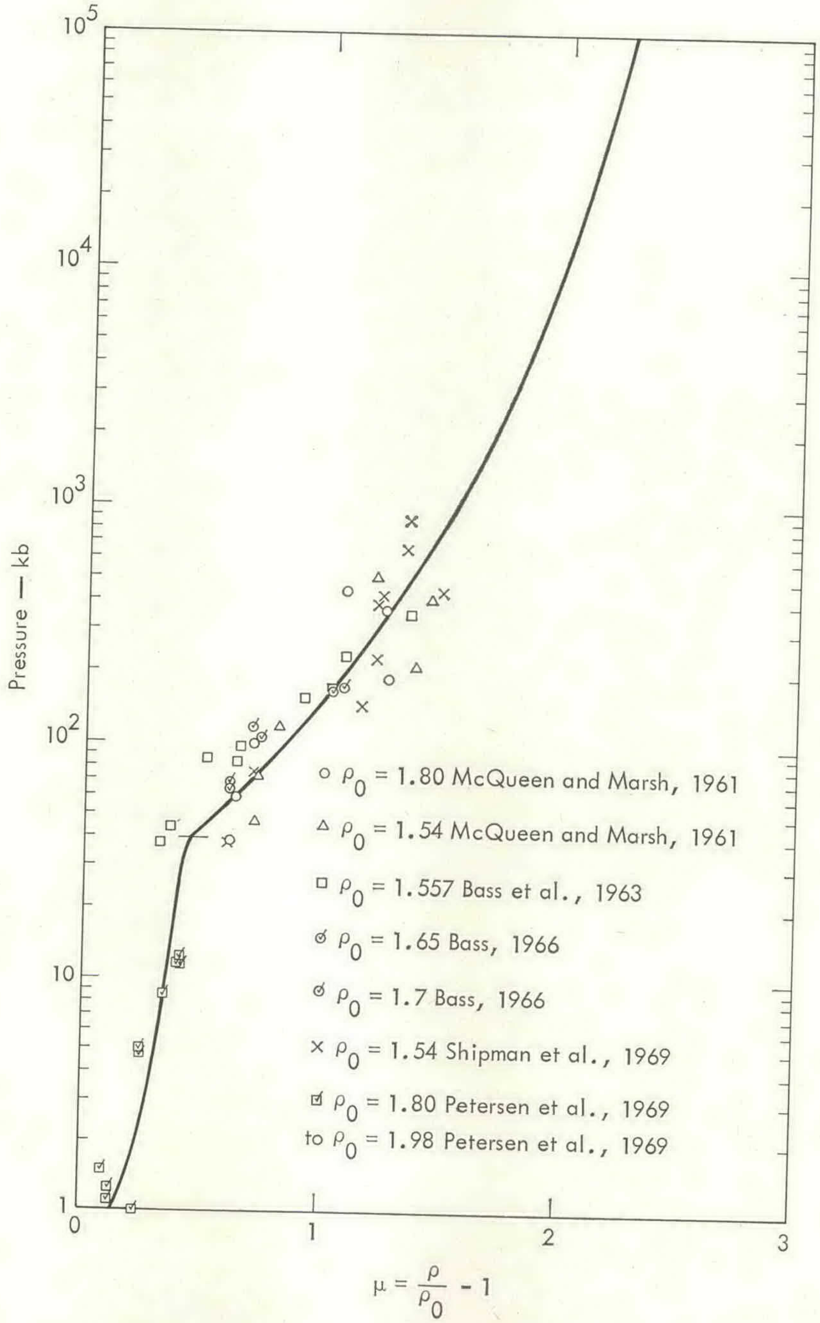

Fig. 11*a*. Consolidated and crushed P–μ curves for Marvel alluvium.

performed by continuing to increase the steepness of the P–μ curve slightly until, at 100 mb, $\mu = 2.25$. Preliminary calculations like those described here were performed, considering extrapolations to $\mu = 2.0$ and $\mu = 2.5$ at $P =$ 100 mb. At 100 μsec, the results of these two calculations were virtually identical with pressures in the cavity less than 1 mb. Thus, we feel that although the extrapolation used here ($\mu =$ 2.25 at $P =$ 100 mb) is not based on experi-

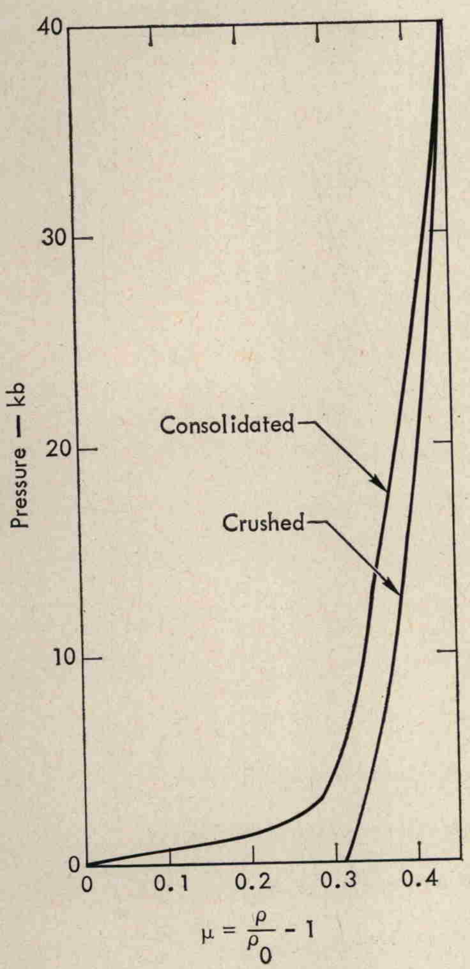

Fig. 11*b*. Details of lower-pressure portion of consolidated and crushed P–μ curves for Marvel alluvium.

mental data or theory, it may be adequate for the numerical simulation of the alluvium surrounding Marvel.

The initial slope of the loading P–μ curve indicates a bulk modulus of $k \approx 18$ kb. By use of $k = 18$ kb and the average measured sound speed of 1200 m/sec, a rigidity modulus of 6.5 kb is obtained. In order to minimize the rigidity of the material after it is considered to be crushed, a Poisson's ratio σ of 0.49 is assumed. This high ratio results in a lower rigidity modulus than that calculated for the consolidated material where $\sigma \approx 0.34$. An estimated yield curve for this very weak alluvium is shown in Figure 11*c*.

There was some concern that the density-matching grout that was used to backfill the drift would continue to release heat into the tunnel air after the access hole had been sealed. However, temperature sensors located in the grout registered nearly constant temperatures in the range of 100° ± 20°F for the three-week period before the shot date (Guido, personal communication, 1968). A 110°F temperature, 1100-meter altitude, an estimated 0.9-bar pressure, and a density of 1.1×10^{-3} g/cm^3 were used as the initial conditions for the tunnel air.

An equation of state for air of the form $p = f(e)$, where pressure is a function of specific internal energy, is used in the calculations. This equation of state, which is shown in Figure 12, was obtained from air data at low energies [*Gilmore*, 1955] and shock relations at higher energies [*Fenter*, 1961]. Over the range of air densities encountered in Marvel ($\rho \approx 10^{-3}$ to 10^{-1} g/cm^3), the pressure at a given specific energy is essentially independent of density; therefore the density dependence in the equation of state is neglected. An auxiliary equation of state, $T = f(e)$, which is shown in Figure 13, is used to obtain the air temperature for calculating the radiative heat flux. A table [*Bond et al.*, 1965] for Rosseland mean opacity, $K_R = f(T, \rho)$, is used for air.

The 2.2-kT yield of Marvel was designed to be initially distributed homogeneously in the source region of volume 1.2×10^6 cm^3. This gave an energy per unit volume of (ϵ) 7.6×10^{13} ergs/cm^3. The mass of the total source-region canister was approximately 1.6×10^6

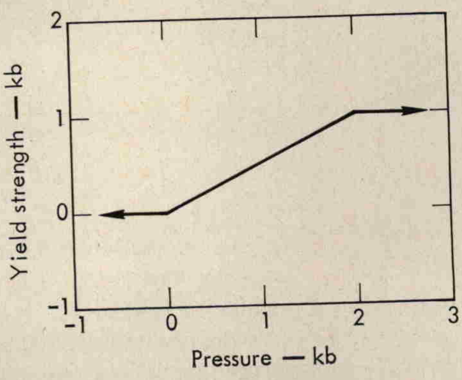

Fig. 11*c*. Estimated yield curve for the very weak Marvel alluvium.