We may evaluate (11) and (14) by substituting values of the physical parameters appropriate to Venus. We adopt $\rho = 3$ g/cm^3, $g = 887$ cm/s^2, and $\nu = 0.25$. The Young's modulus is less certain; the proper value is likely to lie between 10^{11} and 10^{12} dyne/cm^2 (10–100 GPa), with perhaps the lower end of this range preferred for the upper portions of the Venus crust (i.e., at low confining pressures and temperatures near the surface temperature). With these values, $\sigma(\lambda)$ and $h(\lambda)$ are as shown in Figures 3 and 4, respectively.

From Figure 3 it may be seen that a characteristic spacing between bands of 15–20 km corresponds to a compressive stress σ of 1.5–2 kbar (0.15–0.2 GPa) for $E = 10^{11}$ dyn/cm^2 and 3–4 kbar for $E = 10^{12}$ dyn/cm^2. The corresponding values for the thickness of the elastic layer are 1.0–1.5 km and 0.5–0.7 km, respectively. Thus if a surficial elastic layer about 1 km thick is folded as a consequence of horizontal compressive stress of a few kilobars, then the dominant wavelength of folding would match the observed spacing between bands in the mountains of Ishtar Terra.

The level of compressive stress required to produce folding of a uniform elastic layer at wavelengths equal to the observed band spacing, however, is probably too large to be supported by the near-surface portions of the Venus crust. A compressive stress of 1.5–4 kbar is near to or in excess of the level that can be supported by crustal rock at near-surface conditions (see further discussion on this point in a later section). It must be remembered, too, that folding will produce bending stresses, which must be added to the applied compressive stress to determine the net horizontal stress in the elastic layer; where the bending stresses are compressive (e.g., in the troughs of folds in the upper half of the elastic layer), the net compressive stress will exceed σ by an amount that depends on the fold amplitude [*Biot*, 1961]. Under such conditions, compressive failure (i.e., thrust or reverse faulting) is more likely than folding. The relationship analogous to (14) for the case of imbricate thrust or reverse faults is given below.

It is well known from both theory and observations of folding in terrestrial strata that a layered sequence of rock units will fold more readily than will a single uniform layer [e.g., *Johnson*, 1970, pp. 150–153]. In other words the horizontal stress required to produce folding of a given wavelength is less if layering is present. We therefore treat next the folding of a layered elastic plate as a model for the formation of banded terrain on Venus.

Layered elastic plate. Consider a stack of elastic layers between which the friction is zero. Let the ith layer have thickness h_i, Young's modulus E_i, and Poisson's ratio ν_i. The folding of such a layered plate overlying an inviscid fluid in the presence of gravity follows the analysis given above, except that the flexural rigidity D is given by

$$D = \sum_{i=1}^{n} \frac{E_i h_i^3}{12(1 - \nu_i^2)} \tag{15}$$

[*Johnson*, 1970, pp. 150–153]. There is still a dominant wavelength of folding given by (10), with D given by (15) instead of (2). In the simplification where $h_i = h$, $E_i = E$, and $\nu_i = \nu$ for all i, (15) reduces to

$$D = \frac{nEh^3}{12(1 - \nu^2)} = \frac{EH^3}{12n^2(1 - \nu^2)} \tag{16}$$

where $H = nh$ is the total thickness of elastic layers. With this simplification the compressive stress required to produce folding at the dominant wavelength λ is

$$\sigma = \frac{2}{n^{2/3}} \gamma^{2/3} B^{1/3} (\lambda/2\pi)^{2/3} \tag{17}$$

and the thickness of the folded stack of elastic layers is

$$H = n^{2/3} (\gamma/B)^{1/3} (\lambda/2\pi)^{4/3} \tag{18}$$

These relations are similar to (11) and (14), respectively, except that the total thickness of the elastic portion has increased by a factor of $n^{2/3}$, and the stress required to produce folding at the given wavelength has decreased by the same factor.

Equations (17) and (18) are shown graphically in Figures 3 and 4. For a dominant fold wavelength of 15–20 km the required compressive stress is less than 1 kbar if n is 10 or more and is a few hundred bars or less if n exceeds 100. The total thickness of folded rock layers increases by a factor of 4.6 and 21.5 for $n = 10$ and 100, respectively, for other parameters held fixed. For $\lambda = 15$–20 km and $E = 10^{12}$ dyn/cm^2, $H = 2$–3 km for $n = 10$ and 10–15 km for $n = 100$. We conclude that folding of a surficial elastic plate is an acceptable model for the origin of banding on Venus but that the required stresses are more plausible if the folded unit has some internal layering.

The specific nature of layering in the uppermost crust of Venus is not well known. In terrestrial mountain belts, such layering occurs through a sequence of sedimentary units of differing mechanical properties. On Venus, such layering may

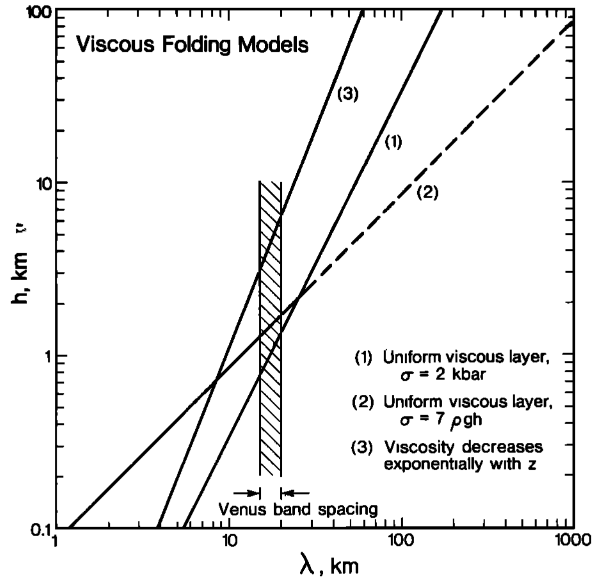

Fig. 5. Thickness h of the surficial high-viscosity layer in the Venus highlands that would be inferred from the spacing λ between bands for several viscous folding models for the formation of banded terrain. Model (1) is a uniform viscous layer overlying an inviscid substrate; h is inversely proportional to the applied compressive stress σ and is shown for $\sigma = 2$ kbar. Model (2) is also for a uniform viscous layer overlying an inviscid substrate, but one in which $\sigma = 7\ \rho g h$, *Biot*'s [1959] minimum condition for significant fold growth; the curve for h is shown dashed where $\sigma > 5$ kbar. Model (3) is for a viscous half space in which viscosity decreases with depth as exp $(-z/s)$; for this model the quantity s takes the place of layer thickness h, and the value for σ at the surface must be assumed (2 kbar for the curve shown). Parameters common to all models include $\rho = 3$ g/cm^3 and $g = 887$ cm/s^2. The characteristic band spacing $\lambda = 15$–20 km observed for Venus banded terrain is shaded.