5.6 Birch Tor / Vitifer Mine

Highlights
- Ancient tin mines worked opencast and underground
- Distinctive quartz-tourmaline-cassiterite-specular hematite mineralisation.

Geographical Coordinates **OS Grid Reference** SX 679 810

Access Moorland site with uneven ground. Sturdy, waterproof shoes required. Hazards include uneven ground, steep and vertical rock faces and mine workings including open shafts and water wheel pits. In summer, the vegetation is high with much bracken: there is a particular risk of tick bites and the associated risk of contracting Lyme Disease. It is sensible to avoid wearing shorts at this locality and to make use of suitable insect repellents. Not advisable for people with mobility issues or impaired vision.

Distance to walk 2 km **Elevation changes** 40 m **Time** 1 ½ - 2 hours

Conservation status National Park – No hammering, drilling or sample collection.

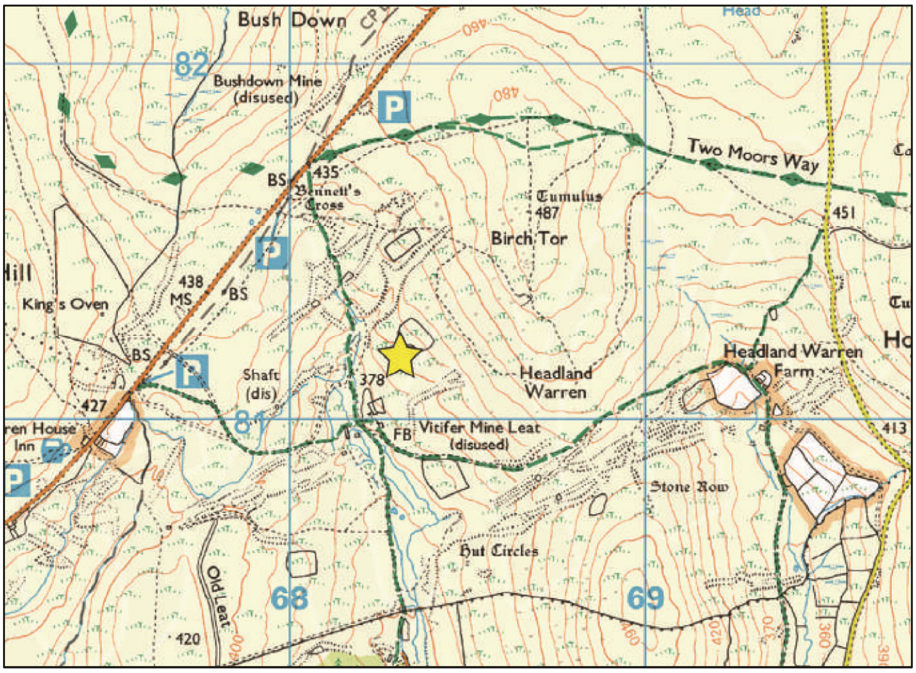

Figure. 5.14 Location map for Birch Tor / Vitifer Mine. © Crown Copyright/database right 2014. An Ordnance Survey / EDINA supplied service.

Directions

This site is located in central Dartmoor, close to the B3212 road from Moretonhampstead to Princetown, in the parish of Postbridge. Parking is on the road close to the Warren House Inn.[SX 674 809}. An unmetalled track into the workings leads off from the B 3212 about 200m E of the Warren House Inn. The excursion will visit the surface workings on Wall Lode (Figure 5.15a) where wall rock sections and waste dump material is available for examination..

Geology

The Birch Tor and Vitifer mining complex is sited around a swarm of tin-bearing hydrothermal veins covering an area of about 15 sq km in the high ground of the central part of the Dartmoor Granite. It lies at a mean elevation of about 370m above sea level and extends along a 3km wide belt trending NE-SW with its centre at Birch Tor (NGR SX 687 814). Mining activity in this district was abandoned some eighty years ago and the principal evidence of the activities of the miners are the large, trench-like openworks that scar the open moorland (Figure 5.15b). The period at which the earliest working took place is not recorded, but it is supposed that the veins were located by the medieval tin streamers in tracing placer deposits to their source. From then onwards the lodes were exploited first by opencast mining, which probably reached a peak in the 16th century, and then by underground development in the 18th and 19th centuries. In modern times the complex was worked as a number of separate mines, the principal of which were Birch Tor and Vitifer, East Birch Tor and Golden Dagger mines. Working in the present century was on a small scale and ended with the closure of Golden Dagger Mine about 1930.

The country rock in which the veins occur is coarse-grained biotite granite with prominent large perthite megacrysts which commonly exhibit some evidence of preferred orientation. The groundmass is formed of coarsely crystalline quartz, K-feldspar, plagioclase and biotite. Muscovite is a minor constituent and appears to be of secondary origin. Accessory minerals include zircon, garnet and ilmenite. Tourmaline is present as isolated grains of schorl, brown in thin section, and as skeletal aggregates intergrown with quartz.

Veins and sills of microgranite (aplite) are extensively developed in the district. Aplite sills are a particular feature of the Golden Dagger and Birch Tor mines, where they are exposed in the workings. Typically, these rocks are pink in colour and consist of a fine-grained equigranular fabric of K-feldspar, albite and quartz, with minor muscovite, and aggregates of tourmaline (Figure 5.15c). Apatite is a very common accessory mineral in many examples. The tourmaline aggregates are formed of skeletal aggregates of schorl (mostly brown in thin section) intergrown with quartz and some accessory rutile. They are commonly rounded in form and may measure several cm in diameter, with a selvedge of orthoclase. Such aggregates may be present in great numbers in parts of the aplite sills, to an extent which gives exposed surfaces a mottled appearance (Figure 5.15d). Pods and irregular masses of K-feldspar-tourmaline-quartz pegmatite are also present in the aplite sills, but are small and not common.

The principal veins vary in strike around ENE-WSW and dip northwards at steep angles, commonly between 75° and 85°. Branch- and cross-veins are common and a predominant strike direction shown by the minor veins, which are seldom traceable at outcrop for more than 200m, is around NW-SE. Barren N-S trending 'crosscourse veins' cut the earlier tin-bearing veins but do not give evidence of major displacement. There is abundant evidence of tectonic movement of the fractures throughout deposition of the lodes. Brecciation is common and at several localities vein debris consists of wallrock and veinstone fragments in a ferruginous clayey fault gouge. Vertical and horizontal slickensides are common on the vein walls in the accessible underground workings, with the former predominating.

Examination of the workings has demonstrated that in many cases the lines used to plot the course of lodes on maps and plans in fact represent the generalised trend of zones of mineralisation, each carrying a swarm of irregular and discontinuous veins rather than a single structure. MacAlister (1909) describes the local occurrence of stockwork-like orebodies and states that in other places (citing the example of Lean's Lodes) massive quartz-filled veins of considerable width are present. Individual veins pinch and swell, exhibiting considerable variation in width over relatively short strike lengths. Tin-bearing orebodies are narrow and patchy: underground sections indicate an average vein width of about 0.50m rising to a maximum of perhaps 2.00m (Figure 5.15e).

The mineralogy of the veins is comparatively simple; cassiterite is the only ore mineral, occurring in a gangue of quartz, tourmaline, hematite and chlorite. Sulphides, apart from rare traces of pyrite, are absent: this is a feature of many of the lodes of the Dartmoor Granite apart from those sited near the contact.

Cassiterite occurs within the veins as aggregates of dark reddish-brown crystals commonly intergrown with quartz and tourmaline. In thin section it exhibits striking yellow and reddish-brown colour zoning and in texture is generally euhedral, though some fracturing of the crystals is evident.

Tourmaline is present in great abundance and in a variety of crystalline forms. The earliest phases of this mineral are associated with the aplite bodies described above. Tourmaline is the predominant early gangue mineral, occurring as impregnations in the wallrocks and in the veins as aggregates of prismatic or fibrous crystals which form dense felted or radiating intergrowths (Figure 5.15f). The earliest generation of vein tourmaline appears to have been the result of hydraulic fracturing and the controlled release of hydrothermal fluids, This stage is much broken up by later tectonic movements and is most commonly seen as brecciated masses enclosed by later mineral phases, when the tectonic environment became extensional. Later tourmaline is intergrown with quartz and is commonly more coarsely crystalline. In thin section the tourmaline associated with cassiterite is greenish-blue to deep blue in colour and basal sections, particularly of the later generations, show well-developed colour zoning.

Hematite is present in the specular, earthy, and more rarely, reniform varieties, but it is the occurrence of specular hematite in unusually large quantities which has attracted earlier attention (MacAlister, 1909). Typically, this mineral forms coarse-grained aggregates of splendent platy crystals in intergrowth with quartz or chlorite. It also occurs as disseminations in the wallrocks close to the veins. Chlorite, as fine-grained, green and greenish-grey masses locally accompanies hematite as a vein mineral and is also disseminated in the wallrocks. Quartz was deposited throughout the mineralisation sequence and is a major constituent of the lodes. It is particularly abundant in their central zones together with minor earthy hematite and clay minerals, and represents the latest part of the fracture filling. This late quartz is commonly very coarsely crystalline and vuggy, with individual crystals showing concentric zoning marked by changes in the density of inclusions.

Typically, an orebody is built up by repeated pulses of mineralisation with the earliest minerals deposited at the vein margins and the latest forming a central core (Figure 5.15g). Major changes in the deposition of mineral assemblages are marked and separated by episodes of tectonic movement.

The first stage of mineralisation (Stage1), the result of hydraulic fracturing as mentioned above, consisted of the formation of tourmaline, both as vein filling and as wallrock replacements together with some quartz. Following brecciation of this material, the deposition of tourmaline continued on a lesser scale, accompanied by quartz and cassiterite (Stage 2). The latest tourmaline is seen in thin sections as fine acicular or prismatic overgrowths on cassiterite. A second episode of movement and brecciation preceded the stage in which specular hematite and quartz were the principal minerals (Stage 3). Chlorite postdates the latest tourmaline but is overgrown by the earliest hematite; its formation ceased during the later deposition of quartz and hematite. Repeated fracturing occurred in the latest stages of mineralisation (Stage 4) in which quartz and minor amounts of clays and earthy or reniform hematite and manganese oxides were the only minerals developed.

Within each of the well-defined stages of mineralisation there is evidence of pulsed hydrothermal activity and minor tectonic movement. In particular, the strong colour-zoning of tourmaline and cassiterite, and the inclusion-zoning of the quartz deposited in the later stages supports deposition from fluids which vary in their chemical or physical nature with the passage of time.

The various types of alteration associated with the mineralisation are considerably overprinted in places and it is not always easy to separate the chronological sequence.

Examination of the surface dump material and of the underground working supports the following scheme:

Stage 1 tourmalisation is accompanied by intense alteration in close proximity to the veins, which involves complete recrystallisation of the host granite, with the growth of bright red feldspar plus aggregates of schorl, and the complete removal of biotite. Minor secondary minerals associated with this alteration include apatite, monazite, rutile and brookite. The deposition of cassiterite in Stage 2 is associated with the growth of pink orthoclase together with tourmaline and muscovite. Stage 3 mineralisation is accompanied by chlorite alteration of feldspar and sericitisation. There are a number of sites within the district where pervasive sericitisation and kaolinisation are recorded in the distal zones of alteration.

Fluid inclusions in quartz from the Birch Tor and Vitifer mines record a remarkable range of inclusion types, salinities and homogenization temperatures. Stage 1 mineralisation and the rare pegmatite occurrences record salinities ranging up to 50 wt % NaCl equivalent and these inclusions contain 4 to 6 daughter salts, commonly with a prominent Fe-rich phase. The Th range is 350-450oC.Stage 2 mineralisation, with the deposition of cassiterite has a salinity range from 15-25 wt % NaCl equivalent and Th from 250-350oC. Stage 2 also records vapour-rich inclusions homogenizing in the same Th range and suggests boiling during this stage of mineralization. The hematite-quartz association of Stage 3 records lower temperatures around 180oC and salinities in the range 2-12 wt % NaCl equivalent. A model in which the earliest fluids evolved from a parent of direct magmatic departure, with progressive dilution by meteoric water and resultant cooling is suggested, and is supported by the geochemical work of Shepherd and others (1985) and Wayne and others (1996). The boiling assemblage data, assuming hydrostatic confinement suggests that cassiterite mineralization took place at a depth of about 2 km.

Chesney and others (1993) record an Ar/Ar plateau age of 277.1 +/- 1.0 Ma for muscovite from a Sn-bearing vein at East Vitifer Mine. Wayne and others (1996) suggest an Rb/Sr age, from the chemical analysis of inclusion fluids, of 276.6 +/- 2.7 Ma for Stage 2 mineralisation at Birch Tor and Vititfer Mine. These results suggest that mineralisation in this district followed 3 – 4 Ma after the main granite emplacement at 280 Ma.

Literature

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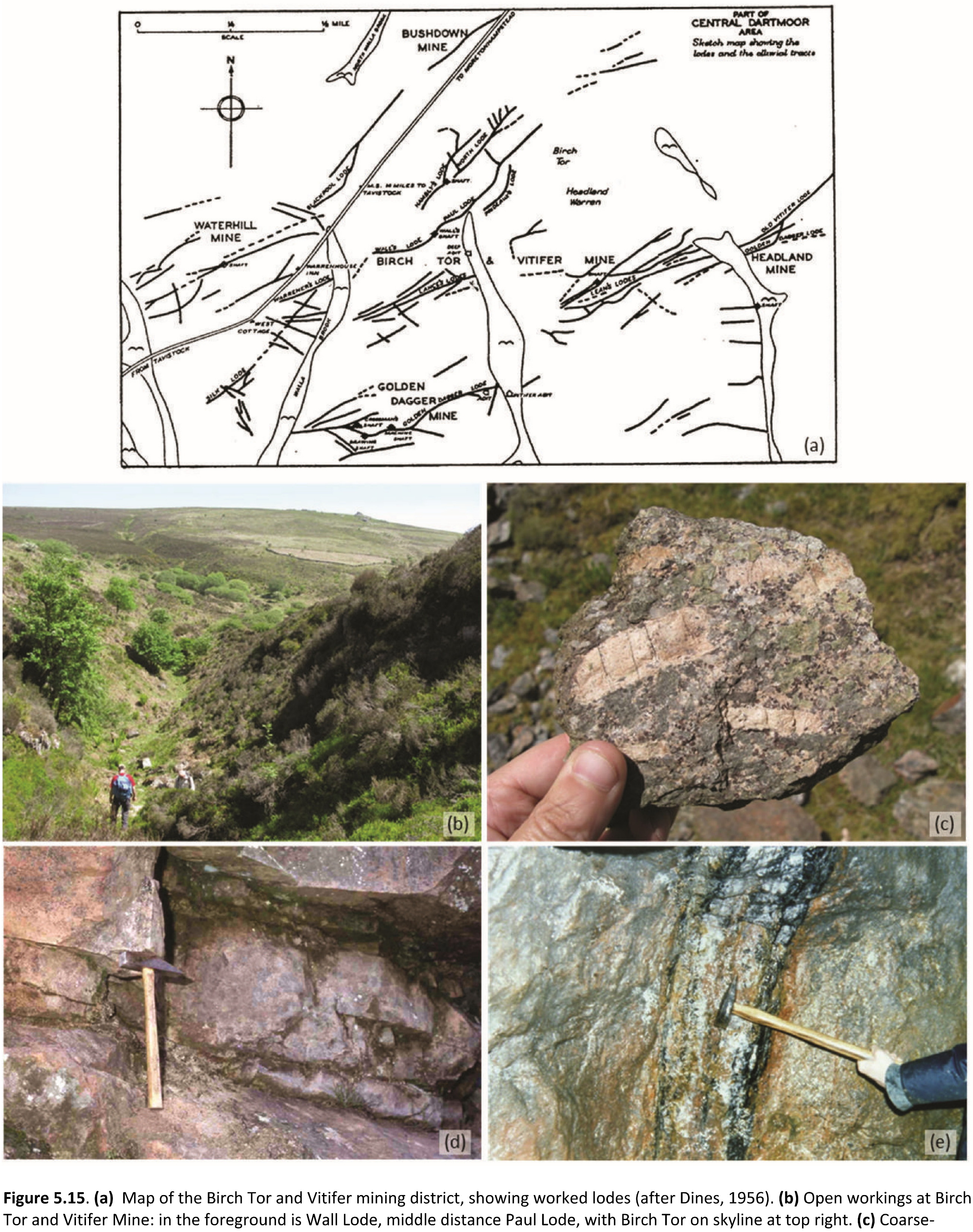

Figure 5.15. **(a)** Map of the Birch Tor and Vitifer mining district, showing worked lodes (after Dines, 1956). **(b)** Open workings at Birch Tor and Vitifer Mine: in the foreground is Wall Lode, middle distance Paul Lode, with Birch Tor on skyline at top right. **(c)** Coarse-grained megacrystic pink granite from the mine dumps. **(d)** Section in aplite sill on Wall Lode, Birch Tor and Vitifer Mine: note the darker mottling due to abundant rounded aggregates of tourmaline. **(e)** In situ underground section in East Vitifer Mine, showing banded structure in quartz-tourmaline-cassiterite vein. Note proximal red alteration zone with feldspar growth along vein margins.

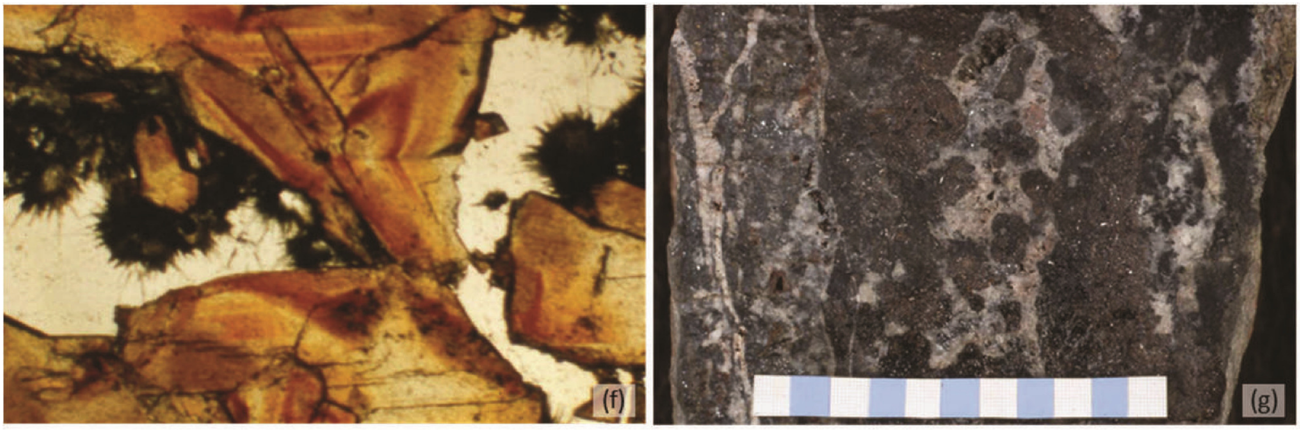

Figure 5.15 continued. **(f)** Detail of blue tourmaline overgrowths on colour-zoned cassiterite crystals from Wall Lode, Birch Tor and Vitifer Mine. Width of field 1.5mm. **(g)** Vein specimen from Headland Mine, Birch Tor and Vitifer complex: Stage 1 tourmaline-quartz on right-hand side, Stage 2 aggregates of cassiterite with tourmaline and quartz in centre, Stage 3 quartz and specular haematite on left. Please note scale in inches (imperial).