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Editorial

Editorial for the Special Issue "Mineralogical, Geological and Geochemical Heterogeneities of Carbonate Reservoirs"

Vahid Tavakoli * and Hamzeh Mehrabi

School of Geology, College of Science, University of Tehran, Tehran 14199-63114, Iran; mehrabi.hamze@ut.ac.ir
* Correspondence: vtavakoli@ut.ac.ir

Carbonate reservoir heterogeneity is a defining characteristic that fundamentally shapes the behavior and properties of subsurface formations. The intricate variations in mineralogical composition, pore structure, and fluid flow properties within carbonate reservoirs produce a complex mosaic of heterogeneities. These variations can manifest at various scales—from microscopic pore-scale heterogeneities to larger-scale facies changes—presenting both a challenge and an opportunity for reservoir characterization and management.

Optimizing exploration and production strategies is reliant on understanding carbonate reservoir heterogeneity. The diversity of carbonate rocks, which are characterized by an assortment of depositional environments and diagenetic processes, results in a wide range of rock types and properties within a single reservoir. These heterogeneities influence fluid flow behavior, porosity distribution, permeability variations, and ultimately, the recoverable reserves within the reservoir.

The importance of comprehending carbonate reservoir heterogeneity extends beyond reservoir characterization, including production forecasting and reservoir management. Heterogeneities can significantly impact fluid flow patterns, leading to optimized flow paths, compartmentalization, and challenges in sweep efficiency during enhanced oil recovery processes. By elucidating the spatial distribution and nature of heterogeneities, engineers can design targeted reservoir management strategies to maximize hydrocarbon recovery and optimize production performance.

The recent exploration of carbonate reservoirs has unveiled myriad mineralogical, geological, and geochemical heterogeneities that challenge our conventional understanding. This Special Issue has, therefore, served as a platform to address these gaps in our knowledge by presenting innovative research that sheds light on the intricate relationships between these heterogeneities within reservoir formations. As the Guest Editor of the Special Issue "Mineralogical, Geological and Geochemical Heterogeneities of Carbonate Reservoirs", it brings us great pleasure to oversee the culmination of these academic developments with the publication of five insightful papers that explore the complexities of carbonate reservoirs.

From the analysis of large scale facies variations to the influence of dolomitization on rock types, the contributions within this Special Issue have expanded our understanding of carbonate reservoir dynamics. However, as we celebrate the achievements of this issue, it is crucial to recognize that our understanding of carbonate reservoirs is far from comprehensive.

We recommend that future research endeavors should focus on exploring the implications of heterogeneities at a broader scale, integrating multidisciplinary approaches to enhance our predictive capabilities. By employing advanced technologies and innovative methodologies, we can explore new avenues of research that will redefine our understanding of carbonate reservoir behavior. We should continue to push the boundaries of knowledge, unravel the complexities of carbonate reservoirs, and pave the way for

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a future where geological heterogeneities are not just challenges, but opportunities for groundbreaking discoveries.

We collected five papers to better understand the nature of heterogeneity in carbonates and are summarized below.

The first article by Guo et al. investigates the genetic mechanism of newly discovered Permian Guadeloupian Maokou Formation reservoirs, focusing on the impact of the Emeishan mantle plume activity (EMP) on sedimentation and diagenesis. Petrographic and geochemical analyses support the influence of EMP, altering the sedimentary environment and inducing complex diagenesis. The study proposes a reservoir genetic model linking EMP intensity to the formation of high-yield dolomite reservoirs, offering insights into carbonate reservoir genesis.

This Special Issue continues the research endeavor began by Memon et al. This investigation focuses on the Chiltan Formation as a potential hydrocarbon-producing reservoir in the Indus Basin, Pakistan, highlighting challenges in characterizing its diagenetic alterations and heterogeneous behavior. Through detailed analysis of six carbonate core samples, including petrography, SEM-EDS, FTIR investigations, and porosity-permeability measurements, this research project identifies three distinct microfacies with significant diagenetic impacts. The findings underscore the complex pore network, varied micropore structures, and low petrophysical properties influenced by diagenesis and depositional settings. Stress sensitivity analysis reveals decreased permeability under varying stress levels, emphasizing the importance of stress effects in reservoir management and providing valuable insights for resource exploration and production strategies.

In their research, Yang et al. focused on the formation mechanism of the dolomite-mottled limestone (DML) reservoir of Ordos Basin. This study employes petrographic and geochemical analyses. The DML comprises dolomite-filled burrows and matrix of wakestone or mudstone. Various diagenetic events, including dolomitization, compaction, cementation, and hydrocarbon charging, have shaped the reservoir. Varied dolomitization degrees from west to east influence reservoir quality, with the western part having better quality due to a higher dolomitization degree and stronger anti-compaction properties.

Wu et al. examines the characteristics of crystalline dolomites in the Sanshanzi Formation in the central-eastern Ordos Basin, focusing on their potential for gas exploration. Different types of dolostones are identified, with medium-coarse crystalline dolostone being the most promising reservoir due to its higher porosity and permeability. This research sheds light on ancient dolomite reservoir development and preservation mechanisms, guiding future oil and gas exploration in the Cambrian period in the Ordos Basin.

Moeini et al. explored the large scale heterogeneity of an isolated platform is. This study delves into the Sarvak Formation, a significant reservoir in Iran, focusing on facies variations and paleoenvironmental reconstruction during the Cenomanian period. Facies and isochore maps reveal spatial variations in paleoenvironmental conditions. The proposed conceptual model suggests an isolated platform surrounded by two ramps in the Lurestan Zone, with distinct sub-zone locations. This model offers insights applicable to isolated platforms globally.

In conclusion, this Special Issue provides a comprehensive exploration of diverse geological formations and reservoirs, producing key insights into paleoenvironmental conditions, facies variations, and reservoir potentials. By focusing on the Sarvak Formation in Iran and the Sanshanzi Formation in the Ordos Basin, the studies presented in this Special Issue contribute to our understanding of ancient carbonate platforms and dolomite reservoirs. From detailed facies analyses to paleoenvironmental reconstructions, the research presented in this Special Issue serves as a cornerstone for future studies in oil and gas exploration. The proposed conceptual models and findings not only enhance our knowledge of specific geological formations, but also provide a framework that can be applied to similar geological settings globally.

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List of Contributions:

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