PLEISTOCENE RESEARCH IN INDIA

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The paper deals with the research done on the Pleistocene period in India. The effects of glaciation in this country with regard to changes in topography, landscape, vegetation, with the soil features in relation to vegetation development, are discussed. Glaciation and the changes in plant distribution, climate, etc. are presented. Need for detailed studies on the problems relating to the Pleistocene period is emphasised.

INTRODUCTION

THE Pleistocene Period in India, as also in other parts of the Northern Hemisphere, was characterized by the extension of Ice Sheets over much of the northern parts of North America and Europe; and the advance of glaciers to lower altitudes in mountainous regions of the southern European countries and America, and the north-western parts of the Himalayas. In India, four glacial advances and three interglacial Periods have been distinguished from the Kashmir Himalayas and plant remains discovered from these deposits, popularly known as the Karewas, reveal an interesting sequence of climatic changes during the Pleistocene.

Contemporaneously with the glaciation, the Himalayas were uplifted by several thousand feet which influenced the survival, migration and succession of plants and animals over the greater part of India. The effects of the glaciation and mountain uplift in the north-west of India were felt in other parts of the country as well. The author has been greatly interested in these for the last several years; his interest having been created originally by the late Prof. Birbal Sahni, F.R.S., under whose guidance and inspiration much of the work on the Pleistocene Period was carried on. I, therefore, consider it a great honour to accept the invitation so kindly extended by Dr. M.R. Sahni to contribute an article in the Birbal Sahni Memorial Volume of the Journal of the Palaeontological Society of India.

Very little work has, in fact, been done on the Pleistocene Period in India ; but in other countries, separate Institutes have been developed for such studies. Recently an organisation has been set up in the United States of America to promote work on this most interesting period which holds the key to the solution of many diverse problems of biology, belonging not only to the present period but also to the Tertiaries.

THE EFFECTS OF GLACIATION IN INDIA

(*a*) *Changes in topography, landscape and vegetation*:—

The most visible effect of glaciation in the north-western Himalayas was the destruction of much of the contemporary topography, landscape and vegetation in which oaks and laurels were dominant on stabilised surfaces. These plants are now almost entirely absent from the modern vegetation of the Kashmir

valley, which has an entirely different landscape and topography, with morainic deposits, Karewas, rounded mountain tops, hanging valleys, etc. The glaciers brought down to lower altitudes all the plant material which got buried in moraines and glacial out-wash deposits. Large lignite deposits of commercial importance have been found in the Kashmir valley, which when fully exploited would be of considerable importance in the development of the area.

As a result of the glaciation the upper slopes of the mountains changed from stable habitats to unstable ones, in which the colonisation of plants, belonging to the earlier vegetation, was made impossible. The immediate effect of glaciation, was therefore, seen in the development of a different type of vegetation in which conifers predominated. Conifers are inhabitants of the northern latitudes of Europe and glacial conditions made their invasion of the Himalayas possible in the Pleistocene.

The morainic deposits at lower altitudes created pockets of fertile soils in the valleys and interesting colonisation of plants from higher altitudes started. Thus, *Abies webbiana* which normally occurs at very high altitudes, colonised morainic deposits at low altitudes in valley bottoms. The glaciation thus brought about an interesting inversion of the altitudinal zonation of a number of the Himalayan species; many examples of which are now found in the Kashmir Himalayas. It also brought about the exit from the Kashmir valley of a number of species which had constituted a dominant part of old vegetation, and instead brought about the dominance of another type of vegetation which can ecologically be called pioneer plant communities. The effects of glaciation in the Kashmir Himalayas have been so pronounced that the valley has not yet been able to reach stability and still supports pioneer plant communities of *Abies*, *Pinus*, *Cedrus deodara*, and mixed communities of conifers or/and broad-leaved species, such as *Aesculus*, *Prunus*, *Populus*, *Alnus*, *Betula*, *Salix*, etc. The stable Himalayan vagetation of *Buxus*, *Litsea*, *Machilus*, *Mallotus*, *Quercus*, etc., had disappeared from the Kashmir valley after the Pleistocene glaciation.

(*b*) *Changes in soil conditions and their effects on vegetation development.*

Much of the mature podsolic types of soils were destroyed by the glaciation, giving rise to immature, skeletal or brown earth type, of soil profiles that have been described from Kashmir and other glaciated parts of the Himalayas under the various conifers and mixed plant communities. The podsolic soil profiles, which are generally associated with the oaks and conifer communities of the northern latitudes in Europe and America, are absent from the glaciated parts of the Himalayas. There is, however, another type of podsolic soils which has been called the "Himalayan podsolic soils". These differ from the normal podsols in having the upper layer of the soil base saturated and with a high pH value. These soils may or may not have a high organic matter content; but at some places peaty conditions to a depth of a foot or two have been found.

These immature soil profiles occur in morainic deposits as well as in other transported soils in valleys. As a result of glaciation, many hanging valleys were formed and rivers were rejuvenated. In the plains, the drainage pattern of many of the rivers changed considerably. The eroding power of these rejuvenated rivers increased tremendously and on reaching the flat portions of the valleys they deposited much of their load forming flood plain deposits, which at some places are several thousand feet in thickness. These deposits occur not only in glaciated regions, but also in the unglaciated parts of the Himalayas through which these rejuvenated rivers passed through. Some riverain deposits belonging to the Pleistocene Period also occur in the Siwaliks and being secondary in origin, are generally more fertile than the old stable and leached soils. The riverain soils support a different type of vegetation than the surrounding areas with mature soils. Most of the Himalayan riverain deposits bear either pure communities of *Cedrus deodara*, or mixed communities of broad-leaved species of *Aesculus*, *Juglans*, *Cornus*, *Populus*, etc. Depending upon the composition of these secondary deposits, the broad-leaved communities and communities of *Cedrus deodara* either get stabilized or complete their succession in oak climaxes. There have developed three oak climaxes

in the western Himalayas; namely, *Quercus semecarpifolia*, *Quercus incana*, and *Quercus ilex*.

The latter oak climax occurs in the inner Himalayan ranges where the main rocks are granitic but in all the three climaxes at one stage or the other, *Cedrus deodara*, either pure communities, or mixed with other conifers and broad-leaved species, may be found. The predominance of *Cedrus deodara* communities, therefore, is the indirect result of the galciation. In the pre-glaciation vegetation there is a little evidence of the occurrence of deodar. The direct result of the glaciation is the invasion of the Himalayas by conifers of northern latitudes and later forming a dominant element in the vegetation of the north-west Himalayas in place of oaks and laurels, that occur predominantly only in the unglaciated regions, both in the north-west Himalayas and in the eastern parts of this range.

As a result of the slow melting of glacial ice, varved clays were also formed in some parts of the glaciated regions of the north-west Himalayas. These varved clays indicate a sequence of climatic conditions under which they were formed and are useful in themselves in revealing the climatic and organic history of the glaciated regions. A good deal of work has been done in Sweden by De Geer and such studies were extended to other parts of Europe and America; but very little work has been done in India. There are vast possibilities of undertaking studies on varved clays and the glacial deposits, if not for geo-chronological purposes, at least for finding out the wealth of plant material that may be present in these. The preliminary studies of the author have revealed an interesting type of pollen flora from the glaciated regions.

SOLUBILITY OF LIMESTONE

The refrigeration of the climate and rejuvenation of rivers resulting from the glaciation in the Pleistocene Period brought about an accelerated dissolution of limestone deposits of the outer ranges. Calcium bicarbonate thus dissolved was transported by rivers to the plains of India and as warmer conditions ensued much of the lime was re-deposited as carbonate. In the Indo-Gangetic Plains and also in valleys of rivers in the Deccan Peninsula, lime deposits in the form of Kankar pan occur at various depths. In cooler climates lime is a favourable factor in the development of a rich vegetation, being available for plant nutrition in the form of bicarbonate; but in warmer regions, much of the lime having been precipitated in the form of carbonate, creates a great deal of difficulties in the growth of luxuriant tree vegetation. A great deal of other salts which were also dissolved out of the Himalayan rocks by glacial conditions during the Pleistocene are now creating a great deal of difficulties in the proper utilisation of soils in the desert region and some parts of the Indo-Gangetic basin. The reclamation of *usar* and *kankar* soils is one of the major problems of India to-day.

GLACIATION AND CHANGES IN THE CLIMATE

Contemporaneously with glaciation, the West Himalayas were uplifted by about 5000-6000 ft., resulting in the blocking of valleys in the inner Himalayas of the free flow of the westerly monsoons. The middle and the inner Himalayas now receive a much lower amount of rainfall than in the Pleistocene. However, snow accumulations have increased in some of the areas. In some of the inner Himalayan valleys climatic conditions have considerably changed from the monsoonic tropical to monsoonic sub-tropical or monsoonic temperate and similar changes in vegetation have occurred.

The glaciation and subsequent melting of snow brought about a slight increase in the level of sea, surrounding India, as a result of which some parts of the western coast were submerged, destroying a good bit of forest areas. It is also believed that as a direct result of subsidence and the later emergence of some of the areas along the coast of India, laterites were formed. Although, opinions differ about the formations of laterites, one view is that laterites are fossil soils, formed due to the rapid leaching of bases from the soil body during glacial conditions in the Pleistocene. The laterites now bear a distinct type of vegetation on the coastal areas and an evergreen forest dominated by *Xylia xylocarpa* is present. Under forest conditions, laterite soils could be quite productive but as soon as vegetation is destroyed and area exposed, laterite hardens

up and the growth of a high forest becomes difficult.

GLACIATION AND CHANGES IN PLANT DISTRIBUTION

As a direct result of glaciation, the climate over much of the Indian sub-continent became frigid and brought about the migration of the Himalayan plants and animals to other suitable areas in India. Quite a number of plants from the Himalayas seem to have gained a foothold in the Deccan Peninsula during the Pleistocene. A good number of Himalayan plants occur in North Kanara on the west coast, some of which are: *Bixa orellana* (East), *Flacouratia ramontchi* (West), *Gynocardia odorata* (East), *Pittosporum floribundum* (East and West), *Garcinia xanthochymus* (East), *Sterculia villosa* (East), *Pterospermum acerifolium* (East and West), *Grewia disperma* (East and West), *Garuga pinnata* (East and West), *Dysoxylum binectariferum* (East), *Heynea trijuga* (East), *Nephelium longana* (East), *Semecarpus anacardium* (East and West), *Spondias mangifera* (East), *Butea monosperma* (East and West), *Barringtonia acutangula* (East), *Careya arborea* (East), *Legerstroemia speciosa* (East), *Ixora nigricans* (East).

Some west Himalayan species have also been found in the Eastern Ghats, some of which are given below:—

Flacourtia ramontchi, Pittosporum floribundum, Salmalia malabarica, Kydia calycina, Toona ciliata, Elaeodendron glaucum, Sterculia urens, Grewia disperma, Cassia fistula, Acacia pinnata, Hymenodictyon excelsum, Diospyros montana, Holarrhena antidysenterica, Ehretia laevis, Cordia dichotoma, Bridelia squamosa, Glochidion velutinum, Putranjiva roxburghii.

The present distribution of plants seems to have been influenced greatly by the Pleistocene glaciation.

GLACIATION AND DESERT CONDITIONS

Another notable feature of the glaciation is considered to be the deposition of loess in parts of the Siwaliks and the Potwar plateau in Pakistan, south of the Himalayas. These loess deposits comprise of organic matter, which was lifted up by wind from the Rajasthan area. As a result of this, much of the soils in the Rajasthan have become sterile and desert conditions had set in during the late Pleistocene. The dessication of this area, therefore, would possibly be related to glaciation of the north-west Himalayas during the Pleistocene.

Much of the Kankar in the old riverain deposits in the Deccan also is the result of the dissolution of limestone from those areas, during the Pleistocene and later deposition when warmer conditions ensued. Although there is little evidence, it may appear that the present pattern of monsoons in India may possibly date back to the Pleistocene Period.

GLACIATION AND HUMAN EVOLUTION

The rise of the human race is considered to be during the Pleistocene time. Human artifacts found in the Narbada Valley and in the Indus and Jhelum valleys in Kashmir seem to date back to some phases of glaciation.

A great deal of work, however, needs to be done in this line to reveal stages of human evolution during the Pleistocene.

CONCLUSIONS

In the above paragraphs, I have tried to indicate briefly the various problems that are peculiar to the Pleistocene Period of this country. The migration of plants and animals and the peculiar phyto-geographical patterns are particularly interesting to us. The study of soils of the Pleistocene deposits would greatly help in understanding the course of edaphic succession and plant succession. It is hoped that the Palaeontological Society of India would set up a suitable organisation to take up detailed studies of the problems related to the Pleistocene Period in India in which the late Prof. Birbal Sahni was greatly interested.