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Oblique slip faulting associated with evolving central Indo-Burmese region from Early Pleistocene deformational sequences

Raghupratim Rakshit [a], Devojit Bezbaruah [a], Bubul Bharali [b],*

[a] Dept. of Applied Geology, Dibrugarh University, Assam, India
[b] Dept. of Geology, Pachhunga University College, Mizoram, India

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Abstract

The Indo-Burmese Ranges (IBR) marks as the boundary between the rigid Burmese Plate and the north-easterly moving, obliquely converging Indian plate. This results in upliftment of Mizoram fold belt alongside of IBR, in the eastern most part of the Indian subcontinent. NS trending fault generated fold belt appears around the region due to the NE stress component from Indian plate movement. There are many linear tectonic features formed due to this process. On the eastern margin of the fold belt in the greater elevated part of IBR, E−W and NW−SE lineament patterns intersect the NS lineaments, and deformed the ridges obliquely to create complex geotectonic settings. In this study, a pristine attempt has been made to understand the geodynamic evolutionary mechanisms for the area to reveal the cause for such surficial convolutions. The arcuate subduction zone along the IBR causes the slab to flex and bend at depth. This relates to differential dipping of the slab and the greater dip surface occurred beneath the study area. The easterly dipping slab can accommodate great amount of sediments and therefore the region having maximum dip upholds the highest Tertiary sediment thickness, above the basement. Champhai district of Mizoram, India had been considered for this study as it has in the zone of convergence with highest slab dip underneath. The surface exposures have sufficient neotectonic evidences which inferred the signs from Early Pleistocene neotectonic to present active tectonic deformational history. Sequential offset of the antecedent rivers carries the signatures of the varying stress component within them. The geodynamic processes produce some tectonic features through the mode of earthquake generation. Epicentral plots and focal mechanism solutions for the area indicate seismic activity associated with the thrust and oblique strike-slip movement along with their correlation for the lineament distribution. The evolutionary model indicates syn-tectonic upliftment of the study area along with evolving IBR during Late Oligocene thrusting events. A Paleo-lake adjacent to the Champhai town is believed to be the source of some northerly flowing rivers that was located on the ridge. Late Pleistocene seismic events produce some contractional strike-slip faults that later transformed to oblique slip component that shaped the area. This study is also important for understanding the earthquake events and related deformation pattern in IBR. This also might be used to locate potential geohazard sites for safer construction as well as to understand the petroleum migration pathways.

Keywords: Oblique slip; Indo-Burmese range; Slab bending; Focal mechanism

1. Introduction

The voyage of Indian plate ends up when it collided with the Eurasian plate during Eocene in the North and later with Burmese plate, which is an elongated tectonic block bounded by Sagaing fault, in the east (Curray et al., 1979). The later event is still believed to be active and results in evolution of folded Indo-Burmese Ranges (IBR) in the eastern margin of the Indian subcontinent. The subduction of Indian plate has been studied by means of seismic, geodetic and GPS methods, from where this process was regarded as active (Verma et al., 1976; Chandra, 1975; Mukhopadhyay and Dasgupta, 1988; Satyabala, 1998; Dasgupta et al., 2003; Copley and McKenzie, 2007; Steckler et al., 2008; Kumar et al., 2015), slow (Le Dain et al., 1984; Ni

* Corresponding author.
E-mail address: bubulearth@gmail.com (B. Bharali).
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et al., 1989; Chen and Molnar, 1990) or inactive (Rao and Kumar, 1999; Gahalaut et al., 2013). In this arcuate plate boundary, the fold belt continues south ward from low hills of western Myanmar near 25°N through Naga Hills to broad ranges near 16°N, and then transitioning into Sumatra-Andaman oceanic subduction zone (Wang et al., 2014; Kumar et al., 2015; Steckler et al., 2016). The upliftment rate of IBR is varied depending on the distance from the plate boundary and position in the arcuate belt. This is caused by the differential stress component associated with the Indian plate motion from Late Eocene. In its course, the cold subducting part of Indian plate is flexed paralleling to the IBR results in buckling of the slab at depth. This process generates intraplate stresses that cause seismic events. The subducted plate shows maximum dip between 23°N and 25°N latitudes which fall around Mizoram Fold belt region in eastern most part of India (Kumar et al., 2015). The fault-propagating folded hills of IBR comprising Oligocene and Miocene rocks, are also transected by strike-slip faults that are shaping the deformed NS trending hill ranges (Ghosh et al., 2016). In such complex setting to understand topographic expression of the tectonic features, seismicity and therefore revealing the proper sub-surface deformational pattern with respect to the subduction is very important.

Lineament patterns are the best tool that can be utilized for producing enough evidences of deformation from the topographic variations with local and regional context. Regional stress component gets sequentially embedded in the lithounits either as shear deformation or associated with fractural features by brittle offsets. Compressional stress caused upliftment of this fold belt and other faulting events had caused offsets of the beds to accommodate the differential motion among the blocks. This is the fact which acts as a rule of similar lineament patterns associated with stress components that work as topographic modifier. In this study the origin of the research problem is based on the change in orientation of local lineaments that were varied from the regional patterns in the study area. Moreover, the newly formed lineaments were superimposed over the older lineaments and therefore the rock beds also show different attitudes rather than regional orientation. Nonetheless this infers the presence of active tectonics in the region which can be verified by both geomorphic markers (river offsets, pull-apart basin etc.) and seismotectonics study (epicentral plot, focal plane mechanism etc.).

In the eastern most Champhai district of Mizoram state which fall under IBR, we found such distinct localized lineament variation bounded by active tectonic features. Therefore, the morpho-dynamic evolution in the eastern edge of Mizoram Fold belt near India–Myanmar international border has been studied in this present context. The differential upliftment results in greater elevated Champhai plateau rather than western outer edges of the hill range, even though subducting Indian slab is dipping towards east. The basement is around 16 km beneath Champhai, which is greater than the estimated average depth of 12 km for Mizoram (Ghosh and Dasgupta, 2013).

The study area comprises Tertiary sedimentary rocks where the Barail Group of rocks thrusted over the Bhuban Formation rocks of Surma Group (Nandy et al., 1983). The argillaceous facies are easily erodible compare to the arenaceous facies in the area (Fig. 1). The evolution of fold belt along with syntectonic thrusting events and the later generation strike-slip faults with few small scale normal faults are inferred in the satellite imagery that were also observed during extensive field investigations. These surface expressions are clear indication of the Neo-tectonic and active tectonic processes. To identify the extent of these features digital elevation model (30 m) had been used. Lineament study and their correlation with geology of the area can provide important information about the stress component, major and minor fault systems and crustal activities. They are also relevant with subsurface fractures which can be the potential migration conduits for the hydrocarbon believed to be present in the Oligocene-Miocene source rocks or even the Eocene shales present in the subsurface under the study area (Ghosh and Dasgupta, 2013). The lineament study is also important for the possible hydro-power and civil engineering constructions (Olgen, 2004). For lineament analysis manual technique is followed as it provides greater control, and allows to choose the scale for analyzing the data (Ramli et al., 2010; Caran et al., 1982). Lineament density analysis is done by producing lineament map showing concentrations of the lineaments over the area. Intersection of the lineaments of different generations are observed, as they produce criss-cross patterns. Many rivers, streams follow these major (>3 km in length) and minor (<3 km) lineaments as they preserve and transform depending on the deformational events (Burbank and Anderson, 2012; Yeats et al., 1997). Strike-slip faults have a different geomorphic expression than thrust and normal faults; combination of these deformational forces can create somehow oblique distortion of crustal blocks. These kinematic changes can be quantified by measuring the offset of the major antecedent rivers.

In this study these neotectonic events have been analysed by following the methods of Wang et al. (2014). Tectonic features that are exposed in the surface or their presence identified in geomorphic ambiguities are results of seismotectonics interacting in the plate boundary systems. In this paper, we aim to find out the actual relationship between crustal and plate boundary deformational settings, that imposed the morpho-dynamic evolution of this part of the IBR; as evident by variation in orientation of lineaments. This result also enhances our understanding of the active tectonics in the region which can be further analysed to predict the future large earthquakes. To understand this stress model the results of lineament study and neotectonic signatures are correlated with earthquake focal mechanisms of the region and for the study area, and then compile the results into a holistic framework. We used the data from Incorporated Research Institutions in Seismology (IRIS) and the Global Centroid-Moment-Tensor (CMT) project as they are easily available and can provide information from different stations which enhance the accuracy of the study. The earthquake events in the region are mostly associated with the subducting slab slipping along the megathrust and upper plate structures, which absorb some of the India-Sunda plate

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