Explaining Clusters to Interpreters Using Opacity Modulation*

Thang Ha[1] and Kurt Marfurt[1]

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[1]The University of Oklahoma, Norman, OK, USA (thang.n.ha-1@ou.edu)

Abstract

Unsupervised classification techniques such as self-organizing map (SOM) and generative topographic maps (GTM) extract geologic features that have similar expression in attribute space. Then, using well control, principals of seismic stratigraphy and seismic geomorphology, or microseismic event location, the interpreter assigns meaning to the clusters. Unfortunately, it is very difficult to understand the relationships between clusters and the original seismic amplitude data using conventional co-rendering method. The purpose of this paper is to demonstrate the advantages of a novel implementation of opacity modulation technique regarding cluster interpretation.

Introduction

Our seismic survey is acquired over the Texas-Louisiana continental self and images chaotic features such as salt and mass transport complexes (MTCs). To interpret the data, we computed several seismic attributes, including Sobel-filter similarity (a type of coherence), coherent energy, and Gray-Level Co-occurrence Matrix (GLCM) contrast. Vertical slice through the seismic amplitude and attributes are shown in Figure 1, Figure 2, Figure 3, and Figure 4.

We then input these three attributes to a 3D SOM classification program to generate a volume of clusters. Since we do not know a priori how many clusters reside in the data, we set the number of clusters to the maximum number of colors that can be displayed in our commercial interpretation software (Roy et al, 2011). Figure 5 shows that these 256 clusters do not span the 2D latent space, with many of the clusters lying on top of each other. Clusters at or near the same location (and representing nearly identical data) are displayed with the same color. Each voxel in 3D space is then displayed using the corresponding cluster color.

Figure 6 shows a vertical slice through seismic amplitude co-rendered with the colored clusters. A best practice is to co-render a polychromatic image with a monochromatic image; for this reason, we changed the color of the seismic amplitude to gray-scale mode. The image is interpret-able, but has two main drawbacks: (1) each cluster cannot be interpreted separately because all clusters are rendered, and (2) it is very hard to relate cluster to reflector strength because amplitude colors are masked by cluster colors.

Discussion

In our opacity modulation technique, a cluster was first selected. Seismic amplitude data points that belong to the selected cluster are set to be opaque, while the rest are set to be transparent. Amplitude data of each cluster are rendered separately on black backgrounds in Figure 7, Figure 8, Figure 9, and Figure 10. We can see immediately that the orange clusters correspond to zero amplitude data above the sea floor. The violet clusters correspond to strong, continuous, low-frequency layers. The magenta clusters correspond to weaker, moderately continuous reflectors. Some coherent reflectors (multiples?) within the salt dome also appear to be in these clusters. Finally, the yellow-cyan clusters correspond to weak, chaotic textures of the main salt dome on the left of the Figure 10 and some slumps (or MTCs) on the right side.

Conclusions

To summarize, by using opacity modulation technique, it is much easier to interpret each cluster separately in terms of seismic amplitude properties, such as reflector strength, continuity, and frequency. It also helps us avoid negative effects of color masking in conventional co-rendering method. Supervision can be added to interpretation by defining interpreter-driven sub-volumes about a well, mapping these sub-volumes to cluster space, and then rendering seismic data exhibiting equivalent patterns in the 3D volume. In a similar manner, a seismic stratigrapher can per-form exploratory data analysis by drawing a polygon around a 3D feature of interest, mapping the attributes vectors to the cluster latent space, and use opacity to display amplitudes exhibiting a similar pattern.

Reference Cited

Roy, A., M.M. C de Matos, and J.K. Marfurt, 2011, Application of 3D clustering analysis for deep marine seismic facies classification - an example from deep-water northern Gulf of Mexico: 31st Annual Gulf Coast Section Society for Sedimentary Geology (GCSSEPM) Research Conference on Seismic Attributes, p. 410–439.

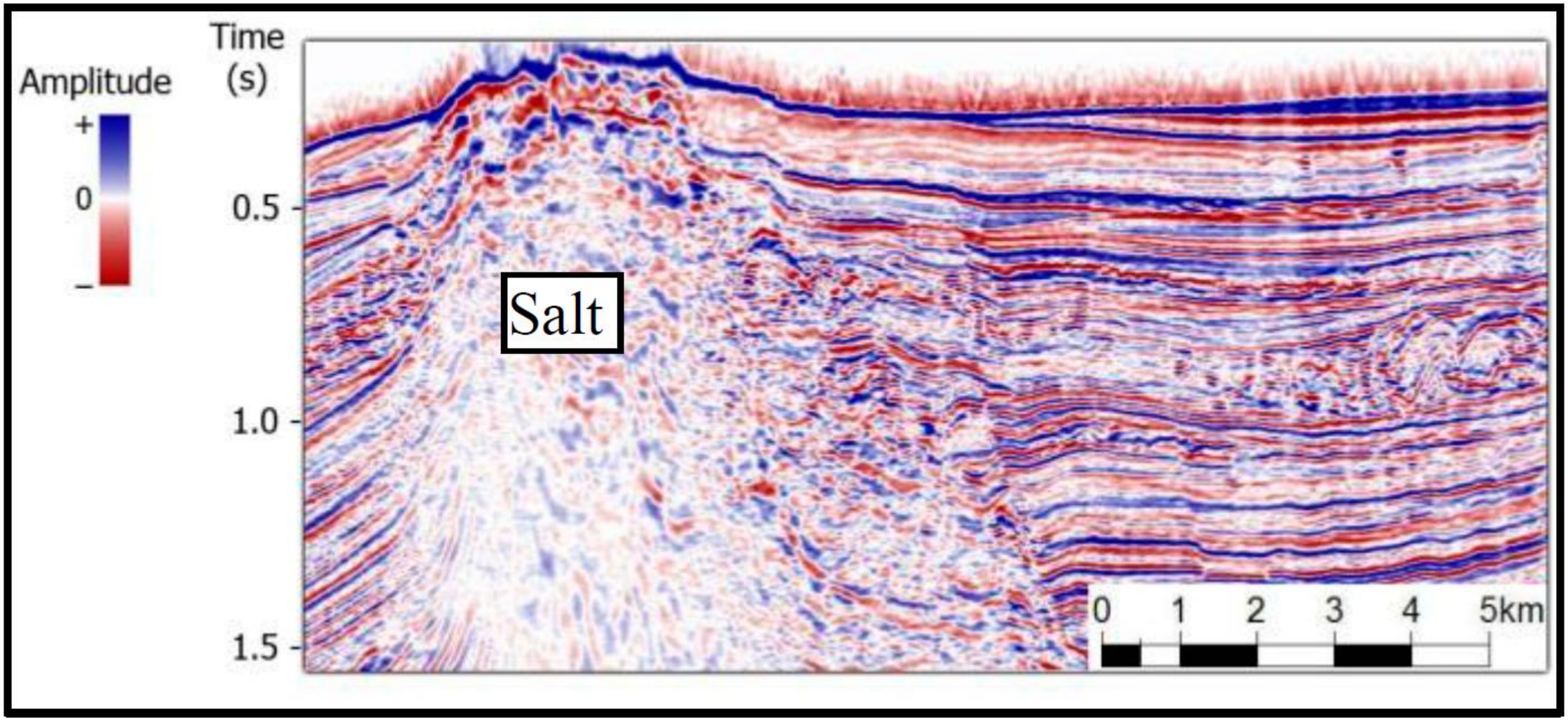

Figure 1. Vertical slice through seismic amplitude.

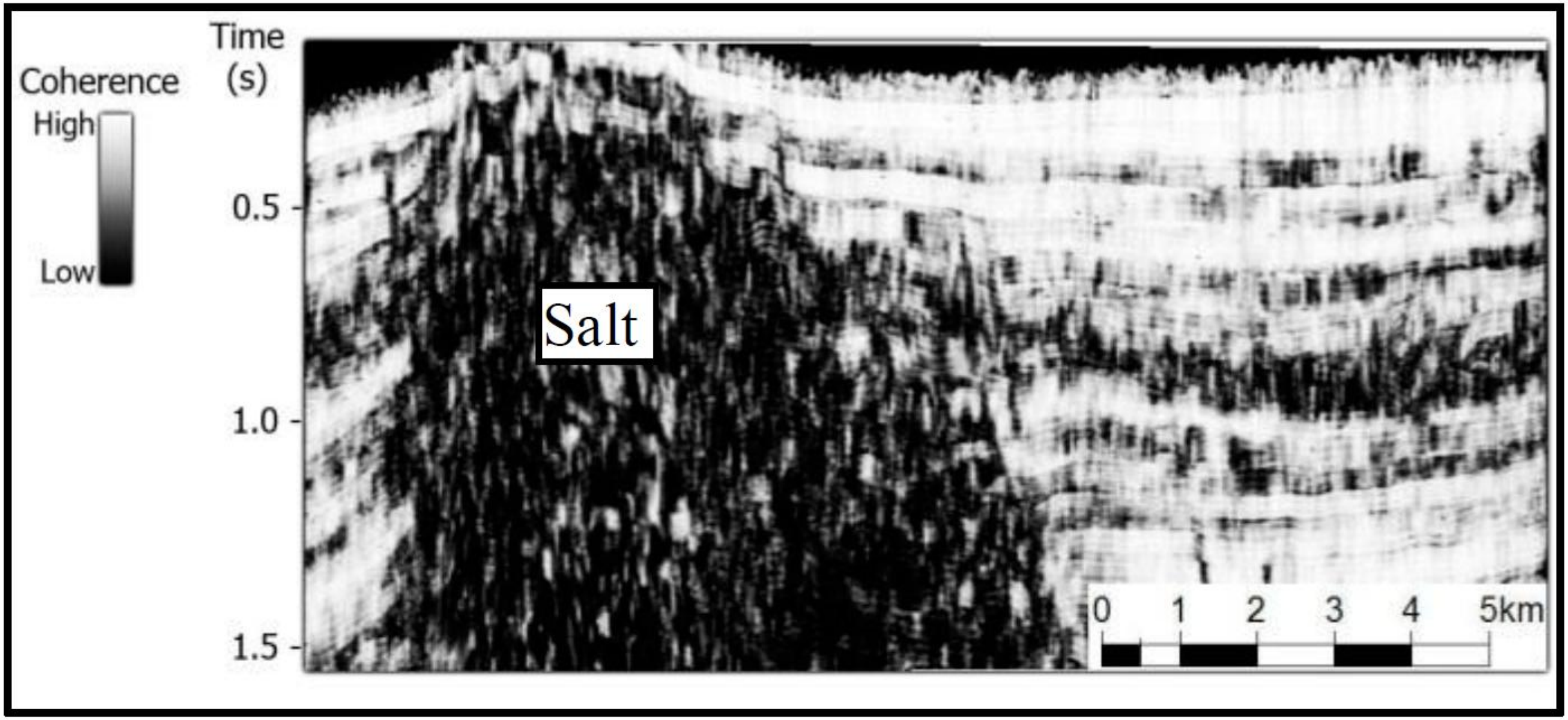

Figure 2. Vertical slice through coherence.

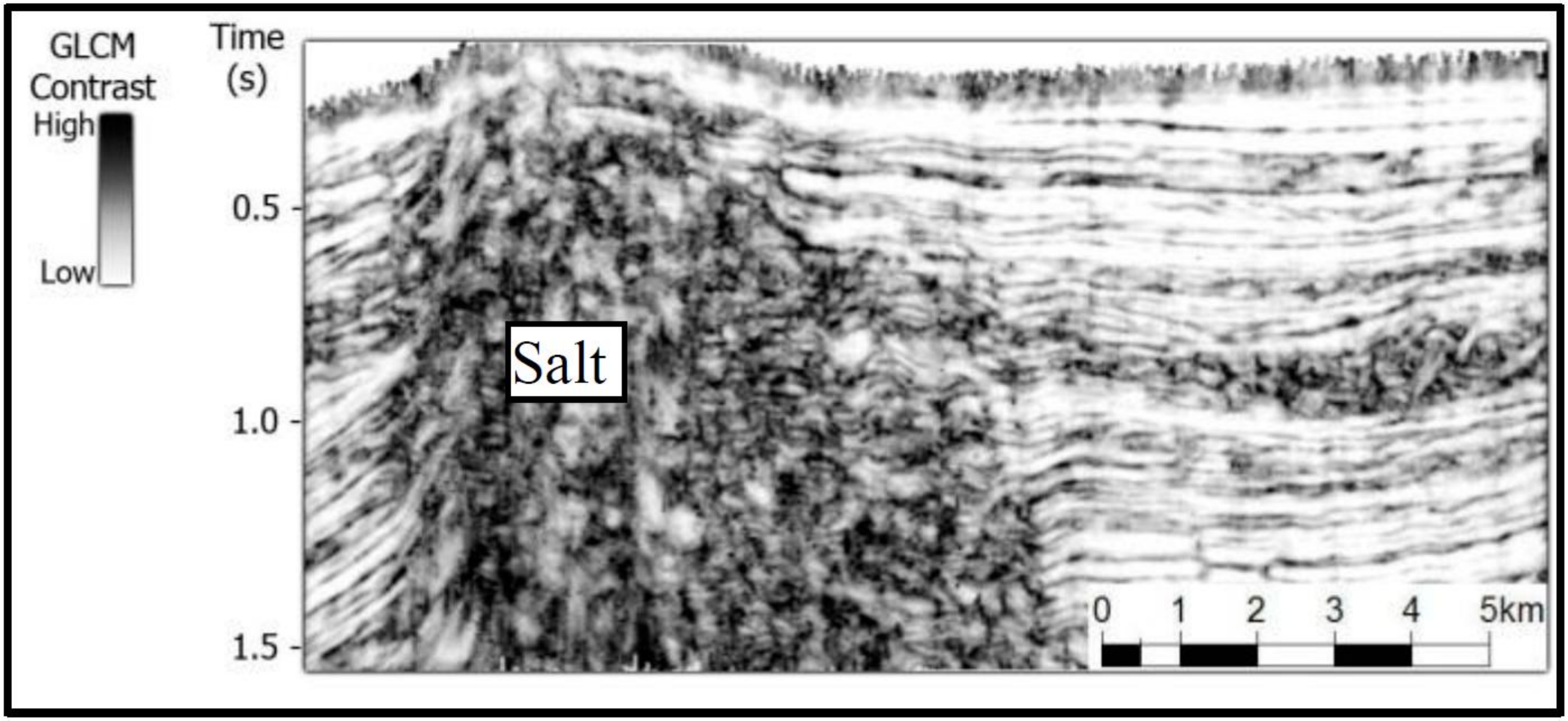

Figure 3. Vertical slice through GLCM contrast.

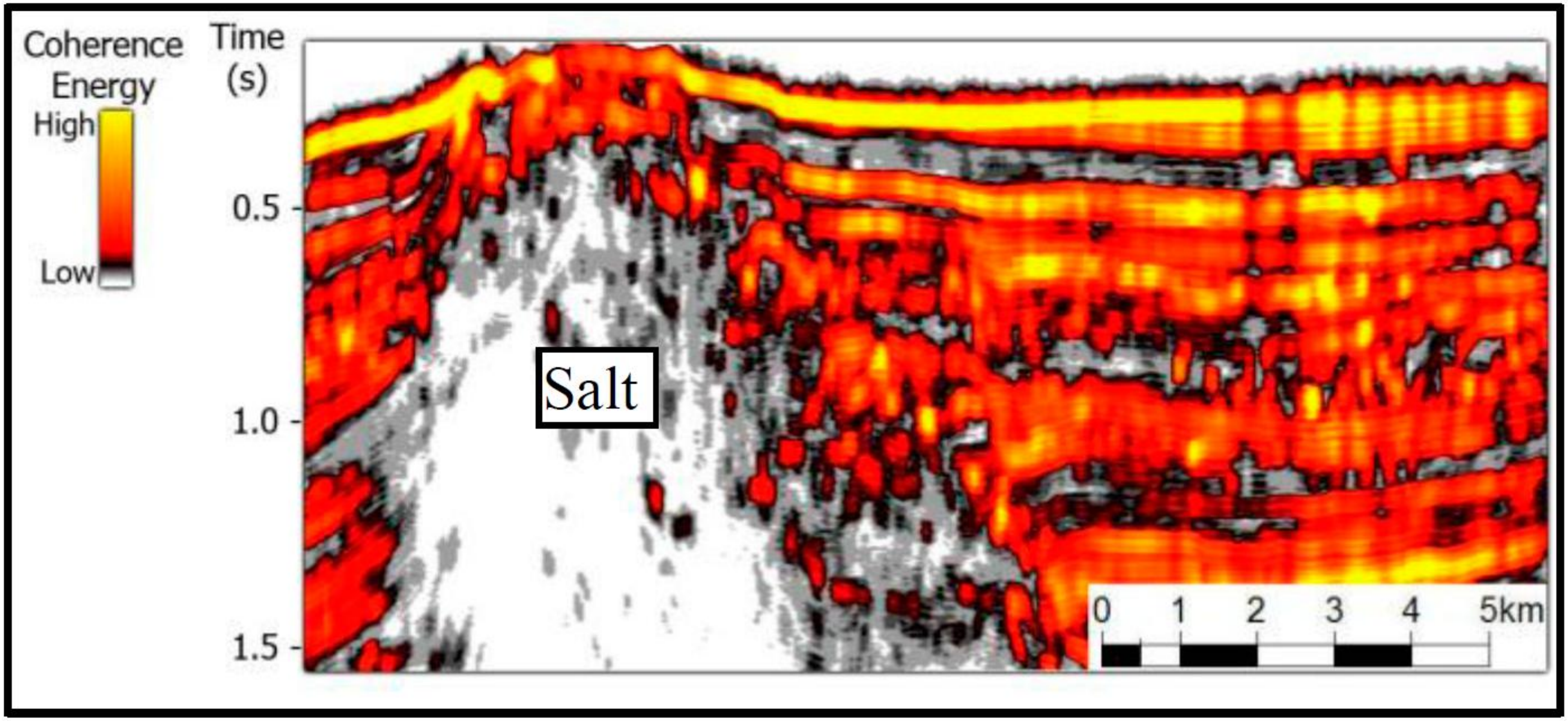

Figure 4. Vertical slice through coherent energy.

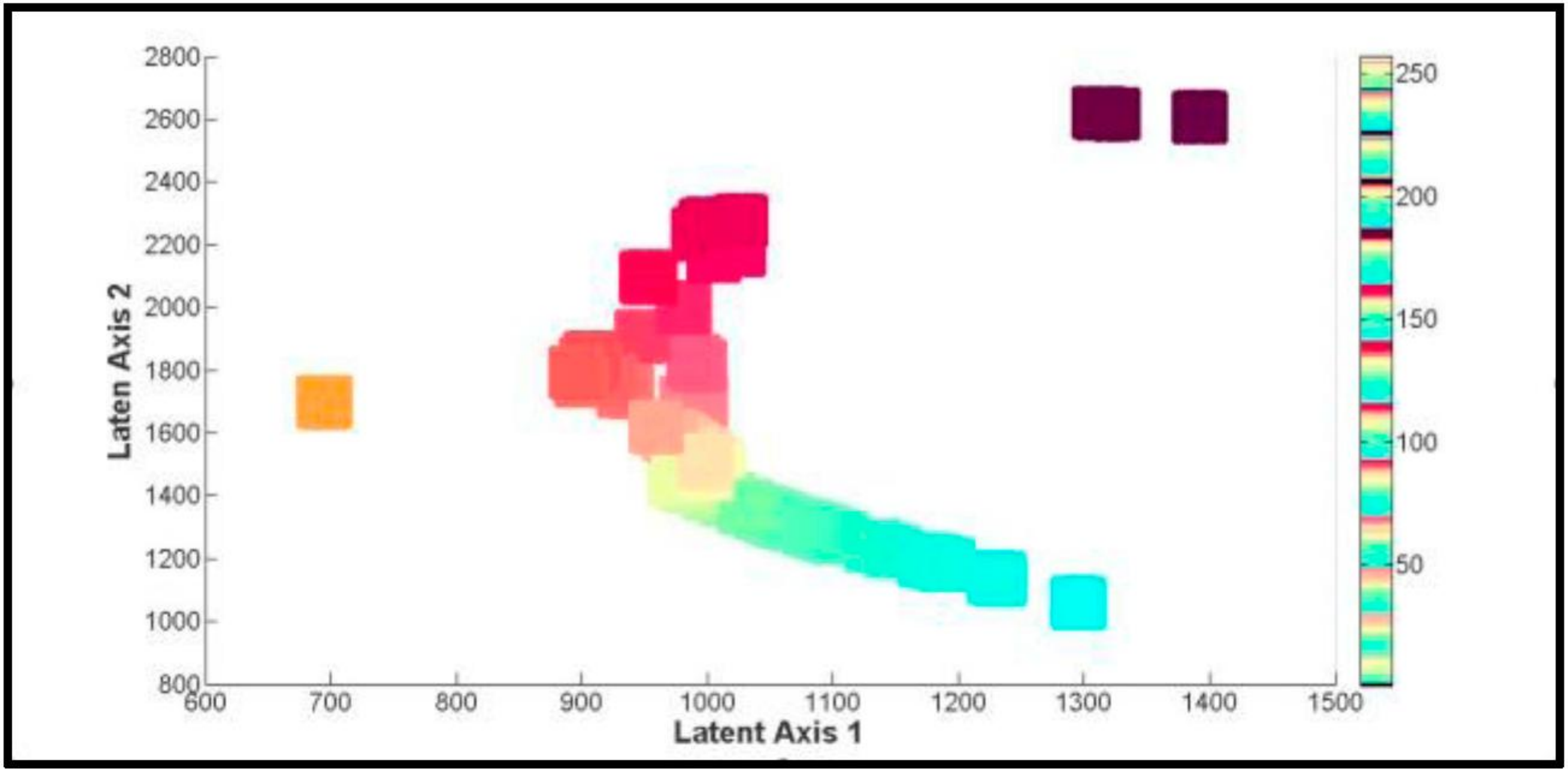

Figure 5. SOM clusters.

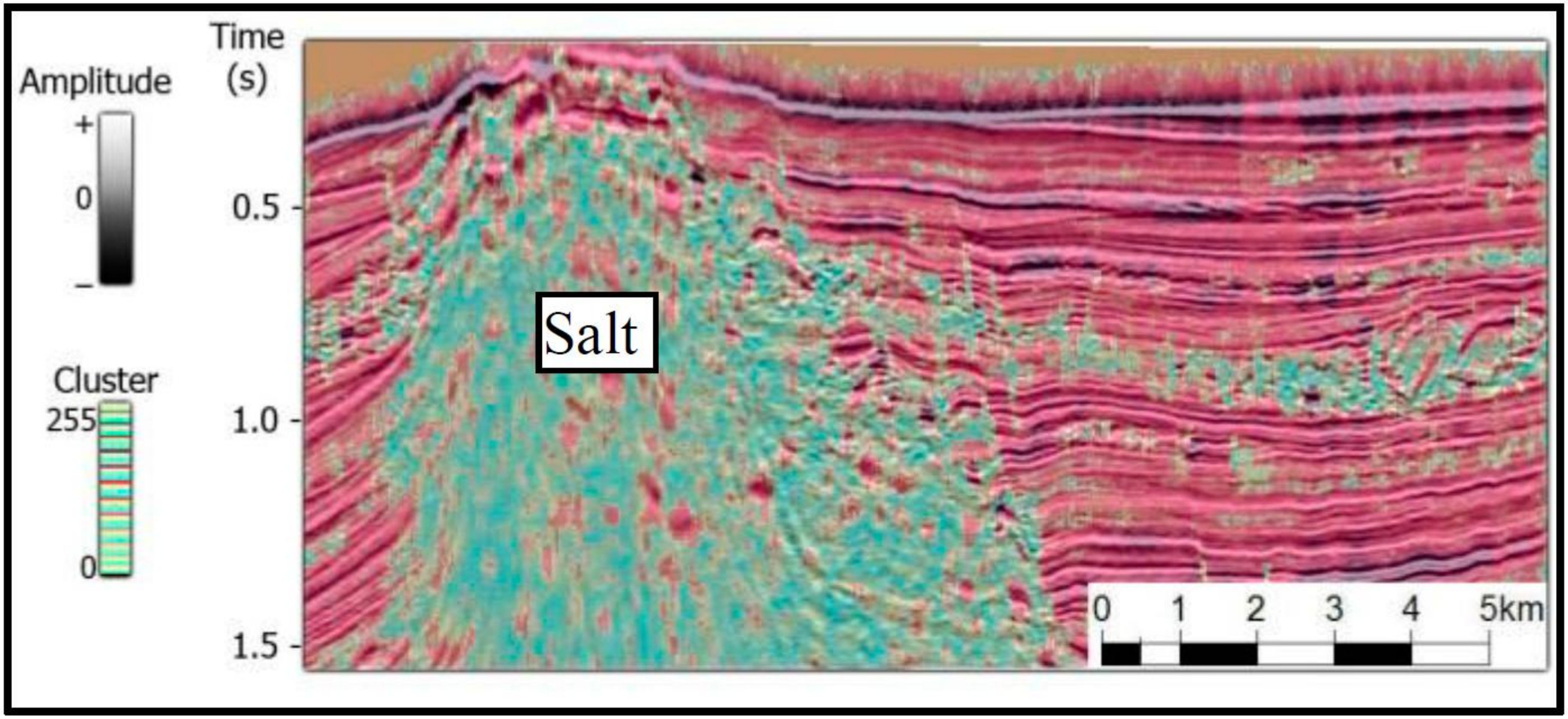

Figure 6. Vertical slice through amplitude co-rendered with the colored clusters. The reflector character is hard to interpret.

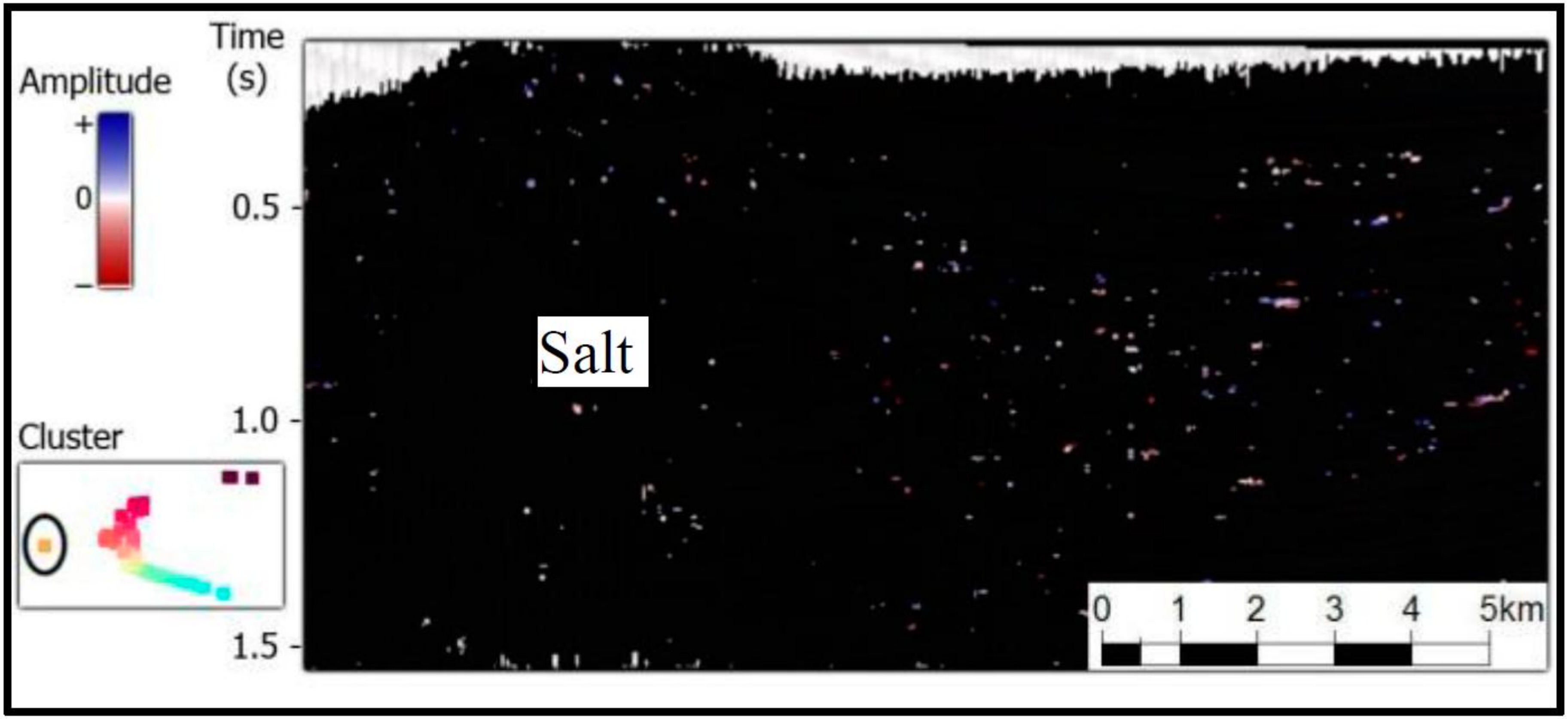

Figure 7. Vertical slice through seismic amplitude corresponding to the orange clusters. These rendered voxels are near zeros and fall predominantly in the water column. Background is set to black.

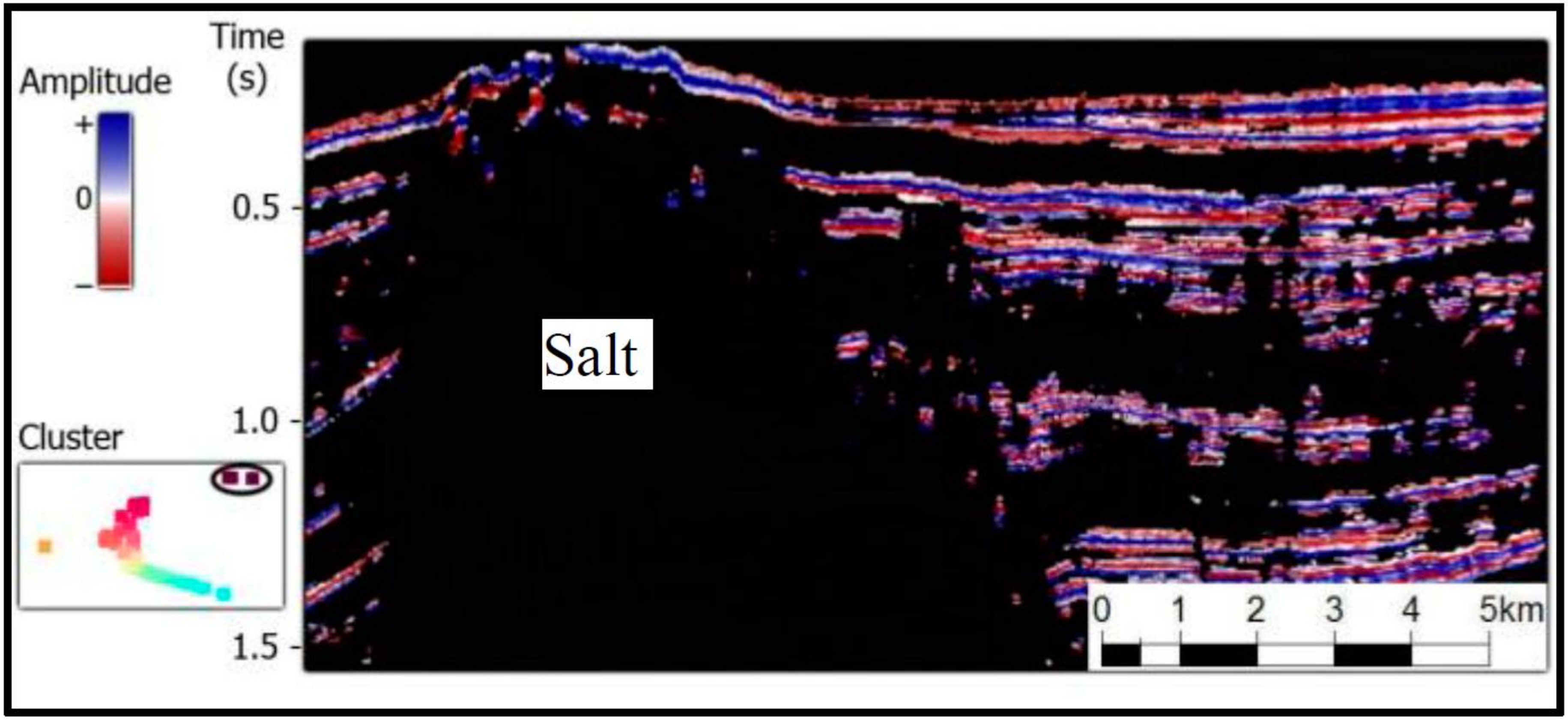

Figure 8. Vertical slice through seismic amplitude corresponding to the violet clusters. These clusters correspond to continuous high amplitude reflectors. Background is set to black.

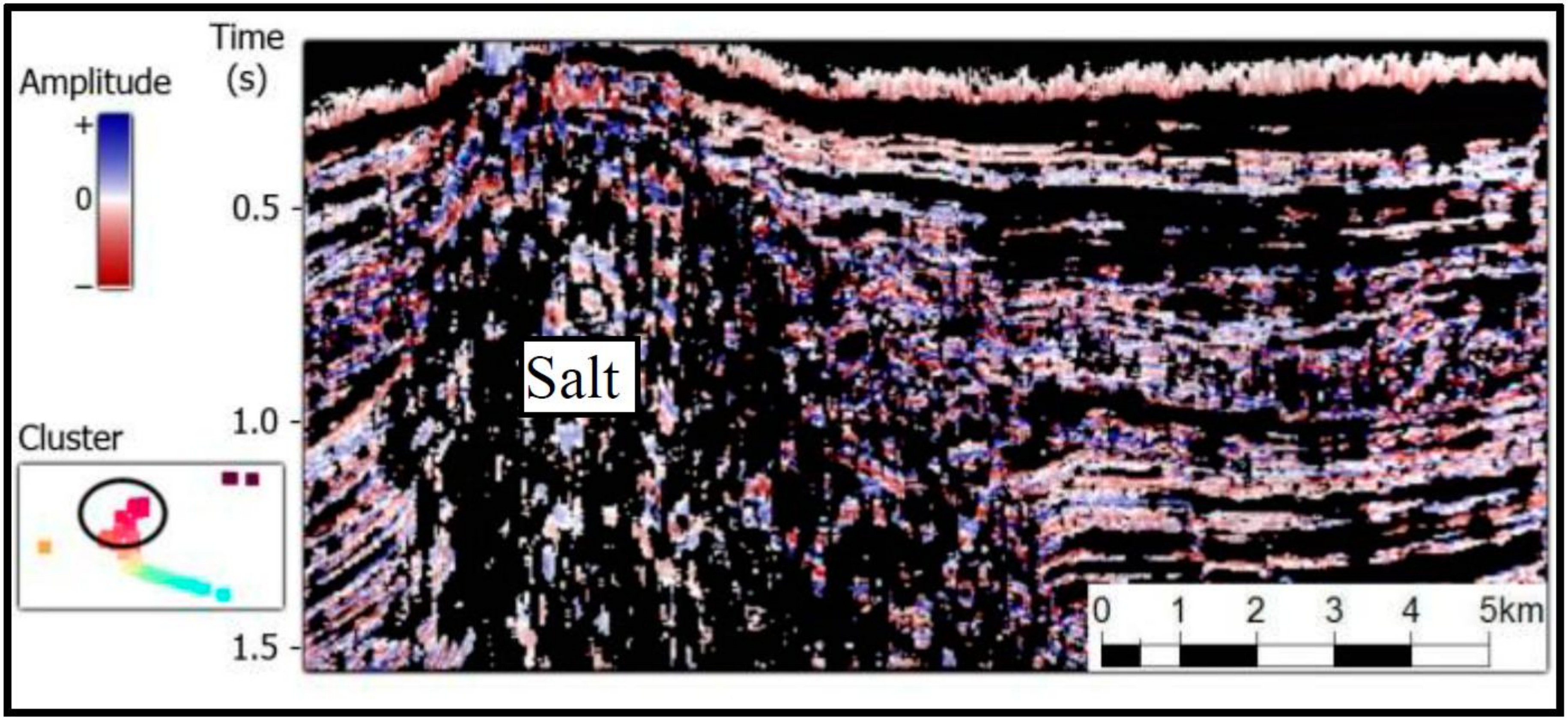

Figure 9. Vertical slice through seismic amplitude corresponding to the magenta clusters. These clusters correspond to moderate amplitude, less coherent reflectors. Background is set to black.

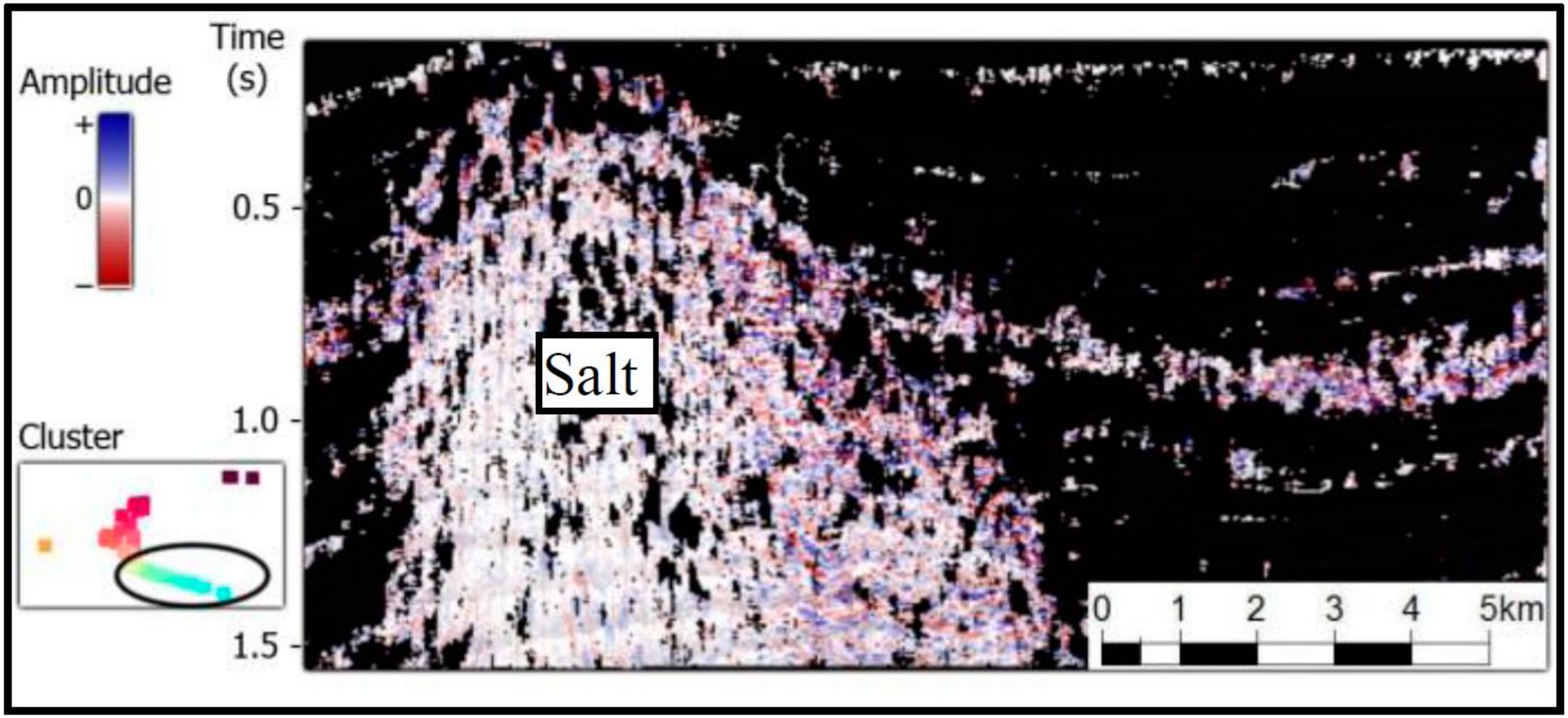

Figure 10. Vertical slice through seismic amplitude corresponding to the yellow-cyan clusters. These clusters correspond to low amplitude, chaotic salt and mass transport complexes. Background is set to black.