Manchester Geological Association
Abstracts for Broadhurst Lectures: Deep Earth Matters
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Surprises from the top of the mantle transition zone

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Recent studies of chromite deposits from the mantle section of ophiolites have revealed a most unusual collection of minerals present as inclusions within the chromite. The initial discoveries were of diamonds from the Luobosa ophiolite in Tibet. Further work has shown that mantle chromitites from ophiolites in Tibet, the Russian Urals and Oman contain a range of crustal minerals including zircon, and a suite of highly reducing minerals including carbides, nitrides and metal alloys. Some of the minerals found represent very high pressure phases indicating that their likely minimum depth is close to the top of the mantle transition zone. These new results suggest that crustal materials may be subducted to mantle transition zone depths and subsequently exhumed during the initiation of new subduction zones – the most likely environment for the formation of their host ophiolites. The presence of highly reducing phases might indicate that at mantle transition zone depths the Earth’s mantle is ‘super’-reducing. New evidence for highly magnesian melts from mantle chromitites indicates a deep hot origin for these melts further supporting deep-sourced mantle processes beneath ophiolites. (Rollinson, H.R., 2016. Surprises from the top of the mantle transition zone. Geology Today, 32, 58-64).

Dynamics of the core-mantle boundary

Dr Andrew Walker, University of Leeds

The profound changes in physical properties across the Earth's core-mantle boundary makes this region key for the understanding of global-scale dynamics. As well as moderating any interaction between the metallic core and rocky mantle, the lowermost few hundred kilometres of the mantle also hosts the basal limb of mantle convection acting as a kind of inaccessible inverse lithosphere. Since its discovery in 2004, the perovskite to post-perovskite phase transition in $MgSiO_3$ has dominated attempts to understand the lowermost mantle. In this talk I will outline a series of models designed to probe the dynamics of the core-mantle boundary region and link convectively driven flow of the mantle to the deformation of post-perovskite. I will show how these models can be used alongside experiments and atomic-scale simulations of mineral behaviour to test our understanding of the composition and dynamics of this inaccessible part of the Earth. Important results include the possibility of enhanced thermal coupling between the convective systems in the core and mantle and an ability to probe the dynamics of the continental scale “large low shear velocity provinces” at the base of the mantle.

The scale, magnitude and distribution of chemical heterogeneities in the Earth: what are they, how do they form, and how do we find them?

Dr Jason Harvey, Institute of Geophysics and Tectonics, University of Leeds.

Since the formation of the Earth, some 4.56 billion years ago, its physical and chemical evolution has resulted in a progressive change from a homogeneous smoking ball in space to the layered planet with which we are familiar today. Although, with the exception of the most volatile elements, the bulk composition of the Earth is unlikely have changed from that of its broadly chondritic building blocks, the distribution of many elements in the deep Earth has become increasingly heterogeneous over time.

On the broadest of scales, the moon-forming impact of Theia, the segregation of Earth's core, and the formation of the earliest continental crust all occurred early in the Earth's history; the layering that we see today was at least initiated within a couple of hundred million years of the formation of the planet. However, the fine-scale detail of chemical and isotopic heterogeneity in the deep Earth began to develop with the onset of recycling of early formed lithosphere, either by an early variant of what we describe as subduction now, or by more esoteric vertical tectonics. This reintroduction of differentiated material back into the mantle, combined with the decreasing ability of sluggish mantle convection to effectively mix this recycled material back into a homogeneous reservoir results in chemical and isotopic variability at a range of length-scales.

Just as many modern medical diagnoses rely on non-intrusive investigations, Earth scientists have become increasingly innovative in their investigations of the deep interior of the Earth. Drilling from the Earth's surface has, to date, only penetrated to a depth of 12 km at the Kola Superdeep in Siberia – approximately 0.3 % of the radius of the Earth – so, much of our knowledge of the Earth's interior comes from indirect evidence…but some does not! In this talk I will discuss some of the measurable chemical heterogeneities that exist in the Earth's mantle and what this tells us about the evolution of the Earth's interior. I will also discuss some of the limitations of modern analytical geochemistry, how some of these barriers are being broken down, and what the implications are for the next generation of investigations into the composition of the Earth's deep interior.