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Estimating peak and solidification temperatures for anatectic pelitic migmatites using phase diagrams: sampling heterogeneous migmatites and confronting melt loss

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Calculating a pressure-temperature phase diagram relevant to an anatectic pelitic migmatite sampled in outcrop is challenging because it is unclear what constitutes a meaningful bulk composition. Melt loss during metamorphism may have changed the bulk composition. The heterogeneous nature of migmatites, with light and dark coloured domains (leucosome and melanosome), means a choice must be made regarding how a migmatitic outcrop should be sampled. To address these issues, migmatites were simulated using thermodynamic modelling techniques for different melting and crystallization scenarios and bulk compositions. Using phase diagrams calculated for varying proportions of simulated melanosome and leucosome, temperatures of interest were estimated and compared with known values.

Our modelling suggests: (1) It is generally possible to constrain the peak temperature using phase diagrams calculated with the composition of the melanosome; the more leucosome that is incorporated, the more innaccurate the estimate. For phase diagrams calculated using a combination of leucosome and melanosome material, peak temperature estimates differ from actual peak conditions by −25 to +50°C. In certain of these cases, such as those involving high proportions of leucosome to melanosome, or in which solid K-feldspar was absent at peak conditions, but is now present in the rock due to later crystallization from melt, it is not possible to estimate peak temperature. (2) The solidification temperature, whether due to crystallization of the last melt or physical loss of the melt during crystallization, will fall between the peak temperature and the water-saturated solidus (∼660°C) if the melt and solids chemically interacted during cooling. This temperature can be accurately constrained from the phase diagram. If the melt crystallized in chemical isolation from the melanosome, the solidification temperature is the water-saturated solidus (625–645°C); however, physical melt loss during crystallization can raise the solidification temperature up to the peak temperature such that it is not possible to determine precisely. (3) Because the solidification temperature dictates the rheological transition from partially molten and weak to solid and strong, variation in solidification temperature is expected to influence the style and duration of tectonic events during orogenesis.