A SIMPLE MODEL FOR PARTICLE SUPPORT IN PYROCLASTIC FLOWS. G. D. Thornhill, Department of Geological Sciences, Brown University, Providence, RI 02912.

Introduction.

A simple model of radial flow, assuming an inviscid fluid, has been used as a basis for examing the support of particles in the early stages of pyroclastic flows, in order to characterise the initial particle sorting process which results in the separation of the flow into a dense basal portion, and a more dilute, frequently convective upper part. The model does not account for any fluidisation in the flow at present. The work represents a preliminary attempt at modelling the evolution of pyroclastic flows, including the particle sorting characteristics, which are important for comparison with field evidence. Results for various combinations of initial parameters are given. Future work will concentrate on tracing particle trajectories within the flow, improving the formulation by addition and examination of other processes, and then modelling the dense part of the flow as it develops from these initial stages.

Method.

The model is based on a simple Navier-Stokes formulation, assuming an inviscid fluid, with a density reflecting the bulk density of the gas and fine particles. An equation of continuity relating the flow velocity, thickness, and radial distance of the flow with the initial quantities is also used [1]. The model also assumes steady-state conditions, so no time-dependence of initial conditions is permitted.

The numerical integration was carried out using a Runge-Kutta 4 numerical integration scheme, and the results checked against the analytical solution for the case with 0° slope. A suitable integration step was selected by checking for convergence as the integration step was reduced.

The particle support is calculated by assuming spherical particles, by calculating the terminal velocity of each particle, and relating this to the friction velocity within the turbulent flow [2,3].

The density of the flow is assumed constant, both with radial distance, and with depth in the flow, although both these conditions will become less valid with distance from the vent, as particles begin to settle out. The effect of various factors on particle support in theearly stages of the flow have been examined, including the initial velocity, underlying slope, particle concentration, and initial temperature (the latter two control the density of the flow).

Results.

The initial parameters will depend on the genesis of the flow from either a collapsing plinian column, or as a low fountain, feeding the flow continuously [1].

In figure 1, the flow velocity as a function of distance from the vent for different particle concentrations (given as mass fraction of particles in the flow). The main effect of the particle concentration is in the density of the flow, which has values of 1.775 kg/m^3, 3.544 kg/m^3 and 7.063 kg/m^3 for the three cases shown. The starting conditions for these examples were an initial velocity of 200 m/s, initial flow thickness of 500m, initial temperature of 1000K, and a slope of 10°.

The velocity initially increases slightly as the flow runs down the slope, but begins to decelerate as the flow thins and the drag coefficient increases as it spreads away from the vent. After the initial rapid deceleration, the velocities decrease more slowly.

In figure 2, the maximum particle diameter (assumed to be pumice, density 1000 kg/m^3) as a function of distance from the vent is plotted. Naturally, the higher density flow supports larger diameter particles, an effect which is augmented by the higher velocity maintained by the denser flow. The denser, faster flow can support particles of 3cm diameter at its peak velocity, compared to 5mm diameter particles in the least dense flow.

Conclusions.

A simple model for calculating particle support in an inviscid, turbulent flow has been developed. The model allows for variation of the initial flow condtions, and calculates directly the maximum size particle supported for any given flow velocity. The effect of parameters such as the particle concentration in the flow on the ability of the flow to carry particles can be investigated, in a preliminary attempt to use particle size characteristics in pyroclastic flows as an indicator of emplacement conditions in a quantitative way.

References. [1] Sparks, R. S. J., Wilson, L., and Hulme, G. (1978) JGR 83, p. 1727. [2] Shreffler, J. H., (1975) Bound. Layer Meteor. 9, p. 191. [3] Wilson, L., Huang, (1979) Earth. Plan. Sci. Lett. 44 p. 311.

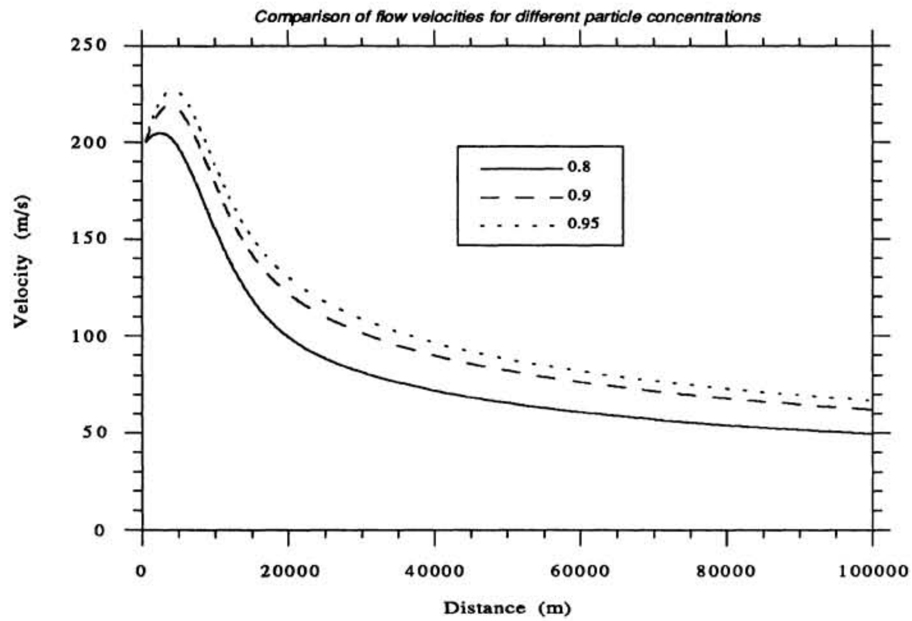

Fig. 1. Graph showing flow velocity as a function of distance for three values of particle concentration (given as a mass fraction). The corresponding densities are 1.775 kg/m^3, 3.544 kg/m^3 and 7.063 kg/m^3.

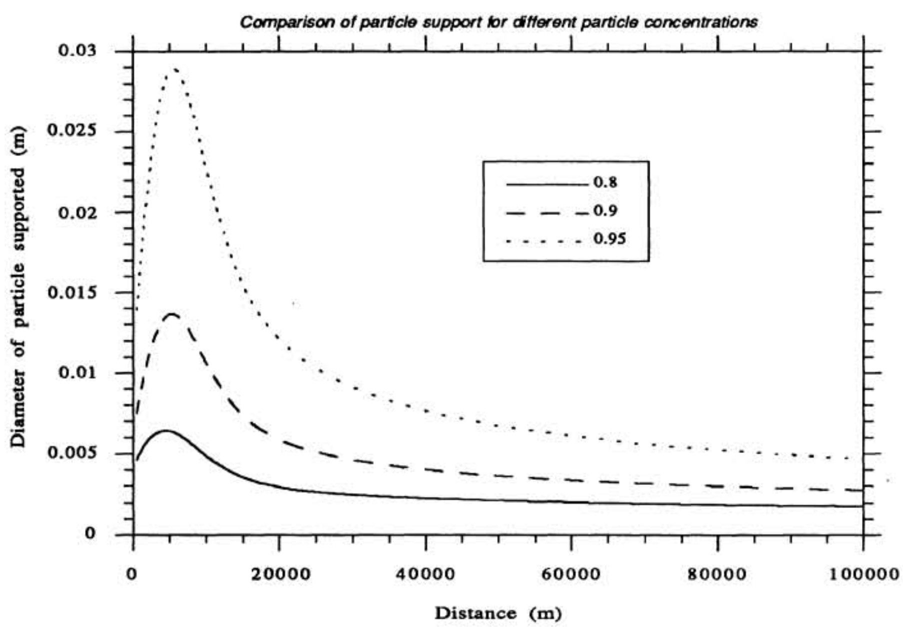

Fig. 2. Graph showing diameter of maximum pumice particle supported (density 1000 kg/m^3) as a function of distance for three particle concentrations. The corresponding flow densities are the same as given for fig. 1.