Unidirectional solidification texture (UST) and garnet layering textures from the Y-enriched garnet-bearing aplite-pegmatites, western part of the Cadomian Brno Batholith, Czech Republic

Hönig, S., Leichmann, J.* & Novák, M.
Dept. of Geological Sciences, Masaryk University, Brno, Czech Republic (*leichman@sci.muni.cz)

Felsic layered garnet-bearing aplite-pegmatite dykes of the Hlína granitic suite, ~2 to 50 m thick and up to ~200 m long with general NW–SE orientation and dip 40-80° into ESE or WSW, cut granodiorites to granites at the SW part of the Brno Batholith, Brunovistulicum. Aplite-pegmatite bodies are characterized by alternation of two main textural units: (i) a fine-grained aplite unit and (ii) a coarse-grained pegmatite with comb-like UST unit both developed in zones with the thickness varying from several cm to ~ 1-2 m for the aplite unit, and ~ 10 cm for the UST unit. In this paper, we use the term "UST" (unidirectional solidification texture) which describes rock layer composed of crystals oriented perpendicularly to the plain of layering.

All rock types are characterized by high contents of SiO_2 (74.6 – 75.7 wt. %), K_2O (4.61 – 4.94 wt.%), Na_2O (3.82 – 4.21 wt.%), moderate concentrations of CaO (0.94 – 1.11 wt. %), and low to very low concentrations of Fe_2O_3 (0.62 – 0.93 wt.%), MgO (0.02 – 0.03 wt. %), and TiO_2 (≤ 0.03 wt. %). Low K/Rb (212–241), high K/Ba ratios (1034 – 2303) and deep Eu anomalies indicate a high degree of fractionation. Both textural units consist of perthitic microcline, plagioclase An_{15-8} and quartz. The total amount of accessory minerals is typically very low, commonly < ~ 1 vol.% in the aplite unit, in the UST unit they are almost absent. Accessory minerals include relatively common Y-rich garnet Sps_{42-38} Alm_{32-28} And_{15-7} Grs_{21-15} Prp_{2-1} (1.10 wt.% Y_2O_3 - 0.06 apfu, 0.53 wt.% Yb_2O_3 and 0.20 wt.% Er_2O_3) with oscillatory and sector zoning. Other minerals commonly closely associated with garnet are extremely rare: magnetite, chloritized biotite, muscovite, Ta-rich titanite I, Al,F-rich titanite II, and ilmenite. Primary zircon, xenotime-(Y), monazite-(Nd), fersmite, ferrocolumbite, REE,Y-rich pyrochlore are strongly altered. Geochemical and mineralogical features of the Hlína aplite-pegmatites characterized by (i) metaluminous to slightly peraluminous A-type (NYF) affinity indicated by elevated concentration of Y, REE (especially HREE), Zr, U, Th, (ii) specific accessory minerals including Y-rich garnet, Nb>>Ta, HREE>>LREE, (iii) almost entire absence of micas and other minerals with volatiles (B, F, P and also H_2O) are remarkable. They differ from all other granitic rocks with UST textures described to date typically characterized by high activity of volatiles and peraluminous signature. Magmatic layering of garnet is explained by the formation of a boundary chemical front bordered margin of the coarse-grained UST unit.

Modelling of nonlinear inter-granular diffusion under local equilibrium with a mineral: an example in the system muscovite – quartz – H_2O

Nishiyama, T.
Dept. of Earth & Environmental Sciences, Kumamoto University, Kunamoto, Japan (tadao@sci.kumamoto-u.ac.jp)

Diffusion through an inter-granular fluid plays an important role in texture formation of the metamorphic rocks such as reaction zones and metamorphic layering. The nature of the diffusion is, however, not well understood. This paper will discuss the situation such that a fluid species diffuses down its chemical potential gradient under the constraint of local equilibrium with a co-existing mineral. The constraint will cause a coupling of diffusive fluxes, which is described by nonlinear diffusion equations. The aim of this paper is to evaluate the effect of the coupling which possibly contributes to the texture formation in metamorphic rocks.

Suppose a metamorphic rock in the system muscovite – quartz – H_2O, which consists of a muscovite – rich layer and a quartz – rich layer. At an initial pressure - temperature condition, the system is in an equilibrium, namely, muscovite, quartz and H_2O (an inter-granular fluid) are in equilibrium with each other in both layers. The system will destabilize according to a pressure – temperature change. If temperature is raised, the solubility of minerals increases. The muscovite – rich layer will reach the muscovite saturation condition before arriving at the new quartz – muscovite equilibrium condition, because the amount of dissolved species is proportional to the total surface area of the mineral and hence the concentration of dissolved Al species is higher than that at the new quartz – muscovite equilibrium condition. Similarly, the quartz – rich layer reaches the quartz saturation condition before arriving at the new quartz – muscovite equilibrium condition. Then spontaneous diffusion will take place between the two layers. The diffusion is assumed to occur under local equilibrium with muscovite. The local equilibrium condition with quartz is not introduced, because it does not drive diffusion of Si species. We will discuss only diffusion of Al and Si species, assuming that diffusion of K is much faster than that. The model nonlinear diffusion equations become coupled PDEs. By Boltzmann transformation, the coupled PDEs are transformed into coupled ODEs. Perturbation expansion decomposes the coupled ODEs into uncoupled ODEs. Finally the uncoupled ODEs are solved numerically with MATLAB. Essential features of the nonlinear diffusion can be summarized as the following. (1) The coupling of diffusive fluxes causes advection in Al concentration profiles. (2) The case of smaller D_{SiSi}/D_{AlAl} shows larger advection effects in Al. (3) The coupling causes suppression in Si concentration profiles. (4) The case of smaller D_{SiSi}/D_{AlAl} shows uphill diffusion of Si in a muscovite – rich layer. This study is a first step to clarify the effect of nonlinear diffusion on the development of texture in metamorphic rocks.

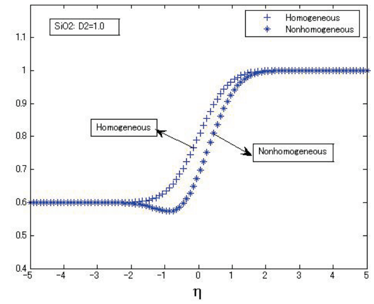

Fig. 1: Comparison of Si profiles between normal and nonlinear diffusion. Nonlinear diffusion shows uphill diffusion near the boundary.