

## **MURCHISON MEDAL**

### **E Bruce Watson**

#### *The Pros and Cons of Equilibrium*

Experimental geoscience has reached a level of sophistication that gives us access to systems ranging from Earth's surface to the core.

Interestingly, we experimentalists tend to classify ourselves according to the prevailing conditions (temperatures and/or pressures) of the systems we study—for example, as high-temperature vs. low-temperature geochemists, igneous vs. metamorphic petrologists, etc. Over my career I have come to realize that physicochemical phenomena do not recognize clear distinctions or classifications of this sort. It has been liberating (if risky) for me to think that phenomena related to crystal growth deep in the Earth might also operate in seawater (for example), or vice versa. But this perspective has also brought home to me the equilibrium vs. non-equilibrium dichotomy: high-temperature systems (both in the laboratory and in nature) are likely to attain equilibrium; low-temperature systems may not. Equilibrium is a good thing – by definition, it is unchanging at a given pressure and temperature, so we can anchor our thinking to the equilibrium state. Still, systems moving toward equilibrium are also very interesting because of what they can tell us about change and process. One could ask the question "Which is better: equilibrium or non-equilibrium?" The answer depends on what we seek to understand. After more than three decades of work on both equilibrium and non-equilibrium (diffusion) phenomena, I've come to cherish both. Understanding diffusion is especially valuable for the perspective it provides in evaluating attainment of equilibrium, both in experiments and in nature.

## **WILLIAM SMITH MEDAL**

### **Stuart Haszeldine**

#### *Geological storage of CO<sub>2</sub> and radioactive waste: liability or giant green-business?*

The provision of electricity, heat, and transportation fuel is a fundamental pre-requisite for industrial societies. The UK has been extraordinarily fortunate since the 1750's in being able to exploit domestic coal, oil shale, then offshore methane gas and crude oil.

Life in the 2010's and beyond is becoming more complex. To meet our ever rising demand for energy, the UK now needs to import coal, oil, and gas as well as experimenting with low carbon generation from nuclear powered electricity, wind power waves and tides. It is clear that combustion of fossil fuels has adverse effects on climate and on ocean acidification. To continue using these fuels governments must mandate geological disposal of carbon dioxide, possibly augmented by geo-engineering. It is also clear that disposal of radioactive waste and spent fuel remains a technically and socially unsolved problem. Geological sciences are essential to the solution of both these problems, both in their perspective of prediction into future deep-time, and in their technical ability to explore for, and construct, robust and resilient storage sites. For radioactive wastes, the UK has made several attempts to attain rapid solutions; these have all foundered upon geological implausibility and social disbelief. Current attempts are clearly addressing social needs, but are overly optimistic in their anticipation of geological security. Radioactive waste remains a unique and very

expensive liability. For carbon dioxide it is clear that the UK has a huge potential resource of storage in pore-space deep beneath the North Sea. This could be developed to serve not just the UK's needs, but also to accommodate carbon dioxide from many states in continental Europe. Development of this resource needs a vision from government which can enable the adaptation and application of the vast geological knowledge, technological abilities, and financial instruments available to global hydrocarbon companies and their successors.

Developing a green carbon-storage geo-economy could create tens of thousands of high-grade jobs as well as £5 billion per year income for the UK. That buys time, during which more fundamental changes can percolate to provide efficient energy use, and reliable very low-carbon electricity. More effort is needed from geoscience societies, professionals and businesses to communicate with government in the invention and capture of this carbon-storage opportunity.

## **WOLLASTON MEDAL**

### **Stephen Sparks**

#### *Global volcanic risk*

There are thought to be about 500 million people living close enough to active volcanoes to be affected when they erupt. Casualties from volcanic eruptions have been modest (around 300,000 in the last 200 years) compared to other natural hazards, but economic losses and societal disruption can be considerable. The modest sized eruption of Eyjafalljokull volcano in Iceland in April and May 2010 did not kill anyone but disrupted the travel of millions of people and costs the airline industry billions of dollars. This emergency highlighted the increasing vulnerability of modern globalised societies. In the very short history of civilisation, a few thousand years, there have been comparably few very large volcanic events, which have global effects. Such events include very large lavas flow eruptions, such as Laki (Iceland) in 1783 and major caldera-forming explosive eruptions, such as Tambora in 1815 and Tianchi around 930 AD. Much larger magnitude eruptions have happened regularly when time scales of millions of years are considered. Such extreme eruptions perturb global climate for several years and can have severe environmental impacts and consequences. The modern globalised world is arguably uniquely vulnerable to very large volcanic events, making the study of their return periods, possible environmental effects and consequences a key goal of volcanology.