

Fossil leaves of *Dipterocarpus* from the Lower Siwalik beds near Jawalamukhi, Himachal Pradesh

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Leaf impressions resembling those of the modern *Dipterocarpus turbinatus* Gaertn. f. and *D. tuberculatus* Roxb., have been described from the Lower Siwalik beds of Balu-Goloa, near Jawalamukhi (Himachal Pradesh) as *Dipterocarpus siwalicus* sp. nov. Their occurrence indicates that a moist tropical forest was growing near Jawalamukhi during the Middle Miocene times.

Key-words—Megafossil, Fossil leaves, *Dipterocarpus*, Lower Siwalik, Middle Miocene (India).

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सारांश

ज्वालामुखी (हिमाचल प्रदेश) के समीपस्थ अधरि शिवालिक संस्तरो से डिप्टेरोकार्पस की अश्मित पत्तियाँ

राजेन्द्र नाथ लखनपाल एवं जसवन्त सिंह गुलेरिया

ज्वालामुखी (हिमाचल प्रदेश) के समीपस्थ बालु-गोलो की अधरि शिवालिक संस्तरो से वर्तमान डिप्टेरोकार्पस टर्बिनेटस गेयर्टन० एफ० एवं डि० ट्यूबरकुलेटस रॉक्सबरो की पत्तियों से मिलती-जुलती पर्ण-छाणों को डिप्टेरोकार्पस शिवालिकस नव जाति के नाम से वर्णित किया गया है। इनकी उपस्थिति से व्यक्त होता है कि मध्य-मध्यनूतन युग में ज्वालामुखी के समीप एक नम उष्णकटिबन्धीय वन विद्यमान था।

A NUMBER of angiospermic leaf-impressions belonging to *Berchemia*, *Ficus*, *Fissistigma*, *Lagerstroemia*, *Smilax* and *Ziziphus* and a fruit of *Dalbergia* were described from the Jawalamukhi area in district Kangra, Himachal Pradesh (Lakhanpal, 1965, 1966, 1968, 1969; Lakhanpal & Dayal, 1966). These fossils came from the Lower Siwalik beds (Sahni & Mathur, 1964; Karunakaran & Ranga Rao, 1979) exposed near the village Balu-Goloa (31° 57' N : 76° 16' E), about 12 km northwest of Jawalamukhi. From the same area, though not from Balu-Goloa, Mathur (1978) described leaf-impressions of *Mallotus* and the artificial genera *Papilionoid* and *Poacites*. In addition, a fossil wood, *Anisopteroxylon jawalamukhi*, had also been described by Ghosh and Ghosh (1958) from the Middle Siwalik exposures near the village Khundian (31° 56' N : 76° 23' E).

The occurrence of leaf-impressions resembling those of *Dipterocarpus* in the Siwalik sediments of the Jawalamukhi area had already been reported by

Lakhanpal (1970, p. 683; 1974, p. 34). They were collected from near Balu-Goloa and are being described in the present paper. These impressions are preserved on compact, fine-grained sandstones of the Lower Siwalik horizon.

DESCRIPTION

Family—*Dipterocarpaceae*

Genus—*Dipterocarpus* Gaertn. f.

Dipterocarpus siwalicus sp. nov.

Fig. 1; Fig. 2 A-C

The species is represented by more than a dozen well preserved impressions of small to large leaves. Leaves seemingly symmetrical, ovate to elliptic, lamina 8.5-21.5 cm in length and 6.0-11.0 cm in width; apex acute to slightly attenuate; base more or less round to cordate; margin entire or slightly undulate; texture thick chartaceous; petiole not preserved; venation pinnate, eucamptodromous;

primary vein (1°) moderate, more or less straight to slightly curved; secondary veins (2°) usually alternate, rarely a few secondaries oppositely arranged, angle of divergence acute, 25° - 80° (mostly 40° - 60°), decreasing from base towards apex, course

straight to uniformly curved, unbranched, intersecondary veins absent; tertiary veins (3°) with angle of origin about 70° - 80° ; pattern percurrent, course somewhat wavy, unbranched, running obliquely in relation to mid-vein, arrangement



Figure 1—*Dipterocarpus siwalicus* sp. nov. \times Natural size. Specimen no. BSIP 35859.

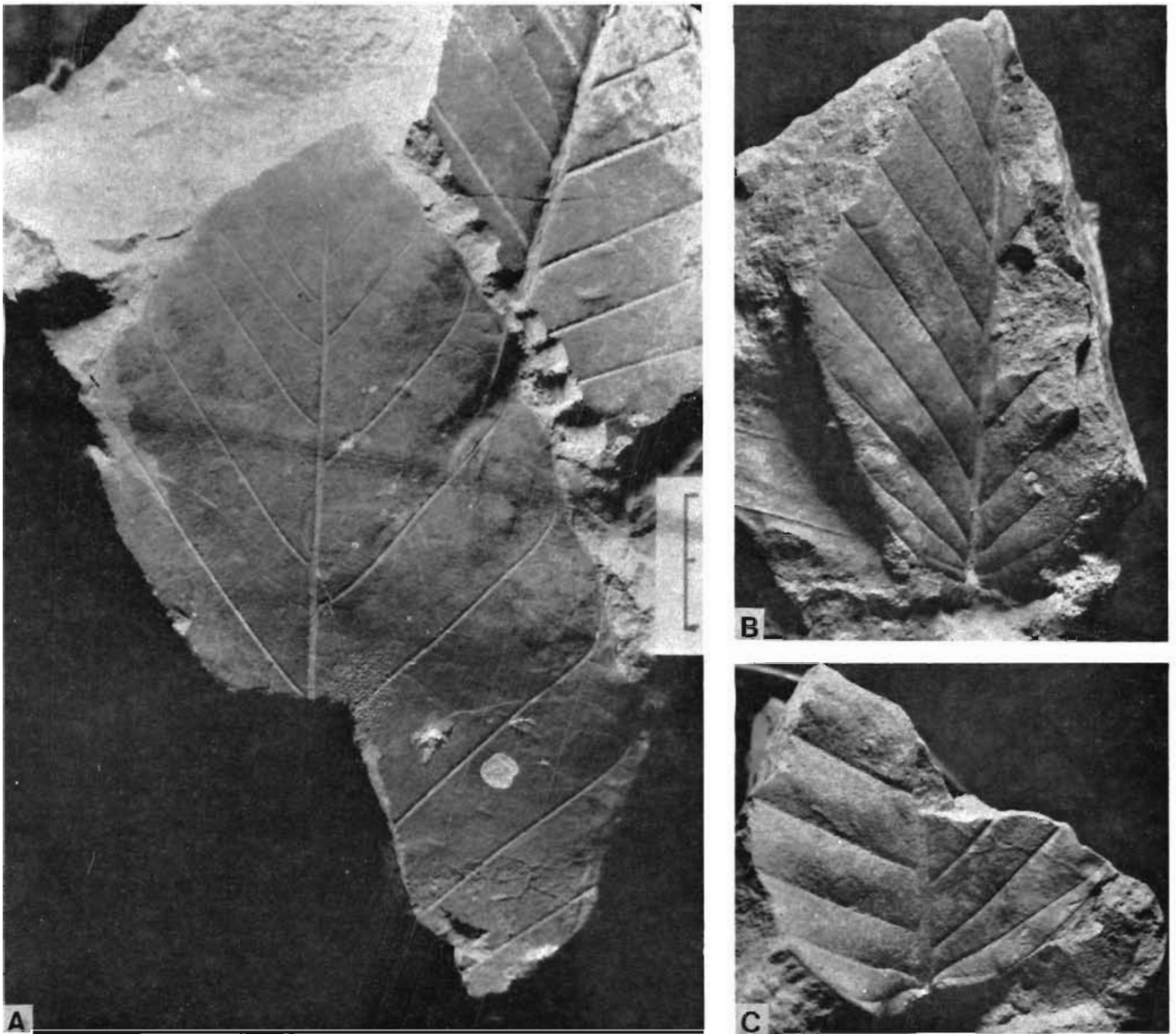


Figure 2A-C—*Dipterocarpus siwalicus*, leaves showing variation in size and shape—Natural size. Specimen nos. BSIP 35860-35862.

mostly alternate, usually close, rarely distant; higher order venation not seen.

Holotype—Specimen no. BSIP 35859.

Paratypes—Specimen nos. BSIP 35860-35862.

Locality—Near Balu-Goloa ($31^{\circ}57' N$; $76^{\circ}16' E$), about 12 km north-west of Jawalamukhi, district Kangra, Himachal Pradesh.

Horizon & Age—Lower Siwalik; Middle Miocene

DISCUSSION

The main features of the fossil leaves are: (i) broadly ovate shape, (ii) medium to large size, (iii) acute to slightly attenuated apex, (iv) broadly obtuse to rounded base, sometimes also cordate, (v) thick texture, (vi) secondaries coming off straight from the midrib and curving up near the

margin, (vii) angle of divergence of the secondaries decreasing from base towards the apex, and (viii) tertiaries in slanting cross-ties. Considered collectively, they clearly indicate that these leaves belong to the family Dipterocarpaceae. Very close comparison is offered by the genera *Shorea* and *Dipterocarpus*. However, in *Shorea* there is very often a prominent branching of some of the secondaries, which is not found in any of the present leaf-impressions. Thus the fossil leaves can be assigned to the genus *Dipterocarpus* Gaertn. f.

There are many living species of *Dipterocarpus*, but some have much larger or thicker and stiffer leaves while in others the leaves are smaller. In 3-4 species there is an occasional inter-secondary between adjacent secondaries. In almost all the characters and range of size, the closest resemblance

is shown by the leaves of *Dipterocarpus turbinatus* Gaertn. f. However, in one feature there is some difference. In *D. turbinatus* the leaf base is broadly obtuse to almost rounded and the same is found in most of the fossil specimens. But in two or three impressions the leaf base is cordate. Such a base is found in the leaves of *D. tuberculatus* Roxb., which are usually larger in size than those of *D. turbinatus*. Thus the present fossil combines almost all the features of the leaves of *D. turbinatus* with one found in those of *D. tuberculatus*. Most probably it represents an ancestral form from which these two species have evolved. As far as we are aware, there are 19 records of fossil leaves referred to Dipterocarpaceae as listed below, giving relevant information about their provenance, age and comparable modern taxa.

It is not our intention here to evaluate the correctness and validity of all these records but to consider those that can be compared with the Balu-Goloa leaves for taxonomic relationship. Going by the identifications given by the previous workers, the following six records merit discussion as far as their affinity with *Dipterocarpus* is concerned:

1. *Dipterocarpus antiquus* Heer
2. *D. atavinus* Heer
3. *D. labuanus* Geyler
4. *D. nordenskiöldi* Geyler
5. *Dipterocarpus* sp. Geyler
6. *Phyllites dipterocarpoides* Crié.

About *Dipterocarpus antiquus* and *D. atavinus* Edwards (1923, p. 161) remarked that these two species might belong to the family Dipterocar-

paceae, particularly *D. atavinus*, but did not comment about their generic identification with *Dipterocarpus*. Earlier Brandis (1895, p. 4) had also accepted *D. atavinus* as belonging to Dipterocarpaceae but considered it as a species of *Shorea* rather than *Dipterocarpus*. Thus these two species are not definitely assignable to the genus *Dipterocarpus*. Edwards (1923, p. 162) had examined the original specimens of *Dipterocarpus labuanus*, *D. nordenskiöldi* and *Dipterocarpus* sp. of Geyler in the Stockholm Museum and was not convinced about the certainty of their attribution as according to him these specimens were not definitely identifiable. According to Brandis (1895, p. 4) these fossils "show no characters which warrant their reference to the Dipterocarpaceae". Bancroft (1933, p. 82) agreed with the above opinions and suggested that these records of Geyler should be left out of any account of the geological history of the Dipterocarpaceae.

Phyllites dipterocarpoides has been compared with the leaves of the modern species *Dipterocarpus baudii* and as such can be considered the only authentic fossil record of a *Dipterocarpus* leaf. Leaves of *D. baudii* (synonym of *D. duperrianus*) are very thick, large and hairy and quite distinct from those of *D. turbinatus* or *D. tuberculatus* with which our fossils are closely comparable. Therefore, we are assigning the Balu-Goloa leaves to a new species, *Dipterocarpus siwalicus*, named after the Siwalik beds from which they were collected.

Dipterocarpus turbinatus, with which *D. siwalicus* shows the closest resemblance, is a lofty tree, 37-46 m, high, distributed in Assam, Andamans,

Name	Author	Locality	Age	Comparable modern taxa
<i>Anisoptera thurifera</i>	Merrill (1923)	Luzon (Philippines)	Pliocene	<i>Anisoptera</i>
<i>Dipterocarpaceophyllum sumatrense</i>	Kräusel (1929)	Sumatra	Tertiary	Dipterocarpaceae, genus indeterminate
<i>Dipterocarpophyllum gregoryi</i>	Edwards (1923)	Burma	Tertiary	Dipterocarpaceae, genus indeterminate
<i>D. bumei</i>	Seward (1935)	Egypt	?Tertiary	<i>Shorea</i>
<i>D. zeraibense</i>	Seward (1935)	Egypt	?Tertiary	<i>Shorea</i>
<i>Dipterocarpus antiquus</i>	Heer (1883)	Sumatra	Tertiary	? <i>Dipterocarpus</i>
<i>D. atavinus</i>	Heer (1883)	Sumatra	Tertiary	? <i>Dipterocarpus</i>
<i>D. labuanus</i>	Geyler (1887)	Labuan	Tertiary	? <i>Dipterocarpus</i>
<i>D. nordenskiöldi</i>	Geyler (1887)	Labuan	Tertiary	? <i>Dipterocarpus</i>
<i>Dipterocarpus</i> sp.	Geyler (1887)	Labuan	Tertiary	? <i>Dipterocarpus</i>
<i>Doona? chaneyi</i>	Wolfe (1977)	Alaska (U.S.A.)	Eocene	<i>Doona</i>
<i>Hopea fagifolia</i>	Schuster (1911)	Java	Pleistocene	<i>Hopea</i>
<i>Parashorea chasmanensis</i>	Wolfe (1977)	Alaska (U.S.A.)	Eocene	<i>Parashorea</i>
<i>P. pseudogoldiana</i>	Wolfe (1977)	Alaska (U.S.A.)	Eocene	<i>Parashorea</i>
<i>Phyllites dipterocarpoides</i>	Crié (1888)	Java	Pliocene	<i>Dipterocarpus</i>
<i>P. (Hopea) praecursor</i>	Geyler (1875)	Borneo	Eocene	<i>Hopea</i>
<i>Shorea guiso</i>	Merrill (1923)	Luzon (Philippines)	Pliocene	<i>Shorea</i>
<i>S. polyspermum</i>	Merrill (1923)	Luzon (Philippines)	Pliocene	<i>Shorea</i>
<i>Vatica lancifolia</i>	Schuster (1911)	Java	Pleistocene	<i>Vatica</i>

Bangla Desh, Burma, Cochin-China and Thailand. The tree is not typically gregarious though sometimes it approaches that condition in patches. It is found in the forests of the moister tropical type, evergreen or semi-evergreen, where it towers over the rest of the associates, often with an undergrowth of palms, canes and climbers. In its natural habitat the absolute maximum shade temperature varies from 37°-41°C and the absolute minimum from 7°-16°C. The rainfall varies from 1,500-5,000 mm.

The other comparable modern species, *D. tuberculatus*, is a large deciduous tree, 30-37 m high, growing gregariously in Burma, Cochin-China and Thailand. From Burma it also extends into the borders of Assam and Bangla Desh. It is found in localities where the absolute maximum shade temperature varies from 37.5°C to 43°C and the absolute minimum shade temperature from 4.5°-10°C. The normal rainfall varies from about 900-3050 mm.

The climatic requirements of the above two species closely comparable with *D. siwalicus*, indicate that a rich, moist tropical forest must have been growing around the fossil locality during the Middle Miocene times when the Lower Siwalik sediments were deposited there.

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