Guidelines and Strategies for Model Building and Interpretation in 3D Space*

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Abstract

Geologists routinely work with a wide range of geological and geophysical data in their attempts to build realistic 3D models of the sub-surface. The approach that the geologist takes to interpretation and model building can vary considerably depending on their background and training, and the techniques and technology that they have access to, chosen to adopt or have been advised to use.

The traditional learning approach that is still taught in most universities and colleges is to start on paper in 2D by learning how to produce field maps and cross-sections. The map will illustrate the outcrop pattern (distribution of rock types/units) at the surface and the section will show how these rock units and associated structures extend beneath the surface. The intersection of the surface geology with topography can be used to help project surfaces and structures at depth and combined with various geometric construction and stereographic projection techniques it is possible to build a robust 3D model of the sub-surface geology. Working on paper, it often helps to visualise the 3D aspects of the geology in the form of a "fence diagram" or a "block diagram", but this relies on the geologist having some artistic/technical skill. It requires considerable knowledge and practice to be able to sketch a block diagram on paper in the correct orientation(s) to demonstrate the 3D aspects of the geology and structural relationships in your area of interest.

The advent of 3D model building and validation software has dramatically improved our ability to construct and visualise the often-complex geology of our planet (and other planets). It is now possible to collect data, generate maps and cross-sections, build and test 3D models and visualise all of this entirely in a digital environment. The same geological skills that were traditionally taught on paper can now be easily demonstrated on tablet devices in the field, and the quality of a 3D model now depends on the knowledge and thinking skills of the geologist rather than their artistic ability.

Introduction

We would argue strongly that it is in teaching field mapping and model building skills that the geologist learns to think in three and four dimensions and this leads to a better appreciation of the geometry and scale of the geological structures that will be encountered during an industry career. Many of the basic techniques for section construction and geometric projection have been in use for over a century, but seem to have fallen out of favour in recent years. Examples of these techniques include structure contours; the three-point method of calculating dips and strikes; calculating depth to detachment; the use of dip isogons and Ramsay's fold classifications.

Discussion

In the hydrocarbon and mining sectors, there is often an over-reliance on geophysical interpretation software packages with auto-tracking systems that favour a geophysical signal over a more realistic horizon or fault interpretation. The basic construction techniques that the geologist should have been exposed to in their early training should be, but are often not, used routinely to produce geologically sensible interpretations of the available data. There is no generally accepted "best practice" approach, which is either taught or generally used. In order to address this deficit, one of our primary objectives at Midland Valley is to deliver easy to use geological model building and construction tools that are tightly integrated with the currently available geophysical interpretation software packages. However, the building of static 2D and 3D models is only the start of a best practice process, and the next step is to test the validity of your interpretation using kinematic modelling, Bond (2012) documents that this latter step can improve interpretational accuracy by a factor of three or more.

Summary

Validation encompasses a range of techniques such as line-length and area balancing, but it is during the kinematic modelling process (sequential restoration and forward modelling) that the geologist can test and understand how the structures have developed in an evolutionary sense (Figure 1). This gives predictive insight into the geometries and linkages of the fault framework through time with implications for the relationships between the petroleum or mineralization system and structure. In this presentation, we will demonstrate various structural modelling techniques and tools that can be used to help reduce the uncertainty and risk in your interpretation. Together these form some of the key components in best practice 3D model building.

Reference Cited

Bond, C.E., R.J. Lunn, Z.K. Shipton, Z.K., and A.D. Lunn, 2012, What makes an expert effective at interpreting seismic images?: Geology, v. 40, p. 75-78.

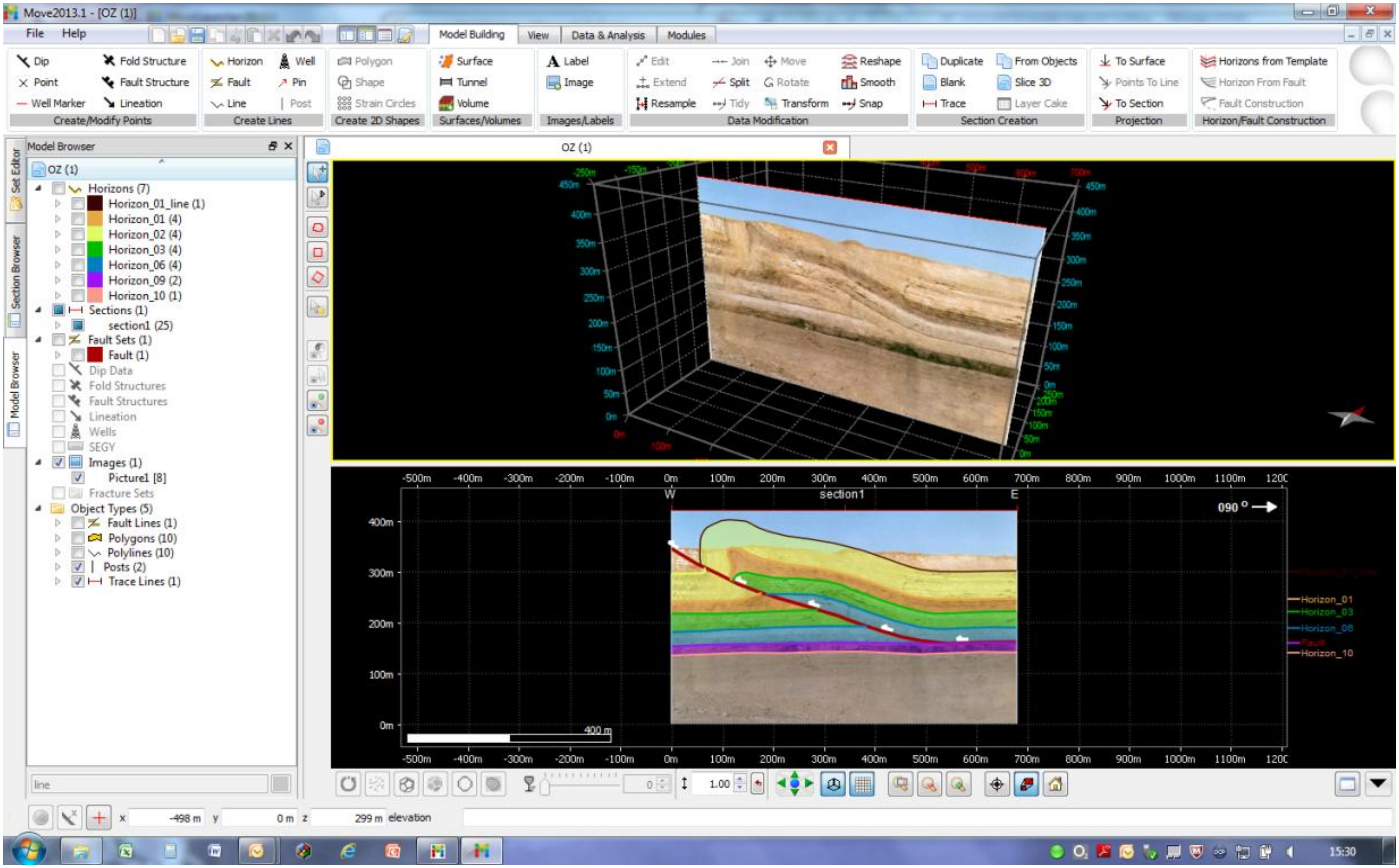

Figure 1. An example of the model building and section construction tools in Move2013.