

# The Ussher Society

## *Geoscience in south-west England*



Priest's Cove - Cape Cornwall



Porth Nanven



Godrevy



Gwithian



Porthmear Cove



Carn Galver Mine

*Images of Penwith geology*

**46<sup>th</sup> Annual Conference**  
**Tregenna Castle Hotel, St Ives**  
**3<sup>rd</sup>-5<sup>th</sup> January 2008**

**Programme and abstracts**

# Welcome

To west Cornwall and the Tregenna Castle Hotel for the 46th Annual Conference of the Ussher Society – the first occasion that we have met in St Ives. As ever, there is a diverse range of presentations across the geosciences, including a substantial proportion with an applied theme.

If this is the first time that you have attended an Ussher Society Conference, please consider joining The Society. Benefits include a hard copy of our annual journal, *Geoscience in south-west England* and, from this year, access to a pdf archive of the first 25 years of the *Proceedings of the Ussher Society*.

## CONFERENCE PROGRAMME

Morning/afternoon tea/or coffee and a buffet lunch are included within the registration fee. Please wear your badge to indicate that you've registered.

### Thursday 3<sup>rd</sup> January

Verbal and poster presentations commence (posters can be viewed during all scheduled breaks). The Scott Simpson Lecture entitled 'From Dines to the 21<sup>st</sup> Century: Past activity, research and prospects for metal mining in SW England' will be given by Dr Richard Scrivener, of the British Geological Survey. The Annual General Meeting, to which all Members of The Society are invited, will be held following a short break for refreshments at the end of the afternoon session. There will then be a reception at the Tregenna Castle Hotel, sponsored by IGI Ltd, prior to the Conference Dinner at around 20:00.

### Friday 4<sup>th</sup> of January

Verbal and poster presentations continue and the joint afternoon session with the South West Regional Group of the Geological Society has the theme 'Applied Geology in South West England'.

### Saturday 5<sup>th</sup> January

Those registered for field excursions will depart shortly after 09:00. It is still possible to register during the Conference – see Peter Frost. Likewise, if you have registered and are unable to attend, please let us know.

## Contributors

If you are making a verbal contribution, please ensure that presentation file(s) are copied to the desktop of the laptop/PC and saved with a filename that includes your surname at least 20 minutes before the start of your session. Please also make yourself known to the Conference Chairman.

## And finally . . .

Many thanks to Chris Cornford, of IGI Ltd, for his generous sponsorship of the Conference Reception, and to Terri Birch of the Tregenna Castle Hotel for helping with the organisation at such a great venue. Don't hesitate to contact Peter Frost (Conference Secretary) or Robin Shail should you have any queries.

We hope you enjoy the Conference and St Ives.

[www.ussher.org.uk](http://www.ussher.org.uk)

*Peter Frost and Robin Shail  
Camborne School of Mines  
University of Exeter*

## Thursday 3<sup>rd</sup> January: Presentation of papers and posters

|               |  |
|---------------|--|
| 08:30 onwards | <b>Registration</b>  |
| 09:15 – 09:20 | <b>Chairman's Introduction</b><br>Bob Symes  |
| 09:20 – 09:45 | The Cornish Building Stone and Slate Guide and associated planning considerations<br><b>Denise Pascoe</b>  |
| 09:45 – 10:10 | Public domain geological data for Cornwall in the age of Google Earth<br><b>Charles Moon</b>   |
| 10:10 – 10:35 | The tectonics of mineralization associated with the Land's End Granite<br><b>Nick LeBoutillier and Robin Shail</b>   |
| 10:35 – 11:10 | <b>Morning Coffee/Tea</b>  |
| 11:10 – 12:20 | <b>SCOTT SIMPSON LECTURE</b><br>From Dines to the 21 <sup>st</sup> Century: Past activity, research and prospects for metal mining in SW England<br><b>Richard Scrivener</b>   |
| 12:20 – 12:45 | Late 18 <sup>th</sup> and Early 19 <sup>th</sup> Century forays into economic geology – little-known Franco-German papers describing Carclaze Old Pit, St Austell<br><b>Colin Bristow</b>  |
| 12:45 – 13:00 | Proceedings of The Ussher Society: members pdf archive<br><b>Chris Cornford</b>  |
| 13:00 – 14:15 | <b>Lunch</b>   |
| 14:15 – 14:40 | Redcliff Point, Weymouth, Dorset, SW England and Savournon, Serres, Haute Provence, SE France: candidate Global Stratotype Section and Points (GSSP) for the base of the Oxfordian Stage (Upper Jurassic)<br><b>Kevin Page, Guillermo Meléndez and Francois Atrops</b> |
| 14:40 – 15:05 | The stratigraphy of the Charmouth Mudstone Formation (Lower Jurassic); Vale of Ilchester and adjacent areas (Somerset, SW England)<br><b>Hugh Prudden and Kevin Page</b>   |
| 15:05 – 15:30 | Lower Jurassic mud volcanoes and methane, Kilve, west Somerset<br><b>Gregory Price, N. Vowles-Sheridan and M.W. Anderson</b>   |
| 15:30 – 16:00 | <b>Afternoon Coffee/Tea</b>  |
| 16:00 – 16:25 | Geodiversity and conservation in Devon: integrated approaches to heritage management.<br><b>Kevin Page</b>   |
| 16:25 – 16:50 | The English Riviera European Geopark: geodiversity and community in Torbay<br><b>Kevin Page and Mel Border</b>   |
| 17:15 – 18:30 | <b>Annual General Meeting of the Ussher Society</b>  |
| 18:45 – 20:00 | <b>Reception (kindly sponsored by IGI Ltd)</b>   |
| 20:00         | <b>Ussher Society Conference Dinner</b>  |

## Friday 4<sup>th</sup> January: Presentation of papers and posters

- 08:30 onwards      **Registration**
- 09:15 – 09:40      A new study of Pleistocene sediments along the North Devon Coast  
**C. Rolfe, A. Brown, P. Toms, S. Boreham and R. Scrivener**
- 09:40 – 10:05      Some microscale analyses of periglacial aeolian sands in west Cornwall  
**Jasper Knight**
- 10:05 – 10:30      An extension of the well-known Quaternary section at Godrevy, west Cornwall: Analysis and Review.  
**H.C.L. James**
- 10:30 – 11:00      **Morning Coffee/Tea**
- 11:00 – 11:25      Towards a Middle-Late Pleistocene fluvial chronology for SW England: Recent work by the Palaeolithic Rivers of South West Britain Project  
**Laura Basell, Tony Brown, Philip Toms and Rob Hosfield**
- 11:25 – 11:50      The water issue in Jersey : 1987 to 2007  
**John Renouf**
- 11:50 – 12:15      Measurements of Polycyclic Aromatic Hydrocarbon (PAH) bioaccessibility and their use in the assessment of Human Health Risk  
**Rod Smith, A.M. Robertson and C.J. Wachtel**
- 12:15 – 12:40      Improving health and safety performance – research into leading indicators and management approaches in the minerals industry  
**Jon Bennett**
- 12:45 – 14:00      **Lunch**
- 14:00 – 14:25      The geology of Penlee Quarry: its impact on previous quarrying and future use  
**Peter Scott and Geoffrey Walton**
- 14:25– 14:50      Geological controls on the failure mechanisms within the Black Ven Landslip, Lyme Regis, Dorset.  
**Ramues Gallois**
- 14:50 – 15:15      Use of the observational technique in facilitating site demolition and the construction of a contiguous piled wall into the toe of a recently stabilized coastal landslip at Lyme Regis, Dorset  
**John Grimes, M. Crumplin and M. Burrows**
- 15:15 – 15:45      **Afternoon Coffee/Tea**
- 15:45 – 16:10      Climate change, slope instability and necessary stabilization of the Access Road, Lundy Island, Bristol Channel  
**John Grimes and M. Burrows**
- 16:10 – 16:35      Use of remote mapping techniques for rock mass characterisation  
**Xander P. Gwynn, John S. Coggan, Andy Wetherelt and Robert J. Pine**

***End of Conference presentations – but there may still be spaces available on one of three field excursions running tomorrow – see the Conference Secretary.***

## Field Excursions: Saturday 5<sup>th</sup> January 2008

All participants must book with the Conference Secretary. Please inform us if you have previously booked and are unable to attend.

### Excursion 1: Penlee Quarry - geology, extractive industry and afteruse

**Leaders:** Professor Geoffrey Walton (PGW&A LLP)  
Professor Peter Scott (Camborne School of Mines, University of Exeter)

Penlee Quarry is located just south of Newlyn. It primarily exposes thick metadolerites of the Upper Devonian Mylor Slate Formation and is within the contact metamorphic aureole of the Land's End Granite. The foreshore at Penlee Point, further south, is a GCR Site (Igneous Rocks of SW England) and Penlee Quarry is a GCR Site (Mineralogy of SW England). Early veins host a variety of As, Bi, Cu, Fe, Mo, Pb, Sn, Te and Zn minerals. A large later vein is dominantly of quartz and chalcedony. The quarry, which was dormant for a while in the 1990s, is presently under development for future production of armourstone for local coastal protection and breakwater works. It is intended that the site will eventually be developed into a marina, with associated facilities, together with housing. The visit will include an examination of the geology of the foreshore and quarry (possible through the kind permission of MDL Ltd), along with explanations of the geotechnical and other issues associated with the future development.

**Meeting point:** The quarry office, just inside the main gate, at 10.00 (there is ample parking - reverse parking rules apply). Depart approx. 14.00. Lifts will be available from Tregenna Castle Hotel (departure by 0920). **All participants require hi-vis vest, hard hat**

### Excursion 2: Devonian and Quaternary geology of St Ives Bay

**Leaders:** Dr Robin Shail (Camborne School of Mines, University of Exeter)  
Dr Jasper Knight (Department of Geography, University of Exeter)

The Tregenna Castle Hotel provides, on good days, a superb eastwards view across St Ives Bay towards Godrevy Lighthouse. The excursion will provide an overview of the stratigraphy, sedimentology and structure of the superb Devonian and Quaternary sections exposed in the southern and eastern parts of the Bay at Black Cliff, Gwithian and Godrevy (including three GCR Sites). Lunch will be taken at a public house or café.

**Meeting point:** The excursion will depart, and lifts will be available, from the Tregenna Castle Hotel at 0930. The precise itinerary will be weather/tide dependent.

### Excursion 3: Land's End Granite - geology and mining landscape

**Leaders:** Dr Nick LeBoutillier  
Simon Camm

The excursion will provide an overview of the geology, mineralization and mining landscapes of the northern margin of the Land's End Granite. The first locality will be Cape Cornwall, where pre-granite host rock deformation, contacts with the granite(s), textural variations, vein mineralization and Quaternary sediments are all superbly exposed. The historic workings of Cape Cornwall, St Just United ( $\pm$  Boswedden) mines will be discussed. The excursion will then head back northeastwards towards St Ives, along the scenic B3306 coast road, stopping at Botallack, Levant/Geevor and Carn Galver mines to further investigate geology, mineralization and mining landscapes. Lunch will be taken at a public house or café.

**Meeting point:** The excursion will depart, and lifts will be available, from the Tregenna Castle Hotel at 0915. The precise itinerary will be weather/tide dependent.

# **Abstracts of verbal presentations**

*Organised alphabetically  
by first author*

## **Towards a Middle-Late Pleistocene fluvial chronology for SW England: Recent work by the Palaeolithic Rivers of South West Britain Project**

*Laura Basell<sup>1</sup>, Tony Brown<sup>2</sup>, Philip Toms<sup>3</sup> and Rob Hosfield<sup>4</sup>*

<sup>1</sup> *Research Laboratory for Archaeology & the History of Art, University of Oxford, Dyson Perrins Building South Parks Road, Oxford, OX1 3QY UK*

<sup>2</sup> *School of Geography, University of Southampton, Highfields Campus, Southampton SO17 1BJ UK*

<sup>3</sup> *Geochronology Laboratories, Department of Natural and Environmental Sciences, University of Gloucestershire, Swindon Road, Cheltenham GL50 4AZ UK*

<sup>4</sup> *Department of Archaeology, School of Human and Environmental Science, University of Reading, Whiteknights, PO Box 227, Reading RG6 6AB UK*

In Britain the majority of Lower and Middle Palaeolithic archaeological finds come from river terrace deposits (Wymer, 1999). Studies of the impressive “staircase” terrace sequences of the Thames Basin and the palaeo-drainage systems of Central and Eastern England largely facilitated by aggregate extraction has greatly increased our knowledge of the Palaeolithic of Central and South Eastern England. Such research has been useful in considering rates of uplift, climatic cycles, archaeological chronologies, and the landscapes of which hominids formed a part. It has also promoted the view that south east England was a major hominid route into Britain.

By contrast the terrace deposits of the South West of England have been little studied largely due to a lack of aggregate extraction. The Palaeolithic Rivers of South West Britain project has employed a range of geoarchaeological methodologies to address questions at different scales, focussing on the rivers Exe, Axe and Otter, and the palaeo-river Washford. Preliminary analysis of the fieldwork results suggested that the evolution of these catchments is complex and that the evolution of the Axe is anomalous. This is important, partly due to the location of the most prolific Middle Palaeolithic site in South West England at Broom in the Axe Valley. Although in general the terrace deposits are less extensive than elsewhere in Britain, vertical and lateral differentiation between terraces does exist and new dates show that some of the middle altitude terraces are as old as 180+ K years. The new chronology, sedimentological studies and GIS analysis have a direct impact on our understanding of the palaeolandscapes of the south west region, and therefore our interpretations of the Palaeolithic.

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## **Improving health and safety performance – research into leading indicators and management approaches in the minerals industry**

*Jon Bennett*

*Camborne School of Mines, University of Exeter, Cornwall Campus*

Introduction – The UK quarrying industry has been working hard to improve health and safety in the sector. CSM has been conducting research as part of the industry ‘Target Zero’ campaign of continuous improvement.

An Organisational View of Health and Safety: a look at the organisational factors that have an impact upon health and safety performance and how these may be used to influence performance.

Leading Indicators of Health and Safety Performance: arising from field research with a major quarrying company, recommendations have been made to the quarrying industry for areas to work with across the sector in order to raise the overall standard of health and safety management.

Behavioural Safety: as part of this programme, CSM has been running a research initiative into behavioural safety in quarries in partnership with a quarrying company. A brief overview of lessons learned so far.

Health and Safety Management Systems: following a review of different approaches to health and safety management systems, a Quarry Health and Safety Management System has been developed and is available to the industry. This links outwards from a core of good management practice to very practical field checks that reflect the requirements of the Quarries Regulations 1999 and other important needs in the industry.

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### **Late 18<sup>th</sup> and Early 19<sup>th</sup> Century forays into economic geology – some little-known Franco-German papers describing Carclaze Old Pit, near St Austell**

*Colin Bristow*

Carclaze Old Pit lies on the southern boundary of the St Austell granite about 3 km NNE of St Austell. It probably originated from tin stream workings in the Phernyssick Valley following a rich source of tin to the crest of the hill, where a massive stockwork consisting of a tin-bearing greisen-bordered quartz-tourmaline vein swarm straddling the granite/killas contact was developed by an open pit. If early accounts are to be believed, a very large quantity of tin was extracted, equivalent to £100million at the present tin price. Tin extraction from the pit had virtually ceased by the mid 19<sup>th</sup> C as production switched to china clay.

This pit was a 'must-see' site for late 18<sup>th</sup> and early 19<sup>th</sup> C visitors to Cornwall and there are many accounts, lithographs, paintings, etc. describing the pit and the method of working. This involved breaking down the soft clay-bearing matrix in the pit with water brought to the site, and then treating in the pit some of the resulting slurry with waterwheel driven stamps to recover tin; vein material was taken away in boats via an underground canal for stamping and further treatment at Phernyssick. A second lower drainage level took away surplus water, clay and sand, some of which was also reprocessed at Phernyssick. To begin with no attempt was made to recover the china clay.

The earliest scientific account was by a Frenchman; M. Jars from the Académie Royale des Sciences de Paris, who visited the pit in 1765, this was followed by other Frenchmen: Bonnard in 1803, Dufrénoy and de Beaumont (1824-7) and Daubrée (1841). Von Oeynhausien and Von Dechen from Germany provided in 1829 the first geological map and section of the pit, showing the layout of the veins. These accounts contain detailed descriptions of the orebody and discuss its genesis and, for this early date, show a surprising depth of understanding of economic geology; they are reminiscent of what would be called a 'feasibility study' today. This suggests that, at this time, in parallel with the development of academic geology mainly led by British geologists, there was a development of metalliferous economic geology, mainly led by French and German scientists.

The earliest account of the pit by an English author was by Adam Sedgwick in 1822; in a later paper in 1835 he speculated (wrongly) on the relationship between



stress, slaty cleavage and the formation of parallel vein swarms, partly based on his observations in Carclaze pit. There were brief mentions in 1822 and 1832 by a group of Cornish mining men, including Hawkins, Carne and Boase. An account by De la Beche in 1839 provided a delightful pen and ink sketch of the pit. Subsequent accounts by Henwood and others largely rely on the descriptions provided by the earlier writers.

These accounts also show how the technology of the early china clay industry evolved from large scale open pit tin operations. Techniques such as washing the stopes with water brought from distant sources to break down the matrix into a slurry, a level under the pit to take away the slurry and settling ponds to recover fine sediment, were developed at Carclaze in the late 18<sup>th</sup> C before the china clay industry had started to develop. The idea for the sky tip probably originated from the incline in the Happy Union tin stream works in the Pentewan valley, sketches of which are found in a German account published in Berlin in 1783.

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### **Geological controls on the failure mechanisms within the Black Ven Landslip, Lyme Regis, Dorset**

*R.W. Gallois*

*92 Stoke Valley Rd. Exeter EX4 5ER. Tel/ E-Mail: 01392 677572  
[gallois@geologist.co.uk](mailto:gallois@geologist.co.uk)*

The Black Ven Landslip is one of largest active landslip systems on the south coast of England. It was probably initiated in the Pleistocene in a periglacial climate, but then remained inactive for most of the Holocene. There is photographic evidence to show that it has been especially active in the last 60 years and that it is expanding westwards towards the Lyme Regis urban area. The landslip can be divided into two distinct parts, an upper Cretaceous-based part that behaves independently and an underlying Jurassic-based part that is greatly influenced by movements in the Cretaceous part. The upper landslip is composed of collapsed Gault Formation clay (c 5 m thick when undisturbed) overlain by a c 40 m-thick succession of decalcified Upper Greensand Formation calcareous sandstones and calcarenites. Below this and extending to the sea, the 100 m-thick Jurassic Charmouth Mudstone Formation crops out in a series of low cliffs each of which is capped by a thin bed of limestone. After prolonged periods of rain, water and sludges derived from the Cretaceous rocks pour over the Charmouth Mudstone outcrop and initiate failures in the more clay-mineral-rich parts of the succession. The more calcareous parts are not prone to failure and form stable ribs within the complex.

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### **Climate change, slope instability and necessary stabilization of the Access Road, Lundy Island, Bristol Channel**

*John N. Grimes and M. Burrows*

*John Grimes Partnership*

Records compiled over the last 30 years suggest that Lundy is getting wetter. During the last 40 years and under the management of the Landmark Trust public access to Lundy has been maintained and enhanced. Both day-trippers and longer term visitors can gain ready access to the island all the year round sailing to Lundy

on the MS Oldenburg. The ship frequently sails to Lundy from either Ilfracombe or Bideford access to the island is via a new jetty constructed some 10 years ago.

The only vehicular access from the jetty to the village situated some 100m above sea level is via track which traverses the coastal slopes on the east side of the island. These slopes are historically unstable. Over the last 15-20 years the track has exhibited evidence of mass movement. In more recent years this movement has accelerated and the use of the track has only been facilitated by detailed risk assessment and implementation of a rigorous management routine. In 2006 it was considered that the risk associated with using the track was too great and a first phase of stabilisation works were carried out in the winter and spring of 2006-2007.

This paper presents the engineering solution in context of the relevant geology environment and service ability.

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### **Use of the observational technique in facilitating site demolition and the construction of a contiguous piled wall into the toe of a recently stabilized coastal landslide at Lyme Regis, Dorset**

*John N.Grimes, M. Crumplin and M Burrows*

*John Grimes Partnership Ltd, Leonards Road, Ivybridge, Devon, PL21 9TT*

The landslide had caused structural damage to two properties in Marine Parade. The properties were evacuated and temporarily supported in 2002. This paper presents the geotechnical engineering involved in the construction of a reinforced concrete faced contiguous piled anchored retaining wall. The works included a provision for groundwater drainage and were constructed during the wet winter of 2006 and 2007.

Pressure meter testing showed that lateral earth pressures within the landslide albeit close to its toe were significantly higher than at rest pressures. The depths of landslide material which was derived from both Lower Lias clays and green sand material is approximately 3m this overlaid the mid Shales-with-beef. The shales slake in water.

The engineering rational included design with prediction of lateral wall displacements. Base line monitoring for pore water and displacement were carried out and maintained during the works as part of the observational approach used.

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### **Use of remote mapping techniques for rock mass characterisation**

*Xander P. Gwynn, John S. Coggan, Andy Wetherelt and Robert J. Pine*

*Camborne School of Mines, University of Exeter, Cornwall Campus, Penryn, Cornwall, TR10 9EZ, UK*

The use of remote techniques to capture the geometrical characteristics of rock masses has seen increased use and development in recent years. Apart from the obvious improved Health and Safety aspects, remote techniques allow rapid collection of digital data that can be subsequently analysed to provide input parameters for a variety of geomechanical models.

Recent research at the Camborne School of Mines, University of Exeter, has focussed on comparison of different remote data capture techniques for effective rock mass characterisation in order to quantify their benefits and limitations whilst comparing them with conventional hand-mapping. The paper describes the results of a detailed comparison between hand-mapping, terrestrial photogrammetry and high definition surveying (laser scanning) methods of data collection. The key advantages of remote techniques are their speed, greater area coverage and ability to map inaccessible areas. Automated analysis of data is, however, not yet recommended and there is still a need for educated users to provide manual intervention, spot checks and associated interpretation. Experience suggests that there is also a need to establish a representative scale of measurement, so that key features of the rock mass are captured and incorporated during the characterisation process.

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### **An extension of the well-known Quaternary section at Godrevy, West Cornwall: analysis and review**

*H.C.L. James*

*The University of Reading*

The well-known Quaternary section at Godrevy, west Cornwall has been oft described, most recently in Campbell *et alia*, 1998. However, a further section, about a kilometre to the south is considered for the first time. This 200 m exposure rests upon a raised shore platform and consists of a basal raised beach and littoral sand, overlain by a local diamict revealing evidence of post-depositional disturbance and finally Holocene dune sand. It is proposed that the Strap Rock exposure be included within the general discussion of the 800 m Godrevy section.

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### **Some microscale analyses of periglacial aeolian sands in west Cornwall**

*Jasper Knight*

*Department of Geography, University of Exeter, Cornwall Campus,  
Penryn, TR10 9EZ, UK (E-mail: j.knight@exeter.ac.uk)*

In west Cornwall, aeolian sands that are interbedded with solifluction breccias (periglacial slope deposits) are often observed within the Quaternary sedimentary record of coastal lowlands. These aeolian sands are usually located towards the bottoms and tops of the solifluction units (and sometimes as stringers and lenses between individual breccia beds), and reflect periods of enhanced wind activity over stable land surfaces. As such, the accumulation of aeolian sand represents a transient landscape response to climatic disturbance that usually terminates as land surface destabilisation (climate cooling) or soil/vegetation development (climate warming) takes over. It is uncommon, therefore, for thick sand sequences to accumulate, hence the potential importance of multiproxy microscale analyses to characterise and thus identify aeolian sands. Some preliminary results of microscale analyses of aeolian sands are shown from Pendower (which shows clear outcrop-scale evidence for wind deposition), and from Godrevy, whose outcrop-scale evidence is less clear. Some climatic and palaeoenvironmental deductions are presented based on evidence from these two sites.

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## The tectonics of mineralization associated with the Land's End Granite

*Nick LeBoutillier and Robin Shail*

*Camborne School of Mines, University of Exeter, Cornwall Campus*

Granite-associated mineralization across SW England is diachronous, and reflects a complex interaction of magmatic, hydrothermal and post-Variscan tectonic processes over c. 40 Ma. Previous models invoking contemporaneous batholith-wide stages of mineralization (e.g. Dines, 1934, 1956; Moore, 1975) are unsustainable. Mineral vein geometries, kinematics and relative chronologies in the Land's End Granite have been re-assessed and do not support the hypothesis of an approximately synchronous radial fracture system (Moore, 1975). Instead, data are consistent with repeated changes in the regional/local stress regime during pluton assembly and the release/mixing of magmatic-hydrothermal and other fluids.

The data presented here, when combined with published geochronological data (e.g. Chen *et al.*, 1993; Chesley *et al.*, 1993), indicate the Land's End Granite evolved as follows: ① Emplacement of the Zennor Granite, ~275 Ma, followed by the St Buryan Granite, ~274 Ma. ② Formation of ENE-WSW trending schorl veins, across the Zennor and St Buryan granites, under conditions of NNW-SSE extension. The emplacement of the St Just Granite. ③ ENE-WSW shortening (D4 of Shail and Alexander, 1997); formation of E-W veins with sinistral displacements. ④ Transition to N-S shortening (D5 of Shail and Alexander, 1997). Mineralization associated with the St Just Granite in NW-SE and NNW-SSE trending fractures. Early movements are strike-slip dominated (Garnett, 1961, 1962; Jackson, 1977), but most Sn-Cu mineralization is associated with ENE-WSW extension. ⑤ Formation of iron-rich, jasper-quartz-siderite infilled guides under NE-SW shortening (Garnett, 1962) or N-S shortening; these structures fault lodes, but sometimes host Sn-Cu mineralization. ⑥ Quartz-infilled N-S trending tensile veins cut all other vein sets; their timing is unconstrained but may be an early expression of 'cross-course' mineralization in the Middle Triassic (Scrivener *et al.*, 1994); this is a province wide ENE-WSW extensional event recorded by lower temperature chalcedony-dominated assemblages and a hydrothermal overprint (secondary clays) within the optimally orientated lodes around St Just.

The 'anomalous' orientation of the majority of the Sn-Cu lodes around St Just (and elsewhere around St Austell) reflects a coincidence between the latest stages of magmatism and a changing regional stress regime.

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## Public domain geological data for Cornwall in the age of Google Earth

*Charles J. Moon*

*Rose Cottage, Church Hill Calstock PL18 9QQ [cjm@moongeology.co.uk](mailto:cjm@moongeology.co.uk) &  
Camborne School of Mines, University of Exeter, Cornwall Campus,  
Penryn TR10 9EZ*

The advent of Google Earth (and similar products) has revolutionised the availability of non-copyright topographic data using high resolution air

photography and LANDSAT data. It is relatively straightforward to add (mash) user defined data, locations and photographs.

The easy availability of geological data would encourage more interest in geology amongst the general public and in schools. There have been some attempts to add data for Cornwall, in particular, the location of mines, but these are, like much of the data on the internet, partial and flawed. An initial attempt to add comprehensive data on mineral vein location for Cornwall will be discussed, as will possible sources of non-copyright geological mapping and the scope for further work.

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**Redcliff Point, Weymouth, Dorset, SW England and Savournon, Serres, Haute Provence, SE France: candidate Global Stratotype Section and Points (GSSP) for the base of the Oxfordian Stage (Upper Jurassic)**

*Kevin N. Page*<sup>(1)</sup>, *Guillermo Meléndez*<sup>(2)</sup> and *Francois Atrops*<sup>(3)</sup>

<sup>(1)</sup> *School of Earth, Ocean & Environmental Sciences, University of Plymouth, Drake Circus, Plymouth PL4 8AA, UK (kpage@plymouth.ac.uk; mhart@plymouth.ac.uk; G.Price@plymouth.ac.uk);*

<sup>(2)</sup> *Paleontología, Dpto. Geología, Universidad de Zaragoza, 50009 Zaragoza, Spain ([gmelende@unizar.es](mailto:gmelende@unizar.es));*

<sup>(3)</sup> *Centre Sciences de la Terre, Fac. Sciences de Lyon-1, 27-43 Bd du 11 Novembre, F-69622 Villeurbanne (France) (Francois.Atrops@univ-lyon1.fr).*

In the global search for a stratotype at which to define the base of the Oxfordian Stage and hence the base of the Upper Jurassic, two candidates remain: Hamcliff near Redcliff Point, Weymouth, Dorset (SW England) and the Peyral section, near Savournon and Serres, Haute Provence (SE France). Both sites show an expanded sequence in mudrock facies across the Callovian-Oxfordian boundary and both have now provided a range of stratigraphical useful data which can aid the correlation of the base of the latter stage. First and foremost are the ammonite faunas, which although having overall characteristics typical of different faunal provinces, include a remarkably detailed sequence of cardioceratid species which, by convention, are used to correlate the boundary. Crucially, both sites have now yielded the basal Oxfordian indicator species *Cardioceras redcliffense* Page, Meléndez & Wright so can be correlated precisely. In addition, supporting geochemical and micropalaeontological information is now available from both sites, although only the Redcliff section has yielded magnetostratigraphical results. The results from both sites will be presented and discussed in the context of their suitability as GSSPs for the base of the Oxfordian Stage. Formal selection of a GSSP, however, must wait until later in 2008 when both sites will be presented to the International Subcommission on Jurassic Stratigraphy (ISJS) in 2008 as part of a voting process, with ratification of the successful candidate GSSP expected at the International Geological Congress in Oslo later in the year.

## The English Riviera European Geopark: geodiversity and community in Torbay

*Kevin N. Page <sup>(1)</sup> and Mel Border <sup>(2)</sup>*

<sup>1</sup> *School of Earth, Ocean and Environmental Science, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK (kpage@plymouth.ac.uk)*

<sup>2</sup> *Torbay Coast and Countryside Trust, Cockington Court, Torbay, TQ2 6XA, UK (geopark@countryside-trust.org.uk)*

In 2007 Torbay became SW England's first European Geopark, a designation recognised by UNESCO. The area has a rich and well-exposed geological heritage, from Devonian reefs to Pleistocene bone-caves, with strong links to the cultural history of the region. Not surprisingly, Torbay includes one of the highest concentrations of protected geological sites in the UK with 11 nationally protected Sites of Special Scientific Interest and at least 14 County Geological Sites (or 'RIGS'). Every year, large numbers of educational groups visit the Bay and use this resource and the area is ideal as a base for heritage tourists exploring other areas of south-west England. With the establishment of the Geopark, new approaches to presenting geological interpretation are being developed - the concept of a Geopark as promoting the sustainable use of a geological resource being extremely relevant in the context of existing nature conservation strategies and philosophies within the Bay. Crucially, the Geopark has the potential to become a framework for other heritage tourism initiatives in the area and an identity through which Torbay can be identified globally for the excellence of its facilities. The unique combination of a superb geological resource, well developed site management frameworks, established tourism facilities and partnerships between the public, private and voluntary sectors makes Torbay well placed to develop a dynamic and successful Geopark, promoting geological heritage and sustainable development for the 21<sup>st</sup> Century.

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### **Geodiversity and conservation in Devon: integrated approaches to heritage management**

*Kevin N. Page*

*School of Earth, Ocean and Environmental Science, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK (kpage@plymouth.ac.uk)*

The conservation of bio- and geodiversity in Devon is integrated, reflecting long established principles in UK practice, as recently confirmed by the central Government Planning Policy Statement 9, on Biodiversity and *Geological Conservation* (2005). This process is underpinned by the Devon Biodiversity Action Plan, first established in 1998 and revised in 2007, which informs similar integrated nature conservation action plans elsewhere within the boundaries of the historical county. The document includes 40 action plans to guide the management of key 'habitats' within the County, 10 of which have significant or dominant geological components (such as quarries, caves, cliffs, mines and periglacial landforms). A range of other initiatives also contribute to the process of raising awareness of and managing the County's rich geological heritage, including the ongoing work of the Devon RIGS Group, geodiversity audits and interpretative and educational provision by local authorities and trusts. In several cases, these projects have been integrated with historical and archaeological initiatives, for instance within the Mining Landscapes World Heritage Site in West Devon and the national Palaeolithic Rivers project. This range of initiatives will be reviewed and

demonstrates the truly holistic approach to heritage conservation that is now developing within the County.

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### **'The Cornish Building Stone and Slate Guide' and associated planning considerations**

*Denise Pascoe*

*Cornwall County Council*

The Cornish Building Stone and Slate Guide was produced as a handbook for developers, architects and householders on where to source new and reclaimed building stone and slate. It also includes information on local stonemasons and other skilled trades associated with the working of natural stone. Information on training courses available is also included. The aim of the document is to promote local distinctiveness and reduce distance materials are transported. Policies produced by the mineral planning authority (Cornwall County Council) underpin the aims of the guide and a brief overview of associated planning matters is given.

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### **Lower Jurassic mud volcanoes and methane, Kilve, west Somerset**

*Price, G.D., Vowles-Sheridan, N. and Anderson, M.W.*

*School of Earth, Ocean and Environmental Sciences, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK (email [g.price@plymouth.ac.uk](mailto:g.price@plymouth.ac.uk))*

A series of mud volcano structures from Kilve, west Somerset, UK are described. They occur within the *Psiloceras planorbis* ammonite zone of the Lower Jurassic (Hettangian) Blue Lias Formation. The flanks of each of the three mud volcanoes consist of micritic limestone and alternating shale beds, whilst tufa-like deposits cap the top of each structure. Two of the mud volcanoes contain a mud breccia which includes dark grey lithoclasts, red mudstone clasts and abundant crinoidal fragments together with an abundance of the benthic foraminifera *Involutina liassica*. Evidence for methane associated with the mud volcanoes is derived from the isotopic analysis of the tufa deposits. All three structures yielded very negative  $\delta^{13}\text{C}$  values (-21.4 to -32.4‰), values considerably lighter than associated sediments. Such negative  $\delta^{13}\text{C}$  values typically occur when authigenic carbonates incorporate variable proportions of carbon derived from the anaerobic oxidation of methane. Relative to modern mud volcanoes the structures present in Somerset are small, which may indicate limited activity and limited volume extruded. Much methane released from submarine mud volcanoes is commonly oxidised, as evidenced by the tufa caps at Kilve. Hence in conjunction with low activity levels this may suggest that only a modest amount of methane may have reached the atmosphere during the Jurassic from this source.

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## The stratigraphy of the Charmouth Mudstone Formation (Lower Jurassic) of the Vale of Ilchester and adjacent areas (Somerset, SW England).

*Hugh Prudden <sup>(1)</sup> and Kevin N. Page <sup>(2)</sup>*

<sup>(1)</sup> 2 Yeovil Road, Montacute, Somerset, TA15 6XG,  
[hugh@hughprudden.wanadoo.co.uk](mailto:hugh@hughprudden.wanadoo.co.uk)),

<sup>(2)</sup> School of Earth, Ocean and Environmental Science, University of Plymouth, Drake Circus, Plymouth PL4 8AA, UK ([kpage@plymouth.ac.uk](mailto:kpage@plymouth.ac.uk))

Although famously well exposed on the West Dorset Coast, inland in SW England the mudrocks of the Lower Jurassic, Charmouth Mudstone Formation are poorly exposed. Not surprisingly, details of their stratigraphy and faunas have consequently remained poorly known. The systematic recording of temporary exposures in excavations in southern and eastern Somerset by HCP over 40 years, however, has now revealed one of the most complete sequences of ammonite faunas known in Europe for the Upper Sinemurian and Lower Pliensbachian stages. These results have now been supplemented from other temporary section records including by KNP and Mr M. Harvey, Chilthorne Domer. Additional information is available from other sources, This succession can be correlated with that known on the Dorset coast and key areas elsewhere in the UK and across Europe to provide a high-resolution time-scale against which other Lower Jurassic processes and events, including sedimentological and tectonic, can be accurately compared.

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## The water issue in Jersey: 1987 to 2007

*J.T. Renouf*

*Le Côté des Pelles, La Route du Petit Port, St Brelade, Jersey JE3 8HH 00 44  
(0)1534 741 545 [johnrenouf@orpheusinternet.co.uk](mailto:johnrenouf@orpheusinternet.co.uk)*

A significant number of private and commercial boreholes have been sunk in Jersey during the last 40 years, and concern about over extraction increased over the years, until the issue was taken up seriously in the last years of the 1980s by the Public Works Department of the time. The British Geological Survey (BGS) was employed to research the groundwater potential and assess its ability to satisfy estimated demand. A vociferous group of water diviners and borehole drillers were resolutely opposed to any restriction on what they considered an unlimited supply of water recharged from France. Another group, consisting of local geologists, was appointed to advise on the work of the BGS.

A water law was finally agreed and implemented by the States of Jersey in the summer of 2007, but only after a protracted series of reverses, occasioned by the differing views of the water diviners and borehole drillers on the one hand and geologists and the staff of the Public Works Department on the other. The experiences of the geologists, during their efforts to convince sufficient politicians of the need for a water law to safeguard the island's aquifer, raise issues that are considered of real importance to scientists of whatever discipline when confronted by persons or groups using a different set of criteria, ultimately non-scientific, to form their opinion.

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## A New Study of Pleistocene Sediments along the North Devon Coast

*C. J. Rolfe<sup>1,3</sup>, A. G. Brown<sup>1</sup>, Toms, P. S.<sup>2</sup>, S. Boreham<sup>3</sup> and R. Scrivener<sup>4</sup>*

<sup>1</sup> *School of Geography, University of Southampton, Highfields Campus, Southampton SO17 1BJ UK*

<sup>2</sup> *Geochronology Laboratories, Department of natural and Environmental Sciences, University of Gloucestershire, Swindon Road, Cheltenham GL50 4AZ UK*

<sup>3</sup> *Department of Geography, University of Cambridge, Downing Site, Cambridge CB2 3EN UK*

<sup>4</sup> *British Geological Survey, Forde House, Park Five, Harrier Way, Exeter EX2 7HU*

This paper will present some of the recently discovered, and re-discovered Pleistocene sediments which can be found in pockets along the North Devon coast which have prompted a project re-examining the Pleistocene history of this area. Previous studies of supposedly glacial or proglacial sediments near the coast have been used as evidence for postulating a glacial limit adjacent to the coast during the middle-late Pleistocene. Both the postulated sedimentary environment and age of these sediments has been controversial. It is also not easy to reconcile the most commonly quoted age and genesis of the North Devon sediments, especially those in Barnstaple area, with recent work in South Wales, the north coast of Cornwall and the Scilly Isles. The paper will report on preliminary work on these new sedimentary deposits in the Lynton area and outline future plans for the project. The area and the questions these deposits raise are regionally important as the location of ice sheet margins in the Northern Hemisphere is an important boundary condition in global climate modelling of past climatic fluctuations in the Pleistocene.

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## The geology of Penlee Quarry its impact on previous quarrying and future use

*Peter Scott<sup>(1)</sup> and Geoffrey Walton<sup>(2)</sup>*

<sup>(1)</sup> *Camborne School of Mines, University of Exeter, Cornwall Campus*

<sup>(2)</sup> *Mining and Minerals Engineering, University of Leeds and PGW&A LLP*

This paper sets out the geology of the currently dormant Penlee Quarry that lies just south of Newlyn, Cornwall. It largely comprises a dolerite altered by low grade metamorphism with two distinct phases of later mineralization. The quarry is a Geological SSSI designated in 1997 due to its diversity of mineralization types, having been identified in the JNCC book on Igneous Rocks of SW England (1993). This paper sets out the findings of a more detailed investigation of the features of geological interest appropriate for geoconservation undertaken on behalf of the quarry owners, MDL Developments Limited.

Quarry development started in the late 1880s near Newlyn as a hillside operation advancing to the west and subsequently south. The impact of geological features and related geotechnical constraints on subsequent quarry development will be outlined. The rock has a characteristic high density of *ca.* 2.95t/m<sup>3</sup> and for England, an exceptional strength of up to 350MPa. Workings ceased in the early 1990s due to a combination of problems relating to access and transport, and to the non-acceptability of the aggregate for road surfacing due in part to its low PSV. In 1999 planning permission was obtained for revised conditions that permitted the further extraction of 28Mt of rock, extending to a depth of 100m below sea level. In practice little is recoverable under the constraints of the Quarries Regulations 1999.

The intended future after-use of the quarry is as a marina with housing and commercial development following the production of armourstone for nearby coastal works, during which further development benches will be formed. The geotechnical and other controls on this proposed development will be outlined.

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## **SCOTT SIMPSON LECTURE**

### **From Dines to the 21st Century: past activity, research and prospects for metal mining in SW England**

*Richard C. Scrivener*

*British Geological Survey, Forde House, Park Five, Harrier Way, Exeter, EX2 7HU  
(E-mail - rcs@bgs.ac.uk)*

After the publication, just over 50 years ago, of H G Dines two-volume work on the metalliferous mining region of SW England, rises in world metal prices supported a revival of interest in the mining industry of Cornwall and Devon. This occurred in the period from the mid-1960s to the mid-1980s. Geevor and South Crofty expanded production of tin concentrates, Wheal Jane, Mount Wellington and Pendarves mines were brought into production, and there were numerous prospects including the large-tonnage low-grade tungsten deposit at Hemerdon.

This revival fuelled new and important research into the nature and origin of the mineralization, of the Cornubian granites and of the geological framework around them. The scientific studies included structural analysis, mineralogy and petrology, geochemistry, fluid inclusion studies and isotopic dating. As a result of this work, understanding of the mineralising processes and their relationship with the development of the Variscan fold belt is significantly improved. The history of mineralization in the province now extends from syn- and epigenetic processes recognised in Early Devonian to Early Carboniferous strata, through granite-related hydrothermal events in the Early and Middle Permian, to low-temperature mineralization associated with basinal brines in the Middle to Late Triassic.

This broader and better-understood scenario will assist in the next phase of metalliferous exploration and development in the province, which has already been signalled against the world background of high metal commodity prices.

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### **Measurements of Polycyclic Aromatic Hydrocarbon (PAH) bioaccessibility and their use in the assessment of human health risk**

*Rod P. Smith, A.M. Robertson and C.J. Wachtel*

*John Grimes Partnership Ltd*

Bioaccessibility testing for soil arsenic is accepted by many Local Authorities in the South West as part of the Detailed Quantitative Risk Assessments (DQRA) phase of the UK CLR11 framework for the management of Contaminated Land. However, the use of bioaccessibility testing has not regularly been used for the assessment of other contaminants in soils in the UK.

We describe using the RIVM method for the measurement of PAH bioaccessibility for an urban soil from Cornwall and its incorporation into the risk assessment of

long term human health. The concept of Hazard Indices is extended to PAH mixtures in soils. The results for individual PAH compounds are compared with published fugicities for these compounds.

The use of bioaccessibility measurements as an appropriate surrogate for bioavailability is discussed in the light of recent research on the metabolism of PAHS and current guidance from the Environment Agency.

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# **Abstracts of poster presentations**

*Organised alphabetically  
by first author*

## **Re-examination of the type section of the Goonhilly Member of the Lizard Loess Formation, Countybridge Quarry, the Lizard Peninsula, Cornwall**

*Cornwall RIGS Volunteer Team*

*Peter Ealey, Roaring Stile, St Keverne, Helston, Cornwall . TR12 6RQ.  
Email: pealey1@tiscali.co.uk. Tel: 01326 280130*

The type section of the Goonhilly Member (massive rather than head-loess) of the Lizard Loess Formation occurs in Countybridge/ Kemp's Quarry, which lies on the northwards sloping boundary of the Goonhilly Downs and Lizard Ophiolite Complex. Since its initial description by Roberts (1985) the section had become badly overgrown but has been recently cleared and exposed.

The metre thick section is characterised by upper massive loess passing down into a mottled zone which is underlain by a darker clast-rich zone with involution-like structures. The upper part of the underlying serpentinite is intensely fragmented. The density of fractures is orders of magnitude greater than the well developed joint sets in the main quarry walls. This brecciation is in marked contrast to the well-known reticulate sub-aerial weathering seen elsewhere in the Lizard serpentinites.

The section may be of regional importance for other reasons than its current designation (arguably not sustainable) as type section of the Goonhilly Member of the Lizard Loess Formation implies, and is discussed in the light of recent work on the Isle of Thanet, Kent.

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## **Geochemistry of the Bude and Bideford formations, Devon**

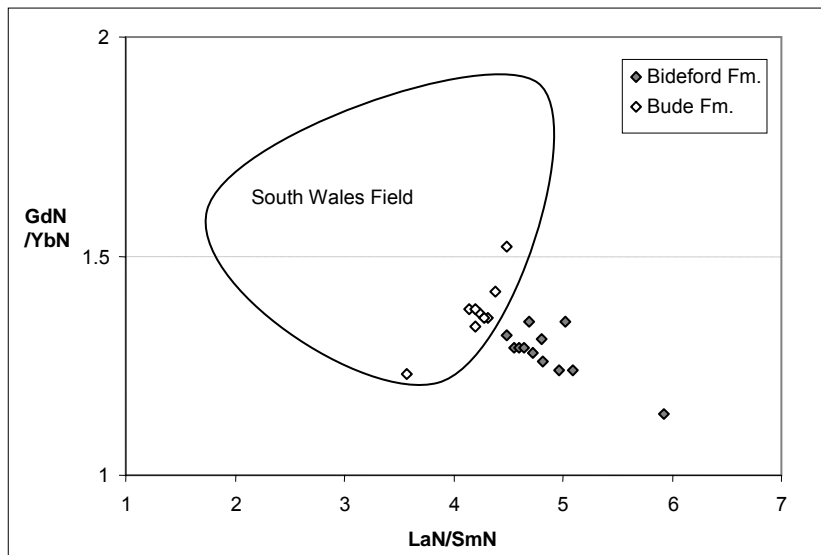
*Sorcha Diskin*

*University of Bostwana*

The relationship of the Bude and Bideford Formations is not fully understood. A geochemical study was undertaken to help elucidate it. 21 samples were collected from mudstones and siltstones from the Bude and Bideford (including Westward Ho!) Formations and were analysed for major and trace (including REEs) elements as determined by ICP-AES and ICP-MS. The discussion focuses on REEs because they are generally considered to have been transported to the place of deposition with little fractionation, and therefore may provide valuable information regarding the sediment source.

The major and trace elements in general do not suggest any differences between the sedimentary material in the two formations. All samples have fractionated LREE (LaN/SmN), a small or absent Eu anomaly, and less fractionated HREE (GdN/YbN) patterns. Absolute abundances and pattern shapes of the REE are similar within each group, as well as a small negative, but persistent Eu anomaly ( $\text{Eu}/\text{Eu}^* \approx 0.77$ ).

Two non-overlapping fields can be drawn showing the distribution of LaN/SmN against GdN/YbN. The Bideford Formation shows a comparative enrichment in LREEs and depletion in HREEs as would be expected for sediments with more Archaean crustal input. The Bude Formation sediments all fall into a Westphalian South Wales Field (Diskin 2003), whereas the Bideford Formation sediments do not.



Diskin, S. (2003) Geochemical and Isotopic aids to Provenance Studies in the Westphalian of the British Isles. Unpublished PhD Thesis, Oxford Brookes University.

### **The chronology and kinematics of D3 deformation and its relation to the emplacement of the Land's End Granite**

*Samuel P. Hughes, Ross J. Stickland and Robin K. Shail*

*Camborne School of Mines, University of Exeter, Cornwall Campus*

The chronology of emplacement of the Land's End Granite and D3 post-Variscan extension has been established by large scale field mapping of metasediments at Priest's Cove and Porth Ledden on the western margin of the contact aureole. Deformation phases in the contact aureole were referenced to a south coast section between Loe Bar and Megiligar Rocks which clearly displays the tectonic history of D1 and D2 Variscan convergence deformation, D3 post-Variscan extension and D4 late E-W shortening. The data set from the south coast was applied to the heavily thermally metamorphosed hornfels of the Mylor Slate Formation close to the contact with the Land's End Granite. Both the S1-S<sub>0</sub> and S3 fabrics are NW-dipping on the western margin of the pluton, whereas they dip SE (S1-S<sub>0</sub>) or are flat-lying (S3) on the south coast. Also, there is an apparent anticlockwise rotation of both D2 structures (F2 folds and S2 cleavages) and D3 structures on the western margin of the pluton. These are interpreted as granite emplacement causing both inflation of the hornfels host rock, and the anticlockwise rotation of D2 and D3 structures observed at Cape Cornwall. D3 deformation appears to pre-date granite emplacement. This is confirmed by the vergence of folds on the west coast, and by granite veins seen to intrude both existing S3 cleavage and cross-cut existing F3 folds.

## Rhenohercynian passive margin evolution in SW England

*B. E. Leveridge<sup>1</sup> and R.K.Shail<sup>2</sup>.*

<sup>1</sup>*British Geological Survey (HRA), Exeter, EX2 7HU [bel@bgs.ac.uk](mailto:bel@bgs.ac.uk)*

<sup>2</sup>*Camborne School of Mines, University of Exeter, Cornwall Campus, TR10 9EZ  
[R.K.Shail@ex.ac.uk](mailto:R.K.Shail@ex.ac.uk)*

Mapping and research in the province over the last 25 years has refined understanding of the Rhenohercynian in SW England. Its passive margin developed over ~80 Ma from the Lochkovian and involved sequential northwards formation of sedimentary basins. Convergence and closure of the southernmost Gramscatho Basin (and Lizard 'ocean') from the late Eifelian, continued for some 30 Ma, and was contemporaneous with rifting further north. The onset of continental collision was marked by the emergence of nappes, comprising, upwards, deep marine sedimentary and volcanic rocks, oceanic lithosphere pre-rift basement, and upper plate high-grade gneisses, onto the passive margin by the earliest Carboniferous. Deformation migrated through the margin during the Dinantian and early Namurian (~30 Ma) inverting the rift basins filled with Devonian deposits and the southern parts of the Carboniferous Culm Basin. Styles of deformation, including 'facing confrontations', were largely determined by basin geometry. The Culm Basin rift became a late Namurian-Westphalian foreland basin with its sediments, derived from east and north, probably products of movement and overthrusting along the Bristol Channel-Bray Fault. As this basin locked, late in the Westphalian (c. 305 Ma), province-wide deformation occurred and the Silesian fill of the Culm Basin was inverted and deformed for the first time. Latest Carboniferous regional extensional structures continued to reflect the influence of the earlier basinal architecture. It is unclear how recent models invoking Middle Devonian northwards subduction of the Rheic Ocean, as a cause for Acadian deformation in Wales, can be reconciled with synchronous passive margin development in SW England.

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## Geology in the South West of England - the founding of the Ussher Society

*Peter R Pay*

*Hole Farm, Chulmleigh, N Devon, EX18 7DS. 01769 580159 [ppay@btinternet.com](mailto:ppay@btinternet.com)*

In a tabulated chronology, geological progress in the South West of England is traced from the late eighteenth century to the founding of the Ussher Society in 1962. Sequential detail is collated under five headings: Geological developments in the SW; Related events; Regional surveys; Association and institute business; Key publications.

This chronology follows the advancement of geological knowledge, including the identification of the Devonian, development of district surveys, the role of regional institutions and formation of the Ussher Society. A growing comprehension of the fabric of the region emerges through the proceedings that document lively debate between elite geologists, competent researchers and persistent amateurs. Their work of observation and conceptual analysis increasingly relies on the application of science made available through specialist commercial and research establishments.

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## **Landslide mechanisms in the Mercia Mudstone Group (Triassic) of the East Devon coast**

*R.W. Gallois*

*92 Stoke Valley Rd. Exeter EX4 5ER. Tel/ E-Mail: 01392 677572  
[gallois@geologist.co.uk](mailto:gallois@geologist.co.uk)*

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 ( $< 1^\circ$ ) 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 hydraulic stoping acting on jointing and bedding, and in the upper parts of the cliffs by joint-bounded wedge failures. Thin ( $< 10$  mm thick) beds of laminated mudstone in the Dunscombe Mudstone Formation give rise to failures on rotational slip surfaces.

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## **The lithostratigraphy of the Shales-with-Beef Member of the Charmouth Mudstone Formation, Lower Jurassic**

*Ramues W. Gallois*

*92 Stoke Valley Rd. Exeter EX4 5ER. Tel/ E-Mail: 01392 677572  
[gallois@geologist.co.uk](mailto:gallois@geologist.co.uk)*

At its type section on the foreshore and in low cliffs below Black Ven, Charmouth, the Shales-with-Beef Member consists of c 25 m of thinly interbedded organic-rich mudstones and calcareous mudstones with numerous thin beds of fibrous calcite ('beef') and several beds of tabular and nodular limestone. Many of the individual thin beds are richly fossiliferous and this was used by W. D. Land in combination with the lithological variations to divide the succession into over 100 beds. However, the type section is disturbed by faulting and some of the thicknesses and stratigraphical relationships there are unclear. In addition, many of Lang's marker beds cannot be traced for more than a few hundred metres along the outcrop due to lateral variations in the succession, some of which are related to penecontemporaneous fault movements. A revised and simplified lithostratigraphy is suggested for the member based on undisturbed sections and cored boreholes. This provides a framework that takes account of the lateral variations in the member over its full outcrop distance of c 7 km, from west of Lyme Regis to Charmouth, and enables material collected from every part of the exposure to be placed in its stratigraphical context.