Hyperarid early Pleistocene geomorphic surfaces: Paran plains, Israel

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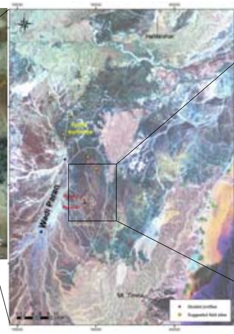
Summary

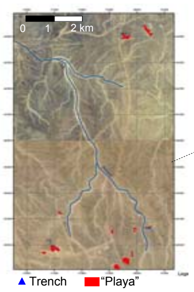
The plains of Paran (Negev, Israel and Sinai Egypt) are an ancient, remarkably flat complex of pediments, alluvial fans, terraces and straths, and even distal colluvium and near-surface bedrock. All are leveled to gradients not characteristic of more recent erosional and alluvial features in the region. They are totally barren of any vegetation, except in rare recent gullies. In the Negev, where they cover 20%-25% of the area, these ancient surfaces have a wide age range but stratigraphically they are late Pliocene and early Pleistocene. Currently they are experiencing extremely arid conditions. The surfaces are typical of the Near East desert terrain (~30% in a few regions) and therefore a focus of our efforts. Their seeming homogeneity can mislead users of these landscapes: traffic conditions are diverse and the surfaces are a potential source of dust. They are actually a mosaic of sub-environments with different properties. The results discussed here are preliminary.

Our goals are to: (1) characterize the soils and surfaces, specifically as sources of dust emission; (2) map and distinguish among the sub- environments on the widespread surfaces; (3) produce a conceptual predictive model and map of dust potential; (4) characterize similar terrains in other Middle East deserts.



Top: Distribution of Plio-Pleistocene surfaces in Isreal and Jordan. Right: Paran Surfaces in the central western Negev with existing and proposed trenching sites.

The ancient surfaces of the Paran are covered by well-developed desert pavement and characterized by a complex gypsic/calcic Reg soil with relatively high amounts of very fine dust. Unlike the middle to late Pleistocene surficial Reg soils on flat alluvium in the area, most of these surfaces underwent several cycles of erosion and reformation of desert pavement associated with changes in soil evolution. A relatively common feature on these surfaces are the uncommon small "playas" (most are 20-30 m in diameter and less than 0.5 m deep, below). The "playas" are sources of dust (below left). Their origins are unexplained. We hypothesize that if the "playas" result from a natural process (which we will test) then their spatial distribution is a temporal snapshot of the long and complex evolution of the ancient surfaces.



Sponsors

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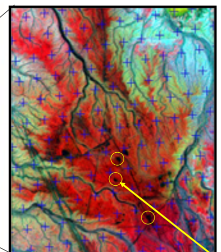
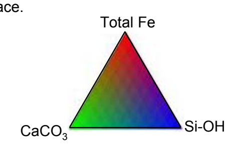
The flat alluvial surfaces developed lags/pavements of dark chert clasts. This also indicate their antiquity. Visually, the chert mimics varnished clasts, but in the thermal infrared the chert clasts show a distinctive emission feature at ~9 µm, about 0.5 µm shorter than the clay features characteristic of most varnishes (e.g., Death Valley). Thus, multispectral TIR satellite images, but not multispectral VNIR (visible/near-infrared) images, are able to distinguish black/dark chert pebbles from other pebbles coated by rock varnish. We explore the feasibility of detecting diverse properties and mapping the ancient surface from the concentration and composition of the desert pavements. Mapping these surfaces by diverse methods at a range of scales will assist in detecting surfaces with different dust-emission potentials according to the degree of erosion and exposure of their subsurface.

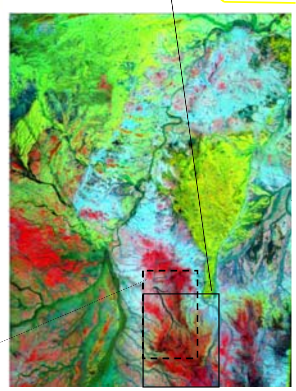


ASTER
Red= Band 4/3
Green= Band 3/8
Blue= Band 4/6



Center of the Paran plains (red) in this color scheme red indicates iron-rich surfaces. Field observations indicate that these areas are composed of compact desert pavement (80-100% clast coverage). Of the clasts 80-90% are dark coated cherts with iron-rich varnish, which probably masks the Si-OH absorption feature. The rest of the clasts are carbonates.

The "playas" are in black. carbonates ≈ iron ≈ clays Probably the composition of dust.



Greenish areas at margins of red surfaces Pavement is composed of ~50% chert and ~50% carbonate clasts. These areas are at lower elevation, transitional between the higher red areas (chert) and the wadies and represent recent erosion of the surfaces and their alluvial lithologic composition.

The light blue areas surrounding the red and greenish areas

Field observations indicate a similar appearance to the high, chert surfaces. The RS difference probably reflects the presence of less varnished chert and thus a more pronounced Si-OH absorbtion feature. Why is it less varnished? Age cannot explain this as surfaces are very old. Perhaps a different type of chert.

The age of the Paran surfaces

According to regional stratigraphy, the upper Paran alluvial surfaces have been developing since at least the early Pleistocene under variable conditions but are the most stable alluvial surfaces in the Negev. As part of the current effort we aim to determine their ages, the rates of dust accumulation in playas and soils, and/or the erosion rates of these surfaces. These are keys to the understanding their development through time and their present morphologic characteristics and a basis to map such surfaces elsewhere in the Near East deserts.

In this regard cosmogenic isotopes are powerful tools. The analyses of cosmogenic isotopes such as ^{10}Be, ^{26}Al, ^{36}Cl, ^{21}Ne in surface and subsurface sediment will allow the determination of the rates of dust accumulation and bedrock weathering that controlled the development of the surfaces and the time at which they operated. Such results will contribute to the understanding of dust production in hyper arid environments. Similar efforts using OSL will be concentrated in the "playa" deposits.

The development of vesicular horizon through dust accumulation (notice the dust "fingers", above right)

These surfaces are similar in appearance to the Pleistocene surfaces that are covered by well-developed desert pavement. These pavements erased any previous evidence of their fluvial origin and are composed of a single layer of angular pebbles. However, the properties of the soils developed underneath these pavements are different from the properties of the 'regular' Pleistocene Reg soils (e.g., Amit et al., 1993).These ancient surfaces are probably stable in the landscape but their genetic history, which is the clue to the spatial distribution of their properties, was complex. Through time the soils experienced cycles of erosion and climate change (influencing influx of rain, dust, salt, vegetation) resulting in complex, partially welded soils. The Pleistocene soils in the Negev desert developed under hyperarid conditions.

These ancient soils present the only documented calcic horizon in gravelly Reg soil in the Negev under current mean annual rainfall of 50 mm or less. This was hypothesized by Amit et al., 2006 as these soils are old enough to experience early Plistocene wetter climates.

Ancient Surface Soil

Ao Desert pavement (see above).

Av 0-10 cm: With "fingers" of vf sand and silt as continuations of the columns boundaries (above left). Av is thicker than in normal hyperarid Negev Pleistocene Reg soil (0.5-1 cm). Byz 7-14 cm Reddish silt, non-plastic, no cutans. Coatings of Fe-oxides, >2 mm 3-8%. A few fingers are cemented by gypsum. Displaced shattered clasts. Byz2 14-22 cm Loose single grain, non-plastic reddish silt, no cutans, grains coated by Fe-oxides. > 2 cm 5-15%, displaced shattered gravel. Less gypsum than above. Fingers curve from vertical to horizontal. Byz3 22-36 cm Reddish silty gravel coated by Fe-oxides, >2 mm 10-20%, few >5 mm. Gypsum and salts round to irregular nodules 2-10 mm and below >10 mm clast. Abundant angular shattered clasts.

Bkyz 36-53 cm A transitional horizon between an upper Reg soil and a lower calcic soil. Massive, gravely >2 mm 30-40%, few >5cm. Most matrix is silty sandy with salts forming 5-15 mm irregular nodules and pendants. The granular structure formed by salts. Clasts <5 cm shattered and angular most of them displaced. Carbonates mostly occur as pendants but occur with greater cementation at the lower 1/3 of the horizon. Some biogenic structures are observed.**Bkyz2 53-80 cm** gravely, massive, cemented by carbonates and salts, >2 mm 45-65% few >5 cm. Many shattered angular clasts, calcic cement soft pendants; most of the matrix contains salt. **Bkm1 80-140 cm** Calcic horizon, massive, >2 mm 45-65% >5 cm mostly single grain. No evidence of salt shattered. Gravel amount increase downward (Fig. 11). 140 – 180 cm matrix is composed mostly of chalk fragments, very white matrix, abundant chert.

The playa trenched presents different soil characterized by 50 – 60 cm of playa-like silty clay material overlying alluvium w/calcic soil horizon. The soil-stratigraphy indicates that the playa soil/deposits are later addition into a lower part on the surface, probably formed by a drainage developed on the earlier surface, This playa probably buried partially eroded well developed soil and continue to develop to a different morphology.

The playa silts are highly compacted and although originally dust, they are currently not a source for dust. We think that the paved surfaces are more readily source when disturbed.

Playa Soil

Av 0-4.5 cm The surface is patterned by small polygonal cracks. Prismatic structure. (**above**). AC 4.5 – 10 cm Clay films and gypsum is deposited within in the silty matrix. ABb1 10-18 cm Platy structure, > 2 mm 5-10 %. Shattered gravel. Biogenic activity insects and plants. **Bwky1b1 18-30 cm** Calcic horizon with borrows, salt and gypsum accumulation, a few calcic nodules and gypsum cubes. **Bwky2b1 30-61 cm** >2 mm 1-2%, columnar structure/subangular blocky, biogenic activity mainly roots. Calcic cementation. **Bwky3b1 61-94 cm** 1-2 subangular blocky, > 2 mm 5-15% >3 cm all shattered. Calcic cementation. This horizon is a transition from playa into alluvium. **Bkm1b2 94-123 cm** the parent material indicates a channel incised into the existed alluvium. Gypsum structure subangular blocky, **Bkm2b2 123-160 cm** some chalk fragments abundant. Similar to the previous horizon. more calcic than previous.