EARTH SURFACE PROCESSES AND LANDFORMS
Earth Surf. Process. Landforms **37**, 422–433 (2012)

Published online 1 December 2011 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/esp.2259

A progression of induration in Medusae Fossae Formation transverse aeolian ridges: evidence for ancient aeolian bedforms and extensive reworking

Laura Kerber* **and James W. Head**
Department of Geological Sciences, Brown University, Providence, RI 02912, USA

Received 1 April 2011; Revised 26 September 2011; Accepted 31 October 2011

*Correspondence to: L. Kerber, Department of Geological Sciences, Brown University, 324 Brook Street, Box 1846, Providence, RI 02912, USA. E-mail: Laura_Kerber@brown.edu

ESPL
Earth Surface Processes and Landforms

ABSTRACT: A progression of induration, erosion, and redeposition of transverse and networked transverse aeolian ridges (TARs) has been documented in the Medusae Fossae Formation (MFF), Mars. Cratered and eroded aeolian bedforms are rarely observed on Mars, indicating that those found in the MFF have been inactive for much longer than those found elsewhere. Indurated TARs are observed to grade into faceted MFF terrain, indicating a genetic relationship between the two. We propose that TAR deposition, induration and erosion have played a larger role in the surface morphology and evolution of the MFF than previously recognized. The deposition, induration, and erosion of TARs indicate that the MFF has undergone multiple cycles of reworking, and that much of its current surface morphology does not reflect the circumstances of its primary emplacement. Copyright © 2011 John Wiley & Sons, Ltd.

KEYWORDS: Mars; aeolian; ancient; Medusae Fossae Formation; transverse aeolian ridge

Introduction

The Medusae Fossae Formation

The Medusae Fossae Formation (MFF), is a fine-grained, friable unit of uncertain origin located near the equator of Mars (130–230°E and 12°S–12°N), which has been intensively modified by aeolian processes (Ward, 1979; Scott and Tanaka, 1986; Greeley and Guest, 1987; Bradley *et al*., 2002; Mandt *et al*., 2008; Zimbelman and Griffin, 2010; Figure 1). The MFF is an extremely rough deposit (on the scale of centimeters up to tens of kilometers; Kreslavsky and Head, 2000; Carter *et al*., 2009), with heavily eroded surfaces often covered with fields of streamlined, sculpted ridges known as yardangs (Ward, 1979) (Figure 2). The MFF has been divided into three units, upper (Amu), middle (Amm) and lower (Aml), based on the color of the units and their states of degradation (Scott and Tanaka, 1986; Greeley and Guest, 1987). The lowest member is the most eroded unit and the upper member is the least eroded unit. A large number of hypotheses have been advanced to explain the genesis of the MFF, including emplacement by pyroclastic flows or ash fall (Scott and Tanaka, 1982, 1986; Bradley *et al*., 2002; Hynek *et al*., 2003; Mandt *et al*., 2007, 2008; Kerber and Head, 2010; Kerber *et al*., 2011), accumulation of aeolian debris (Scott and Tanaka, 1986; Greeley and Guest, 1987; Tanaka, 2000), paleopolar deposits formed during polar wandering (Schultz and Lutz, 1988; Schultz, 2002), or obliquity-driven deposition of ice and dust (Head and Kreslavsky, 2004).

A detailed analysis of formation hypotheses was undertaken by Zimbelman *et al*., 1997 and Mandt *et al*., 2008, who came to the conclusion that ash fall, pyroclastic flows, and aeolian deposition were the most likely formation mechanisms based on morphology and radar properties. Specifically, the morphology and topography of the MFF deposits was found to be dissimilar to the current polar layered deposits (Bradley *et al*., 2002), and SHARAD radar returned no evidence of polar-like layering within the deposit (Carter, 2009). High resolution images revealed bidirectional sets of yardangs, which were interpreted to reflect jointing in the deposit, a trait that is often found in terrestrial ignimbrites (Bradley *et al*., 2002).

The MFF has traditionally been mapped as an Amazonian deposit (Scott and Tanaka, 1986; Greeley and Guest, 1987; Werner, 2006) on the basis of low crater-size-density derived ages and several stratigraphic contacts where MFF material overlies young Amazonian lavas. The Amazonian is the youngest of the three eras on Mars, dating from between 3.4 and 2.0 Ga to the present (Hartmann and Neukum, 2001). Schultz and Lutz (1988) argued that the formation was much older based on the presence of many degraded and modified craters, which implied that craters were being continually erased, eroded, and buried by aeolian processes, and that the age determined from the superposed crater population reflected a modification age rather than a formation age. Recent work (Kerber and Head, 2010) has confirmed the findings of Schultz and Lutz (1988) regarding the erosion of craters in the MFF, and has demonstrated that based on directly observed and implied stratigraphic relations between Hesperian lava flows and outcroppings of the MFF, deposition began at the latest in the Hesperian. Kerber and Head (2010) showed that in some cases (such as the southeastern fan of Apollinaris Patera), Hesperian