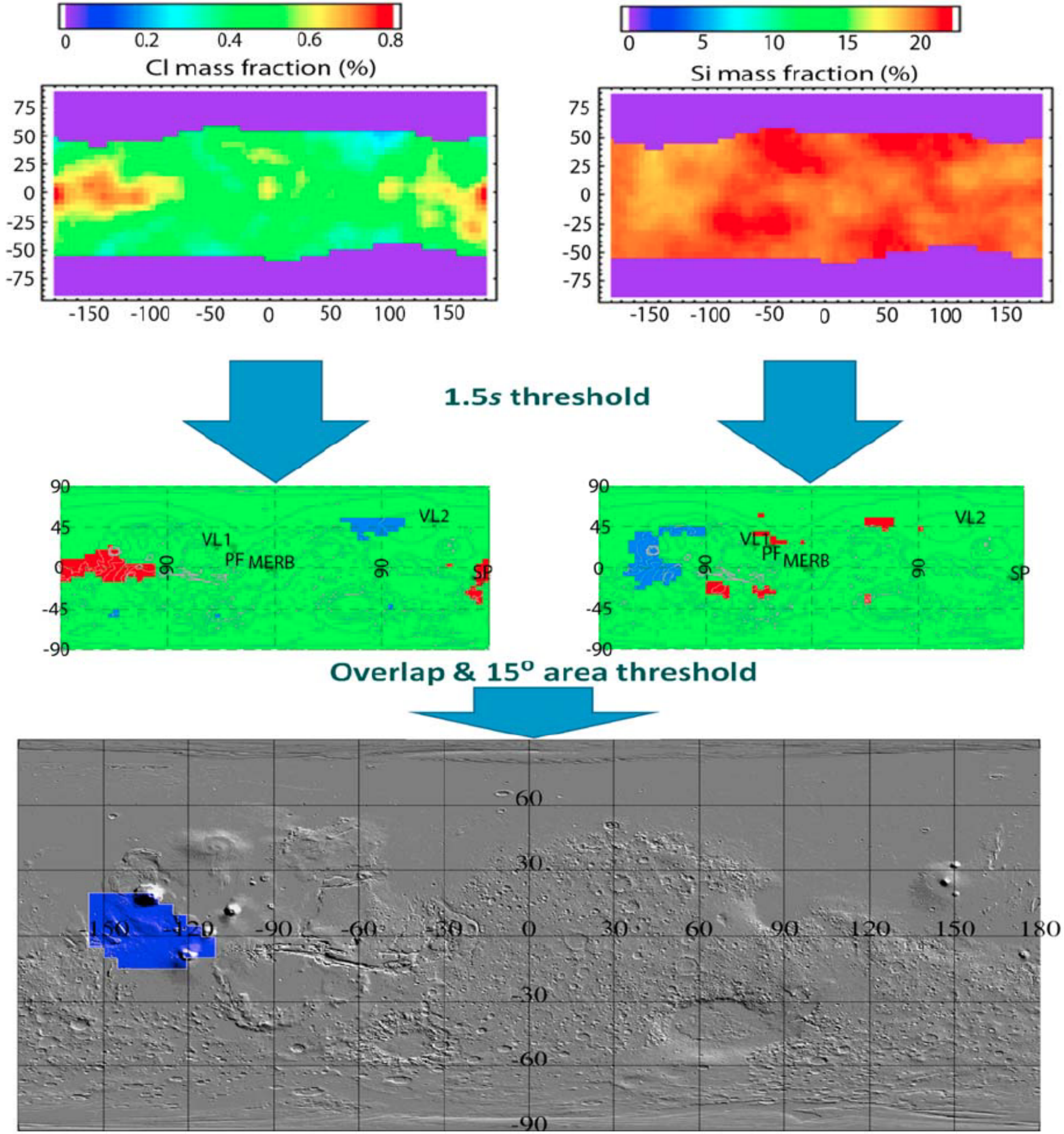
Get most insight from regions with ***correlated elemental anomalies***



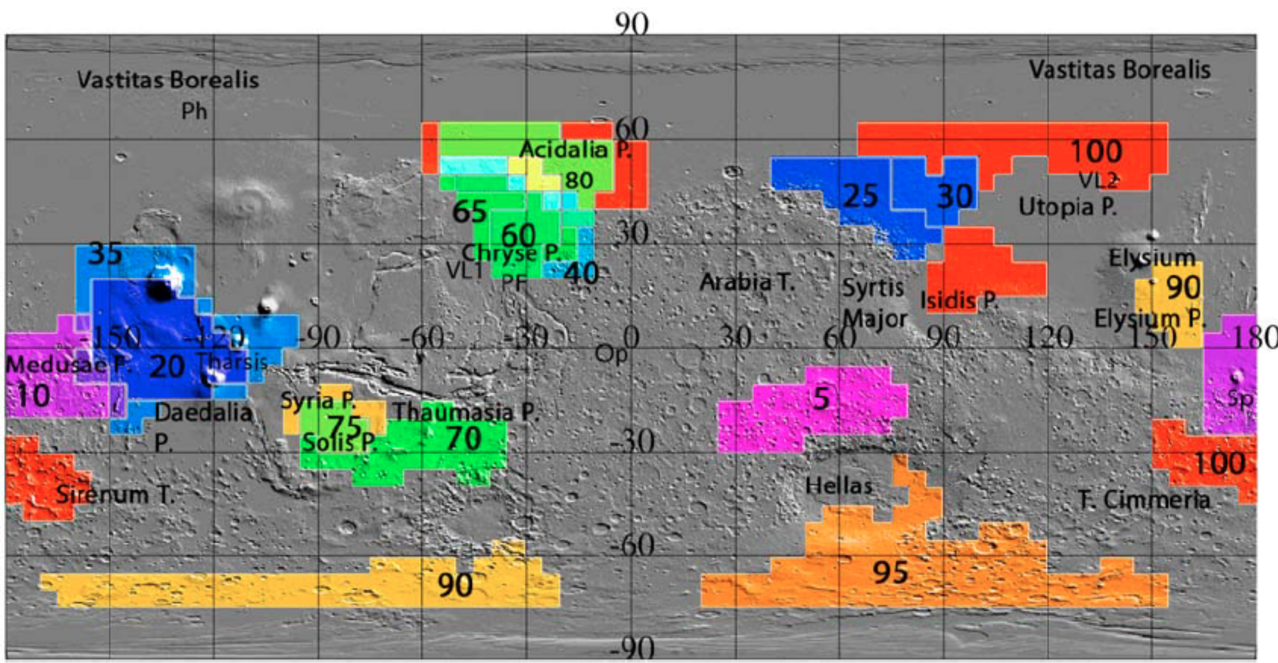
Karunatillake et al. (2009)

“Chemically striking regions” defined by correlated elemental anomalies

Table 3. Key to the Numerical Code of Chemically Striking Regions in Figure 3[a]

Key	Value
Unclassified	0
{Al, Fe} 1s ED 15°	5
{Cl, H} 1s EE 15°	10
{Cl, H} 1s EE 15° {Cl, Si} 1s ED 15°	15
{Cl, Si} 1.5s ED 15°	20
{Cl, Si} 1s DE 15°	25
{Cl, Si} 1s DE 15° {K, Th} 1s EE 15°	30
{Cl, Si} 1s ED 15°	35
{Fe, Th} 1s EE 15°	40
{Fe, Th} 1s EE 15° {K, Th} 1.5s EE 10°	45
{Fe, Th} 1s EE 15° {K, Th} 1.5s EE 10° {Si, Th} 1s EE 15°	50
{Fe, Th} 1s EE 15° {K, Th} 1s EE 15°	55
{Fe, Th} 1s EE 15° {K, Th} 1s EE 15° {Si, Th} 1s EE 15°	60
{Fe, Th} 1s EE 15° {Si, Th} 1s EE 15°	65
{H, Si} 1s DE 15°	70
{H, Si} 1s DE 15° {K, Th} 1s DD 10°	75
{K, Th} 1.5s EE 10°	80
{K, Th} 1.5s EE 10° {Si, Th} 1s EE 15°	85
{K, Th} 1s DD 10°	90
{K, Th} 1s DD 15°	95
{K, Th} 1s EE 15°	100

[a]Each chemically striking region (CSR) is denoted by the corresponding set of elements in curly braces, confidence (Table 2) as an approximation to a multiple of the standard deviation (*s*), enrichment (E) and/or depletion (D) in element order, and arc radius of the area threshold (Table 1). For example, {Cl, Si} 1.5s ED 15° would denote a bin belonging to a single CSR marked by the enrichment of Cl and depletion of Si at better than 1.5*s* confidence and exceeding a 15° radius area. On the other hand, {Cl, H} 1s EE 15° {Cl, Si} 1s ED 15° identifies a bin of overlap between two CSRs: One {Cl, H} 1s EE 15° and the other {Cl, Si} 1s ED 15°. Note that such bins generally do not delineate a sufficiently large contiguous area to be classified as a CSR in its own right. CSRs of Si and Th overlap completely with the CSRs of K and Th albeit at different statistical confidence levels. The one region on the basis of Al is solely to motivate future investigations as the Al map is being refined. Higher numerical uncertainties and weak correlation with other elements caused the absence of Ca-based CSRs.



Karunatillake et al. (2009)

"RAVE" – a Cl-rich, Si/Fe-poor region

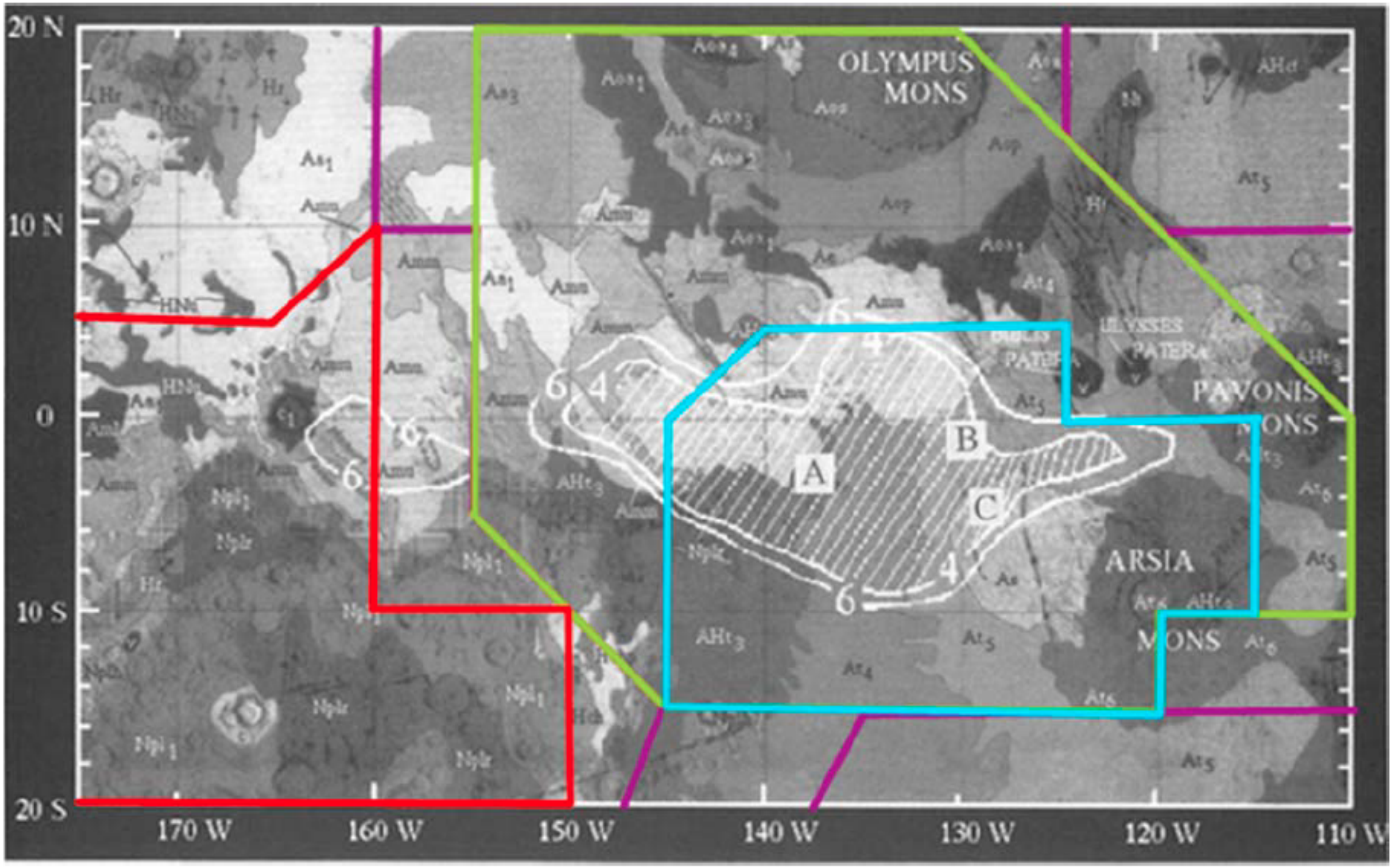


Figure 11. Sketch of RAVE (sky blue) overlain on Stealth region at 3.5 cm and mapped geologic units (adapted from *Edgett et al.* [1997, Figure 4]). Note the striking spatial overlap between RAVE and Stealth of greatest confidence (hatched region) relative to the Medusae Fossae formation units: Amm, Amu, and Aml. The surrounding CSRs include {ClSi ED 1.5s 15°} in lime and {ClSi ED 1s 15°} in purple. Surficial chemical differences between eastern and western Medusae Fossae are revealed by {ClH EE 1s 15°} CSR (red) to the west and {ClSi ED 1s 15°} to the east.

Karunatillake et al. (2009)

"RAVE": brightness, low thermal inertia → dust

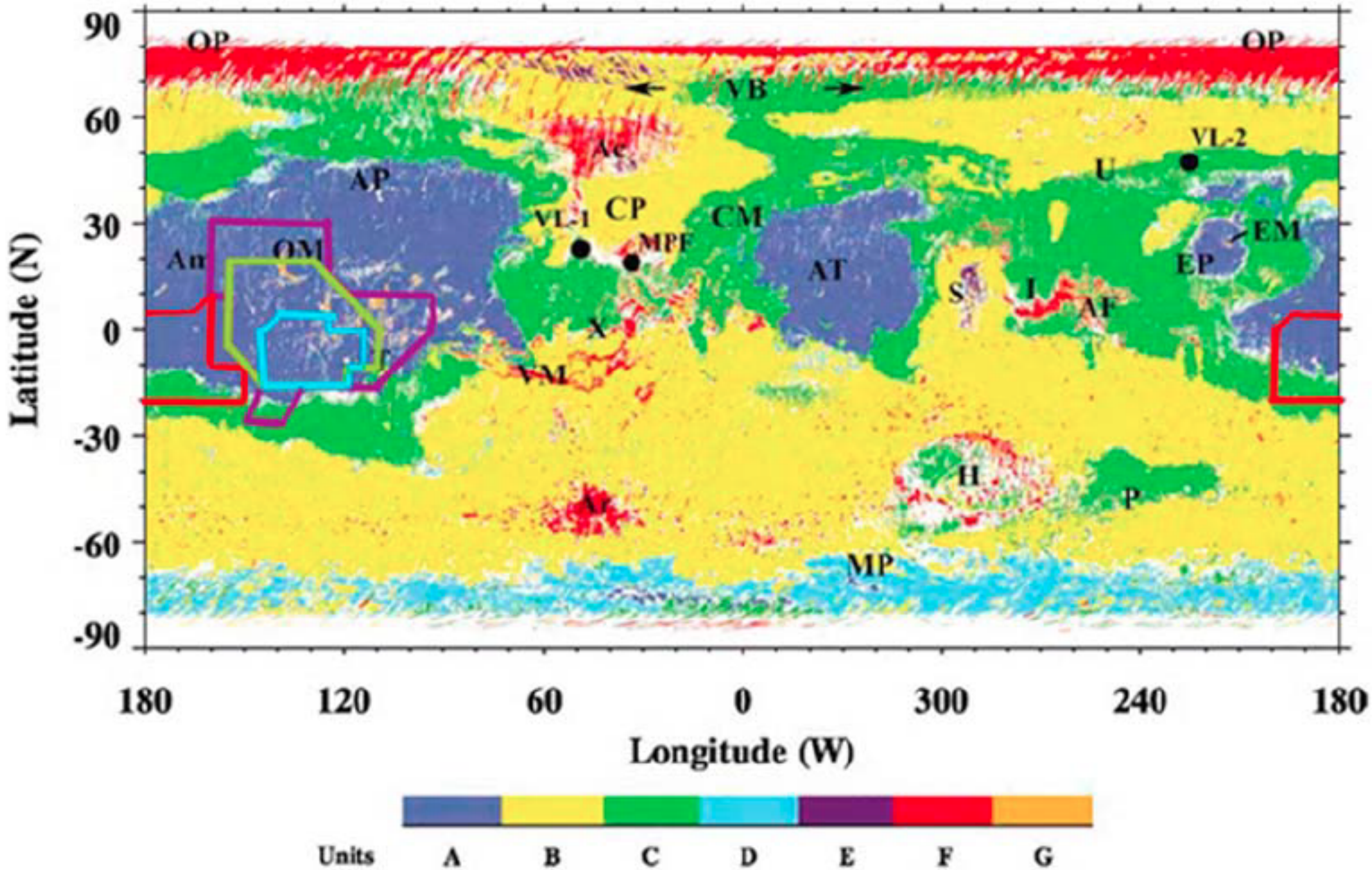
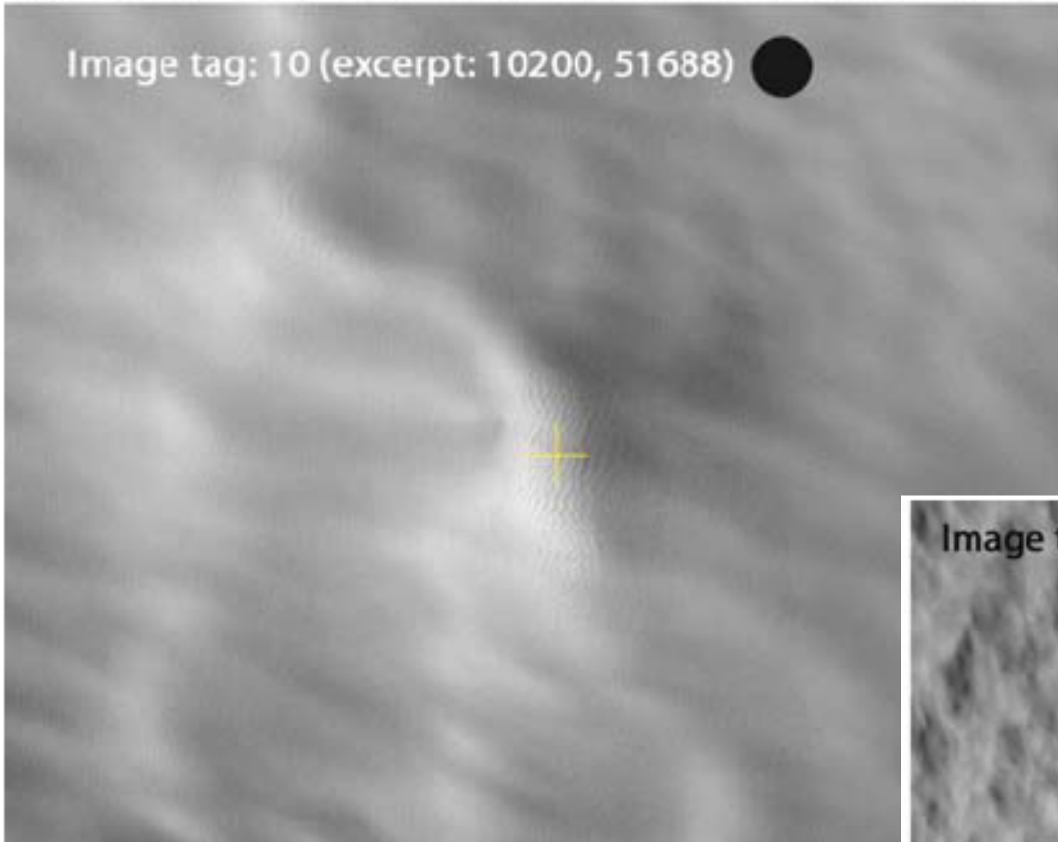
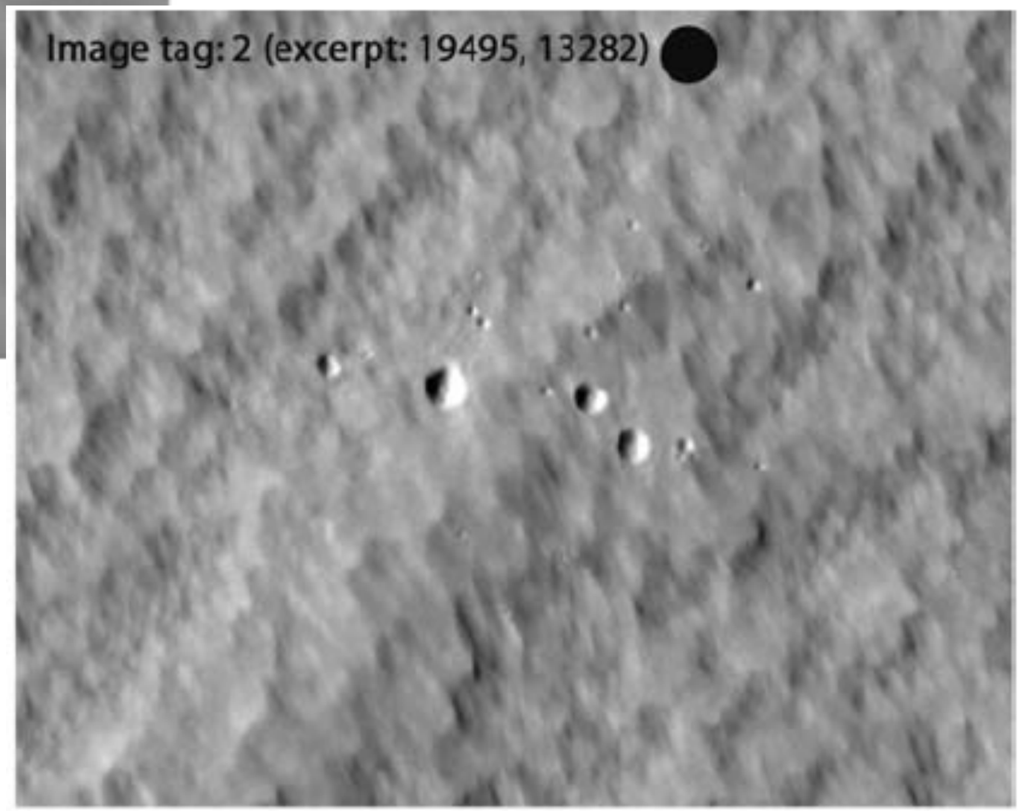


Figure 12. Sketch of RAVE (sky blue line) overlaid on the thermal inertia/albedo unit map (adapted from *Putzig et al.* [2005, Figure 5] with permission from Elsevier). RAVE is contained entirely within the low thermal inertia/high-albedo unit (blue) as is the bulk of the two surrounding CSRs. These are {ClSi ED 1.5s 15°} outlined in lime and {ClSi ED 1s 15°} outlined purple. The {ClH EE 1s 15°} to the west is outlined red and its southern portion is filled in green indicating high thermal inertia and medium albedo.

Karunatillake et al. (2009)

"RAVE": high-resolution imagery → blanketed by dust





Black circles are 10 meters across

Karunatillake et al. (2009)

Chemical comparisons: RAVE similar to dust at rover sites, but with less Si and more Ca

→ *dust diluted & cemented by Ca-salts??*

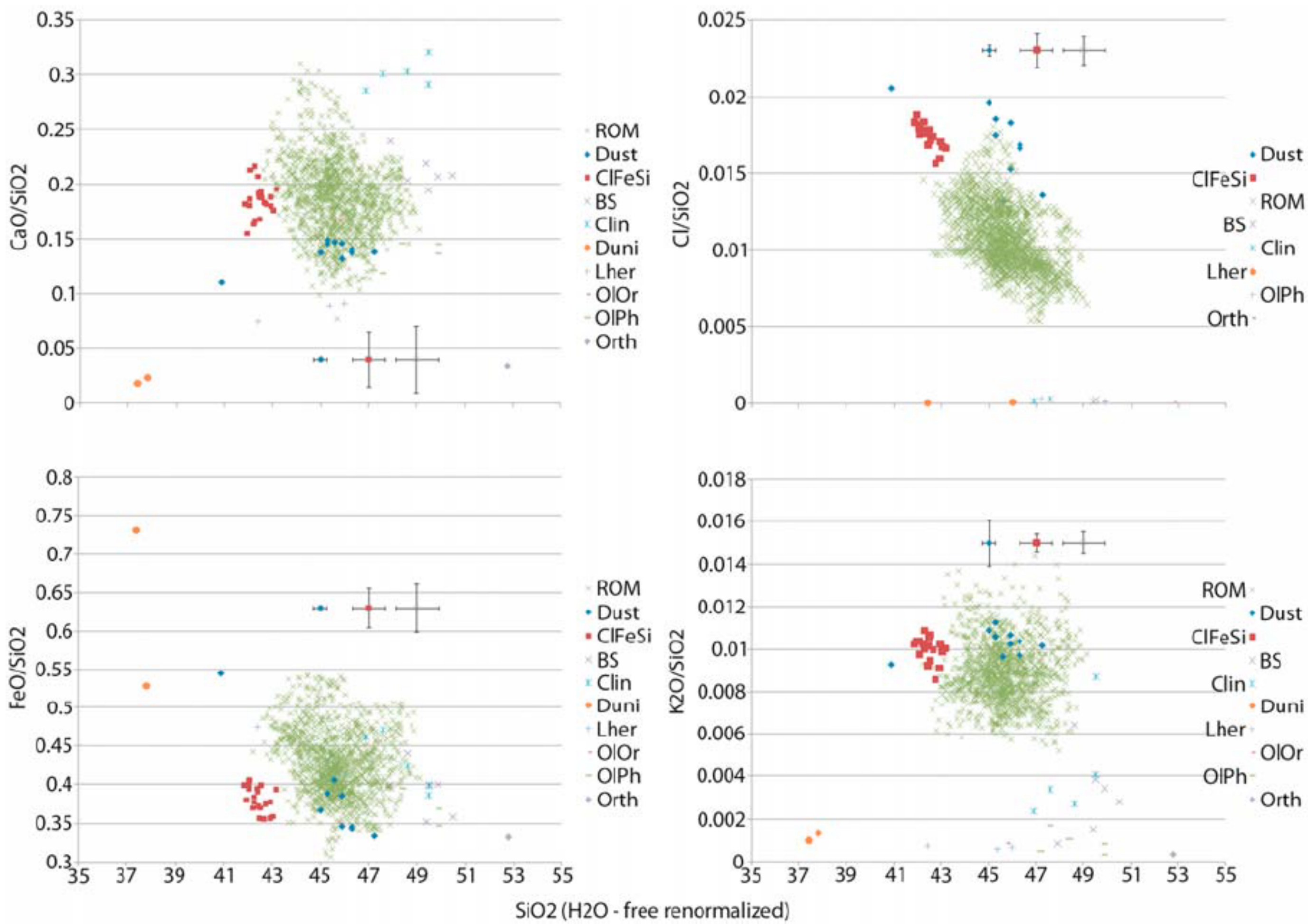
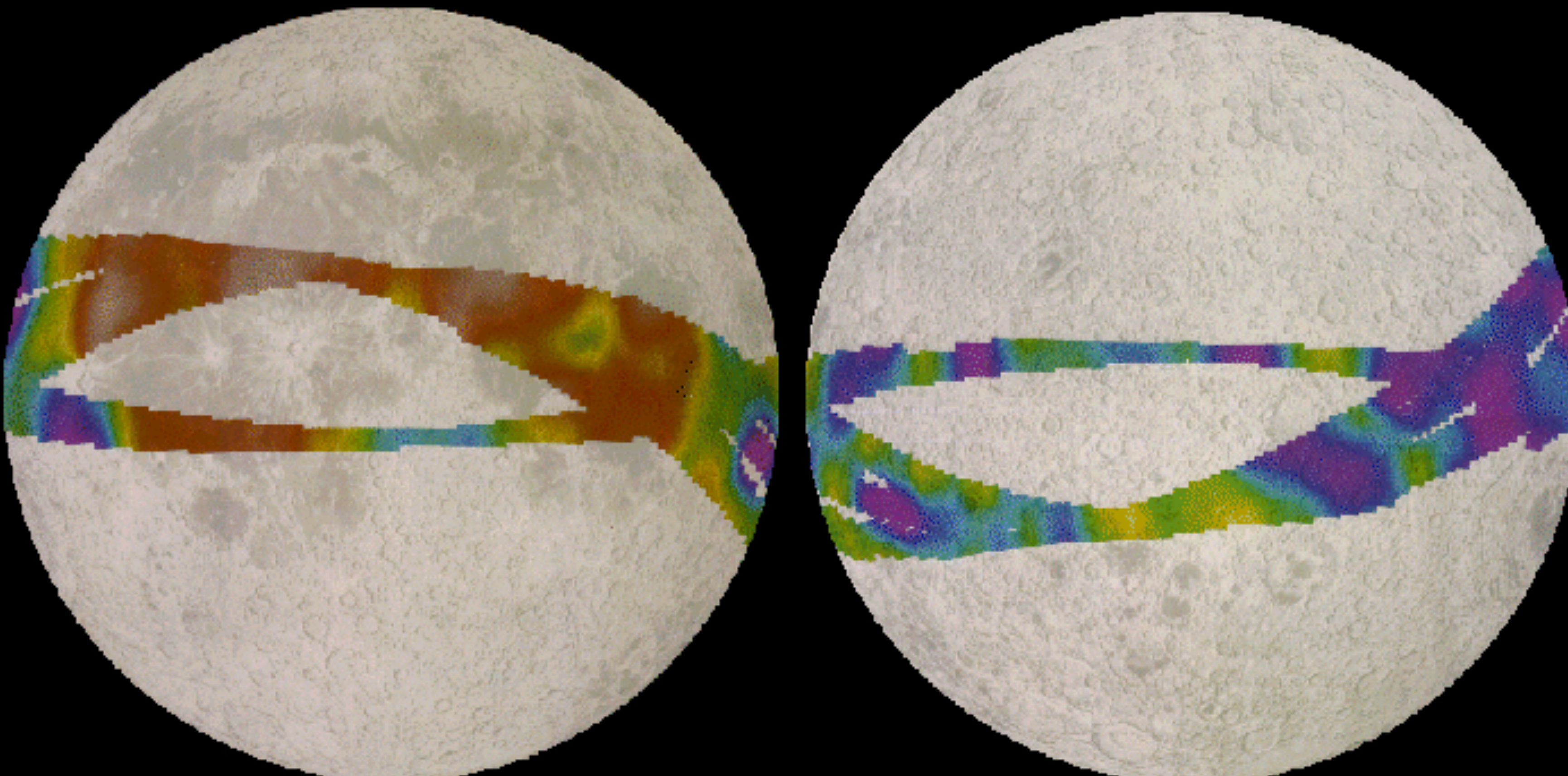


Figure 24. Scatterplots of oxide mass fraction to SiO_2 mass fraction ratios versus the SiO_2 mass fraction for SNC meteorite classes and RAVE (legend, ClFeSi) with the rest of Mars (ROM) and dust included

Karunatillake et al. (2009)

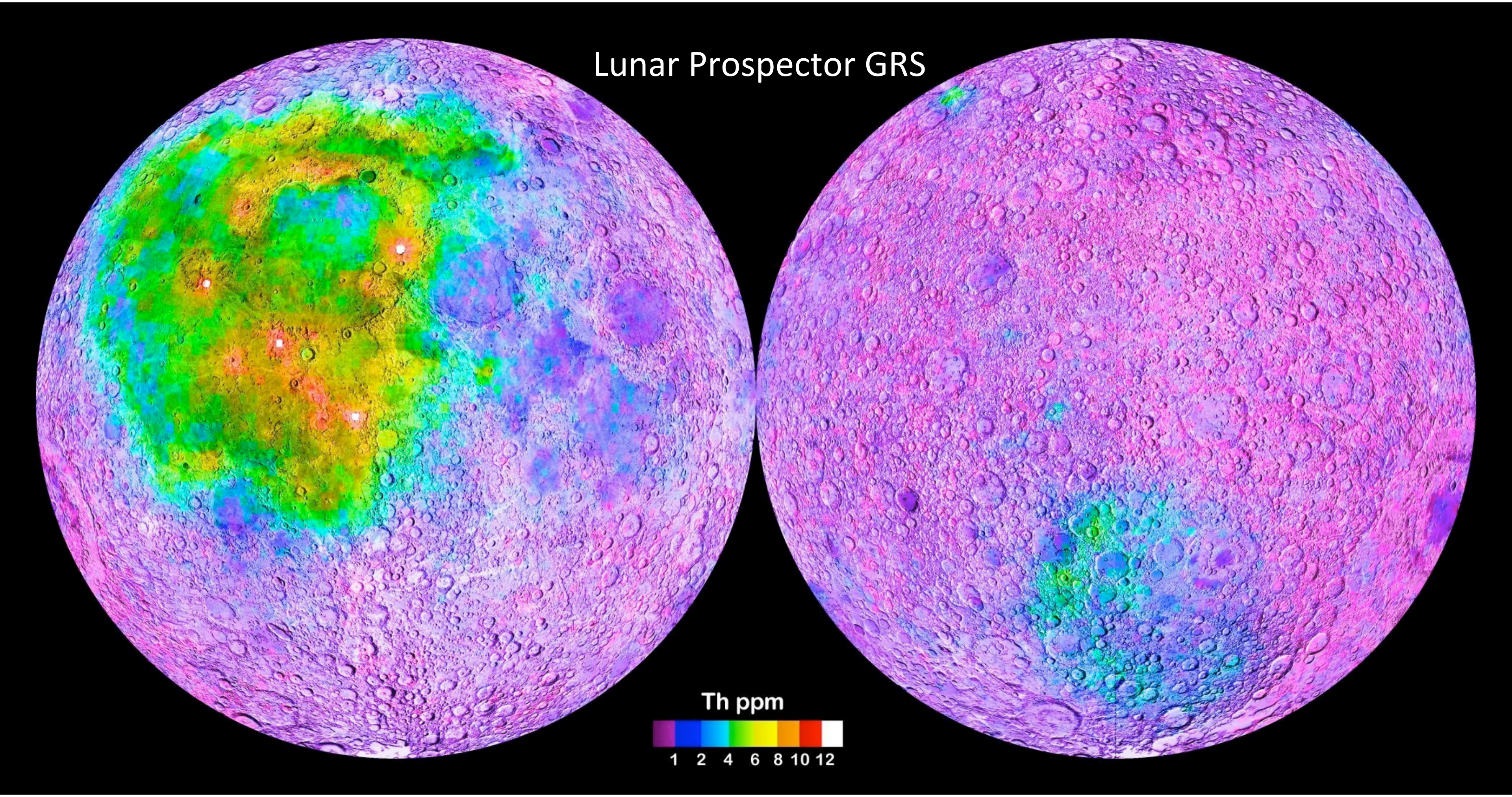
Apollo Gamma-ray Spectrometer
Iron Abundance



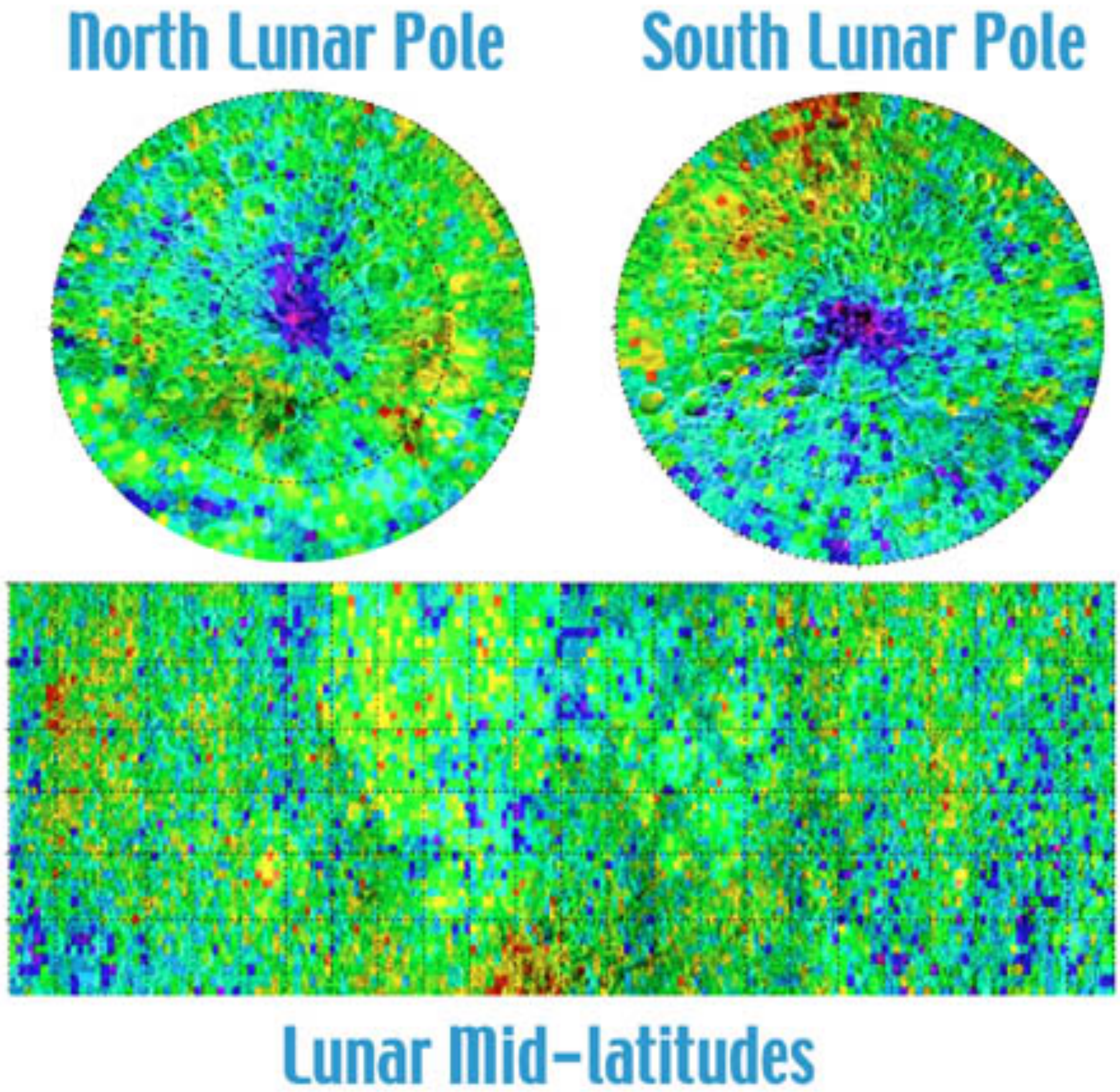
Nearside Farside

Lunar KREEP (potassium, rare-Earth elements, phosphorus)

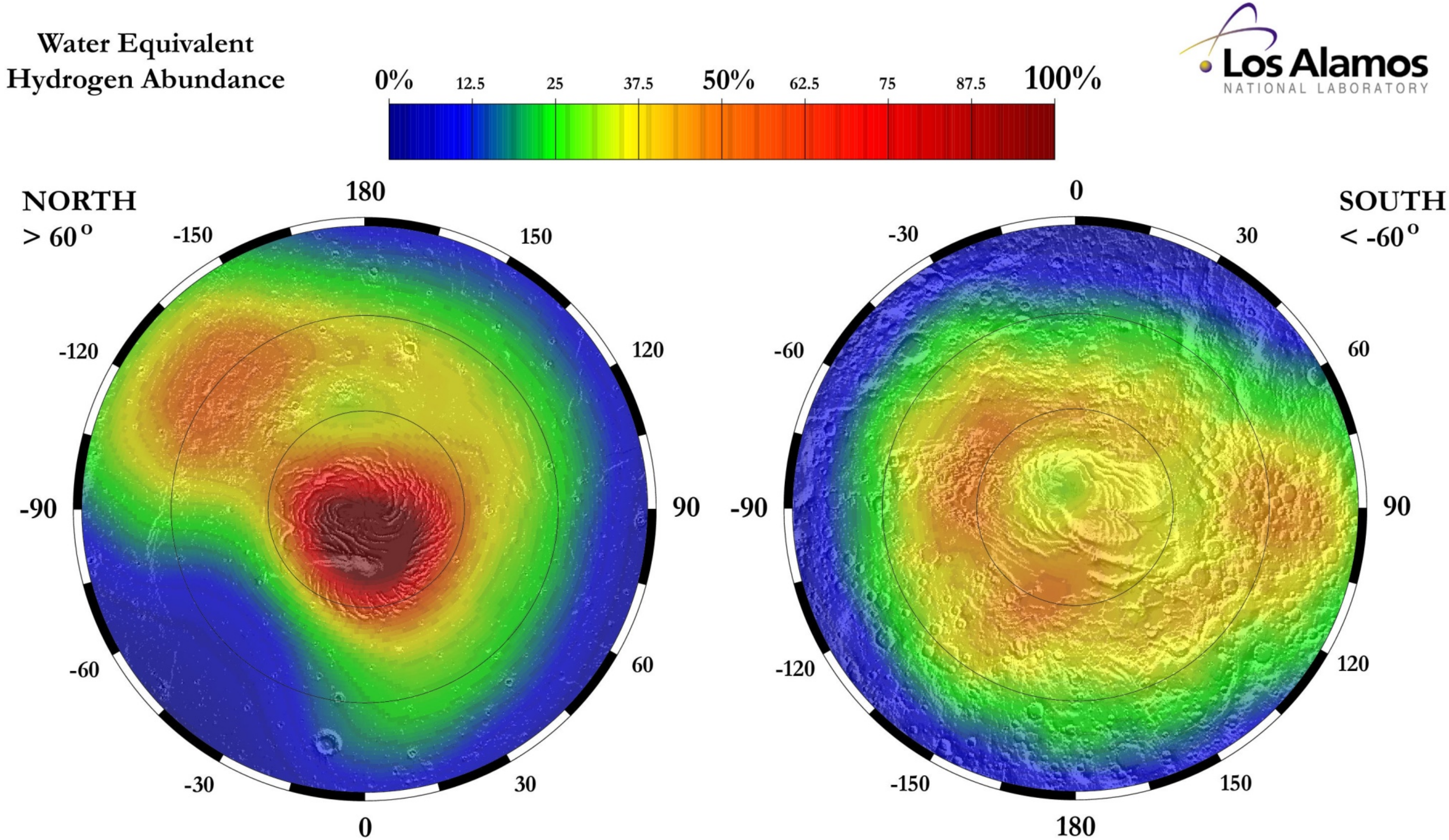
- From Moon's middle layer, between anorthositic highlands and olivine/pyroxene-rich mantle
- In samples from every Apollo site … but all Imbrium basin ejecta?



For a great explanation, see: http://www.planetary.org/blogs/emily-lakdawalla/2011/3013.html



Lunar hydrogen map from Lunar Prospector neutron detector



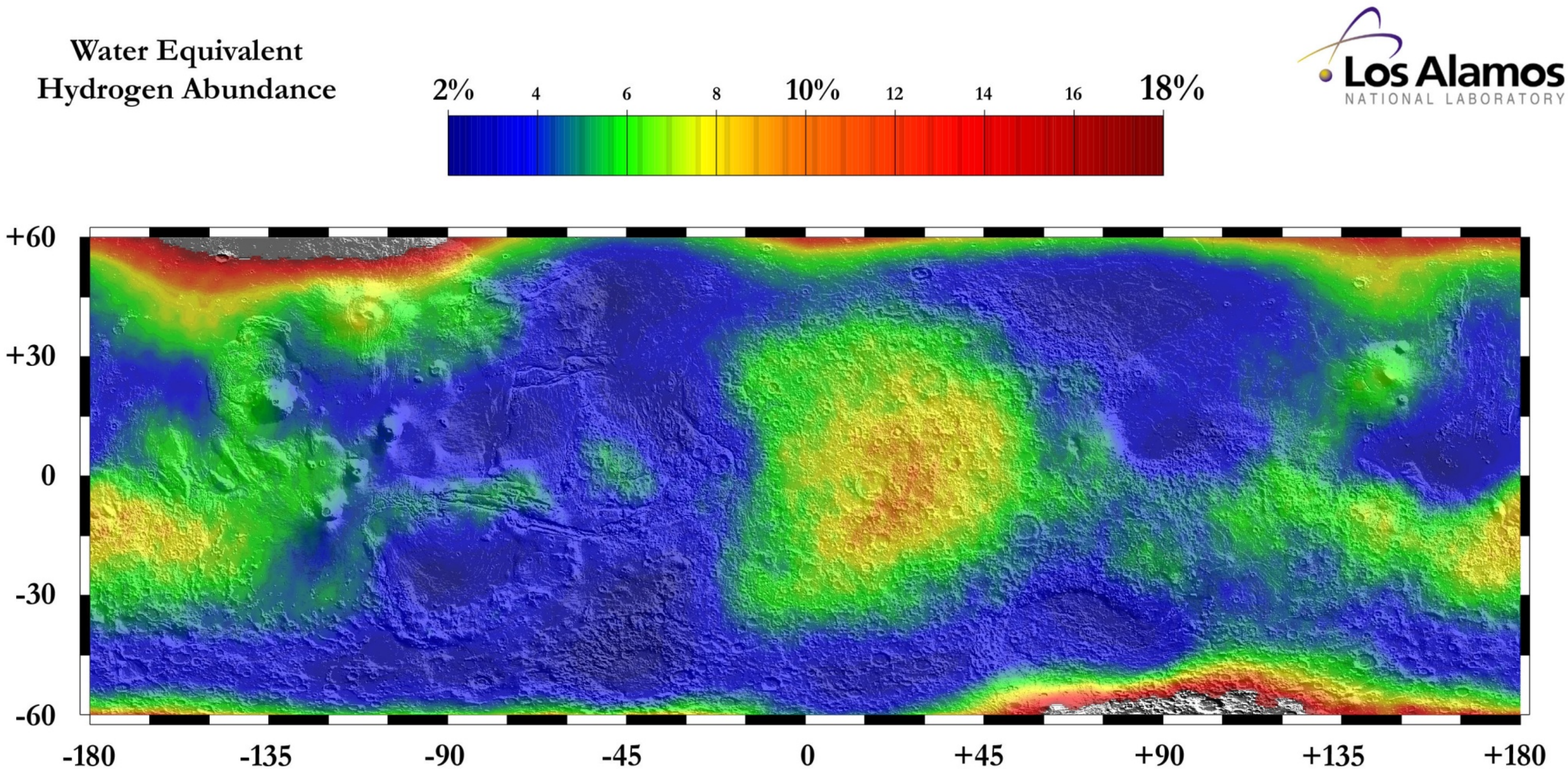
Distribution of Water on Mars: Overlay of water equivalent hydrogen abundances and a shaded relief map derived from MOLA topography. Mass percents of water were determined from epithermal neutron counting rates using the Neutron Spectrometer aboard Mars Odyssey between Feb. 2002 and Apr. 2003.

Reference: Feldman W. C., T. H. Prettyman, S. Maurice, J. J. Plaut, D. L. Bish, D. T. Vaniman, M. T. Mellon, A. E. Metzger, S. W. Squyres, S. Karunatillake, W. V. Boynton, R. C. Elphic, H. O. Funsten, D. J. Lawrence, and R. L. Tokar, The global distribution of near-surface hydrogen on Mars, *JGR-planets*, submitted July 2003.

These data were generated by the Planetary Science Team at Los Alamos: B. Barraclough, D. Bish, D. Delapp, R. Elphic, W. Feldman, H. Funsten, O. Gasnault*, D. Lawrence, S. Maurice*, G. McKinney, K. Moore, T. Prettyman, R. Tokar, D. Vaniman, and R. Wiens. * Also at Observatoire Midi-Pyrenees, France

The neutron spectrometer aboard Mars Odyssey, a component of the Gamma-ray Spectrometer suite of instruments, was designed and built by the Los Alamos National Laboratory and is operated by the University of Arizona in Tucson. The Mars Odyssey mission is managed by the Jet Propulsion Laboratory.

Mars Hydrogen from Neutron Measurements: Polar Regions



Distribution of Water on Mars: Overlay of water equivalent hydrogen abundances and a shaded relief map derived from MOLA topography. Mass percents of water were determined from epithermal neutron counting rates using the Neutron Spectrometer aboard Mars Odyssey between Feb. 2002 and Apr. 2003.

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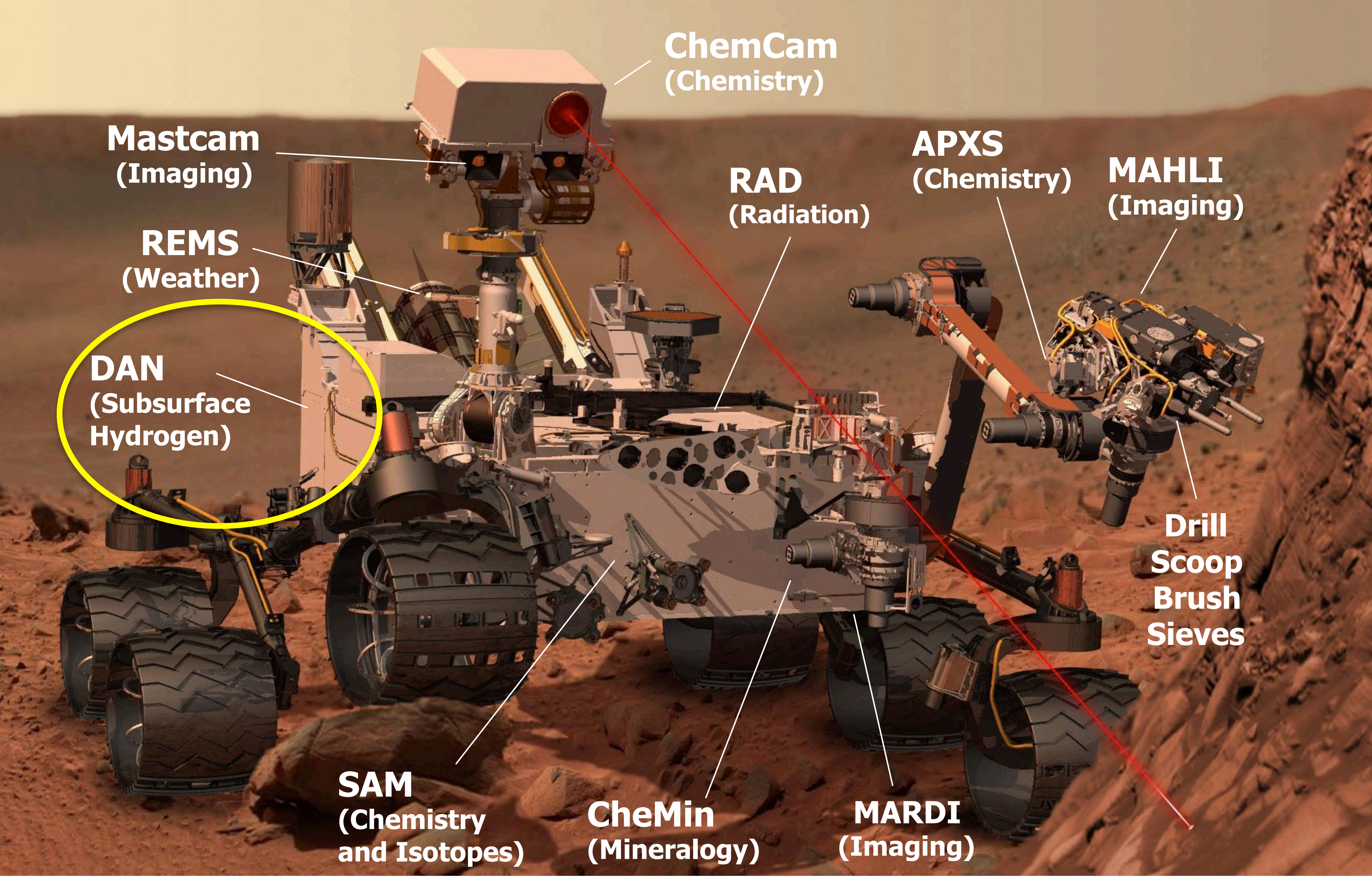
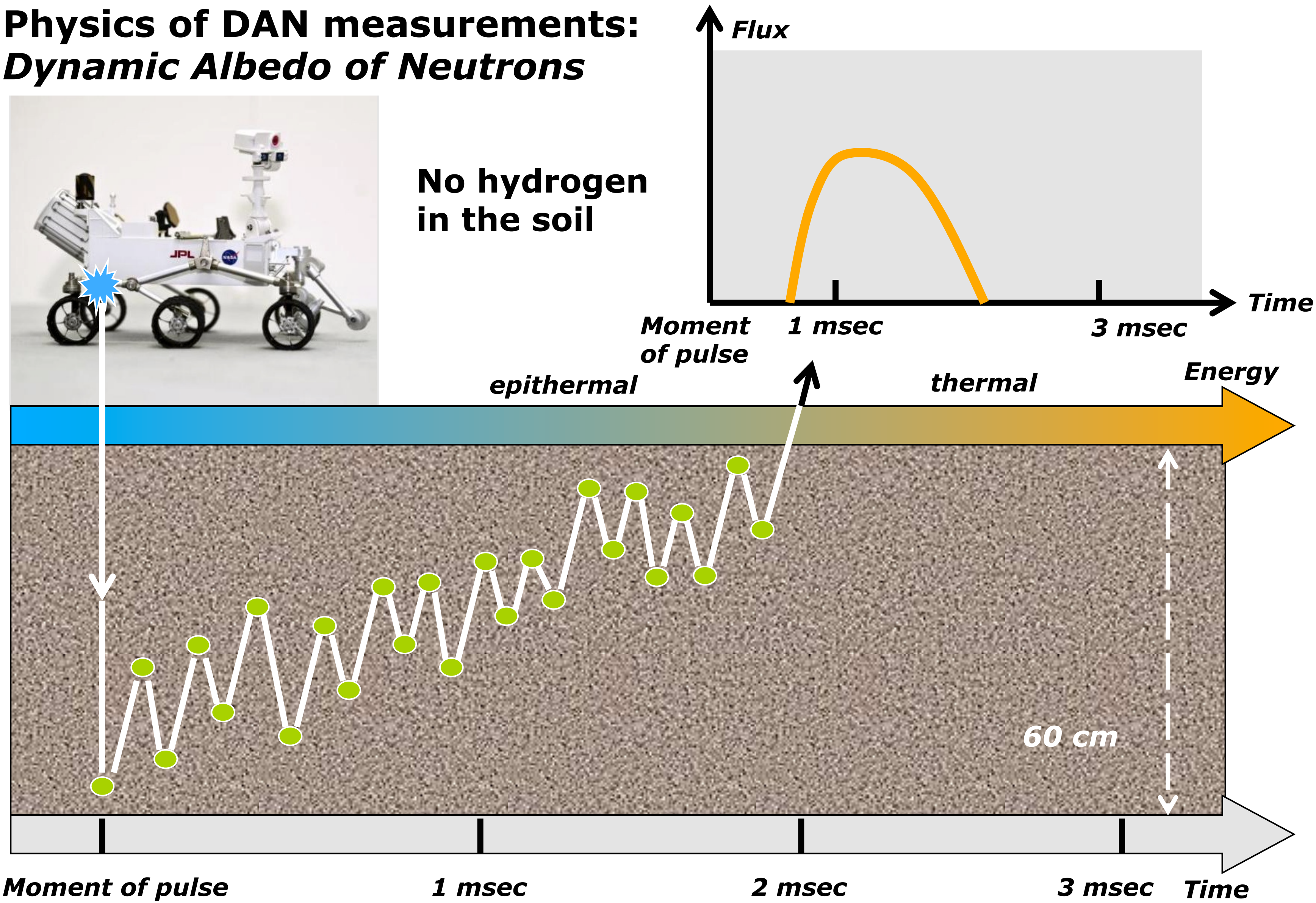
The neutron spectrometer aboard Mars Odyssey, a component of the Gamma-ray Spectrometer suite of instruments, was designed and built by the Los Alamos National Laboratory and is operated by the University of Arizona in Tucson. The Mars Odyssey mission is managed by the Jet Propulsion Laboratory.

Mars Hydrogen from Neutron Measurements: Mid and Low Latitudes

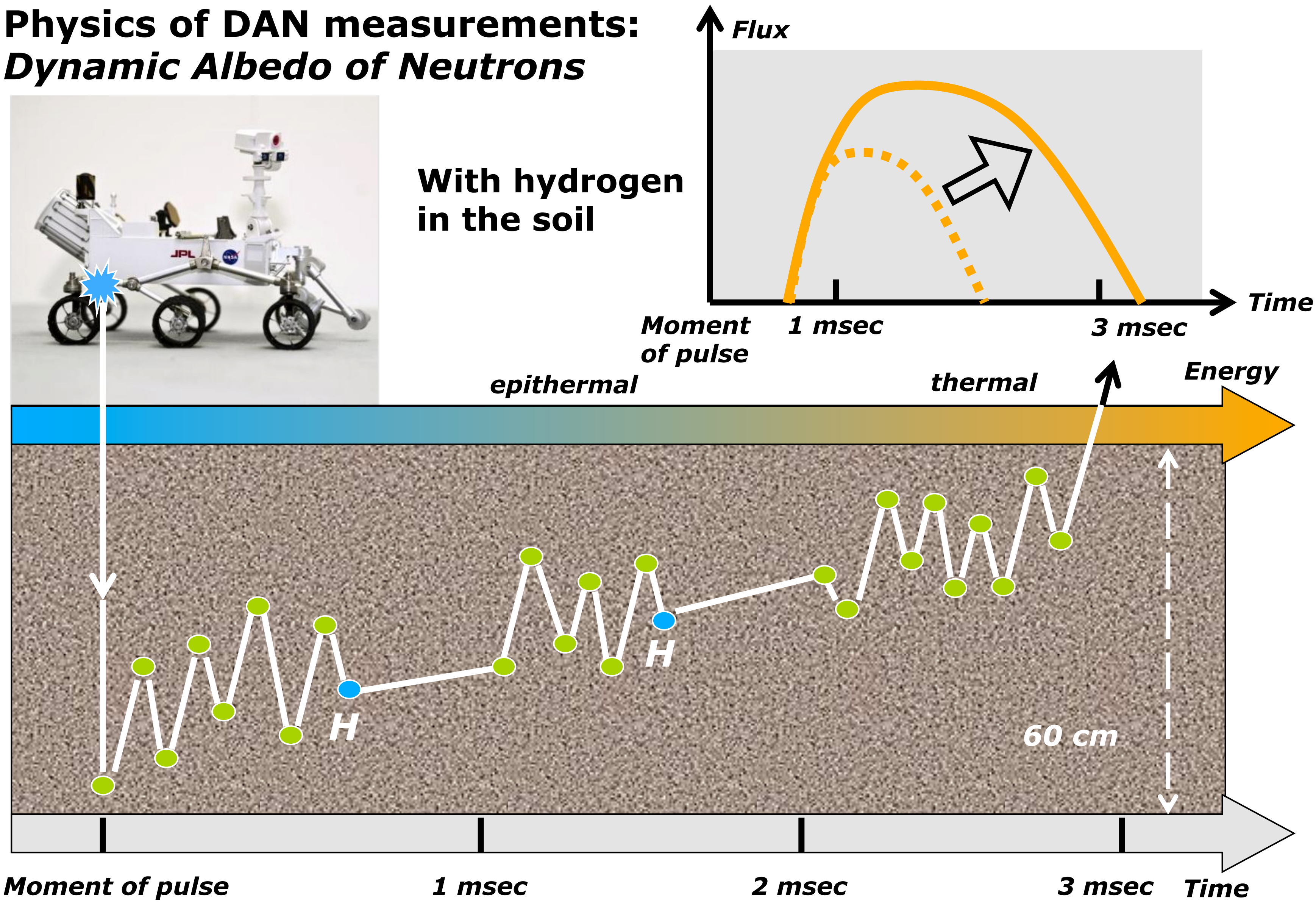

ChemCam
(Chemistry)
Mastcam
(Imaging)
REMS
(Weather)
DAN
(Subsurface
Hydrogen)
RAD
(Radiation)
APXS
(Chemistry)
MAHLI
(Imaging)
Drill
Scoop
Brush
Sieves
SAM
(Chemistry
and Isotopes)
CheMin
(Mineralogy)
MARDI
(Imaging)

CURIOSITY

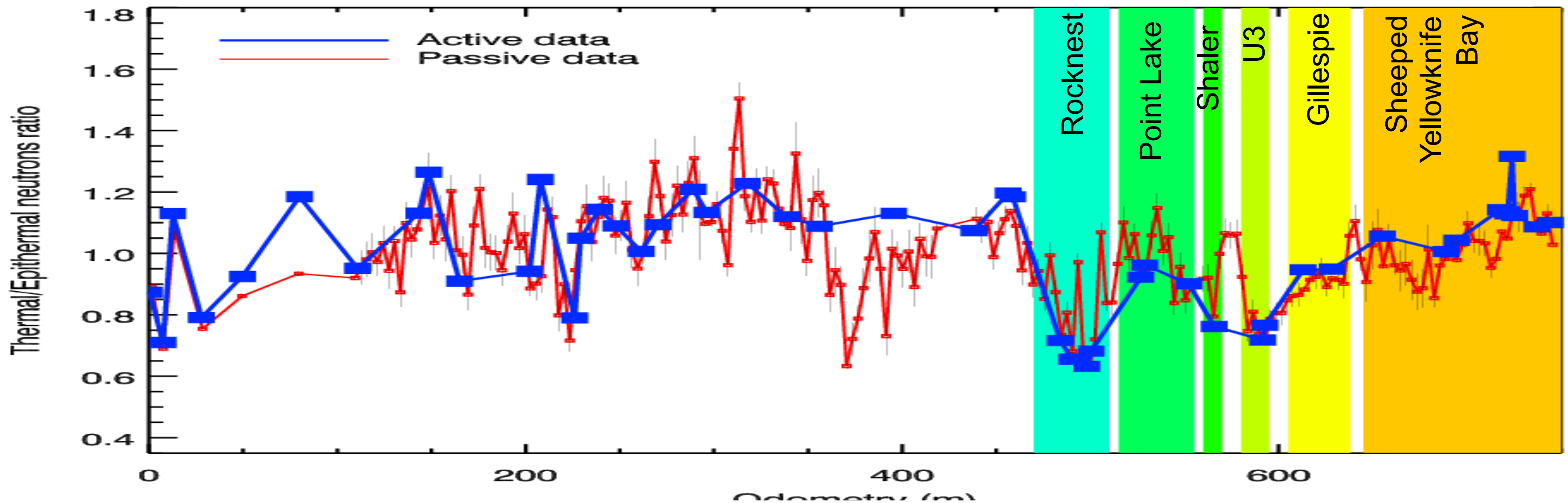
Physics of DAN measurements:
Dynamic Albedo of Neutrons



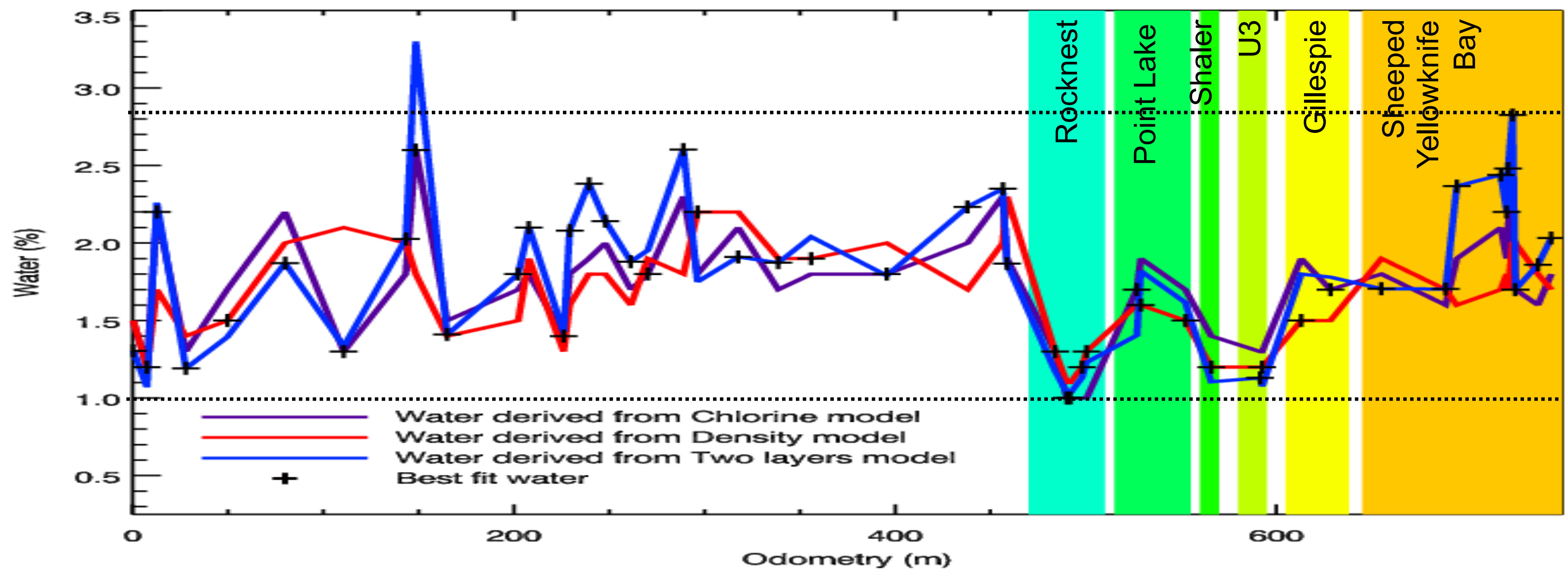
Physics of DAN measurements: *Dynamic Albedo of Neutrons*



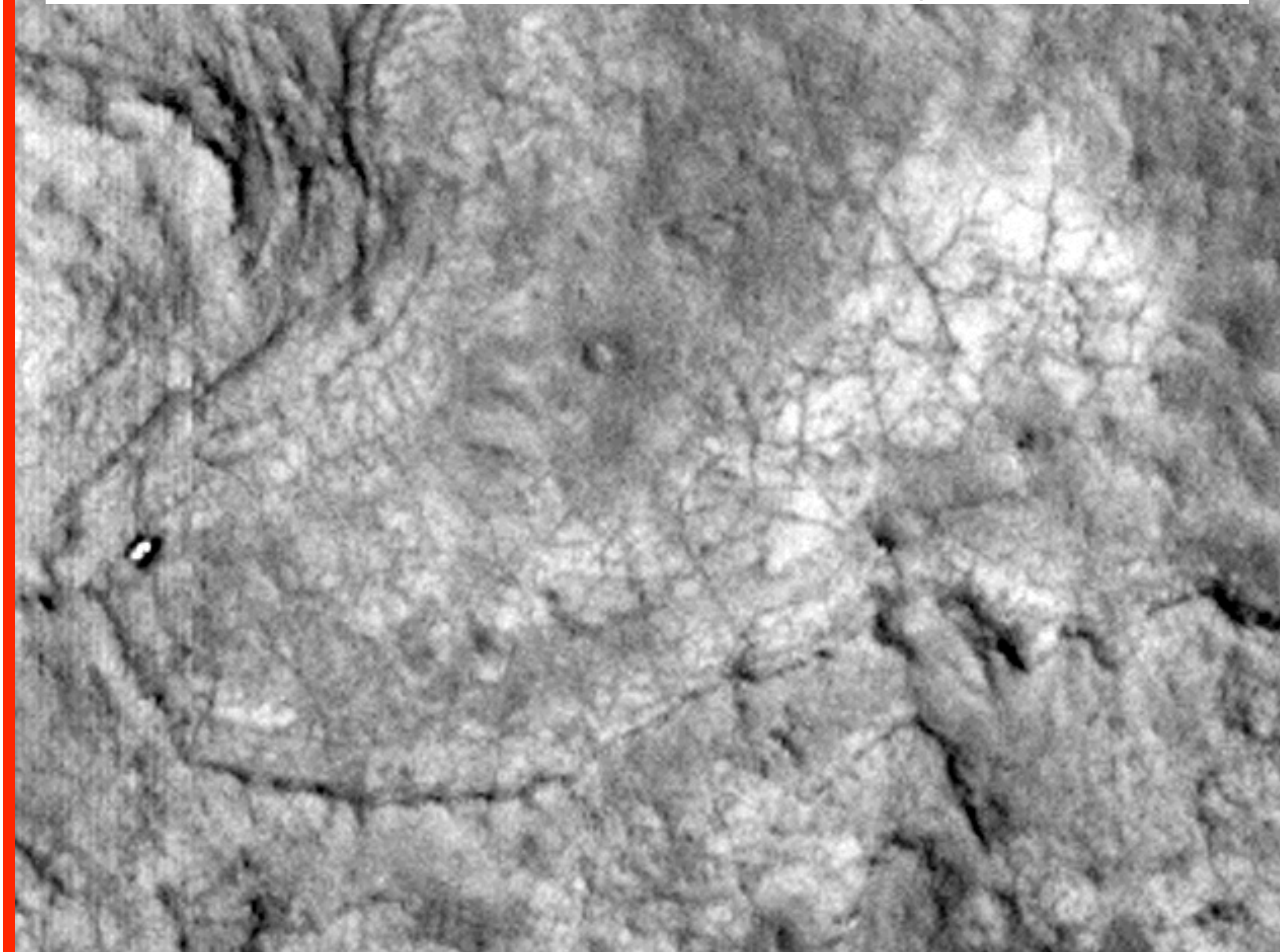
Variations of DAN data along the Curiosity traverse



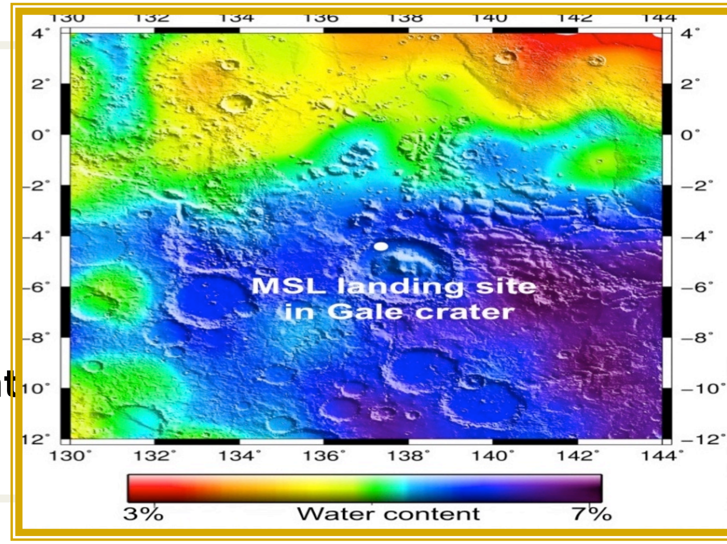
Variations of water content in the soil along the Curiosity traverse



MSL in Yellowknife Bay



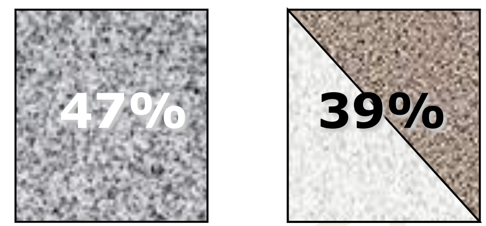
Results of DAN investigation after 200 sols on Mars:



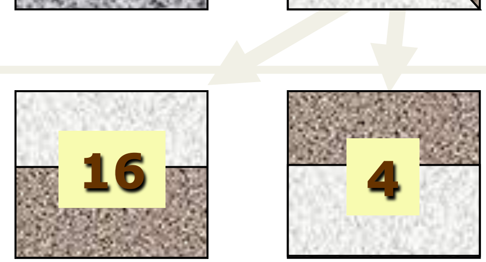
(1)Neutron data from DAN show the water variations from 1.0 up to 2.8 wt% within 60 cm of subsurface.

These values are much less than the estimated content of water ~ 5% according to the orbital neutron data from the Russian HEND instrument onboard the NASA's Mars Odyssey.

(2) Water in-depth distribution is found to be homogeneous in 47% of tested spots; the non-homogeneous water in-depth is found in 39% of tested spots (14% of tested spots do not agree with any used model of subsurface).



(3) Water increasing with depth is found for 16 spots and water decreasing with depth is found for 4 spots



(4) At the *Yellowknife Bay* the water distribution corresponds to the model with increasing water in depth: from 1.3 – 1.9 wt% on the top up to 1.9 – 2.9 wt% at the depth of 5 – 20 cm