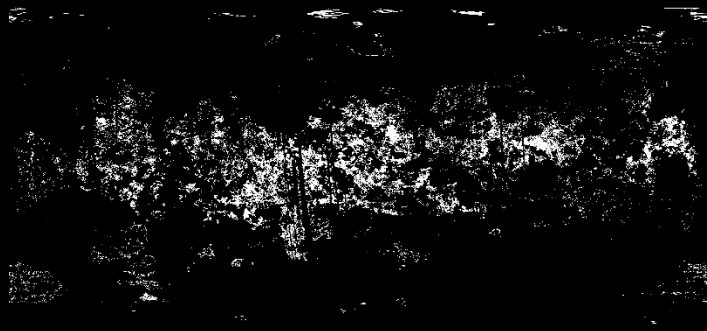


Jet Propulsion Laboratory
California Institute of Technology

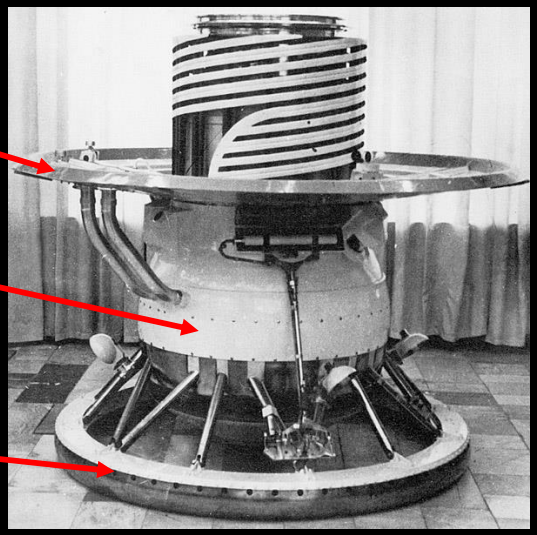
Global Characterization of Safe Landing Sites on Venus Using Venera Panoramas and Magellan Radar Properties

Jason Rabinovitch and Katie M. Stack
Jet Propulsion Laboratory, California Institute of Technology

Venera-D Landing Sites Selection and Cloud Layer Habitability Workshop 2019
9/3/2019

“Safe” Landing Site Selection on Venus

- Previous Venera/VEGA landers have had an excellent success record for safe-landing on Venus
- How can we use existing surface panoramas in conjunction with orbital data to aid in future landing site selections?

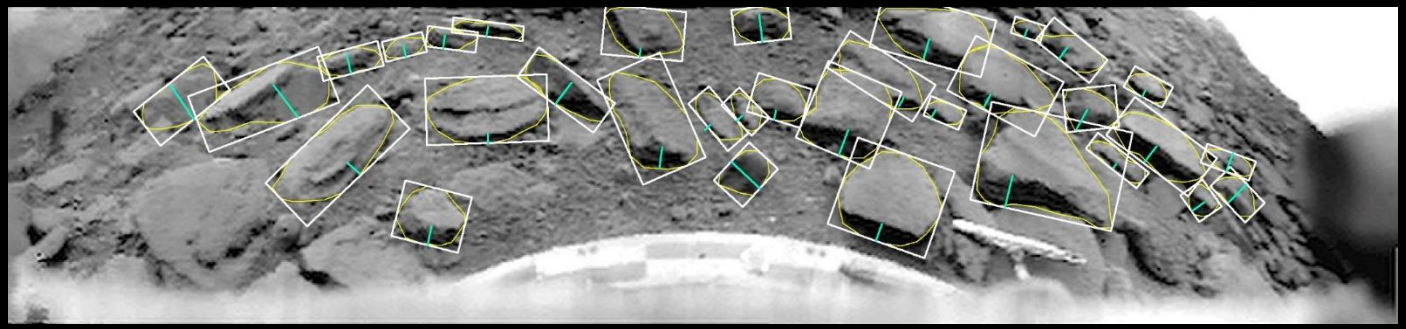


Venera 9 Descent Module

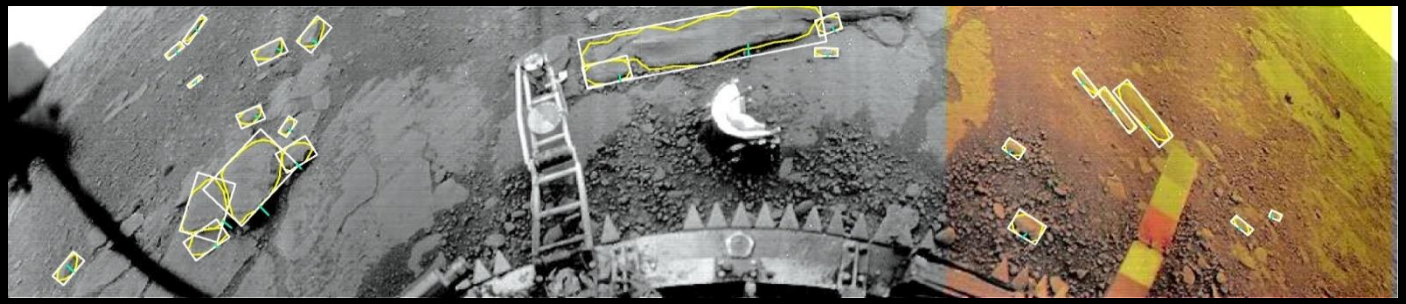
http://mentallandscape.com/V_Lavochkin2.htm

Surface Panoramas from Venera 9 and 13

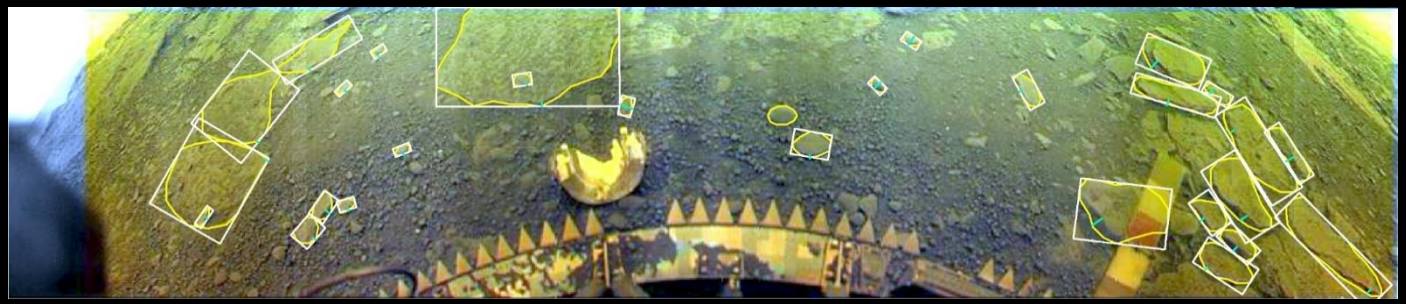
Venera 9



Venera 13



Venera 13



Stack et al., LPSC 2017

Linking Surface Data and Orbital Data

Surface panoramas and Magellan orbital radar properties

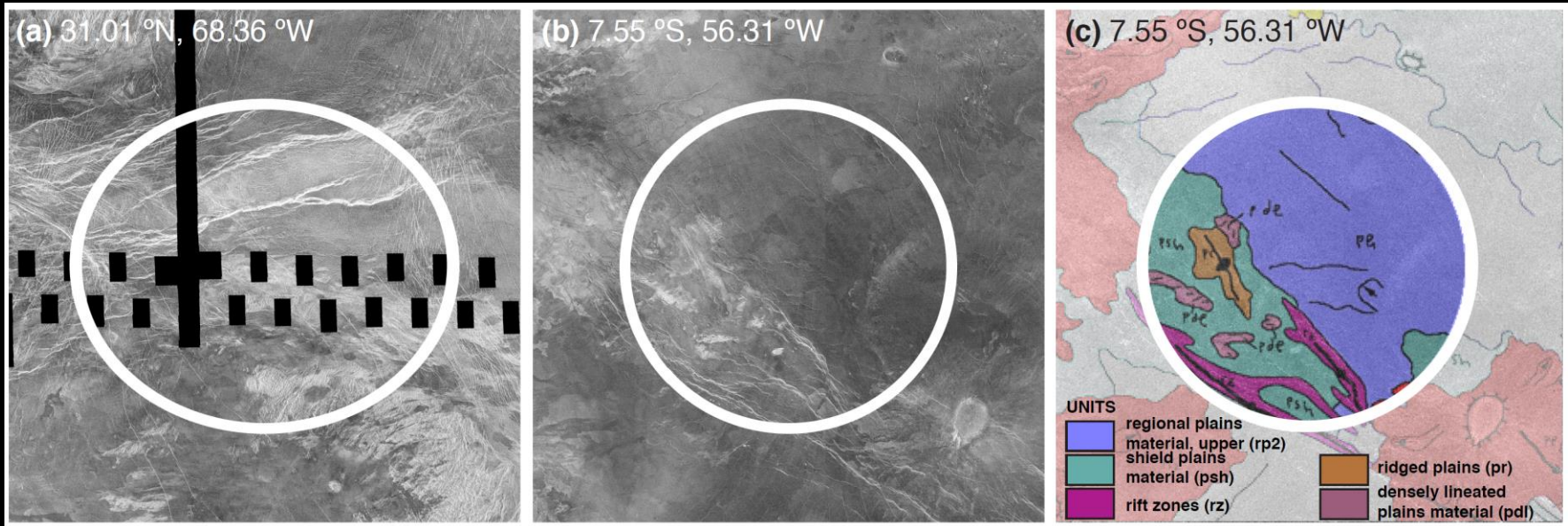


Figure 3. Contrast-stretched 75 m/pixel Magellan Synthetic Aperture Radar (SAR) images of (a) the Venera 9 landing area, (b) the Venera 13 landing area, (c) the Venera 13 landing area overlain by Ivanov and Head's (2011) global geologic map interpretation. Landing areas are 300 m in diameter (Akim and Stepanyantz, 1993).

Image processing performed by authors, digital version of geological map provided by Mikhail A. Ivanov and James W. Head

Stack et al., LPSC 2017

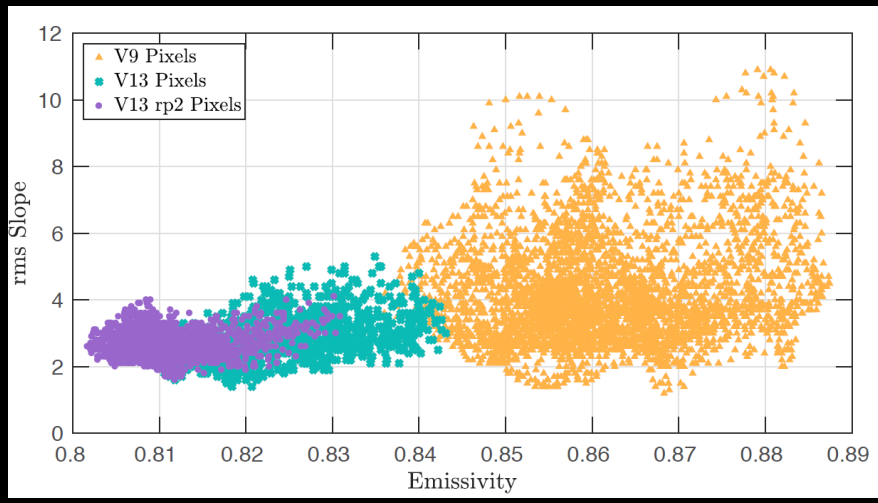
Developing a Global Filter for Landing Safety

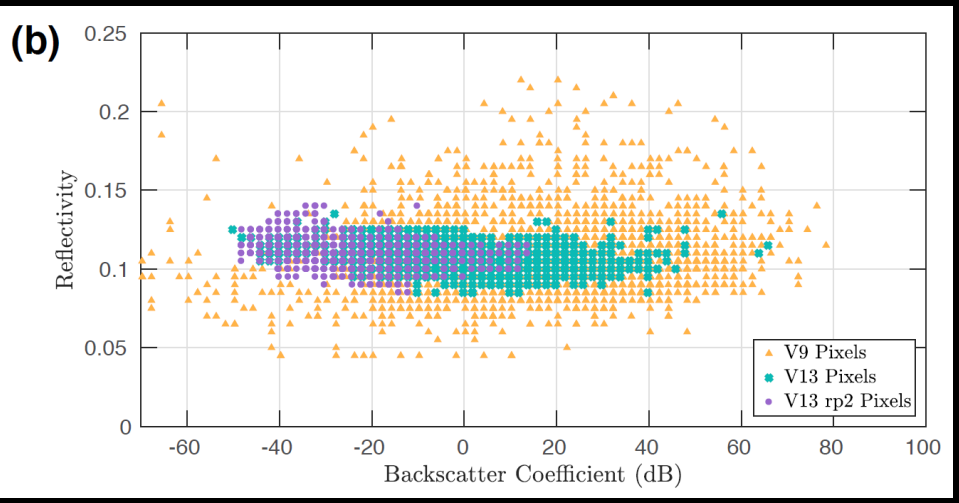
*This approach **does not** start with surface geological classifications*

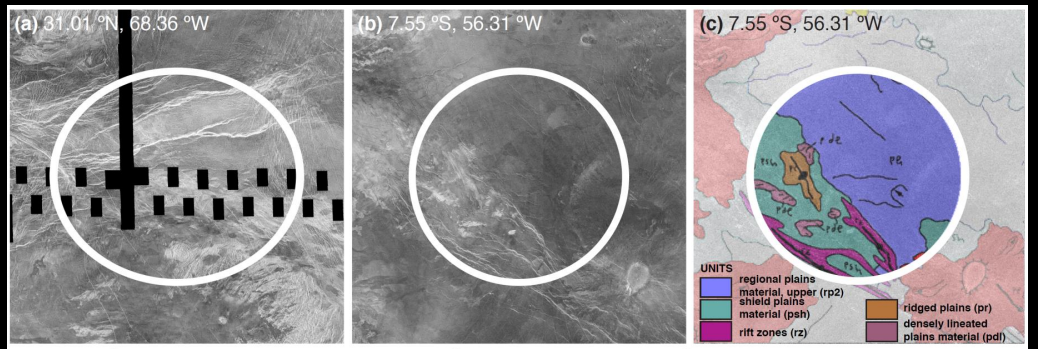
- Assume that Venera 13-like terrain is more desirable for landing safety than Venera 9-like terrain
- Most extensive, radar dark, and featureless unit within the Venera 13 landing area is Ivanov and Head's "Regional plains, upper unit" (rp2)
- Rms slope, emissivity, reflectivity, and radar backscatter values were extracted for pixels within the Venera 9 and 13 landing areas using 4641m Magellan Global Altimetry and Radiometry Records
- **Safe landing sites are then defined to be:**
  - **At least 95% of pixels within a 150 km diameter ellipse exhibit radar properties (reflectivity and emissivity) within the Venera 13 rp2 bounds, and meter-scale slopes <5º**
  - **Ellipses can be further filtered based on a quantitative assessment of SAR radar backscatter.**

Linking Surface Data and Orbital Data

Surface panoramas and Magellan orbital radar properties







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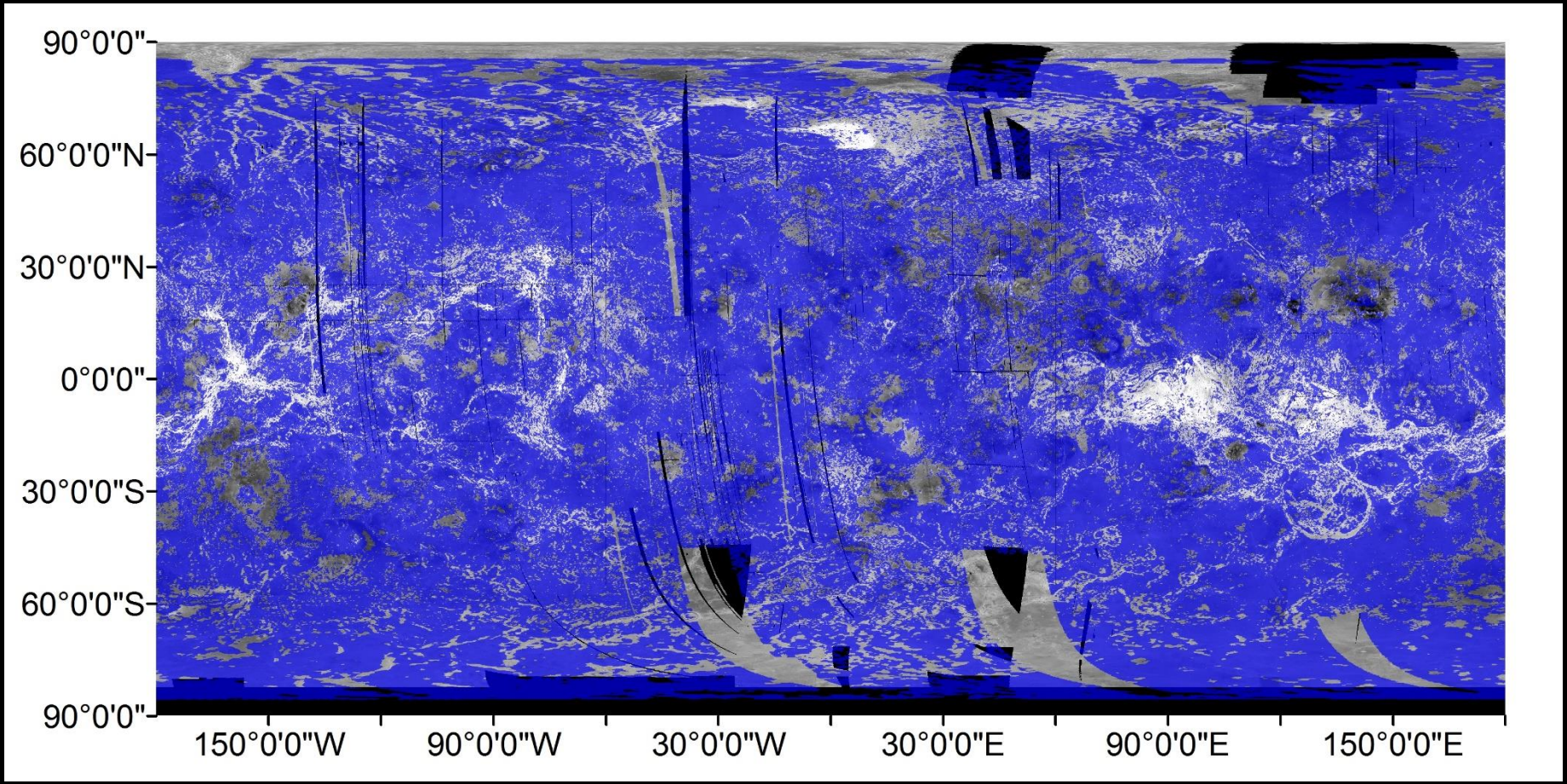
Stack et al., LPSC 2017

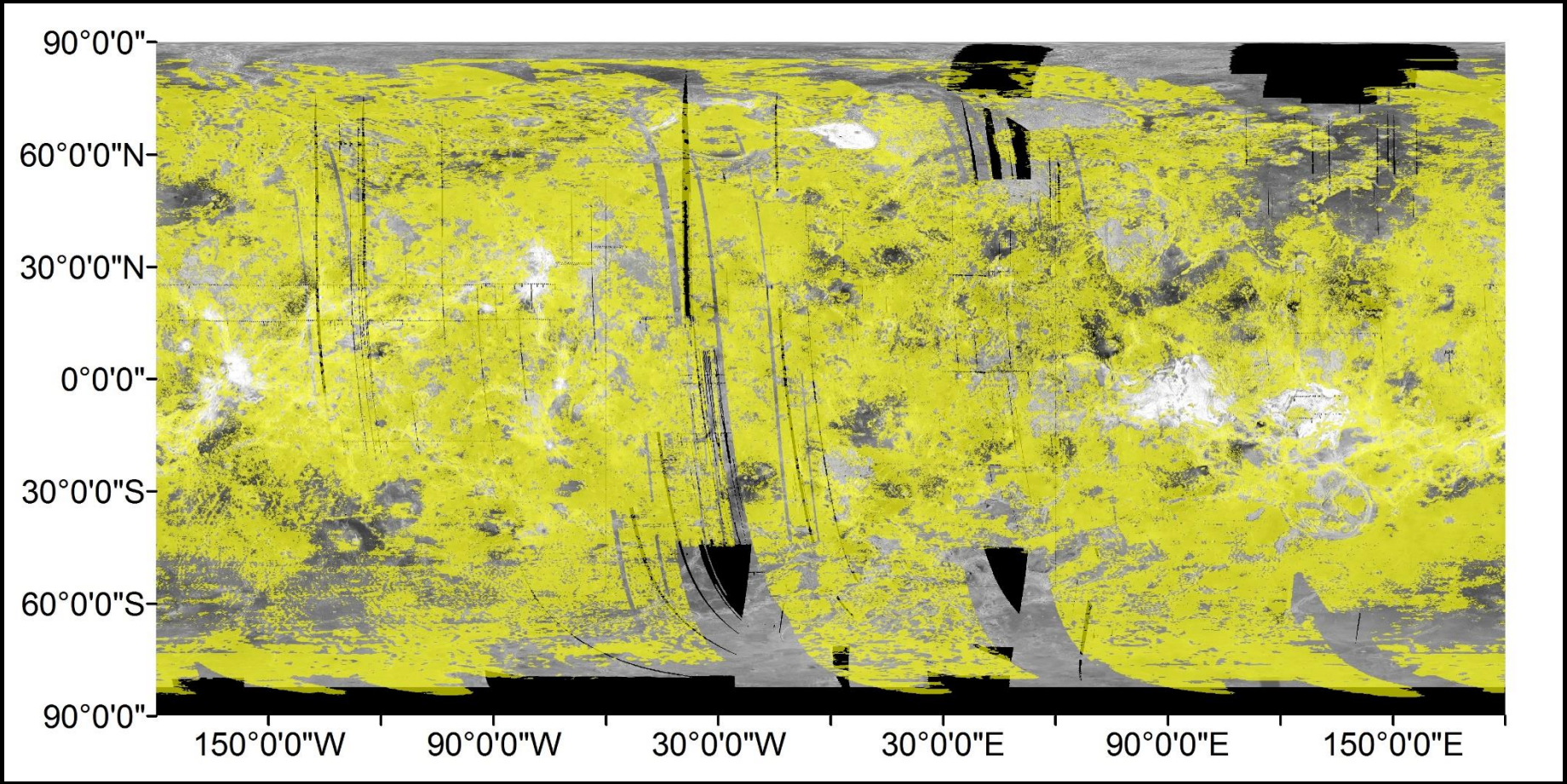
Filter surface by Venera 13 rp2 Radar Data

Rms slope <5º



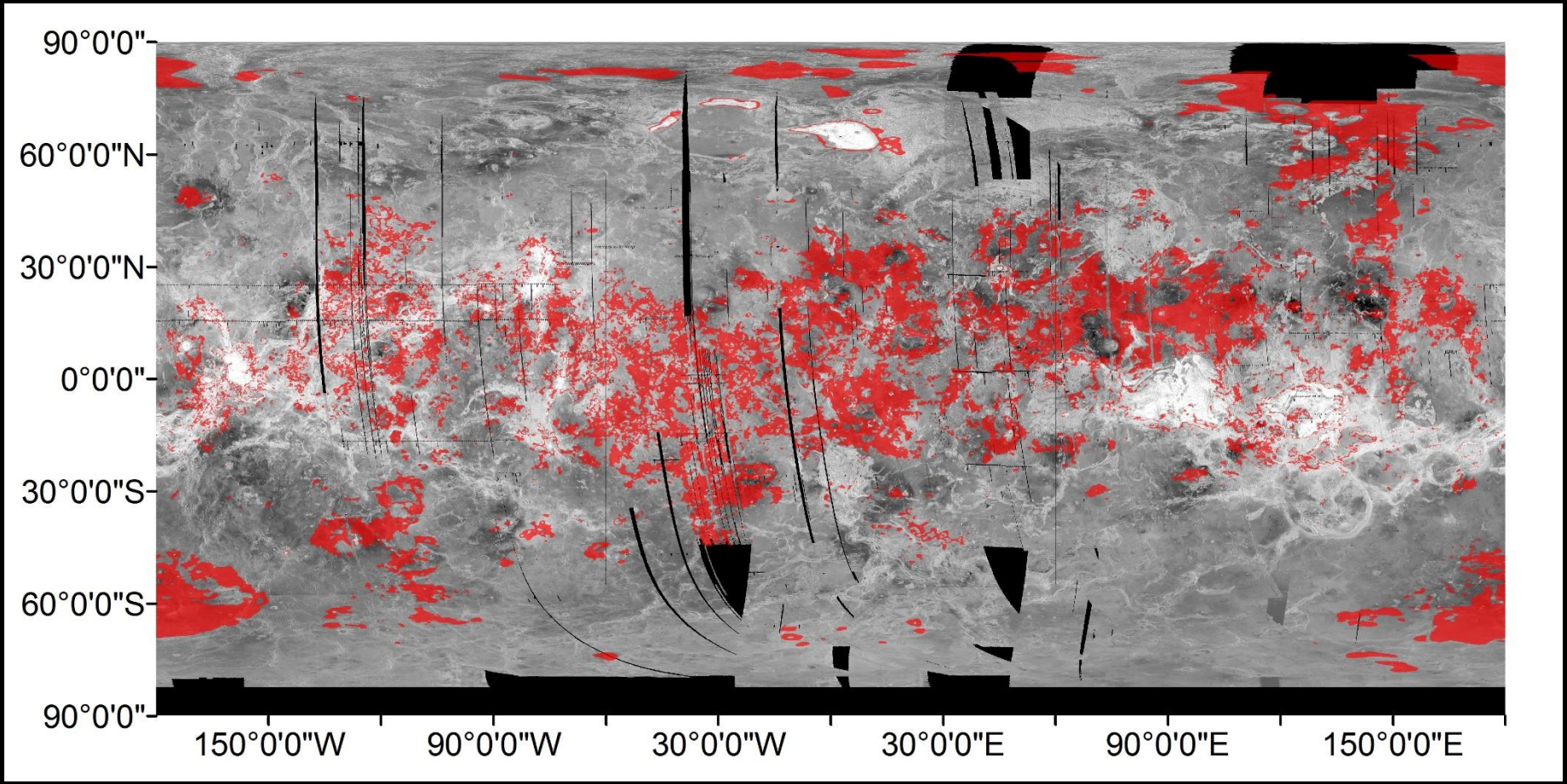
Filter surface by Venera 13 rp2 Radar Data

Reflectivity



Filter surface by Venera 13 rp2 Radar Data

Emissivity



Candidate Landing Sites (150 km diameter)

SAR down-select performed qualitatively

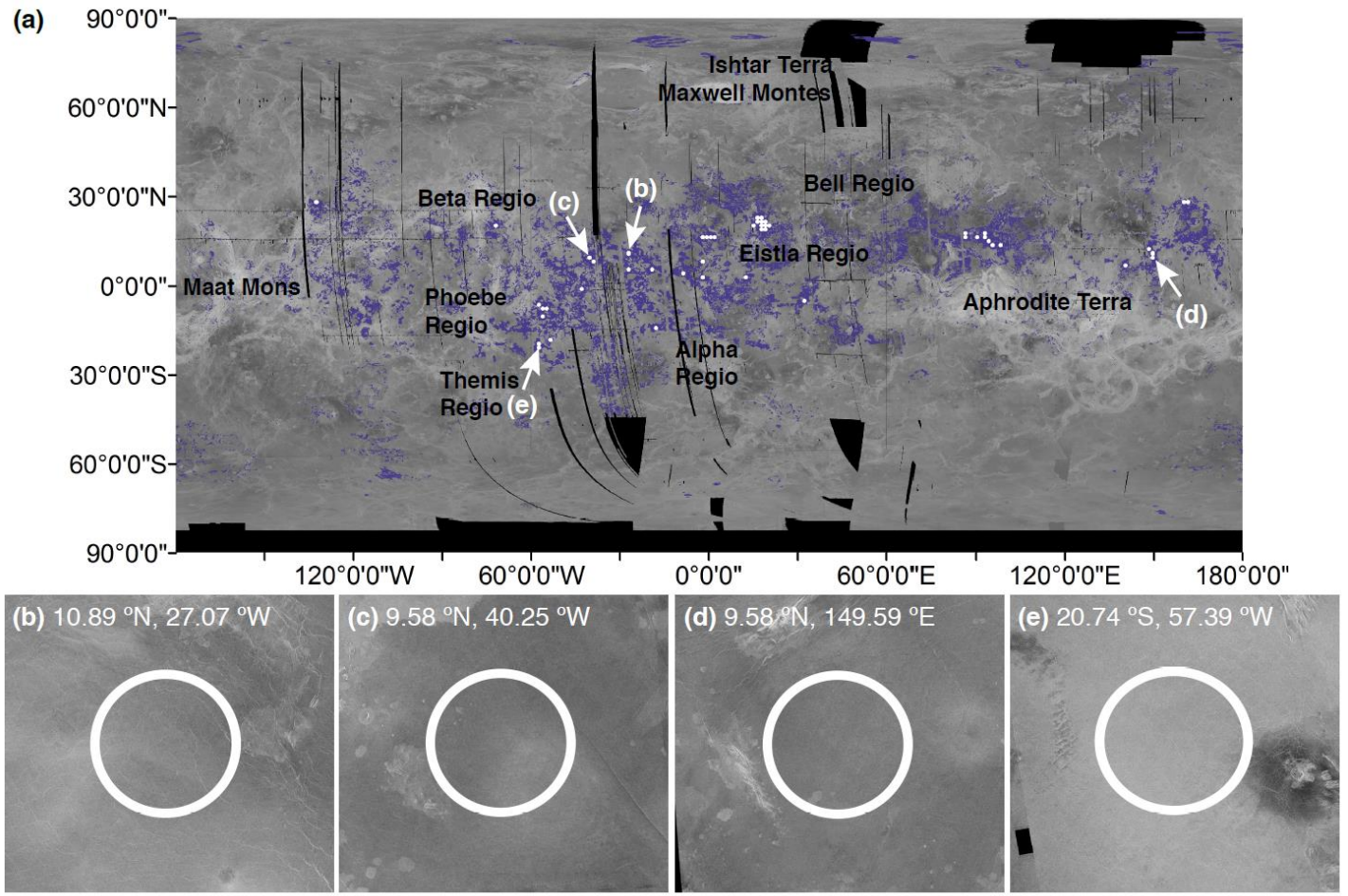


Figure 6. (a) Cylindrically projected Magellan SAR basemap highlighting in purple the ~8% of the Venus surface whose rms slope, emissivity, and reflectivity values fall within the range observed for the Venera 13 rp2 unit and exhibit meter scale slopes < 5º. 150 km ellipses are shown in white. (b)-(e) Sample 150 km diameter candidate landing ellipses (outlined in white) identified through visual inspection of contrast-stretched 75 m/pixel SAR images.

Candidate Landing Sites with SAR (150 km)

Focuses on more “radar dark” areas

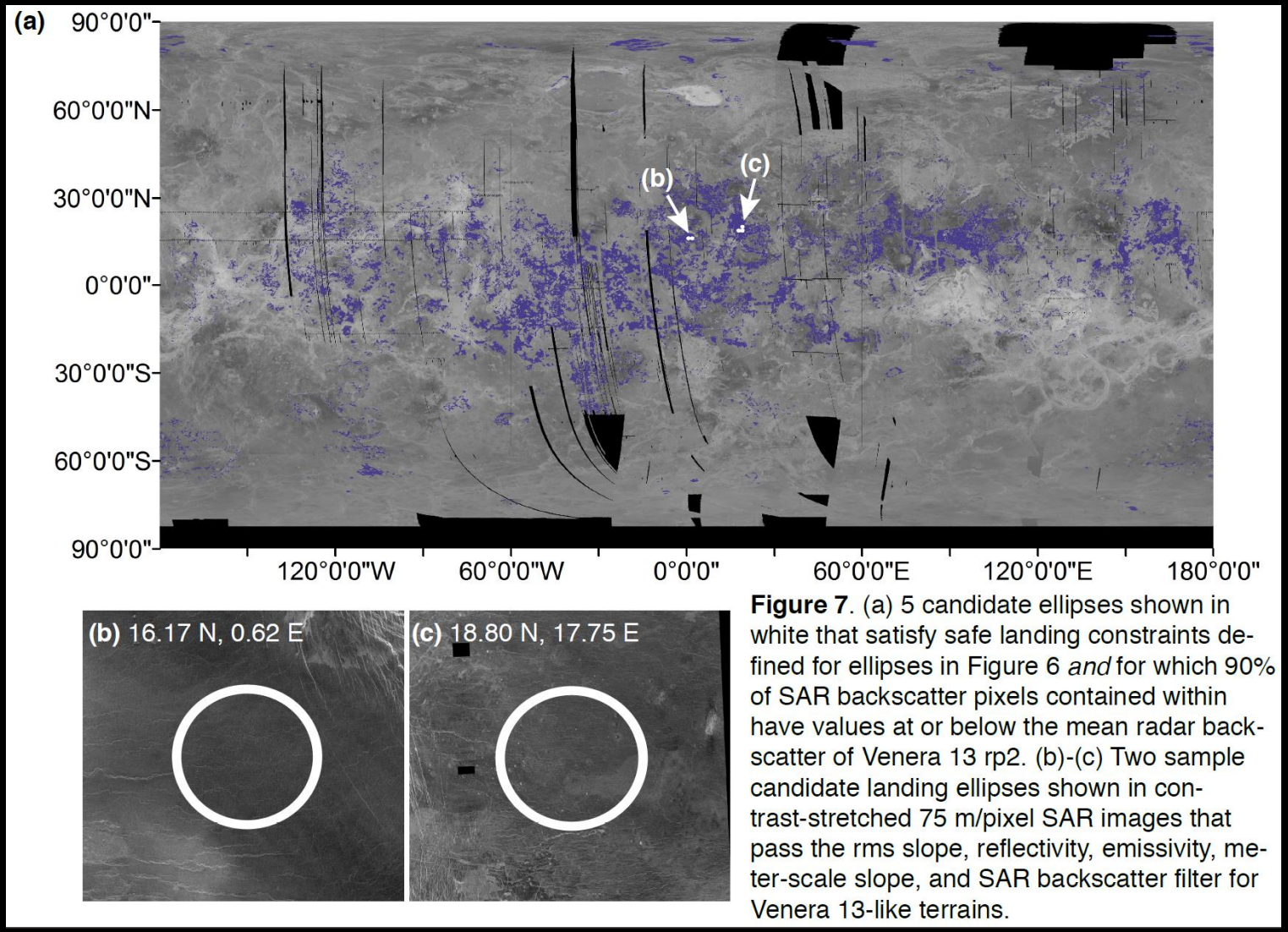
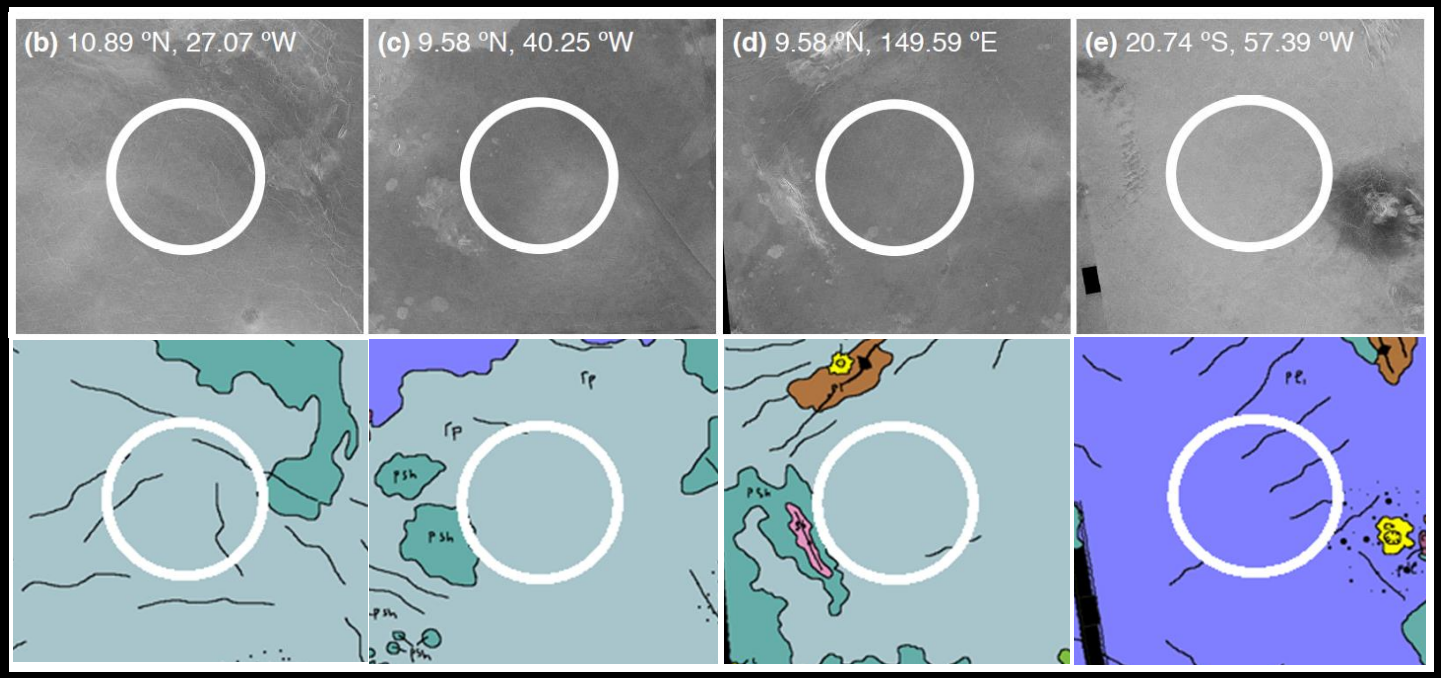


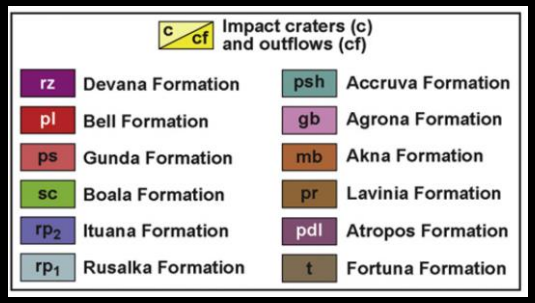
Figure 7. (a) 5 candidate ellipses shown in white that satisfy safe landing constraints defined for ellipses in Figure 6 *and* for which 90% of SAR backscatter pixels contained within have values at or below the mean radar backscatter of Venera 13 rp2. (b)-(c) Two sample candidate landing ellipses shown in contrast-stretched 75 m/pixel SAR images that pass the rms slope, reflectivity, emissivity, meter-scale slope, and SAR backscatter filter for Venera 13-like terrains.

Geological Units of Landing Sites

Previous landing areas overlaid on geological map from Ivanov and Head(2011)



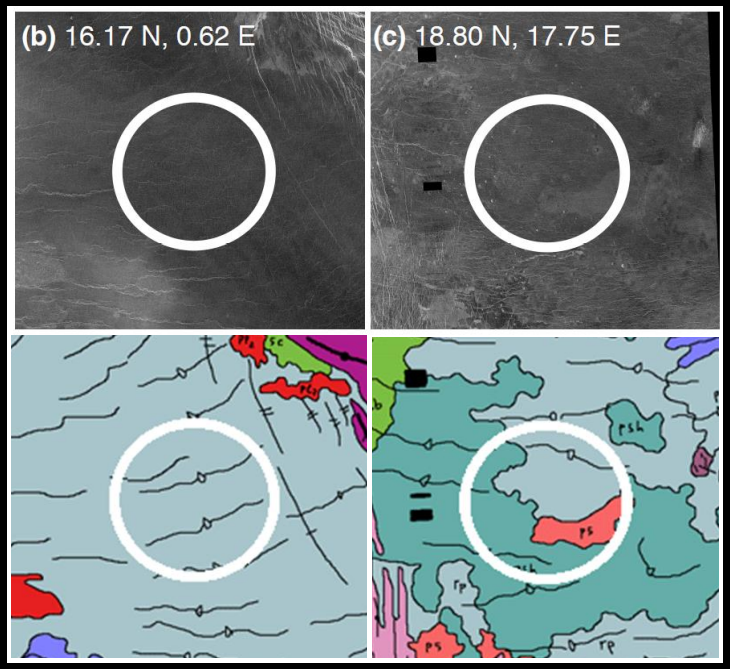
rp_1 rp_1 rp_1 rp_2



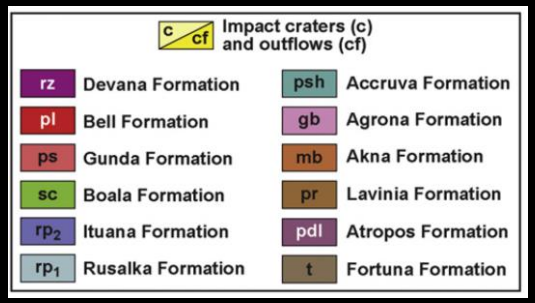
(scaling between SAR and geological map approximate)

Geological Units of Landing Sites (with SAR)

Previous landing areas overlaid on geological map from Ivanov and Head(2011)



rp_1 psh, ps, rp_1



(scaling between SAR and geological map approximate)

Discussion

- Landing site has to be **accessible based on the trajectory** and **meet the science requirements**
- The method presented in this work is conservative, but it represents a best-effort starting point that uses existing data to discriminate between areas of the Venus surface that may be less challenging from a landing safety perspective
- Caveats:
  1) This approach does not account for the potential non-uniqueness of radar-derived properties,
  2) the properties used to define Venera 13-like terrains may not be directly relevant to lander safety, and
  3) this method likely misses many areas that would be safe land sites, but that fall outside the radar parameter ranges for Venera 13 rp2 unit due to variations in composition or material properties not relevant to lander safety.

Acknowledgements

The research described in this document was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. Special thanks to the VISAGE proposal team, and to Mark Bullock for being a part of the early analysis of this work.

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