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# Web-microscopy of crystalline forms

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**Abstract**. The use of Web-microscopy to determine the morphological forms of minerals is discussed. Like other branches of technology, the development of computer crystallography and the recognition of geological minerals are relevant. The perspective direction: express diagnostics by means of electronic gadgets. Web cameras have become publicly available image recording tools. Focusing of the rays on the sensor requires the use of a lens with a short focal length. The lens arrangement is optimized as close as possible to the recording matrix. In this way, high-resolution photographs are obtained for the optical region of the spectrum. The digital form of presentation of graphics creates conditions for the use of software for pattern recognition. A variety of forms based on a single mineral can be classified using deep training techniques.

## 1. Introduction

100 years have passed since the publication of the fundamental works on the description of crystalline forms [1, 2]. In the Atlas of Victor Goldschmidt [1], most of the crystal figures published by that time were collected. The number of figures for one mineral in individual cases exceeds 1000. The maximum number of figures for calcite reaches 2662.

In 1937, a fundamental attempt was made to systematize the available data on the drawings of geological minerals [3]. A large team of authors worked on this monumental work. The main goal of the "determinant of crystals" was to create a method for determining crystalline substances at the angles between the crystal faces (the law of constancy of angles). The second task is to form the most complete database of the main actual mineralogical parameters. And do this for the maximum possible number of crystals.In the process of work, the authors also worked on the development of crystallochemical systematics of crystalline substances.

According to the results of [3], it can be argued that crystallography is an independent science. In the basis of taxonomy, the authors laid down the three ideas formulated in [4]. The structure of the crystal can be determined from its external form. Classify the crystals by their structure. The substance of the crystals can be determined from their external forms, previously determining their structure.

It should be mentioned that the active development of knowledge about the structure of crystals was associated with the success of physics in the early twentieth century. First of all, these are X-ray studies of crystals. Observation of the diffraction scattering pattern in the experiments made it possible to compile models of crystallographic structures of a set of substances.

The variety of crystalline structures of geological minerals does not allow us to formulate a universal systematics similar to Mendeleyev's table.

Perfect efforts [3] showed the inadequacy of technical means to solve such cumbersome task.

## 2. To computer crystallography

Today, you can expect to achieve a higher level of classification. Based on the achievements of the application software for recognizing graphic forms [5,6]. Modern recognition systems with elements of self-learning allow you to break photographs of minerals into groups of one habit [7]. This approach is more common in sociology. In this case, the variety of forms in the world of crystalline minerals is analyzed.

The technology of pattern recognition is developing rapidly. The needs of forensic science, observation, verification contribute to attracting programmers and investments to create effective image analysis systems. The efforts of the expert community are aimed at solving two problems. This is the development of effective algorithms for recognition - image comparison, and to create databases with the functions of artificial intelligence, deep learning technologies.

From steganography, computerized steganography has grown.

Similarly, we see the prerequisites for the development of computer crystallography.

To determine the mineral, a macroscopic method is considered, by external features. This is the most accessible and elementary method for physical properties: morphology, color, gloss, hardness, etc. The method of determining minerals by external characteristics does not require special equipment. In the laboratory practice, the laboratory microscope and film photography are used. With the development of digital technology, digital photography is widely introduced.

To view the structure and texture of minerals with multiple magnifications, we propose a modern approach, based on the use of widespread gadgets. The way accessible to everyone is photographing. You can use microscope based on a simple webcam.

Figure 1 shows a digital photo taken with a conventional web camera.
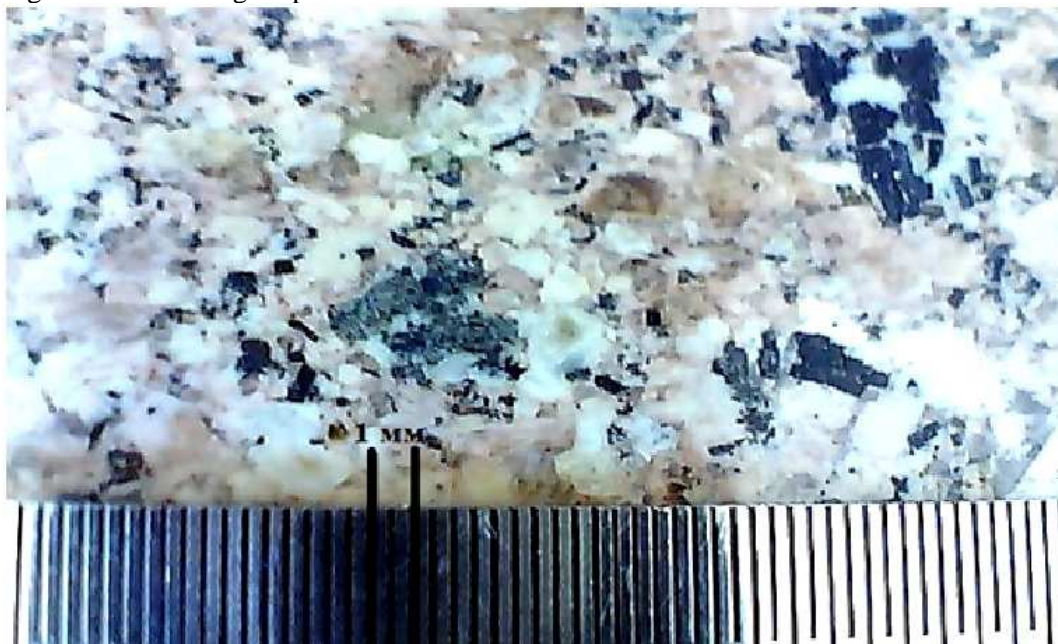


**Figure 1.** Sample core in the section.

Digital microscopy covers large areas of applications. Advantages of web-microscopy of crystals consist in the rapidity of determining minerals and rocks, as well as the ability to monitor any error in focus, alignment, exposure and contrast in optical adjustment. The image (it seems) is almost identical to what is seen on the camera or computer screen. There are many more options for adjusting the color balance, contrast, brightness, hues and other parameters.

To get a digital image of a mineral using a web camera, we used a device like DNS-0301B. This gadget has an extension of 640x480 and a sensor element of 5 megapixels. The procedure for preliminary adaptation is quite simple.

Upgrading the camera was reduced to the maximum possible approximation of the lens to the sensor array. There was a reverse assembly and inspection of the camera. The new configuration works in the normal mode.

The microscope on the web-camera allows you to zoom in dozens of times the image and see the structure and texture of the mineral (Fig. 2).
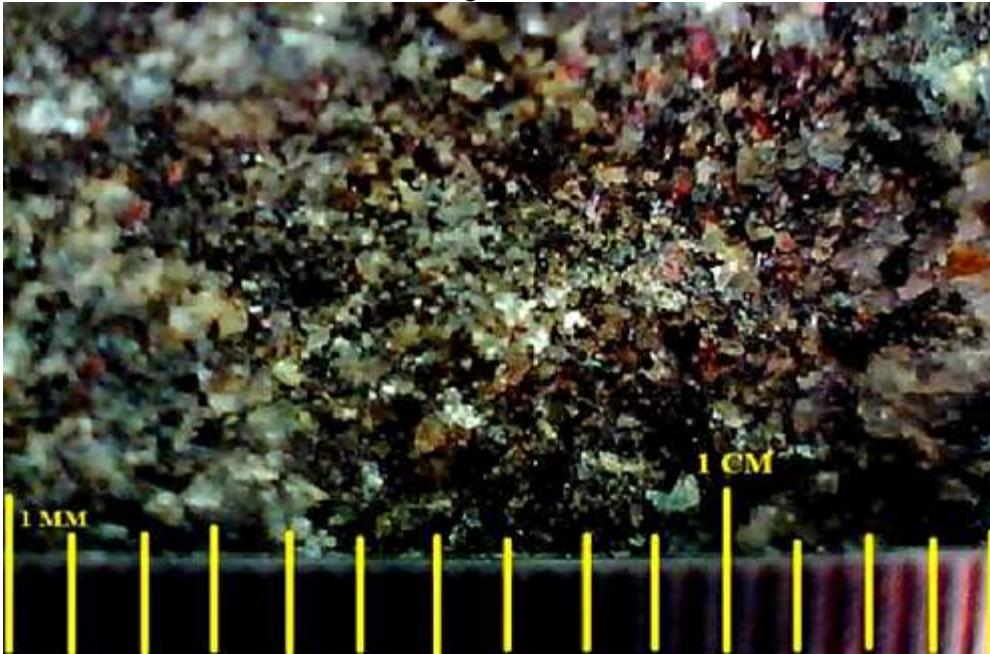


**Figure 2.** Mineral sample.

In the process of shooting, you need to adapt the digital camera to light. The best image is obtained in daylight. Having come to some optical compromise, one needs to view the image on the computer screen, and check whether the frame is lit.

The digital format of photographs of rock samples of minerals provides the full range of possibilities for processing graphic images using the available application software.

## 3. Discussion

Today, a wide variety of graphic applications is presented among the image processing software. There are a number of programs for presenting information on geological maps. Manufacturers of such software products are looking for opportunities to develop additional market sectors. Such prospects open the need for the systematics of the enormous variety of geological manifestations of crystalline minerals. The solution of this task is only possible for a team of software developers using elements of artificial intelligence technology.

On the other hand, there is a need for tools for express diagnostics of mountain minerals and rocks, including in the field. Promotion of the relevant application is possible on the basis of the development of infrastructure that includes a set of hardware, network and software tools.

## 4. Conclusion

Web-camera adopted to solve problems of microscopy of geological forms is the key. It opens up the perspective direction of information technologies. Figure 3 shows a stretched software element of Figure 2. Figure 3 shows that the resolution in our experiment was about 100 microns.

IPDME2018

IOP Conf. Series: Earth and Environmental Science **194** (2018) 062010

IOP Publishing

doi:10.1088/1755-1315/194/6/062010

**Figure 3.** Sample of the dot pattern of Figure 2.

This parameter can be improved in the limit to 1 micron, i.e. approximately 100 times. This level of optical resolution is determined by the wavelength of the visible range of light (0.5 microns for the green beam). Such progress can be achieved by using a more sophisticated sensing element, with a greater density of sensory points per unit area. And also it is possible to further optimize the optical part of the web-camera and use higher-quality optical lenses and improve the geometry of the optical system. Approaching the lens to the observed object is the simplest way to increase the resolution (see Figure 4).
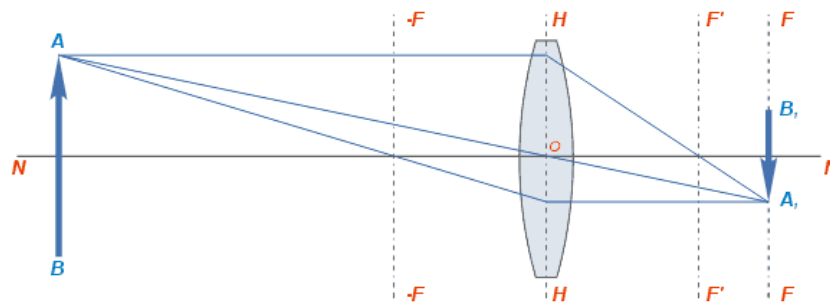


**Figure 4.** Paths of rays in a single-lens microscope

A microscope on a web-camera opens a new set of possibilities for geology and crystallography. The undoubted advantage of the proposed technique for analyzing mountain samples is the prospect of using various application programs, which opens up yet unconscious possibilities.

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