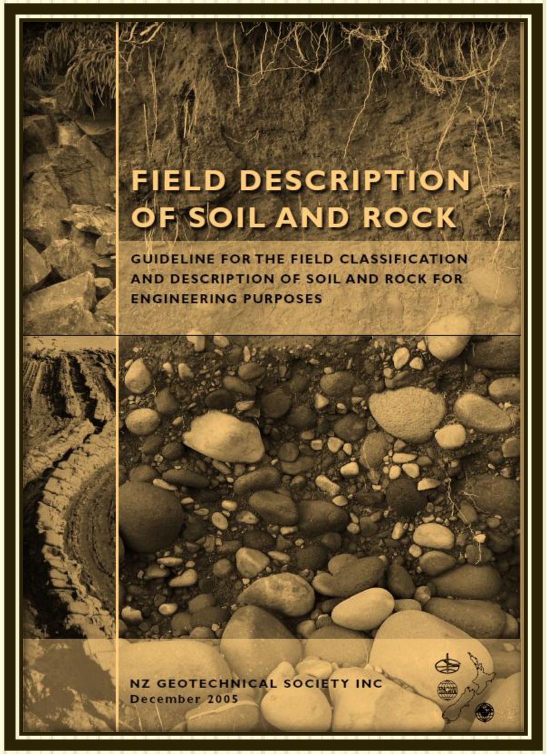
Description Rock



ROCK

The order of terms used for describing rock is similar to that given for soils, however the description gives greater attention to the presence of discontinuities in the rock mass (fractures or defects) and the effects of weathering, both of these having a significant influence on the mechanical properties and behaviour of a rock mass.

A rock mass is made up of the rock material or rock substance (i.e. parent lithology) and the discontinuities. The presence of discontinuities influences the mechanical behaviour of the rock mass such that it is often different from that of the rock material, which has no discontinuities

Colour

Colour should be described using the terms set out in Table. for soil description. Colour may

indicate the degree of weathering or the geological origin, and can be used to trace stratigraphic layers. Colour descriptions should focus on the main overall colour, rather than the fine details of

colour variability.

The effects of weathering are to be described using the standard soil and rock description terminology in terms of:

- colour and colour changes;
- strength and reduction of strength;
- condition of discontinuities and their infill;
- weathering products.

While primarily applicable to rock masses it is intended that the effects of weathering on other geological materials such as alluvial and volcanic deposits also be routinely included in descriptions.

Based on the descriptions of weathering effects and products, the rock mass can be classified according to a general weathering scale

Term	Grade	Abbreviation	Description
Unweathered (fresh)	I	UW	Rock mass shows no loss of strength, discolouration or other effects due to weathering. There may be slight discolouration on major rock mass defect surfaces or on clasts.
Slightly Weathered	II	SW	The rock mass is not significantly weaker than when unweathered. Rock may be discoloured along defects, some of which may have been opened slightly.
Moderately Weathered	III	MW	The rock mass is significantly weaker than the fresh rock and part of the rock mass may have been changed to a soil. Rock material may be discoloured, and defect and clast surfaces will have a greater discolouration, which also penetrates slightly into the rock material. Increase in density of defects due to physical disintegration process such as slaking, stress relief, thermal expansion/contraction and freeze/thaw.
Highly Weathered	IV	HW	Most of the original rock mass strength is lost. Material is discoloured and more than half the mass is changed to a soil by chemical decomposition or disintegration (increase in density of defects/fractures). Decomposition adjacent to defects and at the surface of clasts penetrates deeply into the rock material. Lithorelicts or corestones of unweathered or slightly weathered rock may be present.
Completely Weathered	V	CW	Original rock strength is lost and the rock mass changed to a soil either by chemical decomposition (with some rock fabric preserved) or by physical disintegration.
Residual Soil	VI	RS	Rock is completely changed to a soil with the original fabric destroyed.

Fabric

Fabric refers to the arrangement of minerals and particles in the rock. The arrangement may be of similar mineral/particle sizes, composition or arrangement including showing a preferred orientation. in metamorphic rocks it refers to the development of foliation. General fabric terms are set out in table

Term	Description
Fine fabric	< 25 mm
Coarse fabric	25 – 100 mm
Massive	No fabric observed

Bedding

The term bedded indicates the presence of layers. The latter can be qualified with terms to describe how visible the bedding is, such as indistinctly bedded, or distinctly bedded. Bedding inclination and bedding thickness should be included using terms defined in Tables

Term	Inclination (degrees from the horizontal)
Sub-horizontal	0 – 5
Gently inclined	6 – 15
Moderately inclined	16 – 30
Steeply inclined	31 – 60
Very steeply inclined	61 – 80
Sub-vertical	81 – 90

Term	Bed Thickness
Thinly laminated	< 2 mm
Laminated	2 mm – 6 mm
Very thin	6 mm – 20 mm
Thin	20 mm – 60 mm
Moderately thin	60 mm – 200 mm
Moderately thick	0.2 m – 0.6 m
Thick	0.6 m – 2 m
Very thick	> 2 m

For sedimentary rocks it is preferable to use the descriptors given in Table

Strength

The strength term is based on a range of the uniaxial compressive strength (qu) of the intact rock material comprising the rock mass. The means by which the strength term is selected in the field is given in Table , together with values of qu and Is(50) (from the point load index strength test).

The description of rock material strength using the terms strong and weak is preferred to the use of the terms high strength and low strength. The latter terms are considered as more appropriate to the description of rock mass strength.

Term	Field Identification of Specimen	Unconfined uniaxial compressive strength q_u (MPa)	Point load strength $I_{s(50)}$ (MPa)
Extremely strong	Can only be chipped with geological hammer	> 250	>10
Very strong	Requires many blows of geological hammer to break it	100 – 250	5 – 10
Strong	Requires more than one blow of geological hammer to fracture it	50 – 100	2 – 5
Moderately strong	Cannot be scraped or peeled with a pocket knife. Can be fractured with single firm blow of geological hammer	20 – 50	1 – 2
Weak	Can be peeled by a pocket knife with difficulty. Shallow indentations made by firm blow with point of geological hammer	5 – 20	<1
Very weak	Crumbles under firm blows with point of geological hammer. Can be peeled by a pocket knife	1 – 5	
Extremely weak (also needs additional description in soil terminology)	Indented by thumb nail or other lesser strength terms used for soils	<1	

Note: No correlation is implied between q_u and $I_{s(50)}$

Commonly, rocks with qu values in excess of 50 MPa are informally referred to as 'hard' rocks and those less than 20 MPa (especially < 10 MPa) as 'soft' rocks.
Although the boundary between soil and rock is commonly recognised as being between very weak and extremely weak (i.e. 1 MPa), rock descriptions may include materials with a strength of less than
1 MPa (e.g. Tertiary sandstone) and in such cases a soil description should also be included

TABLE 23: SCALE OF RELATIVE ROCK HARDNESS

(Modified, After Ref.3,12,17)

Term	Hardness Designation	Field Identification	Approximate Unconfined Compressive Strength
Extremely Soft	R0	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife. Scratched with finger nail.	100-1000 psi
Soft	R2	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1000-4000 psi
Medium Hard	R3	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4000-8000 psi
Hard	R4	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8000-16000 psi
Very Hard	R5	Cannot be scratched by knife or sharp pick. Specimen requires many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16000 psi

Discontinuities (or Defects)

Discontinuities such as joints, bedding and cleavage should be described where applicable in terms of their spacing, persistence, orientation, separation, tightness and roughness, as well as noting the presence of any coatings or infillings and the nature of these (eg slickensided or polished).

Larger discontinuities such as sheared or crushed zones should be described in terms of their orientation, continuity, aperture, spacing of any internal defects, condition of their walls, and the presence and nature of infillings, coatings and planes of preferential movement.

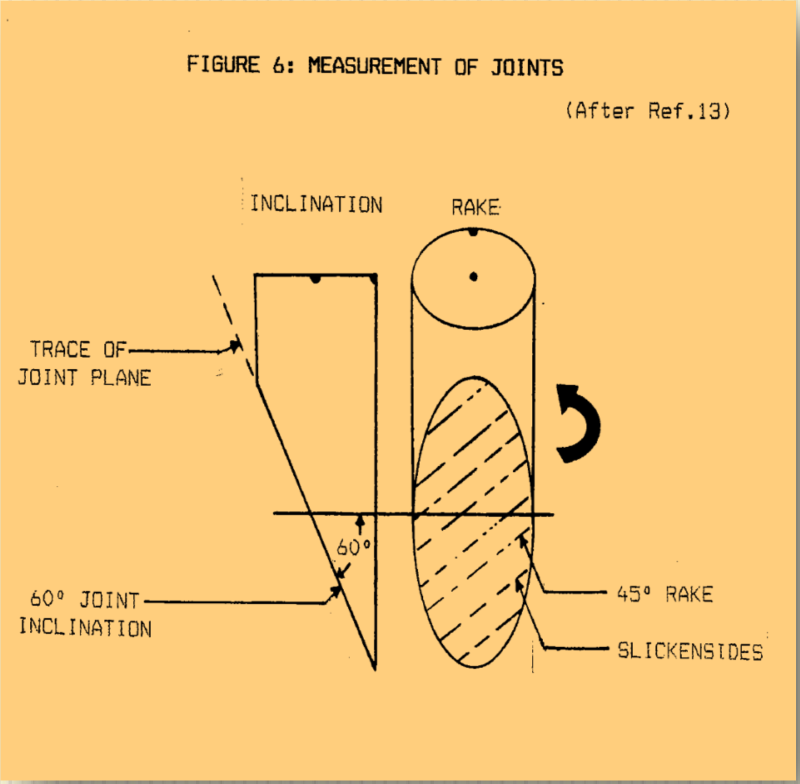
The full description of discontinuities requires attention to the following:

- Orientation
- Spacing
- Persistence
- Roughness
- Wall Strength
- Aperture
- Infill
- Seepage
- Sets
- Block size and shape.

Orientation

Attitude of the discontinuity in space. Described by the dip direction (azimuth) and dip of the line of steepest declination in the plane of the discontinuity.

Example: dip direction/amount of dip (015 /35) or strike and dip (105 /35 N).



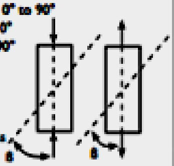
Spacing

Perpendicular distance between adjacent discontinuities. Spacing refers to the mean or modal spacing of a set of joints as defined in Table

Term	Spacing
Very widely spaced	>2 m
Widely spaced	600 mm – 2 m
Moderately widely spaced	200 mm – 600 mm
Closely spaced	60 mm – 200 mm
Very closely spaced	20 mm – 60 mm
Extremely closely spaced	<20 mm

Persistence

Discontinuity trace length to its termination in solid rock or against other discontinuities, as observed in an exposure. A crude measure of the areal extent or penetration of a discontinuity may br given. For major discontinuities, the plane may extend beyond the limits of the exposure and then the maximum trace length or area should be recorded

TERM[1] GENERAL / SPECIFIC	LAYERING (LAYER)[2] BEDDING	FOLIATION	CLEAVAGE	FRACTURES AND FRACTURED ZONES JOINT	SHEARED ZONE	WEAK SEAMS OR ZONES CRUSHED SEAM/ZONE	DECOMPOSED SEAM/ZONE	INFILLED SEAM/ZONE
PHYSICAL DESCRIPTION	Arrangement in layers, of mineral grains of similar sizes or composition, and/or arrangement of elongated or tabular minerals, near parallel to one another, and/or to the layers. Generally no microfractures	Discontinuous microfractures may be present, near parallel to the layering		A discontinuity or crack: planar curved or irregular across which the rock has little tensile strength. The joint may be open (filled with air or water) or filled by soil substances or by rock substance which acts as a cement. Joint surfaces may be rough, smooth or slickensided.	Zone, with roughly parallel planar boundaries, of rock material intersected by closely spaced (generally <50mm) joints and/or microscopic fracture (cleavage) planes. The joints are at small angles to the zone boundaries; they are slightly curved and divide the mass into unit blocks of lenticular or wedge shape. Their surfaces are smooth or slickensided. Type R ranging to Type S Joints tightly closed, cemented but cements (usually chlorite or calcite) are weaker than the rock substance. / Joints are cemented but either coated with soil substances or are open, filled with air and/or water.	Zone with roughly parallel planar boundaries, composed of disoriented, usually angular fragments of the host rock substance. The fragments may be of clay, silt, sand or gravel sizes or mixtures of any of these. Some minerals may be altered or decomposed but this is not necessarily so. Boundaries commonly slickensided.	Zone of any shape, but commonly with roughly parallel planar boundaries in which the rock material is discoloured and usually weakened. The boundaries with fresh rock are usually gradational. Geological structures in the fresh rock are usually preserved in the decomposed rock. "Weathered" and "altered" are more specific terms.	Zone, of any shape, but commonly with roughly parallel planar boundaries composed of soil substance. May show layering roughly parallel to the zone boundaries. Geological structures in the adjacent rock do not continue into the infill substance.
ENGINEERING PROPERTIES[3,4]	• Where uniformly developed in a rock substance any of these types of structure render that rock substance anisotropic in its behaviour under stress • Comprehensive strengths and initial shear usually { min when θ = 30° to 45°, max when θ = 0° to 90° • Tensile strength usually { max when θ = 0°, min when θ = 90° Deformation Modulus usually higher for θ = 0° than for θ = 90° When not uniformly developed, these structures represent defects in the rock mass i.e. as individual layers or layered zones. 			• Tensile strength low/zero • Sliding resistance depends upon properties of coatings or cement and/or condition of surfaces PARAMETERS c Cohesion of coating/cement/ wall-rock Ø Friction angle of coating/ cement/ wall-rock i Angle of roughness of surface k_n Normal stiffness k_t Tangential stiffness	• Rock properties, very fissile rock mass • When excavated forms GRAVEL / • SOIL properties, GRAVEL • Both types show extreme planar anisotropy. Lowest shear strength in direction of slickensides, in plane parallel to boundaries.	• SOIL properties either cohesive or non-cohesive • Usually shows planar anisotropy; lowest shear strength in direction of slickensides in plane parallel to boundaries	• Extremely decomposed seam has SOIL properties usually cohesive but may be non-cohesive • Mostly very compact except when soluble minerals removed • Slightly to highly decomposed substances. ROCK properties but usually lower strengths than the fresh rock substance.	• SOIL properties, usually cohesive but may be non-cohesive.
				Engineering properties commonly different from place to place especially where the defect passes through several different rock substance types.				
EXTENT	Usually governed by the thickness and lateral extent of the rock substance or mass containing the defect.	May occur in a zone continuous through several different rock substance types.		From 10mm to 50m or more, depends on origin.	Generally large (50m to many km)		Weathered zones related to present or past land surface limited extent. Altered zones occur at any depth.	Usually small, limited to mechanically weathered zone. Can be great in rocks subject to solution.
ORIGIN (USUALLY CONTROLS EXTENT)	Deposition in layers	• Viscous flow • Crystal grown at high pressures and temperatures • Shearing under high confining pressure	• Shearing during folding or faulting • Consolidation compaction	• Shearing, extension or torsion failure, arising from faulting, folding relief of pressure, shrinkage due to cooling or loss of fluid	FAULTING • Shear failure by small displacements along a large number of near-parallel intersecting planes • The different strengths of types R and S are usually due to a) Different depths of rock cover at the time of faulting, or b) Later cementation, or c) Later mechanical weathering	• Failure by large movement within narrow zone • Generally formed at shallow depth (<3000m)	• Decomposition of minerals, removal or rupture of cement, due to circulation of mineralized waters usually along joints, sheared zones or crushed zones	• Cohesive soil carried into open joint or cavity as a suspension in water • Non-cohesive soil falls or washes in
DESCRIPTION REQUIRED	Bed thickness, grain types and sizes	Fabric description and spacing and extent of microfractures		Shape, aperture, surface condition, coating, filling, extent	Zone width, shape and extent Pattern of joints or micro-fractures and resulting shape and size of unit blocks. Standard description of joints.		Degree of Decomposition	
	Ease of splitting and nature of fracture faces					Standard description of soil or rock substance		
ASSOCIATED DESCRIPTION ETC	Graded –, discord –, and slump-bedding other primary structures: facing, attitudes and lineations	Attitude of planes and of any linear structure extent		Spacing, attitude of joint and/of slickenslides	Attitude of zone. Direction of slickensides and amount, direction, and sense of displacement. Type of fault. History of past movements. Any modern activity. Likelihood of future movements. The terms "major" and "minor" fault are defined whenever used. The definitions are made on the basis of a) width and nature of the fault materials b) significance to the project.		Attitude of zone. Classify as weathered or altered if possible and determine origin, and defect or defects influencing decomposition.	Attitude of zone. Type of defect which is infilled, origin of infill substance.
		Allocate to set determine origin type						
MAP SYMBOLS (TO RIGHT SYMBOLS IN SEQUENCE HORIZONTAL, VERTICAL, DIPPING)								

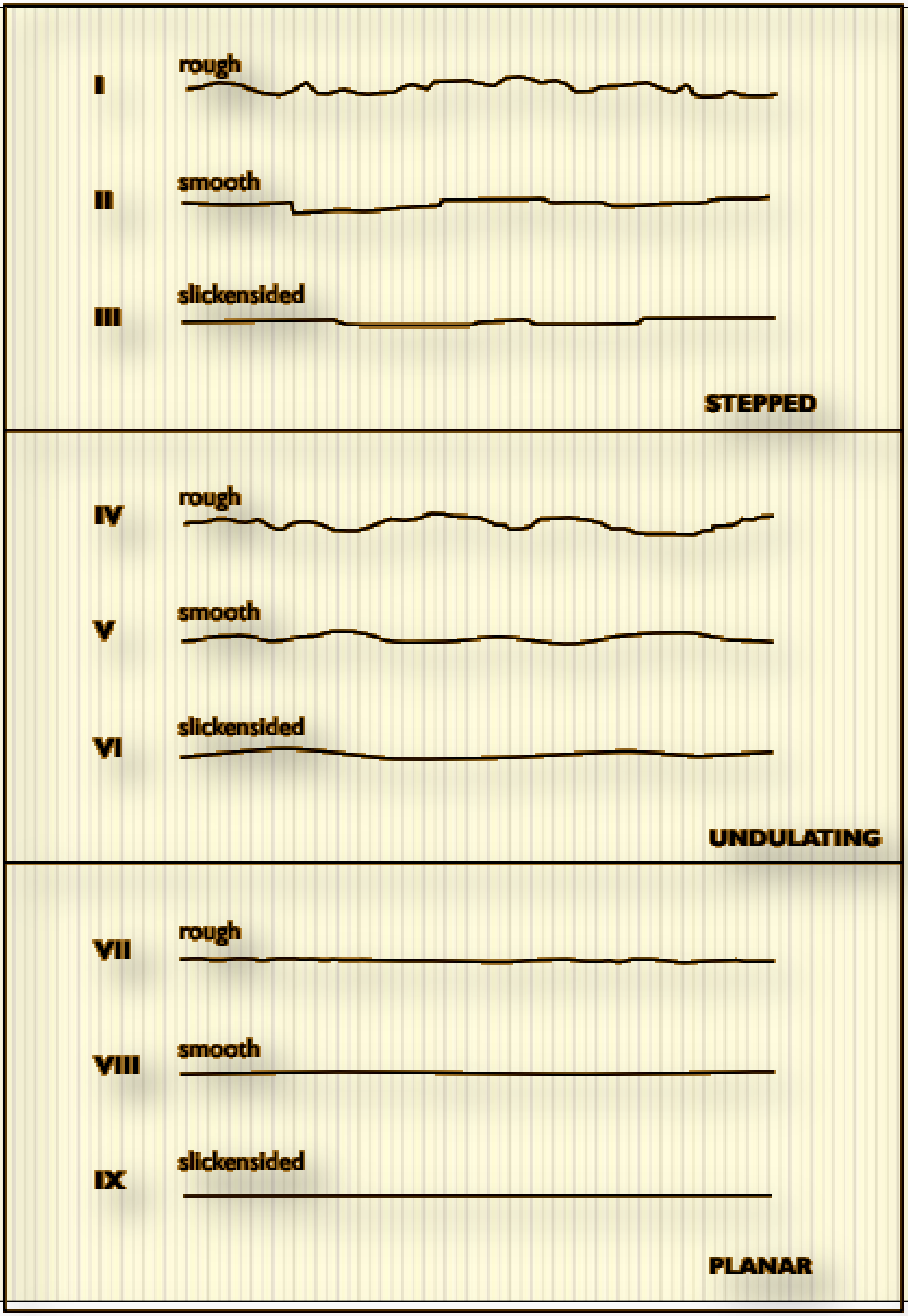
NOTES

Adapted from Stapledon (1973).

1. The actual defect is described, not the process which formed or may have formed it e.g. "sheared zone" not "zone of shearing", the latter suggests a currently active process.
2. The terms "layering", "bedding" etc are used as the main headings on this portion of the table instead of "layer", "bed" etc. This is for convenience in descriptions and other notes, allowing them to refer to both rock substances and masses.
3. These notes refer to the engineering properties of the defect type, not those of the rock mass containing the defect.

Roughness

A discontinuity surface may be planar, undulating or stepped. Descriptive terms given in Table occur at both small scale (tens of millimetres) and large scale (several metres). Both roughness and waviness contribute to the shear strength. Large scale waviness may also alter the dip locally.



Wall Strength

Wall strength is the equivalent compressive strength of the adjacent rock walls of a discontinuity, and may be lower than the rock material strength due to the weathering or alteration of the walls. The shear strength of a discontinuity may be significantly affected by the condition or strength of the rock forming the walls of the discontinuity, particularly where infill is limited or the rock walls are in contact. An estimate of unconfined compressive strength can be obtained by using the Schmidt Hammer value (Deere & Miller 1966).

Aperture

The mean perpendicular distance between adjacent rock walls of a discontinuity, in which the intervening space is filled with air or water, as described in Table

Term	Aperture (mm)	Description
Tight	Nil	Closed
Very Narrow	> 0 – 2	
Narrow	2 – 6	
Moderately Narrow	6 – 20	Gapped
Moderately Wide	20 – 60	Open
Wide	60 – 200	
Very Wide	> 200	

Infill

Material that separates the adjacent rock walls of a discontinuity and that is usually weaker than the parent rock. The infill may be soil introduced to the opening, minerals such as calcite or quartz, or clay gouge or breccia in a fault.

The width of an infilled discontinuity may, together with the roughness, be important in determining the resistance to shear along the discontinuity.

The infill material should be identified and described, and the strength of the infill assessed.

Seepage

Water flow and free moisture visible in individual discontinuities or in the rock mass as a whole should be described and if appropriate, the rate of flow estimated.

Number of Sets

Systematic discontinuity sets are parallel or sub-parallel sets of discontinuities that tend to be persistent. The number, orientation and spacing of sets will influence block size and shape. Discontinuities that are irregular or have limited persistence, without arrangement into distinct sets are called non-systematic.

Block Size and Shape

The size of blocks bound by discontinuities can be described using the terms in Table

Term	Average Dimension
Very Small	< 60 mm
Small	60 – 200 mm
Medium	200 – 600 mm
Large	600 mm – 2 m
Very Large	> 2 m

The shape of blocks is dependent on the spacing of discontinuities and the relative persistence of the different discontinuity sets. On weathering, block shape alters by rounding of block edges. Terms given in Table can be used to describe rock block shape.

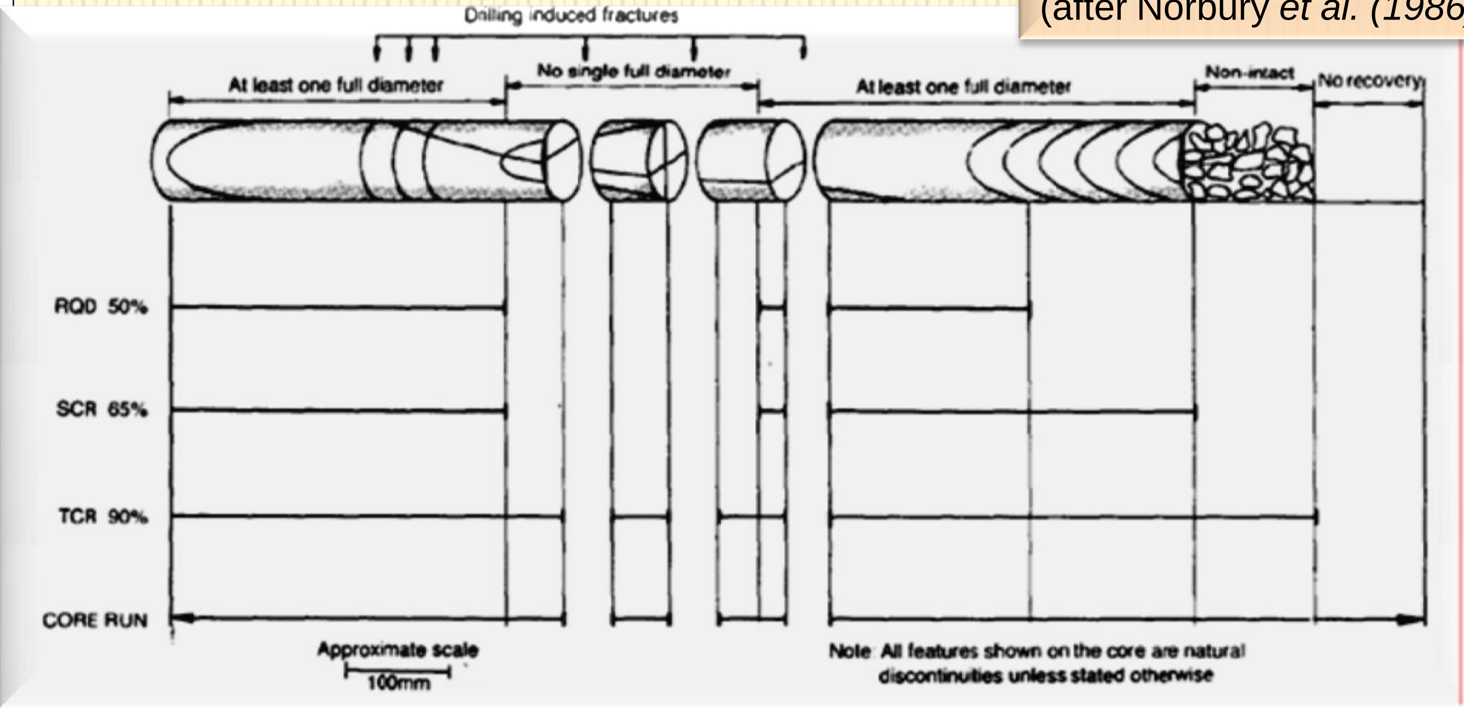
Block Shape	Discontinuity Arrangement
Polyhedral	Irregular discontinuities without arrangement into distinct sets, and of small persistence
Tabular	One dominant set of parallel discontinuities (eg bedding planes), with other non-continuous discontinuities; block length and width >> thickness
Prismatic	Two dominant sets of discontinuities orthogonal and parallel, with a third irregular set; block length and width >> thickness
Equidimensional	Three dominant orthogonal sets of discontinuities, with some irregular discontinuities
Rhomboidal	Three or more dominant, mutually oblique sets of discontinuities; oblique shaped equidimensional blocks
Columnar	Several (usually more than three) sets of continuous, parallel discontinuities crossed by irregular discontinuities; length >> other dimensions

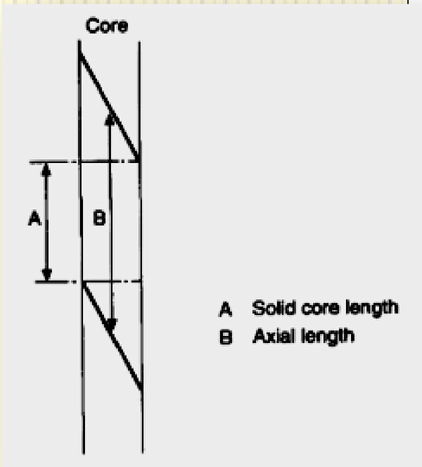
Table 2.32 Methods of classifying the quality of rock cores

Classification	Definition	Category of core considered	Remarks
Total core recovery	Percentage of the rock recovered during a single coring 'run'	(1), (2), (3), (5), i.e. all the core placed in the core box	Gives indication of material that has been washed into suspension or the presence of natural voids
Solid core recovery	Percentage of full diameter core recovered during a single coring 'run'	(1) and (2)	Gives indication of fracture state
Rock quality designation (RQD) (Deere 1964)	Percentage of constant diameter solid core greater than 0.1m in length recovered during a single coring 'run'	(1)	Can give indication of fracture state but does not take changes in core diameter into account. The diameter of the core should preferably not be less than 55mm (NWX or NWM size)
Fracture index	Number of fractures per metre. This is generally calculated for each core run	(1) and (2)	Can give indication of fracture spacing
Stability index (Ege 1968)	Index no. = 0.1 x core loss (length drilled-total recovery) x 10^{-2}+no. of fractures per 0.3m (1 ft) + 0.1 x broken core (core <7.5 cm in length) + weathering (graded 1-4 from fresh to completely weathered) + hardness (graded 1-4 from very hard to incompetent)	(1), (2), (3), (5)	Can give indication of fracture state but does not take changes in core diameter into account

The quality of rock recovered may be classified in terms of total or solid core recovery or in terms of a quality index such as rock quality designation (RQD), fracture index or stability index, provided only natural fractures are considered. The definitions of these terms are given in Table. The determination of the more commonly used parameters are shown schematically in Fig.. Solid core recovery (SCR), RQD, fracture index and stability index may be used as criteria for a quantitative description of the fracture state of the cores. The simplest of these is solid core recovery and is always shown along with total core recovery in a graphical form in the borehole log. The stability index is the most complicated method of assessing rock quality and hence is rarely used in practice. Core recovery (total and/or solid), RQD and fracture index are normally shown in the borehole log in a graphical form with some indication of changes in corebarrel size. The fracture state of the core recovered may be assessed using these parameters together with the fracture log discussed earlier.

Schematic illustration of fracture logging terms (after Norbury *et al. (1986))*.

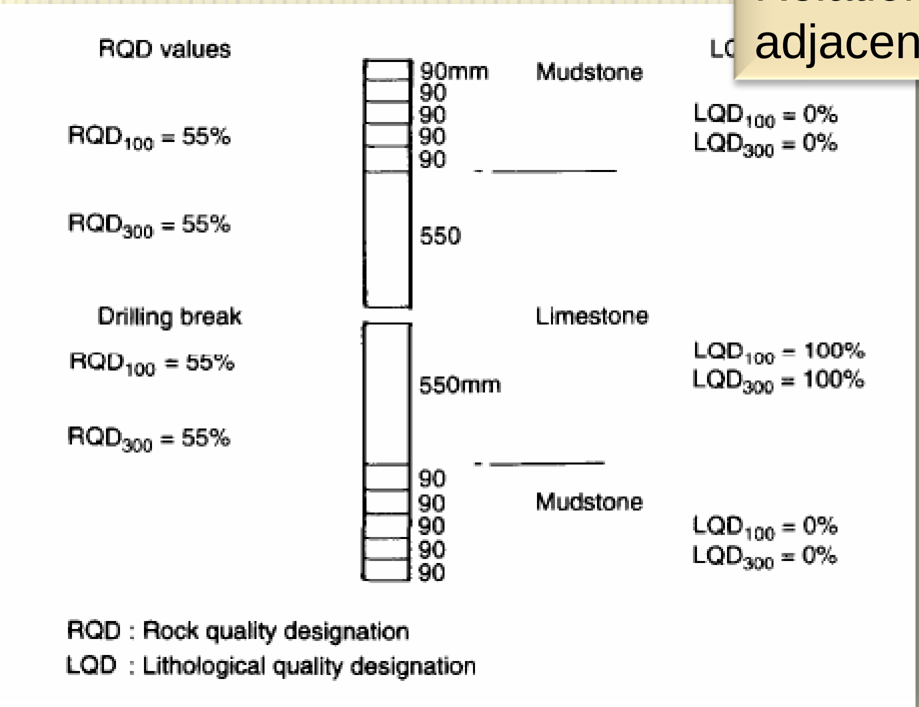




Hawkins (1986) suggests that a new rock quality designation value be introduced based on minimum core lengths of 300mm instead of 100 mm. This new value would be referred to as RQD300. The reasoning behind this proposal is that 300 mm approximates to the maximum thickness that can be ripped in certain rock types. A more sound argument for changing the base length for RQD measurements relates to the comments made above concerning the value of RQD in relation to the number of test specimens that can be obtained from a single core run. Since it is now common practice to use P and S size corebarrels, particularly in weak rocks, solid core lengths of greater than 230 mm or 281mm respectively are required to meet the 2.5:1 length to diameter ratio recommended by ISRM for strength and stiffness tests (ISRM 1981). The disadvantage of using a different base length however is that RQD100 is required for the conventional rock mass classification systems such as the RMR or the Q-System (Bieniawski 1989).

The measurement of RQD does not take into account any changes in lithology within the core run. Changes in lithology are often associated with a change in the fracture pattern owing to the different mechanical properties of each rock type. There is a natural tendency for engineers to assume that a high RQD value comes from a stronger rock. In a sequence of interbedded limestones and mudstones, for example, the limestone units may dominate in contributing to a relatively high RQD value, thus masking the fracture state of the less competent mudstone units.

In the example shown, the mudstone units contribute nothing to the RQD value of 55% for each run since they are characterized by a horizontal fracture spacing of 90 mm. Hawkins (1986) suggests
that this type of problem may be avoided if RQD values are based on the thickness of lithological units rather than core run length. The lithological quality designation (LQD) could be shown on core logs alongside the conventional RQD values. Fig. shows the relationship between LQD and RQD for two adjacent core runs. Clearly LQD is of particular value when dealing with interbedded rocks of contrasting mechanical properties. In cases where the thickness of each rock unit is equal to or greater than the core run length the value of the LQD is diminished since the conventional RQD measurements are likely to reflect the changes in fracture state associated with lithology.



Relationship of RQD and LQD on two adjacent core runs (after Hawkins 1986).

Rock Name

The most common rock names are given in Table although more common usage is limited to the names in uppercase. The table follows general geological practice, and the inclusion is intended as a guide only as geological training is required for satisfactory identification. It must be remembered that engineering properties cannot be inferred from rock names.

Additional Features and Geological Information

This includes all additional relevant information such as the name of the geological unit. Additional information may be particularly important when describing weathered rocks that have the properties of soils (e.g. residual soils). In such cases a description of the material as a soil (Section 2.0) should also be given.

A. Mechanical Sedimentary Rocks

Rock Name	Original Sediment
Conglomerate	Gravel, or sand and gravel
Sandstone	Sand
Siltstone	Silt
Claystone	Clay
Mudstone	Silt, clay, possibly with sand and/or gravel inclusions, nonoriented
Shale (laminated claystone/siltstone)	Oriented, laminated, fissile, clay and silt

B. Chemical Sedimentary Rocks

Rock Name	Main Mineral
Limestone	Calcite
Dolomite	Dolomite
Chert	Quartz

Table 2.11 Classification of igneous rocks

Field relations	texture	Grain size	Acid	Intermediate	Basic	Ultrabasic
			Light coloured rocks	Light/dark coloured rocks	Dark coloured rocks	Dark coloured rocks
Intrusive	Crystalline	Very coarse grained 60 mm	Rock consists of very large and often well developed crystals of quartz, feldspar, mica and frequently rare minerals. PEGMATITE			
		Coarse grained 2 mm	At least 50% of the rock is coarse grained enough to allow individual minerals to be identified.			Rock is coarse grained and dark in colour (dull green to black) with a granular texture. It contains olivine and augite in abundance but no feldspars. PERIDOTITE
			Rock is light coloured with an equigranular texture (majority of grains approximately the same size) and contains >20% quartz with feldspar in abundance. GRANITE	Rock may be medium to dark in colour with a more or less equigranular texture and contains <20% quartz with feldspar and hornblende in abundance. DIORITE	Rock is dark coloured and often greenish with abundant plagioclase (about 60%) and augite together with some olivine. The rock usually feels dense. GABBRO	
		Medium grained 0.06 mm	At least 50% of the rock is medium grained. Crystal outlines are generally visible with the aid of a hand lens but individual minerals may be difficult to identify.			Rock is greyish green to black with a splintery fracture when broken and generally feels soapy or waxy to the touch. It is often criss-crossed by veins of fibrous minerals and/or banded. SERPENTINITE
			Rock is similar in appearance to granite but the crystals are generally much smaller. MICRO-GRANITE	Rock is similar in appearance to dionte but the crystals are generally much smaller. MICRO-DIORITE	Rock is dark coloured and often greenish with a granular texture. Individual minerals may be difficult to identify. The rock usually feels dense. DOLERITE	
Extrusive	Crystalline/glassy	Fine grained	At least 50% of the rock is fine grained. Outlines of crystals are not usually visible even with the aid of a hand lens. All rocks in this category may be vesicular.			
			Rock is light coloured (often pale reddish brown or pinkish grey) and may be banded. RHYOLITE Rock is light coloured with a very low specific gravity and highly vesicular. PUMICE	Rock is medium to dark in colour (shades of grey, purple, brown, or green) and frequently porphyritic ANDESITE	Rock is black when fresh and becomes red or green when weathered. The rock is often vesicular and/or amygdaloidal. BASALT	
	Glassy	Glassy	Rock is glassy and contains few or no phenocrysts. It is often black in colour and has a characteristic vitreous lustre and conchoidal fracture. OBSIDIAN Rock is glassy and contains few or no phenocrysts. It may be black, brown or grey in colour with a characteristic dull or waxy lustre. PITCHSTONE			

Table 2.12 Classification of sedimentary rocks

Group Usual structure	Grain size	Composition and texture	Detrital sediments Bedded	
			Quartz, rock fragments, feldspar, and other minerals.	At least 50% of the rock is composed of carbonate minerals (rocks usually react with dilute HCl).
Granular	Coarse-grained 2 mm	Rudaceous	Rock is composed of more or less rounded grains in a finer grained matrix: CONGLOMERATE Rock is composed of angular or sub-angular grains in a finer grained matrix: BRECCIA	CALCI-RUDITE
Granular	Medium-grained 0.06 mm	Arenaceous	Rock is composed of: (i) mainly mineral and rock fragments. SANDSTONE (ii) 95% quartz. The voids between the grains may be empty or filled with chemical cement. QUARTZ SANDSTONE (iii) 75% quartz and rock fragments and up to 25% feldspar (grains commonly angular). The voids may be empty or filled with chemical cement. ARKOSE (iv) 75% quartz and rock fragments together with 15% + fine detrital material. ARGILLACEOUS SANDSTONE	CALC-ARENITE
Smooth	Fine-grained 0.002 mm	Argillaceous	Rock is composed of at least 50% fine-grained particles and feels slightly rough to the touch. SILTSTONE Rock is homogeneous and fine-grained. Feels slightly rough to smooth to the touch. MUDSTONE Rock has same appearance and feels as mudstone but reacts with dilute HCl. CALCAREOUS MUDSTONE	CALCI-SILTITE CHALK (Bioclastic)
Smooth	Very fine-grained	Argillaceous	Rock is composed of at least 50% very fine-grained particles and feels smooth to the touch. CLAYSTONE Rock is finely laminated and or fissile. It may be fine or very fine grained SHALE	CALCI-LUTITE

Group Usual structure	Grain size	Composition and texture	Pyroclastic sediments Bedded	Chemical and organic sediments Bedded	Chemical and organic sediments Massive/Bedded
			At least 50% of the grains are of fine-grained volcanic material. Rocks often composed of angular mineral or igneous rock fragments in a fine-grained matrix.	Crystalline carbonate rocks depositional texture not recognizable. Fabric is non-elastic.	Depositional textures often not recognizable.
Granular	Coarse-grained 2 mm	Rudaceous	Rock is composed of: (i) Rounded grains in a fine-grained matrix: AGGLOMERATE (ii) Angular grains in a fine-grained matrix: VOLCANIC BRECCIA	Rock is crystalline and composed of carbonate (>90%) reacts violently with HCl. LIMESTONE Rock is crystalline and may show a yellowish colouration and/or the presence of voids. Reacts mildly with cold dilute HCl. Reaction increases by heating the HCl. DOLOMITE LIMESTONE Rock is crystalline and composed of magnesium carbonate (>90%). When small chip of rock is immersed in dilute HCl, these is no immediate reaction, but a slow formation of CO_2 beads on surface of chip; reaction slowly accelerates. Rate of reaction in increased by heating HCl. DOLOMITE	Rock is crystalline, salty to taste and may be scratched with the finger nail. HALITE (rock salt) Rock is crystalline and may be scratched with the finger nail. Grains turn into a chalky white substance when burnt for a few minutes. GYPSUM Rock is crystalline: colourless to white, frequently with a bluish tinge. It is harder than gypsum and has three orthogonal cleavages. ANHYDRITE Rock is black or brownish black and has a low specific gravity (1.8—1.9). It may have a vitreous lustre and conchoidal fracture and/or breaks into pieces that are roughly cuboidal. COAL
Granular	Medium-grained 0.06 mm	Arenaceous	Rock is composed of mainly sand sized angular mineral and rock fragments in a fine-grained matrix. TUFF		
Smooth	Fine-grained 0.002 mm	Argillaceous	Rock is composed of silt sized fragments in a fine- to very fine-grained matrix. Matrix and fragments may not always be distinguished in the hand specimen. FINE-GRAINED TUFF		Rock is black or various shades of grey and breaks with a characteristic conchoidal fracture affording sharp cutting edges. The rock cannot be scratched with a penknife. FLINT Rock has similar appearance and hardness as flint but breaks with a more or less flat fracture. CHERT
Smooth	Very fine-grained	Argillaceous	VERY FINE-GRAINED TUFF		

Table 2.13 Classification of metamorphic rocks

Fabric / Grain size	Foliated	Massive
Coarse-grained	Rock appears to be a complex intermix of metamorphic schists and gneisses and granular igneous rock. Foliations tend to be irregular and are best seen in field exposure: MIGMATITE	Rock contains randomly orientated mineral grains (fine- to coarse-grained). Foliation, if present, is poorly developed. This rock type is essentially a product of thermal metamorphism associated with igneous intrusions and is generally stronger than the parent rock: HORNFELS
	Rock contains abundant quartz and/or feldspar. Often the rock consists of alternating layers of light coloured quartz and/or feldspar with layers of dark coloured biotite and hornblende. Foliation is often best seen in field exposures: GNEISS	Rock contains more than 50% calcite (reacts violently with dilute HCl), is generally light in colour with a granular texture: MARBLE
2 mm	Rock consists mainly of large platey crystals of mica, showing a distinct subparallel or parallel preferred orientation. Foliation is well developed and often undulose: SCHIST	If the major constituent is dolomite instead of calcite (dolomite does not react immediately with dilute HCl), then the rock is termed a: DOLOMITIC MARBLE
Medium-grained	Rock consists of medium- to fine grained platey, prismatic or needle-like minerals with a preferred orientation. Foliation often slightly nodulose due to isolated larger crystals which give rise to a spotted appearance: PHYLLITE	Rock is medium to coarse-grained with a granular texture and is often banded. This rock type is associated with regional metamorphism: GRANULITE
0.06 mm		
Fine-grained	Rock consists of very fine grains (individual grains cannot be recognized in hand specimen) with a preferred orientation such that the rock splits easily into thin plates: SLATE	Rock consists mainly of quartz (95%) grains which are generally randomly orientated giving rise to a granular texture: QUARTZITE (METAQUARTZITE)

The following scheme for systematic rock material description is commonly used in practice:

(a) colour;
(b) grain size;
(c) texture fabric and structure;
(d) weathered state and alteration state where relevant;
(e) minor lithological characteristics, including cementation state where relevant;
(f) ROCK NAME (in capitals);
(g) estimated strength of the rock material; and
(h) other terms indicating special engineering characteristics.

Table 2.15 Example of systematic rock material description

	(i)	(ii)	(iii)
(a)	Light pinkish grey	Light yellowish brown	Light pinkish white
(b)	Coarse-grained	Fine-grained	Medium-grained
(c)	Porphyritic, massive	Thickly bedded	Foliated
(d)	Slightly weathered Slightly kaolinized	Fresh	Fresh
(e)		Weakly cemented Ferruginous	With bands of dark coloured biotite with preferred orientation
(f)	GRANITE	QUARTZ SANDSTONE	GNEISS
(g)	Very strong	Weak	Very strong
(h)	Impermeable except along joints	Porous	

Table 2.15 Example of systematic rock material description

	(i)	(ii)	(iii)
(a)	Light pinkish grey	Light yellowish brown	Light pinkish white
(b)	Coarse-grained	Fine-grained	Medium-grained
(c)	Porphyritic, massive	Thickly bedded	Foliated
(d)	Slightly weathered Slightly kaolinized	Fresh	Fresh
(e)		Weakly cemented Ferruginous	With bands of dark coloured biotite with preferred orientation
(f)	GRANITE	QUARTZ SANDSTONE	GNEISS
(g)	Very strong	Weak	Very strong
(h)	Impermeable except along joints	Porous	

Table 2.16 Comparison between soil and rock descriptions

Soil	Rock
Consistency or relative density	Colour
Fabric or fissuring	Grain size
Colour	Texture, fabric and structure
Subsidiary constituents	Weathered state and alteration state
Angularity or grading of principal soil type	Minor lithological characteristics
PRINCIPAL SOIL TYPE	ROCK NAME
More detailed comments on constituents or fabric	Estimated strength of the rock material
	Other terms indicating special engineering characteristics

Grain size, mm	Bedded Rocks (mostly sedimentary)					Foliated rocks (mostly metamorphic)	Rocks generally with massive structure and crystalline texture (mostly igneous)					
More than 20	Grain size description		At least 50% of grains are carbonate	At least 50% of grains are fine-grained volcanic rock				Grain size description	Pegmatite			
20 6 2	RUDACEOUS	CONGLOMERATE Rounded boulders, cobbles and gravel cemented in a finer matrix BRECCIA Irregular rock fragments in a finer matrix	LIMESTONE and DOLOMITE (undifferentiated) Calcirudite	Fragments of volcanic ejecta in a finer matrix Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	SALINE ROCKS Halite Anhydrite Gypsum	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands Migmatite Irregularly foliated: mixed schists and gneisses	MARBLE QUARTZITE HORNFELS	COARSE	GRANITE[1]	Diorite[1,2] Granodiorite[1,2]	GABBRO[3] Amphibolite	Peridotite Serpen-tinite
0.6 0.2 0.06	ARENACEOUS (Coarse / Medium / Fine)	SANDSTONE Angular or rounded grains, commonly cemented by clay, calcite or iron minerals QUARTZITE Quartz grains and siliceous cement ARKOSE Many feldspar grains GREYWACKE Many rock chips	Calcarenite	Cemented volcanic ash TUFF		SCHIST Well developed undulose foliation; generally much mica		MEDIUM	Microgranite[1]	Microdiorite[1,2] Micro-granodiorite[1,2]	Dolerite[3,4]	
0.002 Less than 0.002	ARGILLACEOUS	MUDSTONE SILTSTONE Mostly silt CLAY STONE Mostly clay	Calcareous mudstone Calcisiltite Calcilutite	Fine-grained TUFF Very fine-grained TUFF		Textural zones (II-IV) identified on basis of mineralogy and development of foliation		FINE	RHYOLITE[4,5,7] IGNIMBRITE[7]	ANDESITE[4,5,7] DACITE[4,5]	BASALT[4,5]	
Amorphous or crypto-crystalline		Chert: occurs as nodules and beds in limestone and calcareous sandstone			COAL LIGNITE	MYLONITE found in fault zones, mainly in igneous and metamorphic areas			Obsidian[5]	Volcanic glass[7]		
		Granular cemented, except amorphous rocks				CRYSTALLINE			Pale ← Colour → Dark			
		SILICEOUS	CALCAREOUS	overlap with effusive igneous	CARBON-ACEOUS	SILICEOUS	mainly SILICEOUS		ACID Much quartz	INTER-MEDIATE Some quartz	BASIC Little or no quartz	ULTRA BASIC

SEDIMENTARY ROCKS
- Granular cemented rocks vary greatly in strength, some sandstones are stronger than many igneous rocks. Bedding may not show in hand specimens and is best seen in outcrop. Only sedimentary rocks, and some metamorphic rocks derived from them, contain fossils.
- Calcareous rocks contain calcite (calcium carbonate) which effervesces with dilute hydrochloric acid.

METAMORPHIC ROCKS
- Most metamorphic rocks are distinguished by foliation which may impart fissility. Foliation in gneisses is best observed in outcrop. Non-foliated metamorphics are difficult to recognise except by association. Any rock baked by contact metamorphism is described as a 'hornfels' and is generally somewhat stronger than the parent rock.
- Most fresh metamorphic rocks are strong although perhaps fissile.

IGNEOUS ROCKS
Composed of closely interlocking mineral grains. Commonly strong and not porous when fresh, except in many cases for ignimbrite.

Mode of occurrence:
1. Batholiths
2. Laccoliths
3. Sills
4. Dykes
5. Lava flows
6. Veins
7. Effusive and ejecta

This table follows general geological practice but is intended as a guide only. Geological training is required for the satisfactory identification of rocks. Engineering properties cannot be inferred from rock names in the table.

The whole sequence is written in the lower case except for the rock name.
Terms in the sequence are separated by commas.

- Weathering
- Colour
- Fabric
- ROCK NAME
- Strength
- Discontinuities
- [Additional features and geological information]

Main Paragraph	Example	Item
Weathering	Unweathered	Visual characteristics
Colour	Grey	
Fabric	Foliated	
Rock Name	SCHIST	Rock name
Qualifying Paragraph		
Strength	Strong	Rock mass qualifications
Discontinuities	Foliation dips 20-25°, well-developed; several thin sheared zones along foliation. Steep joints moderately widely spaced.	
Geological Information	HAAST SCHIST Textural Zone 4	Additional information

The example in Table should be written:

Unweathered, foliated, grey SCHIST; strong; foliation dips 20-25 , well developed, with several thin sheared zones along foliation. Joints steep and moderately widely spaced

Main Paragraph	Example	Item
Weathering	Highly weathered	Visual characteristics
Colour	Light yellow-brown	
Fabric	Homogeneous	
Rock Name	SANDSTONE	Rock name
Qualifying Paragraph		
Strength	Very weak	Rock mass qualifications
Discontinuities	Joints closely spaced; very narrow to tight	
Geological Information	TORLESSE SUPERGROUP greywacke	Additional information

Highly weathered, light yellow-brown, homogeneous SANDSTONE. Very weak; closely spaced joints very narrow to tight [TORLESSE SUPERGROUP greywacke]

Main Paragraph	Example	Item
Weathering	Slightly weathered	Visual characteristics
Colour	Blue-grey	
Fabric	Indistinctly bedded	
Rock Name	SILTSTONE	Rock name
Qualifying Paragraph		
Strength	Extremely weak	Rock mass qualifications
Discontinuities		
Geological Information	MANGAWEKA MUDSTONE	Additional information

Slightly weathered, blue-grey, indistinctly bedded SILTSTONE; extremely weak [MANGAWEKA MUDSTONE].