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GEOCHRONOLOGICAL RESEARCH OF ANTROPOGENIC SEDIMENTS

Geochronology is the science of determining the age of rocks and geological processes. Geochronology allows to establish quantitative and qualitative changes that occur in nature. Geochronology studies paleogeography, sediment provenance, depositional timing and basin development. The main aim of sampling for the analysis of deep horizons is the study of the sequence of processes and their regularities, that took place in the past and affect the present [3, 5].

There are many different geochronological methods of studying sediments. Geochronological data indicate relative age and chronostratigraphic data indicate the absolute age. Let’s consider a brief description of various dating methods.

Paleomagnetism is the study of Earth's magnetic field, that fixed in sediments. Paleomagnetism allows to determine the direction of the paleomagnetic field during the formation of rocks. Paleomagnetism utilizes the reversals of Earth's magnetic field through time. Then time-scale is assigned by analyzing the magnetic changes recorded in sedimentary sequencees.

Radiocarbon dating can determine the age of organic materials which are no more than sixty thousands years old.

Paleontology is the relative dating method. It is based on the comparison of fossil assemblages of sediments and assigning them to an interval of time when these fossils are known to have existed. The fossil assemblage is compared with fossils of similar physical characteristics, and by knowing both age and the spatial extent of particular species, we can determine an interval of time.

Geological expertise of deposits includes description of deposits, determination of age, analysis of the sequence of their formation and composition. Samples for analysis has been taken from Quaternary sediments.

Determing the age requires a systematic approach to identifying fossil soils, loess and other types of deposits. It should be noted, that the whole range of different methods, such as stratigraphic, physical and mathematical are applied for solution of these tasks.

The thermoluminescence method (TL-method) is one of most efficient methods for determining the age of sediments [1]. The knowledge of the age of the studied objects helps to understand laws, sequences and development of processes and phenomena.

After determining the age, opportunities open up for comparison and correlation of various fairly remote areas, sections and phenomena. The main criteria for correlations are the age of the deposits, physical properties and their mineral composition. Covering deposits in the conditions of their natural position are influenced by environmental factors constantly [4].

The TL-method of determining the “absolute” and relative age of subaerial deposits is based on the properties of crystals to accumulate energy of decay of radioactive elements and to radiate it under the influence of heat. This energy is accumulated in crystalline lattices [2]. During heating process, the accumulated energy is emitted in the form of photons of light. We register this luminescence using our devices. Thermoluminescence dating of sediments depends on time of their burial.

The thermoluminescence effect is fixed in the form of curves of thermal influence. Dividing the amount of measured energy to the background radioactivity of the rock, we get the value, that characterizes the age of the sample.

Different optically transparent crystalline minerals-dielectrics are used as paleodosimeters. We are interested in such minerals, that can act as a paleodosimeter, that accumulate and save the age-related information for a long period of time. Quartz is the such a suitable mineral.

Our research allows to compare the geological structure of Quaternary sediments and to determine the age of sediments. It permits to conduct the structural analysis of sediments.

Analyzing the obtained results of TL-method, we can make a conclusion, that the geological processes recorded in the deposits of the sections are identical to those in other regions. It means, that these geological processes occurred under the influence of the same external factors of the Quaternary period.

Let’s note, that the thermoluminescence effect is fixed in the form of curves of thermal light, determing the area bounded the curve or the intensity of the peak. Older sediments have larger age indices and younger sediments have lower age indices. We should use such minerals, that can act as a paleodosimeter, that accumulates and preserves the age-related information for a long period of time. Quartz is the such a suitable mineral. Quartz is one of the most common minerals of the earth's crust. Crystals of quartz have certain structural defects, that characterize a sufficient depth of the trap to ensure the saving of metastable state of the electrons for a long time [1].

The technique is best suited to the age determination of sediments which have been zeroed by influence of solar radiation during transposition.

Aeolian sediments are more likely to have undergone considerable solar exposure prior to deposition and therefore are more likely to have been effectively zeroed. Study must also be taken ensure that the sample is taken from an undisturbed area and has not been has not been exposed to any influence.

TL dating may be applied to aeolian, fluvial, coastal and, in some cases, marine sediments. The technique is also successfully applied to volcanic materials and heated firehearth samples and therefore may be directly applicable in certain archaeological contexts [4].

The main problem with determining the age of Pleistocene rocks by the TL-method consists in accurately calculation of some value (let's name it as age parameter (T)). The value of this age parameter is directly proportional to the time of formation of the investigated rocks. Therefore, for determining of the age of Pleistocene rocks by the TL-method, we can use this age parameter [1].

The age parameter is represented by the expression: $T = \frac{D}{P}$,

where *T* – time, *D* – dose, that was accumulated by the sample, *P*-annual dose.

Apha, beta and gamma radiation during whole burial period form structural defects with constant velocity $(V_{\alpha,\beta,\gamma})$ in quartz.

Let's note, that velocity of formation of radiation defects is determined as:

$$V_{\alpha,\beta,\gamma} = \beta \cdot E, \tag{1}$$

where β – the sensivity of the dose of the mineral, E – the capacity of the expositional dose of gamma radiation.

The velocity of annihilation is proportional to the concentration of localized electrons in quartz at the selected moment of time:

$$V_A = k \cdot n, \tag{2}$$

where, *k* is the constant of the velocity of the of annihilation of localized electrons or a coefficient of proportionality.

Let's note, that at saturation the velocity of formation of radiation defects will be equal to the velocity of their annihilation:

$$V_{\alpha,\beta,\gamma} = V_A. \tag{3}$$

From equations (1)-(3) we get the next equation (4):

$$\beta \cdot E = k \cdot n. \tag{4}$$

At the saturation concentration of localized electrons is denoted as *N*:

$$\beta \cdot E = k \cdot N. \tag{5}$$

From equation (5) we get the constant of the velocity of the of annihilation of localized electrons (coefficient of proportionality):

$$k = \frac{\beta \cdot E}{N}. \tag{6}$$

The velocity of change of the concentration of localized electrons is equal to the first derivative from concentration of localized electrons:

$$\frac{dn}{dt} = V_{\alpha,\beta,\gamma} - V_A = \beta \cdot E - \frac{\beta \cdot E}{N} \cdot n. \tag{7}$$

We have obtained the differential equation:

$$\frac{dn}{\beta \cdot E - \frac{\beta \cdot E}{N} \cdot n} = dT. \qquad (8)$$

After the integration of this equation we have got the next formula:

$$T = \int \frac{dn}{\beta \cdot E - \frac{\beta \cdot E}{N} \cdot n} = \left| \begin{matrix} \beta \cdot E - \frac{\beta \cdot E}{N} \cdot n = z \\ dn = \frac{N}{\beta \cdot E} dz \end{matrix} \right| = \int \frac{N}{\beta E} \cdot \frac{1}{z} dz = \frac{N}{\beta E} \ln \left| \beta E - \frac{\beta E}{N} \cdot n \right|. \qquad (9)$$

Taking the upper limit of the integral – n_0 (accumulated concentration of localized electrons) and taking the lower limit of the integral – $n_{\min}$ (residual concentration of electrons after whitening), we get equation (10):

$$T = \frac{N}{\beta \cdot E} \left[\ln \left(\beta \cdot E - \beta \cdot E \cdot \frac{n_{\min}}{N} \right) - \ln \left(\beta \cdot E - \beta \cdot E \cdot \frac{n_0}{N} \right) \right] = \frac{N}{\beta \cdot E} \ln \frac{1 - \frac{n_{\min}}{N}}{1 - \frac{n_0}{N}}. \qquad (10)$$

So, we have found the equation (10) for the determination of the age of the rocks.

In this work we proposed the mathematical apparatus, that can be applied for calculating the age of anthropogenic sediments. This mathematical apparatus is based on the solution of the differential equation. A mathematical formula for the age parameter has been considered in this work. The velocity of annihilation, the velocity of the formation of radiation defects and the energy that was accumulated by the investigated sample over time were applied for derivation of this formula. It also was noted, that this mathematical apparatus helps to conduct correlation of various Quaternary sediments from various areas. It shows which rocks of a section are older and which are younger. It also determines the sequence of the rock accumulation.

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