The composition and stratigraphy of the northern lowlands and implications for InSight mission

Lu Pan, Cathy Quantin, Chloé Michaut

THE COMPOSITION AND STRATIGRAPHY OF THE NORTHERN LOWLANDS AND IMPLICATIONS FOR INSIGHT MISSION. Lu Pan[1], Cathy Quantin[1], Chloé Michaut[2], [1]Univ. Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE*, F-69622 Villeurbanne, France (2 rue Raphaël Dubois, Bâtiment GEODE, Villeurbanne, 69622. lu.pan@univ-lyon1.fr). [2]Univ. Lyon, ENS de Lyon, Université Claude Bernard Lyon 1, CNRS, UMR 5276 LGL-TPE*, F-69007 46 Allée d'Italie, Lyon, France.

Introduction: The Martian dichotomy presents a striking contrast between the northern and southern hemispheres in elevation [1], crustal thickness [2], surface roughness [3] and composition [4,5]. Data acquired in the recent decades give clues to diverse aqueous environments [4,5] and igneous lithologies [6,7] in the southern highlands, while much is left to explore within the northern lowlands. The subsurface of the lowlands records the major stages in Mars evolution, including the formation of the Martian dichotomy, the evolution of the Martian crust, the existence of a global ocean, etc. Here we present the updated understanding of the geologic processes in the lowlands and discuss its implications for the InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) mission to Mars.

A hemispheric dichotomy of the Martian crust?: Crustal thicknesses in the highlands and lowlands interpreted from topography and gravity models [1,2] rely on the assumption of uniform bulk density. However, if the northern lowlands formed from a giant impact, the lowlands crust could be partially formed from subsequent mantle melts, with a distinct composition from the highlands. Based on constraints from the Martian elastic lithosphere thickness, thermal evolution models suggest the highlands could have higher radiogenic elements concentration and smaller bulk density than the lowlands [8], which would result in different crustal thickness and heat flow estimates [8, 9].

The largest craters may excavate materials beneath the sedimentary layers in the northern lowlands and expose part of the underlying crust. Through investigations of impact craters using data acquired by CRISM (Compact Reconnaissance Imaging Spectrometer for Mars), diverse hydrated minerals (including Fe/Mg phyllosilicates, chlorites, silica) have been identified, indicating a hydrated basement overlain by mafic mineral bearing units [10,11]. The mineralogical classes imply a similar, altered basement as the southern highlands, and there is yet no strong geological evidence for different crustal materials.

Mineralogical record of sedimentary and volcanic infilling: Earlier study using data acquired from Thermal Emission Spectrometer (TES) showed the lowlands surface differ from the basaltic type terrain in the highlands [12] and the spectral features are later interpreted to be due to a veneer of alteration products [13,14] on the surface of the lowlands. Through the mineralogy exposed in impact craters, widespread mafic minerals have been identified [11, 15], confirming the hypothesis that the lowlands are filled with wrinkle-ridge forming mafic lava flows [16]. The identification of layered deposits in Chryse and Acidalia Planitia [17] supports the notion that sedimentation occurred after the volcanic emplacement, possibly due to late outflow channel activities. Interestingly, no direct evidence of widespread carbonates or chlorides has been identified in the lowlands [11].

Implications for InSight: The complex resurfacing stratigraphy at the dichotomy boundary will pose complexities on the signals of the seismic waves collected by the SEIS (Seismic Experiment for Interior Structures) instrument on board InSight lander. Characterization of the geological context is thus important to the data interpretation. From recent mapping work [18], we have identified mafic mineral detections surrounding the landing site ellipse, confirming the composition of the volcanic plains unit. Layered sediments found in several crater central peaks suggest a possible extension of the sedimentary unit (Medusae Fossae Formation) to the north and east of the landing site. On the other hand, with the advent of InSight mission to Mars, we may be able to detect the seismic discontinuities in the subsurface of the landing site. The future measurements of heat flow and seismic properties will place major constraints on the thermal and density structure of the crust and shed new lights on the nature of the dichotomy boundary and the complex stratigraphy within the northern lowlands of Mars.

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