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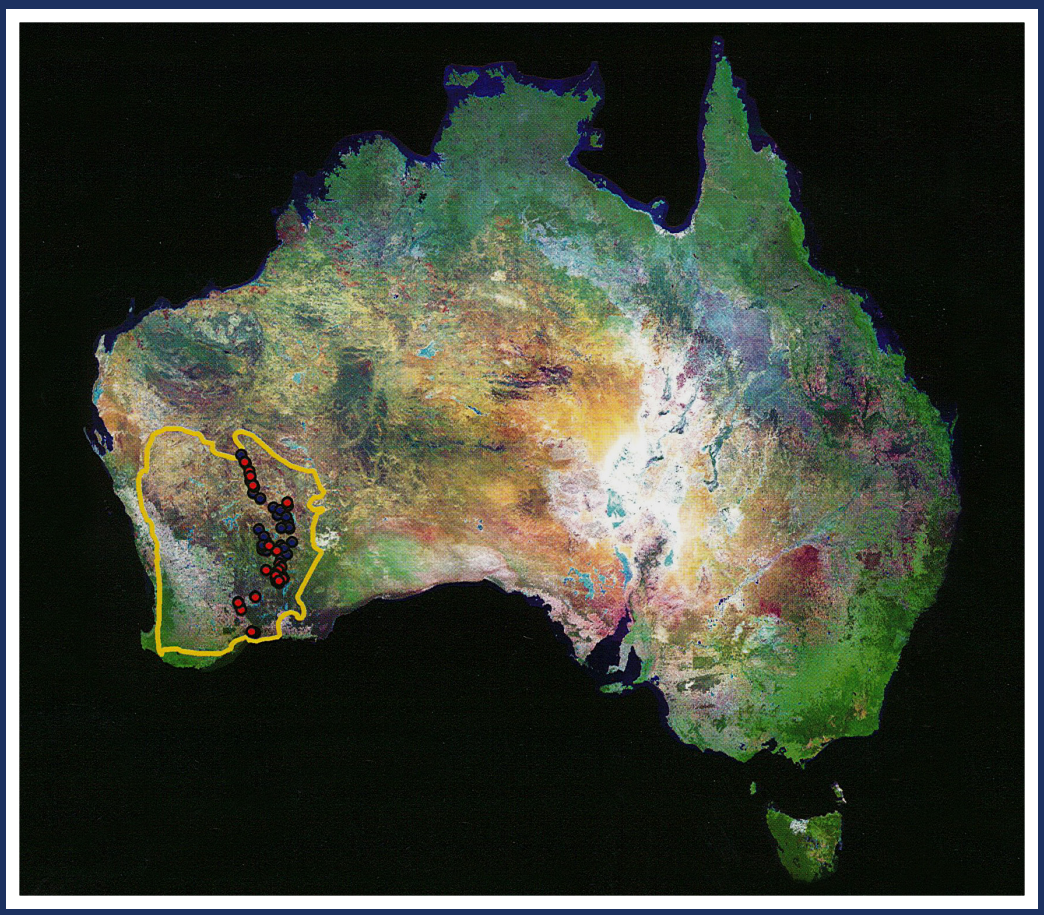
Nickel Deposits of the Yilgarn Craton: Geology, Geochemistry, and Geophysics Applied to Exploration



Editor

S.J. Barnes

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S.J. Barnes, Editor

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Table of Contents

Preface

The eastern half of the Archean Yilgarn craton in Western Australia is one of the world's major nickel provinces. It currently accounts for approximately 16 percent of world nickel mine production, and between 1966 and the time of writing has produced over 2.5 million tonnes of nickel metal (Hronsky and Schodde, 2006). It contains approximately 13 percent of global resources and reserves of nickel metal, divided between laterite and sulfide deposits, with about 40 percent of this in komatiite-hosted sulfide deposits. With the sole exception of one small gabbro-hosted sulfide deposit, Carr Boyd Rocks, this entire resource endowment is associated with ultramafic rocks of komatiitic affinity. The Yilgarn craton is the only nickel province in the world which contains both lateritic and sulfide deposits of economically exploitable size and grade (Maps 1 and 2).

This book was initially conceived as a handbook for geologists involved in the exploration for, and exploitation of, nickel deposits hosted in the komatiites of the Yilgarn craton. It covers the essential disciplines—geology, geochemistry, mineralogy, and geophysics—which are crucial not only to exploration but also to successful mining and processing of the ore. The scope of the volume grew somewhat in preparation, and I am hopeful that it will prove useful to geologists working in Archean terranes and on ultramafic rocks worldwide.

The history of the province began in the mid-1960s with the discovery at Kambalda of a previously unrecognized deposit type. The remarkable story of the emergence, from nowhere, of a major global resource province is documented in chapter 1 by Jon Hronsky and Richard Schodde, formerly of WMC Resources and now with BHP Billiton Ltd. The Yilgarn nickel province is a very instructive exploration case history, and the innovative approach taken by these authors is of relevance to explorationists for any metallic commodity (The reader should note that the final version of this chapter was submitted and accepted for publication in May 2005, prior to some recent nickel sulfide discoveries in the belt).

Chapters 2 and 3, by the editor (Barnes, 2006a, b), provide the geologic underpinning for understanding the nature and distribution of komatiite-hosted nickel sulfide deposits. Chapter 2 is an introduction to komatiites, the remarkable class of igneous rocks which hosts the deposits. The chapter emphasizes the primary features of this diverse suite of rocks, which can be used to determine their emplacement history. Most researchers in the field agree that the environment of emplacement, specifically the presence of long-lived magma pathways, is crucial to controlling the deposition of the orebodies. The komatiites are in almost all cases completely reconstituted during polyphase metamorphism and deformation, and recognizing the favorable environments and processes involves coming to grips with the geochemistry and metamorphic mineralogy of these rocks.

Chapter 3 is a broad overview of essential aspects of the geology, geochemistry, and genesis of the whole class of komatiite-hosted nickel sulfide deposits, with an emphasis on the type 1 deposits, i.e., those consisting of accumulations of sulfide-rich ore at the base of host komatiite units. An exhaustive account of all the deposits is impossible within the scope of this book, and to a large degree would duplicate information in the classic review of Marston (1984), so the chapter picks a limited number of deposits which exemplify the spectrum of primary and secondary features. A central section makes a case in favor of the broadly (but not universally) accepted substrate erosion hypothesis for the origin of the deposit class, and discusses its implications for exploration strategies. The relationship and contrast between the two major deposit classes, type 1 disseminated ores and type 2 sulfide-rich contact ores, is discussed and called into question.

Chapter 4, by Ben Grguric and coworkers (2006), formerly of WMC Resources and now with BHP Billiton Ltd, follows the previous chapter in being an account of the geology of some important deposits, in this case focusing on the large type 2 deposits of the central Agnew-Wiluna belt. The chapter is expanded in scope to include information on the mining and extraction strategies used for the giant Mount Keith deposit. These details are included because of the size and importance of the deposit, and of the crucial importance of secondary mineralogy and alteration processes to the economics of the operation. Mount Keith is exceptional among mined nickel sulfide deposits in the extent to which every aspect of the geologic history impinges on the economics of the operation, and these relationships are explored in this chapter.

Chapter 5 is an account by Charles Butt and Ernie Nickel of CSIRO Exploration and Mining, with Nigel Brand of ioGeochemistry Inc. (2006), of the consequences on nickel sulfide deposits and their host rocks of the prolonged and complex lateritic weathering which affects the entire province. Nickel sulfide deposits show supergene effects down to great depths owing to electrochemical reactions set up during the weathering process. Weathering processes have had a significant impact on geochemical dispersion of nickel and pathfinder elements, and unravelling these impacts depends upon a detailed understanding of landscape evolution since the Tertiary. The chapter summarizes the pioneering work on this topic carried out largely by CSIRO researchers over the last 30 years. This work is of specific application to Australian conditions, but has important implications in lateritic terranes elsewhere.

Chapter 6 is an account by Bill Peters (2006), of Southern Geoscience Consulting, of the geophysical methodologies in common use in nickel exploration in Western Australia. This chapter gives a general introduction to each method and case studies of the geophysical signatures of various Yilgarn deposits. Particular emphasis is given to the two most im-