Tectonics in East Asia and mechanism of stress propagation

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The Indentation theory by Tapponnier and Molnar [1976] successfully explained tectonic deformation in east Asia in which many plates converge. This theory has fallen into two controversial models in addressing how stress propagation; blockwise rigid motions or spatially continuous straing? We have tried to clarify the characteristics of stress propagation in east Asia based on GPS observations, their combination and numerical modeling with 2-D thin elastic plate. Through these continuous modelings we found that tectonics in east Asia may be due to three factor; the Indo - Eurasian collision, the Sunda block motion (including the Red River fault motion), and the Amurian plate motion, although magnificent clockwise rotation in the east of India was not modeled well in the present study.

Asia - Pacific region is the area of plate convergence among megaplates such as Eurasian, Indo - Australian, and Pacific plate as well as other smaller plates and blocks such as Philippine Sea plate, Amurian plate, and Sunda block etc. In this area many tectonic phenomena can be seen such as crustal deformation, collision of plates, subductions etc.

The indentation theory by Tapponnier and Molnar et al. [1976] successfully explained tectonic deformations and roles of faults in China. Recent introduction of space geodetic techniques, especially Global Positioning System (GPS), have revealed detailed velocity fields in the region. For example, Kato et al. [1998] and Kotake [2000] showed the effects of Indo - Eurasia collision in the Chinese continent, while Simons et al. [1999] estimated the motion of Sunda block in the south east Asia. Also the existence of Amurian plate has been suggested by Heki et al. [1999], although the geometry of the plate boundary is not well constrained.

We have tried to clarify the characteristics of stress propagation in east Asia based on GPS observations, their combination and numerical modeling.

First, considering sparse GPS velocities in the Indo - China peninsula, we established five permanent sites in Thailand in 1998. Two years of data have been analyzed to delineate velocities in the region. Results suggest that the area is presumably in a part of the Sunda block as was proposed by Simons et al. [1999].

Then, the published velocity fields in the east Asia as well as Thailand data are combined to draw a unified velocity field in the region. We adopted the stable Eurasia fixed reference frame and used Kotake [2000] as the reference velocity field. Eight velocity fields are converted so that the commonly occupied sites have the same velocities as Kotake [2000] in the least squares sense. Obtained unified velocity field clearly portray the instantaneous velocity field in the eastern Asia. Among various interesting local velocity distributions, the following three characteristics seems outstanding.

There is a strong collision in the northern part of Indo - China peninsula, and the boundary might be located in the south of the Red River fault.

Acute bend of the velocities in the north of Tibet is eminent, which might be due to eastward drag by the Amurian plate.

More vectors in the Amurian plate suggested that previous estimate of Euler pole by Heki et al. [1999] is not precise due to biased distribution of GPS sites.

Finally, a simple model consisting of a thin elastic plate was introduced to model the obtained velocity field. Considering complicated pattern of deformation field, modeling has been divided into four steps.

Condition I: Indo - Eurasian collision and Sunda block motion

Condition II: Add the Red River fault motion

Condition III: Add the Amurian plate motion

Consition IV: Implement the re-estimated motions of Amurian plate and Sunda block

Through these modelings we found the followings. First, the effect of the Sunda block should not reach to the south China block, presumably due to the existence of the Red River fault. Then, the acute bend of the north Tibet may be due to the eastward drag of the Amurian plate, though yet the plate boundary cannot be constrained. Magnificent clockwise rotation in the east of India was not modeled well in the present study, though the Longmen Shan - Xiaojiang fault zone that bounds the Tibetan plateau and the south China block might have some role in this rotation.