Two New Candidate Landing Sites for the European 2018 ExoMars Mission Near Libya Montes Alluvial Fans, Layered Delta Deposits and Possible Coastal Cliffs G. Erkeling[1], D. Reiss[1], H. Hiesinger[1], F. Poulet[2], J. Carter[2], M. A. Ivanov[3], E. Hauber[4], R. Jaumann[4], [1]Institut für Planetologie (IfP), WWU Münster, Wilhelm-Klemm-Straße 10, 48149 Münster, Germany (gino.erkeling@uni-muenster.de/ +49-251-8336376) [2]Institut d'Astrophysique Spatiale (IAS), CNRS/Université Paris-Sud, Orsay, France [3]Vernadsky Inst. RAS, Moscow, Russia [4]Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany.

Introduction: Based on the occurrences of landforms at the boundary between the Libya Montes and the Isidis basin indicative both for intense precipitation-induced fluvial activity and hydrous alteration in standing bodies of water throughout significant parts of the Martian history [1-6], we propose two new candidate landing sites for potential future missions to Mars, including the European ExoMars mission in 2018. The first landing site proposed is located close to a delta and alluvial fans in an open-basin paleolake, the second landing site is located close to possible coastal cliffs of the Arabia shoreline [4,7-10]. The morphologies of the delta, the alluvial fans and possible coastal cliffs qualify the proposed landing sites as potential places where liquid water once was present on the surface. In addition, the geologic setting and associated mineral assemblages of both landing sites are interpreted to be results of environmental changes over time toward decreasing water availability [4] and can help to resume the discussion about the possible role of the martian climate change in the redistribution of water. The landing sites in the Libya Montes are proposed for a rover mission comparable to the MSL Curiosity mission, including imaging and

Site Name	**Fans and delta deposits in the Libya Montes highlands**
Center Coordinates (Lat/Lon)	2° 52' 22" N, 85° 48' 01" E
Elevation	- 2.6 / -2.8 km
Ellipse 1 Size	15 km by 10 km (improved size)
Prime Science Targets	Fe/Mg phyllosilicates in intermontane deposits [Highest priority]; Delta deposits with Al phyllosilicates
Distance of Science Targets from Ellipse Center	Fe/Mg phyllosilicates (smectites) mixed with olivine – 0 km Alluvial fans – 2 km to SW Channels – 8-12 km to W Al phyllosilicates of delta – 18 km to NE

Site Name	**Coastal cliffs of the Arabia shoreline north of the Libya Montes**
Center Coordinates (Lat/Lon)	3° 39' 50" N, 85° 57' 38" E
Elevation	- 3.6 / -3.7 km
Ellipse 2 Size	15 km by 10 km (improved size)
Prime Science Targets	Coastal cliffs of Arabia "shoreline" [Highest priority]; Mixtures of Fe/Mg phyllosilicates (smectites) and olivine
Distance of Science Targets from Ellipse Center	Channels – 0 km Cliffs – 1 km to S, 4 km to SW Exhumed terrain – 4 km to S, 8 km to NW Fe/Mg phyllosilicates (smectites) – 8 km to SW, 13 km to S

Tab. 1: Summary of the proposed Libya Montes landing sites near delta deposits (landing site 1) and near the coastal cliffs of the Arabia contact (landing site 2).

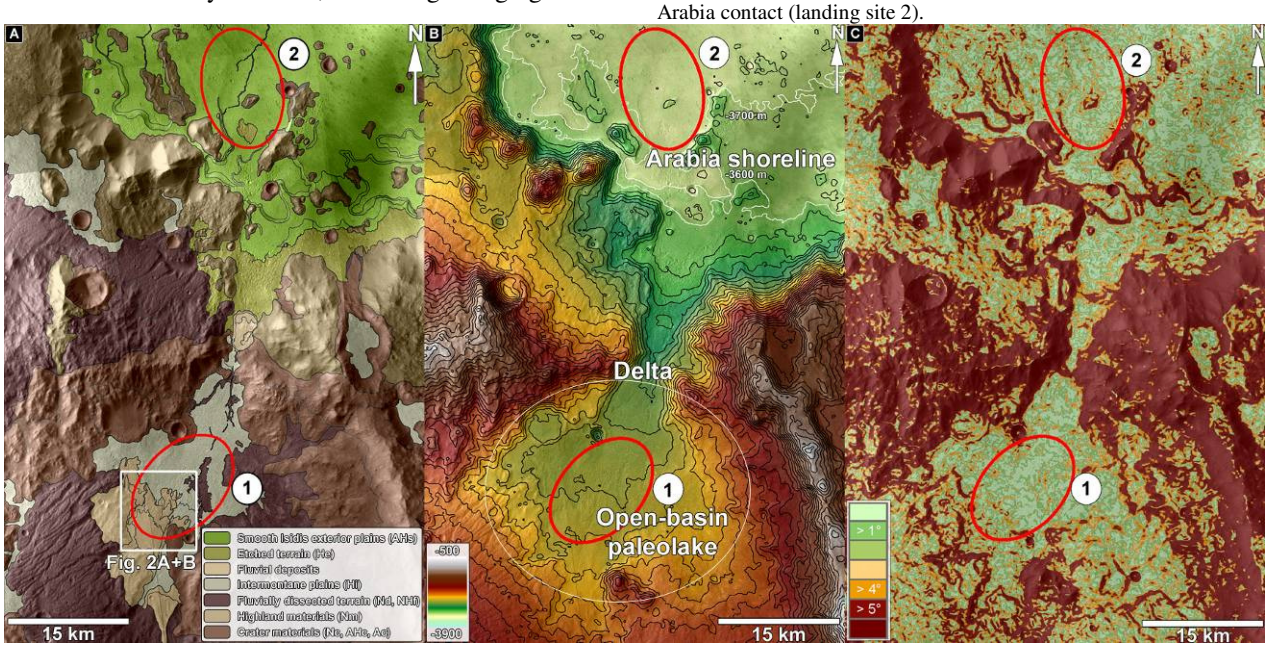

Fig. 1: Proposed landing sites at the boundary between the Libya Montes highlands and the smooth plains of the Isidis basin. Landing site ellipses (red) of 10-15 km across are assumed for missions using the MSL heritage landing system. **A** Morphologic setting for the two landing site ellipses. **B** Proposed landing site ellipses are located below an elevation of -2600 and -3600 meters and comply with the engeneering constraints that landing site ellipses must be located below +1000 meters. Color-coded HRSC h_2162 DTM on CTX mosaic. **C** Landing site ellipses mainly cover smooth surfaces with gentle slopes <5° (based on 50m DTM). Slope values are important for the planning of traverses a rover will use to reach sites of scientific interest. Slope values are derived from the HRSC h_2162 DTM.

instrumental capabilities, which are able to document and evaluate the mineralogy, stratigraphy and morphology of the proposed science targets of highest priority.

Science Merit Related to Mission Objectives:

Morphology: Observed landforms on the floor of the paleolake bear evidence for intense fluvial activity, valley incision and transport and deposition of materials (landing ellipse 1). Multiple layered lobes of possible alluvial fans indicate that repeated events of fluvial activity, including transport and deposition, were responsible for their formation (Fig. 2A). Bright, polygonally fractured materials in the lowest layers at the front of a delta indicate hydrous alteration.

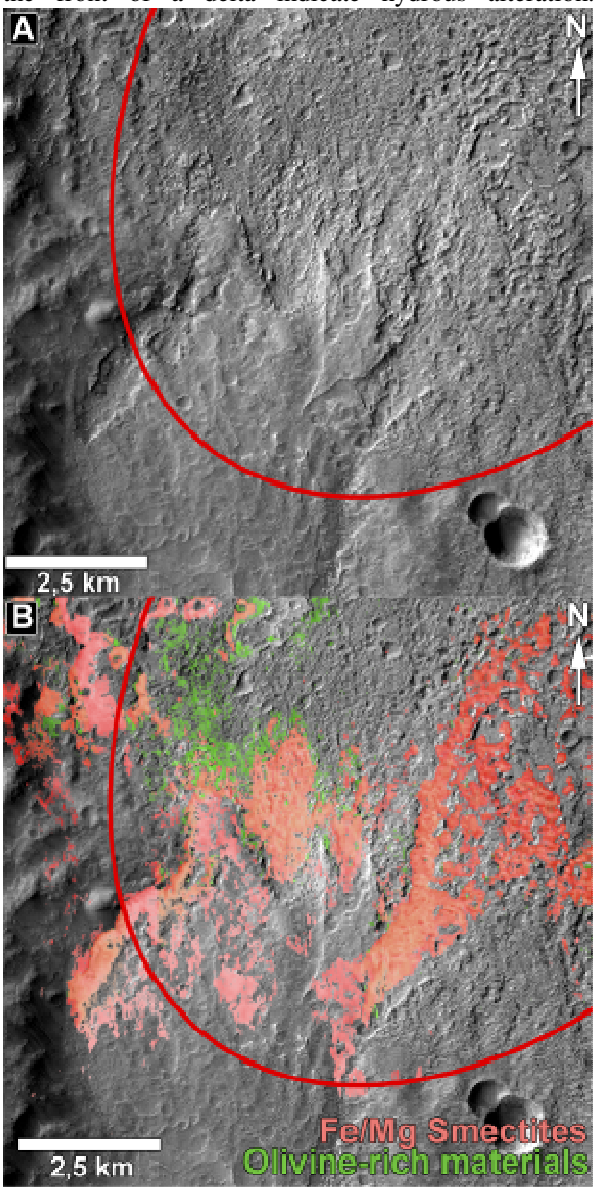

Fig. 2: A Alluvial fan deposits at southern-western edge of landing ellipse 1(CTX_P19_008518_1817). **B** Stratigraphy of alluvial fan. Fe/Mg smectites (red) indicate hydrous alteration of oldest terrains, whereas olivine-rich (green) materials represent remnants of non-altered plains (CRISM_FRT1E2F2).

The landforms associated with the Arabia shoreline [4, 7-10] appear as a series of cliffs and terraces (landing ellipse 2). Most conspicuous are a series of candidate coastal cliffs of the Arabia shoreline that coincide with the -3700 m equipotential surface line. The cliffs show layered morphologies and can be divided into 3 distinct terraces tens of meters high and tens of kilometers long [4].

Mineralogy: The geologic and mineralogic setting, including the spatial distribution and abundance of alteration minerals at the alluvial fan and a delta [4], is characterized by the occurrence of specific mineral assemblages, which are associated with three distinct surface units: 1) Highland units show widespread occurences of Fe/Mg-clay minerals, e.g., mixtures of saponite and vermiculite (Fig. 2B, red color). Fe/Mg-smectites appear as the dominant alteration mineral in the study area and are most abundant in rough units of the Libya Montes highlands, including cratered and degraded terrains, as well as dissected and dendritic surfaces. 2) Intermontane plains, etched surfaces and smooth plains of the Isidis basin show olivine-rich materials and mixtures of olivine and Fe/Mg-smectites (Fig. 2B, green color) which are the result of materials eroded from the highlands and incorporated into the plains. 3) Al-smectites (montmorillonite) appear exclusively within the stratigraphically lowest layers of a delta 18 km north of landing ellipse 1 and usually occur within a bright, polygonally fractured unit at the front of the delta and within eroded parts showing bright layers, located at the eastern and western edge of the deposit.

Conclusion: The selection of one of the Libya Montes / Isidis landing sites for a candidate rover mission such as the European ExoMars rover would provide an opportunity to study (1) Noachian-aged clays and associated clay-forming mechanisms of Martian Fe/Mg- and Al-smectites or (2) possible candidate coastal cliffs of the Arabia shoreline for the first time. The alluvial fan, the delta and possible wave-cut cliffs of the Arabia contact may record the occurrence of liquid, flowing, and standing water on the surface of Mars and could potentially help us to better understand the aqueous and climatic conditions that have changed during Mars' history. The association of the deposits with layered phyllosilicate minerals indicates a great potential for the discovery of past environments that may have been habitable for life.

References: [1] Crumpler and Tanaka, 2003. *JGR, 108*, ROV 21-1. [2] Erkeling, et al., 2010, *EPSL, 294*, 291-305. [3] Jaumann et al., 2010, *EPSL, 294*, 272-290 [4] Erkeling, et al., 2012, *Icarus, 219*. [5] Bishop et al., 2012, *JGR*, in press. [6] Ivanov et al., 2012, *Icarus, 218* [7] Parker et al. (1989) *Icarus, 82,* 111-145 [8] Parker et al. (1993) *JGR, 98,* 11,061-11,078 [9] Head et al. (1999) *Science, 286,* 2134 [10] Clifford and Parker (2001) *Icarus, 154,* 40-79.