ABER MAWR TO PORTH LLEUOG

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Introduction

The volcanic and intrusive rocks of Ramsey Island form part of a belt of bimodal basic–acidic Ordovician igneous rocks in north Pembrokeshire, interpreted as having been emplaced in a marginal basin related to closure of the Iapetus Ocean. The site is of importance in providing important exposures of silicic volcanic and related rocks in the southern part of the Welsh Basin, and in a wider context it provides critical insight into the nature of submarine explosive eruptions and the emplacement of welded ash-flow and ash-fall tuffs.

Ramsey Island is composed of a sequence of rocks ranging from mid-Cambrian through to Ordovician (Llanvirn) in age, in part sedimentary but mainly igneous. The igneous rocks are entirely Ordovician, and are chiefly silicic pyroclastic and volcaniclastic rocks, associated with relatively minor silicic extrusive and intrusive equivalents. The rugged coastline provides excellent exposures and presents detailed sections through the succession.

Early studies of the geology of Ramsey Island concentrated on establishing the age and stratigraphical relationships of the various lithological units. Those by Pringle (1914, 1915, 1930) are particularly important in providing the first detailed account and geological map of the island. Later investigations by Bevins and Roach (1979a), Kokelaar (1982), and Kokelaar *et al*. (1985) presented an interpretation of the various pyroclastic and volcaniclastic rocks. In particular, the studies of Kokelaar *et al*. (1985) have provided an insight into the processes related to the submarine eruption of silicic magmas and their subsequent reworking.

A major N–S fault divides Ramsey Island into two, with contrasting stratigraphies and geological evolutions. The GCR site covers the area to the west of the Ramsey Fault.

Description

The succession to the west of the Ramsey Fault is dominated by silicic pyroclastic rocks of Llanvirn age, comprising the Carn Llundain Formation (Figure 6.14). The lowermost rocks, buff-coloured sandstones, are thought to be of mid-Cambrian age. A spectacular 35 m-thick, poorly bedded conglomerate, the Ogof Colomenod Conglomerate Member, overlies these sandstones with marked unconformity and represents the lowermost member of the Carn Llundain Formation. The conglomerate is poorly sorted, with rounded cobbles and pebbles of rhyolite, set in a finer matrix of rhyolite and rhyolitic sandstone.

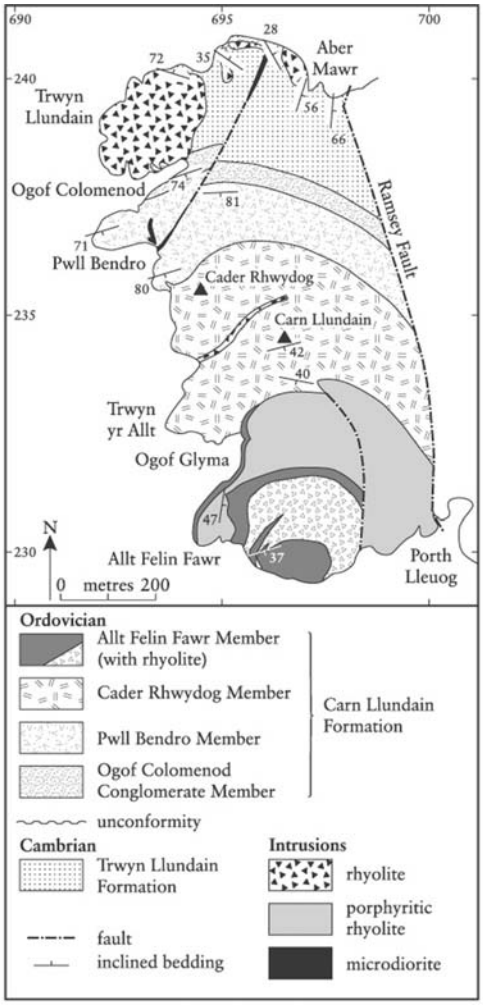

Figure 6.14: Map of the Aber Mawr to Porth Lleuog GCR site, Ramsey Island (after Kokelaar et al., 1985).

The Pwll Bendro Member, comprising 165 m of silicic lapilli-tuffs and fine-grained typically massive tuffs, overlies and grades up from the underlying conglomerates. These tuffs are poorly sorted and poorly bedded, with individual tuff beds ranging from a few centimetres to 20 m in thickness, although typically they are in the range 1–2 m. They chiefly comprise lapilli of rhyolite, tube pumices, plagioclase and quartz crystals, and glass shard fragments. The tuffs are non-welded. A sequence of three ash-flow tuffs, the Cader Rhwydog Tuff (CRT), the Trwyn yr Allt Tuff (TAT) and the Ogof Glyma Tuff (OGT), comprise the overlying Cader Rhwydog Member, totalling some 223 m in thickness. The lowermost tuff, which is 186 m thick, dominates the succession, the other tuffs being 22 and 15 m thick respectively. The CRT is excellently exposed about Carn Llundain. The base is slightly unconformable in relation to the underlying tuffs and shows slight down cutting. A deeply incised ‘palaeo' gulley is also seen. Near the base the CRT includes rounded pebbles and granules of rhyolite, angular clasts of rhyolite, and mudstone clasts. The main part of the CRT, however, contains ragged, commonly elongate, tube pumices (Figure 6.15), up to 32 cm, along with rhyolite fragments, and whole and broken quartz and plagioclase crystals. The pumice fragments are commonly flattened and in places are moulded around rhyolite clasts. Flattened porphyritic rhyolite fiamme are also present. Poorly developed columnar jointing is seen extending upwards from the base for around 100 m. The uppermost 25 m or so of the CRT shows a marked fining, passing eventually into very fine-grained vitric tuffs. The TAT succeeds the CRT conformably, and comprises massive rhyolitic lapilli-tuffs with pumice clasts and quartz and plagioclase crystals. At the top these pass into thinly laminated turbiditic tuffs showing evidence of wet-sediment disturbance (Figure 6.16). The overlying OGT is similar to the TAT, but it also contains streaky, flattened pumices.

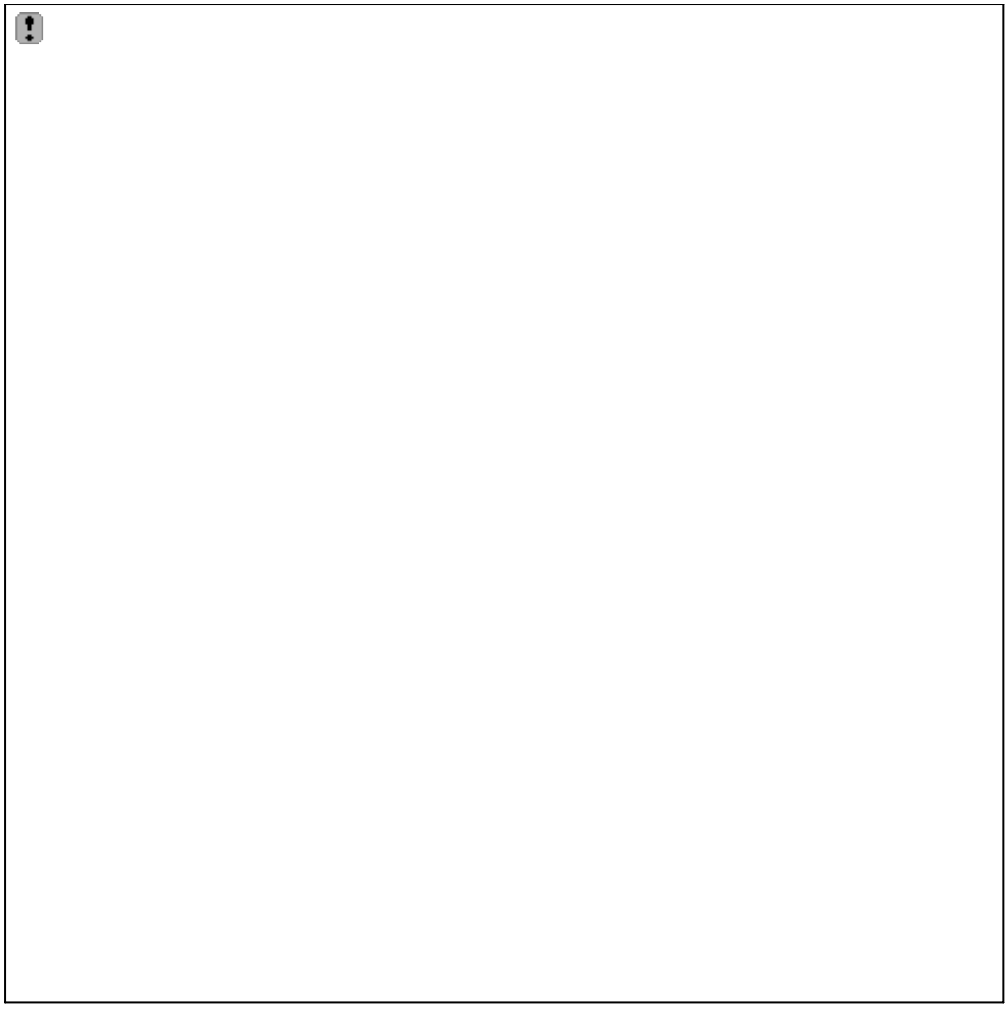

Figure 6.15: Ragged, elongate pumice fragments up to 12 cm in length in the Cader Rhwydog Tuff, Cader Rhwydog, Ramsey Island. (Photo: R.E. Bevins.)

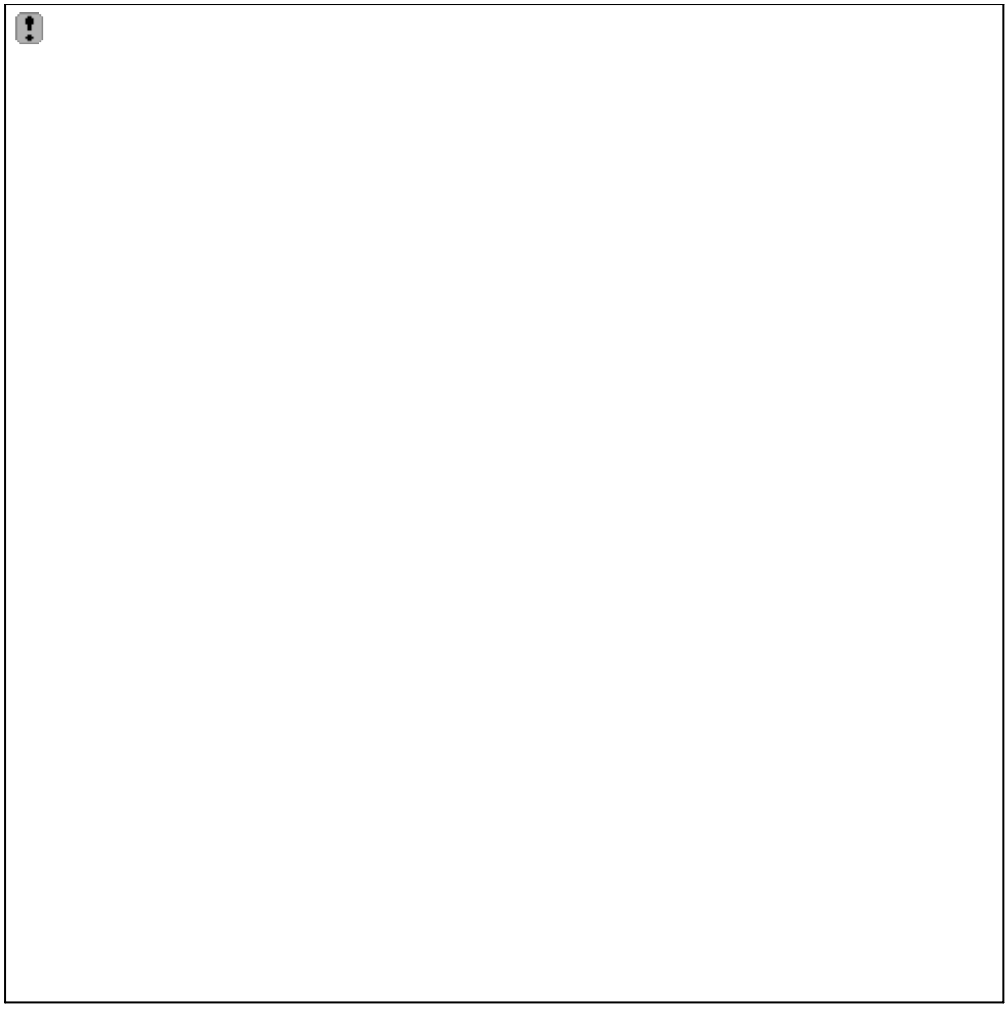

Figure 6.16: Wet sediment disturbance in thinly laminated turbiditic tuffs at the top of the Trwyn yr Allt Tuff, Cader Rhwydog Member, Carn Llundain, Ramsey Island. (Photo: R.E. Bevins.)

The Cader Rhwydog Member is succeeded conformably by several metres of thinly bedded and laminated tuffs of the Allt Felin Fawr Member, although the succession is complicated by a slightly discordant, cross-cutting porphyritic rhyolite intrusion, which shows irregular bulbous and peperitic margins. A maximum of 25 m is exposed beneath the sill with a further 8 m above the sill. The tuffs are silicic, containing rhyolite and pumice lithic clasts and quartz and plagioclase in a fine-grained siliceous matrix. The tuffs are well bedded, fine upwards and show loading structures at the base of individual beds. In the finer-grained tuffs, ripple drift cross-lamination, soft-sediment disruption and convolute lamination are all seen. This sequence is partly repeated by sliding. A large channel structure, up to 20 m wide and 6 m deep, is seen on a small headland to the SE of Allt Felin Fawr. Above this lies a poorly sorted heterolithic deposit, 3 m thick, which contains clasts of pumice, porphyritic rhyolite, rhyolite, fine-grained silicic tuff, and crystals set in a fine-grained silicic matrix. This unit is followed by a thin (0.5 m) conglomerate bed, poorly sorted heterolithic deposits (1.5 m), and then 2 m of laminated and thinly bedded silicic tuffs.

Overlying these various units is an autobrecciated rhyolite exposed to the east and south of Allt Felin Fawr. In the east the lava reaches up to 35 m in thickness, but to the SW the flow becomes compound, as two tuffaceous wedges come in. In the lowermost tuffaceous wedge a thin sequence of turbiditic tuffs occurs, which is overlain by an ash-flow tuff containing rhyolite and pumice lapilli in a vitric matrix with quartz and plagioclase crystals. The top grades sharply into fine tuffs. Towards the SW a flattening fabric is seen and the tuff contains randomly orientated slabs (1 m thick and 10 m in length) of laminated pumice- and crystal-bearing tuffs, in addition to an individual block (2.1 m in diameter) of porphyritic rhyolite with peperitic and lobate margins. A 0.5 m-thick, chaotic unit, containing rhyolite clasts and crystals in a mudstone matrix, lies between the ash-flow tuff below and a further ash-flow tuff above.

Similar to the lower ash-flow tuff, this upper unit contains further contorted slabs of laminated fine tuffs. In places this ash-flow disrupts the thin chaotic unit below, with flames of muddy material penetrating up to 2 m into the ash-flow tuff. To the SW the ash-flow tuff is completely broken up into sac-like masses separated by thin veneers of the chaotic muddy deposit.

The upper wedge in the rhyolite lava flow comprises 20 m of medium- to fine-grained silicic tuffs, which wedge out against the rhyolite. The coarser tuffs show erosive bases, normal grading of the lithic component, and loading structures. The uppermost unit of these tuffs comprises the youngest strata exposed of the Carn Llundain Formation.

Interpretation

The entire sequence of Ordovician volcanic rocks exposed on Ramsey Island is considered to have been erupted and emplaced in a submarine environment, and those of the GCR site are considered to be of proximal origin. Uplift prior to the onset of deposition of the Carn Llundain Formation is represented by the marked unconformable relationship at the base of that formation and is probably related to intrusion at a high level of significant volumes of silicic magma.

The lowest conglomerates of the Ogof Colomenod Member are thought to result from a series of sediment-gravity flows, generated perhaps by volcanotectonic instability and derived from a littoral or supralittoral environment, possibly linked to a rhyolitic volcanic island, but emplaced in deeper water.

Tuffs of the Pwll Bendro Member are considered to have been generated essentially from cold high-density turbidity currents, with the thinner-bedded units resulting from less dense turbidity currents. Eruption of the primary ashes must have been rapid because of the lack of any intercalated background sediments. However it is difficult to establish whether this was in a subaerial or a submarine environment, although Kokelaar *et al*. (1985) favoured a submarine eruptive column as the source. In comparison with tuffs higher in the sequence this source seems to have been at some distance from the site area. They are most probably derived from the slumping of debris immediately following accumulation on the flank of a submarine volcano.

The overlying tuffs of the CRT show crucial evidence for heat retention following emplacement, including the flattening of pumices and the moulding of pumices around lithic clasts. This tuff is interpreted as having been erupted from a major, single, entirely submarine eruption, emplaced as a hot ash-flow tuff with associated ash-fall. A totally subaqueous environment is supported by the presence of soft-sediment convolutions in the overlying fine tuffs. These tuffs are thought to be of proximal origin.

The TAT largely comprises turbiditic tuffs, again thought to be derived from the reworking of unconsolidated ash deposits derived from explosive, most probably submarine, rhyolitic volcanism. Tuffs of the OGT, however, show welded shardic fragments, implying the welding of hot juvenile fragments, suggestive of a very proximal environment.

The Allt Felin Fawr Member is characterized by deposits derived from turbidity currents, which are invaded by a rhyolitic intrusion showing evidence of emplacement into wet, poorly consolidated tuffs, associated with fluidization. This had a catastrophic effect on the overlying tuffs, which were slumped away, exposing the rhyolite at the sea bed, to suffer later reworking into younger debris-flow deposits. Slumping of the tuffs resulted in their repetition in the stratigraphical succession.

The rhyolite appears to have been an autobrecciated lava erupted on to the sea floor, with very shallow (*c*. 6°) slopes. The two wedges intercalated with the rhyolite in the west of the outcrop were derived from the slumping of primary rhyolitic ash-flow tuffs, the extrusive rhyolite providing a topographic restriction to the distribution of the reworked tuffs. The contained contorted slabs are thought to represent turbiditic and ash-fall deposits genetically associated with the ash-flow tuffs but incorporated later, following slumping and mass-gravity flow. The contained block of porphyritic lava from the immediately subjacent sill is considered to reflect the contemporaneous nature of the intrusive activity, the explosive silicic volcanism and the quiet effusion of rhyolitic lavas, all in a submarine environment.

Conclusions

The rugged coastline and crags of Ramsey Island provide magnificent exposures through rhyolitic volcanic rocks that were erupted and emplaced close to their source, entirely in a submarine environment. A variety of processes are demonstrated, including the eruption of rhyolitic lava on to the sea floor, and the emplacement and reworking of silicic ash-flow and ash-fall deposits.

These exposures provide one of the most crucial sites in the British Isles for the interpretation of submarine silicic volcanic processes, and indeed are of international importance in demonstrating the submarine emplacement and welding of a silicic ash-flow tuff and related ash-fall derived from a major submarine explosive eruption. This account is the first record of such welded ash-fall tuffs in the world.

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