Llanbadrig Point RIGS Site

NRW RIGS no. 317 [SH 37447 94661]

GeoMôn Global Geopark original webpage

RIGS Statement of Interest:

The rocks of Llanbadrig Point RIGS Site on the steep northern coast of this headland offer the finest view of the Gwna Melange in Anglesey. The melange consists of a jumble of blocks of rock, ranging in size from several tens of metres to a few centimetres across, mainly quartzite, limestone, and phyllite. The melange is thought to be the product of submarine slumping. As Greenly 1919 remarked “the many-coloured melange is really indescribable and must be seen in the field to be envisaged”. Apart from the three major rock types, the matrix includes a bewildering mozaic of rock types one within another. Grey limestone over 200 m across forms the largest olistolith in the mélange. This site is a good place to view the Ogof Gynfor unconformity between the Precambrian Gwna Group schists and quartzites (Greenly 1919) and the overlying Ordovician (Arenig) conglomerates of the Porth Cynfor Formation. Porth Wen, a short distance to the West exhibits a similar unconformity (see Graig Wen & Porth Wen RIGS). The unconformity is important in understanding the palaeogeography of this area in late Precambrian to early Ordovician times, a time span of around 100 million years and proves that during the intervening period some great earth movements occurred (orogeny) where the mélange which had accumulated in a deep sea trench was uplifted prior to the area being transgressed by the sea and new sediments being deposited at the onset of the Ordovician Period. (RIGS 317)

Geological setting/context: The Precambrian basement rocks of Anglesey and south-west Ll■n can be divided into several discrete groups, all of which were juxtaposed along a series of steep, brittle and/or ductile faults and shear zones (e.g. Dinorwic and Aber-Dinlle faults; Berw, Central Anglesey and Ll■n shear zones) collectively referred to as the Menai Strait Fault System (MSFS). First, the Monian Supergroup consists of a thick sequence of polydeformed metasediments and meta-igneous rocks, comprising the South Stack, New Harbour and Gwna groups, the latter representing the type example of a large-scale submarine debris flow or mélange said by some researchers to be of Lower Cambrian age. Ongoing research, however, may suggest a much older date for the Gwna Group with possible Cambrian ages being put forward for the South Stack metasediments. Second, the Coedana Complex of central Anglesey comprises high-grade metasediments, amphibolites and gneisses, and low-grade, thermally metamorphosed hornfelses adjacent to a granite (Coedana Granite), which has recently yielded a late Precambrian zircon age of 614 ± 4Ma. Third, a belt of schists and metabasites displaying blueschist facies grade of metamorphism lies within the MSFS. The metabasites exhibit a strong mid-ocean ridge basalt signature and have yielded ages of 580–590Ma. Fourth, the Sarn Complex in Ll■n comprises metagabbros and granite rocks which occur to the south-east of the Ll■n Shear Zone (LSZ), a continuation of the MSFS, which separates these igneous rocks from low-grade Monian mélange to the north-west. A late Precambrian zircon magmatic age of 615 ± 2Ma has been obtained from a metagabbro (LSZ). Fifth, on the mainland of north-west Wales, the Arfon Group comprises a thick sequence of tuffs and volcaniclastic rocks, dated at 614 ± 2Ma, which are conformably overlain by late Lower Cambrian siltstones. Correlatives of the Arfon Group may occur as isolated outliers on Anglesey and, if proven, would provide an important potential lithostratigraphical link across the MSFS. The stratigraphical correlation between the various units has proved highly controversial. The recent recognition of mylonitic rocks, for example in the LSZ, emphasises the presence of tectonic contacts and indicates that each component may represent a so-called ‘suspect terrane’ which was transported laterally into position along the major faults and shear zones. Ongoing unpublished research suggests, that Anglesey’s Precambrian rocks accumulated in accretionary prisms, providing a tectonic sequence rather than a stratigraphic sequence which was formerly accepted. This new research would reverse the accepted stratigraphic order established for the island. This Precambrian basement later formed the north-west margin of the Lower Palaeozoic Basin, the initiation of which was contemporaneous with Arfon Group volcanism. The timing of the inferred fault displacements has also been the subject of debate. Investigations on Ll■n have demonstrated that assembly of the basement terranes was completed at least by early Ordovician times since an unconformable Arenig overstep sequence has been identified at several localities such as Wig Bach, Parwyd and Mountain Cottage Quarry. The Arenig sequence of Anglesey and Ll■n is considerably less deformed and metamorphosed than the underlying

basement, although this distinction is not everywhere obvious.

Deformation History of Anglesey: The deformation history of the Anglesey rocks is controversial. In the absence of reliably dated fauna or of radiometric dating, it is not clear which, if any, of the deformation phases is truly Precambrian, rather than Caledonian. At Rhosneigr, basal Arenig conglomerates contain clasts of New Harbour-looking pelites that exhibit small-scale folds; similarly at the faulted junction of the Ordovician and Mona Complex south of Point Lynas, at Porth Corwgl, the clasts in the Caradocian rocks have been reported to contain clasts of New Harbour Group aspect (or their equivalent, the Amlwch Formation of the north coastal area) with pre-existing folds. On the other hand, at Ogof Gynfor and Porth Wen, clasts in the cleaved Caradocian siltstones and sandstones above the unconformity with the Monian, contain no evidence of deformation that pre-dates that of the clasts and their matrix. The Monian and adjacent Ordovician rocks at all the above localities share a common, single-phase deformation history, with open to tight (depending on lithology) folds, trending NE–SW, upright , but verging somewhat to the SE. The geometry of the folds and cleavage in the Ordovician is very similar to that of the dominant deformation in the South Stack Group; the only exception to the general similarity of deformation style in the Monian and in the Lower Palaeozoic rocks is in the polyphase nature of the deformation of the New Harbour Group. If the correlation of the Anglesey outcrops of the Arfon Group with basal Cambrian sequence of the mainland is correct, their accumulation appears to have post-dated any strike-slip movements on the Dinorwic fault, which separates Anglesey and the mainland. Moreover, if a profound unconformity separates Anglesey Arfon Group from the underlying Monian, then at least those Monian rocks must have been deformed in the Precambrian or very earliest Cambrian.

Llanbadrig Point Coast RIGS: The cliff that backs the beach on the west side of Porth Padrig contains a phyllitic rock containing numerous quartz and limestone blocks and more rarely several jasper pits which are not associated with Pillow lavas as at Llanddwyn Island. Although, clearly, the Gwna Group rocks were deformed by tilting, and perhaps gentle folding, before the deposition of the Ordovician, on the evidence seen here there appears to be no reason to attribute this to a major orogenic event, associated with folding or cleavage-formation. Both rock units were affected by the Caledonian deformation, resulting in upright E-W folding and axial-planar cleavage associated with the horizontal shortening of clasts (about 33%) and their sub-vertical elongation. It should be emphasised that the identity and age of the supposed Gwna Group rocks at this site, in relation to those elsewhere in the Mona Complex, is not certain.

To select RIGS to demonstrate the Precambrian evolution of Anglesey and Ll■n, three separate networks were devised. These are: 1. Precambrian stratigraphy and structures. This category includes two sub-sets: a) Precambrian sedimentary structures; and b) tectonic structures, such as folds, faults and unconformities, which may have occurred during a tectonic event in Precambrian times or even later, for example, during the Caledonian Orogeny; 2. Precambrian palaeontology which includes any life-form and trace fossil, such as stromatolites, sponge spicules, worm burrows and bioturbated metasediments. Current research suggests that some of these fossils may be Cambrian or even Ordovician in age, but as these life-forms were previously held to be Precambrian in age, they have been included in this category. 3. Precambrian reference sections. These aim to represent all the important Precambrian rock types found in Anglesey and Ll■n. They include the major units mapped by Greenly (1920). The aim is to provide the best and most accessible exposure of the rock type. These can be considered as ‘type sections’. Where there is a relevant mineralogical, sedimentary, structural or other change across an outcrop, several representative sites have been chosen.

Llanbadrig Point Coast RIGS belongs to category 1b and is classed as a tectonic structure. The Precambrian Gwna Mélange rocks were formed as the result of a mixture of sea bed sediments and great chunks of rock sliding down into a deep sea trench at a destructive plate margin.

References:

BARBER, A.J. & MAX, M.D. 1972. A new look at the Mona Complex (Anglesey, North Wales). Geological Society of London 136, 407–432. B

BATES, D.E.B. 1972. The stratigraphy of the Ordovician rocks of Anglesey. Geological Journal .8,29–58.

GREENLY, E. 1919. Geology of Anglesey. Memoir of the Geological Survey of Great Britain. 2 volumes, London.

GREENLY, E. 1920. 1:50,000 and 1 inch to 1 mile Geological Map of Anglesey. Geological Survey of Great Britain, Special Sheet No. 92 and 93 with parts of Sheets 94,105 and 106.

Section B

Practical considerations:

Accessibility: Take the minor road that leaves the A5025 a short distance from the turn off to Cemaes town Centre on a lane signed to Gadlys Hotel and Llanbadrig Church. Opposite the church is a small car park for about 6 cars.

Safety: The path along the cliff and along Porth Padrig beach allows easy access to all relevant exposures and crosses the headland which is grazed by cattle. The normal precautions of working on cliff exposures and in coastal terrain should be observed, and the state of the tide should be monitored.

Conservation status: Currently, there is a GCR designation in the area covered by this RIGS, however, as yet, it has not been notified as a SSSI. It is in the Anglesey A.O.N.B. and the entire site is within an area owned by the National Trust.

Condition, use & management:

Present use: Porth Padrig and Llanbadrig Point Headland are not difficult to access, so it is ideal for students and the general public to examine a mélange, an unusual rock type which, although sedimentary in type, owes its origin to a tectonic process. Apart from students, the headland and beach are used by tourists, particularly in the summer, and by walkers who cross the site on the Anglesey Coastal Path. The land on the headland is used mainly for grazing purposes.

Site condition: The site is generally in good condition. The small quarry on the headland is associated with a derelict lime kiln, both of which are in good condition with no loose blocks of rock. In time, the lime kiln could become unsafe and this feature should be monitored.

Potential threats: Other than the potential deterioration in the condition of the limekiln and the rugged terrain down steep cliffs to the sea, there are no other obvious threats to the site. The fossils on the headland, included in another RIGS within the area, Ffynnon Badrig RIGS, are not obvious to a general passer-by and should not therefore attract unscrupulous collectors to the area.

Site Management: Ideally, a management plan would benefit from some form of interpretation to include all the RIGS on this headland.

Site development:

Potential use (general): This outstanding example of mélange, the unusual Precambrian ironstone and the fossiliferous limestone, all RIGS on this headland, and the unconformity on the hillside, a short distance to the west, could be part of a trail around the Anglesey coast. It is an ideal place for informing the general public of such matters and could be combined with a look at the historic church of Saint Badrig (Patrick) and the well, attributed to this saint. If the well is to be included in a trail, it would need steps incorporated in the cliff and some remedial repairs made to the roof of the cave to make the site safe for the general public.

Potential use (educational): The site is suitable for the general public and for school children as well as older students.

Other comments: Research notes This description starts at the eastern end of the peninsula and progresses along the top of the northern coast. As Greenly (1919, p. 306) remarked “the many-coloured melange …is really indescribable and must be seen in the field to be envisaged”. Similarly, the map shown here merely indicates the three major blocks of outcrop, which are characterised east to west by limestone, phyllite and quartzite; it makes no attempt to delineate the bewildering mozaic of rock types one within another. Grey limestone forms the principal rock type that makes up the

eastern block of the melange, from [SH 3734 9463] west to [SH 3754 9465]. This mass is over 200m across, west to east, 60m north to south and, at a maximum, 25 metres high. The best approach to it, after entering the headland via the National Trust gate, is to keep to the left of the churchyard wall. To the left the line of grey limestone crags contain a unit of brown, presumed sideritic, limestone. At the bend in the wall turn west and descend into a small quarry. The limestone is well-seen in the quarry and around the disused lime kiln [SH 3750 9465] some 50m to its northwest. The blocks in the wall of the kiln contain good examples of phyllite and limestone. The latter include those exhibiting the delicate bedding that sometimes characterises the limestone, as well folds and stylolites. On the pavement in front of the kiln the limestone has a gritty appearance; with a hand-lens these mm-sized spots are seen to be spherical to elliptical and identified by Greenly (1919) as oolites. However from the illustration in Greenly (1919, Figure 8) it is likely that they are oncoliths, rolled algal fragments. A disrupted, and locally highly altered, 10m wide dyke is seen west of the kiln. This is a fine-grained dolerite, cross-cutting the cleavage; others also trending southeast are seen to the west (e.g.at [SH 3744 9465] and [SH 3737 9465]). Bedding is locally seen in the main limestone outcrop, often steeply ENE-dipping, sometimes folded, but cleavage is not usually developed. However, parts of this grey limestone unit are composed of bodies of yellow/orange and white -coloured carbonate (sideritic, dolomitic?) tens of metres in length. There are also smaller bodies of grey shale, a metre or two across, and cleaved phyllite, up to 20m long, within the limestone and elongate in the SE-trending cleavage. One of the phyllite bodies is well-seen beneath and north and northwest of the lime kiln, containing tight folds with axial-planar cleavage. Contacts of the different coloured carbonates and phyllite are sometimes gradational but elsewhere appear to be bounded by fractures and to have mutual cross-cutting relationships. In the next major bay beyond the kiln is a lens of shattered quartzite 20m long and some 3m thick and another large lens of phyllite in the limestone. Near the junction with the main phyllite block to the east, discussed below, the limestone contains delicate bedding on a cm and mm-scale, which could indicate stromatolitic structure, as described in the Gwna limestone on the peninsula 0.5km to the south by Wood & Nichols (1973). The contact of the principal limestone block with the phyllite block to its west is in the next bay [SH 3734 9463]. It appears to be sharp (110/75°S), possibly faulted or a product of sedimentary detachment (see Geological Setting section below). Immediately south of the junction, the phyllite contains several blocks of quartzite, 10–20cm long, which are angular and highly fractured. It also contains one prominent block of limestone, in which the bedding is noticeably discordant with the surrounding phyllite. The block contains delicately banded (stromatolitic?) beds. A notable feature of the phyllite in the bay, just west of the junction is the presence of several small pits in siltstone associated with bedded jasper which once was extracted. The jasper is not very visible if the pits are flooded by water, but appear to consist of lensoid bedded bodies up to a metre thick. The jasper is best seen in loose blocks; there is no apparent association with the spilitic lava seen elsewhere (see Newborough Forest site). Within the main phyllite block there are many small, scattered, quartzite clasts up to 20cm in length, elongate in the ESE-striking steep cleavage; the cleavage is seen to be axial-planar to tight minor folds of silty beds. Most spectacularly , the phyllite contains several large foreign blocks. One 7m-long limestone block is just south of the western most jasper pit, and beyond, there are several 10m long quartzite blocks at about [SH 3730 9463], not easily accessible, within the phyllite towards the sea. The furthest isolated block of quartzite clearly sits on, and as well as within, the phyllite. Another quartzite block, immediately southeast of the limestone junction, is seen as a prominent sea stack (but accessible at low tide) at [SH 3730 9465]; this appears also to sit on the surrounding phyllite. The smaller quartzite blocks sometimes exhibit bedding, and are often elongate in the E–W trending cleavage. Most blocks are angular and joint-bounded and heavily quartz-veined at right-angles to their length. The furthest SW end of the peninsula [SH 3725 9455] is made up of one large block of quartzite. This is some 100m in exposed NW–SE length, 50m across and 20–30m high. Bedding, dipping about 100/80°N, can best be detected looking to the east. The quartzite is fine-grained and highly quartz-veined. Its contact with the phyllite to its northeast is not easily accessible, but appears to be a curving fracture overall striking 140° and dipping steeply northeast (see Geological Setting, below). On the cliff top, there are some small quartzite blocks, probably in situ, a metre or so across. These possibly represent the continuation of the quartzite block; sporadic outcrops and loose blocks of quartzite are seen along the southern coast of the peninsula, extending to a stack, on the southeastern coast, called White Lady, at [SH 3757 9445]. It is possible to return to the car-park via the beach on the south coast, returning to the road via steps up the cliff south of the White lady. The Gwna melange was first described by Matley (1899) and Greenly (1919) as an “autoclastic” melange, a tectonic breccia produced by the breaking up of an already competent sedimentary sequence during deformation. Shackleton (1969), however, pointed out that the sequence is quite different from the sediments that it was supposed to be derived from; there was no order comparable with that of the adjacent normal Gwna sequence, although the individual components of the Gwna Group – quartzite, limestone, phyllite, grit, serpentine and jasper – were all there. Further, he said that the blocks were sharply angular,

bounded by fractures often producing re-entrant angles, not at all like the geometry of “boudins” produced by tectonic deformation and he noted that the matrix is unstratified. Most persuasively, Shackleton pointed out that elsewhere from Llanbadrig, the unit is directly overlain by undisturbed slate and grit so that the melange must have formed before the deposition of those sediments. He maintained that the deposit was a result of submarine sliding and brecciation of lithified deposits due to instability of the sedimentary slope. Such deposits are now called olistostromes, from similar sequences in the Alps. This explanation is now generally accepted. The precise context of the melange in the sedimentary and tectonic history of Anglesey is still a subject of dispute. Uncertainties include the chronostratigraphic age of the melange and the age and relationship of the deformation(s) seen in the melange and that in the adjacent Ordovician (see description of nearby unconformity at Ogof Gynfor by Gibbons (2000) and discussion by Barber & Max (1979)). The melange has been proposed by the latter authors and others as part of the process of the subduction of ocean floor and the development of an accretionary wedge in the late Precambrian and Lower Palaeozoic. Exposure of these spectacular conglomeratic sandstones and phyllites, start at a steep faulted junction with the rocks described above, and reveals bedding dipping 112/48–55°N and prominent steeply-dipping cleavage at 104/80°N. The phyllitic sandstones are crowded with lozenge-shaped clasts up to 20cm long, mostly of white quartzite, some stained red. Occasional clasts of phyllite and red jasper are also seen. The clasts are wrapped by and flattened in the cleavage surfaces, with a ratio of long to short lengths up to 2.5:1, as seen when viewing sub-vertical surfaces, perpendicular to the cleavage. On the cleavage surfaces themselves, which are less easy to see, there is a slight elongation of the clasts, up to 1.7:1. This elongation direction pitches 50–60° to the west, locally parallel to a quartz slickenside lineation. In thin section the clasts show no sign of internal deformation, but the “tails” incorporate some clast material as well as newly deposited quartz. The conclusion is that the originally slightly elongated clasts lay with their long axes in, or near, bedding and have been rotated into the cleavage direction by the deformation, when the quartz tails also grew. Locally the rocks are crossed by later flat-lying shear-bands, which deform the clasts into striking S-shapes; these are probably related to faulting.