Heat flow, thermal structure and lithospheric rheology of Sanjiang orogen and its neighbouring region, SW China

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Sanjiang orogen is located in the southwestern part of China. Tectonically, it is a part of Tethys–Himalayan orogenic system and has a complex geological history. The widespread active strike-slip faults, intensive earthquake activities and late Cenozoic magmatism in the orogen are related to the India–Asia collision. East of the orogen is Chuxiong basin and Kunming block. They also involved into the Cenozoic transpressional deformation induced by India-Asia collision. The boundary of Kunming block and the stable interior part of Yangtze platform is Xiaojiang fault, one of major active strike-slip faults in SW China.

The regional variation of heat flow in Sanjiang orogen exhibits a decreasing trend from NW to SE. The average heat flow value is over 80 $mW.m^{-2}$ in the north (Lijiang) and the west (Tenchong); and it is related to the Cenozoic magmatism. Meanwhile, the lower values (<65 $mW.m^{-2}$) are observed in the SE part of Sanjiang orogen. The heat flow values in Chuxiong basin and Kunming block manifest the spatial pattern that higher (>70 $mW.m^{-2}$) in the region near major active faults (Ailaoshan–Red River and Xiaojiang faults), and lower in basin's interior. The lower (<65 $mW.m^{-2}$) heat flow values are also observed in the stable Yangtze platform. The thermal structures of crust and upper mantle in Sanjiang orogen and its neighbouring were calculated by 1-D and 2-D calculations.

The rheological profiles of tectonic units in Sanjiang orogen and its neighbouring regions are constructed using calculated geotherms and crustal models derived from deep seismic sounding. The results reveal the existence of very weak middle and lower crustal layers beneath Sanjiang orogen and its environs. This means the detachment between upper and lower crust. The mechanical uncoupling within crust in combination with major active strike-slip faults results in the 'book shelf' faulting and block rotation within Sanjiang orogen. The rotation of blocks around vertical axis is an important mechanism for active deformation and related seismicity in Sanjiang orogen. The weak middle and lower crustal layers also provide the avenue for southward crustal flow from Tibet plateau, the possible mechanism driven the excursion of Sanjiang orogen. It is noted that the upper and lower crust is also uncoupled beneath Yangtze platform. However, the existence of a strong layer in upper mantle prevents the growth of lithospheric scale penetrative faulting within the stable Yangtze platform. On the other hand, the upper mantle beneath Sanjiang orogen is relatively weak, and favour the development of lithospheric fault. The existence or absence of strong layer in upper mantle is also an important factor to influence the deformation pattern and style in Sanjiang orogen and its environs.

Geological, thermal and rheological heterogeneity of China lithosphere and their effects on the present deformation pattern

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China consists of three Precambrian platforms, which include the North China platform (NCP), the Yangtze platform and the Tarim platform, surrounded by accreted terranes and orogens of various ages. China continent was first assembled in the Palaeozoic and has been further deformed and rearranged in multiple episodes throughout the Mesozoic and Cenozoic. These tectonic events resulted in the strong lateral heterogeneity in geological features among major tectonic units of China, such as crustal composition and structure, etc. The heat flow pattern of China also exhibits complicated lateral variation (Wang 1999).

On the basis of over 800 heat flow observations

and other geophysical and geochemical data, the thermal structures of China lithosphere were calculated with the assumption of 1-D steady condition. Then, the rheological profiles were established by the three-layer model of lithosphere. The results show that the rigid blocks or massifs are the Tarim and Yangtze platforms, in where lower heat flow values are observed; meanwhile, the weak zones or belts correspond to the high heat flow regions such as the most of orogens, the western and eastern margins of Yangtze platform, and the eastern part of NCP. This pattern coincides with the present deformation pattern of China, which is exhibited by seismic activities and active tectonics. It is noted that the thermal state is the key factor to influence the strength of lithosphere, and the lithospheric composition structure is the secondary one. Therefore, the thermal state of foreland is also important to influence the mechanical coupling between orogen and its environs, besides the strength of orogen itself.

The spatial range of present far-field deformation induced by India–Asia collision is an important problem for continental tectonics of China; and the arguments focus on whether there is large-scale eastward excursion of the tectonic domains in east of Tibet plateau (i.e., the Yangtze and NCP). The results of this study on thermal and rheological structure of China lithosphere show that the Yangtze platform is a rigid block but its western margin (west Sichuan and Yunnan) is very weak. So the stress from west is absorbed by the deformation within the west Sichuan and Yunnan region, and the eastward excursion of Yangtze platform is insignificant. Meanwhile, the strength of NCP is much weaker than Yangtze platform, especially its eastern part and the periphery of Ordos block. The intensive seismicity in the NCP indicates that the stress from west is absorbed by the deformation within the platform. This explains why there are no penetrative strike-slip faults along the northern and southern margins of NCP, and why NCP does not happen large amount eastward excursion as a whole.

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Dynamic links between internal zone extension and external zone shortening in the Alps: mapping, dating and modelling

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To understand the dynamics of a mountain belt requires knowledge of the geometry and timing of movements as well as of the thermal history. This is true of both shortening and extensional events. Ten years of mapping and geochronological work by us has focussed on constraining extensional events in the Alps, in particular those related to unroofing the Piemonte high and ultra-high pressure eclogites. These eclogites were unroofed by SE-directed extension, in other words along a surface subparallel to the subduction zone but with opposite movement sense. This unroofing occurred in the period 45–36 Ma. In the external zones, a marine foreland basin was actively migrating away from the orogen, and receiving clastic detritus at this time. This migration is of the same order of magnitude as the displacement induced by internal zone extension. They must have been strongly dynamically coupled, and local buoyancy played a key role. Numerical modelling confirms this profound coupling and leads us to reappraise the dynamics of foreland basin evolution in this mountain belt.