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Preface: special section on Australian mineral systems

1. Introduction

Since its development in the 1970s, the concept of a petroleum system (Magoon and Dow, 1994) has led to more effective exploration for oil and natural gas (Australian Academy of Science, 2012). Wyborn et al. (1994) proposed that an analogous system approach could be applied to mineral deposits, defining a mineral system as "all geological factors that control the generation and preservation of mineral deposits". In the two decades since this seminal work, the acceptance of the mineral system concept has been variable, with some organisations and researchers adopting the concept and others pursuing more traditional deposit-focused methods in ore geology research.

Due to a greater diversity in commodities and geological settings, mineral systems are inherently more complex than petroleum systems (Pirajno, 2015). This has inhibited the development of holistic models and the uptake of the mineral system concept. However, recent work at the Centre for Exploration Targeting at the University of Western Australia, Geoscience Australia and State/Territory geological surveys, industry and other groups in Australia has led to important advances in the understanding of mineral systems. These include recognition that the most productive mineral systems, in terms of metal endowment, are constrained in time and in space.

In many cases the development of major mineral systems is triggered by a tectonic event such as the accretion of an exotic block, a reorganisation in the configuration of tectonic plates, the initiation of rifting, the arrival of the head of a mantle plume or a change in the dip of the subducting plate (Barnes et al., 2016-in this volume; Hagemann et al., 2016a-in this volume; Huston et al., 2016a-in this volume). These tectonic events can be recognised directly as in the case of orogenesis (Squire and Miller, 2003), basin evolution and the emplacment of large igneous provinces, or indirectly through changes in plate motion inferred from paleomagnetic apparent polar wander paths (e.g., Idnurm, 2000). As triggering tectonic events are generally rapid, the timing during which mineral systems form is highly restricted, leading to the concept of a critical window in time (Huston et al., 2016a-in this volume; Skirrow et al., 2009) during which major mineral systems form.

One of the more important aspects of the mineral system concept is that of a throttle, advocated by McCuaig et al. (2010). A throttle focuses fluid flow spatially, concentrating the flux of metals into a very restricted volume where depositional processes produce high grades and/or large tonnages. Typically throttles are structural – faults, shear zones or folds that concentrate fluid flow, although in some mineral systems, other geological features can act as throttles. Other examples include apophyses formed in the roofs of crystallising magma bodies, or stratigraphic pinch-outs of aquifers. Like structures, both of these geological features focus diffuse fluid flow into restricted volumes. An important theme from many of the papers in this volume (see below) is the important role or architecture, including deep crustal architecture in focusing fluid flow.

The concept of the mineral system will continue to evolve into the future, and many of the new understandings will benefit not only the science of economic geology, but also the business of mineral exploration. Traditional ore-deposit-centric research has been successful in developing many of the methods used in deposit- and district-scale, but these approaches are more limited in greenfield areas or provinces under cover with few or no known deposits. It is in these provinces that a change of focus to a more predictive mineral system approach will have greatest benefits.

2. Important results

In light of the continuing evolution of the mineral system concept, this Special Issue presents a series of fourteen papers describing aspects of mineral system science from the global, through the province and district scales. Although the examples used are largely based on Australian mineral systems, the descriptions and models developed are applicable more broadly. Important results of these papers, which represent a snapshot of mineral system science in Australia, are presented below. Fig. 1 shows areas covered by regional- and deposit-scale studies from this volume.

2.1. Tectono-metallogenic systems

Since the acceptance of the plate tectonic paradigm in the 1960s, it has been recognised that many types of mineral deposits form in specific tectonic settings (Hutchinson, 1973; Sillitoe, 1972). Sawkins (1984) was among the first to comprehensively discuss the links between mineral deposits and tectonics, a theme re-emphasised by Kerrich et al. (2000, 2005). Huston et al. (2016a-in this volume) continue this theme, presenting an overview of the spatial and temporal distribution of mineral systems within tectonic systems, including how the tectonic and associated mineral systems evolve with time. They demonstrate that many types of mineral systems develop at specific stages of an evolving tectonic system, and that these relationships can be used to predict the style, location, and timing of mineral systems, using the development of the Lachlan Orocline (Cayley, 2015) as an example. As the style of tectonism determines the geometry and composition of basins, it affects the characteristics, in particular the chemistry of ore fluids and location of traps, of mineral systems that develop in the basins.

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Fig. 1. Tectonic elements of Australia, showing the locations of major mineral deposits and areas covered by regional- and deposit-scale mineral systems studies presented in this issue (modified after Huston et al., 2016a-in this volume).

2.2. The link between major crustal boundaries and mineral systems

Over the last decade or so, many types of mineral systems have been recognised to have a link with the margins of crustal blocks, including iron oxide copper-gold deposits (Groves et al., 2010) and magmatic Ni-Cu-PGE deposits (Begg et al., 2010). Korsch and Doublier (2016-in this volume) use deep seismic reflection data collected as part of regional-scale land seismic acquisition programs in Australia since the 1970s to identify major crustal boundaries and then use gravity, magnetic and geological data to interpret these boundaries beyond the seismic lines to produce a continental-scale map. In a second step, the authors evaluate the role of major crustal boundaries for mineral systems using several Australian mineral provinces as examples. These results demonstrate that many mineral systems are, in fact, associated with major crustal boundaries, and the spatial distribution of these boundaries provides a fundamental, first-order control on the distribution of many known mineral deposits and, therefore, can be used as a regional-scale predictor of mineral potential, particularly in under-cover regions.