

## ZECHSTEIN 2 OIL CHARACTERISTICS IN THE SOUTHERN PERMIAN BASIN OF EUROPE: THE ROLE OF C<sub>40</sub> CAROTENOIDS

M. Słowakiewicz<sup>1,2</sup>, M. Blumenberg<sup>3</sup>, D. Więclaw<sup>4</sup>, K. Hindenberg<sup>5</sup>, H.-G. Röhling<sup>6</sup>, G. Scheeder<sup>3</sup>, E. F. Idiz<sup>7</sup>, M. E. Tucker<sup>1,2</sup>, R. D. Pancost<sup>1,2</sup>, M. J. Kotarba<sup>4</sup>, J. P. Gerling<sup>3</sup>

<sup>1</sup>University of Bristol, Bristol, UK

<sup>2</sup>Cabot Institute, Bristol, UK

<sup>3</sup>Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany

<sup>4</sup>AGH University of Science and Technology, Kraków, Poland

<sup>5</sup>Forschungszentrum Jülich GmbH, Jülich, Germany

<sup>6</sup>State Authority for Mining, Energy and Geology, Hannover, Germany

<sup>7</sup>University of Oxford, Oxford, UK

### Introduction

The intracontinental Southern Permian Basin of Europe (SPB) is one of the richest and extensively studied petroliferous basins in Europe (Fig. 1). The SPB oils are predominantly reservoirized in Zechstein 2 (Ca2) porous and fractured carbonate facies, that is the Main Dolomite in Poland and the Staßfurt Karbonat in Germany; which make up the second petroleum reservoir system (the first one is the Upper Rotliegend-Zechstein Limestone) within the Upper Permian deposits. The oils are interpreted to be derived from Ca2 basin, slope and lagoon facies. Although the Ca2 gas accumulations and their origin are relatively well understood, there is almost a complete lack of thorough biomarker studies, such that there are many uncertainties in Ca2 oil-oil correlations and correlations of Ca2 oils to potential source rocks. Furthermore, the lack of information prevents the establishment of oil families, an understanding of their origin, and a prediction of migration routes and possible secondary processes.

Here we integrate the available and newly-generated molecular and isotopic compositions of the Ca2 oils from NW and SW Poland, and NE, SE and S Germany, and identify the characteristic biomarkers to establish oil families. We also evaluate the occurrence of C<sub>40</sub> carotenoids as a useful correlative proxy.

### Results

For the statistical analysis, 34 crude oil samples were collected from NW Poland (Kamień Pomorski and Pomerania carbonate platforms), SW Poland (west Fore-Sudetic Monocline), NE (Mecklenburg-Vorpommern) and SE (Brandenburg) parts of the North German (sub)-Basin and the northern part of the Thuringian (sub)-Basin. From an additional 9 oils from the NE and SE parts of the North German (sub)-Basin, only carbon isotopic data were available.

Source-related biomarker and carbon isotope ratios were used as a training set to construct a chemometric decision tree that allowed a genetic classification of oil samples. Hierarchical cluster analysis, based on the source-related data, allowed an assessment of the genetic relationships between the oil samples and was used to identify 5 distinct families. Twenty-seven genetic geochemical parameters that differentiate the samples include 16 terpane, 6

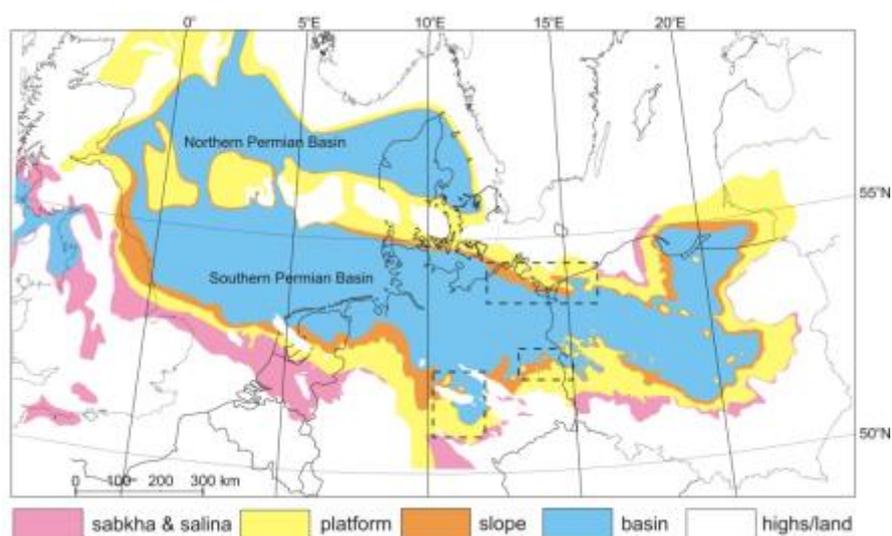
sterane, 3 aromatic (including C<sub>40</sub> carotenoids, i.e., isorenieratane and chlorobactane), and 2 stable carbon isotope ratios. The thermal maturity of the studied oils corresponds to the early-to-peak oil window.

Results indicate that the Ca<sub>2</sub> oils have characteristic biomarkers, most likely controlled by their regional occurrence and reservoir stratigraphy: a) C<sub>40</sub> carotenoids (isorenieratane 16-709 µg/g oil; chlorobactane 1-65 µg/g oil) were detected in oils trapped in shallow-basin to lower slope and lagoonal facies; b) 28,30-bisnorhopane (BNH/C<sub>30</sub> hopane = 0.01-0.07) occurs in oils trapped in the shallow-basin/lower slope-lagoonal facies in NW and SW Poland; c) high abundance of C<sub>35</sub> homohopanes were detected in oils from shallow-basin/lower slope-lagoonal facies in NW Poland and NE Germany; d) a predominance of C<sub>34</sub> homohopanes over C<sub>33</sub> and C<sub>35</sub> homohopane homologues is evidenced in oils from lagoonal facies in S Germany; e) the majority of Ca<sub>2</sub> oils have C<sub>29</sub> steranes dominant over C<sub>27</sub> and C<sub>28</sub> homologues suggesting both an algal and terrestrial organic matter (OM) source; f) a high abundance of diasteranes relative to regular steranes (>0.1) in almost all Ca<sub>2</sub> oils is typical of petroleum derived from carbonate source rocks with an abundant clay content.

## Conclusions

Ca<sub>2</sub> oils were expelled from mixed evaporite (clay, marl)-carbonate source rocks characterized by a significant contribution of sapropelic (algal + microbial) and subordinate terrestrial (clay) OM. The oils were generated from OM preserved in anoxic (presence of 28,30-bisnorhopane, homohopane index >0.1), euxinic (presence of isorenieratene derivatives) and/or hypersaline conditions (gammacerane; euxinia). The biomarker characteristics of Ca<sub>2</sub> oils suggests the oils derived from Ca<sub>2</sub> lower slopes (NE SPB), hypersaline lagoons (SW Poland, SE Germany; SE SPB; northern Thuringian (sub)-Basin, S SPB) and sabkha-like Zechstein 1 and 2 evaporite (anhydrite, halite) deposits overlying and underlying Ca<sub>2</sub> carbonate rocks.

C<sub>40</sub> carotenoids are particularly important in two Ca<sub>2</sub> oil families which allow for positive oil-oil correlation, identification of redox conditions during deposition of OM and are a measure of the contribution of bacteria to the total biomass.



**Figure 1** Palaeoenvironmental map of the Ca<sub>2</sub> in the Late Permian in Europe with marked study areas (dashed lines). Longitude and latitude are present day values.