A6 Porthoustock Point

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Highlights

This site displays the best development of the dolerite dyke swarm, which is interpreted as the sheeted-dyke complex of the Lizard oceanic crust.

Introduction

Dolerite dykes are present in small numbers cutting most rock types of the Lizard Complex, although within the Landewednack Hornblende Schists and Old Lizard Head metasediments they are clearly deformed and not necessarily of the same generation as those discussed here. At Coverack (discussed above), they form a small percentage of the outcrop but, going north through the gabbro, the proportion of dykes gradually increases. Around Leggan Cove there is a dramatic increase in the abundance to around 25%, and in the West of England Quarry at Porthoustock they form about 50% of the outcrop. Locally near the old pier and Porthoustock Point, they form around 80% of the rock with only thin gabbro screens separating the dykes. Flett and Hill (1912) described and figured this great abundance of dykes and commented on the fact that, although many dykes looked very fresh in the field, with sharp straight sides and chilled margins, thin-section studies showed them to be totally altered to actinolite, albite, etc. Dolerites with fresh olivine and pyroxene are rare in the Lizard dykes.

Bromley (1973, 1979) drew attention to the great number of dykes; from his field observations he divided them into three groups and suggested an order of intrusion. The first formed were olivine-phyric, and in some places exhibited a granular texture. They are often disrupted and back-veined by gabbro. The second type were plagioclase-phyric, had chilled or phenocryst-free margins and were occasionally veined by hornblende diorite. The youngest set of dykes are fine-grained, aphyric plagioclase hornblende rocks. He saw no evidence that they had originally contained olivine and pyroxene and suggested that they might be primary amphibolites. This last type is by far the most abundant at Porthoustock.

Kirby (1979, 1984) studied the dykes in detail both in the field and chemically. He also found three groups broadly similar to those of Bromley (1979), but thought that the dykes with the amphibolite mineral assemblages must be older than those with olivine. This is the opposite sequence to that suggested by Bromley (1979). Chemical data showed that the later (olivine) dolerites were the most primitive, with MORB-like characteristics, and that the earlier (aphyric) ones were more fractionated with a slightly calc-alkaline nature (Kirby, 1984).

Davies (1984), as part of his geochemical study of the Lizard, analysed dykes from Porthoustock. He divided the dykes into early and late types along the same lines as Kirby (1984), producing high-quality REE data. He showed that the early dykes were light-REE-enriched and could have been formed by melting of plagioclase lherzolite, similar to that analysed from Coverack. The later dykes were MORB-like, light-REE-depleted and could be formed by melting of pargasite harzburgite. He suggested a model for the generation of the Lizard, similar to the Red Sea, with early rifting, mantle metasomatism and production of light-REE-enriched magmas followed by later MORB-like magmatism.

Sandeman (1988) analysed the dykes as an adjunct to his study of the Kennack Gneiss, and showed the same chemical types as Kirby (1984) and Davies (1984), but suggested, like Bromley (1979), that the aphyric dykes were late, not early. He showed that their light-REE-enriched chemistry was like the basic fraction of the Kennack Gneiss, and suggested that all the rocks with more calc-alkaline affinities are associated with a late, arc-related phase of magmatism, rather than an early rifting phase.

Description

The best places to see the intrusive relations between the various types of dykes and the gabbro are the beach sections around Leggan Cove and Manacle Point, and in the now-disused West of England Quarry. The southern side of the quarry, where the face cuts across the strike of the dykes, is the most informative. The early disrupted dykes and many features of the gabbro, such as shear zones, are best seen in Leggan Cove. At the northern end of the cove is one of the small, late, hornblende diorite bodies that are thought to be differentiates of the gabbro magma. These diorites can be seen veining the dykes in several places.

The sections in the quarry are dominated by the abundance of dykes that form around 50% of the rock exposed. They are mostly of the dark-green aphyric type and are generally around 1 m in thickness. The sides of the dykes are usually fairly straight, and chilling is often seen at the margins. Dykes are seen to intrude other dykes of the same type in many places, but cross-cutting relations between dissimilar dykes are rare. On the upper level of the south wall of the quarry, small veins of a very leucocratic plagioclase diorite invade the aphyric dykes. This is probably the plagiogranite of Davies (1984). The whole sequence is cut by late, steep faults that have calcite veining along them.

Along the beach, just east of the old pier on the north side of Porthoustock Point, the abundance of dykes is at its greatest, forming around 80% of the outcrop (Figure 3.16). They are separated by thin screens of coarse gabbro and this is thought to be part of a sheeted dyke complex. The abundance of dykes increases northwards at Porthoustock, but unfortunately the sequence is truncated and the rocks on the north side of the Cove are very different. It is generally held that a concealed, large fault must run along the valley and out through the cove. The rocks exposed along the north side of the cove are highly deformed amphibolites, with numerous mylonitic zones. Generally, they appear to have been formed from quite coarse-grained precursors with a substantial proportion of finer rocks. Whether this is actually a highly sheared version of the dyke complex is open to speculation, but chemical data to test such a hypothesis are not yet available.

Interpretation

The dyke complex at Porthoustock is a major feature of the Lizard geology that has been recognized since the earliest geological surveys (De la Beche, 1839). The recognition by Bromley (1979) that this is a sheeted dyke complex is important as this is a significant feature in the categorization of the Lizard as an ophiolite. This is also the best example of an ophiolite–sheeted dyke complex in the whole of the UK.

Various workers have studied the dykes and there is agreement that several types of dykes are present, but exactly how they should be divided and what the time relations are is not yet clear. Cross-cutting relations between the different types seem to be few, partly because the different types have their main developments in different places. The aphyric types are most abundant in the north around Porthoustock, whereas the porphyritic types are most abundant in the south, around Coverack. There is a certain logic to extensively altered dykes being earlier than much fresher ones, but as they are in different places and in different structural and possibly hydrothermal regimes, this cannot be accepted without corroboratory evidence. If, for example, the source of fluids causing alteration was high-level hydrothermal systems such as are present in many modern ocean ridges, then the rocks highest in the sequence would be the most altered.

The chemical data that are available show clearly that there are at least two distinct types of dykes: olivine- and plagioclase-phyric MORB-types with light-REE-depleted patterns and the aphyric, light-REE-enriched types. The MORB-like dykes are closely similar to the gabbro, but the aphyric dykes are more evolved and not directly related magmatically. This is in accordance with the field relations, as the aphyric dykes do not root down into the gabbro – as the dykes in several ophiolite complexes do where the dykes are essentially comagmatic with the gabbros. Both Davies (1984) and Sandeman (1988) have produced essentially plausible models to account for the chemical variation. Davies (1984) suggested an analogy with the Red Sea, where initial rifting was associated with calc-alkaline magmatism and was followed by later MORB magmatism. Sandeman (1988), in contrast, suggests that the early MORB magmatism was followed by arc-related magmatism. Both the dykes and the Kennack Gneiss, known to be one of the later rock types, were associated with this later phase. This latter model has the attraction of simplicity, as there is a simple evolution from MORB-like to arc-related magmatism, whereas Davies' model would presumably have, in addition to the MORB magmatism, both an earlier rifting-related phase (to form the aphyric dykes) and a later arc-related phase (to account for the Kennack Gneiss).

A definitive work on the dykes, with the detailed field observation and chemical study to back it up, has yet to be carried out. The uncertainty that remains from current work cannot be resolved with the present data. This is, however, a very important site for the history of the Lizard Complex and the excellent features of igneous geology that can be seen here.

Conclusions

At this locality are seen rocks formed at a deep level in a portion of ancient ocean crust. The particular interests are the basalt and dolerite dykes, the site of which represents the channel-ways for melt feeding the sea-floor lavas above. One of the processes of growth and expansion of present-day oceanic crust is the repeated injection of magma in the form of near-vertical dykes below the spreading centre. At Porthoustock, many such dykes occur, cutting through the older gabbro, and are so closely packed that they make up the majority of rock on the foreshore. Although the chemistry of the dykes is variable, overall they are akin to various types of basalt formed in modern ocean ridges. This site plays a key part in the interpretation of the Lizard Complex, affording definite evidence for the presence and processes that contributed to the growth of early Devonian-aged oceanic crust to the south of what is now South-west England.

References

(Figure 3.16) Sheeted, basic dykes at Porthoustock Point. The dykes locally form about 80% of the outcrop with only thin gabbroic screens separating them. (Photo: M.T. Styles.)