

VISCOUS FLOW IN THE SYSTEM ALBITE - DIOPSIDE; P.Tauber and J.Arndt, Mineralogisch-Petrographisches Institut, Universität Tübingen, Federal Republic of Germany

The ternary system albite-anorthite-diopside is the classic system to illustrate crystallization of basaltic magmas (1). Knowledge of the rheological properties of melts of this system is therefore a basic prerequisite in igneous petrology of lunar and terrestrial basalts.

The variation of viscosity with temperature and composition in the binary system albite-anorthite is well explored (2). Further information on the flow properties of the ternary system is provided by the present study in which the viscosity-temperature relationships of the end member diopside and of three intermediate compositions in the system albite-diopside have been investigated in the viscosity range  $10^{13}$  -  $10^8$  dPas using a micro-indentation viscometer (3).

The presently obtained viscosity-temperature data of diopside are shown in Fig. 1 together with high-temperature data reported by other authors. For comparison are also shown the viscosity-temperature relationships of albite and anorthite. The experimental relationships of these two end members of the ternary system are well represented (2) by the empirical Vogel-Fulcher-Tammann(VFT) equation

$$\log(\eta) = A + B / (T - T_0) \quad (1)$$

where  $\eta$  (dPas) is the viscosity,  $T$  (K) is the absolute temperature and  $A$ ,  $B$  and  $T_0$  are constants. An iterative regression procedure performed on all experimental data given for diopside in Fig. 1 yielded the following parameters:  $A = -3.125$ ,  $B = 4066$  and  $T_0 = 737.5$  (K) with an average error of  $\pm 0.13$  log viscosity units.

It has been shown (2) that the experimental viscosity-temperature relationships of albite and anorthite are best represented by the configurational entropy model for viscosity of Richet (4) given by

$$\log(\eta) = A_e + B_e / T \cdot S_{\text{conf}} \quad (2)$$

where  $A_e$  and  $B_e$  are constants,  $T$  is the absolute temperature and  $S_{\text{conf}}$  (J/mole  $\cdot$  K) is the configurational entropy.

Due to the lack of sufficiently accurate thermodynamic data for diopside equ. (2) must be modified to give

$$\log(\eta) = A_e + B_e / (T \cdot (S_{\text{conf}}(\bar{T}) + \Delta c_p \cdot \ln(T/\bar{T}))) \quad (3)$$

where  $\Delta c_p$  is the difference between the heat capacities of the glass at the fictive temperature  $\bar{T}$  and of the melt at the temperature  $T$ . With an iterative regression procedure and using for the unknown  $\bar{T}$  the presently measured viscosimetric glass transition temperature  $T_g(\eta) = 989$  K, the following parameters have been obtained for diopside:

$A_e = -2.303$ ,  $B_e = 3.999 \cdot 10^5$  J/mole and  $S_{\text{conf}}(T) = 26.40$  J/mole  $\cdot$  K with an average error of  $\pm 0.10$  log viscosity units. The experimental data are thus by 23% better represented by the Richet model than by the VFT approach.

The variation of the isothermal viscosity with composition in the system albite-diopside is shown in Fig. 2. The Richet model is as yet the only theo-

ry that allows the calculation of the dependence of viscosity on composition. Using this theory and a modified version of the "two lattice" mixing model (5), the isothermal viscosities of intermediate plagioclase compositions have been calculated solely from the pertinent data of the two end members albite and anorthite yielding very good agreement with the experimental data (2). The applicability of various theoretical mixing models for similar calculations in the system albite-diopside is presently investigated.

REFERENCES

- (1) Bowen N.L. (1915) *Am.J.Sci.*, **40**, p.161-185
- (2) Hummel W. and Arndt J. (1985) *Contr.Mineral.Petrol.*, **90**, p.83-92
- (3) Arndt J. and Hummel W. (1983) *Fortschr. Min.*, **61**, p.9-10
- (4) Richet P. (1984) *Geochim.Cosmochim.Acta*, **48**, p.471-483
- (5) Weill D.F., Hon R. and Navrotsky A. (1980) p.49-92 in "Physics of Magmatic Processes", ed. Hargraves R.B., Princeton Univ.Press

The references of the papers quoted in Fig.1 are given in reference (2)

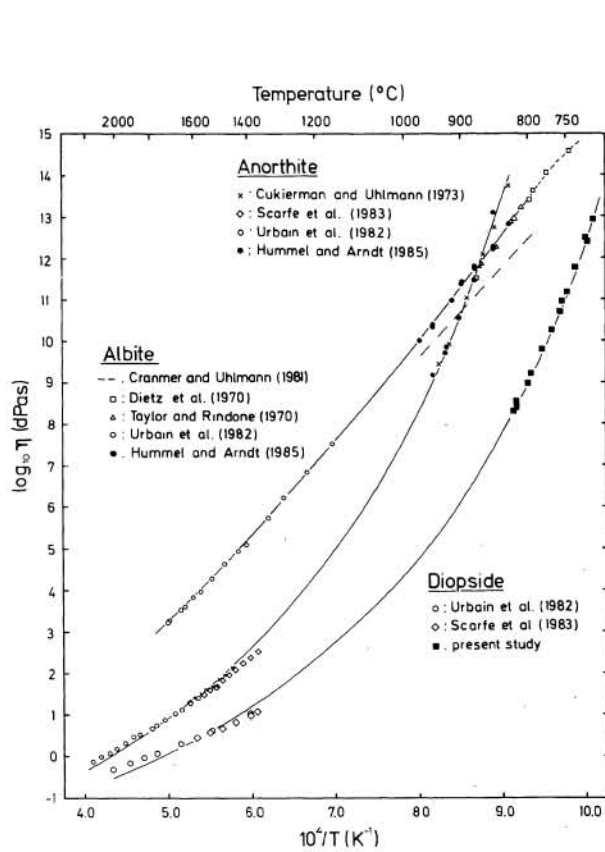


Fig. 1 Log viscosity versus 1/T for diopside, albite and anorthite.

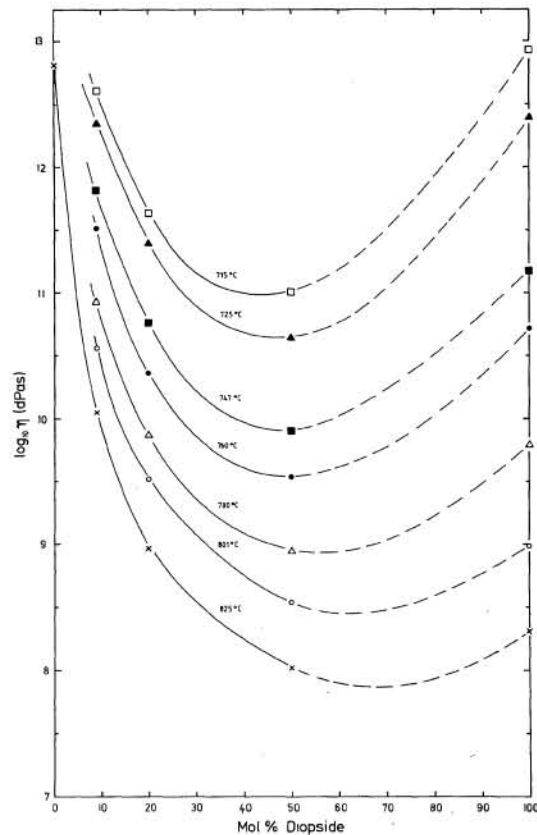


Fig. 2 Isothermal log viscosity in the system albite-diopside. Albite data are from (2). Broken lines are tentative trajectories.