POLSKIE TOWARZYSTWO MINERALOGICZNE – PRACE SPECJALNE
MINERALOGICAL SOCIETY OF POLAND – SPECIAL PAPERS
Zeszyt 24, 2004; Volume 24, 2004

Andrzej BARCZUK[1], *Andrzej KOZŁOWSKI*[1]

FLUID INCLUSIONS IN QUARTZ REGENERATION COATINGS IN BUNTSANDSTEIN FROM THE NORTHERN MARGIN OF ŚWIĘTOKRZYSKIE MTS, CENTRAL POLAND

Abstract: The sandstones of the Buntsandstein beds from Tumlin and Ciosowa, formed from aeolian sands, have usually three regeneration coatings on quartz grains. The earliest fluid inclusions of diagenetic origin bear salts typical of desert evaporate environment ($CaSO_4$), whereas the later ones contain NaCl solution with methane and carbon dioxide. Homogenization temperatures of inclusions (72°C) suggest the burial depth of ca. 2 km and pressure up to ca. 0.6 kbar.

Keywords: fluid inclusion, quartz, regeneration, Buntsandstein, dune, Świętokrzyskie Mts

INTRODUCTION

The Lower Triassic deposits in the Northern margin of Świętokrzyskie Mts (Fig. 1) consist of alternating sandstones, mudstones, claystones and locally conglomerates of the total thickness of several hundred metres (Gradziński et al. 1979). They cover discordantly Zechstein or Devonian beds and are overlain by Rhaetian and Muschelkalk deposits.

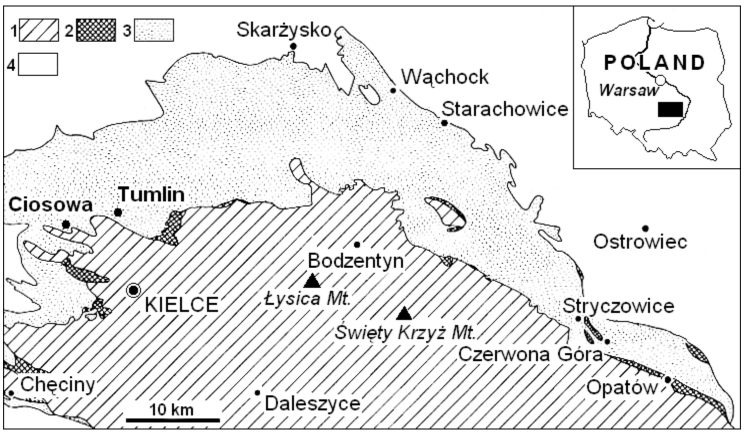

Fig. 1. Lower Triassic (Buntsandstein) deposits in the northern margin of Świętokrzyskie Mts.; 1 – Caledonian and Variscan complex, 2 – Zechstein, 3 – Lower Triassic, 4 – post-Lower-Triassic deposits.

[1]*Institute of Geochemistry, Mineralogy and Petrology, Faculty of Geology, Warsaw University, al. Żwirki i Wigury 93, 02-089 Warszawa, Poland, e-mail: a.barczuk@uw.edu.pl; a.j.kozlowski@uw.edu.pl*

Lower and Middle Buntsandstein sediments formed in the continental and lagoon environments; their lowermost part was alluvium accumulated by braided meandering rivers, flowing generally in the N–S direction (Mader, Barczuk 1985). The overlying lower part of Middle Buntsandstein consists of dune sediments intercalated by subordinate inter-dune accumulations and alluvia of the seasonal braided rivers in the environs of Tumlin (Gradziński et al. 1979).

Upper part of the Buntsandstein log in the NE margin of Świętokrzyskie Mts. consists of the playa sediments alternating with the beds formed in brackish and lagoon basins, and gradually changing to carbonate Muschelkalk marine sediments (Kuleta 1987). The Buntsandstein sediments accumulated in cyclically varying environment (Nawrocki et al. 2003). In its central part, the Buntsandstein basin was of the shallow marine type, periodically changing to saline lake with evaporate (gypsum) sedimentation during the time of stagnation (Szyperko-Teller 1997).

SAMPLES AND METHODS

Thirty three samples of the Lower and Middle Buntsandstein sandstone were collected in the Tumlin and Ciosowa quarries. The samples were used for thin sections to perform the routine microscope studies, and for double-side polished ca. 0.3 mm thick preparations for fluid inclusion studies. The latter studies were made by means of typical freezing and heating microscope techniques (*Fluid Co.* equipment); the inclusions were open by use of the microscope crushing stage (see Roedder 1984). The chemical composition of the inclusion precipitates was determined by means of a Cameca sx100 electron microprobe in the EDS regime in the Inter-Institution Laboratory of Microanalysis of Minerals and Synthetic Substances at the Faculty of Geology, Warsaw University.

RESULTS

Buntsandstein psammites consist of quartz arenites, sub-lithic arenites, quartz wackes of usually well-sorted and well-rounded grains, though poorer rounded grains are common. Cements of the sandstones are mainly clayey-ferriferous, however carbonate, siliceous and gypsum-anhydrite cements are not rare (Barczuk 1979, Kuberska 1999). The sandstones considered as the subaeral, brackish and marine ones typically bear quartz detritic grains with diagenetic regeneration coatings, thus yielding subhedral or euhedral habits. The content of the regenerated detritic quartz grains distinctly increases toward the upper part of the Buntsandstein log. The grains are coated by several (usually three) layers of quartz, separated from the detritic quartz by thin zone of minute black or brown-red solid inclusions. The regeneration coatings are discernible by cathodoluminescence as well. Dissolution of fragments of the detritic quartz grains and decomposition of silicates were the probable sources of silica which formed the coatings afterwards (Barczuk 1979, Kuberska 1999).

Fluid inclusions in the regeneration coatings were found rarely (for this study the measurements were possible in 159 inclusions, located in 89 grains); their size did not exceed 10 μm. Due to their position, the inclusions could be divided into five main groups of different abundance, as characterized here (Fig. 2). **Group 1:** 3 primary liquid aqueous one-phase inclusions in the solid inclusions zone, closest to the detritic grain, precipitate yielded major contents of Ca and S, and minor Na. **Group 2:** 16 primary inclusions filled with carbon dioxide of various density and 47 primary one-phase liquid aqueous inclusions or with very small shrinkage gas bubble within the earliest diagenetic quartz zone; dissolved salts contained Na, Ca, S, Cl and C. **Group 3:** 34 secondary gas-liquid aqueous inclusions in healed fractures cutting detritic core and the earliest diagenetic coating, apparently of heterogeneous trapping, because they contained liquid and gas phases of variable ratios; the dissolved salts contained Na, Ca and Cl. **Group 4:** 31 primary gas-liquid aqueous inclusions of variable phase ratios, however seven of them yielded the same homogenisation temperatures, thus accepted as indicating the formation conditions, the solutions contained Na, Cl and minor Al and Fe, moreover 8 inclusions filled with mixture of methane and nitrogen; these inclusions occurred in the second, outer diagenetic coating. **Group 5:** 14 primary gas-liquid aqueous inclusions of variable phase ratios in the youngest regeneration coatings or interstitial lining between grains, inclusion solutions contained Na and Cl; moreover 6 CO_2-rich inclusions of variable density, occurring in the same regeneration quartz zone.

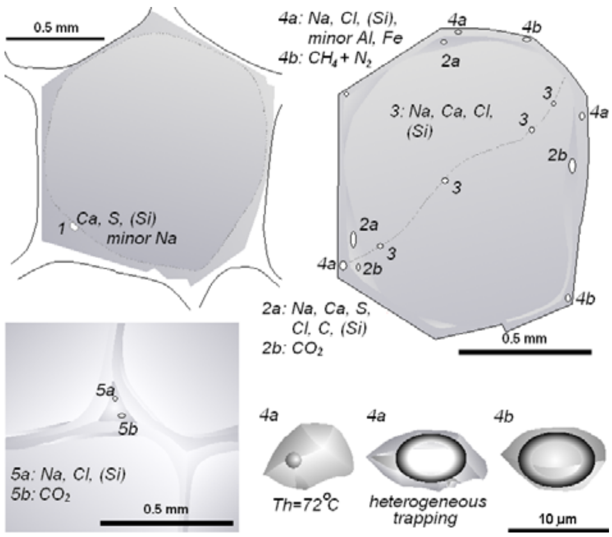

Fig. 2. Regeneration inclusions and their positions in grains and diagenetic coatings, the numbers refer to the descriptions in the text, the letters *a* and *b* distinguish aqueous and non-aqueous inclusions. Si in the analyses comes from host quartz.

CONCLUSIONS

The diagenetic processes in Buntsandstein sediments developed in presence of fluids of variable composition. The early fluids contained calcium and sulphate ions with minor sodium – this reflects well the sandy desert conditions. These solutions were replaced by aqueous fluid with chloride, sulphate, carbonate, sodium and calcium ions, and carbon dioxide. Later the solutions became poorer in ions species (contained Na^+, Ca^{2+} and Cl^-), afterwards gaining aluminum and iron, probably from decomposing silicates; the conditions were reducing at this stage, what was evidenced by occurrence of methane-bearing inclusions. This stage led to a certain stabilization of the diagenesis conditions, as indicated by several inclusions of homogeneous trapping, which gave homogenization temperatures (Th) 72ºC. This value may suggest the depth of burial of ca. 2 km and pressure of ca. 0.6 kbar. Finally, the fluids changed to the oxidized ones (as shown by the presence of carbon dioxide) and with very simple composition of the dissolved salts, which consisted only of sodium chloride (Fig. 3). All the fluids might have been derived from the saline waters of the sedimentation basin.

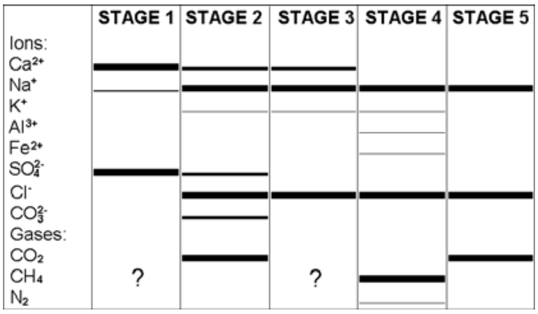

Fig. 3. Changes of composition of fluids during the five stages of diagenesis of the sandstone from Tumlin and Ciosowa, Świętokrzyskie Mts.

The research work was supported by the grants of the Faculty of Geology of the Warsaw University Nos. BW 1642/15, BW 1642/17 and BSt. 977/4.

REFERENCES

BARCZUK A., 1979: Studium petrograficzne utworów pstrego piaskowca w północno – wschodnim obrzeżeniu Gór Świętokrzyskich. Arch. Mineralogiczne, 35 (2), 87–155.

GRADZIŃSKI R., GĄGOL J., ŚLĄCZKA A., 1979: The Tumlin Sandstone (Holy Cross Mts, Central Poland): Lower Triassic deposits of aeolian dune and interdune areas. Acta Geol. Polon., 29 (2), 151–175.

MADER D., BARCZUK A., 1985: Gravelly to sandy braidpain deposition in the Czerwona Góra Beds and Stryczowice Beds (Middle Buntsandstein) of the Northeastern Holy Cross Mountains (Poland). In: Mader D., 1985 (ed.): Aspects of fluvial sedimentation in the Lower Triassic Buntsandstein of Europe. Springer Verlag, Berlin, Heidelberg, New York, Tokyo, 351–397.

KULETA M., 1987: Wykształcenie litologiczne osadów dolnego i środkowego pstrego piaskowca w NW części Gór Świętokrzyskich. Kwart. Geol., 31 (1), 231.

ROEDDER E., 1984: Fluid inclusions. Reviews in Mineralogy, 12. Mineralogical Society of America, Washington, D. C., 644 pp.

SZYPERKO-TELLER A., 1997: Trias dolny (pstry piaskowiec). Litostratygrafia i litofacje. Sedymentacja, paleogeografia i tektonika. In: Marek S., Pajchlowa M. (eds.): Epikontynentalny perm i mezozoik w Polsce. Prace PIG, 153, 112–117 and 121–132.

KUBERSKA M., 1999: Trias dolny – pstry piaskowiec. In: Maliszewska A., 1999, (ed.). Diageneza osadów permu górnego i mezozoiku Kujaw. Prace PIG, 167, 22–35.

NAWROCKI J., KULETA M., ZBROJA ST., 2003: Buntsandstein – magnetostratigraphy from the northern part of the Holy Cross Mts. Geol. Quarterly, 47 (3), 253–260.