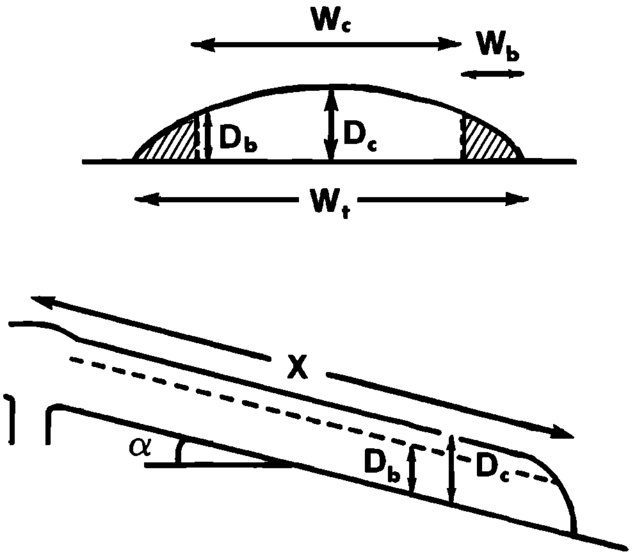

Fig. 6. The geometrical shapes of lava flows having the properties of Bingham plastics [Hulme, 1974]. The stationary banks on either side of the flow are shown shaded in the cross-sectional view perpendicular to the downslope flow direction. See text for definitions of parameters marked.

and it follows that

$$u = F/A \tag{25}$$

If the flow takes a time τ top reach the maximum distance X from the vent possible before it is halted by cooling effects, equation (15) shows that for flows on Venus we have

$$X = \frac{D_c^2 u}{270\kappa} \tag{26}$$

$$\tau = X/u \tag{27}$$

This sequence of equations allows us to make a number of points. First, since the gravity on Venus is only slightly less than that on Earth and since the densities of lavas on Venus will be similar to (or, in view of the comments made earlier about low gas exsolution from Venusian magmas, slightly greater than) those of terrestrial lavas, the equations demonstrate that there is no reason to expect significant systematic differences between Venusian and terrestrial lava flow morphologies unless there are systematic differences in topographic slope, effusion rate, or lava rheology. Studies of the radar altimetry data from the Pioneer Venus orbiter have shown that the range of topographic slopes on Venus, 0.001-0.03 rad, is similar to that on Earth [Sharpton and Head, 1985]. We have argued that there is no obvious reason to expect different ranges of effusion rates on Venus from those on Earth unless there are systematic differences between magma rheologies on the two planets. The issue of differences in flow morphology rests very heavily, therefore, on the question of magma rheology.

In deriving the relationships noted in Figure 2c we commented that if magmas on Venus are relatively dry and erupt at similar temperatures relative to the liquidus compared with terrestrial magmas, then viscosities might be about a factor of 3 greater on Venus than on Earth, while yield strengths should have about the same values. Examination of equations (19)-(27) then shows that we would expect flows on Venus having a given major element composition and effusion rate, and forming on a given slope, to have widths and depths which would be about the same as those on equivalent terrestrial flows but to have central channel widths larger by a factor of 1.2, mean flow speeds smaller by a factor of 1.8, lengths smaller by a factor of 1.1, and flow durations longer by a factor of 1.65. It will be noted that all of these factors are less than 2, so that no gross systematic differences are expected between Venusian and terrestrial flows of similar magmas.

Table 2 shows some examples of the properties of flows forming on slopes typical of the major terrain units on Venus [Sharpton and Head, 1985]; the slopes used are taken from near the upper end of the slope distribution in each case and are 0.003 (lowland units), 0.0045 (upland rolling plains units), and 0.006 (interior of the Beta region) rad, respectively. Properties are calculated for a typical pair of rheological parameters from within the range defined by Figure 2c: Y = 100 Pa, η = 1500 Pa s. A spread of magma effusion rates has been chosen which includes the current terrestrial range for basalts, commonly extending up to about 300 m^3/s [Whitford-Stark, 1982] but sometimes reaching 7 x 10^4 m^3/s in basaltic Plinian eruptions [Walker et al., 1984], and the inferred range for the lunar mare-filling basaltic eruptions, extending up to ~3 x 10^5 m^3/s [Head and Wilson, 1981]. If effusion rates on Venus are limited to the same range as on Earth, it is clear that flow widths and lengths of several tens of kilometers can be reached on moderate slopes by hot, dry basalts. If larger values are assumed for any of the parameters slope, yield strength, or effusion rate, an increase in flow length is produced: if all three parameters are doubled, for example, predicted flow lengths would increase by a factor of 3.5, thus ranging up to a few hundred kilometers.

It may be noted that at low effusion rates on shallow slopes, on both Earth and Venus, flows are generally predicted to be wider than they are long. Under such circumstances, it is clear that the theoretical model used is not appropriate to predict the morphologies of flows, since the lava spreading laterally away from the downslope direction never reaches true dynamic equilibrium with the stresses applied to it. Models of the type developed for viscously relaxing domes by Huppert et al. [1982] will be more applicable, and flows on both Earth and Venus are expected to be narrower, thicker, and longer than indicated in Table 2: much longer in the case of lavas erupted at rates less than 100 m^3/s. There will be a strong tendency for the morphological features produced by multiple, low effusion rate, eruptive episodes in areas with very low regional slopes (on Earth and Venus) to resemble a series of interlocking