ASHGILL SEDIMENTS BETWEEN PLYNLIMON AND MACHYNLLETH, WEST CENTRAL WALES

by

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Summary

The Ashgill sequences between the west flank of the Plynlimon inlier and Machynlleth are of deep water facies and in their uppermost portions are characterized by extreme variation of thickness and facies markedly at variance with the regional development of a rather uniform deep water mudstone facies.

Remapping, aided by new exposures along forestry roads, has resulted in several significant modifications to previous estimates of stratigraphic thickness and correlation. Some differences from the mapping on B.G.S. sheet 163 (Aberystwyth) are highlighted. The former model of control of sedimentation by a single, depositional, intrabasinal slope is refined by more detailed sedimentary studies to a model with two, non-depositional, slopes. The slopes are considered to be induced above basement faults, active at the time, which later controlled the position of the Glandyfi vergence divide.

The ideas developed locally concerning sedimentation across fault induced slopes are combined into a general model applicable at large and small scales.

Introduction

Over much of Central Wales the topmost 200–300 m of Ashgill sediments are dominated by monotonous silty non-bedded mudstones. At Plynlimon (fig. 1) where the local Ashgill succession was first mapped, this facies was defined by O.T. Jones (1909) as the Bryn-Glas Group (now Formation) and it can be recognized both in the inliers west of Llanidloes (W.D.V. Jones, 1945; James, 1983a) and also in the Towy anticline south of Rhayader about 30 km to the SE (James, 1983b). Moreover, silty mudstones of similar thickness and facies, albeit gently thinning northeastwards, occur in the same stratigraphic position at Corris (Pugh, 1923) about 20 km to the NW. The first regional overview of these deposits was given by O.T. Jones & Pugh (1935). However on the west of the Plynlimon inlier and around the Llyfnant valley in the inlier south of Machynlleth this orderly arrangement changes rapidly. Massive arenites suddenly appear and disappear again at a level only about 40–60 metres below the mottled mudstones of the *G. persculptus* Zone. This region of rapid facies variation extends NNE at lower stratigraphic levels to Corris and has been interpreted as representing deposition upon an intra-basinal slope (James, 1972): it has general interest as illustrating the problems in the reconstruction of such an environment.

This paper presents a new and reasonably detailed map of the inlier south of the Llyfnant valley and makes several significant revisions to previous thickness estimates and proposed correlations (see fig. 2). It also details new observations on the sedimentology of the massive arenites in the key exposures of the small inliers that link the Llyfnant area to the west flank of the Plynlimon inlier. It is thus possible to refine the previous interpretation and place the local stratigraphy in a clearer regional context; a revision which is timely in view of recent interest in the sedimentological response to the late Ashgill (intra-Hirnantian) ice age (Brenchley & Newall, 1980; Fortuin, 1984; James, 1985). Moreover it affords a comparison with the relevant areas of one-inch sheet 163, Aberystwyth, recently published (1984) by the British Geological Survey (B.G.S.). The revision does not affect the description and interpretation of the sedimentary facies or the informal numbering of the lithostratigraphic members given previously (James, 1972, 1983a) although it does affect the mutual relationships amongst the latter in certain areas.

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The area discussed lies within 1:50,000 Ordnance Survey Sheet 135 (Aberystwyth). Accessibility is quite good in the vicinity of the Pont Erwyd—Talybont mountain road and the (very narrow) roads in the west of the Llyfnant inlier; elsewhere a good deal of rough walking is required. Exposure is generally fair to good.

The recent revision of the base of the Silurian to the base of the *P. acuminatus* Zone (Cocks *et al.*, 1984) leads to the usage in this paper of pre-*persculptus* zone for sequences formerly placed within the latest Ordovician (Jones, 1909; Cave, 1979; B.G.S., 1984). Thus the term 'inlier' refers to the pre-*persculptus* zone sequences formerly simply called Ordovician.

Lithofacies

For the purpose of this paper, five principal lithofacies are distinguished, the letter designations in parentheses being those adopted in James (1972) where detailed descriptions and interpretation may be found.

Ripple-laminated siltstones (A) are bedded in single or multiple cosets of ripple lamination 0.015–0.08 m thick separated by mudstone partings of 0.005–0.05 m. Some of the siltstones are graded and carry flute moulds on their bases. This facies is interpreted as distal turbidites and is not thought to occur in channels; it is hence very useful for correlation.

Coarse siltstones and fine grained arenites (B) occur in 0.08–0.25 m units and are typically graded although seldom massive. Bouma *bc* sequences are characteristic. Facies B does not form large thicknesses of strata and is in many places associated with thick developments of either facies A or C_1; it is interpreted as of turbidite origin.

Fine to medium grained, typically massive arenites (C_1) occur in 0.25–3 m units. The modal unit is 0.6–1.0 m and thicker units are in most places clearly amalgamated. Flute moduls are rare and grading typically delayed, ripple-lamination is not uncommon but is thin where developed. This facies may be balled and pillowed and can be demonstrated in several places to fill channels; it is interpreted as of proximal turbidite origin.

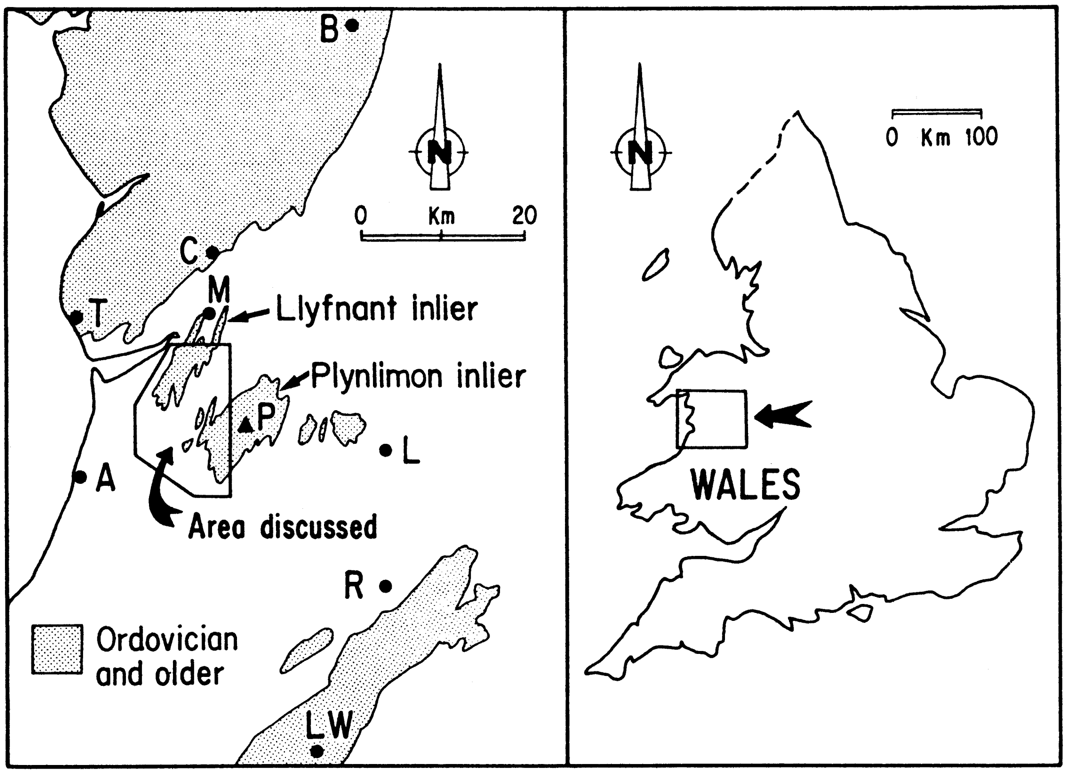

Fig. 1. Location map for Central Wales and the Ashgill inliers. Locality legend: A, Aberystwyth; B, Bala; C, Corris; L, Llanidloes; LW, Llanwrtyd Wells; R, Rhayader; T, Towyn. P is Pen Plynlimon-fawr (752 m).

Conglomerates and pebbly mudstones (respectively D and F) are commonly spatially associated. Most of the conglomerates are very poorly sorted and pebbles seldom exceed 0.05 m. Bedding is markedly lenticular and the fills of scours are heterogeneous. The conglomerates are thought to result from deposition from inertia flows (Lowe, 1982) and the pebbly mudstones are interpreted as mass-flow deposits. With caution the pebbly horizons are useful in correlation.

Muddy sandstones and sandy mudstones (G) differ from facies C_1 in the complete absence of bedforms. Many beds have a dispersed grain framework and small shale fragments are present in some units. The facies grades into facies C_1 by loss of matrix and development of slump and ball and pillow structures; it is thus interpreted to result from mass-flow redistribution of facies C_1 during which admixture of mud took place.

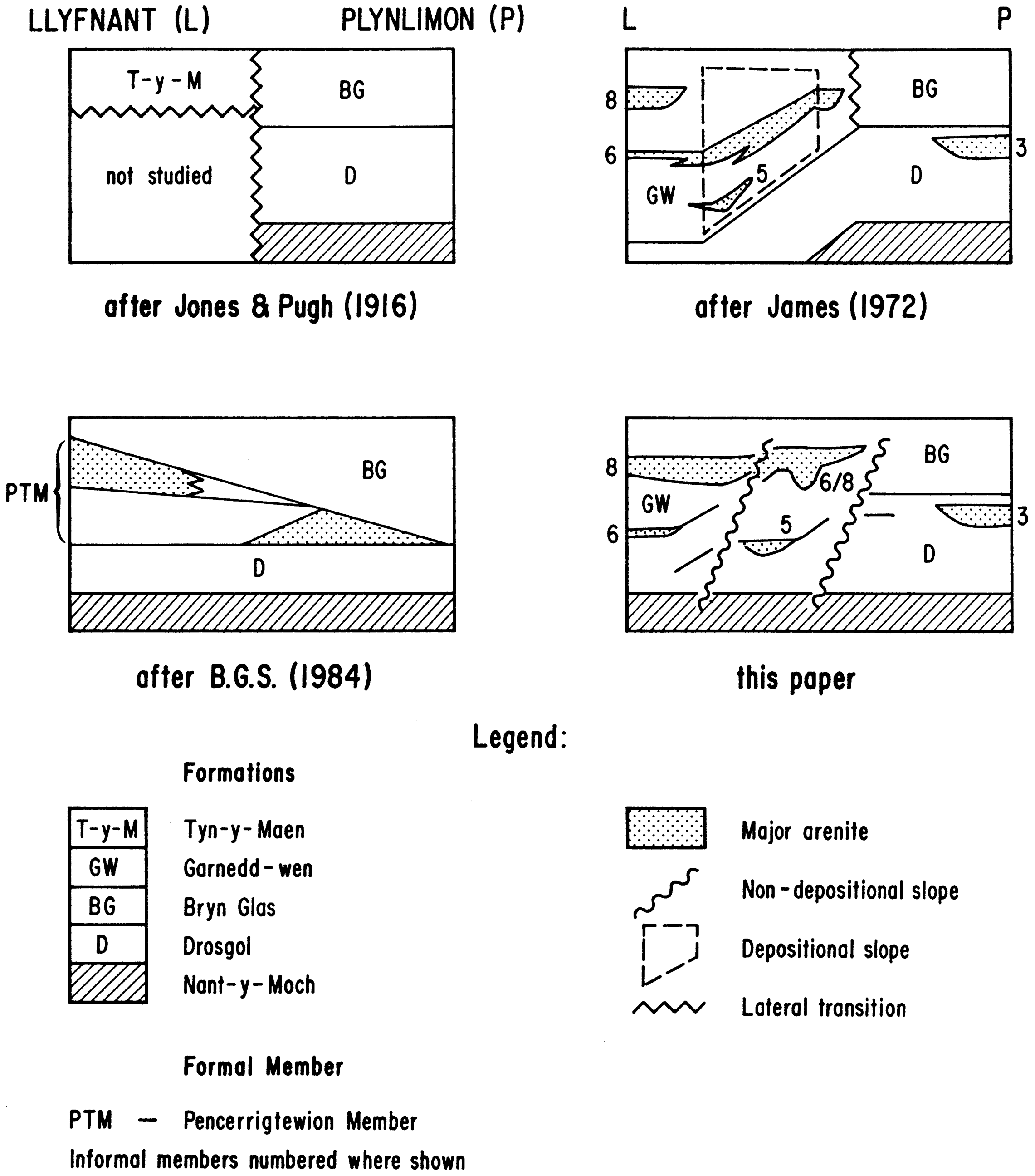

Fig. 2. Schematic illustrations of the various stratigraphic schemes that have been used in the area. Not to scale: thickness estimates are discussed in the text.

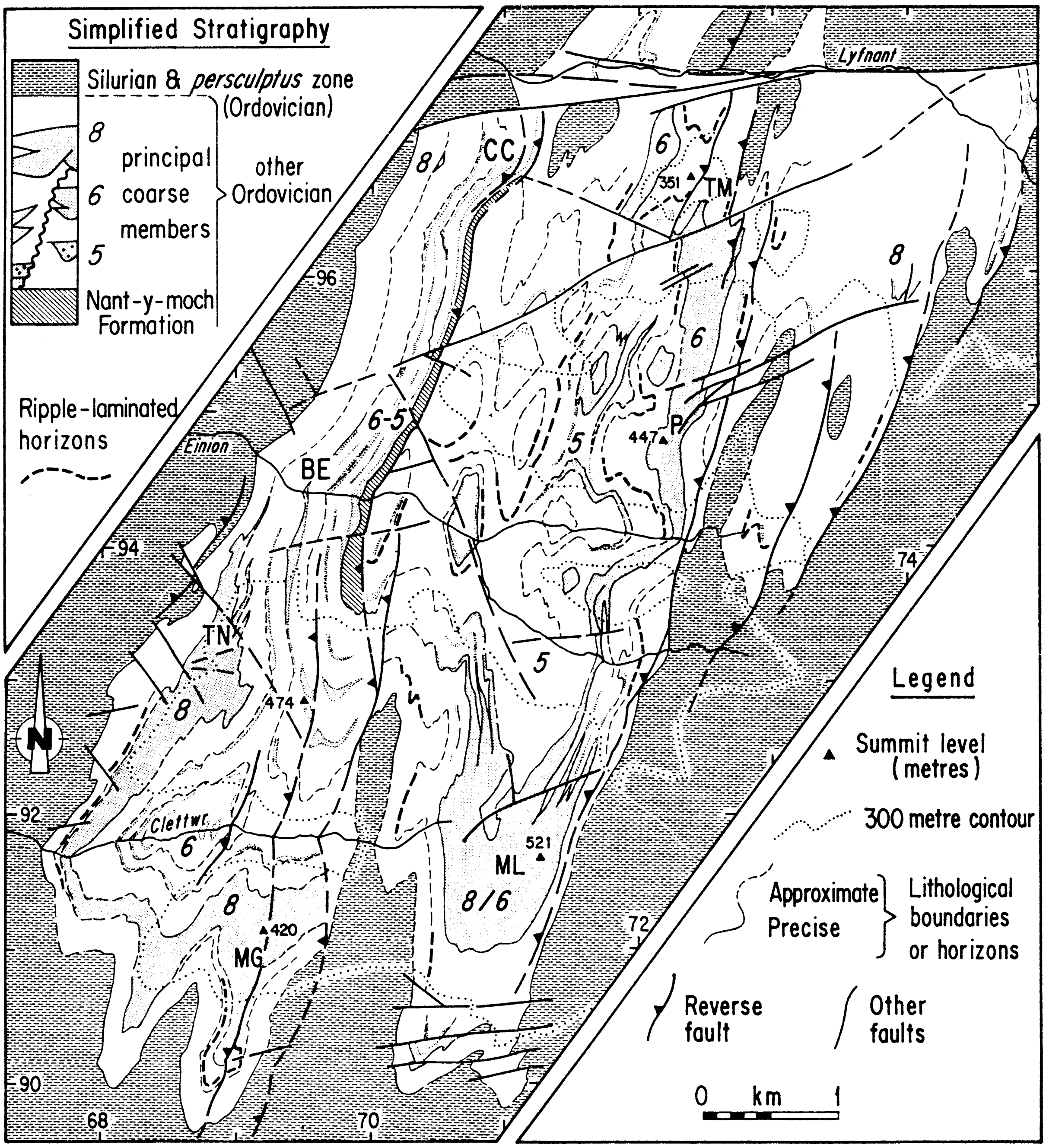

Fig. 3. Geological map of the southern portion of the Llyfnant inlier south of Machynlleth. Topographic elevations in metres. Positions of several faults within the Silurian after Jones and Pugh (1935). Locality legend: BE—Bwlch Einion, CC-Craig Caerhedyn, MG—Moel-y-Garn, ML—Moel-y-Llyn, P—Pencarreg-gopa, TN—Taren Neuadd-Twyd, TM—Tarren Tyn-y-Maen.

The Llyfnant Inlier (fig. 3)

This has been referred to previously as the Machynlleth inlier by the writer (James, 1972) and B.G.S. (1984) but as the town of Machynlleth lies on Silurian strata and some of the most informative Ashgill sections lie adjacent to the Llyfnant valley, the name suggested by Bassett (1969, p. 84) is here adopted. Jones and Pugh (1916) mapped the ground between Machynlleth and about one kilometre south of the Llyfnant valley defining the (new) term Tyn-y-Maen Group for the pre-*persculptus* zone sequence, presumably in recognition of a contrast between the local succession and that at Plynlimon (Jones, 1909) where the terms Bryn-glas Group, Drosgol Group and Nant-y-moch Group (in descending stratigraphic order) had been established. James (1972) maintained the distinction from the Plynlimon succession and allocated the beds to the Garnedd-wen Formation in view of their similarity to equivalent strata at Corris (Pugh, 1923). B.G.S. (1984) used the Plynlimon lithostratigraphy with Group being replaced by Formation in accordance with modern usage. However, separating the Formations, B.G.S. (1984) erected one formal lithological unit (the Pencerrigtewion Member), which appears to lump together the informally defined members 3 to 8 inclusive as set out by James (1971, 1972) and which varies in thickness from zero to 115 m. James' terminology for the members excludes a member 7 at Llyfnant in contrast to Corris where this petrographically distinctive member was defined and was thought to predate member 8 at Llyfnant in view of its much thicker superincumbent Ashgill mudstone. The Institute of Geological Sciences (I.G.S.) gave a short account of the stratigraphy south of the Llyfnant valley in 1967, stressing the differences between the western and eastern limbs of the inlier. Cave (1979, 1984) gave brief notes on the stratigraphy and sedimentation and Davies & Cave (1976) discussed aspects of the regional cleavage development.

(*a*) *The eastern limb*

The major result of the recent work is the revision of thickness on the eastern limb of the inlier (fig. 4a) and the recognition of thrusting within the Ashgill northeast of Moel-y-Llyn. The topmost pre-*persculptus* zone mudstone there is now thought to be rather constant at about 140 m thick north of the Einion valley and to contain horizons of ripple-laminated siltstones and balled arenites (e.g. GR SN 728941). The immediately underlying massive and contorted sandstones, member 6 of James (1972), thicken irregularly southwards from about 25 m at Tyn-y-Maen to around 120 m or more at Moel-y-Llyn. The mudstone unit and the sandstones comprise respectively the groups C (ii) and C (i) of I.G.S. (1967, p. 65) and were thought by I.G.S. to total only 90 m. New exposures along recently made forestry roads clarify the development of member 6 SSE of Pencarreg-gopa at GR SN 724942 where it is 65 m thick and also indicate local overturning adjacent to the thrust. Another key section along new forestry roads lies south of Tarren Tyn-y-Maen between GR SN 719964 and SN 729965. Here, the approximately 30 m development of ripple-laminated siltstones underlying member 6 is much thicker than to the south where the siltstones are progressively removed by the channelized erosive base of the arenites. Pebbly mudstones possibly equivalent to the locally pebbly arenite member 5 are exposed in the core of the fold at SN 722963. Eastwards of this exposure in excess of 110 m of the topmost mudstone above member 6 can now be proven in steeply dipping strata with an internal thrust cut-out. This would be consistent with the new estimate of about 140 m further south. Around GR SN 728968 about 7 m of medium to thick-bedded (0.1–1.0 m) arenites lie approximately on the level of member 8.

The writer believes that the B.G.S. estimate of only 30 m of Ashgill mudstone overlying the arenites east of Moel-y-Llyn is an underestimate due to the presence of thrusting; however, a more precise estimate in non-faulted ground immediately west of the Moel-y-Llyn arenites is not easily made due to poor exposure and minor folding. The estimate here adopted is 60–80 m on both limbs of the fold in contrast to a former correlation showing westerly thickening across it (James, 1972, fig. 5B). This new estimate implies that the Moel-y-Llyn arenites are probably not solely equivalent to member 6 further north as envisaged by James (1972) or member 8 to the west as shown by B.G.S. but are in parts equivalent to both member 6 and member 8. The key area in which to demonstrate this correlation is around Bronwion (GR SN 718926) and is heavily afforested. Despite this lack of detailed control the mapping of the top surface of the arenites hereabouts shown on the B.G.S. map, which implies a strongly concave downwards depositional geometry for this surface, is considered implausible and the solution depicted in fig. 3 is here preferred.

(*b*) *The central area*

In the central portion of the inlier there is adequate exposure to demonstrate conclusively that the arenites of Moel-y-Llyn die out by thinning and development of intercalated mudstones, e.g. around GR SN 705935. The B.G.S. map hereabouts shows a very abrupt termination. Around GR SN 716956 and GR SN 712957 along the Dynyn stream the probable lateral equivalents of the approx. 45 m thick member 6 arenites to the east are a few metres of balled grits and slumped mudstones—the 'disturbed beds' of B.G.S. Likewise the massive uppermost 20 m arenite of member 5 must die out rapidly westwards where there is no obvious faulting. These observations strongly suggest the local development of a non-depositional slope and that correlation of the eastern and western limbs of the inlier is possible in only a general way.

(*c*) *The western limb*

On this limb of the inlier (fig. 4b) the lowest stratigraphic level comprises a sequence of thin-bedded (0.005–0.07 m) ripple-laminated siltstones fairly regularly interbedded with mudstone. It has recently been interpreted by B.G.S. (Cave, 1984) as representing the Nant-y-Moch Formation, an identification not made by James (1972) who presumed this horizon to represent member 4. The writer concurs that the B.G.S. interpretation is most probably correct although not open to direct proof and has adopted it in this paper. However the westerly transport direction given by flutes and ripple-lamination differs appreciably from the SSW transport at the top of the Formation at Plynlimon.

The sequence immediately above the Nant-y-moch Formation, probably in part equivalent to members 5 and 6, forms a mappable package about 250 m thick, a thickness essentially in agreement with that of the group 2 of I.G.S. (1967, p. 65). There is appreciable variation along strike, illustrated in fairly schematic fashion by James (1972, fig. 6). Presumed mass-flow deposits of cleaved very muddy sandstones and sandy mudstones, locally pebbly as at Bwlch Einion, appear to occupy shallow scours and are not laterally persistent. By contrast some of the clean non-cleaved arenites can be traced for considerable distances, e.g. one 3 m unit from GR SN 71009685 near Craig Caerhedyn to GR SN 70659640 in the Brwyno stream, a distance of 600 m. The area adjacent to this traverse and the hillside immediately to the SSW (GR SN 706958) demonstrate considerable southerly decrease in arenite and sandy mudstone abundance. This disappearance is visible in the topography. Content of massive arenites is much lower than that on the eastern limb and, in contrast to the eastern and central portions of the inlier, discrete horizons of ripple-laminated siltstones are rare. The I.G.S. (1967) estimate of 152 m of arenites in the Afon Clettwr (underlying 34 m of what this paper would term member 8) appears to assume continuity of arenite development between scattered exposures. This assumption is in conflict with the much muddier nature of equivalent horizons on the hillsides immediately to the north which are here interpreted as lateral equivalents of member 6. It is also not sustained by the B.G.S. map (1984).

Above the sandy mudstones lie an interdigitating series of mudstones and arenites, the group 3 of I.G.S. They appear to be about 210 m thick near Bwlch Einion, fairly close to the I.G.S. estimate of 180 m. The relation between the member 8 arenites of Moel-y-Garn and the generally muddier arenites of Moel-y-Llyn was thought by I.G.S. to be one of equivalence, but neither the writer's map (fig. 3) nor the maps of B.G.S. can demonstrate this directly. The present interpretation, consistent with palaeocurrent evidence (see also James, 1972, fig. 8), requires member 8 to occupy a major northwest trending channel. The channel is overlain by up to 20 metres of ripple laminated siltstones in marked contrast to the topmost arenites of Moel-y-Llyn and is now indicated by the re-interpretation of thicknesses on the eastern limb of the inlier to lie closer than member 6 to the base of the Silurian. The Moel-y-Llyn arenites although locally well bedded near their base (e.g. GR SN 710099205) and top (e.g. GR SN 71339157) are muddier and less well bedded than member 8 to the west, generally appearing balled or homogenized by (? incipient) mass flow in contrast to the preservation of primary structures in member 8 at Taren Neuadd-Lwyd.

(*d*) *Remarks on the mapping*

Allowing for the simplifications inherent in the printing of a 1:50,000 map, the maps of the writer (fig. 3) and B.G.S. (1984) are rather similar. Some differences exist in the depiction of the northwards thinning of arenites at Moel-y-Llyn and Taren Neuadd-Twyd which the writer believes is in both areas due to channelling at various levels. One obvious difference lies SSW of the Llandovery outcrop on Esgair Foel-ddu around GR SN 701926 where a very small difference in the estimation of fold plunge makes a large difference to the estimation of whether or not unexposed ground in the upper Clettwr valley is Llandovery as mapped by the writer or Ordovician as mapped by B.G.S. whose estimate of the fold plunge is thus less than that of the topography along the synclinal axis (approximately 4–5 °). There is considerable divergence of interpretation around the large fault trending NW-SE crossing Taren Neuadd-Lwyd, termed the Ogof fault by B.G.S. (1984) and shown therein to separate a homoclinal area to the NE from strong folding to the SW before rapidly dying out around GR SN 699915. The interpretation shown in fig. 3 avoids the strain discontinuity implicit in the B.G.S. map. On Tarren Tyn-y-maen the absence of member 6 on the east flank of the fold is interpreted by the writer to indicate a thrust cut-out, not shown on the B.G.S. map. The area of Silurian shown nearby (GR SN 723970) on the B.G.S. map has not been found by the writer.

The West Flank of the Plynlimon Inlier (fig. 5)

In this area massive arenites abruptly appear within the Bryn-glas Formation and, unlike the topmost arenites of the Drosgol Formation (James, 1983a), are not overlain by ripple-laminated siltstones. By analogy with the Corris-Llyfnant sequence, this local stratigraphy was previously referred to the Garnedd-wen Formation (James, 1972) but no thickness data for the arenites was given.

The eastern limit of the arenites is fairly well controlled by exposures around the old mine of Brynyrafr (fig. 5) where the eastern limb of the Cefn-yr-esgair anticline is overturned near the Ordovician-Silurian boundary at GR SN 748878. This section exposes (albeit discontinuously) about 100–120 metres of Ordovician mudstone to the core of the fold and no arenites are seen. Allowing for a dextral component of throw of about 700 metres on the Camdwr fault thereabouts, this absence is consistent with the rapid easterly thinning from Graig Wen to Pen Cerig. At Pen Cerig the arenites are clearly channelled (James, 1972, fig. 3B) and vary between 5 and 15 m; northerly overall thinning is punctuated by a local 11 m massive arenite development in the fault zone at GR SN 736866. Immediately east of Pen Cerig local developments of medium bedded (0.1–0.25 m) arenites at GR SN 739861 probably indicate proximity to the eastern margin of the massive arenites.

The Carn Owen and Graig Wen inliers both contain thick developments of thick-bedded (0.3–1.5 m), commonly massive, arenites which may be either parallel-bedded or balled and contorted. In general the former variety overlies the latter but also at many levels passes progressively into it towards the west.

The Carn Owen fold is structurally simple (fig. 6a) and exposes about 80 m of arenites overlying, with locally violent non-sequence, a complex of arenite channels and associated mudstones at least 50 m thick. This latter succession is only exposed in the main quarry (fig. 7) and the upper quarry face is inaccessible without rope. The sequence within this quarry is locally overturned and internally strongly sheared in the core of the fold; the

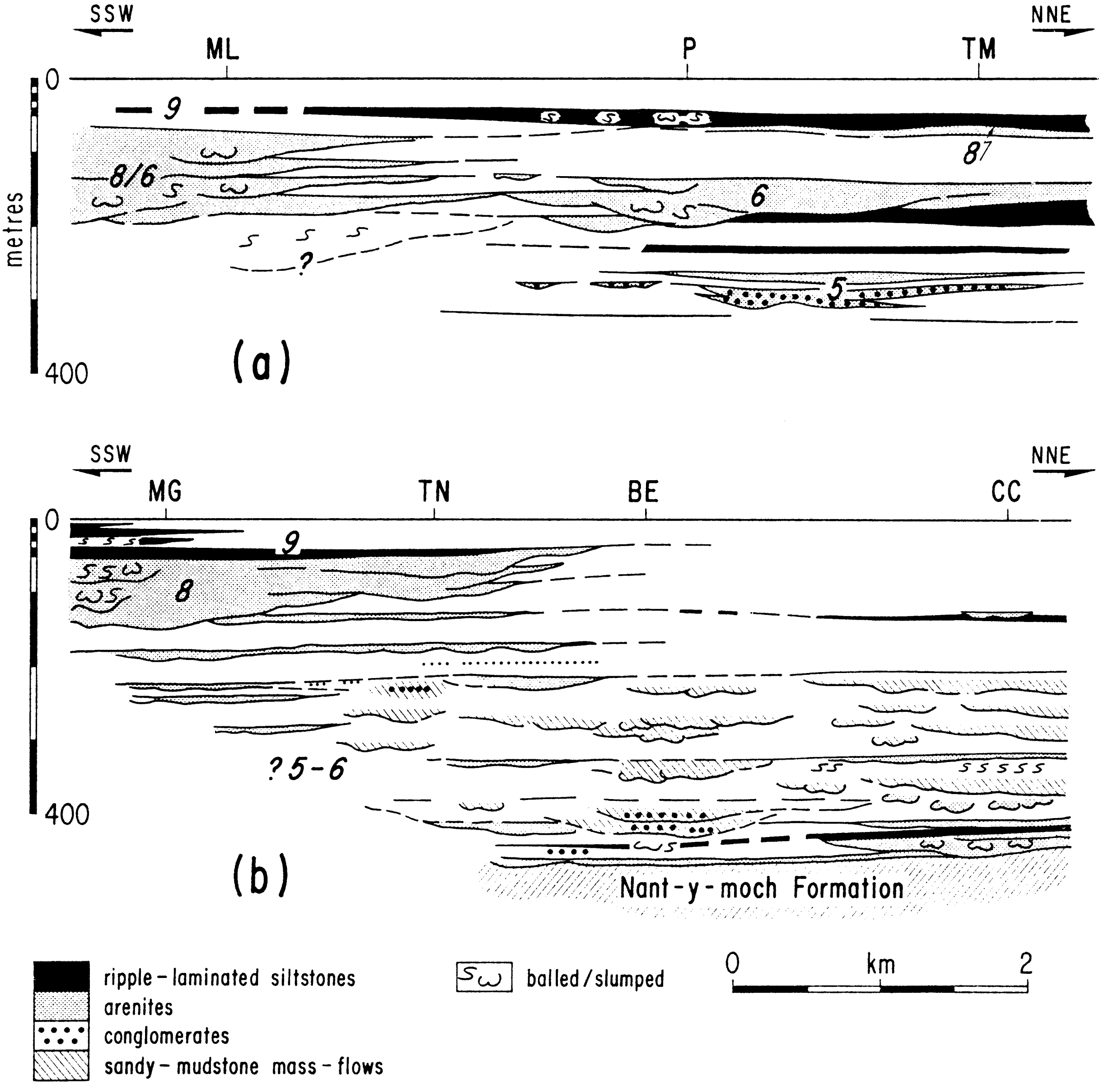

Fig. 4. Correlation sections, Llyfnant inlier, (a) west-flank, (b) east-flank. Base of *persculptus* zone is horizontal zero datum. Locality legend as fig. 3.

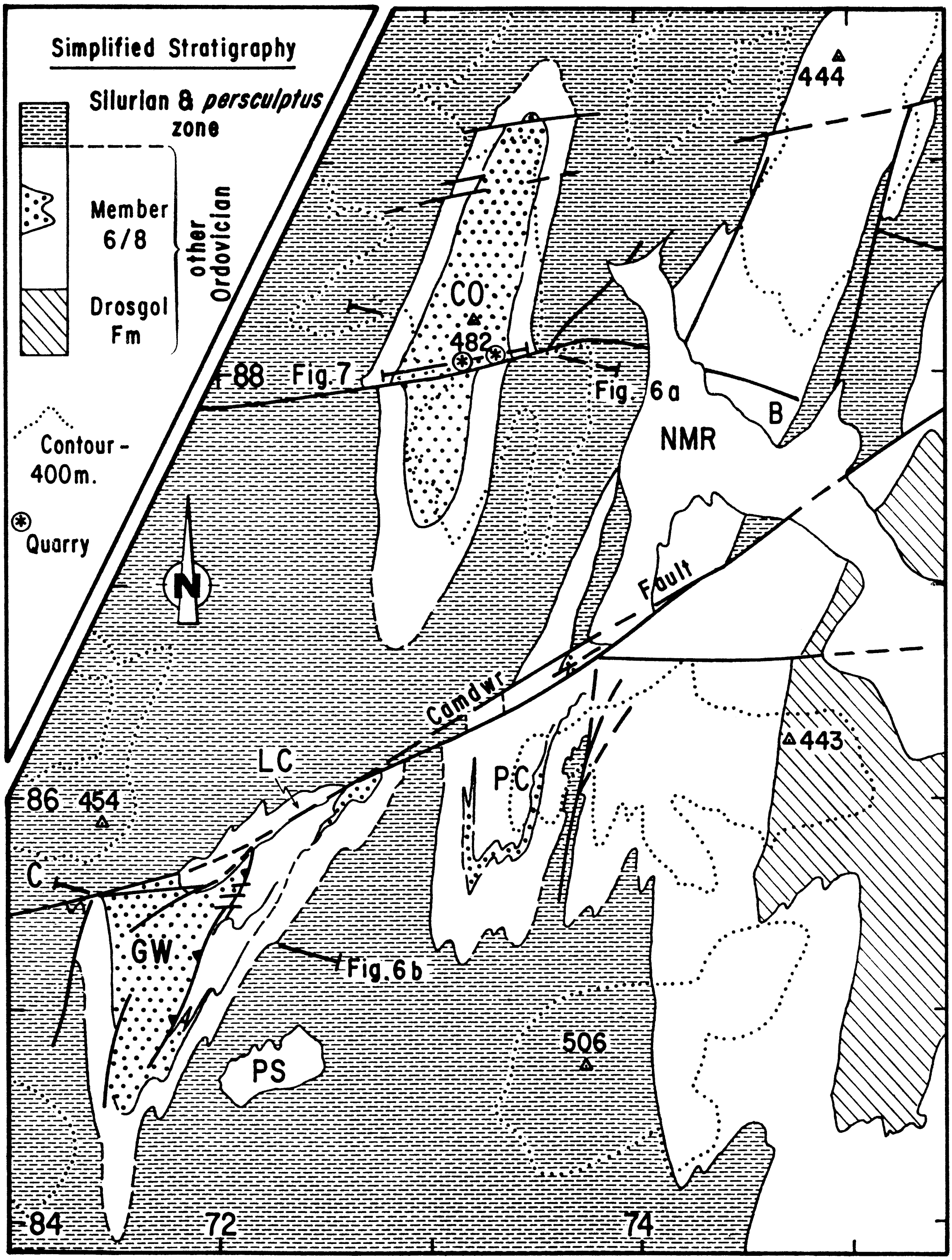

Fig. 5. Geological map illustrating the distribution of arenite member 6/8 on the west of the Plynlimon inlier and within the Carn Owen and Graig Wen inliers. Topographic elevations in metres. Locality legend: B—Brynyrafr mine (former), C—Craigypistyll, CO—Carn Owen, GW—Graig Wen, LC—Llyn Craigypistyll, NMR—Nant-y-moch Reservoir, PC—Pen Cerig, PS—Pond Syfydrin. Scale given by 1 km divisions of National Grid on map margins.

shearing probably being aided by competence contrasts between variable thicknesses of mudstones separating minor channels several metres deep. An example of such a channel at the eastern margin of the quarry has been illustrated previously (James, 1972, fig. 3A) Synsedimentary movement direction within the contorted section in the quarry appears to have been to the SW and may represent sliding into a major channel; possibly that filled by the thick arenites at Graig-Wen. The parallel-bedded arenites are well exposed in the small eastern quarry and also further north around GR SN 733887.

The Graig Wen anticline represents the dextral offset of the Carn Owen anticline across the Camdwr fault (Jones & Pugh, 1935; James, 1972). It was described by Raybould (1975) as the Craigypistyll anticline; an unfortunate name since there is no major anticline in the Llandovery strata at Craigypistyll which lies N of the fault. Contrary to Raybould's description, the 'leading limb' of the Graig Wen anticline is the eastern limb which dips at 75–90° on Banc Lletty-Evan-hen (fig. 5b). East of this steep zone, which is probably thrust bound, there are several small folds of which the crests become lower to the east. The Graig Wen inlier thus comprises outcrops revealed both by these folds and the major Graig Wen anticline. Moreover, the 'movement picture' conforms to the ESE directed movement in the adjacent Ordovician inliers.

The inlier exposes about 130 m of arenites in the core. The higher levels can be shown to thin eastwards (fig. 5) and are heavily balled-up in the west. Much of the south-central portion of the inlier is now afforested but an informative channel margin exposure (fig. 8) at approximately GR SN 718853 was recently located amid young trees.

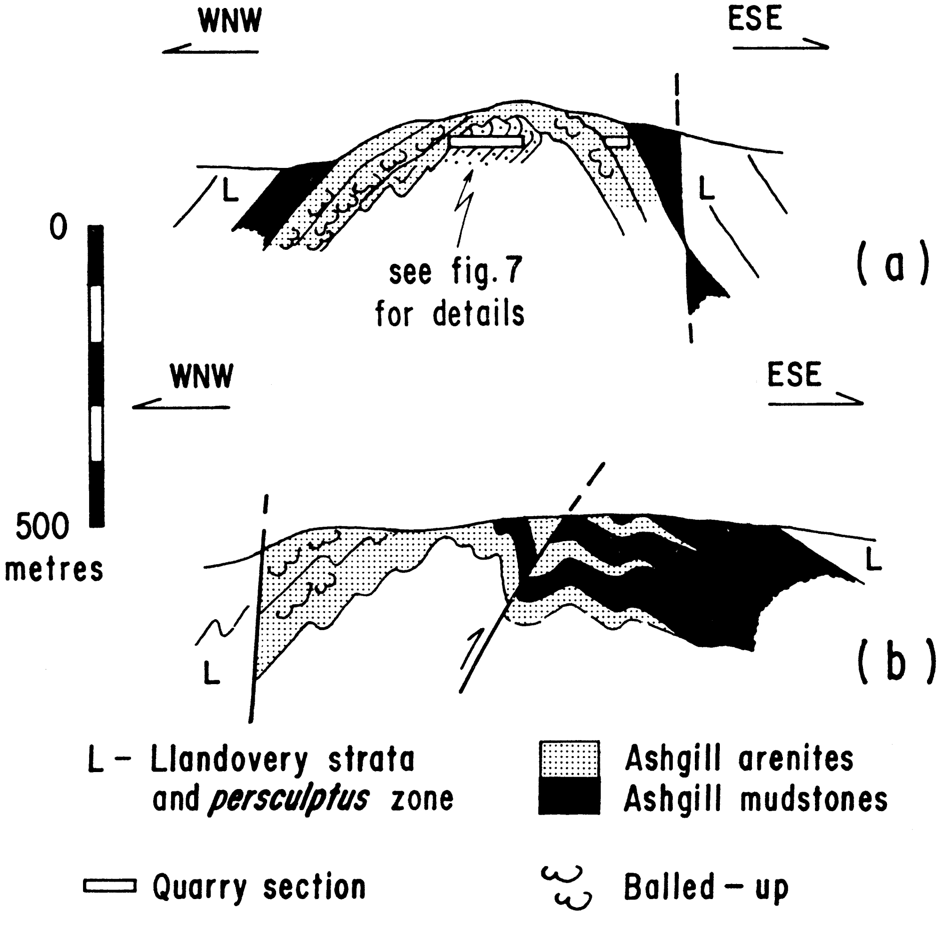

Fig. 6. Natural-scale geological sections through the Ordovician inliers of Carn Owen (a) and Graig Wen (b). Note the eastward passage of arenites into mudstone across Graig Wen. Location of sections indicated on fig. 5.

Correlation and Resultant Models

The area under consideration was not included in the regional Ordovician correlation tables of Williams *et al.* (1972).

Before being able to draw a correlation section (fig. 9) between Plynlimon and Llyfnant on the basis of this new work it is necessary to discuss the thickness of the Bryn-glas Formation; estimates of which at Plynlimon vary between 351 m (Jones & Pugh, 1935) and 183 m (I.G.S., 1968) and at Llyfnant between 30 and 195 m (B.G.S., 1984). The essentially non-bedded nature of the silty mudstones comprising the Formation makes thickness estimation hazardous in that minor folds may be missed. Sectioning of folds along the plunge avoids this but runs the danger of tectonic thickening in the fold cores. Balancing the errors in both approaches the writer estimates a thickness of about 180–190 m, essentially in agreement with I.G.S.

Only in one locality, ENE of Pont Erwyd (around SN 768814), has the main outcrop of the Bryn-glas Formation yet been found to contain thin arenites and ripple-laminated horizons interbedded with mudstones east of the area shown in fig. 5. Although structural control is sparse and parts of the sequence are slumped and inverted on a small scale, the arenites appear to lie about 120 m below the base of the Silurian; they are designated horizon X in fig. 9. Thin, often balled-up, grits also occur nearby at a higher stratigraphic level (SN 768810) and may lie about 60 m below the Silurian. Meagre palaeocurrent data and slump-fold orientation in the lowermost arenites suggest transport to the NW or NNW, possibly down or across the levee of a channel situated south of the area lying at the stratigraphic level of the minor channels in the slump complex in the core of the Carn Owen fold. The two horizons might represent members 6 and 8 respectively at Llyfnant.

Given that the arenites on the Plynlimon west flank are unequivocally correlateable, the key question in the correlation to the Llyfnant inlier is whether these arenites equate with member 6 or member 8 (or both) therein. The question arises in view of the revised thickness estimate of about 140 m of pre-*persculptus* zone sediments above member 6 in the northeast of the Llyfnant inlier in comparison with about 60 m above the arenites at Carn Owen and about 60 m (albeit including 20 m of immediately superincumbent ripple-laminated siltstones) above member 8 near Afon Clettwr. It is tempting, but probably overly simplistic, to equate the parallel-bedded and slumped/channelled sequences at Carn Owen respectively with members 8 and 6 at Llyfnant.

The correlation adopted is set out in fig. 9. It is largely based on sedimentological criteria applicable to fan and slope-base environments (Stanley & Unrug, 1972; Hiscott & Middleton, 1979; Hiscott, 1980; Lowe, 1982; Pickering, 1982) but has also to be consistent with petrographic data (James, 1971). The correlation assumes negligible differential depositional relief at the base of the rather uniform sediments of the *persculptus* zone and overlying Silurian strata in the east of the area (Jones & Pugh, 1935; Cave, 1979). In the west the correlation appears to require gentle depositional relief at this level.

Critical factors determining the choice of a correlation based on an intrabasinal slope model are:–

(*a*) Correlation of the Plynlimon sequence to the Towy "axis" (James, 1983 b, fig. 4) demonstrates unequivocally that the rapid lateral changes in facies and stratigraphy west of Plynlimon were developed under water which was many hundreds of metres deep even at the maximum Hirnantian glacio-eustatic sea level fall. Such changes in deep water sediments imply the presence of localized slopes.

(*b*) The abundance of slumping and channelling both imply presence of slopes west of Plynlimon that are not similarly evidenced over the main Plynlimon inlier. Cave (1984) highlighted the occurrence of slumped sediments with locally internally cohesive rafts of thin-bedded siltstones in the Llyfnant inlier.

(*c*) Palaeocurrent evidence at Llyfnant (James, 1972, fig. 9) is indicative of local westerly reorientation of turbidity current flow, particularly in member 6/8, from dominantly northerly directions at Carn Owen.

(*d*) The possible time equivalents of members 5 and 6 in the west of the Llyfnant inlier are very different in nature to members 5 and 6 in the east and are not persistent into the centre of the inlier where they would be predicted structurally. It appears that deposition of the locally channelized arenites in the east was precluded in the centre of the inlier by the presence of a non-depositional slope. Further west, adjacent to the foot of slope, muddy mass-flow deposits derived by slumping of arenites to the east with admixture of slumped muds from the slope were able to be deposited. The previous interpretation (James, 1972, fig. 5B) did not recognize that the intra-basinal slope was *non-depositional* rather than depositional and that the absence of members 5 and 6 from the centre of the inlier could not be explained by lack of exposure or by faulting.

The new work is thus consistent with a modified (non-depositional) intra-basinal slope model, however it also necessitates changes in the position of the slopes as set out by James (1972), thus;–

(*a*) The Moel Hyrddod channel in member (GR SN 717953) was formerly required as a slope-base deposit related to the eastern slope. It now appears that member 5 is probably time equivalent to one of the arenite/conglomerate horizons pre-dating the major arenite channels (3_p at Plynlimon). Member 6 in the east of Llyfnant inlier includes a higher proportion of horizontally-bedded arenites than previously thought: it is not solely a slump complex although containing many slump fold closures similar to those illustrated by Ksiazkiewicz (1958). Accordingly it is more closely related to the Carn Owen sequence than thought previously and lay somewhat east of, rather than above, a slope break.

(*b*) The rapid eastward disappearance of the Carn Owen arenites is now thought to require ponding of the largely northerly directed turbidity flows by a tectonically created slope near Brynyrafr since the arenites do not fine or thin upwards and no evidence has been found at Brynyrafr or further east for possible lateral equivalents in levee facies. Simple onlap would require a minimum west-facing slope of 2 ° on average and would not be consistent with the palaeocurrent evidence since westerly flow would be induced. Since the turbidity currents depositing the sands must on hydrodynamic grounds be much thicker than the resultant turbidite, it is clear that appreciable depositional relief must have persisted across this slope after the deposition of the arenites.

(*c*) The major channels and associated slumps in (?) member 6 at Carn Owen and Graig Wen are now confirmed to lie adjacent to a top of a slope to their west and this is supported by the rapid westerly development of ball & pillow structures (incipient mobility) from east to west in the horizontally-bedded arenites there.

One result of the new correlation is that the numbering system previously used informally to designate the various lithostratigraphic members no longer orders these members in ascending succession, e.g. member 5 at Llyfnant is now thought to predate member 4 originally defined at Plynlimon. This result has been tolerated, firstly to make clear the extent of the revision from James (1972) and secondly because it is felt that naming, rather than numbering, the members is probably premature and should be the result of wider discussion than yet available.

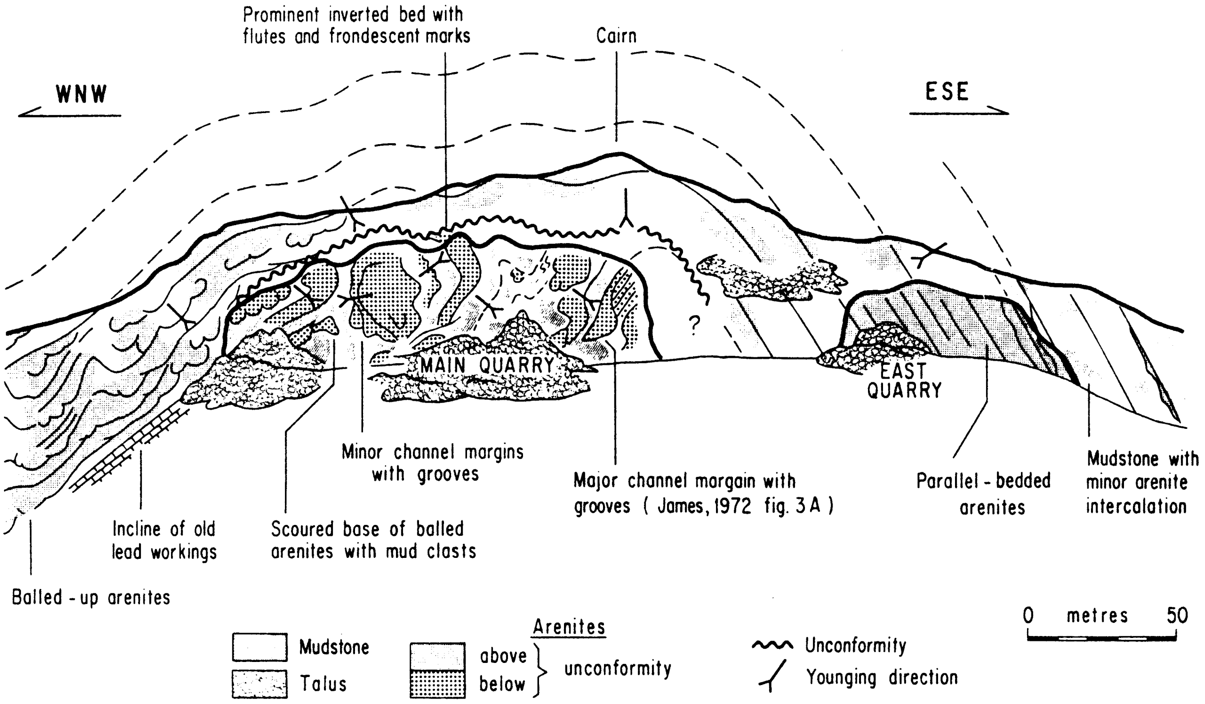

Fig. 7. Geological section—the Carn Owen quarries in detail.

Control of Sedimentation

Palaeocurrent data for member 6/8 shows a dominantly northward transport at Carn Owen swinging to WNW in the Llyfnant inlier as a response to the development of the slope. In detail the picture is more complex with local transport to NW at Graig Wen and Pen Cerig in channels adjacent to the (then active ?) Camdwr fault and the local NE and SW palaeocurrents thereabouts may represent overspill from such channels. Nonetheless, an overall northerly transport is consistent with the lack of arenites on the levels of member 6 and member 8 over virtually all the Plynlimon inlier.

The rapid influx of arenites and conglomerates at Llyfnant is interpreted as a response to the acme of the Hirnantian glacio-eustatic sea-level fall, an earlier pulse of which may have triggered sedimentation of the Drosgol Formation at Plynlimon. The arenite members 6 and 8 at Llyfnant are thicker than the principal arenite (member 3_p) at Plynlimon (James, 1983a) and lie closer to the base of the Silurian which might support the maximum regression occuring very late in the Hirnantian (*cf.* Brenchley & Newall, 1980, fig. 22). It is difficult however to explain the considerable depth of channelling in the Llyfnant sequences unless some type of tectonically induced intra-basinal slope model is adopted—this is because the arenites were presumably far-travelled from a source on the SE margin of the Welsh trough and appear not to have been deposited over most of the Plynlimon inlier. Transport at Carn Owen was northerly prior to re-orientation across the slope. The channels are local features for which the positions of the heads may be roughly located. They are clearly erosional without evidence of aggradation within levees (*cf.* Pickering, 1982). In contrast to the turbidites of the Drosgol Formation at Plynlimon, the local tectonic control of deposition of members 6 and 8 does not make for regional interpretation in terms of a submarine fan model (cf. Woodcock, 1984, p. 330).

The faults governing the positions of the non-depositional slopes are thought to be basement controlled (James & James, 1969). They would probably cut the basement somewhat east of the Glandyfi vergence divide (Woodcock, 1984, p. 324) and were the locus of dip-slip shear strain during folding of the cover (*op. cit.* p. 326). Figure 9 indicates the revised positions of the faults affecting sedimentation. A similar model utilizing two faults is also applicable at Corris where the section (James, 1972, fig. 5A) can be re-interpreted along similar lines.

A considerable variety of sedimentary relationships may develop across slopes induced by the flexural response of sedimentary cover to deep-seated fault movements (fig. 10). Once the slope is created, differences across it may develop in both the type and the rate of supply and deposition of sediment. The diferential accumulation thus induced may augment or diminish the gradient of the initial slope and the resultant variable sediment strengths will result in variable angles of depositional stability. Moreover the position of maximum slope (depositional or non-depositional) will vary laterally as a result of variation in sediment input and will not necessarily lie directly above the former fracture. Once the slope is induced it can be perpetuated without any further movement on the fracture. The internal non-sequences (slopes, slump- scars, channels) within sediments deposited above such fractures may be misinterpreted as arising individually from pulses of tectonic activity. Ordovician-Silurian relationships across the Towy anticline south of Rhayader have recently been reinterpreted with these considerations in mind (James, 1983 b) with consequent simplification of the strain history. Based on non-decompacted sediment thicknesses, depositional relief across the Towy anticline was almost an order of magnitude larger than the relief of 50–200 metres at Llyfnant to be inferred from fig. 10 of this paper. On yet larger scale the processes described above may be applicable to an entire continental slope.

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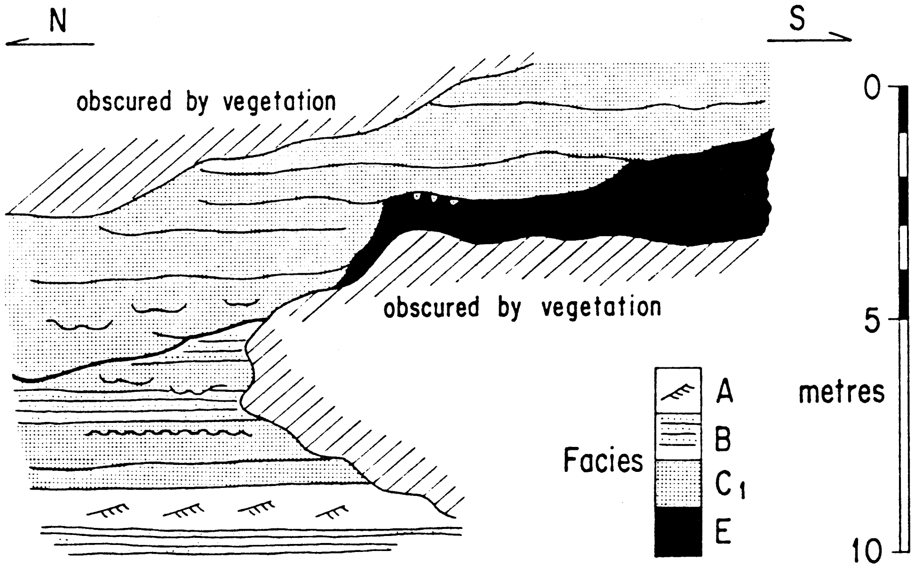

Fig. 8. Channel margin, Graig Wen inlier. Key to facies: A, ripple-laminated siltstone; B, 0.1–0.3 m arenites; C_1, massive arenites thicker than 0.3 m; E, mudstone.

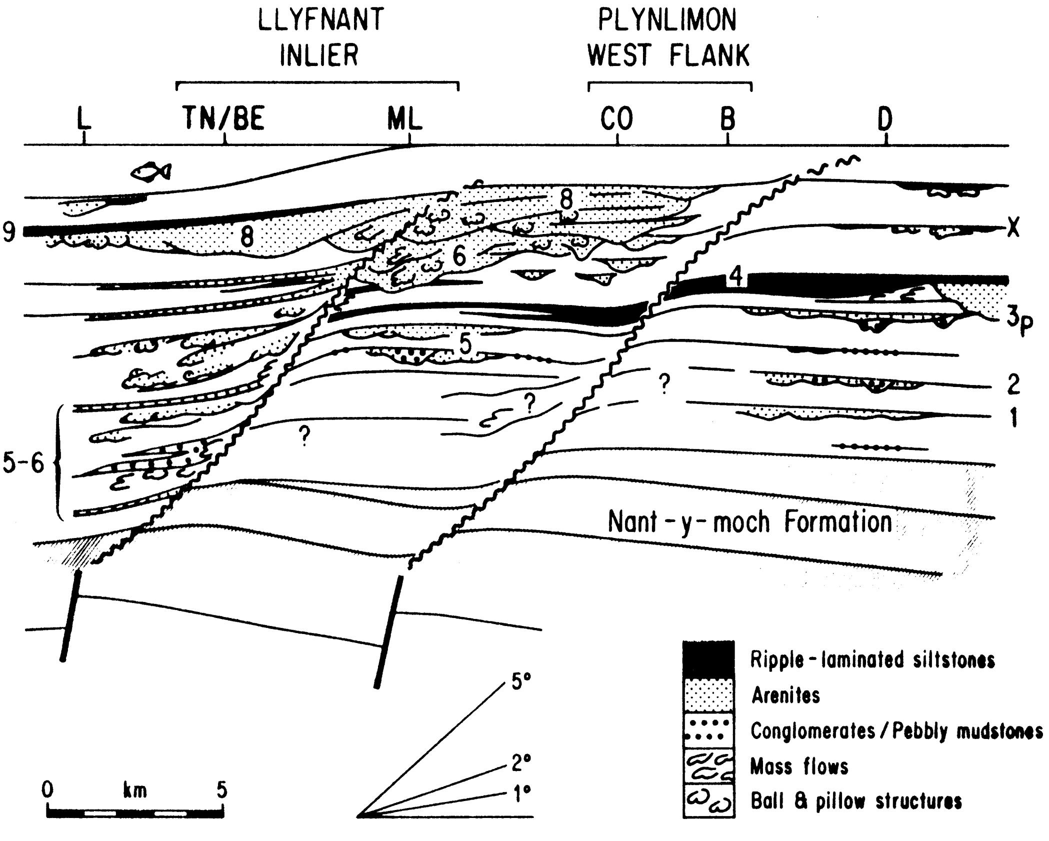

Fig. 9. Synoptic correlation section, Plynlimon west flank to the Llyfnant inlier, illustrating revised view of the relationships of the Plynlimon stratigraphy, members 1–4 (James, 1983a) and that at Llyfnant, members 5–9 (James, 1972). Restored with base of Silurian horizontal east of Moel-y-Llyn. Inset scale shows angular relationships after unfolding. Depth at which non-depositional slopes may pass into fault tips is schematic. Locality legend as fig. 2 with additions: D, Drosgol hill; L, Loveden mine (former) situated at GR SN 670941 on small Ordovician inlier west of Lyfnant inlier.

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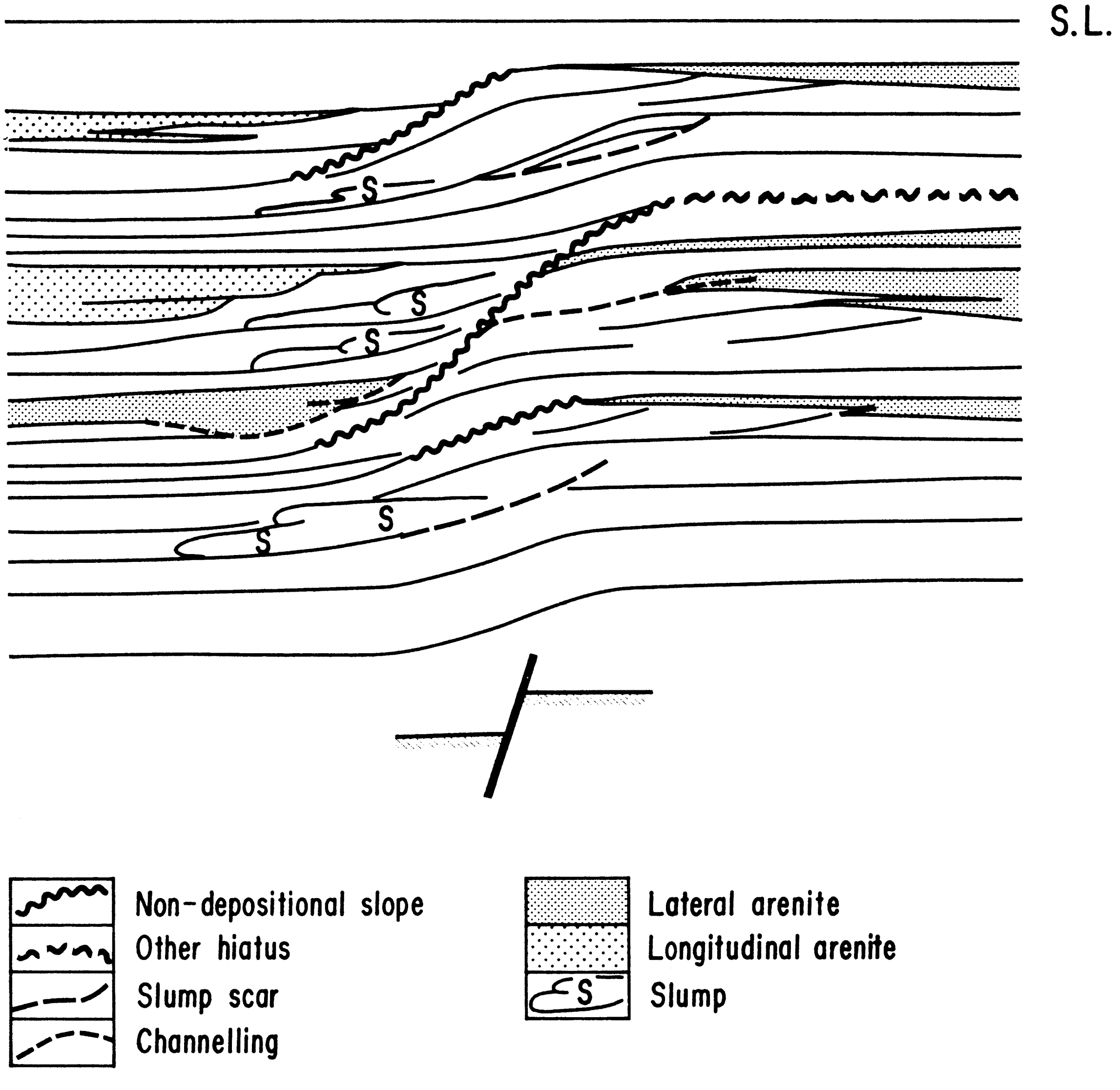

Fig. 10. Schematic section illustrating the variety of sedimentary relationships that may develop over a flexure induced by deep-seated fault movement—see text for discussion.