EVOLUTION OF SYMMETRY IN MINERAL WORLD

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Symmetry is a universal property characteristic of all natural phenomena and objects and simaltaneously in some aspects specific for each of them. Symmetry is particularly pronounced in the mineral world which elements, i.e. crystals, "shine with symmetry", as the great crystallographist E.S.Fedorov put it. That is why symmetry has been used for a long time to characterise as well as to identify minerals and to prognosticate their properties. Moreover, theoretical and methodical fundementals of the theory of symmetry have been formed on the basis of mineral crystals study within the mineralogical science.

In mineralogy main objects to be investigated in terms of symmetry have always been mineral individuals,i.e. crystals. Methods of the theory of symmetry have in fact never been applied to characterize more complicated systems composed of minerals (mineral aggregates, rocks, fault blocks of the crust, geospheres, cosmic bodies etc.), although A.E.Fersman, A.V.Shubnikov, I.I.Shafranovsky, A.Mackay and other crystallographists drew attention to the fact that such an appliance would be very promising. This weakly investigated field of mineralogy became an object for our research (Yushkin, 1984; Yushkin et al, 1987).

Investigations showed that complex mineral systems are characterized by different values of summary symmetry which is typomorphic, alias reflects genetic nature of objects and changes regularly in the process of mineral systems evolution.

We have introduced the concept of crystallosymmetric structure of complex mineral systems (CSS) which we understand as a proportion of minerals of different crystallographic symmetry in their composition. The means of CSS investigation is crystallosymmetric analysis (CSA) which consists in establishing statistic parametres of minerals distribution on the ranks of the symmetry system (Yushkin, 1985). CSA procedure is rather simple and consists in compiling tables containing percentage proportion of minerals belonging to different symmetry ranks and deducing a number of summary values including symmetry index.

The symmetry index is calculated according to the formula:

$$I_s = \frac{1}{6} \sum_{R=0}^{6} P_R \cdot R,$$

in which P_R is the percentage of occurence of minerals of the given rank R, i.e. of the given crystal system (R=0+6: triclinic - 0, monoclinic - 1, orthorhombric - 2, trigonal - 3, tetragonal - 4, hexagonal - 5, cubic - 6); $P_2 = 100\%$. The symmetry index varies from 0 up to 100% towards the increase of the percentage in the polymineral system of highly symmetrical minerals. If a system is presented by mineral species of the triclinic crystal system only, then $I_s = 0$, if of purely cubic system, then $I_s = 100\%$.

The following totality of basic parametres characterizing CSS of the system to investigate has been developed on the basis of CSA in general terms: parametres of mineral distribution on symmetry categories, crystal systems, point groups (crystallographic classes); symmetry indices, informational entropy of crystallosymmetrical structure H_s. These criteria can be calculated on the constitutional (proportion of the number of mineral species) as well as on the concentration (prportion of the volume of substance of different species) basis.

Each geological system composed of minerals is characterized by a definite CSS which finds its expression in constant parametres of mineral species distribution on the ranks of the symmetry system (categories, crystal systems, point groups). We suggest that this conclusion formulated by I.I.Shafranovsky as the basic law of mineral symmetry statistics (Shafranovsky, 1983, p.66) should be called Shafranovsky's law. The latter presupposes that each mineral system can be distinquished by characterizing symmetry parametres. Resulting from CSA carried out on a considerable amount of mineralogical data we have developed certain parametres to characterize the lithosphere and other geospheres of the Earth as well as the Moon's lithosphere, various types of meteorites, large regional structures such as mineralogical provinces, different mineral deposits, mineral complexes (Yushkin, 1985; Yushkin et al., 1987).

A number of common tendencies in the CSS change has been established.

In direction from abyssal to subsurface zones of the Earth, i.e. to the lithosphere, the process of constant and definite decrease of the mineral substance summary symmetry is taking place alongside with the replacement of minerals of the cubic system, when those of orthorhombic and later monoclinic, triclinic and other crystal systems become dominant. Consequently, the value of the symmetry index also decreases (Fig.1).

Similar tendencies in the CSS change are established by the analysis of the evolutional row of cosmic objects: meteorites (chondrites) → the Moon → the Earth which can be regarded as the main stages of iur planet's development, i.e. meteoritic → "lunar"(regolith-nuclear) → modern. Monotonous decrease of summary symmetry of substance (I_s const) from chondrites (62.50%) through the Moon's lithosphere (55.67%) to the lithosphere of the Earth (42.56%) is of particular interest. It reflects a general evolution tendency. Concentrational value of summary symmetry changes in the same direction: $I_s = 33.58 \rightarrow 29.00 \rightarrow$ [illegible]. The number of mineral species of elementary crystal systems grows abruptly in direction from meteoritic, in particular chondritic substance towards lunar and earthly substance, symmetry entropy of the systems also increasing.

Duration and complexity of the evolution of the mineral deposits, mineralogical provinces as well as energy needed for their formation, correlation of endogenuous and exogenuous factors of mineral formation, role of organisms and organic matter are established exactly enough with the help of crystallosymmetrical indications (Yushkin, 1985).

Basing on the investigation results we have formulated the law of geological evolution of mineral systems' crystallosymmetrical structure: in course of cosmic and geological evolution their crystallosymmetrical structure undergoes complication and qualitative change which manifests itself in the increase of entropy of all symmetry characteristics as well as in the replacement of the dominant role of minerals of cubic and orthorhombic systems to monoclinic; decrease of the mineral substance symmetry occurs alongside with still high and even increasing external morphological symmetry of the Earth and other cosmomineral bodies.

Methodical approach described here can be applied not to the mineral world only, but to any other objects containing cristalline matter (chemical and metallurgical products, synthetical systems, objects of human material culture etc.).

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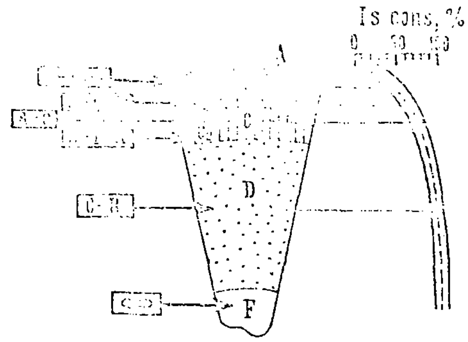

Fig.1 Change of parametres of the Earth's mineral substance crystallosymmetrical structure with depth. Geozones: A - the crust, B - upper mantle, C - intermediate mantle, D - lower mantle, E - external "plastic" core.

Crystal systems: TC - triclinic, M - monoclinic, R - orthorhombic, T - tetragonal, C - cubic.

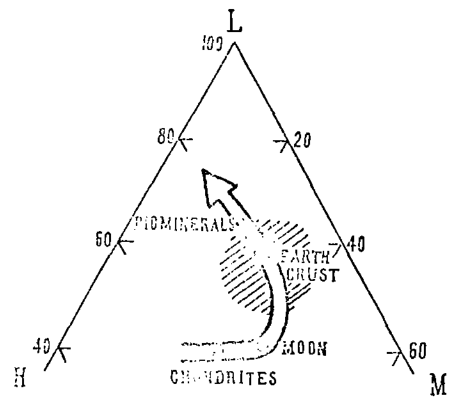

Fig.2 Direction of the change of crystallosymmetrical structure in the row: chondrites - Moon's lithosphere - Earth's lithpspere - biominerals.
Symmetry categories: H - high (cubic system), M - middle (trigonal tetragonal and hexagonal systems), L - low (triclinic, monoclinic and orthorhombic systems). Shaded areas shows the field of figurative points of the mineralogical provinces of the Earth.