Towards a physical kinetic model for feldspar OSL-thermochronometry

B. GURALNIK[1], M. JAIN[2], N.D. BROWN[3], G.E. KING[4], R. LAMBERT[5], R. CHEN[6], S.W.S. MCKEEVER[7]

[1]Wageningen University, The Netherlands
[2]Danish Technical University (Risø Campus), Denmark
[3]University of California, Los Angeles, USA
[4]University of Bern, Switzerland
[5]University of Lausanne, Switzerland
[6]Tel Aviv University, Israel
[7]Oklahoma State University, USA

Optically Stimulated Luminescence (OSL) dating, arguably the latest arrival on the low-temperature thermochronometry scene [1], exploits the low thermal stabilities of electron traps occurring in natural minerals (E_a~1-2 eV, equivalent to ~100-200 kJ/mol), to infer the very recent (<0.5 Ma) passage of rocks through the shallowest (<100 °C) subsurface geotherms [2]. Despite initial hopes that the new technique would utilise the predominantly first-order charge traffic in quartz [1], later studies have shown that bedrock quartz OSL is characteristically dim, exhibits large sensitivity changes, and is frequently contaminated by feldspar emissions [3], thus advocating a methodological shift to the brighter and more reproducible OSL signals from bedrock feldspar [4-7].

The strikingly non-linear response of feldspar OSL to ionising radiation and isothermal storage can be successfully modelled in a variety of seemingly appropriate ways [4]. Here, we take a critical look at two of our former approaches, including general-order kinetics [5], and the band-tail excitation model [6-7]. We present new experimental data that highlight weaknesses in these models, and promote the excited-state tunnelling model [4; 8-9], which captures progressively more features of the feldspar OSL signal via a set of physically-meaningful kinetic parameters.

[1] Herman et al. (2010) EPSL 297, 183–189.
[2] King et al. (2016) Chem. Geol. 446, 3–17.
[3] Guralnik et al. (2015) Quat. Geochronol. 25, 37–48.
[4] Guralnik et al. (2015) Radiat. Meas. 81, 224–231.
[5] Guralnik et al. (2015) EPSL 423, 232–243.
[6] King et al. (2016) Quat. Geochronol. 33, 76–87.
[7] King et al. (2016) Science 353, 800–804.
[8] Jain et al. (2012). J. Phys. Cond. Matt. 24, 385402.
[9] Jain et al. (2015). Radiat. Meas. 81, 242–250.