Quantification of common pelitic mineral assemblages and compositions and deduction of metamorphic evolution under a wide range of tectonic conditions

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To determine how commonly used mineral thermometers and barometers in metapelites are sensitive to reaction assemblage and location of *PT* paths we have calculated mineral stabilities (in the system Na_2O-CaO-MnO-K_2O-FeO-MgO-Al_2O_3-SiO_2-TiO_2-H_2O) over a range of pressures and temperatures representing typical (1–10 kbars), and thickened or subducted crust (10–20 kbars), with standard (400–600 °C) to elevated (600–800 °C) temperatures. We have determined which range of pelitic bulk compositions produce similar distributions of mineral modes and compositions within this *PT* range and note that certain bulk compositional changes result in crossing of pseudo-univariant reactions, often producing significantly different mineralogies in parts of *PT* space. Blueschist and eclogite facies (high-*P*) pelite mineralogy is strongly sensitive to bulk Al_2O_3-CaO-Na_2O content (which controls chlorite, phengite, paragonite, chloritoid, lawsonite, amphibole, kyanite and zoisite stabilities). In contrast, in Barrovian (mid-*P*) metamorphism, minor variations in Al_2O_3, CaO and Na_2O are often manifested as simple, and predictable, changes in plagioclase mode and composition. Calculated isopleths representing $X_{\text{garnet}}^{\text{Ca}}/X_{\text{plagioclase}}^{\text{Ca}}$ and $X_{\text{garnet}}^{\text{Fe}}/X_{\text{biotite}}^{\text{Fe}}$ (in the appropriate buffered assemblages) reveal several *PT*-ranges where commonly used mineral thermobarometers are quite ineffective. For example, although Fe-Mg exchange between garnet and biotite is mostly *T*-dependent at low temperatures, it becomes increasingly *P*-dependent in the presence of sillimanite $\pm$ melt. This thermometer also becomes quite *P* dependent at high-*P* as biotite stability is reduced by phengite. High-*P* instability of plagioclase places a limit on the efficacy of $X_{\text{garnet}}^{\text{Ca}}/X_{\text{plagioclase}}^{\text{Ca}}$ as a barometer, although alternative equilibria can fulfil a similar role in assemblages buffered by lawsonite, zoisite or clinopyroxene.

Our phase diagram calculations permit quantitative assessment of changes in mineral mode and composition that would occur along specific widespread PT paths for many typical compositional domains. We have identified the bulk composition bounds beyond which well-known index mineral successions (e.g. the Barrovian sequence) will not be represented. These observations provide a very powerful framework against which the mineralogy of widespread pelites in metamorphic terranes may be used to precisely determine segments of PT paths and infer specific likely tectonic controls. Since mineral textures commonly record evidence of localised disequilibrium (e.g. mineral zoning), combining the equilibrium mineralogies calculated here with estimates of rates of equilibration (e.g. a simple diffusion volume-diffusion model) allows inference of the duration over which fields of PT-space have been traversed.