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Origin of marginal basins of the NW Pacific and their plate tectonic reconstructions

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ABSTRACT

Geometry of basins can indicate their tectonic origin whether they are small or large. The basins of Bohai Gulf, South China Sea, East China Sea, Japan Sea, Andaman Sea, Okhotsk Sea and Bering Sea have typical geometry of dextral pull-apart. The Java, Makassar, Celebes and Sulu Seas basins together with grabens in Borneo also comprise a local dextral, transform-margin type basin system similar to the central and southern parts of the Shanxi Basin in geometry. The overall configuration of the Philippine Sea resembles a typical sinistral transpressional "pop-up" structure. These marginal basins except the Philippine Sea basin generally have similar (or compatible) rift history in the Cenozoic, but there do be some differences in the rifting history between major basins or their sub-basins due to local differences in tectonic settings. Rifting kinematics of each of these marginal basins can be explained by dextral pull-apart or transtension. These marginal basins except the Philippine Sea basin constitute a gigantic linked, dextral pull-apart basin system.

Formation of the gigantic linked dextral pull-apart basin system in the NW Pacific is due to NNE- to ENE-ward motion of east Eurasia. This mainly was a response to the Indo–Asia collision which started about 50 Ma ago. The displacement of east Eurasia can be estimated using three aspects: (1) the magnitude of pull-apart of the dextral pull-apart basin system, (2) paleomagnetic data from eastern Eurasia and the region around the Arctic, and (3) the shortening deficits in the Large Tibetan Plateau. All the three aspects indicate that there was a large amount (1000 to 1200 km) of northward motion of the South China block and compatible movements of other blocks in eastern Eurasia during the rifting period of the basin system. Such a large amount of motion of the eastern Eurasia region contradicts any traditional rigid plate tectonic reconstruction, but agrees with the more recent concepts of non-rigidity of both continental and oceanic lithosphere over geological times. Based on these three estimates, the method developed for restoration of diffuse deformation of the Eurasian plate and the region around the Arctic, and the related kinematics of the marginal basins, we present plate tectonic reconstructions of these marginal basins in global plate tectonic settings at the four key times: 50, 35, 15 and 5 Ma. The plate tectonic reconstructions show that the first-order rift stage and post-rift stage of the marginal basins are correlated with the first-order slow uplift stage and the rapid uplift stage of the Tibetan Plateau, respectively. The proto-Philippine Sea basin was trapped as a sinistral transpressional pop-up structure at a position that was 20° south of its present position at about 50 Ma ago (or earlier). While the Japan arc migrated eastward during the rifting period of the Japan Sea basin, the Shikoku Basin opened and the Parece Vela Basin widened.

Contents

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1. Introduction

A great deal of research has been devoted to studying the origin of Cenozoic basins along the NW Pacific margin since Wegener (1929) speculated that the basins had formed by extensional process that rifted the east Asian margin. Within the classical plate tectonics, there are numerous hypotheses proposed to explain the origin of these basins that include:

(1) Active back-arc spreading that is the result of mantle diapirism caused by either heat generation along the subducting slab (e.g., Karig, 1971), secondary convection induced by the downgoing slab (Sleep and Toksöz, 1971), or asthenospheric injection (e.g., Miyashiro, 1986; Tatsumi et al., 1989).
(2) Passive back-arc spreading related to "absolute" motions of major plates that includes the anchored-slab model (e.g., Uyeda and Kanamori, 1979), the slab-pull model invoking the seaward retreat or rollback of the downgoing slab (e.g., Dewey, 1980) or by the downgoing asthenospheric flow below the subducted slab (e.g., Glatzmaier et al., 1990).
(3) The collision–extrusion model in which the formation of the South China Sea and the extensional basins in North China are related to SE or eastward ejection of crustal blocks along NW and EW striking, sinistral fault systems, resulting from the collision of the Indian and Eurasian plates (e.g., Tapponnier et al., 1982; Jolivet et al., 1989, 1990; Worrall et al., 1996; Replumaz and Tapponnier, 2003; Royden et al., 2008; Yin, 2009).
(4) Local dextral pull-apart basin development that includes the Andaman Sea, the Japan Sea, Kuril and the Bohai Gulf basins. The formation of the Andaman Sea is the result of the northward drift of India (e.g., Tapponnier et al., 1982; Maung, 1987). The Japan Sea basin was formed due to northward movement of the Amuria plate and the Kuril Basin from CW rotation of the Okhotsk plate (Lallemand and Jolivet, 1985; Kimura and Tamaki, 1986). Jolivet et al. (1994) suggest that the Japan Sea