Geology of Australian ore deposits

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SUMMARY

The *Australian Ore Deposits* monograph, published recently by The Australasian Institute of Mining and Metallurgy, has its focus on descriptive summaries of ore deposit geology. These summaries are expected to be long lasting compilations with value well after mines are exhausted and closed. Along with the more ephemeral genetic ideas as to how deposits might have formed, the descriptive approach remains a major component of any exploration program and invaluable during mine geology. The monograph records the state of the Australian mineral industry in 2017 providing a basis for documenting changes and progress since the previous monograph in 1998 and earlier ones starting in 1953. It will also become a benchmark to measure progress in years ahead.

Key words: *Australian Ore Deposits*, monograph

INTRODUCTION

The *Australian Ore Deposits* monograph is a collection of 175 papers spanning 200 mineral deposits (Figure 1). Ten overview papers are relevant to the mineral industry as a whole and they address Australia-wide issues of fundamental geology and geophysics, resources, data, discovery and terminology. A further six papers focus on the major commodities of nickel, iron, critical metals, rare elements, gold and heavy minerals. Individual deposit papers are organised by age from Archean to Proterozoic to Phanerozoic, then from regional to specific, by commodities, and if necessary, by local geography.

That we are now producing a sixth edition focused on descriptive geology indicates how widely the benefits have been recognised. The ore deposit series remains a very important resource for anyone contemplating mineral exploration in Australia and is a first point of information when moving into a less familiar area. It is the key reference for discovering what the major mineral types are in a region; for reading what the deposits look like and of their distinctive features; to appreciating their diversity of character; and for exposure to prior literature and contemporary genetic ideas.

The intended readership includes geologists and non-geologists who may be Australian or international, many of whom may not necessarily be familiar with a region or ore deposit type. Engagement with those for whom English is not their first language has required much editorial attention to reader-friendly and consistent terminology throughout *Australian Ore Deposits* – a difficult task with so many authors. Terms with multiple meanings among different authors pose a significant issue for a multi-authored monograph. Similarly, switching between different terms with the same meaning can be confusing. We have tried to limit the unnecessary creation of new terms or names where no value is added, reducing terminology variations between companies, districts or commodities, and minimising the mine dialect that has value within small groups working together but rarely beyond. With the long-term role of the volume in mind, we have sometimes asked for more mineralogical detail where authors have condensed complex assemblage information into single generic terms that would be of limited use in ten years. Apart from readers, we hope that a somewhat standardised terminology would appeal to managers, investors and visitors who should not expect to be re-educated before each mine visit.

The classification of a deposit receives less attention here than geological description. Some deposit classification names are useful, but others could disappear without great loss. Ultimately, a useful scheme should be practical to apply and have a theoretical basis; however, too often the definitions need ongoing reorganisation as new deposits are studied, and this is usually a sign that the system is flawed. A strong map legend can add great long-term value and reflects a sound classification and rock-type subdivision.

Scale is critical in geoscience, and rarely can metalliferous ores be considered in isolation of the surrounding geology. *Australian Ore Deposits* addresses this importance of scale by having papers devoted to regional geology and additional papers addressing important mineral provinces and specific commodities. This is a change from the 1998 edition and reflects the great progress made in using geophysics, including aeromagnetic, radiometric, gravity and seismic surveys, as well as collaborative field programs involving governments, universities and industry. The arrangement of the volume with overview papers at the front allows greater depth of discussion of the regional context without requiring repetition within every deposit paper. The contributions on mineral provinces and on commodities enable a synthesis of both large and small deposits, and some mention of recent exploration developments and closed mines.

REFLECTIONS UPON COMPLETION

Much was learned about Australian geoscience as the *Australian Ore Deposits* volume evolved. Of course, with hindsight there are editorial processes and standards that could have been addressed differently. Taking advantage of the global view of Australian ore deposit geology presented here, some ideas have emerged relating to a few easily implemented improvements around communication – using communication here in a broad sense to include data recording.

There are trends underway in geoscience that offer major benefits. For example, data collection is faster and cheaper, computer power has increased orders of magnitude and there are numerous innovative techniques to process and manipulate our data to our advantage in mine geology and exploration; however, the benefits from these opportunities will not come automatically, and will require excellence in communication.

Ideally, we require seamless communication relating to data from the previous decade, this volume and the next decade. We also need our descriptions of deposits and provinces across Australia to be seamless using unambiguous language and consistent terminology, in the same way that we benefit from seamless geology maps. In compiling *Australian Ore Deposits*, we have reduced some of the variations in terminology between companies, districts and commodities.

Structural information is critical in many mines, and much of the underground data becomes inaccessible once a mine is closed. Some companies are working on tenement packages with over 100 local grids at various orientations. Authors have expressed their data relative to true north so that the recorded data are unambiguous, as well as providing the reader with every opportunity to recognise the structural patterns within and between mineral fields that authors believe are important. The emphasis on strike (rather than dip direction) recognises it is strike that is portrayed by rock units on a conventional map.

Oversimplifying rock descriptions and condensing complex rocks to single terms might have a place in informal communication, but involves a substantial loss of information; for example, chloritic alteration can be a useful term for mine mapping, yet it conveys much less information than an accurate mineral assemblage, such as coexisting chlorite-albite-muscovite-quartz-magnetite-hematite-pyrite-siderite-ankerite. Condensing the rock descriptor to *chloritic* eliminates the opportunity to learn more through the application of sophisticated thermodynamic software, such as the redox conditions during metal precipitation. It is helpful when these assemblages can be arranged in a logical order, in this case: silicates, oxides, sulfides and carbonates. There are further terms that condense valuable information to our communal loss. It does not make sense to invest heavily in an airborne hyperspectral study and then reduce the mica information to the single word sericite; does this emphasise fine grain size, K-Na composition or a generic white mica? Reducing this to a single word loses the subtle compositional and crystallographic information that might inform on alteration and mineralisation.

Rock legends within maps influence how geologists think, the questions that they ask and what data are recorded. These rock legends should be presented in the traditional chronological format, not in an order determined by a geographic information system. Some companies have invested substantial resources in the development of a legend; they have been repaid through uniform and meaningful data collection and improved mine and exploration geology. An inspired legend can be the framework of rock classification for decades while still accommodating improvements. Two critical components of an effective legend are:

- The legend has a theoretical basis
- Applying the legend is practical for geologists

As examples, the legends at Kambalda nickel and Kalgoorlie gold mining centres established during the 1960s have had lasting value and international impact. An effective legend encourages the asking of astute questions and the collection of optimal data. However, such a legend does not emerge on the day of discovery; it requires trial and error, theory and practice, and multiple versions.

Virtually every new discovery is different in at least a few ways from any known deposits, so there is a need to describe and characterise each without complete access and with little as comparison. As these discoveries are developed into mines and more information becomes available the deposit description and classification may evolve and necessarily the first attempts at maps and a mine rock legend will improve. A major task in compiling the *Australian Ore Deposits* monograph was to respect and maintain the differences of geological approach between deposits and not to force deposits into one or other category against the available evidence. There was tension between this need to respect deposit individuality and at the same time ensure different terminology was not creating the appearance of difference where the latter was not real. Using common language for technical features was important so that the reader, maybe in 20 years' time, could recognise similarities and patterns without ambiguity.

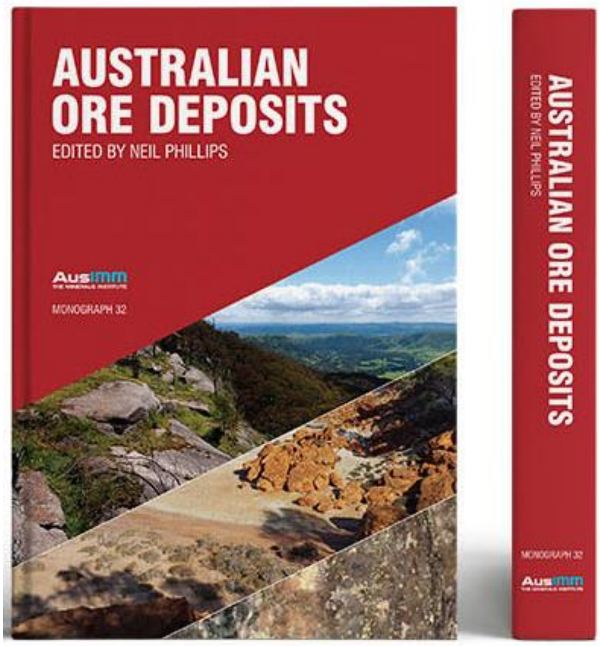

Figure 1. Front cover of *Australian Ore Deposits* monograph.

ACKNOWLEDGEMENTS

The final product is a 900-page volume describing the geology of Australian ore deposits from continent to open pit scales. More than 200 deposits are described by 350 authors. The scientific and literary quality of papers owes much to the AusIMM staff and the reviewers, and the willingness of authors to respond positively to their reviews. Bob Smith is acknowledged for his role championing the value of integrating geophysical details wherever possible. The production is made possible by sponsors particularly the Principal Foundation Sponsor, Rio Tinto. The final quality reflects the professionalism and pride of the AusIMM editorial staff, especially Kelly Steele. A wealth of leading practices and ideas have been generously shared by authors in *Australian Ore Deposits*. It is hoped that the next edition will reveal those who assimilate the best ideas to improve their operations. AusIMM gave permission to use much of the editorial and reflections within AOD as the base for this abstract. Marat Abzalov prepared the map of Australia showing all described deposits.

REFERENCES

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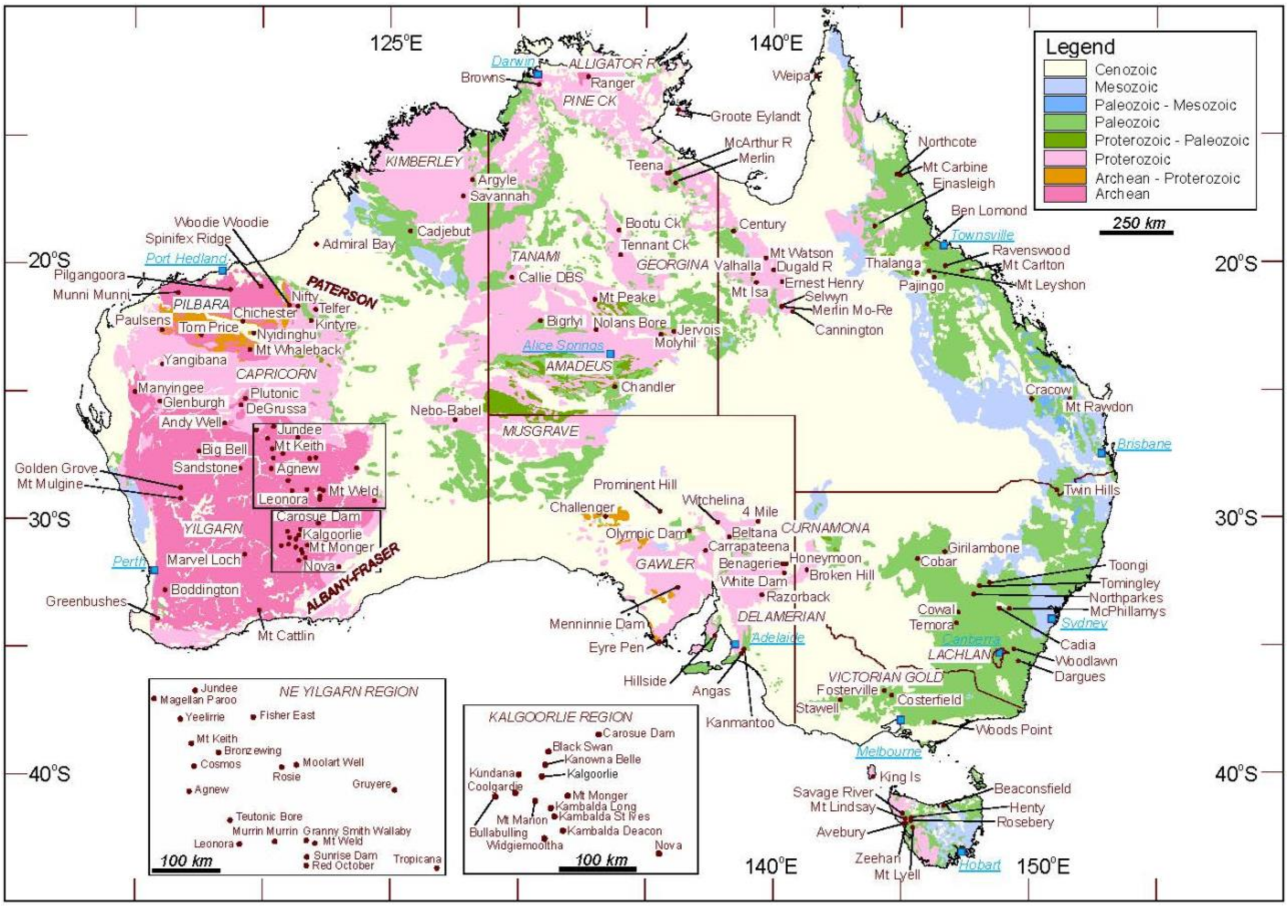

Figure 2. Map showing the location of all deposits included in *Australian Ore Deposits*. This map appears in the inside cover of the publication and is reproduced here with permission.