

# FIRST RECORD OF UPPER CRETACEOUS PLANT MEGAFOSSILS (CLASS: ANGIOSPERMAE) FROM UPPER KROL FORMATION OF MALDEOTA IN MUSSOORIE SYNCLINE OF GARHWAL LESSER HIMALAYA, NORTHERN INDIA

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## ABSTRACT

A rich flora of megafossils in the Maldeota carbonates (Garhwal Lesser Himalaya) was recorded from the upper Krol Formation (cherty Krol D of Auden) in profuse quantities. The megaf flora, in about 12.16 metres thick carbonate belt, is represented by nine species: *Doryanthites cretaceae*, *Magnolia lacoeana*, *Diospyros rotundifolia*, *D. amboyensis*, *Cassia vauhani*, *Hamamelites? cordatus*, *Platanus shirleyensis*, *Oreodaphne shirleyensis*, and *Terminalia phaeocarpoides*. This assemblage is characteristic of the Upper Cretaceous rocks of the Eastern Gulf Coast (USA), and thus suggestive of an Upper Cretaceous age to the upper Krol Formation (Krol D) at Maldeota in Mussoorie Syncline of Garhwal Lesser Himalaya in Northern India. Moreover, it is suggestive of the conformably overlying Tal Formation as being not of Pre-Cretaceous age.

## INTRODUCTION

THE age settlement of the Krol, Tal and associated formations in the Lesser Himalaya of Northern India has been a controversial problem for the last five decades ever since the work of Auden<sup>1</sup>. This dispute still persists and there does not seem to be any agreement<sup>2</sup>. According to some workers, the Krol Formation is assigned a Permo-Carboniferous-Triassic age<sup>1,3</sup>, whereas, Valdiya<sup>4,5</sup> thinks the Krol (uppermost limestone member) at Nainital to be of upper Palaeozoic (upper Carboniferous to Lower Permian) age. In contrast, Singh<sup>6,7</sup> indicated that the Krol Formation represented the deposits of late Precambrian age, hence extending the overlying Tal Formation to be of Cambrian age. Recently, Singh<sup>8</sup> suggested that the topmost part of Krol-E of the Maldeota area (Garhwal Lesser Himalaya) belongs to the lower Cambrian age. A general picture of the controversy of the fossils (as recovered from the Krol Formation) employed to solve this problem has been given by Bhargava<sup>9,10</sup>. However, it may be worth mentioning that the majority of the papers published to date indicate that the Krol Formation (Lesser Himalaya) belongs to the Mesozoic era. Similarly, the Tal Formation, associated closely and conformably overlying the Krol units, also gave rise to an exhaustive dispute<sup>17</sup>. The basic reason for the age settlement controversy might be that the megafossils discovered in these units were either poorly preserved (= diagenetically transformed), hence not permitting a clear identification, or lack of expert examination (and so were wrongly identified<sup>11,12</sup>). The microfloral assem-

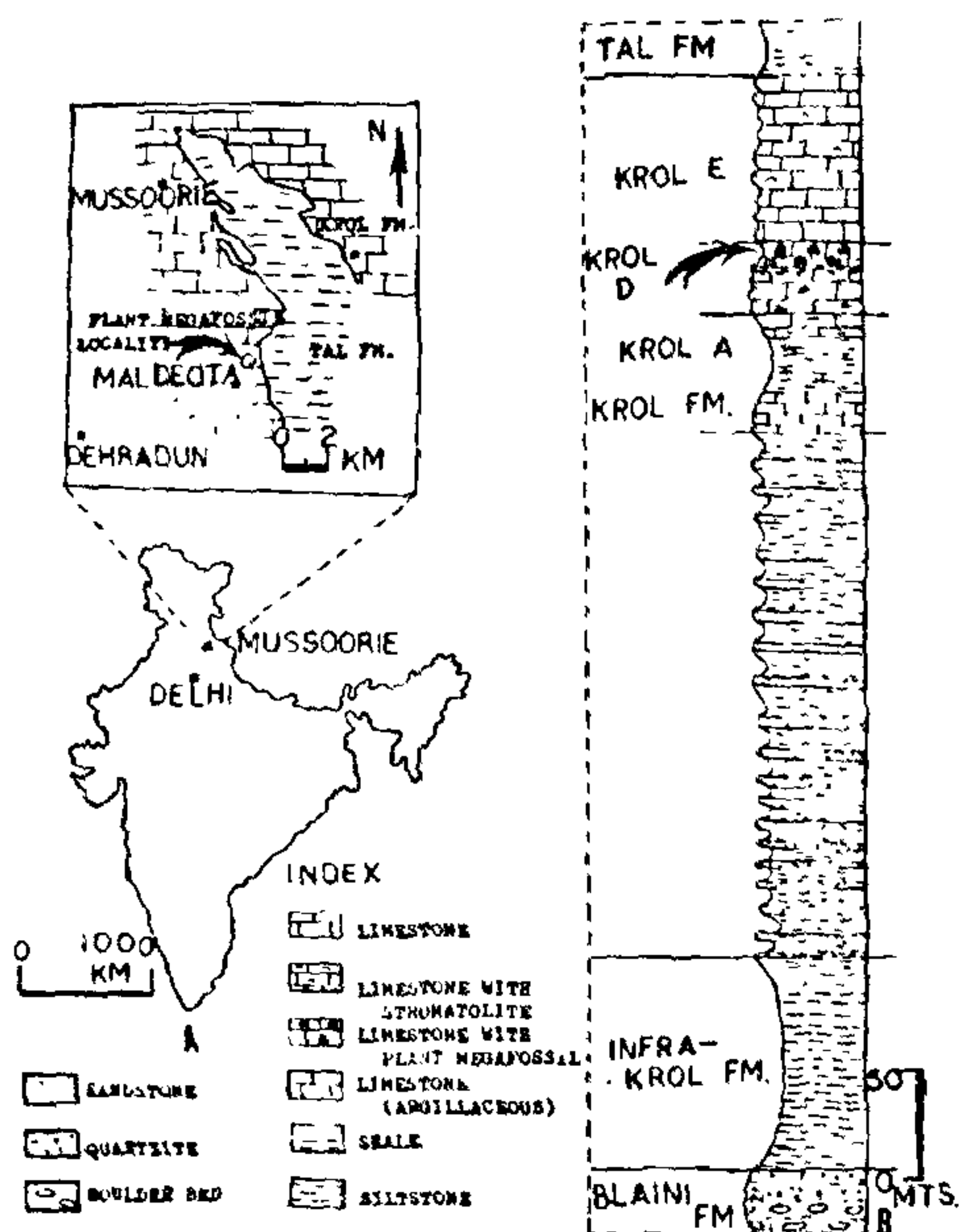
blages (pollen, spores), studied from the Krol and Tal Formations however, gave very promising results, placing both the major units into the Triassic to Cretaceous time span<sup>9,10,13</sup>.

## AREA AND NATURE OF FOSSILS

The plant (leaf) megafossil (figure 2 A-H) (class: Angiospermae)—bearing upper Krol Limestone (about 12.16 metres thick belt) occurs at a locality (figure 1A) about 0.8 km NE of Maldeota milestone, or about 1 mile south of Pyrite Phosphorite Chemicals Limited mine (DehraDun) on the Maldeota—Surkhet mule track. The plant fossils (leaf impressions) occur confined to the upper Krol-D sequence (figure 1 B), and are morphologically very well preserved. It can also be located at immediately west of the Vandal River Bridge (figure 2 A). From this point to the south, along the Maldeota—Surkhet road, the plant fossils bearing carbonate belt extends up to 1 kilometer at a sharp curve of the road (see figure 2 C). The fossiliferous limestones are predominantly yellowish grey to light olive grey in colour.

At the Vandal River Bridge section, the plant leaf impressions occur well preserved in very fine grained limestone (cherty Krol-D, figure 1 B) outcrops and hill sections. In the outcrops, seldom, a good amount of limestone is leached out after heavy rains (especially during monsoon season), thus imparting a vuggy porosity to the rock (figure 2 E) (and eventually destroying the leaf impressions). Despite this natural destruction, the morphological details in the leaf





**Figures 1 A-B.** A. Showing the plant megafossil locality in the upper Krol Formation at Maldeota in Mussoorie Syncline of Garhwal Lesser Himalaya; B. Litholog of the Krol Formation (with plant megafossil horizon in Krol-D) at Maldeota.

impressions can conveniently be studied. But the leaf impressions, being very delicate in the carbonates, usually get damaged during their detachment from the outcrops. However, they are well preserved (and protected) in the hill sections (figure 2 F). In general they occur in profuse quantitative composition (9 species are identified from the lower 6 metres part of the belt at the Vandal River Bridge section, figure 2 A). The entire megafossil assemblage belongs to two groups: Class: Angiospermae; Sub-class, Monocotyledonae and Sub-class, Dicotyledonae. Altogether, the 9 plant species discovered incorporate: *Doryanthites cretaceae* Berry (1914), *Magnolia lacoeana* Lesquereux, *Diospyros rotundifolia* Lesquereux, *Diospyros amboyensis* Berry (1911), *Cassia vughani* Berry (1919), *Hamamelites? cordatus* Lesquereux, *Platanus shirleyensis* Berry (1919), *Oreodaphne shirleyensis* Berry (1919), and *Terminalia phaeocarpoides* Berry (1914) (figure 2 B, D-H; figure 3 A-I). This floral assemblage is characteristic of the

Upper Cretaceous of the East Gulf Coast (USA), suggesting an Upper Cretaceous age to the upper Krol Formation (Krol D of Auden<sup>1</sup>) at Maldeota (in the Mussoorie Syncline of Garhwal Lesser Himalaya).

The general morphological description of five important Angiosperm leaf impressions is as follows:

### SYSTEMATIC DESCRIPTION

Class: ANGIOSPERMAE, Sub-class: MONOCOTYLEDONAE, Order: LILIALES.

Genus: *Doryanthites* Berry (1914); *Doryanthites cretacea* Berry (1914), figure 2 E, G (marked with arrow); Text-figure 3 G. Leaves profusely preserved in long and short fragmental aggregates, linear, possibly lanceolate, commonly occurring in 4 to 6 cm width; margins entire; veins apparently simple and parallel (figure 3 G) immersed, less than 1 mm apart; leaves alike on both surfaces, and appear finely striated under the microscope. *D. cretacea* (plate XVII, figure 3 of Berry, 1914) from the Upper Cretaceous of South Carolina and Georgia, and the same species (plate XIII, figure 1 of Berry, 1919) from the Upper Cretaceous of the Eastern Gulf region (in Tennessee, Mississippi, Alabama, Georgia), closely resemble *D. cretacea* from the Maldeota area.

Sub-class: DICOTYLEDONAE, Order: EBENALES, Family: EBENACEAE,

Genus: *Diospyros* Linne'; *Diospyros amboyensis* Berry (1911), figure 2B; Text-figure 3A. Leaves large, elliptical, 8 to 9 cm long and 4.50 to 5 cm wide (in central part); apex slightly narrowed, becoming rounded, more or less obtuse; base broadly rounded; midrib prominent and stout; secondary venation thin but prominent, numerous, regular, about 10 pairs, arising from the midrib at an angle of about 43°; tertiary venation of large, polygonal meshes and fine in calibre. *D. amboyensis* (plate XXVII, figure 5, Berry, 1919), from the Upper Cretaceous of Eastern Gulf Coast (in Tennessee, Mississippi, Alabama, Georgia), closely compares to similar form from the upper Krol Formation (Krol D) of Maldeota.

Order: RANALES, Family: MAGNOLIACEAE,

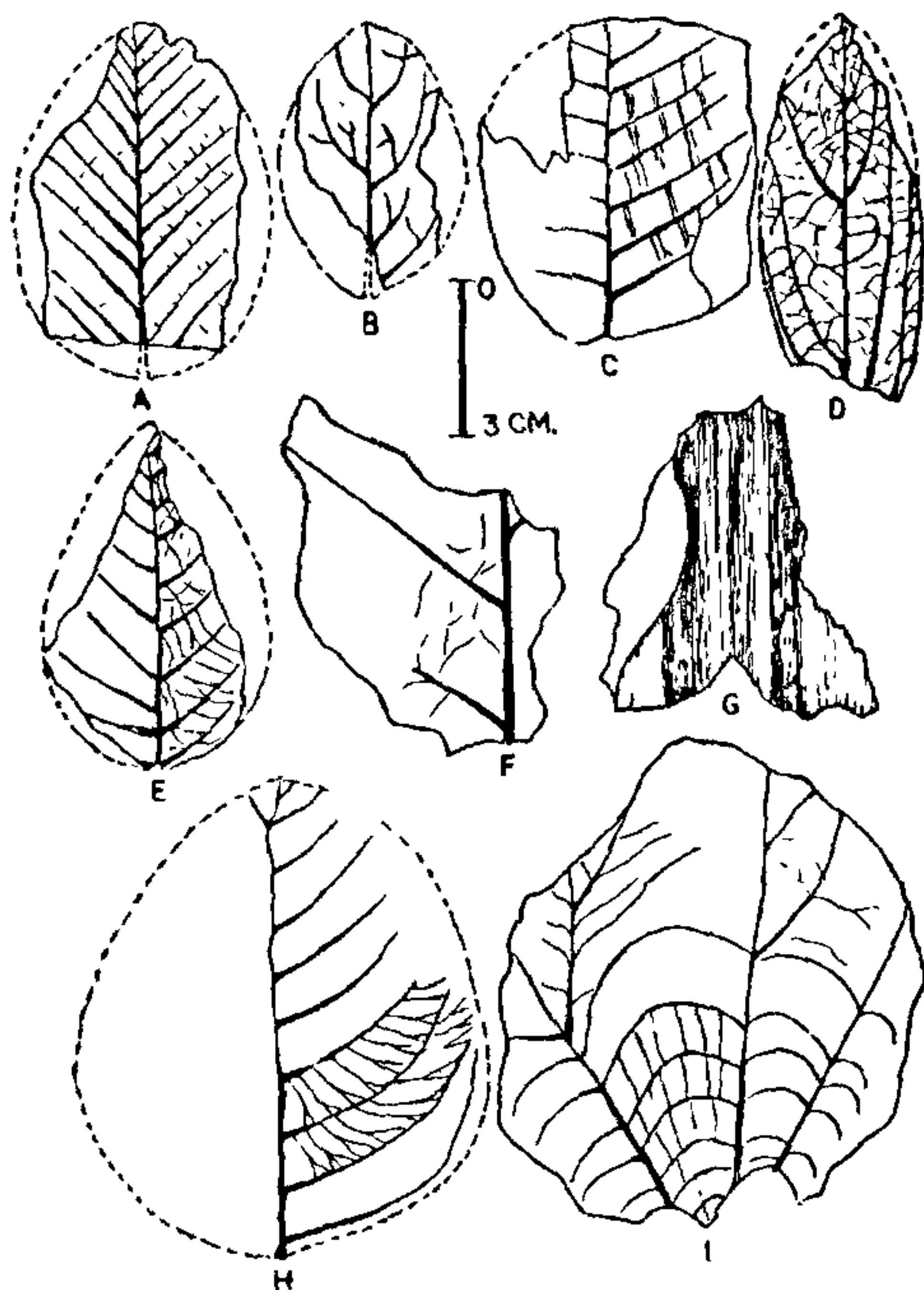
Genus: *Magnolia* Linne'; *Magnolia lacoeana* Lesquereux, figure 2D; Text-figure 3H. Leaves large, broadly oval to more or less orbicular in outline, their base rounded but becoming obtuse above; 9 to 11 cm in length and 7.50 to 9 cm in maximum width; midrib prominent, stout, possibly flexuous; secondary venation prominent, numerous and scattered all over leaf, about 10 pairs and stout; branching from the midrib at acute angles, immediately curving outward





Figures 2A–H





**Figures 3 A-I.** Megaflora (general diagrams) at Vandal River Bridge section (south of PPCL mine, Maldeota). **A.** *Diospyros amboyensis* Berry; **B.** *Diospyros rotundifolia* Lesquereux; **C.** *Hamamelites? cordatus* Lesquereux; **D.** *Oreodaphne shirleyensis* Berry; **E.** *Cassia vauhani* Berry; **F.** *Terminalia phaeocarpoides* Linne'; **G.** *Doryanthites cretacea* Berry; **H.** *Magnolia lacoeana* Lesquereux; **I.** *Platanus shirleyensis* Berry.

and upward, constructing festoons close to the margin. *M. lacoeana* (plate XVII, figure 9 of Berry, 1919) from the Upper Cretaceous of Eastern Gulf

region (USA) closely compares to similar species from the upper Krol Formation of Maldeota.

Order: THYMELEALES, Family: LAURACEAE,

Genus: *Oreodaphne* Nees and Martins; *Oreodaphne shirleyensis* Berry (1919), figure 2 G (fossil in lower part); Text-figure 3D. Leaves of medium size, broadly ovate, acuminate apex, with rounded base; 9 cm long and 4 cm wide (central part), margins curved to base, but gradually narrowing upward with a narrowly-pointed apex; midrib distinct and stout; secondary veins about 6 pairs, stouter, straight but thinner than the midrib, alternate, giving a false impression of a triveined leaf (indeed slightly enlarged secondaries). *O. shirleyensis* (plate XIX, figures 1, 2 of Berry, 1919), from the Upper Cretaceous of Tuscaloosa Formation of Alabama, closely compares to similar species from the upper Krol Formation of Maldeota.

Order: ROSALES, Family: CAESALPINIACEAE,

Genus: *Cassia* Linne'; *Cassia vauhani* Berry (1919), Figure 2 H; Text-figure 3 E. Leaflets of large size, elliptical, with a slightly extended, obtusely pointed apex and a broadly rounded base; about 7 cm long and about 4 cm wide (in central part); margins entire, smooth and rounded; midrib prominent and stout; secondary veins numerous, thin, well-developed in 10 pairs, branching from midrib at an angle of about 47°; tertiary venation obsolete. *C. vauhani* (plate XXII, figure 8 of Berry, 1919), from the Upper Cretaceous of Eastern Gulf region (USA), closely resembles to similar form from the upper Krol Formation of Maldeota.

## DISCUSSION

In general *Magnolia lacoeana* was reported from the Cretaceous rocks of southern New York and New England<sup>16</sup>. Berry<sup>14</sup> recorded *Doryanthites cretacea* from the Upper Cretaceous rocks of South Carolina and Georgia. Besides, the Upper Cretaceous of Eastern Gulf region (in Tennessee, Mississippi, Alabama, Georgia) yielded *Doryanthites cretacea*,

**Figures 2 A-H.** **A.** showing the northern plant megafossil locality (see man standing) at the Vandal River Bridge section on Maldeota-Surkhet road, about 1.60 km south of PPCL mine at Maldeota in Garhwal Lesser Himalaya; **B.** *Diospyros amboyensis* Berry; **C.** showing the southern plant megafossil locality (close to man standing) on Maldeota-Surkhet road, about 1 km-NE of Maldeota town; **D.** *Magnolia lacoeana* Lesquereux; **E.** *Doryanthites cretacea* Berry, leaf fragments in upper Krol Limestone at Vandal River Bridge section in Maldeota; **F.** showing plant (leaf) megafossils in the stratified upper Krol Limestone (Krol D) section (= southern plant megafossil locality) on Maldeota-Surkhet road (about 1 km-NE of Maldeota, hammer 0.30 mts. long); **G.** *Doryanthites cretacea* Berry (see arrow, in upper part of figure), and *Oreodaphne shirleyensis* (in lower part of figure at right corner); **H.** *Cassia vauhani*.

*Magnolia lacoena*, *Diospyros rotundifolia*, *D. amblyensis* and *Cassia vauhani*. *Hamamelites cordatus* was observed in the Upper Cretaceous rocks of south Carolina and Georgia<sup>14</sup>.

*Platanus shirleyensis* and *Oreodaphne shirleyensis* are the characteristic species of the Upper Cretaceous Tuscaloosa Formation in Tuscaloosa County, Alabama<sup>15</sup>. And *Terminalia phaeocarpoides* has been reported in the Upper Cretaceous of Bohemia, and Mc Bean Formation (Clairborne Group, Eocene) of the USA<sup>14</sup>.

As is evident, the discovered megafloreal assemblage (in profuse quantitative composition) belongs to the Upper Cretaceous age. Since most of the leaf impressions occur in entirety—and not as bioclastic limestone debris and so there is no question of contamination and reworking of sediments—and entirely of Angiosperm class, they undoubtedly are of Upper Cretaceous age. And since the Tal Formation conformably overlies the upper Krol Formation in the Maldeota area (figure 1 B), the former sequence cannot be of Pre-Cretaceous age.

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## NEWS

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### LASER IN SURGERY

For the first time, surgeons have applied the laser beam to cure cardiac arrhythmia. The operation has been successfully performed at the Kaunas Medical Institute (Soviet Baltic). After dissecting the thorax, surgeons aim the laser beam at an auricle, destroying those fascicles of nerve fibres which cause an increased frequency of systoles and arrhythmia. According to the scientist, the method of laser surgery is very

convenient for surgeons: the operation lasts 20 or 30 seconds, obviating the need for artificial blood circulation. The cardiologist can perform operations on the heart without surgical operation. Such operations are being already experimented on animals. Soviet doctors also apply lasers to treat the gastrointestinal tract, burns and in thoracic surgery. (*Soviet Features*, Vol. XXIII, No. 194, December 27, 1984)