CHARACTERIZATION AND DESCRIPTION OF SOME ROCK FEATURES

Main engineering characteristics of rock material are:

- Geological name, (type of rock)
- Orientation of foliation/bedding/layering
- Anisotropy, (schistosity, foliation, bedding)
- Weathering or alteration
- Strength and hardness

Other rock characteristics:
Outlook (colour etc.), mineral size and texture, porosity, density

Some of these characteristics are described below.

Name the rock material is given according to the geological classification based on mineral content, texture, mineral size and origin (sedimentary, igneous, metamorphic). For various other purposes, including those for engineering usage, rocks have been classified on the basis of their properties, such as strength, void index, degree of weathering, etc. Rock properties can be found in textbooks, e.g. Lama and Vutukuri, (1978)

The ***orientation*** of a particular plane can be given by its dip and dip direction (alternatively as strike and dip). The dip is the maximum angle between the plane containing the surface and the horizontal plane, recorded in degrees from 0^o to 90^o.

Schistosity of rocks may be divided into:

1. Strong schistosity - well developed schistosity, less than 0.5 cm between schistose planes.
2. Moderate schistosity - schistosity planes are spaced 0.5 - 5.0 cm.
3. Weak schistosity - schistosity weakly developed.

Weathering / alteration of rock material

The process of weathering/alteration is by means of mechanical, chemical and biological action which drastically affects the engineering properties of both the rock material and the rock mass. Some of the more important effects of weathering/alteration on rock are the decrease in strength, density and volumetric stability and the increase in deformability, porosity and weatherability.

Table 1: Definition / classification of weathering/alteration

Term *)	**Description**
Unweathered/unaltered	No visible signs of alteration in the rock material out fracture planes may be stained or discoloured.
Slightly weathered /altered	Fractures are stained or discoloured and may contain a thin filling of altered material. Discolouration may extend into the rock from the fracture planes to a distance of up to 20% of the fracture spacing (i.e. less than 4o% of the core is discoloured).
Medium weathered/altered	Slight discolouration extends from fracture planes for a distance greater than 20% of the fracture spacing (i.e. generally greater part of the rock). Fractures may contain filling of altered material. The surface of the core is not friable (except in the case of poorly cemented sedimentary rocks) and the original texture of the rock has been preserved. Partial opening of grain boundaries may be observed.
Highly weathered/altered	Discolouration extends throughout the rock. The surface of the core is friable and usually pitted due to washing out of highly altered minerals by drilling water. The original texture of the rock has mainly been preserved but separation of grains has occurred.
Completely weathered/altered	The rock is totally discoloured and the external appearance of the core is that of a soil. Internally the rock texture is partly preserved but grains have completely separated.

The term "weathered" (decay caused by influence from weather (at the surface)) is often used where the correct term is "altered".

Table 2: A guide to determine the weathering as given by "A guide to core logging"

DIAGNOSTIC FEATURE / DESCRIPTION TERM	DISCOLOURATION EXTENT	FRACTURE CONDITION	SURFACE CHARACTERISTICS	ORIGINAL TEXTURE	GRAIN BOUNDARY CONDITION
UNWEATHERED	NONE	CLOSED OR DISCOLOURED	UNCHANGED	PRESERVED	TIGHT
SLIGHTLY WEATHERED	20% OF FRACTURE SPACING ON BOTH SIDES OF FRACTURE	DISCOLOURED MAY CONTAIN THIN FILLING	PARTIAL DISCOLOURATION	PRESERVED	TIGHT
MEDIUM WEATHERED	20% OF FRACTURE SPACING ON BOTH SIDES OF FRACTURE	DISCOLOURED MAY CONTAIN THICK FILLING	PARTIAL TO COMPLETE DISCOLOURATION NOT FRIABLE EXCEPT POORLY CEMETED ROCKS	PRESERVED	PARTIAL
HIGHLY WEATHERED	THROUGHOUT	-	FRIABLE AND POSSIBLY PITTED	MAINLY PRESERVED	PARTIAL SEPARATION
COMPLETELY WEATHERED	THROUGHOUT	-	RESEMBLES A SOIL	PARTLY PRESERVED	COMPLETE SEPARATION

Rock strength

The uniaxial compressive strength is determined in accordance with the standard laboratory procedures, but for the purpose of rock mass classification, the use of the well-known point load strength index is recommended. The reason is that the index can be determined in the field on rock core retrieved from borings and the core does not require any specimen preparation (Bieniawski Z.T.,1984).

Table 3: A simple estimate can be made from a field test shown below

CLASSIFICATION	FIELD TEST	RANGE OF COMPRESSSIVE STRENGTH (MPa)
Very soft rock	Can be peeled with a kl1ife, material crumbles under firm blows with the sharp end of a geological pick	1 to 3
Soft rock	Can just be scraped with a knife indentations of 2 to 4 mm with firm blows of the pick point	3 to 10
Medium hard rock	Cannot be scraped or peeled with a knife, hand held specimen breaks with firm blows of the pick	10 to 25
Hard rock	Point load tests must be carried out in order to distinguish between these classifications. These results may be verified by uniaxial compressive strength tests on selected samples.	25 to 70
Very hard rock		70 to 200
Extremely hard rock		>200

Table 5: Another field classification of strength

1. *Loose.* Sediment flows when dry and thus cannot be sampled in aggregate.
2. *Very friable.* Sediment crumbles so easily that pieces are difficult to collect intact.
3. *Friable.* Sediment crumbles under light pressure in the hands.
4. *Somewhat friable.* Rock breaks in the hands under moderate pressure.
5. *Firm, slightly friable.* Rock breaks with difficulty in the hands but readily by hammer blows, sounding a dull "whop"
6. *Weak, nonfriable.* Rock cannot be broken in the hands but breaks under light hammer blows, sounding "whop"
7. *Moderately strong.* Rock breaks under moderate hammer blows, sounding "whap"
8. *Strong.* Rock breaks under hard hammer blows, sounding "whack," with a ring.
9. *Very strong.* Rock difficult to break with hammer, sounding "boink."
10. *Unusually strong.* Rock impossible to break with hammer, sounding like steel.

The hammer test should be made on solid outcrops or on fragments thicker than 1 ft. (0.3 m). It is often performed in tunnels to find whether there is sheeted or (sounding drummy) caused by high stresses

Knowing the rock type and rock material hardness, it is possible for the experienced engineer or engineering geologist to make fairly accurate estimates on rock material strength. The hammer tests should be made with a 2-lb hammer on pieces about 4 in. (10 cm) thick placed on a solid, hard surface, and tests with the hands should be made on pieces about 1.5 in. (4 cm) thick. The pieces must not have incipient fractures, and therefore several should be tested.

Table 6: A scale of rock hardness

1.	*Soft.* All rocks weaker than 5 on the scale-of-strength above.
2.	*Moderately hard.* Slightly friable or nonfriable rocks consisting mainly of soft minerals, as carbonates, sulfates, micas, and clays.
3.	*Hard.* Nonfriable rocks consisting almost entirely of minerals with hardnesses of 4, 5, or 6 on the Mohs scale, and quartz-rich rocks with strength of 6 or 7.
4.	*Very hard.* Rocks stronger than 7 on the scale above and consisting mainly of minerals harder than 6 on the Mohs scale.

Rock outlook

Colour is one of the most obvious characteristics of a rock stratum and therefore one of the most basic and useful in the description of a rock to both the specialist and layman alike. It often provides an excellent guide for rock strata correlation and may be used to identify various "marker" horizons. Colour variation is a primary indication of weathering.

The rock colour is can be described as its predominant colour i.e. brown, green, red, pink, khaki. Where a secondary colour is also evident this colour can be included in the description as an adjective i.e. reddish brown, greyish green, yellowish khaki. Where significant, the colour should be further amplified by using the following descriptions for value: very light, light, medium, dark, very dark i.e. dark reddish brown, light yellowish khaki.

Minerals can be classified according to their chemical composition or Moh's hardness scale.

The figure below presents the hardness of some minerals on the Moh's scale and a linear scale. More information on minerals can be found in Dana (1959) or other textbooks.

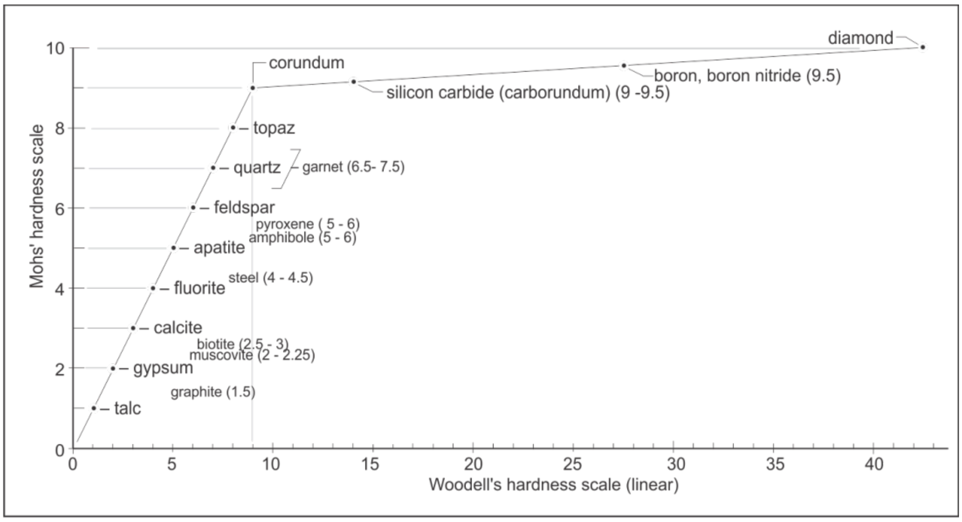

Figure 1: the hardness of some minerals on the Moh's scale and a linear scale

Texture

Rocks are composed of assemblages of minerals. The arrangement and size of the individual grains of these minerals give the rock an individual form or *texture.*

Since the size or arrangement of the individual minerals can affect the physical properties of the rock such as permeability or angle of internal friction, it is necessary to describe them so that their engineering significance can be assessed.

Figure 2 shows a classification of the mineral texture in rocks which may be useful in rock engineering.

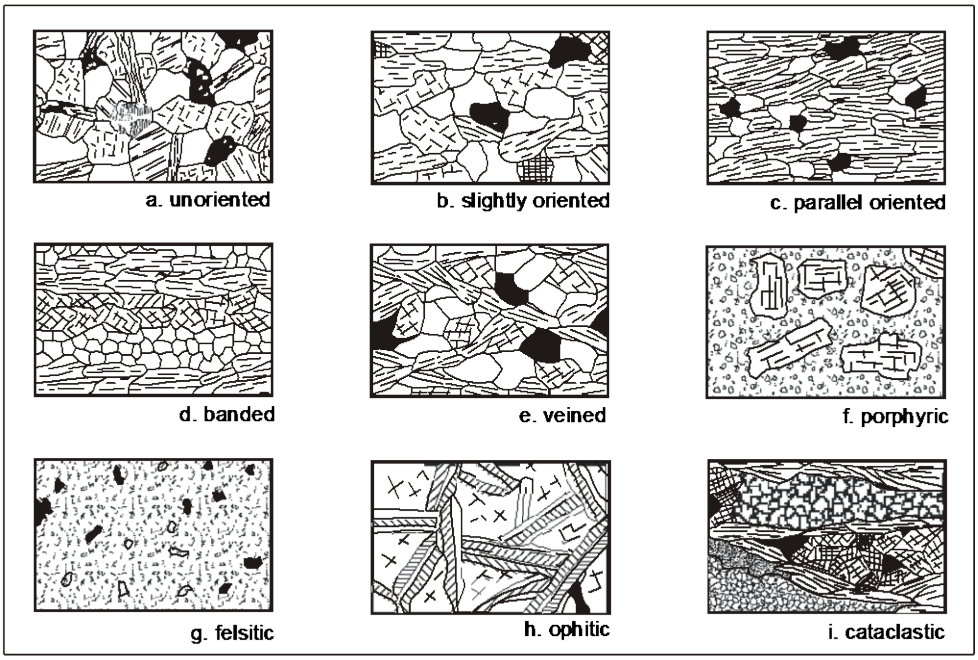

Figure 2: Characterization of mineral textures in rocks (from NBG, 1985, 2000)

Mineral size, or grain size in sedimentary rocks, is a noticeable textural feature. The classification in Table 7 is been based on visual identification using a hand lens. For metamorphic and igneous rocks the same reasoning is applicable, with a grain size qualification only being necessary in the coarser grained rocks.

Table 7: Mineral size classification (from de Beer et al, 1976: "A guide to core logging for rock engineering")

DESCRIPTION	SIZE IN mm	RECOGNITION	EQUIV. SOIL TYPE
Very fine grained	<0.06	Individual grains cannot be seen with a hand lens	Clays & Silts
Fine grained	0.06 – 0.2	Just visible as individual grains under hand lens	Fine sand
Medium grained	0.2 – 0.6	Grains clearly visible under hand lens, just visible to the naked eye	Medium sand
Coarse grained	0.6 – 2.0	Grains clearly visible to naked eye	Coarse sand
Very coarse grained	> 2.0	Grains are measureable	Gravel

References:

Dana J.D. and Hurlbut C.S.jr. (1959): Dana's manual of mineralogy. John Wiley & sons, New York, 609 p.

de Beer J.E., Hammond A.J., MacG. Robertson A., van Schalkwyk A. and Weaver J.M. (1976): A guide to core logging for rock engineering. Proc. Symp.on Exploration for Rock Engineering Johannesburg, Nov. 1976, pp 71 – 86

Lama R.D. and Vutukuri V.S. (1978): Handbook on mechanical properties of rocks. Trans Tech Publications, Clausthal, Germany, 1978, 1650 p.

NBG - Norwegian group of rock mechanics (1985): Handbook in engineering geology - rock. (in Norwegian). Norwegian rock mechanics group (NBG). Tapir, 140 p.

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