Studies of the morphology and distribution of sulfide phases bymethods of the computer tomography (as applied to the rock from the Yoko-Dovyren layered massife)

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Aims

Geology studies various rocks. The study of petrography is based on magmatic rocks that are formed from hot magmatic melts. When the magma is cooled to a solid phase, various minerals pass successively. In the last place, as a rule, they are compounds of platinum, iron, etc. At what the content and distribution of them in the host rock is not uniform. The purpose of this work is to establish mechanisms and conditions for the formation of sulfide mineralization in intrusive layered massifs. The effectiveness of mass transfer and accumulation of sulphides during solidification of hot magmatic melt of intrusions depends to a large extent on the possibility of wetting of the rock-forming silicate grains and the porosity of the host environment by the sulphide liquid. These relationships are deciphered by the morphology of the sulfide phases and their distribution over the volume of the rocks. Obtain this information by modern methods of computer X-ray tomography.

Method

Multiscale research was conducted. In the present work, three different CT systems were used, providing data of various informativeness and resolution.

At the first stage of the survey, the samples were scanned on a RKT-180 tomograph (Geologika, Novosibirsk). This scanner provides a fast enough shooting, and the resolution of the obtained data is from 100 to 200 microns. The sample size is about 8x8x8 cm. These operational data were used to select the most representative samples, a more detailed study of which was carried out at the next stage.

At the second stage of the work, the samples were examined on a Phoenix scanner v | tome | x m300 (GE, USA). The increase in the time of survey and reconstruction of the data led to significant qualitative improvements in the data obtained: the resolution for various samples was already from 40 to 70 microns, the contrast of the data allows us to fairly confidently identify the majority of the radiopaque rock components.

At the final stage of the laboratory work, 10 mm cylinders were drilled out of individual samples. As a result of their shooting on the SkyScan-1172 scanner (Bruker, Germany) data frames with a resolution of about 3 μm were obtained. Such detailed data are often used to stereotyped the microstructure of individual rock components and processes associated with them.

Results

In the same way, the collection of samples of a cubic shape with a resolution of about 40-70 μm was scanned. The scan data of all three scanners was processed using CTan, CTvol, CTvox. Shooting in the first two stages did not allow to establish the morphology of the sulfide inclusions. But it was possible to choose exactly the place for drilling a 10 mm cylinder for detailed shooting (Fig. 1).

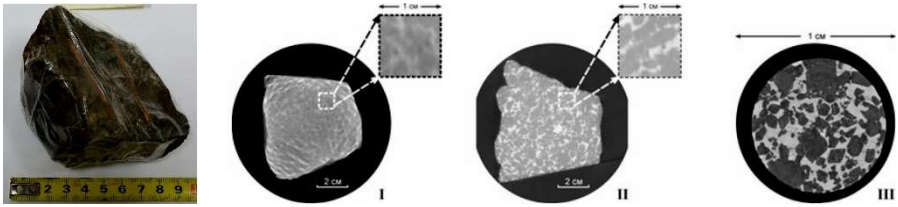

Figure 1: Example of X-ray density sections obtained on different scanners for the same rock: I - survey of RKT-180, II - survey of Phoenix v | tome | x m300, III - survey of SkyScan-1172

On the data obtained on cubic samples, three radiopaque phases are confidently distinguished. As a result of a digital analysis of the radiocontrast phases of mica and sulphide, it was established that the mica phase is almost completely connected to a single system, filling interstitium between olivine crystals. (Fig. 2).

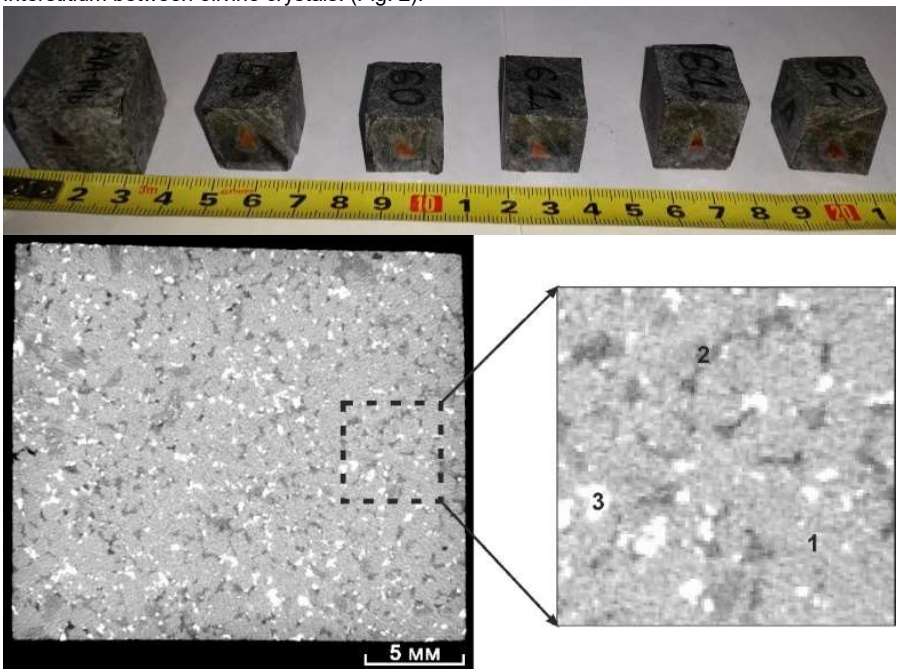

Figure 2: An example of an individual x-ray density section of a cubic sample (59). The enlarged fragment indicates: 1 - olivine, 2 - mica, 3 - sulphide.

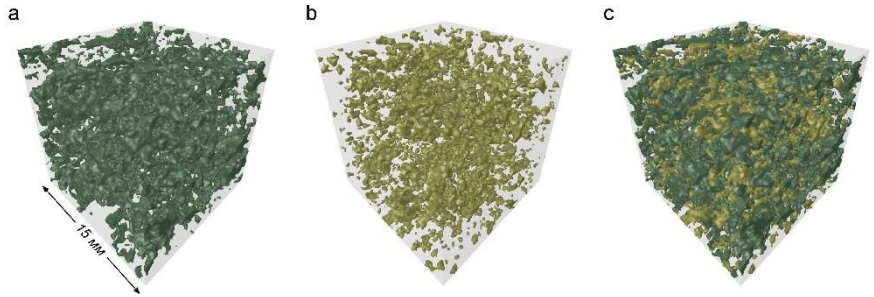

Figure 3: Example of 3D models of individual rock components: phase 1 - transparent, phase 2 - green, phase 3 - golden

The linkage of the phase, where the connectivity is the share of the largest single cluster in the volume of this phase, for the collection of samples studied was 94-97%. At the same time, the phase of sulphides is composed of a multitude (on average, the first thousand) of separately standing objects (Fig. 3).

On the data obtained on the cylindrical samples four radiocontrast phases are already clearly distinguished: 1 - olivine, 2 - mica, 3 - chromite, 4 - sulphide. Such an improvement in the resolution of the X-ray absorption method is explained by two interrelated factors: a significant improvement in spatial resolution and a decrease in the central energy of the source, which led to the dominance of the photoelectronic effect (Fig. 4).

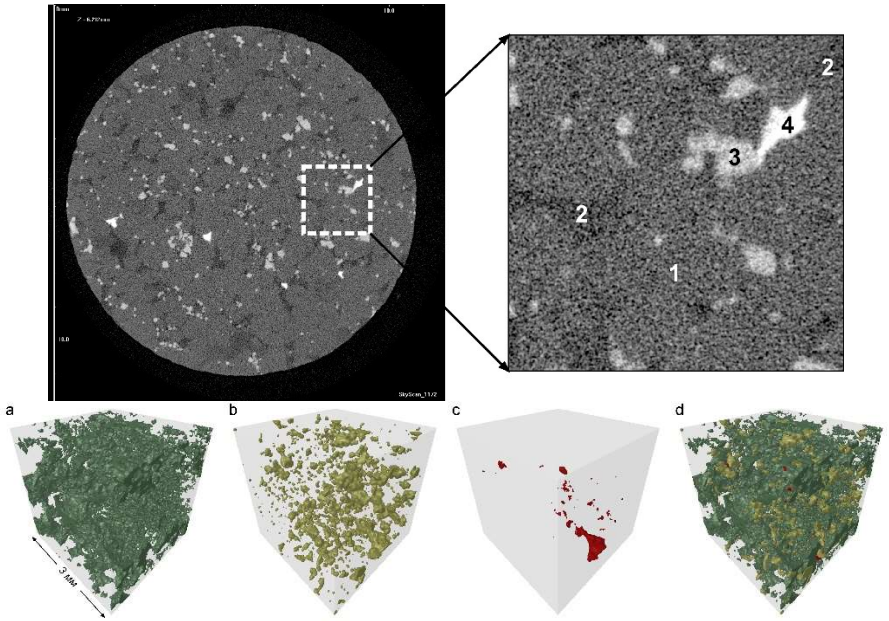

Figure 4: Example of 3D models of individual rock components: phase 1 - transparent, phase 2 - green, phase 3 - red, phase 4 - golden.

For 10 mm samples, as well as for samples of the cubic form, a very high phase 2 (90-95%) bonding and fragmentation of chromite and sulfide phases were established. The results of estimating the phase content in the sample volume are expected to differ slightly, which is obviously explained by the differences in the detail of the surveys and the volumes of the samples themselves. However, we can not speak of a significant difference.
In analyzing the distribution and sphericity of the chromite phase, the mass of its constituent elements was combined with the elements of the sulfide phase, which made it possible to compare such data on cylindrical and cubic samples where it was not possible to separate sulphides and chromites.

Figure 5: 3d models of some of the largest particles of the sulfide phase.

Their stereological relationship with other phases is noteworthy: a visual analysis of the ratio of the largest elements in the phase of the sulphide and the phase of mica showed that they mutually cross each other in the rock volume, forming a single form filling the interstitium between the olivine phase crystals (Fig. 5,6).

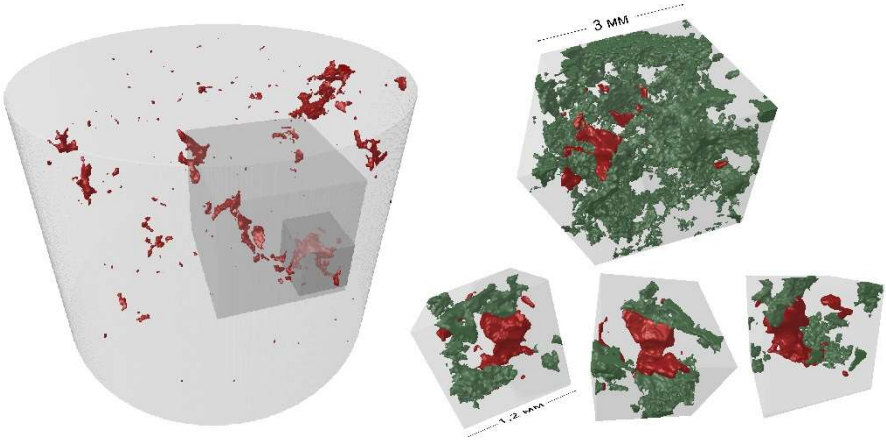

Figure 6: 3d models of the mica phase (green) and sulphide phases (red) in the sample volume 59

Conclusion

As a result, it was possible to establish the shape and degree of the bonding of the sulphide phase by the CT method. Ideas were received about the relationship between the bulk of the rock represented by olivine and sulphides.
In the same way, the technique of multiscale scanning of rock samples.

References:

1. R.A. Ketcham , R.D. Hanna , S.A. Eckley, «Petrography in 3D: Why isn't everybody doing it?», Micro-CT User Meeting 2017, 13-14, 2017.