

**ABSTRACTS OF OTHER PAPERS/POSTERS PRESENTED AT THE
ANNUAL CONFERENCE, JANUARY 2009**



SCOTT SIMPSON LECTURE

**STRUCTURE OF THE CENTRAL AND WESTERN
EUROPE VARISCIDES IN THE LIGHT OF
GRAVIMETRIC, MAGNETIC AND SEISMIC DATA**

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About 65 % of the Palaeozoic basement is hidden by a Mesozoic to recent sedimentary cover. In order to fill up the gaps we used gravity and magnetic maps, - transformed maps of the gravimetric and magnetic anomalies (derivatives, downward and upward continuations, analytical signal) and, - measurements of the densities, induced and remanent magnetizations on outcropping rocks and cores. An interpretative geological map of the Variscides from south west England to the Polish Sudetes is presented. 3D gravimetric and magnetic modelling constrained by the available deep reflection seismic sections allow us to image in depth the structures shown on the map. Thanks to the specific geophysical character of the subduction related rocks, the Devonian and Carboniferous sutures can be traced. Strong magnetic anomalies show the extension of the Carboniferous Morvan – S. Vosges – Swabian Jura – Central Bohemia and the N. Vosges – Odenwald –Thuringia magmatic arcs. The magnetic anomalies of the Central Channel probably represent the western extension of the latter arc. The interpretative map underlines the importance of Carboniferous wrenching which is associated with block rotations and facilitated the intrusion of numerous granitoids. Therefore, emplacement of the large magnetic body responsible for the Paris Basin anomaly was associated with wrenching and clockwise rotation of the Cadomian Armorican block.

**THE GLASTONBURY SHEET – ASPECTS OF
ONGOING RESEARCH**

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The recent ongoing mapping programme by the British Geological Survey in the Glastonbury district (Somerset) has provided a wealth of new information about the Triassic to Jurassic rocks that underlie the area and the younger overlying deposits. Research in this area is still ongoing, but some preliminary results are presented, along with some ideas for further study. Some areas where the research is currently focussed are: (1) The Lias Group rocks have been drilled and cored and together with the use of field data a new stratigraphy has been introduced for the Charmouth Mudstone Formation. (2) NextMap data has been studied to give an overall impression of the complex faulting and structure in the area. (3) Re-mapping of the Burtle Beds (sands and gravels) has shown that current exposures are not as widespread as previously mapped. A re-evaluation of the deposits is currently ongoing.

**ANIMAL, VEGETABLE OR MINERAL?
FOSSIL MOULDS FROM WEMBURY POINT,
SOUTH DEVON**

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The rocks on the foreshore at Wembury Point, near Plymouth belong to the Early Devonian Dartmouth Group. The rocks comprise mainly silty mudstones and siltstones and are likely to be of lacustrine or fluvial mudflat origin. The succession usually yields only fish fragments and very sparse examples of Bellerophon, however at this location unusual fossil moulds in a rosette form are preserved. The preservation of the moulds is unusually good and can be seen to take a radial form. 'Spokes' reach outwards from a central 'orifice' and between some of these connecting ladder like structures are seen. Although the features resemble modern 'jellyfish' or plant like forms, no such structures have been recorded from the Devonian. It is therefore most likely that the features were formed as mineral growths in a continental evaporate sequence.

**ROMAN MINING ON EXMOOR:
A GEOMORPHOLOGICAL APPROACH AT ANSTEY'S
COMBE, DULVERTON**

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A survey of valley fills in south facing combes (headwater valleys) along the south side of the Exmoor massif revealed an anomalously deep infill in one valley. This infill of up to 5 m depth had been gullied revealing a complex stratigraphy. Studies of the stratigraphy, clast orientation and shape suggested several accumulation episodes under different environmental conditions commencing under a periglacial climatic regime. Later units included sandy silts which can be dated using optically stimulated luminescence (OSL) of quartz grains. The OSL dates indicate that the inter-gravel silts accumulated in two periods, the Romano-British period and the 16th-17th centuries AD. A survey of the very small valley catchment revealed a linear trench of a type associated with early iron-mining. Given the anomalously high volume of accumulated sediment from such a small catchment and evidence of mining on the slope above the site, the geomorphic mechanism is almost certainly the downslope transport of mining debris from the slope to the valley floor. This study suggests that the systematic survey of headwater valleys in metalliferous uplands may be one way of locating areas of early mining activity and that such deposits could provide a chronology of working and abandonment.

**THE ENGLISH RIVIERA GEOPARK – PAST,
PRESENT AND FUTURE**

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In September 2007 Torbay received international recognition for its rich geological and cultural heritage, when it became one, of what is now, 57 areas around the world to be endorsed by UNESCO and welcomed into the network of European and Global Geoparks. The Geopark territory has a rich and well-exposed geological heritage, from Devonian reefs to Pleistocene bone-caves. This geology has strong links to the history of the science and culture, not least as Torbay includes sites crucial to the initial characterisation of the Devonian Period. Now just over a year on, the status is wholeheartedly supported by the local council and is recognised as a key tool to promote both community pride in the Bay and sustainable economic regeneration. Most exciting has been the Geoparks ability to successfully drive forward a major funding application totalling £5 million under the UK government Seachange funding programme. The unique combination of a superb geological resource, a well established and mature tourism infrastructure, an innovative conservation trust with well-developed partnerships with public, private and voluntary sectors, makes the English Riviera Geopark well placed to develop in a dynamic and successful way within the Global Geopark Network.

**A LONG PLEISTOCENE SEQUENCE AND RECENT
ARCHAEOLOGICAL FINDS AT CHARD JUNCTION PIT
IN THE AXE VALLEY**

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The Axe Valley on the borders of Devon, Dorset and Somerset has long been known for its rich Palaeolithic archaeology. Likewise it has a long history of research by Quaternary geologists having been once regarded as an outflow from Glacial Lake Maw which was thought to have occupied the Somerset Levels. Whilst this theory has been discredited there remains a geological conundrum in the thickness and form of the Quaternary deposits within the valley. The discovery in July 2008 of two lower Palaeolithic bifaces at the lower levels of the Chard Junction quarry (Hodge Ditch) has re-invigorated this research question. Previous work by the PROSWEB Project had obtained dates on the upper part of the complex fluvial sequence at Chard Junction and this, along with recent research, has proven a remarkably long sequence of deposits extending from the Middle Pleistocene (probably before MIS 12) to the Holocene (MIS 1). This sequence contains many hiatuses and lateral complexities but is clearly a strong terrestrial reflection of the global climate change record and is probably the longest semi-continuous stacked fluvial sequence in the British Isles. This paper will briefly summarise the sedimentary geology of the site and the recent archaeological finds and illustrate their importance for studies of the Palaeolithic in SW England.

THE VARISCAN: WHERE WE ARE IN SW ENGLAND

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SW England is bounded, offshore to the south, by a reactivated late Devonian suture with the Normannian Terrane (Armorican affinities), and to the north and east by the Bristol Channel-Bray Fault that brought about late Westphalian juxtaposition against unequivocal Avalonian lithosphere. Its Upper Palaeozoic geological evolution provides important constraint on Variscan tectonic models due to its proximity to the Rheohercynian and/or Rheic suture(s). Further east in mainland Europe, late Devonian convergence along the active northern margin of the Saxothuringian Zone (Mid-German Crystalline High) resulted in continental collision and progressive inversion of the Devonian (Rheohercynian) passive margin during the Carboniferous. The westwards correlation of the Rheohercynian suture, across the Bristol Channel-Bray Fault, to SW England appears justified. However, the relationship between the closure of the Rheic Ocean and the development and destruction of the Rheohercynian passive margin is poorly constrained. The latter may have developed in a marginal basin north of the Rheic Ocean or, possibly, a successor basin following its closure.

TUNGSTEN PRODUCTION IN CORNWALL AND DEVON: AN OVERVIEW 1860 – 2000

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This paper will look at the context in which mines in South West England began the commercial production of tungsten ore in the late nineteenth century and the principal influences on output during the twentieth century. It will start by looking at the broad changes in metallurgy that created an expanding demand for a wide range of different ferro-alloys and the place of tungsten within that overall movement. Consideration will then be given to the domestic sources of production, their significance within overall world supply, and the degree of self sufficiency that the south western mines provided for the British special steels industry. The most important Devon and Cornwall producers will be identified and some indication given to the overall significance of tungsten production for their economic survival.

HUTTON'S UNCONFORMITY AT SICCAR POINT, BERWICKSHIRE, COMPARED TO PLAYFAIR'S UNCONFORMITY NEAR PAIGNTON, DEVON

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In 1788, James Hutton, accompanied by Sir James Hall of Dunglass and Professor John Playfair, discovered the spectacular unconformity at Siccar Point on the coast of Berwickshire in Scotland. This locality has subsequently become one of the most famous geological localities in the whole world, frequently visited by students of the science of geology. Whereas, we know today that the Siccar Point unconformity represents a gap in time of about 40 million years in the history of the earth, what might be called Playfair's unconformity on the coast of Torbay near Paignton represents a gap in time of about 120 million years. It was first described by Hutton's biographer, John Playfair, in his *Illustrations of the Huttonian Theory* in 1802 following his visit to the Devon coast in Torbay with his friend Lord Webb Seymour after Hutton's death in 1797.

ISOTOPIC ANALYSIS OF LATE JURASSIC FISH OTOLITHS FROM WOOTTON BASSETT MUDSPRINGS

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The $\delta^{18}\text{O}$ compositions of well-preserved Jurassic fish otoliths from Wootton Bassett, UK provide upper ocean palaeotemperature estimates in excess of 30°C rivalling temperatures associated with the mid-Cretaceous thermal maximum. Negative carbon isotopes of the otoliths may point to a freshwater influence and potentially migratory nature of the fish. However, given the large departures from equilibrium fractionation towards more negative values reported from modern marine fish we consider our temperature interpretations to be robust and representative of the marine depositional environment. Depleted $\delta^{13}\text{C}$ values we believe suggest the otoliths examined in this study belong to fish with high metabolic rates.

BIDEFORD BLACK – SOME PROPERTIES OF AND SPECULATION ON THE ORIGIN OF SEAM CARBON IN THE UPPER CARBONIFEROUS OF THE BIDEFORD AREA, NORTH DEVON

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The fluvio-deltaic cycles of sandstones and mudstones of the Bideford Formation contain sheared seams of carbonaceous organic matter. The mined seams, which are reported to be discontinuous and display highly variable thicknesses, could be autochthonous or allochthonous coals, or bitumen, representing oil expelled from the substantial thicknesses of interbedded black shales. The currently exposed Bideford Formation has experienced burial to some 5-8 km prior to uplift. Tectonic burial occurs under compression, where folding is followed by thrust detachment along planes of weakness. The low strength carbonaceous seams appear to have been major planes of detachment. Based on analogues from the Naga Thrust system of Assam (NE India), where the outcropping detachments follow Oligocene coals of the delta-top Barail Group, the highly anisotropic micro-fabric of the Bideford Black is attributed more to Variscan shearing than graphitization under high temperature and lithostatic load. Burial history modelling places limits on sedimentary burial, and demands tectonic burial to obtain calibration against the reflectance of the carbonaceous material.

SYMMETRY OF THE PERI- AND POST-GLACIAL DEPOSITS OF NORTH DEVON AND THE SOUTH GOWER

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The following describes two exposures of post-glacial 'Submerged Forest Series' recently revealed at Port Eynon and Three Cliffs Bay, Gower, South Wales. The objective is to compare sediment type, stratigraphy and thickness with previously reported and dated examples from Westward Ho!, North Devon and consider the existence of similar environments in both areas. At Port Eynon [SS 472 851], an extensive peat layer contains numerous *in-situ* root systems and associated tree trunks. Underlying the peat is a blue clay horizon containing matrix-supported angular clasts of various sizes and types through which the extensive root systems penetrate. The blue clay overlies and partially incorporates a cobble bed with rare metre-scale, diffuse reddened patches observed on the transition. At Three Cliffs Bay [SS 538 882], a peat layer containing wood fragments with an overall absence of complete root systems is underlain by a blue clay horizon with very similar sedimentary characteristics to the Port Eynon exposure. Both these examples are exposed at the mid to high tide level today suggesting a similar elevation at the time of their formation. The South Gower exposures described here share many sedimentary similarities with the reported example from Westward Ho! This, combined with the comparable elevations and relative juxtapositions to raised beaches of probable Ipswichian age of all three exposures may suggest a common age and the existence of peat fens and localised woodland both north and south of the Bristol Channel during the Later Mesolithic.

HEMERDON TUNGSTEN – MODERN METAL MINING IN THE UK – YOU CAN'T 'OFFSHORE' THIS BUSINESS

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The development by Wolf Minerals of Australia of the tungsten deposit at Hemerdon reflects structural global concerns, and more directly, concerns in the developed 'Western' nations about the availability of a range of rare metals and other minerals essential for technological advance. This concern has even reached the heart of Europe where it is now, at last, realised that the brutal 'Darwinian' nature of economic life means that not only can high-tech jobs leak to other areas, but that the BRIC nations and the Middle East countries no longer need our hard currency in exchange for raw minerals. Most of Europe and the USA depend on imports of these minerals but for various reasons this is unsatisfactory, encouraging sourcing from our own resources. These reasons include political stability, security of the supply, cost and availability including the existence of a viable infrastructure to bring the resource to market. Concerns about energy supply and pollution control provide further justification for sourcing minerals such as gallium, rhenium, lithium, PGE minerals etc, internally. Tungsten is important both in providing cutting tools for mining, manufacturing, etc, but also as a catalyst in pollution control. The deposit at Hemerdon is 'World Class' in mineral terms and the first 'modern' metal mining development in the UK. It can also be considered world class due to the location in a politically stable area with excellent infrastructure, steady energy supply and with an existing skilled employment base. With the existing valid planning permission, development of the deposit can proceed rapidly. Importantly for the local economy, one can't relocate a mineral deposit and this is not a business that will disappear offshore. We might shortly get advice from Europe encouraging each nation to take due account of both economic and security issues in mineral supply.

CENOZOIC GEOLOGY OF THE LIZARD PENINSULA, SW ENGLAND

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The Cenozoic history of the Lizard Peninsula dates back to at least the Paleogene, resulting in a relatively complete record, involving the deposition of the anomalous quartzose Crousa gravels, possibly fault controlled uplift, deep Tertiary weathering, development of the current drainage pattern, accompanied by landward coastal retreat from a presumed Miocene cliff line and incision of the valleys, prior to the deposition of presumed Mid to Late Pleistocene raised beaches. These earlier events controlled the nature and distribution of the overlying 'head' deposits and in particular its well-known loess deposits, which may be contemporaneous in part with its conventional 'head' deposits. The Lizard Peninsula is seen as a dynamic landscape, and not as part of a fossilised Tertiary Reskajeage surface. It has been clearly degraded by Quaternary periglacial processes. Key outcrops used to document this study are identified.

SOME PERSPECTIVES ON TUNGSTEN-BEARING VEINS FROM SW ENGLAND AND S CHINA

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Greisen veins containing wolframite are one of the most consistent expressions of granite-associated mineralization found throughout the world. Subtle variations in the metalliferous paragenesis are found from place to place, for instance greater or lesser amounts of associated beryllium and molybdenum. Boron in the form of tourmaline and fluorine in the form of topaz also show regional variations. The lode systems are characteristically endogranitic, though the greisen-bordered fractures frequently pierce the granite carapace and enter the aureoles of hornfels to form tungsten-bearing stockworks of various scales. The lodes typically form parallel systems in sub-vertical or sub-horizontal arrays and the mineral textures are conspicuously pegmatoid. In most systems, feldspar-destructive facies of hydrothermal alteration are observed, but there are evidently transitions between feldspar-stable and feldspar-unstable regimes. This can be seen in successively developed stages of the fracture systems as observed in the Variscan of SW England or in different parts of the same lodes as observed in the Yanshanian granites of southern China. Some aspects of the transition from the pegmatitic to pneumatolytic stages of hydrothermal evolution in granites in these two provinces can be explained in terms of the textures. These systems are a classic expression of 'facies zoning' as defined by Smirnov (1937).

FORAMINIFERA FROM THE OXFORD CLAY FORMATION AT REDCLIFF, WEYMOUTH

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As part of the on-going research on the potential GSSP for the base of the Oxfordian stage, the foraminifera of the Redcliff succession have been described. The assemblage provides nothing diagnostic for the definition of the base of the Oxfordian (which is, in any case, based on ammonites). The fauna is dominated by species of the genus *Epistomina* which, as a result of their aragonite tests, are usually rather poorly preserved – though still identifiable. Agglutinated foraminifera are quite rare, despite being the dominant fauna in other parts of the Oxford Clay succession. The most distinctive feature (as reported in Hart *et al.*, 2007) is the presence of large numbers of pyritized planktic foraminifera placed in the genus *Globuligerina*. The Callovian/Oxfordian boundary interval is characterised by widespread occurrences of these taxa across Europe, though little is known about their occurrence in the UK.

FORAMINIFERA FROM THE CHRISTIAN MALFORD LÄGERSTATTEN

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Borrow pits near Christian Malford (Wiltshire) excavated a large number of coleoids, fish and other macrofauna showing exquisite soft-bodied preservation. In the mid-19th Century, during the construction of the Great Western Railway, some specimens were, unfortunately, destroyed during the bombing of London during 1941. Other specimens have been 'protected' by various coatings and cannot be investigated by modern techniques. In 2007, a team led by Philip Wilby (BGS, Keyworth) excavated the site and collected a number of borehole cores. There is now an inter-disciplinary team of geoscientists working on the new material in an attempt to recover more soft-bodied material as well as provide samples for more "invasive" research (Wilby *et al.*, 2008). The lägerstätten lies within the *K. pbaeimum* Subzone of the Athleta Zone (Callovian); Peterborough Member, Oxford Clay Formation. Many of the surfaces of the mudstones and calcareous shales are covered in small bivalves (spath) and gastropods and these have been interpreted as indicating hostile conditions on the sea floor. In the same levels, however, there are masses of benthic foraminifera (often *Epistomina* spp.) and this would indicate that, for at least some of the time, the sea floor was inhabitable. This work is on-going but preliminary work does indicate that many parts of the succession above and below the 'Squid Bed' contain reasonable foraminiferal assemblages.

A COORDINATED RESPONSE TO SUSTAINABLE MATERIALS MANAGEMENT

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Climate Change issues continue to have a high profile in the media but this tends to focus on only one aspect of the problem that modern industrial societies have to address. The focus on carbon dioxide emissions is like addressing the symptoms of the 'disease' rather than tackling the cause. This study will illustrate how the demand for materials has grown and that, taken together with the increase in the human population, this has created social systems and lifestyles that are un-sustainable. The finite resources of the planet cannot support the impact of increasing consumption per capita and continued growth in population. Some examples of how science and technology can be utilised to reduce the impact that humans are having on the bio-sphere are presented but these will not be effective without the appropriate political decisions. Unless the social conditions can be created to deliver a more sustainable system for the global human family the future will be one of conflicts over resources (oil, water, minerals, land, food, etc).

GEOLOGY AND SETTING OF THE HEMERDON TUNGSTEN DEPOSIT

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The Hemerdon tungsten deposit is hosted within and around a dyke-like body of porphyritic granite, known as the Hemerdon Granite, which forms a cupola or apophysis, to the extreme SW of the main body of the Dartmoor Granite, and cropping out some 1200 m NW of the village of Sparkwell. The country rock around the Hemerdon Granite is late Devonian slate, with minor basic volcanic rocks, mapped as 'diabase'. The northern part of the Hemerdon Granite is essentially a NNE-trending dyke, some 140 m wide and dipping steeply towards the E: this hosts a 'stockwork' of greisen-bordered quartz veins, bearing wolframite and cassiterite, with minor arsenopyrite and sulphide minerals. At least three sets of veins have been distinguished, some lacking greisen borders and others bearing feldspar and haematite in addition to quartz. The stockwork measures at least 600 m from NNE to SSW and is about 140 m wide: mineralization has been demonstrated by drilling to persist to 400 m below ground surface. This paper will review the geology and metallogenesis of this deposit, which has recently been re-explored by Wolf Minerals Ltd. As a result of the re-assessment of earlier work, together with the results of a new diamond drilling programme, the resource estimate published by the Australian Securities Exchange in November 2008 is now 97.4 million tonnes at 0.22% WO₃ and 0.023% Sn – a world class deposit.

THE SIGNIFICANCE OF FRAGIPANS ON THE LIZARD PENINSULA

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Recent investigations into loessic deposits capping an abandoned serpentinite quarry have revealed a unique sedimentological exposure possibly linked to a Last Cold Stage permafrost event in south Cornwall. Discussions of the structural characteristics of the loessic section have led to considerations of a fragipan origin for such features. Recent publications outline at least four possible explanations for fragipans and these are considered in the context of the Lizard Peninsula. A possible periglacial and/or permafrost set of processes appear to be most likely in this example. Whilst considerations for similar Late Cold Stage palaeoenvironments have previously been restricted to discussions of coastal exposures in West Cornwall, it is believed that this is the first time that such features have been recorded in inland localities within the county.

**HERITAGE RESOURCE OF DEVON AS A CONTEXT
FOR TEACHING THE PHILOSOPHY AND PRACTICE
OF EARTH HERITAGE CONSERVATION
AT UNIVERSITY LEVEL**

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In 1990, Birkbeck College, the part-time provider of the federal London University system, launched a postgraduate Diploma in Countryside Management incorporating geological issues as 'underpinning knowledge'. In 1995, in converting this to a Masters' degree, the opportunity was taken to offer an optional module in Earth Heritage Conservation – one of the first in the UK in this field - which can also be taken independently as a professional training course. The development of this module provided a number of challenges, not least conceptual, as its context within and relationships with, the broader University of London's Masters' programme in environmental management was crucial. In particular, three key issues required attention. Firstly, is the need to consider the conceptual issues that are often implicit in the practice of Earth heritage conservation but rarely treated directly. In particular, as the subject of geoconservation and geodiversity is potentially very broad, some limits required definition. Geological and geomorphological sites and materials are clearly central themes, but to what extent should processes such as coastal and even biogeochemical be included? The second challenge concerned the level of underpinning knowledge (understanding) and practical competencies (skills) that students – typically without any geological training - would be expected to achieve. A third key issue concerned the relationship of geoconservation with the remainder of the MSc curriculum, for instance in relation to environmental ethics and utilitarian versus intrinsic values. Crucially, all of these issues had to be addressed within the delivery constraints of a typical Birkbeck MSc Module: a one week residential course with follow-up written assignment. The first such course was based in Caer Llan, Monmouthshire in April 1996, with fieldwork focused on the Forest of Dean, followed by a second course in October at Losehill Hall, Peak District National Park, run in collaboration with English Nature. Two courses have also been run in Slovenia, in collaboration with the University of Ljubljana, with whose MSc in Natural Heritage Protection the London postgraduate award is twinned. The module is now run, however, from the Slapton Ley Field Studies Centre in South Devon, as the diverse and readily accessible geological resource in the area, provides a superb opportunity to explore a wide range of philosophical and practical issues which are fundamental to the practice of Earth Heritage Conservation. The course includes a structured introduction to the subject, together with invited contributions from practitioners and field visits to three key study areas: Dartmoor National Park (igneous geology, including Variscan granites with historical mining industry and classic periglacial landforms), the English Riviera UNESCO Geopark, Torbay (sedimentary geology and palaeontology, including Devonian reef systems, Permian 'Red Beds' and glacial/interglacial caves and raised beach) and the South Devon Area of Outstanding Natural Beauty (metamorphic geology, including Variscan schists, classic Quaternary climate and sea-level change features and modern coastal processes with associated coastal zone management issues). This paper will consider the conceptual development of the Birkbeck Module and illustrate how the principles and practice of Earth Heritage Conservation can be illustrated by the rich geological heritage and innovative conservation management programmes that have been developed within Devon.

**THE USE OF UNDERGROUND SITES ON
DARTMOOR BY BATS**

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Dartmoor National Park has a rich mining history with many mines, adits and shafts, especially on the fringes of the moor. Equally, Dartmoor supports a thriving bat population, with 14 of the 17 UK bat species being recorded within the park. The National Park Authority, Natural England and the Woodland Trust have started a project investigating the use of underground sites by bats. A desk study has been carried out with a review of literature and discussions with geologists and mining experts. However, we are still seeking information on the past use, underground extent and environmental conditions in mines on Dartmoor; exact location of adits; access and ownership details etc. Studies elsewhere have shown that large and complex underground sites are the most likely to be important for bats as mating sites in the autumn and for hibernation in the winter. We would welcome help and information to progress our investigation.