# Timing, Emplacement, and Distribution of Mare-Fill Units in Oceanus Procellarum, a Large Nearside Lunar Basin*

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## Abstract

Although only 17% of the entire lunar surface is covered by basalt and underlying associated magma cooling units, ~60% of the western hemisphere on the lunar nearside contains magmatic complexes emplaced in numerous episodes ranging from approximately 3.75 Ga (billion years ago) to possibly as recently as 0.9 Ga, inferred from crater counts and overlapping relationships between lava-flow units and bright rays associated with Copernican-age craters. Oceanus Procellarum contains the largest continuous extent of lunar basalts on the Moon, and its upper fill is a complex of at least four different flow units, recognized on the basis of albedo and spectral reflectivity. Individually, these flow units are only a few hundreds of meters thick, but may be underlain by 2-4 km thick basin-filling units. Oceanus Procellarum has been interpreted by some authors as the western part of the 2400-km-wide Gargantuan Basin, inferred to have formed from a giant impact ~4.3 Ga. Gargantuan Basin lacks a surrounding mountain rim and underlying mascon, features commonly associated with other nearside lunar basins such as Mare Tranquillitatis, Serenitatis, and Crisium. However, the absence of these features may be due to the Gargantuan Basin having formed so early that the lunar crust may have not been sufficiently rigid to support rim material and excess masses of thick basin-filling units.

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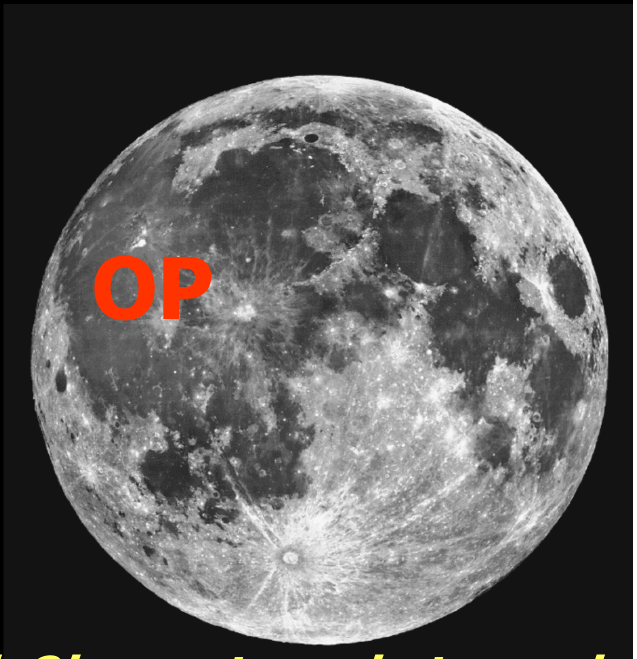
**2008 AAPG International Convention**
**Cape Town, South Africa**
**October 27, 2008**


**William A. Ambrose**

**Bureau of Economic Geology**
**John A. and Katherine G. Jackson School of Geosciences**


*Lick Observatory photograph*

# Outline

- **Oceanus Procellarum**

  *-Morphology, Crustal Structure, Mare-Fill Units*

- **Nearside Megabasin**

  *-Basin Configuration and Marginal Structures*

- **South Pole-Aitken Basin**

  *-Antipodal Basin Structure*

- **Significance**

**Publication was authorized by the Director, Bureau of Economic Geology, The University of Texas at Austin**

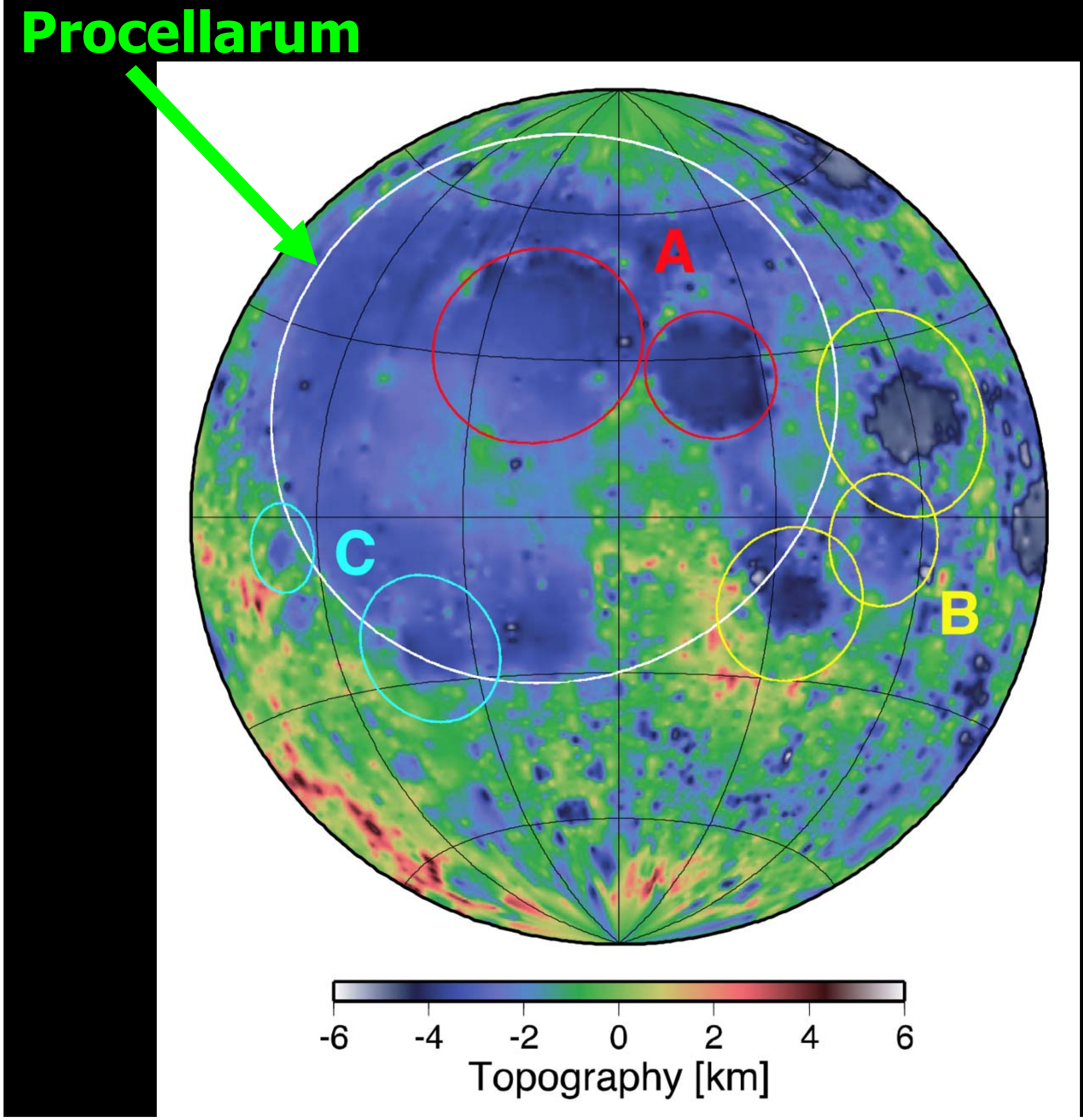
# Oceanus Procellarum


## Facts and highlights

- Largest mare area
- Poorly developed mascons
- Th, KREEP-rich fill
- 3200-km diameter

*Lick Observatory photograph*

# Mascons and Non-Mascon Basins



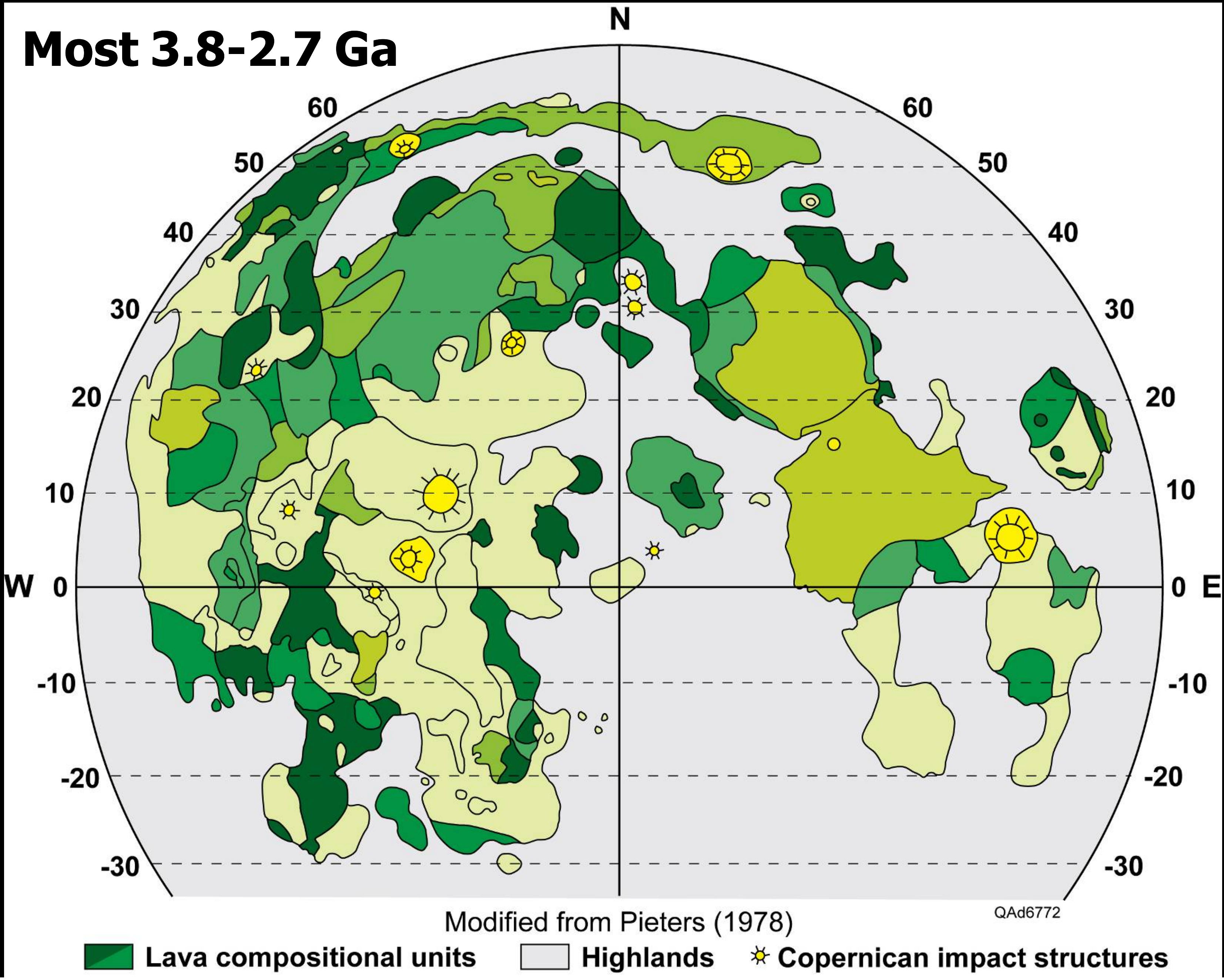

A
Imbrium
Serenitatis

B
Crisium
Fecunditatis
Nectaris

C
Grimaldi
Humorum

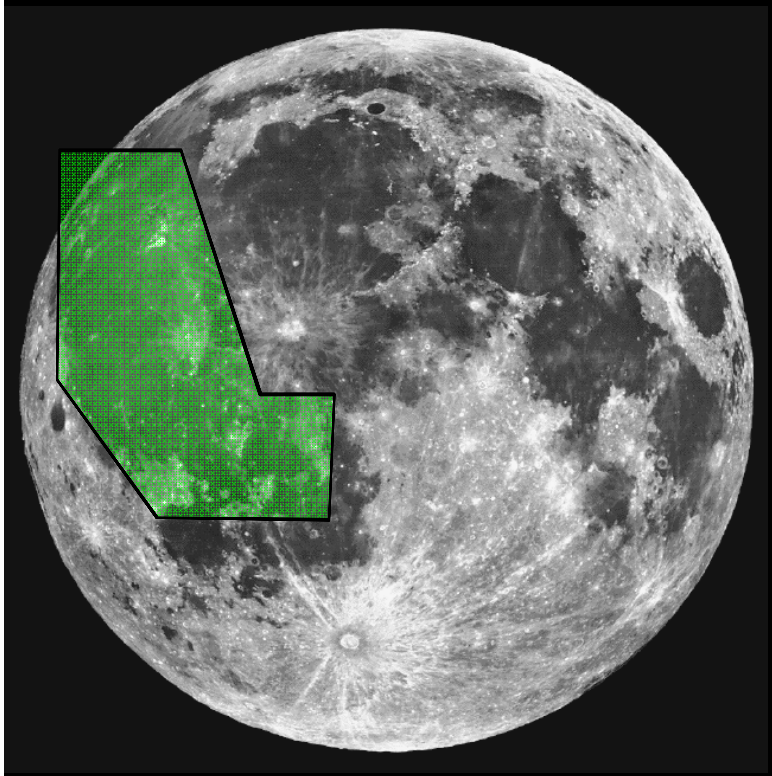
*Sugano and Heki (2004)*

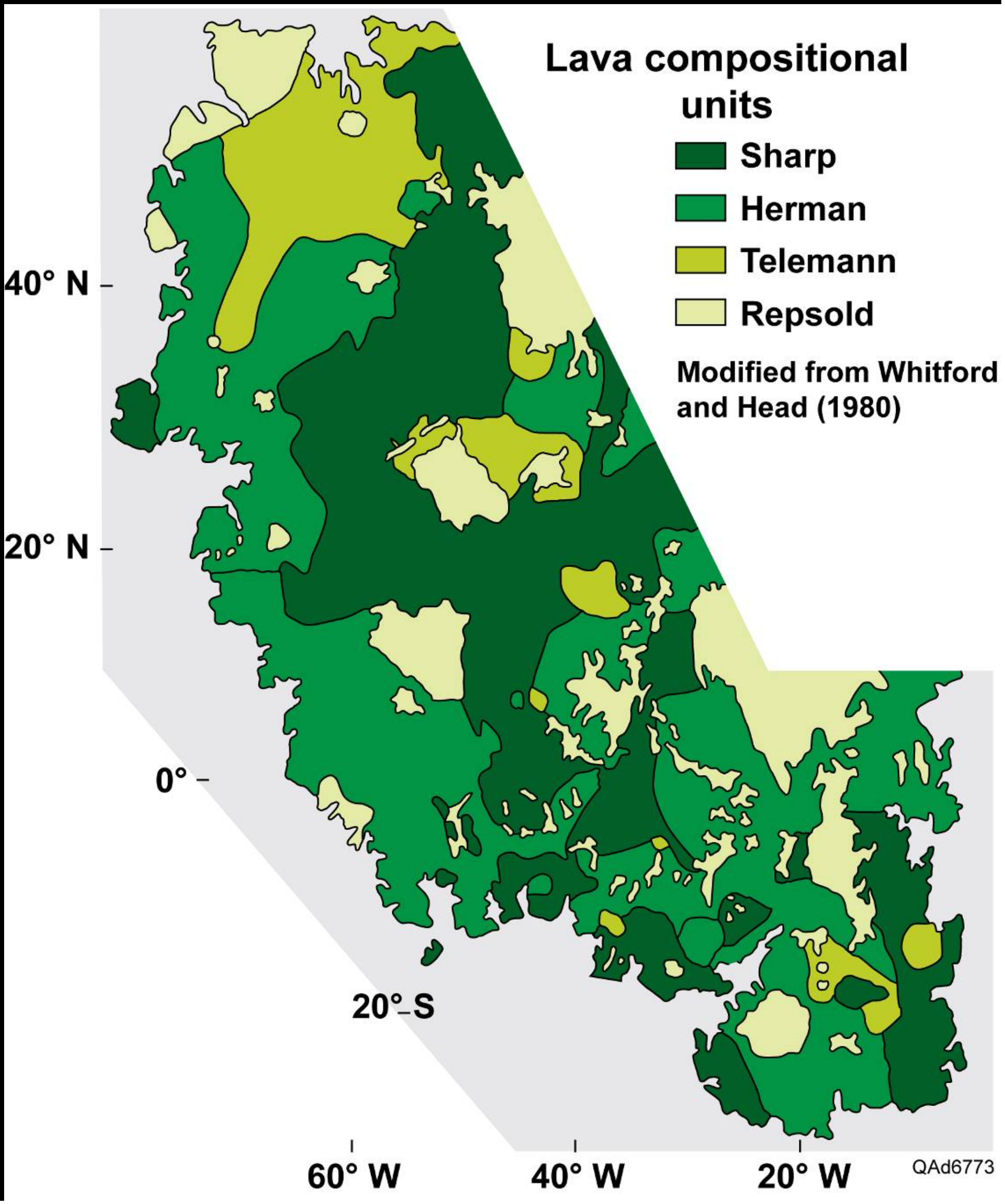
# Nearside Compositional Units




Modified from Pieters (1978)

# Oceanus Procellarum Compositional Units





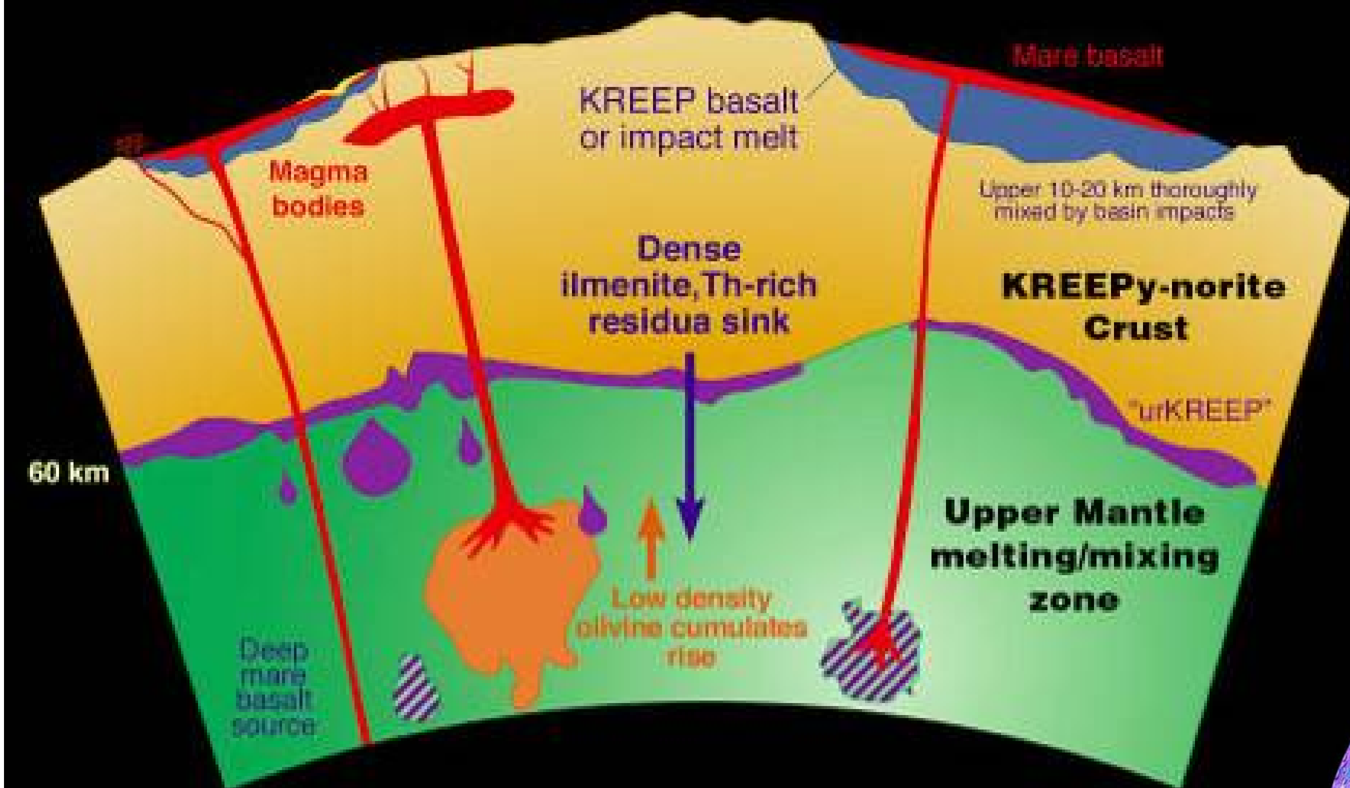

Bureau of Economic Geology

# Oceanus Procellarum Compositional Units

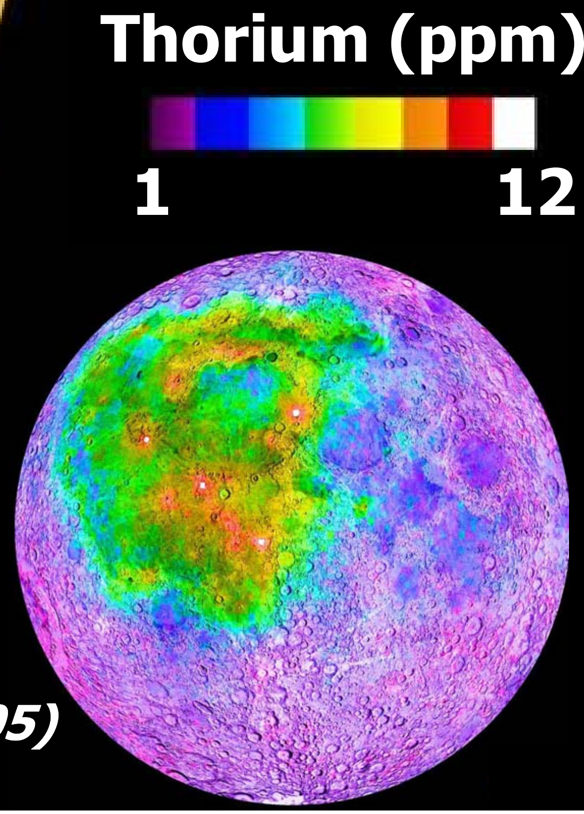
| Attribute | Sharp | Hermann | Telemann | Repsold |
|---|---|---|---|---|
| Brightness | dark | darkish | bright | bright |
| Craters | few | intermediate | many | ? |
| Titanium content % | 3-11 | 1-6 | <2 | ? |
| Thickness (meters) | 25 | 150 | 250 | 125 |
| Area (percent) | 43 | 45 | 11 | 1 |
| Age (billion years) | 2.7±0.7 | 3.3±0.3 | 3.6±0.2 | 3.75? |

QAd6771

# Procellarum KREEP Terrane




*Jolliff, et al. (2000)*




*Spudis (2005)*

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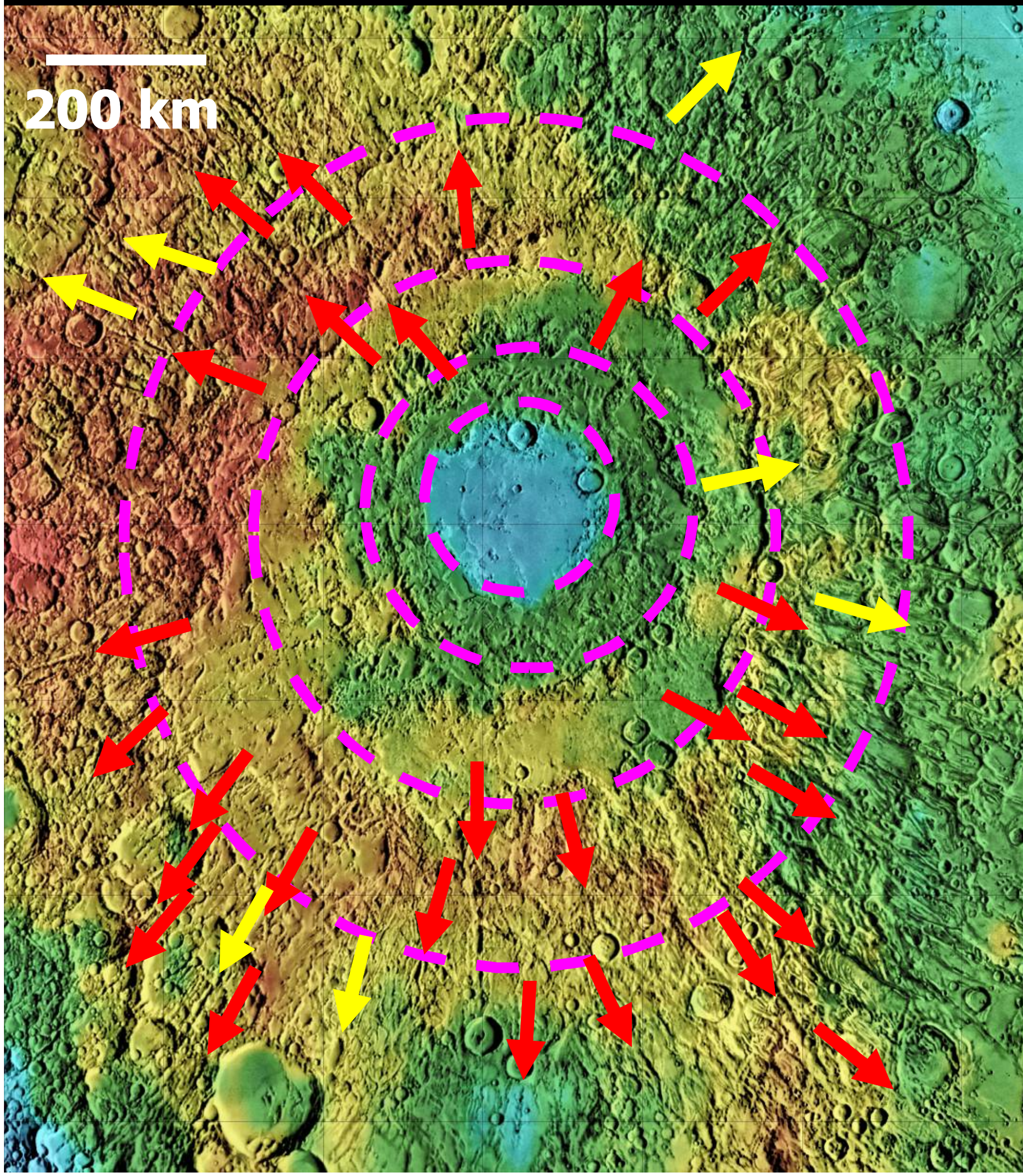
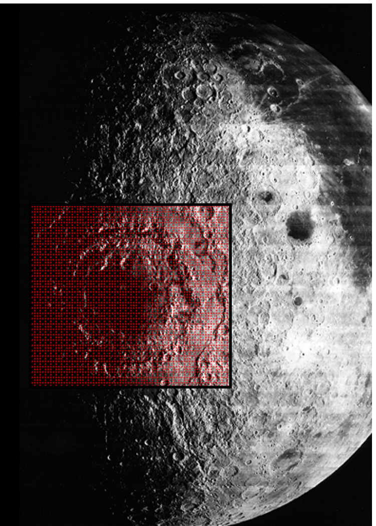
  - *-Basin Configuration and Marginal Structures*
- **South Pole-Aitken Basin**
  - *-Antipodal Basin Structure*
- **Significance**

# Orientale—Multiringed Basin

*USGS Lidar Map*




*Lunar Orbiter 4*



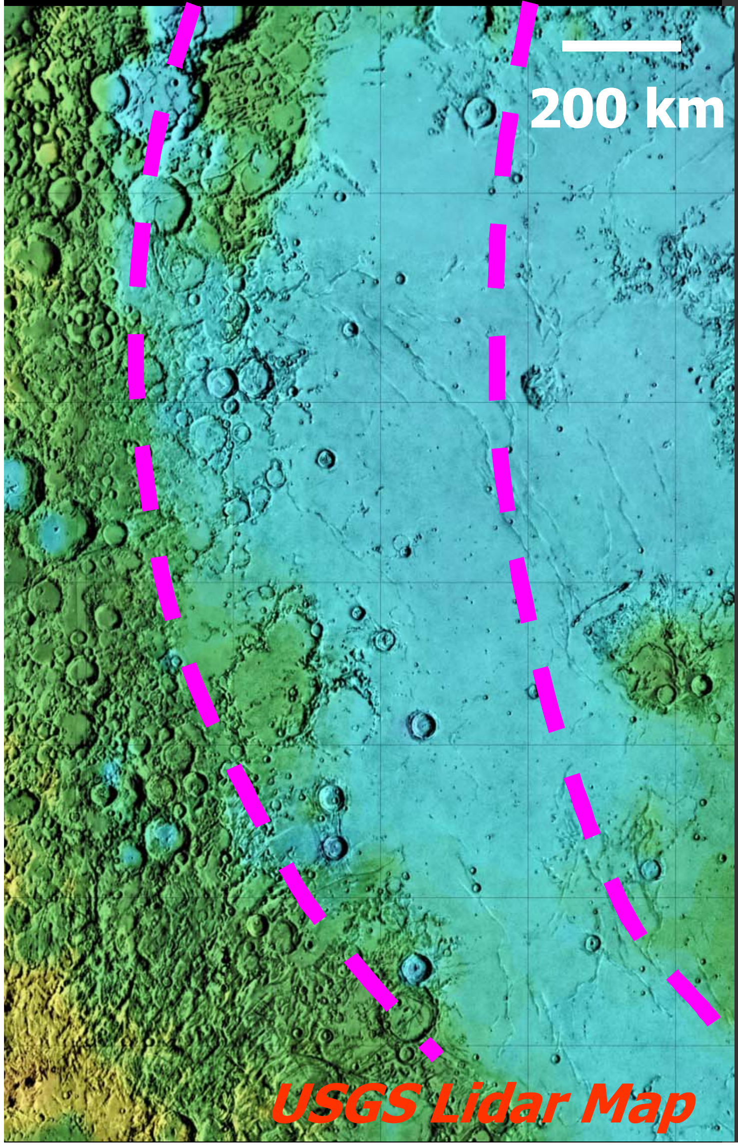
Basin Rings

Secondary Craters

Scours, crater chains, and valleys

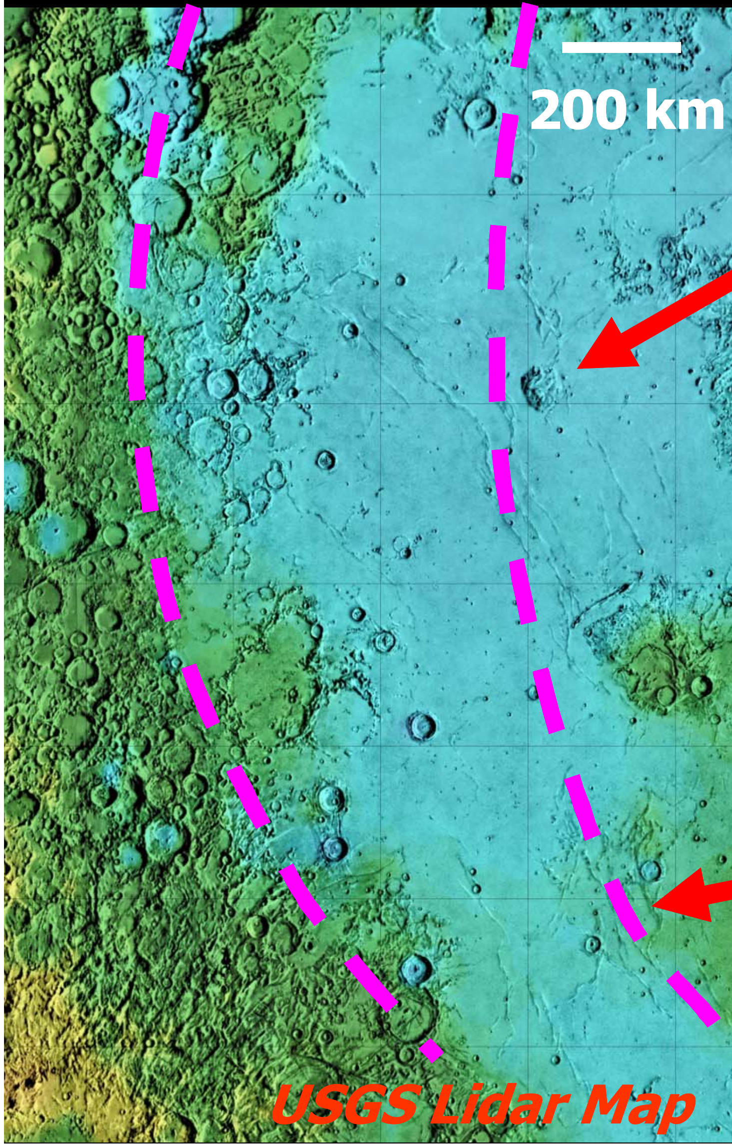
# Nearside Megabasin—Ring Structures

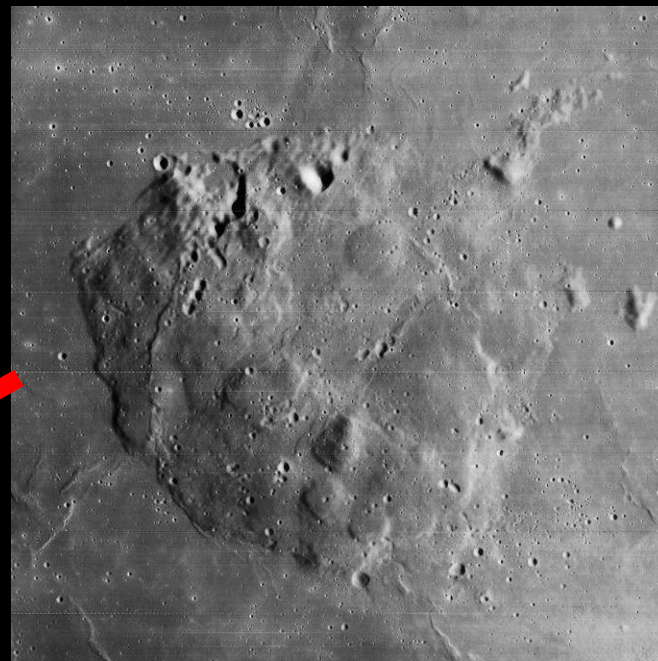
**Western Procellarum Edge**




# Nearside Megabasin—Volcanic Domes

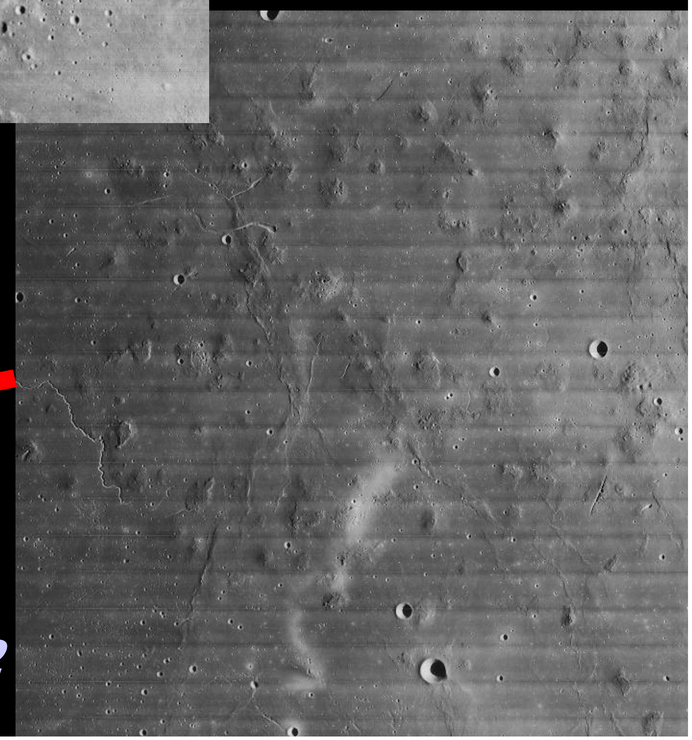
**Western Procellarum Edge**



**Mons Rümker**

*LO-IV-163-H2*

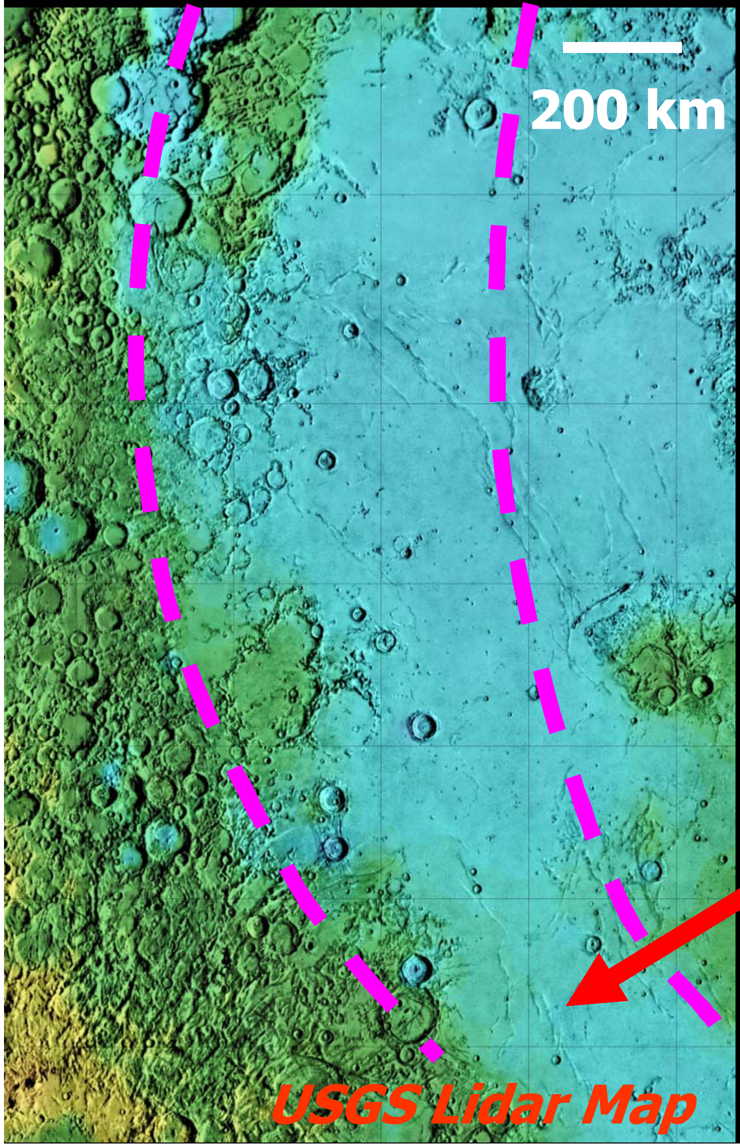


**Marius Hills**

*LO-IV-157-H2*

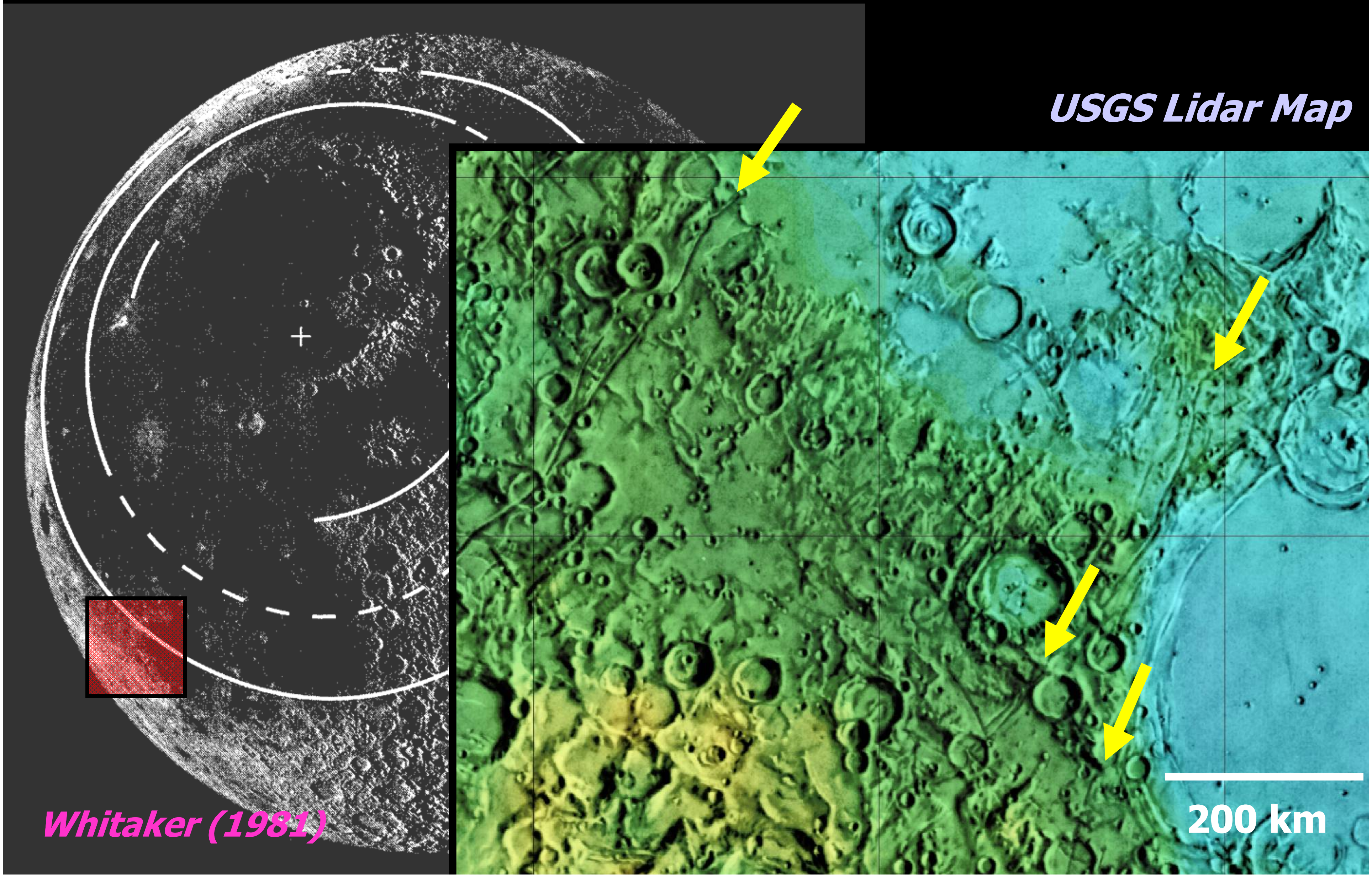
# Nearside Megabasin—Wrinkle Ridges

Western Procellarum Edge




*Lunar Aeronautical Chart 56*

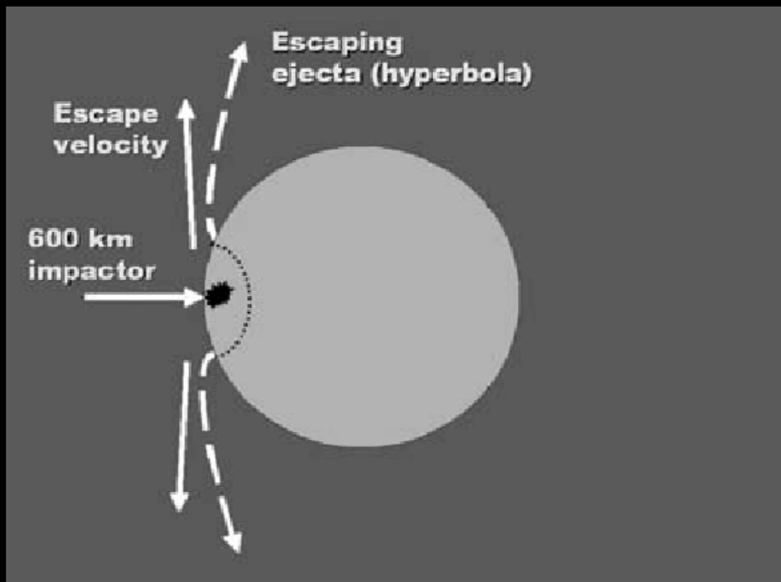
# Nearside Megabasin—Radial Graben

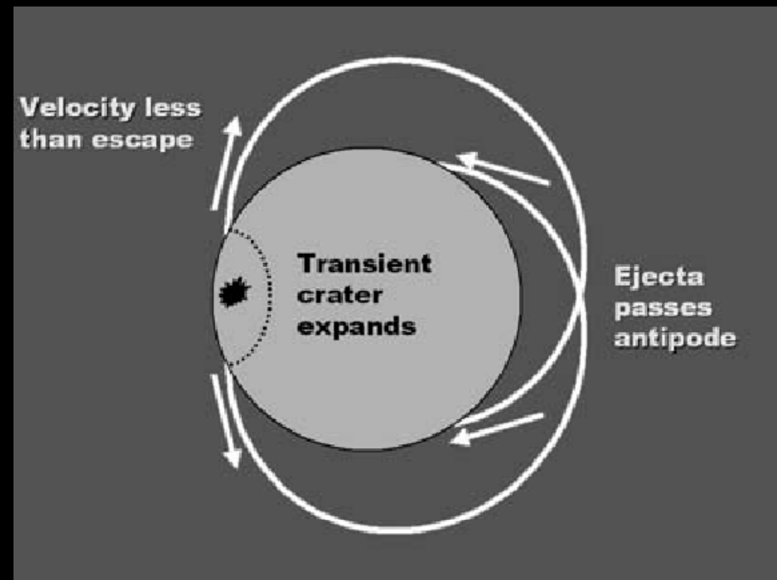


# Nearside Megabasin–Model

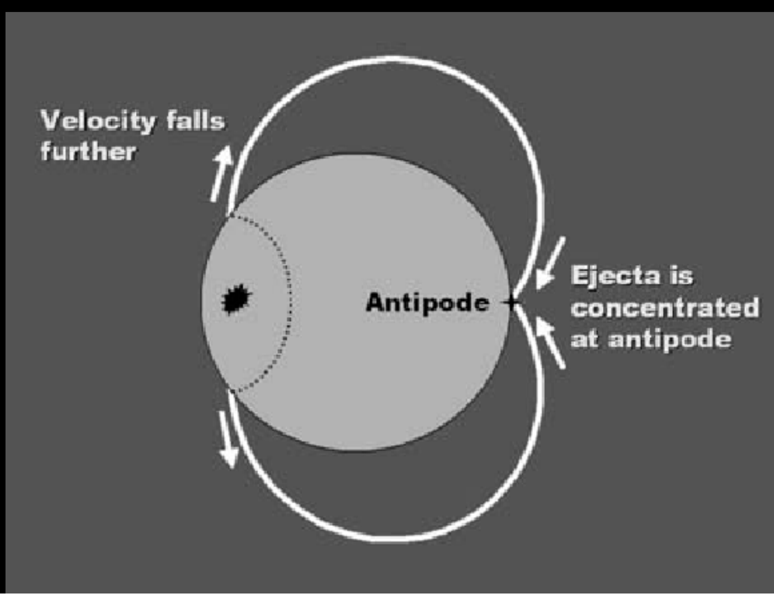
**A**

**B** *Byrne(2007)*

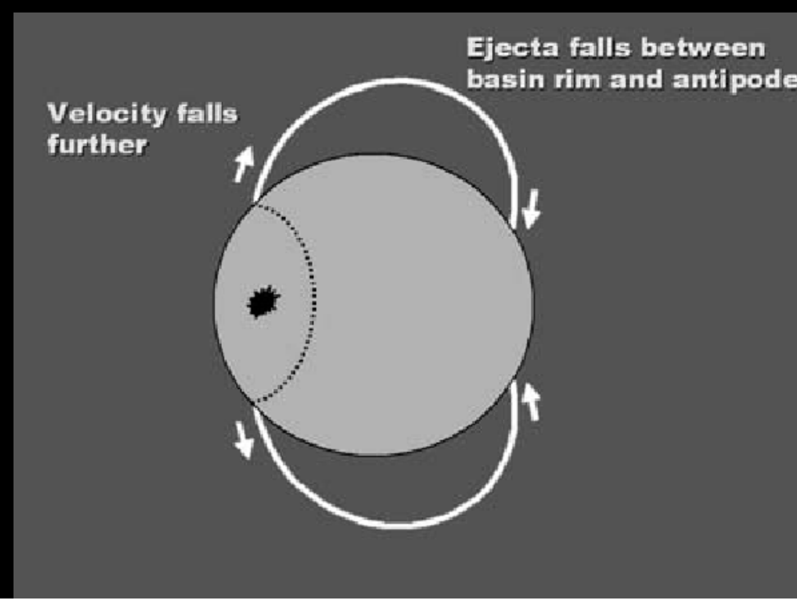



**C**

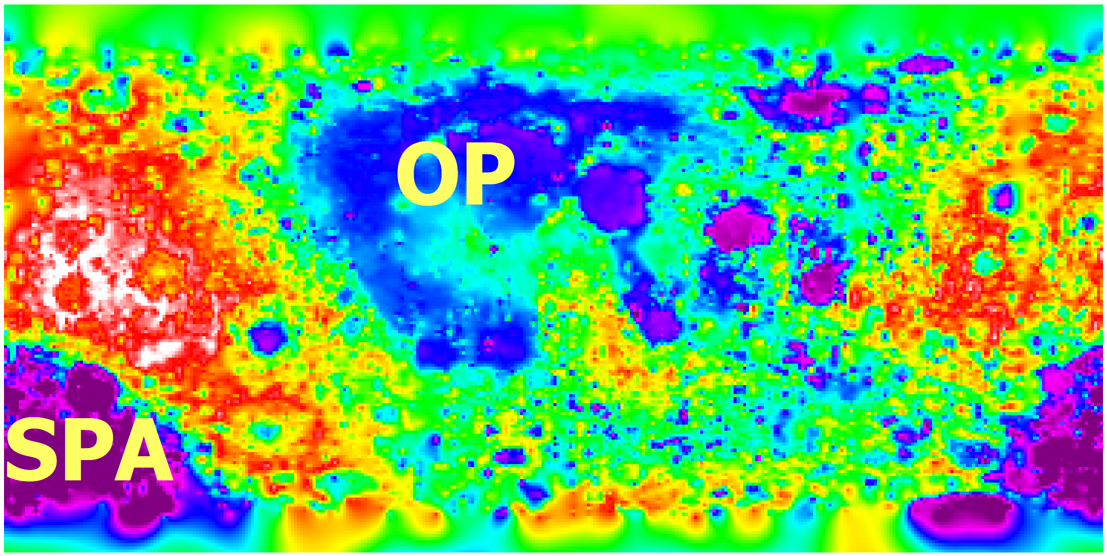


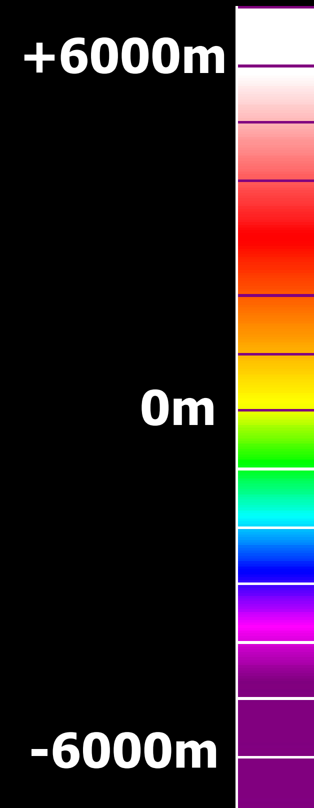

**D**



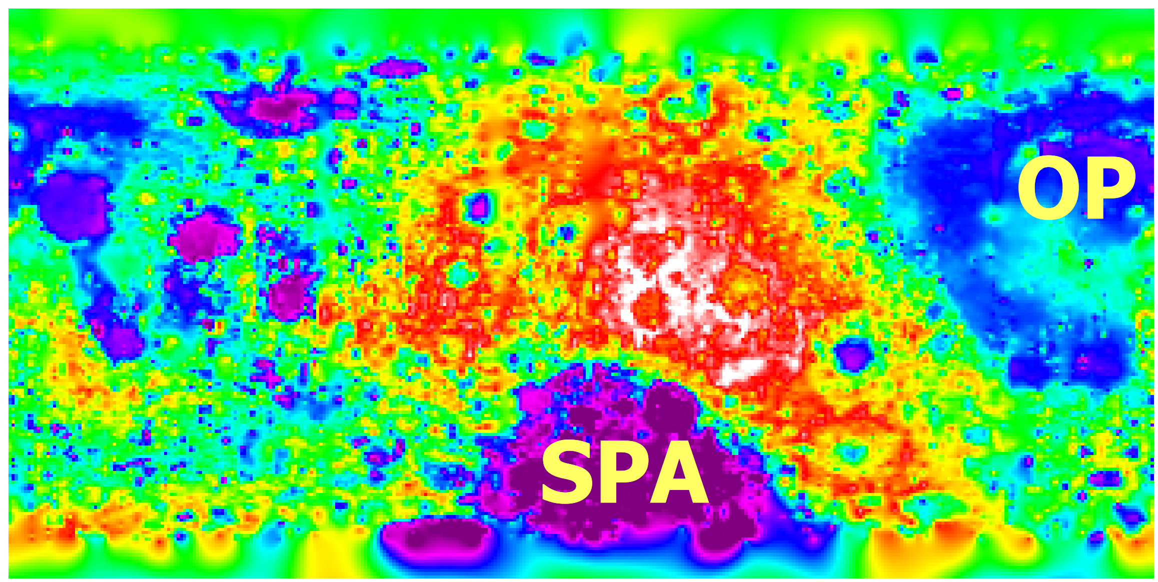
# Nearside Megabasin–Elevation

*Clementine Digital Elevation*



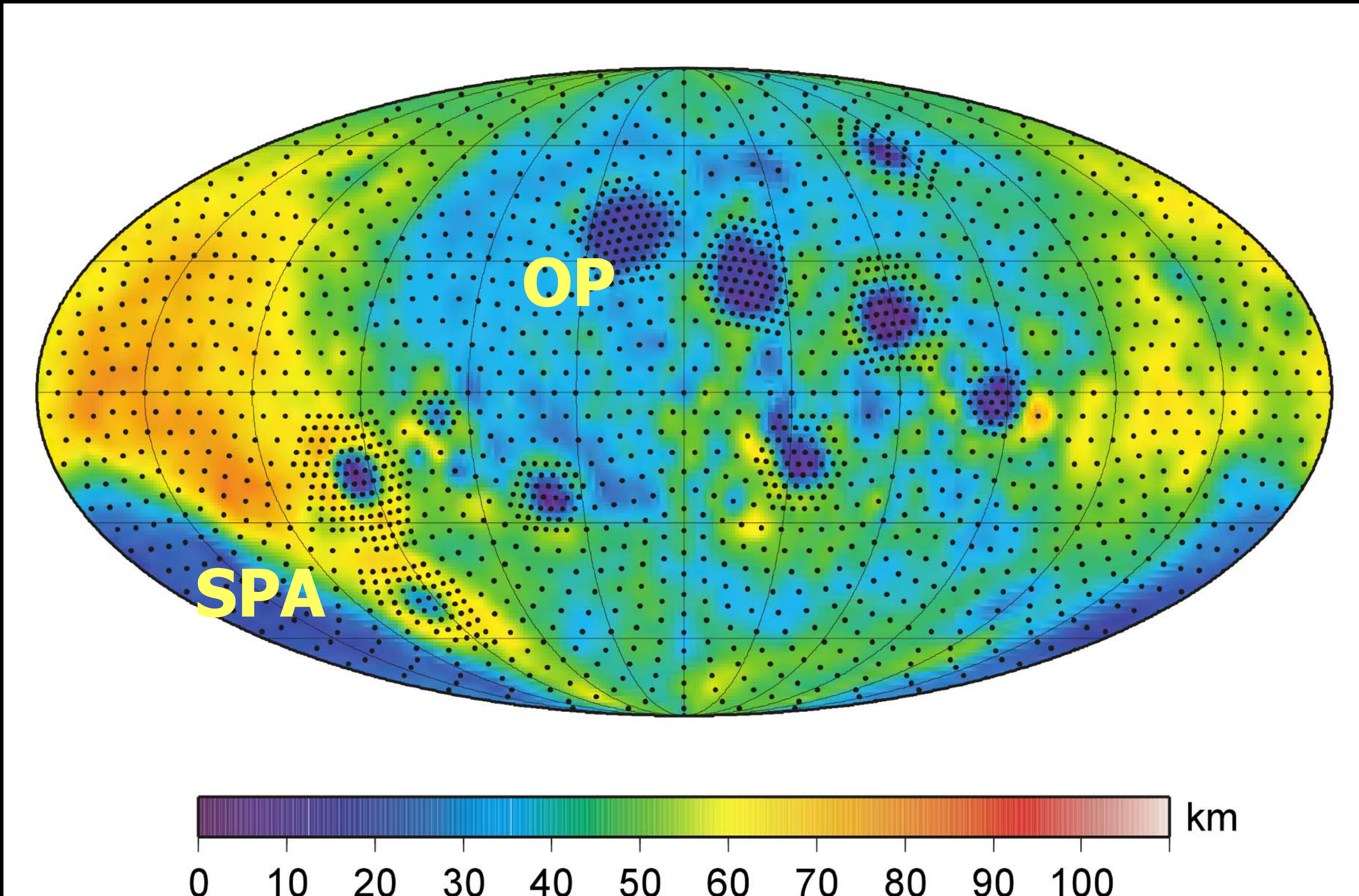

**Near Side**




**Far Side**

*Byrne (2007)*
*From Zuber (2004)*

# Nearside Megabasin–Crustal Thickness




*Wieczorek (2007)*

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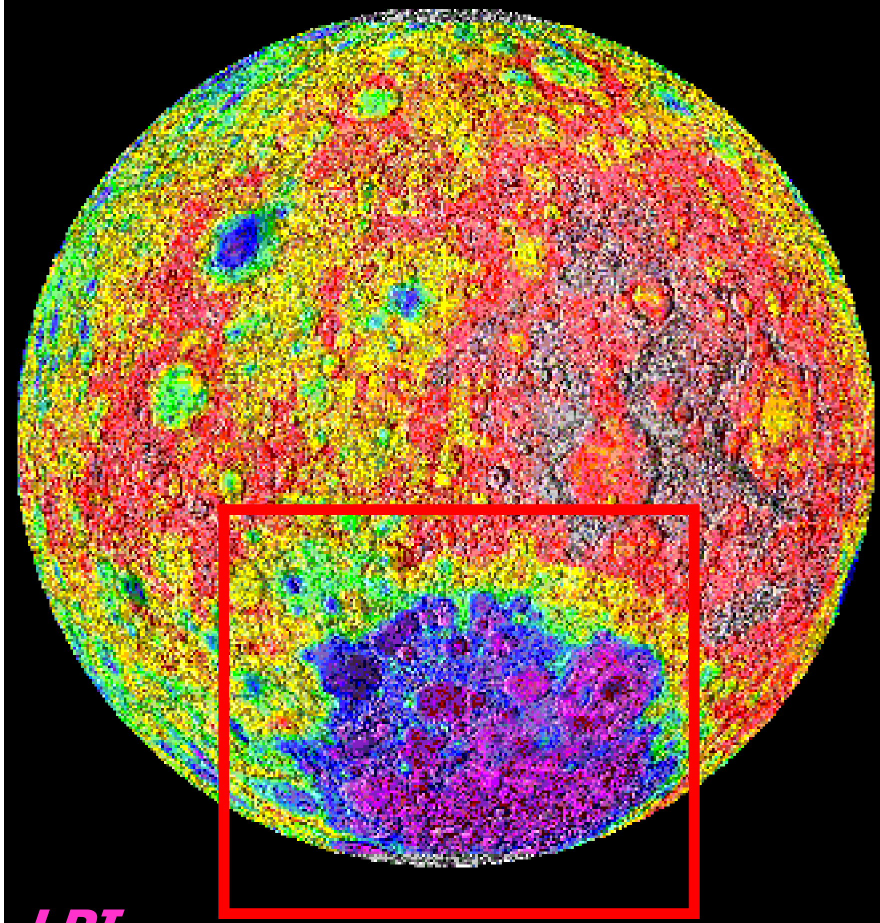
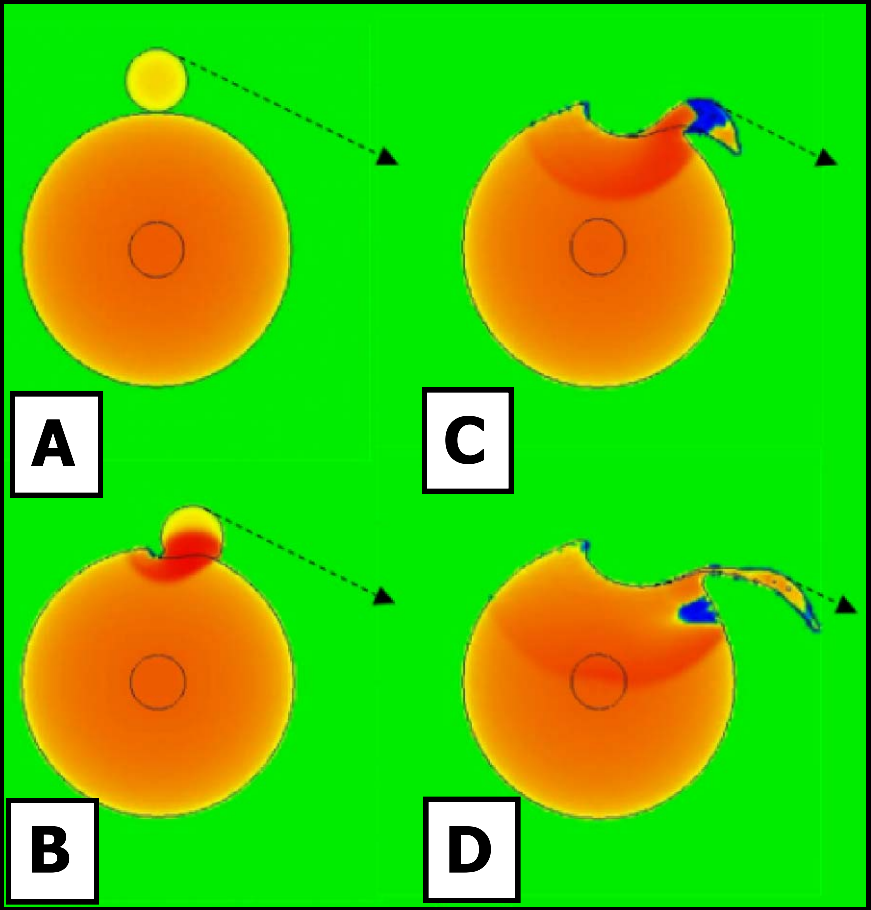
# South Pole-Aitken Basin

**Laser Altimetry**



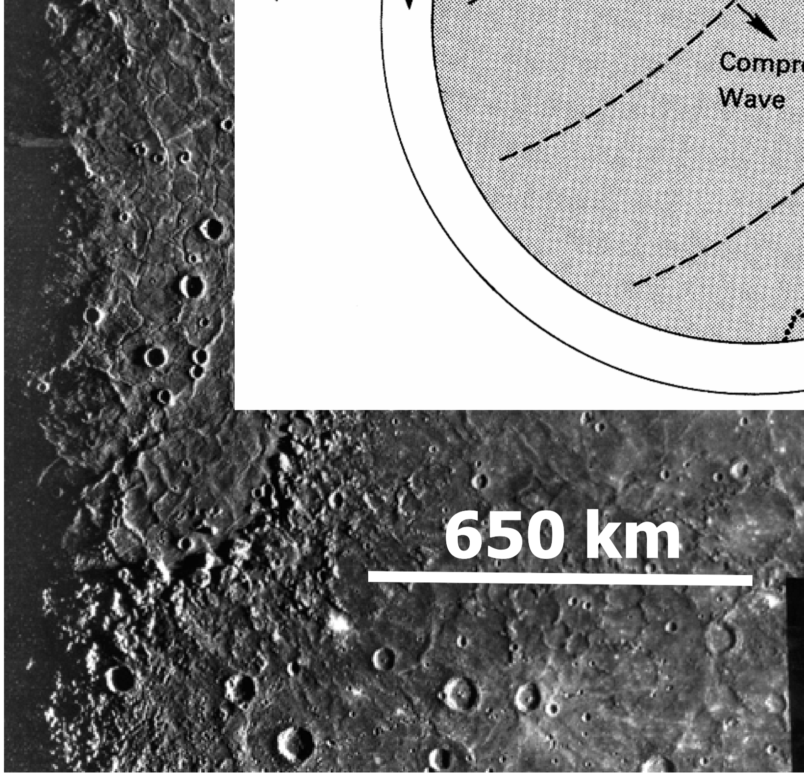
*LPI*

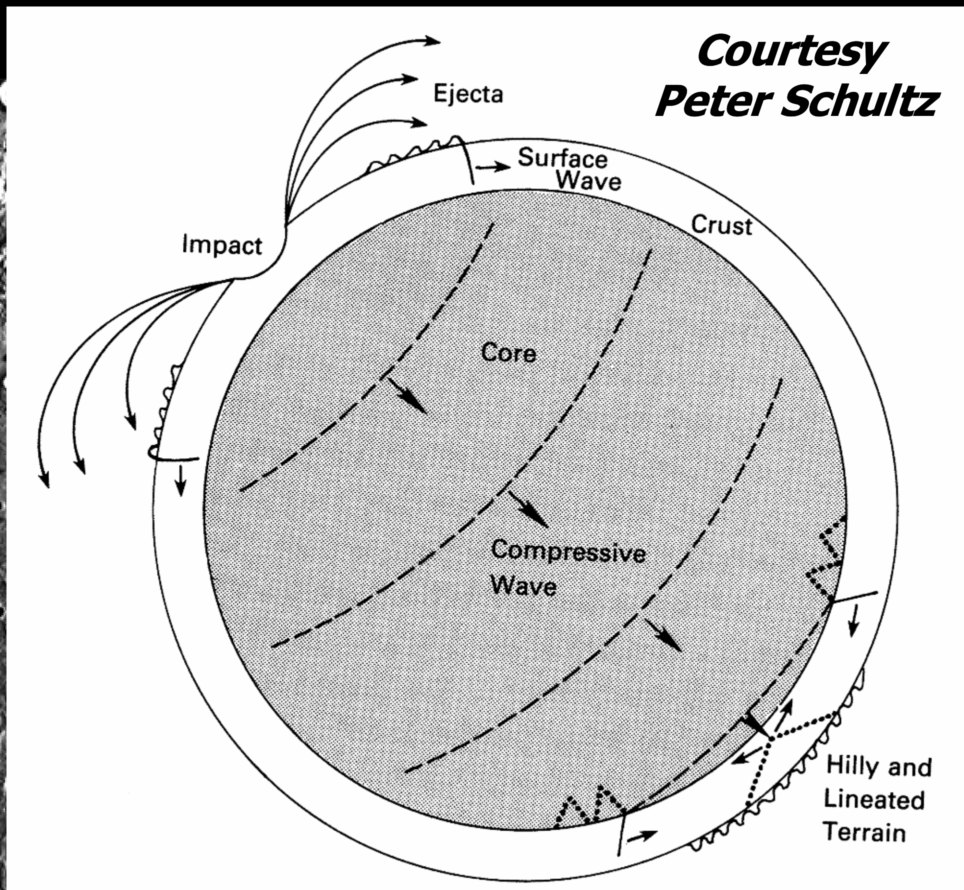
**Collision Model**




*Modified from Schultz and Crawford (2008)*

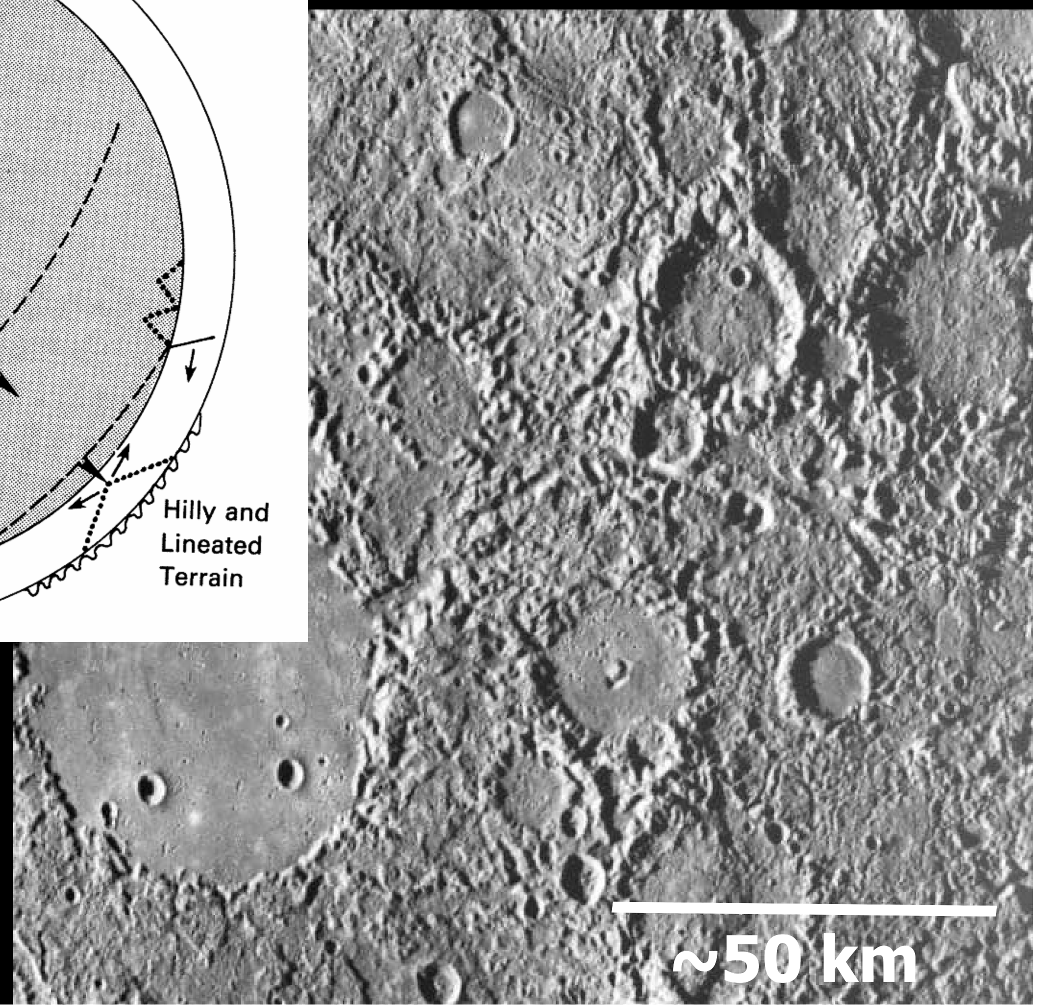
# Mercury: Caloris Basin




*Mariner 10 photographs*

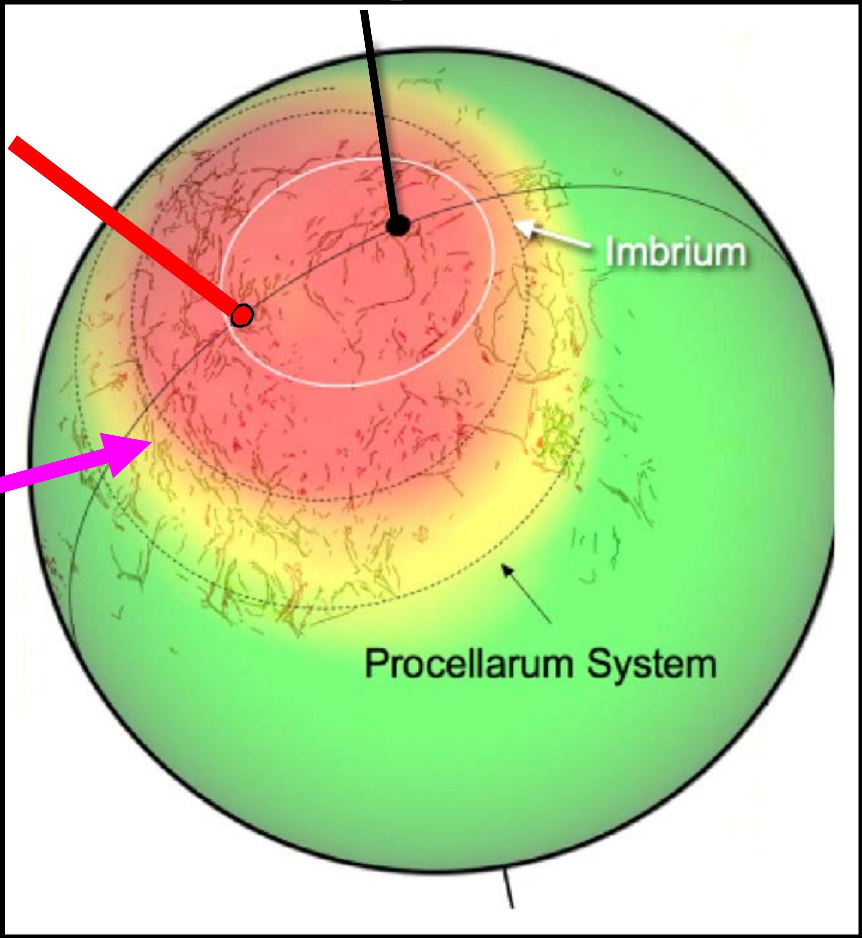
**Antipodal Point**



# Antipodal Effects from SPA Basin

Oceanus Procellarum Center

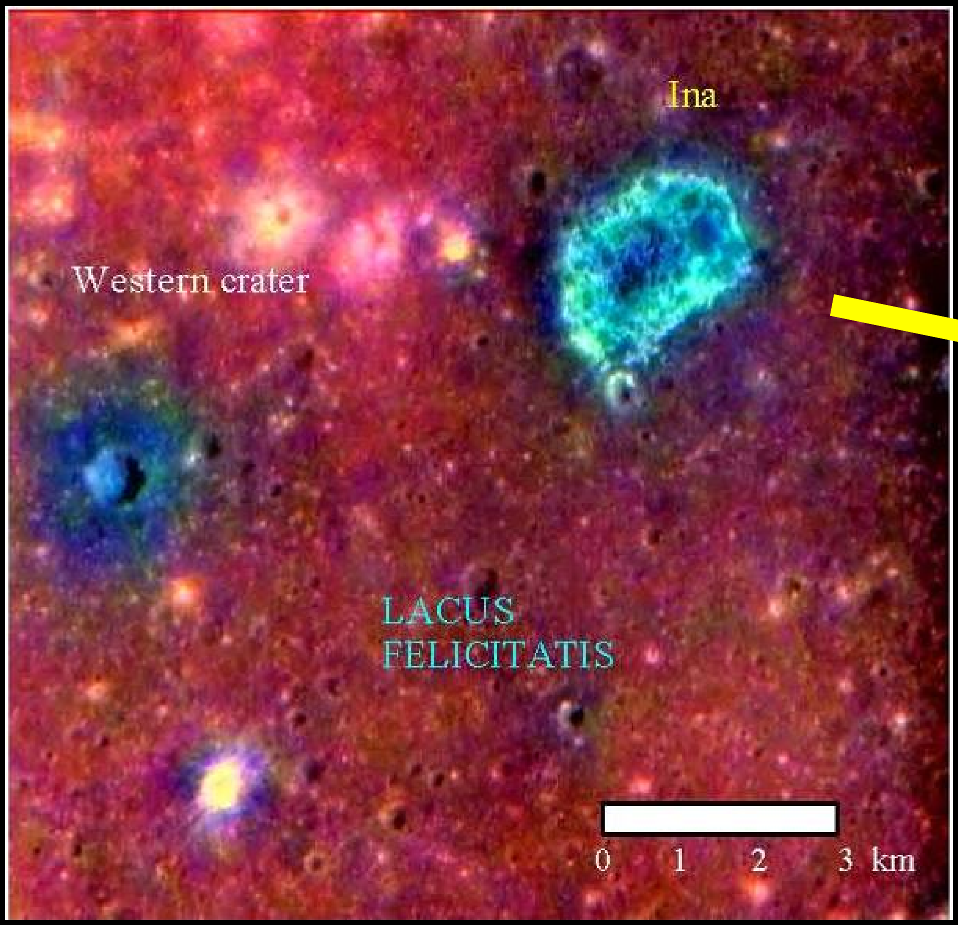
SPA antipode



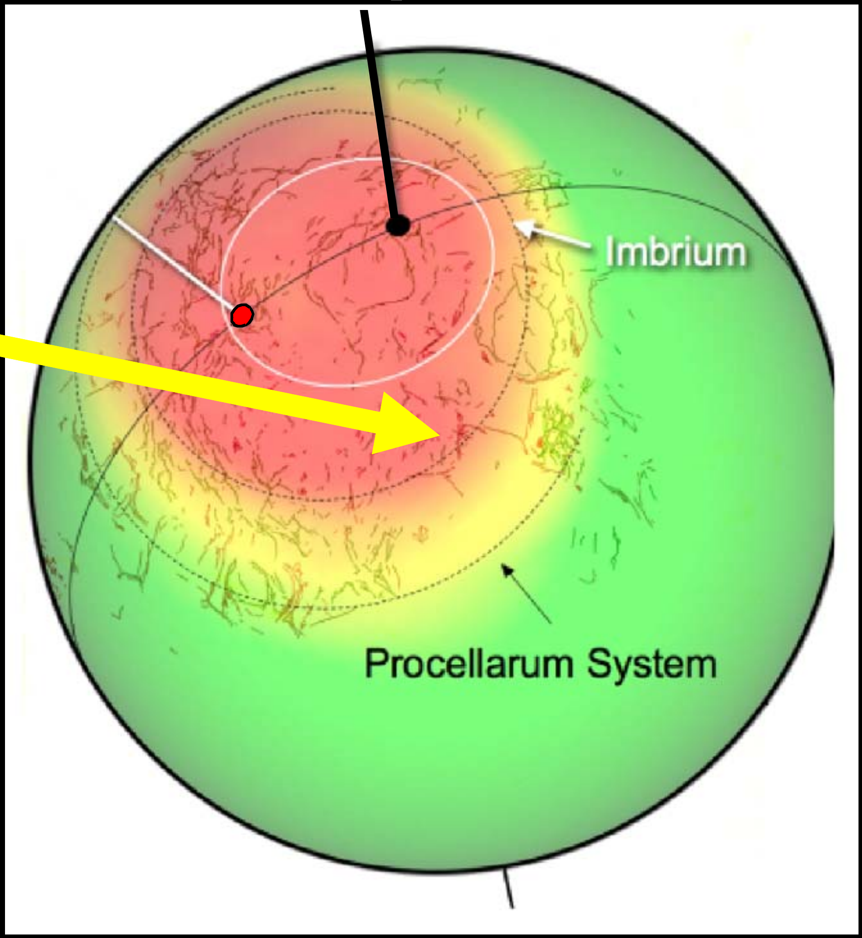

**Arcuate and radial graben and ridges**

*Modified from Schultz and Crawford (2008)*

# Ina–Recent Volatile-Rich Deposits




SPA antipode

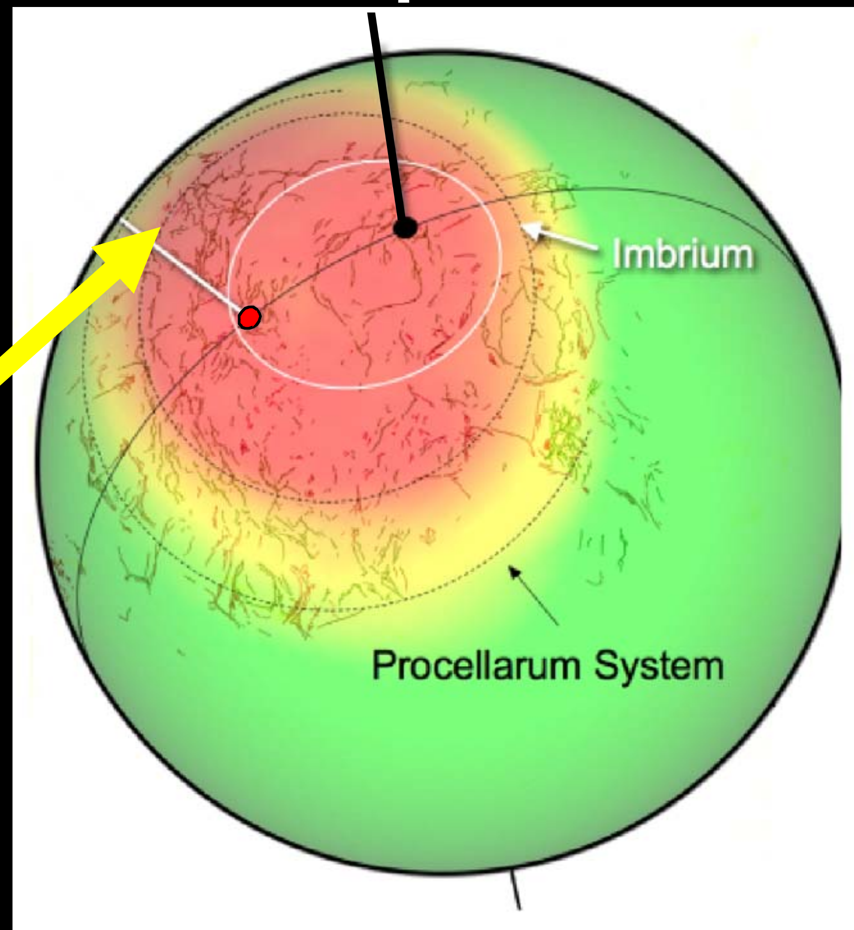



*Schultz et al. (2006)*
*Schultz and Crawford (2008)*

# Lichtenberg–Possible Young Volcanism


*McAlpin et al. (2008)*
*Clementine UV/VIS*

SPA antipode



# Summary

Clementine photograph

- Procellarum Basin: Nearside Megabasin
  - *-Thin, depressed crust*
  - *-Thorium, KREEP enrichment*
  - *-Elevation profile basin-like*
  - *-Radial graben*
  - *-Aligned volcanogenic features*
- Procellarum: Non-basin attributes
  - *-No mascons (isostatic equilibrium)*
  - *-Ring structure incomplete*
  - *-Secondary craters poorly documented*
- South Pole-Aitken Basin:
  - *-Antipodal structures in Procellarum area*
  - *-Procellarum volatile-rich deposits—Ina*

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