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Three-dimensional fault drag

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Fault drag refers to the deflection of curved markers adjacent to a fault and is classically defined for marker lines in two-dimensions. *Normal drag* refers to markers that are convex in the direction of slip, and *reverse drag* to markers that are concave in the direction of slip. Both normal and reverse drag, associated with sealing faults, have great potential to form hydrocarbon traps.

Recently several studies tried to quantify the curvature of fault drag in more detail by using Bézier curves (Coelho et al, 2005) and by describing the magnitude of the curvatures in diopters, using osculating circles of the deformed marker line (Grasemann et al. 2005). However, whereas the curvature in two-dimensions is described by a scalar, curvature at a point on a surface is described by means of a second-order tensor (Lisle and Robinson, 1995) and therefore various tensorial quantities can be used to quantify fault drag: In order to determine the curvatures of a smooth surface at a point P in three-dimensions, curvatures are measured on cross-sections of the surface made by planes which contained the line perpendicular to the tangent surface at P. The curvatures of these cross-sections are called the normal curvatures of the surface at $P$and are strongly dependent on the directions of the cross-sections. The maximum and the minimum of the normal curvatures are called principal curvatures, which are always found on perpendicular cross-sections except the normal curvatures of the surface are constant. It is important to note that the curvature of a curve is an extrinsic geometric property whereas the Gaussian curvature (i.e. the product of the principal curvatures) of a surface is not related to the topological properties but is intrinsic to the surface and independent of how it is embedded in space.The mean curvature of a surface measures the average principal curvature of the normal curvatures. Although this value is a measure of how much the surface is curving, it cannot be directly related to the curvature and thus the fault drag of a curve in two-dimensions.

Although important for the three-dimensional description and quantification of marker horizons, fault drag is not defined in three-dimension; it therefore is high time that this major shortcomming galvanizes structural geologists into a redefinition. A three-dimensional structural model of a natural fault system associated with three-dimensional fault drag demonstrates the importance of quantification using differential geometry.

References:

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