# GSG residential excursion to Aberdeenshire.

Fri 14th Sept to Mon 17th Sept 2018
Leader: Dr Con Gillen Participants 18

**Fri 14th Sept pm**

*Reporters: M Donnelly, Bill Gray* **Crawton Shore**

We met up at Crawton south of Stonehaven, around 1 pm, had lunch and then made our way down the cliff path to the shore of Crawton Bay, NO 877 796. To the west, the bay ended in a high promontory of LORS conglomerates with some crude bedding, and the shore itself consisted of a large selection of pebbles and cobbles. Many of them were of conglomerate but there were also basalts and lavas with vesicles. To the east, a long thin spur of dark rock extended seawards. We were in the Crawton Volcanic Formation, a series of interbedded lavas and conglomerates (of alluvial fan origin) at the top of the Crawton Group of the Lower ORS and this was the highest conglomerate in the sequence. High on the cliff to the north of the beach was a cross-bedded sandier facies which formed part of a seaward dipping fan with slightly steeper apparent dip than the underlying conglomerates. The latter had pebbles and boulders over 50 cm in diameter while the finer-grained material was less well rounded. The conglomerate was mostly clast-supported and had a coarse sandy matrix. Volcanic debris was plentiful, with massive, porphyritic, vesicular lavas, but there were also quartzites, granitic rocks, metagreywackes, felsite, banded chert, jasper and "greenstones". The jasper and greenstones came from rocks similar to those of the Highland Border Complex while the metagreywackes with spaced cleavage came from Dalradian rocks north of the Highland Boundary Fault. Pebble imbrication and source information indicated a variety of convergent transport directions. A good storm beach, which merged with vegetated talus from the cliff, was developed.

The dark spur of rock (NO 878 796) was the top lava, a massive purplish basalt with vesicles, some over 10 cm in diameter and filled with calcite, quartz, and occasional brick red stilbite. Its surface was intermingled with the conglomerate deposited on top. Continuing along the shore, NO 879 795, there were now fewer lava clasts but prominent boulders up to 1 m in diameter of a fine grained pinkish granite whose size range indicated that they had been derived locally.

Lava /conglomerate junction. *Bill Gray*

The top of the next lava, lying under conglomerate , was exposed a few metres beyond. Its top was vesicular and porphyritic with lath-shaped phenocrysts of feldspars (some 20 mm long and 2 – 3 mm thick), and it had impressive flow directions, mainly in the body of the flow. As it had been eroded before deposition of the conglomerate its surface was now irregular with conglomerate-filled erosion hollows.

The contact between the third and second lavas lay at the base of the cliff and had thin, intermittent red mudstones and blocks of altered lava. The reddening indicated a phase of subaerial weathering producing a 'red bole'.

We then climbed the conglomeratic ridge to the top of the cliff and followed the latter's edge north from where we had an excellent view of the promontories formed by the four lava flows. We walked to the southern edge of the vertically sided inlet Trollochy, NO 880 798, whose cliff was of crudely stratified conglomerates. Within these were some lenticular well sorted sandstones with inclined bedding and trough cross-bedding. They probably represented sandy deposits on the gravel bars of an alluvial fan, laid down during periods of low water level and reduced stream power. Trollochy had been eroded along a series of joints and minor faults which threw down to the south.  A prominent joint trending NNW-SSE had been exploited by the sea – a blowhole used to function along its line, but this was now blocked by debris. The stream that formed the waterfall followed a post-glacial course along the line of the blowhole.

We descended a grassy slope onto the lowest lava flow (1) and crossed its top to a small gully eroded along a prominent joint, NO 880 797, within which the subhorizontal surface of the lava flow's central part had cross-sections through columnar jointing.. The columns were generally 30 – 60 cm in diameter; their softer centres hollowed out, and the column margins raised as ridges.  The columns varied in the number of their sides – hexagonal or with 5 or 4 sides. In vertical sections on the west wall the columnar jointing formed downward divergent fans.  The base of this lava had more vesicles and its feldspar phenocrysts were disoriented.  The patches of laminated sandstones and mudstones lying under the lava had been disrupted and baked.  The lava's top surface, now a wave-cut platform, had many small cavities and large joints with a different orientation to those seen earlier, indicating that it had been formed by a different pulse of lava.

Top of lava – wave-cut platform.
*Bill Gray*

We returned to the cars and set off for Stonehaven to book into our accommodation and enjoy a well-earned evening meal.

**Sat 15th Sept 2018, am**
Leader: Dr Con Gillen
Reporter: *Joyce Stewart*

After breakfast we all met at Stonehaven harbour car park at 9.30 am. Our leader gave us a synopsis of what we were going to see today and we walked from the car park along Shorehead Road, near the end of which were large blocks of migmatite from the locality of Girdle Ness, a promontory of migmatite on the north of Nigg Bay. Unfortunately, this had been destroyed by the building of a new harbour. The migmatite consisted of grey metamorphic rock with pink veins. When the rock is close to melting point (700° C) at around 15 km deep, molten material cuts through the mica inside the rock schist and causes melting. Crystals line up during compression and folding. The rock splits like a slate but the pieces are thicker and more irregular. There is no granite in the Stonehaven area – the main rock types are old red sandstone and conglomerate. As we made our way along the shore we found many examples of the junction between fine sandstone and conglomerate.

Fig 1. Junction between fine sand and conglomerate

The example in Fig. 1 has a ‘pebble supported matrix’ falling into the sand. The day before, we found that the rocks had mainly a ‘boulder supported matrix’.

There were also good examples of cross-bedding in the sandstone created by changing currents.

Fig 2.

Photos by *Joyce Stewart.*

We saw an igneous dyke – a dark rock with sharp edges cutting through the sedimentary rock. On either side the sandstone was proud as it had been hardened by the heat and re-crystallised. We then made our way to the cliffs in which there had been two big quarries. Facing the cliffs from the beach on the right was fine sandstone and on the left conglomerate. The conglomerate had made channels in the sandstone with powerful streams bringing in boulders. When the current was reduced it deposited pebbles, cobbles and finally sand.

**Sat 15th Sept 2018, am**
Reporters: *Joyce Stewart, Bob Diamond*

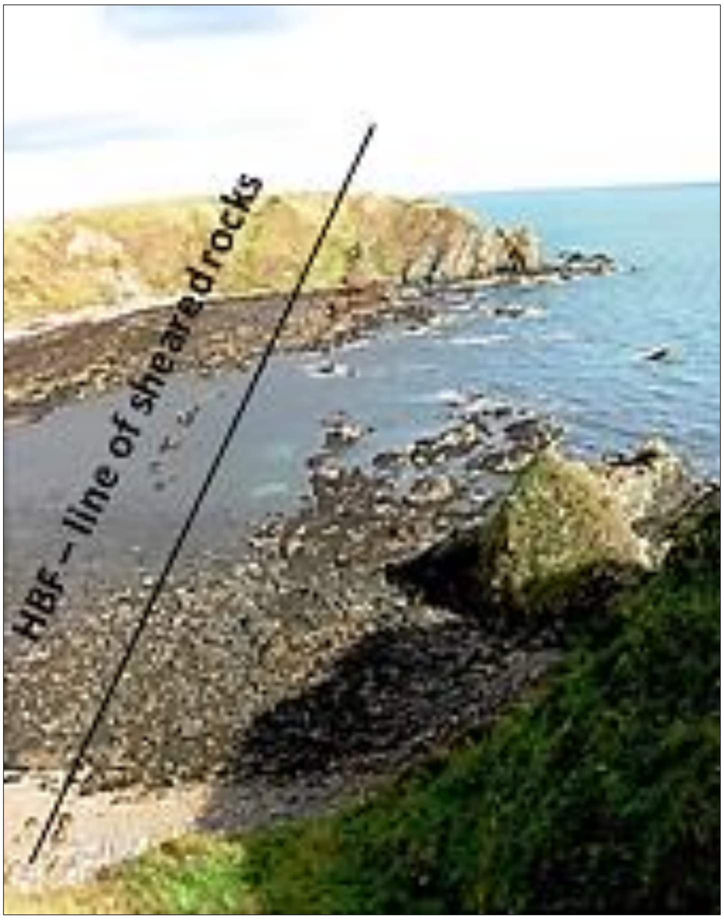
We made our way back to our cars and drove to Cowie Harbour, a small weathered out fault, where we examined the Late Silurian 'fish beds' in which fish scales which belonged to jawless fish such as lampreys (lived on dead material and algae) can be found. These occurred in a sequence of alternating grey sandstones, shales and mudstones with brown, grey and red cross-bedded fluvial sandstones below and above, and lie within almost vertical strata. Con informed us that the Cowie fish beds provided ages for its vertebrates; the oldest of the fossil fresh water fish was found here in 1911. The oldest known air breathing millipede was found here in 2004. We walked along to look at sedimentary structures and came to two irregular quartz-porphyry dykes trending NE-SE which seemed to have been intruded into a fault line – hardly surprising since we were rapidly approaching the Highland Boundary Fault Zone. The sequence then changed to a series of sandstones and mudstones, laid down in a low energy environment – there were a number of depositional cycles, fining upwards. The top often showed signs of erosion indicating some sort of seasonality. We found mud clasts in the sandstone as sometimes rivers would pick up dried mud at the banks and bring them down, spreading them out in a string. Some of the mud flakes are coloured red by oxidised iron, others coloured green by reduced iron. There were also good examples of honeycomb weathering by the sea as the carbonates were worn out. The edges of the network are hardened by silica. Concretions or nodules are elliptical structures which can be formed by a chemical reaction or by organic matter (e.g. when organic matter rots and a gel forms around it). Some nodules have been found to have fish scales inside, as a nucleus is needed to start the process. Sand then gets trapped, builds up over time, and in some of the nodules had formed cross-bedding.

Eventually we reached the irregular unconformity between the Silurian Cowie Formation and the Highland Border Complex (HBC), situated below the ruins of St Mary’s Church. ORS sediments dip to the south at 70-80°, whereas the HBC rocks have a penetrative cleavage which dips steeply to the NW. The cross-bedded units are typically coarse sandstones with a few small pebbles, interbedded with plane laminated or rippled sandstones and red mudstones. The nature of the unconformity and overlying sediments indicated that the local relief had been low, without nearby mountains to provide large volumes of detrital material.

**Sat 15th Sept 2018, pm**

Reporters: *Bob Diamond, Maggie Donnelly*

We returned to the cars, drove north, parked beside the golf course and walked down to an excellent viewpoint overlooking Craigeven Bay. On the opposite north coast of the bay the Highland Boundary Fault with its fault rock could clearly be seen – its line crossed the bay towards us, delineated by pairs of sheared rocks rising above the waves and finally exposed on the beach below us – easily the **best** view of the fault which many of us had seen!!




Easily the best view of the fault which many of us had seen!! *M Donnelly*

We set off down a steep grassy slope to the sandy shore and turned south, climbing over an outcrop of extremely rugged rocks below the ruins of St Mary's Church. These were the pillow lavas!

These were the pillow lavas! *M Donnelly*

They are the lowest part of the HBC. We climbed across to the seaward side and looked back to see a number of vertical faces of well-formed but badly sheared elliptical pillows between 50 and 100 cm long. Their ‘way up’ direction northwards was easily identified, but they did not have typical pillow structures such as concentric interiors nor distinctive rinds. Altered into chlorite schists, they are called ‘greenstones’.

We then started to walk around the bay, stopping at three localities where sheared rocks at the base of the grassy cliffs were exposed. They belonged to the Dalradian grits and phyllites of the Southern Highland Group, with open folds plunging gently to the SW, together with a number of small kink bands. They had a spaced cleavage and were fractured and veined by quartz. Grading in pebbly greywackes gave way-up evidence and in the coarse beds the quartz and feldspar grains were flattened. Eventually we reached the end of the bay and the Highland Boundary Fault where we spent time examining the fault rock and the rocks on either side. Crossing the bay there was a very obvious band of yellow rock – the highly altered fault rock of the Highland Boundary Fault. It was a silicified dolomitic limestone and was cut by many thin carbonate veins. These rocks were of Ordovician Age (*ca* 460Ma), now named the Trossachs Group. This was all in all an excellent end to a fascinating day, and we headed back to Stonehaven.

**Sun 16th Sept am**

*Reporter: Seonaid Leishman*

We all met at Dunnottar Castle – an impressive Pictish site on a sea stack with buildings dating back to the 13th century it has played an important part in Scotland’s history. We followed the path towards the Castle along the edge of a gorge, a meltwater channel formed in the conglomeratic Devonian Dunnottar Formation at the margin of the last major ice sheet as it retreated to the NW. A cleft formed by erosion of a major joint beneath the Castle stack became an escape tunnel seaward during attack! The beach to the north, Castle Haven, is a wave-cut platform where we investigated the conglomerate for clast size, degree of sorting, direction of flow, possible source. Most clasts are Dalradian, Southern Highland Group therefore from the Grampian Block, north of the HBF and can be up to boulder size. The thickness of these beds and distance from source confirm the vast height of the Grampian mountain chain. We also found unusual caliche indicating calcite cement – *and* some quartzite which has still to be fully explained.

We then drove to north of Garron Point, crossing the HBF yet again, to reach Skatie Bay. The path to the beach winds down beneath the railway, following another meltwater channel, formed in original Dalradian rocks, not re-worked as at Castle Haven. This beach is special. It exposes the Dalradian greywackes (deep water sediments) of the Steep belt of the Tay Nappe Downbend which have been sheared, buckled and kinked by movement on the HBF. It should be possible to identify three distinct deformation phases with related ductile folds and penetrative cleavages giving the schistosity, i.e. D1, 2 and 4. To make matters complex, in most places bedding is parallel to cleavage. Con emphasised to those new to Dalradian structures that cleavage is mineral crystal alteration due to deformation or metamorphism, not fracturing.

Skatie Shore and Garron Point

*Seonaid Leishman*

We had lunch at this lovely spot, all the while trying to discern bedding v cleavage and get evidence for way up in the form of graded bedding, cross-bedding and crenulation cleavage. There was even a rare sighting of a D1 fold hinge. This is a locality worth further investigation – certainly by me!

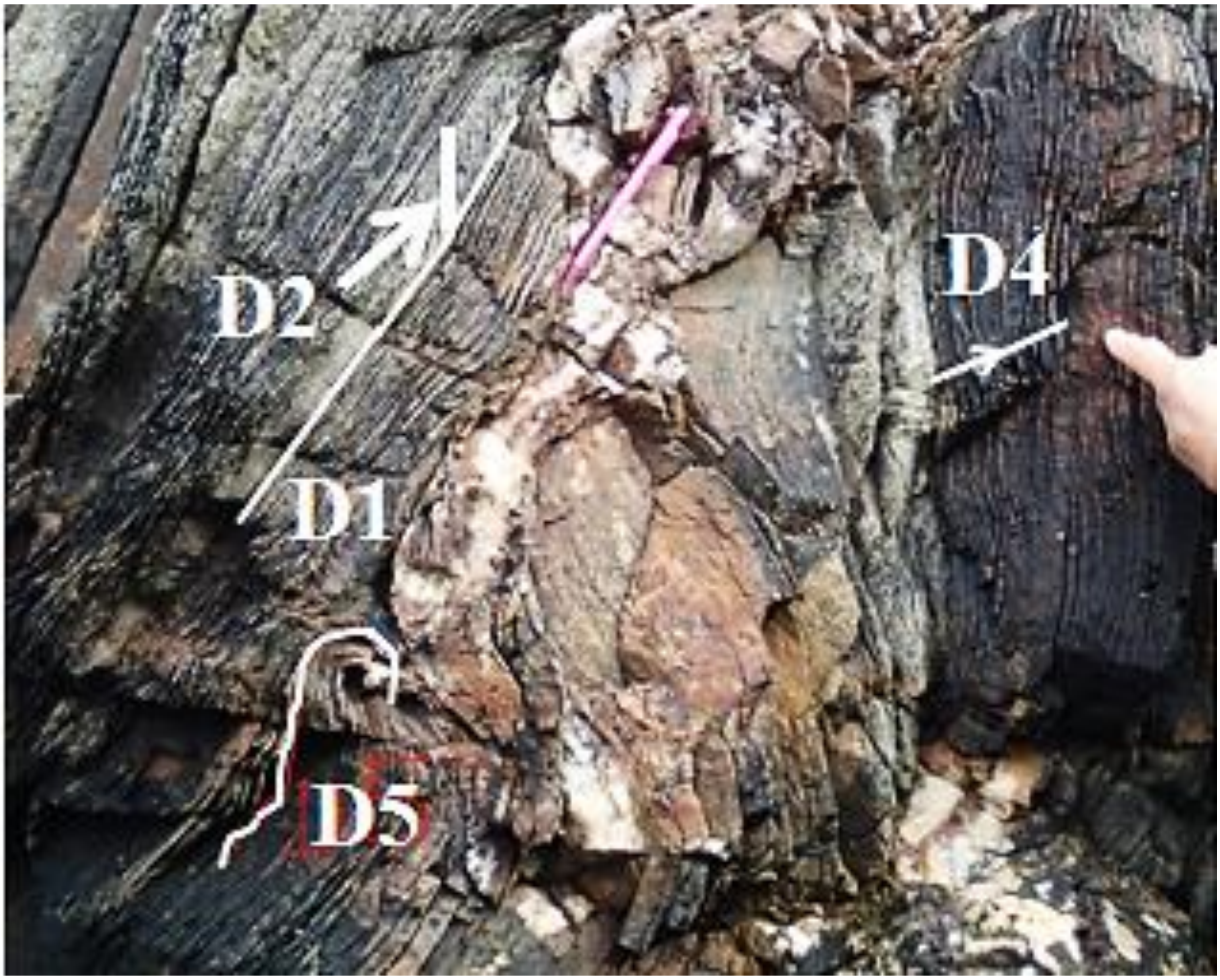
**Sun 16th Sept pm**

*Reporters: M Donnelly, Rhona Fraser*

We walked north a short distance along the shore and then our leader struck out over the intensely sheared, slippery rocks towards the sea and beckoned that we should follow. (About six of us felt that this was a step too far and started back up the cliff path.) The first exposure had micaceous layers showing crenulation, and cleavage parallel to bedding – this was D1.

Bedding and cleavage
*Seonaid Leishman*

In coarser material there was evidence of cross-bedding which was younging to the north. Further north, bedding became less steep than cleavage. The group then walked and paddled to a sea stack with a narrow cleft into which only two or three people could fit at one time. However, this single exposure was ***most impressive***. It displayed four deformations – D1, D2, D4 and D5!! Most of us had ***never*** seen an exposure which so clearly showed four deformations.  D1 is labelled, D2 is at an acute angle to D1, there is no D3 exposed in this area, D4 is crenulation, D5 is a box fold (conjugate folds with rounded hinges).




This single exposure was ***most impressive.***   *Rhona Fraser*

We returned to the cars, drove north on the A92 and turned right onto the A956 which took us to the Cave of Red Rocks, NJ 965 029,.  Parking under the railway bridge we followed the path to the cliff-top on the south side of a deep coastal inlet eroded along a fault line.  This path ran over the upper surface (close to the upper contact) of a slightly porphyritic late Siluro-Devonian felsite sill, about 5 m thick, which contained small quartz and feldspar phenocrysts.  Faint flow-banding, mainly parallel to its edges, permeated the sill but this was more pronounced near the upper and lower contacts where it was occasionally folded and contorted.  The rock was composed almost entirely of quartz, potassium feldspar and oligoclase with very minor biotite, garnet and muscovite. A number of us followed the path **very carefully** down onto the rock platform by the sea where Dalradian migmatites were well exposed. These were originally pelites and semi-pelites, and now contained a number of large muscovite porphyroblasts. A succession of pressure-solution cleavages could be identified, the second of which was folded, indicating at least three deformation events.

We then drove south, almost to Cove Bay (NJ 962 018) and, on foot, followed the path to the cliffs, observing that the surrounding rocks had become extremely brecciated. Soon we arrived at approximately the centre of a huge breccia pipe, 500 m in diameter, with steep contacts and the characteristics of an igneous explosive origin. There was a body of pink muscovite-biotite granite in the central part, thought by some to be a later intrusion, but by others, simply a large breccia block. The fragments of breccia comprised gneissic metasediments, amphibolite and a foliated two-mica granite in a cataclastic matrix. There were several bodies of red felsite, particularly near the margins of the granite, and occasional lamprophyre clasts have been found within this felsite-cut breccia. This is similar to other intrusions in the area. Quartz and calcite filled small cavities throughout, and large fissures contained veins of quartz. The matrix included pyrite and minor molybdenite. Extensive faulting and broad crush zones penetrated the whole breccia. The pipe probably belonged to the 'Newer Granites' suite and had occurred at shallow depth. It had similarities to the appinite suite of Argyllshire. A small Carboniferous aphyric quartz dolerite dyke with obvious chilled contacts cut the breccia at NJ 961 017. After a fascinating day we returned to Stonehaven

**Mon 17th Sept**

*Reporter: Walter Semple*

The rolling fields of Aberdeenshire are a delight to lovers of "Sunset Song", but less rewarding for those in search of rock exposures. After spending the first part of the field trip on the dramatic wave carved rock exposures at the sea on either side of the Highland Boundary Fault, we were led up the course of the river Dee to Dinnet near Aboyne. Beside the Dinnet Bridge, the careful cutting of the bank vegetation to avoid fouling the salmon fishers' casts allowed the bankside rock exposures to be readily seen. We were now on the flat section of the fold in the Argyll South Highland Group in the Grampians. The metamorphic rock is mixed but mainly limestone. On the north bank a small dyke had intruded. Our second stop was at Burn O'Vat, a spectacular feature important enough to support a visitor centre and car park. It is a glacial pothole thought to have formed when a rock became lodged in the river bed causing a torrent of melt water to spiral around and carve out the underlying granite bedrock. It measures 13 meters deep and 18 meters wide with a sediment bed estimated at up to 7 meters. The entrance is a narrow stream passage that suddenly opens into the natural amphitheatre.

group at the uphill entrance to Burn O’ Vat.
*Walter Semple*

Looking downhill across Burn O’ Vat. *Rhona Fraser*

We moved on to the Pass of Ballater to view the well-known granite rock climbing crags. Plentiful examples of the rock can be seen in the rock falls without any need to climb. The granite has two types of red feldspar crystals giving it an attractive red appearance. The crystals are large indicating formation at high temperatures deep in the crust. Our last stop, the final stop before the journey home, was beside Gairnshiel Bridge, a picturesque stone structure built around 1750 as part of the Hanoverian work to open up the Highlands after the Jacobite rebellion. The granite rocks in the slopes above the bridge are a short distance below the Dalradian rocks further up the hill. This indicates that the granite rocks were at the top of the magma intrusion. Our leader Con Gillen explained that the more easily crystallised minerals had crystallised lower down in the magma chamber leaving the last to crystallise at the top. The result was crystallisation of several different minerals, the most abundant being Zinnwaldite, a silicate mineral in the mica group, here predominantly green in colour. Because of the unusual rock, the locality has become well known to geologists and students and abundant examples of the hammered rock are available to be examined.

Finally, our leader was given a very warm and enthusiastic ‘thank you’ for taking us on a such an interesting and fascinating excursion and was presented with the usual gift of appreciation, before we all headed homewards.

**Reference**

!. Excursion Notes provided by our leader, Dr Con Gillen

2. Kneller, B. C., Gillen, C, 2016, Excursion 1, Aberdeen City and Environs.. Aberdeen Geological Society Excursion Guide.

3. Trewin, N. H., 2016, Excursion 22, Crawton. Lavas and Conglomerates of the Lower ORS. Aberdeen Geological Society Excursion Guide.

3. Gillen, C,, Trewin, N. H., Excursion 23, Dunnottar to Stonehaven and the Highland Boundary Fault. Aberdeen Geological Society Excursion Guide.