DUST! Why Should You Care?

By Marith Reheis, Emeritus USGS, presented at the Colorado Scientific Society on December 13, 1917.

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Abstract (partial): Windblown dust is carried all over the world, whether visible or not. Earth-derived dust today is most abundant in arid and semi-arid regions and in the glacial past in glacio-fluvial areas. Why is dust important? Let me count some of the ways: (1) agriculture, (2) ecosystems, (3) dust storms, (4) water supply, (5) human (and animal) health. Dust is the great equalizer of the Earth's surface, because it is the only component (along with other wind-borne materials like volcanic ash and anthropogenic pollutants) that circles the planet.

Biography of Marith Reheis (short): Marith graduated with a B.S. in Geology from the University of Georgia in 1972. Desperate to escape humidity and saprolites, she earned an M.S. from the University of Colorado studying the transport of debris by Arapaho Glacier. After a few years mapping coal in the Conservation Division of USGS, she returned to CU Boulder to study soil genesis under Pete Birkeland. From 1984 to retirement in 2013, Marith resided in the evolving branches of Regional Geology — Environmental Geology — Climate — Earth Surface Processes – Geosciences and Environmental Change Science Center. Field areas included northwest Colorado, the Bighorn Basin, Great Basin and Mojave Deserts, and the eastern Colorado Plateau. In parallel, her career has evolved through bedrock and surficial mapping, soil studies, neotectonics, desert dust sampling and analysis, and paleoclimate research, to a state of mixing them all together.

Why does dust matter? Dust girdles the globe: it helps create the most fertile soils on the planet by adding nutrients; it affects both the water supply and human health; and dust storms can impact traffic and infrastructure. (Hear Marith's original song composition about dust.)

It has been known from the time of Darwin that dust from the Sahara crosses the Atlantic Ocean to South America, the Caribbean and blankets the East Coast of the United States on occasion. By 1999 satellite technology had developed to the point that it was possible to see dust storm crossing oceans. Now it is possible to track such storms over land masses. Dust that originated in the Gobi Desert has been tracked to the Colorado Front Range, where it can be differentiated by its yellow color. About 100 grams/square meter/year of dust is deposited in Asia and Africa, western North America, and parts of South America and Australia

Foreign dust is present in every soil on the planet. Soils in the Northern Bighorn Basin that have formed on a limestone/dolomite sand gravel have been found to contain gypsum, which appears to have been deposited by wind, as there are no sulfates present in the groundwater or rocks. A 1960's study of oxygen isotopes in quartz crystals in saprolites of the southeastern US showed ratios of O^{18}:O^{16} that suggested foreign origin of the quartz, possibly from Africa. The presence of quartz in Hawaii basalts is another example of dust movement. Even the soils of the dry valleys of Antarctica contain dust that blew in from somewhere else...

Local sources of dust include distal alluvial fans and playas. Dust is blown from the alluvial fans in Owens Valley, in addition to dust removed from Owens Lake. When rain falls on dry playas, mud curls form that are easily disaggregated by the wind. Wet playas actually produce more dust than densely packed dry playas. Capillary action tends to carry hydrated salts to the surface, which dry to feathery textures and are easily mobilized as dust. Playas in Death Valley National Park have a broken surface due to the non-uniform dissolution of the underlying salt deposits, and this irregularity makes particles more available to wind activation. Desert loess is building up in this area at the rate of 70 cm in less than 5,000 years.

The composition of modern dust is similar to ancient dust in the major components, but does contain more sodium and less titanium. However, trace elements that humans generate, such as cadmium, copper, nickel and zinc, are found at much higher concentrations in modern dust.

Dust collection systems, constructed from angel food cake pans containing marbles, positioned on a 2-meter high fence post, were used to simulate dust falling into soils. An extensive collection of these traps was set up across the western USA. A system in Canyonlands in Utah was later established to determine the connection between dust and biologic crust. Among the problems to be tackled was dealing with ravens that would drop burro poop into the traps.

Natural dust traps can also be found. Lakes without outlets provide good dust traps. Weathering pits present on the surface of Jurassic sandstones from the Mojave Desert to Canyonlands collect dust. The composition of the top few centimeters of the dust in these traps is very different from the bedrock (aeolian sandstone). Magnetite levels indicate that some of the dust was sourced from the Mojave Desert. The dust is also enriched in plant-critical nutrients, compared to the soils derived from the aeolian bedrock. Thus, the fertility of soil in the Colorado Plateau is improved by this dust.

An important positive aspect of dust is that it generates some of the most fertile soils on the planet. Wind-blown soils may have not been leached of the minerals that are essential for plant development. Thick deposits of loess, which is a German term for wind-derived sediment, are present on the Columbia Plateau, the Chinese Loess Plateau, and parts of the American mid-West and the West, creating good farmland. The original inhabitants of Mesa Verde National Park farmed on top of mesas covered with enriched loess soils. Geochemical research shows that much of the loess in Mesa Verde is coming from the San Juan River glaciofluvial sediments. African dust travels across the Atlantic and fertilizes the Amazon. Approximately 28 million tons of dust is deposited per year in the Amazon, including 22,000 tons of phosphorus. This is important to the region, as the only phosphorus in the Amazon is contained in the vegetation itself. Phosphorus and other nutrients are leached out by heavy rainfall. Caribbean soils also are largely composed of African dust.

Iron-rich dust in the ocean can promote the growth of phytoplankton. The eruption of Pinatubo raised both sulfate and irons levels, which contributed to a phytoplankton bloom.

There are measureable environmental impacts associated with dust. A core history of 5000 yrs in lakes of the San Juan Mountains shows that dust deposition has quadrupled in the last 200 years due to human activity such as animal grazing and plowing. Dust erosion causes a loss of both nutrients and then, perennial grasses. A decrease in dust accumulation has been noticeable after the passing of the Taylor Grazing Act of 1934. Certain areas of Canyon Lands that are largely inaccessible and were never grazed have significantly less dust erosion than more heavily used parts.

White dust storms over Owens Lake in California began occurring after the LA Department of Water and Power obtained and removed the water for municipal use. The white color was due to concentrations of salts. The frequency of these storms has been reduced after the water department was required to maintain a certain water level in the lake as well as to construct mitigation structures on the lake bed that slow the wind velocity.

Dust on snow packs has also increased with recent droughts and higher temperatures. Iron oxide has a pronounced effect on snow packs, as it absorbs radiation and lowers the albedo, causing the snow to melt faster and earlier and creating water supply problems.

Dusts change the composition and water characteristics of soils. In southern Nevada near Las Vegas there are limestone gravels that have created calcretes. However, in these soils are brown patches composed of modern dust, which is up to 70 percent silica, and infiltrates and adds to the soil profile over time.

Human health is impacted when dust is breathed in. Small mineral particles (less than 2.5 to 10 microns) can remain in the lungs. Toxic materials that may be present in dust particles include asbestos, toxic metals, fertilizers, herbicides and insecticides that are routinely used. Dust from Owens Lake prior to mitigation contained arsenic levels more than 1000 times EPA limits. The exposed lakebed of Mesquite Lake near Las Vegas contains both arsenic and uranium salts. A dust storm in 2002 shut down the city. Water from the lake was removed to irrigate nearby alfalfa crops. The soil-dwelling fungus causing Valley fever in California was spread from the dust raised by shaking during the San Gabriel Earthquake.

In answer to questions, Marith said that dust was anything that could be lofted by the wind more than several meters. Sand grains that bounced along the ground were not considered to be dust. The majority of dust consists of silt-sized material and loess is simply dust that piles up in one place. The thick deposits of loess in eastern Colorado come principally from flood plains of the White River Formation. The loess deposits in Iowa are glacio-fluvial in origin.

A member of the audience asked about haboobs – desert dust storms. She explained that their intensity was caused by giant downdrafts preceeding storm fronts. Another question was about the effectiveness of the Chinese planting trees to reduce the advance of the Gobi Desert. She thought that it might be effective on the margins, but they are never going to stabilize the center of the desert.