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Improving the Icelandic tephrochronological record using the thermoluminescence characteristics of rhyolitic volcanic glass shards

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The eruption age and geochemical similarity of tephra deposits from Iceland underpins tephrochronological studies that use 'time-parallel' marker horizons to link palaeoenvironmental records in the North Atlantic and across NW Europe. The lack of eruption-related volcanic phenocrysts is problematic for direct dating of some Icelandic tephra deposits, especially those far from the eruption source, which are often dominated by glass shards. Volcanic phenocrysts can also be unrelated to the eruption event of interest, have their luminescence signal reset by post-eruption exposure to heat or light, and/or suffer from athermal or 'anomalous' fading of their luminescence signal. The aims of this study were to, firstly, develop a rapid thermoluminescence (TL) characterisation technique for the purified coarse-grained (90-150 micron) rhyolitic glass shard-rich fraction of tephra deposits from Iceland, and secondly, use their TL characteristics to better constrain the age of tephra deposits in situations where established radiometric dating methods are not applicable and/or when geochemical correlation produces multiple age matches. Dose response screening tests with four 'known-age' tephra deposits showed an overall age-related increase in naturally accumulated TL. The natural TL of a 134-year old and a 640-year old deposit was too small to undertake fully-quantitative single aliquot regeneration TL (SAR-TL) analysis with the current experimental set up, due, mainly, to the significantly lower TL sensitivity of volcanic glass compared to quartz or feldspar. In SAR-TL experiments, a c. 50 ka deposit did not exhibit significant fading of stored TL, but fading of stored TL, beyond experimental error, was observed with higher doses of >1 kGy applied to a c. 2¼ Ma glass phase, fission track-dated deposit. Changes in TL sensitivity were observed during SAR-TL experiments, and are the most likely cause of the age underestimate for the c. 50 ka deposit. We were unable to obtain a 'SAR-TL age' or 'age estimate' for the c. 2¼ Ma deposit, but our experiments ruled out several potential geochemical matches younger than c. 1.5 Ma, highlighting how volcanic glass shard TL analysis could be a useful discrimination tool for tephra deposits and eruption events that have similar geochemistry and/or debated ages. Rapidly measurable minimum age constraints from small volumes of rhyolitic glass shards are possible, and, with further methodological development, it might be possible to produce SAR-TL age constraints from other glass-rich rhyolitic tephra deposits worldwide that are comparable to 'known' radiometric and fission-track ages.