

Silurian to Scandinavian

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BASSETT, M.G. (1986). Silurian to Scandinavian. *Proceedings of the Shropshire Geological Society*, **5**, 1–3. The account of a lecture describing the Anglo-Baltic area, which formed a single faunal regime in Silurian times. The principles used in correlating Silurian rocks across that area are discussed in terms of the types of rocks and fossils present.

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The lecture focussed on the Anglo-Baltic area which formed a single faunal area in Silurian times, extending from the Eastern Appalachians through Britain to Scandinavia. The principles used in correlating Silurian rocks across that area were discussed in terms of the types of rocks and fossils present.

Roderick Impey Murchison joined The Geological Society in 1825 and became greatly influenced by its President, William Buckland (later to become Dean of Westminster), in the importance of field work. In 1830 Murchison decided with Sedgwick to map the rocks of Wales and the Welsh Borderland, which were then virtually unknown below the Mesozoic and Palaeozoic cover. Murchison's task was to map the Borderland to the Welsh Basin, and he saw his first Silurian rocks in the spring of 1831 near Llandeilo.

In the gorge of the River Wye alongside the Brecon-Hereford road, Murchison saw "low terraced shaped ridges of grey rock dipping slightly to the south east, rising out conformably from beneath the Old Red of Herefordshire." He found these rocks "replete with Transition fossils afterwards identified with those at Ludlow". He realised that identifying those fossils was the key to his mapping. By the end of the summer of 1831, Murchison had essentially solved the problem of the correlation of the Transition rocks, while Sedgwick laboured away in North Wales for another 20 years.

By 1837 Murchison had mapped the Cambrian, Ordovician, Silurian and some Carboniferous and Devonian, of the whole of the Welsh Borderland and South Wales and by 1839 he published "*The Silurian System*", which is still

the key on which all Silurian correlation is based throughout the world.

Today the base of the Silurian is defined in Scotland, the top near Prague, and the boundaries in between are defined in Shropshire – the Llandovery/Wenlock boundary in Hughley Brook, the Wenlock/Ludlow boundary in Pitch Coppice in the core of the Ludlow anticline, and the Ludlow/Downtonian at Ludford Corner.

The best method of correlation involves the use of different groups of fossils. Microfossils such as acritarchs, chitinozoa, ostracods, collodons and dinoflagellates are increasingly used, but the use of graptolites is more common. Shelly fossils are also becoming more useful. Murchison used assemblages of brachiopods and trilobites.

It is now realised that assemblages of fossils are controlled by both the environment and time. Ziegler has conducted a classic study of evolutionary sequences in what was thought to be a single species of *Eocoelia* in the Llandovery. This has demonstrated a progressive loss of ribs through time, so now rather than identifying a single species, there is a tool for finer subdivision.

Thus recognition of evolving lineages has become an important principle of correlation. Such changes take place despite changes in the type of rock fossils are collected from. Therefore the environment does not seem to affect evolutionary change. What has to be done is to tie the keys from shelly faunas against graptolite zones and then erect a whole scale for the system, based in part on the evolution of shelly fossils.

Wenlock Edge was visited by Murchison in 1831 when he erected the three-fold lithological divisions of Llandovery, Wenlock Shale and Wenlock Limestone. In the late 1960's it became

clear that there was international need for a more refined correlation and a definitive description of the type sequences of these rocks. The Geological Society of London set up a Working Group to investigate their potential. Subsequently a borehole was sunk near Much Wenlock, at Hill Farm, from the top of the Wenlock Shale into the Llandovery purple shales. This passed into the Lower Wenlock Shale where there are thick bands of bentonite, blocky mudstone and shale extending for 1000 m, then through Tickwood Beds and into the 90 feet thickness of Wenlock Limestone, which includes the massive reef structures which Murchison called ballstones. Until the early 1970's the rich shelly fossils of this 90 foot unit provided the faunas on which correlations were based, because the Wenlock Shale was apparently poorly fossiliferous.

The Working Group produced a new map on which correlations could be based. This refined Murchison's work by the use of modern techniques and defined four subdivisions of the Wenlock: the Buildwas, Coalbrookdale, Tickwood and Much Wenlock Limestone Formations. Through this work it became clear that there was a great deal of potential for correlation using graptolites and some shelly faunas. Suddenly the type Wenlock fauna was shown to be 90% graptolitic and not mainly shelly.

It is possible to trace Silurian rocks from Wenlock Edge along the Towey Anticline into South Pembrokeshire. These are of Llandovery age with shallow water sandstone facies having quite different fossils from those in Shropshire. The rocks there are well exposed but tipped almost on end and in shallow folds. At the top of the sequence there is an unconformity which was missed by Murchison. This is identified by reddened beds associated with uplift, emergence and weathering, followed by a further marine sequence. The question is: what time does the gap represent? Above that sequence Hercynian folding has produced cleavage in mudstones with bentonite rich in shelly faunas including *Stricklandia*. At the top the sequence goes from marine rocks through fluvial rocks to red sandstones. Murchison assumed this to be Downtonian age Old Red Sandstone and therefore the sequence would be below the Upper Ludlow.

The early 1970's re-survey and correlation showed two species of *Euceta* missing at the

unconformity, which must thus be missing three beds. Above that is a complete sequence of marine rocks, through sandy fluvial beds to red sandstone. In Pembrokeshire the junction between fluvial and red sandstone is not the junction between Ludlow and Downtonian, but the junction between two parts of Upper Wenlock. Therefore, in South Wales, the Old Red Sandstone continental conditions were introduced in Wenlock times and not Downtonian. Fossil evidence shows that there is no trace of Ludlovian in Pembrokeshire. This means that the Old Red Sandstone event was not a single event, but developed at different times. The red beds in South Wales were derived from a landmass in the Bristol area in late Wenlock times, whereas those at Ludlow were derived from the north in late Ludlow/early Downtonian times. It is therefore clear that the ORS is a facies type and not an age indicator.

This work helps to reconstruct events in earth history by reference to palaeogeography. During the early Wenlockian in the South Wales borderland, across the Usk/Bristol Channel area there was a great embayment of sandstone with volcanoes in the Mendips. Limestone started to spread across the south Welsh Borderland with a mud-dominated area covering Wenlock Edge and down into South Wales, and a graptolite basin across central Wales with turbidites being pushed along the Welsh trough into North Wales. By Upper Wenlockian the embayment had gone and a limestone platform built out westwards. Wenlock Limestone began to develop one graptolite zone earlier in the Dudley region, taking one graptolite zone to reach Wenlock.

In 1844 and 1845 Murchison went to southern Sweden, where he confirmed the presence of Silurian rocks in the Oslo region. When he wrote his paper on this he used the term Llandovery for the first time – rocks of this age were previously called Caradoc Sandstone. Murchison was able to correlate the rocks in Oslo Fjord with those in the Welsh Borderland using *Eocelia* and *Stricklandia* pentameroides. Murchison saw a sequence of reefs and equated them with Wenlock Limestone reefs, but these are actually of Lower Wenlock age showing that limestone development started earlier in this region than in the Welsh Borderland.

At the top of the Scandinavian sequence great mats of algae are evidence of sabkhas such as are

now found in the Persian Gulf. These are overlain by red-beds confirming a shallow water environment in a hot dry climate. Murchison interpreted these red-beds as ORS of Downtonian age, just as he had in Pembrokeshire and therefore thought the sabkhas to be of Ludlow age. The red-beds are fluviatile and similar to those in Pembrokeshire. The sabkhas and red-beds are in fact both within the Wenlockian, so ORS conditions were introduced into Oslo prior to their onset in the Welsh Borderland.

On Gotland, the rocks in the north are of Llandovery age, those in the south of uppermost Ludlow age. The Swedish geologists thought the reverse was true, but Murchison proved them wrong by examining the faunas. The paper he wrote is still the basis of Gotland stratigraphy. Murchison brought his fossil collection back with him, which was a rare thing to do, justified by the complete sequence of limestone occurring on Gotland. The exposures are sequences of marine platform limestone and marls rich in fossils, with reefs in the Lower Wenlock. Underlying the reef beds are very weak marls into which the reefs sag. This has resulted in a line of circular structure (called Phillip Structures after the archaeologist who first saw them), below sea level and visible from the air, indicating the former line of the reef belt.

Higher in the Wenlock sequence sandstone beds were swept over the limestone platform from the rising Caledonian mountains to the west. In the Middle Ludlow, reef conditions were established once again. Stromatoporoids can be observed in life position because of the remarkable state of preservation in Gotland exposures. At the top of the sequence red sandstone beds developed in the Upper Ludlow. The sandstone sags down into the mud in the same way as the limestone reefs. At the top of the island, late Ludlow age red-beds can be found containing ostracods, which also occur just below the Ludlow Bone Bed at Ludford.

It has now been proposed that this is not such a simple stacked system. In places they are lateral equivalents representing an evolving lineage of ostracods. If the fossils zones are mapped out, they run obliquely across the rock units so that there is a complex facies variation migrating with time, younging SE to NW.

Because of Murchison's work in Scandinavia, Czar Nicholas I invited him to look at the rocks of Estonia. Murchison subsequently went there in 1841, 1844 and 1845, mapping the whole area on three short visits. He was assisted by a Prussian, Kaiserling, and a French palaeontologist, Vernai. Mrs. Murchison produced the drawings. In 1845 they published "*The Geology of Russia in Europe*", a book which rivals "*The Silurian System*" in its quality and content. It describes the Silurian geology of the western Soviet Union and again later investigations have proved Murchison was right. The Czar insisted that Russian geologists send Murchison fossils from other parts of Russia and Murchison was therefore able to identify Silurian rocks throughout that country.

In his book on Russian geology, Murchison concluded "of Silurian fossils of Russia, a few only are it is true, absolutely identical with forms in the British Isles, but the mass of them is the same as that of the mainland of Scandinavia, which region being intermediate between England and Russia, is found to contain a considerable number of forms common to deposits occupying the same position in both the other countries". He had therefore established his chain of correlation and all that has been done in the last 140 years has been to refine his early pioneering work.

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