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A Treatise on

Pyroclastic Rocks of India In Space and Time

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Published under the aegis of
Indian Geological Congress, Roorkee, India

About the book: The Indian Geological Congress (IGC) encourages individuals to write books, monographs, memoirs and special publications on the thematic subject in the emerging fields of earth and environmental sciences. The present study encompasses one of the earliest endeavours of scientists dealing with rocks formed by magmatic processes, including the fragmental components derived from explosive eruption of a volcano, that is blown to the atmosphere in the form of ‘ashes or tephra’. Although the subject is extensively studied on account of easy accessibility of such rocks on planet Earth and in the extra-terrestrial bodies, however, a closer look of these in larger perspective on the genesis of magmatic rocks as a whole has seldom examined under the lens of a microscope to the extent described herein. The present study of - “Pyroclastic Rocks of India in Space and Time” provides a complete coverage on various aspects of magmatic and metallogenic processes involved in the volcanic ashes in macro-and micro-cosmic levels during crystallization of such rocks.

The current undertaking by the IGC in ‘Earth Sciences Series’, is a step forward towards the study of an interesting subject to a commoner of far-fetching results in the global context of the origin of particles. The book is profusely illustrated in about 500 pages, with over 600 diagrams and photomicrographs of rare distinction, giving intricate details of texture, formation minerals and ores associated with ash particles in magmatic crystallization. The role of hydrothermal processes in bringing out chemical transformation at low temperature, slow kinetic reactions, and mineralization are also dealt with. The subject is developed systematically and presented in the form of separate chapters for easy understanding of the readers.

The hard copy of the book in art paper would cost Rs. 6000/- in India and US \$250 elsewhere, which includes mailing cost. Advance booking will entitle 30% discount until 30.09.2018. The book will be launched in the presence of luminaries and special invitees including the press and news agencies across the world. Contact: The Secretary, Indian Geological Congress (IGC), 402/1 (35 A Civil Lines), Roorkee-247667, India (Ph.: 01332-277827; Hony. Editor: 09756077693; Em: igcroorkee@gmail.com; Website: www.igcroorkee.net)

Pyroclastic Rocks *of India In Time and Space*

Authored by: N.C. Ghose



Volcanic eruption of Barren Island, India, Bay of Bengal:07.01.1909, 8.30 hrs.



Indian Geological Congress Publication

Pyroclastic Rocks of India In Space and Time

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First Edition: 2018

Price: Hard bound: Rs. 6000 (In India)
US \$ 250 (abroad)

ISBN: 978-81-920724-5-6

Publisher: Indian Geology Congress, 402/1 (35 A, Civil Lines) Roorkee-247667, India.
Phone: (091) 01332 – 277827 / 09756077693
E-mail: *igcroorkee@gmail.com* / *igcroorkee@ymail.com*
Website: *www.igcroorkee.net*

Printed and bound: M/s Anubhav Printers, 15, Civil Lines, New Haridwar Road, Roorkee.
Tel. 01332-271237 / 97190043210

Divine message

यच्चापिसर्वभूतानां बीजं तदहमर्जुन।

नतदस्ति विनायत्स्यान्मया भूतंचराचरम् ॥10.39॥

- Bhagavad Gita

Yat-chapisarva-bhutanambijam tad-ahamArjuna

Na tad-astivinayat-syat-mayabhutamcharacharam

Wordmeaning in the Sanskrit language :“Yat- whatever, ca- also, api- may be, sarvabhutanam- of all creation, bijam- seed, tat-that, aham- I am, Arjuna- O Arjuna– the worrier ; na- not, tat- that, asti- there is, vina- without, yat-which, syat- exists, maya- Me, bhutam- created being, chara-charam- moving and non-moving”.

Explanation of the sloka:*Furthermore, O Arjuna, I am the generating seed of all existences. There is no being – moving or non-moving – that can exist without me.*

Expounded further:

- He is the origin, existence, and finality of all creatures–‘*omniscience*’.
- He is the *seed* within all beings by which He perpetuates His *creation*, through Nature’s power of reproduction in different forms.
- Everything that moves (*sattva*)– perceptive, (*rajas*)- active or inactive attributes, and (*tamas*) - obstructive quality, owe their being solely to the omnipresent *consciousness* of Lord and the *omnipotence* of His divine will. He is the embodiment of Perfection or *Absolute Truth*(*Sat-Chit-Ananda*) or ‘*Perception-Existence-Bliss*’ of mankind (Body-Mind-Intellect).

-ParamahansaYoganda

Dedicated to
My mother (b. 26. 10. 1923)

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From Editor's Desk



The book on “*Pyroclastic Rocks of India: Space and Time*”, is a timely publication in view of lack of such literature in India, despite the country to be known for the occurrence of three Large Igneous Provinces (LIPs); the Cretaceous mafic volcanics of the Rajmahal and the Deccan basalts in the eastern and western margins of the Indian shield respectively, and the Neoproterozoic silicic volcanism of Malani igneous suite in the western Rajasthan. The Cretaceous magmatism is also known for marine transgressions (Rajmahal basin and Bagh beds) and Oceanic Anoxic Events (OAE) in Early Aptian (123-118 Ma) and at the K-T (66 Ma) boundary with mass extinction of animals both in the land and the sea due to rise in paleo-temperature and salinity of seawater. The latter is taken to be the prime cause for mass extinction of dinosaurs.

The Rajmahal basalt has an enigmatic history since its birth, coincides with fragmentation of Gondwana since Jurassic (180 Ma) when the Indian sub-continent was joined together with Eastern Antarctica and Western Australia in southern hemisphere. The northward movement of India through a passage of time (3-10 cm/year), and its amalgamation with Eurasia resulted in the birth of Himalaya and Indo-Myanmar Mountain Ranges. The movement has its record in 90°E ridge in the Indian Ocean. The author has shown that the heat source from the Early Cretaceous magmatism along with the east coast is responsible for producing hydrocarbons in the K-G basins, coal bed methane (CBM) in the Gondwana basins and submarine gas hydrates in the coastal regions.

The book may rightly be called a *treatise*, covering an expansive domain of the Indian landmass, developed in different geological periods and tectonic settings. The contents give testimony of the fact giving a comprehensive account of the primary pyroclastic deposits from India, generated by explosive volcanism of magma with low viscosity. The zeal and enthusiasm of the author is duly recognised by the editor, offering him to publish the book under the aegis of Indian Geological Congress, Roorkee. The author is happy that the book could be completed despite his inconsistent health. Were it not so, the script might have been lost to posterity. The editor and his team express their sincere thanks to his daughter and other technical experts to assist him with the work.

The information gathered on fragmental volcanic rocks in this book unveils a new dimension of research on magmatic processes, tectonism and metallogeny. The above features are intricately documented through photomicrographs (~600 nos.) with explanations of textures, microstructures, and mineralogy and ore mineralization and the process subjected at varied P-T conditions, lithology and volatile contents of magma. The book provides wholesome documentation in the formation of volcanoes not dealt earlier. The author is complimented for conceptualization and delivering of a marginal subject to the forefront of igneous petrology, bringing the *inert* ash particles to ‘*innate* object’, carrying the history of millions of years indented in it, since its derivation inside the crust in the form of molten material with straightforward clarification.

The book introduces the subject with basic information on the interior of the earth, plate tectonics, classification and nomenclature of magmatic and primary pyroclastic rocks, textures, types of magma and their genesis. A synthesis on distribution, types of flow, products, economic resources and deleterious effects of volcanic eruptions are also incorporated in the initial chapters. The text provides a complete knowledge on *primary pyroclastic deposits* including those of hyaloclastites/hydroclastites formed by magma-water interactions citing examples from different areas. To support the above features, the author has presented a summarized geological and petrological account of the eleven provinces to a logical conclusion on the source of the parent rocks.

The selection of samples by the author range from the Neoproterozoic to Recent, and include the Archean Kadiri volcanics from Eastern Dharwar Craton (EDC), the Paleoproterozoic Gwalior and Vindhyan basins from central India; the Neoproterozoic Malani Silicic Igneous Province (LIP) from western Rajasthan; the Lower Cretaceous Rajmahal basalts (LIP) in eastern India; the Late Cretaceous Deccan basalts (LIP) and Pavagad volcanics from western and central India; the Late Cretaceous-Paleocene Naga Hills Ophiolites and the Palaeozoic-Palaeocene Abor volcanics from the northeast; the Quarternary dormant volcano of the Narcondam Island and the active volcano of the Barren Island, Bay of Bengal, derived under different tectonic settings. The author has made a logical sequence in Chapter 8 as Discussion, summarising the data generated of each province in different tables with logical comments on pyroclastic rocks as Conclusion.

In Part-II, the author presents photomicrographs of the pyroclastic rocks to help the readers to evaluate the crystallization processes of magmatic rocks through pictorial presentation. The Glossary of terminology reduces efforts of the readers in understanding the subject. The book ends with Subject Index and Locality Index of places where these are quoted in the text and recorded to occur as outcrops. The book is expected to run about 450 to 500 pages and to be printed on high class art paper to bring out details of rocks. It is heartening that the book is created using an inexpensive petrological microscope. The author deserves *high appreciation* for his performance and proficiency in the subject.

Prof. O. P. Varma,
Hony. Editor,
Indian Geological Congress.

Date: 10.05.2018
Roorkee, India

About the Author



Born on 18th, June 1940 in Uttarpara, to Sricharan and Gouri, in a large family of undivided Bengal, Naresh Chandra Ghose was brought-up at Chandan Nagar, a former French colony. He has a very fond memory of his childhood. The family comprising mother (27y) with 3 children was shifted to Varanasi in 1955 under the care of maternal grandfather, Protul Chandra Ghose, a Professor of Physics and highly disciplined teacher of that era.

The tough and disciplined life flourished under the tutelage of grandparents. Mother was awarded Gold medal in literature by the Banaras Hindu University and supported the family as a school teacher. The young ones grew to become professors in different disciplines. The rigours of early life turned to be a boon in disguise and the three are identified as highly successful teachers with humane personality.

Dr.Ghose did his M.Sc. in Geology and Ph.D. in Geochemistry in 1961 and 1964 from the Banaras Hindu University. After a short stint as a lecturer in his alma mater, he joined the Patna University in 1965 and retired as Professor of Geology in 2000. He was involved in teaching post-graduate students in igneous and metamorphic petrology, geochemistry and environmental sciences. He had the opportunity to widen his vision, visiting different laboratories of reckoning in the U.S.A., U.K., U.S.S.R., Japan, and Germany. The aura of personal meetings with many Professors of eminence of bygone eras like those of Prof. Helmut G.F. Winkler, Aleksandr P. Vinogradov, Carl W. Correns, Karl H. Wedepohl, Peter J. Wyllie, Brian F. Windley, Timothy L. Grove, Paul Ramdohr, Ajit K. Saha and the spiritual gurus Dilip K. Biswas and Sujaya Chaitanya of the Chinmaya Mission have enlightened him to look beyond the knowledge written in the text.

The career of Dr. Ghose blossomed in Patna University. He earned his name and fame while working as a faculty member in greatest adversities at the workplace. This has taught him courage and determination to reach to a goal which apparently looks impossible to achieve. He established three fully equipped chemical laboratories in late 80's of the last millennium, with support from the Humboldt Foundation and the Department of Science and Technology, New Delhi, to help the research scholars to carry out their work in Earth and Environmental Sciences. He was successful in producing 12 Ph.D. in Earth Science and guided others in different disciplines.

His sustained research for the past 6 decades in the emerging field of earth and environmental sciences has resulted in notable contributions in petrology on a variety of subjects:

- I. Genesis of granitic magma by experimental melting;
- II. Evolution of early crust;
- III. High-P and low-T assemblages at the converging plate margins;
- IV. Ultra-high-pressure metamorphism (UHP) in the eastern continental margin of the Indian plate; and
- V. Intraplate volcanism.

As a Fellow of the A.V. Humboldt Foundation, Dr. Ghose has carried out post-doctorate research on synthetic minerals and natural rocks and determined the eutectic temperatures and compositions, and phase relationships in the granite system at variable pressures in Gottingen, Germany in 1972-73 with Prof. H.G.F. Winkler.

Notable scientific contributions made by him are listed below:

- Eutectic temperatures and compositions in the system $Qz-Or-An-H_2O$ at 4 and 7 kbs.
- Occurrence of Blueschists and Eclogites in the Naga Hills ophiolites.
- Reported the occurrence of “Coelite and Micro-diamonds” in blueschists and eclogites which in turn established Ultra-High Pressure Metamorphism (UHP) in the Eastern Indian shield margin.
- Established the stratigraphy of the Chotanagpur gneiss terrain based on tectonics, geochronology (Shrimp dating of zircon), metamorphism and petrological studies of granulite facies rocks.
- Identified early Archean lithology of the Singhbhum craton (comprising komatiite-meimechite-foiidite-picrite basalts and tonalite-conglomerate and metasediments) from the study of rafts of mafic-ultramafic-sialic components in the Mesoarchean Chakradharpur granites.
- Established the ‘Style of volcanism’ of the Rajmahal basalts based on lithostratigraphy and petrographic study of primary pyroclastic deposits. It is shown that early eruption of lavas had taken place in shallow coastal region, giving evidence of anoxic environment in early Aptian, accompanied with marine transgression and phreatomagmatic activity in the western margin of the basalt outcrop.
- Based on borehole lithology (>2225 m) of anorthosite pluton (Bengal anorthosite), first time shown cyclic nature of mineralogical and chemical changes in a massif.
- He also made extraordinary debut in the field of groundwater geology and authored a few notable titles on the subject:
 - I. ‘Pollution of River Ganga’ (Ashish, Delhi, 1988)
 - II. Groundwater resources of Patna town (Ashish, Delhi, 1992)
 - III. Iodine concentrations in soil-water-vegetation in the goitre-prone Gandak basin of North Bihar,
 - IV. Organochloro pesticides in the ground and surface waters of the Calcutta metropolitan.

Dr. Ghose is an astute researcher primarily in the field of igneous rocks and contributed over 100 original research papers and 10 reference titles (books), e.g., ‘Ophiolites and Indian Plate Margins’ (in 2 volumes, 1986-89) as a member of the IGCP Projects. Recently, he has published a book on ‘A petrographic Atlas on Ophiolites’ (Springer, 2014), first of its kind in the subject.

The current book “Pyroclastic Rocks of India” is an outcome of the suggestions made by the editor and mentor, Prof. O.P. Varma, IGC. He had been a source of inspiration to the author throughout the preparation of the book. It is praiseworthy that the Indian Geological Congress has taken up the responsibility of documenting these fragmental volcanic rocks in the form of a book.

The book is an outcome of an ambitious task taken up by the author and is successful in completing it despite his falling health. The Pyroclastic rocks dealt in the book are formed over a period of 3000 million years and formed in different tectonic settings. The period is also known for the transformation of global atmosphere from highly anaerobic Archean to oxygen-rich environments in the Early Paleoproterozoic era which is duly explained in this study. Several oceanic anoxic events (OAE) during the Mesozoic period are also given due consideration, citing the cause and effects of such changes. The mass extinction of Dinosaurs at the K-T boundary is discussed as well.

Features of 'ash' particles of its early formation in sub-crustal region to its expulsion on to the crust, is documented first time through pictorial presentations. The ash particles are attributed to be 'micro-particles' keeping analogy with the 'particle physics'. The fine pyroclastic fragments (ash/tuff) are compared with the magical 'black box' of the aviation industry, providing history in the 'making of a volcano'. Prof. Ghose has been successful in projecting the 'ash' particles in global platform as one of the alternative avenues for understanding the magmatic processes compared to parent rocks from which these are derived.