Enhancing Spatial Reasoning and Visualization Skills Using Field Data, Analog Modeling and Digital Visualization Software*

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Abstract

Given that deformation styles vary in space, both along the strike of a deformed belt and along the strike of individual structures within that belt, understanding the spatial relationships in deformed belts becomes a specific skill to be mastered. Traditionally, variation in deformation style is visualized with a series of closely spaced 2D cross-sections. However, the use of 2D section lines implies plane strain along those lines, the true 3D nature of the deformation is not necessarily captured and spatial cognitive reasoning is not always invoked. By using a combination of remotely sensed data, analog modeling of field datasets and this remote data, and numerical and digital visualization of the finished model, a 3D understanding and restoration of the deformation style within the region can be achieved.

Workflow

The workflow used for this study begins by considering the variation in deformation style, which can be observed from satellite, images and combining this data with traditional field data, in order to understand the deformation in the region under consideration. The conceptual model developed at this stage is then modeled using a sand and silicone modeling system, where the kinematics and dynamics of the deformation processes can be examined. A series of closely spaced cross-sections, as well as 3D images of the deformation, are created from the analog model, and input into a digital visualization and modeling system for restoration. In this fashion, the process of spatial reasoning and 3D visualization can be learned and a valid 3D model is created where the internal structure of the deformed system can be visualized and mined for information (Figure 1).

Discussion

The region used in the study is the Sawtooth Range, Montana. The region forms part of the Montana Disturbed Belt in the Front Ranges of the Rocky Mountains, along strike from the Alberta Syncline in the Canadian Rocky Mountains. Interpretation of satellite data indicates that the deformation front structures include both folds and thrust structures. The thrust structures vary from hinterland-verging triangle zones to foreland-verging imbricate thrusts along strike, and the folds vary in geometry along strike. The analog models, constrained by data from exploration wells, indicate that this change in geometry may be related to a change in mechanical stratigraphy along the strike of the belt. The very process of creating an analog model and viewing the results can enhance the ability of a student to learn spatial reasoning skills and thus to visualize a structure in 3D.

Conclusions

Additional implications of such a workflow and visualization system include the possibility of creating and viewing multiple cross-sections, including sections created at oblique angles to the original model. This allows the analysis of the non-plane strain component of the models and thus a more complete analysis, understanding and visualization of the deformed region. This workflow and visualization system is applicable to any region where traditional field methods must be coupled with remote data, intensely processed depth data, or analog modeling systems in order to generate valid geologic or geophysical models and an enhanced understanding of the region in question.

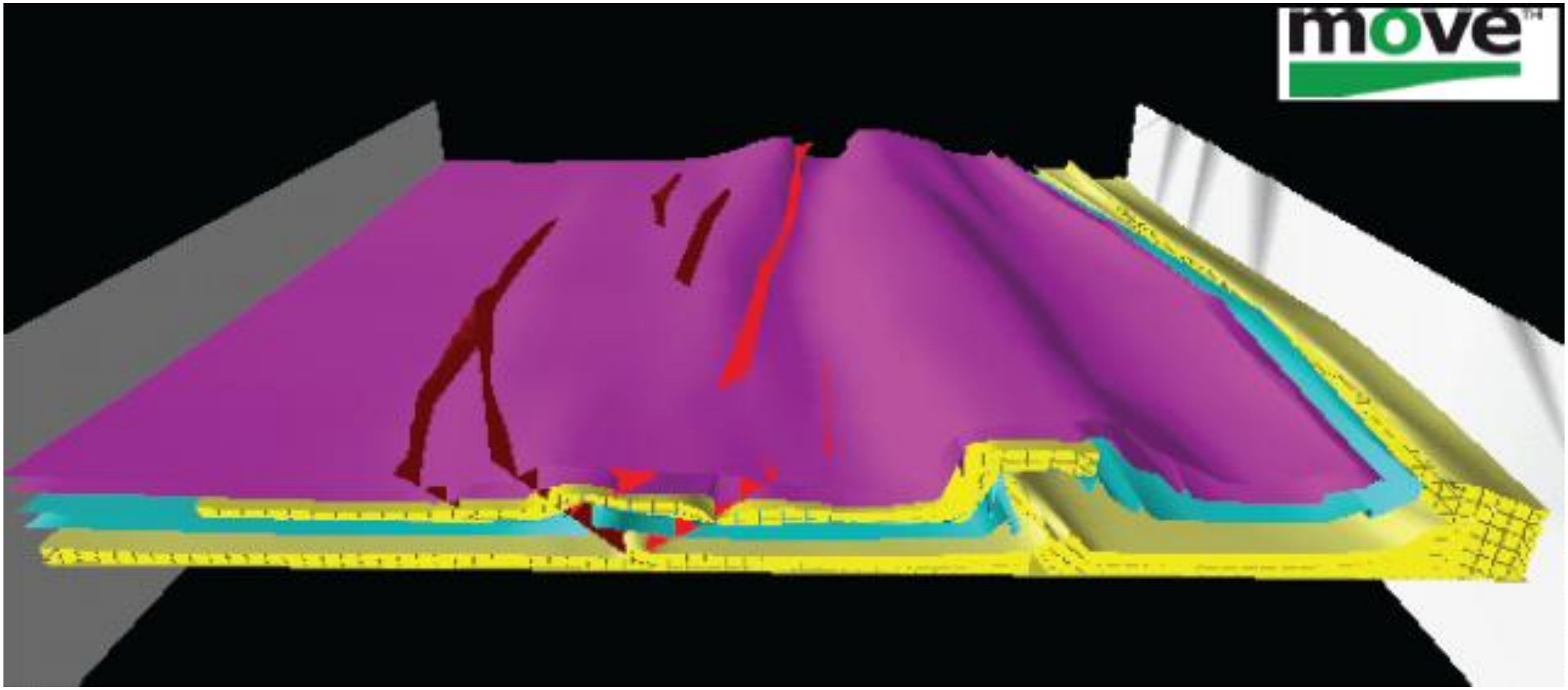

Figure 1. Side view of 3D visualization developed in 3D Move from an analog model, allowing the internal structure of the deformed zone to be viewed and mined for data. Red surfaces are fault surfaces, yellow mesh represents the silicon layers in the model and blue and magenta are marker layers within the sand-pack.