The Jurassic Coast – geoscience and education
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ABSTRACTS

Abstracts

World Heritage – a global context

Tim Badman

The presentation will outline briefly the main goals of the World Heritage Convention, and how these have developed since the Dorset and East Devon Coast was inscribed on the World Heritage List in 2001. The presentation will speak to the early ambitions for the Dorset and East Devon Coast World Heritage Site when it was first listed, what has been achieved since, and how the Jurassic Coast can contribute to advancing World Heritage internationally. Amongst the issues discussed will be the role of World Heritage in geoscience and education, the defining of international approaches to conservation of geodiversity, and the relationship to the new programme of UNESCO on Global Geoparks.

Defining the Permian in Devon

Richard Scrivener and Sarita E. McVicar Wright

The outcrop of the New Red Sandstone in Devon extends along the coast from Torbay to the east of Branscombe. In the 19th Century, the precise stratigraphical position of these rocks was a matter of conjecture: in 1876, W.A.E. Ussher considered them to be entirely Triassic, but by 1912 he had modified this and placed the rocks from Torbay to Exmouth in the Permian, with the Permian/Triassic (PT) boundary at the base of the 'Lower Marls' (now Aylesbeare Group). In the later part of the 20th Century, detailed mapping divided the Permian of Devon into an early succession separated by a considerable hiatus from a mid- to late Permian succession. More recently, geochronological work has demonstrated the breccias in the Torbay area to be of earliest Permian age. Historically, the position of the PT boundary has ranged from above the Dawlish Sandstone (Lower Sandstones of Ussher) to the base of the Budleigh Salterton pebble Beds. Recent heavy mineral and breccia clast studies have shown that the Exe Breccia, above the Dawlish Sandstone, have populations representative of all of the preceding Permian breccia formations and suggests a considerable event with large-scale rejuvenation of the topography. It is suggested that this reactivation may be the T1 event identified in the North Sea, and representing the earliest Triassic sediments.

New fossils from the 'Triassic Coast'

Robert Coram

The Middle Triassic (approximately 245 ma) Otter Sandstone was mostly laid down by braided rivers in a desert environment and is now well exposed along the south-east Devon coast, part of the 'Jurassic Coast' World Heritage Site. Though not as well-known as the prolific Jurassic deposits further to the east, it does yield uncommon fossils, principally of vertebrates, including fish, temnospondyl amphibians and reptiles such as rhynchosaurs, predatory archosaurs, and small superficially lizard-like forms. Collected for about 150 years, these provide important information about a freshwater and terrestrial ecosystem that pre-dated the appearance of dinosaurs and mammals. Most of the fossils have been collected from channel-lag deposits at the base of sandstone beds and are almost invariably

fragmentary, although very rare more intact material has been recovered from other horizons.

The constantly-eroding Otter Sandstone exposures continue to reveal new taxa (for example, freshwater sharks) and microvertebrate material obtained by sieving bone-bearing levels has the potential to further expand the faunal list. Newly discovered associated and articulated vertebrate remains, including small tetrapods, improve knowledge of whole-body anatomy and facilitate systematic work. Trace fossils such as invertebrate burrows and reptile footprints provide information on ecological interactions and detailed bed-by-bed collecting casts light on taphonomic processes and faunal changes over time.

Current research/overview of the Jurassic

Richard Twitchett

The Jurassic Coast records the evolution of shallow-marine shelf ecosystems during a key interval in Earth history, and their responses to biotic and environmental change. Of particular interest is the record of the earliest Jurassic aftermath of the Late Triassic mass extinction event.

Recent advances have come from undertaking quantitative palaeoecological analysis of the well exposed, fossiliferous and historically important Blue Lias Formation between Pinhay Bay and Lyme Regis. Quantitative palaeoecological data were collected from bulk samples and 50 x 50cm quadrats. The use of quadrats has allowed participation of the general public, as citizen scientists, in the ongoing research. Palaeoecological changes were assessed through analyses of diversity, richness, evenness, abundance and functional diversity, as well as in key traits such as body size.

There are general trends in diversity, richness, abundance and evenness through the Hettangian, but there are intervals of relative stasis as well as significant shifts within biozones and even between adjacent beds. Most Hettangian palaeocommunities are dominated by low-level, surficial, suspension feeders, but the appearance of higher- and deeper-tier organisms, and an increase in motility and feeding styles, characterise key stages of post-extinction recovery. Earliest Sinemurian assemblages show a return to low diversity, low evenness assemblages, but with high abundance. Diversity changes recorded in the shelly macroinvertebrate benthos are mirrored by changes in the trace fossil assemblages. Local palaeocommunities were probably responding to local and global environmental and climatic changes, perhaps driven by changes in atmospheric CO_2 through the aftermath of the Late Triassic extinction event.

Ear bones and hooks: a micropalaeontological approach to investigating Jurassic squid-like cephalopods

Malcolm B. Hart

In many micropalaeontological samples of Jurassic age collected in the Wessex Basin ear bones (statoliths) and hooks (onycites) of ‘squid’ are associated with the usual assemblages of foraminifera and ostracods. Statoliths are the small, paired, aragonitic stones found in the fluid-filled cavities (or statocysts) within the cartilaginous heads of all modern and probably all fossil coleoids. Onycites are the small, hardened organic hooks that are found in the arms and tentacles of modern and fossil squid. While these slightly unusual microfossils have been known for ~100 years (or more), they were curiosities rather than significant indicators of cephalopod evolution. Our understanding of both statoliths and onycites changed with the

investigation of the Christian Malford lagertstätte in Wiltshire. At this locality, in both excavations and cored material, very significant numbers of statoliths and onycites were found, closely associated with exceptionally preserved *Belemnotheutis antiquus* Pearce, Mastigophora brevipinnis Owen, *Romaniteuthis* sp. and *Trachyteuthis* sp. Some of these fossils preserve muscle tissue, content of ink sacs, and other soft parts of the squid, including tentacles with hooks *in-situ* and the head area with statoliths present in life position.

Using material from across Wiltshire, Somerset and Dorset, it is hoped to identify which statoliths and onycites are associated with specific host animals and, using these microfossils, determine the complete ranges and possible evolution of the fossil squid. This is not as easy as it sounds as, on the Charmouth coast, in Bed 88f of the Lias Group one finds the statolith 'Jurassic sp. B' in the same sediments as *Phragmoteuthis huxleyi* Donovan and *P. montefiorei* J. Buckman but, until a specimen of the fossil squid containing the statolith is found, then it is just a 'coincidence'.

It is known that both the statoliths and onycites are found all over Europe in the Jurassic (Hettangian–Kimmeridgian) and comparable onycites have been recorded on the Falkland Plateau and in New Zealand. If these microfossils are genuinely inter-continental in their distribution, and can be related to specific taxa, then they should help in the determination of both the palaeogeographical distribution and evolution of the squid-like cephalopods.

Cretaceous gems of the Jurassic Heritage Coastline

Rory Mortimore

Perhaps the most spectacular features of the Jurassic Coast are the exposures of steeply dipping Upper Cretaceous Chalk forming the Ridgeway and Purbeck Hills, the back drop to the embayments cut into coastline from White Nothe to Worbarrow Bay at Durdle Dor, Lulworth Cove and Mupe Bay. No less spectacular are the Chalk cliffs at Beer and Seaton in the west or Ballard Point and Handfast Point in the east. Despite these magnificent Cretaceous exposures their detailed geology is relatively poorly known. Yet hidden within these cliffs is the evidence for sea-level fluctuations represented by overstepping formations, structural controls on sedimentation history and consequent ecological niches controlling the distribution of fossils and the structural evolution of the region. Many of the cliffs are near vertical and dangerous to measure, however, the numerous fallen blocks yield sufficient detail to recognise key lithological marker beds and fossils that link the geology of the cliffs to inland exposures and to the rest of the region. Such detailed information enhances the study of the structural geology for which the coastline is justly famous. New information from recent road construction has enhanced our knowledge of all these aspects of the Cretaceous geology of the Jurassic Coast World Heritage Site.

A perspective on Quaternary of the Jurassic Coast Region

Jim Rose

This short presentation will give a brief perspective on the Quaternary of the Jurassic Coast Region. There is relatively little output about the Quaternary of this area, relative to other parts of the British Isles. For much of the Cainozoic, the region can be placed within the upper reaches of the eastward flowing Solent River, succeeded, in the early Middle Pleistocene, by relatively steep, southward flowing, short rivers. Within this context, very important studies in the western part of the area (the Exe and Axe valleys) give important insight into river development, uplift patterns and human presence. In the east, important

studies on Portland provide evidence of former sea-levels, and again, a steer towards uplift in the region. Between these eastern and western areas, in an area currently dominated by mass movement landforms, there is little of note other than some fine studies of periglacial loading structures revealed in the actively eroding cliffs, and a consistent but undiagnosed succession, revealed in inland temporary exposures and cliff sections, showing a finer, reworked-Greensand clayey sand unit and a very coarse Greensand chert diamicton. Sections at the tops of cliff hint at the presence of complex palaeosols, and the extensive plateaus developed on Cretaceous Chalk or Greensand bedrock, have the potential to provide the most complex weathering histories available for the British Isles, but are yet unresolved. The presentation ends with: i) a consideration of the potential for Quaternary studies in landslip terrain, and ii) an evaluation of the neotectonic context of the region; where a subsiding western English Channel and a rapidly (relatively) rising upland determine the presence of high plateaus, deep valleys and, especially where the geology is appropriate, highly unstable hillside slopes.

Current research/overview of Jurassic Coast coastal geomorphology

Denys Brunsden

This short talk discusses some of the research opportunities that arise on the Dorset Coast associated with the World Heritage designations of 'superlative landforms' and 'dynamic coastal processes'. In recent years the forcing functions of sea level and environmental change have increased landslide and erosional activity. There is a reasonable level of recording (mainly photographic) but, with the exception of the LIDAR and wave monitoring of the Channel Coast Observatory, there are few organized and published research studies. Even the available data are not integrated into large scale understanding. The most comprehensive work has been accomplished by engineering and management projects such as the Lyme Regis Protection works. Very good work has been done at the Portland Port and Portland Gas projects but these data are not properly published and remain in consultancy reports. Several studies have been made on Chesil Beach mainly related to experimental use of Ground Penetrating Radar and monitoring of storm damage but none of these have been gathered together into coherent statements. The conclusion is that there are wonderful research problems to be tackled.

Mapping the Great Undercliffs landslides

Richard Edmonds

The Undercliff National Nature Reserve between Lyme Regis and Axmouth contains three great landslides; the Plateau, which is prehistoric in age and the Bindon and Dowlands complexes which created Goat Island and the Chasm during Christmas 1839. Sixteen acres of land became isolated by the formation of a 65m deep chasm. Buckland and Conybeare thought that the failure surface was the unconformity. Since then variations on a rotational failure have been put forward and challenged.

The nearby Plateau foreshore has been mapped in great detail. It shows that there are multiple failure surfaces within the Jurassic strata, that they are deformed by later failures and that some of the same strata can be seen both '*in situ*' and actively extruding in close proximity, indicating a listric shear surface. The entire Cretaceous, Jurassic, and the highest Triassic strata are rotated in the complex and therefore the failure surface cannot be the unconformity.

The Plateau looks rotational but a translational landslide can also cause rotation of the slipped blocks and create listric movement in the toe. The Bindon landslide is even more problematic with little clear evidence of the failure surface. That said, the complex starts abruptly with insufficient room to accommodate the displaced strata above the unconformity. The displaced strata in the Chasm are also difficult to accommodate as the unconformity lies approximately 20m below the floor of the Chasm. Therefore the failure surface must be deeper but it is not possible to determine it without physical or geophysical investigation and 3D computer modelling. A resistivity survey was undertaken by Plymouth University in February 2016 and the results are eagerly awaited.

Fossil vertebrates along the Jurassic Coast

Michael Benton

The Jurassic coast first came to notice scientifically through the discovery of ichthyosaur, plesiosaur, and pterosaur specimens by Mary Anning more than 200 years ago. Since then, fossil vertebrates have been found at numerous levels through the Triassic, Jurassic, and Cretaceous portions of the coast sections. The continuing discovery of specimens, publication of revisions of older material and announcement of new discoveries, as well as the development of museums old and new, have kept the vertebrate palaeontological aspects of the Jurassic Coast well to the fore. I will describe a little of the history, but concentrate more on research work in the last ten years, in which new methods such as CT scanning and engineering analysis have been used to understand the jaws of the largest sea dragons, and numerical studies have cast unexpected new light on patterns of evolution and the impact of the Triassic-Jurassic mass extinction on reptile evolution.

"Can Dinosaurs play football?" and Other Stories of Public Engagement from the Jurassic Coast

Anjana Ford

It is stated in Article 27 of the World Heritage Convention (1972) that World Heritage Sites have a duty, through educational and information programmes, to strengthen appreciation and respect by their peoples of the cultural and natural heritage of that site. The Jurassic Coast showcases nearly 185 million years of Earth's history across 95 miles of coast and exemplifies some of the most spectacular rocks, fossils and landforms in the world. However imparting these values to non-specialist audiences of all ages, abilities and needs provides unique challenges and opportunities. A critical factor for success in addressing such a wide audience is ensuring that key messages, activities and opportunities remain inclusive, innovative and focused on the needs of the end user. In addition, employing unexpected and creative programming often results in wider audience engagement and greater appreciation of the core values of the site. Crucially, sustainability and infrastructure development sits at the forefront of all Jurassic Coast educational and public engagement programming. For example, by offering training opportunities to enable those members of the community (such as volunteers or teachers) who want promote the Jurassic Coast has broadened our capacity to deliver. This approach will be increasingly important and relevant for all heritage organisations in an environment where funding and support becomes ever more challenging.

"But, rocks don't do anything!"

Ashley Cahill

This is a typical statement made by a number of children in the schools that I work with. I work in the North West of England and the Jurassic Coast is over 250 miles away, yet it is one of the most influential resources we can use to educate the children about rocks and fossils. In February of last year, I was lucky enough to participate in the Big Jurassic Classroom initiative, in which I was given the opportunity to work with a number of earth science specialists and experts in their fields of work. This was inspirational and one of the greatest influences in my teaching. The enthusiasm and expertise passed onto me was incredible and allowed me to inspire a vast amount of children in a number of schools in the North West. This experience awakened a new found love of rocks and fossils that had lain dormant. This transpired to lesson plans, activity days, whole school and community fun

days. All designed to change the children's opinion on what makes rocks special and why it is important to study and learn from them. This is certainly the case as the children that I have worked with have gained a new enthusiasm for rocks and fossils, which has had a positive impact on the children's knowledge and understanding of science and also on the tourism to the Jurassic Coast from the children and families of the North West. The experiences and work completed by the children changes the attitude from "But, rocks don't do anything!" – James aged 9 to "I love rocks now, they are awesome!" – Maisie aged 6.

Heritage Interpretation on the Jurassic Coast

Sam Scriven

The World Heritage status of the Jurassic Coast has important implications for how the earth science of the site is commutated to audiences. UNESCO defines World Heritage Sites as places that have universal value to all people that must be preserved for future generations. Building relationships between people and place is key to conservation and on the Jurassic Coast that is delivered by providing audiences with physical, intellectual and emotional access to the Site. Heritage interpretation offers an effective way to draw these connections and create diverse ways for people to experience the unique Earth Science stories that underpin the World Heritage Status of the Dorset and East Devon Coast. Collaborative working with stakeholders, and particularly with partners in the creative arts sector, has led to innovative methods to communicate key messages and provided distinctive output that supports all aims of Site management. The development of a new interpretation framework for the Jurassic Coast will strengthen the role of heritage interpretation in communicating the Earth science of the Site and provide a platform to raise the profile of geodiversity and its value to Jurassic Coast stakeholders, communities and visitors.

Stone Exposures: A Cultural Geology of the Jurassic Coast

Dr Rose Ferraby, University of Exeter

Stone has stories to tell. As we look along the Jurassic Coast, geologists can extract narratives of environmental change; a dynamic Earth. But there are also the stories of the human relationships that form with stone: their cultural geologies. Using film and photography, this talk will explore some of the narratives and tacit knowledges formed by geologists and quarrymen working with specific stones on the Jurassic Coast.

Posters and displays

The geology of gravestones

Nina Morgan and Philip Powell

For geologists – whether amateur, student or professional – almost any cemetery provides a valuable opportunity to carry out scientific field work at leisure, right on the doorstep, and at no cost. Because gravestones are made from a wide variety of rock types formed in a range of geological settings, cemeteries can be geological treasure-troves. A visit to a cemetery offers a wonderful introduction to geology and the other sciences, such as chemistry, physics and engineering, that underpin it.

Many gravestones are made of polished stone, so reveal details – such as minerals and crystal features – that are not easy to see elsewhere. Some demonstrate the textures and mineral composition of igneous rocks. Others are happy hunting grounds for fossils. Some gravestones reveal sedimentary structures that show how the rock was originally deposited. Others provide clues to Earth movements and environments that occurred hundreds of millions of years ago. For those interested in engineering, examination of gravestones can also provide useful information about topics ranging from weathering of stone to atmospheric chemistry, effects of pollution, stability and settling in soils and land drainage.

Cemeteries also document the evolution of transport systems and advances in stone cutting and polishing technology. While 18th C gravestones in churchyards tend to be made of local stone, the range of rocks used for gravestones expanded rapidly during the 19th C, as first the canal, and later the railway, networks were developed. In the second half of the 19th C the introduction of steam saws and lathes led to the more common use of hard rocks such as granites for gravestones. Now that it is easier and cheaper to transport stone from all parts of the world the use of 'exotic' and decorative stones from places such as South Africa and India for gravestones is very common, particularly in modern municipal cemeteries.

Although this poster is based on examples from geological trails in six cemeteries in Oxford which are documented in a new book, *The Geology of Oxford Gravestones,* the rock types and geological features illustrated can also be recognised in many other parts of Britain. We hope that this poster will encourage you to explore the geology on show in cemeteries in other areas. You'll never look at cemeteries in the same way again.

Enagaging with the public about coastal change along the Jurassic Coast using interactive virtual environments

Palmer S.J., Barrows, T. T., and East, H.K.

Erosion of the UK coastline presents a series of major management issues given high population densities along the coast, the high value of coastal land and its intensity and diversity of use. During the winter of 2013/2014 a succession of major storms over a four week period caused widespread damage to coasts in the south of England. Major transport interruptions, damage to coastal properties, beach erosion and widespread cliff falls represent hazards to local communities and beach/coastal path users. In addition, flooding related to storm surges poses a hazard to coastal (and inland) communities, and the frequency and magnitude of these events is expected to evolve in response to a changing climate and sea level rise.
In this poster, we outline the approaches we plan to take in developing interactive virtual environments designed to inform the public about coastal change and the associated risks. We present results from preliminary work conducted using a widely-used gaming platform

(Unity) to re-create segments of the coastline along the Jurassic Coast. We highlight various challenges presented by each approach and evaluate their strengths and weaknesses.

Chesil Beach at Portland, Dorset: recovering from the winter 2013/14 storms

Alan Frampton

Chesil Beach is a linear, swash-aligned, 18 mile long shingle barrier beach that extends from Portland in the east to West Bay harbour in the west. It is extensively designated for its unique geological and geomorphological features and is an iconic feature of the UNESCO Dorset and East Devon World Heritage Coast (the 'Jurassic Coast').

The focus of this poster is the south-western end of Chesil Beach at Portland. Here, the village of Chiswell and A354 Portland Beach Road located behind the beach have a long history of flooding, erosion and landslides. Attempts to address these issues first occurred between 1958 and 1965 when seawalls were built and slope stabilisation measures installed in the West Weares landslip complex. These first defences were significantly increased in size and added to in the 1980's following two particularly damaging flood events in 1978 and 1979. These are the defences currently found along the frontage and, supported by the shingle beach, provide a unique coastal flood and erosion defence system comprised of concrete seawalls, flood gates, gabion baskets, interceptor drain beneath the beach and flood alleviation channel that diverts flood water percolating through the beach into Portland Harbour to the east.

The Jurassica Project

Alison Smith

Jurassica (www.jurassica.org) is a project to bring to life the lost world of the Jurassic Coast on a spectacular and ambitious scale. It will be an international visitor attraction and a scientific and educational resource of global significance. It will be built in a disused limestone quarry on the Isle of Portland, at the heart of the World Heritage Site, and there will be nothing like it anywhere.

Using the latest scientific research, cutting-edge technology and storytelling on a breath-taking scale, Jurassica will inspire and amaze, making the science and stories of the fossils accessible to all. Jurassica will be a centre for learning, contributing to further scientific advances and bringing to an international audience the latest finds and research.

Jurassica will foster an understanding of the vast changes in the Earth and life through the Mesozoic and in so doing provide a powerful perspective of our place within a changing world. There are incredible places in the world that tell the big stories of who we are or how we came to be, stories of discovery and the understanding that followed. This is our story on this World Heritage Site and our window into the greatest story on Earth.

Jurassica is the next chapter in the story, regenerating a post-industrial landscape created by 200 years of quarrying, and contributing positively to the Isle's aspirations and pride. Jurassica will provide jobs, boost the local economy, stimulate growth in the tourism sector, provide training and skills opportunities, and offer a market for existing skills in the area. It will significantly broaden the tourist season and provide an innovative and exciting new attraction for Dorset, the South West and the UK.