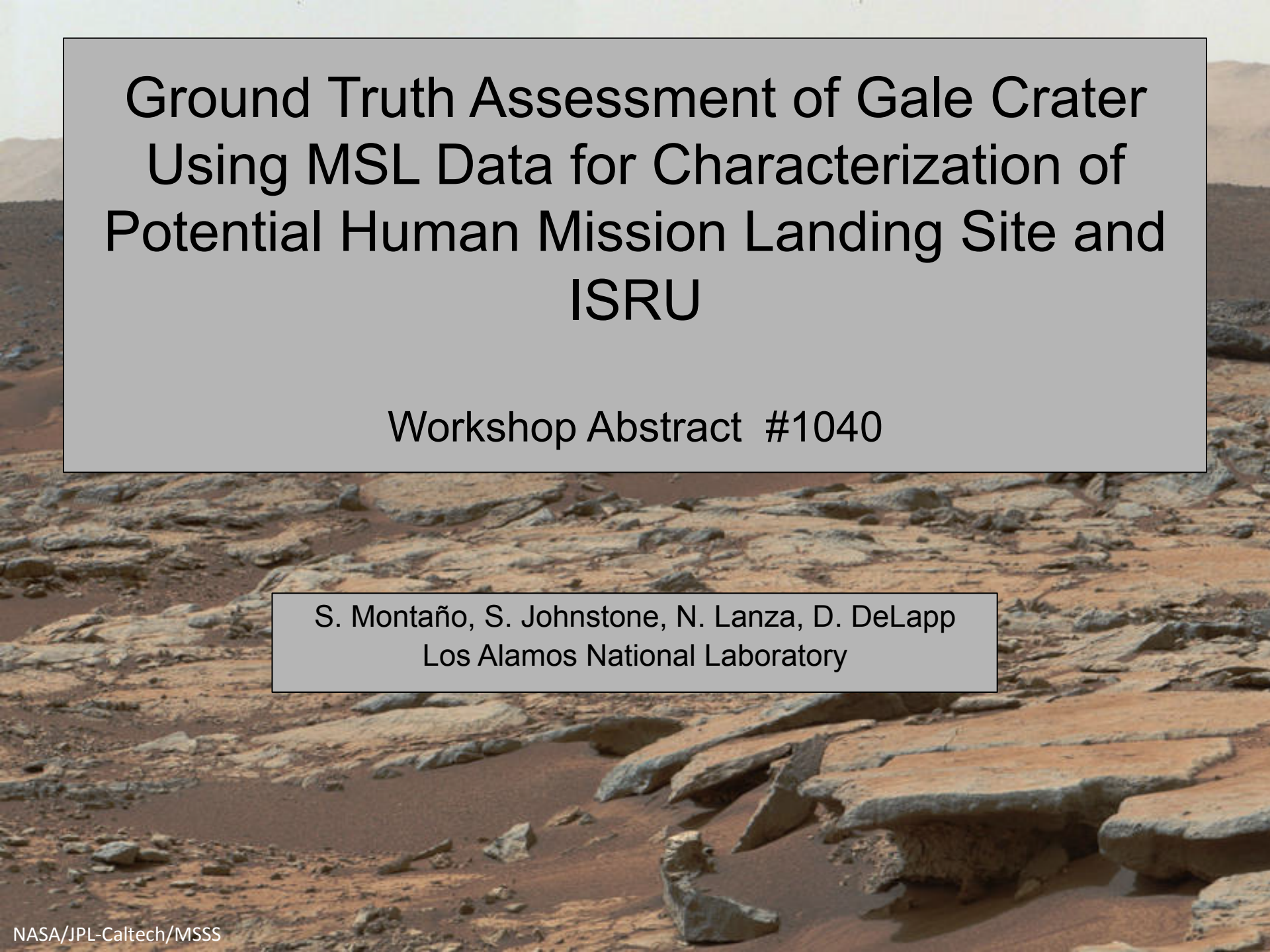
Ground Truth Assessment of Gale Crater Using MSL Data for Characterization of Potential Human Mission Landing Site and ISRU

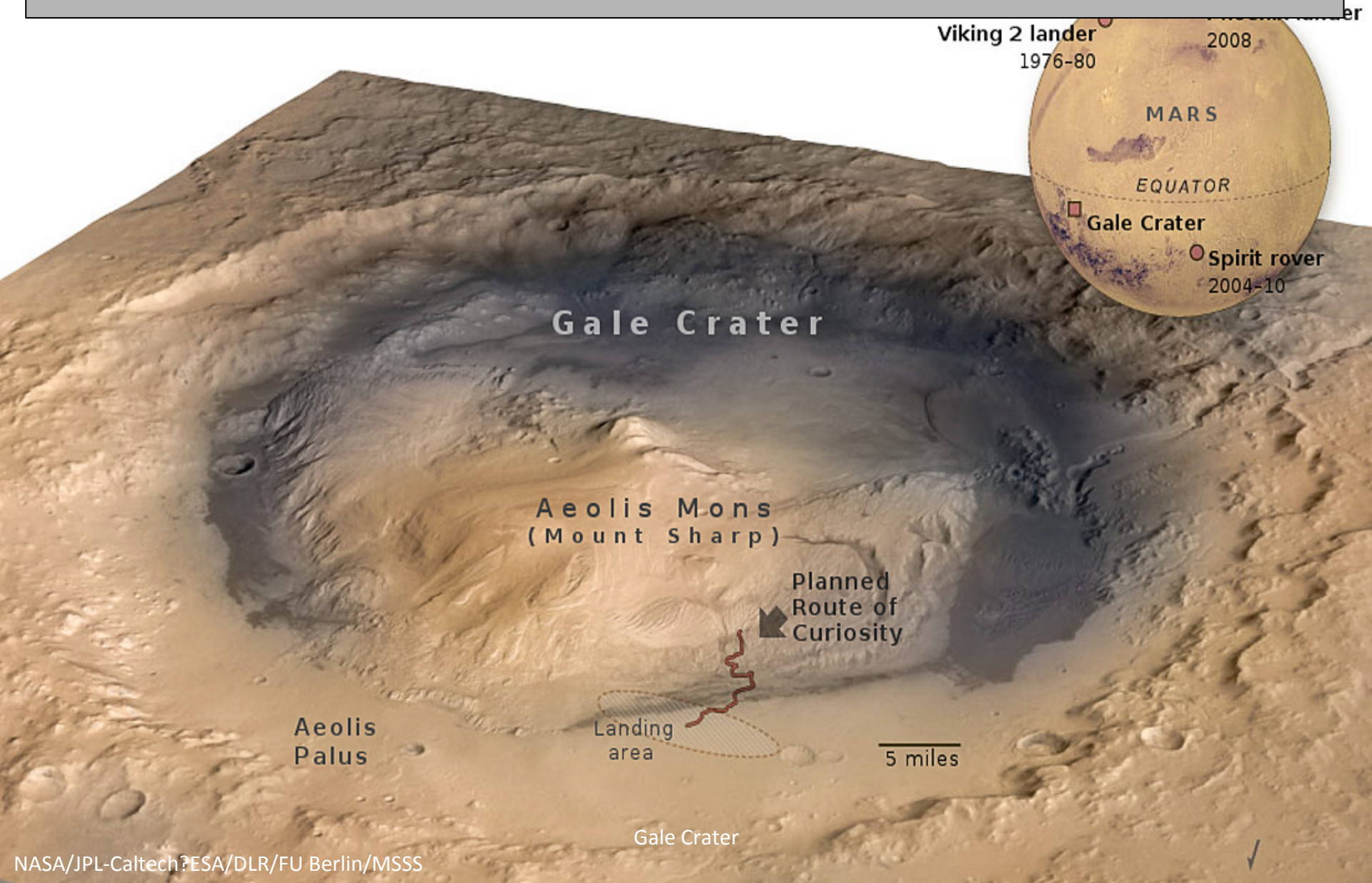
Workshop Abstract #1040

S. Montaño, S. Johnstone, N. Lanza, D. DeLapp
Los Alamos National Laboratory



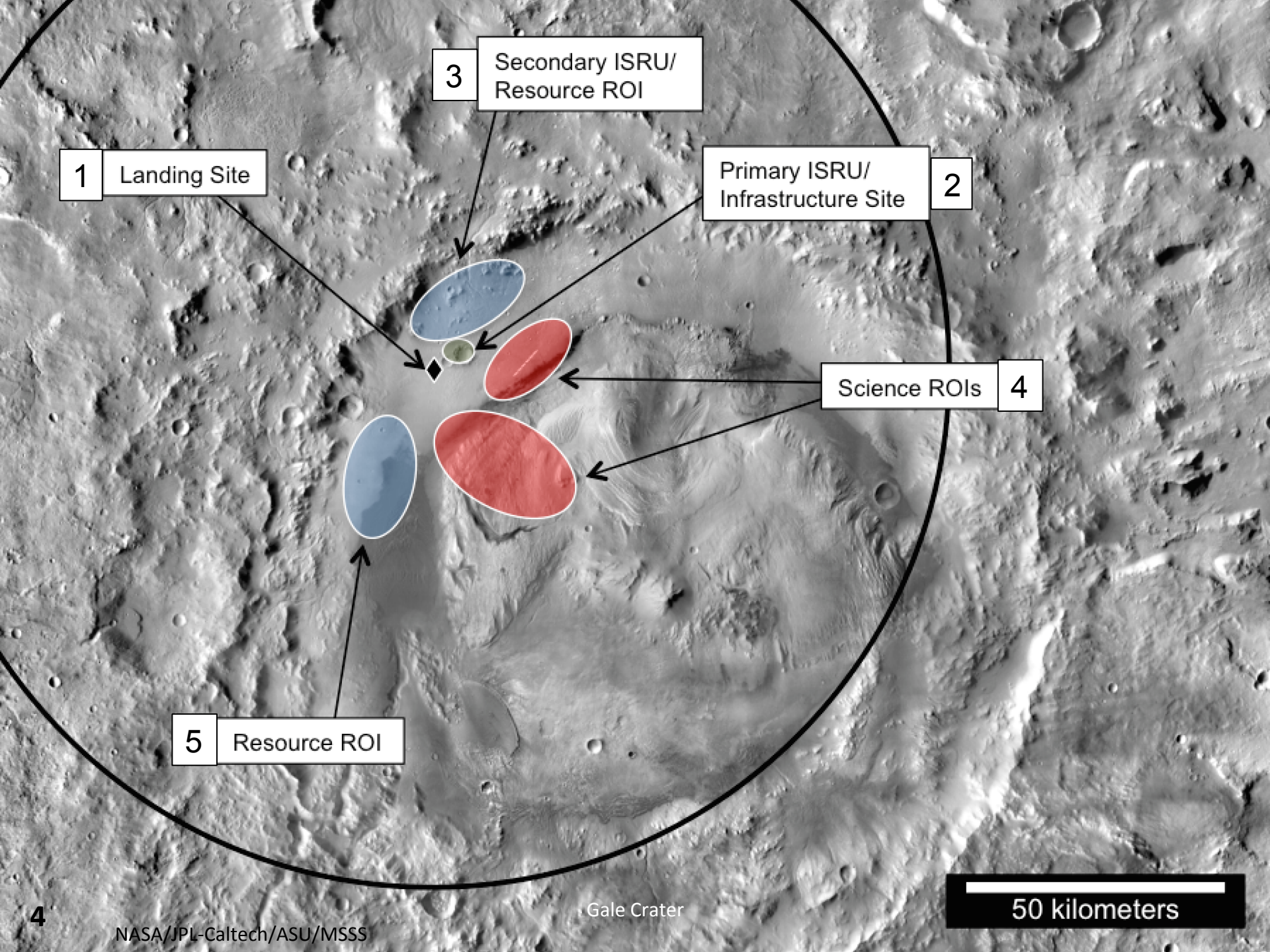
NASA/JPL-Caltech/MSSS

- 137.8°E, 5.4°S
- LS ~4 m below datum
- Crater formed ~ 3.5 Ga
- Ancient lake

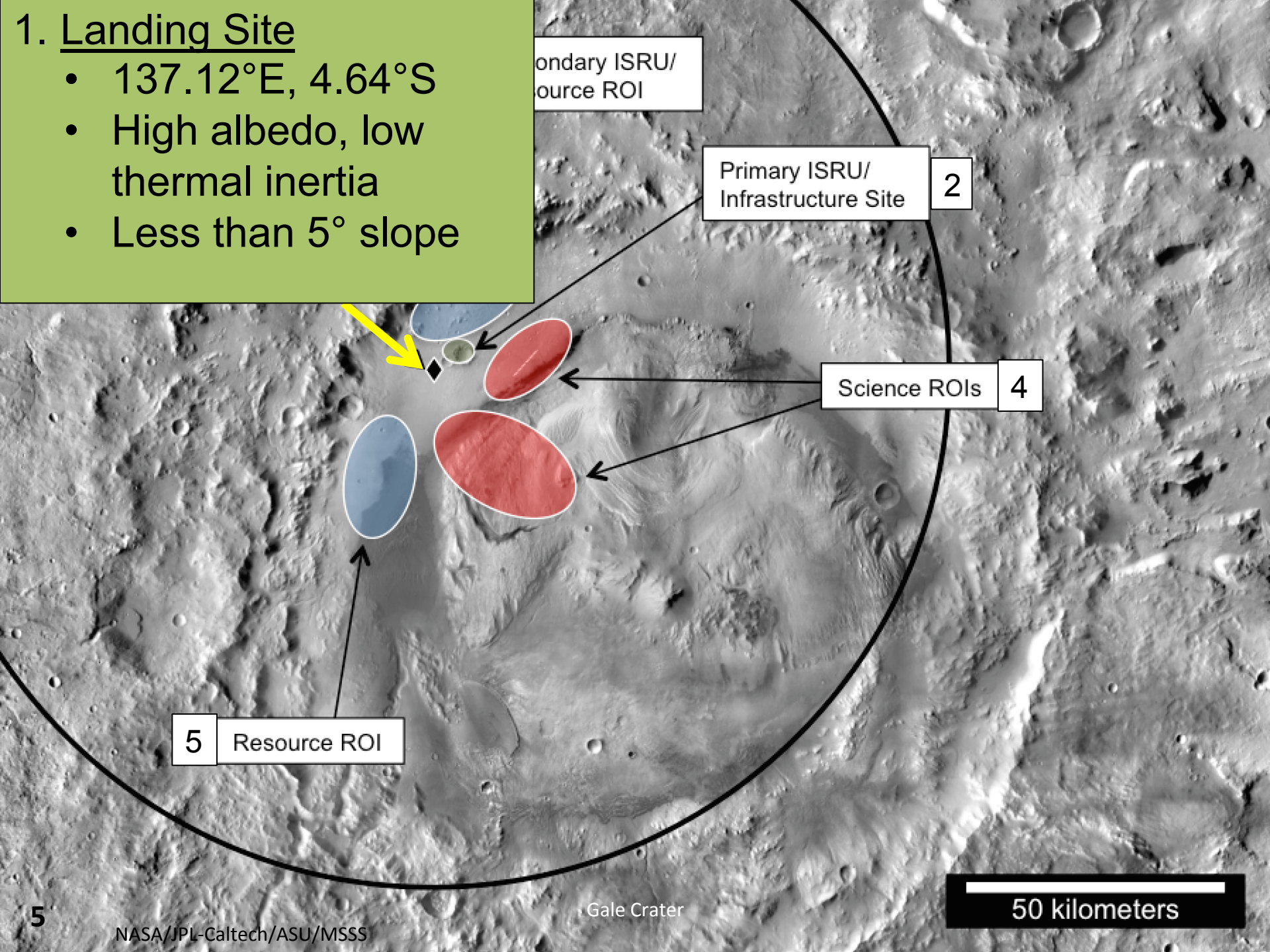


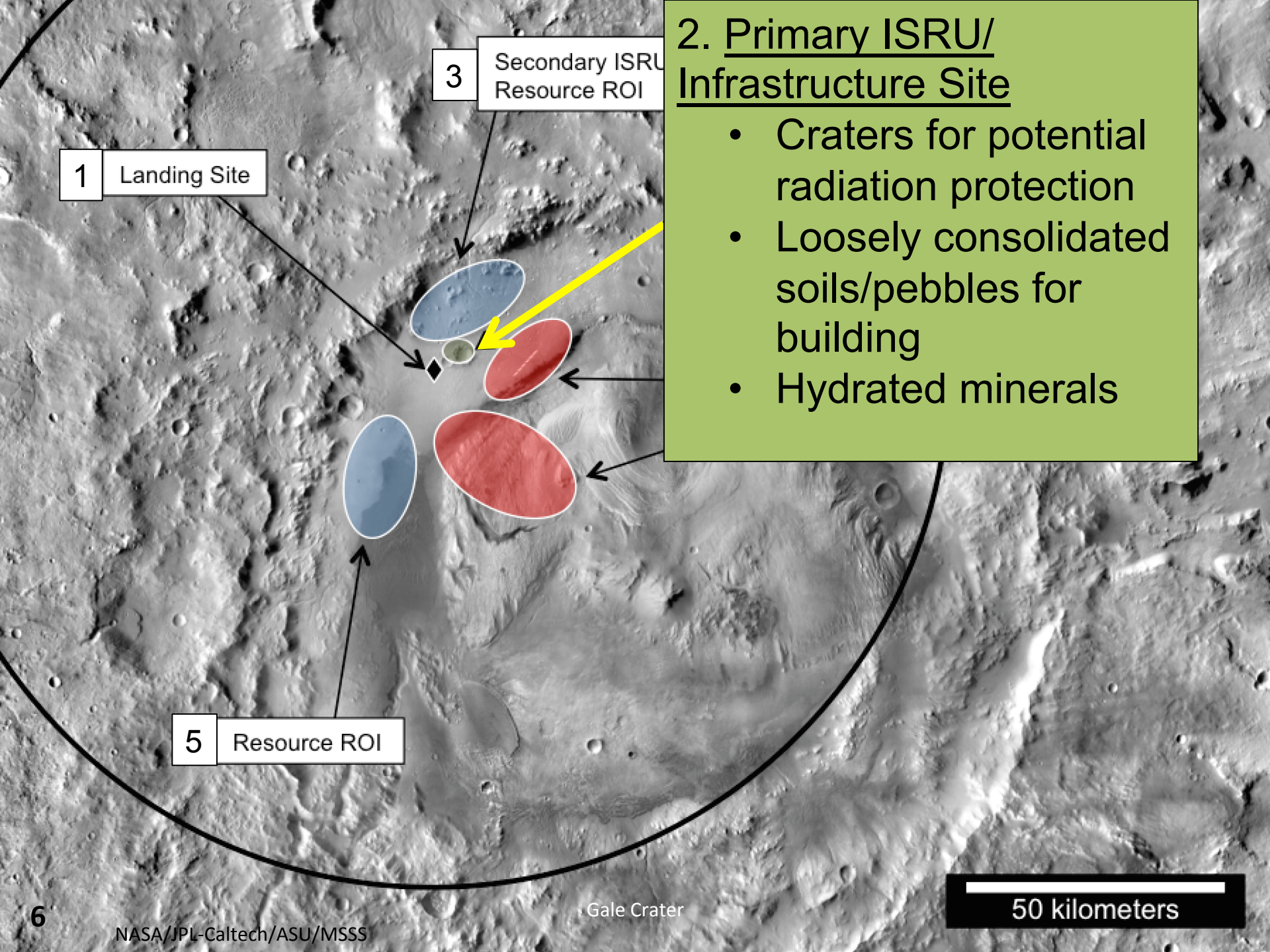
If humans landed at Gale crater tomorrow, how would they fare?

The Martian, 20th Century Fox



NASA/JPL-Caltech/ASU/MSSS


1. Landing Site
• 137.12°E, 4.64°S
• High albedo, low thermal inertia
• Less than 5° slope
ondary ISRU/
ource ROI
Primary ISRU/
Infrastructure Site
2
Science ROIs
4
5
Resource ROI
Gale Crater
50 kilometers
NASA/JPL-Caltech/ASU/MSSS

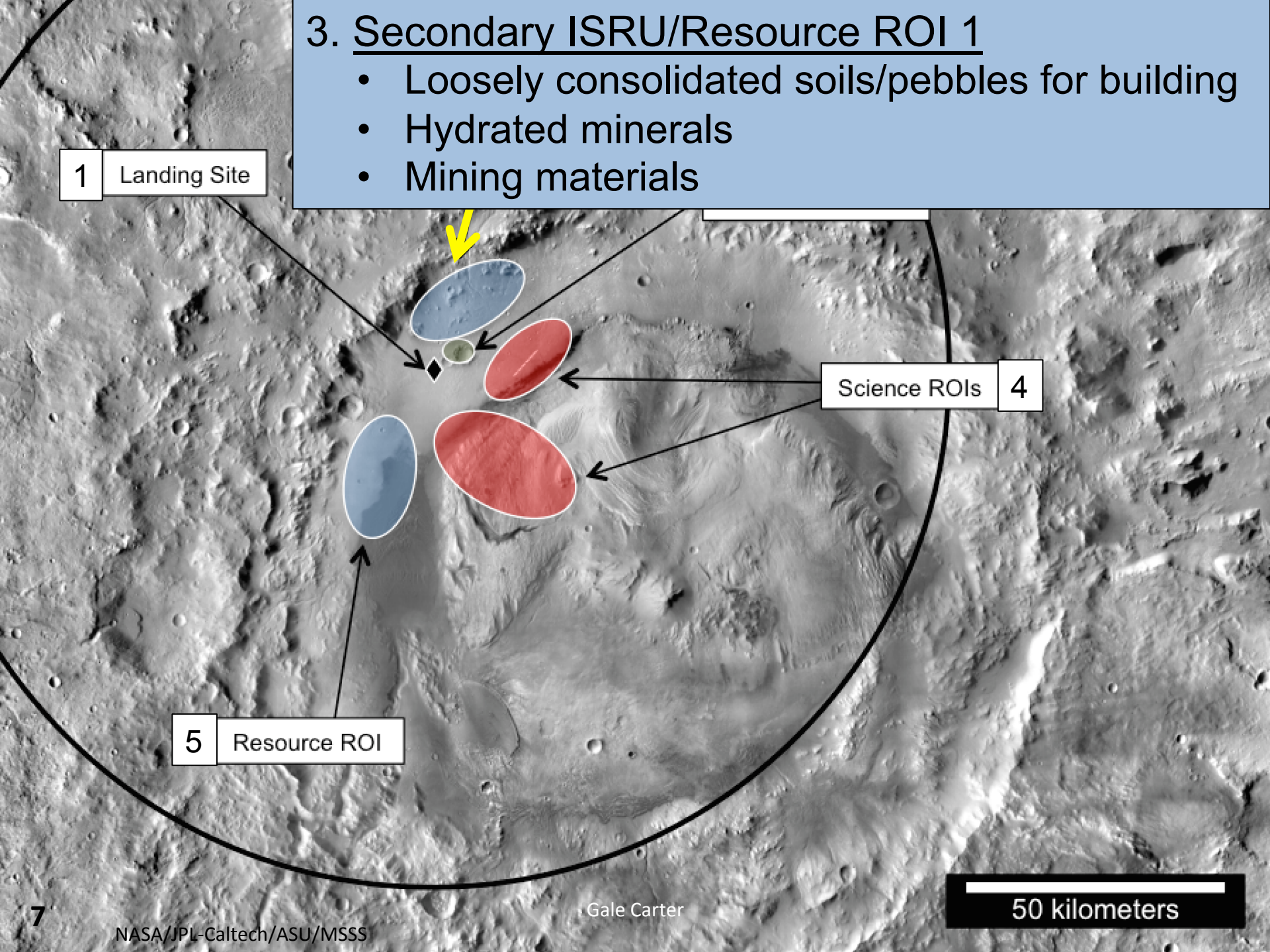


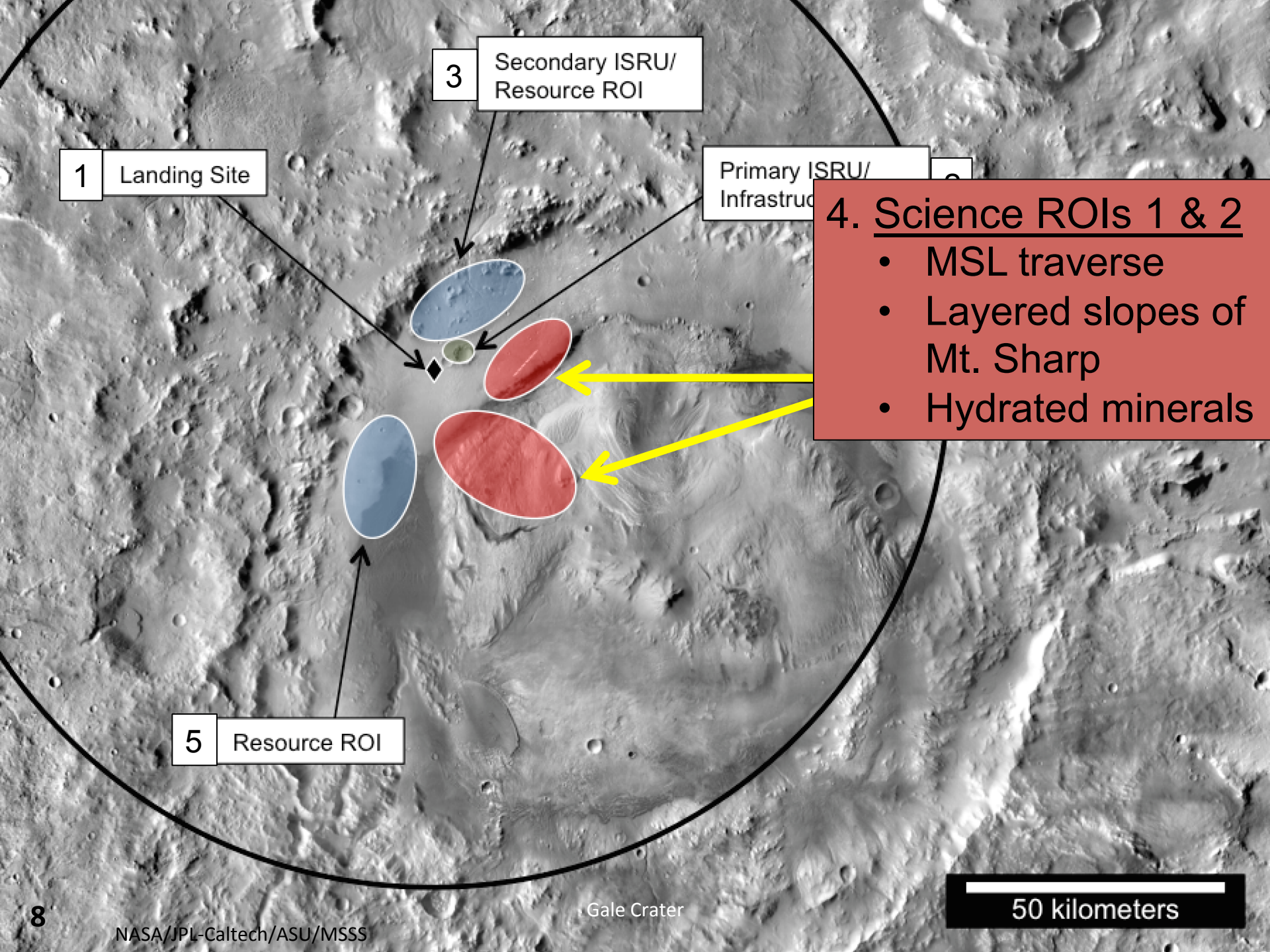
2. Primary ISRU/ Infrastructure Site

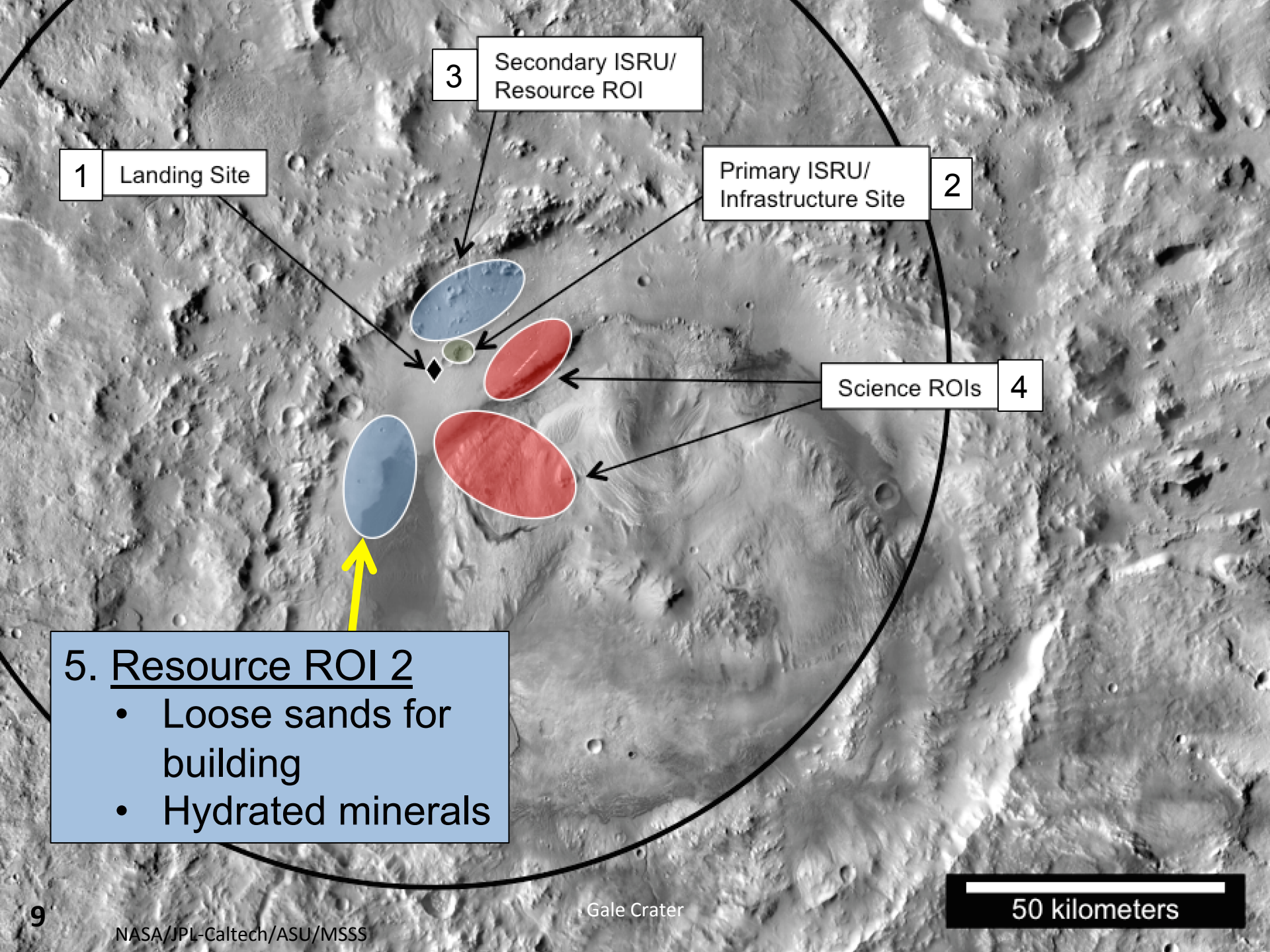
- Craters for potential radiation protection
- Loosely consolidated soils/pebbles for building
- Hydrated minerals

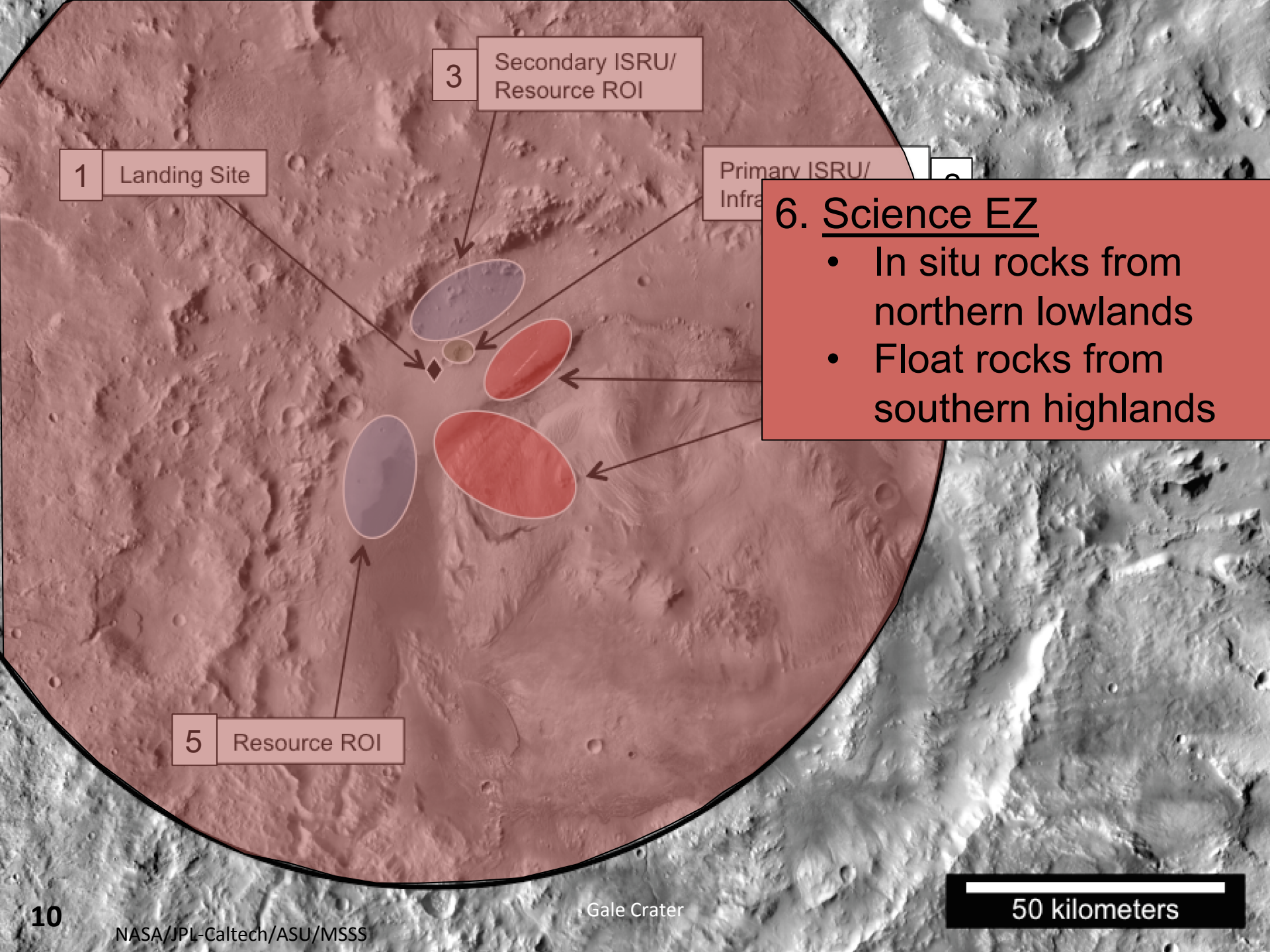
3. Secondary ISRU/Resource ROI 1

- Loosely consolidated soils/pebbles for building
- Hydrated minerals
- Mining materials






3
Secondary ISRU/
Resource ROI
1
Landing Site
Primary ISRU/
Infrastructure Site
2
Science ROIs
4
5. Resource ROI 2
• Loose sands for building
• Hydrated minerals
Gale Crater
50 kilometers
NASA/JPL-Caltech/ASU/MSSS



6. Science EZ
   - In situ rocks from northern lowlands
   - Float rocks from southern highlands

Science ROIs Rubric

Science Site Criteria				Site Factors	SROI1	SROI2	RROI1	RROI2	EZ SUM
	Astrobio	**Threshold**	AND/OR	**Potential for past habitability**	●	●	●	●	**4**
				Potential for present habitability/refugia					
		Qualifying		Potential for organic matter, w/ surface exposure	●	○	○	○	
	Atmospheric Science	**Threshold**		**Noachian/Hesperian rocks w/ trapped atmospheric gases**	●	●	●	●	**4**
		Qualifying		Meteorological diversity in space and time	●	●	○	○	**2,2**
				High likelihood of surface-atmosphere exchange	●	○	○	○	**1,3**
				Amazonian subsurface or high-latitude ice or sediment					
				High likelihood of active trace gas sources	●	○	○	○	**1,3**
	Geoscience	**Threshold**		**Range of martian geologic time; datable surfaces**	●	●	●	●	**4**
				Evidence of aqueous processes	●	●	●	○	**3,1**
				Potential for interpreting relative ages	●	●	○	○	**2,2**
		Qualifying		Igneous Rocks tied to 1+ provinces or different times	●	○	●	○	**2,2**
				Near-surface ice, glacial or permafrost					
				Noachian or pre-Noachian bedrock units					
				Outcrops with remnant magnetization	●	●	○	○	**2,2**
				Primary, secondary, and basin-forming impact deposits	●	○	○	○	**1,3**
				Structural features with regional or global context	●	○	○	○	**1,3**
				Diversity of aeolian sediments and/or landforms	●	●	○	○	**2,2**

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

Resource ROI(s) Rubric

ISRU and Civil Engineering Criteria			Site Factors	SROI1	SROI2	RROI1	RROI2	EZ SUM
	Engineering		Meets First Order Criteria (Latitude, Elevation, Thermal Inertia)					
	Water Resource	Threshold	**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	●	●	●	●	
			Accessible by automated systems	●	○	●	●	3,1
		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	●	●	●	○	3,1
	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	●	●	●	●	4
			Evidence of abundant cobble sized or smaller rocks and bulk, loose regolith	●	○	●	●	3,1
			Utilitarian terrain features	●		●		2
	Food Production	Qualifying	Low latitude	●	●	●	●	4
			No local terrain feature(s) that could shadow light collection facilities	●		●	●	3
			Access to water	●	●	●	●	4
			Access to dark, minimally altered basaltic sands	●	○		●	2,1
	Metal/Silicon Resource	Threshold	**Potential for metal/silicon**	●	●	●	●	4
			Potential to be minable by highly automated systems	○	○	○	○	0,4
			Located less than 3 km from processing equipment site			●		1
			Located no more than 3 meters below the surface	●	●	●	●	4
			Accessible by automated systems	●	○	●	●	3,1
		Qualifying	Potential for multiple sources of metals/silicon					
			Distance to resource location can be >5 km	●	●		●	3
			Route to resource location must be (plausibly) traversable	●	●	●	○	3,1

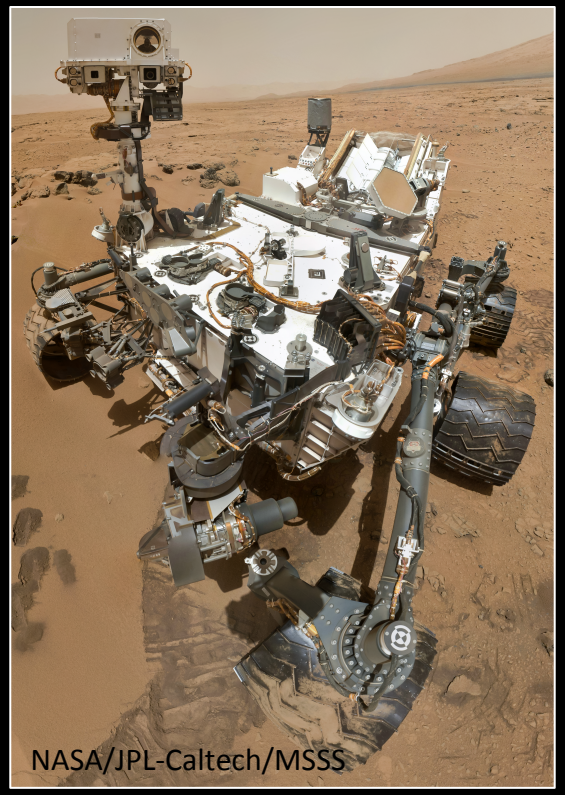
Key	
●	**Yes**
○	**Partial Support or Debated**
	No
?	**Indeterminate**

Objectives

- Survive
- Confirm MSL discoveries of habitability
- Search for life while avoiding contamination
- Complete thorough classification of region

Tools

- Rover
- Building materials
- MSL experience, data set



Gale Crater

Advantages - Science

- Traversable surface
- Regional-scale outcrops
- Stratigraphic materials
- Accessible highlands & lowlands materials
- Accessible impacts
- Collection of analyzed rocks & soils to further investigate

Curiosity - Sol 490
Credit: NASA/JPL-Caltech/MSSS/Marco Di Lorenzo/Ken Kremer

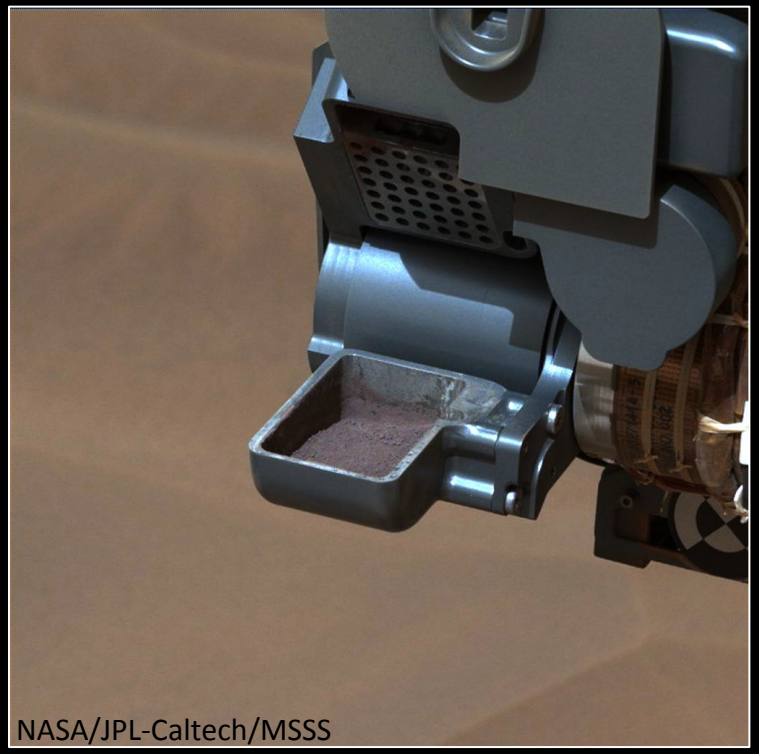
Gale Crater

Advantages - ISRU

- Loose materials for building
- Cratered areas for radiation shielding
- Hydrated minerals as a water source
- High Fe, Al, & Si for mining

NASA/JPL-Caltech/MSSS

Gale Crater



NASA/JPL-Caltech/MSSS

Disadvantages - ISRU

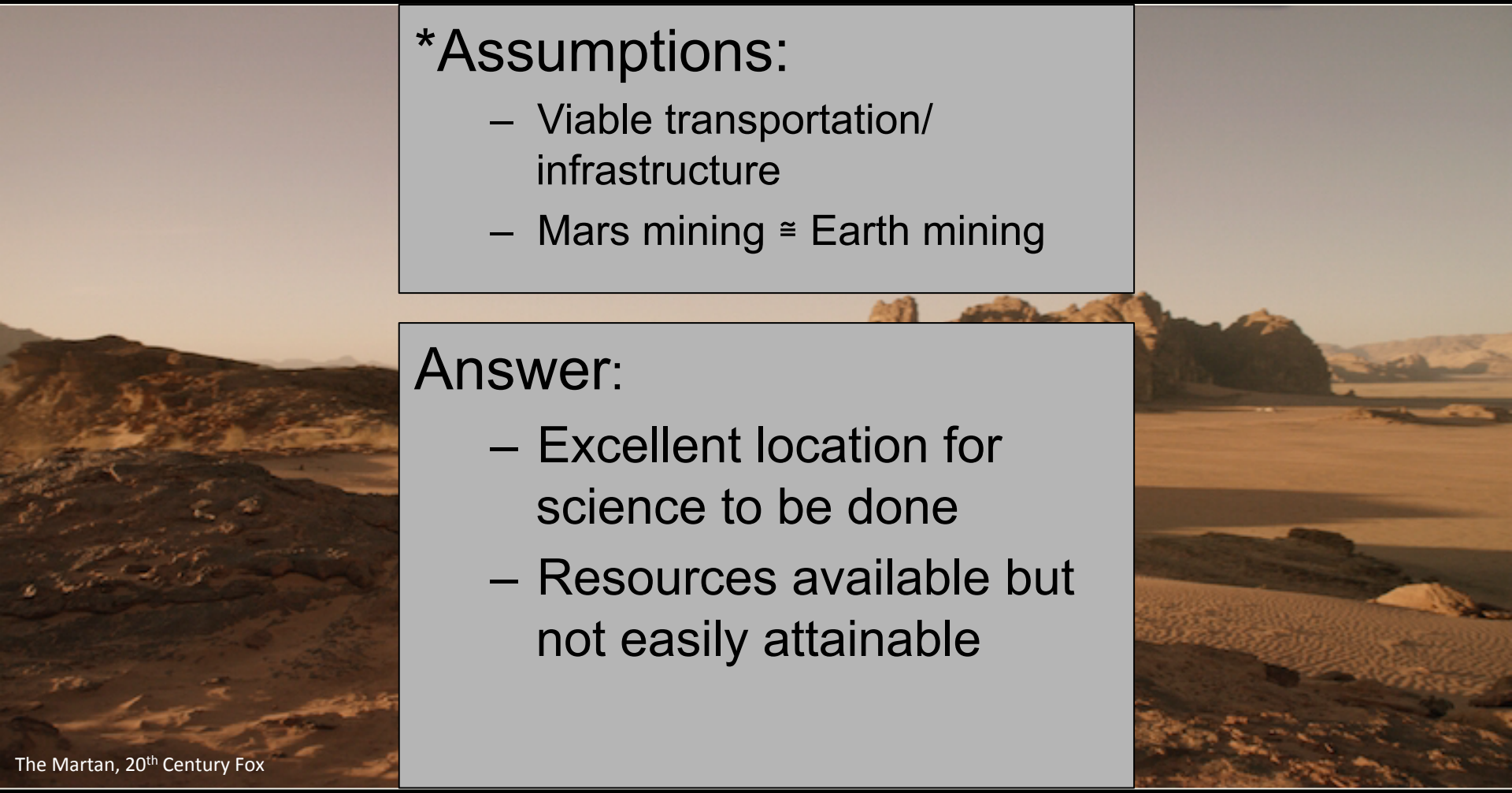
- No clear evidence of subsurface water ice
- Not enough Fe, Al for terrestrial mining standards
- No evidence of subsurface structures to be used as underground shelter

Disadvantages - Science

- No access to Amazonian water ice
- No clear evidence of hydrothermal/volcanic processes

Gale Crater

If humans landed at Gale crater tomorrow, how would they fare?*



*Assumptions:

- Viable transportation/ infrastructure
- Mars mining ≅ Earth mining

Answer:

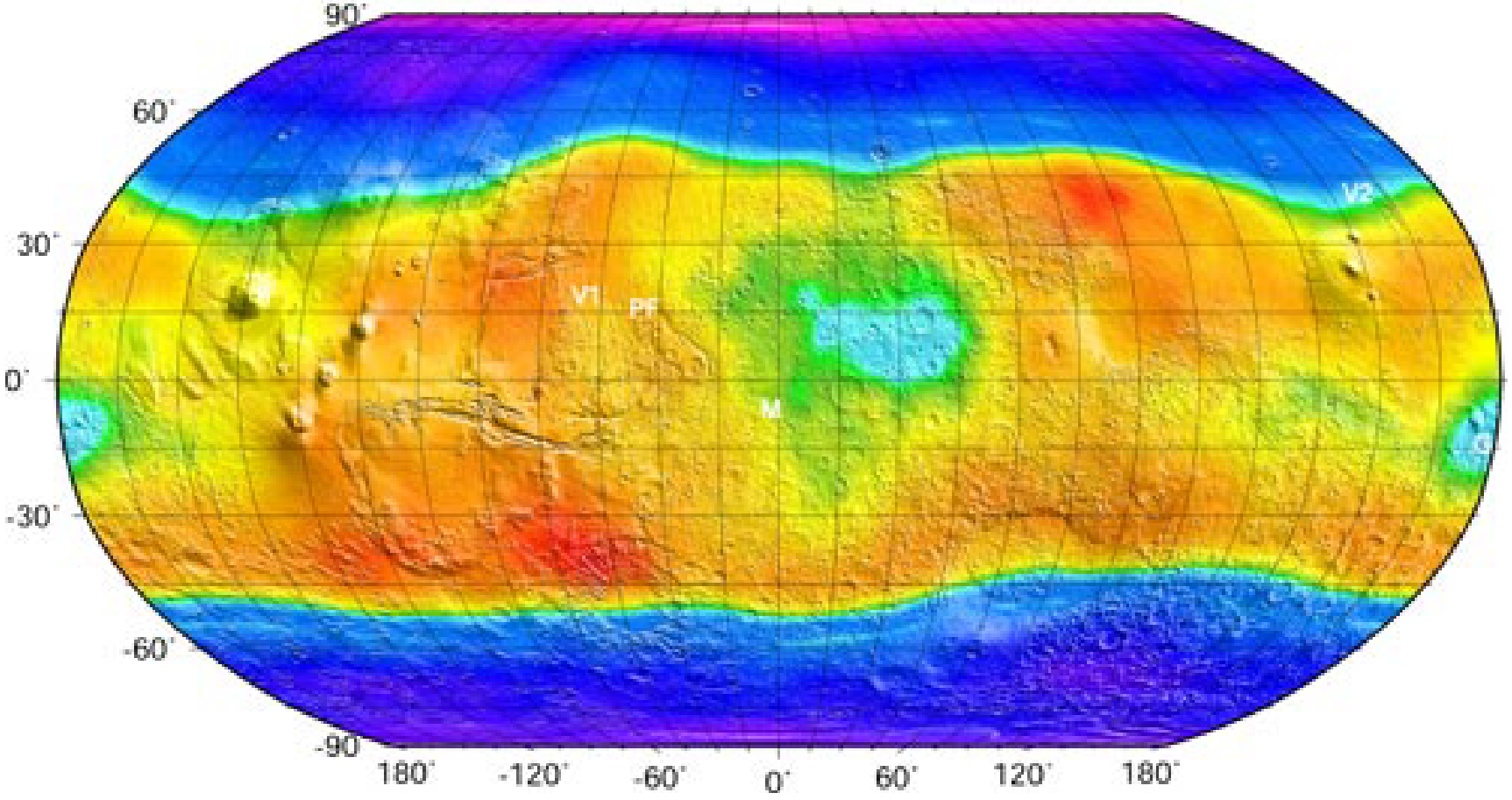
- Excellent location for science to be done
- Resources available but not easily attainable

The Martan, 20th Century Fox

WATER MAP

2001 Mars Odyssey Gamma Ray Spectrometer

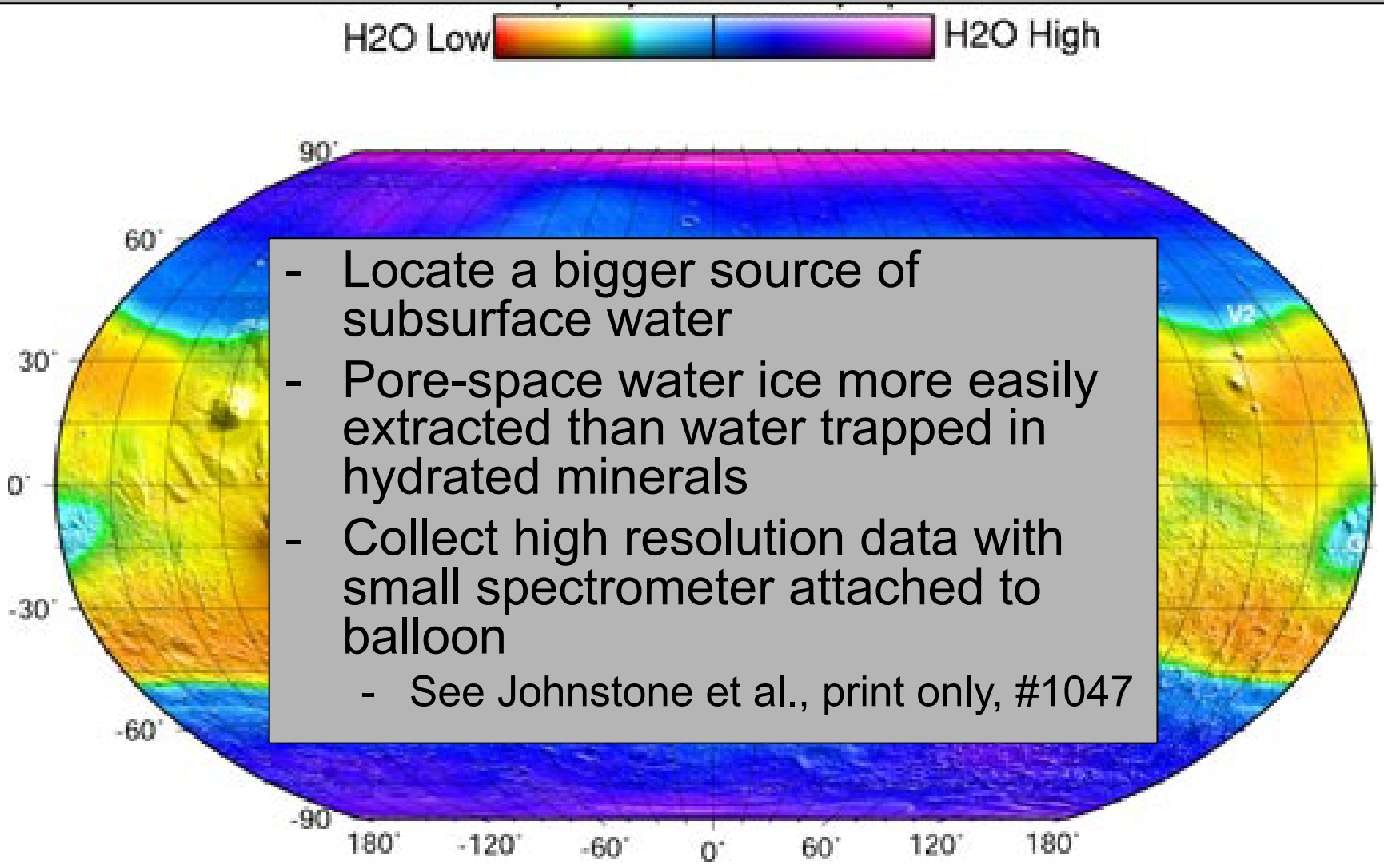
H2O Low — H2O High



NASA/JPL/UA

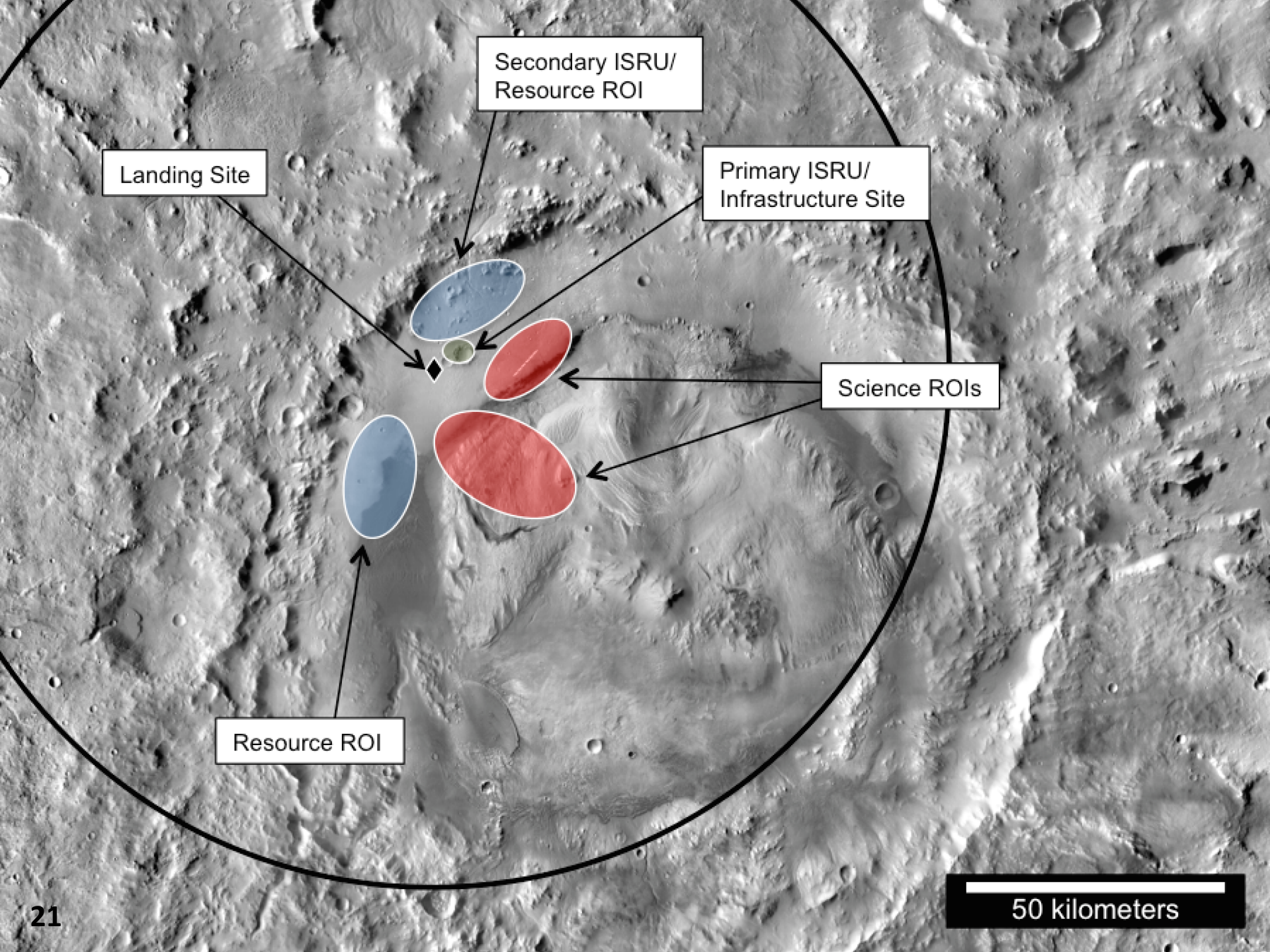
Gale Crater

Most important data set to collect: Neutron spectrometry at high resolution



- Locate a bigger source of subsurface water
- Pore-space water ice more easily extracted than water trapped in hydrated minerals
- Collect high resolution data with small spectrometer attached to balloon
  - See Johnstone et al., print only, #1047

Back Up


Secondary ISRU/
Resource ROI
Landing Site
Primary ISRU/
Infrastructure Site
Science ROIs
Resource ROI
50 kilometers

Tools

- Rover
- Building materials
- MSL experience and data set

Curiosity - Sol 490
Credit: NASA/JPL-Caltech/MSSS/Marco Di Lorenzo/Ken Kremer