Ffynnon Badrig RIGS site

NRW RIGS no. 185 [SH 37531 94673]

GeoMôn Global Geopark original webpage

RIGS Statement of Interest:

Ffynnon Badrig is of national importance for its fossiliferous pseudo-oolitic limestones of Precambrian age. The pseudo-oolitic limestones in Cemaes Bay are found in association with the Gwna Mélange of this area and have been found to contain singular and multiple rounded bodies identified as vesiculites, (originally cyanobacteria) and some filaments. This quarry is of historic importance as it was where the limestones were first recognised as containing fossils.The encompassing mélange is a mud-rich sediment containing rounded boulders of varying size, which accumulated on the sea floor adjacent to a land mass. Large masses of rock, such as limestone and quartzite became incorporated in the muddy matrix as discrete masses, some of them as large as 200m across. These large inclusions are termed olistoliths. The olistoliths and host rock eventually descended into a subduction zone (trench), where they became attached to the inner (continental) wall of a trench to become part of the Monian subduction complex. The limestone, in particular, appears to have been fairly mobile as it was often underlain by graphite schist, that acted as a lubricant, allowing the limestone to ‘float’ on the surface of the mélange. This ensured that it retained its sedimentary features and did not suffer from metamorphic change. Importantly, these rocks contain an assemblage of microfossils. Layered stromatolites, filaments and spheroidal forms have been found. Wood and Nicholls described the layers as stromatolites and the spheroidal bodies as Vesicularites (algal floating or rolling bodies) which may represent bacterial forms. They were described as Precambrian in age but later workers thought they could be Cambrian or even Ordovician fossils. However, new isotope dates have shown them to be between 650 and 700 million years old. This information has a huge bearing on the so-called sedimentary succession described by Greenly and Shackleton and recognises the Gwna succession as the oldest sedimentary Group in North Wales. On-going research identifies these exposures to be part of a tectonic, rather than a stratigraphic sequence. In addition these rocks provide important evidence about the nature and depth of the sea floor and rare fossils from a time prior to the ‘explosion’ of life forms during Early Cambrian times.

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 of the 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 of the bedded succession, since the first (oldest) material to be accreted lies above later accreted material and thus reverses the age relationships for the South Stack Group, the New Harbour Group and the Gwna Group established for the island by Robert Shackleton. This Precambrian basement later formed the north-west margin of the Lower Palaeozoic Basin, the initiation of which was contemporaneous with Arfon basement terranes and 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.

Network context of the site: Ffynnon Badrig RIGS lies adjacent to the Llanbadrig Point RIGS and is part of the Precambrian GCR site, Llanbadrig Area (Precambrian of England and Wales). It provides a critical component of a network of 7 RIGS which represent rare fossil evidence from a time before macrofossils had evolved and demonstrate key features of Greenly's Precambrian rocks in Anglesey. The seven chosen sites reflect three vital components in the evolutionary story, namely, the environment in which the life forms existed, the palaeogeography and climate where they evolved and their possible age. At this location, the stromatolites and algal/bacterial bodies are in regional, unconformable or tectonic contact within the Gwna Mélange and are interpreted as having belonged to an olistolith located in a Precambrian accretionary prism. It is possible that all Precambrian rocks in southern Britain were part of the same Avalonian subduction system as Nova Scotia, Newfoundland and Canada.

The environment in which the life forms existed. During Precambrian times, oxygen levels in the Earth's atmosphere were less than 1%, the critical level for the start of evolution on a vast scale when macrofossils entered the equation. Thus, all types of life had to exist in the sea. By Cambrian times, this critical level had been reached and there was a burst of life and a great variety of organisms evolved. Precambrian fossils were, in the main, bacteria or algae and diverse forms reflected their location, such as deep sea, associated with underwater volcanic eruptions or shallow water and intertidal conditions. The organisms could either be attached to a substrate or free-floating.

The Palaeogeography and climate. During Precambrian times, proto- Anglesey would have been part of the super continent of Pangaea, located somewhere in the region of present day Australia. Later Pangaea split into Gondwanaland and Laurasia and proto Anglesey which was attached to the ancient rocks of western North America became part of the northward-moving continent of Laurasia. The climate in Precambrian times would have been relatively cool compared to the equatorial climate experienced around 300 million years ago which was preceded and succeeded by the tropical climate experienced 100 million years either side of the Carboniferous Period. On its journey northwards it would have experienced two orogenies and one prolonged period of regional metamorphism in late Precambrian times. In addition it would, have been affected by 'Snowball Earth', a prolonged time of freezing snow and ice cover from 750 million years ago to 600 million years, or at least a glacial episode in late Precambrian times. 'Global warming' , caused by volcanic eruptions and the build up of methane and carbon dioxide in the atmosphere finally released the Earth from its icy grasp at the end of Precambrian times and was, in no small part, responsible for the burst of life which heralded in the Cambrian, the first period of the Palaeozoic era.

The age of the Precambrian rocks The complexity of these rocks in Anglesey and Lleyn, both in their composition and tectonic history, has led to great discrepancies in age dating. Normally, rocks are dated by the fossil content or by geochemical analysis using radioactive decay methods. Precambrian fossils are rare and can give only general comparative dates. It was not until the stromatolitic sequence at Cemaes Bay was first dated that this was possible in Anglesey. Later work has found other datable fossils in the cherts of Llanddwyn and the worm casts of South Stack but, much of the work has still to be verified because different workers have produced very different dates for the same rocks. Isotope analyses have produced more accurate dates and particularly Rb/Sr and U/Pb analyses from zircons have proved useful. Collins and Buchanan have found early Cambrian ages for the South Stack Group of rocks, thought originally by Shackleton and later workers to be the oldest of the Monian deposits in the sedimentary sequence. These workers had the South Stack Group as the oldest, succeeded by the New Harbour Group and the Gwna Group as the youngest. Most recently, Horak (pre-publication research) has dated the limestone olistoliths in the Gwna Melange as between 650 and 700 million years old, making the Gwna the oldest Group on Anglesey, as Greenly had said in 1919. This is in agreement with Windley et. al., (in the press) who have proposed a tectonic sequence, rather than sedimentary

sequence as previously proposed. This involves ocean floor sediments and rocks descending into a subduction zone and becoming accreted onto the inner continental wall. These deposits were succeeded by rocks and sediments beneath the accreted ‘prisms’. Thus, unlike a sedimentary sequence where rocks are laid on top of each other, tectonically accreted rocks young down the sequence.

Ffynnon Badrig RIGS is important for the pseudo-oolitic limestones described by Greenly (Gwna Group), now recognised as Vesiculites (cyanobacterial deposits), located in the north of Anglesey. These rounded bodies lived in shallow water or intertidal conditions and were either free floating or rolled about on the sea bed as they accumulated graphitic coatings around the individual rounded bodies. Some of these bodies appear to be multi-cellular and can contain up to six or seven smaller rounded bodies within the outer case. The nearby Gadlys Quarry RIGS with its linear stromatolites has been dated as the oldest fossils in Anglesey (650–700 million years old). There are some associated rocks which do contain poorly preserved pseudo-pisolites on the northernmost end of that site. Six other ‘Precambrian Palaeontology RIGS in Anglesey have been chosen because they show variations in their Palaeontological forms, environment of deposition or age in the Precambrian. 2. A small quarry and coastal section known as Gadlys Quarry RIGS important for stromatolite fossils. 3. Associated with the limestones is an unusual outcrop of siderite which may yield other bacterial forms. 4. Wylfa Head contains various stromatolitic forms and an all important condensed sequence in a narrow band of black limestone (current research). On Holy Island, two fossiliferous beds occur in the South Stack Group. 5. The worm casts in the cliffs to the west of Holyhead Breakwater and 6. The bioturbated rocks west of the lighthouse on South Stack. 7. At the Llanddwyn and Newborough site, jasper, cherts and spilite (pillow lava) occur on the island, in the forest and some appear from beneath the dunes on the foreshore (Greenly’s Gwna Group). The cherts have been found to contain filaments and rounded bodies attributed to bacterial forms.

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 network includes two sub-sets: a) Precambrian sedimentary structures; and b) tectonic structures, such as folds and faults, which may have occurred during a tectonic event in Precambrian times or later, for example, during the Caledonian Orogeny; 2. Precambrian palaeontology which includes any life-form and trace fossil, such as stromatolites, sponge spicules, bacteria, worm burrows and bioturbated metasediments. Some current research suggests that some of these fossils may be Cambrian or even Ordovician in age, although other geologists dispute this. As these life-forms were previously held to be Precambrian in age, they have been included in this category; and 3. Precambrian reference sections. These aim to represent all of the important Precambrian rock types found in Anglesey and Ll■n. They include the major mapped units of Greenly (1920). The aim is to provide the best and most accessible exposure of the rock type. These can be considered as RIGS ‘type sections’. Where there is a relevant metamorphic, mineralogical, sedimentary, structural or other change across an outcrop, several representative sites have been chosen. In this study, Ffynnon Badrig RIGS belongs to Network 2 (RIGS Precambrian Palaeontology; see above).

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