Nature and origin of the Great Perran Iron Lode, Perranporth area, Cornwall

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The nature and origin of the Great Perran Iron Lode at Perranporth, Cornwall is reviewed based on the recent survey work in the Newquay district, together with a re-appraisal of the Duchy Peru exploration boreholes of 1973-4.

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Introduction

One of Cornwall's most interesting mineral deposits, the Great Perran Iron Lode, forms a linear feature extending from Gravel Hill Mine, at the northern end of Perran Bay, south-eastwards for at least 6 km (Reid and Scrivenor, 1906; Dines, 1956). The Perran Iron Lode varies in width from 1-30 m and typically includes brecciated slate with siderite, quartz and black sphalerite. In places the lode is cut by late, low-temperature N-S trending cross-course veins containing pyrite, sphalerite and argentiferous galena. Oxidation of the siderite to depths of 60 m or more below surface has produced oxides and hydrated oxides of iron (hematite, goethite and limonite), which were formerly worked by opencast and underground development at a number of sites, together with other commodities, as listed in Table 1 below. The mines are Gravel Hill Mine, Mount Mine, Treamble Mine, Duchy Peru and Deerpark Mine, and these are shown in plan in Figure 1.

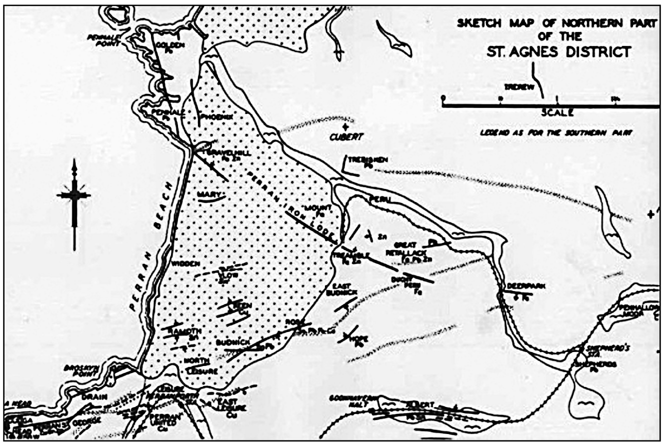

Figure 1. Map of the lodes of the eastern part of the St. Agnes – Perranporth district, including the Great Perran Iron Lode (after Dines, 1956).

Tectonic history and metallogenesis

The Perran Iron Lode is a complex structure with a long history of tectonic activity and metallogenesis. Henley (1971) suggested that fragments of black sphalerite included in the lode may be of stratiform origin, while Scrivener and Shepherd (1998), using an analogy with the Exmoor iron lodes, considered that the siderite mineralization may have formed prior to the intrusion of the Cornubian granite plutons. There are occurrences of calc-silicate 'skarn' minerals, such as hedenbergite and garnet associated with parts of the structure (e.g. Henley, 1971), which suggest the influence of granite-related thermal metamorphism. The late, low-temperature cross-course veins provide a record of post-granite mineralization, that by analogy with similar mineralisation elsewhere in the province, is most probably of Triassic age (Scrivener *et al.*, 1994; Leveridge *et al.*, 2002)

The recent survey work in the Newquay district, together with a re-appraisal of the Duchy Peru exploration boreholes of 1973-4 have shed some new light on the early history of the Perran Iron Lode and help to explain the nature of the mineralization seen in the shallow workings at the present day. The Duchy Peru boreholes proved, at depth, some 40 m of banded, pale grey marble (mostly >99% $CaCO_3$ content), enclosed by sulphide-rich calc-silicate rocks (Goode and Merriman, 1977), in the position of the down-dip projection of

Mine name	Grid reference	Commodities produced	Special features
Gravel Hill Mine	[765 575]	Fe-Zn	Many rare secondary minerals on dump material
Mount Mine	[779 563]	Fe-Pb-Zn	Cross-course vein, local garnet occurrences
Treamble Mine	[787 558]	Fe-Pb-Ag-Zn	Cross-course veins; altered wallrock worked as 'Fullers earth' (impure kaolin)
Duchy Peru Mine	[797 557]	Fe-Zn-Cu-Pb also ochre and pyrite	Cross-course veins; calc-silicate rocks and traces of cassiterite
Deerpark Mine	[808 555]	Fe-Pb-Zn	Cross-course veins; much massive quartz in main structure

Table 1. Constituent mines of the Great Perran Iron Lode

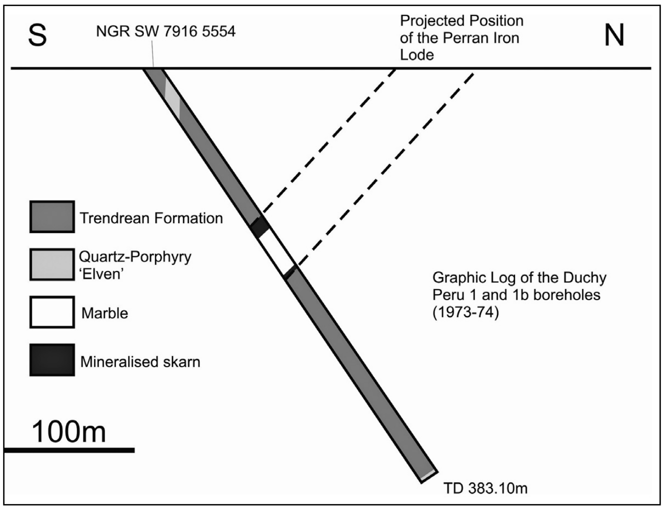

Figure 2. *Section showing the projection of the Perran Iron Lode and the geology of the Duchy Peru borehole.*

Sequence of events	Age	Examples
Supergene alteration	? Miocene to present day	Alteration of pyrite and siderite to secondary Fe-oxide assemblages throughout with collapse breccias due to dissolution of carbonate minerals
Cross-course Pb-Zn-Ag extensional veins	? Triassic	N-S trending Pb-Ag veins e.g. at Mount and Duchy Peru mines
Granite-related hydrothermal activity	Permian	Traces of cassiterite recorded; kaolinisation of wallrocks at Treamble
Thermal metamorphism	Early Permian	Calc-silicate assemblages, e.g. Garnet-hedenbergite-epidote at Duchy Peru mine
Variscan tectonics	Late Devonian to late Carboniferous	Faulting and deformation throughout
Syngenetic carbonates and sulphides	? Early Devonian	Banded marble, 'bedded' sphalerite and siderite

Table 2. *Metallogenesis of the Great Perran Iron Lode.*

the Perran Iron Lode (Figure 2). It is possible that the banded marble, stratiform sphalerite (described by Smyth, 1887 and Henley, 1971) and siderite, which appear to represent the earliest phases of mineralisation, were in fact deposited contemporaneously with the enclosing sedimentary rocks, of probable Middle Devonian age; that is, they originally were formed as a carbonate-sulphide 'sedex' or 'volcanic-exhalative' type of deposit. Three lines of evidence support this hypothesis.

1. The Perran Iron Lode is essentially shallow- to-moderate-dipping and at least in part conformable with the enclosing strata of the Emsian Trendrean Formation (Meadfoot Group) (Hollick *et al.*, 2006), in contrast to the typical discordant hydrothermal base metal-bearing veins of the Cornubian peninsula (Dines, 1956).
2. Specimens of sphalerite and siderite-sphalerite from Great Retallack Mine and other localities (including the Duchy Peru borehole) show banding of a type not observed in hydrothermal fracture veins, but typical of exhalative mineralisation.
3. Preliminary petrographical and chemical investigations suggest that the high-purity marble is without any evidence of a biogenic origin and was most probably a submarine chemical precipitate.

In consideration of its structure, the location of the Great Perran Iron Lode is close and sub-parallel to, the proposed site of a substantial pre-Variscan basement structure that has generated locally complex superposition of fold phases around Ligger Point (see Hollick *et al.*, 2006). This feature is likely to represent a sub-basin boundary once located within the Devonian Looe Basin (Leveridge and Hartley, 2006), in which the fine-grained sediments of the Trendrean Mudstone Formation accumulated. The along-strike and down-dip variation of ore-bearing rocks noted by previous workers (Collins, 1912; Smyth, 1887) support the hypothesis that multiple phases of tectonic reactivation along this and other regional-scale structures in the area have affected an essentially stratiform deposit. Structural movements related to the construction and collapse of the Variscan orogen during late-Devonian to Triassic times, provided a mechanism for fracturing and enhanced flow of hydrothermal fluids along the Perran Iron Lode structure.

Following uplift and erosion in Cainozoic to recent times, weathering of the primary ores in the near-surface zone, with dissolution of the carbonate minerals by acid waters resulting from the breakdown of sulphides, would result in the brecciated (collapsed) Fe-oxide rich material seen at the present day in the shallow workings along the strike of the structure. This and the foregoing proposed history of the Great Perran Iron Lode is presented as a summary in Table 2.

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