Tectonophysics 674 (2016) 65–75

Contents lists available at ScienceDirect

Tectonophysics

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

Paleoseismic investigations in the Kopili Fault Zone of North East India: Evidences from liquefaction chronology

Devender Kumar *, D.V. Reddy, Anand K. Pandey

CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad - 500 007, India

ARTICLE INFO

Article history:
Received 16 November 2015
Received in revised form 3 February 2016
Accepted 8 February 2016
Available online 18 February 2016

Keywords:
Liquefaction
Sand dyke
Kopili Fault Zone
NE India
Paleoseismic events

ABSTRACT

We report the seismogenic liquefaction signatures observed in the Kopili Fault Zone of the Brahmaputra plains, NE India. This seismically active zone has previously been identified as the "Assam seismic gap" and thus necessitates understanding its past seismicity and implied seismic hazard. With this objective, paleo-seismic studies using seismogenic liquefaction features have been carried out in this region largely covered with the flood plain deposits of Kopili and Kalang rivers. The trenches excavated at two locations revealed extensive liquefaction features with more than 20 sub parallel sand dykes having major orientation in NE–SW direction. A total of 29 samples from marker horizons have been processed to constrain chronology of the liquefaction features using optically stimulated luminescence (OSL) and ^{14}C (AMS) dating techniques. The age constraints in terms of respective lower and upper bound age brackets for individual dykes suggest three time intervals of their formations i.e. (i) 250 ± 25 yr. BP, (ii) between 400 to 770 yr. BP and (iii) 900 ± 50 yr. BP. These new ages of liquefaction features correspond to the occurrence timings of causative seismic events which are in addition to the known historical earthquakes and thus enhance our understanding of the paleoseismic history of this region during past ~1000 years.

1. Introduction

The Himalaya and its adjoining regions have experienced several large to great earthquakes during past the 200 years viz. Kashmir Earthquake (2005), Kangra Earthquake (1905), Bihar-Nepal Earthquake (1934), Nepal Earthquake (1833 and 2015), Shillong Plateau (1897) and the Upper Assam Earthquake (1950) [Fig. 1], (Baird Smith, 1843; Oldham, 1899; Middlemiss, 1910; Auden and Ghosh, 1935; Dunn et al., 1939; Poddar, 1950, 1952; Bilham, 1995; Kaneda et al., 2008; Hussain et al., 2009; Avouac et al., 2015). The North East (NE) Indian region is conspicuous to have experienced the largest Himalayan (M_w = 8.44, 1950-Upper Assam) and intraplate (M_w = 8.03, 1897-Shillong Plateau) earthquakes (Oldham, 1899; Poddar, 1950, 1952; Ambraseys and Douglas, 2004). This region is amalgamation of many tectonic blocks viz. Himalayas, Siang Syntaxial Zone, Mishmi Ranges, Indo-Burmese Arc, Mikir Hills and the Shillong Plateau (Fig. 1), which are capable of triggering large to great earthquakes and thus making it among one of the seismically most active regions in the world. The historical earthquake catalogues (Bapat et al., 1983; Iyengar and Sharma, 1999) suggests the region experienced multiple seismic events during last millennium in addition to those inferred from paleoseismic studies based on trenching on primary/secondary faults (Kumar et al., 2010; Jayangondaperumal et al., 2011) and liquefaction based chronology of paleoearthquakes (Rastogi et al., 1993; Sukhija et al., 1999a, 1999b; Rajendran et al., 2004; Thomas et al., 2007; Reddy et al., 2009). Further, triangulation data has been interpreted to have large recurrence interval of the order of several thousand years (Bilham and England, 2001; England and Bilham, 2015) on the Oldham Fault supposed to be responsible for the Shillong Plateau Earthquake of 1897.

Of late, intense seismicity is observed along the Kopili Fault (KF) zone (Bhattacharya et al., 2002), which separates the Shillong plateau and the Mikir hills (Kayal et al., 2006; Kayal, 2008; (Fig. 1) and has experienced large earthquakes in 1869 (M_w = 7.38, Oldham, 1883; Nandy, 2001; Ambraseys and Douglas, 2004) and 1943 (M_w = 7.24, Nandy and Dasgupta, 1991; Dasgupta et al., 2000; Nandy, 2001; Ambraseys and Douglas, 2004). The KF zone has been considered as "Assam seismic gap" (Khattri and Wyss, 1978; Gupta and Singh, 1980; Khattri et al., 1983; Guha and Bhattacharya, 1984; Nandy, 2001; Kayal et al., 2012) having potential to experience earthquake in future and thus necessitates understanding its long term seismic history and implied seismic hazard. As seismogenic liquefaction based paleoseismic studies has proved to a useful tool to decipher the long term seismic history of such regions (Sims, 1973; Obermeier, 1996; McCalpin, 1996; Sukhija et al., 1999a, 1999b, 2002; Tuttle et al., 2002; Rajendran et al., 2004; Sahoo et al., 2007; Reddy et al., 2009), we have carried out paleoseismological investigations in the unexplored abandoned flood plain of Brahmaputra River located in the Kopili Fault zone (KFZ) by making trenches, documenting and characterizing the liquefaction features generated during large to great paleo-earthquakes. The region

* Corresponding author. Tel.: +91 40 27012835; fax: +91 40 23434651.
E-mail address: devender@ngri.res.in (D. Kumar).

http://dx.doi.org/10.1016/j.tecto.2016.02.016
0040-1951/

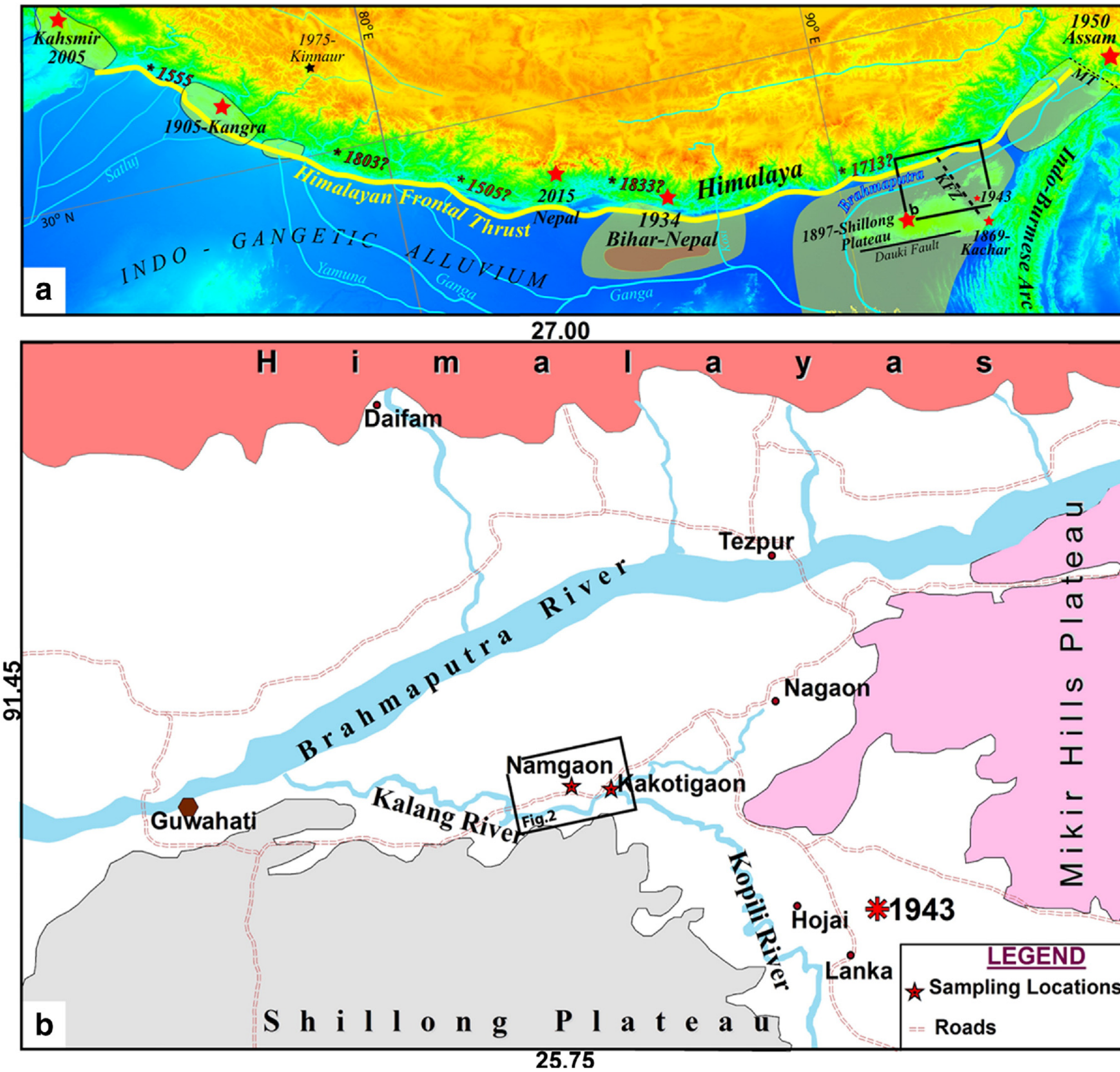

Fig. 1. (a) Regional view of the study area (Modified after Reddy et al., 2009) depicting the main tectonic elements (MT = Mishmi Thrust, KFZ = Kopili Fault Zone) and the known large to great earthquakes experienced in the Himalayas and the adjoining areas. Box indicates the study area (b) Trench locations at Kakotigaon and Namgaon.

has favorable ground conditions for the liquefaction as it is constituted of unconsolidated sands, silts and clay with a very shallow water table. After demarcating seismogenic liquefaction features, we have dated the sediments associated with them with the help of carbon-14 (^{14}C) and OSL dating methods.

2. Seismotectonics, geology and geomorphology of the study area

Regionally, the Shillong plateau, Mikir hills, Assam valley are jawed between the Himalayan and the Indo-Burmese arcs in the north and east, respectively (Fig. 1.) The region experiences several large/great earthquakes occurring in the Himalayan, Indo-Burmese zone as well as the intraplate seismicity in the Assam valley–Shillong Plateau–Bengal basin area (Kayal, 2008). The intra-plate seismic activity is fairly intense in this region due to the complex stress regime (Angelier and Baruah, 2009). Geologically the entire area has evolved during the Mesozoic to Tertiary and is drained by rivers Kopili and Kalang, which occupy the abandoned channel course of Brahmaputra (Figs. 1 & 2) and the flood plains have covered all the tectonic elements under alluvium with maximum sediments thickness ranging from 700 m in southern parts to 1300 m in the northern parts (near Nagaon) of the Kopili valley (Singh, 2005). The Mikir Hills located in the east of the study area (Fig. 1) are detached from the Shillong Plateau (mainly the Archean gneissic complex) by Kopili Fault marked by a 10–15 km broad topographic depression trending NW-SE and extending 300–400 km from the Himalayan front to the Schuppen belt of NE India (Kayal, 2008; Dasgupta and Nandy, 1982).

The present seismicity in the KF region is mostly restricted in the depth zone of ~12–70 km (personal communication, D. Srinagesh) and we do not find any surface expression of the fault, other than a broad topographic depression along the Kopili River (Fig. 1). For this study, our field investigations are confined to the flood plains, river/channel cut-offs and recent sand bars in the southern parts of the Brahmaputra. The Brahmaputra plain in the Assam valley is characterized by Quaternary flood plains, channel cut offs and sand bars. The southern parts of the Brahmaputra plain are drained by the Kalang River, which is an abandoned channel of former. The Kalang River is joined by the Kopili River originating in the Shillong Plateau and flowing towards north through the topographic depression between the former and the Mikir Hills (Fig. 1). The Kalang and Kopili rivers with <1 m/km channel gradient in the southern Brahmaputra plain flow as anastomosing channel system with meandering channels, numerous oxbow lakes, abandoned channels and channel migration bars (Fig. 2). Often it is difficult to trace the original channel linkage and configuration as it evolves through time occupying the old course of Brahmaputra River. However, at places the characteristic growth of point bars during