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Palaeosciences in 2050: Some thoughts

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ONE of the advantages of writing about futuristic scenarios, is that an elderly author has little chance of facing criticism. The Indian born author, George Orwell knew this fact well, when he published his famous novel of life and times *1984* in the summer of 1949. He painted a rather dark, sombre picture of life in 1984 keeping in mind the dark clouds of intrigue and conspiracy that hung over the post WWII world at the time. 1984 came and went and was not as eventful as George Orwell had imagined and most of his predictions went unnoticed. Encouraged by this, I venture to see 2050 as a very crowded planet (with well over 9 billion inhabitants) competing for resources, conscious of the need to preserve and conserve the earth for future generations, sentiments that were not a priority in 1950 when we were rebuilding after 2 world wars. The factor that would dominate all activity is the restriction of the amount of carbon emissions by human actions. The Paris agreement of 2015 points to limiting temperature increase on our planet to below 2°C from start of industrial revolution. Reliance on fossil fuels will be reduced; rise of renewable energy and lower carbon economy will take shape. By 2050, we will have a very electrified world with more electric vehicles replacing internal combustion engines and hydrogen replacing natural gas. These issues will dominate on how and on what topics we will do our research and what challenges need to be tackled. The changes will help mankind towards sustainability, alleviating climate hazards and improving quality of life on our planet. But will that be enough to reverse the course of the planet? Historical climate change and adaptability to climate change by those inhabiting the earth for millions of years before us is something we can learn from. Palaeosciences will play a big role in understanding the past, and how the past informs the future. This is more significant now than it was ever in the past, and the future palaeoscientist will play a pivotal role in helping mankind make good choices for the betterment of our planet.

Modern quantifiable science, one that demands observation, experimentation, quantification and evidence of the natural world, is not that old and can be said to have arrived during the times of Galileo, Copernicus and specially Newton. Mathematics has a much older history. Indeed, modern sciences started with a clear heart, independent and undivided, unfettered until later, when compartmentalism and divisions set in as the sciences grew and became more diverse. In contrast to this, palaeontology had a modest beginning, embroiled in the superstitions of its time, and it was only after Darwin and his famous theory of evolution published in the mid–19th century, that fossils acquired meaning and value.

The growth of science as exemplified by the field of palaeontology is an endless cycle of diversification and integration. I shall try to expand this under the following headings:

1. Increasing integration with allied fields
2. Levels of observation, global ramifications on one hand and ultra microscopy on the other.
3. Natural History Museums and Virtual Palaeosciences.
4. Amber studies and reconstruction of palaeobiodiversity and the reconstruction of past forest ecologies.
5. Ultra–resolutions in chronology and new isotopes in analysis.
6. Special studies: Palaeobiochemistry and the study of macromolecules.
7. Astrobiology and the fossils of the extra–terrestrial realm.
8. Applications relating to the accumulation of fossil fuels and their extraction to provide clean energy.

1. Integration

There are many tried and tested ways to excel in research, one is the super specialization path where a small group of scientists hold nearly exclusive global rights in their field of specialization, and the other, when two seemingly unrelated subjects create new types of information. Perhaps we will see a little of the first but more of the latter approach.

- An example of the latter, is how dinosaur dung (coprolites) at the end Cretaceous gave us information about the origin of grasses and their early diversification, or

- Similarly how isotopic studies of incremental growth lines in mammalian teeth or a sea shell, give us some idea of contemporary climate seasonality.
- India has a rich heritage of archaeological sites and its is time that more human power in universities and research institutes goes into the subject as I am sure it will.
- Meteorites and other extraterrestrial bodies will be probed for organic molecules and life. At present, access to these specimens is restricted and this needs to be rectified for more researchers undertaking palaeoscience research.
- The drift of India and the need for geophysical and seafloor spreading data. An outstanding problem is that when India separated from Madagascar about 88 Ma years ago, and a sea opened up between the two landmasses, India still retained terrestrial elements of its past heritage at 65 Ma, a gap of nearly 23 million years. The palaeoscience approach therefore needs integration with the geophysical one to explain possible migration corridors during this time. What is needed is geophysical data and seafloor data showing possible routes for migration of terrestrial organisms from Madagascar/ East Africa even at a time when most reconstructions show the island subcontinent as ocean isolated.
- Furthermore, similarly in the Early Eocene, one of the mysteries is that some taxa in India, are generically the same as some European forms, for example *Meldimys* implying an unhindered land corridor between the landmasses. For understanding such migrations, I hope that in the coming 30 years there will be a lot of data coming from western Pakistan, Iran, Turkey, Romania and the Arab Emirates. The little data that we have from Turkey is really intriguing but sparse.
- The collisional process between India and Asia will have better resolution: Instead of one sweeping number for the “collision age” for the entire few thousand kilometer northern margin, I believe that collision ages will be detailed enough to be sector by sector as it should be.

2. Levels of observations, global ramifications on one hand and ultra microscopy on the other

The earliest fossils that were described were so discovered because they were easily visible with normal human eyesight. Therefore these fossils were usually of large animals, plants and shells. Two trends have dominated palaeontology in the last few decades and will continue in the coming years. On one hand the global ramifications of the fossils found and on the other, the advent of sophisticated microscopy.

- In the next 30 years at the ultrascopic level, there will be increased focus on the mineralogy and crystallography of skeletal tissues whether these be composed of apatite, calcite or opaline silica.
- For the last 150 years, the role of gravity in shaping size, shape and motion dynamics of large organisms on land, in oceans or in the air, has been well studied. However, the same morphometric criteria for much smaller life forms in the nanometer scale is less understood. Questions related to role of gravity in the dynamics of ultra–small organisms need to be (and will be) studied. What controls the shape of very small microfossils? Are there only limited designs available such as the disc, sphere and the filament?
- The formation of biogenic silica, specially at oceans depths is not a well understood issue and needs further study.
- The physical and chemical reasons for radiolarians built from amorphous silica and having such intricate external morphologies will be explained in terms of physics and hydro–dynamics.
- The three dimensional arrangements of crystallites in organic bodies and their mechanical strengths will have an increasing application in building of light yet strong structures whether these are in the oceans or on land.
- At mega–observational levels, the origin, spread and diversity of organisms will be a major focus of study because more geographic areas such as those in the middle eastern countries increase their geoscience outputs.
- The greatest progress will be made in imaging technologies of fossils (the synchroton for example) and, as usually is the case, the problem will be in understanding and interpreting the features imaged.

3. Natural History Museums and Virtual Palaeosciences

I foresee the continuity of Natural History Museums not only fulfilling their traditional functions but also as repositories for regional biodiversity conservation, augmented by what the virtual world has to offer. The virtual visitor will examine more closely and more fully the fossil world and measure the tempo of evolution while sitting in the comfort of his or her home. Palaeontologists will exchange specimens by giving website links and amateurs will be able to create their own fossil specimens through 3D printing.

4. Amber studies and reconstruction of palaeobiodiversity and the reconstruction of past forest ecologies

The last 15 years have witnessed a phenomenal rise in amber studies in India specially related to the vast amber field found in the Eocene lignite mines of Rajasthan and Gujarat. Amber provides a unique window into the bygone world not only because of the excellent preservation but also because of the diverse ecological niches that can be sampled and the biotic interactions that can be studied. The range extends from the testate amoeba to bird feathers. This diversity will only grow. Amber is by the best way of deciphering past forest ecology.

At present in India, common knowledge about the wonderful world of life in fossil amber is poor and this needs rectifying by the publication of more popular papers on the subject.

5. Ultra–resolutions in chronology and the use of new isotopes in analysis

During the last four decades, the advent of many new techniques in high resolution chronology have radically changed our ideas of cratonization and large igneous provinces. The advent of $^{40}Ar/^{39}Ar$ systems in India transformed the Deccan Traps as a major factor in its role of the K/Pge extinctions by showing that most of the high resolution dates centered around the K/Pge boundary. A short term eruptive volcanic history as demonstrated by radiometric dating, not only changed our perspective on the atmospheric toxity and environmental degradation that volcanic activity could trigger but it also offered new ideas about the mechanics of implacement of these bodies. Hopefully, the Rajmahal Traps will receive their due attention and focus.

The next three decades promise to be more eventful: we can expect geo–thermo chronology using high–precision U–Pb and $^{40}Ar/^{39}Ar$ systems, and high–spatial resolution U–(Th–) Pb geochronology and in addition hematite–, magnetite–and laterite–(U–Th)/iron thermochronology, (KP, pers. comm.).

New and novel isotopes will provide high resolution specialized data. Some of these are stable isotopes of Potassium, Titanium, Vanadium, Rubidium, Strontium, Cadmium, Tin, Antimony, Tellurium, Barium, Lithium and Boron.

6. Palaeobiochemistry and the study of macromolecules

How did life synthesize the major building blocks of life? This subject has been linked to the origin of life and has been at the centre of debate amongst philosophers and scientists. We know that lowly life originated slightly more than a billion years after the earth was formed but the origin of the basic blocks of life, namely carbohydrates, proteins, lipids and lignin has yet to be conclusively studied in time and space. The Neoproterozoic is a good starting point but it is obvious that we must search farther back in time in the Proterozoic.

The fungal clade may hold the key in deciphering how biochemicals were synthesized at a time of low atmospheric oxygen concentrations. The current emphasis on life forms in the Neoproterozoic is bound to be extended deeper in time to the Proterozoic where molecular dating estimates place the origin of fungi. The ancient organisms will throw light on the biosynthesis pathways of chitin (Nitrogen bearing carbohydrates) at a time when life on earth took root (SD, pers. comm.)

The synthesis of the macro–molecule lignin (a supportive tissue) may have something to do with the heliotropic growth of plants in the early Palaeozoic as they tried to overcome gravitational forces to capture sunlight for photosynthesis. In the coming years, this subject will receive more followers as it well deserves.

7. Astrobiology and the fossils of the extra–terrestrial realm

Even for someone not prone to predictions, it is obvious that the fledgling field of Astrobiology will grow by leaps and bounds as space exploration escalates. It will become apparent that earthly life is not a unique event and that like the proverbial frogs in our earthly well, we are unaware that there is life as we know it in other planets. As of now, scientists have been dependent upon meteorites, specially those of the carbonaceous chondrite variety, to assess the mineralogical and organic compounds present. However, active space exploration of nearby planets and asteroid bodies in the present and coming decades will bring more information about the building blocks of RNA, proteins and amino acids. The controversy of whether there was an extra–terrestrial seeding of life on earth will escalate until it will be established that the formation of organic compounds may have multiple origins in space! Current research demonstrates the presence of high molecular weight carbon macromolecules in extra terrestrial bodies, and documents the presence of aliphatic and aromatic hydrocarbons, amino acids and other macromolecules which are known precursor to life.

8. Applications relating to the exploration of fossil fuels and their extraction to provide clean energy

Despite the prophets of doom, fossil fuel exploration will not stop but new technologies will evolve to obtain clean energy in the form of hydrogen and other clean compounds from petroleum products. Non–polluting energy will not be a dream but will become a reality.

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