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7. Welsh Basin

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The Cambrian rocks of Wales mostly lie within the Avalon composite terrane, apart from a small area of Cambrian rocks of the Monian composite terrane that is discussed in Chapter 9. The Cambrian rocks of the Welsh basin form the greater part of the Dyfed Supergroup of Woodcock (1990), the base of which overlies a widespread early Cambrian unconformity and the top of which extends to the late Tremadocian (Ordovician). The Dyfed Supergroup extends onto the Midland microcraton in attenuated form, with substantial gaps in the successions locally. The correlation of the basal parts of the Dyfed Supergroup is uncertain because of the lack of suitable evidence, but Woodcock was able to interpret the supergroup as a megasequence composed of five sequences, labelled in ascending order *Ia* to *Ie*, each separated by eustatic, tectonic or volcanic events, or a combination of these (Woodcock 1990, fig. 6). Sequence *Ib* includes strata assigned to the later Terreneuvian and all of Series 2; the strata of Sequence *Ic* are those of Stage 5 and the Drumian. The bases of sequences *Id* and *Ie* are particularly strongly marked, mainly by eustatic regressions, the former in the Guzhangian and the latter near the top of the Furongian, so that *Ie* is essentially composed of Tremadocian strata.

Based principally on his extensive work in the eastern North American sector of Avalonia, Landing (1996) divided the Cambrian to Tremadocian successions in Avalonia into ten epeirogenic sequences (Landing 1996, figs. 2, 5). He recognized equivalents of some of these sequences in selected Welsh and English successions (Landing 1996, p. 51, fig. 7), for example the base of his Sequence 6 (which corresponds to Woodcock's *Ic*) and Sequence 9 (part of Woodcock's *Id*). Although some correlations are doubtful, the presence in Britain of a hiatus at the level of his Sequence 5, as suggested by Landing's analysis (1996, fig. 7), is a possibility that merits further investigation. On the other hand, the downward extension of the Arvon 'Slate Belt' succession to the base of the Terreneuvian appears speculative.

North Wales (Figure 8)

In North Wales Cambrian rocks are recognized in the large anticlinal structure known as the Harlech Dome, a small inlier of comparable strata to the west at St Tudwal's Peninsula, a group of faulted and tectonized inliers around Nantlle and Bethesda in Arfon to the south of the Menai Straits, and also in the Monian Supergroup on Anglesey (see Fig. 7). Apart from the Monian Supergroup, these rocks were all deposited in an ensialic basin, representing an incipient phase of the Welsh trough, principally that part lying between the Bala Fault and the Menai Straits fault complex. Cambrian rocks are not known in mid-Wales SE of the Bala Fault, and the Monian Supergroup is considered as representative of the Monian composite terranes to the north-west. General accounts of the Cambrian rocks in North Wales are given by Rushton (1974) and by Brenchley & Rawson (2006).

Harlech Dome: Columns 1 & 2

The extensional basinal succession of the Harlech Dome is, along with the shelf succession of the Nuneaton district in Central England, the most complete representation of the Cambrian System in Britain, although the correlation of the lower divisions is not well constrained. The Harlech Grits Group and the overlying Mawddach Group represent two cycles of sedimentation, the Harlech Grits Group consisting mainly of turbiditic sandstone divisions, alternating with cleaved silty mudstones, and the Mawddach Group consisting of alternations of sandstones and silty mudstones with thicker formations of dark mudstone at the base and top. The stratigraphical succession and the thicknesses of the divisions are taken from Allen & Jackson (1985), who assessed earlier work, notably that of Matley & Wilson (1946). Generally speaking, individual formations reach their greatest thicknesses towards the centre or eastern part of the Harlech Dome outcrop, and thin north-westwards towards the Irish Sea Horst-complex (Monian composite terrane). There is some geophysical evidence to suggest that a thinner representation of the Harlech Grits may continue south of the Bala Fault (Rushton *in* Brenchley & Rawson, 2006), but there is no evidence from outcrop or boreholes.

The lowest formation of the Harlech Grits Group, overlying the Bryn-teg Volcanic Formation of inferred Precambrian age, is the Dolwen Formation, a sandy sequence interpreted as of deltaic origin. It has yielded in its upper part only one body fossil, recorded by Rushton (*in* Allen & Jackson 1978, p. 46) as *Platysolenites*

antiquissimus, but now referred to *P. cooperi* by McIlroy *et al*. 2001. This species is taken to represent an early Cambrian age, probably Terreneuvian Series[1].

The remainder of the Harlech Grits Group consists of alternations of turbiditic sandstone divisions and cleaved silty mudstones and has proved almost unfossiliferous, apart from undeterminable lingulate brachiopods from slates of the Llanbedr Formation (Lockley & Wilcox 1979). However, the top of the Rhinog Formation and the overlying manganiferous level at the base of the Hafotty Formation are correlated lithologically with corresponding strata in the small but important exposures at St Tudwal's Peninsula (Column 3), where evidence from trilobites and acritarchs indicate a late early Cambrian age (Young *et al*. 1994), equivalent to the top of Series 2, Stage 4 (see below).

The highest formation of the Harlech Grits Group, the tubiditic and manganiferous Gamlan Formation, has yielded a few trilobites that indicate the Drumian Stage of Series 3 (Allen & Jackson 1985, p. 11). The highest sandstone member of the Gamlan Formation was mapped by Matley & Wilson (1946) as the Cefn Coch Grit; this was correlated approximately with the *fissus* Biozone (basal Drumian) by Cowie *et al*. (1972, plate 3). Allen & Jackson (1985, p. 6) did not recognize the Cefn Coch Grit as a unit distinct from the Gamlan Formation.

Drumian (mid-Series 3) trilobites are known from throughout the cleaved mudstones of the Clogau Formation; they indicate the presence of the *fissus*, *parvifrons* and *punctuosus* biozones (Allen & Jackson 1985, p. 12), above which a hiatus is inferred that corresponds to part of the Guzhangian Stage and with the Andrarum Limestone regressive interval (*brachymetopa* Biozone) observed on the Baltic Platform (Nielsen 1996; Nielsen & Schovsbo 2006). This marks the base of Woodcock's (1990) sequence *Id* and of Landing's (1996) sequence 8.

The Mawddach Group consists of alternations of sandy and slaty divisions. The Maenwrog Formation is locally divisible into the sandstone-rich Vigra Member and a more argillaceous Penrhos Member (column 1), but these divisions cannot be recognized consistently across the whole area (Allen & Jackson 1985, p. 12). At one locality the basal Maentwrog Formation yielded a few agnostoids that Rushton (in

[1] Landing's report (in Landing *et al*. 1989, pp. 755, 765) of the presence of the early Cambrian mollusc *Aldanella kunda* in North Wales is a misapprehension and should be disregarded. Although it was cited as a personal communication from Adrian Rushton, it is not based on any specimen known to Rushton, nor was such information communicated by him to Landing, or to anyone else.

Allen *et al.* 1981, p. 307) interpreted as of latest St David's age and are here tentatively correlated with the Guzhangian Stage. The remainder of the Mawddach Group succession, up to the base of the Tremadocian Stage, is correlated by means of Furongian agnostoids and olenid trilobites. These occur at several levels and indicate the presence of all the main zones up to the Tremadocian, though the *Peltura minor* Biozone is very poorly represented and only about half the constituent subzones are proved (Fig. 2). The sandstones of the Ffestiniog Formation contain abundant *Lingulella davisii* but very few trilobites. Though thick, they appear to represent a relatively brief interval. The Dogellau Formation is much thinner and consists of dark mudstones that accumulated relatively slowly but encompass several olenid biozones (Fig. 2). At Bryn-llin-fawr, in the south-east of the Harlech Dome (column 1), the uppermost Furongian *Acerocare* Biozone is proved (Rushton 1982) and the base of the succeeding Tremadocian (Ordovician) is constrained by trilobites and graptolites including *Rhabdinopora flabelliformis* cf. *parabola* (Rushton *et al*. 1999, p. 104). Landing *et al*. (2000) obtained an age of 489±0.6 Ma from a tuffite lying practically at the contact between the Cambrian and Tremadocian rocks. To the north-west, at Ogof-ddû (column 2), the upper Furongian is more condensed, but many zones and subzones are recognized (Fig. 2). The trilobite succession there includes ashy beds, one of which, in the *scarabaeoides* Biozone, yielded an age of 491±1 Ma to Davidek *et al*. (1998).

St Tudwal's Peninsula: Column 3.

The small inliers around St Tudwal's Peninsula expose essentially the same succession as in the Harlech Dome, and are important because they afford biostratigraphical constraints for the lower parts of the Harlech Group succession. Following the work of Nicholas (1915), Young *et al*. (1994) redefined local divisions of the succession, renaming some of them; they revised the thicknesses of each formation and assessed the succession of trilobite faunas and acritarch floras. Bassett *et al.* (1976) described a trilobite fauna from beds 16.5 m below the top of the Hell's Mouth Formation, below the manganiferous beds of the Trwyn y Fulfran Formation. The fauna includes *Hamatolenus douglasi* and *Leptochilodiscus* [formerly *Kerberodiscus*] *succinctus* and a fragment assigned to *Serrodiscus ctenoa*, and was originally assessed as of late Early Cambrian age; it is now considered to lie in the

upper part of Stage 4, possibly the *Cephalopyge* Biozone, close to the base of Series 3 (as recognized here).

Acritarchs recorded from the upper 100 m of the Hell's Mouth Formation by Young *et al*. (1994) include *Cymatiosphaera capsulara*, *Cymatiosphaera ovillensis*, *Dichotisphaera gregalis*, *Eliasum llaniscum*, *Multiplicisphaeridium dendroideum*, *Peramorpha manuelsensis*, *Retisphaeridium dichamerum*, *Retisphaeridium howellii*, *Skiagia insignis* and *Skiagia scottica*. Most of these have stratigraphical ranges that start in or below Stage 4 ("*Protolenus"* interval) and range through into the base of Stage 5 (*oelandicus* Superzone). The only other record of *Peramorpha manuelsensis*, however, is Martin & Dean's (1983) original description, from the Brigus Formation of eastern Newfoundland, at a level in the *Catadoxides* Biozone that has been correlated with the "*Protolenus*" interval (Young et al. 1994, p. 338). Landing & Westrop (1998, p. 24), however, imply that the location of the sample yielding *Peramorpha manuelsensis* is in the St Mary's Member of the Brigus Formation and the *Callavia broeggeri* Trilobite Zone (Stage 3). The reported association of *Peramorpha manuelsensis* with *Eliasum llaniscum* in the Hell's Mouth Formation, however, is indicative of a level in the "*Protolenus*" interval (Stage 4), and probably in the upper part of that interval, consistent with the trilobite evidence.

From the overlying Trwyn y Fulfran Formation, Young *et al*. (1994) recorded *Eliasum llaniscum*, *Retisphaeridium dichamerum*, *Retisphaeridium howellii* and *Skiagia* spp. All these taxa occur in the Hell's Mouth Formation and suggest a Stage 4 to Stage 5 age, but are insufficient to constrain the age of the formation further. The age of the Cilan Formation is constrained by the acritarchs recorded by Young *et al*. (1994), including *Annulum squamaceum*, *Dichotisphaera gregalis*, *Eliasum llaniscum*, *Retisphaeridium dichamerum*, *Retisphaeridium howellii*, *Skiagia* spp. and *Pterospermella solida*. Apart from *P. solida*, all range upwards from the underlying formations. The range of *Pterospermella solida* is also recorded as being from equivalents of the Vergale Stage to the *oelandicus* Superzone. Hence, the acritarch evidence from the Cilian Formation, like that from the Trwyn y Fulfran Formation, indicates only Stage 4 to Stage 5.

Acritarchs from the Ceiriad Formation include many that range upwards from the underlying formations, but the assemblage is distinguished by the occurrence of *Cristallinium cambriense*, which has its first appearance in the *oelandicus* Superzone. Coupled with the ranges of other taxa, notably *Cymatiosphaera capsulara*, this

occurrence suggests that the Ceiriad Formation is probably referable to the *oelandicus* Biozone, above the base of Stage 5. The succeeding Nant-y-big Formation contains agnostoids such as *Tomagnostus fissus, Ptychagnostus punctuosus* and the paradoxidid *Mawddachites hicksii*. These trilobite assemblages indicate the lower two zones of the Drumian Stage. The acritarch assemblage recorded by Young *et al*. (1994) contains a number of taxa recorded from underlying formations, but *Adara alea* and *Heliosphaeridium*? *llynense* are also present. The former is restricted to Zone A1 of eastern Newfoundland (the *Adara alea* Acritarch Zone), which spans the upper *Tomagnostus fissus* and the *Hypagnostus parvifrons* trilobite zones.

The hiatus between the equivalents of the Clogau and Maentwrog formations is greater at St Tudwal's than in the Harlech Dome, but is peculiar because the conglomerate at the base of the Maentwrog contains limestone clasts with fossils of the *brachymetopa* Biozone, which is otherwise unrepresented in Wales (Young *et al*. 1994). This occurrence is analogous to the Exporrecta Conglomerate of southern Sweden (Nielsen & Schovsbo 2006, fig. 4), which overlies a stratigraphical hiatus at about the horizon of the *brachymetopa* Biozone, and may contain a mixture of reworked material that partly represents the zones missing at the hiatus.

Higher parts of the Mawddach Group are present at St Tudwal's Peninsula, namely thin developments of the Maentwrog and Ffestiniog formations that are overstepped by Arenig strata that locally form the base of the Ordovician. The Maentwrog Formation contains poorly preserved *Homagnostus* cf. *obesus* and doubtful fragments that resemble *Olenus* sp. The acritarch assemblage from the Maentwrog Formation (Young *et al*. 1994) is markedly different from those of the underlying formations, with *Cymatiogalea* spp., including *Cymatiogalea aspergillum* and *C. virgulta*, *Leiofusa stoumonensis*, *Stelliferidium pingiculum*, *Timofeevia* spp., including *T. lancarae*, *T. microretis*, *T. pentagonalis* and *T. phosphoritica*, and *Vulcanisphaera turbata*. A number of these taxa have their first appearances in the upper A2 Zone of eastern Newfoundland, correlated with the *Agnostus pisiformis* and *Olenus* trilobite zones, and range through into the A4 Zone, correlated with the upper part of the *Parabolina spinulosa* Trilobite Zone to lower *Protopeltura praecursor* Trilobite Zone. *Stelliferidium pingiculum*, however, ranges from the upper A2 Zone to the A3b Zone (lower *P. spinulosa* Trilobite Zone). The Ffestiniog Flags Formation has numerous *Lingulella davisii*, as in the main outcrop (Young *et al*. 1994). The acritarch assemblage is similar to that from the Maentwrog Formation. It lacks

Timofeevia microretis, but also includes *Cymatiogalea parvivela*, *Multiplicisphaeridium* cf. *M. eopiriferum*, *Poikilofusa* cf. *P. chalaza* and *Poikilofusa* cf. *P. squama*. Young *et al*. (1994) compared this microflora with that from Zone A3a of Martin & Dean (1988) in eastern Newfoundland.

Arfon: Columns 4 - 6

The Cambrian of Arfon (Carnarvonshire) was in the past commercially important for the large-scale quarrying of excellent roofing-slate. The district is strongly tectonized and this has led to difficulties in interpreting the succession; the area has been the seat of controversy since the mid-19th century. The rocks, mainly sandstones and slates, were deposited in local fault-controlled basins, principally the Arfon Basin that developed along the margin of the Irish Sea Horst. Some of the successions are very thick. They rest with unconformity or paraconformity on the Precambrian basement of Padarn Tuff (Reedman *et al.* 1984), which has yielded radiometric ages of 614±2 Ma (Tucker & Pharaoh 1991) and 604.7±1.6 Ma (Compston *et al*. 2002).

To the south-east of the Aber-Dinlle Fault, the Fachwen Formation (Column 5), which overlies the Padarn Tuff unconformably or paraconformably and is composed very largely of fragments derived from it, was hitherto regarded as of early Cambrian age (e.g. by Rushton *et al.* 1999, p. 42). Now that Compston *et al.* (2002) have recorded an age of 572.5±1.2 Ma from a bed of welded ash-flow tuff within it, the indications are that the Fachwen Formation is substantially older than the age accepted for the base of the Cambrian, and it is assumed that there is an unidentified hiatus somewhere between the dated tuff in the Fachwen Formation and the Llanberis Slates Formation, which contains Cambrian fossils. The Fachwen Formation seems to pass laterally south-westwards into some of the clastic divisions mapped near Nantlle (Column 4) by Morris and Fearnsides (1926) as the Tryfan Grit 'Group', Cilgwyn Conglomerate and Glog Grit 'Group', for none of which is the age known with any certainty.

To the north-west, in a half-graben developed between the Dinorwic and Aber-Dinlle faults, Reedman *et al.* (1984) recognized the Minffordd Formation (Column 6), composed of coarse clastics, including material derived from the Padarn Tuff, and beds of acid tuffite. The age of the formation is uncertain, but the presence of sponge spicules suggests a Cambrian rather than Precambrian age. The unconformably overlying Bangor Formation is lithologically similar to the Minffordd

Formation, and is followed conformably by the Llanberis Slate Formation (Series 2), discussed below.

The Llanberis Slate Formation consists of silty slates with substantial sandstone intervals (Howells, Reedman & Leveridge 1985, p. 5). It is mapped as succeeding the Bangor Formation conformably, but the contact with the Fachwen Formation is presumably paraconformable (see above). The Llanberis Formation succession is fairly uniform along strike (Morris & Fearnsides 1926). Early Cambrian trilobites from the highest unit of the slates (Howell & Stubblefield 1950), namely *Pseudatops viola*, *Protolenus*?, *Strenuella*? and *Serrodiscus*?, suggest a level in Series 2, near the boundary of stages 3 and 4 (<520 Ma), and are considered to be older than those from the top of the Hell's Mouth Formation at St Tudwal's Peninsula (Bassett *et al.* 1976). Correlation charts by Landing (1996) and McIlroy *et al.* (1998) indicate, through lithological correlations, that the basal beds of the Llanberis Formation are as low as, or lower than, the base of the Cambrian. However, if the Cambrian age of the underlying Minfordd and Bangor formations is accepted, such a great age for the basal Llanberis Formation is dubious.

The greywackes of the Bronllwyd Grit Formation (Howells, Reedman & Leveridge 1985, p. 6), and its lateral correlative the Cymffyrch Grit, overlie the Llanberis Formation, but the nature of both the basal and upper contacts is uncertain: each has been claimed to represent either an erosional gap or to be conformable. In the absence of fossils or other evidence, the age and correlation of the Bronllwyd Grit remains uncertain (Rushton 1974, p. 81). Sections by the British Geological Survey (1988) show conformity with the overlying Marchllyn Formation, and if this is accepted, it implies a considerable stratigraphical break below the base of the Bronllwyd Grit Formation.

The Marchllyn Formation (Howells & Smith 1997, p. 8) is a coarser-grained equivalent of the Maentwrog and Ffestiniog formations of the Harlech Dome and has yielded few fossils, but the Carnedd y Filiast Grit Member towards the top contains the brachiopod *Lingulella davisii* (which characterizes the Ffestiniog Formation) and is rich in distinctive trace-fossils including *Cruziana semiplicata* (Crimes 1970a). A local outlier of lower Dolgellau Formation conformably overlying the Marchllyn Formation in Cwm y Ffynnon contains fossils of the *P. spinulosa* Biozone (Howells & Smith 1997, p. 13). Arenig overstep conceals any younger Cambrian rocks in this area.

Red Wharf Bay, Anglesey: Column 7

The Careg-onen Beds of eastern Anglesey were described by Greenly (1919, p. 393) as exposed in four places, and were interpreted by him as small outliers of a formerly continuous formation. Like the Minffordd Formation, they are sandstones and, as they contain sponge spicules, Rushton (1974, p. 79) regarded them as probably of Cambrian age, though Greenly (1946, p. 238) had considered them much older. Greenly showed the north-eastern outlier, at Careg-onen itself, in deformed contact with rocks mapped as the 'Gwna Group' of the Monian Supergroup, which is here regarded as of Cambrian age (Column 20, Fig. 13). The other three outliers he mapped as unconformably overlying "Penmynydd Schist", or blueschist of the Aethwy Terrane, that is Neoproterozoic in age (McIlroy & Horák (2006, p. 20). However, a possibility entertained here is that the Careg-onen Beds are megaclasts of older Cambrian sandstone in the Gwna Group (see Chapter 9).

South Wales (Figure 9)

Although the succession near St David's (Column 8) is well exposed on the coast and has long been known, formal definitions of the lithological divisions have not been published in recent times. However, Prigmore & Rushton (in Rushton *et al*. 1999, pp. 53-67) have summarized published information on the succession. There appear to be three major cycles of basin-filling, as suggested by Crimes (1970b), rather than the two cycles suggested by Brenchley *et al.* (2006, p. 37); the first cycle is represented by the Caerfai Group, the second by the Solva and Menevian groups and the third by the 'Lingula Flags'. A very similar succession is described inland, farther east at Hayscastle (Column 9), whereas the succession at Llangynog (Column 15), near Carmarthen, on the margin of the Wrekin Block of the Midlands Platform, is treated in Chapter 8.

St David's Peninsula: Column 8

The general stratigraphical succession of this classic area has been known since the 19th century and was described by Cox *et al.* (1930). Early work was summarized, with references, by Rushton (1974, pp. 86-91) and detailed guides to the area were written by Stead & Williams (1971) and Williams & Stead (1982). In the present

account we follow research by Loughlin & Hillier (2010), and adopt many details kindly supplied by Dr A. J. Rees and Dr A. T. Thomas, and in particular revise thicknesses of several units based on their as yet unpublished research.

The Caerfai Group (Column 8) represents an Early Cambrian transgressive sequence, referable to the upper Terreneuvian and Series 2, that overlies unconformably the Pebidian volcanic rocks (Precambrian) at the southern edge of the Welsh Basin. The lithologies and thicknesses of the divisions of the Caerfai Group are generally fairly constant across the area towards Hayscastle (Column 9), and the whole group is much less thick than the early Cambrian rocks of North Wales. Loughlin & Hillier (2010) interpreted the Caerfai Group as representing part of a deltaic system. The wider correlatives of the basal conglomerate and the St Non's Sandstone (140 m) are not very certain, but ichnological study showed intense activity producing large *Teichichnus* traces that are taken to post-date the *Trichophycus pedum* Ichnozone and to lie within or above the *Rusophycus avalonensis* Ichnozone (late Fortunian to early Series 2). The succeeding Caerfai Bay Shales include thin interbeds of water-laid crystal tuffs in Caerfai Bay that gave a radiometric age of 519±1 Ma (Landing *et al.* 1998). Farther east, at Cwm Bach near Newgale, red mudstones contain tuffs of the same age (Harvey *et al.*, in press), and at this locality the collection of the bradoriid *Indiana* led Siveter & Williams (1995) to propose a correlation of the Caerfai Bay Shales with the *Callavia* Limestone (Ac2) of Shropshire (Series 2, upper part of Stage 3). However, as Harvey *et al*. (in press) have now shown that the *Callavia* Limestone is younger than 509 Ma, that correlation needs to be revised (see also Chapter 4). Landing *et al.* (1998) proposed a correlation of the base of the Caerfai Bay Shales with beds above an unconformity in the succession in southeastern Newfoundland, but so far no angular unconformity has definitely been identified between the St Non's Sandstone and the Caerfai Bay Shales (Loughlin & Hillier 2010).

No fossils are known from the Caerbwdy Sandstone and the age of those beds is unresolved. In the coastal sections the purple Caerbwdy Sandstone (Column 8) appears to pass up through coarse pebbly beds into the Solva Group, the lower part of which is definitely referable to Stage 5 in Series 3, although the contact has also been regarded as unconformable (Prigmore & Rushton in Rushton *et al*. 1999, p. 57). If the present correlations are approximately correct, either there is an unrecognized hiatus in the succession above the Caerfai Bay Shales or some of the beds are strongly

condensed (Brenchley *et al*. 2006, p. 37). Because Loughlin & Hillier (2010) show that the Caerbwdy Sandstone represents a continuation of the deltaic deposition seen in the lower parts of the Caerfai Group, it seems likely that there is a hiatus. Accordingly, Figure 9 shows, with doubt, a non-sequence between the Caerfai and Solva Groups.

The Solva Group was formerly subdivided into three main divisions, known as the lower, middle and upper Solva beds (summary in Rushton 1974). Stead & Williams (1971) recognized five members within the Lower and Middle Solva, but did not name them formally. The lower Solva division has yielded a fauna that includes *Condylopyge, Plutonides* and *Acadoparadoxides* (*Baltoparadoxides*?), indicating a level in the *oelandicus* Zone in Stage 5. Fossils are rare in the middle division of the Solva, though *Ctenocephalus* (*Hartella*) *solvensis* is recorded. The fauna of the upper Solva includes trilobites (notably *Bailiaspis dalmani*) that represent a level near the top of Stage 5 and approximately equivalent to the *gibbus* Biozone of Scandinavia.

The Menevian Group is also divided into three informal units, summarized by Prigmore & Rushton (in Rushton *et al.* 1999, p. 60), the lower two being of Drumian age and the age of the upper division remaining uncertain. The fauna of the lower unit is typified by *Tomagnostus fissus* and the paradoxidid *Mawddachites hicksii*. The middle Menevian beds yield successive faunas representing the *Hypagnostus parvifrons* and *Ptychagnostus punctuosus* biozones (the latter including *Paradoxides davidis*), and closely resembling the faunas of the Clogau Formation in North Wales. The upper Menevian sandstones yield the brachiopod *Billingsella*? *hicksii,* and Hicks (1892) also recorded trilobites, but the correlation of this division is uncertain.

The upper Cambrian part of the succession is known, rather informally, as the ‘Lingula Flags’, a term that was in general use in North Wales for the Maentwrog and Ffestiniog formations. Parts of the succession have been termed Ogof Velvet Formation, originally for the lower beds on Ramsey Island, and Treffgarne Bridge Beds for the fine-gained upper beds east of Hayscastle, but these have not been fully characterized. The brachiopod *Lingulella davisii* has been recorded in several places, and in the lowest beds near Porth-y-rhaw Dr M. Lewis collected the species *Agnostus pisiformis* (unpublished, specimens held in the National Museum of Wales), suggesting the presence of the *pisiformis* Biozone in the later part of the Guzhangian Stage, i.e. of earliest Merioneth age.

Hayscastle area: Column 9

The succession in this area is generally less well exposed than around St David's. The terminology in Column 9 is from Thomas & Jones but the correlation is shown as revised by Stead & Williams (1971). Much of the succession is similar to that at St David's, especially that of the Caerfai Group; Cwm Bach, in the present area, is the principal source of the fossils that show that the Caerfai Group is of Early Cambrian age (Siveter & Williams 1995). Around Hayscastle and Tremaenhir, however, there are sandstones of uncertain age between the supposed equivalents of the Caerbwdy and Solva rocks: purple sandstones correlated lithologically with the Caerbwdy Sandstone are succeeded by coarser green or yellow sandstones that were placed at the top of the Welsh Hook Beds of Thomas & Jones (1912) and termed the "green quartzose sandstones"; these are succeeded by the Musland Grit which lies at the base of Thomas & Jones's Ford Beds. The green quartzose sandstones have been regarded as a lateral equivalent to the upper Caerbwdy Sandstone or as a separate formation lying between equivalents of the Caerbwdy Sandstone and the Solva Group (summary in Rushton 1974, p. 87). However, Stead & Williams (1971, p. 197) showed that Thomas & Jones's "green quartzose sandstone" and Musland Grit are most closely comparable with the lower and part of the middle Solva Group. At the western end of the Hayscastle Anticline is a faulted outcrop of sandstone referred to as the Newgale Beds, for which Davies & Downie (1964) suggested a Middle Cambrian age based on acritarchs recovered from five samples. They compared specimens from the Newgale Beds with taxa recorded by Timofeev (1959) from the Cambrian of the Baltic. The assemblage consists mainly of sphaeromorph and simple acanthomorph acritarch species, accompanied by a possible *Ooidium* and species of *Acanthodiacrodium*. Davies & Downie (1964) noted that *Acanthodiacrodium* was typical of the Cambrian, as opposed to the Ordovician, but the genus is particularly characteristic of the Tremadocian, which at the time of their report was included in the British Cambrian. *Acanthodiacrodium* does, however, appear in the upper Cambrian, and *Ooidium* is characteristically a late Cambrian form. The acritarchs from the Newgale Beds need a modern reappraisal before the evidence that they provide for the age of the division can be reassessed.

Williams & Stead (1982, p. 48) reported major faulting between the Musland Grit and the 'banded shales' of the Ford Beds [note that they used some of Thomas &

Jones's (1912) nomenclature in a different sense from the original]. A few agnostoids indicate that the 'banded shales' of the Ford Beds are equivalent to the lower part of the Menevian beds of St David's, but there are no known equivalents of the upper Solva beds. Higher in the succession, the argillaceous development of the 'Lingula Flags', distinguished as the Treffgarne Bridge Beds (Cowie *et al*. 1972, p. 32, note 80), contains the Furongian (Paibian) species *Homagnostus obesus* and *Olenus cataractes*, indicating the upper part of the *Olenus* Biozone.

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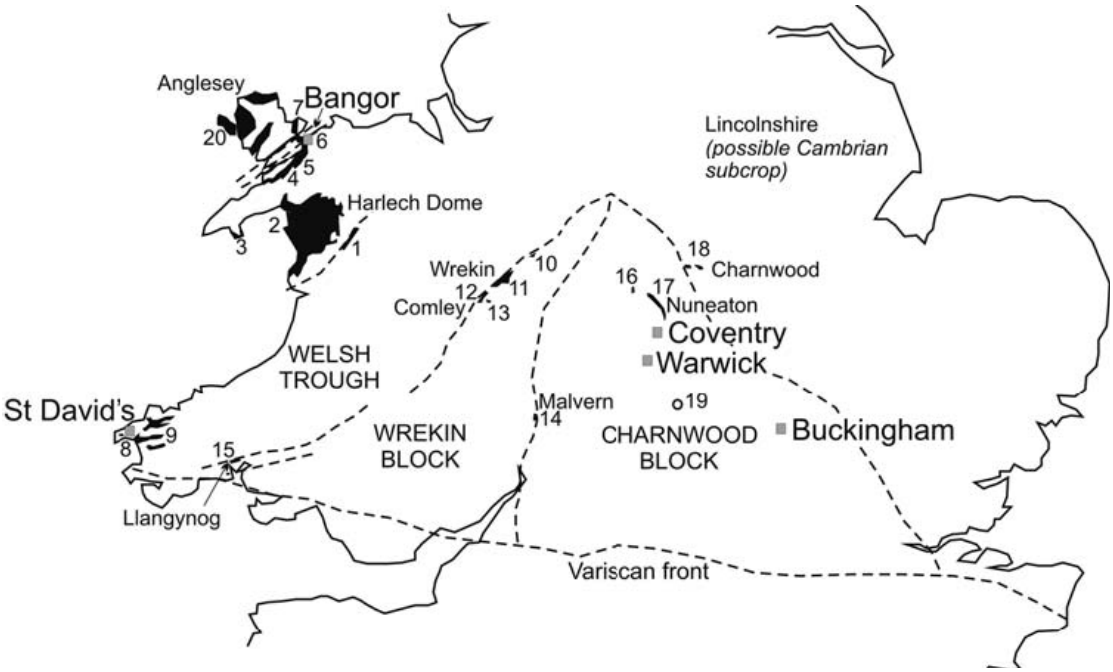

Fig. 7. Distribution of Cambrian outcrops (black) in England and Wales. Important lineaments are shown as dashed lines. The numbers 1-20 refer to the locations of stratigraphical columns 1-20 in Figures 8-13.

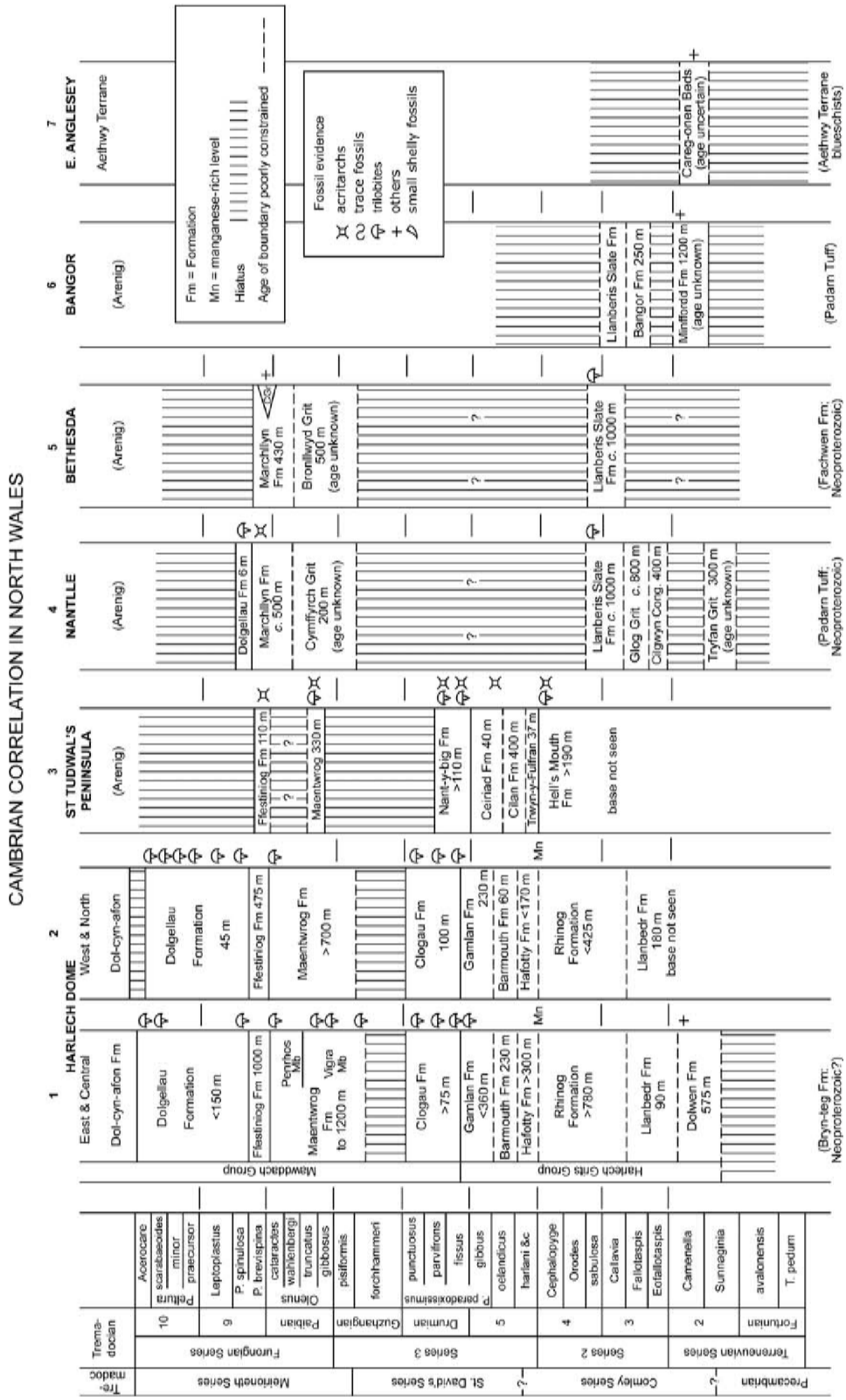

Fig. 8. Correlation of Cambrian successions in North Wales.

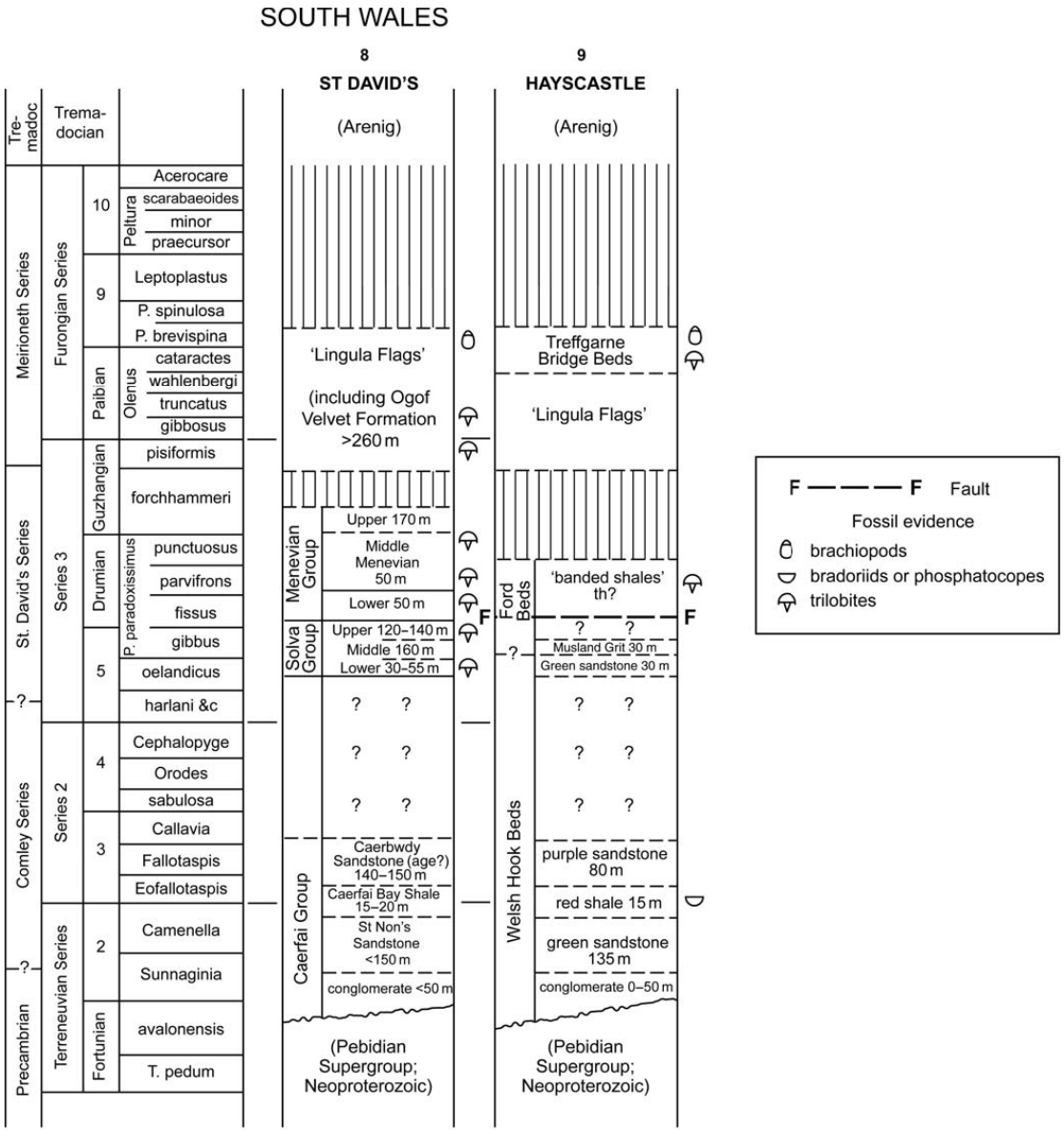

Fig. 9. Correlation of Cambrian rocks in south-west Wales (St David's Peninsula).