

## Diffusion-controlled melting in granitic systems I : experimental results.

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Crustal melting and genesis of granitic magma are important issues in earth science to clarify evolution of continental crust. Incipient melting of crustal rocks, especially that of water-saturated pelitic and granitic rocks, will be expected to take place as a diffusion-controlled process, because melting will occur at first in a grain boundary of quartz, plagioclase and K-feldspar. Therefore the mechanism and time scale of incipient melting are key factors for proper understanding of the crustal melting and the granitic magma genesis. To confirm this view, we carried out melting experiments in granitic systems (Ab-Qtz-H<sub>2</sub>O and Or-Qtz-H<sub>2</sub>O) under the conditions of 100-200MPa and 800-900°C.

### 1) Ab-Qtz-H<sub>2</sub>O system

The run consisting of Ab single crystal and powdered Qtz with H<sub>2</sub>O shows development of a melt layer surrounding the albite crystal at 800°C and 200MPa with 19hrs duration. The higher the temperature and the longer the duration becomes, the more does the degree of melting becomes. There is a boundary layer in the melt adjacent to the albite. The boundary layer is thin (about 22µm) and characterized by distinct concentration gradients of melt components. The melt (MSQ: melt surrounding quartz) outside the boundary layer has a uniform composition of about 48wt% albite under anhydrous basis, which is almost consistent with the liquidus composition in the eutectic system (Tuttle and Bowen, 1958). In the boundary layer, SiO<sub>2</sub> increases from 68 to 77 wt% , and Al<sub>2</sub>O<sub>3</sub> and Na<sub>2</sub>O decrease from 15 to 11 wt% and from 5.5 to 3.5wt%, respectively, away from the albite. Clearly this boundary layer presents evidence of diffusion-controlled melting in the run. We found a positive correlation between the maximum thickness *W* of DCM and the run duration (19, 34, and 72hrs) at 200MPa and 800°C as follows:

$$W \text{ (m)} = 1.92 \times 10^{-7} (t - t_0)^{1/2} \quad (t_0 = 26125 \text{ in second})$$

This relation implies that the diffusion-controlled melting initiates only after some time interval from the onset of the experiment and that the melt grows according to the parabolic growth rate law after the onset of melting. Based on the parabolic growth rate law, we can calculate the magnitude of diffusivity *D*:

$$D = 1.85 \times 10^{-14} \text{ (m}^2\text{/s)}.$$

This magnitude is almost the same order as that of Al diffusivity determined by dissolution experiments of quartz and feldspars in H<sub>2</sub>O-saturated haplogranitic melt at 200MPa and 800°C (Acosta-Vigil et al., 2006). In our case, however, the meaning of the calculated diffusivity is not very clear, because it is based on the measured thickness of DCM, not the concentration profile of a particular component. In the case of diffusion-controlled melting the slowest diffusion will be the rate-determining process. Therefore we interpret the calculated diffusivity as the minimum diffusivity in the melt without specifying the component. To clarify the nature of diffusion in the melt we made a plot of concentrations along the diffusion path in the Na<sub>2</sub>O-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub> ternary diagram. The plotted concentrations make a linear trend between albite and quartz rather than an S-shaped trend which is normally seen in the ternary system, suggesting the binary nature of the diffusion.

### 2) Or-Qtz-H<sub>2</sub>O system

The run consisting of Or and Qtz with H<sub>2</sub>O shows development of DCM similar to the former system. Based on temporal development of DCM at 200MPa and 800°C, the minimum binary diffusivity can be calculated as follows:

$$D = 4.64 \times 10^{-15} \text{ (m}^2\text{/s)}$$

Both of the diffusion experiments in the granitic systems show the development of DCM which obeys the parabolic growth rate law. Diffusion in DCM shows a binary nature rather than a ternary nature, meaning that diffusive component is Ab component or Or component rather than oxide or cation. The calculated diffusivity can serve as an indicator of time scale for crustal melting.