Geomorphology 193 (2013) 81–90

Contents lists available at SciVerse ScienceDirect

Geomorphology

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

Geomorphological and seismological investigations in a part of western Kumaun Himalaya, Uttarakhand, India

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ARTICLE INFO

Article history:
Received 14 September 2012
Received in revised form 3 April 2013
Accepted 4 April 2013
Available online 13 April 2013

Keywords:
Seismotectonics
neotectonics
western Kumaun
Himalaya

ABSTRACT

The Kumaun Himalaya in India is seismotectonically one of the most responsive sectors of the Himalayan arc. The region falls in the seismic gap and is frequently rocked by the earthquakes of low to medium magnitude. In the present investigation, the seismic data of the area were obtained by deploying a seismic network, and an attempt is made to interpret the seismological data of the local events and their relation with the geomorphology and thrusts/faults rejuvenation. The epicentral distribution of the earthquakes defines a relatively narrow zone of seismicity. A majority of earthquakes are confined to shallow depth with low stress drop and higher peak ground velocity (PGV). Further, the neotectonic investigations along the major river valleys indicate the neotectonic activity in the form of paired and unpaired terraces, shifting of river courses, fault scarps, development of palaeolakes, straightening of river channels, and deep cut V-shaped valleys. From the geomorphological and seismological data, the thrust and fault systems in the area are seismotectonically quite active even today. Some of the transverse faults — viz. Dwarahat-Chaukhutia fault, Takula-Basauli fault (Sim Gad valley), Tilora-Jyala fault (Kosi valley) — show spectacular tectonic landforms and seismicity. As a matter of fact, the NNW/NW–SSE/SE trending faults are active in the region.

1. Introduction

The Himalaya constitutes a part of the Alpide belt formed from the collision of the Indian and Eurasian continental crusts where the Indian continental crust underthrusts the Eurasian continental crust (Dewey and Bird, 1970; Zhao et al., 1993). The subduction of the Indian plate under the Eurasian plate has created an arcuate tectonic belt, which is seismotectonically one of the most active orogens in the world. The collision of these two plates — which took place about 50 Ma ago (Curray et al., 1982; Valdiya, 1984) — is still continuing. The global reconstruction suggests that the Indian plate converges obliquely toward the Asian plate at a rate of 50 mm/y (Klootwijk et al., 1992; Larson et al., 1999). The GPS- derived measurement shows that the convergence accommodated in the Himalaya is about 2 cm/y (Bilham et al., 1997; Jauanne et al., 2004), indicating that the strain energy is building up and intermittently releasing in the form of earthquakes. Four great earthquakes of magnitude ≥ 8 have rocked the foothills of Himalaya since 1897 (Shilong earthquake, Ms 8.7), 1905 (Kangra earthquake, Ms 8.6), 1934 (Bihar–Nepal border earthquake, Ms 8.4), and 1950 (Assam earthquake, Ms 8.7). Hence, the Uttarakhand Himalaya and part of western Nepal, lying between the rupture zones of 1905 (Kangra) and 1934 (Bihar–Nepal) are identified as the central seismic gap (Khattri and Tyagi, 1983). Since the last great earthquake almost 62 years ago, the population of the Himalayan region and adjoining plains has increased very rapidly. Therefore, in the event of a future great earthquake, the region may experience extensive loss of life and property. Keeping this in view, the prevailing trends of seismicity in part of the western Kumaun Himalaya are investigated to understand the neotectonics and local seismicity pattern.

The study area (29°30' to 29°45'N and 79°15' to 79°45'E) constitutes a part of the Lesser Himalaya in Kumaun and forms a part of the Almora and Bageshwar districts of the state of Uttrakhand (Fig. 1). The Kosi, Western Ramganga, Saryu, and Gagas are the major rivers along which the geomorphological investigations have been carried out.

2. General geology

Geologically, the area forms a part of the Lesser Himalaya, bounded by the Main Boundary Thrust (MBT) in the south and the Main Central Thrust (MCT) in the north. The rocks are intricately folded and thrusted. The sedimentary succession is overlain by the metasedimentaries, associated with granitic rocks and forming large thrust sheets and their klippen. The sedimentary rocks, bounded by the North Almora Thrust (NAT) and the Kausani Thrust (Fig. 1) belong to the Rautgara, Gangolihat,

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http://dx.doi.org/10.1016/j.geomorph.2013.04.007

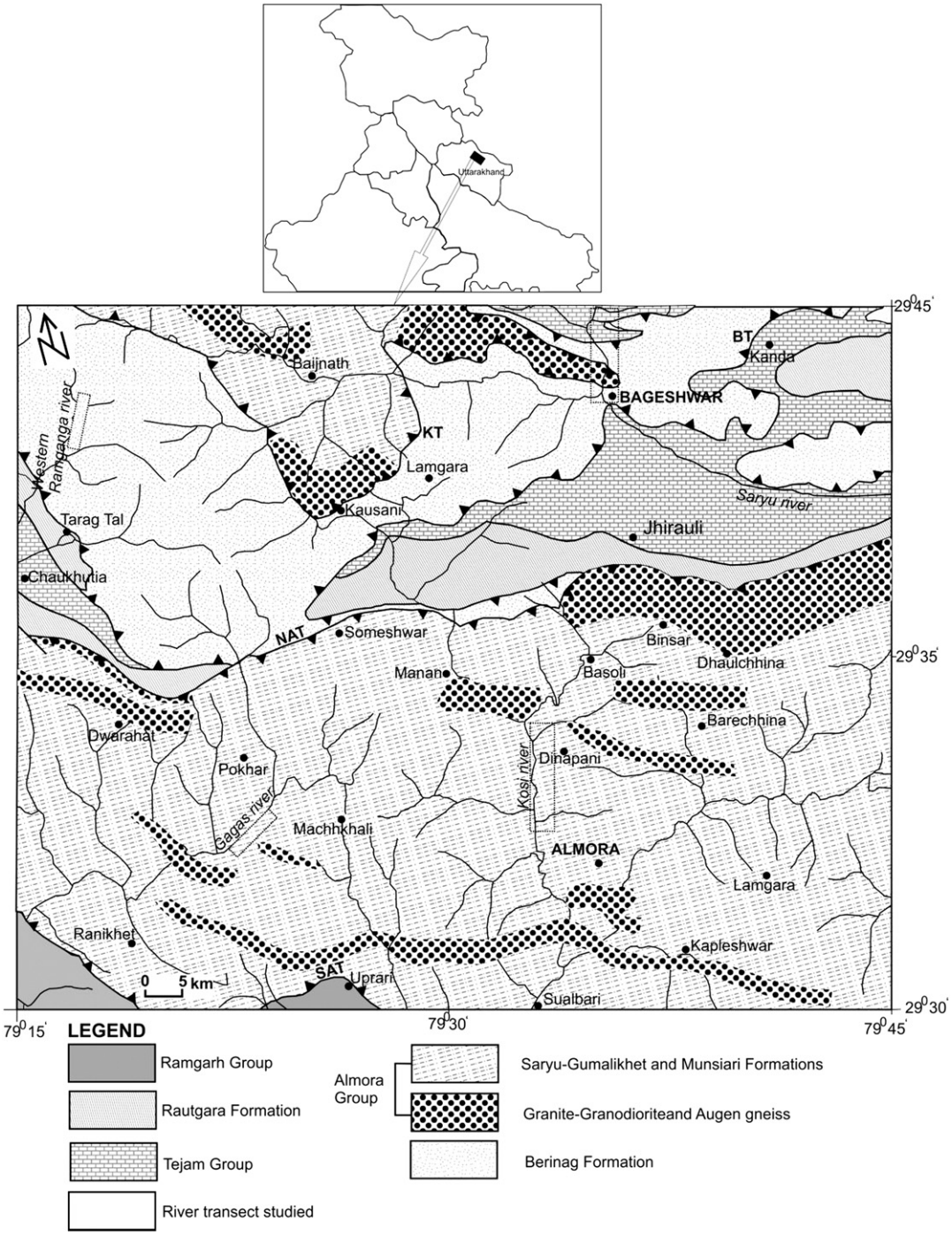

Fig. 1. Location of study area and geological map of the western Kumaun Himalaya. SAT—South Almora Thrust, NAT—North Almora Thrust, MCT—Main Central Thrust, KT—Kausani Thrust, BT—Berinag Thrust.

and Berinag Formations in an ascending order of succession and exposed in the deep valleys and cores of anticlines. A large part of the area is composed of rocks of the Almora Group constituting the Saryu Formation (metasediments), the Almora granite gneisses, metasediments of the Gumalikhet Formation, and the younger Champawat granitoids. The crystalline rocks occur as thrust sheet/klippen. The Almora Group in the south is separated from the Ramgarh Group rocks by the South Almora Thrust (SAT) (Valdiya, 1980).

As a result of convergence between the two crustal blocks, the region has suffered crustal shortening and various thrust sheets have moved southward. The continued push has also been responsible for the development of transverse faults.

3. Materials and methods

To monitor the seismicity of the Kumaun region, a 5-station digital seismic radio frequency-telemetered network was established in May 1999 by the Department of Geology (Kumaun University, Nainital) under a DST-funded (Department of Science and Technology, New Delhi) research project. A large number of low magnitude earthquakes have been recorded since then. The locations of the digital seismographs are shown in (Fig. 2). Each station is equipped with one short-period, three-component (L4-3D) seismograph. The recording stations were installed between the two major thrusts: the Main Central Thrust (MCT) and the Main Boundary Thrust (MBT). The