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Sone megafan: A non-Himalayan megafan of craton origin on the southern margin of the middle Ganga Basin, India

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ABSTRACT

Researchers in the last few decades have focused on the fluvial megafans at the base of Himalayan foothills in the Ganga Basin. No major effort has so far been made to delineate any such large depositional environment at the base of the northern Indian peninsular craton at the distal parts of the basin. In this work, for the first time, we document a megafan, unusually created by the cratonic Sone River in the marginal plains south of the Ganga. The geomorphology of the megafan surface, distribution of palaeochannels, sedimentology, and areal extent of the megafan are described. The study also reconstructs the tectonic and palaeoclimatic conditions, which might have helped in sediment supply from the cratonic catchment areas of the Sone. We suggest tectonic control over the Sone River channel dynamics and development of the megafan.

The oval- and fan-shaped, craton-derived sediment body covers an area of around 12,000 km^2 in the marginal plains and about 9000 km^2 in the central alluvium north of the Ganga River. The megafan is around 190 km long and ~240 km wide. The mean slope of the megafan surface is ~0.03°. An onlap of Himalayan sediments has occurred over the megafan at its toe parts caused by southward encroachment of the Ganga during the Holocene. The megafan sediments comprise brownish yellow fine to coarse sand and gravels with an admixture of carbonaceous nodules (*kankars*). The thickness of the megafan sediment, which directly overlies the Precambrian basement, varies from only a few meters in the south near the peninsular craton to ~1000 m at the north in the central alluvial plain. The granular zones form prolific aquifer systems in an otherwise poor hydrogeological setting of the marginal plains.

1. Introduction

Rivers emerging from large mountainous drainage networks sometimes form unusually large fan-shaped sediment bodies (10^3–10^5 km^2) in planform, which are referred to as fluvial megafans (Gohain and Parkash, 1990; Sinha and Friend, 1994; Horton and DeCelles, 2001; Leier et al., 2005). Formed in a lower slope setting (~0.1°–0.01°), the megafans are distinct from typical sediment-gravity flow-dominated alluvial fans, which rarely exceed 100 km^2 with the maximum length (apex to toe) of ~30 km in a high slope setting in the range of ~1°–4° (Stanistreet and McCarthy, 1993; Blair and McPherson, 1994; DeCelles and Cavazza, 1999; Horton and DeCelles, 2001; Leier et al., 2005). Also referred to as large distributive fluvial systems (DFSs) (Hartley et al., 2010; Weissmann et al., 2010), the megafans control sediment dynamics (sediment storage and transfers) in alluvial plains between source to sink in response to different climatic, tectonic, and base-level conditions (Goodbred, 2003). The megafan environments trap large volumes of clastic sediments, which may be up to hundreds of meters thick (Singh et al., 1993; DeCelles and Cavazza, 1999) and constitute potential aquifer systems (Fogg, 1986; Fitterman et al., 1991).

The rivers forming megafans are associated with high aggradation rates, sufficiently large drainage area, high discharge, and most importantly large seasonal fluctuation in discharge (Leier et al., 2005). Aggradational sedimentary basins in the forelands of young and tectonically active large mountain systems such as the Andes (Chaco Plain) and the Himalayas (Ganga Plain) where high sediment supply prevails, commonly form the suitable locations for the creation of megafans (e.g., Geddes, 1960; Gole and Chitale, 1966; Wells and Dorr, 1987b; Gohain and Parkash, 1990; Mohindra et al., 1992; Singh et al., 1996; DeCelles and Cavazza, 1999; Horton and DeCelles, 2001; Leier et al., 2005; Chakraborty and Ghosh, 2010; Hartley et al., 2010; Weissmann et al., 2010). Though Hartley et al. (2010) have said that large DFSs occur in the peripheral foreland basins and cratonic settings, such DFSs are rare and limited in number. For example, in the Ganga Basin in India, the megafans formed by the rivers Tista, Kosi, Gandak, Sarda-Ghaghra, and the Yamuna-Ganga are located at the Himalayan mountain front only; and no such large-scale reportage of megafan

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environments is available from the southern marginal parts of the plain at the base of the northern peninsula (craton).

In comparison to the Himalayan rivers, the northward-flowing rivers in the Ganga Plain, originating from the northern Indian craton, possess low discharge and sediment load. It seems unlikely that any such river would have formed a megafan. However, the Sone River is an exception and has formed a megafan at the base of the craton at the distal parts of the Ganga Basin. Earlier detected by a few researchers (Geddes, 1960; Leier et al., 2005; Sahu, 2012), the megafan has remained largely unexplored. Though mapping of some of the palaeochannels of the Sone have been carried out (Singh and Singh, 1971; Sahu et al., 2010; Sahu, 2012) and some field evidences regarding the existence of the megafan have been gathered (Sahu, 2013), the megafan still remains unknown to the national as well as the international scientific community. In the present work for the first time we try to document in greater detail the nature and distribution of palaeochannels and the areal extent and sedimentology of the megafan. The work also assesses the tectonic control on the formation of the Sone megafan. The critical forcing factors that might have aided in sediment generation and supply to the megafan formation have also been evaluated.

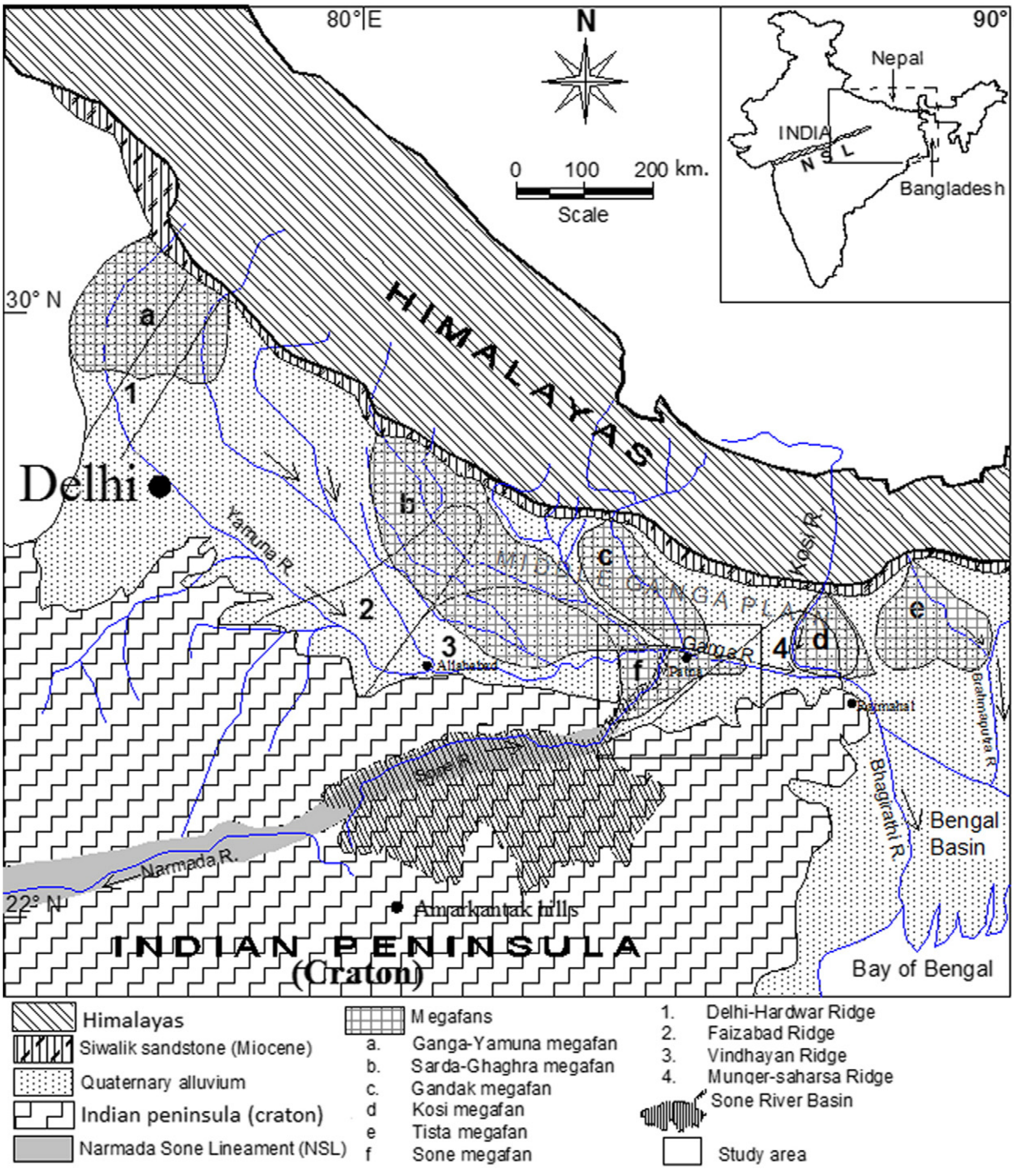

Fig. 1. Location map of the study area and the Sone River Basin. The map shows the southward-facing megafans at the base of the Himalayas in the Ganga Plain and the lone Sone mefagan, which faces northward in the plain at the base of the northern peninsular craton. It also depicts the regional structural elements including the NSL zone with NE-SW alignment (modified after Valdiya (1984); Govt. of India (1986); Singh (1996); GSI (2000); Swamee et al. (2003); Sinha et al. (2005); Sahu et al. (2010)).