

## Science Last Fortnight

### Geology of Peninsular India

#### *A queer connection*

Diamonds are formed at extremely high temperatures and pressure, embedded in kimberlite stones. So, though diamonds are some of the most precious stones on the planet, diamond mines are far rarer than any other mine.



Image: Wikimedia Commons

In order to explore diamond mines, geologists have to map the seismic patterns of the lithosphere and the mantle to understand the geodynamics of the terrain. And the most traditional way of mapping the geology is by using a method called shear wave velocity mapping.

In India, diamond mines are found in the Dharwar–Bastar–Singhbhum supercraton – an amalgamation of three cratons covering parts of Karnataka, Andhra Pradesh, Chhattisgarh and Telangana.

Based on the surface waveform analysis of India, the shear wave velocity of the Indian lithospheric mantle is lower than that observed in other regions of the world –  $V_s \sim 4.5$  km/s. And the absence of keel – found in other regions of the world – reinforced the observed anomaly.

However, shear wave analysis in some regions of peninsular India suggested a higher velocity than that found in other parts of the subcontinent. The scientists found that the changes in mantle temperature could not explain the high seismic shear wave velocity found in peninsular India. The anomaly could only be explained by studying mantle composition. Due to the lack of coherent geophysical datasheets, previous

studies could not explain the anomalies in the shear wave velocities of the subcontinent.

Last fortnight, however, Gokul Saha and S. S. Rai from the Indian Institute of Science Education and Research, Pune in collaboration with Shalivahan from the Indian Institute of Technology (Indian School of Mines), Dhanbad, investigated the seismic velocity anomalies of peninsular India using improved Rayleigh wave group velocity images.

The team observed that the high shear wave velocity layers of approximately 4.7 km/s in peninsular India corresponded to high concentrations of diamondiferous kimberlite fields. They found shear wave velocities of 4.75 km/s at depths of 90–130 km beneath the Bastar, Singhbhum, and Dharwar cratons – regions where diamond mines are found in peninsular India.

With enough datasheets from their experiments, the scientists concluded that the existence of diamondiferous fields best explains the anomaly in the observed shear wave velocities of peninsular India.

After modelling the mineral compositions of the lithospheric mantle of the Dharwar–Bastar–Singhbhum supercraton, the team concluded that the presence of eclogite and diamonds is responsible for the higher velocities. However, the amount of diamonds required to explain the observed anomaly requires further analysis, say the researchers.

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### Geochemical Proxies

#### *For paleo deposition*

Scientists can reconstruct past climates from marine sediments using geochemical proxies such as isotope ratios of elements. But such reconstructions often involve uncertainties due to the complexities introduced by the role of the water column, suspended matter and other depositional factors at the time of sediment deposition.

Recently, Shiba Shankar from the Presidency University, Kolkata and Ramananda Chakrabarti from the Indian Institute of Science, Bengaluru came up with ideas to address this issue in the marine sediments of the Arabian Sea.

Besides the isotopic composition of neodymium and strontium, they examined major and trace elements to understand the geochemical behaviour in the marine sediments of the Arabian Sea under different depositional conditions.

The researchers collected two gravity cores from two different depths in the oxygen minimum zone of the Eastern Arabian Shelf. They also measured the dissolved oxygen in the water column to understand deposition conditions.

After washing the cores to remove salt, they dried and powdered the sediment samples and chemically digested them for analysis. A few selected carbonate-rich samples were chemically leached to separate carbonate and silicate fractions.

The team measured major and trace elemental concentrations as well as strontium and neodymium isotopic compositions. Then, they examined various parameters such as normalized rare earth element patterns, the anomaly of europium and cerium elements, the intensity of chemical weathering and the plagioclase feldspar index of alteration. They found that the sediments show relatively flat heavy rare earth element patterns with positive europium anomalies and low to moderate weathering of the source rocks. They also observed that the strontium isotopic compositions were similar to those of the basement rocks of the drainage basin of the rivers Mandovi and Zuari, carrying sediments to the sea.

The neodymium isotopes showed significantly more radiogenic values than the basement rocks. The results indicate that the geochemical and isotopic composition of sediments do not have any influence on sorting and

modification and can be used for determining the sources as well as the redox conditions during deposition.

The researchers suggest caution while using the Sr–Nd isotopes and different elemental concentrations to interoperate paleo deposition conditions in the continental margin. The study can be useful to overcome uncertainties in interpreting geochemical proxies in other continental margins and for reconstructing paleoclimatic conditions.

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### Probiotics in *Arishtas* *Ayurveda meets Modern Science*

In 2002 the World Health Organisation recognised a calculated dose of living microbes as probiotics for health benefits. The word was newly coined. But the concept was not. It was an underdeveloped concept in health sciences. In fermented ayurvedic preparations, *arishtas* and *asavas*, probiotics have provided health benefits since ancient times but their contribution and identity remained unnoticed until now.

Recently, S. Sekar and A. Vinothkanna of the Bharathidasan University, Tiruchirappalli took the initiative to unravel the identity and health benefits of probiotics present in *arishtas*.

The team worked on three *arishta* preparations – Ashokarishta, Dasamoolarishta and Aswagandharishta. From these three *arishtas*, they isolated 35 bacterial colonies on nutrient agar. The isolates were identified using gram staining, various biochemical tests and 16s rRNA sequencing.

The researchers exposed the isolates to harsh *in vitro* conditions such as gastric juice and bile salt, and found that the isolates were tolerant to gastrointestinal conditions.

The bile salt hydrolytic activity tests of the isolates showed that, out of the 35 bacterial isolates, 14 have high bile salt hydrolytic activity. This means that they can survive under gastrointestinal conditions. The bile salt hydrolytic activity of bacteria helps them deconjugate bile salt and reduce serum cholesterol levels.

The isolates had high hydrophobicity and autoaggregation properties

suggesting that the bacteria can colonize the epithelial cells of the gastrointestinal tract, thereby preventing colonization by pathogenic bacteria ingested with food.

Sekar and Vinothkanna also found that 17 bacterial isolates possessed antibacterial activity while all 35 had antioxidant activity, which provides additional benefits as probiotics.

Degradation of phytates and cellulose is another desirable criterion of a probiotic, which was also fulfilled by the bacterial isolates from *arishtas*.

Based on various biochemical tests and statistical analysis, the scientists could identify a consortium of four bacterial species that could be used strategically in therapeutic applications. Using 16 srRNA sequencing, these species were identified as *Bacillus* and *Brevibacillus* species.

The scientist duo suggests that, in addition to the medicinal properties of the phytochemicals present in fermented ayurvedic preparations, the probiotics present may also provide therapeutic benefits.

This new area of research on the scientific basis of the actions of traditional medicines needs to be explored further and extended to other *arishtas* as well as *asavas*.

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### Shrimp Aquaculture *Reducing protein feed*

Shrimp aquaculture is a flourishing business. But the water in the aquaculture tanks slowly accumulates nitrogenous waste from shrimps. Pumping the water out creates pollution and increases the demand for water. So, scientists devised biofloc technology where carbon sources such as molasses or cassava are added to the water so that the carbon to nitrogen ratio is increased. This allows the growth of bacteria and other organisms. And, if the water is aerated, particulate matter, dead and live bacteria form clumps or biofloc. Biofloc then becomes protein rich food for shrimps.

Biofloc technology seems to lead to the activation of the immune system and increases shrimp biomass. But how much protein feed can be re-

placed by biofloc? A group of scientists from the ICAR-Central Institute of Brackishwater Aquaculture decided to address the issue.

They reared the shrimp, *Litopenaeus vannamei*, in a biofloc technology system and a conventional system without any biofloc. In the conventional system they provided 40% protein feed and in the biofloc technology they tried 24%, 32% and 40% protein feed.



Image: Wikimedia Commons

After 130 days, they found that, in comparison to conventional systems, the biofloc technology system showed higher protein conversion efficiency, average body weight, survival rate and feed conversion ratio even with protein feed level at 24%.

Moreover, when challenged with pathogenic *Vibrio parahaemolyticus*, the shrimps in the biofloc technology system with 40% protein feed showed reduced mortality. The expression of important immune genes and antimicrobial peptides was also much higher in the biofloc technology system than in the control. The scientists suggest that the presence of microorganisms activates the immune response of shrimps.

The scientists say that the biofloc technology, even with low levels of protein feed, can give similar results in terms of immune response and final biomass.

About 50% of the cost of shrimp farming is due to the protein feed. A technology to reduce protein feed levels is greatly beneficial to shrimp farmers as it makes farming more economical. However, shrimp farmers will need to understand the science behind the biofloc technology to use it effectively.

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### Chickpea or Mung Bean?

#### *Which is better for soil health?*

Deterioration of the physical properties of soil and depletion of soil organic carbon are the two main challenges of rice–wheat cropping systems. We know that introducing leguminous crops into the system can restore soil health. But how and to what extent?

With these questions in mind, researchers C. P. Nath and team from the ICAR–Indian Institute of Pulses, Kanpur, K. K. Hazra from the Indian Institute of Technology, Kharagpur and S. S. Singh from the Agricultural Technology Application Research Institute, Kolkata worked on a thirteen-year-long experiment on rice–wheat cropping systems with the inclusion of two grain legumes.

They selected four cropping systems for comparison: rice–wheat, rice–chickpea, rice–wheat–mung bean and rice–wheat–rice–chickpea. And they grew these crops under three nutrient management systems: no fertilizer, integrated nutrient management and chemical fertilizer treatments.

They took soil samples at the time of rice harvest and analysed/assessed soil aggregation, soil carbon pool and carbon stabilization. And found that including legumes increased the water stable macro-aggregates – both in surface and subsurface soils.

Among legumes, mung bean was found to be better than chickpea. The carbon content was also high in aggregates from mung bean grown soils.



Image: Wikimedia commons

Including legumes also increased the soil organic carbon, the active carbon pool and the carbon management index. In all the carbon parameters studied, again, mung bean was superior to chickpea.

The carbon management index was 100 in the no fertilizer treatment, which increased to 105 when chemical fertilizers were added. But the carbon management index was raised to 128 when integrated nutrient management – chemical fertilizers, farmyard manure, bio-fertilizers and crop residues – was followed.

Thus, including grain legumes, especially mung bean as summer fallow, April to June, in rice–wheat rotations improves soil aggregation, aggregate associated carbon content and carbon pools in tropical soils. The carbon management index was highest in integrated nutrient management options.

The research results provide farmers clues to increase the diversity of agricultural output from their lands without depleting their soils.

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### Using Agricultural Waste

#### *Energy or soil enrichment?*

Agricultural residue waste provides raw material for the production of renewable energy – an attractive solution for providing electricity to remote villages. However, agricultural residue is not complete waste. It can be used for animal and human dietary needs as well as for recycling nutrients in the soil for higher crop production in the next crop cycle. So, extensive use of agricultural residue for energy production may compete with food production. Moreover, it can also lead to gradual depletion of soil nutrients and water retention capacity, thus affecting crop productivity.

So, which crop residues should we use for energy production such that livestock and soil are not affected?

Last fortnight, a group of researchers from the Institute of Infrastructure Technology, Research and Management, Ahmedabad analysed the benefits and cost-effectiveness of various commonly used agricultural residues for energy production.

They selected residues from rice and wheat which together cover more than 40% of the total cultivated area in Indian agriculture. Additionally, residues from maize, cotton and groundnut were also selected as these crops cover another 14% of cultivated area.

The research team demonstrated that decentralized energy production from the residues of rice and wheat is cost-effective, while what maize residues provide are only moderately cost-effective. Cotton and groundnut residues – rich sources of nitrogen nutrients – are not cost-effective for energy production. Therefore, recycling cotton and groundnut residues in soil can be used to enrich the availability of the precious nutrient, nitrogen, to help higher crop production.

The trade-off between energy production and soil nutrient replenishment can be attained by using 25% residues of largely cultivated crops such as rice and wheat for producing energy, say the researchers.

India's national electricity policy encourages the use of renewable sources for producing energy to meet an ever-growing demand. However, sustained intensive use of all available agricultural residues for energy production may result in the depletion of soil nutrients and crop production.

The research results from the IITRAM, Ahmedabad provide clues for cost effective utilisation of agricultural waste without jeopardising soil health.

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### Solar Photovoltaic Pumps

#### *For sustainable irrigation*

Solar photovoltaic pumps use renewable solar energy. However, efficiently converting solar energy into a usable form remains a challenge for typical solar photovoltaic pumps to beat cost per watt.

Last fortnight, Kamlesh Yadav from the NISE, Gurugram teamed up with Atul Kumar from the TERI School of Advanced Studies, New Delhi and Rupesh Wandhare from the IIT, Hyderabad to design an economically viable model for a solar photovoltaic pump.

To date, solar photovoltaic water pumping systems work on conventional models, designed based on individual component efficiency or best efficiency point. In general, solar photovoltaic pump performance depends on site-specific parameters like solar irradiance, ambient temperature and water head as well as on system dependent parameters such as solar

photovoltaic module technology, solar photovoltaic tracking structure, pump controller and motor-pump efficiency.



Image: Ajay Tallam via flickr

The research team used a database from the weather radiation resource of the Ministry of New and Renewable Energy for their study, taking into consideration the per minute averaged data for a period of one year. Analysing the parameters, through simulation and experiment, the team proposed an efficient model – a solar operating duty head. 'The new working model provides a 9% gain in water output', says Kamlesh Yadav, NISE, Gurugram.

The team also found that the conventional model is fit for pumps working on constant frequency and voltage. With this new model, better low-cost irrigation could meet the needs of our growing populations.

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### Vocabulary of the Gita A statistical analysis

The *Bhagavad Gita* is an extensively studied Sanskrit poetic treatise. While it has only seven hundred verses, commentaries and interpretations are exhaustive. The rich vocabulary of the original Sanskrit version of the Gita is of interest to linguists. There are several translations of the Gita into Indo-European languages. Is anything lost in translation?

Last fortnight, Nikhil Kumar Rajput and Bhavya Ahuja of the University of Delhi, and Manoj Kumar Riyal from the Veer Chandra Singh Garhwali Uta-

rakhand University scrutinized word length distributions and word frequency in the Gita and a few selected translations. They statistically analysed the original Sanskrit text and translations in Hindi, English and French.

The scientists used the Power law and the Zipf-Mandelbrot law to model word frequency distribution. This gives an idea of the frequency of words used in the text and states that it is inversely proportional to its rank in frequency. A power law pattern with a long tail was seen in the Sanskrit version. The researchers say this is due to the high number of unique words in Sanskrit. This also means that the language is rich in vocabulary. The other three languages also followed a similar pattern in word frequency distributions.

The researchers statistically measured how much information or data can be lost when the language used is concise. They also investigated the Vocabulary quotient, a measure to determine Shannon entropy. According to the researchers, the Sanskrit version of the Gita uses more fusion words than the other three languages. Word length was also longer in the Sanskrit text. The scientists found that the Sanskrit version of the Gita has the highest vocabulary quotient and maximum Shannon entropy.

Now, is that one of the reasons for so many interpretations of the *Bhagavad Gita*, we wonder.

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### 3G Radiations Impact Reproduction Less mobile sperms

If you are active on social media, you must have come across a post or a forwarded message, warning about the ill effects of mobile phones on your health. Is there any truth behind the claims, or are they pure hoax?

A team of scientists, led by Paulraj Rajamani, from the Jawaharlal Nehru University, New Delhi, tried to find the answer. They carried out a set of experiments, to examine the effect of 3G

mobile phone radiations on reproduction, using Wistar rats.

A group of adult rats was divided into two sets. They exposed one set of rats to mobile phone radiations, with the same intensity as a 3G video voice call, for 2 hours, every day, for 45 days. The other set of rats were not exposed to the radiations and acted as the control set for the experiment.

After about a month and a half of exposure to 3G radiations, they measured the reproductive ability of the rats. The team found that the reproductive ability of rats exposed to mobile phones was reduced. The testes weight, sperm count and sperm viability of the rats exposed to mobile phone radiations were significantly less than those in the control rats.

'3G radiations from mobile phones damage resting cells which produce sperms. This seems to be the reason for the reduced total sperm count', explains Paulraj Rajamani, Jawaharlal Nehru University, New Delhi.

In normal cell function, reactive oxygen species produced are kept in check. But in the rats exposed to mobile phone radiations, the levels of reactive oxygen species were found to be significantly high. This leads to oxidative stress in the cells and hinders the sperm function in these rats.

Radiations from mobile phones are found to have deteriorating effects on reproduction in rats. Do they affect humans in the same way?

Surely further research is required to answer this question, but till then we need to be aware of the effects of mobile phone usage.

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