# HERDMAN SYMPOSIUM 2021

## DYNAMIC

## EARTH

UNIVERSITY OF LIVERPOOL

# HERDMAN SYMPOSIUM 2021 PROGRAMME

## Day 1 - Saturday 20th February 2-6pm GMT

**13:50** Zoom opens for *public* (admissions from **13:55**).

**14:00** Welcome to *Day 1* by Jade Hrintchuk & Megan Davies (Herdman Symposium Secretaries), Janine Kavanagh (Staff Representative).

**14:10** **Dr Jacopo Taddeucci (Rome, INGV):** 'The hard life of pyroclasts in between a break and a rest: it's a blast!'

**15:10** *Coffee Break*

**15:20** **Dr David McNamara (Liverpool):** 'The role for geothermal geologists in changing our energy sector.'

**16:20** *Break*

**16:50** **Professor Sonia Tikoo-Schantz (Stanford University):** 'Magnetic fields in the inner solar system.'

**17:50** Final Remarks.

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## Day 2 - Sunday 21st February 2-6pm GMT

**13:50** Zoom opens for *public* (admissions from **13:55**).

**14:00** Welcome to *Day 2* by Jade Hrintchuk & Megan Davies (Herdman Symposium Secretaries), Janine Kavanagh (Staff Representative).

**14:10** **Professor Christopher Jackson (Manchester):** '3D seismic reflection data; has the geological Hubble retained it's focus?'

**15:10** *Coffee Break*

**15:20** **Professor Christine Janis (Bristol):** 'The evolution of grassland environments: what we know from the mammals that inhabited them.'

**16:20** *Break*

**16:50** **Dr Gillian Apps (University of Texas at Austin):** 'How convection churning deep in the Earth's mantle impacts surface processes.'

**17:50** Final Remarks.

# Dr Jacopo Taddeucci (Rome, INGV)

*‘The hard life of pyroclasts in between a break and a rest: it’s a blast!’*

## TALK ABSTRACT:

Pyroclasts are volcanic particles - from microscopic ash grains to van-sized bombs - that result from explosive volcanic eruptions. They are formed by the fragmentation of magma and rocks during eruptions and, after subaerial to subaqueous transport and deposition, become part of the sedimentary record of the planet. In between fragmentation and deposition, the active life of pyroclasts is tumultuous, highly uncertain, and pregnant of implications and consequences at all scales. Spanning seven orders of magnitude or more, size sets the prime control on the physical processes that control the ejection, transport, and deposition of pyroclasts. An ash grain is carried in atmospheric suspension from Iceland to UK, threatening turbine engines and helping a cloud to form before settling in a parking lot. It is then lifted again by wind and ends up fertilizing the Baltic Sea. A volcanic bomb flies a quasi-parabolic ballistic trajectory from the volcanic vent to the ground, where it forms an impact crater that helps determining the past atmospheric density of its source planet, Mars. In this seminar you will see pyroclasts generating acoustic waves, rolling inside a wind tunnel, accelerated in a shock-tube, magnified inside a microscope, flying out of volcanoes at supersonic velocity, and more.

## ABOUT THE SPEAKER:

*Previous study:*

- Laurea, Geology, University of Rome “La Sapienza”, Italy
- Doctorate, Earth Sciences, University of Rome “La Sapienza”, Italy
- Post-Doc, Volcanology, Ludwig Maximilan University of Munich, Germany

*Previous institutes:*

- University of Camerino, Guest Professor, 1999-2001
- University of Hawai’i at Manoa, Faculty Affiliate, 2019

*Current institute:*

- Senior Researcher, Istituto Nazionale di Geofisica e Vulcanologia

*Current work:*

- Geophysical observation of explosive volcanic activity, experimental volcanology, textural analysis of pyroclasts

# Dr David McNamara (Liverpool)

*'The role for geothermal geologists in changing our energy sector.'*

## TALK ABSTRACT:

Many conventional and enhanced, geothermal resources are hosted in reservoir rocks with low intrinsic permeability. As such, successful development of these resources relies on understanding the role subsurface structures, such as fractures and faults, play in reservoir fluid flow. There are two crucial research aspects to developing our understanding of structural permeability in geothermal resources: 1) a comprehensive understanding of geothermal geomechanics, and 2) permeability alteration via geothermal fluid-rock interaction. While many techniques for investigating these research fields exist, they require modification in both underpinning science and method for use in geothermal settings, and often novel, innovative, scientific approaches are required.

Characterisation of subsurface tectonics is critical to understanding the role of structures in geothermal fluid flow. Borehole imaging, regarded as a key dataset in the development reservoir geomechanical models, has only reached the required level of technological development required for acquisition in geothermal conditions within the last decade. Since then the development of innovative geothermal image log data processing and interpretation has allowed structural geologists to characterise in detail the structure and stress of many geothermal fields. The geothermal centres in the Taupo Volcanic Zone are one such resource that has become much better characterised in terms of its geomechanics, facilitating better geological, geomechanical, and fluid flow modelling.

The same fractures and faults that allow fluid flow in geothermal fields, can also behave as fluid barriers when fluids interact with reservoir rock resulting in mineral precipitation within these structures. While common in many aspect of geoscience research, the application of microstructural investigation techniques to analyse crystallographic and chemical properties of reservoir scaling minerals in geothermal systems is rare. The use of microanalytical techniques in geothermal systems is providing new information on evolving geothermal reservoir conditions, mineral nucleation and growth controls in fracture sealing, and on reservoir scaling processes and rates.

Advances in the application of structural geology at multiple scales in the geothermal sector are proving useful for improving geological and operational aspect of this energy industry. As geothermal continues to grow as an international industry, and given its importance as part of the solution to decarbonising our society, it is vital we continue to transition skillsets and methodologies to this sector, as well as innovate and develop geoscience specifically for geothermal advancement.

## ABOUT THE SPEAKER:

David completed his undergraduate in geology in Trinity College Dublin in 2005, and from there went on to complete his PhD at the University of Liverpool in 2009 working on deformation processes of eclogite metamorphic rocks. After finishing his PhD, David took a position as a research scientist and consultant in the Natural Resources Division of the Institute of Geological and Nuclear Sciences, New Zealand.

In New Zealand, David developed an expertise in borehole logging and geomechanics, which he used to assist government agencies and energy companies in the development of both geothermal, CCS, and petroleum reservoirs. David's research has produced a number of adaptations of petroleum-based practises for deployment in geothermal settings, with a specific focus on borehole imaging and wireline logging. David has been involved in reservoir research in New Zealand, U.S.A., Nicaragua, Ireland, Spain, and Indonesia. Further to resource development, David has also carried out borehole logging and geomechanical research for the hazards sector, working on projects such as New Zealand's Deep Fault Drilling Program, and International Ocean Discovery Program Expedition 372 to explore the geomechanics of earthquakes in New Zealand. David has also developed a research theme on fracture sealing to understand the role mineral nucleation and growth play in reservoir performance in geothermal systems, utilising advanced microscopy techniques to examine crystal structure and chemistry.

## Professor Sonia Tikoo-Schantz
## (Stanford University)

*'Magnetic fields in the inner solar system.'*


**TALK ABSTRACT:**

Dynamo magnetic fields are generated by the organized motion of metallic fluid within the cores of rocky planetary bodies. This advection may be driven by thermal core convection, thermochemical convection sustained by inner core crystallization, or mechanical perturbation of core fluid. Obtaining magnetic records of ancient dynamos, either from laboratory analyses of rock samples or from spacecraft measurements of remanent magnetic fields in planetary crusts, provides insight into the internal energy budgets and thermal evolution of planetary bodies. Dynamo records have been identified within rocks from the Earth, Moon, Mercury, Mars, and a number of asteroids. Here we provide an broad overview of planetary magnetism, as well as detail how magnetic studies of Apollo samples have permitted the development of a lunar paleointensity record that spans at least two billion years (Fig. 1).
We also discuss how similar work on meteorites has allowed paleomagnetists to investigate planetesimal melting, dynamo generation, related early solar system processes.


**ABOUT THE SPEAKER:**

- Sonia Tikoo is an Assistant Professor of Geophysics and, by courtesy, Geological Sciences at Stanford University.
- Her research interests are in the application of paleomagnetism to problems in the planetary sciences such include the evolution of dynamo magnetic fields within rocky planets, moons, and small bodies, as well as impact cratering processes.
- Tikoo earned a B.S. degree in Geology and History (Minor) from Caltech in 2008 and. Ph.D. in Planetary Sciences from MIT in 2014.

# Professor Christopher Jackson (Manchester)

*‘3D seismic reflection data; has the geological Hubble retained its focus?’*

## TALK ABSTRACT:

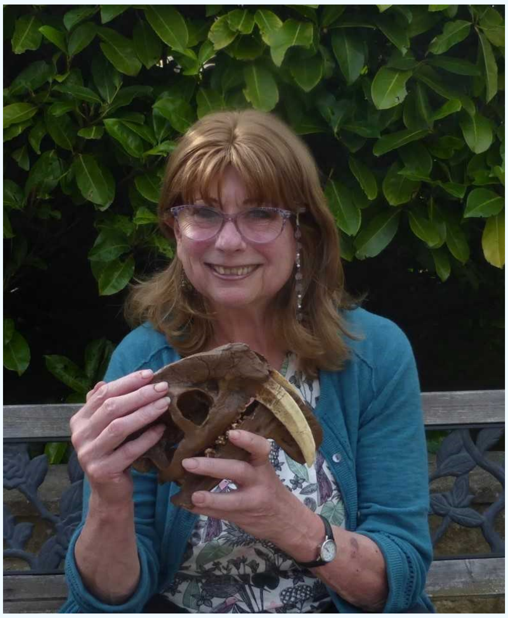
In their seminal paper in 2002, Joe Cartwright and Mads Huuse referred to 3D seismic reflection data as the 'Geological Hubble’, illustrating how these data had the potential to revolutionise our understanding of the genesis and evolution of sedimentary basins. 18 years on, I will here outline just some of the key recent advances made in our understanding of basin structure, stratigraphy, and development. I will outline how ‘geodynamicists’, sedimentologists, structural geologists and geomorphologists, amongst others, can benefit from utilising what I believe are currently an underused data type. I will stress that future advances at least partly relies on hydrocarbon exploration companies and government agencies continuing to make their data freely available via easy-to-access data portals.

## ABOUT THE SPEAKER:

Professor Christopher Jackson is a geologist at the University of Manchester. He previously held the role of Equinor Professor of Basin Analysis at Imperial College. Having completed his BSc (1998) and PhD (2002) at the University of Manchester, Chris was employed as an exploration research geologist in the Norsk Hydro (now Equinor) research centre, Bergen, Norway. Since moving to Imperial College in 2004, Chris’ research has focused on using traditional fieldwork techniques and seismic reflection data to study the tectono-stratigraphic analysis of sedimentary basins. When not studying rocks and the ways in which they deform, Chris gives geoscience lectures to the general public and in schools, having appeared on several, Earth Science-focused, television productions and podcasts. Chris is actively engaged in efforts to improve equality, diversity, and inclusivity in Earth Science in particular, and Higher Education in general.

## Professor Christine Janis (Bristol)

*'The evolution of grassland environments: what we know from the mammals that inhabited them.'*



### TALK ABSTRACT:

Grasslands are a familiar habitat type in today's world, whether the treeless prairies and steppe in the temperate latitudes, or the treed savannas in the tropical latitudes. But grass is a newcomer to Earth's vegetational domain. Grasses are unknown until the latest Cretaceous, and grasslands were not prevalent until the Miocene, around 20 million years ago. Grasslands first spread as higher latitude savannas, and tropical savannas did not appear until around 2-3 million years ago.

Grasslands support grazing mammals such as horses (including zebras, etc.) and antelope. Grazing mammals today have high-crowned (hypsodont) teeth that withstand a lifetime of an abrasive diet: grass itself is tough, and grazers also ingest particles of dust and soil that wear down their teeth. Hypsodont mammals have been used as proxies in the fossil record for the presence of grasslands: but the information from the mammals and from the plant fossil record may be in apparent conflict. Hypsodonty at the level of mammalian communities can be shown to be a proxy for levels of precipitation: grasslands are found in more arid conditions, and so there is a general correlation, but not an absolute one.

Hypsodonty in horse evolution was for many years thought to herald the first arrival of grasslands in North America, but information from phytoliths (silica particles inside plant cells) now shows us that the grasslands had already been present for around five million years when the first hypsodont horses appeared. Nevertheless, the horses may be telling us something important about environmental change and evolutionary processes.

### ABOUT THE SPEAKER:

Christine Janis is currently an Honorary Professor in Earth Sciences at the University of Bristol. She did her undergraduate degree at the University of Cambridge (UK), moved to the USA to do a PhD at Harvard University, moved back to the UK to the University of Cambridge for a postdoctoral fellowship, and then back again to the US to take up a position at Brown University, where she remained for over 30 years. She currently Professor Emerita (i.e., retired) at Brown University (Department of Ecology and Evolutionary Biology), and happy to be living back in the UK again. She has always had an interest in both living and fossil mammals: much of her career has been spent in understanding how the anatomy of the extant ones relates to their behaviour (such as feeding or locomotion), and this can then be applied to determine the likely behavior of the extinct ones. She is currently doing research (along with current and former students at the University of Bristol) on the evolution of locomotion in horses and kangaroos.

# Dr Gillian Apps
# (University of Texas at Austin)

*'How convection churning deep in the Earth's mantle impacts surface processes.'*

**TALK ABSTRACT:**


The Earth is divided into crust, mantle and core, based on composition. There is an equally important division based on mechanical properties: the lithosphere, the asthenosphere and the mesosphere. The outer core boundary is the same in both cases.

The lithosphere is solid, strong and brittle, and includes the upper part of the mantle. It is divided into plates, and their movement makes plate tectonics, and accounts for a lot of the Earth's topography (mountain belts where plates collide; deep trenches where one plate subducts beneath another). The asthenosphere is still solid, but is significantly weaker, and relatively low viscosity.

Between the Earth's crust and its core is the mantle, approximately 3000km thick, which is stiffer than the asthenosphere; it is mostly solid, but over geological time behaves like a liquid. Within it are convection cells, with regions of upwelling hotter mantle and downwelling cooler mantle. There are deep-seated convection cells circulating heat upwards from the core-mantle boundary, and these are called hot spots and they persist for 100s of millions of years; for example, Hawaii sits above a deep-seated hot spot. There are shallow circulation cells in the asthenosphere, which vary spatially and wax and wane over a 1-million-year time scale.

Both types of convection create topographic relief on the earth's surface, with upwelling hot mantle creating broad topographic highs, and regions of down-warped crust forming lows. This is called **Dynamic Topography**, and it may account for a number of apparently unrelated, and as yet unexplained phenomena. We will look at two in our talk, both of which occur on continental margins: the existence of very large deepwater sandy fans and dramatic changes in gravity-driven tectonics. New predictive geological models are emerging which may impact a wide range of human activities from exploration for mineral resources to carbon dioxide storage.


**ABOUT THE SPEAKER:**

Gillian is a Research Scientist with the Applied Geodynamics Laboratory (AGL) at the University of Texas at Austin. She holds an MA in Natural Sciences (Earth Sciences) from the University of Cambridge, and a PhD from the University of Liverpool, where she studied with Professor Trevor Elliott.

During her 33-year long career in the oil and gas industry, she worked for Shell, BP and BHP, and her career spanned basin analysis through exploration to production geophysics. She is a clastic sedimentologist and stratigrapher, with expertise in deepwater reservoirs, salt-sediment interactions, and deepwater fold and thrust belts. Her current research interests focus on deepwater turbidite stratigraphy and reservoir variability in structurally active basins.

Outside her work with the AGL, Gillian is co-director of Appeel Geosciences Ltd, and she teaches field classes in Haute Provence, France.

Gillian grew up in the UK, and has since enjoyed working and living with her family in the US, Australia, Mexico and briefly in Beijing, China. She and her husband have both had careers in geoscience, and they now split their time between Austin, Texas and their UK home in the New Forest.

**Join in the conversation on Discord!**

**Feel free to introduce yourselves to everyone on our server:**

*https://discord.gg/q7jfSWJjPM*

**This year we're asking for your kind donations towards Geology for Global Development (GfGD), a registered charity who's purpose is to champion the role of geology in sustainable development:**

*https://tinyurl.com/ozgk7czd*