The Geology and Tectonic Settings of China's Mineral Deposits

Franco Pirajno

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献给中国人民

to the people of China

Foreword

China is an emerging superpower, with a huge demand for raw materials and mineral resources that are being used to increase the standard of living conditions for its residents and bolster its surge forward in the global economy. To enable this rapid growth, China is also undertaking an education revolution with the help of experts from around the world in many different fields of endeavour.

This authoritative book—encyclopaedic in scope—fits very nicely into that frame by presenting a comprehensive account of China’s mineral deposits and how they relate to the geological history of that vast country by one of the world’s leading experts on mineral systems from Australia, Dr. Franco Pirajno.

Dr. Pirajno is eminently qualified to present this work, having had a diverse career in industry, government and academia that includes 19 years in mineral exploration with the Anglo-American Corporation of South Africa, a stint as Chair of Economic Geology at Rhodes University, South Africa, and 20 years with the Geological Survey of Western Australia. He has held visiting professorships at Peking University and China University of Geosciences and currently has honorary appointments at the Institute of Mineral Resources (Chinese Academy of Geological Sciences), Beijing, the University of Western Australia, Perth, the Centre for Russian and Central EurAsian Mineral Studies (CERCAMS, Natural History Museum, London) and the Australian Centre for Astrobiology, University of New South Wales, Sydney. This is his fourth book on mineral deposits. His first three are “Hydrothermal Mineral Deposits—Principles and fundamental concepts for the Exploration Geologist” (Springer-Verlag 1992), “Ore Deposits and Mantle Plumes” (Kluwer Academic Publishers 2000), and “Hydrothermal processes and mineral systems” (Springer 2009).

More importantly, Dr. Pirajno has travelled extensively through China and visited a variety of that country’s mineral deposits, providing the reader with first-hand accounts of critical observations.

The understated title of the book should not fool anyone: this richly illustrated and comprehensively referenced book achieves two remarkable, never previously attempted (at least in English), feats:

1) It describes and interprets the entire, 3.2 *billion* years, of geological history of China;

and

2) It provides detailed accounts of a wonderfully diverse range of mineral systems and places their genesis in the context of that long and complex history.

These achievements are no mean feat, given that the People's Republic of China is the third largest country in the world, with a land area of about 9.6 million sq km.

The book is divided into seven chapters. An introductory *Chap. 1* presents historical notes on mining and geology in China, time scales and definitions used in the book. *Chapter 2* provides a welcome overview of China's tectonic framework in the global context, together with tectono-thermal events that have formed the various mineral systems. This chapter provides the backdrop to the six chapters that follow, which focus on specific periods of China's geological history. *Chapter 3* describes the Archaean and Palaeoproterozoic geology of the North China and Tarim cratonic blocks, including the Phanerozoic mineral systems found in these areas. In *Chap. 4*, the geology of the Yangtze Craton and Cathaysia are described, together with their Mesoproterozoic through Early Palaeozoic amalgamation to form the South China Block. *Chapter 5* reviews the Phanerozoic South China Fold Belt, and the Qinling-Dabie-Sulu, Qilian and Hinggan orogens. *Chapter 6* presents the geology of the Tianshan, Junggar and Altay orogenic belts in northwest China (Xinjiang), part of the huge Central Asian Orogenic Belt that extends from the Uralides in the west to the Pacific Ocean margin of eastern Asia. The Alpine-Himalayan fold belts (Tethyan orogens), and Kunlun and Songpan-Ganzi terranes are also described in this chapter. *Chapter 7* is devoted to an overview of the Large Igneous Provinces (LIPs) of China, which range in age from Paleoproterozoic through to the Jurassic, and the widespread Yanshanian (Mesozoic) tectono-thermal event. Lastly, *Chap. 8* describes the volcano-sedimentary and sedimentary basins and grabens that cover much of China and are important due to their hydrocarbon resources.

However, the real strength of the book lies in the diversity of mineral systems investigated and the detailed descriptions of their occurrence, including well-known volcanogenic massive sulphide (VMS) deposits, epithermal and orogenic lode Au-Ag deposits, and orthomagmatic Ni-Cu and porphyry-style mineralisation, to less well known rare earth element (REE) deposits, Cu-Fe-Au skarns, rare metal pegmatites, and phosphorite and uranium deposits.

In summary, *The Geology and Tectonic Setting of China's Mineral Deposits* by Dr. Franco Pirajno represents a remarkable contribution in the understanding of China's rich and diverse mineral resource that will significantly enhance the success of commodity exploration in that country and its ability to sustain its growth well into the future.

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Foreword

The study of ore genesis is to understand how different mineral commodities, essential for the well-being of human beings, were formed. Such studies serve two purposes. First, they help to satisfy our curiosities about the world we live in. More practically, a good understanding of how the various mineral deposits were formed gives us the predictive power of defining where to look for new deposits.

I was almost totally ignorant about ore genesis during the early days of my career, partly because of my lack of opportunity to learn about it, partly because I was scared by the jargon such as VMS, MVT, SEDEX etc. Later on through my tectonic work in Jiaodong, eastern China where about a quarter of China's gold production comes from, and through running a research project on the tectonic evolution and iron ore genesis in the Hamersley Province of the southern Pilbara craton in Western Australia, of course also through attending talks by people working in the field, I gradually learnt that ore genesis is just part of the geological process that most of us can relate our research to. In other words, mineral deposits are no more than rocks (or sands in the case of mineral sand deposits) with special concentration of certain minerals or elements that are of economical value to society.

Economic geology is no doubt a field that requires specific knowledge, and has some unique approaches in conducting research. There are many excellent studies which approach ore genesis from the angle of Earth processes, linking mineralisation systems to broader geotectonic processes and events. Nonetheless, I noticed that there are also many studies that appear to stop at classifying mineral deposits into certain known categories, thus producing little new understanding about ore genesis and limiting the potential of having real predictive power of such studies to mineral exploration.

The Chinese continental crust is a mosaic of small cratons or terranes that had diverse origins, complex amalgamation histories, and often multiple post-amalgamation modifications. As such, it exhibits a full range of geotectonic environments and provinces fertile for a wide spectrum of mineral deposits. To fully understand the genesis of major mineralisation systems, be it related to continental rifting, mantle plume events, subduction systems, continental collision, terrane accretion, delamination, etc. etc., it is important to examine such mineralisation systems (not just individual deposits) in the context of the regional geotectonic

environments. Much excellent work has been done in the past, dominantly by Chinese researchers on Chinese ore genesis. A good such example is the study of the V-Fe-Ti-PGE and Ni-Cu-PGE deposits related to the Permian Emeishan mantle plume event. Nonetheless, because of the complex tectonic histories experienced by the Chinese continental blocks and orogenic belts, either between these blocks or within individual blocks, our past understanding of many of the mineral systems has been hampered by our limited knowledge of the tectonic evolution of the region, such as the nature of each major orogenic or magmatic event and how such events influenced the major mineralisation systems and provinces.

All these started to change rapidly in the past decade or so, thanks to the wide availability of modern analytical tools such as LA-ICPMS and SIMS among others, and the introduction of modern research approaches and scientific concepts into the Chinese geoscience community. For instance, we are now able to link discrete gold mineralisation events in Jiadong to precisely dated tectono-thermal events; we can now link the major pulses of magmatic events and related mineralisation systems in south China to possible plume events, orogenic collapses, slab delamination events, and so on. Nonetheless, this renaissance of geoscience research in China has only just started, with many new hypotheses still hotly debated, and many orogenic and magmatic events still poorly understood.

It is from this point of view that Professor Franco Pirajno's new book on "Geology and tectonic settings of China's mineral deposits" is very timely. Franco has a distinguished scientific career specialising on tectonics and mineral systems in Africa, Australia and many other parts of the world. He previously published three books on tectonics and mineral deposits: *Hydrothermal Mineral Deposits* (Springer-Verlag 1992), *Ore Deposits and Mantle Plumes* (Kluwer Academic Publishers 2000) and *Hydrothermal Processes and Mineral Systems* (Springer 2009). His interest turned to China about 15 years ago, leading to many high-impact scientific papers with Chinese colleagues. In the current book, he offers his views, as a western-based researcher, on Chinese tectonics and mineral deposits.

Following an Introduction (Chap. 1), the book is structured in such a way that readers will first get a general picture of the tectonic evolution of the Chinese continent in general (Chap. 2), and that of particular cratons or orogenic belts concerned by each chapter (Chaps. 3 to 6), followed by detailed accounts of all major mineral deposits in geological province concerned. Large Igneous Provinces in China are given special emphasis in a standalone Chap. 7, whereas Chap. 8 is devoted to volcano-sedimentary basins. In such a way individual deposits are no longer being treated in isolation. Instead, they are all part of various mineral systems/provinces lined to particular tectonic events.

During his years of interactions with China-based researchers, Franco has visited many parts of China and numerous deposits. The personal insights gained during such close collaborations are no doubt reflected in the many chapters. Of course, any book of such comprehensive nature would unavoidably involve much literature review and data compilation, including traditional views. In some instances Franco's preferred interpretations differ from mine, but this merely reflects the rapidly evolving nature of our understanding of the region.

This book will thus serve as an invaluable starting point for researchers from both outside and inside China to gain a general knowledge of a specific region or mineral commodity that they are interested in. I look forward to having a printed copy in hand.

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I consider myself lucky to be part of a “sans frontières” geoscience community, which has allowed me to visit and study numerous geological sites and mineral deposits and to share ideas and knowledge with colleagues from China, Australia, New Zealand, Russia, the United Kingdom, South Africa, Kyrgystan, the USA and Canada. They have all been a source of inspiration. Since my early visits and field experiences in China, I witnessed over the years, what can be labelled as an unprecedented surge and achievements by the Chinese in scientific, social and humanistic endeavours, perhaps never before experienced in the history of humanity .

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I take full responsibility for the contents of this book. If I have misrepresented some of the concepts or ideas obtained from the literature, this was unintentional and in no way reflects a disregard for the original author(s)’ work.

Last, but not least, I thank my wife and lifelong companion for not giving up on me.

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