Origin of back-arc basins and effects of western Pacific tectonics on eastern China geological evolution since the Mesozoic

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Assuming that initiation of subduction zones is a consequence of lateral compositional buoyancy contrast within the lithosphere [1] and recognizing that subduction initiation within the normal oceanic lithosphere is practically unlikely [1], then passive continental margins that are locations of the largest compositional buoyancy contrast within the lithosphere are thus likely the loci of future subduction zones. Back-arc basins, as the name implies, are therefore a natural consequence of seafloor subduction. Niu et al. [1] hypothesize that all the western Pacific back-arc basins were developed as and evolved from extensional basins on passive continental margins in response to seafloor subduction. This hypothesis can be tested by demonstrating that all the intra-oceanic island arcs must have basement of continental origin. The geology of the Islands of Japan supports this and the origin and evolution of the Okinawa Trough (back-arc basin) and Ryukyu Arc/Trench systems represents the modern example of subduction initiation and back-arc basin formation along a (Chinese) continental margin. The highly depleted forearc peridotites from Tonga and Mariana offer independent line of evidence for the hypothesis. The observation why there are back-arc basins behind some subduction zones (e.g., western Pacific) but not others (e.g., in South America) is related to the working of subduction. While subducting slabs are non-vertical, the driving force is the gravity and is vertical. This leads to slab-rollback and trench retreat. The latter in the western Pacific results in the development of extension in the upper Eurasian plate and formation of back-arc basins. This is possible because the giant Eurasian plate cannot well respond to this retreat. In the case of South America, where no back-arc basins form because the Nazca Plate trench retreat is accomplished by the spreading of the South Atlantic Ridge. In this case, it is conceptually correct to treat the South Atlantic as a huge “back-arc basin” although its origin may be somewhat different. Because of the negative Clayperon slope of the Perovskite-ringwoodite phase transition at the 660 km mantle seismic discontinuity (660-D), slab penetration across the 660-D is difficult and trench retreat of the western Pacific subduction zones readily result in the horizontal stagnation of the western Pacific plate in the transition zone beneath eastern Asian continent [4,5]. Dehydration of this slab supplies water, which rises and results in “basal hydration weakening” of the eastern China lithosphere and its thinning by converting it into weak material of asthenospheric property [6,7]. In this context, we note that multiple subductions and more water (i.e., subduction beneath, and collision with, of the South China block in the south and the Siberian/Mongolian block in the north) have been proposed to have caused the lithosphere thinning beneath the North China Craton (NCC) [8]. However, South China-North China and Siberian/Mongolian-North China represent two collisional tectonics involving no trench retreat, causing no transition-zone slab stagnation, supplying no water, and thus contributing little to lithosphere thinning beneath the NCC. The incompletely dehydrated South China “slab” and Siberian/Mongolian “slab” penetrate the 660-D into the lower mantle [9]. Also, the amount of water required to weaken the lithosphere is rather small [6]. Furthermore, lithosphere thinning happened to the entire eastern China, not just limited to the North China Craton (although the thinning may not be uniform throughout), emphasizing the role of the western Pacific subduction system.

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