**DISTRIBUTION OF THE VALUES OF NATURAL REMANENT MAGNETIZATION AND MAGNETIC SUSCEPTIBILITY OF SOME MINERALS**

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**Summary:** A statistical treatment is presented of the observed values of natural remanent magnetization and of magnetic susceptibility of natural minerals: magnetite, chromite, ilmenite pyrrhotite, haematite, cassiterite and garnets. It was found that for most minerals the distribution of the natural remanent magnetization as well as the magnetic susceptibility is logarithmically normal at a significance level of $p = 0.05$. The typical values of $J_n$ and $\chi$, the limits of the intervals of reliability of these typical values for $p = 0.05$, and the standard deviations of the distribution were determined for the individual minerals. The end values of the sets were tested by two independent tests of extreme deviations at a level of significance of $p = 0.05$. Following statistical deliberations it was proved that the lognormal distribution of the $J_n$ and $\chi$ values depended on the number of factors affecting these values, independently of the type of distribution of these so-called "disturbing" factors. By generalizing for rocks it was shown that the lognormal and normal types of distribution of $J_n$ and $\chi$ values are extreme cases as regards the observable types with rocks.

1. **INTRODUCTION**

In interpreting the magnetic properties of rocks it is necessary to take into account the known magnetic properties of minerals contained in the rocks. However, due to the variability of the conditions of generation of minerals there is a considerable fluctuation in the magnetic properties. Therefore it is necessary to know the typical properties of the given mineral. One of the possible methods is to investigate the type of statistical distribution for the individual magnetic parameters of the mineral, and to use the distribution obtained to deduce typical values. Naturally, in order to obtain objective and representative values it is necessary to investigate the magnetic properties of extensive collections of samples which represent various genetic conditions in the generation of the minerals.

As regards the magnetism of rocks and geophysical interpretation the parameters which represent the natural state of the mineral, i.e., the natural remanent magnetization and magnetic susceptibility, measured in a magnetic field of the order of the geomagnetic field, are particularly significant.

2. **METHODS OF MEASUREMENT USED AND METHODS OF PROCESSING THE EXPERIMENTAL DATA**

The values of the natural remanent magnetization $J_n$ were mostly measured by a LAM-1 astatic magnetometer [1], or quite exceptionally by a very sensitive spinner magnetometer JR-2 [2]. The values of the magnetic susceptibility $\chi$ were determined by measurements in the lateral position of the astatic magnetometer, symmetric with respect to both the magnets of the astatic pair using the method described, e.g., in [3].

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The fundamental statistical characteristics employed were the arithmetic mean values of the parameter $y$ ($y_p = N^{-1} \sum_{i=1}^{N} y_i$), the median $y_M$ defined by the value of the mean element of a set arranged according to order of magnitude, and the geometrical mean ($y_G = N \prod_{i=1}^{N} y_i^{1/N}$, log $y_G = N^{-1} \sum_{i=1}^{N} \log y_i$). Here, $N$ denotes the number of elements of the statistical set, and $y_i$ a general element of the same set [4].

As regards the minerals for which a larger set of data pertaining to the values of the magnetic parameters was available, it was possible to investigate the type of distribution of the values and the statistical characteristics of the set.

As indicated by preliminary graphical treatment, the distribution of both magnetic parameters investigated, i.e., the natural remanent magnetization $J_r$ and the magnetic susceptibility $x$, had the nature of a lognormal distribution. The distribution function of a lognormal distribution is in general given by $f(y) = \frac{y}{\sigma \sqrt{2\pi}} \exp \left( -\frac{1}{2} \frac{(\log y - \mu)^2}{\sigma^2} \right)$, where $\mu$ is the modus and $\sigma$ the standard deviation of the set.

In order to determine and check the parameters of the set the following statistical treatment was employed:

After taking the logarithms $x_i$ ($x_i = \log y_i$) of all the values of the investigated set $y_i$ ($i = 1, 2, ..., N$) the Dixon test of extreme deviations [5] was used to check the extreme values of the set. The testing value was $Q_N = (x_N - x_{N-1})/(x_N - x_1)$, or $Q_1 = (x_1 - x_N)/(x_N - x_1)$, for a set arranged according to order of magnitude ($x_1 = x_2 = ... = x_{N-1} = x_N$). The appropriate critical values were taken from statistical tables [6]. After this test had been carried out the logarithms of the values were treated with the help of the normal distribution using the method of successive steps (cf., e.g., [7]), and the antilogarithms of the values were found.

In order to show whether the adjusted distribution was an objective model of the experimental set of data, two mutually independent tests were used [8]:

1. the parameteric $\chi^2$-test where the testing value is $\chi^2 = \sum_{j=1}^{k} \left[ \phi_{ej} - \phi(x_j) \right]^2$ : $\phi(x_j)$, $\nu = k - 3$ is the number of degrees of freedom, $k$ the number of classes of the set, $\phi_{ej}$ the experimental and $\phi(x_j)$ the model occurrence frequencies of the $j$-th class.

2. the non-parametric Kolmogorov test where the testing value is $D_N = N^{-1/2} \cdot \max \left| F_{ej} - F(x_j) \right|$, $F_{ej}$ being the experimental and $F(x_j)$ the model cumulative frequency. In both cases the testing was carried out at a level of significance of $p = 0.05$, and the appropriate critical values $\chi^2_{crit}$ and $D_N_{crit}$ were taken from statistical tables [6].

To conclude a check was made using the Grubbs parametric test of extreme deviations [5] where the testing value is $T_N = (x_N - \bar{x})/s$, or $T_1 = (\bar{x} - x_1)/s$, $\bar{x}$ is the arithmetical mean of the logarithms of the elements of the original set and $s$ the standard deviation of the normal distributions of the logarithms of the values of the elements of the set.

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