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Numerical simulation of pebble abrasion in a tumbling barrel using Discrete Element Method (DEM)

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Sediments in torrential flows are transported both as bedload and suspended load according to their sizes. Mechanical abrasion is one of the processes responsible for changes in the grain-size distribution (usually described as “downstream fining”), increasing the suspended fraction of the total amount of sediment transported. This can contribute to the formation of hyperconcentrated suspensions as observed in the marly catchments of Draix (Alpes de haute Provence, France).

Tumbling barrels have been widely used to study experimental abrasion of river-bed material. In this kind of experimentation, measured abrasion rates of pebbles are a combination of two sources of abrasion: impacts between two distinct pebbles and impacts between one pebble and the barrel, which represents the bedrock.

In order to explain and quantify abrasion due to impacts with the barrel, a numerical model for one single pebble abrasion in a tumbling barrel was developed, using the Discrete Element Method. As a first approach, a pebble is represented by an aggregate of 1000 cohesive particles. Two particles interact together according to a linear elastic law and are linked with a cohesive bond. This bond is broken when the traction exceeds a limit value. A Coulomb criterion is used to describe tangential forces between two particles. The pebble is placed into a circular rotating barrel. The lining of the barrel is represented by small particles in order to simulate the roughness.

The model shows different modes of transport of pebbles: saltation, rolling or friction along the bottom of the barrel.

Pebble size appears to be reduced by two mechanisms: surface abrasion by friction on

the bottom of the barrel, and fragmentation by high energy impacts. For pebbles that were completely disaggregated, abrasion rates follow an exponential law, as described in previous experimental studies.

Influence of various parameters is then studied: parameters describing material properties (cohesiveness, stiffness, friction coefficient), and parameters describing the solicitation (barrel rotating speed, barrel roughness).