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Thermal evolution of Lower Paleozoic sedimentary successions from organic and inorganic studies: the case history of the Holy Cross Mountains (central Poland)

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The rapid increase in shale gas production in the USA has triggered a growing interest in unconventional resources in Eastern and Northern Europe. In this framework, the potential shale gas reserves in Poland are the most promising in Europe, extending from the Baltic Sea to the Ukraine border. In this area, the Baltic, Podlasie and Lublin basins have already become objective of shale gas exploration and the Holy Cross Mountains (HCM, Central Poland) represents the outcropping analog of the buried targeted Lower Paleozoic successions, providing a unique opportunity to study and assess source rock potential.
In this work, we provide new thermal maturity data of Paleozoic rocks exposed in the HCM. A multi-method approach, coupling organic matter/graptolites (i.e. marine organoclasts) optical analysis and X-ray diffraction of clay-sized fraction of sediments, was applied to constrain the burial – thermal evolution of the sedimentary succession. The investigated area of the HCM includes two different tectonic blocks: the Łysogóry region to the North and the Kielce region to the South, separated by the Holy Cross Fault (HCF).
lllite content in mixed layer illite-smectite determinations and vitrinite/graptolites reflectance measurements (Roeq%), performed on samples (Cambrian – Devonian) collected from both the regions, show a substantial difference between the two blocks in terms of thermal maturity and burial history. Roeq% values in the southern block range from 0.5% to 1.0%, with few exceptions, indicating early to mid-mature stage of hydrocarbon generation. Samples collected in the northern block show much higher values, mainly from 1.2% up to 1.7%, representative of the gas generation window. The I-S ordering type also shows relevant differences in the two blocks. In the southern block, mixed-layered clay minerals varies from R1 (short-range) to R3 (long-range), whereas R3 structures are recorded in the northern block. Vitrinite reflectance and mixed-layer I-S were integrated with conodont and acritarch alteration indexes from previous works in order to draw a Roeq% distribution map. Bi-clustered distribution between the two blocks, with high values in the Łysogóry region, suggests the evidence of different thermal and burial history. 1D thermal models allowed us to define the onset of gas generation for the Silurian source rocks of the Łysogóry region and point out that sedimentary burial is the main controlling factor of the measured levels of thermal maturity. Surrounding areas with thermal maturity similar to that observed in the northern block can be taken into account for Shale Gas exploration.