

horizons of the champions of the free-market economies. Neither side looks to the future or is willing 'to sacrifice the present for the sake of the future'. The introductory essay is therefore a brief for the voice of science but points out that only ethical considerations can temper the short-sighted, self-interested course of science and technology, and it is here that the voice of religion representing social justice and ethical considerations must be added to the voice of science.

Dyson prefers to use case studies and science fiction (or, dramatized novelistic accounts) to imagine the future. As an aeronautical engineer, I found his use of aeronautical history particularly appealing. What began as an hobby in a small-is-beautiful Tolstoyan way, soon evolved into a technology and became a vast industry and economy. The important lesson is that repeated failure is the only guarantee for success; 'out of a 100,000 types of airplanes, about a 100 survive to form the basis of modern aviation.' The evolution of all technology is supervised by a relentless Darwinian process of elimination and selection. Here is a warning for the Grand Designer, who is ideologically driven to believe in a big-is-best Napoleonic conceit, that to short-circuit the evolutionary learning process is to invite colossal disaster. The R101 airship project and the Comet jetliner serve as signal examples of the tragedy that can ensue. This is a lesson I see for many of our own Grand Designers, blinded by national pride, who promote ideologically driven technologies, believing that we can succeed where we have not failed enough. Technologies should be driven by pragmatism and not ideology. The best technology is the one that 'brightens the lives of individual people.' Dyson quotes three examples of 'joyful technology' over a span of three generations – the motorcycle for his father, the nuclear fission reactor for himself and the CAD-CAM technology, that his son took very gladly to.

Dyson recalls that it has been a hundred years since H. G. Wells' *The Time Machine* projected a dismal future if the gross inequalities and injustices of society had been allowed to continue. 'The main cause of economic tensions today is the unequal distribution of wealth and skill between the rich and poor countries and between the rich and poor segments of society,' observes Dyson. For the fifty years of Wells' working life, these social

injustices were ameliorated, but in the fifty years since his death, these inequalities have again sharpened, often a result of accelerating technological changes.

How science goes about performing its tasks is the subject of an entire chapter. Dyson emphasizes that science can be concept-driven (explaining old things in new ways) or tool-driven (discovering new things that need to be explained). Styles also vary – rigid, organized and disciplined in the Napoleonic fashion, or creative, chaotic and free after a Tolstoyan manner. Future science will require one or a judicious mix of both styles to be employed. Dyson predicts that the dominant science of the next century will be biology, and here, two branches, genetics and neurophysiology, will pose the greatest challenges.

To understand technology, Dyson takes us from Wells to another visionary, J. B. S. Haldane. Haldane uses the myth of Daedalus, in an eponymously named book, to paint again, a skeptical scenario. Science, without ethical concern, will bring confusion and misery. It is as if the scientist is predestined to turn good into evil. The same keys will open the gates of Heaven or Hell. When not leading to war, technology in peace, relentlessly widens the gulf between the rich and the poor. This is inevitable, as science, driven only by market forces, will produce goods (toys) and services (games and leisure) that only the rich can afford. Already in the last decade of this century we see this everywhere. Dyson sees genetic engineering and computer technology as having the potential to turn the world upside down. Genetic engineering could lead to neurotechnology, where the human brain can be explored or manipulated, and to radiotelepathy, where information can be transferred from the brain to another using radio signals.

'The best way to predict the future of human society is to study the past,' concludes Dyson. The chapter entitled 'Evolution' undertakes distant views into the past and the future of human society on time scales up to millions of years. Dyson's prediction is that intelligence and life will mutate in ways unpredictable, but will live forever and inhabit distant worlds. New technologies such as space colonization, computer-assisted selection and reproduction, may be dangerous as well as liberating. Ethics would play a crucial role here in sifting good technology from bad. As a humane and

liberal philosopher, Dyson shows how a moral order is very important. He endorses Samuel Gompers, a pioneer of the Labour Movement in the US whose platform was for 'more school houses, books, learning, leisure and justice' and fewer 'jails, guns,' and less 'vice, greed and revenge.' Is anyone listening out there?

As an activist for nuclear disarmament, Dyson echoes George Kennan's warning that 'Nuclear weapons remain the most serious danger to mankind and the most serious insult to God'. Dyson, prematurely concludes, 'The evil face of science was personified by the nuclear bomb designer. Now, quietly and unexpectedly, the bombs have faded from our view.' And that the nuclear arms race is over. Our own sub-continental Grand Designers have thought otherwise.

Unhesitatingly, I regard this slim volume as one of the most illuminating accounts I have read; perhaps very fittingly the book to close the century with and imagine hopefully to the next.

GANGAN PRATHAP

*Structures Division,  
National Aerospace Laboratories,  
Bangalore 560 017, India*

---

**Vedic Sarasvati: Evolutionary History of a Lost River of North-western India.** B. P. Radhakrishna and S. S. Merh (eds). Memoir 42, The Geological Society of India, P.B. 1922, Gavipuram P.O., Bangalore 560 019. 1999. 329 pp. Price Rs 500/US \$ 50.

---

This book is one of the latest publications of the Geological Society of India. True to its title, the book centres around the great mythical river Sarasvati, which is now lost in the sands of the Thar desert. Bulk of the papers included in this multi-authored volume were presented at a seminar held at M.S. University of Baroda in December 1977, organized by the Geological Society of India on 'Drainage evolution of north-western India with particular reference to the lost Sarasvati'. The title of the book, therefore, suggests a clear shift in focus from a basically geomorphologic theme to a more fasci-

nating subject of Vedic civilization that evolved and matured on the banks of the river Sarasvati. The way the 'lost' Sarasvati has been glorified in Vedic and other Puranic literatures is a clear testimony to the intense emotional bondage between man and environment. The lost river not only contributed in extending the highly fertile flood plains in parts of north-western India, but had also produced a very amicable surrounding for upgradation of faculties of our Vedic ancestors.

It is worth quoting here an excerpt from the inaugural speech at the Baroda Seminar delivered by B. P. Radhakrishna, President of the Geological Society of India, (and one of the Editors of this volume). He said 'we are now on the threshold of the 21st century and before we take a giant leap forward it is but prudent that our feet rested on a firm foundation, with a clear knowledge about our culture and its beginnings which are inextricably interwoven with the lost Sarasvati'. He made a strong plea to gather every available evidence from multi-disciplinary sources for building up a connected history, which would make us feel proud of our own heritage.

Some readers may have reservations about the rationality of linking emotion based on national ethos to an endeavour of uncovering scientific truth; in the present context it is the evolutionary history of an extinct river. For an earth scientist, changes in the course of a river or its extinction is a fundamental process of the earth system dynamics, which constantly changes surface morphology of our planet. Recent geological history of the Indian subcontinent is replete with evidence of changes in the geomorphology in the not-so-distant past. There is hardly any doubt that our ancestors have witnessed quite a few of these. However, the extinction of the Sarasvati is an event, which is quite dear to our heart, because one of the most ancient civilizations of the world, the Vedic civilization, evolved on the banks of this river.

Radhakrishna lamented about the attempted distortion of Indian history by some western scholars, particularly on the question of 'Aryan invasion'. There may be some truth in it. However, it may sound quite paradoxical that although the lost Sarasvati finds many glorifying references in *Vedas* and other Puranic literatures, yet we Indians remained

totally oblivious about it till the end of the nineteenth century when some other western scholars, like A. Cunningham (1883) and R. D. Oldham (1886), drew our attention to the existence of this celebrated river. Prior to these references, the eminent German scholar, Max Müller sought the attention of the world (through translation of Sanskrit verses of the *Vedas*), to the ancient Indian civilization that flourished with grandeur on the banks of the river Sarasvati.

This book is divided in three parts. As expected, the first part includes articles which attempt to trace the Vedic antecedents of the lost river. The other two parts are titled 'Drainage evolution' and 'New approaches'. One edifying feature of this book is that the editors have highlighted the main points in all the papers at the beginning of each part, leaving the choice of meticulous reading to the readers.

Part I dealing with Vedic antecedents, includes nine papers by B. P. Radhakrishna, O. P. Bharadwaj, S. Kalyanaraman, D. S. Chauhan, Rajesh Kochhar, V. S. Wakankar, David Frawley, Navaratna Rajaram and S. G. Katawala. All these authors have drawn our attention to a large number of references in the *Vedas*, *Upanishads*, *Mahabharata* and *Puranas* on different aspects of the river Sarasvati. Special mentions have been made in some writings discounting the extra-Indian origin of the Aryans. A discordant note is, however, sounded by Rajesh Kochhar, who attempted to identify the *naditame* Sarasvati with the river Helmund of south Afganistan! Bharadwaj has mentioned a number of rivers bearing the name Sarasvati in northern India. He, however, insists that the name Sarasvati should be applied strictly to the river of that name, which rises in Sirmur and joins Ghaggar (also known as Hakra). The point that is missed in all these writings is that there are at least two *Triveni sangams* (the junction point of three rivers) in our country, one near Allahabad and the other lying about 25 km north of Kolkata (*nee* Calcutta). In both the cases, the name of the extinct river is Sarasvati! Another feature, which also seems to have lost attention in the euphoria of finding abandoned channels in parts of Rajasthan, Haryana and Punjab, is that the Vedic verses on Sarasvati almost invariably speak of a powerful river whose 'mighty currents easily break the mountains.' The Sarasvati has been ref-

erred to as having 'limitless unbroken flow, swift moving with rapid rush, *that* comes onward with tempestuous roar'. If this is what has been referred to in the *Rigveda* as the *naditame* Sarasvati, one must think of the Vedic river as mountainous stream, and not a quietly flowing 'matured' river watering its flood plains only during the rains! These are some loose ends, which must be tied up if we try to find out precise geographic bearings of the river, extolled so gloriously in the Vedic and Puranic hymns. Instead of being ecstatic, the need is for a more scientific analysis of the Vedic verses in order to find the true 'footprints' of the mythical river.

Information provided in the second part of the book is quite significant. The papers included here present a clear picture about the migration of the river Sarasvati, and its ultimate 'evaporation' in the desert sands. The first paper is by Oldham, which has been reprinted in the present book from the *Asiatic Society Journal* published in 1886. The drainage map prepared by Oldham, which was reproduced on the cover of the seminar volume of abstracts is quite revealing. It helps to mark the great water divide between the two different river systems flowing in different directions. Another interesting feature of the map is the abrupt south-easterly swing of Punjab rivers about 100 km north of Sind-Hyderabad. Credit must go to Oldham for his categorical statement about the great changes in the hydrography of (undivided) Punjab and Sind during the recent geological period. The article by C. F. Oldham is an extract of an earlier paper published in 1893 in the *Journal of the Royal Asiatic Society*. This is also a reprint of an earlier publication. C. F. Oldham's analysis about the courses followed by the river Sarasvati is based essentially on the detailed scrutiny of the hymns of the *Rigveda* and *Mahabharata*. It is presumed that in the time period from *Rigveda* to *Mahabharata* the mighty river lost itself at Vinasana, a place not far from the present day Sirsa. Analysis of five different hypotheses, discussed by the author, may be a rewarding exercise. The third paper by Herbert Wilhelmy is also a reprint extracted from a German geomorphological journal published in 1969. The editors have considered Wilhelmy's paper based on modern approach of field data coupled with critical analysis

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<sup>1,2</sup>, for erecting a reasonable time frame for the specific courses of the migrating Sarasvati. It may be mentioned that Ghosh and his coworkers<sup>1,2</sup>, 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.*<sup>1,2</sup> as well as Kar and Ghosh<sup>3</sup>, 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.

A. B. ROY

*Department of Geology,  
Mohanlal Sukhadia University,  
Udaipur 313 002, India*

**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