Research snippets (*compiled by A. V. Sankaran*)

Neutrino and muon bursts wiped out dinosaurs

During the long history of evolution of life on Earth, there have been periodic mass extinctions of some of the life forms. Many causes, terrestrial and extra-terrestrial have been advanced for their exit, particularly following the publication of the well-known meteorite impact theory[1] in the eighties. The latest agent of extinction invoked is – cancer-causing mutations triggered by massive bursts of neutrinos released by the dying stars in our galaxy[2], or by energetic muons from neutron stars[3].

Theoretical calculations about the damage that can be caused to living tissues when neutrinos collide with the cell nuclei have shown that they can be quite harmful. Neutrinos normally do not interact with matter but under sudden flood of their emission during stellar collapses, such collisions can take place, and in fact this has been happening within 20 light years of Earth almost every 100 million years. The collision results in recoil of nuclei which damages the DNA, inducing cancer-causing mutations; according to calculations, each recoil may deposit more than a thousand electron volts of energy along a track length of 10 nm, which is a substantial amount – about 12 malignant cells per kilogram of tissue – a damage quite severe considering the fact that dinosaurs are large bodied.

Recently, three astrophysicists from Israel, Arnon Dar, Ari Laor and Nir Shaiv of the Technion in Haifa, have also expressed similar views[3] and feel that mass extinctions during past geological history could have been triggered by the collision of neutron stars. Such collisions could deliver in a single day equivalent of 100,000 years' worth of rays which on hitting upper atmosphere of earth could generate a cascade of highly energetic muons capable of killing organisms directly, apart from destroying ozone layer and making the environment radioactive. However, since muons are stopped by rock and a few tens of meters of water, organisms living below these levels are shielded and survive.

1. Alvarez, L. W., Alvarez, W., Asaro, F. and Michel, H. V., *Science*, 1980, **208**, 1095–1108.
2. Collar J. I., *Phys. Rev. Lett.*, 1996, **76**, 999–1002.
3. Review under Science, *New Scientist*, 1996, Sept., no. 2047, 15.

Vagrant North America and its drop out

Ever since Eduard Suess, the Austrian geologist first postulated the giant Gondwanaland, a primeval amalgamation of all the early landmasses, a concept which soon led to the development of the well-known hypothesis of Continental Drifts by Alfred Wegner, geologists have been re-examining and revising the concepts of global palaeogeography. By early sixties, the Wegnerian ideas of continental drifts, which had remained dormant for some decades, were revived with the advent of global plate tectonic theories developed by notable geologists of those times like Hess, Vine and Mathews. According to these theories, continents grew by accretion of crustal fragments and mid-ocean islands; the continents could also break, and segments of such crusts could migrate across oceans. Based on data from stratigraphy, internal structures, fossils, palaeomagnetism, seafloor explorations, mantle dynamics, computer simulations supported by satellite and seismic records, the peregrinations of the continents during the geologic past became clearer, though some of the new thinking about the palaeogeography of the ancient continents are still much debated.

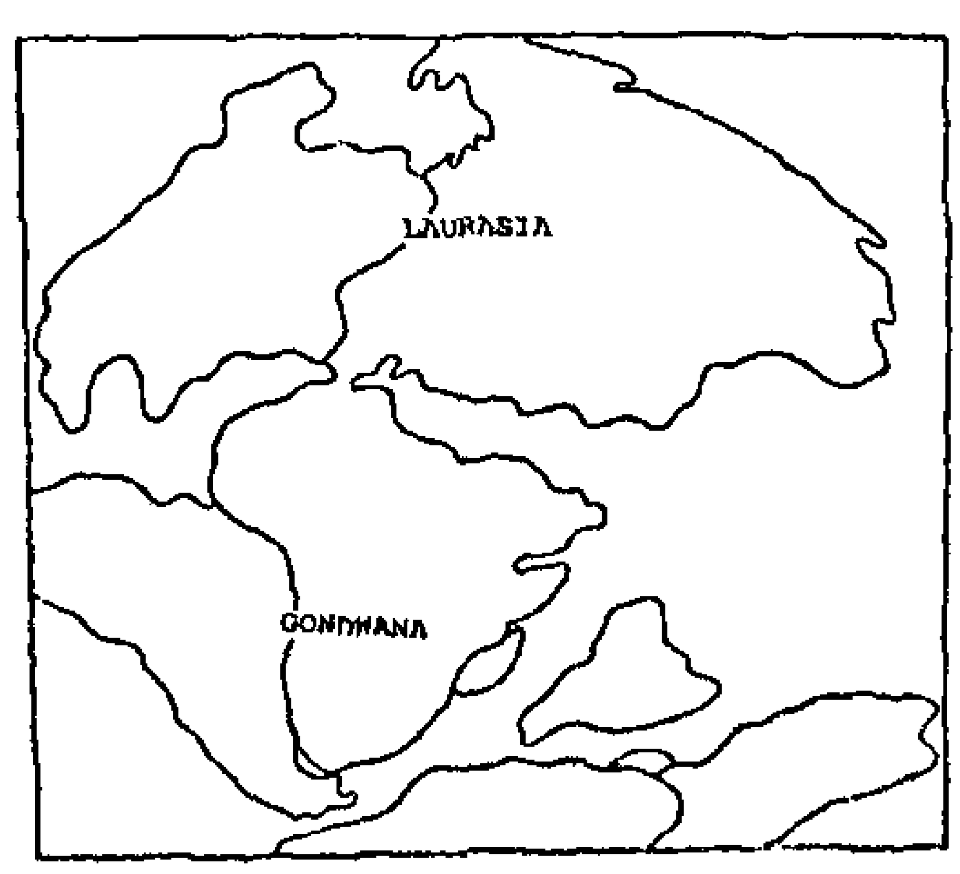

Figure 1. Pangea, 180 million years ago, showing break up into a Northern Laurasia and Southern Gondwana.

Views about the ancient continental dispositions, as a single vast land called 'Pangea', during the Permian times (250 million years ago) and how it split into 'Laurentia' (North America, parts of Europe and a few other continental fragments) and 'Gondwanaland' (Africa, South America, Antartica, Australia, India) during later times are today well known[1] (Figure 1). But the palaeogeography prior to this period, during Palaeozoic and Precambrian times, is difficult to conceive in the absence of ancient ocean floors to provide guidelines. During the last ten years, some attempts at this exercise have yielded a fair picture particularly about the wanderings of the North American continent. This has been deduced from a study of palaeomagnetism in the iron-bearing minerals formed at different periods on this continent. These minerals orient themselves along the magnetic N–S direction (or more precisely, the geomagnetic field) when they crystallize from the magma, and a critical evaluation of their orientation in the rocks formed at different time intervals provides reliable data to infer about the latitudes the continent occupied (wanderings) in the past.

According to a hypothesis[2] presented a few years back called the SWEAT hypothesis (for SW U.S – East Antartica) based on field trips to Antartica by Eldridge M. Moores of the University of California (Davis) and Ian W.D. Dalziel at the University of Texas (Austin), the Shakleton Range of Trans Antartic Mountains expose rocks of similar characters and age (1.8 billion years) as those lying under New Mexico and Arizona or those of Grenville Province on the eastern and southern margins of North America. Hence they believe that these areas must have been juxtaposed at one time during the past eons. This juxtaposition of Laurentia (ancient North America) and East Antartica prior to

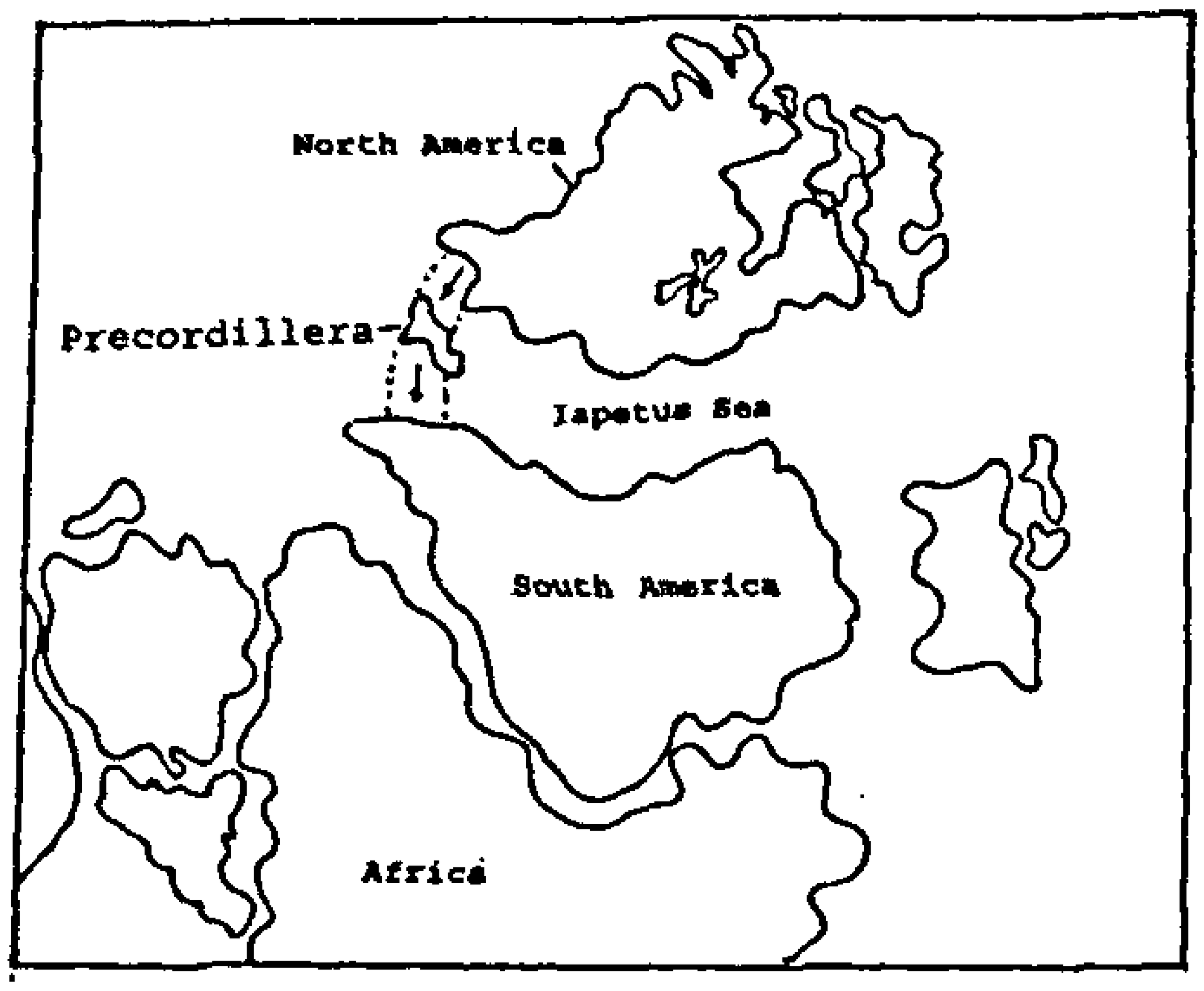

Figure 2. Breakaway microcontinent (Precordillera) adrift in the Iaepetus Sea to dock later with South America (alongside present day Andes).

the formation of Pangea, according to them, could indicate existence of an earlier megacontinent which they called 'Rodinia', a fusion of Antartica, Australia, North America and fragments of South America. The oceans that existed at that time between other continents – India and Africa and Africa and South America were destroyed between 750 and 550 million years and all nucleii of Africa, Australia, Antartica, South America and India amalgamated into the giant 'Gondwanaland'.

They further argue that Laurentia, the ancient North American continent, as per magnetic data, wandered during the late Precambrian and Palaeozoic times around the west coast of South America and collided with it at a place where Andes was pushed up much later and finally, when Pangea was formed, abutted against northwest Africa pushing up the Appalachian mountains in the process. This Laurentia–South America collision during Palaeozoic was also strongly supported by Louis H. Dalla Salda from the Argentinian University of La Plata, on the basis of tectonic and faunal studies in the Andes. Though these inferences about the journeys by the ancient North America were based on computer simulations by Dalziel, he hoped that future discoveries of land fragments, ripped-off continents and accreted to other landmasses, will soon come up in support of his views; and, indeed, they came up soon.

The first such accreted fragment was discovered in the foothills of Andes, as a tract of limestone 100 miles wide and a 1000 miles long, called Precordillera, north of Mendoza in western Argentina. This tract appeared a misfit here and had distinctly different lithology and fossil content with respect to the rest of the surrounding areas. According to Victor Ramos[3] of the University of Buenos Aires, Argentina, the occurrence of distinctly marine trilobites as well as pillow lavas (rocks which form when submarine lava eruptions congeal rapidly) on both sides of the Precordillera would suggest that this segment must have been once surrounded by sea before it became part of South America. He also felt that this piece of land might have broken off the ancient North American east coast (now the southern USA, parts of Texas and Arkansas) some 500 million years ago and drifted to its present position along the Andes mountain range.

The above view recently received strong support from William Thomas of the University of Kentucky and Ricardo Astini of the University of Cordoba, Argentina[4], who found that 'Cambrian fossil fauna of the Precordilerra were identical to those of continental shelf succession of Laurentia and Cambrian succession of Precordillera similar to those of margins of Laurentia'. They also felt that this piece of land must have rifted away from Laurentia (the Ouchita rift), during the Cambrian times and drifted as a micro-continent across the intervening sea (Iapetus Sea, now extinct) as an island before berthing alongside west coast of Gondwana (South America), during the Ordovician, some 80 million years later (Figure 2). Till the time this piece of land was close enough, faunal exchange with mainland Laurentia was taking place; but when the gap widened with time, this segment had its own unique younger fossils which were absent in Laurentia (North America) and later when close to Gondwana (South America), faunal exchanges resumed. They feel that these features strongly support the view that the castaway Laurentian (North American) terrane spent some time as an island before berthing with the west coast of South America; this implies that Laurentia and South America were not in direct contact, a view that questions the direct collision of the two as advanced by Moores, Dalziel and Louis Dalla Salda. There is also a third view[5] that a submarine plateau may have attached the Precordillera to North America. Geologists are now looking for similar castaways – rifted continental segments or terranes – that had accreted to other continents in the globe. Tentatively, they have detected two such possibilities in the rock tract in Piedmont Mountains in North Carolina which appear to be a part of South America as also Oxaco region of southern Mexico.

1. Dietz, R. S. and Holden J. C., *Sci. Am.*, 1970, **223**, 30–41.
2. Dalziel, I. W. D. *Sci. Am.*, 1995, **272**, 38–43.
3. Ramos, V. A., Jordan, T. E., Allmendinger, R. W., Mpodozis, C., Kay, S. M., Cortes, J. M., and Palma, M., *Tectonics*, 1986, **5**, 855–880.
4. Thomas, W. and Astini, R., *Science*, 1996, **273**, 752–757.
5. Kerr, R. A., *Science*, 1995, **270**, 1567–1568.

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The 'Vision 2005: Earth Sciences' document of the Department of Science and Technology was recently printed in the pages of this journal (Curr. Sci., 1996, 71, 820–823). An alternative view, espoused by one of India's leading geologists is reproduced below.

– Editors

Priorities in earth science research

B. P. Radhakrishna

'If we want the world to pay greater attention to geology, and if we want decision makers to allocate more resources for geology, then we need to demonstrate the importance of geology in public affairs and we must accept our public obligation to be good citizen geologists.'

E - an - Zen

As the twentieth century is drawing to a close, scientific institutions in the country have taken to the exercise of presenting 'vision papers' outlining the goals of research to be pursued by them. The United Front Government at the Centre too has come out with a Common Minimum Programme (CMP) to be followed during the coming years. It is worthwhile to examine the relevance of these programmes and the role of Earth Science in the present context.

One of the vision documents lists the following areas of opportunities for research in the field of Earth Science: (1) Evolution of the Indian Crust, (2) Himalayan Orogenic Belt, (3) Earthquake Problems, (4) Reconstruction of Palaeoenvironments and (5) Earth Science Application for Societal Needs.

Are these the priority areas of our research? What are we really going to achieve? Do these in any way contribute to the welfare of our people? If such questions are posed, it will be seen that a good part of our research effort is aimless and that we are trying to answer questions which nobody is asking.

The trouble with our research programmes appears to be that our top research personnel occupying senior positions in our universities and research institutions have received training in universities of UK, Europe and America. So trained they cannot but pursue the type of research that is being practised in those countries. Their vision has seldom extended to finding solutions to the problems faced by this country. Science and Technology have yet to become effective tools for national growth and economic development. The time appears ripe for introspection and rethinking.

The glaring fact remains that this country, even after fifty years of independence continues to be one of the poorest nations in the world. It is not as if we are lacking in resources. For its size, India has a variety of mineral and metal resources to satisfy many of its needs. Compared to other parts of the world it receives copious amounts of rainfall. Its soil is fertile. Hill slopes are covered with evergreen forests. The country is populated not by aborigines but by intelligent people with thousands of years of culture behind them. Its human resources are second to none. And yet, in spite of all these plus points, we remain poor. The reasons are not far to seek. It is because we seem to be wasting our time in imitative and aimless research and serious problems facing the country have been largely ignored. Have we tried to identify gaps in our knowledge and pose the right questions? First and foremost there is need for educating the public and those who are occupying seats of power as to what the scope of Earth Science is and what it can do to better our economic well-being.

Energy needs

As a consequence of the big boost given to the growth of the automobile industry, there has been an alarming increase in the number of vehicles and consequently in oil consumption which stands at 65 million tonnes per year. Indigenous production has remained stationary at around 35 million tonnes, necessitating import of the balance quantity of 30 million tonnes per year! This drain is likely to increase in the years to come, causing a big hole in foreign exchange resources amounting to over 7 billion dollars, or nearly 25,000 crore rupees.

Sedimentary basins having a good potential for oil cover an area of 1,400,000 km^2 on land and 720,000 km^2 offshore. This is an indication of the magnitude of the work before earth scientists – geologists and geophysicists alike – in carrying out detailed exploration of these sedimentary basins with a view to identifying favourable structures for test drilling. No concerted effort is yet evident in this direction. We seem to be waiting for others to come and do the job for us. The zeal and enthusiasm which were in evidence at the time of the formation of the Oil and Natural Gas Commission are lacking today. If goals are set and our scientists motivated and encouraged, there is no reason why India should lag behind in attaining self-sufficiency in respect of her oil requirements. One need not always be on the look out for giant fields, the many smaller fields also require attention.

The same lack of will is evident in the development of natural gas resources. Adequate attention is yet to be directed towards wise utilization of the identified reserves. In any agenda for research in the coming years, the identification of fresh resources of hydrocarbons should, therefore, occupy the first place. Geophysicists and geologists have a challenging task before them in these areas alone.

There is quite a bit of loose money in the country as is revealed by the insatiable thirst for possessing gold. Annually not less than 25,000 crores are being diverted in this way for want of better avenues for investment. Government policies and private initiative should aim at providing incentives to wean people away from investing their surplus money in gold and divert it for nation-building activities.

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