Society of Earth Scientists Series

Series editor

Satish C. Tripathi, Lucknow, India

The Society of Earth Scientists Series aims to publish selected conference proceedings, monographs, edited topical books/text books by leading scientists and experts in the field of geophysics, geology, atmospheric and environmental science, meteorology and oceanography as Special Publications of The Society of Earth Scientists. The objective is to highlight recent multidisciplinary scientific research and to strengthen the scientific literature related to Earth Sciences. Quality scientific contributions from all across the Globe are invited for publication under this series. Series Editor: Dr. Satish C. Tripathi

More information about this series at http://www.springer.com/series/8785

M. E. A. Mondal
Editor

Geological Evolution of the Precambrian Indian Shield

The Society of Earth Scientists
2008

Springer

Editor
M. E. A. Mondal
Department of Geology
Aligarh Muslim University
Aligarh
India

ISSN 2194-9204 ISSN 2194-9212 (electronic)
Society of Earth Scientists Series
ISBN 978-3-319-89697-7 ISBN 978-3-319-89698-4 (eBook)
https://doi.org/10.1007/978-3-319-89698-4

Library of Congress Control Number: 2018940000

Printed on acid-free paper

This Springer imprint is published by the registered company Springer International Publishing AG part of Springer Nature
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Series Editor Foreword

The Indian Subcontinent is largely constituted by Precambrian cratons and mobile belts; sedimentary basins containing record of nearly 3.0 billion years of Earth's history and constantly remained the area of extensive research for geoscientists over period of time. Cratons with Archean nuclei welded together by end Archean and 'Purana basins' developed subsequently in different pulses recorded geodynamic, paleoenvironmental and paleogeographic signatures of Proterozoic. The evolution of life was also first identified in these sedimentary basins. The status of knowledge and future course of study has been evaluated time and again in past, still efforts to understand geological evolution continued with adding new data and interpretations to our knowledge. These new data from Indian subcontinent are useful for understanding global scenario of evolution of Earth during Precambrian.

Understanding the need of the hour, a national conference and field workshop on 'Precambrians of India' was organized at the heart of Bundelkhand craton (22–24 November, 2016, Jhansi, U.P., India) by The Society of Earth Scientists jointly with Bundelkhand University. Based on the presentations, selected scientists were invited to contribute for this volume *Geological Evolution of the Precambrian Indian Shield* edited by Prof. M. E. A. Mondal of Aligarh Muslim University. The contributions address almost all the aspects of Precambrian geology of India. The book is published under prestigious *Society of Earth Scientists Series* by Springer. I hope the contributions will evolve new understanding about the Precambrian times.

Satish C. Tripathi

Contents

About the Editor

Dr. M. E. A. Mondal is Professor of Geology, Aligarh Muslim University, Aligarh, U.P., India. Research interests of Prof. Mondal include magmatic and tectonic processes of Precambrian crustal evolution, hard rock and clastic rock geochemistry. He is particularly interested in understanding the geodynamic evolution of Indian continental lithosphere, viz. Bundelkhand craton, Bastar craton and Aravalli craton through multidisciplinary approach involving field studies, petrology, geochronology and geochemistry. He teaches igneous and metamorphic petrology, geochemistry, geodynamics and engineering geology at U.G. & P.G. levels. He is recipient of National Geoscience Award-2017. He has published 73 research papers in peer-reviewed journals including *Precambrian Research*, *Gondwana Research*, *Lithosphere*, *Tectonophysics*, *Island Arc*, *Journal of Asian Earth Sciences*, *Geochemical Journal*, *Terra Nova*, *Geological Society, London*, *The Journal of Geology*, *Geoscience Frontiers*, *Current Science*, *Journal of the Geological Society of India* and *Journal of Earth System Sciences*. Total citation of his papers is 605 as on May 2018. He has completed 08 research projects sponsored by DST & UGC, and at present carrying out 01 research project sponsored by Ministry of Mines, Govt. of India. He is fellow and life member of many learned bodies and has been a member of National Working Group for International Geological Correlation

Programme (IGCP) on A-type granites and related rocks (IGCP 510), and International Geological Correlation Programme (IGCP) on The Changing Early Earth (IGCP 599). He is member of Science Program Committee and Coordinator of the theme "Hadean to Archaean Earth" of the 36th Indian Geological Congress (IGC-2020).

Introduction

The Precambrian shield of India, like that from different parts of the world, has also a protracted checkered history of evolution with diverse processes of crust formation, crust accretion, cratonization, evolution of basement and cover sequences. Despite efforts in the recent past, there still remain serious knowledge gaps in the geological history of the Indian shield, mainly stemming from the absence of critical data. In some cases, where data are available, many remain uninterpreted, or poorly interpreted or unconnected to robust geological evidence causing hindrance to the understanding of a comprehensive evolutionary model of the Precambrian Indian shield.

During the last two decades, there has been a great transformation in our understanding of the Precambrian history of the Indian shield, as more and more Indian geoscientists started delving into the Precambrian history of the Indian shield armoured with state-of-the-art technology. As a result, a quantum jump is noticed both in terms of quality and quantity of data that contributed tremendously towards better understanding of the Indian shield. There has also been a paradigm shift in our approach to look at the Precambrian shield regions over the years. There is a growing realization that a holistic approach, incorporating huge petrological, geochemical, isotopic, geochronological, structural, metallogenic, sedimentological and paleobiological data of the rocks of the Precambrian shield area, is lacking. This book which is a collation of papers on these diverse topics is an attempt to fulfil this aspiration.

This book presents a collection of 27 papers on varying topics aimed to depict the geological evolutionary history of the Precambrian shield of India. All the papers in the book were peer-reviewed by two or more reviewers. Out of 32 papers received, only 27 have been accepted after peer review.

In the first paper on Indian shield, Roy proposed that the pristine Indian shield had undergone several changes during the break-up of the Gondwana supercontinent. He further suggested that the individual protocontinents comprising the Indian shield have distinctive history of crustal evolution processes, pointing to the non-viability of large-scale process responsible for the evolution of these continental nuclei. Sharma and Mondal gave a new model for the evolution of the Indian shield. On the basis of striking similarities in geochemical signatures, temporal evolution, lithological make-up of the Singhbhum and the Aravalli-Bundelkhand craton, they opined that the partial melting of the amphibolites belonging to the Older Metamorphic Group of the Singhbhum craton was responsible for the formation of the Archean granitoids of the Aravalli and the Bundelkhand cratons. They further proposed an alternative model that invokes fragmentation of a single continental mass to give rise to individual cratons of the Indian shield.

Dey et al. reported high-precision U-Pb (SHRIMP-IIe) zircon geochronological data from the Jahazpur granite and associated Mangalwar gneiss of Deoli-Jahazpur-Hindoli region of the Aravalli Craton. Their work suggests emplacement age of 2538 ± 5 Ma for the Jahazpur granite, and 2520 ± 37 Ma is the timing of the high-grade metamorphism and anatexis of the Mangalwar gneiss. This work further suggests that the Neoarchean Jahazpur granite and Mangalwar gneiss are constituents of the Banded Gneissic Complex which forms the basement of the Hindoli-Jahazpur supracrustal sequence. Using geochemical proxies of the gneissic rocks belonging to BGC-I, Aravalli craton, Ahmad et al. propose that partial melting of an enriched source (such as oceanic plateau), rather than a MORB-type oceanic floor, was responsible for the generation of the TTG magma which are now occurring as gneisses. Rahaman et al. carried out geochemical and Nd isotopic studies of the Neoarchaen-Paleoproterozoic granitoids from the Aravalli craton and argued for heterogeneous crustal evolution processes to produce at least two distinct types of granitoids: sanukitoid-type and high-K type granitoids.

Mohanty reported reducing environment of atmosphere and ocean during Archaean-Paleoproterozoic boundary from Sausar belt of central India from the study of a paleosol horizon. Saikia et al., on the basis of mineral chemistry, Sr-Nd isotope data of granites of Chotanagpur Granite Gneiss Complex, inferred that the granites of the Chotanagpur Granite Gneiss Complex and those of the Mahakoshal Mobile belt are correctable, and during Mesoproterozoic time, significant crust formation took place in arc environment as a consequence of subduction of the South Indian Block beneath the North Indian Block which is now manifested as the Central Indian Tectonic Zone marking the suture between the two proto continental blocks. Based on detailed mapping and structural analysis, Bhardwaj and Biswal proposed that the Punagarh basin probably formed as a result of extension in the Trans-Aravalli terrane by reactivation of faults in Pali lineament. Prabhakar and Shareef made a review of six sulphide mineralized zones from the Eastern Dharwar Craton from the point of view of their style of mineralization and their iron oxide copper gold (IOCG) type affiliation. This work opens up new vistas for their understanding through an integrated and holistic approach which would enable to evaluate the metal potential including by-product values. Mukherjee et al. made an attempt to understand the mismatch between the experimentally achieved deformation mechanisms at different temperature and pressure and observed the brittle or ductile behaviour of pyrite in naturally deformed sulphide bodies by studying pyritic ores in three sediment-hosted Pb-Zn sulphide deposits of Rajasthan (Balaria-Zawar, Rajpura-Dariba and Rampura-Agucha), occurring in broadly similar geological settings, but deformed and metamorphosed at different grades.

The work of Mukhopadhyay et al. on detailed facies, architectural element, paleocurrent and stratigraphic architectural analysis of the Neoproterozoic Badami Group of rocks revealed a frequently avulsive braided pattern, with flashy discharges, for the paleoriver system. In another contribution, Mukhopadhyay et al. put forward aseismic tectonics, related to long-term geoidal tilt in a strike-slip basinal setting, to explain the shallow-depth soft-sediment deformational features almost omnipresent within the Chikkshelikere Limestone Member of the Proterozoic Kaladgi basin. Velmurugan et al., based on geochemical study of the clastic rocks, propose that gneisses and granitic rocks of the Dharwar Craton and the basement rock (schist) of the Kaladgi-Badami Basin could be the source rocks for the Kerur Formation of the Badami Group. Samanta et al. reported cyclicity in sedimentation system from the Neoproterozoic Sirbu Shale of the Upper Vindhyan based on detailed sedimentological analysis. They further opine that although the Sirbu Shale represents a sag basin, tectonics has played a key role in controlling the sequence architecture of the formation. Absar et al. made an attempt to systematically sample the carbonate rocks from three stratigraphic horizons of Bhima Group and conducted geochemical and C-O isotopic studies in order to understand the source of dissolved components, redox condition and biogeochemical cycling of Mesoproterozoic Ocean.

Quasim et al. gave a detailed diagenetic account of the Proterozoic Kaimur Group Sandstone and proposed intermediate burial (2–3 km depth) of the sediments. They further observed that the reservoir quality of the studied sandstones is reduced by authigenic clay minerals, cementations, and on the other hand, it is increased by alteration and dissolution of unstable grains. Rashid et al. proposed crustal history from the geochemical studies of post-Archaean rocks of Arunachal Pradesh, NE Lesser Himalaya. They proposed that the Lesser Himalayan sedimentary rocks are derived from the granites which might be similar to their basement Proterozoic granites from the Himalaya, challenging the existing hypothesis that sediments were derived from the granites of Bundelkhand and Aravalli regions of the peninsular India. Bhattacharya et al. systematically documented tidalites from the Mesoproterozoic Bayana Formation for the first time, and highlighted important aspects of Precambrian sedimentation in the Lalsot sub-basin, North Delhi Fold Belt, Rajasthan.

Hussain et al. made an attempt to ascertain the source composition of the gneisses and the schists comprising the Precambriam basement complex of the Shillong plateau. Based on the geochemical characteristics of both the rock types, it was suggested that the precursor sediments were derived from felsic sources. Khan et al. carried out systematic field survey to delineate a complete sequence of an ophiolite complex, called Phulad ophiolite in South Delhi Fold belt and proposed a fore-arc setting of this complex. Bhagat and Kumar, based on geochemical characteristics, proposed an island arc geodynamic setting for the origin of the epidiorite associated with the Dhalbhum Formation of the Proterozoic Singhbhum basin. Guha et al. conducted detailed geological and geochemical investigations of Anjana granite, Rajasthan and proposed that dehydration reactions of pelitic and mafic precursor rocks produced the granitic melt. Guha in his another paper reported metamorphism, crustal evolution and amalgamation of Meso- to Neoarchaean greenstone-granite terrane in Rajasthan. He proposed amalgamation of different greenstone sequences by simple terrane accretion model wherein the intrusive plutonic granitic bodies acted as stitching joins. The complexly deformed and metamorphosed high-grade granulite gneiss terranes occurring as tectonic wedges between greenstone-granite cratons is explained by deep crustal asymptotic ductile shear zones whereby the granulite gneisses were excavated from deeper levels of the crust.

Raza and Mondal, on the basis of geochemical studies, suggested the occurrence of two distinct rock associations in Bundelkhand greenstone belt: an oceanic assemblage and a subduction-related assemblage. Singh et al. carried out geochemical study of a granite and co-genetic pegmatite of the Kawadgaon area in Bastar craton, central India and observed higher abundances of high field strength elements in the pegmatite. Wani and Mondal carried out detailed geochemical study of the Precambrian Mahakoshal and Sonakhan greenstone belts of the central Indian Shield and proposed that the greenstones developed via subduction processes. Sharma and Singh presented a review of occurrences of megascopic carbonaceous remains from the Proterozoic Vindhyan, Chhattisgarh, Bhima, Kurnool and Deoban Formation of Lesser Himalaya and shed light on the evolutionary history of early life from single-celled prokaryotes to nucleated eukaryotes and multicellular life forms.

Collation of papers in a book like this could not have been possible without the support and cooperation of the authors and the reviewers who painstakingly completed the review work in time. I extend my grateful thanks to the 50 reviewers who spared their valuable time to evaluate the manuscripts. The distinguished reviewers include: Abhijit Basu (USA), Milan Kohut (Bratislavia), S. P. Verma (Mexico), John Armstrong-Altrin (Mexico), Soumen Mallick (USA), J. Madhavaraju (Mexico), R. N. Hota (Bhubaneswar), Rajneesh Bhutani (Poducherry), Saibal Gupta (Kharagpur), M. Ram Mohan (Hyderabad), Debajyoti Paul (Kanpur), Rajesh Srivastava (Varanasi), Somnath Dasgupta (Delhi), Sukanta Dey (Dhanbad), Abhinaba Roy (Kolkata), A. B. Roy (Kolkata), T. K. Biswal (Bombay), H. Wani (Srinagar), N. Absar (Poducherry), Biplab Bhattacharya (Roorkee), P. P. Chakrabarty (Delhi), Santanu Banerjee (Bombay), M. F. Hussain (Silchar), Maibam Bidyananda (Imphal), Santosh Kumar (Nainital), H. K. Sachan (Dehra Dun), Ashima Saikia (Delhi), Vivek Malviya (Lucknow), Sarajit Sensarma (Lucknow), Joydip Mukhopadhyay (Kolkata), J. P. Srivastava (Delhi), R. Nagendra (Chennai), L. Saha (Roorkee), B. C. Prabhakar (Bangaluru), D. B. Guha (Jaipur), N. C. Pant (Delhi), U. K. Shukla (Varanasi), Sandip K. Roy (Delhi), S. K. Ghosh (Dehra Dun), A. R. Bhattacharya (Lucknow), M. W. Y. Khan (Raipur), Pradip Samanta (Durgapur), N. V. Chalapathi Rao (Varanasi), Mohd. Sadiq (Faridabad), Arjit Ray (Kolkata),

S. A. Rashid (Aligarh), Soumik Mukhopadhyay (Kolkata), Yamuna Singh (Hyderabad), Surendra Kumar (Lucknow), Meera Tiwat (Dehra Dun) and Abhijit Roy (Hyderabad).

I am hopeful that the book will be helpful to the researchers working in the field of Precambrian Indian shield.

M. E. A. Mondal