Acta Palaeobot. 35 (2): 189–193, 1995

NATURE AND PRESERVATION OF *VERTEBRARIA* AXES IN THE LOWER GONDWANA BEDS OF INDIA

A. K. SRIVASTAVA

Birbal Sahni Institute of Palaeobotany, 53, University Road, Lucknow – 226007, India

ABSTRACT. Number of *Vertebraria* axes recovered from the Lower Gondwana beds of Auranga Coalfield, India show vertical preservation across the bedding plane alongwith the horizontally lying axes. The available evidences and the review of earlier records of *Vertebraria* axes in different coal fields of India demonstrate the posibility of *in situ* deposition of plant material and autochthonous nature of Indian Gondwana coal in some of the coalfields.

KEY WORDS: *Vertebraria*, preservation, palaeoecology, India

INTRODUCTION

Vertebraria was instituted by Royle (1833) for branched and unbranched leafless axes having two or more longitudinal series of rectangular areas. The presence of *Vertebraria* is closely associated with the Glossopteris flora in Southern Hemisphere. In India, they are known right from the Talchir up to the Panchet formations and in the sense associated with the development and decline of Glossopteris flora (Surange 1975).

The affinity and relationship of *Vertebraria* with *Glossopteris* are discussed by many workers. The supposedly attached leaves of *Glosopteris* with *Vertebraria* – like axes were earlier interpretated as stem, rhizome or root of *Glossopteris* (Zeiller 1896, Oldham 1897, Seward 1910, Walton & Wilson 1932, Pant & Singh 1968, 1974, Pant 1977). However, on the basis of petrified material from Antarctica Schopf (1965, 1971, 1982) and more recently Neish et al (1993) have confirmed the root nature of *Vertebraria*.

Axes of *Vertebraria* are generally found in disperse condition along with the elements of *Glossopteris* flora. In certain areas it is strikingly abundant where other elements of the flora are entirely absent (personal observations in many coalfields of India).

Ever since the discovery of *Vertebraria* by Royle in 1833 from the Gondwana deposits of India, the specimens are known to be preserved in vertical as well as in horizontal position. Royle in 1833 instituted two species *V. indica* (Royle 1833, Pl. 2, figs 1–3) for horizontal axis and *V. radiata* (Royle 1833, Pl. 2, figs 5–7) for vertical axis exposed in sectional view. The same treatment was adopted by Mc Coy (1847) and Dana (1849) for Australian fossils and by Feistmantel (1879, 1880, 1882, 1886) for Indian specimens. However, Arber (1905) objectively proved that both the species instituted by Royle (1833) represent one and the same form but in different state of preservation. Feistmentel (1879, 1881, 1886), Oldham (1897) and Pant & Singh (1968) have also described sectional view of *Vertebraria* axes from different coalfields of India. Banerjee et al. (1991) have recently recorded upright *Vertebraria* root with spreading branches from Saharjuri Coalfield of Deogarh Basin. Horizontally axes are more common showing the lateral view compared to the records of vertical preservation.

MATERIAL AND METHOD

The specimens for the present study were collected from different localities of the Auranga Coalfield, Bihar, India, Barakar shale beds underlying the coal

seams of sikni open east project situated about 12 km. away from the main town Latehar on Daltonganj-Chandwa Road yielded the coalified compression of axes whereas samples from Barakar Formation, exposed in the Sukri River, about 2 km. north of Sasang Village in northern part of Auranga Coalfield (see Map XIII of Raja Rao, 1987) represent cast of the axes with iron impregnated mineral as they are rusty brown in colour.

Apart from *Vertebraria* axes, samples also contain the species of *Glossopteris, Neomariopteris, Sphenophyllum* and *Samaropsis* – type of seeds. Detail investigation of the flora is under progress.

The present study is based on the morphological features and the mode of preservation of axes. Coalified compression material were tried for cuticular recovery but did not yield details.

All the type and figured specimens are preserved in the museum of Birbal Sahni Institute of Palaeobotany, Lucknow.

OBSERVATION

The collections include ten specimens of horizontal axes and nine upright specimens cutting across the bedding plane. Sometimes single rock piece contains 2–3 horizontal and vertical axes. Three horizontally lying axes have found to be embedded in the rock across the plane.

Lateral view of horizontally compressed axes is available over the surface of rock, their maximum length and width are 11 cm and 2.7 cm respectively. The surface of the axes is marked by 2 series of rectangular areas demarcated by a single intervening longitudinal furrow or ridge. Branching axes are not present in the collection, however, thinner branches (less than 1 mm thick) are found to be attached with the sides of axes. Such branches show central longitudinal ridge or grove but their rectangular areas are not descernible.

Rock surface often contains sectional view (0.8 to 2 cm in diameter) of the axes having five to eight radiating spokes seperated by wedge shaped space (Pl. 1, figs 2, 6, Fig. 1. A,B). These spaces are filled with thin layer of carbon (in case of coalified compression) and by rock matrix (in cast). Careful splitting of rock samples containing sectional view over the surface of rock exposes the presence of vertically embedded axes in straight or slightly slanting postion across the bedding plane of rock. such axes are preserved intact from one exposed susrface to other end (Pl. 1, figs 3, 4, 6, 8, Fig. 1 C,D). The vertically preserved axes

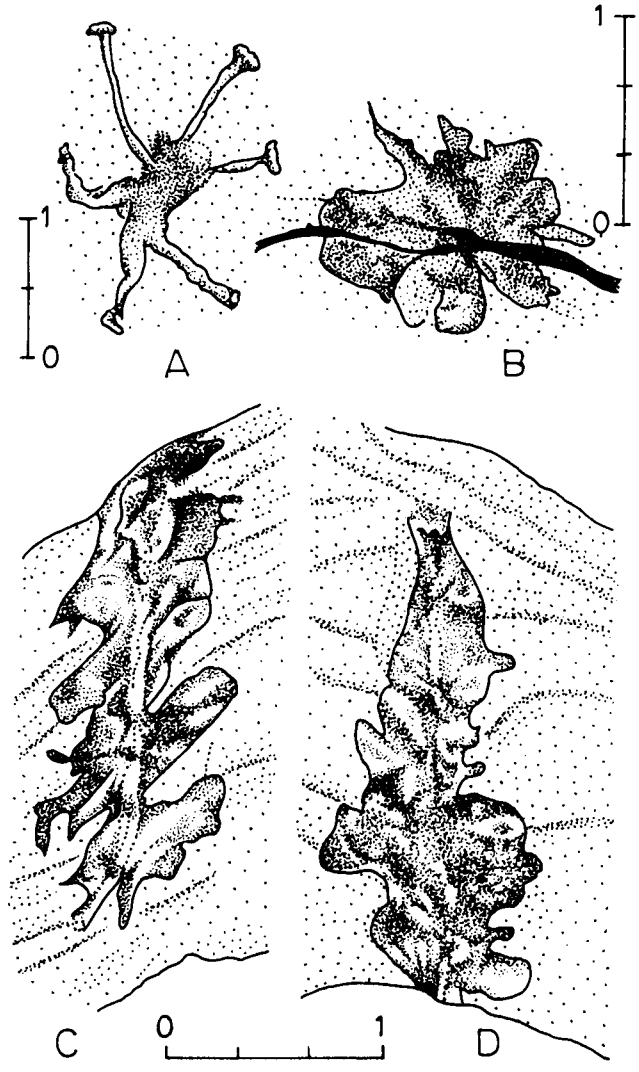


Fig. 1. A,B – Sectional view of *Vertebraria* axes over the surface of rock (Pl. 1, figs 2, 6.); C,D – Part and coundterpart of vertically preserved *Vertebraria* axis recovered after splitting the rock (Pl. 1, figs 6, 7, 8)

are 1 to 6 cm long and 0.5 to 2.0 cm wide and their width is uniform throughout the preserved length in each specimen. Three horizontally lying axes, measuring 8 to 11 cm long and 4–7 mm thick, are found to be embedded in rock across the bedding plane. Smaller branches having 2 to 5 cm long and less than 1 mm thick (resembling rootlets) are present in different directions at right angle to the plane of rock (Pl. 1, figs 3, 4).

The morphological features of all the axes whether lying horizontally on vertically are comparable with *Vertebraria* axes (Pant & Singh 1968, 1974).

PRESERVATION OF *VERTEBRARIA VIS* A *VIS* PALAEOECOLOGICAL SIGNIFICANCE

Unveiling of vertically preserved *Vertebraria* axes after splitting the specimens showing transverse section of axes over the surface of rock in Auranga Coalfield demonstrates that in all likelihood all specimens, hitherto, known in sectional view represent upright preservation of the axes. Horizontally compressed axes found embedded in the rock across the bedding plane in present collection strengthen such state of preservation and possibly indicate the preservation of lateral branch of main axis.

Common distribution of *Vertebraria* axes in horizontal position in most of the coalfields of India has influenced many workers (Fox 1931, Gee 1932, Datta et al. 1977) to believe transported nature of plant material and allochthonous origin of Indian Gondwana coal. However, Ahmad (1961) strongly favour the autochthonous theory on the basis of isopach analysis and the occurrence of *in situ* axes in different Gondwana basins. The records of well preserved, *Vertebraria* axes in Saharjuri, Daltonganj, Jharia, Wardha Valley coalfields (Niyogi 1966, Chaudhari 1985, Manjrekar et al. 1986, Chandra 1989) and presence of *in situ* upright *Glossopteris* plants with branched stems bearing *Glossopteris* leaves and spreading roots in Tulsidabar quarry of Deogarh Coalfield (Banerjee et al. 1991) supports the autochthonous nature of Indian Gondwana coal in some of the coalfields. Upright *Vertebraria* axes recorded from Auranga Coalfield also indcate similar depositional environment.

REFERENCES

ABHAD F. 1961. Paleogeography of the Gondwana period in Gondwana land, with special reference to India and Australia and its bearing on the theory of cpntinental drift. Mem. Geol. Surv. Ind., 90: 1–142.

ARBER E.A.N. 1905. Catalogue of the fossil plants of the Glossopteris flora in the Department of Geology, British Museum (Natural History) London 245.

BANERJEE M., BASU M., HALDAR A. & HAIAT A. 1991. *In Situ Glossopteris* plant with branched stems and spreading roots from Saharjuri Coalfield, India Lower Gondwana. Ind. Biol., 23: 1–7.

CHANDRA S. 1989. Rootlet bed in the floor of Gondwana Coal in India. Ind. Journ. Geol., 61: 30–40.

CHAUDHARY S. 1985. Root beds and palaeoenvironment in Daltonganj Coalfield – a preliminary study. Jour. Geol. Soc. India, 26: 345–349.

DANA J.D. 1849. Fossil plants, Appendix 1, in Unites States Exploring Expedition during the years 1838–1842 under the command of Charles Wilkes, U.S.N.C. Sherman Philadelphia 10 Geology: 714–720.

DATTA N.R., DE A.K. & CHAKRABORTI S.K. 1977. Environmental interpretation of Gondwana Coal Measures in Peninsular India. IV Int. Gond. Symp., Calcutta: 255–264.

FEISTMANTEL O. 1879. The fossil flora of the Lower Gondwana I. The flora of Talchir Karharbari beds. Mem. Geol. Surv. India Palaeont. Indica Ser,. 12: 1–48.

— 1880. The fossil flora of the Gondwana system 3 (Lower Gondwana) 2. The flora of the Damuda and Panchet division (Ist part). Mem. geol. Surv. India Palaeont. Indica Ser., 12: 1–77.

— 1881. Palaeontological notes from the Hazaribagh and Lohardagga districts. Rec. Geol. Surv. India, 14: 41–263.

— 1882. The fossil flora of the Gondwana system 4. 1. The fossil flora of the South Rewa Gondwana Basin. Mem. Geol. Surv. India Palaeont. Indica Ser., 12: 1–52.

— 1886. The fossil flora of the Gondwana system 4. 2. The fossil flora of some of the coalfields in western Bengal. Mem. Geol. Surv. India Palaeont. Indica Ser., 12: 1–71.

FOX C.S. 1931. Coal in India II. The Gondwana syste related formations. Mem. Geol. Surv. India, 58: 1–241.

GEE E.R. 1932. The geology and coal resources of the Ranjganj coalfield. Mem. Geol. Surv. India, 61: 1–343.

MANJREKAR V.D., BANDYOPADHYAY D.N. & GHOSH A. 1956. Environmental Interpretation from facies analysis and root bearing beds of Lower Gondwana Sediments from Meral-Sub basin of the Daltonganj Coalfield, Bihar. Geophytology, 16: 145–152.

Mc COY 1847. On the fossil Botany and zoology of the rocks associated with coals of Australia. Ann. Mag. Nat. Hist., 20.

NEISH P.G., DRINNAN A.G. & CANTRILL D.J. 1993. Structure and ontogeny of *Vertebraria* from silicified Permian sediments in East Antarctica Rev. Palaeobot. Palynol., 79: 221–224.

NIYOGI D. 1966. Lower Gondwana sedimentation in Saharjuri Coalfield, Bihar, India. Journ. Sed. Petrology, 36: 960–972.

OLDHAM R.D. 1897. On a plant of *Glossopteris* with part of the rhizome attached and on the structure of *Vertebraria*. Rec. Geol. Surv. India, 30: 45–50.

PANT D.D. 1956. On two compressed palaeozoic axes *Stigmaria ficoidesin* the Gymnostrobus condition and *Vertebraria indica*. Ann. Bot., 20: 421–249.

— 1977. The Plant of *Glossopteris*. J. Indian Bot. Soc., 56: 1–23.

PANT D.D. & SINGH R.S. 1968. The structure of *Vertebraria indica* Royle. Palaeontology, 11: 643–653.

— & — 1974. On the stem and attachment of Glossopteris and Gangamopteris leaves. Part II – structural features. Palaeontographica B, 147: 42–73.

RAJA RAO C.S. 1987. Coalfields of India. Vol, IV Part I Coal Resources of Bihar Bull. Geol. Surv. Ind. Ser., 4(45): 336.

ROYLE J.F. 1833–39. Illustrations of the botany and other branches of natural history of the Himalayan Mountains etc. London.

SCHOPF J.M. 1965. Anatomy of the axes in *Vertebraria*, Am. Geophys Union, Antarct, Res. Ser., 6: 217–228.

— 1975. Notes on plant tissue preservation and mineralization in a Permian deposit of peat from Antartica. Am. J. Sci., 271: 522–543.

— 1982. Forms and facies of *Vertebraria* in relation to Gondwana coal. Am. Geophys. Union. Antarct., Res. Ser., 36: 37–62.

SEWARD A.C. 1910. Fossil Plants II, Cambridge.

SURANGE K.R. 1975. Indian Lower Gondwana floras: a review. In: Campbell KSW (ed.) Gondwana Geology. Third. Gond. Symp. Canberra, 1973: 135–147.

WALTON J. & WILSON J.A.R. 1932. On the structure *Vertebraria*. Proc. R.S. Edin., 52: 200–207.

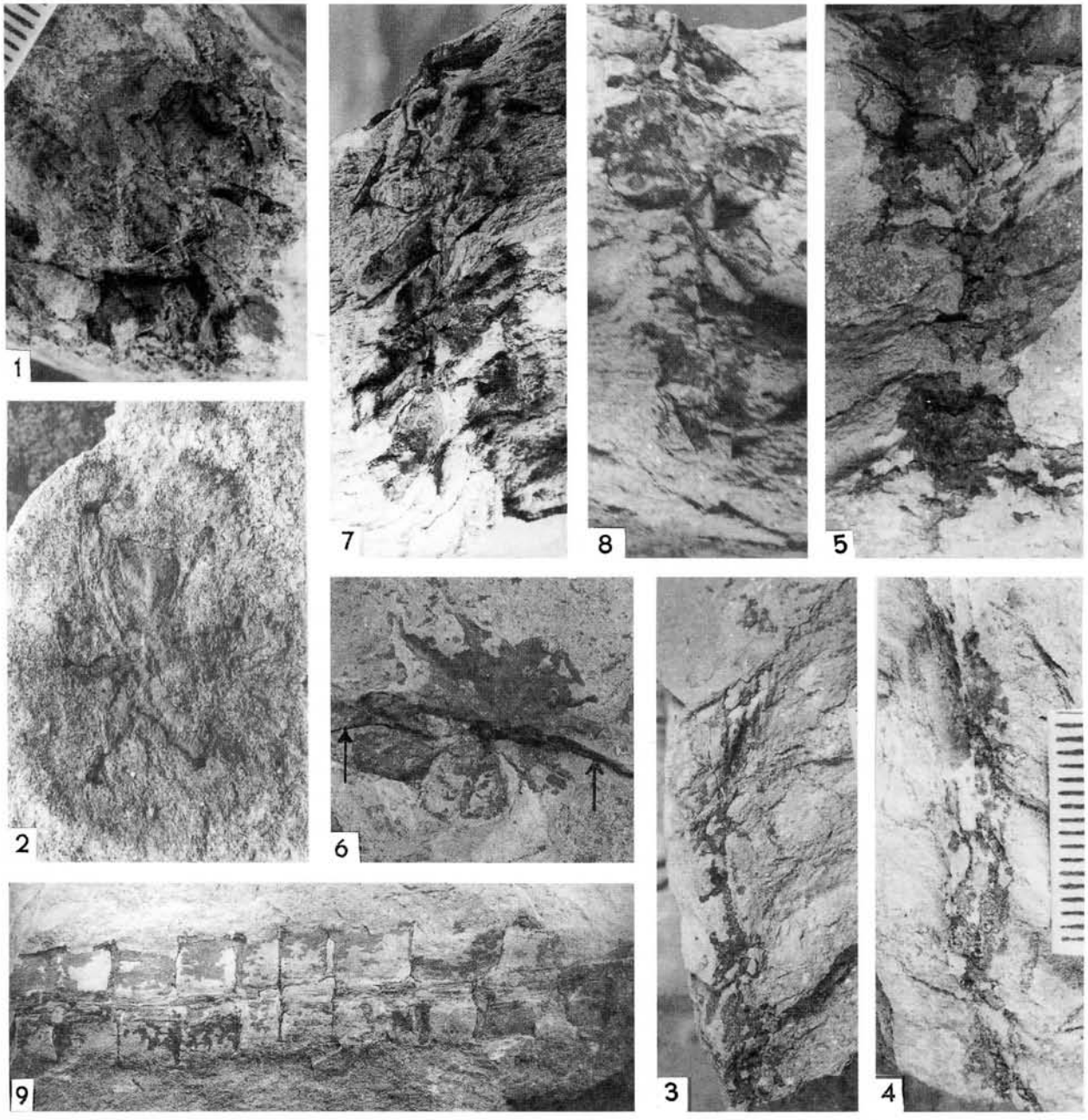
ZEILLER R. 1896. Etude sur quelque plantes Fossiles en particu lar *Vertebraria* et *Glossopteris* des environs de Johannesburg (Transvaal). Bull. Soc. Geol. France Ser., 3(4): 349–378.

PLATE

Plate 1

1. *Vertebraria* axis found embedded in rock, standing across the bedding plane. Locality: Sukri River section BSIP Museum No. 37116, × 2.5.
2. Sectional view of axes showing six radiating spokes over the rock surface. Locality: Sukri River Section BSIP Museum No. 37117, × 2.
3–4. Part and counterpart of vertically preserved *Vertebraria* axis in slightly slanting position showing thin lateral branches coming out from main axis. Locality: Sikni open cast project, BSIP Museum No. 37118, × 3.
5. Another specimen showing preservation across different layers of rock. Locality: Sikni open cast project, BSIP Museum No. 37119, × 2.
6. Coalified compression of *Vertebraria* axis in sectional view over the rock surface. Arrows indicate splitting zone which unravelled the vertical preservation of axis. Locality: Sikni open cast project, BSIP Museum No. 37120, × 2.
7–8. Art and counterpart of upright axis recovered after specimen shown in figure 6, axis preserved across the bedding plane. Locality: Sikni open cast project, BSIP Museum No. 37120, × 2.
9. Lateral view of horizontally compressed axes over the surface of rock marked by two series of rectangular areas. Locality: Sikni open cast project, BSIP Museum No. 37121, × natural size.

Plate 1



A. K. Srivastava
Acta Palaeobot. 35 (2)