GEODYNAMICS AND SEISMIC VULNERABILITY IN INDO-MYANMAR RANGE

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Abstract-Indo Myanmar Range (IMR) is slightly curved and broadly N-S trending fold thrust mountain belt located between the Bengal basin and Central Myanmar basin. It is an active accretionary prism which is composed of Cretaceous ophiolite, Cretaceous to Eocene pelagic sediments, Eocene to Oligocene flysch which is overlain by Neogene shallow water sediments. The complex evolutionary history of IMR is associated with adjoining regions like Bengal basin, Central Myanmar basin and Andaman-Nicobar Island Arc. The Indo-Myanmar-Andaman -Arc evolved through a continental collision during late Oligocene time and followed by the active subduction along the eastern margin of Bengal basin and Andaman trench. Major tectonic and subduction events of IMR have been identified from late Cretaceous to mid- Miocene and Quaternary times. In this paper, we are presenting a brief review of plate boundary, nature of seismicity and seismic vulnerability in IMR.

Keywords: IMR, CMF, subduction, geodynamics, seismicity, vulnerability

Introduction

IMR is located at the easternmost corner of the country. It is slightly curved N-S trending mountain belt having complex geological and geodynamical setting. Only a few portion of this belt is studied and many parts of it remain untouched. The geological study of IMR dates back to 19th century. Godwin-Austen (1874), Oldham (1883), Pascoe (1912) and Evans (1932) are the pioneers. Geophysical studies (gravity and seismic) started during 1940s (Evans & Crampton, 1942), Verma and Mukhopadhyay (1977) and Nandy (1986). Geodetic studies started recently to study crustal deformation (Gahalaut et al, 2006: Sunil, 2007). The geophysical and geodetic studies reveal the complex nature of plate boundary and seismicity. But, whether subduction is active or not is debatable topic. One school claims that subduction is active (Satyabala, 1998: Acharya, 2010; Steckler et al., 2008) and another school claims that there is no active subduction now (Gahalaut and Kundu, 2013; Gahalaut et al., 2006; Rao and Kumar, 1999; Rao and Kalpana, 2005).

Nature of Plate boundary

According to Gahalaut and Kundu (2013), there is no more active subduction of the Indian plate under IMR. They claim that Indo-Myanmar Arc (IMA) acts as a transform fault boundary even though subduction occurred in geological past. They further say that the stress state observed from the inversion of focal mechanism do not support active subduction across IMA. Gahalaut et al. (2006) claim that eastward motion of the Indian plate is generally compensated by eastward motion of the South China plate. Thus, they conclude that almost no subduction occurs along IMA. According to Rao and Kumar (1990), subduction is inactive and two plates shear past each other at this boundary. They find that P-axis of the earthquakes occurred in the region is oriented NNE direction i.e. same with Indian plate motion. They infer that strike slip and thrust type motion along the slab (IMA). Guzman-Speziale and Ni (1996) suggest that the relative motion between Indian and Myanmar plate has been transferred from subduction along arc to right lateral motion along the Sagaing fault (SF) in the east. Recent GPS measurements across SF suggest that SF accommodates about 20mm/year through right lateral strike slip motion of the plate convergence between India and Sundaland plates is about 36mm/year. The remaining motion is accommodated by Churchandpur Mao Fault (CMF) (Gahalaut and Kundu, 2013). Rao and Kalpana (2005) suggest that velocity of subduction slows down in early Oligocene and the resultant velocity component of the slab in the down-dip (eastward) direction would have considerably reduced and finally ceased in recent times.

Fig. 1 Diagram showing tectonic evolutionary model of IMR and adjoining areas (Source: Soibam, 1998)
Fig. 2 A schematic diagram illustrating the various stages of subduction in the Myanmar arc, (a) High subduction velocity sometime during Early Eocene (b) Slowed down subduction followed by rapid sinking of slab during early Oligocene. (c) Overturn of the slab. (d) Cessation of subduction followed by slow sinking of the overturned slab leading to its reverse faulting mechanism in recent times (Source; modified from Rao and Kalpana, 2005)

In contrary to this, Satyabala (1998) states that subduction of Indian plate is going on and active. She opines that Indo-Myanmar region is a coupled subduction zone. Satyabala (2003) gives another opinion of her that possibility of shifting of present margin of subduction to eastward as evidenced by the most recent folds and thrust observed in the Bengal basin and adjacent areas and west of IMA that we consider as the present plate boundary between India and Myanmar. Acharya (2010) and Jade et al. (2007) also support the active subduction hypothesis. Steckler et al. (2008) claim that Myanmar (Burma) Arc on the eastern side of the Ganges-Brahmaputra Delta (GBD) displays all the characteristics of a subduction/convergence zone including a volcanic belt on the Myanmar overriding plate. Baruah et al. (2013) also supports that the Northeast India and its adjoining south Asia region including Myanmar and Bangladesh is tectonically and seismically most active.

Nature of Seismicity

Nature of seismicity in IMR is also a controversial topic. One school claims that earthquakes occur in this region is intraplate (Gahalaut and Kundu, 2013; Chen and Molnar, 1990; Guzman-Speziale and Ni, 1996) and another school claims that the present earthquakes occurs in this region is interplate (Satyabala, 1998; Arunkumar et al., 2016). Based on recent analysis of focal mechanisms of earthquakes in Indo-Myanmar Wedge, Gahalaut and Kundu (2013) suggest that these earthquakes are intraplate earthquakes. They say that the earthquakes occur on planes which do not coincide with the dip of contact surface. The earthquakes occur on steep planes and occur through thrust and strike slip motion. They further say that earthquake hazard in the IMA region due to great and major interplate earthquakes is very low as there is no interplate earthquake in this region. Chen and Molnar (1996) infer that earthquakes might have occurred within the subducting Indian plate and not at the interface between subducting and overriding plates as the P-axis of the earthquake parallels to N-S trending seismic zone and folds of IMR.

On the other hand, Satyabala (1998) claims that the earthquake occurs in IMR is interplate type. She believes that subduction is currently active as T-axis of the focal mechanism of the earthquakes is aligned with the subduction slab. Arunkumar et al. (2016) infer that Mw 6.7 earthquake of Manipur (4 January 2016) is interplate earthquake based on low stress drop (10.1 bar) though a number of past earthquakes associated with strike slip faults. Steckler et al. (2008) suggest that a Wadati-Benioff zone of earthquakes illuminating the subducted oceanic lithosphere characterizes the entire India–Sunda boundary. They further say that while earthquakes deeper than 60 km are concentrated in the slab, shallower epicentres may be on the boundary or on secondary faults above or below it. Some of the plate-boundary earthquakes are huge belt of crustal seismicity following the Myanmar forearc and broadens northward with the fold belt.
Earthquake vulnerability

Dasgupta et al. (2003) opine that IMR is seismically active as Indian plate is subducting. They suggest slab pull extension tectonics as a contributing force for subduction. Based on the GPS and seismotectonics studies, Jade et al. (2016) claim high seismic vulnerability in this region. They also say that Indian plate is subducting below Sunda plate. Steckler et al. (2008) opine that some of the earthquakes are in the lower crust of the subducting plate and may reflect typical bending failures near a plate boundary or high stress from the Himalayan continent–continent collision. They say that seismic hazard in the GBD is largely unconstrained, but may be higher than generally perceived because current estimates do not account for possible large subduction ruptures.

According to Gahalaut and Kundu (2013), CMF is the present active plate boundary fault or deformation fault between Indian and Myanmar plates. But, it is a dextral slip fault and not associated with any earthquakes and slips aseismically. They argue that earthquake hazard in IMA region due to great and major interplate earthquakes are extremely low. They further say that putting Nagaland, Manipur, Lower Assam and Mizoram in seismic Zone V of Indian seismic zonation is not appropriate and it needs to be downgraded.

Conclusion

The previous published research works have attributed that earthquakes occur in both interplate (Satyabala, 1998) and intraplate type (Gahalaut and Kundu, 2013; Chen and Molnar, 1990; Guzman-Speziale and Ni, 1996) though magnitude, focal depth and frequency of occurrence are different. Dasgupta et al. (2003) identify a number of transverse faults within the subsiding lithosphere. This is one of the best ways to solve the controversy of present IMR plate boundary. Based on the results from a large number of focal mechanism solutions a suggestion is made to the contemporary activity along the inferred transverse hinge faults which thereby segment the Benioff zone into smaller blocks in this region. In our opinion, keeping North-east India in seismic zone V is appropriate because IMR is highly complex geodynamic region. It is criss-crossed by many faults which are considered
to be active. Recent earthquake (Mw 6.7 earthquake of Manipur on 4 January, 2016) occurred within the interplate region of IMA. Another factor is that, the less stable and unconsolidated slopes of the hills are inhabited by the people in the region amplify the seismic waves. Rapid urbanization and less availability of open space in highly populated areas like Kohima and Imphal increases the chances of seismic vulnerability in this region. 

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