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Abstract

Objectives/Scope: Carbonate lithofacies mapping is critical to unravel their facies aerial distribution and the processes how these carbonate rocks deposited. However, such an information is often challenging to obtain from the outcrops and require extensive field studies. This is further compounded by the limited exposure and heterogeneity between different carbonate units.

Methods, Procedures, Process: While recent works have utilized remote sensing technology to overcome this issue, there are limited works focusing on carbonates due to subtle variations in the remote sensing signals. The current study integrates Landsat-8, Sentinel 2A datasets, and petrographic analysis to propose updated lithological and lithofacies maps. Here, we proposed a novel approach by integrating multispectral remote sensing datasets, several advanced image processing techniques (Band Ratios (BR), Principal Component Analysis (PCA), and Minimum Noise Fraction (MNF)), and supervised classification to perform high-resolution carbonate lithofacies mapping of a Mesozoic carbonate in Saudi Arabia (Middle Jurassic Tuwaiq Mountain Formation (TMF)). This formation was selected not only because of its excellent exposure and wide aerial distribution, but also its importance as conventional and unconventional reservoirs.

Results, Observations, Conclusions: Our results highlight the promising application of multi-spectral remote sensing datasets to map and delineate different members (T1, T2, T3) and also key lithofacies in the TMF. In addition, for the first time, the middle member of TMF (T2) can be further subdivided into two subunits (a & b) using optical remote sensing datasets. These findings are further corroborated by detailed petrographic analysis, which confirms the presence of two sub-members of T2 (Spiculitic foraminiferal wackestone and Coralline floatstone facies). This study demonstrates that multispectral remote sensing, particularly Landsat8 PCA (5, 3, 1) and Sentinel 2A MNF (3, 4, 5) are effective at distinguishing different TMF lithofacies.

Novel/Additive Information: This resulted in a revised and accurate lithological map that made significant modifications over older maps. The proposed approach should be applicable to other carbonate outcrops globally and could help in improving carbonate lithofacies mapping where the outcrops are not readily accessible.