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Towards "realistic" fault zones in a 3D structure model of the Thuringian Basin, Germany

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3D computer models of geological architecture are evolving into a standard tool for visualization and analysis. Such models typically comprise the bounding surfaces of stratigraphic layers and faults. Faults affect the continuity of aquifers and can themselves act as fluid conduits or barriers. This is one reason why a „realistic“ representation of faults in 3D models is desirable. Still so, many existing models treat faults in a simplistic fashion, e.g. as vertical downward projections of fault traces observed at the surface. Besides being geologically and mechanically unreasonable, this also causes technical difficulties in the modelling workflow. Most natural faults are inclined and may change dips according to rock type or flatten into mechanically weak layers. Boreholes located close to a fault can therefore cross it at depth, resulting in stratigraphic control points allocated to the wrong block. Also, faults tend to split up into several branches, forming fault zones. Obtaining a more accurate representation of faults and fault zones is therefore challenging.

We present work-in-progress from the Thuringian Basin in central Germany. The fault zone geometries are never fully constrained by data and must be extrapolated to depth. We use balancing of serial, parallel cross-sections to constrain subsurface extrapolations. The structure sections are checked for consistency by restoring them to an undeformed state. If this is possible without producing gaps or overlaps, the interpretation is considered valid (but not unique) for a single cross-section. Additional constraints are provided by comparison of adjacent cross-sections. Structures should change continuously from one section to another. Also, from the deformed and restored cross-sections we can measure the strain incurred during deformation. Strain should be compatible among the cross-sections: If at all, it should vary smoothly and systematically along a given fault zone.

The stratigraphic contacts and faults in the resulting grid of parallel balanced sections are then interpolated into a gOcad model containing stratigraphic boundaries and faults as triangulated surfaces. The interpolation is also controlled by borehole data located off the sections and the surface traces of stratigraphic boundaries. We have written customized scripts to largely automatize this step, with particular attention to a seamless fit between stratigraphic surfaces and fault planes which share the same nodes and segments along their contacts. Additional attention was paid to the creation of a uniform triangulated grid with maximized angles. This ensures that uniform triangulated volumes can be created for further use in numerical flow modelling.

An as yet unsolved problem is the implementation of the fault zones and their hydraulic properties in a large-scale model of the entire basin. Short-wavelength folds and subsidiary faults control which aquifers and seals are juxtaposed across the fault zones. It is impossible to include these structures in the regional model, but neglecting them would result in incorrect assessments of hydraulic links or barriers. We presently plan to test and calibrate the hydraulic properties of the fault zones in smaller, high-resolution models and then to implement geometrically simple „equivalent“ fault zones with appropriate, variable transmissivities between specific aquifers.