

Leaf- impressions of *Calophyllum* L. from the Middle Siwalik sediments of Arunachal sub-Himalaya, India

Mahasin Ali Khan, Bimalendu De¹ and Subir Bera²

Department of Botany, University of Calcutta, 35, B.C. Road, Kolkata-700019, India

¹Ex-Deputy Director General, Geological Survey of India, Operation Arunachal, Itanagar, India

²Author for correspondence: e-mail: berasubir@yahoo.co.in

Abstract

Fossil leaf impressions, showing close resemblance with the modern leaves of *Calophyllum polyanthum* Wallich (Clusiaceae), have been recorded from the Middle Siwalik sediments (Subansiri Formation, Pliocene) exposed at road- cutting section of Bhalukpong area in West Kameng district, Arunachal Pradesh. The present day distribution of the modern equivalent of the fossils clearly indicates the prevalence of tropical evergreen forests in the area during the deposition of sediments.

Key words: Leaf impression, *Calophyllum polyanthum*, Middle Siwalik (Pliocene), Arunachal Pradesh

INTRODUCTION

The Siwalik sediments in Arunachal Pradesh are well exposed and are broadly divided into Lower (Dafla Formation, Middle to Upper Miocene), Middle (Subansiri Formation, Pliocene) and Upper (Kimin Formation, Upper Pliocene to Lower Pleistocene) sedimentary strata. The Middle Siwalik is well exposed along Bhalukpong-Tawang road. These sediments are characterized by weakly indurated sandstone, shale and siltstone with plant remains, most of which are leaf impressions. (Joshi & Chakraborty 2001; Table-1).

A number of fossil leaves belonging to angiosperm families Rhamnaceae, Dioscoreaceae, Myrtaceae, Anonaceae, Clusiaceae, Dipterocarpaceae, Poaceae, Arecaceae, Combretaceae, Apocynaceae and fern family Thelypteridaceae have already been reported from the Tertiary sediments of West & East Kameng, Siang and Tirap districts (Khan *et al.* 2008; Joshi & Mehrotra 2007; Khan *et al.* 2007; Das *et al.* 2007; Joshi & Mehrotra, 2003; Joshi *et al.* 2003; Singh & Prakash, 1980 and Mehrotra & Mandaokar 2000). Here we report impression of fossil leaves of modern *Calophyllum polyanthum* Wallich (Clusiaceae) from the Middle Siwalik (Pliocene) sediments of West Kameng District. Earlier, fossil *Calophyllum* leaf was recorded from the Lower Siwalik (Middle to Upper Miocene) sediments of West Kameng District, Arunachal Pradesh (Joshi & Mehrotra 2007).

MATERIALS AND METHODS

The morphological features of leaf impression fossils were studied with the help of hand lens and incident light microscope (Axioskop 40). These fossil leaves have been compared with the herbarium specimens at CAL, Howrah and also fresh modern leaves collected from the forest in the vicinity of the fossil locality. The terminologies adopted by Dilcher (1974) have been followed for description of leaf impressions. The fossil specimens are preserved in the repository of Palaeobotany-Palynology section, Department of Botany, University of Calcutta.

Table-1: Generalised lithotectonic sequence in Kameng district, Arunachal Pradesh (after Joshi & Chakraborty 2001)

NORTH GONDWANA		Carbonaceous shale, sandstone and coal
LOWER SIWALIK		Well indurated sandstone, shale and siltstone with plant fossils
	Main Boundary Thrust	
MIDDLE SIWALIK		Weakly indurated sandstone and shale and siltstone with plant fossils
	Thrust	
UPPER SIWALIK		Sand rock and claystone/shale with plant fossils fossil wood
	Thrust	
ASSAM ALLUVIAL/ QUATERNARY DEPOSITS		
SOUTH	Main Frontal Thrust	

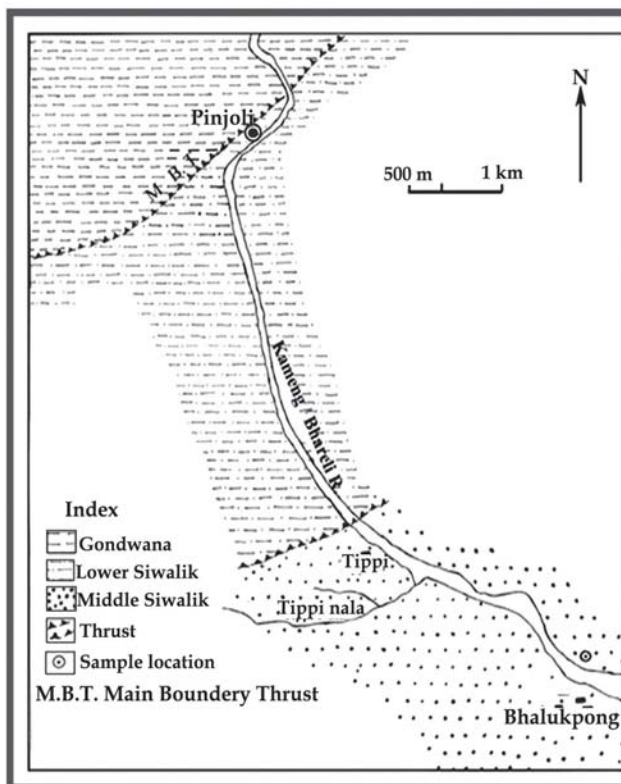


Fig. 1. Geological map of Bhalukpong

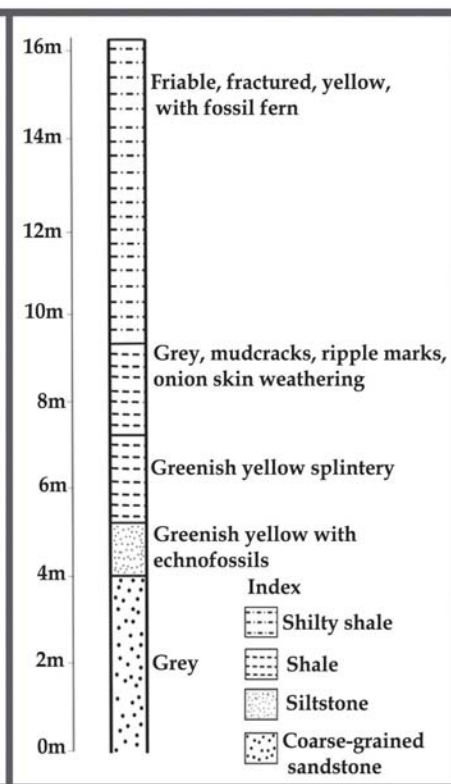


Fig. 2. Lithocolumn of road-cutting section

SYSTEMATIC DESCRIPTION

Clusiaceae

Calophyllum suraikholaensis Awasthi & Prasad, 1990

Material: Two well preserved but incomplete leaf impressions (Specimen no. -CUH/PPL/B₁ and B₅₅).

Locality: Road- cutting section, Bhalukpong area, opposite to Jangchip chorten of West Kameng district.

Horizon: Middle Siwalik (Pliocene), Subansiri Formation

Description: leaf simple, symmetric, narrowly lanceolate; preserved lamina length 2.8 – 6.7 cm; width 2.1-2.4 cm; apex totally broken; base acute; margin entire; texture chartaceous; venation eucamptodromous- craspedodromous; primary vein prominent, straight, stout in the basal region thinning out towards the apex; secondary veins numerous, parallel to each other, very closely placed, in one specimen about 150 pairs (aprox.) could be counted, very closely placed, about 3 veins per mm, opposite or alternate, unbranched, 0.3 mm apart, angle of divergence of secondaries of lower half nearly at right angle, on the other hand angle of divergence of secondaries of upper half slightly acute towards the apex; further details of venation not observed.

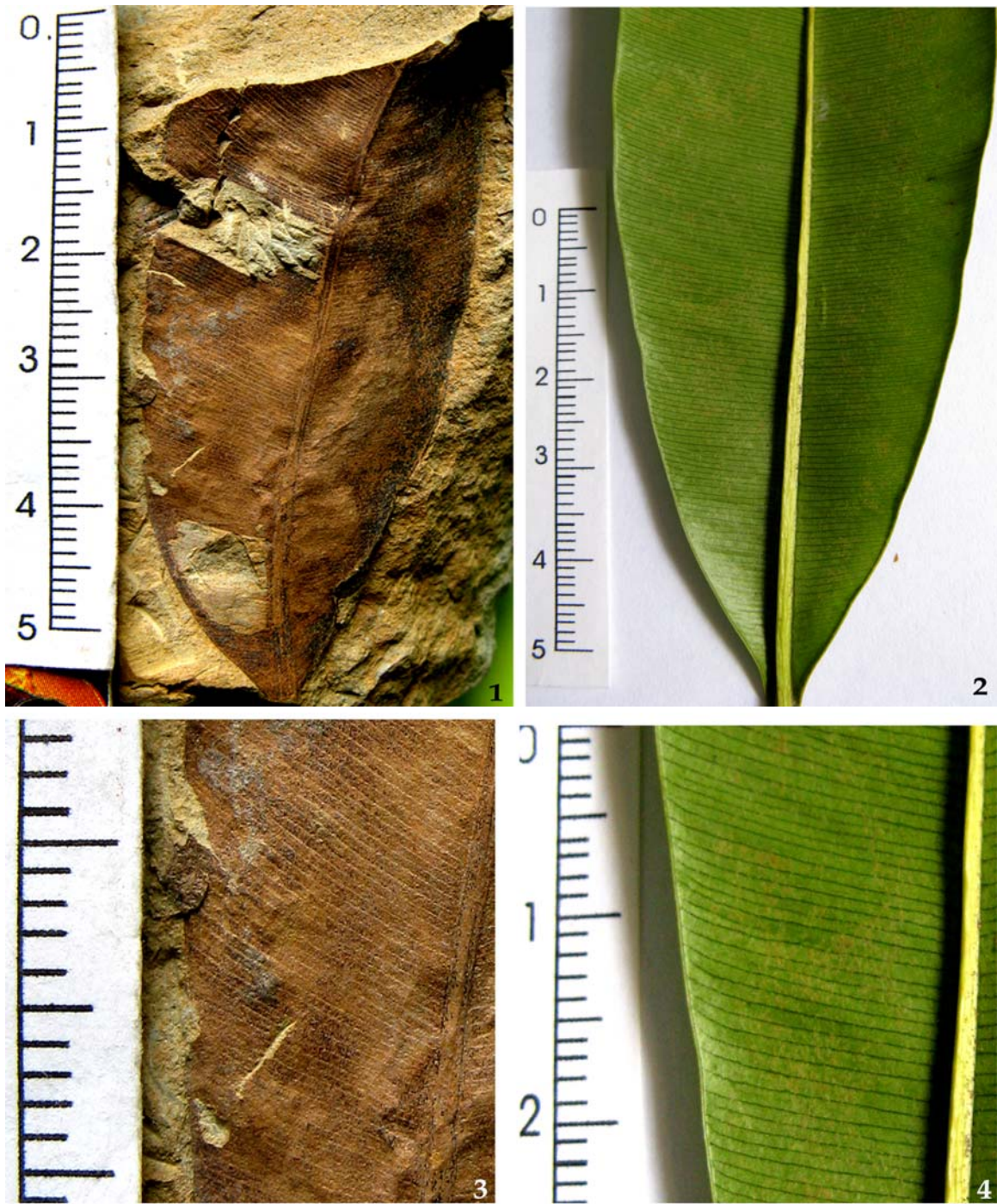
DISCUSSION

The most important characters of the present fossil leaves are lanceolate, entire, with eucamptodromous- craspedodromous venation, numerous, closely spaced parallel secondary veins indicating its affinity with the modern leaves of *Calophyllum* L. (Clusiaceae). In order to compare and find out the specific affinity of the present fossil leaves all the available species of the genus *Calophyllum* L. were examined and closer affinity with the modern *Calophyllum polyanthum* Wallich is suggested.

The fossil leaves showing similarity with the extant genus *Calophyllum* L. known from Tertiary sediments of India and abroad are *Calophyllum pliocenicum* Krasser, 1903 from Ouricanga, Brazil; *C. nathorstii* (Geyler) Krausel and *Calophyllum* sp. Krausel, 1929 from Sumatra, *Calophyllites masensis* Pons, 1978 from Colombia, South America and *Calophyllum suraikholaensis* from the Siwalik sediments of western Nepal by Awasthi & Prasad (1990); Oodlabari, Darjeeling District, West Bengal by Antal & Awasthi (1993); Middle Miocene of Kerala Coast by Awasthi & Srivastava (1992); Upper Palaeocene of Cherrapunji, Meghalaya by Ambwani (1992); Oligocene of the Makum Coalfield, Assam by Awasthi & Mehrotra (1995) and Lower Siwalik sediments of West Kameng district, Arunachal Pradesh by Joshi & Mehrotra (2007). The present fossil leaves have been compared with all the above known fossil leaves and found that *Calophyllum suraikholaensis* Awasthi & Prasad, 1990 (having affinity with modern *Calophyllum polyanthum* Wallich) described from the Siwalik sediments of western Nepal shows closest affinity with the present fossil leaves and hence assigned to the same species.

The genus *Calophyllum* L. includes over 187 species of trees, distributed in the tropical regions of both the hemispheres, but the majorities are grouped in tropical Asia and the East Indies (Pearson & Brown 1932; Mabberley 1997). It is also a large genus of tropical trees with many

PLATE I



Figs.1. *Calophyllum suraikholaensis* Awasthi & Prasad fossil leaf showing shape, size and venation pattern; **2.** *Calophyllum polyanthum* Wallich modern leaf showing similar shape, size and venation pattern; **3.** Enlarged view of fossil leaf; **4.** Enlarged view of modern leaf.

species in Malaya Peninsula and Sri Lanka (Gamble 1972). *Calophyllum polyanthum* Wallich with which the fossil shows close resemblance, is a large evergreen tree of Tenasserim, Andaman and Nicobar Islands, Malaya peninsula and Sri Lanka (Brandis 1971). The present distribution of modern comparable species of the recovered fossils indicates the presence of tropical wet evergreen type forest in the area during Middle Siwalik sedimentation (Pliocene) in contrast to the present day tropical semi-evergreen type forest.

Acknowledgements

The authors are thankful to Sri Sambhu Chakraborty, Senior Geologist, GSI, Operation Arunachal, Itanagar, for his help during collection of fossil specimens. Grateful acknowledgements are due to the Additional Director, Central National Herbarium, Howrah for permitting consultation of the Herbarium. Financial assistance by DST, New Delhi is gratefully acknowledged.

LITERATURE CITED

- Ambwani, K. 1992. Leaf impressions belonging to the Tertiary age of Northeast India. *Phytomorphology*, 41: 139 – 146.
- Antal, J.S. & Awasthi, N. 1993. Fossil flora from the Himalayan foothills of Darjeeling district, West Bengal and its palaeoecological and phytogeographical significance. *Palaeobotanist*, 42(1): 14 – 60.
- Awasthi, N. & Prasad, M 1990. Siwalik plant fossils from Surai khola area, Western Nepal. In: Jain KP & Tiwari RS (Editors)- *Vistas in Indian Palaeobotany*, *Palaeobotanist*, 38: 298 – 318.
- Awasthi, N. & Srivastava, R 1992. Addition to the Neogene flora of Kerala Coast, India. *Geophytology*, 20(2): 148 – 154.
- Awasthi, N. & Mehrotra, R.C. 1995. Oligocene flora from Makum Coalfield, Assam, India. *Palaeobotanist*, 44: 157 – 188.
- Brandis, D. 1971. *Indian Trees*. Bishen Singh, Mahendra Pal Singh, Dehradun, India.
- Das, P.; Khan, M.A.; De, B.; Samajpati, N. & Bera, S. 2007. Evidence of relationship between *Asterina* (Asterinaceae) and *Chonemorpha* (Apocynaceae) from the Upper Siwalik (Kimin Formation) sediments of Arunachal subhimalaya, India. *J. Mycopatho. Res.*, 45(2): 218 – 223.
- Dilcher, D.L. 1974. Approaches to the identification of Angiospermous leaf remains. *Bot. Rev.*, 40: 1 – 157.
- Gamble, J.S. 1972. *A manual of Indian Timbers*. Bishen Singh, Mahendra Pal Singh, Dehradun, India.
- Joshi, A. & Chakraborty, P.P. 2001. Systematic geological mapping in parts of East and West Kameng districts, Arunachal Pradesh. *Geol. Surv. India Unpublished progress report for F.S.1999 – 2000*.
- Joshi, A. & Mehrotra, R.C. 2003. A thelypteridaceous fossil fern from the Lower Siwalik of the East Kameng District, Arunachal Pradesh. *J. Geol. Soc. India*, 61: 483 – 486.
- Joshi, A. & Mehrotra, R.C. 2007. Megaremaines from the Siwalik sediments of West and East Kameng Districts, Arunachal Pradesh. *J. Geol. Soc. India* 69: 1256 – 1266.

- Joshi, A; Tewari, R; Mehrotra, R.C; Chakraborty, P.P.& De, A. 2003. Plant remains from the Upper Siwalik sediments of West Kameng District, Arunachal Pradesh. *J. Geol. Soc. India*, 61: 319 – 324.
- Khan, M.A.; De, B. & Bera, S. 2007. A fossil fern-leaflet of family Thelypteridaceae from the Middle Siwalik sediments of West Kameng district, Arunachal Pradesh. *J. Bot. Soc. Beng.*, 61(1): 65 – 69.
- Khan, M.A.; De, B. & Bera, S. 2008. Fossil leaves resembling modern *Terminalia chebula* Retzius from the Lower Siwalik sediments of Arunachal Pradesh, India. *Pleione*, 2(1): 38 – 41.
- Kumar, G. 1997. *Geology of Arunachal Pradesh*. Geol. Soc. India, Bangalore, pp. 1-217
- Mabberley, D.J. 1997. *The Plant-Book. A probable dictionary of the vascular plants*. Press Syndicate of the University of Cambridge, U.K.
- Mehrotra, R.C. & Mandaokar, B.D. 2000. Leaf impressions from Oligocene sediments of Manmao, Tirap district, Arunachal Pradesh, India. *Palaeobotanist*, 49: 311 – 315.
- Pearson, R.S. & Brown, H.P. 1932. *Commercial timbers of India*. Vols. 1 & 2. Government of India, Central publication Branch, Calcutta.
- Singh, T. & Prakash, U. 1980. Leaf impressions from the Siwalik sediments of Arunachal Pradesh, India. *Geophytology*, 10(1): 104 – 107.