The debate on the age of Lower Vindhyans and the beginnings of complex life forms

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A supercontinent that existed around 1800–1700 Ma, formed from the fusion of the oldest cratonic blocks of Africa, Australia, East Antarctica and India (Eastern and Western Dharwar, Bastar, Bundelkhand and Singhbhum cratons) along with a few more minor cratons rifted, in response to internal stresses, during the Mesoproterozoic (1600–1000 Ma), creating several intracontinental basins[1]. In the Indian segment, four such basins developed, which formed the sites for deposition of a vast volume of sediments. Among them, the Vindhyan Basin that had come up in Central India became the repository for the build-up of a thick sedimentary system called the Vindhyan Supergroup (VSG). This group is divided into four divisions – Semri, Kaimur, Rewa and Bhandar Groups, composed of beds of conglomerates, sandstones, shales, volcanoclastics (tuffs) and limestones. In 1998, fossil evidences reported from the Semri Group, the oldest division of this vast sedimentary system, drew attention of the global geologic community, as they questioned the currently accepted antiquity of multicellular forms of life and also the age of the VSG[2,3].

Tracing the evolution of the earliest forms of life (unicellular organisms) on earth and their progress to higher or advanced forms still remains a topic much discussed. With each passing year, their beginnings are getting pushed back in time, closer to 4.4 Ga, in the light of fresh geochemical and isotopic evidences for the existence of life-supporting liquid water by this time[4]. Their advance to higher or multicellular forms is generally believed to have been slow throughout the major part of the Proterozoic (2500–542 Ma) till about 570 Ma in the late Neoproterozoic. This view is based on the observed rarity of fossil occurrences globally prior to this time and their sudden abundance thereafter. The resumption of the march of evolution is attributed to the advent of several favourable external factors such as climatic (emergence of earth out of intermittent glacial spells or 'snowball' conditions), atmospheric (increase in oxygen) as well as ecological (availability of nutrient-rich basins), and supported by certain intrinsic genetic changes. All these are supposed to have aided the appearance of improved skeletonized taxa enabling better fossilization and thereby their preservation. However, a few molecular biologists dispute this lull in the evolution, as their calculations using the observed regularity in gene-change rate as a molecular clock indicated that the diversification of life must have begun much earlier, by about 1000 Ma and definitely by 700 Ma[5].

Indian records for the earliest life are the simple forms such as the >2500 million-year-old microbiota, cyanobacteria, unicellular structures like stromatolites, pyritized and silicified filamentous forms, algal stromatolites and similar organisms reported from the Archaean formations in Karnataka, Madhya Pradesh and Orissa. Except for these unicellular forms, complex metazoan life has not been recorded for a long time from India till the late Proterozoic, which is in conformity with the global scenario and corroborating the notion about a long evolutionary gap. However, the two fossil discoveries in 1998 from the Semri Group have given a jolt to this complacent view and have called for a rethinking. They have also reactivated the controversy about the age of the Lower Vindhyans as fixed by biochronology (based on occurrence of 'type fossils') and by isotopic geochronology. Whereas the biochronological ages point to a Cambrian age for these fossils and the formations, the isotopic techniques suggested a much older age for both, and pushed back in time the proliferation of animal life.

Of the two fossil discoveries reported in 1998 from the Lower Vindhyans, one was by Adolf Seilacher and Frederich Pflüger (both from the University of Tübingen, Germany) along with Pradip Bose (Jadhavpur University, India). They came across an intricate network of mini-tunnels (5 mm diameter) in Chorhat sandstone, a member of the Semri Group, Son Valley, Central India[2], which they claimed were made by the peristaltic movements of worm-like organisms. Since only quite advanced forms of life having a nervous system to control body movements and digestion of ingested food are capable of such functions, they considered these as clear indicators of their triploblastic (three-layered body plan) anatomy, typical of most of the complex metazoans. On the basis of several published radiometric dates of these formations, they concluded that these advanced multicellular organisms must have lived around 1100 Ma, some 500 million years earlier than so far believed. However, quite a few were skeptical about their claims, since such a network of mini-tunnels is too sophisticated a work to be achieved by simple multicellular forms that were supposed to have lived 1100 million years ago[6]. They felt that the radiometric ages chosen in support of such ages were carried out more than 30 years earlier[7] using K/Ar or Fission Track (FT) methods, whose dates have invariably turned out to be unreliable for sedimentary systems[8]. More importantly, these dates for the formations may actually represent the ages of the older Archaean–Proterozoic rocks (provenance), which provided the material for the build-up of Vindhyan sediments[9], and not the ages of the life forms which had flourished during the sedimentation span in younger times.

The other discovery made in the same year was by R. J. Azmi (Wadia Institute of Himalayan Geology, India), who reported small, shelly fossils in Rhotasgarh limestones[3], another member of the same Semri Group and lying above the Chorhat sandstone bed. This report was soon followed in the next few years by more discoveries of fossils from adjoining areas of the same age[9]. Pointing to the unquestionable biostratigraphic evidence here, of the occurrence of characteristically Cambrian fossil assemblage as seen at several other places around the world belonging to the same Proterozoic–Palaeozoic boundary period, Azmi argues that the age of these sediments, including those studied by Seilacher's group, would be terminal Proterozoic (Vendian) to early Cambrian (650–542 Ma). Rejecting all earlier isotopic dates which point to a Palaeoproterozoic (~1700 Ma) age, he has drawn attention to the fact that the Vindhyan Basin itself opened subsequent

to the Delhi orogenic cycle, closing around 1450 Ma (Late Mesoproterozoic), and hence he reasons that the build-up of the VSG must have commenced much later[9].

The identity of Azmi's findings as fossils, however, was not accepted initially by all and they were dubbed as inorganic artefacts or mineral growths[7]. Now, nine years after the biogenecity of these fossils was doubted and dismissed, a Swedish and Australian group[10] carried out an integrated palaeontological and geochrnological study of similar fossils from the same locality and found them to be authentic fossils. These fossils were found to be similar to the Ediacaran biota that represent the earliest known complex multicellular organisms, thus upholding Azmi's original find of small, shelly fossils. However, the latest study[10] favours the Palaeoproterozoic age for the Lower Vindhyans, which would support conclusions about the existence of triploblastic metazoans by 1100 Ma, as claimed by Seilacher team.

The belief, no doubt, is strong among many palaeontologists about the robustness of correlation using fossil data. Nonetheless, since 1998, several workers have reported through different isotopic methods the depositional ages, that fix the age of the marine life forms[8]. They have used Rb–Sr dating of glauconites formed during the diagenesis of the Semri sandstone sediments, $^{206}Pb/^{207}Pb$ depositional dates of marine carbonates of Rhotasgarh limestones, Sr-istope stratigraphy using pure marine carbonates (calcitic cements) in Semri Group limestone, and U–Pb zircon dating of unmistakably primary euhedral zircons of volcanic tuffs distinct from the abraded ones derived from the intercalated provenance material in the same Group. These have given close isotopic ages, which are consistent and hence currently preferred over the ages based on the occurrence of type fossils.

A recent summing up of the various geochronological ages indicates that the VSG must have had an extended span which began around 1500–1600 Ma and continued till 650 Ma, though its continuation beyond into the Cambrian is not clear[8]. These dates undoubtedly endorse the view about the emergence of multicellular animals to >1 b.y. period, and if this date is ratified officially, it would call for reconsideration of the recent renaming of the Vendian as the 'Ediacaran' era (635–542 Ma period), to mark the beginning of the diversification of animal life recorded globally by the appearance of the Ediacaran fauna[11,12]. As for the Lower Vindhyans, it seems that the deadlock over the ages by biochronology and geochronology is here to stay, but whether the twain will ever meet, only the future studies will have the answer.

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