

Fossil flora of Gollapalle Formation

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The plant megafossil assemblage of Gollapalle Formation, Andhra Pradesh is enriched and updated. The flora is chiefly constituted of *Cladophlebis*, *Sphenopteris*, *Marattiopsis*, *Pachypteris*, *Taeniopteris*, *Ptilophyllum*, *Dictyozamites*, *Pterophyllum*, *Williamsonia*, *Bucklandia*, *Elatocladus*, *Pagiophyllum*, *Brachyphyllum* and *Araucarites*. Conifers and cycadophytes are dominant; pteridophytes and pteridosperms are poorly represented. Early Cretaceous age is supported for the Gollapalle flora.

Key-words—Fossil flora, Gollapalle Formation, Krishna-Godavari Basin, Early Cretaceous (India).

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सारांश

गोलापल्ली शैल-समूह का अशिमत वनस्पतिजात

नीरू पांड्या एवं सुखदेव

आंध्र प्रदेश में गोलापल्ली शैल-समूह से प्राप्त गुरुपादपाश्म समुच्चय के वर्तमान स्वरूप की विवेचना की गई है। यह अशिमत पादप-वनस्पतिजात मुख्यतया क्लेडोफ्लेबिस, स्फीनोप्टेरिस, मेरेट्टिऑप्सिस, पैकिप्टेरिस, टीनोप्टेरिस, टाइलोफिल्लम, डिक्टियोजेमाइटिस, टेरोफिल्लम, विलियमसोनिया, ब्रुकलेन्डिया, इलेटोक्लेडस, पेजियोफिल्लम, ब्रेकिफिल्लम एवं अँराकेराइटिस नामक प्रजातियों से लक्षणित है। इसमें कोनिफरों एवं साइकेडोफाइटीयों की बाहुल्यता है तथा टेरोडोफाइटीयों एवं टेरोडोस्पर्मों की काफी कम संख्या है। इस गोलापल्ली अशिमत वनस्पतिजात की प्रारम्भिक क्रीटेशी आयु प्रस्तावित की गई है।

DESCRIPTION

Unclassified Ferns

Genus—*Cladophlebis* Brongniart 1849

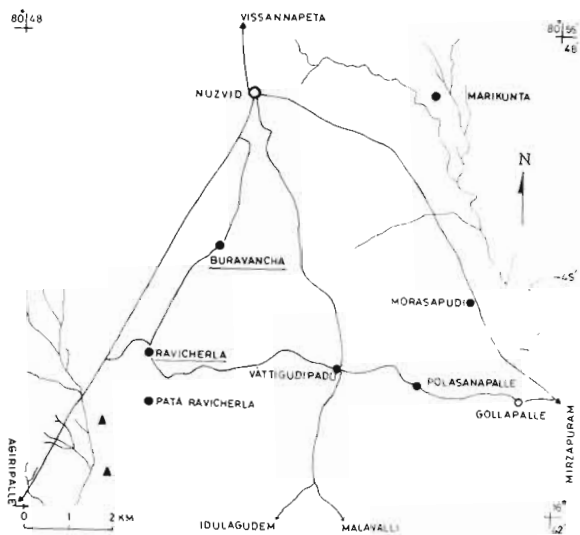
Cladophlebis sp. A

Pl. 1, figs 1, 2; Text-fig. 1A

THE Gollapalle Formation was named after the village Gollapalle (16°43' : 85°58") by King in 1880. It rests unconformably over the Chintalpudi sandstone (Permian) and underlies the Raghavapuram Formation. The Gollapalle sediments are exposed between the deltas of Godavari and Krishna rivers extending from Rajamundry to Eluru, consisting of conglomerate at the base, followed by medium to fine-grained, orange to brown, ferruginous and micaceous sandstone, grit and conglomerates, soft claystones and at places limestones. King (1880) equated this formation with the Rajmahal Formation. Later, it was studied in detail by Sarma (1957, 1958, 1960) who also described plant fossils. Baksi (1964) added more information on plant fossils from two localities—Kannapuram and Gopalapuram.

Description—Pinnae fragmentary, 0.5-0.8 cm in length, 0.6-1.0 cm in width. Pinnules subopposite to alternate, measuring 5-7 mm in length and 3 mm in width at the broadest point, attached by entire broad base at an angle of 30°-70°, falcate, acroscopic basal margin joining basiscopic margin of upper pinnule; margin entire; apex acute or subacute; midrib persisting up to apex; lateral veins forked once.

Collection—Specimen nos. BSIP 36355 and 36356.



Map 1—Showing plant fossil localities in Krishna District, Andhra Pradesh.

Comparison—*Cladophlebis* sp. A is comparable to sterile pinnae of *Todites indicus* (Oldham & Morris) Bose & Sah 1968 in shape and size of pinnules but differs in venation pattern and pinnule margin. Lateral veins forked once are present in *C. kathiawarensis* Roy 1968 as in *Cladophlebis* sp. A. However, the former is distinguished by crenulate or dentate margin of pinnules.

GYMNOSPERMS

Pteridospermales

Family—Corytospermaceae

Genus—Pachypteris Brongniart 1828

Pachypteris indica (Oldham & Morris) Bose & Roy 1968

Pl. 1, fig. 3; Text-fig. 1C

Remarks—*Pachypteris indica* has been reported for the first time from the Gollapalle Formation.

Cycadales

Genus—Taeniopteris Brongniart 1832

Taeniopteris spatulata McClelland 1850
Pl. 1, fig. 4; Text-fig. 1B

Bennettitales

Family—Williamsoniaceae

Genus—Ptilophyllum Morris 1840

Ptilophyllum acutifolium Morris 1840
Pl. 1, figs 7, 8

Ptilophyllum cutchense Morris 1840
Pl. 1, figs 5, 6; Pl. 2, fig. 1

Genus—Williamsonia Carruthers 1870

Williamsonia blandfordii Feistmantel 1876
Pl. 1, fig. 10

Remarks—The female flower of *Williamsonia blandfordii* is comparatively larger in size having 20 bracts and showing faintly marked longitudinal striations. This species has been reported for the first time from the Gollapalle Formation. So far, *W. blandfordii* has been reported from Kera and Kakadbbhit localities of Kutch and Jandameta, Krishna-Godavari Basin (Raghavapuram Formation).

Williamsonia kakadbbhitensis

Bose & Banerji 1984

Pl. 1, fig. 9; Pl. 2, fig. 2

1877 *Williamsonia* comp. *gigas* carr. : Feistmantel, p. 181, pl. 7, figs 1-4.

Description (Based on description and photographs given by Feistmantel 1877 and present specimens)—Flowers broadly rounded to oval, mostly onion shaped, measuring more than 9.0 cm in length and 7.3 cm in width. Bracts 18-24, arranged around receptacle, 1.9-13.4 cm in length and 0.5-1.0 cm in width, narrow at base, gradually broadening

PLATE 1

1. *Cladophlebis* sp., specimen no. BSIP 36355, × 1.
2. *Cladophlebis* sp., specimen no. BSIP 36356, × 2.
3. *Pachypteris indica* (Oldham & Morris) Bose & Roy. specimen no. BSIP 36357, × 1
4. *Taeniopteris spatulata* McClelland, specimen no. BSIP 36358, × 1.
5. *Ptilophyllum cutchense* Morris, specimen no. BSIP 36382, × 1.
6. *P. cutchense*, specimen no. BSIP 36359, × 1
7. *P. cutchense* specimen no. BSIP 36360, × 1.
8. *Ptilophyllum acutifolium* Morris, specimen no. BSIP 36361, × 1.
9. *Williamsonia kakadbbhitensis* Bose & Banerji, specimen no. BSIP 36364, × 1.
10. *Williamsonia blandfordii* Feistmantel, specimen no. BSIP 36362, × 1.
11. A microsporophyll, specimen no. BSIP 36365, × 1.
12. *Bucklandia* sp., specimen no. BSIP 36366, × 1.
13. *Elatocladus confertus* (Oldham & Morris) Halle, specimen no. BSIP 36367, × 1.
14. *Pagiophyllum* sp. cf. *P. grantii* Bose & Banerji, specimen no. BSIP 36375, × 1.
15. *Pagiophyllum gollapallensis* sp. nov., specimen no. BSIP 36372, × 1.
16. *Brachyphyllum* sp., specimen no. BSIP 36378, × 1.

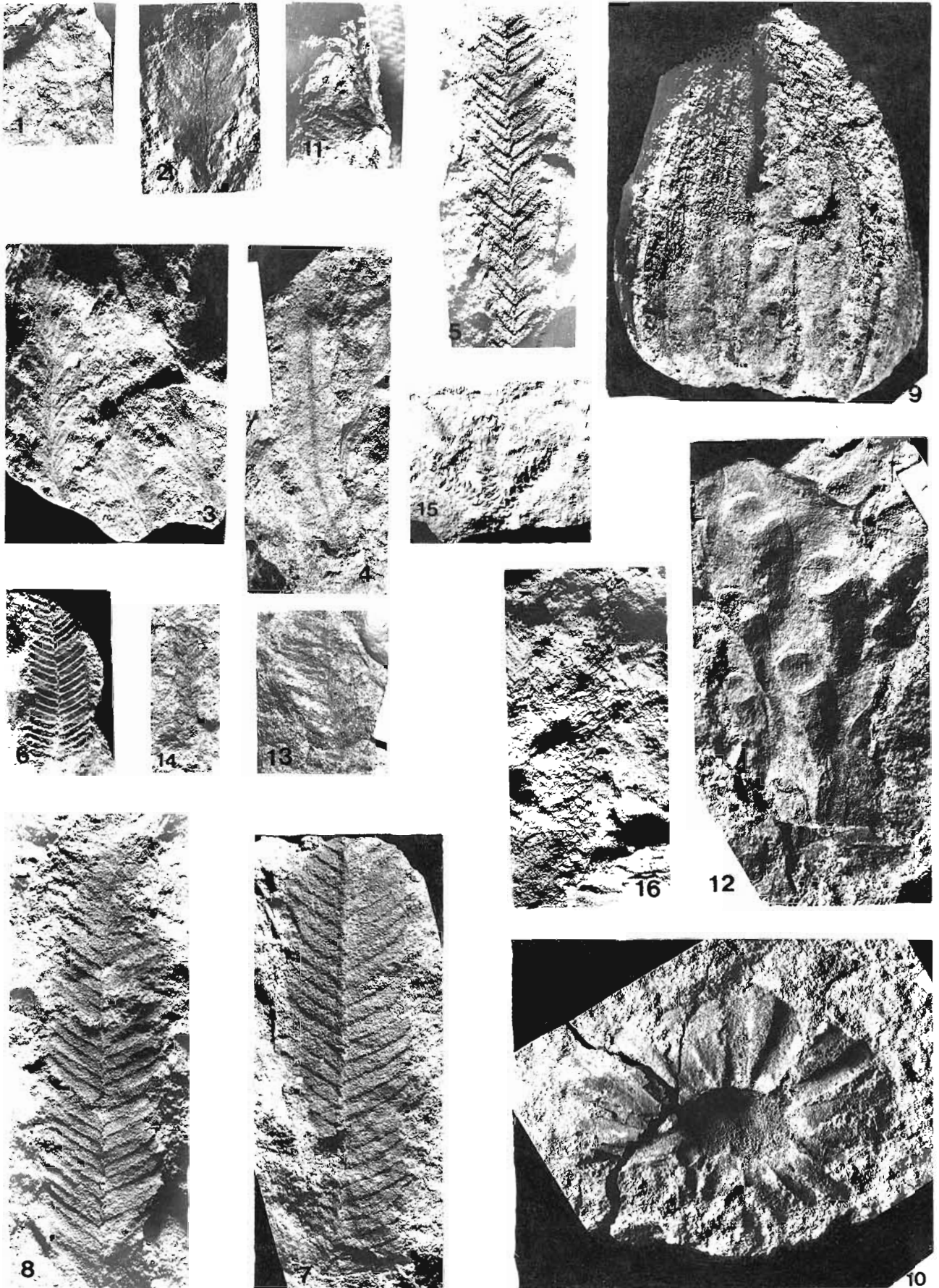
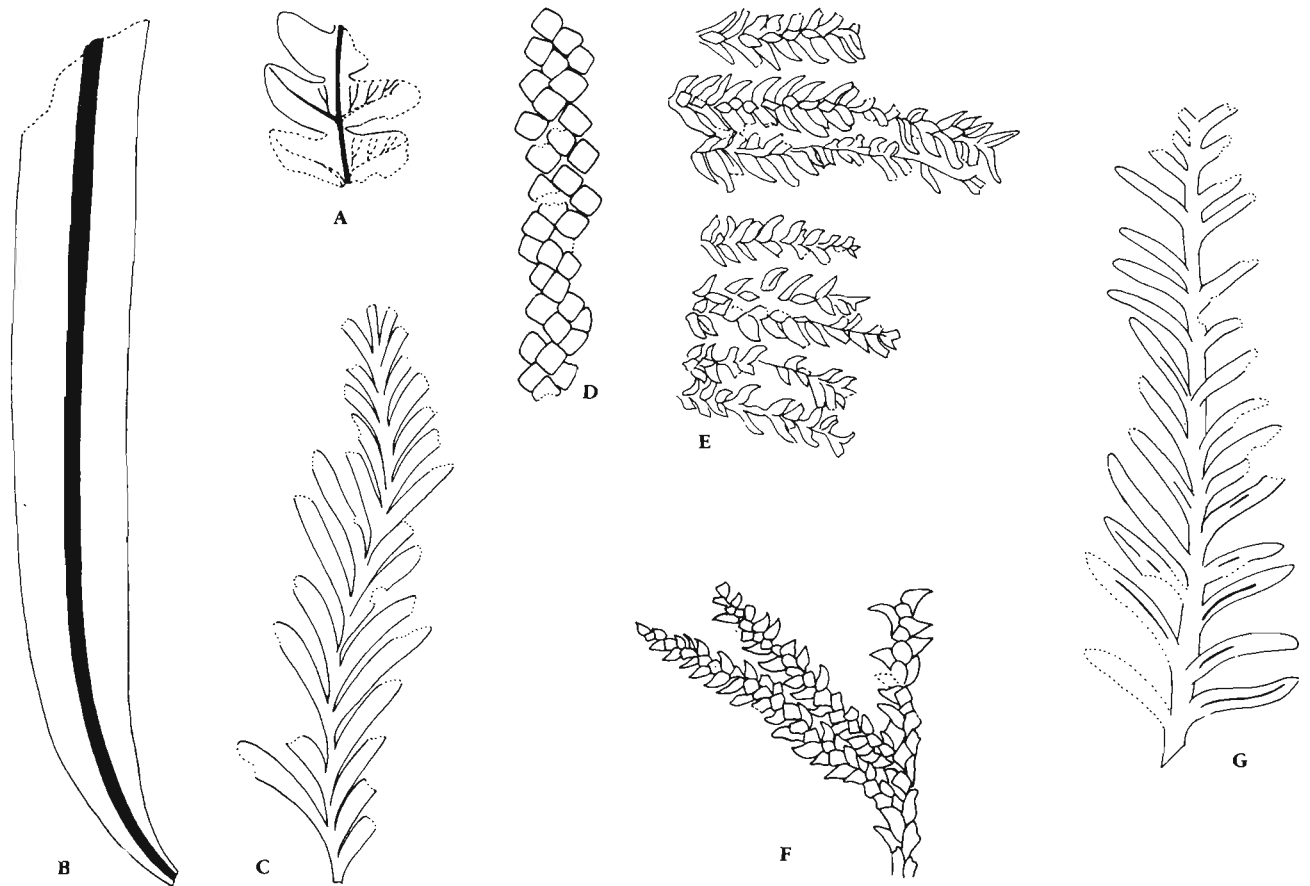


PLATE 1



Text-figure 1—**A.** *Cladoplebis* sp., specimen no. BSIP 36355, $\times 2$; **B.** *Taeniopteris spatulata* McClelland, specimen no. BSIP 36358, $\times 1$; **C.** *Pachypteris indica* (Oldham & Morris) Bose & Roy, specimen no. BSIP 36357, $\times 2$; **D.** *Brachyphyllum* sp., specimen no. BSIP 36378, $\times 2$; **E.** *Pagiophyllum* sp. cf. *P. grantii* Bose & Banerji, specimen no. BSIP 36373, $\times 1$; **F.** *Pagiophyllum gollapallensis* sp. nov., Holotype, specimen no. BSIP 36371, $\times 2$; **G.** *Elatocladus confertus* (Oldham & Morris) Halle, specimen no. BSIP 36370, $\times 2$.

higher up and then again narrowing towards apex, compactly or rather loosely arranged. Longitudinal striations and hair present on the surface of bracts.

Collection—Specimen nos. BSIP 36363, 36364, 126/2711 and 161/2711.

Remarks—This is the first report of *Williamsonia kakadbbitensis* from the Gollapalle Formation. The specimens from the Ravicherla area are comparatively bigger in size.

Microsporophyll
Pl. 1, fig. 11

Description—Fragmentary microsporophyll, 2×0.3 cm in size, distal portion having two rows of small ?fertile appendages, tubular in shape, 3-4 mm long and 1 mm broad.

Collection—Specimen no. BSIP 36365.

Remarks—Only a single fragmentary microsporophyll bearing fertile appendages

comparable to *Weltrichia santalensis* Sitholey & Bose 1971 is obtained; fragmentary nature of fossil precludes detailed comparison.

Genus—*Bucklandia* Presl 1825

Bucklandia sp. A
Pl. 1, fig. 12

Description—Fragmentary stems measuring 3.0-6.7 cm in length and 3.0-4.2 cm in width. Leaf-bases more or less rhomboidal, decurrent, measuring $1.2-2.2 \times 0.8-1.0$ cm, spirally and sparsely placed.

Collection—Specimen nos. BSIP 36366 and 1756/2711.

Comparison—*Bucklandia* sp. A apparently resembles some of the specimens of *Bucklandia sabnii* Bose (1953, pl. 1, fig. 4) and *Bucklandia* sp. (Sharma, 1974, pl. 1, fig. N) from Rajmahal Hills, Bihar. Anatomical details of the present specimens

are not known and hence no comparison is attempted.

Coniferales

Family—Podocarpaceae

Genus—*Elatocladus* Halle 1913

Elatocladus confertus (Oldham & Morris) Halle 1913

Pl. 1, fig. 13; Pl. 2, figs 3, 4; Text-fig. 1G

Remarks—Feistmantel (1877) described this species under the name *Palissya conferta*. The swept back nature of leaves confirms its identification as *E. confertus*. Halle (1913) described this species from Grahamland and Sahni (1928) and Bose and Banerji (1984) from India.

Family—Araucariaceae

Genus—*Pagiophyllum* Heer 1881

Pagiophyllum gollapallensis sp. nov.

Pl. 1, fig. 15; Pl. 2, figs 6, 7; Text-fig. 1F

1877 *Cheirolepis* comp. Münsteri: Feistmantel, p. 185, pl. 8, fig. 8.

1928 *Brachyphyllum expansum* (Sternberg): Sahni, p. 20, pl. 2, figs 28, 29.

Diagnosis—Leafy-twigs branched, maximum available length 8.5 cm and width 7.4 cm. Branches irregular but laterally appressed in one plane, 1.4-3.9 cm long and 0.3-0.4 cm wide, making an angle of 45°-75°. Leaves spirally borne, small, 1.3 × 1.2 mm, keeled, directed forward or laterally, slightly falcate, arising from a rhomboidal leaf-base cushion. Margin entire. Apex acute.

Holotype—Specimen no. BSIP 36371; Pl. 2, fig. 6.

Comparison—*Pagiophyllum gollapallensis* resembles *Pagiophyllum rotzoanum* (Massalongo) Wesley 1956 reported from Veneto, Italy, in morphological characters of leaves and their compact arrangement. However, the latter species is distinguished by lax branching system. Individual leaf-branch of *P. gollapallensis* is comparable to *P. chawadensis* Bose & Banerji 1984 and *P. sberensis* and *P. satpuraensis* (Maheshwari & Kumaran, 1976) in gross features but it differs from them in having compactly arranged larger leaves and the absence of 'Phytolemma'.

Pagiophyllum sp. cf. *P. grantii*

Bose & Banerji 1984

Pl. 1, fig. 14; Pl. 2, fig. 5; Text-fig. 1E

Description—leafy twigs, branched or unbranched, branching irregular, maximum

available length 5.4 cm and width 0.7 cm. Leaves spirally borne, closely arranged at an angle of 20°-60°, straight or falcate, directed forward or laterally, measuring 2.5 × 1-1.5 mm, arising from a rhomboidal leaf-base cushion. Margin entire. Apex acute.

Collection—Specimen nos. BSIP 36373, 36374, 36375, 53/2976 and 56/2976.

Comparison—*Pagiophyllum* sp. cf. *P. grantii* resembles *P. grantii* Bose & Banerji 1984 reported from Kutch in gross features but in the present specimens cuticular features are lacking.

Genus—*Brachyphyllum* Brongniart 1828

Brachyphyllum regularis Borkar & Chiplonkar 1973
Pl. 2, fig. 9

Remarks—A single leafy-twig of *Brachyphyllum regularis* Borkar & Chiplonkar 1973 known from Early Cretaceous of Songad, Kathiawar is identified here for the first time. This species has also been reported from Athgarh Formation.

Brachyphyllum sehoraensis Bose & Maheshwari 1973
Pl. 2, fig. 8

Remarks—The present specimen of *Brachyphyllum sehoraensis* is larger in size than that of Sehora. The phytolemma is not preserved in the present specimen. So far this species has been reported only from Sehora. Recently, Sukh-Dev and Rajanikanth (1988) have reported some isolated leaves from Gangapur Formation.

Brachyphyllum sp. A

Pl. 1, fig. 16; Pl. 2, fig. 10; Text-fig. 1D

Description—Leafy-twigs branched, branching at an angle of 60°, 4.5-6.2 cm in length and 0.4-0.5 cm in width. Leaves rhomboidal, closely appressed, 1.5-3.0 mm in length and width, arising from a rhomboidal leaf-base cushion. Margin entire. Apex subacute.

Collection—Specimen nos. BSIP 36378 and 23/2711.

Comparison—*Brachyphyllum* sp. A resembles *B. rhombicum* (Feistmantel) Sahni 1928 and *B. sehoraensis* Bose & Maheshwari 1973 in form and closely appressed nature of leaves. However, the former is comparable to *B. brevifolia* and *B. rhomboidales* Srivastava *et al.* 1984 in shape and size of leaves but differs in the absence of phytolemma.

Genus—*Araucarites* Presl 1838

Araucarites cutchensis Feistmantel
Pl. 2, fig. 11

DISCUSSION

The floral assemblage of Gollapalle Formation is dominated by conifers and cycadophytes followed by pteridophytes and pteridosperms. Pentoxyleae and Ginkgoales have not been recorded so far. The following species are reported for the first time from this formation: *Cladophlebis* sp., *Pachypteris indica*, *Ptilophyllum acutifolium*, *P. cutchense*, *Williamsonia blandfordii*, *W. kakadbbhitensis*, a microsporophyll, *Bucklandia* sp., *Elatocladus confertus*, *Pagiophyllum gollapallensis* sp. nov., *Pagiophyllum* sp. cf. *P. grantii*, *Brachyphyllum regularis*, *B. sehoraensis*, *Brachyphyllum* sp. and *Araucarites cutchensis*.

The Gollapalle floral assemblage is similar to that of Sehora of the Jabalpur Formation, Narsinghpur District, Madhya Pradesh, in common presence of *Pachypteris*, *Ptilophyllum*, *Elatocladus*, *Pagiophyllum*, *Brachyphyllum* and *Araucarites*. Further, in both *Weichselia* and *Cycadopteris* are lacking and there is also paucity of ferns. Palynologically the sediments of Sehora are dated as Late Jurassic/Early Cretaceous (Bharadwaj *et al.*, 1972; Singh, 1966). However, Sharma *et al.* (1977) and Venkatachala and Sinha (1986) have carried out palynological studies of the Gollapalle Formation from the subsurface samples which contain *Microcachrydites*, *Trilites*, *Sphaeropollenites*, *Leptolepidites*, *Podosporites*, *Klukisporites*, *Aequitriradites*, *Kraeuselisporites*, *Impardecispora* and *Crybelosporites* indicating an Early Cretaceous age. Recently, Singh and Venkatachala (1988) reassessed the Jurassic-Cretaceous palynofloras of India and suggested an Early Cretaceous age for the Sehora and Gollapalle sediments.

The Gangapur floral Assemblage-1 (represented by Butermal Nala flora) is closely comparable to Gollapalle flora in general composition (Sukh-Dev, 1988). In both, *Pachypteris*, *Taeniopteris*,

Table 1—Distribution of plant fossils in the Gollapalle Formation

Taxa/Area	Bura- vancha/ Ravi- cherla	Musa- nur	Kunna- puram	Gopala- puram
<i>Cladophlebis</i> sp.	+	+		
<i>Sphenopteris</i> sp.			+	
<i>Marattiopsis macrocarpa</i>	+			
<i>Pachypteris indica</i>	+			
<i>Taeniopteris ensis</i>	+			
<i>T. spatulata</i>	+			
<i>Ptilophyllum acutifolium</i>	+		+	+
<i>P. cutchense</i>	+			
<i>Dictyozamites</i>				
<i>feistmantelii</i>	+			
<i>Pterophyllum kingianum</i>	+			
<i>Williamsonia</i>				
<i>blandfordii</i>	+			
<i>W. kakadbbhitensis</i>	+			
Microsporophyll	+			
<i>Bucklandia</i> sp.	+			
<i>Elatocladus confertus</i>	+			
<i>Pagiophyllum</i>				
<i>gollapallensis</i> sp. nov.	+			
<i>Pagiophyllum</i> sp. cf.				
<i>P. grantii</i>	+			
<i>Brachyphyllum regularis</i>	+			
<i>B. sehoraensis</i>	+			
<i>Brachyphyllum</i> sp. A	+			
<i>Araucarites cutchensis</i>	+			
<i>A. macropterus</i>	+			

Ptilophyllum, *Dictyozamites*, *Elatocladus*, *Pagiophyllum*, *Brachyphyllum*, particularly *B. sehoraensis* and *Araucarites* are common (Sukh-Dev & Rajanikanth, 1988). However, the Gangapur Assemblage-2 is distinguished chiefly by the presence of *Equisetites*, *Gleichenia*, *Hausmannia*, *Cycadites*, *Anomozamites*, *Otozamites*, *Allocladus*, etc.

The Early Cretaceous flora of Assemblage Zone-8 of *Dictyozamites Pterophyllum-Anomozamites*

PLATE 2

1. *Ptilophyllum cutchense* Morris, specimen no. BSIP 36381, × 1.
2. *Williamsonia kakadbbhitensis* Bose & Banerji, specimen no. BSIP 36363, × 1.
3. *Elatocladus confertus* (Oldham & Morris) Halle, specimen no. BSIP 36370, × 1.
4. *E. confertus*, specimen no. BSIP 36368, × 1.
5. *Pagiophyllum* sp. cf. *P. grantii* Bose & Banerji, specimen no. BSIP 36373, × 1.
6. *Pagiophyllum gollapallensis* sp. nov., holotype, specimen no. BSIP 36371, × 1.
7. *P. gollapallensis*, specimen no. BSIP 36372, × 1.
8. *Brachyphyllum sehoraensis* Bose & Maheshwari, specimen no. BSIP 36377, × 1.
9. *Brachyphyllum regularis* Borkar & Chiplonkar, specimen no. BSIP 36376, × 1.
10. *Brachyphyllum* sp., specimen no. BSIP 36378, × 2.
11. *Araucarites cutchensis* Feistmantel, specimen no. BSIP 36380, × 1.

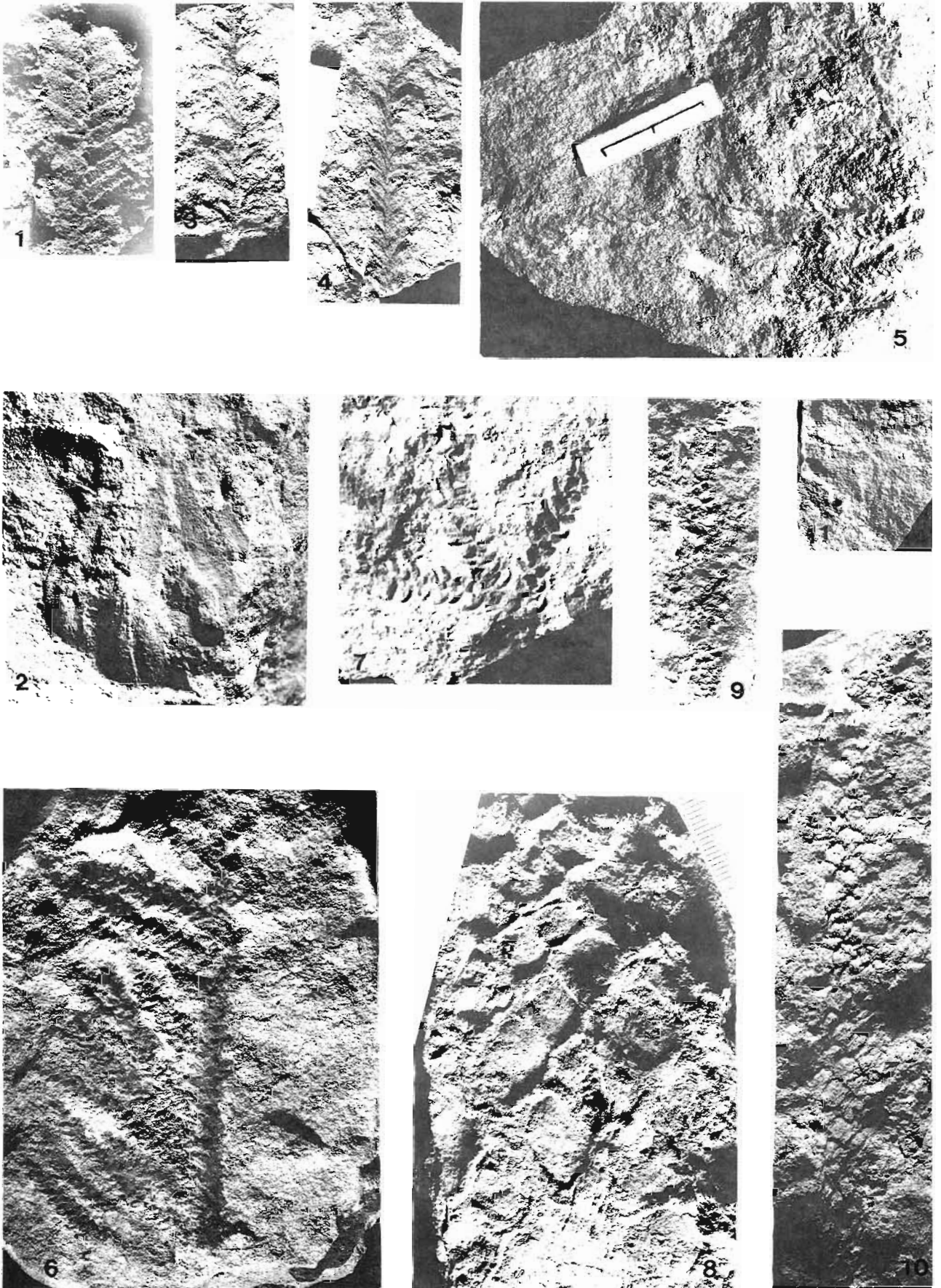


PLATE 2

(Sukh-Dev, 1988) is considered to be less diversified because of the preponderance of broad-leaved cycadophytes, viz., *Ptilophyllum*, *Pterophyllum*, *Dictyozamites*, *Anomozamites*, *Ctenis* and *Taeniopteris*. Besides pteridophytes, e.g., *Equisetites*, *Gleichenites* and *Hausmannia* are also present.

The Gollapalle flora is comparatively less varied than the Bansa flora of Jabalpur Formation, constituted by *Weichselia-Onychiopsis-Gleichenia*, Assemblage Zone-10 (Sukh-Dev, 1988), which is characterised by the richness of pteridophytes and conifers and reduction of cycadophytes and pteridosperms.

The faunal evidences from the Gollapalle Formation are meagre, only *Amobaculites*, *Ammodiscoides*, *Ammodiscus* and *Haplobragmoides* are known (Sastri *et al.*, 1973). Stratigraphically the Gollapalle Formation unconformably overlies the Chintalpudi sandstone (Permian) and unconformably underlies the Raghavapuram Formation which is dated Early Cretaceous (Barremian) on palaeontological evidences (Bhalla, 1969, 1972; Singh & Ghosh, 1977).

The flora of the Gollapalle Formation though representing Assemblage Zone no. 9 (Sukh-Dev, 1988) also shows close affinity with the flora of Gangapur Assemblage-1 (Butermal Nala) in having broad-leaved cycadophytes, like *Dictyozamites* and *Pterophyllum*. The Gollapalle flora is younger than the Chaugan floral assemblage (Zone no. 9) and older than the Bansa floral assemblage (Zone no. 10, Sukh-Dev, 1988).

In view of the present findings the Lower Cretaceous age of Gollapalle megafloora is supported.

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