This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776276

UNIVERSITÀ DEGLI STUDI DI PADOVA

CISAS G. COLOMBO

Title of PhD project :*Geological Mapping and Structural analysis of Fault network in Mars and Mercury*

Supervisor : Prof. Matteo Massironi

Co- Supervisor :

PhD student: El Yazidi Mayssa

12th September 2019,at 2:20 PM, Seminar Room, CISAS

34° Cycle

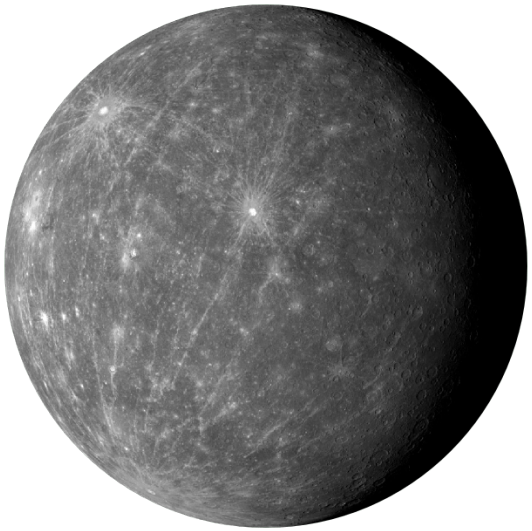
Corso di SCIENZE TECNOLOGIE E MISURE SPAZIALI

Curricoli: Misure meccaniche per l'ingegneria e lo spazio,

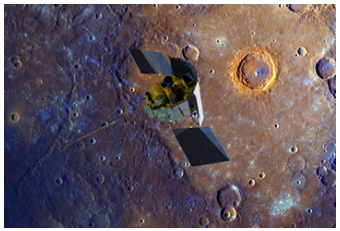
Centro di Ateneo di Studi e Attività Spaziali "Giuseppe

Colombo" - CISAS

Targets: Mars and Mercury



1:3M geological mapping of the Eminescu quadrangle (H9)



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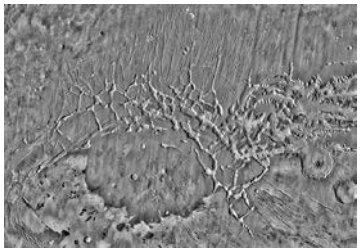
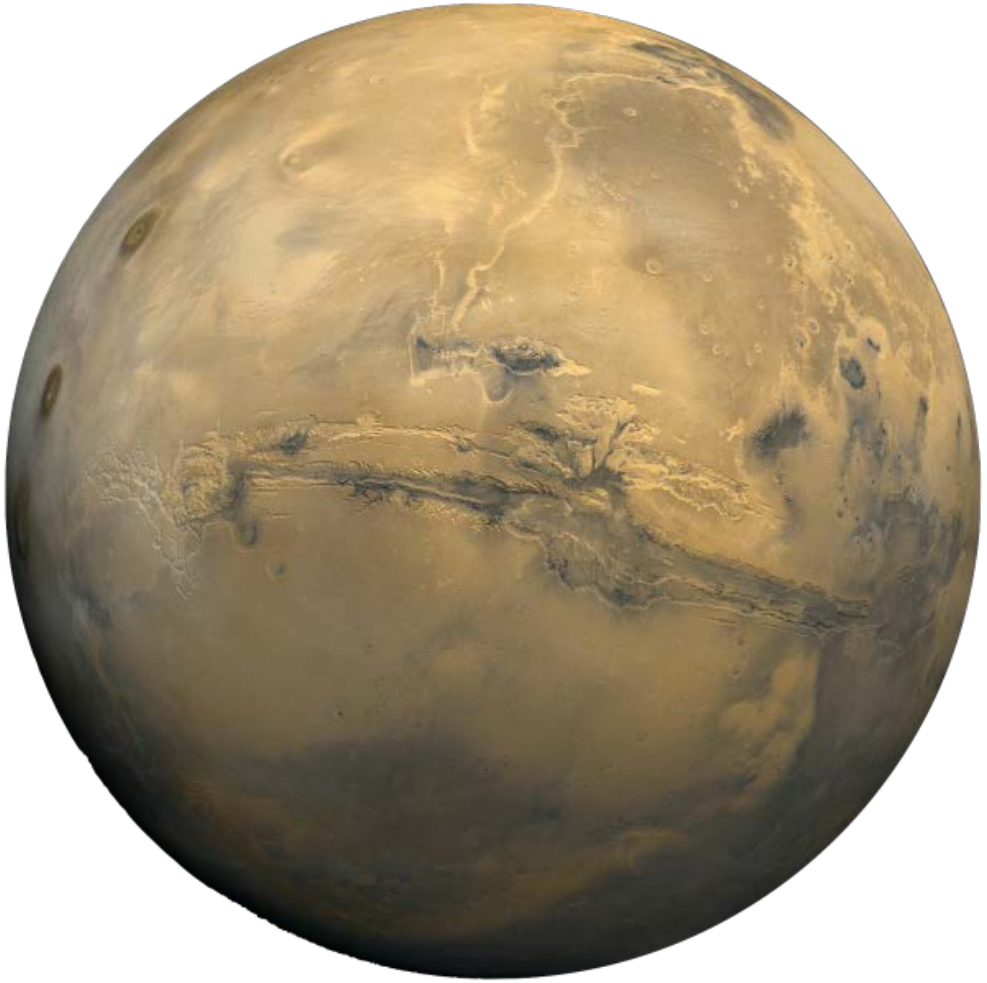
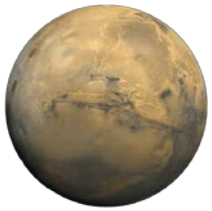
Noctis Labyrinthus, forming the western end of Valles Marineris



Mars





Structural analysis and mapping for Noctis Labyrinthus - Mars

Data and Methodology

Base map : h3210_0000 and h3221_0000 orthoimages (HRSC_Mars Express_12 to 13m/Pixel of SP).

DEM : from MOLA (~460 m/pixel) and HRSC (~100 m/pixel)

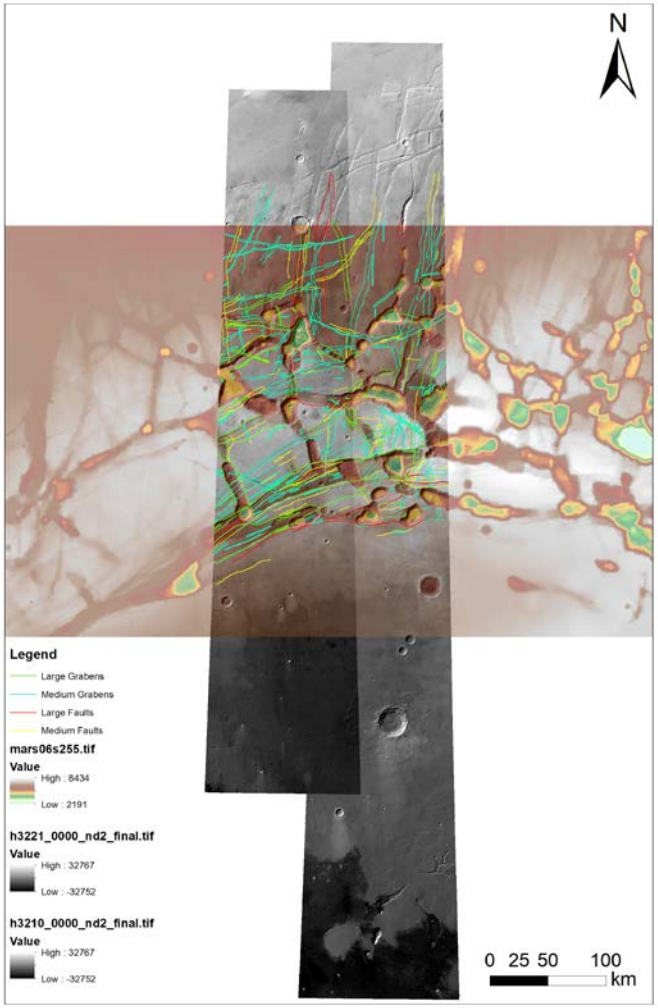
Number of fractures population

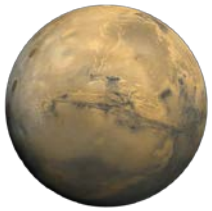
Faults			Grabens		
S1	S2	S3	S1	S2	S3
142	396	23	115	291	22

S1: D =>200m and L => 4 km

S2: D =>40m and L => 4 km

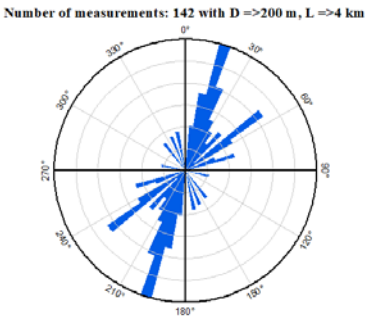
S3: D =>40m and L => 800 m

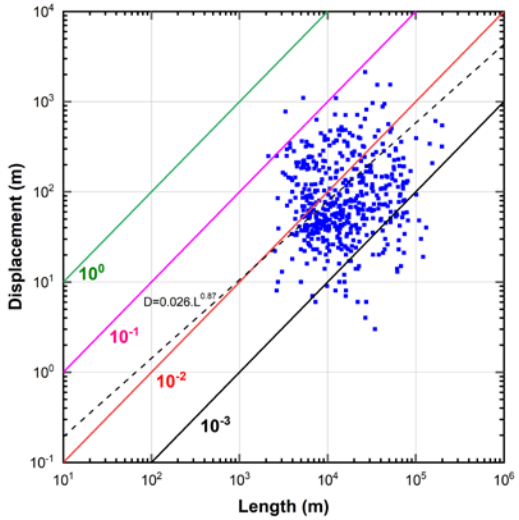


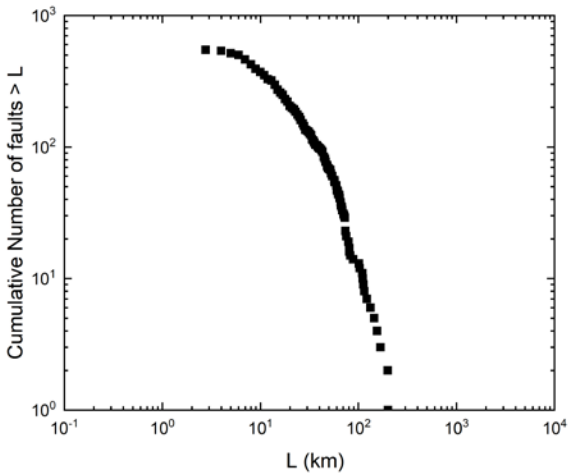


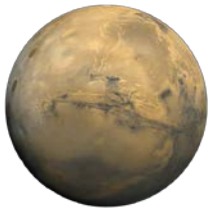
Structural analysis and mapping for Noctis Labyrinthus - Mars

Mapping results



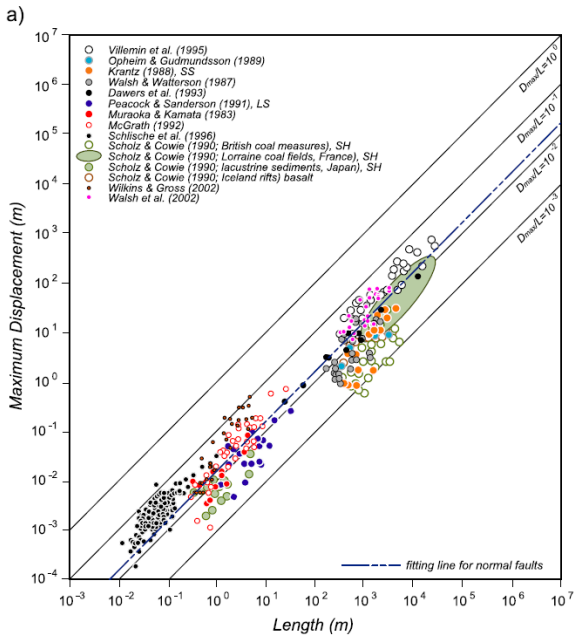


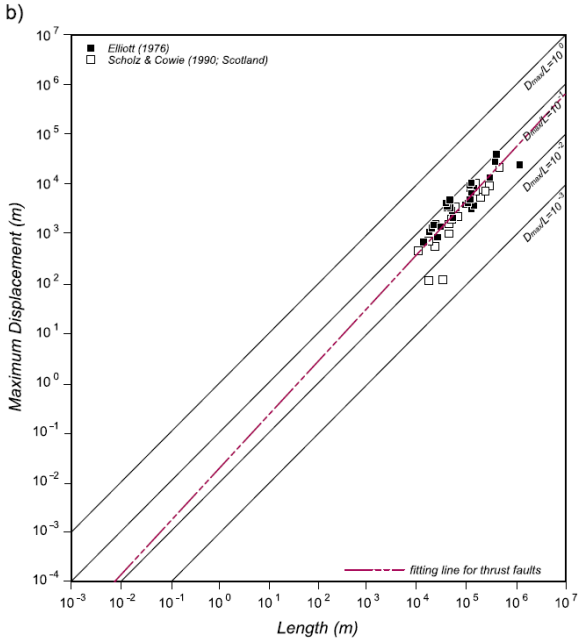


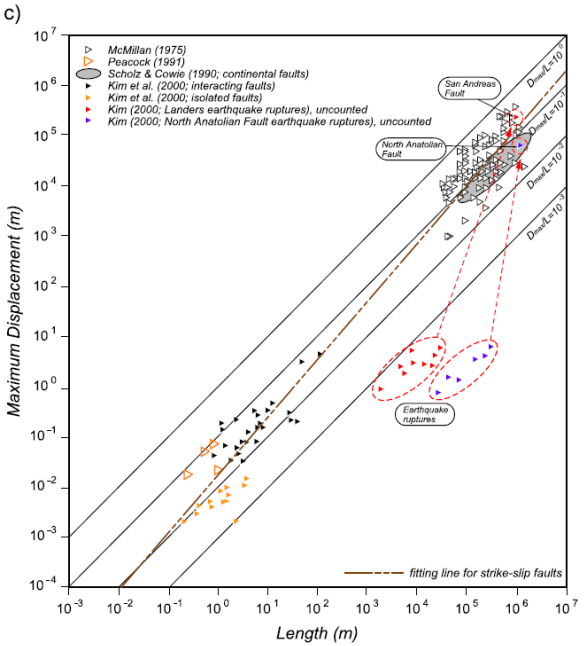


Structural analysis and mapping for Noctis Labyrinthus - Mars

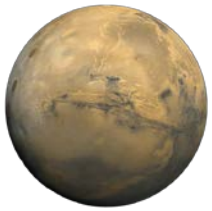
Mapping results (Compared results)





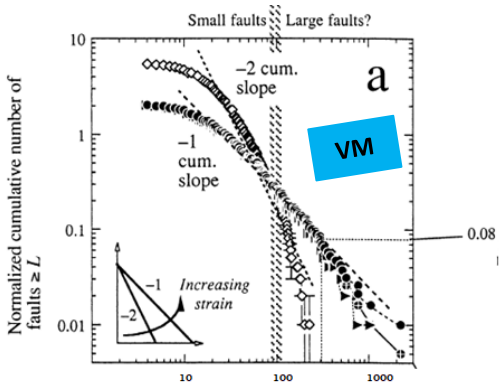


(Y.Kima and D.Sandersonb, 2004)

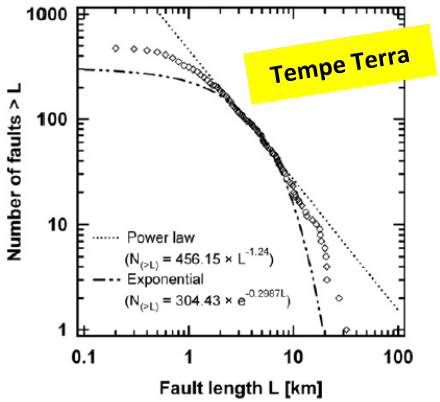


Structural analysis and mapping for Noctis Labyrinthus - Mars

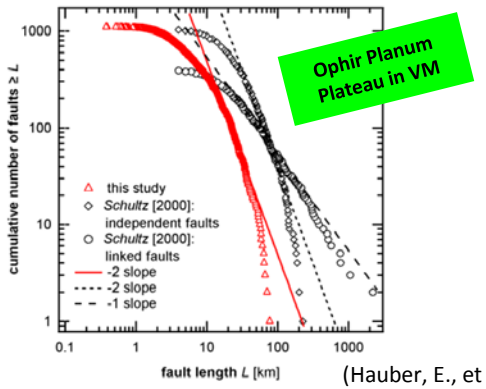
Mapping results (Compared results)



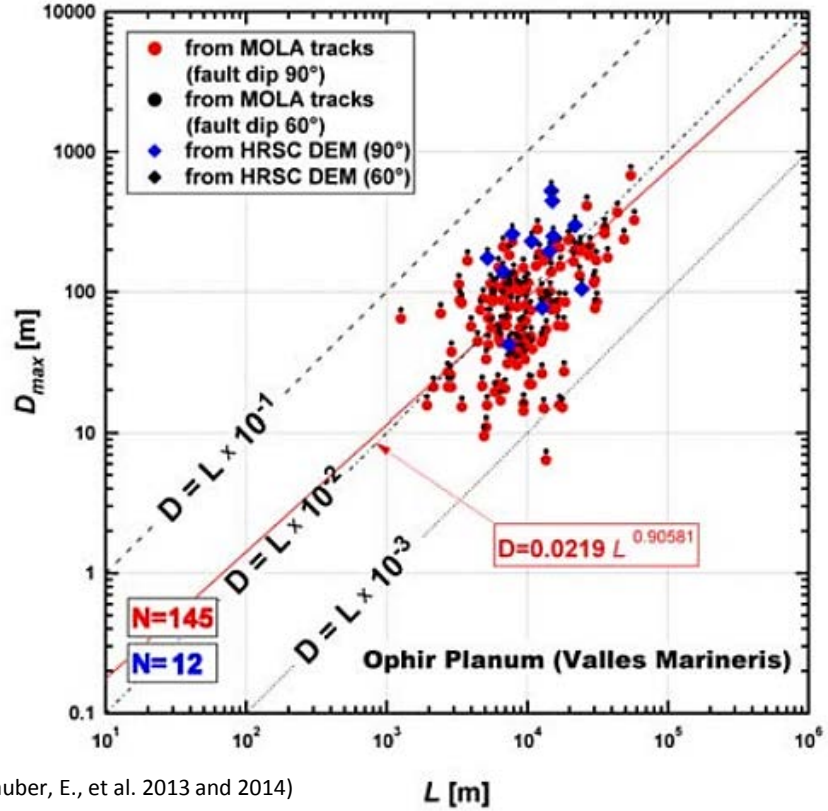
(R.Schultz,1999)



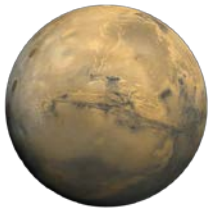
(R.Schultz,1999)



(Hauber, E., et al. 2007)

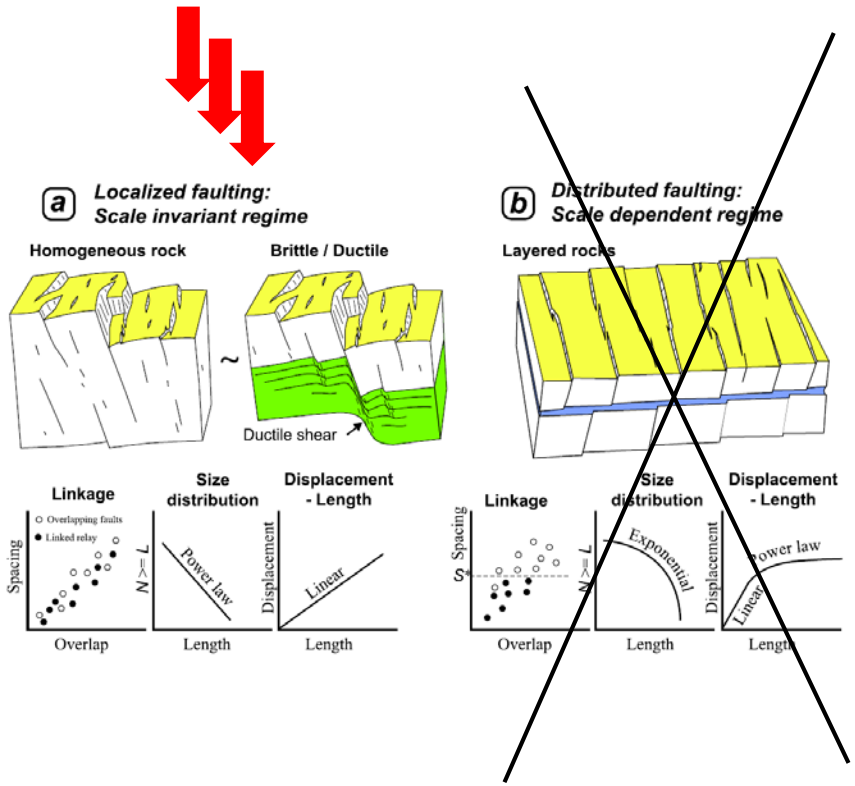


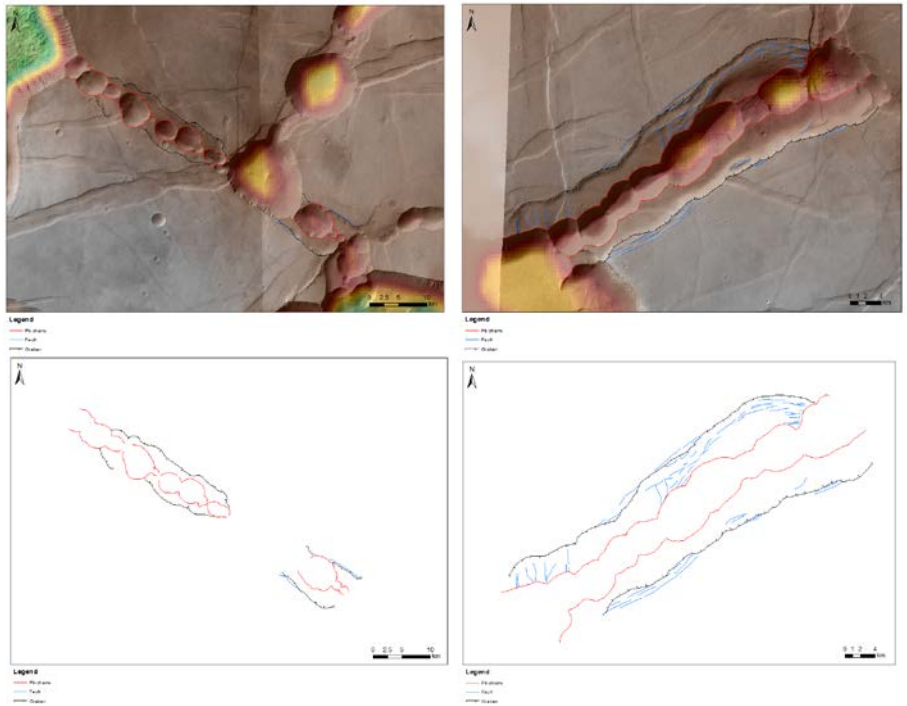
(Hauber, E., et al. 2013 and 2014)

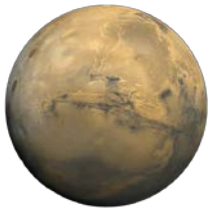


Structural analysis and mapping for Noctis Labyrinthus - Mars

Quantitative fault network analysis



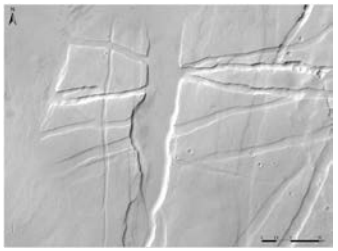


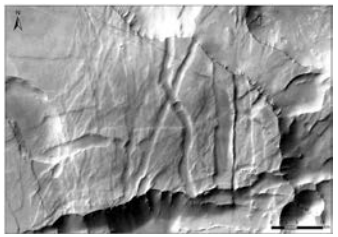


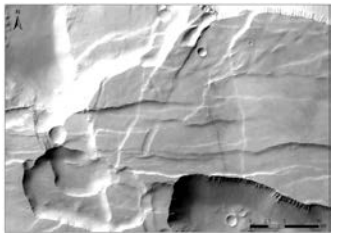
Structural analysis and mapping for Noctis Labyrinthus - Mars

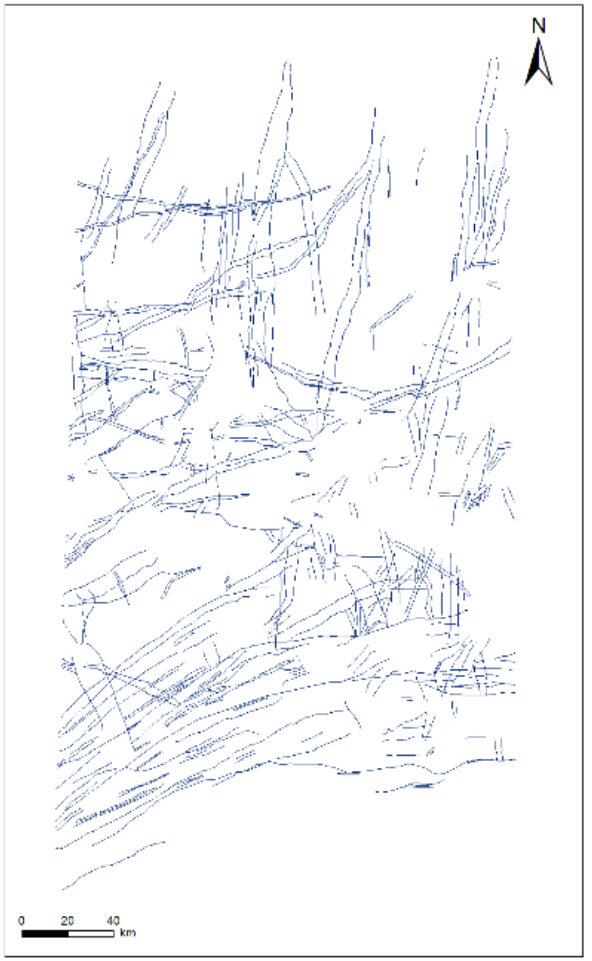
Quantitative fault network analysis

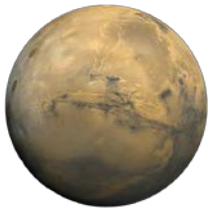
- The nature of the materials in the subsurface.
- The relationship between Faults, Grabens and pit chains.
- The driving processes for the formation of such complicated zone in Mars.
- The nature of the stress field.
- Fault kinematics.





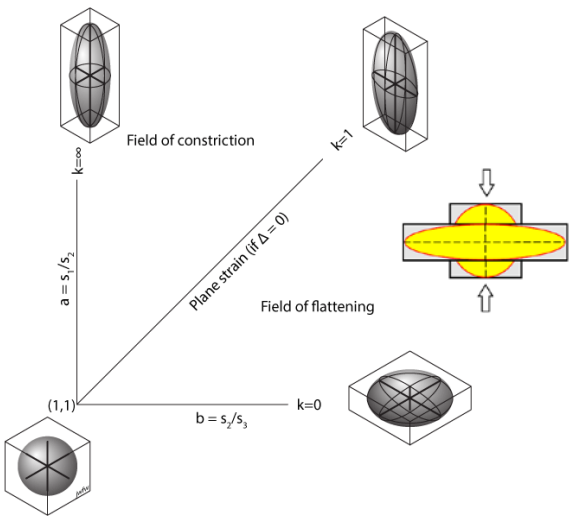


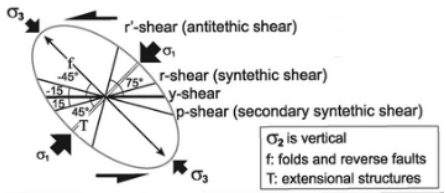


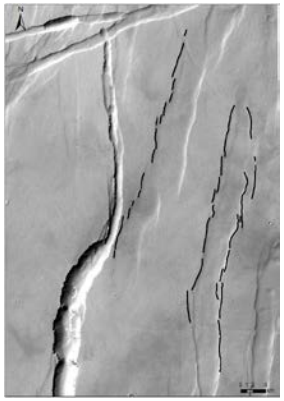


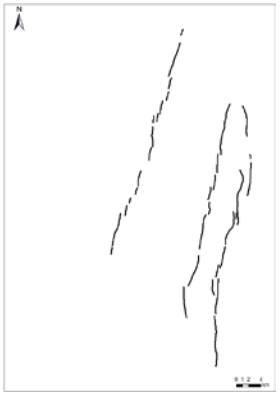
Structural analysis and mapping for Noctis Labyrinthus - Mars

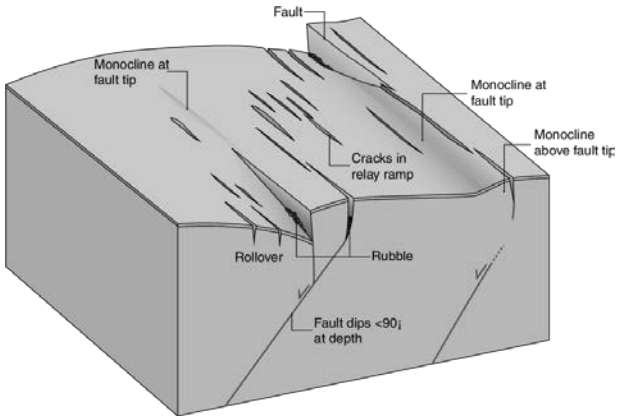
Quantitative fault network analysis

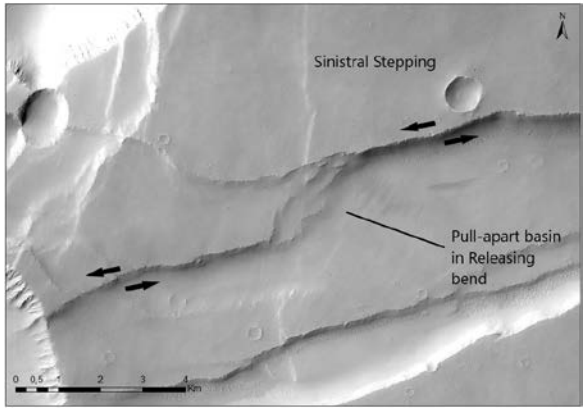










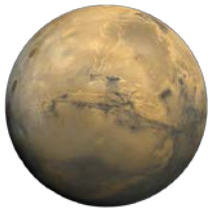


Shear zone represented by left lateral strike slip fault that generate the apparition of transtensional Pull-apart basin in releasing bend.

Strike slip faults

A sinistral transtensional Kinematics

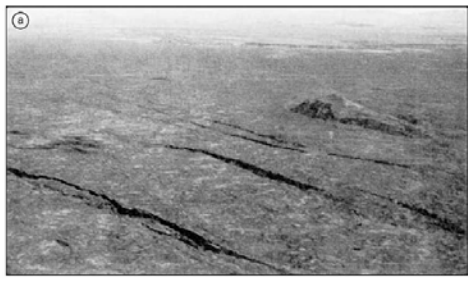
Pull-apart Basin

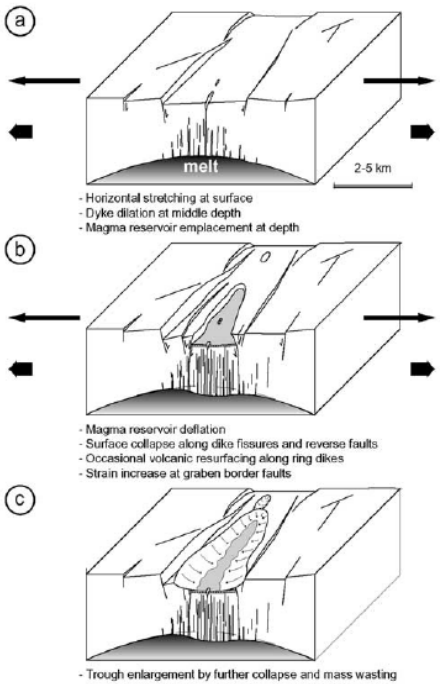


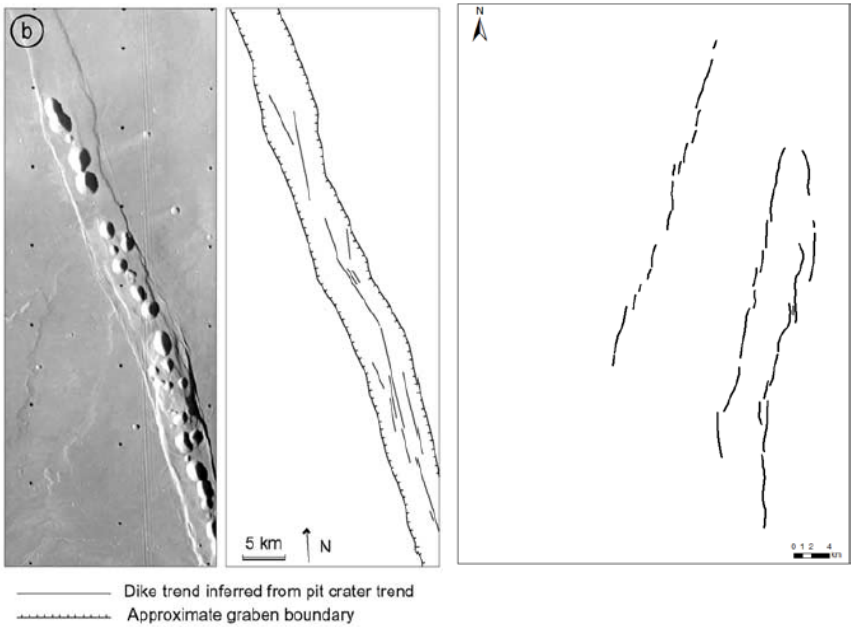
Structural analysis and mapping for Noctis Labyrinthus - Mars

Quantitative fault network analysis

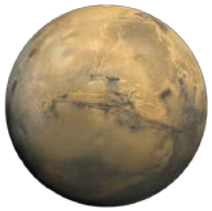
Segmented faults display, connected via relay ramp.







(Mege et al,2003)



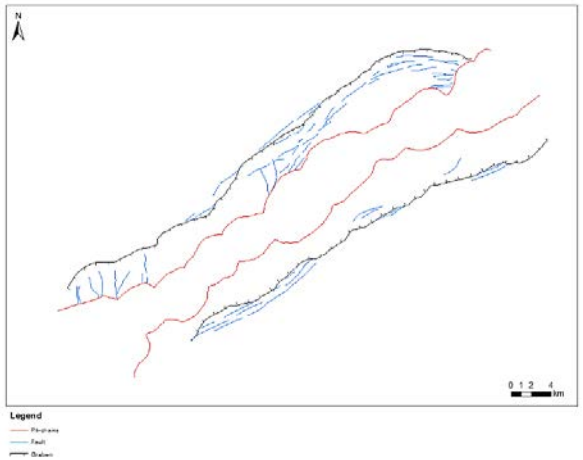
Structural analysis and mapping for Noctis Labyrinthus - Mars

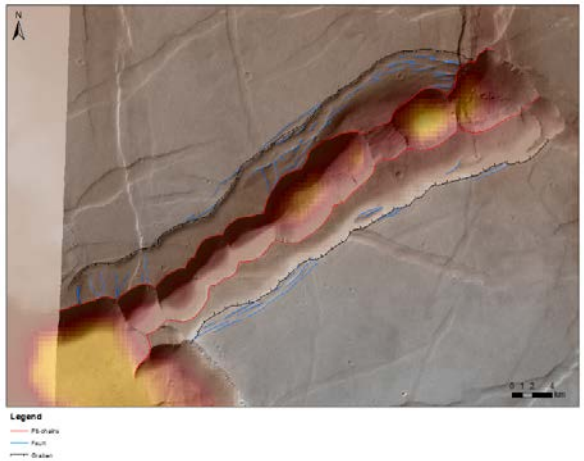
Quantitative fault network analysis

Interconnection between grabens and aligned pits

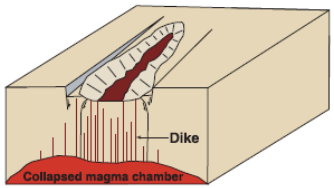
Earlier extensional stress field
+
Magmatic processes

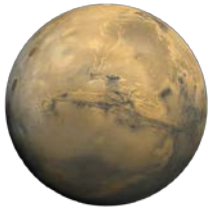
Main driving processes





Collapsed Magma Chamber





Structural analysis and mapping for Noctis Labyrinthus - Mars

Problems and Issues

What has been done

- Rose diagrams with a specific new scale of length and displacement dimensions.
- D_{max} vs L plot (In the frame to carry out a relationship between the displacement of the extended faults and pit chains).
- Negative power law for the cumulative frequency plot.
- Analyses of the results carried out.

What we still need

- DTMs cover the whole area of Stuy with better resolution.
- HR and DTM:
  - **HRSC (12.5m/px)**
  - **DEM Mola (460m/px)**

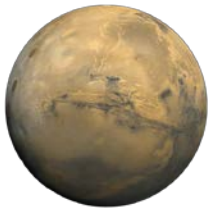
Not enough !

- Extend the area and study faults with large size only ?
- CTX images as a Basemap ? (Incomplete mosaic)

What we are going to do

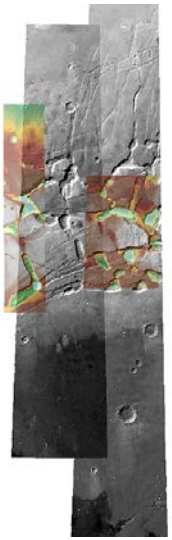
- Look for a availible HRSC DTMs.
- Look for Incomplete mosaic of CTX orthoimages for better surface analyses.

Task must finish on 31 December 2019.



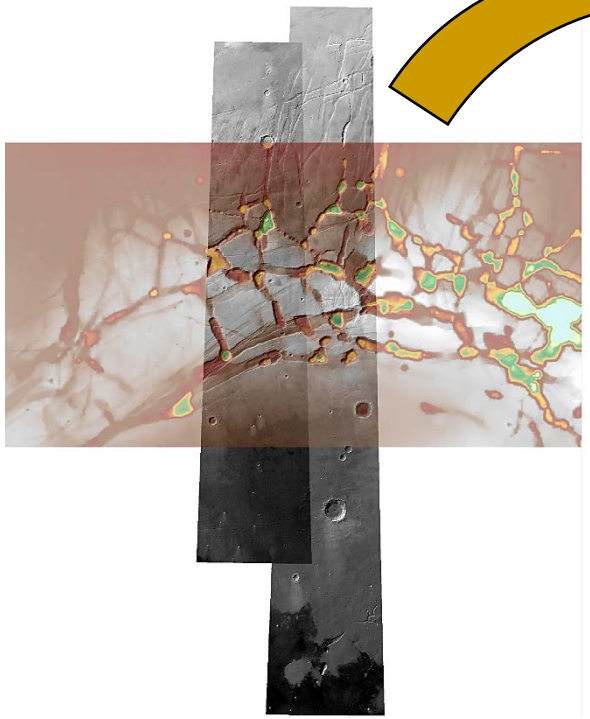
Structural analysis and mapping for Noctis Labyrinthus - Mars

Problems and Issues

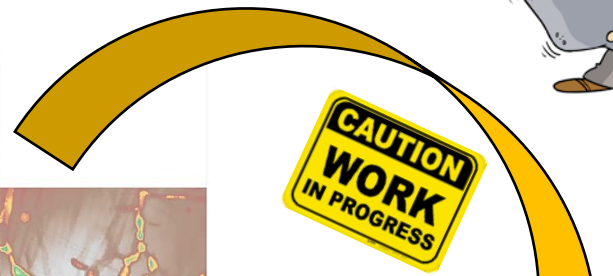


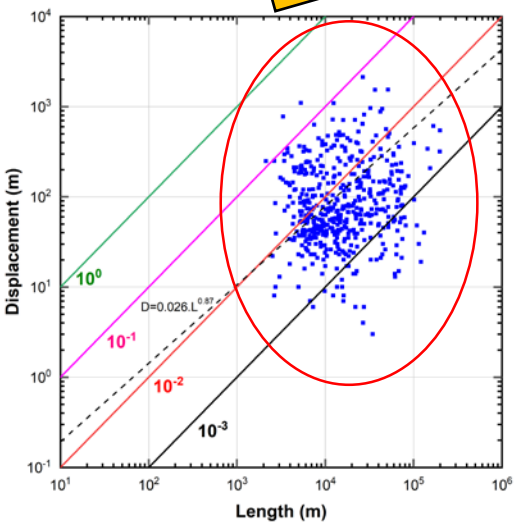
DTMs_HRSC ~100 m/pixel

CTX 5.2m/Pixel



HRSC 12.5 m/pixel
DTM_MOLA ~460 m/pixel





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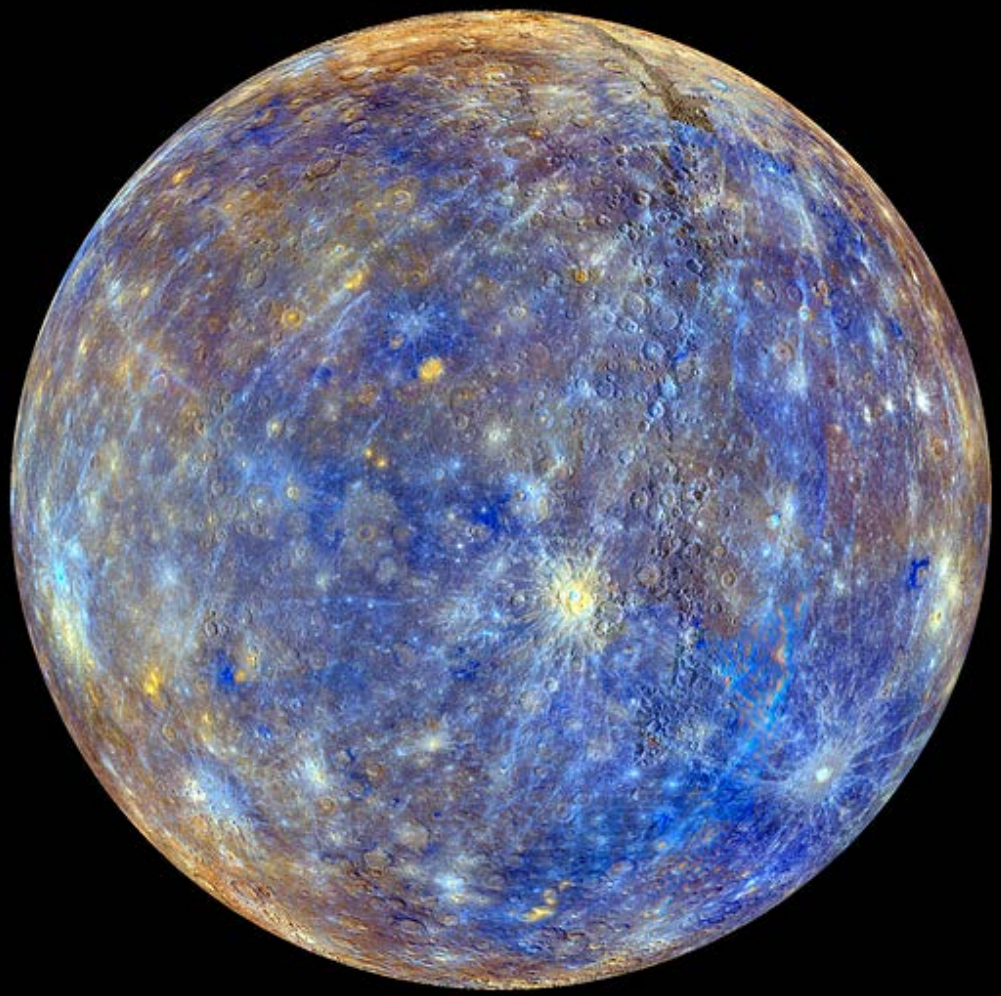
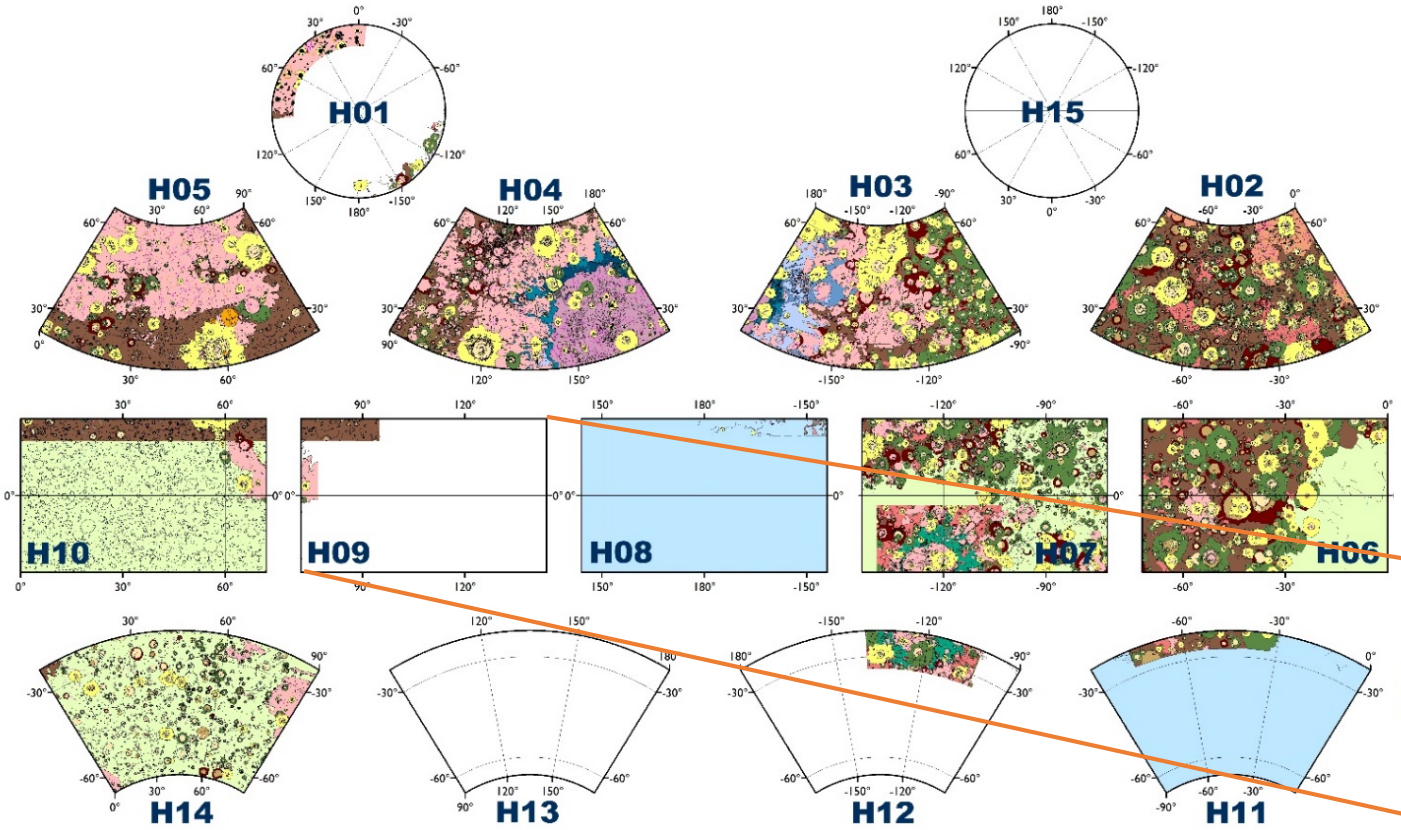
Mercury



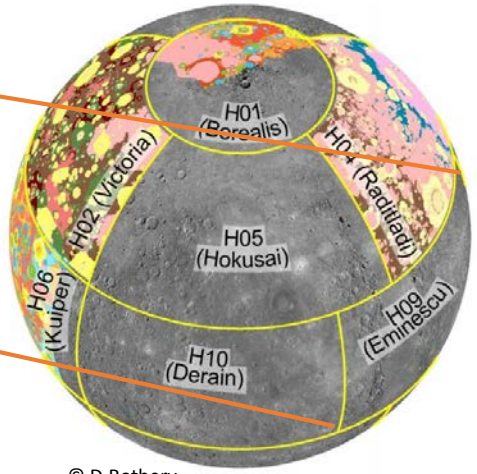
General Context of the chosen quadrangle : Eminescu (H9)



© V.Galluzzi

Coordinates: It runs from 216 to 288° longitude and from -25 to +25° latitude.

Projection System: Cylindrical projection.



© D.Rothery

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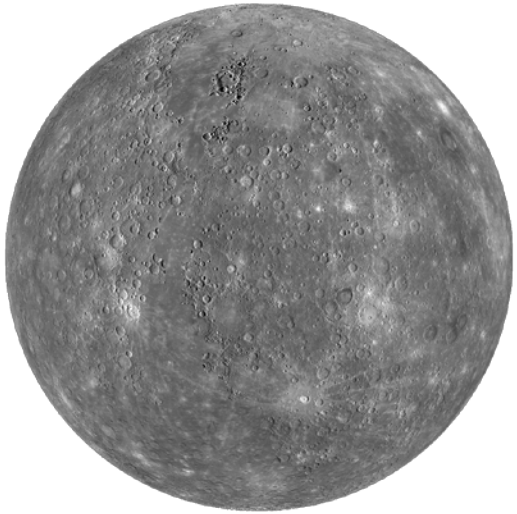
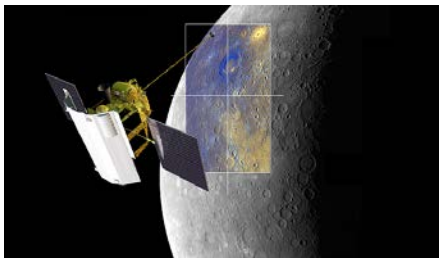
Data and Methodology





© NASA

BaseMap

Mercury Messenger MDIS

MD3 Color Global Mosaic (32ppd)

BaseMap derived by placing images from MESSANGER 1000nm, 750nm and 470nm narrow-band filters in the RGB respectively (Multispectral Data)

BDR (32ppd)

Global Monochrome Map of reflectance

LOI (32ppd)

Global Monochrome Map of reflectance at low angle of Incidence

*Ulluminated from **East** RDR*

*Ulluminated from **WEST** RDR*

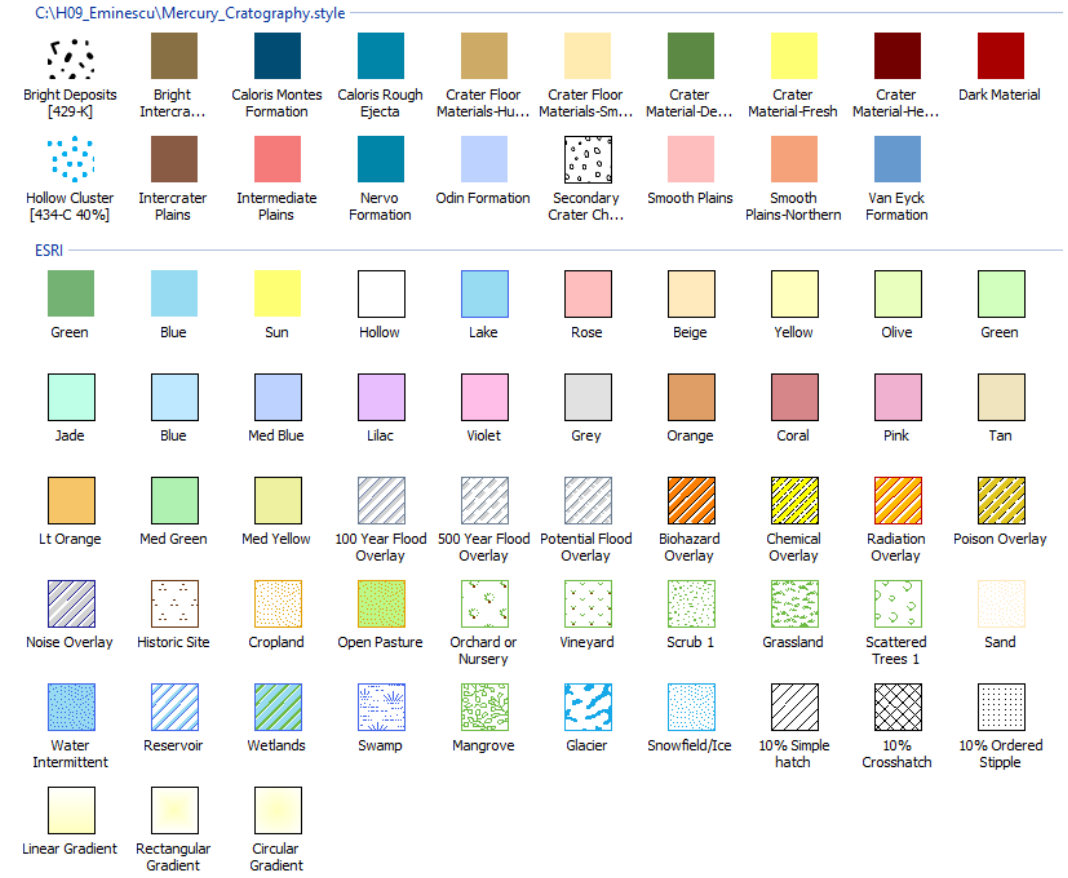
Enhanced Color Global Mosaic (32ppd)

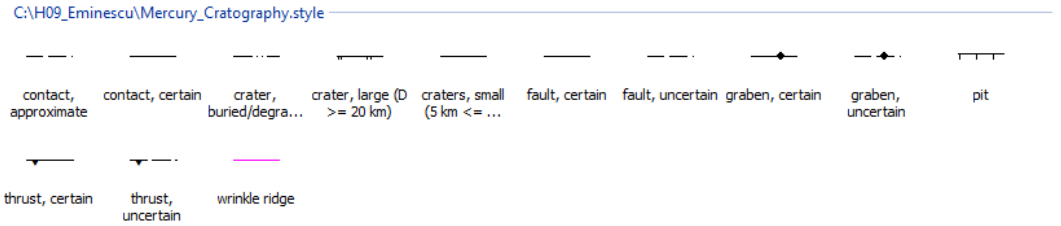
Used to describe color difference on Mercury's Surface

Data and Methodology

Scale : 1: 3000000 Output Scale.

Symbology : Mainly based on the **F**ederal **G**eographic **D**ata **C**ommitte (FGDC), Digital Cartographic Standard for Geologic Map Symbolization prepared by USGS (The same Symbology used by V.Galluzzi)



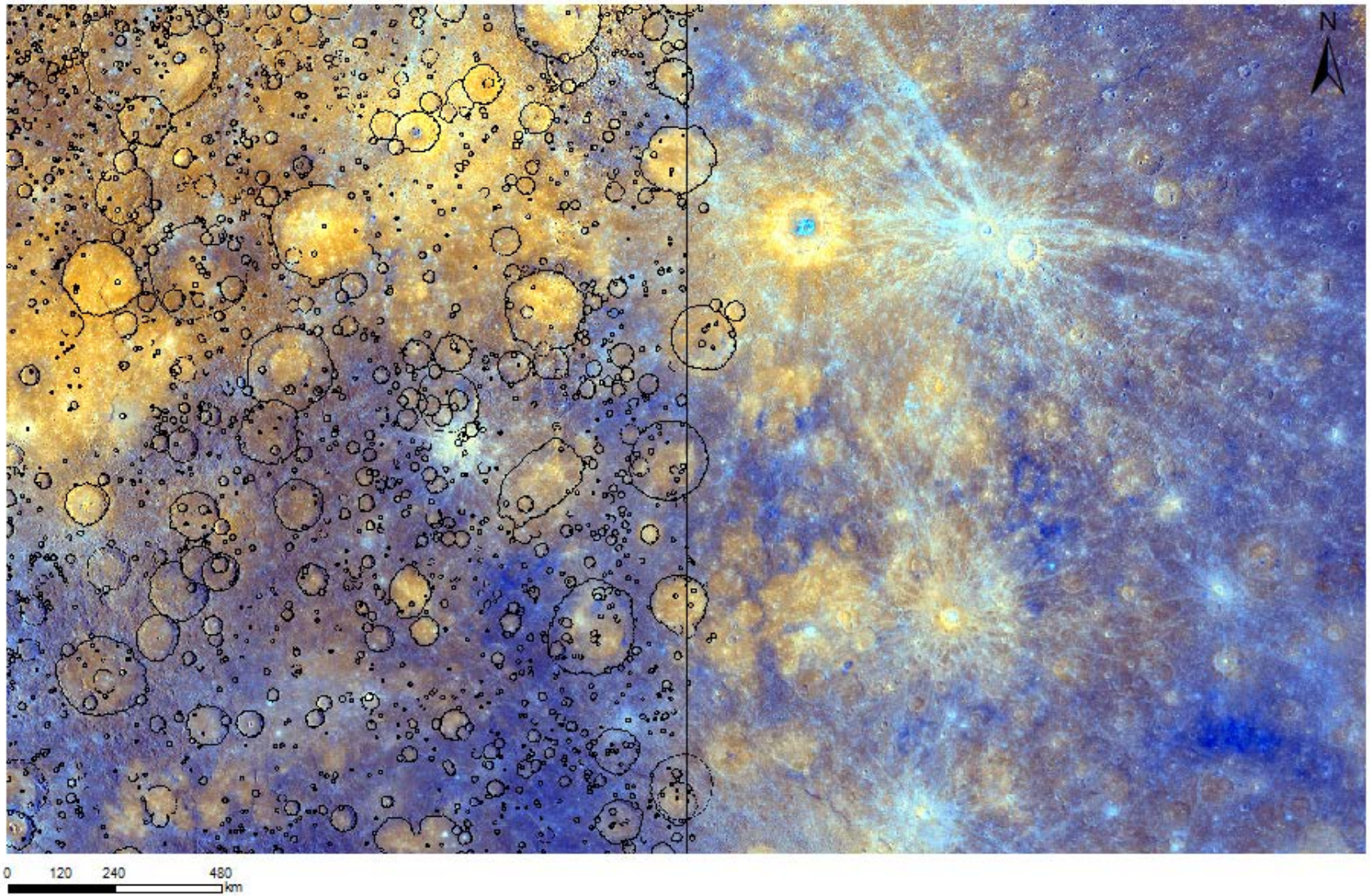


Mapping status

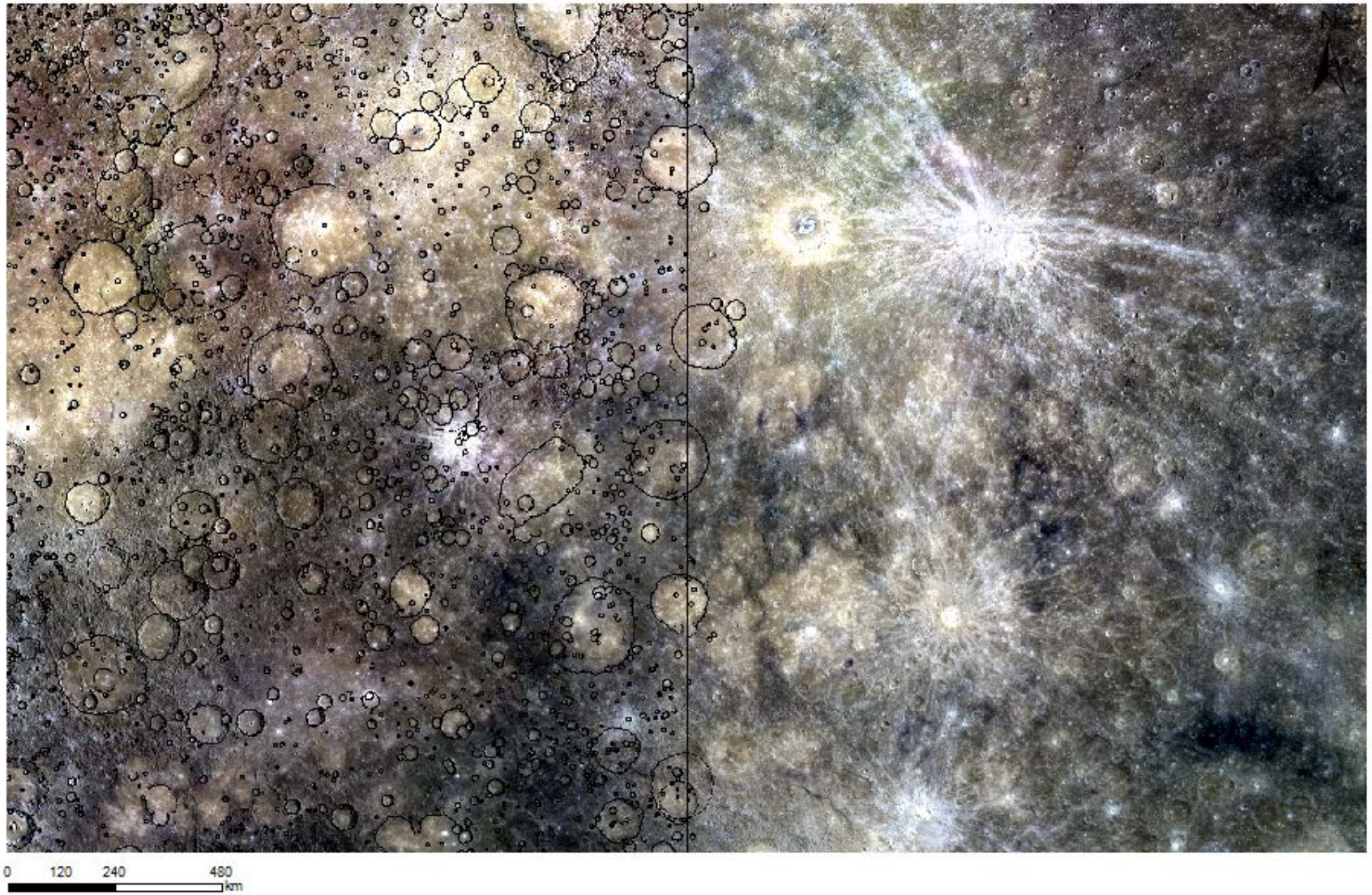
Morpho-stratigraphic map

- Craters rim mapped : 100%

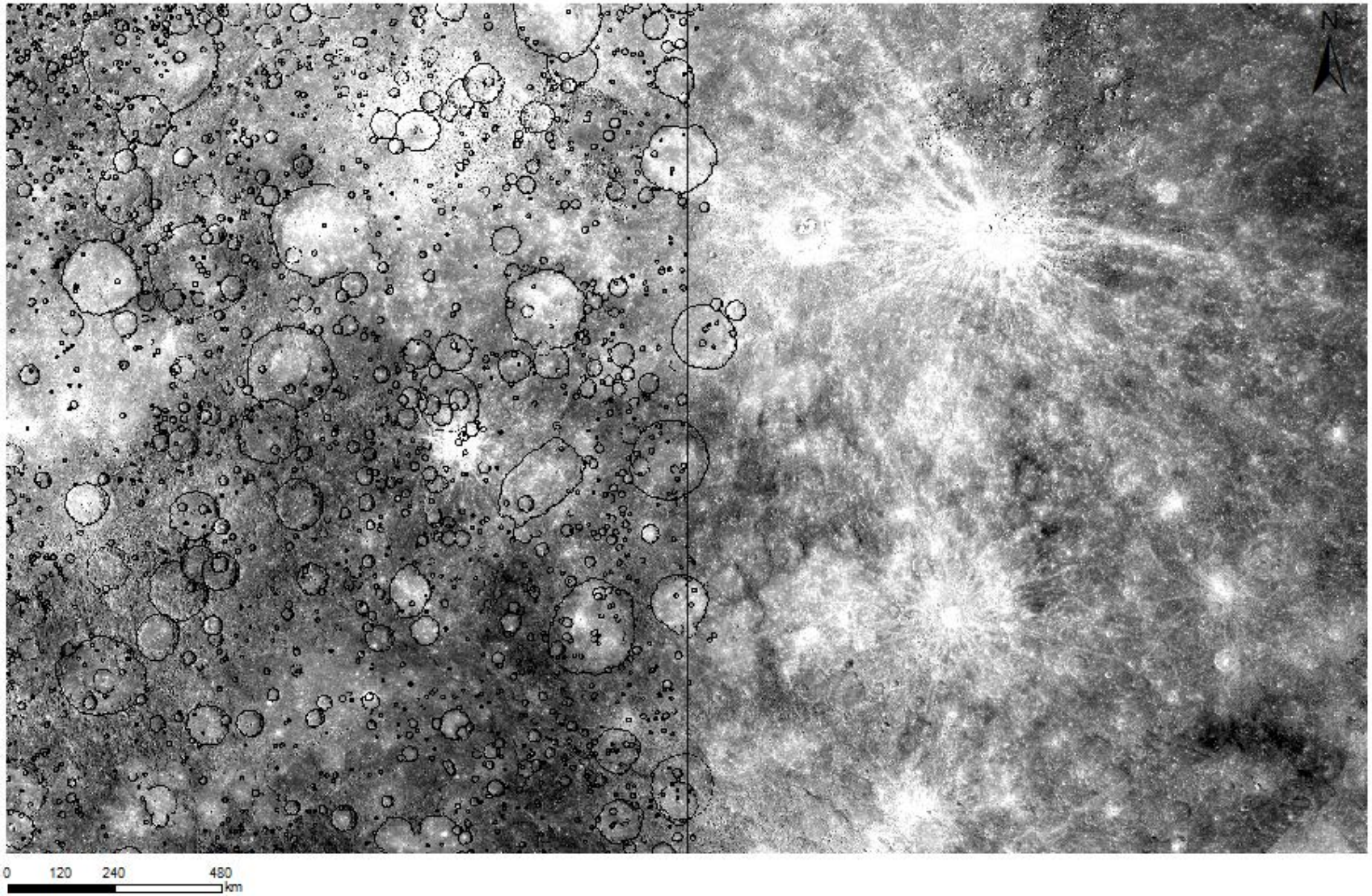
Mapping status (GlobalColor_equi_64ppd)



Mapping status (H09_GlobalColorMD3_64ppd)



Mapping status (H09_MDIS_LOI2_256PPD)



Mapping status

- H09_PointFeatures
  - Undefined point feature
    - TYPE
  - isolated bright spots
  - isolated dark spots
  - isolated hollows

Not yet

- H09_LinearFeatures_Morphology
  - undefined morphology
  - crest of crater rim D > 20 km
  - crest of crater rimp 5 < D < 20 km
  - crest of degraded or buried crater
  - volcanic vent

Done

- H09_LinearFeatures_Structures
  - Undefined Structures
    - TYPE
  - certain fault
  - certain graben axis
  - certain thrust
  - uncertain fault
  - uncertain graben axis
  - uncertain thrust
  - wrinkle ridge

Not yet

- H09_GeologicalContact
  - Undefined contact
    - Geological contact
  - contact, approximate
  - contact, certain

Not yet

- H09_SurfaceFeatures
  - uncertain surface features
    - Surface Features
  - bright material
  - cluster of hollows
  - dark material
  - rough ejecta
  - secondary crater chain or cluster

Not yet

- H09_GeologicalUnits
  - No Unit
    - UNIT
  - c1, heavily degraded crater
  - c2, degraded crater
  - c3, well preserved crater
  - dark material
  - hummocky crater floor
  - intercrater plains
  - intermediate plains
  - smooth crater floor
  - smooth plains

Not yet

PhD Courses and Credits

PERSONAL TRAINING PLAN OF DOCTORAL STUDENT EL YAZIDI Mayssa

EDUCATIONAL ACTIVITIES ACTIVATED BY THE STMS PHD COURSE						
Interdisciplinary Module/Activity	**Lecturer**	**Expected credits**	**Frequency (YES/NO)**	**Exam (YES/NO)***	**Date of exam**	**Attained credits**
Aerospace propulsion	Prof.Marco Manente	4	Yes	Yes	First year	4
Exploring the Solar System and its environment	Prof.Lucchetti/ Prof.Marzari /Prof.Pajola	4	Yes	Yes	First year	4
Space optics and detectors	Prof.Naletto/ Prof.Pelizzo	4	Yes	Yes	First year	4
Astrophysics of the Solar System	Prof.Monica Lazzarin	6	Yes	Yes	First year	6
Space systems and their control	Prof.Francesconi/ Prof.Lorenzini	0.8	Yes	No	First year	0.8
Introduction to computational fluid dynamics	Prof.Francesco Picano	0.4	Yes	No	First year	0.4
Geologia ed esplorazione dei corpi planetari	Prof.Matteo Massironi	1.6	Yes	No	First year	1.6
Research Project Proposal/Preparing a Scientific Paper	Prof.Naletto	2	Yes	Yes	First year	2
Presentation of Doctoral Activities	-	0.5	-	-	First year	0.5
Curriculum oriented seminars	**Lecturer**	**Expected credits**	**Frequency (YES/NO)**	**Exam (YES/NO)***	**Date of exam**	**Attained credits**
09 Seminars activated by STMS PhD course	-	3.6	Yes	Yes	First year	3.6
Seminar "Space Technologies"	Giampaolo Preti	0.06	Yes	No	First year	0.06
Seminar "Galileo: The European infrastructure for global navigation satellites system services"	Giuditta Montesanti	0.06	Yes	No	First year	0.06

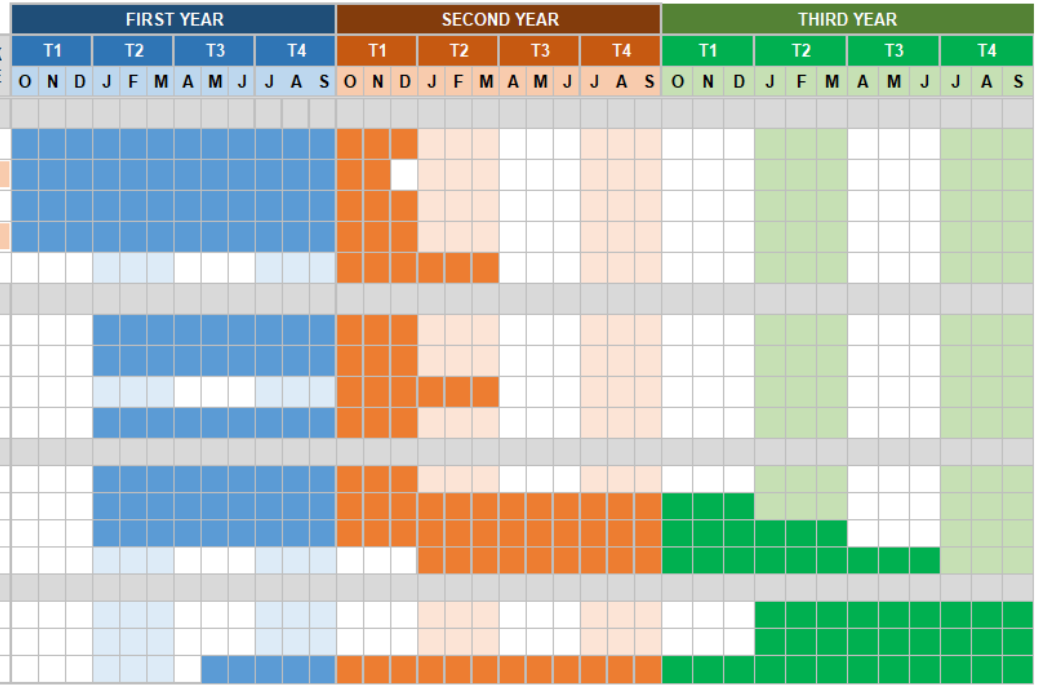
OTHER EDUCATIONAL ACTIVITIES							
Title of the activity (Date/Period/University)	**Lecturer**	**Duration of activity**	**Expected credits**	**Frequency (YES/NO)**	**Exam (YES/NO)**	**Date of exam**	**Attained credits**
Educational support for Planetary Geology Mapping-INAF-IAPS di Roma.	Prof.Valentina Galluzzi	40 hours	1.6	Yes	No	First year	1.6
Workshop "Planetary Mapping and Virtual Observatory"	-	24 hours	0.96	Yes	No	First year	0.96
School "Detectors and Electronics for High Energy Physics, Astrophysics, Space applications and Medical Physics"Legnaro (Laboratori Nazionali di Legnaro dell'INFN)	-	40 hours	1.6	Yes	No	First year	1.6
Total of expected ECTS credits attainable in educational activities (>30):			**31.18**	**Total of credits attained in educational activities (at date 30 August 2019):**			**31.18**

Gantt Chart

GANTT CHART

PHD STUDENT	EL YAZIDI Mayssa	DATE	9/12/2019
PHD THESIS	Geological Mapping and Structural analysis of Fault r	ADMISSION TO	Second Year (2019-2020)

WBS NUMBER	TASK TITLE	% OF TASK COMPLETE
1	State of the Art Research	
1.1	Bibliography Research	50%
1,2	Collect of different Data, Raster layers and DEMs Images	90%
1,3	Methods and tools of Study and analyses	70%
1,4	A knowledge of the basic notion of the geological mapping	90%
1,5	A knowledge of the basic notion of the 3D Geo-Modeling,	0%
2	Noctis Labyrinthus - Mars	
2.1	Mapping and measuring the faults and studying their kinematic properties	80%
2,2	Quantitative fault network analysis (Carrying out different diagrams)	80%
2,3	3D reconstruction of the fault network and analogue model	0%
2,4	Analyse, discuss and interpret of the results carried out	50%
3	A geological map for Eminescu quadrangle (H9) in Mercury	
3,1	Eminescu quadrangle - H9 (Mercury) : Studying the general context of the selected qu	40%
3,2	Studing the main geological features	5%
3,3	Geological maps	5%
3,4	Structural analysis of the fault network	0%
4	Discussion and Conclusion	
4,1	The importance of this study	0%
4,2	The importance of the produced maps for future work in the frame of the selection of	0%
5	Compilation of the thesis and work reports	2%



Preliminary Index of my thesis project

1. Noctis Labyrinthus (Mars)
    a. General view
    b. Volcanic Activity
    c. Tectonic and rifting : A complex zone with branched network of faults and grabens
2. Surface interconnection Grabens/Pit chains
3. Structural Analysis
    a. Data and Methodology
    b. Rose diagrams and faults kinematic
    c. Dmax Vs L and cumulative frequency plot
    d. Quantitative and qualitative analyses for the fracture
4. Volcano-Tectonic relationship as a superficial driving process for Noctis Labyrinthus formation.
5. Mercury Overview
    a. Physical and Orbital properties
    b. Magnetic field
    c. Weather and exosphere
    d. Surface characteristics
    e. Stratigraphy, Topography and Surface geology
    f. Hollows, a mysterious volatile substance and the sublimation phenomena
    g. Cratering and Mercurain chart
    h. Interior
    i. Volcanic Activity
6. Mercury Space Mission
    a. Mariner 10
    b. MESSENGER
    c. BepiColombo
7. New geological mapping for Eminescu quadrangle (H9) with the scale 1:3M
    a. General context of the project as a part of PlanMap
    b. Data and Methods
    c. Geological maps
    a. Morpho-stratigraphic map
    b. Chrono-stratigraphic map
    d. 3D Geo-Modeling : Volume, Depth and effusion estimation
    e. Analyses and Interpretation
8. Stress field comparison between Mars and Mercury fault network
9. Purpose of this study

Thank you for your attention