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# MEASUREMENT AND CALCULATION OF CRYSTAL GROWTH RATES IN SILICATE SYSTEMS

R. JAMES KIRKPATRICK

*Deep Sea Drilling Project, A-031, Scripps Institution of Oceanography, La Jolla, California, U.S.A. 92093*

Rates of crystal growth are necessary for a quantitative understanding of the crystallization kinetics in igneous systems. Since the rate of growth depends upon composition, oxygen fugacity, water pressure, and other factors, to do kinetic calculations for igneous rocks it is necessary to have values for this rate for many different compositions and conditions. Crystal growth in silicate systems at relatively small undercooling seems to be controlled by the reaction at the crystal–melt interface, even if the crystal and melt are not of the same composition (Kirkpatrick 1975). For interface-controlled growth, the growth rate, $Y$, can be written

$$Y = \frac{fkT}{3\pi a_o^2 \eta} [1 - \exp(-L\Delta T/RTT_L)] \quad (1)$$

(Uhlmann 1972), where $f$ is the fraction of sites on the crystal surface available for molecular attachment, $k$ is Boltzmann's constant, $a_o$ is the interatomic spacing, $\eta$ is the melt viscosity, $L$ is the latent heat of fusion, $T$ is temperature, $\Delta T$ is undercooling, $T_L$ is the liquidus temperature, and $R$ is the gas constant. If a crystalline phase grows by the same mechanism from melts of different composition, $a_o$ will be nearly the same for both, and $f$ will vary with undercooling in the same way for both. Therefore, the growth rates for one composition can be obtained from the rates for the other from the expression

$$Y = Y_o \frac{T\eta_o}{T_o\eta} \frac{[1 - \exp(-L\Delta T/RTT_L)]}{[1 - \exp(-L_o\Delta T/R\,T_oT_{Lo})]} \quad (2)$$

where the subscript o refers to the composition for which the rates are known.

Growth rates have been obtained for plagioclase crystals grown from melts with the compositions $An_{100}$, $An_{75}Ab_{25}$, and $An_{50}Ab_{50}$ using microscope heating-stage techniques (Kirkpatrick *et al.* 1975). The rate at a given undercooling decreases with increasing albite content because of the increasing viscosity. The rates obtained (in cm/sec) range from $9.0\times10^{-5}$ to $1.5\times10^{-2}$ for $An_{100}$, $1.7\times10^{-5}$ to $3.4\times10^{-3}$ for $An_{75}Ab_{25}$, and $6.8\times10^{-6}$ to $3.0\times10^{-4}$ for $An_{50}Ab_{50}$. Plots of $Y\eta/\Delta T$ versus $\Delta T$ indicate that growth from all three compositions occurs by a surface nucleation mechanism. The rates calculated for $An_{75}Ab_{25}$ and $An_{50}Ab_{50}$ using the data for $An_{100}$ as a base agree with the observed values to within the precision of measurement. If equation 2 is valid for complex geologic systems it will greatly reduce the number of growth-rate measurements necessary to allow kinetic calculations of the crystallization of igneous rocks.

## References

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