C9 Porthmeor Cove

[SW 425 376]

Highlights

This site uniquely exposes two satellite 'mini plutons' of the Land's End Granite showing development of a roof complex in biotite granite and a sequence of granitic dykes.

Introduction

This locality is about 3 km WSW of Zennor on the north-west coast of the Penwith Peninsula. It is one of several places where Land's End Granite can be seen in contact with its country rocks but is distinguished by the presence, on the eastern side of the Cove, of two small granite cupolas which have presumably arisen from the main intrusion. These are the only recorded examples in south-west England, of well-exposed, complete 'mini-plutons'.

Most references to the locality are very brief (Reid and Flett, 1907; Booth, 1966; Hall, 1974; Hall and Jackson, 1975; Exley and Stone, 1982; Booth and Exley, 1987; Goode and Taylor, 1988), the only comprehensive account thus far being that of Stone and Exley (1984), who describe the more accessible intrusion and its associated dykes; and also suggest a chronology, drawing attention to the evolution of its roof complex of interbanded leucogranite and pegmatite by differentiation. Bromley and Holl (1986) argue that the magma was emplaced after the foundering of a block of country rock, the overlying pegmatite/ aplite complex developing through pressure changes as the block sank in stages.

Description

The country rocks at Porthmeor Cove are hard, grey, pelitic hornfelses of the banded Mylor Slate Formation which are sometimes spotted; these overlie a massive metadolerite sill some 20–25 m thick. The whole succession dips at about 20° to the north. The more northerly of the two cupolas on the eastern side of the cove, containing angular xenoliths and sending out apophyses, is visible in the cliffs but is inaccessible. The more southerly cupola, measuring about 19 m by 15 m, can easily be examined and displays several component rock types and a complex history (Figure 5.15).

It is an angular body, both in plan and in section, whose emplacement was controlled by the joints in the country rocks. All contacts are sharp and the roof is slightly domed. The main granite body is of megacrystic biotite granite (Dangerfield and Hawkes, 1981; Type B, (Table 5.1); Exley and Stone, 1982; Exley *et al.,* 1983), but an aphyric, slightly banded granite occupies the central parts. A typical Cornubian leucogranite/ pegmatite complex, 0.60–0.70 m thick, underlies the roof and this demonstrates the concentration of late-magmatic volatiles there and thus a considerable degree of differentiation *in situ.*

Three important dykes are associated with the cupola in addition to the vein complexes at the two seaward corners. The youngest dyke, composed of tourmaline microgranite, cuts through the cupola from north-west to south-east and then turns to the east-north-east, merging with a second dyke for a few metres before continuing into the hornfelses. A dyke of intermediate age, about 0.50 m thick and of megacrystic granite, arises directly from the cupola at its south-eastern corner and runs north-east into the country rocks. About 8 m from the pluton it cuts and displaces the oldest, 0.3 m thick, dyke which is of leucogranite (Figure 5.16). On the south side of its convergence with the youngest dyke, it forms a veneer on the steep cliff face and then joins an underlying leucogranite/aplite complex, only seen at low water. Bromley and Holl (1986) state that the top of a 'huge arrested xenolith' is visible at the lowest tides; this has not been confirmed by an examination at low-water spring tides, and rock relations appear to be more complicated than these authors suggest.

Interpretation

The complexity of rock relations at the base of the pluton does not invalidate Bromley and Holl's proposition that the subsidence of a large xenolith gave the opportunity for magma to move into the resulting cavity, decompression causing the volatiles to exsolve and the depleted magma to crystallize as aplite. Above this, the volatile-rich fluid would have cooled and solidified as pegmatite, and cycles of 'foundering, decompression and arrest' thus would have produced a banded complex.

The main Land's End Granite, which also has a roof complex of leucogranite, aplite and pegmatite over megacrystic biotite granite, has an exposed contact towards the head of the cove, but it is separated from the cupola by a fault. Roof complexes are well known in south-west England, and another occurs at Porth Ledden, but they become even more spectacular where lithium-mica granite is associated with them as in the sheets adjacent to the Tregonning intrusion and seen at Megiliggar Rocks (Stone, 1969, 1975).

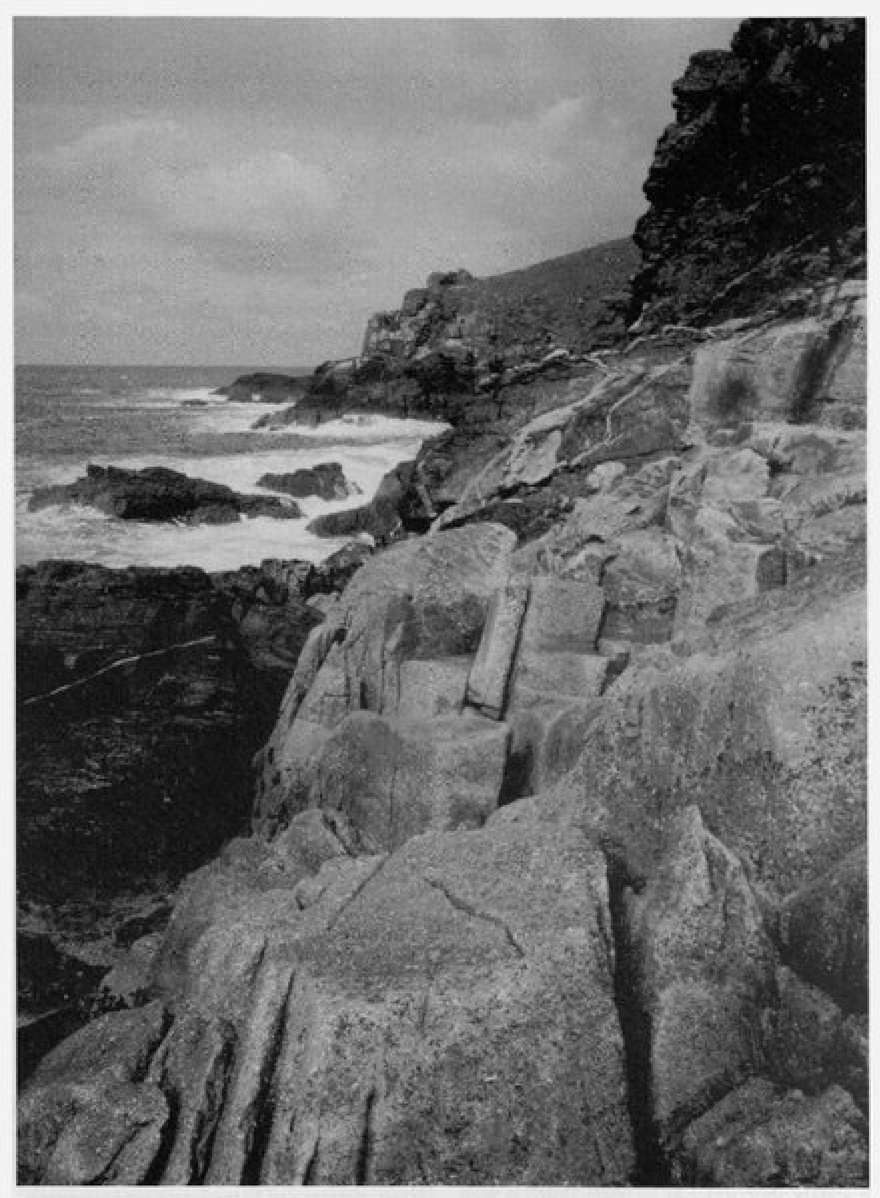
It is significant that despite a degree of differentiation sufficient to produce pegmatite, there is no development of lithium–mica–albite–topaz granite at Porthmeor and Porth Ledden, suggesting that this variety (Type E, (Table 5.1), found only at Tregonning–Godolphin and St Austell) does not evolve directly, and at high levels, from biotite granite magma (Exley *et al,* 1983).

It appears that the main Land's End Granite pluton was intruded, tilting its envelope of sediments and sills to the north, and developed a roof complex through volatile concentration. Either this complex, or a closely related one, then gave rise to the earliest dyke, which is of leucogranite, at Porthmeor. The Porthmeor cupola, composed of biotite granite like the main Land's End intrusion, was subsequently passively emplaced by stoping, sent out the second dyke, also of megacrystic biotite granite, and developed its own roof complex. Finally, the third dyke, of tourmaline microgranite whose source is not seen, was intruded through all the older rocks (Hall and Jackson, 1975; Stone and Exley, 1984). The small cupola therefore repeats the cycle in the main granite in which the build-up of volatiles, principally B, F and OH, during crystallization caused the formation of rocks impoverished in Fe, Ca and Na but enriched in minerals, such as tourmaline, containing these volatiles. The partitioning of some elements between residual silicate magma and OH-rich vapour determined the formation of leucogranite, usually fine grained, or pegmatite. Where jointing provided lines of weakness, the magma from the cupola penetrated to form the second dyke; the last dyke, again following the jointing but younger than the others, represents a last stage in the granite evolution in the area.

Conclusions

Here there occur two domed granite masses (cupolas), one of which is a composite intrusion, made up of an outer (older) coarse-grained granite and a younger component forming the core of the intrusion. The top of the cupola is formed of a capping mass of rock, less than one metre thick, of two types – one coarsely crystalline (pegmatite) and the other finer grained and pale coloured (aplite/leucogranite) above the main mass of the biotite granite. Such rocks have been associated with the final volatile-rich (boron-and water-rich) granite magma, differentiation, cooling and solidification in place at the top of the granite mass. Pegmatite/aplite roof complexes are usually developed from Cornubian Li-mica–albite–topaz granite magmas, but the Porthmeor Cove example is a rare and instructive example of development from biotite granite. This exposure also shows the unusual emplacement of a satellite pluton after the main intrusion, and a clear sequence of related granitic dykes.

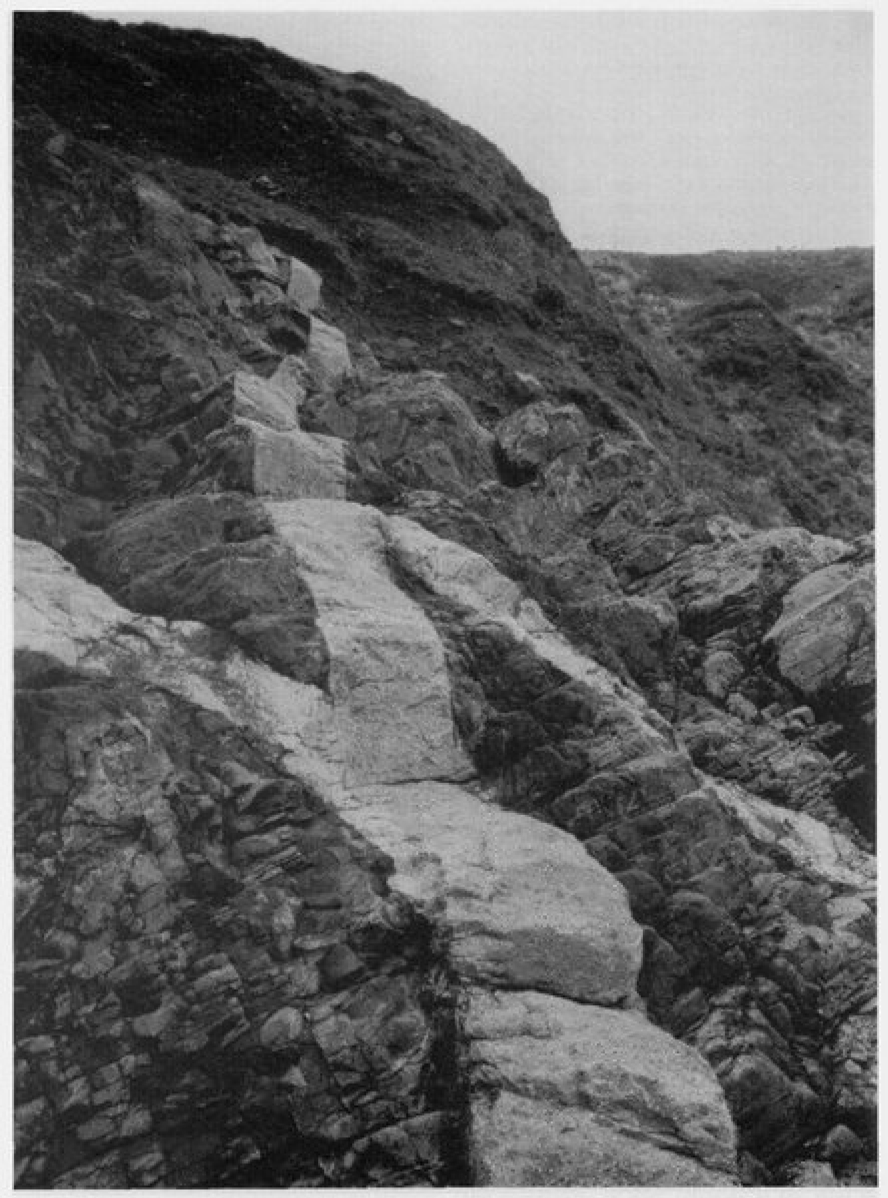
References



(Figure 5.15) Small granite cupola emplaced in pelitic hornfelses of the Mylor Slate Formation. Porthmeor Cove, Cornwall. (Photo: K.A. Cottle.)

Type	Description	Texture	Minerals (approximate mean modal amounts in parentheses)						Other names in literature
			K-feldspar	Plagioclase	Quartz	Micas	Tourmaline	Other	
A	Basic microgranite	Medium to fine; ophitic to hypidiomorphic	(Amounts vary)	Oligoclase-andesine (amounts vary)	(Amounts vary)	Biotite predominant; some muscovite	Often present	Hornblende, apatite, zircon, ore, garnet	Basic segregations (Reid et al., 1912); Basic inclusions (Brammall and Harwood, 1923, 1926)
B	Coarse-grained megacrystic biotite granite	Medium to coarse; megacrysts 5-17 cm maximum, mean about 2 cm. Hypidiomorphic, granular	Euhedral to subhedral; microperthitic (32%)	Euhedral to subhedral. Often zoned: cores An_{35}-An_{30}, rims An_8-An_{15} (22%)	Irregular (34%)	Biotite, often in clusters (6%); muscovite (4%)	Euhedral to anhedral. Often zoned. 'Primary' (1%)	Zircon, ore, apatite, andalusite, etc. (total, 1%)	Includes: Giant or tor granite (Brammall, 1926; Brammall and Harwood, 1923, 1932) = big feldspar granite (Edmonds et al., 1968), coarse megacrystic granite (Hawkes and Dangerfield, 1978). Also blue or quarry granite (Brammall, 1926; Brammall and Harwood, 1923, 1932) = poorly megacrystic granite (Edmonds et al., 1968), coarse megacrystic granite (mesocrystic type) (Hawkes and Dangerfield, 1978), coarse megacrystic granite (small megacryst variant) (Dangerfield and Hawkes, 1981). Also medium-grained granite (Hawkes and Dangerfield, 1978), medium granites with few megacrysts and megacrysts very rare (Dangerfield and Hawkes, 1981). Biotite-muscovite granite (Richardson, 1923; Exley, 1959). Biotite granite, equigranular biotite granite, and globular quartz granite (Hill and Manning, 1987).
C	Fine-grained biotite granite	Medium to fine, sometimes megacrystic; hypidiomorphic to aplitic	Subhedral to anhedral; sometimes microperthitic (30%)	Euhedral to subhedral. Often zoned: cores An_{10}-An_{15} (26%)	Irregular (33%)	Biotite 3%; muscovite (7%)	Euhedral to anhedral. 'Primary' (1%)	Ore, andalusite, fluorite (total, <1%)	Fine granite, megacryst-rich and megacryst-poor types (Hawkes and Dangerfield, 1978; Dangerfield and Hawkes, 1981)
D	Megacrystic lithium-mica granite	Medium to coarse; megacrysts 1-8.5 cm, mean about 2 cm. Hypidiomorphic, granular	Euhedral to subhedral; microperthitic (27%)	Euhedral to subhedral. Unzoned, An_7 (26%)	Irregular; some aggregates (36%)	Lithium-mica (6%)	Euhedral to anhedral 'Primary' (4%)	Fluorite, ore, apatite, topaz (total, 0.5%)	Lithionite granite (Richardson, 1923). Early lithionite granite (Exley, 1959). Porphyritic lithionite granite (Exley and Stone, 1964). Megacrystic lithium-mica granite (Exley and Stone, 1982)
E	Equigranular lithium-mica granite	Medium-grained; hypidiomorphic, granular	Anhedral to interstitial; microperthitic (24%)	Euhedral. Unzoned, An_4 (32%)	Irregular; some aggregates (30%)	Lithium-mica (9%)	Euhedral to anhedral (1%)	Fluorite, apatite (total, 2%); topaz (3%)	Late lithionite granite (Exley, 1959). Non-porphyritic lithionite granite (Exley and Stone, 1964). Medium-grained, non-megacrystic lithium-mica granite (Hawkes and Dangerfield, 1978). Equigranular lithium-mica granite (Exley and Stone, 1982). Topaz granite (Hill and Manning, 1987)
F	Fluorite granite	Medium-grained; hypidiomorphic, granular	Sub-anhedral; microperthitic (27%)	Euhedral. Unzoned, An_4 (34%)	Irregular (30%)	Muscovite (6%)	Absent	Fluorite (2%), topaz (1%), apatite (<1%)	Gilbertite granite (Richardson, 1923)

(Table 5.1) Petrographic summary of main granite types (based on Exley et al., 1983)



(Figure 5.16) Later dyke of megacrystic granite cutting and displacing an earlier leucogranite dyke. Porthmeor Cove, Cornwall. (Photo: R.A. Cottle.)