Chapter-5

Conclusion

Soon after the discovery of the fossiliferous beds in Haridwar by Cautley (1832), where excellent vertebrate fossils were recovered from the sub-Himalayan hill ranges occurring between the rivers Ganga and Yamuna, assemblages of plant megafossils including petrified woods, abundant leafy forms, fruits and seeds were also reported from the Siwalik or Churia hills area.

The earliest report of plant megafossils from the Siwalik beds of India, Nepal and Bhutan was made by Sahani in 1931. He described a fossil wood, *Palmoxylon* sp. (Arecaceae), from Jammu. After a gap of more than two decades Ghose & Ghose (1958), described another fossil wood *Anisopteraoxylon* sp. from the Siwaliks of Himachal Pradesh. A few years later, another fossil wood *Dipterocarpoxylon* sp. was described by Rawat (1964) from the Uttarakhand Siwaliks. Leaves of shrubby plants like *Zizyphus* sp. and *Lagerstroemia* sp. were reported for the first time by Lakhanpal (1965) and Lakhanpal and Dayal (1966) from Himachal Pradesh. Closely following these reports, many more fossil leaves assignable to members of Myrtaceae and Ebenaceae (Varma, 1968), Moraceae (Lakhanpal, 1968), Lauraceae (Pathak, 1969) etc. were recorded from Siwaliks of Uttarakhand, Himachal Pradesh and West Bengal respectively. Besides the above, in subsequent years, innumerable plant fossils have been described from the Siwaliks of Nepal, Bhutan and India assignable to some 68 families and 251 genera of Angiosperm (see previous work in Introduction of thesis pp.5). In addition to angiosperms, a single pteridophytic fossil called *Cyclosorus* sp. of the family Thelipteridaceae has also been reported by Prasad and Pandey (2008), from the Nepal Siwaliks. However, very strangely, no fossil Gymnosperms
or non-vascular cryptogam has been reported so far from these beds. Absence of fossil remains belonging to the above groups, perhaps, indicated non-ideal preservation conditions for non-vascular cryptogams during the Miocene-Pliocene epoch. Even geologically, the period appears to have, not been very conducive for fossilization because of events like continued upliftment of the Himalayas as a result of Continental collision or orogeny along the convergent boundary between the Indo-Australian Plate and the Eurasian Plate. Reports of angiospermous remains alone also indicated that the flowering plants possessed the ability to resist unfavorable fossilization conditions more than other group of plants. Even though structurally unpreserved as compression fossils, the fossil remains are very well preserved in the form of impressions and petrifactions. All the Siwalik fossils described herein were allochthonously deposited in the Himalayan foreland basin as debris of the mountainous vegetation carried down by various mountainous rivers was deposited for fossilization in the shallow depression of the foreland basin.

In my opinion, the number of fossils reported up to date, is too meager compared to the immense debris, brought down by the rivers from the evergreen humid mountain forests. The possibility of quite a huge number of plant parts decaying and deteriorating in the process of transportation, much prior to landing in the bedding plain, cannot be ruled out.

Out of the 68 Angiospermous families, reported so far from the Siwaliks sediments (Prasad, 2008), fossils of 24 families are reported herein from the Arjun Khola area itself. The thesis describes 43 genera and 47, species assigned to the above mentioned 24 families. Out of the described fossils 34 are new reports being recorded for the first time from Arjun Khola area of western Nepal.
Amongst the fossils, are leaf form genera and only three fossil fruit form genera. Unfortunately, in the case of *Butea* Roxb. ex Willd. only the fruit pod and in the case of *Terminalia* L. only the drupe like fruit impression was available in the assemblage, Strangely however, leaves of plants bearing the fruits were observed only in the case of *Sindora* Miq.. Fossil fruits of this type are being reported for the first time from the Arjun Khola site, which adds further significance to the present study.

In the case of leaf forms, absence of cuticular did not hinder structural studies as surface features of leaves were so well impressed on shale that there was no difficulty in comparing morphological characters with living taxa and tracing affinity with modern equivalents existing in various forests of the present day vegetation. The excellent preservation of foliar details has also greatly aided the determination of Palaeoclimate on the basis of Foliar Physiognomy.

Out of the 14 profiles examined, profiles 5a, 6 and 7 have yielded the largest number of fossils while the other profiles have exhibited lesser fossils. The assemblage is dominated by leaf forms and the largest number of leaf form genera (6) is assigned to family Fabaceae. The seventh and eighth form genera taxa of the family *Butea* Roxb. ex Willd. and *Sindora* Miq., are only fruit pods. Amongst other sub-dominant families, the family Sapindaceae lists five leaf form genera, closely followed by family Dipterocarpaceae, showing four taxa of the leaf form genera and Annonaceae with three leaf form taxa. Families Achariaceae (Flacouriaceae), Lauraceae, Combretaceae and Moraceae are represented by two taxa each, while the remaining families like Lythraceae, Sterculiaceae, Anacardiaceae, Myrtaceae, Ebenaceae etc. are represented by a single form genus only.

The fossils of Arjun Khola assemblage are dominated by leaf form taxa exhibiting entire margins. Out of the leaf form described up to date viz., *Dillenia* and
Grewia exhibited non-entire margins while the rest exhibited entire margins. Leaf margin analysis is often considered to and determination of climatic conditions in the opinion of Bailey and Sinnott (1916) woody plants of tropical lowlands generally possessed entire margins while leaves of tree growing in temperate regions possessed non-entire margins. Even Wolf (1969) had suggested that tropical rain forest had the highest percentage of entire margined species. But determinations of climate become difficult in case where leaves showed both entire as well as non-entire margins. However in the case of present study leaf margin analysis seems to have aided determination of palaeoclimate became a majority of fossil leaves in the assemblage not only exhibited entire margins but also showed greater venation density, large to medium sized leaves with drip trips that cumulatively suggested a tropical to subtropical climate in the Middle Miocene-Pliocene epoch all along the Himalayan foot hills and in the Arjun Khola too.