DISCUSSION OF A MICRO-PHYSICAL MODEL FOR PRESSURE SOLUTION OF HOOKEAN SOLIDS

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Within the framework of irreversible thermodynamics, the driving force (X) for stress induced dissolution at interfaces containing a free fluid phase can be expressed as:

$$X = \left\{ f_s + \alpha(\sigma_n / \rho_s) \right\} - \mu$$

where f_s and ρ_s are the Helmholtz free energy and the density of the differentially stressed solid phase respectively, σ_n is the interfacial normal stress, μ is the chemical potential of the differentially stres-sed solid phase in solution, and $0 \leq \alpha \leq 1$ a factor depending on the specific micro-physical pressure solution (PS) model assumed. Commonly, it is assumed that $\alpha=1$, expressing the assumption that all work done on the system during deformation by PS is dissipated driving the PS process itself. The case $\alpha=0$, expresses the assump-tion that the part of the work done on the system associated with the 'PV-term' σ_n/ρ_s (when $\alpha=1$) is 'lost' (i.e., dissipated without driving the PS process, e.g., as elastic waves and/or vibrations, or as heat). In this case, the driving force for PS is much lower, and proportional to gradients in Helmholtz free energy (e.g., gradients in elastic deformation in case of Hookean materials).

A PS-model is presented where $\alpha=0$, assuming Hookean be-haviour of the solid phase (i.e., plastic deformation at the interface is not allowed), and further assuming an interface with a dynamically stable island channel structure. Motion of the channels is assumed to take place by sideways undercutting of stressed interfacial material, while leaving unstressed newly precipitated material behind. This newly precipitated material is assumed to become progressively stressed as the channel propagates (it progressively starts to carry the load). Thus, a very heterogeous stress distribution is obtained. Note that channels start to migrate when the associated increase in surface energy is balanced by the loss of elastic strain energy (Δf_s). Also note that $\alpha=0$, since in case of a (dynamically) stable interfacial structure between Hookean solids, plus sideways undercutting, the 'PV-term' σ_n/ρ_s is dissipated producing elastic waves and/or vibrations, and possibly also heat.

The model is of great interest to geologists as it predicts the rate of PS to depend significantly on crystallographic orientation of the solid when this is elastically anisotropic, and on differences in inter-facial energy (cf. enhanced dissolution at the mica-quartz interface).