

# LLYN DULYN

M. Smith

OS Grid Reference: SH703661

## Introduction

The Llyn Dulyn GCR site lies within the main outcrop of volcanic strata of Caradoc (Soudleyan) age which forms a narrow strip trending NE–SW across northern Snowdonia. Originally mapped and described by the Geological Survey (Ramsay, 1881), the area was remapped by the Geological Survey in 1968–71 and is described in Howells *et al.* (1981). The site (Figure 6.32) provides excellent exposures of a part of the 1st Eruptive Cycle of early Caradoc volcanic activity and preserves the critical contact relationships between the ash-flow tuffs and their confining sedimentary rocks.

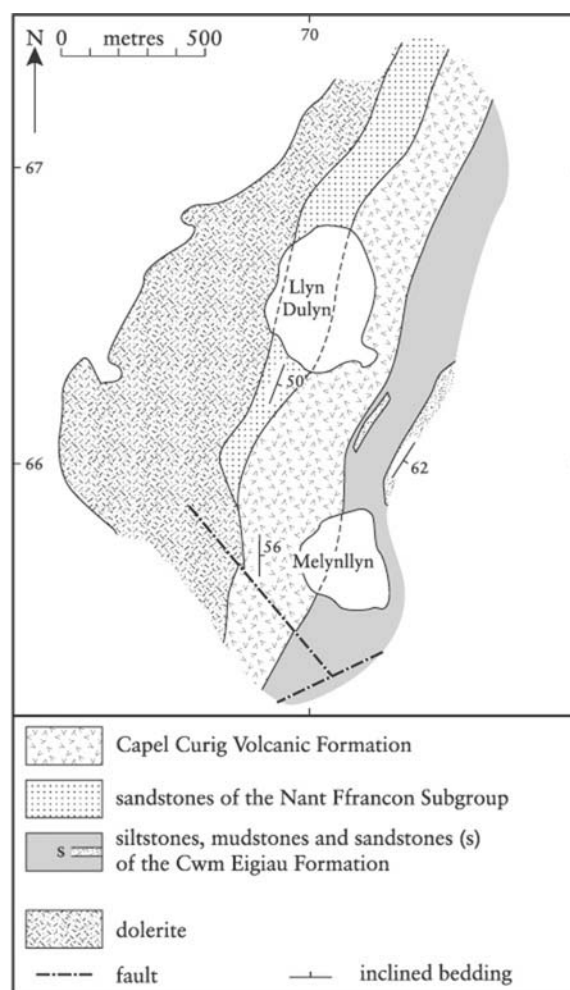


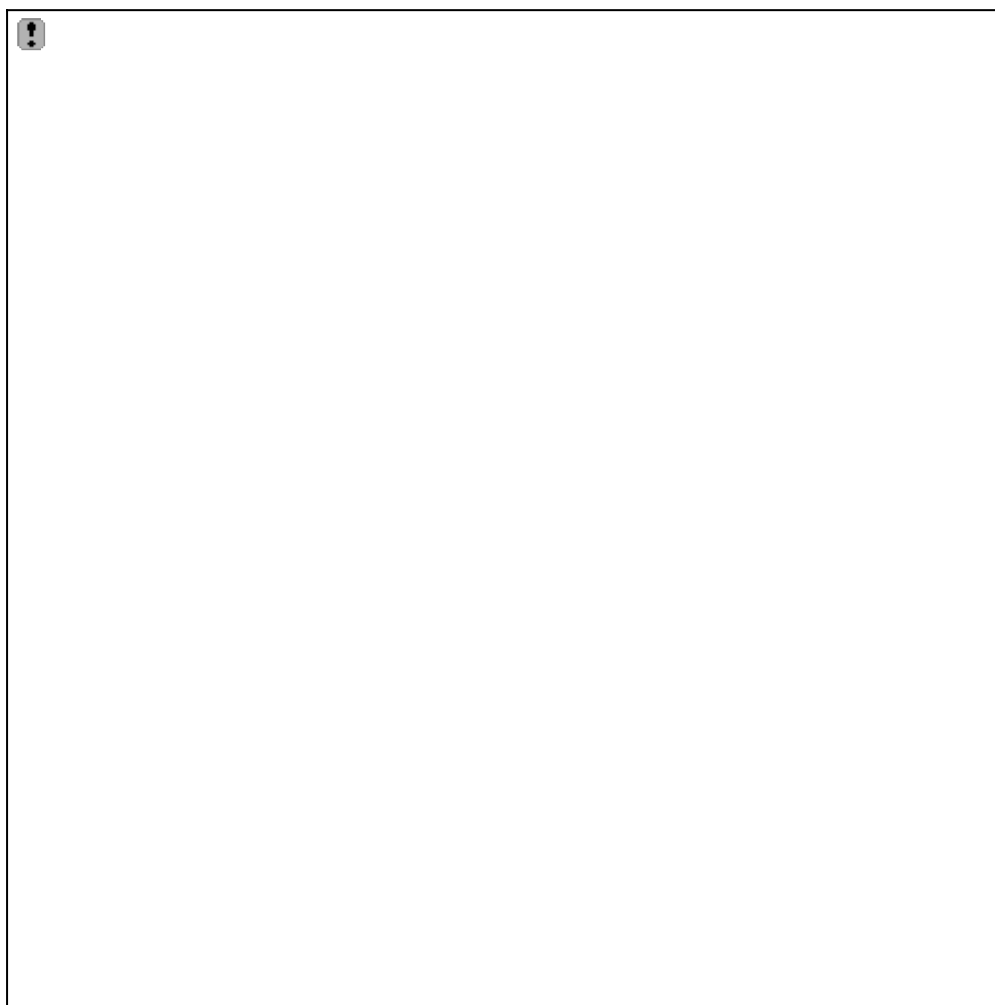
Figure 6.32: Map of Llyn Dulyn, after BGS 1:25 000 sheets 65/66 (1985) and 76 (1981).

Three acid ash-flow tuffs, belonging to the Capel Curig Volcanic Formation, are distinguished and represent the emanations from a series of subaerial volcanic centres in North Wales (Howells *et al.*, 1991). These tuffs are in part correlatives to the three members described at the Capel Curig GCR site but with some important differences; the tuffs here have unwelded bases, contain no interlayered sediments and show no evidence for magma–water interaction. These features, in conjunction with the character of the adjacent sedimentary strata, indicate a subaerial emplacement of hot pyroclastic flow deposits and provide an important contrast with the subaqueous environment at Capel Curig. Recognition of these contrasting environments by Francis and Howells (1973) and Howells *et al.* (1973) led to a radical re-interpretation of Lower

Palaeozoic palaeoenvironments in North Wales.

## Description

The crags forming the south-western backwall to Llyn Dulyn (Figure 6.33) (between 7002 6632 and 7030 6631), expose a near-complete dip section through the Capel Curig Volcanic Formation and into the overlying sedimentary rocks of the Cwm Eigiau Formation. Three of the four members of the formation are present, in upward succession informally termed the 1st, 2nd, and 3rd members. They have a cumulative thickness of up to 180 m and characteristically comprise well-bedded, pale-grey, blocky and jointed fine-grained tuffs.



*Figure 6.33: Moderately dipping welded ash-flow tuffs of the Capel Curig Volcanic Formation, SW side of Llyn Dulyn. (Photo: BGS no L1501.)*

The lowest (1st) member, exposed in the western half of the site, is equivalent to the Garth Tuff farther south. It comprises a single cooling unit, 18 m thick, of a primary welded ash-flow tuff. The basal non-welded zone has an even, planar base with scattered tabular feldspar crystals, often pseudomorphed by sericite, and passes up into a welded central part with a eutaxitic foliation accentuated by concordant segregations of secondary quartz. The topmost 5 m is composed predominantly of non-welded shards and a well-defined zone of thin-walled siliceous nodules.

The 2nd or middle member, correlated with the Racks Tuff at Capel Curig, has a basal zone marked by a non-welded lithic crystal tuff and is overlain by strongly welded ash-flow tuff for 87 m. This thick unit comprises two separate cooling units. The lower tuff, 34 m thick, is rich in lithic clasts including mudstone, welded tuff, altered acidic and basic intrusive rock and feldspar crystals. In thin section, the crystals are of albite–oligoclase with rounded and resorbed textures and commonly are altered to sericite and carbonate. Delicate shards are scattered

throughout, set in a matrix of sericite aggregates. The prominent eutaxitic foliation is defined by aligned, dark-green chloritic fiamme with ragged terminations consisting of chlorite flakes and sericite, which are interpreted as recrystallized pumice. Above 34 m from the base of the unit, feldspar crystals are notably less common and lithic clasts are absent. At 72 m, within the upper cooling unit, siliceous recrystallization along the foliation is distinctive and tends to obscure the eutaxitic foliation. The top part is characterized by a prominent bedding plane that can be traced throughout the immediate area.

The 3rd member, which has no representative in the Capel Curig area, comprises up to 75 m of thinly banded welded tuff with distinctive layers of collapsed pumice and evidence of upward grading. Originally interpreted as a single unit by Howells *et al.* (1981), the fine-grained banding is interpreted here to represent a sequence of thin welded primary ash-flow tuffs. With thicknesses up to 4 m, the tuffs contain pumice-rich layers and locally graded concentrations of feldspar crystals towards the top. They are recrystallized with a platy quartzo-feldspathic mosaic obscuring the original shardic fabric. In the upper parts of the member, feldspar crystals up to 3.5 mm in diameter are common along with segregations of quartz, sericite and chlorite. The uppermost beds are very fine grained with a pronounced penetrative cleavage.

The underlying sedimentary strata exposed in the extreme western part of the site comprise a heterolithic sequence of sandstones, conglomerates and siltstones which form part of the Nant Ffrancon Subgroup. The lower beds are coarse-grained sandstones and conglomerates in units up to 8 m thick and grading up into 2 m-thick cross-bedded sandstones. These coarse-grained beds are interlayered with thinner beds and lenses of laminated tuffaceous siltstone, which may also occur as irregularly orientated blocks. The upper beds are characterized by medium-grained graded sandstones and laminated tuffaceous siltstones. The sandstones are tabular and cross-laminated with symmetrical ripple marks.

The sedimentary rocks overlying the welded tuffs represent the local basal strata of the Cwm Eigiau Formation in the area. They crop out across the rounded shoulder SE of Llyn Dulyn and extend southwards to Melynlyn (Figure 6.32). Up to 12 m of grey siltstone are present immediately above the tuffs, passing upwards into fine-grained, cross-bedded sandstones.

## Interpretation

Analysis of the regional thickness, lithological and textural variations, and volcanic features within the tuffs and adjacent sedimentary rocks of the Capel Curig Volcanic Formation were used by Howells and Leveridge (1980) and Howells *et al.* (1991) to identify the likely source areas for the individual eruptive events and the environments of deposition (Figure 6.34). The individual members of the Capel Curig Formation exposed at the Llyn Dulyn site are interpreted as massive acid ash-flows erupted from subaerial vents to the north (1st and 2nd members) and west (3rd member), travelling southwards and eastwards down the volcano flanks and onto a broad plain. The exceptional thin development (only 20 m) of the 1st member is interpreted by Howells and Leveridge (1980) to represent emplacement on a locally developed topographical high within this plain.

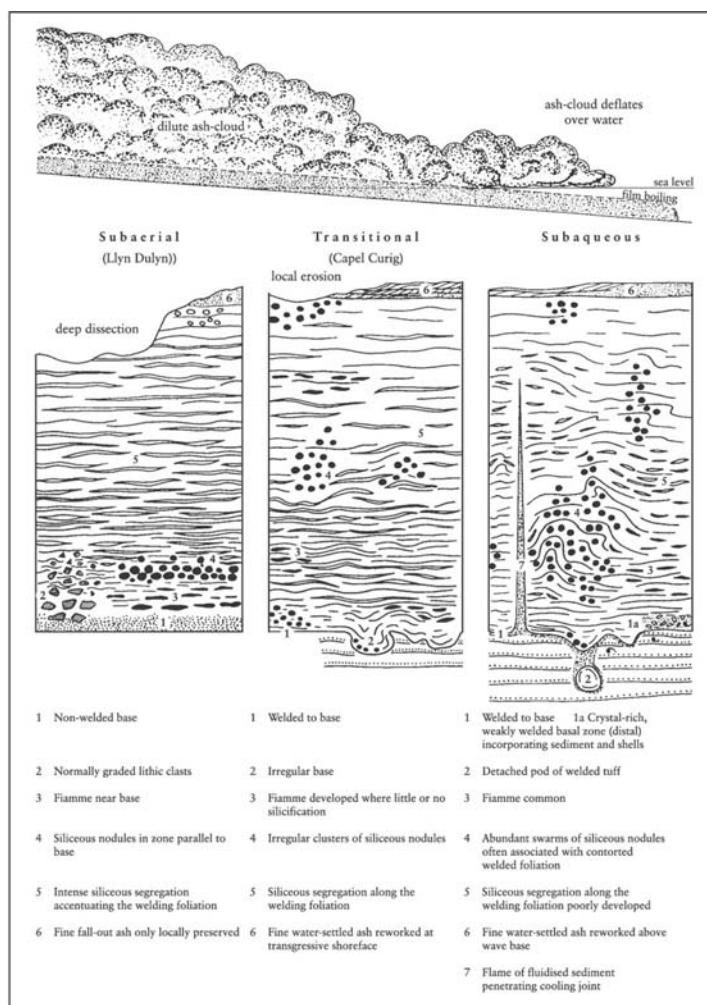


Figure 6.34: Model of ash-flow emplacement, and of contact and internal facies relations of welded ash-flow tuffs with respect to environment of deposition (after Howells et al., 1991).

Features within the tuffs, including the presence of non-welded bases, normally graded lithic clasts and crystals, and the intense siliceous segregation accentuating the eutaxitic foliation, are all indicative of subaerial ash-flow emplacement. When combined with the sedimentary features in the underlying Nant Ffrancon Subgroup strata, which indicate shallow, lacustrine conditions succeeded by high-energy alluvial braided streams, they provide persuasive evidence for emplacement in a subaerial environment. This interpretation contrasts markedly with that of Capel Curig GCR site where the tuffs have extended into a shallow-marine environment (Figure 6.34).

## Conclusions

Llyn Dulyn provides one of the best-exposed sections through the Capel Curig Volcanic Formation belonging to the 1st Eruptive Cycle during Caradoc times in northern Snowdonia. It is a classic site in which to demonstrate the emplacement of ash-flow tuffs in a subaerial environment. The tuffs, derived from eruptive centres located to the north and west, represent a series of hot rhyolitic ash-flows and display textbook examples of welding and cooling textures. Environmental interpretations of the surrounding sedimentary rocks and the lack of evidence for interaction between magma and wet sediment emphasize the subaerial environment. This contrasts markedly with the submarine environment proposed for the tuffs exposed at the Capel Curig GCR site and enhances reconstructions of Lower Palaeozoic environments in North Wales.

## Reference list

- 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., Leveridge, B. E. and Reedman, A. J. (1981) *Snowdonia – Rocks and Fossils*, Unwin Paperbacks, London.
- 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.
- Ramsay, A. C. (1881) The geology of North Wales (2nd edition). *Memoir of the Geological Survey of Great Britain*, Vol. **3**.