THE WEEK'S EXCURSION TO WEST CENTRAL WALES, August 1987

The headquarters for the week was the Dolmelynllyn Hotel at Ganllwyd, 5 miles north of Dolgellau, where 8 of the party of 12 stayed. It proved to be in a scenic position with pre-breakfast walks for those so inclined; the building was old and the ascent to our various bedrooms and bathrooms was tortuous, to say the least, but we nevertheless enjoyed a comfortable and well-fed week.

The journey to Wales had been fine and warm, but after heavy rain during the evening and night the two campers woke up to find a lake surrounding their tent as described below; fortunately, their sleeping compartment remained dry. This was the last rain we saw until after the last excursion on the following Friday.

Sunday 2nd August—The Ordovician rocks at Rhyd and Tan y Grisiau, south-central Snowdonia, North Wales

After a night of heavy rain we woke up in a lake! Cindy and I had decided to camp, but that morning, surrounded by soggy chaos, we wished we had stayed in the hotel with the rest of the party. The morning was however splendidly sunny so we made our way to Ganllwyd anticipating a fine day in south central Snowdonia where Martin Smith of the British Geological Survey (Aberystwyth) was to introduce us to sedimentation and tectonics in the Ordovician rocks at Tan y Grisiau and Rhyd.

We proceeded to Tan y Grisiau and parked near the Tourist Information Centre. At this first locality (SH6814 4529) we traversed a section up through the local Tremadoc-Arenig junction. Classical interpretation of this feature, on the regional scale, involved an important angular unconformity as evidenced by Arenig strata resting on older Precambrian to Cambrian beds (see George 1961 and Anderton *et al* 1979 for summaries). Here however the junction appeared gradational and was marked by the sudden replacement of relatively deep water Tremadoc shales and mudstones by the shallow water conglomeratic Garth Grit of the basal Arenig. Martin demonstrated the junction here was marked by a 'disconformity', with the Garth Grit interdigitating with the finer background sediments. He also showed us a wide range of sedimentary structures, such as cross-bedding, scours, wave ripple channels and crude grading cycles, in the overlying flaggy Arenig strata which indicated deposition within shallow, wave dominated to intertidal environments.

At the second locality, starting in a disused quarry (SH6404 4188) a similar scenario was described. As we climbed to the summit of Moel y Llys we again witnessed an apparently gradational Tremadoc-Arenig junction and saw again similar sedimentary structures in the clean, well sorted Arenig deposits which Martin again interpreted as a basal transgressive sequence.

At the summit we ate lunch and enjoyed a variety of scene. To the north and south we looked respectively towards the Snowdonia foothills and the Harlech Dome, whilst to the west Tremadoc Bay and the Lleyn Peninsular were clearly visible. The view most relevant to the excursion however was to the north-east where in the foreground was part of a complexly structured tract of land, classically interpreted as part of a huge thrust-fault breccia (see George 1961 pp. 52–5). This area was to be the afternoon's subject and Martin introduced it to us as the "Rhyd Olistostrome".

The term olistostrome is applied to chaotic deposits emplaced by debris flows and related mass gravity processes, which are composed of extra-formational material or which contain exotic clasts (olistoliths) which are older than the enclosing sedimentary sequence (Rupke 1981 p. 379). At our next locality (SH6340 4191) Martin showed us a large raft of basal Arenig grit, in bedded and cleaved pelites, which represented a large block within the olistostrome. At its basal contact, the prominant vertical quartz veins seen crossing the block made virtually no inroad into the adjacent meta-sediments, and the cleavage in those meta-sediments was clearly seen to deform around the block. At the final locality on our itinerary (SH 6288 4119) further evidence for the olistostrome was shown to us where several small rafts of Arenig sandstone could be seen in a matrix of slump folded and sheared pelite. The day ended at the spoil heaps of a local pisolitic iron ore mine.

Everyone enjoyed their day with Martin Smith and thanked him for his patient and lucid leadership of this excursion to part of his PhD mapping area. We recognised his bravery to question the conventional explanation of the geology of the Ordovician rocks in south central Snowdonia, and were stimulated by his ideas which were based on an impressive sound and thorough knowledge of the rocks in question. Where appropriate, his

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interpretations also benefited from modern knowledge of sedimentary and tectonic processes. The party wished Martin every success in the future.

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Mark T. Dean
British Geological Survey
Keyworth
Nottingham

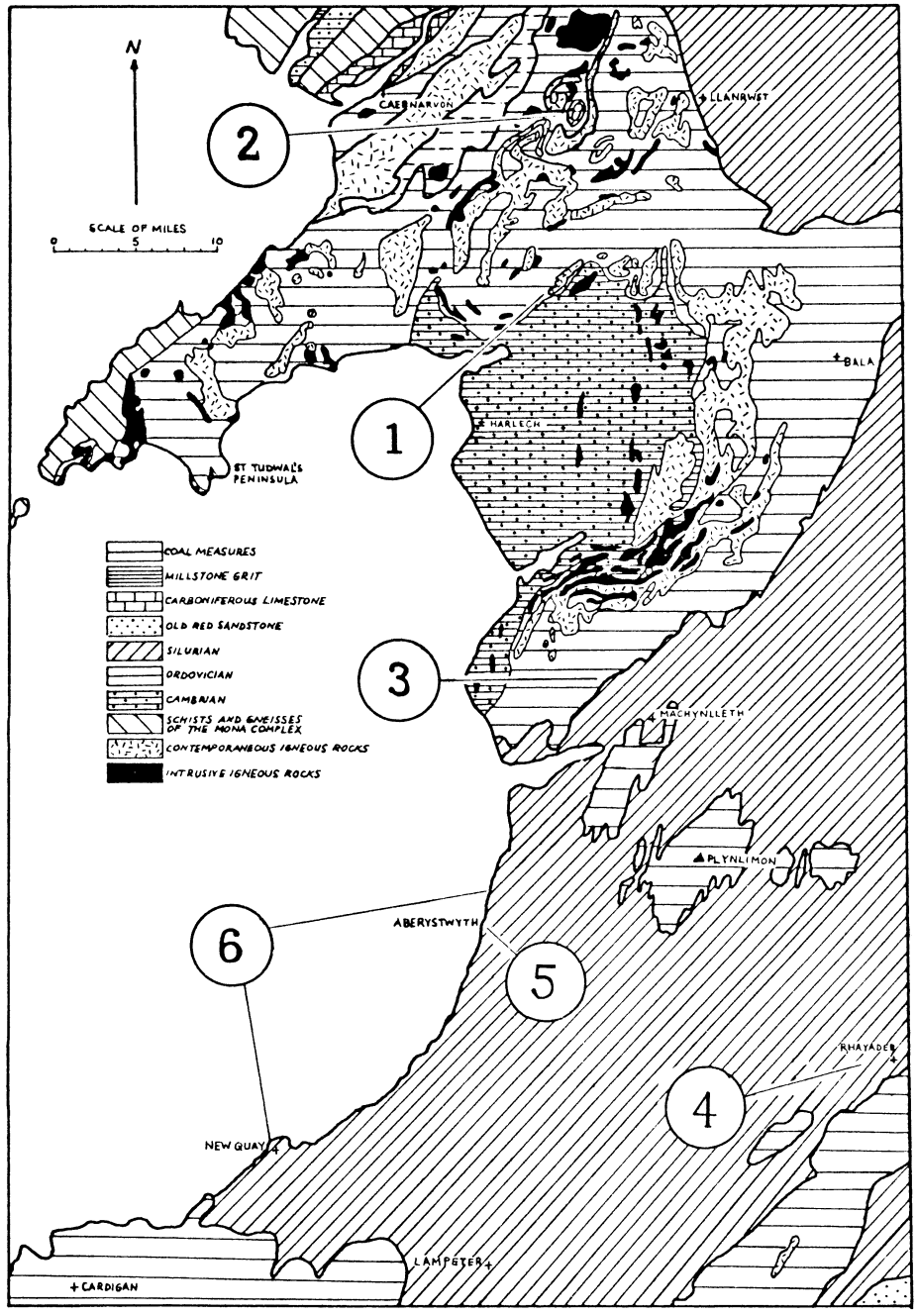

Fig. 1. *Simplified outline map of the solid geology of west-central Wales.* (Based on Smith & George, 1961; George, 1970). *Excursion Locality numbers:* 1. South-central Snowdonia; 2. Northern Snowdonia; 3. Cader Idris; 4. Central Wales; 5. Aberystwyth; 6. New Quay to Clarach.

Monday 3rd August—Volcanism in Northern Snowdonia at Cym Idwal.

We met the leader, Dr. A. J. Reedman, at Bettws y Coed and followed in convoy to Idwal Cottage car park, (SH 648 603), the starting point for our excursion to the rocks of the Snowdon Volcanic Group, (Upper Ordovician), exposed in the Idwal Syncline. The first location was a worked out quarry, south of the car park, where it could be seen that excavation had taken place along the strike of even and cross-bedded tuffs, alternating with thin beds of tuffite and mudstone; this sequence, as the leader explained, resulted from deposits of fine-grained ash, carried by the prevailing wind from a distant erupting vent, settling into water in which muddy sediments were being deposited. The tuffs had been quarried for use as honestones, on account of their fine grain and hard silicous character.

West of the quarry, some distinctive ice-scoured crags expose the ash-flow tuffs of the Pitts Head Tuff, overlain and underlain by sandstones. On weathered surfaces the welding foliation in the Tuff is picked out by siliceous segregations along the closely space foliation planes; a zone of siliceous nodules, 2 to 3cm diam., occurs near the centre of the section, within a fold marked by the foliation planes. The leader explained that similar nodules are common in the Snowdonia volcanic rocks; they may have formed from the infilling of gas bubbles in the tuffs, or by the growth of quartz around a nucleus.

A short distance southwestwards along the ridge brought us to a classic example of a roche moutonnée and much other evidence of ice erosion. This prominent outcrop overlooks spectacular views northwestwards down the ice-carved Nant Ffancon valley, to Bethesda and beyond to Anglesey, and southwestwards into Cym Idwal, and provided a vantage point from which Dr. Reedman pointed out the principal glacial features of the area.

After crossing the morainic drift at the mouth of the cym, and climbing the stile in the nature reserve, we returned to the main purpose of the day and discussed the solid geology of the cym while eating our lunch at the lakeside. Looking southwestwards towards Twll du the structure of the Idwal Syncline, with the basalts high in the back wall forming the core, was readily apparent. Following the track along the east shore of the lake, the steep slope above has been eroded in the lower units of the Lower Rhyolitic Tuff Formation, with prominent dip and scarp features. The basal unit, seen just to the north of Idwal Slabs, comprises breccias formed of blocks of acid tuff, vesicular basalt and sandstone in a matrix of finer volcanic debris. At the edge of the Slabs the breccias grade upwards into massive ash-flow tuffs. Idwal Slabs is a popular venue for climbers; one member of the party confessed to having scaled them in her younger days but was reluctant to give a demonstration on this occasion.

As we continued southwestwards along the track, higher units in the Lower Rhyolitic Tuff Formation were seen to comprise massive-bedded ash-flow tuffs with interbedded tuffs and sediments; a prominent feature, which had been remarked on from the lunch stop, proved to be a weathered out, fine grained tuffaceous mudstone, 1.5m thick. Above this, sedimentary structures were more apparent, cross-lamination and graded bedding being noted in several of the tuffs. Higher beds within this formation, consisting of siltstones and sandstones with thin tuffs and tuffite bands, were crossed as we approached the back wall of the cym, where a dark blue-grey rhyolite forms steep crags. Columnar jointing is developed in places in the rhyolite, and the leader pointed out the flow-banding and flow-brecciation features which can be seen on weathered surfaces.

The uppermost unit of the Lower Rhyolite Tuff Formation, consisting of massive acidic tuffs, were seen, above the rhyolite, just below the cleft of Twll du. The junction of this unit with the base of the overlying Bedded Pyroclastic Formation is well exposed. These green basic tuffs and tuffites show ripples and laminations in places, including both fine and coarse grained beds, representing changes in the nature of the pyroclastic materials erupted from nearby vents.

The more agile members of the group climbed higher up the steep slope to examine, in situ, the pillowed basalts forming the core of the syncline; those less energetic examined these rocks in the fallen blocks.

Turning downslope and following the track towards the western side of the lake, an exposure in the upper part of the Lower Rhyolitic Tuff Formation was seen to include contorted layers, attributed by the leader to slumping or dewatering of the unconsolidated sediments, probably due to earthquake shocks. From here, the track followed the line of the classic moraines on the western side of the lake before rejoining the path down to Idwal Cottage.

The traverse of the Idwal Syncline was completed by a short walk northwestwards along the road to an exposure of the Pitts Head Tuff on the western limb of the syncline. The grey-green tuff is highly silicified; the welding foliation can be picked out on fresh surfaces from the alignment of green fiamme. Contortion in the foliation was noted, and explained by Dr. Reedman as due to movements within the tuff after emplacement but before cooling.

Tuesday 4th August—Field Trip to Southern Part of BGS Sheet 149. (Cader Idris)

The 3 leaders for the day, Mary Shufflebotham, Melanie Leng and Warren Pratt, were met at Tonfanau railway station. (SH 563 038). The main purpose of the day was to examine the Upper Ordovician/Lower Silurian rocks of the area, but this first locality provided an interesting exposure of Quaternary deposits.

Walking through the station and an old army camp to the coast, we were able to examine the boulder clays forming the low cliffs; a distinctive feature is the large rafts of Jurassic sediments seen in the deposits, probably of fairly local origin as Jurassic rocks are present in Cardigan Bay. With a strong breeze blowing along the shore, we were also able to witness the mechanics of wind ripple formation.

The next location, the Tonfanau Dolerite Quarry, is visible from the railway station, and was reached by a short drive southeastwards. A large doleritic body is intruded into the Beacon Hill Volcanic Formation and the Bifidus Slate Formation, but the contacts between the dolerite and the tuffs and sediments of the country rock reveal complex intrusive relationships resulting from two separate phases of intrusion. Quartz vein networks are developed at the contacts, although these could only be seen from a distance. Mineralised zones, with pyrite and chalcopyrite, were seen.

The third location, Bird Rock (Craig yr Aderyn), was reached by driving inland along the valley of Afon Dysynni. Bird Rock provides a spectacular view over the valley, and from this vantage point the leaders pointed out the overall structure of the Bird Rock Anticline. From here, the route took us past the Tal-y-Llyn lake, where a brief stop was made for photographs; the lake is sited in a classic U-shaped glacial valley, and is impounded by a large natural dam, possibly a terminal moraine.

Lunch was taken at the Corris Craft Centre, an unusually civilised location for a geological field trip, but much appreciated as a change from the hotel's packed lunches. It was also to prove a useful preparation for the scramble up the steep scree slopes to the Aberllefenni Slate Quarries, in the Dulas valley. The scree results from the waste thrown out from the quarries. The well-cleaved silty mudstone forming the Narrow Vein Formation, of Ashgill age, is some 20 m thick and is extracted in slabs, from quarries and from underground workings, for use as paving stones, gravestones and in snooker tables.

The Devil's Bridge Formation, of Llandovery age, exposed in the sidings of Machynllech railway station, was to be the last location of the day. The leaders had planned to visit one further locality, near Machynllech Golf Course, but the rival attraction of the steam locomotives in the railway station took up too much of the available time. Tearing ourselves away from the power of steam, we examined the magnificently exposed plunging anticline, comprising a sequence of turbiditic sand-, silt-, and mudstones and the cleavages and joints displayed; the bedding surfaces showed "slickencrysts", probably representative of slip-type movement during folding.

On several occasions during the week the leaders had to compete with the noise of low-flying aircraft, but on this occasion a particularly low one completely disrupted proceedings for a time; the pilot had probably spotted the Cardigan Bay Express in the station and was trying to read its number.

Wednesday, 5th August. Silurian Sediments in Central Wales.

The leaders, Jan Zalasiewicz and David Wilson, met the group in the car park in Rhayader, where we transferred to two Landrovers and a sturdy car; the day was to be spent examining Silurian sediments and structures exposed in outcrops around the reservoirs in the Elan Valley, west of Rhayader, mostly reached by unmetalled roads.

The first stop was at a small roadside shale dump, beyond Caben Coch Reservoir, where the leaders had found specimens of burrows in the shale. None of the party found the evidence totally convincing, but this was obviously because we were not yet sure of what we were looking for. Later, in a stream section below Claerwen Dam, we saw burrows which were much more obvious. Here, too, the rocks displayed good banding, differentiating the succession of shales and mudstones.

The structure of the Towy Anticline became apparent as we drove along, and features of it were pointed out from our lunch-time vantage point beside the Dam. The sheep here seemed particularly hungry and competed strongly for our lunches; those that were not trying to snatch food from our hands were foraging in our rucksacks whenever opportunity occurred.

The unmade roads around the reservoirs were at least as rough as the leaders had promised, and we were grateful for the frequent stops at the various exposures along the traverse, as the Silurian sedimentary history of the area was demonstrated to us. The graptolites required a little imagination, but after our earlier experience with the burrows we were prepared to concede that we were seeing graptolites. The banding in the rocks, formed by the alternation of shale and mud sequences, became less clear than at the earlier exposures.

The final exposure of the day was in the impressive Cabon Quarry, (SN 924 6460), immediately north of Cabon Coch Dam. A conglomerate sequence, some 20 m thick overall, is made up of a wide range of conglomerates, grits and interbedded mudstones, interpreted as part of the proximal portion of a large submarine fan, deposited at the foot of the continental slope. This magnificent and unusual exposure made a fitting climax to the excursion.

Thursday 6th August—Visit to British Geological Survey at Aberystwyth.

Dr. Reedman had invited the group to visit them at Bryn Eithyn Hall, their headquarters in Wales. We were welcomed by him and Dr. Bazely and over coffee they talked of the work of the office and the mapping of areas only superficially covered previously. Various maps and books recently produced were available for purchase. The Hall is situated south of Aberystwyth and overlooks a splendid view. It is thought that the site has been used possibly from the 7th century, although the present building was established in the early 1800's and various alterations later. We left them about midday and the afternoon being free went our various ways.

Friday. 7th August. The Aberystwyth Grits, New Quay to Clarach.

We met the leader, Denis Bates, at University College of Wales, Aberystwyth, and drove to the first locality for the day, at New Quay, where we parked on the cliff top. (SN 387 604). Here, the leader outlined the objects of the day's excursion.

The Aberystwyth Grits, of Silurian age, form a magnificent example of a turbidite sequence, exposed in cliff sections over some 40 km of coast extending from south of New Quay northwards to Borth. The coastal exposures display a wide range of sedimentary and tectonic structures, and indicate a transition from proximal turbidite deposition, in the south, to distal characteristics in the north. Flute and groove casts tend to confirm the S-N current direction. The localities to be visited had been chosen to demonstrate this transition, and to show some of the wealth of structures exposed.

Following this introduction, we scrambled down to the beach near a seafood factory; the factory's products were made very obvious by the smell, and by the waste that we walked through. The cliff section beyond the factory is cut in thin beds, strongly folded and faulted, in contrast to the thicker beds on which the factory is sited.

A short distance further, around the next promontory, a number of rarely seen turbidite features were pointed out; these included a sedimentary sill, with several vertical dykes injected upwards through mudstone into the overlying turbidite unit. Underlying this sequence, thin, laminated sandstone beds occur within 3 m of mudstone and show prominent current ripples. Other turbidites show slump features and large intraclasts; one intraclast, about 30 cm in diameter, contains a cone-in-cone concretion truncated by the clast surface. Other sedimentary dykes were pointed out, injected upwards into mudstone, possibly as a result of earthquake shocks. A thick mudstone occupying a curved hollow in a thick greywacke was interpreted as representing a mud-filled slide scar.

At Aberarth, the first cliff section is composed of boulder clay, with layers of sand and gravel; solifluction features are apparent in the upper part of the cliff. Further north, the cliffs are cut along the strike of the solid rocks, with beds of 30–50 cm thickness. Some of the thicker units include intraclasts ranging in size from 1 cm to rafts of more than 1 m in length. Slurrying was noted in many of the turbidite units and the leader pointed out the "prolapsed bedding" structures which occur. Well-developed bottom structures were seen at several horizons.

This first sequence is faulted against a sequence of thinner units, with turbidites less than 10 cm thick, succeeded in turn by much thicker beds; one multiple bed is 5 m thick, and is clearly recognisable from a distance, when the bedding appears vertical and parallel to the cliff face. Horse-shoe shaped flute casts are a notable feature of this bed.

At Clarach, parking at the north beach, (SN 587 841), we first viewed the beach exposures from the cliffs, noting the clearly visible complex folding. Descending to the beach, we then studied the wide range of sedimentary structures and other features exposed in the wave-cut platform and in the cliffs. The wave-cut platform exposes a sequence of haphazard folding, with slaty cleavage developed in places but with no consistent relationships to the folds. This feature has been interpreted as soft-sediment deformation, the result of down-slope sliding shortly after deposition. Graptolites were found in some beds, more generously proportioned than those seen on the Rhayader excursion.

H.G. Fryer,
13, The Meadows,
Long Bennington,
Newark,
Notts. NG23 5EL.

W. Madge Wright,
311, Mansfield Road,
Redhill, Arnold
Nottingham, NG5 8JL.