GEOLOGY OF ZEOLITES

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ABSTRACT

Different zeolite minerals were found to be formed in different geological environment. Some of these minerals are very rare and some are abundant. Zeolite crystal structures are based on three dimensional framework lattice and knowledge about it is used in artificial production of many zeolite types useful in different technologies.

It is obvious that different porous materials including clay minerals and zeolite minerals play crucial role in evolution of living organisms, but also development of the Earth. Many difficult questions about Earth development could be answered through extending geology and collection of information from other planets in Solar system. Zeolites as well as other hydrous minerals are identified on Mars. This fact has many important implications in reconstruction of its history and interpretation of geological processes.

Keywords: zeolites on the Earth, classification of zeolites, zeolites on Mars.

INTRODUCTION

Zeolites as framework silicates are found in different geological environments on the Earth. Modern classification of zeolite minerals is based on their crystal structures [1] but during field work it is handy to distinguish isometric, platy and needlelike zeolites [2].

Today geology is extended outside the Earth, because it is possible to recognize the same processes on many different bodies in Solar system.

It is well-known that porous silicates are respectable catalysts for many reactions including biologically crucial ones. Due to such properties zeolites and smectites attract attention not just of mineralogists but also other scientists interested in early living organisms on the Earth. Special attention is payed to extremophiles. They are living in extreme conditions not suitable for common organisms sometimes using microporous minerals as source for essential elements.

Essential building blocks of life were present, including carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur, not just on the Earth, but also on the Mars as well as on the Titan, Europe... According to theory of evolution (not just evolution of life, but also chemical and physical evolution) it is necessary to achieve certain level of planetary development which support life [3]. After that such evolution model assumes coevolution of geology, mineralogy and life. In this model the number of mineral species increases from about 60 in early primitive materials (chondritic meteorites) up to more than 7000 known today. Many of this mineral species (estimated around 6500) can crystalize just after appearance of biologically activated processes.

Among the first minerals, in chondritic meteorites, there are native elements, oxides, carbides, nitrides, and silicates. Silicates are restricted to basic feldspars, pyroxenes and silicate glass.

Just during accretion of planetary body and beginning of geological processes formation of other minerals begin, due to new environment.

Development of higher pressures and temperatures enable increasing number of mineral species to be stable. Water has important role in those processes, not just in crystallization of hydrous minerals. Among the others framework silicates, including porous hydrosilicates occur on differentiated planetary bodies.

Identification of zeolites and smectites on other planets than Earth, is important not just for mineralogists, but also to astrobiologists in further search for extraterrestrial life. After robot missions to Mars smectites and zeolite are recognized in the soil. These minerals are result of water activity and its interaction with basaltic rocks. Hydrothermal activity in basalt rocks on the Earth is studied as process in which many zeolite minerals could crystalize.

Among the other minerals on Mars these minerals are found

Phyllosilicates

(Clay minerals)

Fe,Mg smectites (e.g., nontronite, saponite)

Al-smectite (e.g. montmorillonite, beidellite)

Kaolin group minerals (e.g. kaolinite, halloysite)

Chlorite

Serpentine

High charge Al,K phyllosilicate (e.g. illite)

Other hydrated silicates

Prehnite

Analcime

Opal (n=0) [4].

Existence of hydrous phyllosilicates is confirmed on Mars, mostly as phyllosilicates, but also analcime, as first zeolite, is also identified.

Increasing number of zeolites and clay minerals could be not surprising in further investigation of Mars. This expectation is in accordance with abundance of basaltic rocks and water activity on the surface, but also underground.

Zeolites are strong sorbents of atmospheric gases, they can be shelters for organic compounds (including organisms), and they have exchangeable ions. Such properties enable to collect important information about zeolite crystallization, but also information about interaction between them and living organisms.

The Curiosity rover has sent back data on these multi-phase mineral vein system from Mars.

REFERENCES

[1] Coombs, D., Alberti, A., Armbruster, Th., Atrioli, G., Colella, C., Galli, E., Grice, J.D., Liebau, F., Minato, H., Nickel, E.H, Passaglia, E., Peacor, D.R., Quartieri, S., Rinaldi, R., Ross, M., Sheppard, R.A., Tillmanns, E., Vezzalini, G. *The Canadian mineralogist* 1997, **35**, 1571-1606

[2] Slovenec, D. and Bermanec, V. Sistematska mineralogija – mineralogija silikata, Denona, Zagreb, 2006, pp 359

[3] Hazen, R.M., D. Papineau, W. Bleeker, R.T. Downs, J. Ferry, T. McCoy, D. Sverjensky, and H. Yang *Mineral evolution, The American mineralogist*, 93, 1693-1720

[4] Ehlmann & Edwards, *Ann. Rev. Earth Plan. Sci*., 2014