C8 Cape Cornwall area

[SW 352 318]

Highlights

The Cape Cornwall area shows a stoped contact between metasediments and Land's End Granite, which shows evidence of being a two-stage intrusion. Greisen-bordered mineral veins, sapphire in thermally metamorphosed country rock and evidence of potassium metasomatism of granite and metamorphic aureole also occur here with late-stage veins, pipes and pods of pegmatite and quartz–tourmaline, and a quartz–tourmaline contact facies, all resulting from a concentration of a volatile-rich phase at the granite margin.

Introduction

Although the cliff and beaches immediately north and south of Cape Cornwall have become, in recent years, famous exposures for demonstrating both contact and late-stage igneous phenomena of the Land's End Granite mass, very little has been published on the area. The Land's End Granites as a whole were described in the Geological Survey Memoir by Reid and Flett (1907), with a revision, following publication of a new 1:50 000 map in 1984, by Goode and Taylor (1988); the latter, which contained little petrological discussion, is supplemented by an 'Open File' report (Goode *et al.,* 1987) in which there is substantially more detail. A specific study was made by Booth (1966), followed by a note on the granites' relations with the 'granite system' (Booth, 1967) and a paper by Booth and Exley (1987). Most of these contain passing references to the Cape Cornwall area, but van Marcke de Lummen (1986) used material from both Priest's Cove and Porth Ledden in his study of the crystallization sequence in the granites.

Charoy (1979, 1981, 1982) has quoted examples from Porth Ledden in his work on late-stage phenomena, especially tourmalinization, and Lister (1979b) has included specimens from both Priest's Cove and Porth Ledden in her investigations into quartz-cored tourmaline crystals. At least part of this tourmalinization, which Manning (1981) and Pichavant and Manning (1984) thought might have been due to a complex hydrothermal/metasomatic process, may be related to the 270 Ma BP intrusive phase noted in Chapter 2 (Bristow *et al,* in press). Duddridge (1988) has argued that at least some tourmaline must be metasomatic.

Description

Cape Cornwall is situated on the west coast of the Penwith Peninsula about 2 km WNW of St Just; the cliffs and beach immediately to the north and south of the Cape exhibit a variety of phenomena associated with the contact between the Land's End Granite and the Mylor Slate Formation metasediments ('killas') (Figure 5.13). Such phenomena are typical of Cornubian granites, but it is seldom that so many are displayed together in so small an area and can be related to one another so directly (Figure 5.14).

The country rocks are originally mudstones with subordinate sandstones, and these have been folded and metamorphosed into hard, splintery, grey, banded hornfelses, in which andalusite, chiastolite, cordierite, corundum and tourmaline have been identified. Corundum is of special interest, being unusual in Cornubian contact rocks and occurring as the variety sapphire in some exposures in the cliffs above Priest's Cove. Mobilization of the silica has produced extensive convoluted quartz bands and veins in the metasediments and, while these are typical of granite contacts throughout Cornwall and Devon, it is worth noting that there is no migmatization of the sort seen at Leusdon Common on Dartmoor (C5).

The contacts in Priest's Cove and near the stream at the northern end of Porth Leddon are faulted and hematized, and strike nearly east–west. The Priest's Cove contact is clearly exposed, vertical, and accompanied by a complex of quartz, quartz–tourmaline and pegmatite veins striking NW–SE, which is the trend of the tin-bearing veins formerly worked in the area. The breccia at this contact, formerly regarded as a result of faulting, is interpreted by Badham (1980) as 'a small breccia pipe formed during stoping'. Movement during and shortly after emplacement is usual in the Cornubian granites and, as here, often provided pathways for mineralizing solutions. Some of the quartz–tourmaline veins have dark, greisen borders a few centimetres wide.

The contact running down the cliff and across the beach in Porth Ledden is, in contrast, not faulted. Large K-feldspar megacrysts, both close to the contact itself and in isolated exposures presumed to be in an eroded roof pendant or large xenolith, provide examples of potassium metasomatism of the hornfels.

There is no evidence of more than slight disturbance of the country-rock structures as a result of intrusion, and granite emplacement must have taken place principally by stoping and subsidence; the step-like contacts which can result from this process, although discernible, are not well seen in this area and are better displayed at Rinsey Cove.

The Land's End Granite mass has been given an age of 268 ± 2 Ma BP (Rb/Sr method) (Darbyshire and Shepherd, 1985) but this is seriously at odds with mineral ages and the general age of the batholith and is thought to have been reset by mineralization (Table 5.1). Alternatively, it could relate to the later major intrusive phase at about 270 Ma. In the Cape Cornwall area, the granite contains many xenoliths of killas, and it is variable in both composition and texture. The main variety is a medium-grained and poorly megacrystic biotite granite (Dangerfield and Hawkes, 1981; Booth and Exley, 1987); this is a subdivision of the Type B of Exley and Stone (1982) shown in (Table 5.1). It has megacrysts up to 40 mm long, but in some places it is almost aphyric, and elsewhere it contains veins and patches of a distinctly coarser variety. In Porth Ledden, a very coarsely megacrystic facies occurs close to the contact with the killas, where there is a pronounced parallelism between the megacrysts and the contact. This is quite different from the foliation seen, for example, in and about the De Lank Quarries on Bodmin Moor where there has been a strong tectonic influence. Good examples of aplite–pegmatite roof–complexes are also present, although these are not as well developed as those around Megiliggar Rocks near Porthleven, probably because the Land's End intrusion is devoid of a lithium-mica granite phase like that of Tregonning.

On the granite side of the Porth Ledden contact there is a lens of quartz–tourmaline rock which extends northwards from about halfway along the beach at the foot of the cliff. In some places this is subhorizontally banded and it passes downwards into aphyric, medium-grained granite. Within the main granite at the southern end, there are orbicular patches with tourmaline-rich rims and feldspathic cores which contrast with the pegmatitic pods, pipes and veins with tourmaline cores occurring in Priest's Cove. Some tourmaline is 'cored' (Lister, 1979b).

Many veins and apophyses of granite intrude the country rocks, their strikes often being controlled by the joint pattern; complexes of such veins are present in both Priest's Cove and Porth Ledden. The range of veins includes pegmatite (a notable one in Porth Ledden has curved feldspar crystals; '*stockscheider*'), medium-grained granite, aplogranite, microgranite and aplite. Some are relatively rich in tourmaline; some have a variety of textures including a development of pegmatite along their hanging-wall contacts.

Interpretation

The evidence of the veining and breaking up of medium-grained by coarse-grained granite suggests that in this area the Land's End magma was intruded in two pulses, the second following closely after the first had started to consolidate.

Together, these intrusions tilted the Mylor metasediments and thermally metamorphosed them to the equivalent of the anthophyllite–cordierite subfacies (examples of which are seen to the north of Porth Ledden at Kenidjack), with the development of sapphire locally as in Priest's Cove. Again, this is a rare phenomenon. The granites also sent out various veins and apophyses and incorporated fragments of country rock.

The remaining features, such as veins and pods of pegmatite and quartz–tourmaline, were dependent on the effects of volatile phases which became concentrated close to the granite–killas contact, as is usual in Cornubian rocks (although not so well displayed), but exceptional among British granites in general, presumably as a result of their lower volatile content. Thus the early concentration of water, particularly as it migrated to outer, cooler regions, would have accomplished the transfer of potassium within both granite and aureole, and led to the growth of megacrysts. At the same time, this migration facilitated the growth of feldspars in favoured localities, giving rise to pegmatitic bands, pipes and pods. Along with this aqueous phase was boron, which was concentrated enough in some places to form early, disseminated tourmaline within both granite and killas, although most of the tourmaline growth followed later, perhaps being linked with the 270 Ma BP intrusive episode (Chapter 2). In some places, such as at Wheal Remfry in the western lobe of the St Austell Granite mass, and at the Priest's Cove contact, the boron-rich fluid built up enough pressure to brecciate the confining rock (Allman-Ward *et al.,* 1982; Bromley and Holl, 1986; Halls, 1987; Bromley, 1989), but in others, for instance, Roche Rock and here at Porth Ledden, its effect was to cause pervasive tourmalinization (Bristow *et al.* in press). The fluid itself was probably a boron- and silica-rich component of the magma which separated either completely and formed areas of massive tourmalinite, or partially to form spots and patches (Badham, 1980; Charoy, 1979, 1981, 1982; and see 'Petrogenesis' section). The mechanism of separation was at least partly metasomatic, although complex (Manning, 1981; Pichavant and Manning, 1984): the precise process and effect in a particular case depending largely on physical conditions such as pressure, temperature and concentration gradients (Badham, 1980).

The cored-tourmaline crystals studied by Lister (1979b) were collected from near-vertical pegmatite veins and contained cores of polycrystalline quartz. Lister concluded from her examinations of the textures, chemical analyses and crystal growth mechanisms that they were formed by the supercooling of the tourmaline-bearing liquid. This would be a consequence of the sudden release of volatiles or of chilling, both of which could cause cooling below the normal crystallization temperature and thus instability at the 'crystal–fluid interface' and growth of unusual crystals. It is another effect of the high volatile content of Cornubian magmas. The greisen-bordered veins, some of which contained metallic minerals such as cassiterite and chalcopyrite, were emplaced last of all at about 270 Ma BP, that is, around 10 Ma after the intrusion of the main granite (Jackson *et al.,* 1982).

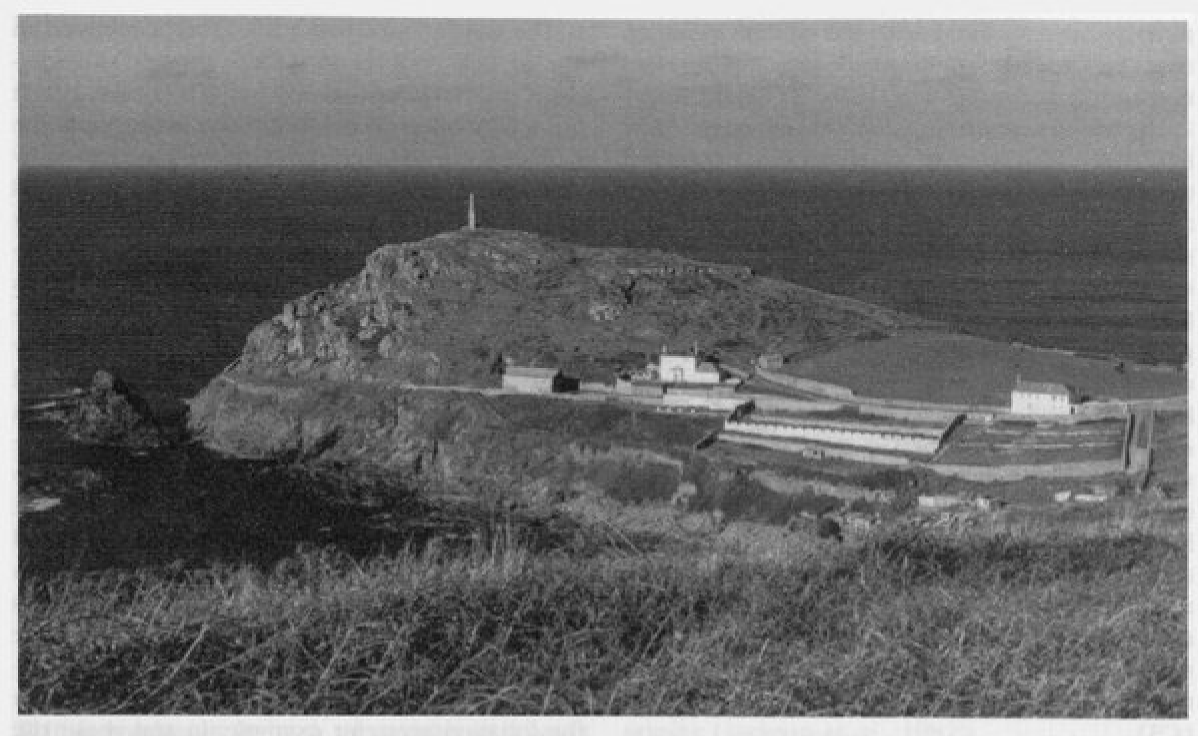
The exposures in the Cape Cornwall vicinity are outstanding, both as examples of the contact of the Land's End Granite mass with its metasedimentary country rock, and of the evolution of its late-stage facies. By analogy, they also provide an insight into the evolution of the other Cornubian granites and that of volatile-(especially boron-)rich granites in general.

The contact indicates that the granite was emplaced passively, by stoping, while K-metasomatism, the presence of pegmatites, extensive tourmalization and mineral veins show that the residual fluids of the magma were enriched in K (at least to begin with) and in B and a number of metallic elements. Depending on temperature and the extent of fracturing, these were able to penetrate both granite and killas and, because of good exposure, they illustrate how such processes must have operated in other granites of similar composition.

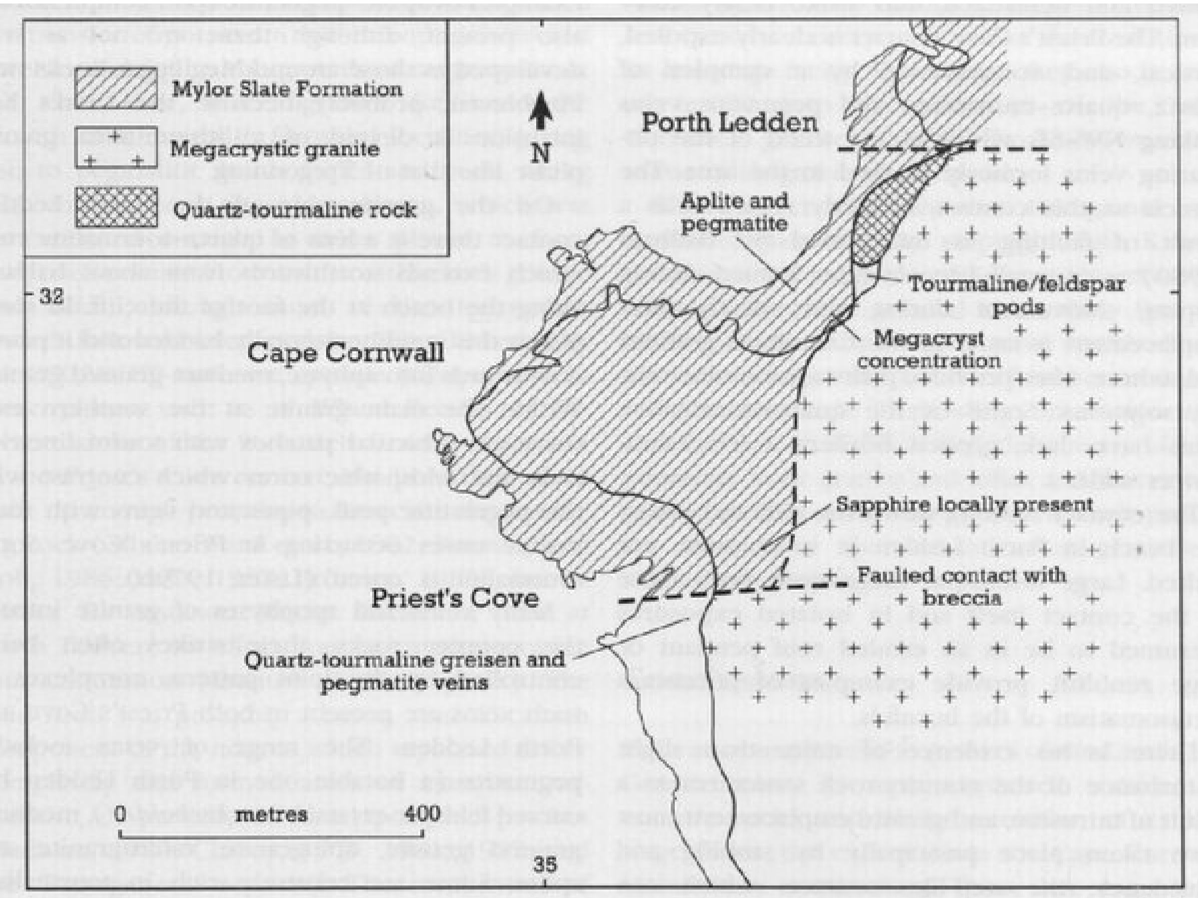
Conclusions

Both as examples of the contact of the Land's End Granite mass, its metamorphosed sedimentary country rocks, and of the evolution of its late-stage facies, the exposures in the Cape Cornwall vicinity are outstanding. These late-stage rocks include granitic rocks such as veins, pipes and pods of pegmatite and quartz–tourmaline rocks formed from volatile-rich solutions working their way to and crystallizing at the margins of the granite. Minerals also formed in the surrounding altered sedimentary rocks as a result of the influx of the late-magmatic fluids, and these include tourmaline and sapphire. By analogy, they also provide an insight into the evolution of the other Cornubian granites and that of volatile-(especially boron-)rich granites in general.

References



(Figure 5.13) The headland of Cape Cornwall which exposes contacts between Land's End Granite and adjacent metasediments. (Photo: S. Campbell.)



(Figure 5.14) Geological sketch map of the Cape Cornwall area (site (:8).

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_{25}-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_{13} (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)