Cambrian and Ordovician, Northern Highlands of Scotland

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Cambrian and Ordovician

Distribution of groups and formations of the Torridonian. P915464.
In the time interval (c.200 Ma) between the deposition of the Torridonian rocks and the Cambrian there was a period of crustal warping during which the Precambrian rocks of what is now the Caledonian Foreland were arched into large folds. Considerable erosion followed this folding and several hundreds of metres of Torridonian rocks were removed in places to lay bare the underlying Lewisian gneiss. By the beginning of Cambrian times the erosion had produced a remarkably flat surface passing across hard gneiss and softer sandstone alike; this may have been formed by marine erosion or as a subaerial peneplain. Cambrian sediments were deposited on this surface as it
progressively and gently subsided to form the floor of a shelf sea. This shelf lay on the south-east side of the continental mass which bounded the Iapetus Ocean on its north-western side and, as a result, the fauna of the Cambro-Ordovician rocks of the North-West Highlands resembles that of the North American Province — the Beekmantown (Canadian) Fauna of older accounts. It shows a marked contrast to that found in the rocks of similar age in England and Wales, which were laid down close to the south shore of the Iapetus. Cambro-Ordovician strata now lie on the Caledonian Foreland and within the Moine Thrust Belt along a narrow zone from Durness to Skye (see P915464). They are overlain by metamorphic rocks of the Moine Nappe which were pushed westward along the Moine Thrust itself.

The long-accustomed names given by the original surveyors (Peach and others, 1907) to the Cambro-Ordovician rocks were revised, First by Swett (1969) and later by the Stratigraphical Committee of the Geological Society (Cowie and others, 1972; Williams and others, 1972). The names currently in use are given in P915508. A further modification proposed by Palmer and others (1980) is also incorporated.

Swett’s account of the depositional and diagenetic history of the Cambro-Ordovician rocks of the North-West Highlands is the most comprehensive modern synthesis available but the memoir by Peach and others (1907) still remains the best for locality descriptions. The formation thicknesses in P915508 are based on Cowie and others (1972) and Williams and others (1972); they differ to some degree from those of Swett.

The junction between the Cambrian and Ordovician systems lies within the Durness Group — a sequence of carbonate rocks which have significant features in common throughout their thickness. Over the years there has been much discussion about how much of the Group is Cambrian (and, if so, what part of the Cambrian) and how much of it is Ordovician. Recently the question seems to have been settled by the recognition by Palmer and others (1980) of a major erosion surface between the Sailmhor (Lower Cambrian) and Sangomore (Arenig) Formations (see P915508). This erosion surface seems to represent a time interval equivalent to the Middle and Upper Cambrian.

**Eriboll Sandstone Group**

This Group consists predominantly of hard white quartzite which forms a conspicuous feature of the landscape of the North-West Highlands. The quartzite has the composition of orthoquartzite with subordinate subarkose and arkose. It comprises a lower False-beded Quartzite Formation and an upper Pipe Rock Formation. The False-beded Quartzite, as its name implies, is conspicuously cross-bedded. It commonly has a pebbly base 0.3 to 3.9 m in thickness. The pebbles are well rounded and consist of quartzite, feldspar and felsite, set in a cream or greenish matrix. The overlying quartzite is made up of sets, 8 cm to 1 m thick, with mainly tubular cross-bedding and bimodal current directions. These features suggest a shallow water, subtidal or intertidal environment. Only in one place have trace fossils (annelid tubes) been found.

The Pipe Rock Formation is also quartzitic, but lacks cross-bedding. Its name is derived from the abundant vertical pipes which are 3-15 mm in diameter and up to 1 m long (P500390). These are the casts of suspension-feeding organisms. One form of pipes is represented by straight, subcylindrical, unbranched tubes normal to the bedding. These are called Skolithus. In another form the tubes pass upwards into a ‘stacked funnel’ arrangement, which appears on the bedding planes as concentric rings (P527489; the ‘Trumpet Pipes’ of the older descriptions). These are called Monocratenon. Hallam and Swett (1966) considered the two forms to be produced by the same organism, the different structures resulting from differences in the response to burrowing in sand of varying thixotropic properties. They found that the zonation of the Pipe Rock established by the older
surveyors (which in part depended on the presence of Trumpet Pipes and in part on the size and frequency of the skolithid tubes) could not be followed in practice, so this well known zonation has now been abandoned.

The Eriboll Sandstone Group is remarkably uniform in thickness (it is slightly thicker in the southern area of its outcrop), suggesting to Swett (1969) either that the deposit is tabular, as might be expected with a gradual transgression, or that its outcrop trends more or less parallel to the strandline of a wedge-shaped deposit.

**An t’Sron Group**

The group derives its name from the promontory An t’Sron on the east shore of Loch Eriboll. It comprises a lower Fucoid Beds Formation and an upper Salterella Grit Formation.

The Fucoid Beds Formation consists of dolomitic siltstone with some dolomitic shale and sandstone, some layers of dolomite, and rare pisolitic ironstones. The beds were originally named Fucoid Beds because the abundant trace fossils which they contain were mistakenly identified as seaweed markings (fucoids). These are now considered to be flattened (?) annelid burrows, termed *Planolites*, but the old name has been retained. They were found by the early surveyors to contain *Olenellus lapworthi* at one horizon, and several new occurrences of this trilobite have been recorded by Brand (1965). In addition to the trilobites *Olenellus* and *Olenelloides*, an assemblage of *Hyolithes sp.*, *Salterella sp.*, a few brachiopods, echinodermata indet. and trace fossils has been recorded (Plate 25, p.153). The fauna indicates a late Lower Cambrian (*Bonnia-Olenellus* zone) age, and provides the only valid index fossils within the Cambrian sequence of the North-West Highlands (Cowie and McNamara, 1978).

The Fucoid Beds have an abnormally high content of potash (Bowie and others, 1966) and are considered to have an economic potential (p.179). The potash is contained in finely divided adularia feldspar. It is considered by Swett (1966) to be due to authigenic enrichment by migrating K2O derived from the Durness Group carbonates.

The Salterella Grit Formation comprises beds of orthoquartzite, with some arkosic grits and dolomitic sandstones. Interleaved shales at the base of the formation contain *Olenellus lapworthi* and, in the upper part, dolomitic sandstones have layers full of *Salterella*. As this fossil was originally identified as *Serpulites*, the old name for the formation was the ‘Serpulite Grit’.

**Durness Group**

Formerly, but inaccurately, referred to as the Durness Limestone, the Group comprises limestone, dolomitic limestone, calcareous dolostone and dolostone (i.e. fine-grained carbonate rock, grading from pure limestone to pure dolomite), with a few minor variants such as cherty limestone; there are chert nodules and bands at some horizons (P001980). Peach and others (1907) divided the ‘Durness Formation’ into seven ‘groups’ and, although Swett (1969) notes that these divisions are indistinct and poorly defined, they form the basis of the ‘Formations’ nomenclature of Cowie and others (1972) given in P915508.

To account for the dolomitic beds, which form a variable part of the sequence, Swett (1969) considers that the presence of dolomitised fossils, dolomitised oolite and dolomite replacement of secondary chert nodules suggests authigenic dolomitisation of limestone, although he does not exclude the possibility that some of the Durness Group sequence comprises primary dolomite.
The Ghrudaidh Formation consists of generally dark, lead-coloured and mottled dolomite with *Salterella* sp. in the lower 10 m. There are some oolitic horizons formed of dolomite, calcite and, more rarely, silica in the middle of the sequence. The Eilean Dubh Formation consists of fine-grained flaggy argillaceous ‘dolomite’ and limestone with many stromatolitic algal bands. Some horizons exhibit small-scale cross lamination, scour structures and load casts, and there are thin lenticular mud flake conglomerates. The Sailmhor Formation comprises massive mottled granular ‘dolomite’.

The spectacular dark grey and white mottling has led to the use of the term ‘Leopard Rock’ for the formation. The mottling is possibly due to differential dolomitisation of branching trace-fossil burrow systems (Palmer and others, 1980). Another characteristic of this formation is the extensive development of chert, both as nodules and as finely laminated layers. A fauna of gastropods, cephalopods and trilobites which was recorded at one locality within the formation is of Tremadoc age. Palmer and others (1980) were unable to confirm its presence and, reviewing the evidence, feel that it may represent a fissure-filling by material which was deposited above a major unconformity.

The macrofaunal content of these lower three formations suggests that they are of Lower Cambrian age, and Brasier (1966) recorded diagnostic Lower Cambrian microfossils from a chert band near the base of the Eilean Dubh Formation.

Palmer and others (1980) have identified a major break between the Sailmhor Formation and the overlying Sangomore Formation. In Balnakeil Bay, west of Durness, the top of the Sailmhor Formation is considered to represent a karst surface. Solution cavities extending downwards from this surface are filled with breccia which can be traced downwards as far as the Eilean Dubh Formation in places. As the four formations above this unconformity contain Ordovician (including Tremadoc) fossils, it is inferred that Middle and Upper Cambrian rocks are not represented in the Durness Group, which is, accordingly, divided into an Upper and Lower Durness Group (see P915508) with the break at the base of the Eilean Dubh Formation.

The Sangomore Formation comprises fine, granular dolomites with cream or pink limestones near the top and chert bands near the base. Only one macrofossil locality has been found (Palmer and others, 1980) with *Murchisonia* sp., *Pleurotomaria* sp. and *Orthoceras* sp. (suggesting Lower Cambrian–Tremadoc age). The Balnakeil Formation comprises dark and light grey ‘dolomites’, limestones and impure layers with chert nodules, while the Croisaphuill Formation is made up of black and dark grey ‘dolomites’ and white limestone. These formations have a fauna of brachiopods, gastropods, cephalopods and trilobites of Arenig age (Williams and others, 1972). The overlying Durine Formation of Fine-grained light grey ‘dolomites’ and limestones contains gastropods and is also thought to contain conodonts of Llanvirn age (although they may in fact come from the upper part of the Croisaphuill Formation).

**Selected bibliography**

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