Glasgow Geological Society

Banffshire Coast Excursion

September 2014

Leaders: - Drs. John Mendum and Con Gillen

Friday 12th September 2014

Report by Bob Diamond Participants 22

After a lengthy journey North from the Central Belt to the North East 22 adventurous souls arrived in dribs and drabs at Cullen, Morayshire, eagerly anticipating a good field trip amongst the Grampian Dalradian. John Mendum and Con Gillen are well known to us, and did not let us down. We had a great time despite the haar coming down at times, and one of us managing to lock himself out of his car.

Our first stop was at Portnockie Harbour, where we started at the lowest part of the stratigraphy the Cullen Quartzite Formation. Although at the base of the sequence (in amphibolites fascies) there was a remarkable amount of structure still visible.
There were massive psammitic beds, showing crossbedding, interbedded with thinner pelitic beds indicating a deltaic/intertidal depositional environment. Other sedimentary features such as slumping and channels could be seen. All these structures had been steeply folded, so that there was evidence of brittle fracture in some of the quartzites

On closer inspection of some of the pelites there was evidence of crenulations cleavage, indicating secondary cleavage (from secondary deformation) of an existing fold

Our second stop was at the Pet Cemetery at Cullen. Right on the shore is this cemetery for pets. Very unusual, and remarkable for the evident love and affection people had for their pets.

We were still in the Cullen quartzites, but this time there were garnets in the rocks. There was some debate as to whether the rocks were ‘right way up’ or slightly overturned. What was evident was that we were looking at a monocline dipping c65o to the North, and younging to the North

As previously we were still in a deltaic environment, but at this location the crossbedding was at a low angle.

The only other feature was that some of the silica around the quartz grains had been replaced by carbonate during diagenesis.

So after a gentle introduction to the complexities awaiting us we retired to our respective Hotels, were the writer at least enjoyed a good bowl of Cullen Skink.

Saturday 13th September 2014 am.

Report by Elisabeth Davenport

Objective: To examine rocks of the Appin Group (mostly).

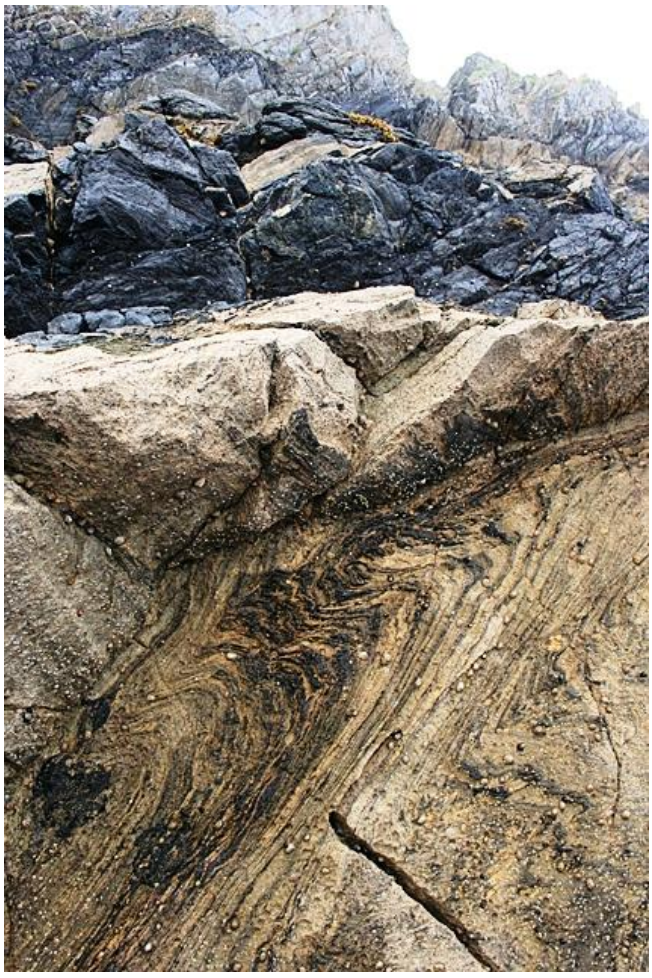
The context of much of the morning was the Lochaber-Ballachulish subgroup transition, marked by a rapid change from calcareous semipelites and micaceous psammites to graphitic pelite and more pure finely banded limestones. This change can be observed extensively along the Dalradian outcrop though it may be noted that the Corriehabbie Quartzite is not exposed in this part of the succession.

Ben Browne standing on the Lochaber-Ballachulish subgroup transition, NJ 5548 6671 *Anne Burges*

First locality: Garron Point (GPS NJ 553 669). We parked at NJ 555664, but the official car park is at NJ 554661. After scrambling down the succession over the beds of the Sandend Harbour Limestone (more on this below), we reached the narrow path to Garron Point. Here graphitic pelite passes into the lighter micaceous psammites and semipelites of the Garron Point Tremolitic Flag Member (of the Cairnfield Calcareous Flag Formation in the Lochaber Subgroup). On a group of small crags we searched for tremolite (an amphibole that is diagnostic of these units); here it takes the form of small pale grey laminae (3 to 4 mm long), difficult to detect on the cleavage surfaces of grey schistose pelites. On some crag faces we found barrel-shaped porphyroblasts (4 to 5 mm), possibly kyanite, interspersed with small garnets. The mineral source for these alumina-silicates was inferred to be a tropical soil washed into a gully. The tremolitic schists represent a major change in sedimentation at the junction of the Lochaber and Ballachulish Subgroups.

Second locality: Sandend Harbour Limestone Member (GPS: there would be a whole range because it's quite an extensive feature) of the Mortlach Graphitic Schist Formation of the Ballachulish Subgroup). Walking eastwards back up the succession we crossed interbedded cream to white metalimestone and graphitic pelite (dark grey to black, schistose and pyrite-bearing) beds of the Sandend Harbour Limestone Member.

These steeply (ENE) dipping beds have been deformed into plunging folds with steep cleavage; the bedding can be inferred from the lithology.



The Sandend Harbour Limestone Member with steeply (ENE) dipping beds, deformed into plunging folds with steep cleavage. *Anne Burgess*

An erratic Inchbae Granite boulder was spotted on our way to the east side of the harbour where we examined grey metalimestone and semipelite-pelite units showing open and tight folding and evidence for two stages of (F1 and F3) deformation (inferred from space and pressure cleavage and crenulation in impure limestones and pelites). The presumed context of deposition is marine transgression resulting in a relatively quiet lagoon environment; the carbon source for graphite is likely to have been algal or bacterial. These rocks are laterally equivalent to the Ballachulish Slate formation which has been dated at 659.6+/- 9.6Ma.

Third locality: path to the shore near Glenglassaugh Distillery (GPS NJ 5611 6586). Here we looked at flat-bedded basal Devonian conglomerate in a burn, and in a small cliff, overlain by till. This well-consolidated water-borne material was deposited at the edge of Lake Orcadie, a mid-Devonian vast inland sea, whose sediments are now lithified, and are extensively exposed in the North-East of Scotland from Shetland to the Banffshire coast.

Saturday 13th September pm.

Report by Bill Gray

After our morning among the rocks of the Lochaber and Ballachulish Subgroups of the Appin Group, we now moved east to study the rocks of the younger Blair Atholl Subgroup and the overlying Argyll Group. Our first stop was at the Glenglassaugh Distillery visitor centre at the east side of Sandend Bay, from which we walked down the path to the shore. On the way, we passed an outcrop of Devonian rock in the form of a small hill, an example of the many Devonian outliers that are found across the Northeast Grampians. The rock was a breccia/conglomerate with till on the top and it displayed surface weathering. The rocks exposed at the shore were metalimestones and semipelites of the Fordyce Limestone Formation of the Blair Atholl Subgroup, and we found a sheltered spot next to them for our lunch. Those of us with access to binoculars had a good view of a pair of Brent Geese swimming in the bay.

After our lunch, we walked eastwards along the shore. The main features here were deformed limestones that displayed folds, distorted bedding and boudinage.

Boudinage in metalimestone at Sandend East

The sun now emerged from behind the clouds (it stayed out for the rest of the afternoon) and illuminated a stretch of limestone with a beautiful striped structure. We then encountered a red outcrop of fine-grained pelite with crenulation cleavage, indicating two stages of deformation – D1 and D3, and limestone with folded folds, which are examples of interference structures.

We also saw further examples of Devonian inliers within the Dalradian, the most spectacular of which, at the furthest point our walk, was a large outcrop that had been created by the infilling of a Dalradian pothole.

The surrounding country rock displayed karstic weathering and calcite veining. We now retraced our steps to the car park.

In a change to the planned order of events, we now drove further east to Portsoy, where we parked on a cliff top to the west of the town. From here we walked to the derelict swimming pool and studied the rocks on the foreshore next to it. These rocks belong to the Argyll Group, specifically to the Portsoy Limestone Formation of the Easdale Subgroup. They are part of the Portsoy Shear Zone, an area which gas been the focus of intense interest to the geological community, as its interpretation is critical in understanding the geological history of the Northeast Grampians. One striking feature of the rocks near the swimming pool is the presence of the metamorphic minerals andalusite, kyanite and sillimanite; knowledge of the order in which the kyanite and sillimanite were formed from the lower grade andalusite is important in determining the tectonic history of the area. (Sillimanite forms at high temperatures and kyanite at high pressures.) We saw several clusters of sillimanite crystals, and also mica pseudomorphs of sillimanite and kyanite pseudomorphs of chiastolite (andalusite with carbon crosses). At the headland to the west side of the pool we saw a spectacular asymmetrical fold structure in the rocks and to the east side of the pool we saw tension gashes in a competent bed with sillimanite crystals occupying the gash spaces.

We now walked eastwards past the old harbour and further along the shore, where we saw tightly folded limestone, reflecting the activity within the Portsoy Shear Zone.

We also saw a gabbro intrusion that had been formed between 473 and 471 Ma, a short time by geological standards. Slightly further on, we saw boulders of 'Portsoy Marble' (actually serpentinite) and then came to the probable source of these boulders, large serpentinised ultramafic bodies intercalated within the metasedimentary rocks. These bodies, which are very Mg rich, were intruded in the Early Ordovician, around the same time as the gabbro intrusion we had seen earlier. They contain grains of iddingsite, a red microcrystalline rock derived from the alteration of olivine. This point marked the end of our traverse, and we now wended our weary way back to the cars.

Sunday 14th September 2014

Report by S Leishman

On Saturday afternoon we had been introduced to the 2 km-wide Portsoy Shear Zone which marks the western edge of the Buchan Block. To the South it is bounded by gabbroic plutons. Dalradian structural timing and basement of the Block have very different histories from the South and West Grampians. Research on this has been continuing for almost 100 years. Put VERY simply, was it horizontal shearing from the east pushing the beds up OR the effect of gabbro intrusions?

Portsoy is famous for ‘portsoy marble’, which is not marble at all! The source is a vein of serpentinite, a metamorphosed ultra basic peridotite with olivine and pyroxene. These magnesium silicates are prone to hydration thus altering to steatite which is relatively easy to carve. The varied colours are due to iron, chromite also iddingsite for the red. John made it clear that this outcrop is not the result of MOR volcanism. It had been an intrusion linked to the gabbro, which can also be seen at Insch and Huntly.

In the coastal ‘marble’ quarry just east of the old Portsoy swimming pool we found a block on the beach measuring ~ 70 x 70. This clearly shows how they were broken up using the Cornish system.

Metal ‘feathers’ are inserted into each drilled hole and a tapered plug hammered in until the ringing tone indicates the correct depth and tightness.

Marble Block

The exposures on this beach from West to East range through mafic intrusions - quartzite - ‘marble’ - pelite - quartzite. A real tectonic melange.

Could this be caused by crustal/mantle weakness followed by Grampian deformation at 470 MY? The deformation would all have been at depth – any shallower and the rocks are not plastic and mobile enough. John also noted that the mantle is not the same composition - or age - everywhere on the planet.

After this comprehensive discourse we discovered that from the middle of the bay to the east, igneous outcrops give way to quartzite, limestone and semi-pelite of the Portsoy Limestone Formation, Easdale sub-Group. An exposure of the calc-silicate quartzite has been greatly sheared to produce rodding or mini-mullions.

mini mullions

A stand-alone stack of dolomitic limestone allowed us to study steeply plunging folds in 3D – with a great deal of help from John and Con!

Then a 'novelty item'. A pod of meta-anorthosite, also ribbed and altered, with sheared boundaries.

The next locality was the Portsoy rubbish tip where it is possible to see the relationship between the older fine-grained folded and foliated amphibolite intruded by the coarse younger metagabbro, which is itself cut by shear zones.

Portsoy New Harbour was our pleasant stop for lunch. Some of us were sitting on two gabbros – one of which is foliated, the other not. This indicates that magma intrusion and deformation were contemporary.

Then over the harbour wall and traversing east along the foreshore is the expected sequence of Easdale sub-group meta limestones, calc/silicate and semi-pelites. However these are cut by huge veins/pods of leucasome pegmatitic granites of the 470 MY age.

Easdale sub-group cut by pegmatitic granites

We drove to the car park at the east end of Links Bay - the eastern edge of the Portsoy shear Zone. By then we were in a new sequence – the Cowhythe psammitic formation (equivalent in age to Crinan sub-group)

The rocks appear very complex indeed. In addition to the full range of meta-sedimentaries there are enclaves of highly deformed migmatic igneous rocks. These have recently been zircon-dated at 1004 MY, the time of the Grenville orogeny. Does this mean that basement has been caught up in the 'shuffle zone'? An intriguing question!

Migmatic igneous (basement?) dated 104 Ma

The Portsoy Shear Zone then ends and we were in the Cowhythe Formation Rosehall Croft Member. Reaching East Point we found ultra-mafic pods of gneiss with anthopholite and cummingtonite (orthorhombic and monoclinic amphiboles) the pods are like a bubble and because they are anhydrous, suck in alteration minerals and become slightly serpentinised.

So we completed another day of fantastic geology and views of the rocks of the North East coast - all in good company and amazing sunshine.

Monday 15th September 2014

Report M. Alexander

The final morning of our excursion arrived and the weather was disappointing-dull and threatening to rain. However most of the group met in the square and, after receiving directions from our leader, we set off in good spirits to the first location of the day.
We drove east through Portsoy turning left down the narrow B9139 until we parked at the top of a lane leading to the Boyne Limestone Quarry. A walk down the lane past the quarry entrance led us to Boyne Bay where, as we had now moved up the succession, the rocks were in the Tayvallach Subgroup of the Argyll Group and we were encountering rocks of the Boyne Limestone Formation.
The first outcrops encountered on the east side of the bay were of much deformed and folded greenish-grey rocks with fine granitic veins through them. They were formed by thin beds of calc-silicate, metalimestone and semipelite rocks which were interbedded, compressed, folded and refolded showing cleavage and giving step folding. These outstanding folds were F1 refolded by F3.
We next walked across the bay to the west where we encountered the challenge of wading across a fast flowing, shallow stream and climbing the grassy bank opposite (gaiters were a great help but some people must have had very wet feet).We were now looking across Old Hythe Ba. Here , in the bay, we first examined the impressive, finely banded exposures of the Boyne Castle Limestone Member where the folding (F1) and refolding (F3) of metalimestone and calc-silicate bands showed the light coloured surfaces with wonderful interference patterns of dark lines through the pale grey rock (we could even imagine the shape of a bear). The thin banding indicated that perhaps some of these layers may have been algal and have formed in warm water on a shallow, marine shelf in lagoons or on algal reefs. Folded outcrops of darker semipelite interbedded with metalimestones and calc-silicates were also found within the bay area.
Lastly, we walked across the beach to the cliff at the west end of the bay which formed the boundary between the Boyne Limestone Formation and the Cowhythe Psammite Formation. This cliff face is the position of the Boyne Line which is thought to be a shear zone as it showed mylonitic recrystallization and possible faulting.
As we returned to the cars the rain began and, as some of the group were leaving early, we decided, while still all together, to express our thanks and appreciation to our leaders. Fortunately the farm was nearby and the silky tongue of our leader persuaded the farmer to allow us to shelter in the barn. After a lively discussion and some chat, including mention of the reported find of the single microfossil arcritarch in the area, we thanked John and Con most sincerely for giving up so much of their time to be with us for the weekend and for all

the effort, preparation, patience and enthusiasm the showed to give us a clear, fascinating insight into what is indeed a very complex area.
After saying our farewells we set off , past Whyntle , to Whitehills and on to the car park at Red Well for lunch. We had now moved up the stratigraphic succession from the Argyll Group into the Macduff Formation of the Southern Highland Group near the top of the Knock Head Grit Member. Fortunately the rain had stopped as we walked along the shore to the east where we soon found bands of rocks which were exposed on the foreshore. These were from turbidite fans flowing down off the subsiding continental shelf and were arenites (or psammites), semipelites and pelites indicating that they were formed from sediments in a much deeper water environment. These rocks were typical of Buchan Metamorphism and had been metamorphosed to amphibolite facies. We could clearly see many large, grey andalusite prophyroblasts scattered on the surface of some pelitic layers. Folds and cleavage could perhaps be found here and the folds around the growth structure of the porphyroblasts showed that metamorphism occurred between the D1 and D3 deformations. As we searched around looking at the pelitic bands we found other metamorphic minerals in the form of black, rounded spots which were cordierites and small, brown staurolite porphyroblasts.
Our final stop involved a drive eastward through Banff and Macduff to the Howe of Tarlair where we parked beside the old swimming pool. Here we saw some of the youngest rocks at the highest structural levels of the Macduff Formation, mainly arenites, greywackes and pelites deposited by turbidite flows. We looked at the sedimentary structures and identified bedding, grading in the psammites and ripple marks indicating that the rocks were right way up . We also found rip-up clasts, flame structures, mud flakes and calcareous blocks left by the turbidite actions. The rock outcrops and
cliff faces showed large scale, upright folding with only one (D1) deformation. Here metamorphism was lower grade at green schist facies giving the rocks a slatey cleavage. The high cliffs at the back of the bay formed an upright, F1, syncline-anticline pair of folds which were upward facing. The relationship of the cleavage to the bedding could be seen. After viewing the large outcrops at the east end of the bay and finding possible dewatering structures we made our way back to our cars where we once again thanked our leaders for a great field trip and wished everyone a safe journey before finally setting off for home.