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Geophysical surveys of a pluvial lake barrier deposit, Beatty Junction, Death Valley, California, USA

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ABSTRACT

We used ground penetrating radar (GPR) and seismic refraction to image the internal stratigraphy of a beach barrier deposit at Beatty Junction, Northern Death Valley, to better understand its depositional environment in the context of variations in the level of the former Lake Manly. The deposit is a gravelly bar ~500 m long with 4 m of surface relief that formed at a shoreline of Lake Manly during the end of the last Pleistocene ice age. The GPR profiles provide subsurface images that we interpret as progradational foreset beachface strata in the uppermost 2 m and the surface of an earlier bar at depths of 2 to 6 m. We conclude that the crest of the bar migrated in a landward direction during the construction of the uppermost 4 m of the bar as lake level rose. The seismic survey indicates a sharp velocity increase from 760 m/s to 1510 m/s at the base of the bar, which we interpret as the boundary between well-sorted gravelly beach deposits, and underlying older fan deposits. The depth of the base of the bar varies between 5 m and 10 m. The elevation of the bar is comparable to that of other shoreline features in Death Valley that formed during the MIS 6/5e (186–120 ka) highstand. Measurements of fault slip on the nearby Northern Death Valley fault have documented only strike–slip motion. In absence of any evidence for significant vertical uplift in the area during the late Pleistocene and Holocene, we conclude that the bar probably formed during MIS 6/5e. This conclusion is subject to uncertainty due to discrepancies in age dates reported for the deposit.

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1. Introduction

1.1. Geologic setting

Many of the enclosed basins in the now arid to semi-arid American Southwest contained pluvial lakes during the late Pleistocene ice ages (Benson, 1999). Variations in the extent of these paleolakes over time are indicated in many cases by relict shoreline features, both erosional and depositional (Warnke and Ibbeken, 2005). The development of shoreline features at pluvial lakes was discussed by Adams and Wesnousky (1998) in a study of Lake Lahontan. The development of barrier islands in coastal settings in response to sea level changes was described by Reineck and Singh (1980, pp. 339–345) and McCubbin (1982). In this study, we investigated shoreline deposits in Death Valley associated with a highstand of Lake Manly (Fig. 1a), which was one of a series of lakes in the American Southwest that alternately filled and desiccated during the Pleistocene and Holocene, and that were sometimes connected. Death Valley is a pull-apart basin bounded by two right-lateral fault systems, the Northern Death Valley and Southern Death Valley fault zones, and one normal fault system, the Black Mountains fault zone. The older and inactive fault zone that extends beyond the southeastern end of the Northern Death Valley fault zone is called the Furnace Creek fault zone (Machette et al., 2001b). Death Valley is floored by a salt pan with an average elevation of approximately 75 m below mean sea level (−75 m), and contains Badwater Basin, which with an elevation of −85.5 m is the lowest point in North America.

1.2. Age and elevation of shoreline deposits

Well-preserved sequences of shoreline features are found in Death Valley at Mormon Point and Shoreline Butte (Hooke, 1972, 1999; Meek, 1997; Ku et al., 1998). Shoreline features at these and other locations in Death Valley have been dated using radionuclide methods (Ku et al., 1998; Lowenstein et al., 1999; Lowenstein, 2002) and cosmogenic nuclide methods (Machette et al., 2008; Owen et al., 2011). The majority of the better-preserved shoreline features have been found at elevations between approximately +30 to +90 m, and formed during a highstand of former Lake Manly during Marine Isotope Stage (MIS) 5e−6, from 120,000 to 186,000 years ago (120 ka to 186 ka). Knott et al. (2002) argued that only the highest bench at Mormon Point (+90 m) is a shoreline, and that the benches and risers at lower elevations described by others as shorelines are in fact fault scarps (Hooke, 2004; Knott et al., 2004). The maximum lake level during MIS

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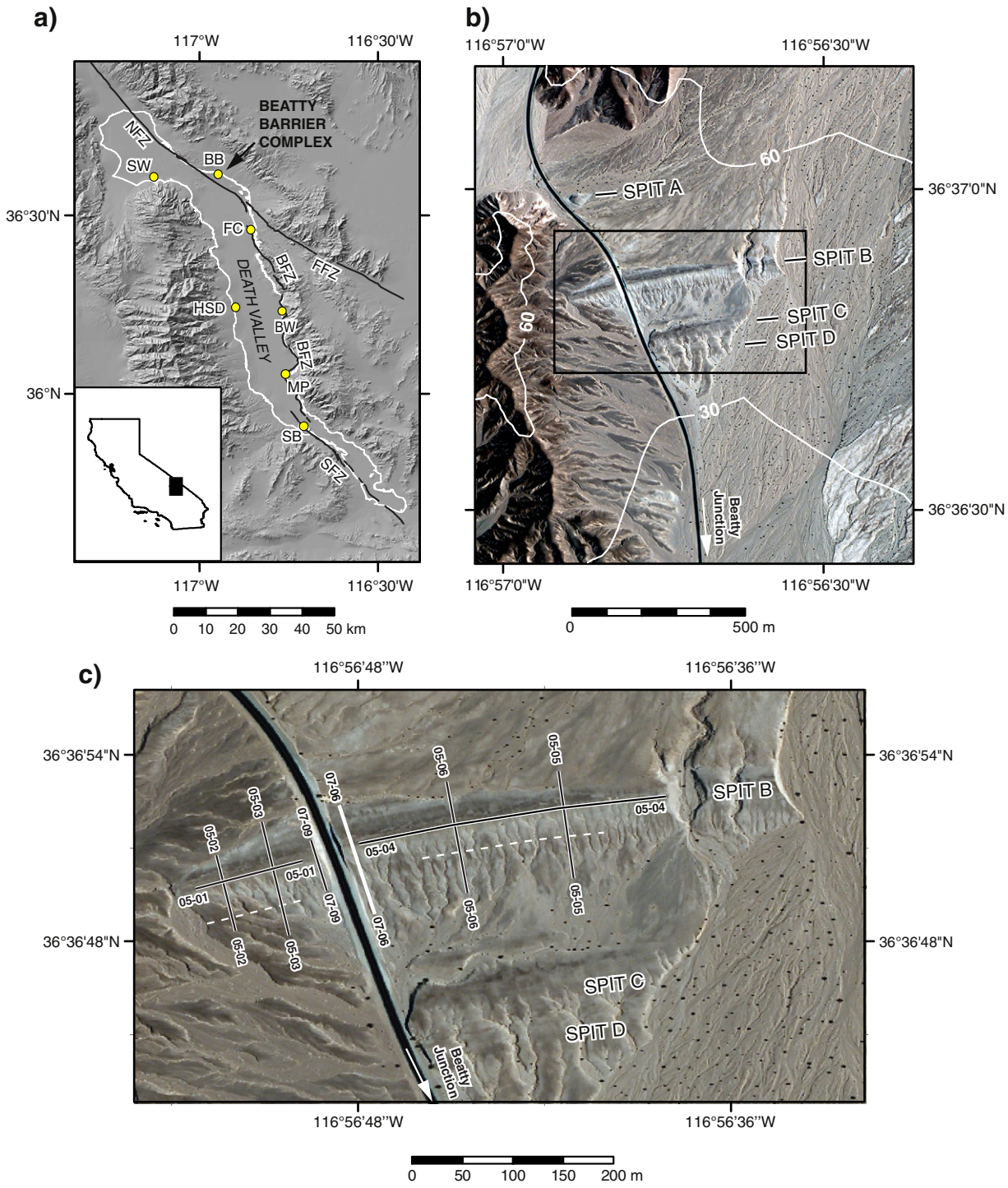

Fig. 1. Location maps. a) Death Valley showing location of named features (circles): BB = Beatty Bar, SW = Stovepipe Wells, FC = Furnace Creek, HSD = Hanaupah Shoreline Deposit, BW = Badwater, MP = Mormon Point, SB = Shoreline Butte. The white line is the 60 m elevation contour, and approximately corresponds to the shoreline of Lake Manly during the MIS 5e-6 highstand. Fault zones are indicated by black lines: NFZ = Northern Death Valley Fault Zone, FFZ = Furnace Creek Fault Zone, BFZ = Black Mountain Fault Zone, and SFZ = Southern Death Valley Fault Zone. Fault zones adapted from Workman et al. (2002). Inset shows boundary of State of California and solid rectangle indicates the extent of panel a. b) Satellite image of Beatty Junction Barrier Complex. Black rectangle indicates the extent of panel c. White lines are 30 m and 60 elevation contours. c) Satellite image showing details of bar complex. Geophysical line locations indicated with black lines. Line 05–01 is a seismic line located along the crest of the main bar on the west side of the road. All other black lines are GPR lines. Lines 05–01 and 05–04 show the modern crest of the main bar (Spit B). Dashed white lines show crest locations of buried bars interpreted from cross-barrier profiles. The center of the former Lake Manly lies to the south. Elevation data from the National Elevation Dataset. Satellite imagery from the USGS Seamless Server.

2 (10 ka to 35 ka) was much lower than the MIS 5e−6 highstand, and almost certainly did not exceed sea level (Ku et al., 1998; Knott et al., 2002; Hooke, 2004). The water depth history of the former Lake Manly during the past 200 ka was determined based on U-series dating (Ku et al., 1998) and sediments and microfossils (Forester, 2005) from drill core of the 186-m deep well DV93-1 at Badwater Basin. Ku et al. (1998) also dated tufa deposits associated with paleoshorelines at several locations in central Death Valley between Badwater and Mormon Point. Tufa deposits of MIS 5e−6 age were found at elevations from +55 to +90 m and associated with a deep lake, while tufas of MIS 2