Preface

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Much has been written in recent years about James Hutton and his *Theory of the Earth*, published between 1785 and 1795. The Hutton Symposia, the Proceedings of which are also published by the Royal Society of Edinburgh in *Transactions*, specifically celebrate his contributions to understanding the origin of granites, one of the cornerstones of his theory. The recent biography of Hutton (Repcheck 2003) is a most welcome analysis of the historical context of his work. It shows how his ideas can be traced directly to Newton by his application of the laws of science to understanding nature without recourse to unexplainable factors, but also how these ideas were revolutionary in rejecting the established religious constraints on the age of the Earth and the duration of surface and internal processes. Jack Repcheck argues that had Hutton been a better communicator of his own theory, then his name might now rank in public esteem among rare scientific geniuses such as Newton, Darwin and Einstein.

The present Hutton volume, the fifth in the series, testifies that after more than two centuries of research the 'problem' of the origin of granites is still very much with us, and that the considerable advances in understanding over that time serve to confirm that a singular 'origin' is no longer scientifically tenable, notwithstanding the 'Huttonian' title our volume. The volume contains abundant evidence for the complexity of the natural processes involved in generating granite magma and controlling its ascent and final emplacement, as well as in influencing its crystallisation and hydrothermal activity. These combine in so many different ways that we now recognise the enormous diversity of granites as different manifestations of thermal perturbation in the lithosphere. This would please James Hutton, for magmatism was central to his theory as the primary mechanism of transporting heat to the near-surface, where it acted to consolidate sediments (although we now know that burial is sufficient for that purpose). He rigorously applied scientific method by making and testing predictions and, in the case of granites, he anticipated the main features of a contact between granite and country rocks and knew just where he should find such a contact to inspect in the field (Glen Tilt). Indeed, he was an enormous enthusiast for examining rocks *in situ* and transmitted that enthusiasm to those accompanying him in the field, including his friend and pioneer chemist, Joseph Black, and other leading intellectuals of that special time known as the Scottish Enlightenment.

This volume is a compilation of invited papers presented at the Fifth Hutton Symposium on the Origin of Granites and Related Rocks held at Toyohashi, Japan in early September 2003. In the following 'Introduction', Shunso Ishihara and his colleagues describe the very successful conference and accompanying field excursions. All participants are enormously grateful to the organisers for arranging an excellent scientific programme and, for the many participants from beyond Asia, a wonderful cultural experience. Papers in this volume address all the major aspects of granite studies, some of which have a strong flavour of Far Eastern granite geology, reflecting the location of the meeting.

Opening the volume are three papers that take rather different approaches to generic models of granite magmatism. Chappell proposes a unified model of crustal granites based on the interaction between source rock composition and varying degrees of partial melting, fractional crystallisation and restite separation. Vigneresse reviews the major processes of melting, melt segregation, ascent and emplacement and links them in a new paradigm to explain the diversity of granite types. Ishihara surveys the occurrences of reduced and oxidised (ilmenite and magnetite series) granites in both time and space, and shows how they can be linked to global tectonic processes and temporal changes in redox conditions (a theme developed on a regional scale later in the volume).

The relationships between melt production, fluid activity and melt migration and segregation are central to modelling of the deformation and thermal evolutions of orogenic belts. These issues are explored from a variety of directions in a series of contributions on the anatectic regime as monitored through experiment and natural rock observation. Brown presents an overview of current approaches to modelling how melt migrates and is extracted from the deep crust, focusing in particular on the concept of ductile fracture propagation. Olsen *et al.* also consider the physical links between zones of melt production and melt transfer, concentrating on competing mechanisms for melt transfer. The efficiencies of these physical processes are strongly influenced by melt composition, especially water contents, which impact strongly on viscosities. This aspect is addressed by Whittington *et al.* through experiments on leucogranites and related modelling of the T–H_2O–viscosity relations of crustal melts. Nabelek & Liu also consider leucogranites, concluding from thermal modelling that these melts are generated in collisional orogenesis only when shear heating along crustal-scale shear zones occurs, providing an effective mechanism for raising temperatures into the dehydration-melting regime. The mineral-melt systematics of this regime, and even higher-temperature deep crustal metamorphism, are addressed by Harley & Thompson. These authors illustrate the role that hydrous and CO_2-bearing cordierite plays in limited the amounts of melt produced through biotite dehydration melting, and combine cordierite-melt volatile partitioning data with mineral equilibria in model pelite systems to evaluate fluid activities in high- and ultrahigh-temperature migmatites. Cordierite is also recognised as an important mineral involved in melting and melt crystallisation by Erdmann *et al.*, who establish chemical and textural criteria for discriminating cordierites formed at different stages of the magmatic evolution of granitoids. Kawakami adopts an alternative approach to establishing the progress of melting in pelites and politic migmatites, using tourmaline as an index mineral for the onset of melting and identifying melt segregation, loss and wall-rock reaction using boron as a chemical tracer.

Source rock controls on magma composition continue to be a major focus of research. Chappell *et al.* develop their model for low- and high-temperature granites in relation to source compositions and thermal conditions. Janousek *et al.* find evidence for old upper crustal granites taken to deep crustal depths for the sources of some granulites of the Bohemian Massif. The occurrence of pyroxene bearing tonalities of both I- and S-type affinity in the Hikada Belt of Hokkaido is attributed by Shimura *et al.* to granulite source rocks of

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different bulk composition. A detailed radiogenic isotope study of Mesozoic granites in South Korea by Jwa provides strong evidence for regional variation in source rock composition and for vertical stratification of the crust in both age and composition. Bryant *et al*. examine the variations in Li isotopes with other petrogenetic indicators in the New England Batholith of Australia and show that this relatively novel isotope system can provide useful new constraints on source rocks and crustal processes.

The relationships between geochronology, granite geochemistry and tectonothermal events are providing new insights into crustal and mantle processes on the lithospheric scale. Poller *et al*. use precise U–Pb geochronology to show that Archaean crustal material is reworked in the Proterozoic (with a minor mantle influence) along the edge of the Siberian craton. The tectonic significance of A-types is still relatively poorly understood and Qiu *et al*. describe different subgroups in the Cretaceous of Fujian Province (SE China) which they attribute to distinct differentiation processes controlled by varying fluorine contents. Geochemistry is used by Chen *et al*. to document the changes from syn-orogenic to post-orogenic crustal granites, which they relate to early lithospheric thickening by basaltic underplating followed by delamination. Geochemistry is also used by Nakajima *et al*. to interpret the relationships between mafic rocks and granites in the Ryoke Belt of Southwest Japan as indicating a major episode of crustal growth during the Cretaceous. Shimizu *et al*. studied felsic veins preserved in peridotite xenoliths at Tallante, Spain and recognised adakitic signatures in melts generated by partial melting of a detached slab beneath the Betic area during the Tertiary.

Insights into the dynamics of magma chamber processes were gained from the study of petrological and compositional variations in a tilted section of the Aztec Wash pluton, Nevada by Harper *et al*., whilst Richards & Collins address the age-old 'room problem' by using combined field and geophysical data to show that plutons from the Bega batholith of the Lachlan orogen (Australia) are wedge-shaped bodies emplaced in active extensional environments. Deep-level interactions between magmas, melts and host rocks in a complex dynamic environment are described by Benn for the late Archaean Kenogamissi complex (Ontario) and evidence is presented for the magmatic differentiation of batholiths by remobilising and extracting of fractionated liquids.

Granite terranes are sometimes economically important for their associated metalliferous deposits and the significance of redox conditions is highlighted by two contributions to this volume. Sato *et al*. show how the redox state of granites is correlated with the nature of the associated country rocks, which in turn determine the associated mineralisation in the circum-Japan Sea region. Hart *et al*. find strong evidence to attribute the contrasting metallogeny associated with three distinct plutonic suites in the northern Canadian cordillera to different source rocks and redox controls.

The volume is completed by two studies of volcanic terranes. Compositional variations in Tertiary volcanics of the northern Colorado River region (USA) are related by Metcalf to contemporaneous plutonic rocks through magma chamber processes, and Gualda *et al*. present a study of the crystals and bubbles in pumice samples from the large volume Bishop Tuff rhyolite, proposing a scenario of rising bubbles and sinking crystals that may have considerable relevance for the study of granite plutons and batholiths.

Although James Hutton would be unfamiliar with many of the techniques used in these studies, he would recognise in most contributions the need for very long periods of time for processes to operate. Before Hutton, such time was not available, and it is this part of his enormous scientific legacy that has enabled us to discover so much about the origin of granites.

Reference

Repcheck, J. 2003. *The Man Who Found Time: James Hutton and the Discovery of the Earth's Antiquity*, 247 pp. Croydon, UK: Simon & Schuster Ltd.

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