DIFFERENTIAL GPS/GIS ANALYSIS OF THE SLIDING ROCK PHENOMENON OF RACETRACK PLAYA, DEATH VALLEY NATIONAL PARK.

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The Racetrack Playa, at an elevation of 1131 m, is a dry lakebed nestled in the Panamint Range in Death Valley National Park, California. Though almost perfectly flat, it shows evidence of dynamic traction (sliding) of boulder-sized and smaller rock fragments that tumble onto it from two abutting cliffs and surrounding alluvial fans (Figure 1). Scars of sliding rock activity in the form of recessed furrows have been noted since the beginning of the twentieth century (Clements, 1952, Kirk, 1952, Shelton, 1953, Stanley, 1955, Schumm, 1956, Sharp, 1960, Sharp and Carey, 1976, Reid et al., 1995, Messina, 1998, others), yet to date no one has witnessed the actual surface process that causes the rocks to slide.

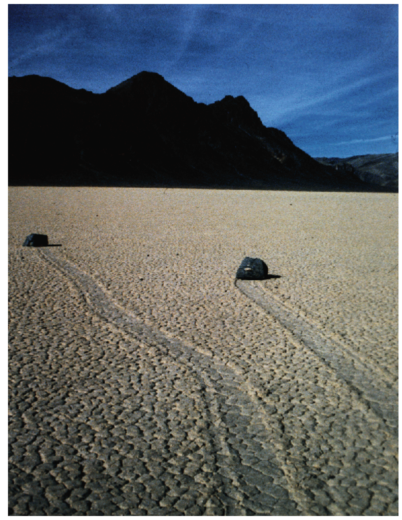

Figure 1: Two diverging sliding cobbles.

Previous mapping missions, particularly those conducted by Stanley (1955) and Reid et al. (1995), showed a high degree of parallelism among selected sliding rock trails. These surveys hypothesized that rocks inscribe grooves on the playa surface while embedded in a cohesive ice sheet, particularly during winter storms. Through experimentation, Sharp and Carey (1976) and Bacon, Cahill and Tombrello (1996) concluded that ice rafts may not necessarily contribute to the phenomenon.

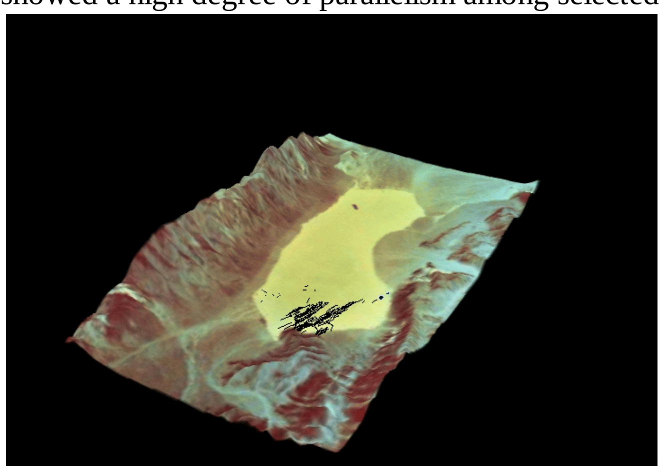

Figure 2: Oblique USGS aerial image of the Racetrack, draped on the USGS Ubehebe Peak 7.5' DEM (2x vertical exaggeration). DGPS sliding rock trails are denoted by black lines.

The location of every rock and its associated trail was recorded using Differential Global Positioning System (DGPS) and Geographic Information System (GIS) methods in July, 1996 (Messina, Stoffer and Clarke, 1997). The resulting map shows a total of 162 rocks and trails to a horizontal accuracy of about 30 centimeters (Figure 2). Surprisingly, a follow-up mapping project conducted in May, 1998, showed that the abnormally stormy El Niño winter conditions of 1997-98, while favorable to the development ice sheets, contributed little to the displacement of rocks from their original mapped locations,

Figure 3: Large-scale detail of trails in the Racetrack's central region.

Examination of trail patterns shows an inferred general trend in rock movement toward the north-northeast (Figure 3). This is consistent with the direction of prevailing winds. However, there is a high degree of variation in trail character. Surprisingly, trail lengths and headings are not well correlated with rock shape, volume or area of surface contact.

Analysis of the digital data set shows that large rocks tend to produce shorter, straighter trails. However, a rock's total distance traveled and the degree to which it follows a straight-line path is more significantly influenced by its location on the playa at the onset of motion than on any physical attribute of the rock itself.

The Racetrack's southeast sector, about 5 cm lower in elevation than the main playa, is more frequently saturated by collecting rain water. In addition, three natural springs there may contribute to lower friction coefficients over the long-term in this region. The longest and straightest trails are preferentially concentrated in the southeast, as rocks are propelled by the amplified force of horizontal winds when air is channeled through one of two topographic corridors to the south. On the central part of the playa, which is a focal point for two such natural wind tunnels, trails are most convoluted suggesting entrainment of rocks in wind vortices.

GIS integration of the DGPS data with the USGS 30-m 7.5' Ubehebe Peak Quadrangle DEM provided the framework for extensive geomorphometry and statistical tests. Terrain analysis of the surrounding basin quantifies the influence of topography on inferred airflow, which ultimately governs the nature and magnitude of sliding rock episodes.

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