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YR ARDDU

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OS Grid Reference: SH621452–SH631472

Introduction

The present-day mountainous glaciated terrain of Snowdonia represents the deeply eroded roots to a series of large-scale (15–20 km in diameter) caldera-forming eruptive centres. These centres, of Caradoc age, have been largely identified from detailed geological mapping and studies of the internal facies and thickness variations and the emplacement environments of the bedded volcaniclastic deposits (Howells *et al*., 1991). Within this environment, smaller-scale eruptive centres are surprisingly scarce. One of the best exposed and clearly defined of these smaller centres is that of Yr Arddu, interpreted as one of the earliest phases of activity related to the 2nd Eruptive Cycle of volcanic activity in Snowdonia in Caradoc times (Howells *et al*., 1991). The well-exposed acid ash-flow tuffs, intrusive lava domes and breccias, and associated sedimentary rocks provide an important example of emplacement mechanisms and volcanic processes proximal to a fissure-controlled eruptive vent.

Originally mapped by the Geological Survey in 1851 as ‘contemporaneous felsite', Yr Arddu was not described in detail until the work of Beavon in 1963. Beavon subdivided the tuff sequence on Yr Arddu into the Lower, Middle and Upper lapilli-tuffs, which he correlated with various outflow tuffs of the Lower Rhyolitic Tuff Formation on Moel Hebog and Snowdon. Shelly faunas in the subjacent sandstones were ascribed a Soudleyan age (Williams and Harper, in Beavon, 1963). Yr Arddu was later remapped by the British Geological Survey and was described by Howells *et al*. (1987). This work refuted the correlations proposed by Beavon, and showed that, geochemically, the Yr Arddu Tuffs form a distinctive group within the Lower Rhyolitic Tuff Formation with significantly lower Nb/Th ratios than other ash-flow tuffs of the formation (Howells *et al*., 1991, figs 54 and 55).

The GCR site, which includes all of the main mass of Yr Arddu, covers an area of some 3 km² and includes the outcrop of the Yr Arddu Tuffs and the immediate underlying sedimentary strata (Figure 6.42). It is included in the geological 1:25 000 scale Sheet SH 64 and 65 (Snowdon) (1989) and the 1:50 000 scale Sheet 119 (Snowdon) (1997). The description given below is based largely on Howells *et al*. (1987) and is presented in stratigraphical order.

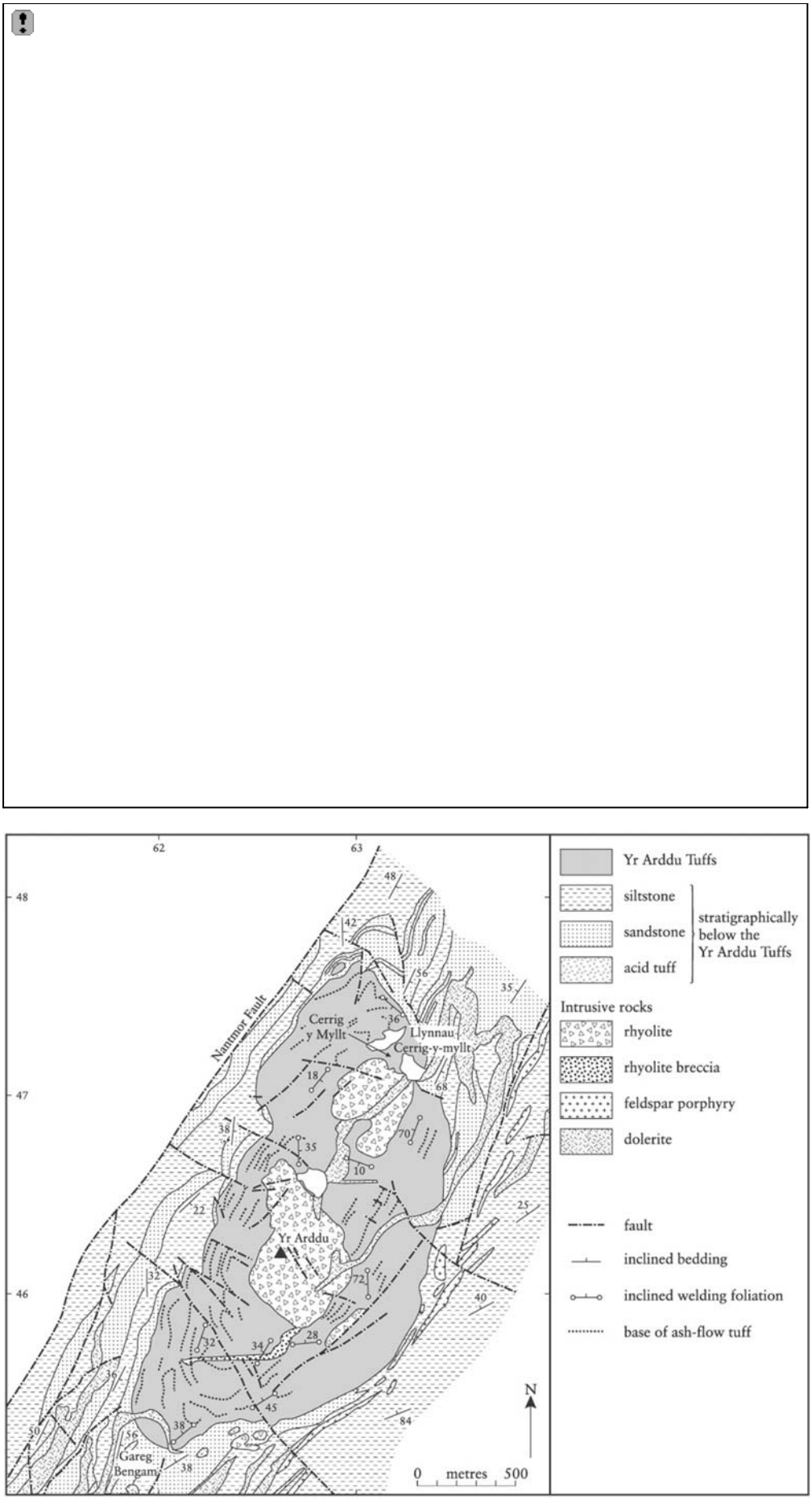

Figure 6.42: Map showing the Yr Arddu Tuffs, subjacent sedimentary rocks and associated intrusions (after Howells et al., 1987).

Description

Yr Arddu forms an elongate synclinal outlier situated along the site of a deep-seated fracture on the south-eastern margin of the Snowdon eruptive centre (Howells *et al*., 1991). The site includes sandstones and siltstones of the Cwm Eigiau Formation (interlayered with rare, thin, acid tuffs), which are overlain by the Yr Arddu Tuffs, one of the oldest units within the Lower Rhyolitic Tuff Formation. The Yr Arddu Tuffs form a pile more than 180 m thick, intruded by later rhyolite domes, a distinctive breccia dyke, and sills of dolerite.

Exposure on Yr Arddu is excellent and all of the main lithologies can be studied in a traverse from immediately south of Gareg Bengam at 6182 4520 to the vicinity of Llynnau Cerrig-y-myllt at 6330 4722 (Figure 6.42).

The lower beds comprise interlayered siltstones and mudstones coarsening up into blue-grey, well-bedded sandstones and siltstones. The sandstones are flaggy to massive and locally conglomeratic with common cross-bedding and channelized pebbly sandstones. The presence of plagioclase crystals and lithic-tuff fragments indicates that the coarser sandstones are probably volcaniclastic. The siltstones are grey and homogeneous and may include thin layers of laminated sandstone up to 2 cm thick. Thin (up 3 m thick), pale weathering beds representing fine-grained reworked air-fall and/or primary non-welded rhyolitic ash-flow tuff with reworked tops are commonly developed. The primary ash-flow deposits comprise delicate cuspate and bubble shards and a few feldspar crystals. Also present are tuffaceous sedimentary rocks, thin coarse-grained lithic tuffs and debris-flow deposits with acid tuff clasts in a silt matrix (e.g. at 6181 4512). The tuffaceous sedimentary rocks, 1–20 cm thick, commonly display trough cross-bedding and abundant minor syndepositional faults.

Shelly faunas, dominated by disarticulated brachiopods and fragmentary trilobites, occur typically in the coarser sandstone layers and have been collected mainly from the south-eastern and north-eastern margins of Yr Arddu, (for example at 6224 4519 and 6360 4701). Originally interpreted as indicative of a Soudleyan age, the presence of *Kloucekia apiculata*, *Flexicalymene planimarginata* and *Broeggerolithus nicholsoni* (see plate 9 in Howells and Smith (1997) and plate 4 in Howells *et al*. (1991) for examples) indicate a Longvillian age. Detailed collecting has established the Longvillian–Soudleyan boundary on the eastern side of Yr Arddu.

Upslope, outcrops from Gareg Bengam to the summit of Yr Arddu are dominated by massive white-weathering, welded and non-welded rhyolitic pumice-lapilli tuffs interlayered with pyroclastic breccia deposits. They form a series of distinctive scarp features and intervening depressions, reflecting the primary stratification in the tuffs, and define a broad synclinal structure. Resting discordantly on the underlying sandstones, the tuffs are variably cleaved and eutaxitic fabrics, defined by chloritic segregations and fiamme, subdivide the sequence above Gareg Bengam into a series of welded and non-welded ash-flows. They are devitrified, locally crystal rich, and siliceous nodules, up to 40 cm in diameter, are often concentrated near the bases and tops of flows. Petrographical descriptions of these tuffs are given in Howells *et al*. (1987). Reworking of the tops of the tuff beds is common near the base of the sequence as indicated by the presence of cross-lamination and shelly debris, including disarticulated brachiopods and crinoid fragments (e.g. at 6219 4524). The tuffs grade into block-and-ash tuffs and pyroclastic breccia deposits, dominated by pumice fragments up to 35 cm in diameter and blocks of acid tuff and rhyolite up to 1.5 m. Minor clast compositions include siltstone, sandstone, basalt and dolerite. A weak eutaxitic foliation is present and is commonly moulded around the blocks.

Midway up the slope to the summit and near the axis of the synform, a dyke-like apophysis of rhyolitic breccia cross-cuts the tuffs. This apophysis, up to 10 m wide, comprises blocks of flow-banded and flow-folded rhyolite up to 2 m in diameter set in a matrix of lapilli-tuff.

Immediately south of the main summit crags, the largest of the two rhyolite domes on Yr Arddu cuts through the tuffs. The contact zone is marked by the spectacular development of siliceous nodules locally up to the size of footballs (Figure 6.43). Typically the rhyolites are sparsely porphyritic, and flow-banded. The second and smaller dome is centred about Cerig y Myllt where it is cut by a dolerite sill.

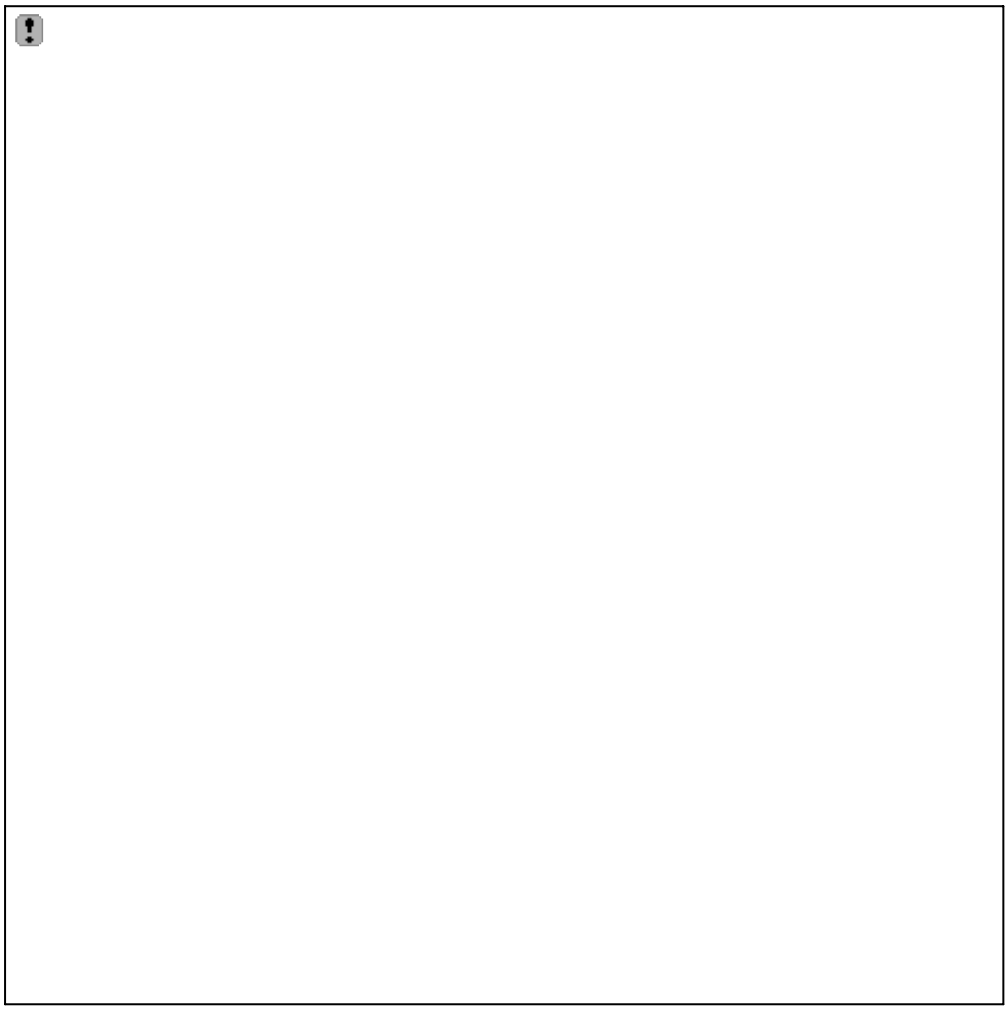

Figure 6.43: Siliceous nodules at the top of an acid ash-flow tuff, Lower Rhyolitic Tuff Formation, Yr Arddu. (Photo: BGS no. A14435.)

Interpretation

By Caradoc times Snowdonia had undergone regional subsidence and was the site of a major NE-trending incipient rift or graben structure that became the focus for the 2nd Eruptive Cycle of magmatism in North Wales. The bedforms and faunal assemblages of the background sediment within the graben reflect the development of a moderate- to high-energy subtidal shallow-marine environment and indicate local uplift and temporary emergence prior to the onset of volcanic activity.

Within this incipient graben structure, and close to the eastern margin of the future Lower Rhyolitic Tuff Formation caldera, the Yr Arddu Tuffs represent a significant local accumulation of primary welded ash-flow deposits with lesser volumes of block- and ash-flow tuff and pyroclastic breccia deposits (Howells *et al.*, 1987). In contrast to the more internally uniform outflow facies of the Lower Rhyolitic Tuff Formation their heterogeneity suggests proximity to an eruptive source, and a linear NE-trending fissure is thought to underlie the site. The general absence of grading, the concentration of blocks near the bases of individual flows, the limited evidence for reworking and erosion, and the lack of interbedded sediments all suggest that volcanic activity from this vent was largely uninterrupted and dominated by suppressed eruptive columns. Geochemical correlations with the rhyolite domes suggest that they were probably emplaced into the fissure during the waning stages of activity.

The inward-dipping (centroclinal) configuration and the locally large discordance at the base of the tuff pile have been interpreted by Howells *et al.* (1987) as volcanotectonic features subsequently modified by tectonism. The outflow facies from this fissure-controlled centre

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crops out as a series of welded ash-flow tuffs on Moel y Dyniewyd immediately to the NW of Yr Arddu.

Conclusions

The Yr Arddu GCR site provides a magnificent section through a minor fissure-controlled eruptive centre formed in a shallow-marine environment. Significant volumes of tuff and breccia accumulated close to their source, within an elongate depression and were later intruded by rhyolite domes representing resurgent activity along an underlying fissure. This fissure line represents an important early axis of magmatic activity parallel to the trend of the main graben structure and later fissures within the developing Lower Rhyolitic Tuff Formation caldera.

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