
Chapter 7 Tremadoc Series in Wales and England

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Introduction

The Tremadoc Series stems from the lithostratigraphically conceived Tremadoc Group of Sedgwick (1852), who named it after the village (now Tremadog) in North Wales. This group of strata was characterized palaeontologically by Salter (1866b), who recognized the significance of the fauna as forming a transition between the 'primordial' (Cambrian) and 'lower Silurian' (Ordovician) faunas. Whittard (1960) discussed in detail the historical development of the Tremadoc Series.

The Tremadoc Series, though formerly often treated as the uppermost part of the Cambrian, is now internationally accepted as one of the designations of the lowest series of the Ordovician System. The base of the Ordovician and the definition of the primary divisions of the system are under international debate, and the Cambrian—Ordovician Working Group has recommended a stratotype for the base at a level close to the base of the Tremadoc Series as recognized in Wales. Whether the Tremadoc is to be adopted as the lowest primary international series division of the Ordovician or merely a secondary (regional) series, it remains of worldwide significance, and the sites that exemplify it are accorded corresponding importance.

In Britain the Tremadoc is divided biostratigraphically into a composite sequence of zones (see (Figure 6.2)) derived mainly from the Tremadoc successions in Shropshire, though the lower and upper limits are better defined in Welsh and northern English sites. Fortey *et al.* (1995) divided the Tremadoc Series into two stages. The lower Cressagian Stage encompasses the *flabelliformis* and *tenellus* graptolite zones and the overlying poorly characterized interzone. This stage approximates to Cooper's (1979) Graptolite Assemblages 1–3 and 'corresponds to Salter's (1866b, p. 253) 'Lower Tremadoc' and 'Passage Beds'. The Migneintian Stage is defined at the base of the *salopiensis* trilobite zone and extends upwards through the *sedgwickii* Zone and the overlying strata of pre-Arenig age. It corresponds to Salter's 'Upper Tremadoc', together with overlying strata of which he had no knowledge.

The Tremadoc is developed in two main settings: the Welsh Basin, particularly in North Wales, and the English cratonic area, especially the Welsh Borderland.

Wales

In the North Wales basin there are cleaved mudstones with significant but only locally developed sandstone units, of total thickness up to about 500 m. Many stratigraphical terms have been applied in the past (Cowie *et al.*, 1972, pl. 3), and those employed by Fearnside's (1905, 1910) are listed here because they remain useful labels for local lithostratigraphical divisions in the Arenig and Tremadog (or Ynyscynhaiarn) areas. However, wider mapping of Fearnside's units has proved impracticable, and recent work refers all the slaty mudstones of Tremadoc age in North Wales to the Dol-cyn-afon Formation (Pratt *et al.*, 1995, p. 14) and leaves the sandstone divisions as unnamed members (Howells and Smith, 1997). The divisions may be correlated approximately as given in (Table 7.1).

The whole sequence was laid down in a fairly shallow open marine setting with some divisions showing striking local changes in thickness across synsedimentary faults (Howells and Smith 1997).

The succession follows the Cambrian conformably, or locally with slight non-sequence, and the boundary is marked by a subtle change in sedimentation linked to oceanic changes such as an increase in marine oxygenation. The stratigraphical succession in North Wales is nearly complete, from the lowest part of the *flabelliformis* Zone where it overlies the highest Cambrian Zone of *Acerocare* to the *sedgwickii* Zone; however, the top of the latter is not seen and there is a hiatus of uncertain magnitude between the youngest Tremadoc and the oldest Arenig in North Wales.

The sites that exemplify the North Welsh Tremadoc succession are indicated in (Figure 3.2) and their stratigraphical positions are shown in (Figure 7.1). The lower parts of the Tremadoc are represented at Ogof Ddû (Rhiw-for-fawr), which is principally in the Merioneth Series but extends up from the Dolgellau Formation, through a putative non-sequence, into the Lower Sandstone Member of the Dol-cyn-afon Formation (Tremadoc), for which it is the best lithostratigraphical section. Bryn-llin-fawr shows a biostratigraphical succession from the *Acerocare* Zone to the designated base of the Cressagian Stage at the base of the *flabelliformis* Zone and is the best locality in Britain at which to define the base of the Tremadoc Series, whereas Dol-cyn-afon shows more clearly the lithological transition from the Dolgellau to the Dol-cyn-afon formations, though with less good biostratigraphical control. Biostratigraphically the Lower Sandstone Member is best served by Tyn-llan, which is a classic site for lower Tremadoc trilobites, and the Lower Mudstone Member by the Wern Road section. Besides these, the more westerly site at Pen Benar shows a sand-rich development of Cressagian rocks in a position closer than any other to the putative Irish Sea positive area (see (Figure 9.1)).

The lithology and palaeontology of the upper parts of the Tremadoc succession are exemplified by Amnodd Bwll, which shows the Upper Mudstone Member and includes the intended base of the Migneintian Stage, and Y Garth, which exemplifies a different facies of the Upper Mudstone Member. The Upper Sandstone Member exposed at the coast around Porthmadog and inland at Tan-y-Grisiau is not yet represented by a GCR site.

The Tremadoc rocks of South Wales have been described only relatively recently (Owens *et al.*, 1982; Cope and Rushton, 1992). They somewhat resemble the Shineton Shales of the Welsh Borderlands, though the full succession and its aggregate thickness are unknown. The site at Cwm Crymlyn near Llangynog (Figure 7.2) shows the lithology and displays the fauna of the *tenellus* Zone better than elsewhere in Wales.

[Bryn-llin-fawr](#)

[Dol-cyn-afon](#)

[Tyn-llan](#)

[Pen Benar](#)

[Wern Road](#)

[Amnodd-bwll](#)

[Y Garth](#)

[Cwm Crymlyn](#)

England

The Tremadoc of the Welsh Borderland and the English Midlands is represented mainly by the Shineton Shale Formation and its equivalents, to which several local names have been given (Cowie *et al.*, 1972, pl. 1). These are unmetamorphosed mudstones and siltstones deposited across the Midlands microcraton, partly in grabens or half-grabens associated with local rifting, in which their thickness may be 2000 m or more (Smith and Rushton, 1993). The succession is generally incomplete at the base, because of either non-sequence or (as at Cherme's Dingle) faulting. Even where there is sedimentary continuity, as in the subcrop in central England, faunas of the topmost Merioneth and lowest Tremadoc remain unproved and the transition beds are of uncertain age (Old *et al.*, 1987; Bridge *et al.*, 1998). At the top of the Shineton Shale Formation there is widespread erosion and an unconformity with overlying beds. Only in the Shelve area is there an approach to continuity between the Tremadoc and the overlying Arenig.

The Shineton Shales are generally poorly exposed, but much of the Cressagian, represented by the *flabelliformis* and *tenellus* zones, is exposed in the Cherme's Dingle site, and the lower parts of the Migneintian, namely the *salopiensis* Zone, are exposed in Sheinton Brook and, at a slightly higher level at Cound-moor Brook, Evenwood see (Figure 7.1) and (Figure 7.10). The highest Tremadoc of the Welsh Borderland, the Habberley Formation, crops out in Linley Big

Wood (Fortey and Owens, 1992) and is represented by the Granham's Moor, Eastridge Wood and Linley Big Wood GCR sites (Figure 7.11).

In northern England, Tremadoc rocks have now been proved at a few places in the Skiddaw Group of the Lake District (Molyneux and Rushton, 1985). Typical acritarch floras of various Tremadoc ages are known from clasts within an olistostrome deposit, the Buttermere Formation of Cooper *et al.* (1995, p. 201), and a similar derivation may apply also to the strata at the River Calder site (see (Figure 11.1)), where upper Tremadoc trilobites have been described (Rushton, 1988). Of international significance is the presence of a fossiliferous section through highest Tremadoc to lowest Arenig at Trusmadoor, Great Cockup (described in Chapter 11), because it is the best candidate in Britain for a graptolitic base to the Moridunian Stage of the lower Arenig Series.

[Cherme's Dingle](#)

[Sheinton Brook](#)

[Coundmoor Brook, Evenwood](#)

[Granham's Moor and Eastridge Wood, and Linley Big Wood](#)

[River Calder, Latter Barrow](#)

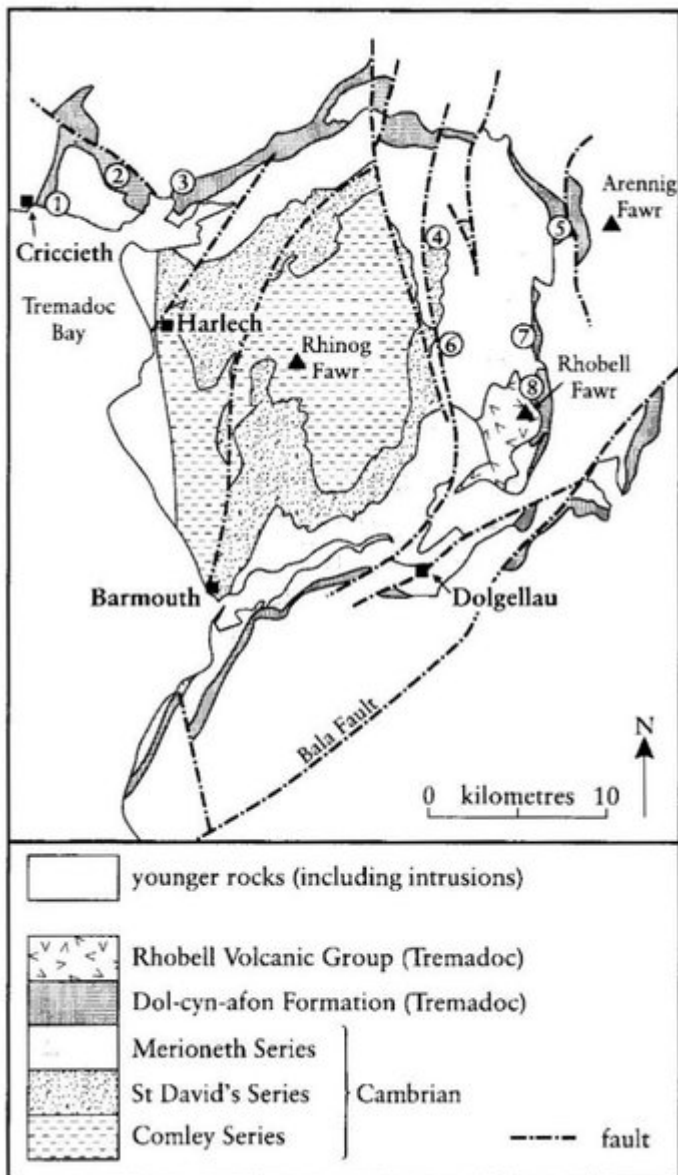
[References](#)

British graptolite zonation	Chronostratigraphy (with stages and substages)	Isotopic dates
<i>'Glyptograptus' persculptus</i>		
<i>Climacograptus? extraordinarius</i>	Hirnantian	
<i>Dicellograptus anceps</i> <i>Paraorthograptus pacificus</i>	Rawtheyan	446 ± 2 ¹
<i>Dicellograptus complexus</i>		
<i>Dicellograptus complanatus</i>	Cautleyan	
<i>Plesnograptus linearis</i>	Pusgillian	
<i>Dicranograptus clingani</i> <i>Dicellograptus morrissi</i>	Streffordian	Onnian Actonian
<i>Ensigraptus caudatus</i>		
<i>Diplograptus multidentis</i>	Cheneyan	Marshbrookian Woolstonian
<i>Nemagraptus gracilis</i>	Burrellian	Longvillian ← 448 ± 4 ² , or Soudleyan ← 457 ± 2 ¹ Harnagian ← 456 ± 2 ⁵
<i>Hustedograptus teretiusculus</i>		
<i>Didymograptus marchisoni</i>	Aurelucian	Costonian Velfreyan
<i>Didymograptus artus</i>	Llandeilian	460 ± 2 ⁵
<i>Expansograptus hirundo</i>		
<i>Isograptus caduceus gibberulus</i>	Aberiddian	← 465 ± 2 ¹ ← 462 ± 3 ² , or ← 466 ± 2 ¹
<i>Didymograptus simulans</i>	Fennian	
<i>Didymograptus varicosus</i>	Whitlandian	← 471 ± 3 ²
<i>Tetragraptus phyllograptoides</i>		
<i>Araneograptus murrayi</i>	Moridunian	
Trilobite zones (no graptolites) <i>Angelina sedgewickii</i> ? <i>Conophrys salopiensis</i> ?	Migneintian	483 ± 1 ³
<i>Adelograptus tenellus</i> ?		
<i>Rhabdinopora flabelliformis</i> s.l.	Cressagian	<491 ± 1 ⁴

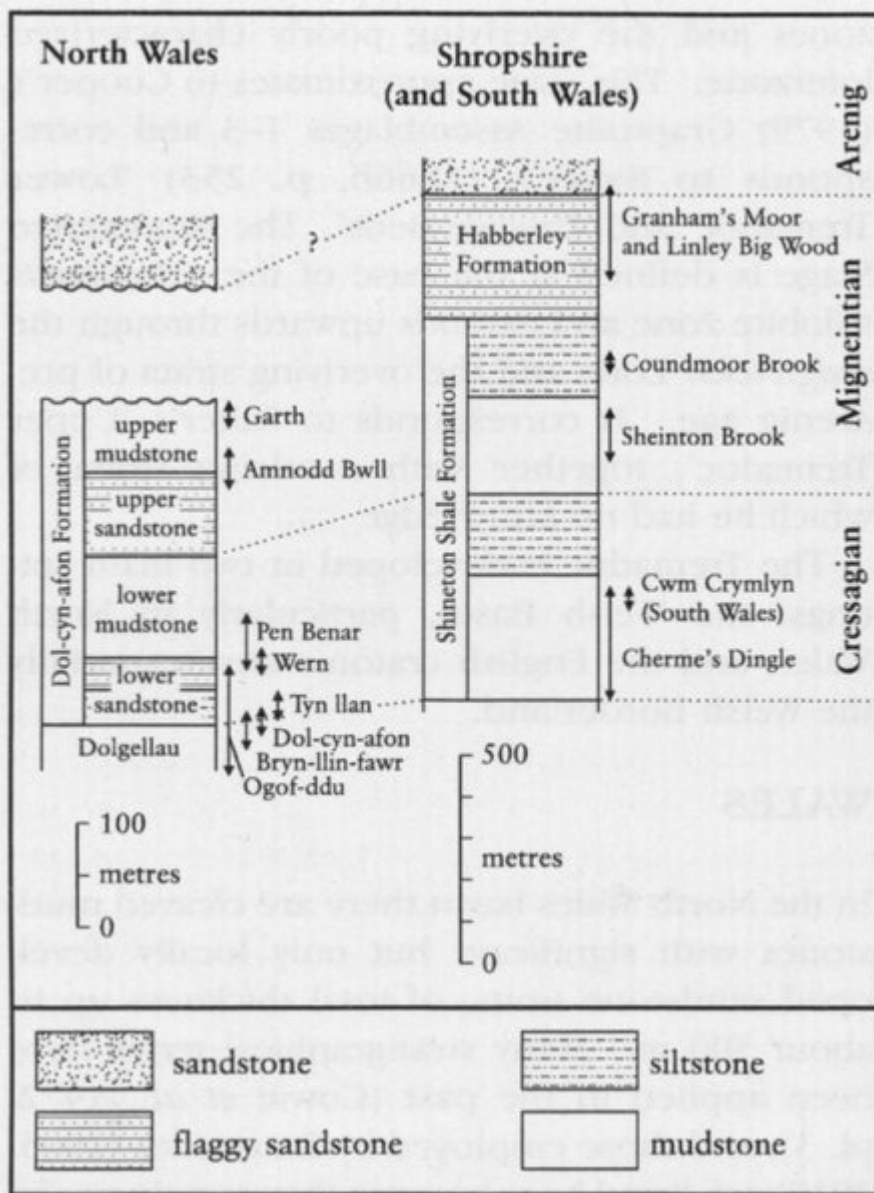
(Figure 6.2) Chronostratigraphy of the Ordovician of England and Wales, correlated with the graptolite zonation. Selected ages (in millions of years) from the study of radioactive isotopes are shown to the right. Sources: 1, Tucker et al. (1990); 2, Compston and Williams (1992); 3, Landing et al. (1997); 4, Davidek et al. (1998); 5, Tucker and McKerrow (1995).

Fearnside's (1910) (Tremadoc or Ynyscynhaiarn)	Howells and Smith (1997)	Fearnside's (1905) (Arenig area)
Garth Hill Beds Penmorfa Beds	Upper Mudstone	— Amnodd Beds
Portmadoc Flags Moel-y-gest Beds Tyn-Ilan Beds (Dolgelly Beds)		Tai-hirion Flags Nant-ddu Beds Niobe Beds Dolgelly Beds
	Upper Sandstone Lower Mudstone Lower Sandstone Dolgellau Formation	Migneintian Cressagian Merioneth

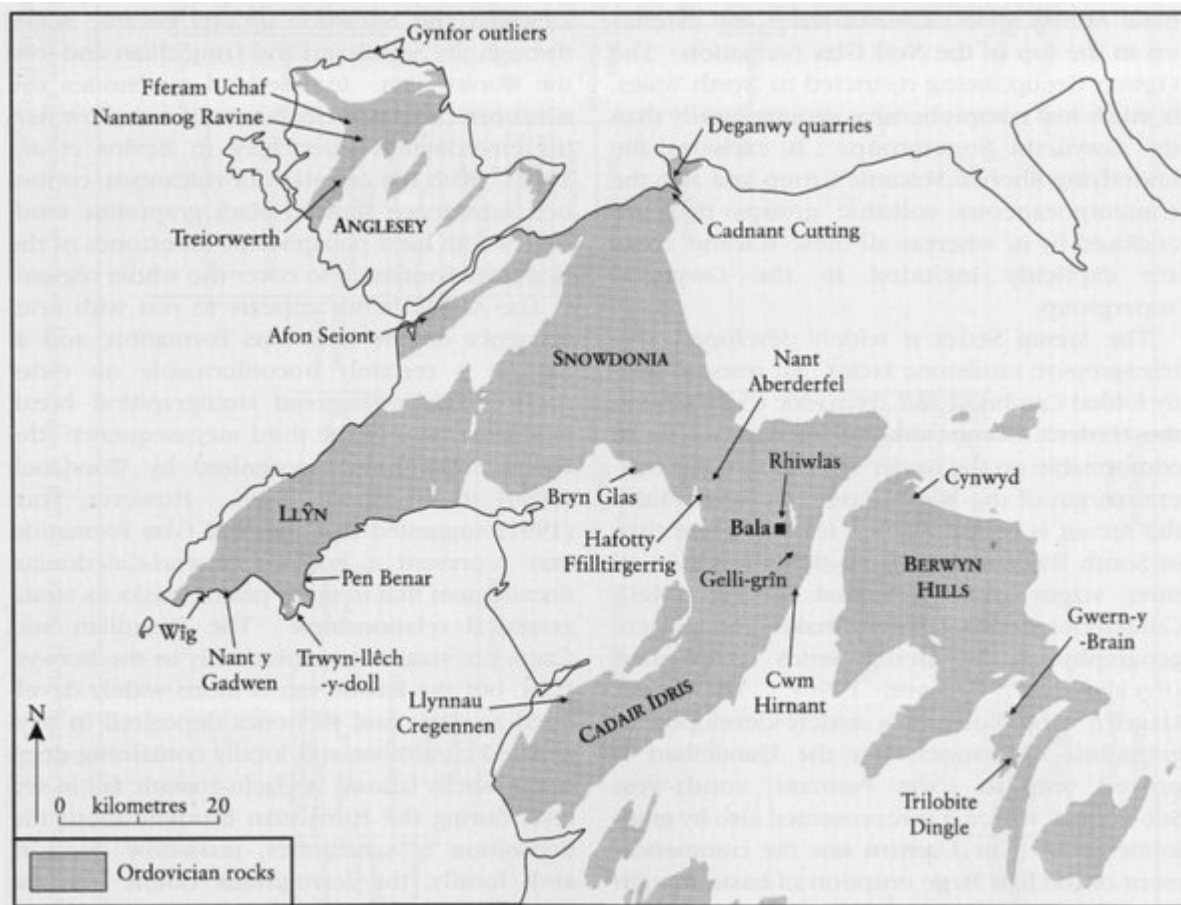
(Table 7.1) Divisions of the Tremadoc in Wales, showing their approximate correlation.



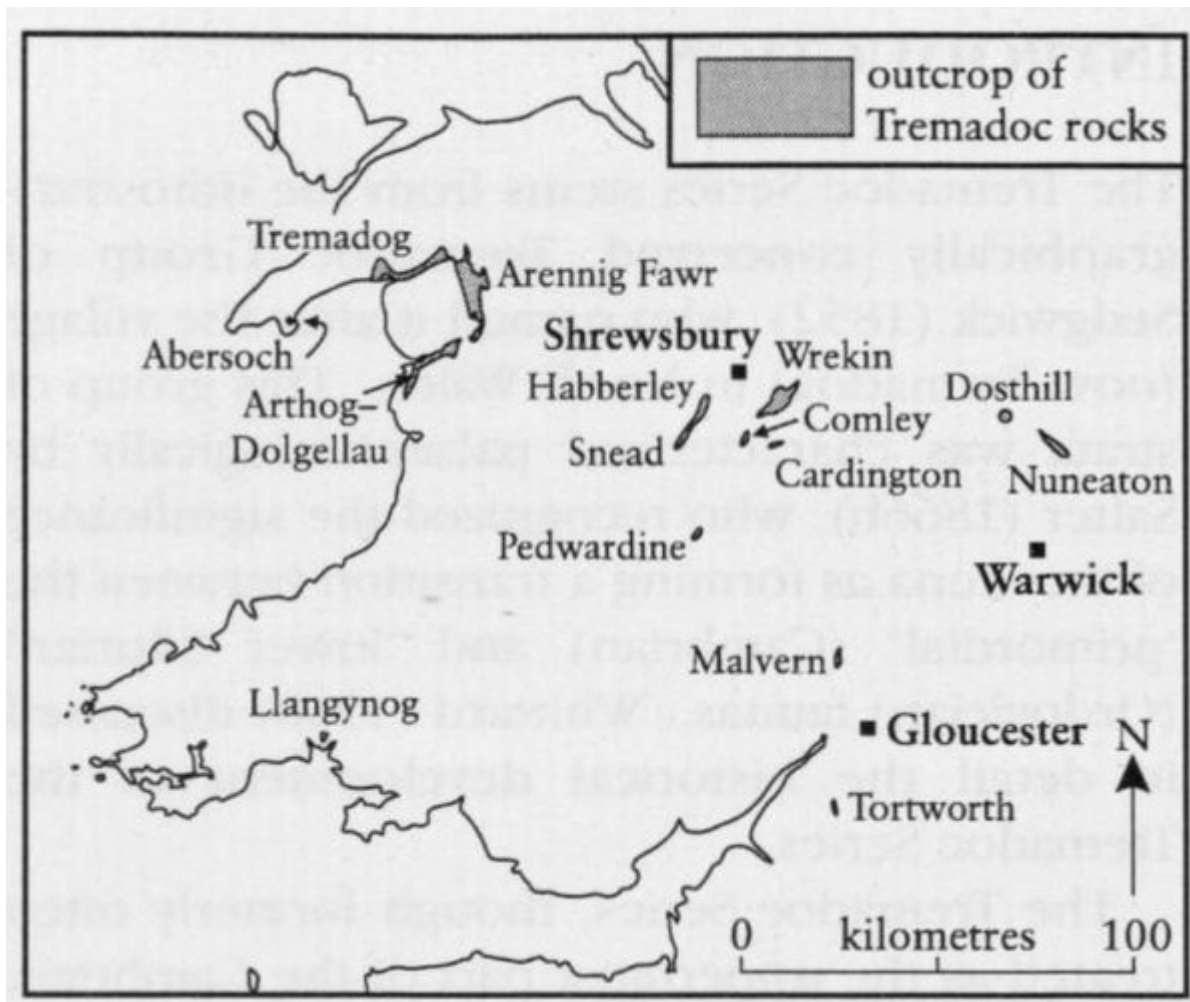
(Figure 3.2) Geological sketch-map of the Harlech Dome, after the British Geological Survey (1994b). Cambrian and Tremadoc GCR sites are as follows: 1, Ogof Ddû; 2, Tyn-Ilan and Wern; 3, Y Garth; 4, Afon Llafar; 5, Amnodd Bwll; 6, Nant-y-graeon; 7, Bryn-Ilin-fawr; 8, Rhobell-y-big and Dol-cyn-afon.



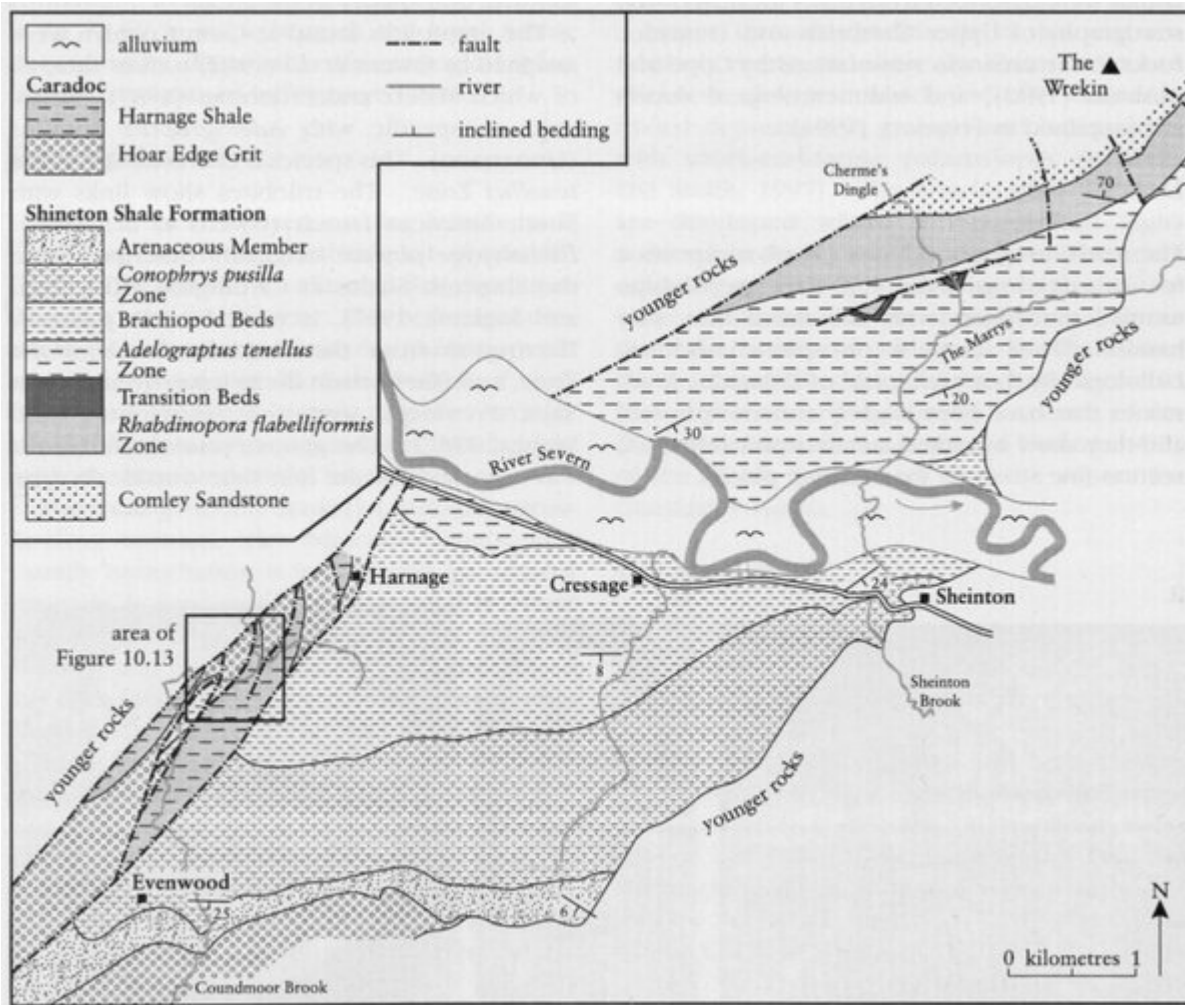
(Figure 7.2) Outcrops of Tremadoc rocks in Wales and central England, after Bulman and Rushton (1973).



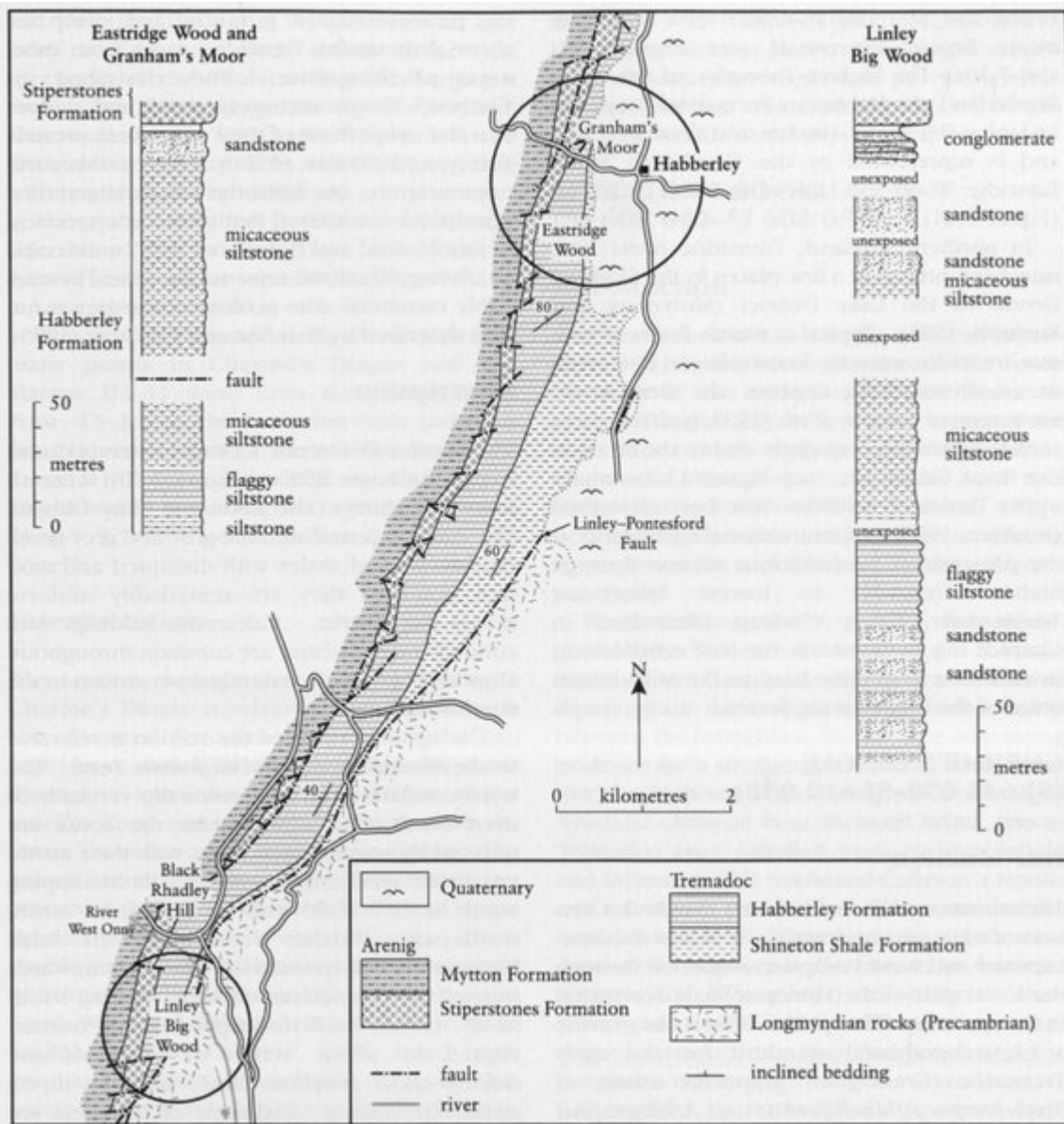
(Figure 9.1) Distribution of Ordovician (Arenig to Ashgill) rocks in North Wales, after British Geological Survey (1994c), showing the location of GCR sites. For the Tremadoc site at Pen Benar, see Chapter 7.



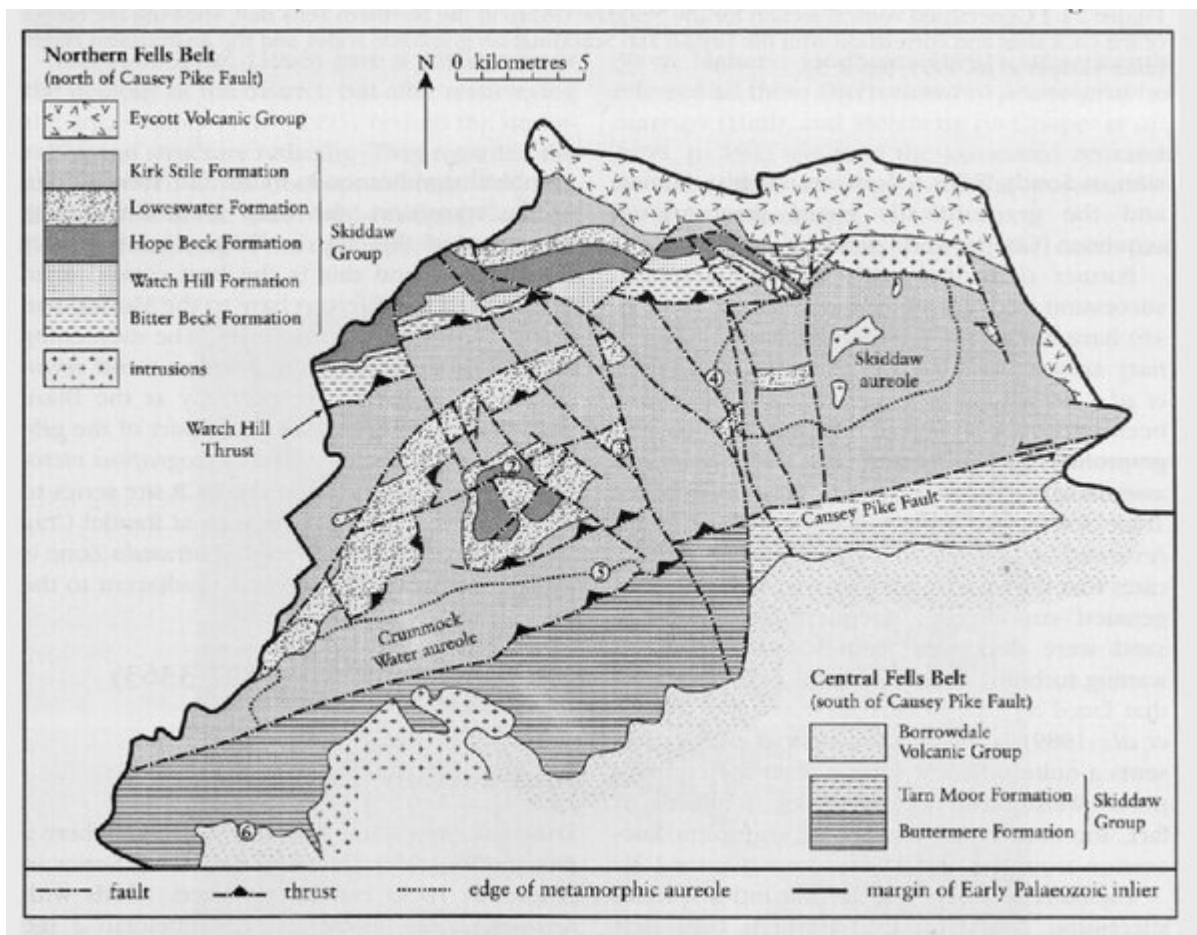
(Figure 7.1) Generalized sequences of Tremadoc rocks in North Wales and Shropshire, showing stratigraphical ranges of individual GCR sites. For locations of sites see (Figure 3.2), (Figure 7.9), (Figure 9.1) and (Figure 10.1).



(Figure 7.10) Geological map of the Shineton Shales of the Wrekin district, after Stubblefield and Bulman (1927, pl. 5). Coundmoor Brook includes the Tremadoc GCR site south-east of Evenwood and the type Harnage Shale locality south-west of Harnage (Chapter 10).



(Figure 7.11) Geological sketch-map of the Tremadoc rocks from the area of Granham's Moor to Linley Big Wood, with vertical sections exposed in each area, after Fortey and Owens (1992, fig. 1).



(Figure 11.1) Geological sketch-map of the Skiddaw Group in the main outcrop of the English Lake District, after Cooper et al. (1995, fig. 2). GCR localities: 1, Trusmadoor; 2, Blaze Bridge and Scawgill Quarry; 3, Barf; 4, Randel Crag; 5, Outside; 6, River Calder (Tremadoc, Chapter 7).