Core Lab 3 - Mineral Identification

Purpose and Outcomes

The students will

- recognize and describe the physical properties of minerals.
- identify several minerals by sight.
- list the uses of several minerals.
- select appropriate instruments for collecting evidence, and appropriate processes for problem solving, inquiring, and decision making.
- use instruments effectively and accurately for collecting data.
- compile and organize data using appropriate formats and data treatments that facilitate interpretation of the data.
- use a mineral identification key to name minerals.

Materials

- hand lens
- mineral samples
- streak plate
- magnet
- stereoscopic microscope
- dilute hydrochloric acid
- quartz crystals (various sizes)
- contact goniometer
- crystal growth solution(s)

Common Minerals

1. List the uses for the following minerals:
   a) Chalcopyrite
   b) Feldspar
   c) Fluorite
   d) Galena
   e) Graphite
   f) Gypsum
   g) Halite
   h) Hematite
   i) Magnetite
   j) Pyrite
   k) Quartz
   l) Sphalerite
   m) Talc

Physical Properties of Minerals

2. Primary properties include: optical properties (in particular lustre and the ability to transmit light), hardness, colour, streak, crystal form, cleavage and specific gravity. Briefly define these terms.

The Mohs scale of hardness (Table 1), widely used today by geologists and engineers, uses ten index minerals as a reference set to determine the hardness of other minerals.

Table 1: Mohs scale of hardness with the hardness of some common objects.

Mineral	*Scale*	*Common Objects*
Diamond	10	Steel file (6.5) Glass (5.5) Knife blade (5.1) Wire Nail (4.5) Penney (3.5) Fingernail (2.5)
Corundum	9	
Topaz	8	
Quartz	7	
Orthoclase	6	
Apatite	5	
Fluorite	4	
Calcite	3	
Gypsum	2	
Talc	1	

Table 2: Hardness Guide.

Hardness	Description
Less than 2.5	A mineral that can be scratched by your fingernail (hardness = 2.5)
2.5 - 5.5	A mineral that cannot be scratched by your fingernail (hardness = 2.5), and cannot scratch glass (hardness = 5.5)
Greater than 5.5	A mineral that scratches glass (hardness 5.5)

3. Test the hardness of several of the mineral specimens provided by your teacher by rubbing any two together to determine which are hard (the minerals that do the scratching) and which are soft (the minerals that are scratched). Doing this will give you an indication of what is meant by the term “relative hardness” of minerals.
4. Use the hardness guide in Table 3 to find an example of a mineral supplied by your teacher that falls in each of the three categories.
5. Colour, although an obvious feature of minerals, may also be misleading. Explain why this is so.
6. Observe two varieties of the same mineral, quartz. What is the reason for the variety of colours that quartz exhibits?
7. Examine your mineral specimens and identify any that appear to be the same mineral but with variable colours.
8. Why is streak a more reliable indicator than colour?
9. Select three of the mineral specimens provided. Do they exhibit a streak? If so, is the streak the same colour as the mineral specimen? List your observations for each specimen.
10. Most of the time, minerals must compete for space and the result is a dense inter-grown mass in which crystals do not exhibit their crystal form, especially to the unaided eye. Nonetheless, crystal form can often be used to identify mineral samples. At the discretion of your teacher, you may be asked to grow crystals by evaporating prepared concentrated solutions. Following the specific directions of your teacher, and after you have completed your experiment(s), write a brief paragraph summarizing your observations.
11. The mineral, quartz has a well-developed crystal form with six faces that intersect at about 120^0 and come to a point. Why do muscovite and biotite, two varieties of the same mineral, not exhibit crystal form?
12. Select one of the mineral specimens, other than quartz, that exhibits its crystal form and describe its shape.
13. Observe the various size crystals of the mineral quartz. Use the contact goniometer to measure the angle between similar, adjacent crystal faces on several crystals. Then, write a statement relating the angle between adjacent crystal faces to the size of the crystal.
14. Distinguish between crystal form and cleavage.
15. Distinguish between cleavage and fracture.

Minerals may have one, two, three, four, or six directions of cleavage. Table 3 describes some of the common cleavage directions of minerals.

16. The minerals, muscovite and biotite, have one direction of cleavage. Describe the appearance of a mineral that exhibits this type of cleavage.
17. Observe the calcite specimen. Several smooth, flat planes result when the mineral is broken.

    a) How many planes of cleavage are present?

    b) How many directions of cleavage are present?

    c) The cleavage directions meet at what angle? (90^0 angles or angles other than 90^0)
18. Select one mineral specimen that exhibits cleavage. Describe its cleavage by completing the following

Table 3: Common cleavage directions of minerals.	
Number of Cleavage Directions	Shape
0	Irregular mass
1	Flat sheets
2 at 90^0	Elongated form with rectangle cross section (prism)
2 not at 90^0	Elongated form with parallelogram cross section (prism)
3 at 90^0	Cube
3 not at 90^0	Rhombohedron
4	Octahedron
6	Dodecahedron

statement:_______ directions of cleavage at _____ degrees.

Secondary Properties of Minerals

19. Secondary or special properties include feel and taste. These properties are of use in identifying certain minerals. List at least 3 more special properties.
20. Examine the mineral specimens provided by your teacher and answer the following questions.
    a) How many of your specimens can be grouped into each of the following lustre types?
    Metallic _______, Non-metallic or glassy _______.
    b) How many of your specimens are transparent and how many are opaque?
    Transparent _______, Opaque _______.
21. Give at least one example, for each property, of a mineral that can be identified using it.
    a) Taste
    b) Feel
    c) Striations
    d) Magnetism
    e) Reaction to Dilute Hydrochloric Acid:

(CAUTION: Hydrochloric acid can discolour, decompose, and disintegrate mineral and rock samples. Use the acid only after you have received specific instructions on its use from your teacher. Never taste minerals that have had acid placed on them.)

22. Following the directions given by your teacher, examine the mineral specimens to determine if any exhibit one or more of the special properties listed above.

Identification of Minerals

To identify a mineral, you must first determine, using available tools, as many of its physical properties as you can. Next, knowing the properties of the mineral, you use a mineral identification key to narrow down the choices and arrive at a specific name. *As you complete the exercise, remember that the goal is to learn the procedure for identifying minerals through observation and not simply to put a name on them.*

23. Arrange your mineral specimens by placing them on a numbered sheet of paper. Locate the mineral identification chart, Table 4, and write the numbers of your mineral specimens, in order, under the column labelled “Specimen Number”.

Table 5 is a mineral identification key that uses the property of lustre as the primary division of minerals into two groups, those with metallic lustres and those with non-metallic lustres. Colour (either dark or light) is used as a secondary division for the non-metallic minerals. Examine the mineral identification key closely to see how it is arranged.

24. Use the mineral identification key. What would be the name of the mineral with these properties: non-metallic lustre, light coloured, softer than a fingernail, produces small, thin plates or sheets when scratched by a fingernail, white colour, and a “soapy” feel?
25. Complete the mineral identification chart, Table 4, by listing the properties of each of the mineral specimens supplied by your teacher. Use the mineral identification key, Table 5, to determine the name of each of the minerals.
26. In question 1 you researched the use of some economic minerals. List their use in the column to the right of their name on the mineral identification chart, Table 4.

Table 4: Mineral Identification Chart

Specimen Number	**Lustre**	**Hardness**	**Colour**	**Streak**	**Fracture**	**Cleavage (# of** directions & angle)	**Other** Properties	**Name**	**Economic Use or** Rock-forming

Table 5: Mineral Identification Key

Group I
Metallic Lustre

Hardness	**Streak**	**Other Diagnostic Properties**	**Name** (Chemical Comp.)
Harder than glass	Black	Black; magnetic; hardness = 6; specific gravity - 5.2; often granular	Magnetite (Fe_3O_4)
	Greenish-black	Brass yellow; hardness =6; specific gravity = 5.2; generally an aggregate of cubic crystals	Pyrite (FeS_2) - fool's gold
	Red-brown	Grey or reddish brown; hardness = 5-6; specific gravity =5, platy appearance	Hematite (Fe_2O_3)
Softer than glass	Greenish-black	Golden yellow; hardness = 4; specific gravity = 4.2; massive	Chalcopyrite ($CuFeS_2$)
	Grey-black	Silvery grey; hardness = 2.5; specific gravity = 7.6 (very heavy); good cubic cleavage	Galena (PbS)
	Yellow-brown	Yellow brown to dark brown; hardness variable (1-6); specific gravity = 3.5-4; often found in rounded masses; earthy appearance	Limonite ($Fe_2O_3 \cdot H_2O$)
	Grey-black	Black to bronze; tarnishes to purples and greens; hardness = 3; specific gravity = 5; massive	Bornite (Cu_5FeS_4)
Softer than your fingernail	Dark grey	Silvery grey; hardness =1 (very soft); specific gravity = 2.2; massive to platy; writes on paper (pencil lead); feels greasy	Graphite (C)
		Red to reddish-brown; hardness = 6-5; conchoridal fracture; glass lustre	Garnet (Fe, Mg, Ca, Al silicate)

Table 5: Mineral Identification Key (Cont'd)

Group II
Non-Metallic Lustre (dark coloured)

Hardness	**Cleavage**	**Other Diagnostic Properties**	**Name (Chemical** Comp.)
Harder than glass	Cleavage present	Black to greenish-black; hardness = 5-6; specific gravity = 3.4; fair cleavage, two directions at nearly 90 degrees	Augite (Ca, Mg, Fe, Al silicate)
		Black to greenish-black; hardness = 5-6; specific gravity = 3.2 fair cleavage, two directions at nearly 60 and 120 degrees	Hornblende (Ca, Na, Fe, OH, Al silicate)
		Red to reddish-brown; hardness = 6.5-7.5; conchoridal fracture; glass lustre	Garnet (Fe, Mg, Ca, Al silicate)
	Cleavage not prominent	Grey to brown; hardness =9; specific gravity =4; hexagonal crystals common	Corundum (Al_2O_3)
		Dark-brown to black; hardness =7; conchoidal fracture; glass lustre	Smoky quartz (SiO_2)
		Olive green; hardness =6.5-7; small glassy grains	Olivine $(Mg, Fe)_2 SiO_2$
Softer than glass	Cleavage present	Yellow-brown to black; hardness =4; good cleavage in six directions, light yellow streak that has the smell of sulphur	Sphalerite (ZnS)
		Dark-brown to black; hardness =2.5-3; excellent cleavage in one direction; elastic in thin sheets; black mica	Biotite (K, Mg, Fe, OH, Al silicate)
	Cleavage absent	Generally tarnished to brown or green; hardness =2.5; specific gravity =9; massive	Native Copper (Cu)
Softer than your fingernail	Cleavage not prominent	Reddish-brown; hardness =1.5; specific gravity =4-5; red streak; earthy appearance	Hematite (Fe_2O_3)
		Yellow-brown; hardness =1-3; specific gravity =3.5; earthy appearance; powders easily	Limonite ($Fe_2O_3 . H_20$)

Table 5: Mineral Identification Key (Cont'd)

Group III
Non-Metallic Lustre (dark coloured)

Hardness	**Cleavage**	**Other Diagnostic Properties**	**Name (Chemical** Comp.)
Harder than glass	Cleavage present	Pink or white to grey; hardness =6; specific gravity =2.6; two directions of cleavage at nearly right angles	Potassium feldspar (KAIS3O8) (pink)
			Plagioclase feldspar ($NaALSI_3O_8$) (white to grey)
	Cleavage absent	Any colour; hardness =7; specific gravity =2.65; conchoidal fracture; glassy appearance; varieties: milky, rose, smoky, amethyst (violet)	Quartz (SiO_2)
Softer than glass	Cleavage present	White, yellowish to colourless; hardness =3; three directions of cleavage at 75 degrees (rhombohedral); effervesces in HCI; often transparent	Calcite ($CaCO_3$)
		White to colourless; hardness =2.5; three directions of cleavage at 90 degrees (cubic); salty taste	Halite (NaCI)
		Yellow, purple, green colourless; hardness =4; white streak; translucent to transparent; four directions of cleavage	Fluorite (CaF_2)
Softer than your fingernail	Cleavage present	Colourless; hardness =2-2.5; transparent and elastic in thin sheets; excellent cleavage in one direction; light mica	Muscovite (K, OH, Al silicate)
		White to transparent; hardness =2; when in sheets, is flexible but not elastic; varieties: selenite (transparent, three directions of cleavage); satin spar (fibrous, silky lustre); alabaster (aggregate of small crystals)	Gypsum ($CaSO_4 \cdot 2H_2O$)
	Cleavage not prominent	White, pink, green; hardness =1-2; forms in thin plates; soapy feel; pearly lustre	Talc (Mg silicate)
		Yellow; hardness =1-2.5	Sulphur (S)
		White; hardness =2; smooth feel; earthy odour; when moistened, has typical clay texture	Kaolinite (Hydrous Al silicate)
		Green; hardness =2.5; fibrous; variety of serpentine	Asbestos (Mg, Al silicate)
		Pale to dark reddish-brown; hardness =1-3; dull lustre; earthy; often contains spheroidal-shaped particles; not a true mineral	Bauxite (Hydrous Al oxide)

Core Lab 4 - Specific Gravity

Density and Specific Gravity

Two important properties of a material are its density and specific gravity. Density is the mass of a substance per unit volume, usually expressed in grams per cubic centimetre (g/cm^3) in the metric system. The specific gravity of a solid is the ratio of the mass of a given volume of the substance to the mass of an equal volume of some other substance taken as a standard (usually water at 4^{0}C). Because specific gravity is a ratio, it is expressed as a pure number and has no units. For example, a specific gravity of 6 means that the substance has six times more mass than an equal volume of water. Because the density of pure water at 4^{0}C is 1 g/cm^3, the specific gravity of a substance will be numerically equal to its density.

Purpose and Outcomes

The students will

- find the specific gravity of selected minerals.
- identify minerals using specific gravity.
- compare theoretical and empirical values and account for differences.

Materials

- metric balance
- graduated cylinder (large)
- water
- mineral samples (magnetite, hematite, galena, sphalerite, quartz, calcite)

Method

The approximate density and specific gravity of a rock, or other solid, can be arrived at using the following steps:

1. Determine the mass of a small sample using a metric balance.
2. Fill a graduated cylinder that has its divisions marked in millilitres approximately two-thirds full with water. Note the level of the water in the cylinder in millilitres.
3. Tie a thread to the rock and immerse the rock into the water in the graduated cylinder. Note the new level of the water in the cylinder.
4. Determine the difference between the beginning level and the after-immersion level of the water in the cylinder.

5. Calculate the density and specific gravity using the following information and appropriate equations.

A millilitre of water has a volume approximately equal to a cubic centimetre (cm^3). Therefore, the difference between the beginning water level and the after-immersion level in the cylinder equals the volume of the rock in cubic centimetres. Furthermore, a cubic centimetre (one millilitre) of water has a mass of approximately one gram. (Note: Utilising the equipment already present in the lab, you may want to devise a simple experiment to confirm this fact.) Therefore, the difference between the beginning water level and the after-immersion level in the cylinder is the mass of a volume of water equal to the volume of the rock.

1. Determine the density and specific gravity of hematite, sphalerite, and quartz by completing the following:
   a) Mass of mineral sample ______ g
   b) After-immersion level of water in cylinder ______ ml
      Beginning level of water in cylinder ______ ml
      Difference ______ ml
   c) Volume of mineral sample ______ cm^3
   d) Mass of a volume of water equal to the volume of the mineral sample ______ g
   e) Density of mineral

$$\text{Density} = \frac{\text{mass of mineral sample (g)}}{\text{volume of mineral sample (cm}^3\text{)}} = \underline{\qquad} \text{ g/cm}^3$$

   f) Specific Gravity of Mineral Sample

$$\text{Specific Gravity} = \frac{\text{mass of mineral sample (g)}}{\text{mass of equal volume of water (g)}} = \underline{\qquad}$$

2. Using the same procedure and specific gravity data in Table 1, identify three unknown minerals by their specific gravity. (Note to teachers - use magnetite, galena, and calcite.)

3. Calculate the percentage of error using the following formula. (Actual specific gravity data can be found in Table 1 below.)

$$\%\text{ error} = \frac{\text{Actual Value - Calculated Value}}{\text{Actual Value}} \times 100\% = \underline{\qquad}\%$$

4. Suggest possible explanations for the error in your result.

Table 1. Specific Gravity of Some Common Minerals

Mineral	Specific Gravity
Magnetite	5.2
Pyrite	5.2
Chalcopyrite	4.2
Galena	7.6
Limonite	3.5 - 4
Graphite	2.2
Augite	3.4
Hornblende	3.2
Quartz	2.6
Sphalerite	4
Biotite	2.8 - 3.2
Native Copper	9
Hematite	4 - 5
Feldspar	2.6
Calcite	2.7