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Sweet Spot Interpretation from Multiple Attributes: Machine Learning and Neural Networks Technologies

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Summary

The "sweet spot" interpretation of shale gas routinely involves advanced visualization techniques, and generation of numerous seismic data types and attributes. Commonly used seismic attributes include the total organic carbon content (TOC), pore pressure, stresses, rock elasticity, brittleness and fracture development. To derive even more useful information from the multiple attributes and provide a easily tool for the characteristic analysis of the target shale reservoir, current visualization techniques, machine learning and neural networks technologies, including self-organizing map (SOM), K-means clustering, principal component analysis (PCA) and two-dimensional HSV color map have been all introduced to reveal the geologic features that are not previously identified or easily interpreted from the numerous seismic attributes. Through the attribute patterns generated by SOM, the unsupervised (K-means clustering), supervised (human-computer interaction monitoring clustering) classifications can be applied for flexibly explaining the characteristics of "sweet spot". Integrating with the PCA and HSV color map techniques, the distribution in the attributes selected are intuitively reflected and described.

Introduction

During the exploration and development of shale gas, the key is to find the "sweet spot" where shows good characteristics of natural fracture and hydrocarbon enrichment. There have been efforts to distill numerous seismic attributes into volumes that are easily evaluated for improved seismic interpretation. Aiming at the multi-attributes comprehensive evaluation of the unconventional reservoirs, the research work has been carried out on neural network technology including self-organizing map (SOM) and K-means clustering algorithm (Kohonen, 2001). According to the fusion evaluation target with various attribute parameters, such as the total organic carbon content (TOC), brittleness and pore pressure, principal component analysis (PCA) technology, two-dimensional HSV coloring technology (Roy and Marfurt, 2015) and human-computer interaction monitoring clustering technology are further applied for flexibly explaining the characteristics of "sweet spot" . Through the attribute clusters and patterns, the ultimate goal is to enable the geoscientist to produce a more accurate interpretation and reduce exploration and development risk.

Method

For different shale exploration areas, the evaluation criteria of shale reservoirs and the main control parameters are different, involving various factors including TOC, brittleness, fracture development, pore pressure, stress difference and so on. To comprehensively identify the reservoir favorable area, the SOM algorithm is first considered to solve the issue that humans cannot visualize high-dimensional data of these multiple attributes,.

SOM is a data visualization technique to reduce the dimensions of data through the use of unsupervised neural networks. By producing a 2D map that plots the similarities of the selected attributes of shale reservoir by grouping similar data items together, it is easily to understand how these attributes relate and to classify various patterns. Then unsupervised (K-means clustering), supervised (human-computer interaction monitoring clustering), and HSV color map are proceeded for the classification of the "sweet spot" and the evaluation of the attribute templates at each pattern.

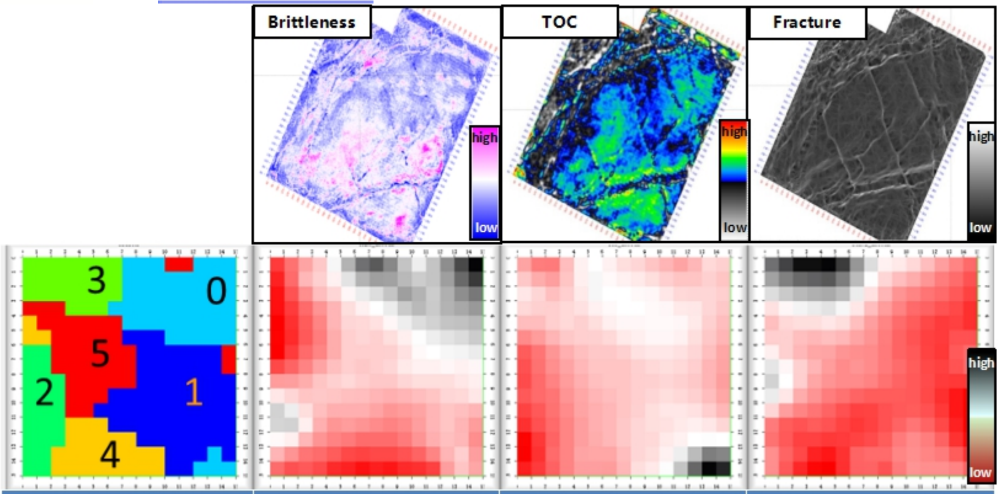
Examples

Figure 1 is the example of the "SOM+unsupervised" result for multi-attributes analysis of the shale reservoir. TOC, brittleness and fracture are selected for the transformed patterns each. Then 6 clusters are obtained by K-means clustering to produce a more accurate interpretation integrating these three attributes.

Figure 2 is the example of the "SOM+HSV colormap" result. After PCA and 2D HSV coloring, the distribution in the attributes TOC, brittleness and fracture of the target shale reservoir are intuitively reflected from the result.

Conclusions

Applying current visualization techniques, machine learning and neural networks technologies, including SOM, K-means, PCA and HSV color map, the distribution in the attributes are intuitively reflected and described, providing a easily tool for the characteristic analysis of the target shale reservoir.



Classification	Brittleness	TOC	Fracture develop
0	high	high	middle
1	middle	low	weak
2	low	low	strong
3	high	low	strong
4	high	middle	weak
5	middle	middle	middle

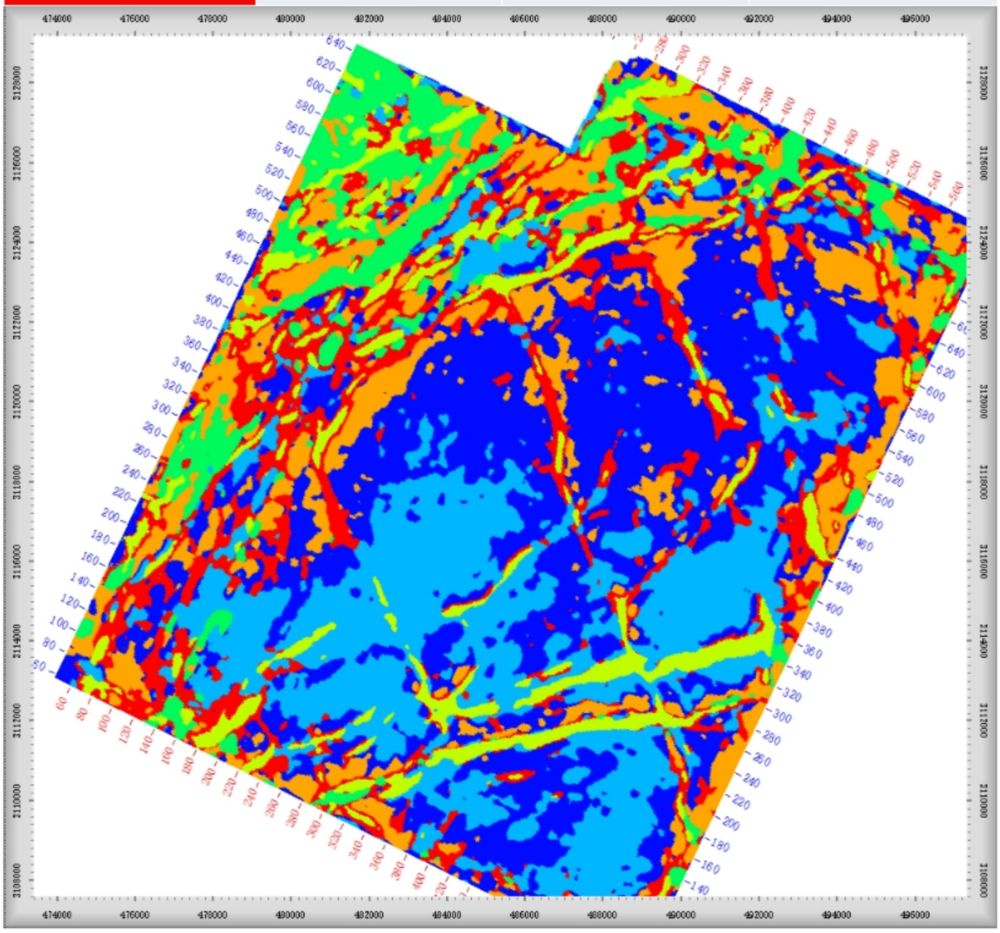


***Figure 1** "SOM+supervised" example.*

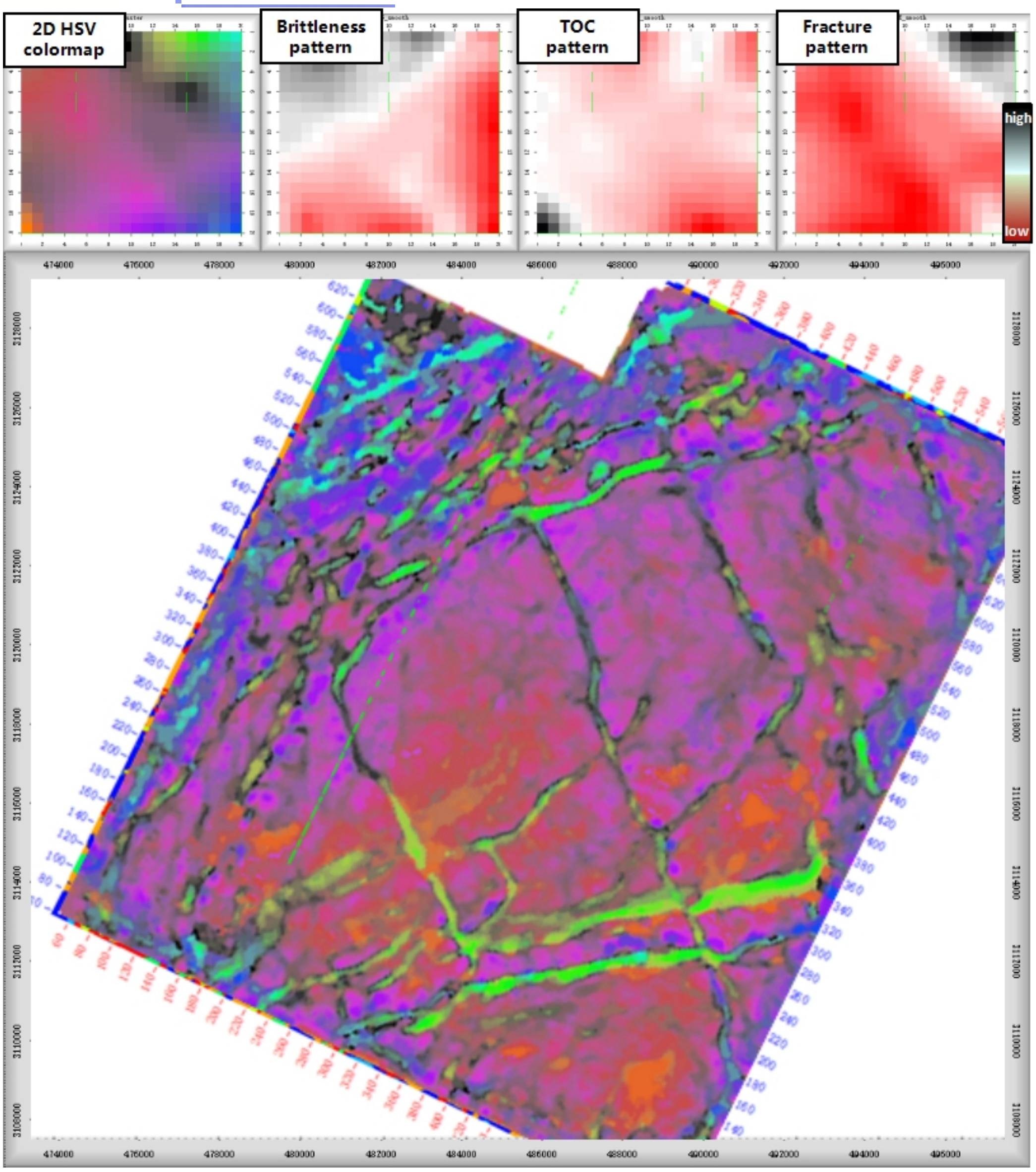


Figure 2 *"SOM+HSV colormap" example.*

Acknowledgements

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Reference

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