

Igneous rocks are interlocking crystals of minerals

minerals are the **building blocks** for all igneous rocks, and they are **made up of several chemical elements**, and they have a **specific chemical makeup** and **crystal structure** and a **chemical formula**.

the chemical formula shows the amount of various **chemical elements** in its makeup

there are **thousands** of kinds of minerals

6 types of minerals are common in **igneous rocks**

1. **Quartz**: Silicon dioxide (SiO_2)
2. **Feldspars**: Complex; typically a combination of aluminum, silica, and alkali metals or alkaline earth metals (e.g., potassium feldspar - KAlSi_3O_8)
3. **Micas**: Two main types - muscovite (potassium aluminum silicate hydroxide $\text{KAl}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$) and biotite (iron magnesium aluminum hydroxide $\text{K}(\text{Fe, Mg})_3\text{AlSi}_3\text{O}_{10}(\text{OH})_2$)
4. **Pyroxenes**: Calcium, magnesium, iron silicate minerals (e.g., augite - $(\text{Ca, Na})(\text{Mg, Fe, Al})(\text{Al, Si})_2\text{O}_6$)
5. **Amphiboles**: Complex silicate minerals containing ions like calcium, magnesium, iron, and aluminum (e.g., hornblende - $(\text{Ca, Na})_2\text{-3}(\text{Mg, Fe, Al})_5(\text{Al, Si})_8\text{O}_{22}(\text{OH})_2$)
6. **Olivine**: Magnesium iron silicate ($(\text{Mg, Fe})_2\text{SiO}_4$)

All of these are called **silicate minerals**, Because they contain **silica (SiO)**

You would see that all minerals other than **quarks** are listed in **plural**, because their chemical makeup can vary greatly through the basic nature

FELDSPAR

Property	Orthoclase (Potassium Feldspar)	Plagioclase
Chemical Formula	KAlSi_3O_8	$(\text{Na, Ca})(\text{Al, Si})\text{AlSi}_2\text{O}_8$
Color	Usually pink, white, or gray	White, gray, green, brown
Cleavage	Perfect on two planes at 90°	Perfect on two planes at nearly 90°
Hardness	6 on Mohs scale	6 - 6.5 on Mohs scale
Density	$2.54 - 2.57 \text{ g/cm}^3$	$2.62 - 2.76 \text{ g/cm}^3$
Streak	White	White
Luster	Vitreous	Vitreous
Twinning	Carlsbad and Baveno twins common	Albite and Pericline twins
Composition	Rich in potassium (K), aluminum (Al), and silica (Si)	Sodium (Na), calcium (Ca), aluminum (Al), and silica (Si)

They have slightly different structure but very different chemical makeup



MICA

Property	Muscovite (Mica)	Biotite (Mica)
Chemical Formula	$KAl_2(AlSi_3O_{10})(F,OH)_2$	$K(Fe,Mg)_3(AlSi_3O_{10})(F,OH)_2$
Color	Colorless to pale shades	Dark brown to black
Cleavage	Perfect in one direction	Perfect in one direction
Hardness	2.5 - 3 on Mohs scale	2.5 - 3 on Mohs scale
Density	2.76 - 3.0 g/cm ³	2.7 - 3.3 g/cm ³
Streak	White	White to grayish-brown
Luster	Vitreous to pearly	Vitreous to pearly
Transparency	Transparent to translucent	Translucent to opaque
Composition	Rich in potassium (K), aluminum (Al), silica (Si), and minor fluorine (F) or hydroxide (OH) ions	Rich in iron (Fe), magnesium (Mg), potassium (K), aluminum (Al), silica (Si), and minor fluorine (F) or hydroxide (OH) ions

They have slightly different structure, but completely different chemical powders

MAGMA, LAVA, IGNEOUS ROCKS

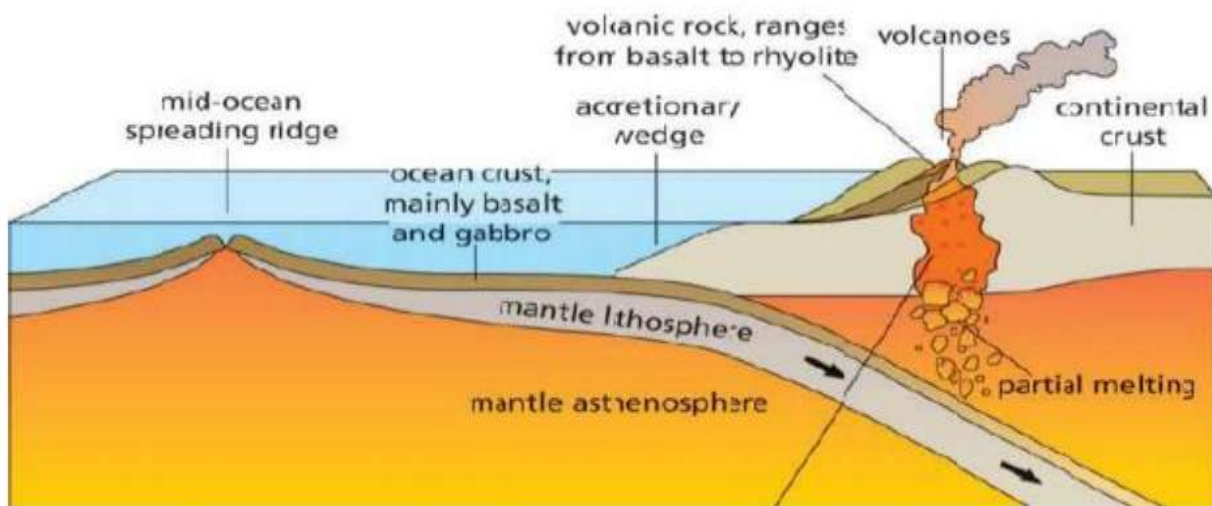
Every 1 km deep is 30c

The reason hot stuff get to the surface is when rock is melted into **magma**, its volume increase by 10% making it less dense than rocks around it, so it will begin to go up

Lava -> magma on surface

Extrusive igneous rocks -> magma cools on the surface

Intrusive igneous rocks -> magma cools under the surface



Classifying igneous rocks

TEXTURE

When magma begins to cool down, crystals are beginning to form, now depending on the time they have to grow, they give us different textures

properties	Coarse grained	Medium grained	Fine grained	glassy texture
scale	Visible with the naked eye	A bit smaller but visible	Impossible to see without a magnifying glass	No crystals formed
origin	When magma cools slowly, especially under the surface	When magma cools slowly on the surface	When magma cools quickly	When magma cools near instantly
examples	granite	granite	Diorite	obsidian

Chemical and mineral composition

- **Igneous rocks that contain (quartz, potassium feldspar, muscovite mica)** are **light** in color, because they contain **oxygen & silicon (silica)**, they contain some iron and magnesium, causing them to be (**white, light grey, pink**), they are associated with **lithospheric plates (outer layers)**
- **Granite** is formed when **Magma rich in silica** cools before reaching the surface, this is because silica slows down flow rate
- Iron and magnesium cause rocks to be black to dark green in color when there are too much of them, rocks like **pyroxenes, amphiboles, plagioclase feldspar, biotite mica, olivine**
- **Rhyolite** is a pale fine grained volcanic rock composed like granite, typically **porphyritic** in texture, it is formed when magma cools quickly on the surface
- **Basalt** is the most common rock on earth's surface as it is found in oceanic crust, it's a dark extrusive igneous rock, it is formed where lithospheric plates are spreading a part, it's common in huwaian islands
- **Gabbro** is an intrusive igneous rock rich in iron & magnesium, therefore it is dark in color, it is the course-grained counterpart of the basalt
- **Andesite** is an extrusive rock named for the andes mountains due to its abundance, it is made of a mix of minerals and some of them have iron and magnesium, there fore it's a mix in dark and light color
- **Diorite** is the corresponding intrusive rock formed where an oceanic lithospheric plate
- Some magma have a high content of dissolved gasses, this is true with magmas that have high-silica, they bubble out of the magma due to the pressure, **Pumice** is a volcanic rock with bubbly holes because of these gasses, it has a low density and can float on water
- The product of eruption are pieces of mineral grains and broken igneous rocks called **volcanic ash** , it is a sedimentary rock because it is formed from materials sedemneting

Classification of Igneous Rocks				
Color		Light	Intermediate	Dark
Mineral composition		quartz ($\geq 5\%$) plagioclase feldspar potassium feldspar iron-magnesium rich minerals ($\leq 15\%$)	quartz ($< 5\%$) plagioclase feldspar potassium feldspar iron-magnesium rich minerals (15–40%)	no quartz plagioclase feldspar (~50%) no potassium feldspar iron-magnesium rich minerals (~40%)
Texture	Crystals > 10 mm	granite pegmatite	diorite pegmatite	gabbro pegmatite
	Crystals 1–10 mm	granite	diorite	gabbro
	Crystals < 1 mm	rhyolite	andesite	basalt
	Glassy	obsidian		obsidian
	Frothy	pumice		scoria



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