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Combined effects of Eurasia/Sunda oblique convergence and East-Tibetan crustal flow on the active tectonics of Burma

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ABSTRACT

It is widely accepted that deformation of the India/Sunda plate is the result of partitioned hyper oblique convergence. Presently, sub-meridian dextral strike slip faulting accommodates this India/Sunda motion in a buffer zone, the Burma platelet. This wide dextral strike slip shear zone is complicated by the side effect of the Tibet plateau collapse that can be described in term of crustal flow and gravity tectonics. The loss of potential energy related to this plateau collapse affects most of the Burmese platelet particularly in its northernmost part.

Interaction of these two distinct geodynamic processes is recorded in the GPS based regional strain field, the analysis of seismic focal mechanism but also from direct geologic observations both onshore and offshore Myanmar and Bangladesh.

We propose the apparent E–W shortening component of this so called partitioned hyper-oblique subduction is only the effect of regional gravitational forces related to the Tibet plateau collapse whereas the NS strike slip faulting accommodates the India/Sunda motion.

1. Introduction

The Indian plate can be considered as a rigid plate moving northward toward Eurasia during the last 100 my, until collision occurred between these two continental plates around 50–45 Ma (Patriat and Segoufin, 1988; Royer and Sandwell, 1989). Since the Eocene, the crust below the Tibet plateau has become considerably thickened and a large amount of gravitational potential energy was accumulated during 30–40 Ma, following India/Eurasia collision. Release of this potential energy on the Tibet plateau has initiated crustal flow around the East Himalaya syntaxes since 13–9 Ma (Clark et al., 2005).

During the India Eurasia collision the eastern margin of India was brushing the western margin of Sundaland (Bertrand and Rangin, 2003). This oblique convergence was dominantly transtensive before 10 My, then transpressive afterwards (Fig. 1).

The hypothesis of shear-partitioning along this oblique convergent zone was favoured to explain the deformation observed within the Burma platelet (Nielsen et al., 2004). Two distinct fault zones are identified along this platelet (Fig. 2): the dextral NS trending Sagaing fault and the so-called Indo Burma wedge considered as accommodating part of the EW shortening component (Maurin and Rangin, 2009a). Internal deformation across the Burma platelet itself has to be considered also.

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2. The GPS global strain velocity field across the India/Eurasia convergent zone

Recently, geodetic networks (campaigns or permanent) have been developed in Myanmar and neighboring countries. These networks have been used to study the behavior of major active tectonic features in the region such as the Sagaing fault (Vigny et al., 2003; Maurin et al., 2010), the Indo-Burmese wedge (Gahalaut et al., 2013), the large-scale movement of the Indian plate (Banerjee et al., 2008) and the Tibetan crustal flow (Gan et al., 2007). These separate velocity fields have been individually combined by applying rotational transformations, which minimize the residual misfit of GPS velocities for the sites. Fig. 3 is a synthesis of these already published data shown here in an Eurasian fixed reference frame. Oblique India/Eurasia motion is distributed across the Burma platelet and its margins. However, in Northern Myanmar and Eastern India, the Tibetan crustal flow around the East Himalaya syntaxes is well highlighted in the velocity field.

Local and temporary GPS networks were installed and measured in Myanmar, particularly along the Sagaing Fault (Vigny et al., 2003; Maurin et al., 2010). The central and northern Myanmar networks both indicate a rather constant 1.8 cm/year of right lateral motion along this fault. The elastic thickness of the crust is 15 km in central Myanmar, but only 4–5 km into the north, approaching the region of Tibetan crustal flow.

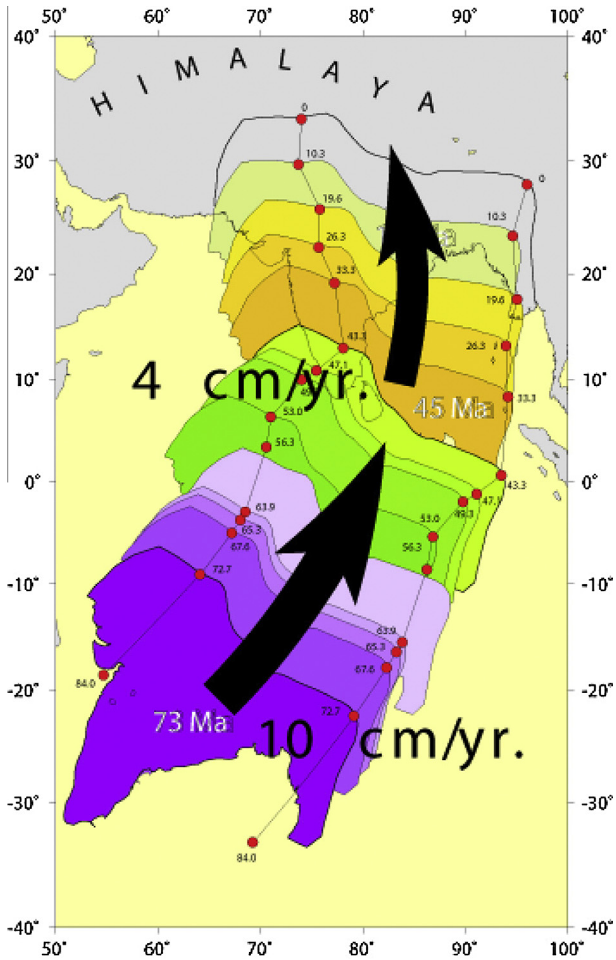

Fig. 1. The path of India (plus great India) toward Eurasia with the attached Bengal basin and Burma continental block. Four main stages can be recognized in this path: A fast drift of India (10 cm/year) shown in blue (84–60 Ma). Collision of India with Eurasia and Sunda shown in green (55–43.3 Ma). Brushing of India along the Sunda plate (4 cm/year) shown in orange yellow and pale green (43.3–10.5 Ma), and slower (3.5 cm/year) NNW India/Sunda convergence (10.5–0 Ma). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3. Oblique India/Eurasia convergence, and strain partitioning

India–Sunda hyper-oblique convergence is responsible for the formation of the Burma micro-plate as a result of strain partitioning. This micro-plate is detached from the Sunda plate by right lateral strike slip along the Sagaing fault and subduction along the Eastern margin of the Bengal basins (Curray et al., 1979; Le Dain et al., 1984). Southward, the Sagaing fault is considered to be connected to the active Andaman rift. The onset of seafloor spreading in the Andaman rift (Chamot Rooke et al., 2001; Raju et al., 2004) provides a minimum age for the Sagaing fault: 4.5 Ma. The onset of rifting in the Mid Miocene (Raju et al., 2004) can be considered as the maximum age.

An instantaneous slip rate along the Sagaing fault of 18 mm/year was obtained by geodetic measurements in its central part (Vigny et al., 2003). The same value was obtained along the northern termination of this fault in Northern Myanmar. The India/Sunda finite motion was estimated at 36 mm/year (Socquet et al., 2006). In Fig. 3, two sites located within stable India show a motion of ∼33 mm/year with respect to Sundaland (Gahalaut et al., 2013). Consequently the Sagaing fault accommodates only half of the India/Sunda motion. The missing half of the motion can be either absorbed by hyper-oblique subduction along the Eastern margin of the Bengal basin if we consider the Burma micro-plate as rigid, or by deformation distributed across a semi rigid micro-plate.

The hyper oblique subduction is accepted as accommodating around 2 cm/year of Bengal basin oceanic crust subduction below the Burma micro-plate (Nandy, 1986; Acharya et al., 1990). The Indo-Burma Ranges are interpreted as the accretionary wedge associated with this subduction. Actually subduction is not supported by the analysis of focal mechanisms. Numerous authors have outlined the dominant N–S *P*-axes for most of the seismic events below the Indo Burma Ranges (Le Dain et al., 1984; Guzman-Speziale and Ni, 1996). Fig. 5 shows that the deepest (>40 km) seismic focal mechanisms of this supposed active subduction indicate NS shortening or downward extension of the slab. Only two focal mechanisms above 40 km indicate EW shortening. Associated alkaline and calk-alkaline volcanism in the late Neogene Burmese volcanic arc was interpreted by Maury et al. (2004) as a slab detachment inducing opening of a mantle window into this slab. We then interpret the seismic activity below the Burma platelet as a slab detachment process along a starved subduction zone as previously suggested by Guzman-Speziale and Ni (1996). The corresponding tomography reveals part of this slab is already detached, and is detectable in the middle mantle.

Fig. 4 shows that Centroid Moment Tensors (CMTs) for the Indo Burma ranges are dominantly strike slip with NE–SW *P*-axes. Geological mapping of this range in Myanmar and Bangladesh (Maurin and Rangin, 2009a), shows the presence of important regional N–S trending dextral shear zones The core of this mountain range is bounded by the dextral Kabaw Fault into the East and the Lelon Fault to the west (Fig. 4, and km 350 and km 300 in Fig. 5, respectively). West of this core, folded Paleogene clastic sediments are bounded by the Lelon dextral strike slip fault to the east and the dextral Kaladan strike slip fault to the west (Fig. 4). Numerous but minor N–S trending dextral faults dissect this elongated Paleogene terrain. In outcrop the Kaladan fault shows a component of westward thrusting evidenced by oblique slicken sides along the fault plane. This transpressive right lateral Kaladan fault is illustrated in Fig. 5 (km 200). This Paleogene terrain is also present west of the Kabaw fault in the Central Myanmar basins where it was conformably deposited above the Late Cretaceous Kabaw formation (Maurin and Rangin, 2009a).

The core of the Indo Burma Range in Myanmar can be considered as a pop up structure, comprising a pre-Cenozoic subduction/collision complex that protrudes from the overlying Paleogene basin. This basin extends from the Bay of Bengal eastwards to the Myanmar Central basins. The Outer unit (or western terrain) of the Indo-Burma ranges, is framed by Kaladan Fault to the West and the Coastal Fault to the East (Maurin and Rangin, 2009a). This N160E–N170E trending tectonic slice is exclusively composed of Neogene clastic sediments affected by narrow en echelon folds and thrusts, separating large open synclines (Figs. 4 and 5). On land, in the Bangladesh Chittagong province and along the Myanmar coast, these sediments were exclusively dated as Late Miocene to Plio-Pleistocene at the surface and no older than Lower Miocene sediments in wells.

We interpret these Paleogene and Neogene tectonic units as successive sedimentary slivers docked along the central core of the Indo Burma ranges.

4. The core of the Indo-Burmese ranges: the trace of a Mesozoic subduction and collision zone

The elongated N–S core of this Range is formed by Mesozoic ophiolites (serpentinized peridotites, Pillow basalts and red cherts), locally dated as Late Jurassic in age (Susuki et al., 2004).