Chapter 6 Post-orogenic volcanics (Group D sites)

The five sites descibed in this chapter include examples of the small-volume extrusives and intrusives that developed after the emplacement of the main granite plutons of the Cornubian batholith. Their locations are shown in (Figure 6.1). Volcanism occurred during the prevalence of the 'red-bed' environment of the late Carboniferous and the early Permian Periods; it includes the mixed volcanics of the Exeter Volcanic 'Series', as well as suprabatholithic rhyolite lavas which were fed by late granite porphyry dykes. The volcanics of this period are often referred to as being Permian in age, although recalculated isotopic age dates suggest that they could also represent late Carboniferous activity. These volcanics represent the last remnant of magmatic activity that developed largely after continent–continent collision in a post-orogenic, tectonic setting.

List of sites

Rhyolitic suite:

D1 Kingsand Beach [SX 435 506]

Basaltic suite:

D2 Webberton Cross Quarry [SX 875 871]

D3 Posbury Clump Quarry [SX 815 978]

Potassic suite – lamprophyres:

D4 Hannaborough Quarry [SS 529 029]

D5 Killerton Park [SS 971 005]

Lithological and chemical variation

Although three series of post-orogenic volcanics are generally recognized (see Chapter 2), in compositional terms they can be grouped as follows:

1. basaltic suite (in Exeter Volcanic 'Series');
2. potassic suite (dominated by minette-type lamprophyres in the Exeter Volcanic 'Series' and regionally throughout south-west England);
3. rhyolitic suite (including pebbles of acidic volcanics in 'red bed' sequences).

The petrogenesis of these small-volume volcanics and high-level intrusives has often been linked to the Cornubian granites and cross-cutting granite-porphyry dykes. Rhyolites have been interpreted as the volcanic expression of the plutonic granites (Goode, 1973; Cosgrove and Elliott, 1976), whereas the highly potassic nature of some basic lavas was considered to reflect contamination by granitic material or fluids (Tidmarsh, 1932; Knill, 1969). Although this latter feature is no longer considered significant for the production of potassic magmas, Leat *et al.* (1987) have suggested that the granites could have been derived by fractionation of a mantle-derived potassic magma that contaminated melts mainly produced by crustal anatexis.

Basaltic suite

This comprises a comagmatic, mildly alkaline series of olivine–plagioclase-phyric basalts and ophitic olivine dolerites invariably altered by post-eruptive weathering (Knill, 1969). They are characterized chemically by high incompatible-element contents (especially the LIL group), moderate light REE enrichment (La_n/Yb_n = 6–10) and relatively evolved mafic compositions, with Ni varying between 100–200 ppm (Cosgrove, 1972; Thorpe *et al.,* 1986; Thorpe, 1987; Leat *et al.,* 1987). As seen in (Figure 6.2) chondrite-normalized multi-element diagrams show progressive enrichment patterns with increasing element incompatibility (Thorpe *et al.,* 1986; Grimmer and Floyd, 1986; Leat *et al.,* 1987), together with large negative Sr anomalies (that reflect plagioclase fractionation) and minor, but variable, Nb–Ta anomalies, that Grimmer and Floyd (1986) interpreted as possible sediment or crustal contamination. Overall the basalts have a chemical composition indicative of a within-plate, continental, eruptive setting.

Potassic suite

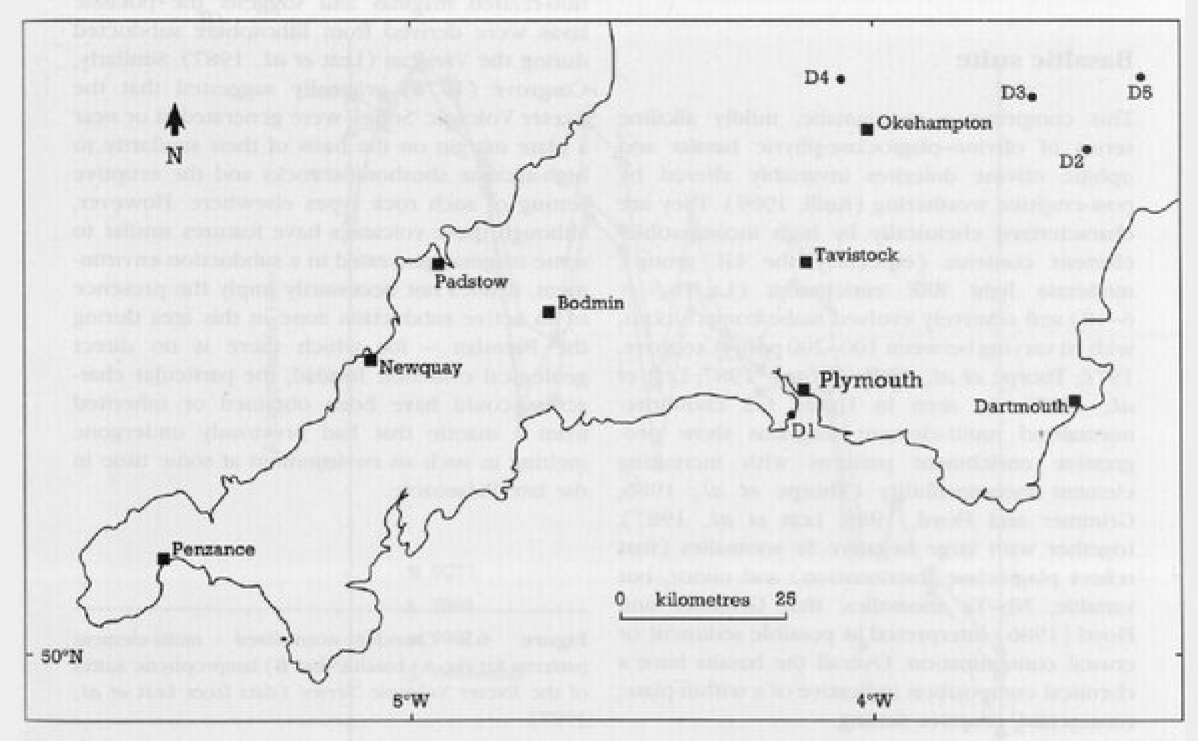
This suite comprises all the lamprophyres (minet-tes) and minor trachybasalts, mafic syenites and leucitites (Knill, 1969, 1982), all of which feature abundant K-feldspar. The minettes are characterized by aligned phenocrysts of dark-rimmed phlogopitic biotite, rarer diopsidic augite, olivine and small idiomorphic apatites set in an often highly altered and reddened biotite–alkali–feldspar–Fe ore matrix (Knill, 1969; Exley *et al.,* 1982). Plagioclase may occasionally be common, but is very variable in its distribution; brown amphiboles are also recorded (Hall, 1982). Some of the lamprophyres may be vesicular, with infillings of alkali feldspar, quartz, calcite, chlorite and clays (Exley *et al.,* 1982). Sedimentary and granitic inclusions, together with a variety of xenocrysts, are relatively common (Smith, 1929).

By far the most interesting chemical feature of the potassic lavas and intrusives (Figure 6.2) are the strong enrichments in light REE and LIL elements, marked depletions of Nb, Ta and Ti (Cosgrove, 1972; Thorpe, 1987; Leat *et al.,* 1987) and high $^{87}Sr/^{86}Sr$ (Thorpe *et al.,* 1986). This chemical fingerprint is characteristic of subduc-tion-related magmas and suggests the potassic lavas were derived from lithosphere subducted during the Variscan (Leat *et al.,* 1987). Similarly, Cosgrove (1972) originally suggested that the Exeter Volcanic 'Series' were generated at or near a plate margin on the basis of their similarity to high-alkaline shoshonitic rocks and the eruptive setting of such rock types elsewhere. However, although these volcanics have features similar to some magmas generated in a subduction environment, it does not necessarily imply the presence of an active subduction zone in this area during the Permian – for which there is no direct geological evidence. Instead, the particular characters could have been obtained or inherited from a mantle that had previously undergone melting in such an environment at some time in the late Palaeozoic.

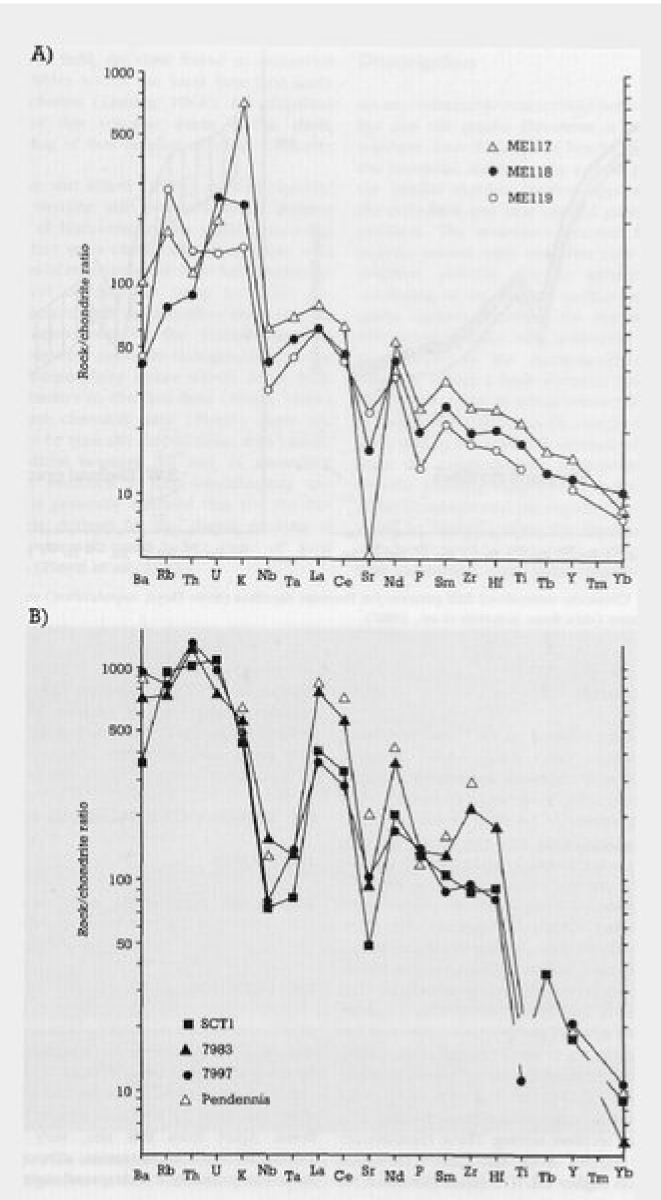
Rhyolitic suite

Rhyolitic pebbles found in the New Red Sandstone (Laming, 1966) have similar textural, petrographic and chemical features to exposed flow-banded rhyolite lavas near Plymouth. They form the remnants of possibly extensive supra-batholithic calc-alkaline acid volcanism that was fed by the granite-porphyry dykes which cut the main granite plutons. Most commonly, they are reddened quartz–K-feldspar–biotite-phyric rhyolites with relict spherulitic textures, that have often recrystallized to a granular cryptocrystalline quartzofeldspathic matrix (Cosgrove and Elliott, 1976). Chondrite-normalized geochemical data (from Cosgrove and Elliott, 1976; Floyd, unpublished) shows strong LIL enrichment patterns, but with marked Nb, Ta, Sr and Ti negative anomalies, light REE enrichment (Figure 6.3) with negative Eu anomalies (Eu/Eu* *c.* 0.4). All are typical features of acidic calc-alkaline rocks formed in a syncollisional tectonic setting. These rhyolites are chemically distinct from the Lower Devonian rhyolites with higher LIUHFS ratios (Rb/Nb *c.* 50 relative to *c.* 5) and although REE patterns are broadly similar to, and overlap, those of the granites (Figure 6.3), they have more in common with the granite porphyries (Exley *et al.,* 1983).

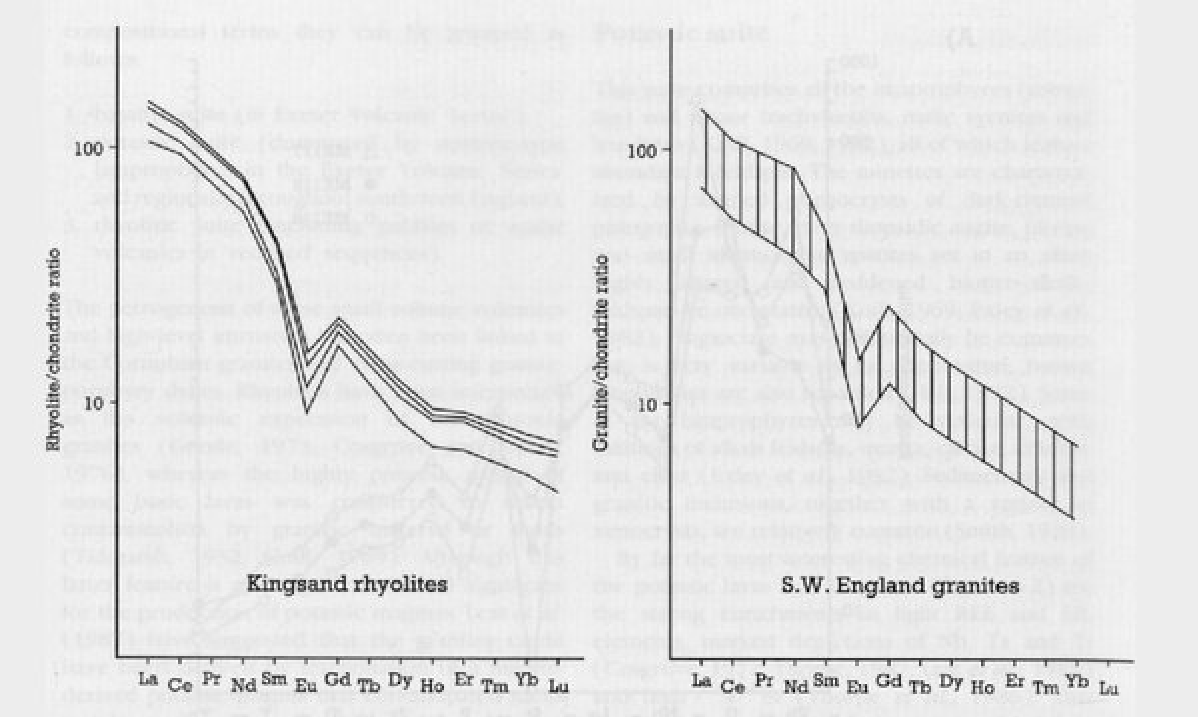
References



(Figure 6.1) Outline map of south-west England, showing the location of Group-D sites.



(Figure 6.2) Chondrite-normalized multi-element patterns for the A) basaltic and B) lamprophyric suites of the Exeter Volcanic 'Series' (data from Leat et al., 1987).



(Figure 6.3) Chondrite-normalized REE patterns for Permian rhyolites (from Floyd, unpublished) and south-west England granites (data from Alderton et al., 1980).