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Machine Learning Assisted 3D Seismic Interpretation of Shelf-to-Basin Geomorphology

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ABSTRACT

An understanding of the distribution and geometry of geomorphological features in the shelf-to-basin setting is important to decipher stratigraphic processes and reservoir characterization. With the advent of large mega-merge and even giga-merge 3D seismic surveys, it has become essential to increase the efficiency of subsurface interpretation using limited time and resources effectively. Machine learning (ML) offers an attractive value proposition in this context. This study primarily utilizes a large 3D seismic survey (covering 670 square miles) along with borehole logs from a sedimentary basin in the US. After basic seismic interpretation, we compute an ensemble of seismic attributes, such as coherence, coherent energy, gray-level co-occurrence matrix homogeneity, and spectral decomposition, to identify and interpret geomorphological features in the study area. We compute coherence to detect the boundaries of the geomorphological features. Coherent energy is an amplitude-related attribute that involves singular-value decomposition of the seismic data in different principal components, with different windows aligned along the structural dip of the formations. Spectral decomposition elements help discern the varying thickness of stratigraphic features. Each attribute's results are unique, in terms of resulting output, including external boundary, geometry, and internal texture of geobodies. We used an unsupervised ML approach, generative topographic mapping (GTM), to cluster different seismic facies. GTM is a technique for nonlinear dimensionality reduction that provides a probabilistic representation. Unlike other popular ML algorithms, such as K–means, GTM preserves the topology and associative order of clusters. We use our human-level interpretation skills to analyze GTM results. Clusters at different stratal slices represent slope channels, canyons, basin-floor fans, and sediment wave deposits. The canyon and basin-floor fans have a high thickness. GTM results show the detailed distribution of channel facies that was not visible before.

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