C19 Cligga Head area

[SW 738 536]

Highlights

This classic site contains metamorphosed and mineralized metasediments adjacent to a small granite stock deformed to show an antiform-and-synform structure. The concentration of spectacular greisening, condensed W–Sn–Cu–Fe mineralization and kaolinization into zones is determined by this structure.

Introduction

Cligga Head is a classic site for the study of greisening, mineralization and kaolinization. Described by several authors in the last century, among whom were Conybeare (1817), Sedgwick (1820), Henwood (1838, 1843), De la Beche (1839) and le Neve Foster (1877), and then by Scrivenor (1903) and Reid and Scrivenor (1906), it is situated on the north Cornish coast between Perranporth and St Agnes, and consists of a small stock of altered granite and adjoining metasediments, the former being superbly exposed in section in the westerly facing cliffs (Figure 5.22).

The granite, together with the neighbouring St Agnes stock, rises from a northerly projection of the Cornubian batholith (Bott *et al.,* 1958; Toombs, 1977) and is composed of a coarse, poorly megacrystic granite (Dangerfield and Hawkes, 1981), but the presence of lithium mica makes it a Type-D granite (Table 5.1) of Exley and Stone (1982). This mica has been variously named by Hall (1971) as protolithionite, and by Stone *et al.* (1988) as lithian siderophylite; its presence suggests that the present granite evolved by metasomatic alteration of biotite granite (Hawkes and Dangerfield, 1978; Dangerfield *et al.,* 1980; Exley and Stone, 1982; Exley *et al.,* 1983; Manning and Exley, 1984; Stone and Exley, 1986, Hawkes *et al.,* 1987). Charoy (1981) considers the albite was derived from original oligoclase by hydrothermal alteration. There is disagreement as to the nature of the granite's southern contact (Moore and Jackson, 1977; Badham, 1980).

The granite has been deformed in a way not seen elsewhere in south-west England, and Moore and Jackson (1977) have related the distribution of alteration and mineralization zones to this deformation. Hall (1971) has described the nature of the greisening and Charoy (1979, 1981, 1982) has discussed the tourmalinization, greisening and kaolinization. From fluid-inclusion studies, Jackson *et al.)* (1977 have reported three phases of mineralization at temperatures below 400°C.

Description

Cligga Head itself and the westerly facing cliffs immediately to the south are formed of altered granite, which is part of an elliptical stock measuring roughly 600 m from north to south and 350 m from east to west. The westerly part has been eroded down to sea-level. As is usual in Cornubian granites, the concentration of megacrysts is somewhat variable, and those near the adjoining upper Gramscatho Group hornfelses are aligned approximately parallel with the margin. All visible contacts are steep, but while those in the north and east (seen in old mine workings) appear intrusive, that in the south is described as a fault by Moore and Jackson (1977), and as a stoped contact by Badham (1980). The hornfelses within about 30 m of the junctions are spotted.

The flat-lying joints of the granite constitute an antiform with a WSW-plunging axis about 350 m south of the Head and a synform to the south of this. The steep joints are often curved, some of them having developed into small faults. Zones of greisening are found along the walls of the primary joints and, where these are closely spaced, they merge to give pervasive greisening of the intervening rock, a feature well developed in the core of the antiform and also seen in the Cameron Quarry, St Agnes (discussed above). Hall (1971) lists Fe, Ca, F, B, Li, Mn, Rb, Sn, W and Zn as being enriched by this process, which extends as far as the southern boundary; and Na, Al, Ba, Cu and Sr as being depleted.

The mineral assemblage wolframite–cassiterite–arsenopyrite–molybdenite–mispickel, associated with a quartz gangue, also follows the joints, although some of the veins are transgressive. There are two intensely mineralized zones: one situated about 200 m south of Cligga Head (this is some 130 m wide) and the second at the southern boundary (up to 30 m wide). Iron staining is conspicuous in the vicinity of the latter. Zones of extreme kaolinization are also present in these areas, although the whole stock has been kaolinized to some extent. The adjacent 'killas' has also been affected locally by these processes.

About 100 m south of the spotted hornfelses of the southern contact, two narrow, steeply dipping outcrops of granite-porphyry con

Interpretation

The granite at Cligga appears, like that in the central parts of the St Austell mass, to have been a biotite granite which has been metasomatized. Apart from the lithium-rich nature of the mica, Charoy (1981) points out that the present albite has been derived from earlier oligoclase. This alteration is thought to have been brought about by a complex exchange process induced by a Li-and F-rich differentiated magma which substituted Na, Al and Li for Ca, Fe and Mg, as described in the 'Petrogenesis' section and under Tregargus Quarries. The Li-bearing mica now present has been identified as protolithionite (Hall, 1971; Charoy, 1981) or lithian siderophyllite close to zinnwaldite in composition (Stone *et al.,* 1988). The implication is that Type-E granite (Table 5.1), which brought about metasomatism, could be present in the batholith nearby.

As explained earlier in this chapter, the crystallization of the granite magma gave rise to hydrothermal fluids capable of causing metasomatism and producing pegmatites, aplites, metalliferous mineralization and eventually kaolinization. The origin of the water in these fluids was increasingly meteoric and decreasingly magmatic with time and they were associated with two periods of granite intrusion, at 290 Ma and 270 Ma BP. From the Li-rich nature of the Cligga Head Granite, it is evident that the mineralization here belongs to the second period and it therefore corresponds with the 'Main mineralization' described from the St Just area of Land's End by Jackson *et al.* (1982).

According to Moore and Jackson (1977) the development of the undulating 'floor' joints and subvertical joints and faults resulted from stress in a NNW–SSE direction, first synkinematically due to magmatic pressure and then cooling, and secondly, post-kinematically from the relaxation of stress, while Halls (1987) argues for a successsion of hydrothermal pulses. These controlled the distribution of both hydrothermal alteration and mineralization (Figure 5.22), the wide-ranging mineral assemblage indicating a condensed or telescoped sequence in which mineralized zones overlap instead of being separate, like that at Cameron Quarry but not to the same degree. The work of Jackson *et al.* (1977) led them to conclude that mineralization took place in three stages. The first was itself a two-stage process; the earlier, at a T_h range of 400–280°C, deposited cassiterite and wolframite and the later, with a T_h range of 320–240°C, deposited sulphides of Sn, Cu, As, Zn, Fe, Bi and Mo. The hydrothermal fluids involved were of low salinity (2–12 equiv. wt. % NaCl) and might also have caused the greisening. The second stage, post-faulting, resulted in quartz–hematite and quartz–pyrite–chalcopyrite assemblages from fluids with a T_h range of 260–210°C and a narrower range of low salinities (3–9 equiv. wt. % NaCl); and the final stage, leaving iron hydroxides, was effected at T_h of 150 to <70°C from fluids with salinities as low as 1–3 equiv. wt. % NaCl. Jackson *et al.* suggest that the minimum depth of formation of these deposits was 400 m, and that the last fluids might have played a part in the kaolinization process which, at similar temperatures, subsequently broke down the feldspar.

It is interesting that the salinities recorded by Jackson *et al.* (1977) are lower than those measured in the Main Mineralization of the Land's End area by Jackson *et al.* (1982) at 10–20 (and locally 40) equiv. wt. % NaCl, and that the depth of cover at 400 m minimum compares with 2800 for Land's End. Cligga Head Granite is a small granite, peripheral to the main batholith, and, as Jackson *et al.* (1982, Figure 2) suggest, salinities in the flanks of the intrusion tend to be lower than those in the main body. Jackson *et al.* (1977) do not date the later episodes of mineralization at Cligga but, by analogy with Land's End (Jackson *et al.,* 1982), they probably include Mesozoic and Cenozoic events.

Charoy (1979, 1981, 1982) has used the Cligga Head Granite in his studies of all three of the 'traditional' alteration processes in Cornwall. As regards greisening, he agrees in essence with Jackson *et as* (1977) about the temperature

and salinity of the altering fluids but, in addition, lays emphasis on the difficulties in drawing firm conclusions about processes and changes in areas where there has been repeated and successive alteration. While Hall (1971) was firm about the changes at Cligga Head, he also emphasized the difficulties in making comparisons. Charoy (1981) pointed out the importance of a shallow depth and relatively open physicochemical system in interpreting a complex site like Cligga Head. Charoy regards the tourmaline at Cligga as 'a true magmatic phase', unlike those at Porth Ledden and Roche Rock, which were a consequence of an unmixed, B-rich, late- or post-magmatic liquid giving rise to a secondary mineral. Kaolinization he regarded as a low-temperature continuation of the earlier hydrothermal processes, again agreeing with Jackson *et al.* (1977).

Conclusions

Like the St Agnes Granite, the Cligga Head Granite mass is a comparatively small projection from the Cornwall–Devon granite (the Cornubian batholith). The flat-lying joints in the granite show that it is folded and all the main joints have been affected by greisenization (see Cameron Quarry above). Cligga Head is an ideal location for the study of this process as well as metalliferous mineralization and kaolinization. The last process, the decomposition of the granite and the transformation of its feldspar crystals to the clay mineral kaolinite, was brought about by the action of the youngest and coolest of the fluids persisting from the magmatic phase which generated the granite. So here may be seen mineral veins with greisen borders and intervening zones of kaolinized granite. The full range of these phenomena, typical of south-west England, is available on this site.

[**References**](#)

The main structural elements of the Cligga Stock

Lithology and mineralization
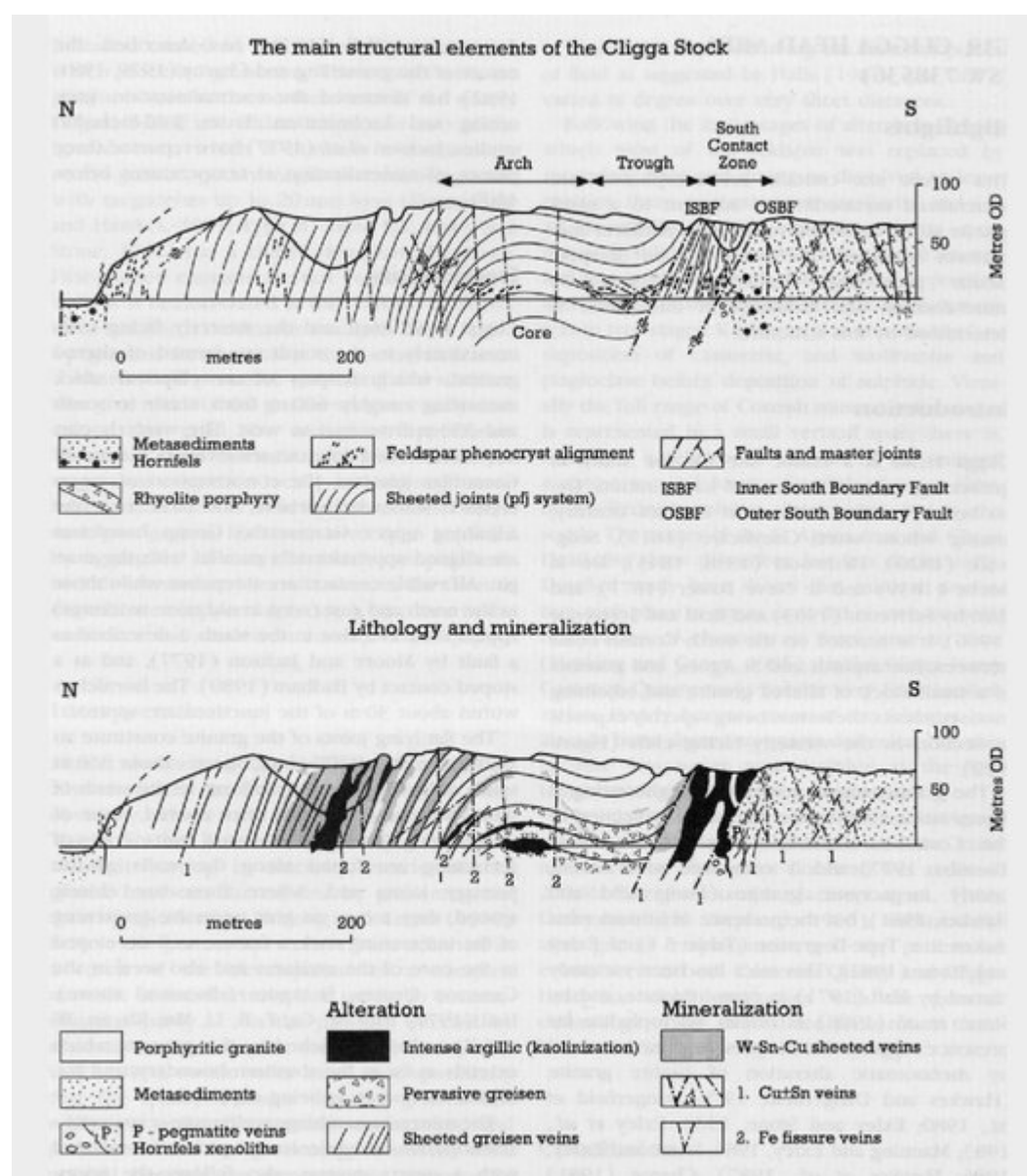
(Figure 5.22) Coastal section of the Cligga Head Granite, site C19 (after Moore and Jackson, 1977).

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_{30}-An_{50}, rims An_7-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 coarse 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 (3%)	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)