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Large-scale gravity sliding in the Miocene Shadow Valley Supradetachment Basin, Eastern Mojave Desert, California

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Abstract

The Miocene Shadow Valley basin in the eastern Mojave Desert of California developed above the active west-dipping Kingston Range-Halloran Hills extensional detachment fault system between 13.5 and ca. 7 mybp. Although mass-wasting processes are common phenomena in supradetachment basins, the Shadow Valley basin is an exceptional locale for the study of such processes, especially rock-avalanches and gravity sliding. A score of megabreccias, interpreted as rock-avalanche deposits, and half that number of very large (>1 km^2, up to 200 m thick), internally intact gravity-driven slide sheets are interbedded with various sedimentary facies. The slide sheets, variably composed of Proterozoic crystalline rocks and Proterozoic, Paleozoic, and Tertiary sedimentary strata, moved across both depositional and erosional surfaces in the basin. Although the majority consist of Paleozoic carbonate rocks, the largest slide sheet, the Eastern Star crystalline allochthon, contains Proterozoic gneisses and their sedimentary cover and is now preserved as klippen atop Miocene lacustrine and alluvial fan deposits over an area >40 km^2. Estimates of slide sheet runouts into the basin from higher eastern and northern source terranes range from approximately a few km to >10 km; in most cases the exact provenances of the slide blocks are not known.

The basal contacts of Shadow Valley slide sheets are characteristically knife sharp, show few signs of lithologic mixing of upper- and lower-plate rocks, and locally exhibit slickensided and striated, planar fault-like bases. Pronounced folding of overridden Miocene lacustrine and fan deposits beneath the Eastern Star allochthon extends to depths up to 40 m at widely scattered localities. We conclude that this slow moving slide sheet encountered isolated topographic asperities (hills) and that stress transfer across the basal slide surface produced folding of footwall strata. Synkinematic gypsum veins in footwall playa sediments, with fibers up to 12 cm long, have trends and shear senses compatible with the direction and sense of displacement of the overriding crystalline allochthon. The undisturbed veins, which closely parallel the base of the slide sheet, attest to high fluid presence and pressure in the playa sediments—factors facilitating allochthon movement across them. The long length of the fibers, indicative of a protracted dilational process, is incompatible with a catastrophic rate of emplacement. We believe that the only explanation for slow displacement of this allochthon and other gravity driven slide sheets across the landscape is that they formed as slumps on high, steep bedrock slopes and that their elevated heads drove their toes across lower fan and playa deposits. Initial detachments from bedrock sources were facilitated by pre-existing structural and stratigraphic anisotropies.

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Detachment of the Eastern Star allochthon from the bedrock of Shadow Mountain likely occurred by inversion along the playaward dip of a preexisting Mesozoic thrust fault within Proterozoic rock units.

Keywords: slide blocks; gravity tectonics; Shadow Valley; Kingston Wash; Mojave Desert

1. Introduction

The Miocene Shadow Valley basin lies within the southern portion of the Mesozoic foreland fold and thrust belt in the easternmost Mojave Desert, California (Fig. 1; Burchfiel and Davis, 1971, 1988). The basin formed above the active Kingston Range-Halloran Hills extensional detachment fault between 13.5 and ca. 7 mybp, during which time it was being displaced and internally extended above the shallow-dipping fault (Fig. 2; Davis et al., 1993; Friedmann et al., 1994, 1996; Fowler et al., 1995; Friedmann, 1999). Sedimentation patterns in the basin were influenced by a number of tectonic factors, among them the corrugated geometry of the detachment fault and its breakaway zone, the emplacement of the shallow-seated Kingston Range pluton across the detachment in northern parts of the early Shadow Valley basin (Davis et al., 1993), contemporaneous normal faulting of the allochthonous basin fill, and late stage folding associated with sinistral strike-slip faulting beneath both Kingston Wash (Davis and Burchfiel, 1993) and the Kingston Spring area.

Four unconformity-bounded informal members referred to as Member I, II, etc., by Friedmann (1999) constitute its 2.5–3.5 km-thick fill (Figs. 2 and 3). Volcanic activity, primarily andesitic to rhyolitic, was concentrated in Members I and II from ca.

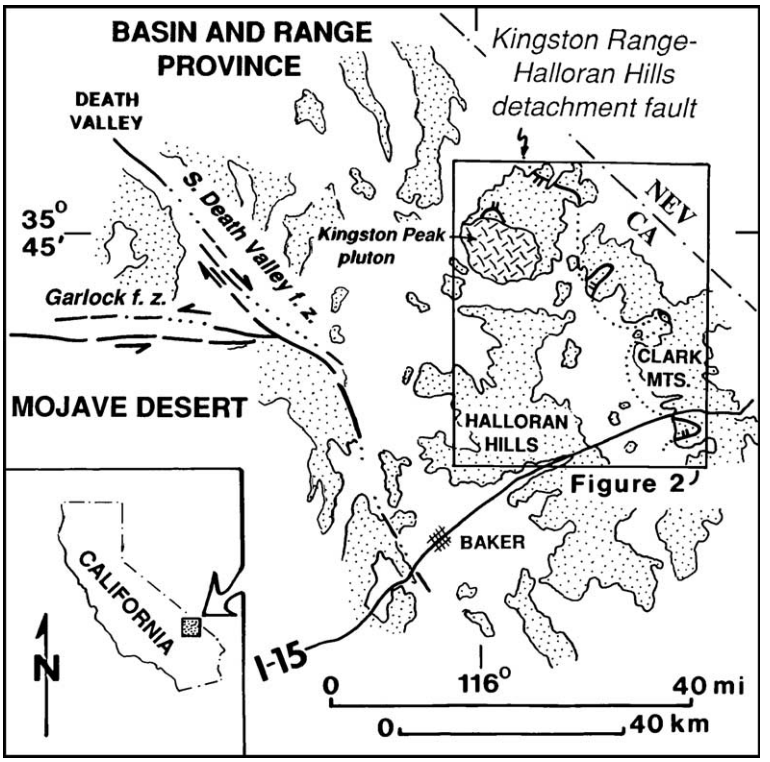

Fig. 1. Location map of Kingston Range-Halloran Hills detachment fault, eastern San Bernardino County, California.