Valleys, Paleolakes and Possible Shorelines at the Libya Montes / Isidis Boundary: Implications for the Hydrologic Evolution of Mars. 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: We describe the results of our morphologic, stratigraphic and mineralogic investigations of fluvial landforms, paleolakes and possible shoreline morphologies at the Libya Montes / Isidis Planitia boundary between 85°/86.5°E and 1.8°/5°N [1]. The landforms are indicative of aqueous activity and standing bodies of water, that are attributed to a complex hydrologic cycle that may have once existed on Mars in the Noachian (>3.7 Ga) and perhaps also in the Hesperian (>3.1 Ga).

At the Libya Montes / Isidis Planitia boundary, we identified series of morphologic landforms at three different elevation levels (Fig. 1). The morphologies have been associated with intense fluvial activity, standing bodies of water, hydrous alteration, wave-cut action, distinct still stands as well as freezing and sublimation of a cold ocean [e.g., 1-10]. We can distinguish between (1) local occurences of fluvial and lacustrine landforms of the Libya / Isidis contact between -2500 and -2800 m, (2) a series of cliffs of the Arabia shoreline at -3600 and -3700 m, and (3) the Deuteronilus contact that occurs as an onlap morphology at the boundary between the Isidis interior plains and the Isidis exterior plains.

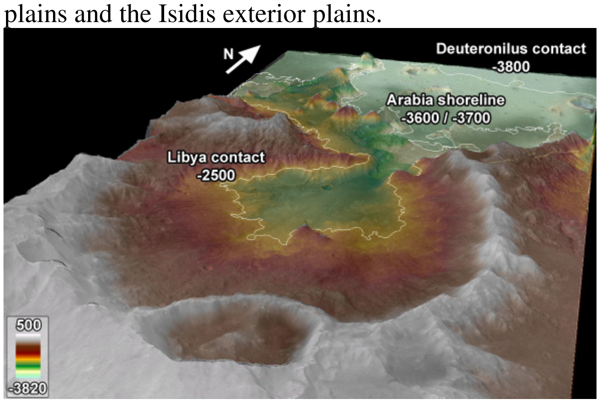

Fig.1: High Resolution Stereo Camera (HRSC) DEM h2162 of our study area shows contour lines of morphologic contacts.

Our study area at the Libya Montes / Isidis Planitia boundary is of particular interest, because local fluvial landforms indicative of standing bodies of water and the landforms of both the global Arabia and the Deuteronilus contact appear close to each other within our study area. Therefore, our study area offers an excellent opportunity to provide significant insights into the water-related geologic record of the Libya Montes / Isidis Planitia boundary and possible sea-scale standing bodies of water in the Isidis basin.

Libya Montes / Isidis contact (-2500 / -2800 m): The observed morphologic landforms between -2500 and -2800 m elevation bear evidence for intense fluvial activity, valley incision and transport and deposition of materials (Fig. 2A+B). Multiple layered lobes of possible alluvial fans (Fig. 2C) indicate that repeated events of fluvial activity, including transport and deposition, were responsible for their formation. Bright, polygonally fractured, Al-phyllosilicate rich materials of a possible delta indicate hydrous alteration [1]. A topographic depression with inlet and outlet is consistent with the presence of a paleolake (Fig. 2D).

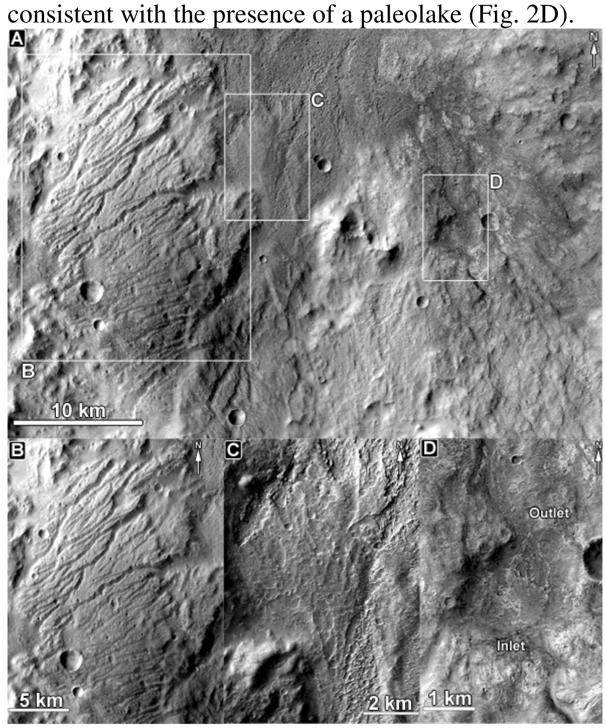

Fig.2: Morphologies of the Libya Montes / Isidis contact between -2500 and -2800 meters. A. Valleys dissect the Libya Montes mountainous terrain. B Pattern of parallel valleys. C. Multiple lobes of possible alluvial fans. D. Paleolake with inlet and outlet channel.

Arabia contact (-3600 / -3700 m): Landforms associated with the Arabia shoreline [e.g., 1-5,7] appear as a series of cliffs and terraces (Fig. 3). 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 (Fig. 3B) and can be divided into 3-4 distinct terraces tens of meters high and tens of kilometers long (Fig. 3C).

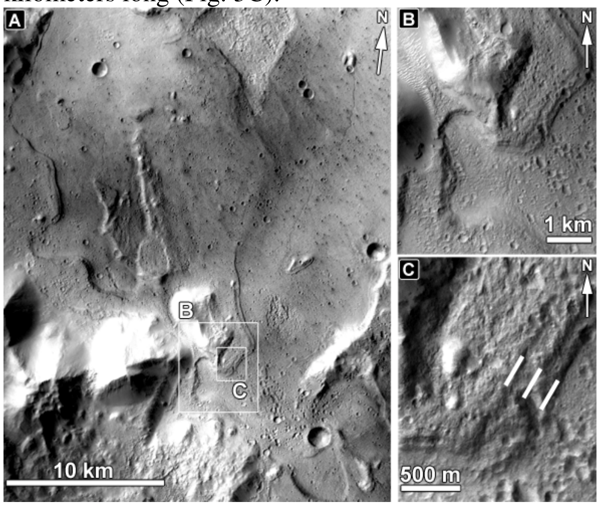

Fig.3: Morphologies of the Arabia contact at -3600 / -3700 meters. A. Cliffs represent the margin between the Libya Montes and the Isidis exterior plains. B. The Arabia contact at -3700 meters. C. Close-up shows a series of cliffs and terraces of the Arabia contact.

Deuteronilus contact (-3800 m): The Deuteronilus contact [e.g., 1-7] appears in the northernmost part of our study area and represents a well-defined and sharp boundary (Fig. 4). The contact is characterized by an onlap geometry where the Isidis exterior plains are superposed by materials of the Isidis interior plains that are stratigraphically higher.

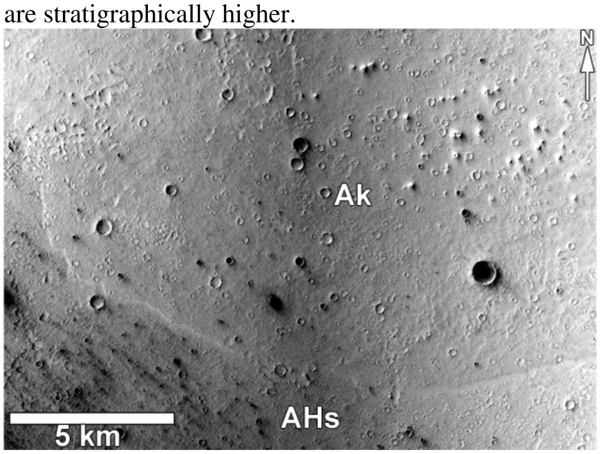

Fig.4: Morphologies of the Deuteronilus contact that builds the boundary between the Isidis interior plains (Ak) and the Isidis exterior plains (AHs).

Stratigraphy: Fluvial activity likely occurred in repeated events in the Noachian and Early Hesperian. The possible delta was formed at the same time (~3.7 Ga) and likely by the same Late Noachian-Early Hesperian fluvial events. Landforms associated with the Arabia shoreline were formed at ~3.5 Ga ago and are younger compared to previous studies that show ages of at least ~4.0 Ga [5]. In addition, the cliffs of the Arabia shoreline in our study area were likely formed after the last fluvial activity in the Libya Montes highlands ceased ~3.7 Ga ago. The Deuteronilus contact was formed later than the Isidis exterior plains (~3.3 – ~2.7 Ga) and no later than the formation of the Isidis interior plains (~2.8 Ga).

Conclusions: Our observations of the Libya Montes / Isidis Planitia boundary suggest, that (1) the termination of valley networks between roughly -2500 and -2800 m coincide with lake-size ponding in basins within the Libya Montes, (2) possible delta and alluvial fans, layered morphologies and associated Al-phyllosilicates identified within bright, polygonally fractured material at the front of deltaic deposits are possibly the result of fluvial activity and discharge into a paleolake, (3) the Arabia "shoreline" appears as a series of possible coastal cliffs at about -3600 and -3700 m indicating two distinct still stands and wave-cut action of a paleosea that temporarily filled the Isidis basin between the Late Noachian and the Early Hesperian, and (4) the Deuteronilus "shoreline" appears at -3800 m and may indicate the edge of the proposed sublimation residue of a frozen sea that might have filled the Isidis basin, similar to the Vastitas Borealis Formation (VBF) identified in the northern lowlands [6]. We interpret the morphologic-geologic setting and associated mineral assemblages of the Libya Montes / Isidis Planitia boundary as results of fluvial and lacustrine activity and an environmental change over time toward decreasing water availability and a cold and dry climate.

Therefore, we propose this site as a new candidate landing site for potential future missions after MSL Curiosity [1,11]. As our study area provides significant insights into the water-related geologic record of the Libya Montes / Isidis boundary it will help to reconstruct the climatic evolution of Mars, in particular the proposed climate change at the Noachian / Hesperian boundary. In addition, our proposed candidate landing site ellipses on smooth plains near alluvial fan deposits and on the smooth Isidis exterior plains near the cliffs of the Arabia "shoreline" allow morphologic and mineralogic in-situ investigations directly at the landing site.

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Acknowledgements: This research has been supported by the Helmholtz Association through the research alliance "Planetary Evolution and Life". We thank the HRSC Experiment Teams at DLR Berlin and Freie Universität Berlin as well as the Mars Express Project Teams at ESTEC and ESOC for their successful planning and acquisition of data as well as for making the processed data available to the HRSC Team.