the methane and condensate zones (Fig. 3) must have been established prior to tectonic emplacement of the Pieniny Klippen Belt (PKB) and prior to/during early tectonic activity along the sub-Tatric detachment fault, which commenced in Late Oligocene (Kohút – Sherlock, 2002) or Early-Middle Miocene (Janák et al., 2001).

Rock temperatures in the CCB and the Magura Nappe have been insufficient for generation of thermogenic methane trapped in fluid inclusions. Hence, vertical upward infiltration of hot fluids from the Dukla Nappe and/or subjacent units into Magura Nappe and lateral infiltration into the Spišská Magura segment of the CCB must be invoked. The methane zone of the CCB overlaps region with N-S-trending normal faults originated during local, pre-Middle Miocene cross-bed W-E extension (Sperner et al., 2002). The local extension is believed to be coeval with the onset of the cross-bed extension in the Outer Carpathians. Geological, geochronological and fluid inclusion data indicate onset of the extension accompanied by incursion of hot methane-bearing fluids during Ottnangian-Karpatian times (Fig. 4). This scenario is supported by K/Ar record of maximum paleotemperature overprint of bentonite, tending to increase from 16 Ma in west to 18.5 Ma in eastern part of the Podhale Basin (Kotarba, 2003).

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Lithostratigraphy and Tectonics of the Krynica Unit, Magura Nappe in the Vicinity of Krościenko on Dunajec River, Poland

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The Magura Nappe forms the largest tectonic unit of the Outer Western Carpathians running from Austria through Czech Republic, western Slovakian, Polish Beskids, and eastern Slovakia to Ukraine. To the south it borders the Pieniny Klippen Belt (PKB). It is subdivided into several subunits, from North to South: the Siary subunit, the Racza subunit, the Bystrica subunit and the Krynica subunit. This division is based on the lithostratigraphic differences. The Krynica and Bystrica subunits form regional thrust-sheets. These separate thrust-sheets are especially visible in the western part of the Magura Nappe in Slovakia. Slovak geologists even use the term "Magura Group of Nappes" (e. g. Kováč and Plašienka, 2002).

The Krościenko area is located in the central part of the Krynica subunit, near the border with the PKB, according to Birkenmajer and Oszczypko (1988, 1989) it is peri – klippen zone and south – central zone.

The oldest rocks belong to PKB and are represented by the Jurassic Cretaceous radiolarites , chert limestones and red marls and knew from the Łupisko klippen and small klippen found in the Ścigocki Creek (Golonka and Sikora, 1981). The tectonic position of this klippens is uncertain. Łupisko outcrop was folded with peri - klippen flysch according to Książkiewcz (1972) but it is also possible that this fragment could be separated from PKB and overthrust on Szczawnica Fm. as a klippe. In Ścigocki stream is probably uplifted klippen at the strike - slip fault (Birkenmajer, 1986).

Similar rocks deposited in the deepest part of the Jurassic-Early Cretaceous Magura basin (Birkenmajer, 1986, Golonka et al., 2003) are involved in the PKB tectonic structure. Oucrops of the Palaeocene-Lower Eocene Szczawnica Fm. occur along the PKB border in the Krośnica-Krościenko area and in Szczawnica Wyżnia. This formation is represented by thin - bedded flysch with thick and very hard sandstones. In the upper part of the Szczawnica Fm. there are very thick - bedded sandstones of the Życzanów Mbr (Lower Eocen). They occur between Krośnica and Szczawnica Wyżna.

The Życzanów Mbr is covered by the thin - bedded turbidites of the Zarzecze Fm. (Lower Eocen) locally with the intercalations of Łącko type marls (Lower Eocen) which were localised in Zawiasy and Czarna Krośnica stream. Above of the Zarzecze Fm. they are the Piwniczna Sandstones (Lower - Middle Eocen) with the red shales, which may be belong to Kowaniec shales (Middle Eocen) occurring in the eastern part of the area. The poorly outcropped red shales, known only from

the Dzwonkówka Mt. could be also equivalent of the Mniszek shales (Middle - Upper Eocen) separating Piwniczna Sandstones, from the Poprad sandstones (Upper Eocen). Lower boundary of the Piwniczna Mbr is marked by conglomerates, thick bedded sandstones and pebbly mudstones (Birkenmajer and Oszczypko, 1989) which were called "Marszałek bed" (Alexandrowicz and Kutyba, 1979, Alexandrowicz et al., 1984) and were found in the Czarna Krośnica stream in Krościenko.

The Miocene andesites form dikes, sometimes sills cutting the PKB and Krynica unit rocks. They are located along the so-called Pieniny Andesite Line between Jarmuta Mtn and Krościenko and between Krośnica and Wżar Mtn. In Krościenko andesites derive from the first phase of intrusions and are dissected by transversal faults. At the Wżar Mtn there are two phases, the second phase vertical andesite dykes follow strike - slip faults transversal to the PAL which cut the first phase andesite dykes (Birkenmajer and Pécskay, 2000).

Several tectonic structures were recognised in the area the largest of them is the syncline with the Piwniczna Mbr, which built the Lubań Mt. and the Dzwonkówka Mt. In the central part of the Krościenko region between Dunajec and Krośnica river is small syncline with Zarzecze Fm. Between of these synclines is Łąkcica anticline built of Szczawnica Fm. and Życzanów Mbr

Anticline with steep, often overturned Szczwnica formation, Życzanów, Zarzecze strikes East - West in the southern part of the area, along the PKP border. This struktures have mainly W-E direction but are cut by numerous strike – slip faults.

West and East of the Marszałek Mtn the Zarzecze Fm. strata dip normally to the North but in the southern part of the region the Szczawnica Fm. and also Zarzecze Fm are strongly folded. The folds are mostly disharmonic and locally concentric in Łąkcica and on the left side of the Dunajec in Krościenko.

The border of Magura Paleogene and PKB is represented mainly by the steeply dipping strike-slip fault nowhere intruded by andesites (Birkenmajer, 1986). In Sczawnica fragments of the PKB units are thrust over the Magura Nappe. How does this dislocation look between Czorsztyn and Krościenko is somewhat speculative, but probably it is very similar. The North dislocation line of PKB is cut by transversal faults of SSW–NNE and SSE – NNW directions. These faults are youngest than the major dislocation and moving klippen. One of these faults continues into the Magura flysch. Other dislocations are strike – slip faults and have mainly directions SSW–NNE or SSE–NNW. The fault which cut Marszałek Mt. (SW–NNE), described as hinge fault by Żytko et al., 1987, is in fact strike – slip fault. Its eastern sides moved to the North about 350 m. The largest displacement of the Paleogene strata reaches about 850 m at the Wżar Mt. along the SSE–NNW fault and along Zawiasy Fault (SSE–NNW–NNE) which comes from PKB and h moves 700 m of the West side fault (Birkenmajer, 1979, 1989).

The major fault displaces PKB along the Dunajec River indicating the age younger then the major phase of the formation of the klippen belt and its border with the Magura Nappe. These faults have strike-slip character. They also cut the Adesitic intrusions, ar least they older generation. It indicates they age as Sarmation. It is possible that the faults were originally strike-slip turned later into th normal ones.

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