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Himalayan detachment avalanche recorded by positive Eu anomalies

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Collisional orogens evolve through feedback between tectonics and magmatism, yet the mechanisms coupling deformation and melting remain poorly constrained. Along the South Tibetan Detachment System (STDS), melt trapped in migmatitic rocks displays positive Eu anomalies (Eu/Eu*>1), in contrast to the negative Eu anomalies of most crustal melts. We use positive Eu anomalies preserved in migmatitic leucosomes to constrain the kinetics of deformation–anatexis episodes in the STDS. Numerical simulations show that positive Eu anomalies arise when Eu release during feldspar breakdown outpaces diffusive re-equilibration in the residue, producing a transient Eu/Eu*>1 signal. Formation is favored in water-fluxed melting pathways, whereas preservation requires rapid cooling within $<10^2$–10^5 yr to avoid diffusive erasure. Translating this preservation window into kinematic rates using regional geothermal gradients implies ultra-rapid exhumation ($>10^1$–10^4 cm·yr^{-1}), indicating episodic high-velocity slip pulses that we term “detachment avalanches”. We propose that meteoric water infiltration triggers such pulses by simultaneously reducing shear zone friction and promoting disequilibrium anatexis. Incipient melt further weakens the shear zone and facilitates rapid melt transport. This interpretation is consistent with the compiled Himalayan leucogranite data, in which positive Eu anomalies are preserved during rapid melt extraction and are spatiotemporally synchronous with STDS activity. The acceleration is intrinsically self-limiting. Progressive melt segregation depletes the available water budget and increases the viscosity and strength of the residue. This “melt-departure hardening” ultimately terminates the tectonic pulse.