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First Record of a Middle Pliocene Hominid from the Siwalik Hills of South Asia

The Siwalik Hills have yielded what is perhaps the world's most ancient early hominid. In December 1992 I discovered a hominid mandibular ramus and a hominid femur in association with stone tools in the Tatrot Formation of the upper Siwalik. The discovery was made from the Tatrot Formation exposed at Khetpurali Village in Haryana, North India. The teeth are bunodont, having a lingually inclined wear plane. The P3 is molariform and single rooted. The femur is platymeric and has medullary stenosis. The stone tools are chopper types. Magnetostratigraphic dating of the Tatrot Formation ranges from 2.47 Myr at the top to 5.44 Myr at the base. The hominid – yielding bed is dated at 3.40 Myr – Middle Pliocene. The palaeoecology of the Tatrot Formation suggests open savannah. The discovery will cast new light on the origin and migration of the early hominids, and hopefully will contribute to a solution of the 100-year-old dispute about the African or Asian origin of humans.

Keywords: Early hominid, Middle Pliocene, Siwalik Hills, South Asia.

Introduction

The Upper Siwalik exposed along the Ghaggar River about 10 Km south-east of Chandigarh are potentially important for the fossil remains of the early hominids and his culture. In November 1980, I made first discovery from this area of the early hominid's teeth and his culture dated at 2 Myr from the Pinjor Formation of the Indian subcontinent. (Singh, 1982a, 1982b, 1986a, 1986b), (Singh et al, 1988), (Singh, 1989, 1990, 1991, 1992, 1996, 1998). During the last 25-years of exploration on this area, I have discovered a number of human fossils, stone tools, vertebrate and invertebrate fossils both from the Pinjor and the Tatrot Formations. All the three Formations of the Upper Siwalik - Tatrot, Pinjor and Boulder Conglomerate are exposed in the present area. (Fig. 1). (Nanda & Halstead, 1975).

Geology

The present area lies between 30 Degrees 40'-30 Degrees 45' N and 76 Degrees. 53'-77 Degrees. 33' E. It falls in the Survey of India toposheet No. 53 B/14. Structurally, the area consists of a syncline, an anticline, a fault and a thrust. Near the western extremity of the area, the beds dip gently 15 Deg. To 20 Deg. eastward with a north – south strike but further east the dips change to north – eastwards and finally to a north – west direction near the eastern extremity of the area, thus forming a plunging syncline.

Near the southern extremity, the beds form an anticline, the axis of which runs roughly east-west. Although the area is traversed by a fault, the dips of the beds on either side of this fault clearly demonstrate that the Upper Siwalik, in this area form part of a single major plunging syncline (Nanda & Halstead 1975).

On 31st December, 1992 I discovered while doing fieldwork with two locals S.K. Sharma and S. Rajput hominids mandibles, femoral fragments and stone tools from a locality situated ½ a Kilometer NNW of the Khetpurali Village in Haryana, North India, (Fig. 1). It was recovered from the brown colour silt stone bed about 10 meters from the base of the Tatrot section, which has a thickness of about 220 meters at Khetpurali Village.

Stratigraphy

The Tatrot section at Khetpurali Village was measured in a dip direction. The section contains brown, gray, pink, purple, red, orange and variegated clays inter-bedded with brown and gray sandstone. The brown sandstone is the characteristic of this section. It shows well developed cross and current bedding. The hominid fossils and stone tools were recovered from the brown silt stone bed at the basal part of this section. More than 50 different taxa was recovered around the hominid locality. Some of which are listed in the section (Fig. 2).

Dating

The Magnetostratigraphic study both in India and Pakistan suggests that the Pinjor – Tatrot contact is at 2.47 Myr and the Tatrot – Dhokpathan contact is at 5.44 Myr (Opdyke et al, 1979), (Azzaroli & Napoleone, 1982), (Tandon et al, 1984). The total thickness of the Tatrot – Pinjor section at Khetpurali is about 900 meters. It has six normal and six reverse magnetozones (Tandon et al, 1984).

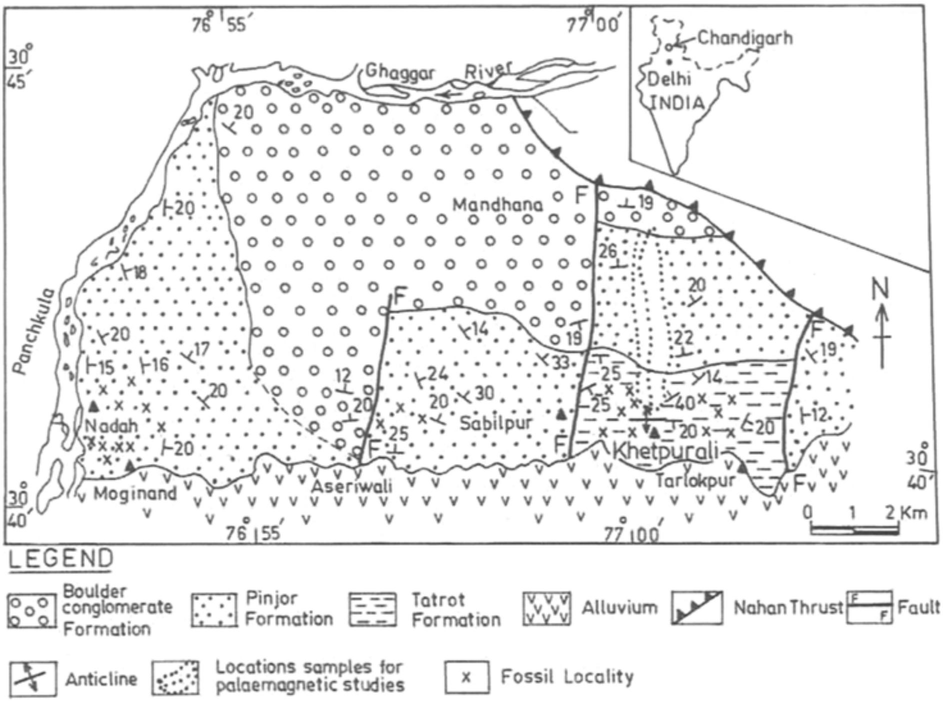

Figure 1. Geological map of the area

The Plio-Pleistocene boundary lies at approximately 350 meters from the base of the section at Khetpurali (Tandon et al, 1984). Magnetostratigraphically, Olduvai is dated at 1.86 Myr and is considered to be the beginning of the Lower Pleistocene. The total thickness of the Tatrot section at Khetpurali is about 220 meters. The hominid – yielding bed is about 10 meters from the base of this section.

All Palaeomagnetic studies suggest that the hominid – yielding bed falls in the basal part of the Gauss Palaeomagnetic Epoch and thus can be dated at 3.40 Myr, i.e. Middle Pliocene. The associated fauna, besides other faunal remains, also include *Hipparion*. The occurrence of which gives Tatrot – age Middle Pliocene for these sediments.

Palaeoecology

The Palaeoecology of the Tatrot Formation reconstructed on the ground of fauna, flora and sedimentological grounds suggests open savannah where the principal vegetation consisted mainly of tall grasses (Sahni & Khan, 1964). At places wooded grassland and bushland were also predominant (Gaur & Chopra, 1984).

The great profusion of bovids, cervids, camelus, giraffids, Hipparion suggest more open ground. The presence of Hexprotodon, Gavialis, Crocodilus suggest presence of fresh – water lakes. The lithology of the Tatrot Formation is uniform for many kilometers at a stretch also reinforce lake deposits (Sahni & Khan, 1964). The presence of crocuta suggests good scavenging grounds for the scavengers as well as for the earliest hominids.

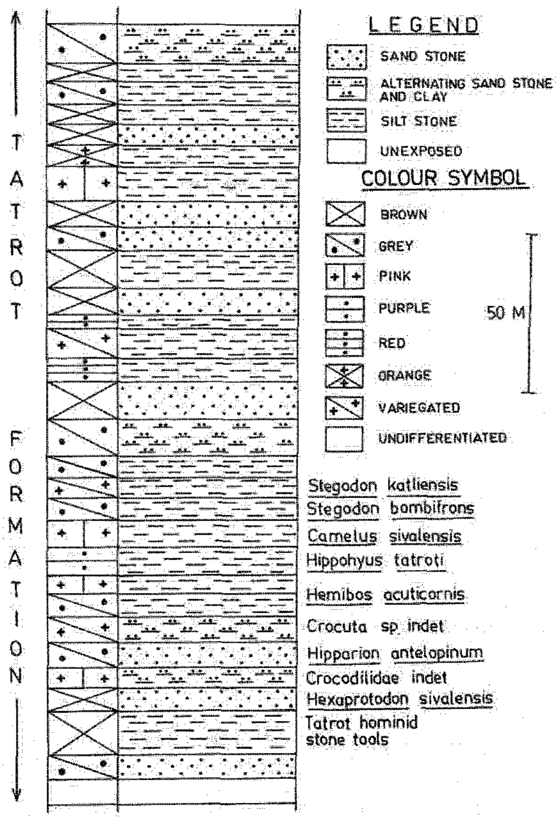

Figure 2. Stratigraphic section at Khetpurali

Tatrot Hominid's Specimens

The mandibular fragment consists of a lower right first molar and alveoli of P3 and P4 (Fig. 3a). The mental foramen is low in position and below the mesial root of M1; which is a Mongoloid trait. The horizontal rami is transversely thick like those of *Australopithecus* and earliest hominids (Simons, 1976). The molar shows mesial – drift like those of earliest hominids (Simons, 1976). It indicates heavy interstitial wear in a savannah adaptation.

The tooth is inclined lingually, an exclusively hominid trait related to pronounced attrition and helicoidal occlusal plane. This trait is expected throughout the *Homo* osteological records geographically and temporally (Tobias, 1980), (Reinhardt, 1983).

The molar appears to be bunodont with thick enamel. The enamel has been worn and dentine is preserved as a smooth belt (Fig. 3b). The enamel appears to be significantly thicker on the labial side and thinner on the lingual side. Such a distribution increases grinding efficiency and resistance to wear which prolongs the life of the tooth needed for the earliest hominids (Molnar & Ward, 1977).

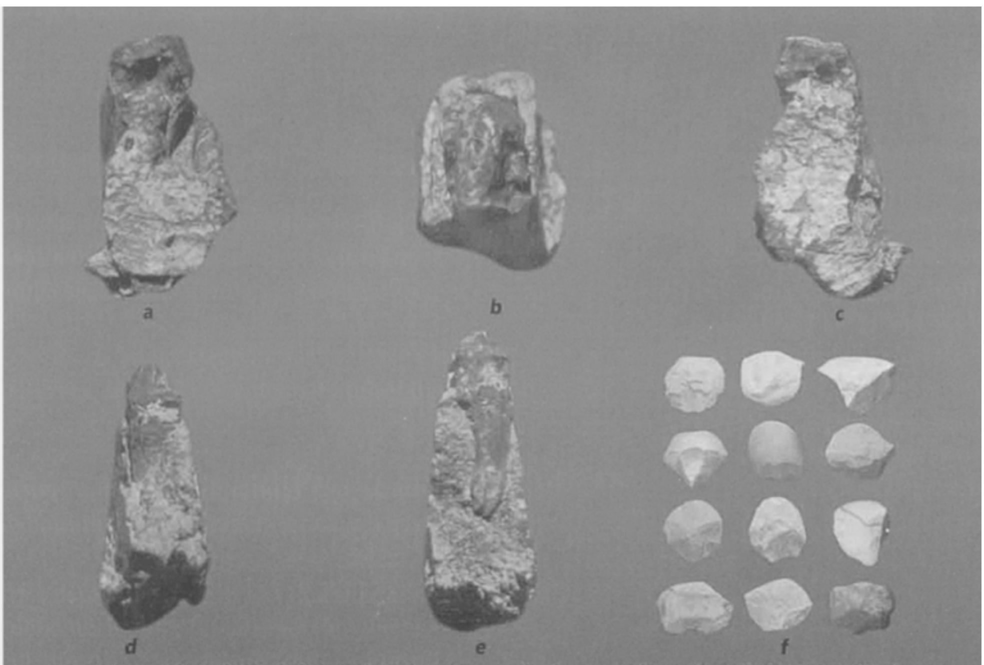

Figure-3. a, labial; b, occlusal; c, lingual; d, mesial; e, distal; f, stone tools.

The molar is broad and worn flat. Such teeth are effective in stress concentration only on objects small enough like cereal grains to be pulverized between the teeth (Kay, 1981). The dentine is smooth, it reflects graminivore diet. Unlike small concavities excavated out on the molars of organg-utan due to nut-cracking (Welsch 1967). The wear on the dentine suggests that mesiolingual and distolingual cusps had been in close harmony like those of hominids (Wheeler, 1968).

The distal cusps are heavily worn than the mesial cusps resulting in a mesiodistal slope. Such a hominid-like feature is related to the lateral excurtion of the mandible during mastication (Wheeler, 1968).

The occlusal wear plane of M1 is lingually sloped (Fig. 3c). An exclusively hominid trait related to dental arch and age in *Homo sapien* (Butler, 1972). It suggests that it belonged to some individual who had died before 18-years of age. Since the tooth had lost the enamel cap and shows extensive wear at such an early age, it supports differential wear diagnostic of hominids (Mann, 1968), (Jolly, 1970), (Simons, 1972). The wear is more evenly distributed on the molars of apes. The interlocking canines result in wear which is initially limited to the buccal cusps of lower molars (Pilbeam, 1972).

On the mesiolabial cusp a facet is discernible (Fig. 3d). It may be the result of tough fibrous material like flesh pulled across the teeth. Such facets are present on the teeth of some human populations who use their teeth as tools (Molnar, 1971). The wear is related to tooth and jaw morphology, genetics, behavior and culture (Turner, 1972). It regularly occurs between the adjacent tooth of species as disparate as Rhinoceros and Man (Brash, 1953).

The masial root is wider than the distal root a characteristic of the family hominidae. The distal root is rounded corresponding to the rounded nature of the distal cusps (Wheeler, 1968). The mandibular bone is thicker on the lingual side than on the labial side like those of hominids (Fig. 3e), and unlike those of apes where it is evenly distributed. Both the roots are somewhat thicker at the lingual borders. This arrangement provides a secure enchorage for the mandibular first molar since rotation is prevented (Wheeler, 1968).

The buccal plate of the alveoli is relatively thin, but the lingual plate is heavy like those of hominids. The alveoli of P3 is shifted medially at an angle of 20 deg. It suggests positive evidence of parabolic dental arch. The alveoli of P4 is single rooted like that of *Homo*. The alveoli of P4 in *Australopithecus* and apes is double rooted. Root size and form are important. What is underneath the surface of a bone is taxonomically just as important as the cusps of the teeth (Simons, 1967). Metrically, M1 is about double the size of an average *Homo sapien's* M1 and significantly larger than all the known early hominids (Table-1).

Table 1 Metrical comparison of the Tatrot hominid M1 with M1 of other hominids.

M1	Homo sapien [1]	Homo erectus (China) [2]	Homo erectus (Java) [3]	Australopithecus [3]	Hadar hominid [4]	Tatrot hominid
M-D (Average)	11.2	12.6	12.5	14.9	12.4	25.0
B-L (Average)	10.3	11.8	13.0	14.1	12.7	20.0

1. (Black, 1902)
2. (Weidenreich, 1937)
3. (Robinson, 1956)
4. (Johanson et al, 1982).

Lower Palaeolithic artefacts chopper – chopping (in situ) were also recovered in association with the hominid mandibular ramus (Fig. 3f). They are made of yellow quartzite pebbles. They are unifacial or bifacial choppers, are about 10-12 cm in length and breadth.

While exploring the above locality, I discovered from the same bed one more right hominid mandibular ramus having P3, P4, M1 and an alveoli of the canine.

The teeth are arranged in a parabolic dental arch like that of *Homo* (Fig. 4a). The teeth are inclined lingually (Fig. 4b) which is related to heavy attrition and helicoidal occlusal plane found in hominids (Tobias, 1980), (Reinhardt, 1983). The occlusal wear plane is inclined lingually which is related to dental arch and age in *Homo sapien* (Butler, 1972). The teeth are heavily worn and the crown height is lost before adolescent. It suggests heavy scavenging activity. Since flesh and bones are more destructive to the dental tissue. The teeth are worn in an even-plane like those of hominids.

The P3 is much smaller mesiodistally than P4, an exclusively hominid trait related to short canine. The P3 is bicuspid and is molariform. The P3 is single rooted like that of *Homo*. (Fig. 4c). While P3 of the Hadar hominids is double – rooted like those of Anthropoids. The P3 and P4 have similar size roots like that of *Homo* (Fig. 4c).

Figure-4. a, occlusal; b, lingual; c, labial; d, distal.

The alveoli of the canine is equal in size to the alveoli of P3 like that of *Homo*. There is a slight diastema also. The teeth shows mesial-drift like those of hominids (Simons, 1976). It indicates heavy interstitial wear in a savannah adaptation.

Metrically, M1 is as large as that of the previous one. The mesiolingual cusp is the largest one. Thus, the *Dryopithecus* pattern can be discernible. The dentine is thicker on the labial side and thinner on the lingual side to increase the grinding efficiency.

The cusps are rounded like that of *Homo*. The distal root is rounded (Fig. 4d) corresponding to the rounded nature of the distal cusp. The ramus is transversely thick like those of hominids (Simons 1976).

While exploring the above locality, I recovered a hominid proximal-end of a left femoral fragment from the same bed where the mandibulars ramus where recovered.

The anterior aspect of the shaft (Fig. 5a) shows neck-shaft angle 125 deg. like those of modern humans. The neck of the femur has trochanteric line. It suggests that the capsular ligament of the hip joint had thicknening of the Ilio-femoral portion. A conspicuous feature of the modern human hip-joint (Lovejoy & Heiple 1972).

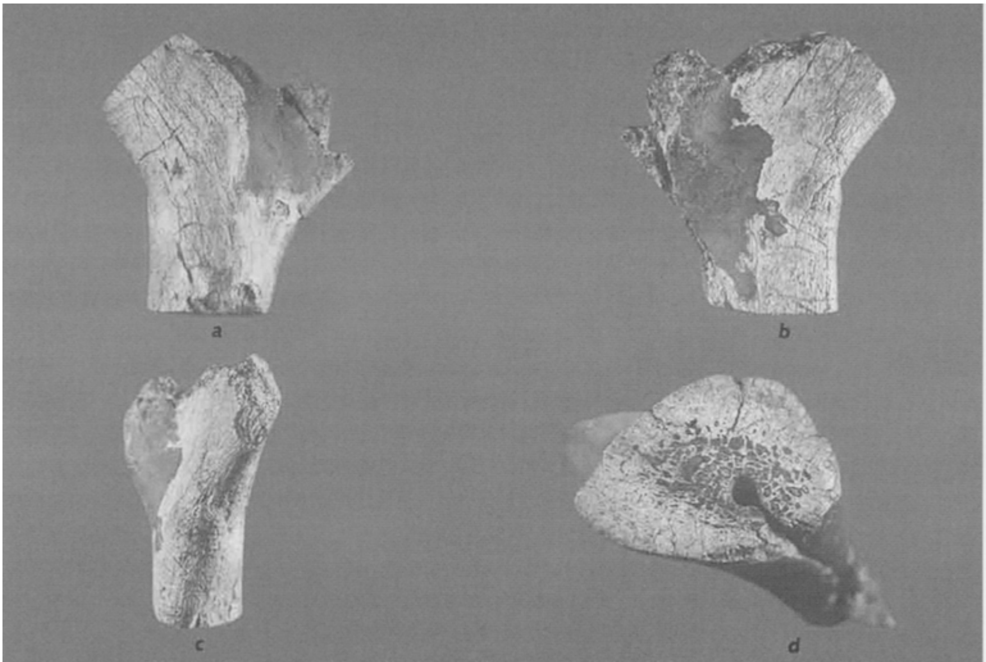

Figure-5. a, anterior; b, posterior; c, medial; d, transverse section.

The neck of the femur appears to be long and strongly compressed anteroposteriorly. It is directed forward as well as upwards and medially, making an angle of 15 deg. with the transverse axis of the shaft. In this feature, it resembles the modern human femora to a remarkable degree.

The posterior aspect of the shaft has marked insertion of the gluteus maximums muscle (Fig. 5b). An exclusively hominid-trait related to bipedality. A small scale – like center of ossification for the lesser trochanter appeared on the medial aspect of the shaft (Fig. 5c).

The position of the lesser trochanter on the medial aspect of the shaft is of considerable interest. As the femur turns increasingly antiverted the position of the lesser trochanter turns more medial in position (Day 1969). In this feature the Tatrot femur resembles with the femur of *Homo erectus* and *Homo sapien* and contrast with that of *Australopithecus*. In the latter the lesser trochanter is posterior in position on the shaft like those of apes (Day, 1969).

The transverse section of the shaft (Fig. 5d) is platymeric having platymeric index = 71.4 like that of *Homo erectus* (Kennedy, 1983). The walls of the shaft are conside-

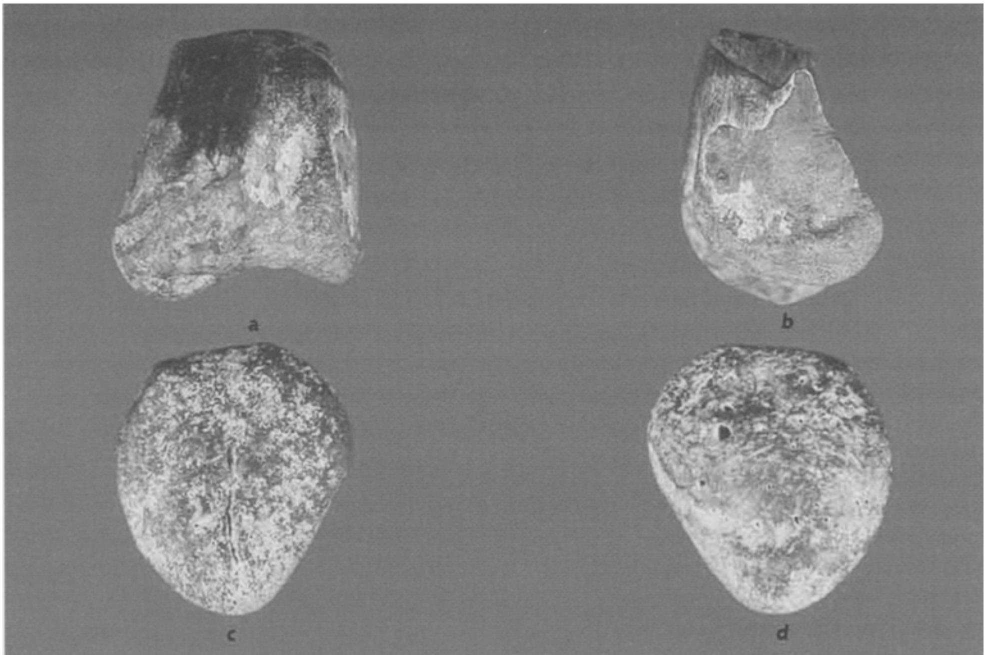

Figure-6. a, anterior; b, lateral; c,anterior; d, posterior.

rably thick resulting in meduallry stenosis a type characteristic of *Homo erectus* was not present in the *Australopithecus* (Kennedy, 1983). The cortical index was equal to 88.0, an exclusively hominid trait related to weight – bearing and bipedalism.

The left distal-end of the femora was also recovered by me in association with the proximal femora. The shaft has a high bicondylar angle 10 deg. very close to the mean of the sapien femora (Fig. 6a).

The medial condyle has a bulging convex medial aspect. The condyle projects distally. The lateral condyle is like that of *Homo sapien*, i.e. elliptical (Fig. 6b). This is indicative of a specialized restriction of maximum true cartilage contact to full extension of the knee (Heiple & Lovejoy, 1971). The patellar groove is deep like that of hominids.

Now, I have started exploring Tatrot Formation exposed at Masol Village which is really about 15 km west of the Khetpurali Village. On 11th of January, 1998, I discovered a hominid right patella from the brown clay bed at the basal part of the Tatrot section which has a thickness of about 270 meters at Masol. The locality is ¼ of a km south-east of the Masol Village.

The patella is flat, distally triangular and proximally curved like that of *Homo sapien* (Gray, 1989). It is length is 60 mm, while breadth is 54 mm. The anterior surface is perforated with numerous nutrient vessels (Fig. 6c). The posterior surface has a proximal, smooth oval articular area crossed by a vertical ridge like that of *Homo sapien*. The lateral facet is slightly larger than the medial facet (Fig. 6d) like that of *Homo sapien* (Gray, 1989).

A great profusion of stone tools and a few ivory tools were also recovered in association with the hominid's patella. Morphometrical, analysis of the Tatrot femur suggests that the Tatrot hominids were as efficient bipedal as that of *Homo sapien* even during the Middle Pliocene Epoch.

A number of isolated hominid teeth, post-cranials, foot bones and a skull cap were also recovered from the Tatrot Formation at Masol Village. Due to limited space, they would be announced later on.

Conclusion

Hominisation, that means progressive evolution towards man begins with the adaptation of a habitual bipedal locomotion. Such an adaptation could certainly not have existed in a tropical forest of Africa, but in temperate open country, steppe or savannah of Asia. Such conditions on a large scale were first realized after the Alpine orogenesis, which created the high mountain ridges in Europe and Asia that changed their climatic and geographical conditions at the Miocene and Pliocene period about 12 million years ago (Von koenigswald, 1976).

While Europe was too cold for the hominisation of earliest apes. In Asia this change from forest condition to open savannah on a large scale can best be seen in the classical palaeoprimatological significance of the Siwalik Hills of South Asia from raddish chingi bed to gray Dhokpathans sedimentation (Von koenigswald, 1976). It is here in the Pliocene biotope *Ramapithecus*, the first ape which embarked on the road to humanity first appeared.

The terminal date for *Ramapithecus* in the Siwalik is around 7 Myr, while the base of the Tatrot Formation is dated at 5.5 Myr. Thus, the Tatrot hominids fit well geographically and temporally in the process of hominisation. The great size of the Tatrot hominids teeth suggest first positive evidence of the **Mighty Himalayan Man**. His one living form may still be living in the Himalayas alias **Yeti.**

In human evolution teeth have undergone reduction in size. The great size of the Tatrot hominid's teeth than any of the known hominid's teeth further reinforce that they had been derived from the sediments oldest in the world. The Tatrot Formation is much older (1.44 Myr) than the Hadar Formation of Ethiopia, where the world's oldest human fossils have so far been discovered (Johanson et. al, 1982).

Morphologically and functionally the Tatrot hominids are more in line with *Homo sapien* even at the Middle Pliocene Epoch, for example, the parabolic dental arch, helicoidal occlusal plane, large teeth with rounded cusps, molariform and signle rooted P3, medullary stenosis, platymeric femora with moderate bicondylar angle, antiverted femora, shape and size of patella, etc.

The southern Asia documents the oldest palaeolithic artefacts dated in the world to 3.40 Myr. It suggest that the Tatrot hominids were having comparatively large brains than that of australopithecinae. Anatomical and archaeological evidences of the Tatrot hominids conclude that they belong to *Homo erectus.* It seems *Homo erectus* first appeared on this planet at 3.40 Myr during the Siwalik orogeny.

What triggered migration of the earliest hominids was Glaciation. The Tatrot Formation experienced the advent of first Glaciation (Mehdiratta, 1959). While East Africa was never under Glaciation during the Pliocene Epoch. Being a tropical was congenial for the earliest hominids immigrants.

Geographically, the Siwalik world's largest (50,000 sq. km. area) and the oldest Mio-Plio sediments exists in South Asia where the transformation of ape to human had occurred. The collision of the South Asian plate with the Major Asian plate resulted in the third and the most powerful upheavel of the Himalayas during the Middle Miocene Epoch. It resulted in cooling climate in the region and the spread of open grounds northwards during that period. The tectonic movement helped in uplifting apes from the scooping position to upright posture of humans by developing the gluteus maximus muscle. Thus, there has been human origin during the Siwalik orogeny.

The morphological, functional, technological, temporal and geographical evidences conclude that the Siwalik Hills of South Asia should be center of human origin and his migration to various continents. Finally, the 100-year dispute about human origins being African or Asian has been solved by the palaeoprimatological significance of the Siwalik Hills of South Asia. Thus, turning Siwalik Hills of South Asia as the **Garden of Eden.**

ACKNOWLEDGEMENTS - I am grateful to many British, American, Italian, Australian, South African, French and Belgium reviewers for their useful comments and encouragement on the Siwalik hominids. Prof. Sahni of the Department of Geology, Panjab University, Chandigarh is appreciated for geological discussions. Dr. R.K. Pant of P.R.L. Ahmedabad is appreciated for providing useful literature. The people of Khetpurali and Masol Village are appreciated for their help during the exploration. The department of Anthropology and Geology Panjab University, Chandigarh and the Department of Biochemistry and Anatomy P.G.I. Chandigarh are appreciated for their cooperation. Financial aid for the exploration of 25-years has been provided by the Author himself. This discovery is dedicated to the Editor of *Nature* who first considered and greatly encouraged the Author on his first discovery of *Homo erectus*_ from the Siwalik in November, 1980. I am grateful to Prof. Tobias and the National Organizing Committee of the Dual Congress, 1998 for kindly providing me return air-ticket which could only enable me to attend the Dual Congress, 1998.

References

Azzaroli, A. & Napoleone, G. (1982). Magneto-stratigraphic investigation of the Upper Siwaliks near Pinjor India. Riv. Ital. Palaeont. Stratigr. Maggio. 87, 739.

Brash, J.C. (1953). Comparative anatomy of tooth movement during growth of The Jaw. Dent. Res. 73, 460-473.

Black, G.V. (1968). In Wheeler, R.C. Dental Anatomy and Physiology p. 428. Saunders Company, W.B.

Butler, R.J. (1972). Age-related variability in occlusal wear plane. Amer. Jr. Phys. Anthropol, 36, 381-390.

Day, M.H. (1969). Femoral fragment of a robust Australopithecine from Olduvai Gorge Tanjania. Nature, 221, 230-232.

Gaur, R. & Chopra. S.R.K. (1984). Taphonomy, fauna, environment and ecologyOf Upper Sivaliks (Plio-Pleistocene) near Chandigarh, India. Nature 308, 353.

Gray, H. (1989). Gray's Anatomy, p. 439. Longman Group U.K. Limited.

Heiple, K.G. & Lovejoy, C.O. (1971). The distal femoral anatomy of *Australopithecus*. Amer. Jr. Phys. Anthropol. 35, 75-84.

Johanson, D.C. Taieb, M. & Coopens, Y. (1982). Pliocene hominids from the Hadar Formation Ethiopia. Amer. Jr. Phys. Anthropol. 57, 375-552.

Jolly, C.J. (1970). The seed eators : a new model of hominid differentiationbased on baboon analogy. Man. 5, 5-27.

Kay, R.E. (1981). The nut-crackers – A new theory of the adaptations of the Ramapithecinae. Amer. Jr. Phys. Anthropol. 55, 141-151.

Kennedy, G.E. (1983). A morphometric and taxonomic assessment of a Hominine femur from the lower member, Koobi Fora, Lake Turkana Amer. Jr. Phys. Anthropol. 61, 429-436.

Lovejoy, C.O. & Heiple, K.G. (1972). Proximal femoral anatomy of *Australopithecus*. Nature 235, 175-176.

Mann, A.E. (1968). Ann Arbor : University Microfilms.

Mehdiratta, R.C. (1959). Indications of Glacierization in the Siwalik System in India. Nature, 184, 833-834.

Molnar, S. & Ward, S.C. (1977). On the hominid marticatory Complex Biomechanical and Evolutionary Perspective. Jr. of Human Evolution, 6, 557-568.

Nanda, A.C. & Halstead, L.B. (1975). A note on the structure of the Upper Siwaliks of Naraingarh Tehsil, Ambala Bull, Indian Geol. Assoc. 8, 85.

Opdyke, N.D. Lindsay, E. Johnson, G.D. Johnson, N. Tahirkheli, R.A.K. & Mirza,M.A. (1979) Magnetic polarity stratigraphy and vertebrate palaeontology Of the Upper Siwaliks sub-group of northern Pakistan Palaeogeography, Palaeoclimatology, Palaeoecology, 27, 1-34.

Pilbeam, D. (1972). The Ascent of Man : An introduction to human evolution. New York. Macmillan.

Reinhardt, G.A. (1983). Relationships between attrition and lingual tilting in Human teeth. Amer. Jr. Phys. Anthropol. 61, 227-237.

Robinson, J.T. (1956). The dentition of the Australopithecinae. Trans. Mus. Mem. 9, 1.

Sahni, M.R. & Khan, E. (1964). Stratigraphy, structure and coorelation of the Upper Siwaliks east of Chandigarh. Journal of Palaeontological SocietyOf India. 5, 61-74.

Simons, E.L. (1967). The significance of the primate palaeontology for Anthropological Studies. Amer. Jr. Phys. Anthropol. 27, 307-322.

Simons, E.L. (1972). Primate Evolution. Macmillan, New York.

Simons, E.L. (1976). The nature of transition in the dental mechanism from Pongids to hominids Journal of Human Evolution. 5, 511-528.

Singh, M.P. (1982a). First record of the Lower Pleistocene hominid *Homo erectus* from the Pinjor Formation of the Indian subcontinent. In Kennedy K.A.R. (U.S.A.). The hominid fossil record in Central Asia. New discoveries and interpretations. International workshop on the Late Cenozoic Palaeoclimatic Changes in Kashmir and Central Asia, Physical Research Laboratory Ahmedabad 19-23 October, 1982.

Singh, M.P. (1982b). First record of the Lower Pleistocene hominid *Homo erectus* from the Pinjor Formation of the Indian subcontinent. Seminar on the Climatic Change and Cultural Response in India. National Museum New Delhi 25-27 October, 1982.

Singh, M.P. (1986a). First record of the hominid remains from the Pinjor Formation of the Indian subcontinent. The World Archaeological Congress held at Southampton and London 1-7 September, 1986. Cassettee No. theme B tape 2 WAC 091-86 Mondy 10.45-12.15. A Bass 16 Longland Drive, London N 20 SHE 01-445 6776.

Singh, M.P. (1986b). Chandigarh home of early Ape-Man. The Tribune Chandigarh 106.1-14.

Singh, M.P. Sahni, A. Kaul, S. & Sharma, S.K. (1988). Further evidence of the hominid remains from the Pinjor Formation, India. International Symposium on Palaeoclimatic and Palaeoenvironmental Changes in Asia during the last 4 Million Years. Physical Research Laboratory, Ahmedabad. 15-21 December, 1986 Proceedings: D.V.S. Jain pp 564-573. The Indian National Science Academy, New Delhi.

Singh, M.P. (1989) *Homo erectus* from the Pinjor Formation of the Siwaliks and its bearing on the evolution of Man in the Indian subcontinent. Presented at International Congress held at Musee de Prehistoire de Tautavel, France 1-10 August 1989.

Singh, M.P. (1991). *Homo erectus* from the Pinjor Formation of South Asia and Its migration to South-East Asia. The International Trinil Centennial Colloquium. (1891-1991) Surabaya, East-Java, Indonesia, 18-21 November, 1991 p. 22.

Singh, M.P. (1992). On the dentition of 2 Million – year – old hominids from the Siwalik Hills of South Asia. Ninth International symposium on Dental Morphology 3-6, September, 1992, Florence, Italy p. 43.

Singh, M.P. (1996). First record of the Middle Pliocene hominid and his culture from the Tatrot Formation of the South Asia. XIII International Congress of Prehistoric and Protohistoric Sciences 8-14 September, 1996. Forli, Italy.

Singh, M.P. (1998). First record of a Middle Pliocene hominid from the Siwalik Hills of South Asia.

Dual Congress. 28th June – 4th July, 1998. Sun City, South Africa p. 67, 101.

Tandon, S.K. Kumar, R. Koyama, M. & Niitsuma, N. (1984) Magnetic Polarity Stratigraphy of the Upper Siwalik sub-group, east of Chandigarh, Haryana Sub-Himalayas, India. Jr. Geol. Soc. India V 25(1) 45-55.

Tobias, P.V. (1980). The natural history of the helicoidal occlusal plane and its evolution in early *Homo* Amer. Jr. Phys. Anthropol. 53, 173-187.

Turner, C.G. (1972). Tooth wear and culture : a survey of tooth functions among Some prehistoric populations. In S. Molnar. Current Anthropology. 13. 511-526.

Von Koenigswald, G.H.R. (1976). The oldest hominid remains of Asia. Union.Internationale Des Sciences Prehistoriques et Portohistoriques, 7-14 September 1976 Centre National De La Recherche Scientifique 15. Qhai anatole – Paris, France 425-429.

Weidenreich, F. (1937). The dentition of Sinanthropus Pekinensis: a Comparative odontology of the hominids. Palaeontologia. Sinica. Peking 101, 1.

Welsch, U. (1967). Tooth wear in living pongids. Journal of Dental Research.46, 989-993.

Wheeler, R.C. (1968). Dental Anatomy and Physiology pp. 259-333. Saunders. Company. W.B.

Received: September 14, 2000 *Accepted: December 20, 2000*