Earth Sciences Research Conference 2016
A showcase for recent postgraduate and staff research

Conference Programme & Abstract Book

Wednesday 16th November
13:00 to 19:00
Lower Lecture Theatre & Exhibition Area
Sherwell Centre, Plymouth University

Twitter: @EarthSciPlymUni, #EarthSciCon16
Greetings and Welcome!

Greetings and a warm welcome to the Earth Sciences Research Conference 2016! This conference showcases the latest research of postgraduates, postdoctorates and academic staff from within the Centre for Research in Earth Sciences (CRES) at Plymouth University. The conference was first held in 2010 and has since been the platform for members of the CRES community to present their varied and expansive research.

We have an exciting programme this year with Professor Christopher Jackson from Imperial College London as our guest keynote speaker. Chris is an expert in the use of 3D seismic reflection data aiming at better understanding the evolution of sedimentary basins. He will give a talk entitled “3D Seismic Reflection Data: Has the Geological Hubble Retained Its Focus?”

Alongside this internationally recognised expert, presentations by Plymouth University researchers will cover a number of topics from palaeotopography and sedimentology to ancient oceans and structural geology. We proudly welcome our new postdoctoral researcher Francesco Giuntoli who will introduce his research on deformation mechanisms in the lower crust of the Swedish Caledonides. Additionally, we are very lucky to have Xiaohong Zhao from Capital Normal University, Beijing giving us a talk about her research on Holocene palaeofloods in the Yongding River, China.

We are very grateful and pleased to announce that this year’s conference has received support from the Curry Fund of the Geologists’ Association. The Curry Fund exists to support a variety of causes such as facilitating geological publications, including film, video and television productions, geological conservation and other initiatives approved by the Council.

Finally, we hope that you enjoy the conference, look forward to informative and interesting presentations and engage with our speakers throughout the day. After the conference please join us for our social gathering with drinks and appetisers where this year’s photo competition winner will be announced.

Grant Cole, Louise Koornneef & Camille Dusséaux
Earth Sciences Research Conference 2016 Organising Committee
Chair: Louise Koornneef
13:10 Opening Remarks by Prof. Gregory Price

Grant Cole

13:45 Alluvial fans as recorders of volcanic island denudation
Dr Martin Stokes

14:00 Atlantid heteropods as sensitive indicators of environmental changes
Dr Deborah Wall-Palmer

14:15 Holocene palaeofloods in the Yongding River, China
Xiaohong Zhao – Capital Normal University, Beijing

14:30 Left high and dry: the importance of stratigraphy in understanding the significance of Pleistocene shoreline deposits
Dr Matthew Watkinson

14:45 – 15:10 BREAK – Tea & Coffee

Chair: Grant Cole
15:15 Clockwise rotation of the entire Oman ophiolite occurred in a suprasubduction zone setting
Prof. Antony Morris

15:30 A new look at the critical material potential of polymetallic nodules using advanced imaging techniques
Wycliff Tupiti

15:45 How high was the Armorican Massif 300 million years ago?
Camille Dusséaux

16:00 Reconstructing the metamorphic history of a polycyclic domain: garnet microtextures as a blackbox of metamorphic processes
Dr Francesco Giuntoli

16:15 Palaeomagnetic Insights into an Ancient Ocean
Louise Koornneef

16:30 – 16:55 BREAK – Tea & Coffee

17.00: KEYNOTE: 3D Seismic Reflection Data: Has the Geological Hubble Retained Its Focus?
Prof. Christopher Jackson – Imperial College London

18.00 Photo competition winner announced – drinks and appetisers
Photography Competition

In the run up to this year's conference we have been running a photography competition for all to enter. The theme was broadened this year to include geographical, geological or geomorphological photographs. We received over 25 entries, all of which were to a very high standard. Of the entries submitted, 10 photographs have been shortlisted, printed and displayed at this year’s conference.

We would like to invite all conference attendees to view the photographs and help to select a winner by voting for their favourite. The winner of the photography competition will be announced at the close of the conference in the Sherwell exhibition space on the ground floor.

Social Media

There are no restrictions on the use of social media covering this event. If you would like to share any photographs or follow the proceedings throughout the day please use the conference ‘hashtag’ #EarthSciCon16.

Proceedings will also be ‘tweeted’ throughout the day through the @EarthSciPlymUni feed.

Geologists’ Association The Curry fund:

The centre for research in Earth Sciences at Plymouth University is grateful for and acknowledges the assistance of The Curry Fund of the Geologist' Association: www.geologistassociation.org.uk
Abstracts
13:30 - Controls on delta mouth bar sandbody architecture in the Early Cretaceous Maestrat Basin, Spain.

Grant Cole¹, Matthew Watkinson¹, Rhodri Jerrett², Mark Anderson¹

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A combination of field data, remote sensing data, structural restoration and validation techniques are being used to evaluate the controls on delta mouth bar sandbody architecture in a superbly exposed succession of deltaic facies and coeval carbonates (Early Cretaceous Xert Formation) in the region of Aliaga, central Spain. A key aim of this study is to develop a methodology for correlation and characterisation of shallow-water delta sandbody architecture.

The field area falls within the Galve sub-basin - a component of the larger Mesozoic Maestrat rift basin system. These basins formed during an extensional phase affecting Iberia from the Oxfordian through to Albian, which created an epicontinental seaway connected to the western Tethys Ocean. Inversion during the Palaeogene left a strong E-W structural fabric, however, the Galve sub-basin has a N-S striking “Aliaga-Miravete” anticline. We hypothesise that this structure is the result of reactive salt tectonics related to extension of the overburden, and not due to Paleogene inversion. This is a new theory for the evolution of the Galve sub-basin, and the potential influence of salt tectonics on the architecture of the deltaic facies is being evaluated.

The shallow-water deltaic succession represents deposition during a high order regression that occurred within a longer term regional transgression. It was strongly river dominated, with progradation into a relatively shallow (20-30m) carbonate shelf setting. This limited mouth-bar complex thicknesses and increased the importance of bed frictional forces. Deltaic sand bodies have been deposited over an area >100km² and determining whether they are a single or multi-delta succession is a key objective of the study. Furthermore, the spatial and temporal relationships between the carbonate dominated abandonment facies that cap or are coeval with the delta parasequences, and the predominantly clean siliciclastic successions form another key objective of this study.
13:45 - Alluvial fans as recorders of volcanic island denudation

Martin Stokes¹, Alberto Gomes², Ana Carracedo Plumed³, Fin Stuart³, Rosa Rocha²

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² Departamento de Geografia, Faculdade de Letras do Porto, Porto, Portugal
³ Scottish Universities Environmental Research Centre, East Kilbride, Scotland, UK

We report remote sensing, field survey and geochronological results of Quaternary alluvial fan development on Santo Antão in the arid Cape Verde archipelago, offshore West Africa. Fans are large coastal coalescent forms restricted to southern edifice flanks. The largest fan (6km long, ~4km wide, area ~10km²) comprises a single surface (Qf0). Cosmogenic ³⁷He dating of surface boulders yields age groupings of ~80-50ka (distal) and 20-10ka (proximal). Qf0 dissection exposes poorly sorted fluvial fan sediments interbedded with (undated) lavas and an Argon dated tephra (~193ka). Boreholes reveal a 180m fan sediment-lava sequence suggesting prolonged fan sedimentation and volcanic activity. A single active channel dissects the Qf0 surface from the coast (~4m deep, ~200m wide in distal fan; ~60m deep, ~10m wide in proximal fan), inland into a backfilled flank margin catchment area (30km²; 1500m relief) with incision increasing to ~110m. Catchment infill comprises inset fill terraces and lava flow channel infilling/damming. The steep volcanic edifice morphology restricts coastal fan development, inhibiting accommodation space and enhancing erosion through base-level fluctuations when fans do form. Flank collapses modify the steep edifice margins, creating space, sediment supply and drainage routing conducive for fan building. Volcanic hydrothermal alteration is important for island morphology where altered rocks can be readily exploited by fluvial erosion, e.g. south island coalescent fan catchments. Sedimentation is long lived (pre-Middle Pleistocene) with the Late Pleistocene Qf0 surface abandonment-incision linked to climate-related sediment-water variability linked to African Humid Periods and base-level change.
14:00 - Atlantid heteropods as sensitive indicators of environmental changes

Deborah Wall-Palmer¹,², Christopher W. Smart¹, Richard Kirby³, Malcolm B. Hart¹, Alice K. Burridge²,⁴ and Katja T.C.A. Peijnenburg²,⁴.

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The atlantids are a family of small (up to 14 mm), aragonite shelled planktonic gastropods (Pterotracheoidea; Atlantidae) with a wide distribution in tropical, subtropical and temperate waters. Despite their susceptibility to post depositional dissolution and mechanical damage, atlantids have a fossil record that extends back to the Oligocene and possibly back to the Cretaceous. Yet they are rarely used as proxies or palaeo-indicators of environmental changes. This is largely because of our relatively poor understanding of atlantid taxonomy and biogeography, which has led to a lack of information about their optimal environmental conditions.

Here we present new research that uses an integrative taxonomic approach, combining shell morphology and DNA barcoding of the COI gene to refine atlantid taxonomy. This research has permitted detailed biogeographic interpretations for some atlantid species, revealing that they inhabit distinct regions with narrow environmental gradients and indicating that they are more specialized than previously thought. This new information suggests that atlantids would be extremely sensitive to environmental changes and demonstrates their potential as indicators of such changes in the past as well as in the future.
14:15 - Holocene palaeofloods in the Yongding River, China

Xiaohong Zhao a, Junping Wang a, Martin Stokes b

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b School of Geography, Earth and Environmental Sciences, Plymouth University, Plymouth, UK

Palaeofloods are past flood events that have left some kind of morphological and/or sedimentary signature in the physical environment, often providing high resolution records of climatic and environmental events. The Yongding River is a major river in eastern China (length = 747 km; catchment area = 47000 km²), forming the largest river that flows through Beijing. Culturally, the Yongding is known as the mother river of Beijing. Historically, floods have occurred frequently on the Yongding River and have caused severe economic impacts and loss of life. This study presents an investigation of palaeoflood deposits at the Tanmugou site in the middle reach of the Yongding River. The Tanmugou site is a fill terrace with palaeoflood deposits overlying and inset into the terraces. The profile comprises three stratigraphic units. Unit A is a Pleistocene terrace and has been partially eroded by subsequent fluvial incision. Unit B is an inset Late Pleistocene (~17ka) terrace. Both units are dominated by cross-stratified gravels. Unit C comprises the overlying palaeoflood deposits, characterised by channelized sand and gravel lenses. Six episodes of palaeoflooding were identified in the Tanmugou profile. The optically stimulated luminescence (OSL) dating method was applied to establish the chronology of the palaeoflood deposits. Both the improved single-aliquot regenerative-dose (SAR) protocol and standard growth curve (SGC) method were employed for equivalent dose (Dₑ) determinations. The OSL dating results show six distinct episodes of palaeoflooding occurring at 8.2±0.7 ka, 8.6±0.7 ka, 3.0±0.2 ka, 1.0±0.1 ka, 0.8±0.1 ka and 0.6±0.1 ka. These ages group at 8.5 ka, 3 ka and 1 ka, coinciding with other studies of palaeoflooding on larger river systems elsewhere in China, linked to global Holocene climatic change events and their associated impacts on the regional SE Asia Monsoon system.
14:30 - Left high and dry: the importance of stratigraphy in understanding the significance of Pleistocene shoreline deposits

Matthew Watkinson

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Sedimentary deposits interpreted as having been deposited in shoreline environments (‘raised beaches’) have long been recognised as significant sources of evidence for the effect global climate changes during the Pleistocene. They are commonly well exposed at the Earth’s surface, are easy to access and their broad environment of deposition can be interpreted relatively unequivocally. As a result of these factors, they are the ongoing focus of research, much of which has recently been directed on the application of expensive dating techniques such as OSL, TL, IRSL and ESR. The results of these studies have, however, often provided equivocal results fuelling the argument for more dating and analyses to resolve the uncertainty.

Late Pleistocene nearshore sandstones from Saunton Sands in north Devon have been well known for decades but their sequence stratigraphic, sedimentological and diagenetic context has been poorly described and interpreted. These marine sandstones are here interpreted to represent the deposits of two separate transgressive-regressive cycles which may correlate to interglacial MIS’s 7 and 5e. The lower unit contains a lower transgressive succession which deepened from foreshore, across a ravinement surface to shoreface (sub-fairweather wave-base) environments. Shallowing through lower and upper foreshore/backshore settings can be demonstrated and be used to constrain the palaeo-tidal range as around 1m (possibly significantly less than today). This regressive sequence is capped by a well-defined palaeosol, with rhizocreations and cements containing field, petrographic and isotopic evidence for meteoric vadose cementation. The succession is consistent with deposition during initially rapid and then decelerating rate of rise of relative sea-level, followed by forced regression evidence by the vadose diagenesis. The subsequent transgression stacked upper foreshore or backshore facies above the palaeosol, indicating renewed generation of accommodation as relative sea-levels rose. The succession is relatively thick indicating relatively high rates of sediment supply during periods of accommodation creation.

This study is just one example where the importance of a rigorous stratigraphic and sedimentological framework is critical to understanding the results of dating.
Clockwise rotation of the entire Oman ophiolite occurred in a suprasubduction zone setting

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The Oman ophiolite provides a natural laboratory for understanding oceanic lithospheric processes. Previous paleomagnetic and structural investigations have been used to support a model involving rotation of the ophiolite during formation at a mid-oceanic microplate. However, recent geochemical evidence indicates the ophiolite instead formed in a nascent forearc environment, opening the potential for alternative rotation mechanisms. Central to the conundrum is the contrast between ESE-SE and NNW magnetizations from the northern and southern ophiolitic massifs respectively, attributed previously to either differential tectonic rotations during spreading or complete emplacement-related remagnetization of the southern massifs. Here we report new paleomagnetic data from lower crustal rocks of the southern massifs that resolve this problem. Sampling of a continuous section in Wadi Abyad reveals ENE magnetizations in the dike rooting zone at the top of the lower crust that change systematically downwards to NNW directions in underlying foliated and layered gabbros. This is only consistent with remagnetization from the base upwards, replacing early remanences in layered and foliated gabbros completely but preserving original ENE magnetizations at higher levels. Comparison with new data from Wadi Khafifah provides a positive fold test that shows this event occurred before late Campanian structural disruption of the regional orientation of the petrologic Moho. These data show that the entire ophiolite experienced large intraoceanic clockwise rotation prior to partial remagnetization, leading to a new tectonic model where formation, rotation and emplacement of the ophiolite are all linked to Late Cretaceous motion of Arabia and roll-back of the Oman subduction zone.
15:30 - A new look at the critical material potential of polymetallic nodules using advanced imaging techniques

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Polymetallic nodules (in the past often referred to as manganese nodules) are rock concretions found on the ocean floor mainly composed of ferromanganese oxides and various metals, including critical metals. These deposits are commonly seen as possible future resources for the supply of traditionally important economic elements such as Cu, Pb, Co, and Zn. However, recently more studies have been focusing on their critical metal potential such as the Rare Earth Elements (REEs) and the Platinum Group Elements (PGEs). The REEs content of polymetallic nodules has been considered economically significant (e.g., Spickermann, 2012; Hein et al., 2013). This has driven countries, mining companies and academic institutions to embark on studying the various aspects of these nodules. This project is still in its initial stages and is looking into the critical material potential of polymetallic nodules. The nodules involved in this study are from the Clarion-Clipperton Fracture Zone area in the Eastern Pacific. This is an area of high nodule abundance that is earmarked by the International Seabed Authority for future exploitation and has already attracted a lot of attention and involvement from many countries in terms of prospecting for valuable metals. Scanning Electron Microscopy (SEM) and other analytical methods such as X-ray Fluorescence (XRF) are currently being used for the analyses of the nodules. Our few initial results using SEM and XRF have shown similar and also varying chemical composition of polymetallic nodules to literature data. However, research work on this project is continuing and hopefully more findings on polymetallic nodules will be added to the existing scientific knowledge on these nodules.
15:45 - How high was the Armorican Massif 300 million years ago?

Camille Dusséaux¹, A. Gébelin¹, P. Boulvais², V. Gardien³, A. Mulch⁴, S. Grimes¹, M. Dubois⁵

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The Armorican Massif belongs to the internal zone of the Variscan belt in Western Europe and results from the continental collision between Gondwana to the south and the Armorica microplate to the north. Based on similarities in tectonic style with the Tibet-Himalaya orogen[1], the Variscan belt, now eroded, could have represented a topographic high during the Carboniferous. As attested by sedimentology and geomorphology studies[2], elevation may have reached more than 4500m. Furthermore, previously reported oxygen isotope (δ¹⁸O) results from the South Armorican shear zone indicate low δ¹⁸O values suggesting interaction with surface-derived fluids sourced at high elevation[3].

Infiltration of meteoric fluids has been documented in the footwall of detachment zones of metamorphic core complexes in the North American Cordillera [4, 5] as well as in the South Tibetan Detachment[6]. Such fluids have been used as paleoelevation proxies to reconstruct the topography in eroded orogens[6, 7, 8] based on a technique that recovers the isotopic composition of ancient meteoric water that scales with elevation[9]. By comparison, we study the stable isotope (hydrogen and oxygen) compositions of fluids in crustal-scale shear zones of the Armorican Massif to reconstruct the paleoelevation history of this segment of the Variscan belt. Therefore, our work involves the measurement of hydrogen and oxygen isotopes ratios in fluid inclusions from syntectonic quartz veins and hydrous silicates that interacted at depth with fluids during the activity of shear zones.

The paleoelevation estimates will be of great interest for the Earth sciences community, but also for biologists and palaeontologists since vertical variations of the Earth’s surface have a direct impact on biotic changes and species diversification. Furthermore this project will allow a better understanding of the transport of fluids in the crust and their roles in mechanisms of deformation (recrystallization and recovery).

16:00 - Reconstructing the metamorphic history of a polycyclic domain: garnet microtextures as a blackbox of metamorphic processes

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The extent to which granulites are transformed to eclogites is thought to impose critical limits on the subduction of continental crust. Although it is seldom possible to document such densification processes in detail, the transformation is believed to depend on fluid availability and deformation. To understand how such metamorphic processes act during subduction it is fundamental to be able to decipher the record preserved in polydeformed and polyorogenic complexes. This is a difficult task because the relics from the former metamorphic stages are partially or completely overprinted during the younger orogenic stages. Garnet is especially suited for such purpose because it is a robust and common metamorphic mineral that is stable over a wide range of P-T conditions.

Complex garnet porphyroblasts are widespread in eclogite facies micaschists of the Sesia Zone. The Sesia Zone in the Western Alps is a continental terrane derived from the NW-Adriatic margin that was subducted and polydeformed at high pressure conditions during Alpine orogeny. Garnets occur in these micaschist with assemblages involving phengite + quartz + epidote + rutile ± paragonite, Na-amphibole, Na-pyroxene, chloritoid. Detailed study of their texture and composition reveals a rich inventory of growth and partial resorption zones. A more critical observation is that relic garnet cores indicate growth at ~800°C and ~0.75 GPa and are derived from granulite facies metapelites of Permian age (pre-Alpine). The Alpine rims are found stable in eclogite facies conditions around 550-650°C and 1.6-2 GPa. These dry protoliths thus must have been extensively hydrated during Cretaceous subduction, and garnet records the conditions of these processes. In summary, the textures and mineral compositions clearly reflect reactive interaction of major amounts of hydrous fluids with high temperature dry protoliths at eclogite facies conditions.
16:15 - Palaeomagnetic Insights into an Ancient Ocean

Louise M.T. Koornneef¹, Antony Morris¹, Michelle Harris¹, Luca Menegon¹, and Christopher J. MacLeod²

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During the Late Cretaceous, part of an ancient ocean called Neo-Tethys was emplaced on top of the continental crust of the Arabian Peninsula, forming the world’s largest and most renowned ophiolite. Previous studies have proposed various tectonic models for the ophiolitic belt of Oman based on paleomagnetic results, suggesting that the ophiolite underwent large tectonic rotations during its history. This includes models involving substantial opposing rotations of the southern and northern ophiolite massifs in order to explain their respective NNW and SE-directed magnetisations. However, recent studies show that the southern massifs of the ophiolite experienced extensive remagnetisation event during emplacement that has likely completely replaced original magnetisation components, making these models invalid.

The key to understanding this remagnetisation event and the earlier history of rotation lies in zones in between the northern and southern massifs. In a critical section exposed in Wadi Abyad, the dyke-rooting zone at the top of the lower crust shows a NE oriented magnetisation, and the whole section demonstrates that the magnetisation shifts from a remagnetised NNW direction in the base of the ophiolite to a ENE direction at the top. In this way, it is possible to determine the upper limit of the remagnetisation and thus distinguish early magnetisations from overprinting magnetisations that have been acquired at different times. This project aims to combine further magnetic analyses with geochemical investigations to determine the nature of the fluids believed to be responsible for remagnetising the crust from the bottom upwards. It will also involve analysis of remagnetised sections to be sampled during the forthcoming ICDP Oman Drilling Project, as part of a collaborative international programme aimed at understanding the effects of fluids during the evolution of the ophiolite.
In their seminal paper in 2002, Joe Cartwright and Mads Huuse referred to 3D seismic reflection data as the 'Geological Hubble', illustrating how these data had the potential to revolutionise our understanding of the genesis and evolution of sedimentary basins. 14 years on, I will here outline just some of the key recent advances made in our understanding of basin structure and stratigraphy, focusing on: (i) the intrusion and extrusion of igneous rocks; (ii) salt tectonics, with particular emphasis on intrasalt structure and the kinematics and mechanics of diapirism; (iii) the geometry and growth of normal faults; and (iv) the structure and emplacement of mass-transport complexes (MTCs). I will stress that future advances at least partly rely on hydrocarbon exploration companies and government agencies continuing to make their data freely available via easy-to-access data portals. I will issue a clarion call to academics, stressing that ‘geodynamicists’, sedimentologists, structural geologists and geomorphologists, amongst many others, can benefit from utilising what I believe are currently a grossly underused data type.
Thank you for attending the Earth Sciences Research Conference 2016!

A meeting such as this requires the assistance of a number of people in order to make it a success. We are grateful to the centre for research in earth sciences for agreeing to host this event and to the School of Geography, Earth and Environmental Sciences. We extend our thanks to the academic staff within Earth Sciences and to Sarah Bishop for her support in organising this conference. We thank Alice Li and Russel Taylor for their support in publicising this event. Furthermore, we extend our thanks to all the postgraduate research students who have helped throughout the organisational process and on the day to make the conference a success.

A final thank you to The Geologist’s Association for providing support through their Curry Fund. The money received has been used to pay for all media promotion (printing of photographs, posters, abstract booklet) and catering for conference attendees.

We hope to see you again next year!