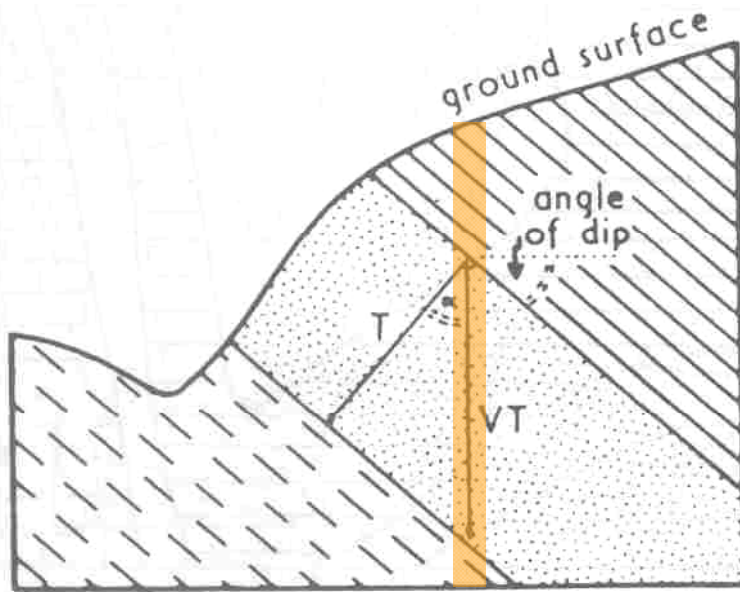
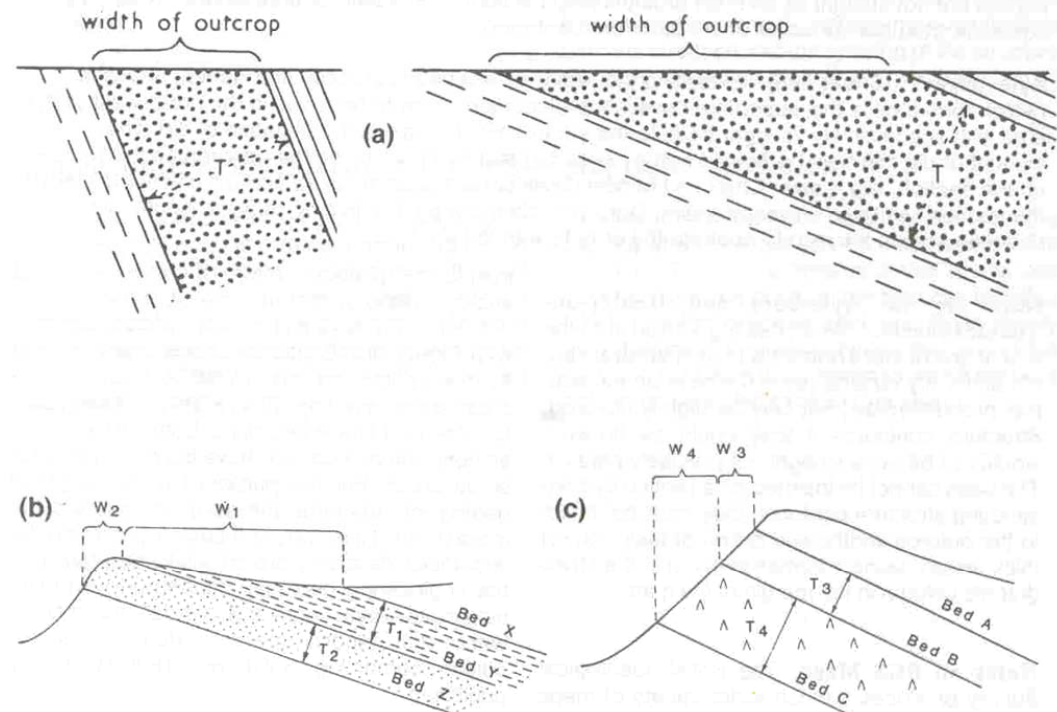


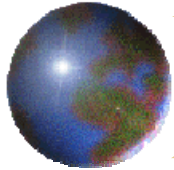
Spacing

Apparent thickness and True thickness



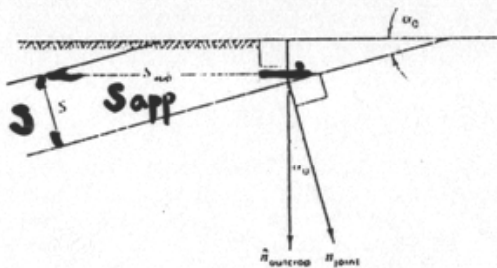
$$T = VT * \cos \alpha$$





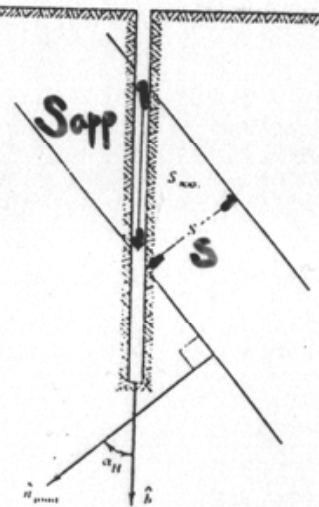
Spacing Apparent spacing and True spacing

$$S = S_{app} \cdot \sin \alpha_0$$



$$S = S_{app} \cdot \sin \alpha_0$$

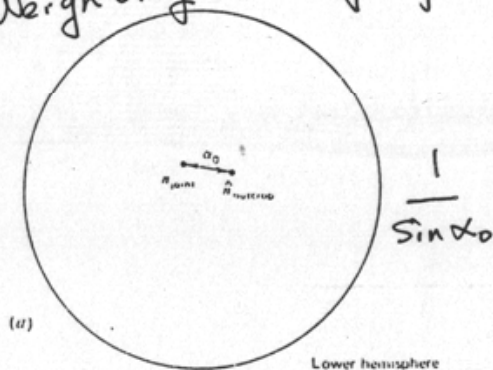
$$S = S_{app} \cdot \cos \alpha_H$$



$$S = S_{app} \cdot \cos \alpha_H$$

Weighting "a single joint"

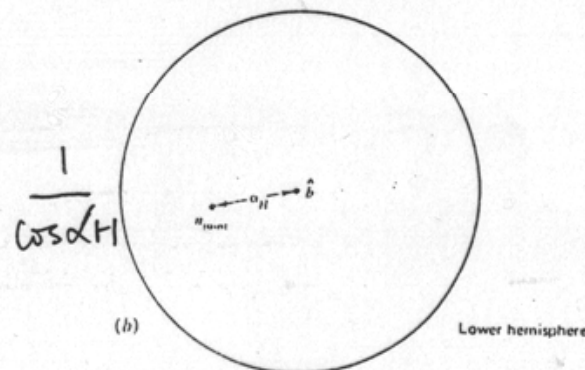
"numbers of joints"



(a)

Lower hemisphere

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

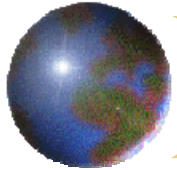


(b)

Lower hemisphere

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

"Sampling bias"



Spacing

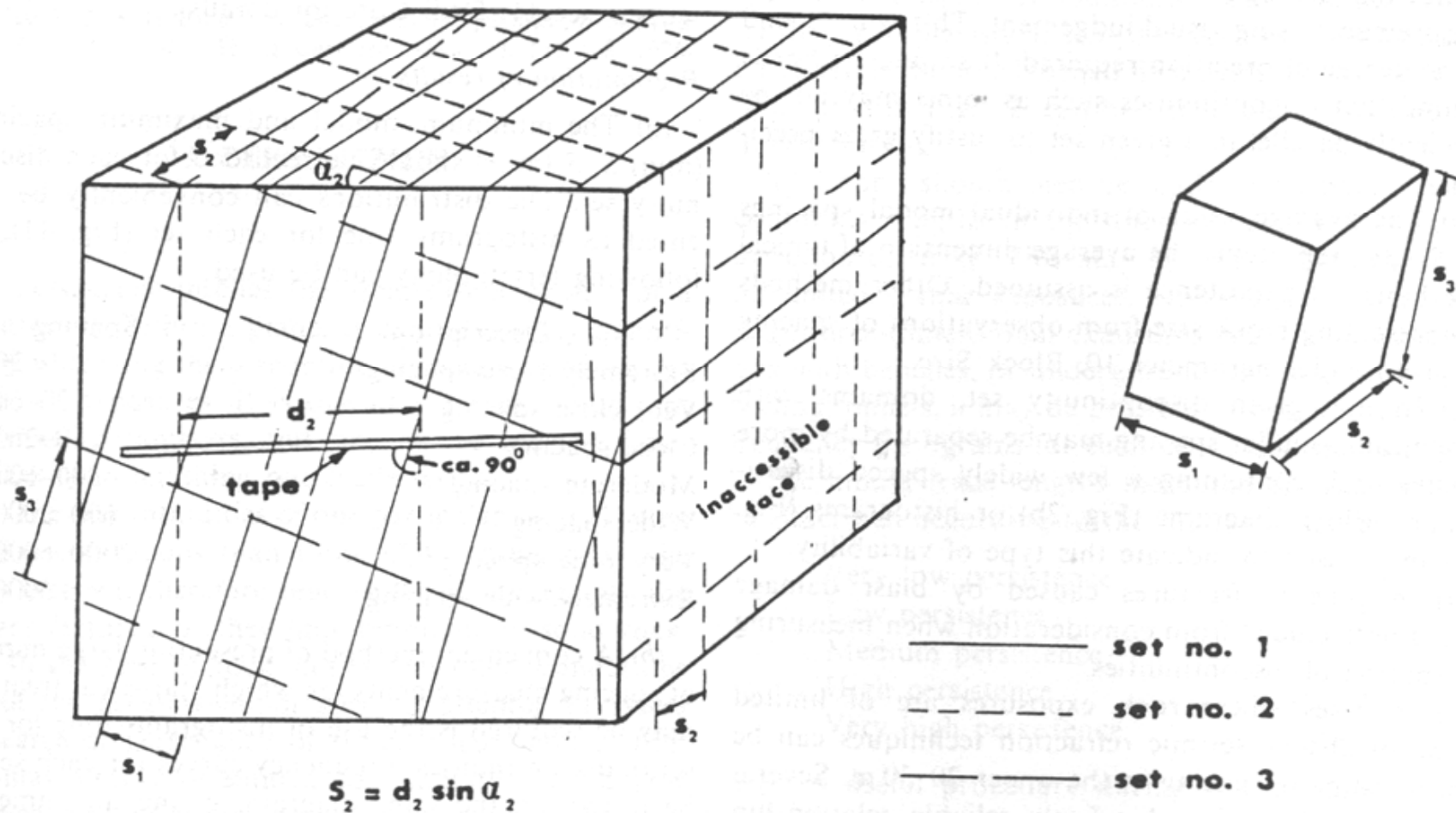
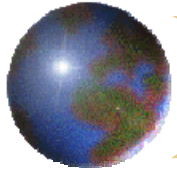
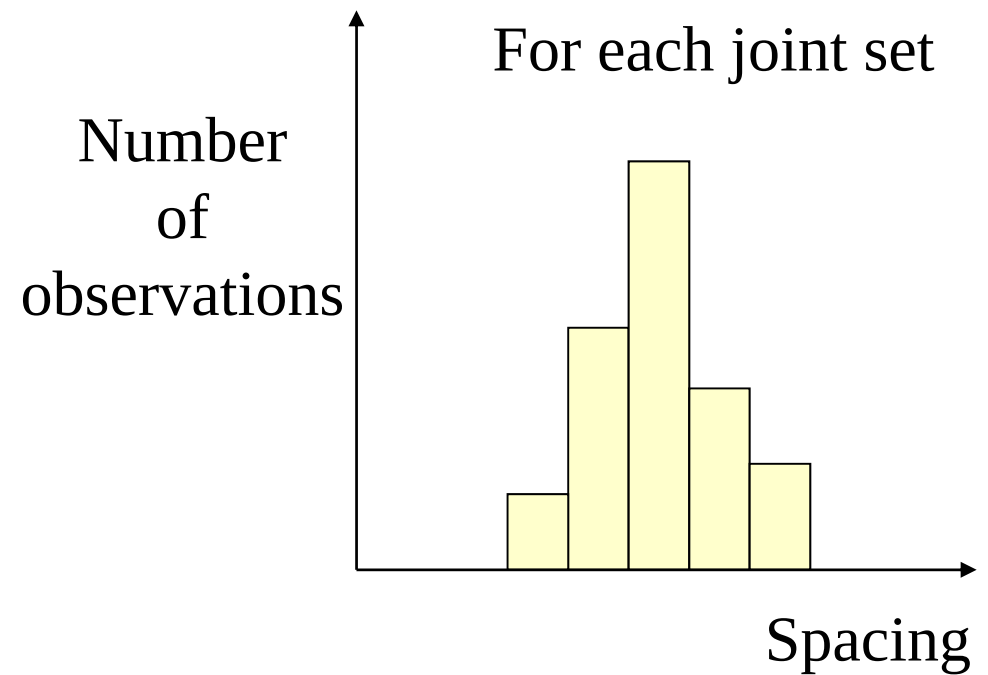
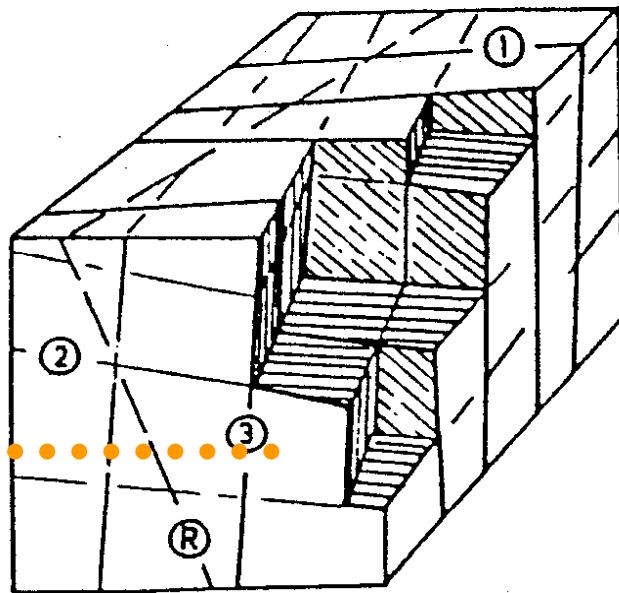


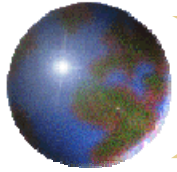
Fig. 10. Measurement of joint spacing from observation of a rock exposure.



Spacing



Measuring tape of at least 3m length



Spacing

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

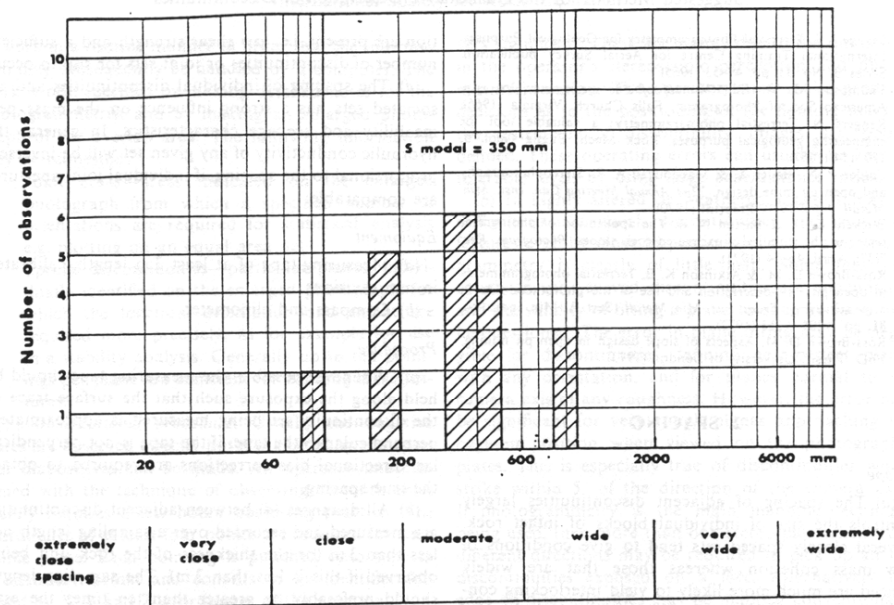
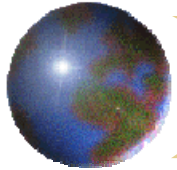


Fig. 11. Histogram showing modal, minimum and maximum spacings obtained from observations of the spacing of one set. Suggested descriptions given at base of histogram.

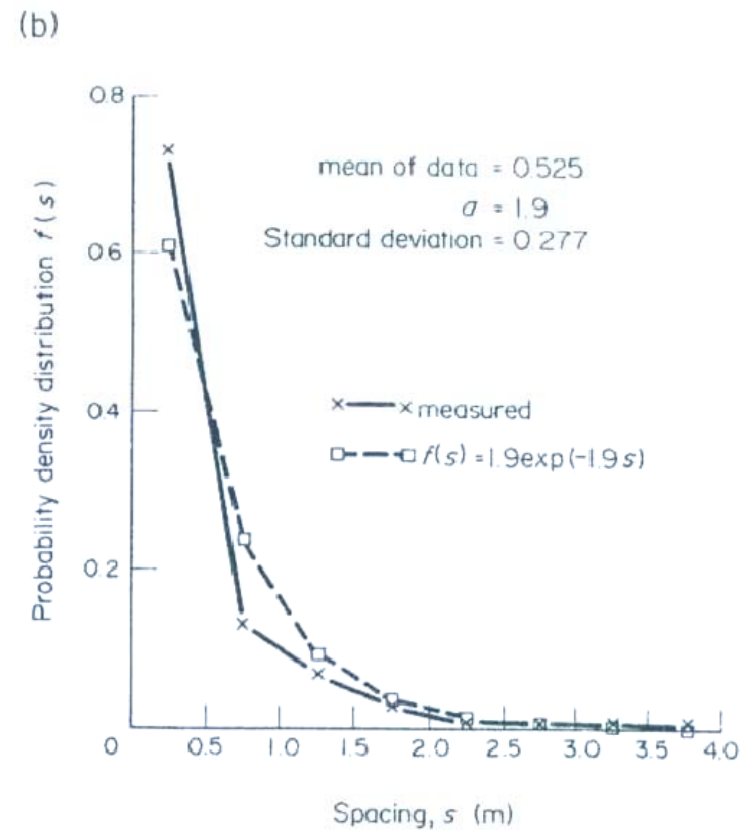
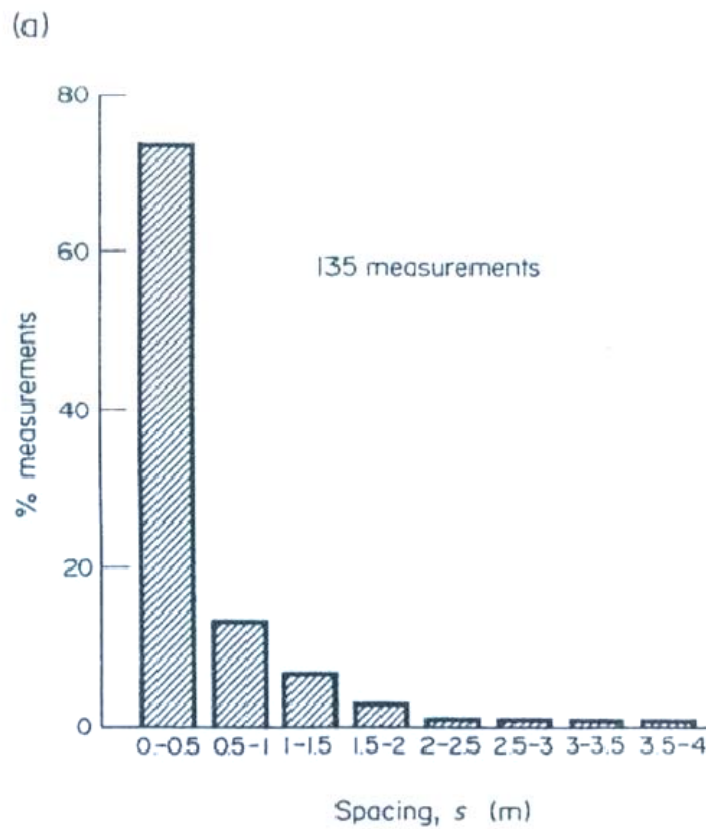


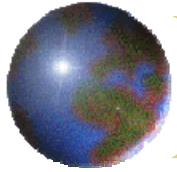
Spacing

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

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

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





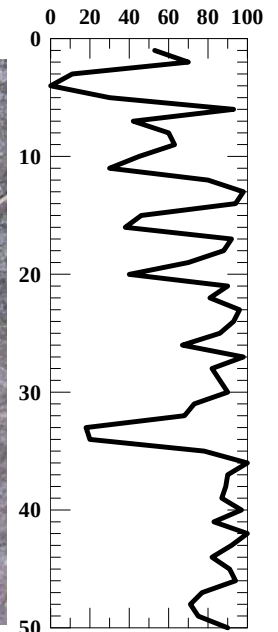
Rock Quality Designation (RQD)

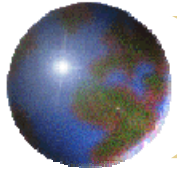
Ratio of core in length > 10 cm and total length

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

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

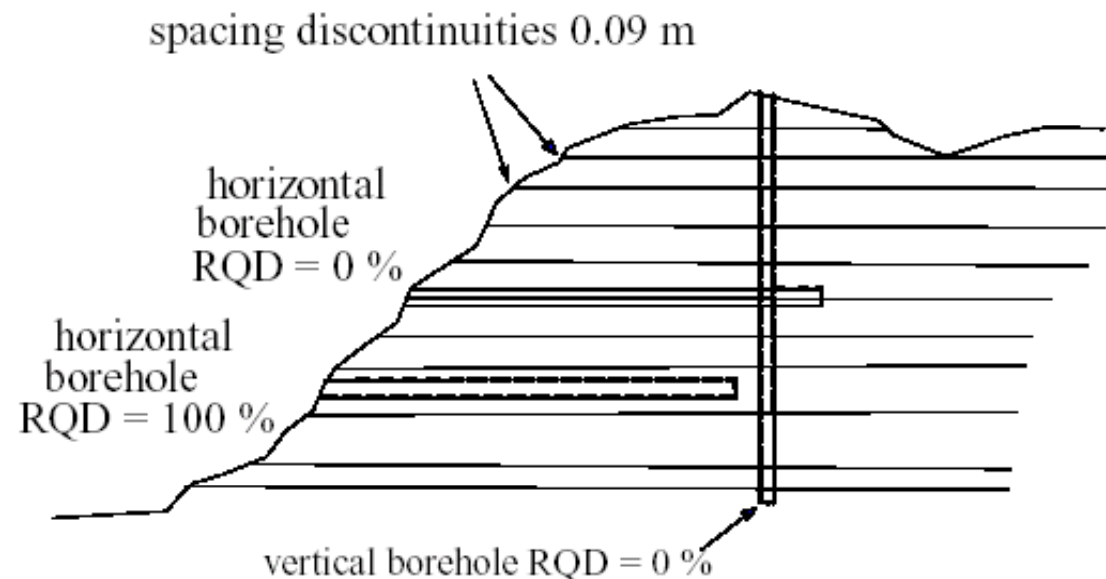
$$RQD = 100 \cdot e^{-0.1\lambda} \cdot (0.1\lambda + 1)$$

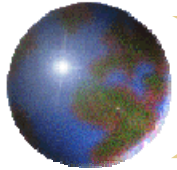




Some problems using RQD to evaluate rock mass structure

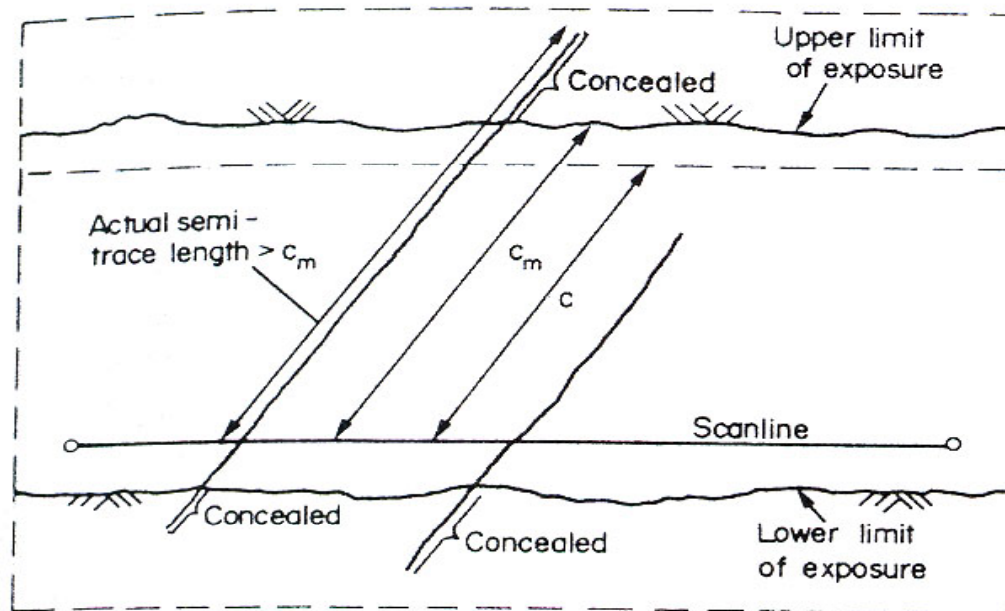
- The RQD value is **influenced by drilling equipment, drilling operators and core handling**. Especially RQD values of weak rocks can be considerably reduced due to inexperienced operators or poor drilling equipment
- **Drilling fractures should be re-fitted**, but what are drilling fractures?
- Besides,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





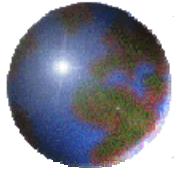
Persistence

- 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.



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

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



Persistence

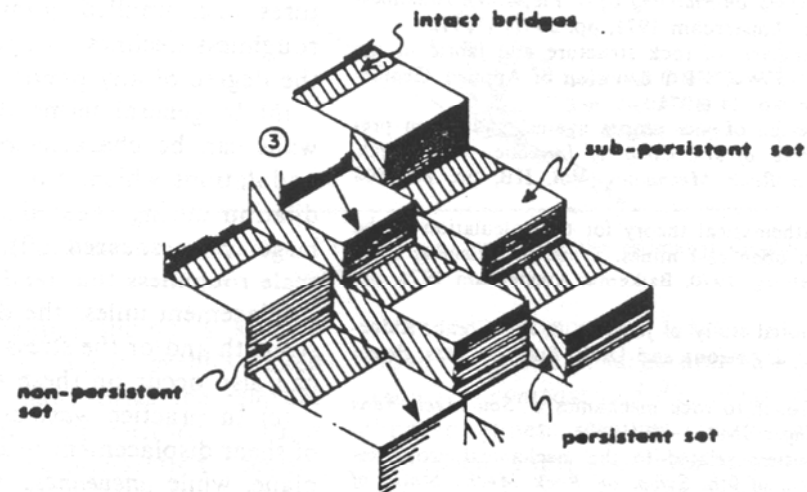
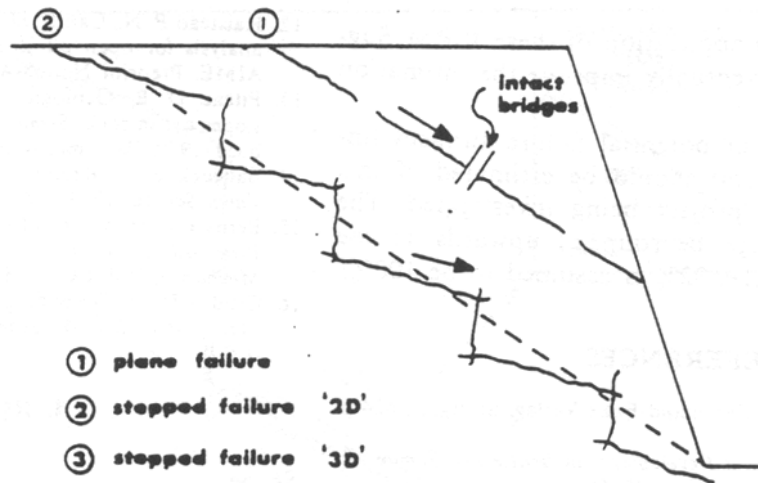
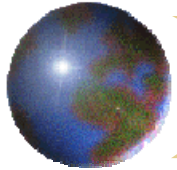


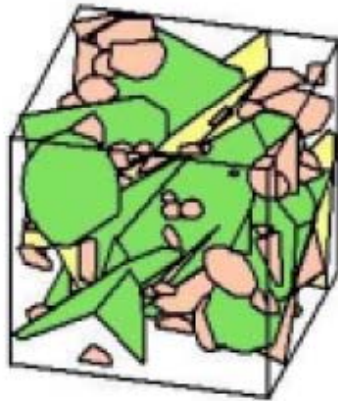
Fig. 13. Idealized examples of potential failure planes showing the importance of "intact bridges" and "down-stepping".
Examples adapted from [4] and [7].



Persistence

Exponential distribution of trace length

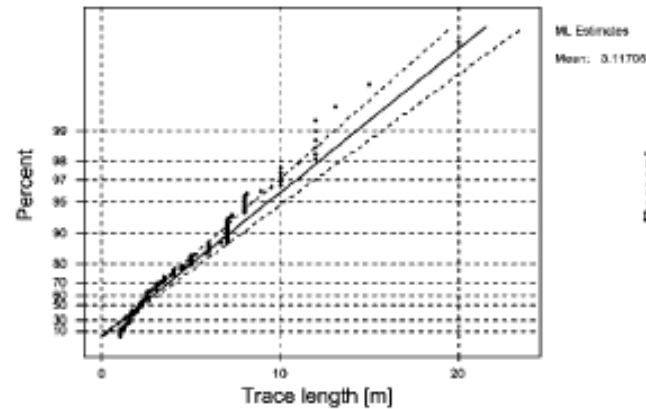
Trace length



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

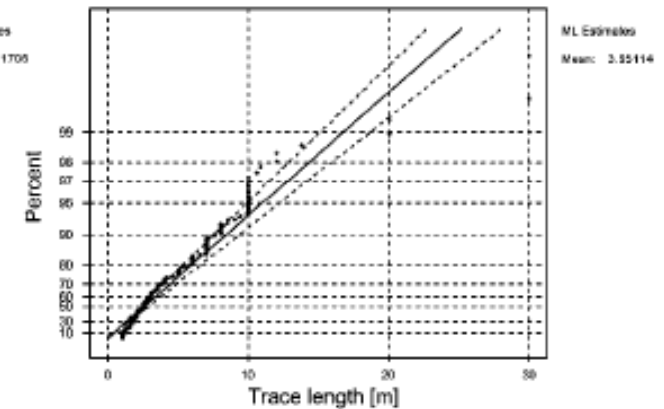
Outcrop only

Exponential Probability Plot for Trace Length of Set 1



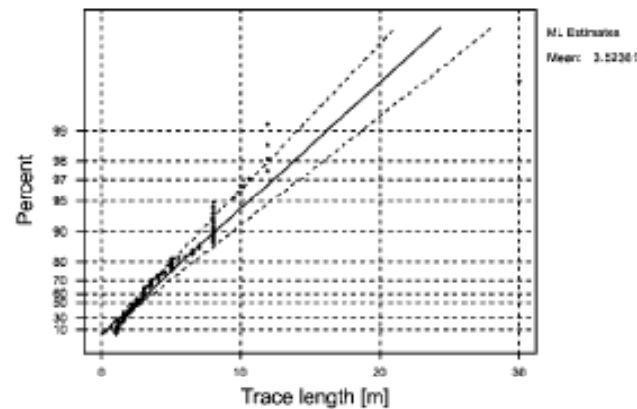
(a) Set 1

Exponential Probability Plot for Trace Length of Set 2



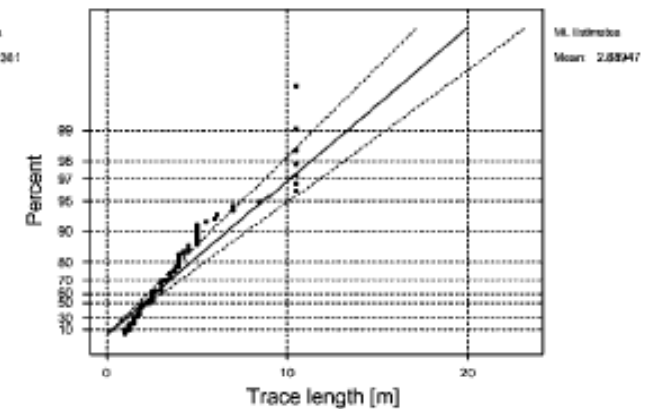
(b) Set 2

Exponential Probability Plot for Trace Length of Set 3

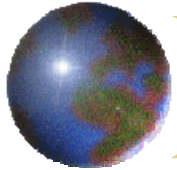


(c) Set 3

Exponential Probability Plot for Trace Length of Set 4



(d) Set 4



Persistence

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

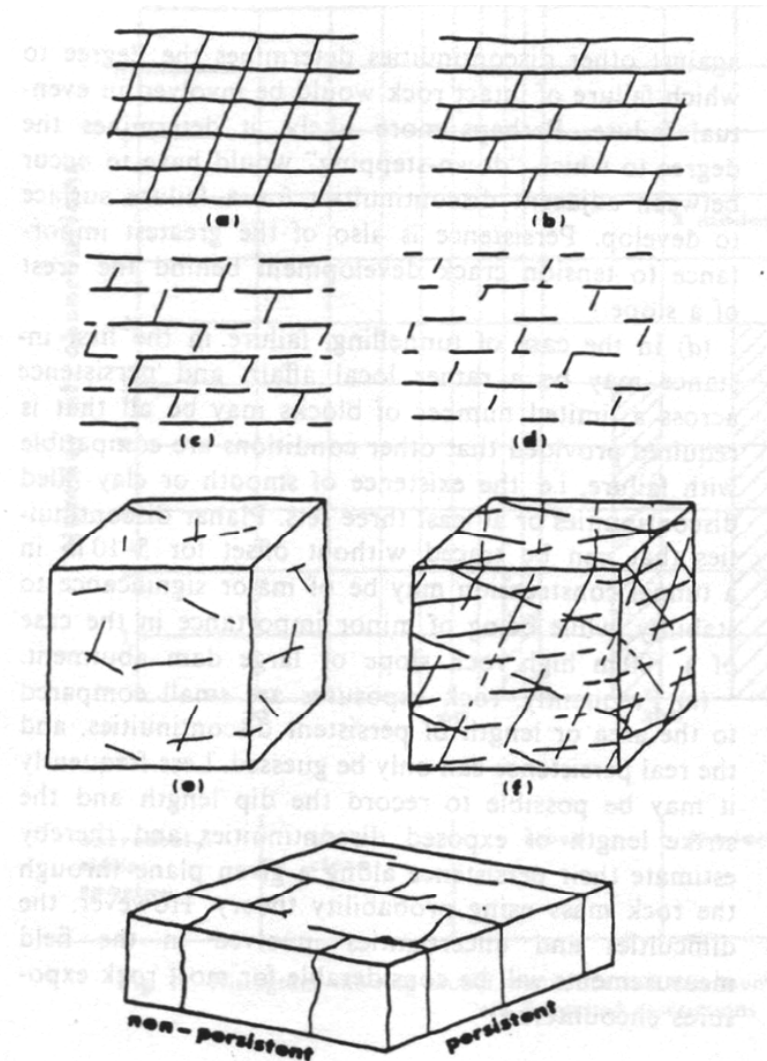
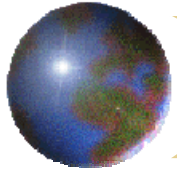


Fig. 12. Simple sketches and block diagrams help to indicate the relative *persistence* of the various sets of discontinuities. Examples adapted from [1] and [2].



Roughness

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

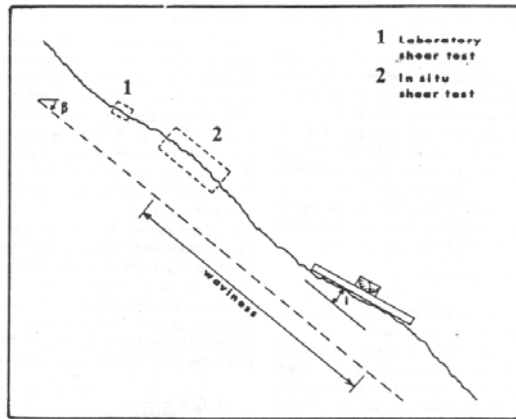


Fig. 14. Different scales of discontinuity roughness are sampled by different scales of tests. Waviness can be characterised by the angle (i).

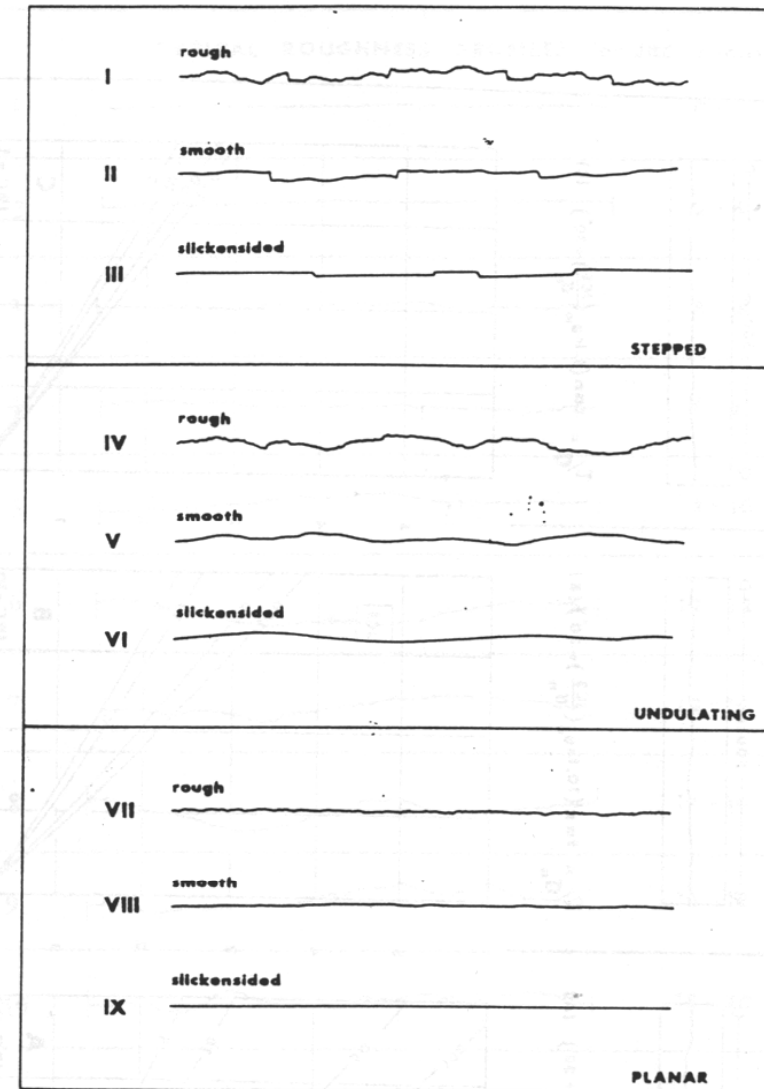
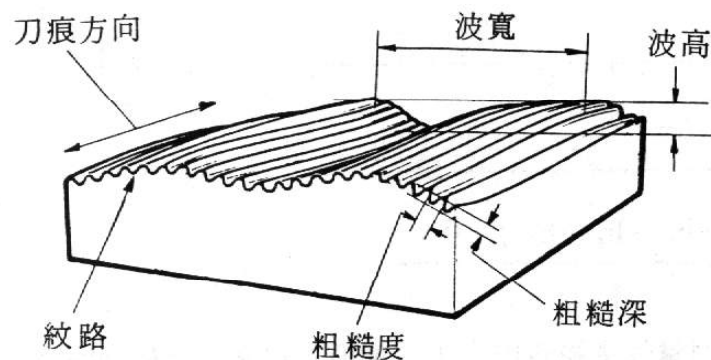
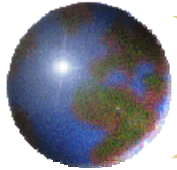


Fig. 17. Typical roughness profiles and suggested nomenclature. The length of each profile is in the range 1 to 10 metres. The vertical and horizontal scales are equal.



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).

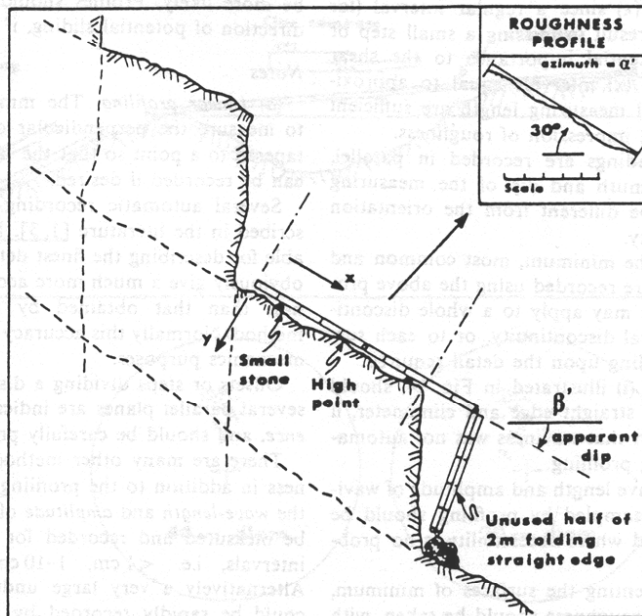


Fig. 15. A method of recording discontinuity roughness in two dimensions, along the estimated direction of potential sliding.

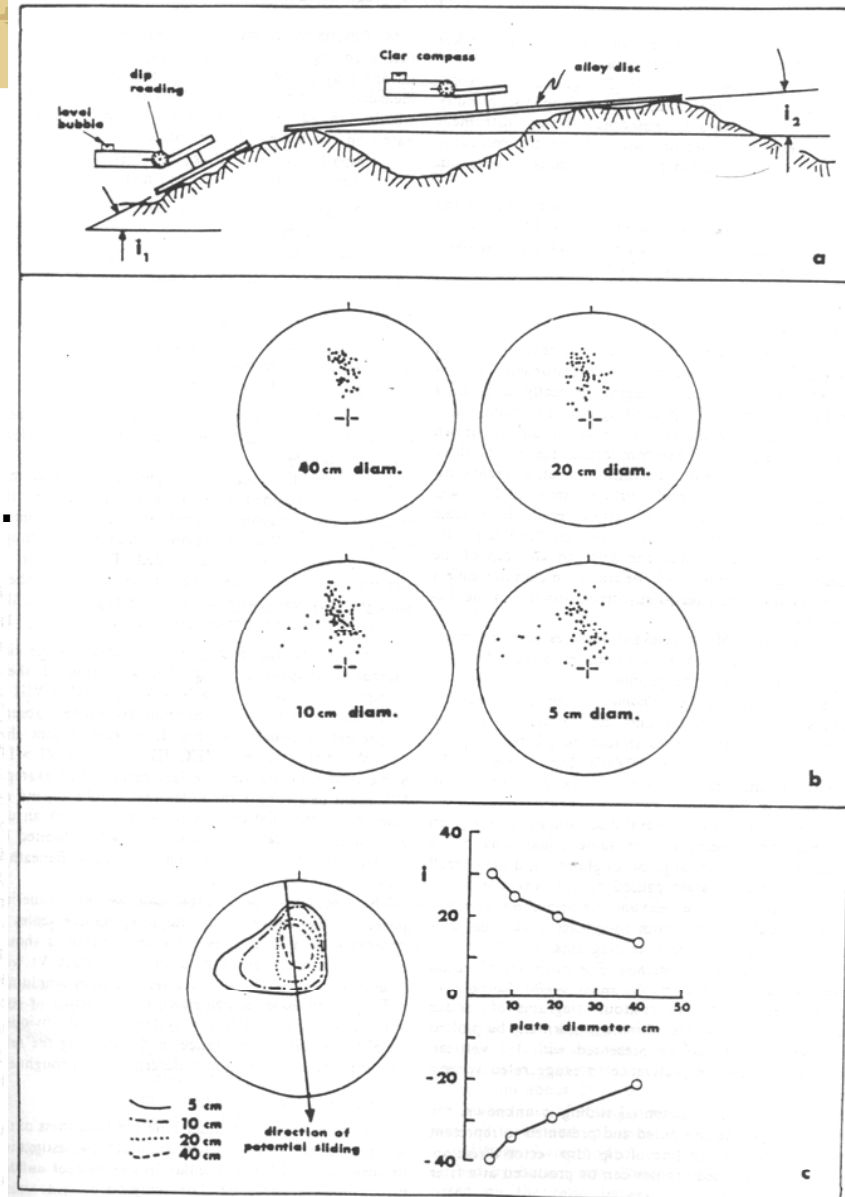
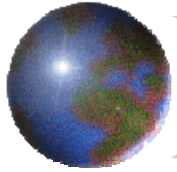
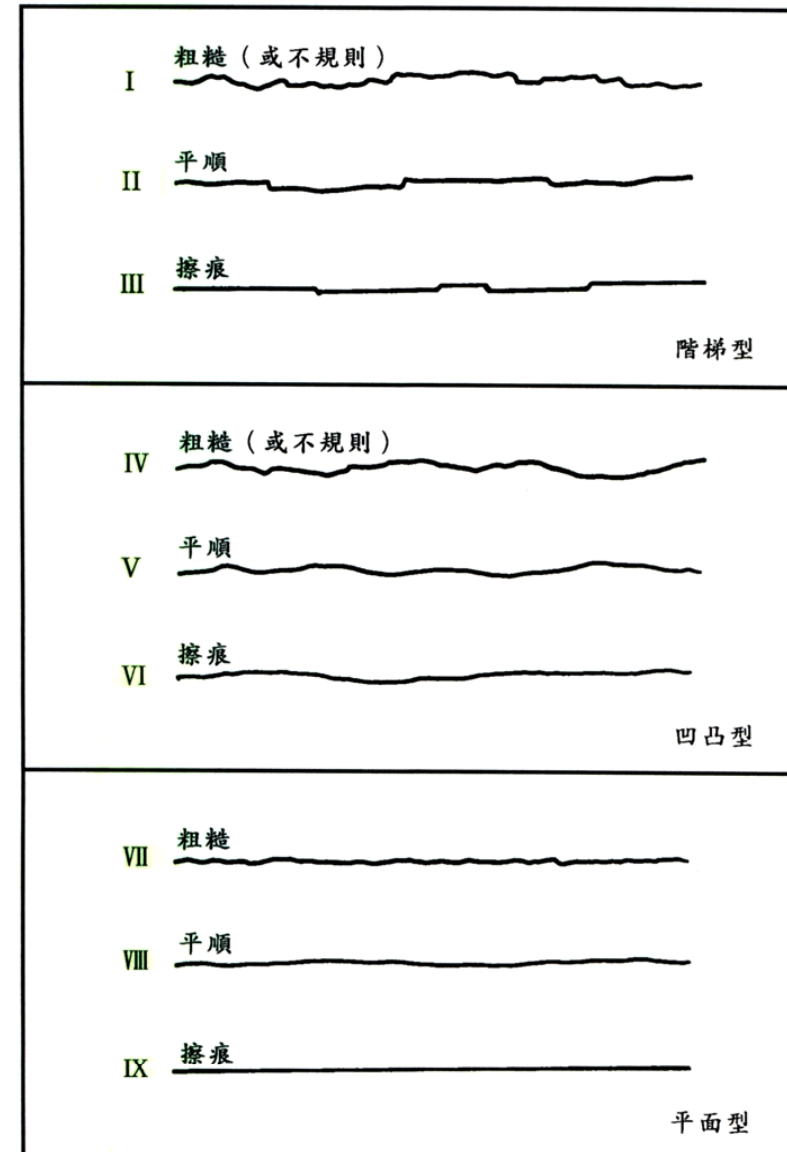


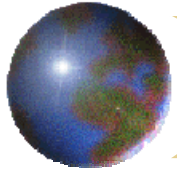
Fig. 16. A method of recording discontinuity roughness in three dimensions, for cases where the potential direction of sliding is not yet known. Circular discs of different dimensions (e.g. 5, 10, 20 and 40 cm) are fixed in turn to a Clar compass and clinometer. The dip direction and dip readings are 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





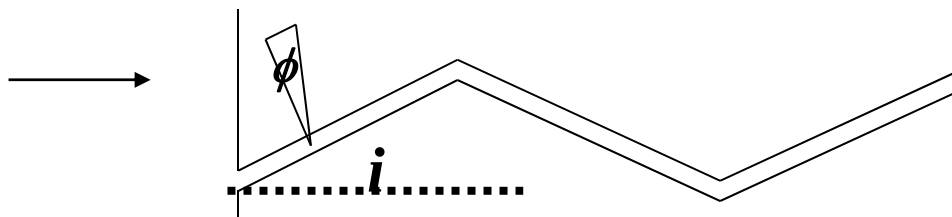
Roughness

Strength of joints

$\phi + i$ **concept**

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

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



2010/8/11

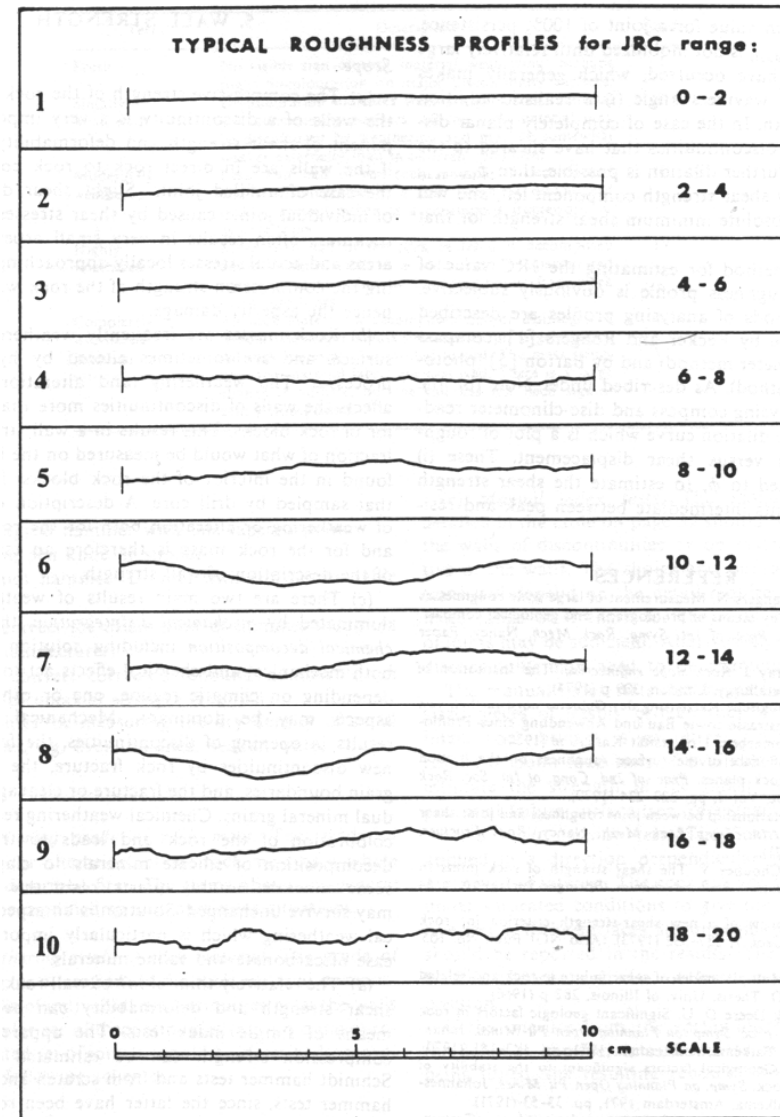
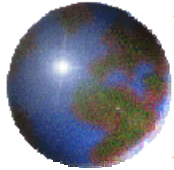


Fig. 19. Roughness profiles and corresponding range of JRC values associated with each one [6].



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

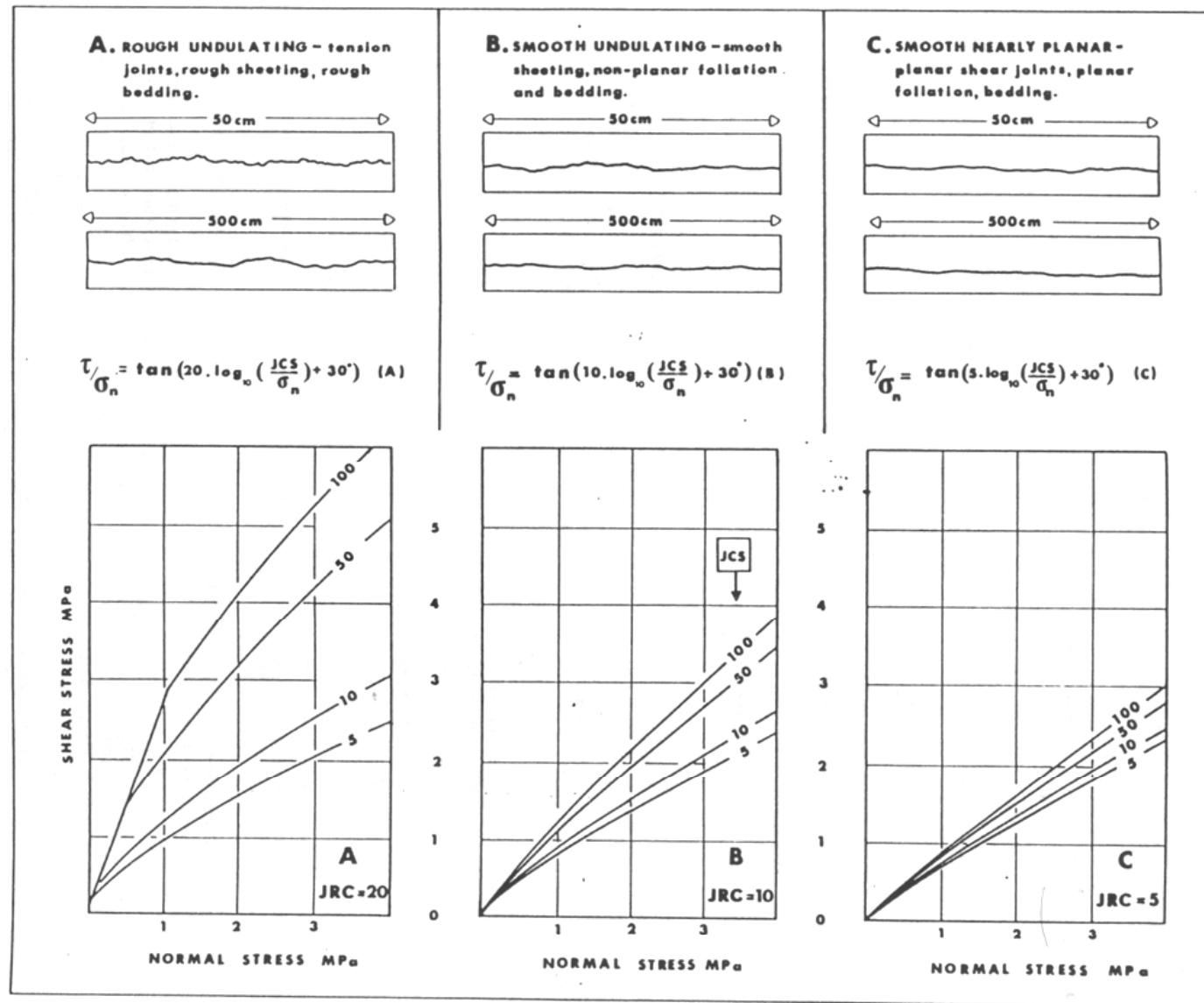
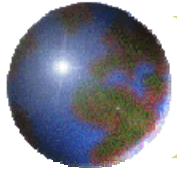


Fig. 18. A method of estimating peak shear strength from roughness profiles. Each curve is numbered with the appropriate JCS value (units of MPa). The roughness profiles are intended as an approximate guide to the appropriate JRC values.



Wall strength

先描述風化程度

A. Defined idealized weathering profiles - without corestones (left) and with corestones (right).

B. Descriptions of characteristics of the idealized profiles.

C. Example of a complex profile with corestones

Humus/topsoil

VI

Residual soil

V

Completely weathered

IV

Highly weathered

III

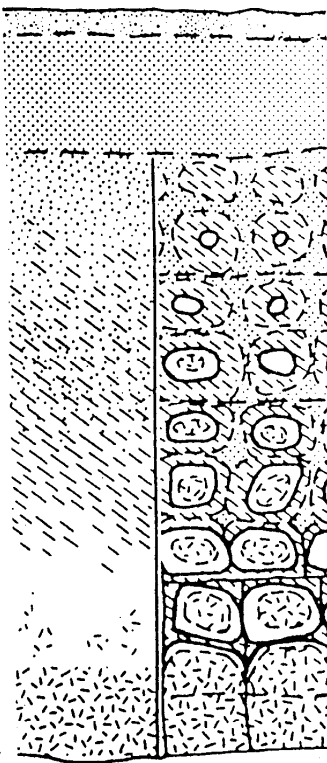
Moderately weathered

II

Slightly weathered

IB Faintly weathered

IA Fresh



Humus and topsoil

All rock material converted to soil; mass structure and material fabric destroyed. Significant change in volume.

All rock material decomposed and/or disintegrated to soil. Original mass structure still largely intact.

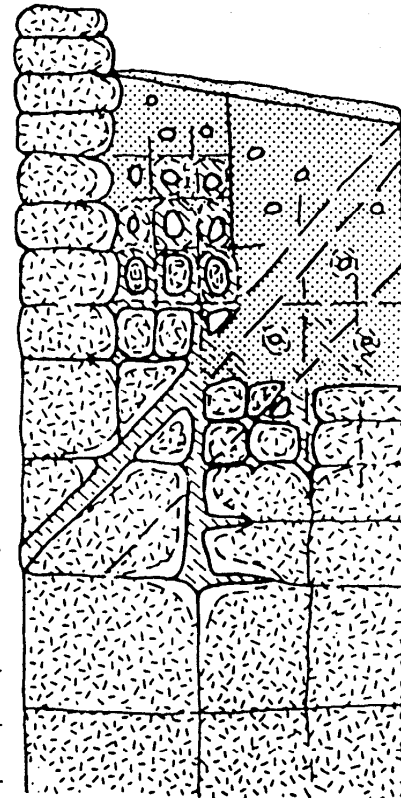
More than 50% of rock material decomposed and/or disintegrated into soil. Fresh/dicolored rock present as discontinuous framework or corestones.

Less than 50% of rock material decomposed and/or disintegrated into soil. Fresh/dicolored rock present as continuous framework or corestones.

Discoloration indicates weathering of rock material and discontinuity surfaces. All rock material may be discolored by weathering and may be weaker than in its fresh condition.

Discoloration on major discontinuity surfaces.

No visible sign of rock material weathering.

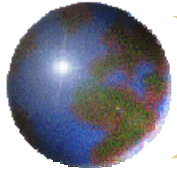


LEGEND

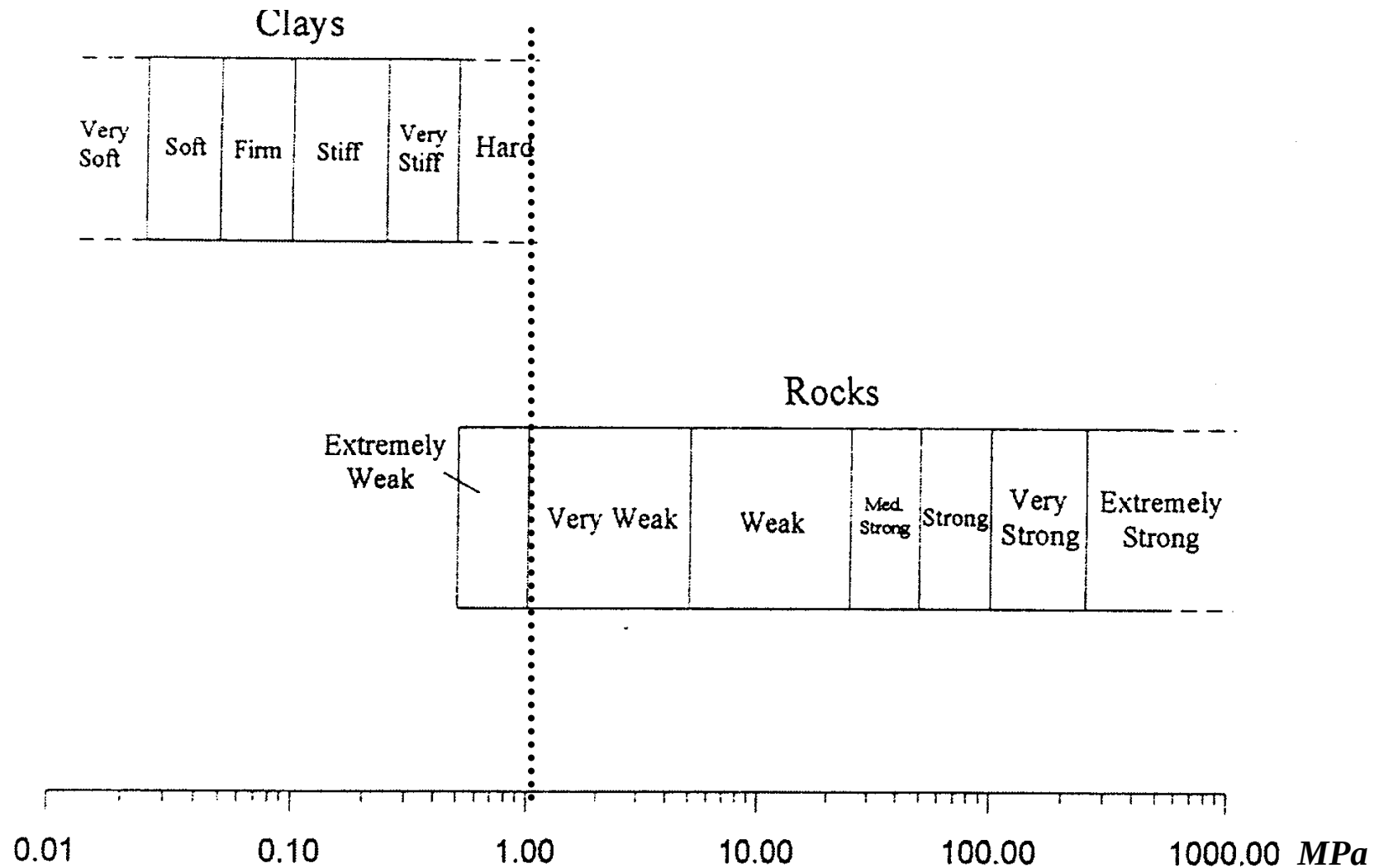


Rock decomposed to soil
Weathered/disintegrated rock
Rock discolored by weathering
Fresh rock

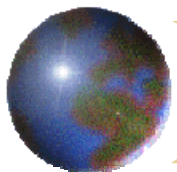
Weathering



Wall strength

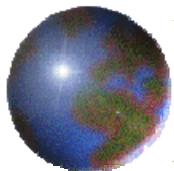


不連續面軟弱夾心以及岩石材料單壓強度與分類(Johnston,1993)



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



施密特锤

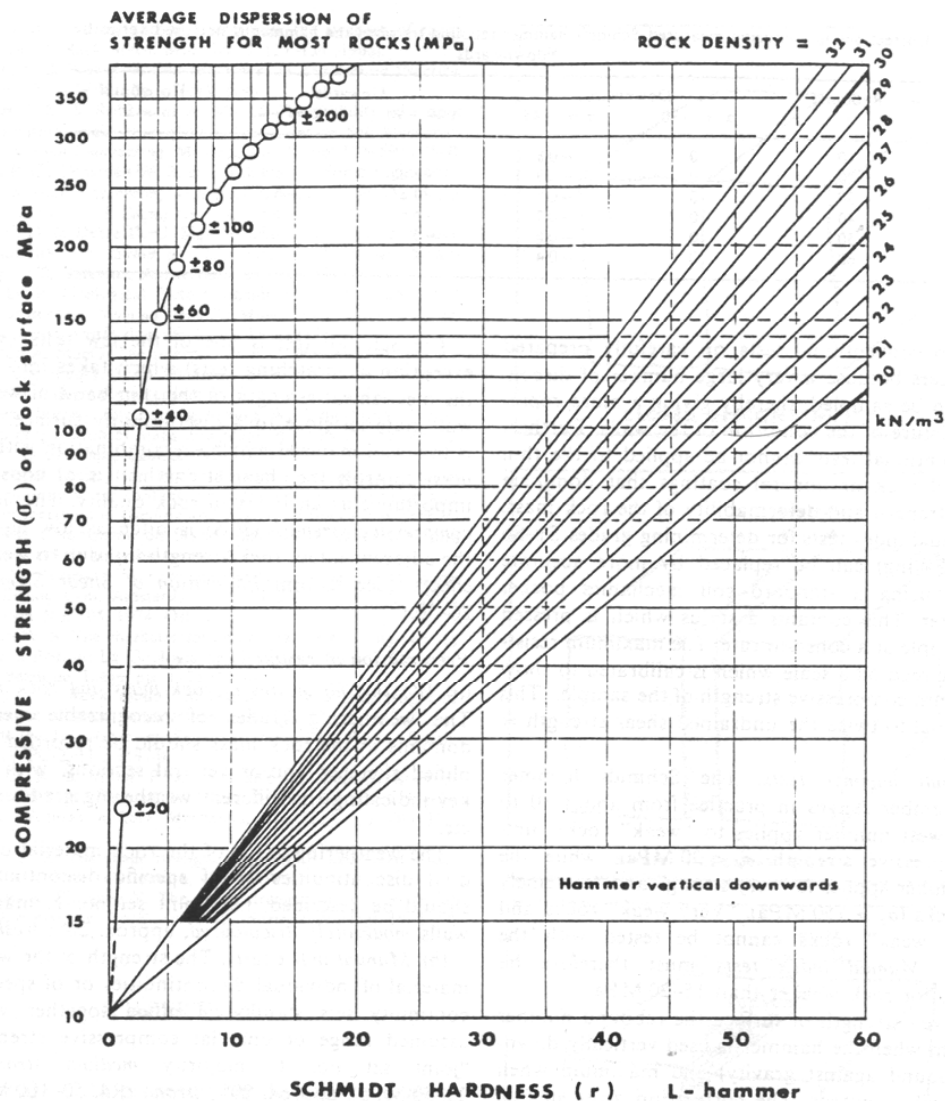


Fig. 20. Correlation chart for Schmidt (L) hammer, relating rock density, compressive strength and rebound number, after Miller [1].

- 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

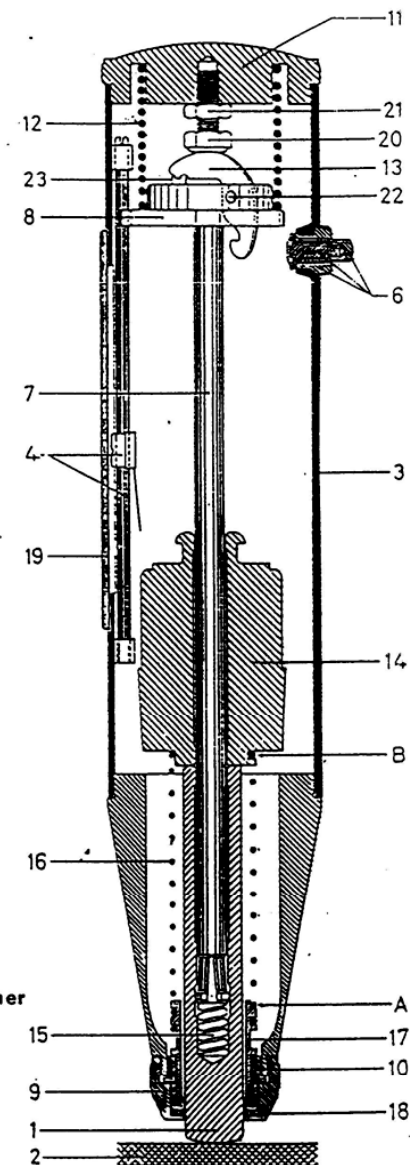
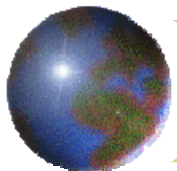
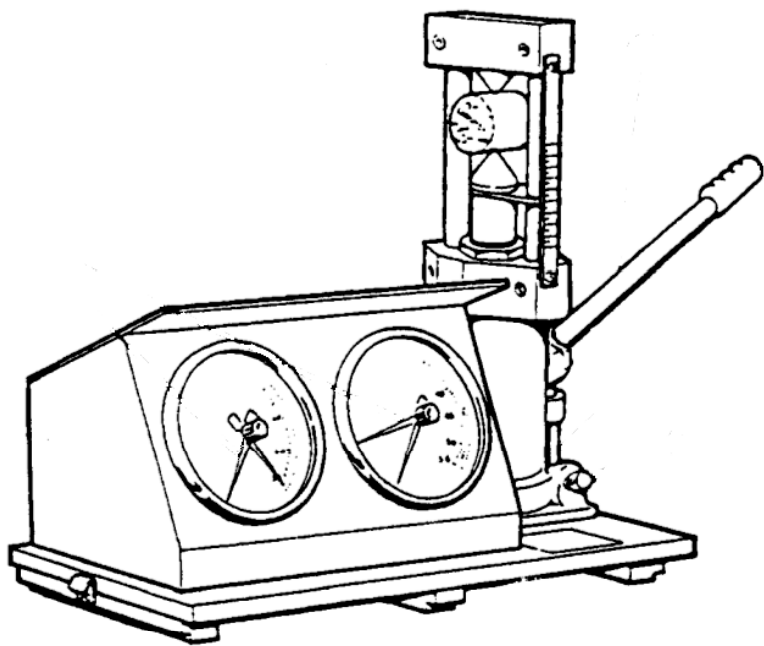
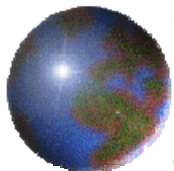


Fig. 2
Longitudinal Section of the
Type N Concrete Test Hammer
Condition on impact
When ordering spare parts,
please state No. of part and
serial No. of test hammer!



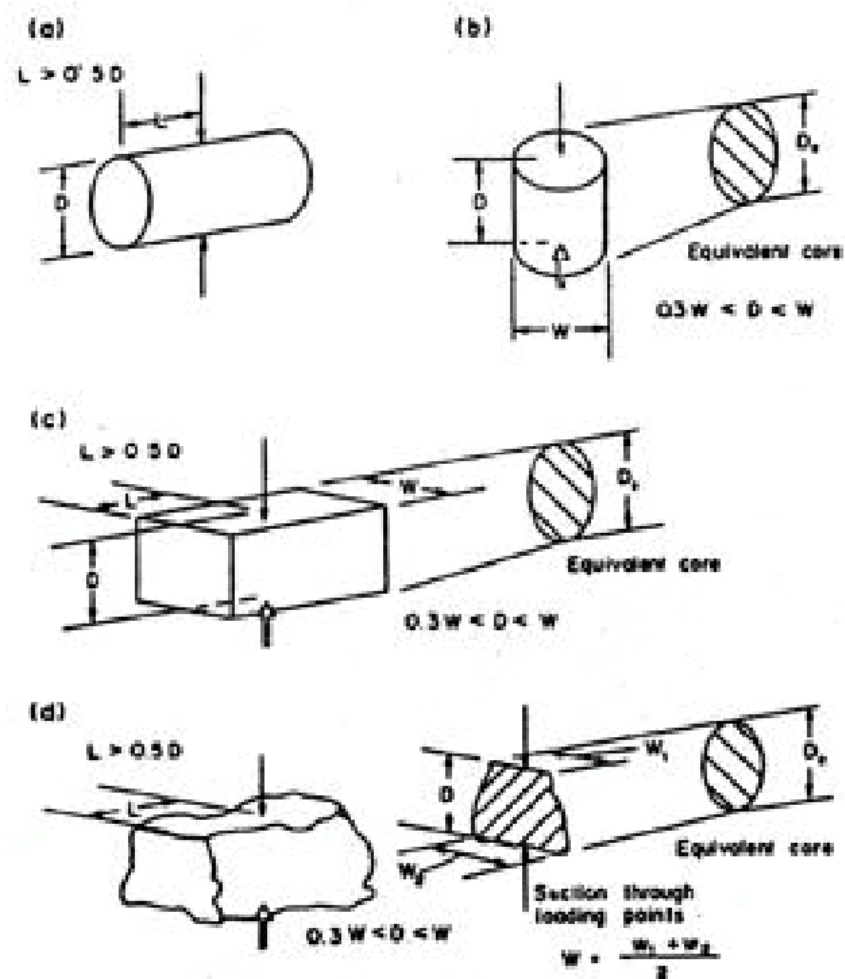
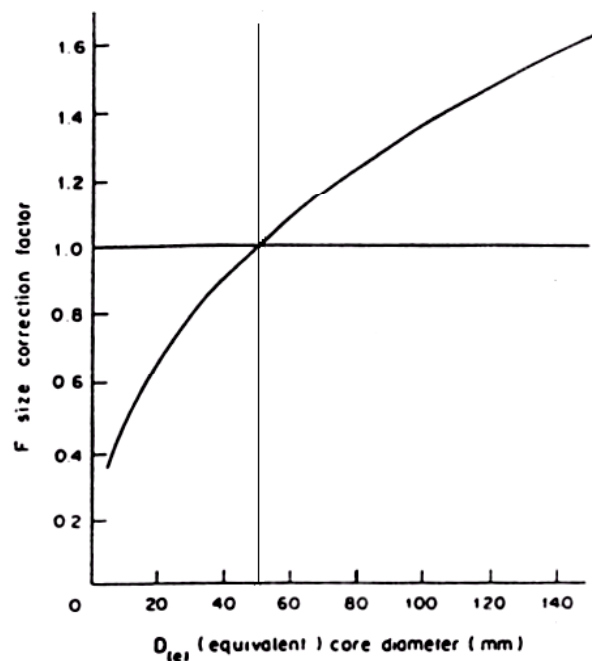
點荷重試驗





點荷重指數 $q_u = 24I_{s50}$

- $P/D_e^2 = I_s$ ，乘上修正因子 F ，使其轉換成標準直徑 $D_e = 50\text{mm}$ 之點荷重指數
- $I_{s50} = F * I_s$



(a)徑向 (b)軸向 (c)塊體 (d)不規則岩塊