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Weekend Field Trip to Dolgellau and the Harlech Dome

Les Dolamore[1]

DOLAMORE, L. (1982). Weekend Field Trip to Dolgellau and the Harlech Dome. *Proceedings of the Shropshire Geological Society*, **2**, 7-11. An overview of the basic types of graptolite and their evolution.

Through time graptolites may have been deteriorating because they were becoming simpler, but there is no such thing as retrograde evolution, only the most efficient forms progress. The simpler forms of graptolite were the most efficient. The colonial form was not particularly efficient and once they became free-floating it was better to become an individual. It is therefore quite possible that graptolites still exist in the plankton totally unknown and unrecognised.

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This was a joint field trip with the Black Country Geological Society led by Graham Hall, Warden of King's Youth Hostel, Dolgellau, 23-25 April 1982. The itinerary included igneous features of the Harlech Dome, slate at Blaenau Ffestiniog, Prince Edward gold mine, and turbidites at Barmouth.

In late Precambrian times the opening of the Iapetus Ocean basin separated the North American - European continent by the intrusion of basaltic magma along a mid-ocean fissure system. By Ordovician times, oceanic crust was being consumed at the basin margins along subduction zones until convergence of the continental plates was completed in the late Silurian and the Devonian periods. Plate motion then ceased, as the relatively low density of the continental plates prevented their descent into the mantle. Many of the features of the geology of North Wales can be related to this model of an ocean expansion - contraction cycle, including the patterns of sedimentation, igneous activity and tectonic events.

The line along which separation of the continental plates took place lies roughly from the Cheviot Hills in northern England, through Ireland between the Mourne and Wicklow mountains, to Newfoundland. In considering the geological history of North Wales, we will be concerned principally with events on the south-eastern margins of the Iapetus Ocean basin and the edges of the European continental mass.

As the Iapetus Ocean began to open, a series of normal faults developed parallel to the continental margin. Vertical movements took place, with blocks of crust sinking to form the Leinster Basin and Welsh Basin whilst adjacent blocks were elevated as the Irish Sea land-mass and Midland platform. These fault blocks continued to control sedimentation throughout Lower Palaeozoic times and are of major significance to the geology of North Wales.

After the initial opening of the Iapetus basin, a phase of oceanic plate subduction first occurred on the margins of the European continent in late Precambrian times. Evidence for this event comes from volcanic activity, folding and metamorphism. These have been identified in the rocks of Anglesey and the Lleyn peninsula of North Wales. After this phase subduction ceased and the Iapetus basin continued to expand during the Cambrian period.

The Cambrian period in Wales was a period of sedimentation undisturbed by volcanic activity. Sands, grits and muds were laid down in a fault-bounded marine trough.

By the beginning of the Ordovician period, a new subduction zone began to operate with oceanic crust descending into the mantle beneath the Welsh Basin. This initiated volcanic activity extending from the Lake District through Snowdonia to Pembrokeshire. Basaltic diapirs ascended until the base of the continental plate was reached. If deep crustal fractures were present basalt magma could continue directly to the surface and be extruded. Alternatively, transfer of heat from the basaltic melt could cause partial fusion of the lower crust, releasing pockets of granitic magma to give extrusions of rhyolitic composition.

Towards the end of the Ordovician period, volcanicity died out in North Wales, but normal marine sedimentation continued in the Welsh Basin until closure of the Iapetus Ocean was

completed in the last parts of tie Silurian period and the early Devonian. At this time major compression, folding and faulting occurred as the continental masses finally converged. Mountain ranges were thrown up on the site of the Welsh Basin. Rapid sub-aerial erosion of this new land area produced the coarse sediments of the Devonian Old Red Sandstone sequence in South Wales and the English Midlands.

The Cambrian Succession

The grits, sandstones and shales making up the Cambrian succession outcrop in the central area of the Harlech Dome. Surrounding the sedimentary outcrop is a circle of Lower Ordovician volcanic rocks and associated igneous intrusions forming the Moelwyn, Arenig, Aran and Cadair Idris ranges.

The Cambrian succession can be divided roughly into a group of coarse resistant grits at the base, overlain by a series of less resistant shales, mudstones and thin sandstones. The coarse grits are responsible for the mountainous central area of the Harlech Dome.

Within the encircling Ordovician outcrop occur several folds lying roughly on a north-south axis to form parts of the major structure. South of Trawsfynydd reservoir is the Dolwen pericline, an anticlinal structure exposing Llanbedr Slate and Dolwen Grit at its core. The Rhinog mountains form an escarpment, composed of resistant Rhinog Grit overlooking the western side of the pericline. Nearer the coast are two complimentary synclines, the Caerdeon syncline plunges south towards the Mawddach estuary and the Traeth Bach syncline plunges north towards the Vale of Ffestiniog. Beyond these structures, outcrops of Rhinog Grit and Llanbedr Slate form the eastern limb of the coastal anticline, by the shoreline between Porthmadog and Barmouth.

The succession of strata in the central Harlech Dome is illustrated in the diagram.

Much of the Cambrian sedimentary sequence in North Wales was deposited by submarine turbidity currents.

Coarse sediment will settle more quickly than fine material as the turbidity flow spreads across the basin floor. The graded grits will be restricted in distribution to the area nearest the source. Some greater distance from the source the only sediment remaining to be deposited will be of fine mud and silt grade. The sequence of sedimentary units can be used as a guide to the distance of deposition from the shelf margin of the basin.

Cambrian sedimentation took place in the Welsh area in a marine basin bounded to the northwest by the Menai fault zone and the Irish Sea landmass and to the south-east by the Church Stretton - Pontesford fault zone and the Midland platform. The basin had an elongated form, but there is no evidence of the original extent of the basin to the south-west or north-east.

The source of sediment varied during Cambrian times as the relative elevations of the bordering landmasses changed. At some stages, sediment came dominantly from the Irish Sea landmass, at other stages from the Midland platform and at times from outside the Welsh area by sea floor currents. Changes in water depth gave rise to variations in sedimentation. During phases of deep water, deposition of turbidite grits and shales was common; whilst during shallow water phases, intertidal sands and muds were laid down and show traces of bottom-dwelling organisms.

The Cambrian succession in the Harlech Dome commences with the Dolwen Grit and Llanbedr Slate. These contain no traces of fossils and indicate a period of deepening water in the North Wales area. The Rhinog Grits represent the first major phase of turbidite deposition. Coarse sediments spread southwards as a fan complex on the basin floor as turbidity currents were released from the shallow water shelf at the margin of the Irish Sea landmass. Finer sands reached the south of the basin and are preserved in Pembrokeshire.

Following the turbidite deposition a pause in sedimentation took place with a sequence of manganese-rich muds accumulating on the basin floor. Near the base of this group is a bed of manganese silicate ore, which has been mined commercially. The manganese probably originated from chemical weathering of volcanic lavas on the bordering landmasses and was precipitated as manganese carbonate when the waters were highly saline due to evaporation under hot climatic conditions. Conversion of the manganese carbonate to silicate minerals occurred due to low grade regional metamorphism during the Caledonian earth movements.

The subsequent deposition of the Barmouth Grits represents a return to turbidity current activity in North Wales.

During deposition of the Barmouth Grits the Midland platform and its shelf sea area rose above

sea level whilst erosion reduced the elevation of the Irish Sea landmass. By the time the Gamlan Shale was being deposited, sediment supply was predominantly from the Midland platform to the south. Turbidite flows were discharged into the basin but the distance from the sediment source meant that shale sequences were deposited in this area. Similar conditions continued during deposition of the Clogau Shales and Maentwrog Beds.

The Ffestiniog Beds mark general shallowing of the water and sediment transport by water currents flowing along the basin floor. Coarse sands and pebble beds were laid down in the Lleyn peninsula in a beach environment. Elsewhere in the Welsh Basin silts and shales were deposited in shallow water and show traces of bottom dwelling organisms. Ripple marks are common on the surface of sandstone beds.

Towards the end of the Cambrian period extensive deposits of mud were laid down in the Welsh Basin to form the Dolgellau and Tremadoc Beds. The water remained relatively shallow and the fine grain size of the sediment can be related to low rates of supply from bordering land-masses reduced by erosion or subsidence to near sea level.

Ordovician Volcanicity

At the close of the Cambrian period subduction of the floor of the Iapetus Ocean recommenced on the south-east margin of the basin and gave rise to a number of active volcanic centres. Basaltic magma rose mainly along deep crustal fractures and volcanic activity at Builth Wells, Snowdonia and the Lleyn peninsula were related to such fault zones.

Earth movements and volcanicity above the subduction zone began in late Tremadoc times when block faulting raised the central area of the Harlech Dome above sea level. Beds of Upper Cambrian sediment were folded to form a monocline between Ffestiniog and Dolgellau, and erosion cut downwards into the sedimentary succession above the Dome. Rise of magma along the fault zone initiated the Rhobell volcanic episode which commenced with eruption of basalt lavas from a series of north-south fissures. An Hawaiian type volcano was formed and lava poured quietly from the vents. Ashes are not seen within the volcanic succession. A common feature of the Rhobell basalts are zones of breccia which are the fragmented early-cooled crusts of the lava flows.

Following the basalt eruptions, a phase of intrusion of diorites occurred beneath the volcanic centre. The intrusions are concentrated immediately to the west of Rhobell Fawr and in a belt along the eastern margin of the Harlech Dome to Ffestiniog in the north and Bontddu in the south. Disseminated copper pyrite crystals within Rhobell diorite intrusions and adjacent sediments in the Capel Hermon area form the Coed y Brenin porphyry copper deposit.

Following the Rhobell volcanic episode, volcanic activity became more widespread along the southern and eastern margins of the Harlech Dome during the Arenig, Llanvirn, Llandeilo and Caradoc divisions of the Ordovician. Eruptions took place from various centres and a thick succession of lavas, pyroclastic deposits and interbedded marine sediments was built up along with the emplacement of sub-volcanic and intra-volcanic intrusions.

At the close of the Rhobell volcanic episode the area again subsided below sea level and marine sediments of early Ordovician age were laid down unconformably on top of the Rhobell lavas and folded Cambrian strata,

The picture which emerges is that acid and basic magmas were erupted in alternate phases during Aran volcanic group times and that normal marine sediments were laid down on the floor of the Welsh Basin in the intervals between volcanic episodes. Acid and basic magmas have different physical characteristics and their eruption produced contrasting volcanic products.

Basic phases of volcanism were dominantly submarine during Aran volcanic group times. Clouds of basalt froth carrying early-formed crystals of felspar would be thrown from the vents and would fall as pyroclastic ash deposits. Quieter flows of degassed basalt would radiate from the vents, with the hot basalt forming pillow structures on contact with the cold water. Beneath the surface of the volcano sheets of degassed basalt magma spread through weaker horizons of country rock such as shales. This produced the dolerite sills common in the area.

Slate

Slate has been quarried at many localities around the Harlech Dome, especially the Blaenau Ffestiniog and Corris areas, where beds of Upper

Ordovician slate have been extensively worked. A variety of other geological formations have been worked on a smaller scale, including: the Lower Cambrian Llanbedr slates at Llanfair, Dolgellau and Tremadoc beds of the Upper Cambrian around Arthog, and slates in the Lower Ordovician Gwynant formation on the northern slopes of Cadair Idris.

The types of sediment which will form slate include mudstones, siltstones, volcanic ashes but the resulting slate is usually only of economic value when produced from a very pure mudstone.

In the area of Barmouth, a strong cleavage with a near vertical orientation and north-south strike is seen in mudstones of the Gamlan formation. In the Ffestiniog area the main cleavage producing high quality roofing slates has a shallow dip to the north nearly parallel to the bedding of the Ordovician sediments. It can be traced around the northern margin of the Harlech Dome and appears concentric with the main Dome structure. The cleavage again appears en the southern margin of the Dome in the Cadair Idris area but this time dipping at a shallow angle towards the south.

The steeply oriented S_2 cleavage which generally trends north-south is present over much of the Harlech Dome.

In the Ffestiniog area it is superimposed on the main S_1 cleavage and forms a line of weakness known by quarrymen as “pillaring”. This can be used to break large slabs of slate away from the quarry face before splitting along the stronger S_1 cleavage planes.

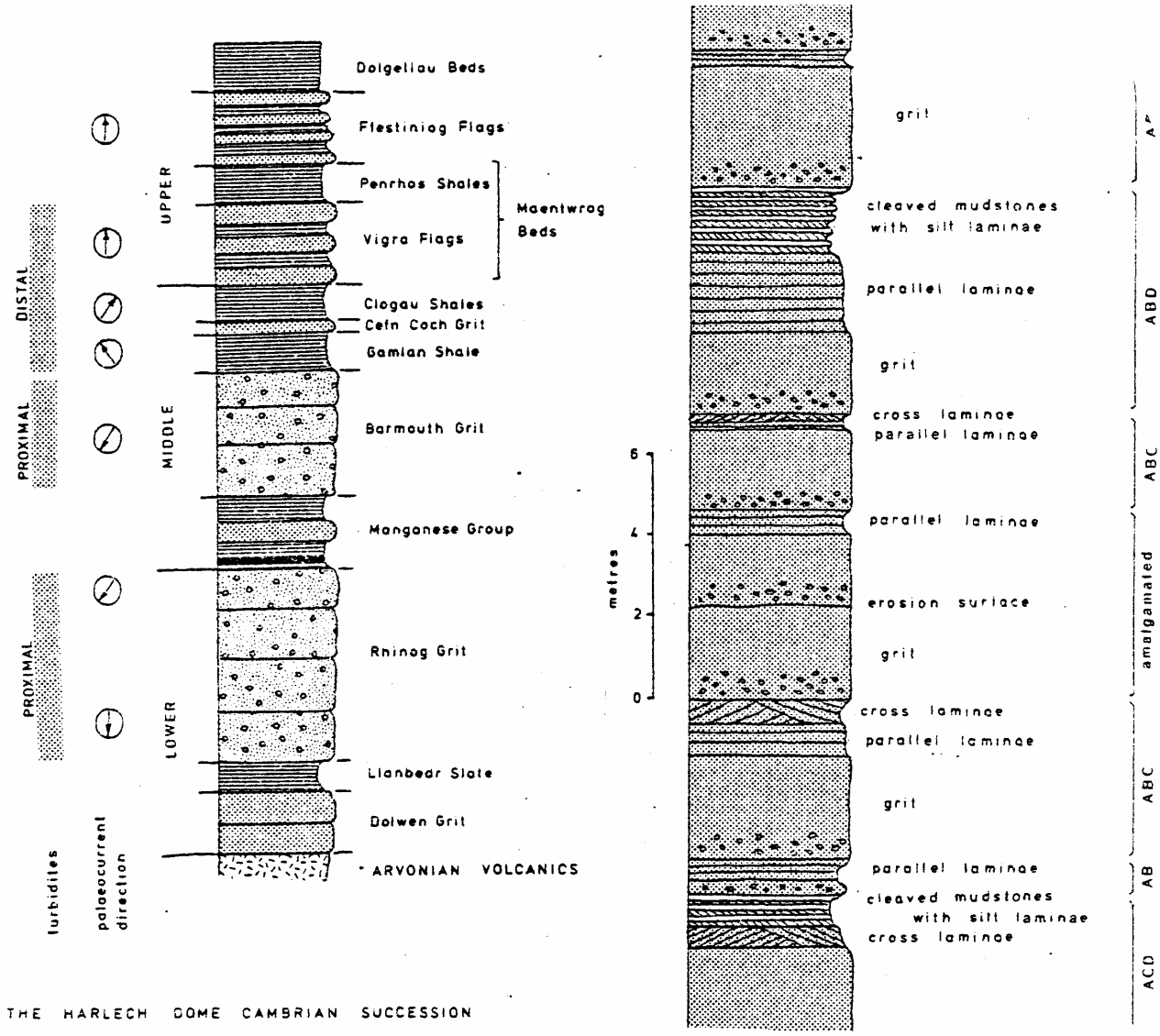
The very steep S_2 cleavage is oriented parallel to the axial planes of the major north-south folds in the Harlech Dome: the Dolwen pericline, Caerdeon syncline, Traeth Bach syncline and the coastal anticline. It is thought that this cleavage resulted from reorientation of mica-type minerals during the compressional phase of the Caledonian earth movements which superimposed north-south folds on the main Dome structure.

Where bands of coarser sediment occur within the slate sequence the cleavage planes often deflect to a gentler angle of dip on passing through these bands; this is known as cleavage refraction. The coarser sediment may be split into thin sheets, termed microlithons, which have been displaced relative to one another along the cleavage fractures. A structure closely resembling sedimentary ripple marking can appear on bedding surfaces in association with well developed cleavage. This represents small scale buckling of the rock into periclinal microfolds during the compressional tectonic phase and is a miniature representation of the fold structure of the region as a whole.

Slate extraction in north Snowdonia has largely been by opencast quarries or open terraces on the mountainsides, a method which is satisfactory where the slate beds dip steeply. In the Blaenau Ffestiniog and Corris areas, however, the gentle dip of the slate beds into the mountainsides has necessitated mining in underground chambers.

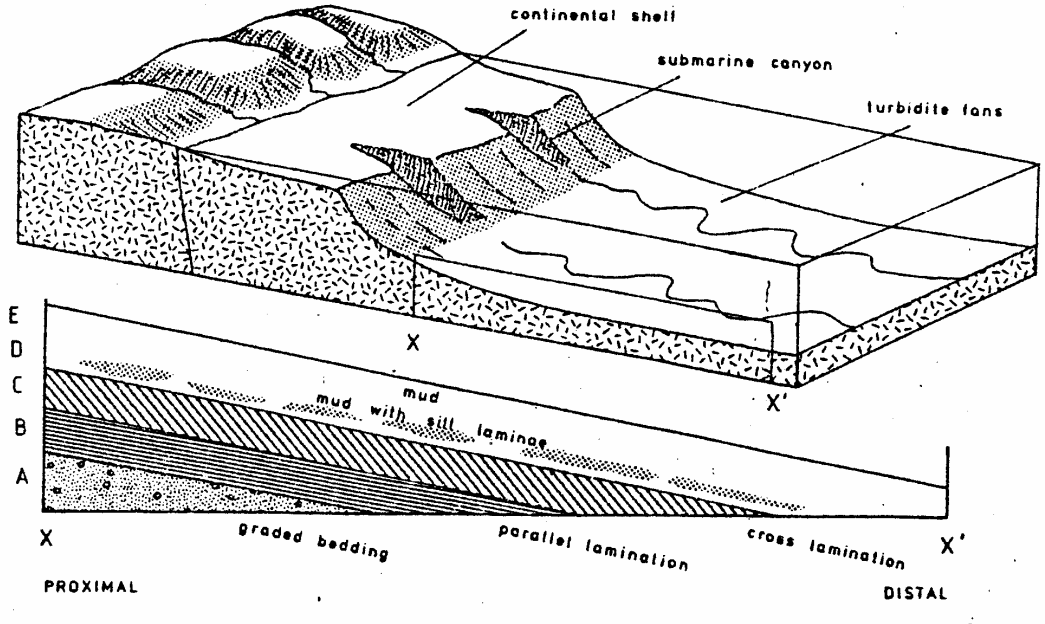
After driving a horizontal gallery along the top of the workable slate vein, the slate is freed from the overlying worthless rock by cutting an inclined slot known as a roofing shaft. The chamber can then be developed by removing blocks of slate along the cleavage planes from the chamber backwall with explosives. When the chamber reaches a height of 50-60 feet, work is stopped and a new chamber commenced alongside or at a lower level. Pillars of slate are left in position to support the roof. If the thickness of the slate vein permits, a chamber may be worked to a height of two or more 'floors' with bridges constructed to maintain transport routes along the horizontal galleries.

Les Dolamore



THE HARLECH DOME CAMBRIAN SUCCESSION

Turbidite sequences in the Barmouth Gr
section at Garn (618166)



TURBIDITE DEPOSITIONAL ENVIRONMENTS

