D1 Kingsand Beach

[SX 435 506]

Highlights

This locality provides the only exposure of *in situ* rhyolite of the post-Variscan volcanics.

Introduction

This site occupies the rocky platforms of a 800 m stretch of foreshore from Kingsand Beach to Sandway Point in Cawsand Bay.

Post-orogenic volcanism included both mafic dykes and flows, as well as extensive rhyolite lava flows. Apart from this site, very few actual exposures of the latter remain, although relicts of what was probably a widespread suprabatholithic rhyolite lava field, are now found as numerous altered pebbles within the local New Red Sandstone succession (Laming, 1966). An additional example of this volcanic event is the small, circular plug of flow-banded rhyolite at nearby Withnoe.

Cosgrove and Elliott (1976) showed that the Kingsand rhyolite still retained many features indicative of high-temperature rapid quenching, and that they were chemically comparable with the pebbles of rhyolite in the New Red Sandstone. Geochemical comparisons using immobile elements indicated that the rhyolites were not the volcanic equivalents of the Cornubian main granites, but were probably comagmatic with the later granite-porphyry dykes which could have acted as feeders to the lava field (Floyd, 1983). Unpublished chemical data (Floyd) show the rhyolites to be typically calc-alkaline, with chondrite-normalized negative Nb and Ta anomalies, and highly enriched in large-ion-lithophile elements. It is generally assumed that the rhyolite magma was derived by the partial melting of lower continental crust rather than of local sediments (Floyd *et al.,* 1983).

Description

An unconformable relationship between the rhyolite and the nearby Devonian is inferred at the southern end of Kingsand Beach. Separated from the Devonian sediments by a small pebble beach, the tabular rhyolite outcrop apparently overlies the deformed and near-vertical green and purple phyllites. The sediments become bleached and heavily veined with hematite near the inferred junction, possibly due to subaerial oxidative reddening of the eroded surface and the subsequent contact effects of the hot lava flow. The only other contact with sediments is near Sandway Cellar, at the north-eastern end of the outcrop, where a basal Permian conglomerate is developed. Again an actual contact is not exposed, although flow banding at the margin of the rhyolite body and in the seaweed-covered reefs dips away from the conglomerate. Back-projection of the rhyolite banding suggests that it could lie on top of the conglomerate, but equally the conglomerate could be banked against the rhyolite margin. The conglomerate was deposited rapidly as a debris flow containing many large rounded/subrounded pebbles and boulders (up to *c.* 1 m in diameter) of quartzite and flow-banded rhyolite. About 4 m is exposed before being succeeded by a uniform, red sandstone.

The general uniformity and tabular shape of the rhyolite along the beach, together with the lack of an extensive autobrecciated carapace, suggests that it is a lava flow, rather than a dome. Also, the lack of internal brecciated horizons indicates that the lateral extent of the outcrop probably represents a single flow. Most of the flow appears massive, with flow banding (Figure 6.4), when present, restricted to narrow, relatively uniform zones and, rarely, highly contorted on the small scale. All of the lava is pervasively reddened due to subaerial oxidation after eruption, although there are small green reduction spots (centred on spherulites) and linear zones adjacent to east–west-trending veins and fractures.

The lava contains many microscopic features indicative of rapid chilling, with a devitrified quartz–feldspar groundmass containing vestiges of glass, spherulites and high-temperature phases (Cosgrove and Elliott, 1976). The rhyolite is composed of interbedded phyric and aphyric flow units, with the former exhibiting variable proportions of quartz, feldspar (sanidine and orthoclase) and dark-red biotite phenocrysts (Figure 6.5). Chemical data on the Kingsand body (Cosgrove and Elliott, 1976; Floyd, unpublished) show it to be a typical calc-alkaline rhyolite, with high contents of large-ion-lithophile elements and chondrite-normalized negative Nb–Ta anomalies.

Interpretation

The importance of the site lies in the fact that it is the only sizeable *in situ* exposure of a supposed Permian rhyolite flow in south-west England. It also has wider regional implications, in that the rhyolites are considered to represent extensive acid volcanism genetically related to the Cornubian granite batholith. The evidence for late Carboniferous–early Permian acid volcanicity, that perhaps formed a volcanic superstructure to the high-level granite plutons, is now seen in rhyolite pebbles and feldspar crystals of extrusive origin in the New Red Sandstone. The Kingsand rhyolite is thus a solitary remnant of a once-extensive, suprabatholithic, volcanic lava field. However, comparisons based on limited chemical data suggest the rhyolites are more likely to be genetically related to the later granite-porphyry dykes than to the main granites of the batholith. The dykes could have acted as feeders to the rhyolite lavas above. Also, isotopic age dating of the granite porphyries overlaps the basal Permian at 280–270 Ma. However, the only age data on the rhyolites, quoted (Hawkes, 1981) for a pebble in a mass-flow conglomerate, adjacent to the Kingsand rhyolite, gives a Stephanian age of 295 Ma.

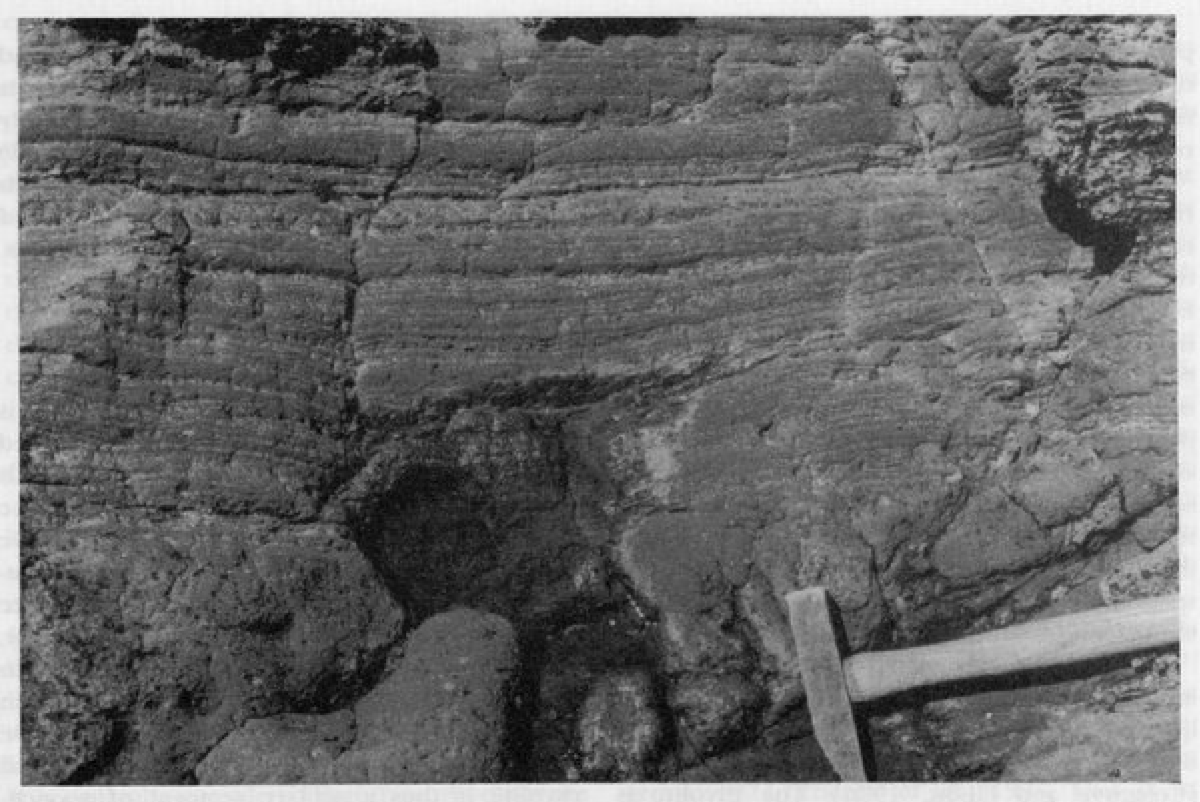
Other points of interest about the flow include its microscopic features and chemical characteristics. Although highly oxidized and reddened, the rhyolite flow still preserves primary features that indicate rapid quenching, together with the presence of high-temperature feldspar, and quartz and biotite phenocrysts. The rhyolite has a typical calc-alkaline composition, chondrite-normalized negative Nb–Ta anomalies and Zr/Nb ratios >10. It is chemically distinct from pre-orogenic Lower Devonian rhyolites in having higher large-ion-lithophile/high-field-strength element ratios which probably reflect derivation from a different crustal source by partial melting. When chemical plots that discriminate the nature of the eruptive environment of acidic rocks are employed (for example, Pearce *et al.,* 1984), the rhyolites apparently have a composition typical of the syncollisional tectonic environment. This chemical discrimination appears to be anomalous, as the rhyolites are clearly post-orogenic and probably later than the main granite emplacement events. The misinterpretation is an artefact of the chemical database used to construct the original tectonic discrimination plot; this assumed that the south-west England granites were typical of the syncollisional environment rather than post-collisional (Pearce *et al.,* 1984).

Conclusions

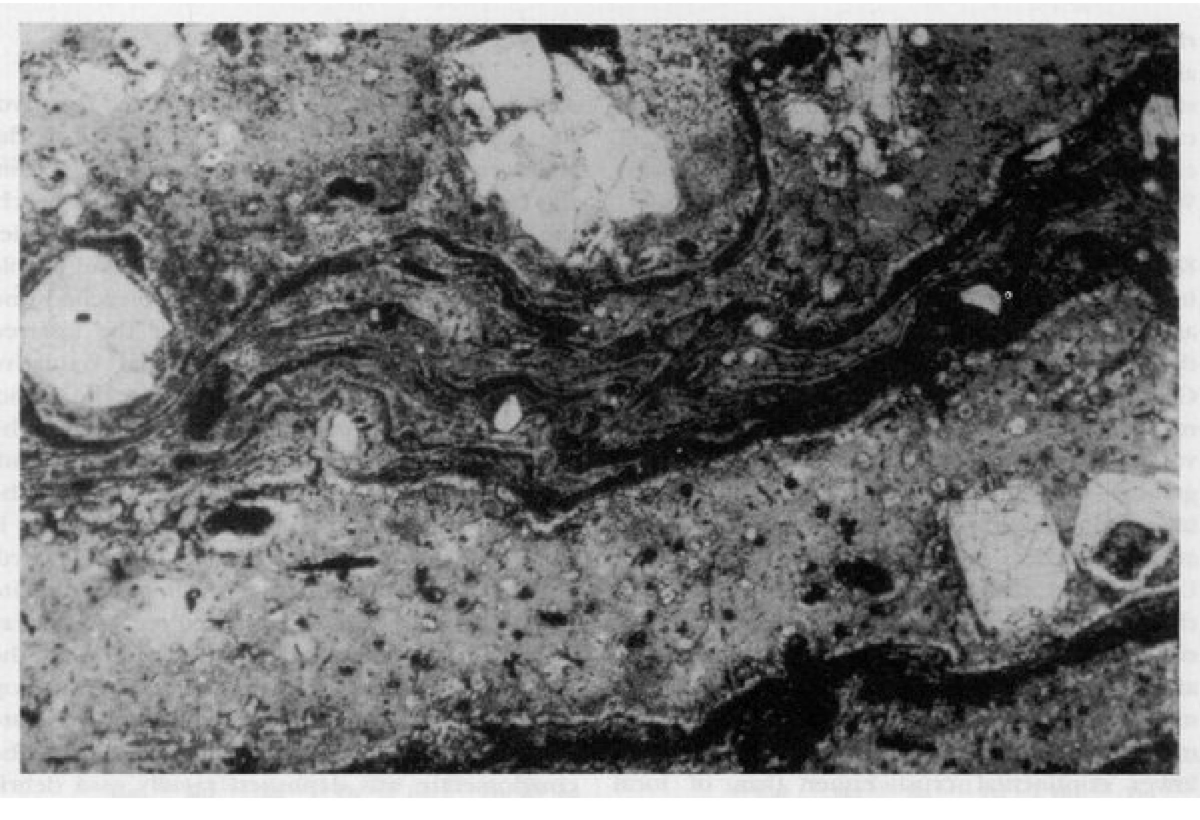
This site is unique in showing an isolated remnant of a rhyolite lava flow that was probably extruded around 295 million years ago. Apart from chemical differences these rhyolites are distinct from the Lower Devonian submarine lavas of similar composition, in being extruded after the main phase of Variscan mountain building had terminated in the late Carboniferous. It is generally considered that these rhyolites are representative of a large volcanic field situated on top of the granite batholith of south-west England.

They were probably fed by late-stage granitic dykes that cut through the main granite and surrounding country rocks. They were once much more extensive, having been eroded away, such that evidence for their existence is largely in the form of pebbles in later sedimentary deposits, particularly the red sandstones and pebble beds of the Permian Period (also seen at Kingsand). Thus Kingsand yields important evidence for the latest phase of volcanic activity at the end of the Carboniferous to earliest Permian times that followed the deformation of the Variscide mountain-building phase.

References



(Figure 6.4) Flow-banded rhyolite lava of Permian age that may have formed part of the volcanic field developed above the Cornubian granite batholith. Kingsand, Devon. (Photo: P.A. Floyd.)



(Figure 6.5) Silica phenocrysts in the flow-banded, partly devitrified matrix of the Permian rhyolite lava. Kingsand, Devon. (Photo: P.A. Floyd.)