Chapter 1

The igneous rocks of south-west England

From:
Floyd, P.A., Exley, C.S. & Styles, M.T., (1993), *Igneous Rocks of South-West England*, Geological Conservation Review Series, No. 5, Chapman and Hall, London, 256 pages, illustrations, A4 hardback, ISBN 0 41248 850 7
For more information see: http://www.jncc.gov.uk/page-2911

INTRODUCTION AND SITE SYNTHESIS

The magmatic rocks of south-west England fall within the northern European Variscan fold belt; they are dominated by pre-orogenic basic–acid volcanics and post-orogenic granites, together with minor volcanics, that span the Devonian and Carboniferous systems. These major magmatic groups have played their part in the evolution of petrogenetic theory, but on a more limited scale than, say, the igneous rocks of the British Tertiary province, and generally relative to the development of the Variscan fold belt. For example, the small-volume, effusive volcanic rocks of Devonian–early Carboniferous age in south-west England were identified in the early European literature as representative of the so-called 'spilite–keratophyre geosynclinal association'; that is, the association of basic and acidic volcanics in a deep basinal setting. They have their temporal counterparts throughout the Variscan Orogenic Belt of Northern Europe and provided the scientific battleground for argument over the primary versus secondary origin of spilitic rocks (for example, Vallance, 1960; Amstutz, 1974), rocks which we now recognize as metamorphosed basalts.

Volcanic activity in Britain during the Devonian–Carboniferous can be broadly divided into two geographically separate areas that show contrasting eruptive and tectonic settings. The volcanic rocks of south-west England are dominated by medium- to deep-water submarine extrusives, shallow intrusives and volcaniclastics generated within rifted ensialic troughs and narrow ocean basins which appear to characterize the Variscides as a whole. Subsequently, they were extensively tectonized and metamorphosed during the different stages of the Variscan Orogeny and are thus characteristic of pre-orogenic volcanism. On the other hand, the foreland continental environment to the north in central-northern England and southern Scotland was outside the active orogenic belt and, as a consequence, deformation of volcanic rocks was relatively limited. The eruptive setting was also different. The calc-alkaline Old Red Sandstone volcanics of southern Scotland are dominated by subaerial lavas and volcaniclastics interbedded with thick sequences of intermontane sedimentary debris. Similarly, the extensive basaltic volcanics of Carboniferous age in northern England and the Midland Valley of Scotland are characterized by subaerial lavas and shallow, but often thick, intrusive complexes. Another significant difference is that volcanism continued throughout the Carboniferous in the northern area, whereas in South-west England it terminated in the Viséan in response to thrust-generated crustal shortening (Floyd, 1982a; fig. 15.2).

The post-orogenic granite batholith volumetrically dominates the magmatic rocks found in south-west England. The granite batholith and its associated metalliferous ore bodies have provided the type area for fractionated, high-level, high heat-flow granitic terranes and models for hydrothermally induced zonal mineralization. From the economic viewpoint, the special character of the granite batholith has been used as a model for tin mineralization and late-stage alteration associated with acidic magmatism throughout the world. Direct comparisons can be made with the chemically distinct Caledonian granites, some of which also feature high heat flow, but lack the extensive mineralization and late-stage effects exhibited in south-west England. Recently the radioactive-element-enriched Cornubian granite batholith has also attracted national attention as a hot, dry rock energy source and as a potential environmental hazard due to the emission of seeping radiogenic radon gas.

Of no less importance is the Lizard Complex in south Cornwall, and the local problem of its age and tectonic significance. Recent work has firmly placed it in the Variscan tectonic regime, as a fragment of obducted ophiolite with an attendant sedimentary *mélange*. If the early Devonian age for this dismembered ophiolite is correct, then it has European significance as being one of the few remnants of ocean crust exposed in the external zone of the Variscides.

The above brief introduction places the south-west England Devonian–Carboniferous igneous rocks in their regional and tectonic context relative to contemporaneous, often more extensive, magmatic episodes in Britain. However, compared with the magmatic character of the northern 'stable' foreland, the rocks of south-west England are characteristic of the various stages of evolution of an orogen and, in particular, illustrate the spectrum of magmatic events relative to tectonic features within the external zone of the Variscan fold belt.

The general localities of the sites that have been selected are shown in Figure 1.1 (numbered as listed in Table 1.1) and an outline of the

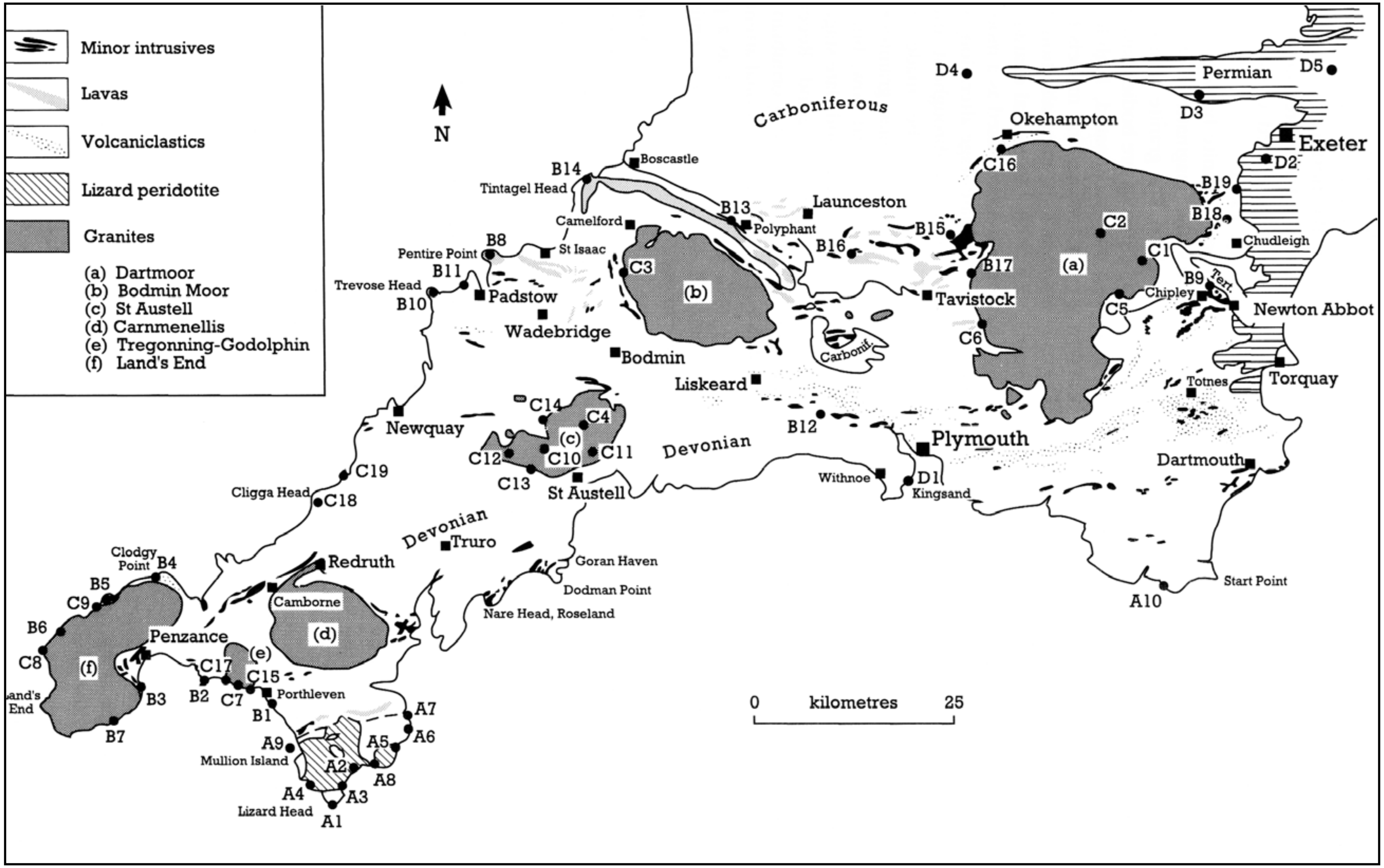

Figure 1.1 Simplified geological map of south-west England showing the distribution of magmatic rocks and the approximate location of sites described in the text (modified from Floyd, 1982b). Sites are numbered and grouped as in Table 1.1.

Table 1.1 List of GCR igneous rock sites in south-west England (see Figure 1.1 for locations).

Group A sites: Lizard ophiolite and melange	**Group B sites: Pre-orogenic volcanics**	**Group C sites Cornubian granite batholith**	**Group D sites: Post-orogenic volcanics**
A1 Lizard Point (SW 695 116–SW 706 115)	B1 Porthleven (SW 628 254–SW 634 250)	C1 Haytor Rocks area (SX 758 773)	D1 Kingsand Beach (SX 435 506)
A2 Kennack Sands (SW 734 165)	B2 Cudden Point–Prussia Cove (SW 548 275–SW 555 278)	C2 Birch Tor (SX 686 814)	D2 Webberton Cross Quarry (SX 875 871)
A3 Polbarrow–The Balk (SW 717 135–SW 715 128)	B3 Penlee Point (SW 474 269)	C3 De Lank Quaries (SX 101 755)	D3 Posbury Clump Quarry (SX 815 978)
A4 Kynance Cove (SW 684 133)	B4 Carrick Du–Clodgy Point (SW 507 414–SW 512 410)	C4 Luxulyan (Goldenpoint, Tregarden) Quarry (SW 054 591)	D4 Hannaborough Quarry (SS 529 029)
A5 Coverack Cove–Dolor Point (SW 784 187–SW 785 181)	B5 Gurnards Head (SW 432 387)	C5 Leusdon Common (SX 704 729)	D5 Killerton Park (SS 971 005)
A6 Porthoustock Point (SW 810 217)	B6 Botallack Head–Porth Ledden (SW 362 339–SW 355 322)	C6 Burrator Quarries (SX 549 677)	
A7 Porthallow Cove–Porthkerris Cove (SW 798 232–SW 806 226)	B7 Tater-du (SW 440 230)	C7 Rinsey Cove (Porthcew) (SW 593 269)	
A8 Lankidden (SW 756 164)	B8 Pentire Point–Rumps Point (SW 923 805–SW 935 812)	C8 Cape Cornwall area (SW 352 318)	
A9 Mullion Island (SW 660 175)	B9 Chipley Quarries (SX 807 712)	C9 Porthmeor Cove (SW 425 376)	
A10 Elender Cove–Black Cove, Prawle Point (SX 769 353–SX 769 356)	B10 Dinas Head–Trevose Head (SW 847 761–SW 850 766)	C10 Wheal Martyn (SW 003 556)	
	B11 Trevone Bay (SW 890 762)	C11 Carn Grey Rock and Quarry (SX 033 551)	
	B12 Clicker Tor Quarry (SX 285 614)	C12 Tregargus Quarries (SW 949 541)	
	B13 Polyphant (SX 262 822)	C13 St Mewan Beacon (SW 985 534)	
	B14 Tintagel Head–Bossiney Haven (SX 047 892–SX 066 895)	C14 Roche Rock (SW 991 596)	
	B15 Brent Tor (SX 471 804)	C15 Megiliggar Rocks (SW 609 266)	
	B16 Greystone Quarry (SX 364 807)	C16 Meldon Aplite Quarries (SX 567 921)	
	B17 Pitts Cleave Quarry (SX 501 761)	C17 Praa Sands (Folly Rocks) (SW 573 280)	
	B18 Trusham Quarry (SX 846 807)	C18 Cameron (Beacon) Quarry (SW 704 506)	
	B19 Ryecroft Quarry (SX 843 847)	C19 Cligga Head area (SW 738 536)	

significant features exhibited by each group of sites is given below. Details of the spatial and temporal location, emplacement environment and origin of the volcanic and plutonic rocks within the tectonic zones of the Variscan Orogen and the local geological framework of south-west England are given in Chapter 2.

Two interrelated criteria were used for the selection of sites in south-west England:

1. to provide a full stratigraphical coverage of different magmatic activity throughout the Hercynian fold belt;
2. to illustrate the special or unique petrological and chemical characteristics of different magmatic units and their petrogenesis.

This allowed the continuum of magmatic activity within a fold belt to be documented, as well as highlighting special features best displayed in this region relative to elsewhere in the United Kingdom. The justification for choosing these specific sites, rather than others showing similar features, often rested on a combination of adequate geological exposure, lithological freshness and accessibility.

The sites can be grouped into four main units (A–D) that roughly relate to stratigraphical age and major magmatic events within the Variscan. Some significant geological features exhibited by these units are summarized below:

Lizard ophiolite, *mélange* and Start Complex

The plutonic complex of the Lizard ophiolite includes serpentinized peridotite, gabbro and basaltic dykes, together with heterogeneous acid–basic gneisses. As representatives of oceanic crust, these units play a role in the interpretation of early Variscan basins in south Cornwall; they also provide evidence for subsequent northward obduction. Although a volcanic carapace to the ophiolite is not present in sequence, tectonically associated, metamorphosed lavas (now hornblende schists) chemically similar to mid-ocean ridge basalts are consistent with a Lizard ocean-crust model. Metamorphism and tectonism possibly occurred both in a suboceanic setting and during obduction. The metavolcanic greenschists of the Start Complex also exhibit mid-ocean ridge chemical features and may represent another tectonized segment of the early Variscan ocean floor in this region.

Pre-orogenic volcanics

This unit comprises various stratigraphically localized volcanic rocks which were erupted contemporaneously with basinal sedimentation. They range in age from Devonian to early Carboniferous, but culminated in late Devonian–Viséan times. Although they represent a bimodal basic–acid suite (the old 'spilite-keratophyre association'), the volcanics are dominated by basaltic pillow lavas and high-level intrusives of both tholeiitic and alkaline character. Basic and acidic tuffaceous volcaniclastics are also common throughout the Upper Palaeozoic. The volcanics invariably have been altered subsequent to consolidation and deposition, exhibiting secondary assemblages indicative of the prehnite–pumpellyite (facies) and lower greenschist facies of metamorphism.

Cornubian granite batholith

The culmination or late stages of the Variscan Orogeny were marked by the emplacement of the Cornubian batholith at the end of the Carboniferous. This body is often interpreted as the product of the melting of sialic crust induced by continent–continent collision. Although predominantly a two-mica calc-alkaline granite, the batholith is composed of multiple intrusions, ranging in age from about 300 to 270 Ma and encompasses a number of highly fractionated acidic members including Li- and F-rich variants. Late-stage alteration effects are well displayed and include extensive tourmalinization, greisenization and kaolinization. The granite was also the source of the hydrothermal Sn–W mineralization as well as the heat engine for associated Cu–Pb–Zn–Fe–As deposits within the margins of plutons and their aureoles.

Post-orogenic volcanics

Shortly after consolidation of the batholith and regional uplift, a post-orogenic volcanic episode began in the late Carboniferous–early Permian. This comprised both suprabatholithic acid volcanism fed by late granite-porphyry dykes, and mafic extrusives and intrusives related to fault-bounded troughs. The latter group include various lamprophyres which often characterize the last stages of magmatic activity, apparently associated with granites of continental origin.