
**ABSTRACTS OF OTHER PAPERS/POSTERS PRESENTED AT THE
ANNUAL CONFERENCE, JANUARY 2014**



**INDIUM AND GALLIUM:
METALS THEY NEVER LOOKED FOR**

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Technological developments have over the last decade resulted in vastly increasing demands for metals that have not traditionally been subject to targeted mining. This puts a renewed emphasis on polymetallic mining regions such as South-West England, where many of these metals can be found. Indium and gallium are among the metals that are particularly sought for, yet the geological background knowledge for their mechanisms of concentration in the crust is lacking. Studies of ore samples from South-West England reveal that these metals are available in concentrations that are economically interesting. The metals are particularly concentrated in sulphide ores. Gallium occurs in significant concentrations in sphalerite, while indium is distributed between sphalerite, chalcopyrite, stannite and cassiterite. Indium occurs in granite-related sulphide occurrences as well as post-granite veins, while gallium is also found associated with pre-granite sulphides. Total indium concentrations in the ores locally exceed 400 ppm while gallium concentrations appear to be consistently below 50 ppm.

**THE STRUCTURAL EVOLUTION OF THE
BOVEY BASIN: A REVISED MODEL**

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A revised model is presented for the stratigraphic and structural evolution of the Eocene-Oligocene Bovey Basin in South Devon. Detailed analysis of the basin geology and its early history are provided utilizing new and existing research across the region. Secondly, the kinematic history, along the length of the pervasive NW-SE trending Sticklepath-Lustleigh fault zone, is investigated; using this information, combined with published literature and the regional, pre-Eocene evolution of Devon, the results give an analogue that further explains the basin's depositional history and geometry. Furthermore, new Sibelco UK logging and cross-sectional data are interpreted and have led to a modified stratigraphic and structural model for the basin. Lastly, the influence of the Variscan basement structure on the basin's evolution is re-evaluated and the basin's location and the initial stages of its

formation are examined. This will prove valuable to the continued economic and geological importance of the Bovey Basin and as a template for the discovery and exploitation of similar basins.

**SOME DUST GEOSCIENCE ISSUES
IN THE SOUTH WEST**

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Developments in dust modelling that have come out of John Bruce's paper in the 2013 issue of *Geoscience in South-West England* are discussed. Details will be presented of dust investigations and objectives in proposed sub-regional dust mapping one area of which includes part of south Devon. Dust issues surrounding solar farms, which have proliferated in the south west, and may have specific chemical and mineralogical concerns are examined.

**SALT AND RECLAMATION - THE SOMERSET COAST
IN THE ROMANO-BRITISH PERIOD**

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During the Romano-British period the Somerset coastal landscape underwent significant changes. In many places the coastal marshes were reclaimed for agriculture and settlement and protected by coastal and riverine flood defences. In the area west of Burtle an extensive salt marsh system had replaced an earlier raised bog and was not reclaimed, but was instead used as the base for an enormous salt-making operation. Hundreds of saltern sites have been identified and two have been investigated in some detail revealing evidence of the process of salt production. Towards the end of the Romano-British period the coastal landscape changed once again with a transgression that covered the tops of the saltern sites and inundated the former reclaimed marsh areas. The reasons for this catastrophic change are not entirely understood but may relate to instability in the Roman province in the 4th Century AD coupled with the pressure of a gradual rise in sea level.

A WINDOW ON THE DEEP WATER JURASSIC AND CRETACEOUS OF THE CENTRAL ATLANTIC - COMPARISON OF THE FUERTEVENTURA BASAL COMPLEX WITH OUR 'JURASSIC COAST'

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From North-West Europe in general and from South-West England in particular we think of the Jurassic Period as one of deposition in shallow shelf seas. To the north, the North Sea graben systems were active, and to the south the Central Atlantic was opening. As part of a study of the petroleum potential of deep water deposits offshore Morocco, the unique small Mesozoic sedimentary outcrop of Fuerteventura (Canary Islands) provides a view of distal pelagic sedimentation on the newly formed Toarcian oceanic crust. Samples of this 'Basal Complex' of Fuerteventura were analysed for source rock geochemistry, apatite fission track analysis, petrography and biostratigraphy. The purpose of this work was to 'see through' all the post depositional effects, including Mesozoic burial, Late Cretaceous/Early Tertiary uplift and Late Tertiary intrusive contact metamorphism, in order to evaluate the original petroleum potential of the sequence as deposited. In terms of petroleum source rock potential, the present day organic content is low throughout (TOC values <0.05% to 0.59%, plus one sample at 1.58%): the turbidites of the Mixed Clastic interval give the highest mean of 0.39%. However, given the pervasive intrusives and consequent elevated maturity levels (2.1-3.94% vitrinite reflectance), today's mean TOC value for the Mixed Clastic shales can be corrected to an original value between 1.56% and 1.95% depending on kerogen type. Extreme thermal alteration makes identifying kerogen type difficult, but metamorphosed phytoclasts within the turbidites of the Mixed Clastic unit were identified as of land plant together with probable bacterial-algal origin. The presence of microscopic bitumen points to at least some oil-prone content. These data allow a speculative reconstruction of the pre-uplift/pre-intrusion 'deep-basin' Mesozoic section and its petroleum geological make-up. As with South-West England, the Upper Jurassic contains the most organic rich intervals, despite very different depositional environments. This assessment can be used to define a new petroleum systems framework applicable to the deep-water petroleum plays of eastern Central Atlantic margin.

AN ANALYTICAL STUDY OF URANIUM MINERALS FROM CORNWALL, ENGLAND

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A variety of secondary uranyl minerals from Cornwall, England, have been studied using a range of analytical techniques. While x-ray experiments are useful in studying the bulk crystal structure, infrared and Raman spectroscopy can provide more information about the chemical bonding involved in a system, as well as details on the hydration structure. Raman spectral bands tend to be sharper than those for infrared - an important consideration when many bands occur within a similar frequency region. Raman spectroscopy has been performed on a range of uranyl phosphates; for all spectra, the ~826cm⁻¹ peak attributed to the symmetric stretch of (UO₂)²⁺ was

present. Other bands seen in the spectra can be interpreted as stretches or bends of the other ions present (e.g. phosphate, sulphate, arsenate), or modes associated with water. Interpreting the full Raman spectrum can be complicated by the presence of water, and the complexity of the mineral structure in general; if a full spectrum is already known, there may be a fingerprint region that can be used in identification. Thus, we have begun to perform a number of atomistic simulations to assist in the analysis of the relationship between detailed crystal structure and vibrational properties.

QUARTZ-TOURMALINE ORBICULES: RECORD OF MAGMATIC MELT IMMISCIBILITY IN THE LAND'S END GRANITE

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Rounded quartz-tourmaline segregations are a common sight in the outer zones of the Land's End granite, South-West England. This study focuses on the type found in the coarse grained biotite granite. Trace element and cathodoluminescence of quartz indicate a more evolved magmatic character in the orbicules with at least two growth stages after the phenocrystic stage, probably simultaneously as the texturally similar fine grained matrix quartz. Tourmaline is weakly zoned from dark to pale brown, well within the schorl field, and occurs as skeletal grains with sub-euhedral poikilitic inclusions of quartz. The geometry and composition of the orbicules is difficult to explain by fractional crystallization alone, since the total FeO content of the granite is low, and Fe is bound to primary magmatic phases such as ilmenite and biotite. A prolonged fractional crystallization sequence would have depleted the magma in respect to Fe, and breakdown of biotite in and nearby the orbicules is not sufficient to stabilize tourmaline. We propose that the orbicules formed from an immiscible hydrous B-Fe rich melt that was to a certain degree allowed to coalesce, restricted by the viscosity of the remaining aluminum-silicate melt. Crystallization was induced by cooling and breakdown of feldspar to supply Al.

POSSIBLE TETRAPOD BURROWS IN THE MID TRIASSIC OTTER SANDSTONE FORMATION AT SIDMOUTH, DEVON, U.K.

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Trace fossils interpreted as tetrapod burrows have been reported from fluvial Triassic deposits in geographically widely separated parts of the former Pangea supercontinent, including Morocco, South Africa, the USA and Antarctica. The burrows at most of these localities are hosted in deposits of ephemeral braided rivers that formed in arid to semi-arid settings. Vertebrate fossils have been recorded from all the burrowed formations, and in some examples vertebrate skeletons have been found in the burrows. Evidence of periods when the

climate was sufficiently wet to support mature vegetation is present in the form of rhizocretions and caliche deposits that are associated with all the burrowed horizons. The depositional environments at all these localities are closely similar to those of the Mid Triassic Otter Sandstone Formation (OSF) of SW England. The sizes and shapes of the trace fossils described in the present account from the Devon coast are similar to Triassic burrows in Antarctica, Morocco and South Africa that have been attributed to small therapsid reptiles. The small number of possible tetrapod burrows recorded and the fragmentary nature of vertebrate fossil occurrences in the OSF mean that it is not possible yet to determine which tetrapods might have made the burrows.

**RETROGRESSIVE LANDSLIDE,
STABILISATION AND ASSESSMENT FOR FURTHER
LANDSLIDE POTENTIAL BELOW THE HISTORIC
MARISCO CASTLE, LUNDY ISLAND**

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Many coastal slopes are at best only marginally stable. Lundy Island is in close proximity to major Palaeogene faulting, which has resulted in intense fracturing, distortion and faulting of Lundy's meta-sedimentary Morte Slates. There are numerous relic landslides within the slates on Lundy Island. One such landslide site is below the 12th Century historic Marisco Castle. Incipient retrogressive failure within this landslide was triggered by marine erosion in 2000 and JGP Ltd engineered the stabilisation works to halt retrogressive sliding in 2009. An appraisal of the complex and varied rock mass geometry across this site indicated the potential for further sliding. Detailed assessment to evaluate the potential for further sliding was facilitated by dividing the site into ten zones. Each zone was individually assessed for stability and the effects of any instability on the site as a whole were considered.

**MID-EOCENE SEDIMENTS OFF-SHORE JERSEY
AND THEIR CORRELATION ACROSS NORTHERN
FRANCE AND SOUTHERN ENGLAND**

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In a paper presented to the Society in January 2013, a current project on the Holocene sea level rise around Jersey was described. In some of the marine boreholes collected to the east of Jersey, a grey siltstone has been recorded resting on the Precambrian-Devonian 'basement', but below a bed of peat that is probably Holocene in age. These grey silts contain abundant gastropods, bivalves, foraminifera and ostracods. The foraminifera are clearly mid-Eocene in age (including abundant

examples of *Alveolina* spp.) and appear coeval with sediments off-shore Selsey Bill, Whitecliff Bay (Isle of Wight) and Valognes (Cotentin Peninsula). To the west of Jersey, Dennis Curry collected a series of marine 'grab' samples in 1955 and identified these as being of mid-Eocene age, with assemblages of foraminifera comparable to those recorded to the east of Jersey. This mid-Eocene assemblage of distinctive, warm-water, foraminifera has been described as Lutetian in age and marks the 'Middle Eocene Climatic Optimum' (MECO). The problem, at present, is that while Curry regarded his material as (largely) being in-situ, the silts to the east of Jersey may not be Eocene in age as all the macrofauna and the microfossils appear to be re-worked. If not mid-Eocene in age, what age are they and how do they fit into the geological history of the area?

**THE HOLOCENE OF NORTH-EAST MOUNT'S BAY,
SOUTH WEST CORNWALL**

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The intertidal 'submerged forest' deposits exposed around Penzance, south west Cornwall, are of local cultural and national scientific significance. These deposits represent the accessible part of an extensive mid to late Holocene sequence of peaty soils, silts and brackish/marine sands and gravels extending onshore and offshore across the northeastern part of Mount's Bay. The peats and brackish sediments preserve a micro- and macroflora indicative of forests, fenland and saltmarsh palaeoenvironments which reflect the cyclic changes in the embayment accompanying sea level changes over the past 12,000 years. This presentation reviews current information on the lithology and stratigraphy of the Mount's Bay Holocene sequence and presents data obtained from recent onshore boreholes undertaken during the development of commercial sites on the east and west sides of Penzance.

**TERRESTRIAL LASER SCANNING INTERTIDAL
ARCHAEOLOGY IN THE SEVERN ESTUARY**

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An increasing number of archaeological sites along the UK coastline are threatened by a combination of sea level rise and coastal development. These sites, which range in age from Palaeolithic to the post-Medieval, are a finite part of our heritage and should be recorded as fully as possible before they are lost forever. Terrestrial laser scanning (TLS) has the capability of recording such sites and providing the data required for the estimation of erosion rates which can in turn be used to predict site loss rates. Some of the most threatened environments are inter-tidal/mudflat sites of Prehistoric to Medieval age. Fieldwork within the Severn Estuary has focused on fish weirs and fishing related structures, these are traditionally difficult to record or excavate due to the restricted time available in the tidal cycle and need to be recorded intensively. This new approach offers a solution to these issues.

**THE TOARCIAN OCEANIC ANOXIC EVENT (T-OAE)
(LOWER JURASSIC) IN SOUTH-WEST ENGLAND:
NEW RESULTS FROM BRENT KNOLL, SOMERSET**

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One of the largest known perturbations of the global carbon cycle in the last 250 Ma of Earth history occurred during the Lower Toarcian Substage of the Lower Jurassic. Known as the Toarcian Oceanic Anoxic Event (T-OAE), it was accompanied by a -6‰ negative carbon isotope excursion (CIE). It has been suggested that this phase was caused by massive injections of isotopically light carbon into the ocean-atmosphere system (possibly caused by destabilisation of marine gas hydrates or volcanism). This paper presents chronostratigraphic, geochemical and palaeontological data from borehole and outcrop localities from Brent Knoll, Somerset, UK, demonstrating, for the first time, a complete carbonate isotopic profile across the T-OAE in South-West England, calibrated against a high resolution ammonite biochronology. Alongside this, preliminary terrestrial organic isotope data based upon fragments of wood elucidate a synchronous CIE in the terrestrial realm. Coinciding with the maximum negative excursion, finely laminated, organic rich paper shales, interpreted as representative of anoxic or euxinic bottom water conditions, were deposited. Additional information from outcrop localities records late T-OAE and recovery phases, including evidence from foraminiferal morphogroup analyses. The latter record increasingly hospitable bottom water conditions with increased oxygenation at the sediment-water interface indicating a return to 'normal' marine conditions.

**TAPHONOMY AND PALAEOECOLOGY OF A
JURASSIC ICHTHYOSAUR: DIFFERENCE AND
SIMILARITIES WITH MODERN WHALE FALLS**

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Bones of an ichthyosaur (*Ophthalmosaurus* sp.) from the Oxfordian (Upper Jurassic) Sandsfoot Formation and the associated invertebrate fauna were investigated to test the hypothesis that carcasses of Mesozoic marine reptiles hosted similar communities to modern and fossil whale falls. Bite marks on the bone surfaces indicate initial scavenging by fishes. Echinoid grazing traces (*Gnatbichnus pentax*) indicate colonisation of the de-fleshed bones by algal or microbial mats. This is confirmed by the presence of micro-borings in the bones and microbially induced carbonates on the bone surface (clotted micrite). Pyrite framboids and peloidal fabrics within the bone spaces possibly indicate microbial decay of the bone organic compounds by sulphate reduction. Finally, numerous suspension feeding macro-invertebrates, free living close by or directly attached to the bones, indicate prolonged exposure and colonization of the carcass on the sea floor prior to final burial. In this marine reptile fall, as in whale falls, we recognise an initial 'mobile scavenger stage' and a final 'reef stage'. The microbial signatures (clotted micrite, pyrite framboids and peloids) may indicate development of a sulphophilic stage, as in modern whale falls, even though no direct evidence for a chemosynthetic-based ecosystem (e.g. chemosynthetic bivalves such as lucinids and thyasirids) was found.

**PROVENANCE STUDIES OF HEAVY MINERALS
FROM THE NEW RED SANDSTONE OF
SOUTH-WEST ENGLAND USING AUTOMATED
MINERALOGY AND GEOCHEMISTRY**

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The stratigraphy of the New Red Sandstone Supergroup (NRSS) of South-West England has posed a challenge for many researchers due to the limited geochronology and paleontological record of these continental deposits. Heavy mineral studies and geochemistry are therefore of considerable importance in understanding the stratigraphy and provenance of these Permian and Triassic red beds. This talk will review the application and results of automated mineralogy to analyse heavy minerals from the NRSS, augmented by SEM and electron microprobe data. Focussing on some of the major mineral groups, findings will be reviewed in light of recent comparisons between the Upper and Lower Permian in the NRSS and a case study will be presented to illustrate these findings.

**A NEW HIGH-RESOLUTION AMMONITE
BIOCHRONOLOGY FOR THE HETTANGIAN STAGE
(LOWEST JURASSIC) OF NORTH WEST EUROPE:
PRELIMINARY RESULTS FROM
SOUTH-WEST BRITAIN**

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New sampling of the remarkable Lower Jurassic coastal sections of the West Somerset coast has confirmed the presence of the most complete known ammonite sequence through the basal Jurassic Hettangian Stage in Europe, possibly the world. Through around 74 m of Blue Lias Formation, around 100 successive ammonite faunas have now been recorded, representing in excess of 2,500 specimens. New high-resolution sampling has also been carried out west of Lyme Regis (Devon) and on the Glamorgan coast (South Wales) at Lavernock Point and St Mary's Well Bay and the results integrated with those from West Somerset. Preliminary analysis suggests that up to around 45 ammonite biohorizons may ultimately be recognisable within the 8 subchronozones of a standard Hettangian Stage for North West Europe, a significant increase in available stratigraphical resolution from an earlier scheme of around 25 biohorizons. Amongst the core Hettangian sequence of North West European ammonite species belonging to the genera *Psiloceras*-*Caloceras*-*Waehneroceras*-*Schlotheimia*, the presence of 'exotic' forms such as 'Sunrisites', *Laqueroceras*, *Alsatites* and *Shrienbachtites* provide tantalising possibilities for more global correlations. Collaborative work also in progress aims to calibrate this ammonite time scale using orbitally-driven (Milankovich) sedimentary cycles, and it is hoped that the new biochronology will ultimately provide an actual time-scale in terms of thousands of years for the Hettangian.

EARLY JURASSIC ISOTOPE VARIATION, DORSET, U.K.

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With respect to the Jurassic record there has been much debate on the possible global significance of isotopic proxies regarding icehouse-greenhouse fluctuations. We present a detailed carbon and oxygen isotope record for the Early Jurassic based on marine molluscs (belemnites) from the marine succession of Dorset, UK. Our new data evaluate a purported climatic event close to the Sinemurian-Pliensbachian boundary.

A NEANDERTALER'S DREAM OR A FRUSTRATION: THE POSSIBILITIES OF MAKING A LIVING IN THE NORMANNO-BRETON GULF DURING THE LAST QUARTER MILLION YEARS

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To the possible Neandertalers occupying NW France, the landscape/seascape, climate and food resources of the Normanno-Breton Gulf could hardly have been more variable over the past quarter million years. An overall epeirogenic uplift averaging out at about $0.07 \text{ mm}^{-1} \text{ year}$ caused changes to the coastal outlines, which became significant when viewed against the superimposed sea-level changes revealed by the alternation of cold and temperate climates of the *c.* 100 ka Milankovitch cycles. A further factor, the varying and often unusually high likely tidal ranges over the Gulf area at times, would have had important effects on effective habitable areas. The climatic changes also caused the vegetation cover to change radically over time and this in turn affected both the associated fauna and the ability of the Neandertalers to take advantage. Against this background, the known distribution of Neandertal sites over and around the Normanno-Breton Gulf is set out before an attempt is made to outline important landscape and climatic changes which would have affected the ability of Neandertalers to occupy the area. Evidence from the internationally important cave shelters of La Cotte de St Brelade and La Cotte à la Chèvre in Jersey is also critically examined with respect to its first period of occupation.

LOCATION, LOCATION, LOCATION: POST-VARISCAN TECTONICS AND GRANITE MAGMATISM IN SOUTH-WEST ENGLAND

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There are three expressions of post-Variscan granite magmatism in SW England: (1) Cornubian Batholith (Early-Mid-Permian), (2) Haig Fras Batholith (Early Permian), (3) Lundy

Granite (Palaeocene). The Cornubian Batholith occurs within an ENE–WSW trending zone, mostly 6–8 km thick, considerably less than some gravity-derived models indicate, but still requiring the generation of extraordinary volumes of predominantly crustally-derived biotite granite magmas. The temperatures required for such melting can only sensibly be achieved by mantle-derived magmas being underplated at the crust mantle boundary or injected into lower crustal sill complexes. The Haig Fras Batholith occurs in an ENE–WSW trending zone within the hanging wall of a major Variscan thrust forming the frontal, westerly continuation of the Bristol Channel Fault Zone. It is speculated that this Batholith was generated by lower crustal partial melting in the footwall of this thrust, controlled by similar post-Variscan extensional processes as the Cornubian. The Lundy Granite is the southernmost expression of the British Palaeocene Igneous Complex and is in close proximity to both the Sticklepath-Lustleigh Fault Zone and the westerly continuation of the Bristol Channel-Bray Fault. It is unclear whether the Sticklepath-Lustleigh Fault Zone has acted solely as a 'passive' magmatic plumbing route to the upper crust or whether there is also a degree of fault-controlled transtensional melting. Substantial mantle melting is implicated in the generation of granite magmatism at all three locations. Several recent geophysical models infer the addition of several km of mantle-derived mafic rock at the base of the South-West England crust during Palaeocene magmatism. But would we expect to see any preservation of underplating associated with generation of the far more voluminous Early Permian Cornubian and Haig Fras batholiths?

CRITICAL METAL FRACTIONATION IN THE GRANITES OF SOUTH-WEST ENGLAND

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Metals such as Li, Be, Nb, Ta, In, W and Bi are critical for the development of the low carbon sector and many of these metals have now been deemed as having 'critical' supply issues. Understanding the behaviour of these elements in geological processes can aid further identification of resources. In South-West England, the granites show an enrichment of these metals compared to global crustal averages. The composite plutons of the Cornubian Batholith show mineralogical and geochemical variations that control distribution of these critical metals. Broadly, the granites can be subdivided into biotite, tourmaline and topaz granites on the basis of their mineralogy and geochemistry. A geochemical continuum exists between the biotite and tourmaline granites controlled by fractionation from a common source. This fractionation between the biotite and tourmaline granites has led to concentration of some metals (e.g. Li, Nb, In, Sn and Ta) within the tourmaline granites with retention of other metals (e.g. Ge, REE) within the biotite granites. Tourmaline granites are believed to be the magmatic precursors for the hydrothermal fluids responsible for mineralisation in the St. Just area (Müller *et al*, 2006) and the presence of critical metals within tourmaline granites is prospective for mineralised systems.

THE CENTRAL SOMERSET BASIN REVISITED

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Aspects of the post-Variscan Central Somerset Basin (CSB) were reviewed by Whittaker (1973), after the completion of the Burton Row Borehole at Brent Knoll in 1972. Much work on that section has been published only in summary form and a review is timely as some requires revision. The base of the Hettangian, now defined in a Global Stratigraphic Sections [sic.] and Point (GSSP) by the appearance of the ammonite *Psiloceras spelae tirolicum* at the base of the Tilmanni Zone (Hillebrandt *et al.*, 2013) cannot be established directly in Britain where the lowest ammonite (*P. erugatum*) may indicate a level in the upper part of that zone. However, comparison of the $\delta^{13}\text{C}_{\text{org}}$ isotope record from the GSSP with that from the west Somerset coast suggests that in the latter section the boundary level may be in Bed 1 in the basal Lias, corresponding to a depth of *c.*409 m in the Burton Row Borehole. The base of the Jurassic has been dated at *c.*201.6 \pm 0.2 Ma (Schaltegger *et al.*, 2008). This is within the range of a revised age of 201 \pm 2 Ma assigned to an impact that occurred in central France (Schmieder *et al.*, 2010) and beds in the latest Triassic Penarth Group in Somerset and elsewhere in the British Isles that are interpreted as seismites may be related to that event. Halite, first encountered in the Triassic Mercia Mudstone Group at Puriton, was also proved at Burton Row and farther east in the CSB. At Burton Row it occurs mainly in a *c.* 48.5m section in which beds 0.74 to 8.04 m thick, but totalling only 19.5 m, comprise haselgebirge with 60 to 80% halite and a further 9.6 m of beds contain <45% halite (Whittaker, 1980). Halite occurs beneath *c.* 300 sq. km of the CSB (Benham *et al.*, 2005) but in the absence of a substantial development of thick beds of the evaporite a suggestion that it resulted in halokinesis in the eastern Bristol Channel (Trude *et al.*, 2012) appears unlikely.

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