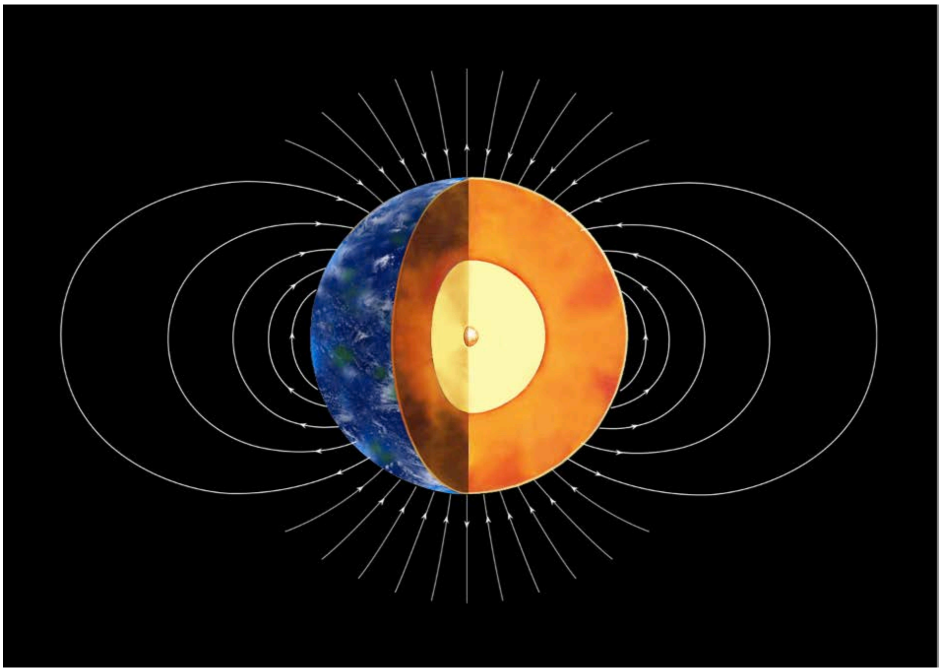
School of Environmental Sciences

HERDMAN SYMPOSIUM

Saturday 27th February

GEOSCIENCE FRONTIERS 2016



'That flipping field'. (Image Credit: Andy Biggin & Kay Lancaster)

GEOSCIENCE FRONTIERS 2016
HERDMAN SYMPOSIUM PROGRAMME
Saturday 27th February

09.30 *Arrival (Tea, Coffee & Soft Drinks Available)*

10.00 **Welcome:** Chris Gregson (Herdman Society President), Emma Branagan & Jake Dolan (Herdman Symposium Secretaries) and Jim Marshall

10.05 **Stephen Brusatte** (Edinburgh) "*Why did the dinosaurs go extinct? New insights into an age-old mystery.”*

10.50 *Coffee Break*

11.20 **Frances Wall** (Exeter) *"Rare Earth Ore Deposits – Carbonatites, Clays and Critical Minerals."*

12.05 **Chris Jackson** (Imperial) *"Terra Infirma; What is salt and why should we care?"*

13.00 *Buffet Lunch*

14.00 **Andy Biggin** (Liverpool) *"That flipping field; a magnetic history of Earth’s deep interior.”*

14.45 *Coffee Break*

15.15 **Sue Mahony** (Bristol) *"Core Blimey! What drilling holes in ocean floors can tell us about volcanoes."*

16.00 **Bob Ward** (LSE) *"Are geoscientists part of the problem or part of the solution when it comes to tackling climate change?"*

16.45 *Wine Reception (Wine and Soft Drinks Available)*

Dr Stephen Brusatte (Edinburgh) "*Why did the dinosaurs go extinct? New insights into an age-old mystery.*"

<u>Talk Abstract</u>

Perhaps no question in the history of paleontology has generated as much speculation and research as why the non-avian dinosaurs disappeared from the fossil record approximately 66 million years ago. This talk reviews a wealth of recent research that is leading to an emerging consensus on why dinosaurs went extinct.

All dinosaurs except for birds perished at the Cretaceous-Paleogene (K-Pg) boundary which new high precision radio isotopic dates place at 66.043 ±0.043 million years ago. Indisputable evidence shows that a large bolide (asteroid or comet) struck the Earth at this time. However, this bolide did not hit a static planet, but rather a world that was undergoing intensive volcanic eruptions, temperature oscillations and sea level fluctuations. Because of the complexity of Earth system changes during the latest Cretaceous, debate remains about which of these events were most responsible for the dinosaur extinction, and whether this extinction was geologically abrupt or more gradual.

Testing specific extinction scenarios is difficult due to several factors, especially the coarseness of the dinosaur fossil record, however an ever expanding fossil record and analytical toolkit are granting scientists greater insight into this age-old mystery.

<u>About the speaker</u>

Dr. Stephen Brusatte is an American paleontologist who is currently a Chancellor’s Fellow in Vertebrate Paleontology at the University of Edinburgh. Steve has a collection of degrees from both the UK (Bristol) and the USA (Chicago, Columbia). He joined Edinburgh’s geoscience department in 2013. Steve works broadly in vertebrate paleontology and evolutionary biology, specializing on the anatomy, genealogy and evolution of dinosaurs and other vertebrate groups. During his illustrious career, he has written over 100-peer reviewed papers, 5 books and has named more than 15 new species of fossil vertebrates. He is a keen popularizer of science and frequently makes appearances on television, in print and at academic lectures (such as this one!).

Prof. Frances Wall (Exeter) *"Rare Earth Ore Deposits – Carbonatites, Clays and Critical Minerals"*

Talk Abstract

Rare earth elements (REE) are essential to modern living. They are components of many digital and green technologies and, although most people know little about these metals, they are all around us in all low energy lighting, computers and cars; in large wind turbines, in small speakers for smartphones and in various medical and military applications.

Actually, REE are not particularly rare but rare earth mining, processing and manufacturing is dominated by just one country, China. It seems unwise for our modern lives to be dependent on just a few mines, almost all in one country. Such raw materials are now called 'critical' and there are major research programmes underway to find new and more diverse raw material supplies to mine, to create more flexible new technologies that don't need so much of the critical metals, and to recycle more of what we have already mined.

Most of the World's REE come from ore deposits related to carbonatites, which are perhaps the most unusual igneous rocks on Earth. Instead of being made of silicate minerals, they are composed mainly of carbonates and contain a range of unusual minor elements. Only one volcano has ever been seen to erupt carbonatite lava but there are over 500 examples of carbonatites in ancient volcanic deposits and the roots of eroded volcanoes. Some contain economic deposits of REE. Igneous fractionation processes are needed to first increase the level of REE and this usually produces deposits very enriched in the lightest, i.e low atomic number REE: La and Ce, plus some Nd. Mountain Pass, USA is an example. Most carbonatites also are subject to much sub-solidus fluid alteration. The World's largest REE deposit at Bayan Obo is most likely to be a highly-altered carbonatite.

Some of the richest REE deposits have an additional enrichment step in which lateritic weathering, helps further concentration, as happened at Mount Weld, Western Australia. Lofdal is an exception to many of the rules about carbonatites, rich in the heavy REE, and being explored for the mineral xenotime-(Y).

Alkaline igneous rocks are subject to exploration activity at the moment because they tend to have higher proportions of the most sought after

heavy rare earths than carbonatites. The REE minerals that they contain, such as eudialyte or loparite-(Ce), are concentrated first by magmatic processes and often altered by later hydrothermal action. The mineralogy can be complex, in fact it is alkaline igneous rocks that have the greatest mineral diversity of any rock type.

Mineral sands were the first REE ores but are now only mined for REE in India, even though mineral sands around the World produce rutile, ilmenite and zircon and REE minerals are certainly potential by products. The problem is that the monazite they contain is rich in Th and the resultant radioactivity is a major problem.

Ion adsorption deposits in southern China provide practically all of the Worlds 'heavy' REE at the moment (i.e. the higher atomic number REE elements such as Dy, Tb and Y). Although ion adsorption deposits are weathered rocks, the concept is quite different to laterites. In these deposits the REE are released from soluble minerals and then adsorbed onto the surface of kaolinite or halloysite clay minerals formed in the weathering profile. The weak bonding means that the REE can simply be leached off the clay with a simple exchange agent such as ammonium sulphate.

<u>About the speaker</u>

Frances Wall is Professor of Applied Mineralogy at the highly-regarded Camborne School of Mines at the University of Exeter. After graduating with a degree in geochemistry from Queen Mary College London, Frances worked in the Natural History Museum's mineralogy department, specialising in carbonatites and alkaline rocks, including economic deposits of rare earths and niobium. She gained her PhD in Mineral chemistry and petrogenesis of rare earth rich carbonatites from the University of London in 2000. Since then she has held many leadership positions at various institutions, namely research and petrology programme leader of the Department of Mineralogy at the Natural History Museum, head of the Camborne School of Mines from 2008 to 2014 and has just recently finished her 2-year term as the President of the Mineralogical Society of Great Britain and Ireland.

Prof Christopher Jackson (Imperial) *"Terra Infirma; What is salt and why should we care?"*

<u>Talk Abstract</u>

Salt is not simply for fish 'n' chips or icy roads. It is a unique and perhaps underappreciated rock type, living in the shadows of its more glamorous carbonate and clastic neighbours. For example, not only is salt one of the economically most important rock types on Earth, forming the seals to super-giant hydrocarbon accumulations, but it is also responsible for forming some of the most complex geological structures observed on the Earth. In this talk I will celebrate salt, highlighting its unique physical properties, its role in the generation of complex geological structures, and its importance in terms of hydrocarbon exploration.

<u>About the speaker</u>

Chris Jackson is a professor of basin analysis at Imperial College London's department of Earth Science & Engineering. Following the completion of both his undergraduate and PhD at the University of Manchester he worked in industry at the Norsk-Hydro (now Statoil) Research Centre in Bergen for 2 years. After working on a wide range of subsurface and field-based structural and stratigraphic projects, Chris left to take up a full-time academic position at Imperial. As the head of the Basins Research Group at the university, Chris and his colleagues have performed excellent research in the analysis of rift basins, salt tectonics and on the seismic expression and economic impact of igneous activity in proliferous sedimentary basins. In his spare time, Chris runs half-marathons the day after giving lectures at the University of Liverpool and replies to the society's Twitter page, much to the excitement of the committee members.

Dr Andy Biggin (Liverpool) "*That flipping field: a magnetic history of Earth's deep interior*"

<u>Talk Abstract</u>

The Earth's magnetic field serves humanity by being both a shield for solar wind radiation, and a window to the Earth's core. It is generated by the flow of liquid iron in the outer core, 2900 km beneath our feet, and is recorded by rocks as they form at the surface. The study of the magnetic records preserved in rocks is called palaeomagnetism and is one of the best ways that we can tell what was going on deep in the Earth back through its long history.

Palaeomagnetism tells us that the planet has been generating its own magnetic field for more than 3 billion years but that the field has undergone many changes since that time. Some of these changes – the "normal" variation that requires you to change your compass every few years as well as occasional full-blown polarity reversals (flips) – are random outgrowths of the chaotic motions within the core. However, variations in the average behaviour over tens of millions of years and longer are probably caused by external "forcing" of the outer core by changes in the overlying mantle and the underlying inner core.

In particular, we think we might have identified the point in Earth's history, around 1.5 billion years ago, when the Earth's inner core first started to form by freezing at the centre of the Earth, making the magnetic field much stronger on average. If correct, this has major implications for our understanding of the planet's evolution through time.

<u>About the speaker</u>

Andy Biggin is a palaeomagnetist and lecturer in geophysics here at the University of Liverpool. Andy completed his undergraduate degree at the University of Liverpool in 1997 and his PhD at Kingston University in 2001. After working as a researcher around the world in exotic locations such as Mexico, France and the Netherlands, he returned in 2009 to an academic position at the university. During his time here, Andy has pioneered research in the field of palaeomagnetism and archaeomagnetism and published near to 50 academic papers including last year's exciting paper on inner core nucleation that was published by Nature.

Dr Sue Mahony (Bristol) *"Core Blimey! What drilling holes in ocean floors can tell us about volcanoes"*

<u>Talk Abstract</u>

Scientific ocean drilling has been going on in an organised international effort since 1966, with the Deep Sea Drilling Program. Since then approximately 300km of core material has been retrieved from the ocean floors, from all around the world's oceans.

The oceans are a great recorder of geological events that have occurred on earth, either locally or globally. Sediments get washed from the land into rivers, then the ocean; or fall onto the ocean surface from the atmosphere or winds. These sediments then fall slowly through the water column of the oceans, before being deposited on the ocean floor. Here they gradually build up, layer upon layer, getting buried deeper and deeper before they eventually turn into rock. These layers are of great interest as they tell us the history of our planet, and are often a more complete record than we find on land.

Volcanic eruptions form plumes of ash that can reach many tens of km into the atmosphere. Eruptions will deposit ash from very close to the volcano (the denser particles as well as ash), to several hundred or even thousands of km away (just ash). Ash deposits on the ocean floor and forms distinct layers that we can identify in ocean drilling cores. A small sample of an ash layer can be taken, examined under a microscope where we see many tiny glass shards, which can help us unravel what size eruption occurred. The chemistry of the ash layer can be measured in a laboratory, which allows us to identify which region or volcano the ash erupted from. By identifying the tiny fossils in the surrounding sediments and by measuring the magnetic signature of the sediments, we can determine the age of the ash layer, and so when the eruption occurred. By looking at many ash layers we can build up a picture of the volcanic history of a region, often back many millions to tens of millions of years. Furthering our understanding of the sediment record of large magnitude volcanic eruptions all around the world will let us link any changes in volcanic activity with changes in other large scale physical processes, such as tectonic or climatic changes.

<u>About the speaker</u>

Dr Sue Mahony's current area of research is the development and analysis of a database of volcanic ash layers from ocean drilled cores used as a record of global explosive volcanism. Her previous research interests focused on developing probabilistic forecasting models for the formation of new volcanoes in Japan, work for which she was awarded her MSci from Bristol in 2004. Sue was awarded her PhD from Bristol in 2009 and is currently a Post- Doctoral Researcher there. .

Bob Ward FGS (LSE) "*Are geoscientists part of the problem or part of the solution when it comes to tackling climate change?*"

Talk Abstract

Managing the risks of climate change is perhaps the biggest challenge facing our current generation. More than 190 governments reached a historic agreement in Paris in December which commits their countries to taking the necessary action to avoid dangerous climate change. The success of the Paris Agreement will depend partly on the role that geoscientists choose to play.

Many geoscientists are employed in the fossil fuel industries which bear much of the responsibility for generating carbon dioxide, the most important greenhouse gas. Some individuals and companies within these industries have tried to obstruct progress on emissions reductions, even promoting denial of the problem.

To properly grapple with this issue, geoscientists should think not just about the implications for their own employment prospects, but should also consider the ethical aspects of making decisions about profound risks that could affect the well-being and prosperity of our children, grandchildren and future generations.

Geoscientists could, for instance, play a vital role in pushing the fossil fuel industries to confront the issue of climate change more urgently, and to find constructive solutions through the development of carbon capture and storage technology, or other low-carbon energy sources, such as nuclear power.

And beyond those employed in the fossil fuel industries, geoscientists have other important contributions to make to the management of the risks of climate change. They can help public debate and decision-making by putting into context the significance of the impacts that are already becoming evident and that might occur in the future as a result of rising greenhouse gas concentrations in the atmosphere.

Even if the world is successful in reducing greenhouse gas emissions to avoid the worst consequences, the climate will continue to change for the next few decades. Many geoscientists have substantial experience of

managing risks of natural disasters, and they can help countries to become more resilient to climate change impacts, such as rising sea levels and shifts in extreme weather.

So they key question that every geoscientist should be asking himself or herself today is: Am I part of the problem or part of the solution when it comes to tackling climate change?

About the speaker

Bob Ward has served as policy and communication director of the Grantham Research Institute on Climate Change and the Environment at the London School of Economics since 2008. Before this Bob worked at the Royal Society, the UK national academy for science for 6 years where his responsibilities included outreach and leading the media relations team. Bob regularly writes articles in newspapers such as the Guardian and the Independent and is interviewed frequently when key climate policy decisions are made both nationally and internationally. Bob obtained a first-class degree in geology from the University of Liverpool and has an unfinished PhD thesis on palaeopiezometry.

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