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Macrofossils of Artocarpaceae and Lauraceae from Siwalik (Upper Miocene) Sediments of Himachal Pradesh, India and their Climatic and Biogeographic Significance

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ABSTRACT
In the present investigation, a morpho-taxonomic study has been carried out on recently recovered plant macrofossils from the Siwalik Group (Middle Miocene) sediments of Sarkaghat, Mandi District, Himachal Pradesh, India. This has revealed the occurrence of two new fossil leaves belonging to the extant taxa, *Artocarpus heterophyllus* Lam. and *Phoebe opaca* Blume. of the tropical dicotyledonous families, Artocarpaceae and Lauraceae respectively. As the nearest living relatives of the macrofossils reported here, are restricted to the southern part of India and southeastern Asia (Sri Lanka, Malaya, Indonesia, and Philippines), it is plausible that tropical forests under moist conditions were prevalent during the Upper Miocene times in this region. The recovered data also indicates prevalence of tropical climatic conditions during the Miocene in the Sarkaghat and nearby area.

Key words: Fossil leaves, Modern affinity, Systematic Palaeobotany, Geographical distribution, Moist deciduous forest, Tropical climate

INTRODUCTION

Plant macrofossils comprising of angiosperm leaves, fruit and seed impressions have been reported previously from the Siwalik Group of India, Nepal and Bhutan (Prakash and Lalitha 1978, Prasad and Tripathi 2000, Prasad 2008, Khan and Bera 2014, Prasad et al. 2015, 2017). A good number of fossils are known from several localities of Himachal Pradesh, India viz., Jawalamukhi, Balugoloa, Ranibag, Nahan, Bilaspur, Nalagarh, Hamirpur and Sarkaghat etc. Balugoloa near Jawalamukhi in Kangra District is one of the oldest fossil localities known for the occurrence of well-preserved leaf-impressions (Lakhanpal 1965, 1967, 1968, Lakhanpal and Guleria 1978, Lakhanpal and Awasthi 1992). The other nearby well-known fossil locality, Nalagarh contains exclusively petrified woods (Prakash 1975, 1981, Yadav 1989). Ranital near Jawalamukhi is another locality of Lower Siwalik from where only a leaf and Culm of bamboo have been reported (Lakhanpal et al. 1987). A solitary wood, *Anisopteroxylon jawalamukhi* is reported from the Middle Siwalik of Khundian in Kangra District (Ghosh and Ghosh 1958). From the same area few seeds are reported as *Boraginocarpon lakhanpalii* and a leaf of Lauraceae, *Litsea bhatiai* from the Upper Siwalik beds (Mathur 1974, 1978). Dayal and Chaudhuri (1966) also reported some ill-preserved dicotyledonous leaves from the Lower Siwalik beds of Koshalya River near Kalka. Prasad (2006) reported the occurrence of a lot of leaf impressions in the Siwalik sediments of Bilaspur area, Himachal Pradesh. Prasad (2010) reported carbonised fossil wood for the first time having distinct anatomical features which enable us to identify with extant taxa as *Hopea sulcata* Sym. and *Daubanga grandiflora* (Roxb. ex DC.) Walp. of the families Dipterocarpaceae and Lytheraceae respectively, from the Middle Siwalik sediments of Hamirpur District, Himachal Pradesh. Fossil leaves from Siwalik sediments (Nahan formation) of Mandi District, Himachal Pradesh have been reported for the first time (Prasad 2012, Prasad et al. 2013). A palynoassemblage comprising algal,

fungal, pteridophytic spores, and gymnosperm and angiosperm pollen has been also recovered from an exposed section at Nahan-Ponta Saheb Road, Himachal Pradesh (Prasad et al. 2011).

Only few fossil leaves resembling the genus, *Gynocardia* (Flacourtiaceae), *Millettia* and *Cynometra* (Fabaceae), *Ventilago* (Rhamnaceae), *Terminalia* (Combretaceae) and *Daemonorops* (Arecaceae), *Parthenocissus* (Vitaceae), *Antedesma* (Phyllanthaceae) and *Cyclosorus* (Thelypteridaceae) have been reported from the Sarkaghat area (Prasad et al. 2013, Tiwari et al. 2022a, 2022b). In view of the meager work done on this aspect from the Sarkaghat area exposing Siwalik Group of sediments, the present investigation has been carried out to study the plant macrofossils from this locality. The objective of present study is to explore the plant fossils from Sarkaghat and nearby area in the western Siwalik and to build up the complete palaeofloristics of the region for interpretation of palaeoclimate and phytogeography of the western Himalayan foot hills.

STUDY AREA

The study area (N 31° 44' 26" E 76° 43'33") lies along the National Highway 70, very near to Sarkaghat area of Mandi District, Himachal Pradesh (Figure 1). A large number of fossil leaves were collected from middle Siwalik beds exposed in a road cutting section (31º 44.265' : 76º 43.339') about 7 Km from Sarkaghat town on the left side of main road which leads to Dharampur and easily approachable through vehicle. The investigation on these fossil leaves revealed the presence of two new fossils showing their affinity with the angiospermous genera, *Artocarpus*, and *Phoebe* of tropical families, Artocarpaceae and Lauraceae respectively. These have been described and discussed in detail with its palaeoclimatic and phytogeographic significance.

The Siwalik Group is delimited by the Main Frontal Thrust (MFT) in the south and by the Main Boundary Thrust (MBT) in the north. The sedimentary sequence of Siwalik Group consists of Neogene fluvial deposits ranging in age from Miocene (~15 million years ago) to the Pliocene (~3 Ma) (Tokuoka et al. 1994). Almost a complete and uninterrupted sequence of Siwalik Group is well exposed all along the road from Sarkaghat to Dharampur (Fig. 2) The lithology and stratigraphy of the Siwalik Group has been discussed in detail, by several geologists (Sahni 1964, Tandon 1976, Sastry and Dutta 1977, Kumar et al. 2017). The Lower Siwalik has an average thickness of about 1800m and is composed of well-bedded indurate sandstones and siltstones. The Middle Siwalik is about 2000m thick and comprises dominantly of arenaceous rocks with clay intercalations, while the Upper Siwalik consists of up to 2500 m thick succession, characterized by fine grained, poorly indurate sandy clays in the lower part and conglomerates in the upper part. The Sarkaghat Anticline is exposed in the north-east part of the Kangra reentrant of the Himachal Sub-Himalaya along the northerly dipping Main Boundary Fault (MBF) between the NNW-SSE trending Awah Devi-Lamba Graon syncline in south and Main Boundary Fault (MBF) in north. It is a regional structure in the Paleogene-Siwalik belt around west Sarkaghat. Based on litho-association, grain size, compactness and internal geometry of beds, five mappable lithostratigraphic units of the Siwalik Group have been classified viz. Nahan Formation of the Lower Siwalik Subgroup, Dewal and Mohargarh formations of the Middle Siwalik Subgroup and Pinjor and Kalar formations of the Upper Siwalik Subgroup within the MBF related Sarkaghat Anticline structure. Middle Siwalik consists predominantly of sandstones of light grey colour, which vary in thickness from 10 to 20 m. They are coarse grained and grade from greywacke in the lower portion to arkose in the higher portions. They are soft and friable because of lack of calcareous matter which occurs in segregation rather than disseminated throughout the mass as in the Lower Siwalik. Pebbles are common in the coarser clastic especially towards the top where the clays are dull colored and more arenaceous. The thickness of Middle Siwalik is 1390 m. In Jammu foot-hills, the Middle Siwalik is made up of sandstones interbedded with the clay bands and segregated calcareous nodules. The sandstones are coarse grained, arkosic, pebbliferous and contain pyrite. In the Jawalamukhi area, a thick prism of conglomerate occurs within the Middle Siwalik. In Sirmur area, the Middle Siwalik is about 2000 m in thickness and consists of alternations of clays and sandstones in the upper part.

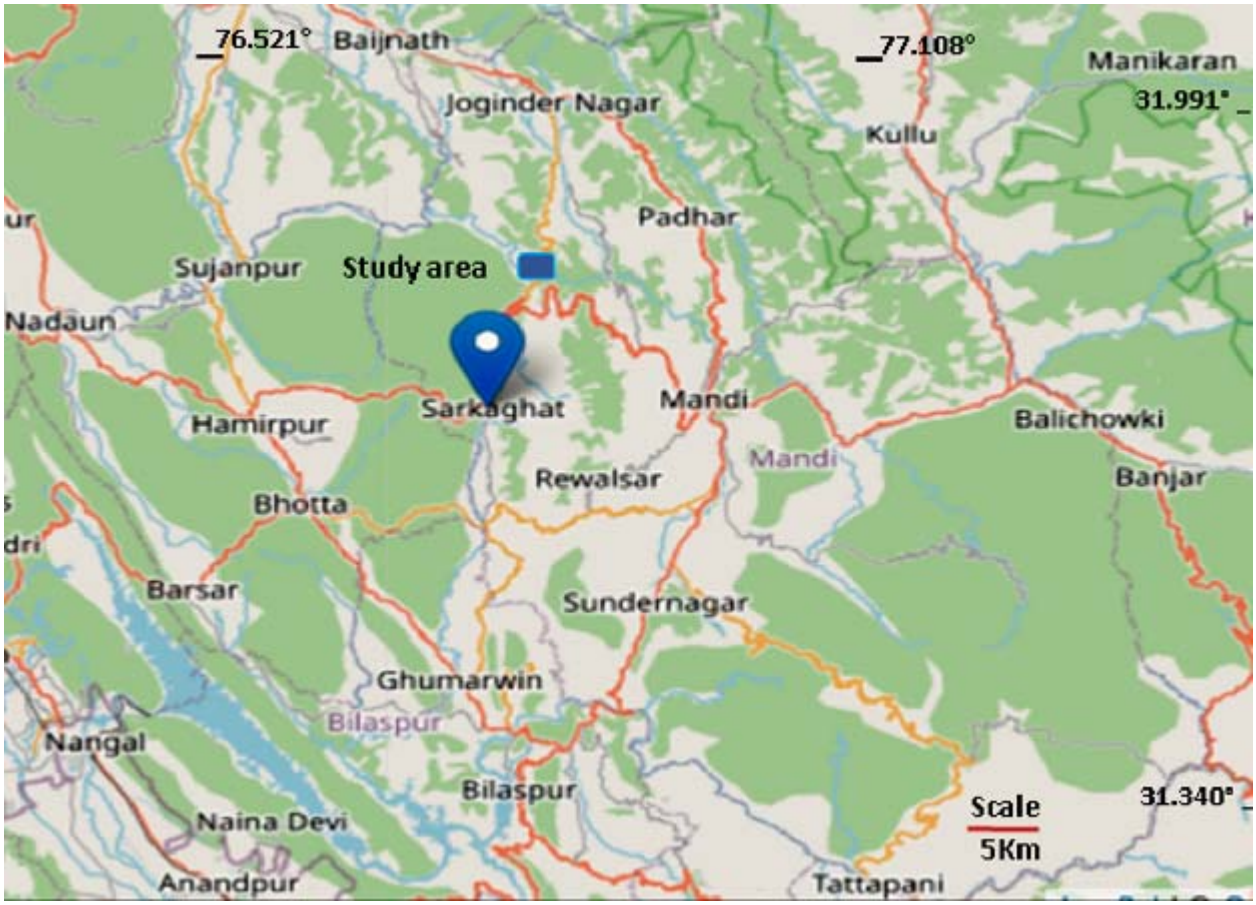

Figure 1. Location of the study area, Sarkaghat in Mandi district, Himachal Pradesh, India

Figure 2. Road cutting section exposed on Sarkaghat-Dharampur road from where fossil leaves were collected for present study (Thick arrow indicates the leaf bearing bed)

The fossil locality lies in Mandi District of Himachal Pradesh is a part of Middle Siwalik Sarkaghat anticline. About 8 km from the leaf fossil site is the Nalad Khad section (Lat. 31°46'N, Long. 76°43'E) which has been magnetostratigraphically studied and dated by earlier workers (Brozovic and Burbank 2000). The Nalad Khad section is located at, on the western limb of the Sarkaghat anticline, and in the Jawalamukhi thrust sheet. It is characterized by mainly thick units of fine to coarse, dark grey indurate, multistoried sandstones with red, yellow and brown pedogenic mudstones. They have also correlated the local magnetic polarity stratigraphy (MPS) to the global magnetic polarity stratigraphic time scale (MPTS) (Cande and Kent 1992). Generally, the sedimentary sequence in Sarkaghat (study area) is characterized by Middle Siwalik and consists of an alternate sequence of sandstones and shales, with predominance of plant macrofossils like impressions and carbonized woods.

METHODS

Sampling

The macrofossils were well preserved in the sedimentary sequence of Siwalik Group (Upper Miocene) exposed along the Sarkaghat-Dharampur Road in Mandi District, Himachal Pradesh, India. The fossil leaves were collected from road cutting section (31º44.265':76º43.339') near Sadhot Bridge about 7 Km from Sarkaghat town on the left side of main road which leads to Dharampur (Figure I & II). The leaf impressions preserved in the purple to gray shales were studied in detail with the help of hand lens and low power microscope under reflected light. The identification of leaves has been carried out at Central National Herbarium, Howrah, West Bengal. We followed the terminologies given for the description of fossil leaves in the present study (Hickey 1973, Dilcher 1974, Ash et al. 1999). The photographs of leaves of modern comparable taxa have been placed along with fossil in order to show their similarity.

Systematic palaeobotany of the fossils

Artocarpus nepalensis Prasad & Awasthi, Order - Rosales, Family – Moraceae, Tribe – Artocarpaceae, Genus - *Artocarpus* Forster & Forster

Artocarpus nepalensis Prasad and Awasthi 1996 (Awasthi and Lakhanpal 1990) (Fig. 3a,c)

Material: One specimen.

Description: Leaf simple, symmetrical, elliptical; preserved size 7.8 x 4.0 cm; apex unpreserved; base acute, slightly inequilateral; margins entire; texture thick chartaceous, petiole not preserved; venation pinnate, eucamptodromous to brochidodromous; primary vein (1º) single, straight, prominent, stout, thicker towards basal region; secondary veins (2º) about 8 pairs visible, alternate, about 0.5 to 1.5 cm apart, unbranched, angle of divergence acute angled (about 60-75º), basal pairs of secondaries arising closely, later curving upwards before reaching the margins, in apical region pairs of secondaries join super adjacent veins and forming a loop; inter-secondary veins present, some time it look like tertiary veins; tertiary veins (3º) angle of origin RR type, percurrent, straight to sometimes sinuous, branched, predominantly alternate and close, oblique to right angled in relation to midvein.

Figured specimen: Specimen No. MLK/S/104.

Locality: Road cutting section (31º44.265':76º 43.339') about 7 Km from Sarkaghat town (31º 44′26′′N: 76º43′33′′E) on the left side of main road which leads to Dharampur, Mandi District, Himachal Pradesh.

Horizon and Age: Middle Siwalik Group, Upper Miocene.

Affinities: Characteristic features of the present fossil leaves like symmetrical, elliptical shape, acute, inequilaterally base, eucamptodromous to brochidodromous venation, alternate secondary veins, markedly curving upwards and joining super adjacent secondaries forming a loop near the margins; RR, percurrent, straight to sinuous, oblique to right angled in relation to mid vein tertiaries, undoubtedly indicate a close resemblance with modern leaves of *Artocarpus heterophyllus* Lam. (C.N.H. Herbarium Sheet No. 6813548, Fig. 3b,d) of the family Moraceae.

So far, about 30 fossil species of the genus *Artocarpus* based on macrofossils (Wood, leaf and fruit) has been reported from Tertiary sediments of India and abroad (Table 1). Of them 20 species are based only on fossil leaves which have been compared with the present fossil. Comparison of the present fossil leaves with the above known species

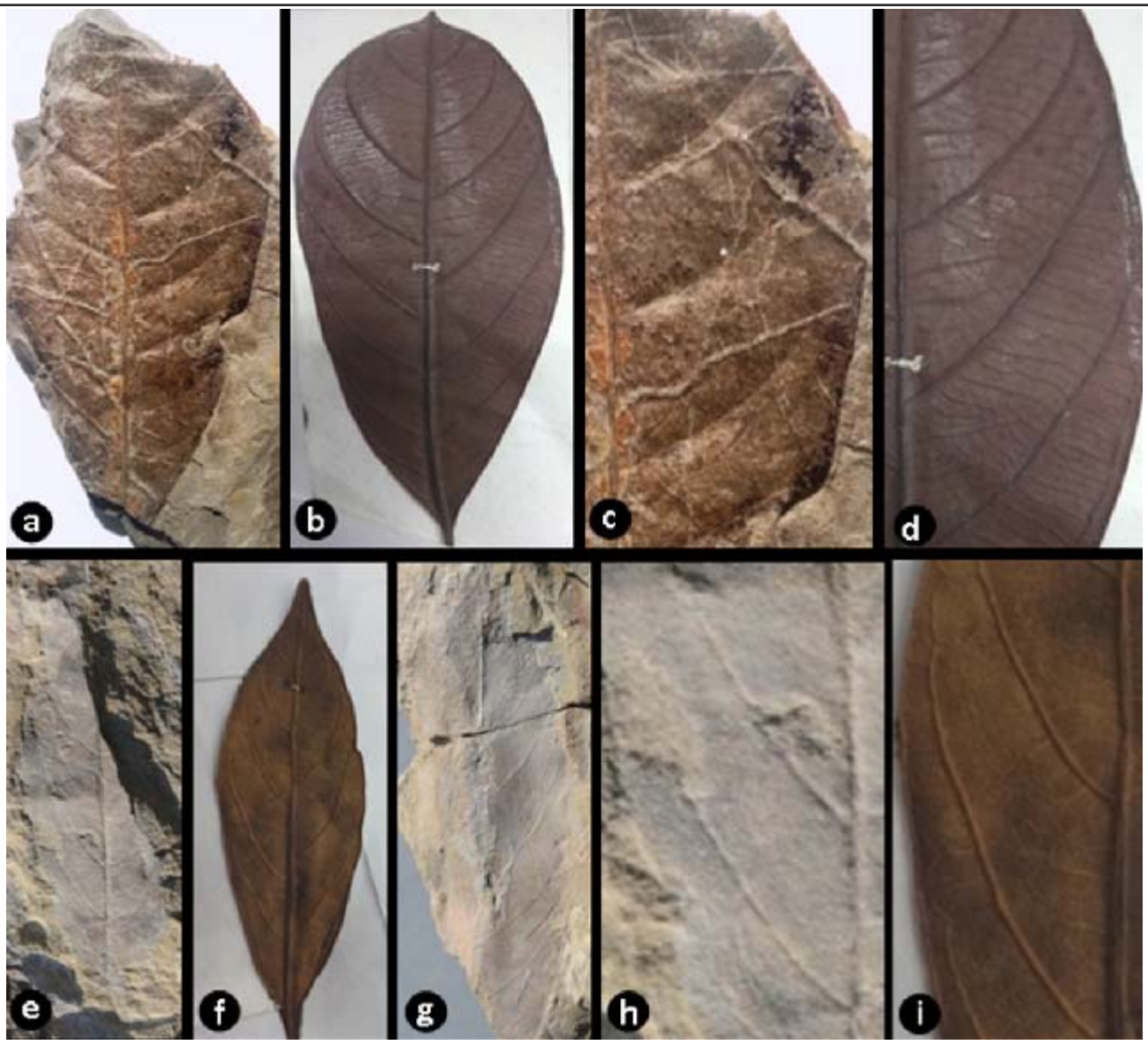

Figure 3 **(a)** Fossil leaf, *Artocarpus nepalensis* Prasad & Awasthi showing shape size and venation pattern; Specimen no. MLK/S/104 **(b)** Modern leaf, *Artocarpus hetrophyllus* Lam. showing affinity with the fossil leaf; Herbarium sheet no. 6813548. **(c)** A part of fossil leaf magnified to show the details of secondary and tertiary veins. **(d)** A part of modern leaf magnified to show the similar details of secondary and tertiary veins as the fossil. **(e & g)** Fossil leaves *Phoebe himachalensis* n. sp. showing shape size and venation pattern. Holotype specimen no MLK/S/105; Paratype specimen no. MLK/S/106. **(f)** Modern leaf, *Phoebe opaca* Blume showing affinity with fossil leaf; Herbarium sheet no. 385303. **(h)** Apart of fossil leaf, *Phoebe himachalensis* n. sp. magnified to show the detail of venation. **(i)** A part of modern leaf, *Phoebe opaca* Blume magnified d to show the similar detail of venation pattern.

revealed conspicuous difference with most of the species described mainly from outside of Indian subcontinents. However, the fossil species like, *A. murrecus* Sharma & Gupta, *A. garoensis* Bhattacharya and *Artocarpus nepalensis* Prasad & Awasthi described from India and Nepal, respectively, show near resemblance but one of these. *A. nepalensis* Awasthi & Prasad shows closest affinity with the present fossil and therefore, later has been treated as same species, *A. nepalensis*

Prasad & Awasthi.

The genus *Artocarpus* Forster & Forster of the family Moraceae (Artocarpaceae) comprises about sixty species native to India, South East Asia and Australasia (Zerega et al. 2005). *A. heterophyllus* Lam. with which fossil shows affinity is an evergreen tree grown in many countries including India, Myanmar, China, Sri Lanka, Malaysia, Indonesia, the Philippines, Brazil, Surinam, Caribbean islands, the United State, Australia and some African countries.

Phoebe himachalensis, Order – Laurales, Family – Lauraceae, Genus - *Phoebe* Nees, *Phoebe himachalensis* n. sp. (Fig. 3e, g).

Material: One specimen.

Description: Leaves simple, symmetrical, narrow elliptical; preserved size 7.0 x 1.3 cm (half lamina width); apex indistinct; base acute; margins entire; texture thick chartaceous, petiole not clear; venation pinnate, eucamptodromous; primary vein (1°) single, straight, prominent, moderately thick towards base, thinning towards apex; secondary veins (2°) 6-7 pairs visible, alternate to opposite, 0.5 to 2.0 cm apart, basal secondary veins closely placed than middle and upper ones, unbranched, angle of divergence narrowly to widely acute (about 45-70°), veins uniformly curving upwards and joining super adjacent secondary veins, inter-secondary veins simple; tertiary veins (3°) poorly preserved, angle of origin usually RR, percurrent, straight to sinuous, predominantly alternate, oblique to right angle in relation to midvein and close to distant.

Figured specimen: Specimen No. MLK/S/105 (Holotype), Specimen No. MLK/S/106 (Paratype).

Locality: Road cutting section (31°44.265′:76° 43.339′) about 7 Km from Sarkaghat town (31° 44′26′′N : 76°43′33′′E) on the left side of main road which leads to Dharampur, Mandi District, Himachal Pradesh.

Horizon and Age: Middle Siwalik Group; Upper Miocene.

Affinities: The narrowly elliptic, bilaterally symmetrical, acute based fossil leaves showing eucamptodromous venation pattern, narrowly to moderately acute angle of divergence of secondary veins, presence of simple inter-secondary veins and RR, percurrent, straight to sinuous, and close to nearly distant tertiaries resemble very closely the modern leaves of *Phoebe opaca* Blume (C.N.H. Herbarium Sheet No. 385303; Figure 3f,i) of the family Lauraceae.

So far, only two fossil leaves resembling the genus *Phoebe* Nees are reported from Tertiary sediments of India. They are *Phoebe champarensis* (Awasthi and Lakhanpal 1990) from Upper Siwalik (Middle Pliocene) of Bhikhnathoree, Champaran District, Bihar and *Phoebe sublanceolata* (Bhattacharyya 1983) from Lower- Middle Eocene (Tura Formation) of Garo Hills, Meghalaya. The comparison of these fossil leaves with the present fossil leaf suggests that *P. chanparensis* Awasthi and Lakhanpal differs in being larger size with lanceolate shape and having less acute angle of divergence than the present fossil leaf. However, *P. sublanceolata* differs in possessing different course of secondary veins. As the present fossil leaf is entirely different from already know fossil species it is being described here as *Phoebe himachalensis* n. sp. Some fossil fruits/ seeds like, *Phoebe thuringiaca, Phoebe boehlensis, Phoebe bohemica, Phoebe cinnamomea,* and *Phoebe cinnamomea* showing affinity with the genus *Phoebe* Nees have also reported from Eocene/Miocene sediments of Germany (Mai 1971). The genus *Phoebe* Nees comprises about 100 species of evergreen trees and shrubs widely distributed in tropical and subtropical Asia, neotropical America and China (Fa′nan and Werff 2008). *Phoebe opaca* Blume. with which present fossil leaf shows affinity is an evergreen tree growing in Malayan region (Ridley 1922).

RESULTS AND DISCUSSION

Study on plant fossils collected from Middle Siwalik sediments of Sarkaghat area revealed the occurrence of two new fossil leaves, showing their affinity with extant taxa, *Artocarpus heterophyllus* Lam. and *Phoebe opaca* Blume, of the family Artocarpaceae and Lauraceae respectively. *A. heterophyllus* Lam. is an evergreen tree presently distributed in the rain forests of Western Ghats as well as South-east Asian regions and *Phoebe opaca* Blume is also restricted to the evergreen forests of Malayan peninsula (Ridley 1922). The forest type and present-day distribution of above extant comparable taxa suggest that the Sarkaghat area enjoyed with tropical humid climate

Table 1. Macrofossils of the genus *Artocarpus* Forster & Forster from Cenozoic sediments of India and abroad.

Fossil species	Fossil locality	Type	Reference
Artocarpus nepalensis	Middle Siwalik of Surai Khola, Nepal Lower Churia Fm. Koilabas, Nepal	Leaf	Prasad and Awasthi 1996, Prasad and Dwivedi 2007
A. garoensis	Upper Palaeocene, Tura Formation, Meghalaya, India	Leaf	Bhattacharya 1983
Artocarpoxylon kartikcherraensis	Middle Miocene of Tippam Sandstone, Assam, India Miocene of Warkla, South India	Wood	Prakash and Lalitha 1978, Prakash et al. 1994, Srivastava 1998
Artocarpidium integrifolium	Tertiary of Austria	Leaf	Unger 1851
Artocarpoides perampla	Eocene of France	Leaf	Saporta 1863
Artocarpoides concephaloides	Eocene of France	Leaf	Saporta 1968
Artocarpoides wilcoxensis	Eocene of Texas	Leaf	Ball 1931
Artocarpoides balli	Eocene of Texas	Leaf	Ball 1931
Aetocarpoides lessigiana Lesquereux	Laramine beds, Colorado, USA	Leaf	Knowlton 1893
Artocarpoxylon deccanensis	Maastachtian/ Deccan Intertrappean beds, Madhya Pradesh and Miocene of Kalagarh, India	Wood	Mehrotra et al. 1984, Prasad 1993
Artocarpus basirotundatus	Middle Miocene of South Fujian China	Leaf	Jacques et al. 2015
Artocarpus dicksoni	Cretaceous formations of West Greenland	Fruit	Hollick 1936
Artocarpus ordinarius	Cretaceous stratum at the south bank of the Yukon River	Leaf	Berry 1916
Artocarpus califoenica	Eocene and Miocene strata of the Pacific coast of California and Oregon	Leaf	Hollick 1936
Artocarpus capellinii, *Artocarpus isseli* *A. macrophylla* *A. massalongoi* *A. multinervis* *A. ovalifolia* *A. sismondai* and *A. taramellii*	Lower Oligocene, of Santa Giustina and Sassello in Central Liguria, Italy	Leaf	Bonci et al. 2011
A. pungens	Lower Eocene of Louisiana, US	Leaf	Hollick 1899
A. dubia	Lower Eocene of Louisiana, US	Leaf	Hollick 1899
A. lessigiana	Eocene of Texas, USA	Leaf	Ball 1930
A. dissecta	Cretaceous of Vermejo Formation	Leaf	Knowlton 1917
A. similis	Cretaceous of Raton Formation	Leaf	Knowlton 1917
Artocarpophyllum occidentale	Cretaceous of Canada	Leaf	Dawson 1893
Aetocarpidium cretaceum Ett.	Cretaceous of Dakota Group, Kansas, USA	Leaf	Lesquereus 1891

during Upper Miocene times. It further inferred that there is existence of evergreen forests during those times in comparison to mixed deciduous forests there at present. Both the above comparable taxa are phytogeographically important because they have some interesting pattern of distribution in the present as well as during the geological past.

The genus *Artocarpus* (Jackfruit) of the family, Artocarpaceae comprises about 60 species native to India, South East Asia and Australasia (Zerega et al. 2005). It is widely distributed in evergreen or deciduous forests of Indo-Malaysia and Polynesia, a few species growing in tropical Africa, Australia and Madagascar (Pearson and Brown 1932, Santapau and Henry 1973, Willis 1973). *A. heterophyllus* Lam. with which fossil shows affinity is an evergreen tree grown in many countries including India, Myanmar, China, Sri Lanka, Malaysia, Indonesia, the Philippines, Brazil, Surinam, Caribbean islands, the US (e.g., Florida), Australia and some African countries. This is also reported on islands such as Palau, Yap, Pohnpei, Nauru, Tabiteuea in Kiribati and Samoa. *A. heterophyllus* Lam. is considered to be originated in the rain forests of the Western Ghats in the Southwestern part of India, but some authors argue that Malaysia could be the possible center of origin (Mowry 1958).

The fossil history of the genus *Artocarpus* goes back to Cretaceous Era. A large number of leaf's remains, woods and fruits are recorded from different Cretaceous and Tertiary sequences of the world (Table 1). The above records of the genus *Artocarpus* indicate its wider distribution in the geological past than present day distribution. The palaeobotanical records of the genus *Artocarpus* (Table 1) shows more than 30 different fossil species have been described from India and abroad. The oldest is a well-marked form based on fossil leaves and fruit, *Artocarpus dicksoni* Nathorst, from the Atane beds (Cenomanian) of West Greenland and *Artocarpoides lessigiana* Lesquereux from Laramie beds, Colorado, USA (Knowlton 1917). *Artocarpophyllum* Dawson is from younger strata (Upper Cretaceous) of Vancouver Island. The genus is widely distributed in the basal Eocene of North America. It continues in the Mississippi Gulf region until the close of the Oligocene, the last recorded occurrence being in the Alum Bluff sands at Alum Bluff on the Apalachicola River. On the Pacific coast it is found in deposits in California and Oregon which are referred to the Miocene. In the European area it occurs in the Tongrian of France, the Tortonian of Baden, the Pontian of France and Italy and the Pliocene of Italy. It is present in both the Pliocene and Pleistocene of the island of Java. *Artocarpus* is represented by petrified wood in the Oligocene of Antigua and it was evidently a member of the American flora from the Upper Cretaceous until late in the Tertiary. An extinct genus related to *Artocarpus* (Artocarpoides) described from the Paleocene of France (Saporta 1868). The time frame in which *Artocarpus* diversification coincides with boreotropical flora and a North Atlantic Land Bridge that could have allowed for dispersal from the Americas into Eurasia (Mcloughlin 2001). *Artocarpus* ancestors probably spread throughout Eurasia in the Eocene and began to diversify during this period of higher global temperatures. There are limited fossils of *Artocarpus* and its ancestors in Asia, but there are well-characterized wood fossils from the Intertrappean Deccan Beds in India dated from the Paleocene to the Miocene periods (present record), suggesting the genus or its ancestors had reached India by then (Mehrotra et al. 1984). This is consistent with dispersal across land, as India collided with Asia sometime between 43 and 50 Mya (Mcloughlin 2001, Sanmartín and Ronquist 2004). The *Artocarpus* fossil from China was recently described from a site that is considered to have strong phytogeographical connections with India (Jacques et al. 2015). The fossil was well preserved and from the Middle Miocene Fotan flora of Zhangpu County, South Fujian, China, an area that has been considered to represent tropical rainforest based on the occurrence of distinctive winged fruit fossils (Jacques et al. 2015). From southern Asia *Artocarpus* could have dispersed across land into the island of Borneo which is reconstructed as the greatest diversity and the ancestral range of *Artocarpus* as it exists today. Diversification in Borneo may have been followed by several separate dispersal events throughout Southeast Asia and Malaysia.

Phoebe Nees is a genus of family Lauraceae including about 100 species of evergreen trees and shrubs and distributed in the tropical and subtropical regions of Asia and neotropical America. The earliest

fossil record of Lauraceae can be dated to the Early Cretaceous (Drinnan et al. 1990). Some paleobotanists have suggested that the family Lauraceae originated at 174±32 million years, while others do not believe they are older than the mid-Cretaceous. Lauraceous fossil flowers showing affinity with (*Mauldinia mirabilis*) occur in clays (Mid-Cretaceous, 90-98 Million years ago) of the Eastern United States (Eklund and Kvaèek 1998). The abundant fossils have also been found in strata younger than Eocene (Li 1995). Most of the fossils of Lauraceae are common in the Tertiary strata of Europe and North America,

Seven species based on the leaf and fruit fossils of Lauraceae (including the genus *Phoebe* Nees) have been reported from the Middle Miocene of Zhangpu, Fujian, China (Wanga et al. 2017). These data provide evidence supporting the fact that a diverse subtropical or tropical evergreen forest having the dominance of lauraceous members surrounded this region about 15 million years ago. In Europe Eklund and Kvaèek (1998) described inflorescence fossils of Lauraceae from the Cenomanian of Bohemia, Czech Republic while Viehofen et al. (2008), reported the occurrence of the species *Mauldinia angustiloba* from the Cretaceous of Germany. Such fossils have also been collected from the Cretaceous of East Asia (Ferumin et al. 2004). Ferumin et al. (2004) also described *Mauldinia hirsuta* from the Late Cretaceous of Kazakhstan, while Takahashi et al. (1999, 2001) reported inflorescence fossils of Lauraceae from similar-aged rocks in Japan. On the basis of above fossil record it is clear that Lauraceae had widely distributed in Laurasia, Gondwana, and in the tropical zone around the Tethys ocean. A number of fossil woods (*Laurinoxylon* Felix) and leaves showing resemblance with the extant species of the genus, *Cinnamomum, Litsea,* and *Persea* are also recorded from the Neogene and Paleogene sediments of Indian subcontinent (Prasad 1990, 2008, Lakhanpal and Guleria 1981, Prasad et al. 2019). Occurrence of the fossil leaves of Phoebe in Lower-Middle Eocene of North east India (Bhattacharyya 1983), upper Miocene of Sarkaghat, Himachal Pradesh, and Middle Pliocene of Bhikhnathoree, Bihar, India, and some fossil fruit of this genus in the Eocene/Miocene of Germany, suggests that *Phoebe* is a genus of Gondwanan origin which spread throughout both the Northern and southern Hemispheres during the Cretaceous (Mai 1871).

CONCLUSIONS

The present investigation in the western Siwalik revealed the occurrence of two new fossil taxa showing their affinity with extant angiospermous species, *Artocarpus heterophyllus* Lam. and *Phoebe opaca* Blume of the family Artocarpaceae and Lauraceae respectively in Sarkaghat area of Himachal Pradesh, India. Both the recovered species are evergreen trees presently distributed in the rain forests of Western Ghats as well as South-east Asian regions. The present day distributions of comparable taxa suggest that the Sarkaghat and nearby area enjoyed with tropical humid climate during Upper Miocene times. The records of the genera, *Artocarpus* (Artocarpaceae) and *Phoebe* (Lauraceae) indicate its wider distribution in the geological past than present day distribution and they are originated prior to Cretaceous period.

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