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**CONTACT METAMORPHISM INDUCED BY TERTIARY BASALTS
IN SANDSTONES AND MARLS (EXAMPLES FROM LOWER SILESIA
AND OPOLE SILESIA)**

Abstract: Contact metamorphosed marls and sandstones were studied. Mineral assemblage allows to determine similar high-temperature zones, both in marls and sandstones. Below these zones lower temperature alterations were noted in the marls. In the sandstones lower temperature metamorphism overprint was not visible. After contact metamorphism hydrothermal activity took place. Final mineral assemblage is the effect of these two processes.

Keywords: contact metamorphism, marls, sandstones, hydrothermal activity, Lower Silesia, Opole Silesia

INTRODUCTION

The aim of this study is to compare metamorphic processes and products in marls from the „Gracze” quarry (Szeliga 2004) and sandstones from the Złotoryja region (Szeliga 2005, in print). All the alterations were induced by Tertiary volcanic rocks dated as: $26,8 \pm 1,1$ Ma in the „Gracze” quarry (Birkenmajer, Pécskay 2002), and $15,5 \pm 2$ Ma in the „Wilcza Góra” quarry (Birkenmajer *et al.* 1977). The volcanic rocks were classified as basanites in the „Wilcza Góra” quarry (Kozłowska-Koch 1987), and tephrite, basanite in the „Gracze” quarry (Kozłowska-Koch 1987). Both basanite bodies are connected with deep discontinuity zones. The altered marls were dated as Senonian/Coniacian (Aleksandrowicz, Birkenmajer 1973) and sandstones of undefined age (Jerzmański 1955; Frąckiewicz 1955; Cymerman 2004). Apart from the contact metamorphism, hydrothermal activity overlapping earlier processes is present.

SAMPLING AND ANALYTICAL METHODS

Marls were sampled in the “Gracze” quarry (the Opole Silesia) under basanite body, on the contact and in various distances from the contact. Samples of dark grey sandstones underlying both marls and basanite were also collected.

Sandstone samples were collected from the „Wilcza Góra” quarry (the Lower Silesia), also from the contact and in various distances from the contact. Non-altered rocks of the same lithology and age were collected in order to make a comparison: marls from brickyard in Komprachcice close to Opole, and Triassic sandstones in the “Czerwony Kamień” quarry, south from Złotoryja and “Wilcza Góra” quarry. The age of the sandstones collected in the “Wilcza Góra” quarry is uncertain. It was denoted as a Cretaceous on the geological map (Jerzmański 1955) it is possible that they are Triassic, emplaced there during

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tectonical activity in this area (the Jerzmanice fault, which is situated close to the quarry, Z. Cymerman personal communications).

X-ray powder diffraction, scanning electron microscopy with energy dispersive system, optical microscopy and cathodoluminescence (so called “hot-CL” and “cold-CL”) were used. Clay minerals were also separated.

RESULTS

Non-altered marls are composed of calcite, quartz, mica (muscovite?), K-feldspar and kaolinite. Non-altered sandstones are composed of quartz, K-feldspar, mica (muscovite), kaolinite and hematite.

Narrow (up to 1,5 m from the contact) zone of high temperature alterations was noted in the marls from the “Gracze” quarry. In this zone quartz, high- and low-sanidine (identified on the basis of triclivity index (Goldshmidt, Leaves 1954), three peak identification (Wright 1968) and PDF (Powder Data File) cards), calcite, pyroxene and very low amount of plagioclase were determined. CL investigations show recrystallisation of calcite in the rock matrix and cracks filled by calcite (three generations with different luminescence). Also two generations of K-feldspar identified on the basis of different luminescence colours were noted close to the contact. Further from the contact (at distance more than 2 m) lower temperature minerals (diopside, low-sanidine) were determined. Illite/smectite dominate in the clay minerals separated from samples in the whole profile.

The metamorphosed sandstones also show the presence of narrow zone of high-temperature contact metamorphism. The rocks are composed of quartz, high- and low-sanidine and clay minerals (illite/smectite). High temperature minerals are present up to 1,5 meter from the contact. Microscope observations revealed the presence of recrystallised quartz and K-feldspar. Quartz in cracks shows red CL colours in the high temperature zone. Also two generations of K-feldspars showing different CL colours can be commonly found close to the contact.

Further from the contact only quartz and K-feldspars (probably orthoclase), and illite/smectite minerals are present.

Hydrothermal activity in marls induced zeolite neoformation. Close to the contact natrolite is present, further from the contact phillipsite dominates.

Hydrothermal activity in sandstones caused hematite removal and illite/smectite growth. Far from the contact neoformed I/S minerals after kaolinite (recognised basing on their morphology) are present.

DISCUSSION AND CONCLUSIONS

Comparison of contact metamorphism in the „Gracze” and „Wilcza Góra” quarries show presence of narrow zone (up to 1,5 m) of high temperature contact metamorphism (Fig. 1). Metamorphic conditions in these zones are similar in marls and sandstones and were determined previously (Szeliga 2004, 2005 – in print). On this basis temperatures were determined within the range 730 – 950° (Miyashiro 1994; Szamałek, Barczuk 1986). Recrystallisation processes are present both in marls (calcite recrystallisation) and sandstones (quartz and feldspar recrystallisation). Red luminescent (CL) quartz can be interpreted as shock quartz – formed in high temperature, pressure and short time metamorphism (Ramsayer *et al.* 1992).

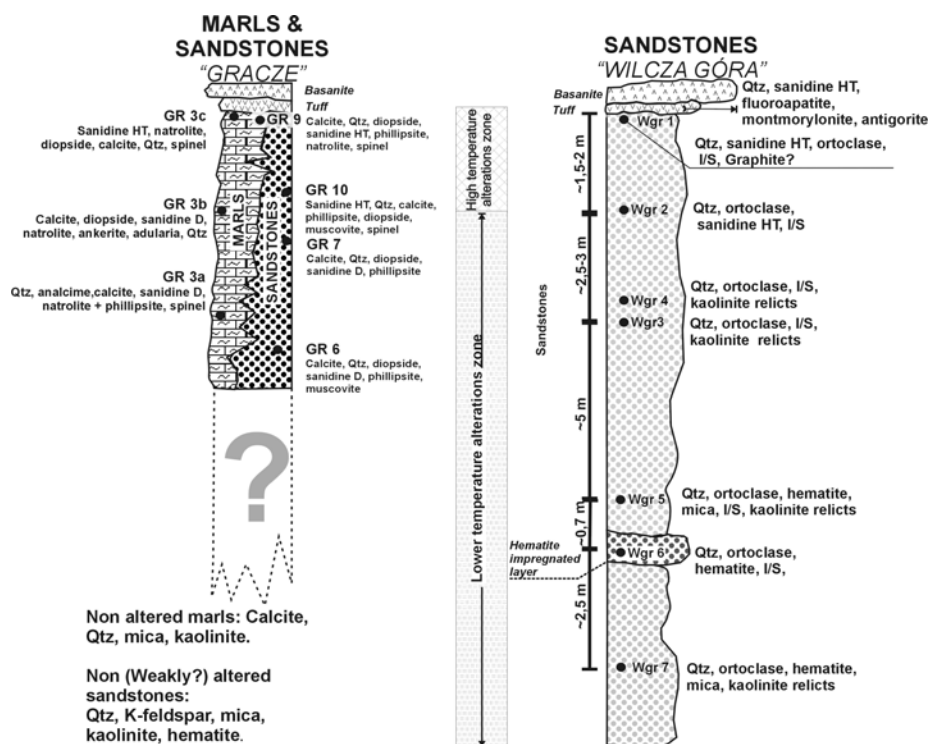


Fig. 1. Profiles of altered marls and sandstones from the „Gracze” and „Wilcza Góra” quarries. Qtz – quartz, sanidine HT – high temperature sanidine, sanidine D – low temperature sanidine, I/S – illite/smectite clay minerals.

Lower temperature metamorphism is present further from the contact. In marls identification of this zone is based on the mineral assemblage (Szeliga 2004; Fig. 1). In sandstones determination of this zone is doubtful due to the lack of diagnostic minerals. Temperature probably ranged 475 – 830°C (cf. Miyashiro 1973).

Hydrothermal alterations observed in the studied samples show similarities in clay minerals formation processes. Those processes may be divided into two stages: 1) illitisation of kaolinite, which may occur in the contact alteration stage, as suggested earlier or in the early hydrothermal stage (Jacobsson, More 1986), and then 2) smectitisation of illite. Formation of zeolites in the marls occurred in temperature range 70 – 250° C and pH ~ 12,5 (cf. Kawano, Tomita 1997; Wirshing 1979, 1981; Szeliga 2003). Hematite was removed by hydrothermal fluids (McKinley *et al.* 2001). “Bleaching” intensity is high close to the contact and then, further from the contact decreases (Fig. 1).

Contact metamorphism processes in the marls and sandstones are similar:

- narrow zone with presence of high-sanidine,
- recrystallisation processes present in metamorphosed marls and sandstones (up to ~1,5 m),
- kaolinite decomposition and I/S minerals neof ormation (partly during hydrothermal activity – smectitization),
- subsequent hydrothermal activity with effects different in marls (zeolite formation) and in sandstones (“bleaching”) caused by primary chemical and mineral composition of the rocks.

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