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DID THE ANCESTRAL INDUS FLOW INTO THE GANGES DRAINAGE ?

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ABSTRACT

The Late Miocene, Pliocene and Pleistocene Upper Siwalik Group molasse sediments of the Eastern Potwar Plateau are shown to include two distinctive sandstone complexes. The older sandstone complex is white colored and carries granitic pebbles. The younger sandstone complex is brown molored and carries quartzite and igneous pebbles. Paleocurrent measurements together with preliminary provenance analysis suggest that the white sandstones were deposited by an ancestral Indus River which flowed to the east-northeast across the Eastern Potwar Plateau. This river system was replaced between 4.5–5.0 MY ago by a southward flowing ancestral Jhelum River. It is possible that the ancestral Indus River may have drained into the Bay of Bengal rather than into the Arabian Sea.

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Detailed examination of the sandstones of the Upper Siwalik Group in the Jhelum area (Raynolds, 1980) suggests that at least two major river systems were responsible for the transportation and deposition of molasse sediments in this area during Late Miocene, Pliocene, and Pleistocene time. The beds of channel sandstone deposited by the major rivers fall into two groups which can be readily distinguished in the field.

The Siwalik Group sediments of the Jhelum area (Figure 1) are characterized by alternating layers of sandstone and mudstone. The sandstone component of the uppermost Siwalik Group rocks in the Jhelum area is dominated by a brown colored sandstone which typically weathers into resistant steep walled cliffs and (where the strata are steeply dipping) into elongated sandstone fins. Lower in the section, a striking change in color of the channel sandstones takes place with the brown sandstones interfingering and ultimately being replaced downwards by a distinctive white colored sandstone. The white sands are poorly cemented, rarely form ridges, and are consequently often less well exposed than the overlying brown sandstone.

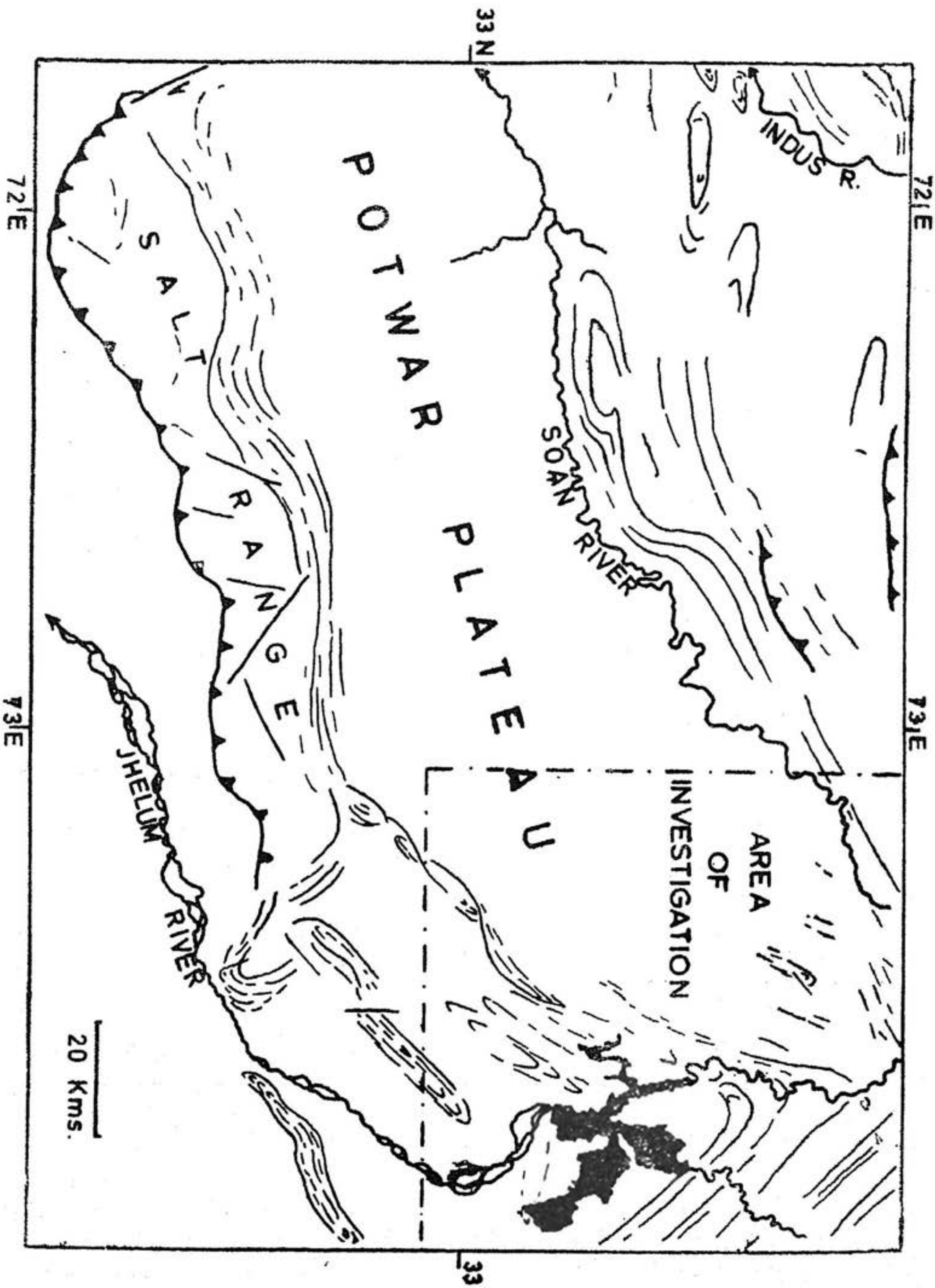

Fig. 1. Location of the study area.

Closer inspection of the sandstones reveal further distinguishing characteristics. The brown sandstones carry a scattered basal pebble lag composed of brown quartzite and igneous clasts, possibly derived from the Tanawal (or equivalent) quartzites, and basic igneous pebbles, possibly derived form the Panjal Traps. In contrast, the white sandstones carry lag pebble populations characterized by white quartzite and granite clasts.

Petrographic analysis of the sandstones, while showing them to have overlapping bulk compositions falling within Folk's (1968) Litharenite field, also shows that a distinctive green hornblende occurs consistently in the white sandstones, while the brown sands characteristically lack hornblende.

The two sandstone types form sheet-like bodies with thickness to width ratios often in excess of 1:100. These sheet-like bodies are quite typical of the Siwalik molasse, an aspect somewhat at varience with standard ideas of fluvial sandstone morphology (Allen, 1965) in which fluvial sands are generally thought of as being more narrow, ribbon-like features.

While the two types of sandstone display similar overall morphology, the white sandstones are characterized by more planar horizontal bedding forms, showing less frequent development of trough cross beds than the brown sandstones.

The composition differences described above, combined with the color difference which is most evident in the field, leads one to speculate that these sandstones were deposited by distinct river systems, each draining a different portion of the growing Himalaya Range. Such a premise can be further substantiated by paleocurrent studies.

The analysis of paleocurrent directions preserved by trough cross-bedded fluvial sandstones can indicate the direction of transport of sediments and the azimuth of the river channel at a given point in time. The paleocurrent direction is deduced by examining the cross bedding features and measuring the azimuth of steepest dip of the trough planes (Figure 2). Erosion patterns are such that the trough cross beds are much easier to discern on sandstone bodies that dip less than 45 degrees. Steeper beds erode into ridges or narrow bands which reveal little internal bedding structure. Similar sedimentary structures have been examined from modern rivers draining the Himalayas and the measured cross bedding azimuths shown to parallel the modern river course (Coleman, 1969).

In conglomeratic facies deposits, such as those which characterize the top of the Siwalik Group in the Jhelum area, paleocurrent directions may also be inferred from the imbrication of flattened clasts. This feature, illustrated in Figure 2, is based on the premise that water flowing over flattened pebbles will tend to leave them in a position such that they incline upstream. Sequences of such imbricated pebbles are readily observed in modern depositional environments, such as in the modern Indus river conglomerates deposited just north of the Grand Trunk Road upstream from the eastern end of the new Attock Bridge.

Over 400 paleocurrent measurements were made at 21 sites within the Upper Siwalik Group of the Jhelum area. The orientation data is presented as a

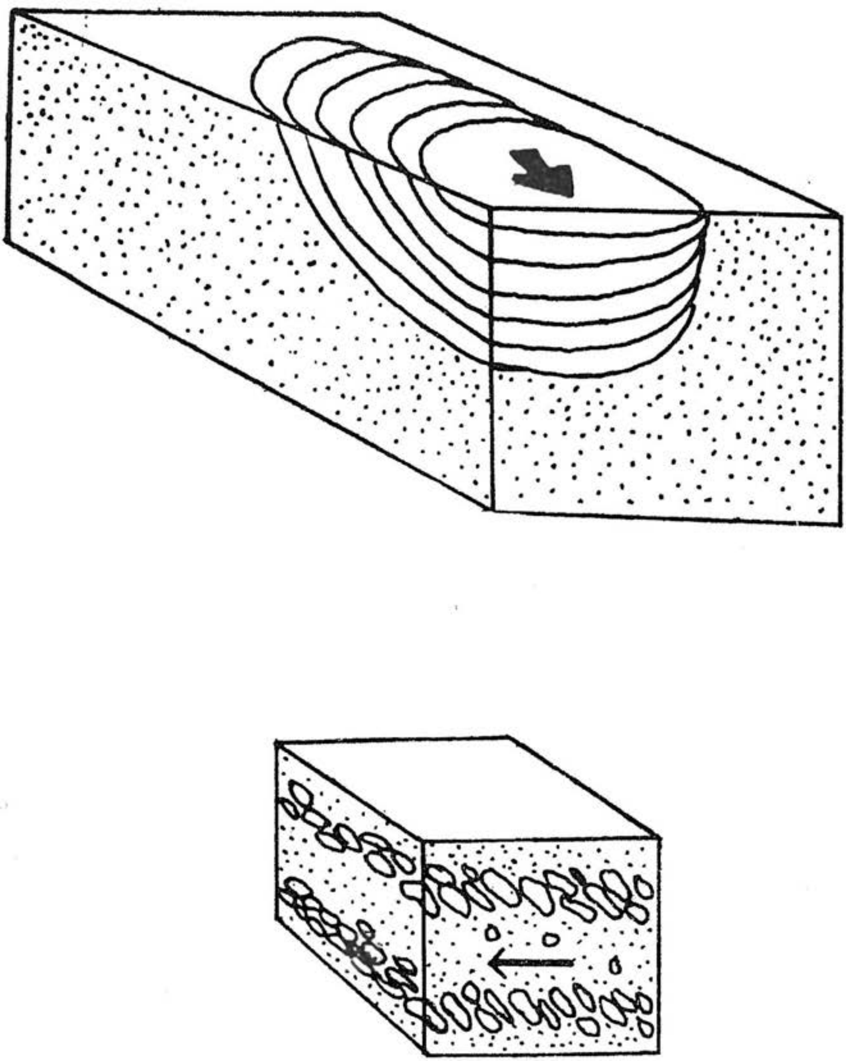

Fig. 2. Sedimentary structures used to determine paleocurrent directions. The top diagram illustrates a trough cross bed set left by a river flowing towards the front of the block diagram. The lower diagram illustrates imbricated pebbles left by a stream flowing towards the left. Each block diagram is 1 meter high.

rose diagram in Figure 3 and in plan view in Figure 4. Three per cent of the measurements were taken from imbricated pebbles; the remainder from trough cross bedding features.

The paleocurrent data serve to clearly separate the white and the brown sandstones. It is evident that the early white sandstones were deposited by rivers which trended NE and that these rivers were gradually replaced by S to SSW flowing rivers which carried brown sands.

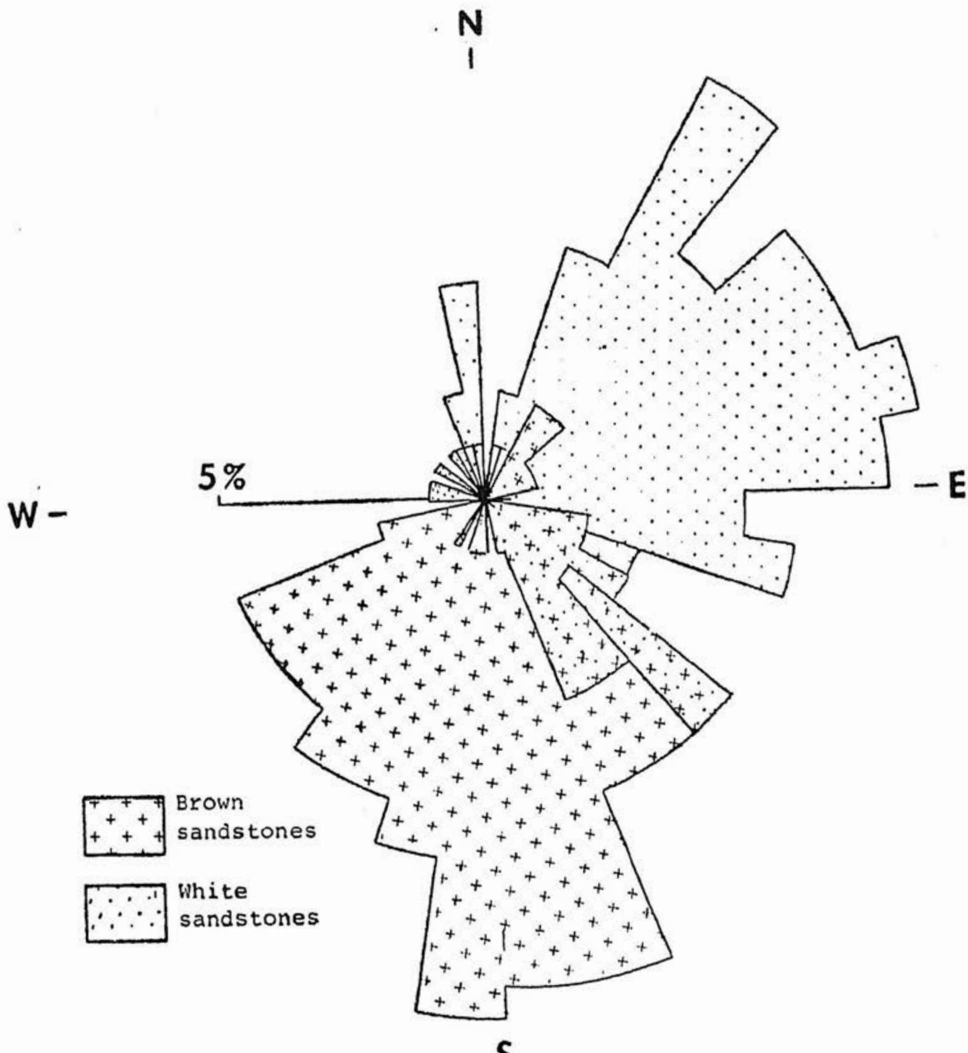

Fig. 3. Rose diagram showing paleocurrent measurements from brown and white sandstones form the Eastern Potwar Plateau.

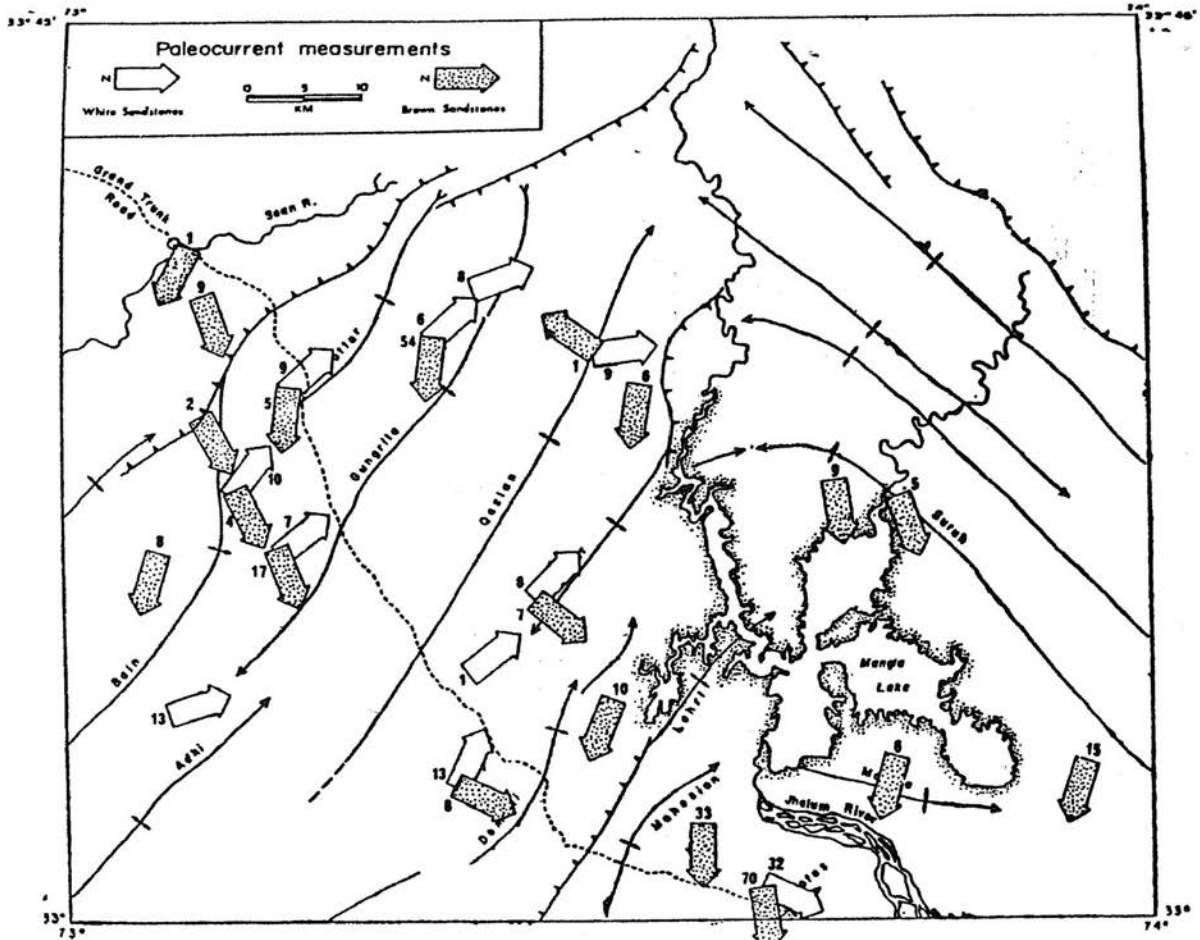

Fig. 4. Means of paleocurrent direction measurements. Number of measurements is indicated for each site.

Other workers have also observed similar patterns in the molasse paleocurrents. Badgley and Behrensmeyer (1980) have examined paleocurrent directions in the Central Potwar Plateau near Khaur. In this area a blue-grey sandstone (resembling in color, though older than the white sandstones described herein), was deposited by rivers which flowed to the ESE. The blue-gray sandstones interfinger with brown sandstones which these authors show to have paleocurrent directions which trend to the SE.

Paleocurrents have also been examined in the Siwalik formations of India. Data presented from the Middle and Upper Siwalik formations by Parkesh *et al.*, 1974; Tandon, 1976; and Parkesh *et al.*, 1980, also suggest that southeasterly trends are often replaced upwards by southerly flow directions.

In attempting to interpret these observations, it is useful to examine the modern environments present at the foot of the Himalayas where similar molasse sediments continue to accumulate on the Indo-Gangetic plain.

In India, the alluvial plain can be subdivided into three realms: on the north side of the basin, large rivers break out of the mountains and flow south across broad distributary fans or cones (Geddes, 1961). These rivers then flow into a second zone in which the drainage is transverse or longitudinal along the long axis of the basin. In this zone, the south flowing rivers mingle together into the assembled eastward flow of the Ganges River. The third zone lies to the south of the Ganges, and is comprised of generally small volume rivers draining the Indian shield. Upon reaching the Ganges, these rivers too change their direction to flow along the basin axis.

Similar flow patterns have been derived for the deposition of the molasse sequence in the Alpine molasse basin (Fuchtbauer, 1967), and for the West Alberta Basin of Canada (Eisbacher, 1974).

The Kosi river in India and Nepal provides a particularly clear modern analogue. Gole and Chitale (1966) have documented the sweep of the Kosi river across its outwash cone. The cone has a surface area of 7800 square kilometers, and the Kosi river has swept from the east side to the west side of this cone within the past 230 years. This river is known to leave flood sands a foot thick over its flood course in an average year (Geddes, 1961, p. 263). It is not hard to visualize an extensive sand accumulation due to the migrations of such a river across its distributary cone. Gole and Chitale (1966) comment on the adverse effects on the agrarian populace and note that in historic times over 7000 square kilometers have been laid bare by sand deposition.

Gole and Chitale (p. 119) note that the overall course of the individual distributaries on the Kosi delta are quite straight and in places these streams are well braided.

Thus a model emerges of sublinear braided streams, capable of rapid migration across massive inland cones. It is proposed that these rivers deposit a package of lateral accretion sands during a lateral sweep, then during an interlude, perhaps as the river aggrades a low point on the cone, fine grained deposits accumulate as a result of seasonal flooding.

The above model is suitable for explaining the distribution patterns of the brown sandstones flowing in a southerly direction from the Jhelum structural re-entrant (Visser and Johnsn, 1978). It is most likely that these sandstones were deposited by the ancestral Jhelum River. The white sandstones, which are shown to flow more longitudinally, could not have climbed the brown distributary cone inferred to have been formed by the Ancestral Jhelum River and are thus interpreted to have flowed along the cone toe in a manner much like the modern Ganges flows past the toe of the Kosi river cone.

The white sandstones are similar in general morphology to the brown sheet sandstones. As noted earlier however, they preserve a distinctive horizontal laminated bedding character. Studies of the changing patterns of cross bedding with downstream distance (Smith, 1970) indicate that in the Platte River of the Western United States as well as in the depositional analogues from the Silurian of the Appalachians, the horizontal stratification is best developed in proximal longitudinal bars and diminishes downstream, being replaced by cross bedding developed on transverse bars which forms an acute angle with the horizontal plane. This would suggest that the white sandstones were more proximal than the trough cross bedded brown sandstones. The regional geography does not encourage this interpretation. It is more reasonable to propose that other factors and in particular water volume might contribute to the difference in the nature of these sandstones. Given that the parameters of slope and bank material must have been comparable, particularly at the time that the two sandstone complexes interfingered, one must look elsewhere for the factor which is responsible for the change in bedding character. Water volume is a possible factor: if one river carried a significantly higher volume of water, its channels could preserve higher energy bedding features perhaps analogous to the proximal, high energy modal of Smith (1970). This suggests that the carrier of the white sandstones was a larger river than the ancestral Jhelum.

White sands of similar lithology to those found in the white sandstones of the Jhelum area are being deposited today by the Indus River where it debouches from the mountains onto the Peshawar Plain. Furthermore, the Indus today carries an average of 4 times the amount of water carried by the Jhelum (Kureshy, 1977).

It is therefore proposed that the Jhelum area played host to a NE flowing ancestral Indus River in Late Miocene and Pliocene time. In the Jhelum area the transition from the white ancestral Indus sandstones to the brown ancestral Jhelum sandstones takes place between 4 and 5 million years ago (Raynolds, 1980). Further work is now needed to trace the course of this ancestral river both in the Central and Western Potwar Plateau, and in the Siwalik Hills of NW India. Work in the latter area may one day be able to verify the implications seen in easternmost

Pakistan, that the ancestral Indus River at one time flowed into the Ganges drainage system.

Such a change in flow pattern implies realignment of the drainage pattern of the NW Indo-Ganetic Plain, with the westward shifting of the divide between the rivers draining to the Arabian Sea and those draining towards the Bay of Bengal. Today this drainage divide is located between the Sutlej and the Yamuna river systems, at about 77 degrees E longitude. The structural causes dictating the location of this divide are unclear, however, it is known (Seth, 1978; Geddes, 1961) that the Ghaggar Plain in the divide area has seen considerable change in drainage pattern even within historic times. If the above proposal is correct then in Late Miocene and Early Pliocene time this divide was located west of 73 degrees E longitude.

This hypothesis revives the old proposal for the former existance of a Siwalik River (Pascoe, 1919) or an Indobrahm River (Pilgrim, 1919) which flowed along the entire length of the Indo-Gangetic Basin. While these early authors proposed a river flowing from W to E, based mostly on over simplified facies interpretations (Krishnan and Aiyengar, 1940) the paleocurrent evidence presented here suggests that such a river in fact flowed in the opposite sense.

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