

Igneous Rocks

S = slide

Rock Cycle

Igneous rocks and metamorphic rock with igneous parent rock make up about 95% of the crust. Igneous rocks make up the majority of the mantle which accounts for about 82% of the Earth's volume

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Important Concepts

- 1) How igneous rocks form from a melt
- 2) Classification of igneous rock by texture and silica content
- 3) Partial melting, Bowen's reaction series, differentiation, assimilation, and magma mixing

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Igneous rock

- Igneous is from the Latin word ignis – fire
- Igneous rock forms from molten rock as it cools and solidifies
- Molten material forms from partial melting of rock
- Hot buoyant rock rises to toward the surface
- It may cool below the surface or at the surface

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Intrusive (plutonic) igneous rock

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Extrusive (volcanic) igneous rock

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3 parts of magma

- Liquid or molten – mobile elements of common elements
- Solid - silicate minerals
- Gas or volatiles – vaporize at surface pressure, water, carbon dioxide, sulfur dioxide

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- Crystallization – ions slow as magma cools
- Early minerals have better crystal form

- Solidification of magma occurs over a range of ~200°C not like water

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Texture

- Rate of cooling
- Amount of silica available
- Amount of dissolved volatiles present

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Types of textures

- Aphanitic – fine grained
- Phaneritic – coarse grained
- Porphyritic – coarse and fine grained
- Glassy – no internal structure
- Pyroclastic – fragmental
- Pegmatitic – very large minerals

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Two Types

1. Intrusive (plutonic) rocks cool underground
2. Extrusive (volcanic) rocks cool at the surface

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volcanic breccia: coarse-fragmental (grains > 2 mm) volcanic rock. Extrusive. Deposited during violent eruptions. Press & Siever (2001), p. 95, Fig. 5.8

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Percentage of Silicate
Minerals in Igneous Rocks

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granite: a phaneritic, felsic rock dominated by quartz, potassium feldspar, Na plagioclase, and mica. Intrusive. Tarbuck et al. (2003), p. 21, Fig. 2.2

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Granite with phaneritic texture: coarse (>1 mm) crystalline. Indicates slow cooling and crystallization of deeply buried magma. Hamblin & Howard (1986), p. 29, Fig. 3.11

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rhyolite: an aphanitic, felsic rock dominated by quartz, potassium feldspar, Na plagioclase, and mica. Extrusive.

Tarbuck et al. (2003), p. 21, Fig. 2.3

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tuff: a fine-fragmental (most grains < 2 mm) volcanic rock. Extrusive. Deposited during violent eruptions.

Press & Siever (2001), p. 102, Fig. 5.23

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diorite: a phaneritic, intermediate rock dominated by Na-Ca plagioclase and amphibole. Intrusive.

Hamblin & Howard (1986), p. 30, Fig. 3.14

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andesite: an aphanitic, intermediate rock dominated by Na-Ca plagioclase and amphibole. Extrusive.

Busch (2000), p. 77, Fig. 4.12

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gabbro: a phaneritic, mafic rock dominated by pyroxene and Ca-rich plagioclase. Intrusive.

Hamblin & Howard (1986), p. 31, Fig. 3.17

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basalt: an aphanitic, mafic rock dominated by pyroxene and Ca-rich plagioclase. Extrusive.

Hamblin & Howard (1986), p. 31, Fig. 3.15

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peridotite: a phaneritic, ultramafic rock dominated by olivine and pyroxene. Intrusive.

Hamblin & Howard (1986), p. 32, Fig. 3.18

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Origin of magma

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- Related to plate boundaries
- Produced from melting rock in crust and upper mantle
- Temperature and geothermal gradient
- Pressure and relation to temperature of melting
- Volatiles

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Profile of Plate Tectonics

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Bowen's Reaction Series

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Examples of magma composition becoming more felsic during crystallization:

(top) zoned plagioclase crystal. The core is Ca-rich, the rim is Na-rich.

(bottom) olivine crystal with a rim of pyroxene and amphibole crystals.

Skinner & Porter (2000), p. 113, Fig. 4.39

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Magma evolution

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Differentiation

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Grains of olivine, chromite, and plagioclase settle sequentially to the floor of a diapir, producing three rock types whose compositions differ from the parent magma.

Skinner & Porter (2000), p. 115, Fig. 4.41a

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Other Processes

- Assimilation – incorporating surrounding material
- Magma mixing – two or more magma bodies join together
- Partial melting of rock

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How magma moves upward through country rock.

Press & Siever (2001), p. 84, Fig. 4.14

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Melting country rocks, stage 1.

McGeary et al. (2001), p. 285, Fig. 11.18a

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Melting country rocks, stage 2.

McGeary et al. (2001), p. 285, Fig. 11.18b

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Melting country rocks, stage 3.

McGeary et al. (2001), p. 285, Fig. 11.18c

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Method of emplacement - Assimilation

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Unmelted mafic inclusion in granitic plutonic rock.

Southwest of Lake Isabella, Sierra Nevada, CA.

CWW 06C-12

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Layers of plagioclase (light gray) and chromite (black) formed by repeated fractional crystallization.

Bushveld Igneous Complex, South Africa.

Skinner & Porter (2000), p. 115, Fig. 4.41b

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Alternating gabbro and anorthosite formed by crystal settling.

San Gabriel anorthosite complex, San Gabriel Mtns., CA.

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Assimilation, Crystal Settling & Magma Mixing

1. Assimilation of host rock

as magmas move upwards

2. Crystal Settling mostly of
the mineral olivine

3. Magma Mixing as magma
chambers combine

Partial melting

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Origin of hydrothermal deposits

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