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# PRACTICAL SIGNIFICANCE OF CHEMICAL COMPOSITION, STRUCTURE AND STRENGTH OF URINARY STONES FOR CHOOSING A RATIONAL METHOD OF THEIR DESTRUCTION

**Barannik Constantin**

candidate of medical sciences, Assistant of the Department of Surgery No. 1  
*Dnipro State Medical University, Dnipro, Ukraine*

**Molchanov Robert**

doctor of medical sciences, professor, Professor of the Department of Surgery No. 1  
*Dnipro State Medical University, Dnipro, Ukraine*

**Barannik Serhiy**

doctor of medical sciences, professor, Professor of the Department of General Surgery  
*Dnipro State Medical University, Dnipro, Ukraine*

**Kasparova Marharyta**

Radiologist  
*Society "Hemo Medina Kharkiv", Dnipro, Ukraine*

**Summary.** *The article is devoted to the search for a rational choice of a destructive method of treating patients with urolithiasis. The practical value of the preliminary study of the chemical composition, structure and texture, as well as the density of uroliths on the quality of using a destructive method of their treatment is determined. Features of the structure of uroliths determine their strength, which requires an individual choice of lithotripsy and maximum preservation of kidney function in the postoperative period. Determining the individual characteristics of the chemical composition and texture of uroliths will be useful in determining further metaphylactic measures for each patient.*

**Keywords:** *urolithiasis, chemical composition, texture and structure of uroliths, density of uroliths, Hounsfield index.*

**Introduction.** Urolithiasis is one of the oldest diseases known to medicine; however, the mechanisms of stone formation and development remain largely unclear [1]. Physico-chemical, biological and biochemical processes that take place during the formation of urinary stones determine the peculiarities of their composition and structure, which is confirmed by modern methods of analysis:

spectral, X-ray, polarization optical, immersion, infrared spectrometry, etc. But it was determined that knowledge of the chemical composition and structure of urinary stones does not allow to improve their destruction [2, 3, 4]. Urolithiasis, a complex multifactorial disease, results from an interaction between environmental and genetic factors. Epidemiological studies have shown an association of urolithiasis with a number of lifestyle-related diseases, including cardiovascular disease, hypertension, chronic kidney disease, diabetes, and metabolic disorders. syndrome. Elucidation of the mechanisms underlying the formation of urinary stones will allow the development of new prophylactic agents. Of great importance for the choice of both invasive methods of treating urolithiasis and methods for preventing recurrent stone formation are data on the chemical composition of the urinary stone, more precisely, on its metabolic type [4, 5, 6]. However, urinary stones are not always available for analysis, which complicates the choice of optimal treatment methods and leads to the need to find (develop) methods for assessing the chemical composition of urinary stones in a patient in vivo. One of the areas of research is a comprehensive analysis of lithogenic metabolic factors, the long-term impact of which leads to the formation of urinary stones. For the development of new modern methods of mechanical destruction of urinary stones, data on the structure of urinary stones, which primarily determines their physical properties, are of particular importance [8]. An example can be the fact that graphite and diamond have the same mineral composition (carbon), but the strength of each of them cannot be compared: one is fragile, the other is the hardest.

**The goal of the work** — to improve the quality of destruction of uroliths from the kidneys of residents of the Dnipropetrovsk region, primarily related to the preliminary study of the structure, morphology and strength of these formations.

**Research methods.** To carry out the work, a comparative analysis of the morphology of more than 246 renal uroliths of residents of the Dnipropetrovsk region was carried out and their petrographic study was performed. The sizes of the studied stones were from 5 mm to 67 mm in length, from 4 mm to 54 mm in width, from 3 mm to 31 mm in thickness. Some stones were larger. The shape of the stones was varied. The morphology of uroliths was studied using a stereoscopic binocular microscope MBS-9. Microscopic examination of sections of uroliths was performed using an optical polarizing microscope MIN-8. Density characteristics were determined using computed tomography on a Siemens SOMATOM device [7].

**Discussion of results.** It is known that solid bodies differ from each other not only in mineral composition, but also in structure and texture. The construction of a solid body, which is a urinary stone, is characterized by structural and textural features due to its origin and subsequent transformation (genesis). Structure and texture determine the structure of matter at different levels. Texture is the composition of a sedimentary rock, determined by the orientation, relative arrangement of constituent parts, and the manner of filling the space. Texture is mainly a macroscopic feature, the study of which is carried out on rock samples (on dissections of stones, on the surface of anschliffe). Structure - the structure of the rock, which is determined by the size, shape, orientation of the particles and the degree of preservation of the organic residue (microscopic feature). The structure of rocks of chemical origin, including urinary stones, is characterized by the degree of crystallinity and the size (sizes) of grains.

The structure is of great importance in the strength of the urinary stone. The most durable and resistant to destruction are stones that have a fully crystalline equally medium-grained or fine-grained structure. Large-grained, coarse-grained, giant-grained formations are more prone to destruction, both under conditions of mechanical impact and under conditions of significant temperature changes, because large crystals with significantly pronounced adhesion in large-grained formations easily split and break. Vitreous stones quickly split under conditions of sudden temperature changes. Stones are characterized by the presence of cavities, such as cracks and caverns. Cavities are different in shape - bubbly, channel-like, fissure-like, branched, etc. The shape and degree of hollowness of the stone determine its properties such as density, strength, and susceptibility to destruction.

In previous works, the most complete attention was paid to the structure and composition of urinary stones, including single kidney stones, using petrography, infrared spectrography, laser and electron probe microanalysis. During the study by X-ray structural analysis of urinary stones, the predominant amount of calcium oxalate was found - 59%, followed by calcium urate - 36% and the least amount of calcium hydrogen phosphate - 2%. It was established that oxalate stones are characterized by a fine-grained and fine-grained structure. The main types of texture of these stones were concentric, zonal and radial-radial. A characteristic structural feature of urate stones is a microcrystalline structure, and the predominant textures are spherulite, sector-spherulite, and chaotic. Amorphous minerals in the vast majority are provided in the form of cementing, binding individual crystals of the mass. Recrystallization processes with the formation of hollowness were more often observed in these stones. Coral-like stones are characterized by a mixed composition. They were formed in the presence of amorphous minerals with the addition of salts of different composition. The structural feature of coral-like stones was their chaotic construction.

Thus, the analysis of own data shows that urinary stones have a different composition and, depending on the type, mainly consist of crystals of uric acid, sodium or ammonium uric acid, calcium oxalate or ammonia, calcium phosphate, magnesium phosphate or ammonia. All stones consist of organic and mineral parts. Many of them are mixed in their composition. Mineral silkad contains from 6 to 17 or more trace elements. As for the structure of stones, the studies devoted to this issue touch on the study of the microstructure as a consequence of stone formation. It was established that the microstructure of stones, as well as their composition, depends on the type of urinary stones. Studying the structure and composition of urinary stones in order to detail the mechanism of their destruction is an important task, because the principle of mechanical destruction is the basis of remote and contact methods of stone disintegration.

According to external features, the studied stones were divided into groups of known types: urates, oxalates, phosphates and mixed composition.

Urate had a solid consistency, color from yellow to dark brown. Their surface was often smooth. Individual stones were covered with small grains that were tightly connected to the surface or (less often) easily separated from the surface of the stone after a slight pressure. Oxalates were solid formations from yellow to dark brown (more often). Their surface was also smooth, sometimes warty or rough, covered with dull sharp spines. Phosphate stones were of different consistency: some of them were easily crushed, others had a solid consistency. They had a mostly white or yellowish-white color, a smooth or slightly rough surface. The stones of

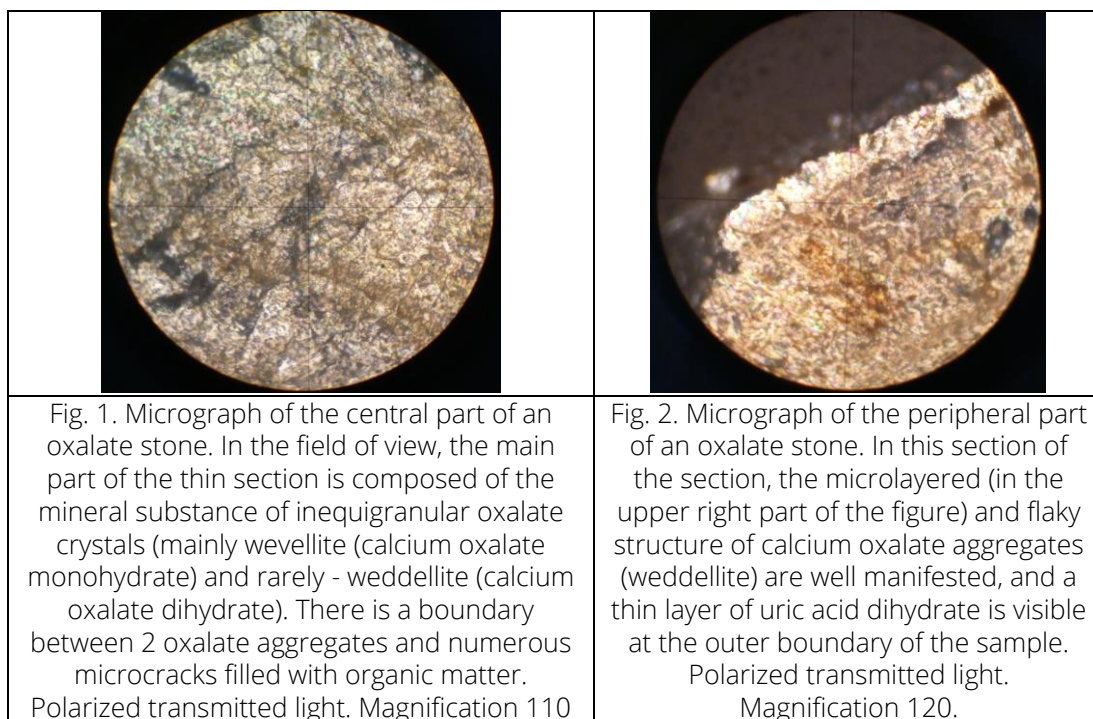
mixed composition had various colors and surfaces. Depending on the predominant ratio of constituent parts and internal connections, some of them were solid, others were easily crushed. Some of them were easily crushed only after the destruction of the solid surface layer. Others, on the contrary, were solid even after the destruction of the surface layer.

Depending on the component, we divided the studied stones into three groups: 1) crystalline, among which we additionally identified two groups: a) monomineral and b) polymineral; 2) amorphous; 3) mixed in composition - complex salts of various acids. Depending on the location of the crystals, radial-radiant, spherulite, globular, and chaotic structures were distinguished.

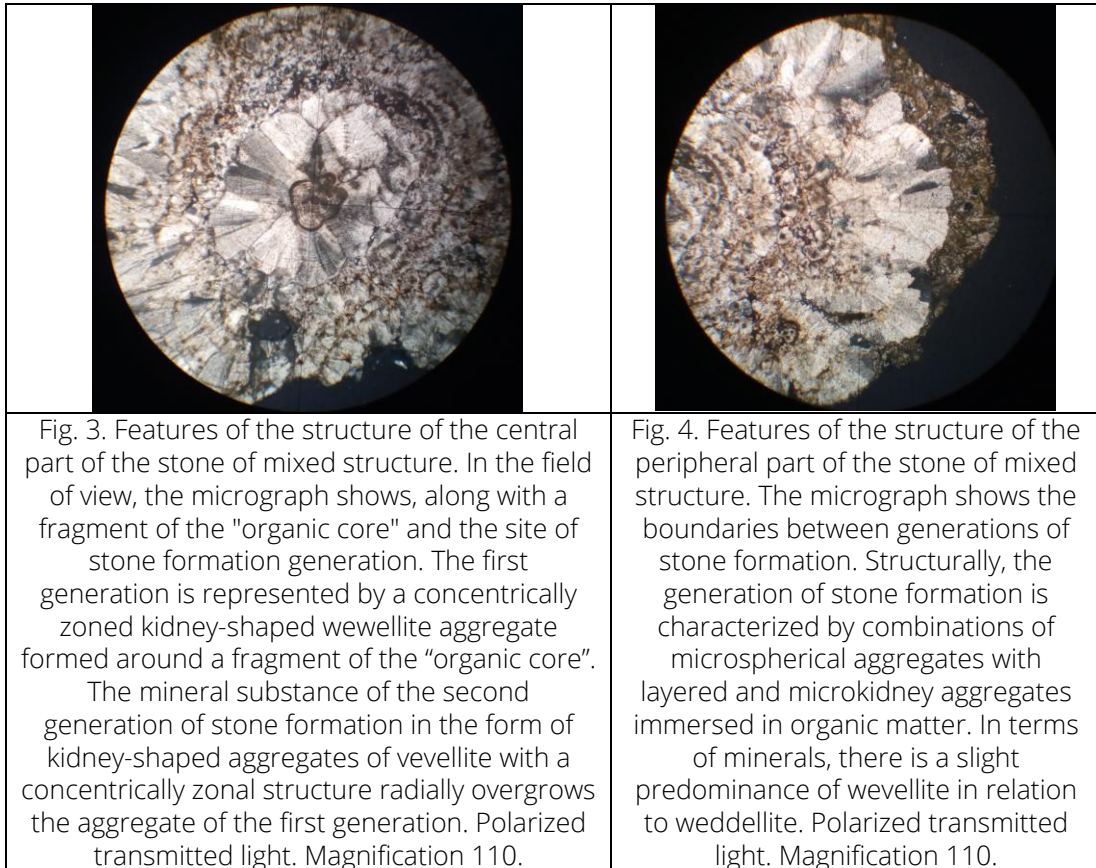
It was established that urates are characterized by a concentric structure. In 90% of stones, a well-formed core is visible, the diameter of which (measured on the samples) ranges from 0.1 to 0.5 mm. The core is surrounded by dense layers with loose layers 0.1-0.5 mm wide. Often, "holes" are formed around the core, which leads to the separation of layers and further destruction of the stone. The obtained data make it possible to determine the structure of urates as pelitomorphic-hidden crystalline, equivalently fine-grained (crystal size 0.01 mm).

Research results showed that phosphates, like urates, have a concentric structure around the nucleus, often have 2 or more nuclei and a coral-like shape. The diameter of the nuclei is from 0.1 to 0.5 mm. Phosphates have multi-step cleavages and loose layers. The width of the layers is 0.1 mm and less. The structure of the stones is cryptic, equally fine-grained.

Unlike urates and phosphates, oxalates do not have a clear concentric structure (Figs. 1 and 2). These are monolithic stones. Only 20% of samples have a well-formed nucleus. Oxalates consist of dense layers that do not have loose layers. When studying them under a microscope, it can be seen that pronounced crystals are not defined, but microcracks have a very fine structure, which is filled with an organic part. That is, according to the degree of crystallization, the structure of oxalates is vitreous, fine-grained, stones do not have clearly marked crystals.



Stones of a mixed warehouse (Fig.3 and 4) are characterized by rices like phosphates and oxalates. The stench may be concentric, often 2 or more nuclei with a diameter of 0.01-0.1 mm. Stones of mixed type are found in their own elements of oxalates and phosphates, concentric in appearance of the core, like balls differ in width (0.1-0.2 mm), and in hardness. Often, similarly to phosphates, fillets of a fluffy material with a width of 0.001 mm are established. The structure of the stones is pelitomorph-grained.



Computed tomography (CT) is the gold standard for diagnosing stones in nirks; high sensitivity and specificity of the temples (~94% and ~97% vaguely), and small structures close to 1 mm can be identified. In addition, CT determines the quantity, shape, polishing and coefficients of stone weakening.

Units of Hounsfield (HU) are tied with a layer of fabric or stone. HU is the result of a linear scale of weakened x-ray viability, and the value of HU is associated with distilled water at normal pressure and temperature. In addition, the fallowness between the radio shield stone, expressed in HU, and the size of the stone can be taken as a guide to the warehouse of stones near the nirkah. The whole world is called the Hounsfield branch. Kilka doslidzhen pov'yazuyut HU zi warehouse kameniv nirkah. There is little proof of the connection between Hounsfield's schism and the warehouse of stones at nirkah.

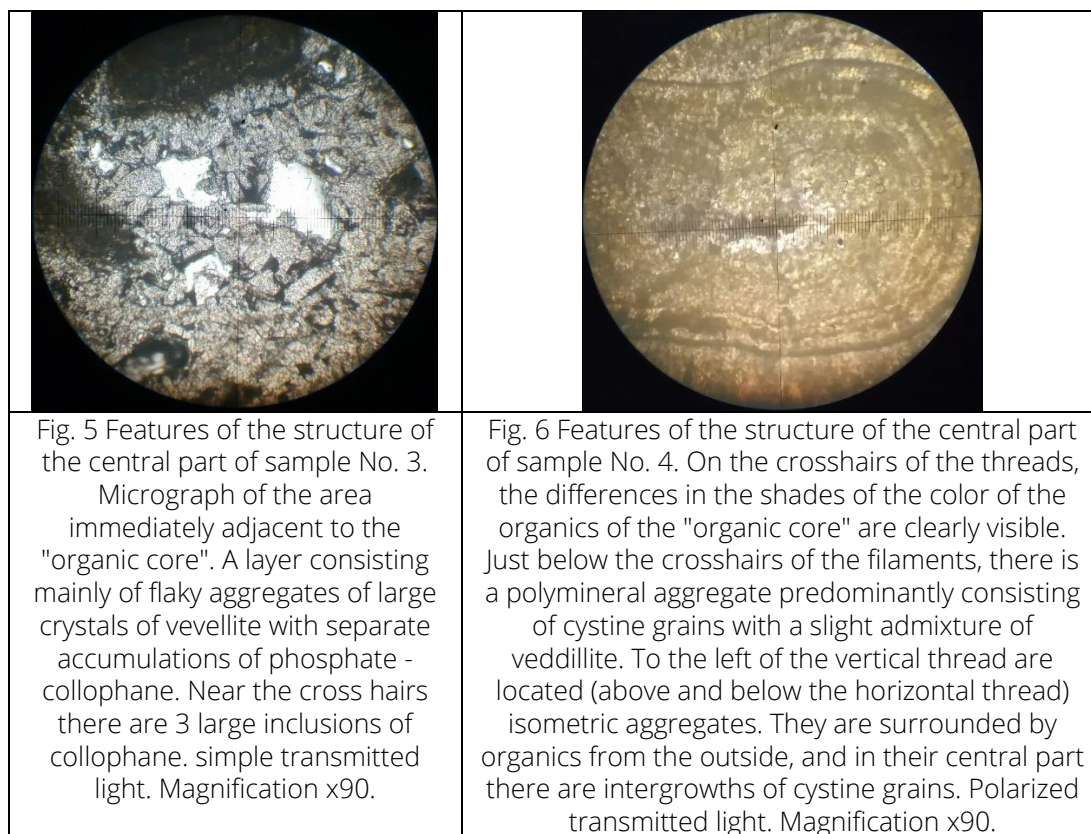
Anterior grafting of the structure of different types of stones with the help of CT in the experiment showed advanced results (Table 1).

Table 1

Indicators of heterogeneity of the structure of uroliths

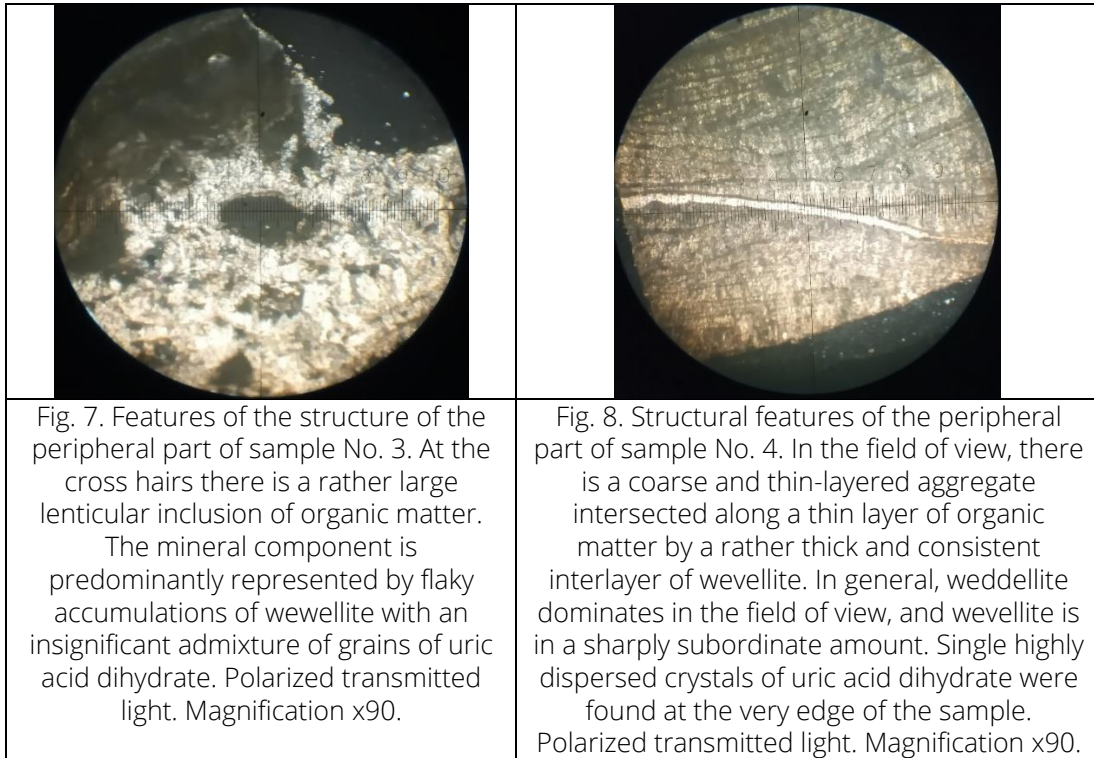
Parameters of uroliths	Viewer 1	Viewer 2	Viewer 3	Viewer 4
The form	wrong	wrong	wrong	wrong
Dimensions (mm)	15x9x17	14x11x17	14x9x16	11x9x13
Medium density	1329	1584	1516	570
Minimum density	639	503	108	436
Maximum density	1765	1910	1855	623
Heterogeneity index (standard deviation of density)	263	278	379	38

Indicators of heterogeneity of the structure of urinary stones were compared with the data of their further petrographic study. As a result of the comparative analysis, it was proved that in the vast majority of stones there is a coincidence of structural features with indicators of structural heterogeneity. The latter may indicate the nature of the strength of the stone. A special coincidence of indicators was determined in samples 3 and 4 (Fig. 5-8).



Stones of mixed composition are characterized by features of both phosphates and oxalates. They have a concentric structure, often 2 or more nuclei with a diameter of 0.01-0.1 mm. Stones of the mixed type combine the elements of oxalates and phosphates, the structure is concentric in the form of a core, which is surrounded by layers of different width (0.1-0.2 mm) and hardness. Often, similarly to phosphates, layers of loose material with a width of 0.001 mm are formed. The stone structure is pelitomorph-fine-grained.





It can be seen from the above that the three types of stones, except oxalates, have the same structure. The texture of all is layered or irregular. Chips are especially important in the construction of stone. Cleavage failure is the most brittle form of failure that can occur in a crystalline material when crystallographic surfaces separate. Due to the fact that neighboring crystal grains have different orientations, the brittle fracture at the crystal grain boundary changes its direction and continues to propagate in the most favorable direction of the fracture surface. It was noted that the cracks have a step that is parallel to the crack propagation direction and perpendicular to the crack plane. In all types of such stones, cavities, cracks, and splits around the cores were identified, along which the separation of layers and subsequent destruction of the stone occurs. But it should be noted that these formations are most pronounced and often occur in phosphates and urates. In phosphates, cracks are more often multi-step. There are almost no cracks in oxalate stones, cavities and cracks are occasionally found.

**Conclusions.** Thus, urinary stones, as biological objects, in contrast to hard bodies of mineral origin, have characteristic diagnostic signs and stable types of structures and textures for each type. It is known that the nature of destruction is significantly influenced by the structure of urinary stones. In turn, the structure reflects the peculiarities of the chemical composition and distribution of elements of zonal structures. However, in order to be able to improve the methods of their litholysis, destruction and, especially, metaphylactics of recurrent stone formation, in-depth knowledge about the peculiarities of the physical and technical properties of urinary stones is required.

The existing world standards for the diagnosis and treatment of patients with urolithiasis provide for a mandatory study of urolith for each patient with urolithiasis. Determination of the mineral composition and structure of uroliths is necessary for

the reasonable individual appointment of adequate therapeutic and preventive actions for each patient with urolithiasis. This is especially true for the rational choice of an effective method of lithotripsy.

The methodological approach to the study of uroliths includes a set of modern methods: light and electron scanning microscopy, X-ray spectral, X-ray diffraction, neutron activation, energy-dispersive X-ray fluorescence method, laser microprobing, chemical research methods and other types of analyzes.

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