Morphologic change in the Tottabetsu River, eastern Hokkaido, tracked by ALS and ALB surveys after a flood in the 2016

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In soft bedrock regions, rapid river erosion often raises concerns for maintaining infrastructure along the courses. A thorough understanding of the erosion process is necessary to take effective measures in order to mitigate the impact on river structures. This study reports morphological changes in 1.2 km of the Toritabetsu River (average gradient 0.44˚) in eastern Hokkaido, Japan, based on ALS (Airborne Laser Scanning) in 2016 and 2018, and three ALB (Airborne Laser Bathymetry) surveys from 2019 to 2021.

The study reach is characterized as a mixed bedrock-alluvial river and has been experiencing continuous channel bed degradation since at least early 2000s. Channel erosion was intensified after the flood of August 2016, which brought in a large amount of sediment, especially during the snowmelt season and storms in late summer.The bedrock consists of the alternating layers of silt rocks and lignite belonging to the Pleistocene lacustrine deposit (Osarushinai Formation). The uniaxial compressive strength of the silt rock was 8.1 MPa, being defined as “soft rock” according to the criteria by JSCE. Potholes and the smooth surface of the exposed rocks indicates that the abrasion of suspended load played a major role on river erosion. There were also traces of gravels dragged onto the rocks. Alluvial sediment ranged from sand to boulders and were poorly sorted. They were loose and easily mobile during high flows.

The observation results showed that there was a section where severe bed degradation occurred at a rate of 1-2m/year, and that it moved upstream at a rate of 100-200m/year. In the section channel incision was closely associated with the development of point bars. These bars encouraged flows to erode the opposite banks consisting of soft rocks at a rate of 10 to 60 meters per year, facilitating a meandering channel. Immediately downstream of the lower edges of such bars, soft bedrock was incised to form pools more than two meters deep. Eventually, those pools filled with sediment from the expansion of the point bars, and the process was repeated by the formation of another pool downstream. During the observation period, the proportion of area with exposed bedrock relative to the entire study reach decreased from 20 to 10 % from 2019 to 2020, and then remained mostly unchanged until 2021. However, the location of bedrock exposure was constantly changing due to the process mentioned above.

Several knickpoints formed on bedrock during the observation migrated upstream, but all disappeared within a year due to weathering or burial in sediments. On the other hand, knickpoints formed at the edge of the point bars remained for a long time and contributed to channel bed degradation along the course. These observation indicate that mobile alluvial sediments play a major role in promoting channel erosion by altering the topography and sequentially exposing vulnerable bedrock. Considering the thin layer of alluvial sediment and the long history of channel degradation, the study reach is expected to continue to degrade.

Keywords: soft rock, riverbed degradation, ALB, ALS, meandering, knickpoints

