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Chasing Mass Transport Deposits with Deep Neural Networks; The Good, the Bad, and the Ugly

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Summary

Mass transport deposits (MTDs) are widespread along continental margins and may constitute the majority of sediments accumulating in some deep-water basins. Although MTDs are more often associated with hydrocarbon seals composed of fine-grained deposits, coarser-grained MTDs may also form hydrocarbon-bearing reservoirs. Likewise, the topography generated along the top surfaces of some mud-prone MTDs may prompt deposition from subsequent coarse-grained sediment-gravity flows, providing an indirect link between MTD emplacement and reservoir distribution. The recognition of MTDs in the stratigraphic record, particularly in shallow intervals, is also critical for assessing the hazard they may pose to drilling activities or subsea infrastructure, since MTDs may be associated with over-pressured subsurface zones or unstable seabed conditions.

Because many MTDS lack distinct, consistent markers along their top and base surfaces, mapping MTDs can be a time-consuming and tedious exercise for seismic interpreters. Here we apply machine learning, incorporating a state-of-the-art deep neural network (DNN) based on ResNet architecture to identify convoluted MTD features in seismic data. We trained the DNN with over 48,000 interpreted images showing the full variety of geometries, seismic architectures and facies of MTDs. These datasets are conditioned, and manually interpreted to produce the biggest machine learning dataset available worldwide for MTD identification. The output of the resulting model shows >97% overlap with manual interpretations in the validation phase. We evaluate the robustness of the candidate DNN, compared to the human interpretation, in a variety of geological environments, input seismic attributes, changes in data quality, and noise levels within the imagery records. The DNN is then applied to over 10,000 square kilometers of the Shell's Shelburne 3D seismic reflection survey (Nova Scotia offshore) to map Cenozoic MTDs and investigate the influence of mass failure events on the geological history of the margin.