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Implication of fractures in determining of potential Area of life on planet Mars : Cartography of mineralogy in Nili Fossae

by Hadarou Sare

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Introduction

One of the most important goal of Mars exploration is to obtain data that wil help determine whether life ever existed on Mars. This goal might be easily achieved if we know the characteristics of areas with fissure(fractures). In the other word, how areas with fracture can help us to determine the presence of life on Nili Fossae and then on Mars because this research might be applied to another areas with fractures. It is therefore essential to determine characteristics of differents rocks and or minerals in Nili Fossae in order to justify our hypothesise which is that we could find rocks and or minerals containing chemicals organics (proof of life) in areas with fissures because those areas are areas where we could find potentially water and then rocks or minerals containing chemical organics such as mafics minerals, hydrated minerals, phyllosilicates, hydroxylated minerals,… related to presence of water.
The THEMIS (Thermal Emission Imaging System) and the GeoInformatics will contribute to these goal. In fact, we will have access to satellite Images from THEMIS website and we will use some GeoInformatics technology such as Erdas Imagine to treat those images and ArcGis to create not only a database but to also create a cartography.

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Background Information

A fracture is any separation in a geologic formation, such as a joint or a fault that divides the rock into two or more pieces. A fracture will sometimes form a deep fissure or crevice in the rock. Fractures are commonly caused by stress exceeding the rock strength, causing the rock to lose cohesion along its weakest plane. Fractures can provide permeability for fluid movement, such as water or hydrocarbons. Highly fractured rocks can make good aquifers or hydrocarbon reservoirs, since they may possess both significant permeability and fracture porosity.

There are differents types of fractures

Tectonic Fracture

According to UCLA scientist An Yin ,there is strong evidence of plate tectonics on Mars. By examining images of geological examples on Earth and comparing them to Mars, he has shown that Earth isn't the only planet in the solar system with plate tectonics.

Plate tectonics are large, raft-like pieces of the crust sitting on a sea of fiery magma. Interactions between these plates can cause tectonic fissures. Plate boundaries can be divergent (pull apart), convergent (push together/under), transform (slide against each other), and micro-plates (complex geological features). (Understanding plate motions, 2012).

The slower plate movement on Mars could be accounted for by less thermal energy than Earth, fewer main plates than Earth, or a more primitive stage of plate tectonics. (Dvorsky, 2012), (Villard, 2012), (Wolpert, 2012).

Stretching of the crust also creates tectonic fissures, a process called regional tectonic stretching.

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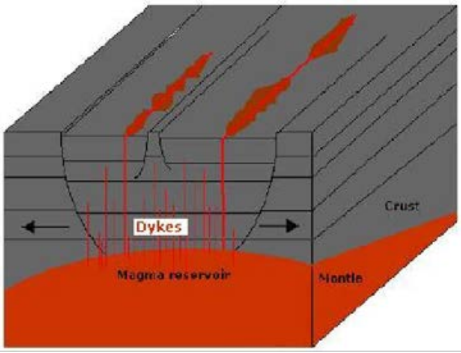
Volcanic Fissures



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Volcanic fissures form when magma is injected through the ground along long vertical fractures called dykes. These dykes can be parallel, which may indicate a tectonic role in their formation. The magma explosively forces the dykes open.

Ice Fissures

Ice fissures are polygon-shaped depressions with raised rims.They appear on Mars and Earth's polar surfaces, are formed through the gradual freeze-thaw process, where the gradual cycle of freezing and thawing causes ice to expand between the rocks themselves, creating large, polygonal depressions.
The seasonal warming and cooling of the ice causes the expansion of ice and the freeze-thaw cycle. (Mangold, et. al.)

Water Formed Fissures (Canyons)

Canyons on Earth and elsewhere form when fast-flowing water from a channel such as a river slowly.

Rocks

Rock or stone is a naturally occurring substance, a solid aggregate of one or more minerals or mineraloids. For example, granite, a common rock, is a combination of the minerals quartz, feldspar and biotite. The Earth's outer solid layer, the lithosphere, is made of rock.

Three major groups of rocks are defined: igneous, sedimentary, and metamorphic. The scientific study of rocks is called petrology, which is an essential component of geology.

There are many differents types of rock found on Mars by Curiosity

Mineral

A mineral is a naturally occurring chemical compound usually of crystalline form and abiogenic in origin. A mineral has one specific chemical composition, whereas a rock can be an aggregate of minerals or mineraloids. The study of minerals is called mineralogy.

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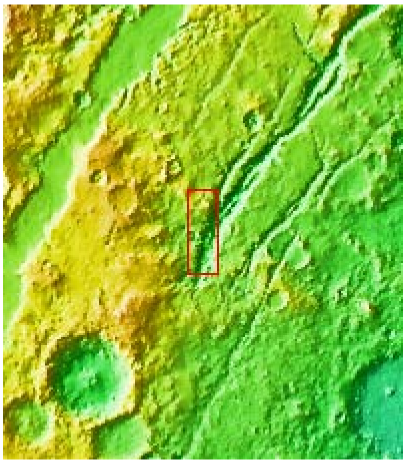
Area of study

Nili Fossae is a large band of parallel graben located to the northeast of Syrtis Major. The graben in this VIS image were formed by tectonic activity, with faulting that creates the linear depression.



V43177008 (View data in Mars Image Explorer)
Latitude: 22.186
Longitude: 77.2742
Orbit Number: 43177
Captured: 2011-09-08 12:28
Posted to Web: Wed, 2016-09-07
Instrument: VIS
Image Width: 512 pixels (19 km)
Image Height: 1824 pixels (68 km)
Vertical Resolution: 0.037334 km/pixel
Horizontal Resolution: 0.0372368 km/pixel
View this image on a map

There are five main fractures in our image. The fractures in our image look older and more eroded (the fact that they are cold in Night IR and there are craters inside also suggests their age), and also have some craters inside of them. The northern half of our image is more smooth, while the southern half is much higher and more rugged.

There is a much smaller fracture, as well as lava fields. The fact there are no lava fields elsewhere around fractures we are studying, this suggests the lava field was formed independently from the fissure, though lava has been known to explode from fissures.

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PART I: MATERIALS AND METHODS

I. Materials

-Images with extension TIFF (both visible and Infrared) has been download from THEMIS website. We use in our project all bands disponible in Nili Fossae from THEMIS website in order not to loose any information.
-Erdas Imagine will be use to treat the images. This GeoInformatic software will be use to create spectral images and to research indices of mineralogy.
-ArcGis will be use to create a database and to create a cartography of differents minerals find in our area of study.

II. Methodology of treatment of Images

1. *Spectral Image*

Spectral enhancement is the process of creating new spectral data from the available bands. The new channels are generated on the basis of pixel-to-pixel processing, by applying operators (for example subtraction, division) to the corresponding pixels in the existing bands.
Spectral enhancement is only applicable to multiband images.

2. *Spectral Ratioing*

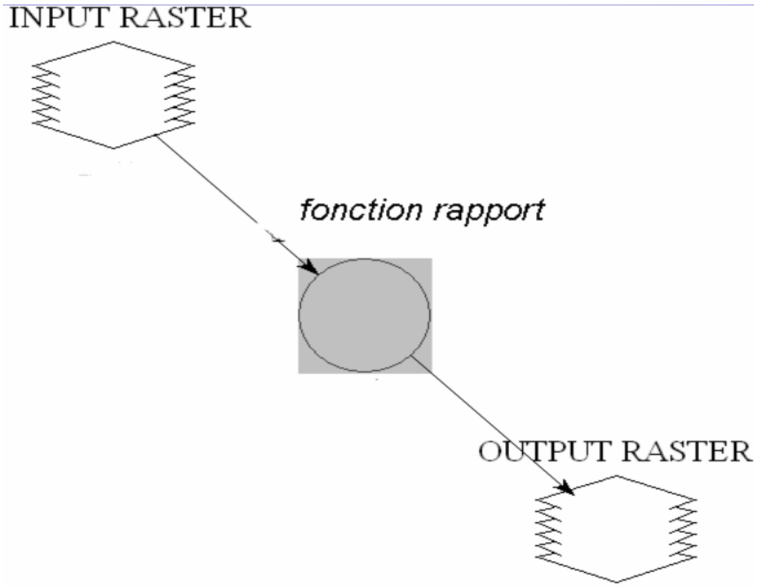
The Spectral Ratio is the operation of dividing the DNs of a spectral band by the DNs of the corresponding pixels of another spectral band.
An important advantage of the ratio images is their independence relative to the variations of the states of stage illumination (Lillesand & Kiefer, p.513
).

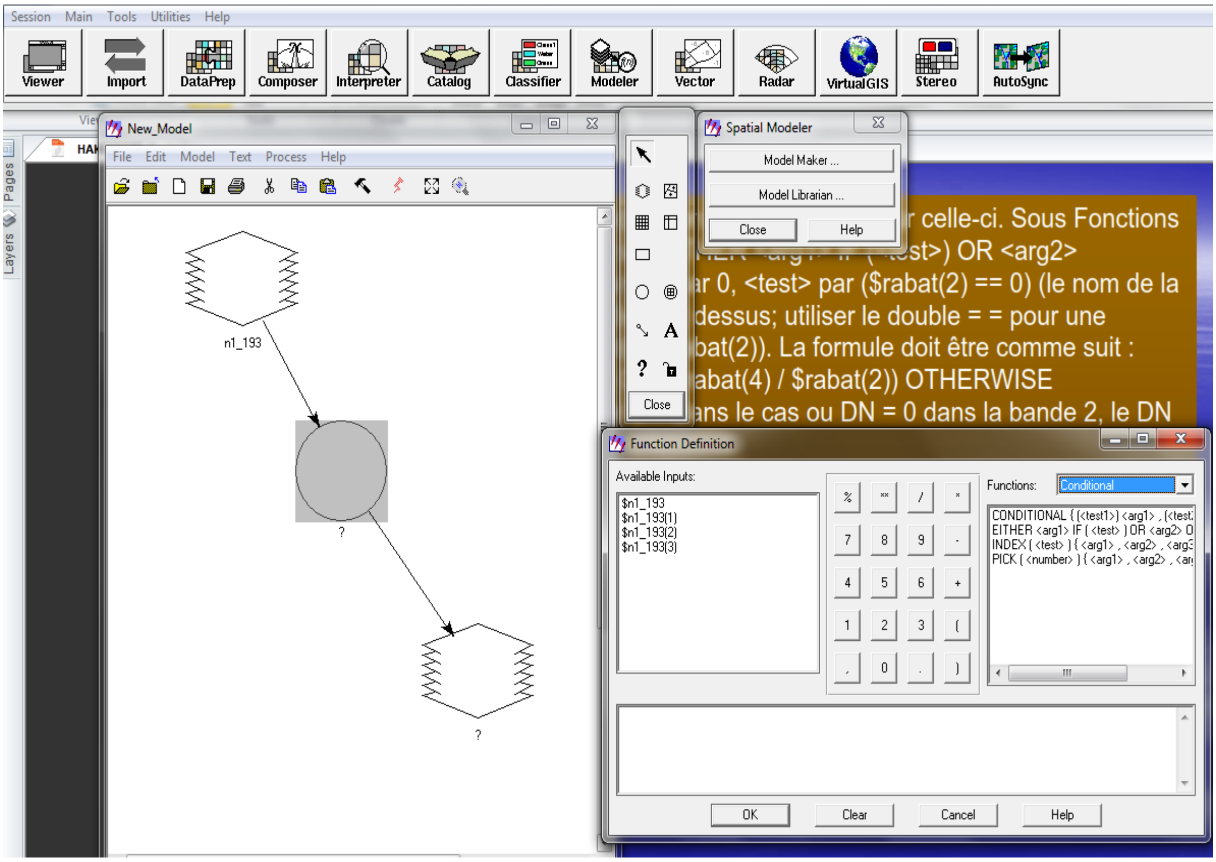
3. Calculation of Channel Ratios by the Model Maker

To calculate any ratio, a graphic model must first be created using the Modeler.
Click Model (in the icon panel) choose Model Maker ... An empty graphic template page is opened.
We will now use the palette of the model generator tool to build the model. Use  To add a raster image  , To add a function, and  To connect the raster images to the function, and the function to The output raster image.
Double click on the input image;
Give the name of the image to be processed and Declare as Float.
Click OK.

Open the properties of the function by double clicking on it.
Under Features choose Conditional, and click on EITHER <arg1> IF (<test>) OR <arg2> OTHERWISE. Replace <arg1> with 0, <test> with ($ img (b2) == 0) (the name of the tape can be entered by clicking on it,
use double = = for an equality), and <arg2> $ Img (b4) / $ img (b2)).
The formula must be as follows: EITHER 0 IF ($ img (b2) == 0) OR ($ img (b4) / $ img (b2)) OTHERWISE To avoid dividing by 0 - In band 2, the output DN will also be 0.
Close the dialog box of the function by clicking "OK".
Double click on the output image and give a name to this image.
And put Data Type on Unsigned 8-bit.
Click "OK".
Finally, click File / Save As ... to save the model as ratiocanaux.gmd
To be able to use it again, Choose Process / Run now to run the model and Open the created image in another viewer.

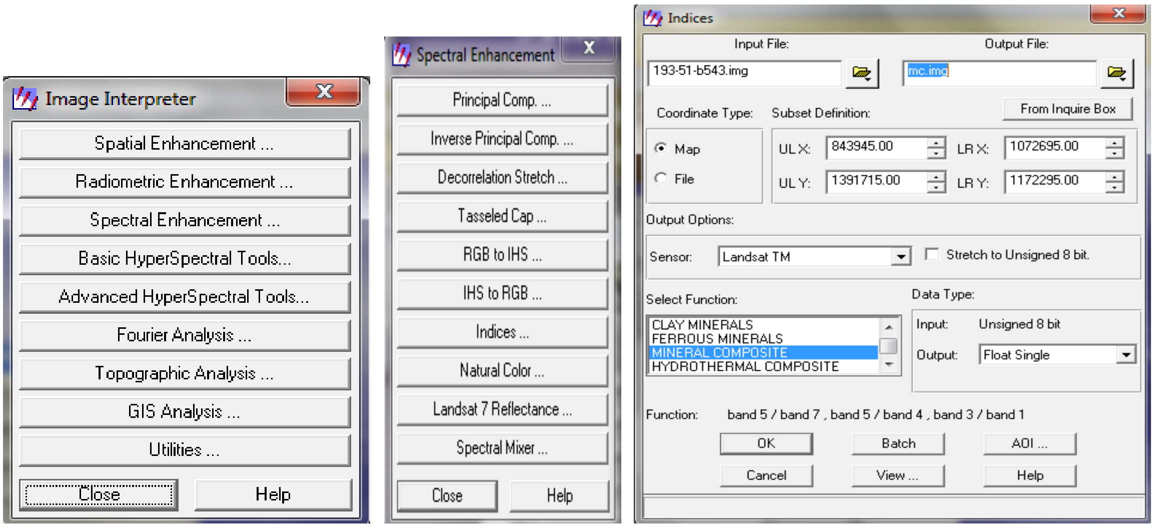
III. Procedure for Modeling



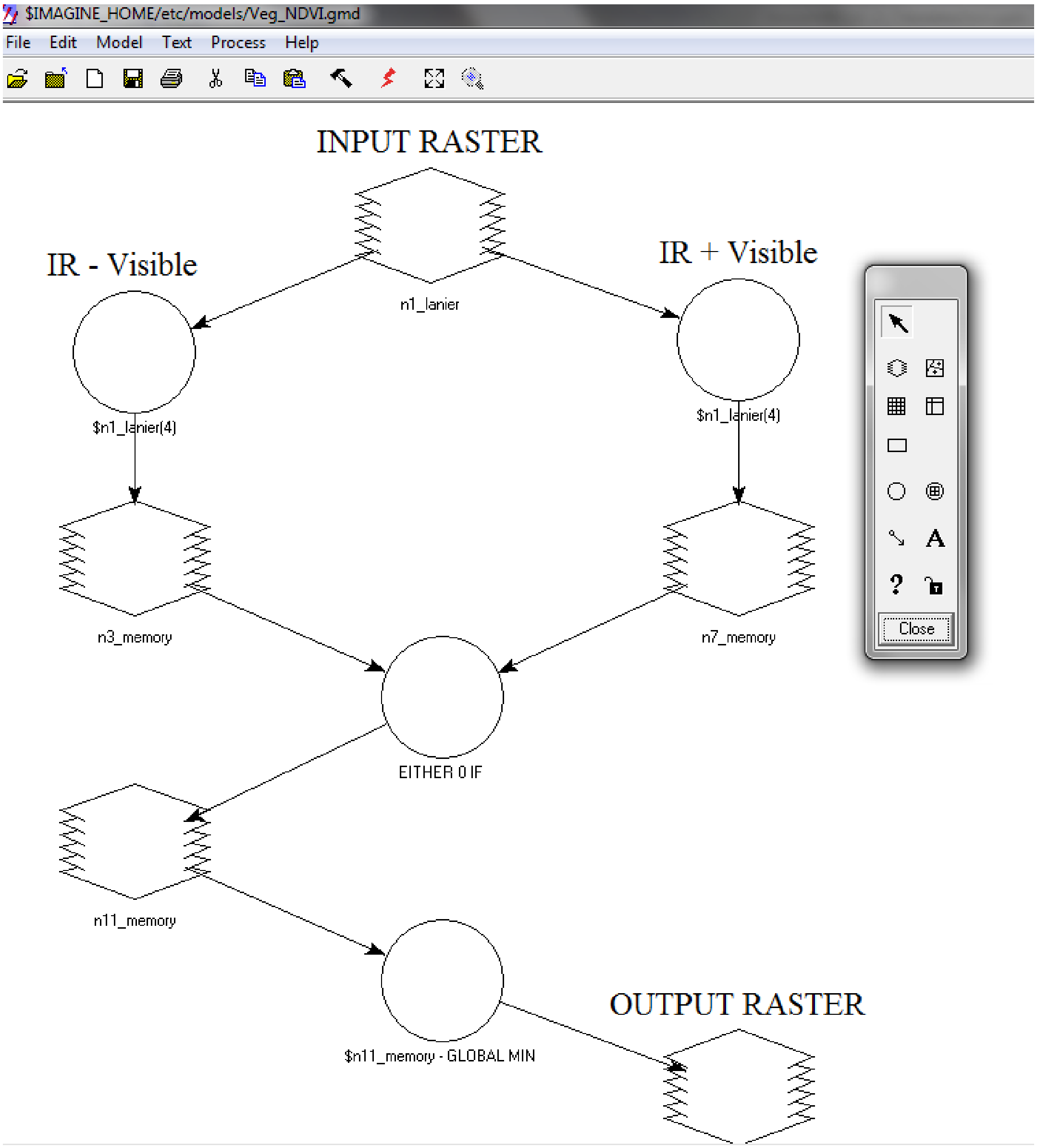

Session Main Tools Utilities Help
Viewer
Import
DataPrep
Composer
Interpreter
Catalog
Classifier
Modeler
Vector
Radar
VirtualGIS
Stereo
AutoSync
New_Model
File Edit Model Text Process Help
n1_193
?
?
Close
Spatial Modeler
Model Maker ...
Model Librarian ...
Close
Help
r celle-ci. Sous Fonctions
st>) OR <arg2>
ar 0, <test> par ($rabat(2) == 0) (le nom de la
dessus; utiliser le double = = pour une
bat(2)). La formule doit être comme suit :
abat(4) / $rabat(2)) OTHERWISE
ans le cas ou DN = 0 dans la bande 2, le DN
Function Definition
Available Inputs:
$n1_193
$n1_193(1)
$n1_193(2)
$n1_193(3)
Functions:
Conditional
OK
Clear
Cancel
Help

IV. spectral indices

To calculate the spectral index of an image, click on Interpreter / Spectral Enhancement / Indices ... Opening the index dialog



You can see the graphic model of some of the indices displayed on the list. To view the graphic model of this index (for example the NDVI) select the, and then click View. However, please note that we do not have any graphic models of the clues listed.



$IMAGINE_HOME/etc/models/Veg_NDVI.gmd
File Edit Model Text Process Help
INPUT RASTER
IR - Visible
IR + Visible
n1_lanier
$n1_lanier(4)
$n1_lanier(4)
n3_memory
n7_memory
EITHER 0 IF
n11_memory
$n11_memory - GLOBAL MIN
OUTPUT RASTER
Close

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PART II: RESULTS

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Chapter I: Results of treatment of images and interpretations

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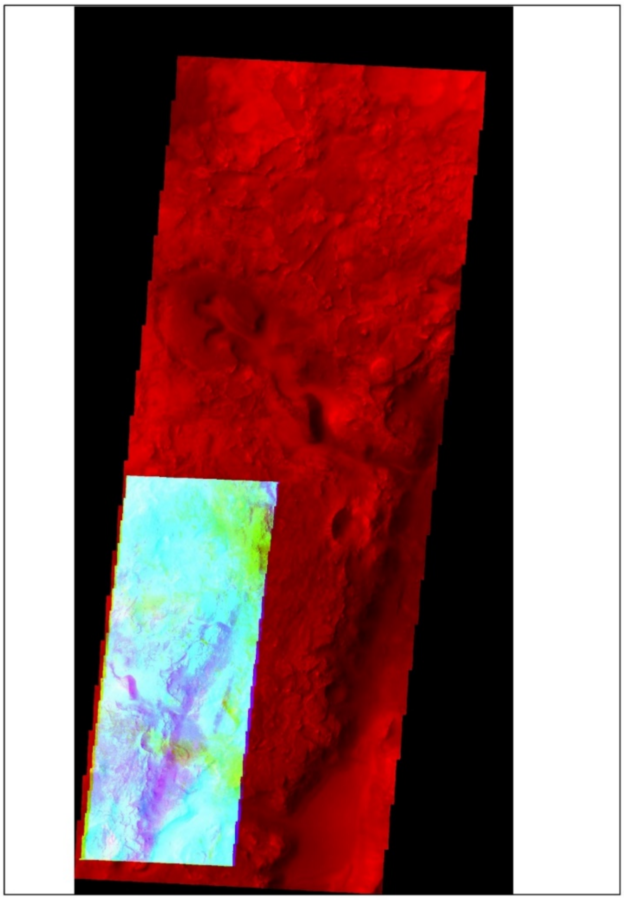
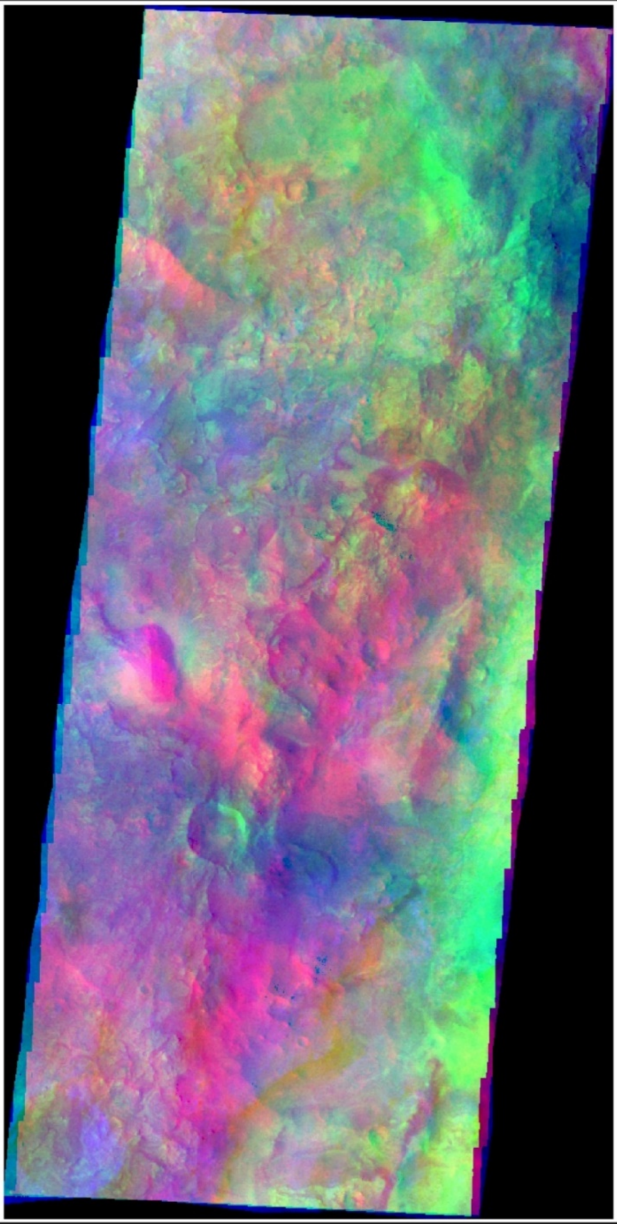
I. Spectral Images

1. Spectral Image of the whole Nili Fossae



The spectral image shows differents colors. There are evidences that the area is covered by many differents types of minerals.
A large are seem to be underlain by one type of mineral.This area is represent by the color red.
Another area (small) is obviously covered by many different types of minerals. This area is represent by mix colors. Maybe that area is the most important.

2. Partial spectral Image

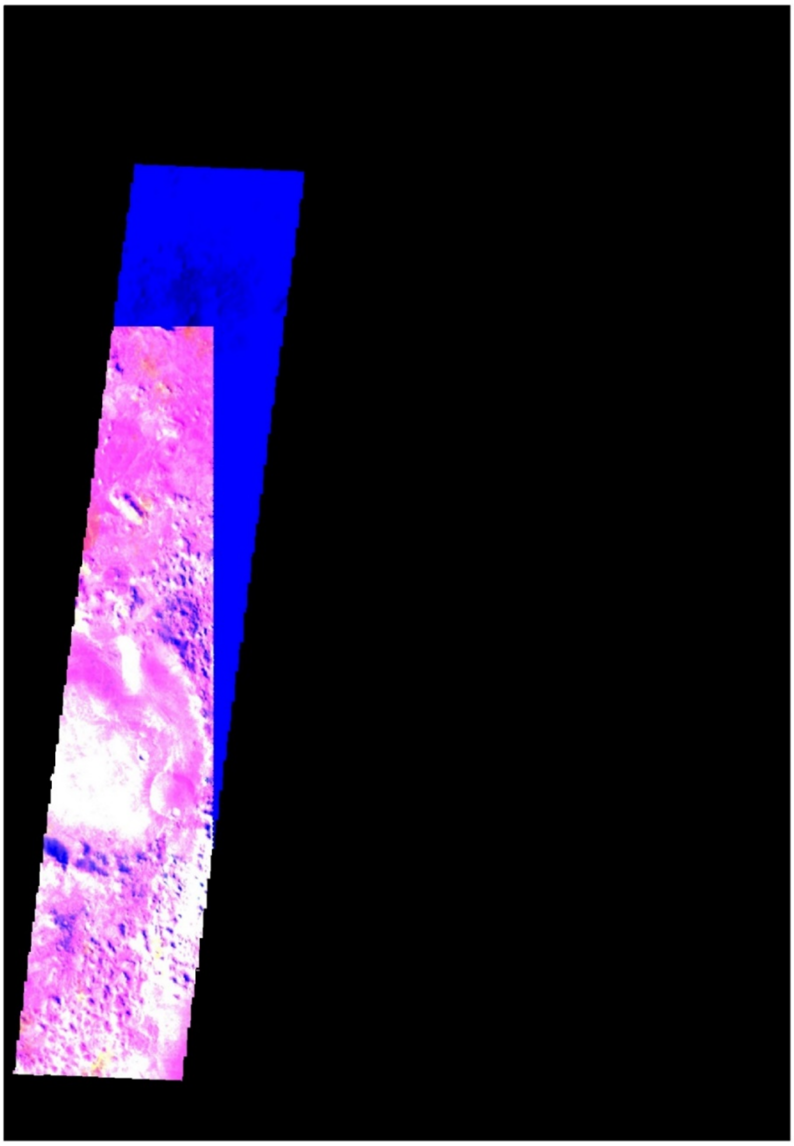


We decide to study also separately the small area showing a mosaic color and compare it to total spectral image of Nili Fossae in order to know if there is any difference and if so, why this area is singularly different to the whole spectrale image.

We have extracted this part from the spectrale image of all Nili Fossae.

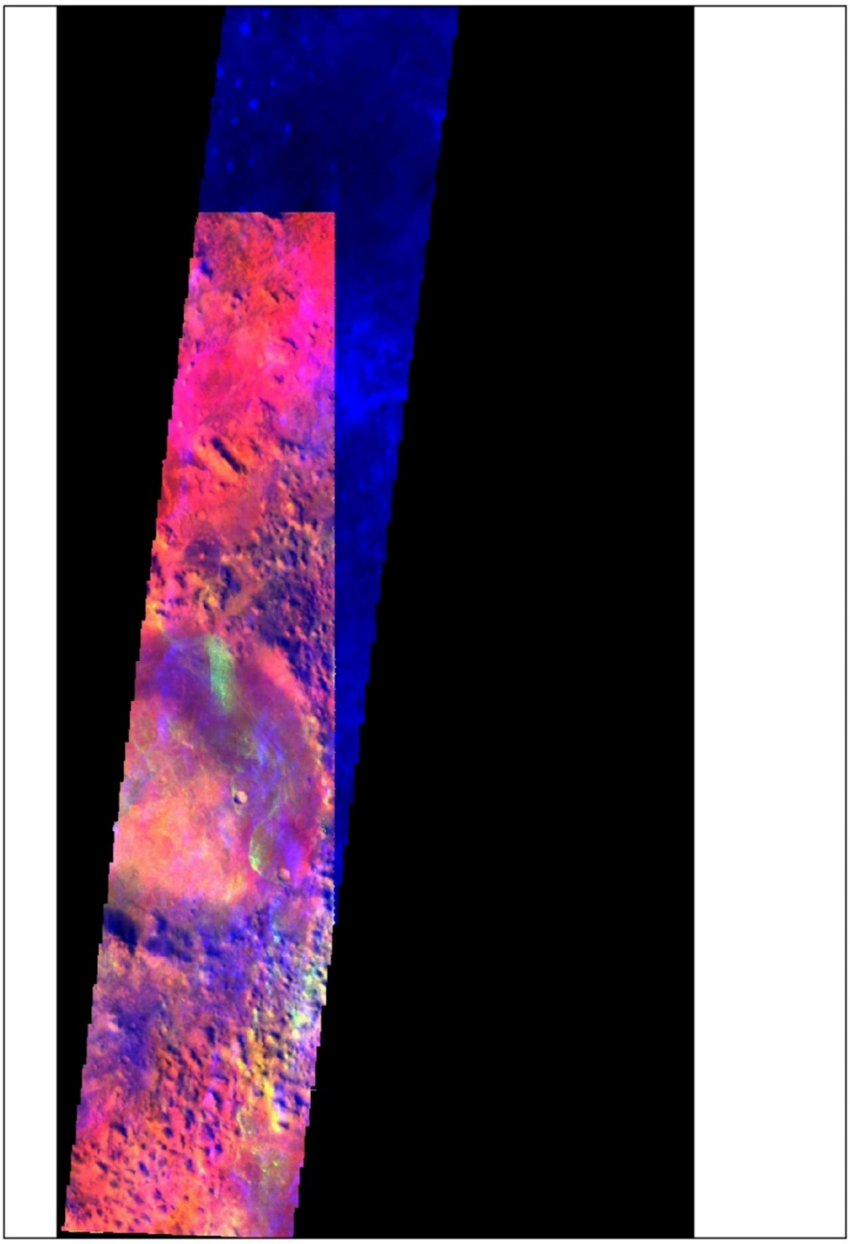
II. Results of Indices

1. Mineralogical repartition on the whole spectral image



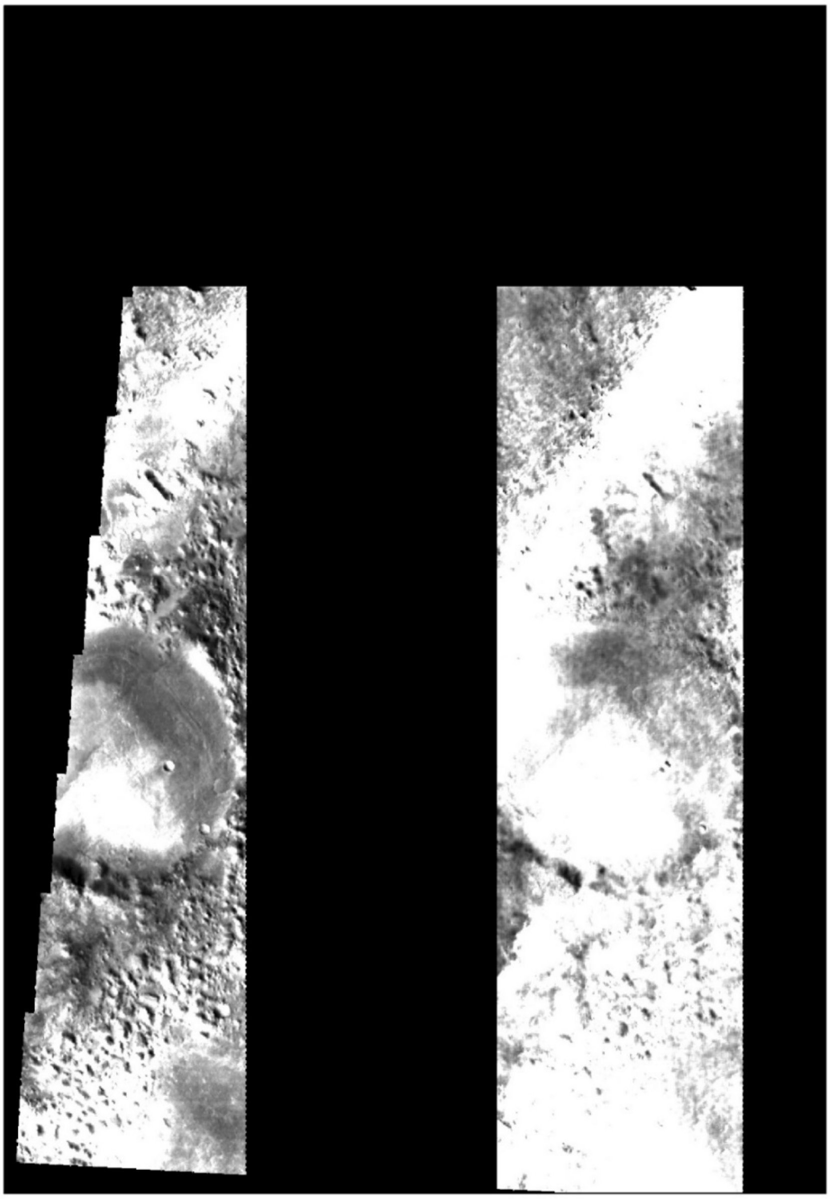
This image shows that the area is globally covered by three (3) type of minerals
The blue colors represent the phyllosilicates
The purple color represent mafics minerals
The white color represent hydrated minerals

2. Mineralogical repartition on the partial spectral Image



There is almost no difference between the differents mimerals identifies on the complete spectral image and on the partial spectral image extracted from the complete one.
Maybe the single red color on the complete spectral image is due to combination of bands while treating images on Erdas Imagine (Geomatics software).

III. Another Indices (repartition of Clays)



This treatment goal is to identify area covered by clays minerals.
White colors are areas covered by Clays minerals.
Nili Fossae is covered in majority by lot of clay mineral. Those minerals are Phyllosilicates.

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Chapter II: Results from CRISM TEAM

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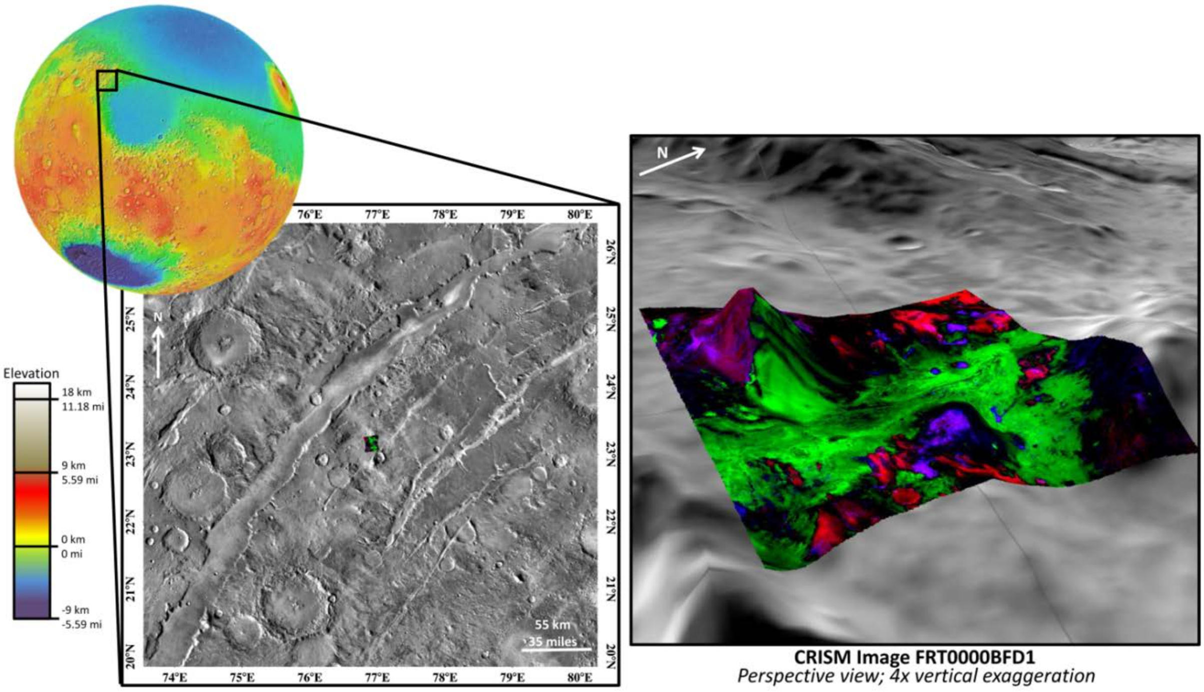
I. Mafics minerals in Nili Fossae



CRISM Image FRT0000BFD1
Perspective view; 4x vertical exaggeration

This image has been taken in August 13, 2009 and has been released in June 27, 2014
Latitiude : 23.12 N
Longitude 76.89 E

The image in the bottom is from that area and shows what the scientist have found

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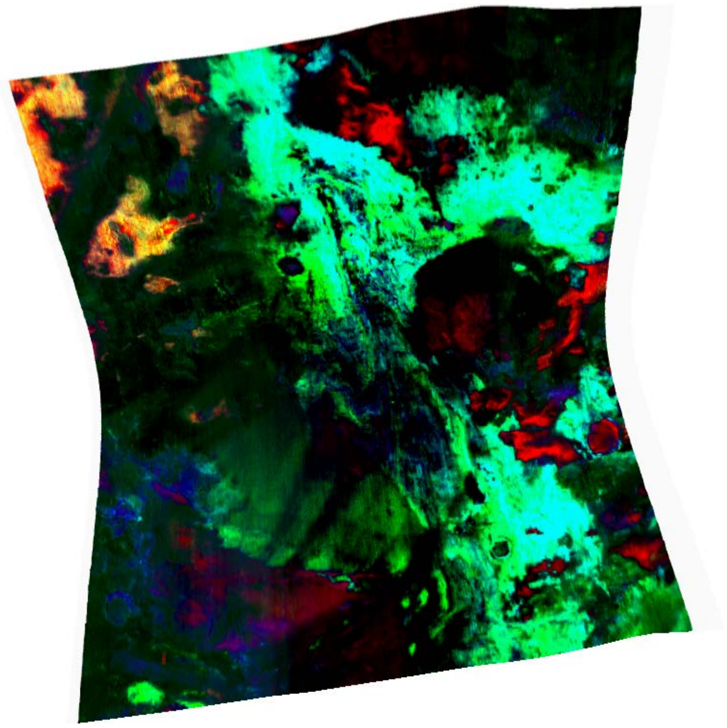

Red colors represent olivine or iron phyllosilicates
Green colors represent low-Ca pyroxene
Blue colors represent high- Ca pyroxene

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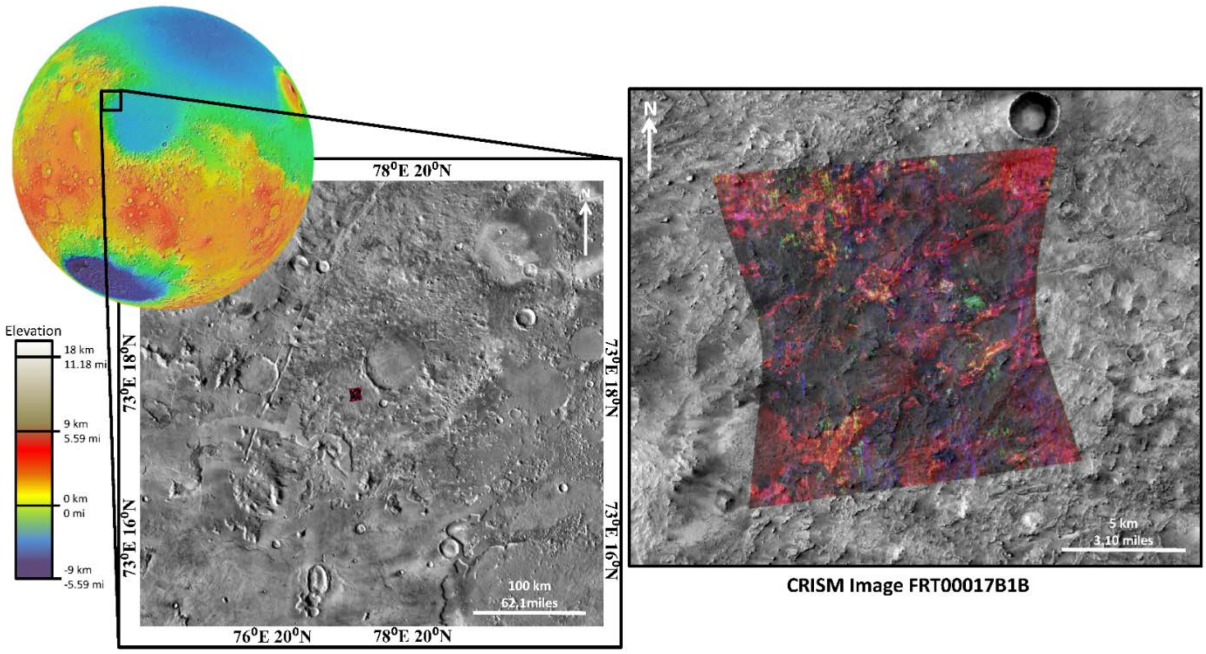
II. Hydrated minerals near Nili Fossae



CRISM Image FRT00017B1B

This image has been taken in April 4, 2010 and has been released in December 5, 2014

Latitude: 17.99 N
Longitude: 77.09 E

The image in the bottom is from that area and shows exactly what the scientist have found in this area

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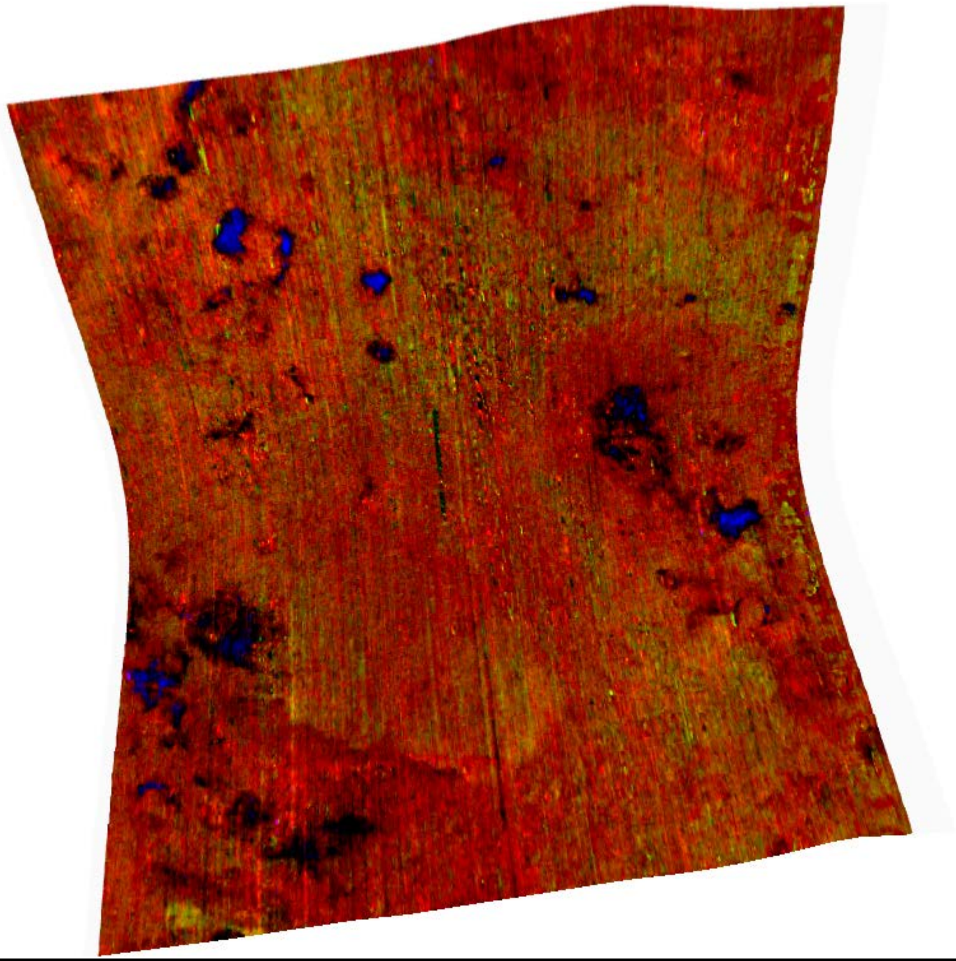

Red color represent water-containing minerals or water ice
Green colors represent monohydrated sulfate or water ice
Blue colors represent Hydrated sulfates, clay or water ice

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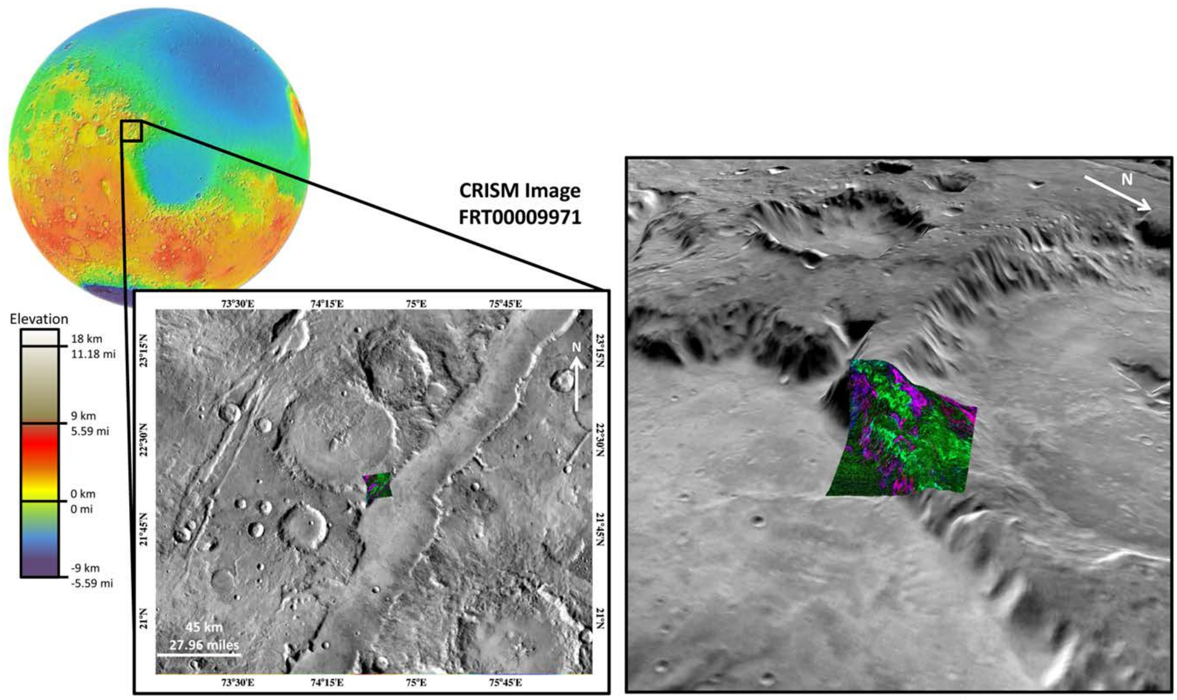
III. Phyllosilicates in Nili Fossae



Perspective view; 5x vertical exaggeration

This image has been taken in January 23, 2008 and has been released in December 20, 2013

Latitiude: 22.05 N

Longitude: 74.62 E

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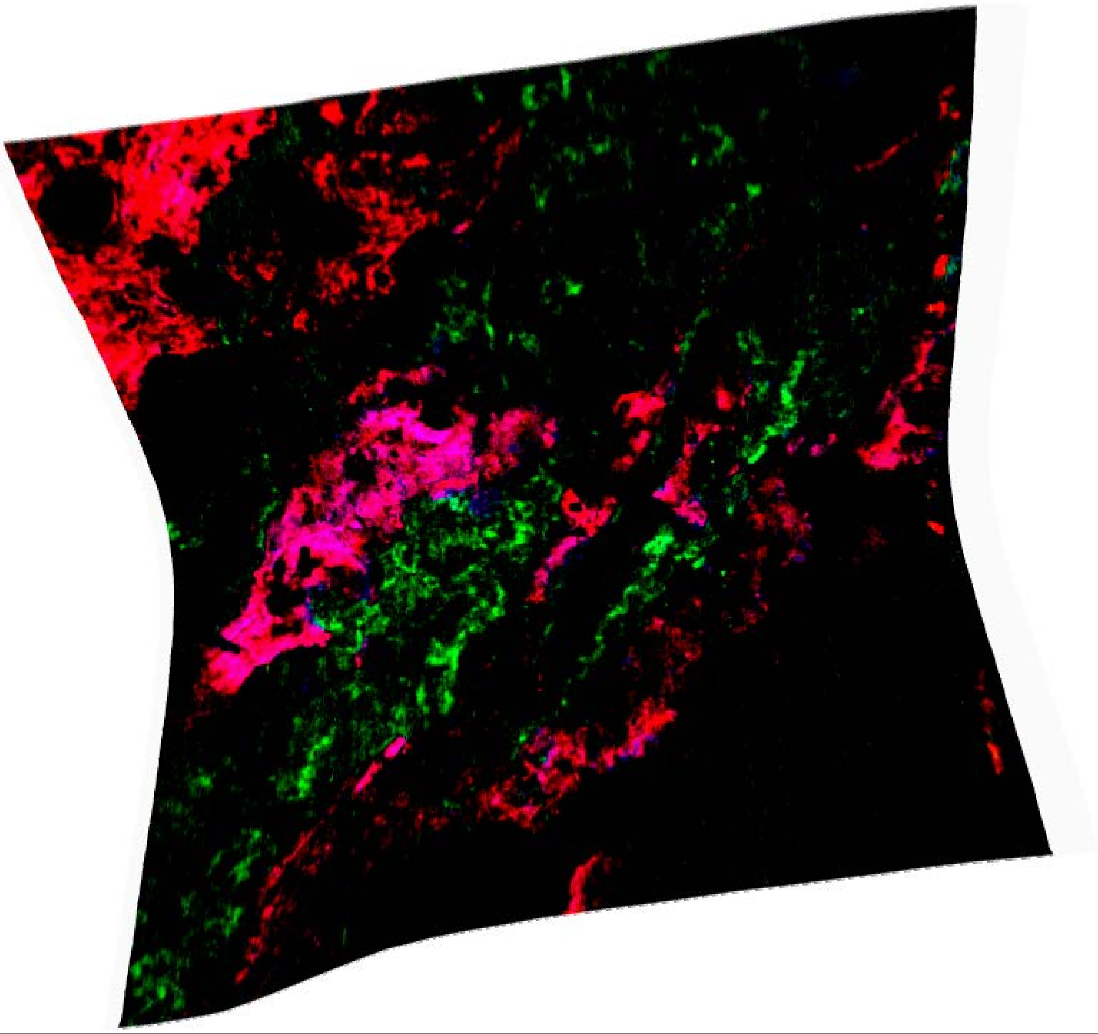

Scientists found in this area :
Red colors represent Fe/Mg phyllosilicate
Green colors represent Al phyllosilicate or hydrated glass
Blue colors represent hydrated sulfates, clays, glass or water ice

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PART III: ANALYSES OF RESULTS

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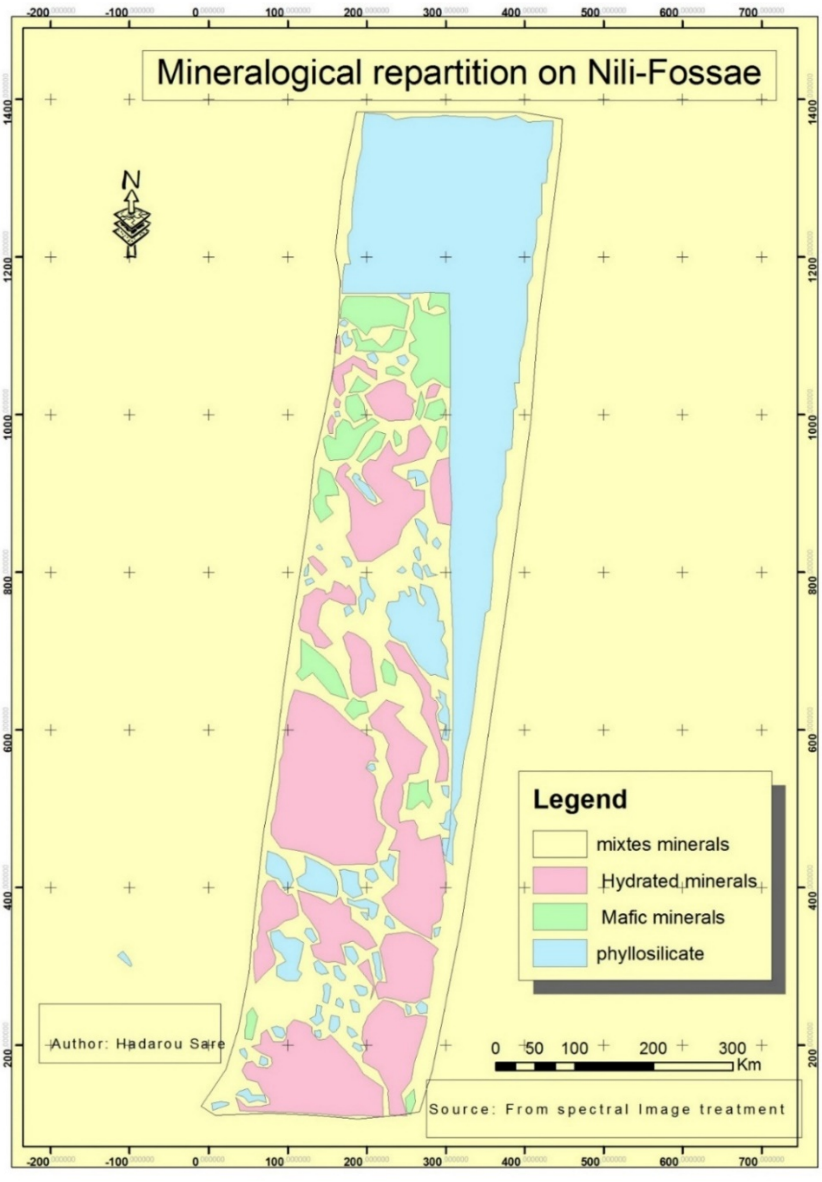
I. Cartography of mineral repartition in Nili Fossae



This map show repartition of three main minerals in Nili Fossae : mafic minerals, hydrated minerals and phyllosilicates.

II. Table of superficies

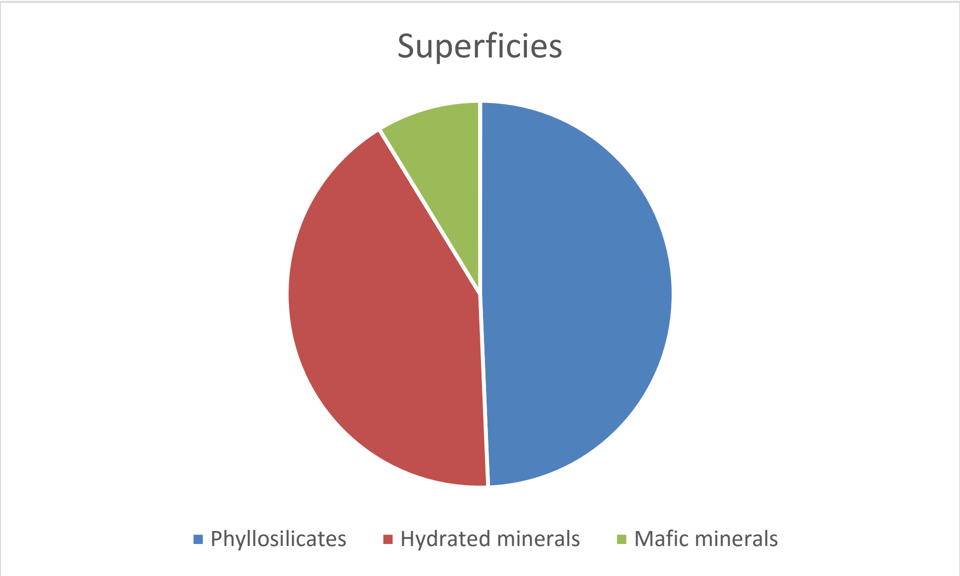
Number	Minerals	Superficies
1. 0	phyllosilicate	78,87
1. 0	phyllosilicate	149,58
2. 0	phyllosilicate	121,76
3. 0	phyllosilicate	128,25
4. 0	phyllosilicate	60,31
5. 0	phyllosilicate	36,58
6. 0	phyllosilicate	362,02
7. 0	phyllosilicate	312,02
8. 0	phyllosilicate	218,51
9. 0	phyllosilicate	505,81
10. 0	phyllosilicate	93,65
11. 0	phyllosilicate	29,66
12. 0	phyllosilicate	55,51
13. 0	phyllosilicate	177,41
14. 0	phyllosilicate	107,35
15. 0	phyllosilicate	103,25
16. 0	phyllosilicate	5605,70
17. 0	phyllosilicate	92,94
18. 0	phyllosilicate	65,26
19. 0	phyllosilicate	532,22
20. 0	phyllosilicate	74,01
21. 0	phyllosilicate	106,22
22. 0	phyllosilicate	346,62
23. 0	phyllosilicate	200,01
24. 0	phyllosilicate	707,37
25. 0	phyllosilicate	1572,80
26. 0	phyllosilicate	50,71
27. 0	phyllosilicate	51,13
28. 0	phyllosilicate	237,16
29. 0	phyllosilicate	998,76
30. 0	phyllosilicate	189,41
31. 0	phyllosilicate	136,22
32. 0	phyllosilicate	89402,08

33. 0	phyllosilicate	136,22
34. 0	phyllosilicate	136,22
35. 0	phyllosilicate	1678,73
36. 0	phyllosilicate	186,16
37. 0	phyllosilicate	169,21
38. 0	phyllosilicate	250,43
39. 0	phyllosilicate	272,32
40. 0	phyllosilicate	99,15
41. 0	phyllosilicate	164,69
42. 0	phyllosilicate	135,46
43. 0	phyllosilicate	204,52
44. 0	phyllosilicate	80,79
45. 0	phyllosilicate	45,06
46. 0	phyllosilicate	56,64
47. 0	phyllosilicate	74,01
48. 0	phyllosilicate	130,65
49. 0	phyllosilicate	62,85
50. 0	phyllosilicate	101,70
51. 0	phyllosilicate	82,21
52. 0	phyllosilicate	225,71
53. 0	phyllosilicate	66,81
54. 0	phyllosilicate	173,03
55. 0	phyllosilicate	68,93
56. 0	phyllosilicate	88,99
57. 0	phyllosilicate	73,45
58. 0	phyllosilicate	224,87
59. 0	phyllosilicate	157,63
60. 0	phyllosilicate	63,42
61. 0	phyllosilicate	57,07
62. 0	phyllosilicate	64,13
63. 0	phyllosilicate	51,98
64. 0	phyllosilicate	98,03
65. 0	phyllosilicate	46,89
66. 0	phyllosilicate	74,15
67. 0	phyllosilicate	315,27
68. 0	phyllosilicate	150,85
69. 0	phyllosilicate	185,46
70. 0	phyllosilicate	442,39
71. 0	phyllosilicate	55,37
72. 0	Hydrated minerals	2326,91
73. 0	Hydrated minerals	994,81
74. 0	Hydrated minerals	67,52
75. 0	Hydrated minerals	134,89
76. 0	Hydrated minerals	130,23
77. 0	Hydrated minerals	222,75

78.	0	Hydrated minerals	9800,60
79.	0	Hydrated minerals	1804,60
80.	0	Hydrated minerals	248,88
81.	0	Hydrated minerals	2237,37
82.	0	Hydrated minerals	2741,62
83.	0	Hydrated minerals	22990,04
84.	0	Hydrated minerals	12800,58
85.	0	Hydrated minerals	13838,32
86.	0	Hydrated minerals	6951,93
87.	0	Hydrated minerals	5674,05
88.	0	Hydrated minerals	4458,34
89.	0	Hydrated minerals	3278,64
90.	0	Hydrated minerals	2422,54
91.	0	Mafic minerals	3020,44
92.	0	Mafic minerals	4871,65
93.	0	Mafic minerals	662,03
94.	0	Mafic minerals	1913,77
95.	0	Mafic minerals	1203,43
96.	0	Mafic minerals	1996,82
97.	0	Mafic minerals	442,10
98.	0	Mafic minerals	809,21
99.	0	Mafic minerals	505,67
100.	0	Mafic minerals	330,24
101.	0	Mafic minerals	589,85
102.	0	Mafic minerals	176,70
103.	0	Mafic minerals	287,72
104.	0	Mafic minerals	131,08
105.	0	Mafic minerals	217,80
106.	0	Mafic minerals	1077,15
107.	0	Mafic minerals	264,70
108.	0	Mafic minerals	431,23
109.	0	Mafic minerals	488,15
110.	0	Mafic minerals	0,00
111.	0		0,00

III. Statistics of minerals repartition

Minerals	Superficies
Phyllosilicates	109660.6
Hydrated minerals	93124.62
Mafic minerals	19419.74



The combination of the map of mineralogy's repartition, the tables and the graph show that Nili Fossae is mainly underlain by phyllosilicates, hydrated minerals and mafic minerals. Phyllosilicates and hydrated minerals covered vast area in Nili Fossae.

IV. Analyses

1. Mafic minerals

It appear occurrences of aqueously altered rocks linked to past water activity despite the fact that The vast majority of the area crust is unaltered igneous rock.the cartography of minerals and the THEMIS team research show concentration of different minerals common in rocks and might tell us about processes that happened in Mars past.. Pyroxene is the dominant silicate mineral in most igneous rocks and contains iron, magnesium, and variable amounts of calcium as well as silicon and oxygen. Phyllosilicates are clay and clay-like mineral formed by chemical reactions with liquid water.

2. Hydrated minerals

Nili Fossae is underlain by a graben(a group of long narrow tectonic depressions). There are aqueously-altered minerals in our datas, so the minerals have been change by water. Minerals reflect the presence of iron/magnesium-containing phyllosilicates.

The CRISM team took this image to search for interesting mineral near Nilli Fossae in preparation for the Mars Science Laboratory(Curiosity) rover mission. While MSL did not make it to Nili Fossae, this location is prime candidate for the new Mars 2020 rover.

3. Phyllosilicates

Again our datas show a group of long, narrow tectonic depressions called graben.When loking at our cartography of mineralogy, our datas from treatment of images and the result from THEMIS team, we see layers of clay and clay-like minerals called phyllosilicates that are found in many of the oldest rocks on Mars.

If we compare aluminium-phyllosilicates overlying iron/magnesium-phyllosilicates that we see on earth to the datas we got from Nili Fossae, we can say that a pedogenic (soil forming) process may have been responsible for the clay mineral formation. This layering of minerals may imply that more soluble elements (like iron and magnesium) were leached from overlying rocks, creating a residue of aluminium-

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PART IV: DISCUSSION AND CONCLUSION

I. Discussion

some points which appear to lie on lines, implying that the variables for these fissures are correlated. Fissures seem to have long depth and large width.
The Nili Fossae region is important to understanding the history of water on Mars and to know if water was formed in environments favorable for life, because the region is covered by a lot of phyllosilicate (clay) minerals., phyllosilicates can contain organic chemicals associated with life (if life was present).
There are some very interesting unanswered questions involving these fissures that we have uncovered during our research. We would look into further into these if we were to do more research in this area.We could look to know if the Nili Fossae fissures in our image were formed by explosive eruptions? Have the fields eroded away? Are tectonic Fissures? Volcanic Fissures ? Ice Fissures ? or Water Formed Fissures (Canyons) ? what are the depth and the width of fissures? We could also cartography differents lineaments in Nili Fossae and analyse them because lineament which are related to fractures are very important in identification presence of water or other mineral ressources.

II. Conclusion

We conclude that the research on Nili Fossae is very important because it might help scientist to answer definitely the question about potential life or the possibility for human being to live on palnet Mars. Nili Fossae is a potential zone where we could find water and rocks or minerals containing chemical organics , so zones with fractures can help us to find areas with biosphere (all living things include human being) on planet Mars . We believe that further work looking at erosion, and mineral data, as well as probing other fissure sets may lead in the ability to classify fissures, in terms of age, and formation mechanisms.

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PART V: ACKNOWLEDGMENTS AND REFERENCES

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