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**ABSTRACTS OF OTHER PAPERS/POSTERS PRESENTED AT THE  
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**AN INVESTIGATION INTO USE OF THE  
FRESHWATER GASTROPOD *VIVIPARUS* AS A  
RECORDER OF PAST CLIMATE CHANGE**

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Through isotopic analysis of *Viviparus lentus* a high resolution record of changes in  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  across the Eocene/Oligocene transition and Oi-1 glacial maximum has been produced for the Solent Group strata, Isle of Wight (UK). In order to calculate temperatures from this record an investigation into the biology of modern *Viviparus* and its affect on the isotopic composition of its shell carbonate was undertaken. Experimental measurements of the  $^{18}\text{O}/^{16}\text{O}$  isotope fractionation between the biogenic aragonite of *Viviparus* and its host freshwater were undertaken from samples derived from the Somerset Levels in order to generate a genus specific thermometry equation. Application of this thermometry equation to the  $\delta^{18}\text{O}$  record from the fossil *Viviparus lentus* has produced a high resolution temperature record. The recorded isotopic and temperature shifts used in combination with other palaeoflora and palaeofauna data indicate several climatic events taking place prior to the Oi-1 glacial maximum. The similarity of the  $\delta^{18}\text{O}$  records to those seen in the marine realm, in particular the shifts relating to the E/O transition and Oi-1 glacial maximum, suggests the possibility that there is a coupling of terrestrial and marine environments via atmosphere and ocean circulations. An investigation into seasonal isotopic variability using whole well preserved *Viviparus lentus* specimens has revealed a shift from tropical/subtropical to temperate climatic zones occurring before the Oi-1 glacial maximum.

**STRATEGIC MINERALS IN SOUTH WEST ENGLAND:  
HEMERDON UPDATE, THE EUROPEAN RAW  
MATERIALS INITIATIVE AND DEMANDS FOR MINERALS  
IN 'ALTERNATIVE' MANUFACTURES**

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Following last years presentation and the subsequent site visit to Hemerdon, an update on progress on bringing on stream the World Class tungsten deposit at Hemerdon is provided. Reference was made last year to the impact of the 'Darwinian' nature of economic life which tests and rejects non-viable activities. The impact of the global recession has strenuously tested many mining projects. In that testing a number of projects have fallen by the wayside. However, while the recession produced funding difficulties, and slowed development at Hemerdon, the project has emerged stronger than before and can be clearly seen as being of strategic supply significance in both UK and global terms. Last year, the adoption in November 2008 by the EU of "The Raw Materials Initiative", which, inter alia, sought to support supply of minerals from within Europe was also described. Unfortunately, during the economic hiatus over the last year, the EU seems to have lost an opportunity to fully develop and promulgate policies and advice on the importance of mineral supply and especially supply of what might loosely be described as 'strategic' or 'high-tech' minerals, to help the EU climb out of recession. Instead, it has first decided to assess existing strategy/policies in individual nations and the question of what is or isn't 'strategic' etc in the EU. Perhaps all that is needed is a simple statement of EU policy supporting provision of mineral resources which are currently imported. Unfortunately, in comparison with other EU nations, the UK contribution to this debate has been notable by its absence.

The issue and relevance of supply cannot be considered just in the light of current demands. New and developing technologies in energy supply, pollution control, nanotechnology, electronics, etc are often driven by the unique properties of 'alternative' new materials derived, in part, from less common minerals. However, there often seems in the UK a complete dislocation in decision makers and politicians between support for such technologies, in for example solar power, and the raw material needs. The South West of England remains a prime target for development of such raw materials and this could help to develop a substantial technological edge within the region. But are we about to miss the boat?

## HOLOCENE FLOODPLAIN FORMATION OF THE RIVER CULM, DEVON AND IMPLICATIONS FOR PREHISTORIC ARCHAEOLOGY

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The River Culm draining the western Blackdown Hills (east Devon) is in part a multi-channel system, with relatively stable channels separated by gravel, sand and silt 'islands' or low terrace fragments. The floodplain has been investigated using field mapping of floodplain surface morphology and channels, coring, the use of ground penetrating radar (GPR) and the establishment of a comprehensive dating program (<sup>14</sup>C, <sup>210</sup>Pb, <sup>137</sup>Cs and OSL). When this data is combined with a survey of scour-pools and riffles (including diagonal bars) an association is evident which implies a geological memory-effect on the contemporary channel morphology. Dating of the gravels and overlying sands and silts shows an early to middle-Holocene change in fluvial behaviour and a pronounced chronological grouping of dates, providing evidence of periods of increased flood magnitude. This pattern of floodplain evolution, which is almost certainly not unique to the Culm, has important implications for the distribution and preservation of evidence of human Prehistoric, and particularly Mesolithic, activity in lowland river valleys.

## MINES, QUARRIES AND PITS - IMPROVING THE RECORD OF HISTORICAL MINERAL EXTRACTION SITES

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Records of mineral extraction sites are important for many reasons. Regional and national planning policies need information to review mineral extraction permissions, waste disposal sites and also to safeguard strategic resources. Old workings may also present hazards such as soil and water contamination, subsidence and slope instability. South-West England and Wales both have long histories of mining and quarrying. Historically these areas have supplied not only metal ore and coal, but also building stone, road aggregate and industrial clay minerals both nationally and internationally. BritPits is a unique database held by the British Geological Survey (BGS), which contains details of mines, quarries, oil and gas wells and mineral workings. Originally, only active sites were included in the database, therefore despite parts of SW England and Wales historically having the highest density of mines and quarries within the UK, few sites were recorded in these areas of largely abandoned mining activity. Collaborative work between the University of Glamorgan and the BGS using adapted GIS (Geographic Information Systems) software, historical Ordnance Survey maps and a variety of other data sources has helped to provide a wealth of new data from these historically important regions of mineral extraction.

## TYNTESFIELD MANOR, WRAXALL AND THE CONTRIBUTION OF GEOLOGY TO ITS UNDERSTANDING

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Acquired in 2005 from the last surviving member of the family, Tyntesfield Manor is regarded by the National Trust as their prize for visitors to the West of England. To this end they are spending many thousands of pounds on repairs and improvements at the present time. Whilst it will always be an almost intact Edwardian mansion with all contemporary fittings, it should also be regarded as a geological monument to the architectural choices of the time, deserving your notice.

In the mid 19th Century, the Gibbs family, Bristol merchants gaining their wealth from trade with Spain, undertook the 'improvement' of a very ordinary Elizabethan house to an outstanding High Gothic pile, the work of a Bristol architect, John Norton, a man who had worked under the master craftsman August Welby Pugin. The influences are clear to see: the materials however, are satisfactorily of the region.

The site is south facing on the southern flank of the Clevedon Ridge, a western Mendip 'pericline'. In one sense, this was unfortunate as the thick units of the Carboniferous Limestone can be heavily charged with groundwaters which drain freely to the site. The local limestones do not figure in the Manor, Norton wisely choosing best quality Bath Stone of freestone grades, allowing free style carving and smooth ashlar finish to the walls. Family interest in the Great Western Railway probably solved whatever transport problems and charges which were incurred. They certainly helped with the interiors which are rich in imported marbles from Italy, including complete Venetian fireplaces brought in through the port of Bristol. The family had a fleet of vessels on the high seas, primarily carrying the Peruvian guano, a valued import for which they had the exclusive contract for Europe. Almost all the granites are Scottish, supplied either by sea or the rail connections which linked with the Great Western between 1865 and 1880.

The Gibbs family were High Church and had connections with Oxford University, to the extent that they had funded the Chapel at Keble College of William Butterfield (1875). Shortly afterwards when they chose to add a Chapel to their estate, they again chose John Norton with a few Pugin-trained aides, to produce a Keble-style Chapel appropriate to the worship of an Oxford Movement. While the parallels are clear, Norton choose to marry rough dressed dolomitic conglomerate quarried in the estate grounds with Coombe Down Bath Freestone and with orange toned Ham Hill Stone.

For the interiors, the Italian and French marbles of Keble College Chapel are here replaced by slender columns of the Devonian limestones and marbles. Notably absent, however, are the familiar Ashburton, an omission which seems puzzling.

My involvement at Tyntesfield as a means of providing the c. 170 volunteers whom man the rooms through the busy season with a geology which is in near-everyday terms as answers to the questions 'Is this marble?' or 'What is alabaster?' With luck, this may open up other Trust properties to a fuller geological analysis and persuade powers that be that geological accounts would attract a favourable response from those of us who are Trust members and also geologists.

## EVAPORITES OF THE MERCIA MUDSTONE, BRISTOL CHANNEL BASIN, UK

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Evaporites can be observed throughout much of the Mercia Mudstone Group of the Bristol Channel Basin. Halite is described from boreholes within the basin depocentre, whilst carbonates and sulphates prevail towards the basin's edge. This suite of evaporites has a range of origins. Gypsum precipitated from basinal brines to form surficial crusts on the surface of the playa lake. During subsequent burial, gypsum crystals coalesced to form bands of nodular sulphate. Two stages of satin-spar (fibrous gypsum) vein growth resulted from syn-tectonic events. Celestite nodules precipitated from hydrothermal waters that mixed with connate water in the Mercia Mudstone Group. Elsewhere, hydrothermal waters, rich in barium and lead, precipitated mineralisation products in localised areas.

The formational history of these evaporites reveals much about the sedimentology, diagenesis, tectonic activity, palaeoclimate and palaeoenvironment of the Bristol Channel Basin during the Triassic.

## A SILK PURSE FROM A SOW'S EAR? FROM PLASTICITY INDEX TO PALAEOENVIRONMENT

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It has been known for many years that the plasticity of the London Clay increases eastwards and recently it has been shown that the geotechnical properties vary with stratigraphic height in London in a predictable manner. It has been realised therefore that an understanding of the geology is beneficial in designing and interpreting geotechnical investigations. This contribution aims to show that the inverse is also true, and that geotechnical parameters can help better define the geology.

Over 2200 plasticity determinations from routine investigations in London Clay from Dorset to Suffolk have been compiled and their stratigraphic position determined as far as possible. In most parts of the sequence, the observed pattern is one of many progressive gradual upward decreases in plasticity, followed by abrupt increases, defining a series of coarsening upward cycles, even within wholly clay sequences. The expected general basinward (eastward) increase in plasticity index (and clay content) is observed, at a rate of 0.16% per kilometre. More detailed work in the Hampshire Basin and western London Basin shows that similar trends can be traced in individual units, allowing creation of contoured maps of plasticity and inferred clay content.

## THE GAS SHALE POTENTIAL OF SOUTHWEST ENGLAND

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Petroleum gas, mainly methane, is conventionally produced from porous reservoir rocks, typically sandstones or carbonates. The gas migrates, often many kilometres, from mature source rocks – typically fine grained shales. The concept of shales gas is to cut out the middleman and drill directly into the source rock. The source rock must be thermally mature (>0.7% Ro) and organic rich (TOC >1%) but the kerogen may be oil or gas-prone. Exploiting the gas adsorbed within the source rock requires the drilling of a high density of cheap wells, and then to fracture the rock to gather commercial volumes of methane into the well bore. The cheapness criteria requires the wells to be shallow (e.g. <2 km) and to be drilled onshore. Current US experience is that costs run at \$1 to \$3 million/well. The requirement to fracture the organic-rich shale requires a brittle rock – a combination of quartz or carbonate content and compaction (deep burial). For the organic-rich shales to be thermally mature also demands deep burial. The paradoxical combination of the 'shallow-well' criteria with the 'deep burial' requirement, points to areas of tectonic inversion. Drilling a high density of wells places environmental restrictions, as does the large amounts of water required for many of the fracturing processes.

Applying these gas shale exploration 'rules' to Southwest England suggest that the late gas-mature pre-Variscan (Devonian and Carboniferous) organic-rich shales of Devon and Cornwall are more prospective than the better known immature to oil-mature Mesozoic (Lower and Upper Jurassic) source rocks of Dorset, Hampshire and the Bristol Channel. No shale gas wells have yet been drilled in the UK, but the options will be discussed with reference to what is known from the actively explored and prolifically producing basins of onshore US.

## REVIEW OF THE WEST DORSET FOSSIL COLLECTING CODE OF CONDUCT

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The West Dorset fossil collecting code of conduct has been running for 10 years and was developed through a working party of interested groups with wider consultation. The code was accepted by UNESCO as appropriate management for a rapidly eroding coastline. As part of the Dorset and East Devon Coast Management Plan review, it was agreed that now is the time to undertake a review of the code. The aim of the review is to examine the effectiveness of the code and to consult widely with organisations with an Earth science and Geoconservation interest although views are welcome from individuals with any background. It is unlikely that the review will be ready for consultation by the time of the Ussher meeting but it will be available shortly afterwards and Ussher will be seen as a 'launch'. The paper will examine the state of the coast, the record of important specimens, issues, criticisms and a discussion. The review will also look at collecting management across the wider World Heritage Site where the management is in accordance with Natural England's national policy of 'responsible collecting'. Indeed, the code is simply a refinement of that approach based on the specific and unusual nature of the West Dorset coast.

## LANDSLIDING AT BRENT KNOLL, SOMERSET

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Brent Knoll is an outlier of Lower Jurassic bedrock. It forms an anomalous island-like topography with steep sides (25°), rising up to 137 m above the flat-lying ~10 m surface of the Somerset Levels. This paper provides the first detailed assessment of landslides that are developed onto the northern, eastern and southern flanks of the Brent Knoll topography.

The base and lower slopes of Brent Knoll comprise mudstones of the Dyrham Formation. The middle to upper slopes are characterised by limestone of the Beacon Limestone Formation, with the summit comprising a limestone, sandstone and mudstone sequence of the Inferior Oolite Group. Landslides occur primarily within weak mudstones of the Dyrham Formation. These landslides are small in area, ranging from 0.016 km<sup>2</sup> to 0.28 km<sup>2</sup> and generally display classic landslide morphologies (back scar, back tilted slopes etc) suggesting rotation and slide mechanisms with a component of earth flow in down slope areas. A single large landslide of ~1 km<sup>2</sup> has been mapped in the northwest of Brent Knoll. Its landslide origin is currently unclear as its morphology could reflect an extensional fault block structure.

In the contemporary landscape the landslides are inactive and thus are relict features. The toes of some of the larger landslides are buried by Holocene sediments of the Somerset Levels suggesting a Pleistocene or Early Holocene age for hill slope failure(s). Sea-level fluctuations that have periodically flooded the Somerset Levels during the Pleistocene could provide a base-level mechanism for erosion and failure of the lower slopes of Brent Knoll. Alternatively, erosion and subsequent landsliding could be linked to Pleistocene river incision during low sea levels.

## LANDSLIDE MECHANISMS IN THE MERCIA MUDSTONE GROUP (TRIASSIC) OF THE EAST DEVON COAST, UK

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The Mercia Mudstone crops out over a distance of 13 km on the east Devon coast between Sidmouth and Seaton where it forms steep to near-vertical cliffs up to 100 m high. The bulk of the 450-m thick succession consists of what at first sight appear to be lithologically monotonous red mudstones and silty mudstones. The group has been divided on the basis of gross lithology into four formations and nine members each of which has different bulk geotechnical properties and each of which gives rise to different weathering and cliff profiles. There are few faults in the section and the average dip is low (< 01°) with the result that discontinuities along steeply dipping and bedding-related joints are the dominant structural control on cliff falls. Failures in the stronger silty mudstones in the Sidmouth Mudstone and Branscombe Mudstone formations are initiated in the lower part of the cliffs by hydraulic stoping acting on joining and bedding, and in the upper parts of the cliffs by weathering and joint-bounded wedge failures. Thin (< 10 mm thick) beds of laminated mudstone in the Dunscombe Mudstone Formation give rise to rotational failures, and seepages along porous, former salt-rich beds give rise to mudflows.

## MICROFOSSIL EVIDENCE FOR A MID-JURASSIC SQUID EGG-LAYING AREA IN ASSOCIATION WITH THE CHRISTIAN MALFORD LAGERSTÄTTE

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In the 1840s, during the construction of the Great Western Railway west of Swindon, a number of beautifully preserved coleoids (belemnites and squid-like cephalopods) were found. These famous specimens of *Belemniteutbis* and *Mastigophora*, as well as a number of fish, were eventually described as a fossil *lagerstätte* under the name of the "Christian Malford Squid Bed". Many of these specimens, which come from the Phaeinum Zone (Callovian) of the Oxford Clay Formation, contain soft tissue, muscle fibres and the content of their ink sacs. In October 2007 the British Geological Survey funded an excavation of the site some ~100 m from the original borrow pits alongside the railway. This pit yielded some new coleoid specimens as well as many ammonites, bivalves and gastropods, all of which are exquisitely preserved. Some of the bedding surfaces recovered are plastered with monospecific assemblages of foraminifera (*Epistomina* spp.). Our work on borehole core No. 10 (from the same location) has recovered exceptionally large numbers of statoliths, otoliths (fish 'ear' bones), squid hooks and foraminifera. Statoliths are the small, paired, aragonitic stones found in the heads of modern and fossil coleoids. Jurassic statoliths have yet to be described in any detail as there is only one reference to them in the literature (Clarke, 2003).

The exceptional abundance of statoliths and squid hooks recorded in the samples from the core is thought to represent a Jurassic squid-breeding ground which existed for a substantial interval of late Callovian time. The annual spawning of female squids massively enlarges their ovaries and this breaks down the body wall leaving spent individuals to die. The lack of belemnites in the same strata suggests that the animals involved (unknown at present) did not possess a calcified "guard". The highest numbers of statoliths occur over a 3 m thickness of strata with the greatest abundance ~1 m below the Christian Malford Squid Bed. The numbers recorded in this part of the Phaeinum Zone are well above background levels in the rest of the Jurassic in the UK (Malcolm Clarke, *pers.com.*) where one has to wash several kg of sediment to recover <200 statoliths.

The occurrence of abundant, though low diversity, foraminiferal assemblages in the same samples point to an oxic, though possibly stressed, environment. The significant proportion of deformed foraminifera in the assemblages appears to confirm that the environment was less than optimum.

## REFERENCES

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## THE SIGNIFICANCE OF FRAGIPANS IN WEST CORNWALL'S PERIGLACIAL ENVIRONMENT

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Fragipans are generally defined in soil science as a dense, brittle and compact layer found deep in a soil profile, having a high bulk density, and polygonal fracture pattern. Considerable discussion of the environmental conditions in other parts of the U.K. and Western Europe necessary for fragipan development has been focussed upon the presence of permafrost and associated periglacial conditions linked to the end of the Last Cold Stage. This investigation indicates the presence of at least three fragipans in the loessic soils of the Lizard Peninsula. The results of the analyses of the soil samples from these sites around the Lizard Peninsula are examined and compared with earlier investigations into the loess based soils in the region. Thermoluminescence (TL) dates for the loesses in Cornwall constrain the probable period of fragipan formation to between 15-25 Ka BP and possibly as recent as 10-11 Ka BP.

## TESTING THE USE OF SOIL MINERALOGY IN SERIOUS CRIME INVESTIGATIONS; A CASE STUDY FROM SW ENGLAND

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In some criminal investigations, soils have been used as critical forensic evidence, associating a suspected offender with a particular place. Many different attributes of soils can be quantified and used for comparative purposes. In this study we simulated a criminal activity, and then collected soil samples from (a) items of footwear worn by our 'offenders', along with (b) soil samples and (c) mineralogical samples from leaf litter at our 'crime scene' and (d) comparator soil samples from the home addresses of our suspected 'offenders'. The simulated crime was the deposition of a 'body' in an area of undergrowth. The chosen location for the body deposition site was consistent with recognised offender behaviour profiling, and was an area of woodland, underlain by the Carnmenellis Granite, at Treverva, near Penryn, Cornwall.

All of the soil samples were quantified using automated SEM-EDS analysis using QEMSCAN® technology, and the data processed and reported as both the overall modal mineralogy, but also as 'lithotypes' whereby individual grains which are composed of more than one mineral, are reported as lithological groupings (e.g. granite). The data show that based on the modal mineralogy data from the footwear, there is a high degree of similarity between the soil samples collected from the soles of the footwear and the soils present along the access path leading to the body deposition site. In addition, the lithotyping results show that the underlying bedrock geology can be interpreted from the mineralogical data collected from the footwear.

## NEW OBSERVATIONS ON THE AMMONITE FAUNAS OF THE HETTANGIAN STAGE (EARLIEST JURASSIC) ON THE EAST DEVON AND WEST DORSET COASTS

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A recent review of the ammonite faunas of the Lower Lias in East Devon and West Dorset has revealed new insights into the taxonomy of ammonite faunas of the basal Jurassic, Hettangian Stage in the area – as developed within Blue Lias Formation limestone-mudrock facies. In particular, the study has generated some of the first photographic representations of many of the ammonite species represented in the area, including of several type specimens. Some of the latter had been previously figured only as stylized drawings in the 1870s and 1880s by Thomas Wright in the Palaeontographical Society *Monograph on the Lias ammonites of the British Isles* (although sometimes named much later by L.F. Spath in the 1920s and 1930s within appendices to the still unsurpassed bed by bed descriptions of the sequences in the area by W.D. Lang). The earliest ammonites recorded in East Devon are tentatively referred to *Neophyllites*, based on their general whorl shape, and are taken here to mark the base of the Planorbis Chronozone. Although no ammonites of the earlier Tilmanni Chronozone are currently recorded in the area, the base of the Chronozone, and hence the base of the Jurassic System, can still be identified using a carbon isotope excursion near the base of the Blue Lias Formation in the region. Although preservation in mudrock intervals is often poor, within limestones units occasional well preserved specimens have been obtained over the years. Above the first ?*Neophyllites*, the Hettangian faunas include representatives of *Psiloceras*, *Caloceras*, *Psilophyllites*, *Waehneroceras* (*Curviceras*), *W. (?Macrogrammites)*, *W. (Saxoceras)*, *Schlotheimia*, *Alsatites* (*Laqueroeras*) and *A. (Alsatites)*. Notable rarities include the early *Arietitid*, *Schreibachites* in the Upper Hettangian and the Mediterranean zonal index for the end of the stage, *Angulaticeras* (*Charmasseiceras*) *marmorium* (Wähner).

## FORAMINIFERA OF PLYMOUTH SOUND: THE LEGACY OF EDWARD HERON-ALLEN 70 YEARS ON

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Edward Heron-Allen FRS published a series of monographs on the "Foraminifera of Plymouth Sound" in 1930, prompted by the earlier work on foraminifera from the Cornish coastline by Fortescue Millett. This was the beginning of an interest in the foraminifera of this estuary that was continued by staff of the Marine Biological Association (including seminal works by John Murray) and then the University of Plymouth. The fauna in the Sound is diverse and quite abundant, although the living component of the fauna has reduced in recent years with the "clean sweep" undertaken by South West Water. This has, effectively, reduced the bacteria in the Sound on which the foraminifera live. The different sediment types (gravels, shell sands, shell-rich muds and pure clays) provide a range of habitats, all of which have their own faunas. The drawings made by Heron-Allen are all beautifully crafted and compare well to the modern scanning electron images used by present-day micropalaeontologists. Many of the taxa he described were new to science and are still in use today.

**THE PROVENANCE OF PERMO-TRIASSIC  
OUTLIERS IN SW ENGLAND:  
A PRELIMINARY LOOK AT THE APPLICATION OF  
AUTOMATED MINERALOGICAL ANALYSIS TO  
HEAVY MINERAL ASSEMBLAGES**

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The Permo-Triassic successions of SW England have been the subject of several detailed provenance studies utilizing lithic fragments and heavy mineral separates. The purpose of this study is to evaluate the potential for use of automated SEM-EDS mineral analysis, using the QEMSCAN system, to generate quantitative mineral data, complemented by the use of XRD, SEM and electron microprobe. Samples have been prepared from several Permo-Triassic outliers, including Cawsand, Hollacombe, Porlock, Portledge-Peppercombe, Slapton and Thurlstone.

QEMSCAN analysis has been undertaken on panned concentrates, heavy mineral separates and whole rock samples. The latter allow heavy minerals to be correlated with parent clast types, but lower heavy mineral yield means they are unlikely to be a viable alternative to panned concentrates or heavy mineral separates. Assemblages are dominated by rutile, ilmenite, tourmaline and apatite, with lesser zircon, xenotime, iron oxides, monazite and rare chrome spinel and Ni minerals. Further work was undertaken with XRD to differentiate EDS overlap between chlorite and almandine, iron-manganese oxides and carbonates.

**CREATING A ROCK PARK TO SHOW THE ROCKS AND  
GEOLOGY OF MELDON QUARRY, DEVON**

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Boulders from Meldon Quarry have been placed in the Rock Park to show the great variety of the rocks and geology found in the quarry. As a working quarry, there is no safe access for the general public or for geological studies, and the Rock Park has been created to allow close examination of the rocks in a safe location. The boulders are a representative selection of the main rock types of Meldon, and have been placed in an order reflecting a north-south section across the quarry. The rock types include chert, hornfels, slate-with-lenticles, chialstolite slate, crystalline tuff and dolerite dykes. The geology of Meldon Quarry is complex with rocks of great age (about 350 million years old) with large folds and faults, which have been altered by thermal metamorphism due to intrusion of the nearby Dartmoor Granite.

The Rock Park project was created in 2009 with funding from the Aggregates Levy Sustainability Fund (ALSF) through the Devon RockETS scheme administered by Devon County Council, and with contributions in-kind. The project was arranged and undertaken by David Roche GeoConsulting, and the work was carried out in close collaboration with Aggregate Industries and Bardon Aggregates who own and operate the quarry, and with Dartmoor Railway and Dartmoor National Park Authority. The works involved levelling and new surfacing to the Rock Park area, moving and placing boulders, new picnic tables, gates and fences, direction signs and an information board.

**RECONSTRUCTION OF JURASSIC (BATHONIAN)  
PALAEO-SALINITY OF DORSET USING STABLE  
ISOTOPES AND FAUNAL ASSOCIATIONS**

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The Bathonian of the UK is an interval from which salinity-controlled benthic faunas are particularly well known demonstrated through sedimentological, palaeoecological and stable isotope evidence. Although local facies variations are complex, greatest faunal diversity is found in Oxfordshire, where facies associations suggest a low-energy backbarrier to platform interior environment. Published studies suggest that faunal diversity decreases in north-eastern Oxfordshire and through Northamptonshire, representing shallower, probably lagoonal environments. It has also been suggested that low diversity Bathonian faunas indicative of substantially reduced salinities occur as far south as Dorset (e.g. the Boueti Bed). The oldest beds examined in this study, the mudstones of the Wattonensis Beds (of the Fullers Earth), are of known marine origin based on a diverse typical marine assemblage and are considered as being deposited in an offshore to deeper shelf environment. The overlying Boueti Bed marks the base of the Forest Marble and consists of a rubbly, detrital, micritic limestone. Oxygen isotope values of belemnites (*Belemnopsis* sp.) from the Wattonensis Beds range from -1.4 to -0.7 permil and carbon isotope values range from -2.3 to -0.5 permil. The isotope values of well-preserved *Rhynchonella* sp. from the Wattonensis Beds range from -2.4 to -1.3 permil for oxygen and -1.1 to 0.6 permil for carbon. Significantly a similar spread of values is seen for the well-preserved brachiopods, (*Gontiorhynchia boueti*) from the Boueti Bed, ranging from -3.3 to -1.0 permil for oxygen and -0.9 to 1.0 permil for carbon. These data are also consistent with published data derived from the Bathonian of Oxfordshire. Given the marine origin of the Wattonensis Beds and overlap of data, the reduced faunal diversity of the Boueti Bed is therefore unlikely to be the result of reduced salinity on the basis of the stable isotope signatures. The reduced faunal diversity of the Boueti Bed may consequently be due to a combination of a number of other factors including, sediment substrate, productivity or food and oxygen supply.

**FURTHER OBSERVATIONS ON HAYTOR IRON MINE**

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A short paper on the mineralogy and paragenesis of the Haytor iron ore deposit was presented to this society in 1987. Since that time, in recent years, regular geotechnical inspections of the underground workings have facilitated detailed examination of the mine and a photographic record of the various features. Further mineralogical and geochemical work has also been undertaken, and these results will be presented, together with some thoughts on the nature of the protolith and the origin of this interesting skarn deposit.

**ST CATHERINE'S POINT LIGHTHOUSE;  
ISLE OF WIGHT, U.K.;**  
**A CASE STUDY OF THE USE OF AERIAL IMAGERY  
AND LAND BASED DATA TO MONITOR A  
COASTAL LANDSLIDE**

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St Catherine's Point lighthouse is situated at the western end of a large 9 to 10 km long landslide complex which incorporates the southernmost part of the Isle of Wight. The width of the landslide complex varies along the coast from 400 to 700 m, and is in a southerly direction. This is one of the largest landslides in Europe. The lighthouse, its associated structures and the surrounding compound are constructed on the debris apron created by the landslide. The debris apron is generally flat when compared with the rear scarp of the landslide complex, but has been eroded on the southern side by the sea to form a cliff whose height varies from 10 m to 20 m. This cliff is gradually being eroded northwards towards the lighthouse. Scott Wilson, on behalf of Trinity House Lighthouse services, were commissioned to evaluate the extent of movement of the landslide and the implications to the continued operation of the lighthouse. Data sets available includes crack monitoring records since 2001, tilt monitoring records from within the lighthouse since 2001 and coastal cliff surveys conducted up to 2009. In addition, LiDAR data was acquired to allow large scale mapping of the overall landslide complex and a GPS survey was carried out of the cliff section. Aerial photographs have also been acquired to allow an evaluation of coastal recession rates. Airborne LiDAR and orthophotography, acquired from Channel Coast Observatory (<http://www.channelcoast.org>), were processed in ArcGIS and Ermapper to assist in the detailed geomorphological assessment of the landslide complex using a combination of sun shaded topographic models, slope maps and three dimensional overlays combining the LiDAR and ortho imagery.

The crack monitoring and tilt monitoring indicated that since 2001 the landslide complex in the vicinity of the lighthouse, has undergone little to no movement. The GPS cliff survey was compared to aerial photographs and a previous assessment made in 2001. Although some minor changes have occurred due to localised failures, the overall cliff line has remained the same. The results of the study indicate that the area is undergoing a quiet period of movement and under these conditions the continued operation of the lighthouse is unaffected by the landslide complex and coastal erosion. However it does not allow for the large scale rapid movements that might occur given the right climatic conditions. This stable trend of data, the GPS points installed around the lighthouse and the setting up of an accurate cliff line survey will allow the easy identification of anomalous readings and act as a warning for any potential instability that may affect the continued operation of the lighthouse.

**GROUND INVESTIGATION, INSTRUMENTATION AND  
MONITORING OF EARTHWORKS STABILITY AND  
SETTLEMENT FOR WEYMOUTH RELIEF ROAD**

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A long awaited relief road for Weymouth has at last started being constructed over a 7 km long route. Geotechnics Ltd undertook the main GI in 2008, as well as having carried out investigations along previously proposed routes over the last few years. Utilisation of several ground investigation techniques and *in situ* testing, together with laboratory testing allowed the final design to incorporate sustainable use of local geology. This included using over 20 million tons of chalk from Ridgeway Hill with local Oxford clay to construct the large road embankments.

The potential impact of new embankments and bridge structures on the underlying geology and existing railway structures required accurate and precise monitoring during construction to enable early detection of ground instability. Geotechnics Ltd installed several types of instrumentation including Vibrating Wire Piezometers (VWP), In-Place Inclinator (IPI) strings and Hydrostatic Profile Gauges (HPG) around substantial structures to remotely monitor in real-time the pore water pressures, lateral earth movements and settlement via a website. Collectively this provided near instant data and ensured that remedial steps could be made at the first sign of problems. The instrumentation assisted in successful construction of the embankments and ongoing monitoring continues to confirm stable settlement and unaffected adjacent structures.

**RESCUE PALAEOLOGY**

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Rescue archaeology is a relatively well-known activity, involving the excavation and documentation of vulnerable sites. We have been involved in a similar activity, 'capturing' important and vulnerable palaeontological outcrops for posterity.

1. Dinosaur trackway. Replica supplied to the National Trust visitors' centre at Robin Hood's Bay (about 4 m<sup>2</sup>) from a crumbling cliff outcrop, working with the Yorkshire Museum.

2. SSSI outcrops in Charnwood Forest containing Holotype Ediacaran fauna, in danger of vandalism and erosion, replicas of the faces now archived at BGS (about 24 m<sup>2</sup>).

3. SSSI outcrop in Charnwood Forest containing Ediacaran fauna (the original *Charnia masoni* site). Here the faces are relatively inaccessible and incompletely described. Replicas are now archived at BGS (130 m<sup>2</sup>).

4. Old Limestone Mines in Dudley, West Midlands. Mines have been filled to avoid surface collapse.

The advantages of this method are: Some fossils are not visible until the faces had been cleaned of algae and lichens, which quickly recolonise. Lightly stained casts, suitably lit, can reveal fossils not seen in the field (research). Lightweight casts can be used where original material is too heavy/precious/fragile for display (museum). Once a good mould has been made, many replica casts can be made (teaching).

**REDRAWING THE BASE OF THE JURASSIC SYSTEM  
IN SOUTH-WEST ENGLAND  
AND THE TILMANNI CHRONOZONE IN  
NORTH-WEST EUROPE**

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The recent discovery of the earliest known Jurassic-type ammonites faunas in Austria (Hillebrandt *et al.*, 2007) and the subsequently international agreement to define the Global Stratotype Section and Point (GSSP) for the base of the system at Kuhjoch in the Karwendel Mountains, at a level corresponding to the first fauna of these ammonites (*Psiloceras spelae* Guex), has had significant implications for UK Jurassic stratigraphy. Previously the base of the system had been drawn at the base of the later Planorbis Chronozone and eventually at the base of the *Psiloceras erugatum* Biohorizon – the first ammonite fauna in the UK sequence (Bloos and Page, 2000). The earliest Jurassic faunas in Austria and their correlatives in North and South America have been assigned to a Tilmanni Chronozone (Index: *Psiloceras tilmanni* Lange), but have not been definitively recorded in North West Europe, the interval corresponding to the typically non-ammonite bearing 'Pre-planorbis' Beds of the basal Blue Lias Formation (which are, therefore, usually placed in the latest Triassic). The base of the Tilmanni Chronozone, and hence the base of the Jurassic System, can still be correlated in Britain, however, using carbon isotope stratigraphy and lies between the two negative Carbon Isotope Excursions (CIE) widely recorded at this level. On the West Somerset coast this level lies at or close to the base of the Blue Lias Formation and on the Devon coast it is likely that the boundary will correspond to a similar level - and this correlation is adopted here.

Defining the base of the Planorbis Chronozone above becomes less clear, however, and several definitions exist, including the base of the *P. planorbis* Biohorizon (fourth in the UK ammonite succession and the base of the *P. erugatum* Biohorizon (first in the UK succession). Neither definition is particularly helpful in a correlative sense, however, as neither fauna can currently be clearly recognized outwith of Britain. A compromise and pragmatic solution, therefore, would be to draw the base of the Planorbis Chronozone at an *intermediate* level which *can* be correlated internationally - the base of the first *Neophyllites* level in Britain, (at the base of the *imitans* Biohorizon) and this is proposed here. This level can be clearly recognized within the classic Triassic-Jurassic boundary sections of West Somerset, in the Wilkesley boreholes in NW England, Waterloo Bay in Ulster, on the island of Mull in western Scotland as well as across Europe including in Germany and, crucially, at the Hettangian GSSP in Austria. A consequence of this decision is that *P. erugatum* (Phillips) in the UK becomes a species of the late Tilmanni Chronozone - crucially, however, *P. erugatum*, *P. spelae* and *P. tilmanni* all possess nuclei with small nodes, unlike later species of *Psiloceras*, which therefore provides a reliable character for recognizing Tilmanni Chronozone faunas, even when specimens are crushed.

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