Litho- and biostratigraphy of the Siwalik succession in Surai Khola area, Nepal

G. Corvinus

Corvinus, G. 1990. Litho- and biostratigraphy of the Siwalik succession in Surai Khola area, Nepal. *In* Jain, K. P. & Tiwari, R. S. (eds)—*Proc. Symp. 'Vistas in Indian Palaeobotany', Palaeobotanist* **38** : 293-297

The Surai Khola succession of Siwalik sediments comprises an uninterrupted body of molasse sediments of a thickness of 5,500 m, which have been divided into six lithological units. The sequence has yielded abundant vertebrate and invertebrate fossils, particularly of mammals. These indicate that the lower part of the Surai Khola succession belongs to the Chinji zone of the Lower Siwalik, while the rich fauna of the upper beds belong to the Tatrot and Pinjor faunal zones of the Upper Siwalik. Apart from the mammalian fauna, a wealth of plant fossils has come to light, particularly from the lower and middle part of the sequence. The finer clastics throughout the sequence yielded palynofossils.

Key-words—Lithostratigraphy, Biostratigraphy, Siwalik, Nepal Himalaya.

G. Corvinus, Institute fur Urgeschichte, Erlangen University, Germany.

सारॉंश

नेपाल में सुराई खोला क्षेत्र में शिवालिक अनुक्रम का शैल-एवं जैवस्तरविन्यास

गुंदरून कोर्वाइनस

शिवालिक अवसादों के सुराई खोला अनुक्रम में 5,500 मीटर मोटे अबाधित अवसाद विद्यमान हैं जिन्हें छः शैलिकीय इकाईयों में विभक्त किया गया है। इस अनुक्रम से काफी रीढ़धारी एवं अरीढ़धारी अश्मित जन्तु मिले हैं जिनमें विशेषतया स्तनधारी जन्तु हैं। इनसे यह प्रदर्शित होता है कि सुराई खोला का निचला भाग अधरि शिवालिक के चिन्जी क्षेत्र से सम्बन्धित है जबकि ऊपरी संस्तरों का जन्तुजात उपरि शिवालिक के तत्रोत एवं पिंजौर मंडलों से समानता दर्शाता है। स्तनधारी जन्तुजात के अलावा पर्याप्त मात्रा में अश्मित पौधे भी मिले हैं, विशेषकर अनुक्रम के बीच के एवं निचले भाग से। पूरे अनुक्रम के बारीक खंडजों से अश्मित परागकण उपलब्ध हुए हैं।

UNDER the Geo-archaeological Project, University of Erlangen, financed by the German Research Council, the author carried out field as well as research work during the last five years in several areas in the Siwalik Hills of Nepal. The research includes stratigraphical and biogeographical investigations in the Miocene to Pleistocene deposits of the Siwalik ranges in the Dang area in western Nepal, particularly in the Surai Khola area and in the Kamla Nadi area in eastern Nepal (Corvinus, 1988a, b).

The Siwalik mountains being the youngest, of the Himalayan orogeny, form the foot-hills along the entire Himalaya margin from Pakistan to Assam. In Nepal alone they are ca 800 km in length, consisting of molasse sediments, sandstones, mudstones, shales and claystones of up to 8,000 m thickness. They are deposited during the last ca 15 million years as erosional debris from the rising Himalaya into the foredeep basin along the foot of the mountains; they are folded and thrusted against the Himalaya during the Middle Pleistocene, as the last phase of the Himalayan orogeny.

The movement and the mountain building are not terminated. India continues to be subducted underneath the Central Asian Block and neo-tectonic movements are going on. Earthquakes show that it is still a zone of unrest and unstability. One day the thick deposits of the Terai plains, all of which have been washed down from the Himalaya, too, will be subjected by these movements and folded against the Himalaya. The Siwalik deposits have once been very similar to the recent deposits of the Terai and the Gangetic plains. Driving east-westwards along the Terai one crosses river after river with wide,

meandering flood-beds filled with sand, silt, and gravels. The rivers carry a tremendous amount of load into the plains each year, and the accumulation of erosional debris from the mountains into the Gangetic plains is estimated to be some 6,000 to 8,000 m thick.

The research has yielded results in many aspects. A detailed lithostratigraphy of almost 6,000 m could be established at the Surai khola, and owing to the abundance of *in situ* fossils, all bio geographical data could be recorded into the comprehensive stratigraphical column (Text-fig. 2).

In the course of investigations, a wealth of plant fossils in the form of megafossils and pollen has come to light which necessitated the author to collaborate with the Birbal Sahni Institute of Palaeobotany, Lucknow to study the Palaeobotanical aspects. Thus, the kind assistance and suggestions of the Director, Dr B. S. Venkatachala, resulted a joint research programme. Drs N. Awasthi and M. Prasad of BSIP are studying the plant megafossils, and Dr S. Sarkar is carrying out the palynostratigraphic analysis. In this way we will be able to build up a complete floristic succession from Lower to Upper Siwaliks in one area, in the Nepal Siwaliks as model (Reports of their work are published in this issue). This report deals with the litho- and biostratigraphical background of this multi-faceted research project, where every aspect plays an important role for the whole, and where palaeobotany is one aspect which reaches its fullest importance when combined with all the other aspects of the research.

GEOGRAPHY AND MODERN ENVIRONMENT

Below the Siwalik foot-hills in south a flat, wide plain called the Terai stretches east-west which constitutes fertile farmland. Formerly, the flat land at the foot of the Himalaya was a thick belt of tropical forest, called the Bhabar zone, of mainly Saal and bamboo which was once one of the richest wild life areas of the world. But now most of these virgin forests are disappearing fast due to the continued cutting of trees and the wild life has disappeared completely.

The climate in the Terai is like in north India, with cool and dry winters, extreme hot summers and rather heavy monsoon seasons with rainfall between 1,600 to 2,000 mm/annum (more so in the east than in the west). The climate supports a tropical to sub-tropical, moist deciduous to dry deciduous vegetation.

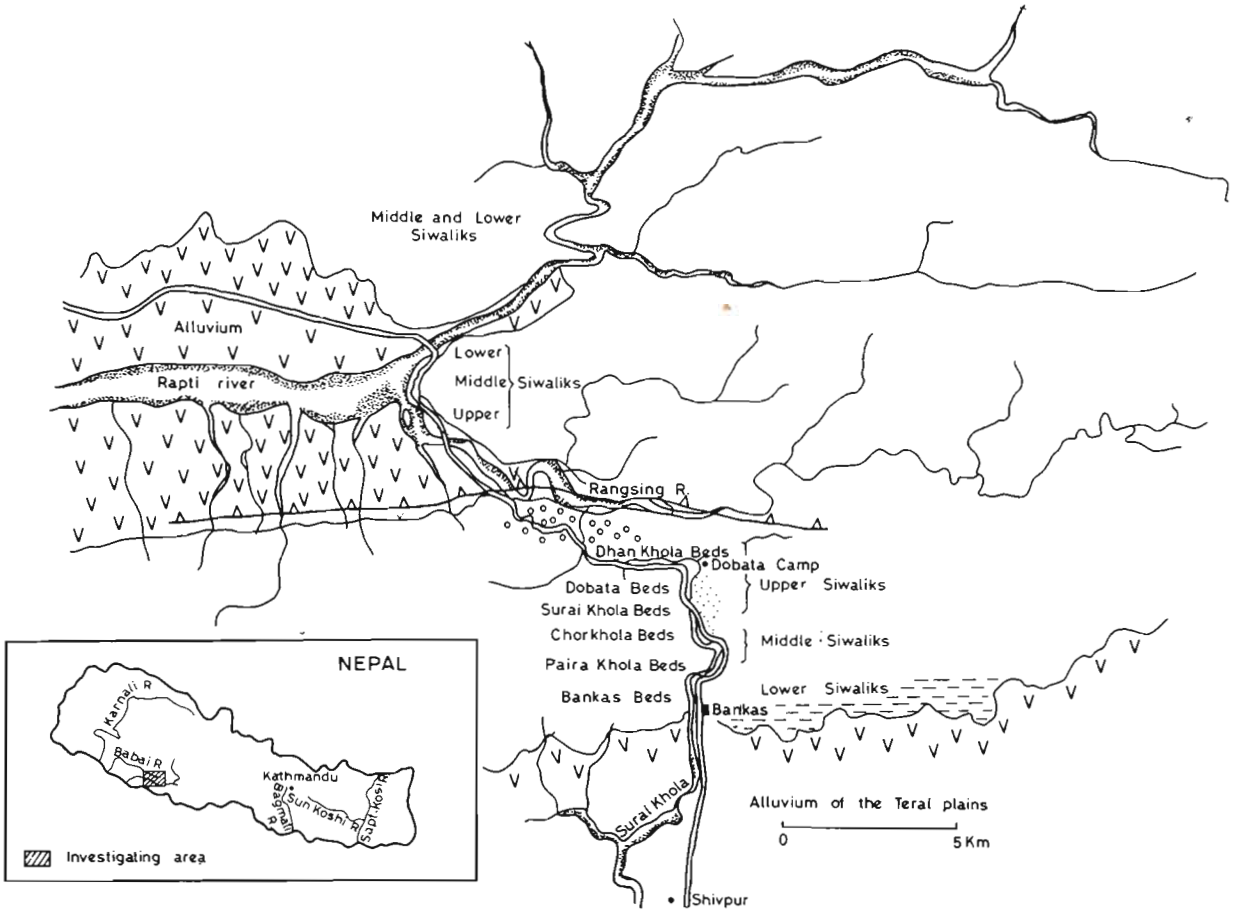
PREVIOUS WORK

The Siwalik deposits in Nepal have not been studied in detail until recently. The rock successions were only roughly known and there was no clear distinction between rock units and faunal zones. The fossils, which had been recorded (West *et al.*, 1978, 1988; West & Munthe, 1983) have not been described in their stratigraphical context; though they opened first vistas about the fauna of Nepal Siwaliks. No precise ages, therefore, could be ascribed to the various rock units. Recent works on the structural evolution of the eastern Nepal Siwalik have been published by Mascle and Herail (1982) and Herail *et al.* (1986).

A Japanese team has recently carried out detailed mapping and lithostratigraphical studies of another area of the Siwalik, east of Butwal (Tokuoka *et al.*, 1986). Here the magneto-polarity, too, has been recorded, but it is not linked with fossil vertebrate remains. Munthe *et al.* (1983) reported one molar of *Ramapithecus* from near Butwal in Nepal. Unfortunately no other fossil-remain of this elusive hominoid has so far come to light from this area.

OBSERVATIONS

Two areas were chosen for detailed study: the Surai Khola area in Dang District in west Nepal and the Rato Khola area in Janakpur District in east Nepal, which were found to be fossiliferous. Only the Surai Khola area is described here (Text-fig. 1). The map shows the traverse through the described Siwalik sequence exposed along the Surai Khola from the lower strata at Bankas to the upper strata south of Rangsing Khola. In the Surai Khola area, a road was being built during 1983 and 1984 (Text-fig. 1) which gave the author unique opportunity to study the rock succession which were freshly exposed due to the blasting and cutting, and which greatly helped in the measurement of sections and collection of fossils. The road cuts practically at right angles to the strike of the rocks, which is more or less 60° to 75° to the north. It was found that an uninterrupted and undisturbed sediment body of almost 6,000 m was exposed around the Surai Khola area where an almost entire sequence of Siwalik sediments could be recorded. The vertebrate fossils found in the sediments suggest that the Surai Khola sequence represents the periods from the Chinji faunal zone of the Lower Siwalik at Bankas to the boulder conglomerate of the uppermost Siwalik south of Rangsing Khola. In short, the Surai Khola



Text-figure 1

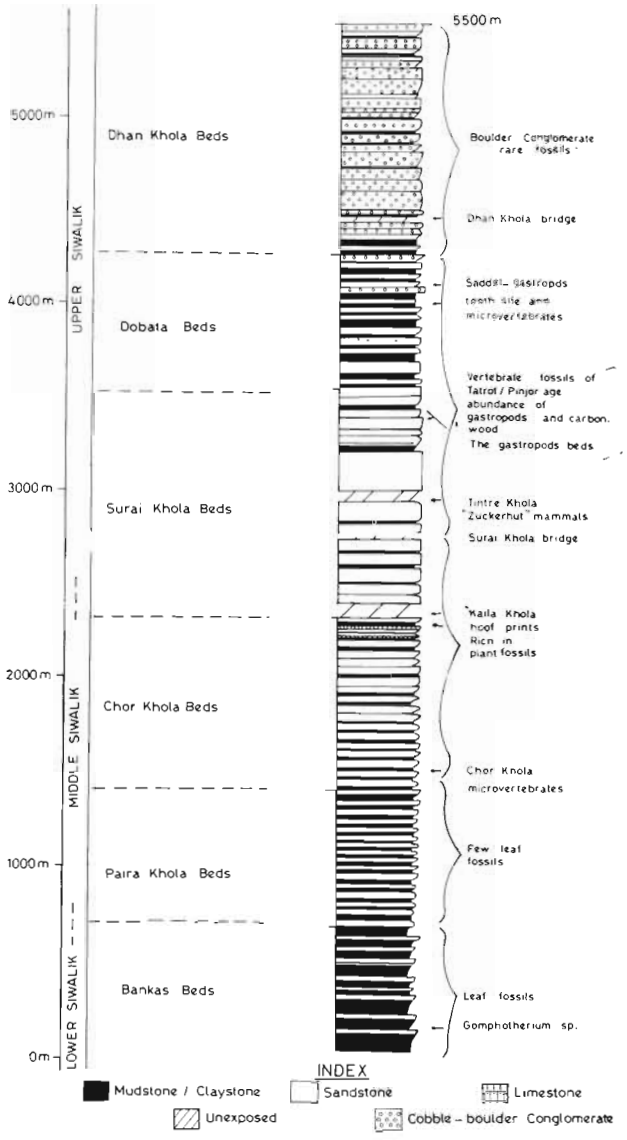
sequence represents almost entire Siwalik succession.

The rock succession (Text-fig. 2) shows a gradual coarsening up from finer clasts of clays and mudstones and shales in the lower part to sandstones and finally to gravel and boulder conglomerates in the uppermost part. The sequence has been divided into six lithological units (Text-fig. 2). All collected and observed data have been recorded and, for the first time, a comprehensive stratigraphical column with *in situ* fossil data has been drawn up.

Great variety of fossils have been recovered from the area. The lowermost part of the succession, the Bankas beds, which is dominated by variegated claystones and mottled mudstones reveal an environment of low-water-regime, with backwaters, pools and swampy areas. The discovery of *Gomphotherium* sp. by its similarity to this fossil group from Pakistan places these beds into the Chinji faunal zone of the Lower Siwalik. In Pakistan, this zone has been magnetostratigraphically dated between 13 to 10 Ma.

Vertebrate fossils are absent, as yet, in the subsequent 1,800 m of the Paira Khola and Chor Khola beds (tentatively equivalent to Middle Siwalik), which mark a change from predominantly colourful clays and mudstones to more pronounced sandstone banks with shales and mudstone and claystone intercalations. The lithology points to an environment of increased fluvial activities, resulting in the deposition of sand bars, but the continued strong component of clays suggests that still-water conditions co-existed. No faunal correlation could be established for these beds as yet. These are, however, extremely rich in plant fossils, especially of leaf-impressions which are particularly prominent and well-preserved in the shaly sediments. In mottled claystones and mudstones also they have been recorded, although poorly preserved. Stratigraphically oriented collections were made from the most important of the recorded 48 plant bearing horizons.

A drastic change in sedimentation marked by thick, micaceous sandstones of the Surai Khola beds suggests a strongly increased fluvial activity. The



Text-figure 2—Surai Khola profile.

rivers, emerging from the rising Himalaya deposited thick fans of sandy erosional debris at the margin of the mountain front. The current being strong, the roots of tree and animal bones were embedded in the sand.

The sandstone facies of the Surai Khola beds proved to be the richest in vertebrate fossils of the entire succession, and their identification puts these sandstones equivalent to Tatrot and Pinjor formations of the Upper Siwalik. Most common were the remains of reptiles (Crocodylidae, Trionychidae) indicating an environment of rich water resources. Large mammals of the family Elephantidae, Suidae, Hippopotamidae, Cervidae, Giraffidae and Bovidae were found in the thick fluvial sandstone successions in the Upper part of the sequence, pointing to a forested environment, criss-crossed by wide, sandy meandering streams. Large tree trunks and branches found in the same sandstone which contain vertebrate fossils are equally indicative of thickly forested and heavily flooded environments.

Many clay beds are abundant of molluscs (lamellibranchs and gastropods), sometimes even in the form of lumachelles. The few clay horizons which are intercalated in the sandstone proved to be rich in pollen, but leaf containing horizons are rather rare.

After an interval of a quieter fluvial regime during the period of the Dobata beds which may be equivalent to the Pinjor Formation thick screes of cobble to boulder conglomerates (here called the Dhan Khola beds) were transported down from the rising Himalaya. The boulder conglomerates are devoid of fossils, except a few pollen bearing horizons. A fault running east-west along the Rangsing River thrusts older Siwalik deposits against the conglomerates of the Dhankhola beds.

It is important to note that at the Surai Khola area throughout the entire sequence, most of the clay horizons are surprisingly rich in pollen which is not common in the Indian Siwaliks. The combined data from the palynostratigraphical analysis, complimenting the studies of fossil plants will result in a comprehensive evaluation of the floristic through the sequence which will serve as a model for understanding the changes in plant life and environment during the Siwalik period is one area. This means that we are able to describe an entire Siwalik sequence not only lithologically and faunistically but also climatically and environmentally by establishing the floristic development through megafossils and pollen. Apart from the surveyed Surai Khola succession, the other areas in the Nepal Siwalik too yielded quite abundant vertebrate and plant fossils.

It is apparent that the thick micaceous sandstone facies similar to those of the Surai Khola beds in the Nepal Siwaliks, wherever exposed, are synchronous to the Tatrot and Pinjor faunal zones of the Upper Siwalik. One of the most fossiliferous areas was found to be the Rato Khola in east Nepal, north of Janakpur, where massive micaceous sandstones are exposed. Here, we collected and excavated a large number of vertebrate fossils which are also present in Tatrot and Pinjor sediments. Great stress was laid in collecting the fossils *in situ*. Only those fossils were included in the collection for identification of which the provenance was definite. The remains of crocodile and gavialis as well as a great variety of turtles are always found in abundance. Most of the fossils are of large

mammals—particularly of elephantidae (for example, a skull and other remains of *Stegodon ganesa* and teeth and other parts of *Archidiskodon planiforns*) and of hippopotamidae (a whole skull, skull part, post cranial bones, etc of *Hexaprotodon siwalensis*). A well preserved skull of the pig *Hippohyus tatroti*, jaws and teeth of bovids and antelope species are found. One of the most interesting finding is that of an entire skull with part of the tusks belonging to *Archidiskodon planiforns*, described from Pinjor, which was excavated from a sandstone cliff.

One of the most important features of the data from the Surai Khola is the possibility to link up a substantial vertebrate fauna within a stratified, large sediment-body with that of the plant life during the same periods. It will greatly increase our insights into the palaeoenvironment of the Siwalik period by evaluating both plant as well as animal life in their geological setting during the same time and place.

In order to establish a magneto-polarity time scale, palaeo-magnetic sampling has been undertaken this year by W. Roesler and Fassbinder under Dr Appel from the Geophysical Department of the University of Munich. The final results will be a first comprehensive model of a chronostratigraphy of the Nepal Siwaliks and its palaeoenvironmental and climatical interpretations for the last ca 12 million years.

A joint detailed report will soon be forthcoming under the auspices of the Birbal Sahni Institute of Palaeobotany, Lucknow.

ACKNOWLEDGEMENTS

I am extremely grateful for the collaboration with the Birbal Sahni Institute of Palaeobotany through its Director, Dr Venkatachala to whome I am thankful for his encouragement and assistance. I thank my collegues from this Institute, Drs N. Awasthi, S. Sarkar and M. Prasad for their collaboration. I am grateful to the Research Division under Dr Pradhan and the Geology Department of Tribhuvan University, Kathmandu, and its Director, Dr M. P Sharma for their great assistance I thank the German Research Council for the grant under which this research was made possible. My particular thanks go always to Prof Dr Gisela Freund, Institut fur Urgeschichte, University of Erlangen, Germany for her untiring encouragement and promotion of this research.

REFERENCES

Awasthi, N. & Prasad, Mahesh 1990. Siwalik plant fossils from Surai Khola, western Nepal. *In*: Jain, K. P. & Tiwari, R. S. (eds)— *Proc of Symp Vistas in Indian Palaeobotany, Palaeobotanist* **38** : 298-318. Birbal Sahni Institute of Palaeobotany, Lucknow.

Corvinus G. 1988a. The Mio-Plio Pleistocene Litho- and biostratigraphy of the Surai Khola Siwaliks in West Nepal: First results. *C.R. Acad Sci Paris* **306**(2) : 1471-1477

Corvinus, G. 1988b. Plio-Pleistocene fauna and flora from the Siwalik groups of sediments in Nepal and their environmental implications, a preliminary report *In*: White, P. (Ed.)— *The palaeoenvironment of East Asia from the mid-Tertiary* **2** 908-915. Hong Kong.

Herail, G., Mascle, G. & Delcaillau, B 1986. Les Siwaliks de l' Himalaya du Nepal; un example d' evolution géodynamique d' unprise d' accretion intractioninental. *Sci Terre, mem.* **47** : 155-182.

Mascle, G. & Herail, G. 1982. Les Siwaliks: le prisme d' accretion tectonique associé a la subduction intracontinentale himalayenne. *Geol. Alpine* **58** : 95-103.

Munthe, J., Dongol, B., Hutchison, J. H., Keans, W. F., Munthe, K. & West, R. M. 1983. New fossil discoveries from the Miocene of Nepal include a hominoid. *Nature* **303**(5915) : 331-333.

Tokuoka, T., Takayasu, K., Yoshida, M. & Hisatomi, K. 1986. The Churia (Siwalik) Group of the Arung Khola area, west central Nepal. *Mem Fac. Sci. Shimane Univ. Matsue, 1986*, pp. 135-210.

West, R. M., Lukacs, J. R., Munthe, J. & Taseer Hussain, S. 1978 Vertebrate fauna from Neogene Siwalik Group, Dang Valley, western Nepal. *J. Palaeont.* **52**(5) . 1015-1022.

West, R. M. & Munthe, J. 1983. Cenozoic vertebrate palaeontology and stratigraphy of Nepal. *Him. Geol.* **11** : 18-27

West, R. M., Dongol, G. Munthe, J., Hutchison, J. H. & Gupta, V. J. 1988. Late Neogene and Quaternary geology, palaeontology and palaeoenvironment of the Kathmandu Valley, central Nepal and the Churia Hills, western Nepal. *In*: White, P. (Ed.)— *The palaeoenvironment of East Asia from the Mid-Tertiary* **2** 916-936, Hong Kong.