

was instead covered by fine dust. The most important of all of his theories, to date, is his theory of Deep Hot Biosphere.

The book is indeed well laid-out. It starts with the discovery, in 1977, of presence of exotic submarine life at ocean vents. Shortly thereafter, followed the discovery of new species of bacteria which were only found near ocean vents and in isolated hot springs. Most notable amongst these were the hyperthermophilic microbes, which are known to grow best at 80°C or higher and survive on account of their waxy cell membranes. In the late 1990s occurred the most remarkable discovery of the presence of an entire anaerobic biosphere, at depths of several kilometers, that was isolated from and independent of surface ecology. The finding of previously unknown strains of bacteria and microbial fossils, embedded deep within basement granite, has led to the realization that an entirely new biosphere has been discovered. Thomas Gold has boldly set forth the hypothesis that this deep biosphere is the source of surface life, and that a similar deep biosphere perhaps exists inside other planets as well.

The book then goes on to lay the foundations of this new theory, namely the Deep-Earth Gas Hypothesis. This equally controversial model posits a non-organic theory for the origin of petroleum; and is well-summarized. In Chapter 5, Gold then unifies the deep-hot biosphere model with the non-organic theory of the genesis of petroleum, providing a logically consistent super-model that has far-reaching implications for Geology, Biology, and Physics. According to this enlarged theory, primordial hydrocarbons are welling upwards from the mantle, filling intermediate subterranean reservoirs on the way upwards. It is in these subterranean reservoirs that life first evolved, spreading thence onto the surface. The non-organic theory of the origin of petroleum is then extended to the formation of petroleum, thereby explaining the close correlation observed between oil and coal deposits. Gold then, convincingly, illustrates how upwelling methane can considerably enhance existing peat deposits; although peat is likely to represent preponderantly organic material.

The Siljan Ring Project, undertaken by Thomas Gold in collaboration with the Swedish Government, is also dealt with

in ample detail. Although no commercially utilizable form of petroleum deposit was found, deep-earth petroleum was found, providing strong support for the non-organic theory. The occurrence of petroleum at 6 km depth inside granite bedrock virtually rules out the possibility of an organic origin for this petroleum. The additional discovery of microbes and microbially produced magnetite at this depth confirmed that a deep biosphere in fact exists, and provided another valuable by-product of the project.

In Chapter 7, Gold makes a bold extension of the enlarged deep-biosphere-deep-petroleum theory to provide a new model for the origin of metal deposits. The drawbacks of the conventional hydrothermal theory include the insolubility of metals and their compounds in even highly salty brines, the likely deficiency of naturally available pumping power, and the unrealistic quantities of water required for the creation of commercially viable metal deposits. As an alternative, Gold sets forth the Hydrocarbon Carrier Theory for the formation of metal deposits, in which organometallic compounds in hydrocarbons play the major role in the deposition of metals. In this scenario, anaerobic microbes built up the metal deposits by oxidising the hydrocarbons and reducing the metal oxides in a manner similarly adopted by the deep magnetite-producing microbes which were discovered deep in the Siljan Ring. The vast implications of Gold's Deep Hot Biosphere cover the field of diamond formation as well. The fact that diamond-bearing kimberlite represents powerful explosions of deep magma, the occurrence of gas-filled inclusions and the finding of graphite in the shape of diamonds, supports the concept of diamond origin from hydrocarbons. The middle section of the book is thus an excellent summary of the Deep-Earth Gas Theory.

The last section of the book is devoted to the impact of the Deep Hot Biosphere Theory on the origin of life. The probability of life evolving deep inside the earth, with its greater volume of available pore spaces and abundant supplies of upwelling hydrocarbons, is higher for the deep biosphere than the surface biosphere. The fact that the microbes discovered deep inside the earth are more primitive than those found on the surface, and that they are dependent on a simpler form of non-photosynthetic chemistry,

leads Gold to propose that life first originated inside the Earth. From here, it migrated, along with upwelling hydrocarbons, to the surface. Gold then suggests that the search for extraterrestrial life, which has failed to uncover any form of surface life in the Solar System, should instead switch to the interiors of the planet, where he predicts for the existence of life.

This book is evidently one of the most controversial of all books published in recent history. It is bound to cause much debate, and, if found to be correct, is likely to revolutionize the face of science. Although his ideas have not particularly caught on in the West, this should not prevent Indian scientists from pursuing Gold's Theories and taking a lead in this direction. Furthermore, since his work covers several diverse fields of science, pursuit of his theories is therefore likely to impact these various fields; but, in particular areas in biology, geology and astrophysics. For this reason alone the work under consideration deserves careful scrutiny by scientists.

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**Deccan Volcanic Province, West Volume.** K. V. Subbarao (ed.). Mem. Geological Society of India. 1999. v. 43(1). Price, Rs 750. 547 pp.

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Deccan volcanism is a significant event in Indian geological history, and it has drawn much attention from geoscientists world over. International seminars on Deccan Volcanism have been organized in India during recent years. Since classical and seminal contributions on various aspects of Deccan Volcanism, by many stalwarts on Indian Geology, are not readily available, attempts have been made in recent years to reproduce excerpts from their pioneering works. During March 1996, at Nagpur a seminar was organized jointly by Geological Survey of India and Gondwana Geological Society. On that



occasion, *Annals of Deccan Traps Study*, covering early studies carried out during 1835 to 1940, including a *Bibliography on Deccan Trap*, was brought out by the Geological Survey of India in its Special Publication No. 38. The *West Volume Memoir* on Deccan Volcanic Province by the Geological Society of India, too contains excerpts and texts from pioneers, including those of W. D. West. It also includes contributions from later and modern workers. The compilation on the subject of lifetime-interest of West has been assembled into two volumes and dedicated to his memory. Unfortunately, he passed away (on 23 May 1994) before the volumes could be brought out. The volume one, which has come out recently, includes chapters on: Early Works, Winds of Change, Palaeomagnetism, Stratigraphy, and Structure and Tectonics. The volume two, which is to follow, would include chapters on Geomorphology, Mineralogy and Petrology, Geochemistry and Lonar Lake.

The chapter on Early Works includes excerpts and text of some important contributions by pioneers covering nearly the same period from 1844 to 1934. That 'These works have long been out of print and thus not readily available', as commented in the Preface, is not valid. In fact, many of these are obviously available, since these works have been reproduced earlier in the Special Publication No. 38 of the Geological Survey of India. Infact, the repetition could have been avoided with a cross-reference to the above. Indeed, it is rather unusual that no reference is made on this earlier publication of the Geological Survey of India.

The Royal Asiatic Society first published monumental contribution on Deccan volcanics and on Indian geology by T. J. Newbold, a self-taught army officer. It secured him fellowship of the Royal Society London. He recognized anticlinal nature of the elevated plateau forming the Ghats. He noted absence of quaquaversal dip in the layers of basalts surrounding the Lonar Lake, and thus discounted its volcanic origin. Blanford's contributions are of recognized excellence. He noted the presence of ash beds and the subaerial nature of Deccan Volcanism from western India and Malwa Plateau. Based on stratigraphic relation of Deccan with the Bagh Beds below and overlying beds of nummulitic age, the traps were assigned Upper

Cretaceous age. He was also the first to record acid and alkaline rocks from the Narmada Valley and the Rajpipla Hill. P. N. Bose, the first Indian geologist recruited to the Geological Survey of India, has described depositions of agglomerates and ash beds opposite Mandaleswar. He also described a basic dyke there carrying blocks of 'felsite'. This remarkable outcrop was a subject of later study, establishing assimilation of Proterozoic Granite. The classic contribution by Fermor and Fox is on mapping of the selected areas of Deccan Trap around Linga, and establishing these as extrusive flow. They were the first to map flow by flow, which was applied by the Survey much later. They also reported, 'curious circular hollows' which may represent vents through which lava or gases escaped. The contribution by West (1934) is a review on several pioneering studies made till then on Deccan volcanics.

The inaugural address, Picrite basalt controversy, by K. G. Cox at the Workshop 'Deccan-96: Winds of Change', organized at IIT, Mumbai, 1996, has been reproduced in this volume. He recalled West's benchmark contribution on 'Forty-eight flows', from Saurashtra (included in volume 2 of the Memoir) wherein West had emphasized the role of picrites as source magma, contesting the postulate of Bowen that picritic lavas are formed by accumulation of largely olivine crystals. The section, Winds of Change, has assembled other contributions on changes in concepts as well; such as the doubt expressed by West on presumed long period of Deccan Volcanism in view of lack of evidence of erosion between the flows. This got corroborated by  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  incremental heating ages in the range 67 Ma-68 Ma on Deccan flows from Igatpuri-Mahabaleswar section (Duncan and Pyle 1988).

Another important aspect is the application of chemo-magnetostratigraphy for Deccan Lava Sequence from Western Ghats and Narmada Area. The results challenged the traditional view that older flows occur in the east. Pioneering palaeomagnetic studies on Deccan lava have also established northward journey of the Indian continent. Najafi and others (1981) were the first to outline geochemical changes in 47 flows with height in the Mahabaleswar section. Beane and others (1983, 1986), Cox and Hawkesworth (1985) contain results of collaborative

work by the American, British and Indian research group on petrology and chemical composition of traps. Sreenivasa Rao and others (1985) recorded for the first time N-R-N magnetic polarity sequence from the Narmada lava pile, which supplemented further with chemo-stratigraphy, helped them to identify four units. The study established the presence of older flows here than those from the Western Ghats. Yedekar and others (Gondwana Geol. Soc., 1996) have reported N-R-N-R polarity sequence from this sector. Deutsch and coworkers (1959) and Sahasrabudhe (1963) were the first to highlight that the Deccan Flows of Western Ghats are reversely magnetized, whereas the upper section of the lava is normal. Their results also established northward drift of the Indian continent over great distance, from the southern to the present northern hemisphere location during the last 70 Ma. After re-evaluation of these results and some new data, McElhinny (1968) estimated the duration of Deccan Volcanism to be 5 Ma. On the other hand, integrated magnetic polarity and radiometric dating programme by Courtillot and others (1986), while confirming earlier results, narrowed down the duration of volcanism to 1 Ma. Collaborative studies between University of London and IIT, Mumbai, by Khadri and others have attempted flow-by-flow stratigraphy of lava pile east of Pune, from Western Deccan to the Malwa region. The coloured geological map provided shows disposition of flows to the east of Pune. It is rather unusual that the map and corresponding geological profiles are inconsistent. How can there be two different N-S profiles drawn across Pune? Comparing with the map, it was found that one profile actually trends NE and the other NW from Pune. Geological distribution of lava units is not shown to the west of Pune, although one of the sections has been produced. Other than the top-most Mahabaleswar Fm., none of the lava formations and their nomenclature in the geological map by Khadri and others match with the geological map of Deccan Flows from Western Maharashtra after Godbole and others (Gondwana Geol. Soc., 1996); there is no cross reference to this work either. Pattanayak and Srivastava have also tried to unravel flow stratigraphy from the eastern Deccan Province relying on petrography, field disposition and major element chemical signatures. Their



Table 1 (pp. 237-238) includes megascopic character, field criteria, thickness and range. Relevance of 'Age' in this table under thickness in metres is ambiguous. Lot of basic data on megascopic and micro-petrographic nature of various flows has been documented. But recognition of lava-stratigraphic units based on petrography, major oxide and their correlation would remain suspect and pose major problems. One should recognize that chemically similar lava types in different areas are not necessarily contemporaneous as revealed by contrasting magnetic polarity signals from chemically similar flows. Yedekar and others (op. cit.) have also worked on chemo-magnetostratigraphy of Chhindwara-Jabalpur-Seoni-Mandla sector of Eastern Deccan Province and they too have discussed on such correlation problems.

Workers from Geological Survey of India, independently and also in collaboration with Japanese research group, have carried out chemo-magneto-stratigraphic work on Deccan Lava Flows. The pre-seminar proceeding by the Gondwana Geological Society (1996) has included number of these contributions. Geological Survey of India has also published a number of Quadrangle geological maps of Deccan Trap Area. Apparently these publications have not been consulted or cross-referred, resulting in introduction of a plethora of uncorrelatable names of Deccan lava units.

The section on Structure and Tectonics begins with Auden's (1949) contribution on dykes of Western India, reproduced without abridging. Auden's contribution has been discussed on dykes in clusters, swarms, radial networks in Gujarat and Konkan areas. Most of the dykes cutting the traps are shown to be post-lava. Glennie and Takin emphasized thick mafic intrusives, positive gravity anomaly over Bombay, and have provided insights into evolution of Deccan Province under influence of mantle plume, magma underplating and epirogenic uplift. West (1962) was the first to draw attention to the geological significance of the Narmada-Son lineament. This zone marks a Quaternary Basin along the faulted junction between two major blocks of the Indian continent, and has controlled the development of the Vindhyan and Gondwana Basins on its either side. The complex nature of this mega-lineament has been a subject of later studies. However, it is worthwhile to clarify that West did not

postulate that Narmada-Son lineament represents a 'geosuture'; as commented in the Introduction. The term 'geosuture' has specific tectonic connotation. The Narmada-Son lineament, on the other hand, is an intra-continental zone of crustal weakness that witnessed several reactivations at different geological times. Crustal structure of this zone has been brought out by DSS profiles (Reddy and others). K. S. Mishra expanded the work of Auden on the distribution of dykes in Saurashtra and Kutch based on studies of satellite imagery and aerial photographs. Sant described control of tectonics, relief and climate on geomorphology of the Deccan landscape. Seismogenic aspects of Deccan Province are discussed in three papers. Chadda and co-workers from NGRI reviewed the incidence of reservoir-induced seismicity (RIS) along the western coastal margin, especially the events of Koyna, Warna and Bhatsa in the Deccan Province. Mahadevan and others discussed seismicity of Deccan Province, especially on factors like role of compressive stress, pore pressures, etc. in different crustal blocks, such as Western Pericratonic Belt of Active Rifts, Saurashtra Block, Son-Narmada Belt, and the platforms to the south and north of SONATA Belt. Widdowson and Mitchell have discussed on the role of denudational isostasy. Keszthelyi and others have presented their studies on the morphology and dynamics of the Columbia River Basalt and Hawaiian flows. They have discussed continental flood basalt eruptions and mass extinction, raised certain unresolved questions on Deccan Volcanism, and proposed certain topics for future research.

The Memoir 43(1) by the Geological Society of India, edited by K. V. Subbarao, is thus a useful compilation on Deccan Volcanism dedicated to W. D. West. The volume one has recently been published (Price Rs 750), and volume two would follow soon. However, these volumes would be incomplete reference sets on Deccan so far as contemporary contributions are concerned; and *Deccan Basalt* (Price Rs 800) by Gondwana Geological Society (1996) would compliment this aspect. The *Annals of Deccan Traps Study and Bibliography on Deccan Trap*, Special Publication No. 38 of the Geological Survey of India (Price Rs 260), would provide glimpses into earlier studies, together with the bibliography.

These volumes combined together would provide complete collection of different aspects on Deccan Volcanism. Browsing the contents of the Memoir clearly brings out the extent of lack of communication and co-ordination among different teams working on Deccan Volcanism. It is noticed that different groups, or even same group working in the same or adjacent areas have independently classified the flows, numbered and grouped them into formations which at times have also been named. Thus there is a dire need for co-ordination among the workers on Deccan chemo-magneto-stratigraphy, as well as, in other aspects for arriving at a meaningful synthesis.

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**The Life and Works of a Demographer: An Autobiography.** Chidambara Chandrasekaran. Tata McGraw-Hill Publishing Company Ltd., New Delhi 110 008. 1999. 327 pp.

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This autobiography is topical, as India is in the throes of transition from a Malthusian population to a modern demographic regime of low fertility and mortality. The author narrates in a lucid style, for the lay reader, his trials and triumphs in shaping a professional career in what was colonial India.

C. Chandrasekaran, the author of the book, was born in an illustrious South Indian Brahmin family with high values for scholarship and research. Job migration broke up the joint family which was not spared demographic visitations. The influenza pandemic claimed his mother, and his step-mother died in child birth. His education, both in India and England, was interrupted due to illness caused by bouts of virulent malaria.

Two Nobel laureates came from Chandrasekaran's family and had a profound influence on his career. His uncle, Sir C. V. Raman, won the Nobel prize for physics. Chandrasekaran's cousin and