INTRODUCTION

Frontiers in geofluids: introduction

This set of papers was originally published electronically as a special double issue of Geofluids to mark the tenth anniversary of the launch of the journal. For this volume, we sought to bring together a collection of papers spanning a range of topics to which the role of fluids in the Earth is central. Geofluids was founded to help emphasise the common ground between fluid processes that take place in different geological settings, and to provide an outlet for research that considers the interactions of chemical and physical processes. While we cannot pretend to provide a comprehensive coverage of all the important recent advances, we are delighted to have been able to bring together some excellent and wide-ranging new science that continues in this tradition.

The first four articles all concern our fundamental theoretical and experimental understanding of essentially aqueous fluids. Liebscher provides an overview of the properties of water-rich fluid systems and how these are affected by solutes, while noting the remaining limitations in the experimental database. Dolejs and Manning present the first comprehensive study to produce a more flexible alternative to the HKF model for aqueous electrolytes, better suited to the range of compositions and conditions encountered in nature, while Sherman shows how modern computational power means that some fundamental problems in natural fluid chemistry can be addressed from first principles using quantum chemistry and molecular dynamics. In the final article in this section, Newton and Manning review recent experimental results for lower crustal conditions and present new data to quantify the importance of dissolved salts for the solubility of the major rock –forming elements, Si and Al, and for a range of important Ca-minerals.

The second group of articles relate to a specific geological setting where fluid processes are of the highest importance: sedimentary basins. Parnell provides a concise review of the use of hydrocarbon fluid inclusions to understand the evolution of reservoirs through time and the relationships between fluid stages and mineral cements. He shows in particular how this approach has contributed to understanding the oil charge history of the North Sea and UK Atlantic margin. Hanor and Mercer describe the behaviour of saline waters and their distribution in the Gulf of Mexico, and show how salinity differences arising through salt dissolution can dictate flow patterns. They also explore the likely impacts of salt on the potential of the region as a source of methane hydrates. The article by Manzocchi, Childs and Walsh reviews how faults affect the flow of fluids, in particular hydrocarbons, in siliciclastic basins, and also comment on the extent to which current industry practice for evaluating the effects of faults is actually grounded in science.

A third group of article deals with fluid processes in oceanic settings. Saffer has modelled the lateral variations along the Nankai margin of Japan and shown that large scale variations along strike in the taper angle of the accretionary wedge can be linked back to lithological variations from more turbidite-rich sequences to mudrocks. The lithology affects the development of fluid overpressure and the draining of the subduction zone fault, which in turn influences the overall geometry of the wedge. The interplay between permeability, heat flow and discharge characteristics at mid-ocean ridges is explored by Driesner. His results support some findings from terrestrial geothermal systems: high temperature discharges, and the highest fluid salinities, may be associated with low fluid fluxes, while large discharges at relatively low temperatures may in fact dominate the removal of heat. Fisher and Harris take three specific examples of mid-ocean ridge settings to explore the controls on heat loss. The relative importance of conductive heat loss is variable, and specific features of the basement geology can serve to target fluid flow and hence heat loss. Hydrothermal vents are also of likely significance for both abiotic and metabolic organosynthesis and this is explored by Shock and Canovas. Different patterns of mixing of seawater with different hydrothermal fluids can lead to different evolutionary paths, but in general, the mixing favours formation of organic compounds from inorganic reactants. Hence, microbes could produce components of biomolecules simply by catalysis of reactions that are already energetically favoured.

A fourth group of articles deals with the continental crust. Ingebritsen and Manning present a crustal-scale overview of permeability and argue that while there is a power–law relation between permeability and depth in tectonically active continental crust, some regions exhibit markedly higher permeabilities, probably as transients, while stable crust may decay to lower permeability. The specific issue of the relationship of hydrologic response to earthquake activity is discussed by Wang and Manga. They

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demonstrate that, in the intermediate and far-field, changes in groundwater flow are linked to changes in permeability which arise in response to cyclic deformation and oscillatory flow. The relationships between faulting and flow at depth is explored by Cox, who shows how fluid pressure and stress influence failure modes and hence the styles of permeability enhancement and vein development, in both mineralized and unmineralized systems. Fluid flow coupled to deformation often introduces water into high grade crystalline basement rocks which undergo retrogression. Yardley, Harlov and Heinrich present the results of experiments designed to measure the rate at which high grade rocks undergo retrogression under mid- to lower-crustal conditions, and conclude that water infiltrated along fine cracks is likely to be rapidly consumed. The article by Bucher and Stober addresses deep groundwaters found in crystalline basement rocks today by tunnelling and drilling. They argue that in areas of high relief such as the Alps, such waters are of relatively low TDS because of flushing by meteoric water, whereas much more saline brines may evolve where the hydraulic gradients are less. Migration of fluids can lead to mineralogical and chemical changes (metasomatism) in a wide variety of crustal settings, and Putnis and Austreheim explore some diverse examples of metasomatism on a range of scales. They are able to demonstrate that, while aqueous fluids partly act as a catalyst to permit minerals to react, they can also influence the course of the reaction through a thermodynamic role.

The final section comprises two interdisciplinary articles that deal with ore deposits and draw on a range of aspects of fluids. Boiron, Cathelineau and Richard review the fluid systems that give rise to ore deposits near the unconformity between sedimentary basins and their underlying crystalline basement. They contrast the Proterozoic unconformity uranium deposits with younger base metal deposits that develop in similar settings, and conclude that there are many similarities in both the nature of the fluids and the flow patterns that give rise to mineralization. Kamenetsky and Kamenetsky evaluate fluid processes at the other temperature extreme of ore formation, associated with magmatism. They present evidence from inclusions to document the development of immiscibility as magmas cool, and evaluate the importance of immiscibility for magma chamber processes, including degassing and the partitioning of metals.

Although we have grouped the articles for convenience, we believe that the true value of the collection arises from the basic new data presented, from the insight into the interactions between physical and chemical processes, and from the opportunity they provide to take ideas developed in a field where particular types of observation or measurement may be possible to understand processes in different settings or at different times, where different types of data may be available.

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