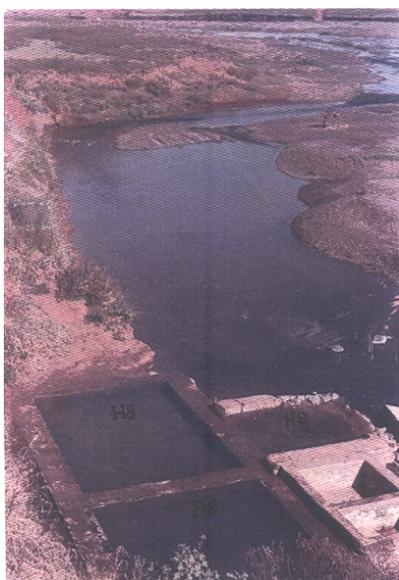


the extent of the lava flows in terms of spatial distribution and thickness. In the section on structure of the Deccan Trap province, the authors mention some important lineaments and faults, but the inclusion of a lineament map is much desired. Recently gained knowledge on the structure and possible origin of the Panvel Flexure needs to be added in future editions to make the section more comprehensive. The attempt at presenting the chemostratigraphy and lithostratigraphy of the Deccan Trap is laudable. The authors have included the lithostratigraphy of the central, southeastern and eastern parts of the Deccan subprovince where chemostratigraphy is poorly understood and is complicated by normal–reverse–normal palaeomagnetic signature of the lava flows. Sadly though, the physical characters of lava flows need to be updated. The physical volcanology of the lava flows from the Deccan Traps has received considerable attention in the past decade. In the Deccan Traps, attempts at classification of lava flows on the basis of external morphology and internal structures have been initiated and their emplacement dynamics has been deciphered using modern volcanological tools. Such studies have led to the identification of pahoehoe, aa and transitional flows like slabby and rubbly pahoehoe. Recently, dykes, sills and other minor intrusive along the Narmada–Son and West Coast tectonic zone have been studied for their field, petrological and geochemical aspects and these also need to



Koknere hot spring.

be incorporated in the next edition. The chapter on Deccan Traps is made interesting by inclusion of a good description of the world famous Lonar crater, the only hypervelocity impact crater in a basaltic province.

In the chapter on Tertiary–Quaternary of Maharashtra, the emphasis is on explaining the 1.5 million year long hiatus or lack of sedimentation during the early Tertiary. According to the authors, the period is marked by widespread Earth movements that are responsible for the development of a major part of the physiographic features in western Maharashtra, especially along the Sahyadris. The description on the occurrence of laterites along the Sahyadri crest and Konkan plain is informative. Fair descriptions of the older and younger alluvium in the Tapi–Purna, Godavari, Wardha, Penganga and Wainganga basins are also included. The preliminary information on the volcanic ash at Bori in the Kukdi river basin is fascinating, but its relation to the Toba eruption could have further enriched its value. A small section on the Quaternary sands and beachrock deposits along the Konkan coastline that has important bearing on sea-level fluctuation, salt-water intrusion and placer deposits may also be included in the next edition.

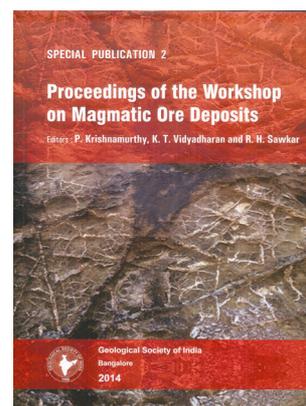
The compilation on the mineral resources of Maharashtra is one of the best available for the state and is an important chapter in the book. It includes some important occurrences and reserves of metallic (e.g. manganese, iron, chromite, gold, etc.) and non-metallic deposits (barite, bauxite, clays, etc.) in the state. The authors have also included crucial information on fossil-fuel occurrences like coal, lignite, oil and gas, coal-bed methane and shale gas. The summary on the geothermal potential of Maharashtra that deals with important aspects like occurrence, discharge and hydrogeochemistry of hot springs from the West Coast geothermal field is scholarly and invaluable. Its inclusion has enriched the utility of the book. This chapter thus sets the tone towards natural resources management and energy potential of the state, two issues that will prove critical in the near future.

The authors through their mastery, dedication and passion have painstakingly researched and compiled a commendable textbook on the geology of Maharashtra, for which they need to be

congratulated. This standard textbook has all the ingredients to satisfy the needs of undergraduate and postgraduate students studying geology and will appeal to researchers as a ready reference on the subject. A good bargain, the book must occupy a prominent place in departmental libraries and personal collections. It should be increasingly used in class while teaching subjects like stratigraphy, economic geology and mineral deposits of Maharashtra. We, the faculty, professionals and students of geology in Maharashtra are grateful to the authors for providing an excellent overview of the Geology of Maharashtra.

RAYMOND A. DURAISWAMI

*Department of Geology,
Savitribai Phule Pune University,
Pune 411 007, India
e-mail: raymond_d@rediffmail.com*



Proceedings of the Workshop on Magmatic Ore Deposits. P. Krishnamurthy, K. T. Vidyadharan and R. H. Sawkar (eds). Special Publication No. 2, Geological Society of India, Post Box No. 1922, Gavipuram P.O., Bangalore 560 019. 2014. x + 230 pp. Price: Rs 1500.

Magmatic ore deposits form within igneous rocks or along their contacts in which ore minerals are crystallized from a melt or were transported in a melt. Some of the important magmatic deposits are hosted by mafic and ultramafic rocks. These include chromite deposits, nickel–copper (Ni–Cu) deposits and platinum group of elements (PGE). While the chromite and nickel–copper deposits play a vital role in metal industry, the PGE are crucial in the

automotive and healthcare industries. During the last decade, considerable new insights have been gained worldwide in the processes which govern the metallogenesis, tectonics and structural controls of these deposits. These new insights also necessitated induction of new methods in the exploration, laboratory studies and chemical analysis. In this background, it is but natural that a new publication on the magmatic ore deposits of India will be eagerly read by the mineral exploration fraternity.

This special publication of the Geological Society of India represents a collection of 18 papers presented at the International Workshop on 'Recent development in the chromite-platinum group elements and Ni-Cu sulphides, Cr, Ti and V ore fields' held at Bangalore in December 2012. In his foreword, Anthony Naldrett who has provided phenomenal insights into the metallogenesis of magmatic ore deposits worldwide, makes the interesting observation that most of the world's important Ni-Cu-PGE mineralization has occurred within or at the exits of magma conduits and future discoveries will likely be associated with mafic-ultramafic bodies that have only a small footprint. This statement echoes observations made in the beginning of the current century that exploration for magmatic Ni-Cu sulphide ores should be redirected from layered intrusions to their associated conduits. Yet layered intrusions still remain the main target of exploration in the Indian context as observed from most papers in this publication.

The papers are arranged in three sections, namely (1) Ni-Cu-PGE, chromite and V-Ti magnetite mineralization and exploration strategies, (2) geology, mineralogy and geochemistry of V-Ti magnetite, chromite and PGE in ultramafic and mafic rocks, and (3) experimental studies in sulphide-bearing systems.

The first section has seven papers. Dhanendran *et al.* present details of the sulphide and PGE minerals identified by electron probe micro analysis (EPMA) in the chromitites of the Sittampundi layered anorthosite complex in Tamil Nadu, where the Geological Survey of India (GSI) has established a small PGE resource of 0.25 million tonnes of ore with an average grade of 1.44 g/tonne of Pt + Pd. The Mothinamakki-Birolli mafic-ultramafic body in Uttara Kannada district, Karnataka has been investigated

recently by Ramakrishna Setty *et al.* to assess its PGE potential. They record anomalous Pt (up to 658 ppb) and Pd (up to 593 ppb) contents from the sulphide-bearing pyroxenite layers of this body. Dora *et al.* present the results of their investigations on the sulphide-bearing zones within gabbroic rocks of Heti area in Chandrapur district, Maharashtra, where a team led by Dora has proved the presence of Ni-Cu-PGE mineralization. This paper also highlights the challenges faced in chemical analysis of drill core samples for PGE.

While the above three papers dealt with reasonably well-preserved layered mafic-ultramafic complexes, Mohanty *et al.* provide the challenges involved in the exploration of PGE in a highly deformed and dismembered layered ultramafic complex – the Archean Nuggihalli Schist Belt of Karnataka. They provide detailed description of the field, petrographic and electron probe studies of the major rock types from the Ranganatha Gudda prospect, where they have recorded more than 2.5 g/tonne of Pt + Pd from gabbroic anorthosite. Devaraju and Alapieti provide a review of their persistent efforts, lasting over a decade, to scan the major mafic-ultramafic bodies of Karnataka in search of PGE mineralization. Among the areas sampled by them, they reckon that the Hanumalapur prospect in the Channagiri mafic-ultramafic complex is most promising, where they have recorded PGE assays up to 5 g/tonne in komatitic basalt. The paper by Vidyadharan *et al.* makes an effort to identify new exploration targets for Ni-Cu-sulphides, PGE, V-Ti-magnetite (VTM) and chromite in Karnataka, in the light of the existing data and emerging trends worldwide. In the only contribution in the volume from the mining companies, R. K. Mohanty *et al.* (Tata Steel) share their experience on the use of modern core orientation and deviation tools in the Sukinda chromite mine. They also highlight the use of modern proprietary software in resource estimation using geo-statistical techniques. While these hardware/software tools are now routinely used by most private sector exploration companies as part of their QA/QC practices, most government exploration agencies in India are yet to fully exploit the huge advantages from such practices in their drilling projects.

There are nine papers in the second section. Chakraborty *et al.* describe the

field, petrographic and ore mineralogical features of vanadium-bearing titaniferous magnetite (VTM) near Ramchandrapur, West Bengal. They have inferred that the textures observed in these magnetite bands which are associated with high-grade rocks such as mafic granulites and khondalite are indicative of their polycyclic nature. The paper by Subba Rao *et al.* presents the PGE geochemistry of the mafic-ultramafic rocks and chromitites of Nuggihalli Schist Belt. The paper by Das is on the VTM bodies of Mayurbhanj, Odisha, associated with gabbro-anorthosite rocks. Citing evidences from mineralogy, texture and ore chemistry, he infers that these bodies were formed due to residual liquid injection.

Maibam *et al.* provide new data on the chemistry of the chrome spinels from Indo-Myanmar ophiolite belt and attempt to infer their tectonic setting. They present a rather interesting observation that these rocks, though presently located along the collision zone, show certain characteristics of both Mid Ocean Ridge setting as well as fore arc environments. Satyanarayana *et al.* present the geochemistry of ultramafic rocks of Madawara complex in Lalitpur district, Madhya Pradesh, where slightly anomalous PGE assays were recorded in ultramafic rocks. Manikyamba and Saha provide geochemistry of Sigegudda komatites of Karnataka, where they have recorded relative enrichment of PPGE (Pd, Pt, Rh) over IPGE (Ir, Os, Ru). PGE potential of the numerous Sargur-type mafic and ultramafic enclaves in the Antarghatta belt is the topic of the paper by Sunder Raju *et al.* They report Pt + Pd assays up to 6.5 g/tonne from this belt. Subramanyam *et al.* describe the PGE geochemistry of the Boggulakonda gabbroic complex in Prakasam district, Andhra Pradesh. Balaram traces the recent developments in quantitative determination of PGE in a timely review. He compares the detection limits achieved by various contemporary analytical techniques.

The last section of the volume has two papers. In the first paper, Jehan and Pruseth report that they could successfully create melt even at 595°C in the experimental system PbS-FeS-ZnS-Cu₂S by adding excess sulphur and copper. Using this observation as a proxy, in the second paper Pruseth and Mishra indicate the possibility of Sargipalli lead zinc deposit being formed by high-temperature melting of a sulphide

assemblage as a magmatic sulphide deposit.

As expected from a volume of this nature, it is not completely bereft of shortcomings. The maps accompanying some of the papers not only lack clarity but also lack detailed structural and petrological data. It is a matter of concern that while the present-day field geologists have easier access to the modern laboratories, the data generated in these laboratories are not fully utilized in refining the geological maps. This is all the more important since the emphasis in

the exploration of magmatic ore deposits should be towards locating the magma conduits, as mentioned by Naldrett in his foreword. Location of such conduits is most likely to be controlled by transtensional domains within the regional structural framework. Several diagrams are also not legible. The most important PGE deposit in India, the Baula Nausahi PGE deposit in Odisha, where a significant resource has been identified recently, is not represented in this volume. In spite of these shortcomings, this volume with contributions from active workers in the

field of exploration of magmatic ore deposits would be useful to students, researchers, professional agencies, as well as exploration companies interested in magmatic ore deposits.

M. K. DEVARAJAN

*Geomysore Services India Pvt Ltd,
'Raja Ikon', 4th Floor,
89/1, Opposite Hotel Park Plaza,
Marathahalli,
Bangalore 560 037, India
e-mail: devarajan@geomysore.com*
