Causeway Coast Fri 8th Sept – Mon 8th Sept 2017 Leader: Fiona Meade

Friday 8th Sept
Reporter: *Maggie Donnelly*

Cushendun

Nine of us travelled to Coleraine on Thursday where we stayed in the Premier Inn. On a sunny but showery Friday morning we drove north to the coast and visited the ruins of Dunluce Castle perched on the edge of basalt cliffs, before driving on to the northeast coast and Cushendun, near the Glens of Antrim. Here we met the rest of the group at 1.30 pm. By now the rain was serious so we took refuge in a local café for lunch before the sixteen of us plus Fiona and her friend Paul set out north along the shore to the far end of the bay where we found ourselves facing metamorphic rocks of schist and metabasites – the Glendun Formation, the top and final formation of the Dalradian Southern Highland Group and part of the Dalradian 'Antrim Inlier'. It consisted of grey and green tinged schists, with a number of large and well-formed pink crystals of (surprisingly!) albite, conspicuous in some bands. Their pink colouration, we were told, was the result of weathering. The many other crystals present included chlorite, biotite and tourmaline. There were a number of sheets of a distinctive porphyry – the Cushendun Granodiorite. It was pinkish brown and contained large oligoclase crystals showing zoning (reflecting different stages of growth) in a quartz-rich, fine grained groundmass. There were coarsely crystalline pegmatites, formed in the closing stages of slow granite cooling when albite crystals more than 2.5cm long were able to grow. The original pebbly and sandy sediments of the schists were deposited as turbidites prior to *ca* 595 Ma. Towards the end of this period, dolerite dykes were intruded into the lithified sediments, and then during the Grampian orogeny of the Ordovician Period, the collision of a continental margin across the island arc of the Tyrone Igneous Complex folded, deeply buried and metamorphosed the Dalradian rocks.

The area is famous partly because it was an essential part of a serious academic controversy about the origins of albite schists. The original view, argued by Bailey and McCallien in 1934, was that the schists merely reflected the chemical composition of the original sediments, probably albite-rich muds, altered during metamorphism. However, in 1942 Doris Reynolds took a radically different view and proposed that hot fluids percolated the quartz-rich rocks during metamorphism and introduced sodium (essential for albite formation), potassium and possibly iron. Reynold's work was a fundamental contribution to the understanding of these rocks worldwide, making this a vital reference site in international geology and one of international importance – it *should* be designated and fully protected.

We walked back along the shore and coastal path to the south end of the bay (the rain had gone off) where there were huge cliffs right down to the path. They were made of an extremely coarse conglomerate – the 'Cushendun Puddingstone' or Conglomerate of the Cushendun Formation. In Antrim its thin basal layer is rich in schists but higher up the succession, where we stood, it comprised cobbles and large pebbles of mostly quartzite derived from the NW. The matrix was a lithic arenite with single cycle detritus of minor quartz and abundant fragments of welded tuff, schist and quartzite. It was **very** similar in appearance to the Basal Lower Devonian Red Sandstone of the Midland Valley, of which it is a continuation. We took time to examine it – all the clasts were very rounded, indicating a polycyclic history, and some were sheared. Further along, the cliffs extended across the path

and down to the sea but two gaping holes appeared in front of us – the first of the 'Cushendun Caves'.

The caves of Cushendun became internationally famous when they featured in the hit fantasy drama 'Game of Thrones', attracting tourists worldwide, who probably would not have known that these caves have their own fascinating story.

We entered the right-hand one and followed the tunnel for some distance to the end where it opened up into a large cave. There was an exit, fenced off for safety and security, but beyond this the path continued through thick vegetation to the 'Cave House'. An historical 18th century residence it was once magnificent, but is now a shell and requires total restoration or demolition. Nicholas de la Cherois Crommelin lived here during the middle years of the 19th century and in 1903, Crommelin's grand-daughter Constance married John Masefield – the "poet of the sea". At one time it was home to the Sisters of Mercy and is undoubtedly one of the most secluded of retreats, best seen from sea or air.

We returned and entered the second tunnel. Its roof was low allowing us a close-up of the conglomerate. It terminated at an exit onto a small beach where the cliffs were low and overhanging – again a close-up view.

Bedding and cross-bedding.
M Donnelly

In the cliff walls some bedding and cross-bedding were distinguishable.

Bedding and cross-bedding. *M Donnelly*

We returned to the cars and on our way home via the beautiful Glens of Antrim we stopped at the mysterious 'vanishing lake' of Loughareema. The bedrock is limestone and at times the water finds its way down through small cracks, leaving an empty patch on the surface!! At other times the cracks get blocked and the lake 'appears'!! It was there for us!!

References

1. Cushendun geology. http://www.habitas.org.uk/escr/summary.asp?item=164.

2. Cushendun Caves & Cave House. http://www.irishnews.com/lifestyle/property/movein/2017/06/22/news/cave-story-invites-you-along-for-a-poetic-adventure-in-cushendun-1063859/.

Saturday 9th Sept, am
Report: *Isabel Collins*

Ballintoy Harbour

On leaving our accommodation in Coleraine we drove across a lava plateau. Obscured as it was by the last of the morning's rain, the topography appeared slightly stepped indicating the various terminations of the lava flows. Fiona explained later that these are the lavas of the Antrim lava field and they are part of the North Atlantic Igneous Province which relates to the Iceland plume and the opening of the North Atlantic. We learned that there are two lava fields in Antrim, known as the Upper and Lower Basalts. Coleraine is situated on the younger Upper Basalts and as we drove to Ballintoy we gradually came down sequence, passing through the inter-basaltic layer. This layer is marked by what is called a laterite, formed in a wet tropical environment, essentially eroding and chemically weathering the surface of the lavas into a red soil over a period of about 1-2 million years between the two phases of lava eruption. It is during this period that a small localised eruption of basalt formed the Giants Causeway, known as the Causeway Tholeiites. The basalts we were to see at Ballintoy were mainly the older Lower Basalts and the Causeway Tholeiites.

On arriving at Ballintoy harbour car park we discovered that it was situated in a redundant chalk quarry. The creation of the harbour itself was a direct result of the need to transport local stone from mining and quarrying. We later came across the remnants of old lime kilns which were used to burn the chalk for the production of agricultural lime that was exported along with dolerite setts for road construction on an industrial scale. Leaving Ballintoy harbour car park we headed westwards along the coastal path towards White Park Bay. The coastline itself was very dramatic with a series of islands, skerries, rock arches and sea stacks. Most of the exposed rock on the shoreline consisted of metamorphosed chalk, known as the Ulster White Limestone Formation. The chalk itself was laid down in marine conditions during the Cretaceous and was later covered with and metamorphosed by the molten lava of the Palaeogene. As a result of being buried under several kilometres of basalt the chalk here is physically hard and cemented. Following the formation of the Lower Basalts there was a period of quiescence in which the laterite was formed before the Upper Basalts were extruded. Underneath the Cretaceous chalk are Jurassic rocks which unfortunately, due to timings, we did not get to examine, as they were to be found in the tidal zone. We stopped at various localities along the way looking at the interactions of the lavas and chalks along the coastline.

Fig. 1. Former Sea Cave caused by erosion along fault breccias formed along the Ballintoy Fault
A Geological Excursion Guide to the Causeway Coast by Paul Lyle

Our first stop was to the nearby raised sea cave (Fig. 1) close to the car park. This was one of the many indicators that we were to come across on the shoreline, that the area was raised due to isostatic rebound following the last ice age. It was also the first place where we saw evidence of a line of weakness in the area. Fiona confirmed there was Tertiary faulting, and outlined the Ballintoy Fault running parallel to the coast which forms part of the larger Portbradden Fault. An estimated 100 m has moved downwards, north of the break in the earth's crust, resulting in the Upper Basalts here lowering down to the level of the Cretaceous chalks at sea level.

When the North Atlantic was opening the area would have experienced rifting and movement on faults which suggests that rather than being a single line of weakness here, there may have been several faults forming a fault zone, and the movement has left the chalk in the sea cave with a fractured and brecciated appearance (Fig. 3).

Fig. 3.
Joyce Stewart

This fault boundary filled with the Causeway Tholeiites north of the faults (Fig. 2). The chalk was characterised by having quite obvious flint nodules which also appear to have been crushed by the faulting (Fig. 3).

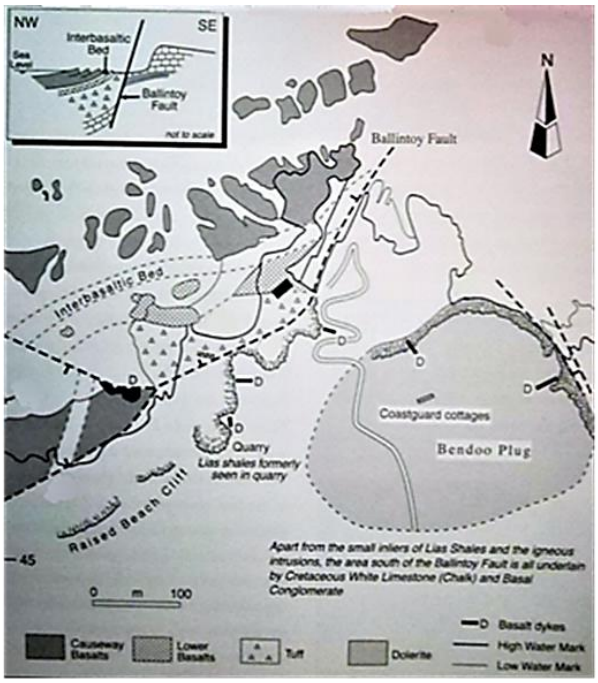


Fig. 2. Geological map of Ballintoy Harbour
A Geological Excursion Guide to the Causeway Coast by Paul Lyle

Fig 2. Geological map of Ballintoy Harbour. A Geological Excursion Guide to the Causeway Coast. *Paul Lyle*

Beside the cottages we got up close to Tertiary volcanic rocks. We first had a look at the laterite with the younger basalt flow on top (Fig. 4). As the lava flow cools the vesicles left behind by the escaping gasses are filled with secondary minerals called amygdales, such as calcite, quartz, chlorite or one of the zeolites. Typically, the Antrim basalts are quite amygdaloidal. These amygdales are a useful tool telling us about the thickness of the basalt pile and the fluids that passed through it at a later time.

Fig. 4.
Joyce Stewart

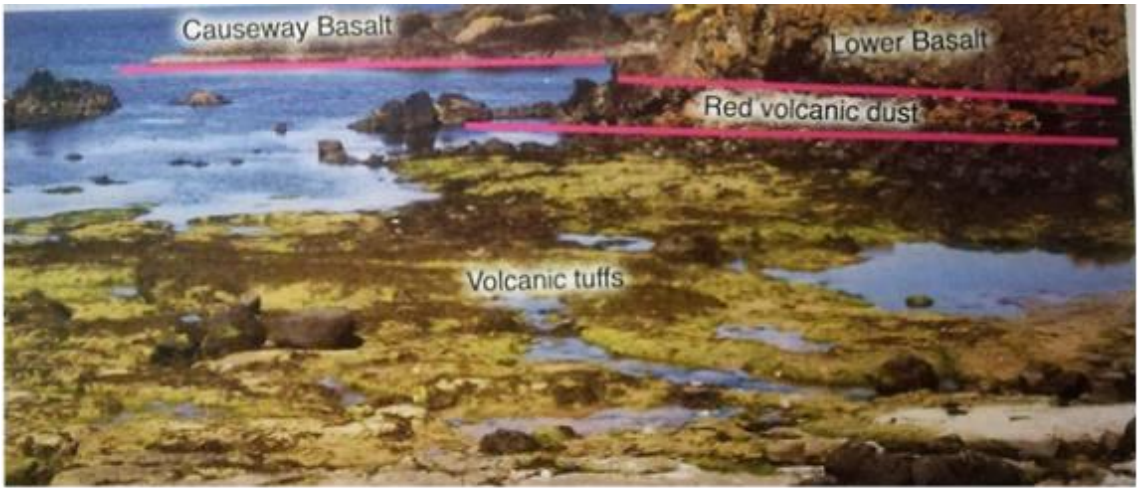


Fig. 5. Lower Basalts underlain by red volcanic dust and with Causeway Basalts to Seaward
A Geological Excursion Guide to the Causeway Coast by Paul Lyle

We were standing on two beds of volcanic tuff (Fig. 5). The first bed nearest the laterite was pale green volcanic tuff and the next a darker basaltic tuff. This volcanic ash would have been ejected by a nearby explosive vent, the likely source being the vents just at the next headland at Carrick-a-Rede and Kinbane Head.

We stood right on the fault line at the harbour with black rocks on one side and white rocks on the other. A similar scenario was to be found at White Park Bay.

There were further examples of this fault breccia viewed as we walked along the raised beach where the fault planes had a different orientation than before. Again the action of the sea emphasised the fault and you could see the fractures and stresses the whole way through the rock. The chalk formed at the bottom of the sea bed following the gradual accumulation of calcium rich shells, mainly cocoliths.

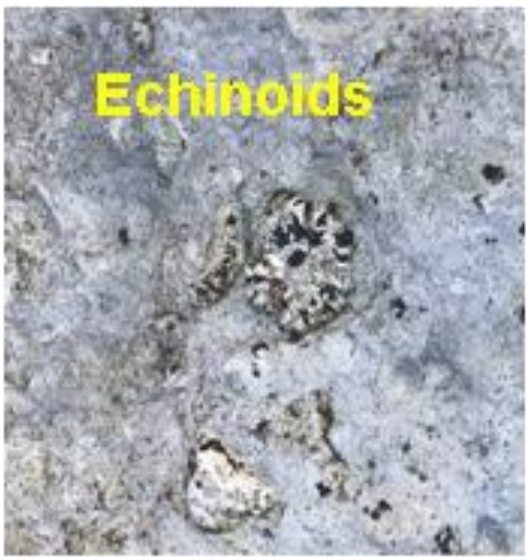


Fig. 9.
Joyce Stewart

Continuing along the coast where the chalk is not so brecciated, you can identify some fossils in the chalk, Echinoids (a kind of sea urchin), Fig. 9 and belemnites (bullet shaped fossils, essentially the core of a squid type creature).

There were also numerous horizons of flint nodules to be found within the chalk (Fig. 11). It is thought that flint forms in pockets in the sediment as a result of siliciclastic input from silica rich organisms such as the spicules of sponges. The flint nodules are typically elongate round or tabular but they can be found in larger more cylindrical shapes called paramoudra flints.

Fig. 11.
Joyce Stewart

With the combination of the cave systems and the abundance of flint, this area was popular in Neolithic times. There are signs along this coastline of early human habitation by Neolithic people in the form of so called axe factories, producing knapped flint and axe heads.

Fig. 12.
Joyce Stewart

We came across another section of raised beach with sea stacks and sea arches on our way to White Park Bay where there were clear signs of instability. The bedding in the chalk cliffs at this point was much more apparent and essentially, we were not far away from the base of the chalk sequence. The whole slope is characterised by rotational slumps, landslips off the edge of the cliffs. This is a function of sea erosion but there is also a geological reason. The underlying Jurassic is a Liassic or Lias known as the Waterloo Mudstone Formation. This mud and clay forms a slip surface and so the chalk cliffs are moving into the sea forming stacks. As we walked further there was a freshwater stream (with delicious watercress growing all around) emerging from the base of the chalk as the water could not pass through the underlying impermeable clays. The exposed chalk here had a larger grain size and the lower beds contained fragments of rock and pebbles.

These course grained beds are referred to as Conglomerates, which formed as a result of flooding of the Jurassic surface by the sea in the Cretaceous. Regrettably, because of the tide, we did not make it around the headland to the Jurassic rocks. Incidentally, the last picture (Fig. 12) shows our view from the grass verge where we sat and ate our lunch while looking onto Elephant Island, before returning to Ballintoy car park with our excellent guide Fiona.

Saturday 9th Sept, pm
Report: *Joyce Stewart*

Bendaloo Pug and Portrush Sill

Fig 1. Path to Bendaloo Plug

We started the afternoon excursion walking up to a lime kiln above Ballintoy harbour. There are lots of lime kilns in the area due to the large-scale mining of the chalk. There was a stunning view from the top. No wonder the Antrim coast is designated an area of outstanding natural beauty.

Above the kiln, Fiona showed us a basalt dyke intruding into the chalk. The chalk is the remains of microscopic algae in the sea around 100 million years ago and the basalt formed by volcanic eruptions about 60 million years ago.

Fig 2. Dolerite dyke intruding chalk

We went on to see where the chalk exhibits a fractured appearance which is known as breccia. We saw flints in the chalk in layers, some of which were linear and in other parts not so linear.

We followed the path east of the harbour to the beach with the dolerite Bendoo plug which pushed up through the chalk and is cylindrical in aspect and about 350m in diameter. When the hot magma comes into contact with the colder rock it is called intruding.

The rock often becomes hardened with the heat and discolours the contact rock. This is known as contact or thermal metamorphism.

As the changes at the contact between the dolerite Bendoo plug and the chalk are slight, the zone of metamorphism is only a few centimetres wide. This shows that it was not a long lasting intrusion and not a major feeder for the Antrim lavas. The erosion from the sea has left the harder dolerite plug and eroded the softer chalk rock leaving not much chalk showing on the shore until you go back to the cliff edge. We searched for small belemnite fossils in the chalk; there were very little samples available to see. We then walked back to the cars to drive to Portrush.

Fig3. Bendoo Plug Erosion

Fig. 4. Chalk erosion

Unfortunately the dry weather did not last – it started raining at Portrush. Fiona informed us of the two schools of thought on the origin of igneous rocks – one Neptunists, who thought that these rocks were crystallisation from seawater. The other, known as Plutonists, thought that the rocks were the crystallisation, or solidification of molten material. At first the Neptunists were winning due to the appearance of fossils in what they thought was basaltic rock led by Reverent William Richardson in the late 18th century.

By the early 19th Century it was discovered that the Reverend Richardson had mistaken the Lias rocks with ammonite fossils for Basalt. He had not noticed the contact between the Lias rock and the coarser dolerite and the sill.

The Portrush sill extends offshore and forms a chain of islands called the Skerries. The sill is formed from a coarse dolerite intruding into Lias mudstone (part of the lower Jurassic period) which was baked by the hot magma into a hard dark fine grained brittle rock known as hornfels. There are many ammonite fossils found in the baked Lias mudstone. These Jurassic rocks are identified by the appearance of a specific species of ammonite known as *Psiloceras Planorbis*. In 2014 geo-vandalism occurred and sixteen rocks believed to contain samples of the ammonite fossils were stolen from the Portrush Sill nature reserve, spoiling the site for future generations.

After a very enjoyable full day with our excellent leader Fiona we drove back to our hotels to get ready for our dinner at Elliott's Bistro.

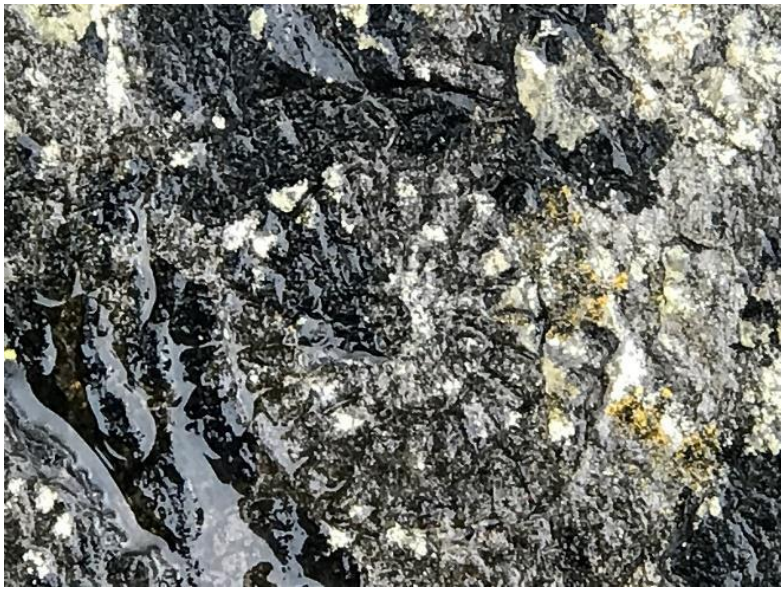


Fig. 5. Ammonite fossil in the Jurassic mudstone.

Sunday 10th Sept, am
Reporter: *Anne Gray*

Giant's Causeway

Under Fiona's expert guidance, we had been travelling up the geological time scale from the Dalradian schists at Cushendun, to the Cretaceous limestone cliffs along the northern coast. Today we reached the Paleogene with the Giant's Causeway. The Causeway consists of tens of thousands of basalt columnar blocks, some still intact in the hillside and rising 10 to 25 metres high, some truncated to stepping stone level and reaching out in a vast tapering pattern into the sea and towards the Scottish coast. Under the aegis of the National Trust, the site has World Heritage Status, both for its outstanding natural beauty and geological significance. These tholeiite blocks were formed at the time of the opening of the Atlantic, between 60 and 55 million years ago. Following an initial pulse of relatively thin basaltic lavas which make up the Lower Basaltic formation, the Causeway lavas were a short-lived and highly regional extrusion which poured into a deep river valley that became blocked allowing the lava to become deep and to cool more slowly, forming tall columns in the typical 6 sided formation. A second pulse of thinner layers of lava then capped these tholeiites and preserved them, creating the spectacle we enjoy today.

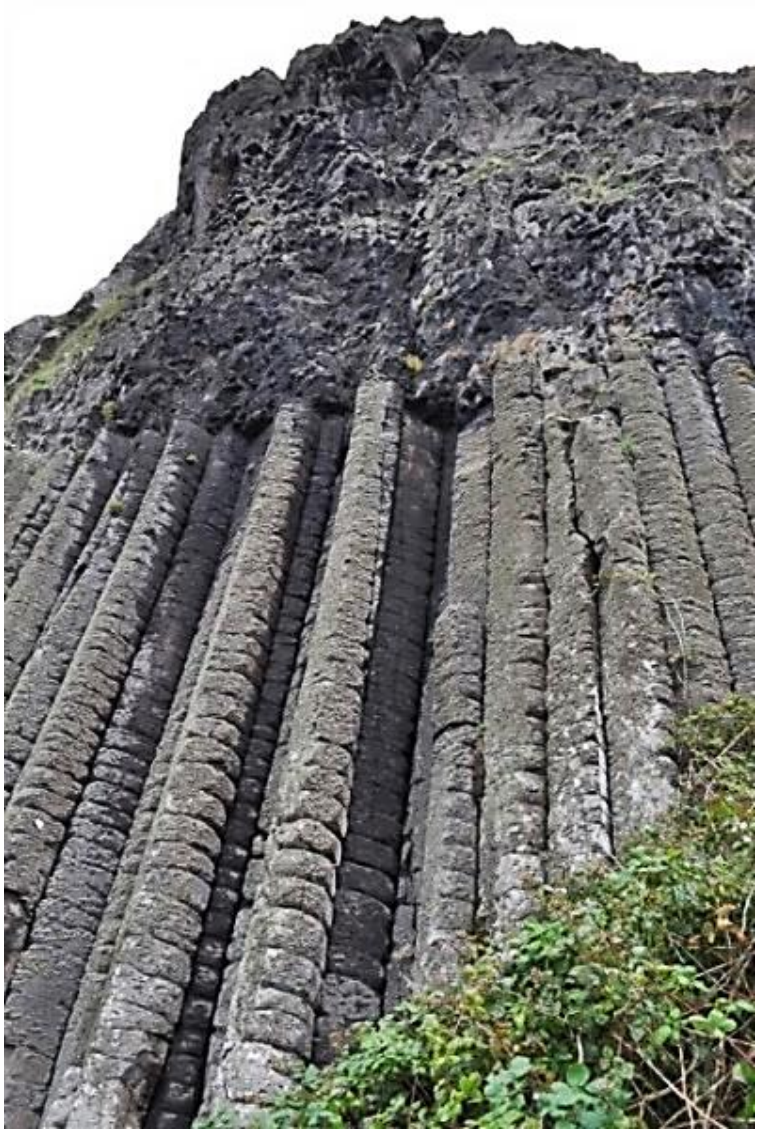
On the 15 minute walk down from the interpretive centre to the shore, Fiona pointed out several features: the presence of a red laterite layer above the lower basalt, in testament to the subtropical conditions that pertained for Northern Ireland 60 Ma. ago

Fiona points out onion weathering, Giant's Causeway
Bill Gray

Also indicative of weathering were the examples of onion weathering in some of the blocks. Through the Giant's Gate we assembled at the foot of a wall of 8 metre high columns and examined their vertical jointing, and horizontal joints that formed ball-and-socket patterns. We were then free to wander across the stepping stones in the footsteps of the giants of old.

We gathered again to walk up the scenic path to the Organ, a bank of 20 metre high columns capped with entablature; this foliage-like topping Fiona explained as having formed from the flow of river water over the lava and cooling it faster, resulting in much smaller and irregular columns. Further up this path we encountered an impressively wide bed of laterite, bright red and with much coloured markings, the most famous of these being the Giant's Eye. The pale colours form by reduction of the iron in the laterite. Its thickness indicates a long period of weathering before the upper basalt was laid down. As we turned the corner, more columnar formations on the far side of the bay were visible. Very tall columns, these were interesting in that they displayed horizontal joints two-thirds of the way up the columns, where the cooling from top-down had met the cooling from the base upwards. As well as numerous photos of geological significance, we were treated to wonderful scenic views of the Antrim coastline. We then returned, some by the courtesy bus, some by rock steps in the hillside, to coffees and lunches at the café.

Group Photo Giant's Causeway *Bill Gray*



The Organ Colonnade and Entablature *Bill Gray*

Sunday 9th Sept, pm
Reporter: *Seonaid Leishman*

White Rock Beach

After the hustle and bustle of The Giant's Causeway it was good to drive to the car park above White Rocks Bay and descend to a beautiful sandy beach almost empty apart from a few surfers and dog walkers. The sand by the way is not local; it must be 'imported' by tidal action. We were standing beneath magnificent cliffs of the White Limestone Formation. These are in fact Northern Ireland's very own White Cliffs of Upper Cretaceous chalk similar to the White Cliffs of Dover. The chalk is a pelagic limestone formed from protozoa (cocoliths and foraminifera) in shallow water. It contains bands of flint – precipitation of silica in the calcareous ooze which may be caused by water depth change. The conchoidal fracture of flint means it was treasured as a cutting tool and weapon. Before we investigated further Fiona pointed out the major unconformity exposed on the roadside far above us. It is stark and obvious – the black Lower Basalt Formation undulating on top of

the White Limestone Formation. This is the earliest evidence of explosive volcanism at the base of the Antrim lava.

On the beach we were to discover the inner workings of this explosive volcanism, but first we worked out why this chalk is so very hard. It had been 'cooked' as it lay buried under many layers of molten magma and is therefore hornfelsed. It is still pretty pure and can be used in medicine as well as industry.

The volcanic mechanism comprised magma rising via dykes which eventually met water on the carst chalk landscape. The explosion produced tuff and a zone of destruction which was then infilled with chalk boulders and basalt agglomerate. As we wandered along the cliffs, in and out of weathered chalk arches we saw examples of all stages. Some of the flint accretions were shattered, others pink coloured because of iron from the lava.

A dyke intruded into the limestone cliffs *Seonaid Leishman*

It was disconcerting to be fossil hunting in this scene of desolation! In the pristine chalk, folk found evidence of Belemnites, Echinoid spines and brachiopods including *Rhynchonella*. Near to the vents even the fossils showed evidence of destruction!

Remains of the huge vent on the beach *Seonaid Leishman*

Fossil hunting!
Seonaid Leishman

Mon 11th Sept
Reporter: *M Donnelly*

Carrack-a-Rede Rope Bridge

Our final morning started off showery and blustery with bits of sun and blue sky coming and going. The plan was to visit and cross over the Rope Bridge. However we were greeted in the car park of the Inn by Fiona who told us that we were unlikely to get across as the wind was too strong. We set off regardless, east along the north coastal Ballycastle road, taking a narrow road signposted to Larry Bane just past Ballintoy, and down towards the coast. This was steep and curvy – quite a challenge – but took us to the car park and café about halfway down the cliff. Here the wind was strong and gusty, 40 mph; the Rope Bridge was indeed closed so, as ever, we had a brief respite in the café before heading along the coastal path at the edge of steep cliffs. We walked past the huge Knocksoghy Sill with its towering columns of dolerite and its disused quarry at the base. This is the only sill in Antrim intruded into the basalt, part of which probably forms Sheep Island offshore. We stopped from time to time to take in the view – Sheep Island looked beautiful and mystical in the occasional sunbeam. The path took us to the top of a ***very*** long flight of steep wooden steps down the face of the cliff and we started the descent. The gusts of wind were **very** strong and at times we had to hold on tightly to the wooden railing to prevent becoming airborne!!

Halfway down there was an open area with an information board and a marvellous view of Carrick-a-Rede, the bay with its immense cliffs and the wild blue sea whose breakers were crashing against the coast. Then we were off again on the second stage down to the bridge. Its entrance was barred by a sturdy steel gate and guarded by a friendly 'National Trust lady'; we could look over and see a **very** steep ladder of about fifteen steps leading right to the bridge.

The Rope Bridge *M Donnelly*

At about 600 m in diameter, Carrick-a-Rede Island and the surrounding land are the remains of the most extensive explosive volcano in Antrim, erupting at the start of the igneous activity about 60 Ma. The main vent is just adjacent onshore and extends to the rocks under the bridge, both on and off the island. It consists of agglomerate of basalt blocks up to 3 m in diameter in a matrix of volcanic ash with a few fragments of chalk and Lias clay country rock. The ash has hollows and cavities suggesting the presence of finely ground soluble limestone. Further afield the agglomerate is of basalt, chalk and Lias clay fragments and all of this was blown out of the volcano during the initial explosive phase. In its later phase, dolerite sills were intruded, one of which forms the cliffs on the east side of the island.

While we were down at this entrance we had the opportunity to examine the agglomerate closely on the hill slope, as well as that on the island from a distance. We also had an excellent view of the tall columns of the dolerite sill on the east of the island.

Sheep Island *M Donnelly*

We then made our back up the massive flight of steps and to the car park, where Fiona was presented with a token of our appreciation for a marvellous weekend, for all the experience and knowledge which she had shared with us, and for taking us to little known sites which we should never had found by ourselves.

References

1. Our Leader's itinerary
2. **Lyle, P.** *A Geological Excursion Guide to the Causeway Coast. Northern Ireland Environment Agency, Department of the Environment. Third Edition, 2014.*