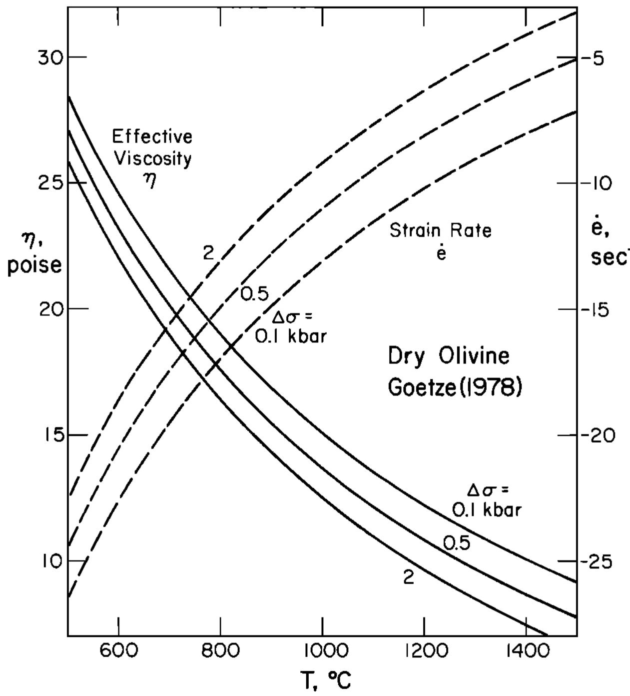

Fig. 3a

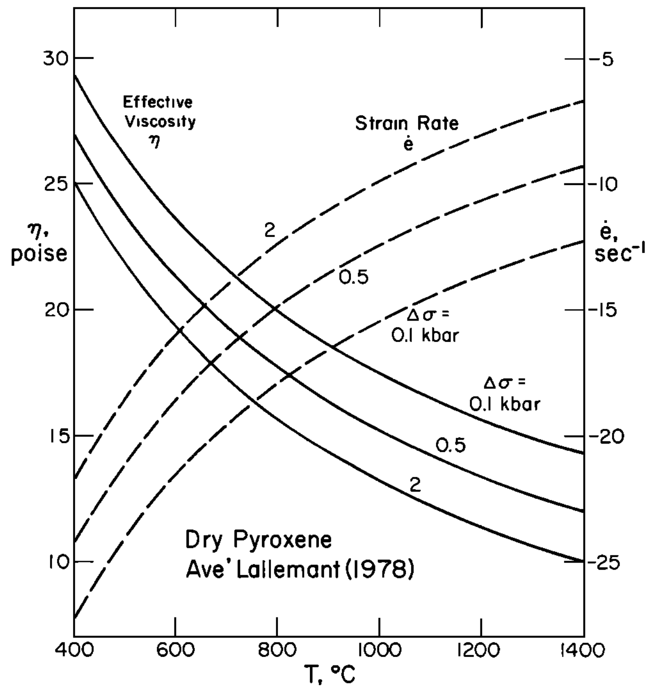

Fig. 3b

Fig. 3. Effective viscosity η and strain rate $\dot{e}$ (both $\log_{10}$) versus temperature T and stress difference $\Delta\sigma$ for polycrystalline olivine (Figure 3*a*) and polycrystalline pyroxene (Figure 3*b*) at low pressures and at 'dry' conditions. The curves for olivine are from the flow law for dislocation creep given in equation (7) of *Goetze* [1978] and are appropriate to olivine of approximate composition $(Mg_{0.9}Fe_{0.1})_2SiO_4$ at stress differences of 2 kbar and less and at confining pressures of 15 kbar and less. The possible effect of Coble creep [*Goetze*, 1978] at stress differences greater than a few hundred bars has not been considered in constructing these curves. The curves for pyroxene are based on the flow law parameters obtained by *Avé Lallemant* [1978] from creep measurements on 'dry' websterite (68% diopside, 32% bronzite) at stress differences less than 7 kbar and at confining pressures of 10 kbar.

processes can be important but occur on long time scales (e.g., millions of years), in contrast to the underlying asthenosphere in which, by analogy to the earth, viscous processes have much shorter characteristic times (10^3 to 10^4 years). We ignore, for this model, any possible density contrast between the layer and the underlying half space and therefore any isostatic compensation of topography. In general, both η and H are free parameters. A somewhat similar model, also without isostatic compensation, was treated by *Parmentier and Head* [1981].

The viscous relaxation of axisymmetric topography with this model (see the appendix) is again given by equations (4) and (5) except that $\tau(k)$ is given by

$$\tau(k) = \frac{2\eta k}{\rho g}\left[\frac{e^{2kH} + e^{-2kH} - 4(kH)^2 - 2}{e^{2kH} - e^{-2kH} + 4kH}\right] \qquad (6)$$

Thus the relaxation time differs from the half-space solution $\tau_0(k)$, given in (3), by the factor in brackets; that factor is plotted as a function of $2kH$ in Figure 4. From the figure it may be seen that $\tau(k)$ is indistinguishable from the half-space solution for $2kH \gtrsim 10$; i.e., for wavelengths $2\pi/k$ less than the layer thickness H. For $2kH < 10$, viscous relaxation is faster than for the half-space solution because motion of the underlying inviscid fluid is an important component of the response. For $2kH \ll 1$, the factor in brackets in (6) behaves as $(kH)^3/6$, so that the longest wavelength topography decays at a rate substantially faster than for the half-space model. The viscosity of a planetary asthenosphere is not negligible, of course, at sufficiently short time scales (10^4 years and less). For a rheological model with a layer of viscosity η and thickness H overlying a half space of viscosity $\eta_m \ll \eta$, the time constant $\tau(k)$ is well approximated by (3) for wavelengths less than H and approaches $2\eta_m k/\rho g$ in the long-wavelength limit.

The viscous relaxation of Orientale topography is shown for the model of a viscous layer over an inviscid half space in Figures 5 and 6 for two values of H, 50 and 100 km, respectively. These two values are similar to the effective thicknesses of the elastic lithosphere of the moon derived from the tectonic response to mare basalt loading of mascon mare basins in the approximate time period 3.6 to 3.8 b.y. ago [*Solomon and Head*, 1980], times probably more recent than those over which viscous effects were important in the lunar lithosphere at spatial scales corresponding to impact basin dimensions. It is clear from Figures 5 and 6 that relaxation of long-wavelength topographic relief is considerably faster for the layer model than for the half-space model (Figure 2) and is faster for the 50-km-thick layer than for the 100-km thick layer for wavelengths of 50 km and greater.

As discussed at length in the appendix, several approximations are necessary in the derivation of (4), (5), and (6) for this model. From equations (A15) and (A22), for a harmonic load,

$$\begin{aligned} k|F| &\ll 1 && \text{for all } k \\ k|F| &\ll (kH)^3/3 && \text{for } (kH) \ll 1 \end{aligned} \qquad (7)$$

For our problem of circularly symmetric loads in which the integral in (4) is replaced by a discrete sum over a finite