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Study of Fractal Dimensionality of Secondary Technogenic Uranium Ores

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ABSTRACT: This paper presents the results of the study of granulometric composition of secondary technogenic uranium ores using fractal geometry methods. The object of research is secondary technogenic ores of Uchkuduk deposit, and also the subject of research is determination of fractal dimensions of these technogenic ores.
Using the computer programme Python obtained a logarithmic grid, which can determine the parameter (tangent angle) to find the fractal size of particles of uranium ores. Five groups of uranium ore samples were set up to study the dependence of fractal dimension on ore particle size distribution.
The results show that: the fractal dimensionality can increase or decrease when the granule size changes, depending on the specific structure and formation process.

KEYWORDS: secondary technogenic ore, heap leaching, fractal dimensionality, logarithmic grid, cell counting.

I.INTRODUCTION

Any technological process ends with the formation of secondary waste. Similarly, the technological process of uranium production is associated with the formation of secondary waste [1, 2]. This waste is a poor technogenic uranium waste and contains uranium in its composition in small amounts.

There are many gravimetric sorting equipment available in uranium geotechnology today, but so far most of them are only really effective for particles larger than 1 mm. Since the grains of secondary technogenic uranium ores are of different sizes and in them uranium is mostly distributed in fine grades.

To reduce the cost of processing of secondary technogenic ores granulometric separation was applied.

Rocks and massifs due to heterogeneity of composition and structure have a complex structure of defect space, dislocations and other places of 'weakening', which is a three-dimensional system of conditionally unconnected (conditionally interconnected) defects of different shapes and sizes. The description of the structure of the defect space is a rather complex task, requiring the input of simplifying models and other assumptions. Therefore, determination of the fractal dimension of secondary technogenic ores is an urgent task.

In 1975, Benoit Mandelbrot published the work 'Fractal Geometry of Nature', in which he formulated the theory of complex geometric figures possessing the property of self-similarity and applied it to the analysis of natural formations of nature [3].

Fractal analysis, which can be reduced to the determination of the nature of the change in fractal dimension in the process of destruction, allows us to move to models that take into account the complexity of the spatial organisation of a real physical system [4]. As studies [5,6,7] have shown, an effective way of modelling rough (non-differentiable) surfaces for solving uranium ore problems is the use of fractal geometry methods that take into account roughness.

The task of this work is to determine the fractal dimension of secondary technogenic ores of Uchkuduk deposit.

II. TECHNIQUE AND METHODS OF EXPERIMENT

To separate the samples into fractions, a set of sieves with different mesh sizes (e.g., from large to small) was used. Sieve analysis was carried out manually on a set of sieves. Secondary anthropogenic ores were transferred to the top sieve of the set, covered with a lid and sieved for 15 min. The residue of material from each sieve was separately transferred to clean, pre-dried to constant mass evaporation bowls and weighed. The mass fraction of the residue on each sieve was calculated. The dependence of mass fractions of secondary technogenic ores on the dimensions is given in Table 1.

Table 1.
Results of granulometric analysis of averaged samples taken from uranium dumps

№	Coarseness class,	Mass fraction, g	Yield, %
1.	-25+10	1815	30,0
2.	-10+5	912	15,0
3.	-5+3	507	8,3
4.	-3+2	412	6,6
5.	-2+1	434	7,5
6.	-1+0,5	1689	28,3
7.	-0,5+0	231	4,16
8.	Initial	6000	100,0

The fractality of uranium ore particles was investigated by optical analysis. The particles were photographed through an optical microscope at a given magnification. Figure 1 a, b, c shows the determination of the fractal dimension of secondary technogenic ores by counting the cells (box-counting method) of a certain scale per its particle. A grid with boxes (squares) of a certain size is superimposed on the fractal image.

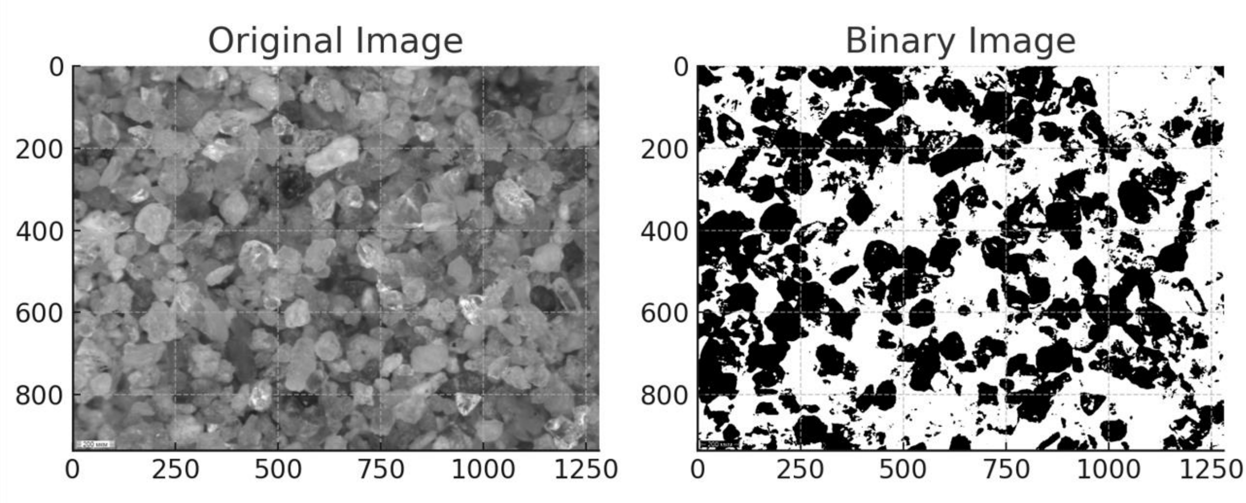

Fig. 1 a. Optical microscope imaging of secondary technogenic ores of the Uchkuduk deposit of 0.2 mm fraction.

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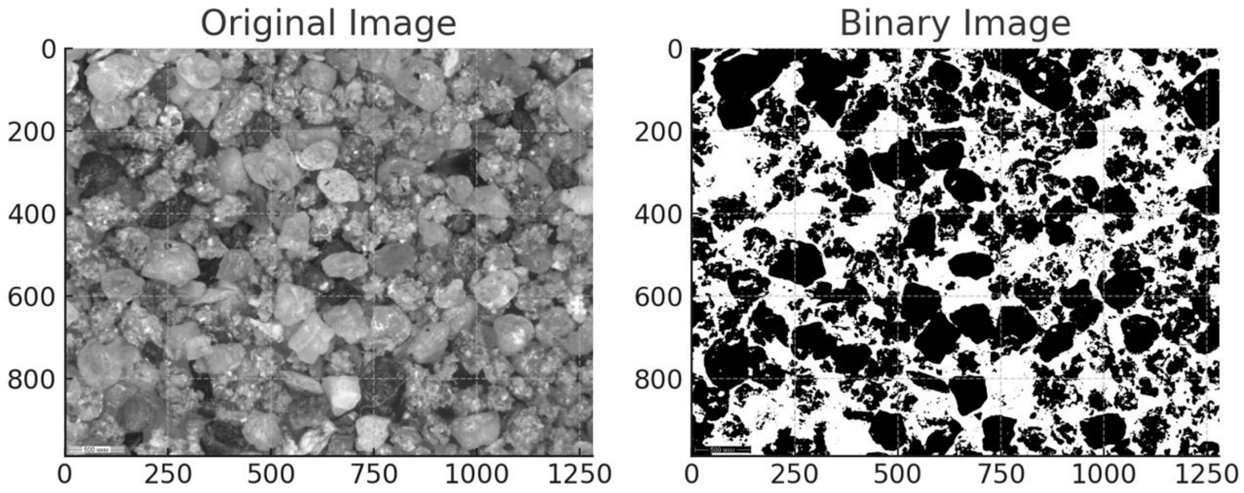

Fig. 1 c. Optical microscope imaging of secondary technogenic ores of Uchkuduk deposit of 1 mm fraction

To determine the fractal, we count the number of squares N(r), and the area of a small box (r) and further reduce the size of the box by one r=r-1. The process is repeated with smaller boxes and again the number of boxes containing a fractal is counted. For each box size, the logarithm of the number of boxes containing the fractal log(N(r)) and the logarithm of the inverse of the box size log (1/r) are calculated. The fractal dimension (D) is defined as the slope of the line approximating the points on the graph, where log(1/r)) is plotted on the abscissa axis and log(N(r)) is plotted on the ordinate axis. Using the formula Hausdovskogo d=logN/(log (1/r)), we find the fractal dimension of uranium ore particles of different sizes. And to get a straight line we used logarithmic grid and to create a logarithmic grid we used Python programme as shown in figure 2:

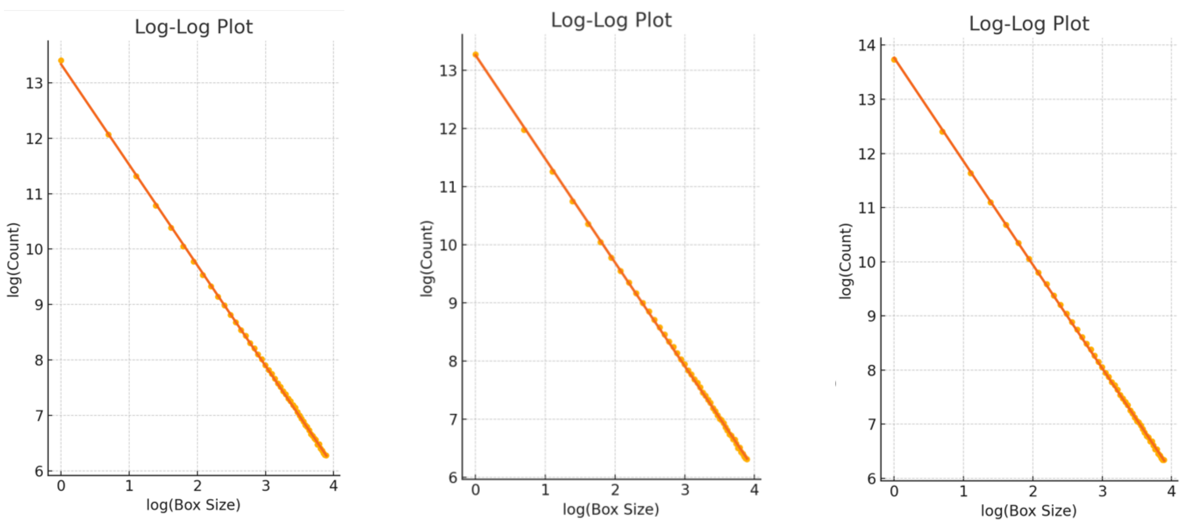

Figure 2: Logarithmic grid and the graph created on this grid: a) uranium ore of 0.2 mm fraction; b) uranium ore of 0.5 mm fraction; c) uranium ore of 1 mm fraction.

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The tangent of slope angle and fractal dimension for each fraction of uranium ore were found on the graph: D1=1.813 (for 0.2 µm fraction), D2= 1.780 (for 0.5 µm fraction), D3= 1.910 (for 1 mm fraction).

Thus, the use of the method of determining fractal dimensions makes it possible to obtain quantitative information on the structure of secondary technogenic ores, the relationship of the elements of the structure among themselves, as well as to make assumptions about the mechanism of formation of complex self-similar structures. Further study of the surface of technogenic uranium ores from the point of view of fractal geometry will allow to determine the influence of fractal dimension of ores on such important characteristics as bulk density and dependence on particle size.

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