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3D analysis of deformation bands in unconsolidated Pleistocene sediments

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Deformation bands are planar structural elements that occur in porous sandstones, even in the unconsolidated state (e.g. Aydin, 1978, Fossen *et al.*, 2007). Whereas faults are discrete surfaces, deformation bands are much thicker, tabular zones of continuous displacement (Draganits *et al.* 2005). They have attracted much attention in the past because of their low permeabilities and their potential impact on fluid flow in sedimentary basins (e.g. Fossen & Bale, 2007).

We present an outcrop-based study on the 3D geometry and strain of deformation band faults, which developed in Pleistocene unconsolidated sands in northern Germany. We digitally photographed a 150×150 cm square, near-vertical outcrop wall in a quarry, against an orthogonal scale. Then 15 cm of sand was scraped away and the procedure repeated. A total of ten sections were procured. The photographs were interpreted for upper and lower boundaries of the deformation band faults and distinctive stratigraphic horizons. The sections were then imported into Move2009.1 (Midland Valley Exploration Ltd, 2009) with the correct orientation and scale. Using the Move2009.1 software, we analysed the thickness of the deformation band faults, along-strike displacement of beds along the faults, and the total extension caused by faulting.

The three-dimensional model is cut by a set of nine major deformation band faults, all with a normal sense of displacement; one set of six faults strike SE–NW, dipping NE by ca. 50°, the other set of three faults strike NNE–SSW, dipping WSW by ca. 45°. The former cross-cut the latter, thus their age relationship is shown. In the dip direction the faults are straight, but slightly arcuate in their strike direction. We identified seven distinct stratigraphic horizons, from which we were able to analyse along-strike displacement and total extension due to faulting. The three dimensional model shows that thickness of the deformation band faults varies elliptically and ranges from zero to 4.5 cm. Analysis of along-strike fault displacement proves that fault thickness is inversely proportional to fault displacement. We calculated horizontal extension along three sections, perpendicular to the strike of the faults. Because fault displacement varies so much along-strike, extension ranges from 30 to 60%. Clearly the deformation is unevenly distributed on this scale. Nevertheless, these are very high amounts of deformation and this has wide implications when upscaled to the whole outcrop or locality.

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