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Surface paleothermometry using thermoluminescence: Theoretical development

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Reconstructing past temperature enable to predict past variability in climate. Trapped charge phenomenon in crystal lattice, due to ambient radioactivity, e.g. thermoluminescence (TL) has the potential to predict past temperature because the resident time of trapped electron is temperature dependent. TL signals from feldspar arise from a series of traps having a resident time at room temperature ranging from <y to >Ba. Trapped electrons associated with higher temperature TL (>300 °C) or deeper traps are suitable for dating application, as trapped electrons are least sensitive to ambient temperature. However, lower temperature TL (>100 °C to <300 °C) or shallower traps are sensitive enough for surface temperature fluctuations. The influence of temperature and climate upon the natural equilibrium TL has been demonstrated and exploited to estimate past climate of rock surface (Ronca, 1964; Ronca and Zeller, 1965). Although the feasibilities of these studies were successfully demonstrated, application was restricted due to a lack of appropriate theoretical model and numerical inverse modeling. Recent understanding of thermal influence on trapped charge kinetics and advance inverse modeling (Biswas et al., 2017) rekindled our interest to reinvestigate the application of TL as paleo-thermometer.

The present study explore the variation of equilibrium natural TL for different varying thermal field, monotonically cooling, warming and oscillating, and determine the response and limitation for different TL signals. It has been observed that for fluctuating thermal field the resident time of trapped electron at mean temperature should be comparable or less than the period of oscillation. For example, typically the resident time of trapped electrons at 10°C corresponding to 200 and 300 °C TL signals are 100 ka and 100 Ma respectively. So for ∼ka oscillation with a mean temperature of 10 °C and amplitude of 10 °C, <200 °C TL would be appropriate whereas higher temperature TL (>200 °C) would not responsive enough to detect that temperature variability. The advantage of using multiple TL signals with varying thermal stability will possibly unfold the past temperature variation through appropriate inverse modeling.

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