

# WHY IT IS CRITICAL TO BALANCE YOUR INTERPRETATION

by Catalina Luneburg

Cross-section Balancing is a concept introduced over a hundred years ago (Chamberlain, 1910) based on the assumption that a rock volume remains constant from the undeformed to the deformed state.

This simple concept is key to testing and validating your structural interpretation and ruling out scenarios that are not possible or less likely. Following rules of volume or area preservation and admissibility of structural geometries, a balanced section is intrinsically correct and provides a high-confidence interpretation.

A balanced section is also restorable, which means we can reconstruct time steps of the deformation history and the conditions during that time. This is key information for understanding migration and accumulation of Hydrocarbons in your area of interest.

## ***Why is it important?***

A geologic interpretation is the basis of any exploration workflow, whether you are building a 3D framework or a geocellular model, or you are modeling a basin or estimating HC reserves etc. All these workflows rely on the most realistic and accurate interpretation in order to reduce uncertainty and minimize risk.

Despite the importance, this step is often underestimated as we mostly focus on honoring seismic reflectors and well data without really testing the geometrical and/or mechanical validity of the entire interpretation. This becomes especially critical in areas of poor or missing data, where we interpolate between existing data points using our best logic and geologic understanding but not applying validation and balancing rules.

The reason might be that we don't have the time, or the skills or the software to make this part of our standard workflow and best practices. Interpretation validation should be part of any QA process and incorporated into every step of our workflow from the very beginning on.

## ***What are the problems?***

Unbalanced sections have incompatible geometries such as thickness variations that are not caused by stratigraphic changes, hangingwall geometries that don't fit the faults, inconsistent fault geometries, missing structural elements etc. These incompatibilities are often not obvious at first sight, and only revealed during the process of balancing and restoration. While an interpretation can look realistic and fit most data, it can still be unbalanced and incorrect.

Considering that these geometries define structural traps and reservoirs, any spatial deviation will impact the volume and distribution of HC reservoirs. For example, changing a fault dip by about 10 degrees can result in a 20% error in your reserve estimates, a missed fault can breach your reservoir; an incorrect hangingwall geometry can under – or overestimate the size of your reservoir, inconsistent stratigraphic thicknesses can provide false reservoir thicknesses, incorrect fault cutoffs will impact hangingwall geometries etc.

## ***What are the solutions?***

The process of balancing and restoration will reveal geometrical inconsistencies and allow to correct the problems using techniques of line-length and area-balancing. For example, we can predict fault traces through depth- to-detachment calculations, we can use kinematic models such as flexural slip and vertical/oblique

shear to model hangingwall geometries and project stratigraphic thicknesses, we can balance shortening and extension rates and interpolate between data points using kinematic rules.

The same techniques are used to restore a cross sections. Restoration is the process of reversing deformation to illustrate the geologic evolution through time. In addition to reversing the effects of deformation, we can also reverse the effects of compaction, subsidence and isostacy (backstripping). While any section can be restored, only a balanced section will lead to a geologically valid undeformed state.

Studies show that best results are obtained from modeling and comparing different interpretation scenarios, often there is more than one solution that fits the data and we need to evaluate different options to find the solution that not only balances and restores but fits your data and regional geologic model.

### ***How do we do it?***

Depending on structural complexity and scale, the process of balancing can be more or less time consuming and involved, applying anything from manual techniques to software modeling.

There are simple manual techniques that can help you predict a fault, construct a correct hangingwall or project geometries and that can be used on the fly as interpreting.

Structural Modeling software applications that will efficiently balance and restore also complex scenarios are limited on the market, and mainly standalone such as LithoTect, 2DMove and Structural Solver, integrated applications with larger software packages do often not have the same functionality and effectiveness. Using structural restoration software requires not only learning the application but also understanding the underlying concepts and methodologies.

For very complex and large sections it is often beneficial outsourcing the work to an expert to save time and resources. Considering the impact of an unbalanced section down the road this is worth the investment.

### ***Can you learn it?***

The concepts of balancing and restoration can be learned, applying the concepts to real data takes a bit more practice and experience. Learning to use the software will require a few days of training and applying it to your own data is a process that becomes easier with time. Even if you outsource a project you should understand the concepts and the assumptions that have been used to come to a specific result.

A good start is our public 1-day workshop that will provide an overview of the basic concepts and techniques used for cross section balancing – see below. You will learn manual techniques and get an overview of the software modeling solutions for various geologic scenarios such as Fold- and Thrust Belts, extensional and salt-dominated basins etc.

A more in-depth training also involving software applications, can be done inhouse with the option to use your own data or analog case studies. In addition, we mentor and support you with a specific project and coach you to become an expert yourself.

If you feel the work is too complex and time-consuming we take your data and deliver consulting work with a quick turn-around. We currently have eight industry renowned experts on our team with ample experience and expertise in the restoration and balancing of a variety of HC scenarios. We love a complex challenge!

**Mini Workshop; 25 February, 2020 “HOW TO BALANCE YOUR CROSS SECTION”; Catalina Luneburg**

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