of available evidence, as the best available account on the river Sarasvati. The author with the help of clear-cut illustrations attempted to trace different stages of evolution of the mythical river. Readers would agree with the editors that the inferences drawn by Wilhelmy are quite clear and convincing. This line of approach should be pursued carefully in future research works. Migration of river Sarasvati is the theme of three different papers, which are based on the studies of satellite imageries. The paper by P. C. Bakliwal and A. K. Grover is an extract from the *Records of Geological Survey of India* published in 1988. S. M. Ramaswamy who seems to agree with the conclusion drawn earlier by Bakliwal and Grover, attributes neotectonic movements in the region to the north-westerly migration of Sarasvati. Baldev Sahai in his paper, quoted with approval the works of B. Ghosh, A. Kar and Z. Hussain[1,2], for erecting a reasonable time frame for the specific courses of the migrating Sarasvati. It may be mentioned that Ghosh and his coworkers[1,2], based on their studies of aerial photography and satellite imageries, had earlier suggested that the Sarasvati flowed in NE–SW direction (from Nohar onwards) through the Rajasthan desert and that the Luni was one of its tributaries. The river later moved westward, severing its connection with the Luni and flowed all the way through the desert terrain in the Jaisalmer district. Sahai in his article made liberal quotations about the work of Ghosh *et al.*[1,2] as well as Kar and Ghosh[3], which are highly informative. Drainage development is also the theme of a paper by J. L. Thussu, who attributes the changes in the river channels in Haryana and Punjab to the normal process of drainage without any recourse to neotectonics. Thussu claims that some of the changes in the channel patterns occurred during historical times. In two different papers J. N. Mallick, S. S. Merh and V. Sridhar adduced geological evidence to prove that the rivers Sindhu, Satadru (Sutlej), Sarasvati and Drishadvati had more or less parallel courses, and emptied at the Great Rann of Kachchh forming large delta complexes. This information may appear crucial in tracing the correct path followed by the migrating Sarasvati. S. N. Rajguru and G. L Badam presented useful information about the Quaternary geomorphology of parts of Himachal Pradesh. The book includes extracts of an important interdisciplinary work by R. J. Wasson, S. N. Rajguru, V. N. Mishra, D. P. Agarwal, R. P. Dhir, A. K. Singhvi and K. Kameswara Rao, which includes details of Quaternary stratigraphy with well constrained time frame for climatic changes in the Thar desert during the last 10,000 years. K. S. Raghav's paper on evolution of drainage basins in the Thar desert marks a significant departure from other studies. He asserts that the drainage of the Ghaggar river in the north and the Luni river in the south has remained separate by an E–W water divide since earliest time of Quaternary sedimentation.

Different papers included in the second part of the book provide enough data for building a coherent evolutionary history of the lost Sarasvati. To substantiate this, papers based on advanced knowledge in the fields of remote sensing, carbon dating of ground water, TL dating of sands, information on palaeoclimate through oxygen isotope studies and palynological data have been included in the third part of the book. Some of the papers included in this section do not add any specific information about Sarasvati. New technologies based on Radar Imagery (A. Kar), space-based multispectral data (D. P. Rao), Radar (ERS-1/2SAR) and high-resolution IRS-1C data (A. S. Rajawat, A. Narain, R. R. Navalgund, S. Pathak, J. R. Sharma, V. Soni, M. K. Babel, K. S. Srivastava and D. C. Sharma), and application of Pyramidal processing methods of IRS-1C data (A. S. Rajawat, C. V. S. Sastry and A. Narain) have been used for precise location of hidden palaeochannels and relict valleys, some of which could be identified as left over channels of Sarasvati and Drishadvati. N. H. Hasimi, R. Nigam, R. R. Nair and G. Rajagopalan attempted updating of data on the sea-level changes in western Indian continental margin. Using oxygen isotope, P. D. Naidu reviewed the scenario of Holocene climatic changes in the Indian subcontinent. A. R. Nair, S. V. Navada and S. M. Rao attempted to date the groundwater along the palaeochannels in the Jaisalmer and Ganganagar districts of Rajasthan. Based on data which may not be very precise, these authors argued against any possibility of head water connection of the buried courses in these regions with the Himalayan sources. The Editors could have avoided the brief articles by A. R. Nair (on 'Dating of groundwater'), and R. N. Athwale (on 'Holocene' period record of earth movements in North-western India).

This book has turned out to be an important document on the evolutionary history of the Vedic river Sarasvati. The editors must be congratulated for their sincere efforts in bringing together diverse views to a single platform. The different articles included in the volume, however, expose a considerable lack of communication amongst different workers, and because of this there is evidence of duplication of efforts by different individuals and working groups. The success of the book lies not only in exposing gaps in our knowledge, but also in focusing our attention on the overlapping efforts being made by different workers. Hopefully, this publication would help to stir up concerted efforts for more dispassionate and coordinated studies in discovering the truth about the river Sarasvati, which still remains in veils of myth.

1. Ghose, B. Kar, A. and Hussain, Z., *Geogr. J.*, 1979, **145**, 446–451.
2. Ghose, B. Kar, A. and Hussain, Z., *Man Environ.*, 1980, **4**, 8–12.
3. Kar, A. and Ghose, B., *Geogr. J.* 1984, **150**, 221–229.

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Ore Genesis – A Holistic Approach. Asoke Mookherjee. Allied Publishers Ltd., P.O. Box 7203, 13/14 Asaf Ali Road, New Delhi 110 002, India. 1999. 657 pp. Price: Rs. 570.

Even though earth, early in its history had sorted out elements to make up its crust, mantle and core, various geological processes unceasingly continue to shift them or re-sort them to form economically recoverable deposits. The tremendous advances in geophysics and geochemistry in the last five decades have enhanced our knowledge about the diverse ore genetic routes and the physical and chemical

parameters that operate in nature while forming their deposits. As a result, several of the earlier notions about ore-formation have required revision, but books for the benefit of the student community, incorporating the current thinking have been few. In this respect, *Ore Genesis – A Holistic Approach* by Asoke Mookherjee is a welcome addition as it has taken care to reflect the new ideas including those that have come up during the last few years.

In the opening section, the author has presented an overview of temporal, spatial and chemical–lithological traits of the global ore occurrences. A temporal irregularity in ore-distribution is seen in the occurrence of prodigious metallogenic provinces (e.g. Au, Ni, Fe, Cu, and Zn) in Archaean period noted for intense magmatism, but mineralization in the younger Proterozoic period was lean. He has pointed out the habitat-specific ore-types associated with the making and breaking of continents through time. This trend was exemplified in the deep marine environment of the Archaean iron-ore deposits which was followed by shallow continental shelf type ores, while deposits associated with epicontinental seas marked the Palaeozoic–Mesozoic times and continental type weathering and secondary deposits (laterites and bauxites) dominated the Tertiary period. Ores exclusive to certain geographic regions or regions exhibiting unique structural or tectonic features (e.g. Cu, U in Singhbhum thrust belt and the Pb, Zn, Cu mineralization in the Proterozoic mobile belt of Rajasthan) and likewise ores exclusive to certain host rocks like granitoids (Mo, Sn, W, Nb, Ta, U), or ultrabasic–basic rocks (diamonds, Pt, Ir, Os, Cr, Cu, Ni, Zn, REE) or sedimentary rocks (Mn, Cu, Pb, Zn, Ba, Al, Fe) are examples displaying spatial trait of ore distribution.

Fundamentally, apart from the chemical zonation of earth early in its history, several other geological events that followed in younger times like plate tectonism and related magmatism and orogeny, climatic variations due to latitude shifts of migrating continents, and sea-level changes have also dictated the evolution of ores. Aiming to cater to post graduate students, this book devotes nearly 30 pages to many of the new thinking related to these phenomena. The inclusion of a table at the end of this section identifying Indian ore deposits in relation to these major events is valuable in this context. Against this backdrop of spatial, temporal and chemical–lithological characteristics of ores worldwide, the next section discusses their modes of occurrence with respect to ore–host rock relationship, in terms of their disposition (morphology), relationships linked to host rock lithology, structure and deformational history, besides genetic links with host rock. While many classic ore occurrences are explained in the treatment of these topics, the strata-bound type, one of the major types of ore deposits has been discussed at length.

Researches carried out during the last half century, unlike in the previous years, emphasize on the fundamental aspects of mineral and ore formation like the chemical kinetics, thermodynamic control of reactions and transport of solutions. These approaches have greatly enhanced our understanding of the principles operating behind ore genesis in diverse settings and time. Various physico-chemical aspects governing melting, inversion, exsolution phenomena, oxidation, reduction, and several other phases are described in good detail to enable the reader to grasp their significant role. Graphical elaboration of some typical ore-systems like Fe–Ni–S, Cu–Fe–S, Fe–Zn–As, sulphosalts from various geological environments given here should be helpful to the readers. Apart from field-based studies, several inferences and interpretations have come out of laboratory techniques like optical and electron microscopic examination, trace and minor element analysis through a variety of probes like plasma, lasers, ion beams and X-rays. Ore genetic studies benefited very much with application of high-powered optical microscopy and particularly through use of electron microscope in evaluation of microtextures, intergrowths and hyperfine details of the minerals. The abundance and trends exhibited by trace elements, in particular the lanthanides, have been useful in ore genetic interpretations in igneous, metamorphic and sedimentary environments. Interpretations regarding the age of the rocks and ores, in fixing of their provenances, about magma parentage, in characterizing the nature and environment source of S, C, H_2O, about P–T conditions and a host of other aspects of ore fluids have been made possible through judicious application of isotopes, both radioactive and stable. Microscopic study of inclusions of fluids entrapped in ores and associated minerals, which are actually 'microgeological systems that captured representative samples of ambient fluids' have contributed to geothermometry and phase relations which are relevant to the study of ore genetic problems. Several of these newer approaches are stressed with explanations of the basic principles behind these laboratory techniques, citing relevant case histories drawn from typical areas.

The important role of micro-organisms in catalysing reactions like sulphate reduction or oxidation, mobilization of elements by chelation, complex formation in ore extraction through leaching and in controlling the pH and E_h in the ore environment is increasingly recognized and results coming out of basic studies on biogeochemical aspects of ore formation are, thoughtfully, included. In the final section, which roughly covers a little over half the book, ore genetic association with magmatic (ultramafic, mafic and felsic), metamorphic, sedimentary (syn- and post-sedimentary) and weathering processes are presented. Recent geophysical and geochemical studies about magma generation in the earth's interior have recognized processes like intense upwelling of magma through volcanism (particularly during early Archaean), magmatism through partial melting of mantle, magma related to plume and hot spot activities, mantle convection related magma dynamics and heterogeneity in the mantle melts brought about by subducting crustal slabs. Their bearing on ore genesis has compelled geologists to temper existing views about magma-related ores, particularly with respect to spatial and temporal evolution. Against this background, the author discusses ores related to ultramafic and mafic parentage (diamondiferous kimberlites, REE, Nb–Ta bearing carbonatites, platinum group elements, Ni, Ti, Cr bearing mafics) as well as those showing silicic igneous associations involving magmas of varied composition (granitoid including hydrothermal, felsic including alkaline suites) evolved under diverse tectonic settings (compressional, tensional, neutral). Appropriately, he has accented the late-stage magmatic processes involving pegmatites, pegmatoids, greisens, skarns, and porphyries in view of their potential for hosting several rare metals.

Ores of sedimentary affiliation have been recognized as distinct from sediment-hosted ores, and in which the sedimentary processes have participated in collecting, transporting or concentrating them. After elaborating on the types of sources and temporal relationships with sedimentation of host rocks, the author has broadly categorized these ores as either detrital (placers) or as concentrates derived by chemical action on ore constituents in the sedimentary rocks. Description of placers is provided in the context of tectonic, i.e. volcanogenic and passive continental margin-related placers (diamond, Au, Th, Zr, Ti) and temporal, i.e. lithologic variations in clastic sediments like predominance of greywacke during the Archaean, and quartz-rich sediments in progressively younger period rocks. A number of sedimentary differentiation processes based on solubility of concerned elements are explained in the second category of chemical-sedimentary concentration. The classic deposits of U, Mn, Fe, Pb, Zn, Ba apart from enrichment of several others like Cu, Cd, As, Pb formed through an agency of chemical action and the manner of their concentration, the physical and chemical parameters that control their extraction are topics well highlighted. In dealing with these deposits, the interdependence of tectonic–hydrospheric–atmospheric–biotic processes for the interactions is emphasized. The last two chapters are devoted to the role of various metamorphic processes – prograde, retrograde, thermal, shock and variations of these under different tectonic settings in the evolution of ores (Au, Mn, Fe, Pb, Zn), and to the role of weathering of rocks in the production of secondary concentrations of gold and diamond and in the formation of phosphates, bauxites, pyrochlore, cassiterite, laterites including auriferous and nickelian types.

A major asset of this book is that most of the ore genetic processes are discussed in terms of the physics and chemistry involved in their evolution, and not just empirically, in the style of earlier texts. As Mookherjee himself points out in his preface, Indian students will be 'a little disappointed with scarcity of Indian examples' but this book, as he hastens to explain, is on 'ore genesis' and not on 'ore deposits'. Readers will agree with him in this respect when they find that the treatment of the multi-faceted genesis of ores itself has taken him more than 600 pages of print. The list of references given is quite exhaustive and should be very helpful for those who wish to know more from the original contributors.

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Theory of Ordinary Differential Equations—With Applications in Biology and Engineering. Shair Ahmed and M. Rama Mohan Rao. Affiliated East-West Press Private Limited, 105, Nirmal Tower, 26 Barakhamba Road, New Delhi 110 001. 1999. 335 pp. Price: Rs. 220.

This book has three main parts to it. Chapters 1, 2 and 4 give a review of the theory of linear ordinary differential equations (ODEs), chapters 3 and 5 deal with their stability, while chapter 6 concerns applications to population dynamics. The introductory chapters are lucidly written and profusely illustrated with examples; all the definitions are set out carefully. The chapters on stability of ODEs form the strong point of the book. Some of the standard equations such as Lienard, Duffing and Van der Pol are discussed in detail.

The style of writing is user-friendly. Therefore a student with a basic course in ODEs and analysis should be able to access the book.

The reviewer finds a few points rather irksome. The book's title should more aptly emphasize stability of ODEs. It refers to applications in biology and engineering while the main chapter in applications is entitled 'Mathematical models in population dynamics'. The latter does have applications to biology but engineering applications are rather minimal. The scope of applications is therefore limited.

There are considerable number of exercises at the end of each chapter but no answers or hints are provided.

In spite of these foibles, this book is a useful addition to the subject of ODEs and would be welcomed by both students and researchers, particularly those dealing with stability theory.

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