



108.01

工程地質

Engineering Geology

第五週

不連續面(弱面) II

授課教師：邱雅筑

2019/10/14



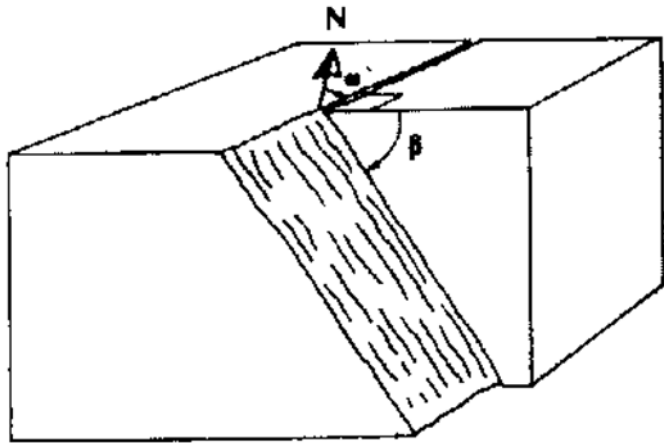
大綱Content

- 不連續面如何調查/描述/評估？
 1. 位態(位置、方位) Orientation：立體投影法
 2. 間距 Spacing
 3. 持續性 Persistence
 4. 粗糙度 Roughness
 5. 內壁材料強度 Strength
 6. 內寬
 7. 軟弱夾心
 8. 滲水情形
 9. 組數
 10. 弱面密度與岩體幾何形狀



不連續面如何調查/
描述/評估？

1. 位態 Orientation



• 位態的表示方法 1) 走向傾角符號

45° represents a discontinuity with a dip of 45° and strike as shown by the orientation of the line. The dip direction is indicated by the down-dip symbol.

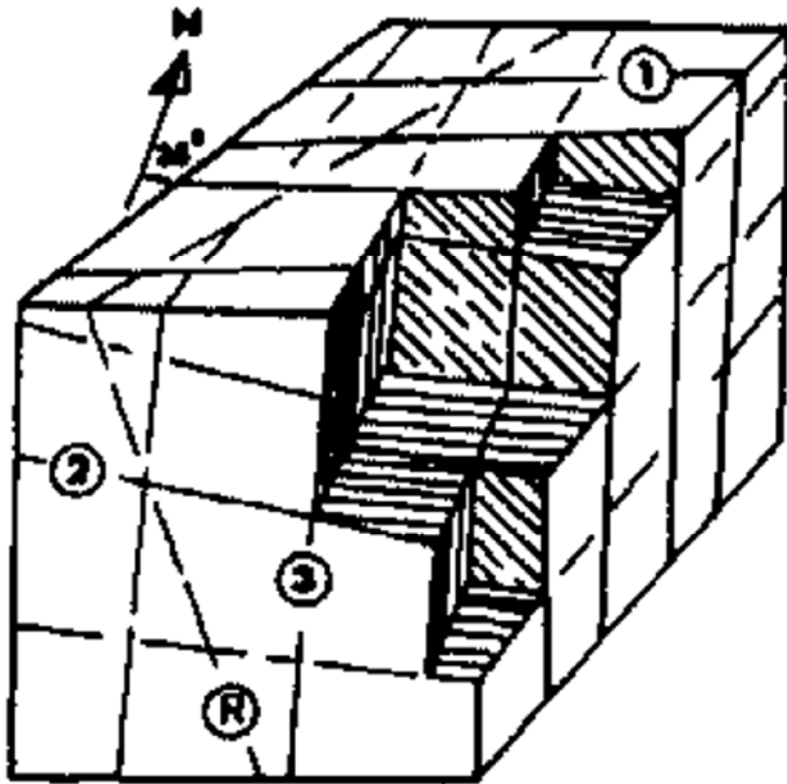
— represents a horizontal discontinuity.
— represents a vertical discontinuity with a strike as shown by the orientation of the line.

↘ joints ↘ bedding ↘ foliation

- 不連續面的空間姿態，包含走向及傾向/傾角
- 以地質羅盤量測
- 在關鍵地區挑選露頭較佳的地段設立調查站
- 隨機地測量不連續面之位態，不能主觀地挑選某一個面，而且不能只挑選明顯的一組，必須找各種不同方向的露頭面進行測量
- 每個調查站取得至少50個數據才有意義
- 拍照並放入報告內

1. 位態 Orientation

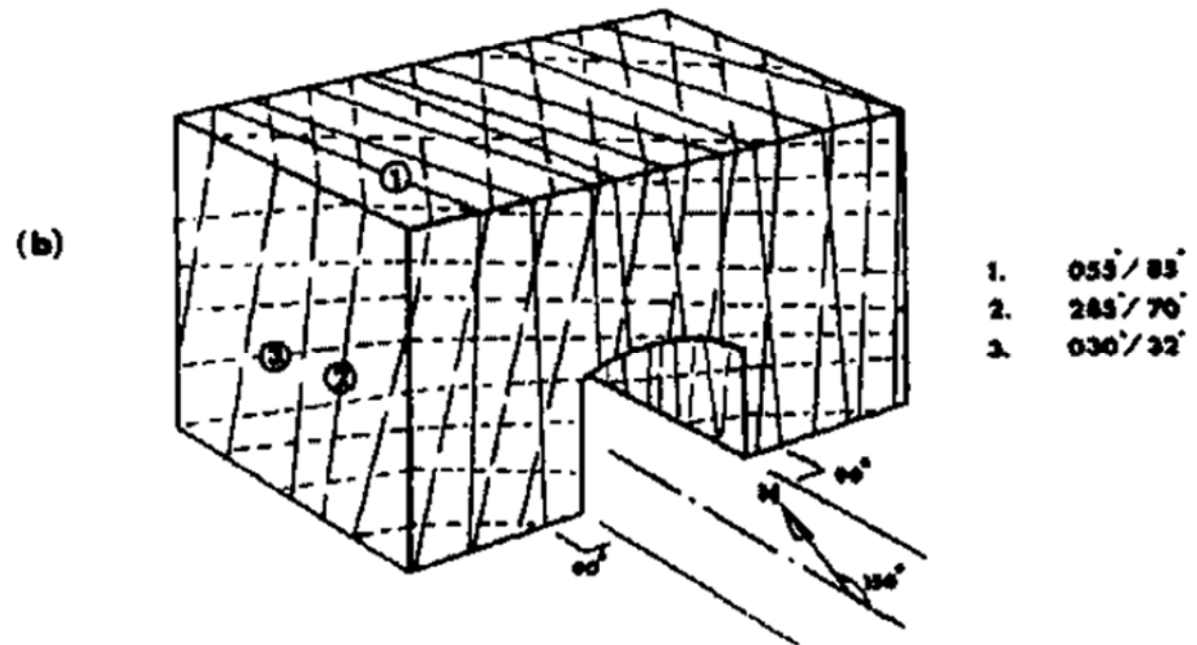
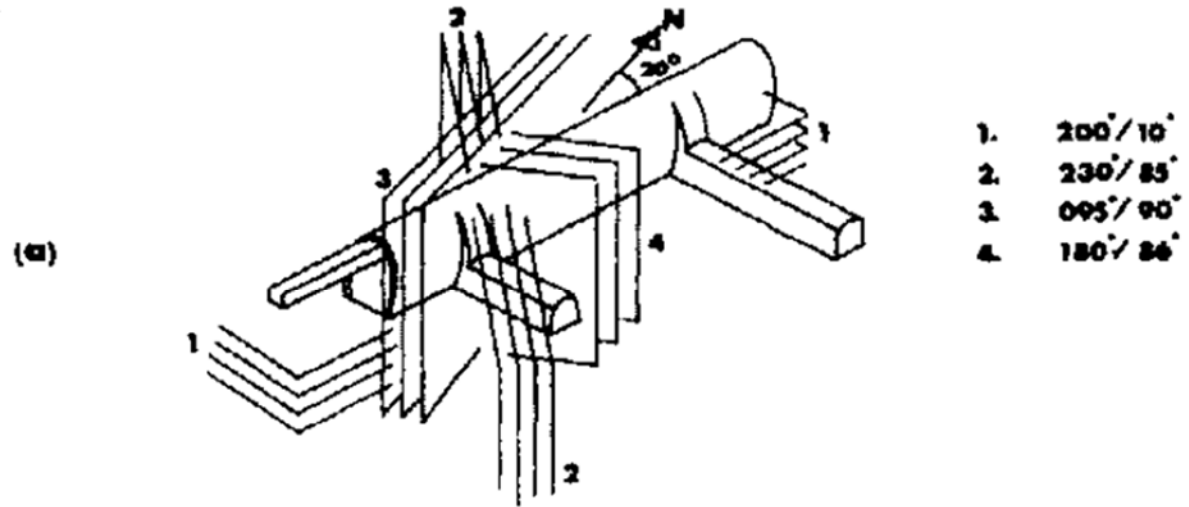
- 位態的表示方法
 - 2) 方塊圖 Block diagram



- 1. $200^{\circ} / 88^{\circ}$
- 2. $130^{\circ} / 15^{\circ}$
- 3. $285^{\circ} / 85^{\circ}$

1. 位態 Orientation

- 位態的表示方法
 - 2) 方塊圖 Block diagram



1. 位態 Orientation

- 位態的表示方法

- 3) 節理玫瑰圖 Joint rosettes

- 4) 球形投影 Spherical projection

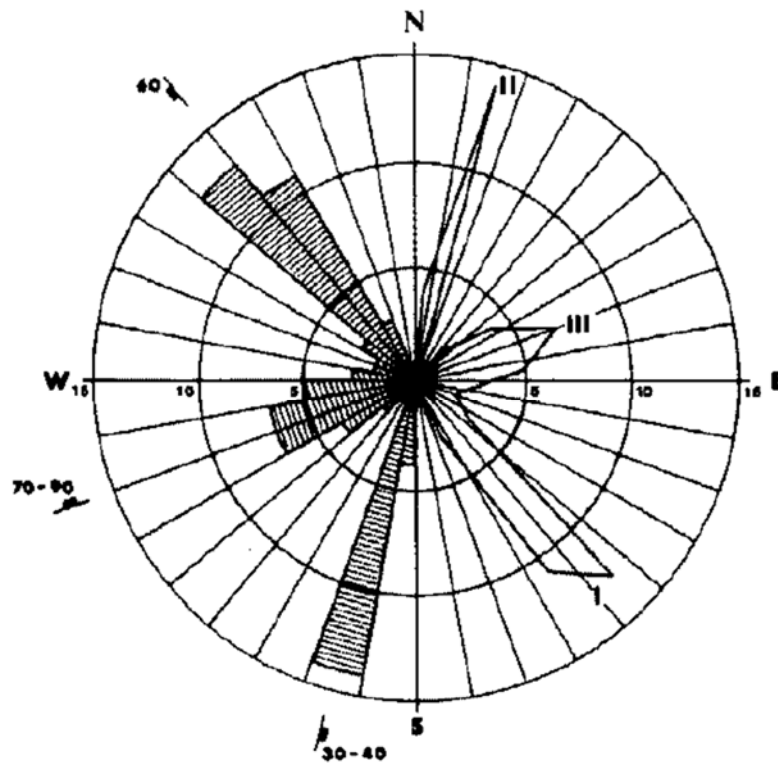


Fig. 3. Two methods of representing orientation data on a joint rosette

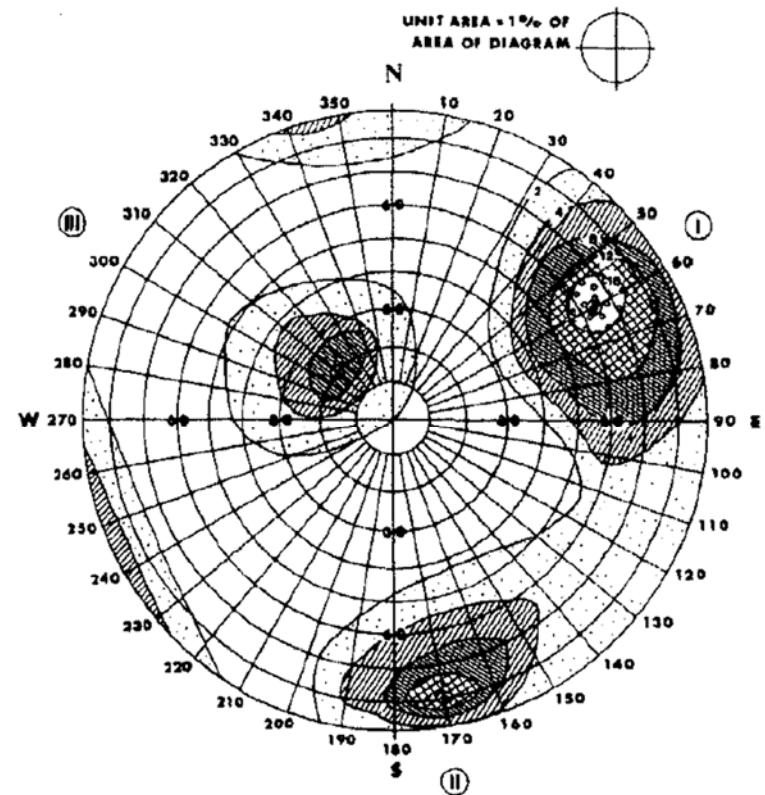


Fig. 5. Schmidt contour diagram representing the orientation of three sets of joints plotted on a polar equal-area net. The main sets I and II are approximately normal to each other, and the minor set III is nearly horizontal.

2. 間距 Spacing

- 沿著所選擇的某一個測線方向上(一般是垂直於某一組不連續面)相鄰不連續面間的距離。
- 不連續面間距反映岩體的完整程度及岩塊的大小

測線(方向
不同則間
距不同

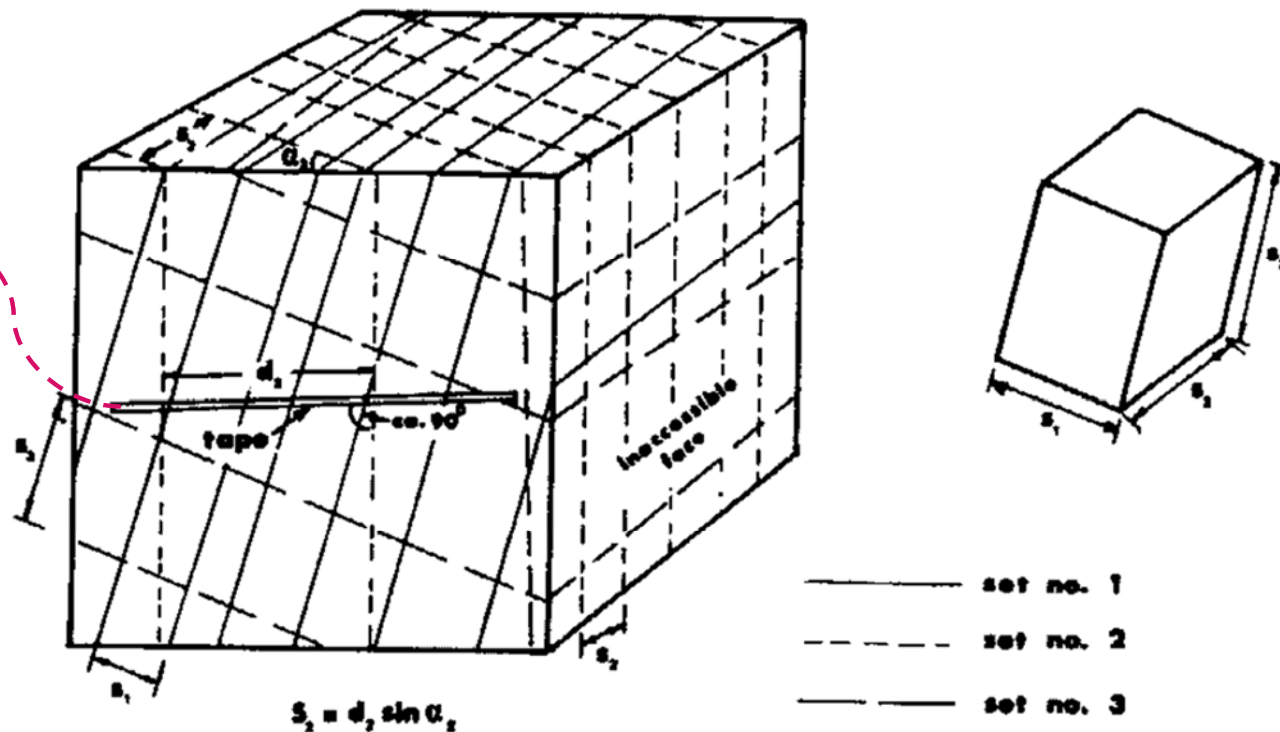


Fig. 10. Measurement of joint spacing from observation of a rock exposure.

不連續面(節理)組數？
間距？



不連續面(節理)組數？
間距？



2. 間距 Spacing

- 間距(s)的表示方法

1) 最小間距，型態間距modal spacing，最大間距

Description	Spacing
Extremely close spacing	< 20 mm
Very close spacing	20–60 mm
Close spacing	60–200 mm
Moderate spacing	200–600 mm
Wide spacing	600–2000 mm
Very wide spacing	2000–6000 mm
Extremely wide spacing	> 6000 mm

2. 間距 Spacing

2) 直方圖 histogram

Description
 Extremely close spacing
 Very close spacing
 Close spacing
 Moderate spacing
 Wide spacing
 Very wide spacing
 Extremely wide spacing

Spacing
 < 20 mm
 20-60 mm
 60-200 mm
 200-600 mm
 600-2000 mm
 2000-6000 mm
 > 6000 mm

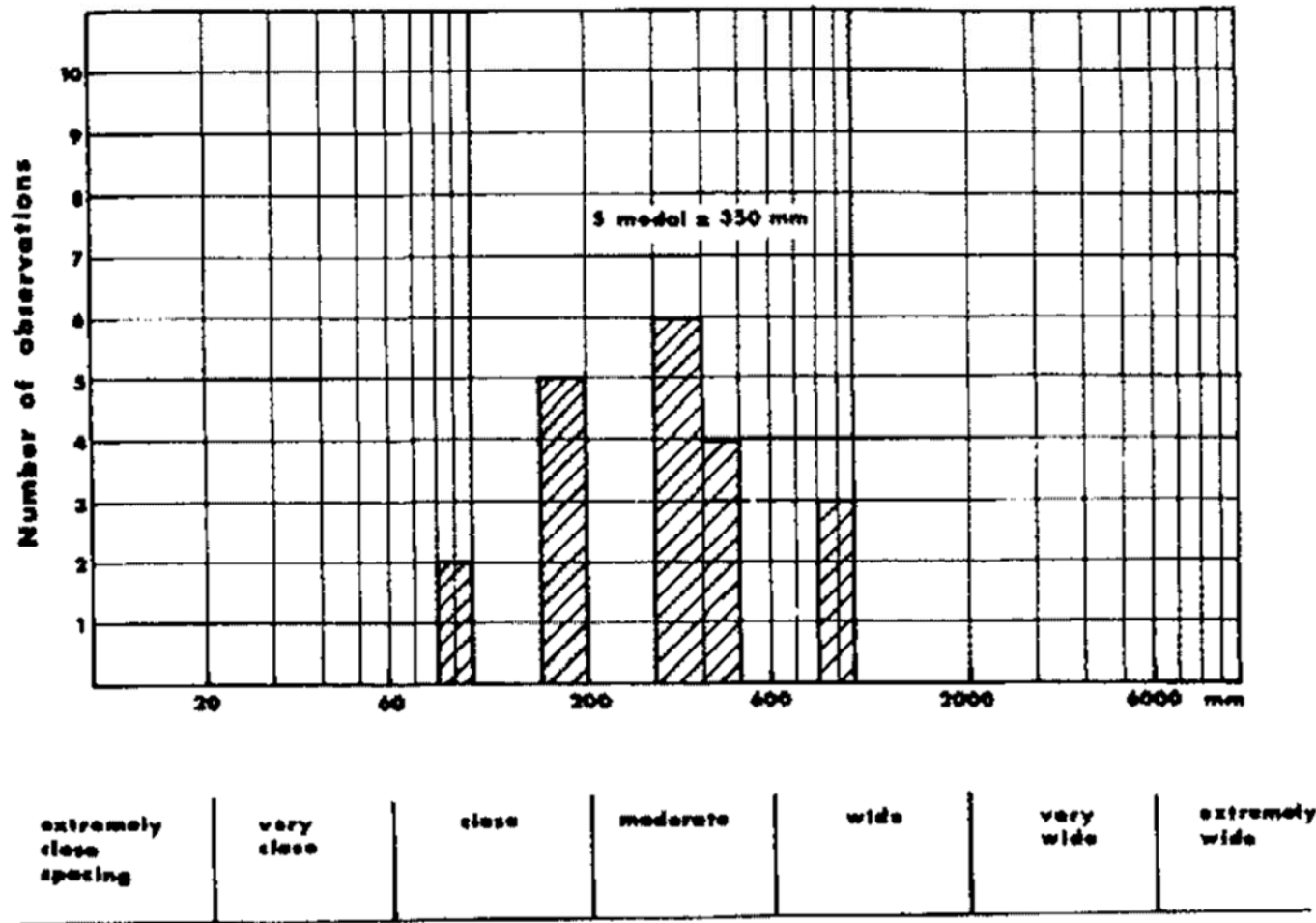


Fig. 11. Histogram showing modal, minimum and maximum spacings obtained from observations of the spacing of one set. Suggested descriptions given at base of histogram.

2. 間距 Spacing

- 注意：
 - 使用地質羅盤及測量捲尺
 - 可在露頭上釘釘子及拉尼龍線輔助
- 節理密度/節理頻率
 - $J_d = 1/s$, 其中 J_d = 節理密度(條/m), s = 間距(m)

測線(方向
不同則間
距不同

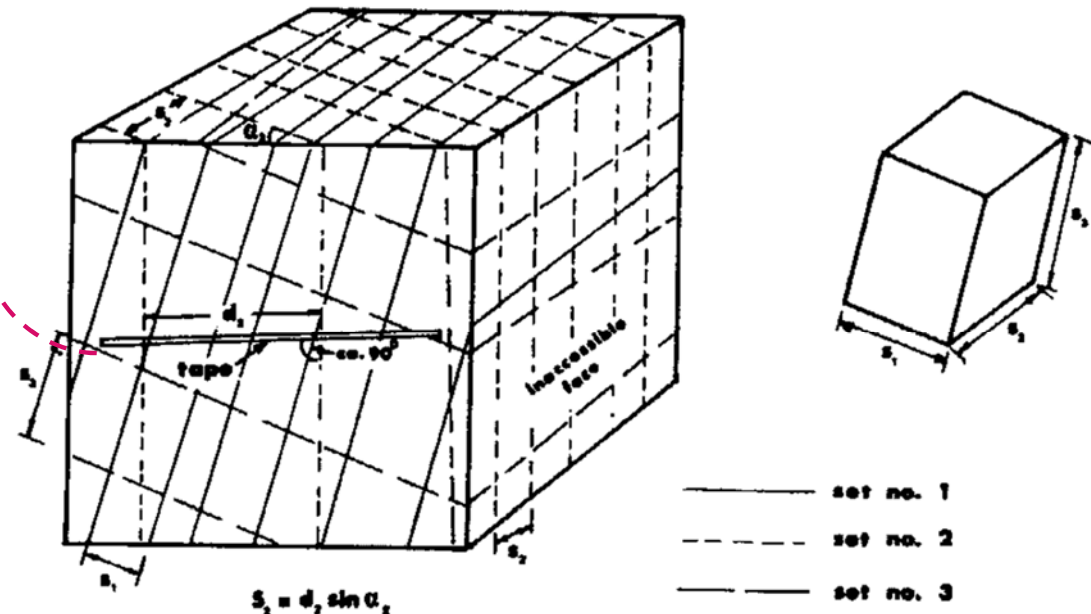


Fig. 10. Measurement of joint spacing from observation of a rock exposure.

3. 持續性/延續性 Persistence

- 不連續面的**延展範圍**及其**長短**
- 如果不連續面的**條數**相同，則**端點總數**越多者表示不連續面的**延續性**越差
- 測線至少要10 m

Very low persistence	< 1 m
Low persistence	1-3 m
Medium persistence	3-10 m
High persistence	10-20 m
Very high persistence	> 20 m

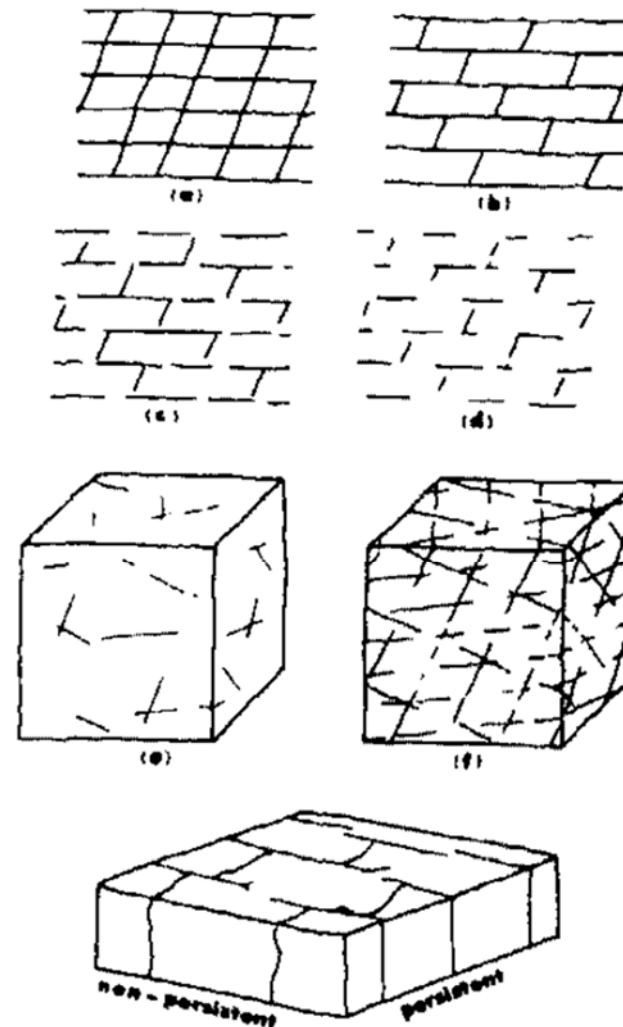


Fig 12 Simple sketches and block diagrams help to indicate the relative persistence of the various sets of discontinuities. Examples adapted from [1] and [2].

3. 持續性/延續性 Persistence

- 終止方式
 - (r): visibly terminate in rock in the exposure (終止於岩石)
 - (d): terminate against other discontinuities (終止於破裂面)
 - (x): Extend outside the exposure (終點無法測量)
- 延續性的影響

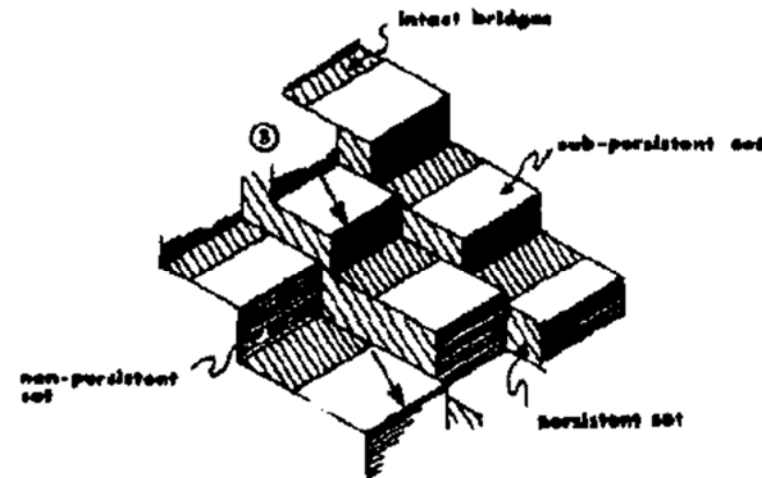
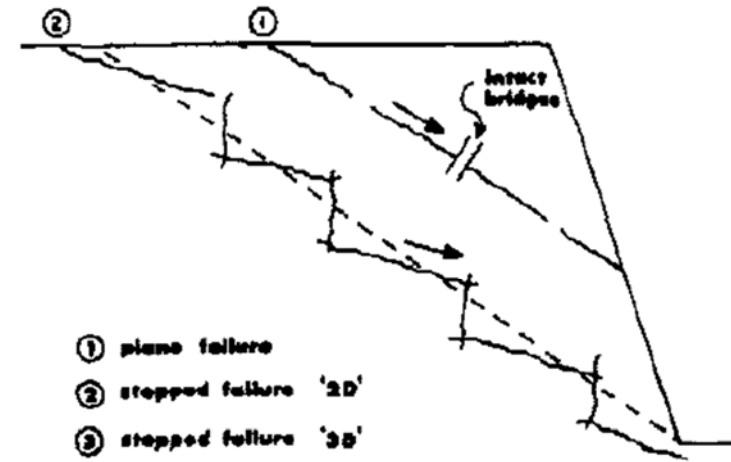


Fig. 13. Idealized examples of potential failure planes showing the importance of "intact bridges" and "down-stepping". Examples adapted from [4] and [7].

作業2

測線1





測線2

3.持續性/延續性 Persistence

- 延續性的影響
 - Persistent set
 - Non-persistent set
 - Sub-persistent set
 - Intact bridges
 - Down-stepping

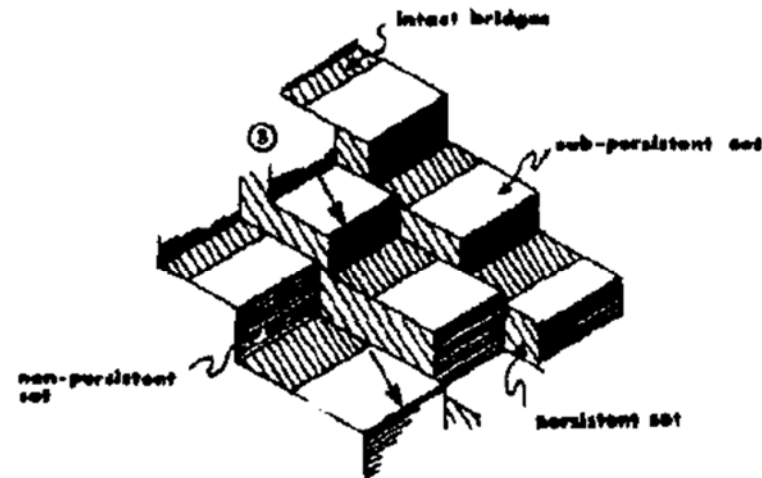
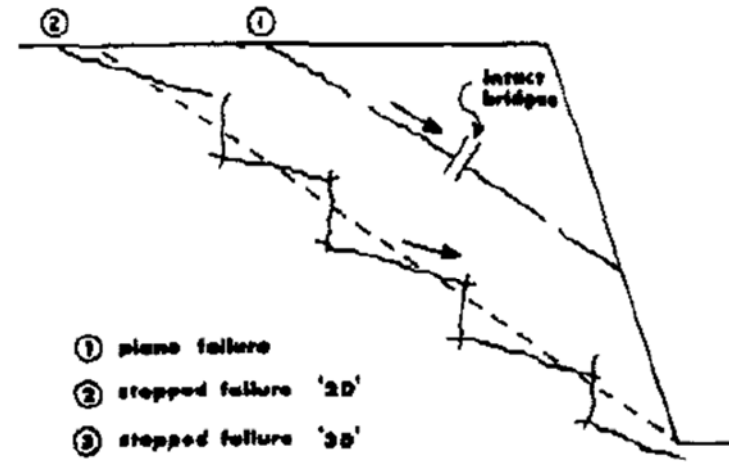


Fig. 13. Idealized examples of potential failure planes showing the importance of "intact bridges" and "down-stepping".
Examples adapted from [4] and [7].

3.持續性/延續性 Persistence

- 延續性的表示方法
 - 方塊圖
 - 照片
 - 計算比例

$$T_r = \frac{(\sum r) \times 100}{2(\text{no. of discontinuities observed})} \%$$

- (r): visibly terminate in rock in the exposure (終止於岩石)
- (d): terminate against other discontinuities (終止於破裂面)
- (x): Extend outside the exposure (終點無法測量)

4. 粗糙度 Roughness

- 控制不連續面的力學性質之重要指標

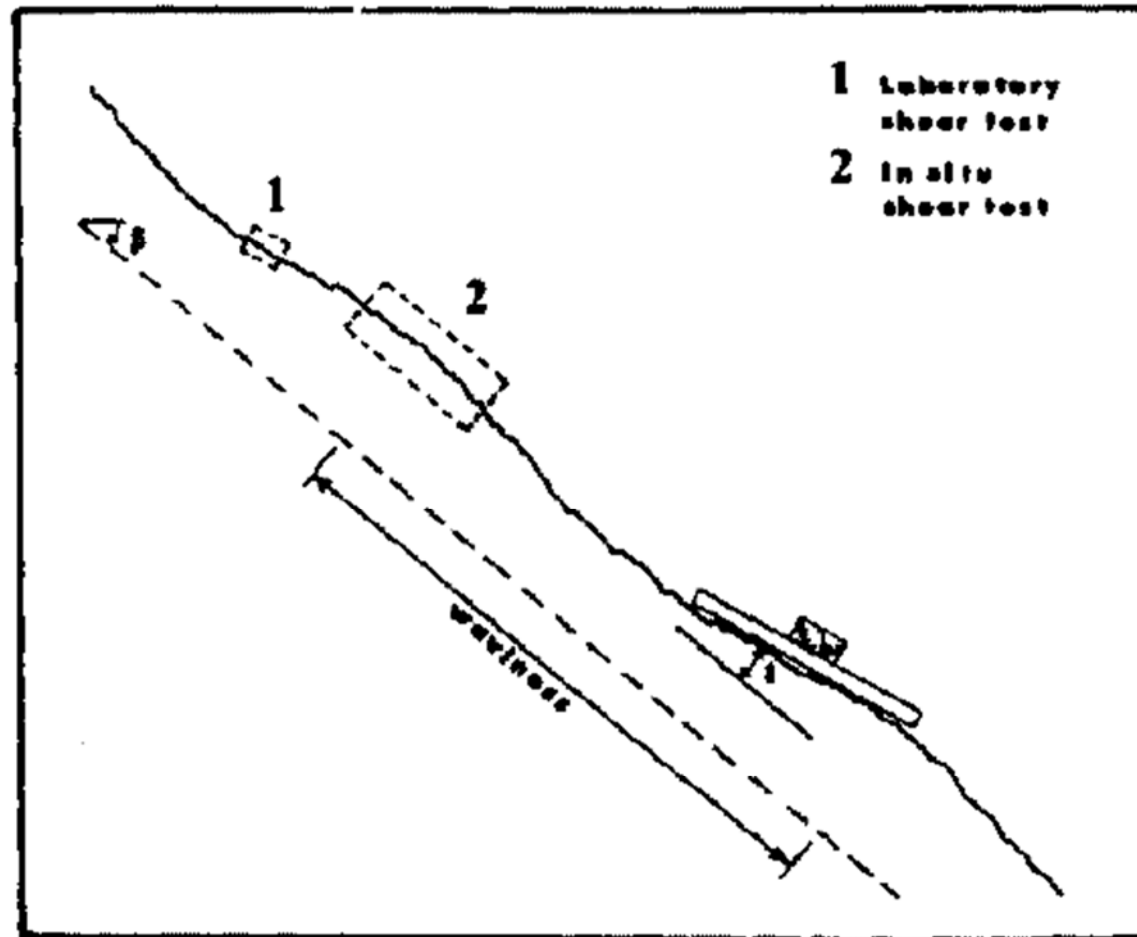


Fig. 14. Different scales of discontinuity roughness are sampled by different scales of tests. Waviness can be characterised by the angle (α).

4. 粗糙度 Roughness

- 量測方法：folding ruler

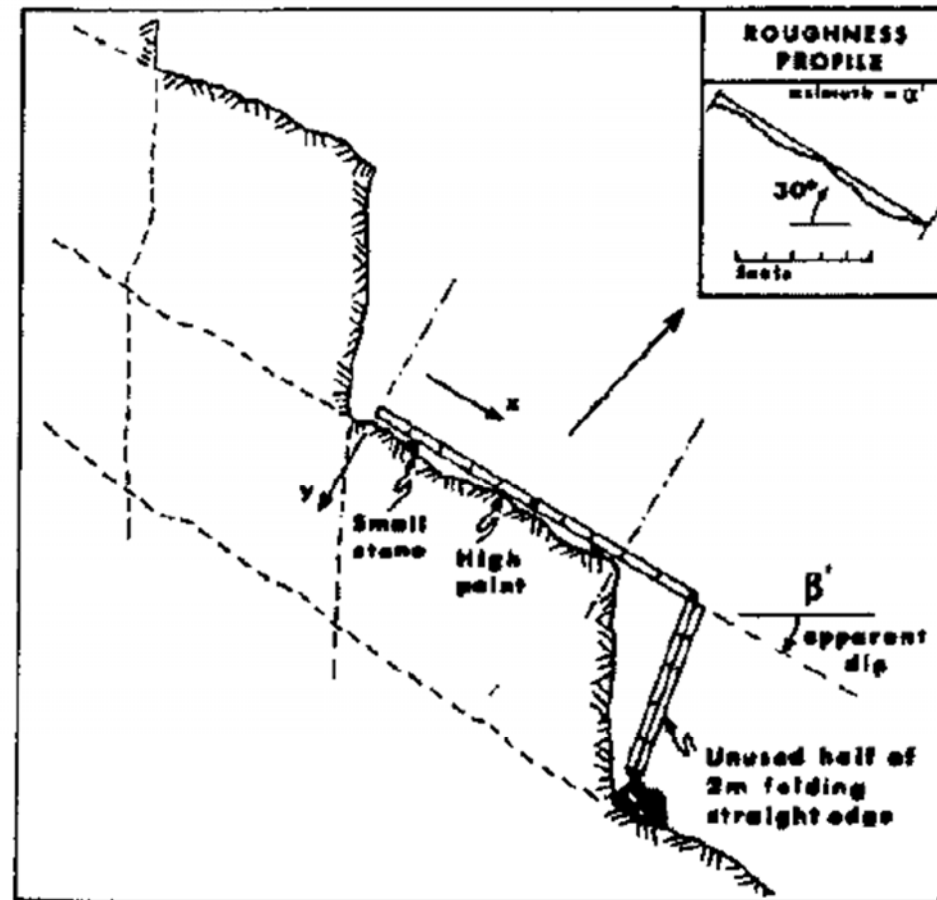
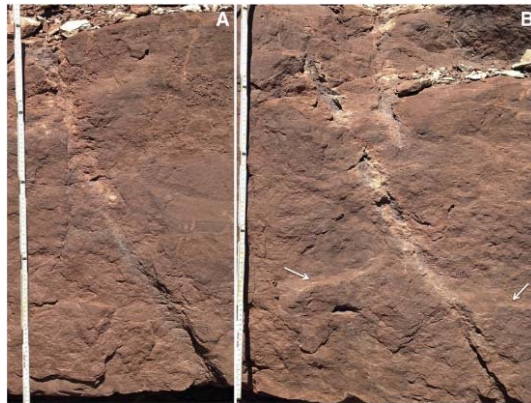
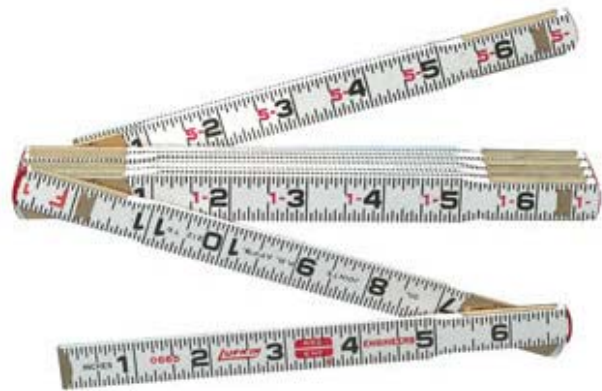
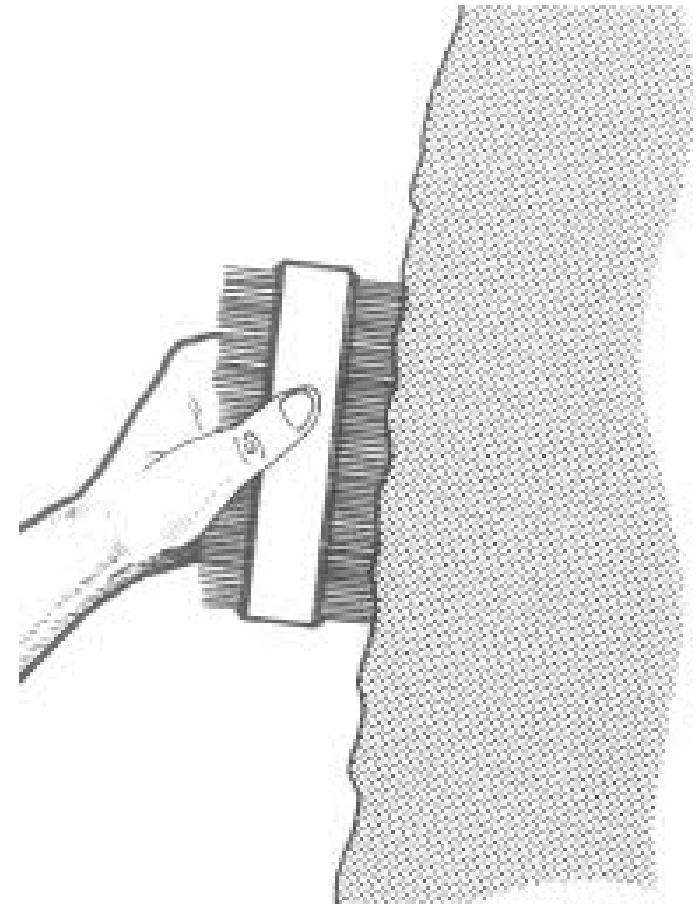


Fig. 15. A method of recording discontinuity roughness in two dimensions, along the estimated direction of potential sliding.

4. 粗糙度 Roughness

- 量測方法：linear profiling (粗糙尺)



4. 粗糙度 Roughness

- 量測方法：circular disc + 地質羅盤
 - 將圓盤貼在露頭上
 - 以地質羅盤量測位態
 - 使用不同直徑的圓盤

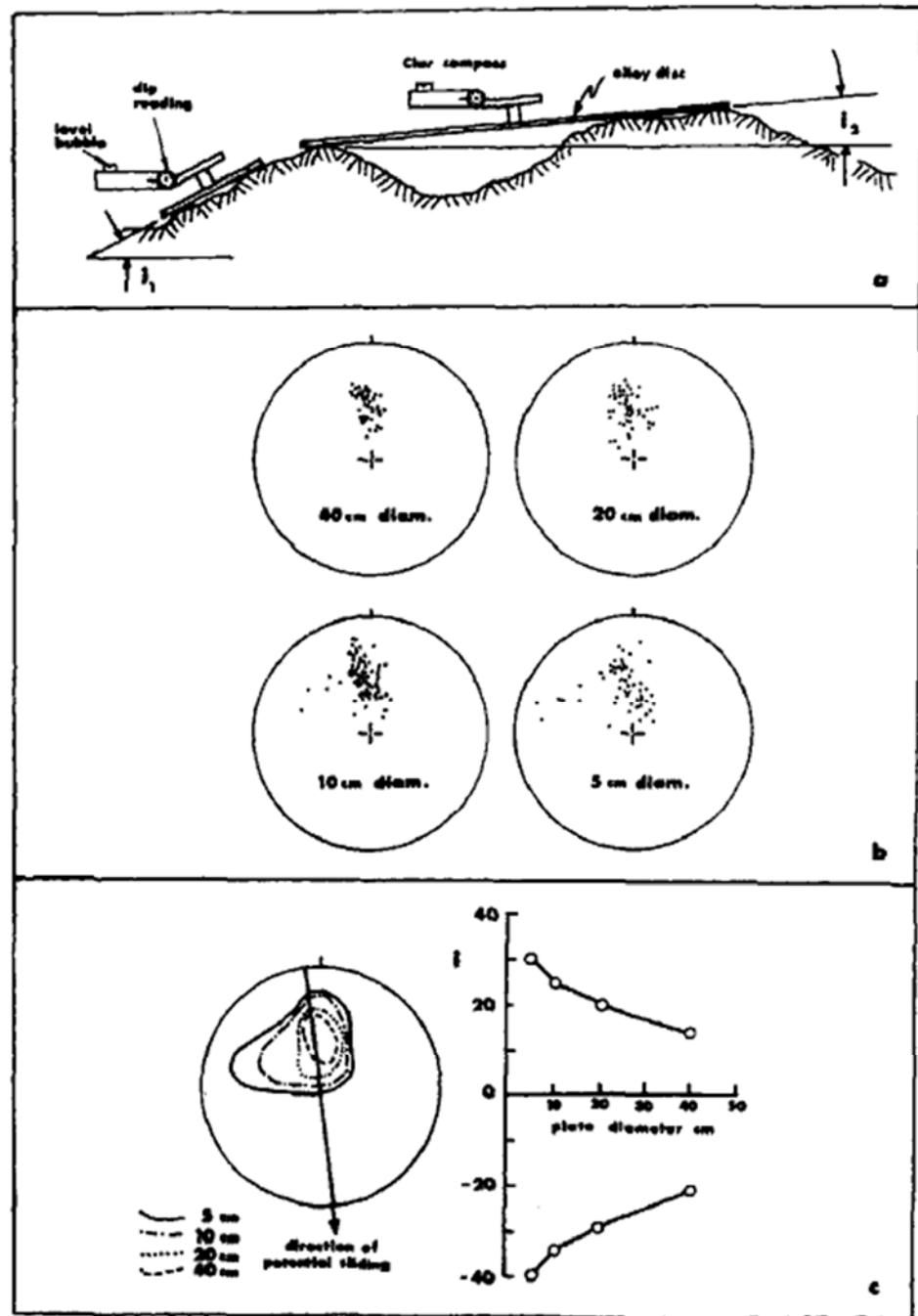


Fig. 16. A method of recording discontinuity roughness in three dimensions, for cases where the potential direction of sliding is not yet known. Circular discs of different dimensions (e.g. 5, 10, 20 and 40 cm) are fixed in turn to a Clair compass and clinometer. The dip direction and dip readings are plotted as poles on equal-area nets. Adapted from [1] and [2].

4. 粗糙度 Roughness

- 粗糙度的表示方式

Small scale (several centimetres)
Intermediate scale (several metres)

- I Rough (or irregular), stepped
- II Smooth, stepped
- III Slickensided, stepped
- IV Rough (or irregular), undulating
- V Smooth, undulating
- VI Slickensided, undulating
- VII Rough (or irregular), planar
- VIII Smooth, planar
- IX Slickensided, planar

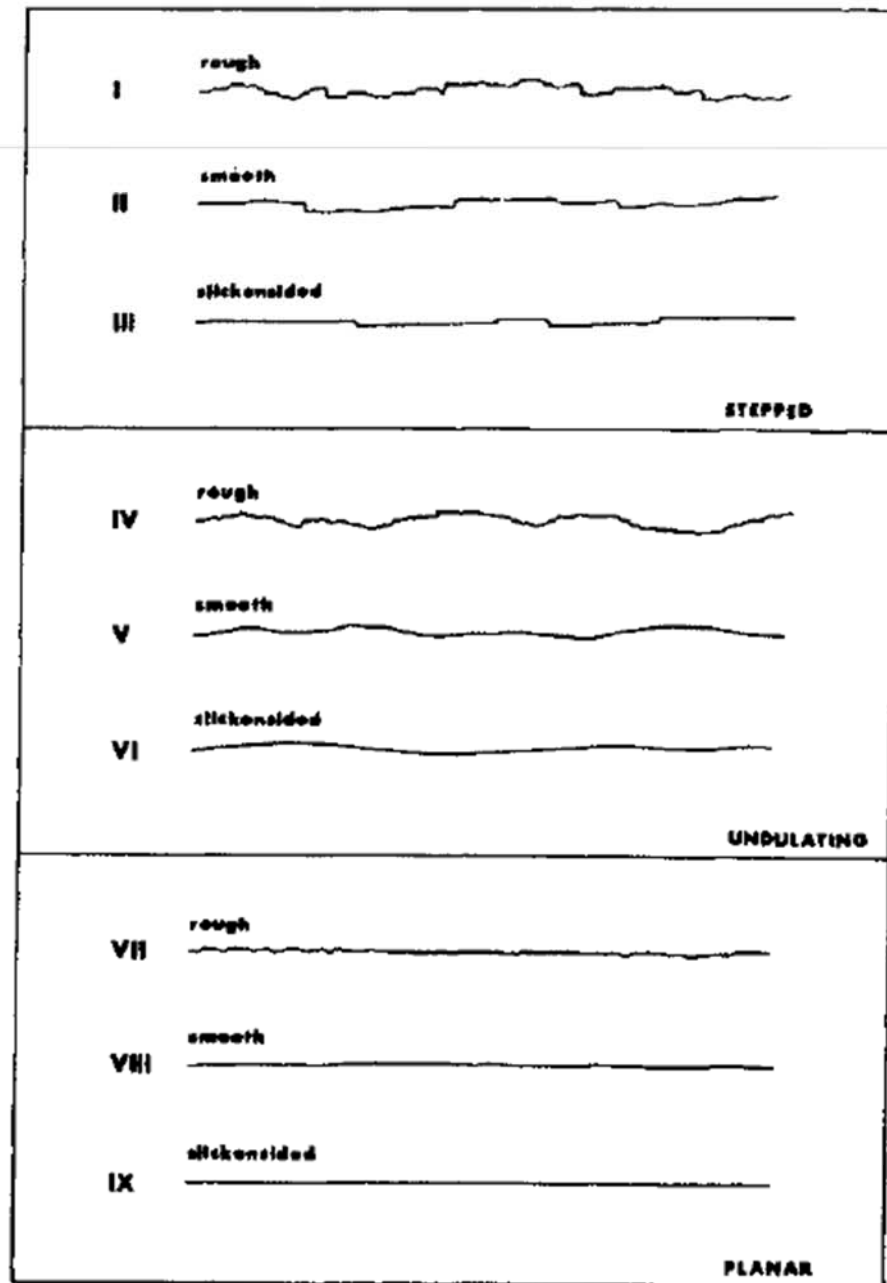


Fig. 17. Typical roughness profiles and suggested nomenclature. The length of each profile is in the range 1 to 10 metres. The vertical and horizontal scales are equal.

4. 粗糙度 Roughness

- 粗糙度的表示方式：
 - Joint roughness coefficient 節理粗糙度細數
 - 比對標準剖面

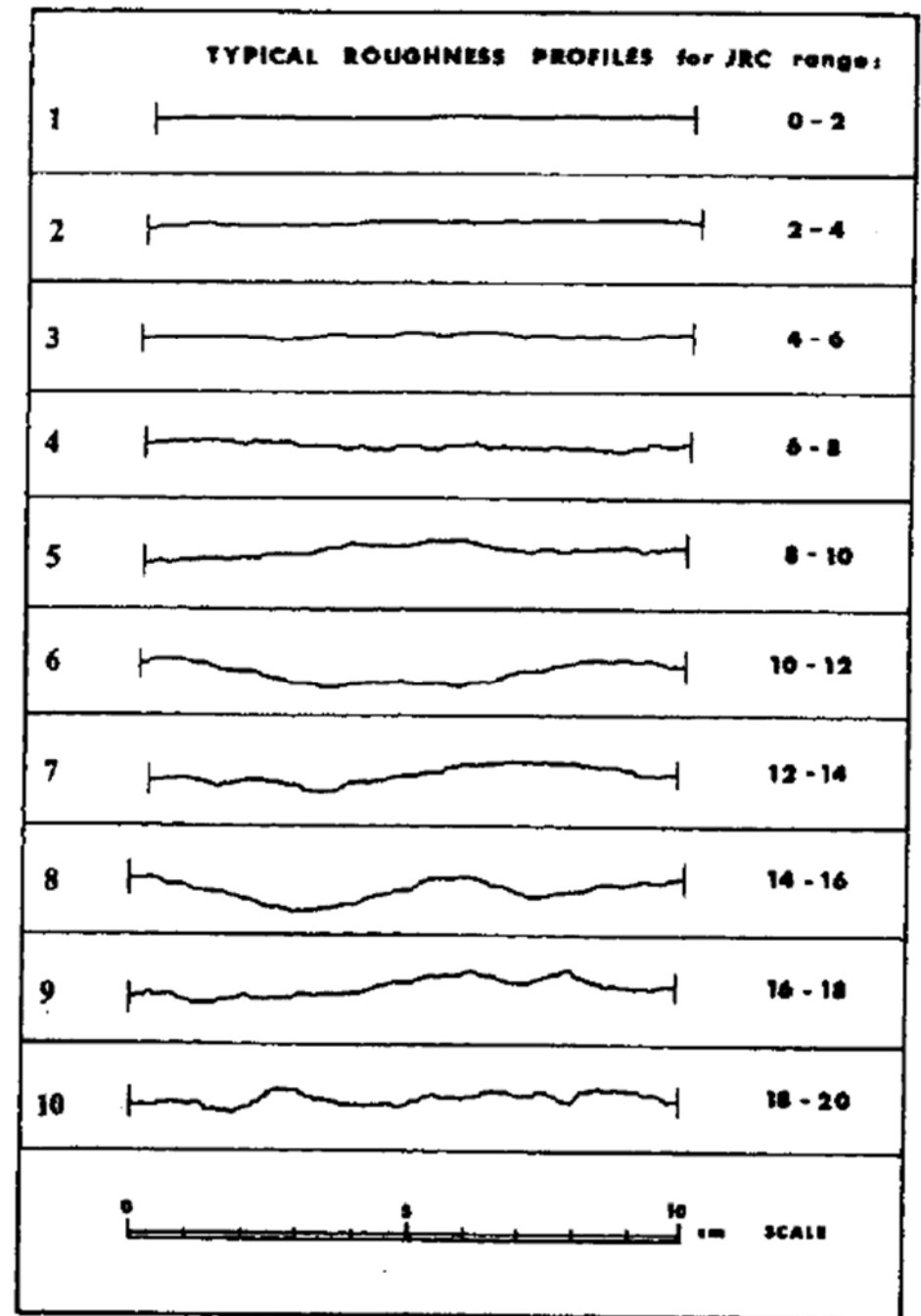
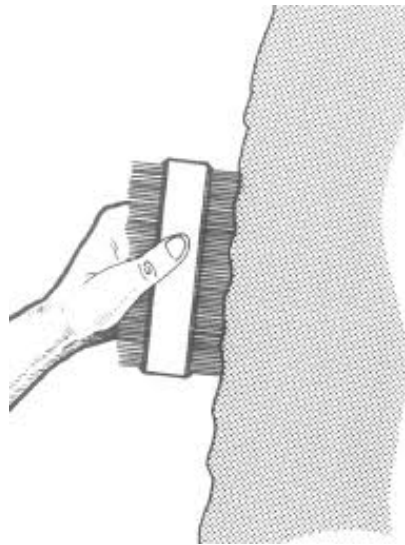


Fig. 19. Roughness profiles and corresponding range of JRC values associated with each one [6].