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Domainal cleavage as an Anisotropic Reaction-diffusion Process

Kieran Mulchrone (1) and Patrick Meere ()

(1) Department of Applied Mathematics, School of Mathematical Sciences, Western Gateway Building, Western Road, University College Cork, Cork, Ireland., (2) School of BEES, University College Cork, Distillery Fields, North Mall, Cork, Ireland.

Domainal cleavage comprises zones dominated by quartz and feldspar (QF-domains) and zones dominated by Mica (M-domains) which form at low metamorphic grades. The protolith is typically fairly homogeneous mudstone, siltstone, sandstone or limestone. Wet diffusion or pressure solution along grain boundaries is a key mechanism in the development of domanial cleavage. However, this does not explain why M-domains become sub-regularly spaced, visually evident in coarser-grained rocks, and take on an anastomising morphology. The ratio of M to QF-domains by volume can range from 1 to 0.1 and lower i.e. in extreme cases M-domains are intermittent but regularly spaced.

It is suggested here that an anisotropic reaction-diffusion process model can explain these features. The imposed stress field instantaneously leads to anisotropy of diffusion by narrowing intergranular channels perpendicular to the principal stress. This leads to a preferred diffusion of chemicals parallel to the principal stress direction and lower diffusion rates in the normal direction. Combining this with the chemical reaction of pressure solution produces an anisotropic reaction-diffusion system. Both isotropic and anistropic reaction diffusion systems lead to pattern formation as discovered by Alan Turing on the 1950's as an explanation for patterns found in animal skins such as spots and stripes. Thus domanial cleavage is a striped pattern induced by diffusion anisotropy combined with a chemical reaction.

Furthermore, rates of chemical reaction in intergranular fluids is likely to be many orders of magnitude greater that rates of deformation. Therefore we expect domanial cleavage to form relatively rapidly. As deformation progresses the M-domains behave less competently and may be the site of enhanced shearing. An example from Co. Cork, Ireland demonstrates shear folding in low-grade metasedimentary rocks with reverse shear along M-domains at a high angle to the maximum compressive stress.