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Thermochronometry using red TL of quartz – a feasibility study from in-situ drill-hole samples

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Thermochronometry – the revelation of the temperature history of rock related to subsidence or uplift and erosion – relies on methods with closure temperatures >40-70 °C, such as (U-Th-Sm)/He or fission track analysis on apatite. These methods are applicable to young and tectonically active mountain ranges, but results of calculated mean denudation rates are too imprecise for older orogens. Several studies attested the quartz luminescence signal (325 °C TL peak, OSL fast component) isothermal decay at ambient temperatures as low as 56 °C (Prokein and Wagner, 1994; Herman et al., 2010; de Sarkar et al., 2013). The so far determined closure temperatures of the quartz luminescence thermochronometry system vary between ∼35 °C for the OSL fast component (Herman et al., 2010) and ∼70 °C for red thermoluminescence (RTL; Tsuchiya and Fujino, 2000) and are dependent on the cooling rate and the charge trap parameters. Although featuring a favourably low closure temperature – thus allowing to study the geologically most recent temperature history -, especially quartz OSL suffers from low dose saturation, limiting the application to highly erosive orogens.
Saturation doses of RTL exceed those of OSL by a factor of 10 or more (Fattahi and Stokes, 2000), what opens up new perspectives in low-temperature thermochronometry. We here present experimental results on the general suitability of RTL for thermochronometry, obtained for samples from a drilling hole in the granitic basement of the Variscan Fichtelgebirge (Franconia, Germany). The samples allowed studying the RTL signal saturation level in-situ at different ambient temperatures up to ∼55 °C (at 1831 m depth). Measurements confirmed depletion of the 325 °C RTL peak for ambient temperatures >25 °C, most probably for even lower temperatures. Irradiation experiments showed that the RTL signal is not in saturation for ambient temperatures >25 °C, even for this 'old' mountain range. We could further demonstrate that the luminescence sensitivity of samples strongly increases with rising ambient temperature, opposite to the findings of Ypma and Hochman (1991) for samples from sedimentary basins.

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