

# Photic Zone Euxinia, Organic Matter Preservation and Source Rock Type in the Late Permian Z2 Carbonate Sea (Southern and Northern Permian Basins of Europe)\*

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## Abstract

We report significant spatial and temporal variations in the paleowater-column redox state in the Southern (SPB) and Northern (NPB) Permian basins of northwestern Europe focusing on the petroliferous second carbonate unit (Z2C, Zechstein Main Dolomite and equivalents), based on 200 rock samples from 23 boreholes and outcrops. Samples representing toe-of-slope apron, slope and hypersaline lagoonal facies of the northeastern SPB margin (Poland) contain abundant chlorobactane, isorenieratane and its likely degradation products (C<sub>15</sub> to C<sub>31</sub> 2, 3, 6-aryl isoprenoids) ([Figure 1](#)). These indicate that part of the photic zone was euxinic during significant intervals of the Z2C. Further evidence for strongly anoxic conditions includes the occurrence of C<sub>28</sub>-bisnorhopane, high concentrations of pentakishomohopanes (i.e. high homohopane indices), and the occurrence of framboidal micropyrrite and native sulfur crystals in slope facies. However, both bisnorhopane, chlorobactane and isorenieratane (and its derivatives) are absent in samples from basinal and outer ooid shoal facies, and homohopane indices are below 0.1, all suggesting that strongly reducing conditions were restricted to the slope and toe-of-slope facies.

Basinal facies are in general significantly depleted in or lacking steranes, hopanes, and polycyclic aromatic hydrocarbons and are characterized by low total organic carbon contents (average ~0.3-0.1 wt%). This suggests that organic matter productivity was not concentrated in the basinal parts but rather restricted to slopes (TOC up to 2 wt%) and platform interiors (restricted lagoons, TOC ~0.5 wt%). This further implies that the Z2C basin was not entirely anoxic but rather possessed a pronounced oxygen minimum zone above suboxic and non-sulphidic bottom waters. This is contrary to previous work which suggested that a large part of the basin was anoxic. By extension, it appears that there was minimal or

no potential for source rock formation in the basinal parts of the Z2C; instead we suggest that source rocks were primarily deposited on slopes and in more restricted lagoons and bays.

### **Results and Conclusions**

The results indicate that photic zone euxinia did not occur periodically but was persistent in the Zechstein Sea. Comparison with biomarkers from the NPB and west SPB implies that the Zechstein Sea varied in terms of its hydrologic system, oxicity and salinity. Deep-basin anoxia existed along the southern margin of the SPB in Thuringia, whereas in west SPB and NPB the water column was oxic with suboxic bottom waters.

In addition, SEM-EDS and BSE analyses revealed the presence of oil droplets filling and trapped within micro-cavities and oval micro-caverns originated from bacterial activity in Z2C slope facies of northwest Poland. This suggests the occurrence of a tight oil system in Z2C carbonates which supports a common view that hydrocarbons were generated from within this Z2C formation. Initial studies indicate that the tight oil is restricted to the slope and basin-rise facies. This discovery may lead to the recognition of additional unconventional oil reserves in the eastern part of the Z2C northern margin and hence, new exploration perspectives and challenges and a re-evaluation of current petroleum reserves.

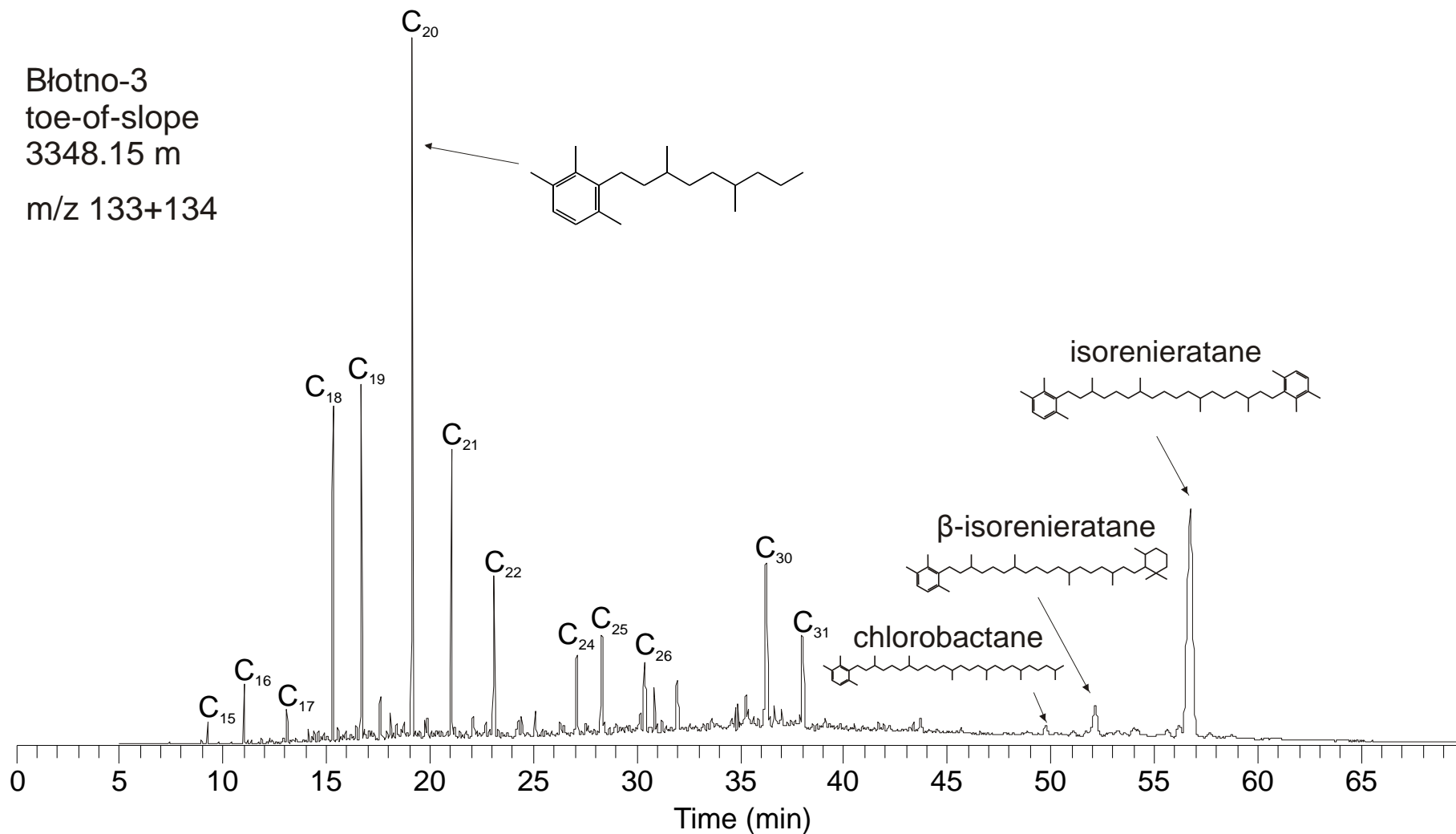


Figure 1. A GC-MS selected ion chromatogram of m/z 133+134 from an aromatic hydrocarbon fraction from Main Dolomite toe-of-slope facies of Błotno-3, depth 3348.15 m. Aryl isoprenoids from C<sub>15</sub> to C<sub>31</sub> have been identified and the intact C<sub>40</sub> carotenoid skeleton of isorenieratane, β-isorenieratane and chlorobactane.