

Contrasting Geologic Settings for Lunar Ice Deposits Near Shackleton Crater versus Mons Mouton

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Outline

- **Brief geologic history of the Moon**
- **Three hypotheses for ice deposition**
- **A closer look at the South Pole**
 - **Mons Mouton**
 - **Shackleton Crater**
- **Summary**

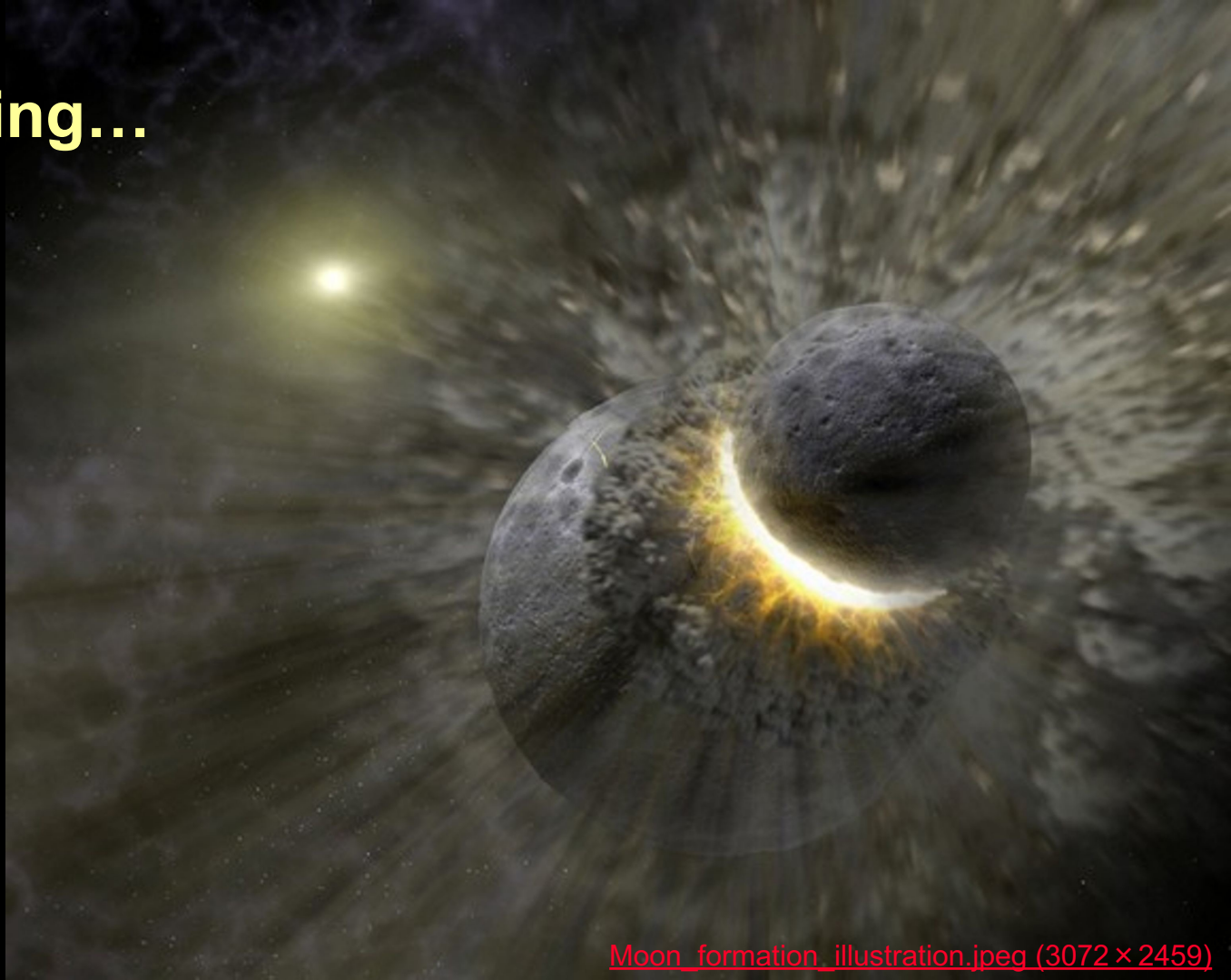


In the Beginning...

- Giant impact!
- 4.50 Ga

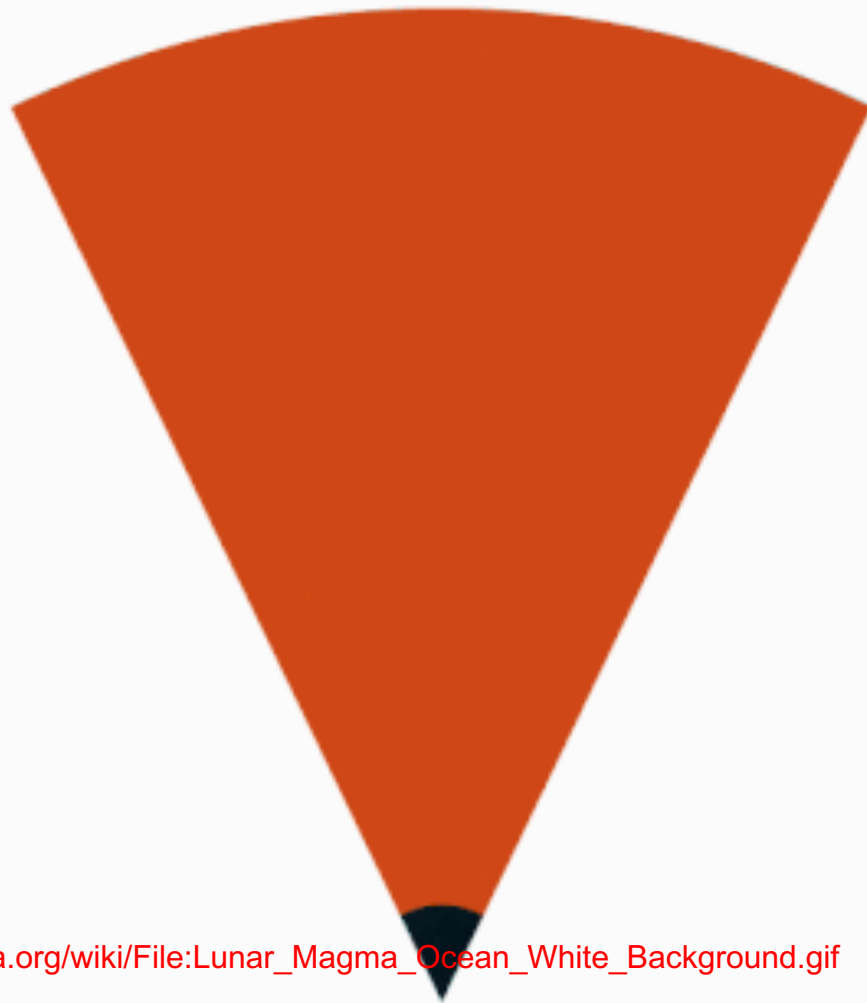
[Schneider & Kleine 2025](#)

[EPSL 669](#), Article 119592

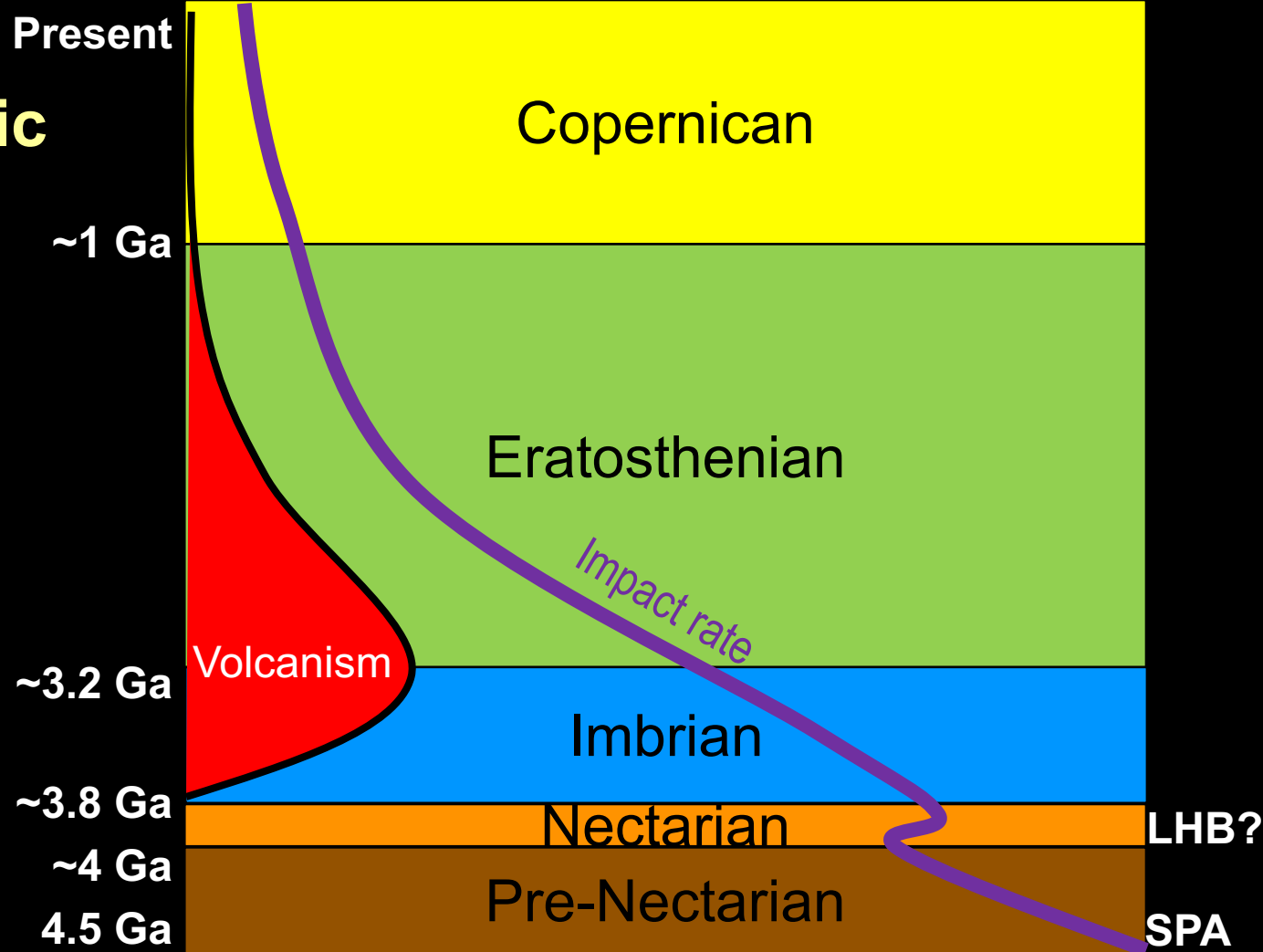


The Beginning Ends

- Magma ocean freezes
- Anorthosite crust floats
- urKREEP lurks below
- Takes ~70 My?
- Dichotomy forms by ???



Lunar Geologic Timescale



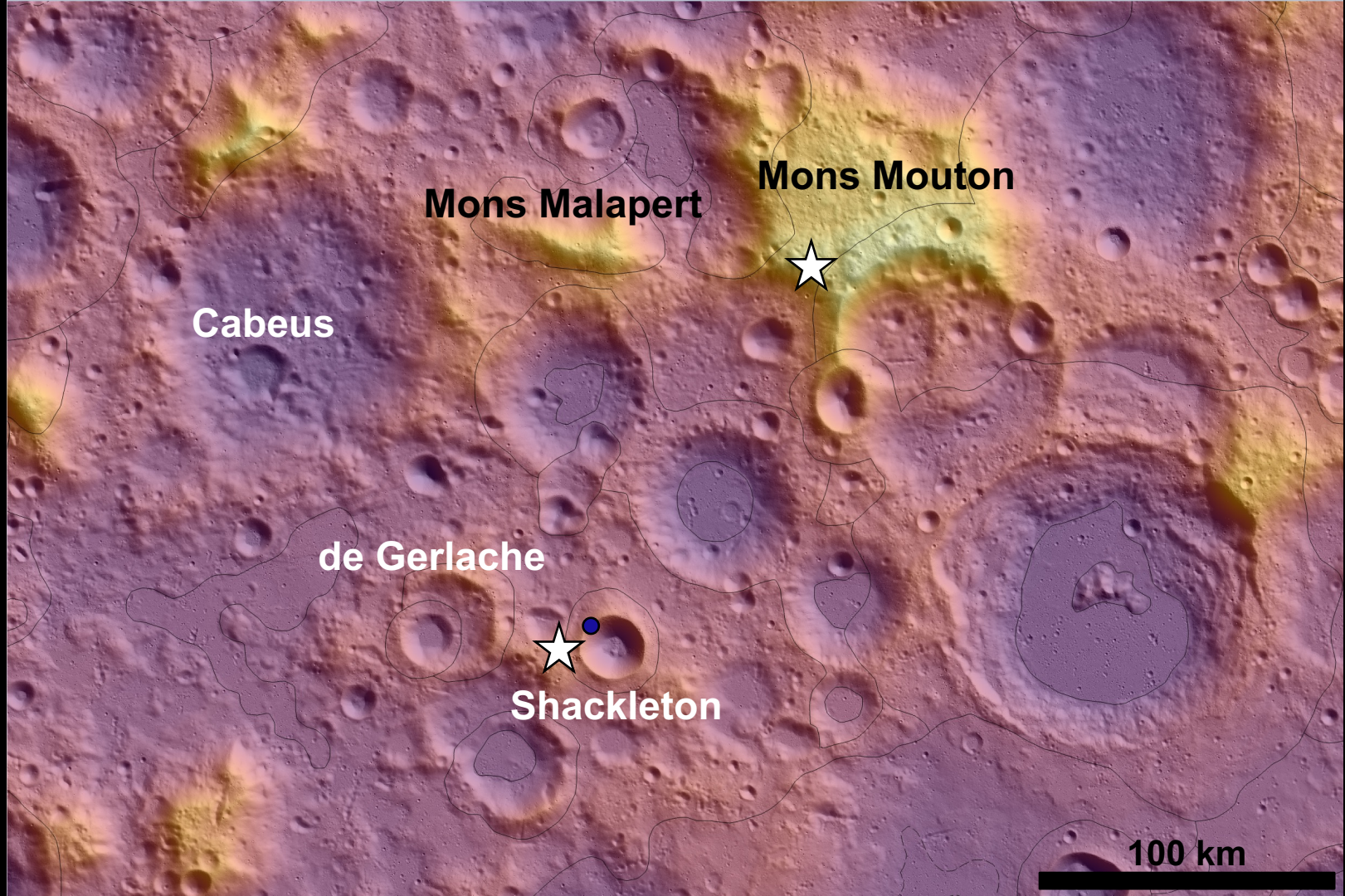
Ice Deposit Formation Hypotheses

- **Impacts**: ~Gt water per impact; ~95% by 3.8 Ga [Cannon et al. 2020]; expect N, C, and S with H
- **Volcanism**: ~Mt water per eruption; >95% by 3.2 Ga; expect C, S, and Cl+F with H [Needham & Kring, 2017]
- **Solar Wind**: Continual. 100s of ppm (in the very top grains) in only 100s of yrs (e.g. Hurley et al., 2023¹; Starukhina, 2001²)
- **Altered by impacts, radiation, temperature changes...**

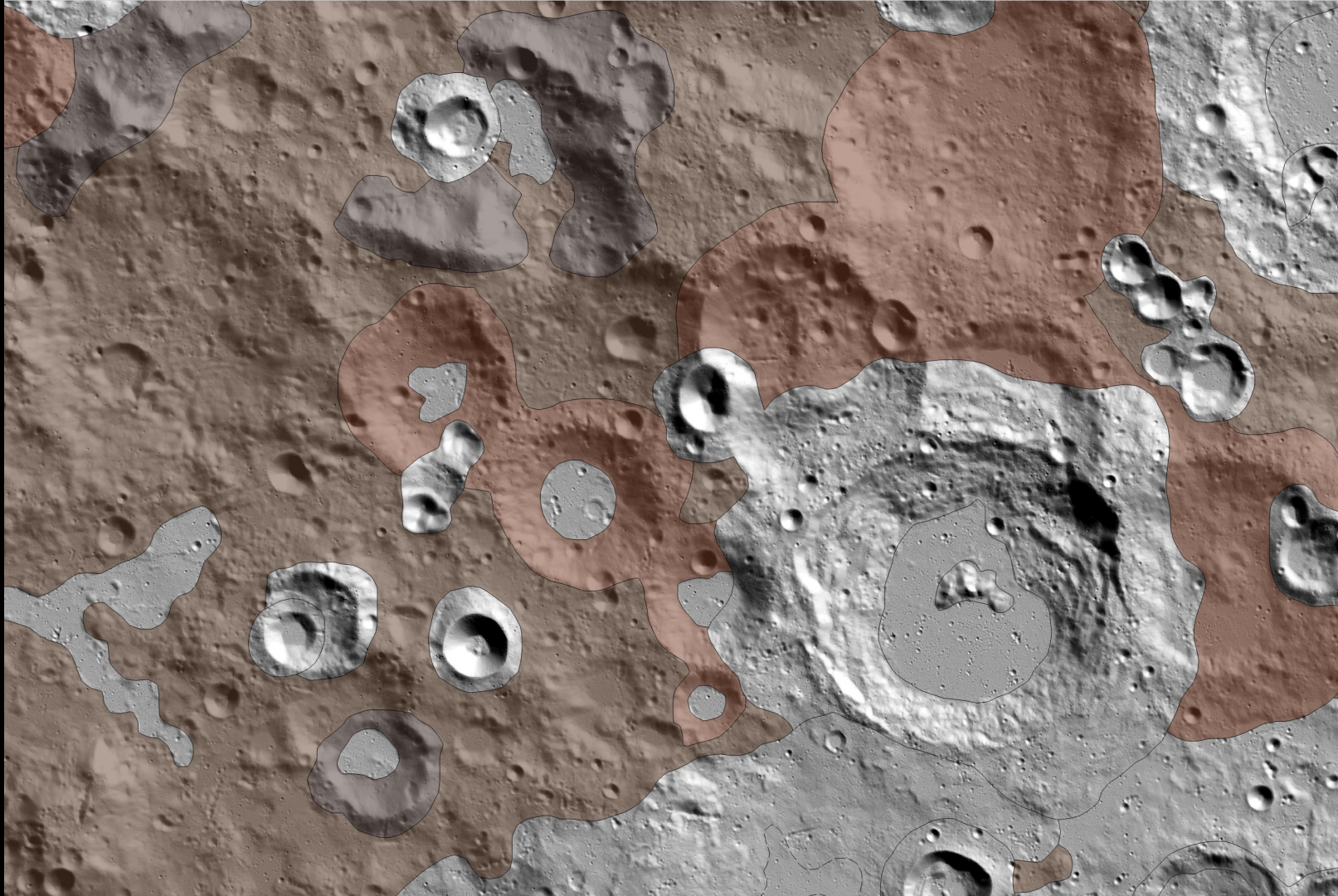


1: New Views of the Moon 2, Rev. Mineral. Geochem. 89 pp. 787-827;
<http://dx.doi.org/10.2138/rmg.2023.89.18>
2: J. Geophys. Res. 106, 14,701-14,71

South Pole

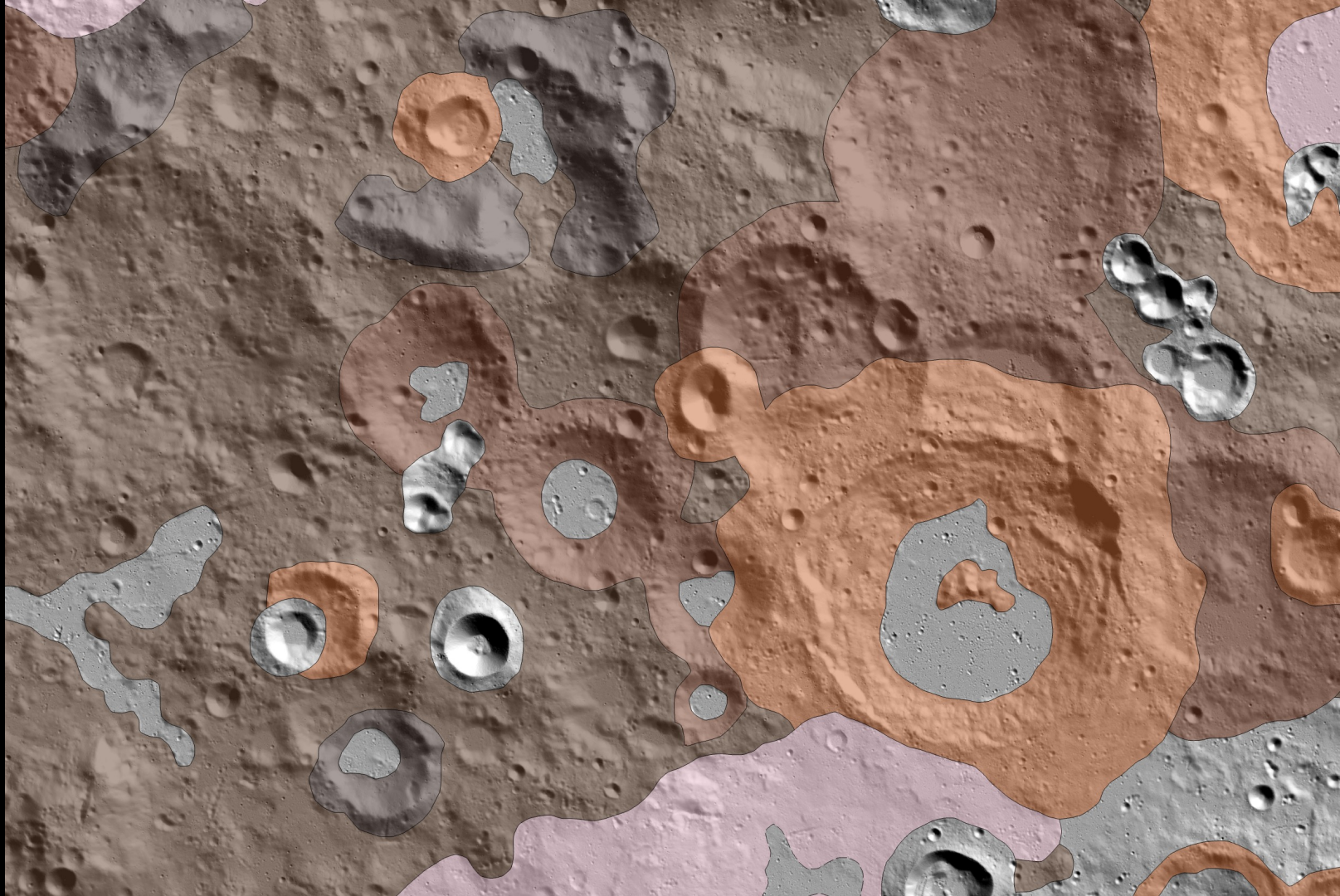


pN
>4 Ga

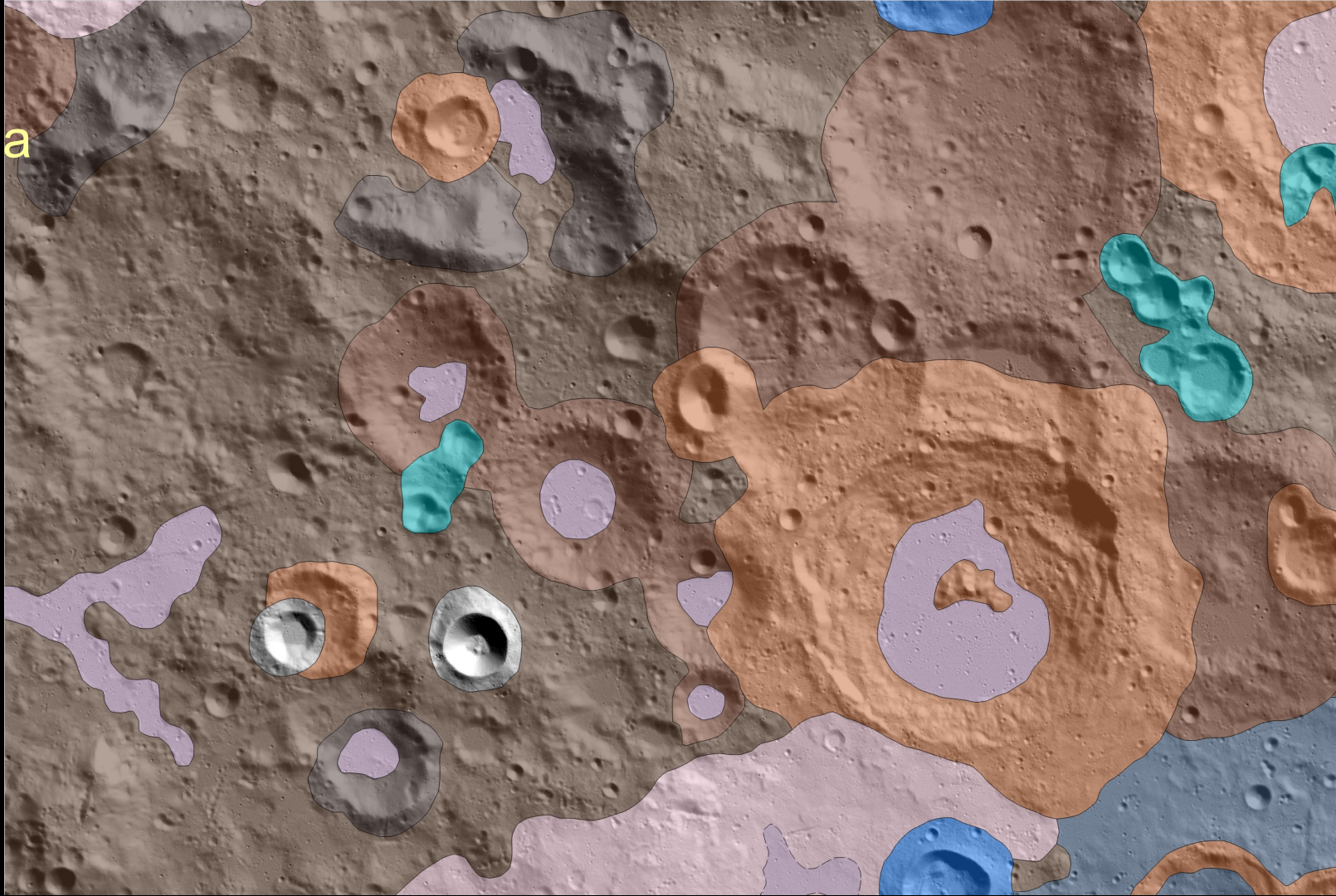


N

4-3.8 Ga

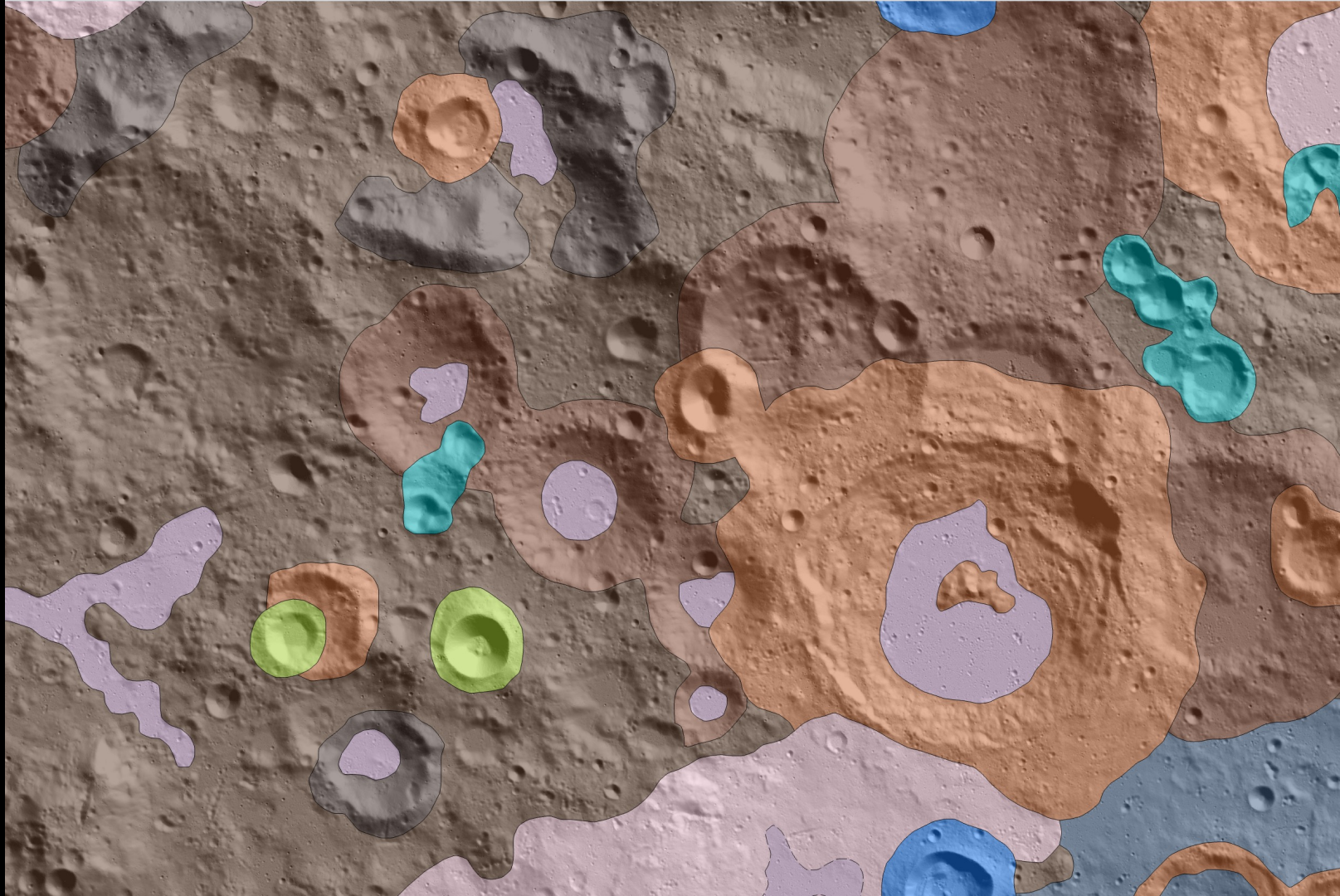


I
3.8-3.2 Ga

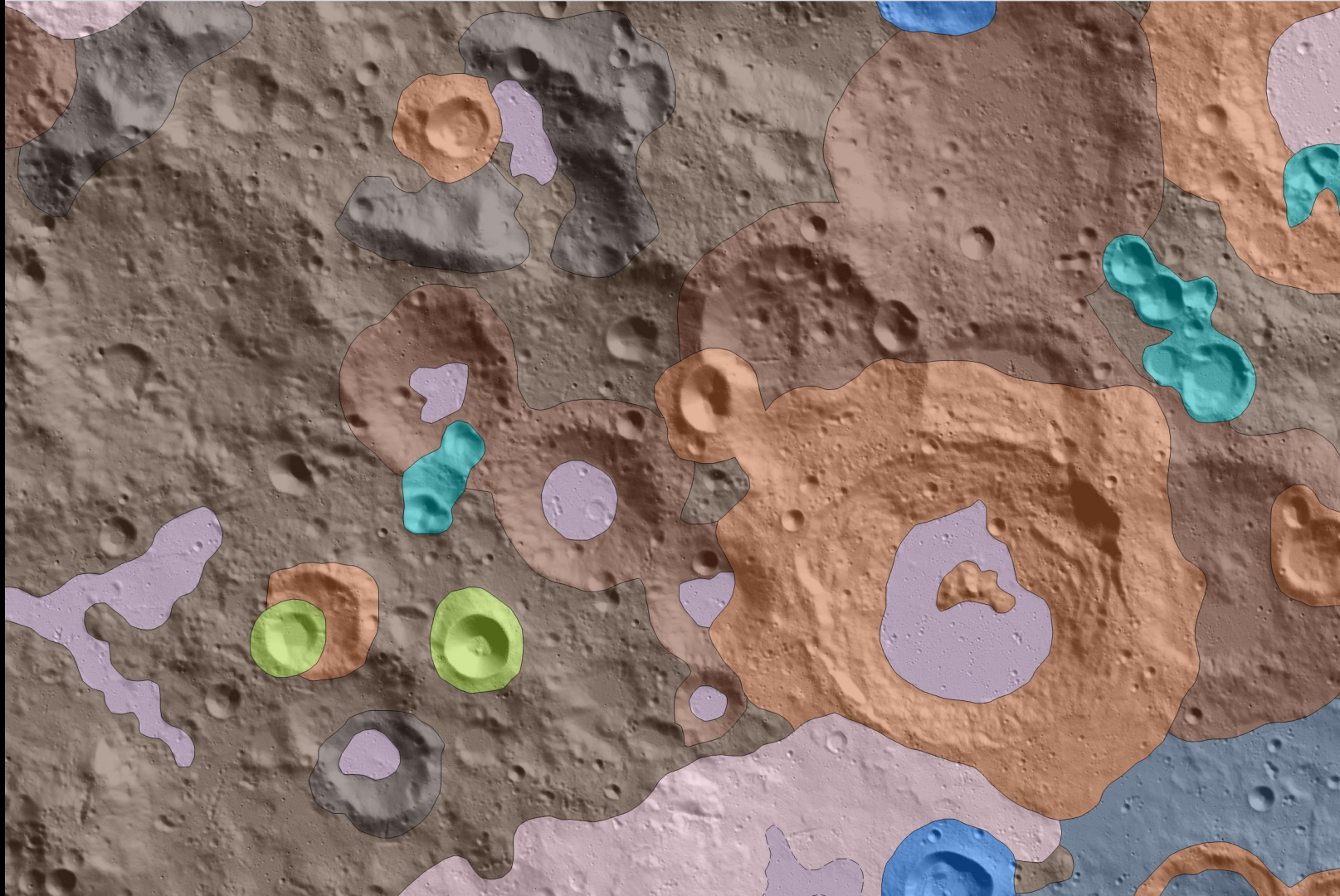


E

3.2-1 Ga

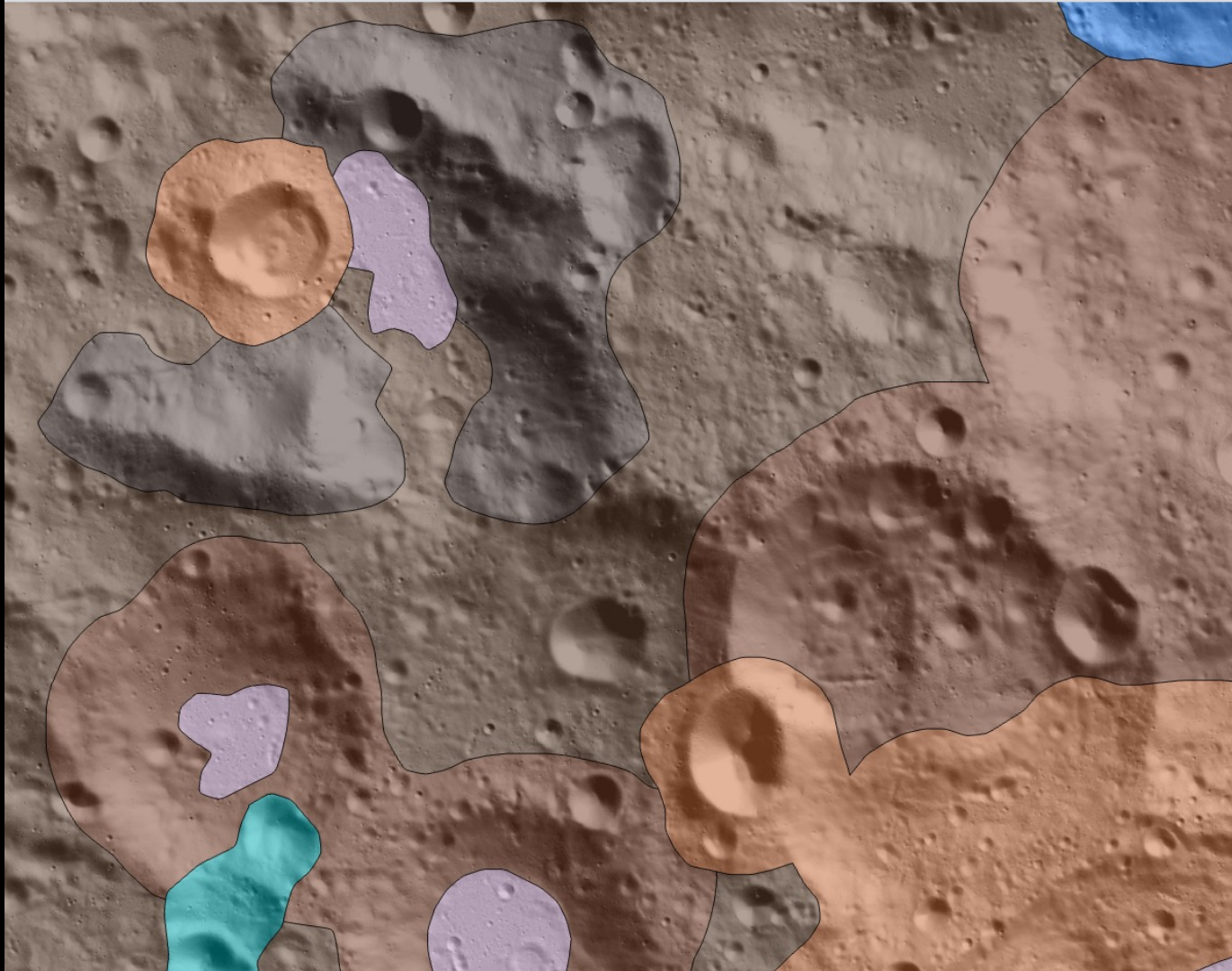


C
<1 Ga



Mons Mouton

- Ancient!!!
- Highest peaks in the region (>8000 m of relief ~Mt. Everest)



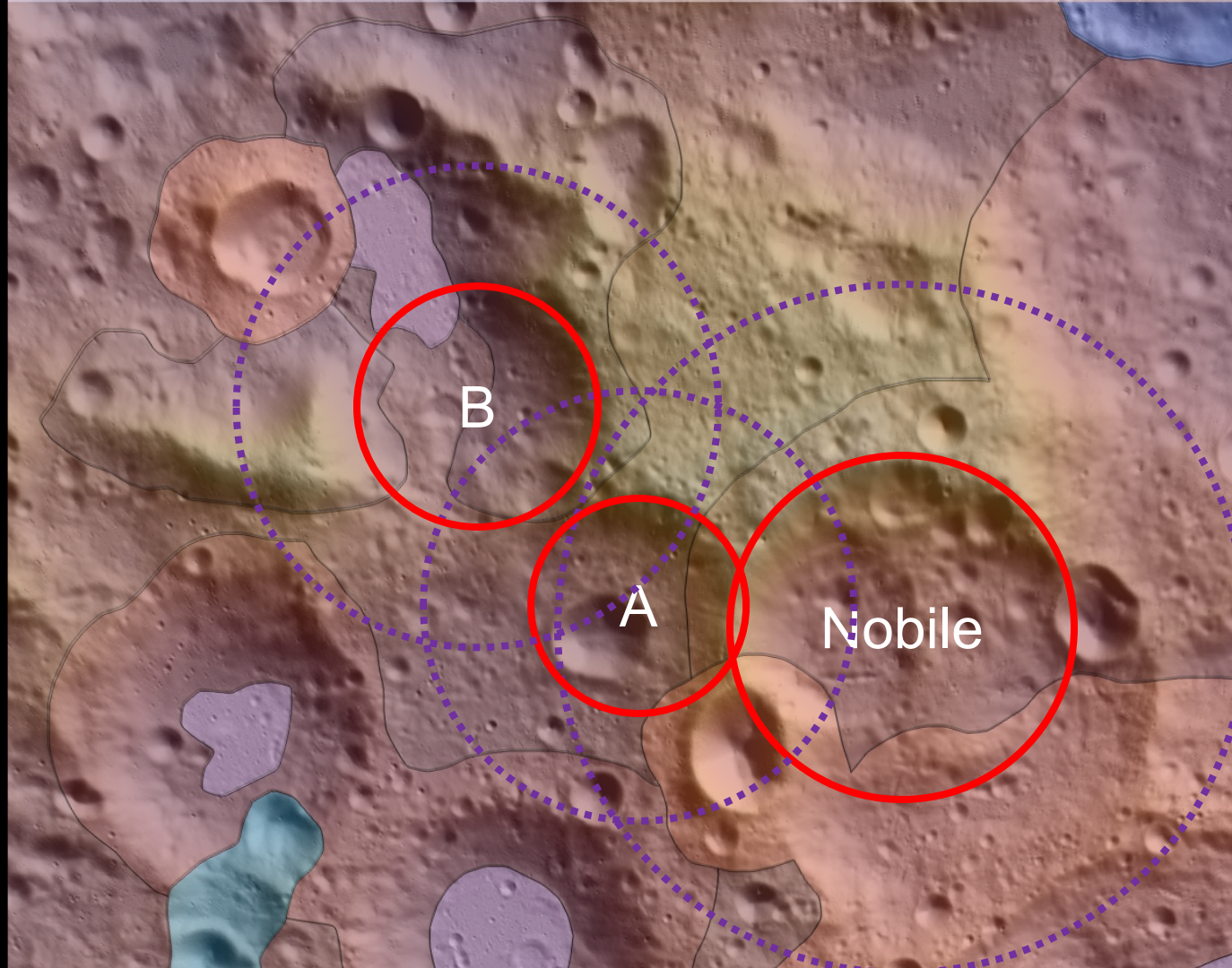
Mons Mouton

- Expect decameters of ejecta from surrounding craters

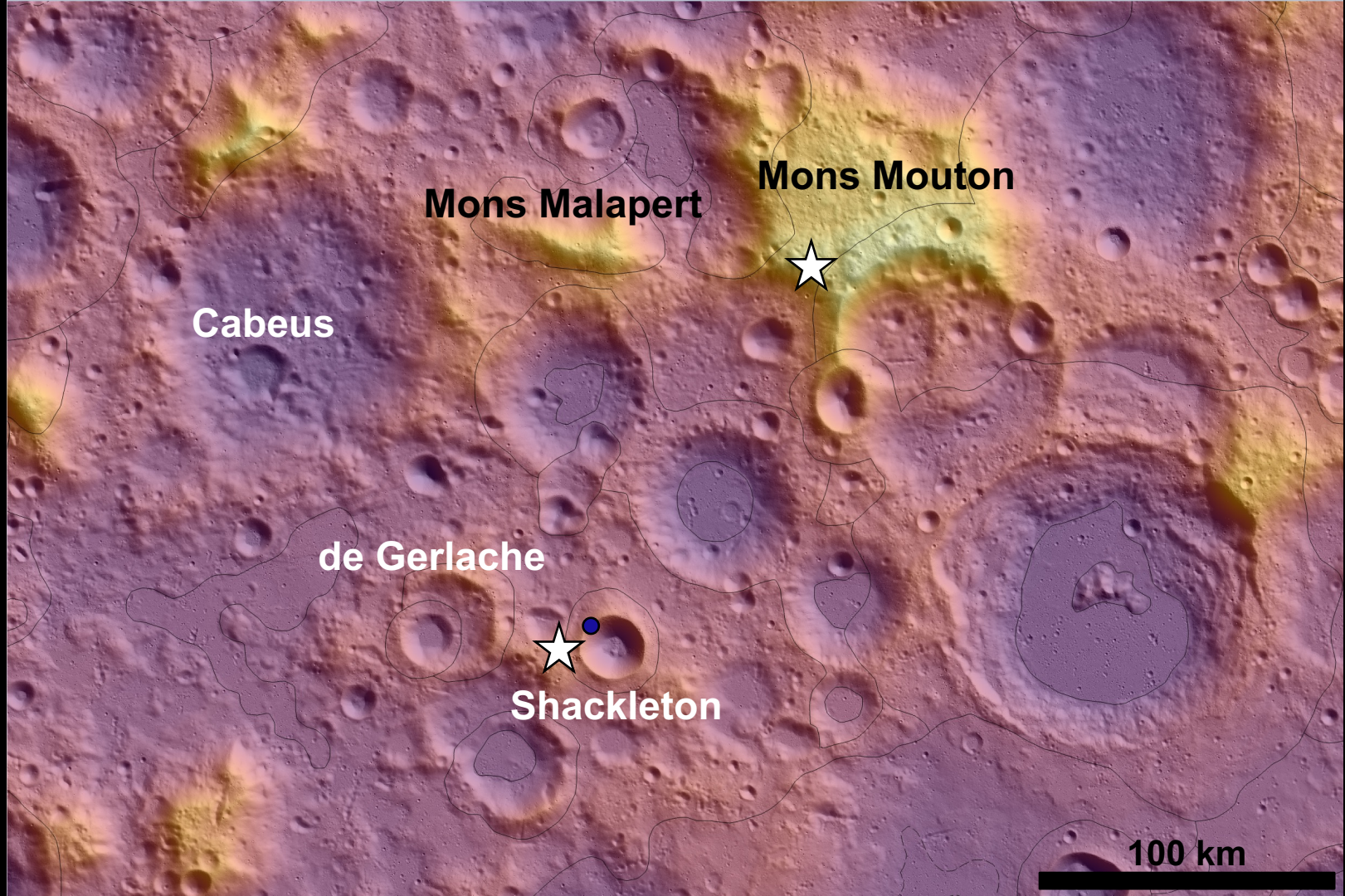
Nobile: $D=80$ km;
ejecta@80km=70m

Crater A: $D=50$ km;
ejecta@50km=50m

Crater B: $D=60$ km;
ejecta@60km=60 m

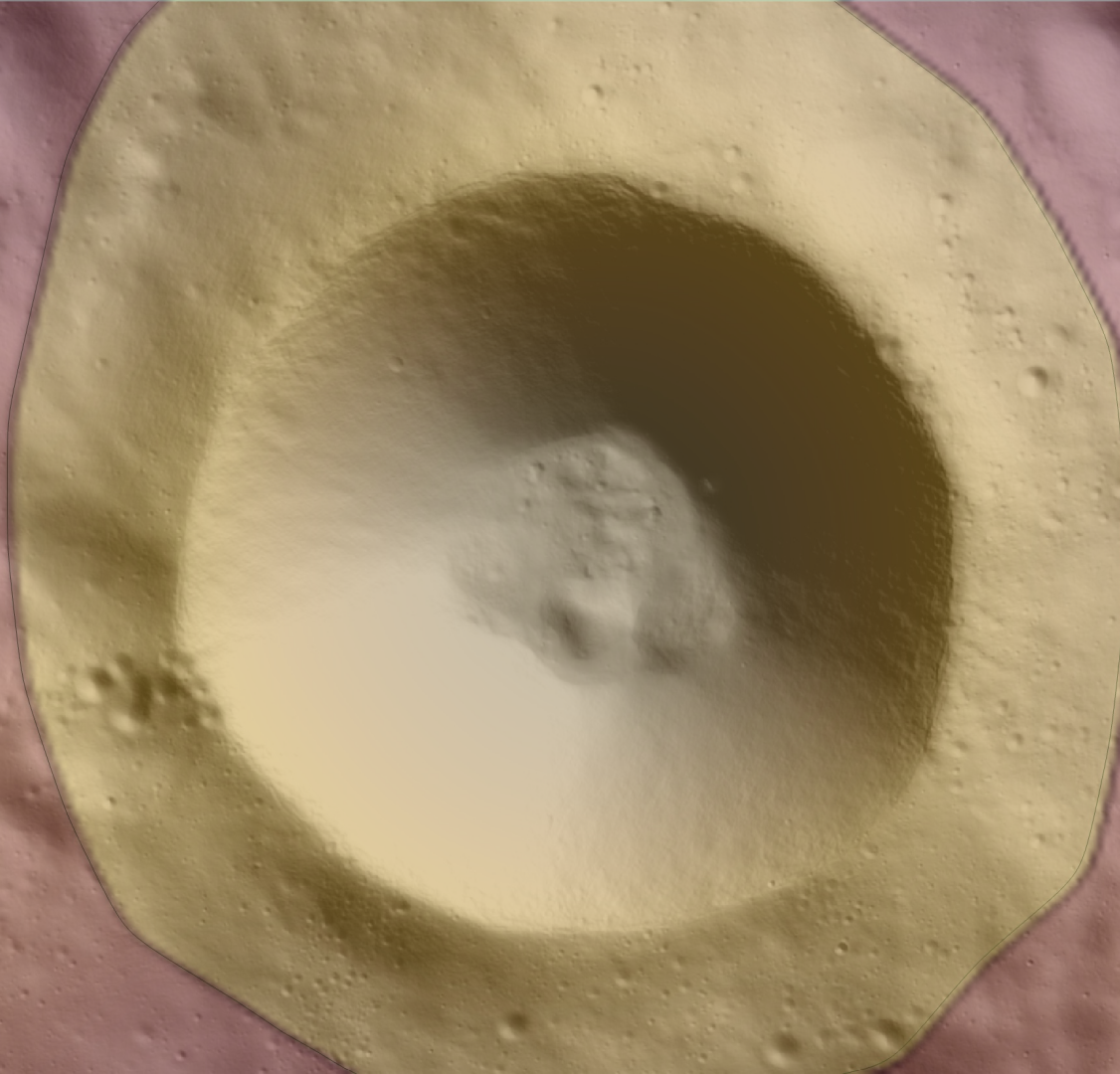


South Pole



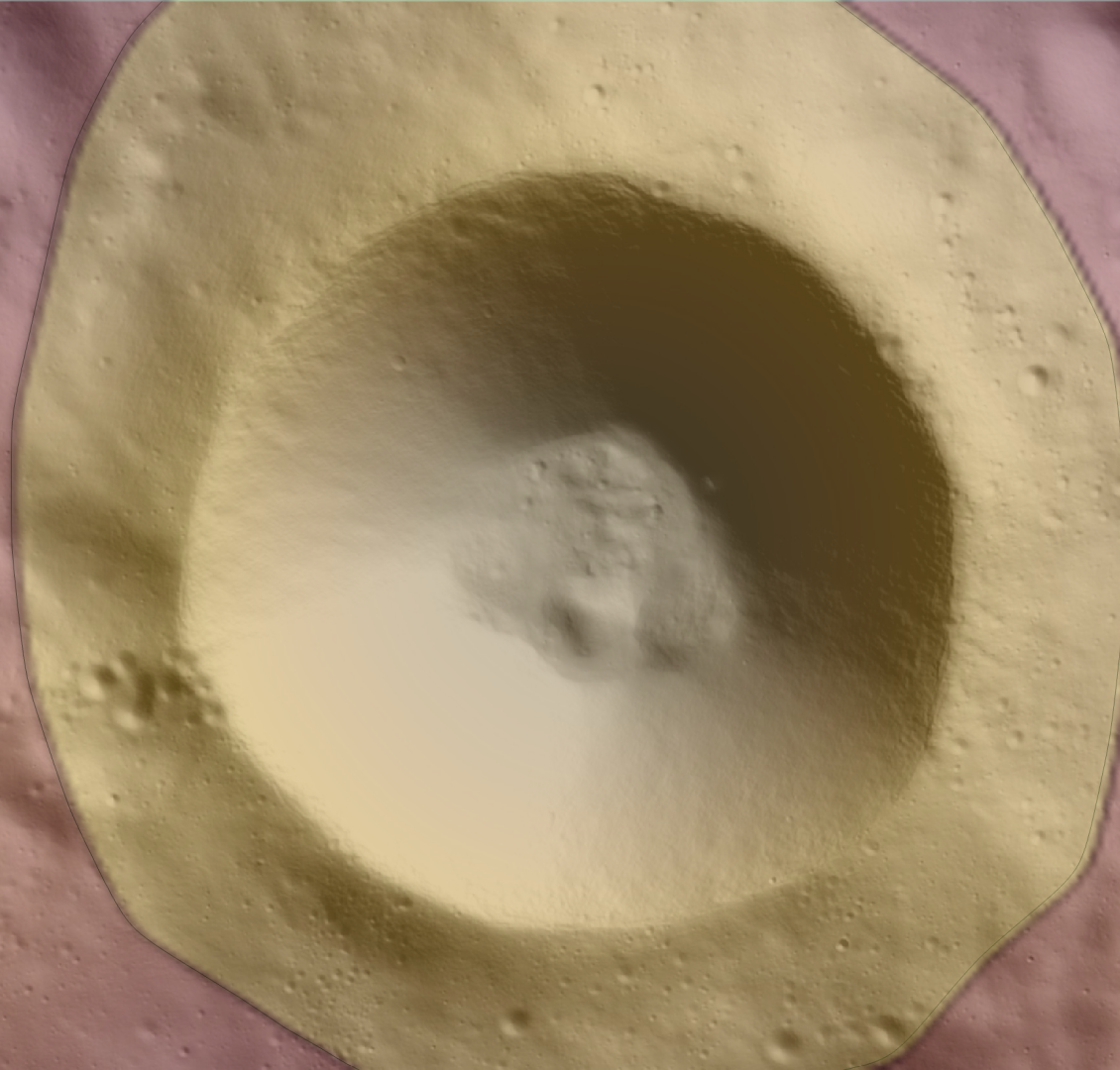
Shackleton Crater

- Most recent significant crater (20-km diameter)
- Age is debated: ~1-3.6 Ga (3.1?)
- After most large impacts; *may* have trapped volcanic gasses



Shackleton Crater

- Ice not protected by ejecta, maybe slump materials
- Access is difficult:
 - Crater is 4.6 km deep
 - Slopes consistently $>30^\circ$



Summary

- What type of ice, or other forms of water, you *might* find depends on the local/regional geologic and thermal history
- We must explore multiple locations to learn how ice forms and evolves as part of resource exploration
- International cooperation will be critical



<https://science.nasa.gov/wp-content/uploads/2023/05/viper-cdr-hero-08-lrg-jpeg.webp>



<https://humans-in-space.jaxa.jp/en/biz-lab/tech/lupe/x/>