Stop 2: Deformation Bands in unconsolidated sands and gravels of the sand pit St. Georgen, Burgenland

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UTM Zone 33N, 615 200 E, 5 301 720 N, 226m NN

Introduction

The sand pit St. Georgen, NE of the city of Eisenstadt, offers extraordinary examples of tectonic deformation structures in unconsolidated sands and gravels. The outcrop is now used as a storage place for building materials, permission to access needs to be requested at the entrance gate next to the fire brigade school along the road from Eisenstadt to Stotzing (Fig. 1).

TOLLMANN (1995) identified a normal fault in the southern part of the quarry, which juxtaposes calcareous sandstones and intercalated limestone beds in the hanging wall against the terrigeneous, carbonate-free sand and gravel (Burgstall Schotter) in the footwall. The dip slip displacement is documented by dip-parallel slickensides in the carbonatic hanging wall (see fig. 72 of SAUER et al. 1992), which have been eroded and are no longer exposed. This normal fault is oriented subparallel to the Eisenstadt fault, which represents a major fault bordering the Eisenstadt Basin.

The footwall of the fault comprises coarse clastic sediments, (Burgstall Schotter), deposited in a shallow marine environment with strong fluvial influence (SAUER et al. 1992, ZORN 2007). While a Badenian age is constrained for the calcareous rocks in the hanging wall by abundant microfossils (ZORN 2007), the lack of biogenic material in the underlying gravels and sands so far inhibited an exact age determination (KROH et al. 2003). The exposed sediment is dominated by coarse sand with channels comprising gravel.

X-ray diffractometry analysis of the sands shows quartz, feldspar, muscovite and clay minerals, indicating a crystalline source of the material. Single gravel clasts up to 8cm in diameter can be identified as quartzites, micaschists and garnet-bearing gneisses. According to TOLLMANN (1955), the source of these metamorphic rocks is located in the south of the Eisenstadt Basin, not in the nearby Leitha Mountains. The lack of carbonate material can be documented at all grain sizes.

Deformation bands

The gravels and sands at the St. Georgen sand pit are cut by a multitude of conjugate deformation bands (AYDIN 1978) with normal offset. Note, that due to the lack of cementation in these lithologies, the structures do not develop as faults with a localized slip surfaces typical for brittle deformation in solid rock (Fig. 1), but the form broader zones of continuous deformation (Fig. 5 and 6). Deformation bands develop in granular materials, such as porous rocks with weak or no cementation. Within these planar deformation zones strain is accommodated by translation, rotation and breaking of grains resulting usually in porosity reduction. Several types of deformation bands have been distinguished in the literature, depending on the amount of shear and amount of compaction or dilation within the deformation band (see FOSSEN et al. 2007 for a review). Additionally, different types of rock with different porosity, amount of compaction or cementation, composition (especially clay content) were found to develop specific types of deformation bands.

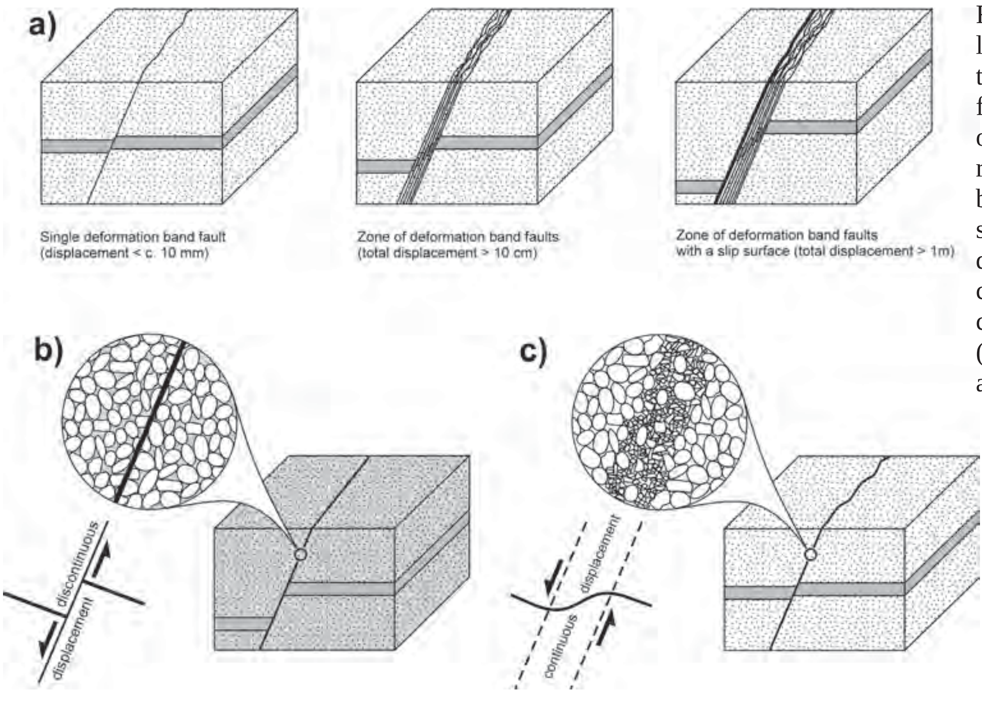

Fig. 5: (a) Progressive development of a single deformation band into a zone of deformation bands and a zone of deformation bands bordered on one side by a fault.
b) Fault with a localized slip surface and discontinuous displacement.
c) Deformation band with continuous displacement (modified after DRAGANITS et al. 2005).

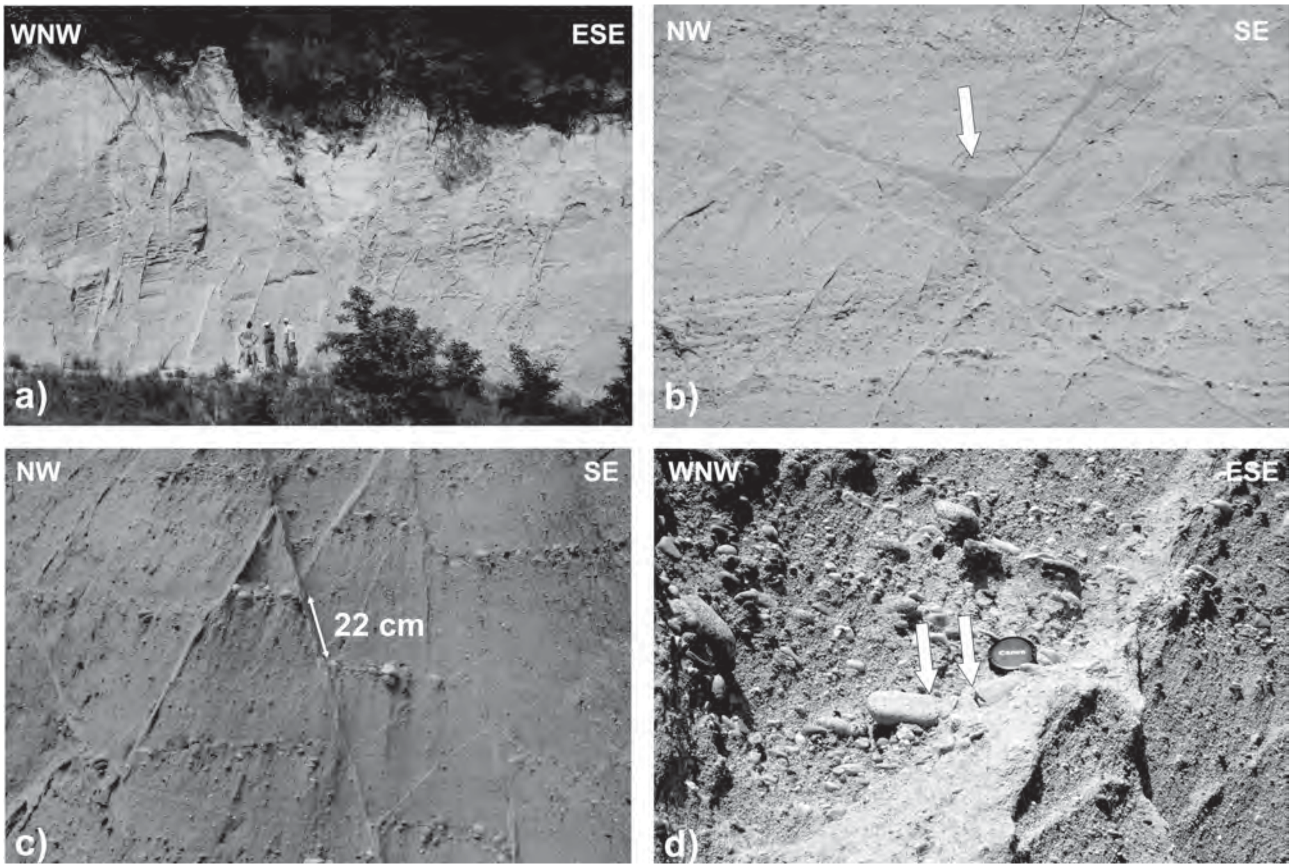

Fig. 6: (a) Set of conjugate deformation bands in the St. Georgen sand pit. (b) Red-brownish staining by infiltration of surface water in a bowl shaped compartment between a conjugate set of deformation bands highlighting the compartmentalisation of the sediments and the role of deformation bands as barriers and pathways for fluid flow. (c) Offset of gravel layers by conjugate sets of deformation bands. d) Broken pebble adjacent to a deformation band.

In this outcrop, the deformation bands occur as up to 15cm thick, planar zones protruding from the surrounding, undisturbed sediment. The bands record normal offset of the sedimentary beds between few cm and 1 m (Fig. 6). Comparison between thin sections from the deformation bands and the host rock revealed a pronounced porosity reduction, not only due to compaction, but especially due to preferential growth and possibly also precipitation of clay minerals within the deformation bands. Grain size distributions in the undisturbed sand and within a deformation band record an increased amount of coarse silt and fine-medium sand in the deformation band (Fig. 7).

The kinematics of the deformation bands can be described as follows (Fig. 8): Two sets of conjugate deformation bands are developed. One set is oriented parallel and conjugated, respectively, to the normal fault exposed in the southern part of the outcrop, striking NNE-SSW. Additionally, a second conjugate set can be observed, with one dominant orientation of long and continuous bands dipping steeply to the S, while the associated conjugate bands are not only much shorter and often thinner, but also show a more shallow dip to the N. Furthermore, due to their restriction to areas between closely spaced S-dipping bands, we conclude that the N-dipping, subordinate bands accommodate the strain between the more prominent S-dipping ones.

Migration of iron- or organic-rich fluids between the sets of deformation bands is documented by brownish staining, which highlight the compartmentalisation of the sediments and the role of deformation bands as barriers and pathways for fluid flow.

Notably, no deformation bands have been observed in the calcareous sediments of the hanging wall, where lower porosity and carbonatic cementation favoured the localisation of deformation in distinct slip surfaces.

Acknowledgements

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References

AYDIN, A. (1978): Small faults formed as deformation bands in sandstone. - Pure Appl. Geophys., **116**: 913-930, Basel.

DRAGANITS, E., GRASEMANN, B. & HAGER, C. (2005): Conjugate deformation band faults in the Lower Devonian Muth Formation (Tethyan Zone, NW India): evidence for pre-Himalayan deformation structures. Geological Magazine, **142**,: 765-781, London.

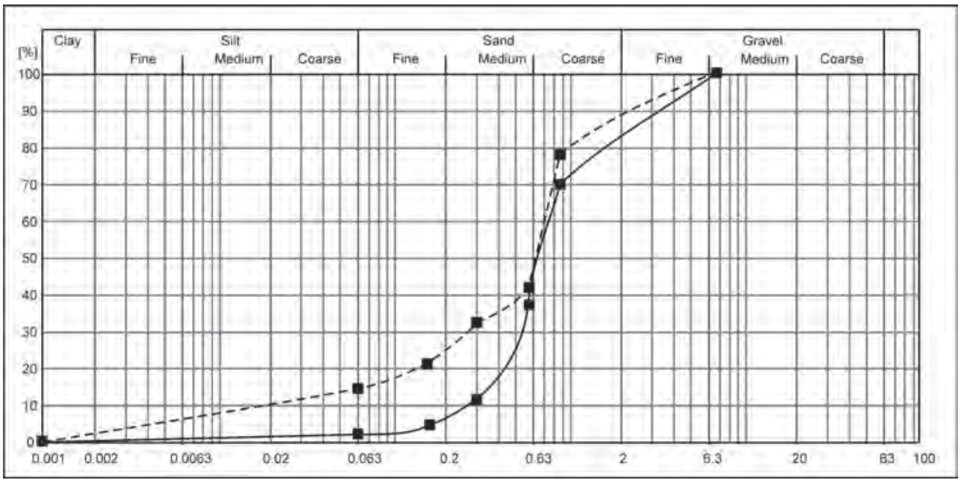

Fig. 7. Grain size distributions in the undisturbed sand (solid line) and with a deformation band (dashed line). Note the increased amount of coarse silt and fine-medium sand in the deformation band.

FOSSEN, H., SCHULTZ, R.A., SHIPTON, Z.K. & MAIR, K. (2007): Deformation bands in sandstone: a review. - J. Geol. Soc., **164**: 755-769, London.

KROH, A., HARZHAUSER, M., PILLER, W.E. & RÖGL, F. (2003): The Lower Badenian (Middle Miocene) Hartl Formation (Eisenstadt-Sopron Basin, Austria). - In: Piller, W.E. (Ed): Stratigraphia Austriaca. - Österr. Akad. Wiss., Schriftenr. Erdwiss. Komm., **16**: 87-109, Wien.

RATH, A. (2008): Deformation Bands in nicht kohäsiven Sanden (St. Georgen, Burgenland). - Bachelor Thesis, Department of Geodynamics and Sedimentology, University of Vienna, 44 p., Wien.

SAUER, R., SEIFERT, P. & WESSELY, G. (1992): Guidebook to excursions in the Vienna Basin and the adjacent Alpine-Carpathian thrustbelt in Austria. Mitt. Geol. Ges. **85**: 1-264, Wien.

TOLLMANN, A. (1955): Das Neogen am Nordwestrand der Eisenstädter Bucht. - Wissenschaftliche Arbeiten aus dem Burgenland, **10**: 1-79, Eisenstadt.

ZORN, I. (2007): St. Georgen: Eine „küstennahe“ Sandgrube. In: HOFMANN, T. (Ed.): Wien, Niederösterreich, Burgenland. - Wanderungen in die Erdgeschichte, **22**, 160-161, (Dr. Fritz Pfeil) München.

Fig. 8. Stereoplot, lower hemisphere:
(a) bedding,
(b) master fault
(c) conjugate set of deformation bands, subparallel and conjugate to masterfault,
(d) E-W trending, second set of conjugate deformation bands.