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Regional mapping in Central Wales

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FLETCHER, C.J.N. (1990). Regional mapping in Central Wales. *Proceedings of the Shropshire Geological Society*, **9**, 16–19. Summary of a talk to describe the recently begun mapping by the BGS of the Lower Palaeozoic basin of Wales, an area of interest because it contains a variety of turbiditic sediments, it is deformed, but not intensively, it has been subjected to low grade metamorphism, and contains mineralisation although there are very few igneous intrusions.

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BACKGROUND

The Lower Palaeozoic basin of Wales is of interest because of various factors. It contains a variety of turbiditic sediments, it is deformed, but not intensively, it has been subjected to low grade metamorphism, and contains mineralisation although there are very few igneous intrusions.

DEVELOPMENT OF MAPPING

First to be considered is the development of the basin and to see how it progresses from its formation, through infilling and deformation, and fluid movement within the basin, which may control metamorphism and mineralisation. The present study covers the area from Aberystwyth to Builth Wells. The maps which are already published leave large gaps in 1:50,000 coverage which BGS are hoping to rectify. Some sporadic work has been done in the universities as PhD projects.

As an example, contrast the old map of the Rhayader area with the Rhyader sheet which has just been finished, showing much more detail. Satellite imagery is also now available and shows the geology in considerable detail. The pixel size is equivalent to 30 m across but tonal value means that detail less than 30 m is detectable. In an unknown territory about 80% of the geology can be detected. This aspect is illustrated within the South Wales coalfield and the Ludlow escarpment, and towards the north more detail including the Elan valleys and reservoirs, and the Ystwyth fault.

SEDIMENTATION WITHIN THE BASIN

Next to be discussed is the sedimentation within the 'basin' (inverted commas emphasising that the shape is not known). From the sediments, information could be gained on the controls which had formed the 'basin' and affected its infilling. A cartoon showed typical shelf and slope deposits such as the development of turbidite systems and slumping, and also canyons and distributary systems going across a shelf and exuding mudstones and coarse sandstones into turbiditic fan systems on the basin floor.

The background sedimentation to all these deposits is a general rain of pelagic material and fossil detritus – mostly graptolites. Conditions on the bottom of the basin varied – sometimes oxic with bioturbation, sometimes anoxic rather like a stagnant pool where nothing lives. Transitions from one to the other type of environment are reflected in the deposits.

Looking more closely at the mudstones, a particularly clear slide showed a repeating sequence of mud turbidite interbedded with pelagic rain which was much darker in colour – all on a scale of a few centimetres. It is suggested that the turbidite was probably deposited in minutes, or perhaps an hour while the pelagic 'rain' took, perhaps 10,000 years – thus a contrast in time scale!

Another slab, this time from near Claerwen, showed how chemical differences of the bottom sea water are reflected in the rocks, e.g. turbidite muds deposited in oxic conditions had medium and light grey alternating bands. Dark mottling in the light grey mudstone indicated burrows of organisms. The upper part of each layer of mudstone is also lighter because it has been oxidised. By contrast anoxic bottom conditions are shown by medium grey bands overlaid by laminated dark bands (no bioturbation) of undisturbed pelagic rain. Small black blobs of phosphate also formed during the diagenesis of the mudstone.

Contrasting with the background sedimentation of mudstone, the turbidite fan systems are sandstone-dominated.

Next to be considered were a series of slides showing the cross section of a conglomerate channel within the shales – the Caban conglomerate system which sourced the turbidites in the basin. A quarry had been opened in these sandstones to build walls for the dam for the reservoir. Conglomerates and sandstones are interleaved with the shale until they gradually die out and are overlaid with mudstones. Some of the lenses of sandstones and conglomerates are very large. The conglomerates are made up of large boulders of acid volcanic origin. Recent isotopic analyses of the pebbles have given Precambrian ages suggesting they were sourced from the Midland Platform.

Away from the main fan systems the amount of conglomerate and sandstone decreases: thinner and thinner sandstones towards the distal part of the turbidite fan system. In this region there is a lot of mud amongst the sandstone and thin sandstone beds are interbedded with muds. There are two styles: (1) thicker high matrix sandstones with very little structure deposited as dilute debris flows, interbedded with (2) cleaner turbiditic sandstones made up mainly of pure quartz grains. Within the latter are convolute bedding, slump structures, etc. which may form the base of the thicker sandstones above. In the yet more distal region of the turbidite system there are less and less sandstones until only thin quartz sandstones occur, interbedded with mudstones at the far distal end.

GEOPHYSICS AND REGIONAL MAPPING

Geophysics has revealed a vast amount of information about the subsurface structure which has been accumulated by BGS. This information is based on the variations in gravity and magnetic readings from several thousand stations. The direct readings show broad outlines of structure, with gravity readings in the west being high whereas those towards the east are low.

The computer can also look at changes in the gradient of gravity data. Where there is a sudden change this can be enhanced by simulating shining a light from a particular direction. This then defines the structures which confine the Cheshire basin. The area under consideration – Central Wales – looks at first sight fairly monotonous but in fact this technique picks up very minor variations in the gravity and magnetic fields.

The features in the basin displayed by this technique may be due to a variety of causes such as variations in the type of sediment, large amounts of volcanics, etc. This technique reveals linear features in the basin suggesting a series of major faults at depth.

Combining these two types of map identifies an important linear feature which coincides with the change from shelf to basin sedimentation. This may represent a fault, or series of faults, active in Lower Palaeozoic times. The feature also defines the margin of the Cheshire Mesozoic basin and thus was activated probably in Ordovician times, and then reactivated through subsequent geological time. It is thus fundamental to the structure of this part of Britain.

Clearly volcanic rocks will be more strongly magnetic than sedimentary ones, so North Wales is magnetic. In central Wales the magnetic measurements also pick up linear features. Around the Cheshire basin they show volcanic centres, probably of Carboniferous age. In places the magnetic anomalies correlate well with the gravity anomalies. The map correlation extends down to Shelve and Builth Wells where there was Ordovician volcanic activity – perhaps the faults were conduits for lavas and igneous intrusions.

The Rhayader sheet shows that the Towy anticline lies parallel to one of the lineations. Around the nose of the Towy anticline the maps show several minor unconformities. A more detailed map of the nose of the anticline, with its Ordovician core, is revealed by the 1:25,000 maps but these will not be published, although available as dyeline copies from the BGS.

The transition from shelf to deep sea sedimentation across the anticline and also a major mid-Silurian unconformity around the nose of the Towy anticline can be picked out, indicating that this was active during Silurian times and possibly subject to subaerial erosion – most of the mid-Silurian is missing and some fossils suggest subaerial conditions in this area.

The model which has been compiled from all this information on the Towy anticline area is of a fault system, possibly with strike-slip movement and a "flower" of faults above. If this developed during sedimentation, with an anticline forming at the same time, it would develop an unconformity over the ridge of the anticline but conformable sedimentation on the flanks. Wenlock sediment goes over it all undisturbed, suggesting that the movement had ceased by that time.

STRUCTURAL DEVELOPMENT

The structure of the area consists of the mid-Wales "basin", including a whole series of folds with Ordovician cores, and a series of periclinal folds.

Most of the folds in the "basin" face towards the east (i.e. steep-limbed to the east), suggesting in a simplistic manner a force from the west. The deformation fades quite rapidly to the east of the Towy anticline, towards the Midland Platform.

To the west the rocks are cleaved, including the Ordovician, but much less so to the east. It has been suggested that the deformation in the Welsh Basin was the result of the collision of ancient plates to the north. Many of the structures may be explained by an element of strike-slip displacement along basement faults.

The majority of structures face eastwards over central Wales. On the western coast however the structures face west, possibly reflecting a deep basement fault?

The folding is commonly assumed to be early-middle Devonian. Attempts have been made to date the structures by Rb/Sr isotopes on the mudrocks, a method commonly used on igneous rock. This produced a very good series of isochrons from cleaved mudstones, i.e. very low grade metamorphic rocks, which gave an age of 430 million years, roughly the same as the sediments. Dates from other rocks gave a second group at 390-400 million years (Silurian-Devonian boundary). The initial interpretation was that the results were so consistent that they must reflect an event, perhaps the diagenesis or perhaps alteration of older material. The 400 Ma date is thought to reflect the peak of deformation which may extend into the Lower Devonian.

From the metamorphic aspect the rocks are all low grade metamorphosed mudstones but some are more cleaved than others. Studies of the very fine micas which grow during metamorphism and measuring their sizes can be done using an X-ray diffraction machine. It is expected that increased size of mica reflects an increase in metamorphism. By sampling every square kilometre a contour map can be built up reflecting the mica sizes. This varies from a diagenetic zone to a greenschist zone (i.e. slate deformation) with contours between. Metamorphism may be related to just depth but also to degree of deformation. The Ordovician rocks in the Towy anticline are low grade, in spite of being the oldest rocks. Other Ordovician rocks in different areas of the basin reflect a higher grade of metamorphism. The interpretation is that the depth of sediment over the Towy anticline was much reduced, due to erosion, and so the sediments within the basin were buried more deeply and so reached a higher grade of metamorphism.

In the Central Wales "syncline" the sediments are low grade but the adjacent anticline is high grade, suggesting a strong depth control on the degree of metamorphism. The linear features in the metamorphic grade are parallel to the tectonic lineations and may be related to increased strain above basement faults.

MINERALISATION

The origin of the mineralisation of the area has also been considered in the light of an apparent lack of intrusions. Was there a mechanism which could account for the mineralisation being generated from the muds? As it lies along fault lines it must be structurally controlled too. The study looked at tiny fluid inclusions within the quartz veins. Some of these inclusions are high in methane which may have come from the host sediment. Other inclusions are high in carbon dioxide. These inclusions are thought to have sampled the ore-bearing fluids. The lead isotopes in the mineralisation give a crude age dating system but also give an indication of the source of the lead. Different populations of lead have been identified which may reflect either different ages or different sources.

Mineralisation within the cleavage can be shown up by electron back scatter photography which shows chalcopyrite and galena, suggesting that ore elements had migrated during the formation of the cleavage. Some of the muds had big diagenetic nodules, some of which were carbonate rich, sometimes with nickel centres. This seems to indicate migration and recrystallisation of ore minerals during diagenesis. It would seem that much of the mineralisation of the basin was caused by the remobilisation and concentration of elements already existing within the basin. How had this happened? How did the fluids migrate, and what were their pathways?

The talk concluded with a short discussion of Parys Mountain mine on Anglesey, which had been visited recently. In the mid-nineteenth century Parys Mountain was the largest copper mine in the world but production declined with the market. Recently several companies have had another look at it. The cause of the mineralisation is not agreed but probably the ore body was an exhalative deposit, formed on the sea floor. Currently the massive lead, copper and zinc ores are sought.

The geological setting of the ore bodies indicate that originally the copper was the main element sought but within the last few decades high grade lead and zinc have been the main interest. The structure is a truncated. syncline but it is difficult to interpret. The mineralisation seems to be associated with the "white rock": a sinter (banded, brecciated quartz) formed by crystallisation around a hydrothermal spring. In places large angular blocks of sinter are set in black shale plus blocks of copper sulphide in the same shale. This might indicate that the sinter and massive sulphide had been caught up in a mud slide. The nature of the breccia made it very difficult to find the ore.

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