

## Discrimination between glacial and landslide deposits using sand particles: a preliminary study in the Swiss and Japanese Alps

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Along the main ridges of the Japanese Alps, several researchers had mapped many glacial landforms formed in the last glacial period. However, some of them were recently reinterpreted as large landslides from dating and detailed description of the sediments. It must be a breakthrough if we could identify the origin of such old sediments more quantitatively and unambiguously. In 2013, a report was published, in which new mathematical approaches were tested to distinguish the shape of quartz sand sampled from beach, riverbank and glacier foreland. However, the test sites of glacial deposits were limited in the report, and it was not examined whether the glacial sediments were transported above the glacier bed or on it. In this research, firstly we examined the particle shape of basal till and marginal till using the new method. Secondly, whether the shape of sands distinguishes deep-seated landslide deposits from glacial deposits or not was discussed.

Sediments were sampled in two glacial drainages (12 sites) in the Swiss Alps and from a large landslide deposit in the Japanese Alps (3 sites). All the sites are composed by granite and granodiorite, except for one glacial drainage in the Swiss Alps also including metamorphic rocks. During the sampling, the pit profiles of the sediments and the surrounding landforms were described. The percentages of mud in the fine samples were calculated after gravels were excluded from the samples. Quartz sands from 0.5 to 1 mm in diameter were photographed with an optical microscope. These images were analyzed to give a fractal dimension and elliptic Fourier principal components of each particle.

The percentages of mud in the basal till varied from 24% to 37%, and were higher than those of the marginal till and the deep-seated landslide deposit (9% to 23%). Marginal till showing relatively high mud concentration probably reflects mixing with basal till. The fractal dimensions, each of which represents the irregularity of a sand surface, did not indicate any difference between the basal till and marginal till. On the other hand, the sands possibly originated from metamorphic rocks had higher fractal dimensions than those of the other granite/granodiorite drainage. Compared the fractal dimensions of the glacial and landslide sediments in the areas only consisting of granite and granodiorite, we can possibly distinguish glacial sands from landslide sands having more irregular surface. Contributions of the first, second and third principal components of the elliptic Fourier analysis were 43%, 18% and 16%, respectively. The first principal component indicates the elongation of the particle (true circle to ellipse), and the second and third principal components represent the magnitude of the protrusion. All the parameters varied within the same range (i.e. no difference) for all sites. Muddy basal till can be discriminated from coarse landslide deposits. If the drainage geology is restricted to the granite/granodiorite, higher fractal dimensions, from one of the new mathematical approaches, possibly indicate landslide origin of the sediment rather than glacial origin. However, test sites should be added to get more concrete conclusions.

Keywords: glacier, deep-seated landslide, grain size distribution, fractal dimension analysis, elliptic Fourier analysis

