

Michał ŻYWIECKI^{1,2}, Paweł POPRAWA³, Tomasz MALATA⁴

PROVENANCE OF THE WESTERN OUTER CARPATHIAN QUARTZ
PEBBLES – PRELIMINARY CONSTRAINTS FROM FLUID INCLUSIONS

Abstract: Conglomerate fraction of the Western Outer Carpathian flysch commonly contains vast amounts of quartz pebbles. These were analysed by means of fluid inclusion microthermometry to constrain their provenance. Two genetic types of source rocks for quartz pebbles were recognised. The first type of granulated and monocrystalline quartz, supplied to both Silesian and Magura basins from the south, were derived from hydrothermal veins. The second type of polycrystalline and monocrystalline quartz, supplied to the Silesian basin from south and to the Skole basin from north, represents metamorphic origin.

Keywords: Western Outer Carpathians, sediment source areas, quartz pebbles, fluid inclusions

INTRODUCTION

The Western Outer Carpathians (WOC) form a thin-skinned fold-and-thrust belt, build predominantly of the upper Jurassic to lower Miocene sediments of flysch character. These sediments constitute fill of former basins or sub-basins, which were detached from the original basement and thrust over the European plate. The basins or sub-basins were filled by detritus from source areas either external to the WOC (northern source, corresponding to the southern margin of Euroasian plate), or located inside the system of WOC, so called “cordilleras” (see e.g. Książkiewicz 1965, Wieser 1985). All the source areas avoided the Miocene detachment and subsequent tectonic transport towards foreland over a distance of a few hundred kilometres. Particularly, suitable for analysis of WOC’s source areas are sediments of conglomerate fraction. Common presence of quartz pebbles (e.g. Wieser 1985) is characteristic feature of flysch deposits throughout all time span. Therefore silica-rich rocks constituted volumetrically important contribution to all of the WOC’s source areas. Little is known about source rocks for the quartz pebbles. Often used term “vein quartz” suggests their origin, although there are no clear data to support it. Unrug (1968), who described quartz grains in sandstone

¹ *Institute of Geochemistry, Mineralogy & Petrology, Warsaw University, al. Żwirki i Wigury 93, 02-089 Warszawa, Poland; m.m.zywiecki@uw.edu.pl*

² *OG Petroleum Consulting, ul. Artura Grotgera 5A/6, 00-785 Warszawa, Poland*

³ *Polish Geological Institute, Department of Regional and Petroleum Geology, ul. Rakowiecka 4, 00-975 Warszawa, Poland*

⁴ *Polish Geological Institute, Carpathian Branch, ul. Skrzatów 1, 31-560 Kraków, Poland*

fraction from the Istebna Beds, suggested three types of such grains: granulated, derived from metamorphic rocks, polycrystalline related to veins and monocrystalline. According to Wieser (1985) quartz pebbles could be eroded from marginal, hydrothermally altered zones of plutonic domes or their aureoles. The above mentioned statements lack any analytical evidences.

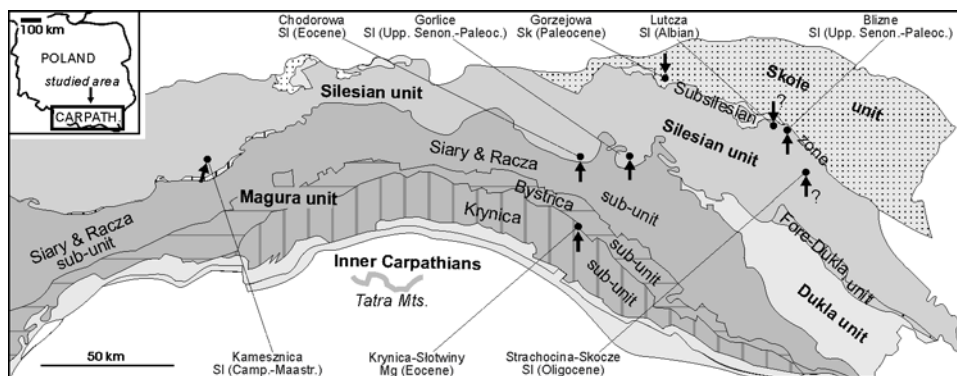


Fig. 1. Location of sampled outcrops at a background of simplified tectonic map of the WOC. Presumed deposition direction for each sampled formation is given with the black arrow. Stratigraphic age of each one is given in brackets. Sk – Skole unit; SI – Silesian unit; Mg – Magura unit.

The main objective of the present work is to discriminate between the above options using microthermometric analysis of primary fluid inclusions. At the present stage quartz pebbles from 6 localities in the Silesian unit and 1 locality in both Magura and Skole units were analysed (Fig. 1). Due to limited amount of examined material, present results should be regarded only as a preliminary. This research was supported by KBN/MOŚ (project no. PCZ-007-21), PGI (project no. 6.14.0007.00.0), and the Warsaw University (project no. BST-977/4).

MICROTHERMOMETRIC ANALYSIS OF FLUID INCLUSIONS IN QUARTZ PEBBLES

Thin sections from quartz pebbles were analysed by use of LINKAM TP92 stage with heating-cooling HFS 91 equipment. Measurements were calibrated by SynFlinc synthetic fluid inclusions. The accuracy of heating runs were $\pm 1^\circ\text{C}$ and for freezing ones $\pm 0.2^\circ\text{C}$. Inclusion trapping temperatures and pressures were calculated by crossed isochors method with physico-chemical plots of aqueous solutions and gases by Roedder (1984) and computer program FLUIDS supplied by R. Bakker. Salinities of aqueous solutions were calculated by equation described by Roedder (1984) and determination of main ions in the aqueous inclusions were done on the basis of Kozłowski (1984) procedures. Gas types were determined by the method of Roedder (1984), and van den Kerkhof (1990).

According to primary fluid inclusions analysis, four groups (1-4) of inclusion were distinguished (Fig. 2); in a single quartz pebble only one type were found.

Each of type contains both (a) gaseous and (b) aqueous inclusions, characterised as below.

Inclusions in granulated quartz in pebbles (Fig. 1) collected from Silesian Unit (Strachocina-Skocze), and Magura Unit (Krynica-Słotwiny):

1a) gaseous inclusions, 4–15 μm in size, filled by liquid and gaseous carbon dioxide, having Th from +10.5 to +11°C.

1b) aqueous inclusions, 1–10 μm in size, filled by solutions of salts, mainly NaCl, with salinity of 7.5–7.8 wt.% of NaCl equivalent, and CaCl_2 16% and MgCl_2 4% of total salts. Homogenisation temperatures were from +90 to +94°C.

Inclusions in monocrystalline quartz from pebbles (Fig. 1) collected from Silesian Unit (Kamesznica):

2a) gaseous inclusions, 5–15 μm in size, filled by liquid and gaseous methane, having Th from –93 to –90°C.

2b) aqueous inclusions, 4–8 μm in size, filled by aqueous solutions of salts, mainly NaCl with salinity of 1.0–1.4 wt.% of NaCl equivalent, and CaCl_2 5% of total salts. Homogenisation temperatures were from +110 to +148°C.

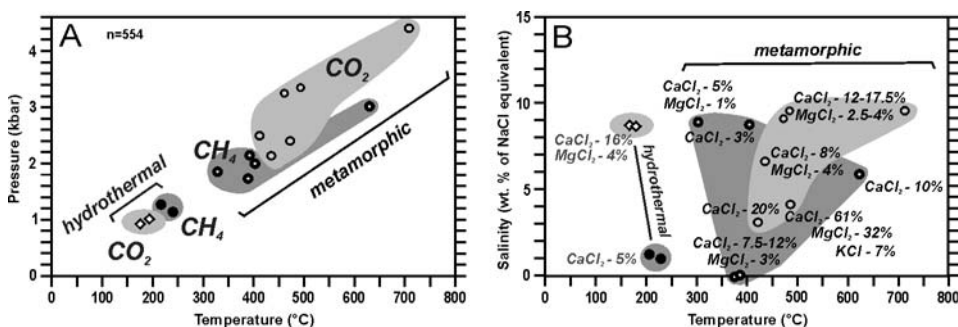


Fig. 2. (A) Four groups of quartz pebbles, distinguished upon fluid inclusion characteristics, joint in two genetic types. (B) Main ions concentrations in aqueous inclusion solutions. Visible significant differences in solution chemical composition of inclusions from metamorphic rocks.

Inclusions in polycrystalline and monocrystalline quartz from pebbles (Fig. 1) collected from Silesian Unit (Strachocina-Skocze, Blizne, Gorlice, and Kamesznica):

3a) gaseous inclusions, 5–40 μm in size, filled by liquid and gaseous methane, having Th from –101 to –93°C.

3b) aqueous inclusions, 1–10 μm in size, filled by aqueous solutions of salts, mainly NaCl with various salinity of 0.0–9.2 wt.% of NaCl equivalent, and chemistry of additional ions with only CaCl_2 3–12%, sometimes with MgCl_2 1–3% of total salts. Homogenisation temperatures were from +160 to +375°C.

Inclusions in polycrystalline and monocrystalline quartz from pebbles (Fig. 1) collected from Silesian Unit (Blizne, Lutcza, Chodorowa, and Kamesznica), and Skole Unit (Gorzejowa):

4a) gaseous inclusions, 5–50 μm in size, filled by liquid and gaseous carbon dioxide, having Th from +8 to +18°C.

4b) aqueous inclusions, 1–40 μm in size, filled by aqueous solutions of salts, mainly NaCl with various salinity of 3.0–9.2 wt.% of NaCl equivalent, and additional ions: only CaCl_2 up to 20% of total salts, mixed CaCl_2 8–17.5% with MgCl_2 2.5–4% of total salts, solutions of CaCl_2 61%, MgCl_2 32%, and KCl 7% of total salts with absence of NaCl. Homogenisation temperatures were from +170 to +290°C.

ORIGIN OF QUARTZ PEBBLES – PRELIMINARY DISCUSSION

Fluid inclusion analysis in quartz pebbles from WOC enabled to recognise two genetic types of source rocks for this sediment type. The first one represents hydrothermal conditions of granulated and monocrystalline quartz growth which were characterised by CO_2 - or CH_4 -rich solutions of 0.9–1.2 kbar and 175–225°C (Fig. 2A). Steady solution salinities and main ion contents suggest their crystallization in open hydrothermal veins of plutonic aureoles (Fig. 2B). Those quartz pebbles were supplied to the both Silesian and Magura basins from the south (Fig. 1). The second type represents metamorphic rocks of polycrystalline and monocrystalline quartz growth which were characterised by CH_4 - or CO_2 -rich solutions of 1.8–4.5 kbar and 320–720°C (Fig. 2A). In this case various salinities and main ion contents support their crystallization as part of metamorphic rock complexes (Fig. 2B). Those quartz pebbles were supplied to the Silesian basin from south and to the Skole basin from north (Fig. 1).

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