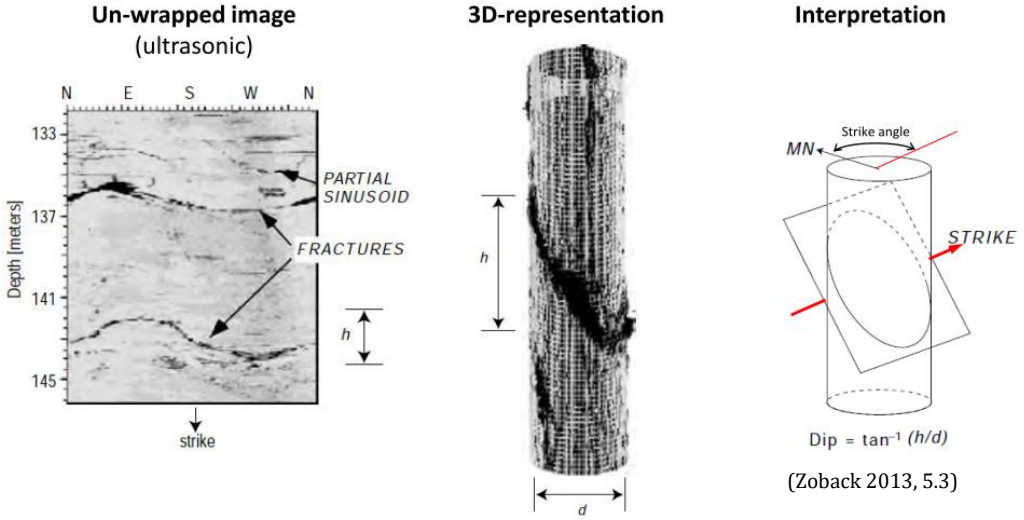
Project #2

Borehole imaging (http://petrowiki.org/Borehole_imaging) in the well from the Vaca Muerta Formation (Project # 1) shows the presence of several fractures below Depth E. We would like to know what the shear stresses τ and effective normal stresses σ_n are at this location.



(Zoback 2013, 5.3)

Additional borehole images at the depth of leak-off tests show that the azimuth of S_{Hmax} is 90°.

Tasks (to be implemented in Matlab, Python, or similar software):

1) Input the principal stress tensor at Depth E in the principal directions coordinate system and calculate the tensor in the geographical coordinate system.
2) Generate 100 randomly distributed fracture orientations (strike and dip) and compute their effective normal stress and shear stress. Plot all in a σ_n-τ diagram together with the 3D Mohr circle(s).
   EXTRA 1 (not required): color symbols for each point (σ_n-τ) from blue to red according to the value of τ/σ_n
   EXTRA 2 (not required): plot all fractures in a stereonet projection with symbols colored by the value of τ/σ_n.
   About stereonets: Section 5.22 in https://dnicolasespinoza.github.io
3) Are there any fractures prone to shear slip (assume friction coefficient μ=0.5±0.1)? What fractures are likely to be hydraulically conductive based on the τ/σ_n criterion and which others are not?
4) Wellbore images actually show that there are two major sets of fractures:
   - Set 1: strike = 60° ± 5°, dip = 80° ± 5°
   - Set 2: strike = 10° ± 5°, dip = 80° ± 5°
   Plot results for 20 fractures for each set (errors represent one standard deviation with normal distribution).
   Which fracture set is more likely to slip in shear? Why?

Help: check Prof. Foster's widget for the convention on rotation angles for the principal stress orientations.