AN ORTHOIMAGE MAP USING DATA OBTAINED FROM THE MARS ORBITER CAMERA OF MARS GLOBAL SURVEYOR

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ABSTRACT:

A basic requirement for the planning of future Mars missions are precise and high resolution maps, especially, of the landing site area. We present a new digital orthoimage map of Mars using data obtained from the Mars Orbiter Camera (MOC) of the Mars Global Surveyor (MGS). The new map covers the Mars surface from 180° E (180° W) to 360° E (0° W) and from 60° South to 60° North with a resolution of 231.529 m/pixel (256 pixel/degree). The mosaic was divided into 8 parts, according to the digital size of the Mars Digital Image Mosaics (MDIM2). They are available digitally at http://solarsystem.dlr.de/PG/MOC/. In addition, we announce the release of a printed map of Coprates (MC 18) based on MGS data. For map creation, digital image processing methods have been applied. Furthermore, we developed a general processing method for creating image mosaics based on MOC data. This method can be used for creating image mosaics using CCD (Charged Coupled Device) line camera data and it is applicable also for other Mars missions, whenever a CCD line camera is employed.

1. INTRODUCTION

In this paper, we report our efforts processing MOC wide-angle red images, derived from the orbits M00-M18 in 1999/2000 at a resolution of about 250 m/pixel or less. The data set has two big advantages in comparison to the 30 years old Viking data set. First, the better knowledge of the navigation data: As it was reported in a paper of Smith (2001), the spacecraft pointing has an accuracy of 1 to 3 mrad (400 m to 2000 m, depending on the spacecraft altitude) and absolute spacecraft position uncertainties in order of 100 m. Second, the Mars Orbiter Camera has an 8 bit dynamic range instead of the 7 bit dynamic range of the Viking vidicon. Due to this technical progress, the processing of the images offers the opportunity to get a new map of Mars with better radiometric and geometric quality.

2. INPUT DATA

The MOC wide-angle (WA) camera is a line scanner camera operating in the push-broom mode. In order to map the whole planet, stripes of images (4° longitude range by 17° latitude range) were obtained at the beginning of the MGS mission during the Geodesy Campaign (Caplinger, 2001). When the mapping with the narrow-angle camera started, WA- context images (2° by 2°) were obtained. Inspecting the available images of the red WA camera, it was obvious, that the dynamic range of the recently obtained MOC context images is better than the dynamic range of images of the Geodesy Campaign. To take advantage of the 8 bit dynamic range of the MOC camera, we decided to use not only the long strips of the Geodesy Campaign, but all available context images. We found 4,339 context images and 183 Geodesy images of good quality in the investigated area and with a resolution better than 250 m/pixel. Additionally, we had to use 313 images of the Geodesy Campaign with a resolution > 250 m/pixel and < 435 m/pixel. Approximately 10 % of the visually inspected images were sorted out for lack of quality.

3. METHODS

Image data processing has been performed using multiple VICAR (Video Image Communication and Retrieval) and IDL (Interactive Data Language) programs, developed by the JPL (Jet Propulsion Laboratory), DLR (German Aerospace Center) and the TUB (Technical University of Berlin) (Scholten, 1996). Furthermore, ISIS (Integrated Software for Imagers and Spectrometers software), developed by the USGS (U.S. Geological Survey), was applied (see figure 1).

First, each MOC image was corrected for radiometric camera errors. After visual inspection, some images were edited manually to remove image artifacts (stripes of pixel errors, etc.). Images containing too many artifacts, were not included. The correction of images with major differences in brightness was performed using IDL routines developed at the DLR. After all radiometric and brightness corrections, the images were Mars referenced, geometrically corrected (Kirk, 2001) and orthoprojected using a global Martian Digital Terrain Model (DTM), developed by the DLR and based on MGS Mars Orbiter Laser Altimeter (MOLA) data (Smith, 2001): We used all released MOLA binary data. Reading out these files, we got about 588,000,000 measurements of planetographic latitude, east longitude (referenced to the radii: A=B=3,396.19 km, C=3,376.2 km) and Mars geoid heights. All longitudes were shifted by a value of +0.238 to convert the longitudes from International Astronomical Union (IAU) 1991 (the MOLA reference system) to the IAU 2000 reference system (Seidelmann, 2001). Finally, a gridded DTM from all these object points was computed using DLR/TUB software (Scholten, 1996). The DTM has a resolution of 64 pixel/degree and is Mercator projected. The images were sinusoidal map projected onto this DTM to get orthoimages. As a reference system the IAU 2000 reference system was adopted. For the 0° to 90° W region, the longitude 45° W represents the reference meridian, for the 90° W to 180° W region the longitude 135° W. To eliminate major differences in brightness between the individual images of the mosaics, high- and low-pass filter processing techniques were applied for each image after the map projection.

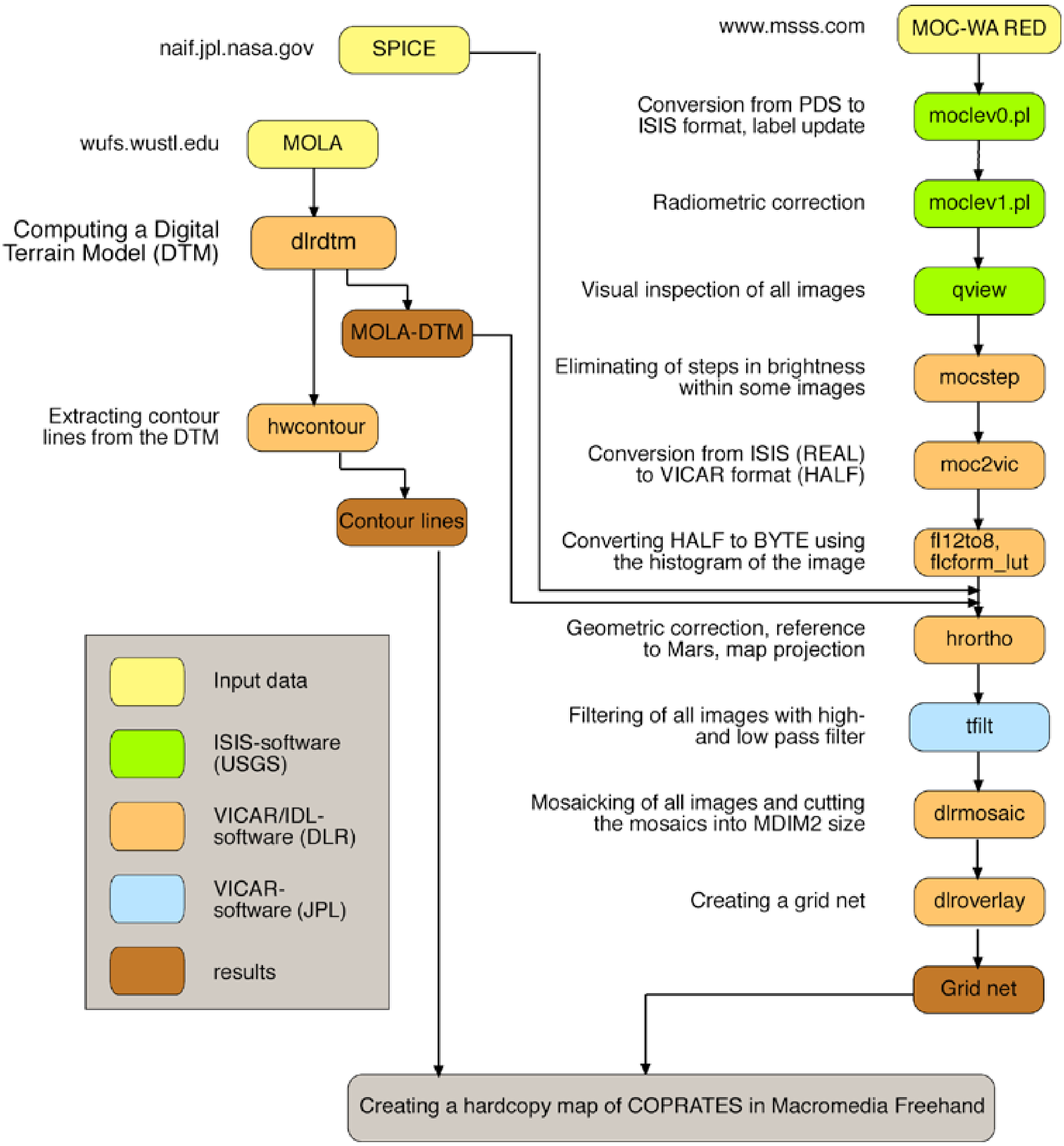

Figure 1: Image data processing scheme

After filtering the images, we mosaicked the images together. No registering or block adjustment techniques were used in order to improve the geometric quality. We recognized that the accuracy of the navigation data has such a good quality, that the orthoimages fit very well to each other except for some images of the Geodesy Campaign in the North and South of the investigated region.
Depending on the resolution and dynamic range, we created three layers of MOC mosaics, which were stacked afterwards: The upper layer consists of context images (orbits M00-M18) with a resolution < 250 m/pixel, the middle layer consists of images of the Geodesy Campaign (orbit M01) with a resolution < 250 m/pixel and the bottom layer consists of images of the Geodesy Campaign (orbit M01) with a resolution > 250 m/pixel and < 435 m/pixel (see figure 2).

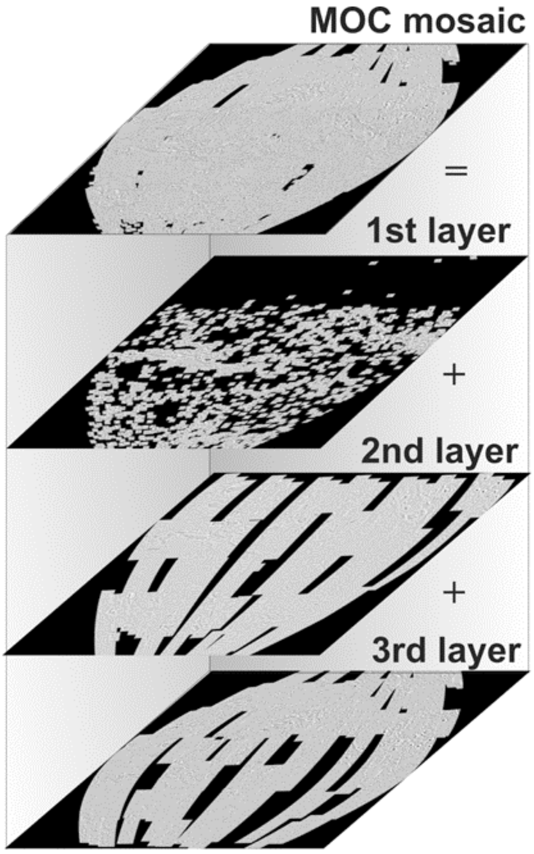

Figure 2: Tree layers of mosaics were stacked afterwards depending on their resolution and their dynamic range.

A few remaining gaps in the coverage were filled with MDIM2, based on 7 bit VIKING-Data. Figure 3 (next page) shows a small part of the Valles Marineris in full resolution. For comparisons with existing maps of Mars, the mosaic was divided into 8 parts, according to the digital size of the MDIM2 (see figure 4). The 8 map parts with a resolution of 231.529 m/pixel (256 pixel/degree) are available digitally at http://solarsystem.dlr.de/PG/MOC/.

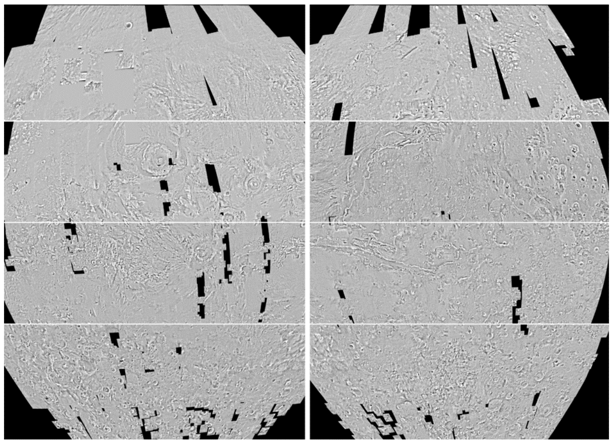

Figure 4: The 8 mosaics of the Martian western hemisphere in MDIM2 resolution.

4. CREATING A TOPOGRAPHIC IMAGE MAP

One part, MC-18 Coprates, was cartographically processed in detail and printed using a commercial oversize plotter with a scale of 1 : 2,000,000 (see figure 5). The printed map represents the left part of the MDIM2 j quadrangle. The scale results in a map field of 0,89 m x 1,33 m. For cartographic processing the mosaic was imported into Macromedia FreeHand as a TIFF file. Both IAU supported coordinate systems: 1) planetocentric latitude and East longitude and 2) planetographic latitude and West longitude were calculated and added, since the map is intended to serve several scientific interests. The grid in planetocentric/East is the primary grid-net printed as a black line. The secondary coordinate system (planetographic/West) has been printed in cyan and is used for historical reasons.
The contour lines calculated for this map were extracted from the global Martian Digital Terrain Model (DTM), which was developed by the DLR. The contour data were imported as vector data into Macromedia FreeHand as a separate layer and corrected interactively. The heights are areoid heights and were referenced to an equipotential surface (gravitational plus rotational). The average radius of this surface is equal to the mean equatorial radius of 3396.2 km.
Besides the basic information, it is essential to provide additional information such as camera data, digital data processing steps, map projection parameters, and nomenclature.
The map sheet consists of 6 fields: i) the map field containing the topographic image mosaic, ii) the cover with title, scale, map serial number, author and a shaded relief overview map of Mars with latitude/longitude grids, iii) information regarding the camera and mosaic processing methods within a separate text field, iv) the quadrangle sheet, an additional text block and scale, v) a map showing the gaps which were filled with MDIM2 in the “main map”, vi) an outline of the system of coordinates and the imprint.
For layout reasons, the legend was placed in the lower map part. Due to the map size, the best folding system resulted in a final folded map size of 20 cm x 27.8 cm.

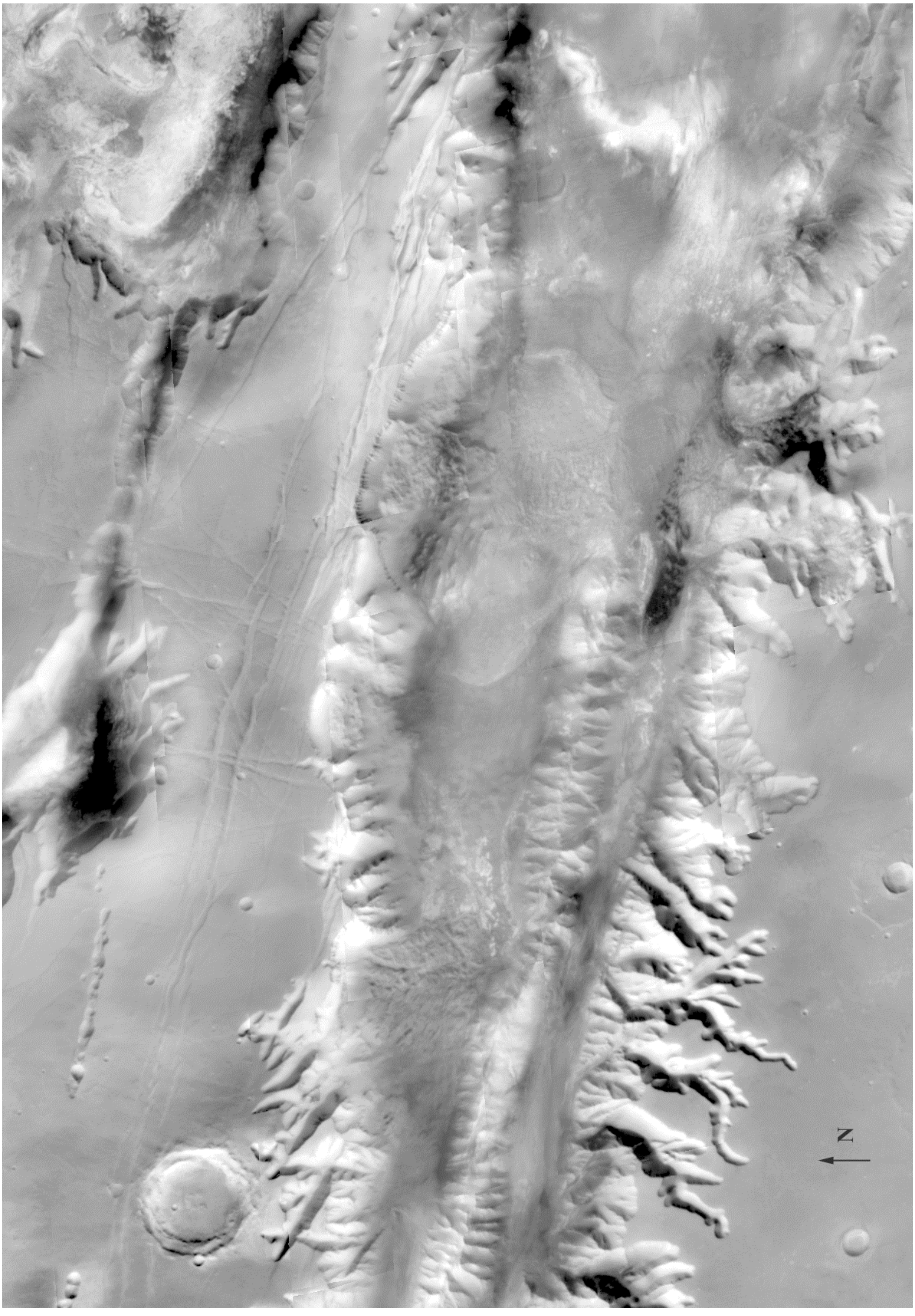

Figure 3: Detail of the orthomap of Melas Chasma in full resolution

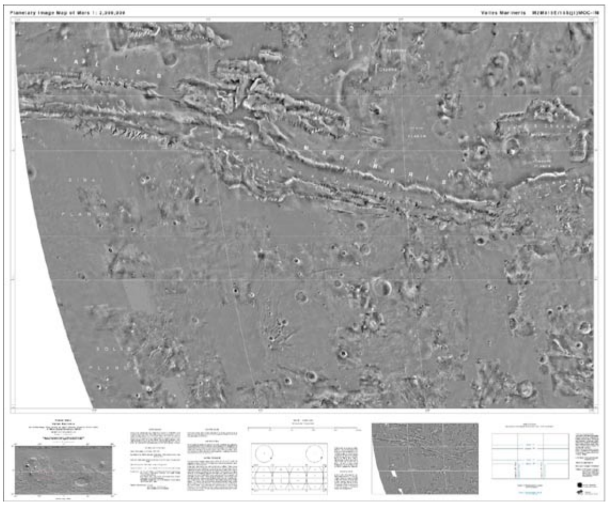

Figure 5: Topographic image map of the MC-18 quadrangle “Coprates” 1:2,000,000.

5. RESULTS AND OUTLOOK

We present a new digital orthoimage map of the Martian western hemisphere with a resolution and map projection parameters, except the radii, according to the MDIM2. The reference system is the new defined IAU 2000. We see good correspondence between MOLA and MOC datasets by merging the MOC mosaic with the MOLA data using IHS-transformation (see figure 6).

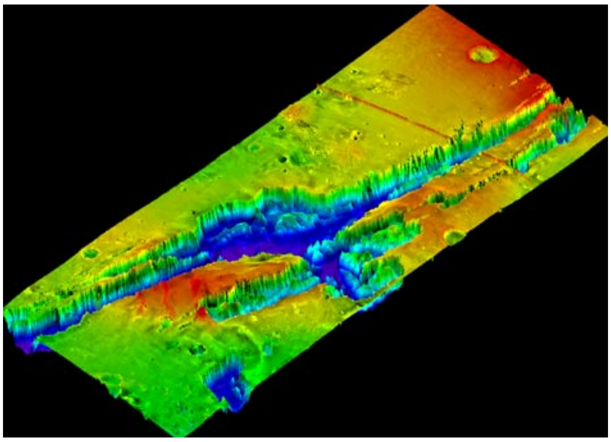

Figure 6: Detail of MOC mosaic merged with MOLA (IHS transformation), Valles Marineris region, North is on the bottom right.

The 8 derived mosaics are new geometrically precise orthoimage maps in MDIM2 resolution. They will be used for the targeting of future lander missions to Mars and in the planning of imaging sequences from orbit, e.g. within the Mars Express mission in 2003. This satellite will carry the HRSC (High-Resolution Stereo Camera), a multiple-line multispectral stereo scanner instrument (Neukum, 1995). The developed method for creating orthoimage maps from line scanner data is also applicable for the HRSC data. Further activity is planned to fill the remaining gaps with MOC Geodesy images of lower resolution (< 435m) or MDIM2 data. It is necessary to process also the Martian Eastern hemisphere and the pole regions depending on the available data in order to get a global Martian mosaic of the same quality.
It is still important to use both datasets for photogeological interpretations due to the difference of the photometric conditions of the MOC and MDIM2 images. The photometric correction of the MOC images still needs to be done.

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