B8 Pentire Point–Rumps Point

[SW 923 805]–(SW935 812)

Highlights

This classic British site for the study of pillow lavas, is one of the best exposed in Cornwall. The alkali-basalt lavas are only weakly metamorphosed and a massive metadolerite (greenstone) is also well exposed.

Introduction

This scenic section of the north Cornish coast includes the steep 80–100 m high cliffs around Pentire Point and also the rocky crags of the The Rumps Peninsula. The latter has a prehistoric cliff castle and is joined to Pentire Point proper by a neck of land showing the now subdued remains of an ancient earthwork.

During the late Devonian, the main expression of magmatism associated with basin development was the production of localized pillow-lava sequences. The north Cornish coast from Pentire Point westwards to Port Isaac shows many isolated examples of pillow lavas, although the best-exposed sequences are found along the Pentire cliff section. These rocks were some of the first lavas of submarine origin to be recognized in Britain (Whitley, 1849). The Pentire Point pillow lavas were described in detail by Reid and Dewey (1908) and Dewey and Flett (1911) and provided evidence for early ideas as to their mode of formation (Reid *et al.,* 1910; Dewey, 1914). To early workers like Dewey (1914), pillow lavas were individual spheroids, each representing a 'thick-walled bubble of lava' and, together with their highly vesicular nature, he suggested that each lava droplet welled up independently to form a buoyant, gas-filled, floating pillow. Another interesting feature of the initial work on the Pentire pillows was the notion that 'vapours' or 'juices' trapped within the lava reacted with the hot, partially crystallized rock to produce the alteration assemblages we recognize today as the effects of post-consolidation metamorphism (Vallance, 1965).

Description

The steep east–west orientated cliffs of Pentire Point and the rock platforms below, show the underside of the pillow lava sequence in longitudinal section. Here the lavas can be seen to be elongate tubes drapped over each other, with the pillow interspaces filled with chert or sometimes calcareous argillite.

On the other hand, cross-sections (seen on joint faces at right angles to the cliffs) are characteristically ovoid in shape with each pillow moulded over the ones below, providing evidence for 'way-up' and a southwards-younging direction. The total cliff section is composed of three main pillow-lava domes, separated by argillite that laps on to the sides of the domes as well as eventually enveloping them completely (Figure 4.23).

Stratigraphically, the pillow lavas are Frasnian in age and they form the basal part of a sequence of Upper Devonian slates that are slightly overturned and which young southwards, away from the coast. They comprise the Pentire Pillow Lava Group (Gauss and House, 1972), which is about 450 m thick and includes various pillow-lava horizons and subordinate tuffaceous sediments and agglomerates in the local area. The Upper Devonian here is allochthonous, the pillow lavas forming part of the Port Isaac Nappe (Selwood and Thomas, 1986a). They are chemically distinctive, relative to the west Cornish tholeiitic lavas of similar age in the Penwith Peninsula, in being alkali basalts with intraplate chemical features (Floyd, 1982a, 1983).

The pillows are generally 0.3–0.6 m in diameter, rarely over 1 m, and are highly vesicular. Some show a series of vesicular zones separated by massive lava and a central vacuole. The vesicles are now filled with chlorite at the margins and carbonate and/or silica in the interior which appears to have replaced earlier chlorite or smectite. Originally glassy margins are no longer seen, either having spalled off during extrusion or been completely replaced by secondary chlorite. Small, black, wispy fragments of laminated argillite may be seen within some pillows, and these represent partly

consolidated sediment entrapped during extrusion. Although relatively uncommon, pillow breccias (Figure 4.24) are present, situated near the margins of the lava domes. These demonstrate the partial fragmentation of the lavas along both radial and concentric cooling joints within the pillows (Figure 4.25). The breccias have suffered minimum downslope movement, as individual fragments can often be fitted together jigsaw fashion.

Although now metabasalts, the pillow lavas still display features that can be used to infer their primary characteristics. The lavas are plagioclase-phyric, with lath-shaped microphenocrysts and skeletal microliths, now converted to secondary albite. The microliths may be curved and sometimes show tuning-fork terminations indicative of rapid quenching. The matrix is largely composed of chlorite, carbonate and oxidized materials which probably replaced original glass. No primary mafic minerals remain. Stable-element chemical data demonstrate that the Pentire lavas form a single differentiated suite of basalts which were not comagmatic with the intrusive dolerite at The Rumps. One interesting chemical feature concerns the location of stable elements in the altered pillow basalts. A study by Williams and Floyd (1981) showed that elements like Ti, Zr and Nb are relocated on alteration into stable secondary phases like rutile and zirconolite. On the other hand, U migrated throughout the matrix, eventually concentrating around vesicle margins and sometimes, within the infilling calcite, giving it a cloudy appearance.

The pillow-lava sequence is underlain by the Middle Devonian Trevose Slate Formation which has been intruded by a massive greenstone sill at The Rumps. Separated from Pentire by a small fault, this body is typical of differentiated dolerite-gabbro intrusives often associated with lavas, although in this case there is no evidence for high-level emplacement or chemical association with the lava sequences. The body exhibits a sharp concordant junction with the sediments which are bleached and indurated, but not adinolized. One feature of interest shown by the greenstone is the effect of intense shearing that has granulated and foliated the body into highly oxidized chloritic schist zones.

Interpretation

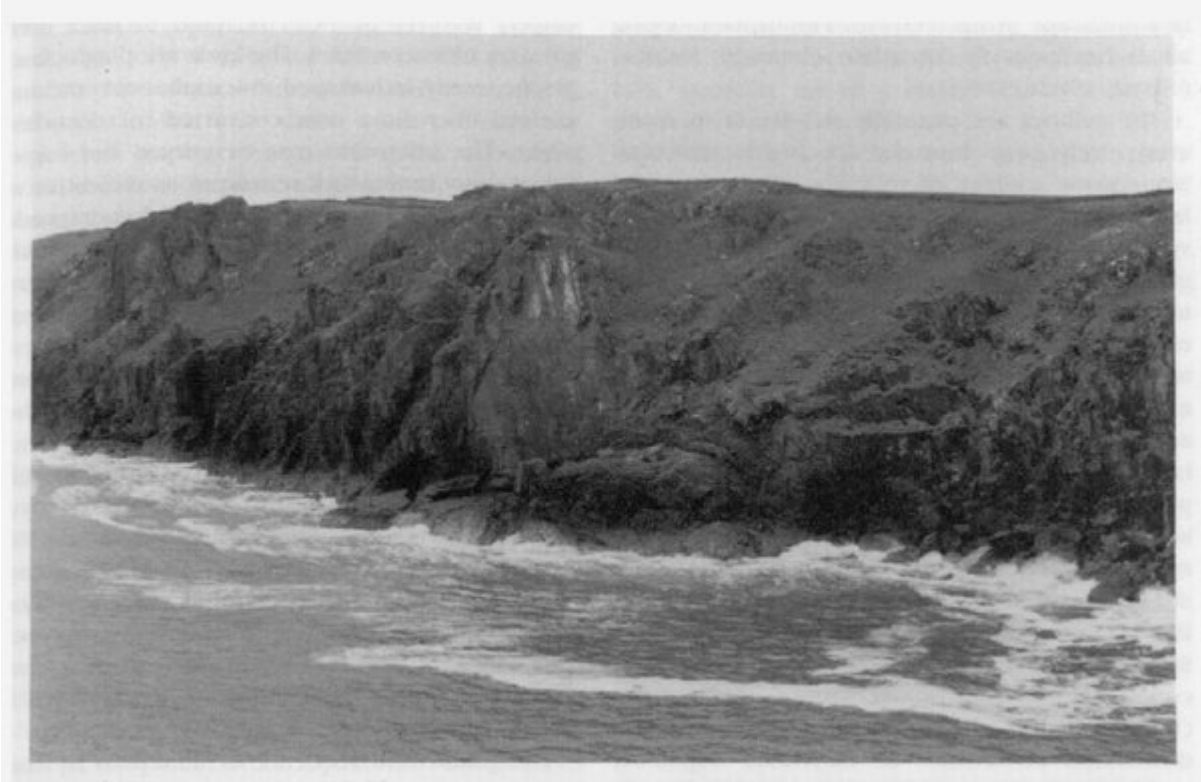
The interest of this site is that it not only represents one of the classic pillow-lava locations in Britain, but is typical of the major episode of extrusive late Devonian activity within the Vari-scan fold belt, such as that exhibited in the Harz Mountains and Lahn-Dill in Germany. It was here that some of the early ideas concerning pillow-lava development were formulated and enabled the correlation with similar, but more extensive, volcanism of similar age within the Rhenohercynian Zone of Germany to be made. In tectonic terms, the volcanic activity represents the onset of basinal development, with magma penetrating marginal fractures that mark the site of the change from platform to slope. They are also typical of Variscan spilites, characterized almost entirely by secondary assemblages, which were at one time considered to have been produced by late primary magmatic (deuteric) processes. We now recognize these lavas as low-grade metamorphosed basalts.

This site is significant in the magmatic history of Variscan south-west England, as the lavas are plagioclase-phyric alkali basalts with enriched incompatible-element patterns, forming a province quite distinct from temporally analogous pillow lavas in south Cornwall. They exhibit chemical features typical of intraplate volcanics that are also characteristic of many lavas within the Variscan fold belt of Northern Europe.

Conclusions

This is a key site for the study of Upper Devonian submarine lavas and has been studied since the middle of the nineteenth century, when it was realized that the peculiar pillow-shaped masses of lava, normally up to a metre across, were the product of eruption of basalt lava into sea-water. Rapid chilling by the sea-water produced glassy margins which often spalled off or completely fragmented the pillow into small angular blocks. Similar pillow lavas may be seen forming today where submarine volcanism occurs, producing rounded or sausage-shaped extrusions on the seabed, venting bubbles of gas. At Pentire Head, the lavas and subordinate fragmented volcanic rocks make up a 450-m-thick pile locally. The lavas were originally basalts, although they have been altered subsequently under conditions of low-grade metamorphism during the Variscan Orogeny. Pillow lavas are characteristic of a major phase of volcanic activity in the Devonian and Carboniferous seas of Variscan Europe; this is one of the classic sites where they were first studied and attempts made to explain their form, chemistry and origins.

References



(Figure 4.23) View of Pentire Point cliffs showing Upper Devonian pillow-lava mounds. (Photo: P.A. Floyd.)

(Figure 4.24) Pillow-lava breccia formed by fragmentation on cooling soon after submarine extrusion. Pentire Point, Cornwall. (Photo: P.A. Floyd.)

(Figure 4.25) In situ autobrecciation of a lava pillow. Pentire Point, Cornwall. (Photo: P.A. Floyd.)