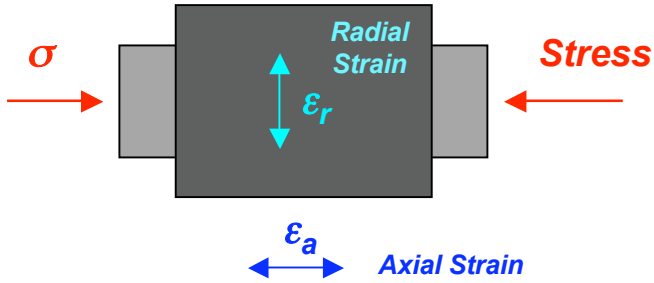
ROCK PHYSICS BASICS

Static and Dynamic Moduli

By definition, the dynamic moduli of rock are those calculated from the elastic-wave velocity and density. The static moduli are those directly measured in a deformational experiment.

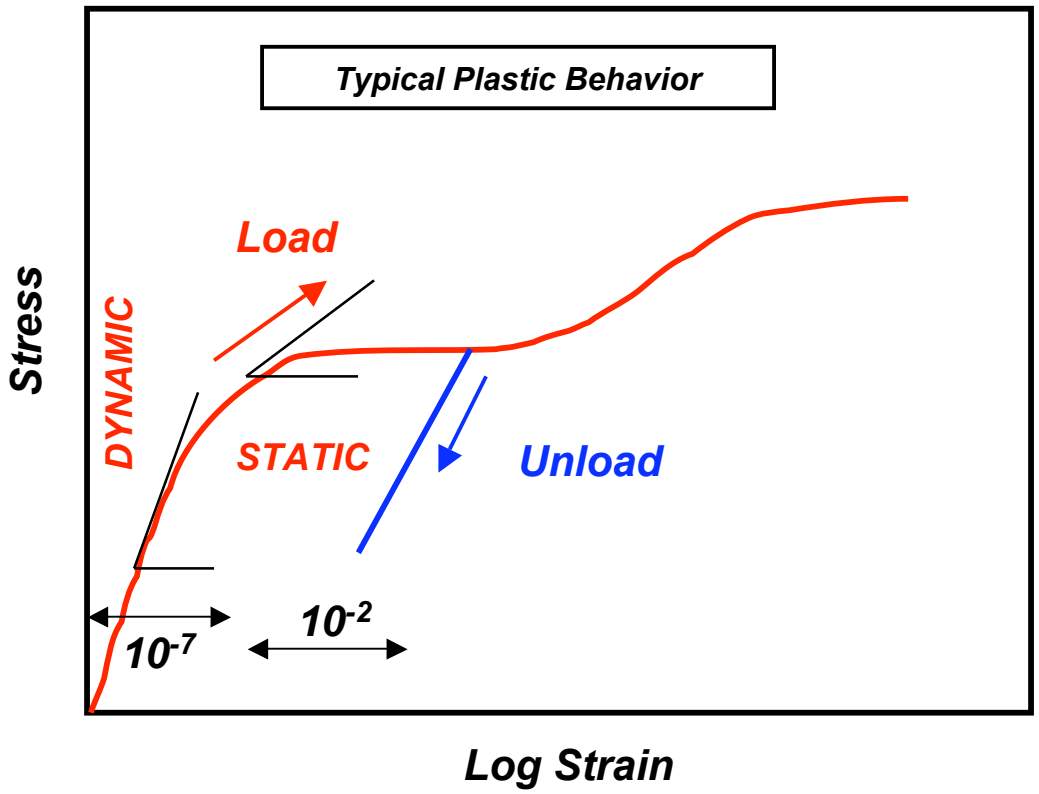
The static and dynamic moduli of the same rock may significantly differ from each other. The main reason is likely to be the difference in the deformation (strain) amplitude between the dynamic and static experiments.

In the dynamic wave propagation experiment the strain is about 10^{-7} while static strain may reach 10^{-2}.



$$E = \sigma / \varepsilon_a$$

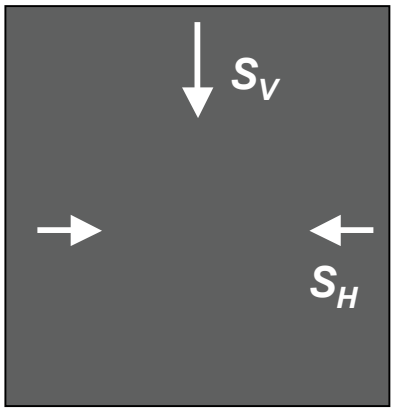
$$\nu = \varepsilon_r / \varepsilon_a$$



ROCK PHYSICS BASICS

Need for Static Moduli

Static moduli are often used in wellbore stability and in-situ stress applications to evaluate the possibility of breakouts, elevated pore pressure, and tectonic stress distribution. For example, a common method of calculating the horizontal stress in earth is by assuming that the earth is elastic and does not deform in the horizontal direction.



Horizontal Stress

Poisson's Ratio

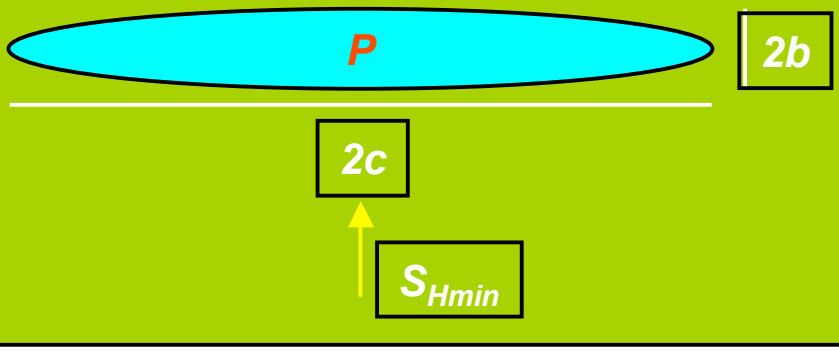
$$S_H = S_V \frac{\nu}{1-\nu}$$

Vertical (Overburden) Stress

Hydrofracture can be approximated by a 2D elliptical crack who's dimensions depend on the static Young's modulus and Poisson's ratio.

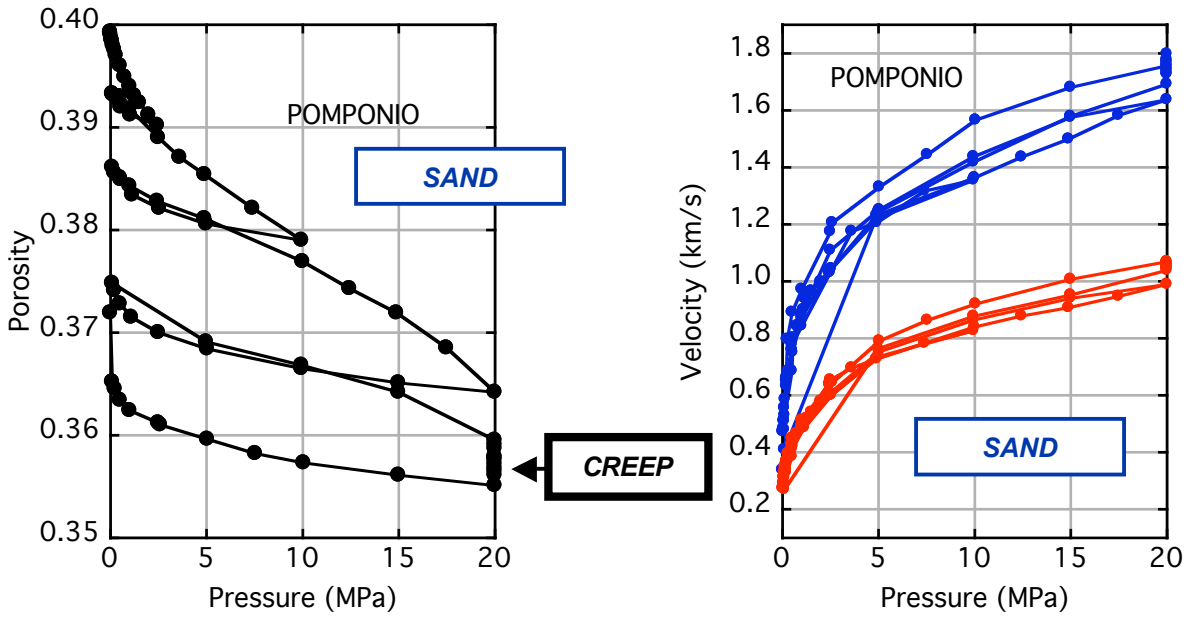
$$b = 2c\frac{1-\nu^2}{E}(P - SH_{\min})$$

Importance of Static Young's Modulus and Poisson's Ratio for Hydrofracture Design

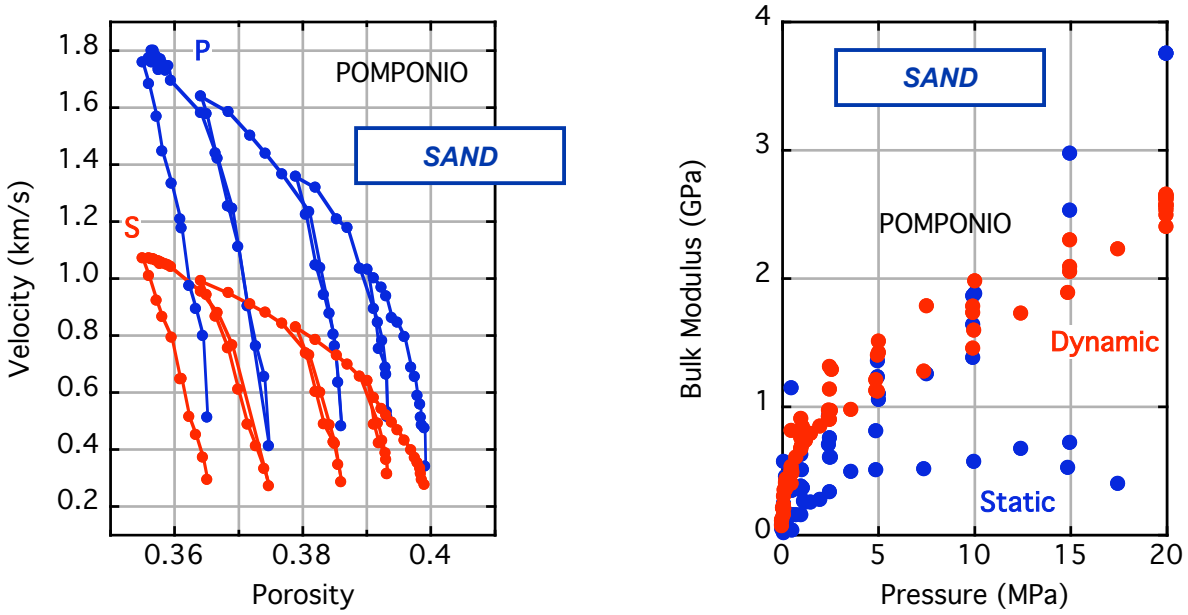


ROCK PHYSICS BASICS

Static and Dynamic Moduli in Sand



Porosity (left) and velocity (right) versus pressure in high-porosity room-dry sand sample from the Gulf of Mexico.



Velocity versus porosity (left) and dynamic and static bulk moduli calculated for the same sample.

Zimmer, M., 2003, Doctoral Thesis, Stanford University .