St Michael's Mount, Cornwall

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Introduction

The megacrystic granite of St Michael's Mount is a fractured cusp of the Cornubian Batholith. Indeed Hosking (1949) suggested that the mount may be the highest part of an undulatory granite ridge extending from Land's End to the Tregonning–Godolphin Granite masses.

The granite contains disseminated tin mineralization and is of considerable interest and importance, as the granite contains an abundance of sub-parallel, endogranitic greisen-bordered mineral veins (see (Figure 7.32)), rather similar to those at the Cligga Head GCR site. At St Michael's Mount the veins are excellently exposed over a wide area in a tidal-covered platform, thus providing exposure of the greisen veins and an opportunity to study the lateral and longitudinal (strike) mineralogical and chemical variation produced by the greisenization, and additional features of the post-consolidation alteration of the granite.

A detailed description of the nature and formation of the greisen-bordered veins has been provided by Hosking (1957). The results of a fluid-inclusion study were reported by Jackson and Rankin (1976).

Description

The granite of St Michael's Mount forms an island some 60 m high capped by an elegant castellated building (see (Figure 7.33)a). Although both the granite and veins contain cassiterite, it does not seem that the area has ever been exploited commercially, although it has been suggested that it was one of the legendary Phoenician sources of tin.

The contact between the granite and thermally metamorphosed Mylor Slate Formation metasedimentary rocks (now biotite-andalusite hornfels) is exposed in the foreshore around the northern side of the island. The granite forms most of the southern part of the island (see (Figure 7.32)). The junction between these major components is an east-west arc, which is concave towards the south. As the effects of thermal metamorphism die out between the island and the mainland it is probable that the granite dips steeply to the north.

Large numbers of granite-related veins penetrate into the slate (hornfels) (see (Figure 7.33)b). Excellent exposures of these can be seen in a more-or-less continuous rock outcrop on the eastern side of the island in line with a small fortification, just above the foreshore. Although large numbers of veins can be seen to cut the quartz-rich hornfels at this rock outcrop, greisenization has not occurred. Several small aplitic and pegmatitic bodies are developed close to the granite contact. Within the western part of the rock platform, parallel pegmatitic veins are cut by some of the greisen veins; in these areas the feldspars have a rough comb-layered texture. Similar comb-layered feldspar-rich veins can be seen at low tide in the beach section of the Priest's Cove GCR site, at Cape Cornwall.

The pegmatitic veins arc later than the joint system in the granite but earlier than greisenization and mineralization.

The granite is a megacrystic K-feldspar variety with muscovite as the main mica, although biotite increases to the south of the outcrop. Plagioclase is said by Moore (1977) to be about An_{12} (albite–oligoclase). There is very little evidence of post-magmatic alteration, although the granite carries abundant tourmaline and some accessory topaz, fluorite, zircon, apatite, and cassiterite. Cassiterite is most highly concentrated in the west-central portion of the granite platform where veins are most numerous and greisenization most intense.

The swarm of roughly parallel, east-west (20° to the north of east) quartz veins cut the granite, which is altered to greisen on either side of the veins. Some of the greisen structures are up to 1 m in width and may contain several quartz veins. The veins sometimes diverge and then coalesce, sometimes forming large patches of massive greisen. The greisen areas usually consist of quartz, sericite, muscovite, topaz, tourmaline, apatite, Li-mica and cassiterite. The veins are mineralized, and black plates of wolframite, with some cassiterite, can often be seen in the central vuggy parts of the veins. In a few places green secondary copper minerals can be seen to be disseminated in the greisen as well as in the vuggy quartz veins (good examples of copper-carrying veins can be seen below the small gated entrance to the foreshore). In many areas the greisen and quartz veins stand out above the surface (sometimes up to a few centimetres), due to the greater resistance of the veins to erosion in comparison to the granite. The greisen veins can be seen to coalesce, and in places intersect and also open and taper. Hosking (1957) presented a detailed study of the morphology of the veins. Sometimes a vein, perhaps 25–50 mm, shrinks rapidly to only a few millimetres and then 1 m along strike opens up again to its original width. Hosking (1964) presented sketches of the vein types exposed in the wave-cut platform exposures.

Metalliferous minerals recorded in the veins include cassiterite, stannoidite, wolframite, chalcopyrite, arsenopyrite, löllingite and varlamoffite, the latter being an alteration product of Sn sulphides. Gangue minerals are mostly quartz along with tourmaline, topaz and apatite. However, detailed inspection of the veins shows considerable variation in the amounts of the various minerals present such that there may be phases of infill of the veins (or fissures) with changing compositions to the infilling fluids over time. Unlike most of the greisen at the Cligga Head GCR site, the mineral veins may not be centrally disposed with respect to greisenization and may not occupy the same fractures. A different timing is inferred for phases of vein infill.

Hosking (1957) considered that the distribution characteristics of the minerals in the veins are of considerable importance when attempting to provide a formation model. For instance the narrow portions of some of the veins may often be very rich in relatively coarse mica at the expense of quartz; such mica may be early and formed along narrow micro-fractures, which are eventually widened and greisenized. Topaz crystals, rarely more than a few millimetres In length, also occur in the narrow vein areas.

Feldspar tends to become more common as the vein systems are traced from east to west. Also in places throughout the development feldspathization and mica enrichment of the greisen have taken place. Virtually all the vein feldspar is orthoclase.

Interpretation

The St Michael's Mount Granite can be equated with a type-D granite (Exley *et al*., 1983) similar to that at the Cligga Head GCR site, although it is somewhat less metasomatized. The greisen, when compared to that at Cligga Head, contains higher concentrations of Li, F, and P (Hall, 1971; Moore, 1977). The processes that have taken place are similar to other areas of greisen-bordered veins, but the nature of the fissure 'plumbing system' and evolution of the ascending greisenizing and mineralizing fluids warrants further study.

The formation of systems of parallel greisen lodes in the granites of South-west England was discussed by Halls *et al.* (1999), while the influence of fluid pressure in governing fracture geometry and mineral textures was presented by Halls *et al.* (2000).

A general interpretation is as follows:

1. on consolidation of the granite, open fissures were developed (linked perhaps to regional stress, contraction associated with cooling of the granite, or varying gas pressure);
2. solutions then ascended along these fissures, depositing quartz, cassiterite, wolframite and other phases. At about the same time as the minerals were being deposited within the fissures, the adjacent granite was being converted to greisen.

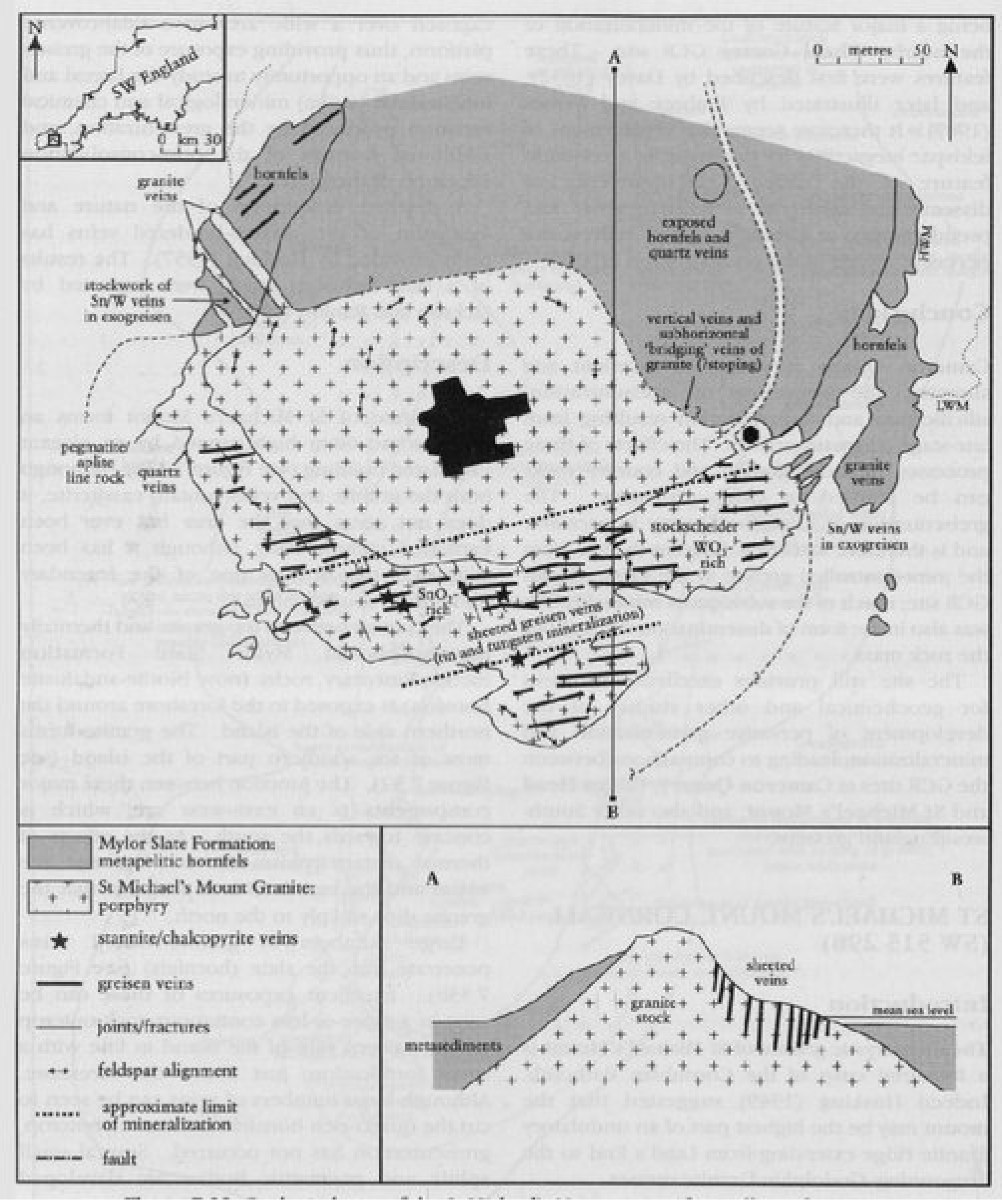
Detailed studies by Hosking and others have, however, suggested that such an interpretation is too simplistic and does not take into account many relevant features, including the greisen-vein relationships, the shapes and nature of the veins, and the varying distribution of the minerals composing the veins.

During the early phases of granite emplacement the adjacent country rocks were thermally metamorphosed and a few quartz-tourmaline veins were developed in them. At about the same time poorly developed pegmatitic and aplitic bands developed in structural traps, while a later magmatic differentiate formed a fine-grained granite, containing feldspar phenocrysts (Hosking, 1964). This stage was followed by the formation of simple, vein-like, feldspar-rich pegmatites, which are usually parallel to the later hydrothermal and/or pneumatolytic veins. Towards the end of the pegmatitic phase mineralizing agents migrated along a series of vertical fissures, and converted the granite to greisen for an equal distance on either side of the fissure passageways. Eventually the micro-fissures along which the greisen-forming fluids passed were further used by mineral-forming fluids. In time a succession of other fissures within the greisened areas and also in the greisen-free granite were opened up and filled. Mineralization may have formed veins by replacement or by the thrusting apart of walls of microfractures. Reactions may have converted the original greisen textures and mineralogy, such that veins became feldspar- and mica-rich areas along with some tourmaline development. A more-or-less final stage of fissure infill gave rise to a mineralogical assemblage of mica, apatite, topaz and quartz, and a large number of replacement veins consisting essentially of quartz. After this a succession of new fractures was initiated, largely in the greisen but also in the granite and hornfels, which are generally wider vein structures, containing much of the cassiterite, wolframite and copper-bearing sulphides.

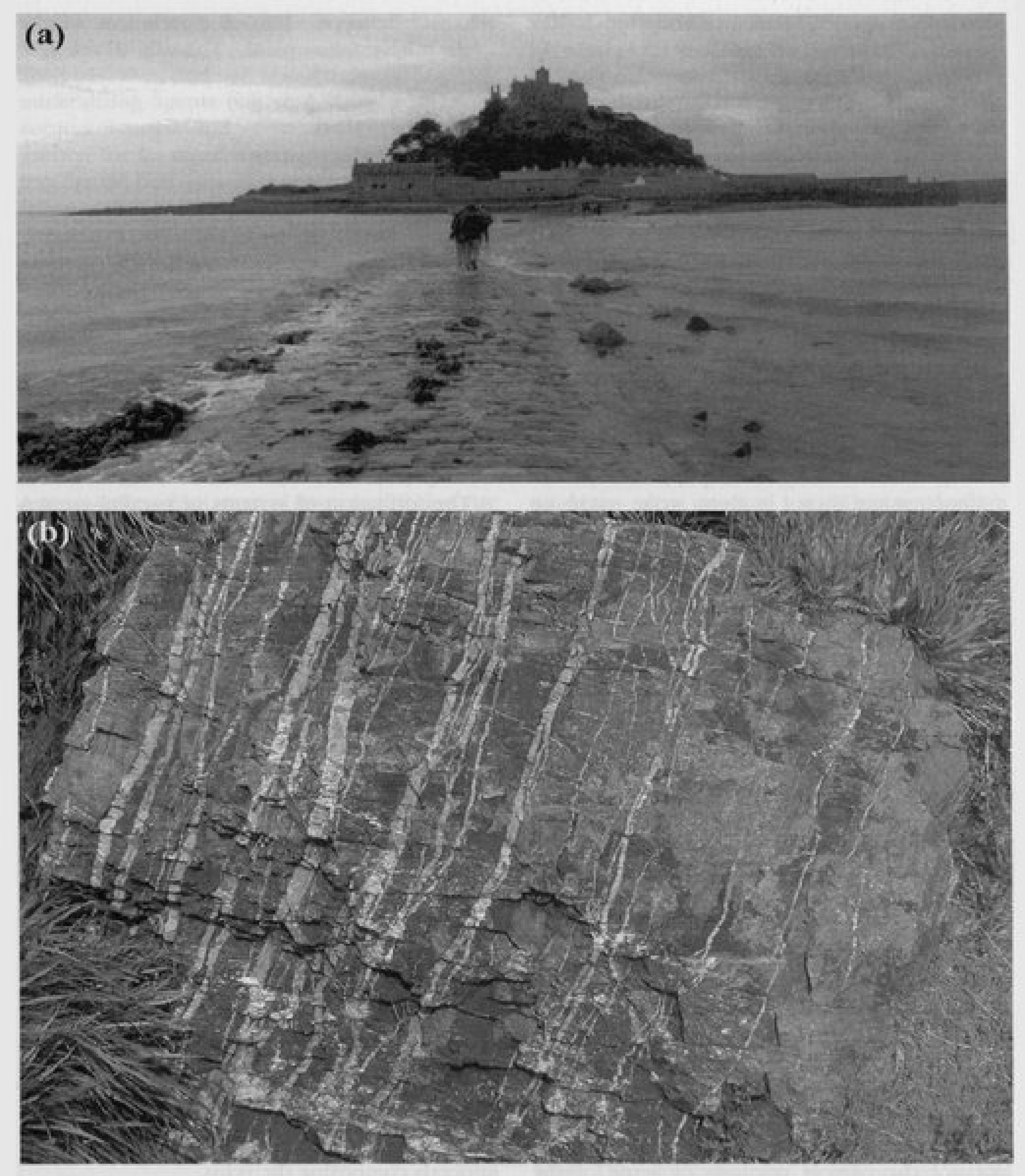
Conclusions

The St Michael's Mount GCR site provides excellent exposures of endogranitic greisen-bordered mineralized veins in a wave-cut platform. These exposures exhibit the variation in chemistry and mineralogy of the greisenizing process along and across the veins. Comparisons can be made with other greisen-swarm areas of South-west England, for example at the Cligga Head and Cameron Quarry GCR sites.

References



(Figure 7.32) Geological map of the St Michael's Mount area. After Halls el al. (2000).



(Figure 7.33) (a) St Michael's Mount causeway from Marazion. (Photo: Natural England.) (b) Veins cutting through slate, St Michael's Mount. (Photo: M. Murphy, Natural England.)