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Combination of stress-controlled erosion and tensile failures during development of piping conduits in locked sand

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Piping is an erosion process in which cracks and macropores extend into channels with a diameter of cm or more. This process is important for the formation of highly permeable porosity, failure of the levees, formation of gullies and intense erosion of agricultural soil. In this research we studied the evolution of conduits in Střeleč locked sand (SLS). This material composes mainly of quartz and resembles friable sandstone. Study was done in Střeleč quarry (Czech Republic), where depression in the regional water table (decrease of water table by ~20 m) due to the water pumping causes fast flow (up to 40 cm/s) through fractures in the SLS body. Large conduit systems developed along fracture zones that divide the SLS body into subvertical blocks with a width of cm to tens of cm in each fracture zone. Erosion starts at water table and blocks bordered by fractures are eroded by the fast water flow, especially the parts that are in stress shadows due to inefficient loading from the surrounding sandstone mass. Blocks whose base is eroded tend to collapse, which leads to the creation of free space above the water table and also possibly destabilization of the sides. Empty space propagates upward mostly meters but sometimes tens of meters toward ground surface. Experiments showed that the SLS is prone to erosion when it is under low gravity induced stress. In addition to observation of the existing conduits, the experiments focused on the evolution of transversal section of conduits in SLS were performed. Experimental erosion was done on fracture systems exposed in quarry by the flow of water from the hose. Sequence of photos of fracture zones evolving into conduit during experiments was taken and the evolution of the transverse section of conduits was observed. By this method the blocks were eroded to a depth of several decimeters. Based on field experiments and time-laps photos two erosion mechanisms are responsible for conduits evolution. While the less thick blocks are eroded mainly by rapid water flow, thicker blocks are eroded by tension failures (gravity driven wasting). The tension failure dominates, forming about 65 % of total erosion.

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