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Macropolygon morphology, development, and classification on North Panamint and Eureka playas, Death Valley National Park CA

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Abstract

Panamint and Eureka playas, both located within Death Valley National Park, exhibit a host of surficial features including fissures, pits, mounds, and plant-covered ridges, representing topographic highs and lows that vary up to 2 m of relief from the playa surface. Aerial photographs reveal that these linear strands often converge to form polygons, ranging in length from several meters to nearly a kilometer. These features stand out in generally dark contrast to the brighter intervening expanse of flat, plant-free, desiccated mud of the typical playa surface.

Ground-truth mapping of playa features with differential GPS (Global Positioning System) was conducted in 1999 (North Panamint Valley) and 2002 (Eureka Valley). High-resolution digital maps reveal that both playas possess macropolygons of similar scale and geometry, and that fissures may be categorized into one of two genetic groups: (1) shore-parallel or playa-interior desiccation and shrinkage; and (2) tectonic-induced cracks. Early investigations of these features in Eureka Valley concluded that their origin may have been related to agricultural activity by paleo-Indian communities. Although human artifacts are abundant at each locale, there is no evidence to support the inference that surface features reported on Eureka Playa are anthropogenic in origin.

Our assumptions into the genesis of polygons on playas is based on our fortuitous experience of witnessing a fissure in the process of formation on Panamint Playa after a flash flood (May 1999); our observations revealed a paradox that saturation of the upper playa crusts contributes to the establishment of some desiccation features. Follow-up visits to the same feature over 2 yrs' time are a foundation for insight into the evolution and possible longevity of these features.

Keywords: GIS; GPS; surficial processes; Quaternary; desiccation fissures; playa

1. Introduction

North Panamint and Eureka playas were annexed to Death Valley National Park in 1994, when the

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park's boundaries were extended. North Panamint Playa lies within Panamint Basin, a north–south-striking valley separated from Death Valley by the Panamint Range to the east, from Owens Valley by the Argus and Coso Ranges to the west, and from Searles Valley by the Slate Range to the southwest (Smith, 1976). Eureka Playa lies within Eureka Valley, bounded by the Inyo Range to the west, and separated by Northern Death Valley by the Last Chance Range to the east. Both playas lie within structurally controlled basins that serve as local watershed termini. At comparable elevations (North Panamint Playa, 640 m; Eureka Playa, 877 m), their hard, smooth surfaces are composed of similar unremarkable clays, fine-grained silts, and minor sands (Motts and Carpenter, 1968; Smith, 1978). North Panamint Playa possesses more-plastic lacustrine sediments of Pleistocene Lake Panamint at depth (Neal, 1968b); there are no reports of Eureka Playa cores in the literature, and samples were not collected for this study, as per the limitations of our national park research permit.

North Panamint and Eureka playas are typical of numerous southwestern dry lake beds, in that they possess several common geomorphic features, including solution depressions, drain holes, mud volcanoes, phreatophyte and spring mounds.

Among the most striking surface features on these playas are long, deep cracks, vegetated lineaments, or tonal stripes. These features represent what were originally fissures in various forms of development; they may extend for hundreds of meters, and many are part of geometric networks, observable on aerial photographs.

2. Playa fissures and macropolygons

Extensive reconnaissance was conducted by the United States military in the second half of the twentieth century (Neal, 1968a,b; Motts, 1970) with an interest in identifying playa surfaces that would be suitable for landing aircraft. The research revealed desiccation cracks, often defining patterns radiating at roughly 90° or 120° angles (hence the term *macropolygon*) on numerous southwestern playas. This form of "patterned ground" had not been extensively studied, and some aspects of the origin of patterned ground in warm arid climates remains puzzling (Hunt et al., 1966).

Neal and Motts (1967) reported that in the 15 yrs prior to their study, increasingly greater numbers of giant desiccation polygons had been noted on aerial photographs. While a small fraction of this increase may be due to enhanced remote sensing capabilities, much of the increase has been confirmed by ground-truthing. Over the last century, natural climatic and environmental changes (i.e., variations in the frequency and intensity of rainstorms), and changes induced by human activity (i.e., ground water pumping) have resulted in a lowering of ground water tables, piezometric surfaces, capillary zones, and overall soil moisture; it is likely that all of these factors are playing a role in the increasing development of giant desiccation features (Neal and Motts, 1967). However, drying and shrinking may not be the only phenomena that form fissures and macropolygon segments.

In tectonically active areas such as the Basin and Range Province, earthquakes may rupture playa sediments forming long fissure-like scarps. Such a rupture was noted on Lavic Lake resulting from the Hector Mine earthquake (magnitude 7.1) in October 1999 (Morrison, 2002). The Bullion Fault and at least four others ruptured coseismically, producing a spectacular surface rupture with a total length of 48 m on Lavic Lake (Treiman et al., 2002).

Another hypothesis proposes that some linear scars are "irrigation ditches," excavated by paleo-Indians (Patch, 1951). One such feature described as an irrigation ditch was exploited as evidence of an agricultural community in Eureka Valley; this classification was later used to support the existence of farming in Owens Valley (Lawton et al., 1976). The persistence of this inference led Ward C. Smith (1978) to visit Eureka Playa to investigate the "aqueduct." His observations laid the groundwork for our field investigations conducted on Eureka Playa in 2002.

3. Field methods

While many earlier surveys of southwestern playas were conducted remotely (most notably, Neal, 1965a,b), we found that it was important to investigate features on-site. While aerial photographs and