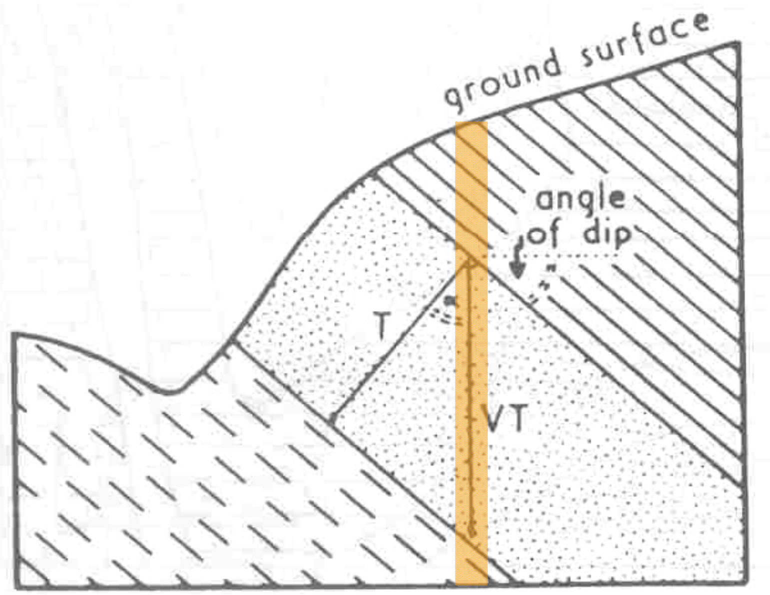
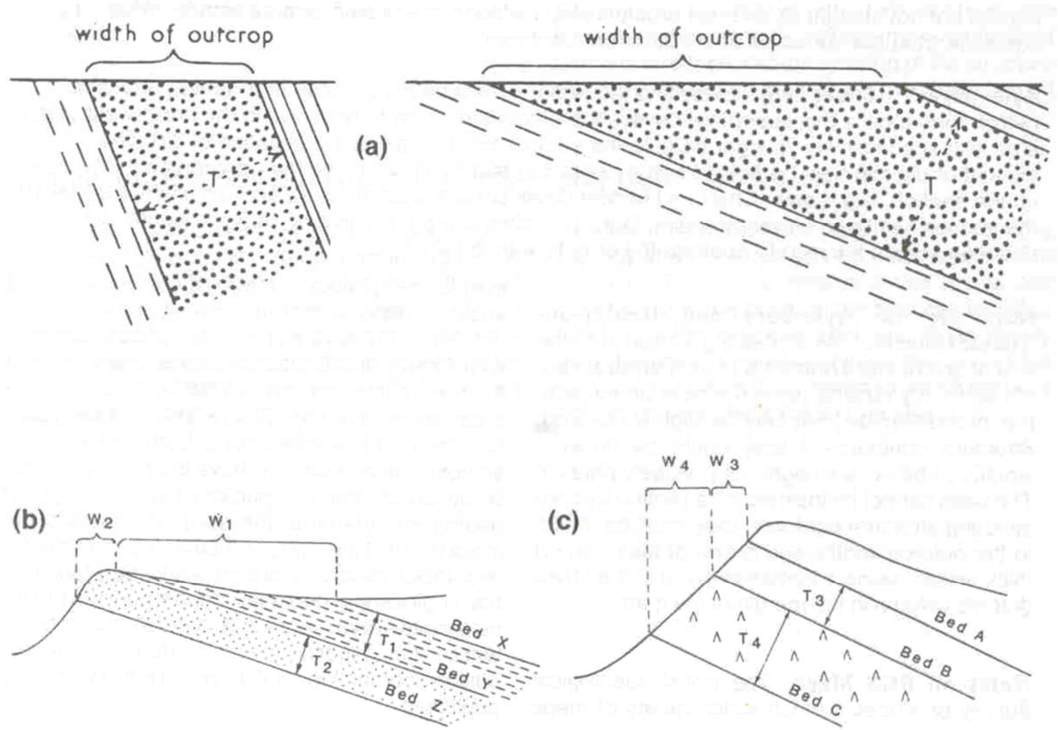
# Apparent thickness and True thickness




$$T = VT * \cos \alpha$$

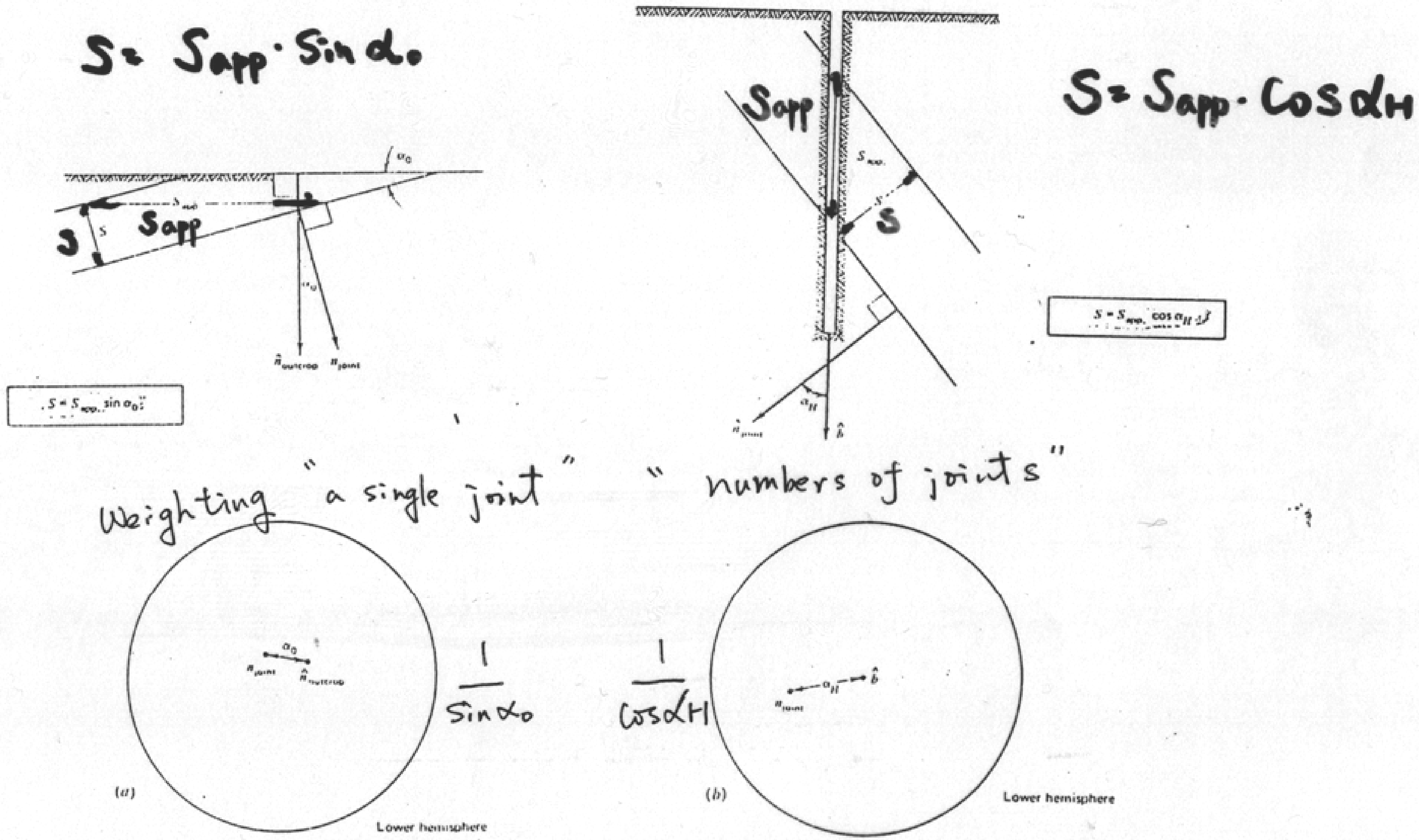
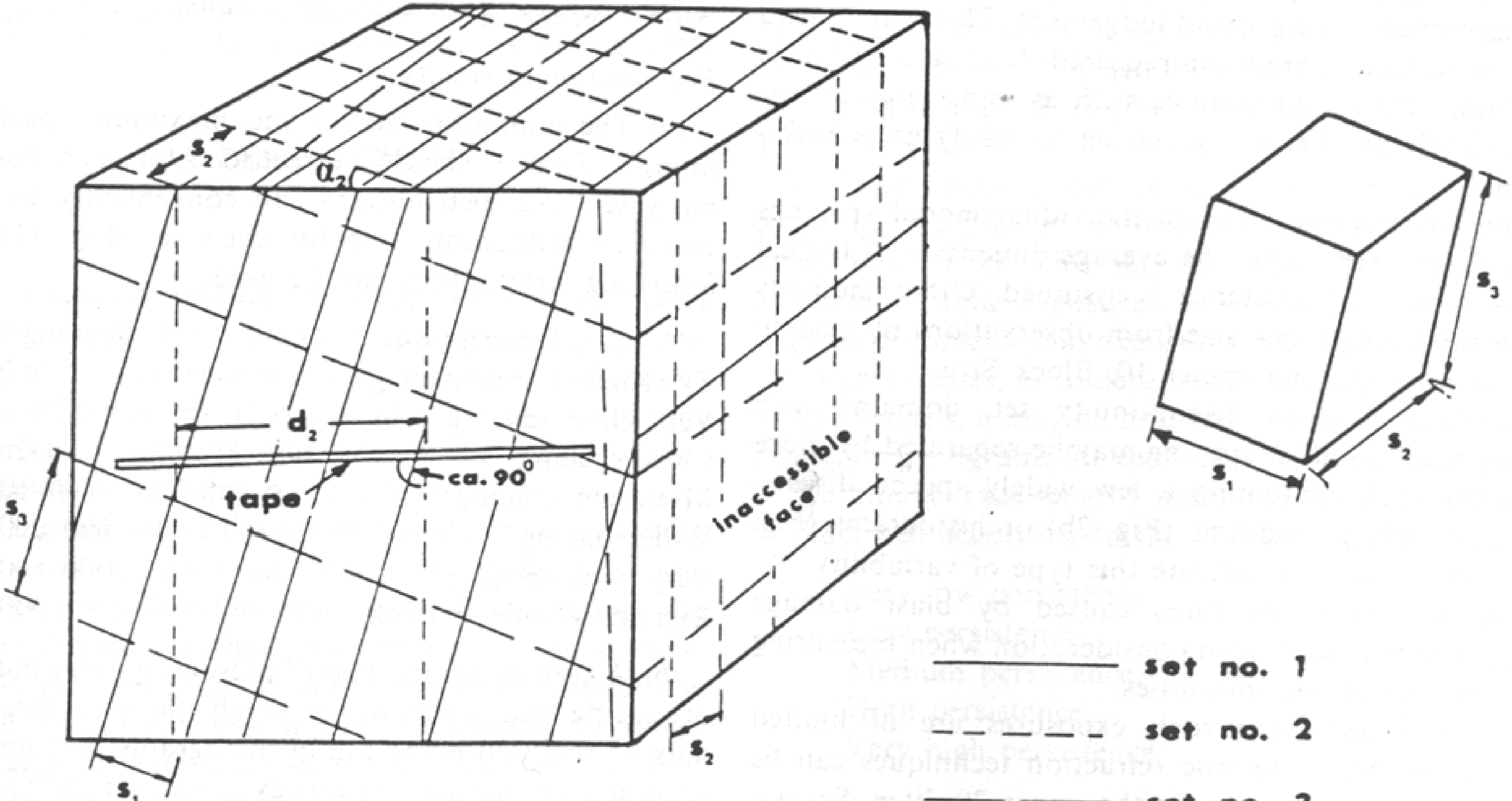



*Figure 5.7* Bias in occurrence of joints in (*a*) outcrops.

*Figure 5.7* Bias in occurrence of joints in (*b*) drill holes.

"Sampling bias"

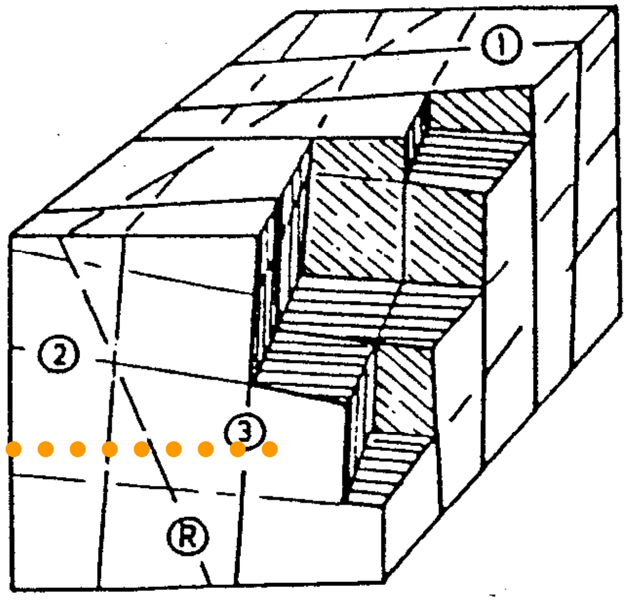
# Spacing

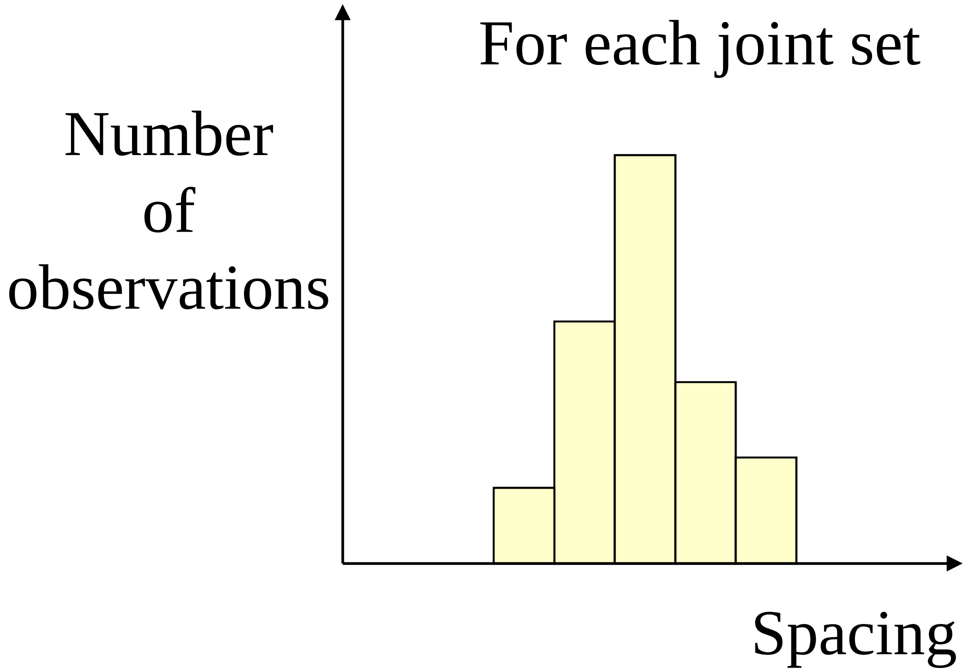



$S_2 = d_2 \sin \alpha_2$

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

# Spacing




Measuring tape of at least 3m length

# Spacing

| 術語 | 間距 |
|---|---|
| 極密<br>Extremely close spacing | <20mm |
| 很密<br>Very close spacing | 20-60mm |
| 密<br>Close spacing | 60-200mm |
| 中度<br>Moderate spacing | 200-600mm |
| 疏<br>Wide spacing | 600-2000mm |
| 很疏<br>Very wide spacing | 2000-6000mm |
| 極疏<br>Extremely wide spacing | >6000mm |

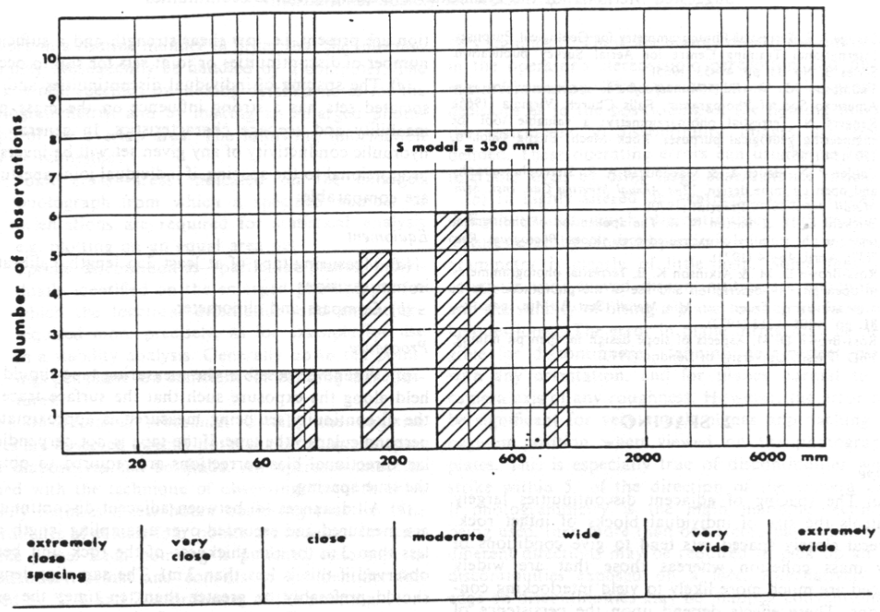


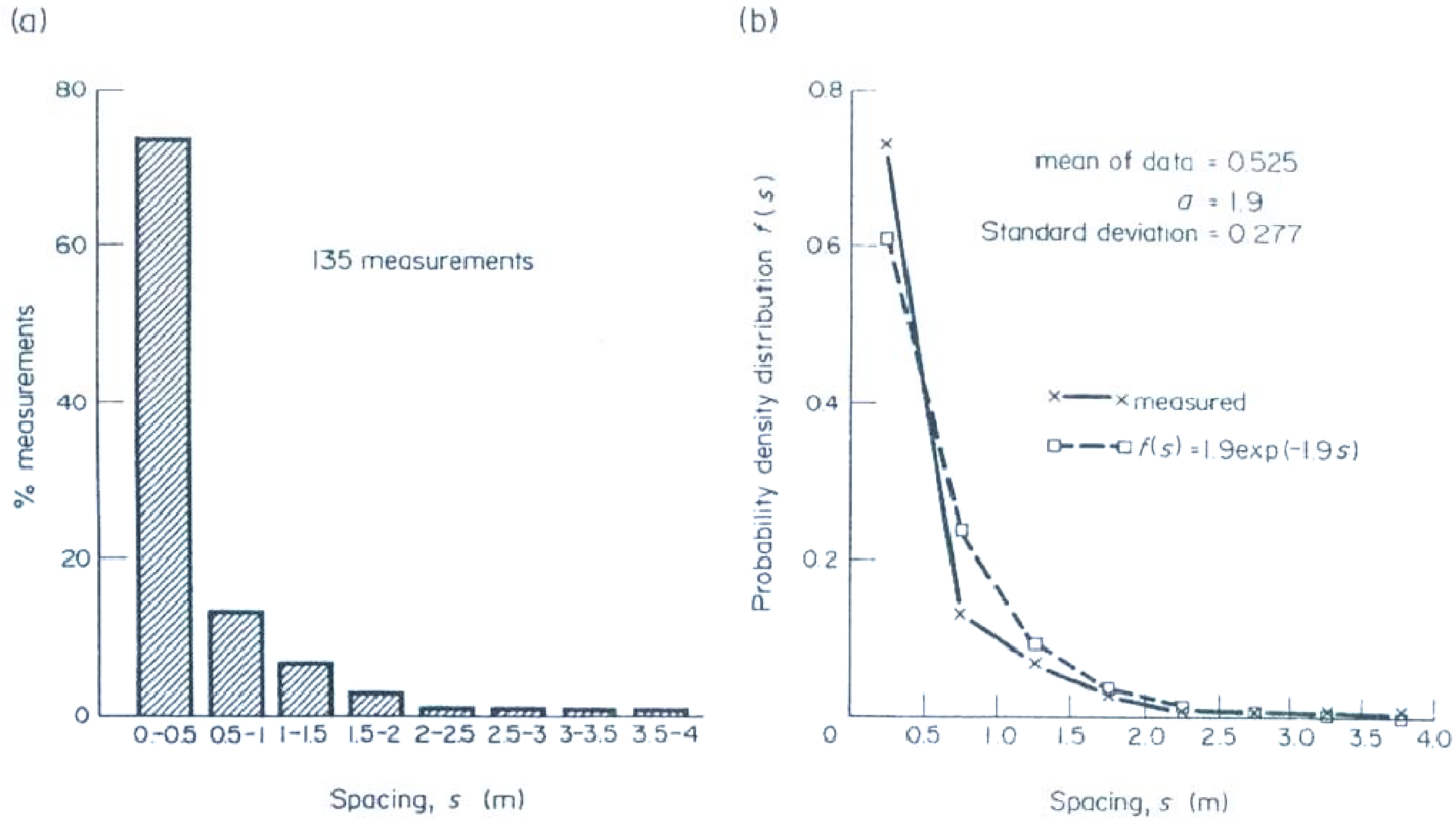
Fig. 11. Histogram showing modal, minimum and maximum spacings obtained from observations of the spacing of one set. Suggested descriptions given at base of histogram.

# Spacing

$$f(s) = \lambda \cdot e^{-\lambda \cdot s}$$

$$\lambda \sim \frac{1}{\bar{s}}$$

$$\int_0^{\infty} f(s) \cdot ds = \int_0^{\infty} \lambda \cdot e^{-\lambda \cdot s} \cdot ds = -e^{-\lambda \cdot s}\Big|_0^{\infty} = 1$$



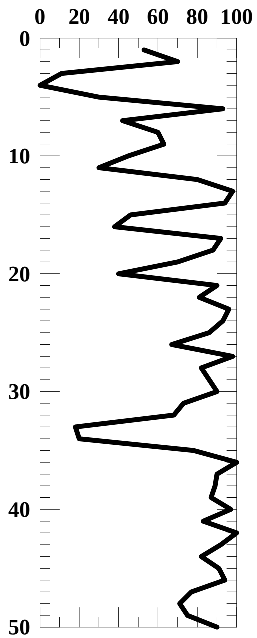
# Rock Quality Designation (RQD)

**Ratio of core in length > 10 cm and total length**

$$RQD = \frac{100 \cdot \sum x_i}{L}$$

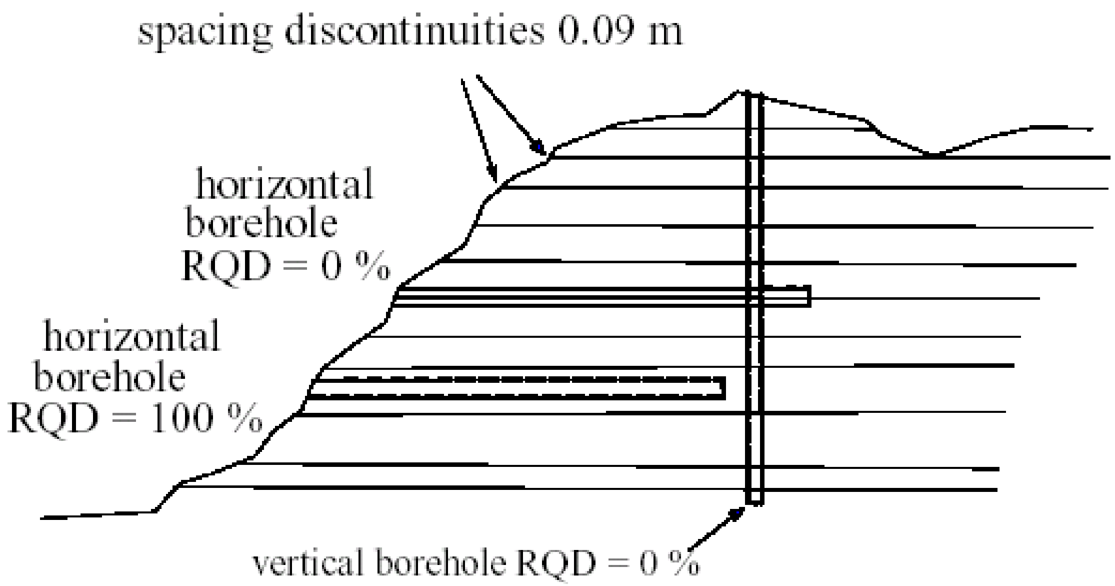
$$f(s) = \lambda \cdot e^{-\lambda \cdot s}$$

$$RQD = 100 \cdot e^{-0.1\lambda} \cdot (0.1\lambda + 1)$$

## *Some problems using RQD to evaluate rock mass structure*

- **The RQD value is influenced by drilling equipment, drilling operators and core handling. Especially RQD values of weak rocks can be considerably reduced due to inexperienced operators or poor drilling equipment**
- **Drilling fractures should be re-fitted, but what are drilling fractures?**
- **Besides, …**



# Persistence

- **It is one of the most important rock mass parameters, but the most difficult to be quantified.**
- **It can be crudely quantified by observing the discontinuity trace lengths on the surface of exposures.**

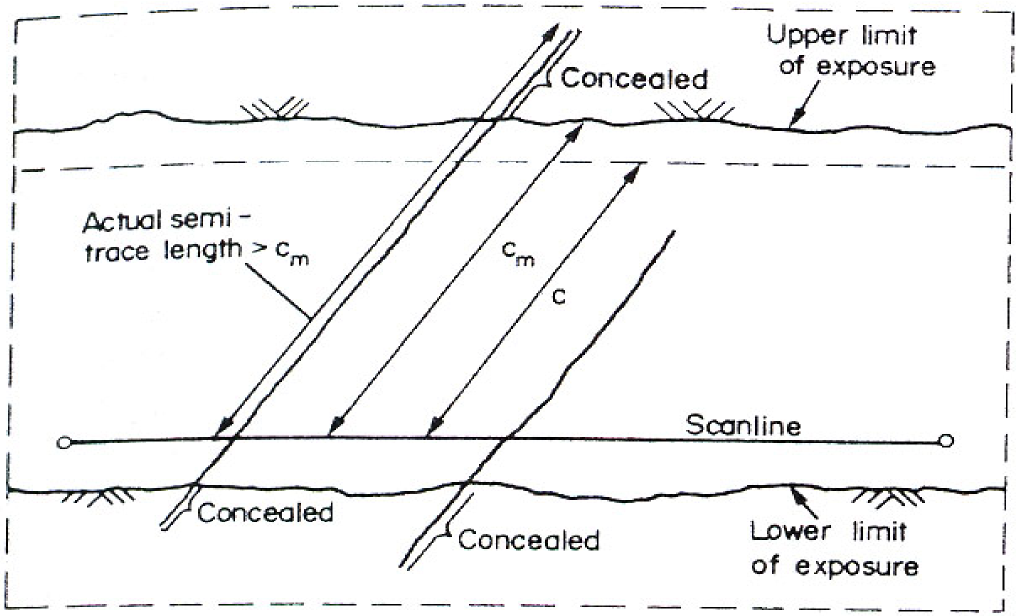



Fig. 6. Diagrammatic representation of discontinuity traces intersecting a scanline set up on a planar face of limited extent.

***Type of termination Should be recorded x (out side of the exposure), r (rock), and d (discontinuity).***

# Persistence

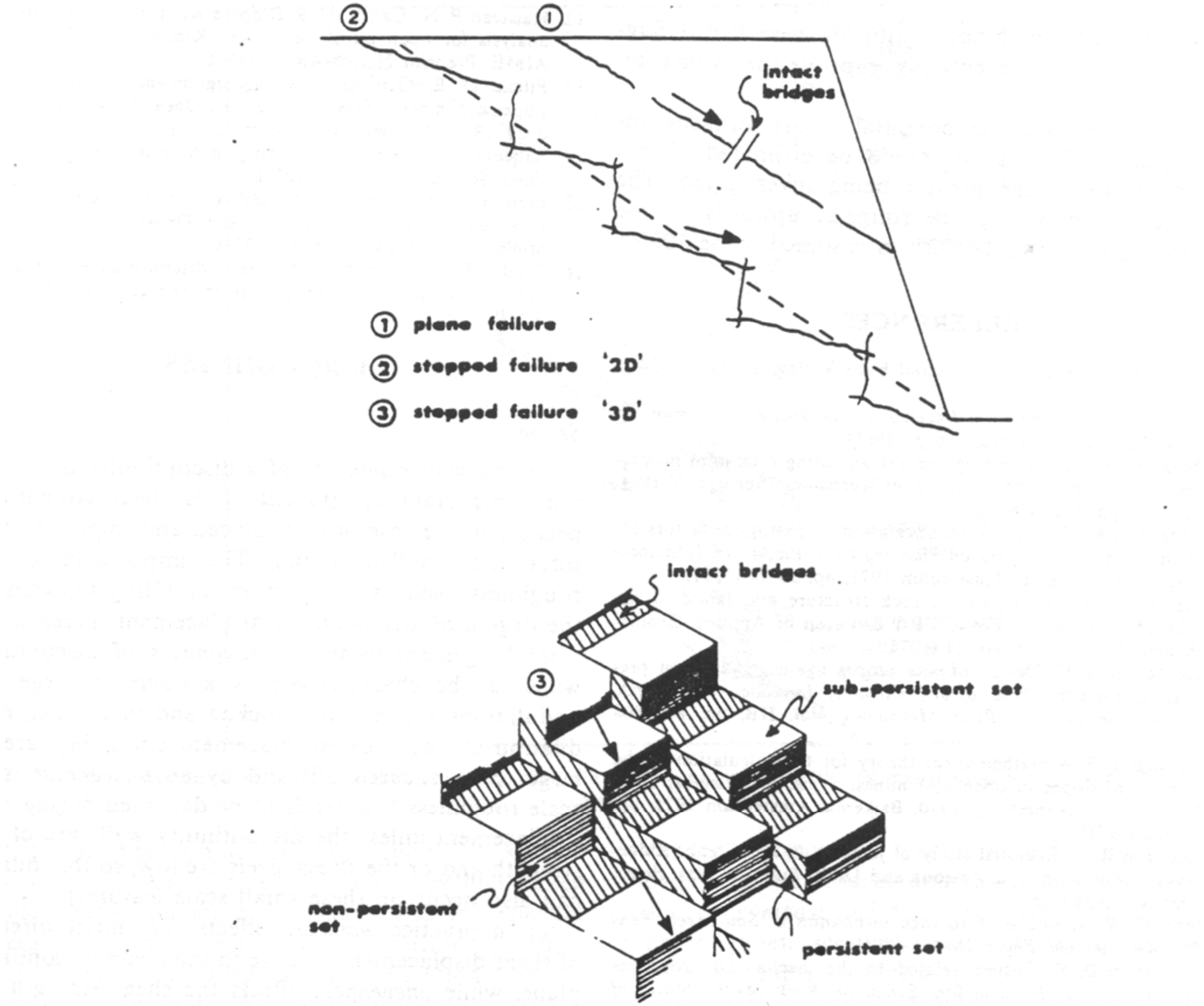
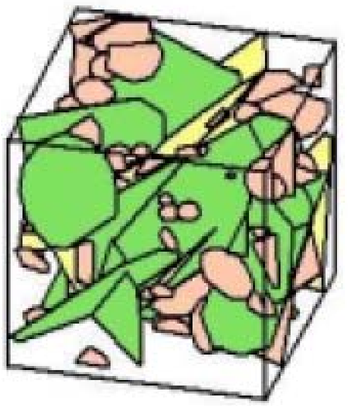



Fig. 13. Idealized examples of potential failure planes showing the importance of "intact bridges" and "down-stepping". Examples adapted from [4] and [7].

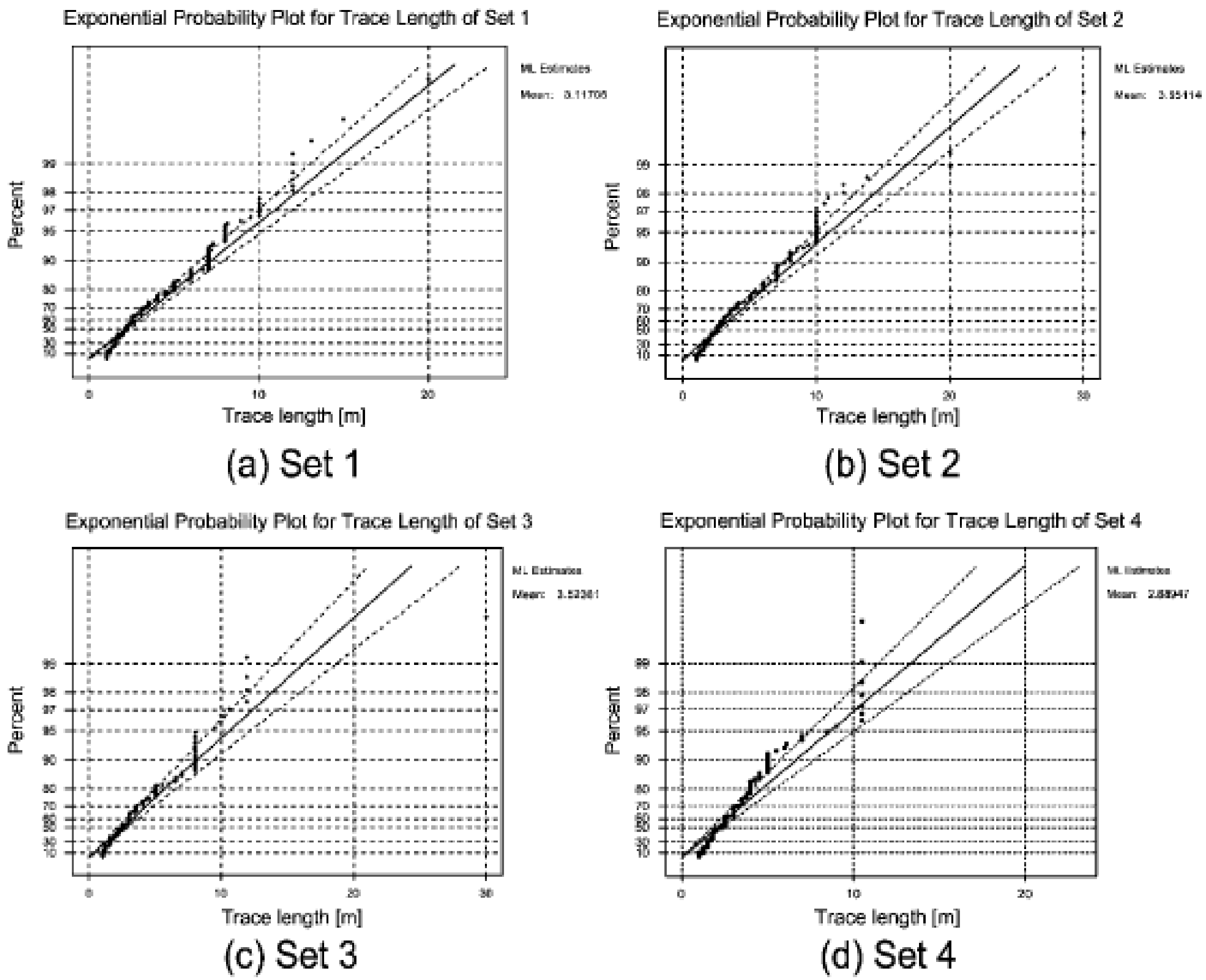
## Exponential distribution of trace length

***Trace length***



$$f(L) = CL^{-\lambda}$$

***Outcrop only***




(a) Set 1 (b) Set 2

(c) Set 3 (d) Set 4

# Persistence

| 術語 | 長度 |
|---|---|
| 持續性極低<br>**Very low persistence** | **<1m** |
| 持續性低<br>**Low persistence** | **1-3m** |
| 中度持續性<br>**Medium persistence** | **3-10m** |
| 持續性高<br>**High persistence** | **10-20m** |
| 持續性極高<br>**Very high persistence** | **>20m** |

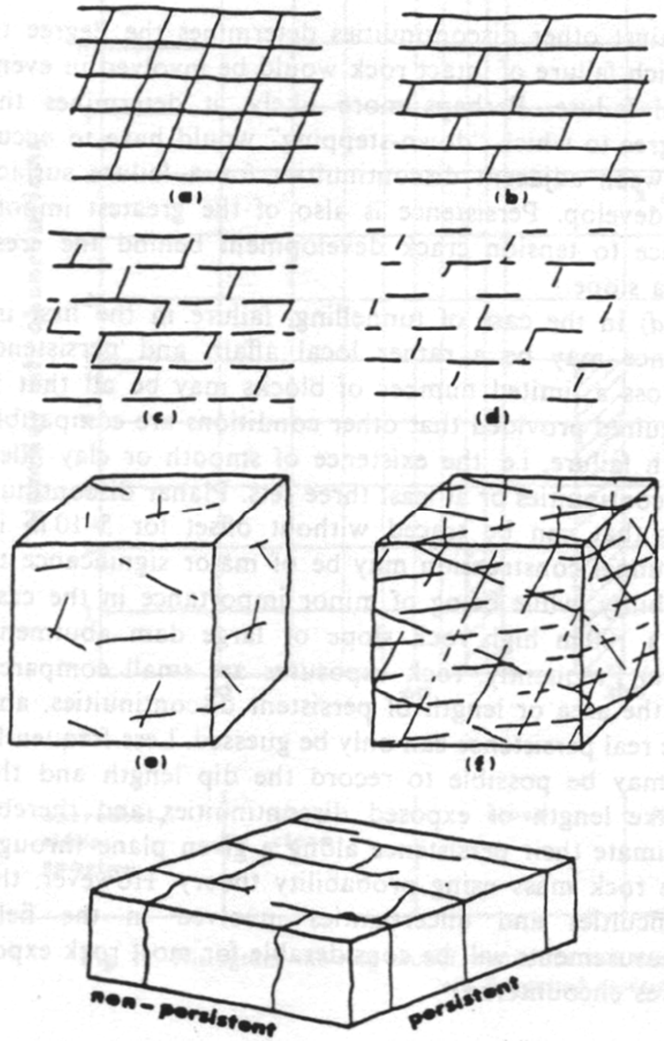



Fig. 12. Simple sketches and block diagrams help to indicate the relative *persistence* of the various sets of discontinuities. Examples adapted from [1] and [2].

# Roughness

- **The roughness of discontinuity walls can be characterized by a waviness (large scale) and unevenness (small scale).**

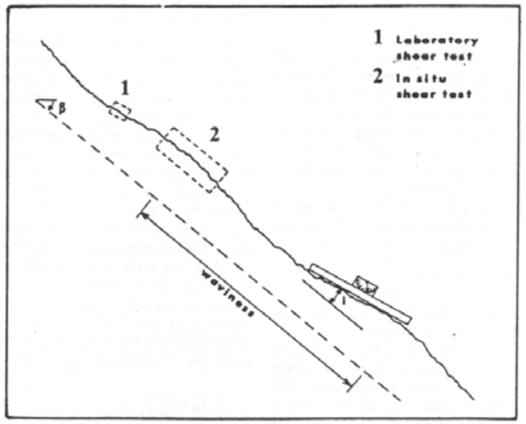
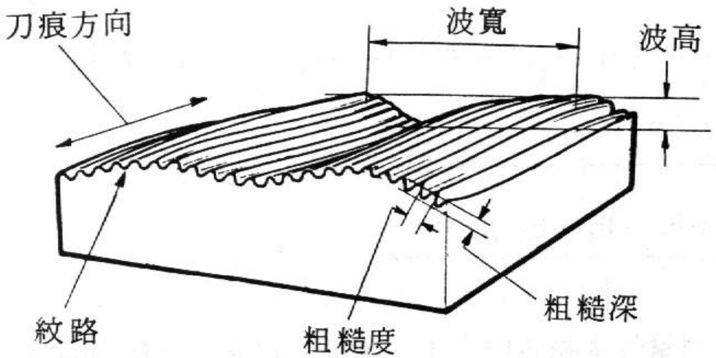



Fig. 14. Different scales of discontinuity roughness are sampled by different scales of tests. Waviness can be characterised by the angle (i).



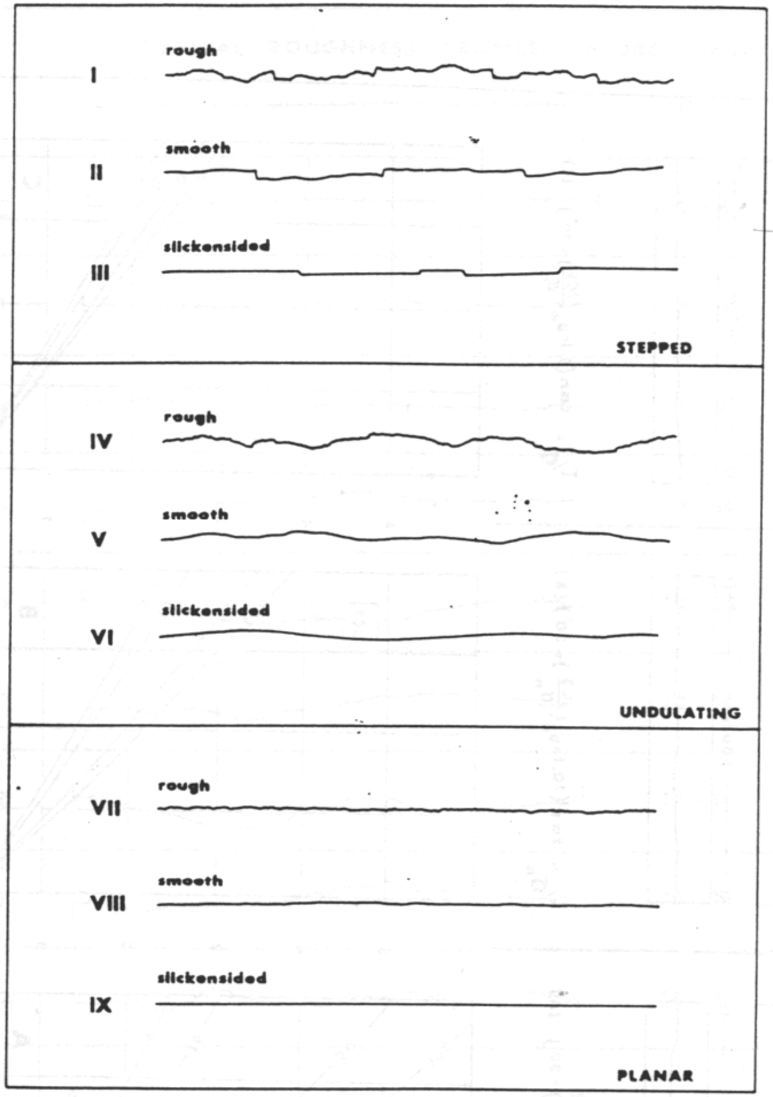




Fig. 17. Typical roughness profiles and suggested nomenclature. The length of each profile is in the range 1 to 10 metres. The vertical and horizontal scales are equal.

# Roughness

- It can be measured by
  - Linear profiling : measuring x and y
  - Compass /clinometer : four thin circular plates of various diameters (i.e. 5, 10, 15, 20 cm).

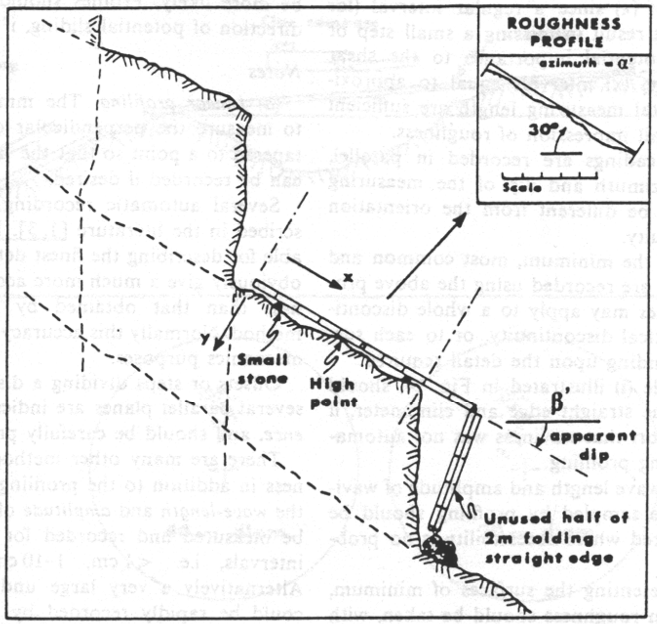



Fig. 15. A method of recording discontinuity roughness in two dimensions, along the estimated direction of potential sliding.

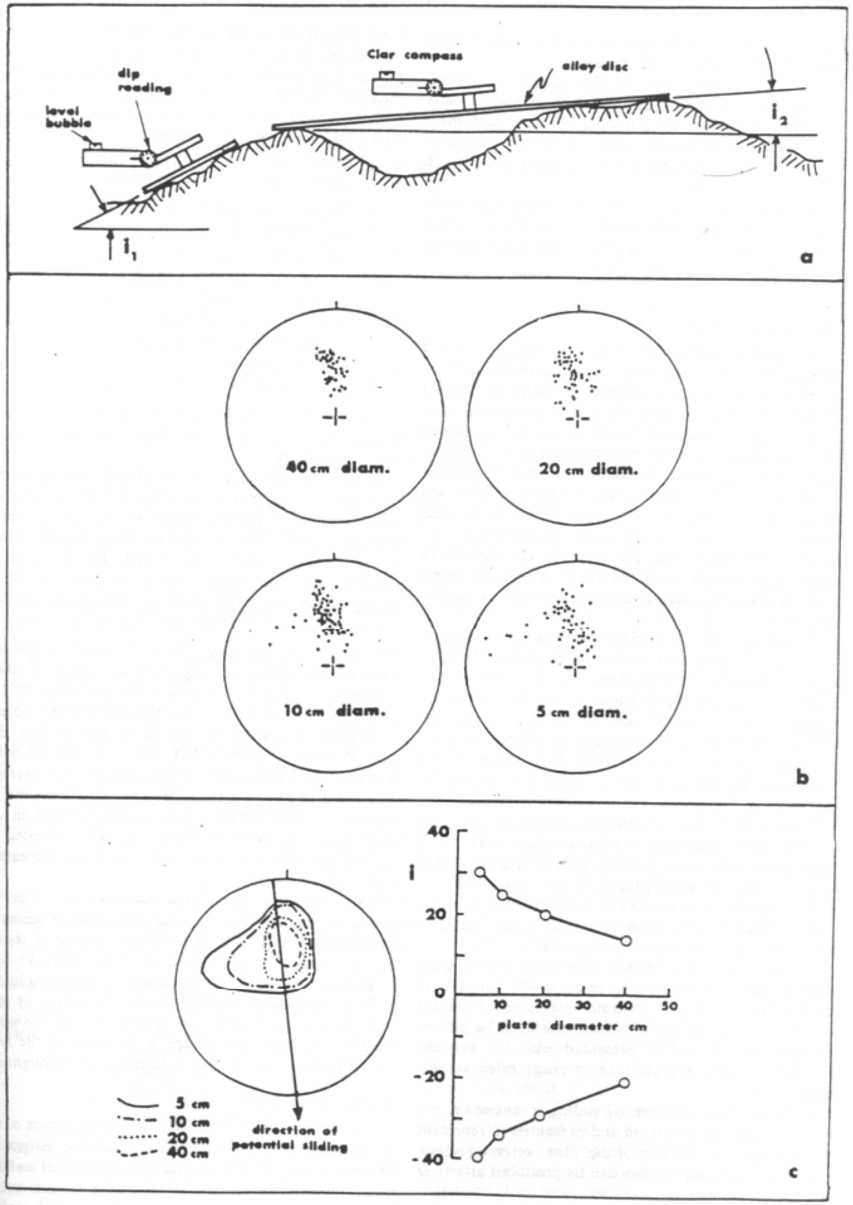
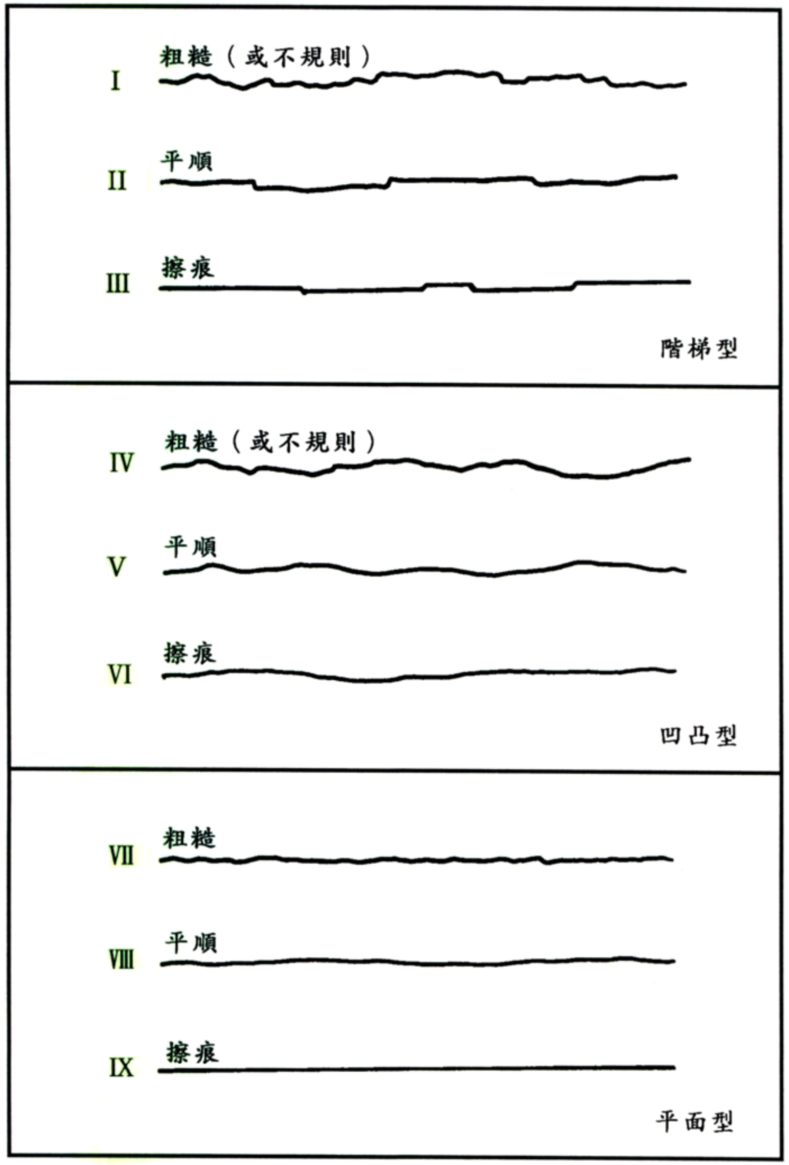



Fig. 16. A method of recording discontinuity roughness in three dimensions, for cases where the potential direction of sliding is not yet known. Circular discs of different dimensions (e.g. 5, 10, 20 and 40 cm) are fixed in turn to a Clar compass and clinometer. The dip direction and dip readings are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

# Roughness

| 微起伏分級 | 小尺度 | 中尺度 |
|---|---|---|
| I | 粗糙（或不規則） | 階梯型 |
| II | 平順 | 階梯型 |
| III | 擦痕 | 階梯型 |
| IV | 粗糙（或不規則） | 凹凸型 |
| V | 平順 | 凹凸型 |
| VI | 擦痕 | 凹凸型 |
| VII | 粗糙 | 平面型 |
| VIII | 平順 | 平面型 |
| IX | 擦痕 | 平面型 |



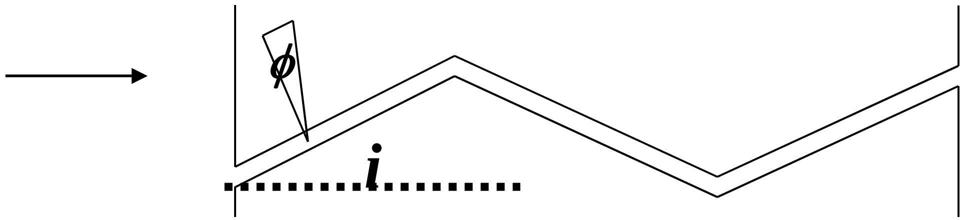
# Roughness

***Strength of joints***

$\phi + i$ **concept**

$$\phi_{peak} = i + \phi_r$$

$$\phi_{peak} = JRC \cdot \log_{10}\left(\frac{JCS}{\sigma_n}\right) + \phi_r$$



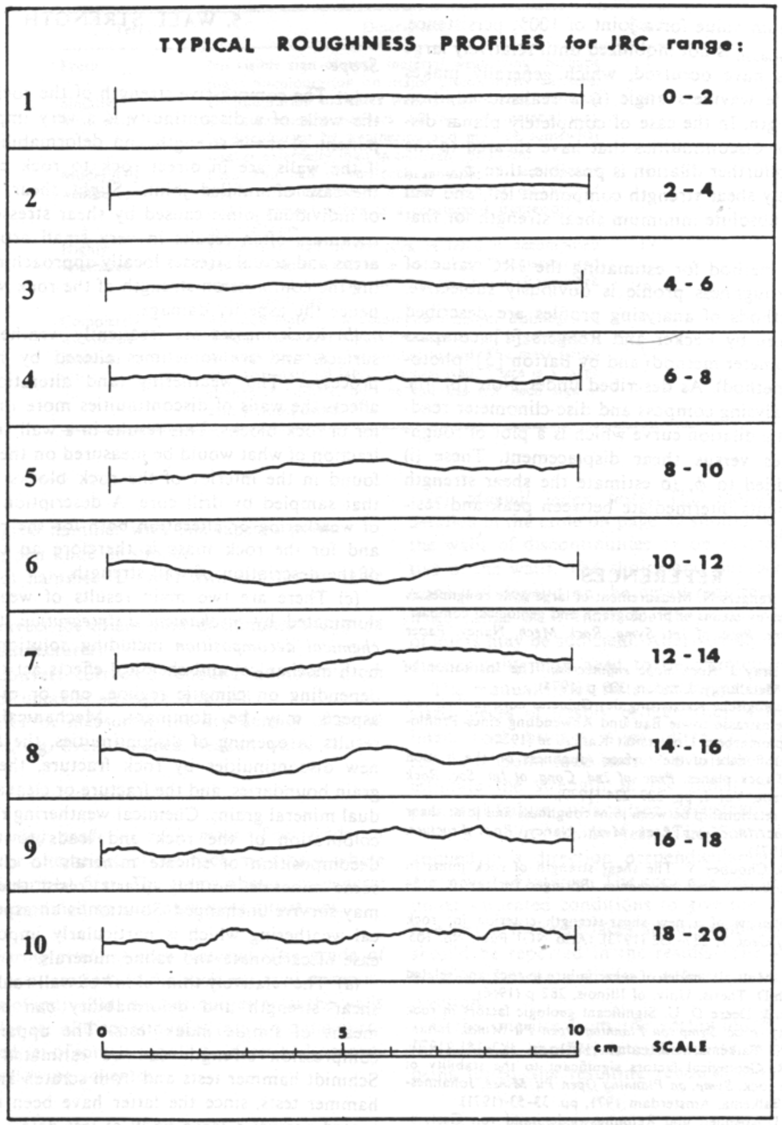




Fig. 19. Roughness profiles and corresponding range of JRC values associated with each one [6].

$$\phi_{peak} = JRC \cdot \log_{10}(\frac{JCS}{\sigma_n}) + \phi_r$$

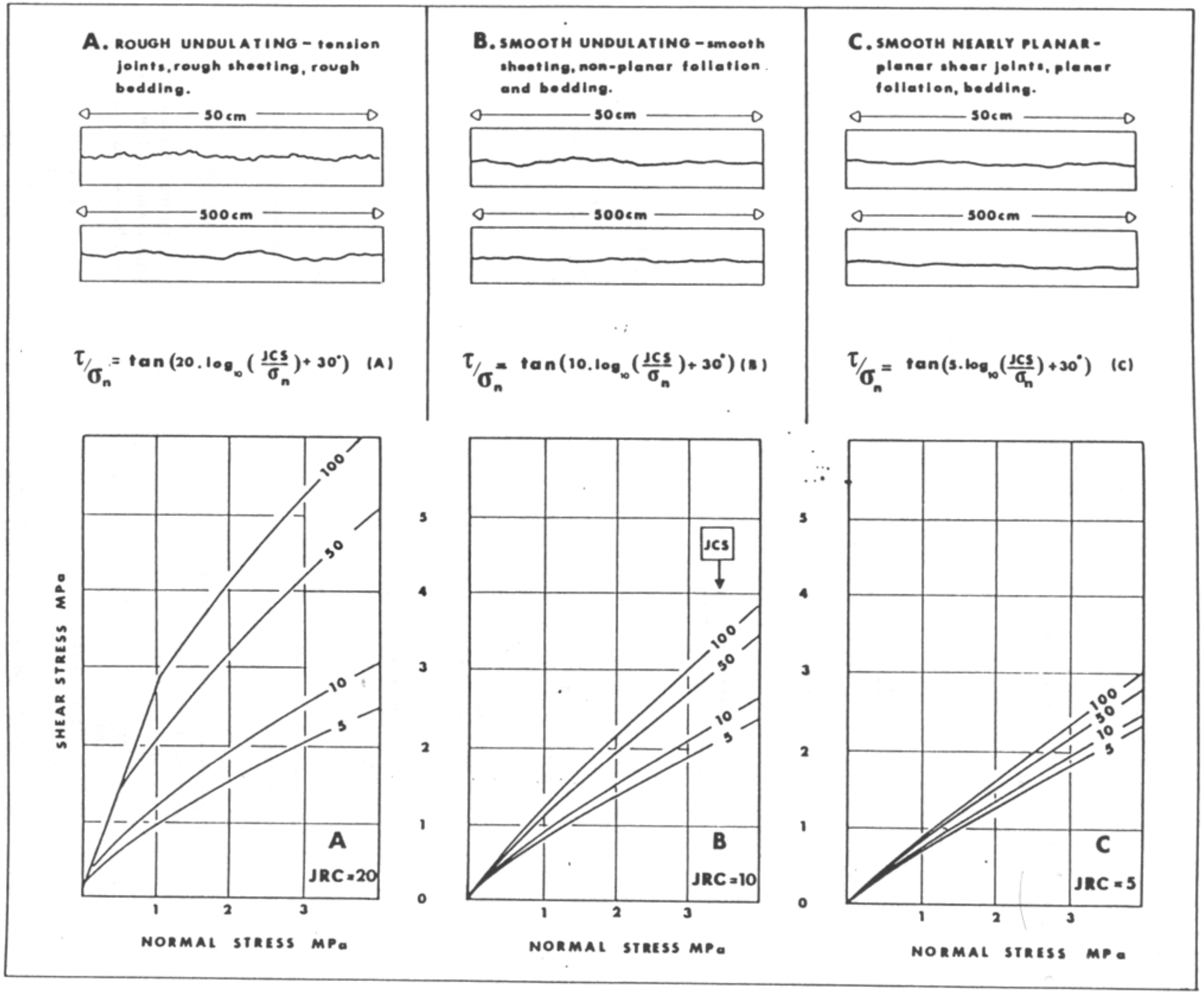
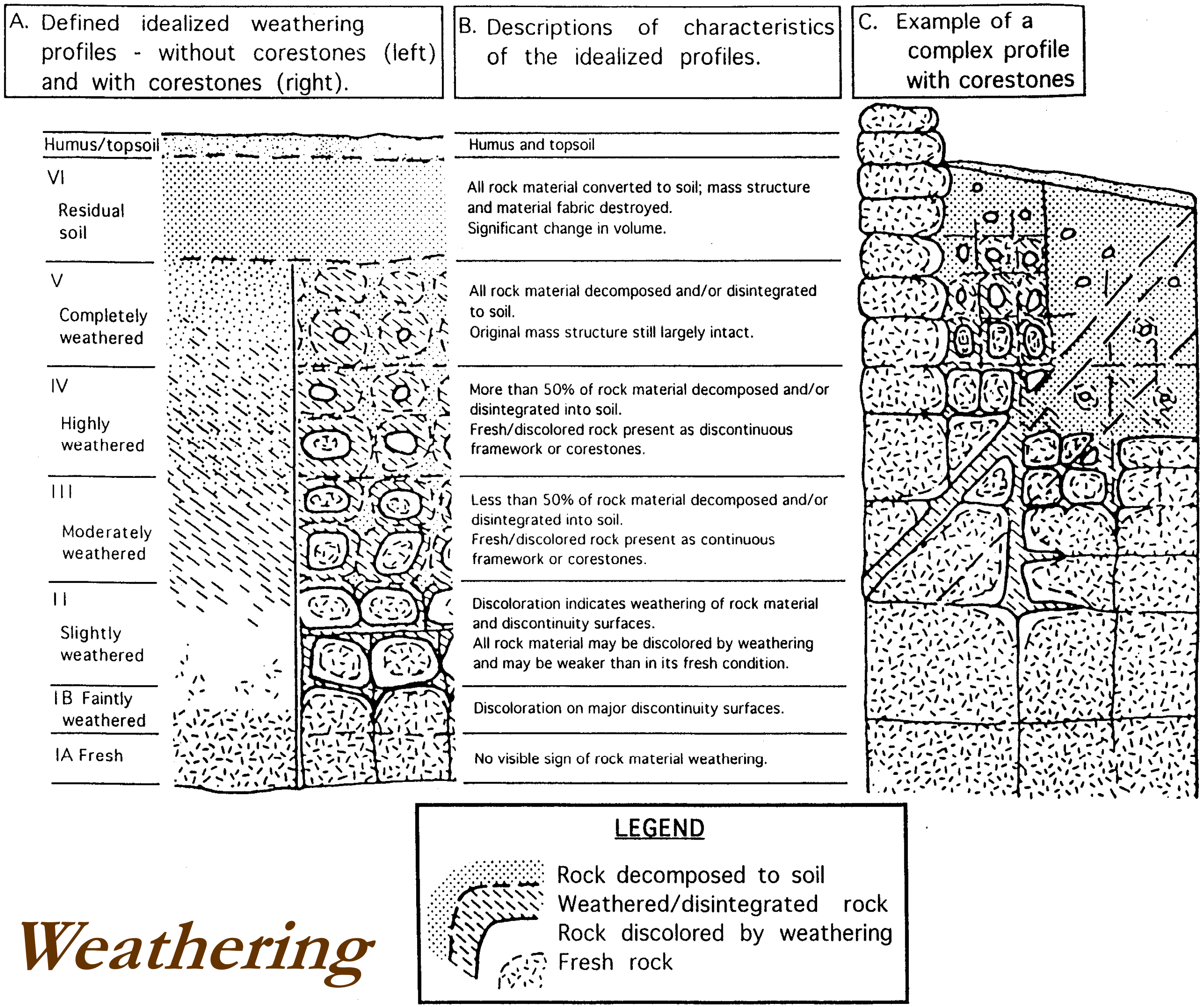



Fig. 18. A method of estimating peak shear strength from roughness profiles. Each curve is numbered with the appropriate JCS value (units of MPa). The roughness profiles are intended as an approximate guide to the appropriate JRC values

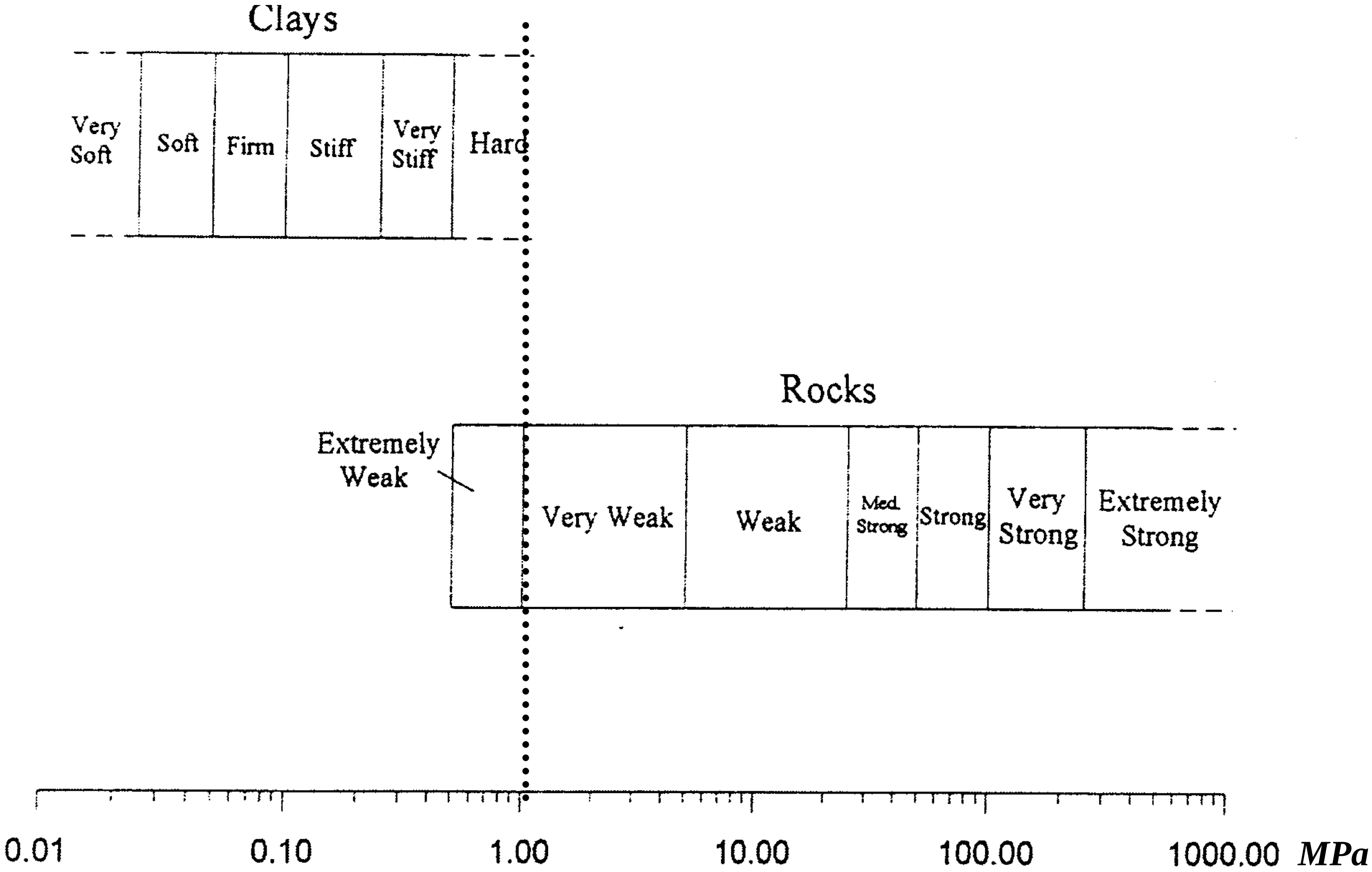
# Wall strength

先描述風化程度




## Weathering

# Wall strength




不連續面軟弱夾心以及岩石材料單壓強度與分類(Johnston,1993)

# Wall strength

| 分級 | 描述 | 現場識別 | 單 壓 強 度（MPa） |
|---|---|---|---|
| R6 | 極 強 岩 | 地質錘猛敲僅見小碎片跳，極難敲裂 | ＞250 |
| R5 | 甚 強 岩 | 地質錘敲擊多次始裂 | 100 ～ 250 |
| R4 | 強 岩 | 地質錘敲擊一次以上始裂 | 50 ～ 100 |
| R3 | 中 強 岩 | 小刀無法切削，地質錘敲擊一次可裂 | 25 ～ 50 |
| R2 | 弱 岩 | 小刀難以切削，地質錘細端敲出淺痕 | 5 ～ 25 |
| R1 | 甚 弱 岩 | 可以地質錘細端敲碎，可以小刀切削之 | 1 ～ 5 |
| R0 | 極 弱 岩 | 大拇指甲能壓出凹痕 | 0.25 ～ 1 |
| S6 | 堅硬黏土 | 大拇指甲難壓出凹痕 | > 0.5 |
| S5 | 甚硬黏土 | 大拇指甲易於壓出凹痕 | 0.25 ～ 0.5 |
| S4 | 硬黏土 | 大拇指甲易於壓出凹痕，但難貫入 | 0.1 ～ 0.25 |
| S3 | 堅實黏土 | 大拇指用力可貫入 | 0.05 ～ 0.1 |
| S2 | 軟黏土 | 大拇指易貫入 | 0.025 ～ 0.05 |
| S1 | 甚軟黏土 | 手掌易貫入 | < 0.025 |

# 施密特錘

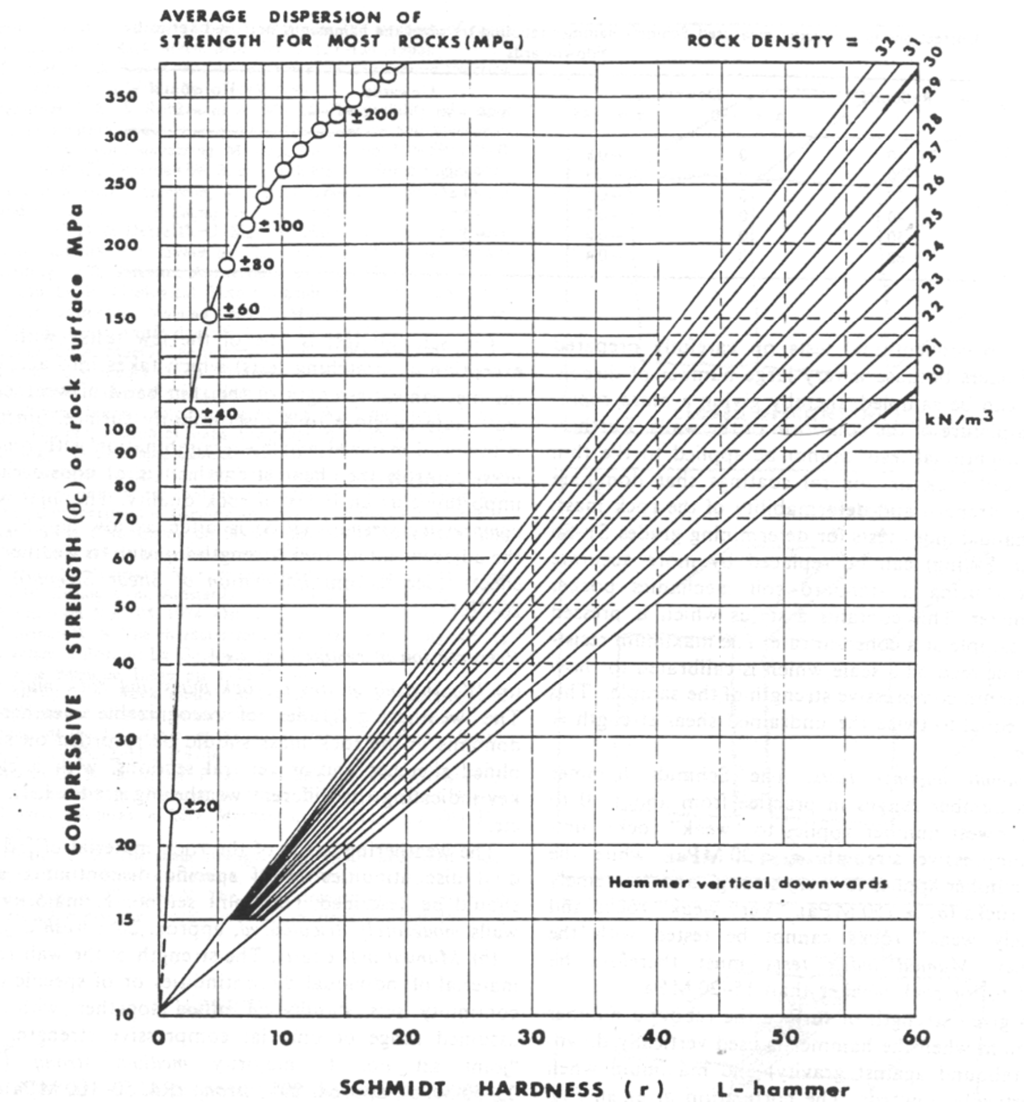



Fig. 20. Correlation chart for Schmidt (L) hammer, relating rock density, compressive strength and rebound number, after Miller [1].

1 Impact plunger
3 Housing compl.
4 Rider with guide rod
6 Pushbutton compl.
7 Hammer guide bar
8 Disk
9 Cap
10 Two-part ring
11 Rear cover
12 Compression spring
13 Pawl
14 Hammer mass
15 Retaining spring
16 Impact spring
17 Guide sleeve
18 Felt washer
19 Plexiglass window scale printed on window
20 Trip screw
21 Lock nut
22 Pin
23 Pawl spring

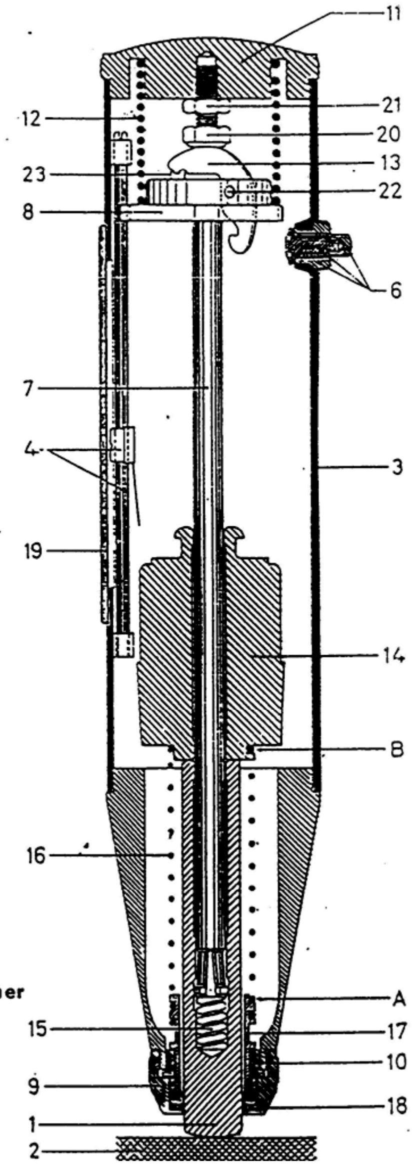
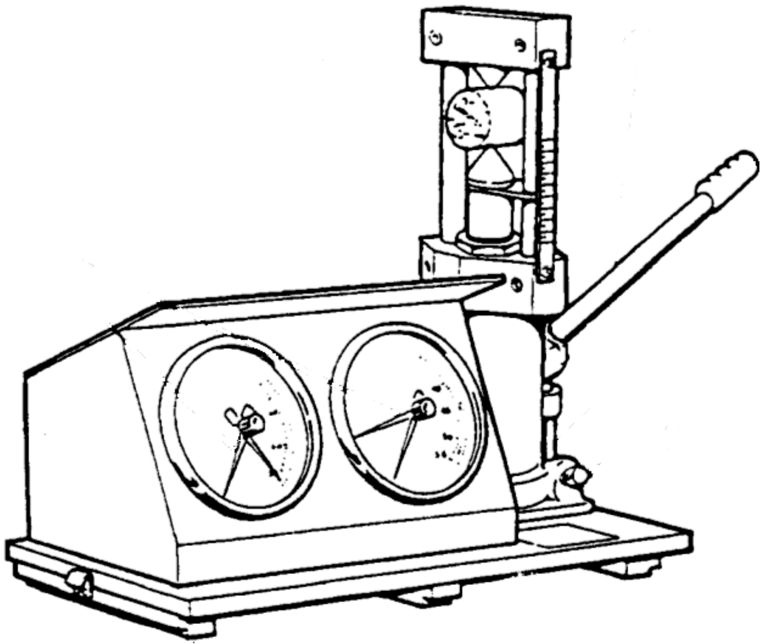



Fig. 2
Longitudinal Section of the Type N Concrete Test Hammer

Condition on impact

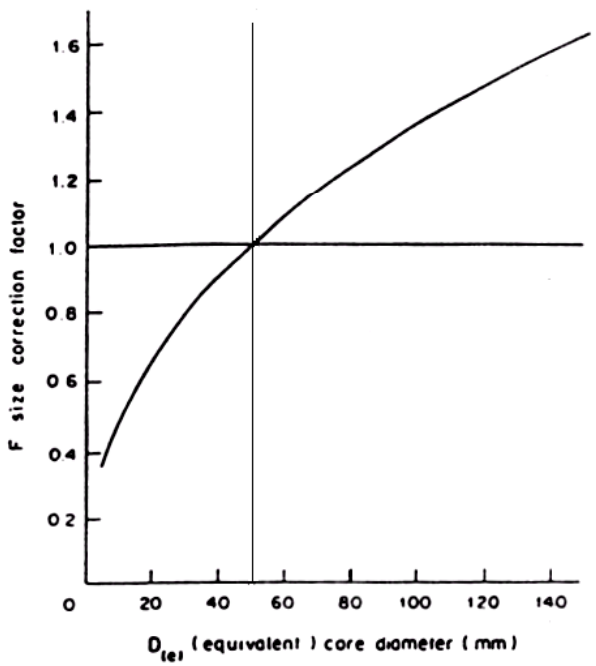
When ordering spare parts, please state No. of part and serial No. of test hammer!

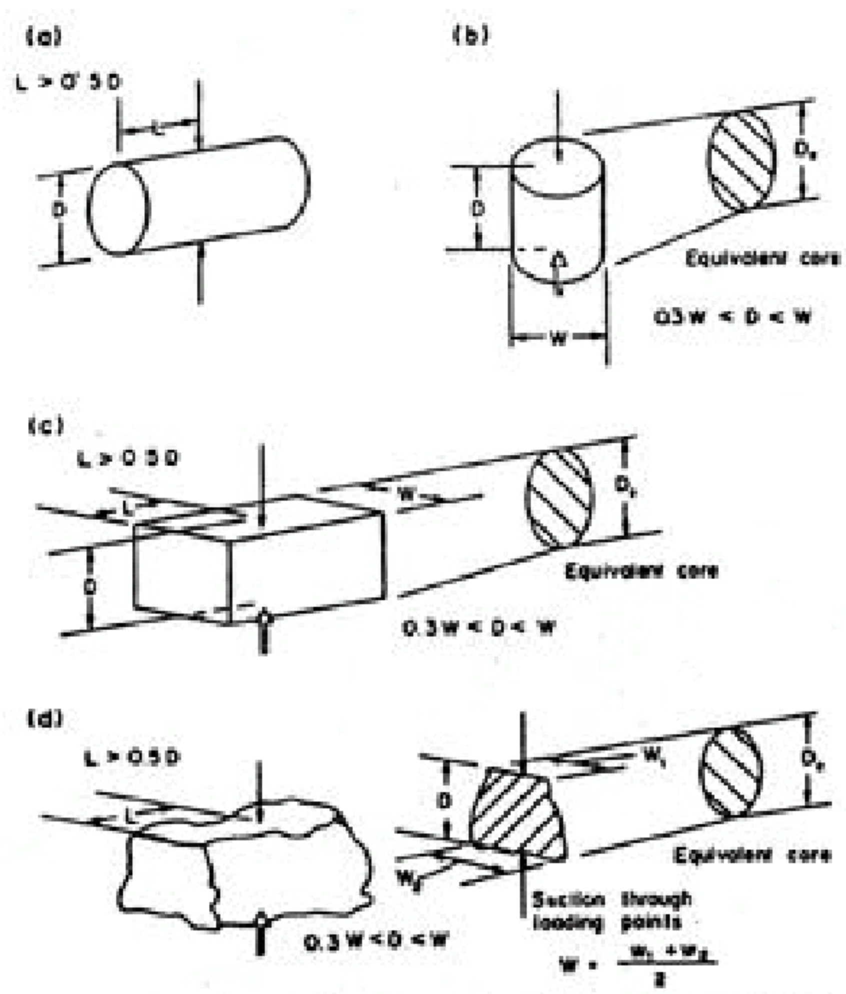
# 點荷重試驗



# 點荷重指數 $q_u$=24$Is_{50}$

- $P/D_e^2 = Is$，乘上修正因子$F$，使其轉換成標準直徑$D_e$＝50mm之點荷重指數
- $Is_{50} = F * Is$




(a)徑向 (b)軸向 (c)塊體 (d)不規則岩塊