Role of breaking and abrasion mechanisms during fluvial grain producing–transport processes revealed from roundness changes and lithological characteristics of gravel–sand grains

（河川砕屑物の生産－運搬過程における破砕・摩耗作用の役割

—礫および砂の形状変化と岩質特性を利用して—）

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Abstract

Downstream fining, which sediment grain size on a river bed tends to decrease to downstream, take places as the results of two processes: "hydraulic sorting," which implies that finer grains are transported farther to downstream than coarser grains, and "breaking and abrasion mechanisms," which implies that the size reducing mechanical process affecting individual particles. The author focused on the breaking and abrasion mechanisms of detritus.

Most of previous studies exclusively addressed the breaking and abrasion mechanisms of the gravel or sand fraction behavior alone. Although it has been mentioned that both mechanisms is affected by rock type and size of grain, many studies did not consider these relationships sufficiently. Hence, the author studied on the role of breaking and abrasion mechanisms during fluvial producing–transport processes based on the original perspectives as follows: (i) not only gravels but also sands, which are produced newly from broken and/or abraded gravels, are investigated, (ii) rock type and size of investigated detritus are unified to evaluate minutely the breaking and abrasion mechanisms reflecting these characteristics.

[Chapter II] The grain shape becomes angulated and/or rounded during transport process and the pristine finer particles produced from the original grain are angular. Hence, the author focuses on change in roundness and classifies size reduction process into "breaking" and "abrasion," controlling grain size and roundness variations of the original grains. In addition, the author reviewed the history of detrital grain shape analysis, particularly "roundness", since the early half of the 20th century and current studies. As a result of reviewing, the author redefined surface texture, a smaller-scale shape feature, as the scale is smaller than one tenth of the diameter, because the boundary between roundness and surface texture becomes ambiguous in recent studies with high-resolution image analysis. The author suggests a flow chart supporting stable evaluation of grain roundness on gross (Krumbein roundness chart), which has been commonly used, to avoid the measurer's error. Furthermore, the correction equation is established to correspond the roundness of 0.5–4 mm in diameter grains utilizing the image analysis to the one of 4–128 mm in diameter grains with observation on gross.

[Chapter III] In order to examine the factors contributing to pristine grain production accompanying with breaking and abrasion mechanisms and changes in roundness of detritus during fluvial transport process, the author focuses on the watershed of Watarase River (two tributaries) having no huge constructions interrupting the stream. The changes in roundness and ratio of "hard" chert and "fragile" shale of sand–gravels (0.5–128 mm in diameter) to downstream were examined with field surveys and laboratory analyses. As the results, it was proposed that detritus grains coarser than 0.125 mm have a limiting roundness value, the roundness of no more rounding of grain during transport process, peculiar to rock type of grain, and practically, a specific size of detritus grains transported actively owing to river flow condition achieve the limiting roundness value promptly. Furthermore, the author pointed out that a specific rock type of river bed (sediment) affects breaking and abrasion mechanisms of gravels not only with hardness but also with form, e.g., flatness, and so on.

[Chapter IV] The influence of dams on grain producing–transport processes was examined utilizing the watershed of the Tenryu River including huge dams preventing not only water resources but also detritus. The changes in roundness of fragile shale of sands–gravels (0.5–64 mm in diameter) was measured in the upstream and downstream side of the Funagira Dam located at the lowest in the watershed of Tenryu River, having a relative low dam height and being often flushed. As the result, it was suggested that grains finer than 1 mm in diameter may be transported through the Funagira Dam and breaking and abrasion mechanisms acting upon pebbles deposited before the dam construction may produce finer pristine grains (e.g., sand) due to flushing of the dam.

[Chapter V] In advanced discussion, the roundness of coarse to very coarse sand-sized grains (0.5–2 mm in diameter) being hard to abrade were investigated to estimate limiting roundness value and transport condition under which the roundness are saturated in river–beach system (the lower reaches of Tenryu River and Enshu Coast). As the results, it is obviously shown that not only coarse grain size fraction but also finer grain size fraction would be abraded and finally would achieve the roundness in saturation and the limiting roundness value of chert and shale were estimated. In addition, it was suggested that at proximal a river mouth, roundness of sand-sized shale grains decrease in spite of being located on beach because of input of pristine angular shale grains due to the collision of shale gravels by swash.

As the conclusion, according to these roundness tendency investigated in the natural river and beach, the author proposed the practical model of the roundness in saturation, which has not been revealed by the experiments and simulations demonstrated under the simplified conditions, and that the breaking and abrasion mechanisms of detritus are affected by flow condition and characteristics of bed sediments; i.e., grain size and rock type.