51st HERDMAN SYMPOSIUM
ENERGY AND SUSTAINABILITY

Saturday, 17 February 2024

Time:

Registration from 9:30

10:00 - 17:00

Drinks reception 17:00 - 18:00

Location:

Central Teaching Hub,
University of Liverpool,
L69 7BX

Contents

The Herdman Society would like to give a massive thank you to all our sponsors, the University of Liverpool School of Environmental Sciences, and Earth Science Research Group (ESRG) for their support and donations to help run this event.

Schedule

09:30 **Welcome and registration**

10:00 **Introduction**
Presentation by Jack Lynch (Herdman Society President). Introductions from Dr Janine Kavanagh (Reader in Volcanology, University of Liverpool), Jennifer Davies and Liam Rooney (Herdman Symposium Secretaries).

10:10 **Dr David McNamara - University of Liverpool**
'Mineral processes impacting geological solutions for Net Zero'

11:00 **Dr Frances Cooper - University College London**
'Tectonics, climate, and copper in the Central Andes'

11:50 **Break**

12:10 **Dr Joshua Griffiths - National Nuclear Laboratory**
'Nuclear waste management and disposal in the UK'

13:00 **Lunch**

14:00 **Dr Jessica Pugsley - University of Aberdeen**
'Virtual outcrops in the modern geological toolkit'

14:50 **Dr Jeremy Sloan - University of Warwick**
'Perovskites in geology and material science: from igneous rocks to the picoscale'

15:40 **Break**

16:00 **Dr Kathyrn Moore - Camborne School of Mines, University of Exeter**
'Geoenergy, critical metals and responsible mining'

16:50 **Final remarks**

17:00 **Drinks reception**

Perovskites in Geology and Materials Science: from Igneous Rocks to the Picoscale

Dr. Jeremy Sloan - Reader in Electron Microscopy, Department of Physics & Warwick Centre for Analytical Science, University of Warwick Coventry

Background

Jeremy completed his PhD in Materials in 1995 in the School of Engineering at the University of Wales, Cardiff under Prof. Richard J. D. Tilley FRSC. He then joined the Inorganic Chemistry Laboratory at the University of Oxford in 1995 as a PDRA, initially working with Prof. Malcolm L. H. Green FRS, and during this time discovered 2 x 2 and 3 x 3 atomic layer KI "Feynman Crystals" (aka 'Extreme Nanowires') and 1D polyhedral chains of lanthanide, barium, cobalt and other halides grown in single walled nanotubes. In 2000 he was awarded a Royal Society University Research Fellowship and in 2004 I received the FEI European Microscopy Award at the ICEM in Antwerp. After a Senior Lectureship at the University of Surrey and a Readership at QMUL, Jeremy moved to the University of Warwick where he is now Reader in Electron Microscopy. Subsequently in 2018 he was awarded an EPSRC Established Career Fellowship to further research the crystallography and functional evolution of atomically thin confined nanowires formed in carbon nanotubes.

Abstract

The perovskite structure, with its almost infinitely adaptable array of derivatives, must count as one of the most important in materials science with the essential ABX_3 (A = a large cation; B = a smaller cation; X = an anion) structural archetype contributing to ferroelectric, piezoelectric, superconducting, photochemical, and many other technologically important properties. The Perovskite structure of course has geological origins and was discovered in 1839 by the Prussian mineralogist Gustav Rose in mineral deposits in the Ural Mountains who named the structure for the Russian mineralogist Count Lev Aleksevich von Petroski. This name has been extended to a family of compounds collectively referred to as the perovskites in order to accommodate the vast proliferation of derivatives many of which deviate from the ABX_3 archetype (e.g. Ruddlesden Popper $A_{x+1}B_xO_{3x+1}$ and Roth $A_xB_xO_{3x+2}$ phases). The immense diversity of perovskite functional properties did not just develop from the interests of materials scientists as many of the defining characteristics are also present in the original minerals. For example, naturally occuring $CaTiO_3$ and $BaTiO_3$ both exhibit non-centrosymmetric distortions causing them to have orthorhombic rather than the expected cubic crystal structures. These deviations from 'ideal' symmetry, paired with the immense compositional variety possible at the A and B sites have given rise to so many of the important physical characteristics mentioned above and below.
Global Interest in perovskites is rapidly accelerated by developments in the fabrication of hybrid or all-inorganic halide perovskite ABX_3 structures where A is an organic or alkali metal counterion, B typically lead or tin, and X any one of the halogens, allowing materials with optical and photovoltaic characteristics, exploitable in solar cells, supercapacitors, and other energy storage devices to be developed. These structures also have geological counterparts among fluoroperovskites, for example elpasolite (i.e. K_2NiAlF_6), thomsenolite ($NaCaAlF_6.H_2O$), weberite (Na_2MgAlF_7) and cryolithionite ($Na_3Li_3Al_2F_{12}$) among many others.
In common with synthetic oxide perovskites, halide perovskites are typically manufactured in gram to milligram quantities whereas naturally occurring perovskites on Earth's surface typically form μm^3 to cm^3-scale crystals that can be observed in an optical microscope or a magnifying glass. This belies the fact that silicate perovskites predominate in the Earth's mantle with Bridgmanite (or silicate-perovskite) forming an astonishing 38% of the Earth's volume. At the other end of the scale, how small can we go ? Modern applications of perovskites often require them to be made on a quantum scale with colloidal, 2D, quantum dot, and, in thin films, molecular-scale preparations being developed, fine tuning optical band gaps and other properties. In Warwick and, in complementary research in Berkeley in the US, we have made unit-cell and sub-unit cell halide perovskites by growing them inside carbon nanotubes. This has enabled the growth of single-unit (and sub-unit cell) cell wide $CsPbX_3$ (X = Br, I) and $CsSnI_3$. Even on this small scale, these materials reproduce many of the same structural characteristics that we commonly associate with the bulk materials but also with some eye-catching differences. In my presentation, I will attempt to put all of these aspects into context, never losing sight of the fact that, without the contribution of the geological sciences, none of this would have been possible.

Speakers

SPONSORS

Liverpool Geological Society

The Liverpool Geological Society (LGS) has been a consistent sponsor of the Herdman Symposium for many years, for which we, as a society, are very grateful.

The LGS was formed in 1859. Our Past President and Member, Professor Herdman and his wife endowed a Chair of Geology in The University of Liverpool in 1916 in memory of their son Lieutenant George Herdman who was killed in the First World War. With the opening of a Department of Geology in 1929, again due to Professor Herdman's generosity in memory of his wife, Jane, many LGS meetings were held in that building at the invitation of Professor PGH Boswell, the first Professor of Geology at The University of Liverpool.

After more than 160 years, meetings continue to be held in The University of Liverpool, although are now held in the Central Teaching Hub. The Society still flourishes and offers a varied programme of illustrated talks, occasional practical sessions, and field excursions.

Lecture meetings and practical sessions are held on selected Tuesday evenings from October to April. Guest speakers include local experts and internationally recognised scientists. Field excursions, usually on selected weekends during March to September, include nearby day trips as well as residential visits to more distant parts of the UK or overseas. Visitors and new members are welcome at all meetings.

For more information about the society and its activities follow the link to its website:

https://www.liverpoolgeologicalsociety.org/

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Geoscience Energy Society of Great Britain (GESGB)

The GESGB (previously called PESGB) was established in 1964 by a group of like-minded professionals keen to create a community of geoscientists for networking and sharing ideas. Over 50 years on, we have maintained those founding principles.

With a membership of around 3000 individuals, active in six continents, the GESGB community is supported by various Regional Branches and Special Interest Groups. We have established a number of flagship events where professionals network, share technical excellence, and discuss the latest developments. These events include PETEX, BEOS, Asia Pacific and a vast array of field trips, courses, seminars and conferences.

We have donated over £2m over the years supporting various educational projects including; school-based education, university support and public engagement, with the aim of raising the profile and impact of geoscience. We also established a public annual lecture programme designed to promote geology and earth science which has featured speakers including Lord Robert Winston, Sir Tony Robinson, Hugh Dennis, Dallas Campbell and Professor Iain Stewart. In 2017, Professor Kenneth Lacovara headlined our national GEOLiteracy Tour where he delivered his engaging talk 'Why Dinosaurs Matter', which engaged over 1,500 people outside the society.

As we work to promote our industry, GESGB has created partnerships with other professional societies and organisations to share knowledge and support the aspirations of our members. For more information about the society and its activities follow the link to its website:
https://www.ges-gb.org.uk/