Palaeogeography, Palaeoclimatology, Palaeoecology 356–357 (2012) 38–53

Contents lists available at SciVerse ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Aggradation, incision and interfluve flooding in the Ganga Valley over the past 100,000 years: Testing the influence of monsoonal precipitation

N.G. Roy [a], R. Sinha [a,*], M.R. Gibling [b]

[a] Engineering Geosciences Group, Department of Civil Engineering, IIT Kanpur, Kanpur 208016, Uttar Pradesh, India
[b] Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4R2

ARTICLE INFO

Article history:
Received 24 December 2010
Received in revised form 21 August 2011
Accepted 23 August 2011
Available online 1 September 2011

Keywords:
Valleys
Interfluves
Discontinuities
Monsoon
Aggradation
Incision
Equilibrium profile
Himalayan foreland
Ganga River
Palaeoclimate

ABSTRACT

In order to investigate fluvial responses to climate forcing, stratigraphic data from seven cores in the Ganga Valley of India and a valley-margin cliff section 1.3 km long are compared with proxy records for the intensity of the Southwest Indian Monsoon. Luminescence dates indicate that the strata cover the past ~100 ka. Five aggradational periods separated by incisional episodes are apparent in the valley fill, some of which have correlative strata along the valley margin. During Marine Isotope Stages (MIS) 4 and 5, the valley experienced fluvial activity, with thin floodplain successions and probable discontinuities along the interfluve margin. Modest fluvial activity characterised the mid part of MIS 3 at about 37 ka. Aggradation of channel sands preceded by incision is documented for late MIS 3 (23 to 30 ka), as well as for late MIS 2 to early MIS 1 (11–16 ka) with fluvial dates focused around the Younger Dryas period of monsoon reduction. The most recent aggradational period took place in the latest Holocene (<2.5 ka). On the proximal part of the interfluve, thin deposits that include lacustrine and aeolian beds continued to accumulate until about 26 ka, after which the interfluve was apparently not inundated by the Ganga and underwent degradation through gully erosion. There is little evidence of fluvial activity during the Last Glacial Maximum of MIS 2, when the Ganga appears to have been underfit. The alluvial records fit well with proxy precipitation records, and the main aggradational periods correspond to times of declining monsoonal strength. Although more difficult to constrain, the timing of incisional periods corresponds broadly with periods of monsoonal intensification, and the river appears to have shifted course in its valley mainly during these times.
© 2011 Elsevier B.V. All rights reserved.

1. Introduction

Over timescales of thousands to a few tens of thousands of years, inland river systems undergo phases of aggradation and incision induced by tectonic, climatic and intrinsic factors. Consequently, fluvial stratigraphy typically displays complexity in architecture and internal heterogeneity (Ambrose et al., 1991), dependent on the interplay between autocyclic and allocyclic variables. These variables include the magnitude and rate of channel scour, channel deposition and migration rate, downstream change in grain size and varied sediment flux, channel belt avulsion, base-level change, climatic fluctuations, and tectonic subsidence patterns and local fault movement (Miall, 1996; Blum and Törnqvist, 2000; Catuneanu, 2006; Gibling, 2006). The effects of these complex variables on sediment preservation form the basis for alluvial-architecture models that seek to predict subsurface sandbody geometry.

Valleys are prominent landforms in many coastal and inland alluvial settings, and their cutting and filling exert a major influence on alluvial architecture. Valley filling and incision are commonly episodic in space and time due to changes in external forcing factors, especially stream--power variations linked to the balance between discharge of water and sediment (Bull, 1991; Bogaart et al., 2003; Strong and Paola, 2008; Martin et al., 2011). Such cut-and-fill architecture can be studied to understand the rhythmic control of external forcing (Bull, 1991; Bestland, 1997; Weissmann et al., 2002; Gibling et al., 2005; Mack et al., 2006). Architectural models for valley fills need to be tested for well-dated Quaternary successions where proxy records for forcing factors are available. However, only a few modern plains have been studied in sufficient detail to test the models effectively (Blum and Aslan, 2006; Stouthamer and Berendsen, 2007; Amorosi et al., 2008).

The Ganga Plains in the Himalayan Foreland Basin of India are underlain by sediment laid down by the Ganga River, among the world's largest rivers. The plains have a well preserved alluvial record accessible through drilling, and strata are locally exposed in cliff sections along incised reaches. These records form important continental archives for understanding landscape dynamics against the backdrop of late Quaternary environmental changes driven mainly by hinterland (Himalayan) tectonics and palaeo-monsoonal dynamics (Gibling et al., 2011). The present paper extends previous research through a detailed study of the Ganga Valley near Kannauj in Uttar Pradesh (Fig. 1). In this area, a long stretch of previously

* Corresponding author.
E-mail address: rsinha_64_99@yahoo.com (R. Sinha).

0031-0182/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.palaeo.2011.08.012

undescribed cliffs, ~10–20 m high, allows a high-resolution analysis of floodplain facies and their architecture at a relatively high elevation along the valley margin. Seven drill cores with near-complete recovery down to a depth of 32 m were organised in two traverses across the valley to a distance of 14 km from the cliffs (Fig. 1). Cliff and core strata were placed in a chronological framework that spans the past ~100 ka based on 25 samples dated using luminescence methods. Comparison with available information on palaeo-monsoon intensity suggests that, to a first order, major monsoonal fluctuations governed fluvial events of aggradation, incision, and inundation of the interfluve adjoining the Ganga Valley.

2. Geographic and geomorphic setting of the Ganga Plains

The study area falls in the middle Ganga Plains and is located ~300 km downstream of the Himalayan tectonic front and more than 1200 km upstream of the modern day tidal limit. Of the total catchment area of 2435 km^2, an area of about 206 km^2 (8.5%) is presently glaciated. The glaciated area was only slightly larger during the LGM (13%) (Owen et al., 2002), and glacial melt water may have played a modest role in the Ganga River's water and sediment flux through the Late Quaternary. The study area experiences monsoonal rainfall of about 60–80 cm per year. The hinterland of the Ganga receives >200 cm/year and that of the Ramganga receives 160–180 cm/year. Most of this rainfall is concentrated during July–September, while the rest of the year is dry or has little rainfall. The monsoonal rainfall therefore exerts an important control on the hydrology and sediment flux in the basin. The winter temperature varies from 2 to 15 °C and the summer temperature from 25 to 45 °C (Singh, 1994). The hydrology of the Ganga River is strongly controlled by the monsoonal rainfall, and the proportion of glacial melt where the Ganga enters the plains, although debatable, has been estimated at 15% (Das Gupta, 1975).

Topographic analysis based on SRTM data (Fig. 2a) and a regional geomorphic map of the study area (Fig. 3) show that the modern Ganga River flows in an asymmetric valley (Fig. 2a). Field observations also confirm that the right channel bank is incised, exposing a 15–20 m high cliff line (Fig. 2c) that also marks the right valley margin. The left channel bank borders a flat-lying active floodplain tract (Fig. 2d) with palaeochannels and meander scars. Fig. 3 suggests long-term southwest migration of the channel (see also Roy and Sinha, 2005, 2007). The left valley margin does not form a prominent geomorphic feature but is delineated where the active floodplain passes northeastward into an inactive floodplain belt.

Fig. 3 shows five major geomorphic units in the study area, namely (i) the major active channel belt of the present Ganga and its large tributary, the Ramganga, currently about 5–7 km and 2.5–3 km wide, respectively; (ii) the active floodplains of these major channels within the valley margin; (iii) the active minor channels and floodplains of other smaller tributaries; (iv) wide inactive floodplains northeast of the Ganga; and (v) a slightly dissected interfluve surface southwest of the Ganga that extends as far south as the Yamuna River near the southern margin of the plains (Gibling et al., 2005; Sinha et al., 2005a). The southern margin is strongly gullied and degraded, forming irregular cliffs along the river.

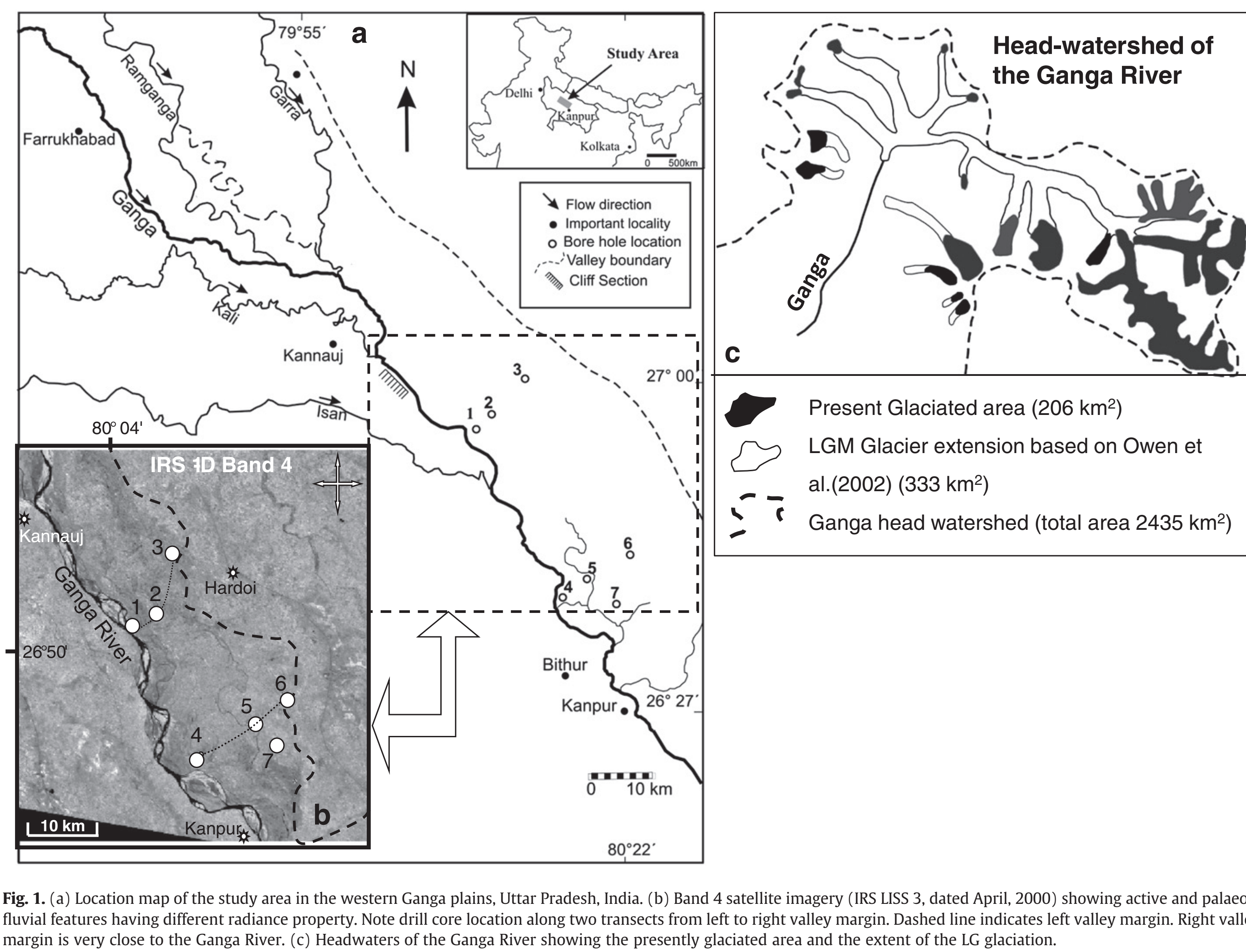

Fig. 1. (a) Location map of the study area in the western Ganga plains, Uttar Pradesh, India. (b) Band 4 satellite imagery (IRS LISS 3, dated April, 2000) showing active and palaeo--fluvial features having different radiance property. Note drill core location along two transects from left to right valley margin. Dashed line indicates left valley margin. Right valley margin is very close to the Ganga River. (c) Headwaters of the Ganga River showing the presently glaciated area and the extent of the LG glaciation.

Download English Version:

https://daneshyari.com/en/article/4466806

Download Persian Version:

https://daneshyari.com/article/4466806

Daneshyari.com