Sarnau

[SH 779 587]–[SH 776 600]

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Introduction

The Sarnau GCR site provides key exposures of the eruptive products from the most north-easterly and youngest of the three major eruptive centres that were active during the 2nd Eruptive Cycle in Caradoc times in Snowdonia. In contrast to the two other centres at Snowdon and Llwyd Mawr, the Crafnant Centre is completely buried by younger strata and its eruptive history and palaeoenvironment can only be inferred from its outflow products. The exposed strata at the Sarnau site include the Middle and Upper Crafnant volcanic formations which represent acid ash-flow tuffs derived from this centre, and their emplacement into dark marine mudstones and siltstones suggests a deep water submarine eruption.

Originally mapped by the Geological Survey in 1848, the area was included in a regional study by Davies (1936) but was not studied in detail until the resurvey on the 1:10 560 scale by the Geological Survey in 1968–70. The site area is covered by the geological sheets SH75 (Capel Curig and Betws-y-Coed), 1:25 000 scale (1976), and 109 (Bangor), 1:50 000 scale (1985). The strata, of Longvillian age, are described in Howells *et al.* (1978, 1991) and comprise ash-flow tuffs and reworked tuffs of rhyolitic to rhyodacitic composition. They are probably contemporaneous with the Bedded Pyroclastic and Upper Rhyolitic Tuff formations in central northern Snowdonia and form part of the Snowdon Volcanic Group.

Description

The Sarnau site (Figure 6.54) lies in the wooded uplands NNW of Betws-y-Coed, between Llyn Sarnau and Mynydd Bwlch-yr-haiarn. Moderately dipping to the north and east, the strata lie on the SE limb of an anticline, one of a series of NE-trending open fold structures in the area. A complex array of steeply dipping brittle faults form prominent topographical features in the area and are the focus of lead and zinc mineralization (Howells *et al.,* 1978).

The Middle Crafnant Volcanic Formation, which elsewhere reaches a total thickness of 90 m, forms the lowest stratigraphical unit in the area. At Sarnau the formation is characterized by an ordered sequence of thin, primary acid ash-flow tuffs, interlayered with flaggy, evenly bedded, remobilized tuffs, tuffaceous to volcaniclastic sedimentary rocks, and black pyritic mudstones and siltstones. These form a series of well-developed scarp and dip features (e.g. at [SH 7730 5880]). The interlayered sedimentary rocks comprise mainly dark-grey structureless mudstones and siltstones with infrequent ribs of turbiditic sandstone. The mudstones and siltstones contain varying proportions of iron oxide, sericite and chlorite, with scattered fragments of feldspar crystals, locally up to 0.5 mm in length. The thin sandstones are normally graded with scoured and loaded bases often marked by con centrations of pyrite. Flame structures, indicating subsequent deformation of the sequence while semi-lithified, include lobes of sandstone completely surrounded by flames of the underlying mudstone.

The various units range from primary tuffs through tuffaceous to volcaniclastic sedimentary rocks and display a wide range of grain size from ash to breccia. The thin flaggy turbiditic tuffs with recrystallized cuspate shards set in a fine-grained vitroclastic and micaceous matrix show fine cross-lamination and grading and may contain fragmentary fossiliferous debris including crinoid columns and graptolites (Howells *et al.,* 1978). The coarser tuff-breccias are well exposed in the forest track (at [SH 7705 5910]) where they form massive beds up to 1.3 m thick with blocks of angular to subrounded, indurated siltstone, mudstone (Figure 6.55) and tuffaceous and volcaniclastic sedimentary rocks, and are invariably associated with thin fine-grained siliceous air-fall tuffs. Some of the blocks show a faint internal planar lamination that parallels the irregular periphery of the block indicating that the blocks were probably unlithified at the time they were incorporated into the breccia.

The reworked tuffs, comprising varying admixtures of pyroclastic and sedimentary components, form distinctive striped parallel-bedded sequences of fine-grained blue-grey mudstones and paler siltstones. Gradations from fine-grained tuffaceous mudstone to mudstone and siltstone are common and locally the basal contacts may be deformed by loading. Other sedimentary features include convolute lamination, penecontemporaneous microfaulting, and flame structures (e.g. [SH 7745 5884]). Within the striped sequences coarser beds, with recognizable crystals and glass shards in thin section, form units up to 1.5 m thick and grade in places into tuffs. They consist of small rounded albite crystals, up to 1.2 mm, in a matrix of quartz, feldspar, chlorite and fragments of carbonaceous material.

The Upper Crafnant Volcanic Formation comprises a massive heterogeneous unsorted tuffaceous sedimentary unit up to 70 m thick. It is separated from the underlying formation in the Sarnau area by blue-black cleaved mudstones. The formation is well exposed in the northern part of the site in the region of Mynydd Bwlch-yr-haiarn but is poorly bedded and only forms subdued scarp features. The tuffaceous rocks are generally structureless, strongly cleaved due to the high proportion of mudstone, and consist of cuspate shards with fragmentary feldspar crystals and pumice admixed with fine aggregates of chlorite, sericite and carbonaceous material. The proportions of constituents are highly variable. A typical exposure is in a small quarry adjacent to the forestry track at [SH 7729 6019].

Interpretation

By its nature, a submarine eruptive centre will be more difficult to identify in the rock record due to subsequent burial and obscuring of contemporaneous tectonic features. Nevertheless, using regional variations in the lithological characteristics and the degree of internal disruption, Howells *et al.* (1978, 1991) interpreted the Middle and Upper Crafnant volcanic formations as representing outflow tuffs derived from a major caldera centre tentatively located to the north and east (the Crafnant Centre).

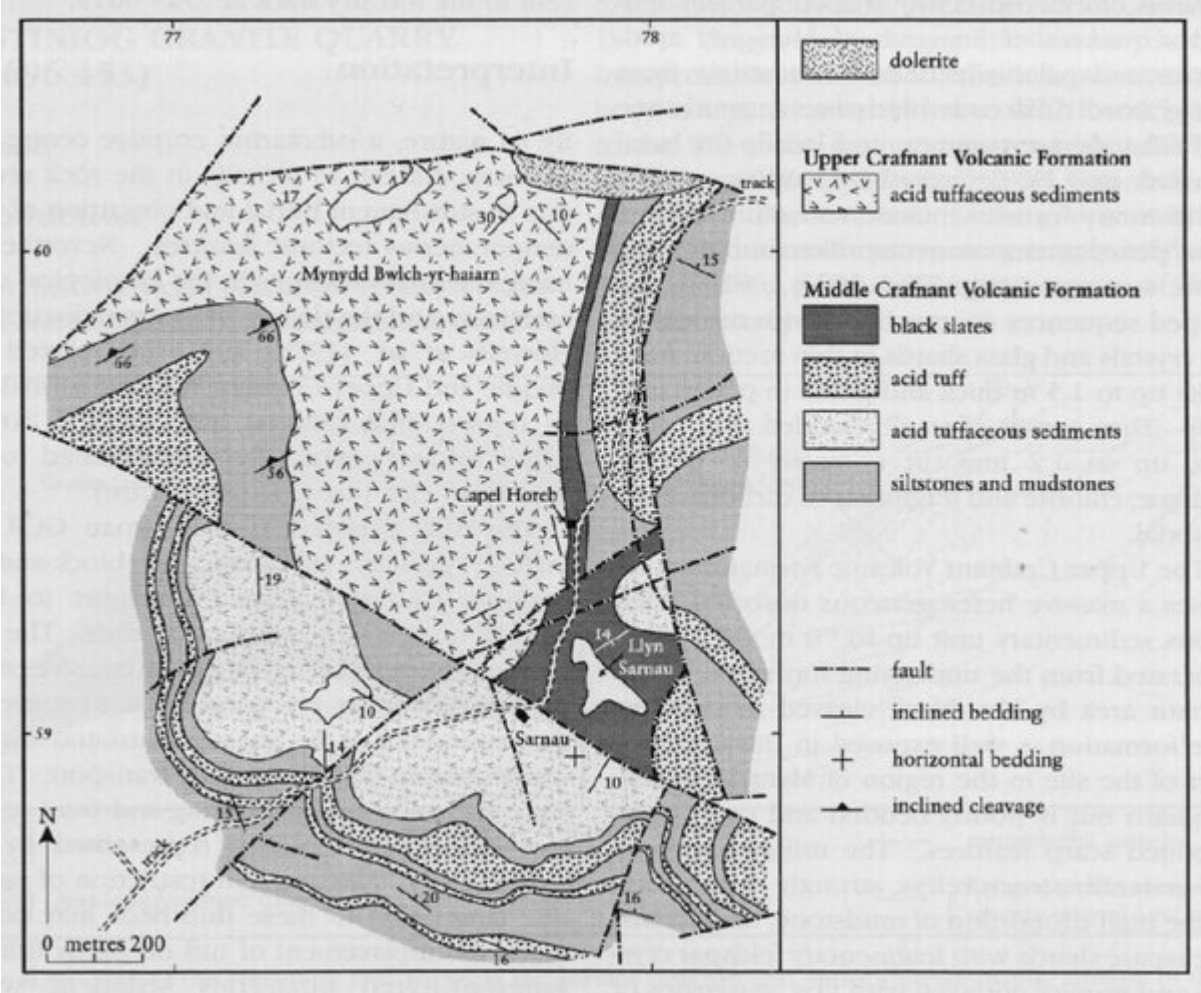
The tuffs exposed at the Sarnau GCR site include primary ash-flows and block-and-ash deposits disrupted during transport to form slurries of unstable pyroclastic debris. The thin siliceous beds associated with the massive coarse tuffs and breccias are considered to represent the settling out of the fine ash elutriated into the water column during ash-flow transport. These were also subject to reworking and were resedimented as tuff-turbidites represented by the striped beds. The frequent restriction of convolute lamination to these thin beds may be the result of emplacement of tuff on partly lithified water-saturated tuffaceous sediment which deformed thixotropically, possibly in response to seismic shocks (Howells *et al.,* 1978).

Within the Upper Crafnant volcaniclastic deposits, the general lack of sorting and internal bedding suggests that they were deposited from high-density turbid flows of pyroclastic debris that incorporated sedimentary material from a semi-lithified substrate during transport. As Howells *et al.* (1991) noted, however, such a process might not be expected to produce such a well-mixed sequence, and an alternative model of an underwater explosive eruption through unlithified mud could also be considered.

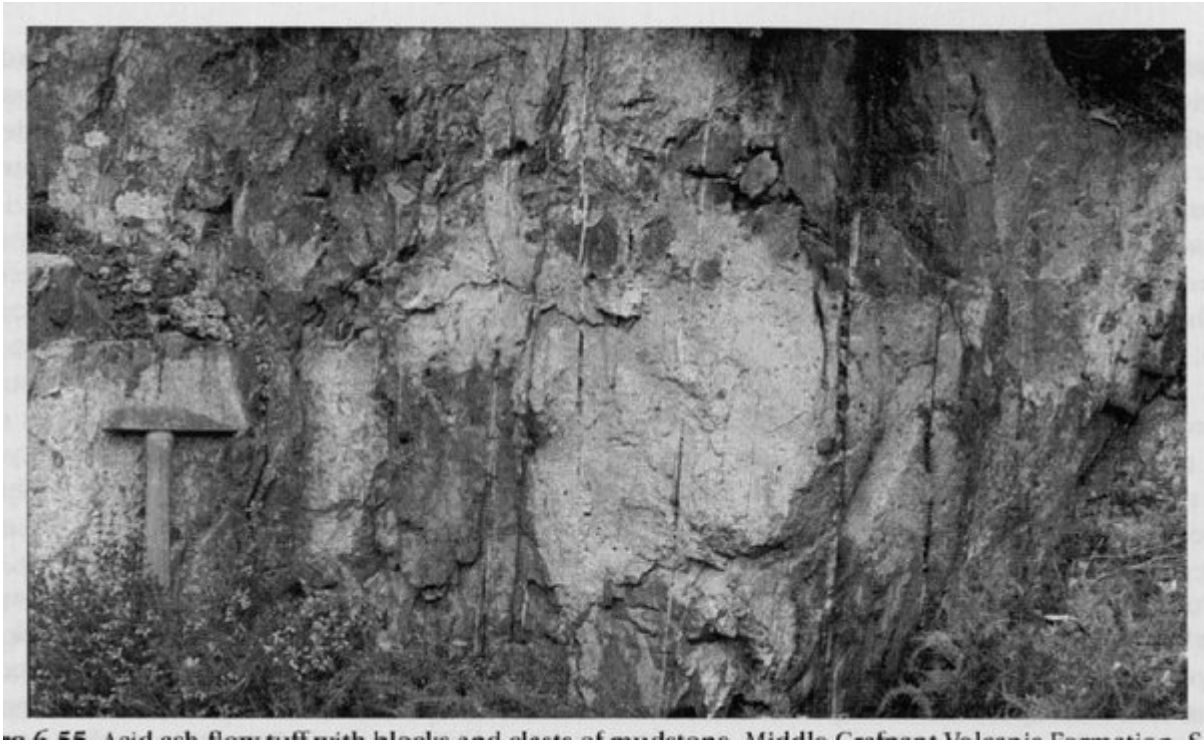
Conclusions

The GCR site at Sarnau represents a typical series of primary and reworked acid ash-flow tuffs emplaced within a deep water marine environment. It provides a well-exposed section through tuffs erupted from the Crafnant Centre, the most north-easterly of the three main Ordovician caldera centres which developed during the 2nd Eruptive Cycle in Snowdonia in Caradoc times.

References



(Figure 6.54) Map of the Sarnau GCR site area, after BGS 1:10 560 sheets SH75SE (1977) and SH76NE (1979).



(Figure 6.55) Acid ash-flow tuff with blocks and clasts of mudstone, Middle Crafnant Volcanic Formation, Sarnau [SH 7721 5891]. (Photo: BGS no. L2905).