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United Nations Educational, Scientific and Cultural Organization

Cornwall and West Devon Mining Landscape
inscribed on the World Heritage List in 2006

Geology and landscapes - overview

The landscape is formed and shaped by a combination of climate, geology, natural features and human activity. The geographical setting of the Cornish Mining World Heritage Site is dominated by its underlying geology and maritime location.

Much of the area is a gently sloping plateau of metamorphosed rock underlain and punctuated by granite intrusions. The granite forms a central spine, 240-300m above sea level in the west to over 400m in the east - which manifests itself at the surface by rough upland. The moors are confined to the upland areas and provide some of the most important and appreciated 'wild' landscapes. Their combination of altitude, climate and traditional management make these important habitats, typically un-improved grassland rich in plant species. The wide open landscapes of the moors, marshes and meadows support a number of rare plants and animals including golden plover, otter, and the marsh fritillary butterfly.

The land is incised by a number of river valleys harbouring rivers and estuaries that meander across much of the county, often arising high on the moorland spine as fast and tumbling streams before winding through farmland, towns and villages on their way to the sea.

The valleys are often quiet havens for wildlife, supporting reedbeds, wet willow carr, marshes, ancient woodlands, saltmarshes and mudflats. The north coast estuaries include the Camel, Gannel and Hayle rivers with ever-changing sand banks and channels at their mouths. On the south coast, the gentler cliffs are punctuated by the deep estuaries or drowned river valleys of the Fal, Helford, Fowey and Tamar rivers, many of which have been designated as candidate Special Areas of Conservation for the estuarine wildlife they support.

To the east the natural boundary of the River Tamar forms the border between the administrative counties of Cornwall and Devon. The World Heritage Site extends at this point beyond the Tamar Valley Mining District to the west Devon town of Tavistock.

Cornwall and west Devon was essentially a rural economy based on farming and fishing before industrialisation changed the face of the landscape. Cornwall now has more derelict land than any other county in England, with 12 per cent of the total national resource at 4,888 hectares. However one might view them, Cornwall's mine sites provide a home and protected sanctuary for many species of flora and fauna including animals such as rabbits, snakes, birds and field mice.

Associated with these habitats are disused engine houses, mine shafts and adits, which form important roosting sites for bats and for birds such as the barn owl, raven and stock dove. Common lizards and slow worms also colonise these areas. The bare ground and heathland areas are important for a wide range of invertebrates, including the naturally scarce species silver-studded blue, tiger-beetle wasp and western bee-fly. Soil rich in copper supports many national rare species of liverwort and mosses as well as highly specialised plants.

Geology, mining and the natural environment

The geological history of the geo-cultural region in which the World Heritage Site is located begins nearly 400 million years ago (Ma). Sand and mud settled on the floor of a Devonian sea, and molten rock formed submarine lavas and intrusions within the sediments. Around 320 Ma, during Carboniferous times, continents collided and caused a major earth-movement. This subjected the earlier rock formations to folding, faulting and cleavage on a general axis with an east-north-east to west-southwest trend. It is this alignment that accounts both for the orientation of the granite emplacement and the main tin and copper lodes. Mudstones became slates, which together with subordinate bands of sandstones have long been known collectively by the Cornish term 'killas'.

Between 300-270 Ma, during the late Carboniferous and Permian periods, continental collision generated considerable heat and pressure which melted the crust to form granite, a coarse crystalline igneous rock formed deep in the earth. Separate granite masses intruded into the rocks above them between 290-270 Ma. They merged to form an elongate body of granite, known to geologists as a batholith. The intense heat also caused water to circulate within the granite, producing the main tin, copper and tungsten mineralisation around 270 Ma.

Around 250 Ma, during the late Permian, a mountain chain was created during a period of considerable uplift. The rocks which once covered the granite were then gradually removed by deep weathering and erosion, exposing the tops of the granite domes. Around 236 Ma, during the Triassic, the cross-course lead-silver-zinc mineralisation formed in a north-south structural orientation. This alignment, perpendicular to the main tin and copper mineralisation, was due to changes in geological stress regimes.

Within the past 4 million years, marine erosion created a relatively flat surface (the 130-metre planation surface), as well as wave-cut platforms and raised beaches. It is likely that tin placer deposits were formed within the same period, and went on being formed until relatively recent times. The sea level fell during the Ice Ages of the past 1 million years, (ending around 10,000 years ago) and rose in recent times by about 15 metres. River valleys (known as 'rias') were cut and subsequently flooded by these events, including the River Tamar and the Fal estuary.

Mining and the natural environment have always been inextricably linked. Geological and geomorphological processes which took many millions of years to develop determined the resources available for mining and the sites where they awaited discovery and exploitation. Long ago, miners learnt the tell-tale signs of mineralisation - the characteristic greens of secondary copper minerals, the reds of iron-bearing rocks, the hard resistant whiteness of quartz stringers and reefs, the local softening and erosion of other altered rocks that signalled the presence of valuable ores. Elsewhere they began to realise that common plants were stunted or absent where such minerals occurred, or that some species - indicator plants - alone thrived where certain minerals lay not far beneath the surface. They dowsed, tasted the water, learned the smells of pyrite and mundic - developed a sense of geology that was instinctual long before it was written down or scientifically analysed - picking up subtle hints from their natural environment - clues that unerringly guided them to what it was they sought.

In turn, their activities changed the environment. Rocks whose weathering products were far more acidic or toxic to plant life than those experienced in the landscape - softened and tamed by long exposure to wind, water and bacteria - were brought from deep beneath the earth in vast quantities, broken into fragments, crushed to fine sands, burnt so that they turned to toxic gases, discarded as waste and spread across its surface or spilled into its watercourses. Across its landscape, environments were created which had not existed in Cornwall or west Devon for tens of millions of years. The few plants which could live there are very specialised - pioneer species which can gain a tenuous foothold in such dangerous habitats and after many decades create the conditions where other, less tolerant species could, perhaps, build on the shallow, poor soils they had painstakingly created. A slight change in their habitat - the disturbance of the surface of a waste dump, the spreading of a mere inch of nutrient-rich topsoil, the removal of a mineral-rich input to a stream - can undo the work of centuries and destroy such habitats for ever.

These are special places - rare not only in Cornwall, but worldwide. Some are so free-draining that they resemble miniature deserts, others are so utterly saturated with acidic water that only the most primitive species can survive; many are rich in freely-available toxic minerals whose closest comparisons are lava flows. The plants and animals that survive - and in many cases thrive here - are often unusual and find these conditions nowhere else in a landscape which agriculture has slowly modified over thousands of years - these are wild, primitive and important places in our landscape - but also vulnerable places - for their inhabitants are often small and undramatic, their value often unrecognised until they have gone. These are the homes of rare mosses and lichens, of stunted variants of common plants, of bare sands and clays, exposed rocks and the insects, beetles and other animals which are found here and which can survive nowhere else. Many generations of such plants and animals must have lived out their lives in islanded areas like these, utterly isolated from contact with other such colonies, that subtle changes brought about through specialisation and inbreeding may have occurred. Other species rely on chains of sites like these, spread throughout the landscape, moving from one oasis to another in what is to them a sterile and inhospitable desert of farmland and townscape. Remove enough of these sites, and they are trapped.

The contents of the spoil heaps, hacked as they have been from deep below the ground, are also extremely important resources for the geologist and mineralogist. These are types of rocks and minerals which simply do not occur at the surface, where millions of years of exposure to air and water chemistry, coupled with the effects of some of the smallest, yet most abundant life forms on the planet have changed them into the stable, familiar materials which make up most of our environment. They provide rare and valuable glimpses into the formation of our planet and the way it has developed. Seventy one globally-rare species of minerals were recorded in Cornwall up until 1992 from such sources - twelve had never been recorded anywhere in the world before that date, and it is certain that many more await discovery. The words ‘waste’ and ‘spoil’ are often so wrongly applied to such sites - these are treasure houses which may prove to be as important for the knowledge of the natural world which they provide us as the copper and tin from which they were once separated and discarded.

For further information, please log on to the following sites:

Cornwall Wildlife Trust - http://www.cornwallwildlifetrust.org.uk/

Natural England - http://www.naturalengland.org.uk/

Cornwall RIGS Group - http://www.cornwallwildlifetrust.org.uk/geology/geology

The Russell Society - http://www.russellsoc.org/

Camborne School of Mines - http://emps.exeter.ac.uk/csm/

The geological and mineralogical importance of Cornwall and west Devon's mining landscapes

The most economically important mineral veins, or lodes as they are known in Devon and Cornwall, were formed at a time shortly after the intrusion of the granite. Residual heat from the granite (together with radioactive related heat) raised the temperature within the surrounding rocks and caused water to circulate in the fractures by means of convection. The water dissolved metal salts which were distributed in small amounts throughout the rock that surrounded the fractures.

Repeated circulation led to metal concentration and as the water cooled it deposited metallic ore minerals along fractures and faults. Higher temperature minerals, such as those bearing tin and tungsten formed earliest and tended to occur within or closer to the granite, and lower temperature minerals such as lead and zinc formed later and tended to occur furthest from the granite.

Mineralogical diversity was a major factor in the economy of Cornish Mining. Fifteen different metals were produced and a great variety of minerals occurred along with the main ore minerals being worked in the Cornubian Orefield. Many of these are of international interest to scientists and mineral collectors. The pattern of the various components that make up the Cornish mining landscape was dictated by the location of the different metal ores and the periods in which they were worked.

The principal metal ores usually occurred in structurally similar deposits. The underground mining methods used to gain access to these was by sinking shafts, driving tunnels (levels) along the lodes and excavating the payable parts of the lodes (by stoping). Consequently the archaeology of underground extraction (shafts, levels and stopes) is common to most mines whether they were worked for copper, tin, arsenic or lead, although there is some variation for metals such as iron and manganese which occur in different types of mineral deposits.

The following text and recommendations have been taken/adapted from Bristow, C. and Sparrow, C., within Johnson, N., Payton, P. and Spalding, A., 1996, *The conservation value of metalliferous mine sites*, Cornwall Archaeological Unit and the Institute of Cornish Studies

Cornwall is renowned for the richness and diversity of its metalliferous mineral lodes, which form part of the Cornubian orefield. A smaller eastern section of the orefield occurs in and around the Dartmoor granite in Devon. The minerals which occur in the orefield are extremely varied and, in some cases, unique. They have formed the basis for scientific enquiry ever since the earliest days of mineralogical science in Britain at the beginning of the eighteenth century, and mineralogical investigation in the area represents one of the most important, but less well known, parts of its intellectual heritage.

Historical aspects

Early mineral collectors included Dr John Woodward (1665-1728) and the Rev. William Borlase (1695-1772); the collection of the former still exists in the Sedgwick Museum at Cambridge. One of the most important early collections of Cornish minerals was assembled by Philip Rashleigh of Menabilly (1729-1811), who put together a magnificent well-documented collection in the late eighteenth century, mostly derived from mines active at that time. This collection now forms the basis for the mineral collection in the Rashleigh Gallery of the Royal Cornwall Museum. An early account of Cornish minerals was provided by Pryce in *Mineralogia Cornubiensis* (1778).

This early interest in geology and mineralogy in Cornwall led to the formation of the Royal Geological Society of Cornwall in 1814, the second oldest geological society in the country, with some of the leading British scientists of the day, such as Humphry Davy and Davies Gilbert, being involved in its formation (Crook, 1991). The Museum of the Society (the 'Cornwall Geological Museum' in Penzance) contains many fine specimens from the Cornubian orefield collected by some of the early pioneers in geology and mineralogy.

Many famous mineral collectors (Edward Fox, Robert Were Fox, John Hawkins, Joseph Came, John Williams, Robert Hunt and above all Sir Arthur Russell, plus many others too numerous to mention) have since been active in Cornwall in the nineteenth and twentieth centuries. Their collections are now mostly in museums, and nearly every major mineral collection in the world contains a selection of Cornish specimens (Embrey & Symes, 1987). Cornwall, together with the Erzegebirge/Bohemia region in central Europe, provided many of the localities from which important ore minerals were first described. As a source of minerals for reference and study, Cornwall is one of the more important orefields in the world.

Mineral collecting

Most of the early mineral collections were put together when there were perhaps as many as several hundred mines active at any one time and the un-mechanised underground mining methods were such that important specimens tended to be recognised before they were destroyed or damaged by the mining process. By operating a bounty system, early collectors were able to encourage a steady flow of specimens collected by the miners themselves. Most of the large showpiece mineral specimens were acquired in this way at a time when the mines concerned were active. There are no active mines in Cornwall today, although the large open pits of the china clay industry and aggregate quarries can provide valuable sources of minerals for research. Apart from these active extractive operations, collectors nowadays have to be content with studying material recovered from the waste tips of old mines, or attempting to collect specimens from surface workings and those few old underground mines which are accessible and not flooded. The latter is especially dangerous, because of the risk of collapse of old workings and the presence of pockets of gases such as radon and carbon dioxide. In spite of these limitations, a steady flow of important specimens continues to be found, mostly from old dumps. The use of modern miniaturised methods of mineral identification such as X-ray Diffraction and X-ray Fluorescence continue to add to our knowledge of the mineralogy of the Cornubian Orefield. In addition, the coastal exposures, the massive china clay pits and the quarries for crushed stone, still yield much important new material.

Because of popular interest in mineral collecting, many of the well-known localities now yield very few striking macroscopic specimens, although microscopic examination often reveals interesting material. Where a dump is used as a source of hardcore, the freshly dug spoil can often be a source of useful mineral specimens.

Where specimens are required for research, excavation or turning over the dump material with a mechanical excavator can often be the only practical way of retrieving worthwhile specimens, but this can be destructive. Several local organisations cater for the interest in mineral collecting, the most notable of which is the Southwestern Branch of the Russell Society.

Significance of Cornish mineralogy

The Cornish suite of minerals (Golley & Williams, 1995) comprises 450 different types of mineral, which represents nearly 15 per cent of the worldwide total of recognised minerals. Five of the Cornish mineral occurrences are unique to Cornwall and 225 represent the first British occurrence. Of these, 37 are the first recorded occurrence in the world. More than 130 of Cornwall's mineral occurrences fall into the world occurrence classification of ‘rare’ or ‘ultrarare’. During the past 18 years, of 160 occurrences of new minerals recorded in Britain, 83 are from Cornish locations, including 7 minerals new to science.

With approximately 600 sites of mining activity throughout Cornwall where spoil heaps exist, and given that the vast majority of new finds in the last two decades have been made at surface rather than underground, there is still potential for significant new discoveries of minerals or suites of minerals. It is important to emphasise that it is not simply a question of identifying the minerals, but of understanding the association of the minerals together and their processes of formation (paragenesis). Such information may be valuable in the context of locating new deposits, whether in Cornwall or elsewhere, and establishing the most appropriate methods of recovering their valuable mineral components. In some cases, the dumps contain rocks which came from a considerable depth, and therefore may yield valuable information about the overall geological structure of the area. The sequence of spoil in old dumps and the location of different types of mine waste may yield valuable information on the way the mine was worked and what part of the mine the waste came from. Hence, bulldozing all the waste into a single pile can destroy much valuable contextual information, in much the same way as it would for an archaeological site.

Geology of the metalliferous mineral deposits

The geology of the Cornubian orefield has recently been summarised in a popular publication (Bristow, 1996). More detailed accounts will be found in Willis-Richards & Jackson (1989), Jackson, Willis-Richards, Manning & Sams (1989) and Alderton (1993). The Cornubian orefield is associated with the Cornubian granite batholith, which consists of six major granite masses (Dartmoor, Bodmin Moor, St. Austell, Carnmenellis, Land's End and the Isles of Scilly). Although geophysical studies show the granite masses merge into one single batholith at depths of over six kilometres, nevertheless recent studies using sophisticated dating methods have shown that the granite masses were separately generated over a period of 30 Ma (Ma = million years) from 300 to 270 Mya (Mya = million years ago), in the Late Carboniferous and Early Permian periods. It is now believed that some of the earlier granites (e.g. Bodmin Moor and Carnmenellis) were already in place and being mineralized before some of the younger granites (e.g. Land's End and the western part of the St. Austell granite) had been intruded. Several of the granite masses (Land's End and St. Austell) are composite, as they are composed of two or more separate phases of intrusion, of differing ages.

A few small mineral occurrences were formed at the time when the Devonian and Carboniferous rocks were being laid down, mainly in sedimentary environments where there was some igneous activity, such as the manganese deposits in the Launceston area. Some of the gold occurrences in Cornwall may also belong to this category. Many interesting and unusual minerals were also formed in the granites at the time of crystallization.

However, most of the mineral deposits were formed in the hydrothermal phases of metalliferous mineralisation following the intrusion of the granite. Heat from the cooling granites caused metals to be 'sweated' out from them and their surrounding rocks, and hot solutions containing these metals moved through cracks until they reached cooler locations where the ores of tin, copper and other metals crystallized as mineral veins. Four phases of mineralisation can be recognised (Bristow, 1996): Pegmatites and aplites can be seen in china clay pits such as Goonbarrow and Gunheath, and in many coastal exposures of granite, such as Rinsey Cove and Megiliggar Rocks in the Tregonning-Godolphin granite, and the various coves around Cape Cornwall. Sometimes this type of deposit was worked in open pits. In the present day workings of South Crofty tin mine, pegmatites sometimes contain useful tin values.

The mineralogical interest in this type of deposit may often be in the associated minerals, for example apatite, rather than the ore minerals themselves, or in the way the original mineralogy has been modified by later phases of mineralizing activity. Greisen-bordered sheeted vein systems are very characteristic of the Cornubian orefield, with classic examples being seen at Cligga Head and on the south side of St. Michael's Mount, as well as in Carclaze and Goonbarrow china clay pits. The ores are mainly tin and wolfram, but a wide variety of other minerals are associated with these features, some common and some exceedingly rare. China clay pits like Gunheath are world-famous for yielding the rare iron/tin hydroxide varlarnoffite, as well as a whole suite of tin sulphides and phosphates such as turquoise, chalcosiderite and libethenite (Weiss, 1994); were it not for Gunheath china clay pit, the only (poor) source of these minerals would be the dumps from Bunny tin mine.

The main-stage mineralization involved substantial quantities of water being drawn into the fluid circulation in and around the granites, which led to the formation of well-defined lodes containing tin and copper ores, as well as the ores of many other metals. Chemical weathering of the copper sulphide ores in these lodes took place during the Mesozoic and Palaeogene (210-30 Ma). This led to the development of profiles which showed a 'gossan' at the surface, underlain by a leached zone, in turn underlain by a zone of secondary enrichment where the minerals were precipitated at or just below the water table, giving way downwards to the primary ore (for diagram, see Bristow, 1996, page III).

The zone of secondary enrichment is particularly rich in unusual minerals, involving elements such as copper, zinc, phosphorous, arsenic, iron and sulphur. The cross-course mineralization involved lower temperature, briny fluids with a different chemistry, which circulated about 30 Ma after the higher temperature hydrothermal fluids, mainly during the Triassic Period. The ores formed are therefore distinctly different, and involve minerals containing iron, lead, zinc and uranium, occasionally copper. Much of the galena (lead containing mineral) contains a significant proportion of silver; mines working argentiferous galena in the Bere Alston area were an important source of silver for the medieval economy.

As with the main-stage mineralization, deep weathering has sometimes produced unusual secondary minerals. Associated with the main ore minerals of tin, copper, tungsten, lead, iron, and zinc, there are smaller occurrences of many other elements, including silver, gold, manganese, uranium, nickel and cobalt; as well as non-metallic ores containing fluorine, barium and arsenic. Minerals involving these pigments in unusual combinations make up a significant proportion of those on the ‘rare’ and ‘ultrarare’ list.

Weathering of the mineral containing lodes has been taking place ever since they came within range of surface-derived water, producing a wide range of secondary minerals. Many minerals were destroyed by this weathering, but some such as cassiterite (the ore of tin) were more stable than the minerals forming the rock in which they occurred. This enabled the cassiterite to be released, which accumulated in the valleys and depressions on the surface to form deposits of alluvial tin, often with small amounts of tungsten and gold as well. There is little mineralogical interest in these deposits, although the landform produced after alluvial tin working has often, after a period of many years, developed into a semi-wetland area of exceptional biological interest, such as Goss Moor (last worked in 1910), Red Moor and Breney Common.

Occasionally, weathering has produced concentrations of ore (mainly tin and wolfram) in the soft weathering mantle overlying a mineralized zone ('eluvial' deposits). This was sometimes exploited in the past by diverting a stream so that it flowed over the mineralized area and eroded the soft weathered material, the ore minerals then being recovered in a similar way to alluvial tin working. The kind of landform resulting from this kind of activity can often be seen in places like Bodmin Moor. In a few cases, features of geological interest are seen at the mine site, which are unrelated to the minerals which were sought during the mining operation, e.g. skarns at Botallack. Finally, it is important to realise that minerals once in a dump may further decompose and react with one another to produce new minerals, some of which can be of considerable interest.

Conservation of the mineralogical heritage in derelict land arising from metalliferous mine working

As has been described above, Cornwall possesses a valuable heritage of old workings and waste tips arising from past metalliferous mining activities, which contain many interesting and rare minerals, or suites of minerals. The dumps also can provide samples of rocks from some distance below the surface and, properly interpreted, can yield information about the way the mine was worked and the minerals exploited. Continued study of these locations will probably yield much valuable scientific information.

These sites are at risk from a variety of factors: Removal of the dumps for re-processing or as sources of hardcore. Extraction of large quantities of material will result in rapid destruction of the scientific resource. Small-scale extraction over a protracted period may have a similar result. Use of metalliferous mine waste for constructional use may not be advisable in any case, because of the potential for chemical reactions leading to loss of structural integrity (e.g. mundic blocks).

Reprofiling (i.e. levelling or flattening) mine dumps serves to disturb and redistribute material and, although it may result in some short-term gains in exposing fresh dump material, in the long- term it can lead to the destruction of much of the scientific interest. Some 'improvements' associated with derelict land reclamation schemes, which result in the stony content of the dumps being completely covered with soil and vegetation, can also result in the scientific resource no longer being available for research, although this may be a way in which material can be conserved for future generations; see below, however.

Reprofiling of old surface workings can have much the same effect as above, with the short-term possibility of some interesting material being turned up during the reprofiling operation. However, infilling of old workings, either with adjacent material, or as a landfill site, usually completely destroys any scientific interest.

Development (i.e. building) on reclaimed mine dumps will also lead to a rapid loss of scientific resource, as the dump material will probably become inaccessible. Chemicals (e.g. arsenic, heavy metals) and/or gases (e.g. radon), may be released from the dump material and can, under certain conditions, contaminate the buildings and their grounds, or cause accelerated corrosion of foundations. A similar note of caution needs to be sounded about disturbing naturally occurring carcinogenic asbestiform minerals in some dumps, a subject about which little is known at present. Dumps may also cover unrecorded insecurely capped mine. Excessive collecting by professional mineral dealers and amateur mineral collectors, which removes all the mineralogically interesting material, can result in rapid loss of the scientific resource. Sometimes good finds or rare specimens are referred to local museums or scientific societies, so collected material may not always be entirely lost to science.

Percolating rainwater and exposure to the atmosphere causes many minerals, particularly minerals such as sulphides, originally from below the water table, to decompose and, ultimately to be destroyed. Repeated disturbance of the dump material accelerates this process. Capping of shafts so that underground access is no longer possible may prevent bona fide researchers from reaching important locations underground where particular minerals or mineralization suites may be studied. Blocking of all means of ingress and egress to the underground workings may also stop limited air circulation, which helps to disperse the build-up of gases such as carbon dioxide or radon. This can prevent underground inspection of the engineering stability of the workings (e.g. Dolcoath), which may be important in the context of structures placed on the ground above. Access to underground sites should be maintained by stabilising the surroundings of the surface opening by means of a concrete collar or similar and preventing public access by means of a steel grill or gate through which air (and bats) can circulate.

Types of designated conservation site

Sites which are particularly important, or vulnerable, can be recognised by the following designations:

- Sites of Special Scientific Interest (SSSI). These sites are regarded as of at least national, and often international, significance and must conform to strict criteria. SSSIs have legal (statutory) status under the 1981 Wildlife and Countryside Act, which provides a high degree of legally enforceable protection. English Nature (the governmental adviser on nature conservation in England) is responsible for their designation and monitoring. Removal of samples from SSSIs is not possible without permission from English Nature. Many old dump sites in coastal locations are included in the large coastal SSSIs, e.g. Wheal Owles, which is contained in the Aire Point to Carrick Du SSSI, and Wheal Coates, which is included in the Godrevy to St. Agnes SSSI. A few coastal SSSIs cater specifically for mineralogical interest, e.g. Cligga Head SSSI. Some inland SSSIs have been specially created to cater for the mineralogical interest at old mine locations, e.g. Penberthy Croft Mine SSSI (near St Hilary), Wheal Alfred SSSI (near Hayle) and Wheal Gorland SSSI (near St Day).

- Important mineralogical sites were also identified by means of the Geological Conservation Review (GCR sites). The Nature Conservancy Council (the predecessor to English Nature with a country-wide remit) instituted a national review of all potential geological conservation sites in 1977 (Ellis et al. 1996). Sites were selected by appropriate experts in a series of geologically defined subject areas called 'blocks' or 'networks' and the work of selection has essentially been completed. The network which covers sites of mineralogical interest in Cornwall is called 'Mineralogy of south-west England' and a list of sites is available, although the explanatory monograph is not yet published.

Although GCR sites have no legal status in the planning process, they are frequently in SSSIs. Indeed, many SSSIs were set up because a GCR site was identified first at a locality. In many of the large coastal combined biological/geological SSSIs, the GCR sites more specifically identify the areas of greatest geological/mineralogical interest.

- Regionally Important Geological/ Geomorphological Sites are non-statutory sites which are of county or regional significance. The original initiative for RIGS came from English Nature in 1990. The designation of these sites in Cornwall is the responsibility of the Cornwall RIGS Group, a voluntary body set up in 1991, which is affiliated to Cornwall Wildlife Trust. RIGS are recognised by the Department of the Environment in Planning Policy Guidance (PPG) 9 on "Nature Conservation" (Paragraph 17), and where development is proposed on or near a RIGS site the Local Authority is required to consult with the local RIGS Group. Typical sites include Gilson's Cove Mine near Portquin, Wheal Basset near Redruth, Wheal Phoenix near Minions and Wheal Uny near Redruth. Sometimes a RIGS site will be identified within a SSSI, to draw attention to a particular geological/mineralogical feature which is not covered by a GCR designation, e.g. Gryll's Bunny and Wheal Cock near Botallack

Recommendations

Conservation of sites of former metalliferous mining activity must take into account the possible mineralogical interest. Destruction or despoliation of former mine sites could result in a loss of valuable and unique scientific material. Because of the considerable variation in the nature of sites, it is suggested that, in most cases, site-specific conservation measures are appropriate. In general, the best conservation policy with most old mine dumps and surface workings is to leave them alone. If any disturbance of a former mining site (including shaft capping) is under consideration, the following guidelines should be applied before works commence: the site should be checked against the register of SSSI, GCR and RIGS sites. If it is one of these, then advice from English Nature (for SSSIs and GCR sites) or the Cornwall RIGS Group (for RIGS sites') should be sought. In all cases, a reconnaissance mineralogical survey of the spoil heaps on site should be undertaken, and an assessment of the scientific value sought by a review of the published information sources by an appropriately qualified person. Where a significant mineralogical interest is demonstrated, then the site should be subjected to the minimum disturbance possible. Wherever possible, shafts and other underground entrances should not be sealed up, but should be grilled or gated so as to allow access by bona fide interested parties in the future.

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Cornwall and West Devon
Mining Landscape
inscribed on the World Heritage List in 2006

The ecological value of metalliferous mining sites

At some 4,888 hectares (ha) Cornwall has more derelict land than any other administrative county, this being 12 per cent of the national total; 3,899 ha of this is made up of spoil heaps produced through metalliferous mining.

Mining land presents special problems for plants and wildlife, but also unique habitat opportunities. Some of the factors special to these sites include:

- A mosaic of hummocks and hollows
- Compacted and often contaminated soils, leading to long-standing bare ground, affected by wind and water erosion and prone to extremes of temperature
- Lack of topsoil, soil structure, nutrients and micro-organisms
- Steep slopes
- Toxicity due to mineral content – for example residual, fine particulate copper, zinc, lead and arsenic
- Unstable substrates
- Derelict buildings and building rubble
- Abandoned tanks and ponds, as well as poorly drained areas
- Shafts, adits and openworks

The vegetation which develops on such sites is generally typical of the surrounding area, and may thus be composed of gorse scrub, willow, acid grassland, heathland, bare ground, ruderal habitats in disturbed ground, wetlands or open water. In Cornwall, gorse and willow scrub typically take the place of woodland. The precise composition of habitats on any site will be related to particular conditions, and may give rise to rare and unusual communities – for example, some mosses and lichens are associated with concentrations of heavy metals, particularly copper.

As a general rule, the longer such sites have been abandoned, the more diverse the vegetation development and the greater the nature conservation interest, though mere vegetation cover is not a guarantee of importance, since species requiring ‘pioneer’ conditions are a key feature of such sites. Variation in abandonment of different areas of a site can also play its part in ensuring biodiversity. Many of the most important sites in Cornwall and west Devon have been long abandoned and have been relatively isolated from the effects of recent disturbance by mineral reprocessing, land reclamation, tipping or motorcycle scrambling.

These sites now represent some of the last remaining semi-natural habitat in Cornwall, often forming islands of wildlife habitat within urban and industrial areas, or within areas of improved farmland. As such, they may well be important reserves for the wider community. Many also contain small areas of heathland, a declining resource both in Cornwall and nationally. The areas of bare ground they often include are also increasingly rare in the region.

Plants

Compacted, contaminated soils on such sites may provide suitable growing conditions for a wide range of species which may not be able to grow in more fertile areas where they are out-competed. Typical of these are grasses and other plants adapted to contaminated soils such as Common Bent (Agrostis capillaris), some varieties of Thrift and Heathers. The calcareous pointing on derelict walls may provide niches for plants unsuitable for acid Cornish soils. Rushes may grow in metal contaminated water and silts, whilst stream beds may be coated with the metal tolerant algae Microthamnion species.

Bryophytes, mosses and lichens

Soils rich in copper are globally scarce and over 25 per cent of the total number of mosses and liverworts found in Cornwall have been recorded on abandoned metalliferous mine sites. Several of these species are nationally rare and many are restricted to metal-contaminated conditions. The rarest include Cornish Path Moss (Ditrichum cornubicum) which is unique to Cornwall, the moss Scopelophila which is found on only three or four sites in Britain, one of these being in Cornwall and the liverwort Cephaloziella nicholsonii, which is unique to Britain, over 90 per cent of the population being found in Cornwall. Cornish mining sites also support nine 'Nationally Rare' species, including all of the national population of Cephaloziella integerrima and most of Cephaloziella massalongi and Scopelophilia cataractae. An SSSI including seven discrete sites have now been designated for its bryophyte importance. A further 138 SSSIs protect sites of mineralogical or biological interest, as does one SAC designated for the importance of the flora of an area of former mining land.

Lichens are the born survivors of extreme environments, and are often important colonisers, occurring on spoil heaps, mine buildings and adit walls. It has recently been established that mineralisation type is a key factor in determining the composition of assemblages on mine spoil, some species favouring low pH iron-rich substrates, others high pH copper-rich sites. A visit to Cornwall by the British Lichen Society in 1987 identified a range of metallophyte lichens and metal-rich eco-types near Redruth and Liskeard. These are rare in Britain, and are best developed at some Cornish mine sites.

Animals

Disused shafts and ruined buildings often provide important nest and hibernation sites for a wide range of birds such as Raven and Peregrine, whilst bats, including the rare Greater Horseshoe Bat, use open mine workings as roost sites. Dry areas may be colonised by common lizards and slow-worms, whilst wetter areas provide habitats for frogs and toads.

Terrestrial invertebrates

Areas of heathland provide important autumn nectar sources for flying insects; heather is also an important food source for several invertebrates. Bare ground habitats are important for a range of insects which use open areas for nesting, chasing after prey and basking. Of note are the Mottled grasshoper (Myrmeleotettix maculatus), the Grayling butterfly (Hipparchia semele), the Silver-studded blue, tiger-beetle wasp and western bee-fly, several mining bees and other nationally rare species.

Freshwater invertebrates

Freshwater contaminated by metalliferous run-off is usually low in invertebrate diversity, the low pH and lack of available calcium making molluscs and crustaceans rare in such conditions. Some species thrive here, however, including Polycentropodid caseless caddisflies, Nemourid stonefly larvae, non-biting Chironomid midge larvae and the larvae of Dragonflies, including the Nationally Scarce Ischnura pumilio. The small red damselfly Ceriagrion tenellum has been found on several former mining sites near Camborne. In addition, a range of beetles and bugs live in the less contaminated upper areas of these water bodies.

The following species have been identified as priority species within the Cornwall Biodiversity Initiative Action Plan short and middle lists for metalliferous mine sites:

- *Cephaloziella calyculata* Entire threadwort
- *Cephaloziella intergerimma* Lobed threadwort
- *Cephaloziella nicholsonii* Greater copperwort
- *Ditrichum cornubicum* Cornish path moss
- *Ishnura pumilio* Scarce blue-tailed damselfly
- *Cephaloziella massalongi* Liverwort
- *Pohlia andalusica* Gravel nodding moss