Hope's Nose, Devon

[SX 949 636]

Introduction

Hope's Nose forms a promontory on the northern side of Torbay, Devon, and comprises a steeply sloping headland bounded by low cliffs, about 3 km east of the centre of Torquay. The Hope's Nose GCR site consists of the seaward exposures on this promontory (see (Figure 7.54)). At Hope's Nose, the Middle Devonian (Eifelian) beds form a wave-cut platform below a small cliff. The platform is some 100 m long and roughly 25 m wide, and is mostly covered under tidal or storm conditions. The mineralized veins of interest are located on either side of a major outfall pipe.

Gold-bearing carbonate veins cut the Middle Devonian limestones of the wave-cut platform, and also contain rare palladium and selenium minerals. The mineralization is believed to result from hydrothermal activity. Stanley *et al.* (1990a) described a low-temperature epithermal environment for the mineralization, associated with the Lundy–Sticklepath–Lustleigh–Torquay Fault System.

Description

The geology of this part of south Devon is complex and, because there are so few inland exposures, it is poorly understood. The area lies in a roughly east-west tectonic belt made up of Devonian to Lower Carboniferous sedimentary rocks, typically marine shales and sandstones together with interbedded lavas and tuffs (see (Figure 7.54)). During Middle to Upper Devonian times extensive carbonate platforms developed within a predominantly marine sequence, and the Tor Bay reef complex, of which the limestones at Hope's Nose are a part, formed on the eastern margin of one of these platforms. During the Variscan Orogeny this sedimentary succession was deformed and has been referred to as a 'thrust and nappe terrane' (Chandler and Isaac, 1982).

Today, a variably developed wave-cut platform provides most of the coastal exposure in the northern part of Hope's Nose. In these exposures, and in a small disused quarry on the headland to the east, massively bedded, hard and fossiliferous limestones are overlain, apparently disconformably, by a thin to poorly bedded dark-grey and shaley limestone with interbedded tuff horizons. This sequence has been assigned to the Daddyhole Member of Eifelian age, the earliest of the three members of the Middle Devonian Torquay Limestone Formation (Scrutton, 1978; Goodger *et al.,* 1984).

The massive limestones are cut by a number of calcite veins and stringers (see (Figure 7.55)) for about 50 m north-east and south-west of the outfall. The veins are steeply dipping and trend roughly N70°W Some of them show slickensides and most have been subject to faulting, although they display little vertical displacement (Scrivener *et al.,* 1982). Wall-rock alteration around the veins is restricted to patchily developed hematization.

The veins vary in colour and texture, commonly consisting of coarse, purple and yellowish ferroan calcite enveloping clasts of the host limestones, as well as biscuit-coloured, anhedral calcite and dolomite, often with a saccharoidal texture. These veins often have voids filled with iron hydroxides. It is these calcite veins that seem to be most commonly associated with gold.

Gold was first found in these veins by Gordon (1922), and was fully described by Russell (1929) who reported arborescent sprigs of gold in five distinct calcite veins to the north of the outflow. However, since the locality was 'rediscovered' in the 1980s gold has also been found in veins south of the outfall. Some of the gold was found to be palladian by electron-probe micro-analysis and to be associated with the palladium antimonides isomertieite and mertieite-II (Clark and Criddle, 1982) (see (Figure 7.56)).

Subsequently, specimens from close to the outfall and also from the western side of the quarry were found to contain a suite of selenide minerals (Stanley *et al.,* 1990a). The full assemblage is calcite, hematite, dolomite, pyrite, chalcopyrite, gold, palladian gold, isomertieite, tiemannite, trastedtite, tyrrellite, penroseite, umangite, fischesserite, eucairite, naumannite, clausthalite, klockmannite, cerussite, malachite, aragonite and goethite.

Additional material was collected at a later date from a vein about 50 m north-east of the 'selenide vein' of Stanley *et al.* (1990a), and further selenide minerals were found. Subsequent studies led to the identification of the new mineral chrisstanleyite ($Ag_2Pd_3Se_4$), a mineral similar to oosterboschite. In addition, two unknown minerals of composition $PdSe_2$ and $HgPd_2Se_3$ (Paar *et al.,* 1998) were identified. The former mineral has been identified subsequently as the new mineral verbeekite (Roberts *et ed.,* 2002), with its type locality being Musoni Mine, in the Democratic Republic of Congo.

Alderton (1993) attributed this episode of mineralization to post-granite emplacement and linked it possibly to a source derived from either Permian red-beds or, perhaps more likely, from Permian alkaline volcanic rocks and lamprophyres.

Interpretation

Fluid-inclusion studies on calcite and quartz from the gold-bearing veins gave a range of homogenization temperatures of 65°–120°C. The fluids were rich in $CaCl_2$, with total gross salinities of 20–23 equivalent wt% NaCl and a $CaCl_2$:NaCl ratio probably with a minimum of 3:1. Such salinities are within the ranges for South-west England Pb-Zn-F mineralization.

Although the mineral association at Hope's Nose is unusual it is not unique. There are distinct similarities between Hope's Nose and the classic selenide deposits in the Harz Mountains. For the Tilkerode and other Harz selenide deposits, Tischendorf (1968) suggested that the metal and selenium contents had been leached from black carbonaceous shale host-rocks, and that solutions from a deeper source, possibly residual fluids from a relatively basic magma, contributed Fe, Ca, Mn and Mg.

Another comparison can be drawn with the overall element package associated with noble metal-bearing shales in the Zechstein of Poland, where a thin black-shale horizon, enriched in Ni, Co, Pt, Pd, Ir, Cu, Se, Hg, Mo, Re, Au, As and Bi, forms a boundary between oxic and anoxic conditions, the metals being fixed by absorption, 'complexation' and reduction by the organic matter (Mountain and Wood, 1988). At Hope's Nose, the high salinities in fluid inclusions, high Ca: Na ratios, and the widespread hematization of the limestone adjacent to the veins all suggest that conditions for complexing could have been present. However, as the Daddyhole Member is not notably bituminous, the mechanism for reduction and deposition is less certain. It may be that fluids driven from below ponded against the overlying thinly bedded shaly limestone, were neutralized by reaction *in situ* and could no longer hold their trace-element content in solution.

In any case, the low temperature and low amount of silica in the veins might indicate a relatively shallow and restricted circulatory system since chemically active fluids would be expected to react with any siliceous wall-rocks and pick silica up into solution.

The fracture system into which the fluids were drawn may have been controlled by movements along a major NNW–SSE lineament, the Lundy–Sticklepath–Lustleigh–Torquay Fault System. Local thrusting may also have been important in localizing the deposit (Stanley *et al.,* 1990a). A possible link with nearby shallow intrusive igneous bodies is provided by a significant positive gravity anomaly, while Alderton (1993) has suggested that the source of the gold may have been Permian volcanic rocks and associated lamprophyres.

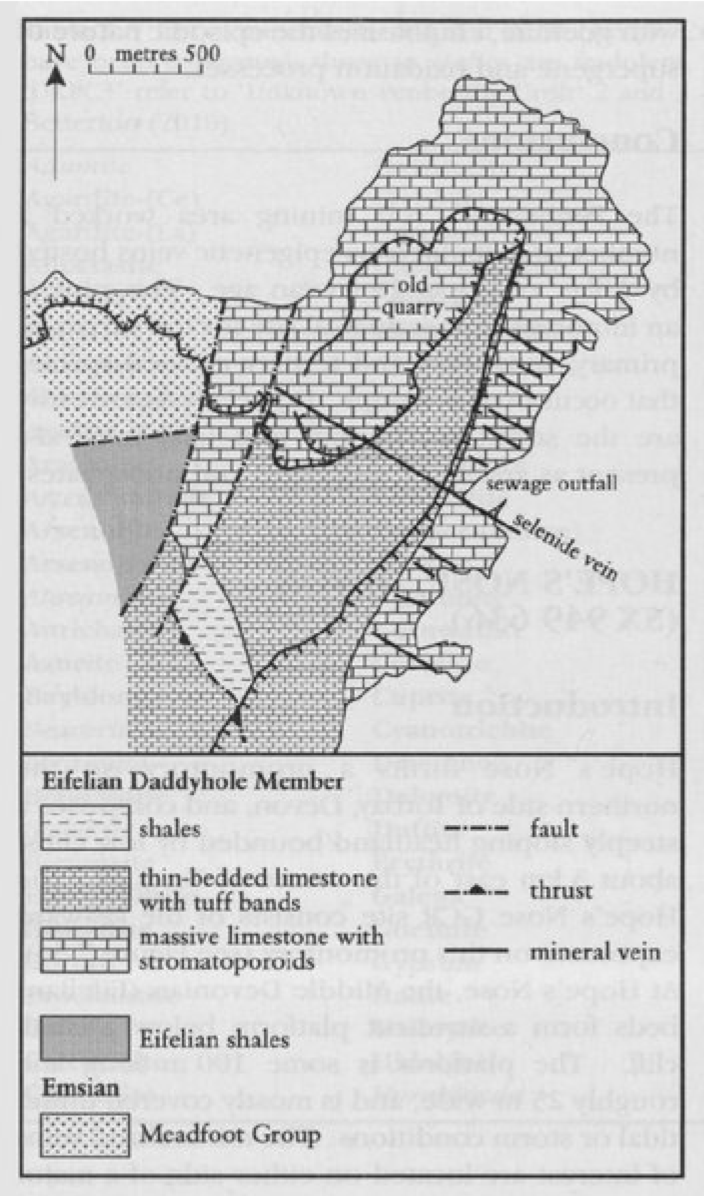
Conclusions

A rare association of gold-palladium and selenide mineralization occurs in carbonate veins at Hope's Nose. This is the only known occurrence of this mineral assemblage in Britain, and is therefore an internationally important mineral site.

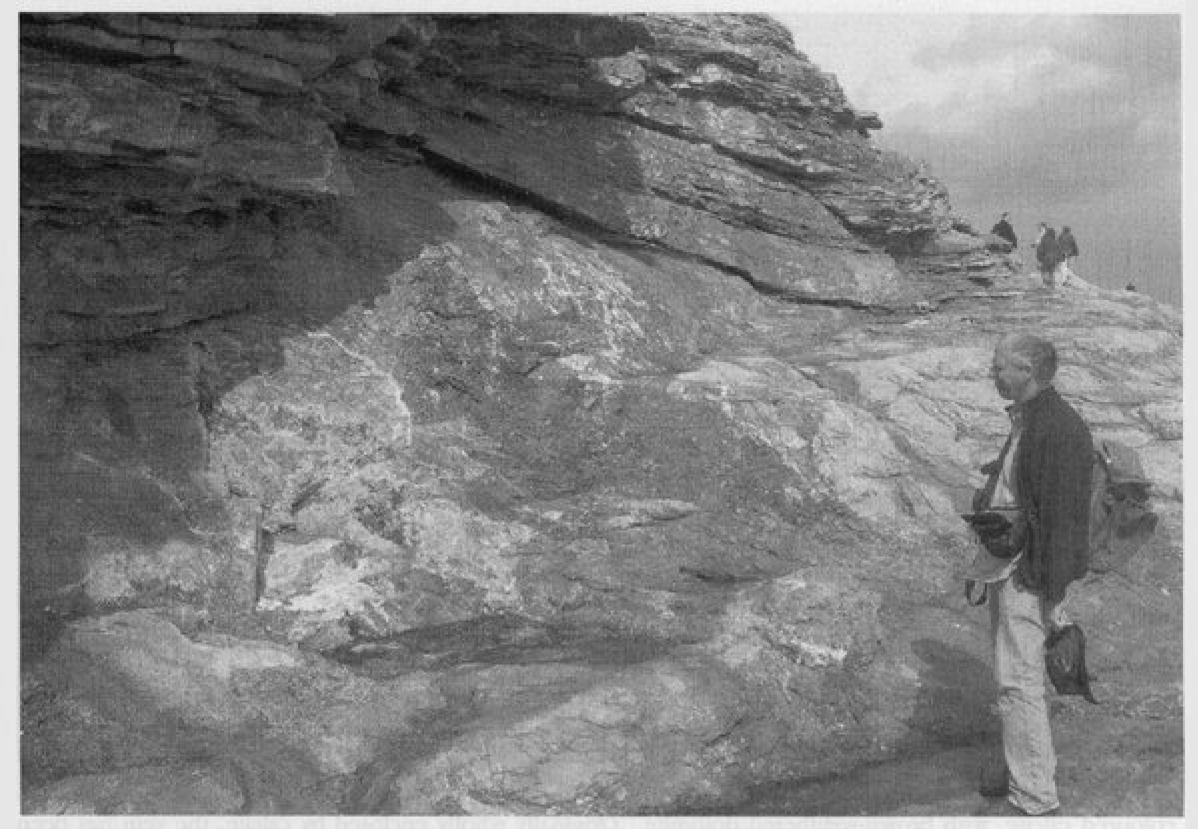
Gold in small amounts is widespread throughout the area, having been recorded from Daddyhole Quarry (Gordon, 1922) and from several 'panned' areas of the River Dart. Recent surveys by the British Geological Survey have shown gold to be distributed in the drainage channels and soils of the area.

Mineralization is thought to have formed by low-temperature hydrothermal remobilization of precious metals, possibly associated with concealed, local mafic igneous rocks, the gold possibly being derived from the underlying Permian alkaline volcanic rocks and associated lamprophyres. Specimens of delicate dendritic growth of gold in cream-coloured calcite are most attractive; in many specimens the gold has been further exposed by acid treatment (see Embrey and Symes, 1987).

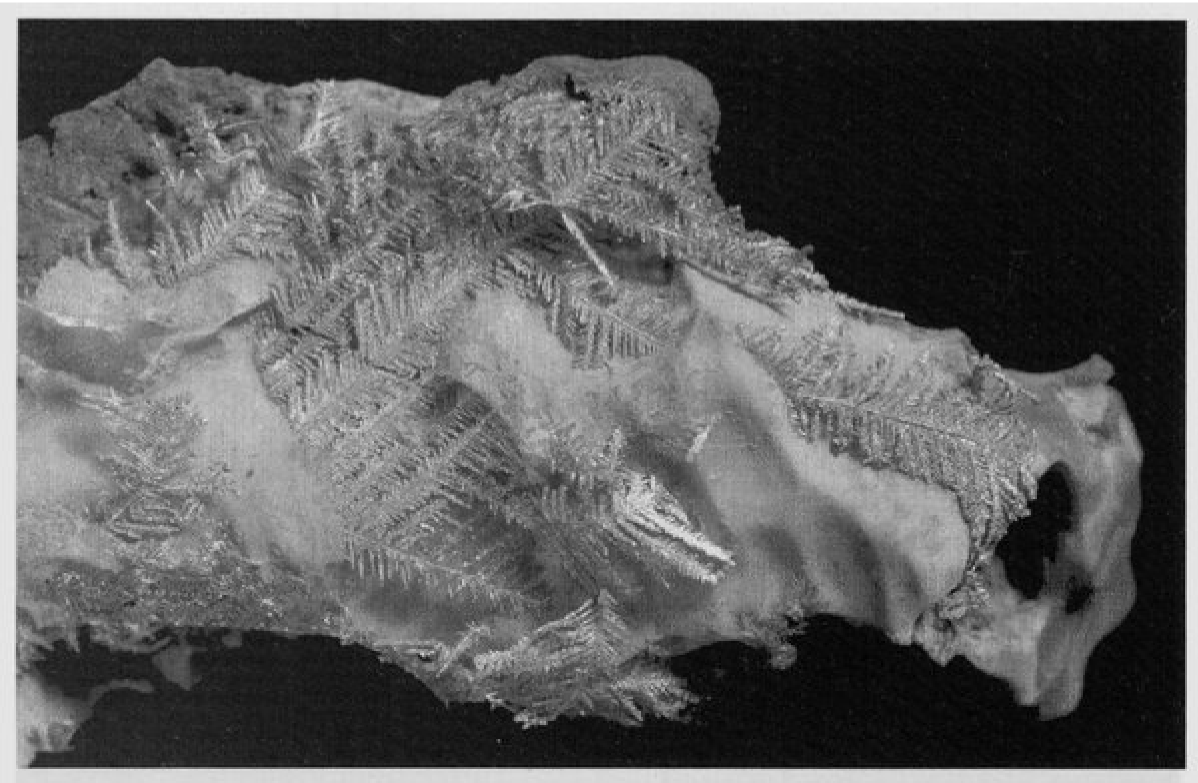
References



(Figure 7.54) Sketch map of Hope's Nose, showing the geology and the location of the principal gold-bearing veins. After Stanley et al. (1990a).



(Figure 7.55) One of the remaining areas of vein mineralization at Hope's Nose. The vein cuts the massive limestone beds. (Photo: H. Townley, Natural England.)



(Figure 7.56) Gold, from Hope's Nose, near Torquay, Devon. A beautifully delicate dendritic growth in cream-coloured calcite, with brown-weathered dolomite. Originally wholly enclosed by calcite, the vein has been exposed by acid treatment. The small veins at this locality crop out on the sea coast, near the sewage outfall of Torquay and are remarkable for the palladium minerals isomertieite and mertieite-II which have recently been found there in small amounts. (Photo: © The Natural History Museum, London.)