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PALAEONTOLOGY, AGE, PALAEOENVIRONMENT AND PALAEOECOLOGY OF THE KAREWA INTERMONTANE BASIN OF KASHMIR (J&K, INDIA)

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Key–words: Vertebrate fauna, Age, Palaeoecology, Karewa Group, Kashmir India, Plio–Pleistocene magnetostratigraphy.

Riassunto. Una ricca associazione di Vertebrati fossili, composta in particolare di Pesci e di Mammiferi, è stata raccolta nei sedimenti plio–pleistocenici del Gruppo di Karewa nella Valle del Kashmir, India. I componenti più significativi dell'associazione a Mammiferi, per lo più alloctona, sono costituiti da Roditori Microtini e da Insettivori, che comprendono oltre ad alcuni nuovi taxa, anche taxa di nuova segnalazione per il subcontinente indiano. La fauna a Vertebrati di Karewa è stata correlata con la scala cronologica paleomagnetica e ciò ha consentito di fissare il limite Plio–Pleistocene in corrispondenza della comparsa dei Roditori Microtini. L'associazione fossile a Pesci, considerata in genere autoctona, è composta per lo più di Schizothoracini e Cyprinidi, che comprendono una mescolanza di forme di basse e alte latitudini. La fauna a Mammiferi da parte sua suggerisce la presenza di un mosaico costituito in prevalenza da praterie aperte e da praterie con macchie di alberi, con subordinate aree boschive e coperture di cespugli. I sedimenti di Karewa sono in predominanza di origine lacustre, solo parzialmente fluvio–glaciali ed eolici.

Abstract. A rich assemblage of vertebrate fossils, especially fish and mammals, has been recovered from the Plio–Pleistocene Karewa deposits of Kashmir (J & K, India). Microtine rodents and insectivores, including some new taxa and first reports, form the most significant component of the assemblage. The Karewa vertebrate palaeontology is correlated with the magnetic polarity time scale. The Plio–Pleistocene boundary in Karewas is marked by the appearance of microtine rodents. The fossil assemblage is an admixture of high altitude and low altitude fauna. The fauna indicates the occurrence of a mosaic of dominant grassland and wooded grassland with some bush cover and wooded areas. A dominant lacustrine with some glacio–fluvial and aeolian environments are indicated for the Karewa sediments.

Introduction.

The Kashmir Valley in northwestern India preserves a complete record of the Late Cenozoic sedimentation and the mountain building history of the last 4 Myr in the form of continental deposits. These deposits are spread over

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nearly half the expanse of the valley and are collectively known as the «Karewas» or the «Karewa Group». The Kashmir basin is a typical intermontane basin and is about 140 km long and 40 km wide. It is widely understood that this basin developed as a result of the ponding of the southwardly flowing drainage lines by the uplift of a mountain range, the Pir Panjal Range, in the Pliocene. This basin provides an excellent case for the investigation of the origin and development of intermontane basin.

Vertebrate fossils from the Karewa basin have been collected since the early 20th century. Majority of the reports document the fossil fish (Godwin–Austin, 1864; Mukerji, 1936; Hora, 1937; de Terra & Paterson, 1939) and very few fossil mammals have been described (Badam, 1968, 1972; Tewari & Kachroo, 1977; Sahni, 1982; Sahni & Kotlia, 1983, 1985; Kotlia, 1985a). The micromammals which are very useful for biostratigraphic and environmental purposes are poorly recorded from the Karewa deposits (Kotlia, 1985b). Although some fission track dating and palaeomagnetic studies have been conducted on the «Karewa Group» (Burbank & Johnson, 1982, 1983; Kusumgar et al., 1985 a,b), no serious effort has so far been made to correlate the vertebrate palaeontology with the palaeomagnetic time scale.

We present here a report on the vertebrate fauna, age, palaeoenvironment and palaeoecology of the Plio–Pleistocene Karewa deposits of Kashmir. An attempt has also been made for the first time to integrate the vertebrate palaeontology with the magnetostratigraphy and to identify the faunal associations at the Plio–Pleistocene boundary in the Karewas.

Geological setting.

The Kashmir basin of northwestern India is bounded in the northeast, southwest, northwest and southeast by the Great Himalayan Range, Pir Panjal Range, Kaznag Range and Saribal Range, respectively. The Plio–Pleistocene Karewa deposits which fill this basin rest unconformably over the Palaeozoic and Triassic bed rocks. These deposits are over a km thick and exposed as plateau–like terraces of sandstone–mudstone successions intercalated with gravel and thin but extensive bands of lignite or lignitic mud. The Karewa sediments are commonly divided into two lithostratigraphic units, viz., the Lower Karewa Formation and the Upper Karewa Formation. Lower Karewa deposits are much thicker and extensively exposed on the Pir Panjal flank while the Upper Karewa deposits are relatively thin and better exposed on the Himalayan flank.

Lower Karewa deposits are gently inclined, dipping in general from 5° to 12°, and have an unconformable contact with the overlying nearly horizontal Upper Karewas. However, dips of about 60° associated with sharp monoclinal folding were measured in the lowest part of the Lower Karewas when

these sediments abut upon the Pir Panjals on the southwestern border of the valley (Kotlia, 1984). This indicates that Pir Panjals have undergone considerable elevation since Karewa deposition. Although more than a dozen section were measured, the best exposed Lower Karewa sections are along Rembiara river, between Dubjan and Krachipatra, and Romushi river, between Ichhagoz and Romu. Well–exposed Upper Karewa sections were measured at Sombur and Burzahom (Fig. 1).

Lithologically, the Lower Karewas are characterized by bluish to greyish compact mudstone, laminated greyish claystone yellowish muddy rhythmites, light grey to bluish silty claystone, fine to coarse–grained greyish to greenish sandstone, thin but extensive lignite layers, and conglomerate horizons with mudstone and claystone lenses. Upper Karewas are characterized by greyish, brownish, and laminated yellowish claystone and siltstone, greyish to greenish

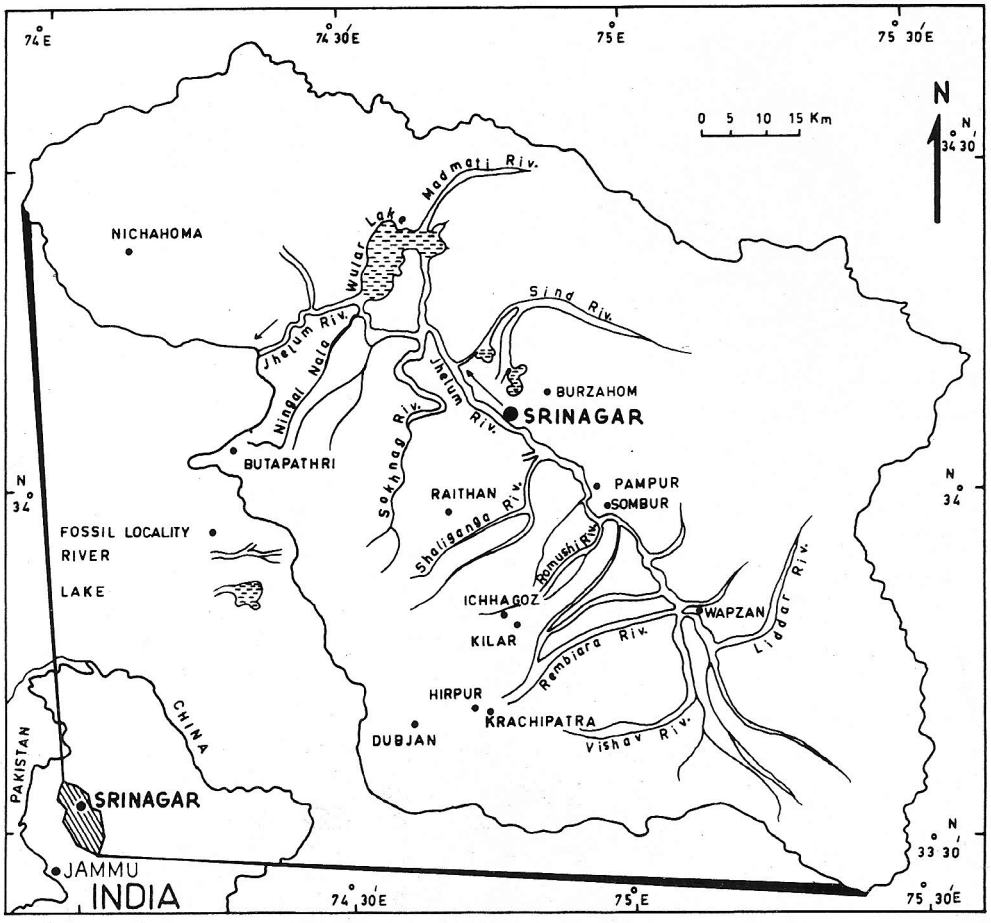

Fig. 1 – Generalized locality map of the Karewa Basin.

fine–to–medium–grained sandstone, some conglomeratic layers and fine silt–sized wind deposited structureless sediment (loess) associated with some dark humic layers (palaeosols). Sedimentary structures, such as graded bedding, large– and small–scale cross–stratification, scour and fill structures, internally graded thin laminations, convolute laminations, micro–ripple laminations, etc., were observed in the Karewa deposits.

Vertebrate fauna.

During the field sessions of 1980–1983 a large number of fossil vertebrates were collected from different localities (Fig. 1) in the Karewa basin. A list of different fossil taxa along with the minimum number of individuals is presented in Table 1. Lower Karewa deposits yielded a greater number of specimens than the Upper Karewa deposits. This disparity in the proportion of fossil content between Lower and Upper Karewa Formations could be attributed to the greater thickness and better exposed nature of the former. As is evident from Table 1, a major proportion of the vertebrate assemblage consists of fish. Among the mammals, microtine rodents, *Cervus, Elephas* and *Equus* are better represented. In contrast with the Tatrot and Pinjor Formations of Upper Siwalik, where one–third of the mammalian assemblage consists of bovids (Gaur & Chopra, 1984), the present assemblage is devoid of bovids. Even in literature only a couple of bovide specimens (de Terra & Paterson, 1939; Badam, 1972) have been documented in the past. Apart from the taxa reported in Table 1, *Sivatherium, Rhinoceros, Sus, Felis* and *Bos* have also been reported from the Karewa deposits by de Terra and Paterson (1939) and Badam (1968, 1972). Camelids, reduncines and antelopes are unrecorded from the Karewas.

Some microtine rodent taxa, viz. *Pliopotamys, Pitymys, Microtus* and *Mimomys* are reported here for the first time from the Plio–Pleistocene deposits of the Indian subcontinent. In addition to the above mentioned microtine taxa, the present collection also includes many specimens of a microtine, viz. *Kilarkola kashmiriensis*. As can be seen in Table 1, six new species of fossil mammals (to be described elsewhere), viz. *Pliopotamys* sp. nov., *Pitymys* sp. nov., *Microtus* sp. nov., *Mimomys* sp. nov., *Apodemus* sp. nov. and *Canis* sp. nov. are recorded here from the Karewa sediments.

Besides mammals, thousands of specimens of five fish taxa, namely *Schizothorax, Cyprinus, Schizopygopsis, Oreinus* and *Diptychus*, and some yet unidentified specimens of frogs, lizards and aquatic bird egg shells were also collected. Large reptiles such as crocodiles and turtles are absent in the Karewa vertebrate assemblage. In addition to vertebrates, numerous specimens of ostracods, gastropods and charophytes were also sampled.

Except a few fish skeletons, most of the skeletal material in the present assemblage is disarticulated and fragmentary. The skeletal elements are not

represented in proportions that would be expected if complete animals were preserved. Majority of the mammalian and some fish material has been recovered from coarse to medium–grained sandstone lenses associated with laminated claystone, and channel sandstone. The mammalian bones show signs of transportation, in the form of abraded corners and edges, and preburial sur-

Table 1 – Vertebrate fauna from the Plio–Pleistocene Karewa basin.

Pisces	
Cypriniformes	
Schizothorax esocinus	387
Cyprinus carpio	3104
Schizopygopsis sp.	1
Oreinus sinuatus	43
Diptychus sp.	24
Cypriniformes indet.	1047
Reptilia	
Small lizards	3
Amphibia	
Frogs	2
Aves	
Aquatic birds	7
Mammalia	
Insectivora	
Indosuncus bhatiai	6 (3)
Rodentia	
Microtidae	
Kilarkola kashmiriensis	46 (4)
Pliopotamys sp. nov.	6 (1)
Pitymys sp. nov.	6 (2)
Microtus sp. nov.	4 (2)
Mimomys sp. nov.	7 (1)
Muridae	
Apodemus sp. nov.	1 (1)
Murinae indet.	8 (2)
Carnivora	
Canis sp. nov.	3 (1)
Proboscidea	
Elephas hysudricus	26 (3)
Perissodactyla	
Equus sivalensis	24 (3)
Artiodactyla	
Cervidae	
Cervus punjabiensis	24 (3)
Cervus sivalensis	27 (2)
Giraffidae indet.	1 (1)
Hippopotamidae	
Hexaprotodon sp.	1 (1)

(Figures in parentheses represent the minimum number of individuals)

face damage. It appears that a section of the mammalian bones was washed down from higher areas by streams into the lake basin and consequently hard, durable and dense bone material was preferably preserved. Teeth mandibular ramii and antlers are proportionally better represented. The high proportional percentage of antlers is probably artificial as a single antler can break down into a number of fragments. The large–sized mammalian bone material appears to have undergone syngenetic chemical activity. This is evident from the dissolution of cement and in some cases even the dentine of the teeth.

The nature of the mammalian bone assemblage, which is allochthonous to the lake environment, suggests that it was considerably modified by various taphonomic agents before final burial. On the other hand, much of the fish material is better preserved, shows less disparity in preservation, and displays little signs of transportation and preburial demage indicating its autochthonous nature.

Palaeoenvironment.

The geology of the Karewas indicates that Karewa sediments were deposited in a lacustrine basin distributed initially over the entire expanse of the Kashmir Valley. The major facies types observed in the Karewas include lacustrine, alluvial fan, lake delta margin, and aeolian. The Lower Karewa sedimentation started in a lake spread over the whole Kashmir Valley, as a result of the ponding of the southwardly flowing drainage lines by the initial uplift of the mountain ranges in the Pir Panjal area. A number of streams left the surrounding mountain ranges to offload their sediment load, which sometimes included mega– and micro–vertebrate remains, in the newly formed lake. This sedimentation was interrupted for some time by a sharp uplift in the Pir Panjals resulting in the deposition of thick conglomerate beds (more than 200 m thick) by the braided channels of the alluvial fans. This phase was again followed by a predominantly lacustrine sedimentation which persisted up to the end of Lower Karewa sedimentation. The Upper part of Lower Karewa is marked by the regression of the lake, either due to the draining out of the lake by the reactivation, due to tectonic activity, of some of the drainage outlets or as a result of reduced precipitation. Consequently, the Lower Karewa lake shrank from the southwestern part of the valley and was shifted to the northeastern part (Singh, 1982; Bhatt, 1976, 1982). During Lower Karewas, there were extensive swamps on the lake margin as is indicated by numerous lignite seams of variable thickness in the entire section of Lower Karewas. The interfingering of the lacustrine and lake delta facies probably indicates fluctuation in the lake level from time to time. It has been suggested by Singh (1982) that the Karewas were deposited in a shallow lake. The red coloured sediments, so common in the Pliocene Tatrot Formation of Upper Siwaliks and which indicate warm, humid and oxi-

dizing conditions (Gaur & Chopra, 1983, 1984) are absent in the Karewas. The dominant grey colour of Lower Karewa deposits probably suggests deposition in a poorly drained basin.

The lacustrine sedimentation continued during Upper Karewas which were deposited in the reduced lake restricted to the northeastern part of the valley. Lake depth probably changed from time to time. The deeper parts of the lake might be delimited along the small central stretch of the valley extending from Pampur and Sombur to Pattan (Fig. 1). The absence of lignite in the Upper Karewas indicates the absence of marginal swamps (Bhatt, 1982). Upper Karewa conglomeratic layers contain well–sorted pebbles which are worn to a degree as might be expected from components washed out of a delta or fan. On the Himalayan flank, thick sediments and braided stream deposits constitute the bulk of Upper Karewas. The conglomerates were probably deposited during cold climatic conditions and the sandstone, siltstone and claystone were deeply stained suggesting abundant intermittent rainfall. The climate grew colder and more stormy towards the top of the Karewas and the streams spread their gravel load across the plains. The topmost part of Upper Karewas is formed by aeolian fine silt–sized sediment, the loess, which is associated with some darker humic layers, the palaeosols. The loess is usually deposited by wind in the peri–glacial environment and represents cold and arid conditons. The cold arid environment was interrupted by warmer/wetter phases as is suggested by the occurrence of palaeosols in the loess. Thus, from the base of the Upper Karewas to the top, the evidence indicates a general increase in aridity associated with a fall in temperature.

Palaeoecology.

The occurrence of a variety of fresh–water ostracods and gastropods, charophytes, and terrestrial mammals suggests a fresh–water origin for Karewa deposits. The ostracod fauna, charophytes and fish indicate the prevalence of general lacustrine conditions. The Karewa ostracods, many of which still live in the present day lakes of Kashmir Valley, suggest that beside shallow to deep lacustrine environment, swampy and fluvial conditions also prevailed in parts. The presence of *Cypridopsis vidua* (Kotlia, 1984) an ostracode, indicates that the lake depth could have been up to 70 m (Bhatia, 1968). Upper Karewa ostracod assemblage also suggests that the lake was slightly alkaline and was fed by many weed–filled tributaries. The charophytes preserved in Karewa deposits indicate a clear water body with little current and a high pH. The presence of marginal swamps is suggested by occurrence of some marsh–loving snails recovered from Lower Karewas.

The absence of crocodiles and chelonids, which are so abundant in the Tatrot and Pinjor Formations of Upper Siwaliks, indicates that the climate dur-

ing Karewa deposition was probably colder than that of Pinjors and Tatrots. It is well–known that the reptiles being poikilothermic attain profusion and great size only in warmer climates (Schwarzbach, 1963). The fish assemblage of Karewas is an admixture of low altitude (*Cyprinus*) and high altitude (*Schizothorax*) varieties, the latter has been reported from altitudes as high as 3577 m (Mukerji, 1936). It may be, therefore, inferred that the surrounding mountains were at least 3577 m high during Karewa deposition. The occurrence of voles indicates cold climatic conditions during parts of Lower Karewas. The present day Himalayan vole (*Alticola*) is known to occur at altitudes of 3000 m (Prater, 1980). The voles, which are the most abundant mammals in the present assemblage, were probably of water–loving type and perhaps inhabited the banks of upland streams which washed down their remains, along with the *Schizothoracinae* fish, into the accumulating sediments of the Karewa lake. The insectivores probably inhabited the thickets and bush undergrowth around the lake and along river deltas.

Among the large mammals, the grazing forms, such as horses and elephants, and browsers such as cervids are better represented (Table 1). The greater frequency of the horses and elephants probably suggests the presence of enough grasscovered areas to support large herds of these animals. The occurrence of enough browse along with grasses is indicated by the cervids. The habitat spectra of Karewa mammals (Fig. 2) suggest a mosaic of dominant grassland and wooded grassland, with subordinate woodland and some bushland. It appears that the areas close to the lake were more open and supported grassy vegetation

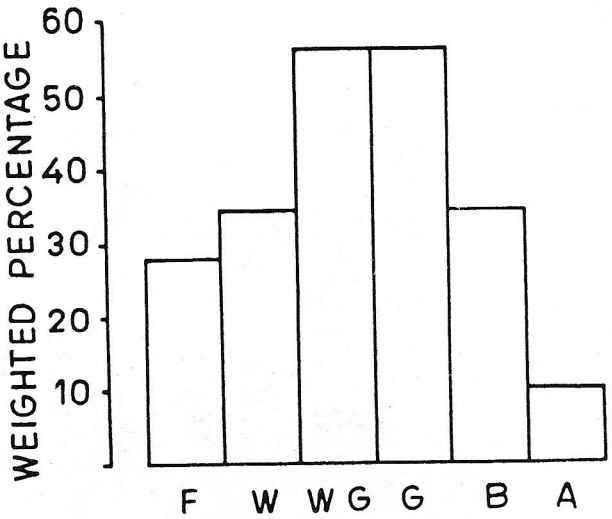

Fig. 2 – Habitat spectra of Karewa fossil mammals. F) forest; W) woodland; WG) wooded grassland; G) grassland; B) bushland; A) aquatic margin.

with some tree and bush cover. The mountain slopes were probably covered with temperate forests.

Age.

Various workers have assigned different ages to Karewas. These deposits have been interpreted as being of Pleistocene age (de Terra & Paterson, 1939; Vishnu Mittre, 1964; Tewari & Kachroo, 1977), of Late Pliocene to much of Pleistocene age (Bhatt, 1975; Kusumgar et al., 1985a, b) and perhaps of Late Miocene to Pleistocene age (Roy, 1975). Preliminary magnetostratigraphic investigations revealed an age of between late Gilbert Chron to early Matuyama Chron (3.5 to 2.0 Myr) for a part of Karewas in the southwestern part of Kashmir Valley (Agrawal et al., 1981). Recently conducted detailed magnetostratigraphic and fission track dating by Burbank and Johnson (1982, 1983), Kusumgar et al. (1985 a, b) and Agrawal (1985) suggests that Karewa sedimentation started in the Gilbert Chron about 4.0 Myr ago and continued until 0.3–0.4 Myr into the Brunhes Chron.

Information about the magnetostratigraphy and fission track dating for Karewa deposits is now available, but without much reference to the fossils. We present here the integration of the magnetostratigraphic data and the fossil content recovered by the authors from the Karewa deposits. Fig. 3 shows the correlation of the four main sections, viz., Rembiara, Romushi, Birnai Nala and Sombur, along with their vertebrate fossils, with the magnetic polarity time scale. As can be seen in Fig. 3 a large number of vertebrate groups occur in the Matuyama magnetic epoch. Despite extensive explorations no fossil mammal could be recovered from the Gauss magnetic epoch and only *Hexaprotodon* is reported from the Gilbert magnetic epoch in the Rembiara section near Dubjan, which forms the base of the Karewas and has been dated to about 4.0 Myr – 3.4 Myr B.P.

The oldest occurrence of *Equus* in the Kashmir Valley is recorded by us slightly above the Gauss/Matuyama boundary (2.48 Myr B.P.) in the Rembiara section. From Romushi and Birnai Nala sections *Equus* is recorded from the base of the Olduvai event and from the top of Olduvai event, respectively. The oldest appearance of *Cervus* with antlers in Karewas is recorded in the Romushi section from the Matuyama magnetic epoch, at about 2.0 Myr ago. Thus *Equus* antedates *Cervus* in the Karewas of Kashmir. The earliest occurrence of *Elephas* is recorded here from the Brunhes magnetic epoch in the Romushi (Lower Karewa) and Sombur (Upper Karewa) localities. *Canis* is recorded from near Burzahom which falls within the Brunhes magnetic epoch.

Among the micromammals, the microtine rodents were recovered from the Olduvai event in the Birnai Nala and Rembiara sections at Kilar and within the Brunhes magnetic epoch at Sombur. The oldest occurrence of microtine

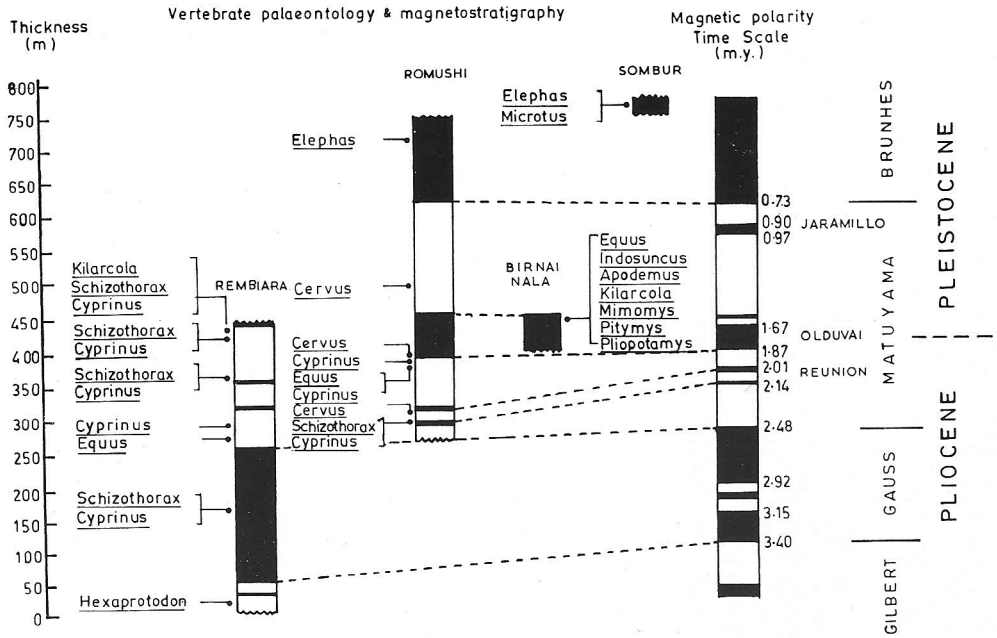

Fig. 3 – Synthetic chart of Karewa sections with correlation of vertebrate palaeontology and magnetostratigraphy (modified after Kotlia, 1984).

rodents collected so far from the Karewas is therefore from the Olduvai event. Thus the Plio–Pleistocene boundary in the Karewa deposits is marked by the appearance of the microtine rodents. The fossil fish referable to *Schizothoracinae* and *Cyprininae* are distributed throughout the Karewa section right from the top to the base in the Dubjan section, which falls in the Gilbert magnetic epoch and is considered as old as 4.0 Myr B.P. (Burbank, 1983; Burbank & Johnson, 1982, 1983; Kusumgar et al., 1985b; Kotlia, 1984).

Summary.

1) The Karewa group represents a sequence of Plio–Pleistocene molassic sediments deposited in an intermontane basin which developed as a result of the blocking of the southwardly flowing drainage lines by the uplift of the Pir Panjals during Pliocene.

2) The Karewa vertebrates are an admixture of upland and lowland fauna and are dominated by schizothoracine and cyprinid fish. Among mammals the cold–loving microtine rodents, the elephants, horses and cervids are better represented. *Pitymys, Pliopotamys, Microtus* and *Mimomys* are reported for the first time from the Indian subcontinent.

3) The mammalian assemblage, most of which is allochthonous, was con-

siderably modified by various taphonomic agents, while the largely autochthonous fish assemblage is much less altered.

4) The Karewas are predominantly lacustrine and partly glacio–fluvial and aeolian. The Lower Karewas were probably deposited as lacustrine, lake data, lake margin swamps, and alluvial deposits. The Upper Karewas are on the whole lacustrine, braided stream and aeolian deposits. The climate was probably warm and humid in the beginning and became cold and arid later on.

5) The mammalian fauna suggests the presence of a mosaic of dominant grassland and wooded grassland with bushland and some woodland.

6) The Plio–Pleistocene boundary in Karewas is marked by the appearance of microtine rodents. In Karewas, *Equus*, which occurs slightly above the Gauss/Matuyama boundary (2.48 Myr B.P.), antedates *Cervus* which is recorded from Matuyama Chron at about 2.0 Myr B.P. The oldest record of a mammal is in the Gilbert Chron, about 4–3.4 Myr B.P. The base of Karewas is in the Gilbert Chron at about 4.0 Myr B.P.

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