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Gaussian distributions on a logarithmic scale. As in England, width commonly exceeds length. Vertical dimensions correlate with length more than with width. Cirque form varies with geology, but also with relief as both vary between mountain groups. The main contrast is between larger, better-developed cirques and higher relief on volcanic rocks in the north-west, and smaller, less-developed cirques and lower relief on sedimentary rocks in the south.

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Allometric development of glacial cirque form:
geological, relief and regional effects on the cirques of Wales

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Abstract

Headward and downward erosion near glacier sources, at rates exceeding fluvial erosion, is important in recent discussions of orogen development and the limits to relief. This relates to a long history of debate on how the form of glacial cirques develops, which can be advanced by relating shape to size in large data sets. For 260 cirques in Wales, this confirms different rates of enlargement in the three dimensions: faster in length than in width, and slower in vertical dimension whether expressed as overall height range, axial height range or wall height. Maximum gradient, plan closure and number of cols increase with overall size. This allometric development applies over different cirque types, regions and rock types. Headwall retreat, often by collapse following glacial erosion at the base, is faster than downward erosion. Welsh cirques form a scale-specific population and, as in other regions, size variables follow Gaussian distributions on a logarithmic scale. As in England, width commonly exceeds length. Vertical dimensions correlate with length more than with width. Cirque form varies with geology, but also with relief as both vary between mountain groups. The main contrast is between larger, better-developed cirques and higher relief on volcanic rocks in the north-west, and smaller, less-developed cirques and lower relief on sedimentary rocks in the south.

Keywords: Glacial erosion; Cirque form; Allometry; Morphometry; Wales; Statistical graphics.

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1. Introduction

1.1. Aims and objectives

The erosion of glacial cirques takes tens to hundreds of thousands of years and is thus not susceptible to direct observation. Clearly cirques start from glacial occupation of already indented topography, often fluvial but sometimes volcanic or following landsliding. Several schemes have been proposed for cirque development (e.g. Gordon, 1977; Bennett, 1990): all are based on the concept that cirques enlarge over time, as the bedrock removed cannot be replaced in the same form. This substitution of spatial variation for change over time is known as the ergodic hypothesis (Cox, 1977; Thorn, 1988).

Cirque distribution is excellent evidence of former glaciation and is fairly well established, but data on the precise form of glacial cirques are limited and based on varied definitions. Here I report on an effort to provide comprehensive and comparable data, relevant to hypotheses of cirque development.

The aim of this paper is to use extensive data on spatial variation in cirque form to show how cirques may develop. This involves relating both morphometric and qualitative data to a number of possible controls: geology, relief, position and timing or type of last glacial occupation. The objectives are to present a high-resolution data set for all cirques in Wales, to use it to test hypotheses of changes in cirque shape with size and of environmental controls on both, and to set the statistical results in the context of a long historical debate on downward and headward cirque erosion. The data set is sufficiently large to be subdivided on various criteria, with numerous cirques in each class of geology or grade of development. This permits more reliable models, narrower confidence intervals, and statistical tests of greater power. The data also provide a sampling frame for future detailed studies of glacial morphology and Quaternary chronology, comparable to that provided for the English Lake District by Evans and Cox (1995).

1.2. Review of cirque development models: wearing down and wearing back

There is no obvious reason why downward erosion by glacial plucking, abrasion and meltwater should be equal to headwall recession by these and other processes (frost action and slope collapse). Contradictory views have been published, and it is worth considering the development of ideas on this controversial subject before presenting morphometric data permitting a test of their applicability. Fuller historical depth is provided in Evans (in press).

In the early twentieth century, cirques were considered to wear back by ‘sapping’ of the base of the headwall, usually by frost weathering and rockfall. Local glaciers flatten and deepen cirque floors, but by removing rockfall they constantly attack headwalls at their bases (de

Martonne, 1901). Richter (1900) emphasized cirque enlargement by headwall retreat through frost weathering, with glaciers abrading cirque floors but protecting them from fluvial incision; this produced a high terrace which could eventually truncate a mountain range. Richter's hypothesis that in Norway this retreat had gone so far as to create the high mountain plateaus (the Palaeic surface) was regarded as inconceivable by Ahlmann (1919, p. 220).

Johnson's (1904) bergschrund hypothesis explained headwall retreat by vigorous frost weathering in a narrow zone. This provided debris that aided glacial abrasion downstream. Hobbs (1910, 1911) proposed four stages of sculpture by mountain glaciers, from youthful 'channelled and grooved' uplands through adolescent 'early fretted ' and mature 'fretted' to senile 'monumented' upland, as cirques enlarged laterally at the expense of 'pre-glacial' upland. This 'Cycle of Mountain Glaciation', emphasizing headward recession, was discussed at some length in Embleton and King (1968). It involves, however, a dangerous substitution of time by space, the more so as Hobbs' main examples of the four stages are widely separated over space, respectively in the Bighorn Mountains of Wyoming, in northwest Wales, in the (Swiss) Alps, and in Glacier National Park, Montana. Hobbs suggested that cirques become more complicated with age: others attribute the complexity of broader cirques to coalescence. Davis (1911, pp. 56-61) described the enlargement and coalescence of cirques in Colorado and supported Richter's idea of mountain truncation at the snowline by prolonged glaciation.

Blache (1952, pp. 112-5) rejected Hobbs' four stages: instead of duration of glaciation, he related such differences to increased altitude, giving greater slope and greater ice discharge. The stages seem to relate also to dissection of the initial topography. Blache (1960, p. 30) denied that cirques expand laterally as in Hobbs' scheme. Derbyshire and Evans (1976) related Hobbs' 'stages' to tectonic environment and degree of dissection, especially the spacing of valleys.

Lewis (1938, 1940) suggested that meltwater forced its way down far below the bergschrund, explaining the great height of some cirque headwalls (over 300 m, even in Britain). Following later fieldwork, in the Jötunheimen, Norway (Clark, 1951; Clark and Lewis, 1951), Lewis emphasized the importance of rotational flow in cirque development (Lewis, 1949, 1960). Rotational flow maximises basal sliding but requires a certain range of ice surface gradients (see section 3.2). Lewis (1949) calculated that gradients of 15 - 20° and ice thicknesses of 80 - 100 m gave the greatest probabilities of rotational slip, and thus erosion of rock basins, both in cirques and below valley steps. Rotational flow has now been clearly demonstrated in Norway on Veslgjuv-breen (Grove, 1960) and Vesl-Skautbreen (McCall, 1960), and in Colorado on the Arapaho Glacier (Waldrop, 1964). Overall centre-line gradients were some 17°, 27° and 19° respectively. Lewis (1960) calculated that the 63 m deep rock basin of Blea Water, in a cirque in the English Lake

District, was excavated by a rotationally flowing glacier sloping at 13° to 16°, and that at least 7° was required to overcome basal friction.

A few authors have given more prominence to the downward erosion of cirque floors. Strøm (1945) contrasted the rapid cirque backwall recession in the quartzite of Rondane (southeast Norway) with the apparent vertical erosion (producing rock basins up to 170 m deep) in the plutonic rocks of Moskenesøy, Lofoten Islands. Galibert (1962, p. 16) proposed that in the Alps, crest retreat could be negligible compared with vertical incision of glacial cirques where jointing was most pronounced. Incision was due to greater abrasion under thick ice, accompanied by collapse of the headwall base by pressure release on deglaciation (see also Birot, 1968): high summits are deeply frozen and 'paralysed'.

Referring mainly to the Uinta Mountains of Utah, and to some Norwegian cirques, White (1970, p. 123) maintained that "In many mountainous areas… arêtes between opposing cirques are so narrow and steep that very slight additional headward erosion by either of the opposing glaciers would have breached the arêtes to form a col or a pass. Yet these arêtes persist, in rarely broken continuity threading their precarious way for great distances between the headwalls of successions of opposing cirques". Avalanche ravines on some headwalls would not have survived undermining by active sapping. White concluded that cirque floors are lowered by glacial erosion more rapidly than walls are cut back, a view that provides the opposite extreme to Richter.

Evidence of strong headward erosion was found in south-central Alaska by Tuck (1935), who proposed divide migration of up to 1 km due to stronger glacial erosion in northward-facing valley heads; the effects of differential insolation on glacier balance were reinforced by south winds. A similar interpretation of southward divide migration had been applied in west-central British Columbia where north-facing glaciers "have cut short northerly-trending valleys on the north side of the higher mountains" (Hanson 1924, p.31). Evans (1972) confirmed Hanson's hypothesis for several ranges in the Coast Mountains of southwest British Columbia. The main divides of the Bendor and Tatlow Ranges appear to have been shifted 1 to 2 km southward by cirque headwall retreat.

Evans (1997) emphasized the role of slope collapse in cirque headwall retreat, and listed examples of historical rock avalanches from cirque headwalls. The 1873, 1991 and other collapses around Mount Cook can be added to this list. These were controlled by stress-release joints slightly steeper than the cliffs, in cohesionless, closely jointed rock. "Many occur high on mountain slopes where gravitational collapse is the only operative erosion process to keep pace with glacial and fluvial valley incision" (McSaveney, 2002, p. 69). In the Ben Ohau Range, also in New Zealand, Brook et al. (2006) suggest that cirques lengthen and deepen faster than they widen, increasing in maximum gradient and reaching well-developed shapes after 600 ka. Brocklehurst and Whipple (2002) suggested that cirque headwall retreat is important on the east slope of the Californian Sierra Nevada, causing divide recession of up to 2.5 km beyond that expected from fluvial erosion.

Two recent publications based on analyses of DEMs (Digital Elevation Models) emphasize the importance of glacial erosion in cirques, in mid-latitude mountains. In part of the Washington Cascades, Mitchell and Montgomery (2006) note a parallelism between three trends: non-volcano summit altitudes, cirque floors and modern glacier median altitudes. Each rises eastward at 9 to 15 m km^{-1}. Only about 10% of each subdivision rises above the highest cirque floors, and few peaks rise more than 600 m above. Rock exhumation rates suggest vertical erosion of 2 to 5 km in the last 15 Ma, and are greatest 30 to 40 km west of the highest peaks. This is not the pattern expected from fluvial or slope erosion, so Mitchell and Montgomery propose a 'glacial buzzsaw' of greatest glacial erosion at the average Quaternary glacial equilibrium line represented by the cirque floors, where ice discharge and velocity were greatest. This increased the slope gradients above cirque floors to over 30°, causing slope failure. Thus both vertical and headward erosion in cirques is considered to dominate landscape development at high altitudes.

Uplift rates are greater in the Kyrgyz Range of the Tien Shan, where Oskin and Burbank (2005) use the sub-Cenozoic unconformity to suggest an east - west spatial gradient of uplift and thus of landform development. As mountains are taken above the snowline, glacial erosion both deepens and widens fluvial valleys, increasing local relief. This starts from the north slope where the snowline is some 200 m lower, pushing the divide 0.9 to 4.4 km southward. Erosion is localized at the bases of cirque headwalls, and cirque headwall retreat is two to three times the rate of vertical erosion. Glacial erosion is thus not simply a function of ice flux, but requires further help, perhaps from subglacial water pressure fluctuations in cirques. "Cirque retreat can effectively bevel across an elevated alpine plateau …" (Oskin and Burbank, 2005, p. 936).

Discussions of cirque development often assume that the cirque is isolated. In many areas, however, cirque headwalls intersect: cirques are side by side along one side of a ridge or more rarely (where glaciation has been more symmetrical) back to back across a ridge. This may limit further enlargement of cirques despite ongoing erosion, as arêtes are lowered along with cirque floors. Also cirque thresholds may recede by erosion of a glacial trough downstream.

Most authors regard both modes of development as important, and Evans (1997) emphasized the need for erosion to be greatest at the base of the headwall, to account for development of the characteristic break of slope and a low-gradient floor. This may be facilitated by water pressure fluctuations, or by a transition from cold to warm, sliding ice as the glacier thickens: both mechanisms encourage plucking of blocks of rock. Erosion of a rock basin is even stronger evidence of glacial erosion and probably requires rotational flow, but only a minority of cirques have a rock basin or even a lake (Derbyshire and Evans, 1976). If cirque development proceeds differently in different regions, the factors controlling this need to be established. Cirques are eroded both downward and headward. They are initiated by glaciers filling hollows of diverse types, and positive feedbacks (Graf, 1976) prevent them from escaping this inheritance: they remain diverse (Evans and Cox, 1995).

[Fig. 1 about here]

2. Data

2.1. Study Area: Wales

"I cannot imagine a more instructive and interesting lesson for any one who wishes (as I did) to learn the effects produced by the passage of glaciers, than to ascend a mountain like one of those south of the upper lake of Llanberis…convex domes or bosses of naked rock, generally smoothed, but with their steep faces often deeply scored in nearly horizontal lines…" (Darwin, 1842, p. 188). Darwin's early work on the glaciation of Wales (in the classic area of northern Snowdonia) is of historical importance in the acceptance of the glacial theory, and is set in its full context by Herbert (2005, pp. 277-284).

Choice of Wales as a study area provides a large number of cirques on a variety of rock types from Cambrian to Carboniferous (Silesian) in age, and in relief varying from the narrow mountainous ridges of Snowdon, through the more massive Carneddau Mountains, to the plateaus of central Wales and the sandstone escarpments of the south. Wales is on the west coast of Great Britain, between England and Ireland, and between 51.4 ° and 53.4 ° N. The morphology of Wales defies brief summarization, but the highest ground is in the northwest (northern Snowdonia), followed by the Aran – Cadair Idris Range in the western part of north-central Wales, and the Brecon Beacons in the south (Fig. 1). Wales and its English borderland form the Cambrian Massif, a Caledonian massif with a strong northeast-southwest grain and a Hercynian accretion in the south with a roughly east-west grain. Thomas (1970) has shown many structural influences in the topography. Quaternary tectonic movements are believed to have been subdued.

Position is used as a surrogate for climate (Evans, 1999) as there are few direct climatic observations in cirques and none for the glacial periods when they were developing. In Wales temperature varies mainly with altitude (Sumner, 1997), but at present precipitation varies with exposure, related mainly to distance from the west and south coasts but with a lag so that the wettest mountains (Snowdon, Arenigs, Arans, Pumlumon, the Rhondda area and the western Brecon

Beacons) are 20 to 30 km from the coast. In areas with cirques, modern annual precipitation (1916-50) varied from 4500 mm on Snowdon and 2500 mm on Pumlumon (also spelled Plumlumon and Plynlimon) and the western Brecon Beacons to 1300 mm in the southeast (in the Black Mountains, the Radnor Forest, and near Abergavenny), and in Yr Eifl in northwest Wales (MHLG, 1967). The driest mountains are the Clwydian Range in the northeast, which show no clear cirques. Almost all areas with modern annual precipitation over 2000 mm support glacial cirques. Precipitation in the winter half-year is mainly 54-58% of the total on the mountains of North Wales, and 57-61% on South Wales mountains.

[Fig. 2 about here]

British and Irish cirques are believed to have developed over a series of glaciations, each intermediate in extent between the present non-glacial conditions and glacial maxima when most of Wales, Ireland, Scotland and northern England was covered by a coalescent ice sheet. Wales has undergone both ice-cap and local glaciation (Campbell and Bowen, 1989; Lewis and Richards, 2005). ‘Irish Sea’ ice from Scotland and Cumbria covered the north coast and western peninsulas, but the local Welsh Ice Cap was strong enough to prevent exotic ice from penetrating the areas with cirques: it built up to at least 850 m altitude from Snowdon to Carnedd Llewelyn (McCarroll and Ballantyne, 2000), and 750 m around Cadair Idris (Ballantyne, 2001) and the Rhinog mountains. Jansson and Glasser (2004) recognize varying ice flow patterns, and extents of cold-based ice, during build-up, maximum, and decline of the Last Glaciation. Cold ice covered the highest summits at the maximum. Ice streams formed during deglaciation, but did not affect areas with cirques (Jansson and Glasser 2004, Fig. 3). As these areas were mainly ice sources, and often covered by ice frozen to the bed, cirques suffered little modification by ice-cap glaciation except in the Moelwyn, Rhinog and Migneint areas, between Snowdon and Cadair Idris.

Wales covers 20,760 km^2, and the 260 cirques occur in an area 180 x 50 km (Fig. 2). Thus the distribution is much less dense than in the Maritime Alps, where Federici and Spagnolo (2004) measured 432 glacial cirques in 67 x 26 km (1742 km^2). There is, however, a large gap between the cirques of Mid Wales and those of the Brecon Beacons, and there are few cirques in northeast Wales. The greatest concentrations are in northern Snowdonia (103 cirques in 30 x 18 km), Aran – Cadair Idris (48 cirques in 30 x 11 km) and the Brecon Beacons (30 cirques in 29 x 7 km) (Fig. 2). With one cirque per 5.2, 6.9 and 6.8 km^2 respectively, each of these sub-regions has a density of cirques rather less than the Maritime Alps (one per 4.0 km^2). The English Lake District (excluding Black Combe) has 155 cirques in 33 x 31 km (Evans and Cox, 1995, Fig. 1a); one per 6.6 km^2.

In Wales approximately 35% of cirques are named ‘Cwm…’, although this term is also applied to steep-sided fluvial valleys especially below confluences. The classic cirques of the Snowdon area have been well known since Davis (1909), and mapped and illustrated by Addison (1987). Lewis (1938) considered Llyn Cau on Cadair Idris, and Embleton and Hamann (1988) illustrated Glaslyn on Snowdon, but the cirques in many other parts of Wales have received little attention. Distributions of aspect (azimuth) are summarised by vector mean and vector strength (Evans, 2006), also known as mean direction and mean resultant length. Fig. 3 confirms that most cirques face north or east (Evans, 1999): for all 260 cirques the vector strengths are 53% for axis aspect and 58% for headwall aspect; vector means are 049° for both.

Many, but far from all, cirques were occupied by glaciers in the Devensian Late Glacial, the Loch Lomond Stadial (Gray, 1982; Ballantyne, 2001). Evans (1999) showed that the distribution of cirques occupied by these glaciers or by snowpatches was comparable to that of the whole set, but floors averaged 68 m higher and crests, 90 m higher; larger and better-developed cirques are more likely to have been occupied. For the present study, data have been updated from the work of Lynas (1996), Lowe and Larsen (in Ballantyne, 2001), Carr (2001) and Hughes (2002), mainly extending the Late Glacial occupation of cirques. However, the occupation of 83 cirques remains uncertain, pending considerable further fieldwork. Further references on Welsh moraines and glaciation are given in Evans (1999), Walker and McCarroll (2001) and Lewis and Richards (2005).

[Fig. 3 about here]

2.2. Data variables and definitions

The main data set used here covers all identified cirques in Wales and supersedes the provisional data set used in a previous study of cirque distribution (Evans, 1999). Cirque form has been re-measured and particular attention has been paid to marginal (debatable) features. One objective is to provide a high-quality data set for comparison with that for the Lake District (Evans and Cox, 1995). The Lake District data have been used by a number of investigators (e.g. Cox, 2004, 2005a) and no measurements have been challenged. The only challenge to the definition of cirques there has come from Wilson (2002) who proposed one extra cirque at Blindtarn Moss west of Grasmere: the headwall had been rejected as relating to a transverse ice flow.

If the development of cirques is to be studied, it is essential to consider all cirques from the most debatable to the most classic and from the smallest to the largest. Hence a complete inventory is needed. Cirques were graded 1 to 5, from classic to marginal or debatable (Fig. 2). Field checks have been extensive, but given the large area over which the 260 cirques are spread in Wales, checks could not be as thorough as those in the Lake District, and it is likely that detailed investigations will add some further cirques and reject some grade 5 (marginal, debatable) cirques. It is supposed that all definite (grade 3 and better) cirques are included here, and that all measurements are accurate. From the present data, the robustness of results can be tested by repeating analyses with exclusion of marginal cirques, or also of poor ones; or more stringent thresholds for floor or headwall gradient can be set.

Numbers in each grade, 1 to 5, are 23, 51, 68, 59 and 59 respectively. Fig. 4 illustrates the characteristics of differently graded cirques, from less well-known areas. The classic and well-defined cirques (Llyn Lluncaws and Craig Trum y Ddysgl) have sharp contrasts between steep headwalls and flat floors; post-glacial talus accumulation has produced or extended intermediate slopes. Cwm Cwareli has a gentler headwall of alternating sandstone and shale and is less deeply enclosed, but still a definite (average) cirque. Craig Rhiw-erch would also be definite but for the steepness of its floor, which makes it marginal and caused hesitation over its inclusion.

Increasingly, such measurements will be made on-line from scanned maps in GIS, and more automatically by processing DEMs. High-quality DEMs are becoming available and their use is particularly appealing as more broadly-based variables can be defined (Evans, 1987; e.g. gradient-weighted vector mean aspect, and vector strength instead of plan closure). Also profiles and surfaces can be fitted within a cirque. At present, the initial stage of defining and delimiting cirques is subjective and involves air photo interpretation and fieldwork; it takes longer than measurement of the variables used here. The availability of accurate manually measured data sets such as this for Wales should provide useful calibration for future GIS-derived measurements.

Cirques are defined according to the agreed definition reported by Evans and Cox (1974). This is compatible with that of de Martonne (1901). Compared with previous definitions of Snowdonian cirques, the present approach appears to be more stringent in requiring at least part of the headwall to be steep, and more tolerant in accepting sloping floors, up to just over 20°. Thus cirques mapped by both Unwin (1973) and Bennett (1990) at Cwm Bychan (Conwy), Cwm Tŷ-du (Llanberis), Cwm Merch (east of Snowdon), Cwm Planwydd (northeast of Nantlle) and Cwm Ciprwth (above Cwm Pennant, south of Nantlle) are excluded because they lack cliffs, as is Bennett's Cwm yr Afon Goch (Aber). Their cirque on the northwest slope of Moel Cynghorion, west of Snowdon, is retained in spite of a large landslide from its headwall: before this postglacial event, the cirque floor was lower. Addison (1987, and in Addison et al., 1990, p. 13) was also more demanding than Unwin or Bennett, but omitted most of the Moelwyn-Siabod cirques (which have been modified by the over-riding Welsh ice cap). In the South Wales coalfield numerous landslides are mapped, but their distribution is mainly outside cirques.

[Fig. 4 –photos- about here]

Cirques were classified also by type, most being valley-side (157, including those on escarpments) or valley-head (75, of which two thirds have thresholds). All these are simple, as opposed to nested cirques. Seventeen inner (upper) cirques are contained within 11 outer (lower) cirques: the southernmost are on the north slope of Pumlumon, in the middle of Wales. Ten of the inner cirques are contained in five outer cirques on the Snowdon (Yr Wyddfa) range. This concentration arises because here the summits rise highest above the former glacier equilibrium lines. Furthermore, only on Snowdon itself are three nested levels recognized, for Cwm Llydaw and Cwm Llan; Snowdon has cirques on all sides (Davis, 1909; Addison, 1987; Addison et al., 1990). The criterion for recognizing outer cirques around lower floors is that each should have significant additional headwall that served as an ice source, as opposed to a trough side. When measuring the characteristics of outer cirques, their inner cirques are included except for floor characteristics.

2.3. Measurements and their accuracy

Measurement accuracy depends of course on the care taken by those measuring, and on the quality and resolution (e.g. contour interval) of the maps used. The main differences come from use of different definitions in delimiting cirques, as discussed above. Full definitions of the variables measured and calculated are given in Evans and Cox (1995, Tables 1 and 2); many are in common with those used earlier by Gordon (1977) and by Andrews and Dugdale (1971), facilitating comparisons. Using these tried and tested methods, with a given cirque outline and the accurate photogrammetric contours at 10 m interval on Ordnance Survey 1:10,000 scale maps enlarged for use here, measurements are quite accurate and reproducible. Field experience has increased confidence in the accuracy of these contours.

Once the cirque outline is established it is best next to delimit the floor from the headwall. A spacing of 20 m for 10 m contours gives a slope of 1 in 2, or 26.6°, which usefully defines the boundary between cirque floor (ideally <20°: Evans and Cox,1974) and headwall (ideally >33°, steeper than talus). (A similar spacing is used in delimiting the headwall crest, i.e. the cirque outline, wherever there are gentler slopes above.) Generalizing slightly to give a fairly simple boundary, this permits estimation of maximum floor altitude. It is also needed for locating maximum (head)wall height, along a single slope line, which gives an ancillary measure of vertical dimension.

Outlining the headwall is also useful when it comes to estimating the cirque focal point, the mid-point of the threshold or sill. This is straightforward for cirques which are internally symmetrical, but many cirques deviate from this and many thresholds are sloping, so the mid-point deviates from the lowest point. In these cases there is an inevitable subjectivity, as it is necessary to compromise between the mid-points given by several contours on the headwall, and that half-way between the intersections of the headwall-floor boundary with the cirque outline. Differences in the focal point shift the median axis, changing its aspect and length.

The median axis (Unwin, 1973) has been visually estimated as leaving half the cirque map area to the left, and half to the right. Use of tracings to superimpose the two sides suggests that initial visual estimates give axial aspects within 5° of the final value, which in turn is within 2° of the true value. Thus such manual estimates are fully comparable with the exact measurements now possible in GIS (Federici and Spagnolo, 2004). Estimates of headwall aspect are less precise, but they are unaffected by uncertainty over the focal point and less affected by variations in cirque outline definition, such as those due to possible headwall extensions with marginal gradients. Here the future use of DEMs will permit calculation of a headwall resultant vector based on point values of slope aspect, weighted by gradient in excess of the 26.6° threshold. The present manual estimates are considered accurate within 10°. It is reassuring also that the difference between headwall and axis aspect is symmetrically distributed, with a standard deviation of only 20°; its range is ±65°.

Six altitude variables are defined. Estimates are accurate within 5 m, but considerable variance may come from differences in cirque outline, floor boundary and median axis. Thus the most reproducible variables are probably modal floor altitude and maximum crest altitude. The maximum altitude above, draining into a cirque, is often given exactly by a spot height, but estimates could be out by tens of metres where the location is uncertain on a mountain shoulder with divergent flow.

Again given the focal point and outline, length and width measurements are accurate within 10 m. Larger differences come from shifting the focal point or changing the cirque boundary. Visual estimates of the perpendicular nature of length and width were within 2°. Plan closure (Evans, 1969; Gordon, 1977) is a variable that requires some experience, to avoid problems with quadrants and complementary angles, but after careful measurement reproducibility within a few degrees is achieved.

With these methods of measurement and estimation from maps, and given a map with the cirque outline, all directly measured variables can be established within about an hour. This varies with cirque size, between about 30 and 90 minutes. Once a data set is complete and entered into a statistical program, hours should be spent on consistency and outlier checks, extending to days if numerous errors are discovered and corrected. Before the final measurement by the author, most of these cirques were measured at different times, from different maps, and/or by different people, under the author's supervision. This improved the establishment of the best cirque outline, and aided avoidance of substantial errors.

[Fig. 5 about here]

3. Results

3.1. Size

Welsh cirques are comparable in size to those described from Scotland and the English Lake District. They do not fall into discrete size classes, but give fairly smooth continua on all measures of size. Positive skewness ranges from 1.22 for wall height to 2.45 for length. After logarithmic transformations these are reduced to –0.06 and 0.32. For variables measuring components of vertical dimension, generated as differences between altitude variables, skewness of 0.76 to 2.49 is reduced to –0.22 to –0.76. Fig. 5a shows how well-behaved the main size variables are on a logarithmic scale. These quantile plots (Cleveland, 1994, pp. 143-9) permit the observed distribution to be compared with a model probability distribution, in this case the log-Gaussian (also known as log-normal). Compared with histograms, they emphasize the overall shape and show every observation, unaffected by binning (classing), and they 'stack' onto one plot to facilitate comparisons (Cox, 2005b). Their linearity confirms that each is well approximated by the log-Gaussian model, and thus all further analyses deal with logarithms of these size variables. Note that each variable is ranked separately, so vertical comparisons on Fig. 5a generally concern different cases.

As is usual, extreme values are more erratic than those in the middles of the distributions. One notable effect is that ranked length is less than ranked width except for the four longest cirques. These are in fact the outer cirques of Cwms Llydaw, Llan and Dwythwch, all on Snowdon, plus Cwmffynnon on the Glyderau. (Except for Cwm Dwythwch these are also the three widest cirques, although the ranking process for the plots is independent for each variable.) Omission of all 11 'outer' cirques reduces skewness, but when relations between variables are considered (below) these cirques are 'on trend' and strengthen rather than weaken correlations, so it is best to retain them.

As in other regions, for example the Rocky Mountains of the USA (Graf, 1976) or Canada (Trenhaile, 1976), Welsh cirques have width close to length so that plan form is compact. Median (and mean) values for Wales are 610 (667) m for length, 700 (772) m for width and 215 (236) m for amplitude. Spreads represented by the 5 and 95 percentiles (used here in preference to the range of extreme values) are 310-1235 m for length, 375-1502 m for width and 112-431 m for amplitude. These dimensions are comparable to those in England and in Scotland (Gordon, 1977), but rather smaller than those in northern Scandinavia (Hassinen, 1998) and considerably smaller than those in the Canadian Rockies and Columbia Mountains (Trenhaile, 1976) and the Antarctic Dry Valleys (Aniya and Welch, 1981). Cirques in the Maritime Alps (Federici and Spagnolo, 2004), the central Spanish Pyrenees (García-Ruiz et al., 2000) and the Cayoosh Range of British Columbia (Evans, 1994, Table 26.3) are comparable to Welsh cirques in area, but have rather greater vertical dimensions.

Confidence intervals show that cirque width is significantly greater than length, more so in Wales than in the Lake District. Width exceeds length also in the central Pyrenees (García-Ruiz et al., 2000), in central Sweden (Vilborg, 1984) and in northern Scandinavia (Hassinen, 1998) but in most other studies (northwest Scotland, the Maritime Alps, the whole Italian Piemonte, the Cayoosh Range, Baffin Island, the Canadian Rockies and Columbia Mountains and the Antarctic Dry Valleys) length is commonly greater. Width/length ratio averages 1.22 in Wales, and ranges from 0.49 to 3.47, so only one cirque is twice as long as broad. Cirques with width over twice length tend to be poor or marginal. Six of the 16 are in the Rhondda – Hirwaun group, and a further six are also in South Wales; all but one of these are on sandstone.

[Fig. 6 about here]

Fig. 6 shows, in five equal classes, the spatial distribution of cirque (overall) size, a combination of the three orthogonal dimensions. Size is defined as the cube root of (length x width x amplitude), so that it too has units of metres: it is required for analyses later in the paper. Larger cirques are concentrated in northern Snowdonia, and smaller ones are more common in South Wales. Cadair Idris and most northern regions have means above 460 m while the Brecon Beacons average 448 m and Corris and the rest of South Wales have means below 420 m, except that Pumlumon (mean 486 m) can compete with the northern regions and Migneint and Upper Dyfi bring down their regional group means.

These regional variations in the size and shape of Welsh cirques are further demonstrated by the variables in Figs. 7 and 8. The point-and-box plots show both the individual data and the quartile summaries (25, 50 and 75 percentiles). They are preferred over conventional box plots, which can mislead by masking the number of cases on which they are based, and which have difficulties handling log scales because inter-quartile range is dependent on the metric.

As expected, the greatest vertical dimensions are in the Snowdon and Glyder groups, followed by Carneddau, Nantlle – Hebog, Cadair Idris and the Aran Range (Fig. 1), with mean amplitudes greater than 250 m. All these are within the main Ordovician volcanic belt, although some cirques are on intercalated siltstones. The least deep vertically are in South Wales (means less than 195 m) and in the Migneint area (between the Arenig and Moelwyn mountains), followed by Corris and Pumlumon (Fig. 7a). These are on sedimentary or lightly metamorphosed rocks. The low outlier for Arenig – Migneint is Llynnau Barlwyd, where the median axis intersects a very low central col, an unusual situation.

Length too is greater in North Wales than in the South (Fig. 7b) but Cadair Idris, Nantlle – Hebog and the Carneddau have surprisingly low medians and the cirques of Mid Wales (Pumlumon) are surprisingly long. There is, however, much less North – South contrast in width (not illustrated), which is greatest in the Western Brecon Beacons and Moelwyn – Siabod and least in the Black Mountains, Abergavenny and Corris.

These results are affected by inclusion of marginal cirques, which form 30% of the total from Corris southward, but only 18% farther north. Overall, in spite of some impressive cirques on sandstone in South Wales, cirques on sedimentary, slaty and greywacke rocks are smaller than those on volcanic and igneous rocks. For analyses of variance over the 17 regional groups, R^2 values are 0.294, 0.093 and 0.014 for the logarithms of amplitude, length and width respectively. Length is significant at P=0.0007, whereas width is quite insignificant.

Fig. 5b shows that altitude variables are well distributed without transformation, across broad ranges, except that ‘high’ altitudes cannot exceed the limiting value of 1065 m, the highest point in Wales.

[Fig. 7 about here]

3.2. Shape and gradient

Gradient and closure variables are symmetrically distributed (Fig. 5c and d) except for minimum gradient where proximity to the lower bounding value of zero inevitably produces positive skew. Reversed slopes in lakes and bogs are excluded because of inadequate data. As in the Lake District (Evans and Cox, 1995, Fig. 5), quantile plots for plan closure (Fig. 5d) and axial gradient are very linear, confirming well-behaved Gaussian distributions with no need for transformation. Profile closure and maximum and minimum gradient have tails shorter than the Gaussian, giving mildly S-shaped quantile plots.

Measuring how deeply cirques cut into mountains, closure in plan is greatest (mean 149°) in the Pumlumon group, where most cirques are at the heads of valleys incised into the plateau. Otherwise it is greater in groups containing igneous rocks, including the Berwyns (Fig. 7c). The high outlier for Moelwyn is Cwmorthin (295°), which has a complicated headwall. Easily the lowest plan closures are in the Black Mountains (61°), where the four cirques are shallow recesses in long, smooth valley sides. Other sandstone groups, including the Rhinogs, have relatively low closures. Over the 17 regional groups, R^2 is 0.073, $P = 0.0043$.

Maximum gradients (not illustrated) show a clear contrast between the five mountain groups of northern Snowdonia, plus Cadair Idris and the Arans, and all the rest. Low values are found south of Cadair Idris, especially in the Western Brecon Beacons. Minimum gradients are lowest throughout Snowdonia. High minima for Corris (mean 9.4°) and the six Upper Dyfi cirques reflect the inclusion of marginal cirques on the weak Silurian and Upper Ordovician siltstones. R^2 is 0.191 for maximum and 0.158 for minimum gradient; both are highly significant.

Axial gradient (Fig. 7d; R^2 is 0.180) is a more representative measure of overall cirque steepness. All groups have values both above and below 20°, but Corris and the four north-western Snowdonia groups have means above 21°. Moelwyn – Siabod joins the three groups immediately to its south in having low gradients, together with all of South Wales where the Brecon Beacons have means just below 18°. This mixed picture arises because cirques are steep both where relief is highest (around Snowdon) and where cirque development is more marginal (as around Corris).

As a glacier filling a cirque is likely to start near the top of the median axis, axial gradients are usefully compared with the gradients of cirque glaciers. Glaciers not reaching that high up the headwall, and those overflowing the cirque threshold, would have gentler gradients. Only 10% of Welsh axial gradients are less than 13°, which is sufficient to support rotational flow (section 1.2). Only three (1% of cirques) are gentler than 8°; 10% are steeper than 30°, and the maximum axial gradient is 38°. Thus the great majority of cirques can be related to cirque glaciers or glacier sources capable of rotational flow.

As in the Lake District, correlations within this group of shape and gradient variables are weak, except that axial gradient correlates +0.63 with minimum gradient. Maximum and minimum gradients correlate only –0.26. Plan closure correlates –0.35 with axial, but only ±0.19 with the other two gradients (still significant, at the 0.005 level), and –0.20 with width/length. Principal component analysis of six shape and gradient variables confirms the weakness of their interrelations; the components have 40, 26, 19, 12, 3 and 0 percent of the total variance. This contrasts with the six altitude variables, for which the first component has 86%, and the seven logarithmic size variables, 71%.

3.3. Geological effects

All erosional landforms are affected by the material into which they cut, but it is often difficult to pin down precise morphometric contrasts between lithologies (Evans, 1994). In Snowdonia, Unwin (1973, p. 87) noted structural control of detail but "considerable disregard for geological structure" with cirques cross-cutting different lithologies in the Nantlle – Hebog group. In the Snowdon group and especially in Y Glyderau, some cirques are elongated along the strike. Floors are often on weaker strata, giving exaggerated forms deep in profile in several cirques of Y Carneddau. Bennett (1990) developed the concept of 'strike cirques' further.

The importance of joints, faults and other planes of parting in cirque development was emphasized for example by Haynes (1968) and Addison (1981). In Snowdonia, the fracture network disregards lithological boundaries, but lithology controls fracture spacing and rock mass strength at smaller scales (Addison, 1981). However, data are not available on a broad basis and for the present survey the units mapped by the British Geological Survey and others are used. Thirteen units are distinguished in Fig. 8; 22% of Welsh cirques are on Devonian and Carboniferous sandstones (with intercalated shales), 14% are on weak Ordovician and Silurian siltstones and greywackes, 19% are on tuffaceous Ordovician sediments, 29% are on Ordovician volcanic rocks, 8% are on Cambrian rocks and 6% are on intrusive granitic rocks and dolerites.

For each variable, a one-way analysis of variance gives the variability accounted for by the 13 classes of geology. Table 1 ranks the 14 variables, and shows that the most closely related to geology are vertical dimensions and altitudes, followed by gradients (especially maximum) and plan closure. The relations are weaker than those over regional groups, but their ranking is comparable. The variation of length with geology is small (Fig. 8a), and that of width is insignificant. Coal Measures cirques (which have mainly Pennant sandstone headwalls) are shorter than others, and have lower amplitudes, but are just as wide. Lengths are greatest on tuffs.

[Table 1 about here]

The strongest relation to geology comes from relief (within 2 km radius), which is another controlling factor rather than a cirque characteristic. This suggests considering the joint effects of the two on the other variables. Relief is in fact the greater control for maximum gradient, axial gradient, size and length, with no additional effect from geology. It is also the greater for maximum crest altitude, wall height, height range and amplitude, for which geology has small but significant further effects. On the other hand, relief is quite unrelated to plan closure, width and minimum gradient, and has no significant addition for lowest altitude. Thus it seems that for vertical dimensions, related gradients, length and thus size, relief is the direct control, but is itself affected by geology. Geology affects plan closure and minimum gradient (floor development) directly. For a selection of well-developed Austrian and British cirques, Embleton and Hamann (1988) also found that relief was more important than geology in controlling cirque form.

Rock basin lakes are a characteristic more closely related to geology (Haynes, 1968; Evans, 1994). In Wales, 11 of the 21 major rock basin lakes are on 'ignimbrite, lava and rhyolite', forming 29% of the cirques on that geological class. There are none on Lower Ordovician siltstones or on Silurian or younger rocks, although there are three major moraine-dammed lakes on Coal Measures sandstones and three more on Old Red Sandstone (Devonian).

[Fig. 8 about here]

Fig. 8b shows greater cirque amplitude (height range along the median axis) for volcanic and igneous rocks and tuffaceous sediments than for other rock types; amplitude is lowest on Devonian and Carboniferous rocks. As amplitude is more variable between rock types than are length and width (Table 1), variation in the compound variable 'size' is similar to that for amplitude. Relief (Fig. 8c) shows a similar pattern (and relief at 1 km radius correlates +0.89 with relief at 2 km), with clearly lower values on the younger, sedimentary rocks of the South, including the Silurian, and highest values on the three volcanic rock types and on microgranite; tuffaceous siltstones rank lower than for amplitude.

Maximum gradient (Fig. 8d) shows a clear dichotomy around 64°, between steep headwalls on volcanic and igneous rocks and gentle ones on sedimentary rocks – including Cambrian grits, and tuffaceous siltstones but not tuffaceous sandstones. Plan closure shows a different pattern (Fig. 8e), being greater on Silurian and Lower Ordovician siltstones, mudstones and greywackes (with numerous valley-head cirques), and lowest on the intrusive rocks (microgranite and dolerite) which are difficult to incise. It is fairly low on sandstones: around 100°, whether Cambrian, Devonian or Carboniferous.

3.4. Effects of other controls

As expected, the altitude and size groups of variables each have strong intercorrelations. The three 'high' altitude variables all correlate +0.91 or more: the three 'low' ones, +0.93 or more, and all six, +0.68 or more. Width and length, as logarithms, correlate +0.72 . Length correlates +0.62 to +0.71 with the three measures of vertical dimension, whereas width correlates only +0.36 to +0.45.

Thus it is necessary to be selective in relating characteristics to combinations of others. Length, width and amplitude all increase with (any of the three) maximum altitudes, and they increase as lowest altitude decreases. Regressions including dummy variables for categories show that length is a function first of maximum altitude above, followed by lowest altitude, cirque type and occupation, with $R^2 = 0.54$, to which relief adds a little but geology adds nothing. Width gives $R^2 = 0.36$ for the same four, with lowest altitude being more important than maximum: relief increases this to 0.41. Amplitude relates more to maximum altitude than to lowest, and as it is calculated as the difference between a high and a low variable, including both gives a spuriously strong prediction. $R^2 = 0.41$ for amplitude as a function of maximum altitude above, cirque type and geology; relief increases this to 0.47 but occupation gives no further improvement.

[Table 2 about here]

4. Allometry

4.1. Variations of shape with size

Table 2 shows that maximum headwall gradient increases with all five size variables, and minimum floor gradient decreases. But maximum increases mainly with vertical dimensions, to which minimum is barely related. Overall axial gradient, as expected, rises with vertical dimensions and falls with increasing length and width. The width/length ratio has modest correlations with all size variables; these are negative for vertical dimensions, which as noted above relate more to length than to width. Plan closure also relates first to length, then to width. Larger cirques are likely to have more cols (over 30 m deep) in their crests; average sizes are 440 m for no cols, 566 m for one, 743 m for two, 754 m for three, and 1501 m for the one cirque with four cols.

[Fig. 9 about here]

A more graphic way of relating shape to size is to divide size into five equal classes and draw representative profiles for each (Fig. 9). The choice of five classes gives a reasonable number, 52, in each class for reliable estimation of mean values. For each size class, modal and maximum floor altitude, median and maximum crest altitude, and maximum altitude above are plotted relative to lowest altitude, and against horizontal coordinates based on length, minimum gradient (lowest segment), maximum gradient (either side of the dot), and an assumed 10° above the crest. This is comparable to the developmental diagrams in Gordon (1977) and Bennett (1990), but based more directly on the data. Assuming a space-time transformation, headwall recession is greater than vertical enlargement, but the latter is considerable.

Development in length and width can be portrayed by a similar series (Fig. 10), using mean plan closures to dictate the curvatures. The full width is used, but as plan closure is measured along the mid-height contour which does not extend to either end of the median axis, only half the length is represented here: these are not cirque outlines. Shape changes are more subtle than size changes, but there is a progressive broadening out.

[Fig. 10 about here]

4.2. Allometric development

The concept of allometry, widely applied in developmental biology, simply implies that shape changes as organisms grow. Thus it is opposed to isometry, the maintenance of constant shape. These alternatives are commonly assessed on logarithmic scales, so that a given interval on an axis represents multiplication by a given factor. Applications to surveys of landforms at a single time are based on the assumption that the landforms have grown over time. This is not unreasonable for bedrock landforms, especially those such as cirques where positive feedback is involved. Application of allometry to glacial cirques was initiated by Olyphant (1981, p. 681), who took 'volume' (length x width x depth) as a reference measure of size to which other size measures could be related. He defined length as from cirque lip to headwall midpoint, width as the average of four measurements equally spaced along the length axis, starting at the cirque lip, and depth as the vertical difference between the cirque lip and the average cirque rim altitude. The width and depth measures are more averaged than those used here, but this is likely to affect the base constants rather than the gradients of logarithmic relations.

Here, following Evans and Cox (1995) and Evans and McClean (1995), I use median-axial length, maximum width at right angles to that axis, and vertical amplitude as the difference between crest altitude at the median axis and lowest altitude. 'Volume' is the product of the three linear dimensions, and 'size' is its cube root, useful in giving a linear measure comparable in magnitude to the three original measures. As volume = size^3, the power exponents (gradients of logarithmic regressions) are three times as great for size as for volume. That is, while length, width and amplitude exponents sum to 1.0 for predictions from volume, they sum to 3.0 for predictions from size.

An advantage of the present data set is that there are two further definitions of vertical dimension, whose exponents can be compared with those for amplitude. Wall height is measured independently as the greatest drop along any headwall slope line, from crest to floor at right angles to contours. Overall height range is the extreme, relating maximum crest altitude to lowest altitude: it cannot be less than amplitude or wall height. It is also possible to compare exponents for different geologies or grades. Confidence intervals are considered the best way of comparing the feasible variations in estimates of exponents, and the significance of differences between them.

[Table 3 about here]

Table 3 confirms that exponents for the three components of size do indeed sum to 3.0. It shows that length increases (with size) faster than does width, and width probably increases faster than amplitude. Width and wall height show exponents not significantly different from 1.0 throughout; thus they are isometric, increasing in proportion to overall size. Length has significantly greater exponents; it increases faster than size. The confidence interval on the length exponent does not overlap with any other, except wall height. The results for overall height range are very similar to those for amplitude, except for valley-head cirques. The 'better' column, where poor and debatable cirques are excluded, gives very similar exponents except for wall height. Although 'outer' cirques form a distinctly larger population, their exclusion makes no difference to the exponents obtained. Valley-side cirques show almost the same exponents as the total set, but the smaller set of valley-head cirques does give a steeper variation in amplitude with size, and a reduced variation in length. Fig. 11 shows that the scatter of data points around these regressions is well-behaved, with near constant variance on a logarithmic scale.

[Fig. 11 about here]

These results provide a powerful confirmation of cirque allometry, robust over different cirque types. Length increases faster than size, and vertical dimension increases more slowly whether axial or overall height range is used (Fig. 11); this is consistent with Gordon's (1977, Fig. 7) model. Large cirques are relatively longer and less deep than if growth were isometric. The isometry of wall height is interesting, but it does show considerably more scatter than the other vertical variables in both dimensionless (R^2) and dimensional (RMS error) terms.

[Table 4 about here]

From Table 4 it seems that allometry of cirques in Wales is less pronounced than in the other areas. This may reflect the varied relief and geology of Wales. The greater increase of length than width is shared with the English Lake District and the Cayoosh Range. It is contrary to what would occur if allometry were due to lateral coalescence, which would increase width rather than depth.

Relations within different regions and broad rock types will now be considered. As confidence intervals are too broad for the 13 classes, three broader divisions of geology are used: igneous and volcanic; other, that is Cambrian and Ordovician sediments including tuffaceous; and Silurian and younger rocks. In relation to Fig. 8, these three are defined as the first five geological classes, the next four, and the final four which equate to South Wales and parts of Mid Wales.

In Table 5, the strongly overlapping confidence intervals for each variable show that none has exponents differing significantly between these three rock types. The high R^2 and low RMS errors confirm the strengths of these relations. The poorer result for amplitude on 'other' rocks is due to the outlying but real value for Llynnau Barlwyd (on siltstones), noted above: thus overall height range gives a better result for 'other'. Wall height shows greater scatter than the other variables, and unlike height range and amplitude its exponents for igneous and other do not differ significantly from 1.0.

[Table 5 about here]

Throughout Table 5, length exponents consistently exceed those for width, except on the Silurian and younger rocks, and all vertical dimensions produce lower exponents. Thus the results of Table 3 apply across the three main rock divisions. A similar analysis (not shown) for three broad regional divisions, North (Carneddau to Moelwyn-Siabod), Mid (Arenig-Migneint to Pumlumon) and South (Brecon Beacons to Rhondda) further reinforced the results. Here all three vertical dimensions gave exponent values significantly less than 1.0 for North and South, but closer to 1.0 for Mid Wales, which mixes high and low relief. Length and width gave highly overlapping confidence intervals, with the length exponent greater in North but the width exponent slightly greater in South.

5. Summary and Conclusions

In Wales, width exceeds length in 66% of the 260 cirques. This ratio applies across different cirque types, but rises to 91% for the 56 cirques on Devonian and Carboniferous sandstones, often on escarpments or straight valley-sides. Width averages 772 m, length 667 m, (axial) amplitude 236 m, overall height range 269 m and wall height 197 m. Cirque dimensions are thus comparable to those in other mid-latitude studies, and especially to those in the English Lake District. Axial gradients are compatible with rotational flow of former glaciers in the great majority of these cirques.

Although differences between regions in length and width and their variations could arise from different practices of cirque definition, this is not the case for the contrast between Wales and the Lake District, with mean length/width ratios of 0.90 and 0.94, and the Cayoosh Range with 1.14, as I am responsible for all these definitions. The differences probably reflect regional topographic and tectonic settings, especially the degree of dissection of the landscape and the available relief. Although length and width behave somewhat differently, the slower increase of vertical dimension with cirque size is observed in all these regions.

If size (a combination of length, width and amplitude) is divided into five quintiles, each of its components (and the other vertical dimensions) increases monotonically, but there are changes in shape. Length increases most, vertical dimensions least. Plan and profile closure increase, and maximum gradient increases faster than minimum decreases.

These data provide the strongest test yet of allometry in glacial cirques. As elsewhere, vertical dimensions – amplitude, height range and wall height – increase with overall size, but significantly less than do horizontal dimensions. In Wales, only length has an exponent significantly greater than 1.0; that is, it increases faster than size in general. With minor variations, these results hold over different cirque types, regions and rock types. This type of allometry is logical given the role of glacial erosion in cirque development; the glacier rises higher against the backwall and moves away from it faster than from the sidewalls, thus increasing length faster than width. It is also reasonable that headwall retreat, often by collapse following glacial erosion at the base (Evans, 1997), is faster than downward erosion. Such importance of cirque headwall retreat has been emphasized recently by Mitchell and Montgomery (2006) and especially by Oskin and Burbank (2005), raising the question whether glacial erosion in mid-latitude mountains works largely as a ‘buzzsaw’ at the snowline or mainly by the calibration of glacial troughs to ice discharge. The divide retreat proposed by Evans (1972), Oskin and Burbank (2005) and others, shows that lateral coalescence of cirques cannot explain the greater increase of horizontal dimensions, especially since length increases with size faster than does width.

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Figures

Fig. 1. Wales: altitudes of the highest summits in each of the 17 cirque groups used here (e.g. Fig. 7), plus important secondary summits. Names of the groups are used (or parts of compound names such as Moelwyn – Siabod and Nantlle – Hebog), rather than summit names. Here, and on Figs. 2 and 3, the grid lines are kilometres on the Ordnance Survey National Grid, a variant of the Universal Transverse Mercator.

Fig. 2. The distribution of cirques in Wales, by grade.
Grades are defined as:

1. Classic, with all textbook attributes, – a steep headwall curving around a deeply excavated floor;
2. Well-defined, with the headwall curving around the floor and both clearly developed;
3. Definite, with no debate about cirque status but one weak characteristic;
4. Poor, open to some doubt but with better characteristics compensating for weaker ones; and
5. Marginal, open to debate on cirque status and origin.

Fig. 3. The distribution and headwall aspects of cirques in three parts of Wales by size for (a): Northern Snowdonia, (b): the Dolgellau region (Meirionnydd district), and (c): South Wales. The scales vary, and are shown by the grid coordinates in km. Arrows start from cirque mid-points and their length is proportional to cirque size.

Fig. 4. Photographs of cirques of various grades of development.
a: Llyn Lluncaws, in a classic cirque in the Berwyns.
b: Craig Trum y Ddysgl, the west side of a well-defined cirque above the Nantlle, viewed from Mynydd Drws-y-coed.
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Fig. 5. Quantile plots of measured variables, each individually in rank order, for (a): size, (b): altitude, (c): gradient and profile closure, and (d): plan closure.

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Fig. 9. Cirque profile development over five classes of size. This is a data-based generalization, using floor and crest altitudes and maximum and minimum gradients. The values used are means for the 52 cirques in each of five equal size classes. Each dot represents altitude of the top end of the median axis.

Fig. 10. Cirque plan development over five classes of size, represented by a hypothetical average mid-height contour. This is a data-based generalization, using plan closure, width, and half the length. The values used are means for the 52 cirques in each of five equal size classes.

Fig. 11. Allometric relations: logarithmic regressions on size, of (a): length and amplitude (with width regression for comparison), and (b): width, height range and wall height.

Table 1

Analysis of variance results, in rank order, for relation of cirque characteristics to the 13 classes of geology in Fig.8

Variable	*adjusted R^2*	*variance ratio, F*	*P-value*
log(Relief in 2 km)	.506	23.1	.0000
log(Relief in 1 km)	.438	17.8	.0000
Max. crest altitude	.340	12.1	.0000
log(Wall height)	.250	8.2	.0000
log(Height range)	.234	7.6	.0000
Lowest altitude	.208	6.7	.0000
log(Amplitude)	.199	6.4	.0000
Max. gradient	.165	5.3	.0000
Plan closure	.083	3.0	.0007
Min. gradient	.054	2.2	.0113
log(Size)	.046	2.0	.0220
Axial gradient	.045	2.0	.0231
log(Length)	.038	1.9	.0398
log(Width)	–.020	0.6	.8688

Note that adjustment for the 12 fitted constants has reduced R^2 values considerably.

Table 2

100x correlations of five size variables with five shape or gradient variables

	max. gradient	*min. gradient*	*axial gradient*	*plan closure*	*width/length*
log length	38	–51	–49	51	–38
log width	30	–55	–48	39	34
log amplitude	53	–00	36	22	–35
log heightrange	58	–12	20	33	–35
log wall height	57	–20	23	29	–33

Table 3

Exponents for logarithmic (power) regressions of size variables on overall cirque size in Wales

Variable	*expon.*	*95% conf.*	*R^2, %*	*st.dev.*	*better*	*no outer*	*valley-side*	*valley-head*
Length	1.12	1.07-1.18	86	0.16	1.10	1.12	1.13	1.01
Width	0.98	0.89-1.06	68	0.17	0.98	0.99	0.97	0.94
Amplitude	0.90	0.81-0.99	61	0.16	0.91	0.89	0.90	1.05
Height range	0.91	0.83-0.99	67	0.15	0.89	0.90	0.90	0.93
Wall height	0.97	0.86-1.09	52	0.19	0.85	0.97	1.02	0.99

95% confidence intervals and R^2 measures of fit for all 260 cirques in Wales are given on the left. These are followed by the standard deviation of each variable, and exponents for 142 better cirques (graded definite, well-defined or classic), for the 249 cirques excluding 'outer' cirques, for 157 valley-side and for 75 valley-head cirques

Table 4

Comparative exponents for logarithmic (power) regressions of size variables on overall cirque size

Variable	*Wales*	*Lake D.*	*Cayoosh*	*Mar. Alps*	*Blanca*
number of cirques	*260*	*158*	*198*	*432*	*15*
Length	1.12	1.17	1.10	1.08	1.14
Width	0.98	1.10	1.05	1.08	1.20
Amplitude	0.90	0.74	0.85		
Height range	0.91	0.75	0.83	0.84	0.66

Results for the whole of Wales are compared with those for the English Lake District (Evans and Cox, 1995, p. 195), the Cayoosh Range of British Columbia (Evans and McClean, 1995, p. 136), the Maritime Alps of Italy and France (Federici and Spagnolo, 2004, p. 240), and the Blanca Massif in the southern Colorado Rockies. The two former are in 'old massifs': the others, in active orogenic belts.

Table 5

Exponents, with 95% confidence intervals, for logarithmic (power) regressions of size variables on overall size, for three mapped geologies

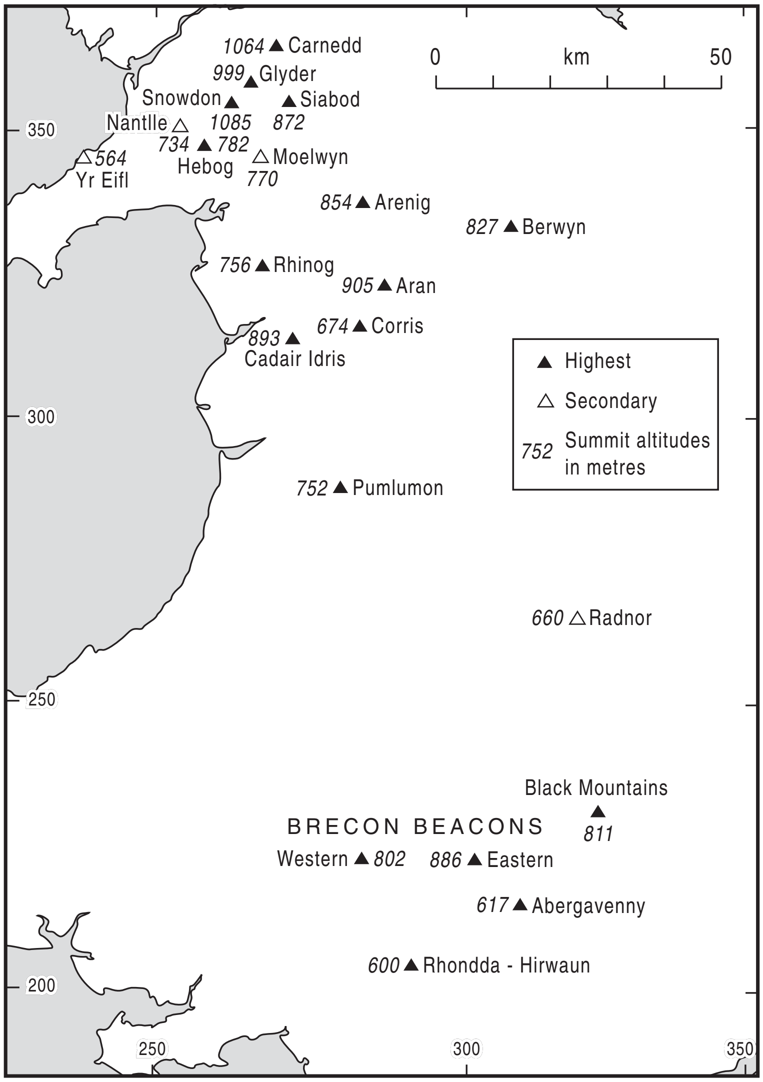
Variable	*geology*	*expon.*	*95% conf.*	R^2, %	*RMS error*
Length	igneous	1.11	1.04-1.18	92	.054
	other	1.18	1.06-1.30	81	.077
	younger	1.10	0.98-1.21	83	.067
Width	igneous	1.04	0.93-1.16	78	.093
	other	0.96	0.82-1.10	66	.093
	younger	1.13	0.97-1.29	73	.093
Amplitude	igneous	0.85	0.71-0.96	65	.104
	other	0.87	0.68-1.05	48	.122
	younger	0.77	0.66-0.87	70	.067
Height range	igneous	0.87	0.74-0.99	67	.101
	other	0.82	0.69-0.95	64	.083
	younger	0.83	0.71-0.95	71	.071
Wall height	igneous	0.87	0.69-1.05	51	.141
	other	0.91	0.72-1.10	50	.124
	younger	0.82	0.64-1.00	51	.107

'Igneous' are intrusive and volcanic (91 cirques), 'other' are Cambrian and Ordovician sediments including tuffaceous (93 cirques), and 'younger' are Silurian, Devonian and Carboniferous rocks (76 cirques).

FIGURES for "Allometric development of glacial cirque form: geological, relief and regional effects on the cirques of Wales"

Ian S. Evans

(submitted 28 Aug 2005, revised 19 January & corrected 22 February 2005)



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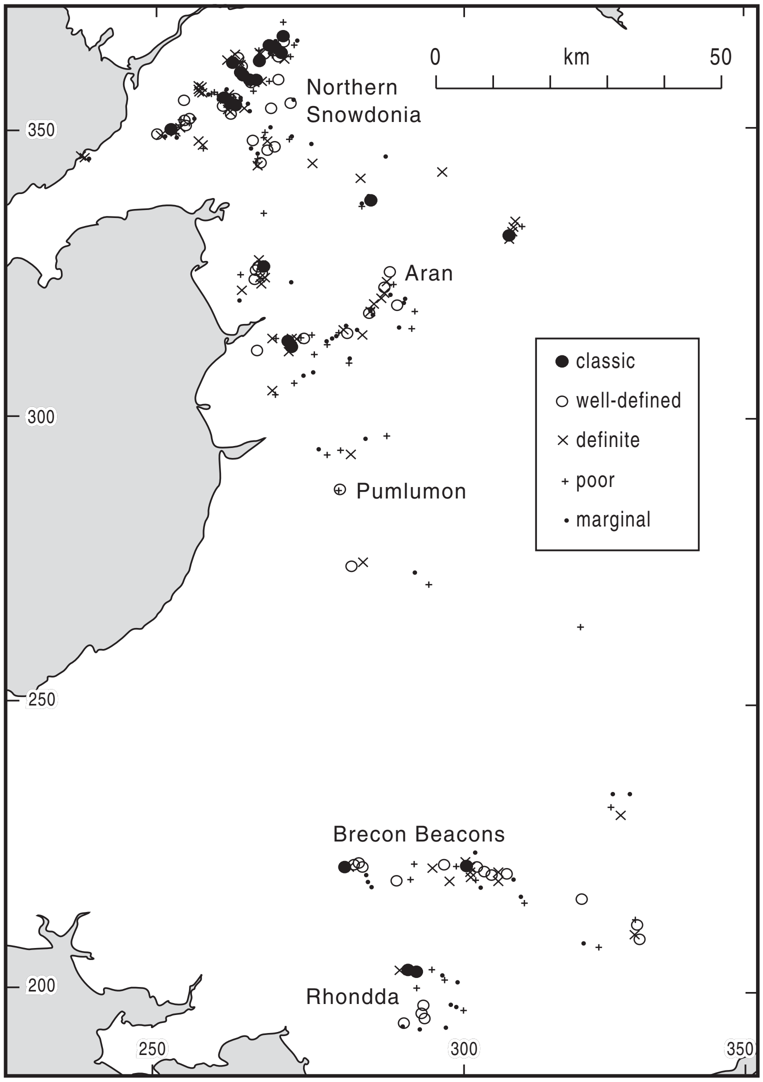

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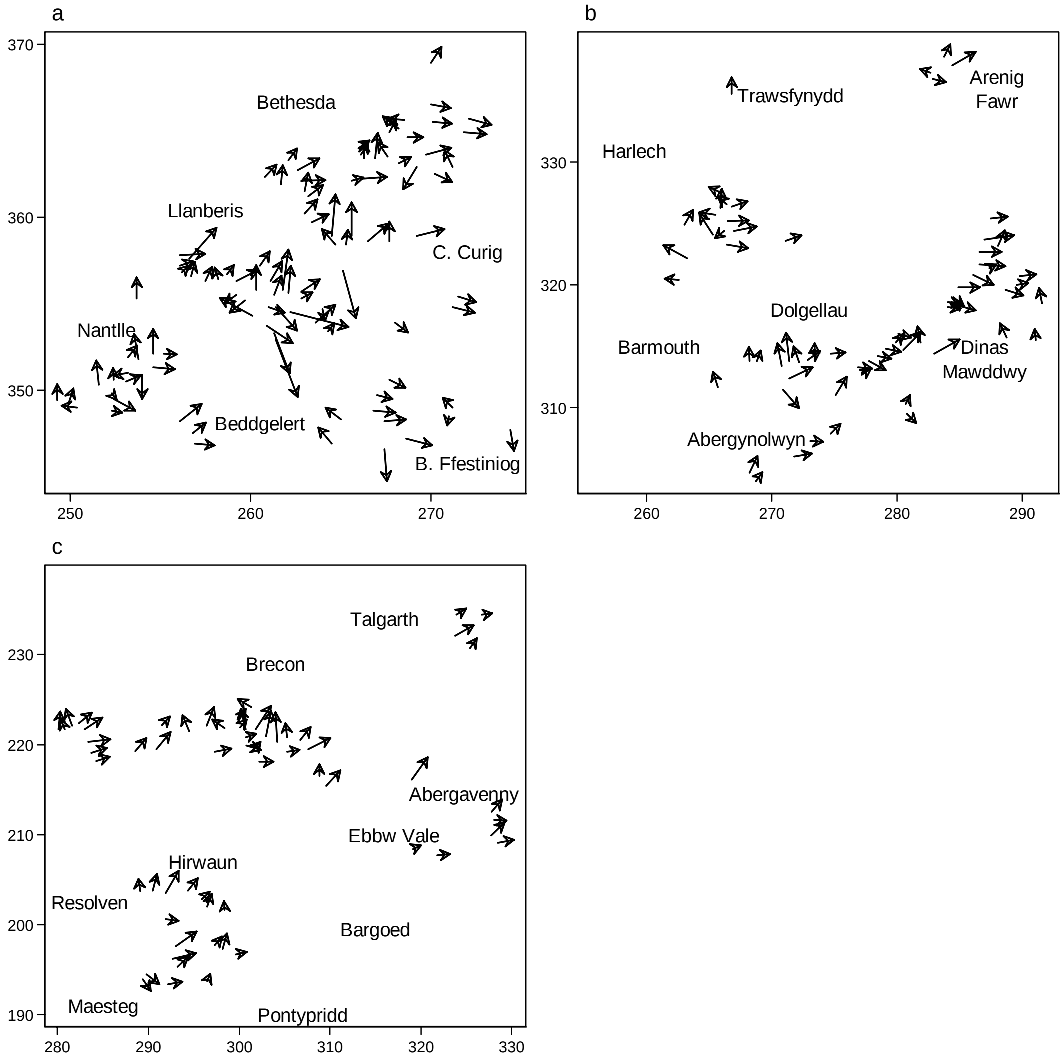

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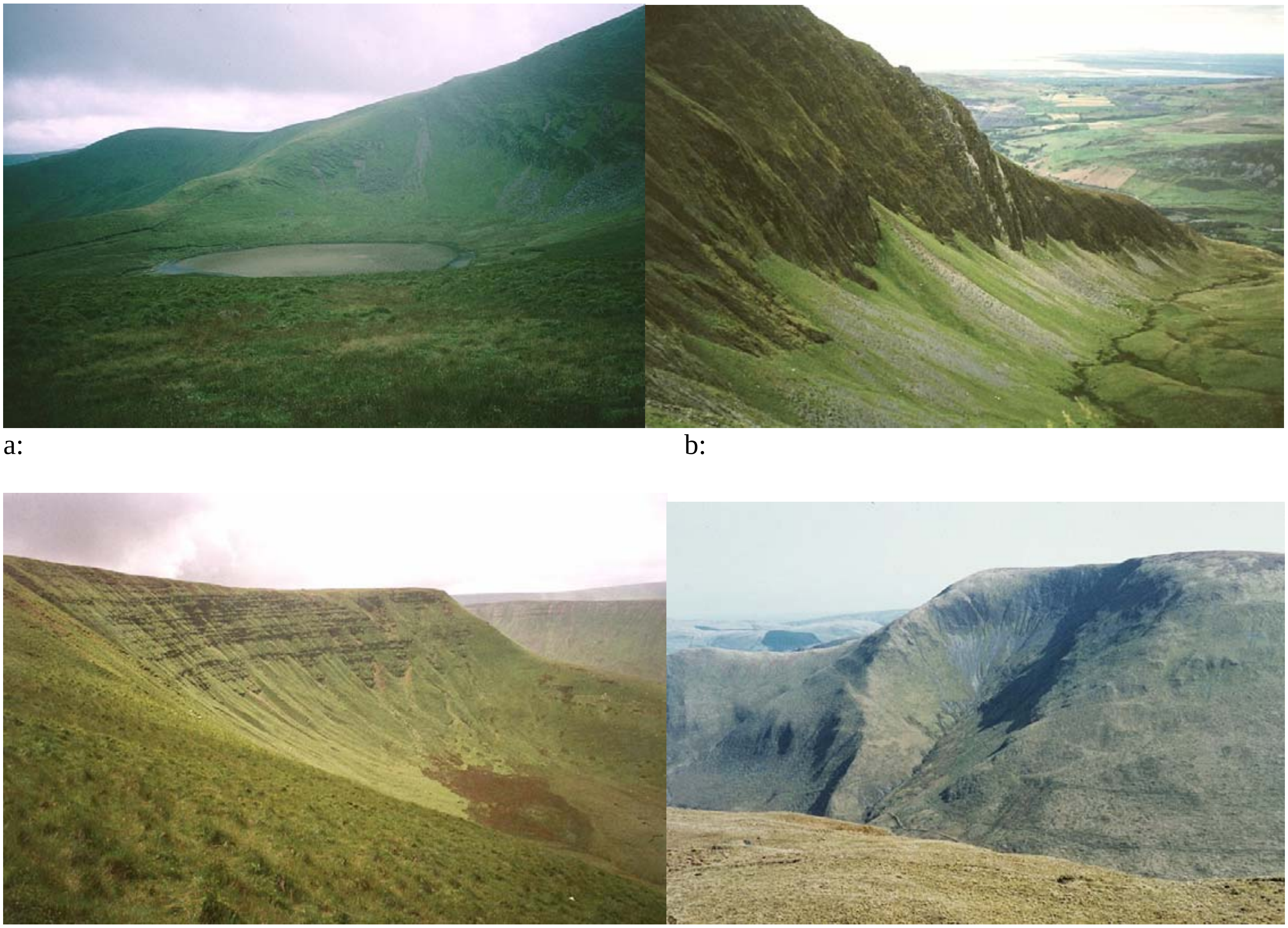

a: b:

c: d:

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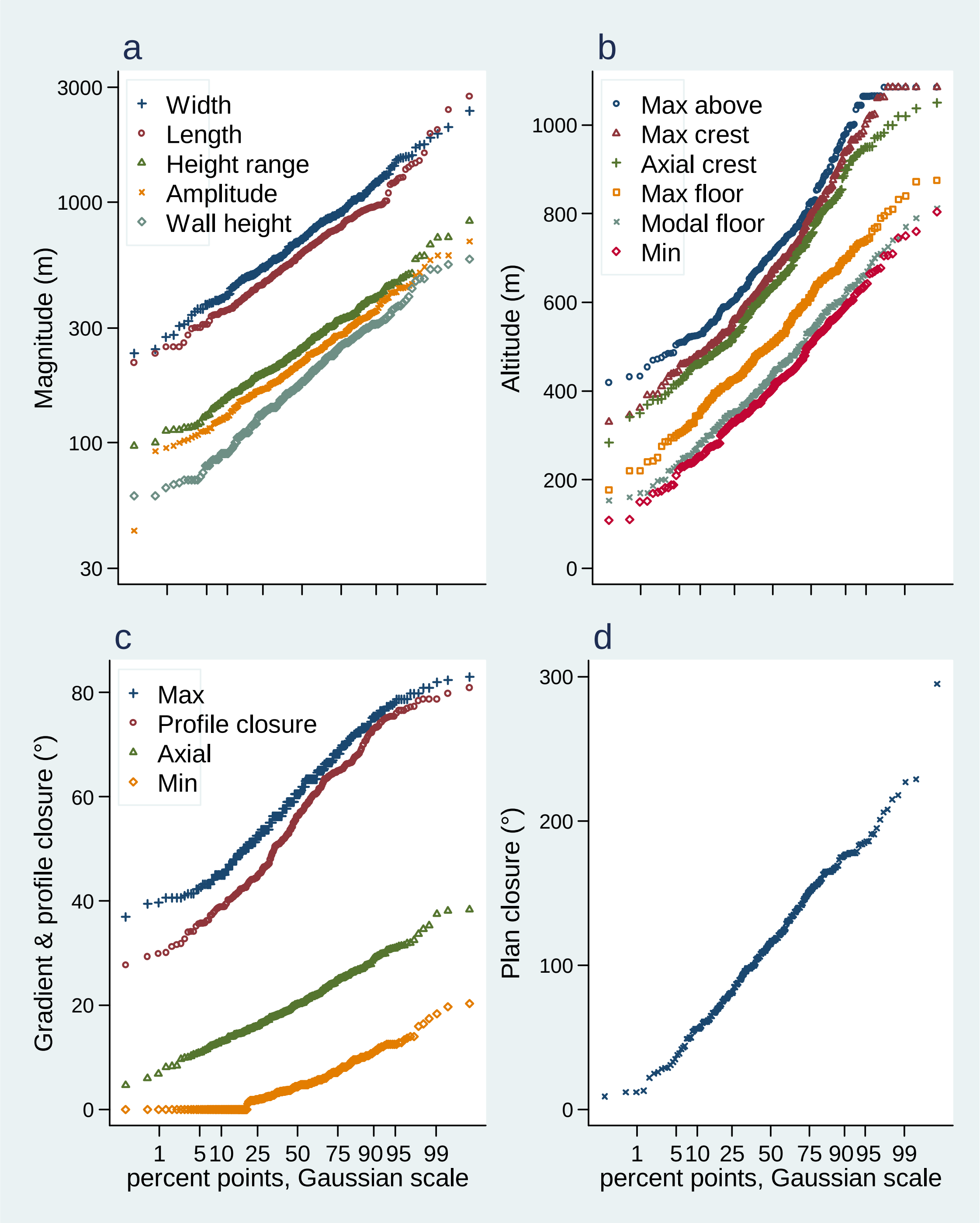

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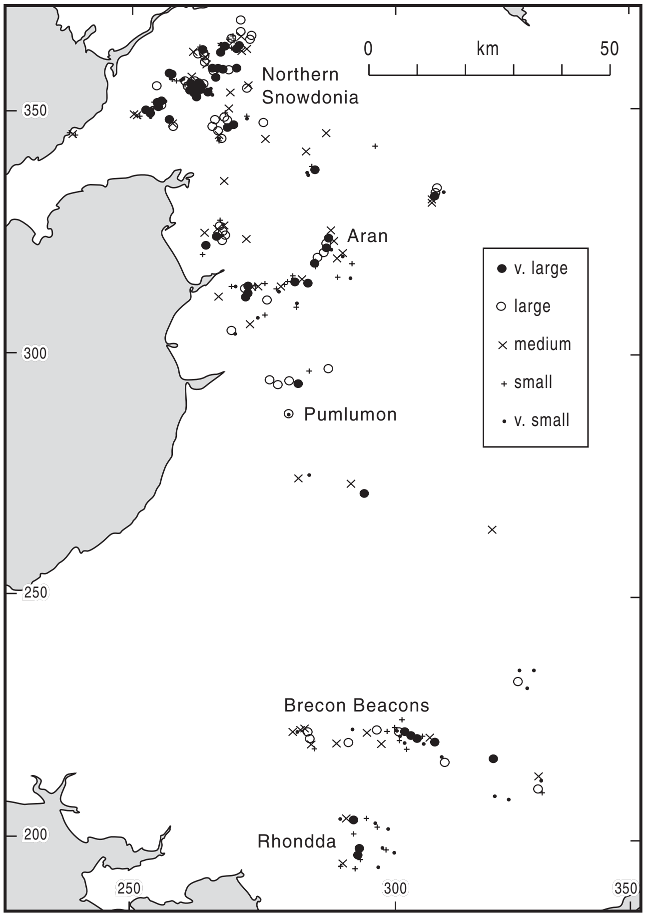

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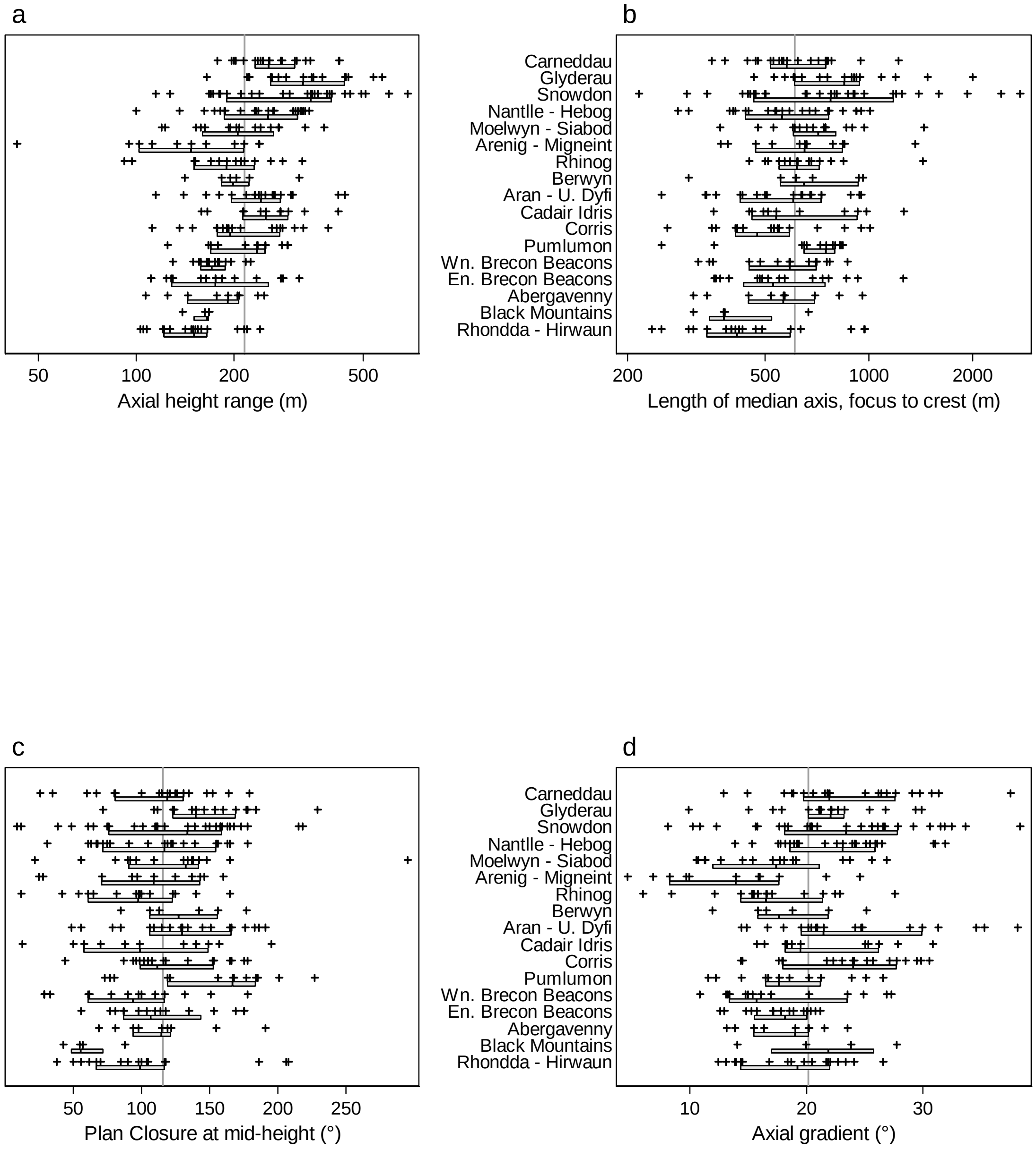

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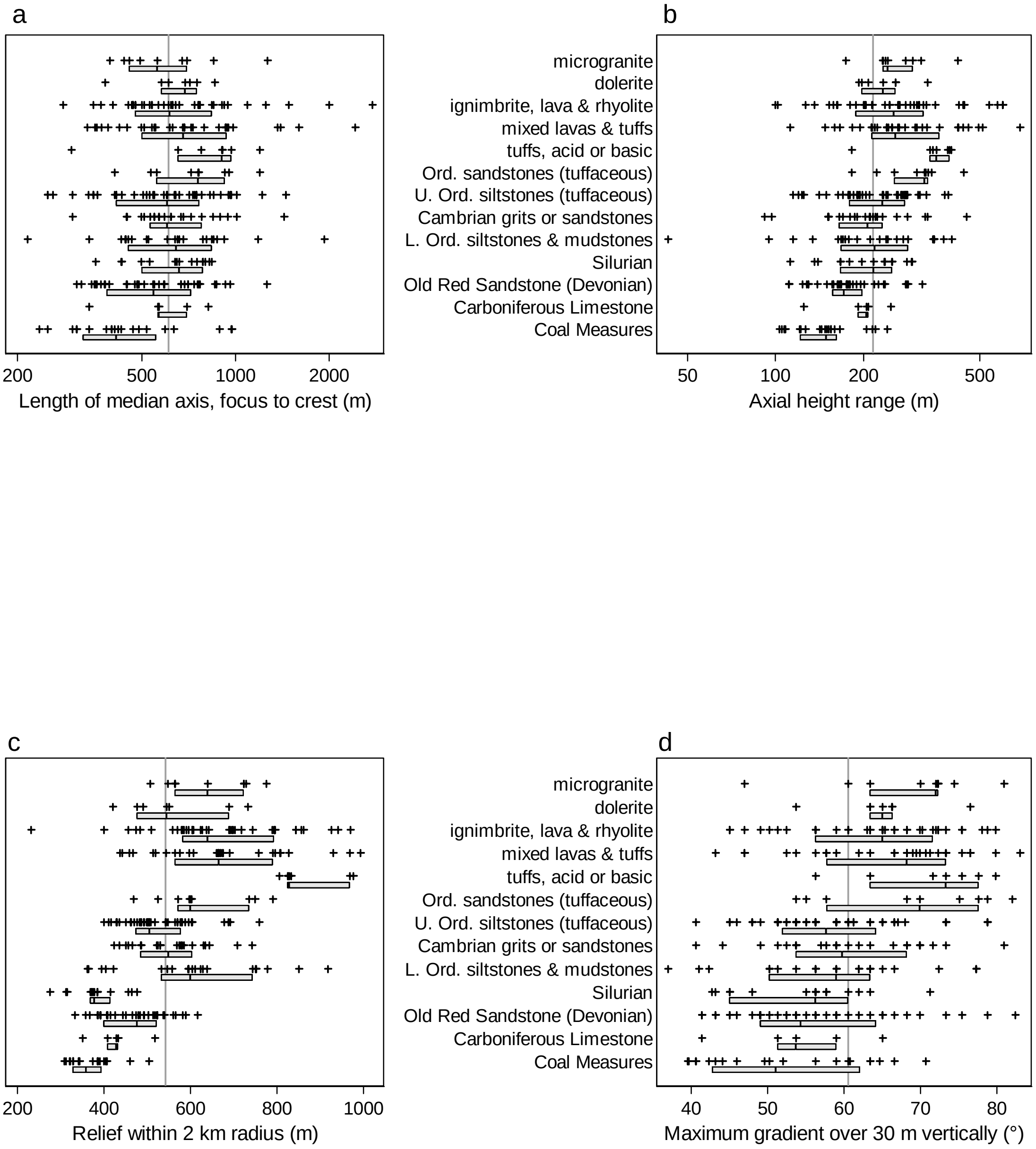
a
b
microgranite
dolerite
ignimbrite, lava & rhyolite
mixed lavas & tuffs
tuffs, acid or basic
Ord. sandstones (tuffaceous)
U. Ord. siltstones (tuffaceous)
Cambrian grits or sandstones
L. Ord. siltstones & mudstones
Silurian
Old Red Sandstone (Devonian)
Carboniferous Limestone
Coal Measures
200
500
1000
2000
Length of median axis, focus to crest (m)
50
100
200
500
Axial height range (m)
c
d
microgranite
dolerite
ignimbrite, lava & rhyolite
mixed lavas & tuffs
tuffs, acid or basic
Ord. sandstones (tuffaceous)
U. Ord. siltstones (tuffaceous)
Cambrian grits or sandstones
L. Ord. siltstones & mudstones
Silurian
Old Red Sandstone (Devonian)
Carboniferous Limestone
Coal Measures
200
400
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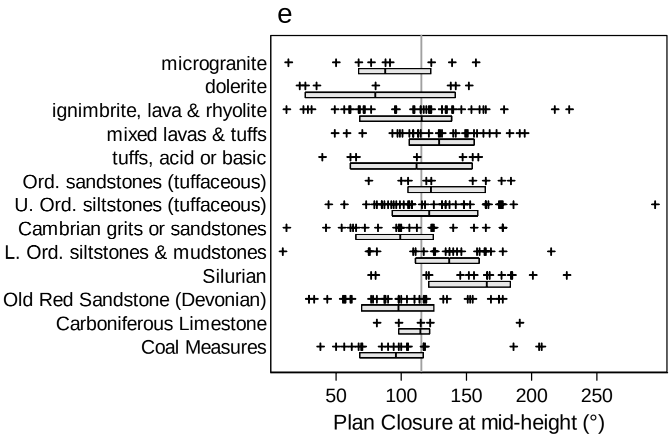
1000
Relief within 2 km radius (m)
40
50
60
70
80
Maximum gradient over 30 m vertically (°)



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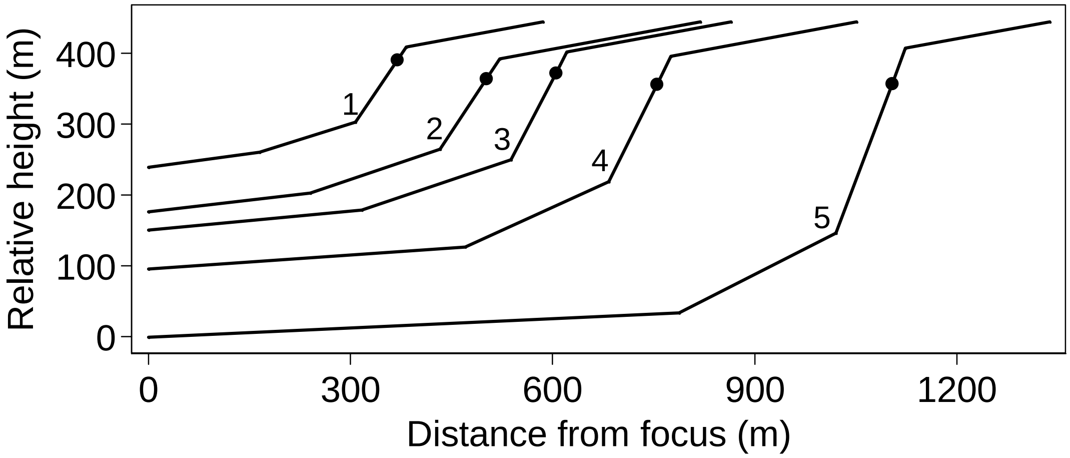

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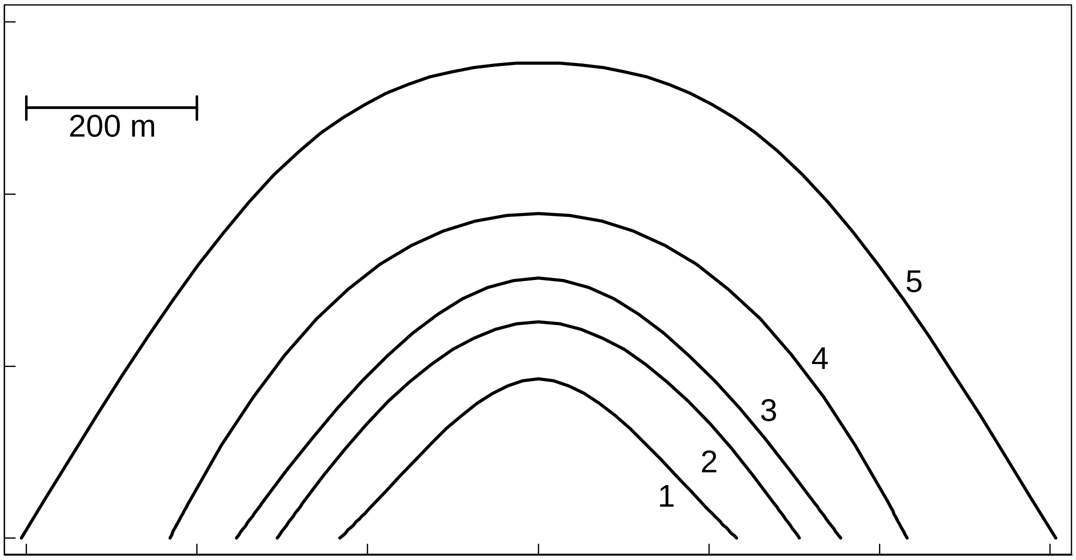

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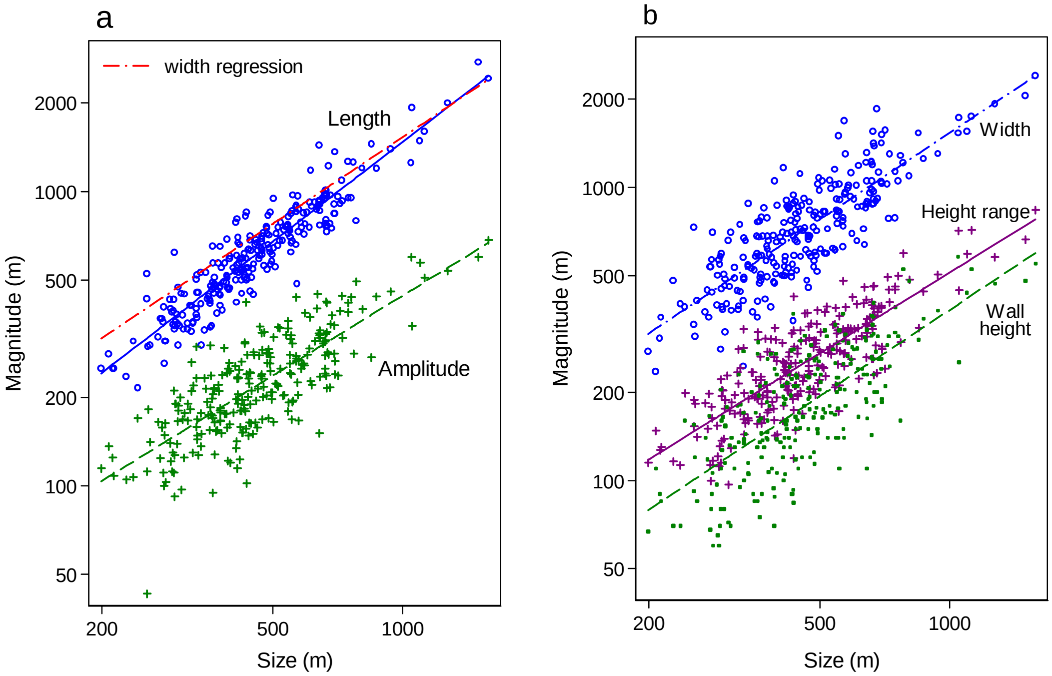

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Dear Takashi,
I have made the necessary figure corrections and just some tiny further changes to the text - removing one more sentence (after Davis 1911 sentence) in 1.2. If you wish I can send the corresponding text with changes.
Many thanks for your help,
Ian.

Data for 260 Welsh cirques

id	easting	northing	lowalt	flooralt	maxflalt	maxcralt	maxabalt	medcralt	length	width	wallht	maxgrad	mingrad	planclos	relief1	relief2	lake	cols	grade	occupat	type	group	geology	axisasp	wallasp	name	amplitude	florange	axgrad	profclos	widlen	volume	size	heightrang	logl	logw	logwallh	logamp	logsize	logflorang	logheightra	rootcols
1	2700	3689	585	660	720	832	942	831	622	783	150	45	4.2	115	447	582	drift	0	poor	LLS glacie	valley-hea	Carneddau	ignimbrite,	11	32	Mynach,Pa	246	135	21.57872	40.8	1.258842	1.20E+08	492.9798	247	2.79379	2.893762	2.176091	2.390935	2.692829	2.130334	2.392697	0
2	2676	3635	666	700	810	965	965	945	567	580	255	63.4	12.5	67	487	637	drift	0	marginal	none	valley-side	Carneddau	ignimbrite,	316	325	Cyfryw-dru	279	144	26.20012	50.9	1.022928	9.18E+07	451.0296	299	2.753583	2.763428	2.40654	2.445604	2.654205	2.158362	2.475671	0
3	2685	3656	677	690	738	940	980	919	518	475	200	56.3	11.8	126	496	604	drift	0	marginal	none	valley-side	Carneddau	L. Ord. silts	281	275	Bychan,Cv	242	61	25.04111	44.5	0.916988	5.95E+07	390.4927	263	2.71433	2.676694	2.30103	2.383815	2.591613	1.78533	2.419956	0
4	2700	3665	533	533	610	812	976	730	580	1074	255	76.5	0	152	450	550	major mora	0	classic	LLS glacie	valley-hea	Carneddau	dolerite	125	100	L.Dulyn, D	197	77	18.76032	76.5	1.851724	1.23E+08	496.9349	279	2.763428	3.031004	2.40654	2.294466	2.6963	1.886491	2.445604	0
5	2701	3655	627	636	734	832	945	830	760	730	164	63.4	0	119	448	688	major mora	0	well-define	LLS glacie	valley-hea	Carneddau	ignimbrite,	58	95	Melynllyn	203	107	14.95488	63.4	0.960526	1.13E+08	482.9226	205	2.880814	2.863323	2.214844	2.307496	2.683877	2.029384	2.311754	0
6	2682	3651	630	670	730	1022	1064	975	680	594	310	50.2	9.2	81	513	611	drift	0	definite	none	valley-side	Carneddau	L. Ord. silts	323	310	E.Caseg,C	345	100	26.90109	41	0.873529	1.39E+08	518.4475	392	2.832509	2.773787	2.491362	2.537819	2.714705	2	2.593286	0
7	2677	3649	745	745	790	1020	1064	923	444	680	260	63.4	0	164	528	629	major mora	1	classic	LLS glacie	valley-hea	Carneddau	L. Ord. silts	61	25	Caseg, Ffy	178	45	21.84589	63.4	1.531532	5.37E+07	377.3728	275	2.647383	2.832509	2.414973	2.25042	2.576771	1.653213	2.439333	1
8	2687	3646	804	812	875	1060	1064	1050	470	538	230	60.5	0	121	456	579	major rock	0	classic	uncertain	valley-hea	Carneddau	ignimbrite,	85	90	Llyffant,Ffy	246	71	27.62775	60.5	1.144681	6.22E+07	396.2218	256	2.672098	2.730782	2.361728	2.390935	2.597938	1.851258	2.40824	0
9	2697	3636	495	507	592	861	931	807	780	1193	340	78.7	1.8	131	499	687	major bog	1	classic	LLS glacie	valley-side	Carneddau	U. Ord. silt	70	74	C.yrYsfa, E	312	97	21.80141	76.89999	1.529487	2.90E+08	662.1604	366	2.892095	3.07664	2.531479	2.494155	2.820963	1.986772	2.563481	1
10	2712	3629	392	396	447	736	775	725	560	580	290	77.6	2.7	100	418	468	major bog	0	poor	LLS glacie	valley-side	Carneddau	Ord. sands	344	335	Tri Marcho	333	55	30.73753	74.9	1.035714	1.08E+08	476.453	344	2.748188	2.763428	2.462398	2.522444	2.67802	1.740363	2.536558	0
11	2702	3625	518	535	700	803	827	800	750	535	125	53.7	7.6	125	434	580	drift	0	definite	LLS glacie	valley-hea	Carneddau	U. Ord. silt	125	115	Bychan,Cv	282	182	20.60626	46.1	0.713333	1.13E+08	483.6762	285	2.875061	2.728354	2.09691	2.450249	2.684555	2.260071	2.454845	0
12	2692	3629	542	546	660	831	1064	822	1220	896	275	73.3	0	148	393	692	major rock	2	well-define	LLS glacie	valley-hea	Carneddau	U. Ord. silt	175	210	Llugwy,Cw	280	118	12.926	73.3	0.734426	3.06E+08	673.9204	289	3.08636	2.952308	2.439333	2.447158	2.828609	2.071882	2.460898	1.414214
13	2682	3631	706	717	872	940	955	920	530	375	90	50.2	3.4	60	447	696	drift	0	poor	LLS glacie	valley-side	Carneddau	ignimbrite,	78	63	C.Llugwy	214	166	21.98755	46.8	0.707547	4.25E+07	349.0655	234	2.724276	2.574031	1.954242	2.330414	2.542907	2.220108	2.369216	0
14	2660	3640	516	590	660	800	800	749	382	410	170	63.4	14	35	623	732	drift	0	poor	none	valley-side	Carneddau	dolerite	63	55	Moch,Cwm	233	144	31.381	49.4	1.073298	3.65E+07	331.6915	284	2.582063	2.612784	2.230449	2.367356	2.520734	2.158362	2.453318	0
15	2661	3636	616	630	642	936	1044	853	477	408	296	63.4	4.8	135	616	794	drift	0	definite	LLS glacie	valley-side	Carneddau	ignimbrite,	26	32	W.Cwmgla	237	26	26.42073	58.6	0.855346	4.61E+07	358.6264	320	2.678518	2.61066	2.471292	2.374748	2.554642	1.414973	2.50515	0
16	2663	3634	598	634	650	1023	1044	1020	550	350	370	83	9.5	113	609	674	drift	0	definite	none	valley-side	Carneddau	mixed lava	0	0	E.Cwmglas	422	52	37.49804	73.5	0.636364	8.12E+07	433.0929	425	2.740363	2.544068	2.568202	2.625313	2.636581	1.716003	2.628389	0
17	2669	3634	552	556	620	1012	1034	976	762	910	404	78	2	131	588	642	drift	0	well-define	LLS glacie	valley-hea	Carneddau	ignimbrite,	351	5	Cwmglas M	424	68	29.0929	76	1.194226	2.94E+08	664.9476	460	2.881955	2.959041	2.606381	2.627366	2.822787	1.832509	2.662758	0
18	2656	3621	750	790	805	978	978	950	350	400	178	56.3	12	115	644	844	drift	0	poor	LLS glacie	inner, cont	Carneddau	ignimbrite,	68	75	Ole Wen (	200	55	29.74488	44.3	1.142857	2.80E+07	303.6589	228	2.544068	2.60206	2.25042	2.30103	2.482386	1.740363	2.357935	0
19	2661	3622	642	656	760	978	1044	951	946	980	263	73.3	0	179	644	844	major rock	0	classic	LLS glacie	outer, cont	Carneddau	ignimbrite,	123	85	Lloer,Cwm	309	118	18.08903	73.3	1.035941	2.86E+08	659.2122	336	2.975891	2.991226	2.419956	2.489959	2.819025	2.071882	2.526339	0
20	2621	3633	480	500	570	785	822	700	570	415	215	53.7	10	124	611	708	outsloping	0	definite	LLS snowp	valley-side	Glyderau	Cambrian	42	35	Ceunant,C	220	90	21.10484	43.7	0.72807	5.20E+07	373.3492	305	2.755875	2.618048	2.332438	2.342423	2.572115	1.954242	2.4843	0
21	2626	3627	355	400	518	812	822	805	892	637	307	73.3	4.5	112	626	742	drift	0	well-define	LLS glacie	valley-side	Glyderau	Cambrian	63	60	Graianog,C	450	163	26.77023	68.8	0.714126	2.56E+08	634.7055	457	2.950365	2.804139	2.487138	2.653213	2.802572	2.212188	2.659916	0
22	2628	3621	400	590	655	800	813	775	920	656	282	59	6.7	137	626	638	outsloping	0	definite	LLS snowp	valley-side	Glyderau	L. Ord. silts	55	88	Perfedd,Cv	375	255	22.17624	52.3	0.713044	2.26E+08	609.4073	400	2.963788	2.816904	2.450249	2.574031	2.784908	2.40654	2.60206	0
23	2608	3623	472	472	550	700	924	695	532	715	228	60.5	0	72	498	644	major mora	0	definite	LLS glacie	valley-side	Glyderau	Cambrian	34	40	B.Marchlyr	223	78	22.74211	60.5	1.343985	8.48E+07	439.3806	228	2.725912	2.854306	2.357935	2.348305	2.642841	1.892095	2.357935	0
24	2617	3619	583	604	660	857	895	748	945	806	217	63.4	0	178	445	574	major mora	1	classic	LLS glacie	valley-hea	Glyderau	Cambrian	325	5	M.Marchly	165	77	9.904183	63.4	0.85291	1.26E+08	500.8991	274	2.975432	2.906335	2.33646	2.217484	2.69975	1.886491	2.437751	1
25	2630	3615	450	530	595	831	831	724	850	515	240	66.6	5.9	109	623	752	drift	0	definite	LLS glacie	valley-side	Glyderau	L. Ord. silts	50	10	Bual,Cwm	274	145	17.86688	60.7	0.605882	1.20E+08	493.165	381	2.929419	2.711807	2.380211	2.437751	2.692992	2.161368	2.580925	0
26	2632	3612	457	480	575	831	831	805	606	481	257	72.4	8.1	140	626	750	drift	0	well-define	LLS glacie	valley-side	Glyderau	L. Ord. silts	65	52	Cwm-coch	348	118	29.86692	64.3	0.793729	1.01E+08	466.3718	374	2.782473	2.682145	2.409933	2.541579	2.668732	2.071882	2.572872	0
27	2630	3602	580	600	657	921	923	840	640	710	261	61.9	4.4	169	599	744	minor lake	0	classic	LLS glacie	valley-hea	Glyderau	L. Ord. silts	36	40	Cywion,Cw	260	77	22.10945	57.5	1.109375	1.18E+08	490.6862	341	2.80618	2.851258	2.416641	2.414973	2.690804	1.886491	2.532754	0
28	2634	3597	640	662	705	947	947	930	610	594	267	66.6	0	146	576	795	major rock	0	classic	LLS glacie	valley-side	Glyderau	ignimbrite,	77	63	Clyd,Cwm;	290	65	25.42687	66.6	0.973771	1.05E+08	471.8871	307	2.78533	2.773787	2.426511	2.462398	2.673838	1.812913	2.487138	0
29	2645	3589	371	371	510	965	999	945	1485	1550	437	78.7	0	229	633	793	major rock	1	classic	LLS glacie	outer, cont	Glyderau	ignimbrite,	359	5	Idwal,Llyn	574	139	21.13311	78.7	1.043771	1.32E+09	1097.295	594	3.171726	3.190332	2.640481	2.758912	3.040323	2.143015	2.773787	1
30	2647	3584	625	640	832	965	999	952	760	618	280	78.7	5.6	177	628	749	drift	0	well-define	LLS glacie	inner, cont	Glyderau	Ord. sands	354	321	Cneifion,C	327	207	23.28043	73.1	0.813158	1.54E+08	535.5294	340	2.880814	2.790988	2.447158	2.514548	2.728783	2.31597	2.531479	0
31	2656	3589	530	551	720	972	990	970	1197	1250	356	75.1	0	184	620	790	major rock	2	classic	LLS glacie	outer, cont	Glyderau	Ord. sands	355	0	Bochlwyd,	440	190	20.1827	75.1	1.044277	6.58E+08	869.9326	442	3.078094	3.09691	2.55145	2.643453	2.939486	2.278754	2.645422	1.414214
32	2653	3584	670	710	745	972	990	932	465	505	270	68.2	8.5	160	604	698	minor lake	1	definite	LLS glacie	inner, cont	Glyderau	ignimbrite,	20	5	U.Bochlwy	262	75	29.39869	59.7	1.086022	6.15E+07	394.774	302	2.667453	2.703291	2.431364	2.418301	2.596349	1.875061	2.480007	1
33	2665	3586	548	590	710	943	962	900	906	1045	240	63.4	4.2	154	529	692	outsloping	1	definite	LLS glacie	valley-hea	Glyderau	ignimbrite,	57	48	Tryfan,Cw	352	162	21.23219	59.2	1.153422	3.33E+08	693.3126	395	2.957128	3.019116	2.380211	2.546543	2.840929	2.209515	2.596597	1
34	2677	3586	563	600	667	805	805	785	720	825	175	68.2	3.3	123	339	735	drift	0	poor	uncertain	valley-hea	Glyderau	Ord. sands	28	0	Gwern Go	222	104	17.13627	64.89999	1.145833	1.32E+08	508.9946	242	2.857332	2.916454	2.243038	2.346353	2.706713	2.017033	2.383815	0
35	2692	3589	282	300	425	730	763	725	1090	780	310	63	2.1	140	503	623	major rock	0	well-define	LLS glacie	valley-side	Glyderau	ignimbrite,	68	75	Gallt yr Og	443	143	22.11791	60.9	0.715596	3.77E+08	722.1736	448	3.037426	2.892095	2.491362	2.646404	2.858642	2.155336	2.651278	0
36	2651	3569	372	382	535	950	999	910	2000	1925	470	59	0	123	615	788	major rock	0	poor	none	valley-hea	Glyderau	ignimbrite,	160	165	Cwmffynn	538	163	15.05616	59	0.9625	2.07E+09	1274.719	578	3.30103	3.284431	2.672098	2.730782	3.105414	2.212188	2.761928	0
37	2636	3539	318	325	415	694	705	673	972	915	310	71.6	2.4	65	518	833	major bog	0	definite	LLS glacie	valley-side	Snowdon	tuffs, acid	62	46	Dyli, Cwm,	355	97	20.06352	69.2	0.941358	3.16E+08	680.9343	376	2.987666	2.961421	2.491362	2.550228	2.833105	1.986772	2.575188	0
38	2640	3547	373	376	425	530	544	500	453	656	144	65	0	95	399	856	major rock	0	marginal	uncertain	valley-side	Snowdon	ignimbrite,	162	170	L.Teyrn	127	52	15.66101	65	1.448124	3.77E+07	335.43	157	2.656098	2.816904	2.158362	2.103804	2.525602	1.716003	2.1959	0
39	2622	3545	420	432	588	1085	1085	1020	2750	2050	480	75.4	0	218	570	861	major rock	4	classic	LLS glacie	outer, cont	Snowdon	ignimbrite,	95	105	Llydaw,Cw	600	168	12.30802	75.4	0.745455	3.38E+09	1501.11	665	3.439333	3.311754	2.681241	2.778151	3.176413	2.225309	2.822822	2
40	2614	3548	600	603	670	1085	1085	1000	1200	1090	480	75.4	0	155	653	805	major rock	1	classic	LLS glacie	inner, cont	Snowdon	tuffs, acid	114	139	Glaslyn,Cv	400	70	18.43495	75.4	0.908333	5.23E+08	805.7913	485	3.079181	3.037426	2.681241	2.60206	2.906223	1.845098	2.685742	1
41	2610	3548	760	770	840	1085	1085	1000	500	680	280	75.4	7.1	158	605	795	minor lake	1	definite	LLS glacie	inner, cont	Snowdon	mixed lava	103	110	llwybr,y (U	240	80	25.64101	68.3	1.36	8.16E+07	433.7406	325	2.69897	2.832509	2.447158	2.380211	2.63723	1.90309	2.511883	1
42	2613	3533	370	420	490	1085	1085	880	1600	1740	525	68.2	3.6	173	734	930	drift	1	definite	uncertain	outer, cont	Snowdon	mixed lava	179	160	Llan,Cwm,	510	120	17.67968	64.6	1.0875	1.42E+09	1123.949	715	3.20412	3.240549	2.720159	2.70757	3.050746	2.079181	2.854306	1
43	2609	3537	488	508	554	1085	1085	982	795	1210	525	66.6	2.5	101	720	827	minor lake	0	definite	LLS glacie	inner, cont	Snowdon	mixed lava	153	125	Tregalan,C	494	66	31.85614	64.1	1.522013	4.75E+08	780.3567	597	2.900367	3.082785	2.720159	2.693727	2.892293	1.819544	2.775974	0
44	2614	3529	250	300	490	1085	1085	936	2420	2397	550	68.2	2.1	163	638	993	drift	2	well-define	uncertain	outer, cont	Snowdon	mixed lava	142	160	Llan,Cwm,	686	240	15.8265	66.1	0.990496	3.98E+09	1584.659	835	3.383815	3.379668	2.740363	2.836324	3.199936	2.380211	2.921686	1.414214
45	2601	3543	480	504	694	985	1085	937	1396	1300	380	69.4	1.7	168	691	790	minor lake	1	well-define	LLS glacie	valley-hea	Snowdon	mixed lava	304	300	Clogwyn,C	457	214	18.12658	67.7	0.931232	8.29E+08	939.5394	505	3.144885	3.113943	2.579784	2.659916	2.972915	2.330414	2.703291	1
46	2597	3552	410	417	473	785	870	756	655	595	325	63.4	2.8	39	567	824	major bog	0	poor	uncertain	valley-side	Snowdon	tuffs, acid	237	230	Afon Goch	346	63	27.845	60.6	0.908397	1.35E+08	512.7962	375	2.816241	2.774517	2.511883	2.539076	2.709945	1.799341	2.574031	0
47	2618	3558	350	390	505	1062	1065	950	1250	1530	580	79.8	2.6	110	855	970	drift	1	poor	LLS glacie	outer, cont	Snowdon	ignimbrite,	13	7	GlasMawr,	600	155	25.64101	77.2	1.224	1.15E+09	1046.93	712	3.09691	3.184691	2.763428	2.778151	3.019917	2.190332	2.85248	1
48	2621	3556	506	648	770	1000	1001	900	910	1025	290	77.6	3.5	159	801	968	minor lake	1	well-define	LLS glacie	inner, cont	Snowdon	tuffs, acid	341	5	Uchaf,Cwr	394	264	23.41102	74.1	1.126374	3.68E+08	716.2872	494	2.959041	3.010724	2.462398	2.595496	2.855087	2.421604	2.693727	1
49	2613	3555	674	707	734	1062	1065	1037	720	610	340	79.8	5.1	150	679	968	minor lake	0	well-define	LLS glacie	inner, cont	Snowdon	mixed lava	48	20	Glas,Cwm	363	60	26.75572	74.7	0.847222	1.59E+08	542.2376	388	2.857332	2.78533	2.531479	2.559907	2.73419	1.778151	2.588832	0
51	2611	3563	430	500	660	852	894	818	776	695	285	73.3	8	112	845	976	outsloping	0	definite	uncertain	inner, cont	Snowdon	tuffs, acid	14	30	Hetiau,Cw	388	230	26.56505	65.3	0.895619	2.09E+08	593.6896	422	2.889862	2.841985	2.454845	2.588832	2.773559	2.361728	2.625313	0
52	2603	3558	561	578	690	900	1065	898	903	875	230	79.8	0	147	649	825	major rock	0	classic	LLS glacie	valley-side	Snowdon	tuffs, acid	308	0	Du'r Arddu	337	129	20.4656	79.8	0.968992	2.66E+08	643.342	339	2.955688	2.942008	2.361728	2.52763	2.808442	2.11059	2.5302	0
53	2605	3572	357	410	470	683	710	641	446	720	300	63.4	12.5	117	651	918	outsloping	0	marginal	none	valley-side	Snowdon	L. Ord. silts	52	35	Llechog N.	284	113	32.48782	50.9	1.61435	9.12E+07	450.1203	326	2.649335	2.857332	2.477121	2.453318	2.653329	2.053078	2.513218	0
54	2587	3567	450	460	487	672	674	661	430	280	204	59	4.8	75	427	623	drift	0	poor	LLS snowp	valley-side	Snowdon	L. Ord. silts	29	35	Cynghorio	211	37	26.13708	54.2	0.651163	2.54E+07	293.97	222	2.633468	2.447158	2.30963	2.324282	2.468303	1.568202	2.346353	0
55	2582	3564	450	480	530	646	674	640	340	490	130	61.9	9.5	76	427	557	drift	0	poor	LLS snowp	valley-side	Snowdon	L. Ord. silts	322	345	W.Cyngho	190	80	29.19749	52.4	1.441176	3.17E+07	316.3318	196	2.531479	2.690196	2.113943	2.278754	2.500143	1.90309	2.292256	0
56	2566	3576	276	283	430	722	726	625	1930	1725	253	77.3	0	215	454	546	major mora	2	definite	none	outer, cont	Snowdon	L. Ord. silts	37	40	Dwythwch,	349	154	10.24998	77.3	0.893782	1.16E+09	1051.293	446	3.285557	3.236789	2.403121	2.542825	3.021724	2.187521	2.649335	1.414214
57	2567	3566	362	425	465	562	605	542	470	630	185	49.1	6.1	139	384	585	drift	1	definite	LLS glacie	inner, cont	Snowdon	ignimbrite,	353	15	NW.Goch,	180	103	20.95578	43	1.340425	5.33E+07	376.3313	200	2.672098	2.79934	2.267172	2.255272	2.57557	2.012837	2.30103	1
58	2562	3568	430	452	478	629	629	600	215	390	160	77.3	12.8	134	467	595	outsloping	0	definite	LLS glacie	inner, cont	Snowdon	L. Ord. silts	54	42	N.Gron,Fo	170	48	38.33334	64.5	1.813954	1.43E+07	242.4659	199	2.332438	2.591065	2.20412	2.230449	2.384651	1.681241	2.298853	0
59	2561	3572	430	450	530	629	629	598	453	485	138	50.2	7	111	443	595	outsloping	1	definite	LLS glacie	inner, cont	Snowdon	L. Ord. silts	76	70	Cesig,Cwn	168	100	20.34785	43.2	1.07064	3.69E+07	332.9531	199	2.656098	2.685742	2.139879	2.225309	2.522383	2	2.298853	1
60	2561	3578	320	345	520	722	726	721	872	720	230	56.3	5.4	158	443	594	drift	0	definite	LLS glacie	inner, cont	Snowdon	L. Ord. silts	87	87	yr Hafod,C	401	200	24.69592	50.9	0.825688	2.52E+08	631.4386	402	2.940516	2.857332	2.361728	2.603144	2.800331	2.30103	2.604226	0
61	2592	3555	422	423	480	618	740	595	465	582	195	51.3	0	9	495	850	major mora	0	marginal	LLS glacie	valley-side	Snowdon	L. Ord. silts	225	232	Ffynnon-y-	173	58	20.40737	51.3	1.251613	4.68E+07	360.4187	196	2.667453	2.764923	2.290035	2.238046	2.556807	1.763428	2.292256	0
62	2537	3553	310	330	360	635	695	625	700	750	295	70	5.7	123	465	507	outsloping	0	well-define	LLS snowp	valley-side	Nantlle-He	microgranit	350	0	Du (M.M.),	315	50	24.22775	64.3	1.071429	1.65E+08	548.8959	325	2.845098	2.875061	2.469822	2.498311	2.73949	1.69897	2.511883	0
63	2592	3563	340	356	530	672	1065	567	1180	855	240	63.4	1.9	178	488	778	major bog	1	poor	uncertain	valley-hea	Snowdon	L. Ord. silts	357	62	Brwynog,	227	190	10.88913	61.5	0.724576	2.29E+08	611.8214	332	3.071882	2.931966	2.380211	2.356026	2.786625	2.278754	2.521138	1
64	2552	3521	446	463	526	680	695	628	410	444	180	57.7	7.1	75	500	571	drift	0	marginal	none	valley-side	Nantlle-He	Ord. sands	100	92	Marchnad,	182	80	23.93655	50.6	1.082927	3.31E+07	321.1782	234	2.612784	2.647383	2.255272	2.260071	2.506746	1.90309	2.369216	0
65	2546	3521	345	500	525	706	709	650	952	957	215	82	3.6	165	470	602	drift	0	well-define	LLS glacie	valley-side	Nantlle-He	Ord. sands	338	0	C. Trum y	305	180	17.76432	78.4	1.005252	2.78E+08	652.5537	361	2.978637	2.980912	2.332438	2.4843	2.814616	2.255272	2.557507	0
66	2532	3519	338	350	479	612	653	576	395	590	180	60.5	5	67	531	639	outsloping	0	poor	none	valley-side	Nantlle-He	microgranit	22	38	Tal-y-mign	238	141	31.07029	55.5	1.493671	5.55E+07	381.3661	274	2.596597	2.770852	2.255272	2.376577	2.581342	2.149219	2.437751	0
67	2538	3518	300	350	410	687	709	632	1010	880	317	61.9	3.7	156	481	634	minor lake	1	well-define	LLS glacie	valley-side	Nantlle-He	Cambrian	329	350	Cwmyffynr	332	110	18.19636	58.2	0.871287	2.95E+08	665.7544	387	3.004321	2.944483	2.501059	2.521138	2.823314	2.041393	2.587711	1
68	2524	3506	534	560	600	722	734	721	300	486	153	59	12.5	63	429	524	outsloping	0	poor	uncertain	valley-side	Nantlle-He	Cambrian	353	357	Trwyn y Cr	187	66	31.93666	46.5	1.62	2.73E+07	300.9768	188	2.477121	2.686636	2.184691	2.271842	2.478533	1.819544	2.274158	0
69	2532	3510	390	410	530	602	653	600	448	560	140	52.5	8.5	178	450	630	drift	0	poor	none	valley-hea	Nantlle-He	Cambrian	263	260	Craig-las E	210	140	25.11484	44	1.25	5.27E+07	374.8824	212	2.651278	2.748188	2.146128	2.322219	2.573895	2.146128	2.326336	0
70	2516	3503	337	337	423	692	730	665	768	1050	327	75.4	0	117	400	627	major mora	0	classic	LLS glacie	valley-hea	Nantlle-He	ignimbrite,	339	354	Silyn,Cwm	328	86	23.12652	75.4	1.367188	2.64E+08	641.9109	355	2.885361	3.021189	2.514548	2.515874	2.807475	1.934498	2.550228	0
71	2499	3492	243	250	295	507	609	507	540	530	230	72	2	68	379	483	major bog	0	definite	none	valley-side	Nantlle-He	ignimbrite,	354	18	C.CwmDul	264	52	26.0535	70	0.981482	7.56E+07	422.7574	264	2.732394	2.724276	2.361728	2.421604	2.626091	1.716003	2.421604	0
72	2504	3490	340	400	480	532	701	502	590	650	138	45	3.5	165	463	474	outsloping	1	marginal	none	valley-hea	Nantlle-He	ignimbrite,	314	275	Bwlch Cwr	162	140	15.35368	41.5	1.101695	6.21E+07	396.0592	192	2.770852	2.812913	2.139879	2.209515	2.59776	2.146128	2.283301	1
74	2523	3488	338	350	360	438	701	438	405	535	80	47	2.9	131	538	604	drift	0	marginal	none	valley-side	Nantlle-He	ignimbrite,	109	100	Clogwyn D	100	22	13.86969	44.1	1.320988	2.17E+07	278.7851	100	2.607455	2.728354	1.90309	2	2.44527	1.342423	2	0
75	2524	3495	340	400	477	651	734	650	920	860	240	56.3	3.4	72	474	606	drift	0	poor	none	outer, cont	Nantlle-He	ignimbrite,	145	120	L.Braich-y-	310	137	18.62158	52.9	0.934783	2.45E+08	625.9639	311	2.963788	2.934499	2.380211	2.491362	2.796549	2.136721	2.49276	0
76	2523	3498	503	530	546	651	721	639	280	235	110	56.3	12.8	122	412	604	outsloping	0	definite	none	inner, cont	Nantlle-He	ignimbrite,	126	140	U.Braich-y	136	43	25.90651	43.5	0.839286	8948800	207.6132	148	2.447158	2.371068	2.041393	2.133539	2.317255	1.633469	2.170262	0
77	2531	3505	385	420	496	680	700	640	535	500	210	69.9	9.5	105	539	599	drift	0	definite	LLS snowp	valley-hea	Nantlle-He	Ord. sands	89	67	C.Pennant	255	111	25.48413	60.4	0.934579	6.82E+07	408.5902	295	2.728354	2.69897	2.322219	2.40654	2.611288	2.045323	2.469822	0
78	2540	3509	276	310	435	690	702	600	923	875	300	55	4.6	155	548	597	drift	0	well-define	none	valley-hea	Nantlle-He	Ord. sands	168	180	Dwyfor,Cw	324	159	19.34257	50.4	0.947996	2.62E+08	639.6144	414	2.965202	2.942008	2.477121	2.510545	2.805918	2.201397	2.617	0
79	2546	3513	359	392	466	701	709	701	763	610	251	53.7	6.7	119	415	524	drift	0	poor	none	valley-hea	Nantlle-He	Ord. sands	129	95	Cwm Du, T	342	107	24.14338	47	0.799476	1.59E+08	541.9512	342	2.882524	2.78533	2.399674	2.534026	2.73396	2.029384	2.534026	0
80	2561	3482	314	355	500	600	783	580	840	1510	190	72.3	4.4	163	456	703	drift	2	definite	none	valley-side	Nantlle-He	ignimbrite,	32	50	Meillionen,	266	186	17.57126	67.9	1.797619	3.37E+08	696.1657	286	2.924279	3.178977	2.278754	2.424882	2.842713	2.269513	2.456366	1.414214
81	2568	3475	403	430	500	721	721	708	510	510	222	72.3	8.7	61	574	743	outsloping	0	definite	none	valley-side	Nantlle-He	ignimbrite,	30	50	Bleiddiaid,	305	97	30.88108	63.6	1	7.93E+07	429.6816	318	2.70757	2.70757	2.346353	2.4843	2.633147	1.986772	2.502427	0
82	2569	3469	460	490	576	781	783	780	642	615	230	68.2	6.7	31	540	718	outsloping	0	poor	none	valley-side	Nantlle-He	ignimbrite,	107	95	Hebog E.,	320	116	26.49361	61.5	0.957944	1.26E+08	501.7877	321	2.807535	2.788875	2.361728	2.50515	2.70052	2.064458	2.506505	0
83	2575	3563	349	355	427	601	630	464	807	756	183	53.7	2.5	165	371	533	drift	1	marginal	none	valley-hea	Snowdon	L. Ord. silts	31	25	Maesgwyn	115	78	8.110222	51.2	0.936803	7.02E+07	412.4434	252	2.906873	2.878522	2.262451	2.060698	2.615364	1.892095	2.401401	1
84	2493	3494	237	238	306	488	609	425	540	770	195	71.6	0	77	386	509	major rock	0	well-define	none	valley-side	Nantlle-He	ignimbrite,	13	0	L.Dulyn, C	188	69	19.19547	71.6	1.425926	7.82E+07	427.5768	251	2.732394	2.886491	2.290035	2.274158	2.631014	1.838849	2.399674	0
85	2715	3554	457	530	650	792	800	788	690	455	225	63.4	6.3	22	461	689	outsloping	0	marginal	none	valley-side	Moelwyn-S	dolerite	71	108	E.Siabod	331	193	25.62751	57.1	0.65942	1.04E+08	470.1425	335	2.838849	2.658011	2.352183	2.519828	2.67223	2.285557	2.525045	0
86	2712	3548	534	536	625	855	872	810	896	735	250	78.7	0	131	487	604	major rock	0	well-define	LLS glacie	valley-side	Moelwyn-S	U. Ord. silt	101	105	L.Siabod, I	276	91	17.1207	78.7	0.820313	1.82E+08	566.4586	321	2.952308	2.866287	2.39794	2.440909	2.753168	1.959041	2.506505	0
87	2680	3539	370	370	420	584	591	493	660	900	150	68	0	142	290	430	major mora	1	well-define	uncertain	valley-hea	Moelwyn-S	U. Ord. silt	120	128	Diwaunyd	123	50	10.55674	68	1.363636	7.31E+07	418.0522	214	2.819544	2.954242	2.176091	2.089905	2.621231	1.69897	2.330414	1
88	2650	3483	372	378	465	592	671	580	610	975	204	65	0	142	364	545	major rock	0	well-define	LLS glacie	valley-side	Moelwyn-S	dolerite	295	309	Llagi, Lyn,	208	93	18.82854	65	1.598361	1.24E+08	498.2714	220	2.78533	2.989005	2.30963	2.318063	2.697466	1.968483	2.342423	0
89	2677	3506	368	410	510	562	589	531	630	856	110	51.3	4.6	96	402	456	drift	0	marginal	none	valley-side	Moelwyn-S	ignimbrite,	80	118	Yr Arddu E	163	142	14.50605	46.7	1.35873	8.79E+07	444.6319	194	2.79934	2.932474	2.041393	2.212188	2.648001	2.152288	2.287802	0
90	2670	3497	441	463	515	585	594	561	603	866	106	66.6	1.9	92	343	486	minor lake	0	poor	uncertain	valley-side	Moelwyn-S	U. Ord. silt	128	105	NE.Ysgafe	120	74	11.2551	64.7	1.436153	6.27E+07	397.1966	144	2.780317	2.937518	2.025306	2.079181	2.599005	1.869232	2.158362	0
91	2668	3488	441	449	570	652	672	634	860	1025	110	53.7	1.9	138	332	490	major bog	0	poor	uncertain	valley-hea	Moelwyn-S	dolerite	66	95	SE.Ysgafe	193	129	12.64867	51.8	1.19186	1.70E+08	554.1064	211	2.934499	3.010724	2.041393	2.285557	2.743593	2.11059	2.324282	0
92	2674	3482	395	422	515	671	676	590	972	905	205	53.7	1.7	148	296	428	drift	0	definite	uncertain	valley-hea	Moelwyn-S	U. Ord. silt	63	85	Druman, M	195	120	11.34394	52	0.93107	1.72E+08	555.6268	276	2.987666	2.956649	2.311754	2.290035	2.744783	2.079181	2.440909	0
93	2686	3472	280	355	432	672	698	660	750	1125	260	65	2.5	137	448	501	drift	1	well-define	uncertain	valley-side	Moelwyn-S	U. Ord. silt	107	105	Allt-fawr E.	380	152	26.86981	62.5	1.5	3.21E+08	684.4354	392	2.875061	3.051152	2.414973	2.579784	2.835332	2.181844	2.593286	1
94	2674	3466	320	325	425	652	695	594	1450	1530	302	67	0	295	373	518	major rock	3	well-define	LLS glacie	valley-side	Moelwyn-S	U. Ord. silt	130	175	Cwmorthin	274	105	10.70075	67	1.055172	6.08E+08	847.1039	332	3.161368	3.184691	2.480007	2.437751	2.927937	2.021189	2.521138	1.732051
95	2663	3444	470	490	588	740	770	674	740	990	170	60.5	0	109	440	570	major rock	1	well-define	LLS glacie	valley-side	Moelwyn-S	ignimbrite,	118	105	Stwlan, Lly	204	118	15.41224	60.5	1.337838	1.49E+08	530.6796	270	2.869232	2.995635	2.230449	2.30963	2.724832	2.071882	2.431364	1
96	2658	3439	507	530	600	702	710	660	478	680	137	66.6	3.9	134	390	590	drift	1	definite	none	valley-side	Moelwyn-S	ignimbrite,	288	272	Bach,Moel	153	93	17.74902	62.7	1.422594	4.97E+07	367.7416	195	2.679428	2.832509	2.136721	2.184691	2.565543	1.968483	2.290035	1
97	2656	3444	464	475	505	662	770	622	370	360	166	65	3.3	56	440	595	drift	0	poor	none	valley-side	Moelwyn-S	ignimbrite,	235	226	Ceseiliau D	158	41	23.12379	61.7	0.972973	2.10E+07	276.092	198	2.568202	2.556303	2.220108	2.198657	2.441054	1.612784	2.296665	0
98	2658	3451	525	595	664	770	770	758	530	580	190	63.4	12.5	81	540	595	outsloping	0	poor	LLS glacie	valley-side	Moelwyn-S	U. Ord. silt	0	10	N.Moelwyr	233	139	23.73138	50.9	1.09434	7.16E+07	415.2917	245	2.724276	2.763428	2.278754	2.367356	2.618353	2.143015	2.389166	0
99	2656	3460	228	255	375	521	770	470	740	910	213	61.2	4.8	165	561	602	drift	1	marginal	uncertain	valley-hea	Moelwyn-S	U. Ord. silt	277	258	Croesor,Cv	242	147	18.10914	56.4	1.22973	1.63E+08	546.214	293	2.869232	2.959041	2.32838	2.383815	2.737363	2.167317	2.466868	1
100	2645	3469	410	465	550	689	689	670	750	835	224	45	4.8	90	502	579	drift	0	marginal	none	valley-side	Moelwyn-S	U. Ord. silt	307	322	Cnicht NW	260	140	19.11973	40.2	1.113333	1.63E+08	546.06	279	2.875061	2.921686	2.350248	2.414973	2.73724	2.146128	2.445604	0
101	2812	2741	270	340	405	501	555	487	723	680	120	55	5	156	324	368	drift	0	well-define	LLS glacie	valley-side	Pumlumon	Silurian	7	4	Cwm-du, Y	217	135	16.70651	50	0.940526	1.07E+08	474.2809	231	2.859138	2.832509	2.079181	2.33646	2.676036	2.130334	2.363612	0
102	2831	2748	338	355	425	507	523	505	356	532	110	56.3	4.8	77	281	315	drift	0	definite	LLS snowp	valley-side	Pumlumon	Silurian	343	0	Cwmtinwe	167	87	25.13133	51.5	1.494382	3.16E+07	316.2467	169	2.55145	2.725912	2.041393	2.222717	2.500026	1.939519	2.227887	0
103	2793	2875	505	508	600	702	752	675	830	820	170	59	0	167	299	410	major mora	1	well-define	LLS glacie	outer, cont	Pumlumon	U. Ord. silt	329	10	LlygadRhe	170	95	11.57519	59	0.987952	1.16E+08	487.2819	197	2.919078	2.913814	2.230449	2.230449	2.68778	1.977724	2.294466	1
104	2791	2873	575	600	620	702	750	700	250	305	90	55	9.3	73	293	416	outsloping	0	poor	LLS glacie	inner, cont	Pumlumon	U. Ord. silt	21	20	Pumlumon	125	45	26.56505	45.7	1.22	9531250	212.0231	127	2.39794	2.4843	1.954242	2.09691	2.326383	1.653213	2.103804	0
105	2870	2968	188	220	250	481	527	480	660	600	230	60.5	5.4	119	368	384	drift	0	poor	uncertain	valley-side	Pumlumon	Silurian	87	70	Cilcwm, Pe	292	62	23.86576	55.1	0.909091	1.16E+08	487.1836	293	2.819544	2.778151	2.361728	2.465383	2.687693	1.792392	2.466868	0
106	2772	2935	169	200	242	501	529	419	785	995	266	57.7	2.3	184	362	385	drift	2	poor	LLS glacie	valley-hea	Pumlumon	Silurian	28	50	Hengwym,	250	73	17.66519	55.4	1.267516	1.95E+08	580.1553	332	2.89487	2.997823	2.424882	2.39794	2.763544	1.863323	2.521138	1.414214
107	2794	2943	240	268	370	512	519	490	785	720	140	56.3	5.7	121	363	477	drift	0	poor	uncertain	valley-side	Pumlumon	Silurian	12	40	Mawnog, F	250	130	17.66519	50.6	0.917198	1.41E+08	520.8517	272	2.89487	2.857332	2.146128	2.39794	2.716714	2.113943	2.434569	0
108	3081	3342	511	565	710	783	794	715	964	945	204	51.3	6.4	177	367	435	drift	1	definite	LLS glacie	valley-hea	Berwyn	U. Ord. silt	68	95	llawenog,C	204	199	11.94855	44.9	0.980291	1.86E+08	570.663	272	2.984077	2.975432	2.30963	2.30963	2.75638	2.298853	2.434569	1
109	3078	3332	570	590	675	815	827	793	554	1050	164	57.7	4.8	156	354	437	drift	1	definite	uncertain	valley-hea	Berwyn	mixed lava	128	130	C.Berwyn	223	105	21.92612	52.9	1.895307	1.30E+08	506.2146	245	2.74351	3.021189	2.214844	2.348305	2.704335	2.021189	2.389166	1
110	3076	3324	504	550	665	823	827	822	935	895	163	52.5	7.1	113	365	442	drift	0	definite	uncertain	valley-hea	Berwyn	mixed lava	87	95	BerwynS	318	161	18.78353	45.4	0.957219	2.66E+08	643.2117	319	2.970812	2.951823	2.212188	2.502427	2.808354	2.206826	2.503791	0
111	3071	3318	604	611	700	822	827	799	686	710	165	56.3	0	142	350	467	major mora	1	classic	LLS glacie	valley-hea	Berwyn	mixed lava	132	115	L.LLuncaw	195	96	15.86815	56.3	1.034985	9.50E+07	456.253	218	2.836324	2.851258	2.217484	2.290035	2.659206	1.982271	2.338456	1
112	3071	3311	495	540	632	691	827	678	615	700	90	47	8.1	106	450	544	drift	0	definite	uncertain	valley-side	Berwyn	mixed lava	108	73	TrumFelen	183	137	16.57095	38.9	1.138211	7.88E+07	428.6881	196	2.788875	2.845098	1.954242	2.262451	2.632141	2.136721	2.292256	0
113	3092	3333	520	538	575	661	742	661	300	410	85	46	10.3	85	324	461	drift	0	poor	LLS glacie	valley-hea	Berwyn	U. Ord. silt	121	130	Tomle NE	141	55	25.17352	35.7	1.366667	1.73E+07	258.846	141	2.477121	2.612784	1.929419	2.149219	2.413041	1.740363	2.149219	0
114	2844	3379	400	404	510	681	780	640	1365	1030	185	71.2	0	109	360	564	major mora	0	classic	LLS glacie	valley-side	Arenig-Mig	mixed lava	77	60	L.Arenig F	240	110	9.972057	71.2	0.754579	3.37E+08	696.1888	281	3.135133	3.012837	2.267172	2.380211	2.842727	2.041393	2.448706	0
115	2829	3368	664	680	736	832	854	812	372	670	134	47	8.1	93	390	458	drift	0	poor	uncertain	valley-side	Arenig-Mig	mixed lava	101	105	ArenigFaw	148	72	21.69511	38.9	1.801075	3.69E+07	332.8842	168	2.570543	2.826075	2.127105	2.170262	2.522293	1.857332	2.225309	0

116	2875	3254	439	445	485	710	720	682	683	520	225	72.3	0	49	522	607	major mora	0	well-define	LLS glacie	valley-side	Aran-Dyfi	mixed lava	84	82	L.Lliwbran	243	46	19.58471	72.3	0.761347	8.63E+07	441.9198	271	2.834421	2.716003	2.352183	2.385606	2.645344	1.662758	2.432969	0
117	2870	3237	385	430	590	885	885	824	950	1050	310	73.3	7.6	109	535	597	drift	1	definite	uncertain	valley-side	Aran-Dyfi	mixed lava	86	81	CwmLlwyd	439	205	24.80191	65.7	1.105263	4.38E+08	759.38	500	2.977724	3.021189	2.491362	2.642465	2.880459	2.311754	2.69897	1
118	2866	3227	577	577	725	905	905	842	885	768	300	69.9	0	129	462	575	major mora	0	well-define	uncertain	valley-side	Aran-Dyfi	mixed lava	135	90	Dyfi,Creigl	265	148	16.66954	69.9	0.867797	1.80E+08	564.7421	328	2.946943	2.885361	2.477121	2.423246	2.75185	2.170262	2.515874	0
119	2866	3217	504	507	670	901	905	754	940	1217	312	69	1.7	151	535	669	drift	0	definite	uncertain	valley-hea	Aran-Dyfi	mixed lava	51	95	Llaethnant	250	166	14.89347	67.3	1.294681	2.86E+08	658.8494	397	2.973128	3.085291	2.494155	2.39794	2.818786	2.220108	2.59879	0
120	2881	3232	368	385	485	580	689	532	638	810	150	60.5	3.3	176	360	587	drift	2	poor	uncertain	valley-hea	Aran-Dyfi	U. Ord. silt	11	22	C.Cwm-du	164	117	14.41596	57.2	1.269593	8.48E+07	439.2548	212	2.804821	2.908485	2.176091	2.214844	2.642716	2.068186	2.326336	1.414214
121	2874	3214	605	625	655	720	731	720	250	275	67	45	10.9	56	350	570	drift	0	marginal	none	valley-side	Aran-Dyfi	U. Ord. silt	58	62	Drysgol,E	115	50	24.70243	34.1	1.1	7906250	199.2157	115	2.39794	2.439333	1.826075	2.060698	2.299324	1.69897	2.060698	0
122	2861	3208	380	470	555	770	770	648	730	960	314	65	10	134	589	758	drift	1	definite	uncertain	valley-hea	Aran-Dyfi	U. Ord. silt	120	115	Gwaun-y-L	268	175	20.15936	55	1.315068	1.88E+08	572.6769	390	2.863323	2.982271	2.49693	2.428135	2.75791	2.243038	2.591065	1
123	2887	3196	258	280	344	504	732	497	642	675	190	59	4.8	186	381	543	outsloping	1	well-define	none	valley-hea	Aran-Dyfi	U. Ord. silt	119	107	Dyniewyd,	239	86	20.419	54.2	1.051402	1.04E+08	469.6189	246	2.807535	2.829304	2.278754	2.378398	2.671746	1.934498	2.390935	1
124	2888	3157	182	230	308	420	432	414	606	498	130	40.6	10.7	106	329	399	drift	0	marginal	none	valley-side	Aran-Dyfi	U. Ord. silt	330	335	Ceseiliau,	232	126	20.94876	29.9	0.821782	7.00E+07	412.1576	238	2.782473	2.697229	2.113943	2.365488	2.615063	2.100371	2.376577	0
125	2916	3185	209	220	286	463	598	406	500	700	193	57.7	10.7	145	436	464	drift	1	poor	uncertain	valley-hea	Aran-Dyfi	Silurian	336	350	Pen-y-gelli	197	77	21.50444	47	1.4	6.90E+07	410.0575	254	2.69897	2.845098	2.285557	2.294466	2.612845	1.886491	2.404834	1
126	2911	3155	330	340	390	484	525	470	430	396	97	48	5.4	166	230	375	drift	0	poor	uncertain	valley-side	Aran-Dyfi	Silurian	346	355	Lloi,Cwm,	140	60	18.03429	42.6	0.92093	2.38E+07	287.8043	154	2.633468	2.597695	1.986772	2.146128	2.459097	1.778151	2.187521	0
127	2849	3198	236	265	380	600	879	540	677	825	325	76.5	10	183	575	660	drift	2	definite	none	valley-side	Aran-Dyfi	mixed lava	141	90	Camddwr,	304	144	24.18198	66.5	1.218611	1.70E+08	553.7394	364	2.830589	2.916454	2.511883	2.482874	2.743305	2.158362	2.561101	1.414214
128	2845	3190	350	385	400	652	780	650	424	360	270	61.9	19.7	115	646	664	outsloping	0	poor	uncertain	valley-side	Aran-Dyfi	mixed lava	140	130	N.Cywarch	300	50	35.28121	42.2	0.849057	4.58E+07	357.7639	302	2.627366	2.556303	2.431364	2.477121	2.553596	1.69897	2.480007	0
129	2841	3186	420	460	485	700	754	683	335	383	230	68.2	20.3	130	630	663	outsloping	0	marginal	uncertain	inner, cont	Aran-Dyfi	mixed lava	88	92	U.Cywarch	263	65	38.13456	47.9	1.143284	3.37E+07	323.1467	280	2.525045	2.583199	2.361728	2.419956	2.5094	1.812913	2.447158	0
130	2841	3182	420	465	488	662	715	639	360	440	182	66.6	10.3	121	607	665	drift	0	well-define	LLS glacie	inner, cont	Aran-Dyfi	mixed lava	72	96	S.Cywarch	219	68	31.31354	56.3	1.222222	3.47E+07	326.1368	242	2.556303	2.643453	2.260071	2.340444	2.5134	1.832509	2.383815	0
131	2845	3179	350	390	437	584	602	583	338	528	200	52.5	18.4	79	570	678	drift	0	marginal	none	valley-side	Aran-Dyfi	U. Ord. silt	50	33	Ychen,Cw	233	87	34.5804	34.1	1.56213	4.16E+07	346.446	234	2.528917	2.722634	2.30103	2.367356	2.539635	1.939519	2.369216	0
132	2830	3144	175	200	300	634	674	565	950	1130	390	66.6	5	153	515	570	drift	0	definite	uncertain	valley-hea	Corris	U. Ord. silt	97	60	Maesglase	390	125	22.31944	61.6	1.189474	4.19E+08	748.093	459	2.977724	3.053078	2.591065	2.591065	2.873955	2.09691	2.661813	0
133	2805	3147	266	350	420	595	659	594	1010	875	260	63.4	5	178	425	505	drift	3	well-define	none	valley-hea	Corris	U. Ord. silt	24	45	Portas,Cra	328	154	17.99133	58.4	0.866337	2.90E+08	661.8117	329	3.004321	2.942008	2.414973	2.515874	2.820735	2.187521	2.517196	1.732051
134	2791	3148	432	470	550	654	664	610	550	675	135	55	12.5	175	378	463	drift	1	poor	LLS snowp	valley-hea	Corris	U. Ord. silt	134	102	E.Waun-oe	178	118	17.93347	42.5	1.227273	6.61E+07	404.2923	222	2.740363	2.829304	2.130334	2.25042	2.606695	2.071882	2.346353	1
135	2785	3142	443	500	570	636	670	636	432	522	85	48	10.3	94	430	482	drift	0	marginal	uncertain	valley-side	Corris	U. Ord. silt	106	100	S.Waun-oe	193	127	24.07315	37.7	1.208333	4.35E+07	351.7525	193	2.635484	2.71767	1.929419	2.285557	2.546237	2.103804	2.285557	0
136	2778	3138	310	440	500	610	626	572	544	800	114	56.3	17.4	165	448	492	drift	0	marginal	none	valley-side	Corris	U. Ord. silt	160	120	CeiswynE.	262	190	25.71629	38.9	1.470588	1.14E+08	484.9125	300	2.735599	2.90309	2.056905	2.418301	2.685663	2.278754	2.477121	0
137	2769	3133	370	430	490	560	590	555	416	593	85	48	10	108	395	476	drift	0	marginal	none	valley-hea	Corris	U. Ord. silt	120	95	N.y Waun,	185	120	23.97527	38	1.425481	4.56E+07	357.3605	190	2.619093	2.773055	1.929419	2.267172	2.553107	2.079181	2.278754	0
138	2772	3127	330	355	430	508	508	479	260	566	90	53.7	9.6	44	402	485	drift	0	poor	none	valley-side	Corris	U. Ord. silt	43	55	S.y Waun,	149	100	29.81603	44.1	2.176923	2.19E+07	279.893	178	2.414973	2.752816	1.954242	2.173186	2.446992	2	2.25042	0
139	2751	3110	253	290	455	524	545	524	852	787	150	51.3	6	134	419	451	drift	1	poor	none	valley-side	Corris	U. Ord. silt	81	30	Bychan,Cv	271	202	17.64457	45.3	0.923709	1.82E+08	566.406	271	2.93044	2.895975	2.176091	2.432969	2.753128	2.305351	2.432969	1
140	2747	3079	152	170	220	362	486	350	350	675	160	61.2	7.6	87	416	542	drift	0	marginal	none	valley-side	Corris	U. Ord. silt	58	46	Cae-coch,	198	68	29.49746	53.6	1.928571	4.68E+07	360.3122	210	2.544068	2.829304	2.20412	2.296665	2.556679	1.832509	2.322219	0
141	2718	3060	347	370	460	647	658	625	590	610	227	56.3	9.6	116	422	504	drift	0	poor	none	valley-hea	Corris	U. Ord. silt	86	80	Ffridd (Tar	278	113	25.22918	46.7	1.033898	1.00E+08	464.2396	300	2.770852	2.78533	2.356026	2.444045	2.666742	2.053078	2.477121	0
142	2687	3040	418	450	495	622	634	608	350	390	127	49.1	13.4	105	423	564	drift	0	poor	none	valley-hea	Corris	U. Ord. silt	55	38	E.Tarrenhe	190	77	28.49564	35.7	1.114286	2.59E+07	296.0025	204	2.544068	2.591065	2.103804	2.278754	2.471295	1.886491	2.30963	0
143	2682	3047	307	330	430	607	634	590	710	585	177	52.5	6	96	434	576	drift	0	definite	none	valley-side	Corris	U. Ord. silt	358	26	N.Tarrenhe	283	123	21.73181	46.5	0.823944	1.18E+08	489.8542	300	2.851258	2.767156	2.247973	2.451787	2.690067	2.089905	2.477121	0
144	2657	3117	351	354	400	584	589	510	540	860	215	53.7	0	140	337	514	major mora	0	well-define	uncertain	valley-hea	Cadair Idri	mixed lava	6	343	L.Cyri	159	49	16.40677	53.7	1.592593	7.38E+07	419.5301	233	2.732394	2.934499	2.332438	2.201397	2.622763	1.690196	2.367356	0
145	2682	3138	390	410	492	616	643	603	450	505	163	63.4	6	58	506	669	drift	0	definite	uncertain	valley-side	Cadair Idri	mixed lava	14	358	C.-las NE,	213	102	25.32975	57.4	1.122222	4.84E+07	364.4415	226	2.653213	2.703291	2.212188	2.32838	2.561628	2.0086	2.354108	0
146	2688	3138	396	415	465	572	616	562	355	460	115	59	9.5	70	480	690	drift	0	poor	uncertain	valley-side	Cadair Idri	mixed lava	6	21	Lwyd,Carn	166	69	25.06106	49.5	1.295775	2.71E+07	300.3987	176	2.550228	2.662758	2.060698	2.220108	2.477698	1.838849	2.245513	0
147	2709	3115	422	480	583	763	791	752	930	850	190	57.7	4.8	131	593	808	drift	0	definite	LLS snowp	valley-side	Cadair Idri	mixed lava	152	140	Amarch, C	330	161	19.53666	52.9	0.913979	2.61E+08	638.9575	341	2.968483	2.929419	2.278754	2.518514	2.805472	2.206826	2.532754	0
148	2714	3124	445	470	568	850	893	723	985	1050	365	76.5	0	195	518	806	major rock	1	classic	LLS glacie	valley-hea	Cadair Idri	mixed lava	85	65	L.Cau	278	123	15.76084	76.5	1.06599	2.88E+08	660.0195	405	2.993436	3.021189	2.562293	2.444045	2.819557	2.089905	2.607455	1
149	2708	3134	556	556	672	885	893	835	850	910	280	72	0	157	508	729	major mora	1	classic	LLS glacie	valley-side	Cadair Idri	microgranit	351	350	Gadair,L.y	279	116	18.17166	72	1.070588	2.16E+08	599.8208	329	2.929419	2.959041	2.447158	2.445604	2.778022	2.064458	2.517196	1
150	2714	3138	403	412	575	852	852	823	1265	784	320	72.2	0	50	525	723	major mora	0	definite	LLS snowp	valley-side	Cadair Idri	microgranit	323	354	Gafr,L.	420	172	18.36698	72.2	0.619763	4.17E+08	746.8246	449	3.102091	2.894316	2.50515	2.623249	2.873219	2.235528	2.652246	0
151	2722	3137	570	630	670	852	863	812	458	782	210	72.3	7.1	88	468	723	outsloping	0	definite	LLS snowp	valley-side	Cadair Idri	microgranit	335	340	NW.Mynyd	242	100	27.85127	65.2	1.707424	8.67E+07	442.5502	282	2.660866	2.893207	2.322219	2.383815	2.645962	2	2.450249	0
152	2729	3139	560	580	640	863	863	855	494	390	270	74.4	12.3	13	427	775	drift	0	poor	none	valley-side	Cadair Idri	microgranit	22	55	NE.Mynyd	295	80	30.84421	62.1	0.789474	5.68E+07	384.4777	303	2.693727	2.591065	2.431364	2.469822	2.584871	1.90309	2.481443	0
153	2734	3138	470	485	552	842	863	684	630	725	312	76.5	0	149	553	757	major mora	0	well-define	LLS glacie	valley-hea	Cadair Idri	mixed lava	9	0	L.Arran	214	82	18.76173	76.5	1.150794	9.77E+07	460.6426	372	2.79934	2.860338	2.494155	2.330414	2.663364	1.913814	2.570543	0
154	2747	3144	339	346	455	671	683	590	510	470	240	70.7	4.4	99	441	675	minor lake	0	poor	uncertain	valley-side	Cadair Idri	mixed lava	82	85	Gau Graig	251	116	26.20442	66.3	0.921569	6.02E+07	391.8446	332	2.70757	2.672098	2.380211	2.399674	2.593114	2.064458	2.521138	0
155	2811	2936	172	186	325	560	582	454	840	1414	260	61.9	1.7	201	407	456	drift	1	definite	uncertain	valley-hea	Pumlumon	Silurian	342	10	Clipyn Du,	282	153	18.55764	60.2	1.683333	3.35E+08	694.4792	388	2.924279	3.15045	2.414973	2.450249	2.841659	2.184691	2.588832	1
156	2833	2963	230	260	275	432	540	397	650	494	160	45	3.4	177	386	415	drift	0	marginal	none	valley-hea	Pumlumon	Silurian	279	295	Cym du, B	167	45	14.40896	41.6	0.76	5.36E+07	377.0963	202	2.812913	2.693727	2.20412	2.222717	2.576452	1.653213	2.305351	0
158	2801	3160	420	480	520	610	642	597	415	536	106	59	7.1	102	467	508	drift	0	marginal	LLS glacie	valley-side	Corris	U. Ord. silt	117	105	Fach,Cribi	177	100	23.09854	51.9	1.291566	3.94E+07	340.1956	190	2.618048	2.729165	2.025306	2.247973	2.531729	2	2.278754	0
159	2799	3153	435	480	560	638	659	625	361	382	165	60.5	12	99	450	501	drift	0	definite	uncertain	valley-side	Corris	U. Ord. silt	85	39	Fawr,Cribi	190	125	27.75854	48.5	1.058172	2.62E+07	297.0125	203	2.557507	2.582063	2.217484	2.278754	2.472775	2.09691	2.307496	0
160	2843	3185	239	250	304	700	764	659	730	964	360	73.3	5.7	191	633	665	drift	0	definite	uncertain	outer, cont	Aran-Dyfi	mixed lava	90	105	Cywarch,	420	65	29.91365	67.60001	1.320548	2.96E+08	666.1158	461	2.863323	2.984077	2.556303	2.623249	2.82355	1.812913	2.663701	0
161	2748	3443	463	468	524	582	584	565	850	940	84	65	0	71	177	231	major rock	0	definite	uncertain	valley-side	Arenig-Mig	ignimbrite,	256	250	GraigGoch	102	61	6.842773	65	1.105882	8.15E+07	433.5598	119	2.929419	2.973128	1.924279	2.0086	2.637049	1.78533	2.075547	0
162	2827	3417	445	450	538	651	689	646	630	835	193	65.3	0	28	339	399	major mora	0	definite	LLS glacie	valley-side	Arenig-Mig	ignimbrite,	71	66	L.Arenig F	201	93	17.69516	65.3	1.325397	1.06E+08	472.8692	206	2.79934	2.921686	2.285557	2.303196	2.674741	1.968483	2.313867	0
163	2838	3386	460	480	585	680	697	675	470	480	145	69.9	4.1	25	362	558	drift	0	marginal	uncertain	valley-side	Arenig-Mig	ignimbrite,	19	25	DaearFaw	215	125	24.58158	65.8	1.021277	4.85E+07	364.6917	220	2.672098	2.681241	2.161368	2.332438	2.561926	2.09691	2.342423	0
164	2808	3095	278	290	327	441	454	414	531	544	115	45	6.6	166	250	372	drift	2	poor	none	valley-hea	Corris	Silurian	172	135	Coeg, Blae	136	49	14.36582	38.4	1.024482	3.93E+07	339.9467	163	2.725095	2.735599	2.060698	2.133539	2.531411	1.690196	2.212188	1.414214
165	2807	3103	257	270	295	445	469	369	432	340	155	56.3	3.5	152	271	371	minor lake	0	marginal	none	valley-hea	Corris	Silurian	344	25	Gerwyn, B	112	38	14.53446	52.8	0.787037	1.65E+07	254.3276	188	2.635484	2.531479	2.190332	2.049218	2.405394	1.579784	2.274158	0
166	2731	3073	380	395	497	594	597	590	410	393	135	51.3	11.1	108	334	470	drift	0	marginal	none	valley-hea	Corris	U. Ord. silt	112	95	Bryn-llwyd	210	117	27.1213	40.2	0.958537	3.38E+07	323.4436	214	2.612784	2.594393	2.130334	2.322219	2.509799	2.068186	2.330414	0
167	2819	3153	355	370	395	673	676	662	520	495	278	60.5	16.4	118	517	548	drift	0	marginal	none	valley-side	Corris	U. Ord. silt	329	350	Rhiw-erch,	307	40	30.55695	44.1	0.951923	7.90E+07	429.1235	318	2.716003	2.694605	2.444045	2.487138	2.632582	1.60206	2.502427	0
168	2827	3373	705	740	795	817	854	817	390	565	60	43.2	10.5	97	386	519	drift	0	marginal	none	valley-side	Arenig-Mig	mixed lava	277	290	NW.Arenig	112	90	16.02298	32.7	1.448718	2.47E+07	291.1457	112	2.591065	2.752048	1.778151	2.049218	2.46411	1.954242	2.049218	0
169	2626	3204	349	357	450	523	589	500	550	656	107	40.6	3.4	140	318	423	minor lake	1	marginal	uncertain	valley-side	Rhinog	Cambrian	296	275	Rhiwgyr, B	151	101	15.35204	37.2	1.192727	5.45E+07	379.0948	174	2.740363	2.816904	2.029384	2.178977	2.578748	2.004321	2.240549	1
170	2896	3200	280	315	329	468	605	460	473	320	154	73.3	7.1	165	424	498	drift	0	marginal	uncertain	valley-side	Aran-Dyfi	U. Ord. silt	100	80	Darren Dd	180	49	20.83431	66.2	0.676533	2.72E+07	300.9039	188	2.674861	2.50515	2.187521	2.255272	2.478428	1.690196	2.274158	0
171	2898	3207	182	280	345	468	632	461	506	584	210	56.3	14	85	419	493	outsloping	0	marginal	none	valley-side	Aran-Dyfi	U. Ord. silt	95	83	Cafn, Nant	279	163	28.87161	42.3	1.15415	8.24E+07	435.2337	286	2.70415	2.766413	2.322219	2.445604	2.638722	2.212188	2.456366	0
173	2756	2945	188	197	355	492	529	481	754	1015	200	63.4	2.3	185	352	385	drift	1	marginal	uncertain	valley-hea	Pumlumon	Silurian	333	10	Llechwedd	293	167	21.23584	61.1	1.346154	2.24E+08	607.5308	304	2.877371	3.006466	2.30103	2.466868	2.783568	2.222717	2.482874	1
178	2914	2730	302	345	423	491	509	481	825	545	90	42.7	7.1	168	265	275	drift	0	marginal	uncertain	valley-side	Pumlumon	Silurian	28	15	Gwnog, Na	179	121	12.24171	35.6	0.660606	8.05E+07	431.7521	189	2.916454	2.736397	1.954242	2.252853	2.635235	2.082785	2.276462	0
179	2939	2709	221	226	410	482	522	458	800	1550	230	71.2	4.7	227	299	312	major bog	1	poor	uncertain	valley-side	Pumlumon	Silurian	69	90	Fergwm (C	237	189	16.50192	66.5	1.9375	2.94E+08	664.8495	261	2.90309	3.190332	2.361728	2.374748	2.822723	2.276462	2.416641	1
180	3188	2635	405	420	530	641	660	641	640	685	150	43.2	8.1	80	344	378	drift	0	poor	none	valley-side	Pumlumon	Silurian	98	93	Pant, Radr	236	125	20.24145	35.1	1.070313	1.03E+08	469.4552	236	2.80618	2.83569	2.176091	2.372912	2.671594	2.09691	2.372912	0
181	2668	3264	438	441	510	712	735	590	592	848	244	57	0	99	412	521	major rock	1	classic	uncertain	valley-side	Rhinog	Cambrian	83	70	L.y Bi, Y Ll	152	72	14.40002	57	1.432432	7.63E+07	424.1509	274	2.772322	2.928396	2.38739	2.181844	2.62752	1.857332	2.437751	1
182	2665	3252	456	468	577	741	756	659	682	1054	180	53.7	1.7	106	411	484	minor lake	0	well-define	uncertain	valley-side	Rhinog	Cambrian	89	88	Y Llethr SE	203	121	16.57585	52	1.545455	1.46E+08	526.47	285	2.833784	3.02284	2.255272	2.307496	2.721374	2.082785	2.454845	0
183	2670	3244	350	355	490	680	688	610	846	928	250	51.3	2.1	61	440	530	major bog	1	definite	none	valley-side	Rhinog	Cambrian	75	78	NE.Diffwys	260	140	17.08369	49.2	1.096927	2.04E+08	588.7947	330	2.92737	2.967548	2.39794	2.414973	2.769964	2.146128	2.518514	1
184	2664	3233	425	460	628	750	750	750	622	824	224	69.9	5.9	100	454	530	drift	0	definite	none	valley-side	Rhinog	Cambrian	113	100	DiffwysSE	325	203	27.58743	64	1.324759	1.67E+08	550.2166	325	2.79379	2.915927	2.350248	2.511883	2.740534	2.307496	2.511883	0
185	2632	3222	307	315	460	540	589	523	778	1850	200	57.7	0	42	331	456	major mora	0	definite	LLS glacie	valley-side	Rhinog	Cambrian	297	300	L.Erddyn	216	153	15.51651	57.7	2.377892	3.11E+08	677.4362	233	2.89098	3.267172	2.30103	2.334454	2.830868	2.184691	2.367356	0
186	2653	3241	379	380	500	642	750	530	1435	1214	185	80.9	0	65	375	486	major mora	2	well-define	uncertain	valley-hea	Rhinog	Cambrian	266	328	L.Bodlyn	151	121	6.006927	80.9	0.845993	2.63E+08	640.741	263	3.156852	3.084219	2.267172	2.178977	2.806683	2.082785	2.419956	1.414214
187	2662	3244	524	534	580	621	715	621	450	657	72	44.1	0	125	390	466	major mora	0	definite	LLS glacie	valley-hea	Rhinog	Cambrian	247	233	L.Dulyn	97	56	12.1643	44.1	1.46	2.87E+07	306.0905	97	2.653213	2.817565	1.857332	1.986772	2.48585	1.748188	1.986772	0
188	2630	3249	323	330	435	551	584	534	510	825	170	66.4	2.5	54	416	451	drift	0	poor	uncertain	valley-side	Rhinog	Cambrian	38	30	MoelfreN	211	112	22.47613	63.9	1.617647	8.88E+07	446.1034	228	2.70757	2.916454	2.230449	2.324282	2.649436	2.049218	2.357935	0
189	2655	3257	470	488	600	704	756	660	670	560	105	49.1	3.8	123	446	584	drift	0	well-define	uncertain	valley-side	Rhinog	Cambrian	292	280	W.Y Llethr	190	130	15.83239	45.3	0.835821	7.13E+07	414.6409	234	2.826075	2.748188	2.021189	2.278754	2.617672	2.113943	2.369216	0
190	2659	3263	440	465	515	740	755	723	720	560	257	68.2	0	96	468	580	major mora	0	well-define	uncertain	valley-side	Rhinog	Cambrian	331	4	L.Perfedda	283	75	21.45758	68.2	0.777778	1.14E+08	485.0304	300	2.857332	2.748188	2.409933	2.451787	2.685769	1.875061	2.477121	0
191	2664	3266	532	535	590	726	735	624	620	450	160	59	0	165	389	568	major rock	1	definite	none	valley-side	Rhinog	Cambrian	330	310	L.Hywel	92	58	8.440365	59	0.725807	2.57E+07	294.9832	194	2.792392	2.653213	2.20412	1.963788	2.469797	1.763428	2.287802	1
192	2660	3275	335	370	405	600	712	505	570	492	210	69.9	3.5	12	474	578	minor lake	0	definite	uncertain	valley-side	Rhinog	Cambrian	335	295	L.Cwmhos	170	70	16.60698	66.4	0.863158	4.77E+07	362.6015	265	2.755875	2.691965	2.322219	2.230449	2.55943	1.845098	2.423246	0
193	2668	3356	330	345	410	533	577	510	500	840	140	68.2	3.6	98	298	435	minor lake	0	poor	uncertain	valley-hea	Rhinog	Cambrian	3	0	Moch,Blae	180	80	19.79888	64.6	1.68	7.56E+07	422.8379	203	2.69897	2.924279	2.146128	2.255272	2.626174	1.90309	2.307496	0
194	2711	3236	278	320	384	530	626	510	550	660	165	71.6	8.6	82	456	604	drift	0	marginal	uncertain	valley-side	Rhinog	Cambrian	80	70	C.y Cae, N	232	106	22.8709	63	1.2	8.42E+07	438.327	252	2.740363	2.819544	2.217484	2.365488	2.641798	2.025306	2.401401	0
195	2712	3490	405	460	510	570	604	500	652	765	75	50.2	4.1	160	334	404	drift	1	marginal	uncertain	valley-hea	Arenig-Mig	L. Ord. silts	331	315	Farlwyd, M	95	105	8.289974	46.1	1.173313	4.74E+07	361.863	165	2.814248	2.883662	1.875061	1.977724	2.558544	2.021189	2.217484	1
196	2710	3485	442	458	505	595	616	485	525	730	92	42.3	0	146	271	394	minor lake	1	poor	uncertain	valley-hea	Arenig-Mig	L. Ord. silts	193	193	Barlwyd, L	43	63	4.682345	42.3	1.390476	1.65E+07	254.478	153	2.720159	2.863323	1.963788	1.633469	2.40565	1.799341	2.184691	1
197	2744	3477	233	255	410	482	529	472	840	830	176	65	3.3	137	329	421	drift	0	marginal	none	valley-hea	Arenig-Mig	L. Ord. silts	124	171	C.Blaen y	239	177	15.88231	61.7	0.988095	1.67E+08	550.2817	249	2.924279	2.919078	2.245513	2.378398	2.740585	2.247973	2.396199	0
198	2961	3428	370	375	450	530	592	504	785	653	120	41	1.5	143	311	361	drift	0	definite	none	valley-hea	Arenig-Mig	L. Ord. silts	31	15	Llan,Cwm,	134	80	9.687057	39.5	0.831847	6.87E+07	409.5396	160	2.89487	2.814913	2.079181	2.127105	2.612296	1.90309	2.20412	0
199	2866	3455	446	470	520	615	669	610	660	865	120	37	5.2	125	275	364	drift	0	marginal	LLS glacie	valley-hea	Arenig-Mig	L. Ord. silts	30	40	Gylchedd,	164	74	13.95451	31.8	1.310606	9.36E+07	454.0824	169	2.819544	2.937016	2.079181	2.214844	2.657135	1.869232	2.227887	0
201	2808	2217	544	570	600	728	749	709	320	375	140	82.4	8.1	98	331	502	drift	0	definite	LLS snowp	valley-side	Wn. Breco	Old Red Sa	320	340	Henllyn, P	165	56	27.27676	74.3	1.171875	1.98E+07	270.5339	184	2.50515	2.574031	2.146128	2.217484	2.432222	1.748188	2.264818	0
202	2816	2221	540	570	650	765	802	698	670	915	180	61.9	1.9	132	353	503	major bog	1	well-define	LLS glacie	valley-side	Wn. Breco	Old Red Sa	313	340	Pant y Bwl	158	110	13.26912	60	1.365672	9.69E+07	459.252	225	2.826075	2.961421	2.255272	2.198657	2.662051	2.041393	2.352183	1
203	2824	2224	598	640	698	802	802	778	590	693	160	63.4	4.8	90	292	392	drift	0	well-define	LLS glacie	valley-side	Wn. Breco	Old Red Sa	44	50	y Cadno, F	180	100	16.96615	58.6	1.174576	7.36E+07	419.0694	204	2.770852	2.840733	2.20412	2.255272	2.622286	2	2.30963	0
204	2830	2217	594	605	682	802	802	773	770	1150	168	55	0	61	275	392	major mora	1	well-define	LLS glacie	valley-side	Wn. Breco	Old Red Sa	66	57	Ban Brych	179	88	13.08697	55	1.493507	1.59E+08	541.1868	208	2.886491	3.060698	2.225309	2.252853	2.733347	1.944483	2.318063	1
205	2886	2193	524	543	593	721	725	713	706	650	160	52.5	1.7	117	335	425	minor lake	0	well-define	LLS glacie	valley-side	Wn. Breco	Old Red Sa	25	40	Fan Gihiry	189	69	14.98697	50.8	0.92068	8.67E+07	442.6495	197	2.848805	2.812913	2.20412	2.276462	2.64606	1.838849	2.294466	0
206	2915	2222	434	449	493	565	603	564	353	545	70	46	5.7	62	327	367	drift	0	poor	LLS glacie	valley-side	Wn. Breco	Old Red Sa	47	44	Chwyth, Fa	130	59	20.21734	40.3	1.543909	2.50E+07	292.4409	131	2.547775	2.736397	1.845098	2.113943	2.466038	1.770852	2.117271	0
207	2909	2195	325	340	530	626	653	492	870	1295	180	59	2.7	178	365	406	drift	1	poor	LLS snowp	valley-hea	Wn. Breco	Old Red Sa	60	39	Senni, Blae	167	205	10.86598	56.3	1.488506	1.88E+08	573.0183	301	2.939519	3.11227	2.255272	2.222717	2.758168	2.311754	2.478566	1
208	2945	2215	360	380	462	562	629	510	545	1110	151	75.4	2.5	100	317	385	drift	1	definite	LLS glacie	valley-side	Wn. Breco	Old Red Sa	325	338	C. Cwm-du	150	102	15.38847	72.9	2.036697	9.07E+07	449.3695	202	2.736397	3.045323	2.178977	2.176091	2.652604	2.0086	2.305351	1
209	2964	2221	396	450	501	623	629	614	755	825	170	73.3	2.7	151	329	391	minor lake	0	well-define	LLS glacie	valley-side	Wn. Breco	Old Red Sa	62	22	Cerrig-glei	218	105	16.10563	70.60001	1.092715	1.36E+08	513.9874	227	2.877947	2.916454	2.230449	2.338456	2.710953	2.021189	2.356026	0
210	2973	2192	560	595	650	734	734	716	592	880	93	45	4.4	78	298	357	drift	0	definite	LLS glacie	valley-hea	Wn. Breco	Old Red Sa	88	80	Fan Fawr E	156	90	14.76262	40.6	1.486486	8.13E+07	433.1547	174	2.772322	2.944483	1.968483	2.193125	2.636643	1.954242	2.240549	0
211	2984	2218	418	450	506	594	615	594	490	685	94	41.4	9.8	77	351	523	drift	0	poor	none	valley-side	En. & C. B	Old Red Sa	304	307	Y Gyrn W.	176	88	19.75746	31.6	1.397959	5.91E+07	389.4632	176	2.690196	2.83569	1.973128	2.245513	2.590466	1.944483	2.245513	0
212	2999	2226	468	495	555	651	666	632	510	585	120	45	5.7	87	388	616	drift	0	definite	LLS glacie	valley-side	En. & C. B	Old Red Sa	37	30	Modrydd, M	164	87	17.82616	39.3	1.147059	4.89E+07	365.7547	183	2.70757	2.767156	2.079181	2.214844	2.56319	1.939519	2.262451	0
213	3001	2219	560	568	610	710	720	684	370	446	118	53.7	0	87	494	589	major mora	0	classic	LLS glacie	valley-side	En. & C. B	Old Red Sa	50	40	Llwch, L. C	124	50	18.52781	53.7	1.205405	2.05E+07	273.5181	150	2.568202	2.649335	2.071882	2.093422	2.436986	1.69897	2.176091	0
214	3007	2217	569	580	694	886	886	848	735	796	200	56.3	5	98	446	582	drift	1	definite	uncertain	valley-hea	En. & C. B	Old Red Sa	333	347	Corn Du, E	279	125	20.78635	51.3	1.082993	1.63E+08	546.5143	317	2.866287	2.900913	2.30103	2.445604	2.737602	2.09691	2.501059	1
215	3018	2217	480	505	669	885	886	798	928	1295	245	69.9	4.8	153	460	560	drift	1	well-define	none	valley-hea	En. & C. B	Old Red Sa	45	33	Sere, Craig	318	189	18.91517	65.1	1.395474	3.82E+08	725.6852	405	2.967548	3.11227	2.389166	2.502427	2.860748	2.276462	2.607455	1
216	3030	2209	430	450	602	795	795	714	764	1380	200	68.2	3.1	175	400	566	drift	1	well-define	LLS snowp	valley-hea	En. & C. B	Old Red Sa	33	10	Cynwyn, C	284	172	20.3915	65.1	1.806283	2.99E+08	669.0064	365	2.883093	3.139879	2.30103	2.453318	2.82543	2.235528	2.562293	1
217	3042	2203	438	540	610	734	742	720	1260	1280	160	57.7	3.7	175	342	450	drift	1	well-define	LLS glacie	valley-hea	En. & C. B	Old Red Sa	22	356	Oergwm,	282	172	12.61544	54	1.015873	4.55E+08	769.0298	296	3.100371	3.10721	2.20412	2.450249	2.885943	2.235528	2.471292	1
218	3053	2208	560	585	635	752	754	744	475	615	138	53.7	5.7	118	354	483	drift	0	definite	LLS snowp	valley-hea	En. & C. B	Old Red Sa	5	352	Cwareli, C	184	75	21.1748	48	1.294737	5.38E+07	377.3945	192	2.676694	2.788875	2.139879	2.264818	2.576796	1.875061	2.283301	0
219	3067	2205	535	590	640	746	769	736	550	756	137	49.1	4.8	114	379	493	minor lake	0	well-define	LLS glacie	valley-hea	En. & C. B	Old Red Sa	50	39	Pwllfa, Cra	201	105	20.07506	44.3	1.374545	8.36E+07	437.2134	211	2.740363	2.878522	2.136721	2.303196	2.640693	2.021189	2.324282	0
220	3076	2195	423	550	646	733	762	658	860	1310	110	43.2	5.9	135	421	536	drift	0	marginal	uncertain	valley-hea	En. & C. B	Old Red Sa	66	64	Tarthwynn	235	223	15.2833	37.3	1.523256	2.65E+08	642.1146	310	2.934499	3.117271	2.041393	2.371068	2.807613	2.348305	2.491362	0
221	3053	2192	540	577	618	711	754	670	356	746	95	49.1	5.2	104	311	479	drift	0	definite	LLS snowp	valley-side	En. & C. B	Old Red Sa	98	82	Caerfanell,	130	78	20.0606	43.9	2.095506	3.45E+07	325.6198	171	2.55145	2.872739	1.977724	2.113943	2.512711	1.892095	2.232996	0
222	3007	2208	709	725	767	824	865	820	393	580	80	48	5.4	98	334	466	drift	0	definite	LLS glacie	valley-side	En. & C. B	Old Red Sa	99	72	Duwynt, B	111	58	15.77195	42.6	1.475827	2.53E+07	293.5719	115	2.594393	2.763428	1.90309	2.045323	2.467715	1.763428	2.060698	0
223	3016	2194	632	650	684	745	745	743	360	535	68	56.3	3.7	56	321	444	drift	0	poor	LLS snowp	valley-side	En. & C. B	Old Red Sa	52	40	Cefn Cul E	111	52	17.13627	52.6	1.486111	2.14E+07	277.5405	113	2.556303	2.728354	1.832509	2.045323	2.443326	1.716003	2.053078	0
224	3022	2181	530	560	610	687	740	658	484	790	90	49	6.7	81	326	386	minor lake	0	marginal	none	valley-side	En. & C. B	Old Red Sa	79	90	Neuadd W	128	80	14.81346	42.3	1.632231	4.89E+07	365.7863	157	2.684845	2.897627	1.954242	2.10721	2.563227	1.90309	2.1959	0
225	3008	2199	619	635	742	780	824	777	688	550	70	50.2	7.6	169	328	474	drift	0	definite	LLS glacie	valley-hea	En. & C. B	Old Red Sa	160	106	Crew, Blae	158	123	12.93378	42.6	0.799419	5.98E+07	391.0234	161	2.837589	2.740363	1.845098	2.198657	2.592203	2.089905	2.206826	0
226	3096	2154	270	300	385	482	617	462	820	1020	140	65	5.2	191	298	408	drift	1	poor	uncertain	valley-hea	Abergaven	Carbonifer	38	42	Crawnon,	192	115	13.17819	59.8	1.243902	1.61E+08	543.5486	212	2.913814	3.0086	2.146128	2.283301	2.735238	2.060698	2.326336	1
227	3190	2161	251	298	318	492	524	488	960	1565	210	65	1.1	155	349	415	major bog	0	well-define	LLS glacie	valley-side	Abergaven	Old Red Sa	30	35	Onnau Fa	237	67	13.8676	63.9	1.630208	3.56E+08	708.7798	241	2.982271	3.194514	2.322219	2.374748	2.850511	1.826075	2.382017	0
228	3088	2165	387	410	455	516	538	512	340	700	70	51.3	9.5	81	346	351	drift	0	marginal	none	valley-side	Abergaven	Carbonifer	346	0	Darren Fa	125	68	20.1858	41.8	2.058824	2.98E+07	309.8577	129	2.531479	2.845098	1.845098	2.09691	2.491162	1.832509	2.11059	0
229	3278	2125	280	310	380	530	555	528	570	512	155	41.4	13.7	98	471	517	drift	0	poor	uncertain	valley-side	Abergaven	Carbonifer	41	40	Craf, Cwm	248	100	23.51327	27.7	0.898246	7.24E+07	416.7403	250	2.755875	2.70927	2.190332	2.394452	2.619865	2	2.39794	0
230	3281	2116	275	284	327	460	555	452	448	380	140	59	3.5	119	425	523	major bog	0	well-define	LLS glacie	valley-side	Abergaven	Old Red Sa	90	93	Punchbow	177	52	21.55844	55.5	0.848214	3.01E+07	311.18	185	2.651278	2.579784	2.146128	2.247973	2.493012	1.716003	2.267172	0
231	3277	2099	260	314	365	475	503	468	565	1025	145	53.7	1.9	115	293	432	major bog	0	definite	LLS glacie	valley-side	Abergaven	Carbonifer	55	46	Malps, The	208	105	20.21076	51.8	1.814159	1.20E+08	493.8691	215	2.752048	3.010724	2.161368	2.318063	2.693612	2.021189	2.332438	0
232	3285	2091	230	237	285	440	485	435	698	498	158	59	2	122	352	428	major bog	0	well-define	LLS glacie	valley-side	Abergaven	Carbonifer	48	80	Craig-y-cw	205	55	16.36732	57	0.713467	7.13E+07	414.5843	210	2.843855	2.697229	2.198657	2.311754	2.617613	1.740363	2.322219	0
233	3218	2077	388	398	428	532	550	532	520	492	100	43.2	2	94	242	341	major bog	0	poor	uncertain	valley-side	Abergaven	Coal Meas	91	84	Blaentillery	144	40	15.47864	41.2	0.946154	3.68E+07	332.744	144	2.716003	2.691965	2	2.158362	2.52211	1.60206	2.158362	0
234	3191	2084	428	436	483	541	550	535	310	400	70	40.6	4.8	69	288	312	drift	0	marginal	uncertain	valley-side	Abergaven	Coal Meas	55	65	Llanerch-y	107	55	19.04269	35.8	1.290323	1.33E+07	236.7383	113	2.491362	2.60206	1.845098	2.029384	2.374269	1.740363	2.053078	0
239	2891	2037	400	418	450	562	571	559	400	575	135	52	4.8	90	335	504	drift	0	definite	uncertain	valley-side	Rhondda-	Coal Meas	346	352	C.-y-Pant,	159	50	21.67782	47.2	1.4375	3.66E+07	331.9263	162	2.60206	2.759668	2.130334	2.201397	2.521042	1.69897	2.209515	0
240	2905	2038	425	446	485	574	600	573	635	894	118	70.7	0	117	326	460	major mora	0	classic	LLS glacie	valley-side	Rhondda-	Coal Meas	3	14	L. Fach, Cr	148	60	13.11976	70.7	1.407874	8.40E+07	437.9834	149	2.802774	2.951338	2.071882	2.170262	2.641458	1.778151	2.173186	0

241	2919	2035	330	365	440	559	600	545	975	1408	180	64.6	0	100	319	385	major mora	0	classic	LLS glacie	valley-side	Rhondda-H	Coal Meas	37	31	L. Fawr, C	215	110	12.43544	64.6	1.444103	2.95E+08	665.8073	229	2.989005	3.148603	2.255272	2.332438	2.823349	2.041393	2.359835	0
242	2944	2038	370	399	438	512	515	492	470	1050	88	60.8	2.7	118	255	320	major bog	0	poor	LLS glacie	valley-side	Rhondda-H	Coal Meas	45	38	C.-y-Bwlch	122	68	14.55138	58.1	2.234043	6.02E+07	391.9365	142	2.672098	3.021189	1.944483	2.08636	2.593216	1.832509	2.152288	0
243	2959	2028	358	400	440	475	510	461	310	700	60	39.7	3.4	38	256	329	drift	0	marginal	uncertain	valley-side	Rhondda-H	Coal Meas	62	47	C.-yr-Ysgo	103	82	18.37948	36.3	2.258065	2.24E+07	281.6862	117	2.491362	2.845098	1.778151	2.012837	2.449766	1.913814	2.068186	0
244	2965	2020	237	248	312	393	510	392	430	680	130	42.3	3.7	98	257	342	drift	0	poor	uncertain	valley-hea	Rhondda-H	Coal Meas	24	18	Tarren-y-B	155	75	19.82246	38.6	1.581395	4.53E+07	356.5357	156	2.633468	2.832509	2.113943	2.190332	2.552103	1.875061	2.193125	0
245	2984	2016	275	290	346	391	433	380	235	480	70	44.1	10.1	56	275	308	drift	0	marginal	uncertain	valley-side	Rhondda-H	Coal Meas	0	356	Cefnrhos-g	105	71	24.0755	34	2.042553	1.18E+07	227.9464	116	2.371068	2.681241	1.845098	2.021189	2.357833	1.851258	2.064458	0
246	2919	2006	330	365	396	490	522	480	300	880	105	56.3	5.7	62	309	343	drift	0	poor	uncertain	valley-side	Rhondda-H	Coal Meas	100	97	C. Blaenrh	150	66	26.56505	50.6	2.933333	3.96E+07	340.8514	160	2.477121	2.944483	2.021189	2.176091	2.532565	1.819544	2.20412	0
247	2930	1976	253	330	417	514	523	494	970	1224	143	60.5	4.4	206	333	386	drift	0	well-define	LLS glacie	valley-side	Rhondda-H	Coal Meas	44	55	Saerbren,	241	164	13.95282	56.1	1.261856	2.86E+08	658.9565	261	2.986772	3.087781	2.155336	2.382017	2.818857	2.214844	2.416641	0
248	2927	1962	321	350	412	544	559	541	890	1184	165	66.6	2	208	308	373	major bog	0	well-define	LLS glacie	valley-hea	Rhondda-H	Coal Meas	80	76	Parc, Cwm	220	91	13.88467	64.6	1.330337	2.32E+08	614.3108	223	2.94939	3.073352	2.217484	2.342423	2.788388	1.959041	2.348305	0
249	2932	1953	337	350	410	508	524	503	410	785	146	63.4	3.1	104	337	386	major bog	0	well-define	LLS glacie	valley-side	Rhondda-H	Coal Meas	43	48	Graig Fach	166	73	22.04194	60.3	1.914634	5.34E+07	376.6349	171	2.612784	2.89487	2.164353	2.220108	2.575921	1.863323	2.232996	0
250	2898	1945	308	320	427	537	565	460	594	854	130	49.6	4.4	186	329	399	drift	1	well-define	LLS glacie	valley-hea	Rhondda-H	Coal Meas	146	128	Blaengarw	152	119	14.35354	45.2	1.43771	7.71E+07	425.6271	229	2.773787	2.931458	2.113943	2.181844	2.629029	2.075547	2.359835	1
251	2965	1937	330	350	378	460	472	438	250	360	85	40.6	11.3	105	259	390	drift	0	marginal	none	valley-side	Rhondda-H	Coal Meas	33	21	Bwllfa, Da	108	48	23.36434	29.3	1.44	9720000	213.4136	130	2.39794	2.556303	1.929419	2.033424	2.329222	1.681241	2.113943	0
252	2973	1977	350	365	413	471	481	471	400	500	65	46	4.8	70	229	328	drift	0	marginal	uncertain	valley-side	Rhondda-H	Coal Meas	29	40	Maerdy, C	121	63	16.83057	41.2	1.25	2.42E+07	289.249	121	2.60206	2.69897	1.812913	2.082785	2.461272	1.799341	2.082785	0
253	2982	1973	282	302	364	462	475	424	420	1165	100	59	2.4	67	252	321	drift	0	marginal	uncertain	valley-side	Rhondda-H	Coal Meas	25	15	Tarren Ma	142	82	18.68015	56.6	2.773809	6.95E+07	411.1067	180	2.623249	3.066326	2	2.152288	2.613955	1.913814	2.255272	0
254	2996	1967	253	254	315	390	419	380	340	593	110	63.4	0	50	231	329	major mora	0	poor	uncertain	valley-side	Rhondda-H	Coal Meas	73	77	C. Rhondd	127	62	20.48214	63.4	1.744118	2.56E+07	294.7445	137	2.531479	2.773055	2.041393	2.103804	2.469446	1.792392	2.136721	0
255	2894	1939	320	359	396	530	555	525	490	471	135	39.5	8.3	117	367	407	drift	0	marginal	uncertain	valley-side	Rhondda-H	Coal Meas	145	145	Gwyn, Cw	205	76	22.70284	31.2	0.961225	4.73E+07	361.6793	210	2.690196	2.673021	2.130334	2.311754	2.558324	1.880814	2.322219	0
256	2922	1934	370	390	434	532	537	525	386	850	130	50.2	3.7	85	339	404	drift	0	marginal	uncertain	valley-side	Rhondda-H	Coal Meas	73	80	Fforch, Ta	155	64	21.87815	46.5	2.202073	5.09E+07	370.4924	162	2.586587	2.929419	2.113943	2.190332	2.568779	1.80618	2.209515	0
270	2368	3456	110	153	177	330	564	284	440	580	170	80.9	5.7	139	541	564	drift	0	definite	uncertain	valley-side	Nantlle-He	microgranit	34	25	Llwyd-y-pri	174	67	21.57655	75.2	1.318182	4.44E+07	354.1142	220	2.643453	2.763428	2.230449	2.240549	2.549143	1.826075	2.342423	0
271	2374	3453	150	170	220	410	564	382	675	664	207	63.4	3.8	91	512	564	drift	0	definite	uncertain	valley-side	Nantlle-He	microgranit	16	23	Ceiliog, Ga	232	70	18.96803	59.6	0.983704	1.04E+08	470.2404	260	2.829304	2.822168	2.31597	2.365488	2.67232	1.845098	2.414973	0
272	2379	3451	108	160	240	345	485	342	562	536	140	47	8.1	77	431	547	drift	0	marginal	uncertain	valley-side	Nantlle-He	microgranit	69	60	Merbwll, T	234	132	22.60538	38.9	0.953737	7.05E+07	413.0846	237	2.749736	2.729165	2.146128	2.369216	2.616039	2.120574	2.374748	0
273	2718	3649	372	372	405	695	790	630	754	1015	295	66.3	0	80	384	477	major mora	0	poor	LLS glacie	valley-side	Carneddau	dolerite	105	95	S.C.Eigiau	258	33	18.88967	66.3	1.346154	1.97E+08	582.3075	323	2.877371	3.006466	2.469822	2.41162	2.765152	1.518514	2.509202	0
274	2721	3657	372	372	395	631	729	629	715	1120	259	66.3	0	26	390	420	major mora	0	marginal	LLS glacie	valley-side	Carneddau	dolerite	106	106	N.C.Eigiau	257	23	19.77049	66.3	1.566434	2.06E+08	590.4082	259	2.854306	3.049218	2.4133	2.409933	2.771152	1.361728	2.4133	0
281	2643	3534	431	460	495	614	619	613	297	310	120	56.3	15.9	61	628	828	outsloping	0	marginal	uncertain	valley-side	Snowdon	tuffs, acid	28	35	Wenallt, G	182	64	31.49974	40.4	1.043771	1.68E+07	255.8958	183	2.472756	2.491362	2.079181	2.260071	2.408063	1.80618	2.262451	0
283	2628	3557	396	420	507	875	921	835	660	625	370	70.2	11.8	49	731	941	outsloping	0	marginal	uncertain	valley-side	Snowdon	ignimbrite,	40	56	Beudy Ma	439	111	33.62992	58.4	0.94697	1.81E+08	565.7564	479	2.819544	2.79588	2.568202	2.642465	2.75263	2.045323	2.680336	0
284	2628	3553	588	610	640	916	921	885	502	245	276	52.5	8.1	12	694	926	outsloping	0	marginal	uncertain	valley-side	Snowdon	ignimbrite,	67	60	CribGoch	297	52	30.60998	44.4	0.488048	3.65E+07	331.7993	328	2.700704	2.389166	2.440909	2.472756	2.520875	1.716003	2.515874	0
290	3267	2344	452	480	521	615	684	615	310	438	106	51.3	12.5	43	330	407	drift	0	marginal	uncertain	valley-side	Black Mou	Old Red Sa	79	83	Olchon, Bl	163	69	27.73568	38.8	1.412903	2.21E+07	280.7638	163	2.491362	2.641474	2.025306	2.212188	2.448341	1.838849	2.212188	0
291	3239	2344	503	515	563	642	671	642	382	504	80	43.2	7	55	281	333	drift	0	marginal	none	valley-side	Black Mou	Old Red Sa	60	57	Efengyl S.,	139	60	19.99515	36.2	1.319372	2.68E+07	299.1136	139	2.582063	2.70243	1.90309	2.143015	2.475836	1.778151	2.143015	0
292	3254	2307	392	400	445	565	640	560	380	458	132	60.5	3.3	57	364	408	major bog	0	definite	LLS glacie	valley-side	Black Mou	Old Red Sa	39	35	Maes-y-ffir	168	53	23.85047	57.2	1.205263	2.92E+07	308.0724	173	2.579784	2.660866	2.120574	2.225309	2.488653	1.724276	2.238046	0
293	3238	2321	430	440	488	602	680	598	669	1494	140	65	1.5	88	328	392	major bog	0	poor	LLS glacie	valley-side	Black Mou	Old Red Sa	66	60	Esgob, Ta	168	58	14.09668	63.5	2.233184	1.68E+08	551.6903	172	2.825426	3.174351	2.146128	2.225309	2.741695	1.763428	2.235528	0
294	3013	2242	339	390	451	525	590	515	570	575	110	41.4	11.3	110	403	521	drift	0	marginal	uncertain	valley-side	En. & C. B	Old Red Sa	307	300	Dyfnant (Ll	176	112	17.15922	30.1	1.008772	5.77E+07	386.3834	186	2.755875	2.759668	2.041393	2.245513	2.587018	2.049218	2.269513	0
295	2843	2182	273	300	343	463	635	448	345	760	130	52.5	3.7	33	379	513	drift	0	marginal	uncertain	valley-side	Wn. Breco	Old Red Sa	71	73	S. Tawe F	175	70	26.89624	48.8	2.202899	4.59E+07	358.006	190	2.537819	2.880814	2.113943	2.243038	2.55389	1.845098	2.278754	0
296	2837	2191	420	490	525	664	667	616	450	860	140	50.2	5.2	29	416	539	drift	0	marginal	uncertain	valley-side	Wn. Breco	Old Red Sa	69	74	C. Tawe F	196	105	23.5358	45	1.911111	7.59E+07	423.3072	244	2.653213	2.934499	2.146128	2.292256	2.626656	2.021189	2.38739	0
297	2834	2203	515	600	642	761	761	740	485	1685	140	66.6	2.4	29	271	518	major bog	0	marginal	LLS glacie	valley-side	Wn. Breco	Old Red Sa	88	84	N. Tawe F	225	127	24.88741	64.2	3.474227	1.84E+08	568.6452	246	2.685742	3.2266	2.146128	2.352183	2.754841	2.103804	2.390935	0
298	2801	2217	500	502	576	700	701	668	705	890	175	78.7	0	110	336	492	major mora	0	classic	LLS glacie	valley-hea	Wn. Breco	Old Red Sa	29	6	L. y Fan Fa	168	76	13.40348	78.7	1.262411	1.05E+08	472.385	200	2.848189	2.94939	2.243038	2.225309	2.674296	1.880814	2.30103	0