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VINDHYAN PALAEOBIOLOGY, STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS: A CRITICAL REVIEW.

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ABSTRACT

This is a critical analysis of the systematic position of certain Precambrian plant genera that have been sometimes assigned to the Animalia and have even been regarded as inorganic. Also brought into focus are the more important aspects of classification, straitigraphy and relevant environmental data concerning the Vindhyan (Table p. 299).

1. The systematic position of certain Vindhyan genera and their (erroneous) assigination to *Chuaria* by T. D. Ford is discussed (W. J. Breed, joint author, disclaims responsibility for this classification pers. comm. p.) The systematic position of certain other genera notably *Fermoria*, Chapman and *Krishnania*, Sahni and Shrivastava is reviewed. It is pointed out that placing these genera as synonyms is open to question. Furthermore, whatever be the significance of the filament-like structures sometimes found associated with *Fermoria* (only), the *presumption*, (Ford and Breed, 1973) that they occur in *Krishnania* indicates inadequate comprehension of the position.

2. Attention is drawn to certain crucial aspects of Vindhyan stratigraphy, the Sone Valley section in particular. These include the issue whether the Tilloid (not Tillite) as here defined is of glaical origin or consolidated volcanic ash implying volcanic (not glacial) origin of Procellanites. Their volcanic origin is accepted by the present author. The Lower Vindhyan sequences (p299) reveals beds of Procellanite separated by limestones followed (downward) by sandstones and finally conglomerates, broadly indicating a sedimentary cycle. The nature of the basal conglomerate in the Vindhyan sequence (F. Ahmad, 1955) has been misinterpreted. It is *not* a glacial Till, but a Tilloid constituting compacted scree material.

3. Reviewing W. Häntschel's assertion (*Treatise*, R. C. Moore *et al.* 1962, revised 1966) that *Fermoria* is inorganic, this author reproduces photographic and other evidence to reaffirm, that these assumptions are basically erroneous. This is supported by several other workers, apart from this author.

4. Recent work brings into focus the age of the Vindhyan to which some have assigned a time range extending from Precambrian to Silurian and even the Devonian (R. C. Misra ; S. K. Saluja *et al.*, R. N. Shrivastava, and others). This evidence needs close scrutiny and requires collation of further data. The palaeobiological evidence cited by these authors relates mainly to the microflora ; in no case has any megafossil evidence been produced despite the fact that :

(*a*) The strata concerned are marine and of vast extent.
(*b*) The Lower Palaeozoic seas were teeming with invertebrate faunas, and should have left a relic or two behind.
(*c*) The available evidence thus affirms a Precambrian origin for these strata.

5. Incidentally, the ages of several other formations that have not yielded evidence of advanced forms of life need to be reassessed. These include the Krols besides other stratigraphic units.

6. The Vindhyan conglomerate marks the original limit of deposition of Vindhayn strata.

INTRODUCTION

Problems concerned with the Indian Precambrian biota, particularly the systematic position of *Fermoria*, Chapman, have often been discussed but a clear picture of the affinities of several of these genera has, apparently, yet to emerge. The position has become further involved in view of far reaching emendations in classification introduced by T. D. Ford, and W. J. Breed (1973), not to speak of W Häntschel's relegation of the genus *Fermoria* to the inorganic state. Thus *Fermoria* has laid claim to all the three domains : Animal, Plant and the Inorganic, with almost equal conviction.

The following summary attempts to focus attention on these and related problems. I propose to review the situation in some detail despite the risk of repetition.

HISTORICAL REVIEW, 1907-1976

About the turn of the century, H. C. Jones of the Geological Survey of India, discovered (1907) certain discoidal bodies in the Suket shales of the Semri series,

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Vindhyan system. These fossils were described (1909) as "small concentrically wrinkled discs of carbonised chitinous substance." Their surface was often presumed to be 'granulated'.

"On account of the bad preservation it is difficult to determine its genus, but the form and structure recall the genus *Obolella*. It also resembles a small discinoid shell described by Dr. Walcott, and named *Chuaria circularis* which occurs in the Precambrian rocks of Arizona[1]". It also very closely resembles the operculum of *Hyolithellus*[2]."

These fossils have received wide attention through the last six decades and constitute a live problem even today. Indeed, rarely has any group of fossils inspired such sustained interest as *Fermoria* and its allies.

A historical (more or less chronological) review of the systematic position of the genus *Fermoria* is summarised below :

(1) Cecil A. Jones compared these fossils with *Chuaria circularis*, Walcott (1907, 1909).

(2) C. A. Matley suggested that these discoidal forms apparently resembled primitive horny brachiopods like *Paterula* (1923).

(3) E. S. Cobbold also found these fossils to be superficially similar to primitive brachiopods like *Neobolus warthi*, but opined that "these Indian discs may be anything" (1923).

(4) E. O. Ulrich, C. D. Walcott, R. E. Resser identified these fossils as brachiopods ; *Acrothele* (M. Cambrian) was regarded as their nearest ally (1926).

(5) B. F. Howell came nearest to the mark when he referred these fossils to marine algae (1928).

(6) Several other palaeontologists of the National Museum, New York, also indentified these fossil as brachiopods.

(7) T. W. Edgeworth David affirmed that these fossils were more allied to obolidae and were similar to *Neobolus* rather than to *Acrothele* (1929).

(8) F. Chapman assigned them to primitive brachiopods and proposed the genus *Fermoria* (1935).

(9) M. R. Sahni emphasised that *Fermoria* was probably algal did not possess a single brachiopod feature ; and he proposed the family, Fermoriidae for their inclusion (1936).

(10) R. C. Misra, declared these discs to be inorganic (1952).

(11) Elso S. Barghoorn, Cambridge, Harvard University, felt "quite certain that the fossils are not of plant origin" (personal communication, Oct. 1952) .

(12) M. R. Sahni and R. N. Shrivastava reconfirmed that the fossils were algal remains (1954).

(13) G. A. Cooper considered these disc-like forms to be similar to *Paterula* (pers. discussion. (Washington 1952).

(14) R. C. Misra reaffirmed their inorganic nature (1957).

(15) R. C. Misra again confirmed that the examples were inorganic (1960).

(16) The Inorganic view was also advocated by W. Häntschel in the *Treatise* (1960, revised 1965).

PALAEOBIOLOGICAL AND STRATIGRAPHIC ASPECTS

Systematic work on Vindhyan fossils was initiated with the publication of F. Chapman's paper (1935) identifying *Fermoria* as a brachiopod.[3] This was followed by the author's note affirming the vegetable origin of *Fermoria* (1936).

Prof. Elso S. Barghoorn of Harvard examined examples of *Fermoria* entrusted to him by this author and gave the following exhaustive opinion :

"At long last I have had an opportunity to examine with care the curious black objects on the surface of sediments collected near Rampura. As you will recall I made a maceration of these at the time of your visit early in the summer.

The organic objects were freed from the rock by cementing them to glass slides, with resin, and then dissolving the rock free by hydrofluoric acid the so-called trans-fer method. They came out in excellent condition and it was possible to examine them under high magnification.

As a result of histological study, *I feel quite certain that the fossils are not of plant origin. There is no evidence of cellular organization, though it is evident that the original structures were spheroidal or ovoidal in shape, probably membranaceous*[4]. The folds produced by compression are very clearly expressed and the substance preserved was probably a homogenous film or pellicle. The fancied resemblance to insect egg cases prompted me to consult Professor Carpenter entomologist in our department here. He suggested that they might be insect skins, but was hesitant about any proof of it. There is no question that they are organic bodies, however.

The physical condition of the organic substance in these fossils is not one of great alteration to graphitic structure, nor even advanced coalification. They are brown and translucent in transmitted light. *I seriously doubt the possibility of their pre-Cambrian age for this reason, since most pre-Cambrian organic carbon in plant fossils/and such are rare indeed, is so highly altered by diagenic change as to be*

[1] *Bull. Geol. Soc. of America*, Vol. X.

[2] *Bull. Geol. Surv.* of the U.S., Vol. IV (1886), p. 141.

[3] There are several other contributions by different authors, but only some of these publications are mentioned here.

[4] Italics this authors.

virtually graphitic[1]. Hence, if there is any possibility of of a later geologic age I would certainly feel it to be more reasonable."

"I enjoyed looking over this material and am sorry that I can offer no further suggestions or explanations. If you wish to follow the problem further I shall be very glad to be of further help. I trust this letter reaches you before you leave Washington, and, if there is any possibility of your returning to Cambridge before leaving for India, please let me know. I enjoyed your visit here very much, especially our discussion of India and the possibility of my hopes to visit your country."

There has been equally wide divergence of views concerning the geological age of the containing beds, the Suket Shales (Semri series).

Based on identification of certain fossils as Dasycladaceae, Misra (1949) considered that the *Fermoria*-bearing Semri series could be about Devonian in age. Later, he and Awasthi (1962) reaffirmed that :

"The age of the Lower Vindhyan may be assigned as Ordovician, and we can, therefore, safely bring the entire Vindhyan sequence to at least the Ordovician."

In 1969 he advocated that :

"the Rohtas Limestone (Semri series) could be near Devonian."

Concluding from varied evidence, primarily incineration tests, Misra had earlier regarded *Fermoria* as inorganic (1957).

R. V. Sitholey *et al* have given possibly the best documented account of Vindhyan fossils and their ages ; they affirm (1935) that the Vindhyan is Precambrian but that the topmost strata might possibly be Cambrian though there is no precise fossil evidence in this regard.

Absence of Trilobites and Brachiopods suggested to B. F. Howell (1956) that the Vindhyan sequence could be mainly Proterozoic and the rest possibly Cambrian.

The fossil identified by Misra as a verticillate alga (Dasycladaceae) was assigned by Vologdin (1959) to Archaeocyatha which range from Lower to Middle Cambrian, but Zhuravleva (1960) and others controvert this. Advanced types of vegetation have been reported from the Vindhyan on the authority of several palaeobotanists, among them Ghosh and Bose (1950), Jacob *et al* (1953), Bose (1956) and others. The flora described by these authors includes vascular plant remains, which, if *correctly reported*, would be noteworthy. Further investigation would certainly be an asset, and is, indeed, indispensible since several specialists have controverted the view.

P. K. Maithy (Institute of Palaeobotany, Lucknow) affirmed the plant character of *Fermoria* but suggested that the genus was near to the Siluro-Devonian acritarch *Tasmanites*. Concerning age he observed (1969) :

"Acritarchs and other algal remains have been reccovered (from the Vindhyans). These are commonly known only from Ordovician stratas. Therefore, from these records it is evident that the whole of the Vindhyan Formation is not Precambrian in age as was originally thought by Holland (1926) and at least some of the strata are definitely younger in age.".

Maithy now prefers reverting to his earlier stand (see postscript) and favours assigning *Fermoria* to the *Precambrian.*

In a prelminary reivew, Ford and Breed (1969) who later placed *Fermoria* as a synonym of *Chuaria*, "left it uncertain whether *Chuaria* was Chitinous Forminifera or algal in nature, and required larger samples for further study."

Other data were added to this in their detailed study wherein, apart from *Fermoria*, several other genera were regarded as synonyms of *Chuaria*, and "a probable age of less than 1000 m.y." was assigned to the Chuar Group (1973).

Departing from earlier views (vide our joint note, 1954) R. N. Shrivastava stated (*independently of this author*) that the *Fermoria*-bearing Suket shales (Lower Vindhyan) could be as young as Ordovician. He later affirmed (1972, p. 12) that :

"these beds in which a few trilete spores having an undoubted triradiate mark and the algal colonies allied to extant alga *Gloeocapsomorpha* have been observed, could possibly be of Silurian age".

Similar views have been expressed by S. K. Saluja and K. Rahman (1972), who, following detailed studies of the microflora, assign a Cambrian age to the Lower Vindhyan and a late Cambrian to early Silurian age, to the Upper Vindhyan.

Important in the context of these studies is the vast time range (Precambrian to Devonian) assigned to the Vindhyan by different authors. All of which suggests that some of these problems are still in a state of flux, and need revision. These and related data, summarised in the author's Inaugural Address delivered at the Purana Symposium (Sagar University, 1971) are introduced here with minor emendations (Table I).

SYSTEMATIC POSITION OF CERTAIN PRECAMBRIAN GENERA : *FERMORIA* AND *KRISHNANIA*

We shall now discuss the systematic position of certain Precambrian genera, primarily *Fermoria* and *Krishnania*, one of our major objectives here. In a joint contribution, W. J. Breed and T. D. Ford (1973) placed seven genera, including both *Fermoria* and *Krishnania* in synonymy with *Chuaria*. While I am not concerned here with the other genera, the magnitude of the conclusions drawn in respect of *Fermoria* and *Krishnania* contrasts with the slenderness of the evidence upon which these

[1]Italics this author's.

TABLE 1

Vindhyan Fossil Record: Summary and Interpretation

Geological Horizon	Fossils and Original Identification	Identified by	Author's Remarks except where otherwise indicated
BHANDER SERIES			
Sirbu Shales	Uncertain organic impressions ..	Vredenburg, E. (1908) ..	Indeterminate markings.
	Algal remains	Sitholey, R. V., Srivastava, P. N. and Verma, C. P. (1953).	....
Lower Bhander limestone..	Lamellibranchs	Hardie, J. (1833)	Age uncertain (Bhander or Nimbahera)
	Inoceramus	Mehta, S. N. (1926) ..	Identification doubtful. Not Vindhyan.
REWA SERIES			
	Trilete spores rare	Bose, A. (1956)	Derived fossils, N. A. Valkova (1965).
Kaimur sandstone ..	Plant microspores. Worm tracks ..	Misra, R. C. and Awasthi, N. (1962).	....
Suket shales	FERMORIA	..	....
	Primitive brachiopod ..	Chapman, F. (1935) ..	*Presumed* brachiopod characters misinterpreted.
	Not a brachiopod	Sahni, M. R. (1936) ..	Assigned to Family Fermoriidae (1936).
	Alga	Sahni, M. R. and Srivastava, R. N. (1954).	Algal nature confirmed.
	Inorganic	Misra, R. C. (1951) ..	Organic.
	Inorganic	Misra, R. C. (1952) ..	Organic.
	Inorganic	Misra, R. C. (1969) ..	Orgainic
	TASMANITES	Maithy, P. K. (1968) ..	Generic assignation uncertain 1971.
	Tasmanites Vindhyanensis Maithy, P. K. ..	Maithy, P. K. and Shukla, N. (1974 issued Feb. 1977).	Provenance uncertain.
	KRISHNANIA	Sahni, M. R. and Srivastava, R. N. (1954).	Algae.
SEMRI SERIES			
Rohtas limestone ..	HYOLITHES	Rode, K. P. (1946) ..	Not organic, mineral crystal replacement; pseudomorph after salt.
	Dasycladaceae	Misra, R. C. (1949) ..	Not Dasycladaceae. I. Zhuravleva (1960).
	Saccate spores rare .. Trilete spores abundant ..	Bose, A. (1956)	Derived fossils .. } N.A. Valkova, (1965).
Kheinjua stage ..	Saccate type spores abundant .. Trilete spores abundant ..	Bose, A. (1956)	Derived fossils } N.A. Valkova, (1965).
Fawn limestone			} N.A. Valkova, (1965).
Olive shales	Vascular plant remains ..	Ghosh, A. K. and Bose, A. (1950) Jacob, Jacob *et al.* (1953).	Derived fossils .. } N.A. Valkova, (1965).
Kajrahat limestone ..	Saccate type spores ..	Bose, A. (1956)	Derived fossils .. } N.A. Valkova, (1965).

are based. The authors have manifestly confused the morphology of the two genera, and have attributed to *Krishnania* 'filament-like structures' *not* found associated with it.

A misconception was naturally followed by a misstatement.

A relevant quotation from our original description of *Krishnania* (1954) is given to clarify the position.

"*Diagnosis*—The fossil is acuminately ovate in shape. Its longest axis measures 7.5 mm.,-------maximum width being 4 mm. It narrows somewhat abruptly at one end, but is evenly rounded at the other-------. A characteristic feature of the genus is a deep, marginal furrow more prominent on one side (probably due to better preservation here) and is apparently continuous all round.--------".

"The general shape, large size and sharp acumination separate this genus from *Fermoria*. The marginal furrows, too, are distinct from the lines seen in the peripheral portion of *Fermoria*,-------".

I wrote to Dr. Breed and gave a line drawing indicating the considerable and manifest differences between the two genera. In a prompt reply (*pers. comm.*, dated 8th Sept., 1975) he disclaimed responsibility for Ford's views elaborated in the palaeobiological section of their note. He wrote :

"Trevor Ford does the main part keeping up with *Chuaria* and all its various ramifications. I am sure he will appreciate your very apt criticism and will do the necessary changes."

In view of William Breed's helpful reply, clarification was sought from Trevor Ford concerning morphological features found associated *only* with *Fermoria*, not *Krishnania*. He replied as follows (*pers. comm.*) :

"My remarks on *Krishnania* are based on Glaessner's comments and you should argue with him, not me".

As I do not consider this necessary, having also written to his co-author, I need merely observe that authors who make critical comments *must* own responsibility for their remarks, instead of being evasive as in this case, when, much more to the point, they have themselves accepted these views in print, initiating, as a consequence, far-reaching modifications in classification. They should also be prepared to clarify controversial issues brought out in print especially when clarification is sought in a written request. In the light of the foregoing, the following paragraph (Ford and Breed, 1973, p. 538), has little significance :

"In 1954 Sahni and Shrivastava briefly described and named a single, larger, new fossil found with *Fermoria* as *Krishnania acuminata*. Their illustration (1954, fig. 4) is entirely unconvincing regarding the *filaments they claim to be attached*, and the writers support Glaessner (1962) in regarding it simply as a large *Fermoria*".

No such claim was made for *Krishnania* (as already noted) while the unusual character of the filaments sometimes associated with *Fermoria* (Sahni and Shrivastava, 1954) was emphasised more than once. If there still be doubt, I commend *careful* re-examination of Pl. II—3-4 and *loc. cit.*, 1954, fig. 4 (*Krishnania acuminata*) ; figs. 1 a, b and c ; fig. 2).

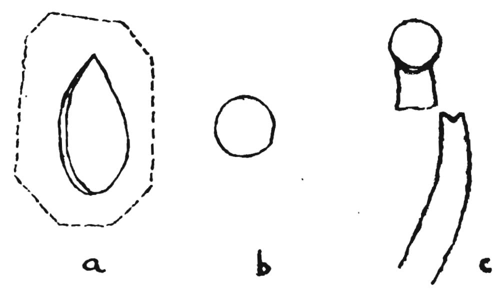

Fig. 1 (a) *Krishnania acuminata* showing acuminately ovate outline and wall structure (× 2)
(b) Outline of *Fermoria minima* for comparison with *Krishnania acuminata*. *K. acuminata* is sharply ovate while *Fermoria minima* is almost perfectly circular. (× 2)
(c) Single specimen of *Fermoria*, attached to a filament, partly broken near the point of attachment. Note the mild constriction immediately below the circular *Fermoria* 'disc'.

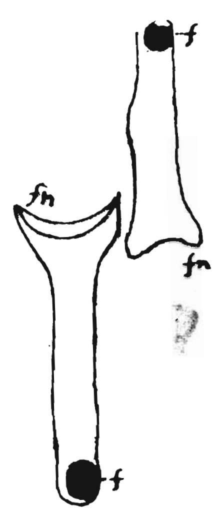

Fig. 2. *Fermoria* specimens occurring terminally of (within) broad, filament-like structures. Reproduced from an original photographic print with this author.

In critical analysis it is less than convincing to usher in a bald statement without giving detailed reasoning or evidence, more so when one is unwilling to clarify it. To sum up : Breed places the responsibility on Ford, who places it on Glaessner who (on Ford and Breed's authority) relegates it to *Krishnania* for being merely an outsize in comparison with *Fermoria*. I would like to affirm that I do not recall seeing Glaessner's paper and am relying on Ford's statements for the information. *Fermoria* and *Krishnania* are entirely different structurally.

Apart from differences in shape and dimensions, the former is almost circular, *the latter acuminately ovate whence, indeed, the name* assigned to it (*loc. cit.*, 1954). It is also much longer (7.5 mm.), which is almost twice the length of the largest recorded Indian examples of *Fermoria* (4 mm.). This *reaffirms* the need to re-examine the systematic position of the extra-Indian material assigned to *Fermoria*[1].

It may be noted further :

(*a*) that the suggestion regarding the nomenclature of *Vindhyanella* to which reference has been made by Ford was *not* this authors and he shares a part only of this responsibility (see below). Further, Ford and Breed missed stating some of the relevant, indeed crucial data, in this context.

(*b*) Criticism implies *careful* reading of *all* relevant, not selective data only. I commend re-reading carefully this author's paper (1936) for further light.

Unique also is the fact that morphological features that are non-existent—just not there—are used for critical evaluation, while others crucial to the diagnosis are glossed over with the remark (without citing evidence) that the "writers support Glaessner (1962) . . . in regarding it simply as a large *Fermoria*". And while *Fermoria* differs from the Brachiopoda unto a Kingdom, the fact is mentioned only in passing.

(*c*) Finally, there is some misconception concerning *Protobolella*. I therefore quote *in extensio* to place thinking on the issue in correct perspective (1936).

"The only specimen which appears to resemble an archaic brachiopod—for example an Obolellid—is the paratype of Mr. Chapman's *Protobolella jonesi*, and this shows, in addition to its outline, concentric lines which bear a striking resemblance to the growth line in *Obolella* and allied forms. *But of several score specimens*", (which please note) "*this is the solitary instance of a specimen showing regular concentric lines on the entire surface and even that specimen is unfortunately missing*" (*Sahni*, 1936).

And further ;

"*Sir Lewis Fermor has offered the suggestion*" (be it also noted) "which appears plausible that if the affinities of the other specimens are doubtful, the one missing may represent a true brachiopod (Sahni, 1936, p. 467), ..."' And further, "The generic diagnosis must for the present remain incomplete and *the description of the missing specimen* given by Mr. Chapman will be accepted as the diagnosis".

"The designation *Protobolella* is not used for a second reason : it suggests phylogenetic relationship with *Obolella* which it is intended to avoid as there does not appear to be sufficient evidence to warrant this relationship. That Mr. Chapman was himself in doubt as to the correct generic position of his species is shown by the fact that he at first referred it to *Obolella*".

To conclude :

"Since a number of earlier names proposed by Mr. Chapman have been published, it will be suitable to draw attention to these in order to prevent confusion in nomenclature. Thus, *Fermoria minima* replaces *Neobolus minima*, *F. capsella* replaces *Obolella jonesi*. According to the proposed classification all these names are superseded by *Fermoria minima*, Chapman".

None of the Vindhyan specimens can be assigned to the Brachiopoda.

The foregoing, I trust, clarifies most of the important issues involved ; one cannot afford to be vague since confusion merely breeds more confusion.

THE GENUS *FERMORIA* AND THE *TREATISE* : NEED FOR REVISION

Other important controversial issues have been raised in recent years concerning the systematic position of *Fermoria*. W. Häntschel (1962 revised 1966) has placed the genera *Fermoria* Chapman and *Krishnania* Sahni and Shrivastava, under the somewhat unusual heading: "*Unrecognised and unrecognisable genera*", and even as "*Inorganic fossils*" (an unfortunate term) despite a mass of evidence affirming their organic nature (F. Chapman 1935 ; Sahni 1936, 1954 ; Howell, 1956, A. J. Stocklin *et al.* (1964), M. Wade (1969) and Rowell (1971), and several other palaeobiologists. Certain forms have been described as '*Body fossils*'. Since many other genera have been similarly treated, parts of the volume of the "*Treatise*" dealing with "*Incertae sedis*" require a new approach and revision of basic data, inevitable where the scope is wide and opportunities for reviewing identifications, few. To repeat, one would like to see such terms as *Body fossils*, *Inorganic fossils*, etc., superseded by more logical and meaningful definitions. Also, an unequivocal statement is required to affirm the organic nature of the so called *Inorganic fossils* and this should be included in the *Treatise*, under the section dealing with the Vindhyan.

FERMORIA AND A RELATED GENUS FROM IRAN

In 1966 I received from R. Assereto, (University of Milan, Italy) certain Iranian fossils for opinion as to their affinities (*pers. comm.*, dated 17.10.1966). Originally lenticular and apparently somewhat inflated, these are now seen as flat disc-shaped ovals (Pl. IV—1-3). Much larger than *Fermoria* in diameter and of gregarious habit (as seen on slabs) the two forms (*Fermoria* and the Iranian species) apparently lived under similar conditions;

[1]True, larger examples have been reported, but not one of these relates to Indian occurrences.

they are related but should, in my opinion, be treated as distinct at the generic level. In remote geological history many broadly similar forms would have emerged contemporaneously with *Fermoria*-like genera. Further, homoeomorphy being a universal phenomenon both in the concept of time and space, such resemblances would be expected. Even the vastly more advanced species of Jurassic and Cretaceous Terebratulids for example, have given many cases of parallel development where outwardly identical physical shapes mask widely divergent internal characters such as brachidia, muscle-marks, etc., (M. R. Sahni 1925, 1925a, 1928, 1929, 1958).

The Iranian fossils referred to later, tend to occur as compact, dense, colonial aggregates (Pl. IV—3). I would however, like to emphasise that such dense concentration could easily be of secondary origin imposed by desiccation of pools or larger sheets of water along the sea coast. This phenomenon can be witnessed almost yearly in many parts of the world.

The Iranian fossils were also examined by Preston Cloud to whom I had sent material from Lucknow following examination here. He expressed the following opinion on this material (*pers. comm.*, dated 17.4.1967):

"The discoidial fossils are, indeed, similar to *Chuaria*, except that, like *Fermoria*, type *Chuaria circularis*, Walcott, is smaller and occurs singly. However, *Chuaria wimani* Brotzen, 1941, occurs in clusters and attains diameters of 2.5 mm., *cf.* 4 mm. for Iranian specimens. I have interpreted such discs with their "fingerprint" ornamentation as squashed algal spheres. The Siluro-Devonian acritarch *Tasmanites* somewhat resembles them when it is found in squashed preservation often scattered but as often closely packed together. The "fingerprint" ornamentation, I believe, represents the wrinkled surface of the squashed sphere. I have no reservations about the biological origin of the Iranian specimens".

The "ornamentation" in *Fermoria*, *Tasmanites* and the Iranian genus has obviously resulted from post-mortem wrinkling due to squashing of the original sub-spherical or lenticular body. Diversity of surface patterns certainly suggests this since individuals show considerable variation in this regard (Pl. IV—1 and 2). Resulting entirely from physical factors such as pressure, desiccation, etc., *this sculpture has no diagnostic import.* It merely suggests that in the living state the individuals were somewhat inflated and, upon burial, the body-wall was thrown into wrinkles due to the weight of the sediment cover. Surface wrinkling is much more haphazard and pronounced in the Iranian genus than in *Fermoria*, wherein, as far as can be made out, *it is confined to the peripheral region* but this could be due to extraneous factors such as the medium or mode of preservation. The irregular surface wrinkling suggests a greater degree of inflation in the Iranian specimens prior to burial than in *Fermoria*, resulting in coarser and more variable patterns.

FERMORIA	IRANIAN SPECIMENS
(Vindhyan of Central India)	(Chapoghlu Shale: Up. Precambrian to Lr. Cambrian)
1. Individuals circular in outline.	1. Individuals tend to be oval in outline.
2. Range up to a maximum diameter of 4 mm. (vide below).	2. Maximum diameter much greater than in *Fermoria*, generally over 4 mm; a maximum of 6mm. has been claimed for some specimens.
3. Surface wrinkling apparently confined to periphral region. (Probably a factor of the mode of preservation).	3. Surface wrinkling irregular; it covers more or less the entire surface and is coarser than in *Fermoria*.
4. Individuals occur scattered, as a rule.	4. Individuals close-set, sometimes exhibit an irregularly moniliform arrangement, probably of no systematic significance.

Both *Fermoria* and the Iranian species flourished in a shallow water marine environment, one in the central Indian the other in the Iranian region.

Organisms identified as *Fermoria* have also recorded from other parts of the globe. It remains to be seen whether all the six or seven genera regarded as synonyms are in fact congeneric with *Fermoria*, as claimed in Ford and Breed (1973). Personally I have undiluted reservations in this regard.

The size range assigned to *Fermoria* is phenomenal, a maximum of 8 mm having been claimed by Wade (1969) for examples from Central Australia. Indian examples of *Fermoria* scarcely ever exceed 4 mm. in diameter.

Recently, *Fermoria* and related genera have received much attention and have formed the subject of a number of detailed studies. It is thus pertinent to review certain aspects of their morphology and classification.

Confusion in classification had resulted from the initial description of *Fermoria* by Chapman (1935) who placed this (plant) genus under "Order? Atremata." Further, his graphic account of "? egg sacs of primitive brachiopods or eurypterids" (*loc. cit.* p. 118) did not improve matters despite (I would say because of) his remarkably detailed description :

"A bag-shaped body having a pyriform outline, more or less swollen and papillate, is figured here. It may represent an egg mass of *Fermoria*, or possibly a similar structure to the egg clusters already ascribed to primitive arthropods. On careful examination it will be seen that the pustules have hook-shaped processes, which perhaps gives more support to the latter idea."

"Dimensions : No. 3 K 21/360. Longest diameter, 1-3 mm.

Geological Horizon and Locality : Vindhyan, near Neemuch, India."

This graphic description, had no relation to reality.

It is well known that first impressions are sometimes more accurate in evaluating relationships than detailed studies. Thus, B. F. Howell's conclusions (1928) concerning the affinities of these fossils came nearest the mark, but were unacceptable to Chapman, who gave the following detailed analysis of Howells views :

"EVIDENCES OF PLANT ORIGIN EXAMINED" :

"In a communication that Dr. L. L. Fermor received from Professor B. F. Howell of Princeton University, dated 21st March, 1927, relating to these Vindhyan fossils, and of which I have been favoured with a copy, Dr. Howell expresses the view that, although at first sight they resemble atrematous fossils, a closer examination seems to prove that they are plant remains. He suggests that this view is supported by the test of incineration, when the bodies disappear. As I have already shown, the end result of the alteration of known chitinous fossils is also carbonisation.

I would appreciate views of other palaeobiologists and petro-scientists on this issue. To continue ;

"So far as I am aware, the only plant form with which the Vindhyan fossils could be compared is *Morania*, which Dr. C. D. Walcott regarded as a blue-green alga of Middle Cambrian age, from British Columbia. It is probably this form to which Prof. Howell refers in a later letter, dated 13th June, 1929, to Dr. Fermor, where he says, 'I have also compared your fossils with the type specimens of such of Dr. Walcott's Middle Cambrian Burgess Shale marine algae from Burgess Pass, British Columbia, as in any way resembled them. The Burgess shale forms are much later than the Vindhyan ones, but show such resemblances as one might expect to find in a Middle Cambrian derivative of a Pre-Cambrian ancestor'. The genus *Morania*, however, does not consist of isolated discs as the fossils do in the Indian shales, and are described by Walcott as a colony with surface raised in low, rounded bosses. The separate cells are certainly rudely discoid, but not to the extent of having a sharply defined margin. Another feature of the Vindhyan fossils is seen in their surface ornament of very fine but distinct concentric or eccentric growth-lines. This structure we do not find in the sacs or cells of the Cyanophycae, for they are more or less flaccid or gelatinous, even though lime-secreting. Apart from any discovery of algal cells, the probability of finding plant remains of this character in pre-Cambrian strata seems to be exceedingly remote. In any case, one would hardly expect to find them in the nature of rigid, shining, discoidal scales, and which remind one so forcibly, in their appearance, of the minute horny valves of brachiopoda in Cambrian shales."

Having decided that these (Vindhyan) fossils were brachiopods ("Atremata") it was natural for Chapman to introduce an appropriate nomenclature. This resulted in assigning the fossils to several species under *Fermoria*. These impressions were accentuated by Chapman's emphasis on relationship of these fossils with *Mickwitzia*, *Thecidea* and *Thecidellina*.

A similar frame of mind led him into other serious discrepancies ; nor were the photographic techniques employed at all helpful. Indeed, I was never able to understand the photographic techniques employed by Chapman and had sought clarification from him in this context.

ADDITIONAL REMARKS

In view of the foregoing, Chapman's descriptions of *Fermoria* and *Protobolella*, and of certain extra-Indian genera by other workers, need further review to determine their correct inter-relationship. The last include important, if erroneous, statements in the '*Treatise*'.

Occasionally *Fermoria* individuals are found lodged at the ends of filament-like structures fanning out from a central region (Pl. II—3 and Pl. III—1). Their exact nature remains undertermined even though they are intimately associated with these organisms. It has been suggested that the so called "filaments" might be contemporaneously formed (fossil) runnels at the ends of which the specimens became trapped while floating downstream ; and, if so, they would have no biological significance, though their clear and well defined outlines are significant. In certain cases, *Fermoria* specimens are found lodged at the rounded ends of short, *single*, funnel-shaped structures (Pl. II—4; Fig. 2). Examples of similar structures also occur in the material collected in 1971.

A detailed analysis and discussion follows ; in addition to photographs (Plates I—IV) five Text-figures have been introduced to elaborate certain points at issue :—

FURTHER DETAILS AND CRITICAL OBSERVATIONS CONCERNING ILLUSTRATIONS IN PLATES I TO III.

Plate I—1 represents the holotype of *F. capsella* as photographed by F. Chapman. *Ped.*, the so called "pedicle at the narrower end of the shell" seen here as a sharp protrusion is of inorganic origin, and has resulted from Chapman's 'restoration' of the specimen.

Chapman's holotype was rephotographed by this author and is seen here (Pl. I—2) for comparison with his illustration. Matrix, *m*, covers the top, supposed pedicle end of the specimen; the straight line represents the sharp boundary of the matrix (partially) covering Chapman's holotype; the right half of the specimen is partly eroded, *e*. The complete outline of the specimen has been reconstructed in broken line (top and right). The so called 'pedicle', *ped.*, in Chapman's illustration is only a protruding speck of matrix; it is *not an organic part of the fossil.*

Pl. III—2 is an original photograph showing the unrestored natural outline of *F. capsella*. The striking difference in outline between Chapman's illustration and this author's is noteworthy. Further, the so called "*pedicle*" and "*lateral pair of muscular areas*" in the 'paratype of' '*Fermoria capsella*, as interpreted by Chapman, (Pl. I, Fig. 3) have been misdefined; they do *not* represent these structures. The "*muscle areas*" (seen as large pear-shaped depressions) are chance imprints in the matrix, while the presumed "pedicle", *ped.*, is merely a part of the rock matrix. The "*moderately granulate ornament*" too represents only the matrix, and has clearly resulted from weathering. The abnormally large size of the so called "*lateral pair of muscular areas*" is noteworthy, and should have cast doubts on authenticity of these features.

Plate I—4, paratype of *F. minima*, shows the so called "*pedicle process*". *ped.*, as determined by Chapman. Actually, his paratype has two "apices" of which one was cut out in his published figure (vide below). The so called "*pedicle process*", *ped.*, in this specimen ('paratype') is merely a part of the flaked matrix; it is not an integral, organic part of the specimen. Noteworthy also is the fact that the second '*apex*' on the left is even better defined and more prominent than the one retained by Chapman as the '*apical angulation*' (Fig. 5).

Plate I—5 and Fig. 5 depict the *complete individual* of Chapman's paratype of *F. minima* (untrimmed photograph). The second "*apical angulation*", *a*, referred to above, occurs to the left of the '*pedicle process*' but was cut out in the figure (of the same specimen) published by Chapman. Indeed, this acumination ('*apical angulation*') could be more justifiably considered as an apex than the one carrying the so called "pedicle' *p*. The carbonised external surface of the specimen has been almost completely removed by weathering.

In *Fermoria minima*, the surface of the specimen figured by Chapman is partly 'granulated', *g.*, (shaded dark) and partly smooth. *The granulation has no organic significance;* it is a surface character (of the matrix), and is merely the product of weathering.

In Plate II—1, two specimens are seen juxtaposed at their *supposedly* acute apices, *cf.*, Chapman, Pl. I, fig. 6, (×16); his Fig. 5 also represents the same pair of specimens at a smaller magnification (×7).

The same two specimens as in Pl. II—1 above, are seen here in normal juxtaposition (Plate II—2 and Fig. 3). These were rephotographed by this author with top light ;

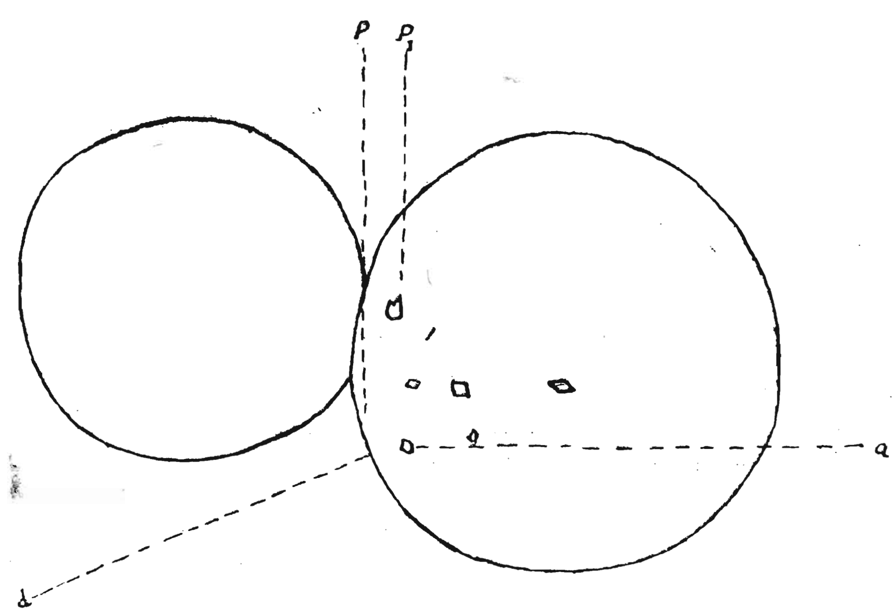

Fig. 3. Two specimens of *Fermoria minima* juxtaposed against each other. Note the complete absence of acumination at the so called "*apical angulation*", as defined by Chapman. Point '*a*', located outside the *Fermoria* specimen in Chapman's illustration actually occurs within the margin '*d*' of the disc. The so called pedicle region, *pp*, makes an even curve, i.e., without any trace of acumination (*cf.* Pl. 2—2).

the illustration affirms that individual specimens are *not* acuminate at their apices but possess perfect, evenly rounded outlines, as in all examples of *Fermoria*. The two specimens were obviously brought into juxtaposition by chance. The more or less *angular* apices as figured by Chapman had resulted from (faulty) photographic technique, as pointed out earlier (p. 20).

In several cases, *Fermoria minima* specimens are known to occur terminally of filament-like structures. About 12 such ' filaments" apparently radiating from a common focus, are seen here occurring in a group (Pl. II—3 and Pl. III—1). There are several other similar examples in my later, (1971), as also earlier, collections. The nature of these filament-like structures is uncertain. Their fairly frequent occurrence is significant, and is very *suggestive* of organic connection with *Fermoria* discs.

Occasionally, the "filaments", terminally of which *Fermoria* specimens occur, are clearly funnel-shaped at one end, e.g., the specimen at extreme left and another immediately above (to the right) of this specimen (Plate II—4; Fig. 2); other (incomplete) examples are also seen in this illustration. Three specimens of *Fermoria* '*f*' occur in a row near the central region of the photograph. Important here is the presence of a *Fermoria* at the bottom of each funnel-shaped structure.

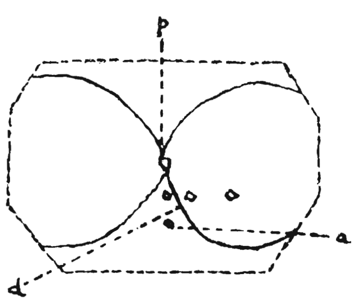

Fig. 4. The same two specimens of *Fermoria minima* as illustrated in Fig. 3, with their supposedly acuminate apices as defined above (Chapman Plate I, fig. 6). A quartz grain, *a*, actually occurring within the body of the disc stands beyond the margin of the disc.

The specimen figured in Pl. II—3 is seen here at a slightly higher magnification; (×2, approx.); Pl. III—1 shows *Fermoria* occurring terminally of individual filament-like structures, in one case with a mild constriction near the base (*cf.* Fig. 1*c*). Frequent occurrence of these structures is suggestive of organic union between the discs and 'filaments'.

Our photograph (Plate III—2) shows Chapman's holotype of *F. capsella* rephotographed with top, even light. The broken line in white (top of photograph) and in black (right) seen in Pl. I—2, is omitted here to emphasise the actual (incomplete) outline of the specimen. This may be compared with Chapman's Plate II—4, 1935, which has a totally different aspect.

Peel sections of *Fermoria* gave only partial success. One such section of the wall surface is reproduced here (Pl. III—3) from Sahni and Srivastava (1954). The lines in the lower half of the figure have been slightly intensified because of the faded print. Original photographs of surface peels are unfortunately not readily available.

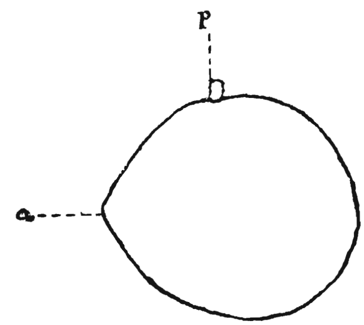

Fig. 5. *Fermoria minima*, Chapman, paratype shows *two* apices; the pedicle '*p*', as defined by Chapman, and a second, better defined *apical angulation*, *a*, trimmed off in Chapman's Plate 1, fig. 3 reproduced here.

AUTHOR'S EVIDENCE MISINTERPRETED

I shall now deal briefly with one of the crucial issues raised.

T. D. Ford (in Ford and Breed, 1973) entirely misread the evidence in assigning filament-like structures to *Krishnania*. These have been recorded only in *Fermoria*, not in *Krishnania*. Plate III—4 and Fig. 1a illustrat the ovate outline and acuminate apex of *Krishnania acuminata*, which contrast sharply with the usually almost perfectly circular shape of the Indian representatives of *Fermoria* (see Pl. II—2). The longitudinal axis in *Krishnania* measures 7.5 mm., the maximum width, 4 mm.; thus *Krishnania acuminata*, the only species known, differs sharply from *Fermoria minima* which has a regularly circular outline (*cf.* Fig. 1b) whereas *Krishnania* is acutely ovate, and has a sharp apex whence, indeed, the Trivial name.

The extremely variable patterns in the Iranian fossils referred to earlier in some detail, have resulted entirely from compression on burial. As seen in Plate IV—1 and 2, they suggest an originally inflated, presumably sub-spherical, succulent body which permitted considerable wrinkling upon pressure. The comparatively broad wrinkles seen to advantages at higher magnifications, suggest a thickened yet pliable outer layer, apparently different from the condition in *Fermoria*.

Clusters of the Iranian fossils (Pl. IV—3) occur closely packed and even appear to be almost conjoint, as in Fig. 2, above. Although this vaguely suggests organic continuity (of individuals) the close concentration would be the result of desiccation of isolated sheets of water along the coast and would thus be a post-mortem phenomenon.

Plate IV—3, represents individuals of natural size, approximately.

STRATIGRAPHIC VARIATION IN VINDHYAN; ITS REGIONAL SIGNIFICANCE

Vindhyan geological sections in different parts of North India show considerable variation since they represent different geological episodes, (Table 2). This basic fact has not always been realised, and explains certain presented in correlation, require clarification.

THE SONE[1] VALLEY

In the Sone valley, for example, the pronounced break following deposition of the Lower Vindhyan is striking and corresponds to the period covered elsewhere as, for example, in the Rampura area, by the Suket Shales. Conceding this, we obviously cannot correlate the (*Fermoria*-bearing) Suket Shales with beds in other sections where deposition was in abeyance. This fact has to be taken cognisance of carefully. The hiatus covers the Lower Vindhyan and was marked by vulcanicity and intrusive dolerite dykes in the Sone Valley, an area characterised also by the occurrence of Porcellanites.

THE ARAVALLI : RAJASTHAN

In Rajasthan, a region covered by extensive lava flows, only Upper Vindhyan strata (Kaimur, Rewa and Bhander Series) are exposed, the sequence resting directly on the Aravalli sequence, the Lower Vindhyan being absent (vide Dr. Heron's memoir : *The Geology of Rajputana and Mewar*, 1936).

[1] The name is variously spelt : Son, Soan, Sohan and Sone.

MALANI RHYOLITE AREA

Vindhyan strata overlying the Malani Rhyolite probably represent yet a different episode to the sequence of events in other areas, and need careful restudy.

RAMPURA AREA

In the Rampura area, the Procellanites are missing implying continuous deposition throughout the Lower Vindhyan.

Other aspects of the Vindhyan that need careful detailed analysis are :

(a) Origin of Procellanites
(b) Variation in the stratigraphic sequence in different regions.
and(c) Contemporary climates.

A. M. Heron (1936) and E. H. Pascoe (1959, revised 1965) had speculated that the great thickness of the Vindhyan sequence might embody some of the 'missing links' in the Lower Palaeozoic hisory of the subcontinent and even of the Himalayan area where evidence has often been obliterated by tectonic events. It is for future workers to determine where exactly to fit in the Vindhyan, or presumed Vindhyan, sections exposed in different regions, and to assess these in stratigraphic and palaeo-

TABLE 2

DISTINCTIVE FEATURES OF VINDHYAN SEDIMENTATION IN DIFFERENT AREAS

NOTE : (*a*) This is not a stratigraphic Table.
(*b*) In the Rampura area, the terms "Lower" and "Upper" lose their significance in view of absence of discordance between Suket Shales and Kaimur.
(*c*) Porcellanites = silicified tuffs.
(*d*) The so called Tillite of authors is a Tilloid and is *not* of glacial origin.

RAMPURA AREA (Madhya Pradesh)	RAJASTHAN	SONE VALLEY AREA (Uttar Pradesh)
1. *No unconformity* between the Suket Shales (topmost beds of Lower Vindhyan) and overlying Kaimur Sandstone (basal beds of Upper Vindhyan).	1. *Marked unconformity* between Lower and Upper Vindhyan. Lower Vindhyan entirely missing except for a siliceous breccia at the base.	1. *Marked unconformity* between topmtost Lower Vindhyan beds (Rohtas stage) and overlying Kaimur stage. Evidence of *vulcanicity*.
2. Suket shales *present*. (topmost beds of Semri, Rohtas stage). These cover the period of stratigraphic break between Lower and Upper Vindhyan in other areas. (Type area, Mewar, Heron, 1936).	2. Suket shales *missing*.	2. Suket shales *missing*.
3. Glauconite beds *missing*	3. Glauconite beds *missing*	3. Glauconite beds (Semri series) *present*.
4. Volcanic rocks *missing*	4. Lava flows *present*	4. Dolerite dykes and basalt *present*.
5. Porcellanites *missing*	5. Porcellanites *missing*	5. Porcellanites *present*.
6. Basal beds as *conglomerates*	6. Basal beds as *conglomerates*	6. Basal beds mostly conglomerates, occasionally associated with Tilloid.

biologic terms. An important question is : did any part of our continental region experience *continuous* deposition from Precambrian to the late Palaeozoic ? Although unbroken deposition might seem plausible in the light of fossil finds of the younger Palaeozoic during the last two decade or so (.e.g., in Central India, Rajasthan and Madhya Pradesh), only the future can reveal the precise and complete picture. Absence of the larger fossils in the Vindhyan, generally undisturbed by earth movement or serious metamorphic effects, has tended to imply that the Vindhyan sequence was entirely pre-Palaeozoic.

Another anomalous situation of which many are not aware is that while the Semri series is named after the Semri river in Bijawar district of Madhya Pradesh, the type Semri area is in the Mirzapur district of Uttar Pradesh.

ORIGIN OF PORCELLANITES : VOLCANIC OR GLACIAL

The Semri series, particularly the Suket Shales, have understandably received the maximum attention in view of the sharp differences in their various facets, some of which need review and fresh interpretation.

It is often maintained, for example, that Vindhyan sedimentation was initiated with the onset of glaciation. On the contrary, "the presence of thick masses of Porcellanite in the Lower Vindhyan proves that the latter were laid during a period of extensive volcanic activity. According to Auden (1933), the porcellanite originated from tuffs which became silicified. They are undoubtedly of marine origin and were deposited in close proximity of volcanic regions. In addition to tuffs, other sediments, such as shales and fine-grained argillaceous rocks underwent silicification and became modified into porcellanites" (Sahni, 1960).

To give such other details as are rarely stated explicitly:

(a) The Lower Vindhyan sequence is frequently intruded into by dolerite dykes.

(b) The Porcellanite stage comprises of two distinct horizons : Upper Porcellanite beds and Lower Porcellanite beds separated by a 30 ft. limestone band as follows :

GEOLOGICAL SECTION IN SONE VALLEY

Rohtas stage	
	Glauconite Sandstone
Kheinjua stage	Fawn Limestone
	Olive Shales
	Upper *Porcellanite* beds
	Limestone (about 30 ft. thick).
Porcellanite stage	Lower *Porcellanite* beds :
	Sandstone with undecomposed feldspar; lower part of sandstone with angular to subangular pebbles of quartz.
Basal stage	Conglomerate and Tilloid

It may be noted further that the so called Tillite of authors is a part of the underlying conglomerate ; it is a Tilloid, *not* a Till of glacial origin.

This aspect needs elaboration.

While it is true that the basal conglomerate is occasionally replaced by a breccia, this occurs only sporadically, and is interpreted as a scree deposit derived from the old Satpura range (as defined by Oldham and his colleagues, 1901). What is important here is that *such deposits of angular material are only of limited occurrence and thus cannot be equated with the basal conglomerate which is an extensive deposit and defines the original Lower Vindhyan sea coast.*

EVIDENCE OF VOLCANIC ORIGIN. GLACIAL THEORY UNTENABLE

F. Ahmad, advocate of Vindhyan glaciation, states that two separate glacial episodes are represented in the Vindhyan, one at the base of the Semri series and the other at the base of the Upper Kaimur (1955, 1955a). Thus excluding the carbonate sequence, he regards almost the entire Vindhyan System as glacial in origin : the conglomerate as a tillite, the Porcellanite stage as 'varvites' and the Susnai Breccia of the Lower Kaimur series as a deposit derived from floating icebergs.

The actual position is, however, at variance with available data. In the first place, the Basal stage of the Semri series gives no evidence of facetted pebbles of a striated pavement. Thus the presumed Vindhyan 'tillite' (correctly a tilloid), cannot be of glacial origin. Indeed, there is complete gradation from the Basal conglomerate to coarse sandstone to limestone (involving a depositional cycle) so that the question of a glacial interlude does not arise ; the concept is purely hypothetical. Other arguments against glaciation (vide Lakshmanan, 1969) are :

(i) Presence of over 80% of quartz-vein pebbles in the conglomerate (implying a uniform source) whereas a glacial till would consist of unsorted pebbles.

(ii) Unlikelihood of a sudden climatic change as inferred from the red beds (indicative of arid conditions) below the supposed tillite.

(iii) Presence of limestones above it, again indicative of warm conditions.

(iv) Association of a thick carbonate sequence with the 'tillite' which precludes the possibility of lowering of temperature.

Concering the Porcellanite, F. Ahmad (1955, 1955a) advocates its glacial origin mainly on the basis of appearance, texture and microscopic characteristics and the presence of fresh grains of feldspar, besides the absence of a near volcanic source. The last is a hypothetical consideration since fine volcanic material can be derived from distant regions, though a near source cannot be precluded for that reason. What is required is to look for ancient volcanoes as a source. There is also the possibility (vide S. K. Saluja and K. Rahman, 1972) that the acid volcanics (rhyolite) gave rise to the Procellanite. This needs careful study for it may yield the clue to the source-material of the composing rocks.

Finally, as already noted, the Basal conglomerate in the Sone valley section (Kaimur conglomerate of Mallet, 1969) is to be correlated with the conglomerate occurring at the base of the Lower Vindhyan sections : *it marks the original limit of desposition as defined by Pascoe* (1959) *and later by W. D. West* (1962). The so called glacial striations and facetting on boulders constituting the Basal conglomerate, have obviously resulted from mechanical action of wind or tides, *not* ice. Such a phenomenon has been recorded by a number of workers, besides Gussow (1956).

F. Ahmad's concept of Vindhyan glaciation is thus vitiated by a mass of evidence to the contrary, clearly and ably marshalled by S. Lakshmanan, besides the evidence put forward by J. B. Auden and the present author.

CONCLUSION

Problems connected with Vindhyan stratigraphy and palaeobiology have been reviewed to place thinking on some of the Vindhyan biota in correct perspective. My main objectives are to reaffirm :

(a) That *Krishnania* and *Fermoria* cannot be considered as synonymous; also, that the basis on which T. D. Ford and W. J. Breed, invoking F. Glaessner, suggest synonymy of these genera with *Chuaria* stems from misinterpretation of basic morphological characters of these genera.

(b) Conclusions drawn by Ford and Breed in regard to (a) above, affirm the need to re-evaluate their statements on Precambrian biota though this author is not immediately concerned with the other genera relegated to *Chuaria*, apart from those mentioned above.

(c) The Vindhyan commenced with a period of volcanic activity *not* glaciation as has been suggested sometimes. The angular breccia occasionally met with, e.g., at Taraka (Sone Valley) is scree material that got buried before removal by stream action.

(*d*) There were at least two periods of volcanic activity during the early Vindhyan intervened by deposition of limestone.

(e) The source of material constituting the Porcellanites needs to be precisely identified. A valid question is : was it local or situated in a comparatively distant region. Fineness of the Porcellanite material could point to a distant source, but the tuffs and agglomerates accompanying the Sone Valley Porcellanites suggest local explosive volcanism, and a possible near source. It is stated that the basement ridge (of acid-rhyolite volcanics) between Khattai and Sahiwal was the source area of this volcanic material. This interesting suggestion by S. K. Saluja and K. Rahman needs following up. Indeed, there are other 'Unsolved Problems of Indian Geology" Sahni (1963) that need to be deciphered, and these certainly cover several aspects of the Vindhyan.

Finally, much remains to be done before Trevor Ford's classification of the Precambrian biota (for which, W. J. Breed disclaims all responsibility) can be unreservedly accepted.

ACKNOWLEDGEMENT

I have had fruitful discussion with Dr. Ashok Sahni concerning various problems of classification and depositional environments discussed herein. I am beholden to Dr. A. R. Bhattacharya for help in arranging the illustrations, and to Mr. Richard D'Souza for tracings of drawings from the original photographs by this author.

FOSSIL LOCALITIES

Collections were made by the author from localities 1 to 20 in 1950 and in 1971 from a new locality no. 21 in western part of Rampura town, besides other localities in and around Rampura.

1. Tulsai nadi, 300 yds. upstream of Rampura-Garot road crossing. Right bank.
2. Tulsai nadi, 100 yds. upstream of Rampura-Garot road crossing. Right bank.
3. Tulsai nadi, 50 yds. downstream of Rampura-Garot road crossing. Left bank, and right bank, same horizon.
4. Tulsai nadi, Left bank at Semri-Dhabla road crossing, within twenty yards of road.
5. Tulsai nadi, 3 furlongs downstream of Semri-Dhabla road crossing. Right bank.
6. Tulsai nadi, 2 furlongs downstream of Semri-Dhabla road crossing. Right bank.
7. Tulsai nadi, about three furlongs downstream of Chaoki, Right bank.
8. Tulsai nadi, about 20 yds. upstream of Chaoki. Left bank.
9. From the Chambal, about 100 yds. from Rampura-Bhanpura road crossing. Downstream of bridge.
10. Nala in scarp north of Rampura.
11. Small nala, immediately S. E. of Majheria, with *Fermoria* dominant.
12. Semli nala, about 100 yds. from Rampura-Jamalpur-Majheria road crossing. Right bank with *Fermoria* dominant. About 1/2 m. of Jamalpur.
13. Main stream, about two miles from Kedarnath, right bank; Rampura-Jhalod-Kedarnath road. *Fermoria* dominant.
14. Ansar nadi, right and left bank; within a few yards

of bridge; Rampura-Bhanpura road.
15. Near Meri.
16. Nala joining 200 yds., upstream of Ansar.
17. At mile 55, main road; from stream bed.
18. Chambal Dam site.
19. Well within Rampura village. Jone's original 'locality'.
20. Eastern bank of Chambal-Rampura-Garot road; about 5 miles from Rampura.
21. Large well sunk in compound of a new public building under construction in 1971. This is the latest subsurface locality brought to light.

POSTSCRIPT

P. K. Maithy and Manoj Shukla have once again reviewed several aspects of the Vindhyan microflora and given interesting new data. (*The Palaeobotanist*, 1974, issued Feb., 1977). Since this paper was brought to my notice very recently, only a brief review of the Vindhyan fossils described can be given here.

(1) The geological age of the microflora formerly regarded as Ordovician by P. K. Maithy, 1968, has now, been (correctly) assigned to the late Precambrian. I have earlier discussed various aspects of this problem in some detail (p. 291).

(2) The report of punctae in the "macerated discs of *Fermoria*" recorded from Suket Shales by Maithy and Shukla (1974, pub. 1977, *see* below) is revealing since earlier studies make no reference to punctae in *Fermoria*. Maithy (1956, issued 1969) had assigned to *Tasmanites* many of the forms referred to in the following publications :

(1) F. Chapman 1935, (2) M. R. Sahni, 1936, (3) R. C. Misra and Dube 1952, (4) R. C. Misra and N. Awasthi 1957.

"The present study of these disc-like bodies", according to Maithy (1968) p. 50) "shows that they closely agree to the genus *Tasmanites* (Newton) Eisenack 1963, which has been regarded as residual envelope of some algal form". The Rampura "*Tasmanites*" was thus clearly included earlier within the genus *Fermoria*.

Further, one would like clarification on the following crucial point : is the *Tasmanites* identified by Maithy and Shukla identical with the large discs which sometimes occur in shoals in the Suket Shales? Do these discs include other genera. Incidentally, besides *Tasmanites* and *Fermoria* the recent study by Ford and Breed, 1973, claims that the genus *Chuaria* and six or seven other genera among which they also include *Fermoria*, are all devoid of pores, and are synonyms.

An important point needing confirmation is whether these large, circular discs from the Suket Shales include several different forms (as, apparently, surmised by Maithy and Shukla) or whether they are only growth stages of one or two (or more) forms. Hardly any worker on *Fermoria* or cognate Indian fossils seems to appreciate that these too must have passed through younger (smaller) stages which would have often become preserved during deposition of Suket Shales.

(3) The nature of the multidimensional white spots (pores) reported by Maithy and Shukla in Pl. 5, Figs. 41 and 42 needs clarification. Also (unless I am mistaken) there appears to be no mention of these two figures in their text ; they are referred to only in the Explanation of Plates. Since these figures are designed to illustrate important aspects of the internal constitution of these fossils, additional, clearer illustrations would be helpful. We look forward to see further details in the near future.

(4) The presence of exceptionally well preserved punctae in the *single* specimen (only) of *Tasmanities* figured by Maithy and Shukla (Pl. 3, Figs. 33 and 34) reproduced from Maithy, 1968, deserved additional *newer* illustrations. The lacuna needs clarification by photographs of other specimens especially as the same illustration has been reproduced despite several year's hiatus. (P. K. Maithy, 1969, Maithy and Shukla 1974).

I presume this specimen (*Tasmanites*) *was* actually derived from the Suket Shales exposed in the Rampura area; its (excellent) state of preservation appears to be quite different to that of the rest of the material illustrated.

(5) Regarding *Krishnania*, a genus well removed from *Fermoria*, the authors have made a crucial observation concerning its systematic position but have given no supporting evidence, nor do they refer to the considerable differences is size, shape absence of filament-like structures (seen only in association with *Fermoria*. Relevant details have been discussed by this author on page ; Fig. 1a and Pl. III—4 are also relevant in this context.

(6) The photographs in Maithy and Shukla do not show clearly morphological details (sculpture, tri-radiate ridges, etc.) referred to in the text. Since important issues are involved, line drawings in addition to photographs would be helpful.

(7) When I visited Rampura in December 1971, much of the country south and east of this town had been submerged ; this included the culvert on Tilsoi (or Talsoi) nadi mentioned by the authors, besides many other localities which I had visited 26 years earlier and which are recorded in the accompanying list. It would be interesting to know which parts were still above water level when Dr. Maithy and Shukla visited this area. The roof top of the PWD Rest House where I had stayed 21 years earlier (Dec.-Jan., 1950-51) was still seen to emerge through the overflow waters of the Gandhi Sagar and stood unruffled, —a silent witness to man's grand designs!

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EXPLANATION OF PLATES

PLATE I

1. *Fermoria minima* Chapman (=*Fermoria capsella*, holotype, ×16) as photographed by Chapman.
2. *Fermoria minima* (=*Fermoria capsella*, Chapman, holotype, × 18) as photographed by this author.
   Note the striking difference in outlines between Chapman's illustration (Fig. 1 above) and this figure.
3. *Fermoria minima* (=*Fermoria capsella*, Chapman). Natural depressions in the matrix, erroneously defined as "*pedicle*" and '*muscle impressions*' by Chapman.
4. *Fermoria minima* Chapman, paratype, shows position of the so called "*pedicle process*" as figured by Chapman.
5. *Fermoria minima*, Chapman, paratype. Illustrates the "*pedicle*" and in addition an "*apical angulation*" as figured by this author for comparison with above. (×6, approx.).
6. *Fermoria minima*, Chapman. Specimen with a partly 'granulated' and partly smooth surface.

PLATE II

1. *Fermoria minima* (=*Protobolella jonesi* Chapman).
   Two specimens juxtaposed at their *presumed* acute angled apices, as figured by Chapman. He interpreted these as two bracniopod valves of a single individual.
2. *Fermoria minima* (=*Protobolella jonesi*, Chapman).
   The same two specimens as in Fig. 1 above, seen with their *normal* (*actual*) outlines under top light. In contrast, note the remarkably even, rounded outlines of these *two specimens juxtaposed by chance.*
3. *Fermoria minima* Chapman : specimens occurring terminally of filament-like structures. Several such specimens, apparently radiating from a common focus are seen in a group. Reproduced here from an original photograph (approx. nat. size) in the authors collection (cf. *Curr. Sci.*, 1954).
4. *Fermoria minima*, Chapman (×2), Occasionally, the "filaments", terminally of which *Fermoria* specimens occur, are clearly funnel-shaped at one end. Reproduced from an original photograph in the author's collection.

PLATE III

1. *Fermoria minima*, Chapman. A group of specimens as figured in Pl. II, Fig. 3, enlarged, approx. ×2. Note the mild constriction at the junction of the *Fermoria* disc with the 'filament'.
2. *Fermoria minima*, (=*Fermoria capsella* Chapman, holotype, as figured earlier).
   Peel section of outer wall surface of *Fermoria minima*, reproduced from Sahni and Shrivastava, 1954, Fig. 3 (×20). Some of the lines have been intensified in part.
3. *Krishnania acuminata* Sahni and Shrivastava, 1954. Genoholotype. The ovate outline and acuminate apex may be compared with the almost perfectly circular outline of *Fermoria minima*, Pl. II, Fig. 2.

PLATE IV

Photographs reproduced here as also the relevant fossil specimens were received by this author from Professor Riccardo Assereto (institute of Geology, University of Milan), for expression of opinion regarding their affinities. For additional details and explanations, see text.

1. Flattened, discoidal plant remains from Chapoghlu Shales; Precambrian, Iran. (×7 approx.)
2. Single specimen (central part of figure) from Chapoghlu Shales, enlarged (×11, approx.).
3. Shales slab from Chapoghlu, crowded with organic remains; the specimens are of approximately natural size.

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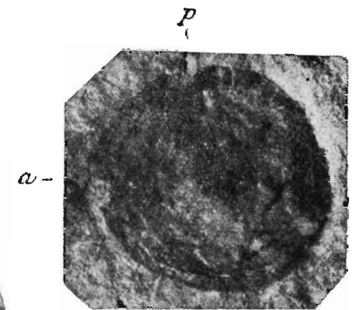

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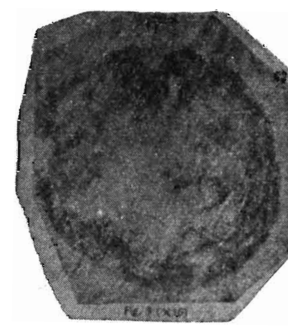

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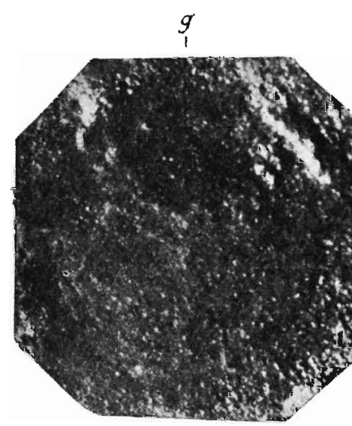

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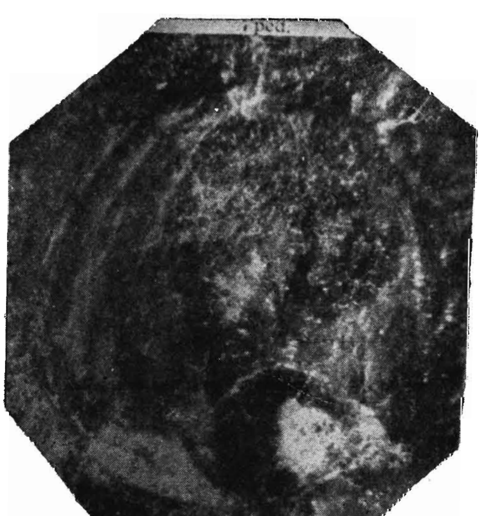

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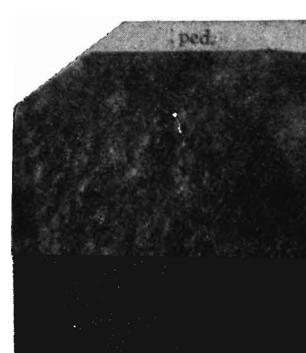

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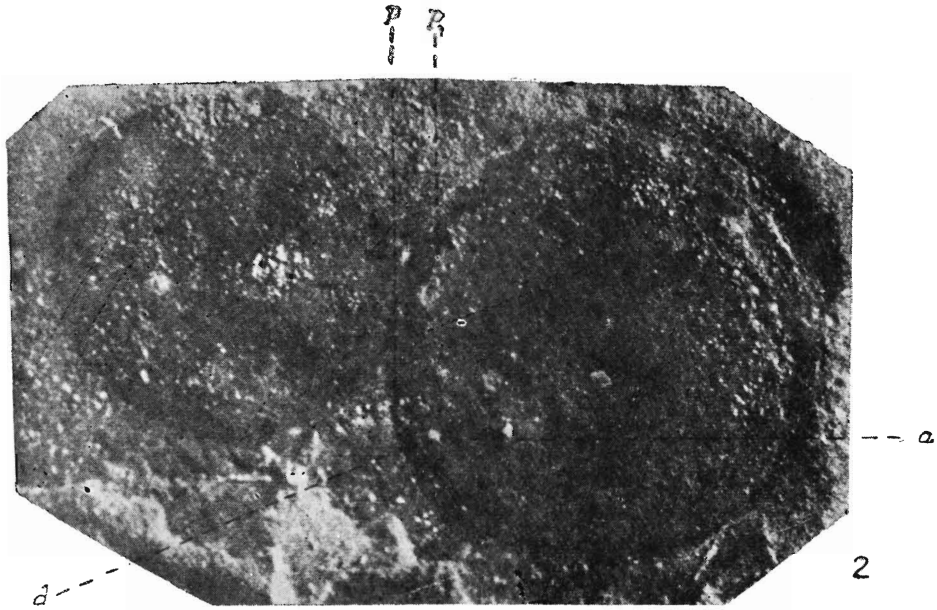

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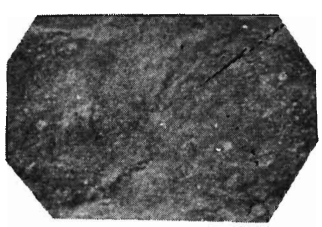

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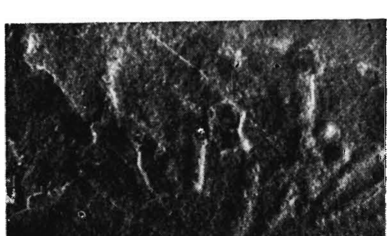

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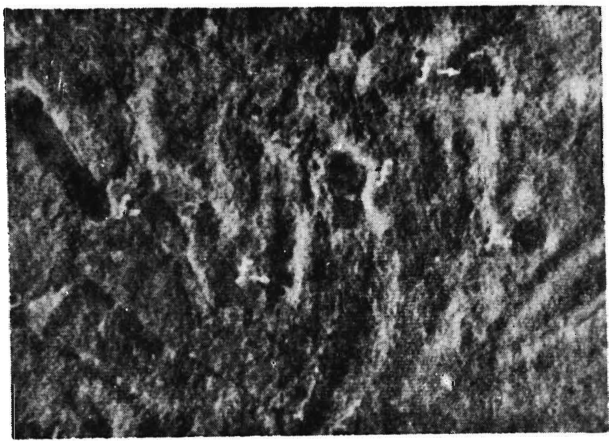

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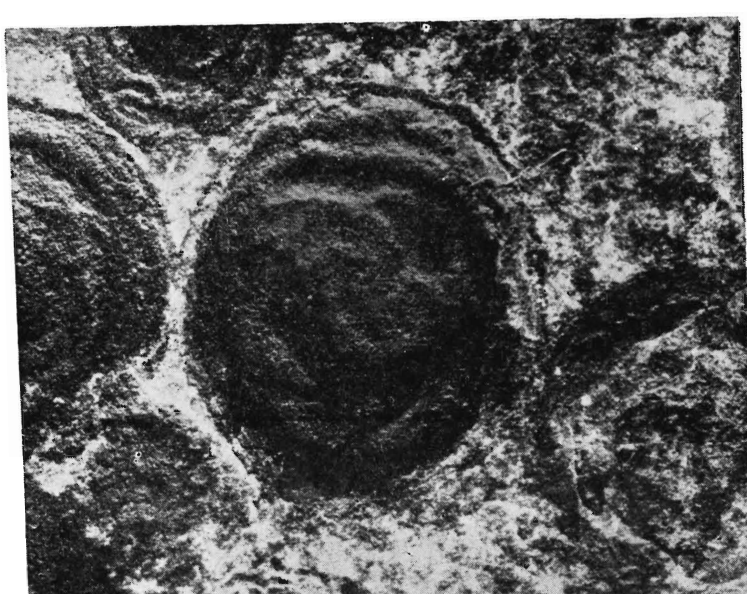

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