

SZAKÁLL SÁNDOR,

# MINERALOGY AND PETROLOGY

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## I. SUBJECT OF MINERALOGY AND PETROLOGY

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### 1. WHAT IS A MINERAL ?

Minerals are crystalline compounds (occasionally elements), mostly with an ordered atomic structure, that were formed (and are being formed even today) in a natural way by the combination of chemical elements.

**Minerals**, with a few exceptions, are characterised by:

- natural way of formation;
- defined chemical composition
- long-term ordered crystalline structure.

#### 1) *WHAT DOES IT TAKE FOR A MATERIAL TO BE CONSIDERED OF NATURAL ORIGIN?*

According to the official definition, minerals were and are formed by geological processes. Compounds formed in pit-heaps and mine shafts created during mining can be regarded as minerals as well, if they contain material typical of the locality. Artificial compounds cannot be regarded as minerals. These are called **synthetic (artificial) material**. But what about compounds produced by the life functions of living creatures, like the calcium carbonate secreted by corals and shellfish?



*The calcium carbonate shell of a shellfish*

According to the wider sense, compounds produced by biological processes that can be regarded as natural are classified as biominerals. Research in recent decades has revealed that biologically produced material – especially that produced by bacteria – have a much greater role in the production of minerals over the history of the Earth than was thought previously.

#### 2) *UNTIL WHAT COMPOSITION CAN A MATERIAL BE REGARDED AS DEFINITIVE?*

This question arises only because compounds produced in nature are of variable chemical composition, as

they are not produced in laboratory environment. Therefore, the formulae used to characterise them can be regarded as idealistic, reflecting an ideal (theoretical) chemical composition. For example, the most important lead mineral, galena, is a lead sulphide with an ideal formula of  $PbS$ . In fact, however, it is impossible to find a galena in nature with just these two elements.



*Galena crystal*

### **3) WHEN DO WE CALL A MATERIAL CRYSTALLINE?**

Until recently materials were classified as having an ordered structure (crystalline) or disordered structure (amorphous). Crystalline material appear, whenever possible in crystals of characteristic shape (morphology) bordered by flat sheets.



It was thought to be characteristic for amorphous material (without morphology) not to be able to appear in such crystals – to occur only in a shapeless mass. From studying material at atomic levels, however, it was revealed that any transition between the two extremes (crystalline – amorphous) is possible. Therefore, today the terms long-term and short-term ordered structure are used. Most minerals are ordered long-term; however, short-term ordered structures cannot be excluded. Around 20-30 minerals are known in that category, the most widely known of which is opal.



*Opal*

As their atoms or molecules show almost no type of ordered structure – in conditions characteristic for the Earth – compounds or elements in a fluid and gaseous state cannot be classified as minerals. The sole exception is mercury,

which solidifies below  $-38^{\circ}\text{C}$ . Water is not a mineral; however, its solid form, ice, is a mineral. Based on the above, minerals can be clearly defined by their chemical composition and crystal structure.

## 2. WHAT IS A ROCK?

It is a material primarily produced by large-scale geological processes. Considering Earth conditions, it is the product of processes in the mantle and the crust that produce physically and chemically similar rocks at a given time and at a given place. Rocks compose the outer, 100-km thick solid sphere, the lithosphere of the Earth, which includes the crust and the upper zone of the mantle. Fundamental components of rocks are minerals. Rocks are generally mixtures of several minerals (however, there are rocks composed of only one mineral, e.g. marble). It is important to note, however, that rocks may have other components than minerals. In certain rocks glass-like, organic or even liquid or gaseous components can be found. These are of significant importance for man, considering water, oil and natural gas.



*Andesite is a mixture of several minerals*

Despite the fact that currently there are 4,500 known minerals, only 15-20 of them dominate in the composition of rocks. These are termed **rock-forming minerals**. Regarding their chemical composition, they consist of the eight most frequent elements of the Earth's crust. The reason for this paradox is found in the united nature of large-scale geological processes. General characterization of rocks is based on the average mineral composition, average chemical composition, quantity and ratio of dominant chemical elements, relationship of the constituents and their texture. Three major groups of rocks are identified regarding their formation specifics: igneous, sedimentary and metamorphic. According to different estimates, 95%, 4% and 1% of the rocks of the crust are igneous, metamorphic and sedimentary, respectively. This surprising ratio is hard to understand here on the surface of the Earth, as the ratio of sedimentary rocks here is generally much greater.

## 3. WHAT IS ORE?

All rocks are termed ore from which metals can be extracted economically at the technological level of the given age.



*Limonite is an ore consisting in a mixture of hydrated iron oxide*

Components of the ore that contain the given metal are **ore minerals**. In the above definition one keyword is the economic extraction of the metal, which may vary with the improvement of the technological level in different ages. Economic extraction of metals is one reason why most metals have had only a limited number of ore types during history. Although around 800 iron-containing minerals are known, iron was extracted in industrial quantities only from half a dozen.

#### 4. WHAT IS A NON-ORE?

In contrast to ore, non-ore is rock containing one or several non-metallic components that are utilized.

Such are argillaceous rocks, from which ceramics have been produced for several thousand years. Quartz is regarded as a non-ore when it is utilized as the base material of glass production. Limestone is also a non-ore when it is applied as the base material of cement production or in burnt form as an additive of mortar. Nowadays, new types of utilization of certain rocks are increasingly important, i.e., non-ores applied in various industrial or agricultural fields. Such are zeolites that have been utilized for numerous purposes in recent decades: for water purification, waste treatment, soil improvement in environmental protection and for medical purposes as well.



*Kaolin has been used to produce ceramics for centuries*

Ores and non-ores together are called **mineral raw material**.