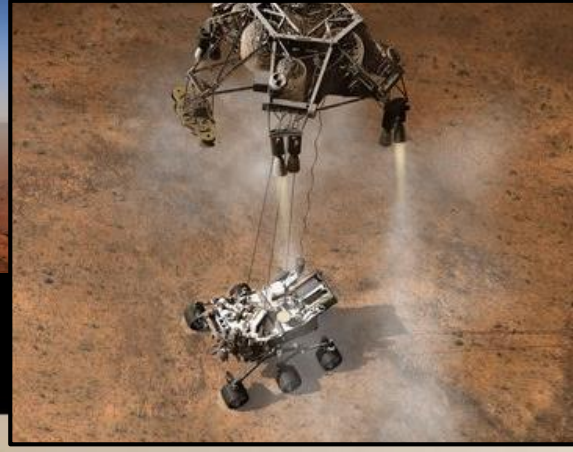
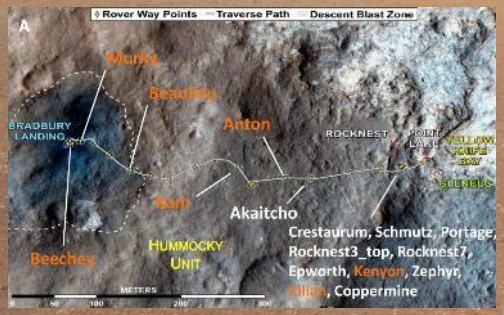
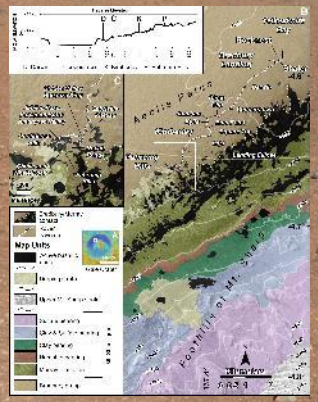
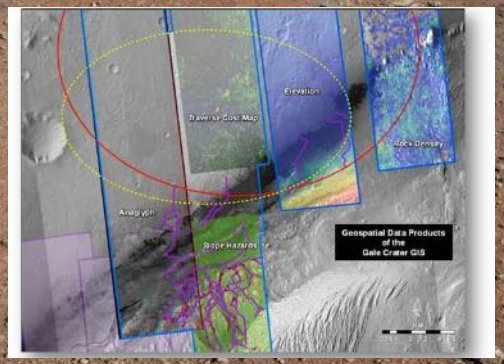
Mapping Curiosity's Traverse from Bradbury Landing to Mt. Sharp









NASA/JPL-Caltech/MSSS

Jet Propulsion Laboratory
California Institute of Technology

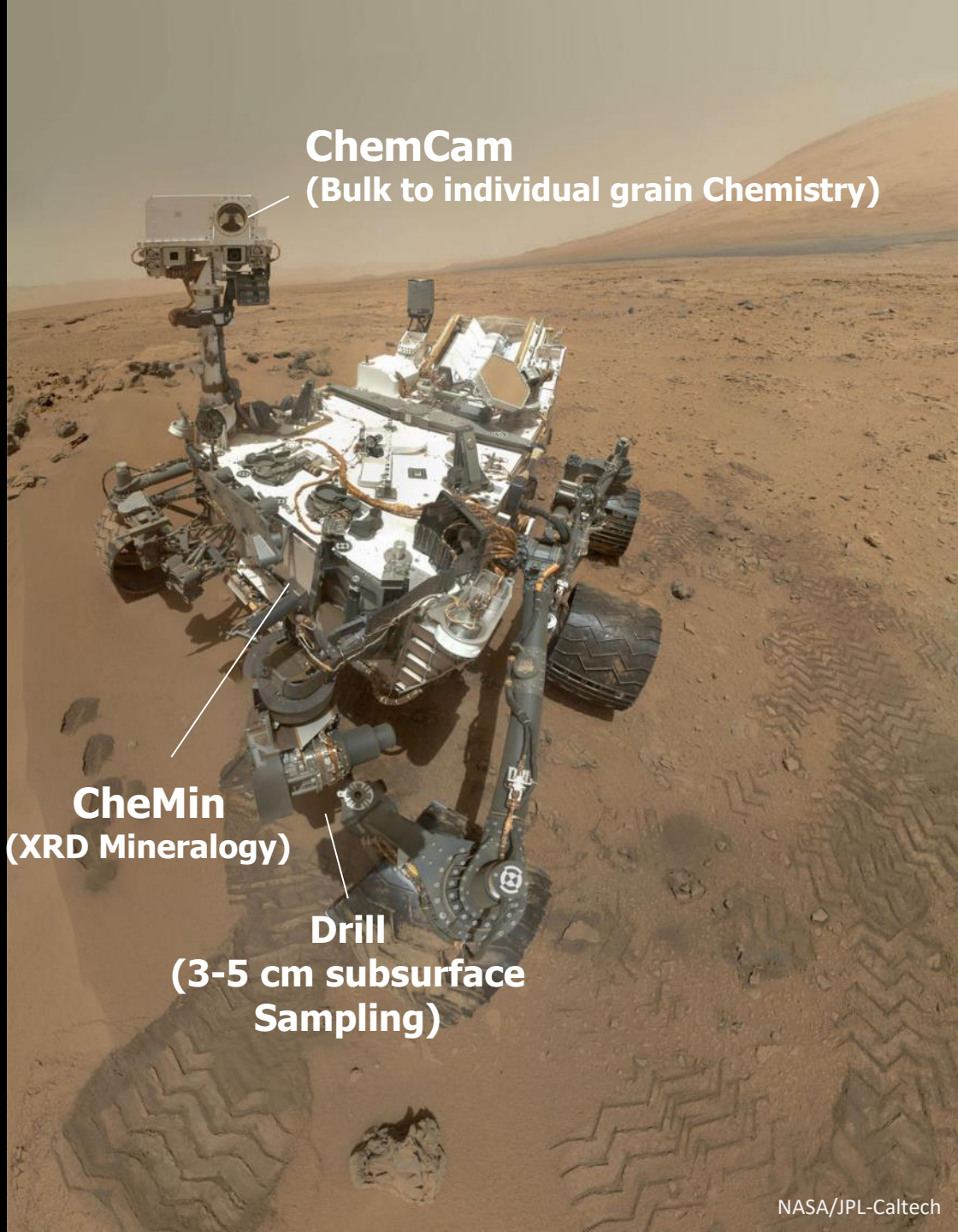
CURIOSITY

F. Calef III[1], L. Edgar[2], H. Gengl[1], T. Parker[1], S. Rowland[3], J. Schroeder[1], and K. Stack[1]

[1]Jet Propulsion Laboratory – California Institute of Technology, [2]USGS, [3]Univ of Hawaii

Curiosity's primary scientific goal is to explore and quantitatively assess a local region on Mars' surface as a potential habitat for life, past or present

- Biological potential
- Geology and geochemistry
- Water, weather, and climate
- Radiation levels and hazards

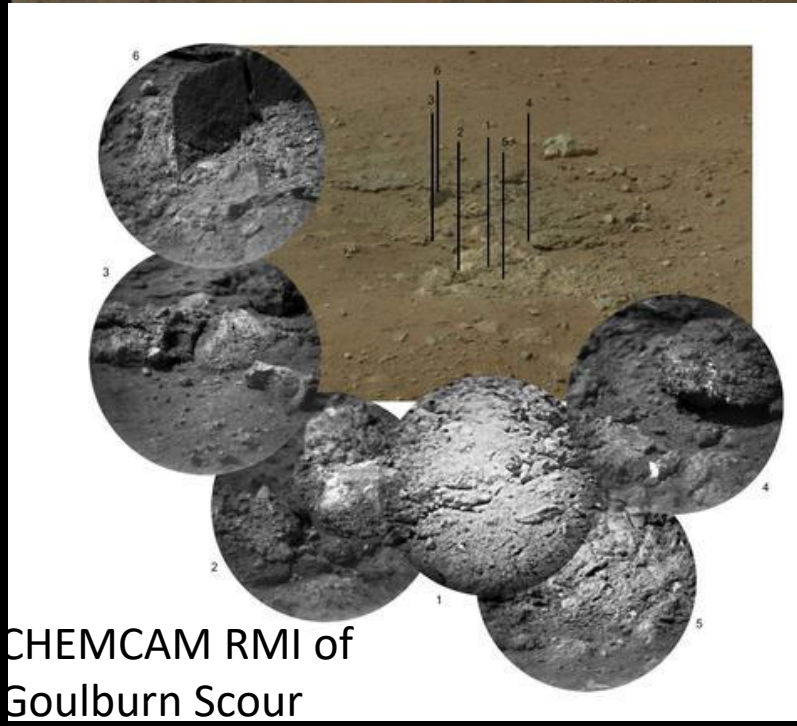


Curiosity self-portrait at Rocknest
Assembled from 55 MAHLI images
Shows four scoop trenches and wheel scuff

Mapping for MSL

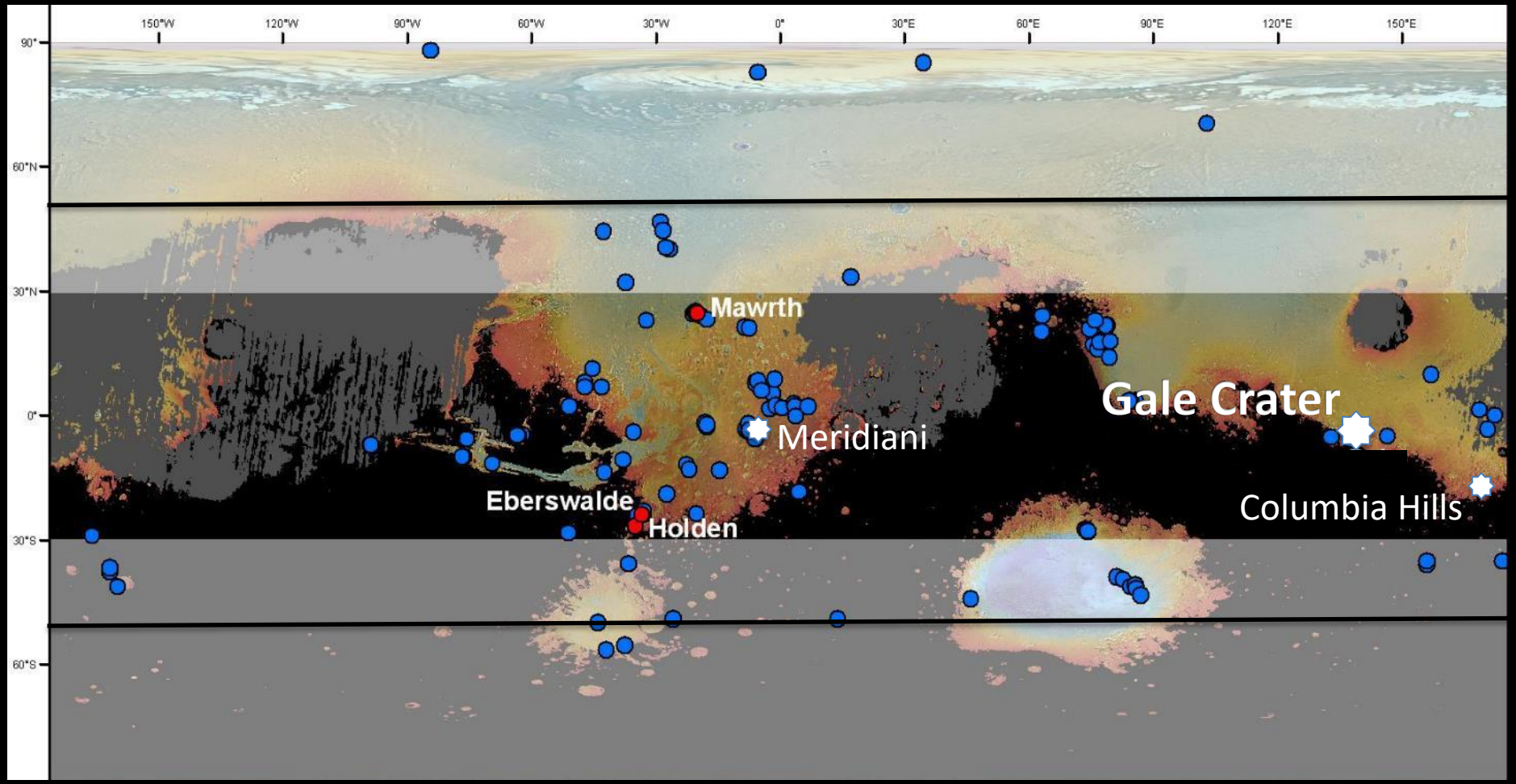
1. Datasets are becoming increasing large
   I. >100 GBs of mapping data.
   II. >10000s science instrument readings
2. Missions last “forever”
   1. Mars Pathfinder 30 days -> 85 days
   2. Mars Exploration Rover (Oppy)
   90 days -> 10 years and STILL. GOING.
   1. MSL: 2 Earth years -> WHO. KNOWS!
3. Rover Mission Needs
   - Where are we now?
   - Why are we here?
   - Where are we going?
   - Why are we going there?

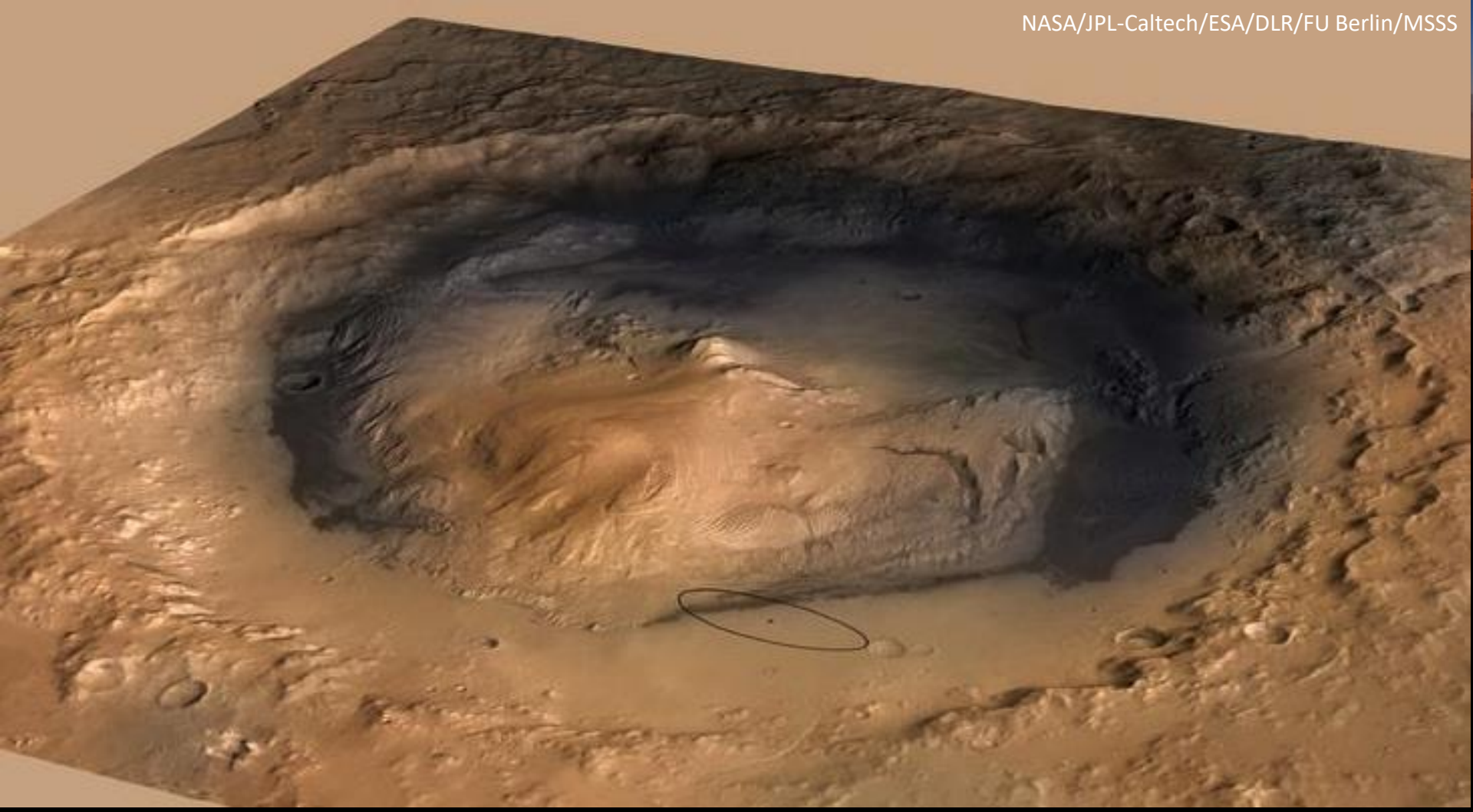
Co-registered MAHLI at Jake Matejevic


CHEMCAM RMI of Goulburn Scour

CURIOSITY

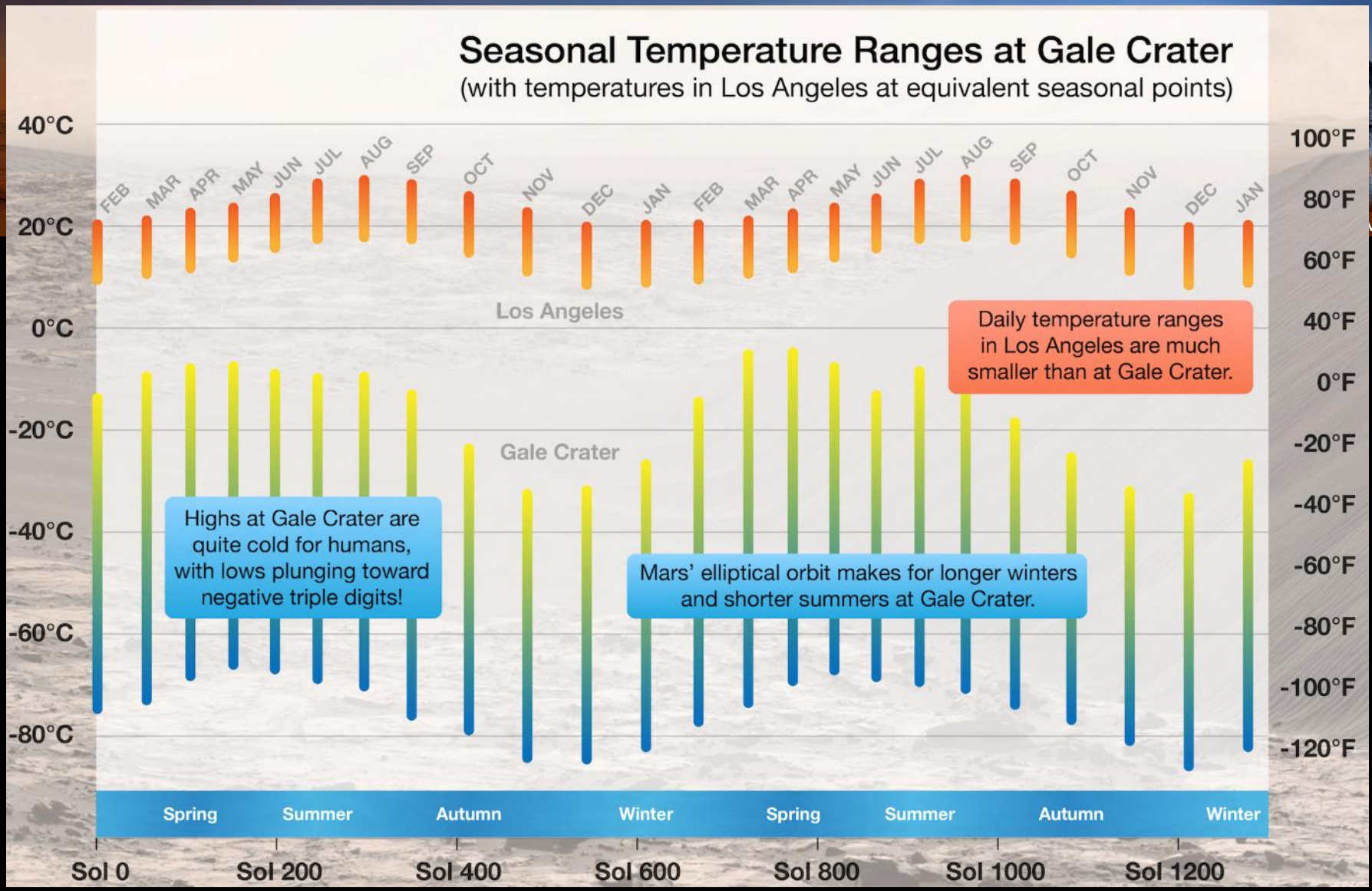
Where we've gone on Mars





155-km Gale Crater contains a 5-km high mound of stratified rock. Strata in the lower section of the mound are composed of clays and sulfates, while the upper mound is dry, suggesting transition from ‘wet’ Mars to ‘dry’ Mars (Late Noachian to Early Hesperian?).

CURIOSITY

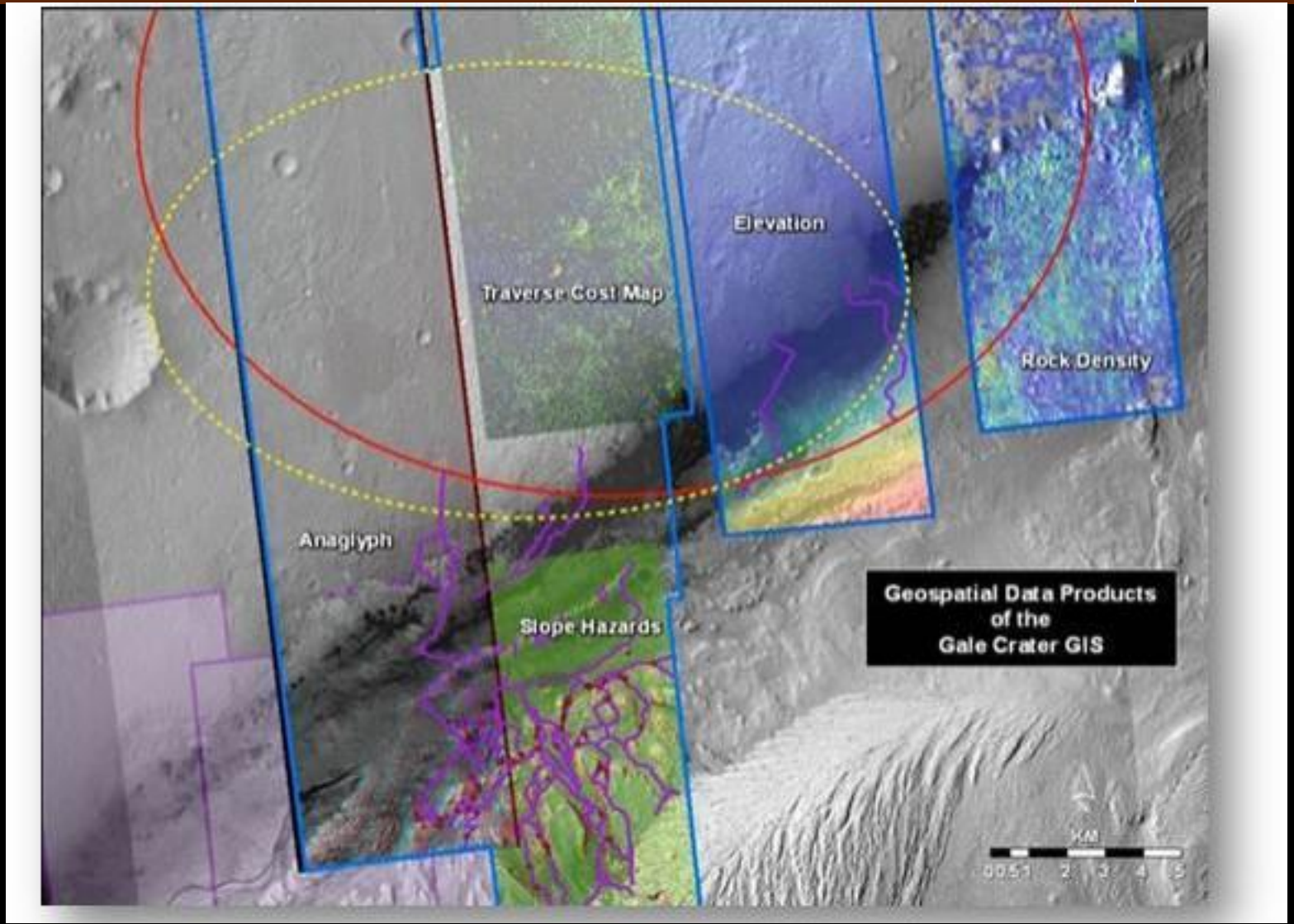


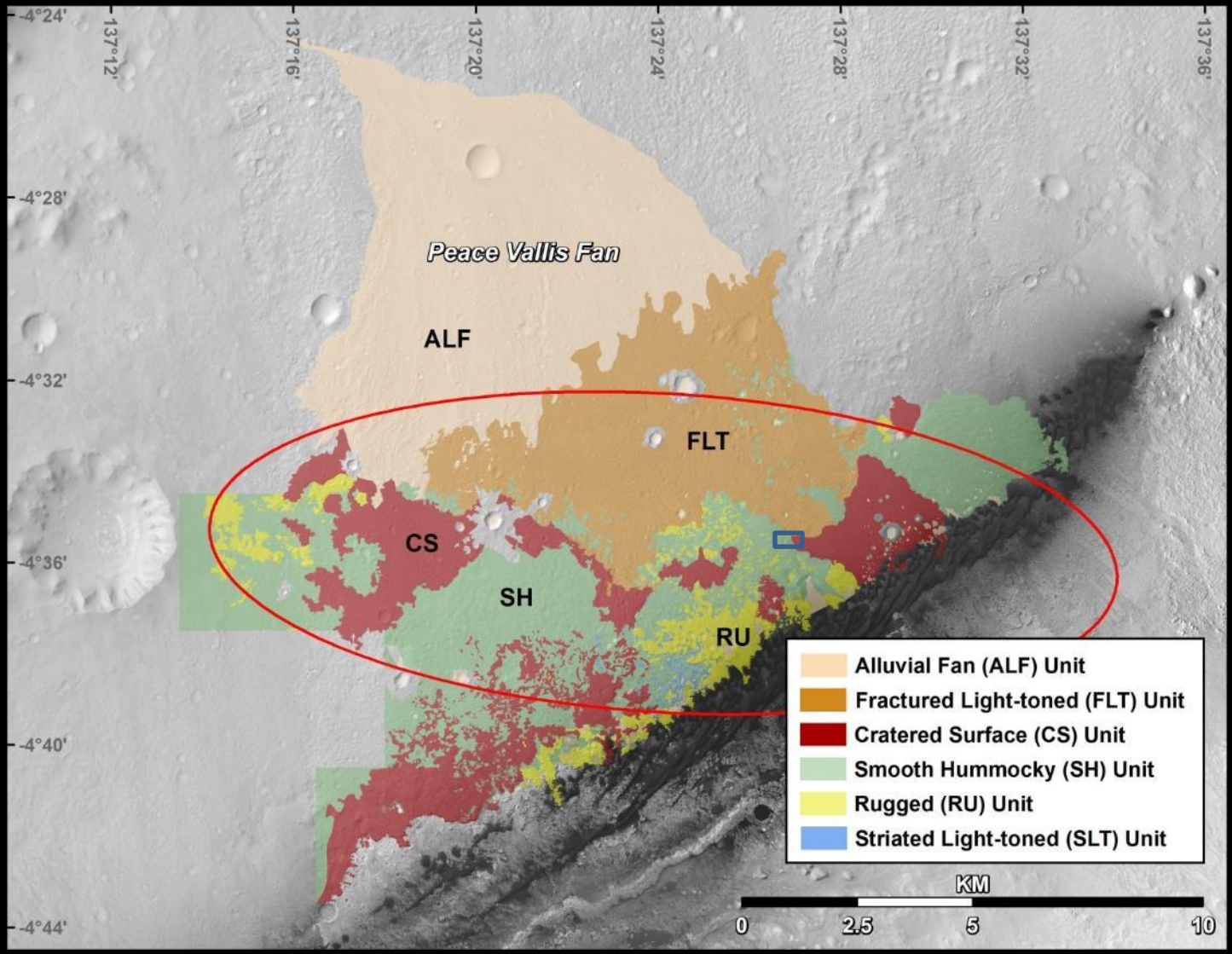
NASA/JPL-Caltech/CAB(CSIC-INTA)

CURIOSITY

Curiosity's Rover Environmental Monitoring Station is taking weather readings continually

Multiple Co-Registered Datasets in Landing Zone: Slope, Rock Abundance, Hazards, and more

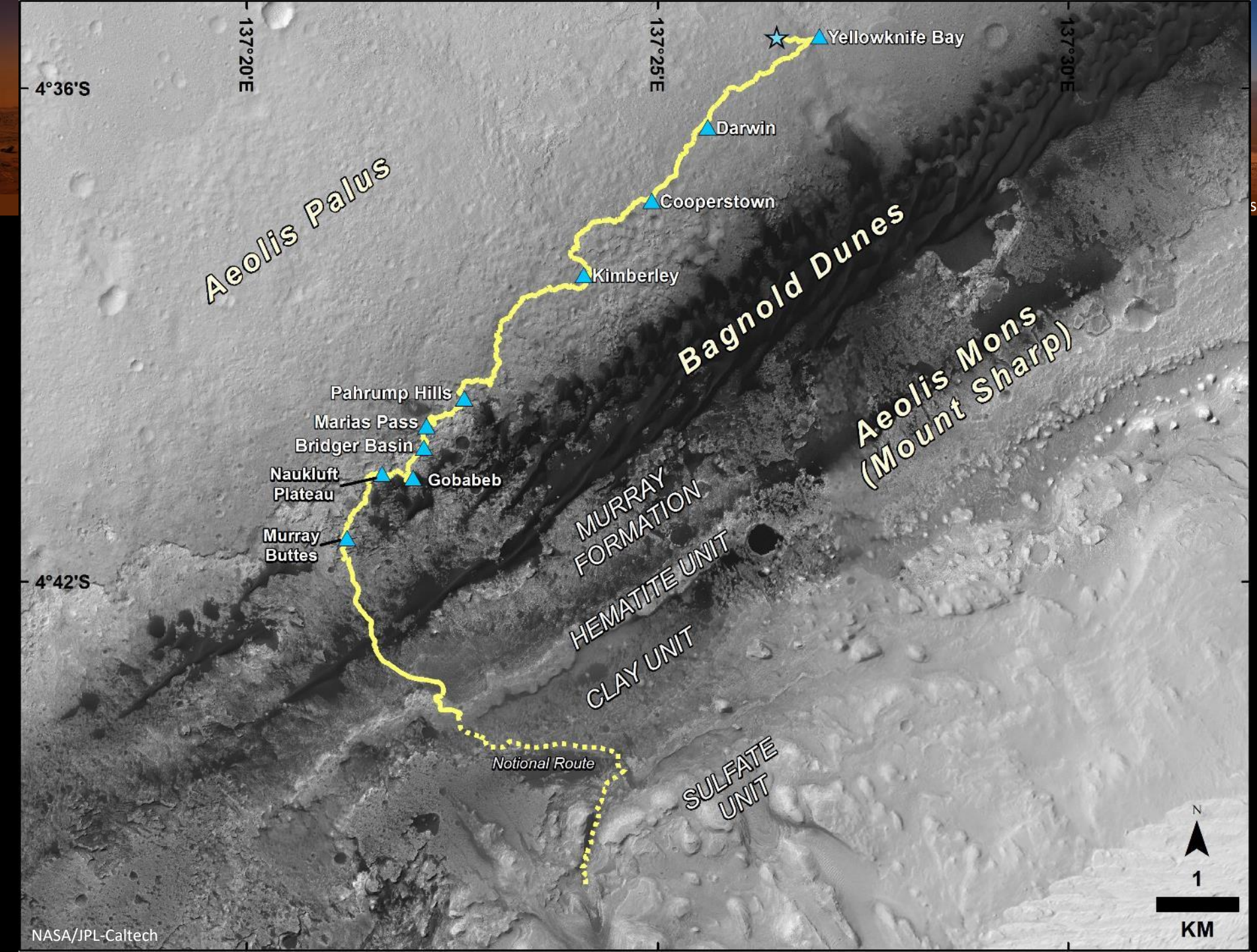


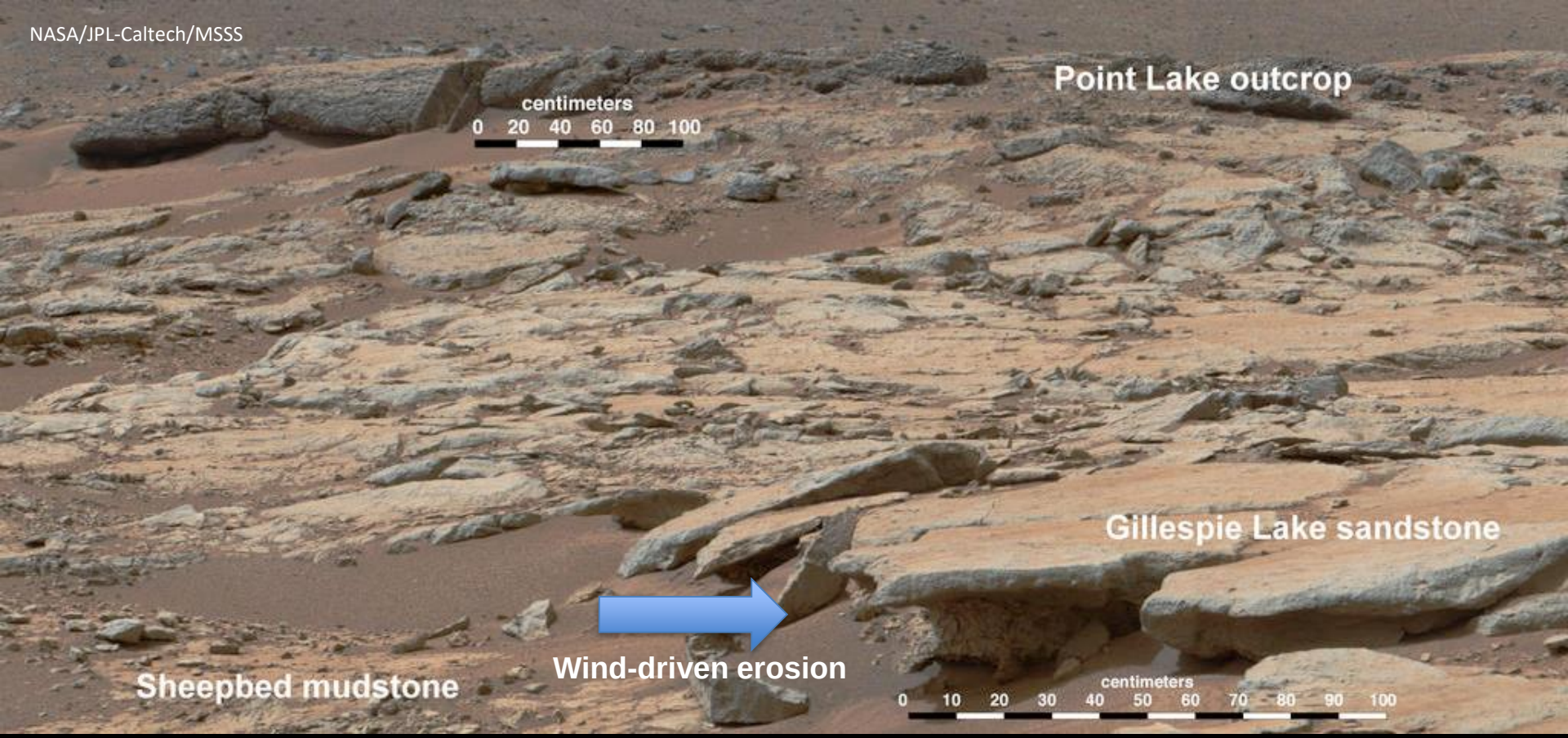


NASA/JPL-Caltech/Univ. of Arizona

Orbital data used to derive first science product (geologic map) & strategic traverse decisions (Where do we go first? Why?)

CURIOSITY

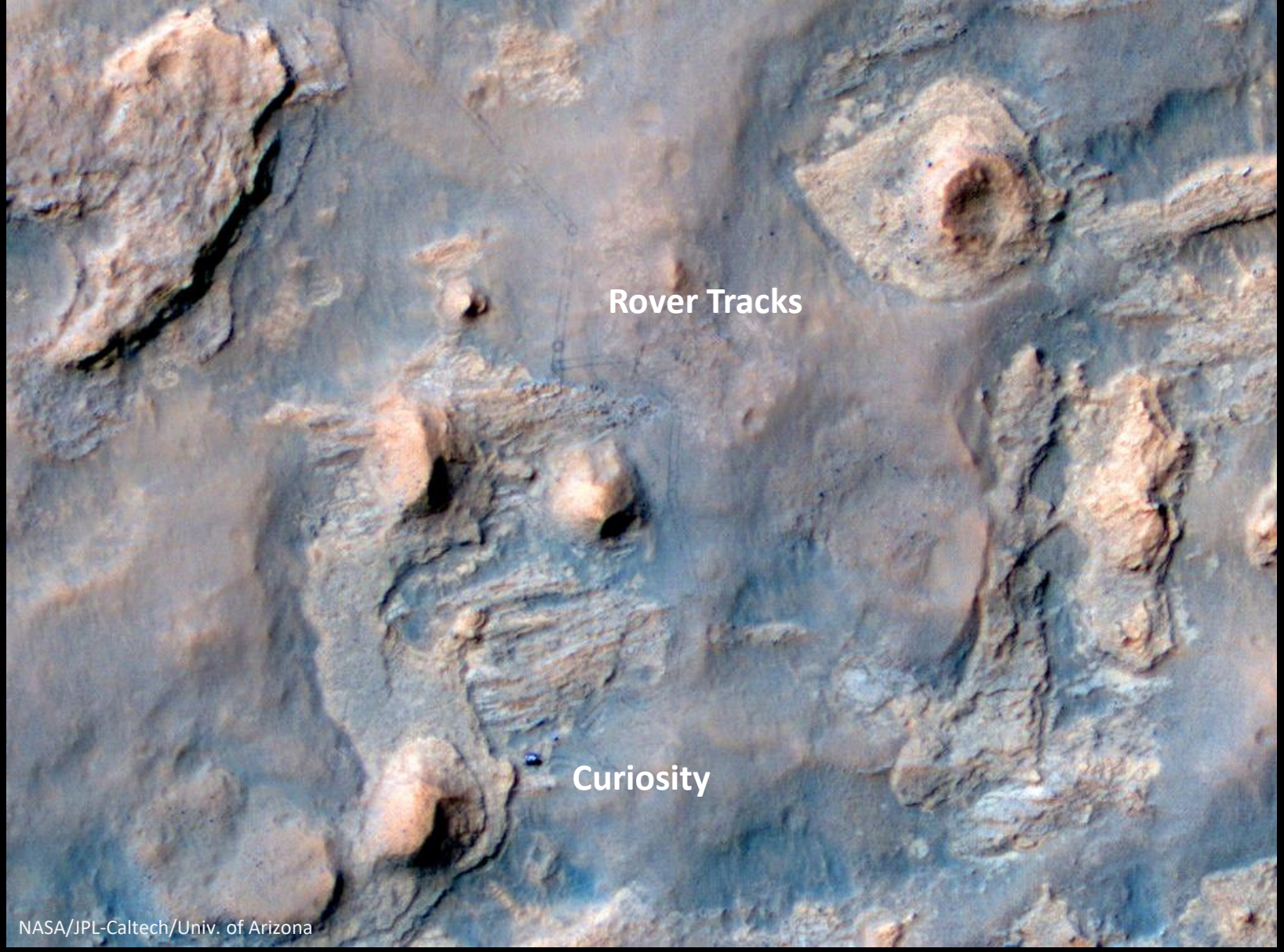

137°20'E
137°25'E
137°30'E
4°36'S
4°42'S
Yellowknife Bay
Darwin
Cooperstown
Kimberley
Pahrump Hills
Marias Pass
Bridger Basin
Naukluft Plateau
Gobabeb
Murray Buttes
Aeolis Palus
Bagnold Dunes
Aeolis Mons (Mount Sharp)
MURRAY FORMATION
HEMATITE UNIT
CLAY UNIT
SULFATE UNIT
Notional Route
N
1
KM
NASA/JPL-Caltech



CURIOSITY

Curiosity carried out the first radiometric (K-Ar) and exposure age dating on the surface of another planet. The "Sheepbed" mudstone has been exposed for only 78 ± 30 million years, based on ^{36}Ar, ^{3}He, and ^{21}Ne cosmogenic isotopes.

These results suggest that natural erosion can be used to find sites where organic materials would have experienced less degradation.



CURIOSITY

Curiosity at the Kimberley, where four rock types typical of Gale Crater's plains come together

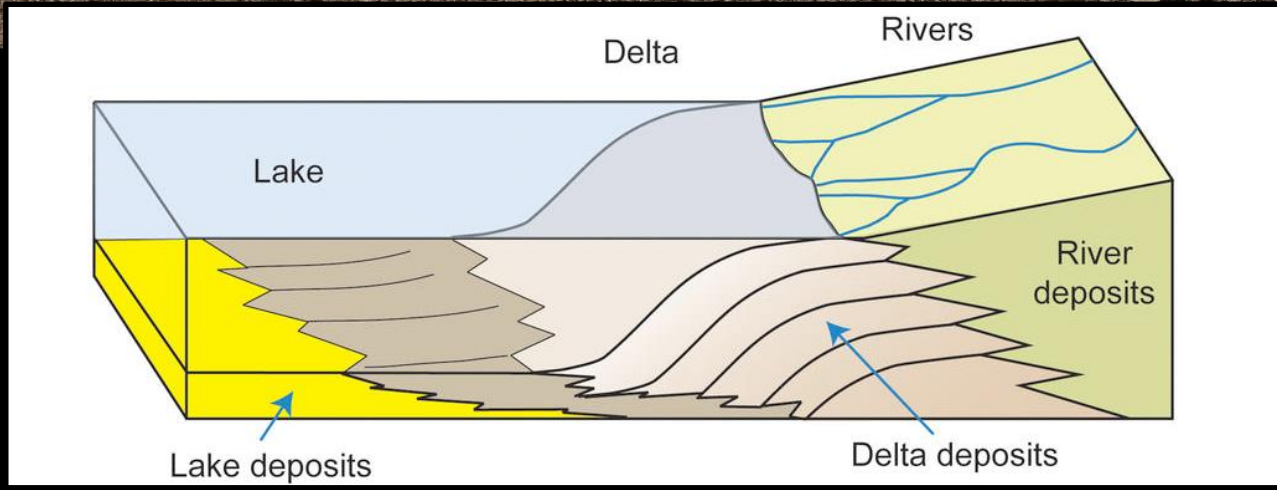
NASA/JPL-Caltech/MSSS

Mount Sharp

meters
0 2 4 6 8 10

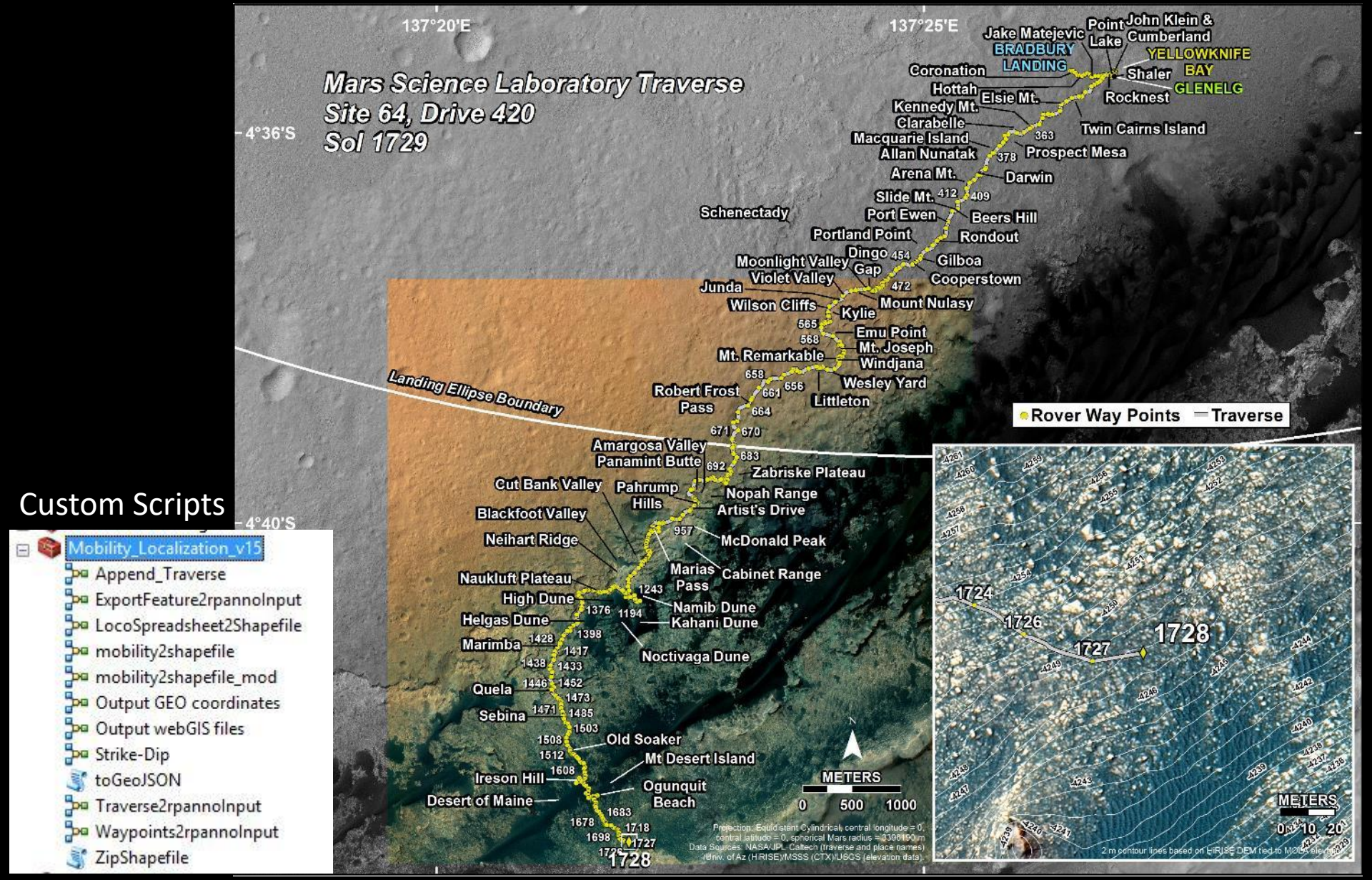
centimeters
0 20 40 60 80 100

Possible lake deposits at the base of Mount Sharp



CURIOSITY

Curiosity discovered south-tilting sandstone beds on Gale Crater's plains that indicate water-driven transport of sediment, building up lower Mount Sharp from lake deposits



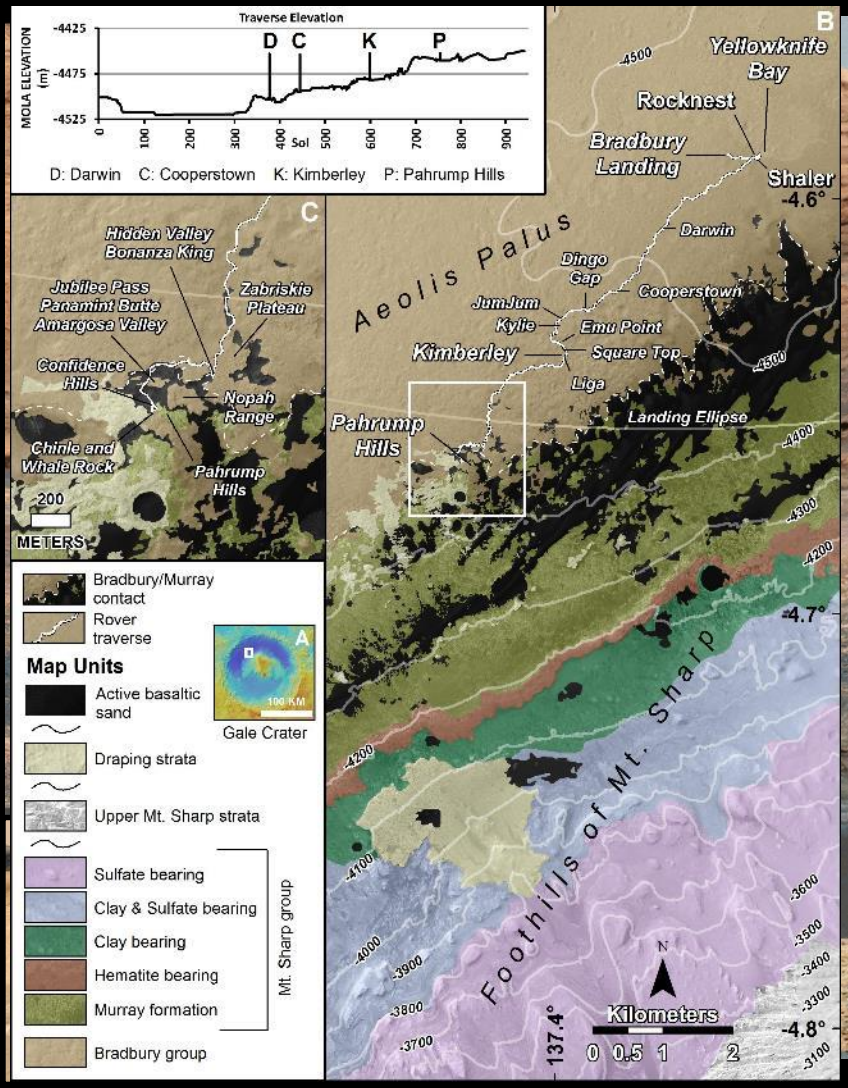
Automated Traverse Map for MSL/Curiosity Rover.

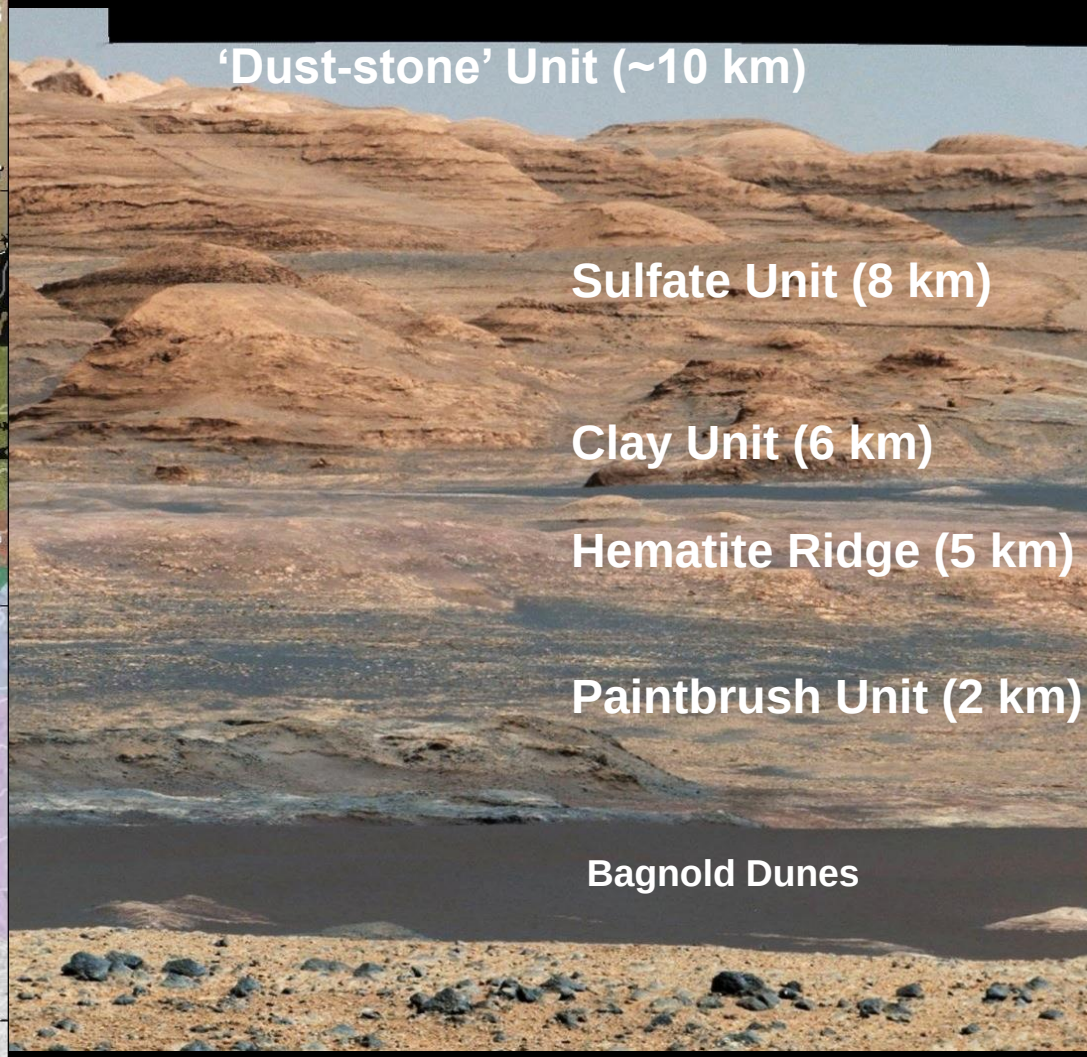
http://mars.jpl.nasa.gov/msl/mission/whereistherovernow

CURIOSITY

NASA/JPL-Caltech/Univ. of Arizona

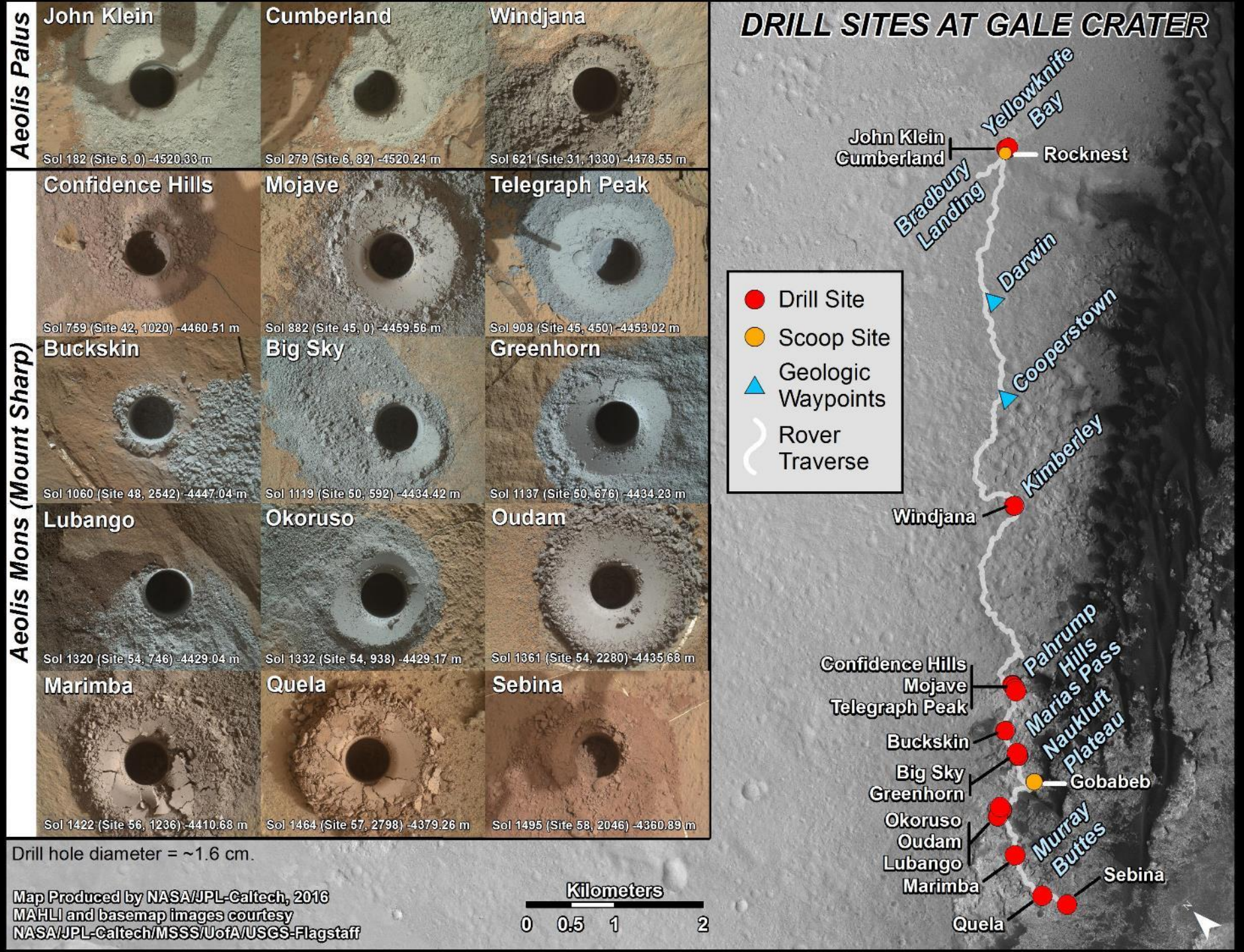
Aeolis Mons (Mt. Sharp) Geology: Transition from 'Wet' to 'Dry' Mars





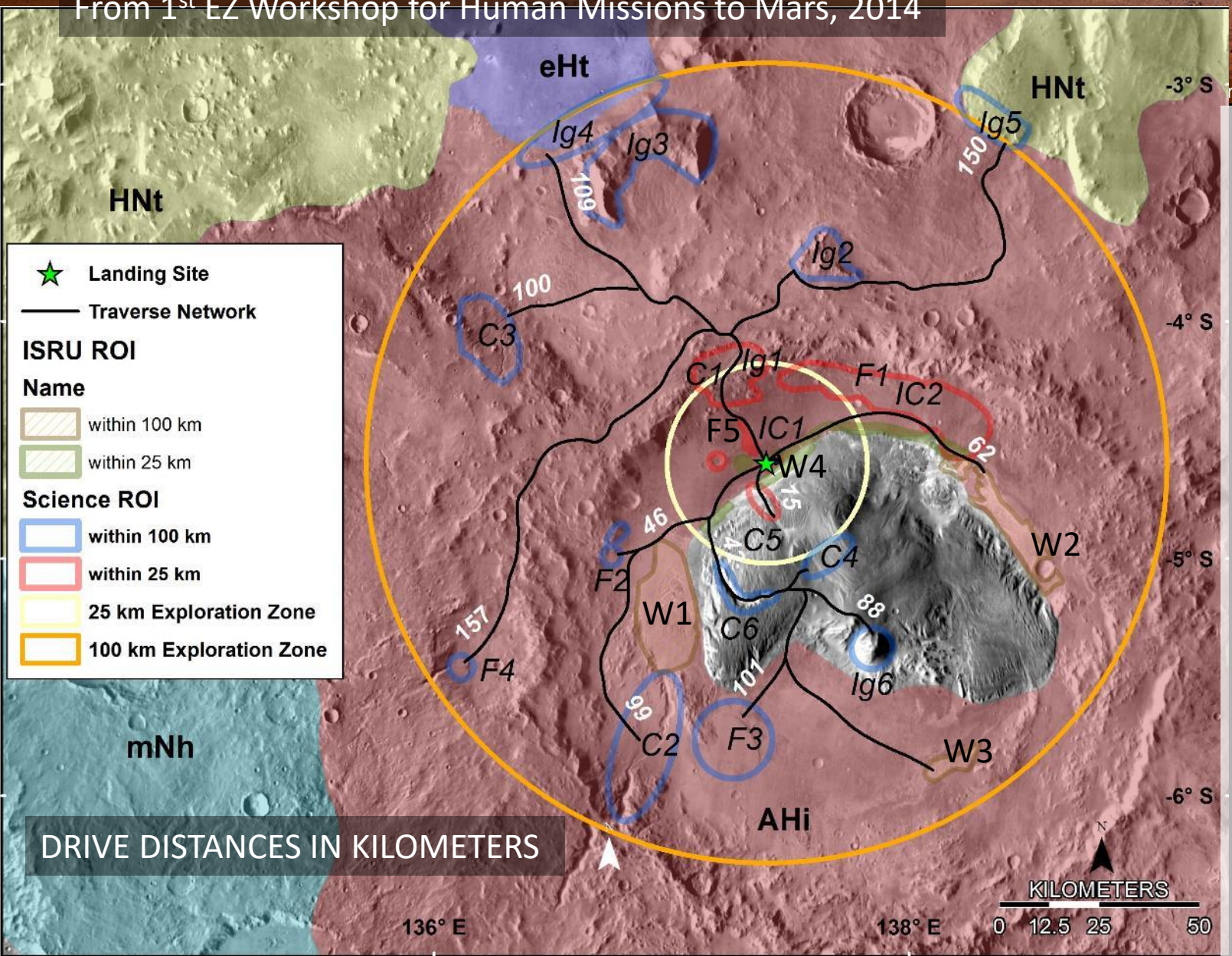
Left figure from Grotzinger et al., Science, 2015

NASA/JPL-Caltech/MSSS


Aeolis Palus
Aeolis Mons (Mount Sharp)
John Klein
Sol 182 (Site 6, 0) -4520.33 m
Cumberland
Sol 279 (Site 6, 82) -4520.24 m
Windjana
Sol 621 (Site 31, 1330) -4478.55 m
Confidence Hills
Sol 759 (Site 42, 1020) -4460.51 m
Mojave
Sol 882 (Site 45, 0) -4459.56 m
Telegraph Peak
Sol 908 (Site 45, 450) -4458.02 m
Buckskin
Sol 1060 (Site 48, 2542) -4447.04 m
Big Sky
Sol 1119 (Site 50, 592) -4434.42 m
Greenhorn
Sol 1137 (Site 50, 676) -4434.23 m
Lubango
Sol 1320 (Site 54, 746) -4429.04 m
Okoruso
Sol 1332 (Site 54, 938) -4429.17 m
Oudam
Sol 1361 (Site 54, 2280) -4435.68 m
Marimba
Sol 1422 (Site 56, 1236) -4410.68 m
Quela
Sol 1464 (Site 57, 2798) -4379.26 m
Sebina
Sol 1495 (Site 58, 2046) -4360.89 m
DRILL SITES AT GALE CRATER
Yellowknife Bay
John Klein
Cumberland
Rocknest
Bradbury Landing
Darwin
Cooperstown
Kimberley
Windjana
Drill Site
Scoop Site
Geologic Waypoints
Rover Traverse
Pahrump Hills
Marias Pass
Naukluft Plateau
Confidence Hills
Mojave
Telegraph Peak
Buckskin
Big Sky
Greenhorn
Gobabeb
Okoruso
Oudam
Lubango
Marimba
Murray Buttes
Sebina
Quela
Drill hole diameter = ~1.6 cm.
Map Produced by NASA/JPL-Caltech, 2016
MAHLI and basemap images courtesy
NASA/JPL-Caltech/MSSS/UofA/USGS-Flagstaff
Kilometers
0 0.5 1 2

Gale Crater as a Human Exploration Zone

From 1st EZ Workshop for Human Missions to Mars, 2014



DRIVE DISTANCES IN KILOMETERS

LZ Coordinates

Longitude (E)

137.42009295˚

Latitude (S)

4.59310427˚

Elevation (MOLA)

-4497.77

Easting

8145534.27 m

Northing -

272254.70 m

Science ROI

C = Channel

F = Fan

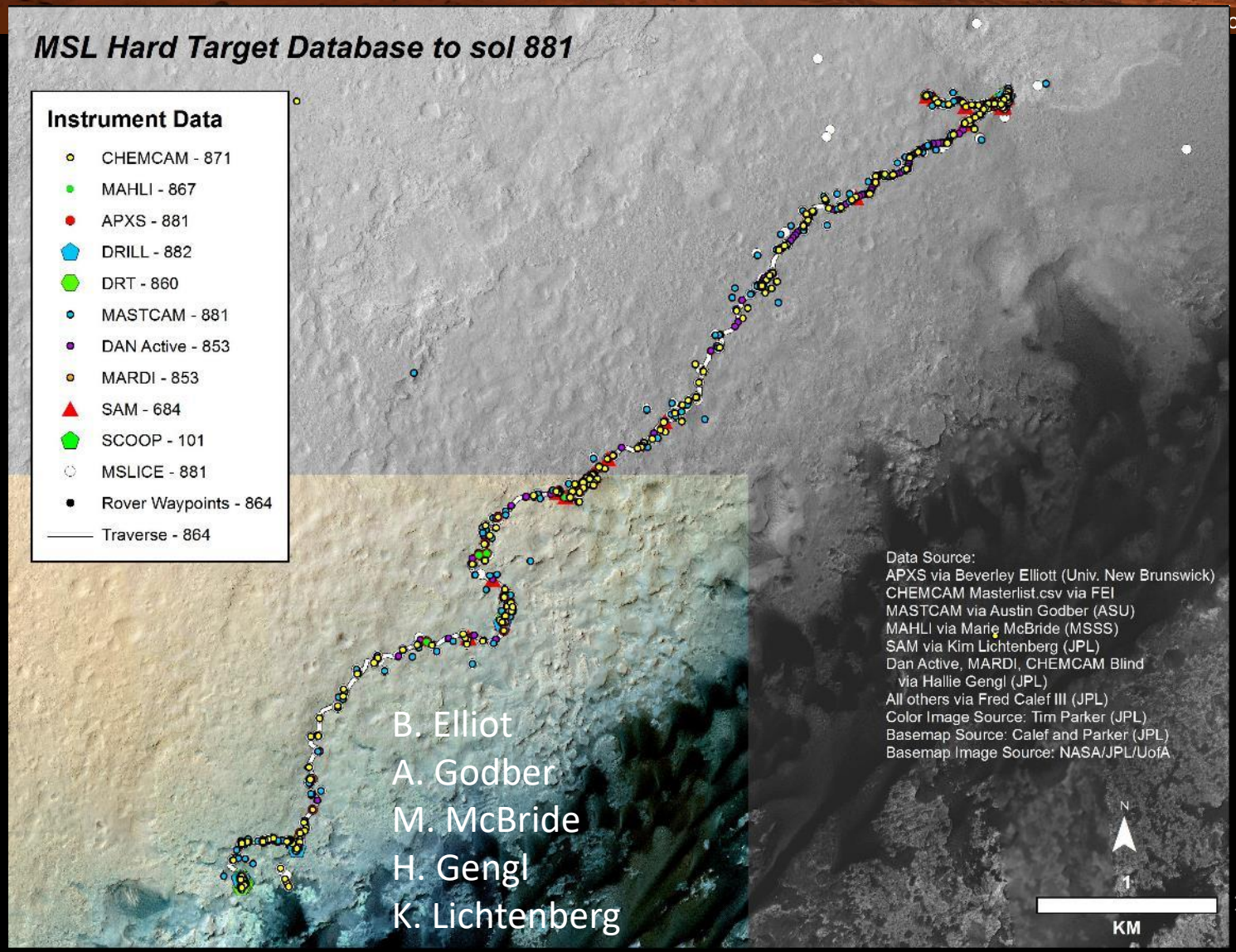
lg = Igneous

IC = Inverted Channels

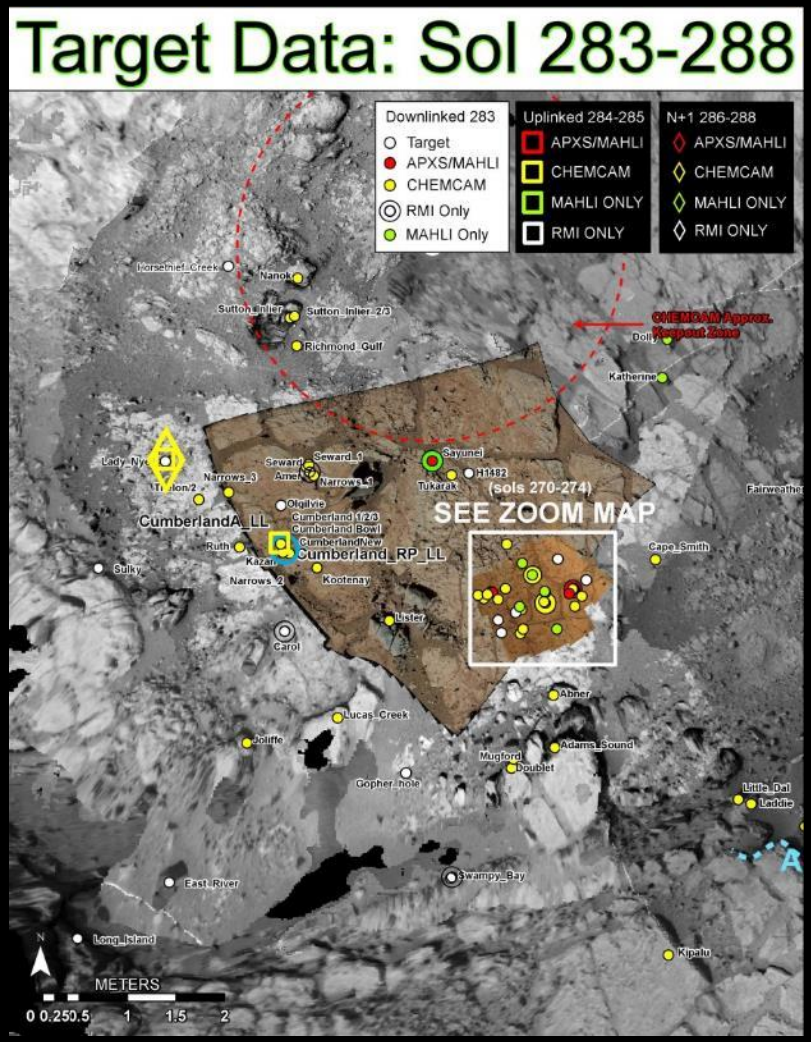
ISRU ROI

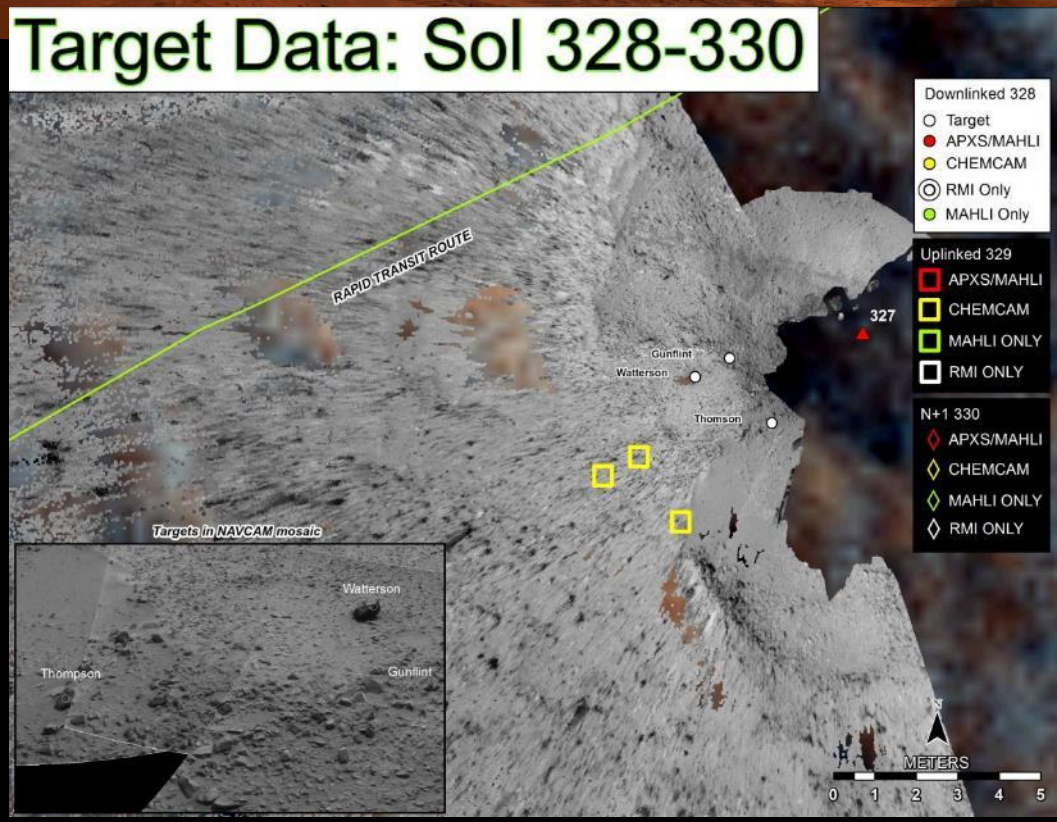
W = Water ROI

Tracking Science Observations: thousands of potential sample locations known to cm scale



Example Target Map from MSL Operations: known locations for future science opportunities maximize science return during field excursions

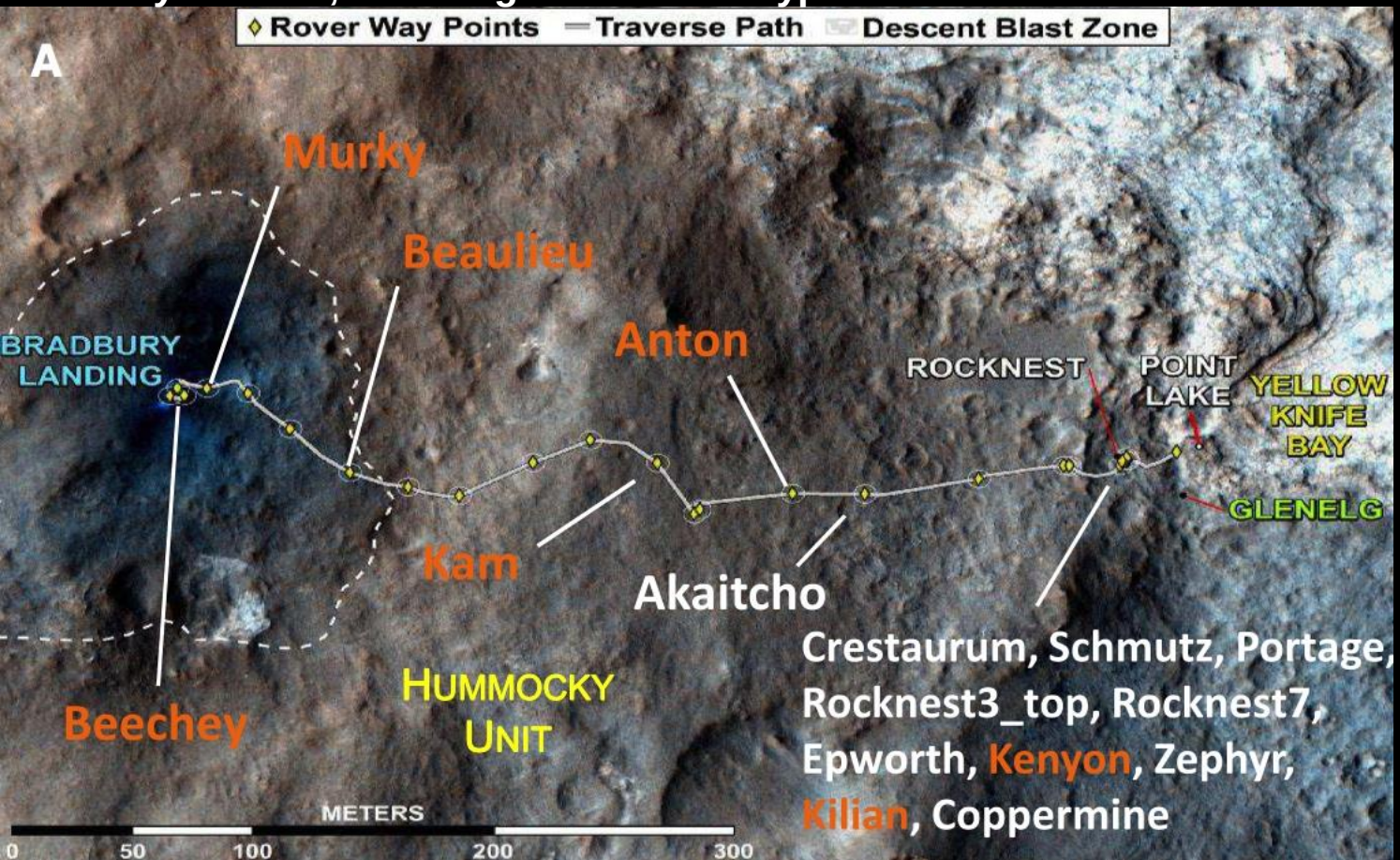




Felsic vs. Mafic ISRU Source Areas

ChemCam identified two principal soil types along the traverse to Yellowknife Bay: a fine-grained, mafic type similar to other soils, and a locally derived, coarse-grained felsic type.

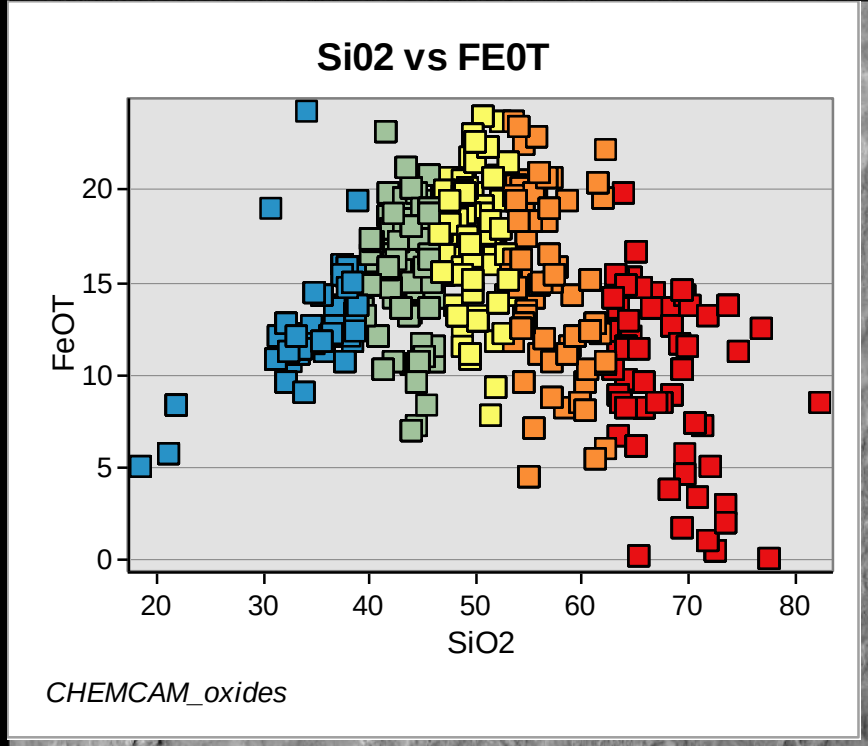
Mafic soil component has hydration signature, corresponding to the X-ray amorphous component sampled by CheMin and SAM.



Meslin et al. [2013]

Mafic

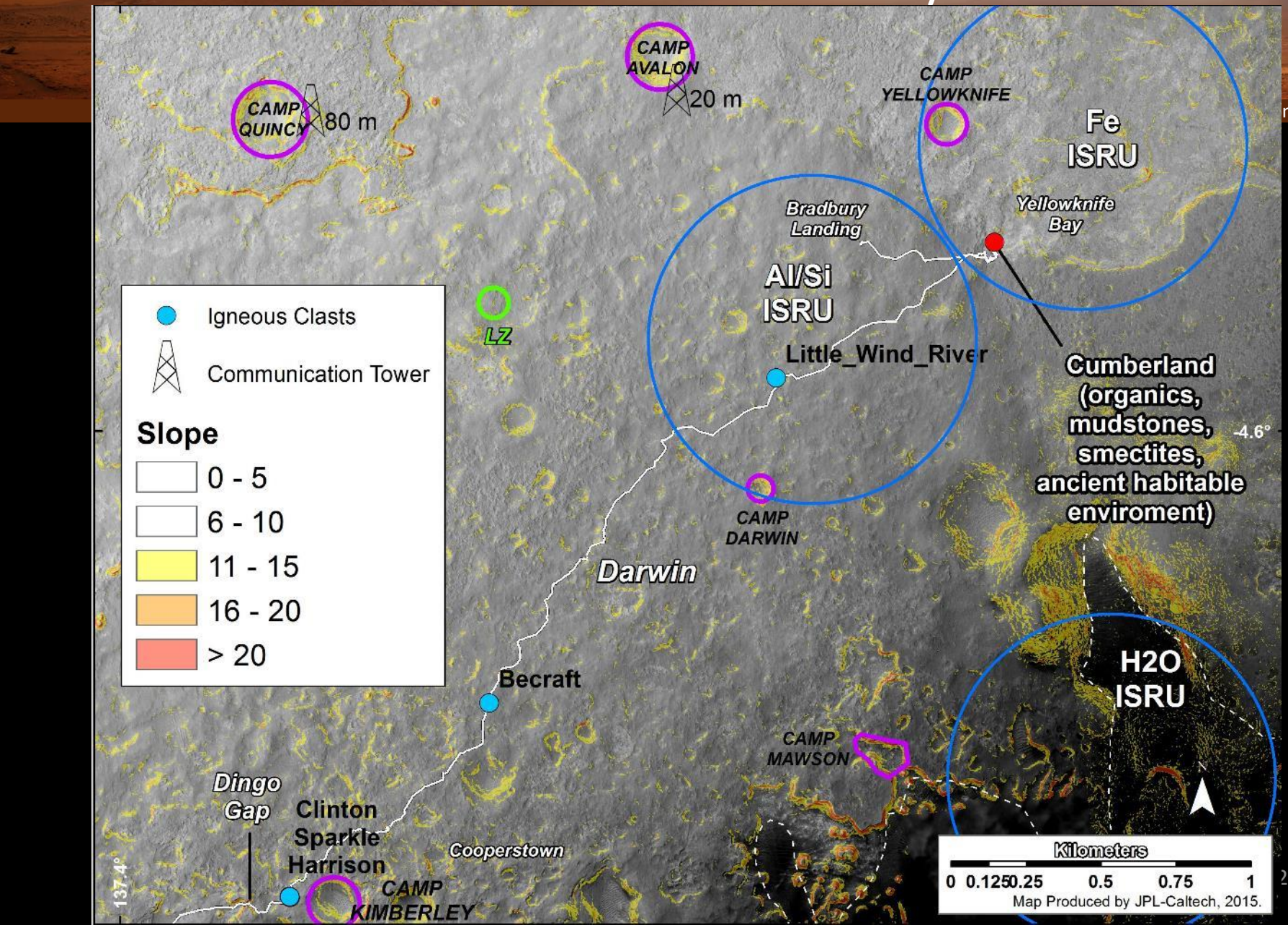
Felsic



>15 % Fe

Iron Detection and Abundance along MSL Traverse

Exploration Zone:
Potential Habitation Sites and nearby ISRU Zones



ISRU Resource Numbers

- Water
  - Based on Leshin et al. (2013), Rocknest soil contained up to 3 wt% H_2O via SAM, Bagnold Dune field contains 10^4-10^6 MT **adsorbed** water (were closer to 1%)
  - Easy to process. Potentially 'reuseable'.
  - Rocknest sand has a typical Mars basalt composition, but also 1.5-3% bound water.
  - Both a water and food growth medium.

- Aluminum and Silicon
  - ISRU01 rocks on average have ~12 wt% Al and ~55-60 wt% Si. ISRU02 rocks, ~18 wt% Fe.
  - Assuming rock density ~2.5 gm/cc:
    - 300 kg/m^3 Al (ISRU01)
    - 1375-1500 kg/m^3 Si (ISRU01)
    - 450 kg/m^3 Fe (ISRU02)

Resource ROI(s) Rubric

			Site Factors	RW01-04	RISUR1	LZ01	ISRU2					EZ SUM
ISRU and Civil Engineering Criteria	Engineering		Meets First Order Criteria (Latitude, Elevation, Thermal Inertia)			●						1
	Water Resource	Threshold	AND/OR **Potential for ice or ice/regolith mix**									
			AND/OR **Potential for hydrated minerals**	●								4
			Quantity for substantial production	●								4
			Potential to be minable by highly automated systems	●								4
			Located less than 3 km from processing equipment site	●								1
			Located no more than 3 meters below the surface	●								4
			Accessible by automated systems	●								4
		Qualifying	Potential for multiple sources of ice, ice/regolith mix **and** hydrated minerals									
			Distance to resource location can be >5 km	●								3
			Route to resource location must be (plausibly) traversable	●								3
	Civil Engineering	Threshold	**~50 sq km region of flat and stable terrain with sparse rock distribution**			●						1
			1–10 km length scale: <10°			●						1
			Located within 5 km of landing site location			●						1
		Qualifying	Located in the northern hemisphere			○						0, 1
			Evidence of abundant cobble sized or smaller rocks and bulk, loose regolith			●						1
			Utilitarian terrain features			●						1
	Food Production	Qualifying	Low latitude			●						1
			No local terrain feature(s) that could shadow light collection facilities			●						1
			Access to water			●						1
			Access to dark, minimally altered basaltic sands			●						1
	Metal/Silicon Resource	Threshold	**Potential for metal/silicon**		●		●					2
			Potential to be minable by highly automated systems		●		●					2
			Located less than 3 km from processing equipment site		●		●					2
			Located no more than 3 meters below the surface		●		●					2
			Accessible by automated systems									
		Qualifying	Potential for multiple sources of metals/silicon		●		●					2
			Distance to resource location can be >5 km		●		●					2
			Route to resource location must be (plausibly) traversable		●		●					2

Key

- ● **Yes**
- ○ **Partial Support or Debated**
- **No**
- **? Indeterminate**