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Application of Spectral Gamma Ray for Lithofacies and Paleo-environmental Interpretation: A Case Study from the Late Ordovician Glaciogenic Deposits, Saudi Arabia

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This study is an integral part of multidisciplinary research being carried out on the Late Ordovician Sarah Formation in the Rub' Al-Khali Basin, Saudi Arabia. Sarah Formation proved to be important target for tight gas reservoir in Saudi Arabia. This study integrates lithofacies characteristics and spectral Gamma Ray of core samples so as to identify and differentiate among different depositional environments. Thorium (Th, ppm) and potassium (K, %) are acquired with approximately a reading point per inch using high-resolution Spectral Core Gamma. The cores description and analysis from six exploratory wells revealed four depositional environments ranging from the glaciofluvial, glaciolacustrine delta, subglacial to the nearshore environments. Based on lithofacies and geochemical analysis of the core samples, four groups of lithofacies including sandstone (G1), claystone and/or argillaceous sandstone (G2), calcareous and/or evaporitic sandstone (G3), and diamictites (G4) were recognized in each well. The bivariate plots of Th and K were used to delineate the minerals contents in each core and environment. The results showed that the G1 facies of the nearshore and glaciofluvial environments are characterized by similar distribution patterns of these elements exhibiting lower clay minerals variations than that in the other groups of lithofacies. These patterns consist of two mineral groups, the first one includes illite and montmorillonite clay minerals while the second one includes mica, glauconite, and feldspar. By contrast, G1 and G2 lithofacies of the glaciolacustrine delta environment are characterized by a range of clay minerals. However, G3 of this environment exhibits similar pattern of the nearshore and the glaciofluvial environments This is because the grains of G3 are cemented by anhydrite rather than by clays. Based on the lithological characteristic, matrix-supported and clast-supported diamictites were identified in the subglacial environment. The differences between these two lithofacies were clearly detected using Th/K plot. Both diamictites are characterized by a range of minerals including illite, mixed layer clays, glauconite, and feldspar. The matrix-supported diamictites contain higher proportions of these minerals. This study indicates that the relationship between Th and K can be used to predict the types of lithofacies and clay contents in different glaciogenic depositional environments. In addition, it can be used to predict the relative amounts of the clay minerals in each lithofacies. In turn, identifying the types and the amounts of clay minerals in lithofacies facilitate the prediction of reservoir quality and eventually lead to enhancement of their development and productivity.