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Complete three-dimensional solution for deformable ellipsoidal particles subjected to shear over large strain

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Despite the often truly three-dimensional flow patterns observed in natural shear zones the models applied usually assume two-dimensional, plain strain deformation. Based on the analytical solution of Eshelby for the elastic fields in and around an ellipsoidal inhomogeneity we study a complete three-dimensional model for deformable, viscous ellipsoids in a Newtonian matrix. This analytical model allows us to investigate the complete set of kinematic and dynamic parameters in space and time. A focus of our study is the comparison of the 3D results to their 2D equivalents. How do deviatoric stress, pressure, and strain rate extrema change due to the transition from elliptical cylinders to ellipsoids? How large is the error that is introduced by 2D approximations? Other effects studied include the influence of viscosity contrast and aspect ratios on the shape evolution of the inclusion subjected to a combined pure and simple shear over finite strain. The boundary separating regimes of oscillatory behaviour and unbounded deformation is quantified. The finite deformation of the matrix is studied by means of numerical integration of the analytical solutions. This allows us to constrain the structural evolution (e.g. foliation development) in the vicinity of the ellipsoidal inclusion. These findings of the analytical model are compared to full three-dimensional finite element models where the interactions between many particles are accounted for.