

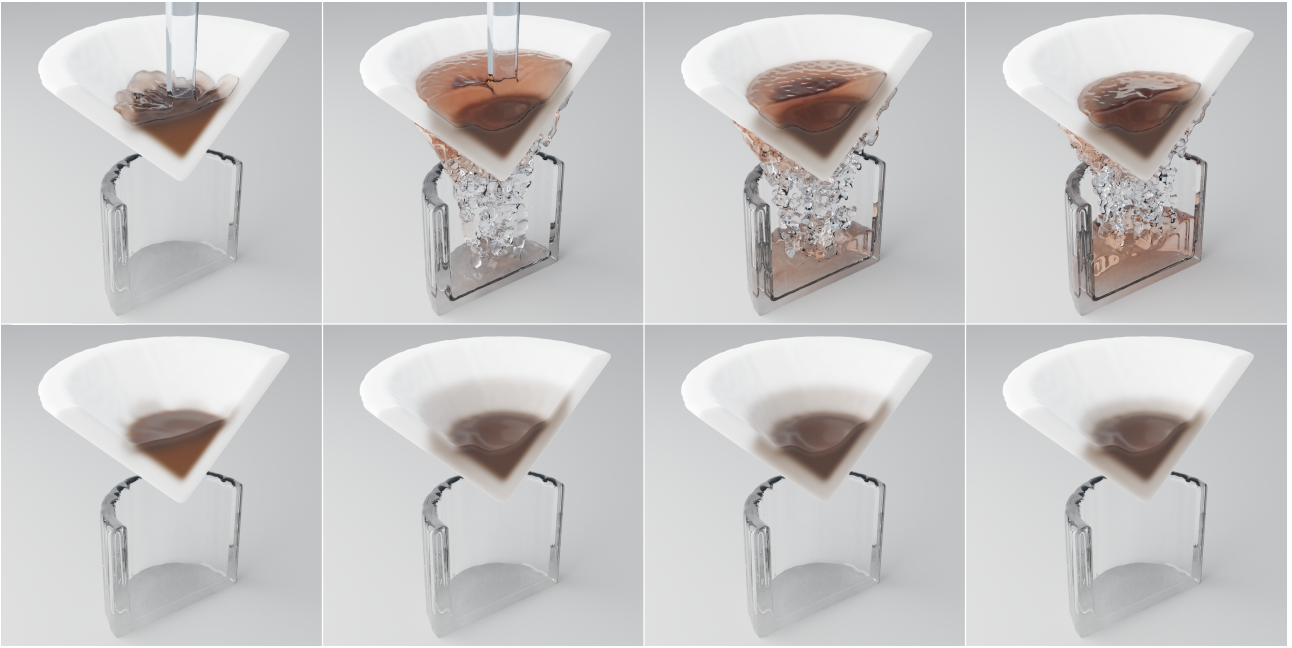
Supplementary Material : Porous Flow and Sediment Transport Simulation for Physically-Based Weathering

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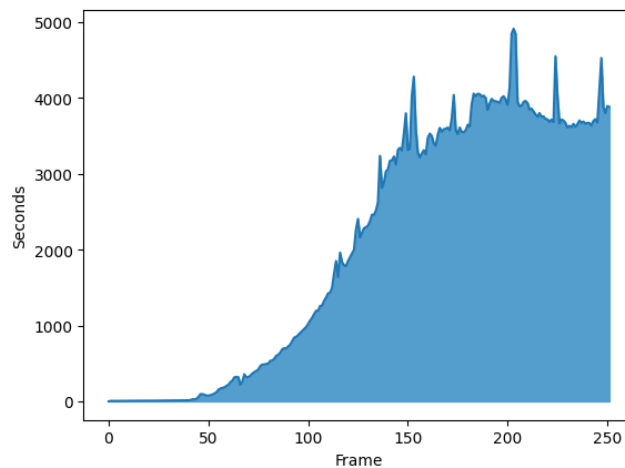
1 Extended Results

2 In this section, we describe in more detail some results shown in the paper. These results have been generated
3 using a machine with an AMD Ryzen 7 5800H (8c/16t @3.2GHz) and a 16Go RAM. We specify that the timings
4 announced in this supplementary material only take into account the time of simulation and not the generation of
5 the geometry nor the associated textures and the OpenVDB volume. Each frame of our simulations corresponds
6 to 1/30 s and is decomposed in sub-steps of simulation of approximately 0.5ms (simulation time).

1.1 Drip coffee maker (Figs. 1 & 4)



2 Figures 1 and 4 show water dripping through a coffee filter. Solubility is controlled through diffusivity ($D^{s^k} =$
3 $2.10 - 3$). Sediment particles have a radius $r^{s^k} = 0.01\text{mm}$ allowing them to travel in pores with mean radius set
4 to $r^{p^k} = 0.05\text{mm}$. At the initial state, this simulation contains 37000 solid particles. Water droplets particles
5 are spawned along with the coffee filter and store escaping fluid until they reach a certain volume and density
6 level to fall into the glass cup. This heavy simulation only requires to update particle position when their
7 volume is greater than one percent of their maximum volume (to prevent dropping too many thin particles).
8 Since particles in the glass cup do not have their maximum volume, it is necessary to significantly increase the
9 neighborhood considered, so that the fluid has its density at rest (i.e. $\rho_i = \rho_0$), which impacts the performance
10 during the simulation. At the final state, there are approximately 145000 fluid particles and each sub-step takes
11 a few minutes to compute (while it takes 0.5s during early steps).

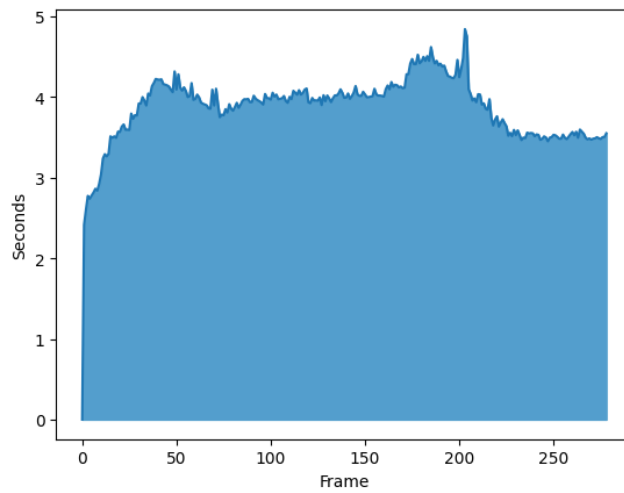


Computation time (in seconds) for each frame of the simulation.

1 **1.2 Eroded Surface (Fig. 5)**

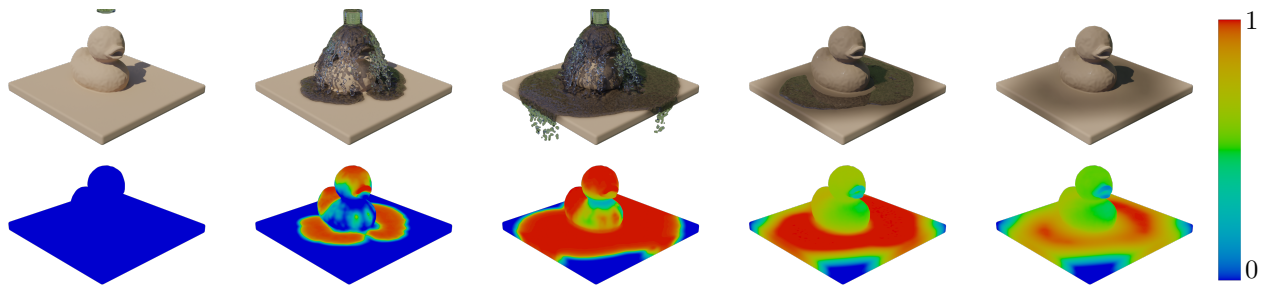


2 Figure 5 depicts the erosion, sediment transport and sediment deposition of a brittle material over an immutable
 3 one. The solid phase is composed of 28000 particles and interacts with 6000 fluid particles. The transfer rate
 4 between solid materials and sediments is controlled by κ_{erosion} (set to $5 \cdot 10^{-3}$). We choose a sediment radius
 5 $r^{s_k} = 0.1$ to model dirt or sand with no diffusivity (i.e. $D^{s_k} = 0$).

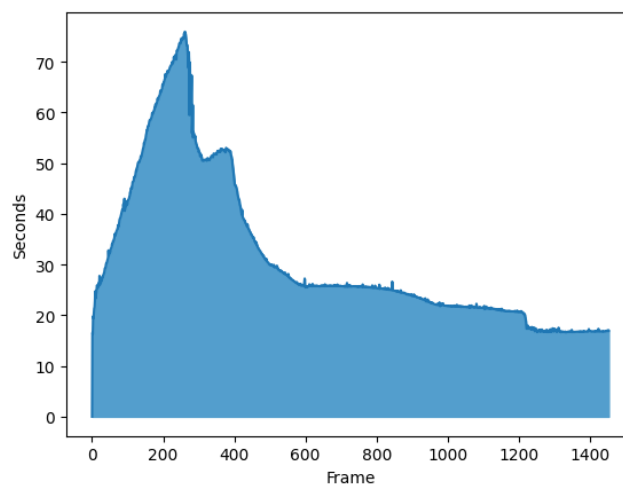


Computation time (in seconds) for each frame of the simulation.

1.3 Wet/Dry Surface (Fig. 6)

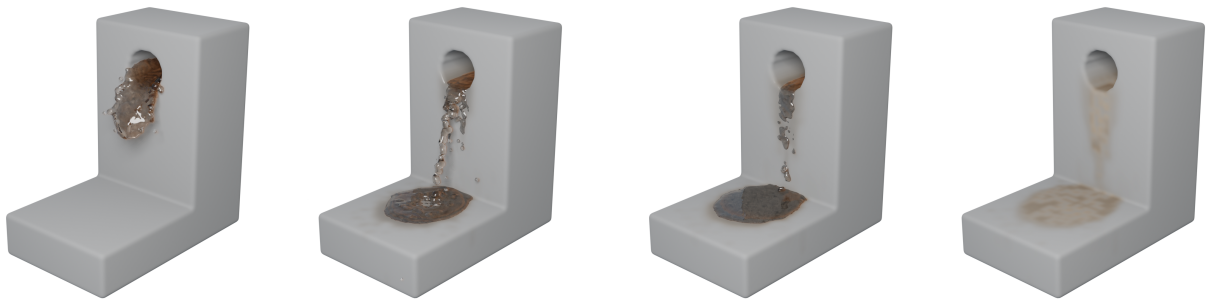


2 Figure 6 illustrates the wetting/drying process of a surface over time. Each frame of this simulation takes an
3 average of 0.47s/frame (or 14 seconds of calculation per second of simulation). The solid phase consists of 184000
4 particles of porous non-erodable and non-diffusive material ($D^{sk} = 0$ and $\kappa_{erosion} = 0$). Solid permeability is
5 set to $5 \cdot 10^{-8} \text{m}^2$ with a 30% porosity.

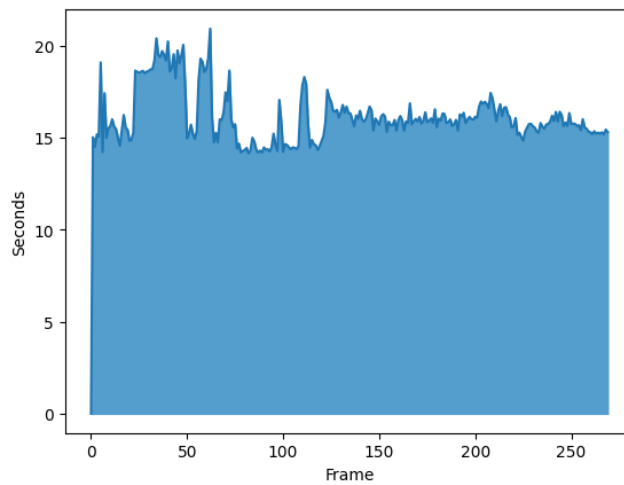


Computation time (in seconds) for each frame of the simulation.

1 1.4 Stains (Fig. 8)

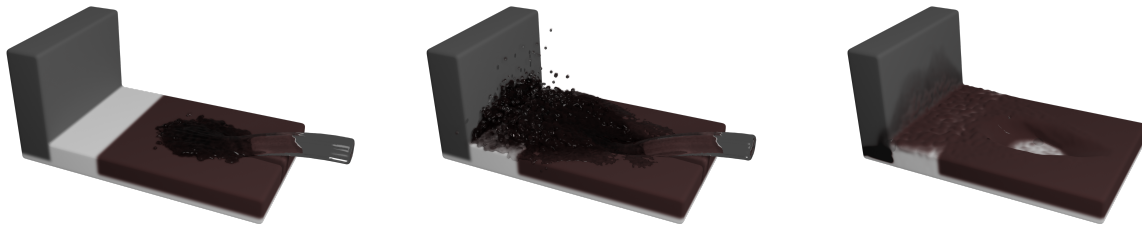


2 Figure 8 shows the formation of stains by water evaporation and deposition of sediments. This simulation
3 uses 3000 fluid particles for 180000 solid ones. Used sediments have a radius $r^{sk} = 0.1\text{mm}$ and a density
4 similar to water ($\rho^{sk} = 1000\text{kg.m}^3$). Maximal sediment concentration in water is set to $\text{MaxC}^{sk} = 0.3$ and wall
5 permeability is set to $\lambda = 1.10^{-6}$. These two parameters are over-estimated to obtain the desired effect in one
6 wetting/drying cycle.

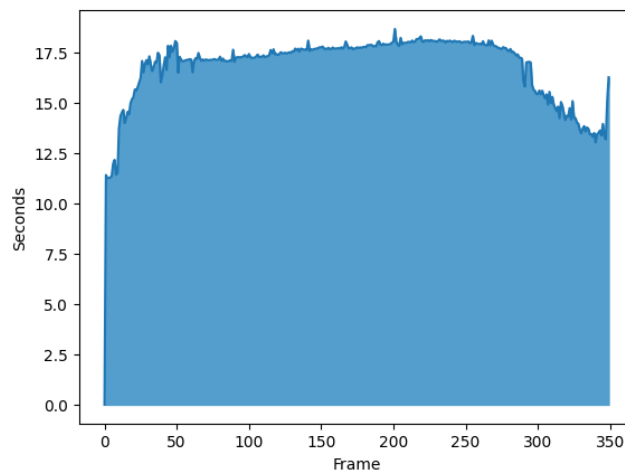


Computation time (in seconds) for each frame of the simulation.

1 1.5 Multi effects (Fig.9)

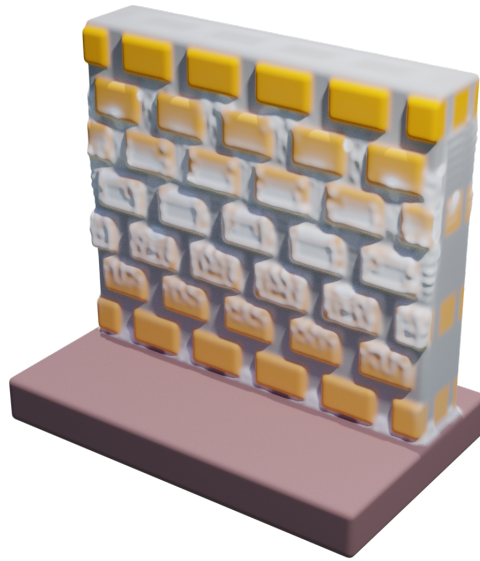


2 Figure 9 shows the erosion of matter, its transport by water both external and in the pore of solid matter. It
3 features 143000 solid particles and about 14000 fluid particles. This figure is a mixture of phenomena depicted
4 in figure 5 and figure 8. Solid materials share the same properties from those simulation, hence the importance
5 of having a material library as it eases the creation of novel scenes.

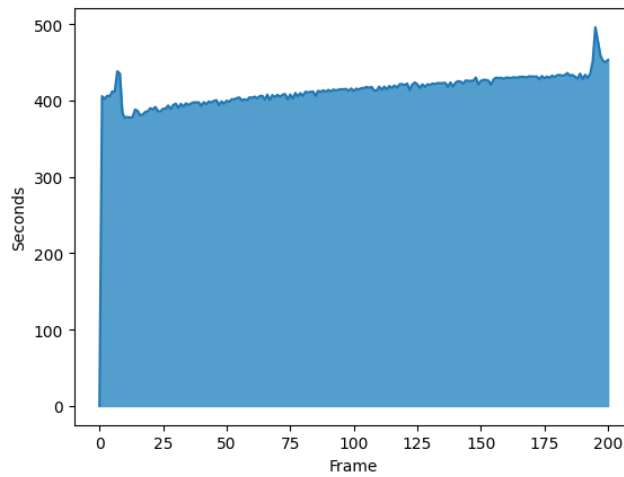


Computation time (in seconds) for each frame of the simulation.

1.6 Efflorescence (Fig. 10)



Efflorescence as shown in figure 10 is a complex phenomenon involving matter transport from the underground water to the surface. In this scene the wall is composed of 2 materials, concrete and bricks. Bricks have lower porosity (0.1) than the concrete (0.2). We used the porous stiffness parameter to 3 for the concrete material to ensure the diffusion is stronger than the gravity force while this parameter is set to 1 for the brick material. The salt itself is a material with density set to the water density as it allows to simulate totally dissolved matter. A layer of particles is maintained saturated in water and sediments at the bottom of the simulation. This enables the transport process to be continuous thus allowing us to have results quickly. The evaporation removes water from the solid surface lowering the saturation of those particle which allows for more water containing salts to reach the surface. When water evaporates, it deposit the salt it was transporting resulting in the gypsum formation. The simulation depicts 486000 particles and each frame corresponds to 1000 simulation steps.



Computation time (in seconds) for each frame of the simulation.