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Exothermic Hydration Reactions Create Transient Thermal Spikes During Subduction: Evidence from Holsnøy, Norway.

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Increasing numbers of diffusion chronometry studies demonstrate that peak metamorphic conditions are frequently short-lived relative to durations inferred from geochronology and geodynamic models, implying that transient thermal excursions may be superimposed on longer-term tectonic burial histories. Holsnøy, Norway—a classic natural laboratory containing eclogite facies shear zones formed by fluid infiltration of metastable granulite during subduction—records evidence for transient heating [1], providing an opportunity to evaluate the causes and *P-T-t* consequences of short-lived thermal events.

Garnet diffusion chronometry from Holsnøy constrains the maximum duration of peak eclogite facies metamorphism (680 °C, 2.2 GPa [2]) to ~300 kyr [1]. Diffusion profiles require minimum linear cooling rates of ~200 °C/Myr if peak conditions were attained instantaneously, and higher rates if cooling was delayed. Such high cooling rates require localized heating, plausibly linked to episodic fluid pulses recorded by multiple generations of garnet rims [1].

We show that the granulite-to-eclogite hydration reaction itself represents a major heat source. Thermodynamic calculations indicate that the reaction is strongly exothermic and capable of raising temperatures in reacting shear zones by 150–200 °C. The spatially uniform reactive heat release can explain the consistent peak eclogite facies temperatures observed across the region. Although shear heating likely contributed to peak temperature conditions, the strong spatial gradients predicted from shear heating are inconsistent with the spatial uniformity of peak temperatures, suggesting it was not the dominant mechanism.

Fluid-triggered, overstepped reactions can therefore generate transient thermal anomalies in which preserved peak temperatures are not representative of the ambient pre-reaction thermal state. Peak temperatures recorded by mineral assemblages may instead reflect reaction enthalpy rather than regional geotherms. To quantify this, we integrate petrochronology (age and thermobarometric constraints) and diffusion chronometry with reaction energetics using a Monte Carlo approach. This combined framework yields probabilistic constraints on both the ambient *P-T-t* pathway and thermal pulse timings and magnitudes. The results support a model in which internally generated reactive heating drives short-lived metamorphic thermal spikes during subduction.

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[1]Hess, B. et al. (2025), *J. Petrol.*, *66(10), egaf083.*

[2]Bhowany, K. et al. (2018). *J. Met. Geol.*, *36*(3), 315-342.