Venera-D Landing Sites Selection and Cloud Layer Habitability Workshop 2019
Moscow, Russia

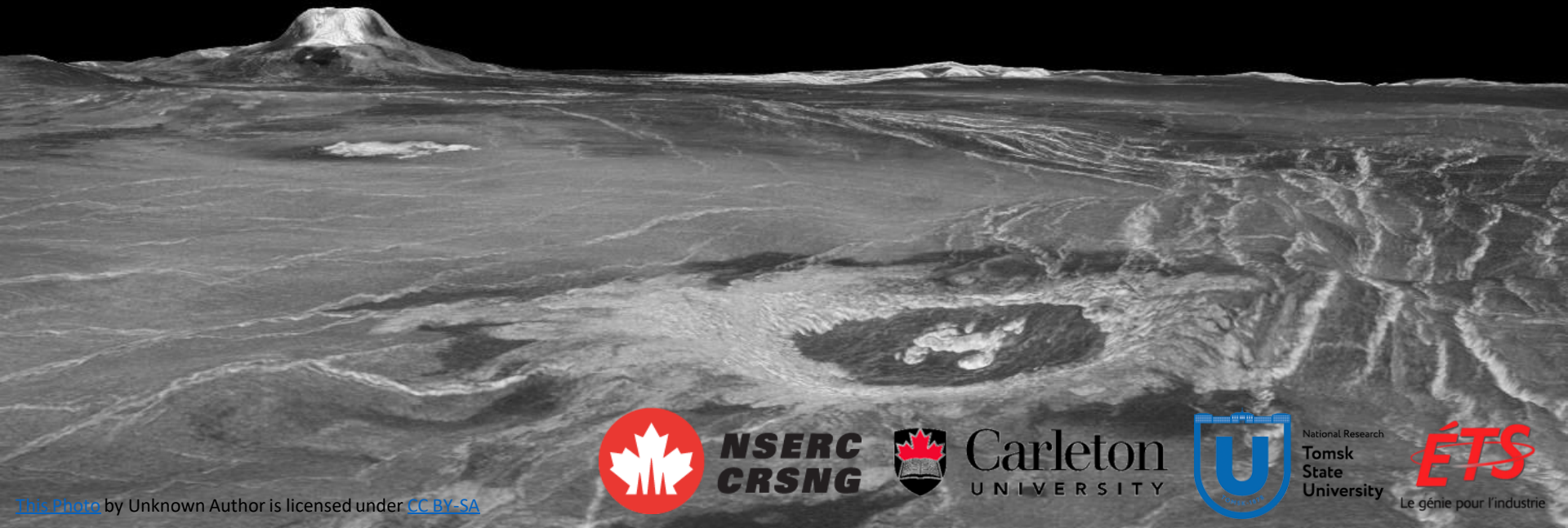
EVALUATION OF LANDING SITE TARGETS IN THE ALPHA REGIO (V-32) QUADRANGLE, VENUS

E. Bethell[1], R.E. Ernst[1,2*], C. Samson[1,3]

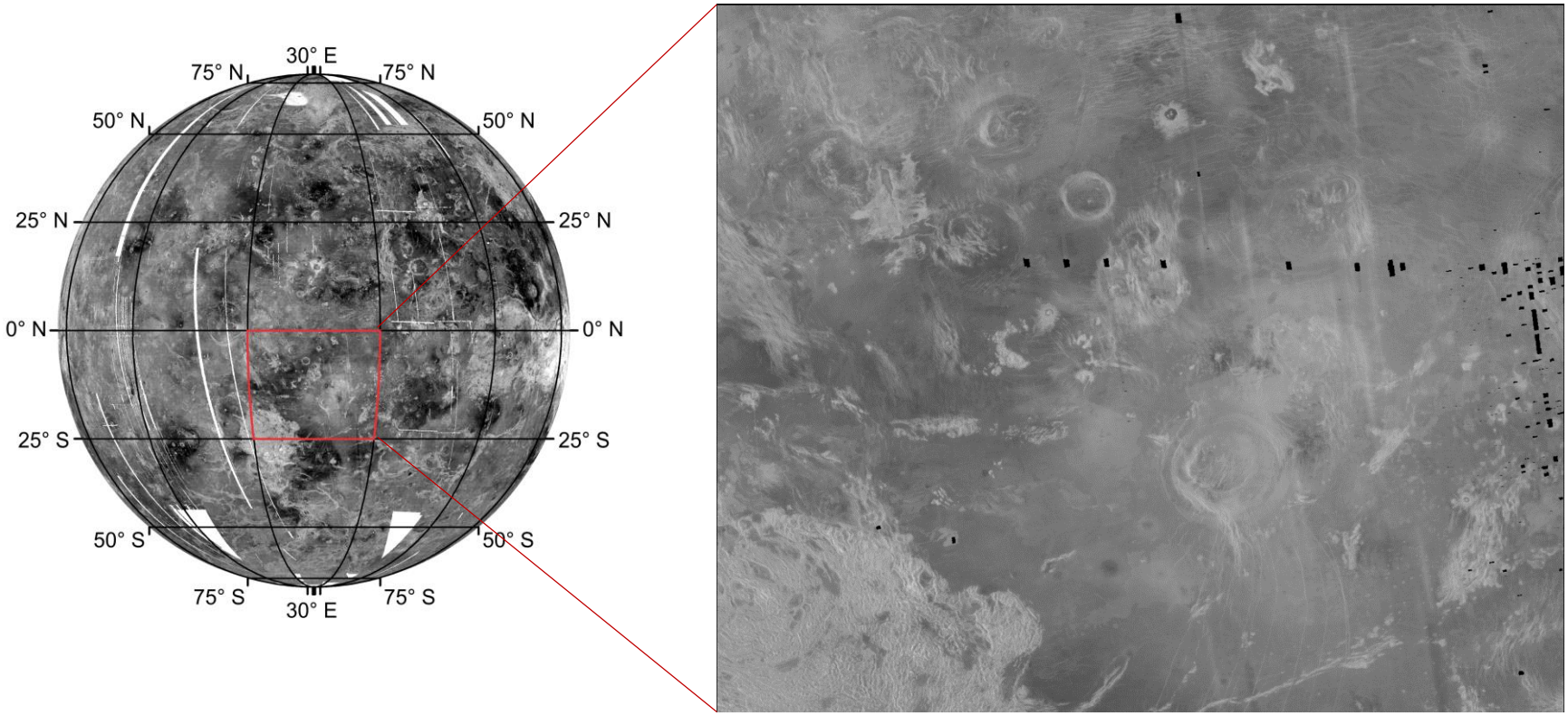
[1]Department of Earth Sciences, Carleton University, Ottawa, ON, Canada

[2]Faculty of Geology and Geography, Tomsk State University, Tomsk, Russia

[3]Department of Construction Engineering, École de Technologie Supérieure, Montréal, Canada



Alpha Regio (V-32) Quadrangle



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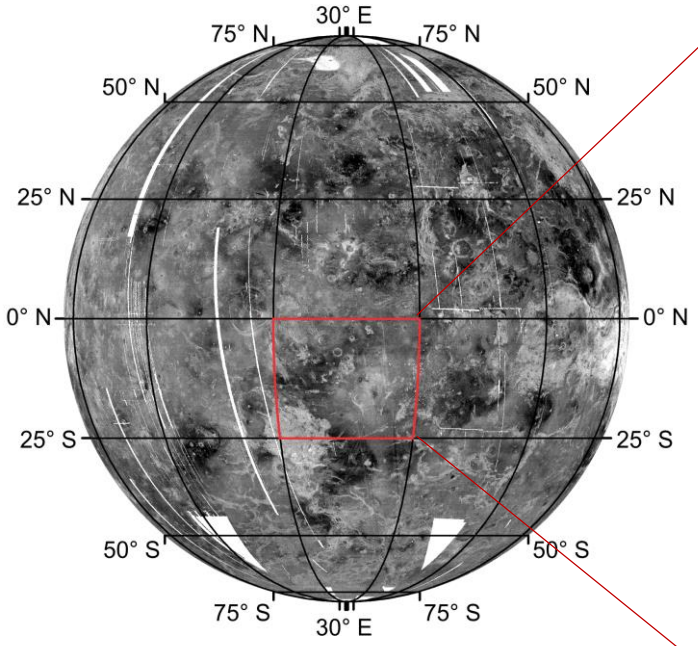
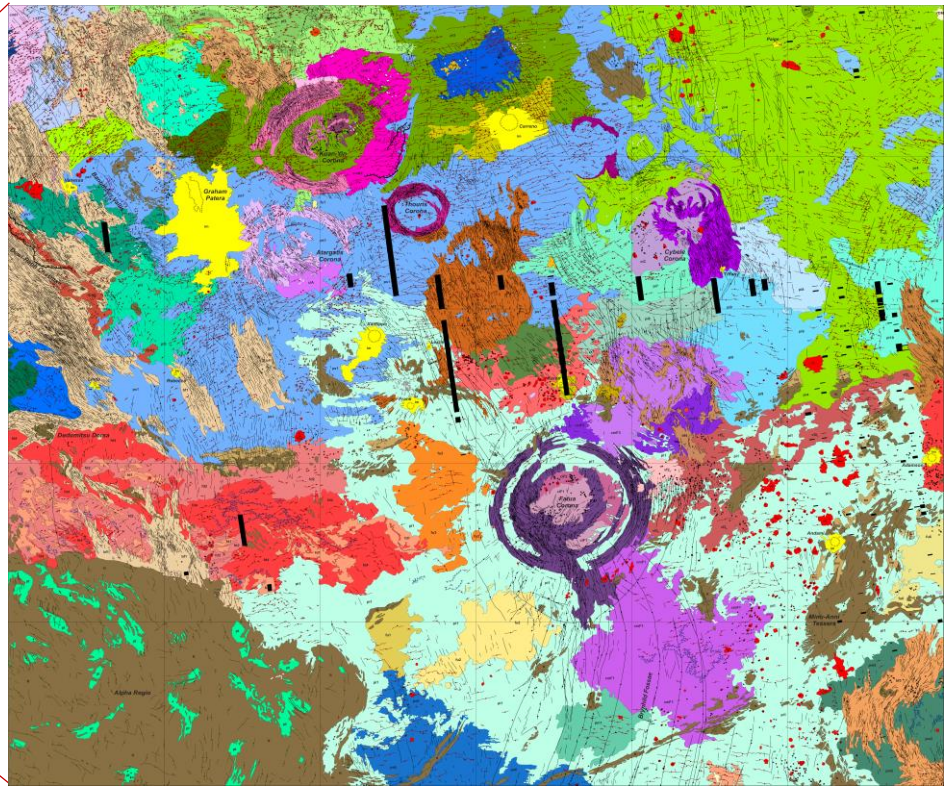
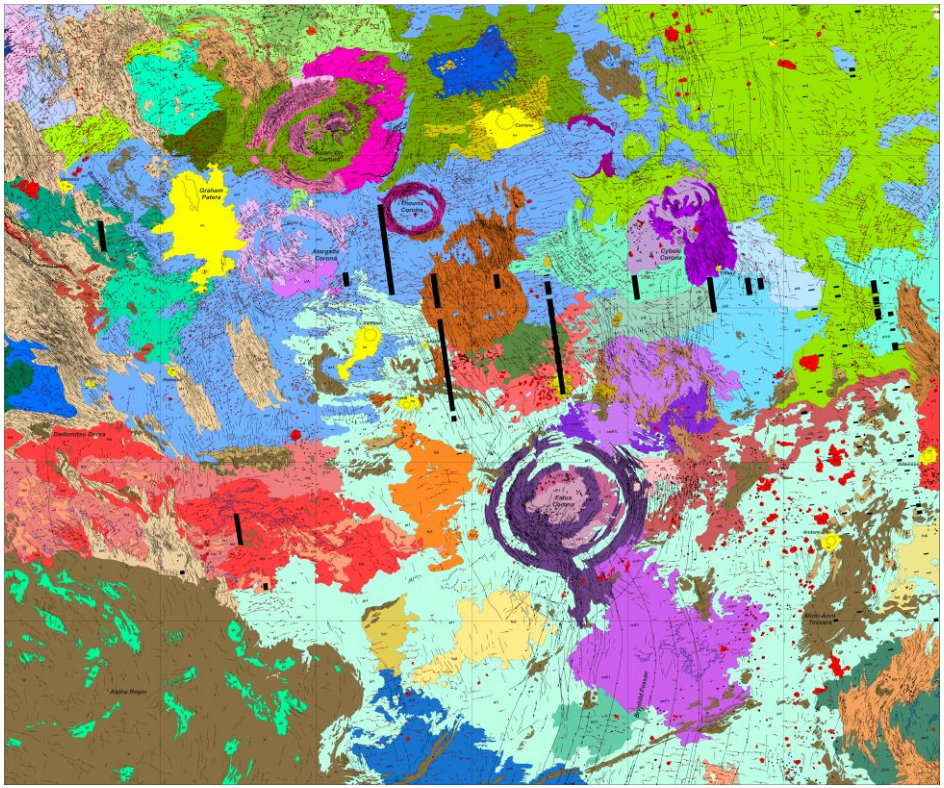




Bethell et al., (2019)

Alpha Regio (V-32) Quadrangle

- 77 geological units mapped
- Grouped into:
  - Volcanic edifice and flow material - red
  - Corona material - purple
  - Plains material - blue, green
  - Structural terrains - beige
  - Tessera terrain - brown
  - Impact material - yellow



Bethell et al., (2019)

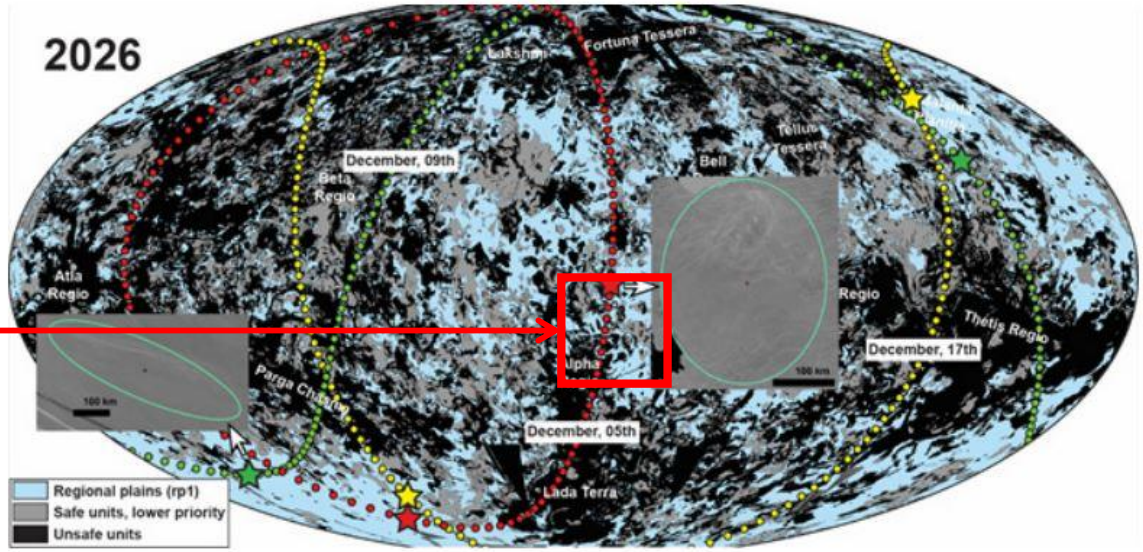
V-32 Quadrangle – Landing Site Targets

- The V-32 quadrangle is attractive for landing site selection:
  - 1) Variety of features and terrains (including high priority)
  - 2) Surface geology mapped in detail (Bethell et al., 2019)
  - 3) Half of the surface area covered by stereo-SAR and stereo-derived topography
  - 4) Intersects with landing site attainability arc for December 5th, 2026

Approximate location of the V-32 quadrangle

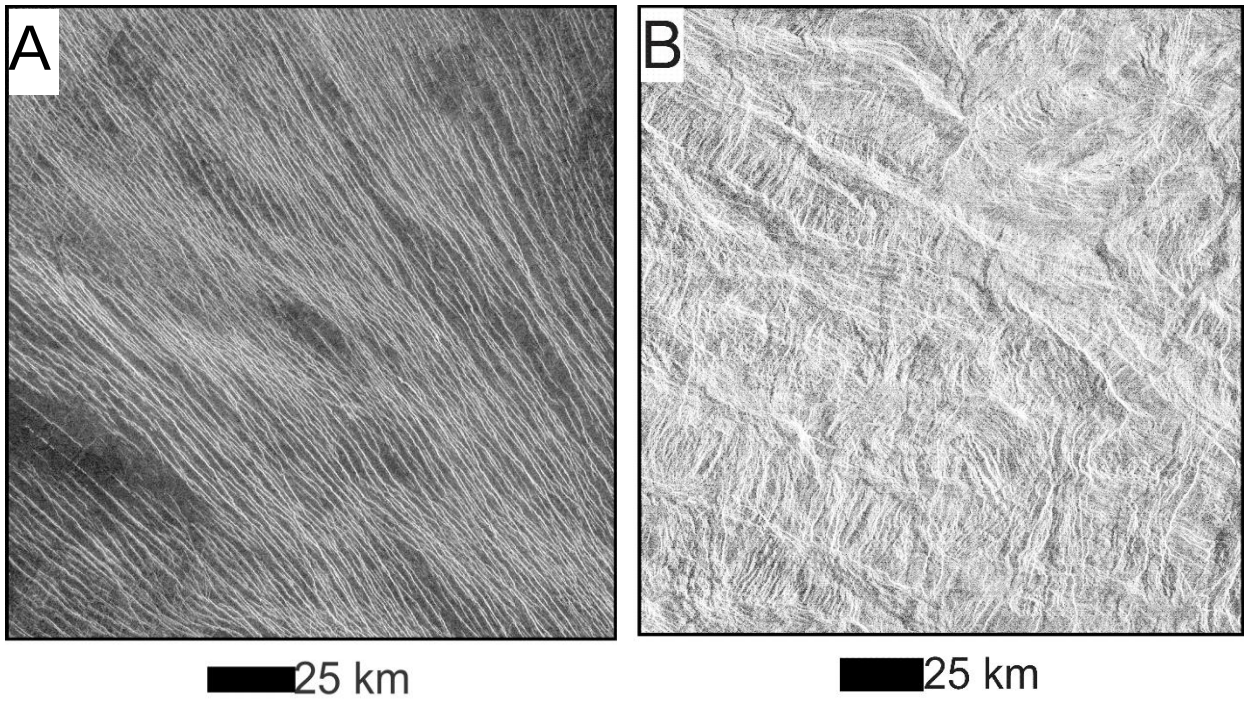
December 5th attainability arc shown in red

After Venera-D Phase II Final Report (2019)



Methods

- Follow guidelines of Venera-D Phase II Final Report (2019)
  - Landing ellipses set to 300 km diameter circles
  - Maximize mission safety, scientific priority, representativeness
  - Avoid unsafe terrains - highly tectonized, steep topographic gradients

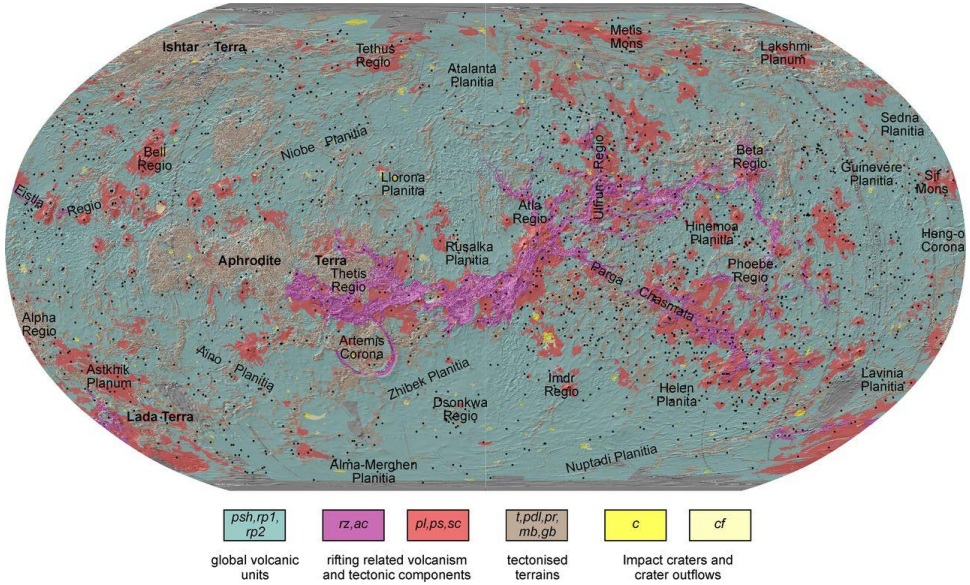


Examples of unsafe terrains not considered herein:
A) Fracture belts
B) Tessera terrain

Volcanic Plains

- The volcanic plains of Venus are an important target:
  - Safe landing sites – generally smooth topography, low surface roughness
  - Cover ~80% of Venus' surface
  - Modern instrumentation could improve upon the data collected by the previous Venera landers

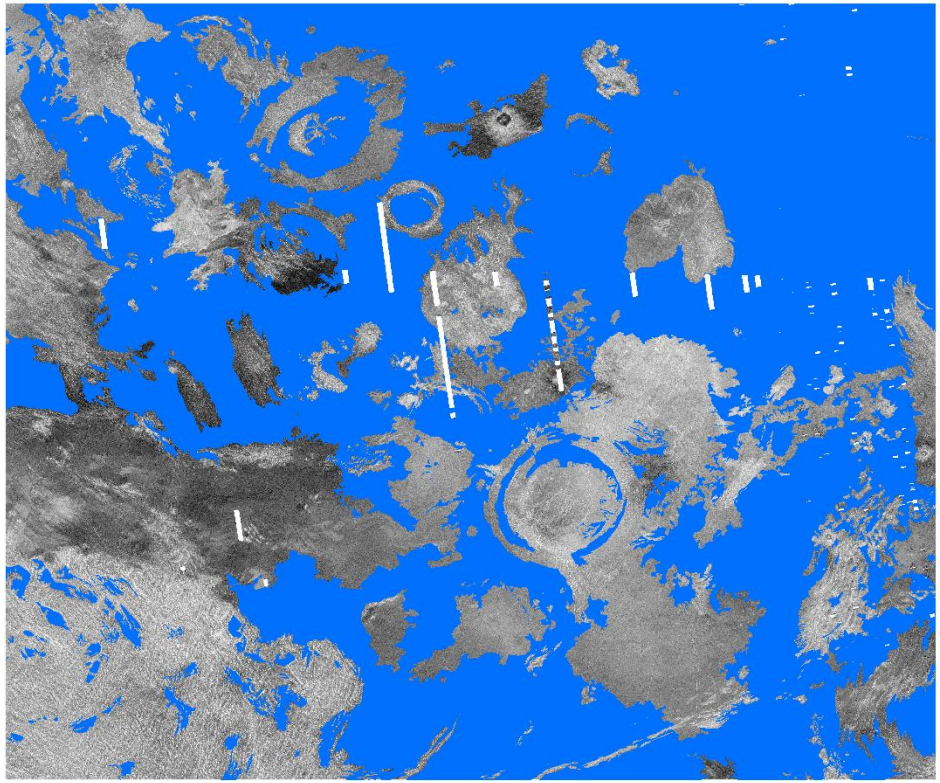
Distribution of plains (blue) on Venus
After Platz et al., (2014) and Ivanov and Head (2011)



Volcanic Plains

- Plains cover 55% of the V-32 quadrangle
- Used subtle differences radar properties in combination with cross-cutting relationships of post-emplacement structures
- Similar units separated by large distances also distinguished as sub-units

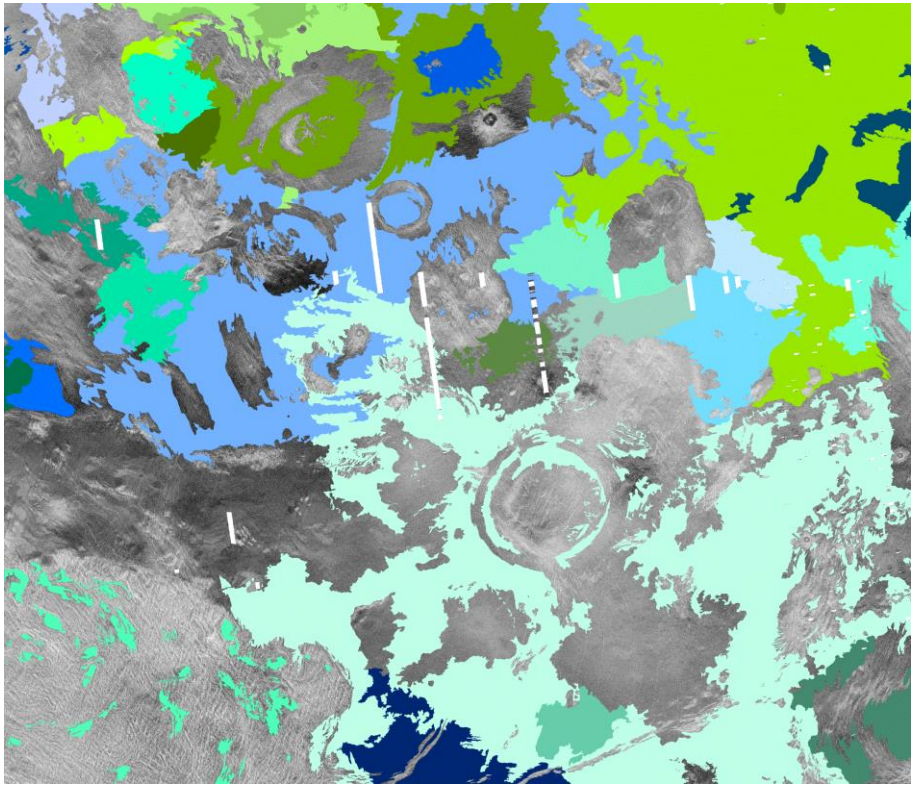
  → Led to the recognition of 8 major units divided into 27 sub-units



Distribution of units classified as plains material

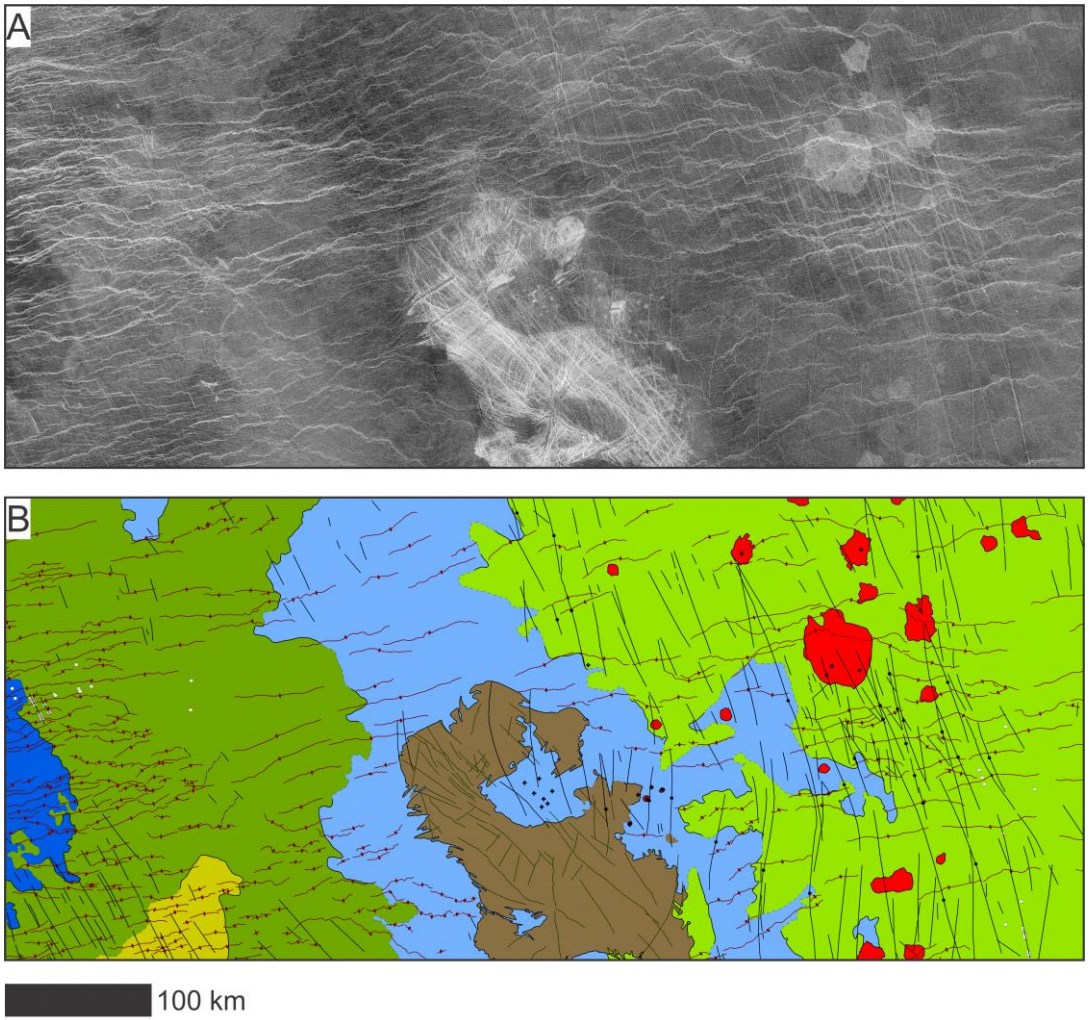
Volcanic Plains

- Previous studies group plains material into a small number of globally or regionally correlated units
- Plains material may not be as homogeneous as commonly thought
  - Local variations in surface properties and relative ages
  - Inhomogeneity may also be reflected in composition



Therefore, the geology of landing site targets in plains material should be carefully analyzed!

Volcanic Plains – Mapping Example



- Ivanov and Head (2011) mapped as regional plains
- We identified 3 units: ps1, pr3, and pr4
- Differences in radar brightness and cross-cutting relationships with NNW-SSE structures

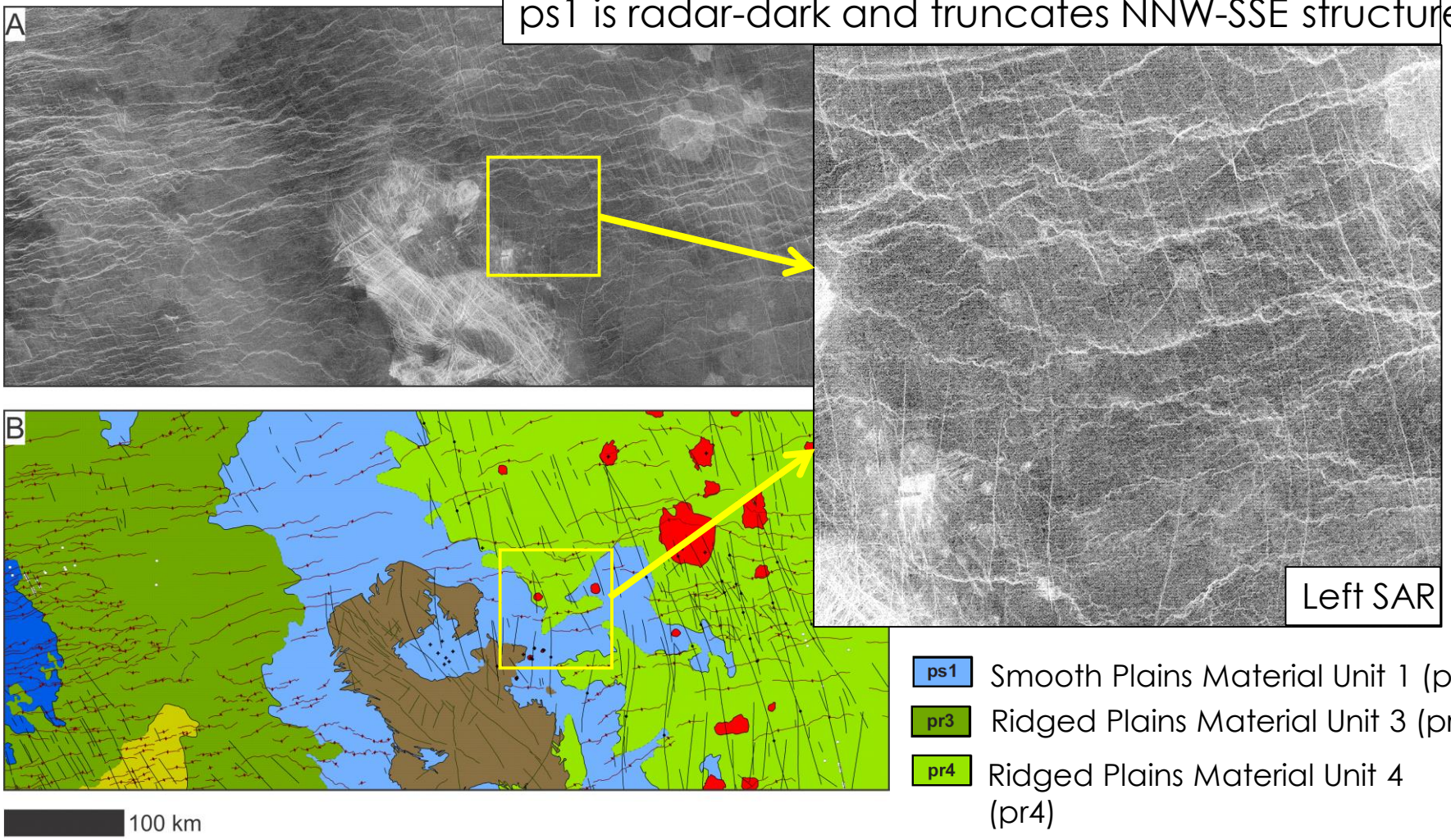
ps1 Smooth Plains Material Unit 1 (ps1)

pr3 Ridged Plains Material Unit 3 (pr3)

pr4 Ridged Plains Material Unit 4 (pr4)

Volcanic Plains – Mapping Example

ps1 is radar-dark and truncates NNW-SSE structures



Volcanic Plains – Mapping Example

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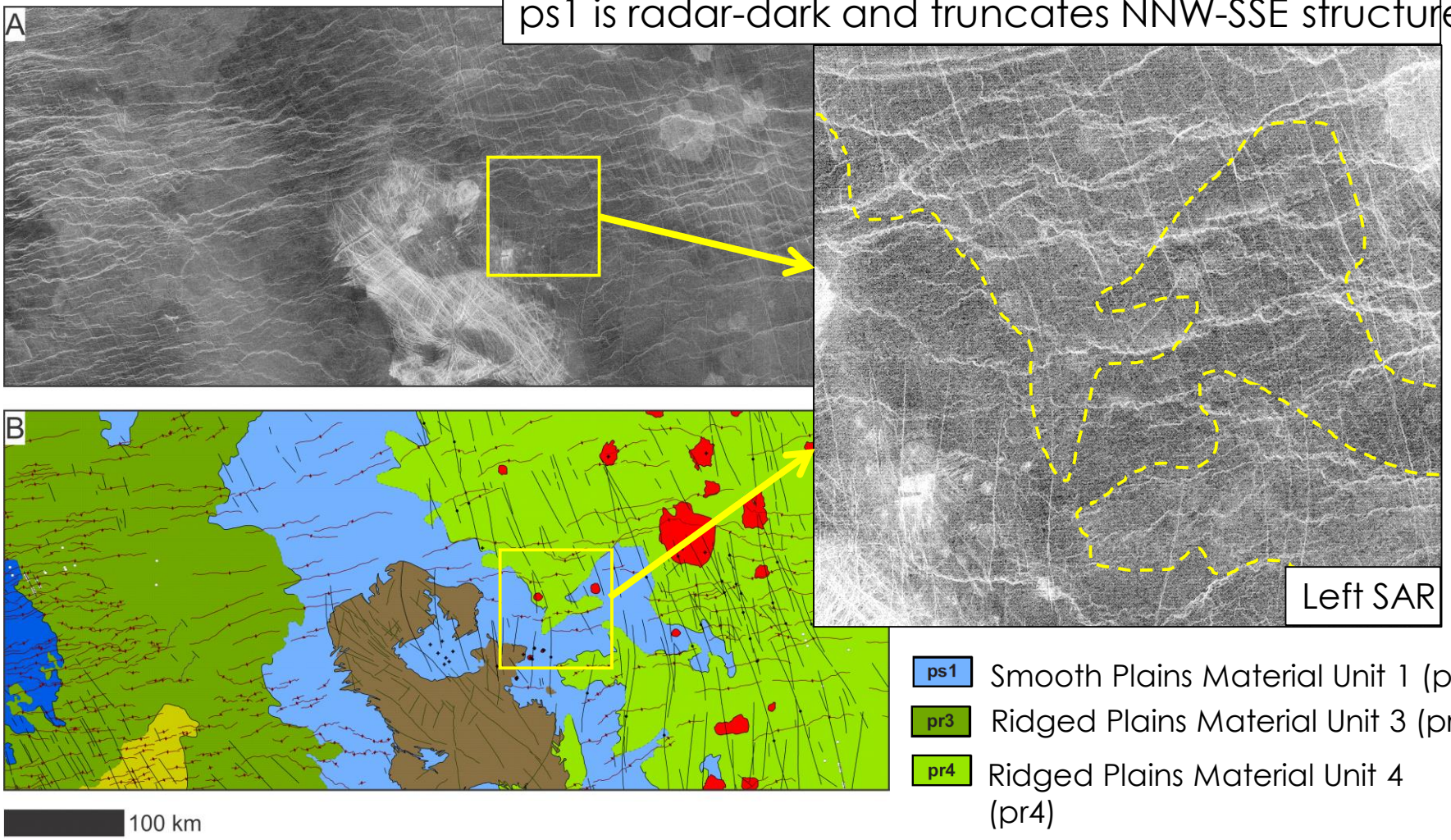
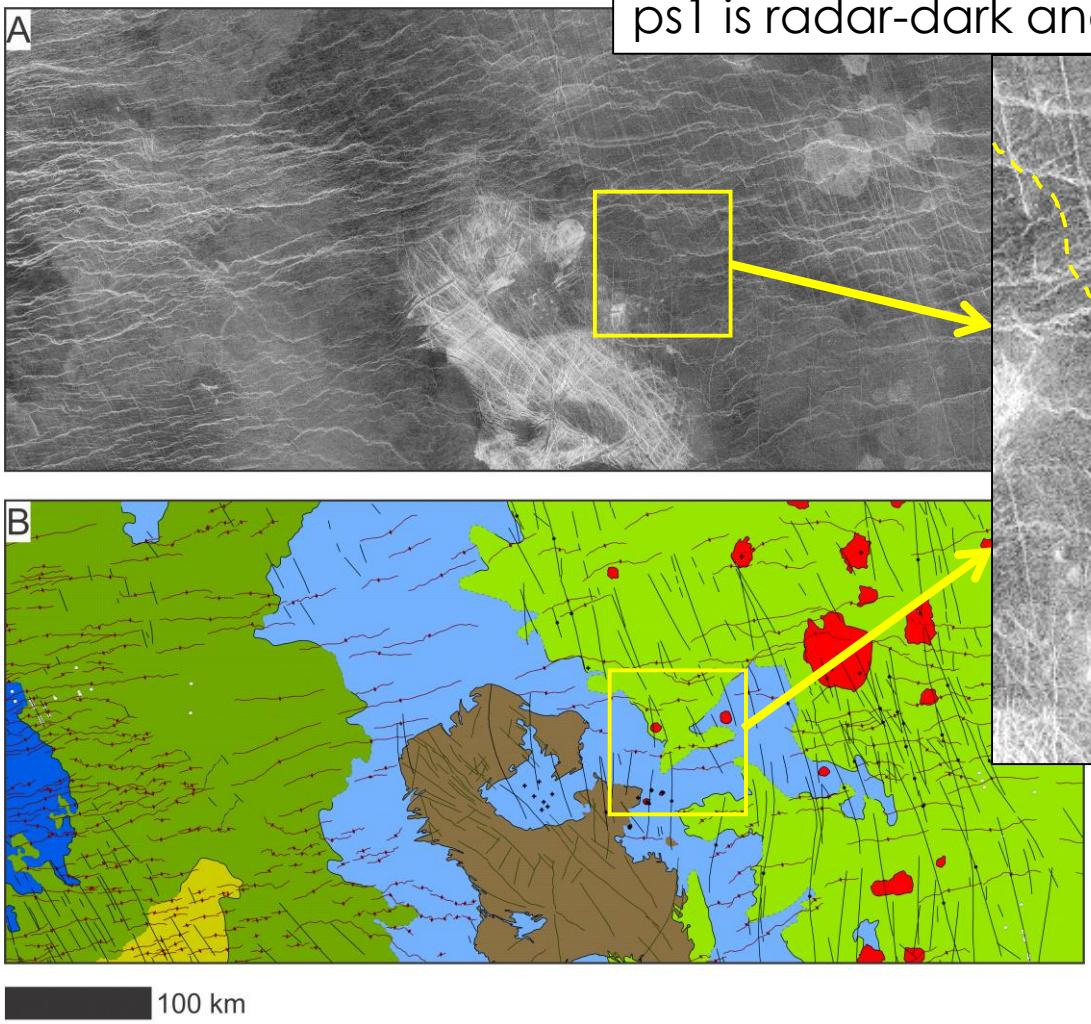


Volcanic Plains – Mapping Example



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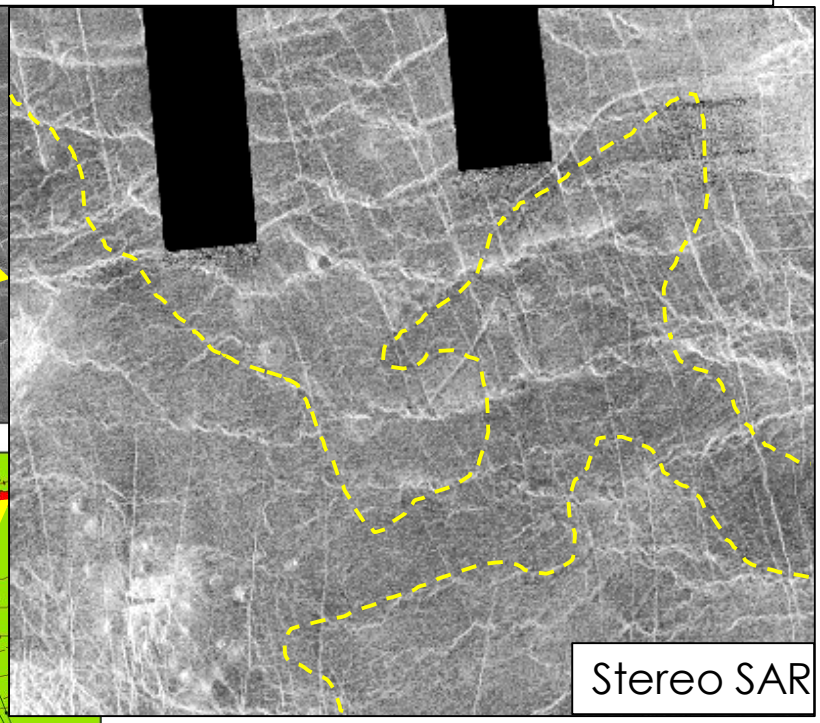


ps1 Smooth Plains Material Unit 1 (ps1)

pr3 Ridged Plains Material Unit 3 (pr3)

pr4 Ridged Plains Material Unit 4 (pr4)

Volcanic Plains: Target A

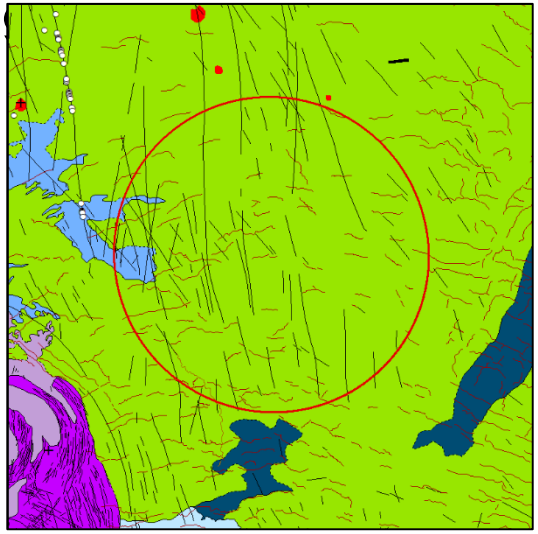
- Two possible landing site targets identified

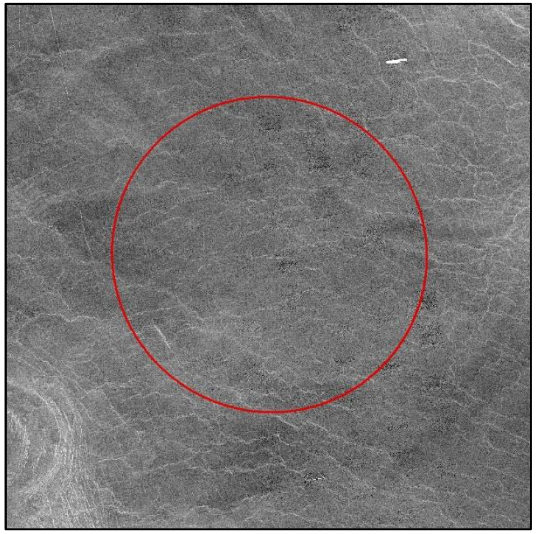
Target A:

- Centred at 25.0° E, 4.4° S
- *Ridged plains material unit 4* (pr4) – intermediate backscatter, numerous wrinkle ridges
- Within ellipse - relatively low wrinkle ridge density (~20-30 km spacing)
- Analysis of wrinkle ridge topography suggest slopes are not likely to exceed a few de

pr4 *Ridged plains material unit 4*

ps1 *Smooth plains material unit 1*





Volcanic Plains: Target B

- Two possible landing site targets identified

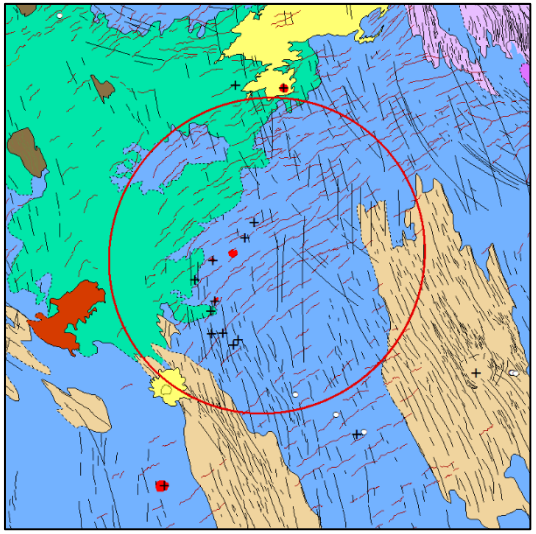
Target B:

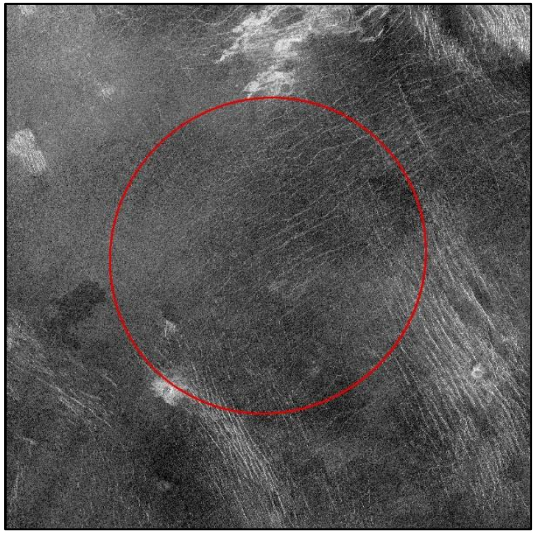
- Centred at 6.5° E, 11.1° S
- Contact between two units
  - *Intermediate plains material unit 3* (pi3) – intermediate backscatter
  - *Smooth plains material unit 1* (ps1) – moderately dark backscatter
- Small number of wrinkle ridges and extensional structures

pi3 *Intermediate plains material unit 3*

ps1 *Smooth plains material unit 1*

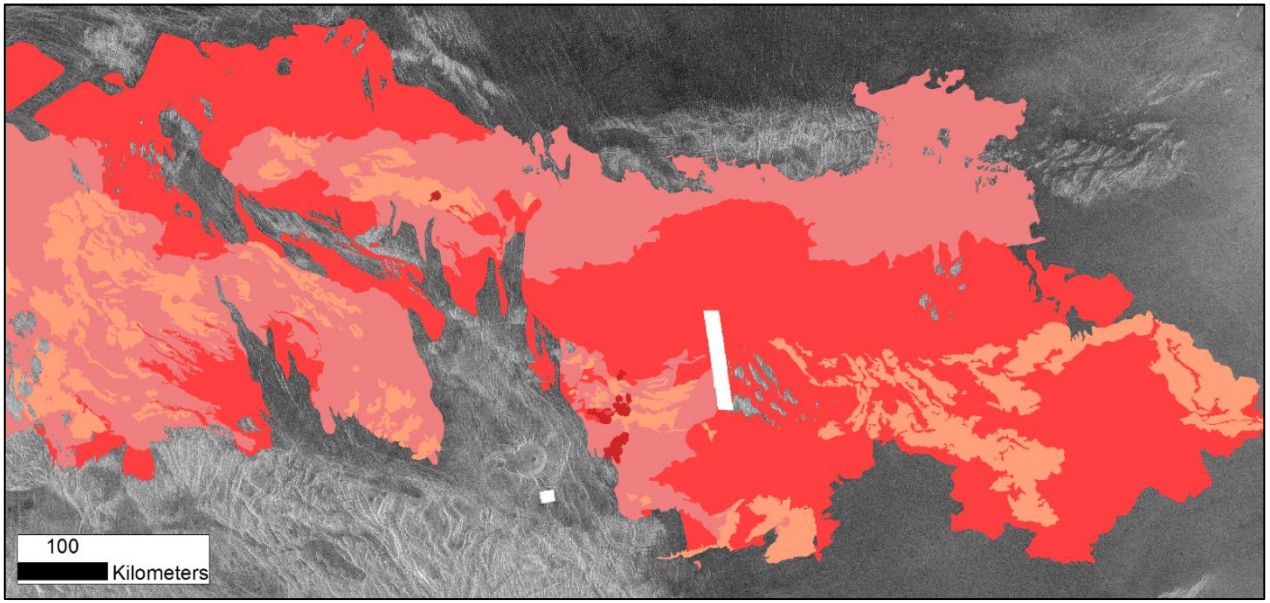
bf1 *Fracture belt unit 1*





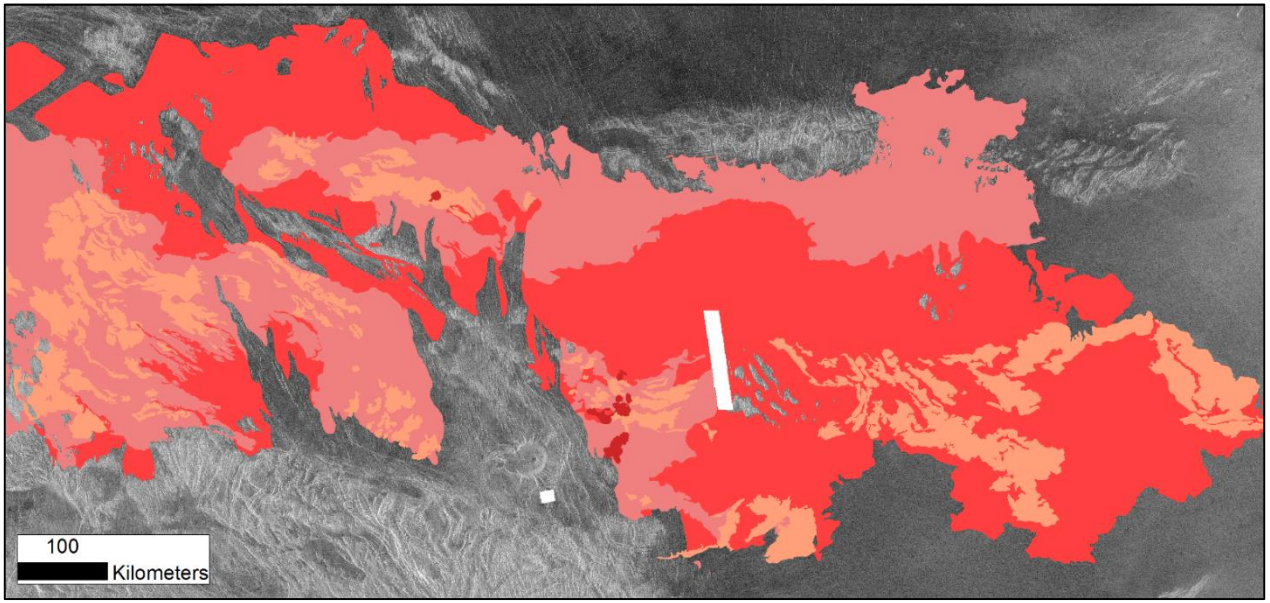
Digitate Volcanic Flows

- A 1400 km long series of layered digitate volcanic flows (unit fd) that covers 5% of the surface area of the quadrangle is present in the central western area
- Different units were mapped within this flow field based on varying radar brightness, ranging from radar-dark to radar-bright
  - Differences in radar brightness – composition (e.g. basalt vs. andesite) and/or surface texture (e.g. pahoehoe vs. a'a)?



Digitate Volcanic Flows

- Surface area of ~452,000 km^2 – at the scale of the largest fluctüs
- These great Venusian flow fields are also an important sampling target:
  - Fluctüs thought to be analogous to flood basalt provinces on Earth and have not yet been sampled
  - Could provide information about Venus' primitive upper mantle
  - Relatively young units – not as weathered/altered



Digitate Flow Material Units

fd1	Unit 1
fd2	Unit 2
fd3	Unit 3
fd4	Unit 4

Digitate Volcanic Flows: Target C

- Two possible landing site targets identified

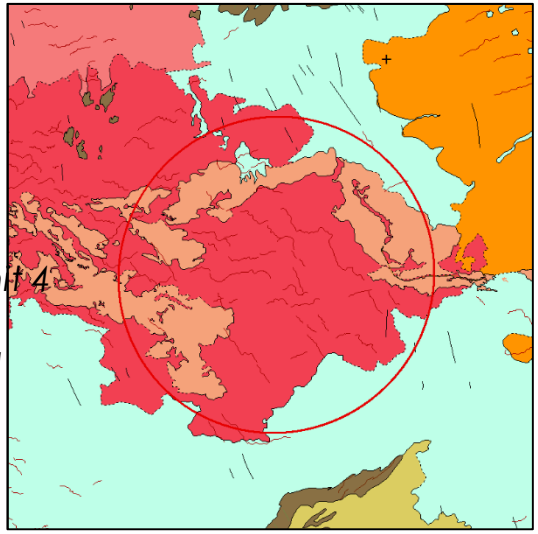
Target C:

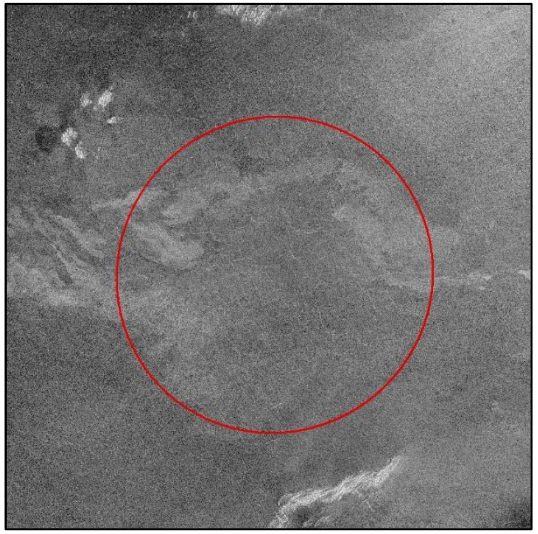
- Centred at 11.5° E, 17.5° S
- Located within: *Digitate volcanic flow material units 1 and 4* (fd)
- Very few structures present; smooth topography

fd1 *Digitate volcanic flow material unit 1*

fd4 *Digitate volcanic flow material unit 4*

pi1 *Intermediate plains material unit 1*





Digitate Volcanic Flows: Target D

- Two possible landing site targets identified

Target D:

- Centred at 1.4° E, 16.5° S
- Located within: *Digitate volcanic flow material units 1,2 and 4* (fd), just north of the contact with the Alpha Regio highland *tessera terrain* (tt)
- Contains some minor wrinkle ridges and extensional structures, and small outcrops of tessera terrain

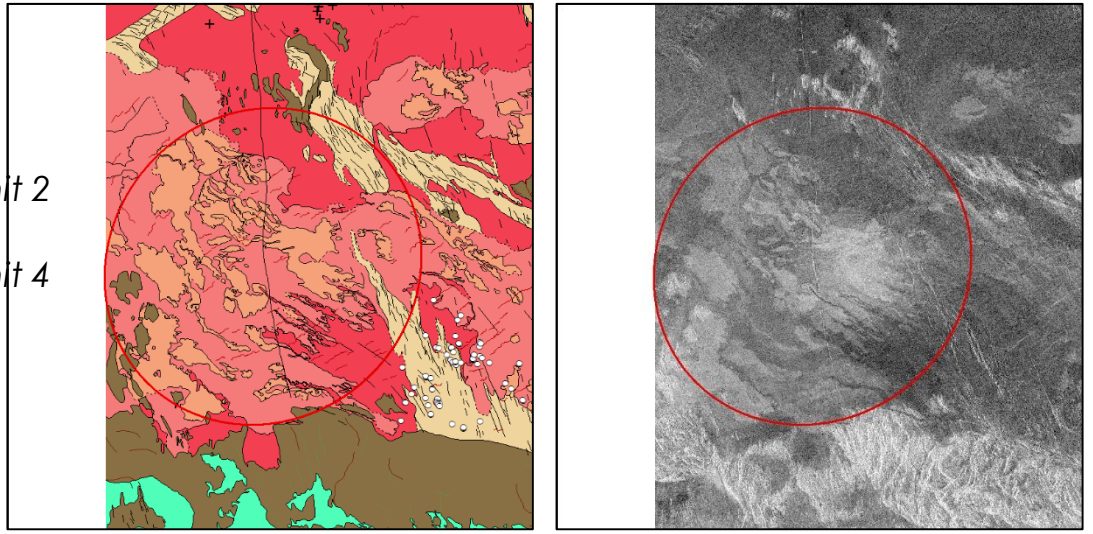
fd1 *Digitate volcanic flow material unit 1*

fd2 *Digitate volcanic flow material unit 2*

fd4 *Digitate volcanic flow material unit 4*

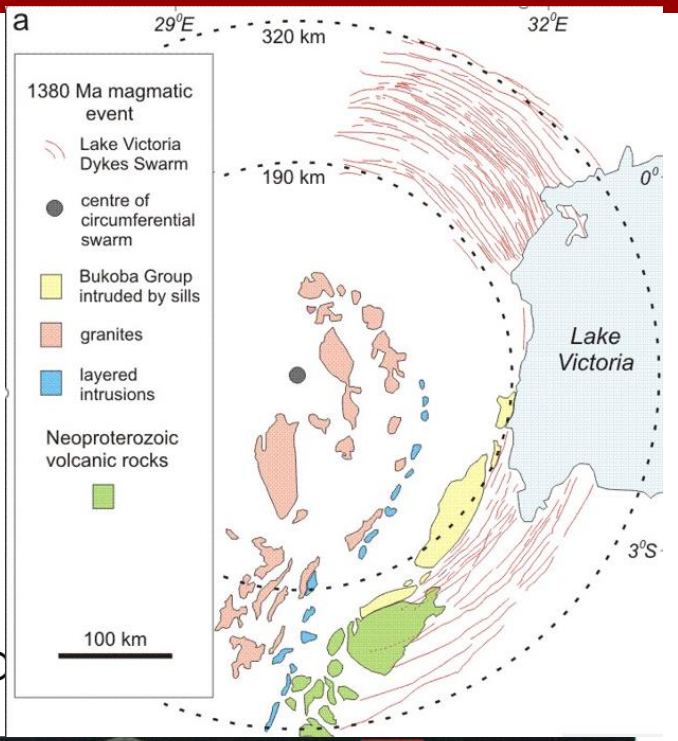
tt *Tessera terrain*

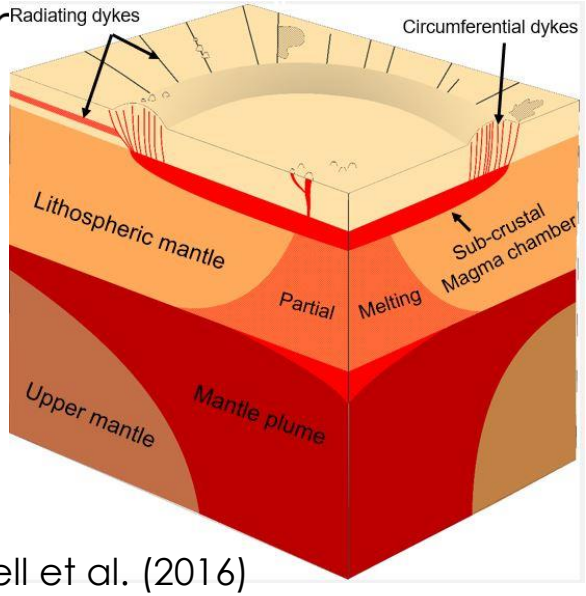
bf1 *Fracture belt unit 1*



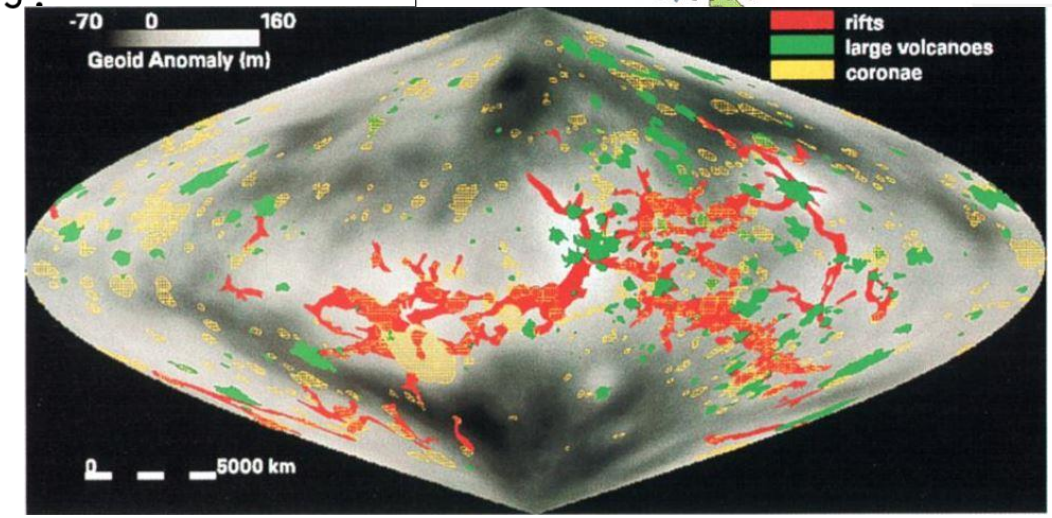
Coronae

- Coronae are quasi-circular tectono-magmatic features, associated with volcanism and tectonism
- Scientific rationale for sampling corona materials:
  - Major feature on Venus – over 500 identified
  - Not yet sampled
  - Provide insight into the processes of corona forr[illegible]es?





From Bethell et al. (2016)

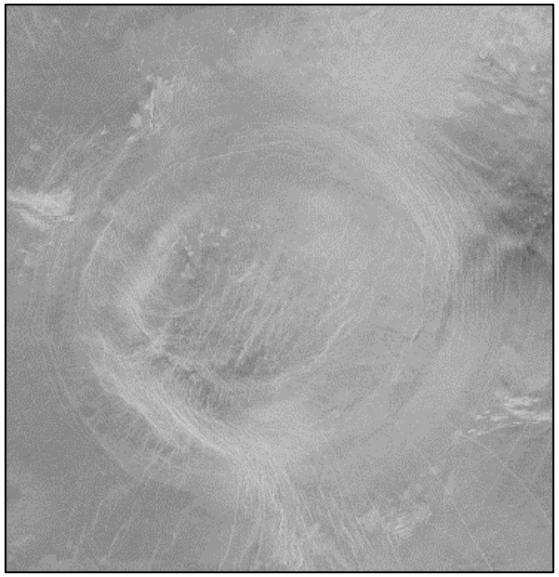


From Herrick (1999)

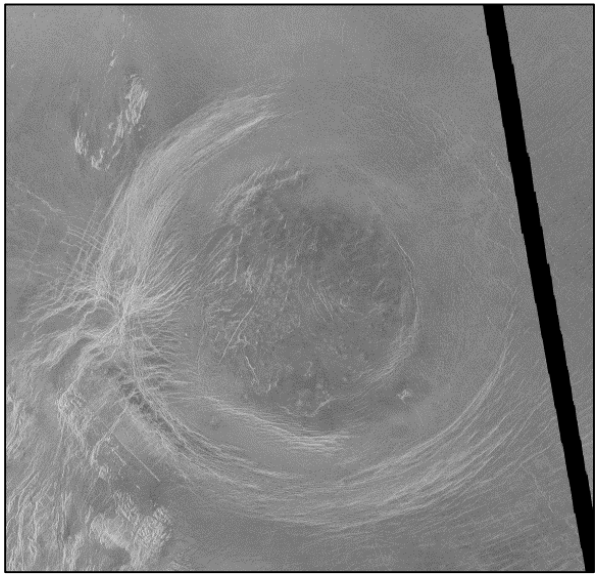
Coronae

- Central regions not safe landing areas – highly tectonized, steep topographic gradients
- However, a reasonable target would be corona-sourced volcanic flows that extend beyond the central region

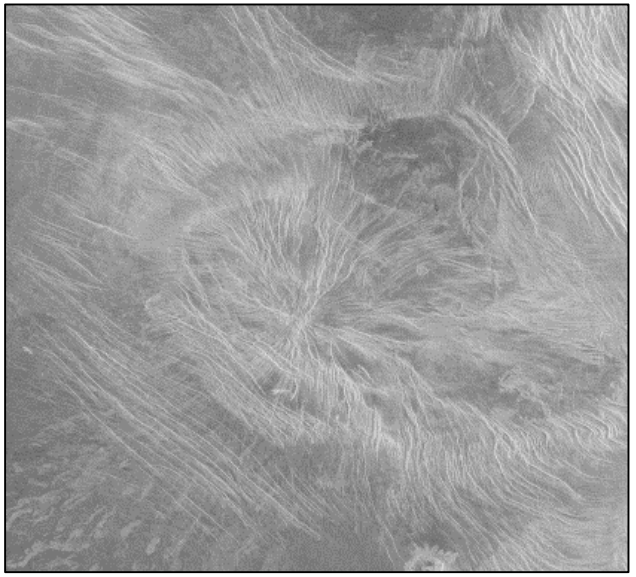
Examples of corona centres, showing their tectonized nature



Fatua Corona



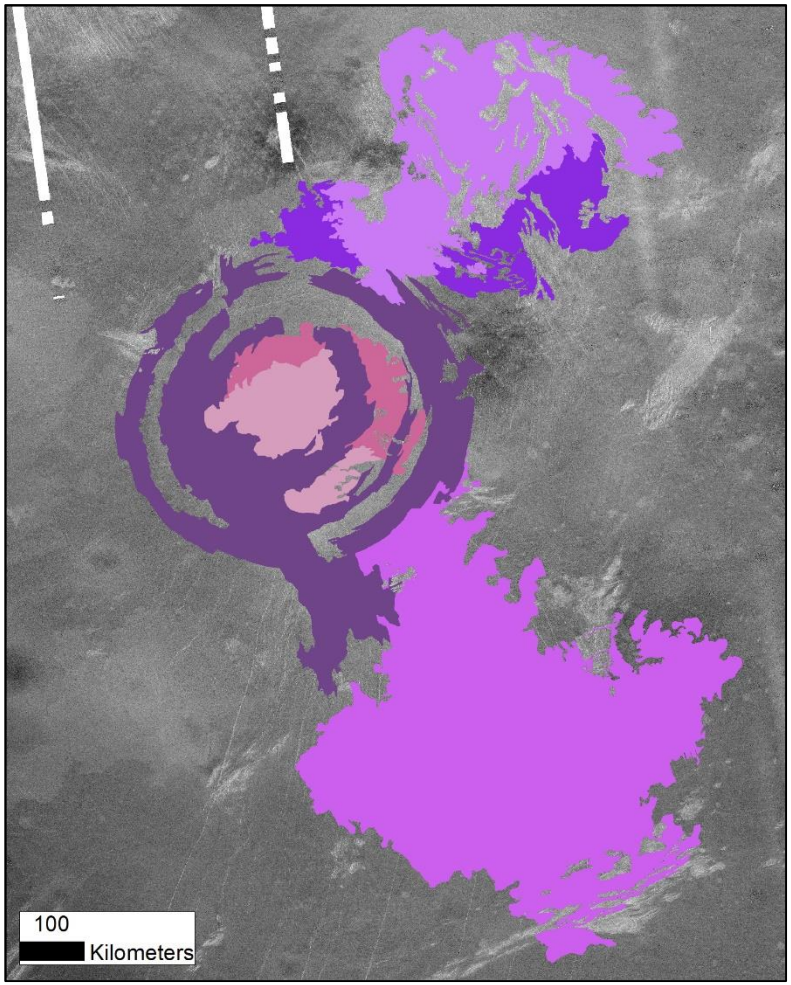
Umay-Ene Corona



Oblemi Corona

Fatua Corona

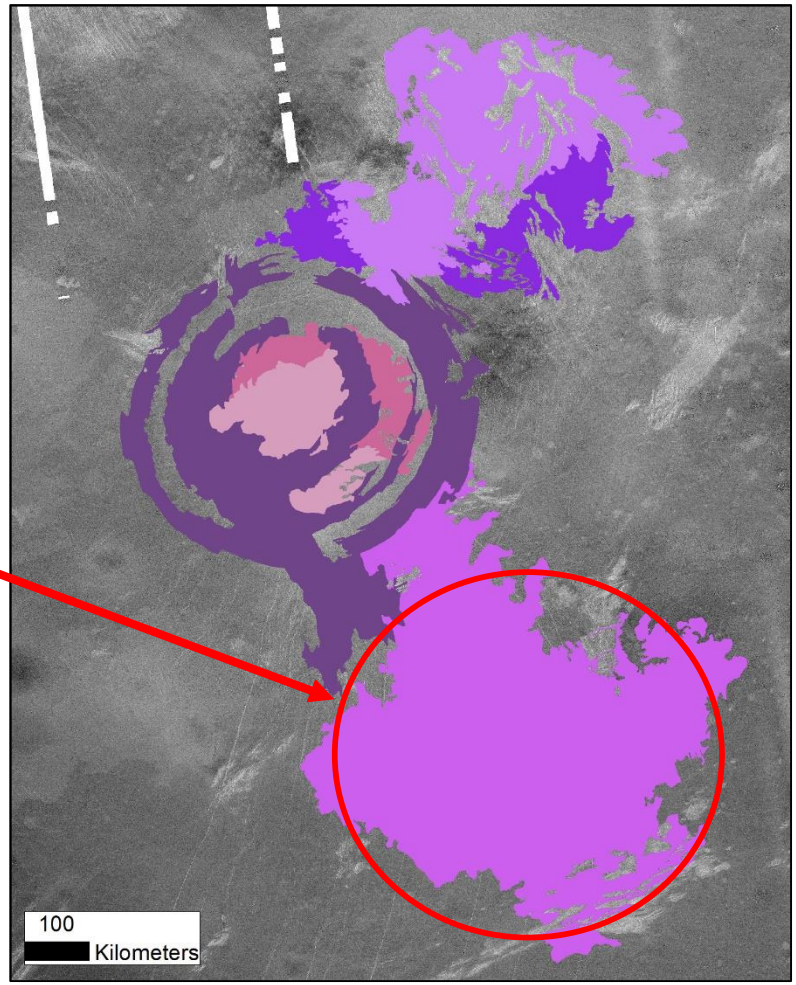
- Three new flow units mapped – *Fatua Corona flow material units 1-3* (cmF1, cmF2 and cmF3)
- A lander may be able to safely sample a distal portion of these flows



cmF1	Fatua Corona Flow Material Unit 1 (cmF1)
cmF2	Fatua Corona Flow Material Unit 2 (cmF2)
cmF3	Fatua Corona Flow Material Unit 3 (cmF3)
ciF1	Fatua Corona Interior Material Unit 1 (ciF1)
ciF2	Fatua Corona Interior Material Unit 2 (ciF2)
cfF	Fatua Corona Fractured Material (cfF)

Fatua Corona

- Three new flow units mapped – *Fatua Corona flow material units 1-3* (cmF1, cmF2 and cmF3)
- A lander may be able to safely sample a distal portion of these flows



cmF1	Fatua Corona Flow Material Unit 1 (cmF1)
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cmF3	Fatua Corona Flow Material Unit 3 (cmF3)
ciF1	Fatua Corona Interior Material Unit 1 (ciF1)
ciF2	Fatua Corona Interior Material Unit 2 (ciF2)
cfF	Fatua Corona Fractured Material (cfF)

Coronae: Target E

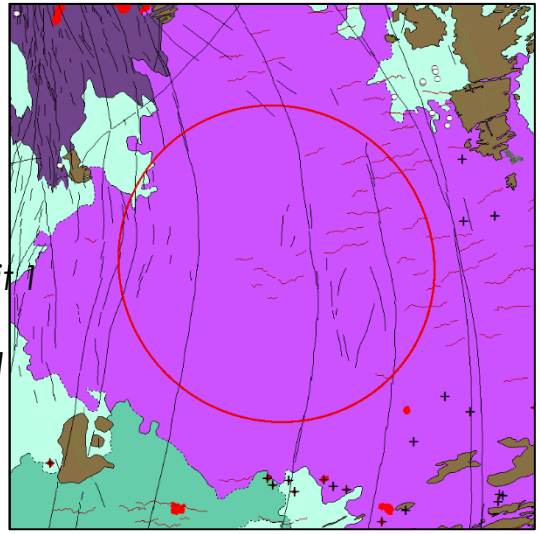
- One possible landing site target identified

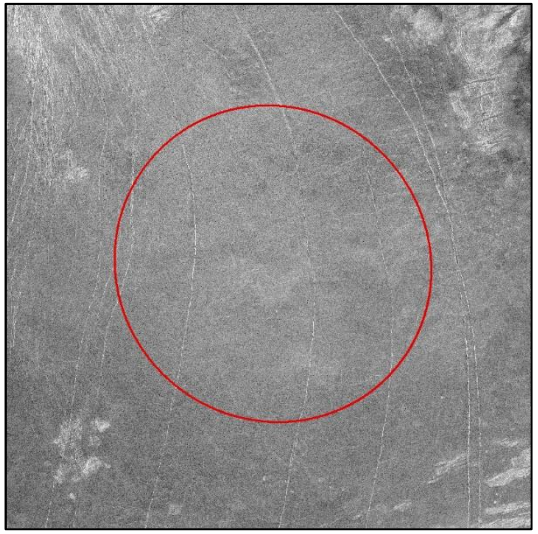
Target E:

- Centred at 20.5° E, 20.5° S
- Southeast of the rim of Fatua Corona, located in: *Fatua Corona flow material unit 1* (cmF1)
- Contains some minor wrinkle ridges and four prominent graben, spaced 50-100 km apart

cmF1 *Fatua Corona flow material unit 1*

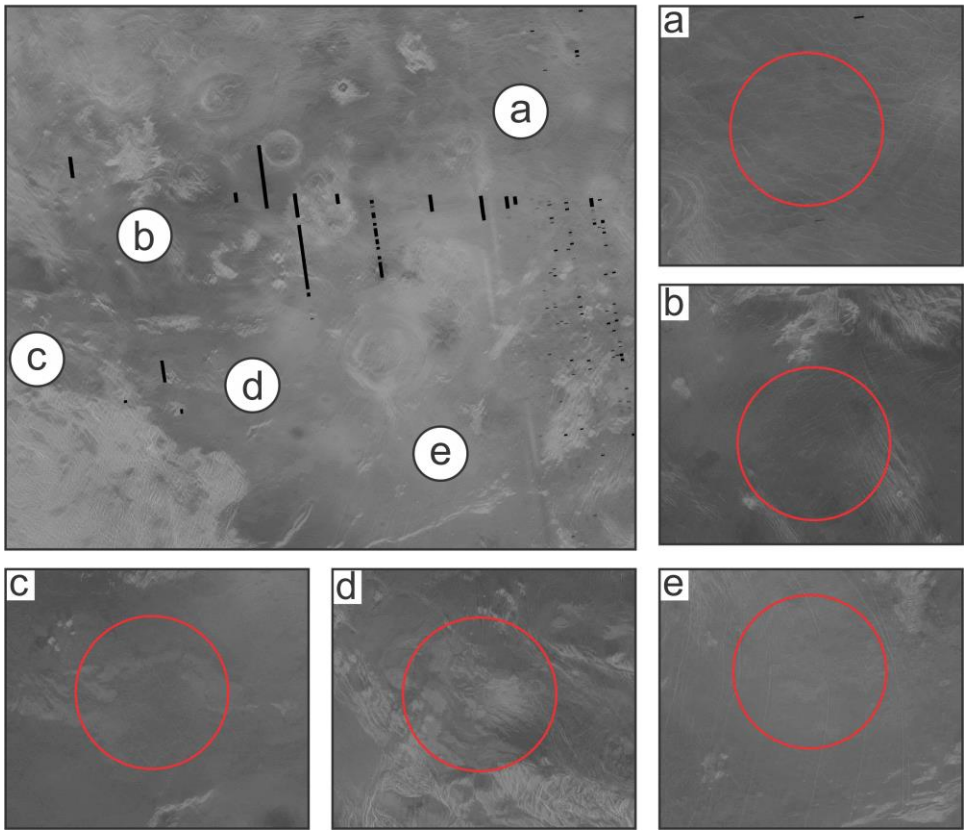
pi1 *Intermediate plains material unit 1*





Summary – Landing Site Targets

- Five potential landing site targets maximizing mission safety and scientific gain were identified in the V-32 quadrangle



- Two within units classified as plains material: A, B
- Two within a digitate volcanic flow field (fluctus): C, D
- One within a corona-sourced volcanic flow unit: E
- Knowledge obtained through detailed geological mapping of these areas (and elsewhere) would aid in the interpretation of the returned data