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Overpressure generated from devolatilization reactions during metamorphism: Implications for breccia pipe formation

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Direct solutions to overpressure generated from devolatilization reactions during metamorphism are derived using analytical and numerical solutions. Devolatilization is particularly important during contact metamorphism where high thermal fluxes cause large volumes of fluids to be generated in the intruded host-rocks. The resulting overpressure is manifest by sediment fracturing, brecciation and generation of large vertical breccia pipes originating in the contact zones of magmatic intrusions.
We employ a model of conductive heat transfer around a magmatic intrusion with latent heat of crystallization, i.e. contact metamorphism, coupled with overpressure buildup resulting from fluid liberation and diffusive fluid flux. Flow of the generated fluids reduces the pressure at the devolatilizing reaction front. From the model results we have isolated the key factors involved in the pressure build-up: 1) The relative difference between the thermal and hydraulic diffusivities controlling the efficiency of flow relative to the reaction progress, 2) the temperature at which the devolatilization reaction occurs relative to the available heat in the system, and 3) the pressure-dependence of the reaction curve in a P-T space, i.e. the Clapeyron-slope.
If the fluid production is more efficient than fluid transport out from the front, the solution simplifies to an isochoric system controlled only by the effective volume change of the reaction. However, significant fluid pressures in the contact aureole can develop even in the presence of fluid flow, and the overpressure will then be proportional to the square root of the ratio of thermal over hydraulic diffusivities times the extent of the reaction progress. If the devolatilization reaction is pressure dependent, the fluid pressure build-up from the reaction will shift the equilibrium conditions for the dehydration reaction towards higher temperatures, which in turn will impede the reaction progress, and may even close the reaction completely. The analysis can be applied to describe a number of geological processes related to dehydration-reactions, like fracturing, breccia-pipe formation, fluidization, reaction progress, and fluid transport.