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METHODS OF IMAGE ANALYSIS IN MORPHOLOGICAL AND QUANTITATIVE-QUALITATIVE INVESTIGATIONS OF HEAVY MINERALS FROM LOWER CARBONIFEROUS ROCKS OF WESTERN POMERANIA

Abstract: The authors applied some methods of image analysis in qualitative and quantitative studies of heavy minerals. Also analysed were such morphological features as the shape and elongation. The subject of investigations represented about 4,000 grains – transparent and opaque heavy minerals, separated out from three lithological rock types: mudstone, lithic arenite and marly dolostone. No essential differences in the development and quantity of the minerals have been found in the three rocks studied. Image analysis has been proved the method considerably speeding up measurements usually carried out using traditional techniques and allowing description of the minerals with a large number of geometric parameters.

This is the preliminary stage of a research process. In the future Authors plan to develop their research further and enrich them with the other, new techniques of image analysis.

Keywords: image analysis, heavy minerals, zircon, Western Pomerania

INTRODUCTION

Heavy minerals are accessory components of rocks from volcaniclastic formations of the Lower Carboniferous from Western Pomerania (tectonic zone Koszalin-Chojnice). Their qualitative and quantitative description provides information on the genesis of the framework minerals. However, standard methods of quantitative measurements are long-lasting and thus not always applied in investigations. The authors aimed to test computerized image analysis for this purpose. Morphological parameters of heavy minerals were measured and compared among three lithologically different rock types. The data obtained give detailed and statistically viable morphological characteristic of heavy minerals.

MATERIAL

The heavy minerals studied were separated out of the rocks collected from boreholes Kurowo-1 and Biesiekierz-2. They represent three lithological types: mudstone, lithic arenite (medium-grained volcaniclastic sandstone) and marly dolomite. The rocks in question lie in the Kurowo-1 (Kr-1/14) at the depth 2,600 m

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(mudstone) and in the Biesiekierz-2 at the depth 2,886.65m (Bs-2/32; lithic arenite) and 2,986.3m (Bs-2/51; marly dolomite), and belong to the lithostratigraphic Gozd Arkosic Sandstone Formation (Matyja et al. 2000).

METHODS

Investigations were carried out on grain mounts. After mineral identification, the grain mounts were photographed under an Olympus BX-51 polarizing microscope equipped with a digital CCD camera. For each grain mount a set of around 100 photographs was taken, each of them containing from several to several tens of grains of heavy minerals. The photographs gave thus about 4,000 objects (mineral grains) for image analysis.

The digital photographs were subjected to preliminary filtration and automatic thresholding, obtaining binary images of heavy minerals. It must be stressed that due to specific procedures of automatic image analysis not all minerals recorded were subjects of measurements. In particular, the grains that exceeded partly the limits of the image, those situated too close to each other and those overlapping, as well the grains poorly visible (e.g. transparent minerals with flat or variable relief, such as carbonates - dolomite, calcite) were omitted.

Among a large quantity of geometrical parameters measurable in the programs used (APHELION v3.2 and MicroMorph 1.3), the following were selected (It must be stressed out that the presented parameters are not all geometrical ones, which may be of use during automatic image analysis of heavy minerals fraction.):

1. Grey levels analysis. The method makes possible differentiation between transparent and opaque minerals. To obtain this goal, the mean grey level was determined for the set of minerals analysed. The value of this parameter was the basis to distinguish the two groups of minerals.

2. Area measurements. The areas of the distinguished transparent and opaque minerals were measured. Separate analyses were carried out on zircons that are numerous in the samples in question and are an important petrogenetic indicator.

3. Shape factor calculated from Feret diameters. Elongations of grains was determinated, taking into consideration the ratio of maximum to minimum Feret diameters (R_{max}/R_{min}) (Tadeusiewicz, Korohoda 1997). This parameter is close to 1 for the grains with circular shape and increases with the grain elongation.

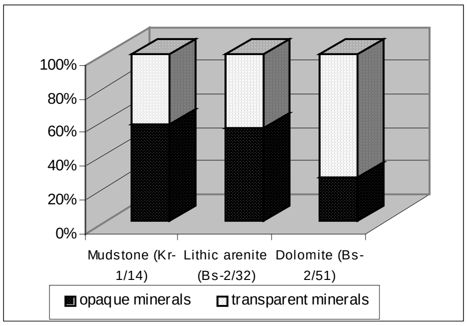

Fig. 1 The ratio of opaque and transparent heavy minerals in the rocks studied

RESULTS

1. Grey level analysis

Figure 1 presents the contents of transparent and opaque minerals. In the Kr-1/14 mudstone and in the Bs-2/32 lithic arenite the proportions of these minerals are almost equal, while in the

BS-2/51 marly dolomite the transparent minerals significantly prevail as their content is about 70%.

2. Area measurements.

The area measurements were carried out for all heavy minerals. The average areas of transparent and opaque minerals as well as separately those of zircons are presented in Figure 2.

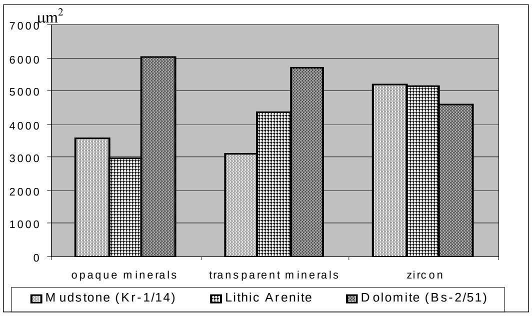

Fig. 2. Mean areas of the heavy minerals from the rocky studied

It must be remembered that the process of preliminary filtration excluded from the measurements the grains with the areas smaller than about 200 μm² (0.0002 mm²). The largest areas of single grains, over 40,000 μm² (0.04 mm²), have been noted among opaque minerals of the BS 2/51 dolomite. The grains of zircon in all the three types of rocks are characterized by approximately similar values of maximum, minimum and mean areas.

3. Feret diameters and shape factor measurements.

The shape factor obtained from Feret diameters determines elongation and shape of the heavy minerals distinguished (Fig. 3). The measurements were carried out on the heavy mineral fractions separated only from the Kr-1/14 mudstone and

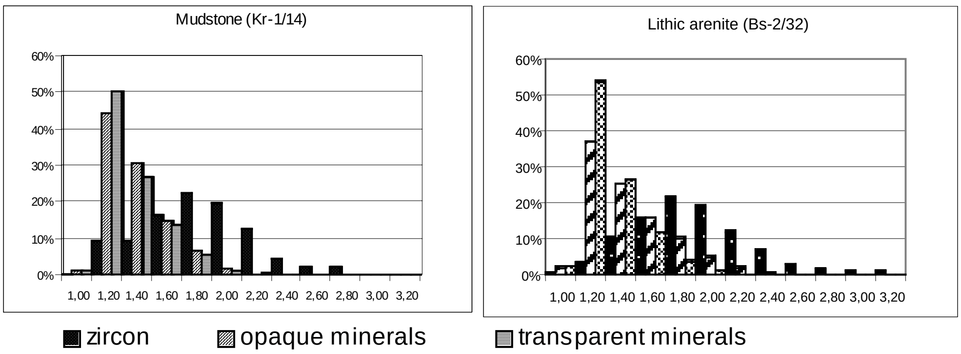

Fig. 3 Elongations of the heavy minerals from the rocky studied

the Bs-2/32 lithic arenite (transparent rains, opaque grains, zircons). In the Bs-2/51 dolomite fraction, although the total amount of heavy minerals is high, zircons are subordinate minerals and statistically representative measurements (Ryś 1982) could not be made.

In both samples (Kr-1/14 and Bs-2/32) transparent heavy minerals (except for zircons) and opaque minerals show elongations in the range 1 to 2, mostprevalent elongations being 1.2. The minerals are well rounded, with their outlines approximating the circle. The grains of zircon have their elongations from 1 to about 3 (most of them from 1.8 to 2.2), thus are less rounded. These figures suggest that among the zircons prevail the grains with sharp outlines and relatively large elongation, typical features of volcanogenic zircons. The remaining heavy minerals, both transparent and opaque, reveal large and medium roundness, according to the classification of Pettijohn et al. (1972), while elongation of their species is rather low.

CONCLUSIONS

The rocks studied are characterized by similar composition of heavy minerals. Their development and geometrical parameters generally do not depend on the rock type. In the Carboniferous volcaniclastic formations of Lower Pomerania occur the rocks, whose heavy fractions are strongly differentiated and, thus, should be subject to separate investigations (Godyń, Muszyński 2002).

The Authors have access to whole variety of parameters which can be used during analytical image analysis, but these were not presented within this thesis. Used parameters were chosen form the great many ones, just to confirm adequacy of performed analyses.

Also it is possible to use the automatic image analysis method for detailed observing the rest of heavy minerals geometrical features characteristics, not only zircons but e.g. tourmalines, apatites, biotites as well.

The methods of automatic image analysis are not common in studies of heavy minerals. The authors have showed that they may be successfully applied in determination of some morphological parameters of mineral grains (shape, size, elongation, and others). Image analysis speeds up tedious and time-consuming traditional methods of measurements, such as point-counting microscopic quantification. Image analysis provides also characteristic of the mineral grains on the basis of a substantial number of geometrical parameters, which are usually indeterminable in traditional measurement techniques.

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