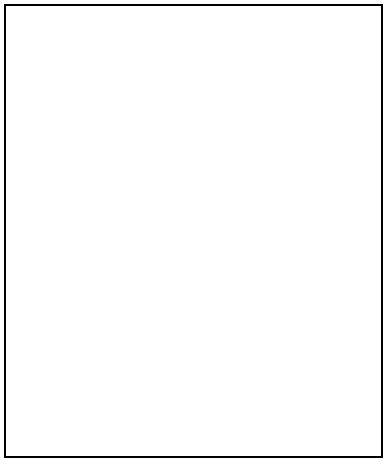
Editorial

To see a World in a Grain of Sand,
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your hand,
An Eternity in an hour.

William Blake

Isotopes which differ from each other by just a few nucleonic masses (10^{-24} gm), are finely ordered in many a natural system as an integrated result of atomic and thermodynamic processes. Relative concentrations of isotopes in an object thus carry incisive information on the rates of natural processes as well as on the chronology of critical events in a system's evolution, right from the time of their formation in the universe. Such information constitutes the key to resolving a host of discriminating questions in earth, environmental and medical sciences, but requires highly accurate determinations of infinitesimally varying quantities that represent isotope abundances in a system, often from a few grains of a sample. The history of our empowerment to glean far-reaching insights into natural processes that span over 10 orders in time, naturally followed that of innovative developments in mass spectrometry, and until the sixties was almost entirely restricted to laboratories where scientists had spearheaded the design and fabrication of mass spectrometers.



K Gopalan

The first mass spectrometer for Rb-Sr measurements was constructed in India in the mid-sixties by Professor Venkatasubramanian at the Indian Institute of Science, Bangalore, and used by K Gopalan to date minerals from the Precambrians of India. This pioneering work in isotope geology in India must rank amongst the earliest studies to date very recent geological processes.

The scene was thus set in this country for gleaning the secrets of earth and solar system processes through isotopic windows. Gopalan, more than anyone else, kept up the struggle to be on the front by dint of a crusading mind and a most rigorous preparation. Thus, between his first flirtation with geochronology at the Indian Institute of Science in the mid-sixties and a more committed marriage to it a few years later at the Tata Institute of Fundamental Research, he painstakingly mastered the art and science of meticulous mass spectrometry in Professor Weatherill's laboratory at the University of California, Los Angeles, producing on the way, some of the first chronologies of the solar system by measuring Rb-Sr ages for each of the chemically coherent groups of chondritic meteorites and of moon rocks brought by Apollo II, for whose analysis, Gopalan had won a well earned reputation for incisiveness and precision.

Seizing the opportunity provided by Devendra Lal to initiate researches in stable isotopes produced by radiogenic parents, at the Tata Institute, Gopalan set

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to realize his dream of unravelling the chronology of terrestrial as well as extra-terrestrial processes and objects. This was one of the prime motivations behind the construction of a 4.5″ radius Reynolds' type mass spectrometer which Gopalan and M N Rao built in a record time of a year by drawing upon the excellent glass blowing facilities of TIFR. This ultra-high vacuum mass spectrometer which incidentally drew a compliment from Reynolds himself, was extensively used for over two decades for noble gas measurements in meteorites and soil samples brought by the Russian Luna 16 and 17. A prototype of this instrument built by him later was used to obtain the first K-Ar ages of Deccan basalts and later, the chemical and isotopic make up of their source material in the earth's upper mantle, questions that had held a challenge to Gopalan's psyche.

The second mass spectrometer built to address the by now growing clamour amongst Indian geoscientists for well constrained chronologies of the Indian rocks, was a 9″ radius Thermal Ionization Mass Spectrometer (TIMS) set up by Gopalan at PRL, a mere eight years after his initiation into geochronology at the Indian Institute of Science. This system was literally built from the bits and pieces of a gas source mass spectrometer which had been donated by DTM to TIFR, and fortuitously the yet unused spare flight tube, for the study of Rb-Sr chronologies. This solid source mass spectrometer had a performance comparable to contemporary systems elsewhere, and was immediately used to determine the first most comprehensive and definitive Rb-Sr ages of rocks from the Rajasthan Craton in northwestern India. A serendipitous discovery, in this quest, was the existence of Archean relicts of a primitive continental crust in Rajasthan, older than 3 billion years suggesting a Precambrian analogue of modern plate tectonic processes of continental collision.

The 9″ TIMS at PRL, since upgraded for Re and Os isotope measurements by PRL scientists, remains the only home made system in India still usable for modern studies. It was diligently used by its author to establish the chronologies of the various geological formations of the Indian crust from the Himalaya to Kanyakumari, until the mid-eighties when he moved to the National Geophysical Research Institute at Hyderabad to set up a new state-of-the-art isotope laboratory for measurements of Sr, Nd, and Pb isotopes.

Two other important developments spearheaded by Gopalan's unflagging zeal, that would further broadbase mass spectrometric endeavours in the country had fortunately taken seed at PRL before his departure, which his erstwhile colleagues in that institute indefatigably advanced. The first of these addressed the then germinating concerns about climate variability from an analysis of the stable isotopes, H, C and O in a variety of natural archives of palaeoclimatology and palaeoceanography.

These studies have since delineated important landmarks in climate evolution during the recent past, using dendrochronology of trees from Kashmir and other tropical habitats of India. The second important development was the establishment of an ion probe laboratory in PRL for planetary research. Recent creative applications of this facility by J N Goswami and his colleagues at PRL to study the very subtle isotopic anomalies in primitive meteorites has shown that 26 Al is most likely the heat source responsible for melting and differentiation of meteorite parent bodies.

Having been somewhat involved with much of the later developments in isotope geochemistry, since the mid-eighties, I know full well where the well spring of truly productive ideas and concerns for advancing Indian endeavours in this field, resides. Pursuing what by now had been established as an inalienable integrity of purpose, Gopalan designed and set up a world class facility at NGRI for precise determinations of Sm-Nd isotopic compositions of a variety of mantle-derived rocks lodged in the Indian crust, while continuing to actively energize other scientists at the Institute to develop new important applications of mass spectrometry. Notable amongst these developments are the stable isotope laboratory and a high precision Helium sniffer which has been creatively used over the past decade to delineate fine scale Helium anomalies that are diagnostic of oil pool accumulations and deep fracture systems in the earth.

Few individuals that I know have so consistently and uncompromisingly striven to grow a tradition of scholarship and excellence. Fewer are fired with a lifelong passion to create and empower others to create. Gopalan's everflowing stream of new ideas to potentiate new opportunities, unable to draw a matching response, often drew only annoyance, and one would never be able to list all the other wonderful things which might have happened to Indian earth science, if he had been listened to with greater sensitivity. Yet, his convictions, always arrived at after a most rigorous analysis, were so strong that a few of his ideas did evoke a response. In particular, I must mention two: the proposal to develop in India an ICP-MS system and an Accelerated Mass Spectrometer by taking advantage of the requisite skills and infrastructure available at BARC and at the Institute of Physics. The latter will hopefully be commissioned this year and revolutionize Indian science in many ways, thanks to the personal interest taken by the erstwhile Director of the Institute and now Secretary, Department of Science and Technology, Prof. V S Ramamurthy.

The content of this special volume on "**Isotopic windows on earth and planetary processes**" was carefully designed by the Advisory Editorial Committee consisting of Professors D Lal, J D McDougall, B L K Somayajulu, and S Krishnaswami and Doctors Y J Bhaskar Rao, Anil Kumar and T V Sivaraman, and

painstakingly reviewed by discerning referees. I owe them all a deep debt of gratitude and hope that the scientific quality of papers herein will prove to be an ample reward for their labours, as it might also be an illuminating record of this fast evolving field for students and researchers in this field.

The volume contains four invited papers from Professors D Lal, J D McDougall, R K O'Nions and G J Wasserburg, all of whom deeply empathized with Gopalan's serious endeavours to establish the high culture of geochronology in India. Other papers expose new significant findings in a variety of earth system archives, using isotopes, particularly stable isotopes. Many of these have been possible because of the unrelenting efforts and labours of a remarkably purposive individual sensible to the excitements of 'beyond here and now'. This volume is accordingly dedicated to his ever vibrant spirit which created imaginative possibilities for many others to explore and advance.

V K Gaur
Editor