

it was to pursue detection and characterization of kinetic intermediates, specially as their detection was often challenged by dead time of the stopped-flow unit linked to an optical or some other detection unit. However, it is not unusual to see, as in many other scientific endeavours, the limits of instrumentation being pushed to an extreme in order to detect the rapidly-forming intermediates in the submilli second region^{7,17}. The experiments often involve rapid addition of a protein in concentrated denaturant like 8M guanidine hydrochloride to none or low denaturant concentration solution, so that the denatured protein folds to its native conformation. The rapid mixing provided by the stopped flow apparatus in conjunction with the detection units then looks for the early intermediates formed in the folding process, the dead time of the stopped flow unit being often the limiting factor. Recent studies on detection of a characteristic optical signal during the burst phase of folding suggests that one may be actually observing an ensemble of partially-folded conformers rather than a distinct kinetic intermediate^{18,19}. A very recent study using ribonuclease A as a model protein effectively establishes this point²⁰. Ribonuclease A has been one of the well studied proteins where pulse labelling NMR studies on folding have provided sufficient evidence for the presence of a stable secondary structure prior to formation of the native protein²¹. The recent study²⁰ takes advantage of the fact that on denaturation, reduced ribonuclease A does not fold back to the native state, but the normal ribonuclease A with its disulphide bonds intact does.

Using stopped-flow CD, the authors measured the signal for the denatured ribonuclease A and did detect a significant signal in the burst phase which finally reached the CD of the native protein over several seconds, as the protein nucleates to its native conformation. However, the reduced ribonuclease A also showed similar burst phase optical signal, even though it did not fold to the native state. The current study thus emphatically proves that one is observing an ensemble of rapidly folding conformers with very similar energy rather than an early kinetic intermediate²⁰. It is quite likely that one is observing a solvent effect (sudden change from 8M guanidine hydrochloride to a very low concentration) in various burst phase studies, rather than formation of any specific kinetic intermediate. This study thus, hopefully, puts to rest what has been very intensively studied in the last few years. It must be emphasized here that this study²⁰ does not argue against the formation of folding intermediates, but cautions regarding what might just be a reflection of drastic and rapid solvent effect change being confused as a kinetic intermediate.

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Cambrian life explosion in fray: Evidence from more than 1 b.y. old animal body fossils and skeletonization event

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Putative outburst of animal phyla in the Cambrian age, mainly, evidenced by the 'absence' of fossils of triploblastic metazoans from rocks predating the Cambrian¹, now appears to be inadaptable following a recent discovery of more than 1-Ga-old triploblastic meta-

zoans from India². But another simultaneous and independent discovery of ancient brachiopods and the shelly fossils indicating an earliest Cambrian age³ is likely to reiterate the Cambrian fossil explosion about 540 million years ago. The brachiopods and shelly fossil

fauna (for convenience read B-Sf as brachiopods and shelly fossils respectively), in particular are so far considered as a useful tool for biostratigraphic correlation of the Precambrian-Cambrian boundary in chert-phosphorite Member of the Tal Formation, lesser Himalaya,

with that of a far distant (> 500 km) occurring Rohtas limestone and shale of the lower Vindhyan Semri Group (Vindhyan Supergroup) in the peninsular India³. Since B-Sf is important evidence for the occurrence of small animal body fossils with hard parts, in the early Cambrian, a re-examination of the age of the sequence in which B-Sf are found to occur is warranted. Surprisingly, isotope geochronological aspect has not yet been properly scrutinized for upholding biochronostratigraphic correlation. Secondly, it is also aimed to assess whether a generalized concept of explosion of diverse skeletonized taxa at the beginning of the Cambrian age has got any role to play with the recently recognized fossil record of B-Sf. The studies presented here may ultimately help in unfolding the mystery of the evolution of Precambrian life world-wide.

Focus on geology and geochronology

As B-Sf fossils have generated commotion amongst earth scientists with regard to the age revision of the Vindhyan Supergroup, i.e. from the existing Proterozoic-Cambrian age to terminal Proterozoic-Cambrian, it is first of all necessary to look over the geological and geochronological aspects of the Vindhyan Supergroup (Figure 1) as a whole in order to resolve the sharp discrepancy as mentioned. Geologically, the lower Vindhyan of the Vindhyan

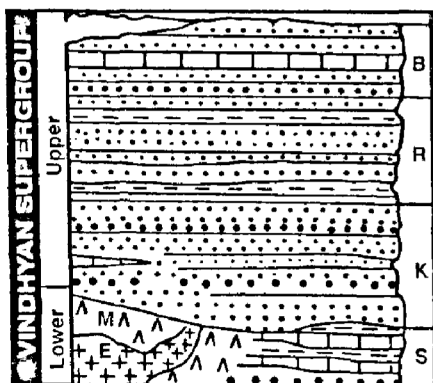


Figure 1. Stratigraphic column^{4,19} of more than 4500 m thick Vindhyan Supergroup rocks. S, Semri Group; K, Kaimur Group; R, Rewa Group and B, Bhandar Group. Erinpura granite (E) and Malani volcanics (M) are coeval in origin.

Supergroup is represented by the Semri Group rocks⁴ which starts with the basal conglomerate and sequential occurrence of limestone, porcellanite, the Kheinjua formations (shows trace fossils of triploblastic metazoa²), olive shale, fawn limestone, glauconitic sandstone and the Rohtas formations (known for containing brachiopods⁵, recently it has shown rich occurrence of B-Sf³) alternate layers of shale and limestone of predominantly continental shallow marine environment. The shaly beds of the Rohtas Formation are followed upward by the upper Vindhyan's Kaimur Group (consisting of lower grits, conglomerate, sandstone and breccia and subsequent sandstone, shale, quartzite and intermittent conglomerate), Rewa Group made up of alternating sequences of shale and sandstone, and then the topmost Bhandar Group where the shale-sandstone sequence is punctuated by limestone beds. All these rocks are mostly undeformed and unmetamorphosed, as a result, they are suitable for radiometric dating. A much modified version of Vinogradov and Tugarinov's⁶ age data, as given by Kreuzer *et al.*⁷, points to 1080 ± 40 Ma age of the upper Semri Group glauconitic sandstone pertaining to Kheinjua Formation. The age of the overlying Rohtas Formation, on the other hand, is comprehensible by taking into account the intriguing situation arising from an intrusion of 1067 ± 31 Ma old diamondiferous Majhgawan kimberlite pipe (which purports a precise age of emplacement obtained from Rb-Sr analyses of acid leached phlogopite mica from kimberlite rock of Majhgawan area⁸) into the older Semri Group rocks and then partly into some of the younger (~ 890 Ma) (ref. 7) Kaimur Group rocks. As a matter of fact, this geological set-up may provide insight into: (i) the age of the Semri Group rocks as older than about 1067 Ma, and (ii) substantial erosion and denudation of the rocks of the upper Rohtas Formation. Both are dealt below.

The erosion was so severe that the diamondiferous kimberlite, within the Rohtas Formation, remain stand as these withstood erosion. The processes must have operated quite gradually over a considerable span of time, and so we find 'major' unconformity atop the Rohtas Formation. Later, these were one of the sites of subsequent sedimentation

corresponding to the Kaimur Group. Wherever it occurred around parts of the pre-existing kimberlite pipes, a false impression of igneous intrusion into the younger Kaimur beds is likely to be imposed upon. These conditions were possible, since the Semri Group rocks, lying over the old (Paleoproterozoic) Bijawar Group and under the young Kaimur Group, had been present in the nearby areas. Furthermore, the complete absence of deep-seated fundamental fractures (which are necessarily required for the emplacement of kimberlite) and any changes in the structural pattern of the rocks, mainly, from the force exertion due to magmatic intrusion⁹ rightly provides impetus to the view offered on sedimentation over and around Majhgawan diatreme. Hence, these assessments maintain significance of the radiometric dating. And it also helps to adduce the minimum possible age of the Rohtas Formation as 1067 Ma, or if not exact, then younger than 1080 Ma, because the underlying Kheinjua Formation rock is of 1080 Ma age. Obviously then, other lower Semri group rocks ought to be older than 1080 Ma age.

The suggested Mesoproterozoic age for the Rohtas Formation is further explicable from K-Ar dating of the lower Kaimur group glauconites (940 ± 30 to 910 ± 30 Ma with a mean of 940 ± 90 Ma) (ref. 6) which occur above Rohtas Formation of ≥ 1067 Ma age. Because both the stratigraphy and geochronology of the upper Semri and the lower Kaimur Groups are in tune with each other, the genuinity of radiometric dating is upheld. As regards to precision, a modified age data of 890 ± 40 Ma, given by Kreuzer *et al.*⁷ on the basis of recalculation of Vinogradov and Tugarinov's radiometric data⁶, can be taken into consideration. This radiometric age also seems to justify the relatively younger isotopic age of the middle Kaimur Group rock (~ 725 Ma) (ref. 10) than the age presented here for the lower Kaimur Group. Particularly the age of 725 Ma points to Neoproterozoic age for the middle Kaimur Group. It has been obtained from the lead isotope dating of galenas found at the transition zone of Ghaghar sandstone and Bijagarh shale, and it indicates the age of both sedimentation and galena mineralization¹⁰. Because galena lead isotope compositions hardly

change during mobilization of galena ores due to deformation and/or metamorphism¹¹, the reported lead age for the middle Kaimur is primary.

Though the evidences demonstrate that the Kheinjua and Rohtas Formations are Mesoproterozoic in age, it is often opined that the age of the Vindhyan sediments could be younger than 745 Ma. This is because of the occurrence of Malani volcanic suit (745 ± 10 Ma) (ref. 12) at the contact of overlying Trans-Aravalli Vindhyan rocks, supposedly of the lower Semri Group. This problem can be dealt with convincingly in an alternative way, i.e. either the Malani volcanics are an intrusive phase into the lower Semri Group having basal conglomeratic horizon, or they simply belong to the lower part of the overlying middle Kaimur Group which also constitutes conglomerate (Figure 1). To settle this controversy, the latter view requires serious thought on account of the fact that there is a scope for changing the stratigraphic position of the Malani volcanics *vis-à-vis* the Trans-Aravalli Vindhyan rocks well within limits of Neoproterozoic to Early Cambrian age. For example, Malani volcanics are deemed equivalent to the upper Vindhyan rocks¹³, whereas Ravindra Kumar¹⁴ has included it right

at the base of the upper Vindhyan Group (i.e. around 1000 to 1070 Ma, inferable from this study). But in the same work of Ravindra Kumar, the Malani volcanic rock is placed just below the Bhandar Group sandstone, mainly, Jodhpur sandstone. This possibility seems improbable because by the time the Jodhpur sandstone got deposited in the Bhandar Group, the thickest pile of Rewa Group rocks as well as the whole upper and middle Kaimur Group rocks (~725 Ma) including relatively old Malani volcanics (~745 Ma) were already existing. All this, therefore, help to substantiate terminal Proterozoic–Cambrian age to the uppermost Vindhyan rocks, viz. Bhandar group¹⁵. Yet, these aspects may still be verified from more geochronological study of the Trans-Aravalli Vindhyan rocks resting over Malani volcanics. But for now it is certain that either of the two aforementioned aspects on the relationship between Vindhyan and Malani volcanics would be the only possibility, mainly because in the overall scenario of the Vindhyan Basin development we find somewhat gradually decreasing chronological order of deposition (Table 1). Interestingly, it reflects an incident in which one expects sedimentary rocks of Mesoproterozoic to Neoproterozoic

age well after the formation of old basin during Archean–Paleoproterozoic time, rather than a sudden onset of geological processes for any basin sediment deposition at terminal Neoproterozoic–Early Cambrian age after the extremely long-continued, yet unrealistic gap of about 1850 Ma to 1150 Ma, more particularly in predominantly marine palaeoenvironment.

Primitive evolution of life

In view of the above, it is, therefore, logically admissible that the shelly body fossils, B-Sfs, from the Rohtas Formation could reveal the specialized B-Sfs record as the oldest known fossil fauna that can be definitely assigned to 1070 Ma age. This in turn manifests that: (1) These fossil records represent the most primitive ancestral fossils of animal lineage belonging to that of the earliest Cambrian, and supports a fact¹⁶ that the Cambrian animals had some familiar-looking predecessor. Hence, in a situation like this it would be naive to consider B-Sfs as a potential biostratigraphic tool for assigning Precambrian–Cambrian transition, and (2) the said interpretation now helps to extend the skeletonization event more than 500 million years to 1070 million years back. Traditionally the event was believed to have occurred during early Cambrian time at 540 Ma (ref. 2).

Why does the opinion about brachiopod and shelly fossils' Proterozoic ancestry sound so realistic? In fact, the key is the very slow evolution of life¹⁷. Some given evidences elsewhere do appear to corroborate the viewpoint held here, which suggests that the Vendian and Cambrian fossils¹⁸ and even the present-day forms of lives are the offshoot from relatively very primitive lives present well within the Precambrian time¹⁶, e.g. close to a billion years ago, that is at least true in the context of invertebrate divergence from chordates¹. The present study, however, for the first time recognizes the earliest ever known age of the shelly animal phylogenesis about 1070 million years ago.

Hence, all these may bespeak: (1) 'Like sedimentary rock formation, life too involves quite gradual process of development', as a result, an impetuous outburst of life at about 540 Ma seems incongruous, and (2) the fossils being con-

Table 1. Examples of gradual sedimentation history in Precambrian time. Table 1a (ref. 20) depicts the Canadian and Australian examples of Wollaston Group and Cahill Formation respectively. The Cuddapah and Vindhyan basins represent Indian examples. Table 1b is a more precise chronostratigraphic presentation of the Vindhyan supergroup's Kheinjua and Rohtas Formations (Semri Group) and Kaimur Group, as deduced from this study

Canada / Australia	Cuddapah basin	Vindhyan basin	KAIMUR GROUP	Thickness: ~ 2000 m
Mesoproterozoic sediments (1.7-1.1 Ga)	Kurnool Group	Bhandar Group	725 Ma	
	- Unconformity -	Rewa Group	1000 Ma	
	Srisaillam quartzite	Kaimur Group	1070 Ma	
		1.1 Ga	ROHTAS FORMATION	
- Unconformity - Paleoproterozoic metasediments, extensively metamorphosed at ca. 1.8 Ga	- Unconformity - Nallamalai Group	Semri Group		
	Chitravati Group	1.4 Ga		
	1.8 Ga basic sill	Bijawar Group		
	Papaghni Group	1.8 Ga basic rocks in Sonrai Fm.	1080 Ma	KHEINJUA FORMATION
- Unconformity - Basement granites / gneisses (2.6 - 2.4 Ga)	- Unconformity - Basement granites / gneisses (2.6 - 2.2 Ga)	- Unconformity -		
		Meharoni Group		
		- Unconformity - Basement granites / gneisses (2.6 - 2.2 Ga)		

ventionally used as a potential biochronostratigraphic tool in the Precambrian/Cambrian sequences need to be reassessed and supported by isotope geochronological data.

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COMMENTARY

National science summit

C. Subramaniam

All of us are aware of the fact that our Nation is facing a critical situation in its history. We have gone in for a planned economy and have implemented eight five-year plans and a few spells of annual plans with reasonable success. We have certainly made great strides in development in many areas. Nevertheless we realize much to our dismay, that notwithstanding the gains we have made over half a century, we remain the poorest and most illiterate country in the Asian region barring our adjacent neighbours, but we rank high in corruption among the countries of the world. Massive problems of environmental degradation, gender discrimination, joblessness and population which continues to grow at a fast rate, stare at us rather menacingly.

The twentieth century has seen many radical changes. The emergence of many colonial countries into freedom, growing awareness of, and emphasis on, human rights and social justice and most importantly the developments in S & T have far-reaching effects on the life system of the planet. But among them all the dominant role of science and

technology and consequently that of education which promotes S & T, have come to occupy the centre stage in the development of every society.

The scientists and technologists of this country have a record of performance and reputation that whenever a task has been assigned to them with a clear definition of the goals and given the autonomy as well as the resources, they have acquitted themselves extremely well and proved their competence beyond expectation. However, it has so happened that the scientists and technologists were not associated in any significant measure with the policy formulation or preparation and implementation of developmental plans. On the other hand, the bureaucratic system that was entrusted with the task over these years has not been found adequate to usher in the social and economic development contemplated. I am therefore inclined to think that scientists of India - I use the term scientists in a broad sense - may have to address themselves to the challenges facing the country and consider evolving a developmental approach and strategy for im-

plementation which may measure up to the dimensions of the task we face.

If we take education, illiteracy is still high at the basic level. In the realm of higher education, we have over 220 universities, 9000 colleges and 6 million students. They seem to work in isolation among themselves and also from the society. Co-ordination between institutions as well as interaction with the community in general and the productive processes in particular is lacking. A complaint that is long standing and universally expressed is about the mismatch between the preparation of our graduates and the competence needed by the employers and society.

Coming to research, there appears to be a slackening of efforts as evidenced by the decreasing allocation of funds in terms of per cent of GNP and also in terms of growth in publications receiving peer attention at the international level.

Universities have been the birth place of research. I am informed that the allocation for research to the universities remains poor. On a long term basis it is important to ensure that our universities