



Rheological consequences of fundamental coupling of stress and chemistry

John Wheeler

Liverpool University, Earth, Ocean and Ecological Sciences, Liverpool, United Kingdom (johnwh@liv.ac.uk)

I assert that the theory for pressure solution (and the dry equivalent, diffusion creep) forms a cornerstone for understanding rheology accompanied by chemical or phase change. This is because pressure solution is a chemical response to an imposed stress. The equations linking stress and chemistry used to describe pressure solution lead to a successful prediction of rheology in single phase aggregates. Those equations must surely be of more general applicability, when more than one phase is involved and perhaps reactions are occurring. This assertion has proved controversial (Wheeler 2014) but is in accord with Materials science theory itself based firmly on fundamental thermodynamics (reviewed in Wheeler 2018). In Wheeler (2014) I show how different reaction pathways give rise to different, but significant, offsets in the conditions of reaction. Here I show that they also give rise to different rheologies, illustrating an intimate link between reaction (or, if you wish, deformation) mechanism, phase change and rheology. Targetted experimental tests are lacking but some two-phase diffusion creep experiments have given rise to rather peculiar behaviour, which demands explanation (e.g. Sundberg and Cooper 2008). I have predicted that the rheology in such instances will not relate simply to that of the single phase aggregates (Wheeler 1992). The mathematical framework I have discussed should, in principle, be a foundation for a unified description of deformation and metamorphism, which would be very useful. However there are mathematical problems with building that description: Ford and Wheeler (2004) revealed some difficulties which are yet to be resolved. This makes the current state of affairs particularly interesting – fresh ideas, stimulated by work from outside Earth science, by targeted experiments, by observations on natural rocks and by new mathematical insights are required.

Ford, J.M., Wheeler, J., 2004. Modelling interface diffusion creep in two-phase materials. *Acta Materialia* 52, 2365-2376.

Sundberg, M., Cooper, R.F., 2008. Crystallographic preferred orientation produced by diffusional creep of harzburgite: Effects of chemical interactions among phases during plastic flow. *Journal Of Geophysical Research-Solid Earth* 113, B12208.

Wheeler, J., 1992. The importance of pressure solution and Coble creep in the deformation of polymineralic rocks. *Journal of Geophysical Research* 97, 4579-4586.

Wheeler, J., 2014. Dramatic effects of stress on metamorphic reactions. *Geology* 42, 647-650.

Wheeler, J., 2018 in press. The effects of stress on reactions in the Earth: sometimes rather mean, usually normal, always important. *Journal Of Metamorphic Geology*.