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Timing constraints on the KunCo pluton and normal fault (south Tibet, P.R.C)

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Estimation of the timing of extension in the Tibetan plateau has been widely used to constraint the geodynamic evolution of the India-Asia convergent zone and test different proposed models. However so far, very few reliable data on the initiation age of the normal faults are available. Armijo et al. (1986), the first to describe active normal faulting in south Tibet, estimated that they initiated after 2.5Ma ago from stratigraphic and morphologic considerations. In this work we focus of one of these potentially Late Pliocene faults, the Kung Co half graben (Southern Tibet, China), bounded by an active normal fault with a minimum vertical offset of about 1600 m (Armijo et al., 1986). In order to constraint the opening age of this half graben we combined high and medium temperature (U-Pb, Ar/Ar) and low temperature ((U-Th)/He) thermochronometry. Ages have been obtained for 6 samples of the Kung Co pluton, collected along a vertical profile located in the hanging wall at elevations between 4560 and 5055 m.

The Kung Co pluton is a two micas granite formed at about 21 Ma (U/Pb zircon), that belongs to the northern Himalayan granitic belt. Obtained biotite and muscovite Ar/Ar

ages are close, ranging from $\sim$16 Ma (Ms) to $\sim$ 15 Ma (Bt). The zircon (U-Th)/He ages are comprised between 10.5 and 9.5 Ma and the apatite (U-Th)/He ages between 9.5 and 3.5 Ma. Both zircon and apatite (U-Th)/He ages increase with elevation.

Thermobarometric study of the contact aureole of the pluton indicates that the granite ascension stopped at 2-3 kbar ($\sim$10km) and $\sim$520-545˚C. At such depth equilibrium temperature is comprised between 200 and 400˚C depending of the geothermal gradient. Thus muscovite and possibly biotite Ar/Ar ages are related with thermal re-equilibration. The biotite and muscovite Ar/Ar ages imply a relatively fast cooling rate of 70 $\pm$ 30˚C/km from 16 to 15 Ma. Coupling between biotite Ar/Ar and zircon (U-Th)/He ages indicate that the cooling rate significantly decrease after 15 Ma to less than 30 ˚C/km. Considering the depth and temperature of emplacement of the pluton, the fast cooling period is associated with post-intrusion thermal re-equilibration occurring around 15-16 Ma. After the thermal-re-equilibration, modeling of the zircon and apatite (U-Th)/He ages indicates that the pluton is exhumed at 1 to 1.5 mm/yr between at least 10.5 and 8 Ma. Our modeling also suggests that such exhumation event might have start around 15 Ma. The two samples from the base of the fault scarp give apatite He ages of 3.5-4.5 Ma, too young to be compatible with the prolongation of that first exhumation event. These young ages may indicate a drop in the exhumation rate from 1-1.5 mm/yr between 15 and 8 Ma to $\sim$ 0.02-0.03 mm/yr between 8 and 4 Ma. However, they can also result from resetting either by fluid circulation or by shear heating along the fault plane.

The first exhumation event, between 15 Ma and 8 Ma, is probably related with southward thrusting and doming along the Gyirong-Kangmar thrust and the formation of the northern Himalayan antiform. The Gyirong-Kangmar thrust is located just south of the Kung Co pluton and is controlling the formation and exhumation of the Kangmar dome between $\sim$15 and 11 Ma (Lee et al., 2000). Since the thrust is crosscut by the normal fault, this implies that the extension started after 8 Ma ago.

If the ages from the two lowest samples have not been reset and are significant for the pluton cooling history, they provide another constraint on the timing of extension in the Kung-Co half graben. Actually, the slow apparent exhumation rate calculated between 8 Ma and $\sim$ 4 Ma (0.02 – 0.03 mm/yr) cannot account for the formation of the Kung-Co half graben as extrapolation of such rate to the present would only produce between 120 and 75 m of exhumation compared with the $\sim$1600 m of vertical offset along the active normal fault. We conclude that the graben probably initiated after 4 Ma ago.