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Influence of Parent Material Lithology on Dust Accumulation in Alluvial Fan Soils, Mojave Desert, California U.S.A

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Characteristic morphologic expressions of desert soils are strongly controlled by accumulation of fine-grained eolian sediment (dust), yet there is limited data to show how the lithologic composition of the soil parent material may also moderate the addition of dust during soil formation. We compare the morphologic expression of dust accumulation among three lithologically different soil chronosequences comprising four soils of different ages (range ca. 3-70 ka). Soils are formed on alluvial fan surfaces that occur along the western slope of the Providence Mountains, Mojave Desert, in southeastern California. The soils are formed in alluvial parent material composed of limestone/marble (LS), an assortment of rhyodacite, limestone, and granitic clasts (VX), and mixed-granitic lithologies (MG), and exhibit dramatic local variability as a result.

We observe significant variability of silt and clay (dust) inventories in the soil profiles among the three soil-chronosequences. Silt plus clay inventories show both temporal differences and lithologic controls in dust accumulation over time as follows: Qf6 (3-5 ka): 0.5 to 4 g/cm2 (LS), 1 to 4 g/cm2 (VX), and 2 to 7 g/cm2 (MG); Qf5 (8-12 ka): 3 to 6 g/cm2 (LS), 4 to 7 g/cm2 (VX), and 8 to 20 g/cm2 (MG); Qf4 (∼30 ka): 3 to 6 g/cm2 (LS), 4 to 7 g/cm2 (VX), and 10 to 25 g/cm2 (MG); and unit Qf3 (∼60-70 ka): 4 to 8 g/cm2 (LS), 9 to 12 g/cm2 (VX), and 17 to 33 g/cm2 (MG). These data demonstrate a strong correspondence between soil age, parent material, and dust content, indicating that parent material lithologies likely moderate dust accumulation rates.

Variations in dust accumulation are also reflected in soil B horizon development. In the MG sequence, soil B horizons range from weakly developed Bw horizons (Qf6), to weakly developed Bt horizons (Qf5), to strongly developed Bt horizons (Qf4, Qf3). By comparison, in the LS chronosequence, soil B horizons range from weakly developed Bk horizons (Qf6, Qf5), to weakly to moderately developed Bkm horizons (Qf4, Qf3). Soils developed in the VX fan-sequence deposits, which represent a general mid-point between the LS and GM sequence soils, exhibit weakly developed Bwk horizons (Qf6, Qf5), weakly developed Bwk-Bkm horizons (Qf4), and weakly developed Bt horizons that overly moderately developed Bkm horizons (Qf3).

Temporal variations in the rate of desert pavement development among the different fan units may explain variations dust accumulation rates. The rate of desert pavement development occurs faster on the VX and LS fans, which have an abundance of 2-10 cm in length gravel whereas the MG surfaces are composed of gravel and cobbles ∼2-50 cm in length. Gravel-rich deposits enhance the formation of pavements, reducing dust-trapping efficiency from reductions in surface turbulence associated with increases in the smoothing and packing of pavement clasts. Recognition of this type of intrinsic feedback between soil formation and the modification of alluvial fan surfaces is critical for interpreting the systematic changes in desert soil formation among soils formed in the different sediments composed on contrasting lithologies.