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Thermal state, rheological structure and mechanical strength of lithosphere beneath continental China: Implications for Late Cenozoic deformation

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The thermal state of lithosphere greatly influences active tectonics and mechanical properties of lithosphere. Under the applied boundary forces, the style and rate of lithospheric deformation depend on its rheology. Studies on the thermo-rheological structure and mechanical properties of the lithosphere in continental China are of vital importance for elucidating the Late Cenozoic deformation, earthquake activities, along with basin formation in China. Here we report our latest results on thermal state, rheological structure and mechanical strength of lithosphere in continental China, combined geophysical data on heat flow, crust and upper mantle structure and composition of the lithosphere with numerical modeling.

Thermal state of lithosphere in eastern China is higher than that in western China in a whole, but variation still exist between different thermo-tectonic domains in continental China, so does each domain. Such cratons as Tarim and Yangtze are still of the thermal state for Precambrian lithosphere with relatively cooler Moho temperature and thick thermal lithosphere, while for the North China craton, it is characterized by relatively higher Moho temperature and thin thermal lithosphere, due to Mesozoic-Cenozoic tectonic reactivation. Reconstruction of the thermal structure evolution of lithosphere in the basin east of North China craton reveals that the thickness of the lithosphere before Pre-Mesozoic is larger than 200km, but only less than 80 km since Late Mesozoic, indicating the existence of prominent lithospheric thinning during Mesozoic. This thermal characteristics show that continental China is of temporal-spatial heterogeneities in thermal evolution considered.

Rheology of the lithosphere beneath continental China is of prominent heterogeneities with lateral variation and vertical stratification. For eastern China, the lithosphere is characterize by relatively stronger upper and middle crust and the weaker lower crust and the uppermost mantle; while for western China, the lithosphere is like a jelly sandwich, with a weak lower crust lying between a strong upper crust and a strong uppermost mantle. The effective elastic thickness (Te) of those regions with relatively low geothermal gradient and large lithospheric strength is larger than their crustal thickness and brittle-ductile transition depth; and the strength of lithosphere is mainly supported by mantle part. Under this condition, the mantle with olivine controls the rheology of lithosphere. For those regions of large geothermal gradient and low lithospheric strength, Te is less than their crustal thickness, approximating to the brittle-ductile transition depth; crustal part contributes almost to the total strength of lithosphere, then the rheology of lithosphere is controlled by the crust of felsic. In addition, our results also indicate that both the rheological patterns with “stronger crust and weaker mantle” and “weaker crust and stronger mantle” all exist in the lithosphere beneath continental China.

Furthermore, combined with observations of continental deformation in China from GPS, active faulting and earthquake activities, here we put forward that heterogeneities of thermo-rheological structure of continental lithosphere and tectonic inheritance are the controlling factors for continental deformation. Take the Tienshan and eastern Tibet as case studies, this working hypothesis on Late Cenozoic deformation is elucidated in detail.