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Thermoluminescence as a multi- thermochronometer

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Natural TL in rocks reflects a dynamic equilibrium between radiation-induced TL growth and decay via thermal and athermal pathways. When rocks exhume through Earth's crust and cool from high to low temperature, this equilibrium level increases as temperature dependent thermal decay decreases. This phenomenon has been exploited to extract thermal histories of rocks using different optical signals (e.g., Guralnik et al. 2013; King et al. 2016). The present study aims to explore TL of feldspar. The advantage of TL is, a single TL glow curve has a wide range of thermal stability ($<$ka to Ba), and hence provides multiple thermochronometers with a multitude of closure temperatures.

Here we constrain the distribution of kinetic parameters of TL in feldspar using a glow curve deconvolution method and fitting of infinitesimal sub-peaks using general order kinetics (Pagonis et al., 2014). In particular, we exploit the fact that TL glow of feldspar arises from a continuous distribution of traps, corresponding to a distribution of energy levels that can be described as a linear combination of large number of peaks. Each peak corresponds to a different but closely located energy level E, and thus a different closure temperature (defined here as the temperature at which thermal decay becomes negligible).

After constraining TL growth, thermal decay and athermal decay in laboratory, appropriate forward modeling was applied for different time-temperature histories, to different TL signals with a wide range of thermal stabilities ($\sim$ka to $\sim$Ba). We test the sensitivity and limitation of each signal for different cooling rates, and predict the closure temperatures of each signal. Traps with low thermal stability (250-260 ˚C, lifetime $\sim 10^5$ y) can constrain low cooling rates ($\sim$50 ˚C/Ma) whereas higher stability traps (310-320 ˚C, lifetime $\sim 10^8$ y) are sensitive only to high cooling rates ($>$300 ˚C/Ma). The closure temperature ranges from $\sim$30 ˚C to $\sim$80 ˚C for TL temperatures ranging from 220 ˚C to 320 ˚C.

The newly developed methodology is successfully applied to rapidly cooled samples from the Southern Alps of New Zealand ($\sim$300 ˚C/Ma) and Namche Barwa, eastern Himalaya ($\sim$1500 ˚C/Ma).

Guralnik B. et al. (2013), Earth and Planetary Science letter, 384, 209-218.

King G.E. et al. (2016), Science, 353, 800-804.

Pagonis V. et al. (2014), Geochronometria, 41, 168-177.