論文内容の要旨

論文題目

Spatial distribution and formation of fluvial knickzones in Japanese mountain watersheds
（日本の山地流域における河床遷急区間の分布と形成）

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Fluvial knickzones are elements of bedrock rivers where stream erosion is enhanced. Their existence has been considered to reflect interactions among earth surface processes including fluvial processes, tectonics, climate and volcanism. Although studies on alluvial rivers have long been the major focus of fluvial geomorphology, studies on bedrock rivers including knickzones have been increasing only in the last few decades. Despite some recent progresses in knickzone studies, systematic geomorphological understandings of knickzones have been limited, especially in terms of their objective identification, spatial distribution in a broad area, and formative causes. To address these issues, this research aims to investigate the distribution and forms of knickzones in bedrock rivers in Japan, and to discuss factors controlling their formation.

An objective method to identify knickzones based on quantitative criteria was first established by means of DEM-based analyses. River profiles and stream gradients of mountain rivers in central Japan were examined using 50-m DEMs, and a quantitative analyses of stream gradients revealed the existence of two types of gradients: local and trend ones. The transition rate of the stream gradient from local to trend types varies depending on relative steepness of riverbed. The rate was thus used as a proxy of the relative steepness of a local river segment, and segments with high rates were identified as knickzones. This method was then applied to all mountain watersheds in Japan underlain by various types of bedrock. Numerous knickzones (5,753) were found in the rivers of about 65,000 km long, indicating that knickzones are common features in the Japanese bedrock rivers.

Characteristics of the knickzones were then examined using GIS in relation to environmental factors of topography, geology and climate. Overall, the results show that

topographic conditions dominantly influence knickzone locations. Distinct knickzones are generally abundant in steep portions of rivers with larg trend gradients. Knickzones are also frequently located around major stream confluences. In contrast, geological properties scarcely show their direct effects on knickzone distribution and forms. Differences in knickzone abundance according to substrate rock types can be explained from differences in the stream trend gradient. Knickzone locations are also scarcely related to geologic boundaries. The distribution of active faults hardly correlates with knickzone locations either.

The results of these analyses for a broad area suggest that main formative cause of knickzones in the study area is hydraulic action. The abundant knickzones in steep river reaches seem to reflect the occurrences of supercritical flows with some intervals, which lead to the scouring of bedrock and the formation of relatively flat segments and adjacent knickzones. Major stream confluences result in abrupt increase in discharge and flow perturbations, which can cause riverbed scouring and local incision, and in turn, knickzones. Indeed, knickzones are frequently observed in reaches slightly upstream and downstream portions of major confluences. The knickzone frequency data indicate that the upper knickzones have recessed from the confluences up to 2 km. This possible maximum length and available information about the knickzone recession rates in the study area suggest that the knickzones started forming in the Holocene period, under a climate characterized by frequent storms. Although some distinct knickzones can also be formed by valley-filling due to volcanic eruption, the number of such knickzones is relatively small. Thrust faulting may also cause knickzones in some cases, but such knickzones are quite limited.

The dominance of knickzones with the two hydraulic origins suggests that the river longitudinal profiles in Japanese mountains do not necessarily have smooth and concave shapes even they are nearly in steady state. Rivers with the trend gradient larger than 0.15 m m^{-1} tend to have a constant knickzone frequency of 0.5 km^{-1}, which may be a manifestation of non-smooth equilibrium river profiles with knickzones.