Experimental study of the temperature dependence of water diffusion in obsidian melts

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Knowledge of the temperature dependence of water diffusion in magmatic melts is one of fundamental problems to understand of a few magmatic processes such as: degassing of magma during volcanic eruptions, the interaction of fluids and magma, the nucleation and growth of crystals and bubbles, and many others. Since the water solubility is much higher than the solubility of other components of the fluid, the diffusion of water is the limiting component of these processes. We have experimentally studied the temperature dependence of the diffusion of H_2O in obsidian melts at the $P(H_2O) = 20$ MPa in the temperature range of $700°–1300°C$ using a new small gradient methodology [*Persikov and Bukhtiyarov*, 2009; *Persikov et. al.*, 2010] (Fig.1).
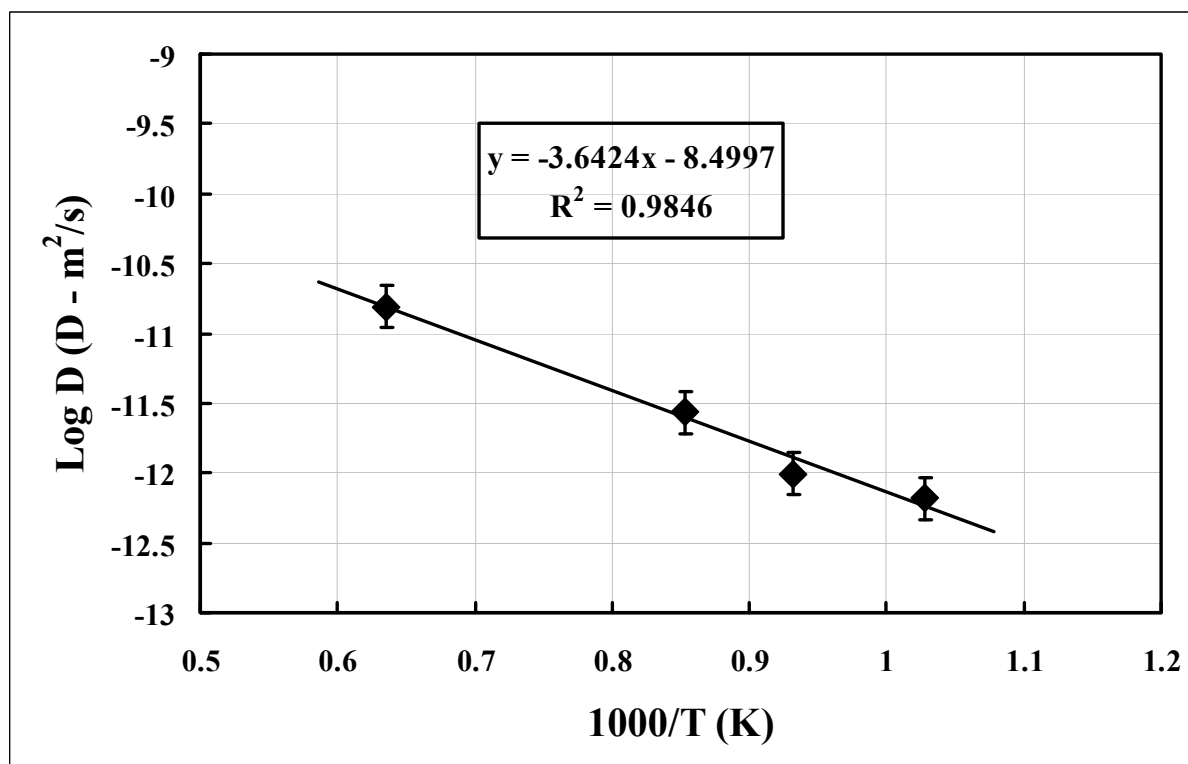

$$y = -3.6424x - 8.4997$$
$$R^2 = 0.9846$$

Fig.1. The temperature dependence of water diffusion in obsidian melts ($C(H_2O) = 0.67$ wt.%)
♦ - is the experimental data with the standard deviation ±25 % rel.

Experiments were performed on a high gas pressure vessel using the original equalizer separator, that is conduct the experiments in open capsules without of the change of the original geometry of the capsules. Diffusion of water was studied by hydration of anhydrous molten obsidian, which received prolonged dehydration of natural obsidian cylinder placed in a platinum capsule, followed by melting at the temperature $1500°C$ for 4 hours. Samples pressurized water heated initially at 1500°C/hour to below the required temperature on the $300–500°C$, and then very quickly heated to the needed temperature at a rate of $300°C/min$ kept for the time and spent the isobaric quenching at

$300–500^{\circ}$C/min. Concentration of water along the diffusion profiles were determined by quantitative FTIR spectroscopy using of the Beer-Lambert's law. The diffusion of water was determined by numerical PC calculations to solve of the second Fick's law of diffusion.

Analysis of experimental data showed that the temperature dependence of water diffusion in obsidian melts at an average concentration of water C (H_2O) = 0.67 wt. % can be described by the following exponential Arrhenius- Frenkel's equation:

D = D$_0$ • exp (-E/RT),

where R = 8.314 J/mol·K is the universal gas constant, E is the activation energy of water diffusion for obsidian melts (J/mol), and T is in K. The activation energy obtained (E = 69.424 kJ/mol) is well consist to a previously obtained data for the haplogranitic melts E = 64 ± 10 kJ/mol [*Nowak and Behrens,* 1997].

Recently a new model was proposed to calculate the water diffusion in a wide range of composition of magmatic melts, pressures and temperatures [*Persikov et al.*, 2010]. The predicted temperature dependencies of water diffusion in obsidian and trachyte melts [*Freda et al,.* 2003] have been obtained using this model (see Fig. 2). The data on the Fig. 2 shows of a good agreement between experimental and predicted of the temperature dependencies of water diffusion in both obsidian and trachyte melts with standard deviation which is equal ± 0.15 log D(H_2O).
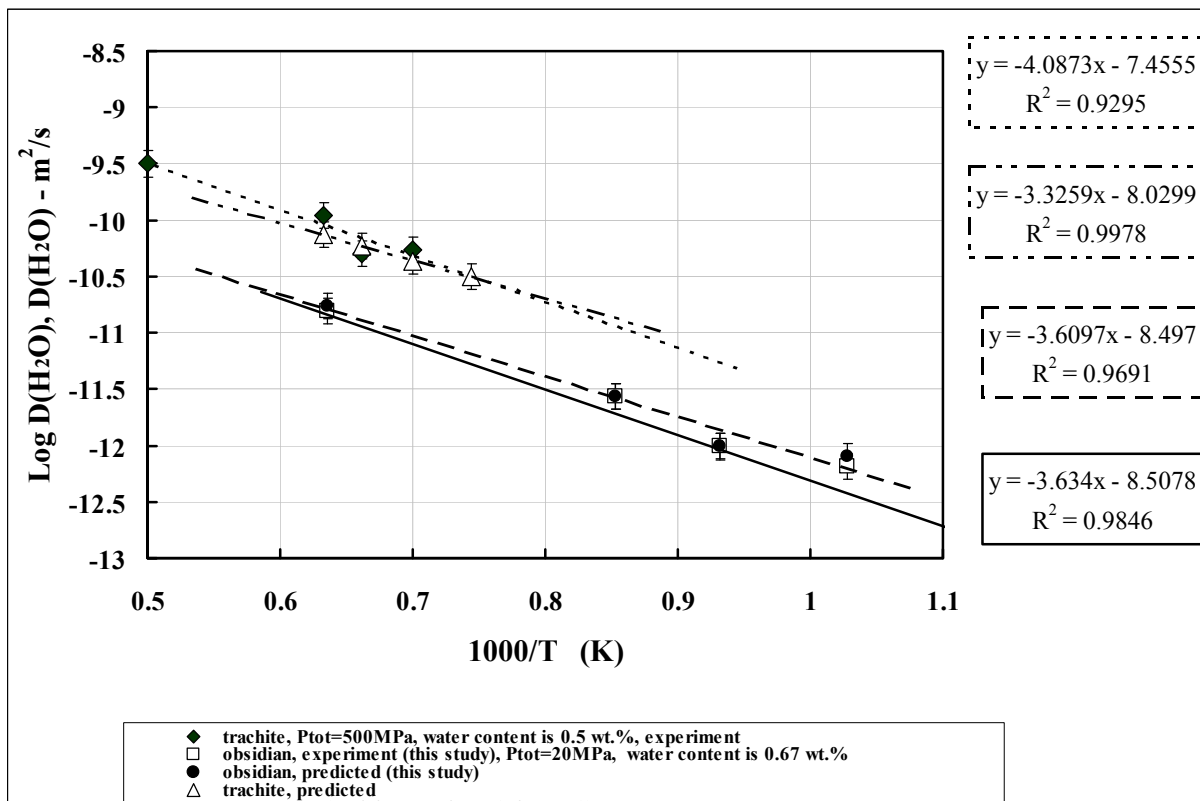

Fig. 2. Temperature dependence of water diffusion in obsidian and trachyte melts [*Freda et al.* 2003] (an experimental and predicting results)

Conclusions:

1. A new experimental data is indicates that the temperature dependence of water diffusion in obsidian melts with an average concentration C (H_2O) = 0.67 wt. % and in the temperature range of 700°–1300°C is obey the exponential Arrhenius-Frenkel's equation with an activation energy equals

E = 69.424 kJ/mol.

2. Model developed to calculate of the water diffusion in silicate melts [*Persikov et al.,* 2010] is allowed to obtain of a well enough data on temperature dependencies of water diffusion in magmatic melts.

References

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