Mini-RF observations of the LCROSS impact site

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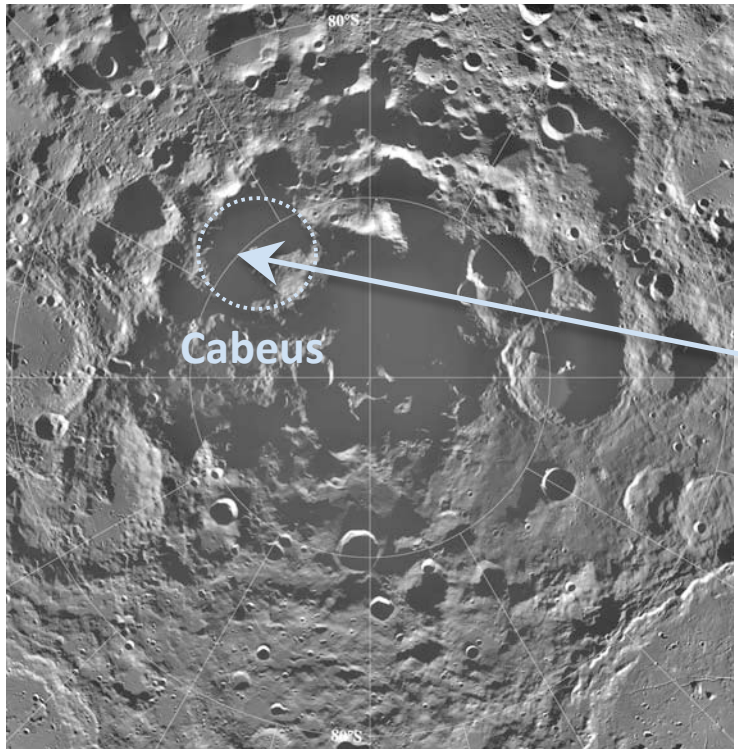
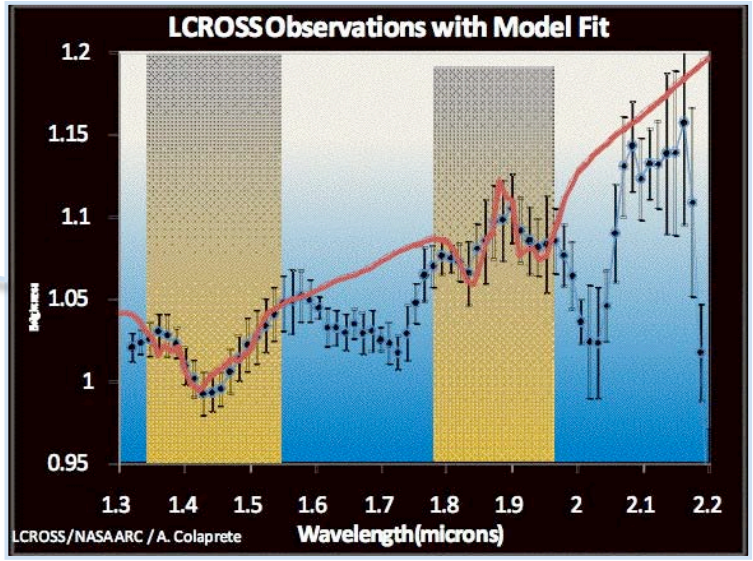
Lunar Science Forum
July 21, 2010

Introduction

- On October 9, 2009, the **LCROSS spacecraft impacted Cabeus crater**, located near the south pole of the Moon
- Early reports from LCROSS indicate the **presence of water** in Cabeus crater





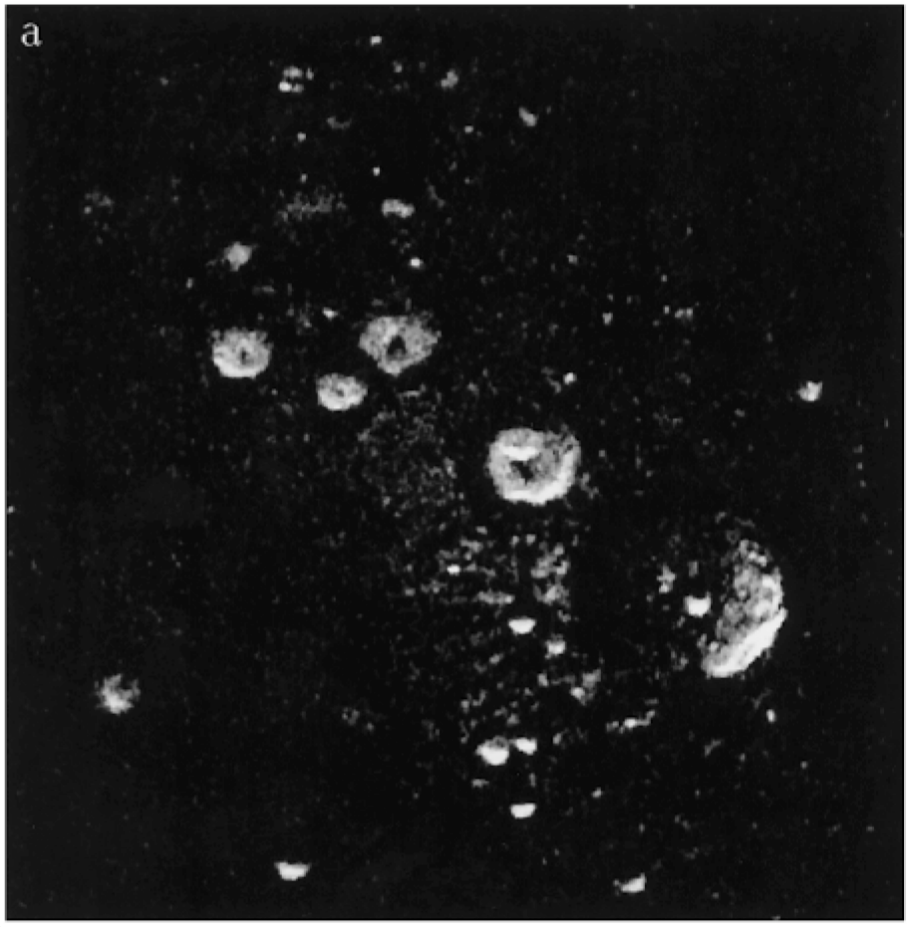
Introduction

- A Miniature Synthetic Aperture Radar was flown on the **Chandrayaan-1** mission and the **Lunar Reconnaissance Orbiter**
- Both instruments obtained S-Band (12.6 cm) **mosaics of Cabeus crater**
- These observations are important because:
  1. The **unique radar properties of ice** allow us to characterize the form of the ice in Cabeus
  2. With an active source, radar allows us to **"see in the dark,"** providing a geologic context for the shadowed impact site

Part I: The Search for Ice

Background

- How does radar detect ice?



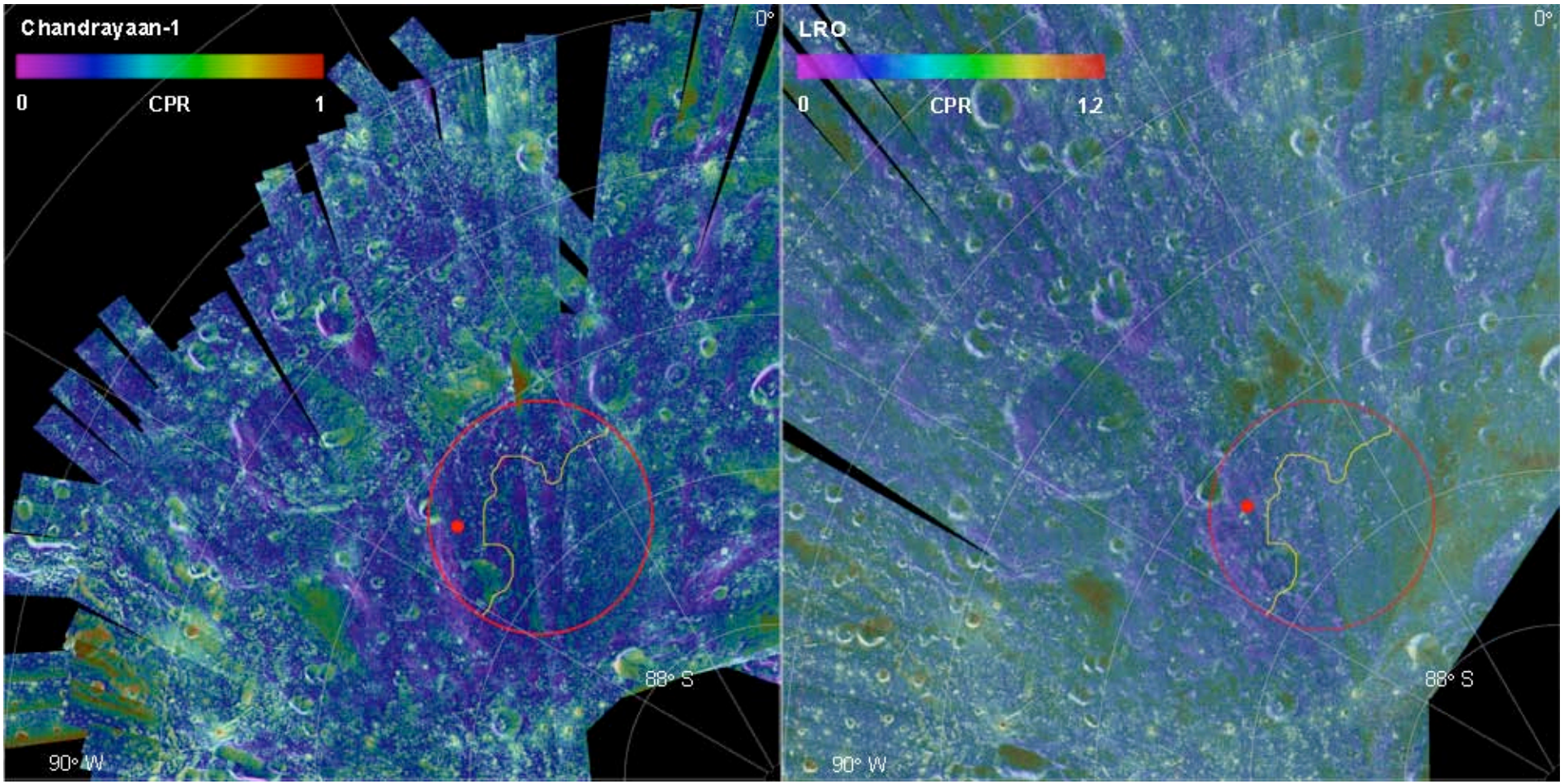
Example: High SC return from the north pole of Mercury (Harmon et al. 2001)

In weakly absorbing media with scattering centers (like water ice), there will be constructive interference between radar signals that follow the same path in opposite directions.

These signals are forward scattered, which preserves the original sense of polarization, leading to **large "same-sense" (SC) returns**, and **high circular polarization ratios (CPR)**.

Cabeus Crater

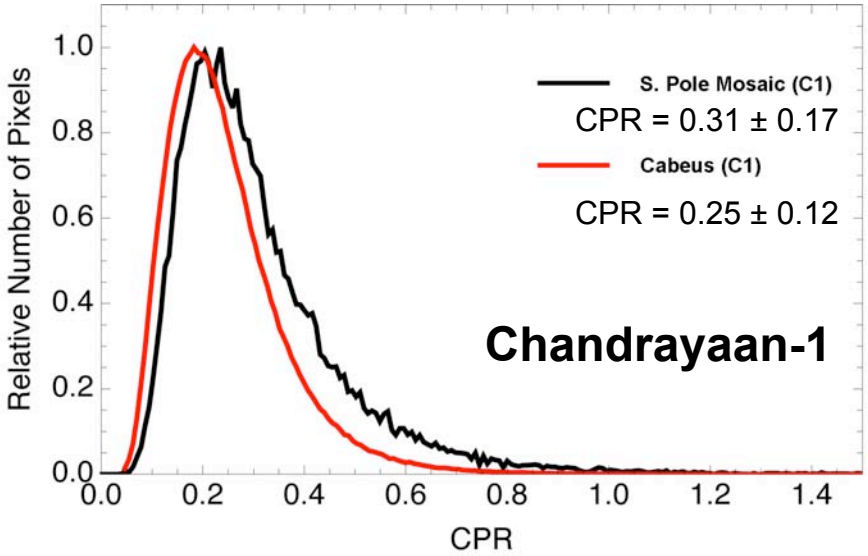
Chandrayaan-1 **LRO**

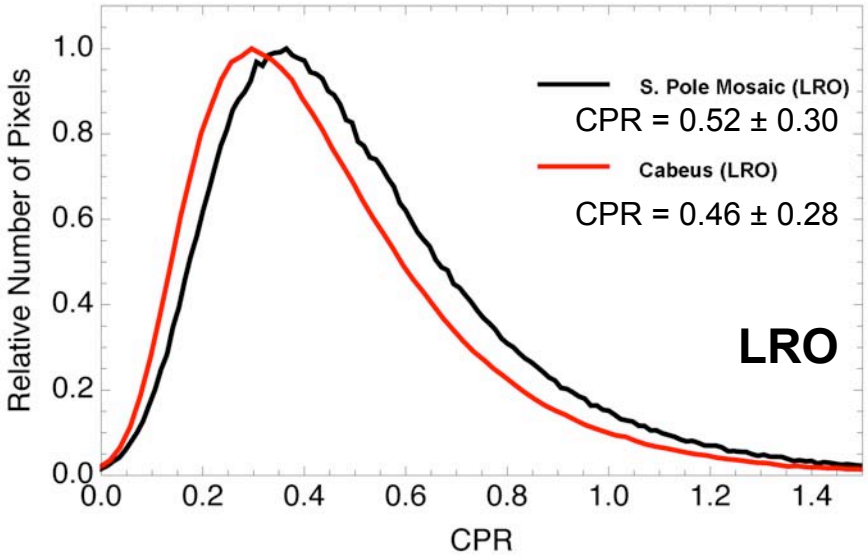


● = approximate location of LCROSS impactor

CPR Values

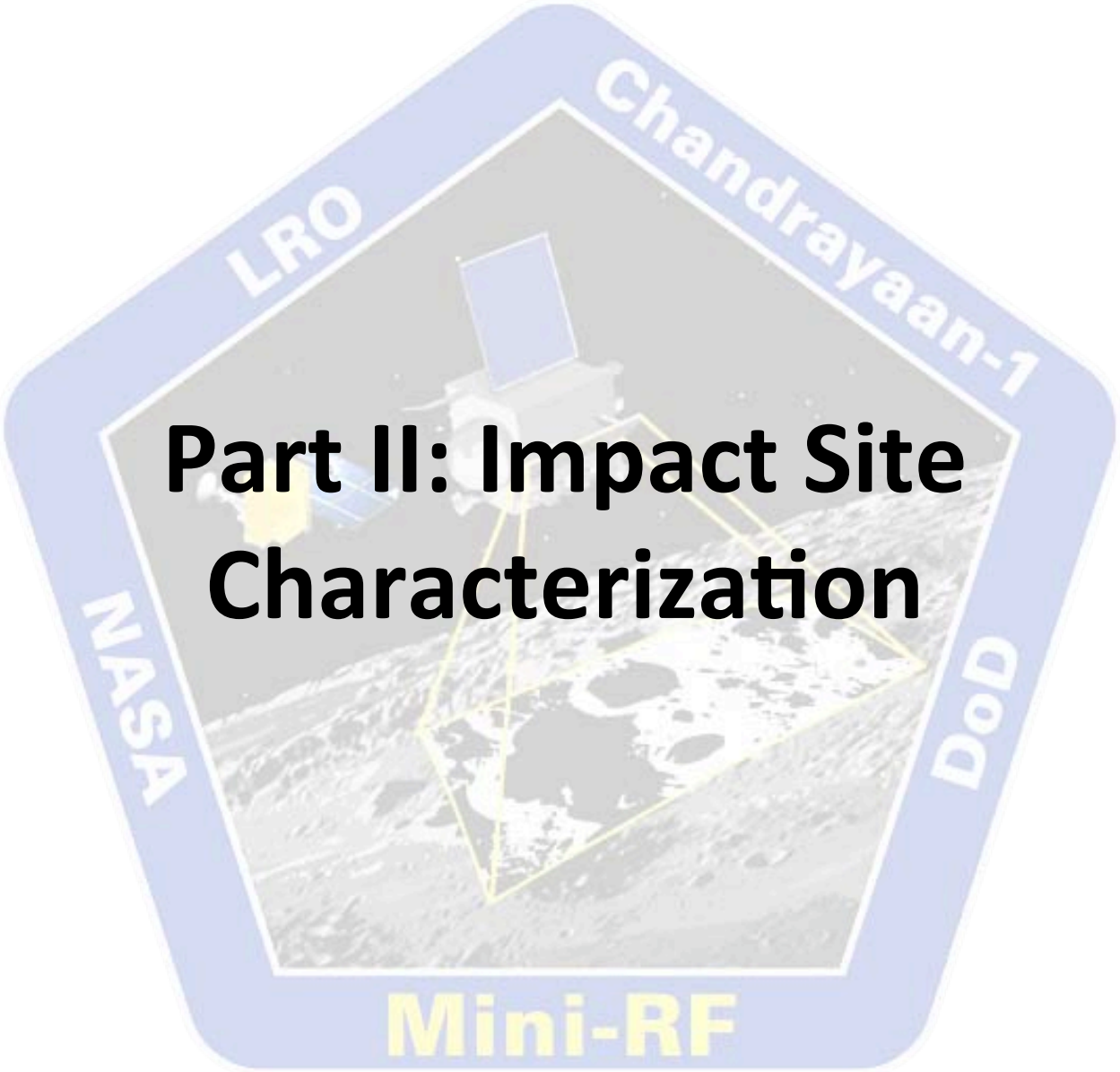
- Cabeus has lower than average CPR values
- Less than 0.01% (C1) or 5% (LRO) of pixels have CPR > 1
- CPR differences between instruments likely due to different look angles (33° vs. 48°)





Part I: Implications

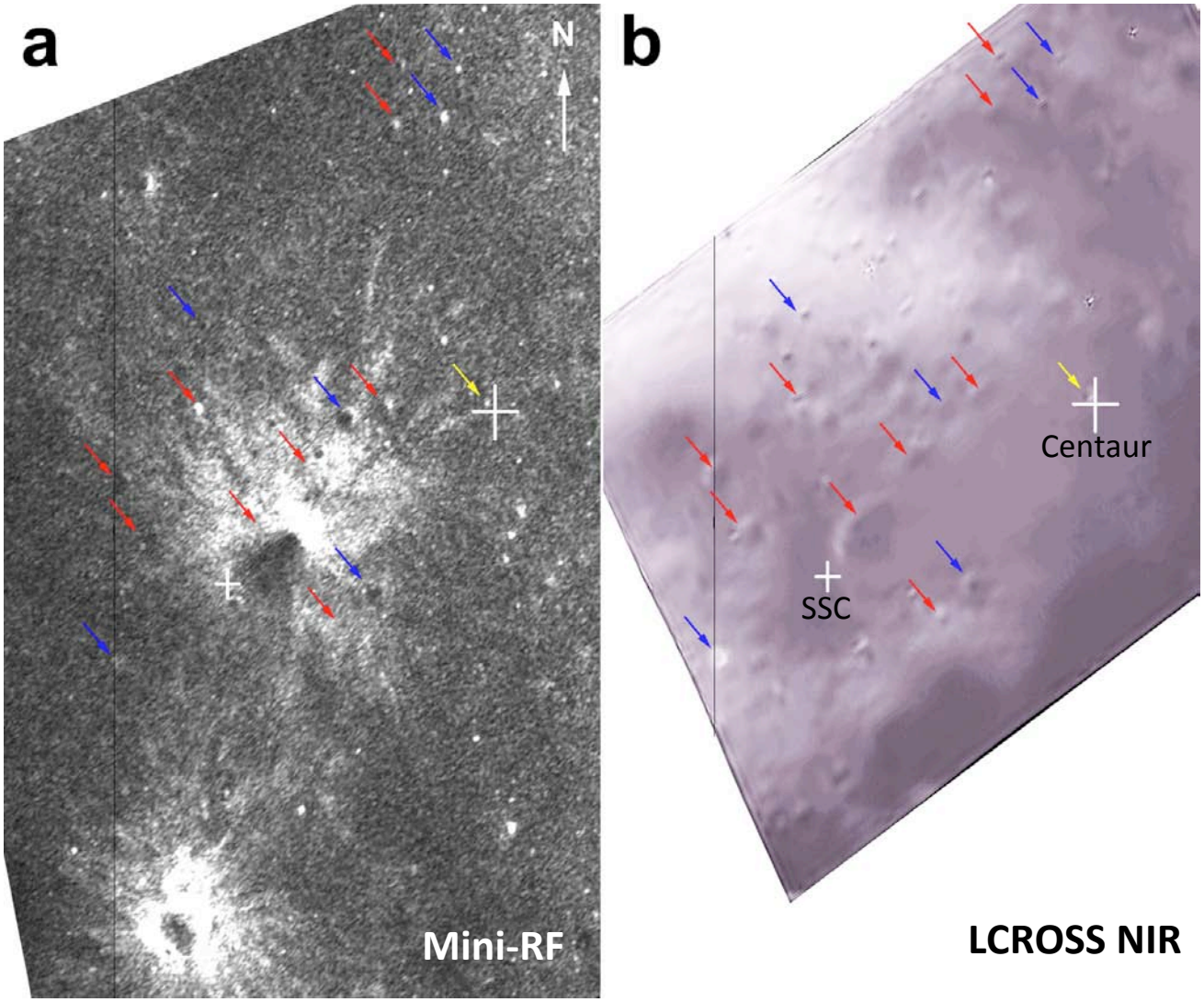
- Since the CPR in Cabeus is so low, there can be **no near-surface (1-10m), thick deposits of ice at the LCROSS impact site**
- Early results from LCROSS indicate the presence of water **and** water ice in Cabeus, however
- This water must therefore be in a form not observable with S-Band radar. For example…
  - Interspersed in the regolith as small grains (less than ~10 cm)
  - Present as a thin coating on rock grains



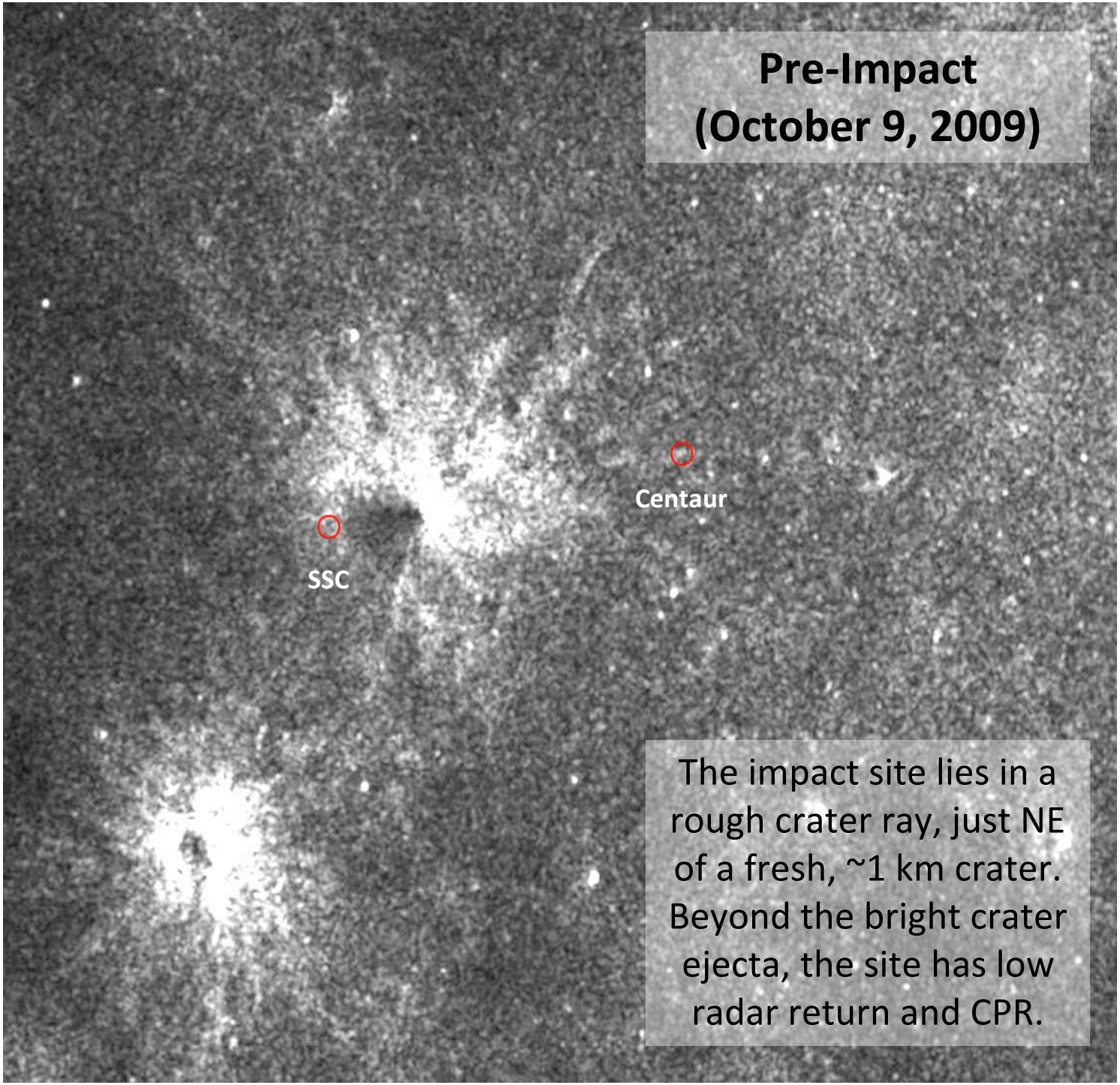
Part II: Impact Site Characterization

Impact Site

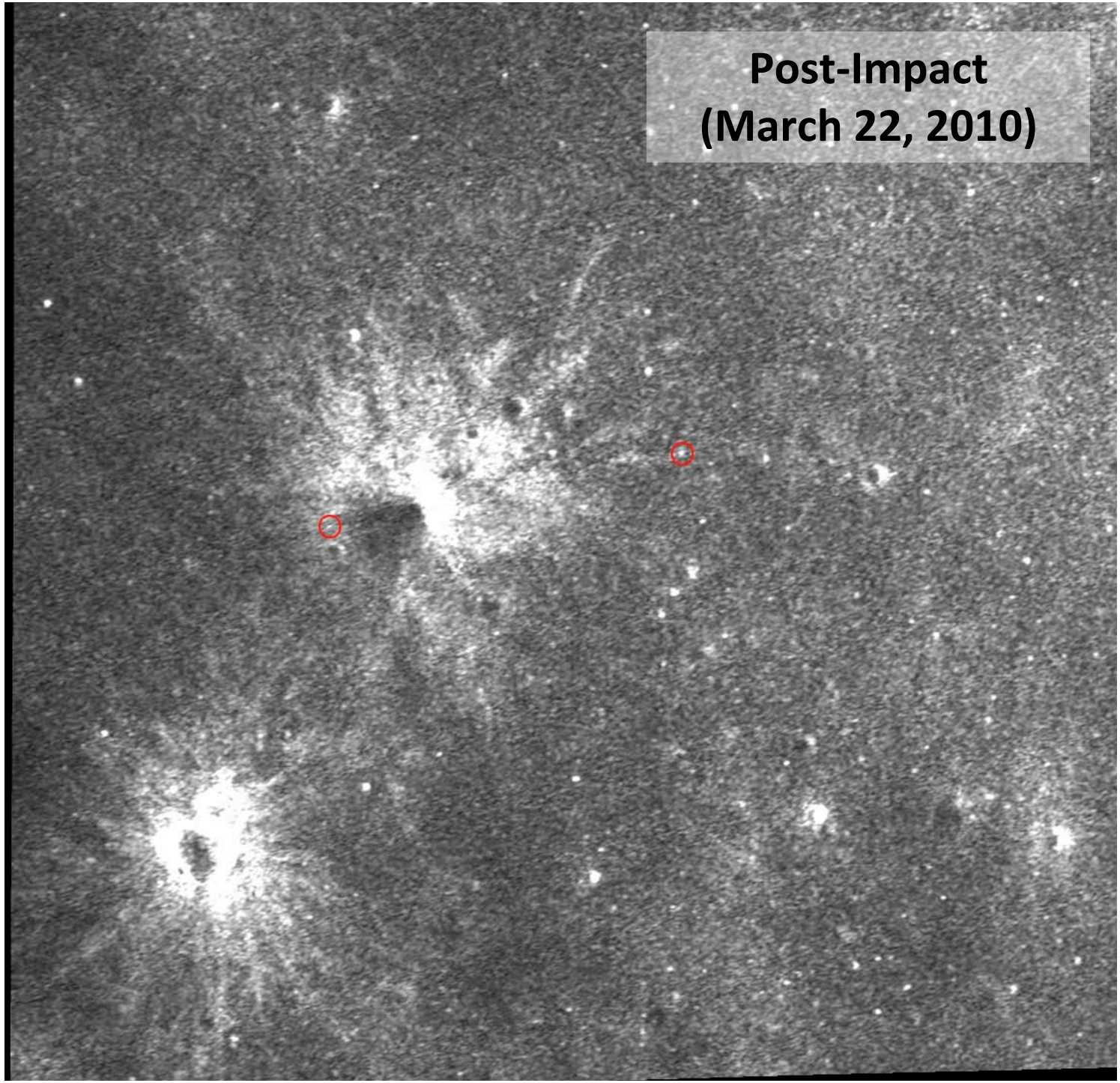
- Mini-RF image was registered to an LCROSS NIR image to determine the position of the LCROSS impactor



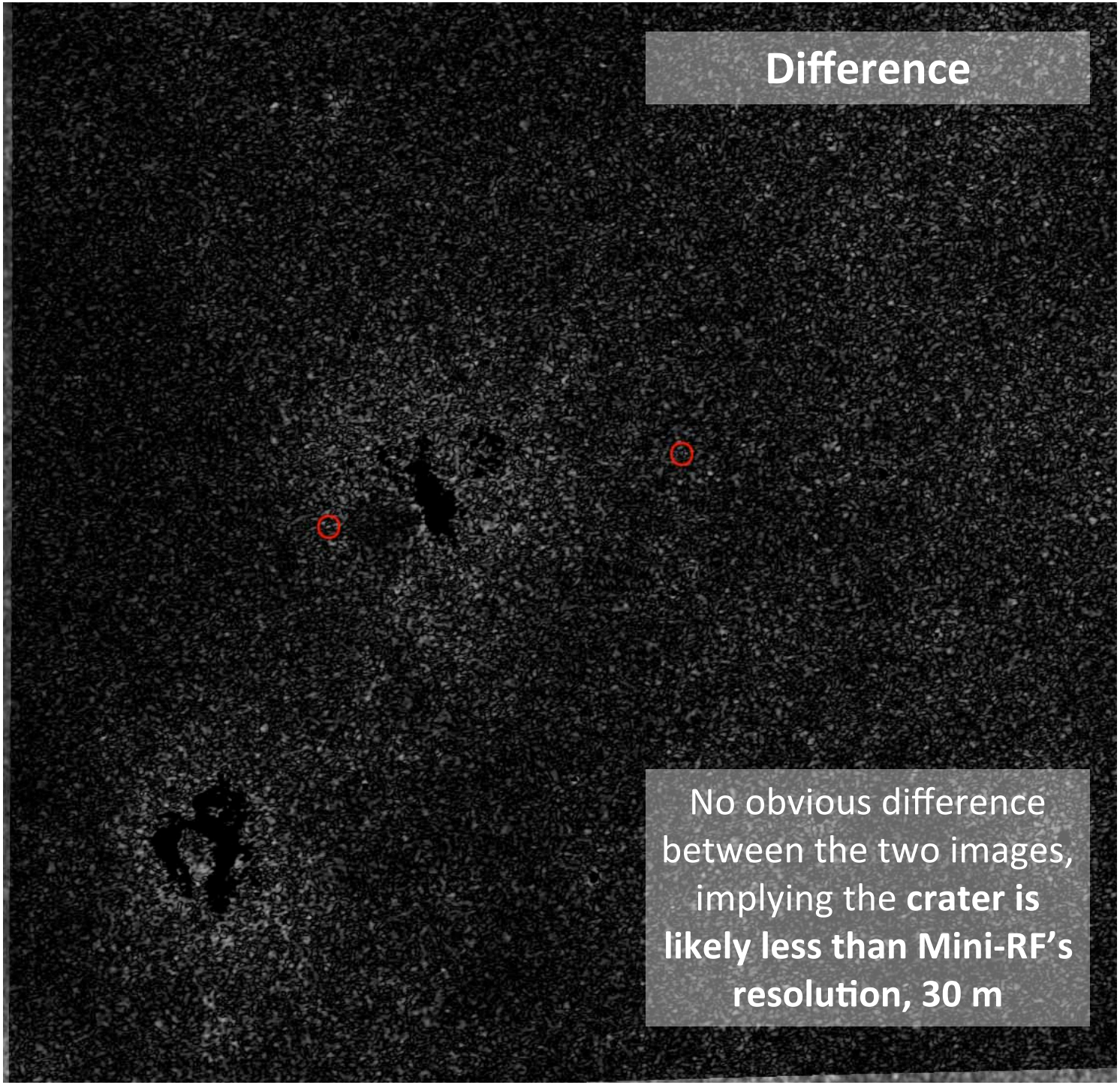
Impact Site


Pre-Impact
(October 9, 2009)
Centaur
SSC
The impact site lies in a rough crater ray, just NE of a fresh, ~1 km crater. Beyond the bright crater ejecta, the site has low radar return and CPR.

Impact Site

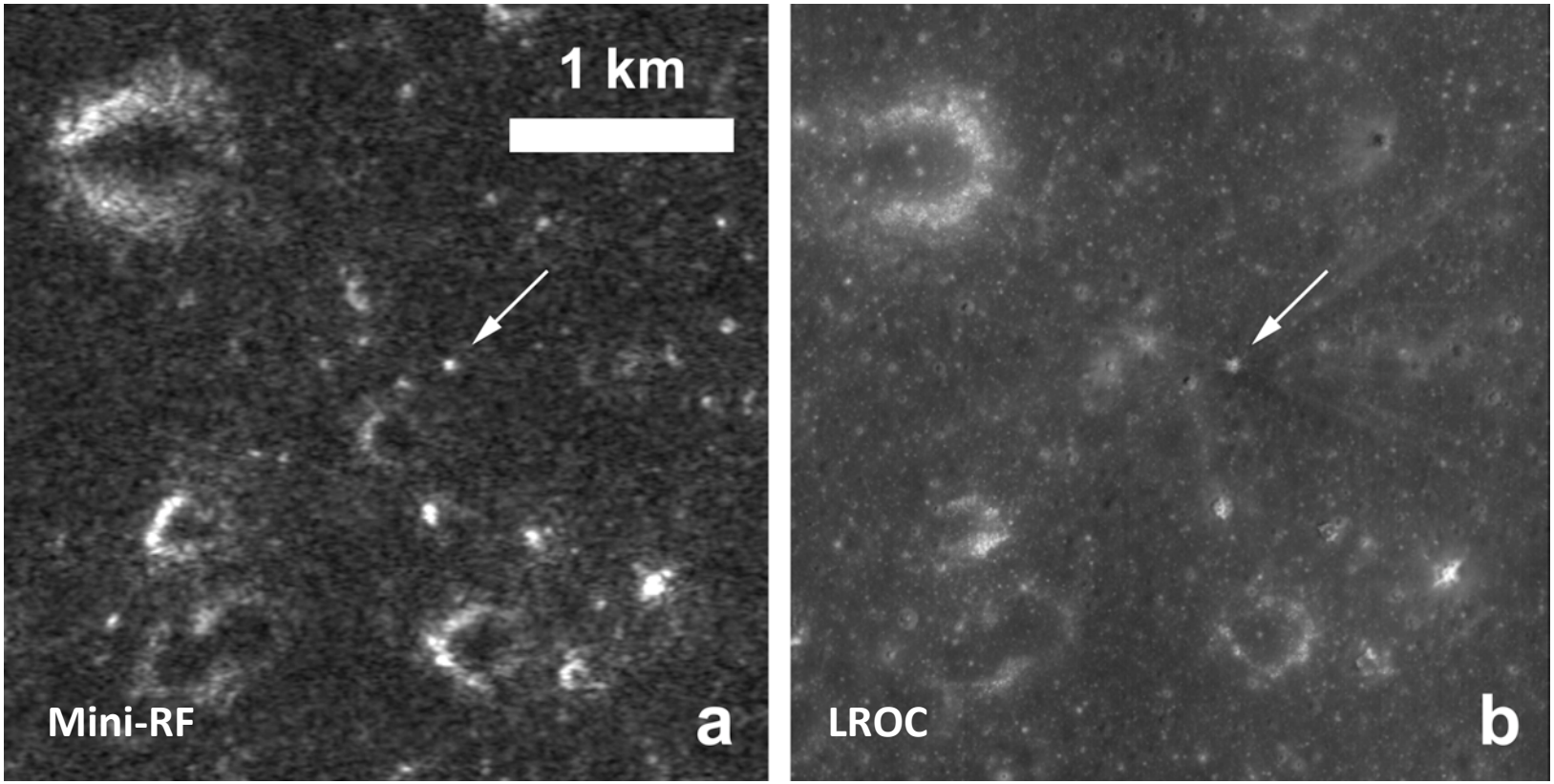


Impact Site


Difference
No obvious difference between the two images, implying the **crater is likely less than Mini-RF's resolution, 30 m**

Apollo SIVB Impact

- Mini-RF has observed other small craters
  - For example, the ~35 m crater made by the **Apollo 14 SIVB impact**
- Thus, if the LCROSS crater was ~30 m, we likely would have observed it



Part II: Implications

- Registering Mini-RF images to an LCROSS NIR image allows us to put the LCROSS impact site in a **broader geologic context**
- Impact site lies in a rough crater ray, in an otherwise radar dark area
- The difference between pre-impact and post-impact images is not above the background noise, allowing us to constrain the size of the LCROSS impact crater as **< 30 m** (consistent with pre-impact predictions)