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Stratigraphical framework for the  
Ordovician of Snowdonia and the Lleyn Peninsula

A discussion of the Tremadoc to Caradoc rocks lying between the  
Menai Straits and the Llanderfel Syncline, and including an  
appendix on Cambrian rocks

Version 2

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## 1 SUMMARY

The lower to middle Ordovician (Tremadoc to Caradoc) stratigraphical divisions in North Wales (but excluding Anglesey and the Berwyn Hills) are reviewed. They are referred to six volcanic groups (Rhobell, Aran, Llewelyn, Snowdon, Upper Lodge and Llanbedrog) and two sedimentary groups (Mawddach and Ogwen), providing a framework for future work in the region. The distribution and relationships of most of the formations are illustrated diagrammatically. The newly proposed Ogwen Group represents a depositional sequence encompassing sedimentary rocks from the regional unconformity at the base of the Allt Lŵyd Formation (Arenig) to the top of the black mudstones of the widely distributed Nod Glas Formation (Caradoc); it encloses some of the volcanic groups. Several formations that are regarded as superfluous pending further investigation and the underlying Cambrian formations currently in use are listed.

## 2 PREFACE

The Stratigraphy Committee of the British Geological Survey has undertaken to carry out a review of the stratigraphical classification and nomenclature for all parts of Great Britain for which modern information is available. To this end several Stratigraphical Framework Committees have been established, each with the following terms of reference:

- i To carry out a complete review of the lithostratigraphical nomenclature of the designated region, identifying problems in classification, correlation and nomenclature.
- ii To propose a stratigraphical framework and lithostratigraphical nomenclature down to formation level for the whole outcrop.
- iii To organise peer review of the scheme.
- iv To present the results in a document suitable for publication.
- v To see that the Lexicon entries are completed for their area of responsibility.

The Ordovician rocks of Snowdonia have been discussed by a small group under the leadership of Dr A W A Rushton and are the subject of this report, together with a brief resumé of the Cambrian rocks.

The purpose of all the Stratigraphical Framework Committees is to establish a framework down to formation level that can be used as a central reference by geologists working in the region. The process of erecting a framework requires decisions to be taken about correlations and equivalences leading to a simplified nomenclature. Inevitably many names will be rendered obsolete. The frameworks are lithostratigraphical and though each is set against a chronostratigraphical reference column the finer points of the chronostratigraphy of the succession are not our prime concern.

The lithostratigraphical rules applied are those of the North American Commission on Stratigraphic Nomenclature (1983). It is expected that the framework documents will be refined and improved with time. Indeed, erecting them effectively poses a challenge to stratigraphers which I hope will be taken up to contribute to a better understanding of British stratigraphy.

This report was reviewed by the Geological Society Stratigraphy Commission by Drs R E Bevins and R Fortey, and is endorsed by the Commission.

P M Allen, BSc, PhD

*Chairman*

*British Geological Survey Stratigraphy Committee*

Professor P F Rawson

*Chairman*

*Geological Society Stratigraphy Commission*

23 October 1997

## 3 INTRODUCTION

This report provides an overview of lower to middle Ordovician stratigraphy in much of North Wales. This is complicated because of the interdigitation of the deposits from local volcanic centres with the sedimentary deposits of an unstable marine trough. However, recent mapping of many British Geological Survey 1:50 000 scale sheets around the Harlech Dome (Figure 1) has led to advances in the understanding of the emplacement of the volcanic sequences (Howells, Reedman and Campbell, 1991; Kokelaar, 1992), and presents an opportunity for a new synthesis of the stratigraphy, with emphasis on processes and events.

Over several decades many geologists have established detailed successions in various areas, and although each may be valid, in many cases they are not easily related to those of adjoining areas. As the detailed interpretation of the Ordovician geology of North Wales has evolved, so has the stratigraphy used to describe it, with consequent changes of classification and nomenclature. Within the area considered here there are about 100 stratal divisions for the lower to middle Ordovician named on current British Geological Survey maps, or recently proposed for maps in press, and in addition there are very many older terms (Whittard, 1960). The need to pursue geological boundaries from one 1:50 000 map to the next has indicated many discrepancies of usage, but doing so provides an opportunity to rationalise, and where possible to simplify, the Ordovician stratigraphical terminology in north-west Wales.

An overview of lower to middle Ordovician stratigraphy in Snowdonia and on the Lleyn Peninsula (Llŷn) is illustrated in the schematic diagrams, Figures 2, 3, and the biostratigraphical and chronostratigraphical correlation in Figure 4.

## 4 SCOPE

### 4.1 Geographical coverage

The area under consideration lies south-east of the Dinorwic Fault, part of the Menai Straits Fault Zone, and north-west of the Llanderfel Syncline which separates the main volcanic area of north-west Wales from the Berwyn Dome. There has been much recent primary surveying in this area; published maps are available for the Bangor, Snowdon, Harlech, Cadair Idris and Aberdaron districts (Figure 1), and published compilations are available for the Corwen and Bala districts. In contrast, there are no recent comprehensive surveys in Anglesey or the Berwyn Hills,

where separate stratigraphical schemes (not considered here) have been proposed. The Ordovician rocks of Anglesey were reviewed by Bates (1972), and those of the Berwyn Hills by Brenchley (1978) and the British Geological Survey (1986).

## 4.2 Stratigraphical scope

The sequence considered here consists mainly of the lower and mid-Ordovician, from the base of the Tremadoc Series to about the top of the Caradoc Series. The upper part of the Ordovician sequence, essentially the Ashgill Series, is not drawn into the synthesis because a large and important part of this outcrop, mainly on the Corwen and Bala sheets, has not been resurveyed comprehensively, though aspects of the sequence have been reviewed in the southern area by Pratt, Woodhall and Howells (1995), around Bala by Pugh (1929) and Bassett, Whittington and Williams (1966), in northern Snowdonia by Stevenson (1971) and in the Lley Peninsula by Matley (1938) and Young et al. (in press).

The Cambrian formations, which present fewer problems, are shown in outline in Figure 3 and are listed in Appendix 4.

## 5 LITHOSTRATIGRAPHICAL FRAMEWORK

The strata considered here fall within the 'Gwynedd Supergroup' of Woodcock (1990), whose conception was of an Ordovician megasequence bounded by basin-wide unconformities, one approximating to the base of the Arenig Series, the other to the base of the Ashgill. The Arenig to Caradoc sequence which unconformably overlies the Tremadoc Series is mainly composed of silty mudstones and siltstones, with local, impersistent sandstone intercalations, and throughout the area it is overlain by black graptolitic mudstones of the Nod Glas Formation and its equivalents. Within this sedimentary sequence several major volcanic divisions are emplaced, as shown schematically in Figure 2. In approximate upward succession they are the Rhobell, Aran, Llewelyn, Snowdon and Llanbedrog Volcanic groups. The local intercalation of these groups, together with their wedging-out laterally, cause many problems in correlation, in the hierarchical status of individual formations, their terminology and synonymy.

The broad geographical distribution and stratigraphical relationships of the named formations, including the underlying Cambrian rocks, are outlined schematically in Figure 3. The stratigraphical divisions (formations and members) are listed below, together with stratotype and other relevant information where available, and bibliographic references. Names that are deemed superfluous are listed in Appendix 3 and shown within brackets [ ] on Figure 3. The stratigraphical names of both Cambrian and Ordovician divisions, with their abbreviations as used on British Geological Survey maps, are listed alphabetically in Appendix 1. These abbreviations, which serve as a key to Figures 3 and 4, are listed alphabetically in Appendix 2.

Preferred Ordovician stratigraphical divisions in the Framework Committee Report are arranged by stratigraphical group in sections 7 to 13, roughly in ascending stratigraphical order. Stratigraphical relationships are illustrated in Figure 3 and their correlation in Figure 4. Older stratigraphical names are listed, with bibliographic references, by Whittard (1960).

The account of the stratigraphy of the Pwllheli area is still in preparation (Young et al., in press.), but the projected divisions in the manuscript memoir are in general accepted here.

## 5.1 Group terminology of the volcanic divisions (Figure 2)

The volcanic deposits that are interpreted as having originated during a single cycle of volcanic activity, from one or more volcanic centres, are referred to one lithostratigraphical group. The sedimentary sequence that interdigitates with the volcanic deposits is, in principle, more appropriately referred to the contemporaneous sedimentary groups or formations, as discussed below. This approach entails some compromises, such as the inclusion of certain sedimentary formations in the volcanic groups or of named tuffs in the sedimentary groups; it also implies the non-hierarchical arrangement whereby the Llewelyn Volcanic Group, for example, falls within the Ogwen Group, and indeed is enveloped by sediments of the Nant Ffrancon Subgroup.

### 5.1.1 RHOBELL VOLCANIC GROUP

This group, a subduction-related basaltic sequence of relatively local distribution, was taken by Woodcock (1990, p. 541) as the lowest division of the Gwynedd Supergroup, because the unconformity below it is apparently more pronounced than that above it. No constituent formations have been named.

### 5.1.2 ARAN VOLCANIC GROUP

Constituent formations recognised, listed alphabetically, are:

Aran Fawddwy	AF
Benglog	Bgl
Brithion	Brt
Craig Cau	Cgu
Craig y Ffynnon	CF
Cregennen	Crg
Llyn y Gafr Volcanic	LgV
Melau	Mu
Offrwm Volcanic	Of
Pen-y-gadair Volcanic	PgV
Pistyllion	PNF
Rhiw Bach Volcanic	RBV

This bimodal acid and basic group is widely distributed around the south and east sides of the Harlech Dome thinning to a feather edge on the northern side. Its base was placed (Ridgway, 1975; Allen and Jackson, 1985, p. 26) at the sub-Arenig unconformity, which is overlain by coarse sandstones ('Basement Beds'), now referred to the Allt Lŵyd Formation. In order to confine the Aran Volcanic Group to a cycle of volcanic activity, it is proposed here that the base of the Aran Volcanic Group be defined at the base of the Offrwm Volcanic Formation, which comprises widespread acid tuffs and which marked the onset of marginal basin volcanism. The top of the Aran Volcanic Group is clearly distinguished by the top of the Aran Fawddwy and Craig Cau formations and their correlatives. Intercalated in the volcanic sequence are sedimentary divisions, mainly unnamed units of dark grey mudstone containing pyroclastic or epiclastic volcanic material. The thickest such division is the Cregennan Formation, consisting primarily of mudstone, but which includes two named volcanic members (Pratt, Woodhall and Howells, 1995, p. 27), and also includes many layers of feldspar crystals and volcanic fragments.

### 5.1.3 LLEWELYN VOLCANIC GROUP

Constituent formations recognised are:

Braich tu du Volcanic	BDT
Capel Curig Volcanic	CCV
Conwy Rhyolite	CoR
Foel Fras Volcanic Complex	FFV
Foel Grach Basalt	FgB
Gwern Goff Tuff	GGT

This group reflects the first major eruptive cycle in the Ordovician in northern Snowdonia. It comprises five formations which distinguish activity at separate eruptive centres. The earliest activity gave rise to four partly contemporaneous formations (from north to south, Conwy Rhyolite, Foel Fras, Foel Grach and Braich tu du; see Figure 3). The uppermost division, the Capel Curig Volcanic Formation, is widely distributed and is the first major expression of ash-flow tuffs. The sedimentary strata that underlie the Capel Curig Formation and interdigitate with the lower formations of the Llewelyn Volcanic Group are not separately named, but are assigned to the Nant Ffrancon Subgroup.

### 5.1.4 SNOWDON VOLCANIC GROUP

Constituent formations recognised, listed alphabetically, are:

Bedded Pyroclastic	BP
Dolgarrog	DV
Lower Crafnant Volcanic	LCV
Lower Rhyolitic Tuff	LR
Llwyd Mawr Tuff	LMI
Middle Crafnant Volcanic	MCV
Pitts Head Tuff	PT
Tal y Fan	TF
Upper Crafnant Volcanic	UCV
Upper Rhyolitic Tuff	UR
Yr Arddu Tuffs	YAT

The base of the group is placed at the base of the Pitts Head Tuff and Yr Arddu Tuff formations, where those are present (Howells, Reedman and Campbell, 1991, p. 48), and elsewhere at the base of the Lower Rhyolitic Tuff Formation. The activity of the Crafnant Volcanic Group was broadly contemporaneous with that of the Snowdon Volcanic Group (Howells, Reedman and Campbell, 1991, p. 48), and the Tal y Fan and Dolgarrog Volcanic formations, local expressions of basaltic volcanic activity, are assigned to the group.

### 5.1.5 UPPER LODGE VOLCANIC GROUP AND LLANBEDROG VOLCANIC GROUP

Upper Lodge	(ULG)
<i>Named formation:</i>	
Allt Fawr Rhyolitic Tuff	AIF
Pitts Head Tuff	
<i>Llanbedrog Volcanic</i>	
(LVG)	
<i>Constituent formations:</i>	
Carneddol Rhyolitic Tuff	CRT
Foel Ddu Rhyodacite	FD
Penmaen	Pm
Yoke House	YkH

Their accumulation was contemporaneous with that of the Snowdon Volcanic Group, but took place about separate centres lying to the south-west of the Snowdon area (Young et al. in press).

## 5.2 Group terminology of sedimentary divisions

Although several units of marine sedimentary rocks are intercalated within the volcanic groups, they may extend far beyond the limits of the eruptive rocks, and in principle are parts of a sedimentary cycle partly independent of the cycles of volcanic activity. Examples are the Allt Lŵyd and the Nod Glas formations. Particularly difficult to classify are the units of undistinctive mudstone and siltstone that are intercalated in the volcanic formations, such as the Ceiswyn, and Nant Hir formations and much of the Nant Ffrancon Subgroup.

Names of group status have been proposed for parts of the sedimentary succession: the Carneddau Group (Howells et al., 1978, p. 9) later raised to supergroup (Howells et al., 1981, p. 5), the Nantmor Group (Howells, Reedman and Campbell, 1991, p. 48; British Geological Survey 1989a) and the Nant Ffrancon Group (Howells and Smith, 1997), upgraded from Nant Ffrancon Formation (Howells et al., 1983, p. 13). In each the upper limits are hard to recognise where the volcanic formations thin out.

To encompass the sedimentary succession more completely it is here suggested that a new term, the Ogwen Group, is used to embrace the sedimentary sequence from the base of the Allt Lŵyd Formation to the top of the Nod Glas Formation. The basal stratotype corresponds to that of the Allt Lŵyd (in the upper Mawddach Valley), but the body stratotype extends from Cwm Graianog in Nant Ffrancon, along the Ogwen and Llugwy valleys towards the syncline south-west of Grinllwm, where Ashgill strata overlie the Nod Glas Formation.

The Ogwen Group differs from the Gwynedd Supergroup in being geographically far less comprehensive, in excluding the Rhobell Volcanic Group, and in excluding the volcanic groups with which parts of it are contemporaneous. The Ogwen Group is composed mainly of mudstone and siltstone, but includes basal sandstone divisions (Allt Lŵyd Formation), other sandstones (Cwm Eigiau Formation, Moel Hebog and Prenteg sandstones), certain tuffs not otherwise assigned to volcanic groups (Penamnen Tuffs, Cefn Gwyn Tuff) and oolitic ironstone units (Fron Newydd and Hen-dy-capel members).

In the Bangor and Snowdon districts, the Ogwen Group includes a major mudstone-siltstone division extending from the top of the Allt Lŵyd Formation to the base of Capel Curig Volcanic Formation; this is the Nant Ffrancon Formation of Howells et al. (1983) which has itself subsequently been raised to group status (Howells and Smith, 1997); we here propose that the Nant Ffrancon should be made of Subgroup status, because in the Pwllheli district well-exposed equivalents of the Nant Ffrancon have been subdivided into formations and members on the basis of subtle lithological differences (Young et al., in press). The base of the Nant Ffrancon Subgroup is taken at the base of the Allt Lŵyd Formation and the top at the base of the Capel Curig Volcanic Formation, where present, or the Cwm Eigiau Formation.

To the east and south of the Harlech Dome the Ogwen Group encompasses a widespread disconformity at the level of the base of the Fron Newydd (oolitic ironstone) Member (Figure 3), potentially allowing recognition of two subgroups: firstly, a lower, unnamed, division from the Allt Lŵyd Formation to the non-sequence at the base of the Fron Newydd Member: secondly, an upper subgroup

from the Fron Newydd to the top of the Nod Glas Formation — for this Pugh's (1923, p. 513) old term Hengae [Sub]group may be employed, slightly adapted by adding the Ty'r Gawen Formation to his concept; this may seem inappropriate where the Craig Cau Formation is massively developed, but where it thins away the Ty'r Gawen and Ceiswyn formations are barely separable (see 'Cadair Idris', Figure 3).

Constituent formations of the Ogwen Group, listed alphabetically, are:

Allt Lŵyd	All
Bryncroes	Br
Ceiswyn	Csw
Cwm Eigiau	CEi
Dwyfach	DwF
Gelli-grin Calcareous Ashes	Gel
Llanengan	Lgn
Moelwyn Volcanic	Mv
Nod Glas	Nog
Penamnen Tuffs	PnT
Porth Meudwy	PMu
St Tudwal's	ST
Trygarn	Tgn
Ty'r Gawen Mudstone	TyG
Wig Bâch	WgB

Of these, the Nant Ffrancon Subgroup includes the Allt Lŵyd, Bryncroes, Llanengan, Moelwyn, Penamnen Tuffs, Porth Meudwy, St Tudwal's, Trygarn and Wig Bâch formations.

### 5.3 Discussion of some problems at formational level

The Rhiw Bach Volcanic Formation is considered by Howells and Smith (1997) to be of Llanvirn age and to be a lateral equivalent of the Serw Formation; it is included here within the Aran Volcanic Group because its stratigraphical setting is similar to that of the lower part of the Serw. On the Corwen Sheet (British Geological Survey, 1993), however, the Serw is said to correlate with the Benglog Formation which is of Caradoc age. It is evident that in the Arenig area the Serw includes a non-sequence (Zalasiewicz, 1992), but it is not yet clear that the formation can be partitioned between the Rhiw Bach and Benglog formations.

The Craig Cau Formation (Cgu) is shown as the lateral equivalent of Craig y Ffynnon (CF), Pistyllion (PNF) and Aran Fawddwy (AF) formations (Figure 3). The latter are not reduced to member status because the correlation across the Bala and Tal-y-llyn faults is not certain (Pratt, Woodhall and Howells 1995, p. 42). As an alternative view, P Dunkley (personal communication) places the Aran Fawddwy Formation as correlative with Craig Cau Formation and the Pistyllion Formation as a correlative with Pen y gadair Formation (PgV).

According to Pugh (1929) and Lockley (1980), the Ceiswyn Formation (Csw) passes northwards, towards Bala, into the Nant Hir Mudstones (NHM), Glyn Gower Siltstones (GyG) and Allt Ddu Mudstones (ADM); see 'Bala' in Figure 3. The Bala succession is subdivisible (Bassett, Whittington and Williams, 1966) because there are tuff beds which serve as marker-beds at the top and base of the Glyn Gower, but these fail southwards and the divisions become unclear. Lockley (1980) mapped the transitional area, but his stratigraphy was not adopted on the Bala Sheet (British Geological Survey, 1986) and has yet to be tested on the

Dinas Mawddwy sheet. Although the Nant Hir Mudstone has been traced on the Corwen sheet and even on the east of the Snowdon Sheet (Lynas 1973), the Bala succession has not otherwise been adopted for divisions of the Ogwen Group. It is considered appropriate to assign the fine-grained clastic divisions to the most comprehensive unit, the Ceiswyn Formation, and where possible to recognise the Glyn Gower Siltstones as a member. An arbitrary boundary has to be drawn between the Ceiswyn Formation (including the succession around Bala) and the Nant Ffrancon Subgroup, the latter being recognised west of the Ffynnon Eidda Fault where the Snowdon Volcanic Group provides an upper limit (Figures 2, 3).

Biostratigraphical correlation of the tuffs of the Bala succession suggest that the Cefn Gwyn Ash is of about the same age as the Penamnen Tuffs (PnT), and the Frondderw Tuff (Fron) is the same as Capel Curig Volcanic Formation. They are not considered to be synonymous as they apparently originate from different centres (Schiener, 1970; Howells, Reedman and Campbell, 1991, p. 35). The Pont-y-ceunant 'Ash' is of about the same age as the Pitts Head Tuff (PT) but is not known west of the Bala Fault, and there is a broad tract across which neither is known to be represented.

A further problem is the extent to which the black mudstones of the Nod Glas Formation and Cadnant Shales are lateral equivalents and hence synonyms, together with the Llanrychwyn Slates, Black Slates of Dolwyddelan, Tyn-y-glyn Mudstones and Penarwel Mudstones. Although the onset of black shale deposition seems to have been diachronous, these formations are contemporaneous during the *clingani* Biozone. It is here considered that all these formations are the product of relative sediment-starvation in an anoxic basin during a high-stand of sea level. Of these divisions, the Cadnant Shales reach the greatest thickness and, unlike the Nod Glas of the type area, are said to include an earlier graptolite fauna, namely that of the *multidens* Biozone, though some records of that zone are dubitable (see section 6, below); unlike the Nod Glas, the Cadnant Shales are not known to range to the upper part of the *clingani* Biozone. Continuity between the Cadnant Shales and the Nod Glas is broken by the sub-Ashgill erosion in the Bala area.

## 6 BIOSTRATIGRAPHICAL CORRELATION

Correlation of the sedimentary formations depends largely on their fossil content, and is summarised in the correlation chart (Figure 4). The left-hand margin used is based on that proposed by Fortey et al. (1995) for the revised Ordovician Correlation Chart sponsored by the Geological Society of London. It contains some as yet untested terms that aim to make the British Series more useful internationally.

The criteria for recognising the stages and substages are based largely on the shelly faunal succession (mainly brachiopods and trilobites). There are important graptolitic faunas at some levels. These are assigned to established graptolite zones, some of which, however, remain inadequately characterised (Rushton, 1990). It remains uncertain how the graptolitic zonal sequences should be correlated with the stages, particularly at the mid-Caradoc level, as shown by the difficulties with correlating the Nod Glas. South of Cadair Idris the Nod Glas contains graptolite faunas of the *clingani* Biozone, and to the east, at Dinas Mawddwy, it overlies strata with Soudleyan trilobites (Pratt, Woodhall and Howells, 1995, p. 48). Towards Bala the Nod

Glas lacks graptolites and, according to Lockley (1980), passes laterally into Longvillian and Woolstonian strata. Yet in the Dolgarrog area, eastern Snowdonia, the graptolitic black shales are referred to the *multidens* Biozone (as well as the *clingani* Biozone at Dolwyddelan), and they overlie Woolstonian shelly faunas (Howells et al., 1981). It is possible that the discrepancies in the level at which *clingani* faunas seem to appear are due to a cryptic non-sequence at the base of the Nod Glas, in which case this would be pronounced in the Dinas Mawddwy area; but it is also possible that the problem is only caused by the difficulty of distinguishing diplograptid faunas of the *multidens* Biozone from those of the *clingani* Biozone, especially when the rocks are cleaved and the fossils distorted. The presence of the *multidens* Biozone in the type area of the Cadnant Shales (Cadnant railway cutting) was questioned by Strachan (in Wood and Harper, 1962, p. 184).

The results from study of new fossil collections and review of older collections have been enhanced by the study of organic-walled microfossils (acritarchs and chitinozoa) undertaken during the course of British Geological Survey mapping programme. Figure 4 shows the levels at which relevant information from microfloral, graptolitic or shelly faunas was obtained.

## 7 MAWDDACH GROUP (PART)

### 7.1 Dol-cyn-afon Formation (Dyn)

#### *Stratotype:*

Dol-cyn-afon, upper Mawddach [SH 7941 2873] (Allen and Jackson, 1985, p. 12).

#### *Lithology:*

Grey mudstone, silty mudstone and siltstone, with bioturbated sandstone locally.

#### *Ranking:*

Uppermost division of the Mawddach Group. Includes informal sandstone members in southern Snowdonia.

#### *Lower boundary:*

Conformable on black mudstones of the Dolgellau Formation.

#### *Upper boundary:*

Unconformably overlain by the Allt Lŵyd Formation, and locally, to the south-east of the Harlech Dome, by the Rhobell Volcanic Group.

#### *Thickness:*

Typically 340 to 400 m, in southern Snowdonia locally thickening to about 900 m.

#### *Age:*

Tremadoc.

#### *Remarks:*

Upgraded from Dol-cyn-afon Member of Allen and Jackson, 1985 (Howells and Smith, 1997; Pratt, Woodhall and Howells, 1995). Preferred name for the formations of Tremadoc age, including the Afon Gam and Glanypwll formations and the 'Tremadoc Slates' of authors.

#### *Reference:*

Allen and Jackson, 1985; Howells and Smith, 1997; Pratt, Woodhall and Howells, 1995.

All other formations of the Mawddach Group are of Cambrian age and are listed in the Appendix.

## 8 OGWEN GROUP

### 8.1 Nant Ffrancon Subgroup (NFr)

#### *Lithology:*

Largely composed of mudstone and siltstone, but includes sandstone divisions (some separately named) oolitic ironstone units, tuffs (some named) and the Moelwyn Volcanic Formation.

#### *Ranking:*

The Nant Ffrancon Subgroup is a major division of the Ogwen Group in the north of the Harlech Dome.

#### *Lower boundary:*

Taken at the base of the Allt Lŵyd Formation.

#### *Upper boundary:*

Overlain by the Capel Curig Volcanic Formation, or, where that is absent, by sandstones of the Cwm Eigiau Formation.

#### *Age:*

Arenig to Caradoc.

#### *Remarks:*

Originally proposed as a formation (Howells et al., 1983) and raised to group status by Howells and Smith, 1997, the Nant Ffrancon is here reduced to a subgroup of the Ogwen Group. It includes the Aberdearon Bay Group of Gibbons and McCarroll (1993).

#### *Reference:*

Howells and Smith, 1997; Young et al., in press.

### 8.2 Allt Lŵyd Formation (All)

#### *Stratotype:*

Upper Mawddach valley [SH 7969 2912]. Allen and Jackson, 1985, p. 34.

#### *Lithology:*

Interbedded siltstone and sandstone, quartzose sandstone, volcanoclastic sandstone.

#### *Ranking:*

Here excluded from the Aran Volcanic Group. Forms the base of the Ogwen Group in Snowdonia; lies between the Mawddach and Aran Volcanic groups to the east and south. Includes the Garth Grit Member at the base and, locally, the Aran Boulder Bed Member at the top.

#### *Lower boundary:*

Unconformable on the Mawddach Group and the Rhobell Volcanic Group.

#### *Upper boundary:*

Succeeded chiefly by the Offrwm Volcanic Formation in the south and by mudstones of the Nant Ffrancon Subgroup in the north.

#### *Thickness:*

Typically 130 to 330 m.



*Age:*  
Arenig.

*Remarks:*  
Preferred name, equivalent to the Carnedd Iago Formation of the Bala and Corwen sheets (British Geological Survey, 1986; British Geological Survey, 1993) and the Cwmorthin Formation (British Geological Survey, 1989a). Appears to be equivalent to the Graianog Sandstone of the Bangor Sheet. The Arenig sandstones in the Pwllheli area (St Tudwal's Formation) are considered to be from a distinct source (Young, et al., in press).

*Reference:*  
Allen and Jackson, 1985; Pratt, Woodhall and Howells, 1995; Howells and Smith, 1997.

### **GARTH GRIT MEMBER (GAG)**

*Stratotype:*  
Reference section north of Tan y Grisiau dam [SH 6800 4528] (Howells and Smith, 1997).

*Lithology:*  
Quartzose conglomeratic sandstone.

*Ranking:*  
Basal member of the Allt Lŵyd Formation.

*Reference:*  
Allen and Jackson, 1985, p. 35; Howells and Smith, 1997.

### **ARAN BOULDER BED MEMBER**

*Stratotype:*  
P Dunkley recommends Bryn Mawr [SH 8225 2040].

*Ranking:*  
Local member at top of the Allt Lŵyd Formation.

*Reference:*  
Allen and Jackson, 1985, p. 34.

### **8.3 Moelwyn Volcanic Formation (Mv)**

*Stratotype:*  
Not defined. Reference section in the Moelwyn Mountains, above the Tan y Grisiau Dam [SH 665 440]; for the lower member at Glan y Morfa [SH 5557 4552] and the upper member at Cefn Fedw [SH 5572 4144].

*Lithology:*  
Volcaniclastic debris-flow deposits, acid tuffs and tuffites.

*Nomenclature:*  
The same as the Y Glog Volcanic Series (Shackleton, 1959, p. 230).

*Ranking:*  
Acid volcanic division assigned to the Nant Ffrancon Subgroup. Includes an informal lower (LMv) and upper member (UMv).

*Boundaries:*  
Lies within silty mudstones of the Nant Ffrancon Subgroup.

*Thickness:*  
Lower member (LmV) to 100 m; Upper member (UmV) to 100 m.

*Age:*  
Early Caradoc, overlain by Costonian or Harnagian strata.

*Remarks:*  
Not assigned to the Aran Volcanic Group, because its identity with a particular formation remains unproved, and it is isolated from the constituent formations of that group by the ground between the Trawsfynydd-Cwm Bowydd and Fynnon Eidda faults.

*Reference:*  
Howells and Smith, 1997.

### **8.4 Penamnen Tuffs (PnT)**

*Stratotype:*  
Head of Cwm Penamnen [SH 7340 5001] (Howells et al., 1978, p. 9).

*Lithology:*  
Acid tuffs.

*Ranking:*  
Formation in the Nant Ffrancon Subgroup.

*Boundaries:*  
Within the upper part of the Nant Ffrancon Subgroup.

*Thickness:*  
To 10 m.

*Age:*  
Caradoc (approximately Soudleyan).

*Remarks:*  
May be equivalent to the Gwern Gof Tuff.

*Reference:*  
Howells and Smith, 1997.

### **MOELFRE TUFF (MT)**

*Ranking:*  
Basic tuff member in the Nant Ffrancon Subgroup.

*Reference:*  
British Geological Survey, 1989b.

### **8.5 St Tudwal's Formation (ST)**

*Stratotype:*  
Reference section at Pared Mawr [SH 3055 2472].

*Lithology:*  
Coarse to medium well-bedded and bioturbated muddy sandstone.

*Ranking:*  
Local basal division of the Ogwen Group (Nant Ffrancon Subgroup).

*Lower boundary:*  
Transgresses the Mawddach Group and Harlech Grits Group.

*Upper boundary:*  
Overlain by Llanengan Formation of the Ogwen Group.

*Thickness:*  
120 m.

*Age:*  
Arenig (Fennian in upper part).

*Remarks:*  
Shallow marine sandstone formed on an intra-basinal high. (Young et al., in press.). Includes, in ascending order, the Pared Mawr, Penrhyn Du, Trwyn yr Wylfa and Machroes members.

*Reference:*  
Young et al., in press.

#### **PARED MAWR MEMBER (PM)**

*Stratotype:*  
Pared Mawr [SH 3055 2472].

*Lithology:*  
Coarse bioturbated sandstones.

*Ranking:*  
Lowest member of the St Tudwal's Formation.

*Reference:*  
Young et al., in press.

#### **TRWYN YR WYLFA MEMBER (TW)**

*Stratotype:*  
Trwyn yr Wylfa [SH 3206 2450].

*Lithology:*  
Thickly bedded pale weathering sandstones.

*Ranking:*  
Member of the St Tudwal's Formation.

*Reference:*  
Young et al., in press.

#### **PENRHYN DU MEMBER (PD)**

*Stratotype:*  
Penrhyn Du [SH 3244 2649].

*Lithology:*  
Bioturbated muddy sandstones.

*Ranking:*  
Muddy sandstone member of the St Tudwal's Formation.

*Reference:*  
Young et al., in press.

#### **MACHROES MEMBER (MCH)**

*Stratotype:*  
Machroes [SH 3182 2652].

*Lithology:*  
Well-bedded sandstones with mudstone interbeds.

*Ranking:*  
Upper member of the St Tudwal's Formation.

*Reference:*  
Young et al., in press.

### **8.6 Llanengan Formation (Lgn)**

*Stratotype:*  
Borth Fawr [SH 3198 2650].

*Lithology:*  
Dark grey mudstone with thin sandstone and siltstone laminae.

*Ranking:*  
Formation in the Nant Ffrancon Subgroup of the Ogwen Group.

*Lower boundary:*  
Conformable on the St Tudwal's Formation.

*Upper boundary:*  
Underlies the Hen-dy-capel Ironstone (possibly with a non-sequence).

*Thickness:*  
80 m

*Age:*  
Arenig (Fennian)

*Remarks:*  
Mudstone division of Arenig age in the Ogwen Group, above the St Tudwal's Formation, distinguished from the Wig Bâch Formation by the thinness and undisturbed nature of the sandstone laminae.

*Reference:*  
Young et al., in press.

#### **HEN-DY-CAPEL IRONSTONE (HdC)**

*Stratotype:*  
Hen-dy-capel Quarry [SH 2993 2706].

*Ranking:*  
Oolitic ironstone member at the base of unnamed mudstones of the Nant Ffrancon Subgroup.

*Remarks:*  
Age discussed by Trythall et al., 1987 and Young, 1991.

*Reference:*  
Young et al., in press.

### **8.7 Wig Bâch Formation (WgB)**

*Stratotype:*  
Eastern side of Aberdaron Bay [SH 1860 2567 to 1868 2550], base exposed at Wig [SH 1863 2570].

*Lithology:*  
Mudstones and siltstones with sandstone laminae.

*Ranking:*  
Part of the Ogwen Group (Nant Ffrancon Subgroup).

*Lower boundary:*

Rests unconformably on the Gwna Melange, Sarn Complex and Dol-cyn-afon Formation.

*Upper boundary:*

Overlain by the Porth Meudwy, Llanengan and Trygarn formations, and mudstones of the Nant Ffrancon Subgroup.

*Thickness:*

Up to 600 m.

*Age:*

Arenig (Moridunian to Fennian).

*Remarks:*

Includes the Wîg Member near its base and the Trwyn Cam Member near its top. Corresponds to the Aberdaron Formation of Beckly, 1988.

*Reference:*

Gibbons and McCarroll, 1993, p. 34; Young et al., in press.

**WÎG MEMBER (WÎG)**

*Stratotype:*

Wîg, Aberdaron Bay [SH 1862 2569].

*Lithology:*

Grey mudstone member containing phosphatic nodules at the base of the Wig Bâch Formation.

*Reference:*

Beckly, 1988, p. 326; Gibbons and McCarroll, 1993, p. 34.

**TRWYN CAM MEMBER (TnC)**

*Stratotype:*

Not defined — presumably Trwyn Cam [SH 1663 2600].

*Lithology:*

Distinctive sandstone member towards top of Wig Bâch Formation.

*Reference:*

Gibbons and McCarroll, 1993, p.34.

**8.8 Porth Meudwy Formation (PMu)**

*Stratotype:*

North side of Porth Meudwy [SH 1640 2557 to 1643 2557], but the best section is at Bau Ogof-eiral [SH 1563 2402] (Gibbons and McCarroll, 1993).

*Lithology:*

Coarse matrix-supported conglomerate, a mass-flow deposit.

*Ranking:*

Part of the Ogwen Group (Nant Ffrancon Subgroup).

*Lower boundary:*

Overlies the Wig Bâch Formation.

*Upper boundary:*

Underlies the Trygarn Formation of the Ogwen Group.

*Thickness:*

25 to 35 m.

*Age:*

Arenig (Fennian).

*Remarks:*

Upgraded from member status in Gibbons and McCarroll, 1993, p. 34.

*Reference:*

Beckly, 1988, p. 327; Gibbons and McCarroll, 1993.

**8.9 Bryncroes Formation (Br)**

*Stratotype:*

Basal stratotype at Mountain Cottage Quarry [SH 2300 3470] (Beckly, 1988).

*Lithology:*

Interlaminated sandstone and mudstone, conglomeratic base.

*Ranking:*

Local base of the Ogwen Group (Nant Ffrancon Subgroup).

*Lower boundary:*

Unconformable on the Sarn Complex.

*Upper boundary:*

Overlain by the Trygarn Formation.

*Thickness:*

200 m.

*Age:*

Arenig (Fennian in upper part).

*Remarks:*

Equivalent to the Sarn Formation of Beckly (1988, p. 324), renamed by Young et al., in press., to distinguish it from the contiguous Sarn Complex.

**8.10 Trygarn Formation (Tgn)**

*Stratotype:*

Nant y Carw [base at SH 2337 3234].

*Lithology:*

Mudstones and siltstones with coarse sandstone interbeds containing ferruginous ooids.

*Ranking:*

Part of the Ogwen Group (Nant Ffrancon Subgroup).

*Lower boundary:*

Overlies the Porth Meudwy and Wig Bâch formations.

*Upper boundary:*

Underlies the Hen-dy-capel Ironstone.

*Thickness:*

90 m.

*Age:*

Possibly early Llanvirn.

*Reference:*

Young et al., in press.

DIVISIONS NOT ASSIGNED TO THE NANT FFRANCON SUBGROUP

**8.11 Ty'r Gawen Mudstone Formation (TyG)**

*Stratotype:*

T'yr Gawen [SH 6240 0660].

*Lithology:*

Grey mudstones.

*Nomenclature:*

Supersedes the Llyn y Gader and Llyn Cau mudstones of Cox, 1925. Includes the Fron Newydd (oolitic ironstone) Member at the base.

*Ranking:*

In the Ogwen Group, and the basal formation of a prospective Hengae Subgroup.

*Lower boundary:*

Regionally unconformable on the Allt Lŵyd Formation, Offrwm Volcanic Formation and Cregennan Formation, and paraconformable on the Llyn y Gafr Volcanic Formation.

*Upper boundary:*

Overlain by the Craig Cau Formation, and in the extreme west by the Caeswyn Formation.

*Thickness:*

0 to 1000 m.

*Age:*

Caradoc, *gracilis?* to *multidens* Biozones.

*Remarks:*

Interdigitates laterally with the Pen y gadair Volcanic Formation. Separation from the Ceiswyn Formation above is problematical in the west of its outcrop. The hiatus at the base was discussed by Smith, Rushton and Howells, 1995.

*Reference:*

Pratt, Woodhall and Howells, 1995.

**FRON NEWYDD MEMBER (FRN)**

*Stratotype:*

100 m east-north-east of Llwyn Cottage, Llanegryn [SH 6055 0598 to 6058 0583].

*Lithology:*

Oolitic ironstone.

*Ranking:*

Basal member of Ty'r Gawen Mudstone Formation.

*Remarks:*

Apparently forms a non-sequential base to a prospective Hengae Subgroup.

*Reference:*

Pratt, Woodhall and Howells, 1995.

**8.12 Ceiswyn Formation (Csw)**

*Stratotype:*

Nant Ceiswyn [SH 7878 1537 to 7980 1424].

*Lithology:*

Mudstone and siltstone.

*Ranking:*

Upper part of the Ogwen Group.

*Lower boundary:*

Aran Volcanic Group.

*Upper boundary:*

Nod Glas Formation.

*Thickness:*

Up to 1550 m.

*Age:*

Caradoc (mainly Soudleyan), *multidens* Biozone.

*Remarks:*

Includes the Craig Hen-gae Member (Pratt, Woodhall and Howells, 1995) near the top and the Llaethnant Siltstone (Lockley, 1980). The lateral equivalent of the Allt Ddu Mudstones, Glyn Gower Siltstones and Nant Hir Mudstones of the Bala Sheet (British Geological Survey, 1986).

*Reference:*

Pratt, Woodhall and Howells, 1995.

**DERFEL LIMESTONE MEMBER**

*Stratotype:*

Nant Aber Derfel [SH 850 395].

*Ranking:*

Basal member of the Ceiswyn Formation (formerly the Nant Hir Mudstones).

*Age:*

Basal Caradoc (Costonian or Harnagian, *multidens* Biozone).

*Remarks:*

Lenses of 'equivalent' rocks occur within Llyn Conwy Formation (Lynas, 1973, p. 490).

*Reference:*

Bassett, Whittington and Williams, 1966, p. 229; Zalasiewicz, 1992.

**CEFN GWYN TUFF**

*Stratotype:*

Glyn Gower, north of Cefn Gwyn [c.SH 914 314] (Bassett, Whittington and Williams 1966, p. 230).

*Lithology:*

Acid tuff; a north-easterly source is inferred (Schiener, 1970).

*Ranking:*

Basal member of the Glyn Gower Siltstones, regraded here as a member of the Ceiswyn Formation.

*Remarks:*

Equivalent to the Cwm Clwyd Tuff Formation (of British Geological Survey, 1993).

*Reference:*

Bassett, Whittington and Williams, 1966; Schiener, 1970.

**GLYN GOWER SILTSTONES MEMBER (GYG)**

*Stratotype:*

Glyn Gower [SH 915 314] (Bassett, Whittington and Williams, 1966, p. 230).

*Lithology:*

Siltstones with thin tuff beds.

*Ranking:*

Member of the Ceiswyn Formation, part of the Ogwen Group.

*Lower boundary:*

Gradational with mudstones of the Ceiswyn Formation (Nant Hir Mudstones) below, but taken at the top of the Cefn Gwyn Tuff.

*Upper boundary:*

Gradational with the Ceiswyn Formation (Allt Ddu Mudstones) above, but taken at the base of the Frondderw Tuff.

*Thickness:*

130 to 150 m.

*Age:*

Caradoc (Soudleyan).

*Reference:*

Bassett, Whittington and Williams, 1966.

**FRONDDERW TUFF (FRON)**

*Stratotype:*

North-north-west of Ffrondderw (Maes Awelon) [SH 920 366].

*Lithology:*

Acidic water-laid tuffite from a north-easterly source (Schiener, 1970).

*Ranking:*

Member of the Ceiswyn Formation at the top of the Glyn Gower Siltstones Member.

*Reference:*

Schiener, 1970, p.233.

**CRAIG HEN-GAE MEMBER (CH)**

*Stratotype:*

Craig Hen-gae [SH 7572 1026].

*Remarks:*

Member containing black hemipelagite layers at the top of the Ceiswyn Formation.

*Reference:*

Pratt, Woodhall and Howells 1995.

**8.13 Gelli-grin Calcareous Ashes (Gel)**

*Stratotype:*

Gelli-Grîn [c.SH 945 340] (Bassett, Whittington and Williams, 1966, pp. 239, 241).

*Lithology:*

Calcareous volcanoclastic sandstone and tuffites.

*Ranking:*

Formation within the Ogwen Group. Includes the Pont-y-ceunant 'Ash' as a basal member, and the Cymerig Limestone as a member towards the top.

*Lower boundary:*

Overlies the upper part of the Ceiswyn Formation (Allt Ddu Mudstones).

*Upper boundary:*

Underlies the Nod Glas Formation, but also passes laterally into its lower part (Lockley, 1980). Also overlain, with an unconformity, by the Rhiwlas Limestone (of Ashgill age).

*Thickness:*

60 m.

*Age:*

Caradoc (Longvillian and Woolstonian).

*Reference:*

Bassett, Whittington and Williams, 1966; British Geological Survey, 1986.

**PONT-Y-CEUNANT 'ASH'**

*Stratotype:*

Not defined. Exposures near Pont-y-ceunant [SH 952 355], strata well seen at Y Garnedd [SH 946 343].

*Lithology:*

Acid tuff.

*Ranking:*

Member marks the base of the Gelli-Grin Calcareous Ashes.

*Reference:*

Bassett, Whittington and Williams, 1966, p. 241; Schiener, 1970, p. 41.

**CYMERIG LIMESTONE MEMBER (CY)**

*Stratotype:*

Gelli-grîn [near 9449 3401].

*Ranking:*

Member of Gelli-Grin Calcareous Ashes.

*Age:*

Caradoc (Woolstonian).

*Remarks:*

The member was traced laterally into the Dyfi Mudstone Member of the Nod Glas Formation (Lockley, 1980, p. 39).

*Reference:*

Bassett, Whittington and Williams, 1966, pp. 239, 241; British Geological Survey, 1986.

**8.14 Dwyfach Formation (Dwf)**

*Stratotype:*

Plas Talhenbont [SH 462 397].

*Lithology:*

Dark siltstones with sandstones.

*Ranking:*

Formation at the top of the Ogwen Group on Llŷn.

*Lower boundary:*

Overlies the Allt Fawr Rhyolitic Tuff Formation.

*Upper boundary:*

Underlies the Llanbedrog Volcanic Group and Nod Glas Formation.

*Thickness:*

150 to 600 m.

*Age:*

Caradoc (Longvillian to Woolstonian).

*Remarks:*

Partly interbedded with the Llanbedrog Volcanic Group. Includes the Bodwrog and Plastirion members.

*Reference:*

Young et al., in press.

**PLASTIRION MEMBER (PTN)**

*Stratotype:*

North-east of Pwllheli [SH 381 356].

*Ranking:*

Calcareous mudstone and sandstone member of Longvillian age in the Dwyfach Formation.

*Reference:*

Young et al., in press.

**BODWROG MEMBER (BWG)**

*Stratotype:*

Near Bodwrog [SH 3220 3137].

*Ranking:*

Sandstone member in the lower part of the Dwyfach Formation.

*Reference:*

Young et al., in press.

**8.15 Nod Glas Formation (Nog)**

*Stratotype:*

Nant y Nod [SH 818 137] (Lockley, 1980).

*Lithology:*

Black graptolitic mudstones and slates.

*Ranking:*

Uppermost part of the Ogwen Group.

*Lower boundary:*

Overlies the Caeswyn Formation; in Snowdonia overlies the Snowdon Volcanic Group; on Llŷn overlies the Llanbedrog Volcanic Group or the Dwyfach Formation.

*Upper boundary:*

Overlain with a possible non-sequence by the Broad Vein Formation (Ashgill Series) and unconformably in the Bala area by other units of Ashgill age.

*Thickness:*

0 to 30 m in the type area south and east of the Harlech Dome; up to 450 m recorded in Snowdonia (where it is known as the Cadnant Shales, q.v.).

*Age:*

Mid- to late Caradoc (possibly *multidens* Biozone as discussed under 'Biostratigraphical correlation' above; lower to upper *clingani* Biozone). Parts appear to be equivalent to the Longvillian, Woolstonian and Onnian substages.

*Remarks:*

Preferred name for the black graptolitic mudstones typical of the upper Caradoc. Equivalent to the Tyn-y-glyn Mudstone of the Corwen Sheet, the Cadnant Shales of the Bangor Sheet (Howells, Reedman and Leveridge, 1985), the Llanrhychwyn Slates of Howells et al., 1981, the 'Black Slates of Dolwyddelan' and the Penarwel Shales, though some at least of those divisions are reported to include graptolite faunas of the *multidens* Biozone, which appear to be older than those of the *clingani* Biozone from the type area. Lockley (1980) included the Corris Shale and Dyfi Mudstone as members.

*Reference:*

Pratt, Woodhall and Howells, 1995; Lockley, 1980.

**8.16 Cwm Eigiau Formation (CEi)**

*Stratotype:*

Not defined. Reference sections north-east of Capel Curig [SH 724 586] and Pont y Gromlech [SH 628 564] (Howells, Reedman and Leveridge, 1985, p. 12; Howells et al., 1981, p. 20).

*Lithology:*

Generally sandstones (some coarse) and siltstones; shows lateral variation.

*Nomenclature:*

Equivalent to the Carn y Parc Formation and the Eidda Formation of British Geological Survey 1993. Partly a lateral equivalent of the Allt Ddu Mudstones. Includes the Moel Hebog and the Prenteg Sandstone and the Clogwyn Gottal Tuff as members.

*Ranking:*

Formation in the Ogwen Group, overlying the Llewellyn Volcanic Group and Nant Ffrancon Subgroup, and underlying the Snowdon Volcanic Group.

*Lower boundary:*

Overlies the Capel Curig Volcanic Formation. Where the Capel Curig Volcanic Formation is discontinuous or absent, overlies mudstones of the Nant Ffrancon Subgroup.

*Upper boundary:*

Overlain by the Lower Rhyolitic Tuff Formation and (on the Lleyn Peninsula) the Upper Lodge Volcanic Group.

*Thickness:*

Shallow water sandstones to the north—450 m. Mudstones and siltstones with sandstone beds to the south and east—to c.1300 m.

*Age:*

Caradoc (late Soudleyan to Longvillian).

*Reference:*

Howells et al., 1981, p. 20; Howells and Smith, 1997.

**PRENTEG SANDSTONE MEMBER (Ps)**

*Stratotype:*

North of Hendre Salar [SH 5684 4180] (Shackleton 1959, p. 234).

*Ranking:*

Local member of the Cwm Eigiau Formation.

*Reference:*

Shackleton, 1959; Howells and Smith, 1997.

**MOEL HEBOG SANDSTONE MEMBER (MoH)**

*Stratotype:*

East of Moel Hebog [SH 570 466].

*Nomenclature:*

Preferred term, equivalent to the Gorllwyn Grits of Shackleton, 1959, p.236.

*Ranking:*

Local member of the Cwm Eigiau Formation.

*Reference:*

Howells and Smith, 1997; Shackleton, 1959, p. 236.

**CLOGWYN GOTTAL TUFF (CwG)**

*Stratotype:*

Not defined.

*Lithology:*

Acid tuff.

*Ranking:*

Member of the Cwm Eigiau Formation, towards base, present east of Yr Arddu.

*Remarks:*

Thin acidic tuff, approximately equivalent to Pitts Head Tuff Formation. Symbol CwG on the map (British Geological Survey, 1989a), but CwT on the side-margin.

**9 ARAN VOLCANIC GROUP**

**9.1 Cregennen Formation (Crg)**

*Stratotype:*

Llynnau Cregennen [SH 6577 1436 to 6667 1540].

*Lithology:*

Dark grey slaty mudstone with layers of volcanogenic material.

*Ranking:*

Part of the Aran Volcanic Group.

*Lower boundary:*

Overlies the Offrwm Volcanic Formation.

*Upper boundary:*

Overlain conformably by the Llyn y Gafr Volcanic Formation or locally overstepped by the Fron Newydd Member of the Ty'r Gawen Formation.

*Thickness:*

Up to 350 m.

*Age:*

Llanvirn, *artus* Biozone.

*Remarks:*

Includes the Bryn Brith and Cefn Hir members.

*Reference:*

Pratt, Woodhall and Howells, 1995.

**BRYN BRITH MEMBER (BnB)**

*Stratotype:*

Bryn Brith [SH 6642 1534].

*Lithology:*

Basic tuff and tuffite.

*Ranking:*

Member of the Cregennan Formation.

*Reference:*

Pratt, Woodhall and Howells, 1995.

**CEFN HIR MEMBER (CFN)**

*Stratotype:*

Pared y Cefn-hir [SH 6622 1492].

*Lithology:*

Mainly basic and acid tuffs and tuffites.

*Ranking:*

Member of the Cregennan Formation.

*Reference:*

Pratt, Woodhall and Howells, 1995.

**9.2 Llyn y Gafr Volcanic Formation (LgV)**

*Stratotype:*

Around Llyn Gafr [SH 711 130].

*Lithology:*

Basalts, basic and acid tuffs.

*Ranking:*

Part of the Aran Volcanic Group.

*Lower boundary:*

Overlies the Cregennan Formation.

*Upper boundary:*  
Overlain disconformably by the Fron Newydd Member of the Ty'r Gawen Mudstone Formation.

*Thickness:*  
0 to 360 m.

*Age:*  
Uncertain — lies between earlier Llanvirn and basal Caradoc strata.

*Remarks:*  
Supersedes the Lower Basic or Spilitic groups of Cox and Wells, 1921.

*Reference:*  
Pratt, Woodhall and Howells, 1995.

### 9.3 Pen y gadair Volcanic Formation (PgV)

*Stratotype:*  
West of Pen y gadair [SH 6920 1235 to 7110 1310].

*Lithology:*  
Mainly basalt lavas with thin acid tuffs.

*Ranking:*  
Part of the Aran Volcanic Group.

*Lower boundary:*  
Overlies the Ty'r Gawen Mudstone Formation.

*Upper boundary:*  
Underlies the Craig Cau Formation.

*Thickness:*  
0 to 240 m.

*Age:*  
Caradoc, *gracilis?* or *multidens* Biozone.

*Remarks:*  
Supersedes the Upper Basic Group and Pen y Gader groups of Cox, 1925. Lateral equivalent of the Benglog Formation.

*Reference:*  
Pratt, Woodhall and Howells, 1995.

### 9.4 Craig Cau Formation (Cgu)

*Stratotype:*  
Craig Cau, south of the summit of Cadair Idris [SH 7100 1217].

*Lithology:*  
Acid tuffs.

*Ranking:*  
Uppermost division of the Aran Volcanic Group.

*Lower boundary:*  
Overlies the Pen y gadair Volcanic Formation and the Ty'r Gawen Mudstone Formation.

*Upper boundary:*  
Ceiswyn Formation.

*Thickness:*  
0 to 400 m.

*Age:*  
Caradoc, probably *multidens* Biozone.

*Remarks:*  
Apparently partly equivalent to the Aran Fawddwy Formation

*Reference:*  
Pratt, Woodhall and Howells, 1995.

### 9.5 Offrwm Volcanic Formation (Of)

*Stratotype:*  
Foel Offrwm [around SH 75 21] (Allen and Jackson, 1985, p. 39).

*Lithology:*  
Acidic ash-flow tuff.

*Ranking:*  
Basal division of the Aran Volcanic Group.

*Lower boundary:*  
Overlies the Allt Lŵyd Formation.

*Upper boundary:*  
Overlain at various places by the Cregennan Formation, Melau Formation and Benglog Formation.

*Thickness:*  
To 190 m.

*Age:*  
Approximately basal Llanvirn.

*Remarks:*  
Supersedes the Lower Acid Volcanic Group of the Cadair Idris area. It is recommended that this should form the basal unit of the Aran Volcanic Group.

*Reference:*  
Allen and Jackson, 1985, p. 39; Pratt, Woodhall and Howells, 1995.

### 9.6 Melau Formation (Mu)

*Stratotype:*  
Afon Melau [SH 7961 2229] (Allen and Jackson, 1985, p. 39).

*Lithology:*  
Basic tuff, tuffite and thin lava flows.

*Ranking:*  
Local division of the Aran Volcanic Group.

*Lower boundary:*  
Overlies the Allt Lŵyd Formation and the Offrwm Volcanic Formation.

*Upper boundary:*  
Overlain by silty mudstones of the Aran Volcanic Group.

*Thickness:*  
To 220 m, rapidly wedging out.



*Age:*  
Overlies basal Llanvirn and underlies fossiliferous Llanvirn strata.

*Reference:*  
Allen and Jackson, 1985; British Geological Survey, 1986.

### 9.7 Brithion Formation (Brt)

*Stratotype:*  
P Dunkley recommends Craigau Brithion [SH 834 208 to 843 208].

*Lithology:*  
Acidic ash-flow tuff associated with rhyolitic dome.

*Ranking:*  
Part of the Aran Volcanic Group.

*Lower boundary:*  
Overlies the Allt Lŵyd Formation, locally resting on the Dol-cyn-afon Formation.

*Upper boundary:*  
Overlain by siltstones of the Aran Volcanic Group.

*Thickness:*  
Tuffs to 230 m, dome to 400 m.

*Age:*  
Llanvirn.

*Reference:*  
Allen and Jackson, 1985; p. 41, British Geological Survey, 1986.

### 9.8 Rhiw Bach Volcanic Formation (RBV)

*Stratotype:*  
Rhiw Bach Quarry [SH 7410 4600] (Lynas, 1973, p. 490).

*Lithology:*  
Rhyolitic and dacite extrusions and high-level intrusions, tuffs and intercalated silty mudstones.

*Ranking:*  
Part of Aran Volcanic Group.

*Lower boundary:*  
Overlies Arenig-Llanvirn mudstones of the Nant Ffrancon Subgroup.

*Upper boundary:*  
Overlain (possibly with a non-sequence) by the Aran Fawddwy Formation and by silty mudstones of the Nant Ffrancon Subgroup.

*Thickness:*  
640 m.

*Age:*  
Llanvirn.

*Remarks:*  
Considered to be the lateral equivalent of the Serw Volcanic Formation in Howells and Smith, 1997, but the Serw Formation also includes Caradoc strata (Zalasiewicz, 1992).

*Reference:*  
Lynas, 1973; Howells and Smith, 1997.

### 9.9 Benglog Formation (Bgl)

*Stratotype:*  
West slopes of Craig y Benglog [SH 8013 2408] (Allen and Jackson, 1985, p. 41–42).

*Lithology:*  
Crystal tuffs, pillow lavas, hyaloclastite, with silty mudstone intercalations.

*Ranking:*  
Part of the Aran Volcanic Group.

*Lower boundary:*  
Appears to be an unconformity: the formation rests on siltstones that overlie the Brithion Formation and northwards oversteps the Melau Formation to rest on the Allt Lŵyd Formation. Overlies the Fron Newydd Member at Cadair Idris.

*Upper boundary:*  
Underlies mudstone and basalt that is overlain by the Craig y Ffynnon Formation and the Aran Fawddwy Formation.

*Thickness:*  
To 240 m.

*Age:*  
In the Cadair Idris and Aran areas it overlies mudstones with possible *gracilis* Biozone faunas and itself contains graptolites of early Caradoc age (probably of the *multidens* Biozone); but in the Arenig area part of the formation has been correlated with strata of Llanvirn age (British Geological Survey, 1993).

*Remarks:*  
Partly equivalent to the Serw Volcanic Formation of Lynas, 1973. Supersedes the Basic Volcanic Group of Wells, 1925. Lateral equivalent of Pen y gadair Volcanic Formation.

*Reference:*  
Allen and Jackson, 1985; Pratt, Woodhall and Howells, 1995; British Geological Survey, 1986; 1993.

### 9.10 Craig y Ffynnon Formation (CF)

*Stratotype:*  
Craig y Ffynnon [SH 832 195].

*Lithology:*  
Acidic ash-flow tuff.

*Ranking:*  
Part of the Aran Volcanic Group.

*Lower boundary:*  
Overlies siltstone and basalt at the top of the Benglog Formation.

*Upper boundary:*  
Overlain by the Pistyllion Formation and the Aran Fawddwy Formation.

*Thickness:*

To 212 m.

*Age:*

Early Caradoc (*multidens* Biozone).

*Reference:*

Allen and Jackson, 1985, p. 43.

### 9.11 Pistyllion Formation (PNF)

*Stratotype:*

Pistyllion to Bwlch y Fign [SH 8225 1900 to 8220 1855] (Allen and Jackson, 1985, p. 43).

*Lithology:*

Basaltic and andesitic lavas, with mudstone, mudflow breccias and crystal tuffs.

*Ranking:*

Part of the Aran Volcanic Group.

*Lower boundary:*

Oversteps the Craig y Ffynnon Formation northwards and rests on the Allt Lŵyd Formation.

*Upper boundary:*

Overlain by the Aran Fawddwy Formation.

*Thickness:*

To 300 m.

*Age:*

Early Caradoc (*multidens* Biozone).

*Reference:*

British Geological Survey, 1986.

### 9.12 Aran Fawddwy Formation (AF)

*Stratotype:*

P Dunkley recommends a section in the south-west of the Aran Fawddwy area [SH 817 190 (base) to 819 185 (top)].

*Lithology:*

Acidic ash-flow tuff.

*Ranking:*

Highest division of the Aran Volcanic Group.

*Lower boundary:*

Overlies the Pistyllion Formation and oversteps on to the Benglog Formation and also (under the name Llyn Conwy Formation of Lynas, 1973) on to the Allt Lŵyd and Dol-cyn-afon formations east of the Ffynnon Eidda fault.

*Upper boundary:*

Overlain by mudstones of the Ceiswyn Formation and equivalents.

*Thickness:*

Up to 400 m.

*Age:*

Early Caradoc (*multidens* Biozone), Zalasiewicz, 1992.

*Remarks:*

This formation is widely distributed and is presumably equivalent to the Llyn Conwy Formation (Allen and Jackson, 1985, p. 30). It may be equivalent to part of the Craig Cau Formation (q.v.). It is regarded as separate from the Moelwyn Volcanic Formation which is developed only west of the Trawsfynydd-Cwm Bowydd Fault.

*Reference:*

Allen and Jackson, 1985, p. 43.

### CLOGWYN HIR TUFFS

*Stratotype:*

Clogwyn Hir [SH 777 456].

*Lithology:*

Acid tuffs.

*Ranking:*

Local lower member of the Aran Fawddwy Formation (formerly Llyn Conwy Formation).

*Lower Boundary:*

Oversteps from the Dol-cyn-afon Formation to mudstones of the Nant Ffrancon Subgroup.

*Upper Boundary:*

Pen y Bedw Tuff Member.

*Thickness:*

120 to 480 m.

*Age:*

Caradoc (Costonian Substage).

*Reference:*

Lynas, 1973, p. 489; Howells and Smith, 1997.

### PEN Y BEDW TUFF (PYB)

*Stratotype:*

Pen y Bedw [SH 780 472].

*Lithology:*

Acid ash-flow tuff.

*Ranking:*

Member of the Aran Fawddwy Formation (formerly Llyn Conwy Formation).

*Lower Boundary:*

Overlies the Clogwyn Hir Tuffs and slightly calcareous silty mudstone unit of the Nant Ffrancon Subgroup.

*Upper Boundary:*

Mudstone of the Nant Ffrancon Subgroup.

*Thickness:*

75 m.

*Age:*

Caradoc (Costonian Substage).

*Remarks:*

The underlying mudstones have a fauna similar to that of the Derfel Limestone Member.

*Reference:*  
Lynas, 1973, p. 489.

## 10 LLEWELYN VOLCANIC GROUP

### 10.1 Conwy Rhyolite Formation (CoR)

*Stratotype:*  
Not defined — reference section Cefn Coch [SP 762 746] (Howells et al., 1983, p. 13; Howells, Reedman and Leveridge, 1985, p. 9).

*Lithology:*  
Rhyolite lavas and acidic ash-flow tuffs with siltstone intercalations.

*Ranking:*  
Northern division of the lower part of the Llewellyn Volcanic Group.

*Lower boundary:*  
Overlies mudstones of the Nant Ffrancon Subgroup. Interdigitates with the Foel Fras Volcanic Complex.

*Upper boundary:*  
Underlies part of the Nant Ffrancon Subgroup.

*Thickness:*  
About 1000 m.

*Age:*  
Caradoc (probably early Soudleyan).

*Reference:*  
Howells et al., 1983; Howells, Reedman and Campbell, 1991.

### 10.2 Foel Fras Volcanic Complex (FFV)

*Stratotype:*  
Not defined — reference sections at Foel Fras [SH 698 682] and Bera Bach [SP 672 677] (Howells et al., 1983, p. 13; Howells, Reedman and Leveridge, 1985, p. 9).

*Lithology:*  
Lavas, tuffs and intrusions, mainly of trachyandesitic composition.

*Ranking:*  
Division in lower part of the Llewellyn Volcanic Group.

*Lower boundary:*  
Overlies silty mudstone of the Nant Ffrancon Subgroup. Interdigitates with the Conwy Rhyolite Formation. Outflow overlies the Foel Grach Basalt Formation and the Braich tu du Volcanic Formation.

*Upper boundary:*  
Overlain by a siltstone unit of the Llewellyn Volcanic Group.

*Thickness:*  
About 1000 m.

*Age:*  
Caradoc (probably early Soudleyan).

*Reference:*  
Howells et al., 1983, p. 13; Howells, Reedman and Campbell, 1991.

### 10.3 Foel Grach Basalt Formation (FgB)

*Stratotype:*  
Not defined — reference section at Carnedd Llewelyn [SH 684 645] (Howells, Reedman and Leveridge, 1985, p. 9).

*Lithology:*  
Massive pillowed basalt and breccias to the north; basalt lavas and tuffs with intercalated sandstones etc, to the south.

*Ranking:*  
Division of the lower part of the Llewellyn Volcanic Group.

*Lower boundary:*  
Overlies silty mudstones of the Nant Ffrancon Subgroup in the north; overlies the Braich tu du Volcanic Formation to the south.

*Upper boundary:*  
Overlain by outflow tuffs of the Foel Fras Volcanic Complex.

*Thickness:*  
400 m in the north; to 180 m in the south.

*Age:*  
Caradoc (probably early Soudleyan).

*Reference:*  
Howells et al., 1983, p. 13; Howells, Reedman and Campbell, 1991.

### 10.4 Braich tu du Volcanic Formation (BDT)

*Stratotype:*  
Braich tu du Ridge [SH 652 626] (Howells et al., 1983, p. 13).

*Lithology:*  
Rhyolites and acidic ash-flow tuffs.

*Ranking:*  
Southern division of the lower part of the Llewellyn Volcanic Group.

*Lower boundary:*  
Overlies siltstones of the Nant Ffrancon Subgroup. Interdigitates with the Foel Grach Basalt Formation.

*Upper boundary:*  
Overlain by the Foel Fras Volcanic Complex outflow and by part of the Nant Ffrancon Subgroup.

*Thickness:*  
195 m.

*Age:*  
Caradoc (probably early Soudleyan).

*Reference:*  
Howells et al., 1983; Howells, Reedman and Leveridge, 1985; Howells, Reedman and Campbell, 1991.

## 10.5 Gwern Gof Tuff (GGT)

*Stratotype:*

Not defined — a reference section is available east of Tryfan (Howells, Reedman and Campbell, 1991, p. 28).

*Lithology:*

Massive acidic ash-flow tuff.

*Ranking:*

Formation of the Llewellyn Volcanic Group.

*Lower boundary:*

Overlies sandstones in the Llewellyn Volcanic Group.

*Upper boundary:*

Underlies sandstones below the Capel Curig Volcanic Formation in the Llewellyn Volcanic Group.

*Thickness:*

About 30 m.

*Age:*

Caradoc (Soudleyan).

*Remarks:*

Possibly equivalent to the Penamnen Tuffs (Howells, Reedman and Campbell, 1991, p. 24).

*Reference:*

Howells, Reedman and Leveridge 1985; Howells, Reedman and Campbell, 1991.

## 10.6 Capel Curig Volcanic Formation (CCV)

*Stratotype:*

Not defined — reference sections at Craig yr Ysfa [SH 692 642] and Gallt yr Ogof [SH 693 597] (Howells, Reedman and Leveridge, 1985, p. 11).

*Lithology:*

Acidic ash-flow tuffs.

*Ranking:*

Highest division of the Llewellyn Volcanic Group. Includes as members the Garth, Racks, Dyffryn Mymbyr Tuffs; the Lledr Valley Tuffs is a local name for correlatives of these.

*Lower boundary:*

Overlies unnamed sandstones of the Llewellyn Volcanic Group and siltstones of the Nant Ffrancon Subgroup.

*Upper boundary:*

Overlain by sandstones of the Cwm Eigiau Formation.

*Thickness:*

Total up to 340 m.

*Age:*

Caradoc (Soudleyan).

*Remarks:*

The tuffs were emplaced in various environments: subaerial in the north, where successive tuffs are contiguous, transitional southwards to submarine settings, where the tuffs are separated by sedimentary intercalations, to a distal pod facies (Howells, Reedman and Campbell, 1991).

*Reference:*

Howells and Leveridge, 1980; Howells, Reedman and Campbell, 1991; Howells and Smith, 1997; Howells, Reedman and Leveridge, 1985.

### GARTH TUFF (GART)

*Stratotype:*

Not defined.

*Ranking:*

Lowest member of the Capel Curig Volcanic Formation.

*Reference:*

Howells et al., 1978, p. 11; Howells, Reedman and Campbell, 1991.

### RACKS TUFF (RAT)

*Stratotype:*

Not defined.

*Remarks:*

Middle member of the Capel Curig Volcanic Formation.

*Reference:*

Howells et al., 1978, p. 13; Howells, Reedman and Campbell, 1991.

### DYFFRYN MYMBYR TUFF (DMT)

*Stratotype:*

Not defined.

*Ranking:*

Upper member of the Capel Curig Volcanic Formation.

*Reference:*

Howells et al., 1978, p. 13; Howells, Reedman and Campbell, 1991.

### LLEDR VALLEY TUFFS (LVT)

*Stratotype:*

Not defined.

*Remarks:*

Local members of the Capel Curig Volcanic Formation.

*Reference:*

Howells et al., 1978, p. 13; Howells, Reedman and Campbell, 1991.

## 11 SNOWDON VOLCANIC GROUP

### 11.1 Pitts Head Tuff Formation (PT)

*Stratotype:*

Not defined. Reference sections for the intracaldera facies at Llwyd Mawr [SH 50 45] and for the outflow facies west of Moel Hebog [SH 55 47].

*Lithology:*

Acidic ash-flow tuffs, variably welded.

*Ranking:*  
Basal division of the Snowdon Volcanic Group.

*Lower boundary:*  
Overlies the Cwm Eigiau Formation.

*Upper boundary:*  
Overlain by Cwm Eigiau Formation or the Lower Rhyolitic Tuff Formation.

*Thickness:*  
700 m (intracaldera facies), 0 to 100 m (outflow facies).

*Age:*  
Caradoc (upper Soudleyan).

*Remarks:*  
Excluded from the Snowdon Volcanic Group in Howells et al., 1983, p. 15, but treated as the base of the group in Howells, Reedman and Campbell, 1991 and Howells and Smith, 1997.

*Reference:*  
Reedman et al., 1987; Howells and Smith, 1997.

#### **PEN YCHAIN RHYOLITIC COMPLEX**

*Stratotype:*  
Not defined. Reference section Pen ychain [SH 435 353].

*Remarks:*  
Rhyolitic domes, sills and tuffs associated with the Pitts Head Tuff and Llwyd Mawr Tuff.

*Reference:*  
Young et al., in press.

#### **11.2 Llwyd Mawr Tuff (LMI)**

*Stratotype:*  
Llwyd Mawr [SH 500 407].

*Remarks:*  
Rhyolitic tuff, the intracaldera facies equivalent of the Pitts Head Tuff.

*Reference:*  
Roberts, 1969; Howells, Reedman and Campbell, 1991.

#### **11.3 Yr Arddu Tuffs (YAT)**

*Stratotype:*  
Not defined. Reference section at Yr Arddu [SH 628 463].

*Lithology:*  
Welded acidic ash-flow tuffs.

*Ranking:*  
Locally forms the base of the Snowdon Volcanic Group.

*Boundaries:*  
Lies within Cwm Eigiau Formation.

*Thickness:*  
200 m.

*Age:*  
Caradoc (Longvillian).

*Reference:*  
Howells et al., 1987; Howells and Smith, 1997.

#### **11.4 Lower Rhyolitic Tuff Formation (LR)**

*Stratotype:*  
Not defined. Reference section at Lliwedd [SH 625 532].

*Lithology:*  
Acid ash-flow tuffs and volcanic breccia deposits.

*Ranking:*  
Part of the Snowdon Volcanic Group.

*Lower boundary:*  
Overlies the Cwm Eigiau Formation.

*Upper boundary:*  
Overlain by the Bedded Pyroclastic Formation.

*Thickness:*  
Up to 600 m.

*Age:*  
Caradoc (Longvillian-Woolstonian).

*Reference:*  
Howells, Reedman and Campbell, 1991, p. 67; Howells and Smith, 1997.

#### **11.5 Bedded Pyroclastic Formation (BP)**

*Stratotype:*  
Not defined. Reference sections at Twll Du, Cwm Idwal [SH 639 588] and Cwm Glas, Snowdon [SH 623 555].

*Lithology:*  
Bedded basaltic tuffs, tuffites, breccias and intrusive and extrusive basalts.

*Ranking:*  
Part of the Snowdon Volcanic Group.

*Lower boundary:*  
Overlies the Lower Rhyolitic Tuff Formation.

*Upper boundary:*  
Underlies the Upper Rhyolitic Tuff Formation.

*Thickness:*  
To 450 m.

*Age:*  
Caradoc (Woolstonian).

*Reference:*  
Howells, Reedman and Campbell, 1991, p.91; Howells, Reedman and Leveridge, 1985; Howells and Smith, 1997.

#### **11.6 Upper Rhyolitic Tuff Formation (UR)**

*Stratotype:*  
Not defined. Reference section at Clogwyn y Person [SH 615 554].

*Lithology:*  
Mainly acidic ash-flow tuffs.

*Ranking:*  
Part of the Snowdon Volcanic Group.

*Lower boundary:*  
Overlies the Bedded Pyroclastic Formation.

*Upper boundary:*  
Overlain by the Nod Glas Formation (Cadnant Shales).

*Thickness:*  
Up to 75 m.

*Age:*  
Caradoc. Overlies Woolstonian shelly fauna and underlies *clingani* Biozone graptolites.

*Reference:*  
Howells, Reedman and Campbell, 1991, p. 105; Howells and Smith, 1997.

### 11.7 Tal y Fan Volcanic Formation (TF)

*Stratotype:*  
'Restricted to Tal y Fan [SH 742 730]' (Howells, Reedman and Leveridge, 1985, p. 16).

*Lithology:*  
Basaltic lavas, tuffs and breccias.

*Ranking:*  
Part of the Snowdon Volcanic Group.

*Lower boundary:*  
Overlies the Cwm Eigiau Formation.

*Upper boundary:*  
Underlies the Middle Crafnant Volcanic Formation.

*Thickness:*  
500 m.

*Age:*  
Caradoc (approximately Longvillian to Woolstonian).

*Reference:*  
Howells, Reedman and Leveridge, 1985, p. 16; Howells, Reedman and Campbell, 1991, p. 120.

### 11.8 Lower Crafnant Volcanic Formation (LCV)

*Stratotype:*  
Not defined. Reference sections at Capel Curig [SH 7270 5760] and Cae-mawr [SH 7567 5716] (basal contact).

*Lithology:*  
Acidic ash-flow tuffs.

*Ranking:*  
Part of the Snowdon Volcanic Group.

*Lower boundary:*  
Overlies the Cwm Eigiau Formation.

*Upper boundary:*  
Underlies the Middle Crafnant Volcanic Formation.

*Thickness:*  
Up to 210 m.

*Age:*  
Caradoc (Longvillian).

*Remarks:*  
Consists of three unnamed tuff units separated by sedimentary units.

*Reference:*  
Howells et al., 1978, p. 23; Howells, Reedman and Leveridge, 1985, Howells, Reedman and Campbell, 1991.

### 11.9 Middle Crafnant Volcanic Formation (MCV)

*Stratotype:*  
Between Llyn Bodgynydd and Coed-mawr [SH 7854 5840] (Howells et al., 1978, p. 27).

*Lithology:*  
Acidic tuffs, tuffites and fine-grained sediments.

*Ranking:*  
Part of the Snowdon Volcanic Group.

*Lower boundary:*  
Lower Crafnant Volcanic Formation.

*Upper boundary:*  
Upper Crafnant Volcanic Formation.

*Thickness:*  
30 to 120 m.

*Age:*  
Caradoc, *multidens* Biozone.

*Reference:*  
Howells et al., 1978, p. 27.

### 11.10 Upper Crafnant Volcanic Formation (UCV)

*Stratotype:*  
Not defined — could be in Gwydir Forest [SH 777 587].

*Lithology:*  
Massive acidic tuffite.

*Ranking:*  
Part of the Snowdon Volcanic Group.

*Lower boundary:*  
Overlies the Middle Crafnant Volcanic Formation.

*Upper boundary:*  
Overlain by the Nod Glas (Cadnant Shales) and locally by the Dolgarrog Volcanic Formation.

*Thickness:*  
60 to 150 m.

*Age:*  
Caradoc, *multidens?* to *clingani* Biozone.

*Remarks:*  
North of Crafnant valley the Upper Crafnant Volcanic Formation cannot be separated from the Middle Crafnant Volcanic Formation, and the two are mapped undivided.

*Reference:*  
Howells et al., 1978, p. 31; Howells, Reedman and Leveridge, 1985, p. 15.

### 11.11 Dolgarrog Volcanic Formation (DV)

*Stratotype:*  
Not defined. Reference section in Afon Porth-llwyd [SH 759 670] (Howells et al., 1981, p. 42; Howells, Reedman and Leveridge, 1985, p. 16).

*Lithology:*  
Hyaloclastites, basaltic lavas, pillow basalts.

*Ranking:*  
Uppermost formation of the Snowdon Volcanic Group.

*Lower boundary:*  
Locally overlies the Upper Crafnant Volcanic Formation.

*Upper boundary:*  
Overlain by the Nod Glas Formation (Cadnant Shales).

*Thickness:*  
400 m.

*Age:*  
Caradoc (possibly Woolstonian), overlain by graptolitic mudstones whose diplograptid fauna has been referred to the *multidens* Biozone.

*Remarks:*  
Formerly considered to overlie the Snowdon Volcanic Group (Howells, Reedman and Leveridge, 1985), but now included within the group (Howells, Reedman and Campbell, 1991).

*Reference:*  
Howells et al., 1981; Howells, Reedman and Campbell, 1991.

## 12 UPPER LODGE VOLCANIC GROUP

### 12.1 Upper Lodge Volcanic Group (ULG)

*Stratotype:*  
Not defined. Reference section Near Boduan [SH 323 388].

*Lithology:*  
Basaltic tracyandesite with rhyolitic tuff.

*Lower boundary:*  
Conformable on the Cwm Eigiau Formation.

*Upper boundary:*  
Underlies the Dwyfach Formation.

*Thickness:*  
About 500 m.

*Age:*  
Caradoc (Upper Soudleyan?-Longvillian).

*Reference:*  
Matley and Heard, 1930; Young et al., in press.

### 12.2 Pitts Head Tuff Formation (see p. 19)

This forms the lowest unit of the Upper Lodge Volcanic Group on Llŷn.

### 12.3 Allt Fawr Rhyolitic Tuff Formation (AIF)

*Stratotype:*  
Not defined. Reference sections Moel Bromiod [SH 41 45] and Pen-y-gaer [SH 42 45].

*Lithology:*  
Rhyolitic ash-flow tuff.

*Ranking:*  
Upper part of the Upper Lodge Volcanic Group.

*Lower boundary:*  
Overlies the Cwm Eigiau formation and, with an unconformity, the Llanvirn mudstones of the Nant Ffrancon Subgroup.

*Upper boundary:*  
Underlies the Dwyfach Formation.

*Thickness:*  
150 m.

*Age:*  
Caradoc (Longvillian).

*Reference:*  
Young et al., in press.

## 13 LLANBEDROG VOLCANIC GROUP

### 13.1 Penmaen Formation (PnT)

*Stratotype:*  
Penmaen [SH 362 349].

*Lithology:*  
Basaltic tracyandesite lavas and tuffs and derived sediments.

*Ranking:*  
Lowest division of the Llanbedrog Volcanic Group.

*Lower boundary:*  
Overlies the Dwyfach Formation.

*Upper boundary:*  
Underlies the Foel Ddu Rhyodacite Formation.

*Thickness:*  
300 m.

*Age:*  
Caradoc (Woolstonian).

*Reference:*  
Young et al., in press.

### **13.2 Foel Ddu Rhyodacite Formation (FD)**

*Stratotype:*  
Not defined, reference section between Garn Saethon and Glan-y-gors [SH 298 337 and 306 376].

*Lithology:*  
Rhyodacitic lavas and tuffs.

*Ranking:*  
Part of the Llanbedrog Volcanic Group.

*Lower boundary:*  
Overlies the Penmaen Formation.

*Upper boundary:*  
Underlies the Carneddol Rhyolitic Tuff Formation.

*Thickness:*  
Up to 275 m.

*Age:*  
Caradoc (Woolstonian).

*Reference:*  
Young et al., in press.

### **13.3 Carneddol Rhyolitic Tuff Formation (CRT)**

*Stratotype:*  
See those of the constituent members.

*Lithology:*  
Rhyolitic ash-flow tuffs.

*Ranking:*  
Upper part of the Llanberog Volcanic Group.

*Lower boundary:*  
Overlies the Foel Ddu Rhyodacite and Dwyfach formations.

*Upper boundary:*  
Underlies the Dwyfach and locally Nod Glas formations.

*Thickness:*  
370 to 590 m.

*Age:*  
Caradoc (Woolstonian).

*Remarks:*  
Divided into the Nant y Gledrydd and Bodgadle members.

*Reference:*  
Young et al., in press.

### **NANT Y GLEDRYD MEMBER (NyG)**

*Stratotype:*  
Nant y Gledryd [SH 296 366].

*Ranking:*  
Lower member of the Carneddol Rhyolitic Tuff Formation

*Reference:*  
Young et al., in press.

### **BODGADLE MEMBER (BDL)**

*Stratotype:*  
South-west of Mochras Uchaf [SH 299 365].

*Ranking:*  
Upper member of the Carneddol Rhyolitic Tuff Formation.

*Reference:*  
Young et al., in press.

### **13.4 Yoke House Formation (YkH)**

*Stratotype:*  
Yoke House [SH 379 366].

*Lithology:*  
Rhyolitic tuffs, and reworked volcanoclastic sandstones, siltstones and conglomerates.

*Ranking:*  
Formation in the Llanbedrog Volcanic Group.

*Lower boundary:*  
Overlies both members of the Carneddol Rhyolitic Tuff, and locally the Foel Ddu Rhyodacite Formation.

*Upper boundary:*  
Underlies part of the Carneddol Rhyolitic Tuff and the Nod Glas (Cadnant Shale) formations.

*Thickness:*  
60 to 130 m.

*Age:*  
Caradoc (Woolstonian).

*Remarks:*  
Interpreted as the clastic apron to the Llanbedrog Volcanic Group.

*Reference:*  
Young et al., in press.



## APPENDIX 1

Alphabetical list of Cambrian and Ordovician lithostratigraphical units (with abbreviations) referred to in this report.

Superfluous stratigraphical terms are shown thus [ ]  
*The designated group (this report) is indicated, Ordovician in italics.*

	Page		
[Aberdaron Bay Group]	26	[Cadnant Shales] (CaS)	5, 12, 20, 26, 29
[Aberdaron Formation]	9, 26	Capel Curig Volcanic Formation (CCV) <i>Llewelyn Volcanic</i>	18
[Afon Gam Formation (AfGa)]	26	[Carn y Parc Formation] (Cayp)	13, 29
[Allt Ddu Mudstones] (ADM)	5, 10, 27	[Carnedd Iago Formation] (Carl)	7, 29
Allt Fawr Rhyolitic Tuff Formation (AIF) <i>Upper Lodge Volcanic</i>	21	Carnedd-y-Filiast Grit (CGr) Mawddach	32
Allt Lŵyd Formation (All) <i>Ogwen</i>	6	[Carneddau Group]	4
Aran Boulder Bed Member <i>Ogwen</i>	7	Carneddol Rhyolitic Tuff Formation (CRT) <i>Llanbedrog Volcanic</i>	22
Aran Fawddwy Formation (AF) <i>Aran Volcanic</i>	16	[Carw Formation]	29
Aran Volcanic Group (AVG)	3, 13–17	Cefn Coch Grit Harlech	32
Arfon Group	32	Cefn Gwyn Tuff <i>Ogwen</i>	11
Bangor Formation (Bno) Arfon	32	Cefn Hir Member (Cfn) <i>Aran Volcanic</i>	13
Barmouth Formation (BaGS) Harlech	32	Ceiriad Formation {Cambrian}	32
Bedded Pyroclastic Formation (BP) <i>Snowdon Volcanic</i>	19	Ceiswyn Formation (Csw) <i>Ogwen</i>	10
Benglog Formation (Bgl) <i>Aran Volcanic</i>	15	Cilan Formation Harlech	32
[Black Slates of Dolwyddelan] (BSD)	5, 12, 26	Clogau Formation (Clu) Mawddach	32
[Blaen Eidda Member] (Beid)	26	Clogwyn Gottal Tuff (CwG) <i>Ogwen</i>	13
Bodgadl Member (Bdl) <i>Llanbedrog Volcanic</i>	22	Clogwyn Hir Tuffs <i>Aran Volcanic</i>	16
Bodwrog Member (Bwg) <i>Ogwen</i>	12	Conwy Rhyolite Formation (CoR) <i>Llewelyn Volcanic</i>	17
Braich tu du Volcanic Formation (BDT) <i>Llewelyn Volcanic</i>	17	[Corris Shale]	12, 29
Brithion Formation (Brt) <i>Aran Volcanic</i>	15	Craig Cau Formation (Cgu) <i>Aran Volcanic</i>	14
Bronllwyd Grit (BGr) {Cambrian}	32	Craig Hen-gae Member (CH) <i>Ogwen</i>	11
Bryn Brith Member (BnB) <i>Aran Volcanic</i>	13	Craig y Ffynnon Formation (CF) <i>Aran Volcanic</i>	16
Bryncroes Formation (Br) <i>Ogwen</i>	9	Cregennen Formation (Crg) <i>Aran Volcanic</i>	13
Bryn-teg Volcanic Formation {Cambrian}	32	[Cwm Clwyd Tuff Formation] (CCT)	11, 30
		Cwm Eigiau Formation (CEi) <i>Ogwen</i>	12
		Cwmhesgen Formation (Chn) Mawddach	32
		[Cwmorthin Formation] (Cmt)	7, 31

Cymerig Limestone Member (Cy) <i>Ogwen</i>	12	Harlech Grits Group	33
Derfel Limestone Member <i>Ogwen</i>	10	Hell's Mouth Formation Harlech	33
Dol-cyn-afon Formation (Dyn) Mawddach	6	Hen-dy-capel Ironstone (HdC) <i>Ogwen</i>	8
Dolgarrog Volcanic Formation (DV) <i>Snowdon Volcanic</i>	21	[Laethnant Siltstone]	10, 30
Dolgellau Formation (Dlu) Mawddach	32	Llanbedr Formation (Lbr) Harlech	33
Dolwen Formation (DoG) Harlech	33	Llanbedrog Volcanic Group (LVG)	4, 21
Dwyfach Formation (Dwf) <i>Ogwen</i>	12	Llanberis Slates Formation (Llbs) {Cambrian}	33
Dyffryn Mymbyr Tuff (DMT) <i>Llewelyn Volcanic</i>	18	Llanengan Formation (Lgn) <i>Ogwen</i>	8
[Dyfi Mudstone]	12, 30	[Llanrhychwyn Slates] (LLR)	30
[Eidda Formation] (Eidd)	13, 30	Lledr Valley Tuffs (LVT) <i>Llewelyn Volcanic</i>	18
Fachwen Formation (Fa) <i>Arfon</i>	33	Llewelyn Volcanic Group (LIV)	4, 17–19
Ffestiniog Flags Formation (Ff) Mawddach	33	Llwyd Mawr Tuff <i>Snowdon Volcanic</i>	19
Foel Ddu Rhyodacite Formation (FD) <i>Llanbedrog Volcanic</i>	22	[Llyn Conwy Formation] (LlyC)	10, 16, 30
Foel Fras Volcanic Complex (FFV) <i>Llewelyn Volcanic</i>	17	Llyn y Gafr Volcanic Formation (LgV) <i>Aran Volcanic</i>	14
Foel Grach Basalt Formation (FgB) <i>Llewelyn Volcanic</i>	17	Lower Crafnant Volcanic Formation (LCV) <i>Snowdon Volcanic</i>	20
Fron Newydd Member (FrN) <i>Ogwen</i>	10	Lower Moelwyn Volcanic Formation (LmV) <i>Ogwen</i>	7
Frondderw Tuff (Fron) <i>Ogwen</i>	11	Lower Rhyolitic Tuff Formation (LR) <i>Snowdon Volcanic</i>	19
Gamlan Formation (GnS) Harlech	33	Machroes Member (Mch) <i>Ogwen</i>	8
Garth Grit Member (GaG) <i>Ogwen</i>	7	Maentwrog Formation (Mw) Mawddach	33
Garth Tuff (Gart) <i>Llewelyn Volcanic</i>	18	Marchlyn Formation (MaF) Mawddach	33
Gelli-grin Calcareous Ashes (Gel) <i>Ogwen</i>	11	Mawddach Group	6, 33
[Glanypwll Formation] (Glp)	6, 30	Melau Formation (Mu) <i>Aran Volcanic</i>	15
Glyn Gower Siltstones (GyG) <i>Ogwen</i>	11	Middle Crafnant Volcanic Formation (MCV) <i>Snowdon Volcanic</i>	20
[Graianog Sandstone] (Gra)	7, 30	Minfordd Formation (Mdd) <i>Arfon</i>	33
Gwern Gof Tuff (GGT) <i>Llewelyn Volcanic</i>	18	Moelfre Tuff (MT) <i>Ogwen</i>	7
Hafotty Formation (Hf) Harlech	33	Moel Hebog Sandstone Member (MoH) <i>Ogwen</i>	13
		Moelwyn Volcanic (Mv) <i>Ogwen</i>	7

Nant Ffrancon Subgroup (NFr) <i>Ogwen</i>	4, 6	Rhiw Bach Volcanic Formation (RBV) <i>Aran Volcanic</i>	5, 15
[Nant Hir Mudstone] (NHM)	4, 5, 10, 30	Rhobell Volcanic Group (RhG)	3
Nant-y-big Formation (NyB) {Cambrian}	33	[Sarn Formation] (Srn)	9, 31
Nant y Gledryd Member (NyG) <i>Llanbedrog Volcanic</i>	22	[Serw Volcanic Formation] (Serw)	5, 15, 31
Nod Glas Formation (Nog) <i>Ogwen</i>	12	Snowdon Volcanic Group	4, 19–21
Offrwm Volcanic Formation (Of) <i>Aran Volcanic</i>	14	St Tudwal's Formation (ST) <i>Ogwen</i>	8
Ogwen Group	4, 6–13	[Tai-Hirion Member] (Taih)	31
Padarn Tuff Formation (PdT) <i>Arfon</i>	33	Tal y Fan Volcanic Formation (TF) <i>Snowdon Volcanic</i>	20
Pared Mawr Member (PM) <i>Ogwen</i>	8	Trwyn Cam Member (TnC) <i>Ogwen</i>	9
Pen y Bedw Tuff (PYB) <i>Aran Volcanic</i>	16	Trwyn y Fulfran Formation (TyF) Harlech	34
Pen ychain Rhyolitic Complex <i>Snowdon Volcanic</i>	19	Trwyn-yr-Wylfa Member (TW) <i>Ogwen</i>	8
Pen y gadair Volcanic Formation (PgV) <i>Aran Volcanic</i>	14	Trygarn Formation (Tgn) <i>Ogwen</i>	9
Penamnen Tuffs (PnT) <i>Ogwen</i>	7	Ty'r Gawen Mudstone Formation (TyG) <i>Ogwen</i>	10
[Penarwel Mudstones]	5, 30	[Tyn-y-glyn Mudstone (Tyng)]	5, 12, 31
Penmaen Formation (Pm) <i>Llanbedrog Volcanic</i>	21	Upper Crafnant Volcanic Formation (UCV) <i>Snowdon Volcanic</i>	21
Penrhos Member (Pr) Mawddach	34	Upper Lodge Volcanic Group (ULG)	4, 21
Penrhyn Du Member (PD) <i>Ogwen</i>	8	Upper Moelwyn Volcanic Formation (UmV) <i>Ogwen</i>	7
Pistyllion Formation (PNF) <i>Aran Volcanic</i>	16	Upper Rhyolitic Tuff Formation (UR) <i>Snowdon Volcanic</i>	20
Pitts Head Tuff Formation (PT) <i>Snowdon Volcanic and Upper Lodge Volcanic</i>	19, 21	Vigra Member (Vg) Mawddach	34
Plastirion Member (Ptn) <i>Ogwen</i>	12	Wig Bâch Formation (WgB) <i>Ogwen</i>	9
Pont-y-ceunant 'Ash' <i>Ogwen</i>	11	Wig Member (Wig) <i>Ogwen</i>	9
Porth Meudwy Formation (PMu) <i>Ogwen</i>	9	Yoke House Formation (YkH) <i>Llanbedrog Volcanic</i>	22
Prenteg Sandstone Member (Ps) <i>Ogwen</i>	13	Yr Arddu Tuffs (YAT) <i>Snowdon Volcanic</i>	19
Racks Tuff (RaT) <i>Llewelyn Volcanic</i>	18		
Rhinog Formation (RnS) Harlech	34		

## APPENDIX 2

Alphabetical list of abbreviations used for Cambrian and Ordovician stratigraphical divisions on British Geological Survey maps of North Wales.

*Designated group shown, Ordovician in italics.*

AbB	Aberdaron Bay Group	CCV	Capel Curig Volcanic Formation <i>Llewelyn Volcanic</i>
ADM	Allt Ddu Mudstones	CEi	Cwm Eigiau Formation <i>Ogwen</i>
AF	Aran Fawddwy Formation <i>Aran Volcanic</i>	CF	Craig y Ffynnon Formation <i>Aran Volcanic</i>
AfGa	Afon Gam Formation	Cfn	Cefn Hir Member <i>Aran Volcanic</i>
AIF	Allt Fawr Tuff Formation <i>Upper Lodge Volcanic</i>	CGr	Carnedd-y-Filiast Grit Mawddach
All	Allt Lŵyd Formation <i>Ogwen</i>	Cgu	Craig Cau Formation <i>Aran Volcanic</i>
AVG	Aran Volcanic Group	CH	Craig Hen-gae Member <i>Ogwen</i>
Ba GS	Barmouth Formation Harlech	Chn	Cwmhesgen Formation Mawddach
BbV	Rhiw Bach Volcanic Formation <i>Aran Volcanic</i>	Clu	Clogau Formation Mawddach
Bdl	Bodgadl Member <i>Llanbedrog Volcanic</i>	Cmt	Cwmorthin Formation
BDT	Braich tu du Volcanic Formation <i>Llewelyn Volcanic</i>	CoR	Conwy Rhyolite Formation <i>Llewelyn Volcanic</i>
Beid	Blaen Eidda Member	Crg	Cregennen Formation <i>Aran Volcanic</i>
Bgl	Benglog Formation <i>Aran Volcanic</i>	CRT	Carneddol Rhyolitic Tuff Formation <i>Llanbedrog Volcanic</i>
BGr	Bronllwyd Grit {Cambrian}	Csw	Ceiswyn Formation <i>Ogwen</i>
BnB	Bryn Brith Member <i>Aran Volcanic</i>	CwG	Clogwyn Gottal Tuff <i>Ogwen</i>
Bno	Bangor Formation Arvon	Cy	Cymerig Limestone Member <i>Ogwen</i>
BP	Bedded Pyroclastic Formation <i>Snowdon Volcanic</i>	Dlu	Dolgellau Formation Mawddach
Br	Bryncroes Formation <i>Ogwen</i>	DMT	Dyffryn Mymbyr Tuff <i>Llewelyn Volcanic</i>
Brt	Brithion Formation <i>Aran Volcanic</i>	DoG	Dolwen Formation Harlech
BSD	Black Slates of Dolwyddelan	DV	Dolgarrog Volcanic Formation <i>Snowdon Volcanic</i>
Bwg	Bodwrog Member <i>Ogwen</i>	Dwf	Dwyfach Formation <i>Ogwen</i>
Carl	Carnedd Iago Formation	Dyn	Dol-cyn-afon Formation Mawddach
CaS	Cadnant Shales	Eidd	Eidda Formation
Cayp	Carn y Parc Formation	Fa	Fachwen Formation Arfon
CCT	Cwm Clwyd Tuff Formation	FD	Foel Ddu Rhyodacite Formation <i>Llanbedrog Volcanic</i>

Ff	Ffestiniog Flags Formation Mawddach	MaF	Marchlyn Formation Mawddach
FFV	Foel Fras Volcanic Complex <i>Llewelyn Volcanic</i>	Mch	Machroes Member <i>Ogwen</i>
FgB	Foel Grach Basalt Formation <i>Llewelyn Volcanic</i>	MCV	Middle Crafnant Volcanic Formation <i>Snowdon Volcanic</i>
FrN	Fron Newydd Member <i>Ogwen</i>	Mdd	Minfordd Formation Arfon
Fron	Frondderw Tuff <i>Ogwen</i>	MoH	Moel Hebog Sandstone Member <i>Ogwen</i>
GaG	Garth Grit Member <i>Ogwen</i>	MT	Moelfre Tuff <i>Ogwen</i>
Gart	Garth Tuff <i>Llewelyn Volcanic</i>	Mu	Melau Formation <i>Aran Volcanic</i>
Gel	Gelli-grin Calcareous Ashes <i>Ogwen</i>	Mv	Moelwyn Volcanic <i>Ogwen</i>
GGT	Gwern Gof Tuff <i>Llewelyn Volcanic</i>	Mw	Maentwrog Formation Mawddach
GnS	Gamlan Formation Harlech	NFr	Nant Ffrancon Subgroup <i>Ogwen</i>
Gra	Graianog Sandstone	NHM	Nant Hir Mudstone
GyG	Glyn Gower Siltstones <i>Ogwen</i>	Nog	Nod Glas Formation <i>Ogwen</i>
HdC	Hen-dy-capel Ironstone <i>Ogwen</i>	NyB	Nant-y-big Formation
Hf	Hafotty Formation Harlech	NyG	Nant y Gledryd Member <i>Llanbedrog Volcanic</i>
Lbr	Llanbedr Formation Harlech	Of	Offrwm Volcanic Formation <i>Aran Volcanic</i>
LCC	Lower Crafnant Volcanic Formation <i>Snowdon Volcanic</i>	PD	Penrhyn Du Member <i>Ogwen</i>
Lgn	Llanengan Formation <i>Ogwen</i>	PdT	Padarn Tuff Formation Arfon
LgV	Llyn y Gafr Volcanic Formation <i>Aran Volcanic</i>	PgV	Pen y gadair Volcanic Formation <i>Aran Volcanic</i>
LibS	Llanberis Slates Formation {Cambrian}	PM	Pared Mawr Member <i>Ogwen</i>
LLR	Llanrhychwyn Slates	Pm	Penmaen Formation <i>Llanbedrog Volcanic</i>
LIV	Llewellyn Volcanic Group	PMu	Porth Meudwy Formation <i>Ogwen</i>
LlyC	Llyn Conwy Formation	PNF	Pistyllion Formation <i>Aran Volcanic</i>
LmV	Lower Moelwyn Volcanic Formation <i>Ogwen</i>	PnT	Penamnen Tuffs <i>Ogwen</i>
LR	Lower Rhyolitic Tuff Formation <i>Snowdon Volcanic</i>	Pr	Penrhos Member
LVG	Llanbedrog Volcanic Group	Ps	Prenteg Sandstone Member <i>Ogwen</i>
LVT	Lledr Valley Tuffs <i>Llewelyn Volcanic</i>	PT	Pitts Head Tuff Formation <i>Snowdon Volcanic and Upper Lodge Volcanic</i>
		Ptn	Plastirion Member <i>Ogwen</i>

PYB	Pen y Bedw Tuff <i>Aran Volcanic</i>	TyF	Trwyn y Fulfran Formation
RaT	Racks Tuff <i>Llewelyn Volcanic</i>	TyG	Ty'r Gawen Mudstone Formation <i>Ogwen</i>
RBV	Rhiw Bach Volcanic Group <i>Aran Volcanic</i>	Tyng	Tyn-y-glyn Mudstone
RhG	Rhobell Volcanic Group	UCV	Upper Crafnant Volcanic Formation <i>Snowdon Volcanic</i>
RnS	Rhinog Formation Harlech	ULG	Upper Lodge Volcanic Group
Serw	Serw Volcanic Formation	UmV	Upper Moelwyn Volcanic Formation <i>Ogwen</i>
Sm	Sarn Formation	UR	Upper Rhyolitic Tuff Formation <i>Snowdon Volcanic</i>
ST	St Tudwal's Formation <i>Ogwen</i>	Vg	Vigra Member
Taih	Tai-Hirion Member	WgB	Wig Bâch Formation <i>Ogwen</i>
TF	Tal y Fan Volcanic Formation <i>Snowdon Volcanic</i>	Wig	Wig Member <i>Ogwen</i>
Tgn	Trygarn Formation <i>Ogwen</i>	YAT	Yr Arddu Tuffs <i>Snowdon Volcanic</i>
TnC	Trwyn Cam Member <i>Ogwen</i>	YkH	Yoke House Formation <i>Llanbedrog Volcanic</i>
TW	Trwyn-yr-Wylfa Member <i>Ogwen</i>		

### APPENDIX 3

List of superfluous stratigraphical terms or those of doubtful value.

#### Aberdaron Bay Group (AbB)

Equivalent to and superseded by Nant Ffrancon Subgroup.

#### Aberdaron Formation

*Stratotype:*

Basal stratotype taken at Wîg [SH 1862 2569] (Beckly, 1988, p. 326).

*Remarks:*

Superseded by the Wig Bâch formation.

#### Afon Gam Formation (AfGa)

*Stratotype:*

Afon Gam [SH 747 423] (Lynas, 1973, p. 484).

*Remarks:*

Mudstones and siltstones of Tremadoc age, equivalent to, and superseded by, the Dol-cyn-afon Formation.

*Reference:*

Lynas, 1973; British Geological Survey, 1993.

#### Allt Ddu Mudstones (ADM)

*Stratotype:*

Presumably Allt Ddu [SH 941 343], but best reference section is at Craig y Gath [SH 915 306]. Bassett, Whittington and Williams, 1966, p. 235.

*Lithology:*

Silty mudstones with fine siltstones.

*Ranking:*

Part of the Ogwen Group locally mapped as a formation, but here regarded as the upper part of the Ceiswyn Formation.

*Lower boundary:*

Overlies the Glyn Gower Siltstones, or Frondderw Tuff where that is developed.

*Upper boundary:*

Overlain by the Pont-y-ceunant Ash at base of the Gelli-Grin Calcareous Ashes.

*Thickness:*

About 400 m.

*Age:*

Caradoc (late Soudleyan).

*Remarks:*

Equivalent to part of the Caeswyn Formation, but distinguishable in the areas where the bounding tuffs are present.

*Reference:*

Bassett, Whittington and Williams, 1966; British Geological Survey, 1986.

#### Black Slates of Dolwyddelan (BSD)

*Stratotype:*

Not defined.

*Remarks:*

An outlier of the Cadnant Shales (clingani Biozone), here referred to the Nod Glas Formation.

*Reference:*

Howells et al., 1978.

#### Blaen Eidda Member (Beid)

*Stratotype:*

Not defined.

*Ranking:*

Basal volcanoclastic sandstone member of the Eidda Formation.

*Remarks:*

Equivalent to part of the Cwm Eigiau Formation.

*Reference:*

British Geological Survey, 1993.

#### Cadnant Shales (CaS)

*Stratotype:*

Railway cutting, Conwy [SH 779 776].

*Lithology:*

Black mudstone or slate.

*Ranking:*

Uppermost formation assigned to the Ogwen Group.

*Lower boundary:*

Snowdon Volcanic Group.

*Upper boundary:*

Conwy Mudstone Formation, Bodeidda Mudstone, Trefriw Tuff and equivalent units of Ashgill age.

*Thickness:*

Up to 450 m.

*Age:*

Caradoc, lower *clingani* Biozone, possibly also *multidens* Biozone? (see p. 12).

*Remarks:*

Superseded by the Nod Glas Formation, along with other names used for black slates overlying the Snowdon Volcanic Group, viz. Llanrychwyn Slates, Black Slates of Dolwyddelan, Tyn y glyn Mudstones, Penarwel Mudstones.

*Reference:*

Wood and Harper, 1962; Howells, Reedman and Leveridge, 1985, p. 16.

#### Carn y Parc Formation (Cayp)

*Stratotype:*

Not defined.

*Remarks:*

Siltstones with some sandstones, laterally equivalent to the Cwm Eigiau Formation, and superseded by it.

*Reference:*

British Geological Survey, 1993.

#### Carnedd Iago Formation (CarI)

*Stratotype:*

Carnedd Iago [SH 783 407]

*Remarks:*

Mudstones and siltstones with volcanoclastic sandstones, equivalent to, and superseded by, the Allt Lŵyd Formation.

*Reference:*

Lynas, 1973, p. 485; British Geological Survey, 1993.

#### Carw Formation

*Stratotype:*

Nant y Carw [SH 2352 3233 to 2355 3232].

*Lithology:*

Supposedly fine-grained tuffite.

*Ranking:*

Originally a formation at the top of the Wig Bâch Formation.

*Thickness:*

Up to 80 m thick.

*Age:*

Areng (Fennian).

*Remarks:*

Superseded by the Trygarn Formation, following a reinterpretation of the tuffitic rocks as siliciclastic (Young et al., in press).

*Reference:*

Beckly, 1988.

#### Corris Shale

*Stratotype:*

Nant y Nod [SH 818 137].

*Remarks:*

Upper (black mudstone) member of the Nod Glas Formation.

*Reference:*

Lockley, 1980, p. 39.

**Cwm Clwyd Tuff Formation (CCT)**

*Stratotype:*

Not defined.

*Remarks:*

Local name for the tuff member at the base of the Glyn Gower Siltstones. Superseded by the Cefn Gwyn Ash.

*Reference:*

British Geological Survey, 1993.

**Cwmorthin Formation (Cmt)**

*Stratotype:*

Not defined.

*Remarks:*

Arenig sandstones, superseded by the Allt Lŵyd Formation.

*Reference:*

British Geological Survey, 1989a.

**Dyfi Mudstone**

*Stratotype:*

Between Tan y Bwlch and Aber Cowarch [SH 91 23].

*Remarks:*

Lower dark grey mudstone member of the Nod Glas Formation.

*Reference:*

Lockley, 1980, p. 39.

**Eidda Formation (Eidd)**

*Stratotype:*

Not defined.

*Remarks:*

Caradoc (Longvillian) sandstones. At base includes volcaniclastic sandstones of the Blaen Eidda Member. Superseded by the Cwm Eigiau Formation, of which it is an equivalent.

*Reference:*

British Geological Survey, 1993.

**Glanypwll Formation (Glp)**

*Stratotype:*

Not defined.

*Remarks:*

Sandstone of Tremadoc age, equivalent to part of the Dol-cyn-afon Formation.

*Reference:*

British Geological Survey, 1989a.

**Graianog Sandstone (Gra)**

*Stratotype:*

Not defined. Reference section at Cwm Graianog, Nant Ffrancon [SH 622 624] (Reedman et al., 1983, p. 8).

*Ranking:*

Local basal sandstone member of the Nant Ffrancon Subgroup. The age is Arenig.

*Remarks:*

Member status implicit. Probably referable to the Allt Lŵyd Formation.

**Llaethnant Siltstone**

*Stratotype:*

Llaethnant (upper Dyfi Valley) [about SH 893 217] (Lockley, 1980, p. 28).

*Ranking:*

Siltstone formation in the Ogwen Group. The top is marked by the Frondderw Tuff.

*Thickness:*

To 370 m thick.

*Remarks:*

Lateral equivalent of part of the Caeswyn Formation (but coarser grained) and of the Glyn Gower Siltstones (but more thinly bedded). The value of this division has yet to be tested.

*Reference:*

Lockley, 1980.

**Llanrhychwyn Slates (LLR)**

*Stratotype:*

Not defined—reference section in Pen y Ffridd quarry [SH 7745 6092] (Howells et al., 1981, p. 47).

*Remarks:*

Black slates (about 450 m thick) overlying the Crafnant Volcanic Formations. Superseded by the Nod Glas Formation.

**Llyn Conwy Formation (LlyC)**

*Stratotype:*

Llyn Conwy [SH 780 463]

*Lithology:*

Acid ash-flow tuffs with silty mudstones.

*Ranking:*

Highest division of the Aran Volcanic Group.

*Boundaries:*

Lies within silty mudstones of the Nant Hir Mudstone (Ogwen Group).

*Thickness:*

Up to 500 m or more.

*Age:*

Caradoc.

*Remarks:*

Laterally equivalent to and superseded by the Aran Fawddwy Formation. Includes the Clogwyn Hir Tuffs and the Pen y Bedw Tuff as members (Lynas, 1973, p. 489).

*Reference:*

Lynas, 1973, p. 489.

**Nant Hir Mudstone (NHM)**

*Stratotype:*

Nant Hir valley [SH 845 367 to 857 365]

*Lithology:*

Mudstones and siltstone.

*Ranking:*

Part of the Ogwen Group, locally mapped as a formation but here synonymised with the Ceiswyn Formation.

*Lower boundary:*

Overlies the Aran Volcanic Group.

*Upper boundary:*

Underlies the Cefn Gwyn Tuff.

*Thickness:*

About 1000 m.

*Age:*

Caradoc (Harnagian).

*Remarks:*

Includes the Derfel 'Limestone' Member at the base. Equivalent to the lower part of the Caeswyn Formation and mudstones in the upper part of the Nant Ffrancon Subgroup. Distinguishable separately only where overlain by the Cefn Gwyn Tuff.

*Reference:*

Bassett, Whittington and Williams, 1966, p. 229.

**Penarwel Mudstones**

*Lithology:*

Black graptolitic mudstone.



*Ranking:*

Upper part of the Ogwen Group.

*Age:*

Caradoc (*multidens?* and *clingani* biozones).

*Remarks:*

Superseded by the Nod Glas Formation.

*Reference:*

Matley, 1938.

**Sarn Formation (Srn)**

*Stratotype:*

Basal stratotype at Mountain Cottage Quarry [SH 2300 3470] (Beckly, 1988).

*Remarks:*

Part of the Ogwen Group. The name competes with the Sarn Complex (Precambrian) and is replaced by the Bryn croes Formation (Young et al., in press).

*Reference:*

Beckly, 1988, p. 324; Gibbons and McCarroll, 1993.

**Serw Volcanic Formation (Serw)**

*Stratotype:*

Llyn Serw [SH 779 428].

*Remarks:*

Considered a lateral equivalent of the Rhiw Bach Volcanic

Formation in Howells and Smith, 1997, but includes also lateral equivalents of the Benglog Formation (Zalasiewicz, 1992, British Geological Survey, 1993).

*Reference:*

Lynas, 1973, p. 486.

**Tai-herion Member (Taih)**

*Stratotype:*

Not defined

*Remarks:*

Locally recognised member of the Dol-cyn-afon.

*Reference:*

British Geological Survey, 1993.

**Tyn-y-glyn Mudstone (Tyng)**

*Stratotype:*

Not defined [British Geological Survey Lexicon gives SH 9946 4421].

*Remarks:*

Superseded by the Nod Glas Formation.

*Reference:*

British Geological Survey, 1993.

## APPENDIX 4

### Cambrian Formations in North Wales

#### A1 Group Terminology

The Cambrian rocks of North Wales fall into three major groups, the Arfon, Harlech Grits and Mawddach groups.

The Arfon Group is restricted to northern area (Arfon), and represents a thick but relatively local accumulation of acid volcanic rocks; it is overlain by marine detrital rock formations that are not assigned to a named group.

The Harlech Grits Group was proposed to accommodate the turbiditic divisions of the Harlech Dome succession up to the base of the Clogau formation; at this level dark pyritous mudstones make their appearance and were considered to form the background sedimentation throughout the succeeding Mawddach Group (Allen, Jackson and Rushton, 1981, p. 301). An alternative view (Young et al. 1994, p. 337) places emphasis on the non-sequence at the base of the Maentwrog Formation, and places the base of the Mawddach Group at that non-sequence, whilst confining the Harlech Grits Group to those divisions associated with coarse sand-grade units.

#### A2 Formational Terminology

The terminology of the Cambrian formations is relatively uncontroversial, although opinions differ on the recognition and the hierarchical status of some divisions (e.g. Cefn Coch Grit, Vigra Member), and as to the feasibility of using the same formational names for the lower parts of the succession at St Tudwal's Peninsula as in the Harlech Dome (Pratt 1995; Young and Dean, 1995).

Several older terms for Cambrian rocks are listed, with references, in Stubblefield, 1959.

#### Arfon Group

*Reference:*

Reedman, Leveridge and Evans, 1984.

*Remarks:*

The upper part is considered to be of Cambrian age, the lower part is Precambrian or Cambrian.

#### Bangor Formation (Bno)

*Ranking:*

Part of the Arfon Group.

*Reference:*

Reedman, Leveridge and Evans, 1984, p. 316.

*Remarks:*

Includes the Siliwen Conglomerate and the Mountain Tuffite as members (Reedman, Leveridge and Evans, 1984).

#### Barmouth Formation (BaGS)

*Ranking:*

Part of Harlech Grits Group.

*Age:*

St David's?

*Reference:*

Allen and Jackson, 1985, p. 10.

#### Bronllwyd Grit Formation (BGr)

*Ranking:*

Formation not assigned to a group.

*Age:*

Uncertain, within range Comley–Merioneth.

*Reference:*

Howells, Reedman and Leveridge, 1985, p. 6.

#### Bryn-teg Volcanic Formation

*Ranking:*

Formation not assigned to a group.

*Age:*

Late Precambrian or Comley.

*Reference:*

Allen and Jackson, 1978, pp. 3, 7.

*Remarks:*

Not exposed, but seen in the Bryn-teg Borehole. Underlies the Harlech Grits Group.

#### Carnedd-y-Filiast Grit Member (CGr)

*Ranking:*

Member at top of the Marchlyn Formation.

*Age:*

Merioneth.

*Reference:*

Howells, Reedman and Leveridge, 1985, p. 6.

#### Cefn Coch Grit

*Ranking:*

Member at top of the Gamlan Formation.

*Reference:*

Allen and Jackson, 1985, p. 6.

#### Ceiriad Formation

*Age:*

St David's.

*Ranking:*

Formation not assigned to a group.

*Reference:*

Young et al., 1994, p. 340.

#### Cilan Formation

*Age:*

St David's?

*Ranking:*

Part of the Harlech Grits Group.

*Reference:*

Young et al., 1994, p. 339.

#### Clogau Formation (Clu)

*Ranking:*

Basal unit of the Mawddach Group.

*Age:*

St David's.

*Reference:*

Allen and Jackson, 1985, p. 11; Allen, Jackson and Rushton, 1981, p. 299.

#### Cwmhesgen Formation (Chn)

*Reference:*

Allen and Jackson, 1985, p. 12, Allen, Jackson and Rushton, 1981, p. 312.

*Remarks:*

Superseded by the elevation of the constituent members (Dolgellau, Dol-cyn-afon) to formational status (Howells and Smith, 1997, Pratt, Woodhall and Howells, 1995).

#### Dolgellau Formation (Dlu)

*Ranking:*

Part of the Mawddach Group.

*Age:*

Merioneth.

*Reference:*

Allen and Jackson, 1985, p. 12; Allen, Jackson and Rushton, 1981, p. 312.

*Remarks:*

Raised from member of the Cwmhesgen Formation to formation status (Howells and Smith, 1997; Pratt, Woodhall and Howells 1995).

**Dolwen Formation (DoG)**

*Ranking:*

Lowest part of the Harlech Grits Group.

*Age:*

Comley.

*Reference:*

Allen and Jackson, 1985, p. 6.

**Fachwen Formation (Fa)**

*Ranking:*

Part of the Arfon Group.

*Age:*

Comley?

*Reference:*

Reedman, Leveridge and Evans, 1984, p. 316.

**Ffestiniog Flags Formation (Ff)**

*Ranking:*

Part of the Mawddach Group.

*Age:*

Merioneth.

*Reference:*

Allen and Jackson, 1985, p. 12; Allen, Jackson and Rushton, 1981, p. 310.

**Gamlan Formation (GnS)**

*Ranking:*

Part of the Harlech Grits Group.

*Age:*

St David's.

*Reference:*

Allen and Jackson, 1985, p. 10.

*Remarks:*

Locally includes the Cefn Coch Grit as the terminal member.

**Hafotty Formation (Hf)**

*Ranking:*

Part of the Harlech Grits Group.

*Age:*

Late Comley to early St David's.

*Reference:*

Allen and Jackson, 1985, p. 9.

**Harlech Grits Group**

*Reference:*

Allen and Jackson, 1985, p. 6.

**Hell's Mouth Formation**

*Ranking:*

Part of the Harlech Grits Group.

*Age:*

Comley.

*Reference:*

Young et al. 1994, p. 337.

**Llanbedr Formation (Lbr)**

*Ranking:*

Part of the Harlech Grits Group.

*Age:*

Comley.

*Reference:*

Allen and Jackson, 1985, pp. 8, 9.

**Llanberis Slates Formation (LlBS)**

*Ranking:*

Formation not assigned to a group.

*Age:*

Comley.

*Reference:*

Howells, Reedman and Leveridge 1985, p. 5.

*Remarks:*

Includes coarse sandstone units as members (Dorothea and Pen-y-bryn grits).

**Maentwrog Formation (Mw)**

*Ranking:*

Part of the Mawddach Group.

*Age:*

Late St David's to Merioneth.

*Reference:*

Allen and Jackson 1985, p. 12, Allen, Jackson and Rushton, 1981.

*Remarks:*

Locally the Vigra and Penrhos members are distinguished (Pratt, Woodhall and Howells, 1995).

**Marchlyn Formation (MaF)**

*Ranking:*

Part of the Mawddach Group.

*Age:*

Merioneth.

*Reference:*

Howells, Reedman and Leveridge, 1985, p. 6.

*Remarks:*

Includes the Carnedd-y-Filiast Grit at the top, as a member.

**Mawddach Group**

*Reference:*

Allen, Jackson and Rushton, 1981, p. 299.

**Minfordd Formation (Mdd)**

*Ranking:*

Part of Arfon Group.

*Reference:*

Reedman, Leveridge and Evans, 1984, p. 315; Howells, Reedman and Leveridge, 1985, p. 5.

**Nant-y-big Formation**

*Age:*

St David's.

*Ranking:*

Formation not assigned to a group.

*Reference:*

Young et al. 1994, p. 341.

**Padarn Tuff Formation (PdT)**

*Reference:*

Reedman, Leveridge and Evans, 1984, p. 313.

*Remarks:*

The basal division of the Arfon Group. Its age may be Precambrian.

**Penrhos Member***Reference:*

Pratt, Woodhall and Howells, 1995.

*Remarks:*

Locally recognisable member of the Maentwrog Formation.

**Rhinog Formation (RnS)***Ranking:*

Part of the Harlech Grits Group.

*Age:*

Late Comley.

*Reference:*

Allen and Jackson, 1985, p. 9.

**Trwyn y Fulfran Formation***Ranking:*

Part of the Harlech Grits Group.

*Age:*

Late Comley to early St David's.

*Reference:*

Young et al. 1994, p. 339.

**Vigra Member***Reference:*

Pratt, Woodhall and Howells, 1995.

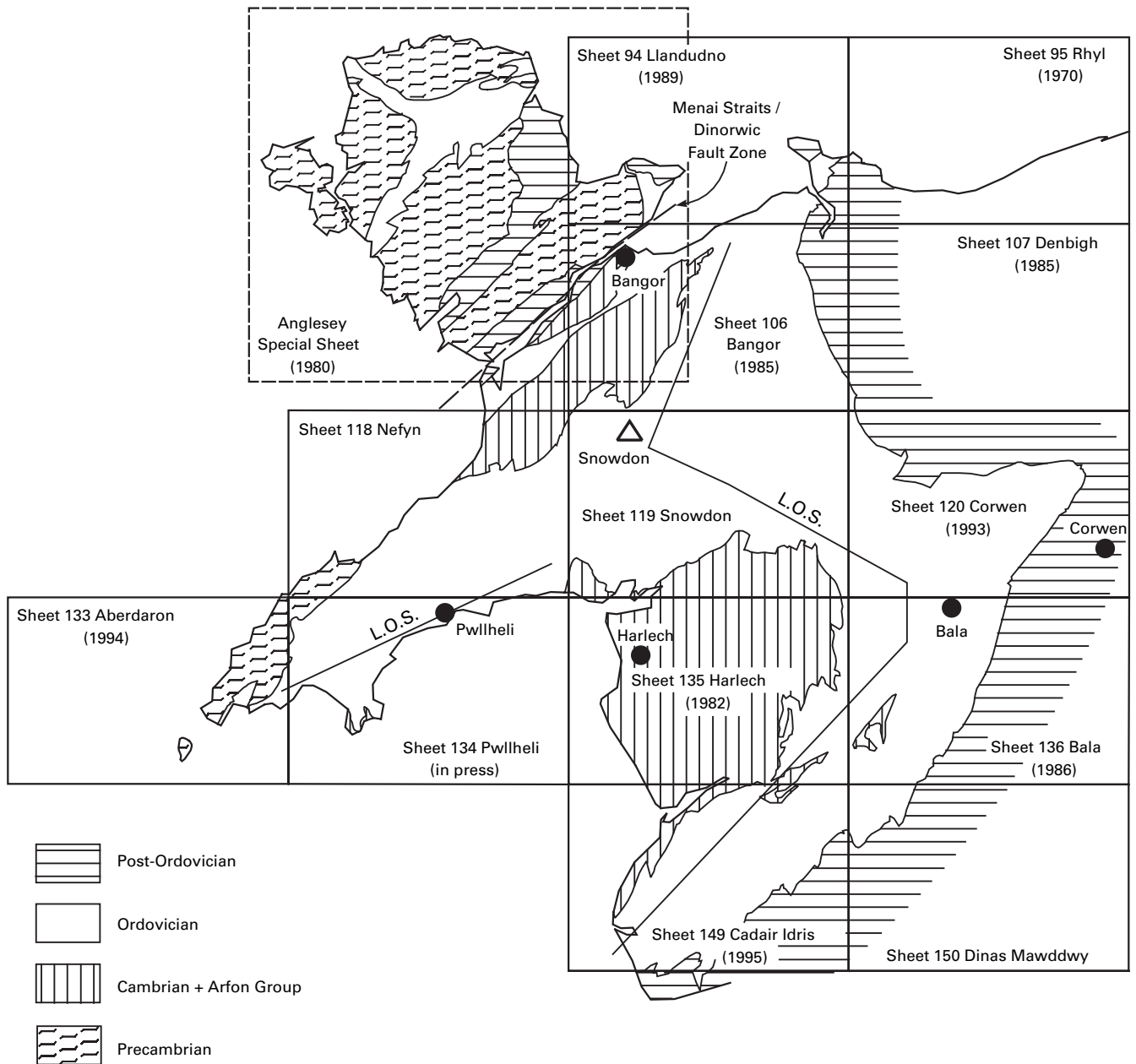
*Remarks:*

Locally recognisable member of Maentwrog Formation.

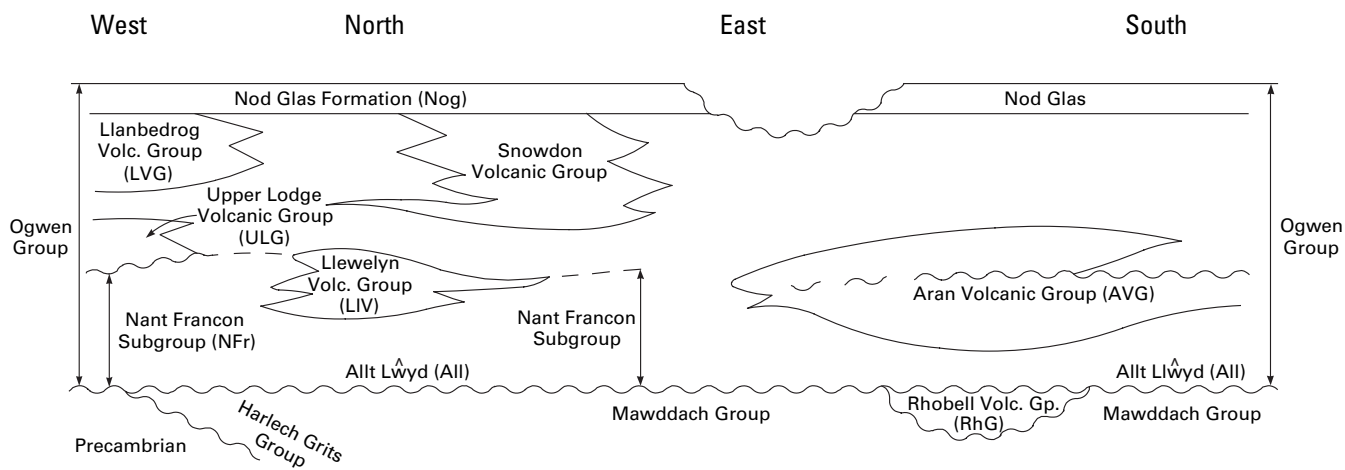
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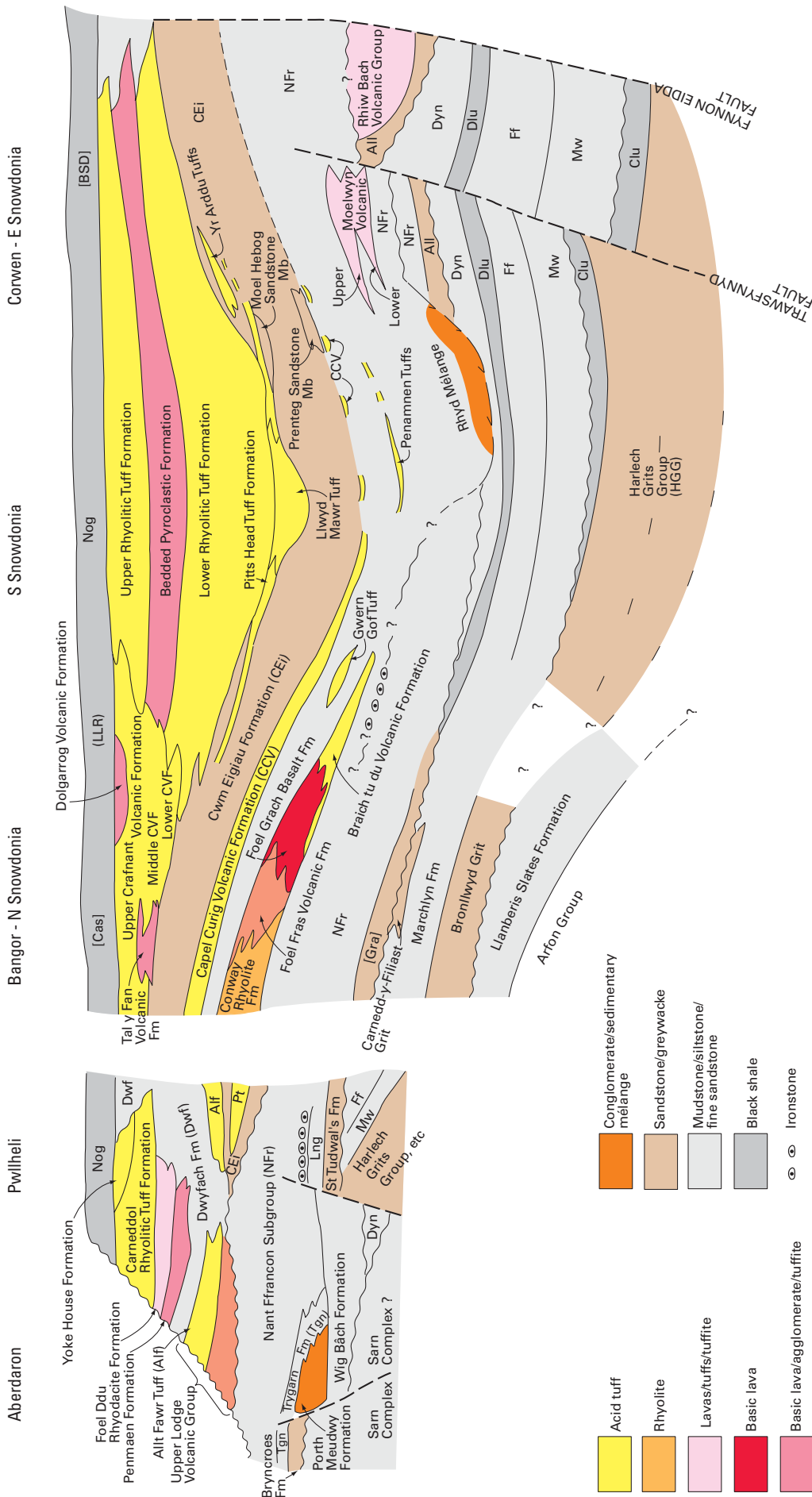


**Figure 1** Simplified geology of north-west Wales and approximate location of schematic sections shown in Figure 3.

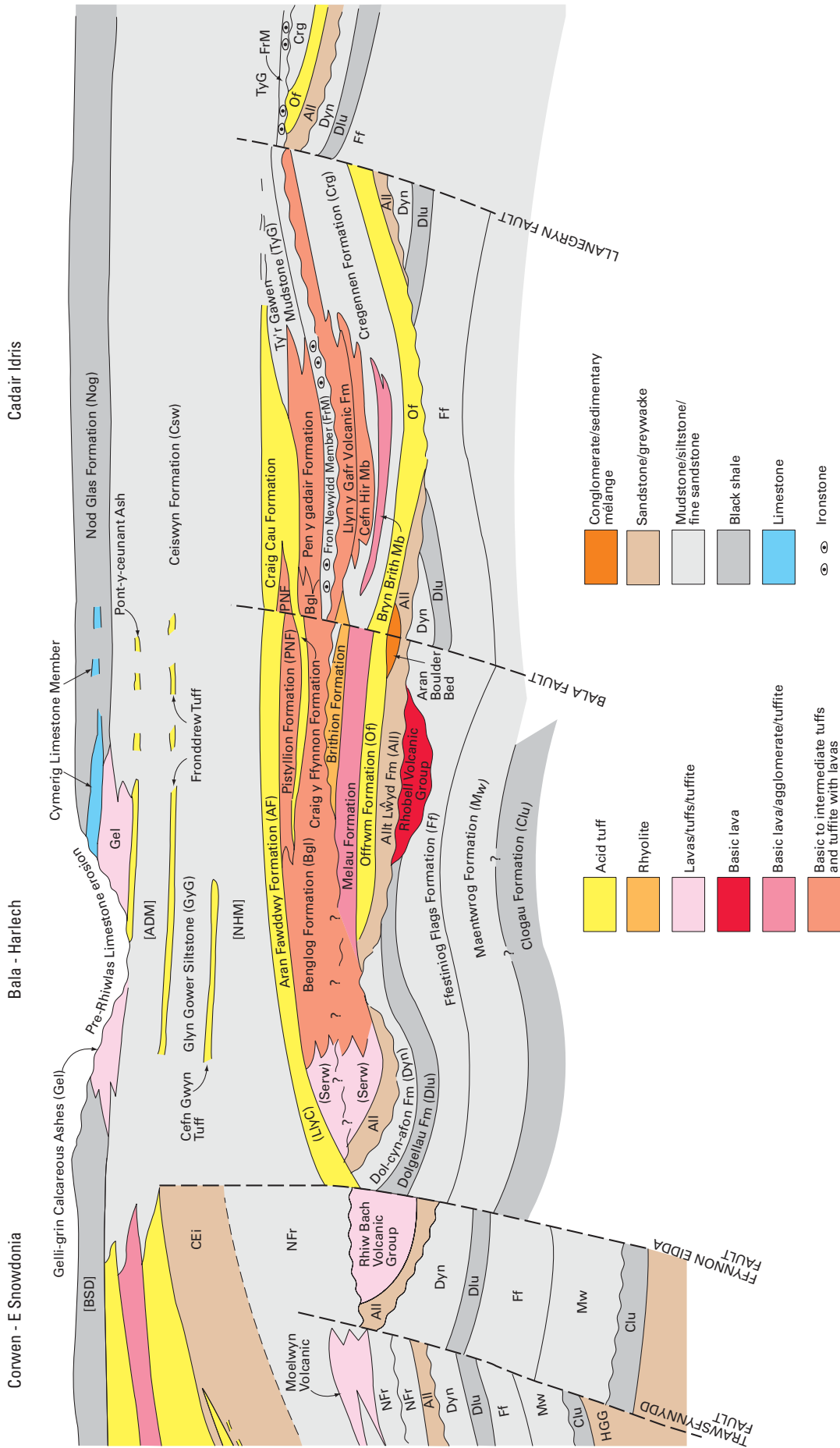


**Figure 2** Schematic relationships of the major stratigraphical groups in the Ordovician of Snowdonia and the Lleyn Peninsula.

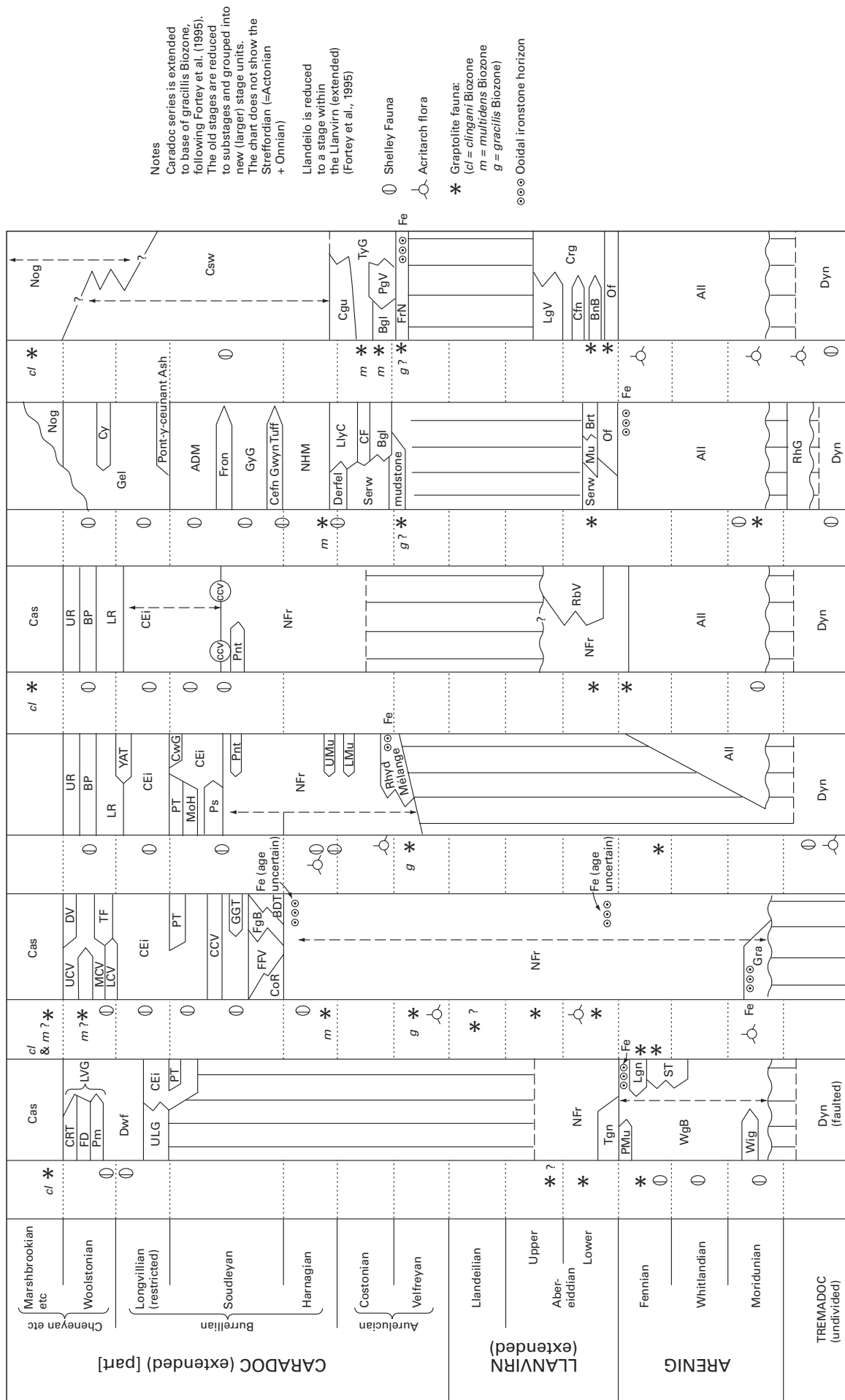




**Figure 3** (Left) Schematic section of the Ordovician of Snowdonia and the Lleyn Peninsula (see Figure 1 for approximate locations) showing the general lithostratigraphical relationships of the formations and principal members. The groups are shown schematically in Figure 2. Abbreviations: Fm Formation, Mb Member, other abbreviations are given in Appendix 2. Names and abbreviations of superfluous terms are in square brackets, thus [Cas].



**Figure 3** (Right) Schematic section of the Ordovician of Snowdonia and the Lleyn Peninsula (see Figure 1 for approximate locations) showing the general lithostratigraphical relationships of the formations and principal members. The groups are shown schematically in Figure 2. Abbreviations: Fm Formation, Mb Member, other abbreviations are given in Appendix. Names and abbreviations of superfluous terms are in square brackets, thus [Cas].



**Figure 4** Biostratigraphical correlation of the Ordovician in Snowdonia and the Lleyrn Peninsula. See Appendix 2 for abbreviations.