HRSC RGB & Pan-sharpening

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HRSC RGB

- HRSC has 4 color bands:
  - Blue
  - Green
  - Red
  - Near Infrared

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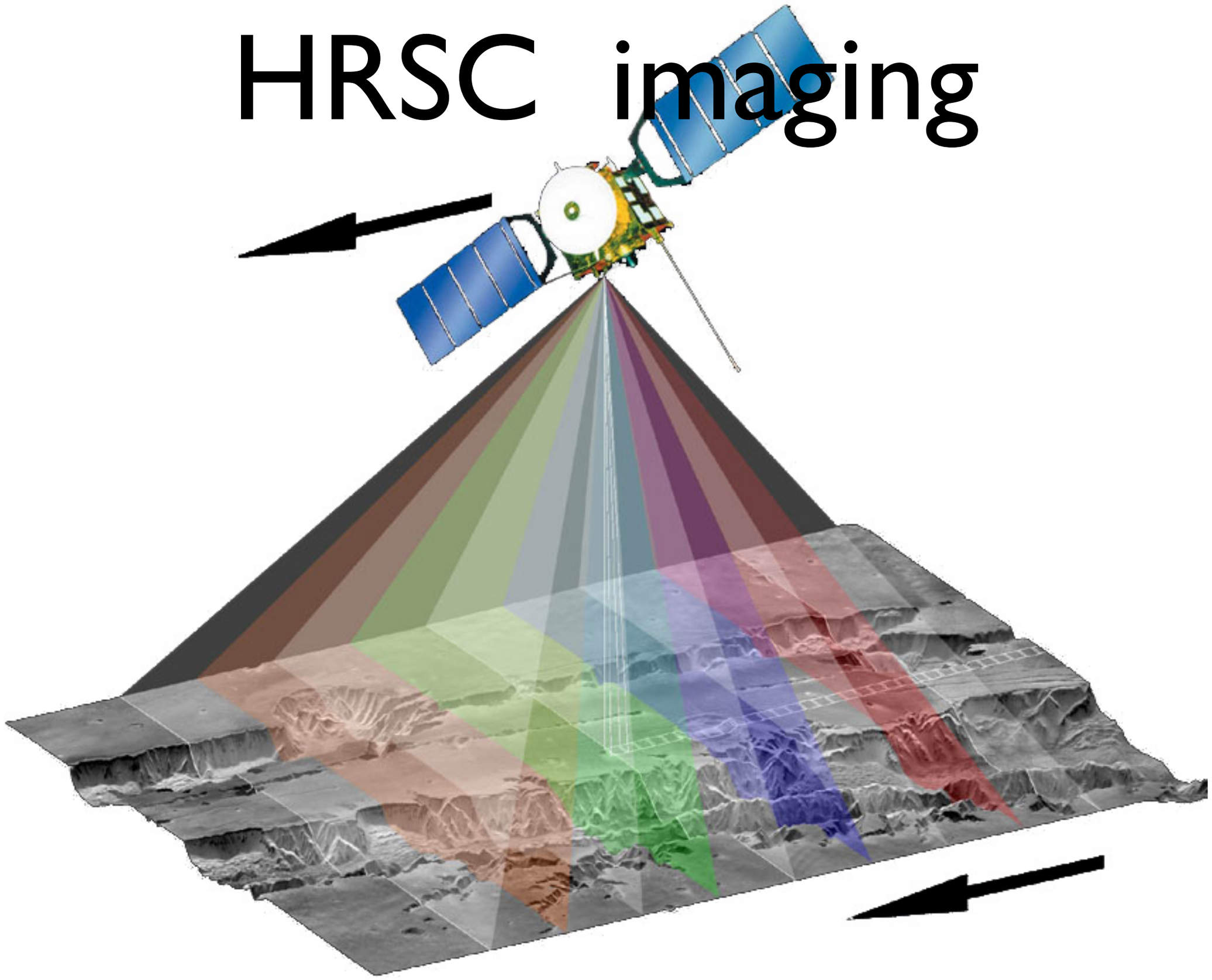
HRSC imaging



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HRSC - band names

```
H0000_0000_ND2.IMG    ND = nadir
H0000_0000_BL2.IMG    BL = blue
H0000_0000_GR2.IMG    GR = green
H0000_0000_RE2.IMG    RE = red
H0000_0000_IR2.IMG    IR = near IR
```

processing level
(Level2)

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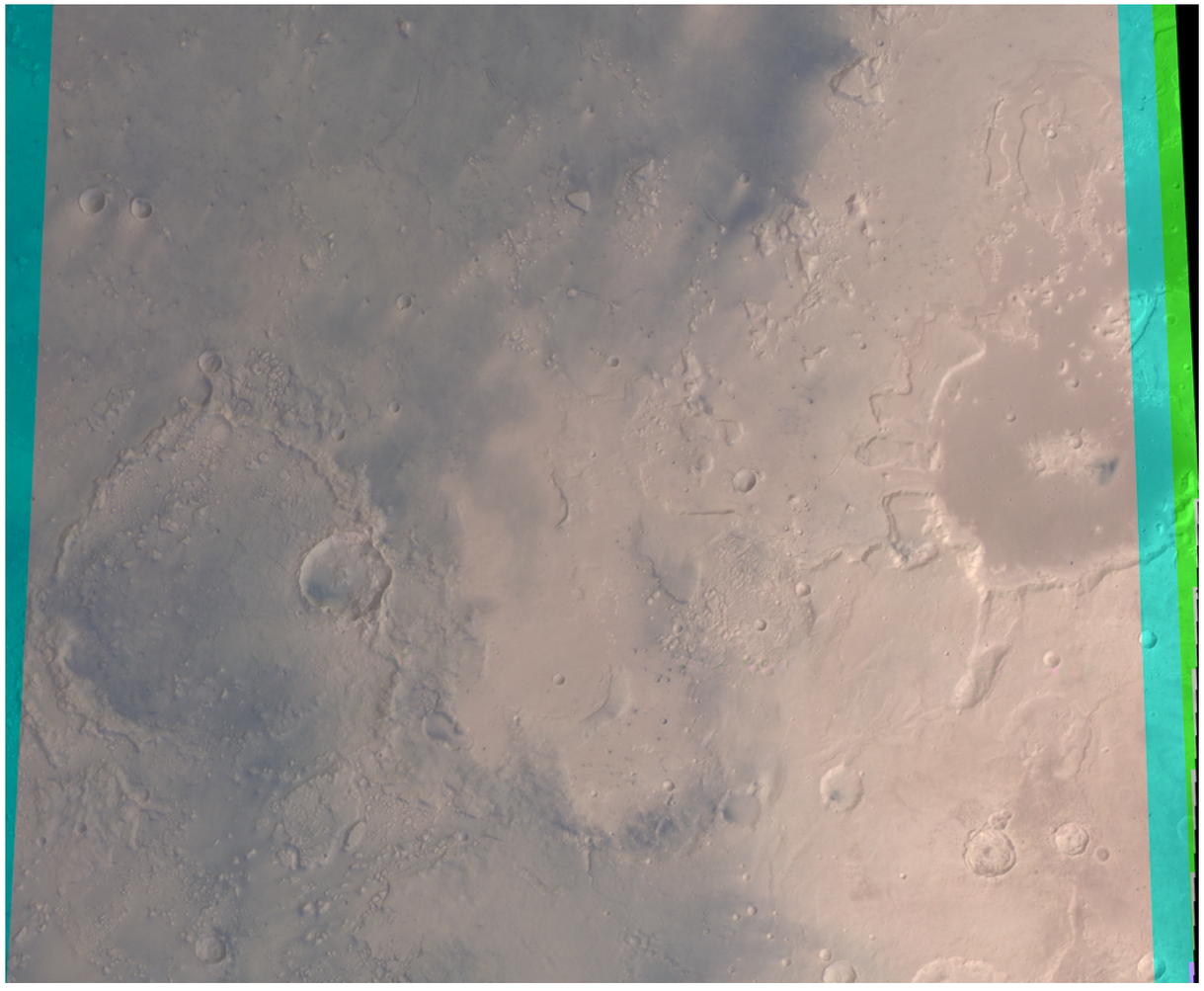
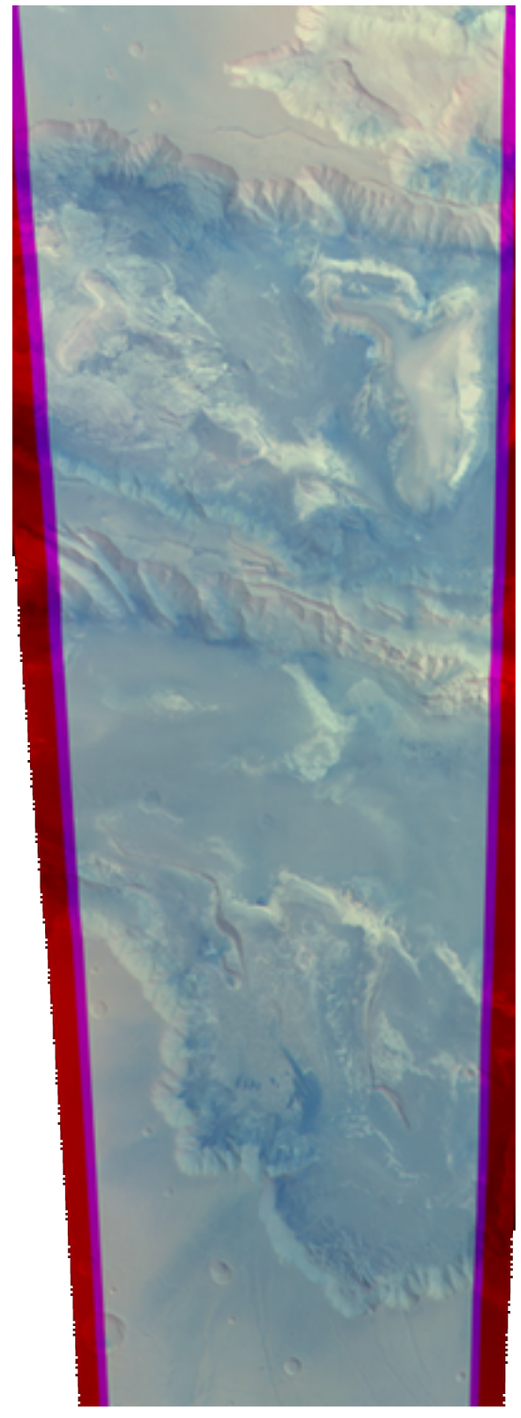
HRSC RGB





examples of HRSC RGB

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hrortho

Syntax:

```
$HWLIB/hrortho inp=... ori=spice dtm=... out=... [optionals]
```

```
dtm=...      dtm-file or height above datum in meter
inp=...      Input image used if
out=...      Output image generated
ori=spice    (spice KERNELS used)
fitto=...    File to which OUT should fit.
sL_inp=...   starting lines of input Level2 image
nl_inp=...   no. lines starting from nl_inp to be processed
```

“hrortho” produced map projected HRSC images

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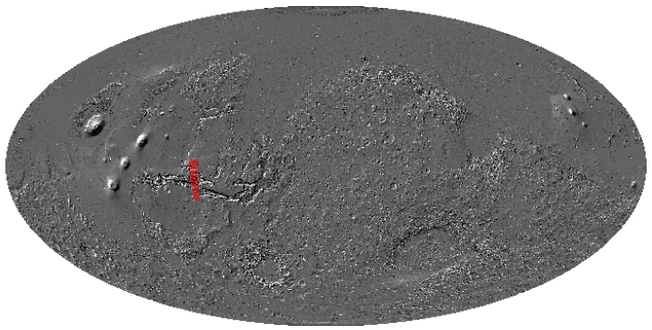
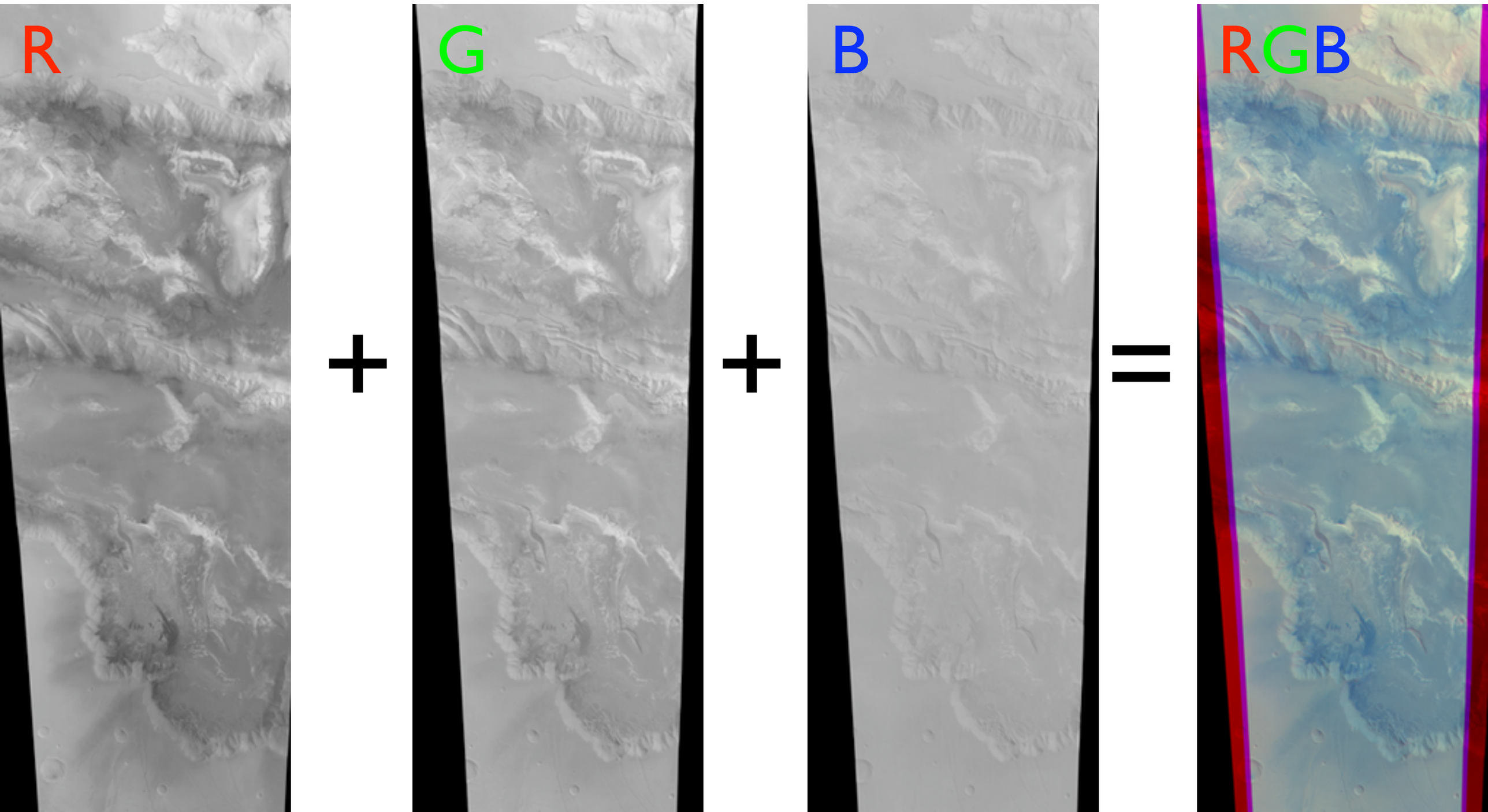
hrortho for RGB

```
hrortho inp=H0572_0000_ND2.IMG out=nadir dtm=0 ori=spice

hrortho inp=H0572_0000_BL2.IMG out=blue dtm=0 fitto=nadir

hrortho inp=H0572_0000_GR2.IMG out=green dtm=0 fitto=nadir

hrortho inp=H0572_0000_RE2.IMG out=red dtm=0 fitto=nadir

hrortho inp=H0572_0000_IR2.IMG out=ir dtm=0 fitto=nadir
```



Candor Chasma

H0360_0000



HRSC RGB -How?

```
$HWLIB/hrortho inp=H0360_0000_ND2.IMG out=nadir dtm=$MOLA64 sl_inp=5000 nl_inp=30000
ori=spice a_axis=3396.19 b_axis=3396.19 c_axis=3396.19

$HWLIB/hrortho inp=H0360_0000_RE2.IMG out=red dtm=$MOLA64 fitto=nadir ori=spice
a_axis=3396.19 b_axis=3396.19 c_axis=3396.19

$HWLIB/hrortho inp=H0360_0000_GR2.IMG out=green dtm=$MOLA64 fitto=nadir ori=spice
a_axis=3396.19 b_axis=3396.19 c_axis=3396.19

$HWLIB/hrortho inp=H0360_0000_BL2.IMG out=blue dtm=$MOLA64 fitto=nadir ori=spice
a_axis=3396.19 b_axis=3396.19 c_axis=3396.19

$HWLIB/hrortho inp=H0360_0000_IR2.IMG out=ir dtm=$MOLA64 fitto=nadir ori=spice
a_axis=3396.19 b_axis=3396.19 c_axis=3396.19
```

Pan-sharpening

- What is it?

  Fusion of a color data set with a panchromatic (greyscale) one with higher spatial resolution

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Example: Landsat 7 ETM+

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Example: Landsat 7 ETM+

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Example: Landsat 7 ETM+

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PAN sharpening algorithms

- Multiple algorithms for pan-sharpening
  - IHS
  - Brovey
  - PCA
  - Wavelet
  - .....

Brovey transformation

$$DN_{fused} = \frac{DN_{b1}}{DN_{b1} + DN_{b2} + DN_{b3}} * DN_{pan}$$

- Multiple tools / software packages available for pan-sharpening:
  - E.g. Envi

PAN sharpening

WHAT TO DO:

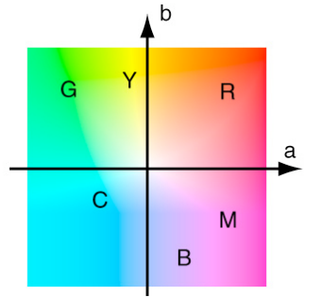
Poor man's sharpening

- Nadir at full resolution
- Red, green, blue oversampled, fitting to Nadir
- RGB to Lab Color
- Nadir pasted into Intensity Channel

L: Lightness of the color (L=0 black, L*=100 white)

a: Position between magenta and green (a<0 green, a>0 magenta)

b: Position between yellow and blue (b<0 blue, b>0 yellow)



PAN sharpening

3 2 1 image

Lightness channel from 3 2 1 image

Panchromatic image

Pan-sharpened 321 image

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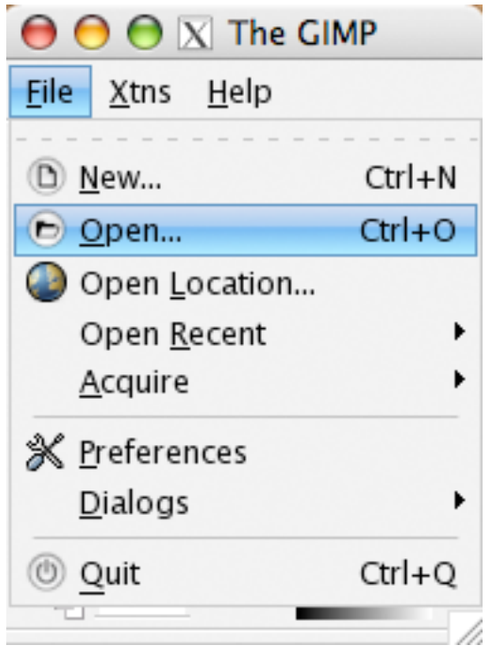
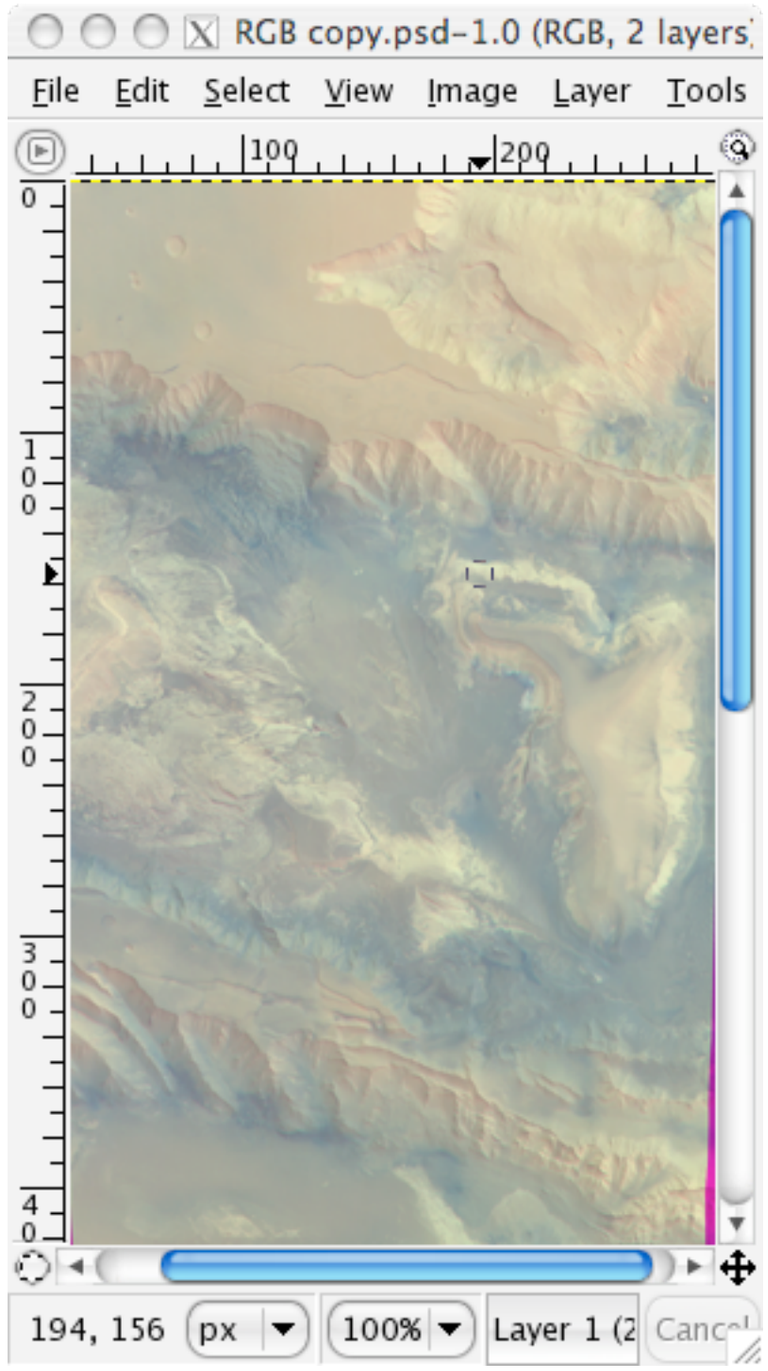
PAN sharpening - How?

- Requirement: Nadir & RGB coregistered, same number of lines & samples
- Build and RGB with Red, Green, Blue bands
- Transform RGB in Lab Color (lightness, a, b)
- Open Nadir
- Paste Nadir into “lightness”
- Transform back Lab Color in RGB

With Gimp

Open RGB image





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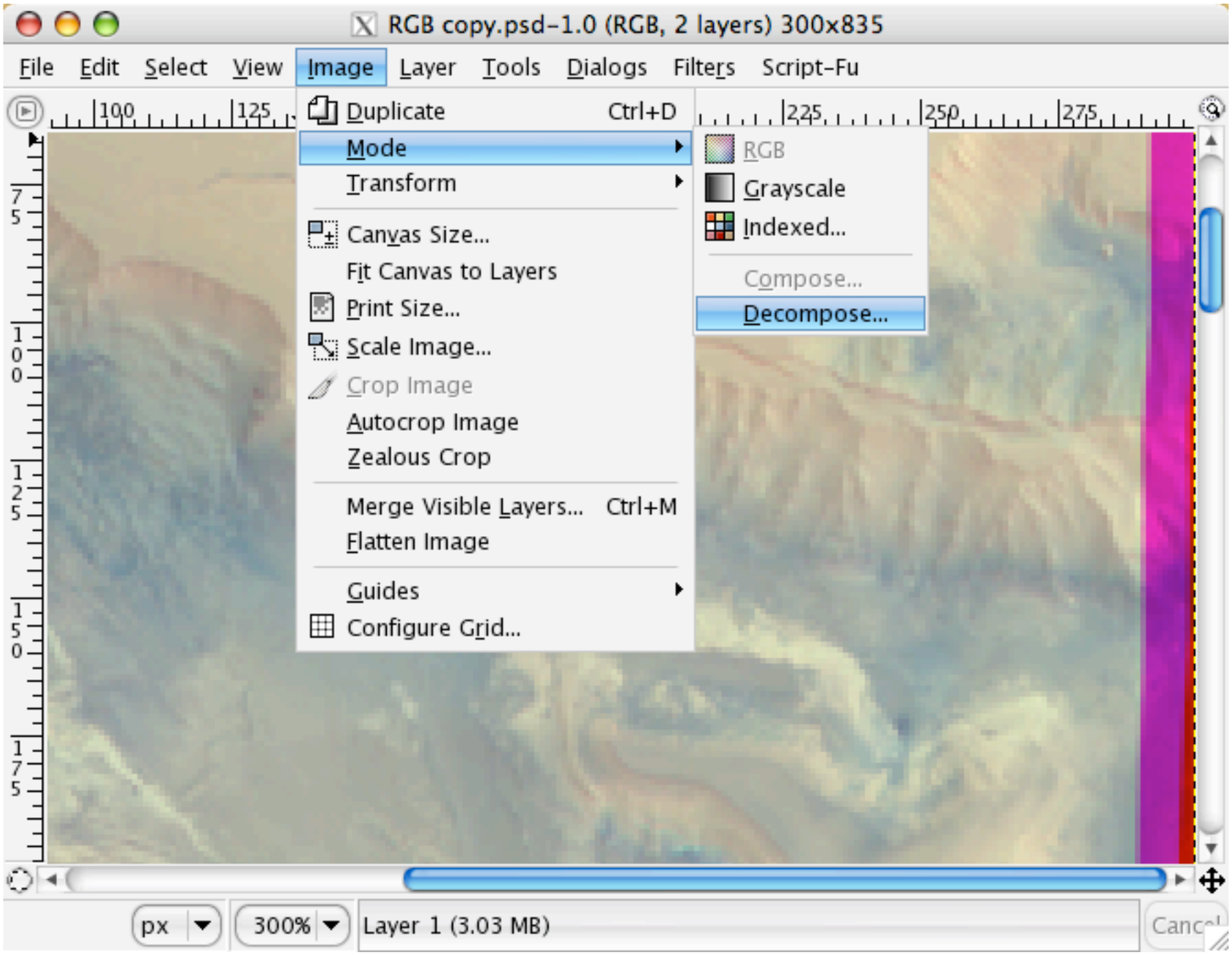
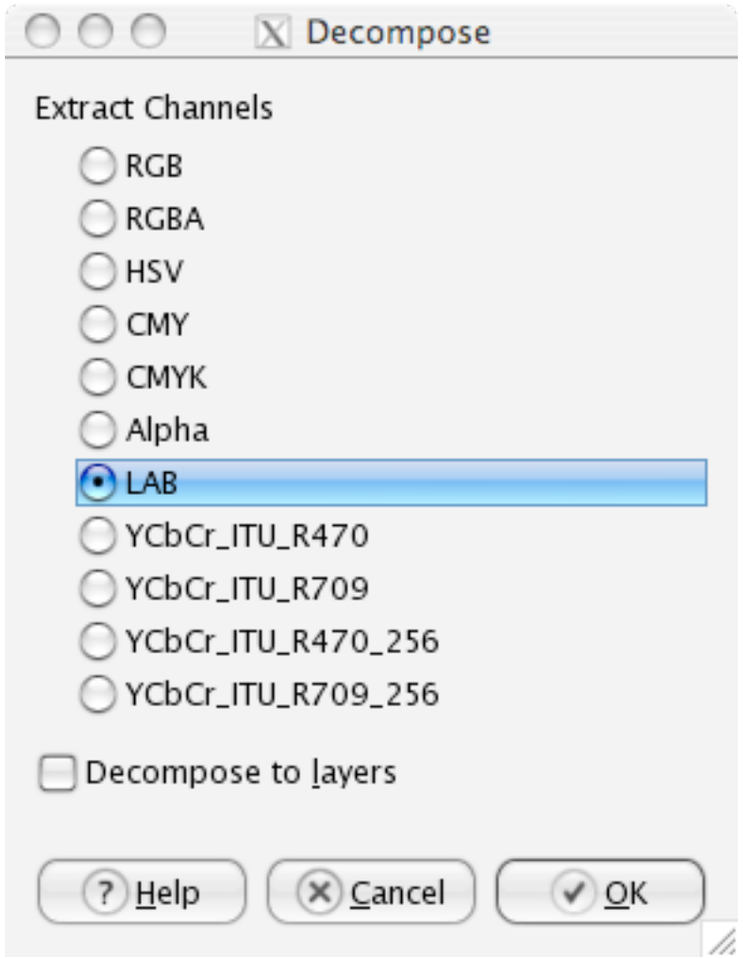
With Gimp



Transform RGB

in Lab Color



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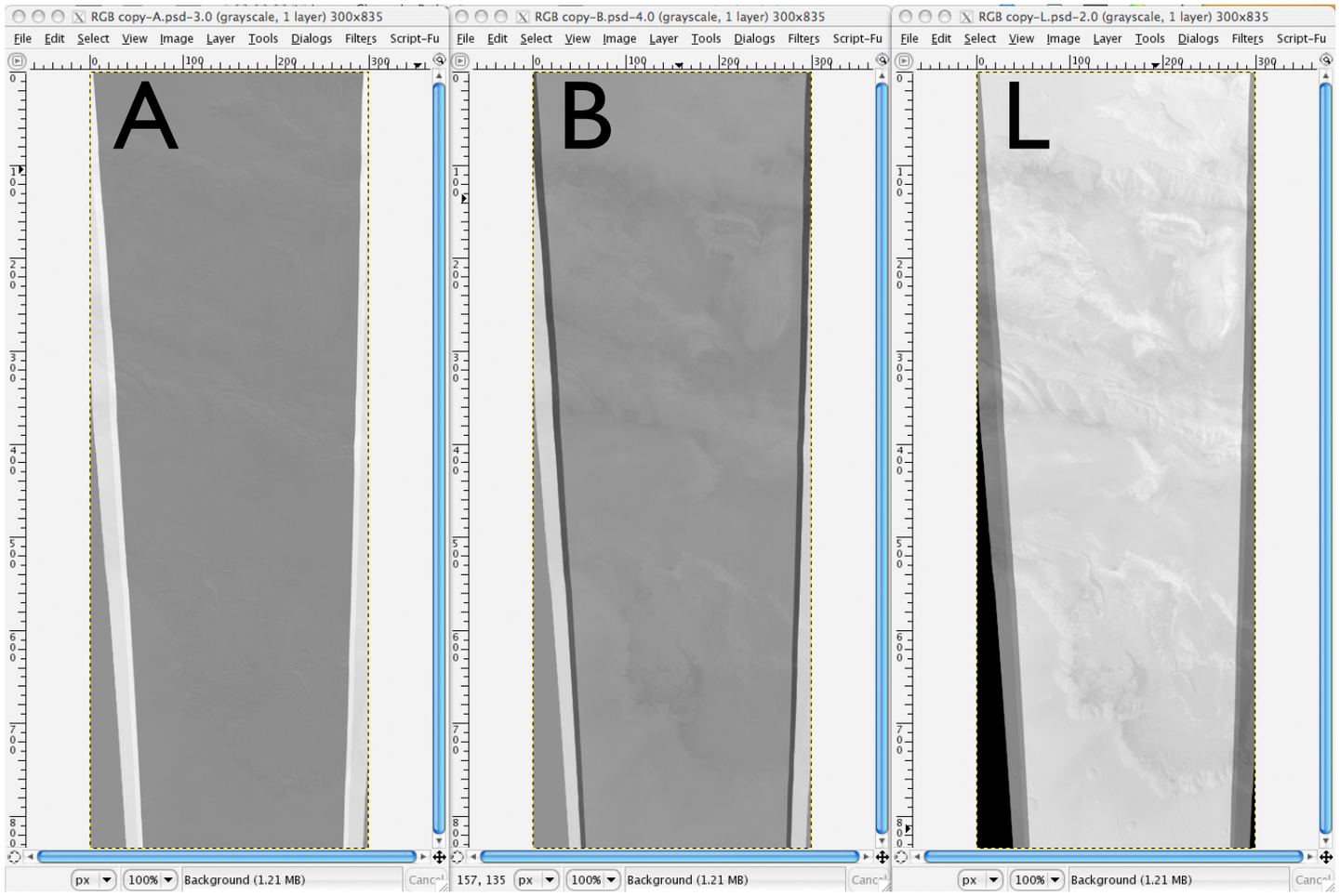
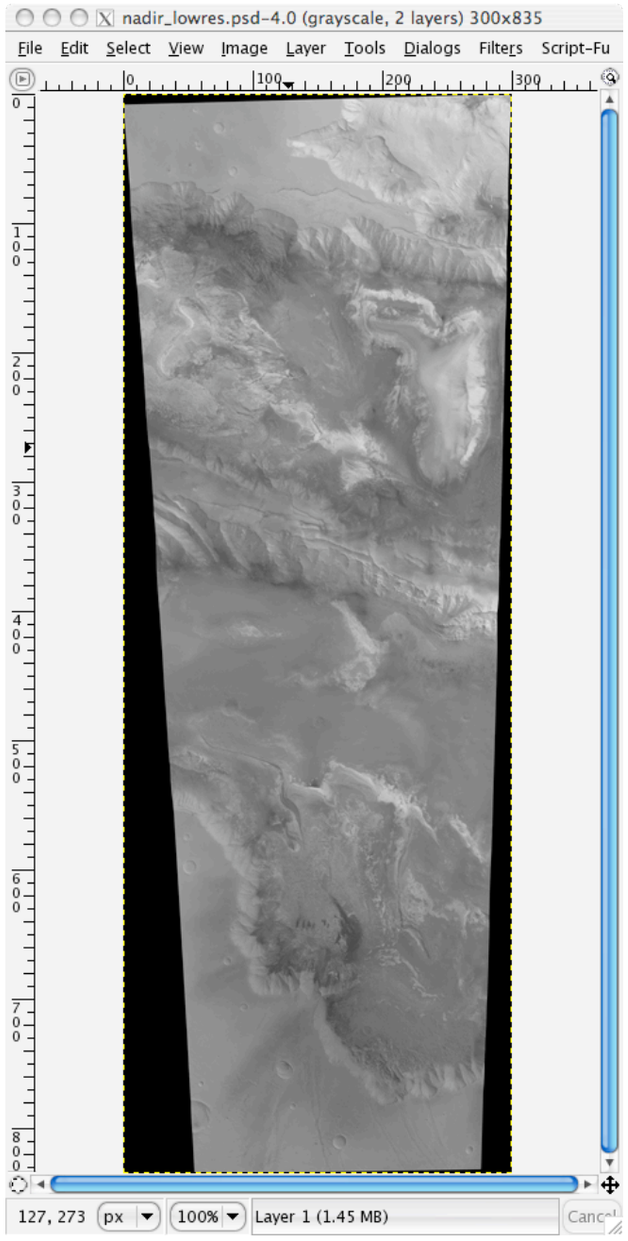
With Gimp

Lab Color





Open Nadir

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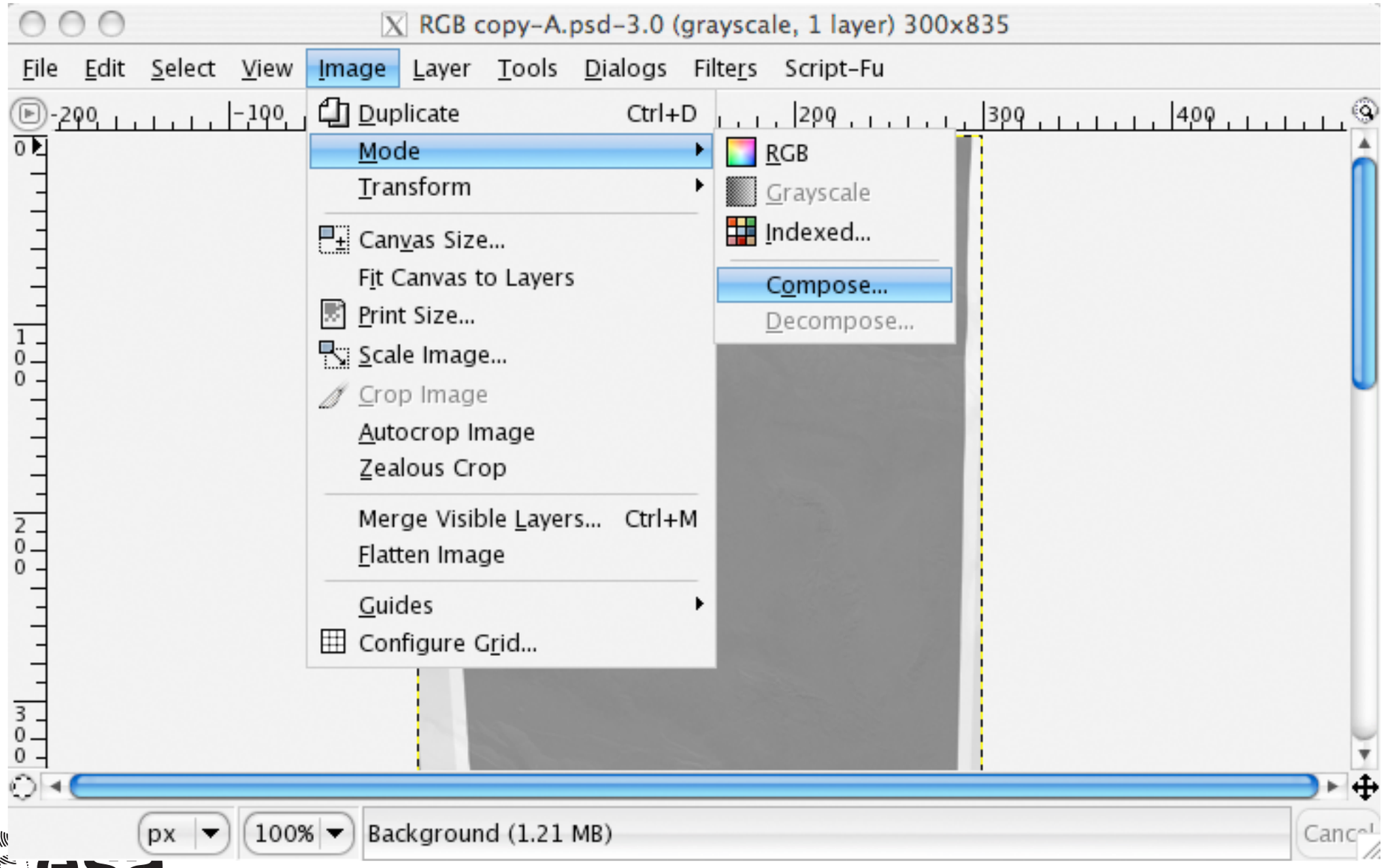
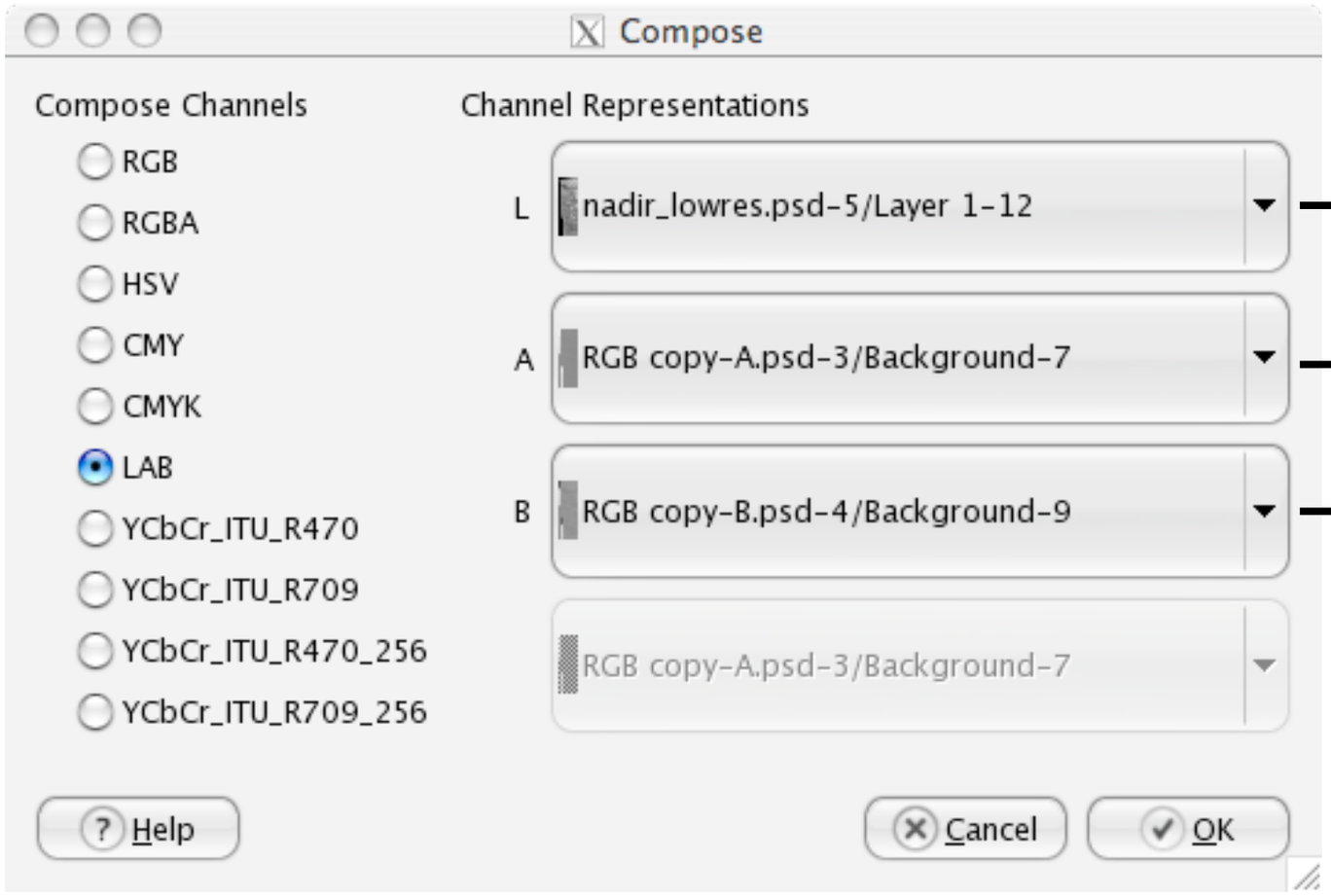
With Gimp

Recompose RGB



With Gimp

Recompose RGB



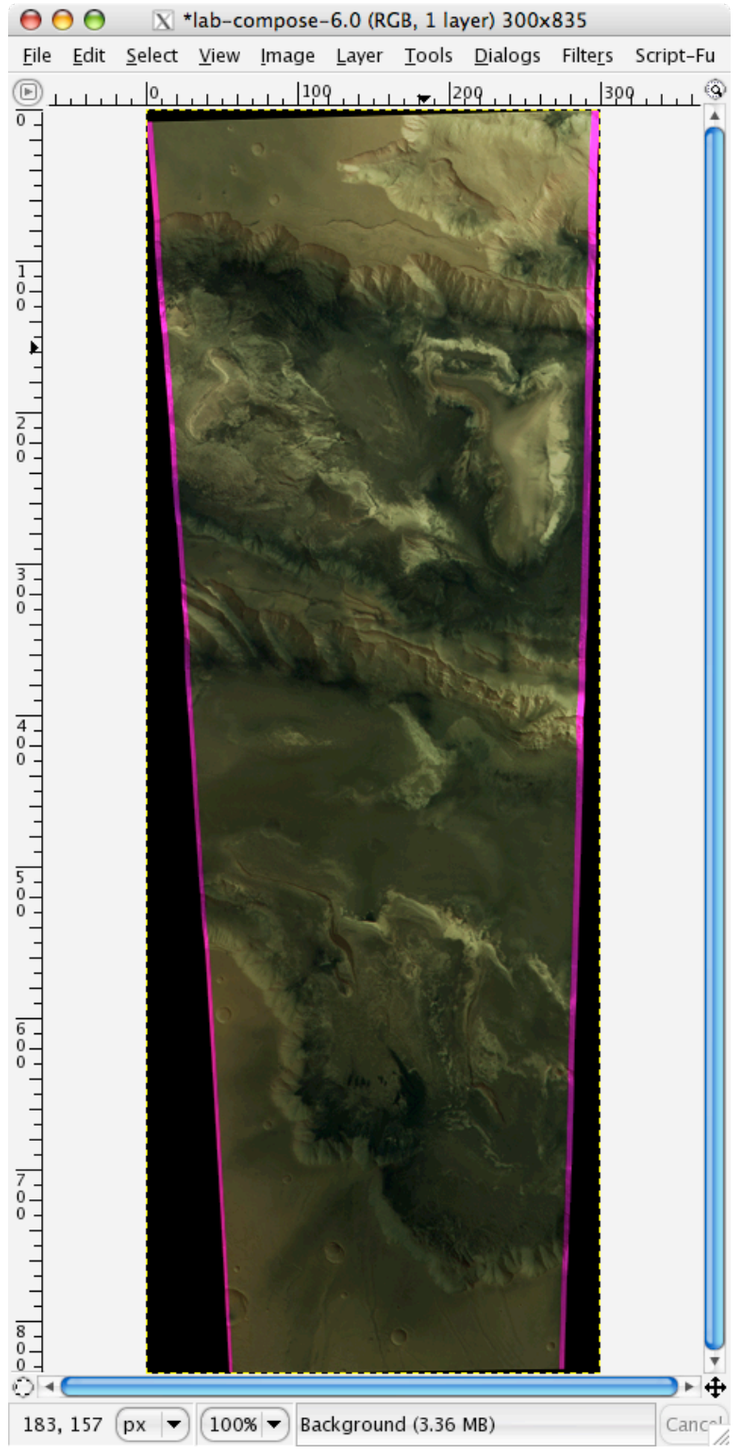
→ Nadir

→ “A” from RGB

→ “B” from RGB

With Gimp

Recompose RGB



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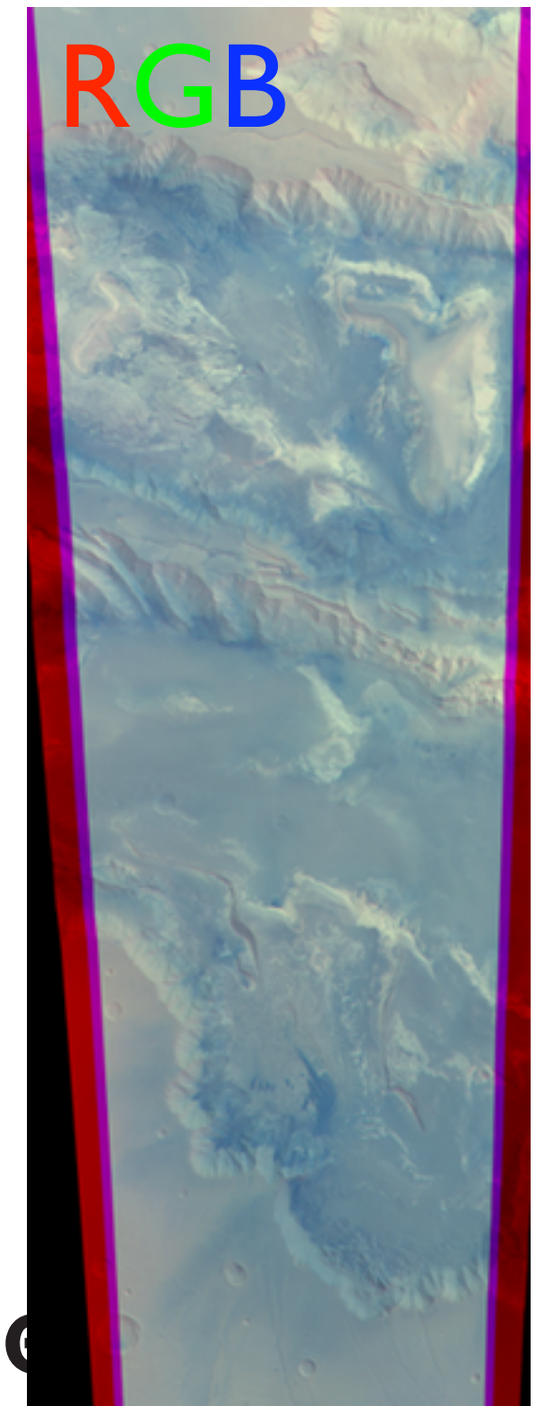
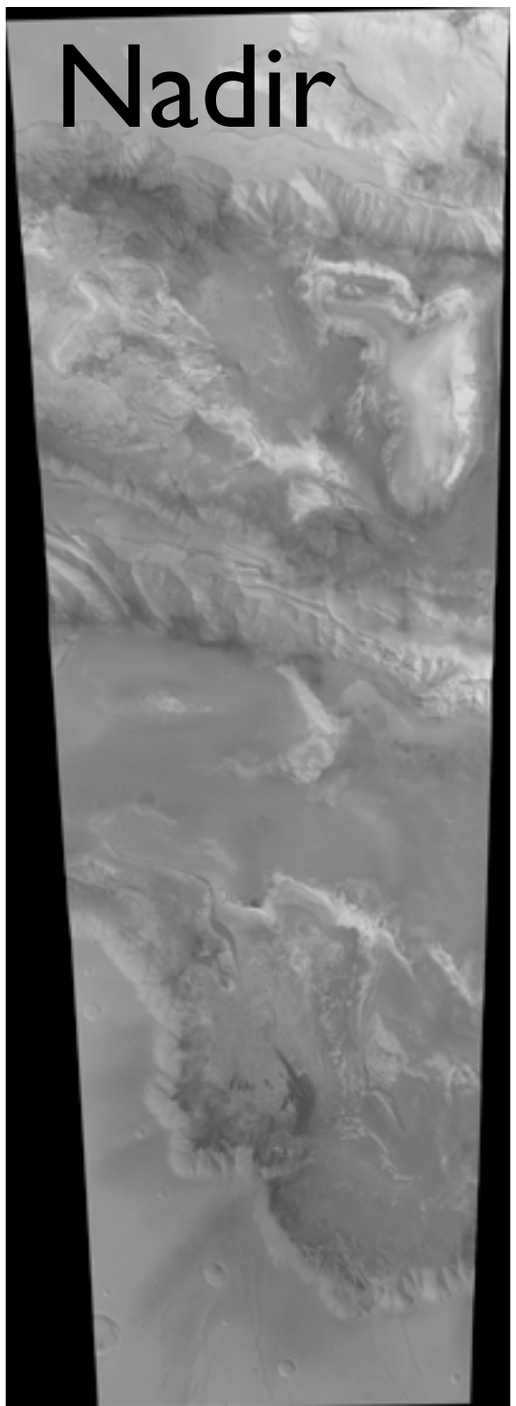
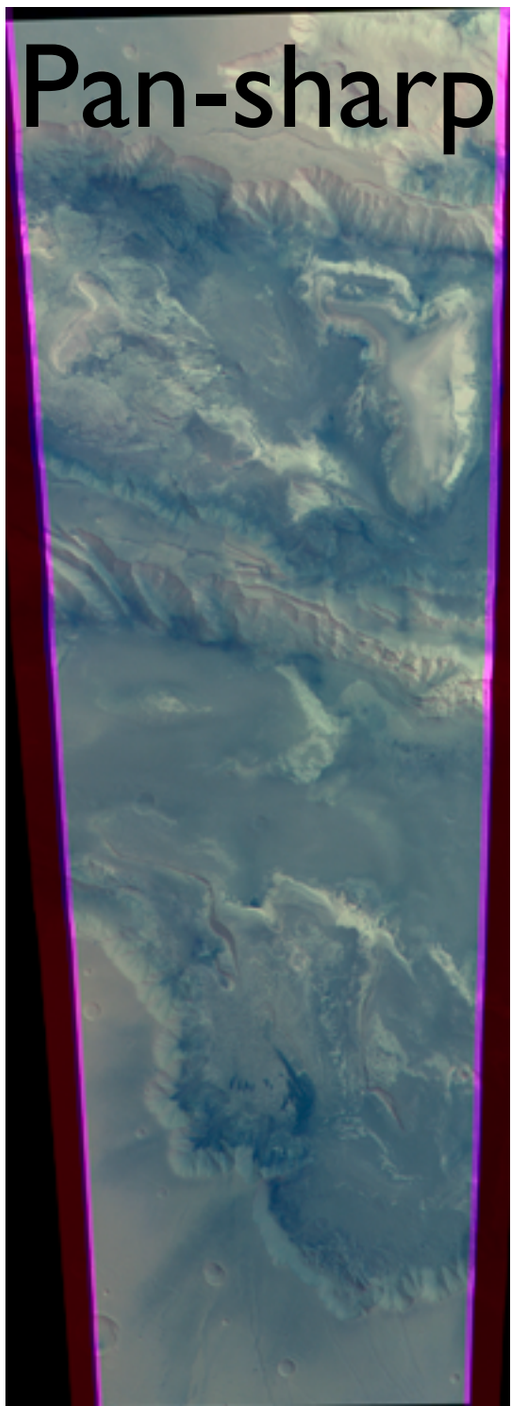
PAN sharpening

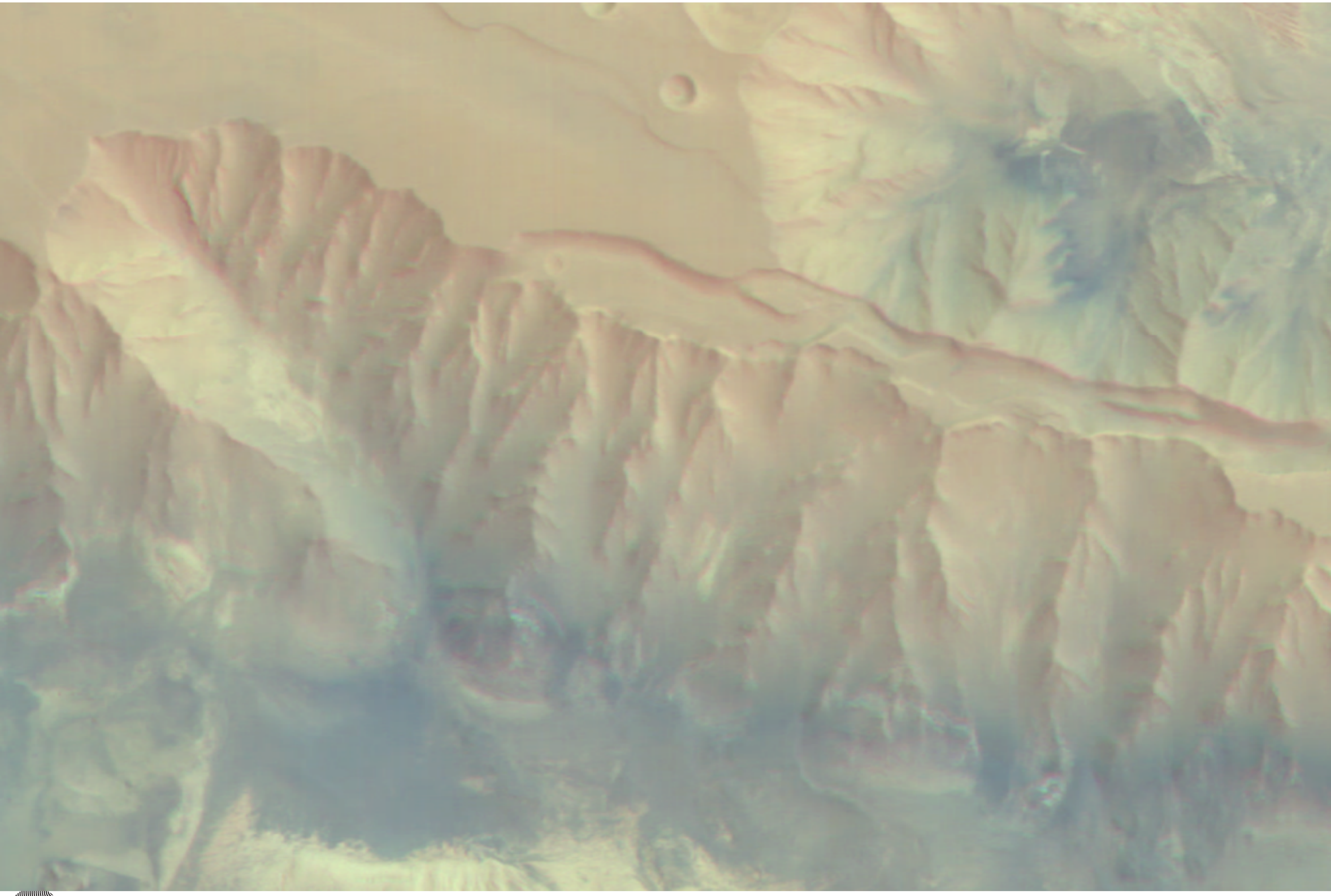


+



=





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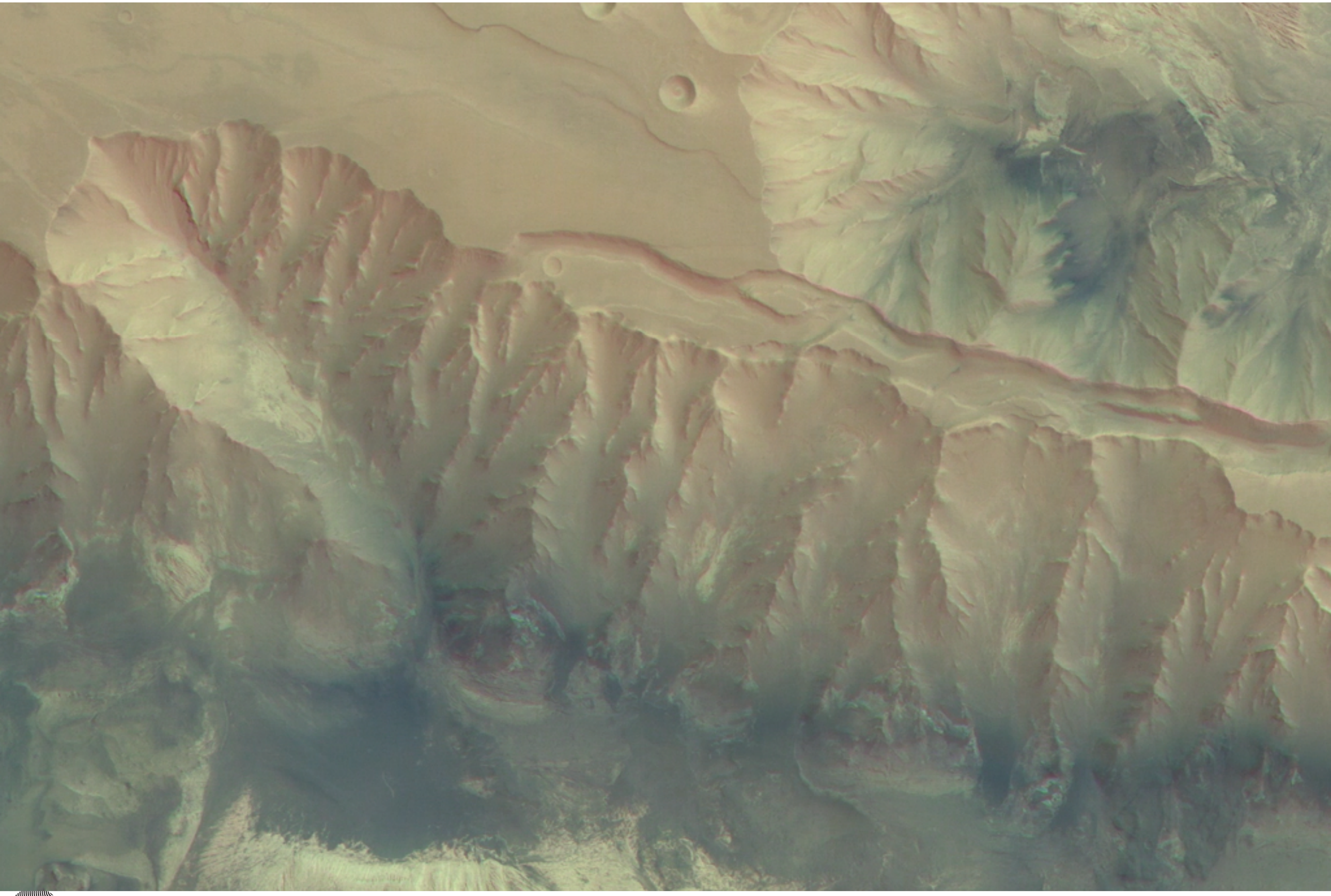

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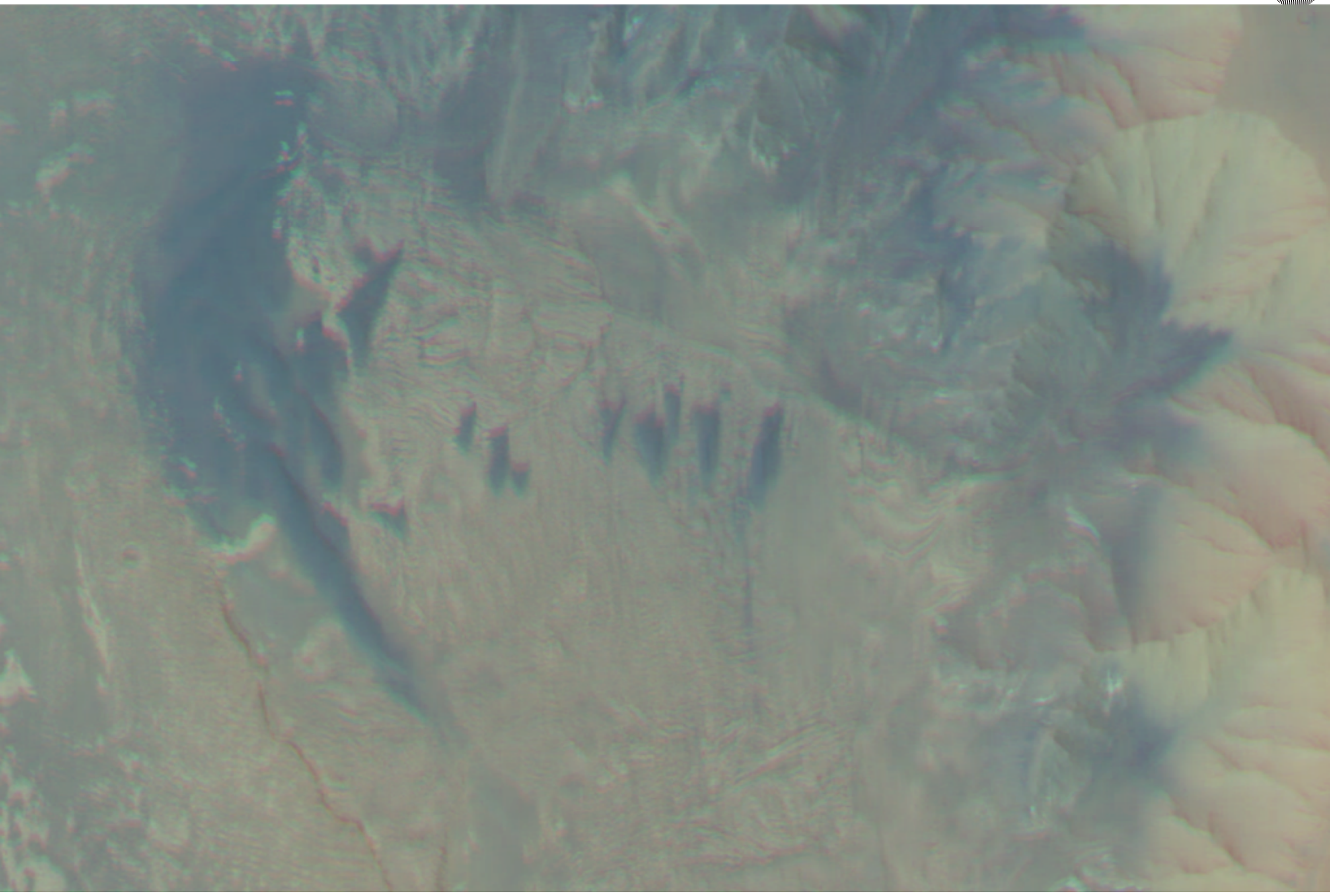

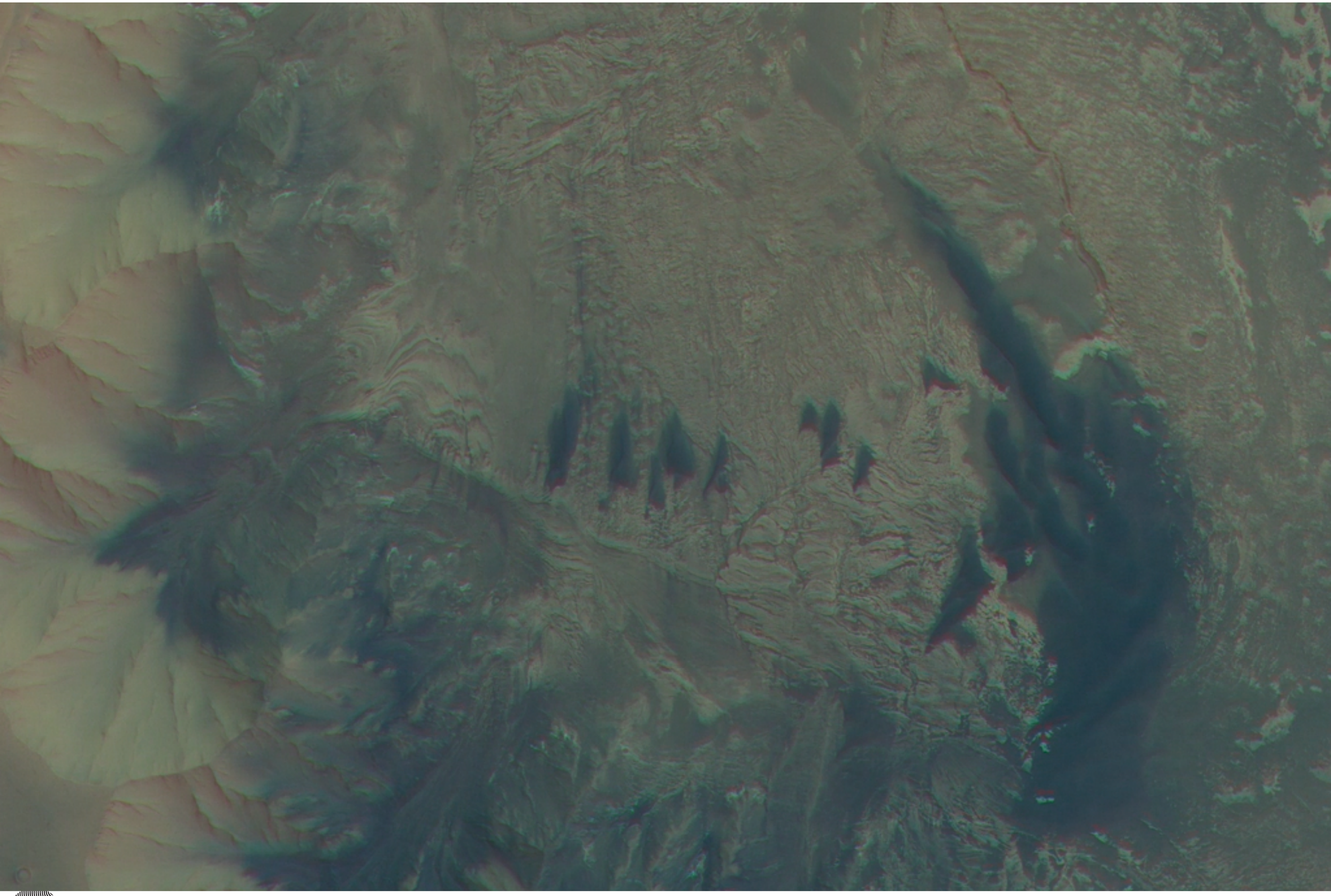

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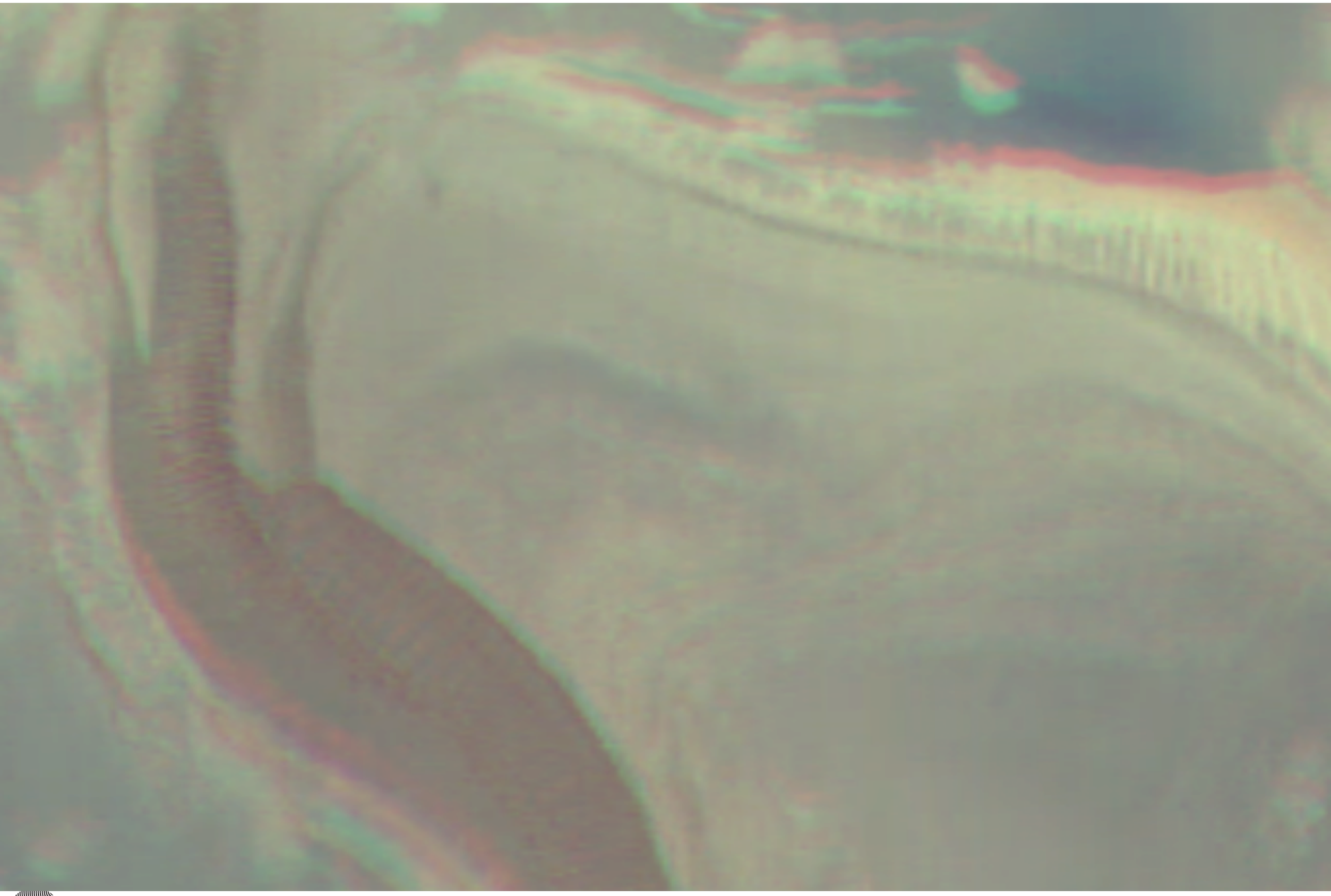

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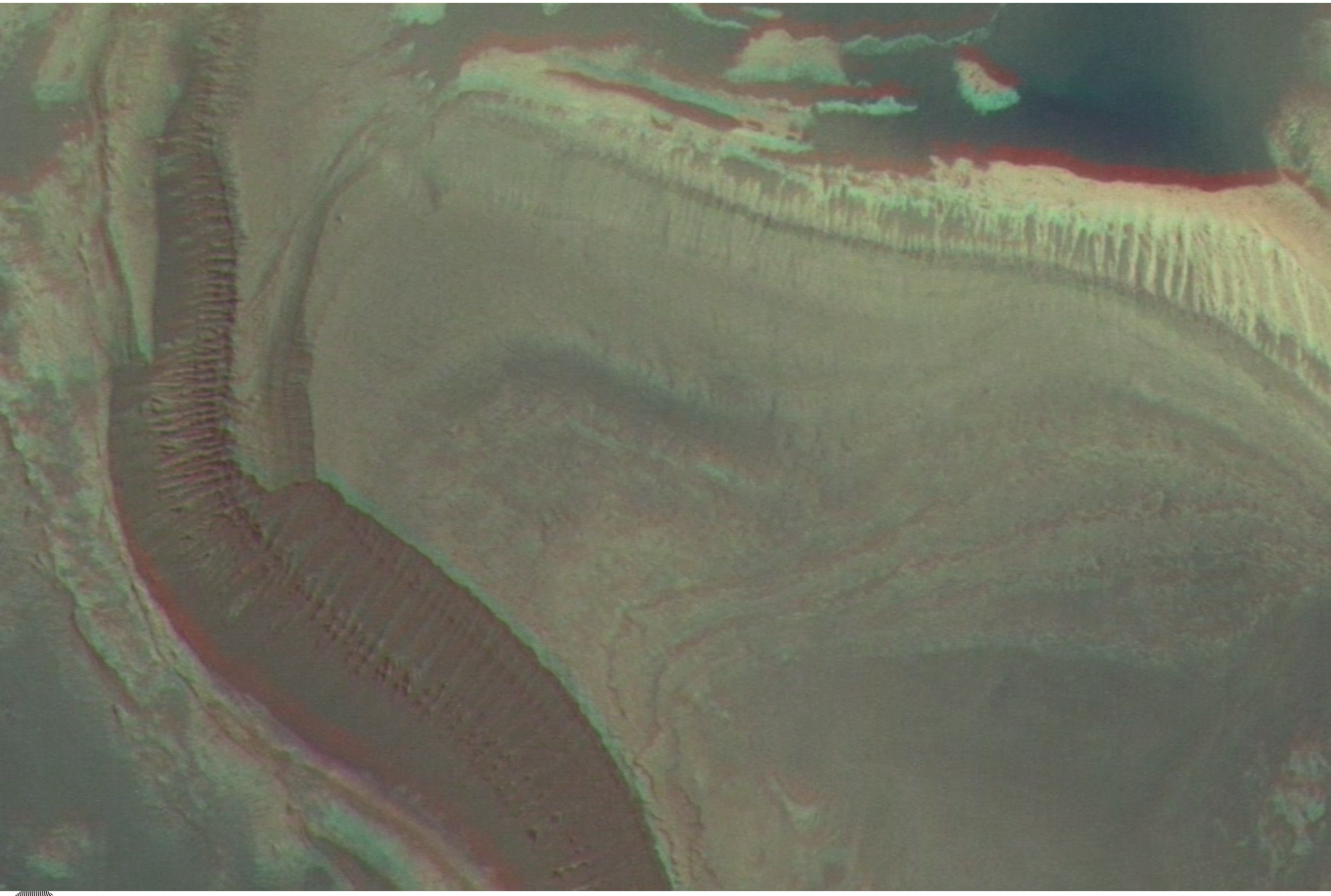

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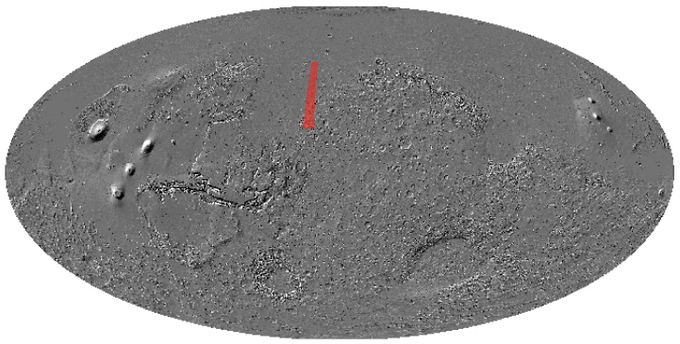
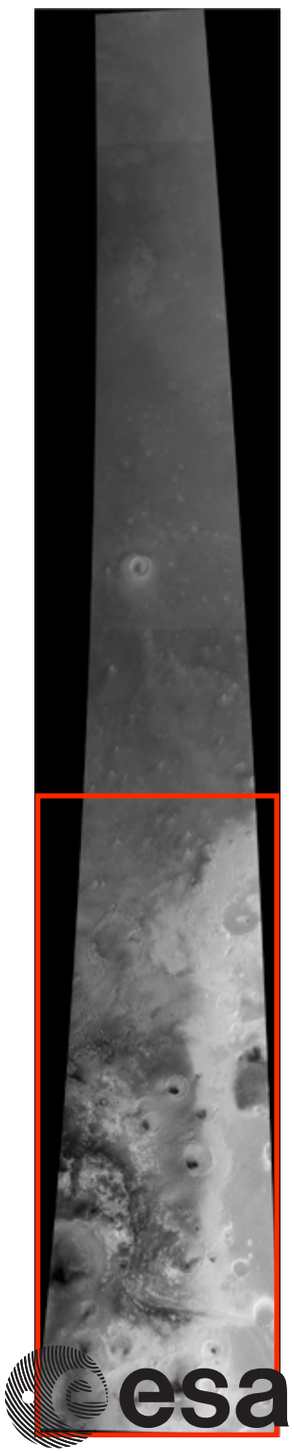
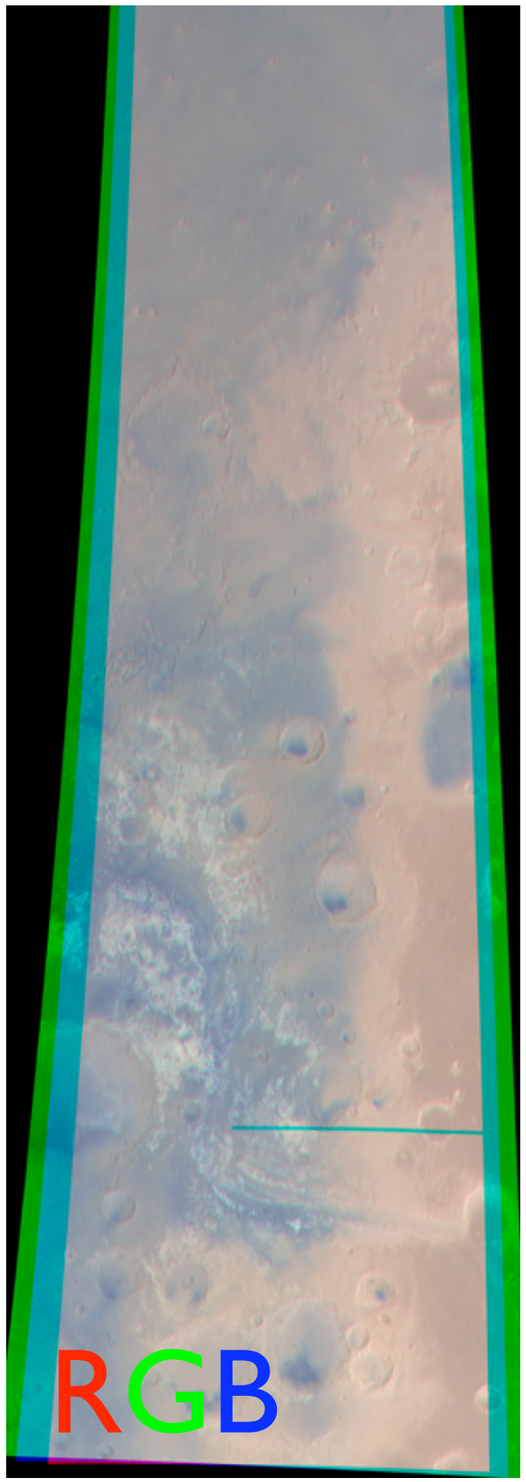
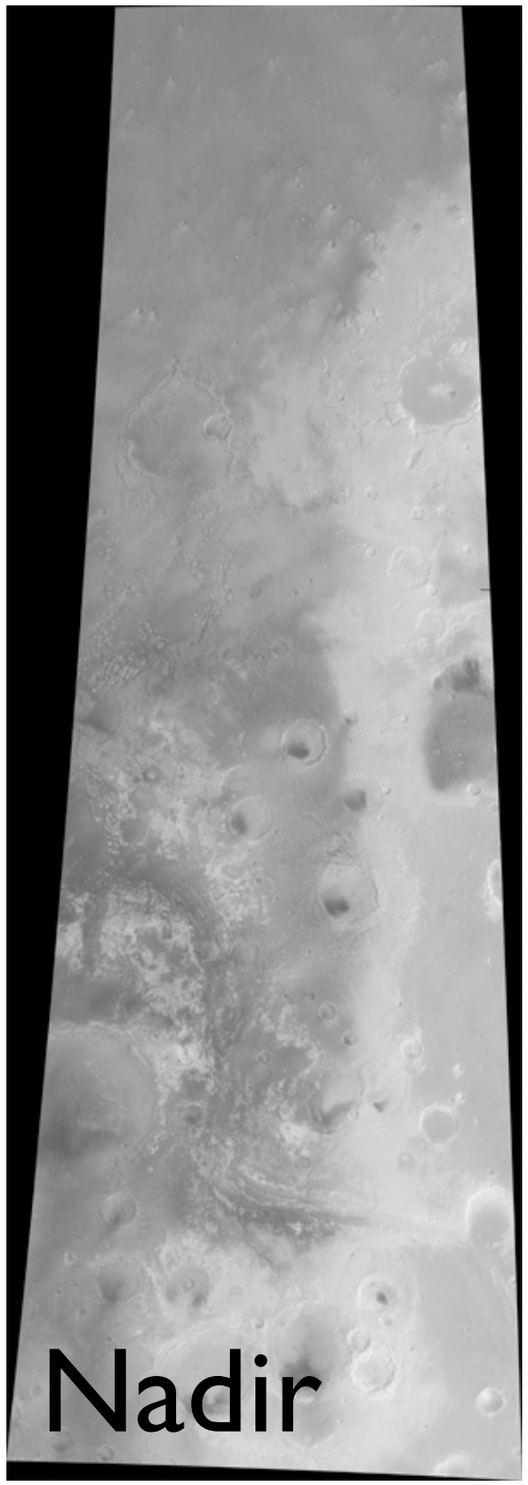
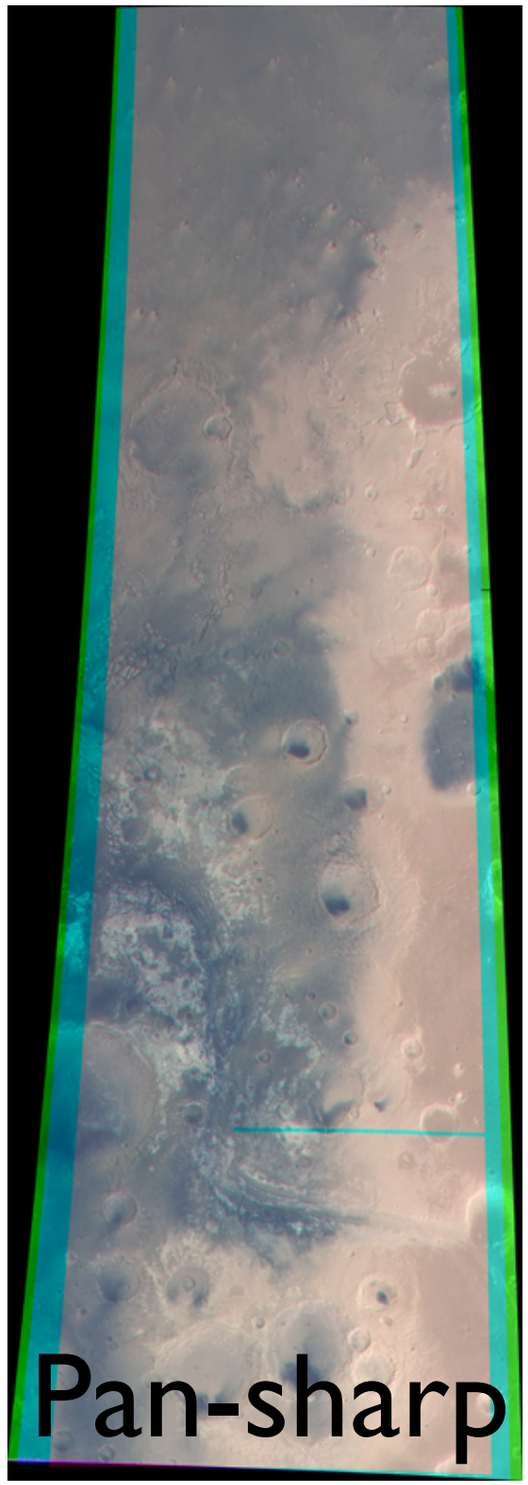


Mawrth vallis









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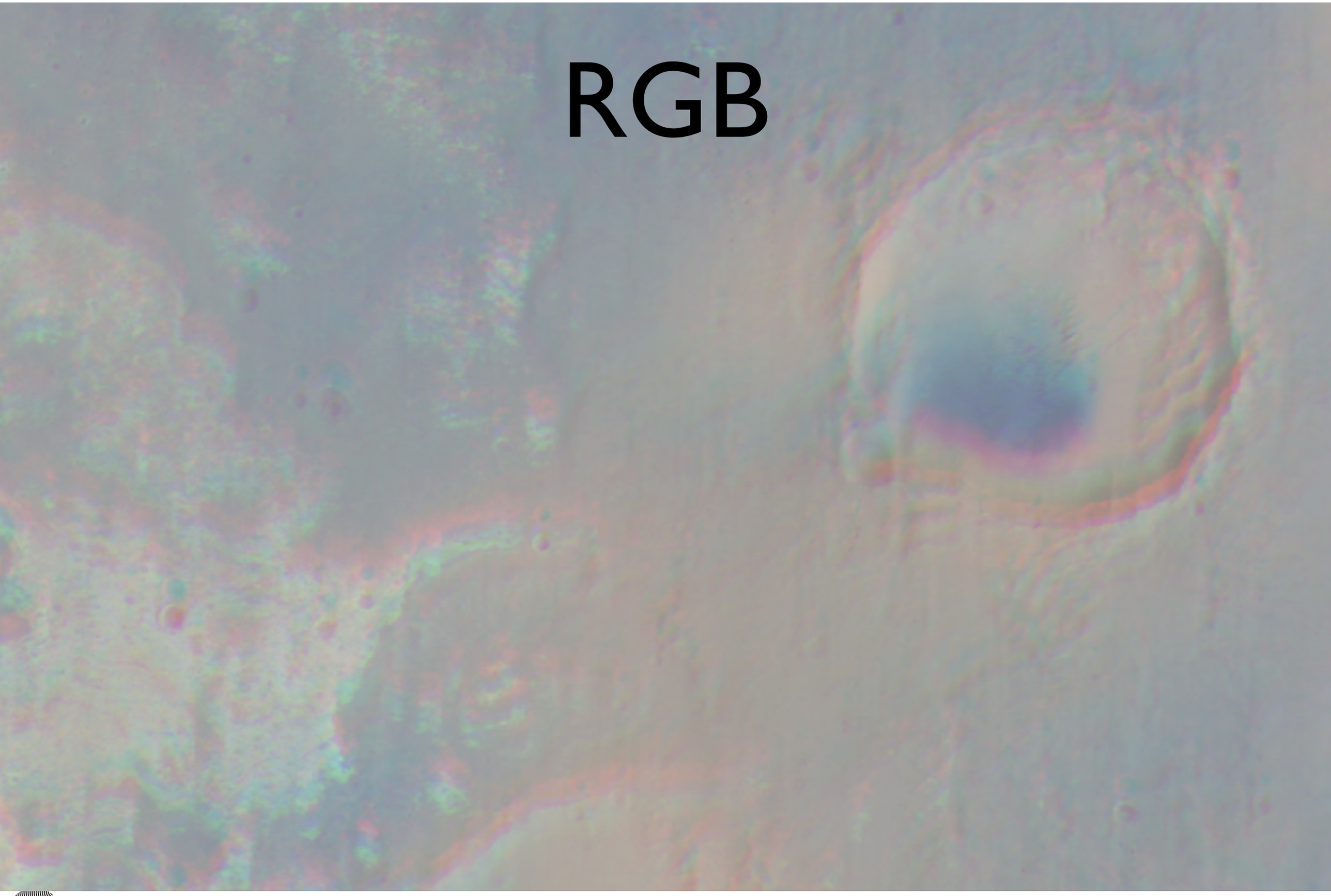
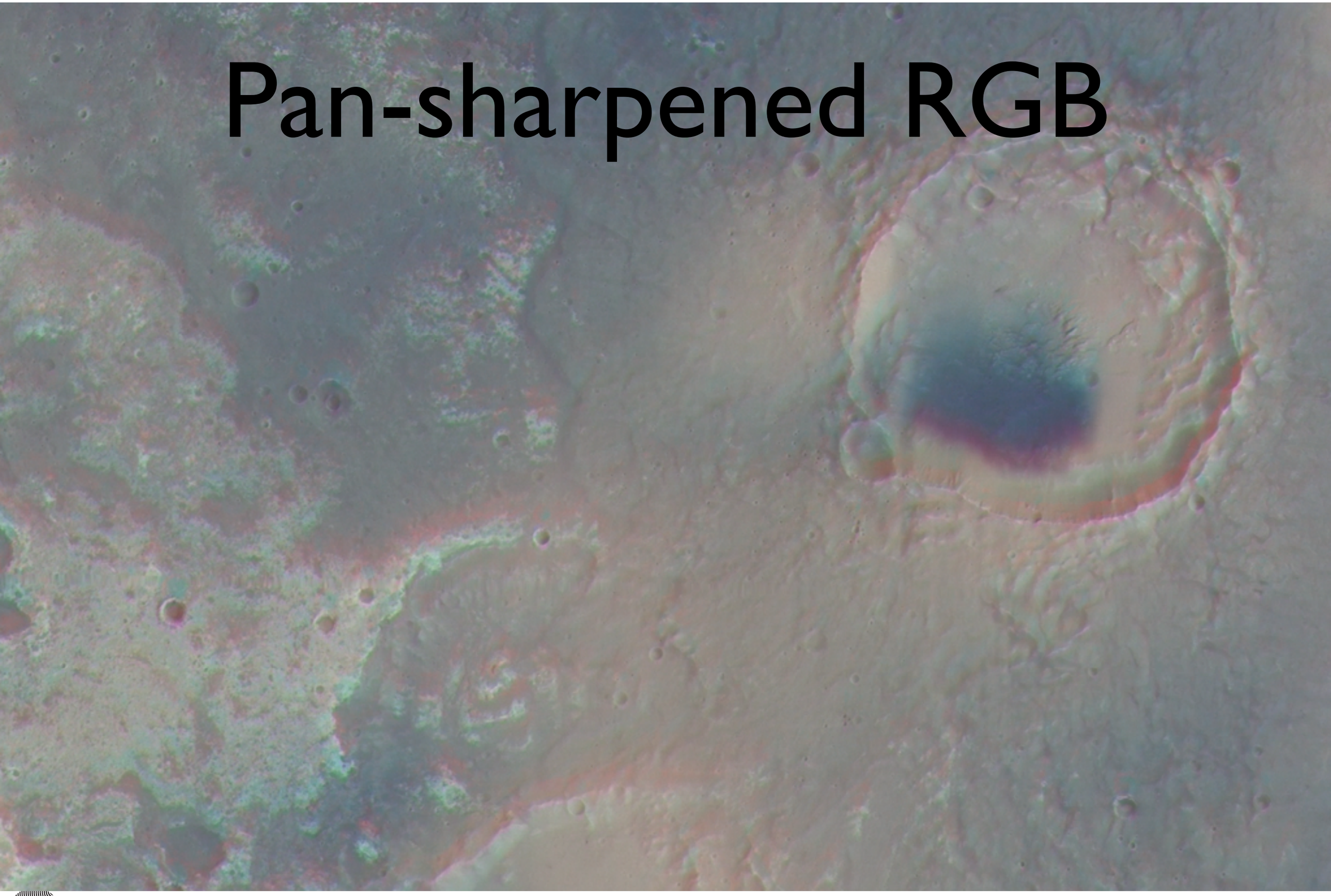
RGB



Pan-sharpened RGB



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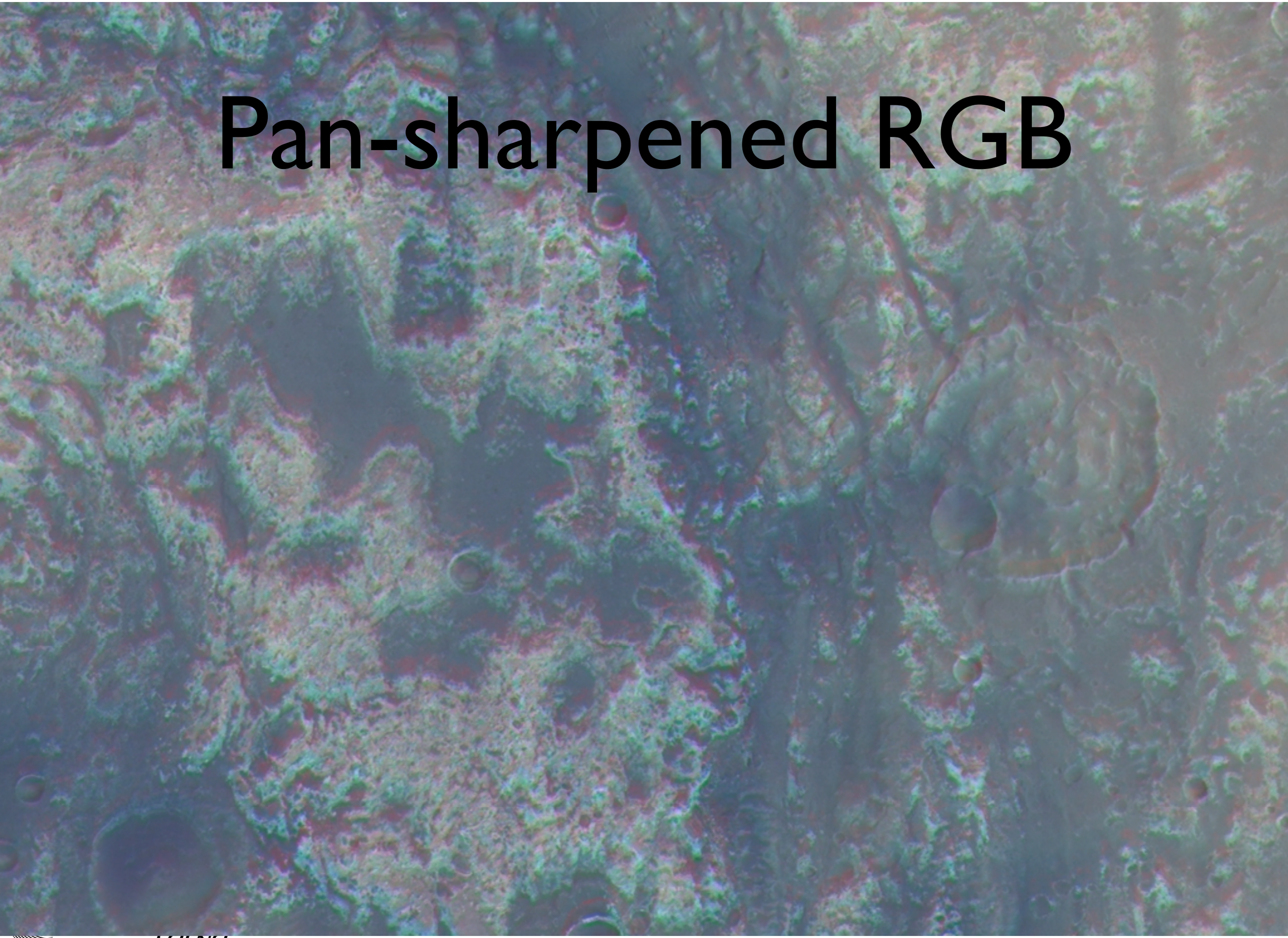
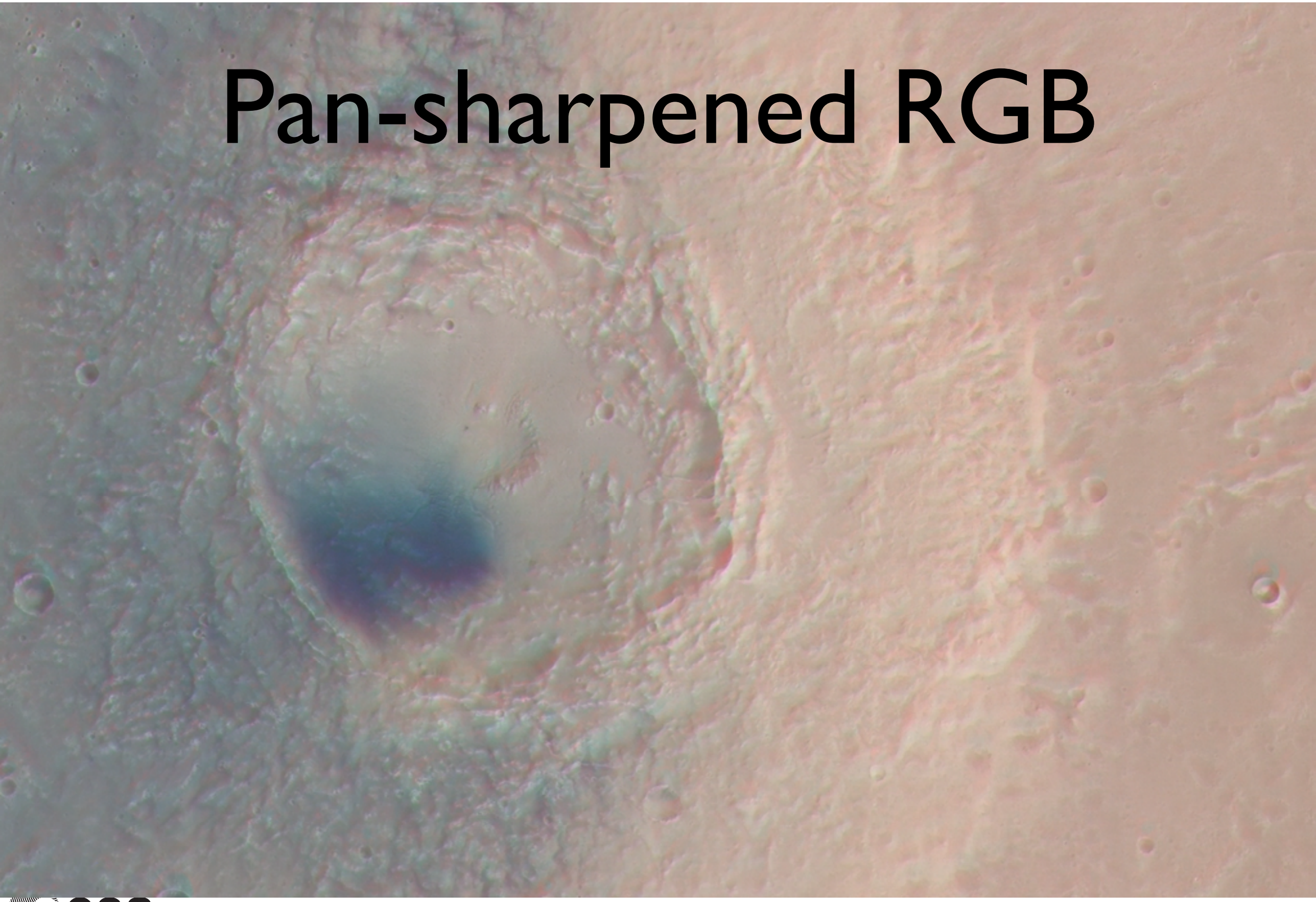
Pan-sharpened RGB



Pan-sharpened RGB

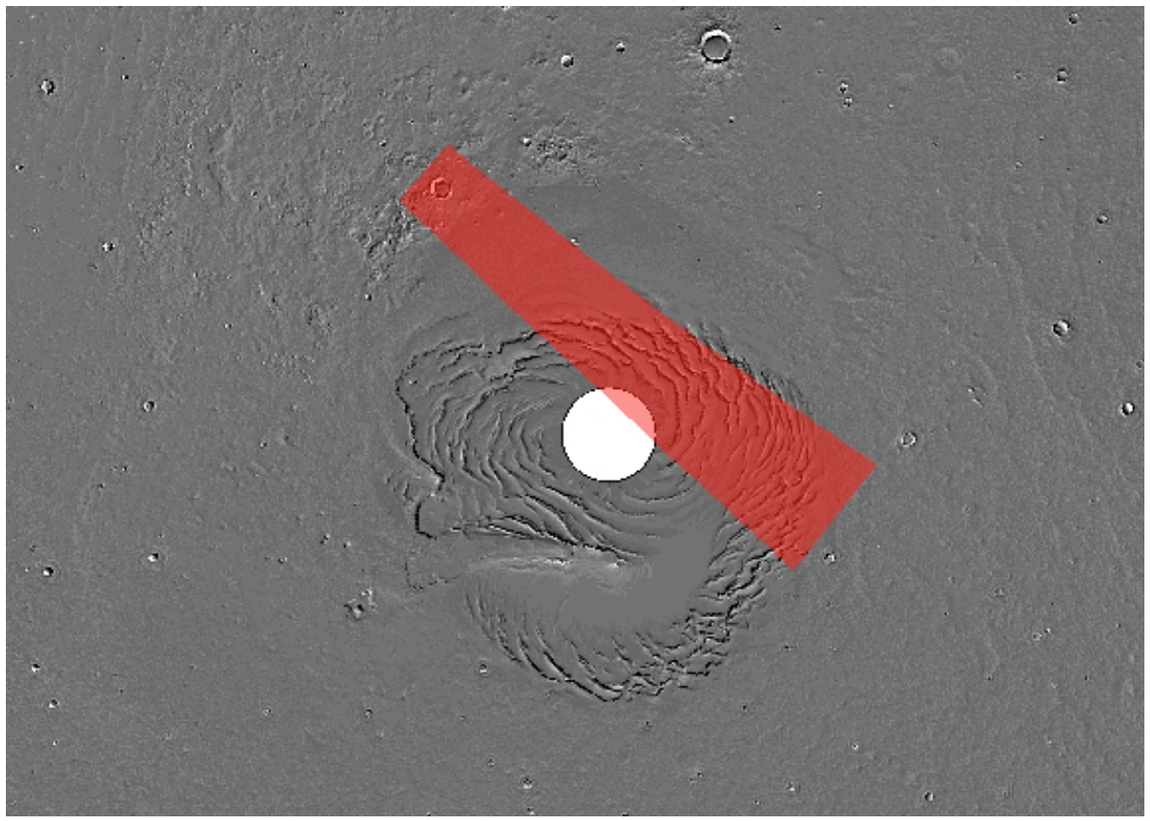


Pan-sharpened RGB

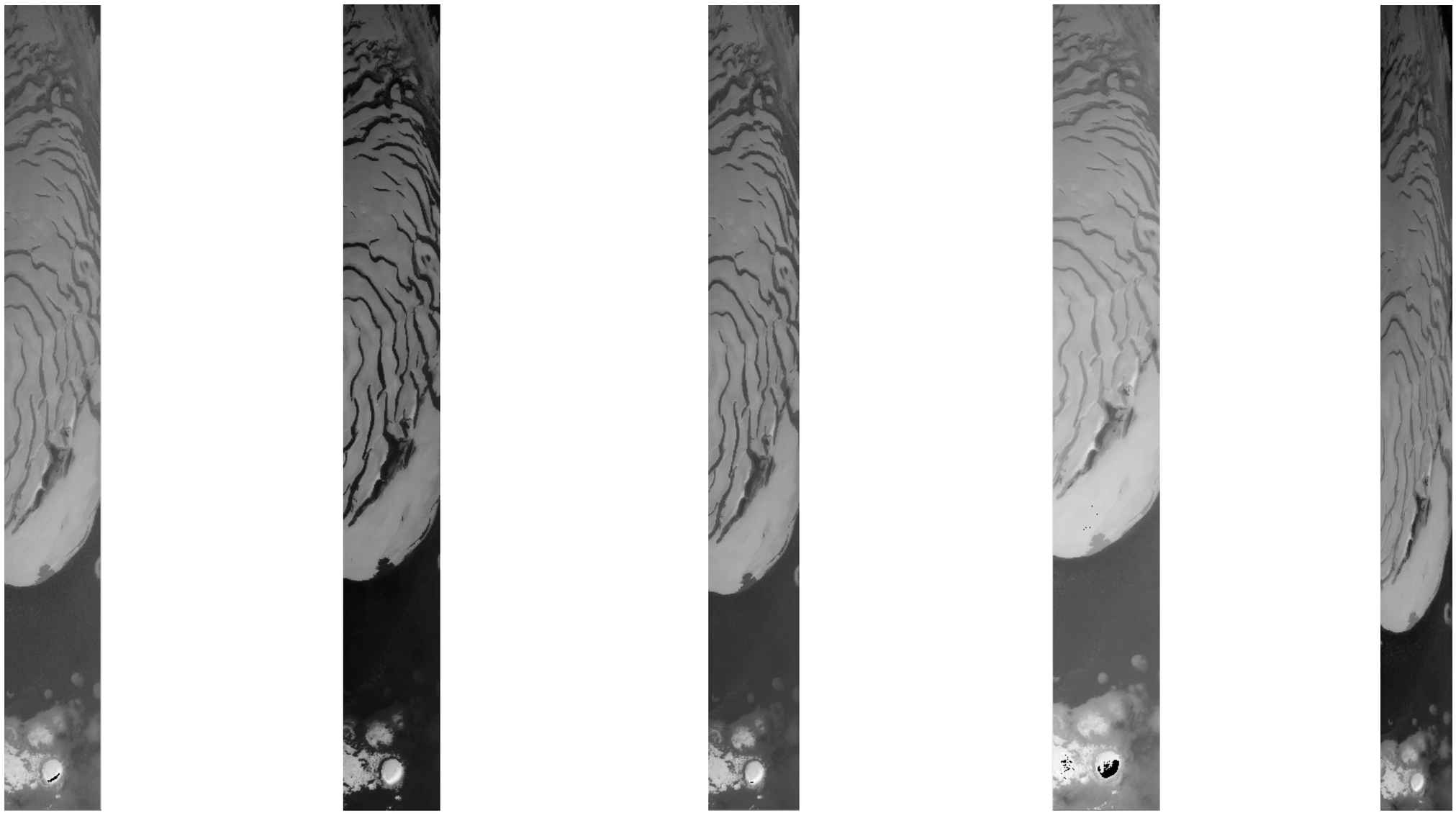
Example - N Pole

Input:
Red, Green, Blue Level2 images

Output:
map-projected RGB
map-projected IrGB
map-projected pan-sharp RGB
map-projected pan-sharp ItGB



HRSC Level2 data



H1177_0000_ND2.IMG H1177_0000_BL2.IMG H1177_0000_GR2.IMG H1177_0000_RE2.IMG H1177_0000_IR2.IMG

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Level2 map projection

WHAT WE NEED:

```
# MINIVICAR VARIABLES

setenv V2TOP /...../minivicar/vicar
source $V2TOP/vicset1.csh
source $V2TOP/vicset2.csh
setenv M94GEOCAL $V2TOP/../GEOCAL
set path = ( $path $V2TOP )

# SPICE KERNELS VARIABLES

setenv MOLA64 $V2TOP/../data/megt88.360hb.vic
setenv LEAPSECONDS $V2TOP/../kernels/NAIF0008.TLS
setenv CONSTANTS $V2TOP/../kernels/PCK00008.TPC
setenv SUNKER $V2TOP/../kernels/DE405S.BSP
setenv HWSPICE_TF $V2TOP/../kernels/MEX_V08.TF
setenv HWSPICE_TI $V2TOP/../kernels/MEX_HRSC_V03.TI
setenv HWSPICE_TSC $V2TOP/../kernels/MEX_070321_STEP.TSC
setenv HWSPICE_BC ./ATNM_P030602191822_00135.BC
setenv HWSPICE_BSP ./ORMM__041201000000_00105.BSP
```

hrortho

WHAT WE DO:

HRORTHO

```
$HWLIB/hrortho inp=H1177_0000_ND2.IMG out=nadir dtm=0 ori=spice sl_inp=3500 nl_inp=4500
a_axis=3376.2 b_axis=3376.2 c_axis=3376.2 mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048

$HWLIB/hrortho inp=H1177_0000_RE2.IMG out=red dtm=0 fitto=nadir ori=spice
a_axis=3376.2 b_axis=3376.2 c_axis=3376.2 mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048

$HWLIB/hrortho inp=H1177_0000_GR2.IMG out=green dtm=0 fitto=nadir ori=spice
a_axis=3376.2 b_axis=3376.2 c_axis=3376.2 mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048

$HWLIB/hrortho inp=H1177_0000_BL2.IMG out=blue dtm=0 fitto=nadir ori=spice
a_axis=3376.2 b_axis=3376.2 c_axis=3376.2 mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048

$HWLIB/hrortho inp=H1177_0000_IR2.IMG out=ir dtm=0 fitto=nadir ori=spice
a_axis=3376.2 b_axis=3376.2 c_axis=3376.2 mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048
```

dlrto8 & dlrvic2png

WHAT WE DO (shown just for one band):

- Convert vicar file from 16 to 8 bit (dlrto8)
- Export 8 bit vicar file to

```
HRORTHO

$HWLIB/dlrto8 inp=nadir out=nadir_8bit.vic dnmin=0


$HWLIB/dlrvic2png inp=nadir_8bit.vic out=NADIR.PNG
```

- Combine rgb single files in RGB file (with imagemagick):

```
convert -combine RED.PNG GREEN.PNG BLUE.PNG RGB.tif
```

Full procedure (i)

Example

```
#!/bin/tcsh

# MINIVICAR VARIABLES
setenv V2TOP /<PATH>/minivicar/vicar
source $V2TOP/vicset1.csh
source $V2TOP/vicset2.csh
setenv M94GEOCAL $V2TOP/../GEOCAL
set PATH = ( $PATH $V2TOP )

# VARIABLES FOR KERNELS AND DATA
setenv LEAPSECONDS $V2TOP/../kernels/NAIF0008.TLS
setenv CONSTANTS $V2TOP/../kernels/PCK00008.TPC
setenv SUNKER $V2TOP/../kernels/DE405S.BSP
setenv HWSPICE_TF $V2TOP/../kernels/MEX_V08.TF
setenv HWSPICE_TI $V2TOP/../kernels/MEX_HRSC_V03.TI
setenv HWSPICE_TSC $V2TOP/../kernels/MEX_070321_STEP.TSC
setenv HWSPICE_BC ./ATNM_P030602191822_00135.BC
setenv HWSPICE_BSP ./ORMM__041201000000_00105.BSP

# HRORTHO
$HWLIB/hrortho inp=H1177_0000_ND2.IMG out=nadir dtm=0 ori=spice a_axis=3376.2 b_axis=3376.2 c_axis=3376.2
mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048 mp_sca=0.2

$HWLIB/hrortho inp=H1177_0000_RE2.IMG out=red dtm=0 fitto=nadir ori=spice a_axis=3376.2 b_axis=3376.2 c_axis=3376.2
mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048

$HWLIB/hrortho inp=H1177_0000_GR2.IMG out=green dtm=0 fitto=nadir ori=spice a_axis=3376.2 b_axis=3376.2
c_axis=3376.2 mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048

$HWLIB/hrortho inp=H1177_0000_BL2.IMG out=blue dtm=0 fitto=nadir ori=spice a_axis=3376.2 b_axis=3376.2
c_axis=3376.2 mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048

$HWLIB/hrortho inp=H1177_0000_IR2.IMG out=ir dtm=0 fitto=nadir ori=spice a_axis=3376.2 b_axis=3376.2 c_axis=3376.2
mp_type=STEREOGRAPHIC cen_lat=90 cen_long=0 outmax=2048
```

Full procedure (ii)

Example

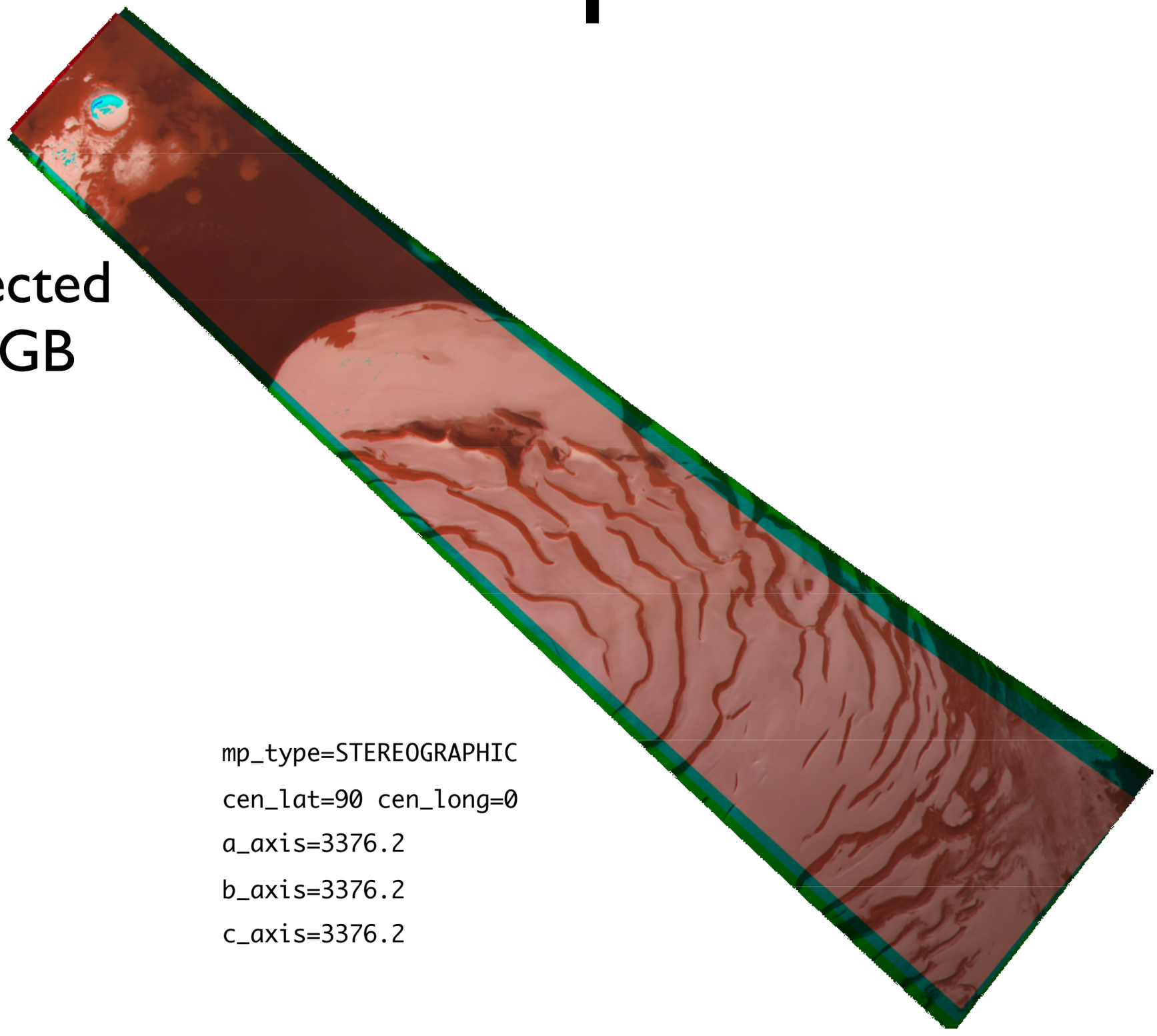
```
# 8 BIT CONVERSION
$HWLIB/dlrto8 inp=nadir out=nadir_8bit.vic dnmin=0
$HWLIB/dlrto8 inp=blue out=blue_8bit.vic dnmin=0
$HWLIB/dlrto8 inp=green out=green_8bit.vic dnmin=0
$HWLIB/dlrto8 inp=red out=red_8bit.vic dnmin=0
$HWLIB/dlrto8 inp=ir out=ir_8bit.vic dnmin=0

# EXPORT TO PNG
$HWLIB/dlrvic2png inp=red_8bit.vic out=RED.PNG
$HWLIB/dlrvic2png inp=green_8bit.vic out=GREEN.PNG
$HWLIB/dlrvic2png inp=blue_8bit.vic out=BLUE.PNG
$HWLIB/dlrvic2png inp=nadir_8bit.vic out=NADIR.PNG
$HWLIB/dlrvic2png inp=ir_8bit.vic out=IR.PNG
```

RGB - example

WHAT WE GET:

Map-projected
HRSC RGB



```
mp_type=STEREOGRAPHIC
cen_lat=90 cen_long=0
a_axis=3376.2
b_axis=3376.2
c_axis=3376.2
```

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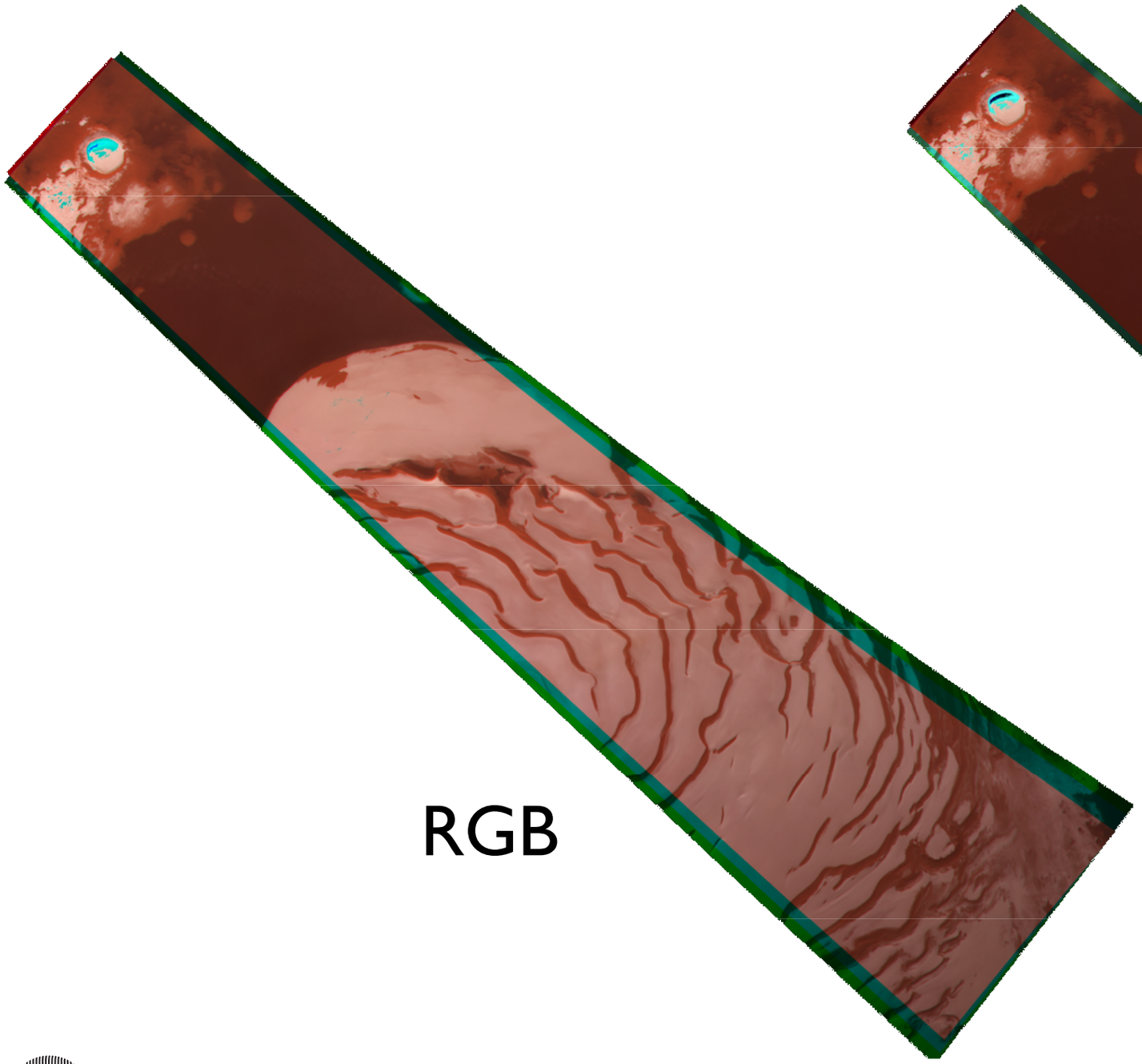
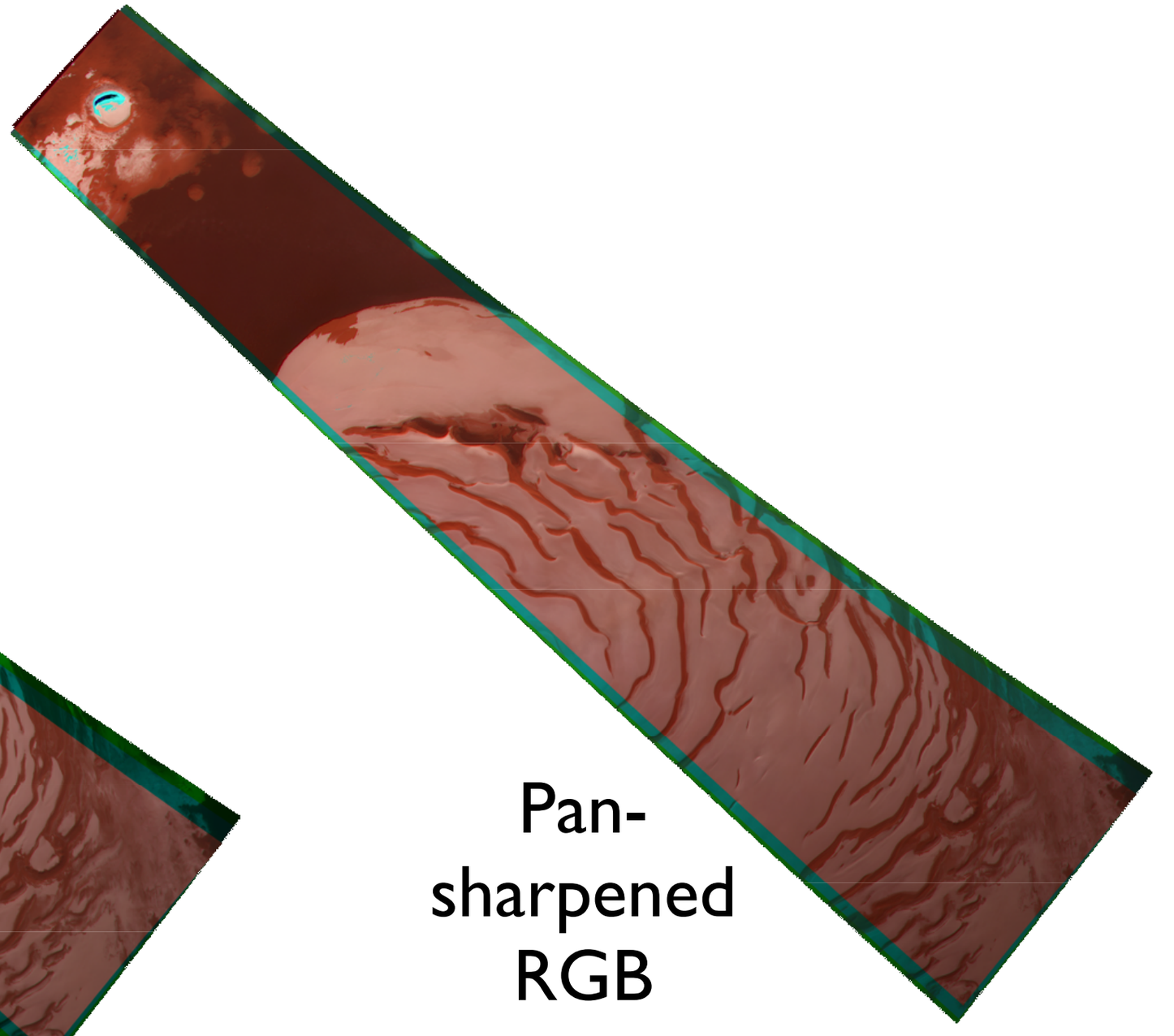
Vicar header

```
PROPERTY = 'MAP'
    TARGET_NAME='MARS'
    MAP_PROJECTION_TYPE='STEREOGRAPHIC'
    COORDINATE_SYSTEM_NAME='PLANETOGRAPHIC'
    POSITIVE_LONGITUDE_DIRECTION='EAST'
    A_AXIS_RADIUS=3376.2
    B_AXIS_RADIUS=3376.2
    C_AXIS_RADIUS=3376.2
    BODY_LONG_AXIS=0.0
    MAP_SCALE=0.2
    CENTER_LATITUDE=90.0
    CENTER_LONGITUDE=0.0
    SPHERICAL_AZIMUTH=0.0
    LINE_PROJECTION_OFFSET=3691.0
    SAMPLE_PROJECTION_OFFSET=2664.0
    MAP_PROJECTION_DESC=(
    'A conformal, azimuthal projection where the central meridian and a particular',
    'parallel (if shown) are straight lines.  This is a perspective projection for',
    'the sphere.  All meridians on the polar aspect and the equator on the',
    'equatorial aspect are straight lines.  All other meridians and parallels are',
    'shown as arcs of circles.  Directions from the center of the projection are',
    'true (except on ellipsoidal oblique and equatorial aspects).  Scale',
    'increases away from the center of the projection.  Equations (21-2), (21-3),',
    '(21-4), (20-14) through (20-18), (21-15) of USGS Paper 1395 (pp 157-159) were used.',
    'The value of the COORDINATE_SYSTEM_NAME item determines whether latitudes are',
    'planetographic or planetocentric;  if this  keyword is absent, then',
    'the default is planetographic.',
    'The direction of increasing longitude is defined by the POSITIVE_LONGITUDE_DIRECTION',
    'item;  if this keyword is absent, then the direction is determined by',
    'COORDINATE_SYSTEM_NAME:  it is East if the system is planetographic, West if it is',
    'planetocentric.',
    'NOTE: Portions of above text taken from U.S. Geological Survey Professional Paper 1395,',
    'second printing 1989, ''Map Projections - A Working Manual'' by John Snyder.',
```

RGB vs. Pan-sharp



RGB



Pan-sharpened RGB

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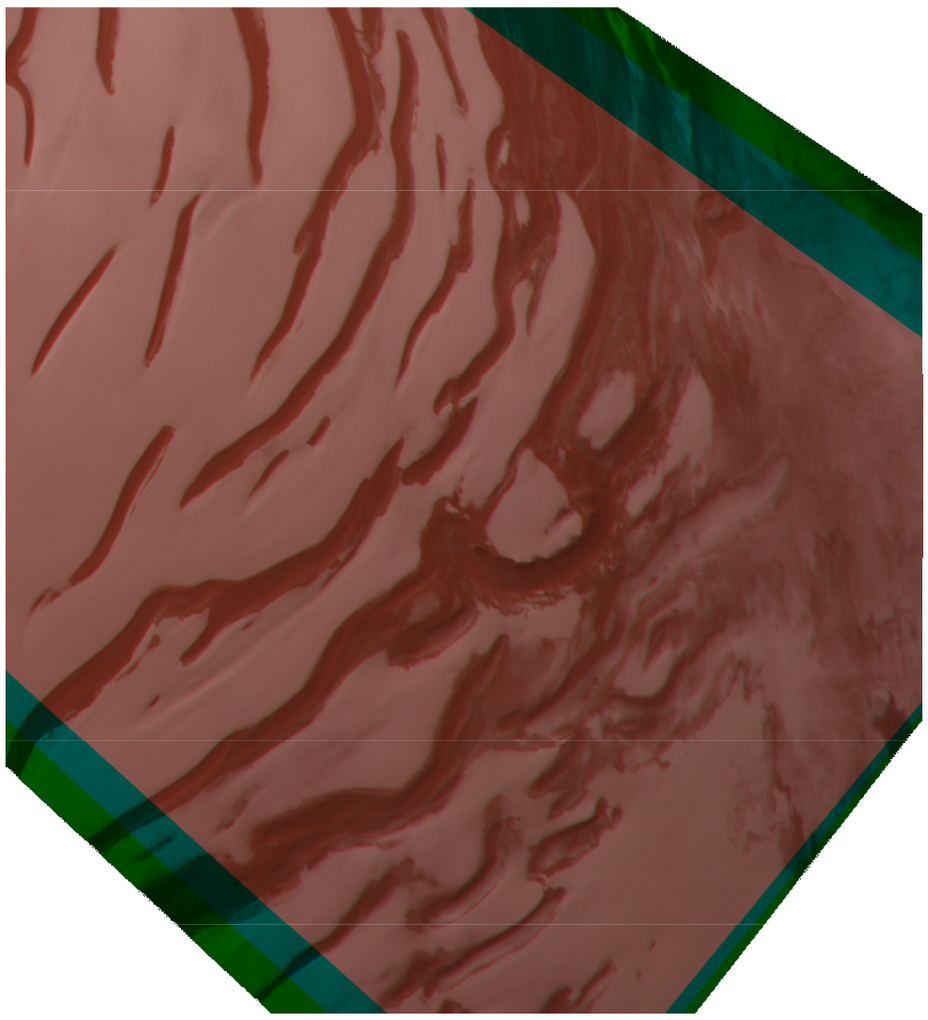
Detail

Subset:

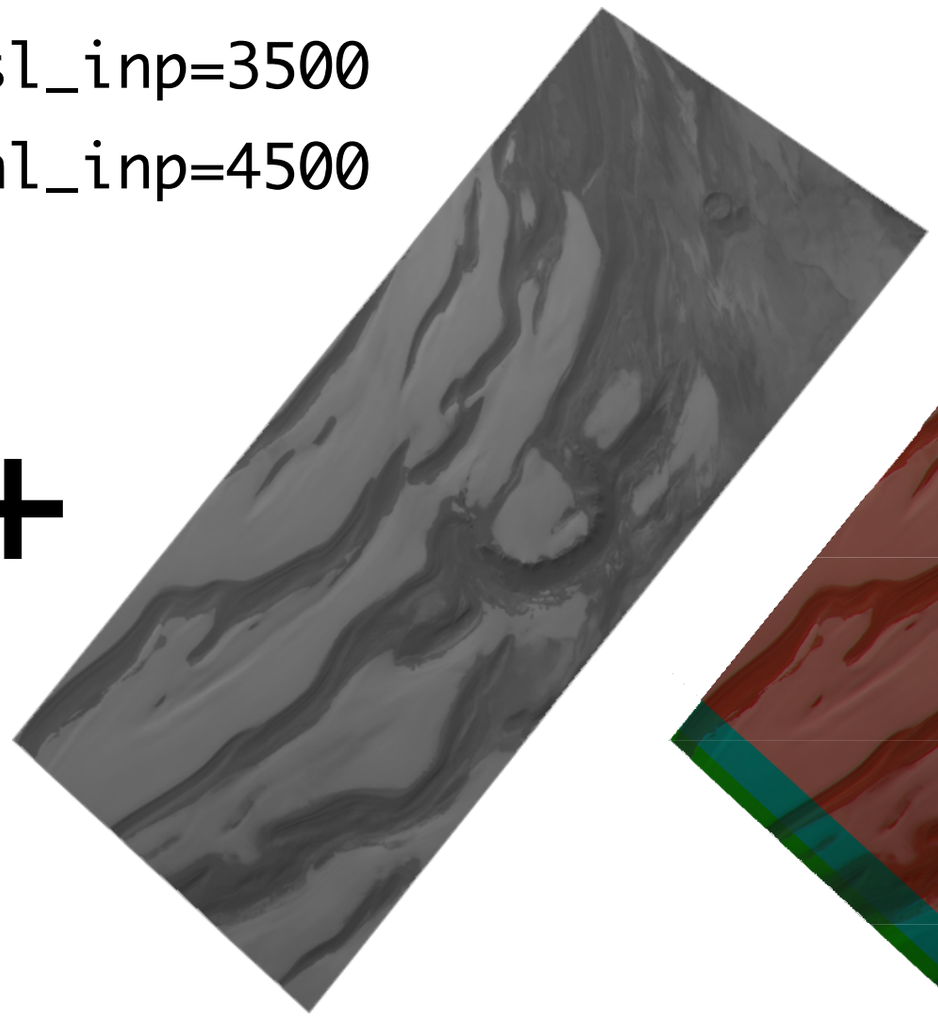
sl_inp=3500

nl_inp=4500

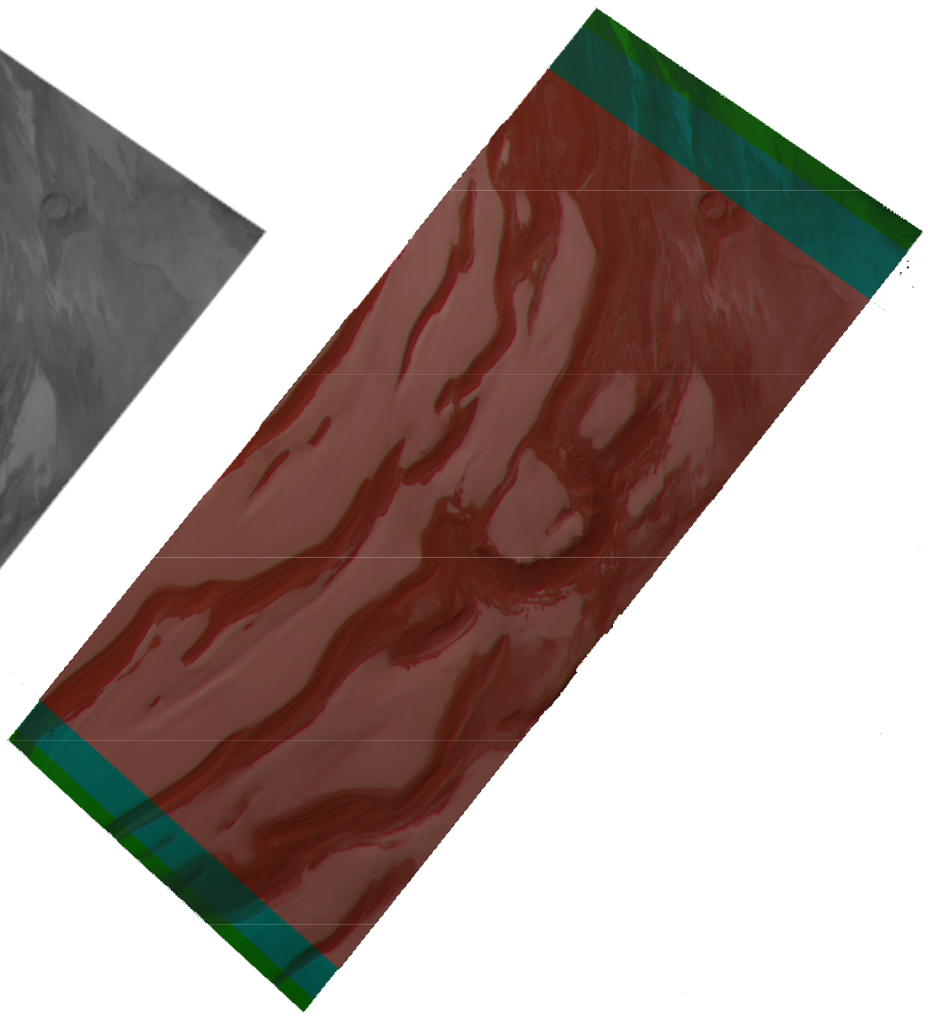


RGB

+



Nadir



Pan-sharp

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Detail

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Detail

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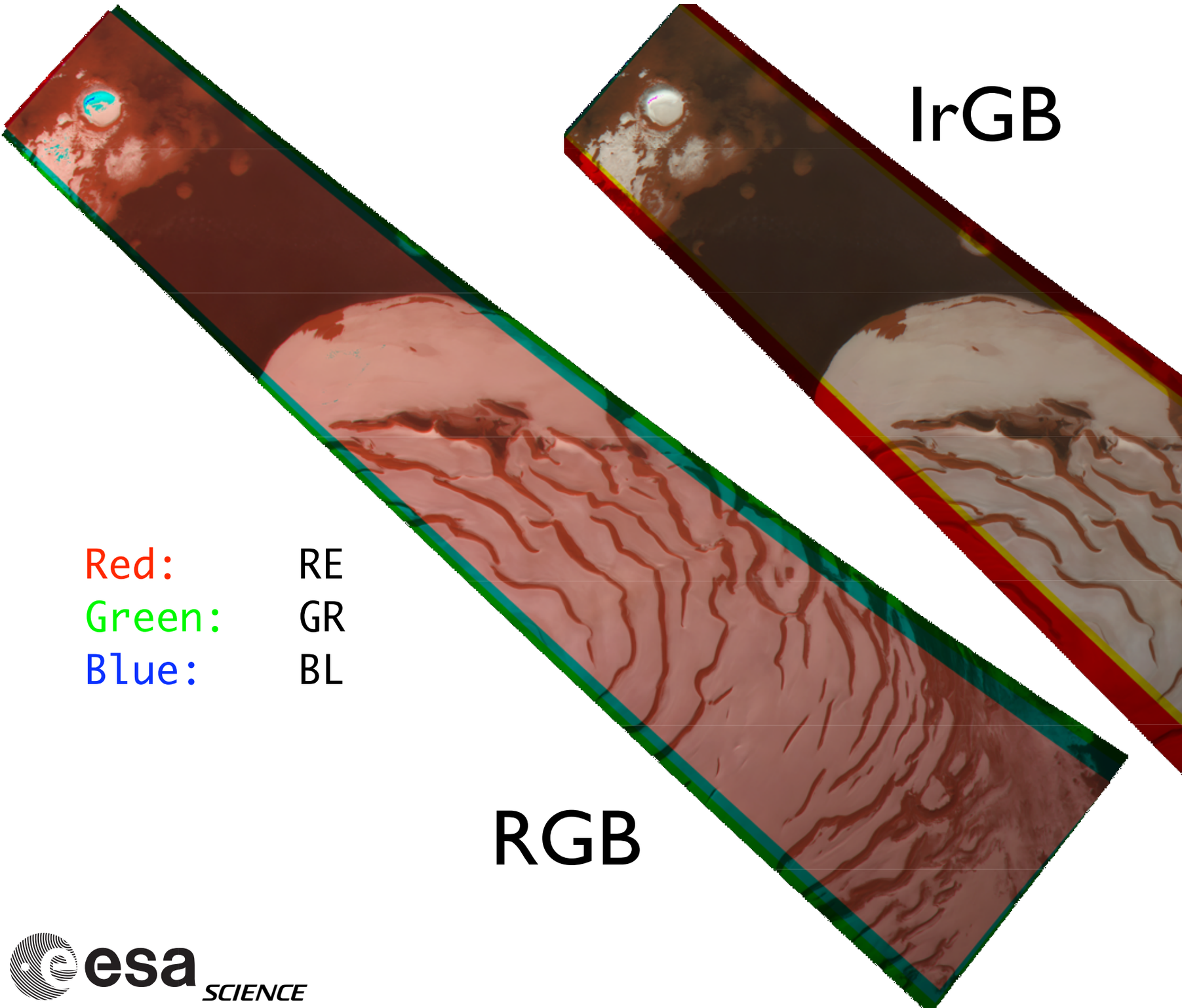
IrGB



Red: RE
Green: GR
Blue: BL

RGB

IrGB

Red: IR
Green: GR
Blue: BL

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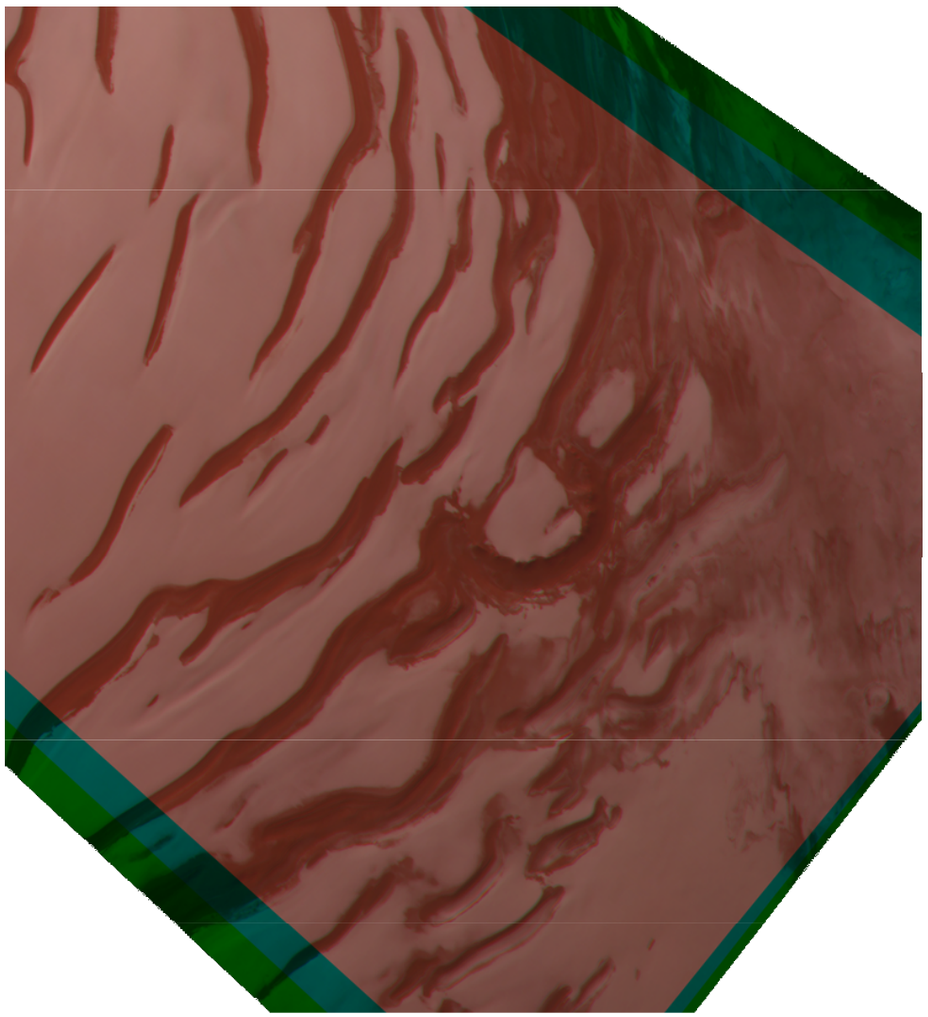
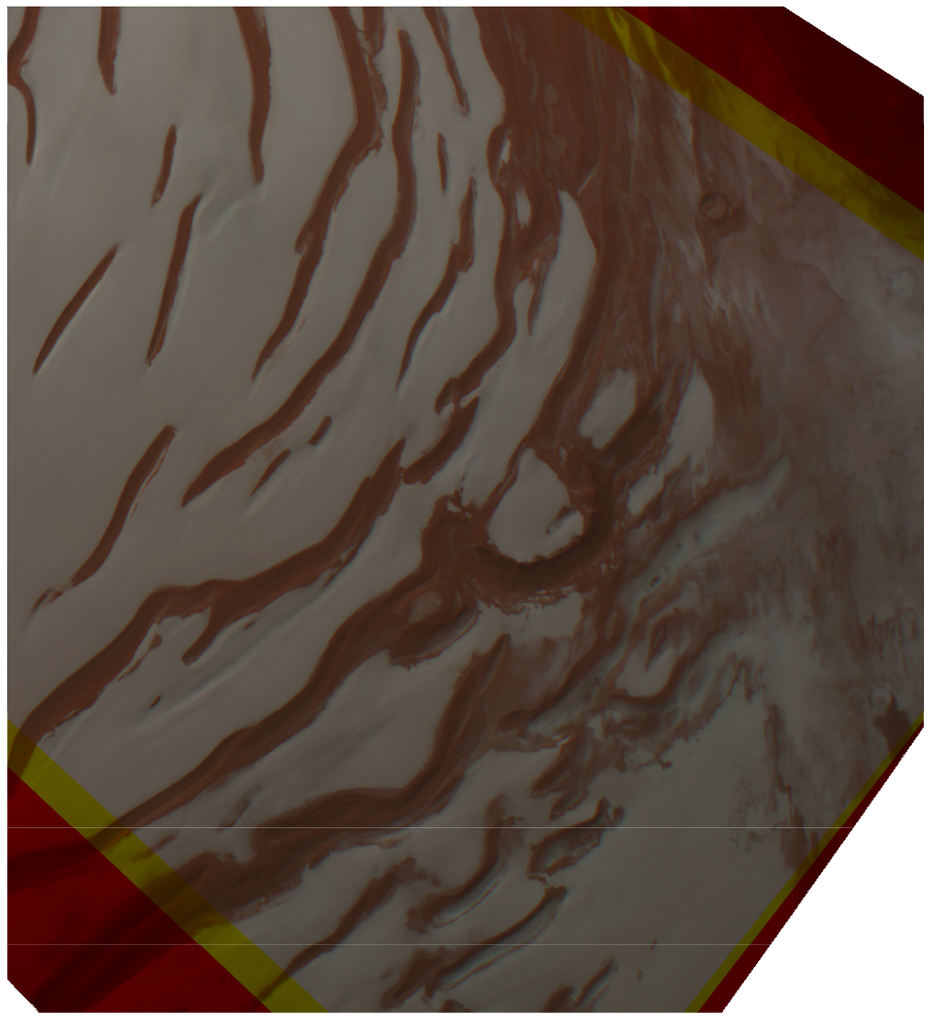
IrGB



RGB



IrGB

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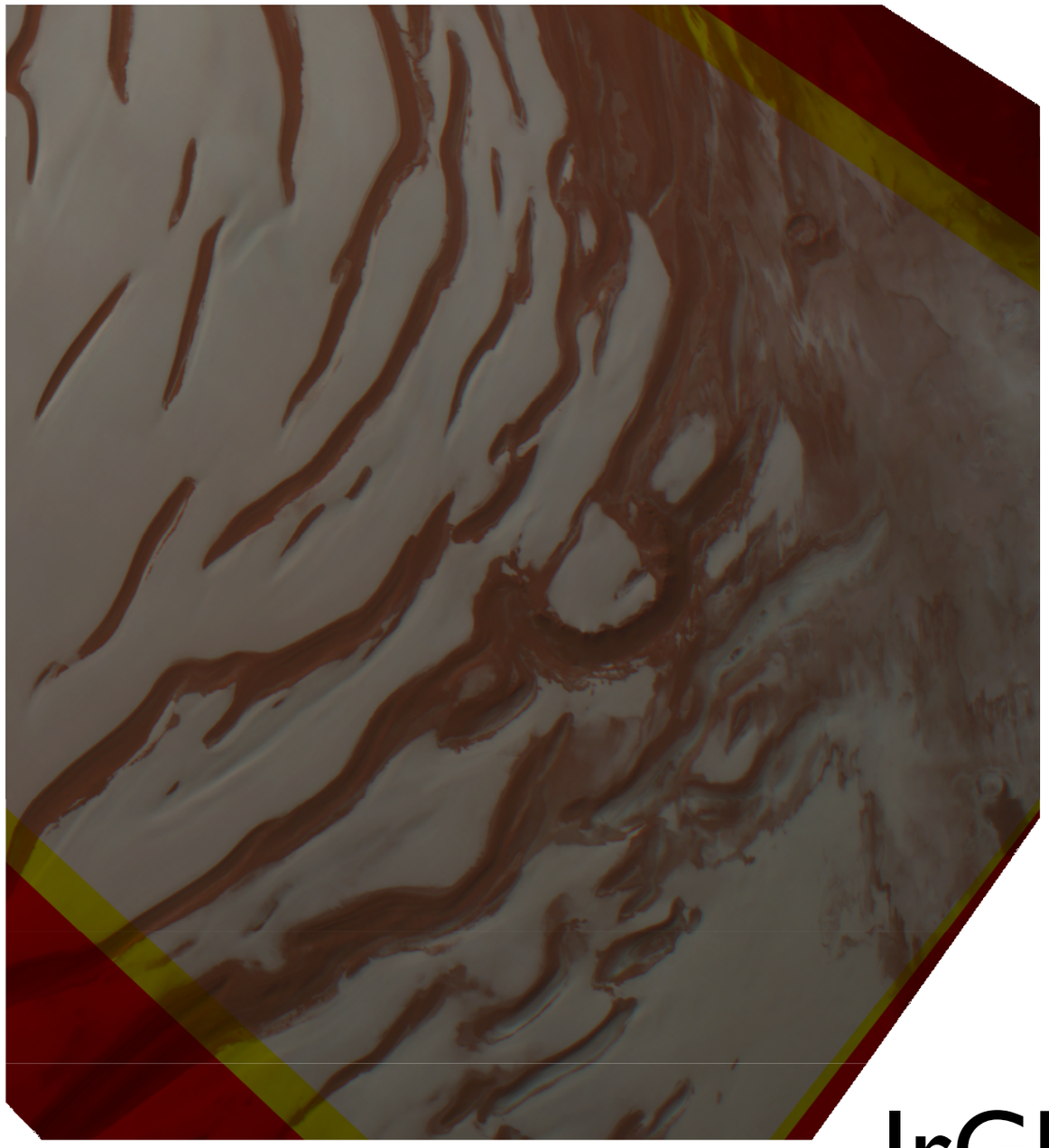
Pan-sharp IrGB



IrGB

Pan-sharp IrGB

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Pan-sharp IrGB

(enhanced brightness, contrast)

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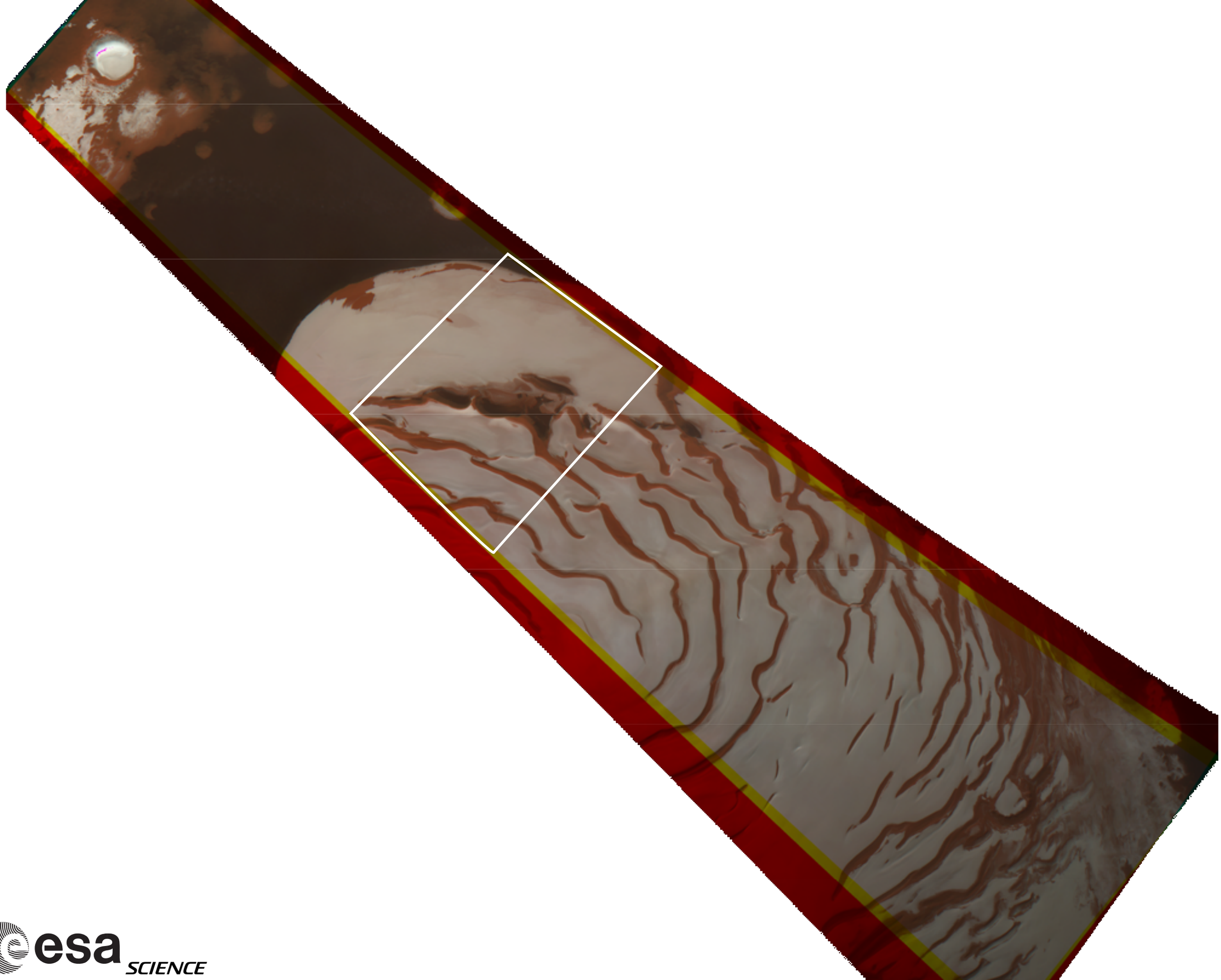

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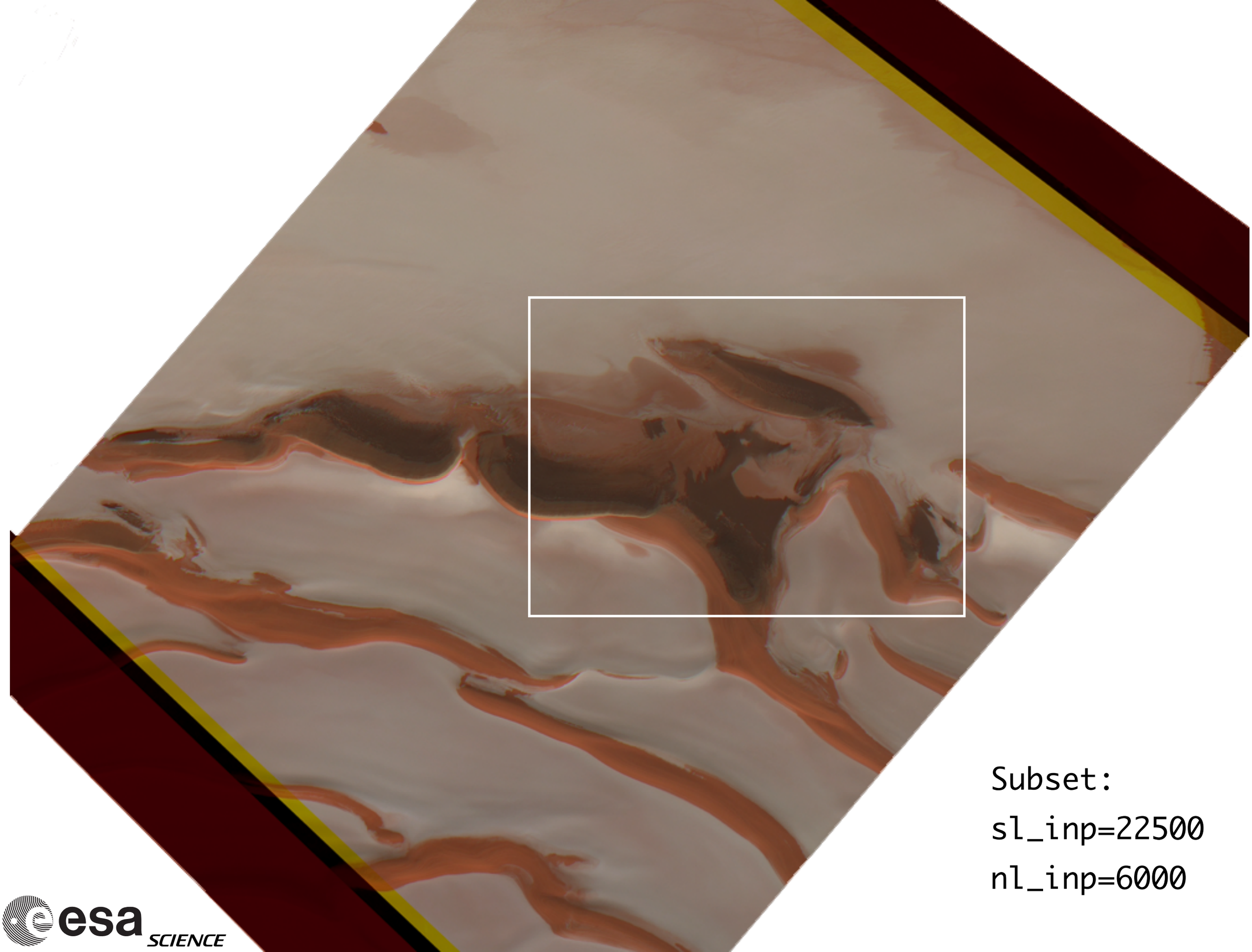

Subset:

sl_inp=22500

nl_inp=6000

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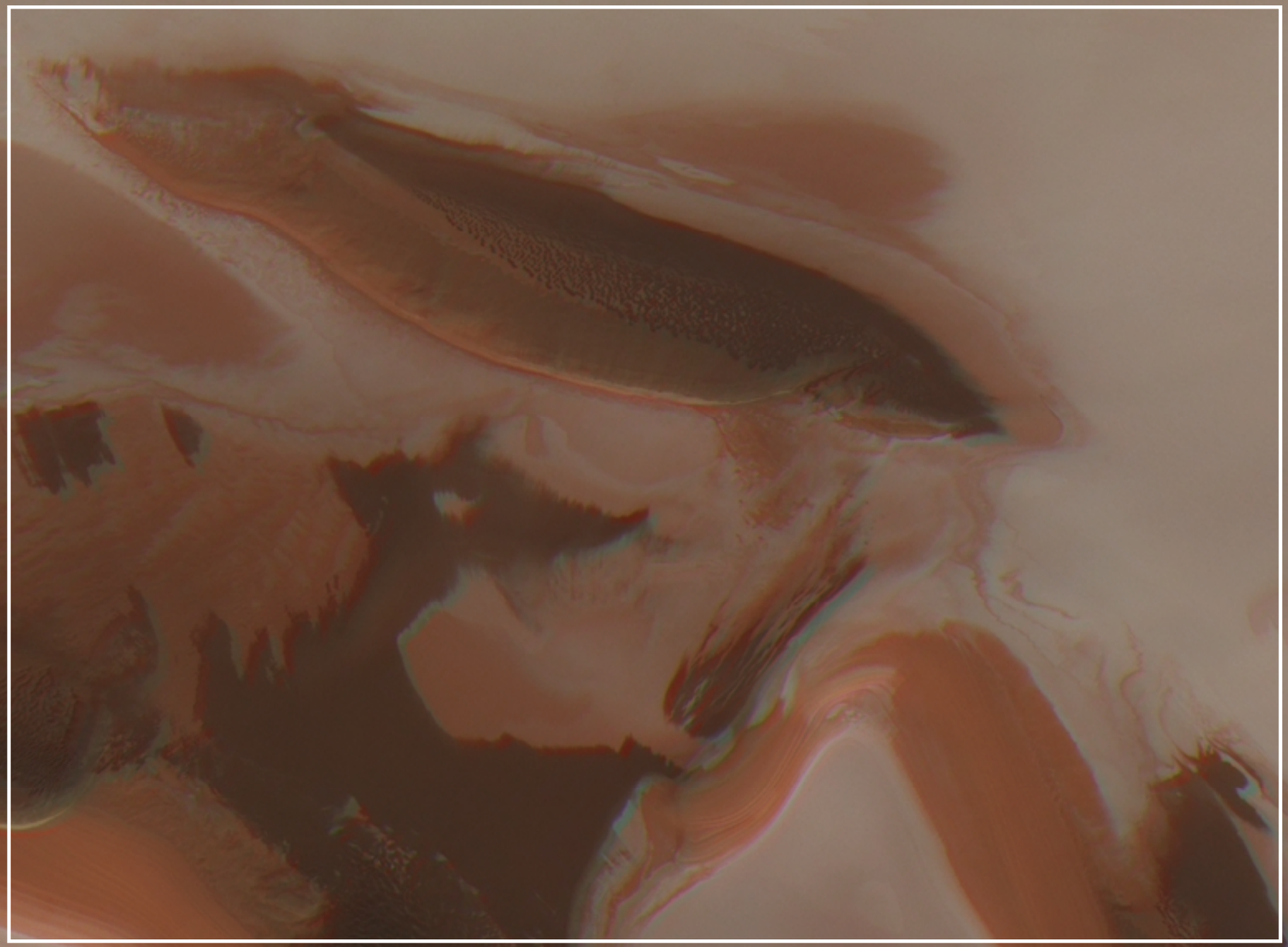

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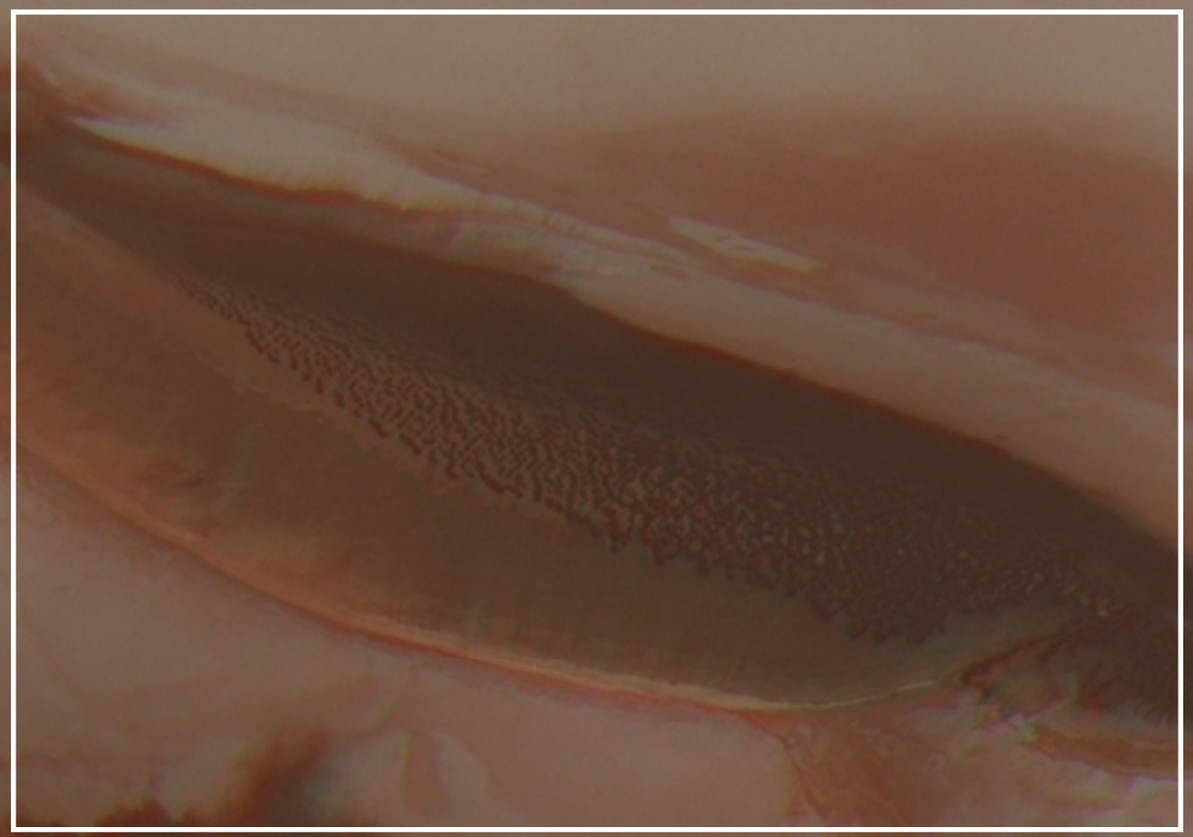

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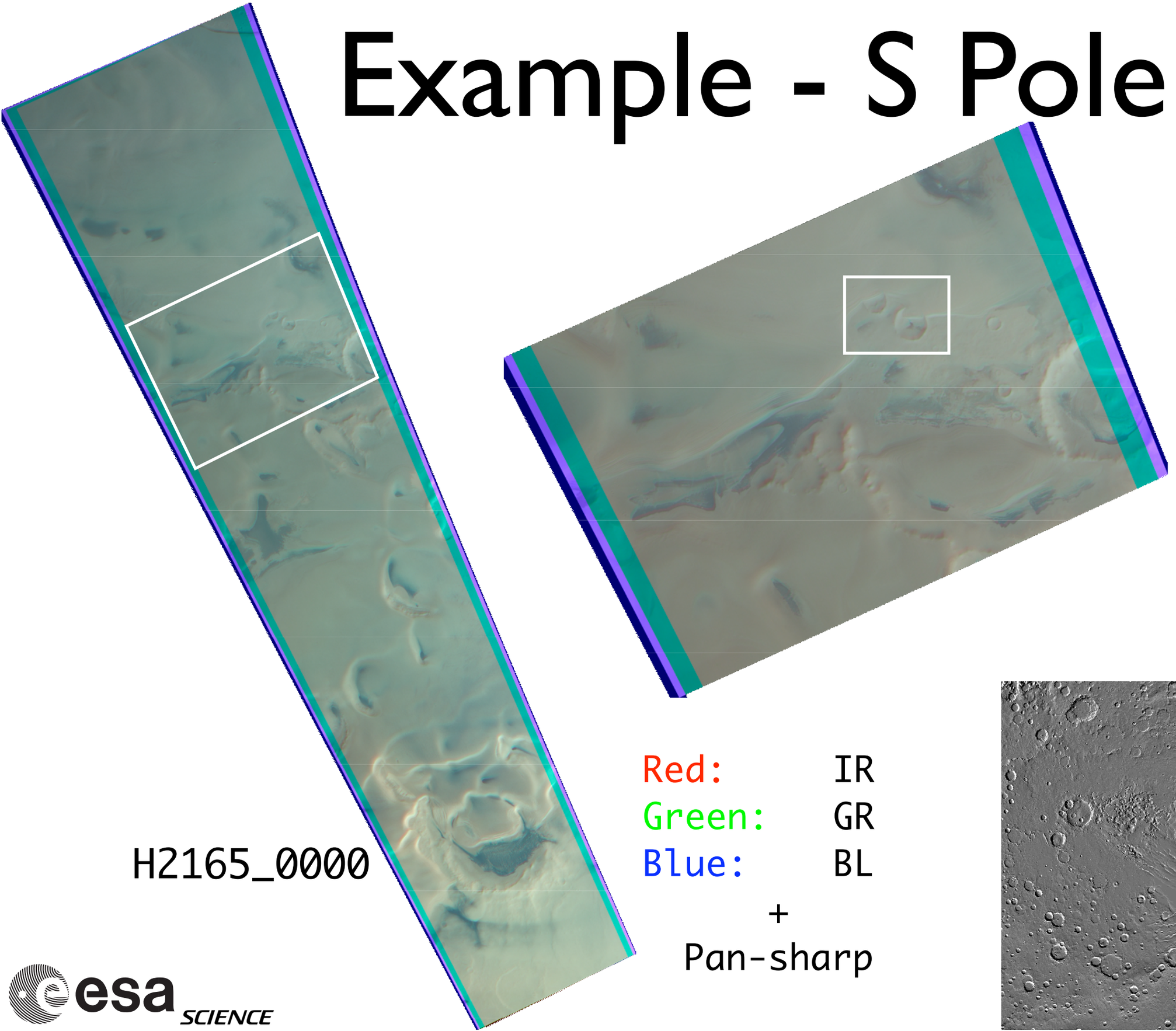
esa SCIENCE

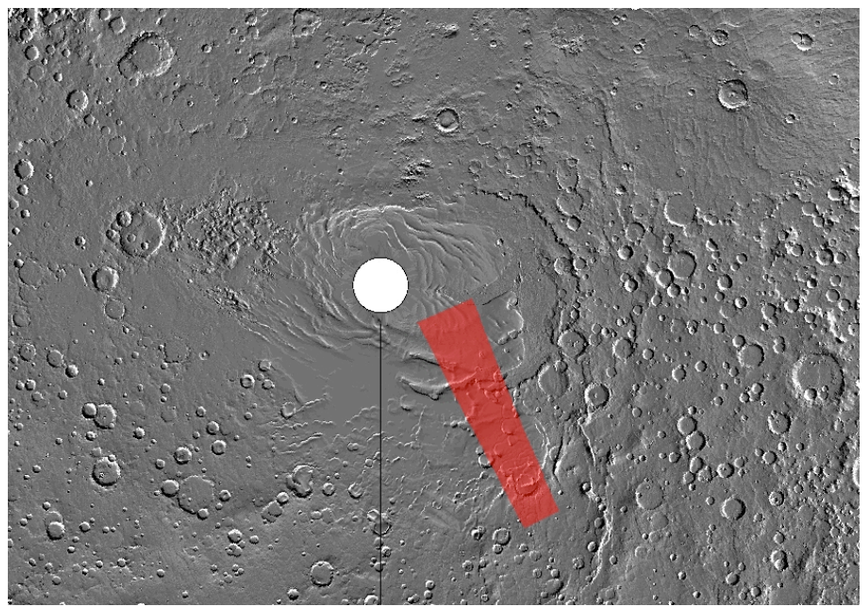
Example - S Pole



H2165_0000

Subset:
sl_inp=10000
nl_inp=6000

Red: IR
Green: GR
Blue: BL
+
Pan-sharp



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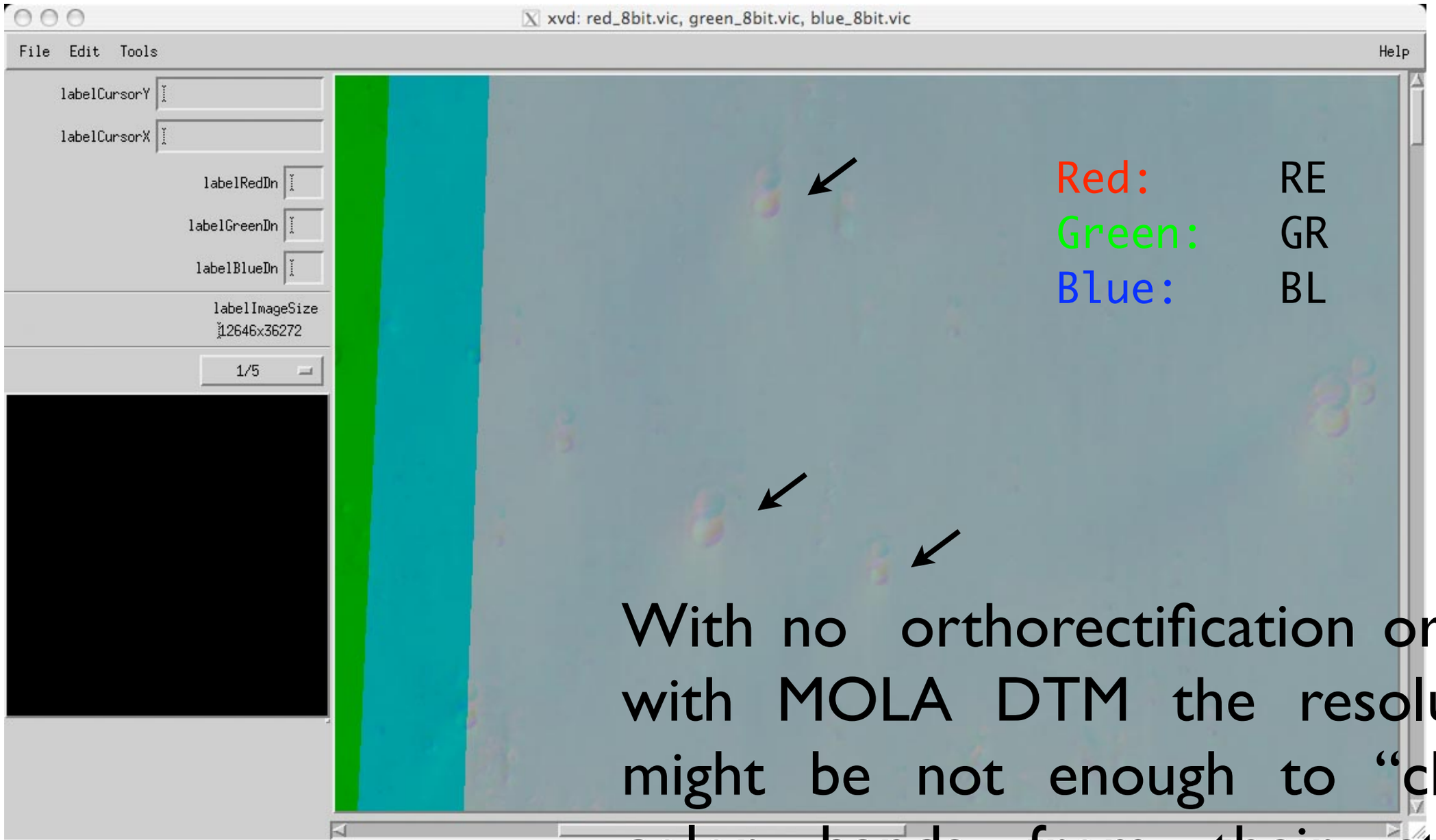
Example - S Pole

Limits



With no orthorectification or just with MOLA DTM the resolution might be not enough to "clean" color bands from their stereo component

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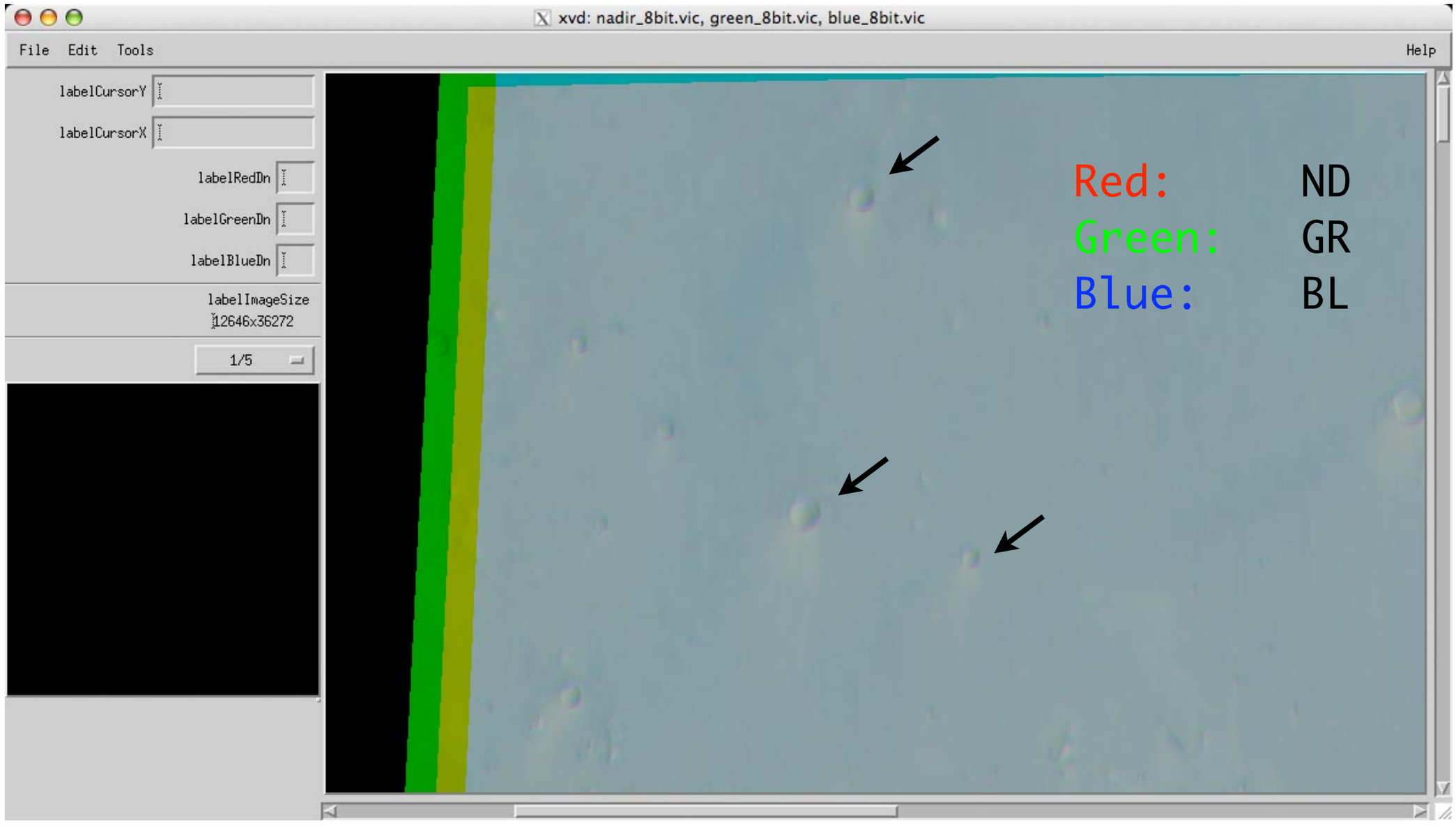
Limits



bands can be more or less affected, depending on viewing geometry

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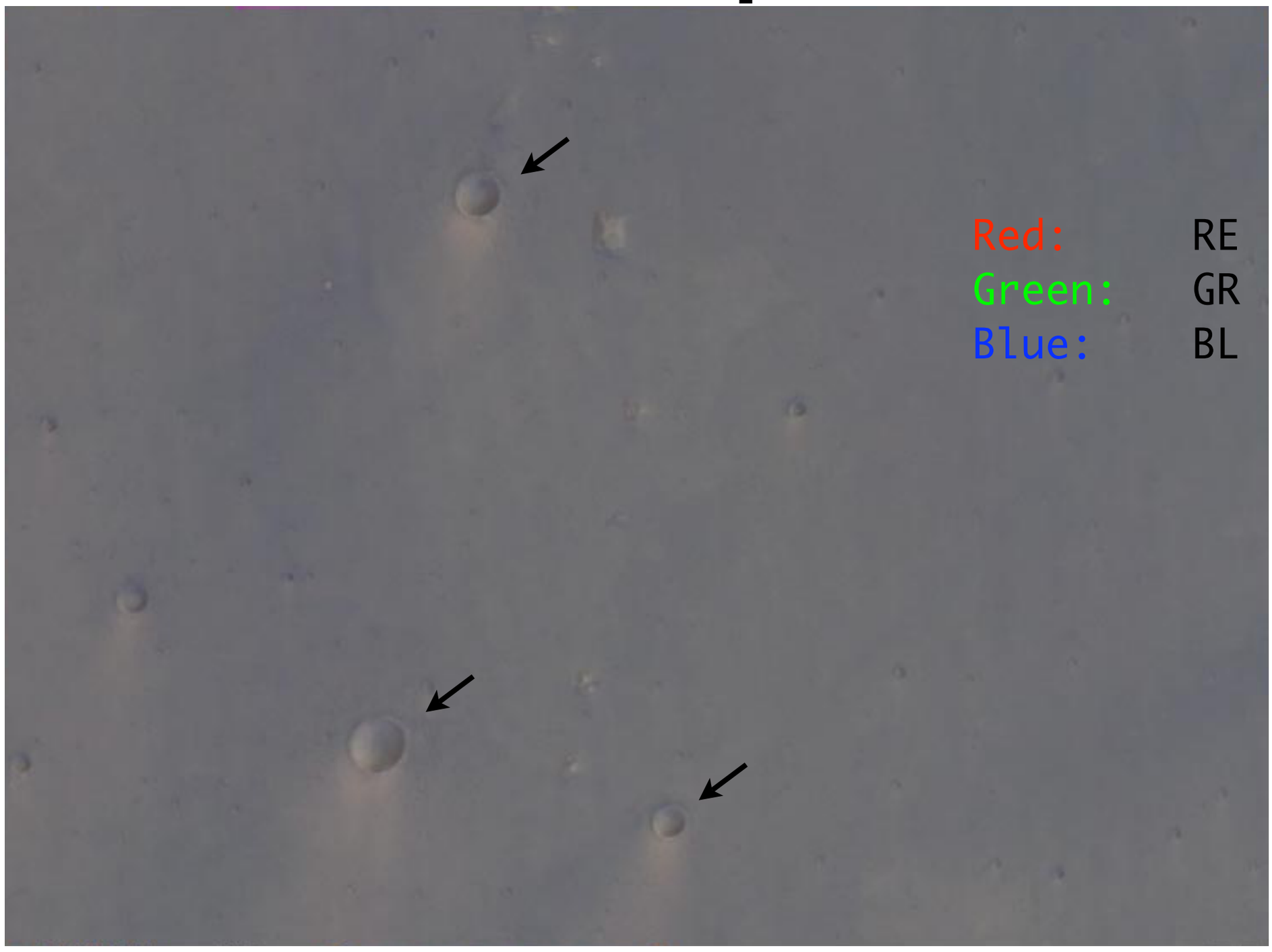
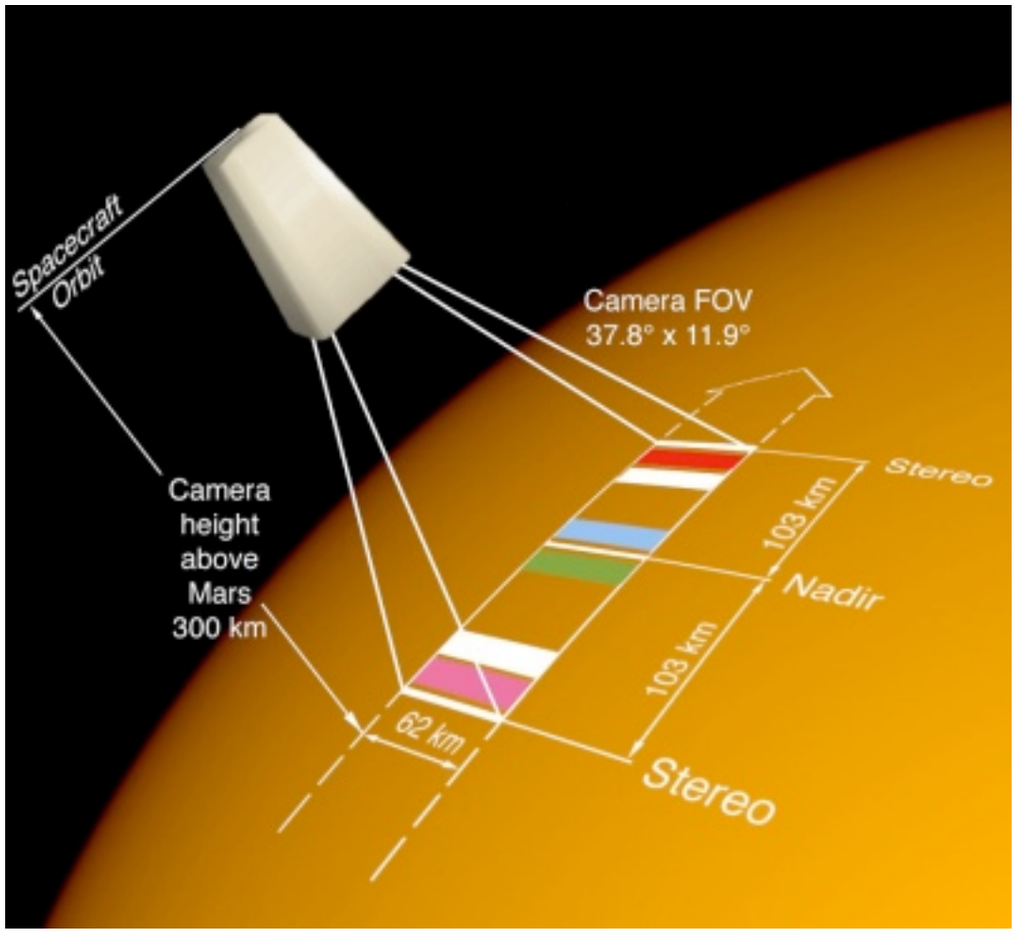
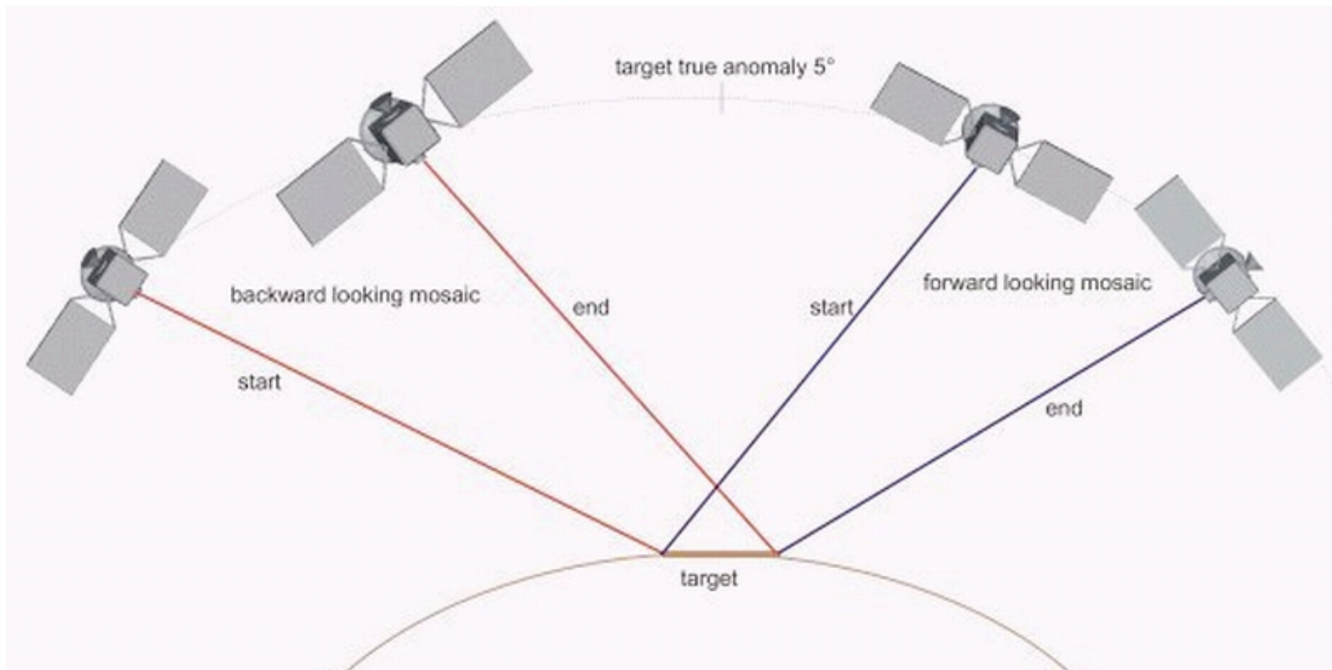
vs. full stereo processing



result with full photogrammetric processing

HRSC stereo





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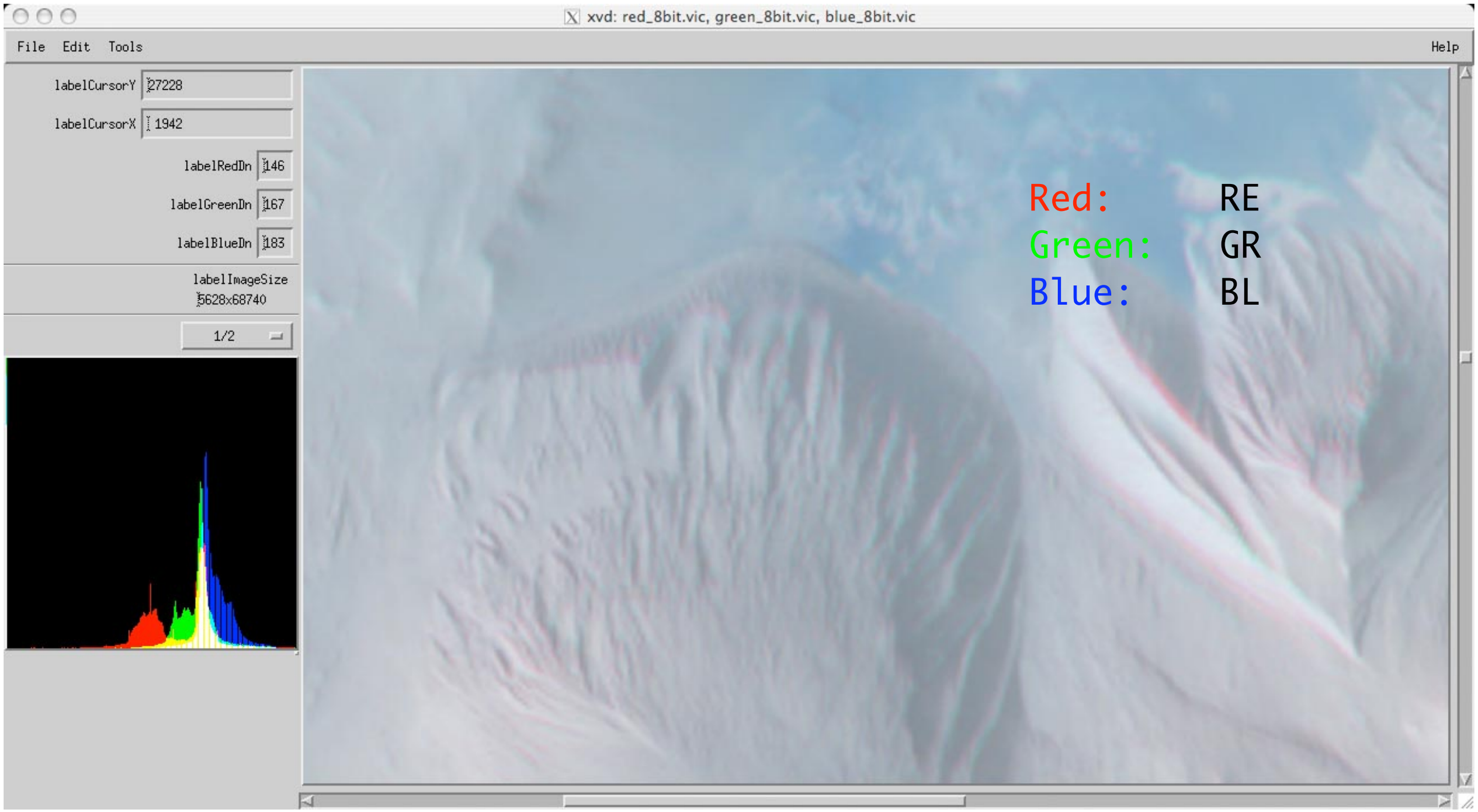
Orbit 2039



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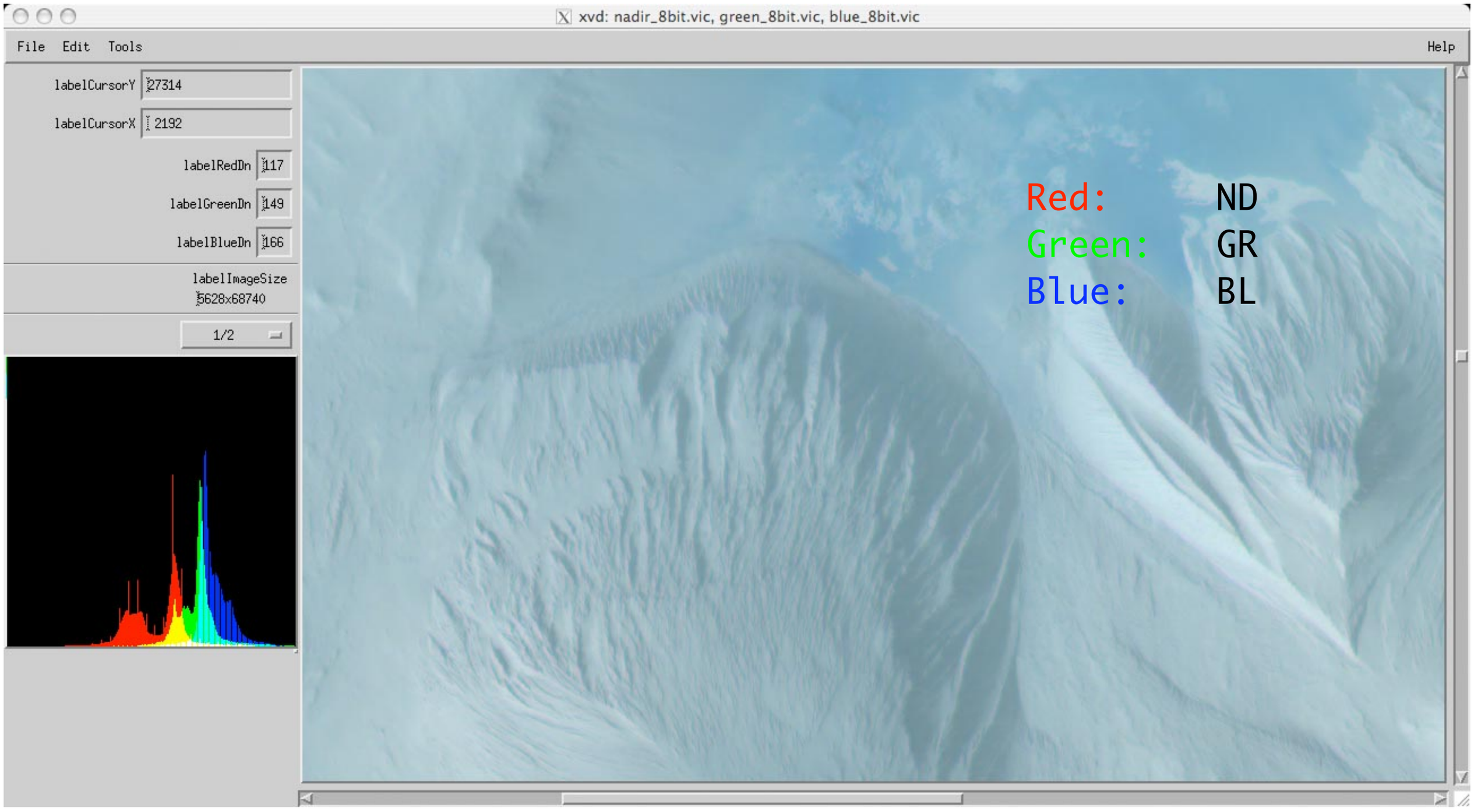
Orbit 2039



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Caveat

- RGB with MOLA used as DTM for orthorectification gives variable results
- Pan-sharpening might improve the general aspect of RGB
- Color misalignement will be solved when higher level HRSC data products are available