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Fluvial landforms and their implication towards understanding the past climate and seismicity in the northern Katrol Hill Range, western India

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A B S T R A C T

The tectonically active Kachchh peninsula in western India lies in the southwest monsoon trajectory and hence provides a rare opportunity to decipher the temporal changes in climate–tectonics interaction in the evolution of the fluvial landforms. Reconstructions based on geomorphology, sedimentology, and geochemistry supported by optical chronology suggest that the fluvial aggradation in the region was initiated during the onset of the Indian Summer Monsoon (ISM) after the Last Glacial Maximum (LGM). The sedimentary characteristics and major elemental concentrations suggest that the sediments are dominated by fluvially reworked miliolites with subordinate contribution from the Mesozoic sandstones and shales and were deposited with the initiation of the ISM after the LGM. Temporal changes in facies architecture and major element concentrations suggest a progressive strengthening of the monsoon between 17 and 12 ka. This was succeeded by an overall strengthened ISM phase with fluctuations after 12 ka and <8 ka. Following this, a gradual decline in the ISM is inferred until around 3 ka. However, presence of the younger valley-fill sediments which are dated to ~1 ka are ascribed to a short-lived phase of renewed strengthened ISM in the region before the onset of present day aridity.

Based on the morphology of the fluvial landforms, two major events of enhanced uplift can be suggested. The geomorphic expression of the older uplift event dated to >17 ka is represented by the beveled Mesozoic bedrock surfaces which accommodated the post LGM valley-fill aggradation. The younger event of enhanced uplift which is assigned to <3 ka was responsible for the incision of the fill sediments and the Mesozoic bedrock, and the evolution of the present day fluvial landforms. The time averaged incision/uplift rate indicates that the Katrol Hill Range is uplifting at the rate of ~4 mm per year, implying seismically active terrain.

1. Introduction

In actively uplifting areas, rivers are dominantly involved in incising the underlying resistant bedrock (Whipple, 2004). Therefore, such rivers lack laterally continuous alluvium cover: instead, discrete sedimentary patches can be found along their courses (Howard et al., 1994). In seismically active and monsoon dominated regions, studies suggest that on millennial time scales, the rivers oscillate between incision and valley aggradation. This is ascribed to the changes in monsoon intensity and sediment flux (Pratt-Sitaula et al., 2004). In view of this, the morphology and sedimentary successions of the rivers can be used to reconstruct the history of enhanced uplift and climate variability.

The Kachchh peninsula in western India is one such region where the interplay between climate and tectonics can be discerned through the fluvial successions which is preserved in various bedrock river valleys. Presently, all the major rivers in the Kachchh peninsula are actively incising the Mesozoic, Palaeogene, and Neogene bedrock (Thakkar et al., 1999; Maurya et al., 2003; Patidar et al., 2007, 2008; Bhattacharya et al., 2013). However, the presence of valley and channel-fill deposits of varying thicknesses preserved in different river valleys suggests that there were periods of tectonic stability in the geological past (Mathew et al., 2006; Patidar et al., 2007). Further, the temporal changes in the pattern

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of fluvial aggradation suggest that the region responded to the ISM variability during the late Quaternary (Bhattacharya et al., 2013). The tectonically active nature of the Kachchh Peninsula is adequately expressed by the presence of E–W trending major faults including the Kachchh Mainland Fault (KMF), Katrol Hill Fault (KHF), South Wagad Fault (SWF), Island Belt Fault (IBF), and Gedi Fault (GF) (Biswas, 2005; Fig. 1a). The seismically active nature of these faults is manifested by major earthquakes during the late Quaternary (Morino et al., 2008; Kundu et al., 2010). Activity continued during recent historical times, including the 1819 Allah Bund earthquake, 1956 Anjar earthquake, and 2001 Bhuj earthquake (Rajenderan and Rajenderan, 2001).

Studies carried out in the past suggest that the terrain has the potential for reconstructing the late Quaternary deformations/uplift and climate variability. However, due to the lack of detailed sedimentological observations and limited chronometric data, the inferences drawn remained speculative (Patidar et al., 2007 and references therein). The present study is an attempt to reconstruct the chronologically constrained history of fluvial aggradation (climate) and incision (uplift) in order to understand the role of climate and tectonics in the evolution of fluvial landforms in the monsoon influenced and tectonically active region of western India. In order to achieve the above objective, we used geomorphology, sedimentology, and sediment geochemistry supported by optical dating.

2. Study area and geomorphology

The studied segment of the Gunawari river is located in the Katrol Hill Range (KHR) ~15 km south of Bhuj (23.17°–23.19°N;

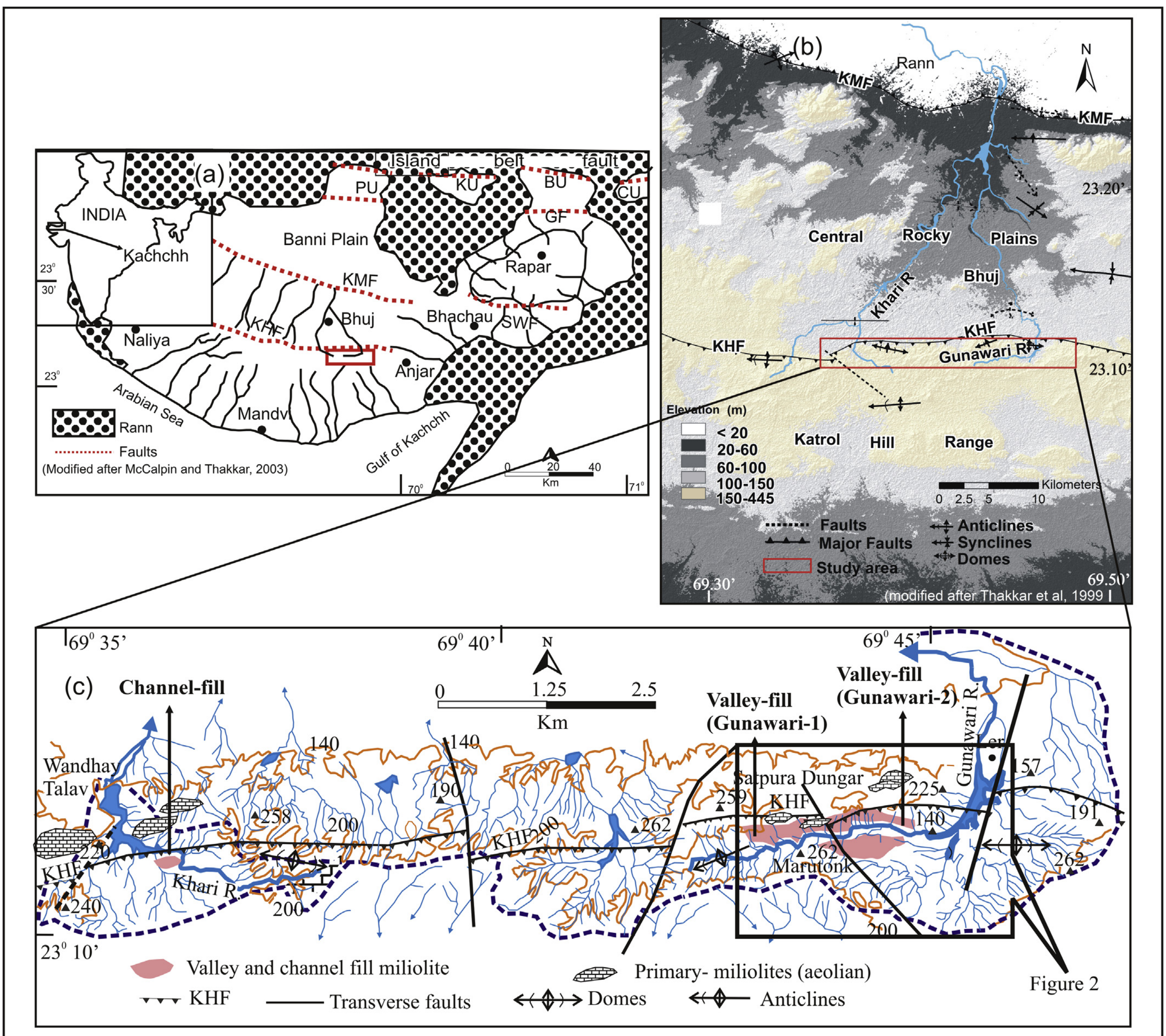

Fig. 1. (a): Map of Kachchh showing major faults viz., Kachchh Mainland Fault (KMF), Katrol Hill Fault (KHF), Island Belt Fault (IBF), South Wagad Fault (SWF) and Gedi Fault (GF). Box indicates the study area (b) Digital elevation map of the terrain between KHF and KMF, also marked are the minor structures (anticlines, synclines and domes, transverse faults). (c) Detailed drainage map of the upper catchment of Khari and Gunawari rivers along with the locations of valley-fill and channel-fill deposits. The rectangle represents the detail geomorphology of the study area enlarged in Fig. 2.