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 (Janáč 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 Śpíšská 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 Ommangian-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).

References


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. Kovač 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 Osyczynko (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 Lupsko klippen and small klippen found in the Scigocki Creek (Golonka and Sikora, 1981). The tectonic position of this klippen is uncertain. Łupsko outcrop was folded with peri - klippen flysch according to Książkiewicz (1972) but it is also possible that this fragment could be separated from PKB and overthrust on Szczawnica Fm. as a klippe. In Scigocki 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. Outcrops of the Palaeocene-Lower Eocene Szczawnica Fm. occur along the PKB border in the Krościenko-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 Żyżanów Mbr (Lower Eocen). They occur between Krościenka and Szczawnica Wyżnia.

The Żyżanów Mbr is covered by the thin - bedded turbidities of the Zarzecze Fm. (Lower Eocen) locally with the intercalations of Łącko type marls (Lower Eocen) which were located in Zawisay and Czarna Krościenka 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

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the Dzwonkówka Mnt. 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 Krościenka 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 Krościenka 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 fol-

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

The border of Magura Paleogene and PKB is represented mainly by the steeply dipping strike-slip fault nowhere intruded by andesites (Birkenmajer, 1986). In Szczawnica 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 younger 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 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, at least they older generation. It indicates they age as Sar-

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The Szczawnica Fm. and Zarzecze Fm. are strongly folded. The border of Magura Paleogene and PKB is represented mainly by the steeply dipping strike-slip fault nowhere intruded by andesites (Birkenmajer, 1986). In Szczawnica 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 younger 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.

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