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Stratigraphic Trapped Carbonate Reservoirs Gas Detection using Mono Frequency Spectral Decomposition Ratio Approach, Application in Saudi Arabia

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ABSTRACT

Kingdom of Saudi Arabia fields were assessed for the feasibility of the Mono-Frequency Spectral Decomposition (FSD) Ratio approach to detect the existence of hydrocarbons in Triassic and Permian carbonate reservoirs. The unconventional Mono-FSD Ratio concept application was integrated with other conventional seismic stratigraphic attributes as a significant objective to reveal new potential of stratigraphic hydrocarbon plays and sweet spots for discoveries.

The amplitude spectrum of gas bearing reservoirs typically diminishes at the high frequencies more rapidly than that of water-wet reservoirs. Therefore, incremental Mono-FSD volumes from 5 to 40 Hz were generated utilizing the latest optimum Relative Amplitude Preserved (RAP) processed 3D seismic data volume available. Horizon maps over the carbonate reservoir intervals of interests were then produced, which included RMS of surface seismic amplitude, acoustic impedance inversion and Mono-FSD attributes.

Wells in the field “A” have hydrocarbon evidence by testing and logs in the Triassic and Permian carbonate reservoirs, while the field “B” crest well shows no hydrocarbon of any kind in the same carbonate reservoir intervals. A flank well in the field “C” proved gas on logs and from well tests in the same Permian carbonate reservoir interval but a crestal well did not, implying a stratigraphic component in the hydrocarbon trapping mechanism. The Mono-FSD maps demonstrated sweet spots at the field “A” and field “C” flank well; and dimmed at the field “B” well at low frequencies, diminishing rapidly on higher frequency maps at these sweet spots. The acoustic impedance maps exhibited low impedance at the field “A”, field “C” flank well and the north flanks of the field “B”, suggesting lithofacies changes from tight reservoir rocks at the field “B” crest to porous rocks on the flanks. The RMS amplitude maps exhibited fairly high amplitudes at field “B” and relatively moderate at field “C” but lower amplitudes at field “A” for both Triassic and Permian carbonate reservoirs. The interpretation of the 3D seismic attributes including Mono-FSD Ratio technique and acoustic impedance inversion maps consistently agreed with the studied fields wells for gas detection and porosity prediction. The integration of these 3D seismic attributes led to identifying potential of stratigraphic carbonates reservoir sweet spots for good porosity and gas accumulations. Permian carbonate reservoir penetrated by discovery well at the flank of the field “B” proved the stratigraphic traps and validated the concepts of Mono-FSD Ratio technology in the Saudi Arabia.