The non-dimensionalized form of the composite viscosity (equation 1.40) is,

$$\begin{aligned}\frac{1}{\eta_{tot}} &= \exp\left(\frac{E_v}{1+T'_o} - \frac{E_v}{T'+T'_o}\right) + \beta_{disl}\sigma'^3 \exp\left(\frac{-E_{disl}}{T'+T'_o}\right) \\ &+ \left(\beta_{GBS}\sigma'^{-0.8} \exp\left(\frac{E_{GBS}}{T'+T'_o}\right) + \beta_{bs}\sigma'^{-1.4} \exp\left(\frac{E_{bs}}{T'+T'_o}\right)\right)^{-1}, \quad (1.44)\end{aligned}$$

where $E_i = Q_i^*/R\Delta T$.

The transition stresses between the various deformation mechanisms are represented in the expression for total viscosity by a series of relative weighting factors (β) between the four rheologies, which govern the relative importance of each deformation mechanism as a function of temperature and grain size. The weighting factor for dislocation creep is given by

$$\beta_{disl} = A_{disl}\eta_o^3\dot{\varepsilon}_o^{-4}, \quad (1.45)$$

where η_o is the reference viscosity, $\dot{\varepsilon}_o = 10^{-13}$ s^{-1} is the reference strain rate. The weighting factors for GBS and basal slip are

$$\beta_{GBS} = \frac{d^{1.4}}{A_{GBS}}\eta_o^{-1.8}\dot{\varepsilon}_o^{-0.8} \quad (1.46)$$

and

$$\beta_{bs} = \frac{1}{A_{bs}}\eta_o^{-2.4}\dot{\varepsilon}_o^{-1.4}. \quad (1.47)$$

Values of the weighting factors for each rheology are shown in Table B.7 for the range of grain sizes used.

Information about the stress field ($\sigma = \eta\dot{\varepsilon}$) is not available to Citcom when the viscosity subroutine is accessed because only the velocity field is known. Following the suggestion of Allen McNamara (personal communication), who implemented composite rheologies for mantle materials in *McNamara et al.* (2003), a subroutine to calculate the stress iteratively using $\sigma = \eta\dot{\varepsilon}_{II}$ was implemented. This procedure permits use of a stress-dependent rheology, but introduces a further iterative loop in the solution, which makes implementation of a stress-dependent composite rheology more computationally expensive than a strain rate-dependent rheology.