Graig Wen & Porth Wen RIGS

NRW RIGS no. 198 [SH 40108 94661]

GeoMôn Global Geopark original webpage

RIGS Statement of Interest:

Graig Wen & Porth Wen RIGS provides rare exposure of the unconformity between the Precambrian Gwna Group schists and quartzites (Greenly 1919) and the Ordovician (Arenig) conglomerates of the Porth Cynfor Formation and the sandstones of the Torllwyn Formation above (Bates 1972). The Ordovician conglomerates are spectacularly exposed on the west shore of Porth Wen [SH 4025 9470], whilst the unconformity between the quartzites of the Gwna Group and the Ordovician conglomerates is well-seen on the Graig Wen ridge to the west at [SH 4000 9466]. This 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. It demonstrates that the sedimentary rocks of the Precambrian must have been involved in uplift and erosion during a tectonic event prior to the area being transgressed by the sea and new sediments being deposited at the onset of the Ordovician Period. Since no intervening Cambrian rocks are to be found in this area, this limits the duration that this tectonic event occurred.

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.

Graig Wen & Porth Wen RIGS: The cliff that backs the beach on the west side of Porth Wen contains highly weathered, slightly phyllitic, cleaved sandstone that is locally pebbly and conglomeratic. This is probably part of the Torllwyn Formation, although its relationship with rocks to its south is unclear. Graded-bedding shows that the beds become younger to the north. At the northern end of the beach, at SH 40229472, a fault brings in some prominent, less-weathered, exposures of purple conglomerates. These are probably infaulted Porth Cynfor conglomerates which occur at the base of the Torllwyn Formation, which we will see on the Graig Wen ridge above. The exposures of conglomerates are some 80m across, before a return to the younger Torllwyn Formation in the bay to the north. Brachiopods in the equivalent rocks on Torllwyn (Bates 1972), to the west, show that these rocks are Arenig in age. 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 steeperer-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 50–60o 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. (B) The scarp on the northern side of Graig Wen begins about 20m to the SE of the winding station at the top of the hill (see “Access” below) at [SH 4000 9471]. The first outcrops here, at the edge of an abandoned quarry, show some of the best exposures of the unconformity between the Gwna Group quartzites and the Ordovician conglomeratic grits. Bedding in the conglomerates dips at 090/65°N, transected by a rough cleavage, steeper-dipping at 085/80°N. The crude bedding in the quartzite to the south, dips towards the unconformity with a 40–60° dip to the north and is clearly truncated by the bedded Ordovician. Confusingly, here the first metre-thick bed of conglomerate above the unconformity is followed north by a further metre width of quartzite, before the main outcrop of conglomerate. The quartzite slice must be infaulted. Another 100m along the edge of the scarp to the west, there is a gap in exposure where a path crosses from the south. On the west side of the gap there is another clear exposure of Ordovician conglomerate in discordant contact with the Gwna Group quartzite. The unconformity surface, as well as both bedding and cleavage in the schistose

conglomerate, are here about vertical and E–W striking, while bedding in the quartzite, although obscure in the heavily quartz-veined quartzite, dips about 50°N. The rhomboid- to ellipse-shaped, clasts in the conglomerate here and elsewhere along the ridge, are less easy to measure and identify than those exposed on the beach at Porth Wen. But they are similarly apparently elongated in the cleavage by about 2.6:1 in vertical view and by about 1.5:1 on cleavage surfaces; the longer axes on the latter surfaces pitch about 65°W. The composition of the clasts is again dominantly quartzite, with lesser grit, jasper and phyllite. The clasts often exhibit pronounced tails in the long direction of the clasts, which in thin-section are seen to be of quartz. The site is important in the controversy concerning the nature of the break between the Mona Complex and the overlying Lower Palaeozoic rocks. Greenly (1919), supported by Bates (1972), treated this as a major tectonic unconformity, while Barber & Max (1979) imply, and confirmed here, that the two rock units suffered a common Caledonian deformation. Although the deformation history of the Gwna Group rocks are not easily studied within the immediate area of the present site, Allam (2003) and the author have examined schistose rocks within the Gwna Group exposures on the south side of the ridge. Here there are occasional exposures of schistose grits beneath the quartzite (e.g. at [SH 3965 9470]) that locally contain scattered quartzite clasts. These rocks show the same deformational history as that in the Ordovician above. They exhibit upright E-W folding associated with a single axial-planar cleavage and the deformed clasts show similar deformation values. 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.

Porth Wen belongs to category 1b and is a tectonic structure. The Precambrian rocks are overlain by Caradoc (Ordovican) sedimentary rocks. Although the Cambrian period occurs between the Precambrian and Ordovician period, Cambrian rocks are absent in this area. This means that there is a time gap of at least 85 million years, the time when Cambrian sedimentation was occurring in other areas. Since there is no evidence of deposition in this area during Cambrian times, it is probable that the Precambrian deposits were uplifted and exposed to the air as a land surface during that time. Such time breaks are called unconformities. At the onset of the Ordovician Period, the sea transgressed the land and sediments again covered the Precambrian surface.

References:

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