The cooling rate of lunar basalts is of interest to understand in a quantitative sense the large amount of mineralogical and petrological data for these rocks. For this purpose we have calculated the variation of temperature with time of lunar lava flows of different thicknesses.

The temperature variation with time inside the basalt flow is given by the equation

\[ \rho C_p(T) \frac{dT}{dt} = \nabla \cdot (K(T) \nabla T) \]

Because of the non-linear boundary conditions and the temperature dependences of the specific heat \(C_p\) and the thermal conductivity \(K\), the above equation was solved numerically by means of an explicit finite difference method. At its top the flow loses energy by radiation into space according to Stefan's law and at the bottom of the flow energy is lost by conduction into the lunar basement. The flow is emplaced, being totally liquid (1200°C), subsequently it crystallizes over the temperature interval 1200°C-1100°C, while liberating latent heat of fusion, and finally it cools down to the lunar ambient temperature. For the temperature dependence of the thermal conductivity we have used the measurements of Murase and Mc Birney (1970); the thermal conductivity of the liquid is taken to be infinite; i.e. the liquid portion of the flow is supposed to be isothermal. The temperature dependence of the specific heat has been taken from Horai et al. (1970). Further it has been assumed that the temperature of the liquid portion of the flow is given by the relation

\[ T = T_s + (T_L - T_s) F \]

where
- \(T_s\) - solidus temperature (1100°C)
- \(T_L\) - liquidus temperature (1200°C)
- \(F\) - the fraction which has solidified
The proportionality expressed by this equation has been observed during the cooling of Hawaiian lava lakes. (Wright and Weiblen, 1967; Peck et al. 1966).

Using the methods of Bottinga and Weill (1970, 1971) to calculate the density and the viscosity of lavas, we conclude that in flows of less than or equal to two meters thickness one should not expect to find the development of cumulate textures. The reason being that the upper crust of the flow grows at a rate greater than the rate at which formed crystals can sink to the bottom. This holds even for the formation of the early ilmenite crystals in the Apollo 11 basalts. The absence of cumulate textures in the Apollo 11 basalts has been noticed by James and Jackson (1970) and Weill et al. (1970).

A one meter thick flow will be totally solid after about 5 days. This time does not depend very much on the melting interval of the basalt but depends of course critically on its thermal conductivity and heat capacity. The radiation at the top surface of the flow is only important, as far as the rate of cooling is concerned, directly after eruption of the basalt; later on conduction in the solid silicate phase is rate determining for the cooling process.

BOTTINGA, Y., and WEILL, D. F., (1970),
Am. J. Sci., 268, 169-182

BOTTINGA, Y. and WEILL, D. F., (1971)

Geochim. et Cosmochim. Acta Suppl. 1, 2243-2251

JAMES, O. B. and JACKSON, E. D., (1970)
J. Geophys. Res., 75, 5793-5824

MURASE, T. and McBIRNEY, A., (1970),
Science, 170, 165-167

Bull. Volc., 29, 629-655