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Upper Pliocene-Quaternary vertebrate communities of the Karewas and Siwaliks

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The Karewa and Upper Siwalik fossil assemblages are of mixed types and include populations derived from different communities. The upland community is better represented in the Karewas while the aquatic community characterizes the Upper Siwalik assemblage. It is suggested that the Karewa fauna has European affinities, while the Upper Siwalik fauna has close relationship to Africa.

Introduction

The Upper Pliocene-Pleistocene non-marine deposits occur in various tectonic settings in NW India, particularly in the submontane Siwalik and in the Himalayan intermontane basins. This paper deals with only the uppermost Pliocene and Pleistocene deposits of the intermontane Karewas of Kashmir and submontane Siwaliks, highlighting biotic similarities, affinities and differences, with a view to assessing the influence of climatic conditions in NW India.

The initiation of the Pleistocene is marked by a global event recorded by microfaunal data in deep-sea sediments and supported by palaeomagnetism, terrestrial vertebrates and evidence for climatic oscillations. Although it is difficult to evolve uniform faunal criteria for boundary demarcation applicable to both marine and continental sequences, this event is considered to have taken place at the Olduvai normal sub-chron (1.8–1.6 m.y. B.P.). This event in India is correlated with the cold (glacial) period[1] and occurrence of Holarctic arvicolid rodents[2,3] in the Karewas, and with the tectonic activity in the Main Boundary Thrust zone that was precursor to the major upliftment of the Pir Panjal Range. As a consequence of uplift there was cessation of intermontane sedimentation at about 1.7 m.y. (ref. 4) and commencement of emplacement of the Boulder Conglomerate in the Siwalik[5] around 1.7 m.y. (ref. 6). In the Siwaliks of northern Pakistan, the first occurrence of conglomerates is observed at the Olduvai sub-chron[7]. All these dates coincide well with the Plio-Pleistocene boundary at the Olduvai event[8].

The Late Cenozoic non-marine sediments of India particularly the Siwalik and the Karewas are crucial to the understanding of the ongoing sedimentation and biotic development in the Indo-Gangetic Plain. Although the Siwaliks have now been studied for more than 150 years, it is only recently that a chronological time framework has been established for the Siwalik of Pakistan, India and Nepal[7,9–14], with the advent of magnetic polarity time scale (MPTS) and micromammalian biostratigraphy. In the lacustrine basins such as the Karewas, magnetic and faunistic correlation offers high degree of precision in building up the stratigraphy[4,15-17]. Very recently, attempts have been made to provide the chronological framework to the mammalian localities in the lake sediments of Central Nepal[18].

Kerewa and Pinjor megamammals: Comparison

Analysis of the main megafaunal elements of the Upper Pliocene-Pleistocene times in the submontane Siwaliks and the intermontane Karewa of Kashmir is shown in Figure 1. A majority of workers[7,11,19-20] place the appearance of *Equus* and *Cervus* within the Matuyama Chron near the base of the Guass/Matuyama boundary. However, the records of *Elephas* (e.g. *E. planifrons*) are older than of *Equus* and *Cervus*[7,19]. These faunal elements appear in the Karewas about 2.2 m.y. ago—a little later than in the Siwaliks[21]. In the lacustrine deposits of the Kathmandu valley of Nepal, the occurrence of the large mammals (*Hexaprotodon, Crocodylus, Elephas*)[22,23] has not been shown within the palaeomagnetically dated stratigraphic succession and therefore these fossils cannot be placed in the magnetic polarity time scale. However, the fossil localities are in the Lukundol Formation which falls within the Gauss and Matuyama chrons[18]. The typical Pinjor fauna in the Siwaliks disappear after the Jaramillo event[20]. In the sediments of Central Nepal, no fossils are found in the upper part of the Lukundol Formation which is younger than 0.9 m.y. (ref. 18). In the Karewas, however, *Elephas* occurs in abundance in the Brunhes Chron (Figure 2).

Vertebrate communities of Karewa and Pinjor

The Pinjor and Karewa fossil assemblages are classified under various communities as shown in Table 1.

Upland community

In the Karewas, the upland vertebrate communities represented by the faunal elements (Schizothoracinae fishes and arvicolid rodents), are not found in the Siwaliks. At present the Schizothoracinae fishes are recovered from the altitudes[24] as high as 3500 m, and the voles are known to occur at high altitudes[25] of about 3000 m. The Karewa arvicolids are recovered from the sediments resembling channel facies. These voles probably inhabited the banks of upland streams which washed down their remains along with the Schizothoracine fishes into the accumulating sediments

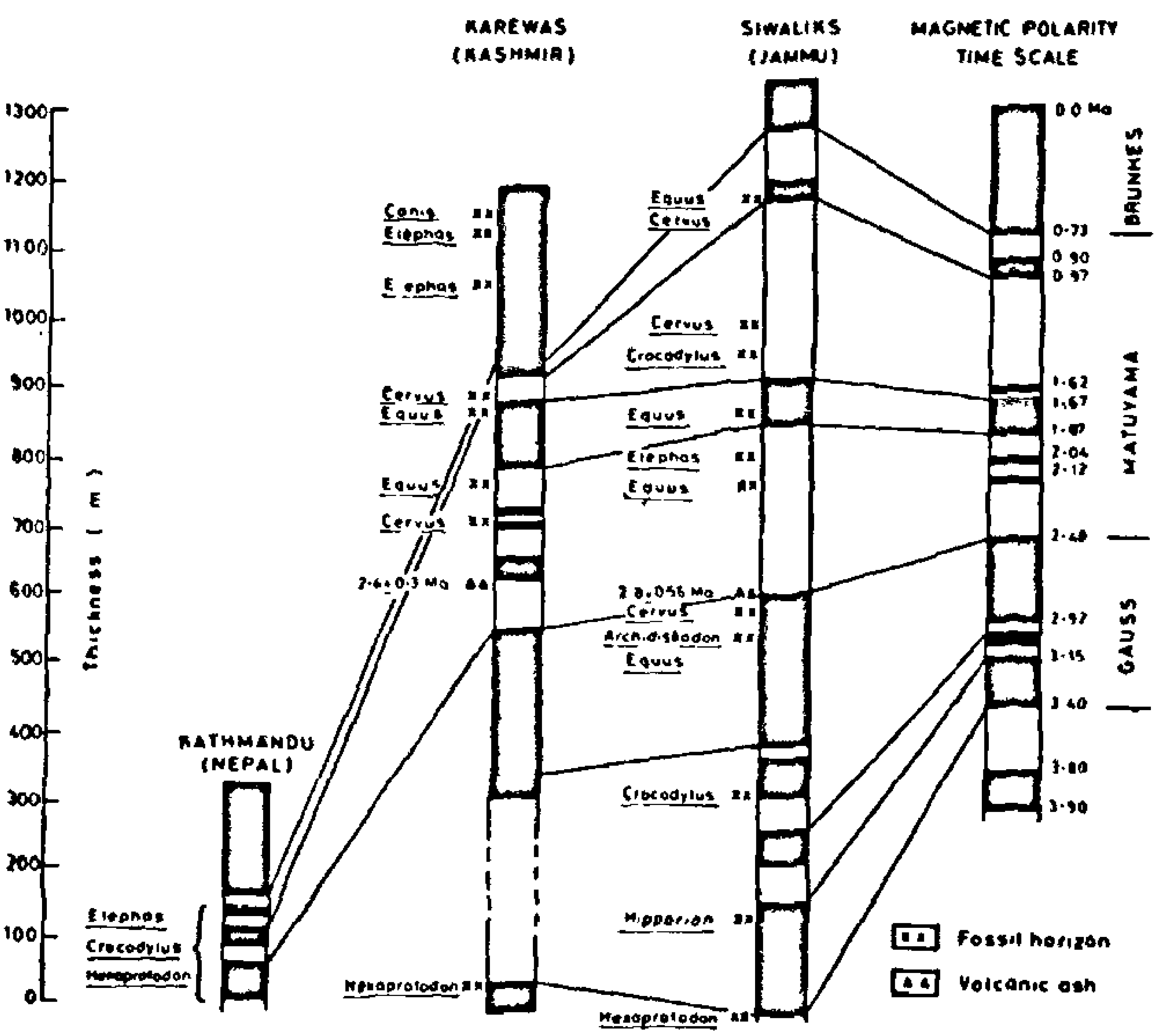

Figure 1. Biostratigraphy and magnetostratigraphy of the Siwaliks, Karewas and lacustrine deposits of Central Nepal. Data are taken from Ranga Rao *et al.*[12], Yoshida and Gautam[18], and Kotlia[21].

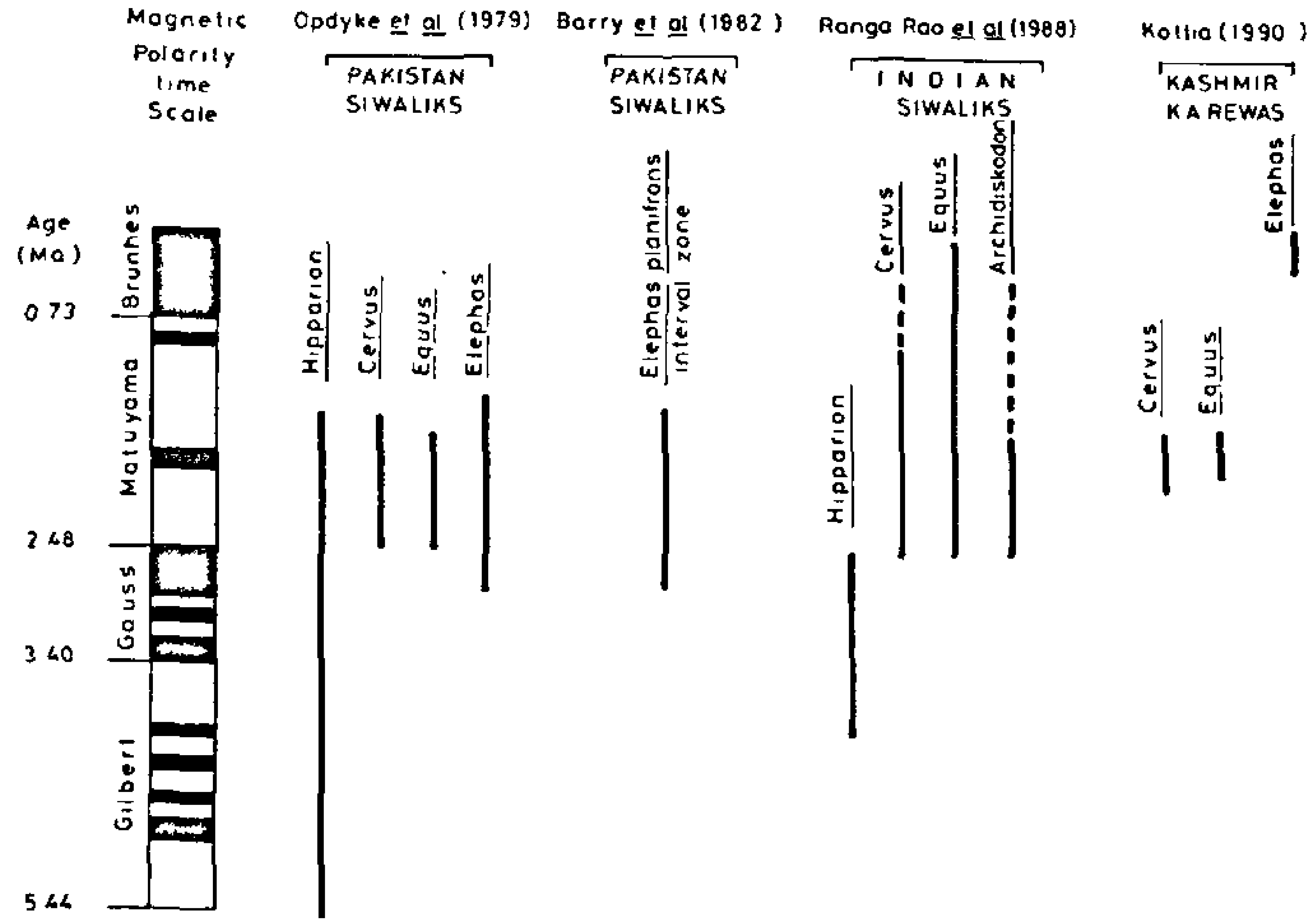

Figure 2. Placement of large mammals from the Karewas and Siwaliks in the magnetic polarity time scale.

Table 1. Upper Siwalik and Karewa vertebrate assemblages

Community	Siwaliks (Pinjor onwards)	Karewas
Upland community	Not well represented	Schizothoracinae fishes Arvicolid rodents
Pool zone/Aquatic community	Channid, bagrid, clariid, silurid and few cyrinid fishes Crocodiles and turtles, *Hexaprotodon*, *Hippopotamus*	*Hexaprotodon* Cyprinidae fishes
Microterrestrial community	*Rhizomyoides, Mus, Nesokia, Hystrix, Caprolagus, Suncus*	*Mus, Apodemus, Episoriculus*
Megaterrestrial community	*Canis, Elephas, Equus, Rhinoceros, Sus, Camelus, Cervus, Sivatherium*, several bovids	*Canis, Elephas, Equus, Rhinoceros, Sus, Cervus, Sivatherium*, bovids rare

of the Karewa lake. Therefore, the presence of the Schizothoracinae fishes and arvicolid rodents in the Karewas indicates that the mountains surrounding the Karewa basin were at least about 3000 m high during deposition of the above-mentioned fossiliferous horizons, while the basin itself was at the elevation 1500 m above m.s.l.

Pool zone/Aquatic community

The palaeoecologically very significant feature of this community is that the reptilian components (crocodiles and turtles), which are the most common elements of the Pinjor Formation, have so far not been recovered from any part of the Karewa basin[26]. This may probably be related to lower temperatures prevailing in the Plio-Pleistocene times in the Kashmir valley, compared to that in the Pinjor. The areas of shallow water, which were devoid of currents, either in the streams or around the periphery of the lakes in both Karewa and Siwalik were probably occupied by *Hexaprotodon* which h is a common presence in both the basins.

Microterrestrial community

This community in the Karewas is represented by the soricid insectivores, murid rodents and cyprinid fishes, present in the low-lying Karewa Basin. This Basin was probably forested, and inhabited by mammals, while the streams supported freshwater molluscs. The dominant Karewa murids are *Mus* and *Apodemus*, the latter being Palearctic and may have gone beyond the Palearctic limit into Kashmir valley[27]. On the other hand in the Siwaliks, the most common rodents are rhizomyids[28,29]. Among the soricids, the presence of two tribes, Soriculini and Beremendiini from the Karewas[30] argue for the faunal similarity between Europe and Kashmir during the Upper Pliocene times. These tribes so far have not been found in the Siwaliks.

Megaterrestrial community

A major portion of the primary and secondary consumer population of both the Karewas and Siwaliks belong to this community which is represented by proboscideans, equids, cervids, giraffids, bovids, canids, etc. The dentition of most of these forms is suited to the harsh vegetation. The abundance of bovids in the Pinjors may reflect more of grasslands and savannah environments. In the Karewas in contrast the bovids are extremely rare.

Microfaunal affinities and climate conditions

An analysis of the faunal affinities and present-day distribution of several vertebrate taxa indicate that the Plio-Pleistocene faunas in these two distinct tectono-sedimentary settings were probably related to the palaeoclimatic fluctuations, rather than to the geographic proximity with each other. The micromammalian assemblages of the Karewas show affinities with the corresponding taxa of the Eurasian origin. On the other hand, the vertebrate assemblages of the Siwaliks affinity show a general affinity with those of the African region.

Karewa faunal affinities

Among the Karewa rodents, the arvicolids are of particular interest. For, they indicate temperate to arctic/glacial conditions, and they had short span of survival. From about 2.5 m.y. onwards, at least five arvicolid occurrences (2.5, 1.8, 0.85, 0.44 and 0.128 m.y.) are recorded in Northern Hemisphere. Three of these occurrences (2.4, 1.6 and 0.2 m.y.) in the Karewas of Kashmir can be correlated with those of N. America and Europe (Figure 3). The Karewa arvicolids from the above mentioned horizons have been described in detail and their phylogenetic relationship with European arvicolids, discussed[31]. It is assumed that the arvicolids migrated to Kashmir Basin across the rising Himalaya across Baluchistan and Afghanistan. It is envisaged that it was the European *Cseria* which migrated to Kashmir valley, prior to 2.4 m.y. in the form of *Kilarcola indicus* and giving rise to *K. kashmiriensis* at about 1.6 Ma (refs. 31, 32). Like in *Mimomys* of Europe, the phyletic gradualism in the Karewa arvicolids is well-documented showing the major stages of development of dental trends such as increase in size and height of dentine tracts, appearance of cement, and disappearance of enamel islet and roots[31].

Figure 3 shows the correlation of climatic and arvicolid stratigraphies in N. America and Europe. At about 2.5 m.y., the climatic stratigraphy as inferred from oceanic records, shows the climax of the first significant accumulation of continental ice in the Northern Hemisphere[33]. In Kashmir this period marks the introduction of the arvicolids acclimatized to the harsh winter conditions[17]. Within the Pleistocene, out of four arvicolid dispersal events, the first took place at the Olduvai normal sub-chron and is characterized by the most dramatic Holarctic arvicolid dispersal so far known[34]. This is dated to about 1.8 m.y. in N. America and Europe and to about 1.6 m.y. in Kashmir. The second Pleistocene dispersal event, which is believed to have taken place at about 0.85 m.y., can be correlated

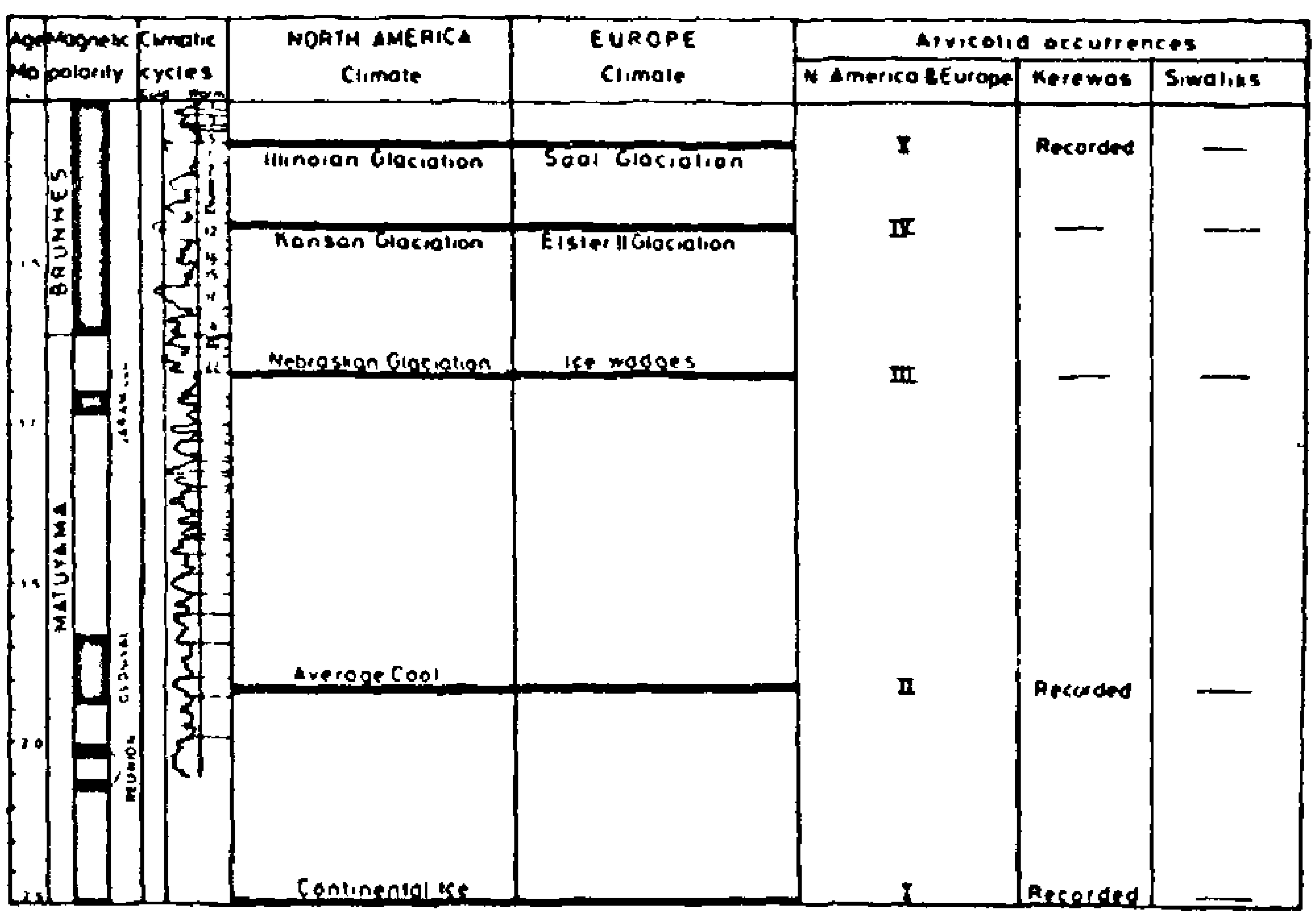

Figure 3. Climatic stratigraphy and arvicolid occurrences in the Upper Pliocene–Pleistocene in N. America, Europe and India (Modified after Repenning[34]).

with the time of the most extensive glacial advance of the Nebraskan glaciation in N. America[35], and with the time of formation of High Terrace in parts of Europe indicating the ice wedges[36]. This event in the Karewas, however, is not yet recognized. The Kansan and Elster II glaciations in N. America and Europe, respectively, were accompanied by the third Pleistocene dispersal event which is dated 0.44 m.y. This event is also not recorded in the Karewas. The fourth Pleistocene dispersal event of the arvicolids is correlated with the Illinoian and Saal glaciations and is dated to 0.128 m.y. in N. America and Europe and to ca. 0.2 m.y. in the Karewas. No arvicolids have so far been recovered from the Siwalik sediments.

The murid rodents seem to be significant for understanding intercontinental faunal exchanges. The Karewa murids indicate the earliest appearance in the Indian subcontinent of *Apodemus* and advanced *Mus* at about 2.4 m.y. (ref. 27). The abundance of *Apodemus* specimens in the Karewas suggests that it was common during the Pliocene in the Kashmir valley as in Europe. *Apodemus* has not yet been reported from the Siwalik molasse.

The presence of the soricid tribes, Soriculini and Beremendiini in the Karewas at about 2.4 m.y. argues for the faunal similarity in Europe and Kashmir valley during the Late Cenozoic period[30]. *Episoriculus*, belonging to tribe Soriculini, was abundant throughout the Pliocene in Europe and became extinct after the Olduvai event[37]. The monogeneric tribe Beremendiini is assigned a Plio-Pleistocene age in Europe[38]. Excepting for the Karewas, the only Asian record of this tribe is from the Pleistocene of China[39].

Siwalik faunal affinities

Several of the larger mammals occurring in the Plio-Pleistocene Siwalik are still found in Africa. There has been, thus a shrinkage in the range of such large herbivores such as giraffes, hippos and rhinos, presumably due to the onset of drier conditions. It is speculated that this control applies to several other groups of vertebrates such as fishes, ostriches and micromammals. Amongst the fishes, restriction in geographic range is exemplified by a clariid *Heterobranchus* which is common component in the Plio-Pleistocence Siwalik faunas[40] but now is restricted to the African region where it is represented by *H. longifilis* and five other species. Clariids in general are marsh loving and pool dwellers, and the absence of *Heterobranchus* in India today may be taken as an indication of increasing aridity.

Similarly, the ostriches found in the Middle Siwalik times and during the Upper Palaeolithic times (Terminal Pleistocene[40]) show close affinity with *Struthio camelus* of Africa.

Conclusion

The Plio-Pleistocene rodent assemblages of Africa and India witnessed several exchange events. It has been shown that *Golunda* and *Mus* infiltrated into India about 2.5 m.y. ago[41]. *Golunda* has been reported from the Tatrot Formation of the Saketi Fossil Park area[41]. The African taxa *Pelomys* and *Mylomys* are considered to be closely related to the Asian extant *Golunda*[29]. At least two genera, *Hardomys* and *Bandicota* are not represented in the fossil records outside the Indian subcontinent.

The faunal data thus indicate that there was distributional disparity in the two basins, probably resulting from palaeoecological difference. Even after allowing for the Pleistocene uplifts of the Kashmir basin, the Karewas appear to have been deposited at a higher elevation than sediments of the upper Pinjor Formation[42]. Much of the Karewa faunal assemblage shows close resemblance with the Eurasian fauna, while the Siwalik fauna shows affinity with the African fauna. It may be assumed that during the Quaternary period, the Pir Panjal was high enough to prevent extensive faunal exchange between the Karewa and the Siwalik basins. Most of the Karewa micromammals (e.g. arvicolid rodents, *Apodemus, Episoriculus*) had probably migrated from Europe. On the other hand, a considerable part of the Siwalik fauna has African affinities.

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Quaternary basins of Ladakh and Lahaul-Spiti in northwestern Himalaya

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The Quaternary basins of Ladakh and Lahaul-Spiti regions are made up of sediments of lacustrine, fluvial and glacial origin. Quaternary tectonics has played a dominant role in the formation of these basins, differential uplift of the orogen having influenced the sedimentation of these basins, *vis-à-vis* climate and vegetation. The differential uplift during the past 35,000 years was substantially responsible for the climatic oscillations between cold-dry and hot-humid phases. These events varied from place to place due to tectonically caused elevational differences.

Introduction

THE Ladakh and Lahaul-Spiti region in northwestern Himalaya (Figure 1) is located between the Great Himalaya in the south and the high plateau of Central Asia in the north. In the cold arid to semiarid climatic zone there are a number of Quaternary basins of lacustrine, fluvial and glacial origin. The Quaternary tectonics has played a dominant role in the formation of these intermontane basins.

The nature of the Quaternary basins with special reference to the Late Pleistocene-Holocene remnant lacustrine deposits of Lamayuru (Ladakh), saline Tsokar lake (Ladakh), relict lake deposits between Kenlung and Yunam Tso (Lahaul) and ancient lacustrine deposits of Hanse-Kioto and Attargo-Lingti-Dankar (Spiti) are discussed (Figure 1). Some aspects of lacustrine sediments of the region have recently been described by Bürgisser *et al.*[1], Fort *et al.*[2], Bhattacharyya[3] and Bagati and Suresh[4].

Tectonic evolution

Following the continent-continent collision between India and Asia, around 45–50 m.y., the first major phase of the uplift occurred around 20 m.y. This event initiated development of the Siwalik foreland basin in front of the rising Himalaya. The second major uplift took place around 4–5 m.y., giving rise to intramontane basins of Kashmir and Peshawar[5]. The Boulder Conglomerate of the Upper Siwalik, dated at 1.6 m.y. and indicative of rapid uplift of the provenance, demarcates the third major phase of uplift in the Himalaya.

In the Trans-Himalaya region the first major phase of uplift produced intramontane basins in the Indus Suture Zone of Ladakh which got filled up with Tertiary molasse. The younger Quaternary molasse are located at Karoo, Liyan and Kyul. At Karoo the molasse deposit resting over the southern margin of the Ladakh batholith is principally derived from Ladakh plutonic complex. The Liyan molasse contains clasts of volcanics and ophiolite of the underlying Nidar Formation. At Kyul, the molasse is totally derived from the Ladakh