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Large strain rheology of syn-tectonic melting and crystallizing metapelites

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This study investigates the rheological behaviour of metapelitic rocks undergoing synkinematic melting and subsequent crystallization of melt during progressive deformation. Torsion experiments on synthetic quartz-mica rock samples close to pelitic compositions were performed at 300 MPa confining pressure and 750^{o}C with a constant strain rate ($\dot{\gamma}$ =3x10^{-4}) for a range of finite shear strains (γ = 0.5-15). The deformed samples were studied along the longitudinal tangential (LT) and axial (LA) sections to obtain data along a range of strain rates for a given finite strain and vice-versa. The results showed that deformation plays an important role on the kinetics of partial melting and crystallization. With increasing strain rate, amount and rate of crystallization is the volumetrically dominant process compared to partial melting at a given finite strain. In contrast, when the strain rate is constant, partial melting is dominates crystallization up to moderate strain (γg $<$ g5). The dominant process reverses at higher strain and the system shows more crystallization than partial melting. Partial melting coupled with strong strain softening ($\sim$ 60%) in the creep behaviour started at relatively low shear strains (γ = 2-4). With further shearing (γ = 4-10) creep became steady state flow associated with nucleation of tiny, new crystals. At higher shear strain (γ = 10-15), crystallization of these new minerals was coeval with small strain hardening until ultimate failure of the sample. A continuous increase of the stress exponent (n) from 3 (at γ = 1) to 28 (at γ = 5) was noted with progressive deformation, indicating a transition of the flow law. Depending on the melt and solid proportions in the system, the new and more realistic experimental data established that the large strain rheology and mechanical response is complex and does not necessarily follow power law flow behaviour.