



General palaeontology, systematics and evolution

Siwalik synopsis: A long stratigraphic sequence for the Later Cenozoic of South Asia



Synopsis Siwalik : longue succession stratigraphique du Cénozoïque moyen et tardif de l'Asie du Sud

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ABSTRACT

The Tertiary sediments of northern Pakistan are an exceptional record of terrestrial sedimentation and represent most of Neogene time. Foremost is the Siwalik Group of the Potwar Plateau, for which multiple, superposed fossil levels span ~18–6 Ma. Well-developed magnetostratigraphic control provides secure dating so that Siwalik fossil horizons may be interpolated into a time scale with resolution to 100,000 years. We describe the geographic setting of the Potwar, give an overview of the temporal distribution of faunas, and discuss changes in paleohabitat and paleoecology with coinciding faunal change, as seen from the Siwalik viewpoint. The long Siwalik biostratigraphy of many successive assemblages with its resolved time scale may be compared directly with other well-dated sequences. Immigrant arrival and timing of faunal change may be traced. The basins of the Iberian Peninsula show somewhat different timing of introduction of hipparionine horses, and faunal turnover in the Siwaliks clearly precedes the Vallesian crisis in Spain. In contrast to the increasingly seasonal precipitation of the late Miocene Potwar, the paleohabitat of coeval North China appears to have been moist and equable, with high diversity faunas. Continued development and comparison of resolved Neogene records allow increasing resolution of the patterns of faunal change on regional to global levels.

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R É S U M É

Les sédiments tertiaires du Pakistan septentrional constituent un registre exceptionnel de la sédimentation continentale et représentent la plus grande partie du Néogène. Le groupe Siwalik du plateau du Potwar, en particulier, comporte de multiples niveaux fossilifères entre environ 18 et 6 Ma. Un contrôle magnétostratigraphique approfondi était la datation, si bien que les horizons fossilifères Siwalik peuvent être interpolés dans une échelle de temps à la résolution de 100 000 ans. Nous décrivons le cadre géographique du Potwar,

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donnons une vue d'ensemble de la distribution des faunes dans le temps et discutons les changements d'habitat et de paléocéologie coïncidant avec un changement dans la faune du groupe Siwalik. La longue biostratigraphie Siwalik de multiples assemblages successifs, avec son échelle de temps résolue, peut être comparée directement avec d'autres séquences bien datées. L'arrivée d'immigrants et le moment où se produit le changement faunique peuvent être retracés. Les bassins de la péninsule Ibérique indiquent un temps quelque peu différent pour l'introduction des chevaux hipparioninés, et le *turnover* faunique dans les Siwaliks précède la crise valésienne en Espagne. Contrairement aux précipitations saisonnières croissantes au Miocène supérieur dans le Potwar, le paléohabitat concomitant du Nord de la Chine semble avoir été humide et constant, avec une grande diversité faunique. Le développement continu et la comparaison des registres néogènes déterminés permettent une résolution croissante des schémas de changement faunique aux niveaux régional et global.

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1. Introduction

The Indian Subcontinent presents a special setting for paleobiologists. The uplift along the northern margin of the landmass, as its leading edge subducts under the mountainous terrain of the Tibetan Plateau, supplies clastic wedges of terrestrial deposits to the south via major river systems. The relatively continuous process of sediment accumulation under conditions favorable for vertebrate fossil preservation has created a series of fossil horizons, superposed and laterally extensive, spanning much of the second half of the Cenozoic Era. Assemblages represent successive samples of the past biota. The most continuous series of superposed fossil horizons is contained in the Siwalik deposits of the Potwar Plateau, Pakistan. This dense biotic record spanning much of the Neogene can be compared with well-dated biostratigraphies from other biogeographic regions to evaluate mammalian dispersal and turnover, timing of high or low rates of appearance and disappearance events, and response to abiotic factors of temperature, moisture, and tectonics. Research is beginning to address direct comparisons of sequences in Spain and China, for example, because their records comprise increasingly well-dated and resolved faunas.

Sedimentary formations of the Indian Subcontinent include primarily the classical Siwalik Group rocks of northern Pakistan, Nepal and India, of late Early Miocene through Pliocene age. Also relevant and preserving similar faunal assemblages are the Manchar Formation of southern Pakistan (Sindh), and coeval to older Zinda Pir Dome and Bugti sediments of western Pakistan (Baluchistan) (Fig. 1). The oldest of the latter deposits are Oligocene in age (Welcomme et al., 2001). Together they produce a rich record of successive faunas that can be studied for questions on lineage evolution, community structure, and faunal change.

The Siwaliks and related formations have been the subject of field exploration for almost 200 years. Early collecting was sporadic, with little attention paid to provenance, but it provided impetus for later expeditions. Two of these were collecting campaigns under the direction of Barnum Brown of the American Museum of Natural History in the 1920s and G. Edward Lewis of Yale University in the

1930s. Their collecting (Lewis, 1937) was geographically controlled and today we can reconstruct in general where many of their collections were made. Richard Dehm (Dehm et al., 1958), Universität München expeditions of 1939 and 1955–1956, and G.H.R. von Koenigswald, Rijksuniversiteit, Universiteit Utrecht (1966–1967), also recorded data for fossils recovered by their groups. However, the potential for biostratigraphic study of long sections in defined areas was still largely unrealized.

It is now feasible to record precisely the level of occurrence of superposed stratigraphic horizons that produce fossils. The sequence of sites records the local histories of organisms during much of the Miocene Epoch, both changes among members in associated faunas as well as evolution within lineages. The fossil horizons of the Potwar Plateau can be dated relative to one another, and ages can generally be resolved on the scale of 100,000 years for the interval of approximately 18 to 6 Ma (Barry et al., 2013). The record can be extended to about 22 Ma by paleomagnetic correlation of deposits of the Zinda Pir area, and into the Pliocene Upper Siwaliks of the southeastern margin of the Potwar Plateau. Sampling density for fossils is not constant throughout this time, which is critical to note when interpreting recorded faunal change. Fig. 2, based mainly on Potwar records and supplemented by Zinda Pir and Upper Siwalik localities, shows the uneven temporal distribution of Neogene sites in Pakistan.

The Siwaliks present a special geobiological case in which many successive and dated levels can be sampled for their often abundant vertebrate fossils and ecological proxies, affording an excellent opportunity to document changes in landscapes, habitats, and faunas through time. The dimensions of information that can be retrieved from the Siwaliks are considerable compared to other sequences of comparable age.

In the following, we discuss the geological and geographic setting for the major fossil-producing regions of the Indian Subcontinent. We sketch the history of exploration by early workers in the Indian Subcontinent. We touch on major features of the terrestrial deposits and age determination, and then turn to our current assessments of faunas and paleohabitats of the Miocene.

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