# Eocene Faulting in Northeastern Tibet: Insights from Coupled Low-Temperature Thermochronometry and Ar Dating of Fault Gouge along the West Qinling Fault

Alison R. Duvall[1], Marin K. Clark[1], Ben van der Pluijm[1], Chuanyou Li[2]

[1] Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109-1005, U.S.A., duvall@umich.edu
[2]Institute of Geology, China Earthquake Administration, Beijing, China

According to the most widely-cited models of Tibetan Plateau evolution, plateau perimeters likely represent the youngest deformation fronts in the expanding orogen (Tapponnier et al., 2001; England and Houseman, 1986). Thus, studies focused along the margins of the Tibetan Plateau offer important tests for models of orogenic growth. In this study, we focus on the West Qinling fault, which is among the longest and most continuous reverse faults within the northeastern margin of Tibet (Figure 1). In general, timing of brittle fault activity is difficult to assess because the low temperatures typical in the shallow crust prevent dateable syntectonic mineral recrystallization that occurs during deeper faulting. Therefore, indirect means, such as erosion studies in hanging wall rocks using low-temperature thermochronometry, are commonly relied upon to constrain reverse fault timing in the near surface (Ehlers and Farley, 2003). Increased rates of erosion, however, can occur solely with increased precipitation (Reiners and others, 2003) thereby complicating unique correlation of erosion events with fault motion. A separate technique, Ar-dating of clays in fault gouge (van der Pluijm, 2001), provides direct timing of fault activity. However, results from this method are limited because they represent a single event in both space and time.

Here we establish the history of West Qinling faulting by pairing Apatite (U-Th)/He cooling ages within the hanging wall rocks with fault gouge dating of illite polytypes along the fault proper in order to provide a more complete and unambiguous interpretation of faulting. Fault-gouge dating results indicate a Middle Eocene age of faulting and a Middle Triassic age of the source area of wall rocks (Duvall and others, in prep). Helium analysis shows little exhumation in the Jurassic and early Cenozoic followed by an increase in apparent erosion rate at 45 – 50 Ma (Clark and others, in press) that was sustained through the Middle-Miocene. Thus, results from the two datasets are in good agreement and support the interpretation that the West Qinling fault initiated at ~ 45 Ma and continued until at least Middle Miocene time. Contrary to the widely accepted models that emphasize northward Tibetan Plateau growth through time, our results indicate that deformation occurred in northeastern Tibet at approximately the same time that the Indo-Asian collision initiated (Rowley, 1996) >3000 km away. Results from this study also emphasize the value of a coupled approach to assessing brittle fault activity.

### References

Clark, M.K., Farley, K.A., Zheng, D., Zhicai, W. and Duvall, A.R., in press, Early Cenozoic faulting of the northern Tibetan Plateau margin from (U-Th)/He ages, Earth Planet Sci Lett..

Duvall, A.R., Clark, M.K., van der Pluijm, B. and Li, C., in prep, Syntectonic fault motion and accelerated erosion in northeastern Tibet circa the onset of Indo-Asia collision.

Ehlers, T. E. and Farley, K. A., 2003, Apatite (U-Th)/He thermochronometry: methods and applications to problems in tectonics and surface processes, Earth Planet Sci Lett., 206, 1-14.

England, P. and Houseman, G., 1986, Finite strain calculations of continental deformation II: comparison with the India-Asia collision zone, J. Geophys, Res., 91, 3664-3676.

Qinghai BGMR (Bureau of Geology and Mineral Resources of Qinghai Province), 1991, Regional geology of Qinghai province: Beijing, China, Geological Publishing House (in Chinese with English abstract).

Reiners, P.W., Ehlers, T.A., Mitchell, S.G. and Montgomery, D.R., 2003, Coupled spatial variation in precipitation and long term erosion rates across the Washington Cascades, Nature, 426, 645 – 647.

Rowley, D., 1998, Age of initiation of collision between India and Asia: A review of stratigraphic data, Earth Planet Sci Lett., 145, 1 – 13.

Tapponnier, P., and others, 2001, Oblique stepwise rise and growth of the Tibet Plateau, Science, 294, 1671-1677.

van der Pluijm, B., Hall, C., Vrolijk, P., Pevear, D., and Covey, M., The dating of shallow faults in the Earth's crust, Nature, 412, 172-175.

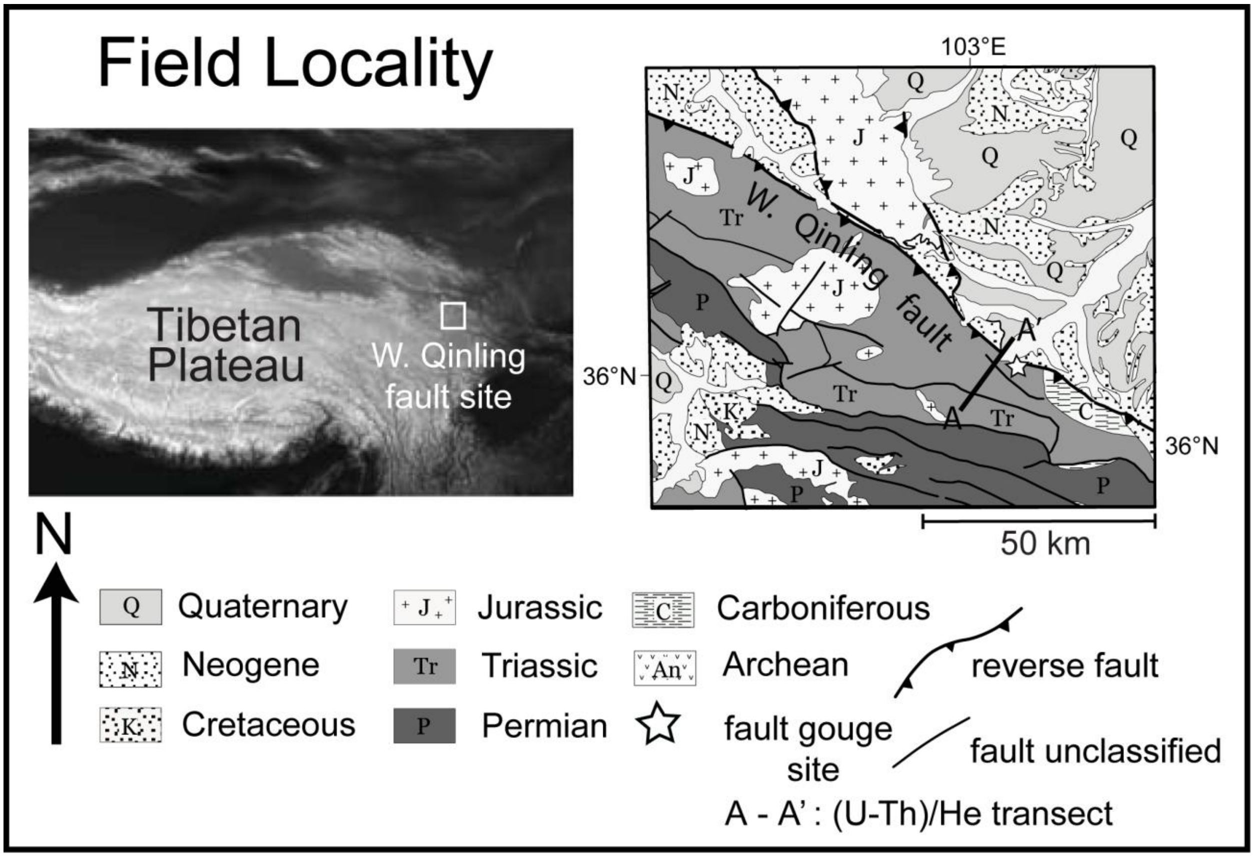


**Figure 1.** Study location and generalized geology for the West Qinling fault site in northeastern Tibet. Generalized geologic map adapted from 1:200,000 Chinese geologic mapping (Qinghai BGMR, 1991). Q-quaternary deposits, N-Neogene sandstones and shales of the Linxia basin, K-Cretaceous sandstones and shales, Tr-Triassic flysch deposits (Songpan Ganzi complex), P-Permian rocks, C-Carboniferous rocks, An-Archean rocks. A-A' line shows the location of the (U-Th)/He vertical transect (Clark and others, in press).

Cite as: Duvall, A.R., Clark, M.K., van der Pluijm, B. and Li, C., 2010, Eocene Faulting in Northeastern Tibet: Insights from Coupled Low-Temperature Thermochronometry and Ar Dating of Fault Gouge along the West Qinling Fault, *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/duvall/].