C13 St Mewan Beacon

[SW 985 534]

Highlights

This site displays a rare exposure of quartz–topaz–tourmaline rock of hydrothermal origin, formed immediately under the metamorphic rocks of the granite roof.

Introduction

St Mewan Beacon is situated on the southern margin of the St Austell Granite, 3 km WNW of St Austell and just outside the Blackpool china-clay pit (Figure 5.10).

The St Austell Granite was emplaced in three episodes, the second of which cuts across the first, near St Dennis (Figure 5.4). Both the first and the second consist of megacrystic biotite granite of typical Cornubian type (Type B, (Table 5.1); Exley and Stone, 1982). A third intrusion of Li-mica–albite–topaz granite (Type E, (Table 5.1)) was emplaced within the second boss, and this is now exposed between St Dennis and St Stephen and near Hensbarrow Beacon. It is believed to have been derived from biotite granite at depth (see 'Petrogenesis' section and site descriptions) and upon emplacement to have metasomatized much of the second intrusion, albitizing the oligoclase, converting biotite to zinnwaldite and introducing topaz. It is this type of granite (Type D, (Table 5.1)) which is adjacent to St Mewan Beacon. Accompanying and following these intrusions, the introduction of boron gave rise to extensive tourmalinization which preceded greisening, metalliferous mineralization and kaolinization (Manning and Exley, 1984).

Field relations, textures and composition have, in the past, been used to suggest either a 'pneumatolytic' (Ussher *et al.,* 1909) or 'magmatic' (Collins and Coon, 1914) origin for the rocks of the Beacon, but Manning (1981) and Pichavant and Manning (1984) have concluded, from fluid-inclusion and other experimental data, that the rock was formed by complex hydrothermal processes.

Description

The rocks exposed at St Mewan make up a line of low crags along the south-facing slope. Storage tanks now occupy a small quarry at the western end, from which rock was formerly taken to pave grinding mills for china stone.

For the most part, the rocks are equigranular, fine- to medium-grained and made up of quartz and topaz with subordinate tourmaline, but banded quartz–tourmaline rock occurs in the southern side of the quarry, the banding dipping at about 40° to the south. The suite forms a contact facies between the main part of the granite, which is very kaolinized here, and its country rock consisting of tourmalinized pelites, semipelites and psammites of the Lower Devonian Meadfoot Group (Collins and Coon, 1914).

Interpretation

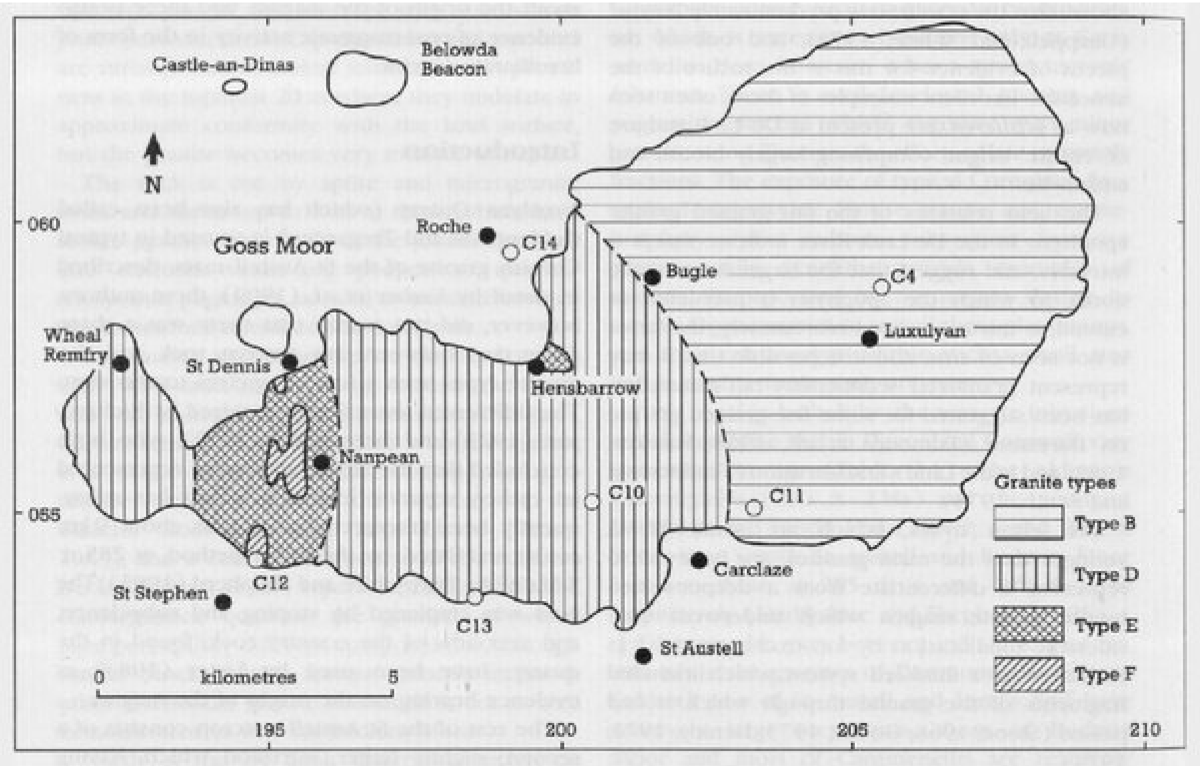
In addition to the quartz, topaz and tourmaline, the rocks of the Beacon contain accessory muscovite (sometimes as a replacement for topaz), apatite and opaque ore. The proportions of the main minerals vary to give rocks which may be very quartz- or tourmaline-rich, especially near the margins of the outcrop, but the average composition is about 60% quartz, 25% topaz and 15% tourmaline. They therefore fit into the St Austell sequence after the main intrusions and metasomatism, and before the main post-magmatic tourmalinization (between Stage III and Stage IIIb of (Table 2.2)). However, not only are these unusual rocks very hard, but experiments on melting relations and fluid-inclusion composition suggest that they are too refractory to have been produced from a straightforward magmatic melt, although they could have crystallized in equilibrium with saline hydrothermal fluid at about 620°C (Manning, 1981). The latter would link them to the hydrothermal (i.e. high-temperature, low-pressure) mineralization stage; occasional exposures of comparable rocks are found in clay workings and mines, although these are seldom long-lived enough and accessible enough to be examined. Manning (1981) concludes that 'multistage and complex processes' were involved, but that more work is required on stability relations in highly saline systems containing B, F and OH in order to advance knowledge of these systems and processes further. The commencement of such work is reported in Pichavant and Manning (1984), where it is concluded that in the H_2O-saturated system Q_z–Ab–Or–H_2O added B partitions into the vapour phase while added F partitions into the melt, and that added B effects little change in the minimum melt compositions.

St Mewan Beacon provides a rare chance to see an unusual topaz-rich rock of high-temperature hydrothermal origin arising in the change from late- to post-magmatic conditions and providing a link in the evolutionary continuum. It is unlikely to have crystallized from an ordinary melt, and is probably the result of interaction between magma and a volatile phase rich in F, B and OH.

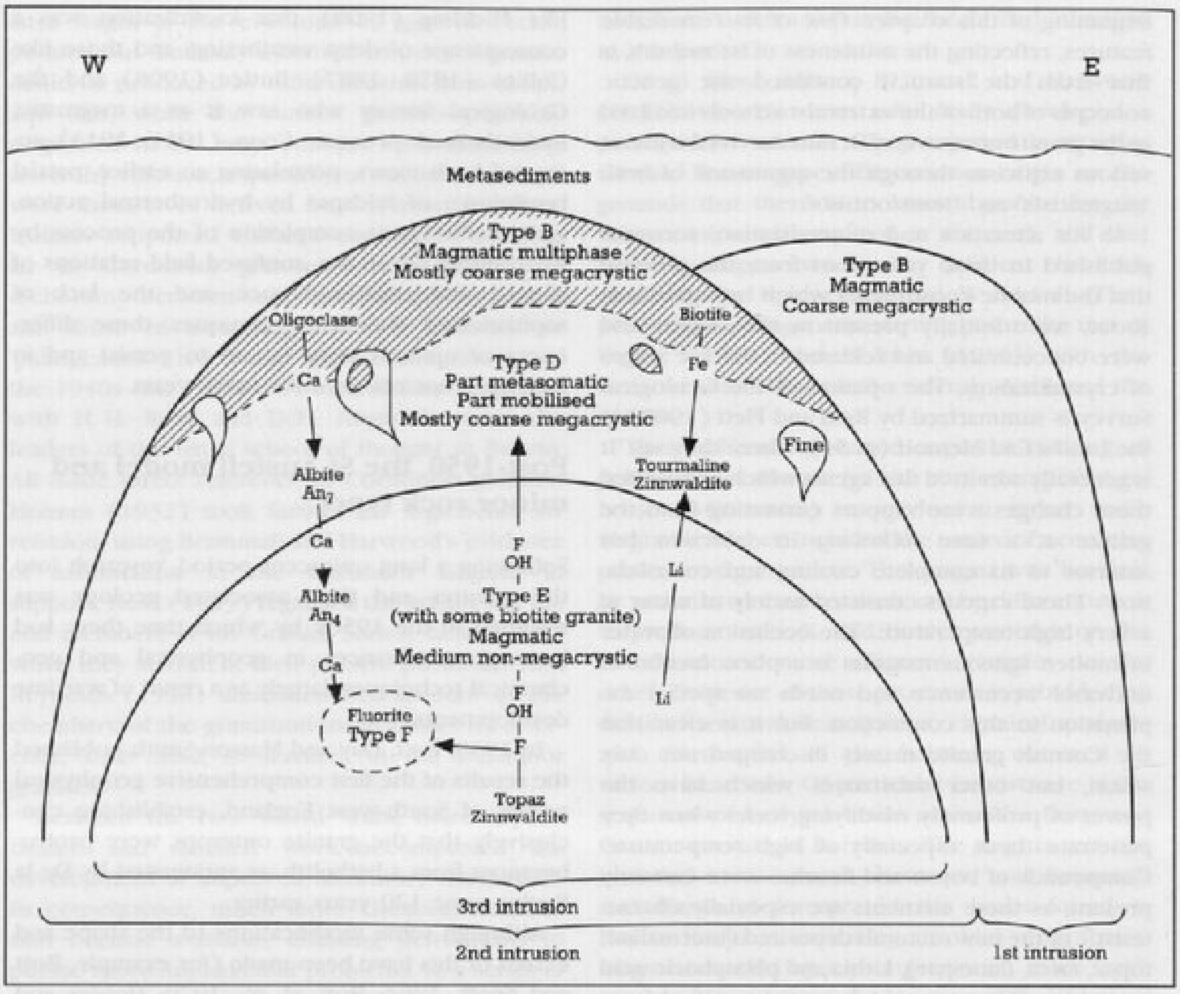
Conclusions

St Mewan Beacon consists of an igneous rock made up predominantly of the minerals: quartz, tourmaline and topaz, believed to have formed within the topmost portion (roof) of part of the St Austell granite intrusion. It has been suggested that it formed by the modification of solidifying granite magma by hot (hydrothermal) solutions containing fluorine, boron and water, through the alteration and reorganization of the chemistry and mineral content of the crystallizing granite. The fluids were a legacy of the waning igneous activity which formed the Cornubian granites. The site provides a rare chance to see an unusual rock of high-temperature origin arising in the change from late- to post-magmatic conditions and providing a link in the evolutionary continuum.

References



(Figure 5.10) Map of the St Austell Granite outcrop, showing the chief granite types, localities mentioned in the text (filled circles) and the following sites: C4 = Luxulyan Quarry; C10 = Wheal Martyn; C11 = Cam Grey Rock; C12 = Tregargus Quarries; C13 = St Mewan Beacon; and C14 = Roche Rock.



(Figure 5.4) The St Austell model. Diagram showing the first intrusion of Type-B granite (Table 5.1) cut by multiphase second intrusion of biotite granite, with metasomatic aureole of Type D caused by intrusion of Type E.

Type	Description	Texture	Minerals (approximate mean modal amounts in parentheses) K-feldspar	Plagioclase	Quartz	Micas	Tourmaline	Other	Other names in literature
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_{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)

Stage	Process	Age (millions of years) *	Depth (km)	Temperature (°C)	Salinity of fluids	Source of heat	Direction of least stress	Main changes in mineralogy			Associated metalliferous mineralization	Comments
								Feldspar	Quartz	Mica		
I	Emplacement of biotite granite, forming main batholith	290-285	? 3	500-600	-	Magmatic	Variscan (E-W)	-	-	-	-	Biotite granite which now forms eastern part of the St Austell granite
II	First phase of post-magmatic alteration and mineralization	285-275	2-3	600-200	Moderate	Magmatic	Initially E - W, then N - S	Limited greisenization alongside veins	-	-	Sn, W	Early greisenization and mineralization e.g. Castle-an-Dinas (W)
IIIa	Emplacement of evolved lithium-rich granites and biotite granites in western part of St Austell granite	275-270	2-3	500-600	-	Magmatic	N - S	-	-	-	-	Granites belonging to this phase may underlie much of the batholith. Granites hydraulically fractured
IIIb	First part of second phase of post-magmatic alteration and mineralization	275-270	? 2	400-300	Moderate	Mainly magmatic, some radiogenic	N - S or NW - SE	Greisenization: converted to quartz, mica and topaz by F-rich fluids, mica of gilbertite type. Tourmalinization: replaced by tourmaline	Repeatedly fractured and fractures annealed by fresh growths of quartz	Some re-crystallization, biotite loses iron which is taken up by tourmaline growth	Sn, W, Cu	Main phase of metalliferous mineralization
IIIc	Emplacement of felsitic elvan dykes	275-270	? 2	600-500	Moderate	Magmatic	N - S	-	-	-	Sn, W, Cu	Further input of magmatic heat
IV	First phase of argillic alteration and NW-SE or N-S quartz-hematite veins and faulting	270-260	? 1-2	350-200	Moderate to high	Mainly radiogenic, possibly some magmatic or mantle heat	E - W	Na feldspar: altered to smectite/illite assemblage, little kaolinite. K feldspar: altered to illite, maybe some smectite	Free silica released by argillation, forms overgrowths on quartz and now iron-stained non-tourmaline bearing lodes (NW - SE and N - S)	Much iron liberated from biotite which is carried out of the granite to form iron lodes. Some mica hydrated to gilbertite	Fe/U/Pb/Zn	Note: Salinity, lack of kaolinite and change in stress direction. Low temperature metalliferous mineralization
Quiescent period?												
V	Second phase of argillic alteration. Main period of kaolinization ?Deep Mesozoic supergene alteration?	260 to present	0.2-1.5	50-150	Low	Radiogenic	Variable E - W or N - S, later becoming vertical	Na feldspar: altered readily to kaolinite. K feldspar: altered less readily to kaolinite. Smectite: altered readily to kaolinite	Free silica released by argillation, forms overgrowths on quartz and some minor quartz veins	Some iron liberated from biotite, not carried out of granite so colours matrix. In areas of intense kaolinization mica/illite altered to kaolinite	Fe/U (minor)	Note: Fresh water and main episode of kaolin formation. Isostatic uplift may have played a part
VI	Early Tertiary chemical weathering (also Mesozoic?)	25-60	0.0-0.2	20-50	Low	High surface temperature	Vertical	Altered kaolinite, is b-axis disordered in Eocene/Oligocene weathering	Some solution of silica from quartz grains	Some iron liberated from biotite, not carried out of the granite so colours matrix. In areas of intense kaolinization mica/illite altered to kaolinite	-	Tertiary weathering mantle is source of material for ball clays and associated sediments

* Radiometric dates from Bray (1980), and Darbyshire and Shepherd (1985, 1987)

(Table 2.2) Main evolution and alteration stages of the St Austell Granite (after Bristow et al., in press)