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Appropriate sampling design in palaeobotany for correlating floristics with stratigraphy

Palaeobotany, the study of plant fossils, is basically concerned with the morphological and taxonomical aspects of different types of plants preserved in stratified succession of rocks. However, recovery of morphologically distinct plant fossils at different time spans of the earth's history, enhances the significance of fossils in stratigraphic sequencing of sediments at particular time periods. Seward[1] has emphasized the role of palaeobotany as 'the distribution of plants in time, that is the range of classes, families, genera and species of plants through the series of strata which make up the crust of the earth is a matter of primary importance from a botanical as well as a geological point of view'.

In order to accomplish the two-fold task in palaeobotany, it is important to design appropriate sampling strategy for maximum stratigraphic coverage of the area, including all lithological variations. The technique helps analyse the plant association and relative changes in plant composition in time and space.

As such, there are no accepted principles or procedures for collecting rock samples for palaeobotanical analysis. The sampling design is based on the type of work, i.e. the study of megafossils covering leaf, fruiting body, stem, root, seeds, etc. and microfossils of pollen-spores, acritarchs, algae, fungi, diatoms, microplanktons, etc.

After establishing the nature of study, appropriate sample size and design are required to collect samples at different stratigraphic intervals in the field. Detailed stratigraphic work requires close sampling, whereas widely spaced samples are used for large stratigraphic intervals. The following sampling techniques are used to study the fossils in relation to superimposition or stratigraphic positions of rocks: spot sampling, channel sampling, core sampling and random sampling.

To locate fossiliferous horizons in a thick sequence of rocks, spot sampling is performed at regular intervals in a regular pattern (square, rhombic or rectangular spacing pattern) from the outcrops of the same lithology. Spot sampling helps identify the general floristic composition of a particular stratigraphic sequence known by thick shales, siltstones or limestones. The sections exposed in road cuts, rail cuts, or in naturally trenched streams and rivers, are suitable sites for spot sampling. The spacing between two samples sites depends on the thickness of the exposures and it can vary from a few centimetres to more than a metre or so. Where outcrop permits, the common practice is to collect spot samples at more or less uniform intervals vertically throughout the deposit; the interval is chosen on the basis of thickness and lithology of the outcrop[2]. Spot sampling is used during a reconnaissance survey or for comparative morphological studies and for supplementing or establishing reference collections.

Channel sampling is a well-established collecting technique for biostratigraphic work especially in palynological and micropalaeontological investigations. In this method, the outcrop is trenched to expose the fresh surfaces and then samples are collected at specified intervals from all stratigraphic columns normal to the bedding through the vertical thickness. In 1 m section, samples at a distance of 30 cm are suitable for study. However, when the outcrop section is not thick and there is a change in lithology at short intervals, close sampling at a regular distance of 2–3 cm provides better results[3].

Channel sampling can be applied at three stages depending upon the thickness and extension of the stratigraphic succession exposed in outcrop section[4]:

Reconnaissance: When the outcrop section is represented by a number of stratigraphic sequences, representative samples from all the horizons are collected to understand the fossiliferous nature of different stratigraphic successions.
Selective sampling: This is carried out at close intervals (1–5 cm) in a particular stratigraphic sequence to understand the comprehensive distribution of flora.
Bulk collection: When there is poor yield of fossils in a particular stratigraphic column, large amounts of samples (1–5 kg) are collected to examine the characteristic fossil contents. The method is useful in standardizing the biozonation of different rock types.

Core sampling is utilized in oil and coal industries to locate the stratigraphic position of sediments. Exact information of lithological changes, contact of different rock types and structural features (faults/folds) are clearly distinguishable in core samples.

Before proceeding to analyse the core samples, these are cleaned of dried mud contamination and sub-samples. The division of core samples in smaller units, labelling and documentation of exact length, core types and lithological variations are essential for undertaking palynological and micropalaeontological work.

Core samples are best suited for analysing floristics with stratigraphy. However, since the coring is carried out in commercially viable areas, the availability and use of core samples are limited to specific areas.

The hand-operated borers are useful to carry out palynological analysis of Quaternary samples from lakes, ponds and dry surfaces[5,6].

As random sampling palaeobotanists have discovered and described a number of fossils found in agriculture fields or forests as drifted specimens from nearby geological formations. Such specimens have little significance in stratigraphy but they do have immense botanical potentiality.

Unique Pentoxylae – a group of plants having *Pentoxylon* – stem, *Nipaniophyllum* – leaf, *Carnoconites* – seed-bearing organs and *Sahania* – pollen-bearing organs, was discovered on the basis of random samples collected from Rajmahal Hills of India[7].

The well-preserved plant fossils of Deccan Intertrappean beds showing the finer anatomical details of angiospermous wood, leaf, flower, fruit, stem, root, rhizome and sporocarp of fern and its allies and the structural features of algae, fungi and bryophyte are known from random sampling. The study of morphological and cuticular features of glossopterid leaves and fructifications collected from shale dumps of collieries and quarries have provided substantial information about the taxonomic significance of Glossopterid group of plants.

The selection of sampling design also concerns the qualitative and quantitative assessments of plant fossils. Once their occurrence, variation, continuation and distribution are known, palaeobotanists would also like to know the mean size variation of individual species or relative change in numerical distribution of flora. The application of statistical model employing closely spaced vertical and aerial sampling from measured outcrop sections is ideally suited for such study[8].

It is difficult to advocate a specific sampling plan for palaeobotanical study. The central strategy and selection are developed according to the aims and objectives. Continuous practice and experience help us to device proper sampling techniques for palaeobotanical studies.

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Is there anything like 'Indian Science'?

It has been argued that there can be only 'good science' or 'bad science', and partitioning science on the basis of nationality or religion (Indian science, Islamic science, etc.) for whatever reason (national pride, statistics, politics, etc.) is only to diminish its universal nature and status. One of the dilemmas facing Indian scientists is the fact that for many awards and academy fellowships, a written and sometimes unwritten rule is that the research of the candidate in question should have been carried out in India, preferably with Indian collaborators (so far so good!), but published in refereed high impact international journals, most of which are not Indian! If this be the case, then in a way it is an implicit admission of our own weakness that our work needs a foreign platform for evaluation. In my opinion this presents a great paradox to the Indian scientist and the issue needs to be addressed by the Indian scientific community as to whether or not science and its practice are truly global in aspect and whether the intrinsic merit of the research alone should decide its quality and peer group assessment.

I can understand the genesis of a rule which tries to put constraints on such Indian scientists (those who work and live here, but have 'foreign' collaborators) who have made their mark in 'superior' laboratories abroad without having to go through the travails and hindrances that many university faculty and some national institute scientists have to overcome in the successful completion of their research. But should peer groups while evaluating scientists, give so much weightage to this perceived 'handicap', so as to virtually tilt the balance against good research done in other parts of the globe by our own people? In our effort to level the playing field, is it possible that we may have lost sight of our goal (metaphor intended!) and our ability to recognize true talent in the Indian scientist, wherever he may have worked?

Good research is simply good research and no other conditions should be attached to it. We should overcome our collective fears that the 'handicap factor' is so significant as to sway an objective assessment of the scientist. If we really feel that we are scientifically in with the best in the world – and I feel that we are, we should discard our old ideas and rise from the shadows of our colonial past.

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