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Mesozoic lithospheric deformation in the North China block: Numerical simulation of evolution from orogenic belt to extensional basin system

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Abstract

Horizontal extension of a previously thickened crust could be the principal mechanism that caused the development of widespread extensional basins throughout the North China block (Hua-Bei region) during the Mesozoic. We develop here a regional tectonic model for the evolution of the lithosphere in the North China block, based on thin sheet models of lithospheric deformation, with numerical solutions obtained using the finite element method. The tectonic evolution of this region is defined conceptually by two stages in our simplified tectonic model: the first stage is dominated by N–S shortening, and the second by E–W extension. We associate the N–S shortening with the Triassic continental collision between the North and South China blocks, assuming that the Tan-Lu Fault system defines the eastern boundary of the North China block. The late Mesozoic E–W extension that created the Mesozoic basin systems requires a change in the regional stress state that could have been triggered by either or both of the following factors: First, gravitational instability of the lithosphere triggered by crustal convergence might have removed the lower layers of the thickened mantle lithosphere and thus caused a rapid increase in the local gravitational potential energy of the lithosphere. Secondly, a change to the constraining stress on the eastern boundary of the North China block, that might have been caused by roll-back of the subducting Pacific slab, could have reduced the E–W horizontal stress enough to activate extension. Our simulations show that widespread thickening of the North China block by as much as 50% can be explained by the collision with South China in the Triassic and Jurassic. If convergence then ceases, E–W extension can occur in the model if the eastern boundary of the region can move outwards. We find that such extension may occur, restoring crustal thickness of order 30 km within a period of 50 Myr or less, if the depth-averaged constitutive relation of the lithosphere is Newtonian, and if the Argand number (the ratio of buoyancy-derived stress to viscous stress) is greater than

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about 4. Widespread convective thinning of the lithosphere is not required in order to drive the extension with these parameters. If, however, the lithospheric viscosity is non-Newtonian (with strain-rate proportional to the third power of stress) the extensional phase would not occur in a geologically plausible time unless the Argand number were significantly increased by a lithospheric thinning event that was triggered by crustal thickening ratios as low as 1.5.

Keywords: Basin formation; Continental shortening and extension; Crustal deformation; Geodynamics; North China block; Thin sheet models; Lithospheric thinning

1. Introduction

The North China block, the western portion of the Sino-Korean Craton, is bounded to the north by the Yanshanian orogenic belt and to the south by the Qinling-Dabie orogenic belt (Fig. 1). Şengör and Natal'in (1996) describe the northern boundary of the North China block as comprised of displaced fragments of the active margin of the North China craton, including medial to late Paleozoic subduction-accretion complexes and related magmatic arcs. The collision between the North China/Tarim block and the Altaid system of Mongolia began in the late Carboniferous (Yin and Nie, 1996). On its southern boundary the North China block is separated from South China by the Qinling-Dabie-Sulu suture zone, which extends westward to the Kunlun Shan. During the late Permian, South China began colliding with North China, initially in the East, but the collision progressively migrated westward along this suture zone (Yin and Nie, 1996).

The North China basement includes Archean age rocks and widespread Proterozoic sedimentary cover. During the Paleozoic, the North China block was a stable craton with shallow marine carbonate sedimentation, giving way in the Carboniferous to terrestrial deposition (Yin and Nie, 1996). Intracontinental deformation was widespread in both South and North China in the Mesozoic. The structures relating to the Yanshanian orogeny (late Jurassic to early Cretaceous) are characterized by E–W trending folds and thrusts in the northern part of North China. Evidence

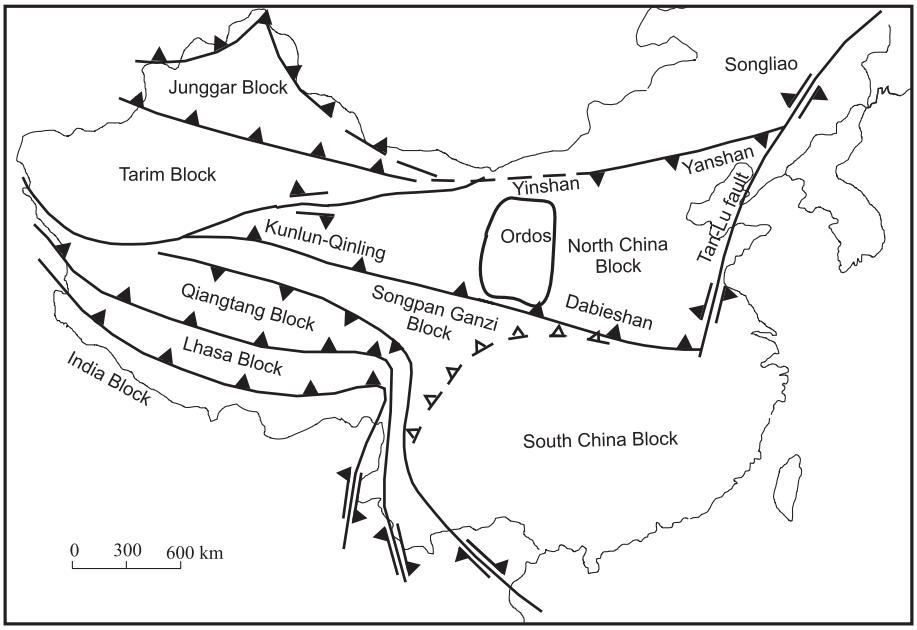

Fig. 1. Tectonic sketch map of China, showing the location of North China block (Hua-Bei region) and of major suture zones.