19 Ma Ductile E–W Extension associated with Normal Faulting in the Kung Co area, Southern Tibet

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Active tectonics in the central part of Tibet is dominated by a linked set of strike-slip and N–S trending normal faults. The normal faulting acts to reduce the overall height of the plateau despite the ongoing convergence of India with Asia. The age at which N–S normal faulting began marks the time when the horizontal deviatoric stresses changed from compressional to extensional and many workers relate this to the time at which the Plateau reached its maximum elevation (e.g. Molnar and others, 1993). Obtaining age constraints for the onset of N–S trending normal faulting is therefore an important topic in understanding the evolution of the region. Dates for the initiation of movement on the major N–S normal faults are generally around 10–14 Ma (Coleman and Hodges, 1995, Garzione and others, 2000). The presence of N–S oriented dykes with intrusion ages of around 18 Ma (Williams and others, 2001) suggests extension may have begun earlier. In this contribution we present evidence for E-W ductile extension at around 19 Ma associated with a major normal fault in the Kung Co area. This ranks with the oldest previously known examples of extension and is a rare documented example of ductile flow associated with E–W extension in this region.

The Kung Co region is located to the north of the Mt Everest and contains a well-developed N–S trending fault (Figure 1). This fault cuts a granite body—the Kung Co granite—that intrudes metasediments (Fig. 2). In this study, we combine ASTER remote-sensing analysis, field studies, microstructural observations and the results of U–Pb dating to determine the relationship between granite intrusion, deformation structures, and normal faulting and constrain the age of the onset of E–W extension in this area.

ASTER remote-sensing data and field studies shows that the Kung Co normal fault trends roughly NNW-SSE but also bends and locally trends both N-S and NW-SE (Figure 2). The lowermost parts of the facets dip 50° to 60° W. Slickenline data suggest a dip-slip movement compatible with the distribution of bedding suggested by ASTER images. Moreover, in the Kung Co area two stages of widespread penetrative ductile deformation, D1 and D2, can be defined. Foliation S2 associated with D2 trends NW to SW and dips at a high angle. The flow direction associated with D2 is roughly E-W and the shear sense is dominantly top-to-the-W to NW. Therefore, the kinematics of D2 ductile deformation is close to the brittle normal faulting.

Field studies and microstructural observations were used to determine the relative timing of granite intrusion and ductile deformations. The granite intrusion cross-cuts D1 deformation fabrics showing D1 was complete at the time of intrusion. In contrast, dyking associated with the granite is locally folded by D2 deformation suggesting intrusion predates D2. However, dykes locally cut D2 fabrics without clear deformation. In addition, andalusite formed in the contact metamorphic aureole shows synkinematic growth during D2 deformation. These observations show the granite intrusion was synchronous with D2 deformation.
U-Pb zircon spot ages show the Kung Co granite crystallized at 19.1 ± 0.5 Ma suggesting D2 ductile deformation representing E–W to NW–SE extension was already active at 19 Ma. The similarities of kinematics between D2 ductile deformation and brittle normal faulting indicate that the two styles of deformation may represent a continuous process. The age for the onset of E–W extension in the Kung Co area overlaps with the age of N–S extension in Everest area (i.e., 19-22 Ma; Hodges and others, 1992). Therefore, a tectonic model is needed that can explain N–S movements occurring at the same time as E–W movements.

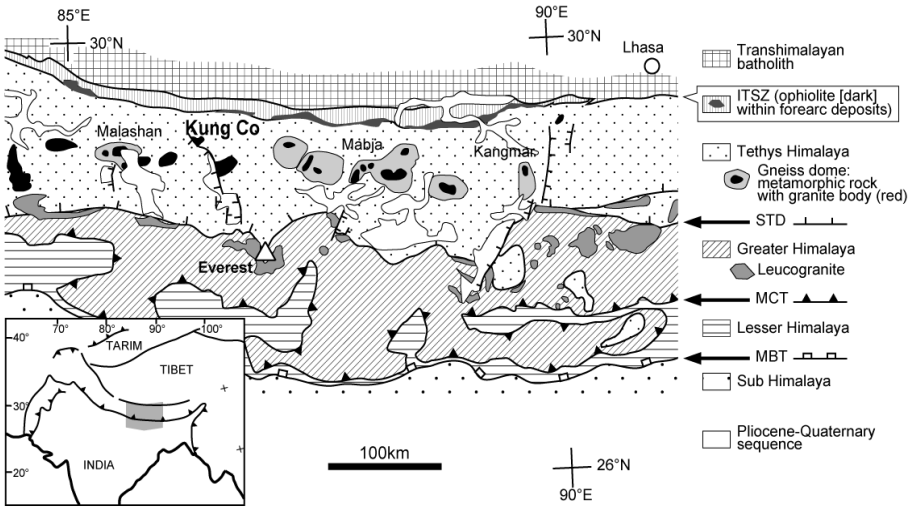
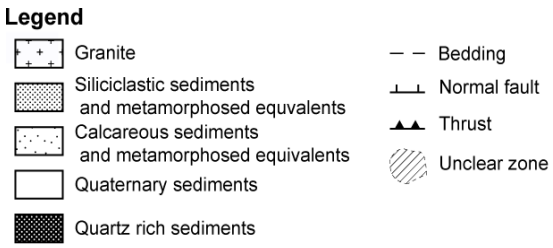


Figure 1. Tectonic map of southern Tibet (modified from Burchfiel and others, 1992) showing Kung Co area. ITSZ = Indus Tsangpo Suture Zone; STD = South Tibetan Detachment system; MCT = Main Central Thrust; MBT = Main Boundary Thrust.



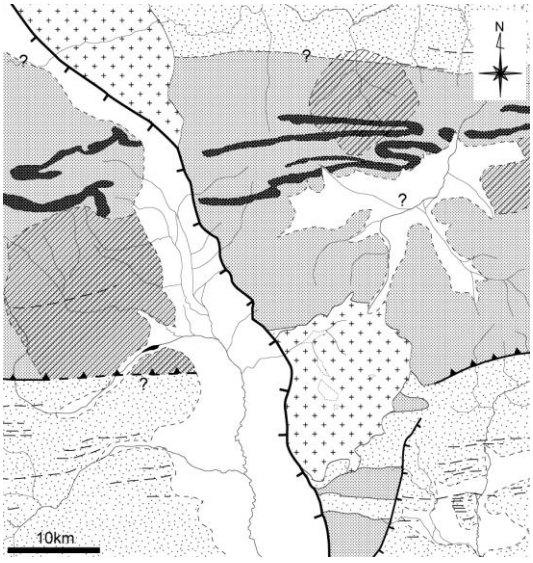


Figure 2. Geological map of Southern Tibet, Kung Co area.

References

Coleman, M. and Hodges, K., 1995, Evidence for Tibetan Plateau Uplift before 14-Myr Ago from a New Minimum Age for East-West Extension, Nature, 372, 49-52.

Garzione, N. C., and others, 2000, High times on the Tibetan Plateau: Paleoelevation of the Thakkhola graben, Nepal, Geology, 28, 339-342.

Hodges, K. V., and others, 1992, Simultaneous Miocene extension and shortening in the Himalayan orogen, Science, 258, 1466-1470.

Molnar, P., and others, 1993, Mantle dynamics, uplift of the Tibetan Plateau, and the Indian Monsoon, Rev. Geophys, 31, 357-396.

Williams, H., and others, 2001, Age and composition of dikes in Southern Tibet: new constraints on the timing of east-west extension and its relationship to postcollisional volcanism, Geology, 29, 339-342.

Cite as: Mitsuishi, M., Wallis, S.R., Aoya, M., Lee, J. and Whitehouse, M., 2010, 19 Ma Ductile E-W Extension associated with Normal Faulting in the Kung Co area, Southern Tibet, *in* Leech, M.L., and others, eds., Proceedings for the 25th Himalaya-Karakoram-Tibet Workshop: U.S. Geological Survey, Open-File Report 2010-1099, 2 p. [http://pubs.usgs.gov/of/2010/1099/mitsuishi/].