3D seismic facies segmentation using supervised and unsupervised learning approaches

Often exploration for oil and gas with seismic data starts with a quick look analysis to assess multiple areas, datasets and stratigraphic levels. This aids both the general understanding of the area and the data. It also helps prioritizing areas that are worth studying in greater detail using more time consuming and expensive workflows. In this presentation, two quick Machine Learning-based workflows are presented that aid identification of good quality reservoir elements in a fast, yet rigorous manner.

The first method is a new application of an old favorite: UVQ (Unsupervised Vector Quantizer) waveform clustering (De Groot and Campbell, 1995). The novelty is that instead of creating a clustered response along a mapped horizon, we now create a high-resolution 3D volume of clustered waveforms. The seismic patterns in the 3D cluster volume are subsequently interpreted in terms of geomorphological features. To facilitate the interpretation, the clustering is performed on a color inverted (relative) impedance volume and the interpretation is done along chrono-stratigraphic events extracted from a HorizonCube (a dense set of automatically generated horizons). This workflow is discussed in the context of two cases, one being a deep marine example, the second showing the analysis applied to a carbonate prospect, see Figures 1 & 2.

In the second workflow, we present a similar supervised workflow. A Convolutional Neural Network (CNN) segments a 3D seismic volume into different seismic facies classes. The CNN is trained on examples that were semi-automatically created by a human interpreter using a Thalweg tracker. A Thalweg tracker tracks 3D bodies along the path of least resistance. In practice this means that we can track sedimentary features such as channels, lobes, splays, and reef buildups. Application of the trained CNN yields a 3D segmentation volume that is further analyzed in the Wheeler domain (flattened seismic domain). see Figure 3.

Both examples were created in OpendTect utilizing different plugins, such as Machine Learning, Seismic Colored Inversion, and HorizonCube.

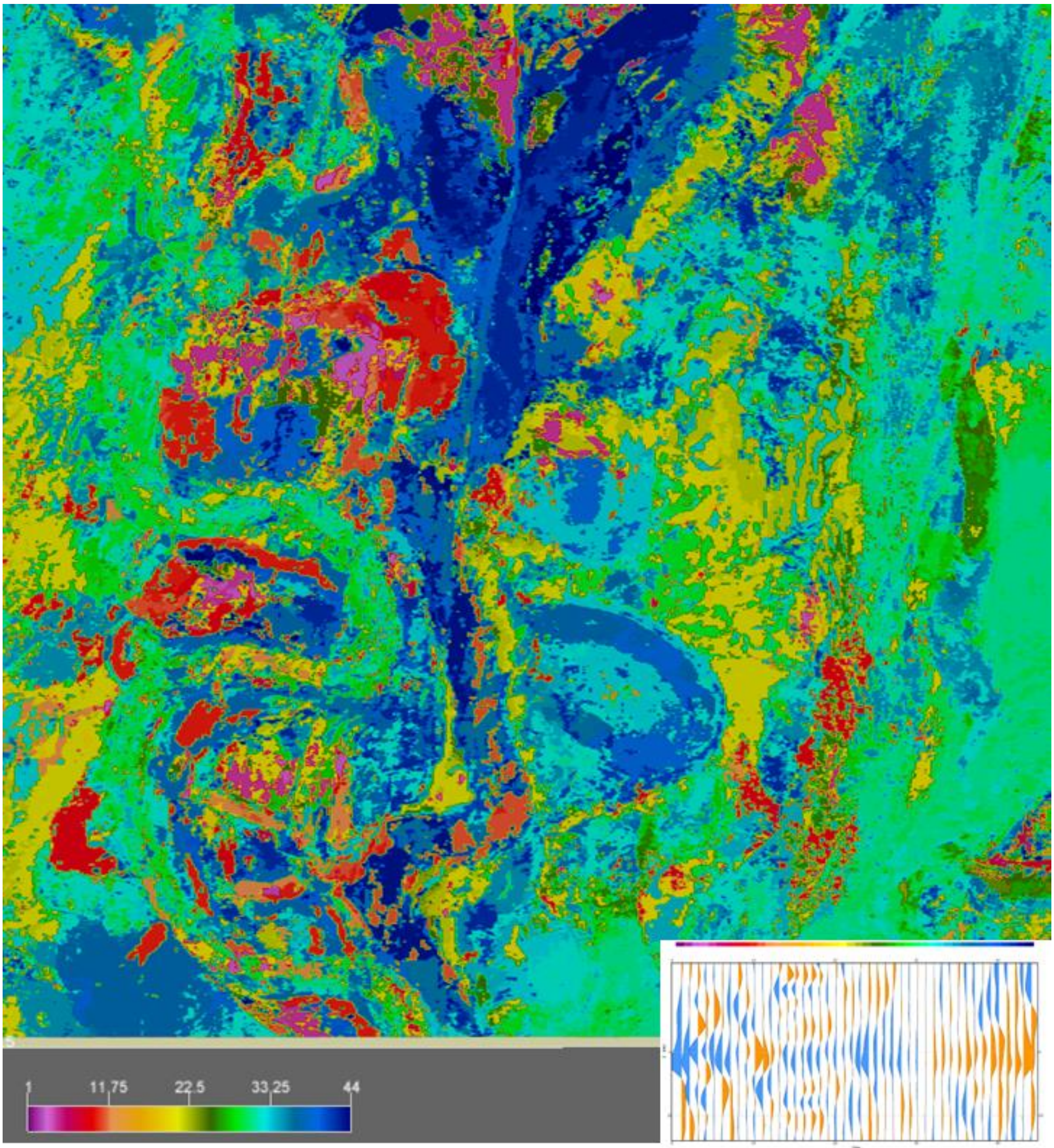

Figure 1. *3D clustering of relative impedance displayed on a HorizonCube slice in a deep marine turbiditic environment. The template waveforms are displayed in the inset right bottom. Different depositional elements can be easily recognized for further interpretation.*

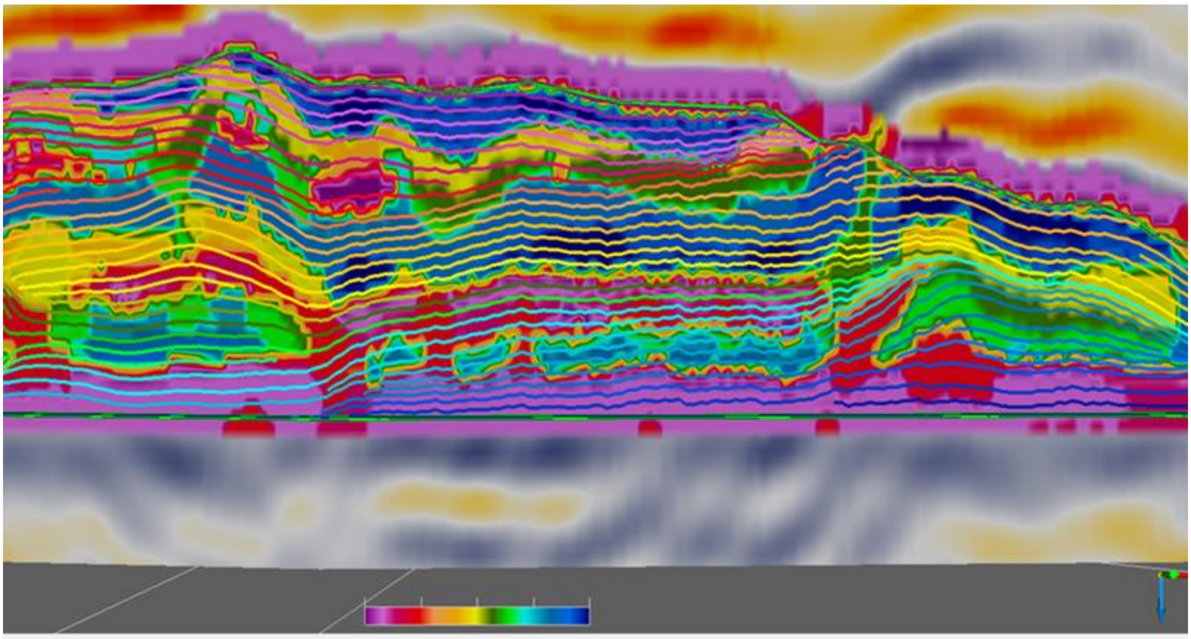

***Figure 2**. 3D clustering of relative impedance along a section through a prospective carbonate build-up. The clustering highlights symmetrical and repetitive patterns in the build-up that can be used to identify elements of the build-up. The chronostratigraphic lines from the HorizonCube are superimposed revealing relative timing and order of the carbonate growth.*

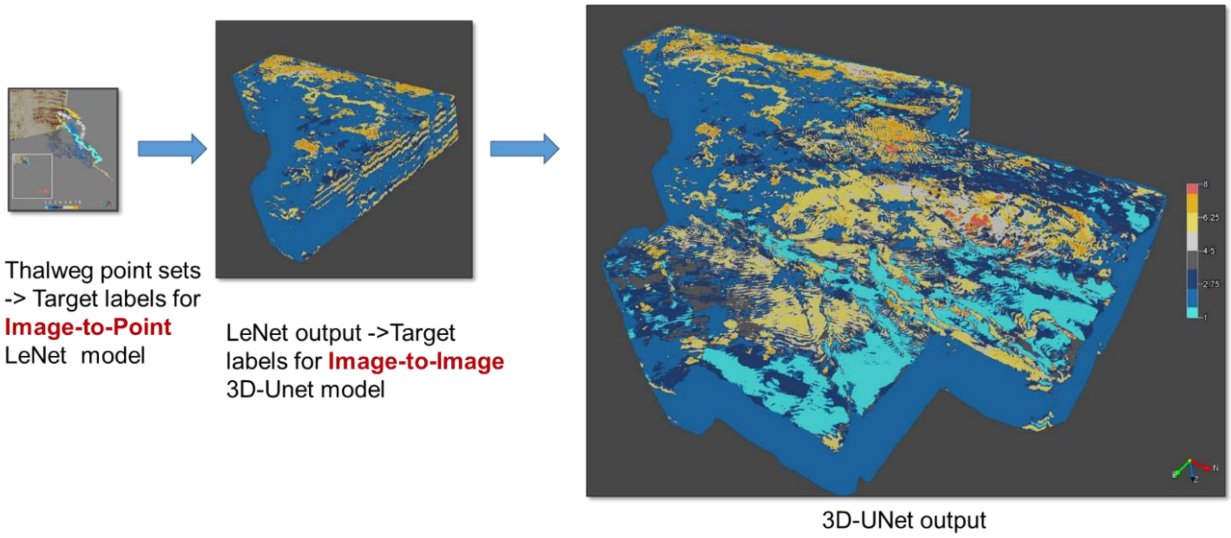

***Figure 3**. Sequential application for detailed facies prediction using supervised convolutional neural networks.*

References

De Groot, P. and Campbell, E. 1995. Seismic reservoir characterization in 'total space'; a Middle Eastern example. OAPEC/John Brown Workshop, New Technologies Applied to Hydrocarbon Production, Delft.