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Fracture network relationships in Ca2 carbonates from outcrop and well data in the Southern Permian Basin, Germany

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Abstract

Understanding fracture network geometries is key for optimizing well planning and improving hydrocarbon recovery in tight carbonate reservoirs. This study integrates outcrop and well data to evaluate their comparability in fracture characteristics. The focus is on Zechstein Ca2 (Stassfurt Formation) carbonates in the Southern Permian Basin, N-Germany. Outcrop data of the Uehrde quarry on the southwestern margin of the Harz mountains exposes dolomitic carbonates resembling slope deposits on the former Eichsfeld-Altmark swell at the southern margin of the Southern Zechstein Basin. Thus, they form an outcrop reservoir analog in terms of stratigraphic position, depositional environment and diagenesis to Wintershall's operated naturally-fractured Ca2 gas fields approximately 130 km to the northwest. We use the reservoir and analog data to compare their reservoir characteristics regarding matrix porosities and permeabilities, and fracture pattern geometries.

Reservoir characteristics are determined using He-pycnometry and single-phase gas flow in an isostatic flow cell. Matrix permeabilities are very low and range over two orders of magnitude (0.0001-0.001 mD) and porosities vary between 2 and 20% in the outcrop samples, which are compared to reservoir data. Regarding the low porosities and permeabilities, natural fractures are the key for hydrocarbon production in those reservoirs. We use terrestrial laser scanning (LIDAR) as a novel approach to automatically derive scanline fracture data in addition to manually measured ones. Results are complemented with fracture analysis from subsurface well log images and compared regarding fracture orientation and density distributions. We highlight to what extent surface fracture data may be beneficial for reservoir quality prediction and well path optimization in analogous subsurface fractured carbonate reservoirs.