EAG Distinguished Lecture Tour 2012

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Lecture Abstracts

The Origin of Precious Metals on Earth

Gold has value for its intrinsic rarity and noble beauty. Other more economically useful metals such as platinum (Pt) also have their intrinsic value enhanced by their scarcity. Yet, the abundance of these rare metals is actually much larger than simple models of the evolution of the Earth would predict. The so-called highly siderophile elements, such as gold and platinum should be efficiently incorporated into the core and thus locked within the inaccessible interior of the Earth since its formation at the beginning of Earth History.

However, the abundance of gold in the outer portion of the Earth is several orders of magnitude greater than that expected after core formation. This has long been attributed to the 'late' addition of meteoritic material to the Earth, after the core formed. This so-called Late Veneer could have replenished the mantle with a fresh inventory of precious metals. Yet, this model has been disputed, as newer experimental data of core formation at high pressures can also potentially explain the over-abundance of highly siderophile elements.

We have been able to resolve this debate using high precision isotopic measurements, showing clearly that the late delivery of meteorites to Earth is responsible for the economic bounty of precious metals we currently enjoy. I will explain the utility of isotope measurements in this endeavour and how these analyses also open up new perspectives in understanding the behaviour of the ancient Earth.

Super Nova Contributions to the Solar System

Material that makes up the solar system represents the end-product of many different stellar explosions. This blend of material is to a first order well mixed and the individual components are hard to identify. There has been much progress identifying the type of star from which individual pre-solar grains derived from their isotopic signatures. However, the relative importance of each grain type within the mix is hard to discern. We have taken a different approach. Rather than looking for large isotopic variations in tiny grains, we have looked for tiny isotopic variation within large, bulk samples. The rationale is that any signature that has survived complete homogenisation should reflect material from a recent input to the solar system. We have identified pre-solar signatures in several elements in bulk meteorites. These point to material derived from a type II super nova. This is reassuringly in keeping with independent lines of evidence and points to a possible 'super-nova' trigger for solar nebula collapse.

Tracing mantle evolution with novel isotopic systems

The notion of mantle heterogeneity and its interrogation to reconstruct the evolution of the mantle was built on observed variability in radiogenic isotope systems in mantle derived melts. These measurements have been most popularly explained by recycling of crustal material, either oceanic or continental. These deductions are, perhaps inevitably, equivocal. It has therefore been as long standing goal to verify these inferences from independent lines of evidence.

Most notably, the surface environment should impart distinctive stable isotopic fractionations on the crust before its return to the mantle. In order to provide a good tracer of recycled material, however, a number of important criteria need to be satisfied:

1) the distinctive stable isotopic signature needs to be associated with a large elemental flux to be discernible after remixing into the mantle
2) the surface cycling of the element of interest needs to have remained the same as present day, or at least predictably different, in order to be able to extrapolate back the effects of recycling over geological time
3) the isotopic systems should be sensitive to the recycling process alone and not to subsequent perturbation during magmatic transport to the surface. In the last decade we have explored the potential of several stable isotope systems, with a range of masses, to these ends including Li, Mo and U.

We will discuss the strengths and weaknesses of these systems in helping to identify the presence of recycled material in shaping the composition of the current mantle. Recently the opportunity to look at the evolution of the mantle in the opposite direction has also become possible. Rather than try to work back from present via the plate tectonic cycle it is possible to observe how some of the most ancient isotopic signatures on Earth, as preserved in anomalous compositions of extinct nuclides (e.g. 182W), have been lost. Reconstructing the history of these changes offers the potential to examine the convective behaviour of the mantle, potentially before plate tectonics. We will preview what might be attempted in this burgeoning field.