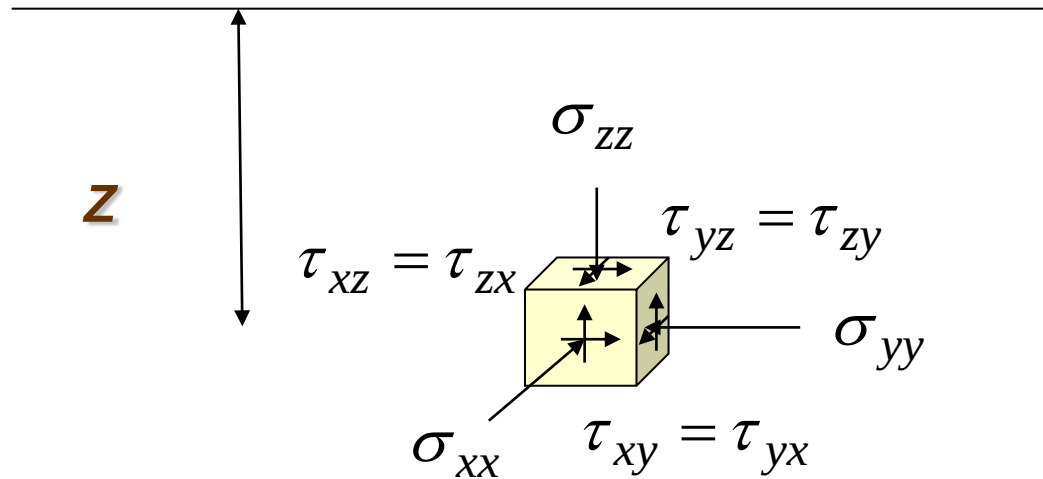
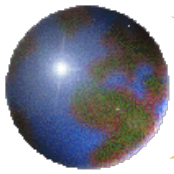


4 Pre-mining state of stress

Topic 1 Factors influencing the state of stress

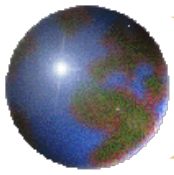
Topic 2 In-situ stress measurement



At Z,

$$\begin{bmatrix} \sigma_{xx} & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_{yy} & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_{zz} \end{bmatrix} = ?$$

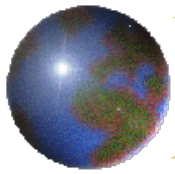
But, how to get there ?



In-situ stress measurement

- ⊕ Hydraulic method (measure stress at failure)
 - ⊞ Hydraulic fracture
 - ⊞ Sleeve fracture
 - ⊞ Hydraulic test on pre-existing fracture
- ⊕ Flat jack method (measure compensate stress)
- ⊕ Relief method (measure displacement or strain)
 - ⊞ Surface relief (pin, Doorstopper biaxial strain cell)
 - ⊞ Borehole relief (USBM gage, CSIRO triaxial strain cell)

An overview of rock stress measurement method



How to get there ?

✚ Hydraulic method

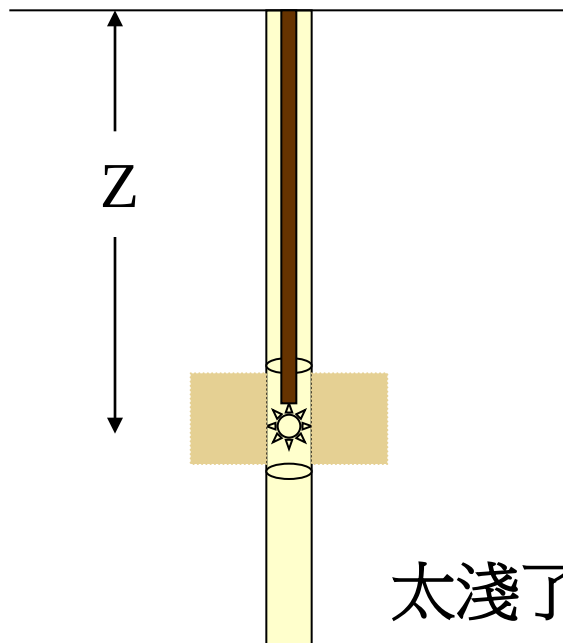
- ✚ Hydraulic fracture

- ✚ Sleeve fracture

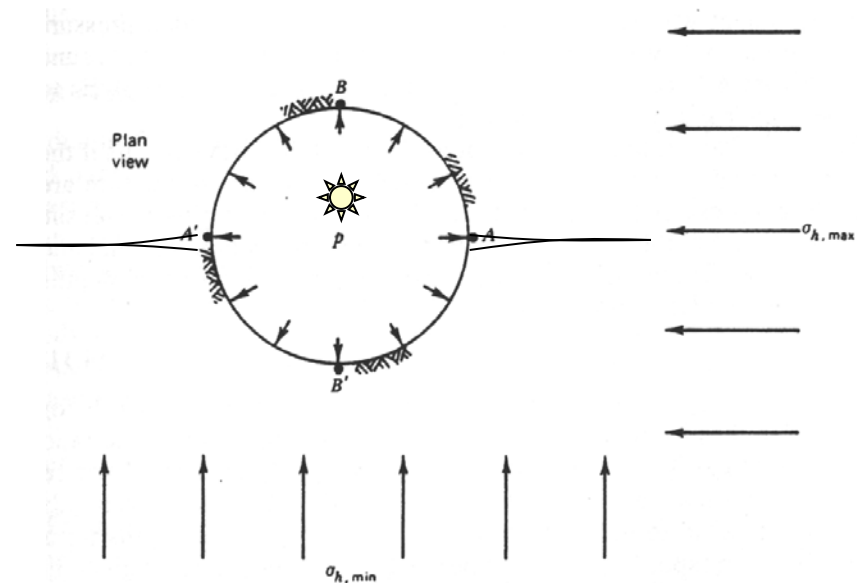
- ✚ Hydraulic test on pre-existing fracture

Door stopper or overcoring ?

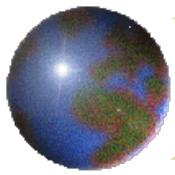
貼 strain gage or 鑽同心圓



太淺了不行！



measure stress at failure

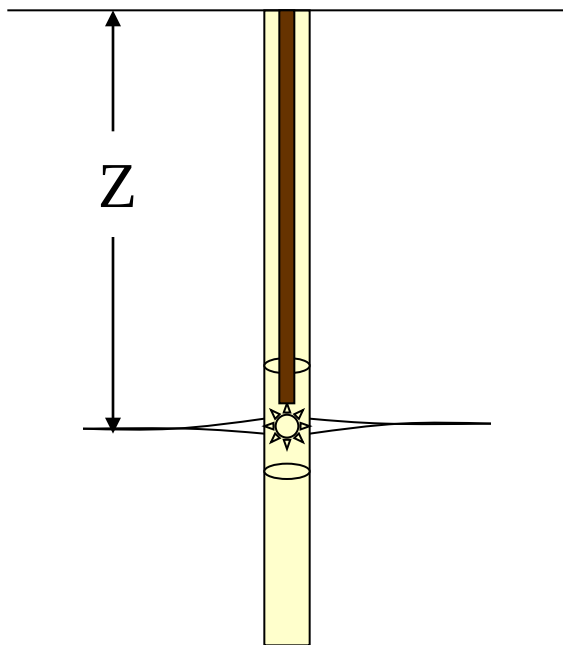


How to get there ?

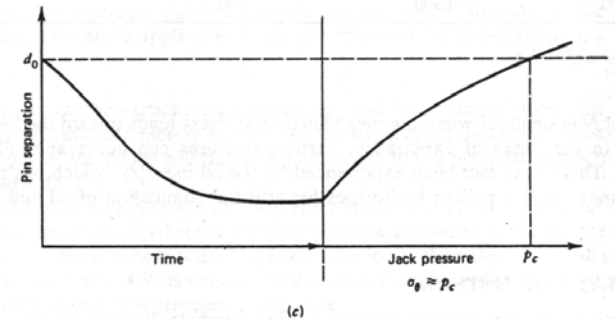
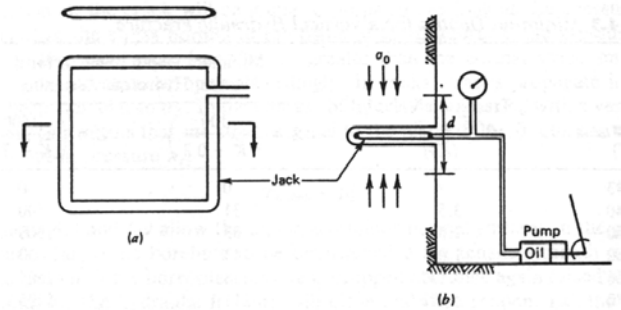
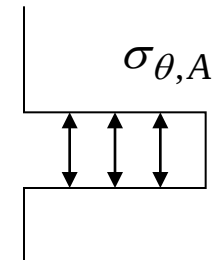
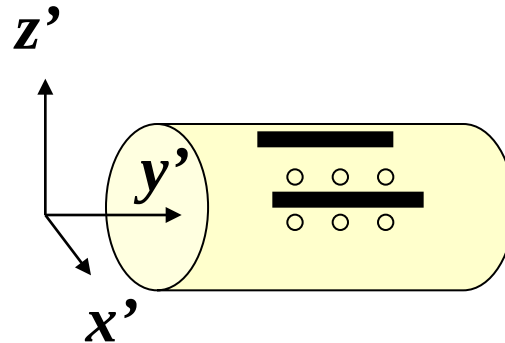
✚ 利用現有隧道或豎井

▣ **Flat jack method**

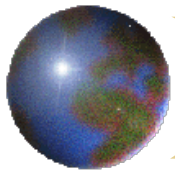
開挖面擾動的問題



$$\begin{Bmatrix} \sigma_{\theta,A} \\ \sigma_{\theta,B} \\ \sigma_{\theta,C} \end{Bmatrix} \rightarrow \begin{Bmatrix} \sigma_{x'} \\ \sigma_{z'} \\ \tau_{x'z'} \end{Bmatrix}$$



measure compensate stress

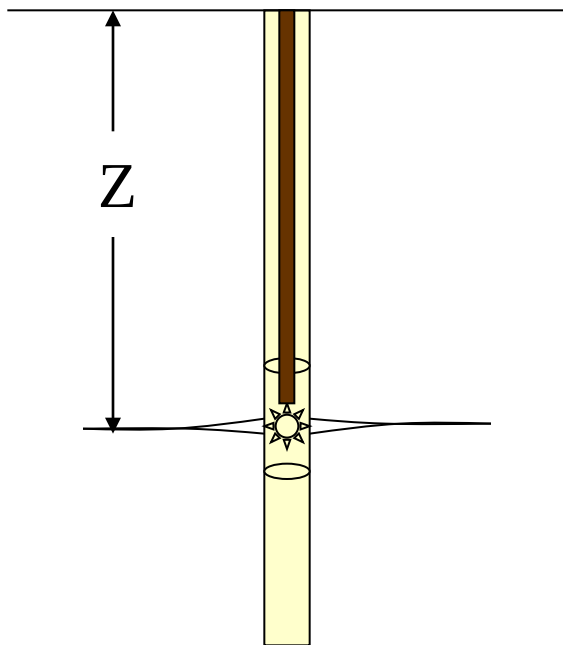


How to get there ?

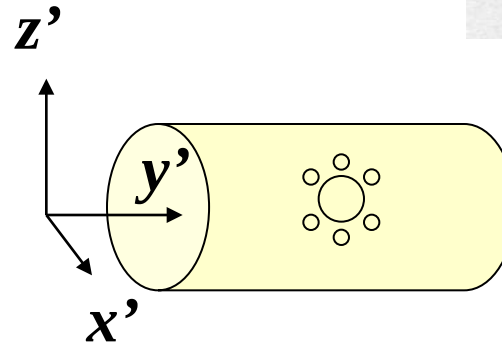
✚ 利用現有隧道或豎井(surface relief)

✚ Pin and undercoring

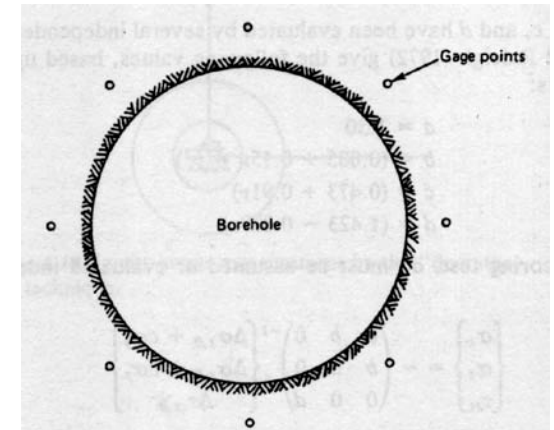
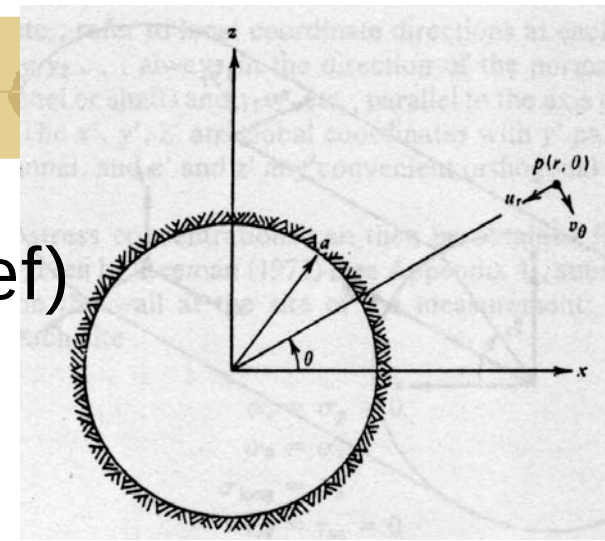
開挖面擾動與應力集中的問題

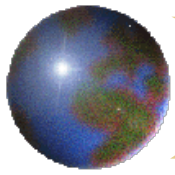


$$\begin{Bmatrix} u_{r,1} \\ u_{r,2} \\ u_{r,3} \end{Bmatrix} \rightarrow \begin{Bmatrix} \sigma_{x'} \\ \sigma_{z'} \\ \tau_{x'z'} \end{Bmatrix}$$



measure displacement or strain



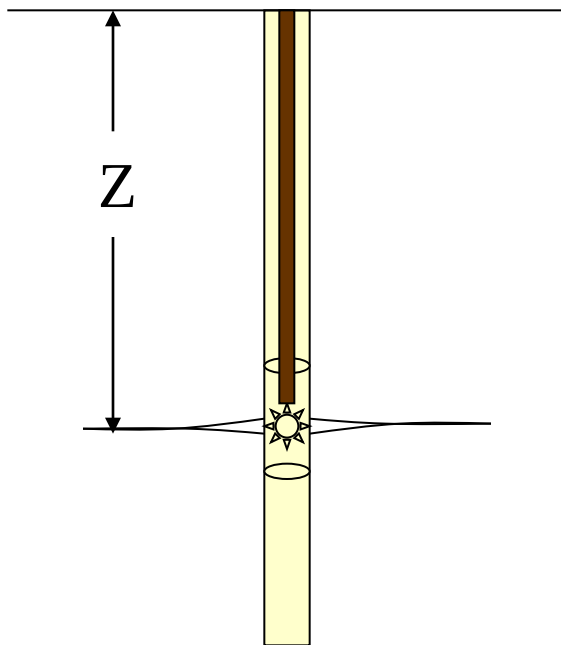


How to get there ?

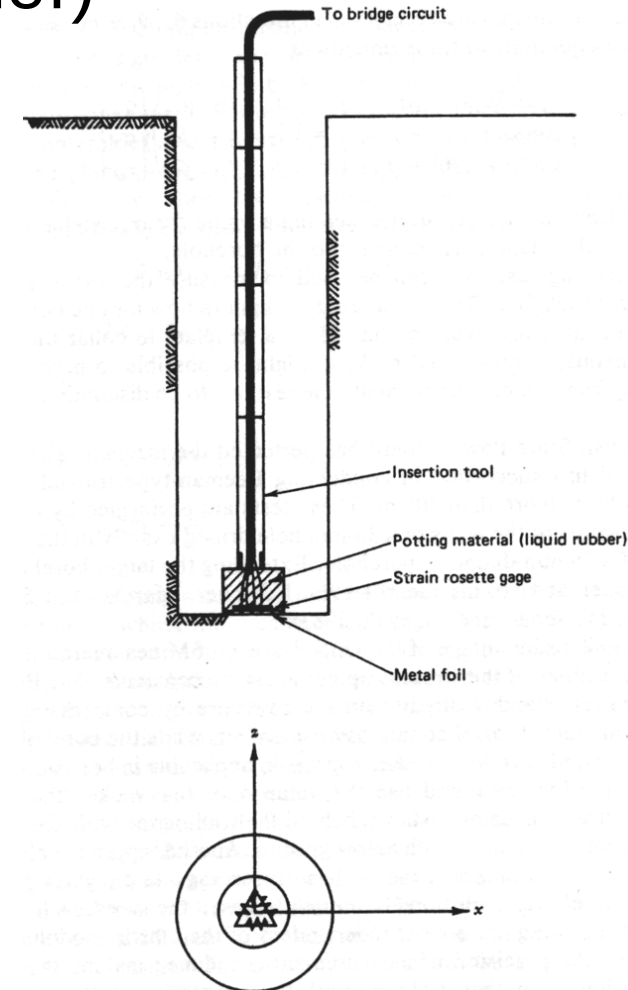
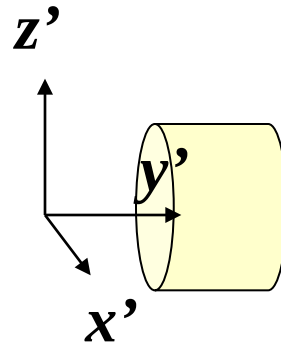
✚ 利用現有隧道或豎井 (surface relief)

▣ **Strain rosettes and overcoring**

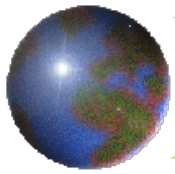
開挖面擾動與應力集中的問題



$$\begin{Bmatrix} \varepsilon_A \\ \varepsilon_B \\ \varepsilon_C \end{Bmatrix} \rightarrow \begin{Bmatrix} \sigma_{x'} \\ \sigma_{z'} \\ \tau_{x'z'} \end{Bmatrix}$$



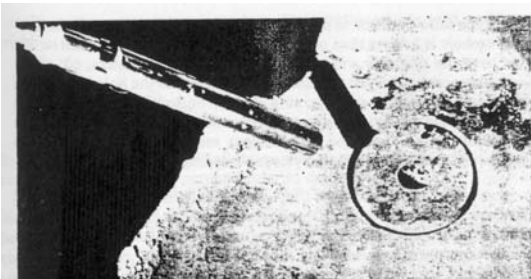
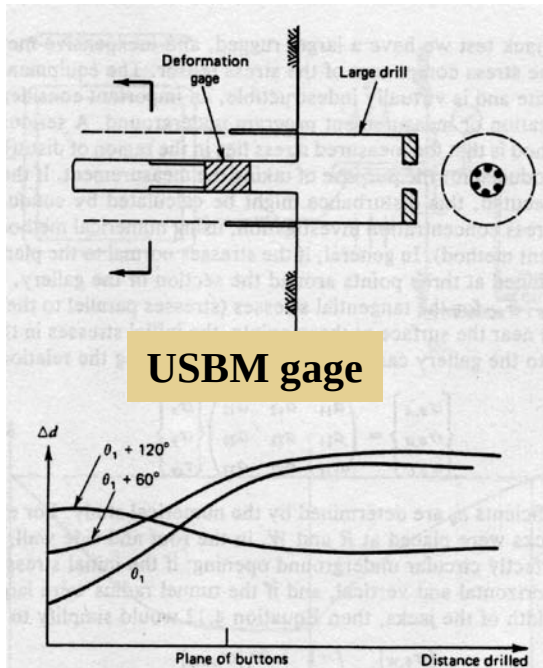
measure displacement or strain



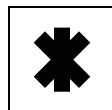
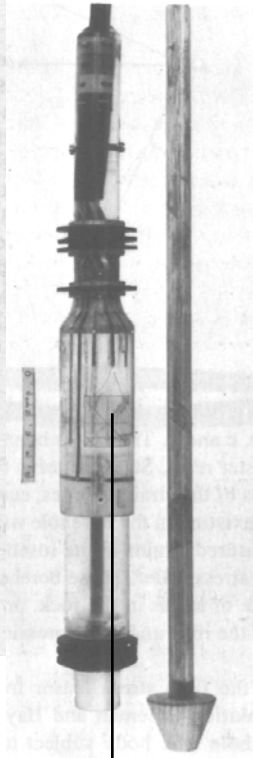
How to get there ?

於隧道或豎井中鑽孔,克服擾動與應力集中問題

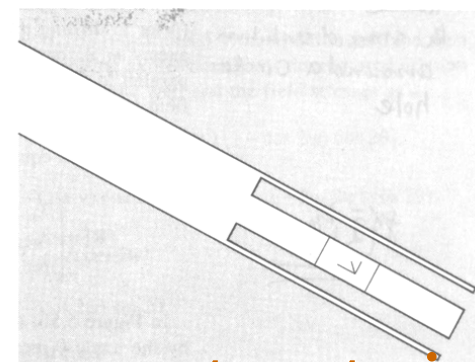
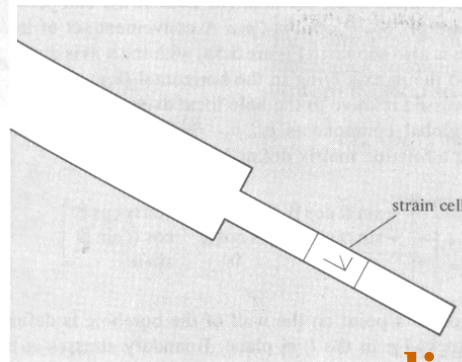
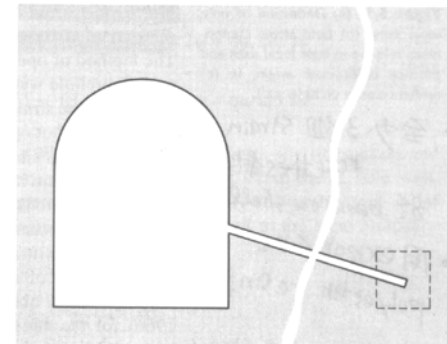
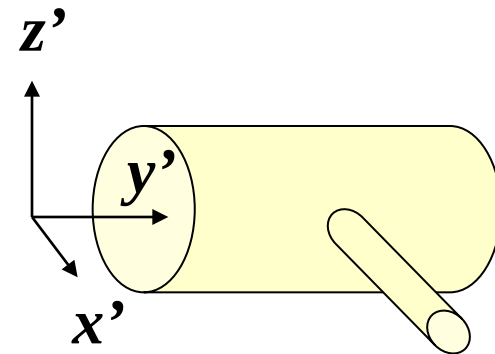
✦ Borehole relief (鑽孔長度應超過1倍隧道直徑)



CSIRO triaxial strain cell



Strain rosette



measure displacement or strain