Minerals in igneous and metamorphic rocks

Abstract

A mineral is a naturally occurring substance that is solid and stable at room temperature, representable by a chemical formula. According to the geological significance Igneous and metamorphic rocks make up 90-95% of the top 16 km of the Earth’s crust by volume. It has been found that there is an existing relationship between the minerals of igneous and metamorphic rocks, since the minerals are influenced by the mineral’s geological environment of formation. And the relationship are observed accordingly to the elements existing in the mineral and the formation process of the minerals of either igneous or metamorphic. Changes in the temperature, pressure, and bulk composition of a rock mass cause changes in its mineralogy; however, a rock can maintain its bulk composition, but as long as temperature and pressure change, its mineralogy can change as well. The relationships according to the chemical and physical properties of the minerals in these rocks are discussed in this paper.

Keywords: Minerals, igneous, metamorphic rocks, abundant elements, mineral composition.

1 Introduction

A mineral is an element or chemical compound that is normally crystalline and that has been formed as a result of geological processes and have a definite chemical composition; minerals are inorganic compounds. Minerals can be characterized according to Structure and habit, hardness, luster, diaphaneity color, streak, tenacity, cleavage, fracture, parting, and specific gravity. Hence the relationship between the minarals of igneous and metamorphic rocks can be analyzed and observed accordingly to the chemical compositions, characteristics, uses, Gneissic mineral banding and the classification of the minerals found in both rocks Just like in igneous rocks, minerals can only form if the necessary chemical constituents are present in the rock . The minerals seem to be related as

2 Mineral geological environment of formation

For the metamorphic rocks where metamorphsm occurs; metamorphism means to change form. Where by under the contact metamorphism which occurs adjacent to igneous intrusion and results from high temperature and the Metamorphic minerals are those that form only at the high temperatures and pressures associated with the process of metamorphism.

Metamorphic minerals, such as olivines, pyroxenes, amphiboles, micas, feldspars, and quartz, may be found in metamorphic rocks, but are not necessarily the result of the process of metamorphism. These minerals formed during the crystallization of igneous rocks. They are stable at high temperatures and pressures and may remain chemically unchanged during the metamorphic process. However, all minerals are stable only within certain limits, and the presence of some minerals in metamorphic rocks indicates the approximate temperatures and pressures at which they formed.

The upper limit of metamorphism occurs at the pressure and temperature where melting of the rock in question begins. Once melting begins, the process changes to an igneous process rather than a metamorphic process. The change in the particle size of the rock during the process of metamorphism is called recrystallization. For instance, , recrystallization of the original quartz sand grains results in very compact quartzite, also known as metaquartzite, in which the often larger quartz crystals are interlocked. Both high temperatures and pressures contribute to recrystallization. High temperatures allow the atoms and ions in solid crystals to migrate, thus reorganizing the crystals, while high pressures cause solution of the crystals within the rock at their point of contact.

Contact Metamorphism marks the relation between minerals of igneous and metamorphic rocks .

Minerals tending to occur on both rocks

For instance mica in the igneous rock Muscovite(mica) which is silvery clear in color and perfect flaky cleavage and also in the metamorphic mica which can be found in a low-grade metamorphic rock (Slate) composed of extremely fine-sized mica and other mineral grains, typically exhibits well-developed rock cleavage. Also Schist – metamorphic rock containing abundant obvious micas, several millimeters across. Several types of schist may be recognized, based on minerals which may be present:

mica schist

garnet schist

chlorite schist

kyanite schist

talc schist

Also the quarts mineral exists in both rocks in the igneous and metamorphic rock, quartzite derived from the metamorphism of quartz sandstone in its gray distinguishing colour, are rounded and bumpy.

While for the igneous rock, Quartz grains tend to be translucent gray, rounded to irregular blobs. The lack of a cleavage means their exposed surfaces.

3 Abundant elements

As minerals are important in the formation of common rocks, because the magma from which the minerals crystallize is rich in only certain elements: silicon, oxygen, aluminium, sodium, potassium, calcium, iron, and magnesium. These are the elements which combine to form the silicate minerals, which account for over ninety percent of all igneous rocks. The chemistry of igneous rocks is expressed differently for major and minor elements and for trace elements. Contents of major and minor elements are conventionally expressed as weight percent oxides (e. g., 51% SiO2, and 1. 50% TiO2). Abundances of trace elements are conventionally expressed as parts per million by weight (e. g., 420 ppm Ni, and 5. 1 ppm Sm). Also for the metamorphic rocks these elements are found in the minerals, hence from the rock cycle when an igneous rock is subjected to heat and pressure then a metamorphic rock is formed with the minerals made up of certain element silicon, oxygen, aluminium, sodium, potassium, calcium, iron, and magnesium, forming a silicates minerals, As metamorphism proceeds, the sheet structure silicates (flat minerals with basal cleavage) such as mica (biotite and muscovite) and chlorite start to grow .

4 Rock composition

This also shows or relates the minerals of igneous and metamorphic rocks, where as in a metamorphic rock with silicate minerals is melted to a hot magma tha after cooling and solidification an igneous rock, igneous rocks because of the dominance of oxygen and silicon in the crust, igneous rocks are mostly made up of silicate minerals. These silicates can be generally divided into light and dark silicates. The dark silicates are also called ferromagnesian because of the presence of iron and magnesium in them. They include olivine, pyroxene, amphibole and biotite. The light-colored silicates include quartz, muscovite and feldspar

5 Gneissic mineral banding

In metamorphic rocks The layering in a rock in which bands or lenses of granular minerals (quartz and feldspar) alternate with bands or lenses in which platy (mica) or elongate (amphibole) minerals predominate. The most intense form of foliation is mineral banding. At the highest grades of metamorphism, minerals begin to segregate into separate bands. The micaceous minerals separate from the quartz and feldspars. Gneissic Mineral Banding. The most intense form of foliation is mineral banding. At the highest grades of metamorphism, minerals begin to segregate into separate bands. The micaceous minerals separate from the quartz and feldspars. as for migmatite in which textures (schistosity or mineral banding) are intermixed with igneous textures (coarse grained igneous rocks). At this stage we are leaving the realm of metamorphism and entering the realm of igneous rocks. Only the rock has not yet completely melted – it has fractionally melted. Click image for more explanation.

6 Mineral development dependency factors

There are few factors that the development of minerals in the either igneous or metamorphic rocks would depend on, for the metamorphic rock the minerals that develop usually depend upon :

1) the grade of metamorphism

2) the composition of the parent material

If we start of with a shale and bury it progressively deeper and deeper within the continental crust, different minerals will be present as the rock undergoes progressive increases in both temperature and pressure. Such a progressive metamorphism of shale results in a systematic appearance of new metamorphic minerals as a function of metamorphic grade. The sequence of appearance of key or index minerals during progressive metamorphism of shale is shown below

- Low-Grade Slate
- Medium-Grade Schist
- High-Grade Gneiss

chlorite –> biotite–>

garnet –> staurolite –> kyanite–>

sillimanite

In addition to these minerals, metamorphosed shales always contain minerals such as quartz, muscovite and plagioclase feldspar. The first-appearance of these key or index minerals results from chemical reactions that produce the new mineral at the expense of other minerals present in the rock before the reaction proceeded. The chemical reactions responsible for the production of the index minerals are complex, and need not be understood in detail for this course. You should recognize, however, that the reactions are largely controlled by temperature, and since temperature is a proxy for “ metamorphic grade”, rocks that were undergoing the same reaction can be said to be of the same grade. What one finds in the field in going from low-grade rocks to high-grade rocks is an abrupt appearance of the minerals listed above in the metamorphosed shales. A line on a map of a metamorphosed area marking the first appearance of one of these index minerals is called an isograd (“= grade”). We can also indicate on such a map zones between the isograds that are characterized by the presence of the index mineral that formed at the isograd marking the lower-grade boundary of the zone. A hypothetical example is shown to the right. In this figure, the metamorphic zones are shown in different colors and the lines separating the zones correspond to the isograds. http://darkwing. uoregon. edu/~drt/Classes/201_99/Rice/Regional. GIF

Many different minerals are found in metamorphosed shales because they are so chemically reactive and undergo a variety of chemical reactions with changing temperature.

in contrast, the metamorphism of quartz sandstone is not very exciting because the parent material contains no other minerals which might react with quartz to produce new metamorphic minerals. The table below gives the minerals and rock name for some other common metamorphic parent material.

For the igneous minerals their development depends upon the the amount or grade of heat for crystallization to take place and the nature and composition of the parent rock. So the factors the mineral development depend upon marks and shows the relationship of the minerals of igneous and metamorphic rocks

7 Agents of mineral change process

For metamorphic rocks where metamorphism takes place, the agents of metamorphism are:

- Heat
- Pressure
- Chemical fluids

Heat There are several sources of heat for metamorphism.

Geothermal gradient

Temperature increases with depth at a rate of 20 – 30 degrees C per km in the crust.

Ultimate source of the heat? Radioactive decay.

Increase of temperature and pressure with depth causes Regional Metamorphism

Heat may come from large bodies of molten rock rising under a wide geographic area.

Intrusions of hot magma can bake rocks as it intrudes them. Lava flows can also bake rocks on the ground surface.

Lava or magma in contact with other rock causes Contact Metamorphism.

Pressure

Burial Pressure. Pressure increases with depth due to the weight of the overlying rocks. A cubic foot of granite weighs 167. 9 pounds. Increase of pressure and temperature with depth causes Regional Metamorphism.

Regional metamorphism occurs at depths of 5 – 40 km.

Tectonic pressures associated with convergent plate boundaries and continental collision also cause Regional Metamorphism.

Pressure along fault zones causes Dynamic Metamorphism, the crushing and ductile flow of rock.

Chemical Fluids

In some metamorphic settings, new materials are introduced by the action of hydrothermal solutions (hot water with dissolved ions). Many metallic ore deposits form in this way.

Hydrothermal solutions associated with magma bodies

Black smokers – Sea water percolates through newly formed oceanic crust, dissolving out metallic sulfide minerals. The hot sea water rises along fractures and pours from vents in the seafloor as black clouds of dark mineral-rich water. Sulfide minerals (such as pyrite, sphalerite, and galena) and copper precipitate when the hot water comes in contact with cold sea water.

As the metamorphic rock is subjected to high heat and after the cooling process an igneous rock minerals are formed and it can also be seen that the agents of mineral change process are important to the formation of minerals in the igneous rock such minerals like:

8 Mineral Composition

Rhyolite (a felsic extrusive rock) has the same mineral composition as granite (an intrusive igneous rock) and is composed dominantly of the minerals potassium feldspar (K-spar), quartz, and lesser amounts of plagioclase feldspar, mica, hornblende, and other minerals. Likewise, basalt (a mafic extrusive rock) has the same mineral composition of the mafic intrusive rock, gabbro. This generalized composition of felsic and mafic can be subdivided into intermediate (between felsic and mafic composition), and ultramafic (rocks extremely enriched in magnesium and iron). Rocks of intermediate composition include diorite (intrusive) and andesite (the extrusive equivalent). Ultramafic rocks have special significance, in that they probably are derived from the mantle. They are relatively unstable on the Earth's surface, and are typically metamorphosed. In nature and in simplistic interpretation, igneous rocks that make up most continental crust typically have a felsic composition (such as rhyolite and granite). The mafic rock basalt is the dominant rock type that makes up most ocean crust. Rocks of intermediate composition are derived from the mixing of continental and oceanic crust.

IGNEOUS ROCKS and MINERALS

- Andesite — extrusive igneous rock
- Basalt — extrusive igneous rock

- Dacite — extrusive igneous rock
- Diabase — fine-textured igneous rock
- Diorite — intrusive igneous rock
- Gabbro — intrusive igneous rock
- Granite — intrusive igneous rock
- Granodiorite — intrusive igneous rock
- Obsidian — volcanic glass
- Olivine — silicate mineral
- Pegmatite — intrusive igneous rock
- Peridotite — gem quality olivine
- Pumice — light, porous, volcanic rock
- Rhyolite — extrusive igneous rock
- Tuffs — volcanic ash matrix

The mineral composition of the igneous rock can be related to the mineral composition of the metamorphic rocks since when a metamorphic rock is subjected to heat and pressure changes to metamorphic rock

9 Limitations

The limitations the had raised during this paper were:

a) difficulties in information searching process on the minerals of both igneous and metamorphic rock.

b) hardnes in obtaining the specific relations between the minerals found in both igneous and metamorphic rocks.

10 Conclusion

There are over 4, 900 known mineral species; over 4, 660 of these have been approved by the International Mineralogical Association (IMA). The silicate minerals compose over 90% of the Earth's crust. The diversity and abundance of mineral species is controlled by the Earth's chemistry. Silicon and oxygen constitute approximately 75% of the Earth's crust, which translates directly into the predominance of silicate minerals. Minerals are essentially important as it can be observed in their uses and they do bring about development growth in any society they are found to exist.

Bibliography

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