Introduction - Capel Curig and Betws-y-Coed. Description of 1:25 000 sheet SH 75

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From: Howells, M. F., Francis, E. H., Leveridge, B. E. and Evans, C. D. R. 1978 Capel Curig and Betws-y-Coed. Description of 1:25 000 sheet SH 75 Classical areas of British geology, Institute of Geological Sciences. (London: Her Majesty's Stationery Office.)
Map: Sheet SH 75 Capel Curig and Betws-y-Coed. 1:25 000 series - Classical areas of British geology]

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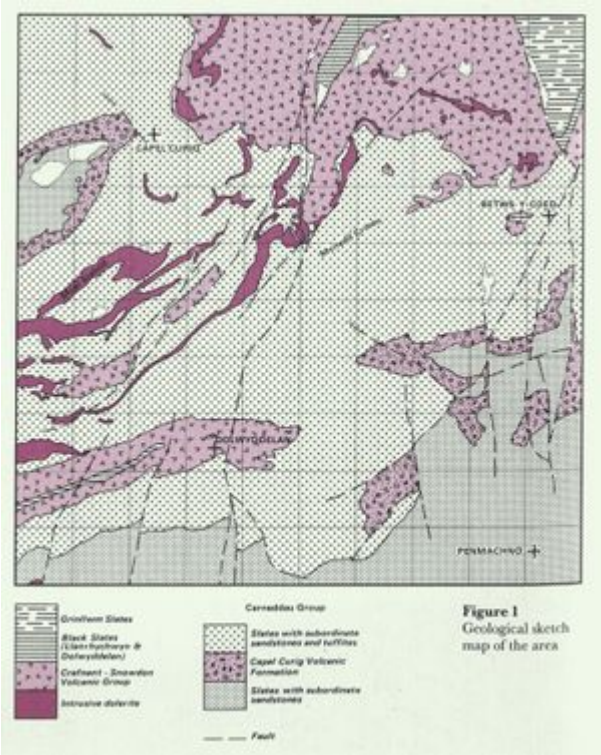


Figure 1 Geological sketch map of the area.

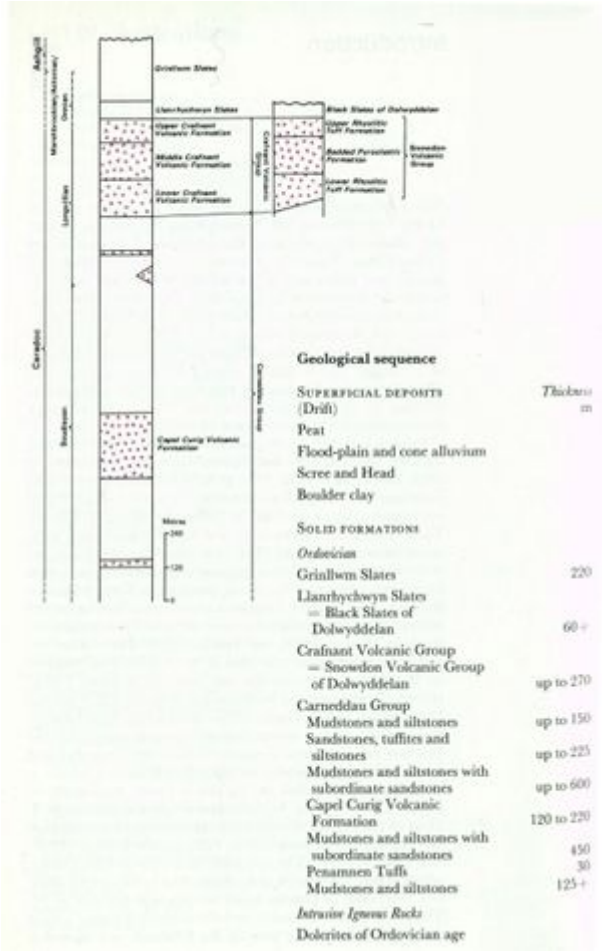


Figure 2 Generalised vertical section showing the relationships of the broad lithostratigraphical divisions to the Caradoc Shelly stages.

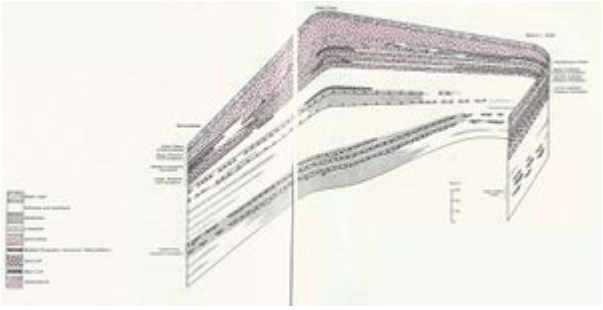


Figure 3 Generalised ribbon diagram showing lateral variations in the Carneddau Group and Snowdon/Crafnant Volcanic groups between Dolwyddelan and Betws-y-Coed. Intrusions omitted.
□

Contents

Chapter 1 Introduction

This publication describes the geology of the district covered by the 1: 25 000 map SH 75, comprising the country around the villages of Capel Curig, Betws-y-Coed, Penmachno and Dolwyddelan (Figure 1). Formerly in Caernarvonshire, the district now forms part of the county of Gwynedd and falls within the Snowdonia National Park. From elevations of less than 20 m above OD on the flood-plain of the Conway Valley in the east, the ground rises to 872 m at the summit of Moel Siâbod in the west. It is for the most part high moorland, much of it craggy, and is utilised mainly for sheep grazing and afforestation. Arable land is restricted to the valley floors flanking the rivers Llugwy, Lledr and Machno, all of which drain eastwards to join the River Conway.

Sedgwick made a traverse of the district from Nant Ffrancon through Moel Siâbod and Dolwyddelan to Penmachno in 1831 (Clark and Hughes, 1890, p. 520), but the first systematic investigation of the geology of the district was the primary one-inch survey begun in 1848 by Jukes, Aveline and Selwyn. Their Geological Survey maps and horizontal sections, published between 1851 and 1854, established the broad outlines of the stratigraphy and structure and were further illuminated by the two editions of the classic memoir on North Wales by Ramsay (1866, 1881). Supplementary contributions to the petrography and correlation of some of the volcanic rocks were made by Harker (1889) and Travis (1909). Three areas, together covering about one third of the district, were mapped on the six-inch scale for the first time by Williams (1922) around Capel Curig, by Williams and Bulman (1931) around Dolwyddelan and by Davies (1936) north of the Mon Llugwy. Some results of the recent primary six-inch survey by the Institute are embodied in papers by Howells, Leveridge and Evans (1973) and Francis and Howells (1973).

The sequence within the district is shown graphically in (Figure 2) and is listed, with thicknesses generalised, on p. 2. Most of the named divisions are refinements of terminology first applied by Williams (1922), Williams and Bulman (1931) and Davies (1936). The exception is the Carneddau Group, which is here introduced as an alternative to 'Glanrafon Beds' –a term used in various senses by previous workers (p. 9). The group is here defined to include all strata from the base of the Ordovician to the base of the Crafnant and Snowdon Volcanic groups. The lowest beds of the group do not crop out within the district.

Geological sequence

SUPERFICIAL DEPOSITS	*Thickness*
(Drift)	
Peat	
Flood-plain and cone alluvium	
Scree and Head	
Boulder clay	
SOLID FORMATIONS	
Ordovician	
Grinllwm Slates	220
Llanrhychwyn Slates = Black Slates of Dolwyddelan	60+
Crafnant Volcanic Group = Snowdon Volcanic Group of Dolwyddelan	up to 270

Carneddau Group	
Mudstones and siltstones	up to 150
Sandstones, tuffites and siltstones	up to 225
Mudstones and siltstones with subordinate sandstones	up to 600
Capel Curig Volcanic Formation	120 to 220
Mudstones and siltstones with subordinate sandstones	450
Penamnen Tuffs	30
Mudstones and siltstones	125+
Intrusive Igneous Rocks	
Dolerites of Ordovician age	

Fossils occur so sporadically in this mixed sequence of volcanic and sedimentary rocks, that many problems of faunal correlation remain to be solved. Collections made during the survey (p. 69) complement earlier work summarised by Diggens and Romano (1968), Romano and Diggens (1969) and Bassett (1972), to suggest that the whole of the sequence exposed in the district falls within the Caradoc and Ashgill series of the Ordovician. The lowest assemblage so far found within the district is a Soudleyan fauna obtained from the Capel Curig Volcanic Formation. The Soudleyan–Longvillian boundary can now be drawn fairly confidently within the sandstone-tuffite-siltstone division in the upper part of the Carneddau Group (Figure 2). The change from shelly faunas to graptolite faunas in the upper part of the Snowdon/Crafnant Volcanic Group, however, lends uncertainty as to the position of the top of the Longvillian and the presence of the three highest stages of the Caradoc. For example, although Williams and Bulman (1931) assigned the Black Slates of Dolwyddelan to the upper part of the *Dicranograptus clingani* Zone, faunas recollected there and from the equivalent Llanrhychwyn Slates during the survey are referred to the underlying *Diplograptus multidens* Zone (p. 70). Moreover, there seems to be no agreement as to where the *D. multidens/D. clingani* zonal boundary should be placed relative to the stage boundaries (compare for example Whittington and Williams, 1964, table 1, with Williams, 1972, fig. 2). The overlying, apparently unfossiliferous, Grinllwm Slates are assigned, in part at least, to the Ashgill on the basis of their correlation with the Bodeidda Mudstones of Conway.

Sedimentary rocks

The sediments of the Carneddau Group are mudstones, siltstones and sandstones containing brachiopod and trilobite faunas. Except for the uppermost beds, they indicate a continuing fairly shallow marine environment in which sedimentation broadly kept pace with subsidence. The sandstones are of greywacke type; their lateral impersistence and repeated intercalation with siltstones and mudstones (Figure 3) may reflect local instability at the margin of a subsiding basin. Unpublished work by the Institute in the ground immediately to the north-west of the district suggests that the coarser terrigenes of the group are fluviodeltaic and neritic rather than turbiditic, with facies variations and current directions indicating derivation from a landmass to the north-west.

Towards the top of the Carneddau Group there is, throughout the district, an upward passage from siltstones to mudstones which indicates an increased depth of water. This increase is further apparent in the overlying Lower Rhyolitic

Tuff Formation and Lower Crafnant Volcanic Formation where, despite the rapid incursions of thick volcanic deposits, the intercalated sediments are of siltstone and argillaceous limestone rather than of sandstone. The lithologies and sedimentary structures in the Middle Crafnant Volcanic Formation are also entirely deep water in character. The penecontemporaneous accumulations of basic rocks in the Bedded Pyroclastic Formation caused local and temporary shallowing around Dolwyddelan.

Towards the top of that formation there, and at the same horizon elsewhere in the district, the widespread establishment of a deeper water environment is signalled by the onset of a black graptolitic mudstone deposition which continued during and after the volcanic episode represented by the Upper Crafnant and Upper Rhyolitic Tuff formations.

During the deposition of the Carneddau Group, while the environment was still one of shallow water, the pattern of sedimentation may have been influenced by contemporaneous volcanism in one of two ways. The first is illustrated by the Capel Curig Volcanic Formation. In the north-western part of the district there is a change from dominantly arenaceous sediments below the volcanic rocks to dominantly argillaceous above (Figure 3), which may reflect the emptying of magma reservoirs under volcanic centres farther north and north-west, so that an initial shallowing, represented by the sandstone immediately overlying the tuffs, was followed by an overall deepening of the depositional environment. The effect did not extend as far from the volcanic centres as the Dolwyddelan area, where alternations of sandstone and siltstone occur both below and above an attenuated sequence of tuffs.

The second type of modification of sedimentation by volcanism is inferred from the sandstone and tuffite division higher in the Carneddau Group. Here the upward sequence of siltstone, tuff or tuffite, sandstone is so commonly repeated as to suggest that the relatively rapid accumulation of pyroclastic material in the shallow-water environment temporarily altered the balance between deposition and subsidence. The suggestion is further supported by the reworking at the tops of those pyroclastic beds and their local impersistence.

Volcanic rocks

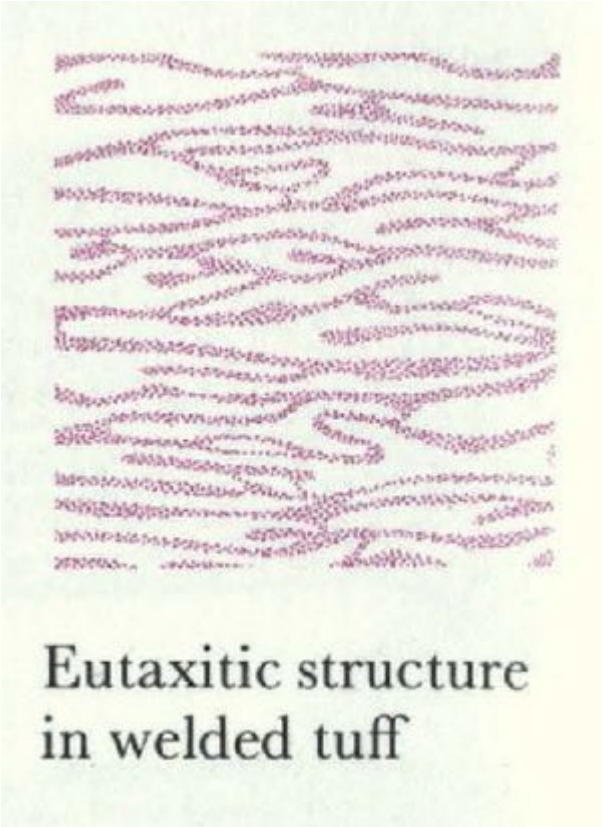


Figure 29 Eutaxitic structure.

Figure 30 Eruption in Snowdonia in Caradoc times.

Large volumes of both basic and acid volcanic rocks occur within the sedimentary sequence. The basic rocks consist mainly of dolerite intrusions, but they also include tuffs and hyaloclastites which are of such limited lateral extent that there can be little doubt that they emanated from local, relatively short-lived, eruptive centres within the district. Their lithologies indicate that the eruptions were mainly submarine, though at late stages some volcanoes may have emerged temporarily above sea level before being rapidly eroded. Their possible relationship to the dolerite sills and the broader issue of the almost simultaneous availability of basic and acid magma fall outside the scope of this account. The geochemistry of the intrusions and basic extrusive rocks in the context of plate tectonics is the subject of a separate work (Floyd and others, 1976). Most of the volcanic rocks of the district, however, are acid tuffs, consisting of shards and crystals with a minor proportion oflithic clasts and matrix. They exhibit both welded and unwelded textures and are typically the products of ash flows (MacDonald, 1972). Associated with them are subordinate amounts of acid air-fall tuffs and tuffites. Many of the ash-flow tuffs cropping out around Capel Curig were formerly described (Williams, 1922; Davies, 1936) as rhyolites and their association with marine sediments led Williams (1922) to suppose that they were submarine flows. Following the recognition of welded shard textures first in the Ogwen area (Oliver, 1954), and subsequently elsewhere in North Wales (Rast and others, 1958; Beavon and others, 1961), many rocks previously called rhyolite were reclassified as ignimbrites. The reclassification was accompanied by a revision of the belief that they were submarine flows, for welding was equated categorically with subaerial environments of eruption and deposition–a concept reconciled with the stratigraphy by postulating repeated emergence of volcanic islands for ash-flow emplacement, followed by repeated subsidence for deposition of the intercalated marine sediments (Rast, 1961; Brenchley, 1964, 1969).

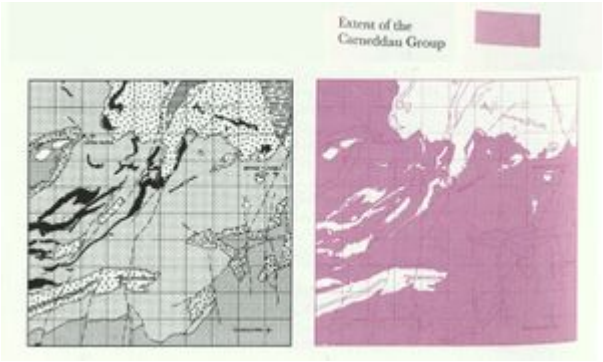
Results of the recent survey have cast doubt on the need to postulate subaerial environments either for welding or for ash-flow eruption and emplacement. In the Capel Curig Volcanic Formation there is a gradual upward transition from strongly welded massive tuff to current-bedded ripple-marked unwelded tuff. Contrasting this tuff lithology and the associated fossiliferous sediments with the lateral equivalent of the formation to the north and west of the district, Francis and Howells (1973) postulated a submarine environment of emplacement within the district and a subaerial environment of eruption and emplacement to the north and west. It is implicit in this interpretation that welding can occur in a submarine environment if the eruptive source is subaerial.

In the Lower Crafnant/Lower Rhyolitic Tuff Formation, the tuffs are unwelded, though composed dominantly of comagmatic material characteristic of ash flows. From their lithology and their associated sediments they have been interpreted as the products of submarine eruptions in which hot suspensive gas was gradually replaced by water to give turbid flows (Howells and others, 1973). Submarine eruption and emplacement is also invoked for the last major volcanic episode in the district – the Upper Crafnant/Upper Rhyolitic Tuff Formation. Graptolitic mudstones were being deposited in a deep-water environment that had been established before the episode began and the

heterogeneous admixtures of ash-flow debris and unlithified muds which are characteristic of the formation, probably resulted from secondary slumping.

The inference to be drawn from the volcanic rocks of the district and their palaeogeographical setting is not that the eruptions and surfaces of emplacement were entirely submarine, for the inclusion of air-fall tuffs in various parts of the sequence and the evidence of the Capel Curig Volcanic Formation shows that at least some of the eruptions were subaerial at some stage. It is rather that the presence of ash flows in a marine sequence does not necessarily imply repeated regional or local emergence with concomitant unconformities and disconformities.

Tectonic setting



Map 2 Map showing the extent of the Carneddau Group.

The district forms part of the Welsh Basin, in which thousands of metres of strata accumulated during Lower Palaeozoic times. The basin is generally assumed to have been separated from a proto-Atlantic ocean to the north by an Irish Sea landmass or horst which Dewey (1969) suggests was related to an earlier Benioff Zone. Evidence for the landmass is provided in Lleyn and Anglesey, where there is a marked overstep by the Ordovician (George, 1961, 1963) and indications of penecontemporaneous uplift and thrusting (Shackleton, 1954). The landmass is presumed to have been the source of the coarser elastics of the Carneddau Group.

The whole of the Ordovician volcanism in North Wales is interpreted by Fitton and Hughes (1970) as part of an island-arc system related to the plate tectonic model of Dewey (1969). Geochemical work on the dolerites, however, suggests to Floyd and others (1976) that continental calc-alkaline volcanism of 'Andean-type' is more likely than a calc-alkaline island-arc environment. Suggestions that the large volume of acid material was derived by crustal fusion have not been challenged, but it is not clear whether the surface expression of the acid volcanism was from fissures or central calderas: the only caldera so far postulated, in Central Snowdonia (Shackleton *in* Beavon, 1963; Rast, 1969; Bromley, 1969), by no means finds general acceptance (see for example Fitch *in* Bromley, 1969). Whether fissures or calderas, there were evidently several eruptive centres, only one of which—the source of the single rhyolite flow near the top of the Carneddau Group, near Betws-y-Coed—lay within the district. The source of the Capel Curig Volcanic Formation appears to have lain west to north-west of the district; the lower, main flows of the Lower Crafnant/Lower Rhyolitic Tuff formations came from the west, and the uppermost flow from the north.

The evidence suggests that the acid volcanism originally found subaerial expression in the uplifted area related to the Benioff Zone and that the centres became progressively submerged during Caradoc times as the depositional regime became one of deeper water.

References

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