UNIVERSITY of SOUTH AUSTRALIA
School of Natural and Built Environments, Mawson Lakes

Igneous rocks

Text reference: Marshak, S. (2012) *Earth: Portrait of a Planet.* 4th edition, WW Norton & Co., p. 140–165.

INTRODUCTION

This practical will introduce you to the mineralogy and textures of igneous rocks, and the ways in which these features are used to identify different rock types.

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

1. Identify the major rock-forming minerals in a variety of common igneous rocks, and thus describe their mineralogy;
2. Distinguish between different igneous textures and interpret their significance in terms of rock-forming processes and cooling histories;
3. Understand the relationship between mineralogy and magma compositions;
4. Use a rock classification key to name some common igneous rocks.

You are provided with a selection of igneous rocks whose mineralogy you will examine using the skills you learned in the Week 1 practical (*Mineral properties and identification*). Some of the samples are polished on one surface making it easier to observe their compositions and textures. These have been provided by an Adelaide stone mason, Ace Granite of 46 Gorge Road, Campbelltown, SA 5074.

IGNEOUS ROCK TEXTURES

Igneous rocks are those that have formed from the cooling and crystallisation of molten rock, which is called *magma* when it remains below Earth's surface, or *lava* when it flows onto Earth's surface from a volcanic vent or crater. Igneous rocks that form within Earth's crust are said to be *intrusive* or *plutonic*, whereas those that form from surface lava flows are called *extrusive* or *volcanic* (Text p. 148–153).

In the study of rocks (*petrology*), texture refers to the sizes, shapes and arrangements of the mineral grains. In igneous rocks there is a close relationship between the rate of cooling of the magma (or lava) and the size of the crystalline minerals. Generally, slow cooling results in large, visible crystals, whereas rapid cooling generates small crystals invisible to the naked eye. Thus, intrusive igneous rocks that crystallise from slowly cooling magma have a coarse grained *phaneritic* texture, and extrusive igneous rocks have a fine grained *aphanitic* texture (Text pp. 153–155). Extremely rapid cooling of lava produces a non-crystalline glass (Text p. 155).

We can illustrate the relationship between crystal size and cooling rate using the crystallisation of molten copper. Molten copper is poured into a mould about the same size and shape as a loaf of bread. Heat is lost rapidly from the outside of the mould, but cooling of the inner liquid copper happens more slowly. When the copper is finally cooled and crystalline, it is removed from the mould and sawn into pieces. Figure 1, on the following page, illustrates a half of one of the slices of copper. Note that around the left, top and right edges of the slice, the crystals of copper are small. These crystals formed quickly and at right angles to the edge. Towards the centre of the bottom edge, where cooling was much slower in the centre of the mould, the copper is much more coarsely crystalline. However, the crystals are still oriented at right angles to the cooling surface, arranging themselves as diagonals.

Figure 1. *Crystalline copper; the illustration shows half of a slice through a copper ingot.*

IGNEOUS ROCK COMPOSITIONS

The mineral compositions of igneous rocks reflect the chemical compositions of the magmas from which they form, particularly the amount of silica (SiO_2) they contain (Text p. 144–145). *Felsic* (high silica) magmas form rocks are predominantly comprised of quartz and potassium feldspar, with lesser abundance of ferromagnesian (Fe–Mg) minerals such as amphibole and pyroxene. A common example of a felsic rock is granite (Fig. 2). *Mafic* (low silica) magmas form rocks that are composed largely of calcium-rich plagioclase feldspar and ferromagnesian minerals including pyroxene and olivine. A common example of a mafic rock is basalt. Igneous rocks of *intermediate* composition are also relatively common; they have moderate amounts of silica and usually contain significant amounts of amphibole. The colour of igneous rocks can generally be used to indicate their composition: mafic rocks are *dark* in colour, whereas felsic rocks are *light* in colour. Colour is especially useful for rocks with an aphanitic texture.

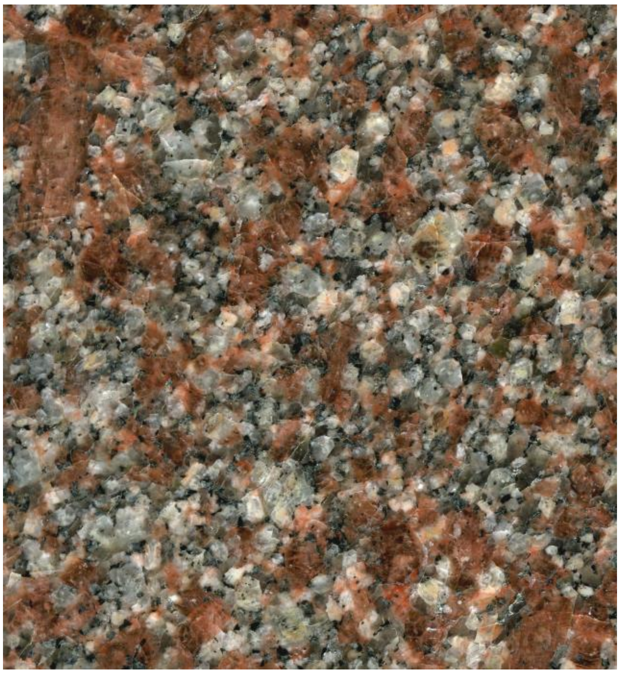
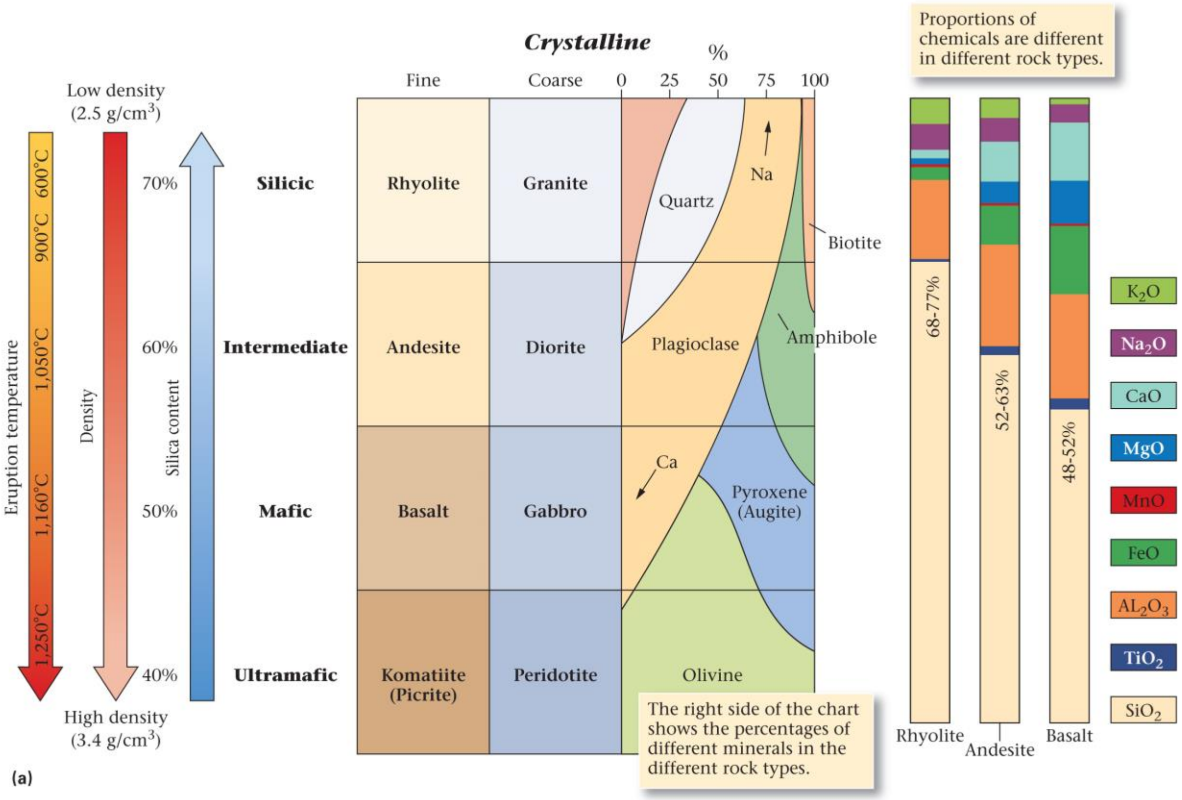


Figure 2. *Polished surface of granite. Approximately natural size.*

The figure below summarises the relationship between magma composition, mineralogy and texture of the common igneous rocks (see also diagram on Page 9 of this handout). **<u>You should refer to these figures frequently when considering the questions that follow.</u>**



Activity #1

✍ Using your hand lens, carefully examine the rock specimen **I31**.

The main minerals comprising this rock are quartz, K-feldspar and biotite. Identify these minerals and estimate the percentage of each. **<u>It may be helpful to refer to the mineral ID key on pages 10–11 of this handout.</u>**

quartz	%
K-feldspar	%
biotite	%

Refer to the previous pages and text references to respond to the following:

✍ Is this rock felsic or mafic? Why?

✍ Is this rock intrusive or extrusive? Why?

✍ Name the type of rock. What is its fine-grained equivalent?

Activity #2
Examine rock specimen **I9**.

✍ What is the black mineral?

✍ What were the mineral properties that enabled your identification?

(i)

(ii)

(iii)

✍ What is the other mineral?

✍ What were the mineral properties that enabled your identification?

(i)

(ii)

(iii)

✍ On Figure 3, label these minerals and state their percentage abundance.

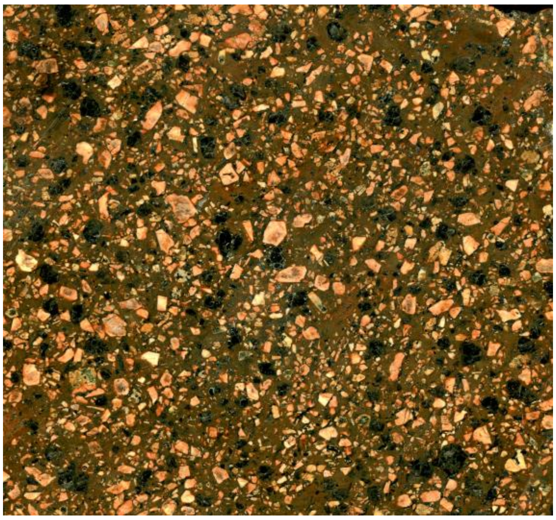


Figure 3. *Cut surface of rock specimen I9 showing the texture and mineralogy of this rock. Natural scale.*

Note that about half the bulk of the rock consists of a groundmass that is too finely grained to identify the minerals (aphanitic).

✍ Label the groundmass on Figure 3.

✍ Outline a theory that would explain the texture of this rock. Be sure to describe its cooling history and environment of formation.

Activity #3

Examine the rock specimen **I32** pictured below.

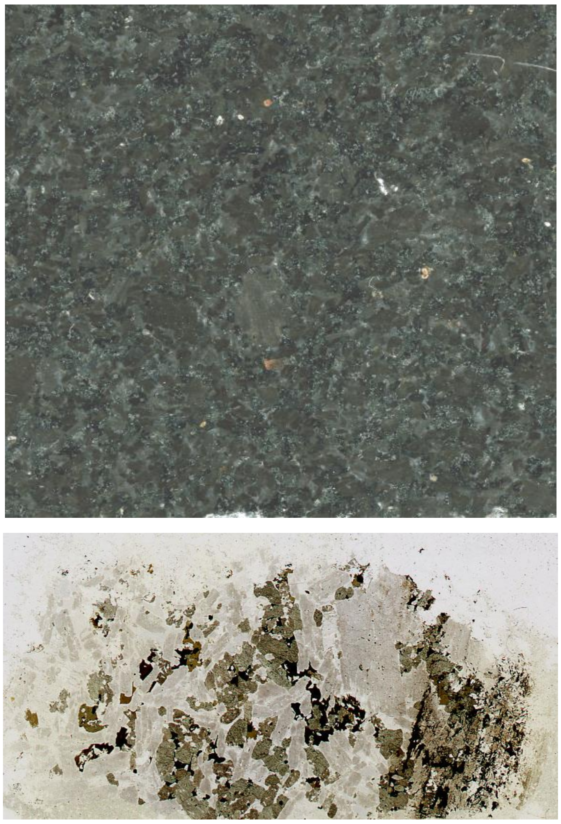


Figure 4. *Upper: polished surface of the rock I32, natural scale. Lower: thin section, approximately 2x magnification. For information about rock thin sections see Text pp. 136–137.*

This rock is quarried at Black Hill near Mannum; it is a popular building and ornamental stone (e.g. gravestone) used in South Australia. There are small amounts of opaque iron oxide (black), but the bulk of the rock is composed of calcium-rich feldspar (plagioclase), which is light in colour, and pyroxene minerals, which are greenish-brown in colour.

✍ Is this rock felsic or mafic?

Explain your answer.

✍ Is this rock intrusive or extrusive?

Explain your answer.

✍ Name the type of rock. What is its fine-grained equivalent?

Activity #4

Specimen **I33** is pictured below. It has a structure similar to that of Swiss cheese, or better still, of frozen frothy Coke. The 'holes' are called *vesicles* (Text p. 157–158).

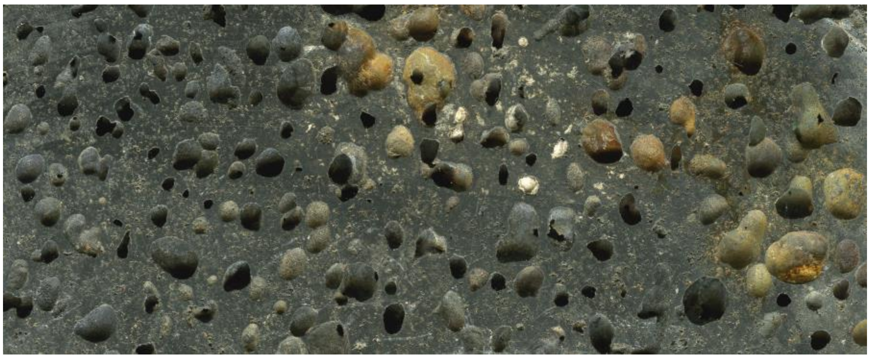


Figure 5. *Cut (unpolished) surface of rock specimen I33. Natural scale.*

✍ Is this rock felsic or mafic?

Explain your answer.

✍ Is this rock intrusive or extrusive?

Explain your answer.

✍ Explain how the vesicles formed.

✍ Name the type of rock. What is its coarse-grained equivalent?

✍ In what kind of tectonic setting would this rock have formed?

Activity #5

Not all igneous rocks are either mafic or felsic – some are intermediate between these compositions. The rock illustrated below (**I34** or **DS8**) comes from Norway and is widely regarded as one of the most beautiful building and ornamental stones. Stone masons call it 'Blue Pearl' because of the large iridescent feldspar crystals; geologists call it *Larvikite*, an intrusive intermediate rock.

Figure 6. *Polished surface of the intermediate intrusive rock Larvikite, I34. Natural scale.*

✍ Explain why this rock is intermediate in composition.

Activity #6

Examine specimen **X3**, which is neither cut nor polished.

For this specimen:

✍ Describe the texture of the rock.

✍ Hence, is the rock intrusive or extrusive?

✍ List the three major minerals that comprise the rock, and for each mineral describe the physical properties that enabled your identification.

1. *Physical properties*

2. *Physical properties*

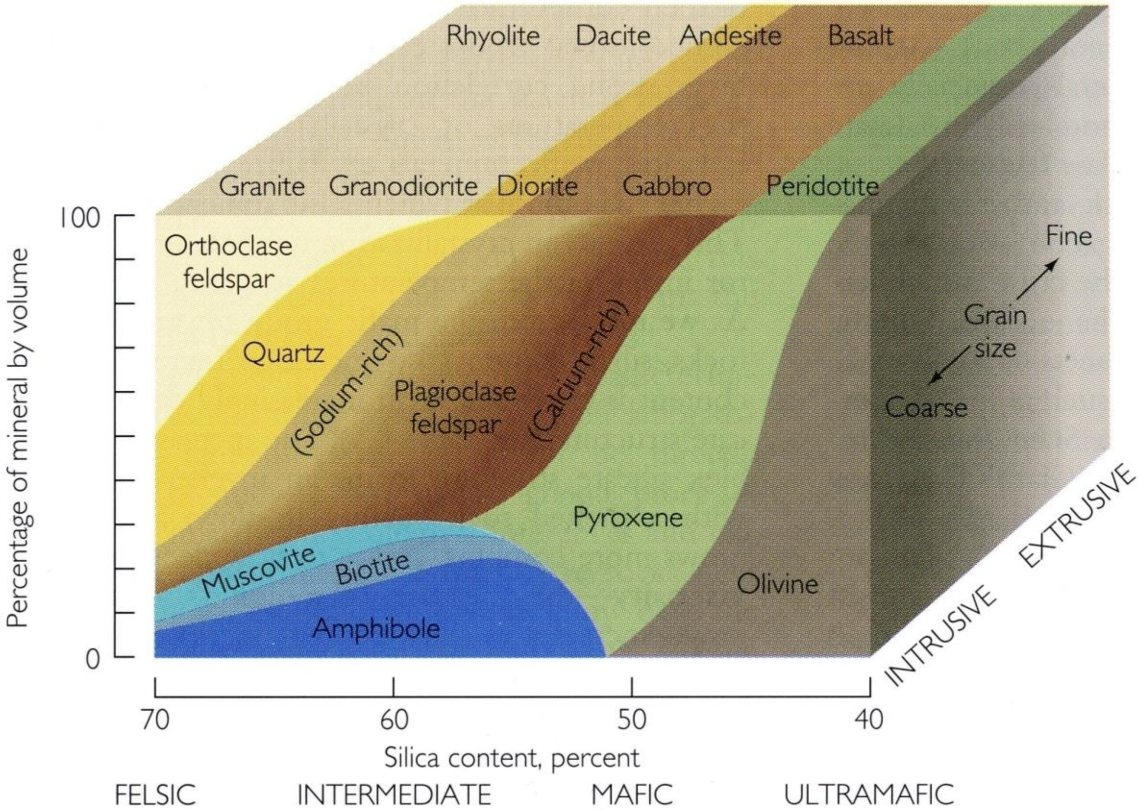
3. *Physical properties*

✍ Hence, is the rock felsic or mafic?

✍ Name the rock type.

✍ In what kind of tectonic setting would this rock have formed?

Mineral compositions of igneous rocks



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