



Hydrocarbon potential of the Zechstein Main Dolomite (Upper Permian) in western Poland: Relation to organic matter and facies characteristics



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ABSTRACT

The Zechstein Main Dolomite (Ca2) in the area between Grotów Platform and western part of the Gorzów Platform, in western Poland, represents the 3rd order sequence of the Polish Zechstein. The deposits are mainly the HST carbonate facies. Totally, fifteen HST microfacies associations were identified and they represent the carbonate platform (shallow subtidal–supratidal deposits), the platform slope (upper–lower slope deposits) and the basin environments. The deposition of the Ca2 was controlled by the pre-Zechstein paleomorphology and the systems of tectonic dislocations. On this background the geochemical results are presented and their source nature characterized in the context of the facial model of the Ca2. The results of geochemical analyses indicate that most of samples collected in the study area contain the epigenetic hydrocarbons. In the Ca2 carbonates the TOC values range from near zero to 5.2 wt.%, and these of hydrocarbons contents reach up to 9.6 mg/g rock. Despite such significant variability, the average values are low and do not exceed 0.5% TOC and 2.5 mg HC/g rock. All geochemical parameters indicate that the Ca2 carbonates from the study area represent poor to fair oil-prone source rocks with local good and/or excellent hydrocarbon potential. The macerals composition reveals predominance of the oil-prone Type II kerogen in all studied microfacies. In the kerogen composition organic–mineral associations and solid bitumens prevail. The organic matter from the Ca2 was deposited under anoxic conditions in the hypersaline depositional environment. The maturity indicators: vitrinite reflectance R_o , temperature T_{max} and biomarker parameters indicate that the maturity of organic matter corresponds to the final phase of the “oil window” and to the early phase of the “gas window”.

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1. Introduction

The study area comprises two units – the Gorzów Platform and Grotów Peninsula (Fig. 1A). They are located in the western part of the Polish Zechstein Basin (PZB; Wagner, 1988; Wagner and Peryt, 1997). The PZB is a eastern part of the Southern Permian Basin (Fig. 1B; van Wees et al., 2000; Geluk, 2007; Doornenbal and Stevenson, 2010). This is the region where facies and microfacies of the Zechstein Main Dolomite (Ca2), and their petroleum potential are the best know facies in the Main Dolomite basin.

The Ca2 is the principal oil reservoir in Poland (Karnkowski, 1999, 2007). The vicinity of Gorzów Wielkopolski town is a

particularly interesting area for petroleum exploration because here, the then largest oil deposit in Poland – Barnówko–Mostno–Buszewo (BMB) has been discovered in 1990ties. Its geological oil reserves reach about 60 Mt (Mamczur et al., 1997; Górski et al., 1999; Dyjaczynski et al., 2006, 2009; Górecki et al., 2008; Czeakański et al., 2010). In the last years intensive hydrocarbon exploration resulted in further discoveries of oil and gas industrial accumulations: Dzeduszyce, Krobielewko, Santok and Stanowice, as well as Lubiatów–Międzychód–Grotów, which is recently the largest oil deposit discovered in Poland (Fig. 1B; Solarska et al., 2005; Papiernik et al., 2009).

The Main Dolomite sediments are simultaneously petroleum source rocks and reservoirs due to perfect sealing from over- and underlying anhydrite and rock salt strata (Słowakiewicz and Mikołajewski, 2009, 2011; Kosakowski and Krajewski, 2014). Therefore, determination of qualitative and quantitative

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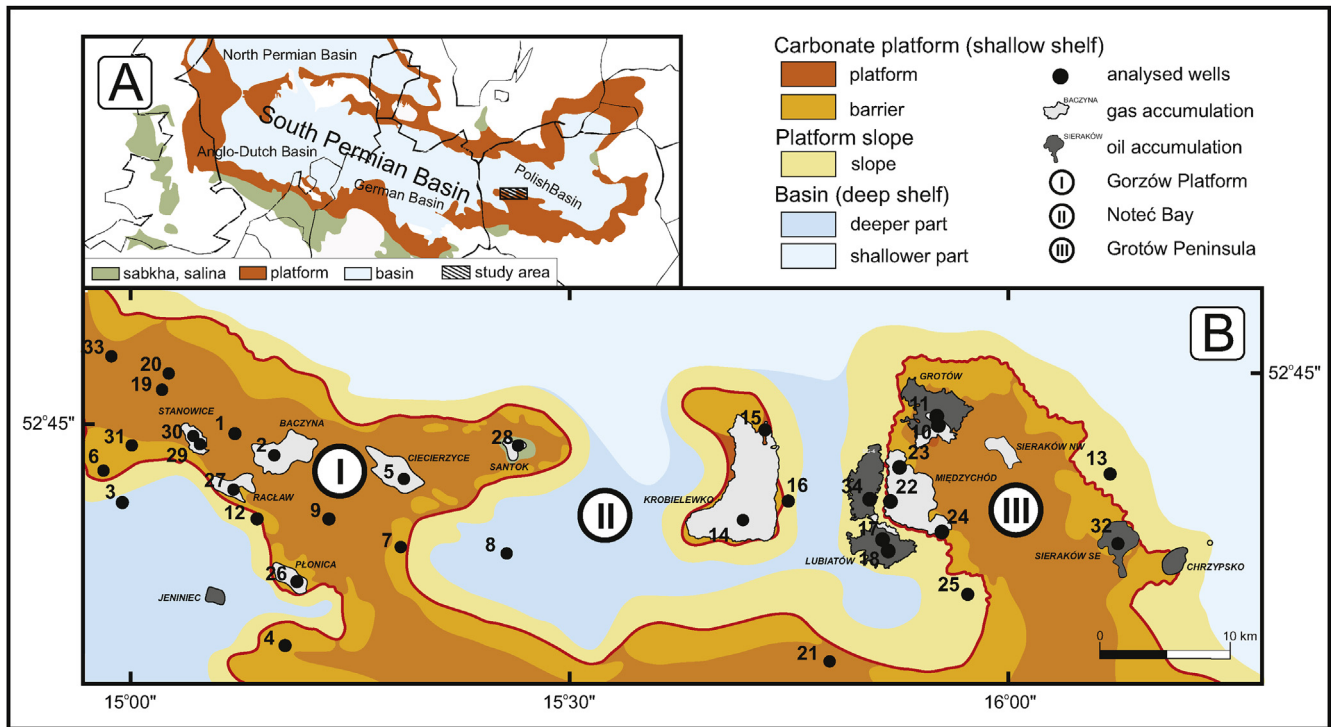


Fig. 1. Paleogeographical map of the (A) Southern Permian Basin (Geluk, 2007) and (B) Zechstein Main Dolomite of the northern part of the Fore-Sudetic Monocline (after Kotarba and Wagner, 2007, modified), with location of analyzed wells. Wells: 1 – Baczyzna 1, 2 – Baczyzna 2, 3 – Bogdaniec 1, 4 – Brzozowa 1, 5 – Ciecierzycze 1, 6 – Dzierżyszycze 1, 7 – Dzierżyszycze 1K, 8 – Gorzów Wielkopolski 2, 9 – Gorzów Wielkopolski IG-1, 10 – Grotów 1, 11 – Grotów 2, 12 – Jeżyki 1, 13 – Kaczin 1, 14 – Krobielewko 2, 15 – Krobielewko 5, 16 – Leszczyny 1/K, 17 – Lubiatów 1, 18 – Lubiatów 2, 19 – Marwice 1/K, 20 – Marwice 3, 21 – Międzychód 2, 22 – Międzychód 4, 23 – Międzychód 5, 24 – Międzychód 6, 25 – Mokrzec 1, 26 – Płonica 1, 27 – Raclań 1K, 28 – Santok 1, 29 – Stanowice 1, 30 – Stanowice 2, 31 – Stanowice 3, 32 – Sieraków 1, 33 – Ściechów 1, 34 – Sowa Góra 1.

parameters of organic matter dispersed in these rocks will enable us to estimate the volumes of hydrocarbons which can be accumulated in traps identified in the study area.

The geochemical characterization of organic matter and the facial identification of the Ca₂ sediments were carried on separately for the two parts of the paleogeographic unit termed Wielkopolska Platform: the northern one represented by the Grotów Peninsula and the eastern one represented by the Gorzów Platform and the Noteć Bay (Fig. 1B). Organic matter was characterized by means of organic carbon content, hydrocarbons content, kerogene genetic type and thermal maturity.

2. Geological background

The study area is located in the eastern part of the Polish Zechstein Basin (PZB) (Fig. 1A; Jaworowski and Mikołajewski, 2007), which is part of the Southern Permian Basin (SPB) (Fig. 1B; van Wees et al., 2000; Peryt et al., 2010a) formed in the Late Carboniferous–Early Permian. The mechanisms of its formation are related to regional thermal destabilization and to transtensional paleo-stress field (Littke et al., 2008). Its geometry reflects to some extent the tectonic structures of pre-Zechstein basement (Kotarba and Wagner, 2007; Kwolek and Mikołajewski, 2007; Geissler et al., 2008; Kiersnowski et al., 2010). The tectonics influenced not only the basin geometry but it has also controlled both the specific distribution of facies and the thickness of Zechstein carbonates (Kiersnowski et al., 1995, 2010; Dyjaczynski et al., 2000; Kosakowski and Krajewski, 2014), as seen in all the evaporite–carbonate cyclothem. In the PZB four depositional sequences were distinguished, comprising four evaporite cycles – PZ1 to PZ4, correlated with the German Zechstein cycles (Wagner and Peryt, 1997).

The study area covers the eastern part of the Gorzów Platform, the Noteć Bay with the Krobielewko Microplatform and the Grotów Peninsula (Fig. 1B). This region hosts two largest oil fields in Poland: the Barnówko–Mostno–Buszewo (BMB) in the western part of the Gorzów Platform and the Lubiatów–Międzychód–Grotów (LMG) in the eastern part of the Grotów Peninsula (Czekański et al., 2010). In the study area, the Main Dolomite comprises three depositional systems related to paleogeography of the basin: (i) carbonate platform, (ii) slope of carbonate platform and (iii) basinal plain (Fig. 2) (Wagner, 1994, 2004; Dadlez et al., 1998; Dyjaczynski et al., 2000). The paleogeography of the basin was described by Kotarba and Wagner (2007) (Fig. 1B), but latest results (Kosakowski and Krajewski, 2014) demonstrate that spatial distribution of depositional systems requires some revision.

Critical analysis of the current state of knowledge in the adjacent area of the western part of the Wielkopolska Platform (Kosakowski and Krajewski, 2014) clearly showed the differences in the existing views (e.g., Kotarba and Wagner, 2007; Siwakiewicz and Mikołajewski, 2009) on the architecture of facies and paleogeography of the Southern Permian Basin. The research carried out in the Wielkopolska Platform allowed us to develop standard of microfacies association for this area (Kosakowski and Krajewski, 2014). A detailed study of facies and microfacies enabled significantly to verify the existing views. These results were the impetus for this type of comprehensive geochemical–sedimentological researches in neighboring regions. A special position of the Gorzów Platform is due to a number of hydrocarbon accumulation (Czekański et al., 2010). As yet, no published detailed profiles of lithofacies with the types of microfacies on the Grotów Peninsula, together with the geochemical studies.

This paper represents a continuation of the previously conducted research in the adjacent area – Wielkopolska Platform. They

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