Acta Mineralogica-Petrographica, Abstract Series 2, Szeged, 2003

ABNORMAL FOSSIL FLUID OVERPRESSURES DURING REGIONAL COLLAPSE OF THE TERTIARY ACCRETIONARY COMPLEX OF THE WESTERN CARPATHIANS

HURAI, V.[1], ŚWIERCZEWSKA, A.[2], TOKARSKI, A.[2], MARKO, F.[1]
[1] Department of Mineralogy and Petrology, Comenius University, 842 15 Bratislava, Slovakia.
[2] Polish Academy of Sciences, Institute of Geological Sciences 31-002 Kraków, Poland.
E-mail: huraiova@fns.uniba.sk

Fluid inclusions have been studied in mineral infilling of the joints hosted by the Cretaceous-Tertiary flysch of the Magura and Dukla nappes, and the underlying Zboj Unit, all representing the southernmost part of the Tertiary accretionary complex of the Outer Carpathians. In the Central Carpathians, the unfolded fore-arc Tertiary flysch basin covering the Variscan crystalline basement and the Cretaceous thrust-and-fold belt has been investigated.

Structural analysis of the Outer Carpathians has revealed several stages of the joint formation correlated with 1) NW-vergent syn-sedimentary folding and thrusting, 2) NE-vergent thrusting accompanied by strike-slip faulting, 3) regional collapse (Tokarski, Świerczewska, 1998; Tokarski et al., 1999). The complex history of joints has resulted in composite texture of their mineral infilling. Świerczewska et al. (2000a, b) have defined diagenetic quartz overgrowths, fibrous, columnar, and blocky textures, corresponding to first two stages of the tectonic development of the accretionary prism. A plethora of compositional types of hydrocarbon-bearing fluid inclusions are hosted in blocky and drusy quartz and calcite attributed to the extensional tectonics during regional collapse and uplift of the Carpathians after Oligocene.

Gaseous inclusions contain methane, condensate, carbon dioxide and nitrogen. The methane and higher hydrocarbons are often associated with aqueous inclusions with low salinity (up to 3.5 wt. % NaCl eq.) and occasionally also with crude oil. Distribution of the hydrocarbons is uneven in the tectonic units studied. The Magura nappe is typical of methane and absence of higher hydrocarbons. Oil and condensate predominate over the methane in the joints hosted by bituminous sequences (e.g. menilite beds) of the Dukla nappe. The Zboj Unit is typical of methane-carbon dioxide-nitrogen mixtures and a lack of oil and condensate. Methane or condensate together with subordinate crude oil is present in the unfolded Central Carpathian flysch basin.

Gas chromatography and UV-luminescence indicated heavy degraded oil within the fluid inclusions. Carbon isotope values suggested thermogenic methane. Microthermometry data revealed fluid temperatures inconsistent with those corresponding to vitrinite reflectance in the surrounding rocks. Occurrence of pyrobitumen, oil and condensate in the CH_4-bearing inclusions trapped at temperatures above the oil window (above 160°C) suggested a short-termed, transient post-orogenic heating coincidental with regional collapse of the Western Carpathians (Hurai et al., 2002).

Review of updated *PT* estimates derived from fluid inclusions trapping immiscible water-methane mixtures points to gradual increase in fluid temperatures from 130-205°C in the Central Carpathian Palaeogene Basin, through 155-210°C in the Magura Nappe, 195-220°C in the Dukla nappe, to as high as 240°C in the Zboj Unit (Fig. 1). Fluid pressures increase in the same manner, from ~0.5 kbar in the CCP Basin, to as much as 4.5 kbar in the Zboj Unit.

The extents of fluid pressures in the CCP Basin (500-1800 bar) and the Magura nappe (750-2000 bar) are consistent with a crack-seal mechanism and hydraulic fracturing due to changing hydrostatic and lithostatic fluid regimes (Holbrook, 1999). Thus, approximately 5 km depth of overburden has been estimated for the western part of the Central Carpathian flysch basin, and about 7 km for the Magura Nappe, north of the Tatry Mts.

Much larger pressure fluctuations, ranging 1100-3700 bars and 820-4500 bars have been recorded in the Dukla and Zboj units, respectively. Minimum fluid pressures in these units would correspond to depths around 8-10 km, assuming a hydrostatic load. Maximum fluid pressures are, however, substantially higher than the uppermost possible limit defined by the sum of lithostatic load and cohesive strength of rock, the last being less than 100 bars in sediments (Sibson, 1992). The extreme fluid overpressures result in methane molar volumes up to 38 cm^3/mol (T_h = -164°C to liquid). Raman microprobe has not revealed additional gas species in the inclusions. A post-entrapment modification due to external overpressure can be ruled out, because the associated aqueous inclusions have consistent densities and are devoid of typical re-equilibration textures.

The extreme methane densities in the Dukla and Zboj Units are thus interpreted to reflect a supralithostatic fluid overpressure, which was caused by thermal cracking of kerogen and/or oil to methane at temperatures >200°C. The extreme fluid pressures must have been maintained for sufficiently long time to permit precipitation of quartz volume needed for sealing the inclusions several tens of µm in diameter.