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Extrinsic anisotropy of two-phase Newtonian aggregates: fabric characterisation and parametrisation, and application to global mantle convection.

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Rocks of the Earth's crust and mantle commonly consist of aggregates of different minerals with contrasting mechanical properties. During progressive, high temperature (ductile) deformation, these rocks tend to develop an extrinsic mechanical anisotropy related to the strain competition of the different minerals, the amount of accumulated bulk strain and the bulk strain geometry. Extrinsic anisotropy is thought to play an important role in a wide range of geodynamic processes up to the scale of mantle convection. However, the evolution of grain-scale and rock-scale associated with this anisotropy cannot be directly implemented in large-scale numerical simulations. For two-phase aggregates -a good rheological approximation of most Earth's rocks- we propose a methodology to indirectly approximate the extrinsic viscous anisotropy by a combination of (i) 3-D mechanical models of rock fabrics, and (ii) analytical effective medium theories. The resulting 3-D mechanical models, confirm that the weak least abundant phase induces substantial rock weakening by forming an inter-connected network of thin layers in the flow direction. 3-D models further suggest, however, that the lateral inter-connection of these weak layers is quite limited, and the maximum structural weakening is considerably less than previously estimated. Ont the other hand, presence of hard inclusions does not have a profound impact in the effective strength of the aggregate, with lineations developing only at relatively low compositional strength contrast. When rigid inclusions become clogged, however, the aggregate viscous resistance can increase over the theoretical upper bound. We show that the modelled grain-scale fabrics can be parameterised as a function of the bulk deformation and material phase properties and can be combined with analytical solutions to approximate the anisotropic viscous tensor. At last, the resulting parameterisation of the extrinsic viscous tensor is implemented in a bi-dimensional global mantle convection code. Preliminary results show that extrinsic is responsible for an increase of the upwelling speed of hot material from the lowermost mantle, different convective cell shapes, and deflection of mantle plumes at the uppermost mantle.