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PLANT LIFE IN THE JURASSIC OF AMARJOLA, RAJMAHAL HILLS, INDIA

Roślinność jurajska z Amarjola, Rajmahal Hills, Indie

ABSTRACT

Most fossil plants from Amarjola belong to gymnosperms. The Jurassic vegetation from Amarjola was composed mainly of herbs and shrubs, while trees occurred rarely. The plants discussed are interesting from the phylogenetic point of view.

INTRODUCTION

The fossiliferous locality of Amarjola is situated about 2 miles northeast of Amarapara in the Rajmahal Hills, India. Fossils are found preserved in petrified state in the dark brown sandy rocks. Besides the plant remains, in Amarjola bivalved molluscs are also found, but they are comparatively rare in occurrence. Plant fossils are mainly of gymnosperms excepting a few ferns which have been described only recently from this locality (Gupta 1970, Sharma 1971). Among the gymnospermes, *Bennettitales* are most commonly occurring plants and they are represented by a number of species. Other gymnosperms known from the Jurassic of Amarjola are the pteridosperms, cycads, *Pentoxylales* and coniferous plants of the families *Podocarpaceae*, *Araucariaceae*, *Cupressaceae* and *Taxaceae*. Ferns are rare in occurrence and they are represented by osmundaceous rhizomes and isolated rachises of unknown affinities.

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DESCRIPTION

Pteridophyta. The osmundaceous rhizomes collected so far from the locality of Amarjola are belonging to the genus *Osmundacaulis* Miller. In all, the vascular zone is an ectophloic, dictyoxylic siphonostele. Cortex is differentiated into two zones. Petiolar traces are adaxially curved, c-shaped structures with endarch protoxylem points. The vascular traces in the isolated petioles and rachises of ferns collected from Amarjola are also osmundaceous but with varying positions of protoxylem points i.e. exarch, mesarch or endarch (Sharma 1971).

Gymnosperms. They formed the major part of the Jurassic vegetation of Amarjola and are represented by fronds, stems and fructifications. All these fossils are found in well preserved petrified state and thus, besides the anatomy, their epidermal structures have also been studied. Fronds are of different shapes and sizes ranging from simple to pinnate types. Similarly, stems are also of different kinds varying in diameter from 0·3 cm to 6·0 cm. On the outer surface of some of these, markings of fallen leaf bases are well preserved, while others are simply decorticated pieces of wood. Fructifications are found comparatively less common than the fronds. In some of these ovules and seeds are found well preserved.

Pteridospermopsida. Only a few vegetative fronds and stems representing this class have been described so far from Amarjola. Leaves are small, pinnate or bipinnate with pinnae of different shapes and sizes. These are described as *Thinnfeldia amarjolense* Sharma et al. (1971, in press) (Fig. 6), *Thinnfeldia* cf. *T. lancifolia*, *Thinnfeldia* cf. *T. feistmanteli*, etc. Anatomy and epidermal structures of these fronds are still to be studied.

The stem genus *Guptioxylon* Sharma (Sharma 1969a), which was collected from Amarjola by the present author, has provisionally been placed in this class (*Pteridospermopsida*), because it shows similarities with *Medulloseae* on the one hand and the *Pentoxyleae* on the other hand. May be that *Guptioxylon amarjolense* Sharma (Sharma 1969a) proves a link between these two groups of plants.

Cycadopsida. This class is represented by only two petrified woods i.e. *Sewardioxylon sahnii* Gupta (1960, 1971) and *Fascisvarioxylon mehtae* Jain (1963). Both these woods are peculiar in their anatomy and they provide further support to the ideas of Worsdell (1906) who derived the monostelic vascular organization of cycadaceous plants from the *Medulloseae*.

Pentoxylopsida. Sahni (1948) described a new group of fossil gymnospermous plants as the *Pentoxyleae* from the fossiliferous locality of Nipania in the Rajmahal Hills. The present author reported the occurrence of these plants also in the locality of Amarjola and described the

anatomy of the stems and the epidermal structures of the leaves of the *Pentoxyleae* (Sharma 1969). Fructifications of these plants are yet to be discovered from this locality.

Bennettitopsida. Plants of this class occur much more commonly than the other gymnospermous plants. They are represented by fronds, stems, and fructifications. Fronds are either simple e.g. *Anomozamites* (Fig. 4) or pinnate e.g. *Ptilophyllum* (Fig. 3). They vary in size from 5 × 0·3 cm to 40 × 5 cm, and are provided with syndetocheilic stomata. *Anomozamites* is represented by a single species e.g. *A. amarjolense* Sharma et al. (1971, in press). Whereas, the occurrence of *Ptilophyllum* is much more common and as many as five species have been described so far from this locality. These are: *Ptilophyllum amarjolense* Bose (1953), *P. guptai* Sharma (1967a), *P. sparsifolia* Sharma (1967a), *P. cutchense* Morr. (Sharma 1967a), and *P. sahnii* Gupta and Sharma (1968).

Bennettitalean stems are also found quite common in the Jurassic rocks of Amarjola. They are either simple (Fig. 5) or branched (Fig. 2). But in both the types, the outer surface is provided with rhomboid and spirally arranged bases of the fallen leaves. Bose (1953) included both branched as well as simple types of stems into his new species *Bucklandia sahnii Bose*. But the present author found that these two types of stems were anatomically different from each other (Sharma 1967). A dichotomously branched stem of *Bucklandia, B. dichotoma* Sharma (1970) has recently been described by the present author. The stem was preserved in a manner similar to *B. sahnii* from Amarjola; but the material of *B. dichotoma* was collected from a place about one kilometre away from the main exposure of Amarjola.

Bennettitalean fructifications are represented in Amarjola by the genus *Williamsonia* Carr. with five species e.g.: *Williamsonia guptai* Sharma (1968), *W. amarjolense* Sharma (1968), *W. harrisiana* Bose (1968), *W.* cf. *W. scotica* Sharma (1970a), *W. sewardiana* Sahni (Sharma 1971a).

All these are unisexual, seed bearing and closed types of flowers. Fertile parts are produced on a conical receptacle which is surrounded by the spirally arranged bracts (Fig. 7). Seeds are produced terminally on the seminiferous scales and are intermingled with the sterile interseminal scales. Probably, the surrounding bracts were shed off as the fructification approached maturity that is why in all the fully developed williamsonias collected so far from Amarjola, the bracts are absent. Similarly, on maturation of the fructification the layer of fertile and sterile scales was also thrown away from the receptacle.

Coniferopsida. Fossil conifers are found in Amarjola mostly in the form of decorticated woods ranging in diameter from 0·3—7·0 cm. Wherever cortex is preserved, it is narrow, parenchymateous and provided with resin canals. Stems are either simple or branched. Tracheids are provided with bordered pits on their radial walls while the tangential

walls are smooth. Coniferous woods which have been described so far from Amarjola are belonging to the families *Podocarpaceae, Araucariaceae, Cupressaceae* and *Taxaceae* (Bhardwaja 1952, 1953, Kräusel and Jain 1964, Sah 1957, Sah and Jain 1964). Leaves are still to be discovered. Fructifications are also rare in occurrence, so much so, that only a single species, *Brachyphyllum spiroxylum* Bose (1952) has been described so far from this locality (Bose and Hsu 1953).

DISCUSSION

From the description given above it is clear that the Jurassic vegetation of Amarjola was composed mainly of the herbs and shrubs, while the trees were rare in occurrence. Majority of these plants produced large sized pinnate leaves. Trunks of the plants were covered with armours of spirally arranged leaf bases. Fructifications were of highly specialized types and they were born either terminally or on the lateral sides of the stems.

Occurrence of fresh-water molluscs with plant remains in Amarjola suggests that the conditions were moist and humid during the Jurassic period and the rocks of this area are fresh-water deposits.

The fossil flora of Amarjola is interesting not only because the plant remains are found in petrified state and preserve all the anatomical details, but also many of them might prove helpful in tracing the phylogeny of a number of groups of plants. For example the discovery of the stem genus *Guptioxylon* Sharma from Amarjola has further strengthened the view that the stem anatomy of members of *Pentoxyleae* has much in common with the medullosean stem structure and perhaps some affinity may exist between these two groups of plants (Stewart and Delevoryas 1956). Similarly, the anatomical studies of the stems of *Sewardioxylon sahnii* Gupta and *Fascisvarioxylon mehtae* Jain have added support to the Worsdell's idea (1906) of deriving the monostelic condition of *Cycadaceae* from the polystelic medullosean plants.

Bennettitalean plants are found in the Mesozoic rocks throughout the world, but their anatomical structures were almost unknown till the discovery of these plants from the fossiliferous locality of Amarjola. Epidermal structures as well as the anatomy of different parts of the plant i.e. fronds, stems and fructifications are known in quite detail (Bose 1953, Gupta and Sharma 1968, Sharma 1967, 1967a, 1968, 1970, 1970a, 1970b, 1970c).

REFERENCES

Bhardwaja D. C. 1952. On a new species of *Taxaceoxylon* Unger from the Jurassic of Rajmahal Hills. Lloydia 15: 234—240.

— 1953. Jurassic woods from the Rajmahal Hills, Bihar. Palaeobotanist 2: 59—70.

Bose M. N. 1952. *Brachyphyllum spiroxylum* sp. nov. from the Rajmahal Hills, India, J. Indian Bot. Soc. 31: 287—296.

— 1953. *Bucklandia saphnii* sp. nov. from the Rajmahal Hills. Paleobotanist 2: 41—50.

— 1968. A new species of *Williamsonia* from the Rajmahal Hills. Bot. J. Linn. Soc. London. 61 (384): 121—127.

Bose M. N., Hsu J. 1953. On some coniferous cones, probably of *Brachyphyllum*, from the Jurassic of Rajmahal Hills, Bihar, India. Proc. Nat. Inst. Sci. India 19, 2: 203—209.

Gupta K. M. 1960. On the anatomy of a new cycadean type of stem *Sewardioxylon sahnii* Gen. et sp. nov. from the Jurassic of Rajmahal Hills. Proc. Indian Sci. Cong. 47, P. 428.

— 1970. On a new species of *Osmundites rajmahalensis* sp. nov. from the Rajmahal Hills, Bihar. Palaeontographica Abt. B. 130, 3—6: 173—180.

— 1971. On the structure and affinities of *Sewardioxylon sahnii* gen. et sp. nov. Gupta, a petrified cycadean wood from the Rajmahal Hills, Bihar. Palaeontographica Abt. B 131, 5—6: 160—166.

Gupta K. M., Sharma B. D. 1968. On a new species of *Ptilophyllum, P. sahnii* from Amarjola in Amarapara region. Jour. Palaeontological Soc. India 11: 1—7.

Jain K. P. 1963. *Fascisvarioxylon mehtae* gen. et sp. nov. A new petrified cycadean wood from the Rajmahal Hills, Bihar. Palaeobotanist 11, 3: 138—143.

Kräusel R., Jain K. P. 1964. New fossil coniferous woods from the Rajmahal Hills, Bihar. Palaeobotanist 12, 1: 59—67.

Sah S. C. D. 1957. *Coniferocaulon latisulcatum* sp. nov. from the Rajmahal Hills, Bihar with remarks on the affinities of the genus. Palaeobotanist 6, 2: 71—76.

Sah S. C. D., Jain K. P. 1964. Some fossil woods from the Jurassic woods from the Rajmahal Hills, Bihar. Palaeobotanist 12, 2: 169—180.

Sahni B. 1948. The *Pentoxyleae* — a new group of Jurassic gymnosperms from the Rajmahal Hills, India. Bot. Gaz. 110: 47—80.

Sharma B. D. 1967. On a new species of Indian *Bucklandia, B. guptai* with remarks on *B. sahnii* of Bose. Ameghiniana 4, 2: 35—46.

— 1967a. A review of the genus *Ptilophyllum* of Morris with description of two new species rom Amarjola in the Rajmahal Hills. Paleontographica Abt. B. 120, 5—6: 139—150.

— 1968. Epidermal studies in the bracts of two new species of *Williamsonia, W. guptai and W. amarjolense.* Acta Bot. Hung. 14: 373—383.

— 1969. On *Pentoxyleae* remains from Amarjola in the Rajmahal Hills, India. Ameghiniana 6, 1: 50—56.

— 1969a. *Guptioxylon amarjolense* gen. et sp. nov. from Amarjola in the Rajmahal Hills, India Palaentographica Abt. B. 126, 4—6: 145—156.

— 1970. *Bucklandia dichotoma* sp. nov. from the Middle Jurassic rocks of the Rajmahal Hills, India. Ameghiniana 6,4: 303—308.

— 1970a. On the structure of a *Williamsonia* cf. *W. scotica* from the Middle Jurassic rocks of Rajmahal Hills, India. Ann. Bot. 34, 135: 289—296.

— 1970b. On the vascular organization of the receptacles of seed bearing williamsonias from the Middle Jurassic rocks of Amarjola in the Rajmahal Hills, India. Ann. Bot. 34, 138: 1063—1070.

— 1970c. On the structure of the seeds of *Williamsonia* collected from Amarjola in the Rajmahal Hills, India. Ann. Bot. 34, 138: 1071—1077.

— 1971. On the anatomy and isolated petioles of ferns from Amarjola, Rajmahal Hills, India. Bot. J. Linn. Soc. London 64, 2: 149—158.

— 1971a. On a collection of bennettitalean stems and fructifications from Amarjola in the Rajmahal Hills, India. Palaeontographica Abt. B. 133, 1—3: 48—52.

Sharma B. D., Surana A. C., Singh A. P. 1971 (in press). On some Jurassic plants from the Rajmahal Hills, India. Jour. Palaeontological Soc. India.
Stewart W. N., Delevoryas T. 1956. On medullosean pteridosperms. Bot. Rev. 22, 1: 45—80.
Worsdell W. C. 1906. The structure and origin of *Cycadaceae*. Ann. Bot. (Old Ser.) 20: 129.

STRESZCZENIE

ROŚLINNOŚĆ JURAJSKA Z AMARJOLA, RAJMAHAL HILLS, INDIE

Rośliny z Amarjola zachowane w stanie skamieniałym należą w znacznej większości do różnych grup nagonasiennych. Przeważają rośliny zielne i krzewy, z rzadko występującymi drzewami (drewna *Coniferae*). Większość z nich posiadała wielkie, pierzaste liście, pnie były pokryte pancerzem z nasad liści, a owocowania były umieszczone na szczycie pnia lub wyrastały z boku.

Omawiane rośliny są interesujące z punktu widzenia filogenii, badania anatomiczne pni zdają się potwierdzać pogląd, że *Pentoxyleae* miały wiele wspólnego z budową pni *Medulloseae*.

Plate

Tablica

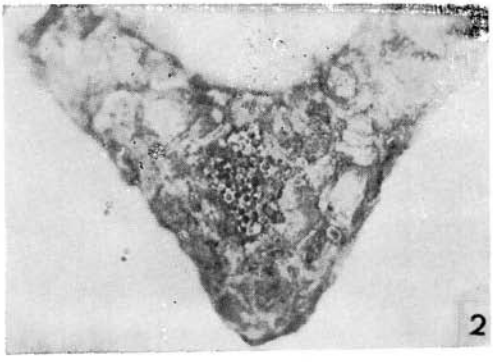
Plate I

1. *Nipaniophyllum raoi* Sahni. A frond of the *Pentoxyleae*, × 1
2. *Bucklandia dichotoma* Sharma. A dichotomously divided bennettitalean stem, × 3/4
3. *Ptilophyllum guptai* Sharma. A bennettitalean frond. × 3/4
4. *Anomozamites amarjolense Sharma et al.* A bennettitalean frond of simple type, × 1
5. *Bucklandia sahnii* Bose. A simple type of bennettitalean stem, × 3/4
6. *Thinnfeldia amarjolense* Sharma et al. A pteridospermous frond, × 1/2
7. *Williamsonia guptai* Sharma. A seed bearing bennettitalean fructification, × 3/4

Tablica I

1. *Nipaniophyllum raoi* Sahni. Liść z grupy *Pentoxyleae*, × 1
2. *Bucklandia dichotoma* Sharma. Dichotomicznie rozdzielony pęd bennetyta, × 3/4
3. *Ptilophyllum guptai* Sharma. Liść bennetyta, × 3/4
4. *Anomozamites amarjolense* Sharma et al. Liść bennetyta prostego typu, × 1
5. *Bucklandia sahnii* Bose. Prosty typ pędu bennetyta, × 3/4
6. *Thinnfeldia amarjolense* Sharma et al. Liść z grupy *Pteridospermae*, × 1/2
7. *Williamsonia guptai* Sharma. Owocowanie bennetyta zawierające nasiona, × 3/4


1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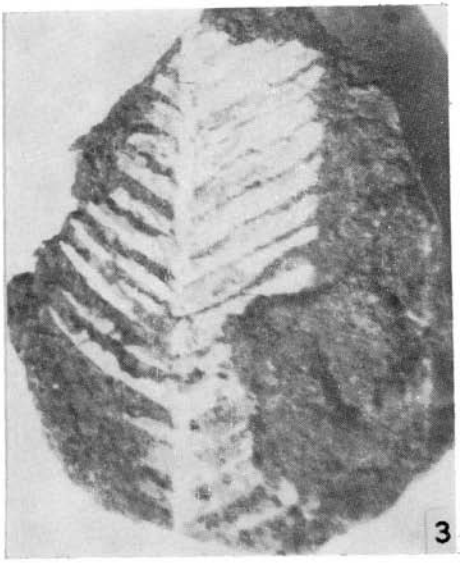
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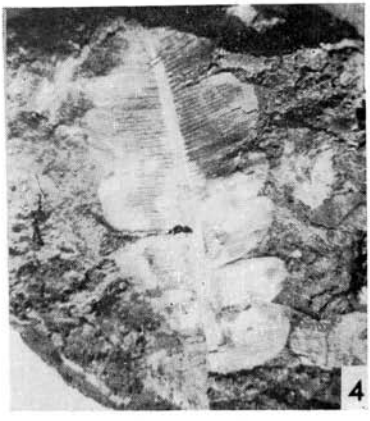
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