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Mineral properties and identification

Text reference: Marshak, S. (2012) *Earth: Portrait of a Planet.* 4th edition, WW Norton & Co., Chapter 5.

INTRODUCTION

This practical is intended to introduce you to the physical properties of minerals and the ways in which those properties are used in the practical identification of mineral specimens.

On completion of this practical, you should be able to:

1. Determine the physical properties of minerals, such as hardness, cleavage and lustre;
2. Distinguish between mineral cleavage, crystal faces and fracture surfaces, and recognise the various types of cleavage;
3. Use a mineral identification key or set of mineral identification tables to successfully identify some common rock-forming minerals.

PHYSICAL PROPERTIES OF MINERALS

What is a mineral?

- Naturally occurring;
- Solid and crystalline;
- Orderly arrangement of atoms;
- Definable chemical composition;
- Usually inorganic.

Each mineral has a unique set of physical properties that allows it to be identified. Together, two or three of these properties may be diagnostic for a given mineral. Some of the most commonly used properties are:

1. <u>COLOUR</u> – *See text page 116; Fig. 5.11a.*
The colour of a mineral is one of its most obvious features. However, it is generally not a diagnostic feature. Some minerals can be identified by their colour, but many minerals can show a variety of colours in different specimens.

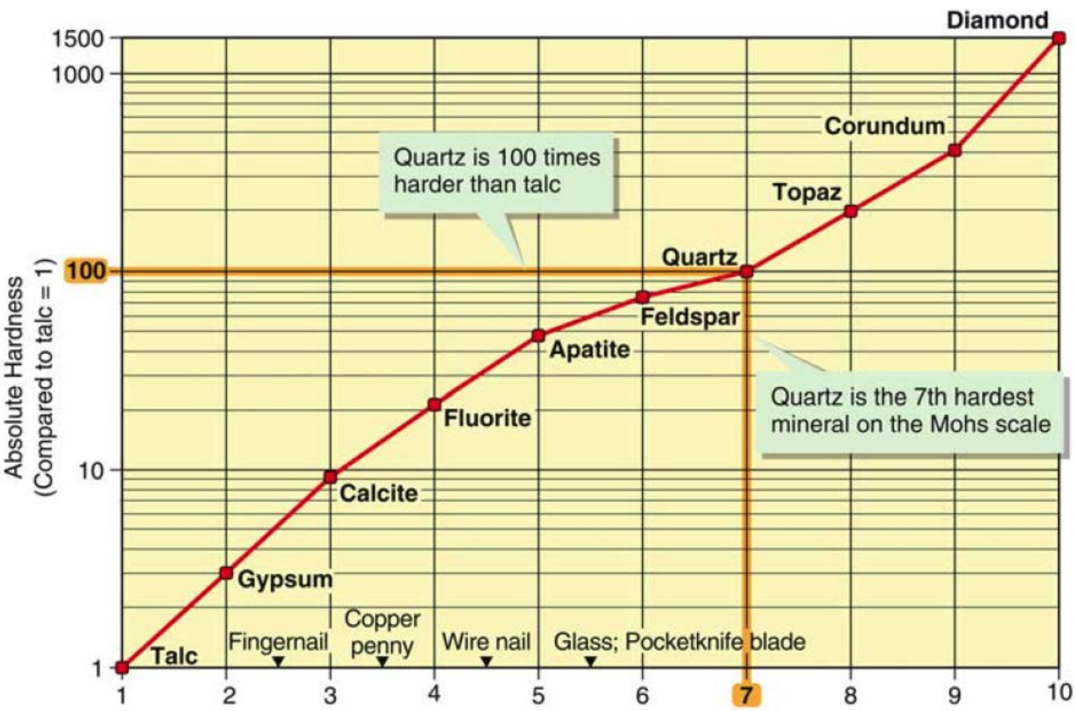
2. <u>STREAK</u> – *See text page 117; Fig. 5.11b.*
While it is common practice in the laboratory to use a streak plate as described in the text, it is more usual in the field to scratch the mineral with the point of a knife blade or geological hammer (while also evaluating mineral hardness) and to rub the thumb over the powdered mineral to obtain its streak. The distinction between coloured and white/colourless streaks is useful. It is, of course, only possible to obtain a streak on a ceramic tile if the mineral is softer than the tile; many are not! In general, streak is most useful for distinguishing between minerals with a metallic lustre; most minerals with a non-metallic lustre have a white streak.

3. <u>LUSTRE</u> – *See text page 117; Fig. 5.11c–d.*
The lustre of a mineral refers to the manner in which it reflects light. Terms used to describe lustre include *metallic*, *vitreous* (like glass), *waxy*, *pearly* and *earthy*. In addition, reference should be made to the degree of reflectivity, i.e. *brilliant* or *dull*.

4. HABIT – *See text pages 119; Fig. 5.11e.*
The examples given in the text are useful, particularly the distinction between single crystals and aggregates of crystals. You should determine if a mineral sample consists of an aggregate of several crystals, one crystal only, or a fragment of a crystal. If a mineral cleaves perfectly (see below) it may be difficult to distinguish between a crystal face and a cleavage surface. Samples that consist of numerous tiny crystals tightly clustered together may have no particular form and are said to be massive. Most minerals can occur in this form.

5. SPECIFIC GRAVITY – *See text page 119.*
The specific gravity of a mineral can be estimated by comparing the weights of similar-sized specimens. It should be recorded as *low* (< 3), *medium* (3–4), *high* (4–6) or *very high* (> 6).

6. HARDNESS – *See text pages 119; Table 5.1.*
For all practical purposes, hardness of a mineral is mostly evaluated using common items such as a fingernail, copper coin and knife blade. Because quartz is also common, a piece of this mineral might also be useful.



7. CLEAVAGE – *See text page 120; Fig. 5.12.*
Cleavage in minerals is a parting that is controlled by the atomic structure of the mineral. When minerals with cleavage are broken, they tend to split along cleavage planes. Cleavage in minerals is best observed by examining the fragments obtained when a sample is hit with a hammer. This is clearly not an acceptable laboratory procedure! However, it is usually possible to detect planes of weakness where parting would easily occur, or multiple parallel surfaces of cleavage. You should record:

1. The number of cleavage planes (i.e. the number of different directions in which a single grain splits);
2. Their degrees of perfection or the degree of ease with which the mineral splits;
3. The angles between the cleavage planes in a single grain.

Note that not all minerals break along cleavage planes, but rather <u>FRACTURE</u> in various ways (*see text page 133; Fig. 5.21.*). The term *conchoidal* (after conch = shell) is used to describe the curved fracture surfaces that can be observed where quartz has broken. **And always remember: quartz has no cleavage!**

8. <u>OTHER PROPERTIES</u> – *See text page 119–120; Fig. 5.11f–g.*
Other special properties that can be diagnostic for certain minerals are: effervescence (reaction with hydrochloric acid), magnetism, taste, striations and conductivity. Effervescence is best tested with a powdered sample of the mineral.

EXERCISE 1: CRYSTALS, CLEAVAGE AND FRACTURE

Some minerals display a well-shaped crystal form that reflects the internal atomic structure of the mineral. Perfect crystals are the exception rather than the rule – that's why we find them locked in museum cabinets! Cleavage fragments of some minerals are sometimes mistaken for crystals, because both may have planar faces. But remember that cleavage is a breakage characteristic, not a growth feature: it should be a **consistent**, **repeated** planar surface.

Question 1.

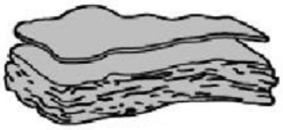
(a) Examine specimen 42 (tourmaline), which is an example of a crystal. This sample has mostly flat (or *striated*) crystal faces, but what do you notice about the nature of the other surfaces? What is the term for these surfaces?

(b) Examine specimen 28 (quartz). How would you describe the 'breaking characteristics' of this specimen? Speculate on why it does not have any crystal faces like sample 42.

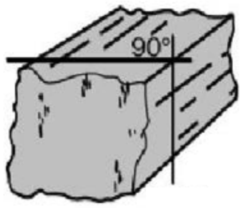
Samples 20, 34 and 35 are calcite, biotite and potassium feldspar, respectively, all common rock-forming minerals. These specimens exhibit *cleavage planes*, flat surfaces produced by a splitting characteristic of the mineral. Most importantly, they are **repeatable parallel surfaces**.

(c) How many different 'breaking planes' or 'cleavage directions' do you observe in these samples? What are the angles between each cleavage plane? Are they perfect or indistinct? You will usually need to use the hand lenses provided to identify the cleavage planes. See the following page for some example diagrams of different cleavage types.

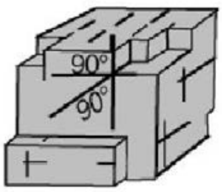
Mineral ID	**No. of cleavage planes**	**Cleavage angle(s)**
20 (calcite)		
34 (biotite)		
35 (K-feldspar)		



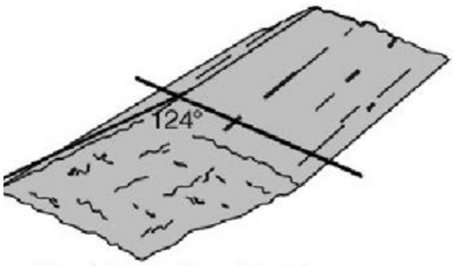
One excellent direction of cleavage.



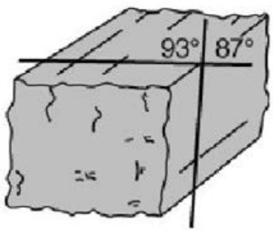
Two good directions of cleavage at 90°.



Three excellent (cubic) cleavage directions.



Two good cleavage directions at 124°.



Two good cleavage directions at 93°.

EXERCISE 2: HARDNESS

For convenience, several common objects are used as tools to perform the hardness test:

Fingernail	Mohs hardness = 2.5
Copper coin	Mohs hardness = 3.5
Steel knife/nail	Mohs hardness = 5.0–5.5
Quartz piece	Mohs hardness = 7.0

Using the above tools, you should be able to determine the hardness of an unknown mineral to the nearest half number on the Mohs hardness scale (see diagram on Page 2 of this handout). Keep the following principles in mind when performing the hardness test:

- That which scratches is harder than that which has been scratched;
- Objects of equal hardness can be scratched with difficulty.

How to perform the scratch test

You should find a sharp corner of a mineral and scratch the smooth surface of the test object (fingernail, coin, glass plate, knife, steel nail, etc.) This is the preferred method because it will preserve the quality of the mineral specimens. If this is not possible, you can also try to scratch the smooth surface of the unknown mineral using a sharp point of the testing tool. When performing the hardness test, you should always start from the soft end of the scale; that is, try using your fingernail first rather than the steel nail or a piece of quartz. Why? The quartz piece is able to scratch minerals with hardness of 7 down to 1, and does not give you any precise information. A fingernail can scratch only a few minerals. When this test fails, the unknown mineral is then harder than your fingernail. You should logically ask, “How much harder than my fingernail is it?”, and proceed to the next harder object, the copper coin. Suppose the unknown mineral easily scratches the coin. Which is harder, the mineral or the coin? The mineral is obviously harder than 3.5, but how much harder? Proceeding with the steel nail, the mineral is unable to scratch it (hardness = 5.0–5.5). Hence, this mineral is approximately 4.0–5.0 on the Mohs scale.

Question 2.

Using the hardness testing tools provided, fill out the table below for the relative hardness of the specimens listed. List an approximate number or range on the Mohs hardness scale.

Mineral ID	**Hardness range (e.g. 4.5–5.5)**
3 (galena)	
10 (halite)	
26 (gypsum)	
41 (garnet)	
46 (talc)	

EXERCISE 3: LUSTRE

The lustre of a mineral is another useful identification property. The way in which light is reflected from a mineral surface can be compared with other familiar materials, such as metals. Thus, the distinction between *metallic* and *non-metallic* lustres is commonly used. However, metals show a wide range of degree of reflectivity; e.g. polished chromium has a brilliant lustre, while weathered lead sheet is dull. Lustre should therefore be described using both a comparative term (i.e. *metallic* or *non-metallic*) and descriptive term (e.g. *shiny, dull, brilliant, glassy, silky, earthy, pearly*).

Question 3.

For each mineral specimen listed below, describe its lustre.

Mineral ID	**Lustre**
2 (molybdenite)	
7 (pyrite)	
11 (fluorite)	
13 (haematite)	
31 (hornblende)	

EXERCISE 4: SPECIFIC GRAVITY

Specific gravity (S.G.) is the ratio of the weight of a substance to the weight of an equal volume of water. The mineral quartz (S.G. = 2.65) is 2.65 times heavier than an equal volume of water. Hefting is an easy way to tell the specific gravity of one mineral relative to another. Starting with equal-sized samples of minerals, feel the difference in the weight between each sample. With practice, you will be able to heft any mineral and tell whether it has a high or low specific gravity. Minerals with an S.G. > 5 feel heavy, whereas those < 5 feel light or average for minerals.

Question 4.

Arrange mineral specimens 3 (galena), 20 (calcite), 37 (andalusite), 38 (sillimanite) and 39 (kyanite) from lowest to highest specific gravity.

Mineral ID	
	Lowest S.G.
	Highest S.G.

EXERCISE 5: MINERAL IDENTIFICATION

Now that you know some of the basic physical properties of minerals, we'll try to identify 10 of them based on their diagnostic features, with reference to a mineral identification key.

Question 5.

Use the following procedure to complete the table given on the following page:

1. Observe the physical characteristics of each specimen, making use of the testing kits provided. These will be particularly useful for minerals which have special properties (e.g. magnetism, effervescence). Make sure you are confident in the use of a hand lens to assist you with identifying mineral cleavage and other properties. It is **highly recommended** that you fill out the table vertically (one column at a time). This ensures that you practice the laboratory technique for each type of test in a consistent and replicable manner.
2. After you have listed the properties for each mineral, consult the mineral identification keys provided at the back of this handout to ensure that your answers are correct.

MINERAL DESCRIPTION TABLE

MINERAL ID AND NAME	COLOUR	STREAK	LUSTRE	HABIT	SPECIFIC GRAVITY	HARDNESS	CLEAVAGE	OTHER PROPERTIES
3 Galena PbS								
15 Magnetite Fe_3O_4								
20 Calcite $CaCO_3$								
26 Gypsum $CaSO_4.2H_2O$								
28 Quartz SiO_2								
29 Olivine $(Mg,Fe)_2SiO_4$								
32 Actinolite $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$								
33 Muscovite $KAl_2(AlSi_3O_{10})(OH)_2$								
36 Plagioclase $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$								
41 Garnet $(Fe,Mg,Ca,Mn)_3Al_2Si_3O_{12}$								

MINERAL IDENTIFICATION KEY

Non-metallic lustre (dark coloured)			
Hardness	***Cleavage***	***Other Diagnostic Properties***	***Name***
Harder or as hard as a steel nail	Cleavage present	Black to greenish-black; hardness = 5–6; specific gravity = 3.4; fair cleavage, two directions at nearly 90 degrees	Pyroxene
		Black to greenish-black; hardness = 5–6; specific gravity = 3.2; fair cleavage, two directions at nearly 60 and 120 degrees	Hornblende
		Red to reddish-brown; hardness = 6.5–7.5; conchoidal fracture; glassy lustre	Garnet
	Poor cleavage	Olive green; hardness = 6.5–7.0; small glassy grains	Olivine
Softer than copper, harder than your fingernail	Cleavage present	Dark brown to black; hardness = 2.5-3; excellent cleavage in one direction; elastic in thin sheets; black mica	Biotite

Non-metallic lustre (light coloured)			
Hardness	***Cleavage***	***Other Diagnostic Properties***	***Name***
Harder than a steel nail, softer than or equal to quartz	Cleavage present	Pink or white to grey; hardness = 6; specific gravity = 2.6; two directions of cleavage at nearly right angles	Potassium feldspar (pink)
			Plagioclase feldspar (white to grey)
	Cleavage absent	Any colour; hardness = 7; specific gravity = 2.65; conchoidal fracture; glassy appearance; varieties: milky, rose, smoky, amethyst (violet)	Quartz
Softer than copper	Cleavage present	White, yellowish to colourless; hardness = 3; three directions of cleavage at 75 degrees (rhombohedral); effervesces with HCl; often transparent	Calcite
		White to colourless; hardness = 2.5; three directions of cleavage at 90 degrees (cubic); salty taste	Halite
As soft or softer than your fingernail	Cleavage present	Colourless; hardness = 2–2.5; transparent and elastic in thin sheets; excellent cleavage in one direction	Muscovite
		Colourless, white to gray; hardness = 2; one perfect cleavage, two less distinct cleavages, vitreous or pearly, sometimes silky	Gypsum

Metallic lustre			
Hardness	***Streak***	***Other Diagnostic Properties***	***Name***
Harder than a steel nail	Black	Black; magnetic; hardness = 6; specific gravity = 5.2; often granular	Magnetite
	Greenish-black	Brassy yellow; hardness = 6; specific gravity = 5.2; generally an aggregate of cubic crystals	Pyrite
	Red-brown	Grey or reddish-brown; hardness = 5–6; specific gravity = 5; platy appearance	Hematite
Softer than a steel nail, harder than copper	Greenish-black	Golden yellow; hardness = 4; specific gravity = 4.2; massive	Chalcopyrite)
Softer than copper, harder than your fingernail	Dark grey to black	Silvery-grey; hardness = 2.5; specific gravity = 7.6; good cubic cleavage	Galena