Icarus 274 (2016) 99–105

Contents lists available at ScienceDirect

Icarus

journal homepage: www.elsevier.com/locate/icarus

Mega-ripples in Iran: A new analog for transverse aeolian ridges on Mars

M. Foroutan[a,*], J.R. Zimbelman[b]

[a] Department of Geography, University of Calgary, Alberta T2N 1N4, Canada
[b] CEPS/NASM MRC 315, Smithsonian Institution, Washington, DC 20013-7012, USA

ARTICLE INFO

Article history:
Received 11 January 2016
Revised 9 March 2016
Accepted 23 March 2016
Available online 5 April 2016

Keywords:
Earth
Mars, surface
Aeolian processes
Mars, climate

ABSTRACT

A new terrestrial analog site for transverse aeolian ridges (TARs) is described in this study. The Lut desert of Iran hosts large ripple-like aeolian bedforms, with the same horizontal length scales and patterns of TARs on Mars. Different classes of TARs and different types of other aeolian features such as sand dunes, zibars, dust devil tracks and yardangs can be found in this area, which signify an active aeolian region. This area represents a unique site to study the formation and evolution of these enigmatic features, with potential relevance toward a better understanding of TARs on Mars.

1. Introduction

Transverse aeolian ridges (TARs) are small-scaled distinct morphological features with narrow transverse dimensions found mostly throughout the equatorial and mid-latitude regions of Mars. TARs can occur singularly or in groups that number in the thousands; they are abundant but not ubiquitous on Mars (Balme et al., 2008; Berman et al., 2011). The term "ridges" was first used by Bourke et al. (2003) because of their unknown origin, i.e. they could have formed either as small sand dunes or large ripples. Although they are found in variable ridge planforms and patterns (Bourke et al., 2003), it was revealed by Kerber and Head (2012) that types of TARs can sometimes grade into each other depending on the regional topography and wind regime. However, one of the most common and distinctive characteristics of TARs are their symmetric profiles (Zimbelman, 2010) and typical triangular cross-sectional shape (Kerber and Head, 2012).

The process responsible for forming TARs occurs over a wide range of elevations and geological formations on Mars (Bourke et al., 2003; Wilson and Zimbelman, 2004), but based on their proximity to layered terrain and steep slopes Berman et al. (201) argued that they formed from locally derived sediments. On the other hand Geissler (2014) hypothesized TARs to be dust deposits features with examples in Syria Planum. TARs are essentially currently inactive, which is demonstrated by superposition of slope streaks and large dark dune materials onto TARs, and by observation of occasional superposed impact craters (Balme et al., 2008; Berman et al., 2015). Their distribution must be a result of both climate and wind regime, but information is still limited about their composition, origin, formation mechanisms, processes that control their distribution and activity, sediment source, age, and superposition relationships.

2. Terrestrial analog studies

Terrestrial analogs of TARs and their characteristics have been studied in order to investigate similar features in detail and develop hypotheses about their formation. TARs on Mars cannot be definitively classified as either ripples or dunes (Wilson and Zimbelman, 2004). Fryberger (1979) suggested that granule megaripples on Earth may develop in wind environments which display the least directional variability, but still the general view remains that TARs appear to be unique to Mars (Fenton et al., 2015). Terrestrial analogs for TARs have been described by de Silva et al. (2013) in Argentinean Puna, where gravel-mantled megaripples are contextually and morphologically similar to small ripple-like TARs on Mars, and that these analogs of TARs may be quite unique on Earth (Fig. 1A). Another analog investigated by Zimbelman and Scheidt (2014) was a large reversing sand dune at Bruneau Dunes, Idaho, where precise profile measurements demonstrated that large TARs may be quite similar to either transitional or mature reversing sand dunes (Fig. 1B). The Bruneau Dunes are much larger than most TARS, and the Puna megaripples involve both pumice and lithics as gravel-sized surface coverings, so it is unclear at present how strong is the analogy of both locations to actual TARs on Mars. This work describes a new TAR analog site in

* Corresponding author. Tel.: +15877073098.
E-mail address: foroutam@ucalgary.ca, foroutam@gmail.com (M. Foroutan).

http://dx.doi.org/10.1016/j.icarus.2016.03.025
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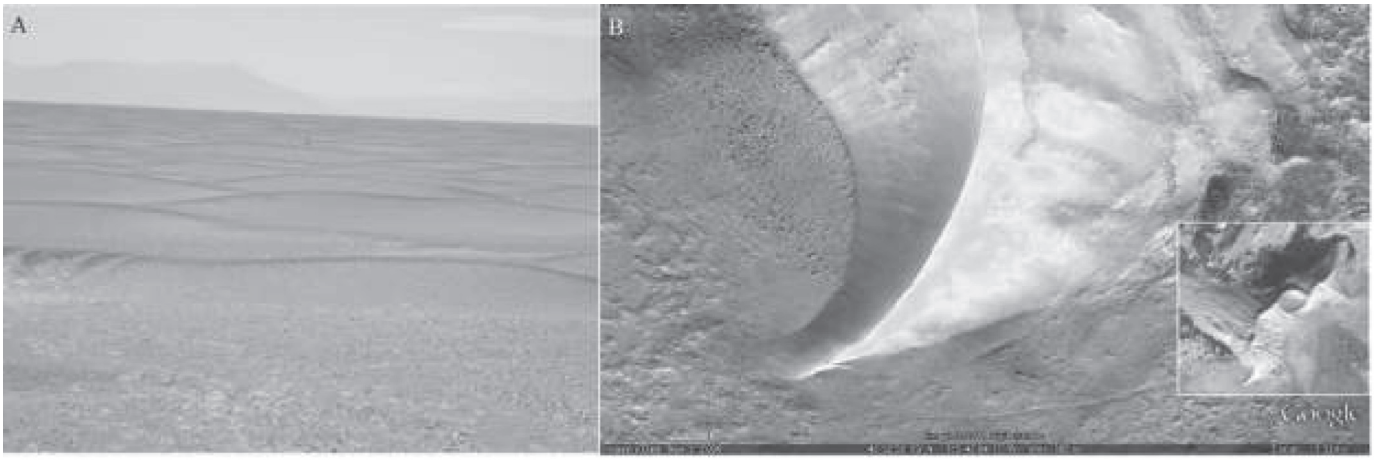

Fig. 1. Terrestrial analogs of TARs: (A) Gravel bedforms in the Campo Piedra Pomez. Located in the Puna Argentina, with heights of about 1 m and wavelengths between 10 and 15 m (from de Silva et al., 2013). (B) Bruneau Dunes, in central Idaho, US; the Google Earth image shows the southern end of one large reversing dune, where precise topographic profiles were obtained, with an inset showing all of the largest dunes, along with the lakes at the northern end of the dunes (from Zimbelman and Scheidt, 2014).

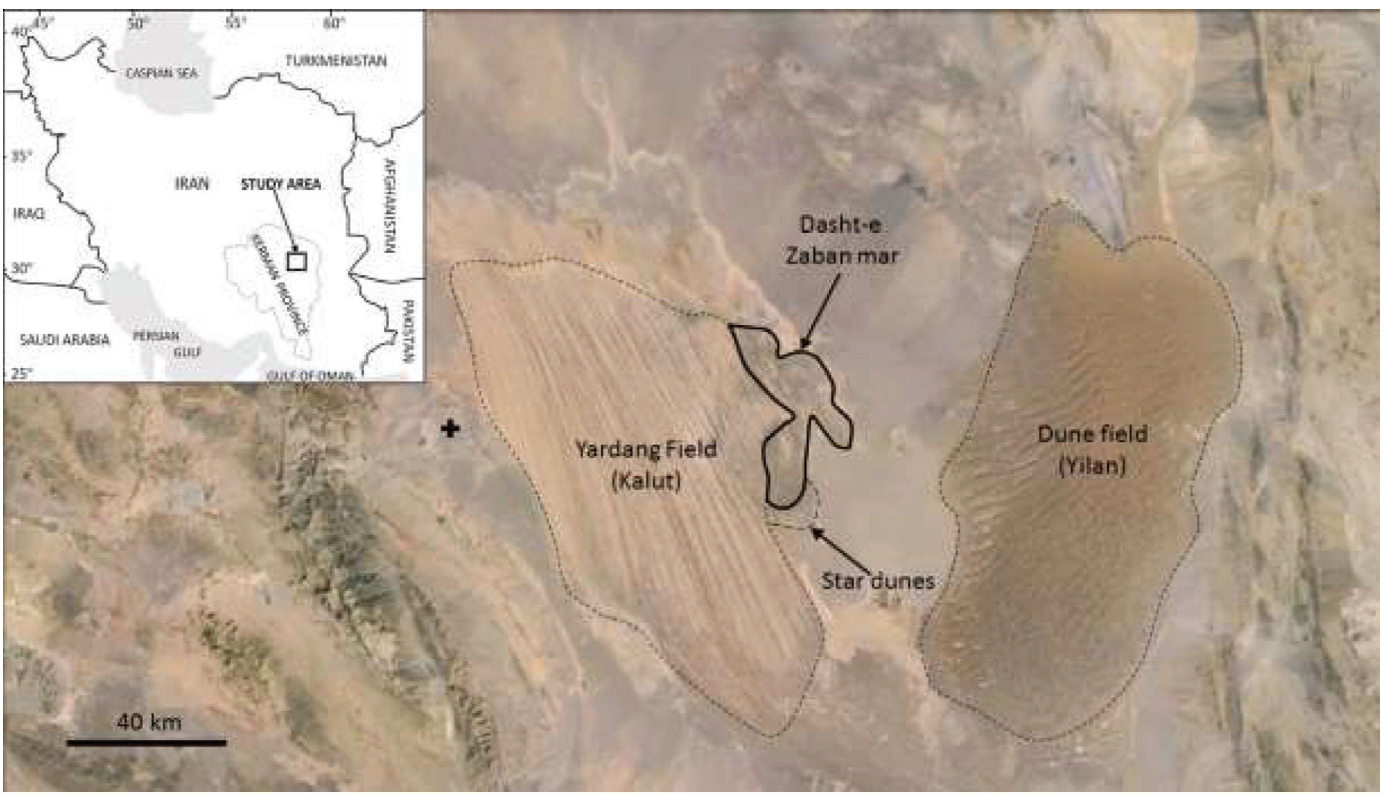

Fig. 2. Google Earth image of the Lut Desert in Iran. An irregularly shaped region shows the location of the area with TAR-like features (Dasht-e Zaban mar). The site of mega-yardangs (elongate NNW-SSE), star-dunes and the Yilan erg are also shown. The cross mark is the location of the Ziyaratgah-e Deh Seif weather station in Shahdad village. Inset map shows regional context of the field area.

the Lut desert of Iran (Fig. 2), where aeolian bedforms have crest symmetry, crest sharpness, and horizontal length scale that are very comparable to the most common TARs on Mars (Fig. 3).

3. Study area

The new TAR terrestrial analog site is located in the hyper-arid Lut desert (Dasht-e Lut) in southeast Iran, within an area of about 80,000 km^2 that is located between 29° 30′ N to 30° 49′ N latitude, and 57° 47′ E to 59° 53′ E longitude (Fig. 2). The Lut desert contains many different kinds of aeolian landforms. However, the two most remarkable features in the Lut desert are first the deposition site at the eastern side of the basin, which is a low plateau covered with salt flats and containing some of the world's tallest sand dunes reaching heights of 300 m (Walker, 1986), and second the wind abrasion in the western part of the desert that has produced huge mega-yardangs up to 80 m tall and 120 km long in a NW–SE direction. The mega-yardangs developed in Pleistocene basin fill deposits (silty clays, gypsiferous sands), with an estimated thickness of 135–200 m (Gabriel, 1938).

In addition this desert is located between two active strike-slip systems which contain several parallel fault strands on either side