1. The Problem of the use of SSDS as Earthquake Indicator

Soft-sediment deformation structures (SSDS) are used as indicators for past seismic events (e.g., Tuttle et al., 2019). However, in regions that were frequently affected by ice-sheet loading/unloading and periglacial processes, the use of SSDS for interpreting seismic events is challenging. In these regions glacial and periglacial processes affected the near-surface sediments and led to the formation of SSDS (Fig. 1) (e.g., Van Vliet-Lanoe et al., 2004; Van Loon, 2009; Brandes and Winsemann, 2013; Gehrmann and Harding, 2018) similar to those caused by earthquakes.

3. Different styles of SSDS

Earthquakes can cause liquefaction and fluidization processes in susceptible sediments, such as fine- to medium-grained water-saturated sand, silt and mud with a loose grain packing. These SSDS include load casts, flame structures, ball-and-pillow structures (pseudonodules), convolute bedding (involution), slide blocks (liquefaction spreads), dish-and-piller structures, clastic dykes, sand volcanoes and craters (Fig. 2). To unambiguously determine earthquakes as the trigger mechanism it is necessary to carefully evaluate the SSDS and the depositional system.

2. Potential and Limitations of the use of SSDS as Earthquake Indicator

Earthquake-induced SSDS show the same deformation style as non-earthquake SSDS. The challenge lies in distinguishing earthquake-related SSDS from other processes such as periglacial, glacial and non-glacial loading (Van Vliet-Lanoe et al., 2004).

5. The Solution - The Combination of Deformation Bands and SSDS

The inconclusive nature of SSDS as indicators for paleo-earthquakes requires a more robust indicator for neotectonic activity. The work of Cashman et al. (2007), Brander and Danes (2012) and Brandes et al. (2018a, b) showed that near-surface deformation bands in unconsolidated sediments are an indicator for neotectonic activity at basement faults. The occurrence of deformation bands and SSDS are the most reliable indicator for paleo-earthquakes, if the deformation bands follow the strike of the nearby fault and the SSDS match some criteria. The deformation bands and SSDS are the most reliable indicator for paleo-earthquakes, if the deformation bands follow the strike of the nearby fault and the SSDS match some criteria.

6. Criteria for Earthquake-related SSDS

Characteristic features of seismically-induced SSDS are:

- the occurrence close to major faults
- a large lateral extent, although high lateral variabilities of the deformation style, pattern, and bed thickness are possible, depending on the susceptibility of the sediments for liquefaction and/or fluidization processes
- the occurrence of deformation bands close to the tipe line, where the fault displacement goes to zero.

References

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Stilleweg 2, 30655 Hannover

Limitations of Soft-Sediment Deformation Structures as Indicators for Paleo-Earthquakes in Formerly Periglacial and Glaciated Areas

Müller, K.,¹ Winsemann, J.,¹ Pisarska-Jamróży², M., Lege, T.,² Spies, T.² and Brandes, C.¹
¹Institut für Geologie, Leibniz Universität Hannover, Callinstr. 30, 30167 Hannover, Germany; ²Institute of Geology, Adam Mickiewicz University, Krygowskiego 12, 61-680 Poznań, Poland