Structural Geology Example Strain Problem

Given:

The finite strain ellipse in a deformed rock has been determined to have the following dimensions:

$S_X = 1.936$ $\quad \lambda_X = 3.750$
$S_Z = 0.707$ $\quad \lambda_Z = 0.500$
$\theta_d = -20°$

Find:

For a deformed line parallel to the $\theta_d = -20°$ direction, calculate the values of stretch (S), quadratic elongation (λ), shear strain (γ), angular shear (ψ), and angle of internal rotation (α). All angular values are given in degrees, and all calculated angular values should be reported in degrees (not radians).

$$\lambda' = \frac{\lambda'_Z + \lambda'_X}{2} - \frac{\lambda'_Z - \lambda'_X}{2} \cos 2\theta_d$$

$$\frac{\gamma}{\lambda} = \frac{\lambda'_Z - \lambda'_X}{2} \sin 2\theta_d$$

$$\lambda' = \frac{\frac{1}{0.500} + \frac{1}{3.750}}{2} - \frac{\frac{1}{0.500} - \frac{1}{3.750}}{2} \cos(-40)$$

$$\lambda' = 1.133 - (0.866)(0.766) = 0.470$$

$$\lambda = \frac{1}{0.470} = 2.128 \quad \therefore \quad S = 1.459$$

$$\frac{\gamma}{\lambda} = \frac{\frac{1}{0.500} - \frac{1}{3.750}}{2} \sin(-40)$$

$$\gamma = (0.866)(-0.643)(2.128) = -1.185$$

$$\psi = \tan^{-1}(\gamma) = \tan^{-1}(-1.185) = -49.8°$$

$$\tan(\theta_d) = \tan(\theta)\left[\frac{S_Z}{S_X}\right]$$

$$\tan(-20) = \tan(\theta)\left[\frac{0.707}{1.936}\right]$$

$$\tan(\theta) = \tan(-20)\left[\frac{1.936}{0.707}\right] = (-0.364)(2.738) = -0.997$$

$$\theta = \tan^{-1}(-0.997) = -44.9°$$

$$\alpha = \theta_d - \theta = (-20°) - (-44.9°) = +24.9°$$