Venus Surface Oxidation and Weathering as Viewed from Orbit with 6-Window VNIR Spectroscopy

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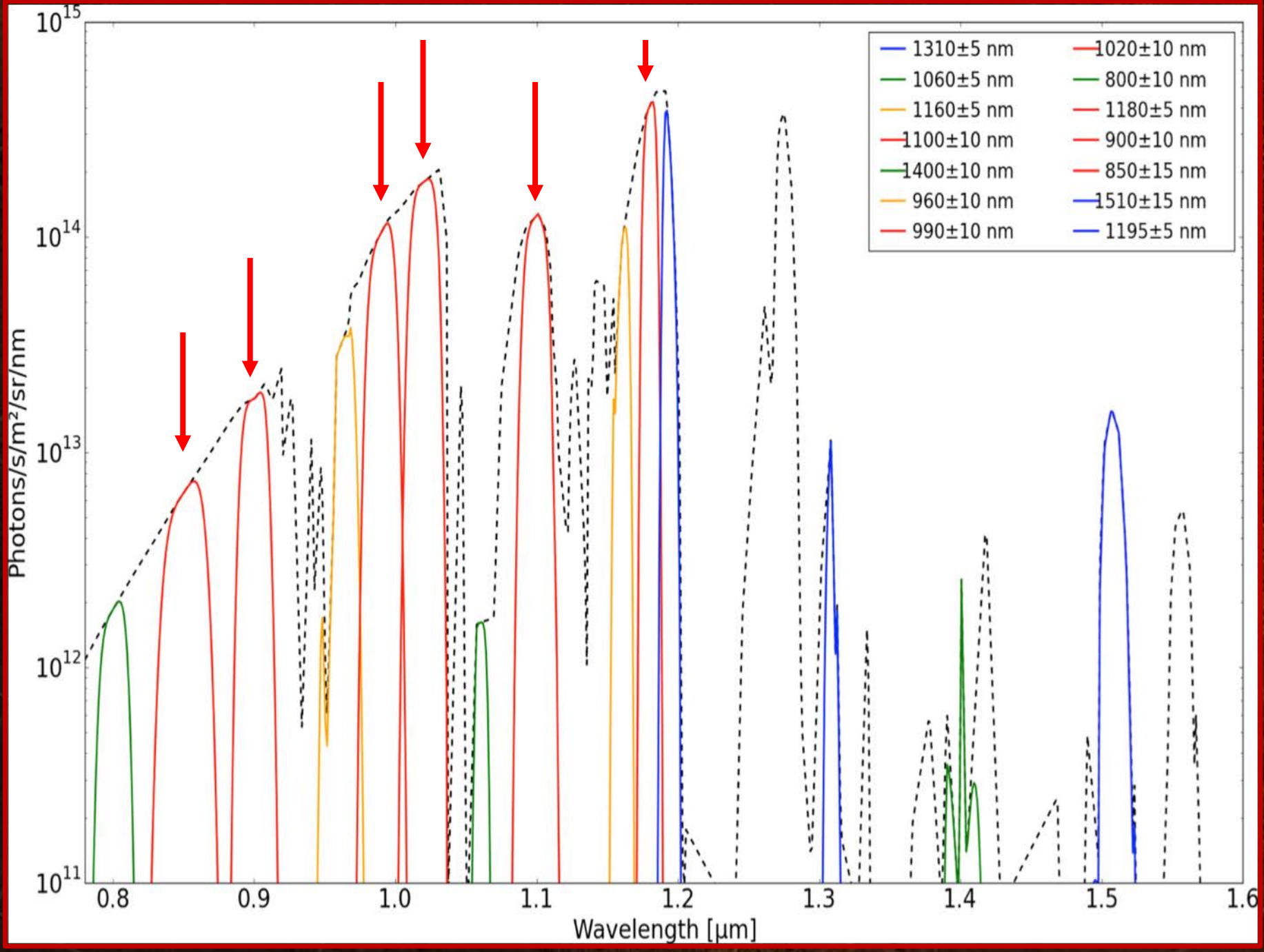
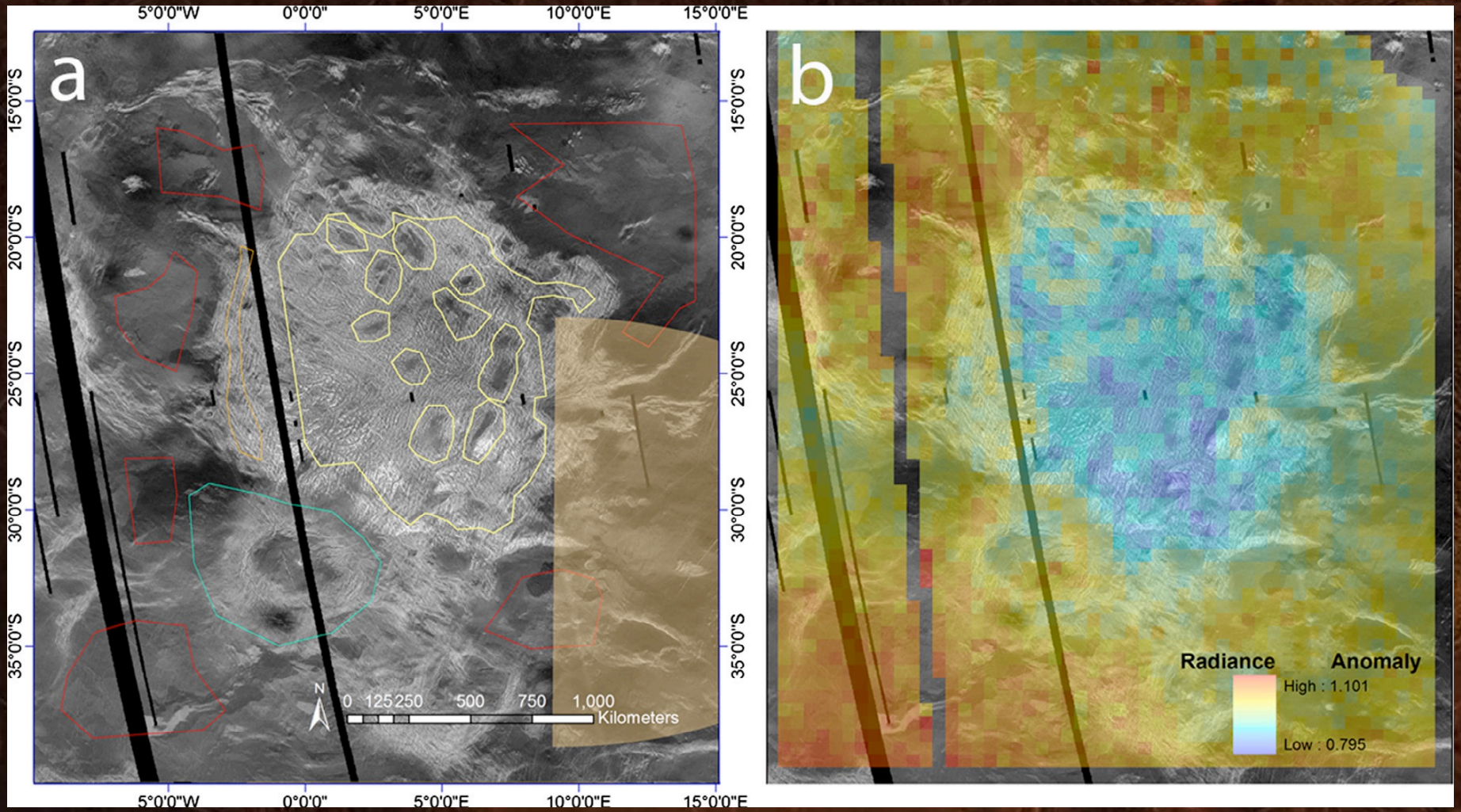
and many, many others!


1310±5 nm
1020±10 nm
1060±5 nm
800±10 nm
1160±5 nm
1180±5 nm
1100±10 nm
900±10 nm
1400±10 nm
850±15 nm
960±10 nm
1510±15 nm
990±10 nm
1195±5 nm
Photons/s/m²/sr/nm
Wavelength [μm]
10^15
10^14
10^13
10^12
10^11
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6

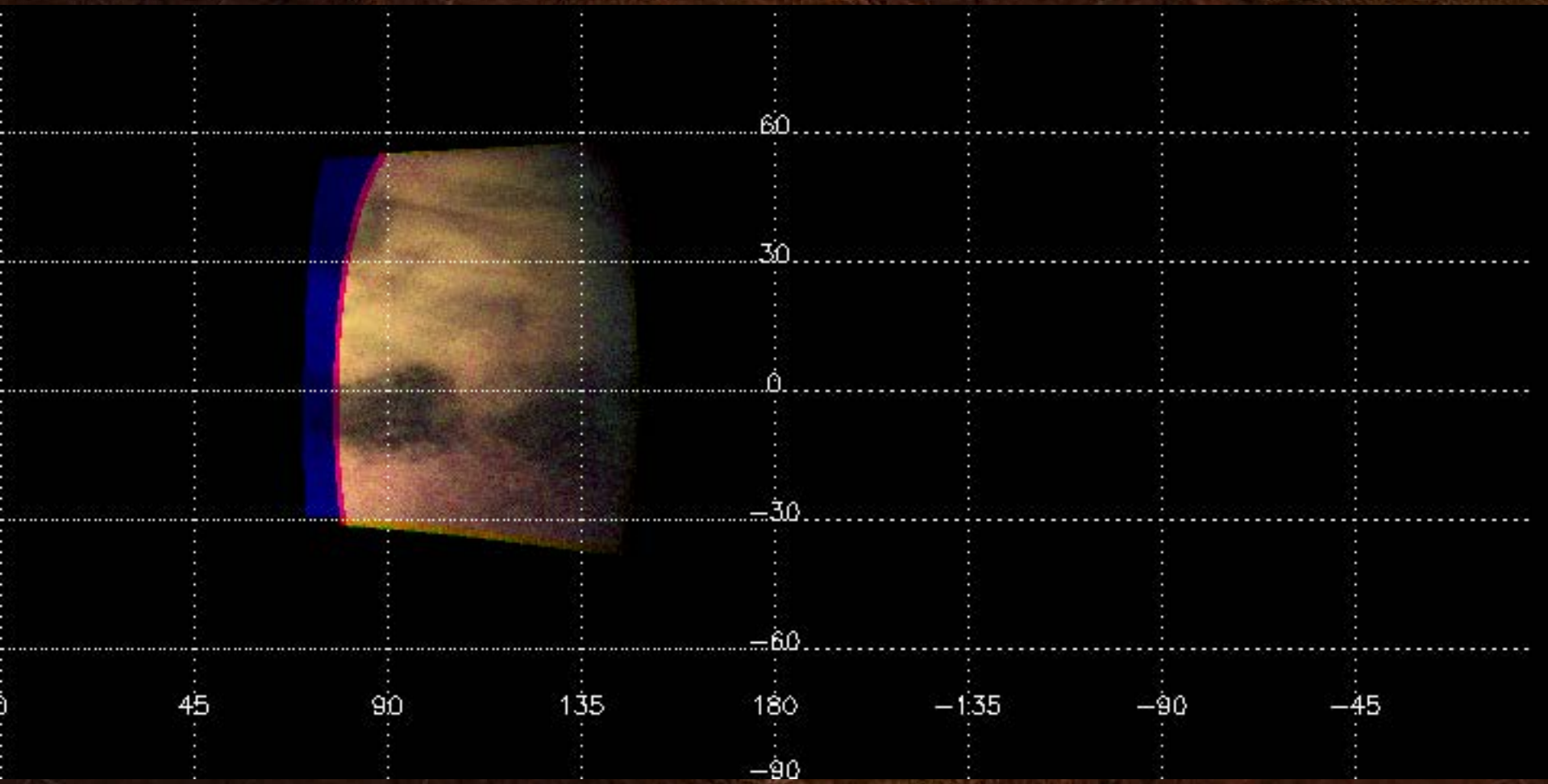
Magellan

1.02 μm VIRTIS

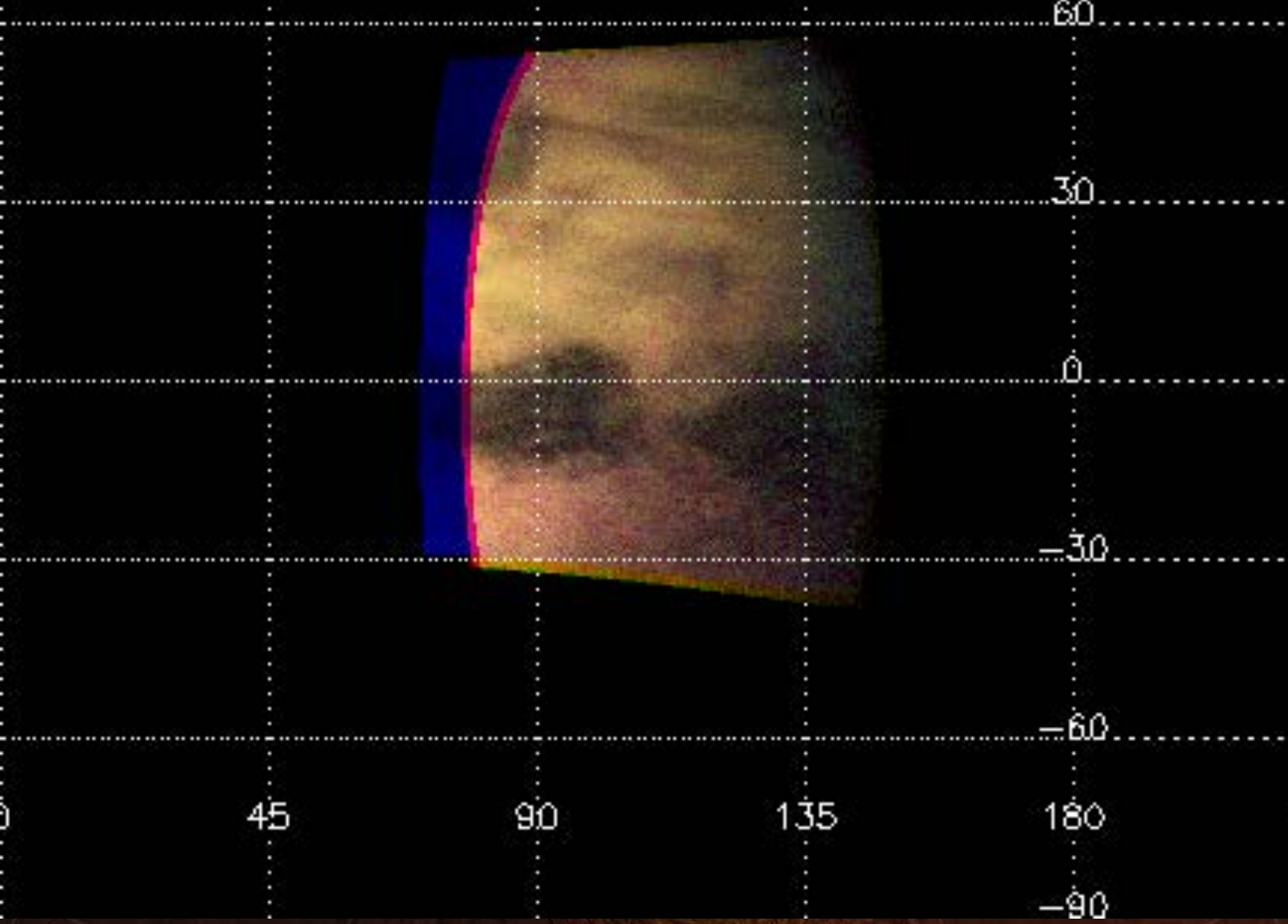


Gilmore et al. (2015)

Tri-Color near-IR Venus Surface Emissivity
Akatsuki IR1 Camera – Jan 21, 2016
Jan 21, 2016 – Red 1.01 μm, Green 0.97 μm, Blue 0.90 μm



M.A. Bullock, N. Iwagami, G. Hashimoto – Akatsuki Science Team



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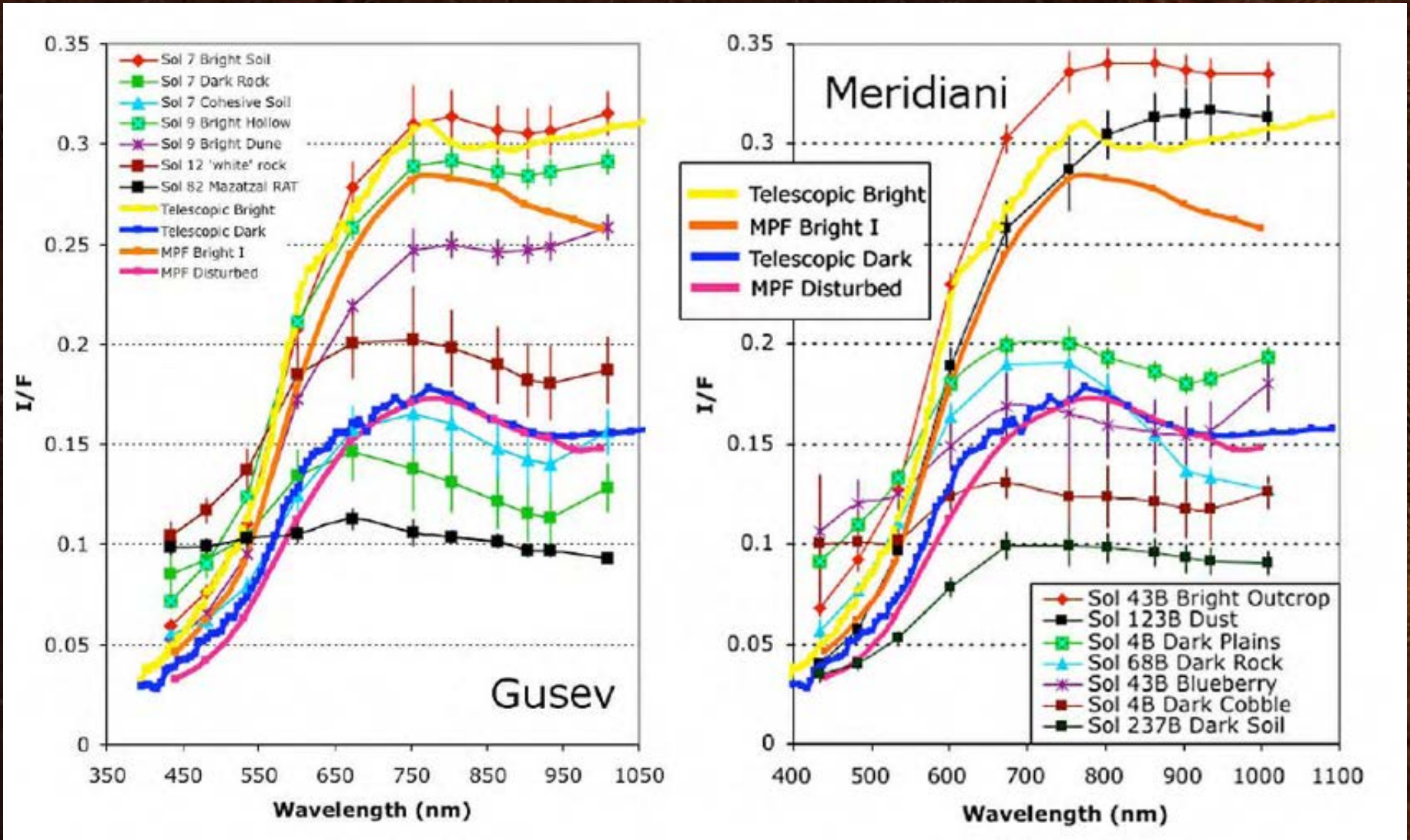
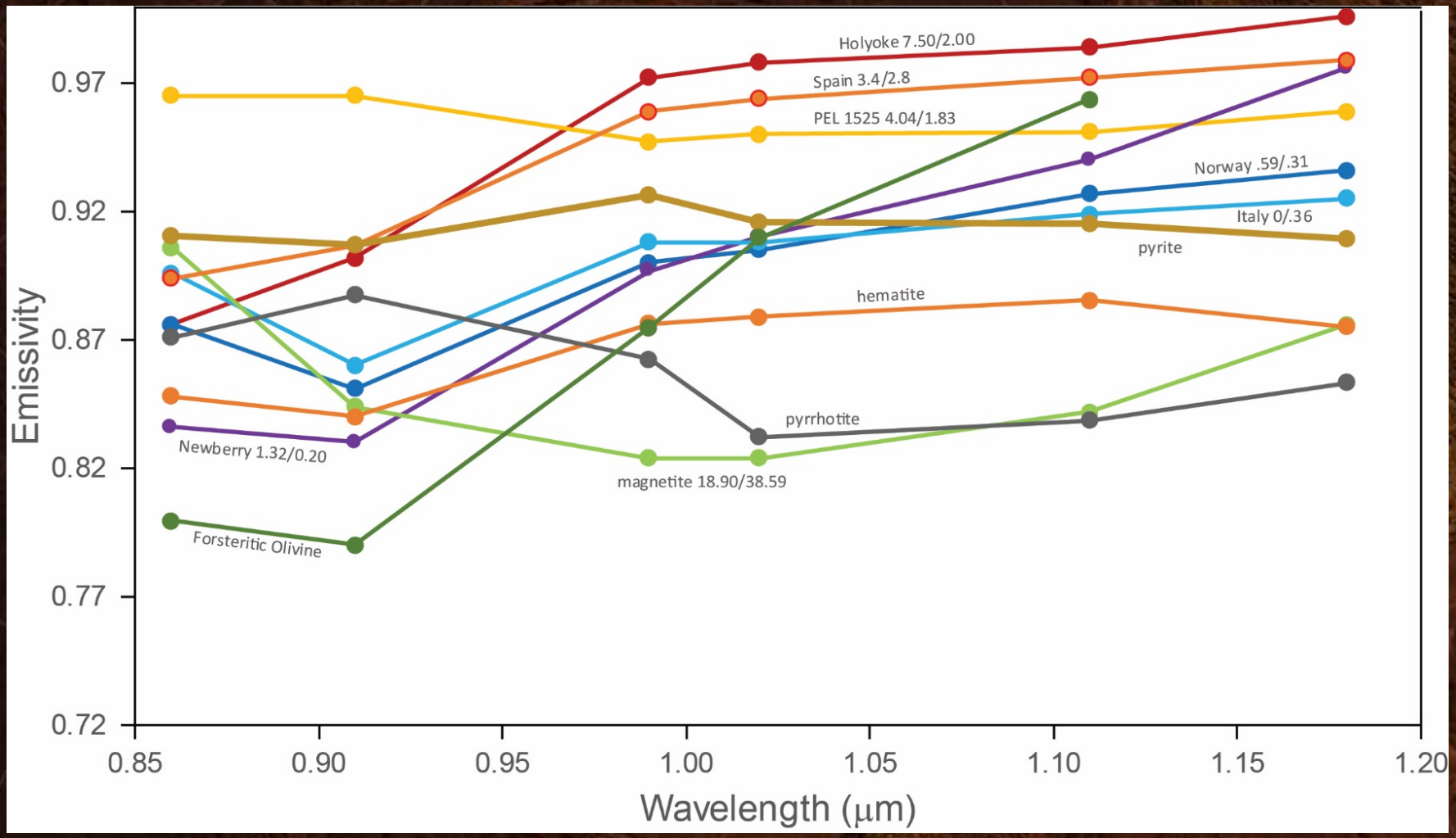
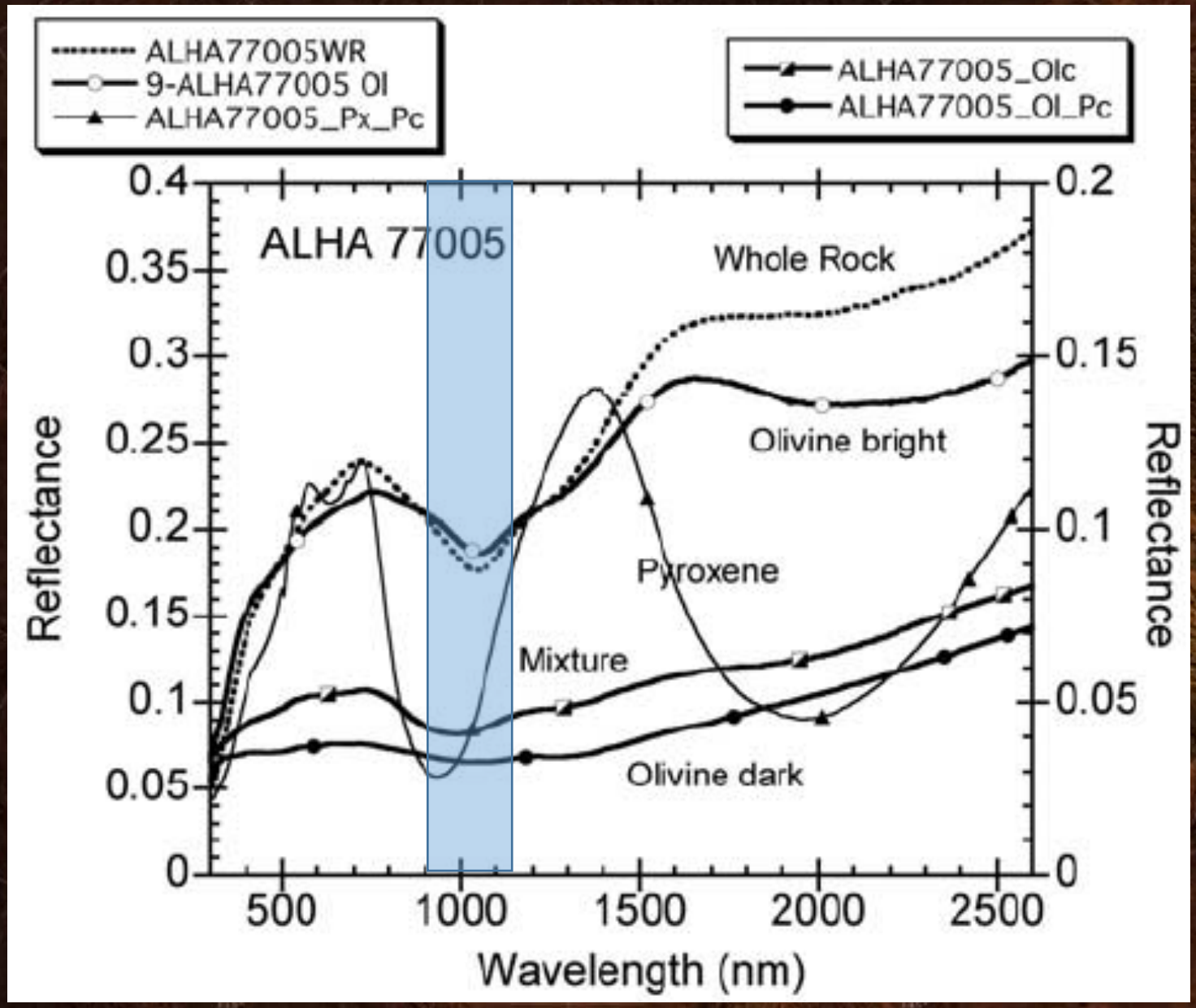


Bell et al. (2006) In-flight calibration and performance of the Mars Exploration Rover Panoramic Camera (Pancam) instruments

VEM Data, Helbert lab, DLR

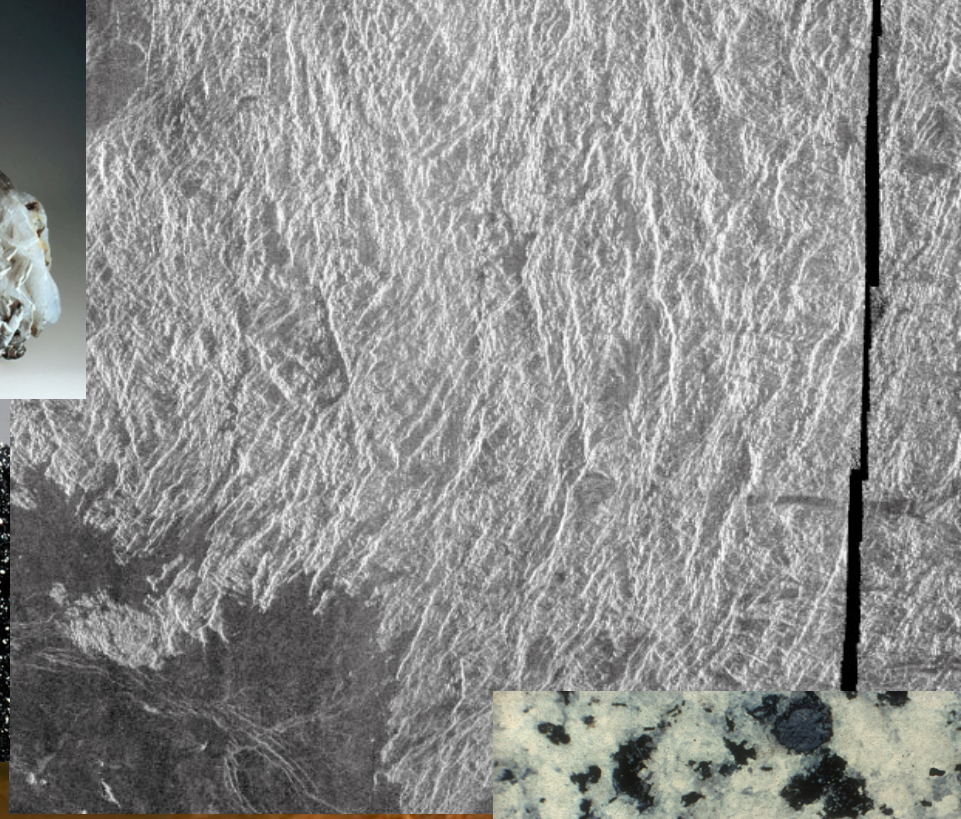




Pieters et al. (2008)

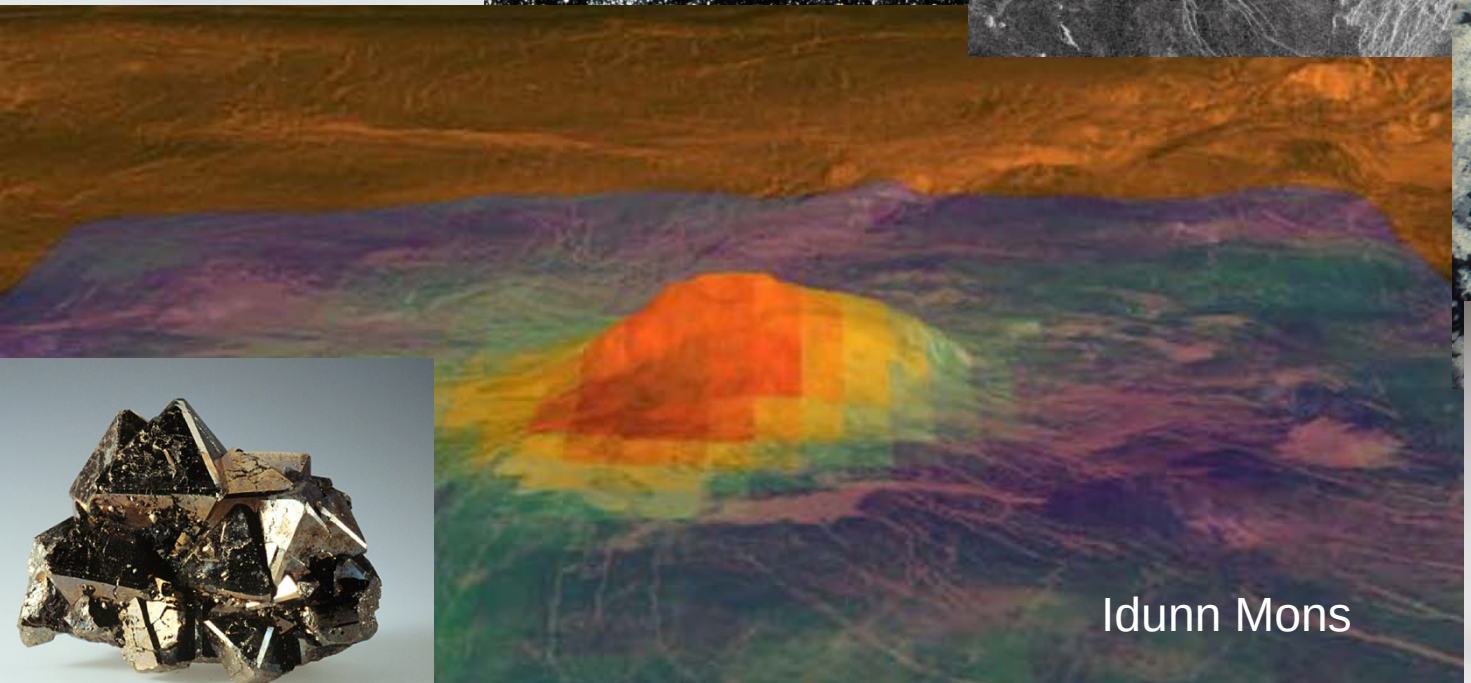

olivine

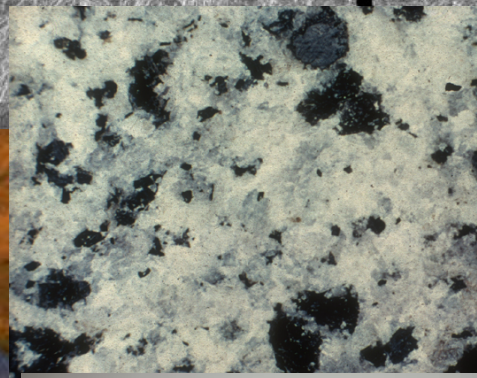

feldspar



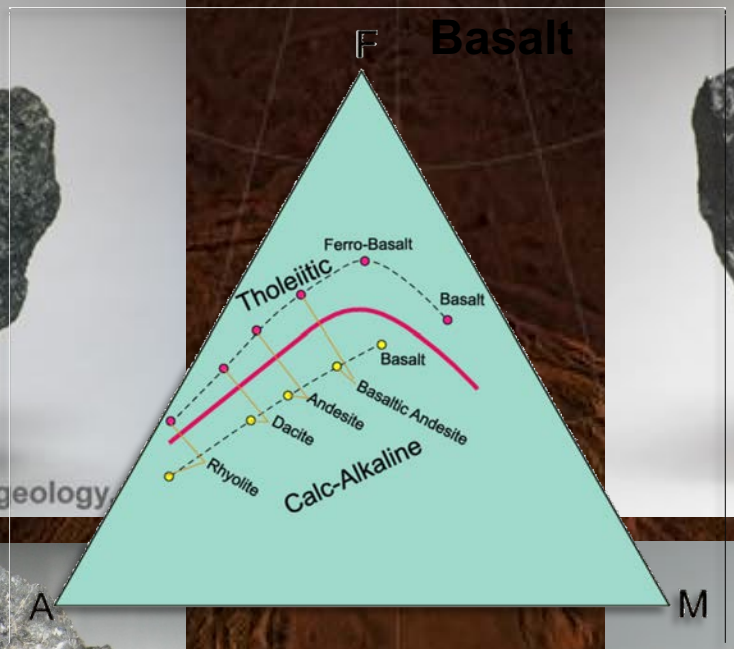

magnetite

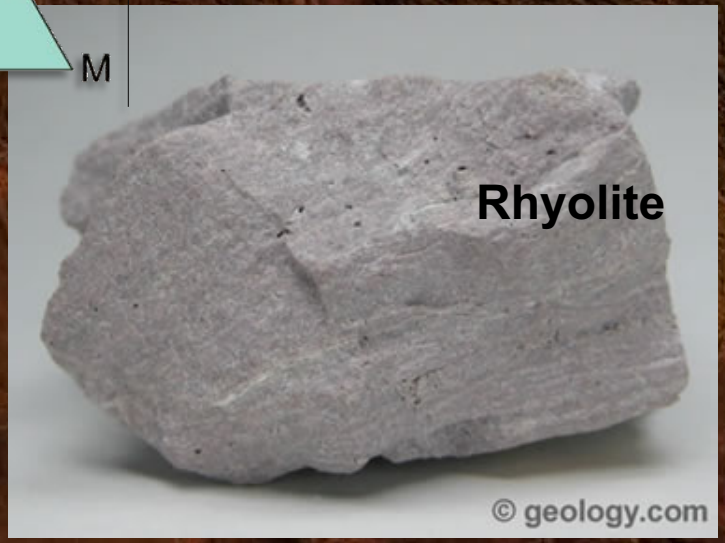

hematite


Idunn Mons




© geolog





Melting of a basaltic parent will yield a range of compositions from basaltic andesite, through andesite, dacite, and finally rhyolite. How well can we distinguish these rock types using orbital VNIR spectroscopy?

magnetite

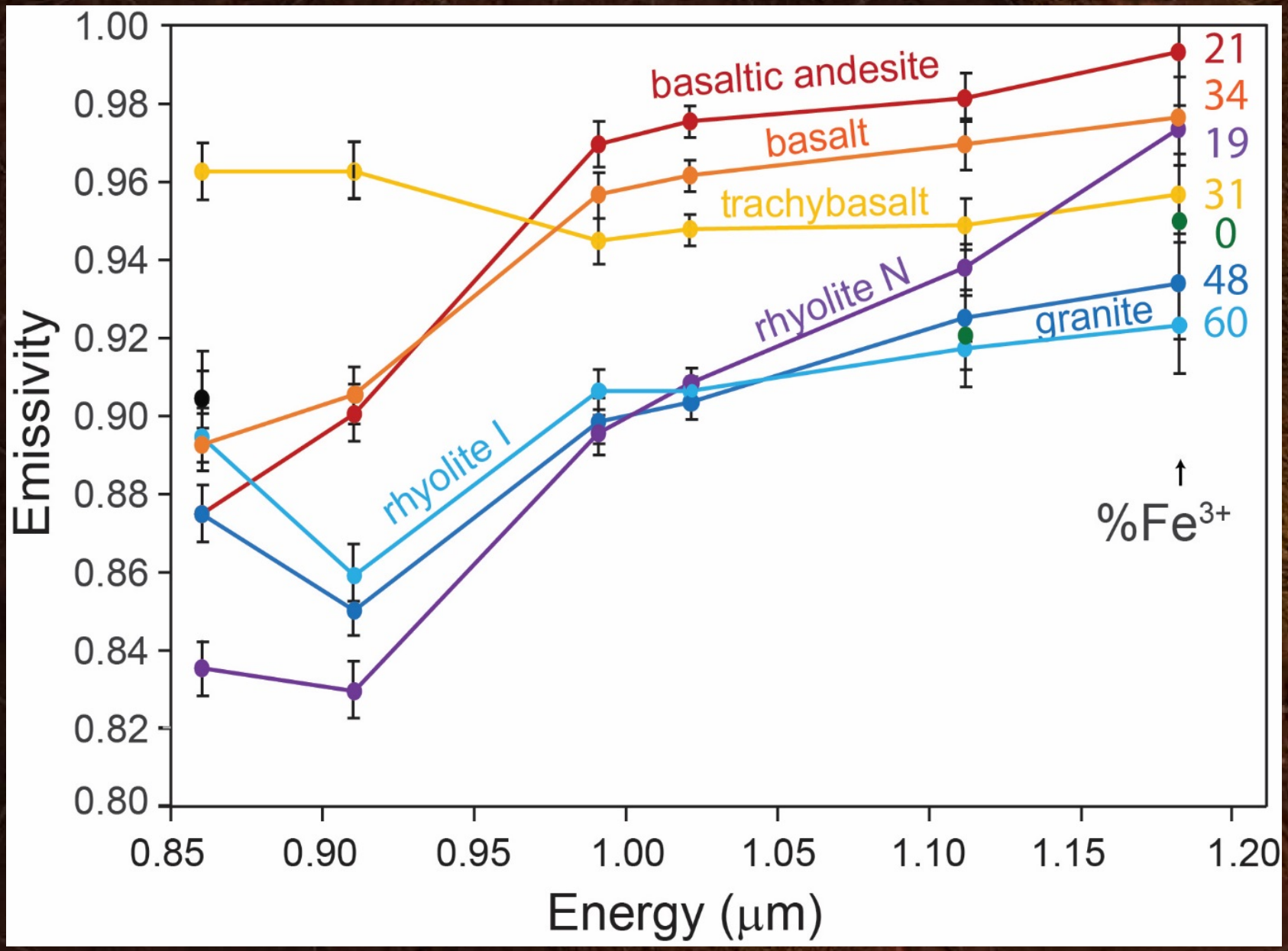
Table 1. Samples Studied			
Sample	DLR #	Type	Source
PSL basalt	1525	rock	PSL collections, locality unknown
Labrador amphibolite	1535	rock	MHC collections, locality unknown
Holyoke basalt	1802	rock	East Granby, CT
Padova basalt	1848	rock	Lanzarote Island, Spain
Newberry andesitic glass	1804	rock	Newberry volcano, Oregon
Padova rhyolite	1846	rock	Seiser Alm, Italy
Padova granite	1847	rock	Lofoten Islands, Norway
magnetite	1805	mineral	MHC collections, locality unknown
pyrite	1814	mineral	MHC collections, locality unknown
pyrrhotite	1815	mineral	MHC collections, locality unknown
hematite	1813	mineral	MHC collections, locality unknown
forsterite olivine	2369	mineral	San Carlos, NM
apatite	tbd	mineral	MHC collections, locality unknown
pyroxene	tbd	mineral	MHC collections, locality unknown
PSL = Planetary Spectroscopy Laboratory, DLR, MHC = Mount Holyoke College			

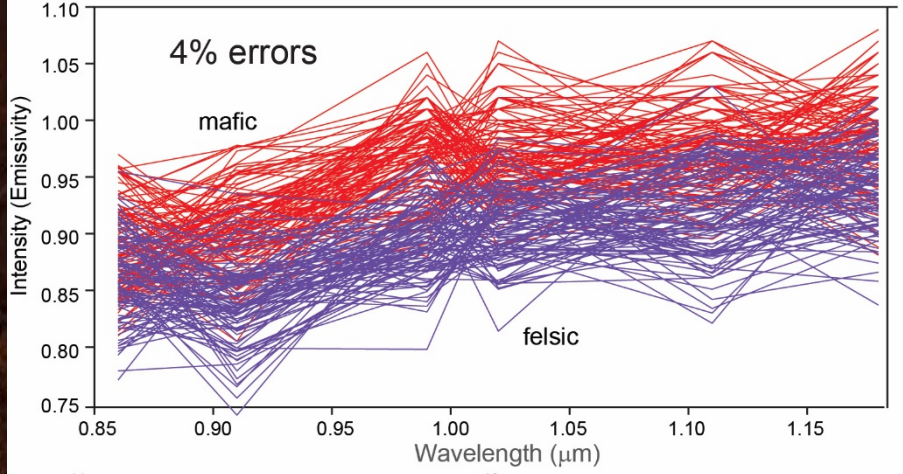
Compositions were determined by x-ray fluorescence (**XRF**) at the University of Massachusetts or by **electron microprobe** at Brown University.

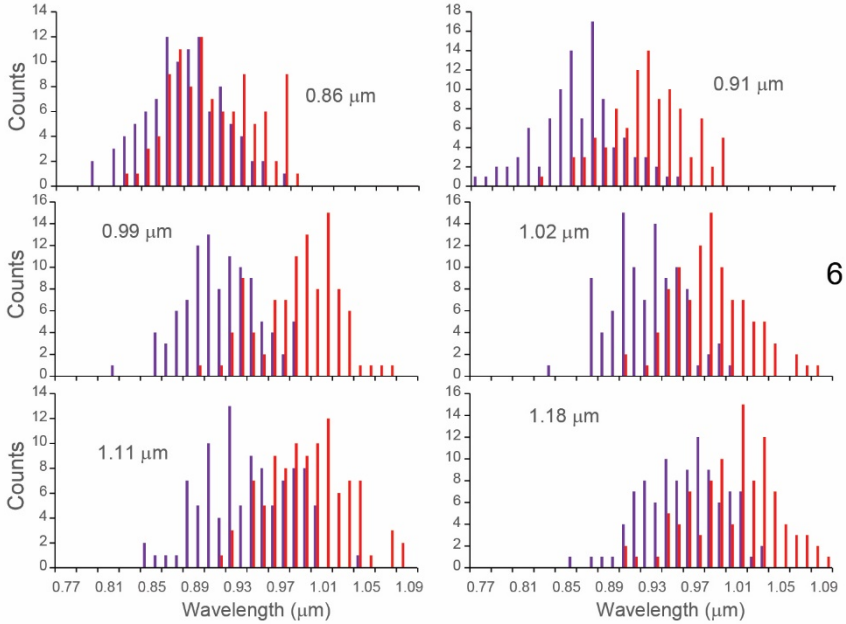
Fe^{3+}/Fe^{2+} ratios were measured using **Mössbauer spectroscopy** in the Mineral Spectroscopy Laboratory at Mount Holyoke.

Visible near-infrared (VNIR) data for this project were collected in the Planetary Spectroscopy Laboratory (PSL) at the German Aerospace Center DLR in Berlin

Discriminating among rock types







6 bands

0.86 to 0.91	0.86 to 0.99	0.86 to 1.02	0.86 to 1.11	0.86 to 1.18	0.91 to 0.99	0.91 to 1.02	0.91 to 1.11
0.91 to 1.18	0.99 to 1.02	0.99 to 1.11	0.99 to 1.18	1.02 to 1.11	1.02 to 1.18	1.11 to 1.18	

15 slopes

0.86 / 0.91	0.86 / 0.99	0.86 / 1.02	0.86 / 1.11	0.86 / 1.18	0.91 / 0.99	0.91 / 1.02	0.91 / 1.11
0.91 / 1.18	0.99 / 1.02	0.99 / 1.11	0.99 / 1.18	1.02 / 1.11	1.02 / 1.18	1.11 / 1.18	

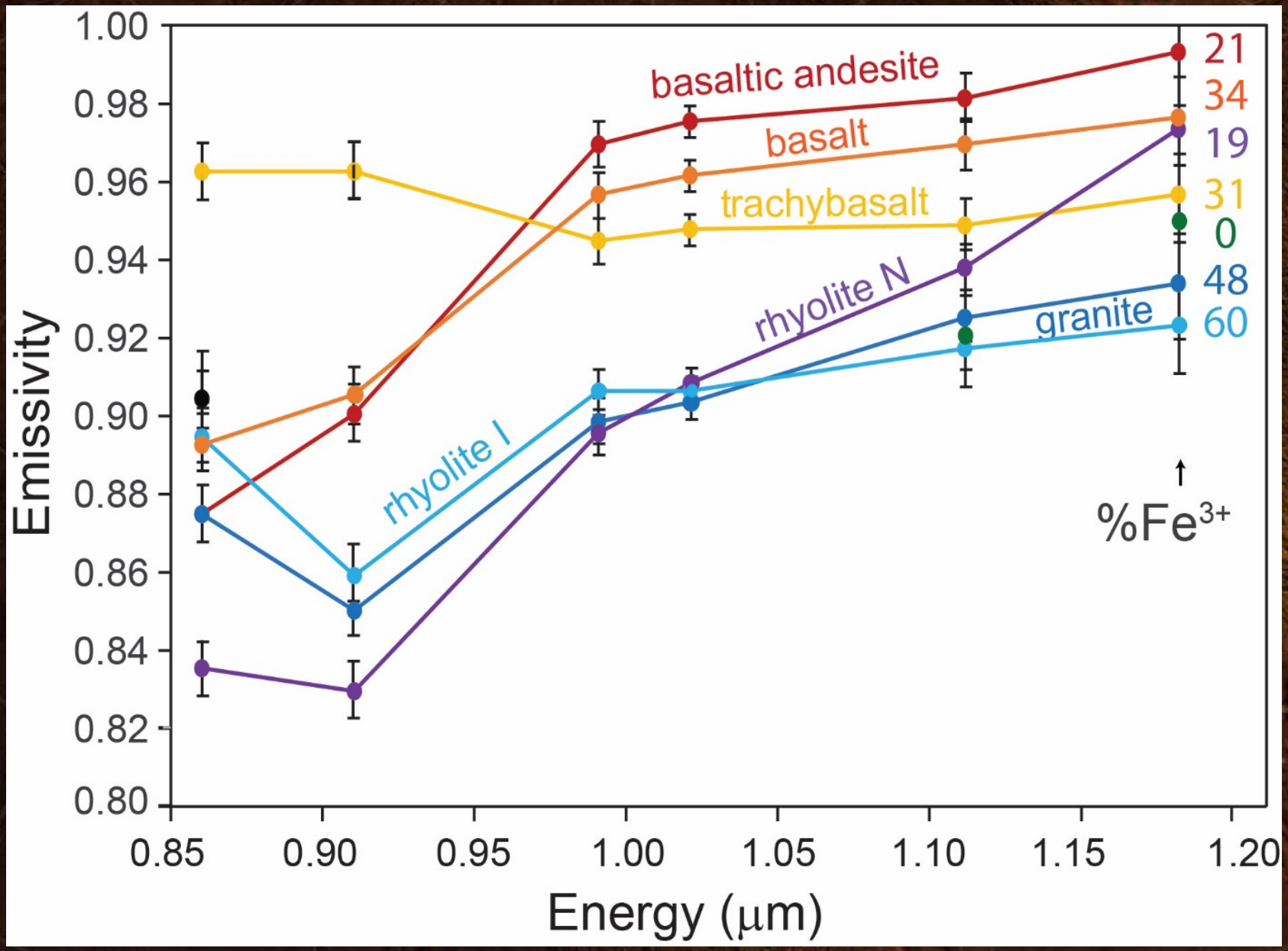
15 band ratios

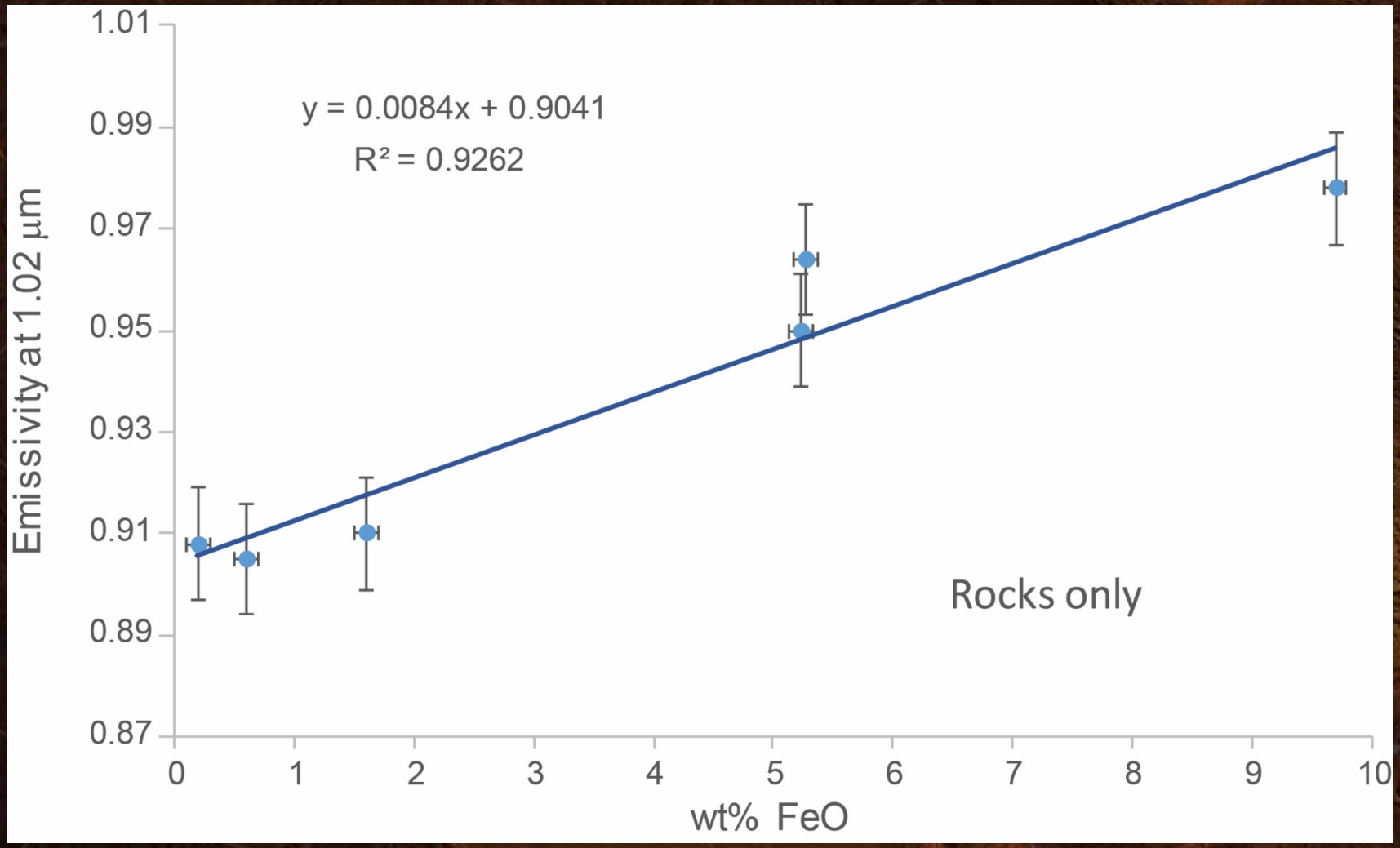
Table 1. Accuracy of Binary Classifier Trained to Distinguish among Rock Types

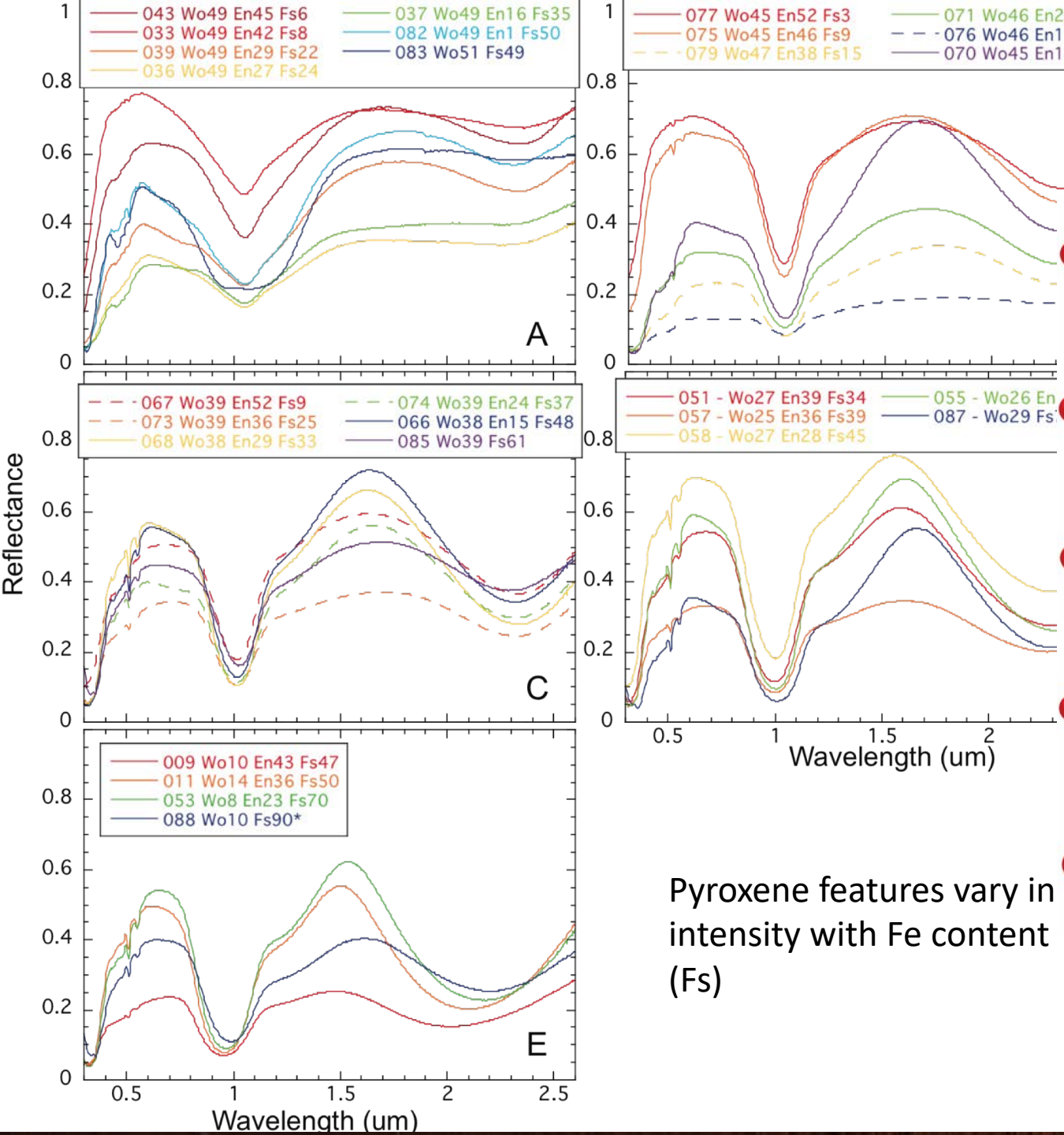
	ΔFeO Content	CBE errors		4% errors (requirement)			
		6 components		36 components		6 components	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Basalt* and felsic	9.0	100.0%	0.0%	94.6	0.6	93.7	0.6
Basalt* and dacite	6.75	100.0%	0.0%	88.5	0.9	86.4	0.9
basalt* and andesite	4.50	100.0%	0.0%	80.4	1.0	80.2	0.9
Basalt* and basaltic andesite	2.24	100.0%	0.0%	65.4	1.2	60.1	1.3

*actual average of specific samples measured in the lab at DLR as shown with solid lines in Figure 1. Dacite, andesite, and basaltic andesite spectra used in the models came from model spectra interpolated between the lab data on the basis of Fe content.

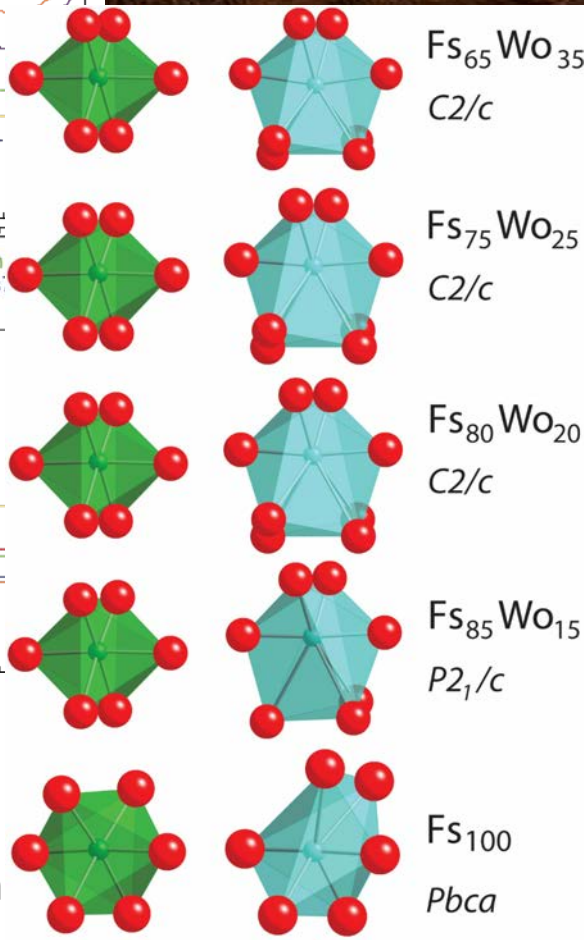
Discriminating among rock types



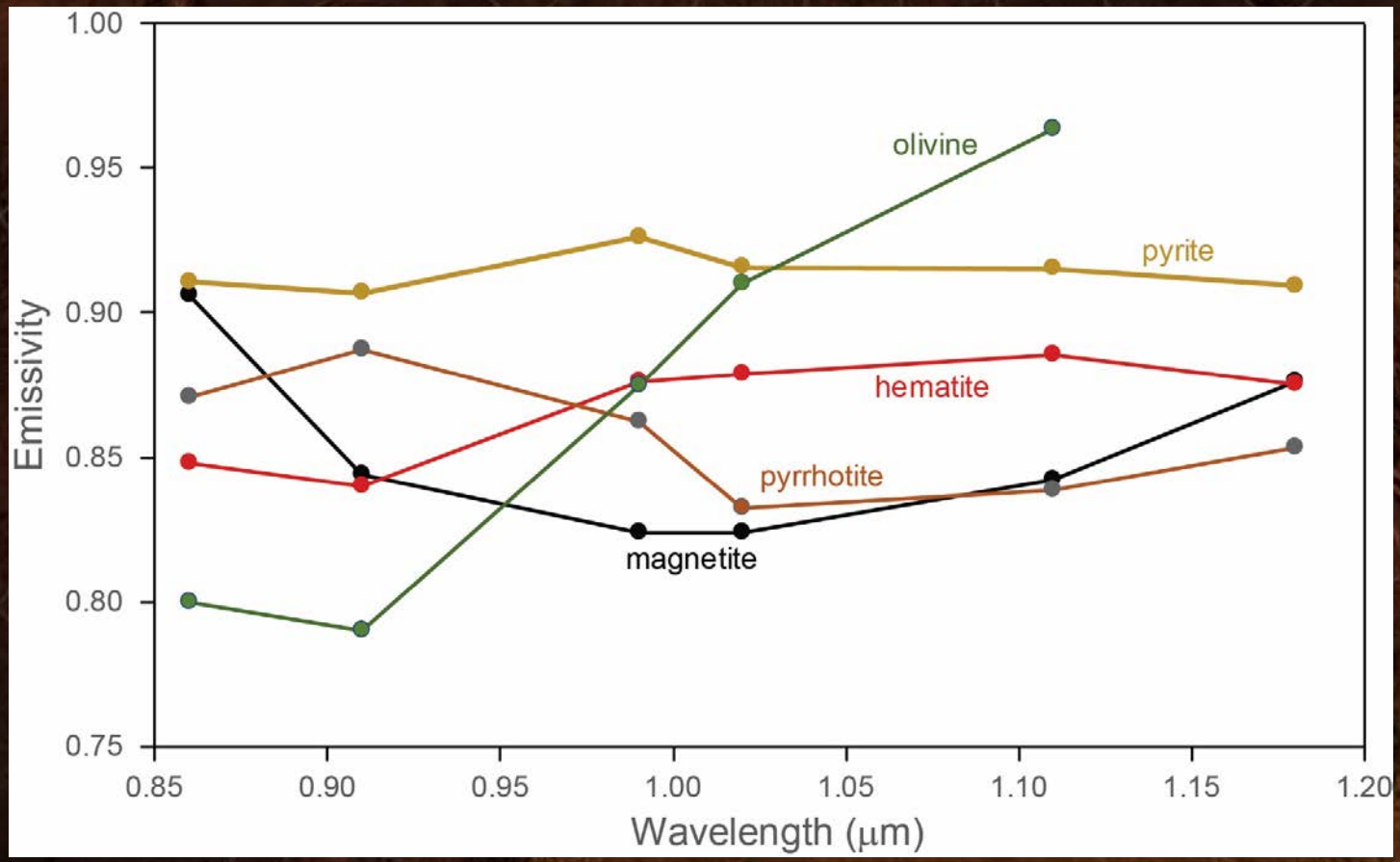

y = 0.0084x + 0.9041
R² = 0.9262
Rocks only
Emissivity at 1.02 µm
wt% FeO
1.01
0.99
0.97
0.95
0.93
0.91
0.89
0.87
0
1
2
3
4
5
6
7
8
9
10

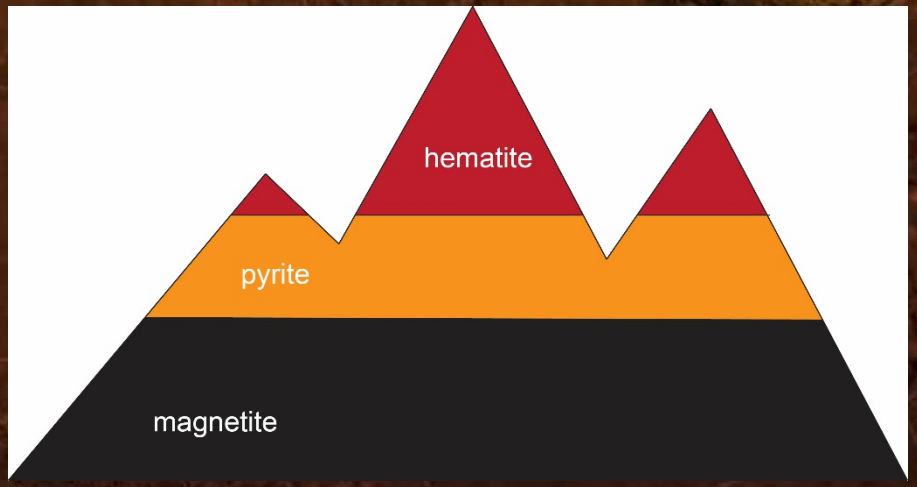


Klima et al. (2010)

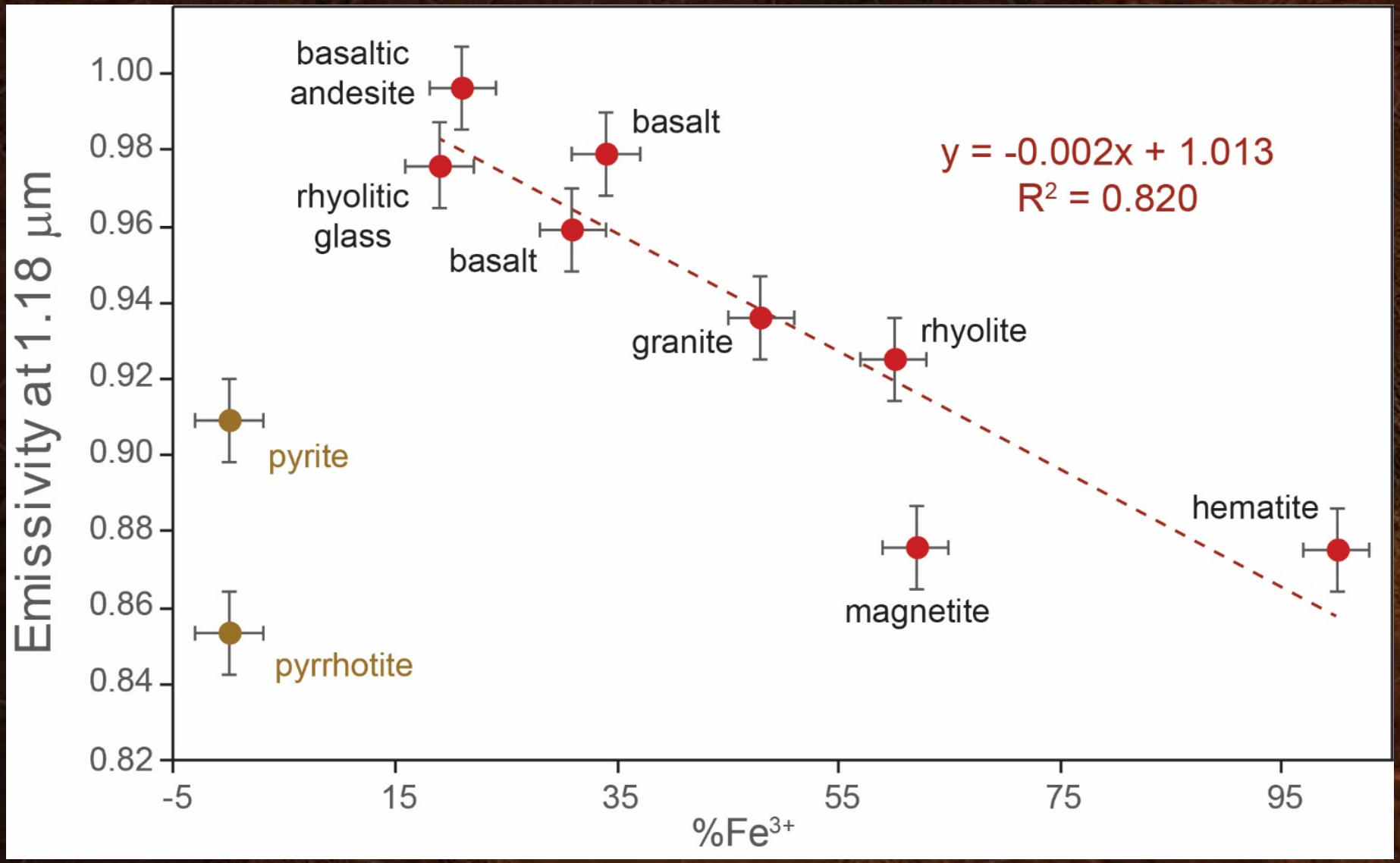


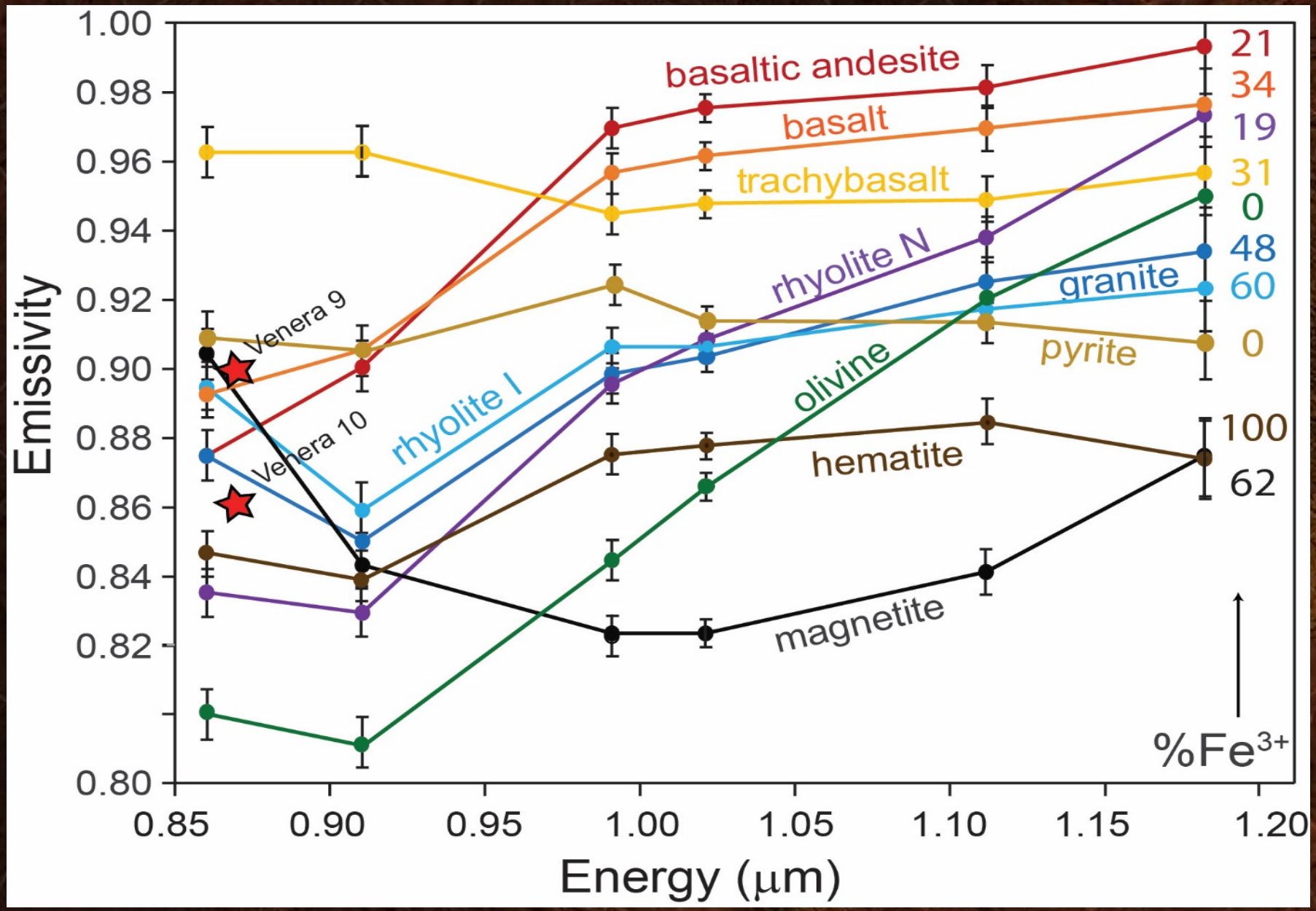
Pyroxene features vary in intensity with Fe content (Fs)





“snow line” on Venus mountains


basaltic andesite
basalt
rhyolitic glass
basalt
granite
rhyolite
pyrite
hematite
magnetite
pyrrhotite
y = -0.002x + 1.013
R² = 0.820
Emissivity at 1.18 µm
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
-5
15
35
55
75
95
%Fe3+


Emissivity
Energy (μm)
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0.80
0.85
0.90
0.95
1.00
1.05
1.10
1.15
1.20
basaltic andesite
basalt
trachybasalt
rhyolite N
granite
pyrite
olivine
hematite
magnetite
rhyolite I
Venera 9
Venera 10
21
34
19
31
0
48
60
0
100
62
%Fe3+

What can we learn from orbit using 6-window spectroscopy?