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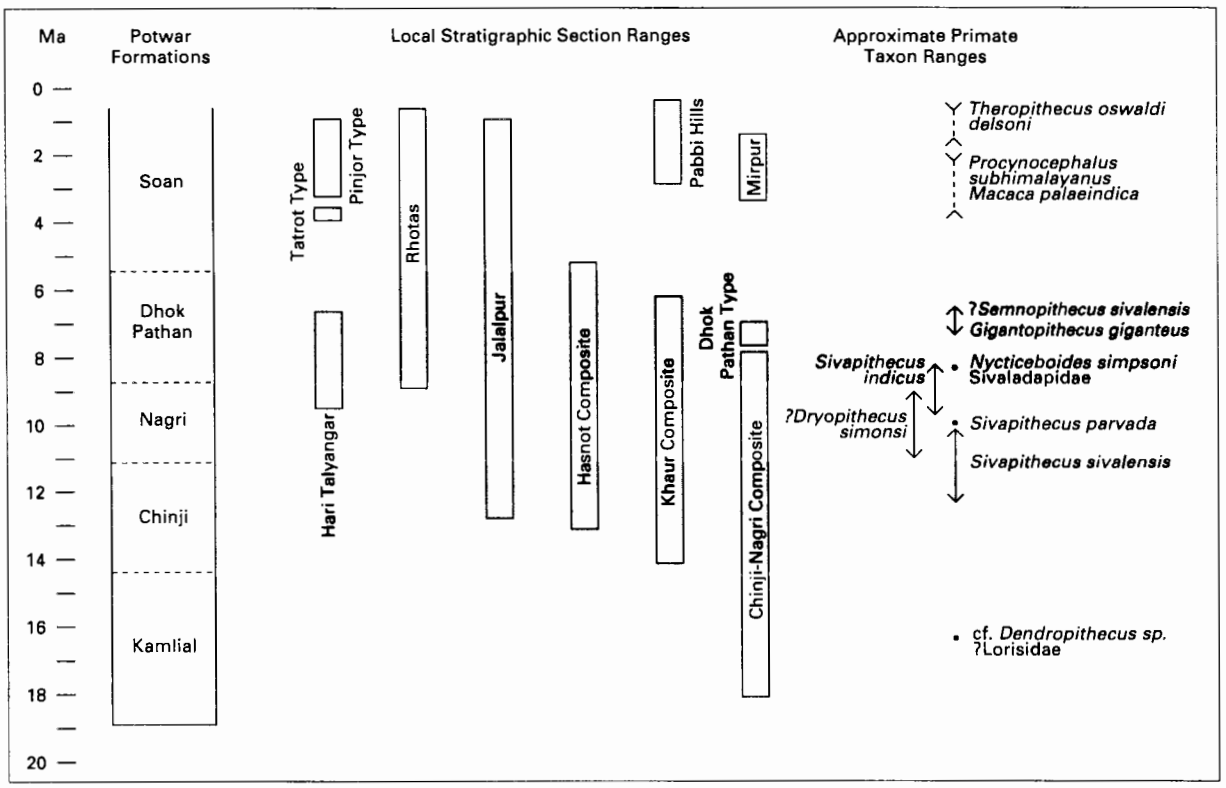
Siwaliks

Neogene strata in the Siwalik Range of northern India and Pakistan are exposed in a huge arc at the foot of the Himalayas extending from the Indus River to the Brahmaputra, a distance of more than 2,500 km. In this vast fossiliferous region, the strata assigned to the Siwalik Group range in time from more than 18 Ma to less than 1.0 Ma, providing one of the most complete successions of mammalian fossil faunas in the world. Fossils, including large hominoids attributed to *Sivapithecus* and *Gigantopithecus*, have been collected from the Siwaliks intermittently since the early 1800s. Since 1973, the Geological Survey of Pakistan has worked with Yale and then Harvard universities in the Siwalik Group exposures on the Potwar Plateau south of Rawalpindi, enormously expanding the faunal sample and clarifying many geological and paleoenvironmental questions. Modern understanding of the Siwaliks and its fossil fauna depends largely on this work.



Stratigraphy of Siwalik deposits in India and Pakistan. Left column shows temporal range of formations (rock units, often used as time or faunal units) in the Potwar region of Pakistan, where the most detailed collecting has been done. Narrow columns indicate range of local sequences, mainly in Pakistan (Tatrot and Pinjor type sections and Hari Talyangar in India). Temporal range of Siwalik primates indicated at right: solid lines are well-dated ranges, dashed lines approximate and single dots isolated occurrences. Modified after Barry, 1995.

Siwalik Stratigraphy

The Siwalik Group is divided, in stratigraphic order, into the Kamlial, Chinji, Nagri, Dhok Pathan, and Soan formations. All of these units have been formally designated as lithostratigraphic bodies with type sections in the Potwar Plateau, but, in their original form, defined by British paleontologist G. Pilgrim in the 1930s, they were essentially fossil-mammal zones. Over the years, problems arising from conflicting usage of these names for faunal units, time units, and rock units was not helped by the difficulty, prior to the recent paleomagnetic work, of accurately dating the succession.

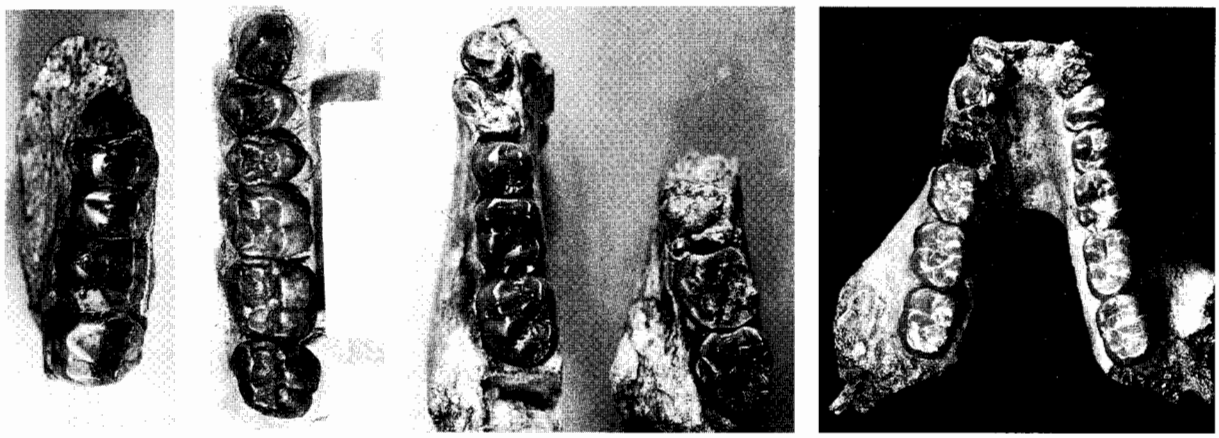
Outside the Potwar region, other correlative and older sediments are often broadly included in "the Siwaliks," but some are, in fact, quite distinct geologically. Parts of the Manchar and the Murree formations yield equivalent (or slightly older) faunas to the Kamlial, while Dera Bugti (Baluchistan) and correlates in the nearby Zinda Pir Dome are significantly older, extending the local faunal succession back to ca. 22 Ma. The Soan Formation is correlative with the Tatrot and Pinjor formations, originally defined in the Siwalik Hills of north India (see Figure). Due to the general lack of datable volcanics (other than rare ash layers suitable for fission-track analyses), geochronometry is based on paleomagnetic correlation of longer sequences, calibrated by faunal comparisons. Continuing changes in the calibration of geomagnetic polarity transitions result in small changes in the precise dates attributed to specific horizons, so that even the recent chart presented here was modified slightly, mainly by increasing the ages of Middle–Late Miocene levels by as much as 0.5 Myr.

In the Potwar Plateau, the Siwalik Group measures several km in thickness and ranges from the Early Miocene, in excess of 18 Ma, to the Pleistocene at 1.0 Ma or less. The lithologic boundaries of the formations are time-transgressive, as must be expected. The sediments represent floodplain deposition in the subduction trough below the Himalayas suture zone, where the leading edge of the Indo-Pakistan plate is descending beneath the Eurasian plate. Erosion in this highly active uplift region produced sediment in vast volumes, which was spread out and buried in the subduction basin by streams large and small. The process shifted southward to the Indus, Ganges, and Brahmaputra floodplains in the Middle Pleistocene, when the Siwaliks zone became caught up in the suture folding. Siwaliks fossils are preserved in a variety of fluviatile sedimentary situations, but particularly in abandoned floodplain channels.

The environment appears to have been characterized by subtropical climate in a low-relief terrain of braided and meandering stream channels, with a variety of vegetation types, including swamp, gallery forest, floodplain forest, woodland, and grassland.

Siwalik Primates

Hundreds of specimens of large fossil hominoids have been collected from the Potwar area of Pakistan. Other significant collections come from India near Ramnagar, in the Kashmir district, and from the Hari Talyangar region north of Delhi (where the fauna is dated mainly between 9.5 and 8.5 Ma



Occlusal views of selected Siwalik hominoids. Sivapithecus indicus *females, left to right: right maxilla with P3-M2 (ex-*"Ramapithecus punjabicus"*), left maxilla with C1-M3, left juvenile mandible with P4-M2 (ex-*"Sugrivapithecus"*), left mandible with M2-3 (ex-*"Ramapithecus"*); mandible of* Gigantopithecus giganteus.

but continues up to 6.5 Ma). Smaller catarrhines and strepsirhines are also known. The large hominoids belong principally to the genus *Sivapithecus,* including specimens formerly assigned to *Ramapithecus.* Many new specimens, including a well-preserved face and a large number of postcranial elements of *Sivapithecus,* are now known. These seem to indicate clearly that this genus is not on the human lineage as once thought but is more closely allied to the ancestry of the modern orangutan. Three species are recognized: *S. sivalensis* dated 12.5–10.3 Ma; *S. indicus* (represented by most material, especially at the U-sandstone horizon that is dated ca. 9 Ma on the latest time scale) between 9.5 and 8.5 Ma in Pakistan and India; and the large *S. parvada,* known only at Loc. Y311 (Sethi Nagri), dated ca. 10 Ma. Small, apparently thin-enameled hominoids are known from levels ca. 11.5–10.5 Ma and at Hari Talyanger; these have been called *S. simonsi* by R.F. Kay but are probably better referred to as *?Dryopithecus.* Specimens attributed to *Gigantopithecus* are rare, with an undated isolated tooth named *G. giganteus* usually synonymized with the ca. 7–6.5 Ma mandible of *G. bilaspurensis* from the upper levels near Hari Talyangar.

A small catarrhine previously referred to *?Dionysopithecus,* but now considered a possible member of the *Dendropithecus*-group and not a pliopithecid, is known mainly from levels dated ca. 16.1 Ma. Similar teeth have been reported at Hari Talyangar. The lorisid *Nycticeboides* derives from levels near the U-sandstone. Small archaic strepsirhines usually included in the Sivaladapidae also occur at this level in Pakistan and at Hari Talyangar, and they extend down into the Kamlial. Cercopithecid primates occur later in the sequence, with the small colobine *?Semnopithecus sivalensis* between ca. 7.5 and 6.5 Ma, and the cercopithecines *Macaca palaeindica* and *Procynocephalus subhimalayanus* probably between 3.5 and 2 Ma. A single specimen of *Theropithecus oswaldi delsoni* is known from Mirzapur, India, perhaps dating to 1.5–0.9 Ma.

As discussed mainly by J. Barry and colleagues, there are several intervals of major faunal turnover in rodent, artiodactyl, and primate taxa through the Miocene portion of the Siwalik sequence. As yet, the Pliocene segment is not well enough known to analyze. The greatest turnovers occur ca. 13 Ma and 8.5–8 Ma, which do not correspond closely to known global events. Small catarrhines are present before the first of these turnovers, while *Sivapithecus* first appears soon after it. The last occurrences of *Sivapithecus, ?Dryopithecus, Nycticeboides,* and Sivaladapidae probably correspond to the second turnover, after which cercopithecids first appear (the oldest-known members of this family east of Afghanistan). In India, however, *Gigantopithecus* is found to at least 6.5 Ma, and in China it continues well into the Pleistocene. This faunal change in the Siwaliks is probably related to climate. For example, studies of soil carbonates reveal that there was a shift between 8 and 5 Ma from environments dominated by C_3 plants to those in which C_4 plants were more common—this may equate to forests being replaced by grasslands. Faunal elements that appeared during and after this time seem to be adapted to more open-country regimes. Prior to the 8 Ma turnover, a smaller turnover may have occurred ca. 10–9.5 Ma with the arrival of equids, but the environmental change, if any, had no major effect on the hominoids.

The great interest of the Siwalik region, and of the Potwar sequence in particular, lies in the information it provides about mammalian faunal change in one region over a long time period. The fact that hominoids are part of this fauna only adds to its value. In conjunction with work elsewhere, periods of successive isolation and connection with other parts of the world can be demonstrated and their effects on the fauna closely documented. The Siwaliks also present the best opportunity available for investigating the possible interactions of climatic events and mammalian evolution through the Neogene.

See also Adapiformes; Asia, Eastern and Southern; Cercopithecinae; Colobinae; Dryopithecus; Gigantopithecus; Hominidae; Hominoidea; Lorisidae; Miocene; Neogene; Paleodietary Analysis; Ponginae; Plate Tectonics; Sivapithecus; Stable Isotopes (in Biological Systems). [J.A.V.C., E.D., A.H.]

Further Readings

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