

## BOOK REVIEW

**Book Review: Geological Belts, Plate Boundaries, and Mineral Deposits in Myanmar.** (2017) By Andrew Mitchell. Elsevier. eBook ISBN: 9780128033838; Paperback ISBN: 9780128033821, 524 p. \$150.00.

Myanmar is host to an abundance of mineral deposits, from gem-quality diamonds, rubies, sapphires, jade, and amber, to numerous occurrences of tin, tungsten, antimony, lead, and zinc, together with their oxides, hydroxides, sulfides, sulfates, carbonates, and many more exotic derivatives. Many of these occurrences are world class. Early in the development of the theory of plate tectonics, it was realized that these deposits were frequently related to activities along plate margins.

Andrew Mitchell, the author of this volume, has worked on the geology of Myanmar for nearly fifty years, first undertaking geological mapping as part of aid programs to Myanmar on behalf of the British Government and the United Nations, and then searching for mineral deposits on behalf of a commercial mineral exploration company. In the course of these projects he has collaborated with a great many Myanmar geologists. Consequently, he has accumulated knowledge of the geology of Myanmar and its mineral deposits, unequalled by any other foreign geologist. The results of his extensive experience have been poured into this volume.

In order to complete the coverage of mineral resources, the author has called upon the expertise of Andrew Racey and Mike Ridd, authors of a recent memoir (Racey and Ridd 2015) on oil and gas, to provide chapters on the on-shore and off-shore hydrocarbon resources of Myanmar.

For many years under the military dictatorship, Myanmar geologists were cut off from the international geological community, unable to purchase international geological books or journals, forbidden to publish their work in international journals, or to attend geological conferences outside Myanmar. In consequence, much geological information is locked away in ministry, university, or company internal reports, and unavailable to the general public. Owing to his long-term contact with geological organizations in Myanmar and individual geologists, the author has gained access to the information in many of these unpublished reports and has been the recipient of the many “oral communications,” which are quoted perhaps too frequently in this volume.

Fortunately, in the last decade or so this situation has vastly improved, with the founding of the Myanmar Geosci-

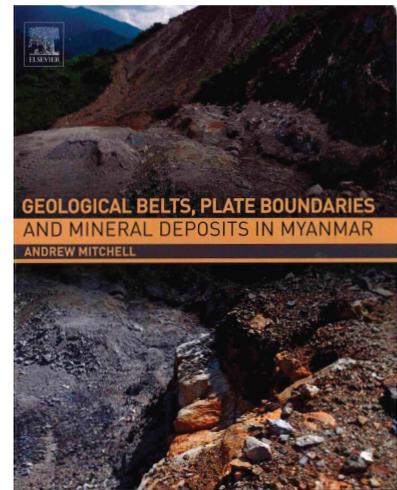
ences Society and the publication of its journal. In addition, Myanmar has hosted many international geological conferences and Myanmar geologists have been encouraged to present the results of their work at conferences elsewhere in Southeast Asia, and foreign geologists have been permitted to conduct research programs in Myanmar in collaboration

with Myanmar universities. These changes are reflected in the reference lists, which accompany each chapter in this volume.

Tectonically, Myanmar lies at the junction of two of the Earth’s major tectonic belts, the east-west Alpine-Himalayan Belt, the result of continental collision, and the northern extension of the Indonesian Island Arc System, with the subduction of the Indo-Australian Plate beneath the Eurasian Plate. In Myanmar this subduction is highly oblique, resulting in the dominance of strike-slip faulting within the continental margin. Andrew Mitchell was among the first to recognize the relationship between plate margins and the distribution of mineral deposits in southeast (SE) Asia (Mitchell 1979).

The author apologizes to readers from the mineral deposits community for the absence of “production data on minerals and gemstones ... [as] ... the focus here is on the geological environments, or settings in which the various types of mineralization formed.”

The strength of this volume lies in the accounts of the mineral deposits, which follow the account of the geology of each structural unit. Descriptions of the geology of Myanmar are given in terms of structural or tectonic units that broadly coincide with the east-to-west order in which they were added to SE Asia, followed by an account of their major mineral occurrences. The mineral deposits are therefore described in order of probable age rather than strictly by commodity or economic importance. Localities of mineral deposits are shown on the accompanying maps. The



author does not include mineral and gemstone production data as the focus of the volume is on geologic environment. Readers interested in production data and lists of occurrences of commodities are referred to the relevant chapters by Myanmar authors in the volume edited by Barber et al. (2017).

The classic Burmese gem fields occur around Mogok, on the Shan Plateau north of Mandalay, where rubies, spinels, and sapphires, with a large number of other mineral species (Kyaw Thu and Khin Zaw 2017), are found in marbles, adjacent to igneous intrusions, and in alluvial deposits. Similar deposits have been discovered recently in 1990 at Mong Hsu in the eastern part of the Plateau.

Myanmar is also famous for jadeitite from the Jade Mines Belt in Kachin State, produced by the metasomatic alteration of peridotites in a subduction zone. Jadeitite may occur as outcrops in situ or as boulders in alluvial deposits. Another is “Burmese Amber” (burmite) in the Hukawng Valley which has the richest biota of any Cretaceous amber, yielding abundant inclusions of plants and insects, occasional reptiles, and the tail of a feathered dinosaur.

The numerous base-metal deposits in Myanmar are described and compared with their international counterparts. The prolific Bawdwin lead-zinc-silver mine on the Shan Plateau is equated with the Kuroko type deposits of Japan, despite interbedded ripple-marked sandstones interpreted as shallow water deposits in the Bawdwin, unlikely to have been formed by black smokers at a mid-ocean ridge. A full account of this occurrence has been given recently by Gardiner et al. (2017), who place it in the siliciclastic-felsic variety of volcanic massive sulfide deposits. The lead-zinc deposits in Ordovician limestones in the southwest part of Shan State are interpreted as Mississippi Valley type. A belt of granites with associated tin-tungsten mineralization extends from the Malay Peninsula through Thailand, the Mergui and Taninthari Districts of Myanmar to Yunnan in China.

Although this reviewer is reasonably familiar with the geography of Myanmar, he found the sections on the geology hard going. The author presumes a familiarity with the geography which few readers outside Myanmar will possess, and although the text is generously illustrated by clear, bold geological maps, cross sections, diagrams and field photographs, not every locality mentioned can be located easily on the maps.

The scope and focus of the book mean that some critically important recent developments in the understanding of the plate tectonics of Myanmar are missing. A case in point is the Plateau Limestone Group on the Shan Plateau. A detailed account of the development of the stratigraphic nomenclature of this extensive limestone group, which ranges in age from Late Cambrian to Late Triassic is given on page 41. In a recent paper, Zaw Win et al.

(2017) give an account of the Permo-Triassic part of this succession, in which they recognize a major unconformity between the Middle Permian and the Middle Triassic. These authors interpret the sequence to indicate that the Permian continental shelf was broken up by extension to form a horst and graben structure in the Triassic. One could never deduce this scenario from the account of the Plateau Limestone given in Mitchell's book.

The same relationships are seen throughout SE Asia, where following the collision between Sibumasu and Indochina in the Indosinian Orogeny, the whole region was subject to extension, with the formation of horst and graben structures, from West Burma to Yunnan, eastern Thailand, Malaysia, and Sumatra, as detailed by Barber et al. (2017).

The major suture zone between Sibumasu and Indochina is located in Thailand and in Yunnan, but to this day it is uncertain where precisely it is situated in eastern Myanmar. Possible positions of the suture zone, as suggested by various authors, are illustrated in their Figure 3.2. Also, it is not known for sure how many north-south continental slivers or closed ocean basins occur in central and western Myanmar. There are also disputes concerning the direction of emplacement of ophiolitic bodies, and whether ocean basins were subducted eastward or westward. All of these problems are fully discussed in the text, for example for the Indo-Burman (Myanmar) Ranges. The author also offers his own solutions, with which not everyone would agree. Many aspects of the plate tectonic history of Myanmar remain for future generations of geologists to resolve. Even with its limitations, this volume makes the geology of Myanmar more accessible to mineralogists and geologists worldwide.

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