CAPEL CURIG

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Introduction

During Caradoc (Soudleyan) times, volcanicity in North Wales was characterized by a series of climactic acid ash-flow eruptions sourced from a number of subaerial volcanic centres in northern Snowdonia. These represent part of the 1st Eruptive Cycle of Howells *et al*. (1991). These ash-flow deposits, and their bounding sedimentary strata, provide important evidence for palaeoenvironment reconstructions and record a transgression from a subaerial environment across a shoreline into a subaqueous environment. Within this framework the exposures west of Capel Curig village are of international importance, as it was here that welded submarine ash-flow tuffs were first identified in ancient rocks by Francis and Howells (1973) and Howells *et al*. (1973). The sections also provide classic examples of magma–sediment interaction and are pertinent to the continuing debate on subaqueous welding of ash-flow tuffs (see for example Cas and Wright, 1987, 1991; McPhie *et al*., 1993).

The GCR site includes volcanic rocks and interlayered marine sedimentary rocks that form the type area for the Capel Curig Volcanic Formation. They lie within the core of the Capel Curig Anticline and are well exposed in the craggy ground to the NW and SE of Llynnau Mymbyr. Originally mapped and described by Ramsay (1881), the type area was remapped by Williams (1922) who interpreted most of the volcanic rocks as rhyolite lavas emplaced in a marine environment. Recognition by Oliver (1954) and Rast *et al*. (1958) that many of the 'rhyolite lavas' of North Wales are in fact welded tuff or ignimbrite radically changed views of the Caradoc palaeoenvironments. The latter authors considered that all of the ignimbrites were erupted and emplaced subaerially. Subsequent detailed mapping by Francis and Howells (1973) in the Capel Curig area convincingly demonstrated that some of the tuffs were emplaced in a submarine environment, work which provided a stimulus for further investigation and led to more realistic assessments of the palaeogeography (Howells *et al*., 1979; Howells and Leveridge, 1980; Orton, 1988; Howells *et al*., 1991). This site is complemented by the Llyn Dulyn GCR site, which demonstrates the lateral equivalents of these ash-flow tuffs emplaced in a subaerial environment (Figure 6.35).

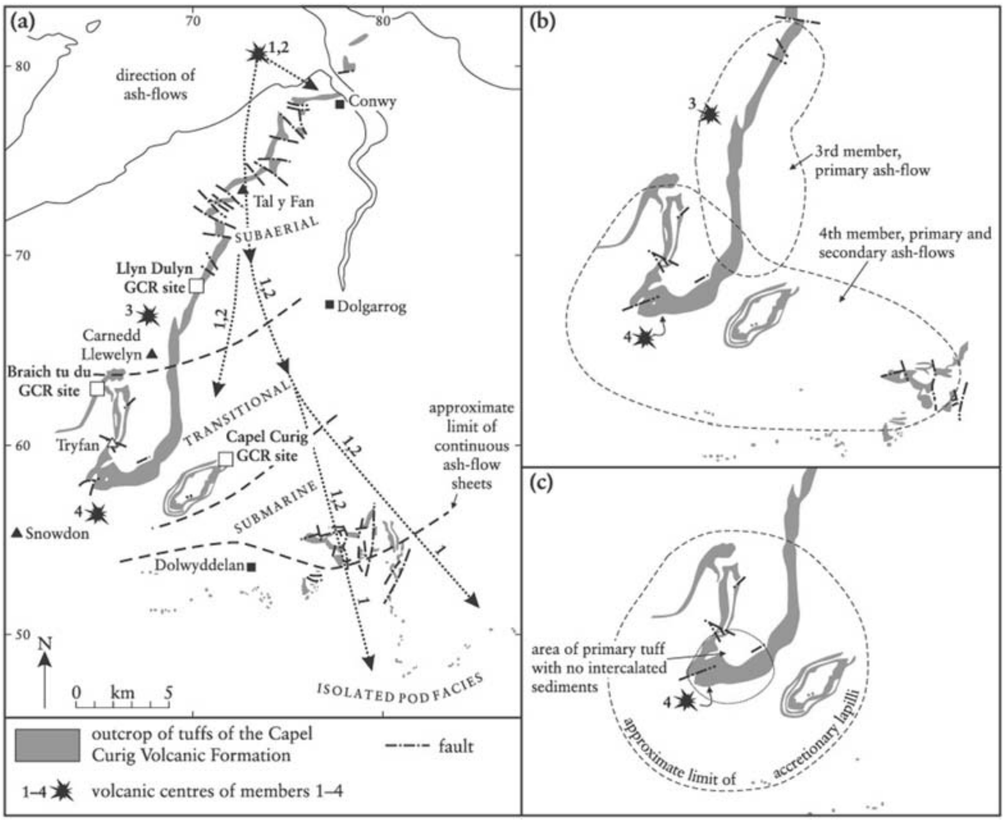

Figure 6.35: (a) Interpretation of the depositional environments of the 1st and 2nd members of the Capel Curig Volcanic Formation, showing flow directions and the distribution of isolated pods of the 1st Member. (b), (c) Distribution of the 3rd and 4th members of the Capel Curig Volcanic Formation. After Howells and Leveridge (1980).

Of the four volcanic members distinguished within the Capel Curig Volcanic Formation, three are present at the Capel Curig GCR site and in upward succession are the Garth Tuff, the Racks Tuff and the Dyffryn Mymbyr Tuff. Geochemical investigations indicate that the tuffs are rhyolitic to rhyodacitic in composition and are spatially and geochemically related to a series of subvolcanic intrusions (Howells *et al.*, 1991). The members may be distinguished by their trace element compositions and can be related by fractional crystallization, with the oldest (the Garth Tuff) being the least evolved.

Description

The Garth Tuff, forming the lower crags north of Llynnau Mymbyr (Figure6.36), is a massive, cream to white, well-jointed unit, generally 10 m thick but increasing up to 40 m in the western part of the Capel Curig Anticline. It is massive and welded in the lower and middle parts, grading up through a zone with faint bedding planes into a reworked upper part, up to 20 m thick, with current bedding and ripples. A prominent eutaxitic foliation is always parallel to the regional dip except at the margins to the tuff. The top is concordant with the overlying sandstones. Lithic clasts, including devitrified perlitic glass and welded tuff, recrystallized shards, siliceous nodules, and isolated and fragmented albite phenocrysts are scattered throughout the unit. The fine-grained matrix is composed of sericite, chlorite, quartz and feldspar. On the south-eastern limb of the anticline, sections exposed above the A4086 road and in forestry cuttings (e.g. 7137 5732), show that the bedded top also contains accretionary lapilli. Here, the base is remarkably discordant, with flames of the underlying sediment penetrating deeply into the tuff. Tuff–sediment contacts at 90° to the regional bedding are not uncommon. The adjacent sedimentary strata are often highly disturbed and are interpreted as reconstituted bedded sandstones. Numerous small tuff apophyses penetrate the sediment and comprise admixtures of tuff and sediment, (e.g. at 7091 5665). Locally, these may be detached and resemble tuff-pipes at outcrop. Large detached bodies of tuff, up to 100 m × 250 m in plan, and surrounded by the underlying sandstones, are sporadically preserved. These bodies of tuff are lithologically identical to the main tuff.

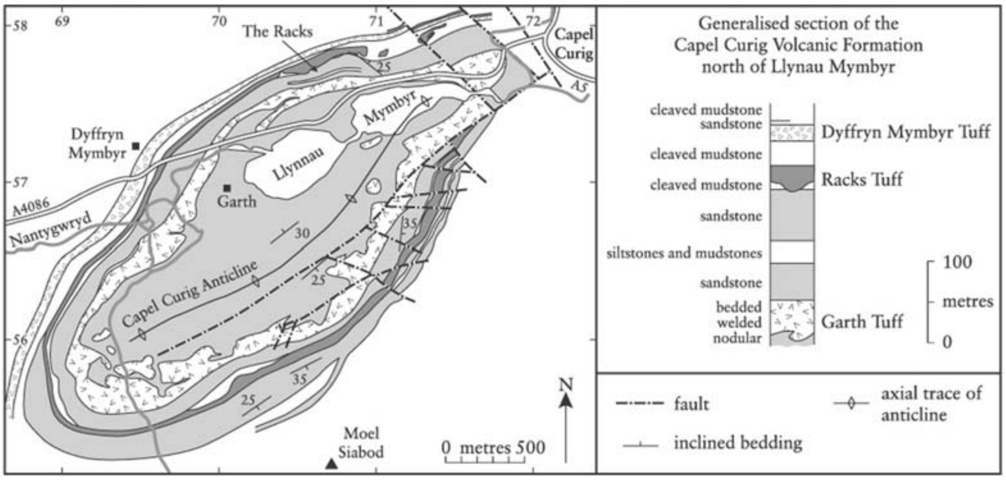

Figure 6.36: Map and vertical section of the Capel Curig Volcanic Formation in the Capel Curig Anticline (after Francis and Howells, 1973).

The overlying strata, between the Garth and Racks tuffs, form part of the Cwm Eigiau Formation and comprise fine-grained pale-green sandstones with thin, impersistent, often disrupted, grey, cleaved mudstones and siltstones in the upper part. Poorly preserved fossiliferous bands are present in crags at 7095 5789 and a disused quarry at 7094 5784. Shelly forms dominate, and include *Dalmanella* sp., *Dinorthis* cf. *berwynensis*, *Howellites* sp. and *Macrocoelia* sp. (Howells *et al.*, 1978).

The Racks Tuff, lithologically comparable to the Garth Tuff, is well exposed on the south-eastern limb of the anticline, where it forms a well-bedded and non-welded unit up to 30 m thick. In contrast, on the northern crags (around 706 579) the tuff is thinner, massive and welded throughout with patches of siliceous nodules. The outcrop is discontinuous and podiform, with the tuff locally wedged out. The lower contact is highly irregular with large flames of mudstone transgressing the upper and lower tuff contacts (e.g. 704 578). The adjacent mudstones and sandstones are highly contorted and are penetrated by thin apophyses of tuff.

The Dyffryn Mymbyr Tuff is only present on the north-western limb of the anticline and thins markedly to the NE, grading from a coarse-grained lithic tuff containing accretionary lapilli to a tuffaceous mudstone.

Supplementary sites in the Lledr Valley (at 7656 5436 and at Rolwyd (765 512) to the SW of Capel Curig) provide additional evidence for the emplacement of isolated pods of tuff within unconsolidated marine sediments (Francis and Howells, 1973). A possible mechanism for the formation of these pods is described in Howells *et al.* (1991, fig. 27).

Interpretation

The presence of eutaxitic welding fabrics and relict shardic textures within the tuffs of the Capel Curig Formation, exposed on the flanks of the Capel Curig Anticline, are indicative of their formation as hot pyroclastic flow deposits. Regional lithological and geochemical studies show that these tuffs (the Garth and Racks tuffs) were erupted from subaerial centres in northern Snowdonia during Caradoc times and transported southwards. Changes in emplacement and cooling textures within the tuffs, combined with complex sediment–tuff relationships and studies of the adjacent sediment, indicate that the environment of deposition changed from subaerial to submarine (Howells and Leveridge, 1980; Howells *et al.*, 1991). The outcrops around Capel Curig represent one of the key areas in this reconstruction, marking the shallow-water transition zone between a shoreline located just north of Capel Curig, and deeper basinal conditions farther south. This interpretation, supported by the sedimentary features and shelly faunas of the enclosing sediment and evidence for reworking of the upper parts of individual tuffs, contrasts markedly with the subaerial conditions at the Llyn Dulyn GCR site.

As the tuffs transgressed the shoreline into the submarine environment, the hot, gaseous and dense ash-flows interacted with the semi-lithified and water-saturated sediments on the sea bed. The remarkable irregularities of the lower tuff contacts may be attributed to the disturbance of the underlying wet unlithified sediments by the rapid emplacement of hot ash-flows on an uneven surface or to seismic shocks attendant on eruption (Francis and Howells, 1973). Either mechanism would induce the sediments to deform thixotropically and the ash-flows to collapse downwards by unequal loading to form irregular lobes and pipe-like masses, which in extreme cases may have become completely detached. Fluidization and magma–water interaction at the tuff–sediment contact probably facilitated these processes. Although still a matter of debate (see Howells *et al*., 1991, pp. 163–5) water depths are generally assumed to be less than the thickness of the pyroclastic flow deposits (McPhie *et al*., 1993).

Conclusions

The Capel Curig GCR site provides classic exposures exemplifying the delivery of subaerial pyroclastic flow deposits into a shallow-marine environment. As one of the first documented examples of this process in an ancient environment, the site is of historical as well as international scientific interest. The presence of a strong foliation within the tuffs and the interaction with the underlying fossiliferous marine sediments have been central to the arguments that the ash-flows crossed the shoreline hot and intact and continued across the sea bed, retaining sufficient heat to become welded when they stopped moving.

Reference list

Cas, R. A. F. and Wright, J. V. (1987) *Volcanic Successions*, *Modern and Ancient: A Geological Approach to Processes*, *Products and Successions*, Allen and Unwin, London.

Francis, E. H. and Howells, M. F. (1973) Transgressive welded ash-flow tuffs among the Ordovician sediments of N.E. Snowdonia, N. Wales. *Journal of the Geological Society of London*, **129**, 621–41.

Howells, M. F. and Leveridge, B. E. (1980) The Capel Curig Volcanic Formation. *Report of the Institute of Geological Sciences*, No. **80/6**.

Howells, M. F., Leveridge, B. E. and Evans, C. D. R. (1973) Ordovician ash-flow tuffs in eastern Snowdonia. *Report of the Institute of Geological Sciences*, No. **73/3**.

Howells, M. F., Francis, E. H., Leveridge, B. E. and Evans, C. D. R. (1978) *Classical areas of British geology: Capel Curig and Betws y Coed: Description of 1:25 000 Sheet SH75*, HMSO, London, for Institute of Geological Sciences.

Howells, M. F., Leveridge, B. E., Addison, R., Evans, C. D. R. and Nutt, M. J. C. (1979) The Capel Curig Volcanic Formation, Snowdonia, North Wales; variations in ash-flow tuffs related to emplacement environment. In *The Caledonides of the British Isles – reviewed* (eds A. Harris, C. H. Holland and B. E. Leake). *Geological Society of London Special Publication*, No. **8**.

Howells, M. F., Reedman, A. J. and Campbell, S. D. G. (1991) *Ordovician (Caradoc) Marginal Basin Volcanism in Snowdonia (North-west Wales)*, HMSO, London, for the British Geological Survey.

McPhie, J., Doyle, M. and Allen, R. (1993) *Volcanic Textures: A Guide to the Interpretation of Textures in Volcanic Rocks*, Centre for Ore Deposit and Exploration Studies, University of Tasmania, Hobart.

Oliver, R. L. (1954) Welded tuffs in the Borrowdale Volcanic Series, English Lake District, with a note on similar rocks in Wales. *Geological Magazine*, **91**, 473–83.

Orton, G. (1988) A spectrum of mid-Ordovician fan and braidplain deltaic sequences, North Wales: a consequence of varying fluvial input. In *Fan Deltas: Tectonic Setting*, *Sedimentology and Recognition* (eds W. Nemex and R. J. Steel), Blackie, Glasgow.

Ramsay, A. C. (1881) The geology of North Wales (2nd edition). *Memoir of the Geological Survey of Great Britain*, Vol. **3**.

Rast, N., Beavon, R. V. and Fitch, F. J. (1958) Sub-aerial volcanicity in Snowdonia. *Nature*, **181**, 508.

Williams, H. (1922) The igneous rocks of the Capel Curig District (North Wales). *Proceedings of the Liverpool Geological Society*, **13**, 166–202.