**Igneous Rocks**

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Rocks form a significant part of the earth’s crust. They are helpful to human beings in ways such as building structures, ornamental values, food additives, and industrial processes. *Rock* can be defined as part of the earth’s crust that is an aggregate of minerals. The study of rocks is called petrology. Rocks exist in three primary types: igneous, metamorphic, and sedimentary. This paper focuses on the rock cycle, processes of formation of rocks, classification of igneous, and, finally, briefly discusses the three types of volcanoes.

**The Rock Cycle**

“It is a series of processes that create and transform the types of rocks in Earth’s crust” (National Geographic, 2023). It describes a series of transitions between the three types of rocks. The types of rocks classified according to their formation are metamorphic, sedimentary, and igneous. The interconversion is possible from one type to another depending on the prevailing conditions, such as heat, pressure, wind, and water. Sedimentary rock can be formed by weathering igneous rocks, pre-existing sedimentary rocks, or metamorphic rocks. The sediments undergo compaction and cementation. Metamorphic rocks can be formed when pre-existing metamorphic, igneous, or sedimentary rocks are exposed to heat and pressure. The rocks undergo metamorphosis. Existing igneous, sedimentary, and metamorphic rocks can then be found in the mantle, where it is hot. They are melted into magma. Magma is then forced on the earth's surface or embedded between the earth’s crust to form either plutonic or volcanic igneous rocks. This process concludes the rock cycle.

Figure 1.1 shows a simplified chart of a rock cycle

 Cooling

 Compaction and

 Weathering and Erosion cementation

 Weathering and

 Heat and Pressure erosion

Cooling

 Melting

 Heat and Pressure

 Melting

Fig. 1.1

**Types of Rocks**

Igneous rocks (also called primary rocks since they were first to be formed) are formed when molten rock materials (lava or magma) cool and solidify either deep in the earth’s crust (as magma) or are forced on the surface (as lava). The solidified rock material forms intrusive (plutonic) igneous or extrusive (volcanic) igneous rocks.

Intrusive igneous rocks are formed when magma does not reach the earth's surface but instead cools and solidifies between the earth's crust over a long time. The cool is slow, forming large rock crystals. Slow cooling over millions of years allows the crystals to grow; hence, the resulting feature will be a coarse-grained texture. Examples are granite and diorite.

Extrusive igneous rocks are formed when magma exits, cools, and solidifies near or above the earth’s surface. When magma erupts to the earth’s surface, it is called lava. The magma cools almost immediately when exposed to the surface of the earth. Since the cooling is rapid, crystals do not have time to grow. The resulting crystals are tiny and fine-grained in texture. Hot gas bubbles or steam might also be trapped in lava, giving a vesicular texture. Examples include basalt and pumice.

Metamorphic rocks are formed when existing rocks are exposed to extreme heat or pressure or both heat and pressure. The existing rocks could be sedimentary, igneous rocks, or even existing metamorphic rocks. The metamorphism is due to plate tectonic motion. Metamorphism is derived from meta, meaning change, and morphos, meaning form (Johnson et al., 2017). The rock changes texture or composition or both texture and composition without melting the mineral crystals content. The rock undergoing metamorphism is called parent rock or protolith. Proto means first, and lithos means rock. Protolith chemistry is changed during metamorphism by increased temperature (heat), a type of pressure called confining temperature, and chemically reactive fluids. Metamorphic rocks are divided into foliates and non-foliates. This division is based on chemical composition.

Foliated metamorphic rocks are composed of large amounts of mica and chlorite. These rocks have distinct cleavage, and splits will occur along these lines parallel to the minerals making up the rock. Foliated can be divided into banding and mineral alignment. Examples are slate and gneiss. Non-foliated metamorphic rocks do not have an alignment of mineral grains. They contain one type of mineral. Examples include marble and quartzites.

 Sedimentary rocks are formed when existing rocks are exposed to weathering agents such as running water, ice, and wind. The weathered rock forms sediments. The sediments undergo compaction and cementation to form sedimentary rocks. This process gives rise to two types of rocks: clastic(detrital) sedimentary rocks and chemical sedimentary rocks.

Clastic or detrital sedimentary rocks are formed from pre-existing sediments (clasts) or bedrock obtained from mechanical weathering or chemically weathered rock. Clastic rocks are classified using grain size, grain shape, and sorting.

Chemical sedimentary rocks are obtained when precipitates are formed from water saturated with minerals. The precipitation is due to evaporation. The precipitates are known as evaporites. Examples are halite and gypsum.

**Classification of Igneous Rocks**

Classification of igneous rocks can be based on texture and composition

**Classification of Igneous According to Texture**

Texture describes the size, arrangement, and shape of mineral grains in a given rock. The texture of an igneous rock can be determined by form, size, or space between the mineral constituents of a rock. Texture can be used to identify the environment in which the rock was formed.

The texture is affected by the cooling rate, the amount of trapped gases, and the amount of silica in their structure. The following types are obtained when igneous rocks are classified according to texture: aphantic, phaneritic, porphyritic, vesicular, glassy, and pegmatitic.

Aphantic are fine-grained rocks whose crystals are invisible without the help of a magnifying instrument. They are formed when lava cools rapidly on the earth’s crust to form an extrusive feature with small grains. Since cooling is fast, minerals do not get enough time to form large crystals. Examples are basalt and andesite.

Phaneritic are coarse-grained rocks whose mineral crystals are visible. The magma cools slowly below the earth’s crust, forming intrusive features with large grains. Examples are granite and olivine.

Vesicular contain voids or holes left behind by escaping gas or steam as lava cools. They are extrusive features. Examples are pumice and scoria.

Porphyritic comprises a mixture of microscopic crystals (groundmass) and larger crystals (phenocrysts). It contains multiple sizes crystals implying multiple cooling stages. Examples include andesite and rhyolite.

A glassy texture is also called vitreous. Volcanic eruptions could lead to faster cooling of lava such that crystals do not form. The resulting feature has few or no crystals and a smooth texture. An example is obsidian rock.

*Pegmatitic* is a coarse-grained rock with most crystals more significant than 1cm. The crystals are large and distinguishable. The rocks contain large crystals of feldspar, quartz, and muscovite.

**Classification of Igneous Rocks According to Composition**

Composition is the constitution of a whole or a mixture of an item. Classifying igneous rocks according to composition is based on the mineral contents in the rock sample. It gives us four categories: felsic, intermediate, mafic, and ultramafic (Mangold et al., 2017). Classification is done depending on the percentage of silica present. The classification is aided by Bowen’s Reaction Series, which shows that an igneous rock's chemical composition depends on the mineral in the rock.

Felsic is from the word feldspar and silica. These rocks contain a high percentage of silica (greater than 65%). They are plutonic, lighter in color, and form large crystals. The magma forming them contains more gases and is viscous. The common ones are mica, quartz, and feldspar.

*Intermediate rocks* are rocks that contain silica between 52% and 63%. They are intermediate between felsic and mafic. They are also called andesitic. The mixture of felsic and mafic gives the rock “salt” and “pepper” appearance.

Mafic rocks contain magnesium and iron in high quantities. Ma stands for magnesium, and F for Ferrum (iron), meaning “it contains.” They are dark in color. They contain 45% to 52% silica. The magma is more viscous than that of ultramafic but still fluid. Since the magma is less viscous, it can travel a long distance before it cools and “flood” the landscape over which they flow.

 Ultramafic rocks contain low content of silica (less than 45%).

We can therefore classify the following rocks according to where they are found and their composition. Rhyolite is fine-grained. It is both extrusive and felsic. Gabbro is black, mafic, and intrusive rock. It is coarse-grained, low in silica, and rich in iron. Peridotite is an intrusive ultramafic rock with coarse grain. Basalt is fine-grained, mafic extrusive rock. Andesite intermediate rock. Its extrusive feature with tiny crystals. Dorite is also intermediate with large crystals. It is intrusive. Granite is felsic. It is an intrusive feature.

**Igneous Rock Containing Minerals**

The mineral is a solid, naturally occurring substance that results from a geological process. In this section, eight igneous rock-forming minerals will be briefly discussed.

 Firstly, feldspar is the most abundant rock-forming mineral. It has a general formula of (K,Na)AlSi3O8 for alkali feldspar. The main components of feldspars are aluminum, silicon, and oxygen. Feldspar can also contain ions of barium and calcium. Second is quartz which is a compound of silicon and oxygen. It has a general chemical formula for SiO2. It is also called silicon dioxide or silica. Third are amphiboles, which are oxygen, hydrogen, silicon, and oxygen compounds. They have a general formula of R14[(OH)4Si16O44]. The R could stand for the ion of magnesium or calcium, or iron (ii). The fourth rock is pyroxenes which are compounds of oxygen and silicon. They have a general formula of R2[Si2O6]. The R could stand for the ion of magnesium or calcium, or iron. The fifth is mica which has a general formula of X2Y4-6Z8O20(OH, F)4. X can be an ion of calcium, sodium, or potassium. Y can be an ion of Aluminum, Magnesium, or iron. Z can be an ion of aluminum or silicon. Some ions are not discussed because they are commonly used to represent X, Y, and Z. Sixth is olivine which has a formula of (Mg, Fe)2SiO4. Seventh is calcite (CaCO3), a carbon, oxygen, and calcium compound. Eighth is garnet, where we have almandine group (Mg, Fe, Mn)Al3Si3O12 and andradite group Ca3(Al, Fe, Ti, Cr)2Si3O12 (MacKenzie & Guilford, 2014). It is described as a set of groups of minerals that results in gemstones. They have the general formula of R3R2(SiO4)3, where R3 is a bivalent metal like calcium while R2 is a trivalent metal like aluminum.

**Types of Volcanoes**

Igneous rocks are formed when magma cools. Magma is formed from molten rocks. When volcanoes erupt, magma is pushed to the surface of the earth. Therefore, studying the volcanoes that make magma available is essential.

Volcanoes are opening on the earth's surface through which gases, ashes, and lava reach the earth’s surface. The three main types of volcanoes are: composite, shield, and cinder volcanoes (de Silva & Lindsay, 2015)

Composite volcanoes (strato volcanoes) are coned shapes with steep sides. Their eruption is violent and occurs periodically. They are active over a long period. Their heights range from 8,000 -10,000 feet. It is made of layers of alternation strata of ash and lava.

 Shield volcanoes are gently sloping volcanoes with broad bases. They are formed from bare lava of low viscosity that flows for a long distance before cooling. The eruption is through fissures and cracks. The eruptions are not violent. They take a long time to build.

Cinder cone volcanoes are formed from eruptions with a prominent crater and are less violent. They are of height between 1,000 and 1,200 feet.

**Conclusion**

Rocks are essential to human beings in the ways already mentioned. Their classification enables humans to know different areas of applications of the rocks. Igneous rocks are the primary rocks, and from them, other rocks were formed; therefore, studying them gives the geologist a basis to understand other types of rocks fully.

**References**

de Silva, S., & Lindsay, J. M. (2015). Primary volcanic landforms. In *The encyclopedia of volcanoes* (pp. 273-297). Academic Press.

Johnson.C, Affolter.M, Inkenbrandt .P, Mosher.C (2017) Salt Lake Community College

MacKenzie, W. S., & Guilford, C. (2014). *Atlas of the rock-forming minerals in thin section*. Routledge

Mangold, N., Schmidt, M. E., Fisk, M. R., Forni, O., McLennan, S. M., Ming, D. W., ... & Wiens, R. C. (2017). Classification scheme for sedimentary and igneous rocks in Gale crater, Mars. *Icarus*, *284*, 1-17.

Osinski, G. R., Grieve, R. A., Bleacher, J. E., Neish, C. D., Pilles, E. A., & Tornabene, L. L. (2018). Igneous rocks formed by hypervelocity impact. *Journal of Volcanology and Geothermal Research*, *353*, 25-54.

Cardarelli, F., & Cardarelli, F. (2018). Rocks and Meteorites. *Materials Handbook: A Concise Desktop Reference*, 1313-1368.