

## Science Last Fortnight

### Himalayan Topography

#### *Evolution of Siwalik ranges*

The Siwalik Frontal Ranges are a part of the Himalayan Frontal Range where the Indian and Eurasian plates converge. The frontal ranges are composed of sedimentary rocks that are between 700,000 and 15 million years old. These sedimentary rocks are thrust over the Gangetic plains along the main frontal thrust to form the ranges.



Image: Spattadar via Wikimedia Commons

What are the forces at work that generate the typical patterns of these mountain structures?

A. Divyadarshini and Vimal Singh from the University of Delhi decided to examine the morphotectonic evolution of the Frontal Siwalik Ranges of the Central Himalayas in Nepal, an area that has not been studied in any great detail. They wanted to find out the number of segments in the Frontal Siwalik Ranges of this area. How do these segments interact? Which segments are active?

The team took the 90-metre resolution digital elevation data of the Frontal Siwalik Ranges of the Central Himalayas from the Shuttle Radar Topographic Mission and armed themselves with ARC-Scene software that can overlay 3D images, one over the other.

They used several topographic parameters to understand the geometry and patterns of the Frontal Siwalik Ranges: the hypsometric integral, mountain front sinuosity and valley floor width to height ratios, stream length gradient, steepness index, surface elevation profiles as well as range scale and catchment reliefs. Using these variables, the researchers could examine the relative activity along various fault segments associated with

the Frontal Siwalik Ranges. Active faults can be identified by their fold morphology based on range width, base level of flanks, flank relief, and flank gradient.

The uplift is governed by tectonic forces. But the catchment that is formed is subject to erosion. So the team investigated 343 catchments in the Frontal Siwalik Ranges. The Narayani and the East Rapti rivers and their tributaries originating from the Inner and Frontal Siwalik Ranges form the drainage network of the study area. The drainage pattern, deflections in drainage, positions of palaeochannels, position and elevations of wind gaps, along with morphometric indices provided the researchers with clues about the evolution of mountain structures in the Frontal Siwalik Ranges.

They found six Main Frontal Thrust segments that have interacted to form the present day topography of the region. The duo also identified a North-West to South-East trending pre-existing tear fault in the region that forms a barrier to the growth and propagation of the Main Frontal Thrust segments and the frontal ranges along it.

Such studies also throw light on the long-term sediment routing that is controlled by the evolving topography in tectonically active areas. Understanding fault-and-fold growth, initiation, propagation and linkage in actively deforming terrains is necessary to anticipate and take action against potential earthquakes.

DOI: 10.1016/j.geomorph.2019.03.028

### Dating Elephanta Magmatism

#### *Age, duration and evolution*

Elephanta Island near Mumbai is a popular tourist destination. Geologically, Elephanta and Mumbai are related.

Both are products of the Deccan flood basalt volcanism within the Panvel Flexure Zone, on the western continental margin of India. The Mumbai volcanic sequence dates back 62.5 million years and is geochemically and stratigraphically different from the 66–

65 million year old Western Ghats sequences to the east. However, when did the Elephanta volcanic sequence take place and what is its stratigraphic status relative to the Western Ghats?

Researchers from the St Xavier's College, Mumbai, IIT Bombay and the Bhabha Atomic Research Centre, Mumbai decided to find out.

They collected eight fresh representative rock samples for argon–argon dating. The samples were crushed, cleaned, sieved and exposed to neutron irradiation for about 100 hours to convert stable potassium atoms into radioactive argon. The team extracted and measured argon from the irradiated samples using a mass spectrometer.

The radioactive decay of potassium produces  $^{40}\text{Ar}$  with a half-life of 1.248 billion years. The researchers measured the isotopic ratio of  $^{40}\text{Ar}/^{39}\text{Ar}$  and determined the age of the samples. They found that two of the Elephanta lava flows and five of the dykes (representing pathways of solidified magma rising to the surface) are about 66.6 million years old, like the Western Ghats sequence. Another dyke gave an age of about 66.1 million years making the total duration of Elephanta magmatism 3.5 to 6 million years, noting the analytical uncertainties.



Image: Hetu Sheth

Thus rapid and intense magmatism occurred at Elephanta Island 65 to 66 million years ago, at the same time as the Western Ghats eruptions, but up to 3–4 million years earlier than volcanism in Mumbai. The Mumbai volcanism was linked to the continental breakup event between the Seychelles and Laxmi Ridge-India, and succeeded the Western Ghats and Elephanta volcanism by several million years, say the researchers.

So next time you go to Elephanta, remember that you are standing on rocks 66–65 million years old!

DOI: 10.1016/j.jvolgeores.2019.05.004

### Chicken Genetic Lineage Conserving valuable traits



Image: commons.wikimedia.org

Chicken is the most ideal and economical poultry resource in India. Local or indigenous breeds are easy to manage and have many genetic advantages such as resistance to diseases and tolerance to extreme environment. But these genetic characteristics are diluted as local breeds are either being replaced or are cross-bred with foreign varieties.

To maintain the diversity and identity of local varieties and to create an inventory of genetic resources, indigenous chickens need to be identified and catalogued. Recently, Sankar Kumar Ghosh and his team from the Assam University, the West Bengal University of Animal and Fishery Science, the University of Kalyani, West Bengal and the College of Veterinary Science and Animal Husbandry, Tripura reported characterizing chickens indigenous to the biodiversity hotspot regions of east and northeast India.

The team collected blood samples from fifteen chicken breeds from the northeast and six species from east India. They isolated mitochondrial DNA, amplified the cytochrome c-oxidase-I gene, sequenced it and conducted a homology search to identify the breeds. All the breeds were identified as *Gallus gallus*, the red jungle fowl.

The team found lowest divergence between *G. gallus* and *G. varius*, the green Javanese jungle fowl. The highest divergence was between *G. gallus* and *G. lafayetii*, the Sri Lankan jungle fowl. There were a few sequences of *G. sonneritti*, the grey jungle fowl, overlapping in the barcode gap.

The phylogenetic tree using neighbour joining method showed distinct clusters of the *Gallus* species under study, except for a few from *G.*

*sonneratii*, that showed cohesive clustering with *G. gallus*. This might be because of intra-species hybridization between the red jungle fowl and the grey jungle fowl, say the researchers. The domesticated chicken, *Gallus domesticus*, is thought to be a viable cross between *G. gallus* and *G. sonneritti* that evolved some 8000 years ago.

Thus, for the first time, mitochondrial cytochrome c-oxidase-I gene barcodes for the indigenous chickens of northeast and east India have been recorded for species identification. The researchers claim that such barcoding will be useful for understanding the biodiversity and to inventory indigenous chicken genetic resources. The barcoding will help farmers and conservationists spot the desired chicken species with genetically distinct characters before they lose their identity.

DOI: 10.1016/j.gene.2019.04.051

### Reactive Nitrogen Species In winter smog, Delhi-NCR

The Delhi-NCR region suffers from intense smog each winter. Smog is produced when fog mixes with smoke from vehicles, industries, domestic fires and crop stubble burning. In smog formation, reactive nitrogen emissions play a key role. These emissions undergo various chemical transformations in the atmosphere.

Recently, Umesh Kulshrestha and Reema Tiwari from JNU, New Delhi reported investigating reactive nitrogen species in gaseous and particulate phases along the urban transect of the Indo-Gangetic plains. They chose three sites with different land-use characteristics in Delhi, Faridabad and Rohtak. Delhi represented an urban site with Rohtak as background site located upwind and Faridabad, downwind from Delhi. In December 2016 and January 2017, they collected day and night air samples. The team analysed the samples for precursor gases such as nitrogen oxides, ammonia and nitric acid. They also measured ammonium and nitrate ions in the particulates.

The concentration of gases recorded was highest at the Faridabad site and

lowest at the Rohtak site, consistent with the land-use pattern of the sites. There was a dominance of ammonia among the gases. This, say the researchers, is probably due to emissions from nearby agricultural fields. However, the contribution of ammonia to total nitrogen was highest in Delhi, where there is little agriculture. This may be due to heavy sludge loadings from urban and vegetative emissions, say the researchers.

Oxidised gases – nitrogen oxides and nitric acid – were highest at Faridabad. The researchers attribute this to fossil fuel combustion from industries and vehicles.

Overall, the gases had relative abundance over respective particulates at all the sites. Particulate ion levels were lower at Rohtak than at Faridabad. This, the researchers say, may be due to the slower oxidation of the precursor gases during transport and the industrial contribution to particulate ions at Faridabad. Further, ammonium ions showed highest contribution at Rohtak and lowest at Faridabad. The contrasting distribution of the gases and ions indicated limited gas to particulate photochemical conversions.

Oxidised nitrogen species showed maximum concentration at Delhi. It was greater at night. However, the day–night variation was lower for nitrate ions confirming the limiting role of photochemical reactions. Moreover, there was an additional input of nitrate ions from local emissions at Faridabad. Thus, the day–night evolution of oxidised nitrogen species was uncertain.

The researchers also found that the photochemical oxidation of nitric oxide and nitrogen dioxide to nitric acid was controlled by preferential scavenging of nitric acid by calcium over ammonium ions. Similarly, the abundance of ammonium nitrate aerosols was driven by local emissions especially at industrial Faridabad, says Umesh Kulshrestha.

Owing to the complex chemistry of gases and particles in the atmosphere, more such studies are required to gain certainty and better understanding about reactive nitrogen.

DOI: 10.1016/j.atmosenv.2019.04.007

## Intercontinental Gales *Disrupting normalcy*

Extreme dust storms in March 2018 resulted in abnormal levels of PM<sub>2.5</sub> and other aerosols in the Eastern Mediterranean. Meteorologists attribute this to the drastic increase in cyclonic movements emanating from North Africa – from the Saharan deserts and the North Atlantic.

U. C. Dumka from the Aryabhata Research Institute of Observational Sciences, Nainital in collaboration with researchers from Iran and Greece recently explained the meteorological dynamics of the events. Of the many storms that hit the region, the team focussed on nine storms that had a profound impact on urban air quality in Athens.

Using data from the Meteosat SEVIRI satellite, the team observed that dry hot winds loaded dust near the Libya–Niger–Algerian border. The gale along the Libyan Desert enhanced and transferred large amounts of dust over Greece, increasing aerosol levels drastically.

The researchers say that the North Atlantic Oscillation is as much to blame as the Westerlies for the enhanced dusty atmosphere and abnormal warmth over the Eastern Mediterranean. The cyclonic activities originating off the western coast of France and the Central Mediterranean moved eastwards, while the southern troughs gathered dust over the Libyan sea.

Particulate matter concentrations observed in data from satellites MODIS and SEVIRI concur with the MERRA-2 reanalysis dataset. During the span of the nine intense storms, PM<sub>10</sub> levels peaked to 6000 micrograms per cubic metre over Crete. Hourly PM<sub>10</sub> levels also reached a record high over Athens on 26 March. PM<sub>2.5</sub> concentrations on five of the seven days crossed the threshold of 26 micrograms per cubic metre.

Multiple Aerosol Robotic Network stations also reported a substantial decrease in surface solar radiation by 40 Watts per square metre in the upper atmosphere. Moreover, due to the dust-aerosol heating, the average atmospheric temperature increased by

0.5 Kelvins per day. However, thanks to early warnings of atmospheric abnormalities, local authorities took necessary action to reduce pulmonary problems caused by exposure to such extreme conditions.

Similar studies for dust storms in Northern India and setting up early warning systems are necessary.

DOI: 10.1016/j.atmosenv.2019.04.025

## Drum Composting *For household kitchen waste*

Composting converts household biodegradable waste into valuable manure. But decomposing household waste through natural means takes 40–300 days.



Image: Smabs Putzer via flickr

Anurag Garg and team from IIT Bombay along with Rakesh Kumar, NEERI Nagpur recently suggested a new drum composting method to make composting inexpensive and to produce good quality manure faster. They used six drums of household wet biodegradable waste for their experiments.

The first drum, used as control, had lower air supply than the others. The other five had air holes all over the walls.

The team collected kitchen waste from IIT, Bombay and added six kilos of waste to the control drum and to three other drums for 12 consecutive days. In the next two drums they added about two and a half kilos of waste for 15 days.

The waste was mixed every six days for the first four drums and every six days for the other two till decomposition started. Drums 3–6 were treated with a soup of microbes that speed up composting.

The researchers then analysed the quality of compost in these drums.

They found that the compost produced in the drum without aeration was of poor quality. Proper aeration, waste turning and adding inoculums produced good quality manure. A one-time addition of the microbial inoculums can reduce composting to about a month.

To make quality manure in minimal time, Anurag and collaborators suggest using this modified drum-based technique.

The ideal weight of household waste for the technique is less than three kilos per day, says Anurag, IIT Bombay

DOI: 10.1016/j.jclepro.2019.03.350

## Inflammatory Bowel Disease *Stevioside supplement therapy*

Inflammatory bowel disease is reported to have risen steeply in South Asian populations in the last decade. Lifestyle and environmental factors are often blamed. The chronic disease has a high rate of relapse and requires regular medication and therapy. But the side effects of medication lead to other complications.

In inflammatory bowel disease, an abnormal immune system response releases pro-inflammatory cytokines. Inflammation in the colon affects the digestive tract leading to bloody diarrhoea, abdominal pain and weight loss.

Ramakrishna Sistla, from CSIR-IICT, Hyderabad, in collaboration with colleagues from CCMB, Hyderabad has been working on the problem of inflammatory diseases for a while now. Building up on their previous findings, and, this time, in collaboration with researchers from the A. U. College of Pharmaceuticals, Visakhapatnam they have come up with a suggestion for therapy: a stevioside supplement.

Steviosides are diterpene compounds attached to three simple sugar molecules, extracted from the leaves of *Stevia rebaudiana*. Steviol glycoside is abundantly available and has established anti-inflammatory properties.

The researchers carried out lab and *in-vivo* experiments on mice using small doses of steviol glycoside. The

results confirmed that the small doses of steviol glycosides used as supplement inhibit pro-inflammatory cytokine function.

In *in-vivo* experiments on mice with inflammatory bowel disease induced by dextran sulphate sodium, the supplement restored the normal structure and functioning of the colon and digestive tract. The researchers say that the anti-inflammatory action is achieved by down regulating the Nuclear Factor kappa B pathway and inhibiting the Mitogen-activated Protein Kinase pathway, the pathways that produce proteins that play a major role in inflammation. The steviol-glycoside supplement therapy reduces the disease activity index in inflammatory bowel disease, a clinical measure to determine disease severity.

Although the dosage of steviosides used in the research is in accordance with the FDA-approved dosage, there is still some concern over the use of steviosides. The dosage of steviosides is known to work differently for mice and humans and an overdose in humans can lead to risk of stroke. Once these concerns are addressed, stevioside therapy could supplement conventional treatments for inflammatory bowel disease.

DOI: 10.1016/j.ejphar.2019.05.015

### Imaging Cancer Cells

#### *Folate receptor-based nanoprobe*

There are usually more folate receptors on the surface of cancerous cells than are seen in normal cells. These receptors have high affinity for folic acid, a water-soluble vitamin. A recent strategy to target cancer cells relies on folate receptors. Imaging nanoprobe and therapeutic agents attached to folic acid home in on cancerous cells. But most imaging probes, such as quantum dots and polymers, continue fluorescing even after entering the cells. Spectroscopic values obtained by imaging can therefore overestimate the amount of folic acid receptors. This is a major drawback in using fluorescence nanoprobe for folate receptors to visualise cancer cells.

So, last fortnight, Chanchal Chakraborty and team from the Birla Institute of Technology and Science, Pilani, Hyderabad campus, came up with a solution to this technical obstacle. They developed a conjugated polymer nanoparticle which can be turned on or off depending on the pH value of the cells.

They used polyfluorene, one of the simplest conjugated polymer nanoparticles to synthesize as nanoprobe. Polyfluorene can amplify target cell response emissions. Polyfluorene nanoprobe can effectively form a molecular complex with folic acid. On treatment with pristine folic acid, folate receptors present on the surface of the cancerous cells bind the folic acid. The cancerous cells have a pH value above 7. At that pH, folate receptor-bound folic acid complexes with the polyfluorene nanoprobe to quench the fluorescence, says Susmita Roy, BITS Pilani, Hyderabad.

The researchers then imaged the cancerous cells using spectroscopy. For comparison, they repeated the process with normal human cells. Normal cells did not absorb the folic acid-treated polyfluorene probes as the folate receptors are not expressed on the surface of normal cells.

The team has demonstrated a fluorescence turn-off mechanism for imaging cancer cells. It is now up to health industries to develop the nanoprobe for clinical applications.

DOI: 10.1016/j.snb.2019.04.029

### PhenoPine Model

#### *For Indian Chir pine*

The Indian Chir pine, *Pinus roxburghii*, is native to the Indian western Himalayan regions. The tree is dominant in cool-temperate and boreal forests. How will it fare under the climate change scenario?

Last fortnight, scientists from the Forest Research Institute, the Indian Agricultural Research Institute, the IISc, the Birla Institute of Technology, the G.B. Pant National Institute of Himalayan Environment and Sustainable Development collaborated with

researchers from the US and Canada to report developing a phenology model for pines – PhenoPine.



Image: Sanjay Ghosh via Wikimedia Commons

The team selected eight districts and ten healthy individuals located under different temperature regimes, in each district. Their model used daily temperature data.

They tagged the trees for monitoring phenological variations on a weekly basis and recorded the onset and offset of these changes. They thus developed a phenological calendar for three parameters – leaf formation, litter fall and cone formation. They recorded the initiation and termination day for each stage. This helped them calculate the duration of each of these stages.

Next, they tested the influence of ambient temperature rise on the phenological phases by comparing observed phenology and simulated data using the model. They found that a rise in temperature has a profound effect. Litterfall and cone formation stages increased with rise in temperature. The needle formation stage was reduced.

PhenoPine is a good model to evaluate the impact of temperature on pine forests at a regional level. But to develop it as full-fledged dynamic vegetation model will take time and effort, says Manoj Kumar, Forest Research Institute, Dehradun.

DOI: 10.1016/j.ecolmodel.2019.05.003

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ACKNOWLEDGEMENT: IISER Pune for access to databases and journals.

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