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**Giunti S., Bojanowski M.J.**

*Institute of Geological Sciences – Polish Academy of Sciences, Ul. Twarda 51/55, 00-818, Warsaw, Poland. E-mail: s.giunti@twarda.pan.pl*

# HYDROCARBON-DERIVED THROMBOLITES FROM THE OUTER CARPATHIANS (POLAND)

Shallow marine thrombolites from a newly discovered Lower Cretaceous cold seep in the Outer Carpathians (Poland) were analysed in order to untangle the complex sedimentological and biogeochemical processes involved in their formation and their diagenetic modifications. The studied thrombolites are made of two components, (i) microcrystalline mesoclots and (ii) fine spar-filled framework cavities. These components are dominated by calcite and show a complex spatial relationship, resulting in a heterogeneous, clotted fabric. The mesoclots exhibit digitate structures, often concentrically-laminated, and are composed of fine spar-cemented micrite with $\delta^{13}C$ values from -34.8 to -19.4‰ PDB. Biomarkers characteristic of anaerobic methanogenic archaebacteria were detected within the mesoclots. The mesoclots host <5 mm-wide microtubes filled with isopachous calcite recording even lower $\delta^{13}C$ values of (from -39.0 to -20.5‰ PDB). The morphology of the mesoclots relative to their internal lamination and their geochemistry indicate that their growth was dependent on anaerobic oxidation of methane (AOM), while the microtubes acted as conduits for hydrocarbon-charged fluids. The framework cavities are internally lined with framboidal pyrite, and are cemented by fine spar with relatively high $\delta^{13}C$ of (-15.1 to -7.3‰ PDB) and low $\delta^{18}O$ values (-9.3 to -4.4‰ PDB). Carbonate precipitation within the framework cavities is interpreted to be related to bacterial sulphate reduction. U-shaped trace fossils attributed to the ichnogenus Balanoglossites cross-cut both mesoclots and framework cavities. The mechanisms involved in the formation and diagenesis of thrombolites at cold seeps are yet to be fully understood, and this work provides new insights on these complex biogeochemical and sedimentological processes.

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