EVIDENCE FOR THE EXISTENCE OF VASCULAR LAND PLANTS IN THE CAMBRIAN

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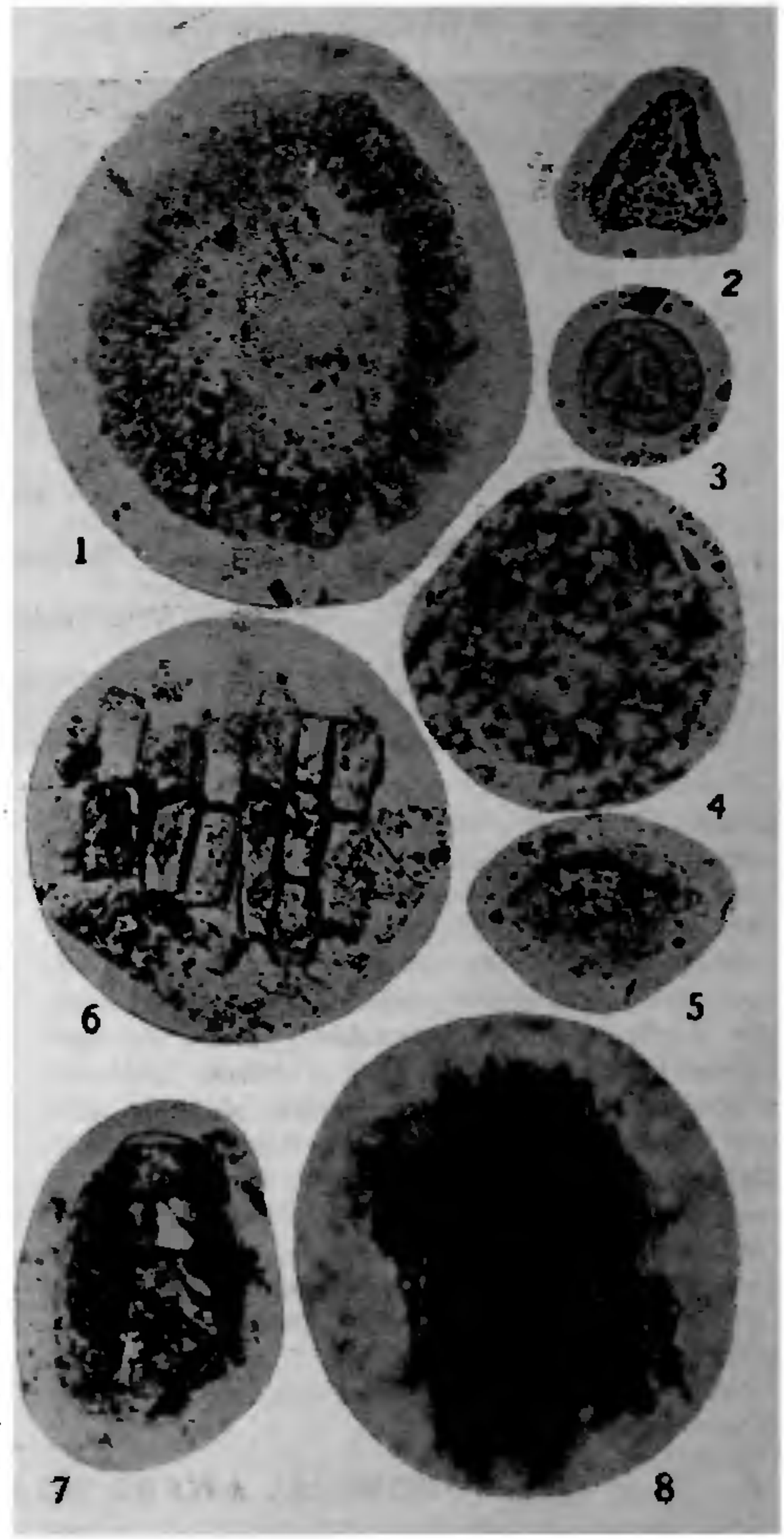
A. K. GHOSH AND A. BOSE in a series of short papers have recorded the presence of spores and woody elements in the Cambrian of the Salt Range[1,2,3] and Kashmir,[4] and from the Vindhyans.[5] With a view to verifying some of their findings which had raised some doubts in India, A. K. Ghosh handed over some of his material to us for investigation in the laboratories of the Geological Survey of India. In addition to these samples, some authentic Cambrian material available in the collection of the Geological Survey were also examined by us.

The specimens investigated include the Cambrian Neobolus shale from the Salt Range containing well-preserved *Neobolus, Redlichia,* etc. (Geological Survey of India, Reg. Nos. K33/591 f, K 17/480), the Middle and Upper Cambrian olive-green, phyllitic shales from the Hundwar Tehsil of Kashmir with *Tonkinella,* ? *Obolus,* etc., present in that horizon (Geological Survey of India, Reg. No. K32/248) and the Upper Cambrian dark grey, fine-grained shale from the Parahio river, Spiti. In addition, a specimen of ? "Neobolus shale" from the Salt Range collected by the geologists of the Burmah Oil Co., and kindly handed over to us by A. K. Ghosh was also examined. Ghosh and Bose[2] have described the organic remains recovered by them from this material.

Samples were treated in hydrofluoric acid and macerated in Schultze's fluid. All possible precautions were taken to avoid contamination in the laboratory.

All the above-mentioned samples examined by us yielded well-preserved spores, tracheids and what appear to be bits of cuticles. On the whole, we support Ghosh's general findings from the Cambrians of India that traces of vascular plants occur in these ancient sediments, but we differ from him in certain details. At least 43 different types of spores were obtained from the different samples examined by us. Some of the organic remains are identical with those found by him.

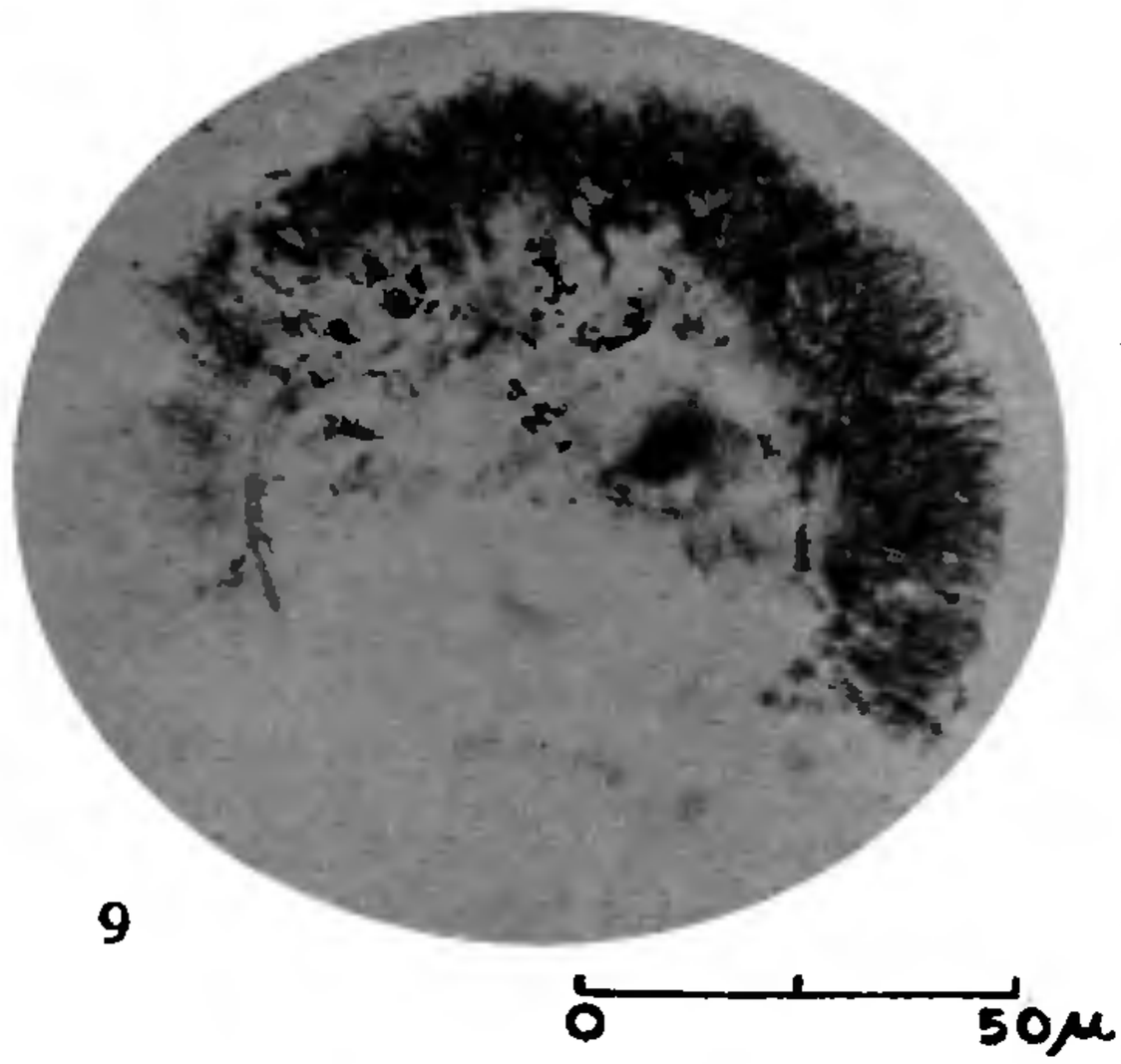
All the spores are cutinised and are light yellow in colour. The shape in the majority is generally round or oval with or without triradiate mark. Spores which are triangular in outline with a clear triradiate mark and well-developed sculpture are found only in the ? "Neobolus shale" of the Salt Range collected by the Burmah Oil Co. These



FIGS, 1–3.—Spores from the Neobolus shale, Salt Range (B.O.C. Coll.).

FIGS. 4, 5.—Spores from the Neobolus shale (Cambrian), Salt Range (G.S.I. Coll., K 17/480).

FIGS. 6, 7—Cuticle (6) and spore (7) from the Neobolus shale (Cambrian), Salt Range (G.S.I. Coll., K33/591f).



FIGS. 8, 9.—Woody elements (8) and pollen (9) from the olive-green shale (Cambrian), Hundwar tehsil, Kashmir (G.S.I. Coll., K32/248).

appear to belong to the primitive pteridophytes. Some of them may even be pteridospermous. Only two are figured here (Figs. 2 & 3).

There are much larger spores, round or oval in outline, possessing a central body, more than 50 μ in diameter in some cases, and a prominently frilled margin (Figs. 1 & 9). In one or two a triradiate mark is visible. Spores of this general type measure 75 μ–130 μ in diameter and are fairly common in the Middle and Upper Cambrian of Kashmir (Fig. 9) and the ? "Neobolus shale" of the Salt Range collected by the Burmah Oil Co. (Fig. 1). At least three distinct types of this group are present in the Kashmir Cambrian sample examined. It is possible that they belong to the Pteridospermæ.

Pollen with two distinct bladders are found in the ? "Neobolus shale" from the Salt Range (B.O.C. Coll.), the Upper Cambrian of Spiti and the Middle and Upper Cambrian of Kashmir. While at least three distinct and well-developed types of this group are recovered from the "Neobolus shale" (B.O.C. Coll.) only two types quite distinct from each other and quite different from any found in the ? "Neobolus shale" (B.O.C. Coll.) occur in the other two localities. Those from the Burmah Oil Co., ? "Neobolus shale" resemble some of the late Palæozoic ? gymnospermous or pteridospermous pollen.

Round or oval spores with faint partition lines simulating a coarse network are found to occur in the Cambrian of Kashmir (37 μ diameter) and the Cambrian Neobolus shale (G.S.I. Coll.) of the Salt Range (50 μ diameter).

A piece of undoubted plant matter recalls what Reissinger[9] distantly compares with Equisetalean prothallia from his material of the Lower Cambrian blue clays of Esthonia. Such comparisons with delicate plant matter which have hardly been met with in the fossil state, should be taken with reserve in the absence of convincing evidence.

It is difficult to suggest the affinities of the woody elements (Fig. 8), several fragments of which have been obtained. While most of them are dark yellow in colour with well-developed bordered or simple pits, some appear to be carbonised. The fragments with bordered pits and the simple pitted carbonised bits from the Spiti and Kashmir Cambrians, are indistinguishable from those shown in Pl. IV, Figs. 7, 12 & 13 of the woody elements from the blue clays of the Cambrian of Kunda in Esthonia.[9] The cuticles are devoid of any stomata in the very fragmentary pieces recovered (Fig. 6).

At least 6 different types of spores from the Cambrian of Spiti, 6 from the Cambrian of Kashmir and 31 from the ? "Neobolus shale" of the Salt Range (twelve in the G.S.I. material and nineteen in the B.O.C. specimen), were obtained in the slides so far examined. The descriptive account of the individual spores will appear in the detailed paper to be published elsewhere. We are inclined to believe that the primitive pteridophytes and the pteridosperms are represented in the Middle and Upper Cambrian sediments examined by us.

The authors would particularly draw the attention of geologists and palæobotanists to the important contributions by Naumova,[6] Kopeliovitch,[7] Reissinger[8,9] and Darrah[10] describing spores of vascular land plants from the Cambrian sediments of Europe.

The general conclusions drawn by Naumova[6] regarding Cambrian spores are not quite in agreement with our observations regarding the size, shape and sculpture of the spores from the Indian Cambrians. The Indian triletes so far recovered by us vary in size from 5 μ–50 μ and the larger frilled spores from 75 μ–130 μ. According to Naumova the Lower Cambrian Pre-Baltic spores from Russia are comparatively small in size varying from 15 μ–25 μ, exclusively round or oval in outline with simple sculpture and well-developed folds indicating a comparatively thin spore coat. Those described by Reissinger[9] also generally agree in shape, size and sculpture with the Pre-Baltic spores. The spores from the oil shales of the Kolm in Sweden described by Darrah[10] are somewhat larger in size and are probably all referable to the Bryophyta or

the Pteridophyta. Apparently, the Indian Cambrians show more highly evolved spores of comparatively large size some of them possibly belonging to the Pteridospermæ. Spores of triangular outline are particularly common in the sample of "Neobolus shale" from the Salt Range collected by the Burmah Oil Co.

The spores from this sample are so well-preserved and so abundant in the slides with several distinct types showing well-developed sculpturing and with quite a few triangular spores that we are somewhat doubtful as to its correct horizon. Further, the spore assemblage even including two-bladder ? pollen closely resembling *Pityosporites* with well-developed striations on the body of the spore, also recalls to a great extent those recovered from the Lower Gondwana sediments of the Salt Range (Speckled sandstone—Middle Products beds) and Pali, Rewah.[11] The B.O.C. specimen is a fine-grained greenish sandstone with streaks of carbonaceous matter with no Cambrian animal remains preserved to be quite certain of its provenance. For the time being we, therefore, hold this specimen as of doubtful Cambrian age, the spores contained in them showing a late Palæozoic affinity, unless, of course, it turns out that the Cambrian forms were already well developed and persisted right up to the Permian without much modification! This was rather unlikely.

The other Cambrian shales from which spores and tracheids have been recovered by us, are, we are convinced, of Cambrian age. On the whole, we believe that there is sufficient evidence to indicate as Naumova,[6] Reissinger,[8,9] Darrah,[10] Ghosh[4] and Jacob[12] have already pointed out, that the vascular land plants were in existence even as early as the Cambrian and not entirely unknown in strata older than the Silurian, as generally believed. The spores, tracheids and cuticle, bear out the fact that the vegetable kingdom had already reached this stage of development during the early Cambrian at least, paving the way for animal life on land.

The present short note is mainly intended to emphasise the need for a careful and systematic search of the pre-Silurian sediments for further evidence of traces of vascular land plants, and to determine the history and evolution of the plant kingdom in the remote times represented by the early Palæozoic or even Proterozoic sediments.

We are grateful to Dr. M. S. Krishnan and Dr. J. B. Auden, Geological Survey of India, for their keen interest in the work. We are thankful to Mr. A. K. Ghosh, Bose Research Institute, Calcutta, for kindly giving us a copy of the English translation of Naumova's paper in Russian and to Mr. P. K. Nag for help in taking some of the photographs.

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INDIAN RARE EARTHS FACTORY

THE Indian Rare Earths Ltd., Alwaye, which was formally opened by the Prime Minister, Shri Jawaharlal Nehru, on 24th December, came into being in September 1950, after the deliberations of a Committee set up by the Government of India in July 1949 The Board of Directors consists of: Mr. J. D. Choksi, Dr. H. J. Bhabha, Dr. S. S. Bhatnagar, Mr. K. R. K. Menon, Dr. K. S. Krishnan, and the Chief Secretary and the Finance Secretary of the Government of Travancore-Cochin.

The occurrence of monazite in Travancore-Cochin State was first discovered by the German chemist, C. W. Schomberg, in 1909. This discovery was followed almost immediately by an investigation of the area by the Geological Survey of India. Monazite was first exported to U.K. in the year 1910. When the agreement between the Government of Travancore and the British firm lapsed, further exports were banned by the Travancore Government.

The factory can process 1,500 tons of monazite sands a year. The sand will be supplied by the Government of Travancore-Cochin. The main products are rare earth chlorides and rare earth carbonates. The plant is capable of producing the entire earth as either chlorides or as carbonate. This is due to the fluctuating nature of the demand for these products. It can produce a maximum of 1,650 tons of chlorides or 1,150 tons of carbonates. Normally it will produce approximately 1,000 tons of chlorides and 450 tons of carbonates. The bye-products are between 1,500 to 1,800 tons of crystalline tri-sodium phosphate and 9,000,000 gallons of caustic soda lye in 10 to 12 per cent.