On the Applicability of Theoretical Models of the Motion of Crystals in Viscous Magma

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There are two basic models that can be applied to the study of crystals in viscous magma. The model of March (1932) considers passive markers that move like lines or planes in a deforming matrix. Historically older and more sophisticated is the model of Jeffery (1922). It is in fact a side product in Jeffery's generalisation of Einstein's approach to the study of the increase of viscosity caused by a suspension of rigid particles, and it is based on the solution of Stokes flow around a rigid ellipsoid. From the sixties, both models have been widely used by geologists for modelling of the development of shape-preferred orientation (SPO) and for the estimation of geometry of flow, especially in igneous rocks. In our contribution we review the basic theoretical properties of both Jeffery and March model, discuss limits of their applicability and show examples of their use.

The advantage of both models is that we can trace a development of a preferred orientation during progressive deformation of a hypothetical geologic body, together with the parameters of strength and symmetry of the fabric. Moreover, if we consider crystals as carriers of magnetism we can evaluate the corresponding AMS. A typical application of these models then proceeds as following. We collect structural data (finite strains, orientation of lineation and foliation, preferred orientations of particular objects and sets or subsets of crystals measured by optical goniometer, AMS measurement) and construct a preliminary concept of tectonic evolution of the geologic body under observation. After that we derive kinematic parameters (type of deformation, strain rates) of the models. We run the computer implementation of models to compare the resulting SPO and AMS with the observed ones. The described procedure may be applied by an iterative manner. The obtained information serves to create boundaries for tectonic hypotheses and help in making the final decisions of the geologist more objective, as we tried, e.g. in Parry et al. (1997), Schulmann et al. (1997).

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