Reading Geological Society and Farnham Geological Society

Joint visit to South Pembrokeshire

Monday 16th – Thursday 19th May 2022

Led by Sid Howells

This visit was the first joint 4 day field meeting between the two societies. A total of 19 people came on this visit – 12 from Reading and 7 from Farnham. We were fortunate to find accommodation in Pembroke in the delightful Coach House Hotel, where we were made very welcome.

Our leader, Sid Howells, lives locally where he runs his small business – Geological & Educational Services(GES) Ltd. He carries out many educational field trips for schools, colleges and universities; he also works part time as the Geologist at Bolton Quarry which we visited on our final day. Several images in this report have been taken from the handouts provided by Sid, and we are grateful to him for permission to use these.

Monday 16th May

Afternoon: Amroth

Grid ref: SN169 070

The day started early for the drive to Pembrokeshire to meet at Kilgetty. After lunch and a short briefing we moved to nearby Amroth on Carmarthen Bay for our first look at the geology.

The glacial maximum occurred 20k years ago, so the sea was not present as it is today. An ice sheet moved west from the Brecon Beacons area, reaching approximately 20 km to the east of Amroth. A river flowed through the middle of what is now the bay.

Here we are on the Carboniferous (Westphalian) Lower Coal Measures which comprise mostly sandstones with some mudstones and marine bands. The outcrop trends roughly east west across the Pembroke Peninsula, as with all other outcrops in the region.

The area is well faulted. Amroth is located on the Erroxhill Fault Zone which is the most south-western extension of the Church Stretton fault.

From the beach we could see the extent of the bay; from Monkstone Point in the west to Ragwen Point in the east. We set off westwards to look at the exposures along the beach.

The strata were well exposed and so the folding and faulting, mostly Variscan in age, were spectacular. Other evidence of tectonic activity we found were tension gashes.

Fig.1 Variscan folding and faulting

Fig. 2 Tension gashes

Looking at the Amroth anticline we found the Kilgetty vein of the Carboniferous Lower Coal Measures. Coal mining was first recorded in this eastern area of the Pembrokeshire coalfield in 1324 and was exported from Saundersfoot until 1954.

Coal had been mined here for over 100 years as an open cast mine. The coal and iron ore, from a seam under the Pennant Sandstone Formation, were transported to ships on the beach by wheelbarrow. There used to be iron works further west and then later in the Swansea Valley. The iron ore was extracted from iron nodules, but being poor quality ore, only pig iron was produced.

The coal in Wales is known as Black Gold. Here the seams are thin and highly distorted and broken; children were used to work the narrow seams. Anthracite coal is more highly metamorphosed than bituminous coals, so is harder, has a higher carbon content and with few volatiles it ignites with difficulty.

On a limestone platform we found a fossil forest at the top of the storm beach. The forest dates from 3-5k years ago when the ice was retreating. In this area there were also symmetrical, non-directional ripple marks, pyrite nodules, trace fossils of stigmaria and calamites. Some of the calamite's trunks were, unusually, vertical.

Fig. 3 Stigmaria

Fig. 4 Vertical calamite's trunks

The strike of the Variscan folds tend NWN / SES.

As well as anticline structures reverse faults and faulted 'S' shaped folds are present.

Fig. 5 Anticline structures

Fig. 6. Reverse faults and faulted 'S' shaped folds

Within the Pennant Sandstones we observed ball type structures within a layer of mudstone. These seemed to be 'attached' to the layer above but did not reach the base of the layer. These are load casts where soft sediments had been deformed by a more solid layer above. Here we also found bioturbation and a normal fault.

Fig.7 Load casts

Report by Ailsa Davies, photos by Ailsa Davies and Roger York

Tuesday 17th May

Morning: Freshwater East

Grid ref: SS02425

Aim: to explore the lithology, structural geology and fossils within the rocks of the northern limb of the Freshwater East anticline – a site of Special Scientific Interest. The oldest Silurian sedimentary and volcanic rocks, found in the South cliff, were too unsafe to visit.

Period covered: early Silurian (Ludlow) to mid Devonian (Lower Old Red Sandstone ORS) and quaternary deposits.

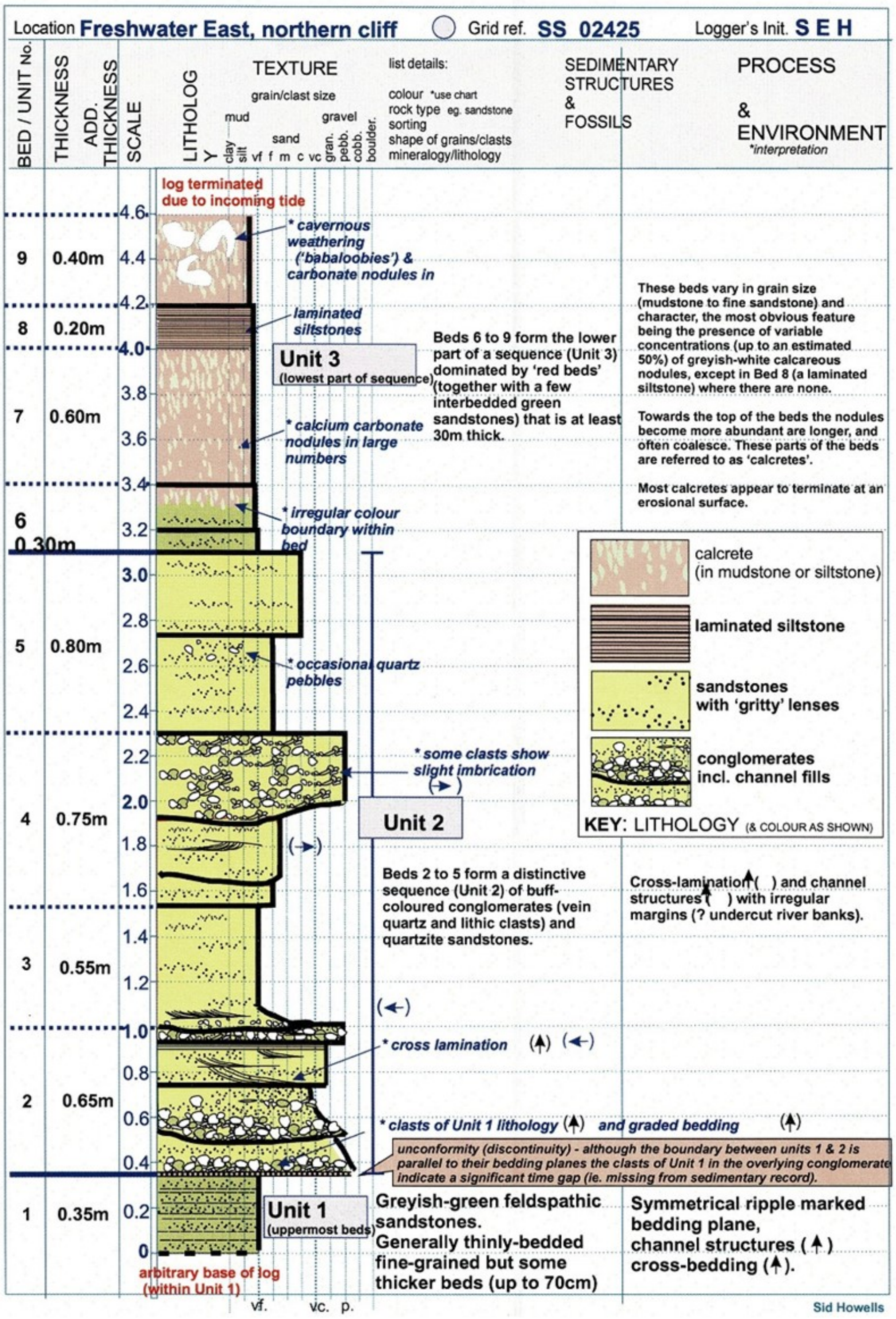

Fig. 1a Log of north cliff at Freshwater East courtesy Sid Howells

Topology: On driving to the entrance to the bay we passed through 'ridge and vale' topology; the ridges comprise harder sandstones, the vales, weathered limestones and shales. The centre of the Freshwater East anticline was obscured by climbing dunes deposited during a recent storm.

We were directed by our leader to the beach to watch current ripples developing first in single then in double channels before becoming braided near the shoreline. We were asked to remember this when looking at the cross bedding later in the north cliff exposure.

Structural geology: the southern limb of the anticline dips at 40^0 SSW, the northern limb dips at 85^0 NNE, but the axis of the anticline is not visible. The northern limb faulting reflects compression during the Variscan period as the fused Avalonia and Laurussian plate moved north. Each gully on the north limb was marked by a fault; F1 at the waterfall was a right lateral fault with notable fault breccia, F2-F3 were left lateral faults whereas smaller faults were listric.

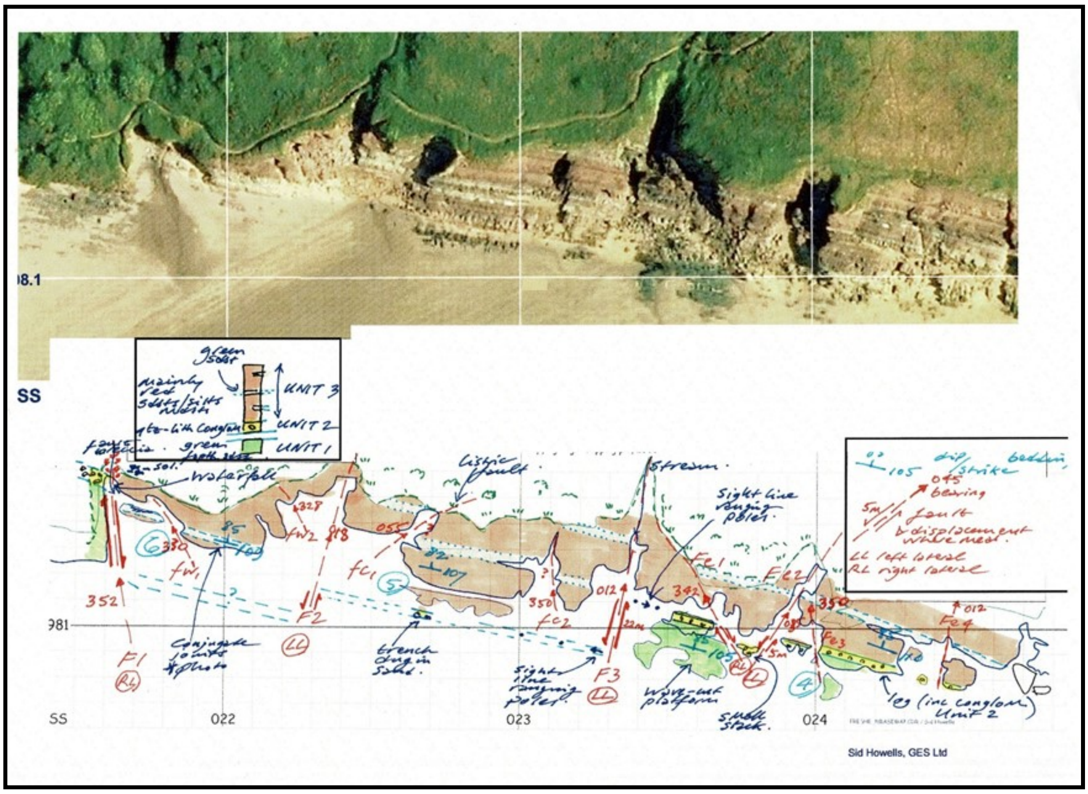

Fig. 1b Aerial photograph of north cliff with interpretation below

Description of rocks (See log in Figure 1a).

The discussion covered:

- The symmetrical ripple marks in the quartz rich basal conglomerate. (Figure 2).
- Measurement of fault displacement (Figure 3) based on the lower green feldspathic sandstone.
- How tundra melt water aligned pebbles in the direction of flow during interglacial periods - solifluction (Figure 4).
- Comparison of cross bedding from the lower marine unit with that in the dry land river system of the middle unit. The way up was determined by channels as the beds were nearly vertical.
- The origin of the iron oxidation (Figure 5), the frequency of monsoon events (10-100 years) and examples of non-bedding related red/green unoxidized boundaries (Figure 6).
- The origin of the calcrete formation; mangrove type roots, occasionally bifurcated, infilled by calcium deposits during rare flooding events with subsequent leaching causing greenish drab halo discoloration around the roots.
- Large, weathered holes in the upper unit called locally 'Babaloobies'
- Exotic pebbles from other periods

Fig. 2 Ripple marks in ORS basal conglomerate

Fig. 3 Measuring fault displacement

Fig. 4 Example of solifluction from an interglacial period c 15000 years ago. Glacial meltwater streams deposited inclined stones in the direction of the down slope movement

Fig. 5 Haematitic discoloration in the Old Red Sandstone sequence

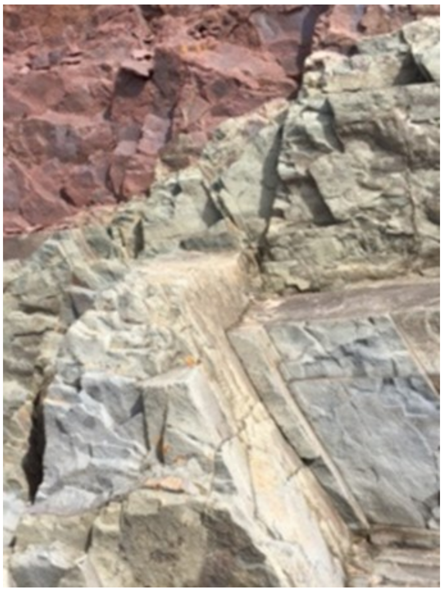

Fig. 6 Example of variable oxidation boundary (red/green) within a dry desert channel

Fig. 7 Tracks of giant water scorpions (Eurypterids)

Fossils found

- Brachiopods and the remains of dorsal fins of Cetalapsid fishes from the late Silurian
- Tracks of the water scorpion Eurypterid (Figure 7) Sid is to be commended for his impersonation of how this top predator moved, you had to be there!

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Full waterproofs were essential, and lunch was taken whilst the hunt for exotics took place. Sarah was the first to find a banded rhyolite from Anglesey

Report by Angela Snowling, photos by Angela Snowling and Sarah Cook. Other figures courtesy of Sid Howells

Tuesday 17th May

Afternoon: Stackpole Quay

Grid Reference SR 99148 95772, (in the rain)

We travelled west along the coast to Stackpole Quay (Figure 1) where we parked in the National Trust car park. The rocks in this area are Carboniferous limestones. Walking along the road to the north we came to a disused limestone quarry and an adjacent, well preserved lime kiln.

In the past the kiln used limestone from the quarry to make quicklime, which was made into mortar and lime wash to apply to the outside of houses and inside barns to sterilise the surfaces to keep things clean. The quicklime was also used as a fertiliser. Apparently when water is added to quick lime to make lime wash it spits and the workers used to protect themselves from burns by using butter. This was linked, by a well-read RGS member, to an obscure quote from the novel ‘Cold Comfort Farm’ by Stella Gibbons, where the vicar’s sermon included the phrase ‘there is no butter in hell’, which could relate to this.

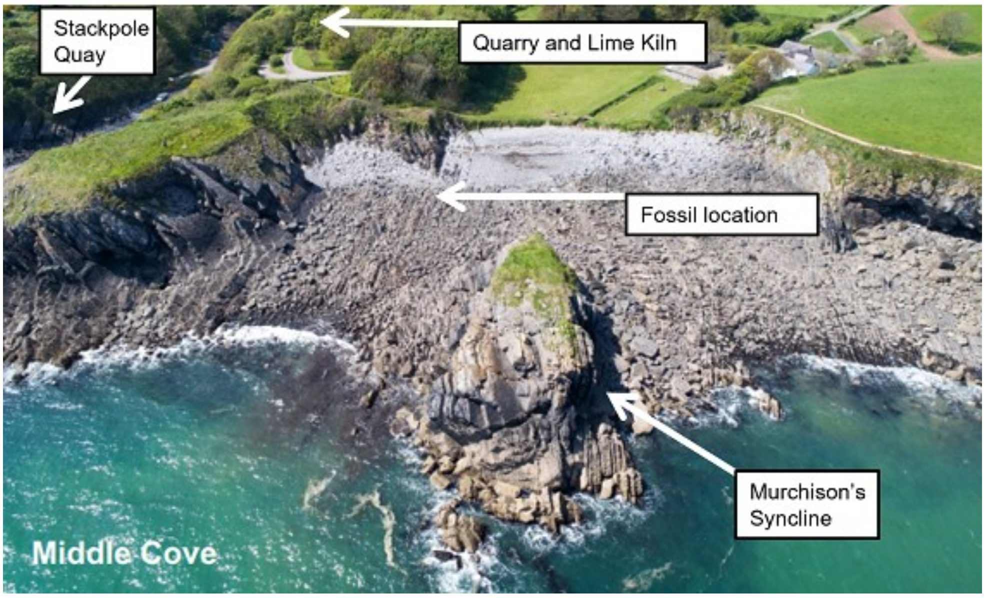

Fig.1 Stackpole Quay

At the end of its life the quarry produced stone for local roads. The quarry is quite overgrown around the edges but to the west huge flat sub-vertical bedding planes showing well developed fractures can be seen, while on the east the beds dip gently indicating an asymmetric fold must exist. An antiform was visible on the northern edge of the quarry, Figure 2, which could be related to the syncline seen on the beach to the south. The quarry has recently been repurposed as an outdoor activity centre and one of the steeply inclined bedding planes has been set up for wheelchair abseiling.

Fig. 2 Antiform on northern edge of quarry

We then moved south, back to the coast and onto the beach adjacent to an isolated stack on the foreshore called 'Murchison's Syncline' that plunges out to sea. The well-developed bedding is emphasized by differential weathering; well cemented 'tempestites'- shallow water carbonate sands - that were moved offshore by storm events, are interbedded with less well cemented, deeper water carbonate mudstones.

On the west side of the beach the limestone beds are sub-vertical, the deeper water carbonate mudstones have weathered out and the tempestites stand proud of the beach. They are fossiliferous, containing solitary and Lithostrotian -type colonial corals, bryozoan colonies, large Productid-type brachiopods, large Bellerophon-type gastropods and crinoid fragments. (Figure 3)

Fig.3 Fossiliferous carbonate mudstones

The pebbles on the beach include glacial erratics. The most impressive of which was a football-size boulder of gneiss which must have travelled a very long way for it be deposited here. We also saw a lump of vein material, probably quartz, containing bright red haematite which was mined and used as ironore in this area in the past.

We then moved back to the inlet at Stackpole Quay, where on the east side we saw a fault cutting through the tempestite limestone sequence with a 1metre wide fault zone of crushed rock. The rocks adjacent to the fault showed prominent, spaced pressure solution seams perpendicular to the fault plane/bedding (Figure 4). All a bit confusing and needs some more interpretation! The limestones at this location are all well cemented and show no bedding with the former bed boundaries reduced to stylolitic contacts.

After an afternoon of constant rain, we retreated to the National Trust café for well-earned refreshments.

Fig. 4 pressure solution seams

Report by Sarah Cook, photos by Sarah Cook and Roger York.

Wednesday 18th May

Morning: Marloes Sands

Grid Ref: SM780 082

The group congregated at the top of the cliff in the NT car park from where we took the path through fields to the edge of the cliff. There the viewpoint allowed us to see SW over Raggle rocks to Gateholm Island and Skokholm (Figure 1) in the far distance and SE towards Red Cliff.

Fig. 1 View from cliff top

Between the two points, shelf sea sediments of Silurian age (443 to 417 mya) represent the final infilling of the marine basin that covered much of South Wales along with volcanic deposits representing associated periods of vulcanicity.

The Silurian rocks occur forming an almost complete sequence viewed as near vertical beds in the spectacular cliffs at the back of Marloes Sands.

The aim was to walk as far along the beach as planned by our leader, Sid Howells, tide allowing, take our lunch then make our way back in the afternoon studying the outcrops we had omitted and examining lithology, fossils and structures in more detail.

However, some stops were made to note certain structural and lithological features and occurrence of specific fossils

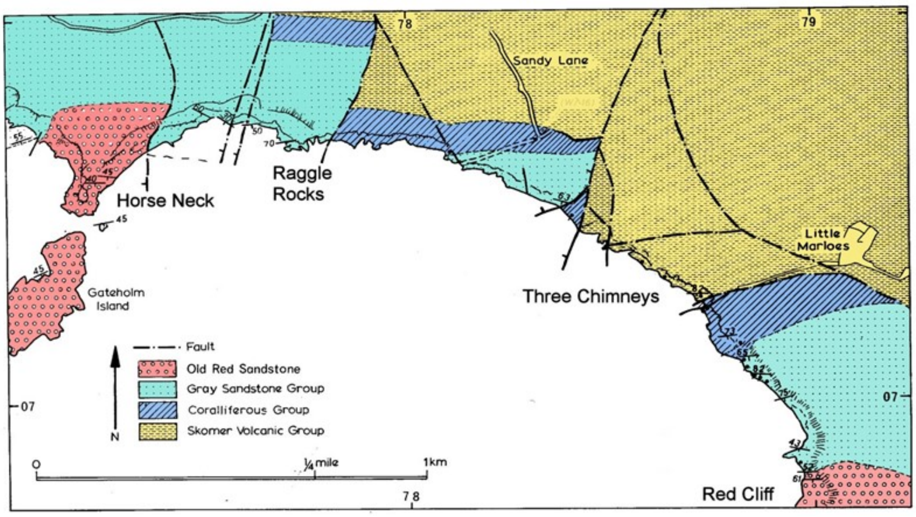

Fig. 2 Marloes Sands Geology

We descended a steep path joining the bottom of Sandy Lane, arriving in the middle of the bay, where rocks of the Coralliferous Series occurred. We crossed the storm beach onto the sand and progressing SE we stopped briefly to observe burrows with haloes in rocks of the Skomer Volcanic group. One theory is that the haloes were probably caused by change in oxidation levels while animals were actually burrowing into soft sediment. (Figure 3). Broken fossil crinoid stems indicative of a warm shelf sea high energy environment were observed in an adjacent outcrop. (Figure 4).

Fig. 3 Haloes

Fig. 4 Crinoid debris

Further on we noted more indications of a shallow sea environment, symmetrical ripples on bedding planes and erosional surfaces. (Figure 5) Some rock surfaces were covered by en echelon tension gashes infilled with quartz produced by pressure solution. Nearby a stack of feldspathic sandstones were heavily iron stained, a possible result of hydrothermal fluid migration (Figure 6). Another beach outcrop of finely laminated siltstones and sandstones showed evidence of tidal rhythms.

Fig. 5 Wave ripples

Fig. 6 Iron staining

We bypassed evidence of volcanic activity, to be studied in the afternoon and continuing south eastwards along the beach we passed the ‘Three Chimneys’ and areas of cliff collapse, while making our way to our lunchtime stop.

Report by Sally Pritchard, photos by Sally Pritchard and Roger York

Wednesday 18th May
Afternoon: Marloes Sands (continued)

Apart from a rather strong wind, the weather was now very pleasant, with sunny intervals. This enabled us to enjoy the beautiful scenery.
After lunch, taken on rocky outcrops on the foreshore about 1km from where we left the Coast Path, the party started to return, carefully examining the cliffs.
Perpendicular sandstones, some coloured red, with alternating mudstones is the Grey Sandstone Formation, which we observed on the walk eastwards. Three very distinct nibs protruded and have the name "The Three Chimneys". Apparently, up to 20 years ago, there were 4. (Figure 1). No fossils were found in this rock, but there were many erratics on the beach to hold our attention, indicative of glacial transport from the North.

Fig. 1 The Three chimneys

A further 100 metres towards the start, a grey, fine-grained rock appeared in the cliff, with about a 30 metre exposure. (Figure 2 and 3). Close examination showed this to be a volcanic rock, a rhyolite and therefore of the Skomer Rhyolite Group. Feldspathic green and white fragments within the rhyolite are indicative of an Ash flow tuff. The Skolmer Volcanic Group also includes sediments, rather confusing for the amateur! One side of this rock rested against an eroded surface in the Sandstone, showing that the rhyolite had flowed over the sandstone before solidifying, thus giving us a "way up" indicator. A search of the beach yielded some very nice green epidote - but it was not clear whether this had come from the Tuff or was of glacial transport origin.

Fig. 2 Rhyolite

Fig. 3

Pyroclastic flow

Another 300 m along the beach, the rock composing the cliff changes again. Here, we had a red and grey “blobby” rock, which is interpreted as a lava flow. (Figure 4) An initial thought that this could be a pillow lava was dismissed – a reddened top indicated a subaerial flow had occurred and contraction joints were present.

Now the cliff had been eroded back to form a shallow valley, defined by faults on each side, these being marked by much alteration of the rocks by flows along the faults, showing limonite staining. The rock within the faults was a grey fossiliferous mudstone, of the Coralliferous Group.

Fig.4 Basalt lava flow

The group descended on the scree at the base, and nice specimens of pieces of trilobite and brachiopods were found along with some solitary and compound corals. (Figure 5, Figure 6)

Fig. 5 Trilobite

Fig. 6 Favosites colonial coral

Fig. 7 Paddling at Marloes

At this point, the RGS contingent showed their true colours – some members paddled, despite interestingly low water temperatures.

Arriving back at the car park, there was some interest in a little further geology, so an intrepid few drove to Martins Haven car park and walked across – what we interpreted as a meltwater channel – onto Wooltack Point and up to the Lookout Station. Great views of Skolmer and Skokholm islands, some distant views along the cliffs and a few less welcome tankers were seen.

At this point, the members realised that dinner and the bar called, so a return to Pembroke was made, concluding a very interesting day.

Report by David Ward, photos by David Ward, Roger York, Sarah Cook and John de Prey

Thursday 19th May 2022

Morning: Bolton Hill Quarry

Grid ref: SM 924 110

Fifteen members of the group assembled in the car park of Bolton Hill Quarry just before 10:00, at Lat/Long 51.762341, - 5.024666. The quarry is owned and operated by G.D Harries & Sons Ltd, who kindly allowed our visit on a working day. The leaders of the visit were Sid Howells and Mike the junior geologist at the quarry, both gave the party an in depth safety briefing and all items of kit were checked. The rock extracted here is Pre-Cambrian Diorite.

After the safety briefing the group walked for a few minutes to view parts of the concrete batching and the bitumen coating plants. Mike explained how rocks from the quarry are crushed to different sizes (4 to 20 mm) and used for making concrete and tarmac. The concrete includes sand dredged from the Bristol Channel, off loaded at Pembroke dock. The concrete plant has a capacity of 200 m^3 per day. The quarry supplies civil engineering projects across much of South and West Wales with a variety of materials.

Fig. 1 Bolton Hill old quarry

The group were then transported in batches of five along the main road and through parts of the old quarry to location 51.762816, -5.017621 to see part of the Johnston Thrust. (Figure 1)

After the vegetation was cut away the exposure of the Johnston Thrust showed the Precambrian diorite on top of the upper Carboniferous Westphalian sequence, with a thrust plane at approximately 40 degrees. Sid explained that the diorite had been thrust over the coal measures by a distance of approximately 4km and from a similar depth. (Figure 2)

Fig. 2 Pre-Cambrian diorite thrust over the coal measures

Fig. 3 Showing a close up of the thrust plane

The coal measures below the thrust plane were pulverised as a result of the tectonic activity. The material has no cohesion, very small grain size and is clay like in nature. This type of material is known technically as a Fault Gouge. It was unclear to what depth below the thrust plane the fault gouge continued, due to the limited nature of the exposure.

As part of the tour of the old quarry, Sid explained that it had stopped being worked in 2011 as supplies of diorite were not of high enough quality due to large scale hydrothermal alterations of the material in the southwest area of the workings. (Figure 4)

The group was then transported to location 51.760580, -5.005839, (Figure 5) a haul road in the new quarry, where we given a brief description of how the Johnston Thrust passed through the area we were on, but due to the spoil we were unable to see any direct indications.

Fig. 4 Bolton Hill New Quarry 2022

Fig. 5 view of quarry from haul road

The group then walked into the top area of the new quarry where we able to see four levels of extraction (L0, L1, L2, L3). A large number of big boulders were evident in L3 and it was explained that these were for a rock-armour project and would soon be transported to site.

The north wall of the quarry was the first to be developed, starting in 2008, and initially good quality diorite was recovered, however, as the extraction moved south two different problems were encountered:-

- A large area of hydrothermally altered diorite was found, this has a different colouration than the unaltered diorite and appears redder in colour and from the distance we were able to observe – more unconsolidated and fragmented.

- Additionally, as the quarry was being extended to get around the area of hydrothermally altered rocks, a glacial run off channel was found, filled with soil, clay and small stones – nothing of any commercial value and a significant problem, as explained by Gareth Phillips the quarry manager who briefly joined us for part of the visit.

The group walked down into the quarry to take a detailed look at the glacial channel, Sid and Mike explained that they had not yet found the bottom of the channel.

We were unable to get a closer look at the hydrothermally altered rocks as they were being excavated and fed into a very large, noisy and dusty crusher.

The group were then transported back to the original car park where a debrief was held and some questions answered. Sid was thanked for leading this trip and presented with an RGS tankard. Around 15:00 the members left to return home or to continue their exploration of Pembrokeshire.

Report by Jim House, photos by Roger York and Carole Gregory