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Quantifying the impacts of an exogenous dust input to the soil and stream chemistry of an upland Mediterranean watershed using a reactive transport modeling framework

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The objective of this research is to quantify how dust affects soil and stream chemistry in an upland watershed using experimental and modeling methods. At our field of study, a small (0.54 km^2) upland Mediterranean watershed located on Mont Lozère in the National Park of Les Cévennes (France), field observations of calcium in stream water, rain, bedrock, soil, and plants could not be produced from reactive transport simulations of the weathering profile without an exogenous, long-term dust input. This place has been documented to be in the path of Saharan dust exports, but the importance of these depositions had not been yet quantified. Thus, we developed a process-based reactive transport framework by modifying the open source CrunchTope software in order to quantitatively interpret the impacts of dust deposition and solubilization in stream water chemistry, regolith weathering rates, and ecosystem nutrient availability.

By adding a carbonate-rich input consistent with the composition of Saharan dust, both stream water chemistry and elemental mass-transfer coefficients in the soil profile better align with field observations, suggesting that dust has become a significant input to this field site in the last ~10 ka. Over this period, this deposition has introduced far more calcium into the system than what could be supplied by the Ca-poor granitic bedrock. This is the first demonstration of solid phase dust deposition incorporated into a multi-component reactive transport framework. Moreover, this work shows how dust incorporation affects geochemical cycling across upland watersheds beyond the limitations of simplified steady state assumptions, a feature which will enable further research of a variety of Critical Zone systems subject to the effects of environmental change scenarios.

Author: ARANDA REINA, Celia (University of Illinois Urbana Champaign - IPGP)

Co-auteurs: Dr BOUCHEZ, Julien (IPGP); Dr GOLLA, Jon K. (Lawrence Livermore National Laboratory, USA); Dr AYRAL, Pierre-Alain (ESPACE, UMR 7300, Aix Marseille University, Côte d'Azur University, Avignon University, CNRS); Prof. DRUHAN, Jennifer L. (University of Illinois Urbana Champaign - IPGP)

Orateur: ARANDA REINA, Celia (University of Illinois Urbana Champaign - IPGP)

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