Sensing fluid pressure during plucking events in a natural bedrock channel and experimental flume

Wilkinson, Clare; Harbor, David; Keel, Tal; Levy, Simon; Kuehner, Joel

River channel erosion by plucking, or quarrying, is believed to be the dominant erosional process in channels with fractured or jointed bedrock. However, despite its significance as an erosional mechanism, plucking is poorly studied in both laboratory and natural channels. In previous flume studies, model bedrock was plucked by fluid forces alone in nonuniform flow near jumps and waves even where blocks do not protrude into the flow.

Here we develop sensor systems to test the hypothesis that bed fluid pressure gradients lift “pluckable” bedrock blocks in a natural field setting and a hydraulic flume. The field setting closely mimics the previous flume setup; the instrumented block is downstream of a roughly 1m step and exhibits no protrusion into the flow. Flow over the step promotes nonuniform flow and changes pressure in the bedrock crack network; slabs of bedrock that have slid downstream and sediment that has been pushed upstream 3-4 m under the bed and in the cracks suggest the influence of pressure differences throughout the crack network and below the bed.

In this initial deployment, we evaluate a sensor that monitors movement and simultaneous pressure above and below the block. Sensors are emplaced in a 26kg, 45-cm-long, 20-cm-wide block broken from a 4.5-m-long, 11-cm-thick sandstone bed with a dense network of cracks nearly parallel to flow direction and include a tri-axial accelerometer/gyroscope and two fluid pressure sensors. The electronics are housed in a custom-designed 3D-printed ABS waterproof capsule that is mounted in a vertical hole through the rock.

A concurrent flume study develops the sensors necessary to investigate the longitudinal pressure difference below a step using multiple analog sensors (0-1 psi gauge pressure) mounted flush to a false floor under the center of a 30x14-cm test zone. The ½-inch 15-mm-wide sensors are aligned along the flow centerline and are placed under 25 1-cm-thick “pluckable” bedrock blocks constructed with a proprietary plaster cement. Measured mean pressure and transmission of pressure pulses under the test bed are compared to the visual record of plucking. In addition, conducting runs with blocks removed permits simulation of the mean and varying pressure conditions above the modeled pluckable layer as a hydraulic jump is moved downstream through the step.

~ 1987 w/o spaces, limit is 2000 w/o spaces

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In this initial deployment, we evaluate a sensor that monitors movement and simultaneous pressure above and below the 26-kg block. Sensors are emplaced in a 45-cm-long, 20-cm-wide block broken from a 4.5-m-long, 11-cm-thick sandstone bed with a dense network of cracks nearly parallel to flow direction and include a tri-axial accelerometer/gyroscope and two fluid pressure sensors. The electronics are housed in a custom-designed 3D-printed ABS waterproof capsule that is mounted in a vertical hole through the rock.

A concurrent flume study develops the sensors necessary to investigate the longitudinal pressure difference below a step using multiple analog sensors (0-1 psi gauge pressure) mounted flush to a false floor under the center of a 30x14-cm test zone. The ½-inch wide sensors are aligned along the flow centerline and are designed for experiments below 25 1-cm-thick "pluckable" bedrock blocks constructed with a proprietary plaster cement. Conducting runs with blocks removed permits simulation of the mean and varying pressure conditions above the modeled pluckable layer as a hydraulic jump is moved downstream through the step. Measured mean pressure and transmission of pressure pulses under the test bed are compared to the visual record of plucking.

~ 1989w/o spaces, limit is 2000 w/o spaces

Sensing fluid pressure during plucking events in a natural bedrock channel and 8experimental flume

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"pluckable" bedrock blocks in a natural field setting and a hydraulic flume. The field setting closely mimics the previous flume setup; the instrumented block is downstream of a 0.x m step and exhibits no protrusion into the flow. Flow over the step promotes nonuniform flow can change pressure in the bedrock crack network; slabs of bedrock have slid downstream and sediment has been pushed upstream x m under the bed and in the cracks are evidence of pressure differences throughout the crack network. Sensors are emplaced in a 45-cm-long, 20-cm-wide block broken from a 4.5-m-long, 11-cm-thick sandstone bed, with a dense network of cracks nearly parallel to flow direction. In this initial deployment, we evaluate a sensor that monitors movement and simultaneous pressure above and below the 26-kg block. Sensors include a tri-axial accelerometer/ gyroscope and two fluid pressure sensors. The electronics are housed in a custom-designed 3D-printed ABS waterproof capsule that is mounted in a vertical hole through the rock. A concurrent flume study develops the sensors necessary to investigate the longitudinal pressure difference below a step using multiple analog sensors (0-1 psi gage pressure) mounted flush to a false floor under the center of a 30x14-cm test zone. The xx-cm wide sensors are aligned along the flow centerline and are designed for experiments below 25, 1-cm-thick pluckable bedrock blocks constructed with a proprietary plaster cement. Conducting runs with them removed permits simulation of the mean and varying pressure conditions above the modeled pluckable layer as a hydraulic jump is moved downstream through the step. Measured mean pressure and transmission of pressure pulses under the test bed are compared to the visual record of plucking.

~1950 w/o spaces, limit is 2000 w/o spaces