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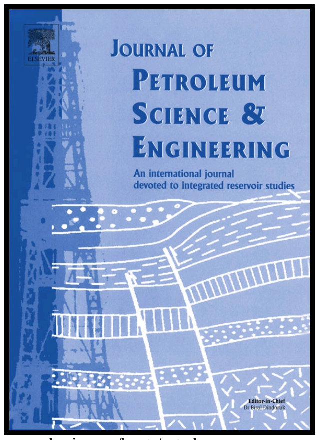

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A textural and diagenetic assessment of the Zechstein Limestone carbonates, Poland using the transverse Nuclear Magnetic Resonance relaxometry.

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Abstract

As a consequence of carbonate pore system ambiguity, only two basic carbonate textures, i.e. mudstone and completely contrasting grainstone have thus far been found to be separable using Nuclear Magnetic Resonance (NMR) relaxometry. Therefore, a new methodology of NMR-derived carbonate facies and diagenetic alteration recognition was prepared and experimentally launched. As many ancient carbonates have often experienced a meteoric exposure stage, this approach focuses on such conditions. Especially the paleoreef carbonate reservoirs are of the main interest of the authors. The Wielichowo Reef (western Poland), developed on an uplifted pre-Zechstein horst structure - the Wolsztyn Ridge - was chosen for the study object. The reef is representative for its region because it is characterized by both high textural and diagenetic variability, often repeatable in case of other objects present on the Wolsztyn Ridge. Consequently, twenty one Zechstein Limestone (Ca1) carbonate core samples from the chosen object were qualitatively studied using a low-field, 50 [mT] NMR spectrometer. Corresponding thin section samples were carefully investigated using both polarizing and electron microscopy, cathodoluminescence and sample staining to obtain a full overview of their petrography and enable further comparisons between NMR and the remaining data. As shown by the obtained results, various carbonate facies can be distinguished on the basis of few criteria. These include: (1) the changeability of the signal's amplitude, (2) the values of clay-bound (MCBW), capillary (BVI) and freely moving (FFI) water, and (3) – the width of the *main T2 peak*, defined as the first peak occurring directly after the BVI, whose average amplitude exceeds or equals at least 75% of the maximal average amplitude encountered within MCBW or BVI systems. Similarly, it seems possible to separate dissolution vugs from other pore systems. The wider the *main peak*, the higher the probability of finding irregularly-shaped vugs, as diameter size variances account for elevating signal's amplitude, corresponding to various relaxation times. Furthermore, fractures and increased cementation have a significant impact on final T2 distribition's appearance, as well - hence making the low-field NMR an invaluable tool in the evaluation of carbonate reservoirs influenced by the meteoric exposure.

Keywords: Nuclear Magnetic Resonance relaxometry; carbonate texture; diagenesis; dissolution vug; facies modelling; paleoreef

1 INTRODUCTION

The nuclear magnetic resonance (NMR) technique has gradually developed since the 1950's (Kleinberg et al. 2001). Later, the development of the technology made it possible to investigate not only effective and total porosities but also the fluid viscosity, allowing engineers and scientists to differentiate between water, gas and crude oil, based on diffusivity contrast (e.g. Kenyon et al. 1995b; Allen et al. 2000; Freedman and Heaton 2004; Akkurt et al. 2009; Dillinger and Esteban 2014). As it was believed, NMR, besides basic reservoir information, also carried some additional data. Since the beginning of NMR in geosciences, an attempt to study solid-phase materials has been undertaken. One of such approaches was associated with an estimation of the gypsum content in carbonate rocks (Vinegar et al. 1989 with references therein). It was finally noticed that NMR can yield one more sort of information, enabling a qualitative interpretation of rock facies and textures. Kenyon et al. (1995a) found a relationship between the pore size distribution provided by the T2 relaxation time phenomenon and the