JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 115, E07005, doi:10.1029/2009JE003519, 2010

Definitive evidence of Hesperian basalt in Acidalia and Chryse planitiae

Mark R. Salvatore,[1] John F. Mustard,[1] Michael B. Wyatt,[1] and Scott L. Murchie[2]

Received 29 September 2009; revised 29 January 2010; accepted 12 March 2010; published 17 July 2010.

[1] The surface materials of Acidalia and Chryse planitiae, Mars, have been variably interpreted morphologically as basalt and compositionally as andesite or altered basalt. A thorough survey using the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) near-infrared spectrometer reveals olivine and high-calcium pyroxene signatures in the shallow subsurface exposed by impact craters. These signatures indicate that the near surface of these regions are primarily basaltic in nature and are similar to other regions of Hesperian volcanism across Mars (e.g., Syrtis Major). Previous spectroscopic studies using coarser-resolution data sets have failed to identify these mafic signatures due to obscuration of the underlying material in addition to the relatively small-scale exposures in impact craters. The nature of the surficial obscuration material is likely multifaceted and includes the deposition of latitude-dependent mantling material and the presence of alteration rinds. This observation shows that the northern plains of Mars are basaltic and must be factored into the thermal and surficial evolution of Mars.

Citation: Salvatore, M. R., J. F. Mustard, M. B. Wyatt, and S. L. Murchie (2010), Definitive evidence of Hesperian basalt in Acidalia and Chryse planitiae, *J. Geophys. Res.*, *115*, E07005, doi:10.1029/2009JE003519.

1. Introduction

[2] The northern plains of Mars in the region of Acidalia and Chryse planitiae have experienced volcanism [*Head et al.*, 2002], sedimentary deposition [*Kreslavsky and Head*, 2002], and the effects of recent climate change [*Mustard et al.*, 2001; *Costard et al.*, 2002]. The chemistry and mineralogy of this large dust-free region is thus crucial toward understanding the evolution of the planet as a whole. Previous studies of orbital spectroscopic data have variably interpreted these materials as representing either primary (basaltic [e.g., *Karunatillake et al.*, 2006] to andesitic [e.g., *Bandfield et al.*, 2000]) or secondary (partly altered basalt [e.g., *Wyatt and McSween*, 2002]) surface compositions. Reconciling these different compositional interpretations will help to both unravel the complex geologic processes of the northern lowlands and better constrain the diversity of igneous and aqueously altered materials on Mars. This paper addresses these questions by placing new high-resolution data sets from the Mars Reconnaissance Orbiter (MRO) into geologic context to explore stratigraphic compositional relationships.

[3] The formation of the northern lowlands has been attributed to tectonism [*Wise et al.*, 1979], mantle convection [*Zhong and Zuber*, 2001], or impact processes [*Wilhelms and Squyres*, 1984; *Frey and Schultz*, 1988; *Nimmo et al.*, 2008] early in Martian history. The northern plains are underlain by a Noachian basement, evident by the identification of quasi-circular depressions in Mars Orbiter Laser Altimeter (MOLA) data [*Frey et al.*, 2002] and exposed Noachian-aged material in central Acidalia Planitia [*Tanaka et al.*, 2005]. The late Noachian and early Hesperian epochs mark the beginning of widespread volcanism across much of the northern plains [*Head et al.*, 2002]. The subsequent formation of wrinkle ridges is due to added stress from the Tharsis edifice and strain produced by large impact basins. Models and stratigraphic relationships suggest that these Hesperian ridged plains have an average thickness between 800 and 1000 m [*Head et al.*, 2002].

[4] Following the widespread volcanism in the early Hesperian, numerous secondary geologic processes began modifying the northern plains. The formation of the circum-Chryse outflow channels resulted from the intense and episodic discharge of groundwater [*Rotto and Tanaka*, 1995; *Dohm et al.*, 2001; *Tanaka et al.*, 2005]. Whether these materials were deposited in a standing body of water [*Baker et al.*, 1991], as an ice-dominated unit [*Carr*, 1996; *Clifford and Parker*, 1999; *Clifford and Parker*, 2001], or as sediment-dominated effluents [*Kreslavsky and Head*, 2002] has additional implications regarding the modification of the northern plains. While the development of the Vastitas Borealis Formation (VBF) has been attributed to the outflow channel sediments [*Parker et al.*, 1989, 1993; *Baker et al.*, 1991; *Tanaka*, 1997] and/or a sediment-laden sublimation residue [*Kreslavsky and Head*, 2002], *Tanaka et al.* [2005] argue that the relatively young age of the VBF suggests that post-outflow channel climatic variations have resulted in extensive modification of the VBF. Other geomorphic

[1]Department of Geological Sciences, Brown University, Providence, Rhode Island, USA.
[2]Applied Physics Laboratory, Johns Hopkins University, Laurel, Maryland, USA.

0148-0227/10/2009JE003519