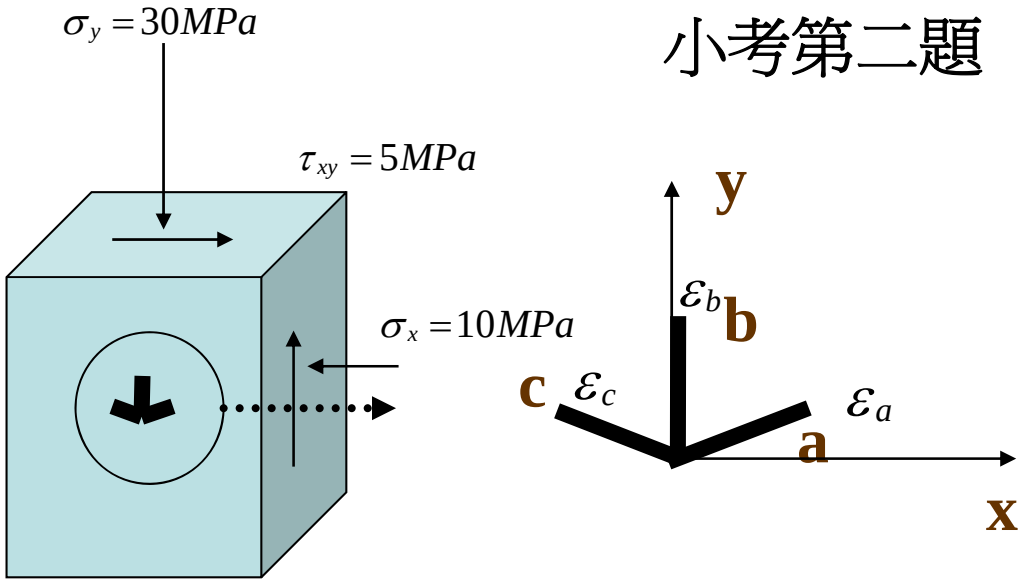
小考第二題



Strain gage a,b,c 分別與水平夾

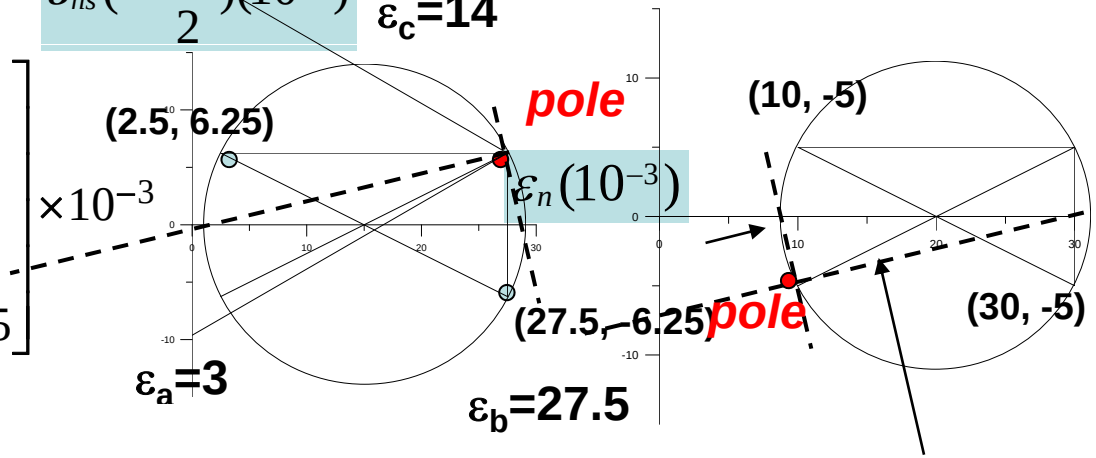
$\theta_a, \theta_b, \theta_c (= 30^o, 90^o, 150^o)$

- *岩石承受應力如下圖(僅考慮2維問題)，若岩石楊氏係數* $E = 1GPa$*，伯松比* $\upsilon = 0.25$*，剪力模數* $G = 0.4GPa$ *，請問應變規量測所得之分別爲何？最大主應變值爲何？主應變方向爲何？主應力方向爲何？主應力值爲何？(應力應變分析須以作圖法進行)*

$$\begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{bmatrix} = \begin{bmatrix} \frac{1}{E} & -\frac{\nu}{E} & 0 \\ -\frac{\nu}{E} & \frac{1}{E} & 0 \\ 0 & 0 & \frac{1}{G} \end{bmatrix} \times \begin{bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{bmatrix} = \begin{bmatrix} 2.5 \\ 27.5 \\ -12.5 \end{bmatrix} \times 10^{-3}$$

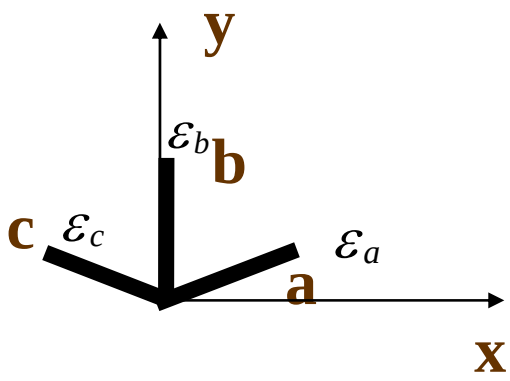
$\varepsilon_{ns} (= \frac{\gamma_{ns}}{2})(10^{-3})$

ε_c=14



瞭解根據應力應變關係獲得之主應力方向與主應變方向相同

or …



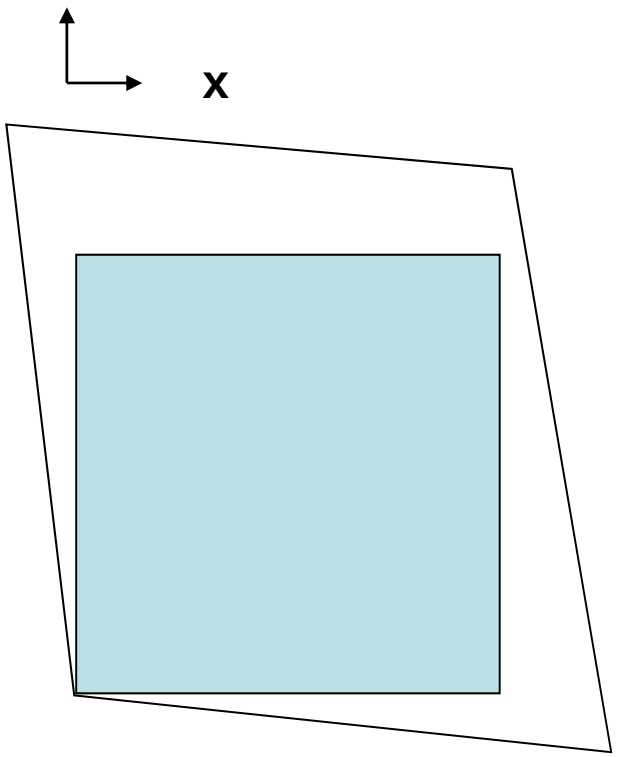
$\theta_a, \theta_b, \theta_c (= 30^o, 90^o, 150^o)$

$$\begin{Bmatrix} \varepsilon(\theta_a) \\ \varepsilon(\theta_b) \\ \varepsilon(\theta_c) \end{Bmatrix} = \begin{bmatrix} \cos^2\theta_a & \sin^2\theta_a & \frac{1}{2}\cdot\sin 2\theta_a \\ \cos^2\theta_b & \sin^2\theta_b & \frac{1}{2}\cdot\sin 2\theta_b \\ \cos^2\theta_c & \sin^2\theta_c & \frac{1}{2}\cdot\sin 2\theta_c \end{bmatrix} \cdot \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} = \begin{bmatrix} 0.75 & 0.25 & 0.433 \\ 0 & 1 & 0 \\ 0.25 & 0.75 & -0.433 \end{bmatrix} \cdot \begin{Bmatrix} 2.5 \\ 27.5 \\ -12.5 \end{Bmatrix} \times 10^{-3} = \begin{Bmatrix} 3 \\ 27.5 \\ 14 \end{Bmatrix} \times 10^{-3}$$

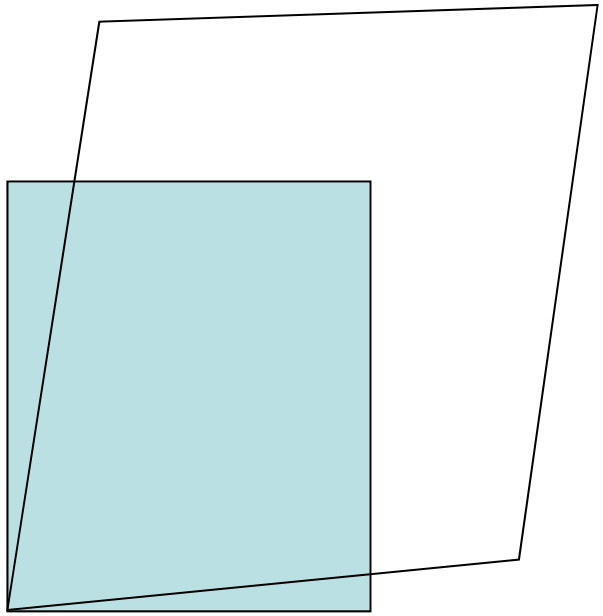
同學一定會問，爲什麼 γ_{xy} 要用負的呢？

以下說明不要與摩爾圓的正負號選擇混淆了

- 以方程式進行應力分析時之正負號選擇方法如下：
  - 根據此一原則，本考題之在方程式中剪應力及剪應變均爲負值



剪應力與剪應變爲正



剪應力與剪應變爲負

Goodman, 1989
Page 389-390;
Page 409-410

Filling

- 區隔不連續面內壁之填充材料，例如方解石、綠泥石、黏土、沉泥、斷層泥、角礫石，磨嶺石**(mylonite)**等
- 此種填充型不連續面內壁之垂直距離稱爲軟弱岩層之寬度**(width)**，恰與間隙型及開口型不連續面之內寬相對應
- 軟弱夾層之特性對不連續面的抗剪強度影響甚大，因此需仔細加以描述下列特性
  - 幾何特性：包括軟弱岩層的寬度、內壁粗糙度及現場素描
  - 軟弱夾層特性：包括礦物成分、顆粒尺寸與級配、風化程度、土壤指數參數、膨脹潛能等
  - 軟弱夾層強度：包括手測指數分級表**(manual index，S1-S6)**、抗剪強度、過壓密比、有無剪動、擦痕之形跡等
  - 滲流特性：包括含水量**(**分爲**W1-W6**六級**)**及定量之滲透性資料

Seepage

無軟弱夾心

滲水分級	滲水情況
1	極緊閉、乾燥，不可能滲水者
2	乾燥，無滲水跡象
3	乾燥但有滲水跡象
4	潮濕，尚無流水
5	滲水，偶有水滴但無連續流水
6	連續流水（應說明流量及水壓）

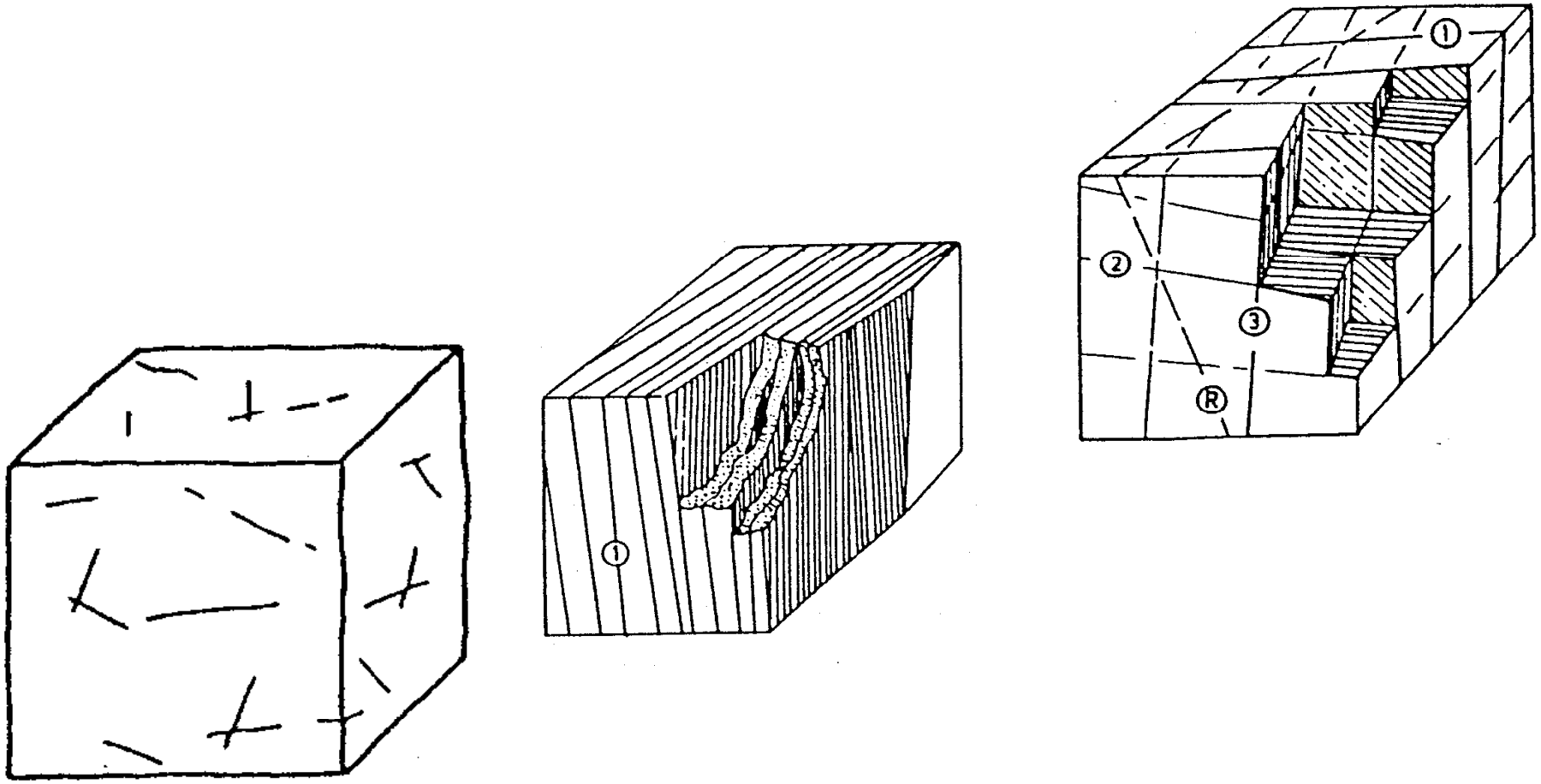
有軟弱夾心

滲水分級	滲水情況
1	軟弱夾層爲高度過份壓密而乾燥者，透水性低，不易有顯著滲流
2	軟弱夾層潮濕，尚無流水
3	軟弱夾層濕潤，偶有水滴
4	少部分軟弱夾層被水沖失，水流連續（說明流量）
5	部分軟弱夾層被水沖失，顯著水流（說明流量、水壓）
6	軟弱夾層全部沖失，挖開之初水壓很高

Number of sets

分 級	說　　明
Ⅰ	巨厚狀，偶有零星節理
Ⅱ	一組節理
Ⅲ	一組節理+零星節理
Ⅳ	二組節理
Ⅴ	二組節理+零星節理
Ⅵ	三組節理
Ⅶ	三組節理+零星節理
Ⅷ	四組節理或更多
Ⅸ	粉碎岩石，土壤狀

Number of sets



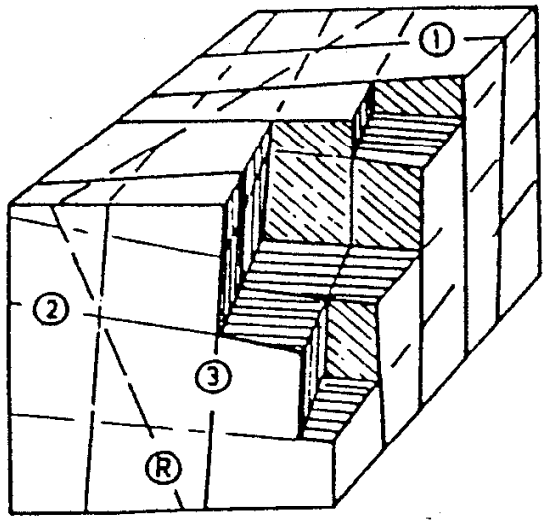
岩體呈 (a)巨厚狀；(b)受一組節理；或(c)三組節理切割

Block size

Block size index : $I_b = \dfrac{S_1 + S_2 + S_3}{3}$

To represent the average dimension of typical rock block.

May not give a realistic value if there are more than three sets of joints.



Block size

The volumetric joint count (Jv) has been described by Palmström (1982, 1985, 1986). It is a measure of the number of joints within a unit volume of rock mass, defined by

$$Jv = \frac{1}{S1} + \frac{1}{S2} + \frac{1}{S3} + \ldots$$

where S1, S2, S3 are the joint spacings.

It is not possible to obtain good correlations between RQD and Jv or between RQD and other measurements of jointing. Palmström (1982) presented the following simple expression:

$$RQD = 115 - 3.3\ Jv$$

Here RQD = 0 for Jv > 35, and RQD = 100 for Jv < 4.5

Especially where many of the core pieces have lengths around 0.1 m, the correlation above may inaccurate. However, when RQD is the only joint data available, it probably the best simple transition from RQD via Jv to block volume.

Block size

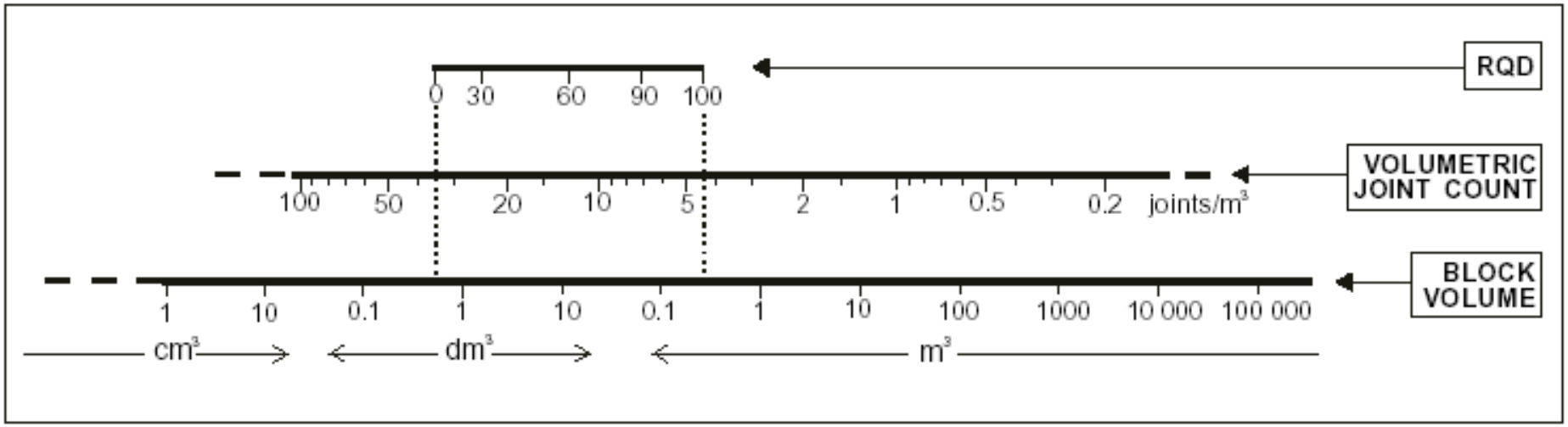


Figure 10 Block size (Vb) and volumetric joint count (Jv) cover a significantly larger interval of the jointing range than the RQD.

Block size

Description of block size according to Jv (ISRM)	
Description of blocks	**Jv (joints/m^3)**
Very large blocks	**＜1**
Large blocks	**1~3**
Medium-size blocks	**3~10**
Small blocks	**10~30**
Very small blocks	**30~60**
Crushed rock	**＞60**

Block size

- Massive = few joints or very wide spacing
- Blocky = approximately equi-dimensional
- Tabular = one dimension considerably smaller than the other two
- Columar = one dimension considerably larger than the other two
- Irregular = wide variations of block size and shape
- Crushed = heavily jointed to “sugar cube”

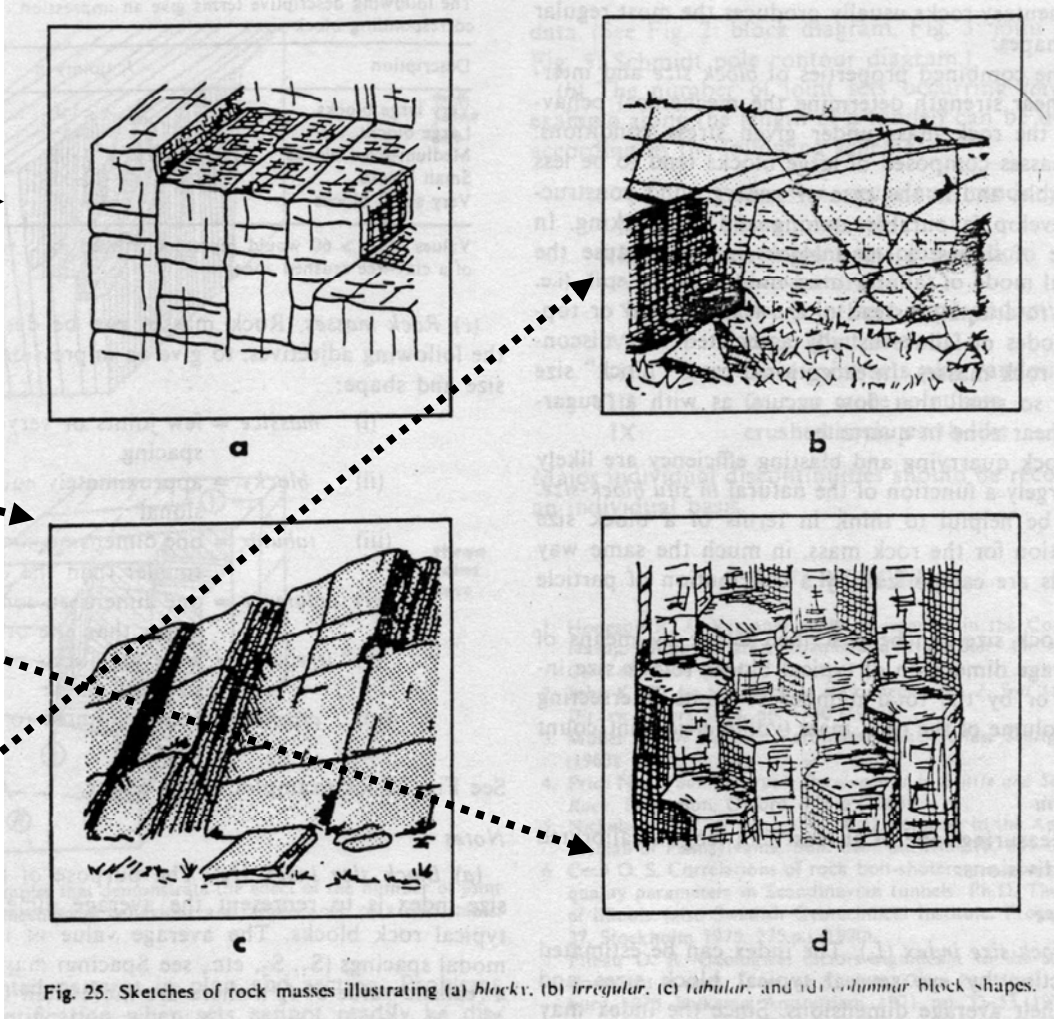
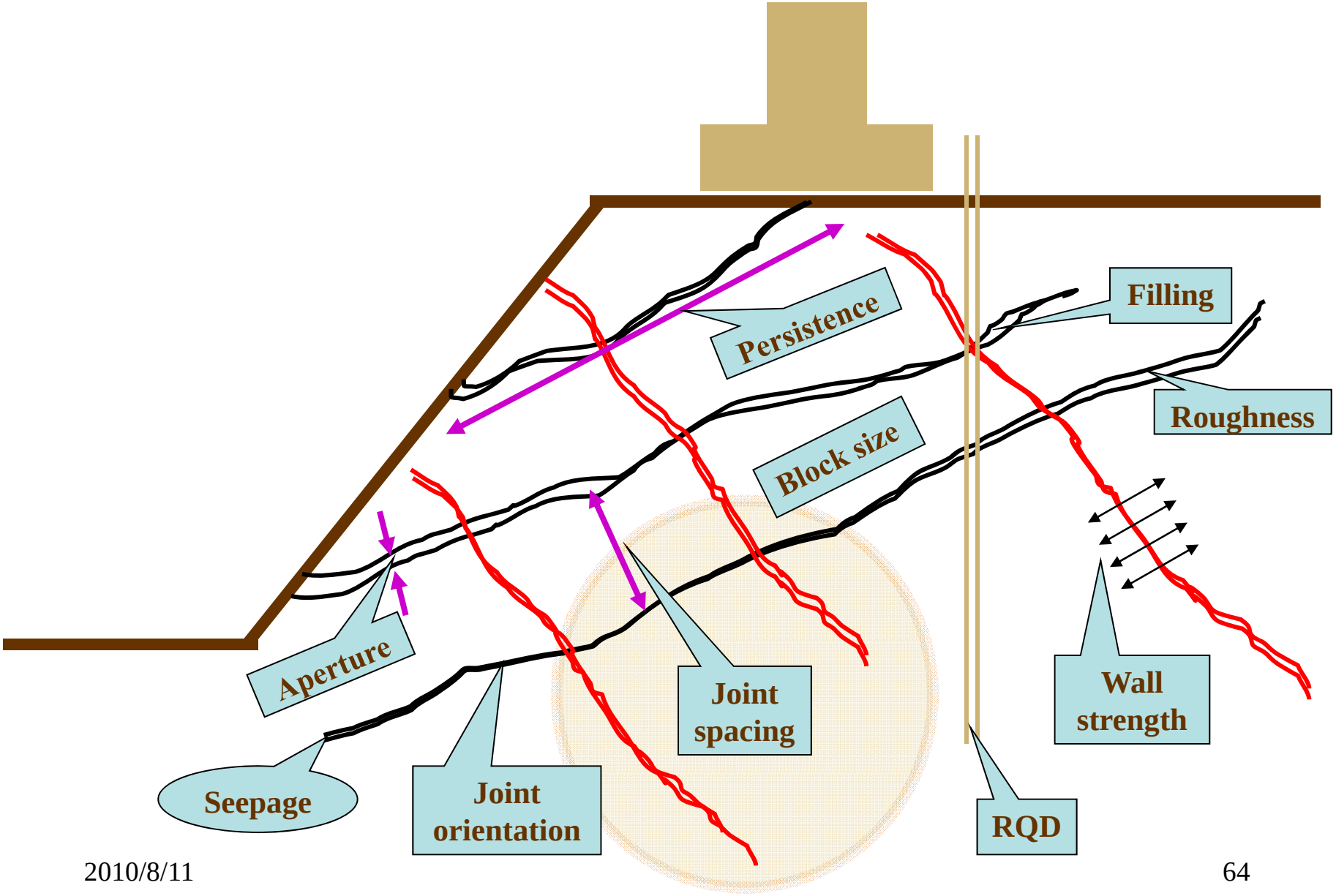


Fig. 25. Sketches of rock masses illustrating (a) *blocky*, (b) *irregular*, (c) *tabular*, and (d) *columnar* block shapes.

Rock mass parameters



節理調查方法

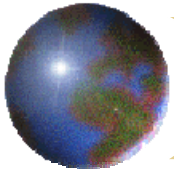
- 主觀取樣
- 視窗取樣
- 掃描線取樣(scanline sampling) **(Priest,1993)**

Intersention distance(m)	Dip Direction (Degrees)	Dip Angle (Degrees)	Semi-trace length(m) above or left of scan line	Semi-trace length(m) below or right of scan line	Termination I=1, A=2 ,O=3	
0	247	50	0.09	0.01	2	2
0.55	190	85	0	0.05	2	2
0.83	204	85	0.03	0.06	2	2
1.00	230	85	0.02	0.02	2	2
1.50	348	90	0.03	0.08	2	2
1.77	306	50	0.09	0.01	2	2
2.54	318	75	0.04	0.19	2	2
2.72	240	60	0.13	0.01	2	2
3.07	240	65	0.06	0.01	2	2
3.33	226	45	1.96	1.63	2	2
3.65	240	45	0.01	0.1	2	2
3.74	250	60	0.12	0.03	2	2
4.99	350	70	0.1	0.01	2	2
5.87	290	50	0.04	0.04	2	2
6.57	16	65	0.03	0.04	2	2

Detail of scanline:
Trend 60
Plunge 15
Length 6.69

Details of rock face:
Dip direction 286
Dip angle 38
Non-overhanging
Height m
Width m

Rock type
薄層砂岩夾薄葉層頁岩
Condition of exposure:
中度風化
內覓 tight



HW1

- Ch 3, problem 1(a) and problem 6

Apparent dip and True dip

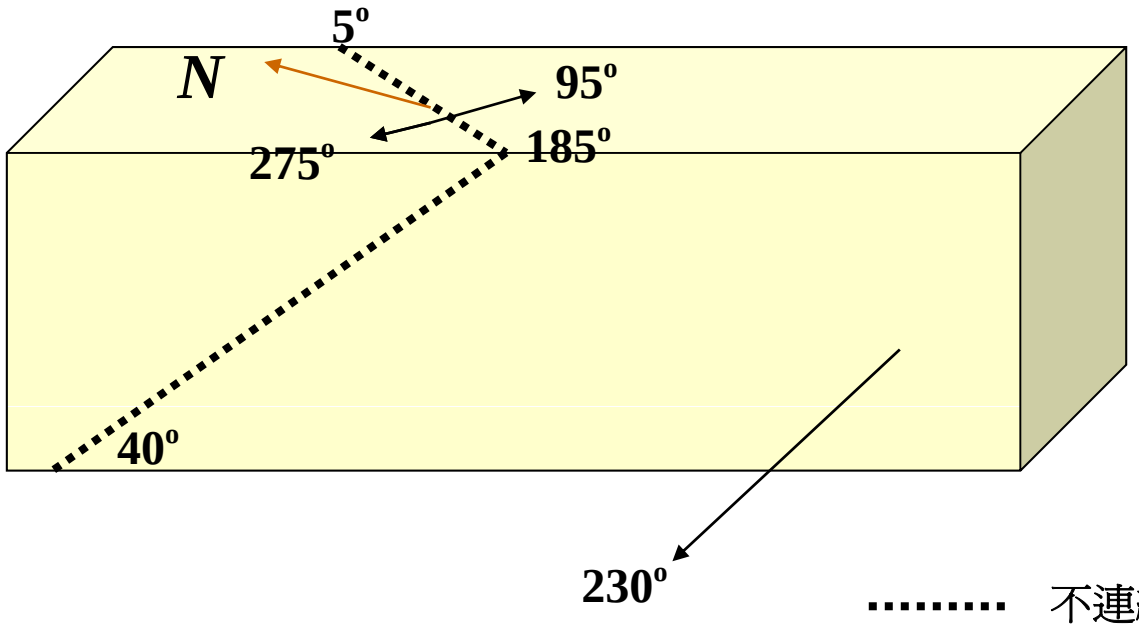
- Ch 3 problem 6

$$\tan\beta_a = \sin\delta \cdot \tan\beta_t$$

$$\delta = 0^o, \beta_a = 0^o$$

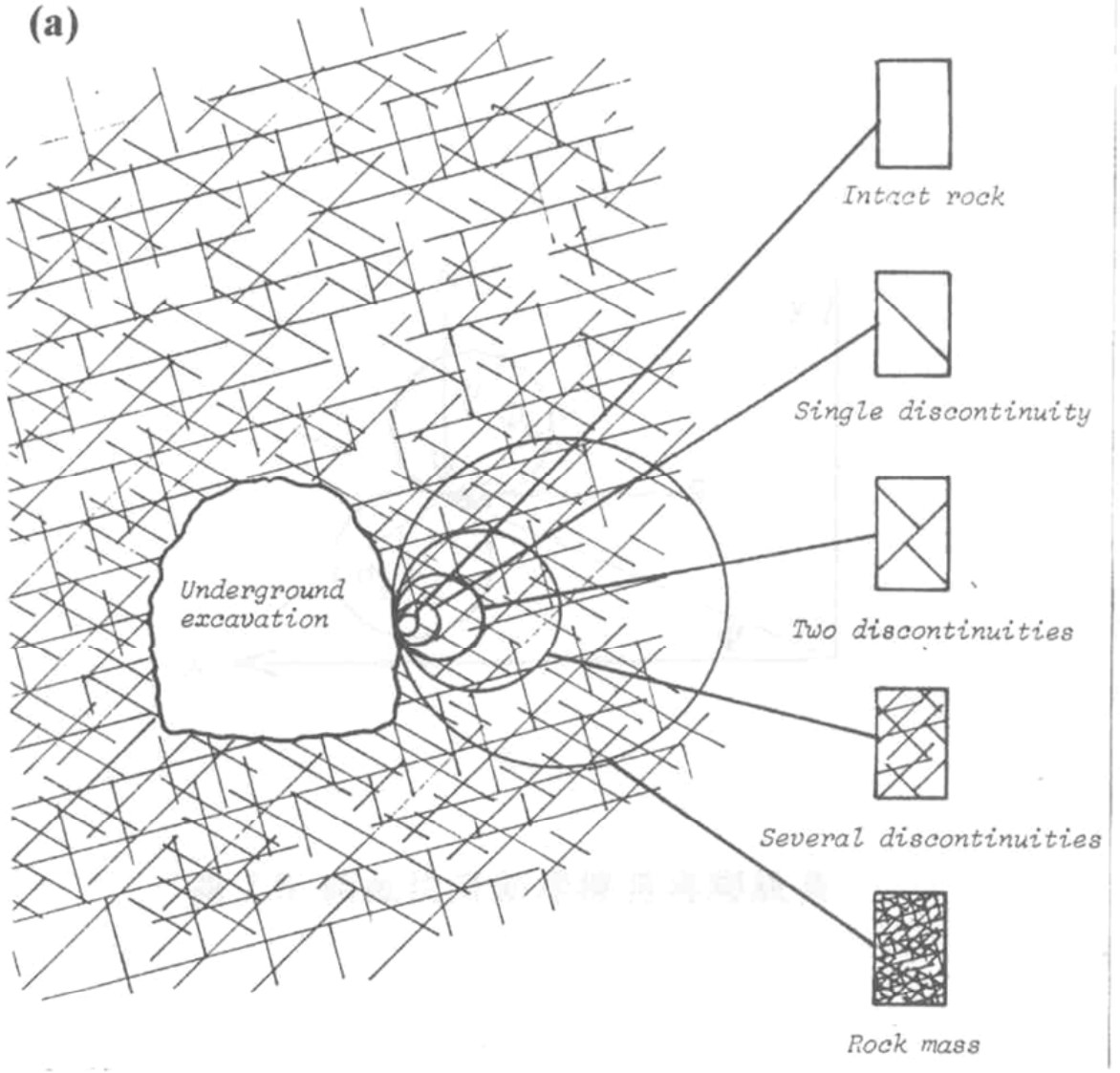
$$\delta = 90^o, \beta_a = \beta_t$$

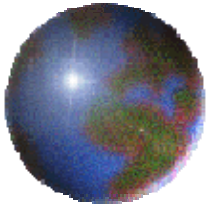
δ Angle between dip direction of discontinuity and outcrop surface



..... 不連續面與隧道壁面之相交軌跡

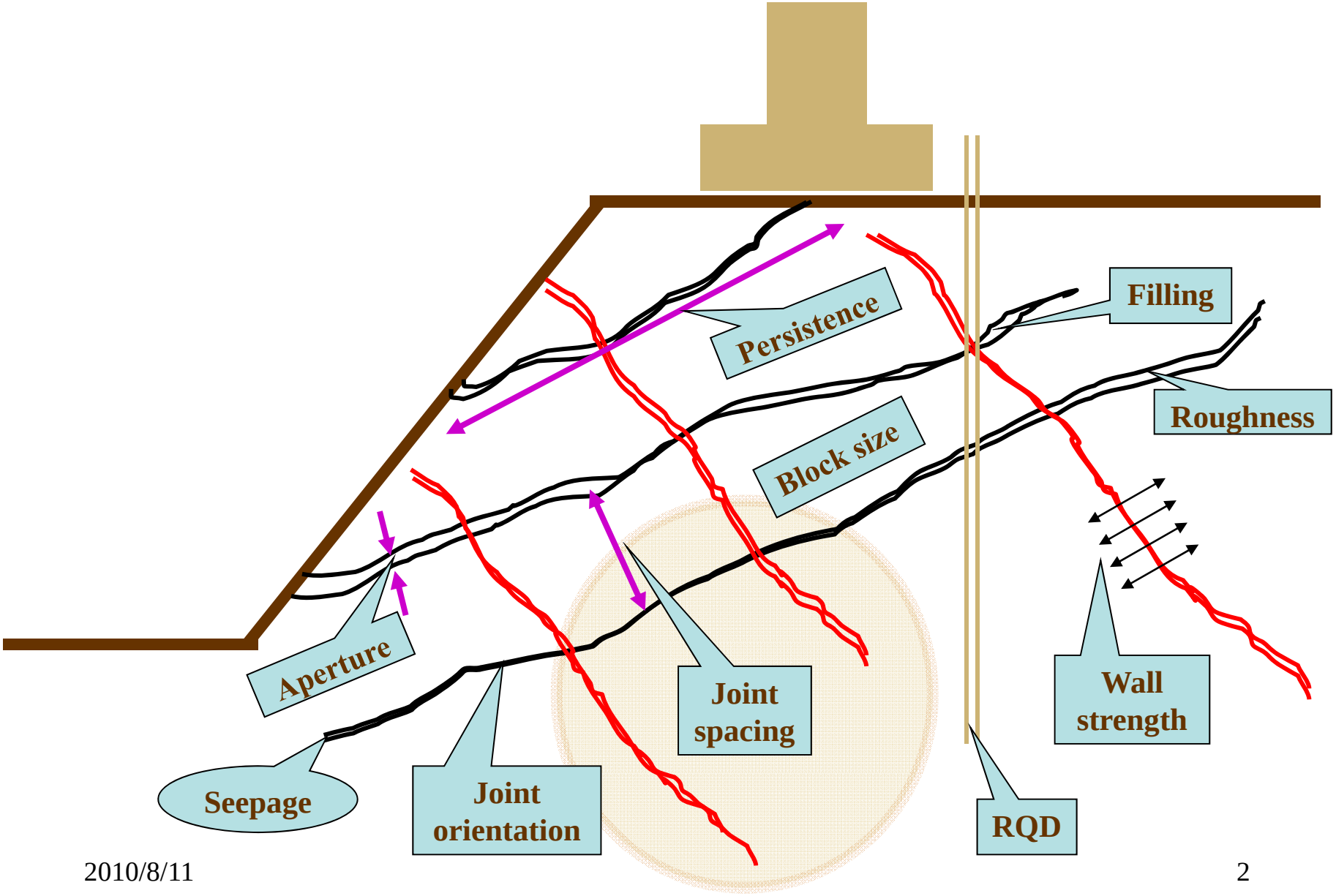
Scale-dependency for rock engineering





2 Discontinuities of rock mass

Rock mass parameters

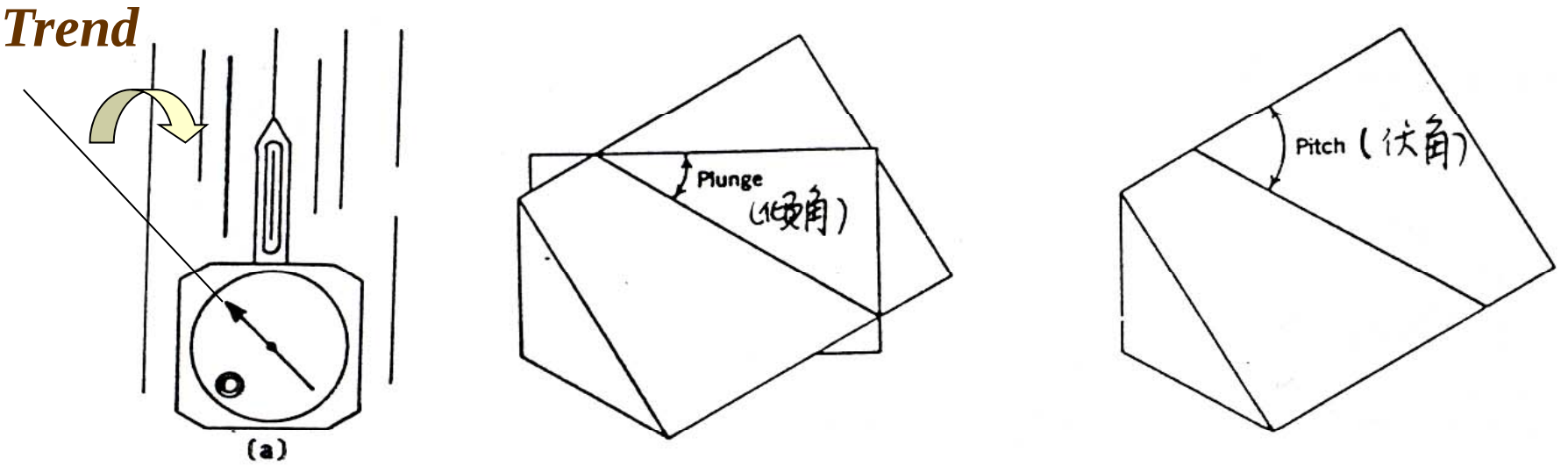


Quantitative description of discontinuities in rock masses

- Orientation
- Spacing
- Persistence
- Roughness
- Wall strength
- Aperture
- Filling
- Seepage
- Number of sets
- Block size

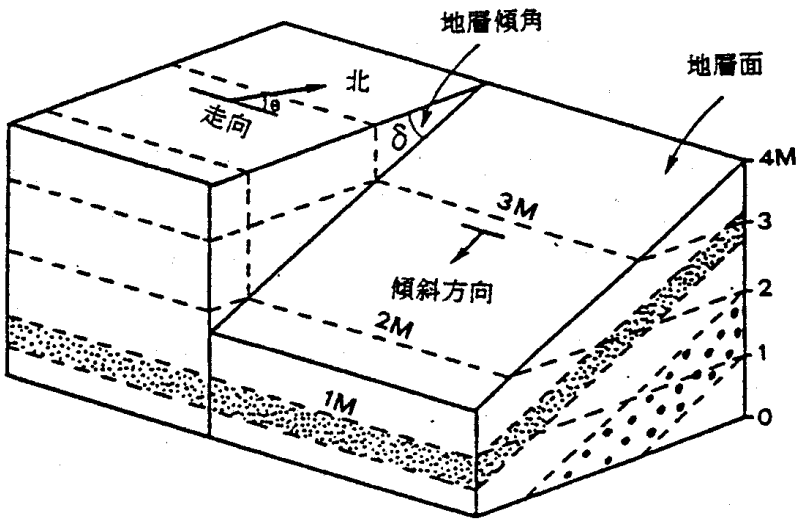
Orientation

- **The orientation of any given line in three dimensional space can be recorded in terms of its Trend (α) and Plunge (β) (eg.240/45)**
- **Pitch : The acute angle measured in some specified plane between a given line and the strike of the plane**



Orientation

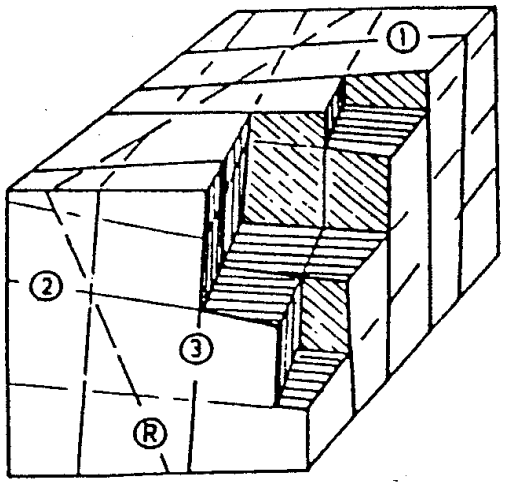
- **Using the line of maximum dip of an inclined plane α_d and β_d (dip direction) to express the orientation of a plane (e.g. 270/45).**
- **Alternatively, using strike and dip angle to express the orientation of a plane (e.g. NS/S45).**



How to display the orientation data

For major fracture zone (e.g. major faults), fully describe its position and its extension

How about minor joints ?



Intersention distance(m)	Dip Direction (Degrees)	Dip Angle (Degrees)	Semi-trace length(m) above or left of scan line	Semi-trace length(m) below or right of scan line	Termination I=1, A=2 ,O=3	
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Detail of scanline:
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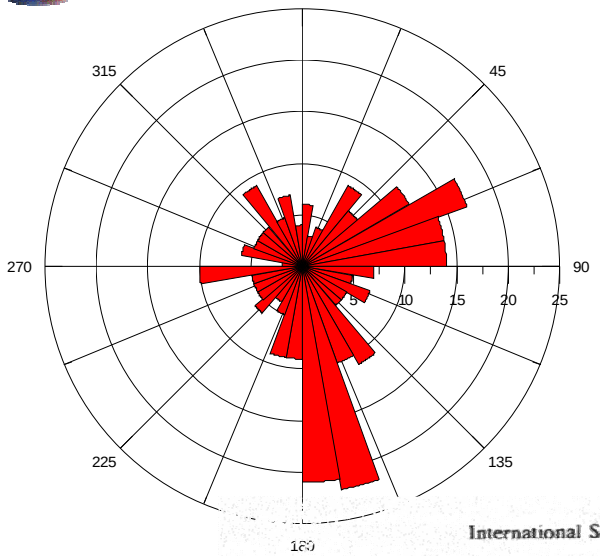
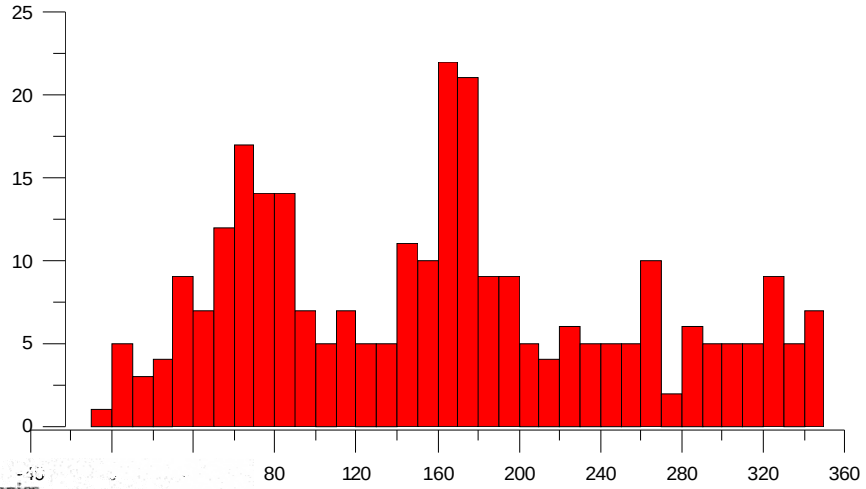
Plunge 15
Length 6.69

Details of rock face:
Dip direction 286
Dip angle 38
Non-overhanging
Height m
Width m

Rock type
薄層砂岩夾薄葉層頁岩
Condition of exposure:
中度風化
內寬 tight





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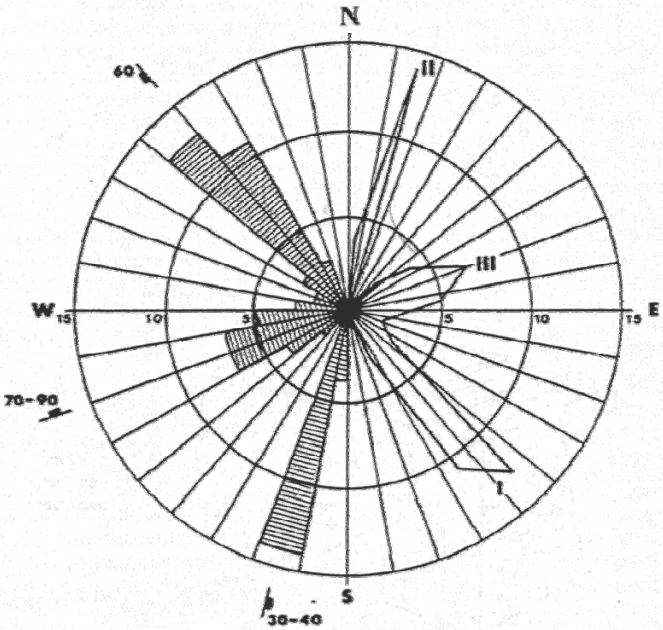
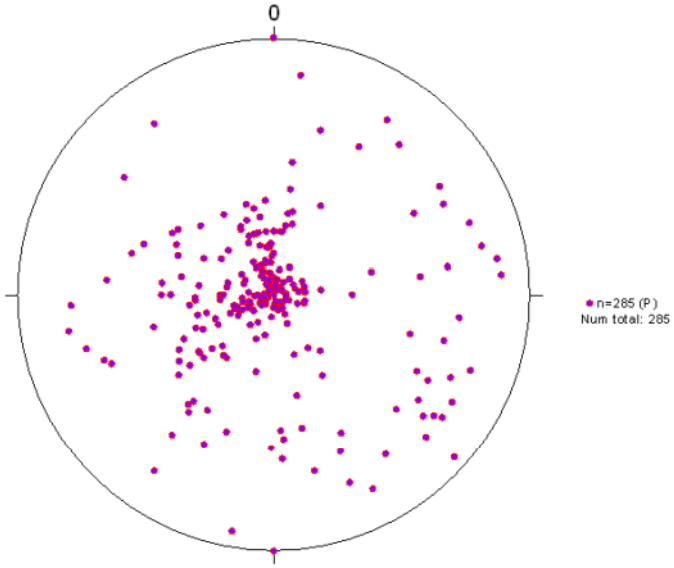
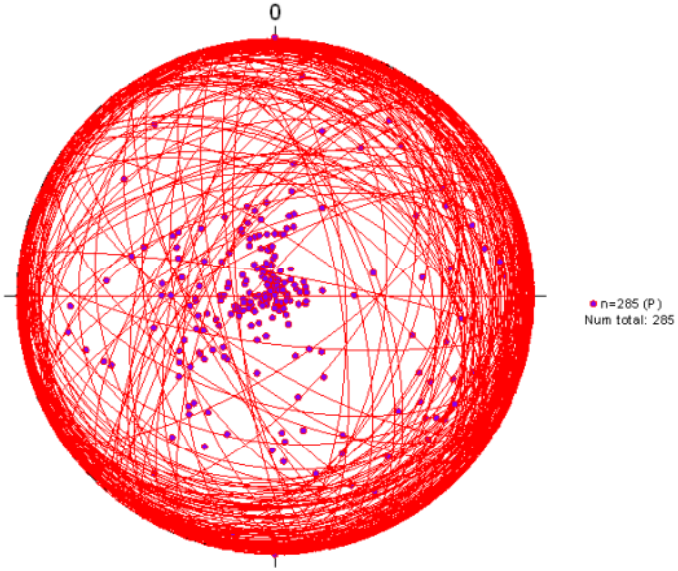


Fig. 3. Two methods of representing orientation data on a joint rosette.

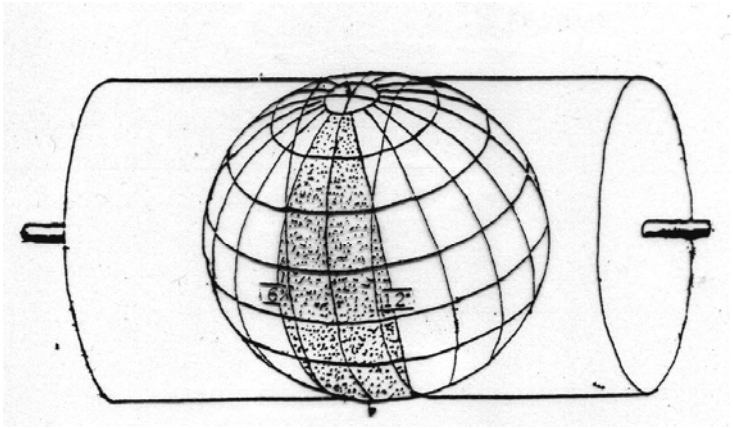


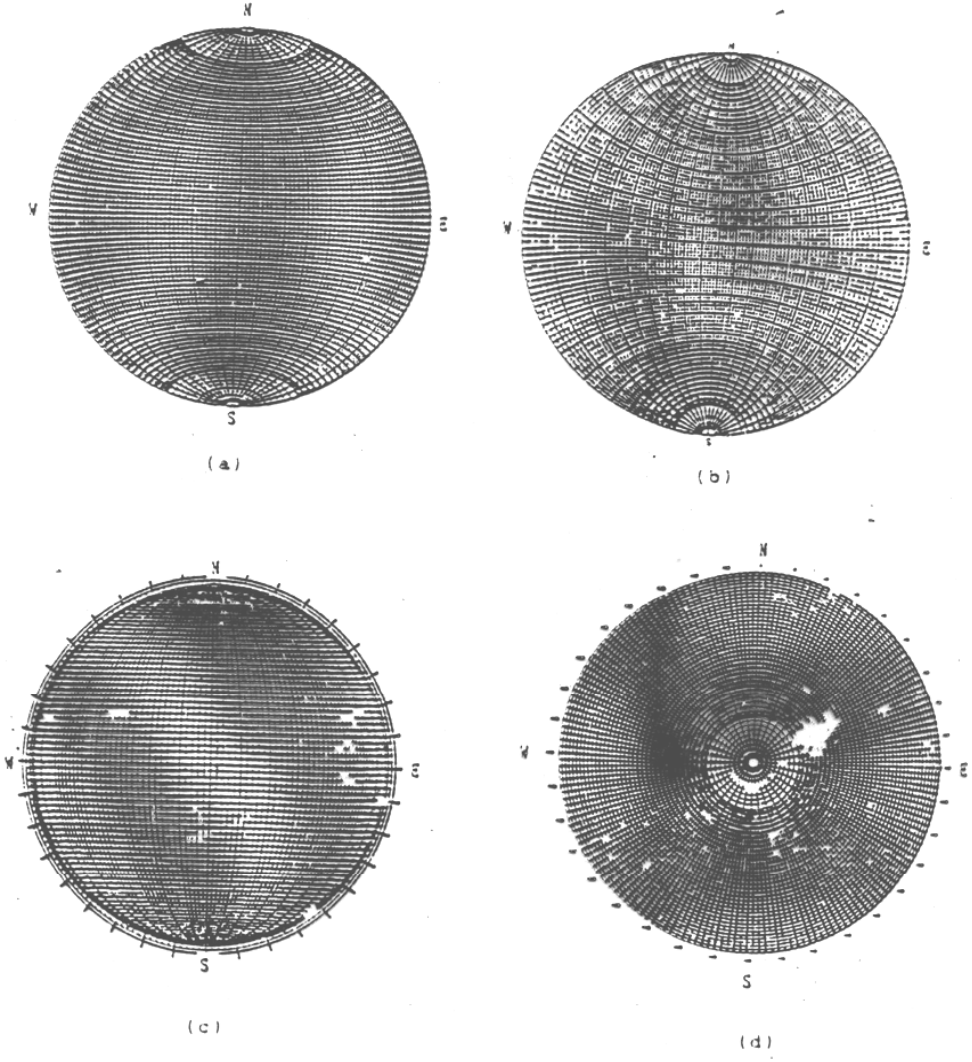
Equal area projection, lower hemisphere



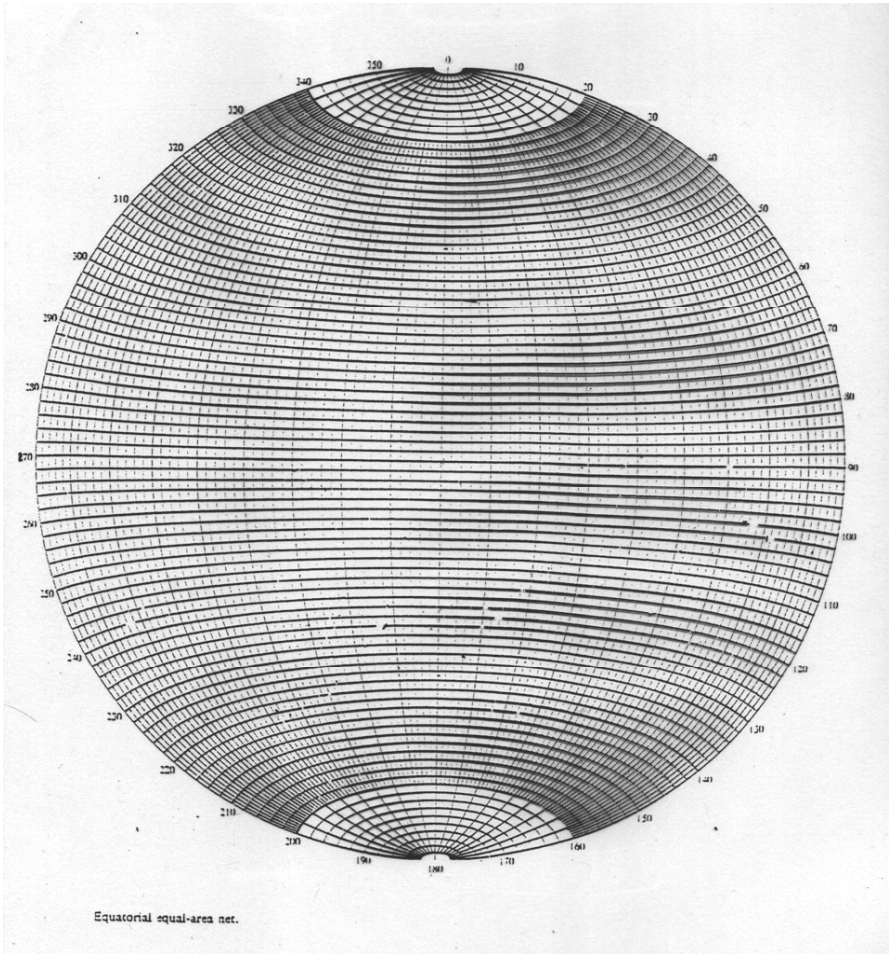
Equal area projection, lower hemisphere

Hemispherical projection





各種立體投影網(a)施密特網(b)吳爾福立體投影網
(c)正交投影網(d)極座標投影網



Equatorial equal-area net.

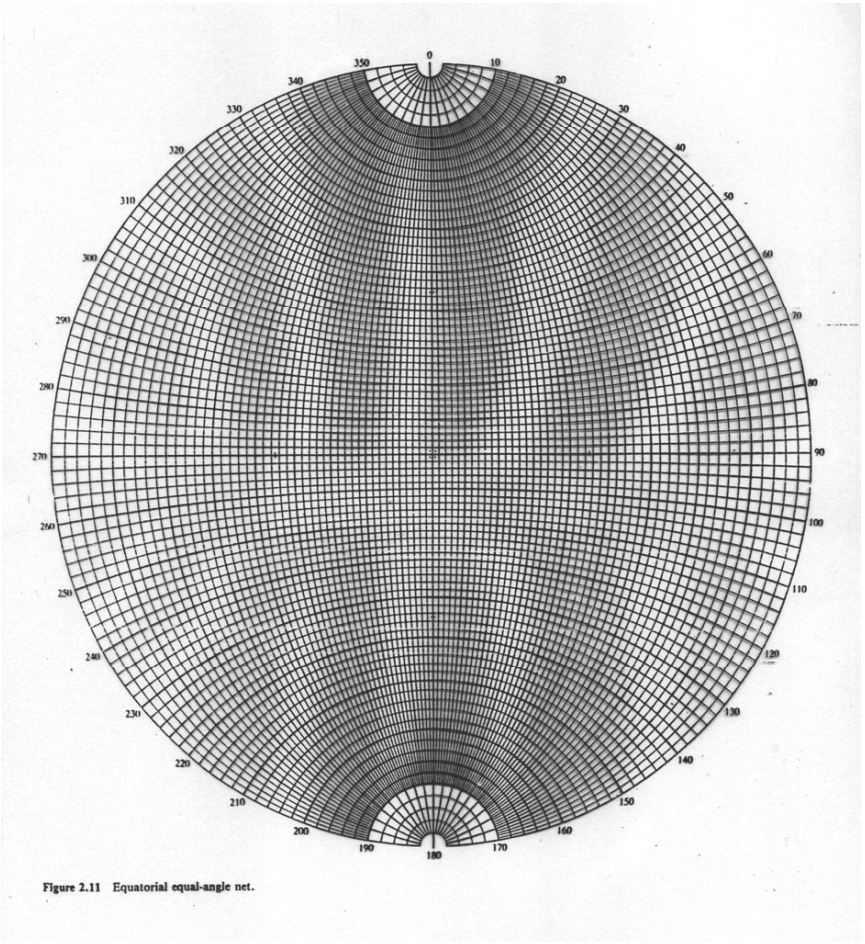


Figure 2.11 Equatorial equal-angle net.

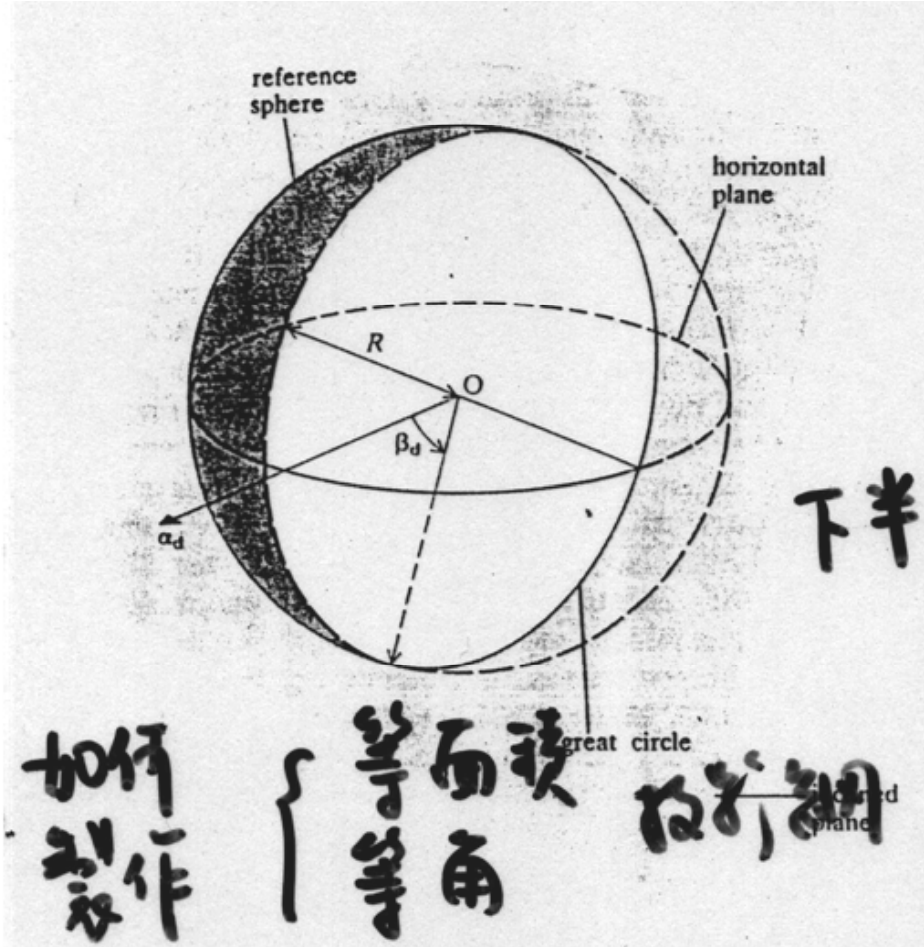


Figure 2.7 The great circle of an inclined plane.

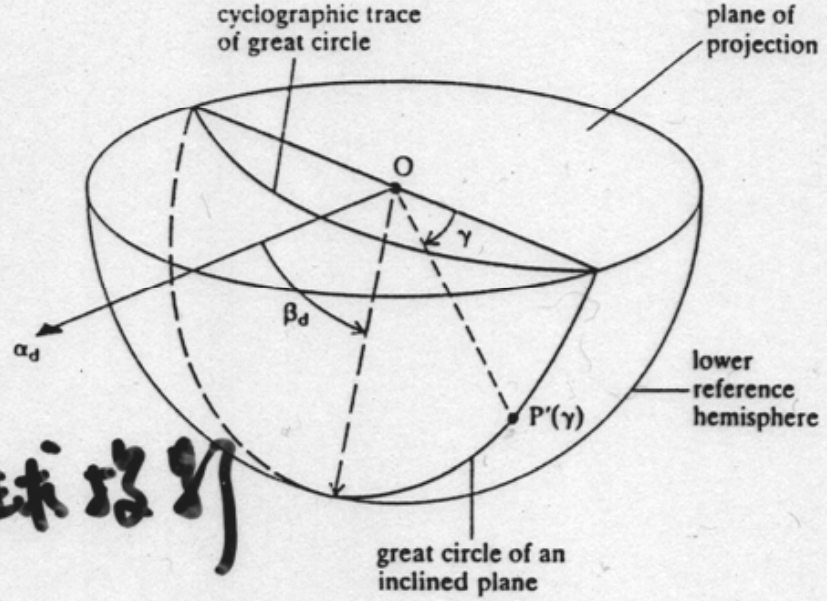


Figure 2.8 The cyclographic trace of a great circle.

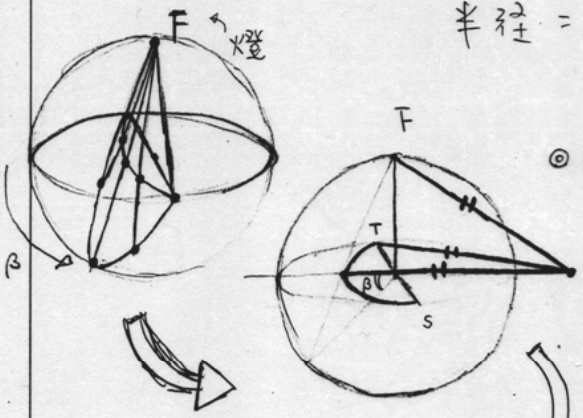
which has its centre at a radial distance

$$r_g = R \tan \beta_d$$

from the centre of the projection measured along a radial line of azimuth $\alpha_d \pm 180^\circ$. This construction is shown in Figure 2.9a. On an equal-area construction, the great circle

◎ 大圓的意義？

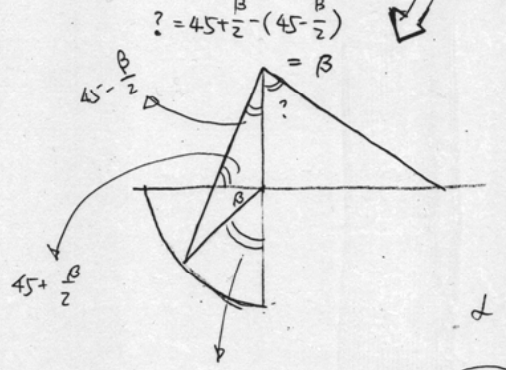
◎ 如何畫大圓？ 圓心＝？ 半徑＝？



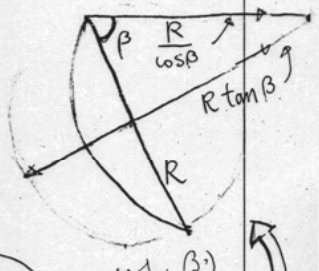
◎ 圓心所在座標
半徑均相等

◎ 基於β角平面之投影

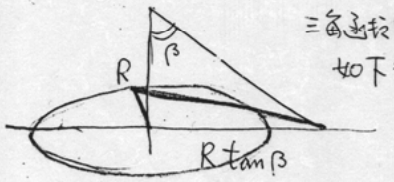
先看垂直切面

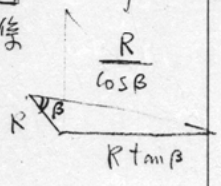


◎ 找到圓心與半徑



三角函數關係如下：





再看水平面

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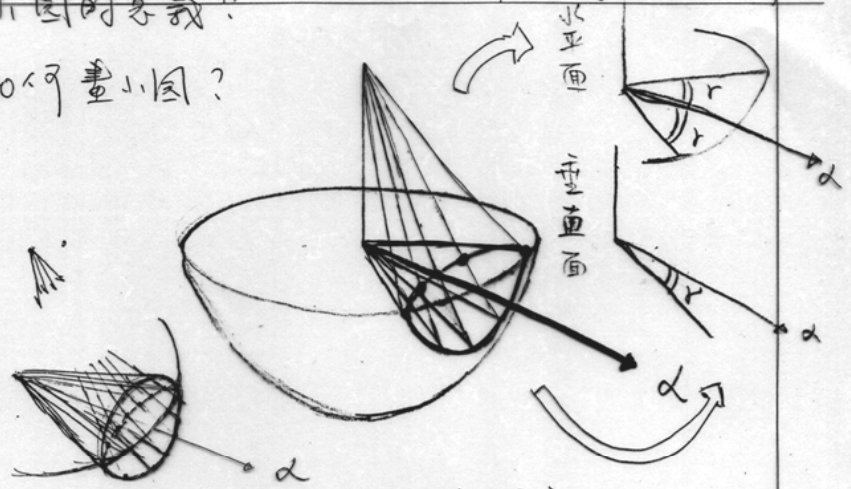
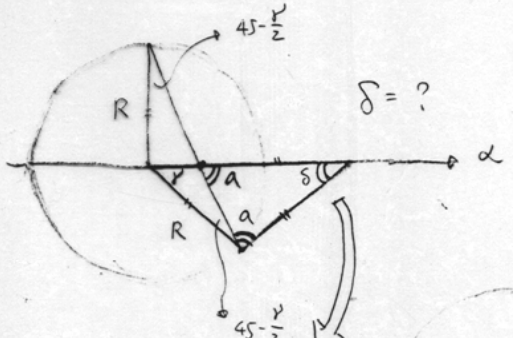
◎ 小圓的意義？

◎ 如何畫小圓？



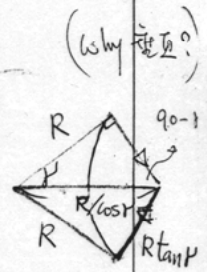
◎ 與α等角度（γ）投影到水平面形成小圓

先看垂直面



→ $a = \gamma + 45 - \frac{\gamma}{2} = 45 + \frac{\gamma}{2}$

→ $\delta = 180 - 2a = 90 - \gamma$



再看水平面

找到圓心與半徑

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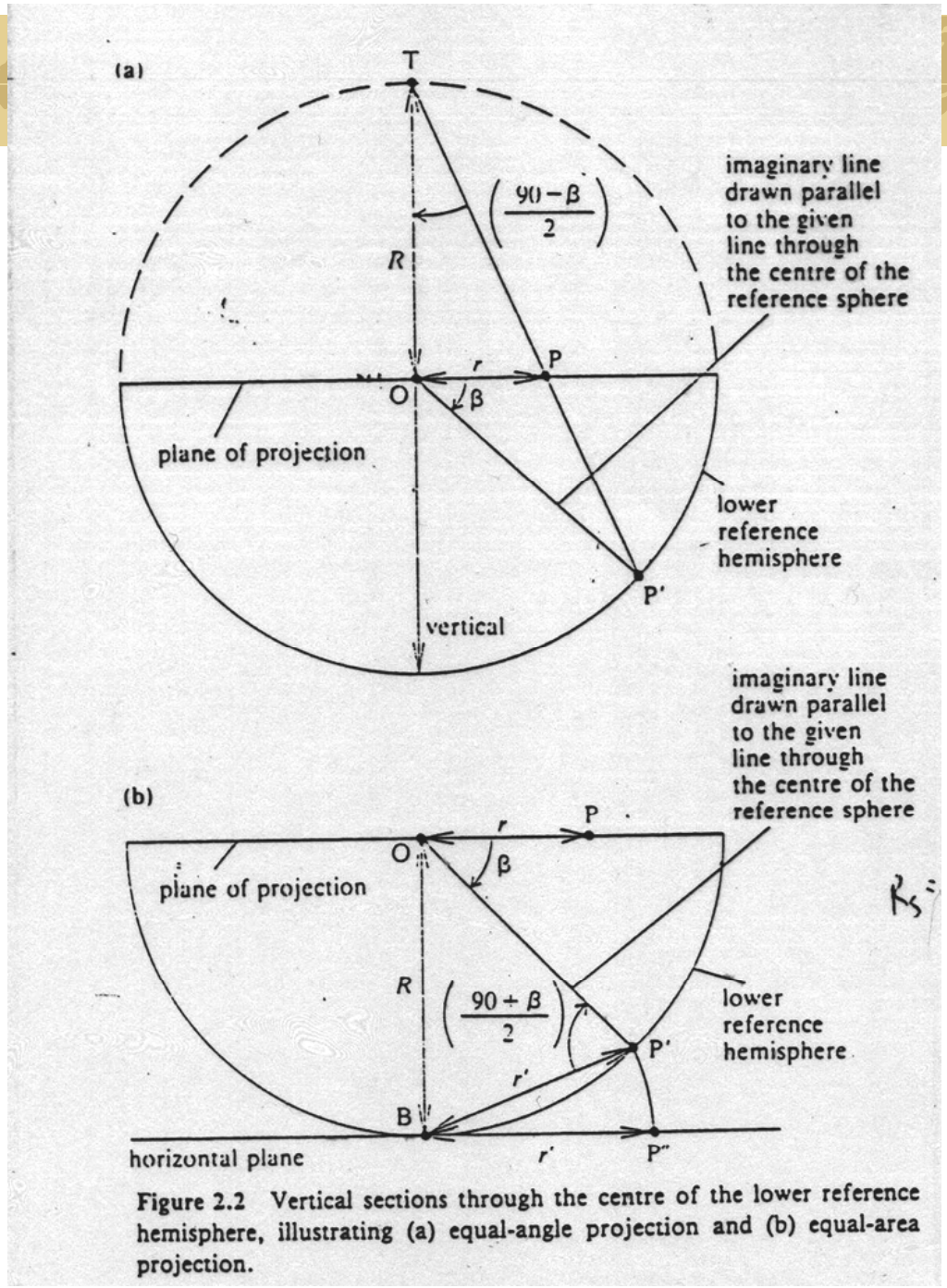


Figure 2.2 Vertical sections through the centre of the lower reference hemisphere, illustrating (a) equal-angle projection and (b) equal-area projection.

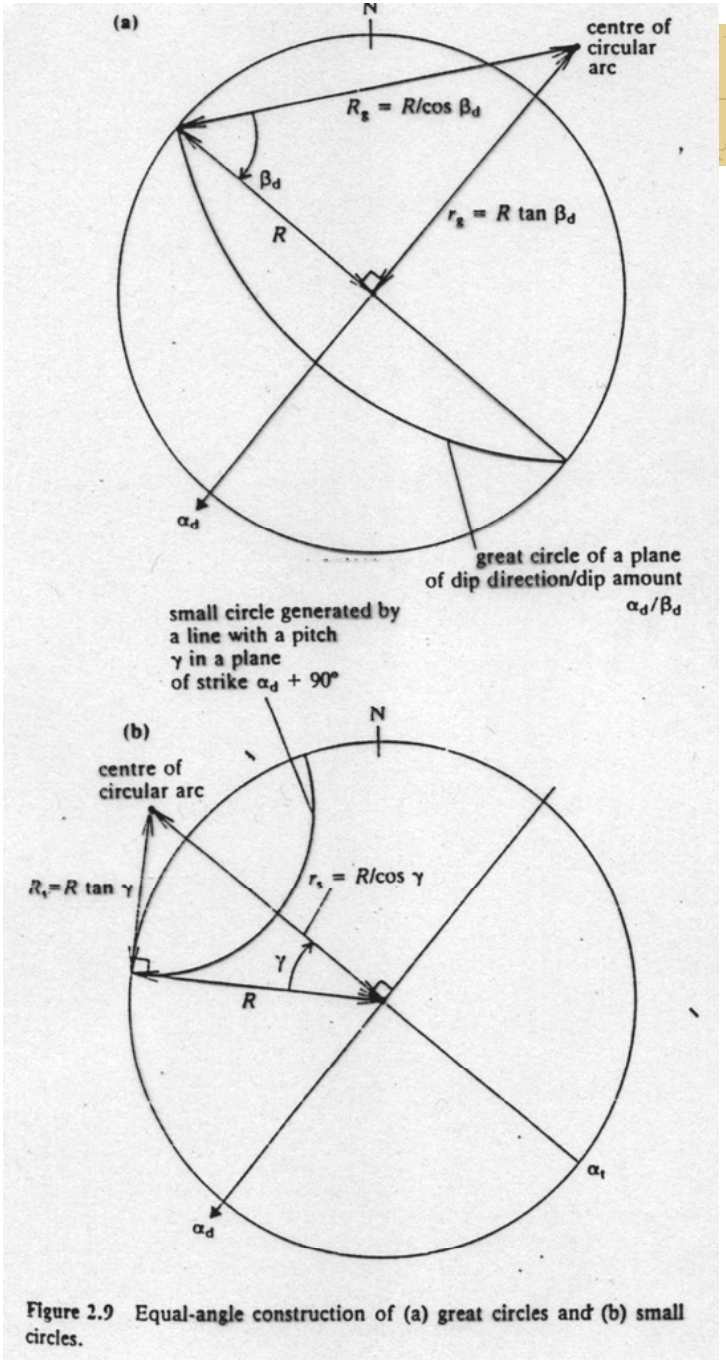


Figure 2.9 Equal-angle construction of (a) great circles and (b) small circles.

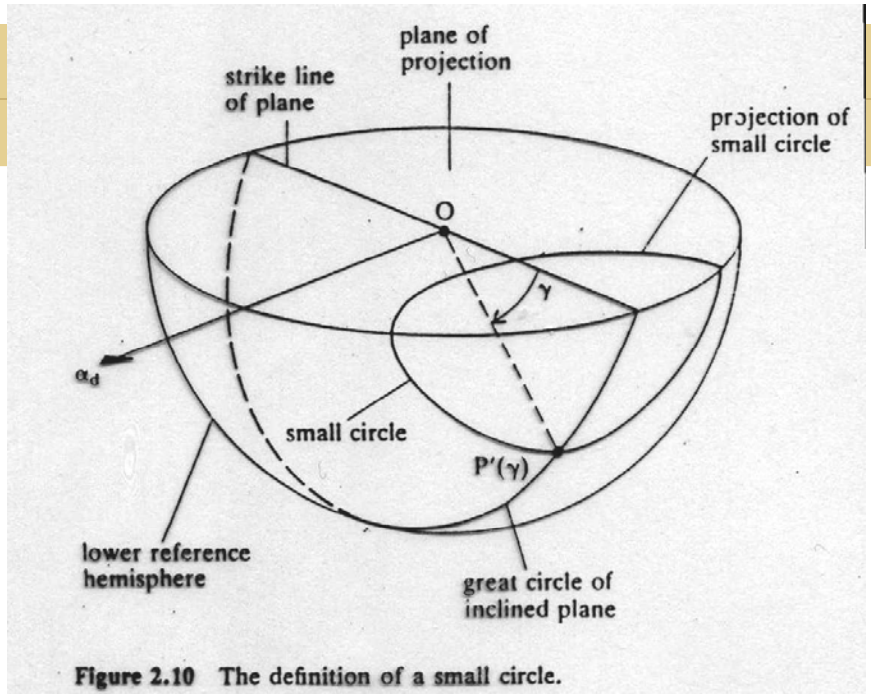


Figure 2.10 The definition of a small circle.

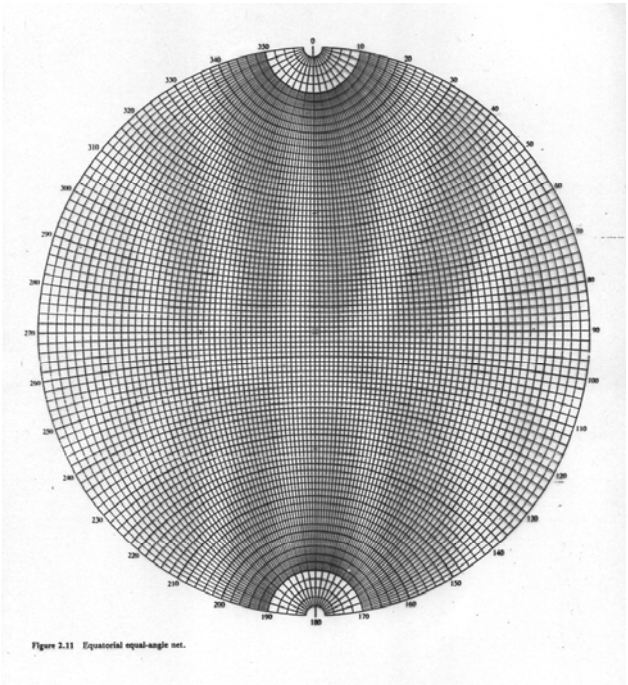


Figure 2.11 Equatorial equal-angle net.

大圓：
某個南北走向的面與球相交之線投影到水平面

小圓：
與某方向夾某一角度 “甜筒” 投影到水平面

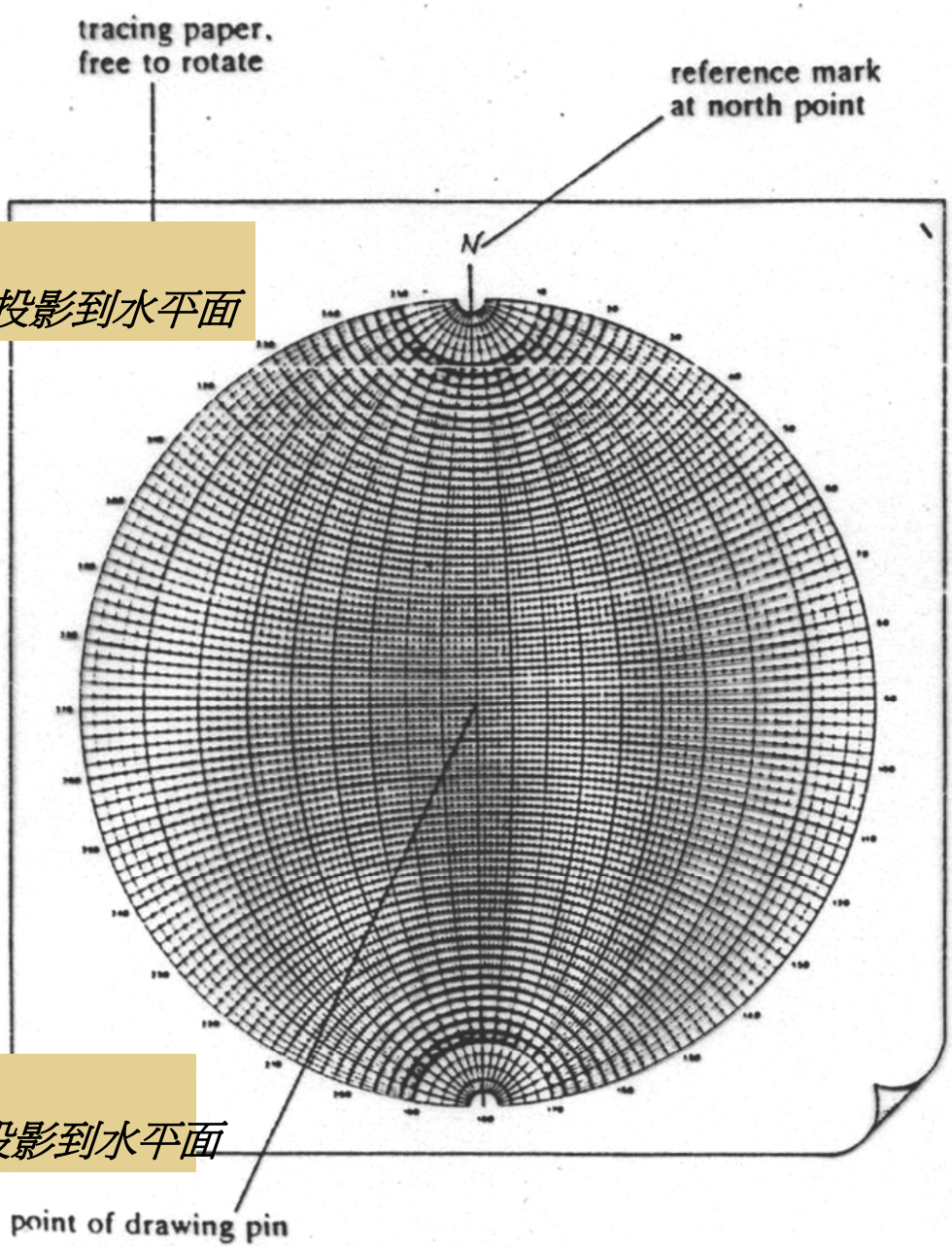


Figure 3.1 The use of a tracing-paper overlay with the net.

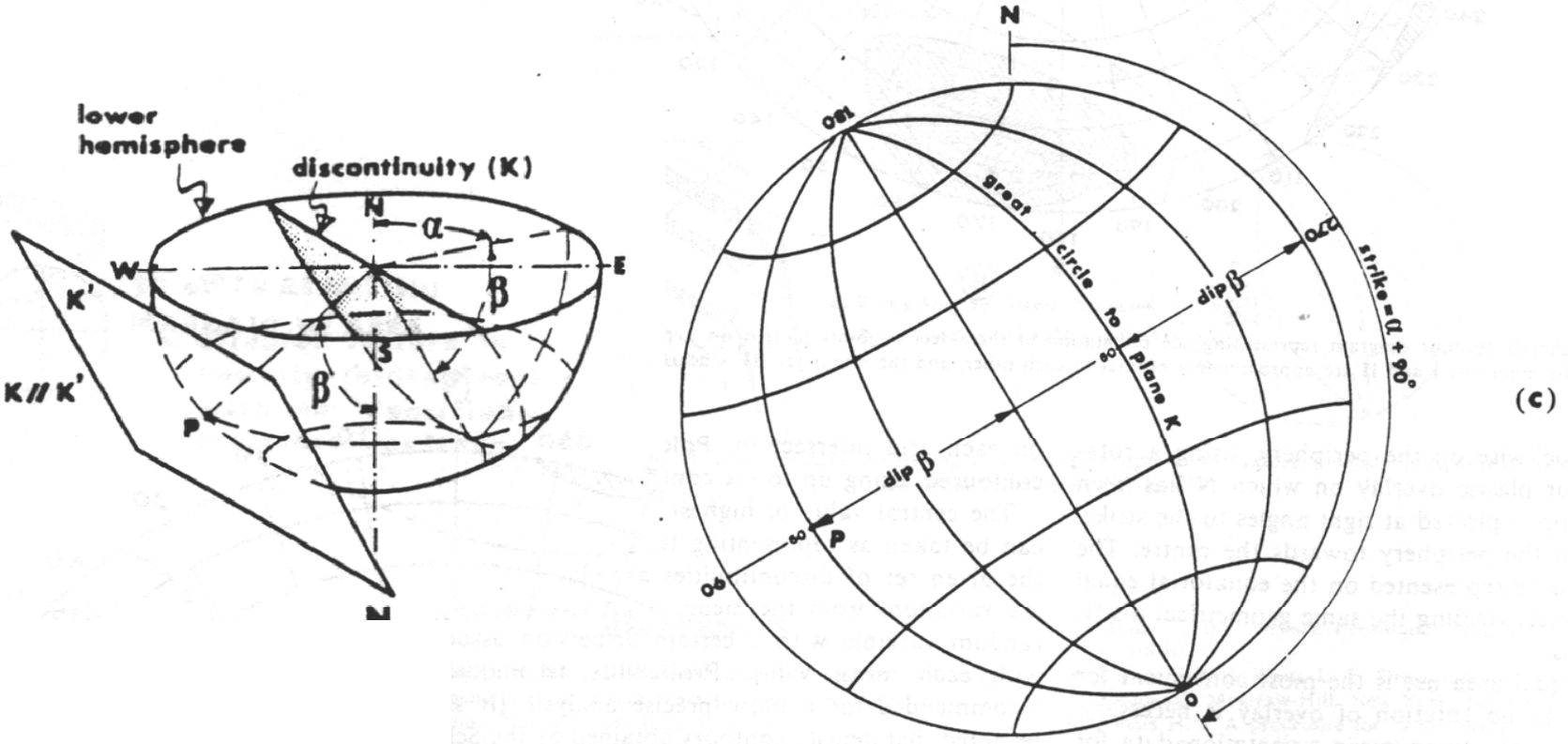
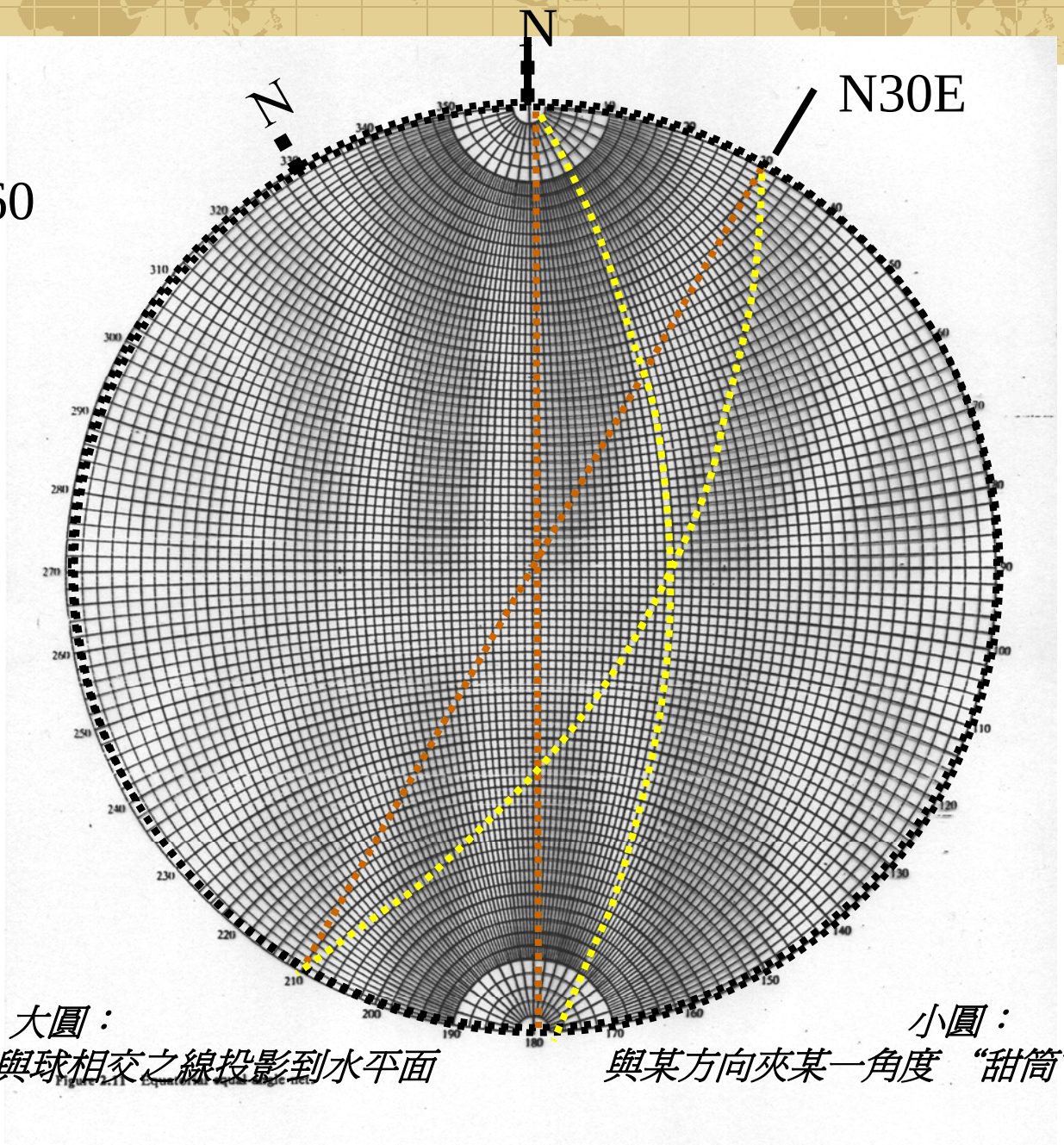


Fig. 4. Method of representing a discontinuity K as a pole P and as a great circle on a polar equal-area net (b) and on an equatorial equal-area net (c), using the lower reference hemisphere. A rotatable transparent overlay is used with the equatorial equal-area net.

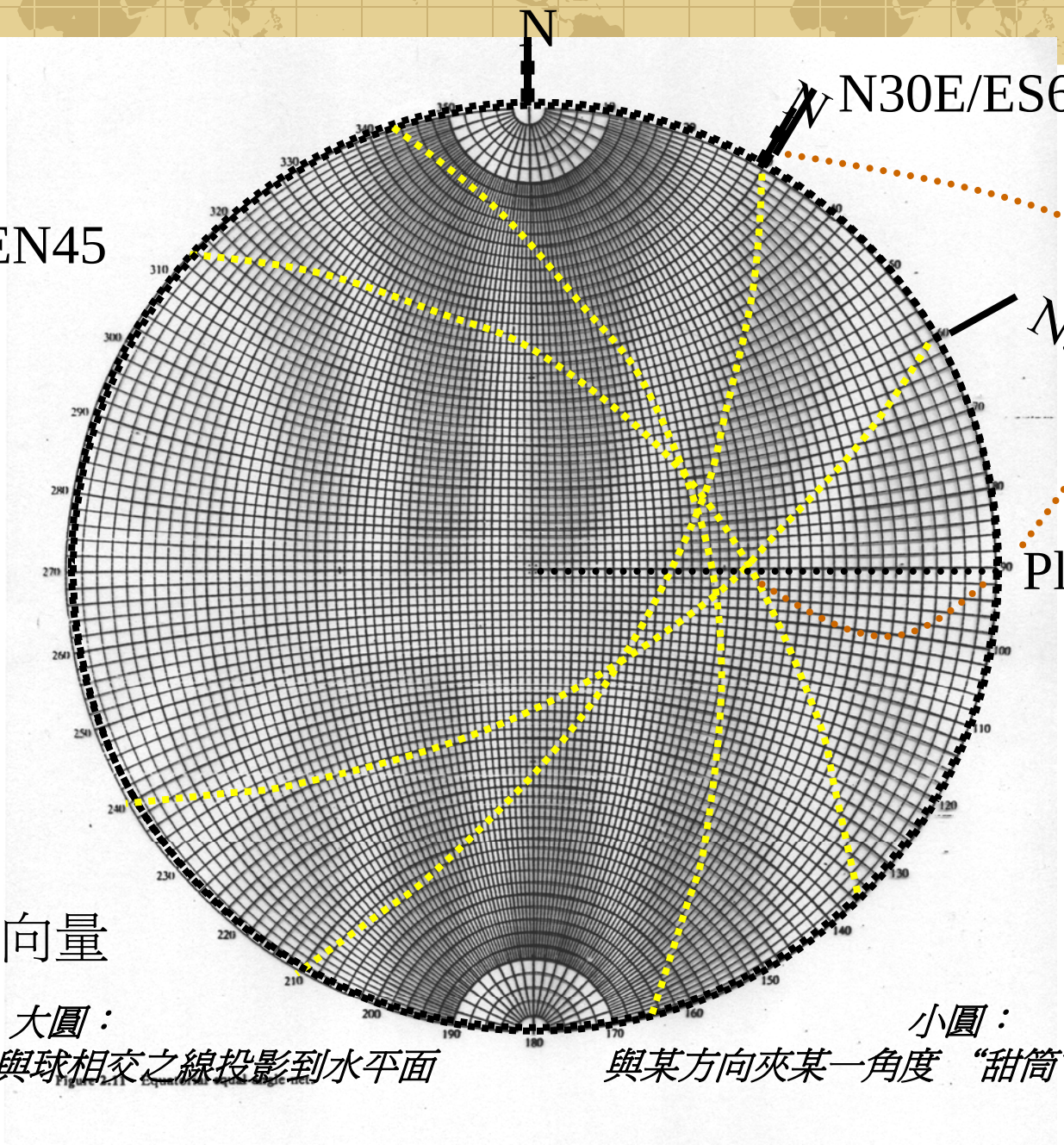
N30E/ES60



ES60

大圓：
某個南北走向的面與球相交之線投影到水平面

小圓：
與某方向夾某一角度 “甜筒” 投影到水平面

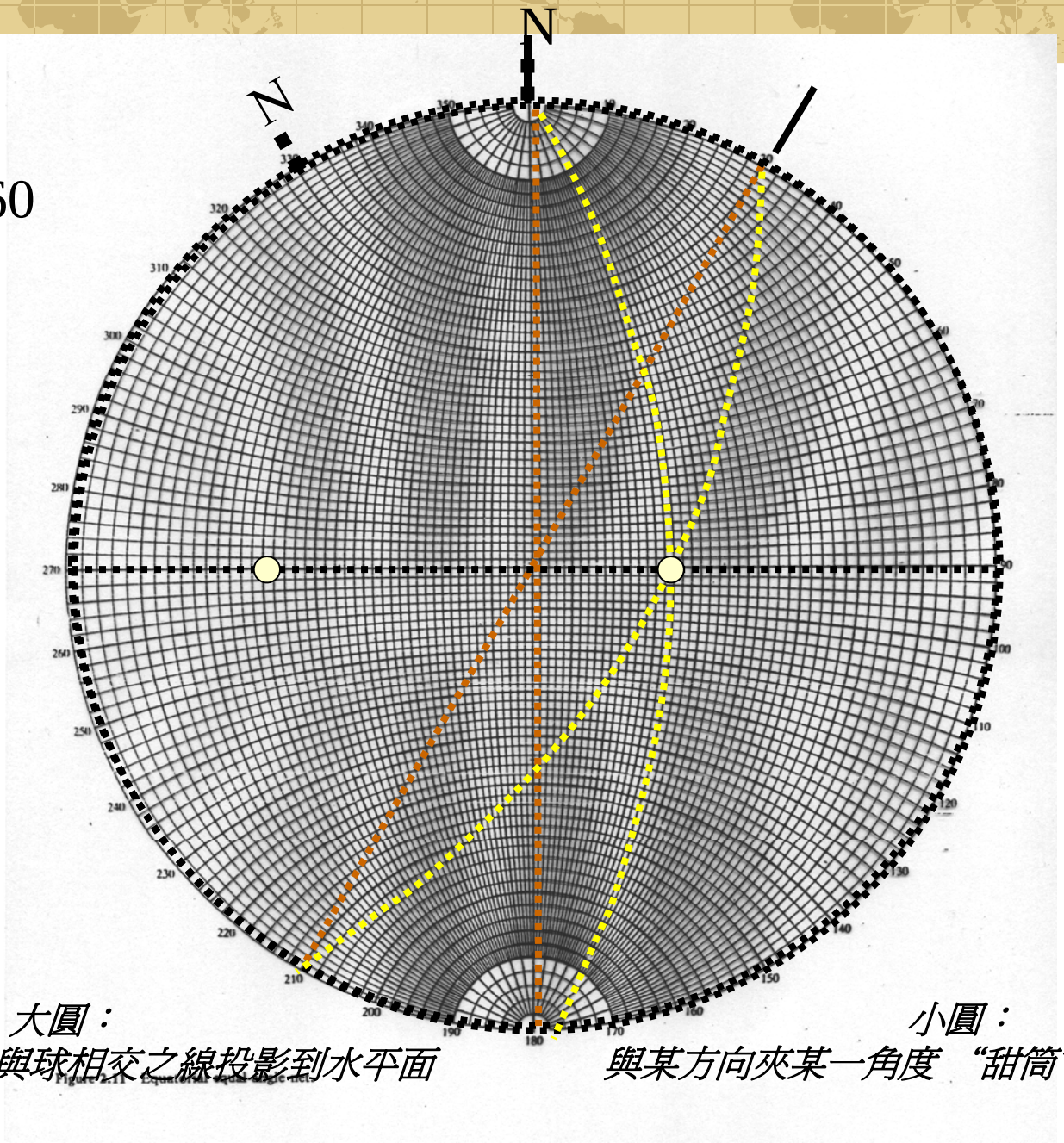


兩平面交線向量

大圓：
某個南北走向的面與球相交之線投影到水平面

小圓：
與某方向夾某一角度 “甜筒” 投影到水平面

N30E/ES60



大圓：
某個南北走向的面與球相交之線投影到水平面

小圓：
與某方向夾某一角度 “甜筒” 投影到水平面

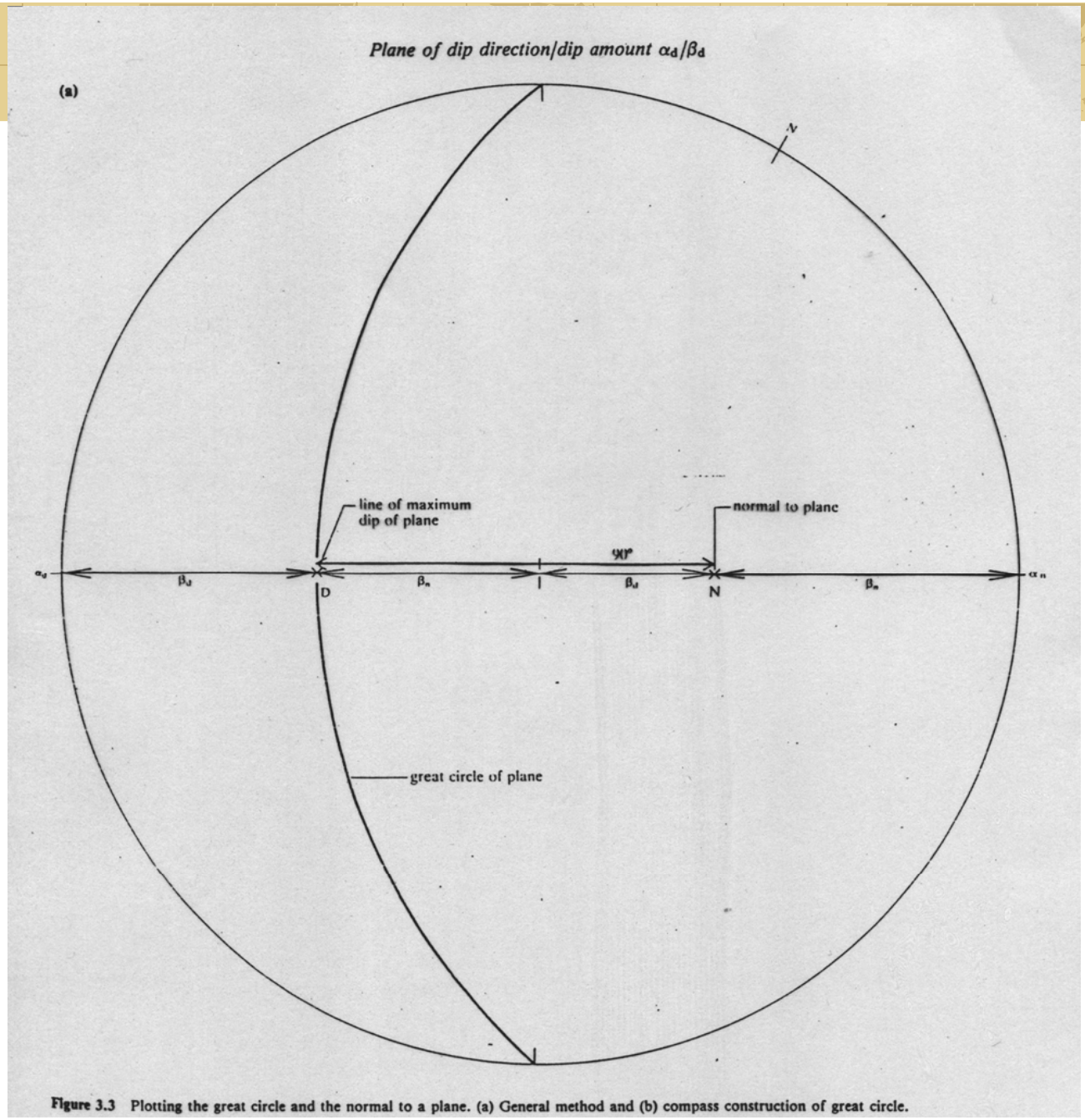
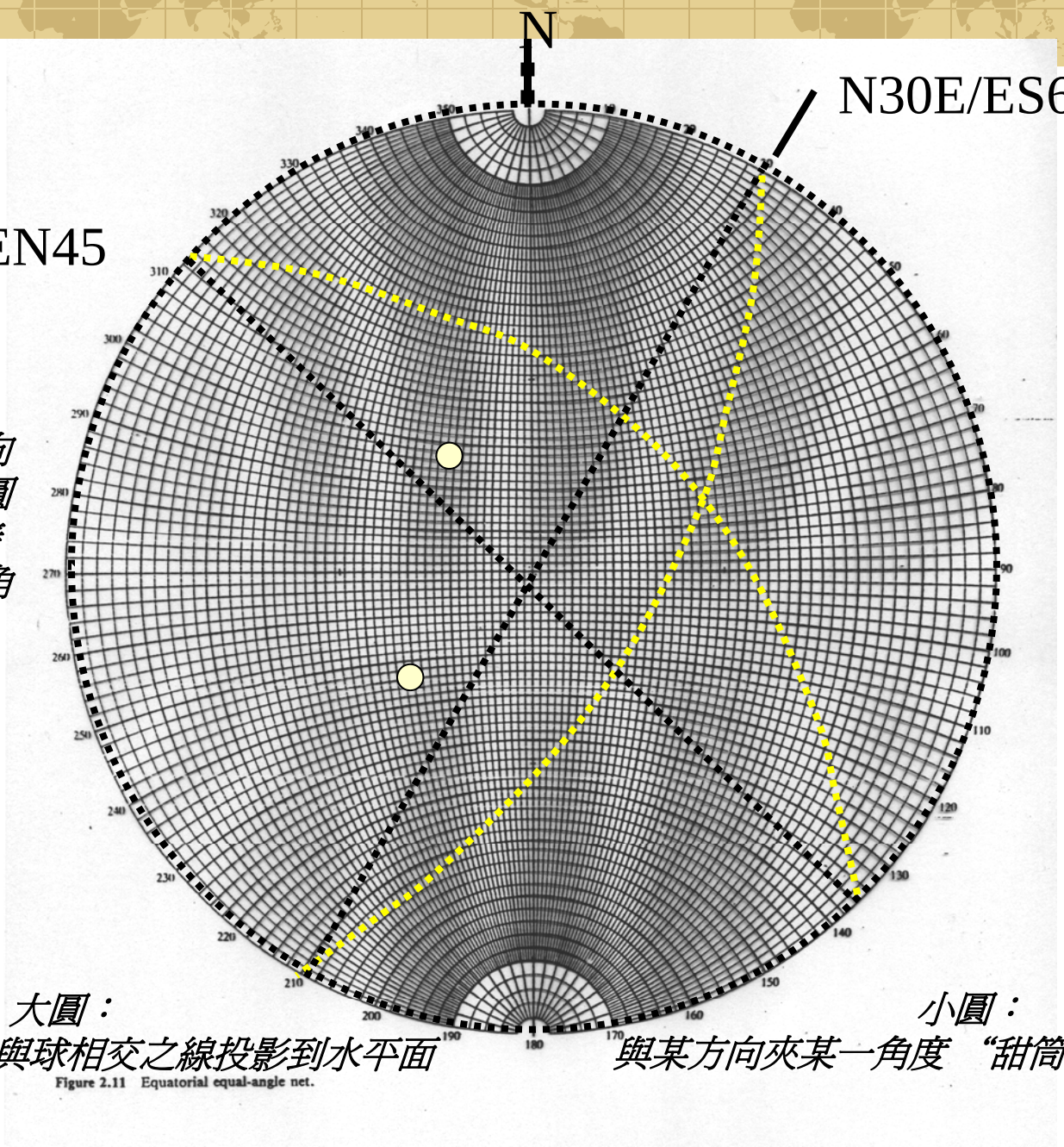


Figure 3.3 Plotting the great circle and the normal to a plane. (a) General method and (b) compass construction of great circle.



旋轉到兩個法線向量落在同一個大圓上(共平面)，直接讀兩法線向量夾角

兩向量交角

大圓：
某個南北走向的面與球相交之線投影到水平面

小圓：
與某方向夾某一角度 “甜筒” 投影到水平面

Figure 2.11 Equatorial equal-angle net.

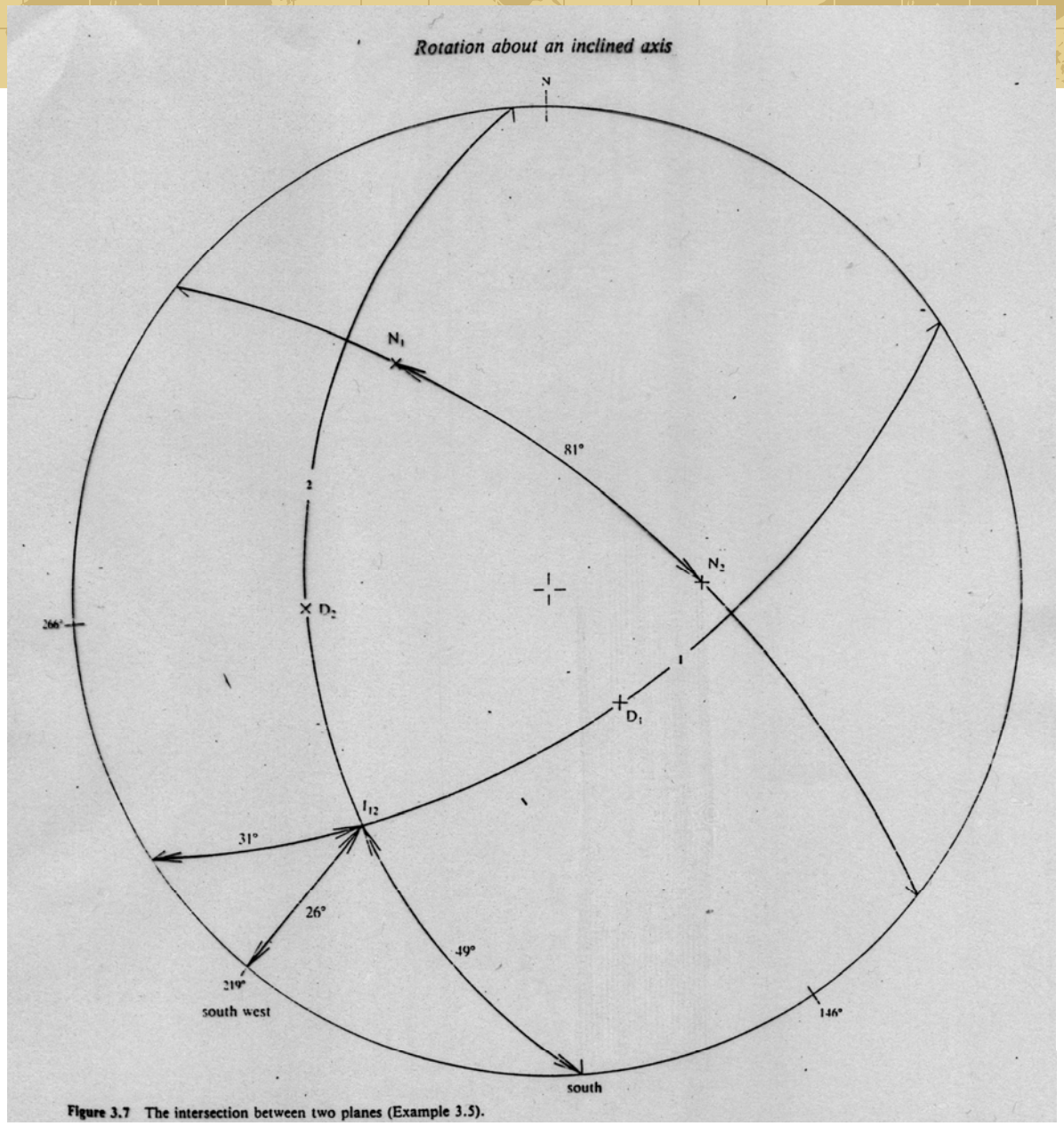


Figure 3.7 The intersection between two planes (Example 3.5).

HW2

- Ch 3, problems 3 , 4, and 5