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APPLICATION OF MAGNETIC METHOD IN THE GEOLOGICAL RESEARCH OF FACIAL DIFFERENTIATION OF THE UPPER JURASSIC LIMESTONES IN KRAKOW-WIELUN UPLAND, SOUTHERN POLAND

According to magnetic survey, there are strong linear and a few 3D anomalies on the Krakow-Wielun Upland. The upland is built mainly of Upper Jurassic massive and bedded limestones. All anomalies were caused by large intrusions in the upland's Palaeozoic basement. They are associated with the significant fault zone that separates terrane-like crustal blocks. In the Late Jurassic, presence of the intrusions in the bedrock caused forming of elevations on the sea bottom. Such elevations were the most important factors which stimulated growth of carbonate reef-like buildups. In the landscape of the Krakow-Wielun Upland these buildups form characteristic monadnocks. The interpretation of magnetic survey conducted in this area allows to understand the genesis and morphology of the upland.

По данным магниторазведки на Краковско-Велюньской возвышенности наблюдаются ярко выраженные линейные и некоторое количество пространственных аномалий. Возвышенность сложена из верхнеюрского массива и наслоенных известняков. Все аномалии вызваны крупными интрузиями в палеозойское основание возвышенности. Они связаны со значительной зоной разлома, которая разделяет автохтонные блоки земной коры. В позднеюрский период присутствие интрузий в материковом основании вызвало формирование поднятий морского дна. Поднятия были наиболее важным фактором, стимулировавшим рост карбонатных рифообразных образований. В рельефе Краковско-Велюньской возвышенности эти образования образуют характерные монадноки. Интерпретация данных магниторазведки, проведенной в данном регионе, позволяет понять генезис и морфологию возвышенности.

INTRODUCTION

The Kraków-Wieluń Upland (KWU) is situated in the southern Poland; it extends from the Kraków area in the south for about 160 km to the Wieluń area in the north (Fig.1). In KWU, there are many hill ranges built of the Upper Jurassic limestones that are separated from each other by extensive morphological depressions. Due to morphology, the KWU is divided into the Kraków Upland, Częstochowa Upland and Wieluń Upland. It is caused mainly by the differentiated lithology of the Upper Jurassic deposits. In the KWU the limestones occur in three facies type: massive, bedded with cherts and platy [4]. The facial differentiation caused varied morphology of the whole upland. Regionalism of the development of the carbonate buildups complexes, which are represented by the massive limestones, in particular parts of the KWU has been discussing since recently in detail [6, 7, 12]. An appearance of the first small carbonate buildups in the end of the Early Oxfordian in the Częstochowa Upland was explained by the existence of small elevation on the sea bottom whose genesis was unclear [14].

Growth of the similar forms in southern part of the Kraków Upland was connected with intensified water movement above the break of bottom slope [14]. Particularly intensive farther development of the carbonate buildups in the Kraków Upland was explained by the presence of intrusions in Palaeozoic basement and, what resulted from it, significantly low subsidence in the Late Jurassic [9, 11]. The magnetic surveys show a relation between facial differentiation of the Upper Jurassic deposits and the Palaeozoic basement.

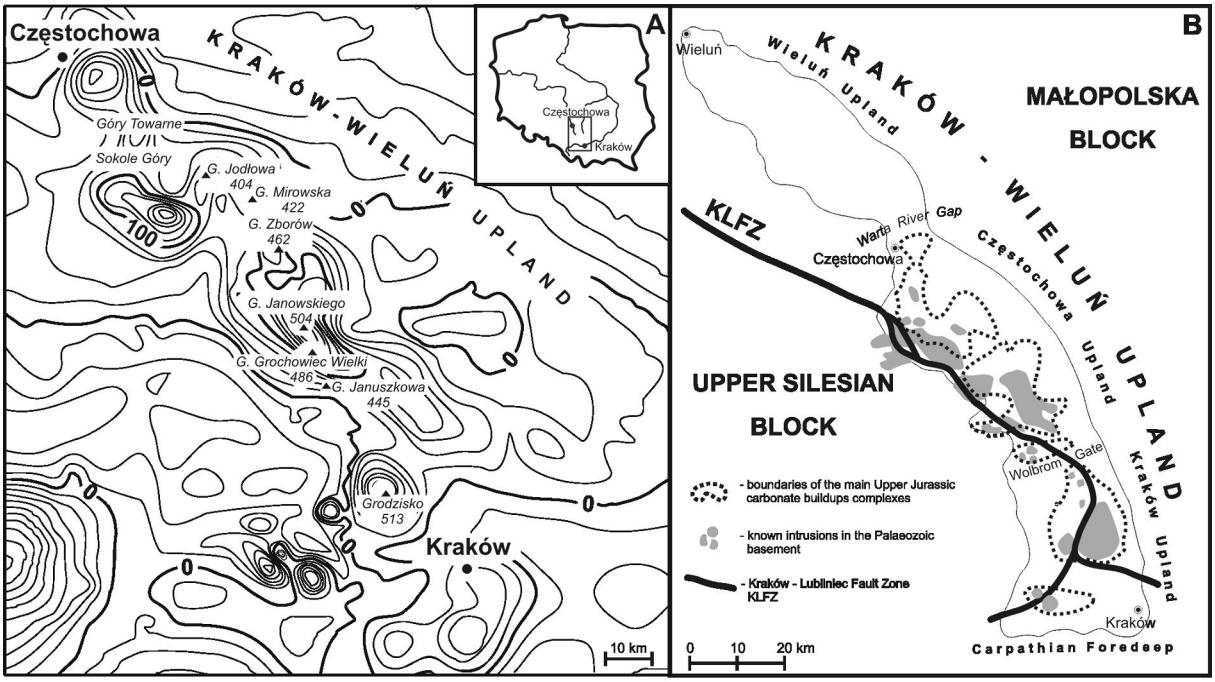

Fig.1. Comparison of the magnetic anomalies of the Kraków-Wieluń Upland with the main Upper Jurassic carbonate buildups location. A – Map of the first vertical derivative ΔT calculated according to Baranov's formula, s = 3 km (after Grabowska *et al.* [5]) with the highest picks. B – Location of the main Upper Jurassic carbonate buildups complexes on the backgrounds of the Palaeozoic intrusions (after Jędrys *et al.* [6], modified)

THE UPPER JURASSIC CARBONATE BUILDUPS COMPLEXES ON THE KRAKÓW-WIELUŃ UPLAND

The Kraków Upland

The south part of the KWU is a solid plateau-like block. From the south it is limited by the Carpathian Foredeep and from the north by the extended depression of the Wolbrom Gate (Fig.1). The absolute heights of the highest exposed Upper Jurassic monadnocks are above 500 m [1], (Fig. 1A). The monadnocks are mainly made of massive limestones, which represent microbial-sponge buildups complexes that are characterised by the presence of rigid framework.

The basement of the central part of the Kraków Upland, so-called the Ojców Plateau, is the Jerzmanowice Ridge which is tectonically lifted [15]. Its maximum height is located between villages Bębło and Jerzmanowice and is shallow under the Jurassic deposits. The magnetic survey in this area revealed a magnetic anomaly, which was a subject of ΔT interpretation – the total magnetic Earth field [6].

On the magnetic vertical component map ΔZ of the Ojców Plateau, on the background of 3D anomaly, which covers almost the whole plateau area, there are a few local anomalies, also 3D [6]. Their maximum values are in the central part of the plateau. The reasons for the regional magnetic anomaly are connected with the structure of Jurassic deposits' basement. From the boreholes data, the presence of a large granitoid intrusion was stated, as well as many smaller ones, mostly porphyritic, which cut through the Cambrian-Silurian formations; and also numerous manifestations of volcanism, which are represented, among others, by lava covers and volcanic necks, mainly andesite and rhyolite [2, 15, 16]. The magmatism manifestations are connected with location and activity of the Kraków-Lubliniec Fault Zone (KLFZ), which is a border between two terrain-like blocks: the Upper Silesian Block and Małopolska Block (Fig. 1B). These blocks are located on the SW forehead of the East European Craton and they belong to the central European part of the Palaeozoic Platform [3].

Due to denudation, which had started in the Late Palaeozoic, the Cambrian–Silurian formations were eroded down to the intrusions that are located along the KLFZ [2, 15, 16].

The location of the intrusions responds to the magnetic anomaly areas (Fig.1). What is more, numerous second-order local anomalies are observed and these are connected with smaller intrusions, which occur shallow under the surface. In the Ojców Plateau a close correlation between the anomalies' pattern and the location of rocks groups that represent the Upper Jurassic carbonate buildups complexes is observed. In the areas where the massive limestones, which represent carbonate buildups, occur, the magnetic anomalies' values are the highest. The minimums are in the depressions, where weakly firm platy limestones and bedded limestones with cherts are; they both represent inter-buildings and basin facies.

The Częstochowa Upland and Wieluń Upland

The Częstochowa Upland is made of numerous, smaller hill ranges built of the Upper Jurassic limestones. This characteristic differs the Czestochowa Upland from the Kraków Upland (Fig. 1B). In the Częstochowa Upland, the Upper Jurassic sediments are more differentiated, significantly different from the uniform Kraków Upland block [9, 10, 12, 14]. In the Częstochowa Upland dominate microbial-sponge buildups, which to the N and W direction are gradually replaced by sponge-microbial ones. These have poorer developed rigid framework and as a result are less weathering-resistant. Between individual carbonate buildups complexes occur weakly firm types of the bedded limestones. Facial differentiation and, connected with it, different weathering-resistance of the individual limestone types resulted in uncovering of the carbonate buildups complexes in the Częstochowa Upland. It causes broad morphological differentiation of this part from the whole KWU.

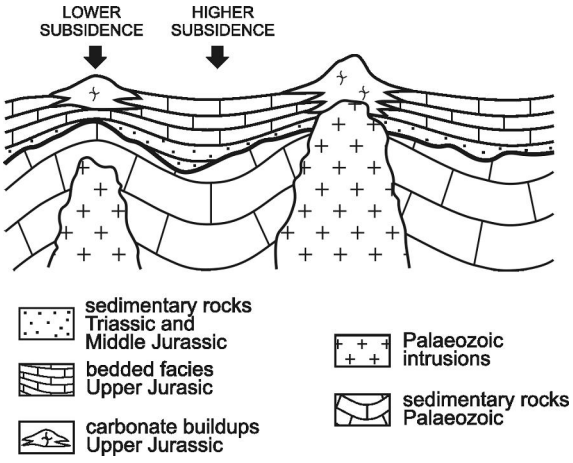

Fig.2. Influence of the intrusions' presence in the Palaeozoic basement onto establishment and development of the carbonate buildups in the Late Jurassic (after Krajewski *et al.* [8], modified). Initially, the establishment and growth of the carbonate buildups took place on the elevated sea bottom fragments (right part of the sketch). The areas, where intrusions lay deeper in the basement, had lower subsidence which caused that there also, with the time, sea bottom elevations were created (left part)

Comparing the main Upper Jurassic rocks complexes distribution on the Częstochowa Upland with the magnetic anomalies location (Fig.1), a strong similarity is to observe. The reasons for these anomalies, like in the Kraków Upland, seem to be connected with the Palaeozoic basement.

The north part of the KWU is the Wieluń Upland. This part, which spreads between Częstochowa and Wieluń, is a plain with not significant drops and absolute heights up to 300 m. The Upper Jurassic sediments rarely occur on the surface because glacial and fluvial-glacial Quaternary sediments cover them. The structure of the Upper Jurassic deposits is monotone, and their natural outcrops are rarely. The massive limestones represented by the carbonate buildups only sporadically occur, and as dominating are weakly firm bedded limestone types, like platy or chalky [9, 10].

The magnetic anomalies in this part of the KWU are not so strong and clear like in its central and southern part, and their values are clearly lower (Fig.1). It is caused by the fact that the KLFZ is behind this part of the upland; it turns to the west, which results in lack of the intrusions.

CONLUSIONS

The magnetic method allows the Palaeozoic basement with the Upper Jurassic buildups distribution in the KWU to compare. It helps in understanding of genesis and facial differentiation of the carbonate buildups. The location of the main hill ranges of the KWU, which are built of the massive limestones, responds to the location of the main Palaeozoic intrusions. It suggests, that among other factors, like syn-

sedimentary tectonics [7, 9, 11], the crucial influence on origin and development of the carbonate complexes had presence of the intrusion along the dislocation KLFZ. Part of them, because of their greater resistance in comparison to the surrounding Palaeozoic sedimentary deposits, was not completely denudated and created elevations on the Tethyan shelf before the Late Jurassic (Fig.2) [2, 4, 6, 15].

In turn, characteristic of the areas where denudation of the Palaeozoic basement did not reach the intrusions was lower subsidence in comparison to the neighbouring areas. This makes them privileged to forming structural elevations on the sea bottom. It resulted in an intensive carbonate production on these elevations, development of benthonic fauna and finally, led to forming of the extended carbonate buildups complexes, which nowadays are very well visible in the morphology of the KWU.

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