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Visualisation and 3-D structural analysis of shear-deformation bands in unconsolidated Pleistocene sands with ground-penetrating radar

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Deformation bands are important structural elements that occur in the upper crust and develop in both porous sandstones and unconsolidated sands. Deformation bands in unconsolidated material are important earthquake-related structural elements, and their orientation and timing can reflect movement on deep-seated faults. They are therefore of great value for paleoseismological studies in sedimentary archives. We present a study using ground-penetrating radar (GPR) to investigate an array of shear-deformation bands that developed in Pleistocene glacifluvial Gilbert-type delta sediments. A grid of GPR profiles with a spacing of 0.6 m was measured on top of a 20 m-long outcrop that exposes shear-deformation bands. The reflectors in the radargrams can be directly tied to the exposure. The shear-deformation bands are partly represented by inclined reflectors and partly by the offset of reflections at delta clinoforms. With the software package MoveTM, we created a 3-D model of the 2-D radar sections. This model shows that the bands have near-planar geometries and that they can be traced throughout the entire sediment volume. Thin sections of sediment samples show that the analysed shear-deformation bands have a denser grain packing than the host sediment and thus have a lower porosity. This, together with a partially-developed weak calcite cementation and the distinct offset along the bands, are likely the major reasons for the clear expression of the shear-deformation bands in the radar survey. The study shows that deformation-band arrays can clearly be detected using GPR and quickly be mapped over larger sediment volumes. 3-D structural analysis allows a further investigation of the orientation and geometry of the bands. This allows correlation of the bands with the regional fault trend. Studying deformation bands in unconsolidated sediments with GPR is therefore a powerful approach in paleoseismological studies.