

Correlation between organic and inorganic indicators of thermal maturity in Dukla Nappe (Polish Outer Carpathians)

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Correlation between organic (vitrinite reflectance (Ro) and Rock-Eval T_{\max} temperature) and inorganic (mixed layer illite/smectite (I/S)) indicators of thermal maturity depend mainly on the maximum temperature achieved by the rock and the time exposure of this temperature. During sedimentary or tectonic burial of rocks, clay minerals may react diversely to organic matter due to heat flow features and the duration of heating (Aldega et al. 2005).

The aim of this study was to correlate maximum paleotemperatures of the Oligocene Menilite Shales from the Polish Outer Carpathians determined based on vitrinite reflectance and Rock-Eval pyrolysis data to those calculated using I/S ratio. The analysis was performed on eight claystone samples collected from natural exposures of the Dukla Nappe. Four of them were taken in tectonic windows within the Magura Nappe: Świątkowa and Grybów tectonic windows. All samples were analyzed by vitrinite reflectance, Rock-Eval and smectite to illite conversion.

Reflectance of vitrinite and huminite macerals was measured under oil immersion using Carl Zeiss Axioplan microscope in reflected white and blue (fluorescence) light. Standard deviation was calculated for all measurements. The values of Ro were converted into paleotemperatures according to Barker & Pawlewicz (1986).

The degree of smectite to illite conversion is shown as the percentage of smectite (%S) in I/S. To define this percentage X-ray powder diffraction

was used (Dudek & Środoń 1996 and references therein). Maximum paleotemperatures were estimated according to Šucha et al. (1993).

Rock-Eval pyrolysis was conducted on Delsi Instruments apparatus equipped in TOC module to determine: a) total organic carbon content (TOC), b) the amount of residual hydrocarbons generated during pyrolysis of organic matter (S_2) and the temperature of maximum of S_2 peak (T_{\max}).

The Rock-Eval data indicate that the analysed samples are rich in organic matter, predominantly of oil-prone Type II kerogen. Values of T_{\max} vary from 421°C to 453°C, and were re-calculated into vitrinite reflectance values using equation proposed by Jarvie et al. (2005) and then into paleotemperatures indicating range between 42–153°C. The Ro values vary between 0.45–1.0% indicating paleotemperatures between 51–154°C. The analyzed rocks contain 12–40% S in I/S suggesting paleotemperatures between 104–176°C. Usually, paleotemperatures determined from I/S are higher than those achieved using organic indicators.

In both, present and previous (Waliczek & Więclaw 2013) studies, a strong positive correlation between organic maturity indicators was observed. The good correlation between the organic and inorganic paleotemperature indicators was noticed for all samples collected from tectonic windows of the Dukla Nappe, where organic matter is mature (above 0.7% in Ro scale). For samples containing immature or early-mature organic matter

maximum paleotemperatures calculated from I/S data are 40–70°C higher than those calculated based on results of organic matter investigations.

The higher maturation of samples from tectonic windows than those from the Dukla Nappe are probably related to the overburden of these rocks by the Magura Nappe.

Illitization process is probably time-independent (Pollastro 1993, Środoń 1995) whereas vitrinite reflectance stabilizes in normal burial coalification after about 10^6 – 10^7 years (Barker 1989). The good positive correlation between the organic and inorganic paleotemperature indicators occurs only for samples from tectonic windows which might lead to the conclusion that these sediments were temperature-affected by at least 10^6 years.

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REFERENCES

- Barker C.E., 1989. Temperature and time in the thermal maturation of sedimentary organic matter. [in:] Naser N.D. & McCulloh T.H. (eds), *Thermal history of sedimentary basins*, Springer, New York, 75–98.
- Barker C.E. & Pawlewicz H.J., 1986. The correlation of vitrinite reflectance with maximum temperature in humic organic matter. [in:] Buntebarth G., Stegena L. (eds), *Paleogeothermics, Lecture Notes in Earth Science*, 5, Springer, Berlin, 79–93.
- Dudek T. & Środoń J., 1996. Identification of illite/smectite by X-ray powder diffraction taking into account the log-normal distribution of crystal thickness. *Geologia Carpathica – Serie Clays*, 5, 21–32.
- Jarvie D.M., Hill R.J. & Pollastro R.M., 2005. Assessment of the Gas Potential and Yields from Shales: the Barnett Shale Model. *Oklahoma Geological Survey Circular*, 110, 37–50.
- Pollastro R.M., 1993. Considerations and applications of the illite/smectite geothermometer in hydrocarbon-bearing rocks of Miocene Mississippian age. *Clays and Clay Minerals*, 41, 119–133.
- Środoń J., 1995. Reconstruction of maximum paleotemperatures at present erosional surface of the Upper Silesia Basin, based on the composition of illite/smectite in shales. *Studia Geologica Polonica*, 108, 9–20.
- Šucha V., Kraus I., Gerthofferová H., Peteš J. & Sereková, M., 1993. Smectite to illite conversion in bentonites and shales of the East Slovak Basin. *Clay Minerals*, 28, 243–253.
- Waliczek M. & Więclaw D., 2013. Maturity of menilite shales from Polish Outer Carpathians based on vitrinite reflectance and Rock-Eval pyrolysis data. *Geology, Geophysics & Environment*, 38, 551–552.