Geology of the eastern Himalayan syntaxis

Yan Liu†*, Zsolt Berner‡, Hans-Joachim Massonne§ and Xuchang Xiao†

† Institute of Geology, Chinese Academy of Geological Sciences, Beijing, 100037, CHINA
‡ Institut für Mineralogie und Geochemie, Universität Karlsruhe, Kaiserstraße 12, D-76128 Karlsruhe, GERMANY
§ Institut für Mineralogie und Kristallchemie, Universität Stuttgart, Azenbergstr. 18, D-70174 Stuttgart, GERMANY

** To whom correspondence should be addressed. E-mail: yanliu0315@yahoo.com.cn*

Before the middle of the nineties, the eastern Himalayan syntaxis was one of the least-known segments of the Himalayas. According to studies several years ago, the eastern Himalayan syntaxis consists of three tectonic units: Gangdise, Yarlung Zangbo, and Himalayan units (Liu and Zhong 1997, Burg et al. 1998). The Gangdise unit consisting of granitoids, migmatites and amphibolite-facies rocks, commonly covered by Palaeozoic and Mesozoic sediments, is separated from the Himalayan unit by the Yarlung Zangbo unit, a mylonitic zone with lenses of metabasites and serpentinites. The basic-ultrabasic lenses of the Yarlung Zangbo unit suggest that the boundary between the Gangdise and the Himalayan units is an eastern extension of the Indus - Yarlung Zangbo suture, which was folded around the eastern Himalayan syntaxis. Recent detailed field mapping has revealed that the Himalayan unit is made up of North Col greenschist to amphibolite facies complex, Greater Himalayan Crystallines, upper Lesser Himalayan Crystallines and lower Lesser Himalayan Crystallines from north to south (**Figure 1**). The dominant mineral assemblage of the North Col complex is plagioclase+quartz+biotite+chlorite+epidote±muscovite, but at the bottom of the complex staurolite+kyanite+K-feldspar+muscovite+quartz+epidote±garnet occur. The latter assemblage is different to that at the bottom of the North Col formation of the central Himalayas. A ductile normal fault referred as STD1 here separates the North Col complex from the Greater Himalayan crystallines below. Strongly deformed granites occur between the STD1 and the top of the Greater Himalayan Crystallines. The Greater Himalayan Crystallines are marked here by the assemblages garnet+prismatic sillimanite+K-feldspar+antiperthite or plagioclase. Spinel+albite+biotite or spinel+cordierite±orthopyroxene form retrograde coronas around sillimanite and garnet. The prismatic sillimanite had been argued to replace early kyanite at elevated temperature, indicating that the Greater Himalayan Crystallines experienced high-pressure metamorphism (Liu and Zhong 1997). The Greater Himalayan Crystallines were thrust over the upper Lesser Himalayan Crystallines consisting generally of amphibolitic gneisses, sillimanite gneisses, granitic gneisses and marble by a ductile thrust system which is referred to as the MCT1. Further south, another ductile thrust system, named as the MCT2, separates the upper Lesser Himalayan Crystallines from the lower Lesser Himalayan Crystallines consisting generally of quartzite, calcschist, limestone, metapsammite and muscovite phyllite (**Figure 1**).

A distinctive feature of the Greater Himalayan Crystallines is the occurrence of numerous dykes of various compositions and different ages along the foliation of granulite facies gneisses. Three rock types can be distinguished. One type is related to carbonate dykes with fine-grained dark 'chilled' margins from several millimeters to centimeters in thickness and extensive metasomatic and/or contact alteration halos. Large dolomitic dykes commonly contain irregular-shaped xenoliths of granulitic gneiss, which seem to have been separated from source rocks nearby. Spatial relationships of carbonate-rich dykes were observed in the field. These field characteristics resemble those of typically igneous dykes and of mantle-derived carbonatites documented in numerous publications (e.g., Le Bas 1981, Tuttle and Gittins 1966). These are also considered as clear indication for an igneous origin of such carbonate dykes. A second rock type is characterized by MgO-rich ultramafic rocks, which occur as small dyke-like bodies in the granulitic terrain or as ball-shaped inclusions in diorite dykes. The third group of rocks is related to biotite-bearing diorites.

Geochemically, the carbonate-rich dykes differ significantly from mantle-derived carbonatites. The dykes are poor in REEs, Ba, Sr, U, Th, Nb, F and P and their $^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$, $\delta^{18}O$ (relative to V-SMOW) and $\delta^{13}C$ (relative to V-PDB) values range from 0.709 to 0.712, 0.5117 to 0.5121, +8 ‰ to +24.4 ‰, and +0.80 ‰ to +3.55 ‰, respectively. These values are similar to those of many sedimentary carbonates. We suggest that the carbonate dykes were formed by remobilized melts that originated as partial melts from sedimentary carbonates at crustal levels. Structural analyses have shown that the hot Greater Himalayan Crystallines were extruded from beneath southern Tibet via ductile channel flow to overlie the limestone/marble-bearing Lesser Himalayan Crystallines. Remobilization of limestones below the Greater Himalayan Crystallines was probably triggered by stacking of the hot Greater Himalayan Crystallines including interaction of fluids enriched in H_2O and poor in CO_2 probably from the lower crust or even the Earth's mantle. In turn, remobilized carbonate melts could contribute to the exhumation of the Greater Himalayan Crystallines. According to K-Ar and Ar-Ar data obtained on amphibole and mica from the carbonate dykes, this event started during the late Neogene.

References

Burg JP, P Nievergelt, F Oberli, D Seward, P Davy, , JC Maurin, Z Diao and M Meier. 1998. The Namche-Barwa syntaxis: evidence for exhumation related to compressional crustal folding. *J Asian Earth Sciences* **16**: 239-252

Liu Y and D Zhong. 1997. Petrology of high-pressure granulite from the eastern Himalayan syntaxis. *J Met Geol* **15**: 451-466

LeBas M J. 1981. Carbonatite magmas. *Min Mag* **44**: 133-140

Tuttle O F and J Gittins. 1966. *Carbonatites*, New York, Wiley, 591 p

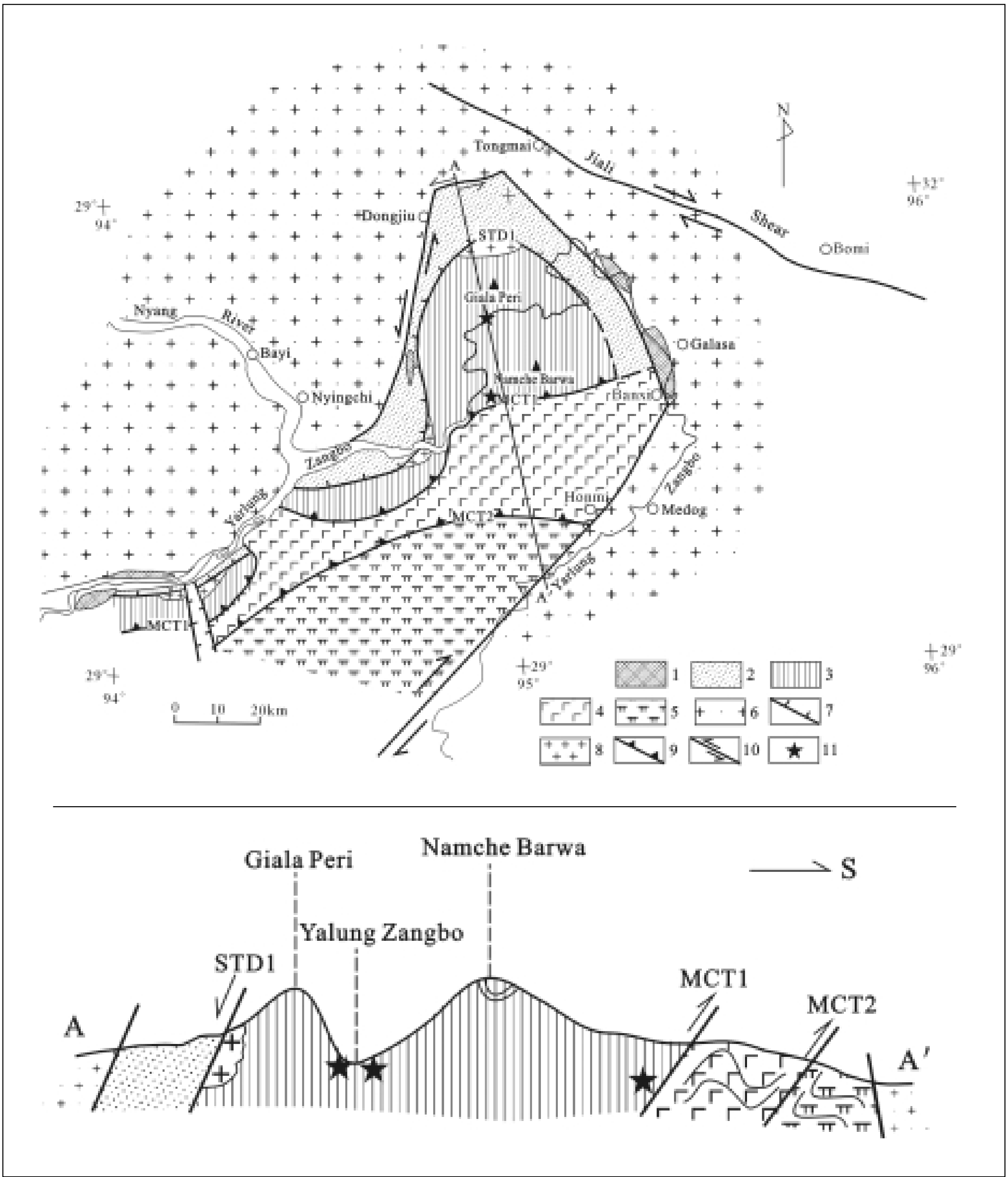

FIGURE 1. Top: Geological sketch map of the eastern Himalayan syntaxis (Liu and Zhong 1997, Burg et al. 1998 and our own observations). Bottom: Geological section. 1, Yarlung Zangbo unit. 2, North Col greenschist to amphibolite facies complex. 3, Greater Himalayan Crystallines. 4, Upper Lesser Himalayan Crystallines. 5, Lower Lesser Himalayan Crystallines. 6, Gangdise unit. 7, Normal fault. 8, Strongly deformed granites. 9, Thrusts. 10, Strike-slip fault. 11, Dyke swarm.