Three-dimensional grain fabric analyses on experimental debris-flow deposits using X-ray microtomography

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Preferred orientation of grains in sedimentary rocks has been known as one of indicators of paleo-flow condition. No study has been done on the 'true' three-dimensional grain fabric of sandstones partly because the size of sands is too small for previous methods. In this study, we used a SR X-ray micro-tomographic system in SPring-8 (SP-microCT) at BL20B2.

To get the information of axes of each grain, we have to divide grains which share the contact points. We have developed an algorithm consists of the following processes: (1) erosion of aggregates of grains, (2) recording the core of each grain, and (3) reconstruction of grains by dilation. This program worked well for well-sorted sand-sized sediments, but not for poor-sorted sediments which includes mud. To analyze debris-flow deposits, we expand the function of the algorithm so that we can use it for poorly-sorted sediments. The new algorithm has more than one condition for recording the core in the second step. Thus large grains will meet the condition for large cores, and small grains for small cores. Since we succeeded in dividing grains, each grain was approximate an ellipsoid and the dimension and orientation of its axes can be calculated.

The sample used in this study is artificially consolidated debris-flow deposits formed in the laboratory flume. We released the mixture of sand (0.11 mm in 50%-diameter), mud and water on the gentle slope. The mass of the mixture then run the slope down and plunged into the water. Deposited sediments were carefully dried and impregnated with resin. From those consolidated sediments, cylindrical samples of 2.0 mm in diameter were cut out. Samples were imaged at X-ray energy 20 keV at SP-microCT. The spatial resolution is about 0.007 mm, which enables us to measure the three-dimensional feature of each grain. As a result, three-dimensional distribution of long-axes of grains was obtained.

The three-dimensional long-axes distribution of the debris-flow deposits showed that the grains whose long-axes lie almost horizontal and parallel to the flow direction are dominant. In addition, the up-current imbrication was observed. The preferred orientation differs between the grain sizes. Sand-sized grains show both horizontal and up-current imbrication. On the other hand, mud-sized grains show only the horizontal orientation. The three-dimensional grain-fabric analysis is also useful to examine the effect of grain shapes on preferred orientation.