EVIDENCE OF TIN AND TUNGSTEN MINERALISATION IN THE ISLES OF SCILLY

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A northeast/north-northeast trending zone at the northern margin of the Isles of Scilly is examined for evidence of cassiterite mineralisation. Cassiterite is recorded at a historical locality and also on two more islands within the group. *In-situ* cassiterite mineralisation is recorded at two otherwise unrecorded localities: one on the north-west of Tresco and one on Bryher. Wolframite, cassiterite and apatite are identified at White Island (St Martin's).

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INTRODUCTION

The fieldwork was initiated in 1979 following a discussion between one of the authors (C. W. Smith) and the late Roger Penhallurick, then assistant curator at the Royal Institution of Cornwall, which led to confirmation of early records of the presence of cassiterite on the Isles of Scilly, (Penhallurick, 1986). Desk study of reports by previous workers and, more recently, reference to satellite mapping data, suggested to the authors that a narrow zone, in the northern part of the islands should be the first area to be studied in detail. For practical reasons, this study commenced with Tresco, then moved to White Island (St Martin's) and finally Bryher. This report therefore does not look at any of the more southerly areas of the islands, further fieldwork being necessary before that area is reported on.

PREVIOUS WORK

Geology

The Isles of Scilly lie approximately 45 km west-southwest of mainland Cornwall (Figure 1) and contain five major and more than fifty minor islands and islets. The bedrock is granite of the Isles of Scilly pluton, whose geology has been described by a number of writers (Majendie, 1814; Carne, 1850; Barrow, 1906; Osman 1928; Jones 1962, Hawkes *et al*., 1986; Stone and Exley, 1989; Mullis *et al*., 2001). A high precision U-Pb monazite date of 292 Ma, assumed to be close to the emplacement age, was obtained from Peninnis Head on St Mary's and the same sample yielded an Ar-Ar mica cooling age of 287 Ma (Chen *et al*., 1993). As such, the pluton is considered, like Carnmenellis and Bodmin Moor, to represent relatively early stages in batholith construction (Chen *et al*., 1993).

Barrow (1906) identified two main granite types within the pluton. Osman (1928) subdivided the pluton into four distinct units. Jones (1962) whilst studying the accessory minerals returned to describing the pluton as being made up of two main granites, G1 an outer zone of coarse-grained granite and

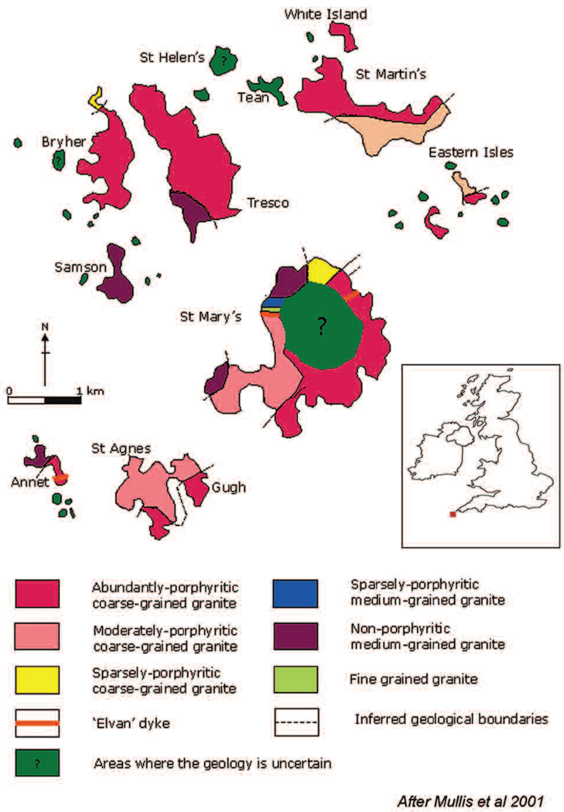


Figure 1. *The distribution of the textural variations in the Isles of Scilly granites (after Mullis et al., 2001).*

G2, a medium-grained granite in the central part of the pluton. Hawkes and Dangerfield (1978) reassessed some of the South-West England granites and proposed a series of three main granite divisions with two sub-divisions based on textural grounds. Subsequent work by Dangerfield and Hawkes (1981), following further study of the Isles of Scilly, Carnmenellis and Bodmin Moor granites, led to the use of the identifier term 'Gm' granite to delineate a small megacrystic variant of the coarse-grained granite classification of Hawkes and Dangerfield (1978). Mullis *et al.* (2001) re-examined the mineralogical and textural variations within the granite and a modified map of their interpretation of the bedrock geology of the islands is shown in (Figure 1).

Pleistocene

Whitly (1882), Barrow (1906), Mitchell and Orme (1967), Hawkes *et al.* (1986) and Scourse, (1991, 2006) have all reported on the superficial geology of the islands. Barrow (1906), Mitchell and Orme (1967) and Scourse (1991) have all recorded the southern limit of glacial processes to be at the northern margins of the Isles of Scilly. The only locality in the present study at which part of the Pleistocene succession was recorded was to the southeast of Piper's Hole (Figure 4).

Structural influences, greisenation and veining

Dangerfield and Hawkes (1981) noted that the Gm granites of the Bodmin Moor granite and the Isles of Scilly granite were variably foliated. In respect of the Isles of Scilly granite, it was noted that: "*Foliation is more pronounced on some of the Scilly Isles. ... traced intermittently from White Island near St Martin's to North Bryher. The strike of this foliation is broadly E-W, paralleling the presumed granite boundary and the dip is variable. ... A similar structure developed along a greisen line near Gimble Point, Tresco ... strikes about 065° and dips 45° south east*".

Hawkes *et al.* (1986) further refer to mineral veining thus: "*Perhaps the largest structure appears at Gimble Point ... coursing ENE across the northern tip of Tresco and dipping at about 45° SSE. It takes the form of a persistent, although in places braided quartz-vein containing tourmaline*".

In the vicinity of Piper's Hole, Tresco, this structure appears as a series of steeply dipping quartz-tourmaline veins with a sheeted vein appearance (Figure 2).

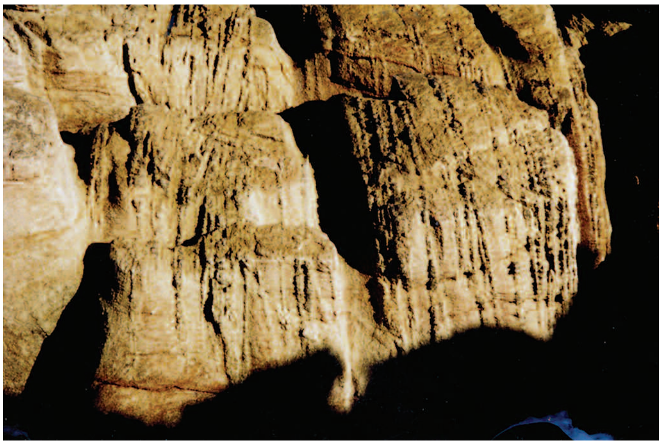


Figure 2. *A view looking approximately northeast across the inlet of Piper's Hole showing the sub-vertical foliation of the granite. The quartz-tourmaline veins are, in general, 5 to 15 cm apart.*

Mineralisation

Borlase (1756) described the line of costean pits at the northern part of Tresco, and Barrow (1906) "*supposed that some of these must have contained a little tin*" and then, in describing the granites, referred to "*small veinlets of typical peach and schorl rock*" at the north end of Tresco. Osman (1928) compared the aplites, pegmatites, quartz-tourmaline veins and greisens of the islands with similar features in the Dartmoor granites. He also made particular reference to the quartz-tourmaline veins of Tresco. Dollar (1957) additionally noted the presence of quartz-porphyry dykes. Hawkes *et al.* (1986) noted that of the dykes and sills that cut the marginal granites, some had pegmatitic borders. They also record the presence of both greisens, some with reddening of the associated granite, and quartz-tourmaline veins in "*most reasonably extensive granite exposures*".

Dangerfield and Hawkes (1981) suggest that the schistose zone interpreted by Barrow (1906) as part of a roof pendant is in fact a schistose granite with late stage quartz and tourmaline. Mullis *et al.* (2001) suggest that most of the predominant joint sets have quartz tourmaline filling possibly associated with magmatic or magmatic hydrothermal fluids during the early cooling history of the granite.

Field data

Field data from the northern areas of Tresco, White Island (St Martin's) and Bryher were recorded from localities identified in Figure 3.

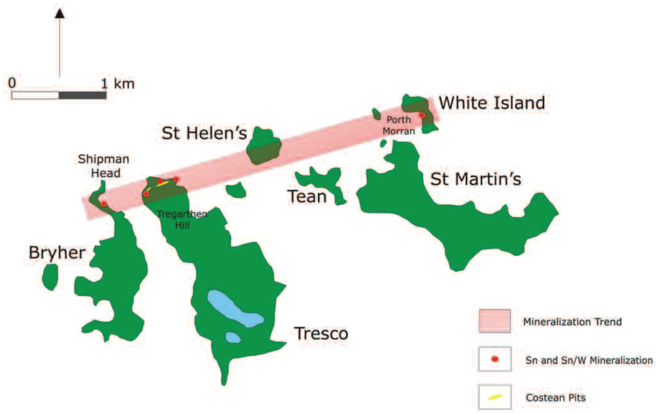


Figure 3. *The location of tin/tungsten mineralisation, costean pits and suggested mineralisation trend on Tresco, White Island and Bryher.*

From Tresco

Cassiterite, in both iron-stained coarse-grained granite and coarse-grained albitised granite, is found both within the head and as loose clasts in an exposure below the cliff edge to the southeast of Piper's Hole (Figure 4). At the same locality in beach debris, a float stone (Figure 5) found lying on the upper eroded surface of a series of quartz-tourmaline veins (Figure 2) within the exposed granite to the east of Piper's Hole contains cassiterite and minor blue tourmaline within a thin quartz vein. Angular cobbles of coarse-grained granite with cassiterite in quartz-tourmaline veins were found in the material lying on the beach below the exposed head (Figure 4) together with well rounded cobbles and pebbles of flint, red sandstone and some metasediments. No cassiterite was found in either the loess or in the upper head at this locality. The quartz-tourmaline veins referred to above and shown in Figure 2 are oriented approximately east-northeast and are aligned parallel to the major lineaments visible in the satellite image (Figure 6) of the northeast corner of Tresco. On the vegetated surface to the north of the east-northeast trending line of costean pits, an angular cobble of very fine-grained cassiterite in a quartz/blue tourmaline matrix was recorded in 1988 by Geoff Treseder of Pendeen (pers. comm.). On the western side of the island, to the south of Gimble Point, a series of "*in situ*" quartz tourmaline veins dip southeast at about 52°. Noted by Hawkes *et al.* (1986), these veins were found to contain fine-grained brown cassiterite in a quartz-tourmaline matrix immediately adjacent to barren quartz. This *in situ* cassiterite was found in a specimen (Figure 7) at the western extremity [SV 8814 1624] of the line of costean pits (Figures 3 and 13).

Figure 4. *An exposure to the southeast of Piper's Hole, where the geology pick head is at the horizon in the lower head from which angular clasts of granite with cassiterite in quartz-tourmaline veins have been recovered. No cassiterite has been noted or recovered from either the loess or the upper head. The beach deposits below the lower head contain angular granite cobbles with quartz-tourmaline-cassiterite veinlets. Glacially derived flint, red sandstone and metasediments are also visible in the beach debris.*

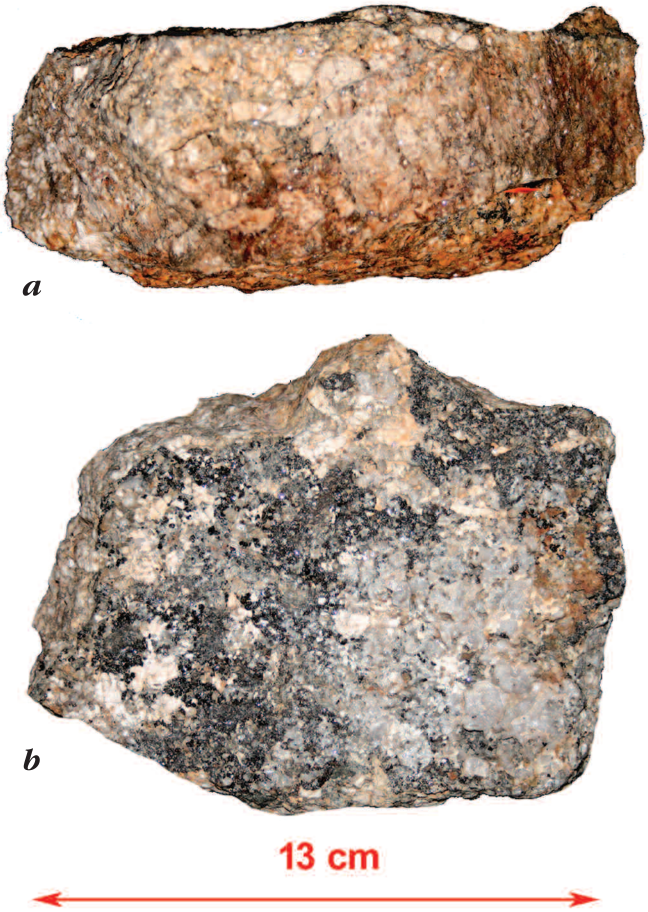


Figure 5. *(**a**) An angular iron-stained granite cobble with an upper surface showing a thin dark line of cassiterite and tourmaline found on top of the eroded surface to the southeast of Piper's Hole inlet and typical of this locality. (**b**) View of upper surface where most of the black area is cassiterite with fine tourmaline, the light grey areas are quartz and the cream-coloured areas are feldspars.*

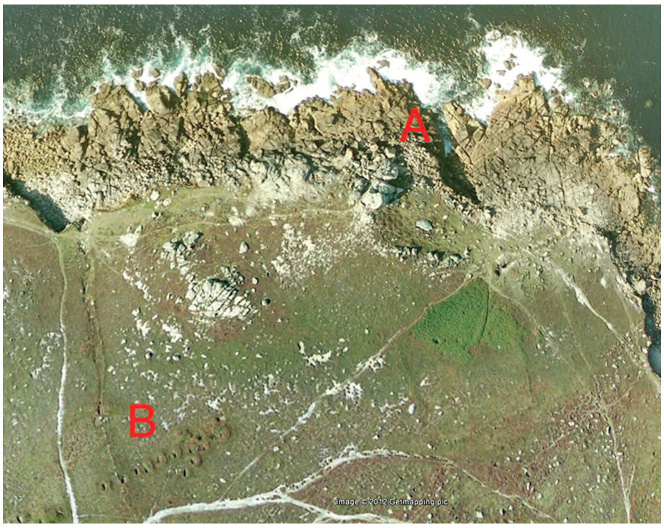


Figure 6. *Aerial view of the northeastern part of Tresco showing Piper's Hole inlet at A with clear northeast lineaments immediately to the east on a surface where the angular cobble in Figure 5 was found. Part of the line of costean pits at B clearly follow the same trend.*

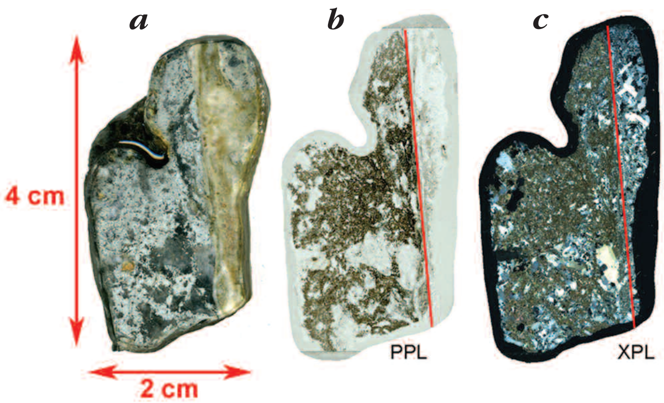


Figure 7. *Scanned images of a clast from a quartz-tourmaline and cassiterite vein in the westernmost costean pit [SV 8814 1624] near Gimble Point, Tresco. (**a**) A cut and ground flat surface after staining with zinc powder and hydrochloric acid. The cassiterite appears as the silvery grey area on the left. (**b**) Thin section in plane-polarised light. The vertical red line shows the approximate boundary between the cassiterite on the left and barren quartz on the right. (**c**) Thin section in cross-polarised light.*

From White Island (St Martin's)

Large cobbles of porcellanous quartz were found within the intertidal zone on the beach at Porth Morran [SV 9242 1744]. Most cobbles were sub-rounded and the appearance of these cobbles suggested a pegmatitic origin. Whilst in some cases cobbles exhibited either coarse cassiterite (Figure 8) or coarse wolframite (Figure 9), some cobbles exhibited coarse cassiterite and wolframite together. One cobble contained shear zones of mylonite or sheared aplite with associated anhedral crystals of apatite together with blebs of fine tourmaline with muscovite mica (Figure 10). Unfortunately, tidal constraints precluded the identification of any of this material '*in situ*', although areas of pegmatite have been noted in large angular boulders (Figure 11) at the north-eastern corner of the causeway between White Island and St Martin's. At the same location, both coarse-grained granite and fine-grained granite '*in situ*' were visible and their relationship may be seen (Figure 11). Schists and/or sheared greisenised granites in this area have been noted by other workers (Dangerfield and Hawkes, 1981; Hawkes *et al*., 1986), whilst Mullis *et al*. (2001) described the textures and relationships of the granites in this complex area. Quartz-tourmaline veins traverse the area to the north of Porth Morran (Figure 12) and may be related to shearing described by earlier writers (Barrow, 1906; Osman, 1928; Hawkes *et al*., 1986; Mullis *et al*., 2001).

Figure 8. *A quartz cobble from White Island with coarse cassiterite. The lighter brown cassiterite is the predominant dark mineral visible, and the very slightly darker mineral to the lower centre of the photograph is mostly fine tourmaline. The underside of this cobble has cassiterite and fine tourmaline together, and the lens of cassiterite traversing the upper part of the cobble continues through to the rear.*

Figure 9. *A quartz cobble from White Island with coarse wolframite. Coarse black wolframite is visible in the upper part of the photograph. The lower black line and the under surface of this cobble are zones of sheared granite/greisens. The underside of the cobble is part of a mylonitic zone and has small spots of apatite distributed throughout.*

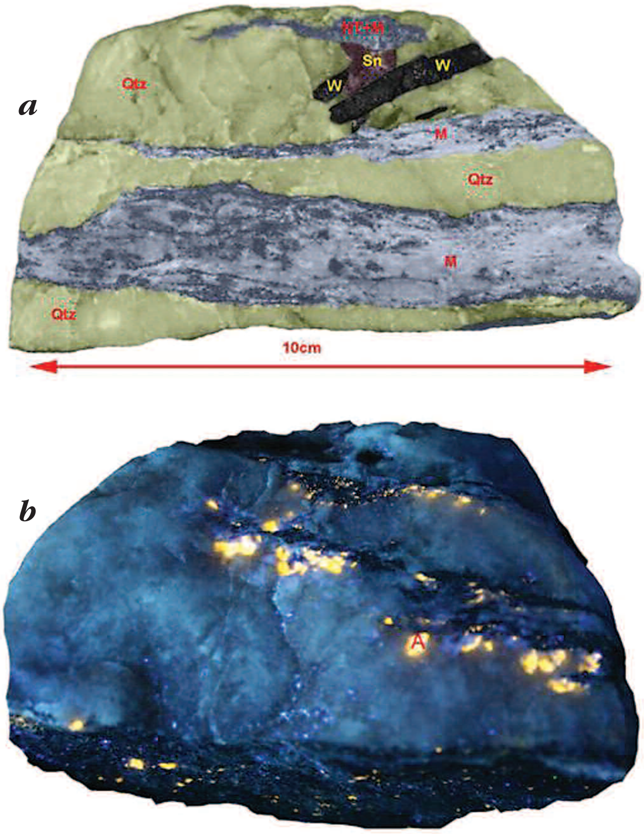


Figure 10. *A predominantly quartz cobble from White Island containing different minerals. (**a**) A face of the cobble after the image has been manipulated to accentuate different minerals present. Cassiterite, wolframite, bulk quartz, mylonitic material and needle tourmaline with muscovite mica are labelled Sn, W, Qtz, M and Nt+M, respectively. Two grains of apatite may be seen as pale cream areas top left and top right of the central quartz band. (**b**) The same cobble illuminated with short-wave ultra-violet light, rotated 120° clockwise and tilted so that the top is away from the viewer. It can be seen that apatite (fluorescing bright yellow) is closely associated with the mylonitic zones.*

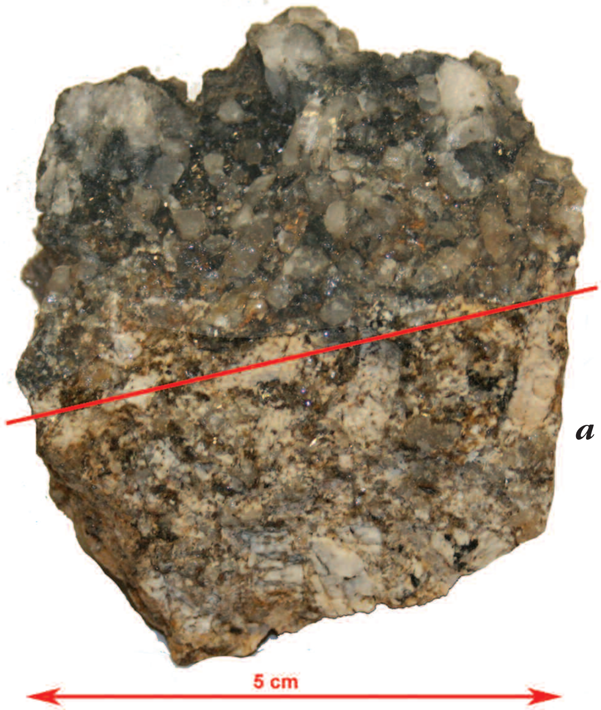
From Bryher

Cassiterite was found *in situ* to the south of Shipman Head [near SV 8760 1608] within the eroded upper surface of a series of parallel quartz-tourmaline veins trending northeast and dipping approximately 60° to the southeast (Figure 13). The cassiterite mineralisation appears to be confined to thin veins of quartz-tourmaline and muscovite mica in a coarse-grained porphyritic granite (Figure 14). At this locality, the cassiterite crystals are coarse, up to *c*. 1.5 mm, euhedral, adamantine, twinned and intergrown. Whilst on both Bryher and Tresco, the granites are of similar grain size, both containing orthoclase crystals up to *c*. 12 mm in length, there does not, on Bryher, appear to be any of the iron staining or albitisation that is notable at Piper's Hole on Tresco.

Figure11. *Lens of pegmatite in a large angular granite boulder at the northeastern end of the causeway between White Island and St Martin's. The 6-inch rule is a scale indicator. The close association between coarse- and fine-grained granites is evident in the upper right hand corner of the photograph.*

Figure 12. *Northeasterly trending quartz-tourmaline vein in coarse-grained granite at the northern end of Porth Morran beach. The rule, opened out to 12 inches, indicates scale.*

Figure 13. *Aerial view of the northern part of Bryher and northwestern part of Tresco. Cassiterite was found in situ on Bryher at A [SV 8760 1608] and on Tresco at B [SV 8814 1624]. The northeasterly trend of the lineaments can be seen on Shipman Head and also in the inlet to the northeast of Gimble Point. The dark mark to the north-east of point B is the largest of the 17th/18th century excavations for cassiterite (Penhalurick, 1986). Images of cassiterite from A are shown in Figures 14. Images of cassiterite from B are shown in Figure 7.*



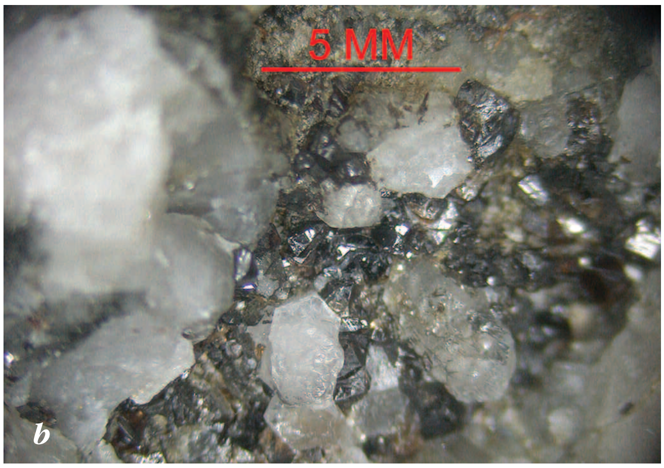


Figure 14. *(**a opposite**) A small clast of quartz-tourmaline-cassiterite vein on a granite substrate. The upper part of the image above the red line is the quartz-tourmaline-cassiterite vein. Below the red line is the coarse granite where the vein has broken away. (**b above**) A 15 mm wide close-up of part of Figure 14. Some small books of muscovite mica are just visible adjacent to the quartz crystal (lower centre). Most of the very dark brown mineral is cassiterite, euhedral, twinned and sometimes fractured. Tourmaline occurs in occasional elongated needles.*

Discussion

The present paper was prompted by a discussion more than 30 years ago about the existence, if any, and thereafter, the extent of cassiterite mineralisation in the Isles of Scilly. With *in situ* cassiterite noted, the discussion turned to the possible extent of any existing mineralisation up into the sedimentary cover prior to denudation. A slab of metasedimentary rock on the northern tip of White Island recorded by Barrow (1906) and more recently reassessed by a number of workers (e.g. Mullis *et al.*, 2001) cannot be used to give any guide to the position of the current erosion surface in relation to the overlying contact between the granite and its host rock. Therefore, so far, it is not possible to make any meaningful estimate of the vertical extent of the original Sn/W zone but, based on evidence from other Cornish plutons, it would be surprising if there had not been mineralization extending up into the sedimentary cover at whatever palaeo-elevation that occurred. The extent of such mineralization has to remain conjectural.

Should there have been significant cassiterite prior to denudation and then inundation, any significant eluvial/alluvial cassiterite would have been carried down the steep northern slope onto the area below the current 40 metre depth contour. Some beach pebbles and cobbles near Piper's Hole would appear to be of glacial origin, whereas the granitic cobbles are angular and derived from the lower head. The quartz cobbles bearing cassiterite and wolframite found at White Island are not primary in origin. However, the sub-rounded appearance of the cobbles is not so significant as to suggest a transported origin. Further fieldwork will be necessary to establish the primary source.

Conclusions

In the present study, sporadic reports of cassiterite on Scilly over the last two and a half centuries have been confirmed and *in situ* mineralisation has been recorded. Tungsten mineralisation has also been shown to be present. A weakly mineralized Sn/W zone is postulated as being located over the northern extremities of Bryher, Tresco and White Island. Studies are now required on Tean, St Helens, Northwethel and Scilly Rock. Greisens, located by Barrow (1906) and since reassessed by later workers, need to be re-examined to establish their Sn/W content, if any, and their gross mineralogy. The wolframite found on White Island will require further analysis to determine its mode and source of origin. The Isles of Scilly pluton with its north-east/north-northeast trending mineralised zone at the northern margin conforms in general terms with those of Carn Brea and Bodmin Moor, although, so far, the concentration of the Sn/W mineralization found is very much weaker.

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