling blocks.

Several small, now derelict jetties on the coast N of the Point served mines just inland which produced iron ore, mainly goethite and also small quantities of bauxite. About 50 small mines produced about 5 m tons between 1875 and 1950. The mines were all adits, working in laterites developed by monsoonal weathering on the surfaces of the basalts, now exposed as bright red beds between the lava flows. The biggest and most successful were the Park Moor Mines in Glenariff, which had a narrow gauge railway to the jetty.

At the conclusion of the day, a vote of thanks was made to Philip Doughty our leader for both leading us on the day and organising the entire week and he was presented with an RGS engraved tankard.

*Report by David Ward and photos by Christine Hooper and Chris Fone*

**Friday morning, September 21st – Coalpit Bay – Leader Dr Bernard Anderson**

Location was the rocky foreshore of Coalpit Bay (J596788; J594790) and Galloways Burn (J595783) Donaghadee, County Down

Our last day of field geology, and our first day without rain (or rainbows). We left Antrim and the basalt plateau, to enter County Down, exchanging the basalt and chalk of Antrim for much older "auld grey monotonous rocks". County Down is dominated by sandstones, shales and mudstones laid down in the turbidity currents of the Iapetus Ocean during Ordovician and Silurian periods (489 – 417 Ma). The compressive forces accompanying the closure of the Iapetus Ocean are evident in the many folds and faults contorting the strata. Island arc volcanoes contributed occasional lavas and volcanic ash. Ireland was much nearer the equator then. Graptolites, brachiopods and trilobites were abundant in the Ordovician oceans. The first land plants appeared in the Upper Silurian and armoured jawless fish were common. It was a time of continental collision, with the closure of the Iapetus Ocean initiating the Caledonian orogeny (Ordovician to mid Devonian: 490-390 Ma).

The morning was spent at Coalpit Bay (see photo below left) and the adjacent bay known as Galloways Burn, part of Landscape Character Area (LCA) ASSI 105 as designated by The Northern Ireland Environment Agency. Coal was once mined on the beach here but that has now ceased, and since there is a recreation ground adjacent, it has been rather unimaginatively renamed 'Recreation Bay' (and apparently some geologists looking for 'Coalpit Bay' have difficulty finding it - a gentle reminder perhaps that grid references are so important).

Bernard Anderson set the scene, describing the geological background, before we went down onto the beach to see specific examples.

With no rain and good visibility, we could clearly see the uplands of Galloway in Scotland and were reminded that the geology of County Down is continuous with that of Scotland. Beneath recent drift, the low-lying Southern Uplands-Down-Longford Terrane of County Down is essentially the same as that across the sea in Galloway and extends on to Berwickshire. In Scotland there are hills, whereas in Down the land is low-lying, but no explanation has been suggested for this difference. County Down is more like an English County than any of the other counties in Northern Ireland, being frequently referred to as Downshire; the only one of the six counties to use the suffix "shire".

The first geological mapping of Ireland was by Richard Griffith 1815. The maps were first published in 1838 (on a scale of about 10 miles to the inch) and subsequently revised, until by 1855 they contained much more detail and were at a scale of 4 miles to the inch. The accuracy of these maps often equals or surpasses more modern maps and led Sir Archibald Geikie to give Griffith credit for producing "…the most remarkable map of a whole country ever constructed by a single individual". However it is now recognised that Griffith was not responsible for this accurate detail. It was his assistant Patrick Ganly who did the field work and interpreted the evidence correctly, but his contribution was unknown until the 1940s when letters written by him to Griffith were discovered. In particular his discovery of the use of cross-bedding in resolving the geology of intensely folded strata facilitated an interpretation of the rocks in this area of Coalpit Bay. He knew when the beds were up-side-down. Considered Ireland's greatest, but least well-known, geologist, he shares a grave with Elizabeth Leary in Dublin's Glasnevin Cemetery. There is no reference to Ganly on the tombstone.

The rocks in the Southern Uplands-Down-Upland Terrane presented what was termed the Southern Upland paradox – the fact that the sedimentary rocks got younger to the north-west, but the graptolite fossil evidence showed younger sediments in the south-east. It was not resolved until plate tectonics was understood. The Caledonian orogeny, like most orogenies, comprises a number of terranes. When oceanic plates collide with continental ones, and are subducted below the continental plate, the crust of the oceanic plate is too light and buoyant to be subducted and instead is crushed at the continental margins. There is no size limit to terranes, they can be large or small. Each one has its own unique history and characteristics. In Northern Ireland there are three terranes: Cushendun (or Grampian); Midland Valley and the Southern Uplands-Down-Longford (south of Belfast). Donaghadee lies on the central belt of the Southern Uplands-Down-Longford Terrane. Large strike-parallel faults separate the terrane into some thirty fault-defined "tracts" forming an accretionary prism.

Greywacke is the predominate rock type seen at this location, with a significant presence of Moffat Shales.
The succession here is:

<table>
<tr><th>Period</th><th>Ma</th><th>Epoch</th><th>Formation</th><th></th></tr>
<tr><td rowspan="2">Silurian (early)</td><td rowspan="2">428<br>443</td><td rowspan="2">Llandovery</td><td>Gala Greywackes</td><td></td></tr>
<tr><td>Birkhill Shales</td><td rowspan="4">Moffat Shales</td></tr>
<tr><td rowspan="3">Ordovician (late)</td><td>443<br>449</td><td>Asgill</td><td>Upper Hartfell Shales</td></tr>
<tr><td rowspan="2">449<br>458</td><td rowspan="2">Caradoc</td><td>Lower Hartfell Shales</td></tr>
<tr><td>Glenkiln Shales</td></tr>
</table>

The black shales of the Moffat Series are exposed in a few inland localities and on the coast here at Donaghadee. At Coalpit Bay a succession of Birkhill shales known as the Coalpit Bay Mudstones have extensive graptolite fossils. These have been used to date the mudstones and the massive (unfossiliferous) greywacke that conformably overlies them. The greywacke must therefore be upper Birkhill or later.

The two above photos show the junction between the Upper (rhs) and Lower (lhs) Hartfell Shales (one boot on each formation).

The Moffat Shale Group, spanning the Ordovician-Silurian boundary, is distinctive and widespread and was initially recognised by Lapworth in 1878. The sequence in Ireland was confirmed by Swanson. Rather than one thick layer, as once thought, it comprises a series of thinner layers repeated by folding and faulting. It is predominantly carbonaceous black shale and siliceous mudstone. Charles Lapworth (1842-1920), whilst a school teacher near Galashiels, not too far from Moffat, did the pioneering work on the Southern Uplands. It had previously been classified as a thick sequence of Silurian rocks. He identified the Ordovician period (previously incorporated with the Silurian), but is probably most famous for establishing a dating sequence using graptolites.

Graptolites dominate the Moffat Shales and the biostratigraphy is based on these fossils. There is a succession of graptolite genera, making them very useful dating tools. There are currently two opposing views to account for the rather rapid evolutionary turnover of these hemichordates. Batchelor & Weir (1988) suggest that repeated, local extinctions of graptolite fauna were caused by intermittent falls of volcanic ash, now preserved as bentonites within the shales. However, Rigby & Davis (2001) argue that the input of 'nutritional' volcanic ash caused increased planktonic activity after the ashfall. Immediately above the bentonites there are abundant graptolites, but they diminish subsequently, the population structure being consistent with that known for planktonic blooms.
Moffat Shales - Graptolite biostratigraphic indicators:

| **MOFFAT SHALE FORMATION** | **GRAPTOLITES USED TO DATE THE SHALES** (those in **bold** have been positively identified at Coalpit Bay; for those in blue there is a tentative identification) |
|---|---|
| Birkhill | *Monograptus sedgwickii*, ***M. convolutus, M. gregarius, M. cyphus***; ***Cystograptus vesiculosus***; *Akidograptus acuminatus; Glyptograptus persculptus* |
| Upper Hartfell | *Dicellograptus anceps, D. complantus* |
| Lower Hartfell | *Pleurograptus linearis; Dicranograptus clingani; Climacograptus wilsoni* |
| Glenkiln | ***C. peitifer***; *Nemagraptus gracilis* |

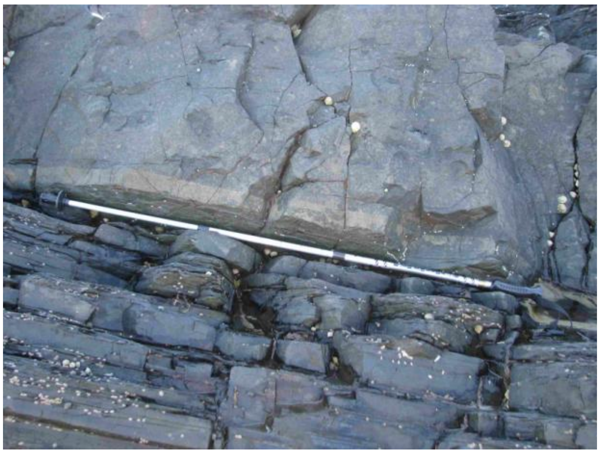
The Hartfell shales, particularly the Upper ones, at Coalpit Bay are barren and monotonous, with very few fossils.

Photo left, - Chris looking for graptolites.

The Moffat Shale Group is very thick in places, but there are no exposures of the complete succession (and it may only have existed as a single entity very locally). [The type section is at Dob's Linn, Moffatdale, an impressive corrie at the source of the Moffat Water in north Dumfries & Galloway.] It is generally considered to be of pelagic, open-ocean origin and its outcrops are always associated with major strike faults at the base of the successive structural tracts of the accretionary prism that is the Southern Uplands-Down-Longford Terrane.

The Moffat Shales are sometimes folded within the overlying greywacke and at Coalpit Bay faulting has resulted in an isolated block of Ordovician rock (an inlier) protruding through the Silurian.

Photo right - Boundary between the black Birkhill Shale and greywacke, with a lighter quartz-rich band at the base of the greywacke layer clearly visible.



Greywacke, a slightly metamorphic sandstone cemented by recrystalised clay, is an ill-sorted grey rock; often containing older rock fragments. Sediment settling out in still water will be stratified, but the sediments of greywacke were not sorted, indicating that they were deposited in deep water (but probably less than 200m), below the wave base. At such depths turbidity currents (denser than the surrounding water) flow downwards quite quickly (40-60km/hr) and then stop suddenly, depositing whatever material they are carrying. The heavier stones drop, but do not settle out according to size. This phenomenon was only appreciated when under-sea cables were laid and subsequently damaged by turbidity currents. These greywackes contain marine fossils indicating their deposition in a marine environment. Greywacke contains feldspar which decomposes rapidly when exposed, so they must have been buried quickly.

With lots of sand grains set in a clay matrix, they have a "high polished stone value" which is needed for motorway surfaces since vehicles stop more quickly when braking on this surface. The quarrying of greywacke for road construction and maintenance is a good export business for this region of Northern Ireland. It fetches a premium, returning £50-60 per tonne compared with around £10 for material with a lower polished stone index.

In the main Longford-Down terrane, the greywackes are both Ordovician and Silurian rocks, formed in deep water by submarine slumps or turbidity currents which carried large quantities of sandy sediments down the sides of subsiding synclines. The layers vary in size from a few centimetres to a few metres thick and are interbedded with thinner beds of siltstone or mudstone. The greywacke sequence contains few fossils, but the mapped division between the Ordovician and Silurian rocks is based mainly on the sporadic occurrences of graptolites in the greywacke. The Ordovician greywacke on the coast here is slightly more metamorphosed than the Silurian, but this distinction is not evident inland.

These turbiditic greywackes are particularly notable for their well-preserved sole structures. We'd seen groove marks in Coalpit Bay, but the beds of Galloways Burn have more good examples of sole structures on the basal bedding surfaces of the greywacke units (see three photos below and on page 36).

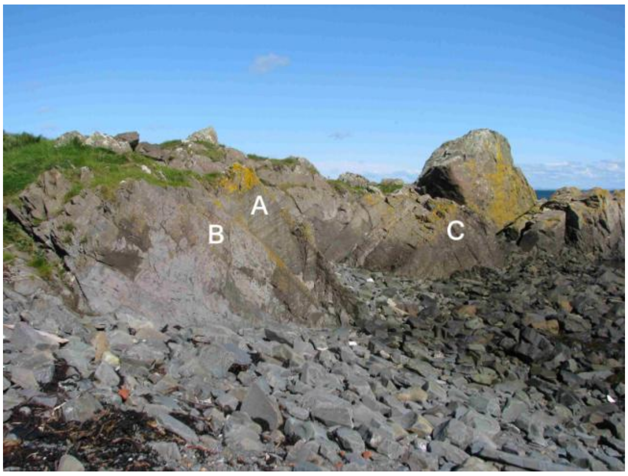



Photo left - Sole structures in Galloways Burn: A - sole plate; B - rock with tool marks; C - rock with load marks

The face of a rock is its original upper surface, the top, the last layer to be deposited and hence the youngest part of the block. The sole is the original lower surface, the bottom and hence the oldest. Sole structures are markings on the sole of a rock and are useful in determining the original orientation of the rock. If the sole surface is an upper surface now, then the rock must have been turned up-side-down at some stage. Hence they are known as way-up structures or geopetal indicators. Sole markings can also be paleocurrent indicators, indicating the direction of water flow when the sediment was deposited. Sole marks are usually small, often only a few centimetres long and appear as raised ridges on the rock. These ridges are just a few millimetre high. They are casts of depressions in the muddy sea floor when the overlying sediment was deposited.

Sole structures are divided into various categories (groove casts, tool marks and load marks, with further subdivisions) depending on their shape and size and their method of formation. They were apparently first recognized in the Devonian rocks of New York State by James Hall in 1843, and initially called fucoids, hieroglyphs or bio hieroglyphs. Ganly knew which rocks were up-side-down, but did not publish the reasons for his deductions. In 1948 Robert Shrock published a more detailed analysis of the different categories of sole marks, with explanations for their formation.

Above photos - "Sole Plate" (location A in photo top of this page) with ripple-like groove marks indicating the original base of the greywacke block (£2 coin scale).

Grove casts are most frequently evident in turbidite deposits, the result of high velocity flows across the underlying sediment. As turbidity currents pass over a bed of mud on the ocean floor, the turbulent eddies at the head of the current scoop out spoon-shaped depressions in the mud, with the deepest part of the depression being up-current. As the tail of the current passes over the depression, it is filled with fine sand. This sand is preserved as a downward projection from the base of the sandstone deposited on top of the mud. In the resulting bulbous or wedge-shaped casts, the tapered ends point in the downstream direction.

Photo left - Groove cast (30cm long) in the greywacke at Coalpit Bay. The less dense shale originally beneath the greywacke has been completely eroded.

Different casts are formed where sold objects (sticks, shell or rock fragments) were dragged along the muddy bottom by the turbidity currents. These are called tool marks and are sub-divided into various categories depending on the type of object involved and the nature of the current. Prod marks (see photos below) are relatively short tool marks caused by objects that were pushed into the muddy sediment and then lifted out. Their distribution can indicate the direction of the current, with deeper marks in the direction of flow and they can end quite abruptly.

Above photo left - Tool marks (prod marks) on a greywacke block at Galloways Burn at Location B in photo page 36 (£2 coin scale)
Above photo right - Close up of one of the prod marks in left photo – length 3cm

Load marks or casts (see photos below at the top of page 38) are formed in a different way. They are caused by dense, overlying sediment (usually sand) settling onto less dense, water-saturated sediment (usually mud).

Above photos - Load marks or fractures on the sole of greywacke at Galloways Burn at location C in photo top of page 36 (£2 coin scale).

All these features are less obvious in Galloways Burn now than when first observed there and photos published in the 1970s show larger and more definite casts.

Thin interbedded bentonite layers occur throughout the shales and greywackes (photos below). The bentonites are silica-rich clay material produced by the diagensis of volcanic ash that fell into the sea. The base of each bentonite layer is sharply defined, but some beds grade upwards into the darker mudstone. These bentonites indicate volcanic activity contemporaneous with the deposition of the turbidites (perhaps an island-arc type of plate margin). Apart from the discrete horizons, many of the black shales also contain a significant proportion of dispersed ash.

Above photos - Bands of yellowish bentonite clays in the mudstone (see above left) and greywacke (see above right) (£2 coin scale)

Other contemporaneous and later igneous activity is also evident. A well exposed lamprophyre dyke (see photos top of page 39) runs east-west with an offset fault at the seaward end. Lamprophyre is intermediate in composition between basalt and granite. This dyke was intruded along an existing fault line and followed the line of the transformed and offset faults, so that it "splits" into three smaller faults at the seaward end. This dyke is one of a group or swarm of dykes, all with a similar composition and orientation. There are four in Coalpit Bay and 1400 around this stretch of coastline. They post-date most of the folding and faulting of the sediment.

Above photo top left - Lamprophyre dyke on the beach at Coalpit Bay.

Above photo top right - Seaward end of the lamprophyre dyke.

Photo left - Looking at the lamprophyre dyke, with Ann (rhs) standing at the end of the fault at the offset point. The rest of the group are standing alongside the dyke.

There are no high grade metamorphic rocks here implying there was no great "crunch" as the plates met. Instead the collision was a sort of sideways slide into place as the ocean closed with no head-on collision and hence no high-grade metamorphics.

Parallel anticlines and synclines with east-west axes are evident below the high water level.

Above photo left - Small anticline located between the dyke and the car park.
Above photo right – Close-up of the anticline in left photo. It is in the Glenkiln formation of the Moffat Shales and is about 90cm wide. It incorporates thin yellowish bands of bentonites.

As we walked from Coalpit Bay to Galloways Burn, 300m south of Coalpit Bay, we paused to briefly examine the Quaternary deposits at the top of the cliff. They contain quite large rounded pebbles implying a beach deposit, but also include some volcanic material.

Photo left - David Price going off topic to examine Quaternary deposits.

An excellent morning ended with our usual picnic lunch, this time in the sun overlooking Coalpit Bay.

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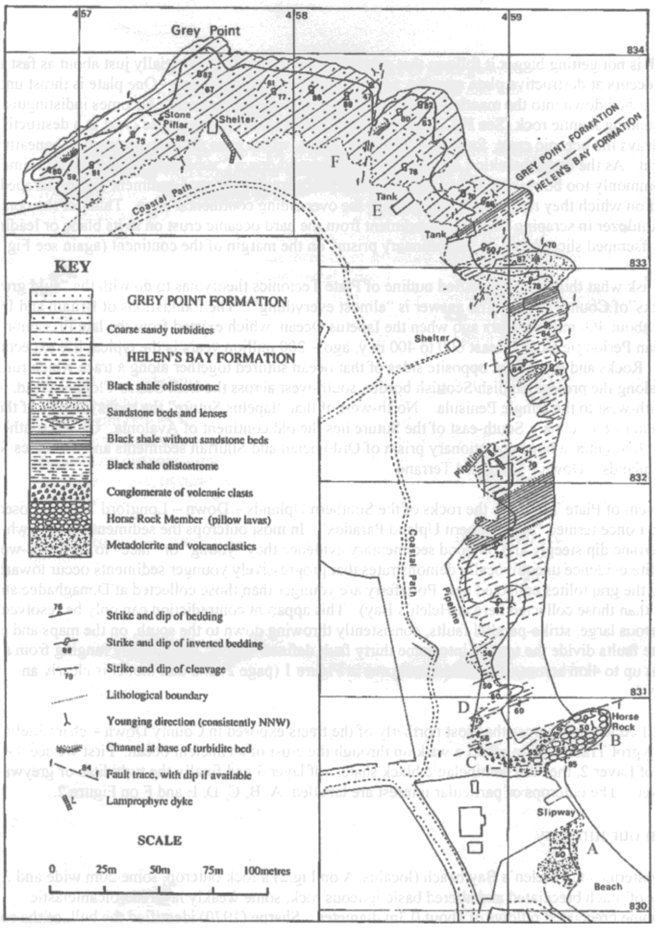
*Report and photos by Elaine Butler*

**Friday afternoon, September 21st – Helen's Bay (grid ref. J459829) – Leader Dr Bernard Anderson**

After lunch at Coalpit Bay, Bernard guided us east along Belfast Lough to Helen's Bay. This area was developed by the Clandeboye Family and named after Lady Helen Dufferin. On the western side of Helen's Bay lie the volcanic rocks of the oceanic crust and the overlying oceanic sediments. The geology of this area is largely the product of Plate Tectonics.

On arrival at the car park Bernard gave us a brief outline of the geology of the area.

The area we visited is shown below:

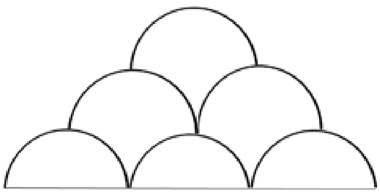



We first visited the north west end of the beach. (A in the diagram). Although the tide was in we saw small brecciated pillow lavas and roughly layered sedimentary material. This sedimentary material was first thought to be an agglomerate but one of Bernard's students pointed out that the material was slightly rounded suggesting that it had been subjected to some form of marine activity, so might be a conglomerate.

We couldn't carry on north along the shore as the way had been blocked off. So we detoured around the obstacle to reach Horse Rock (B in the diagram).

There are only two places where the Crawford Group (Pillow lava and Red mudstone) occur, Helen's Bay and Acton, County Armagh. The most important is Horse Rock which contains magnificent sodium-rich (spilite) pillow lavas. Helen's Bay pillow lavas are not as straightforward as County Antrim basalts as chemically they contain much more sodium which alters the feldspar. Instead of getting a calcium rich Plagioclase feldspar you get a sodium rich one, resulting in Albite or Oligoclase not the Labradorite you see in a thin section of the Antrim basalts.

When the pillow lavas erupted from the sea floor they obtained their sodium from the sea water. The basalts erupted fairly quietly not explosively, and on reaching the surface they immediately came into contact with the cold sea water. The molten basalt lava at the top chilled forming a skin, a bubble blew up within the skin and when it reached a certain size it rolled away and another one formed. (see photo right of pillow lavas and diagram below).



Because of this unique structure its orientation can be determined. Bernard indicated a submerged inverted spilite pillow on the north east corner of Horse Rock.

As we left Horse Rock he showed us conglomerate of spilite in ashy matrix. (see photo left)

We walked north along the coastal path and clambered down to a path nearer to the sea (E in the diagram on page 41) to examine sole-markings (grooved casts) on a turbidite of coarse-grained grey sandstone with thin shale interbeds. The groove casts are probably formed by scouring currents travelling in different directions across the seafloor. (see p*hoto right*)

Further along and by the sea (F in the diagram on page 41) we saw beds of ungraded sandstone channelling down into the underlying strata. These are the best examples of channels in the turbidites of County Down (see p*hoto below*) and the best example of sole-markings in the Ordovician Northern Belt.

On the return to Ballygally we passed Scawt Hill, an SSI 2 km NW of Carncastle, the summit of which marks the outcrop of a volcanic plug composed of olivine dolerite. The volcano has been eroded away and the hill now exposes its root. Prior to plug formation, large volumes of magna would have moved through the vent heating its walls and causing them to change. The rocks that formed the wall of the vent at Scawt Hill are the Cretaceous Ulster White Limestone, which led to the unusual variety of minerals found there. It has yielded five minerals new to science; Larnite; Scawtite; Rankinite; Portlandite and Hydrocalumite.

*Report and photos by Jeff and Sue Taylor*

**Saturday September 22nd – Belfast Museum and the trip home**

Our six days of outstanding geology has come to an end. We packed our bags and paid our bills, enjoyed a leisurely breakfast. Some of us took a last stroll along the beach, but the time had come for us all to board the coach, for a last treat of a couple of hours in the Ulster Museum, before our afternoon flight.
The Ulster Museum was started in 1821 when the Belfast Naturalist and Philanthropist Society, founded by a group of young men, found they had outgrown their meeting place in the Linen Hall Library. Their collections had grown considerably and the Library had become

too small, so in 1920 The Ulster Museum was built to house their expanding collection. In 1970 the building was extended to its now current size. In 2008 the Museum underwent a major refurbishment including modification of the entrance hall, which now houses a Café. The main Entrance Hall has a pair of full size Pterodactyl, an extinct winged reptile hanging from the very high ceiling.

On acquiring a map of the museum I made my way to the Nature Zone on the 2nd floor. I crossed a walkway that passed a full size replica of the dinosaur Triceratops horridus, 65 million years old (Ma). There are nine galleries to explore and my tour began with Earth's Treasures. This display covered four billion years of Earth History and had examples of meteorite fragments that had spun through the solar system to land on earth, which give us an insight into a planet's inner core of nickel and iron. On leaving this gallery I passed a huge quartz crystal mass, made up of many perfect individual crystals.

The next gallery contained a beautiful display of minerals, not all from Northern Ireland, but many were donated by a local, renowned geologist, Robert Bell 1864-1934. He began as a riveter in the Harland and Wolf shipyard. In his spare time he began a lifelong interest in geology and became an expert on the rocks and fossils of Northern Ireland. Part of his rock and fossil collection is still held by the museum. The mineral displays were very well laid out on a stepped, black background, well lit, and annotated, with examples of the silicates (Albite), oxides (Hematite), carbonates (Siderite), sulphides (Zinc Blende) and sulphates (Gypsum), halides (Salt), the natural elements (Gold) and many others. A display of fluorescent minerals - those that respond to ultraviolet light (UV) by emitting light at a different wavelength - gave a show of vivid colours in the dark. The Radioactive minerals display was still being put together, but the noise from the Geiger counter let us know they were radioactive!

In the next gallery were the fossils Echinoderms and related species including Sea Lilies, Starfish, Brittle Stars and Sea Cucumbers. This followed a display of Brachiopods, Bivalves, Corals and Trilobites. A case with a bulldog fish, a fearsome predator 85ma old found in the chalk in Kansas USA was bought on e-bay by the geologist Dr Mike Simms (our leader for Wednesday) for display in the museum. There was also a case with a well preserved Coelacanth -a big fish with leg-like fins - that was thought to be extinct, until one was caught in the 1970's.

The next gallery was the Deep Time gallery - a trip through geological time, with a good display of rocks and fossils of Northern Ireland with some from other countries. Mainly were from the Ordovician and Silurian Periods with their respective fossils, Trilobites, and Graptolites. A very good example was on display of a Spilite Basalt, an extrusive igneous rock that is rich in the mineral Albite. A piece of Sandstone that showed superb ripple marks, and a lithified slab of mudstone with desiccation cracks from Scrabo Hill was also on display. Halite, rock salt from the Mercia Mudstone, Northern Ireland was also on show. An extraordinary find was part of a jaw bone with teeth of a Hadrosaur dinosaur, from the Upper Cretaceous of Mongolia. A case with a well preserved fossil coral of Middle Silurian age was very attractive. Part of the Larne Ichthyosaur, 200 Ma old, from the Upper Triassic in Waterloo Bay, which had been found by one of Mike Simms's students and was Northern Ireland's only dinosaur, reminded us of our visit to Larne with Mike. Finally, a very large

Paramoudra flint and a large piece of silicified Wood reminded us of our visits to the Ulster White Chalk.

In the Evolution gallery was a full size replica of the head of a Tyrannosaurus Rex, the original being in the Natural History Museum in New York (see photo left). The gallery showed how evolution had changed animals such as, for instance, horses through time. The videos of Black smokers and erupting volcanoes were interesting especially the one of the Giant's Causeway.

On the way back to the main entrance was a skeleton of the dinosaur Edmontosaurs annectus from South Dakota, 65 Ma and the most complete dinosaur specimen in the Museum (see photo right). This herbivore moved in herds across North America and is known as "the cattle of the Cretaceous".

All too soon our two hours were up - we had spent as much time as was available looking at some of Northern Ireland's fine preserved fossils and rock collections. We boarded the coach and made our way to Belfast City Airport (George Best Airport) to board our flight home.

A good time of great geology and company was had by all and our thanks go to all the people and their hard work who made it possible.

*Report and photos by Barbara Barrett*

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