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The importance of the pseudotachylyte clast-matrix ratio in determining the mechanism, age and crustal depth of episodic coseismic faulting

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Pseudotachylyte, the product of friction melting during large-magnitude earthquakes, provides a unique opportunity to study the mechanism, age, and location of episodic coseismic faulting. One of the measureable features of these frictional products is the clast-matrix ratio, which can be determined by image analysis of backscattered scanning electron microscopy micrographs using, for example, the NIH image analysis (or SCION) software (http://www.rsb.info.nih.gov/nih-image/). Assuming the matrix represents the melt phase, such ratios may 1) provide information on the amount of viscous melt generated during frictional slip, a parameter important for accessing the degree of fault lubrication, 2) be used to aid more accurate dating of the crystallized melt phase, which combined with known exhumation rates can lead to an crustal depth estimate, and 3) yield information about fractionation process occurring during transport of the molten layer. It has also been proposed that this ratio may indicate the regional paleotemperature where frictional melting occurs. In this contribution, we evaluate the importance of the clast-melt ratio, discuss some of the problems in obtaining accurate measurements and provide some examples where meaningful results have been obtained. Our study focuses on the characteristics of a collection of 20 samples from a single locality along the central section of the Alpine fault, New Zealand, at Harold Creek. These samples contain numerous melt layers that contain between 48-89 % of matrix content and yielded a range of laser-ablation 40Ar/39Ar step-heating analyses between 1-19 Ma. The total gas ages show an exponential decrease with increasing proportion of melt matrix and K content, reflecting incomplete degassing and mixtures of radiogenic Ar sources. Calculation of intercepts for all–melted matrix and all–clast end-member components indicate ca. 570 ka (Quaternary) friction-melting ages of ca. 332 Ma (Lower Carboniferous) source rock. Assuming an average exhumation rate of 6–9 mm/yr for uplift and erosion, these results imply that friction melts were generated during major slip episodes in footwall rocks at relatively shallow ca. 3.5–5 km crustal depth. Our success in determining age and crustal depth from variably textured samples warrants caution about using the clast-matrix ratio for making direct mechanic inferences from pseudotachylyte veins. All of the reservoir and source veins we studied show a range of clast-matrix relationships, as well as variations in both textures and fabrics that indicate fractionation occurs during transport. Changes in the concentration and size of clasts during transport of the molten layer can complicate mechanical inferences drawn for simpler laboratory experiments studies and indicates that the clast-matrix ratio should not be used as a geothermometer.