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Impact of grain size and rock composition on simulated rock weathering

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Both chemical and mechanical processes act together to control the weathering rate of rocks. In rocks with micrometer size grains, enhanced dissolution at grain boundaries has been observed to cause the mechanical detachment of particles. However, it remains unclear how important this effect is in rocks with larger grains, and how the overall weathering rate is influenced by the proportion of high and low reactivity mineral phases. Here, we use a numerical model to assess the effect of grain size on chemical weathering and chemo-mechanical grain detachment. As grain size increases, the weathering rate initially decreases; however, beyond a critical size no significant decrease in the rate is observed. This transition occurs when the density of reactive boundaries is less than $\sim 20\,\%$ of the entire domain. In addition, we examined the weathering rates of rocks containing different proportions of high and low reactivity minerals. We found that as the proportion of low reactivity minerals increases, the weathering rate decreases non-linearly. These simulations indicate that for all compositions, grain detachment contributes more than 36% to the overall weathering rate, with a maximum of $\sim 50\,\%$ when high and low reactivity minerals are equally abundant in the rock. This occurs because selective dissolution of the high reactivity minerals creates large clusters of low reactivity minerals which then become detached. Our results demonstrate that the balance between chemical and mechanical processes can create complex and non-linear relationships between the weathering rate and lithology.