Surficial Geology and Geomorphic Process Studies in Support of Multidisciplinary Ecosystem Investigations—Examples from Parts of Greenwater and Valjean Valleys, Mojave Desert Ecosystem

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Ecosystems, which identify a natural community of interacting organisms and their physical environment, can also serve as organizational and conceptual units that define land-use regions for land-management agencies and study boundaries for large interdisciplinary scientific investigations. The geologic and hydrologic frameworks constitute a fundamental part of the physical environment at the core of the definition of an ecosystem. Of particular importance are surficial geologic studies that involve characterizations of near-surface geologic materials, including soils, determinations of age and nature of geomorphic surfaces, and interpretations of geologic and hydrologic processes that emplace the materials.

The Mojave Desert Ecosystem Science Project <http://geology.wr.usgs.gov/MojaveEco/> is an interdisciplinary investigation that emphasizes the understanding of vulnerability and recoverability of an ecosystem's components in an arid environment. The overall methodology is to characterize the ecosystem's attributes and study key functional links and processes in order to quantitatively model its vulnerability. Surficial geology plays an important role in this approach because data from near-surface deposits provide fundamental information to characterize and model such effects as soil compaction, wind erosion, and water erosion. In addition, surficial deposits contain a physical record of historic and prehistoric processes and can therefore be used to establish baselines for comparisons of human-induced impacts on these natural systems. For these reasons, we have undertaken detailed and regional characterizations of surficial deposits in the Mojave Desert Ecosystem.

Detailed surficial geologic studies are underway in a part of the Greenwater Valley in the eastern portion of Death Valley National Park and in the Valjean area in northern Silurian Valley, approximately 30 km north of Baker, Calif. Each of these areas contains old townsites that are being studied by other project members to establish patterns of soil and vegetative recovery from the disturbances that date to near the beginning of the 20th century.

Greenwater Valley is an intermontane valley formed along the east flank of the Black Mountains; it begins approximately 5 km south of Ryan, Calif., and extends southeast for 60 km to the town of Tecopa. The northern 15 km of the valley contains at least three townsites and is the focus of these studies. The northern portion of the valley is asymmetric in cross section with gentle western slopes, mantled by thin alluvial fans. These fans feed an axial drainage, Furnace Creek Wash, which intermittently flows northwest along the foot of the steeply sloped western flank of the Greenwater Range. Northern Greenwater Valley is perched 1,300 m above the floor of Death Valley and lies immediately above a pronounced nick point in Furnace Creek Wash, below which active erosion and sidestream entrenchment dominate the landscape. Virtually all sediment mantling the valley margins is sandy gravel derived from nearby welded and nonwelded silicic ash-flow tuffs of Tertiary age. The fan surfaces of the broad west-side piedmont are dominantly Holocene (<10,000 yr) in age, based on weak to no soil development, lack of any eolian silt cap or associated desert pavement, and preservation of distinct, yet low-relief microtopography. A few remnants of late to middle Pleistocene surfaces are recognized, based mainly on soil development. These remnants are being buried by Holocene debris near the toe of the slope, and stripped middle Pleistocene surfaces that are overlain by thin Holocene deposits are only visible in the walls of shallow washes in the upper portions of the slope. The short, steep fans of the eastern valley slope and the axial stream system of Furnace Creek Wash share soil properties with their correlatives on the west side of the valley, but the latter deposits are dominated by cobble to boulder gravel and their microtopography is more pronounced. The causes of the asymmetric valley and its opposing stratigraphic relations between valley sides are not completely clear. They probably result from a combination of the following: (1) active back-tilting of the entire valley and the associated Greenwater Range that forms in the footwall block of the Death Valley fault, (2) possible minor down-to-the-west Pliocene and early Quaternary displacement along a fault at the western foot of the Greenwater Range, (3) gentle east dip of the underlying tuff on the west side of the valley, and (4) inheritance of relict (Pliocene to early Quaternary) topography.

To the southeast, the Valjean area comprises the gently west sloping Valjean piedmont, located largely north of the Silurian Hills and east of Silurian Lake. Steep fans from the high Avawatz Mountains meet the Valjean piedmont at Salt Creek Wash. The north edge of the Valjean piedmont is bordered by Kingston Wash, where it exits an hourglass-shaped canyon below the immense (>1,500 km^2) Shadow Valley drainage basin. Kingston Wash carries a distinctive assemblage of granitoid-rich clasts and forms simple fans unlike those of the Valjean piedmont, which is composed of complexly interbraiding systems carrying a mixed assemblage of quartzite/silicic metasediment/granitoid clasts. An unusually complete set of geomorphic surfaces is preserved on the Valjean piedmont, including three or more probable early to middle Pleistocene-age surfaces underlain by Stage IV calcic soils (Gile and others, 1966; Machette, 1985) that are partially to completely stripped of eolian silt caps and dissected to depths of at least 10 m. Middle to late Pleistocene surfaces are distinguished by soils with well-developed to weakly developed Bt and Btk horizons, pronounced eolian silt caps and desert pavements, and flat surfaces lacking bar-and-swale topography. Holocene surfaces have weak or no soil development, no eolian silt caps, and moderate to pronounced bar-and-swale topography. One enormous debris-flow deposit that mantles much of lower Kingston Wash with boulders as much as 2 m in diameter, appears to be early Holocene in age. Finally, the alluvial deposits complexly interfinger with eolian materials along southeast-trending belts downwind of two local sources—Silurian Lake and the lower Amargosa River. The eolian contributions modify microtopography and soil development characteristics, leading to differences in infiltration and vegetation in these belts.

Although several plant, animal, and soil vulnerability and recovery studies are still underway at various Mojave sites, a few initial generalizations can be made regarding surficial geologic controls on ecosystem components, at both Greenwater Valley and the Valjean area. Distinct associations of plant communities with various-age geomorphic surfaces (as noted by several botanists) may be responses to different soil-geomorphic controls depending on the age of the surface. In and near active washes, surface stability is low as a result of active aggradation in channels and flooding of late Holocene surfaces by large depositional events. In such environments, longer lived plants, such as creosote bush, seem to be excluded by rapid colonizers, such as grasses. On Pleistocene surfaces, stability is high, but variations in subsurface soil composition and development, and presence of significant areas of desert pavement, appear to partly control the density and height, if not species composition of the plant community. Clearly, soil compactibility and recoverability also vary with surficial geologic conditions, with the eolian silt caps of middle to late Pleistocene surfaces being particularly compactable. For many recovery-site studies, conventional, stratigraphy-based surficial mapping at 1:12,000 to 1:24,000 scale is inadequate for characterizing all the geologic parameters controlling plant distributions and soil compactibility. Detailed surface and subsurface particle-size distributions and inventories of lithologic composition of gravel clasts and matrix are also required.

REFERENCES

Gile, L.H., Peterson, F.F., and Grossman, R.B., 1966, Morphological and genetic sequences of carbonate accumulation in desert soils: Soil Science, v. 101, p. 347–360.

Machette, M.N., 1985, Calcic soils of the southwestern United States, *in* Weide, D.L., ed., Soils and Quaternary geology of the southwestern United States: Geological Society of America Special Paper 203, p. 1–21.