Multibeam Echosounder Backscattered Data Reveal Lateral Facies Distribution and Heterogeneities in the Al Wajh Carbonate Platform Lagoon, NE Red Sea, Saudi Arabia

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Abstract

In shallow water carbonates reservoirs, the distribution of facies and facies-associated property relationships (phi/k) are commonly used to construct 3D static reservoir models. The population of space with facies is usually achieved using geostatistical methods. Facies distribution also can be populated using a depositional model related to energy level and depth. Depositional models are usually built from data sets with low sample density collected in modern depositional environments. However, subsequent studies with increased sample density revealed more complex heterogeneity that does not display superficial depth relationships. This research presents the first data set connecting individual bottom samples with a continuous seafloor scan in a shallow water carbonate platform. The aim is to investigate the true spatial heterogeneity of facies and sediment texture and the transition from one texture to another. The study area is located in the Al Wajh carbonate platform lagoon, NE Saudi Arabian Red Sea coastline. The latest study shows a high lateral heterogeneity in sediment composition in Al Wajh lagoon's seafloor, including grain size and mud content. However, it is challenging to assess lateral changes in sediment composition over the extent lagoon area because sample spacing remains wide. We acquired 36 km^2 of high-resolution Multibeam Echosounder (MBES) and 45 sediment samples in 2021 using the KAUST RV Explorer. The backscattered intensity and angular response of MBES data were then extracted and analyzed using the Angular Range Analysis (ARA). Furthermore, sediment samples were analyzed and integrated for quantitative accuracy. Results show a strong correlation between backscattered intensity and sediment samples. High intensity is correlated with coarser sediment, while low intensity is related to fine sediment. Likewise, ARA analysis successfully classified the carbonate sediment within the lagoon, ranging from grainstone to mudstone. A continuous facies map was also successfully achieved, showing smooth facies transitions within the lagoon, except in some areas around the reef. Current activities highly influence facies distribution. Coarse sediment is found in the current high-energy area (e.g., around the reefs). In contrast, finer sediments are found in the low-energy current area (e.g., the deep lagoon). Current activities also control the facies transition, shown by a smooth facies transition within the lagoon. The only exception happens in some areas around the reef related to the debris flows from the coral reefs. This study provides a new approach to understanding spatial facies transition and lateral heterogeneity in shallow water carbonate platforms lagoon. Furthermore, this technique can be used to produce a more reliable depositional model that can be used as analogue for the carbonate reservoir in the subsurface.