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CONTACT AND HYDROTHERMAL ALTERATIONS IN CRETACEOUS MARLS FROM THE GRACZE QUARRY - PRELIMINARY RESULTS

Abstract: Cretaceous **s**edimentary rocks (marls and sandstones) from the contact with Tertiary basanite as well as non-altered rocks were studied and numerous newly formed minerals were determined. Sanidine and pyroxene hornfels facies rocks were formed at the expense of marls adjacent to basanite intrusion at the Gracze quarry (Opole Silesia). Late hydrothermal activity resulted in zeolite and clay minerals formation.

Keywords: marls, contact metamorphism, hydrothermal activity, zeolites

INTRODUCTION

The aim of the study is description of contact metamorphism products and determination of PT condition of metamorphism. The study area is situated in the easternmost part of Central European Volcanic Province (CEVP). The occurrence of basalts is related to the Odra fault zone (Birkenmajer 1974). The age of volcanic rocks from the Gracze quarry is Oligocene/Miocene (Rupelian – Langhian) (Birkenmajer, Pécskay 2002). The age of marls in the Gracze, Rutki and Radoszowice quarries is Senonian - Coniacian (Alexandrowicz, Birkenmajer 1973). Basanite is composed of augite, olivine, magnetite, plagioclase and nepheline (Chodyniecka 1969). Tuff accompanying basanite is composed of the same minerals as basanite and additionally contains zeolites (chabazite group; Kapuściński, Probierz 1999). Szeliga (2003) described these zeolites as NAT (natrolite) and PHI (phillipsite) types according to IZA classification (Baerlocher et al. 2001).

SAMPLING AND ANALYTICAL METHODS

Samples were collected in the Gracze quarry under the main basanite body. Samples represent marls from the direct contact with basanite (4 samples) and from different distances from the contact (7 samples). Calcite cemented sandstones under-laying marls and basanite were also collected (4 samples). Non-altered marls were collected for comparison from brickyard in Krompachcice near Opole (2 samples). The age of Krompachcie marl is the same as those in the Gracze quarry.

Scanning electron microscopy with energy dispersive spectrometry, X–ray powder diffraction, cathodoluminescence and optical microscopy were used.

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Triclinicity of K-feldspar was determined according to Goldsmith & Laves method (1954).

RESULTS

Unaltered marls are composed of calcite and quartz with minor amount of mica minerals (muscovite?) and kaolinite.

Mineral composition of metamorphosed marls is varying depending on distance from the contact (Fig. 1). Within 1,5 m zone situated close to the contact, quartz, calcite (three generations of secondary calcite according to determination in cathodoluminescence), pyroxene (diopside), K-feldspar (high-sanidine and probably low-sanidine within the same zone; e.g. sample GR3c, GR9), very low amount of plagioclase, Fe-Ti- spinel and natrolite (NAT type zeolite; close to the contact; e.g. sample GR3c, GR3b) are present (Fig. 1). Only in one sample of marl, collected from strongly tectonised zone at the contact with basanite phillipsite (PHI type zeolite) is present. At the direct contact between marls and basanite aluminosilicate rich in K^+, Na^+, Ca^{2+} was found (probably ternary feldspar).

With increasing distance from the contact with basanite, mineral composition of metamorphosed marls is changing. At the distance 2 - 3,5 m from the contact beside K-feldspar (low-sanidine), zeolite minerals are also present. Natrolite is accompanied by phillipsite (2 – 3,5 m from contact; sample GR3a), and then in lower part of the profile only phillipsite is present (e.g. sample GR6) (Fig. 1). Far from the contact (in marls), and occasionally on the contact (one sample) analcime is present. Clay minerals are dominated by illite/smectite (I/S), but mica is also present

Main metamorphic minerals in sandstones are pyroxene (diopside) and feldspar (high- and low-sanidine) similar as those in marls (Fig. 1). In opposition to marls, phillipsite is present in sandstones in all samples (even close to the contact). Also one sample of marl (GR9) situated close to the contact both with basanite and sandstone exhibits presence of phillipsite.

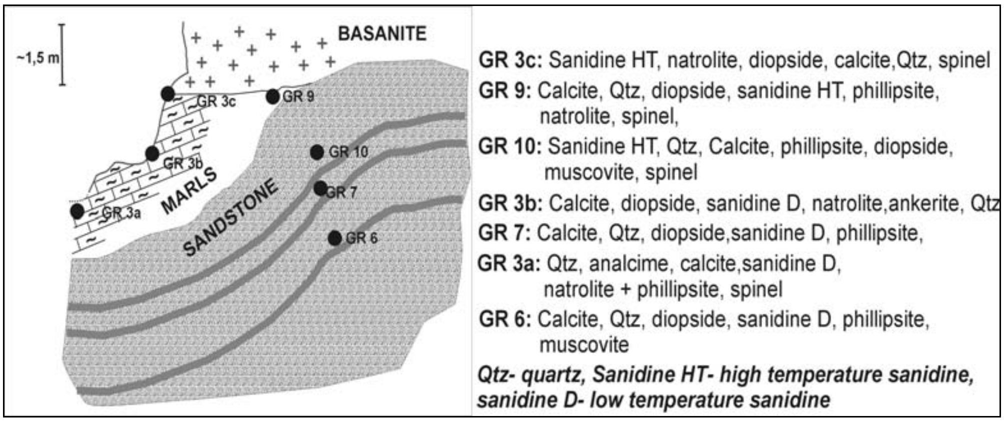

Fig. 1. Sketch of outcrop of contact zone and location of samples studied.

DISCUSSION OF RESULTS AND CONCLUSIONS

Mineral composition of unaltered and metamorphosed marls is different. Kaolinite is decomposed during progress of metamorphism. Calcite is partly decomposed and Ca is consumed during growth of secondary minerals e.g. diopside. Presence of high-sanidine suggests high temperature metamorphism (temperature range between 730-1100 ºC; Miyashiro 1994). Possible presence of ternary feldspar can also indicate high temperature conditions. High temperature metamorphism has affected narrow zone (up to 1.5 m) near the contact (Fig. 1). In distance bigger than 1.5 m low-sanidine and diopside are present what indicates pyroxene hornfelse facies conditions with temperature range from 475 to 830 ºC (Miyashiro 1973).

Presence of zeolites in metamorphosed marls and sandstones can be connected with low temperature metamorphism and with subsequent hydrothermal activity. Growth of natrolite took place in temperatures lower than 150 ºC and pH ~12,5 (according to experimental data by Wirsching 1979, 1981). Phillipsite, which origin is related to higher temperatures (range between 150 and 250 °C and pH 12-13 according to experimental data of Kawano, Tomita 1997) is present in bigger distance from the contact. It can suggest reheating of sedimentary rocks and phillipsite growth (second stage of hydrothermal activity?). Phillipsite can also replace older natrolite during re-heating of sedimentary rocks related to subsequent stages of hydrothermal activity. This process of replacement of Na-zeolites by Ca-zeolites related to increase of temperature was suggested by Thugutt (1899). Other factors like solution/rock ratio controlled by permeability can influence zeolite growth (e.g. phillipsite growth in sandstones close to the contact) (Cartwright, Buick 2000, Dutrow et al 2001). Phillipsite growth can be also caused by differences in chemical composition of protolith. Also neoformed I/S minerals can be related to hydrothermal solutions activity (Jakobsson, More 1986). Three stages of hydrothermal activity are documented by three generations of calcite cement observed in cathodoluminescence.

Occurrence of analcime can suggest dehydratation reactions of natrolite (sample GR3a) caused by reheated of sandstones (Van Houten 1971, Miyashiro 1973).

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