



Special Publication Number 21

Metals, Minerals, and Society

Antonio M. Arribas R. and Jeffrey L. Mauk,
Editors

SOCIETY OF ECONOMIC GEOLOGISTS, INC.

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On the cover: These graphics summarize the progression of ore from discovery, through mining and processing, to contemporary products and devices for society.



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Preface

The volume editors are pleased to offer the economic geology community a new SEG Special Publication, released concurrently with the Society's flagship meeting in Keystone, Colorado: *SEG 2018: Metals, Minerals, and Society*. As with previous Special Publications associated with SEG conferences, the articles included here represent a selection of talks and papers invited by the conference Technical Program Committee, and in particular by David Broughton, who—working together with session chairs—took a leading role in bringing together a remarkable list of relevant and timely topics and authors. We want to highlight the fact that this volume contains an unusually large number of articles authored by professionals from industry, a welcome fact because it brings renewed attention to mine geology issues and other practical topics.

The commitment by the numerous authors and co-authors to produce manuscripts under the strict guidelines and deadlines associated with publication in time for the conference is greatly appreciated. We thank the peer reviewers (see below), Richard Goldfarb (for SEG Publications Board careful editorial oversight), and SEG staff, including Brian Hoal and the Society's copyediting, layout, and print production staff, headed by Alice Bouley and Vivian Smallwood, is gratefully acknowledged; their efforts made this Special Publication possible.

The articles included in this publication have been grouped into three categories: (1) general topics related the broad conference theme of “Metals, Minerals, and Society,” (2) reviews of new metallogenic models, deposit types, and ore controls, and (3) deposit or district studies, including their exploration histories. Each of these categories consists of landmark articles that present the state-of-the-art knowledge on the individual deposit, district, mineral belt, or topic of reference.

Among the deposit studies, the articles by Perelló et al. (Zaldivar porphyry Cu-Au-Mo, Chile), Stegen et al. (Cerro Verde-Santa Rosa porphyry Cu-Mo, Peru), and Ashton et al. (Tara Deep Zn-Pb deposit, Navan, Ireland) present model studies of deposits that, in addition, lacked previous published detailed geological documentation. The wealth of geological, geochemical, exploration, paragenetic, and/or geochronological data provided for these deposits is exceptional. For their part, Knight et al. (giant Molo graphite, Madagascar) and Scherba et al. (South Flank iron deposits, Western Australia) provide a similar level of detailed and careful documentation of deposits and commodities that are not commonly covered in our literature.

We are especially delighted to include a series of overview articles that summarize new metallogenic models and concepts. Emsbo et al. present a fascinating proposal that links the formation of giant Zn-Pb-Ba sedex deposits and districts (e.g., Meggen-Rammelsberg, Germany; Macmillan Pass, Canada; Lisheen-Navan, Ireland; Red Dog, Alaska) with changes in the global geochemical and biological record. As the evidence they present suggests, the effects derived from the massive

venting of the mineralizing brines include measurable spikes in the Sr isotope record of seawater and, through a series of positive feedback mechanisms, mass extinctions of marine organisms. However, the fascinating consequence for economic geologists is the potential for “orphan” $^{87}\text{Sr}/^{86}\text{Sr}$ spikes in the geologic record to represent the signature of yet-to-be-discovered giant Zn-Pb-Ba deposits.

Using new, state-of-the-art isotopic and microchemical arguments collected from deposits in the Cretaceous Chilean iron belt, Simon et al. offer a thorough summary of a novel metallogenic model that helps explain the common temporal and spatial association of Kiruna-type iron oxide-apatite (IOA) and iron oxide copper-gold (IOCG) deposits as a combination of common igneous and magmatic-hydrothermal processes. The model involves a hitherto unexplored key genetic step, the flotation and concentration of igneous magnetite microliths, as these act as nucleation sites for volatile saturation within magma and fluid bubble generation—a process not unlike that used to recover sulfide in flotation cells around the world.

Kinnaird and McDonald and Yudovskaya et al. provide comprehensive and timely overviews of the latest geologic and ore deposit/exploration evidence and metallogenic thinking of one for the richest geologic formations in the world: the Bushveld Layered Igneous Complex, including its Northern Limb, where notable world-class developments have occurred in recent years, including the Flatreef platinum group mineral (PGM-)Au and Waterberg PGM discoveries. Selley et al. provide foundational descriptions of the stratigraphic and structural framework of the world's premier sediment-hosted Cu province—the Central African Copperbelt—showing that extensional geometry was preserved through later orogenic events. They demonstrate that the likely ore fluids were evaporite brines that formed during deposition of basin-wide salt sheets, and that the salt sheets had profound effects on subsequent tectonism and fluid flow. Hall et al. use lithostratigraphy and aeromagnetic data to help delineate the structural framework of the Kalahari Copperbelt in northwestern Botswana. Kalahari orebodies occur on the limbs and in hinges of regional-scale folds; these are structural end members of sedimentary rock-hosted stratiform copper deposits. Walsh et al. review fault-controlled fluid flow in sedimentary basins, which is key to the formation of many sediment-hosted mineral deposits. This review nicely complements the more widely published information on structurally controlled fluid flow in magmatic hydrothermal systems by providing basin-scale context for processes that control the formation of some of the world's largest and richest orebodies.

Four chapters in this volume review topics of general interest. Hayward et al. provide the cutting-edge as well as comprehensive review of a discussion topic common among exploration geologists: the apparent spatial periodicity existing among ore deposits—in particular, the main ore

deposits within some of the world's best-endowed mineral belts. Although a complete explanation of this feature remains elusive, the authors suggest that preexisting basement faults and self-organization, as an effective natural mechanism for dissipation of large energy gradients, may combine to influence spacial periodicity. Jowitt et al. approach the hot topic of critical metals—the concept of criticality being dependent on the situation of a particular country, industry, and government department—from the perspective of identifying and analyzing the main challenges involved in the quantification of criticality. Such challenges start with the simple estimation of global production and production of these metals as a by-product. McCuaig et al. review the systems approach to deposits that occur in sedimentary basins, showing how this process can inform petroleum and minerals exploration across all scales, from basin selection to the prospect scale. Jessell et al. describe 3D modeling and focus on the sources

of uncertainty in those models. They emphasize the scale-dependent nature of many types of uncertainty, and they point out that uncertainty is often quantified for certain steps, but rarely propagated through entire models.

A final word of appreciation goes to the financial sponsorship of SEG, which includes support for the production of this volume. The continued funding by sponsors provides valuable motivation for the Society of Economic Geologists staff and volunteers to continue to engage in high-quality, relevant work.

The Editors

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and Jeffrey L. Mauk,
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