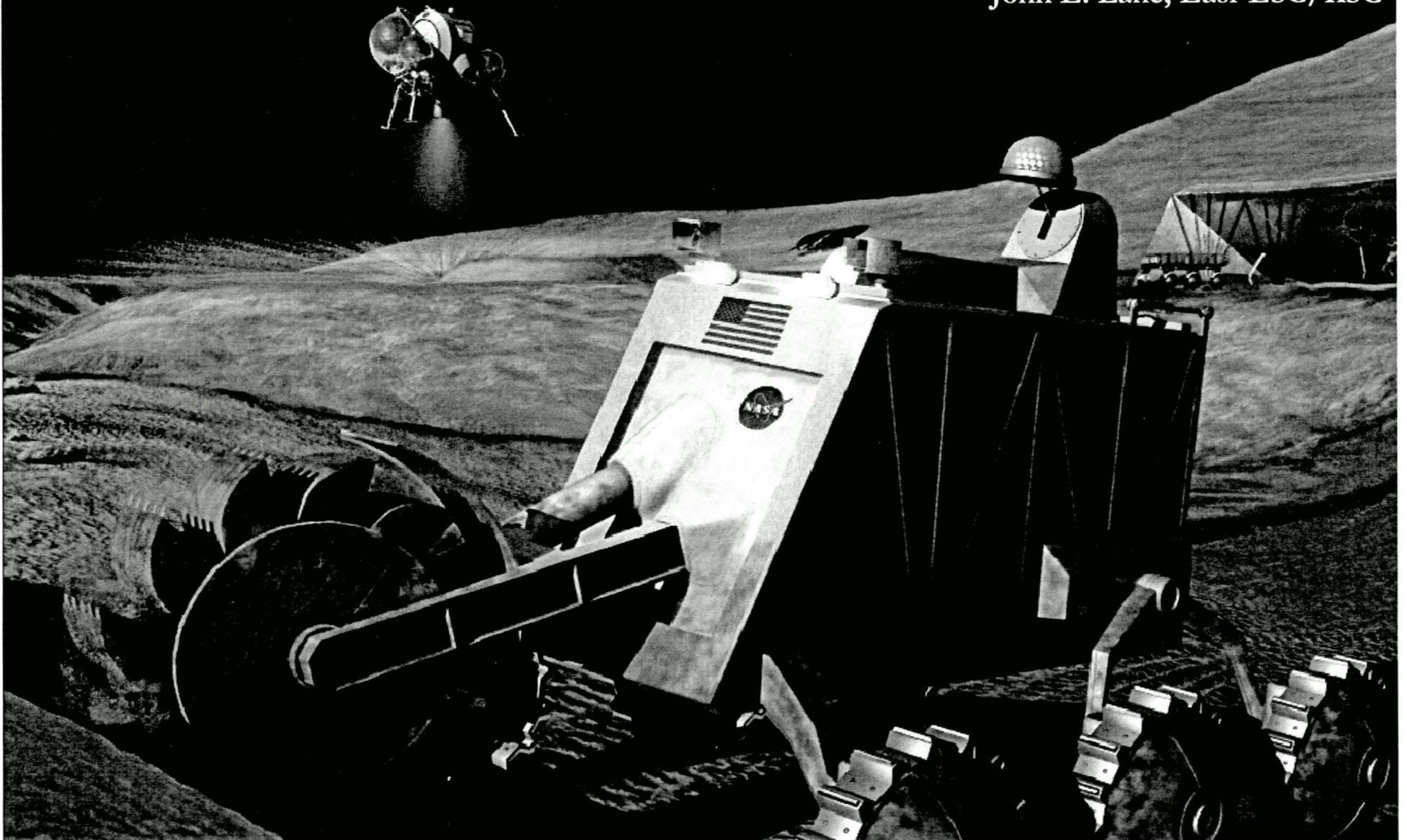


Lunar Rocket Exhaust Phenomenology Indicates that Plume/Soil Models are Too Simple

Philip Metzger, NASA/KSC
John E. Lane, Easi-ESC/KSC



Outline

- Background
- Phenomenology on Mauna Kea
- Phenomenology on the Moon
- What is Needed

Background

Different Effects in Different Environments



Earth



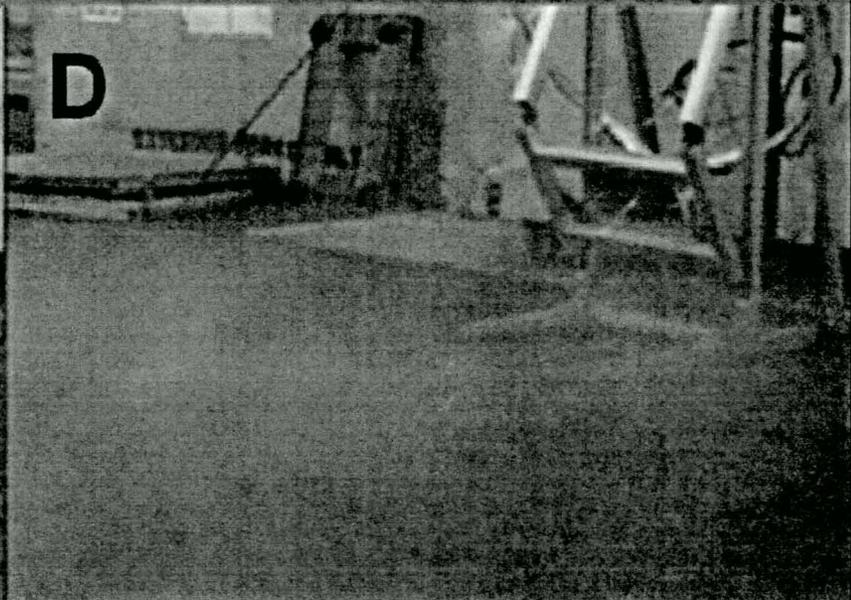
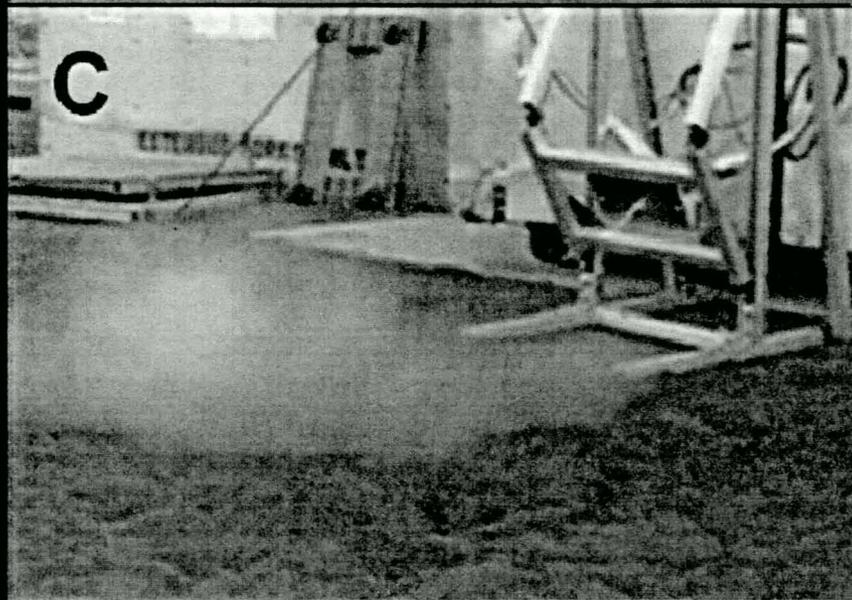
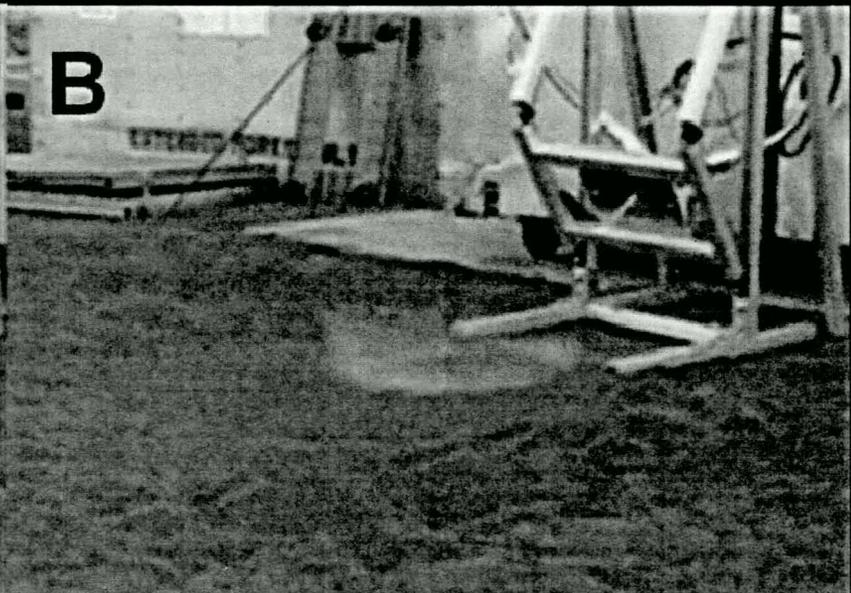
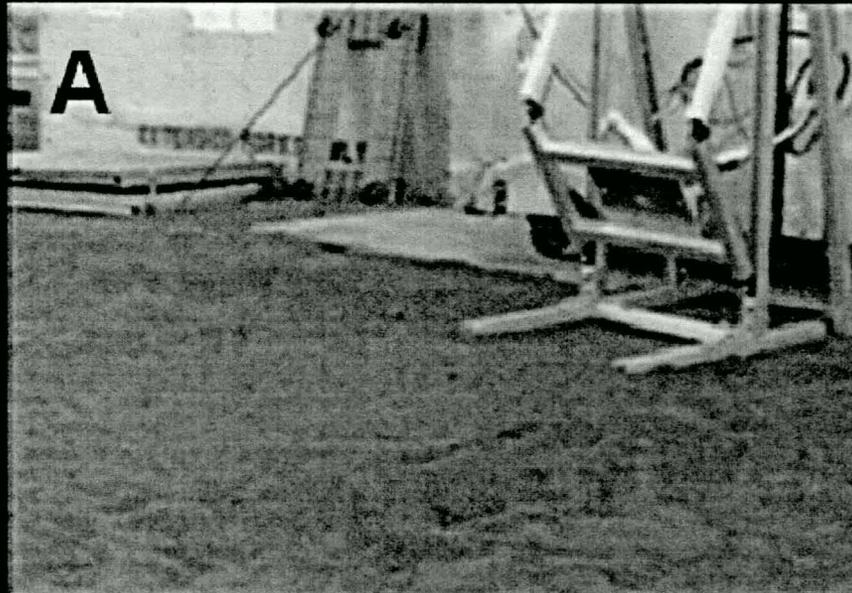
Mars



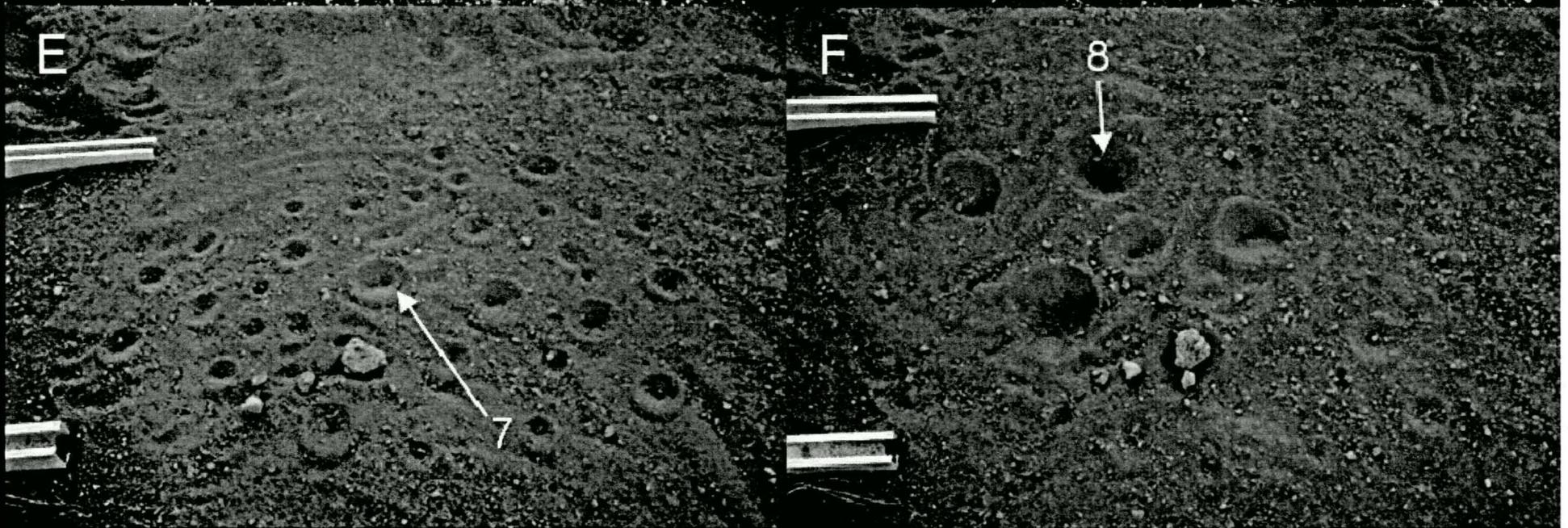
Moon

Phenomenology on Mauna Kea

Four Stages

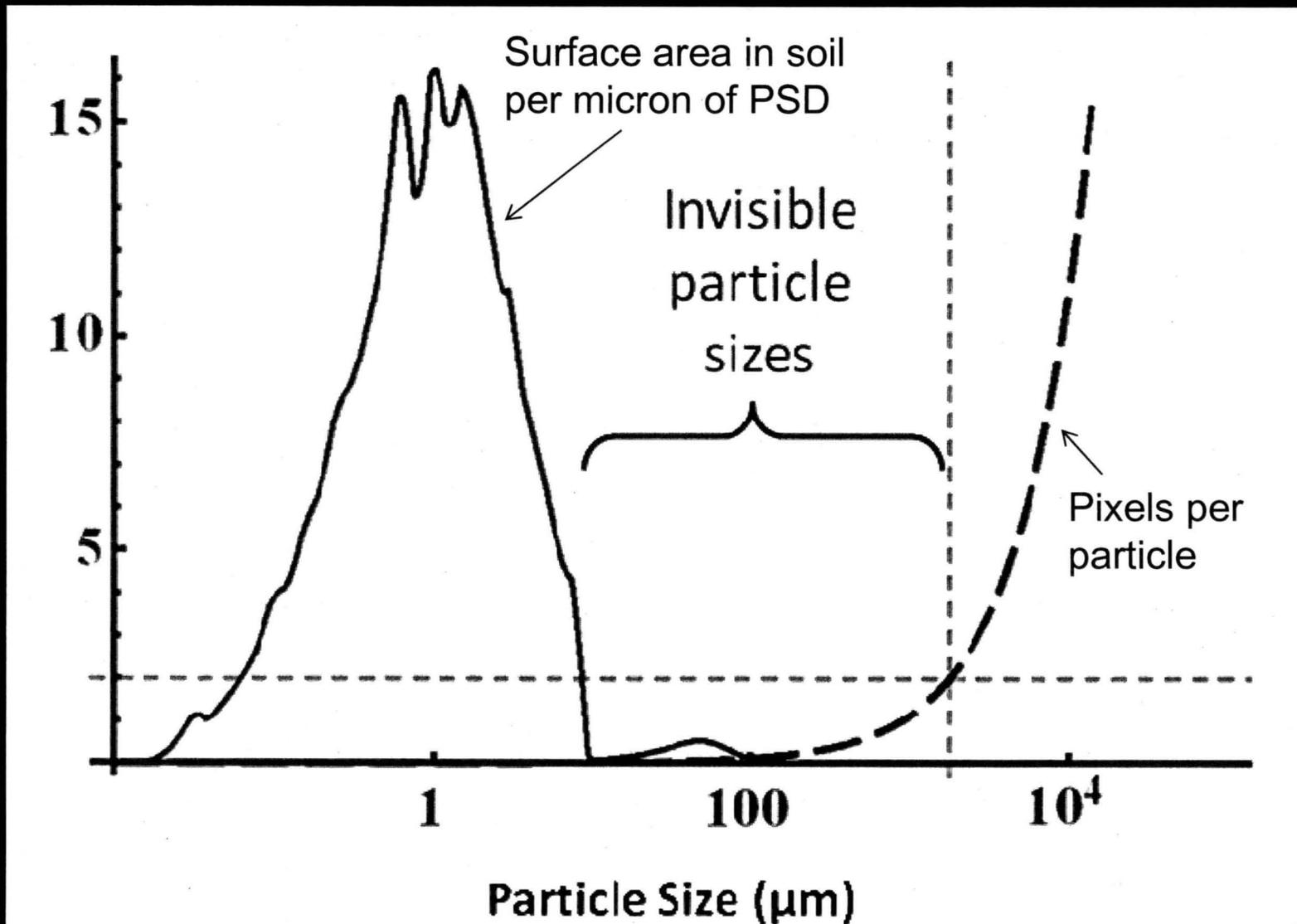


Surface Before Impingement

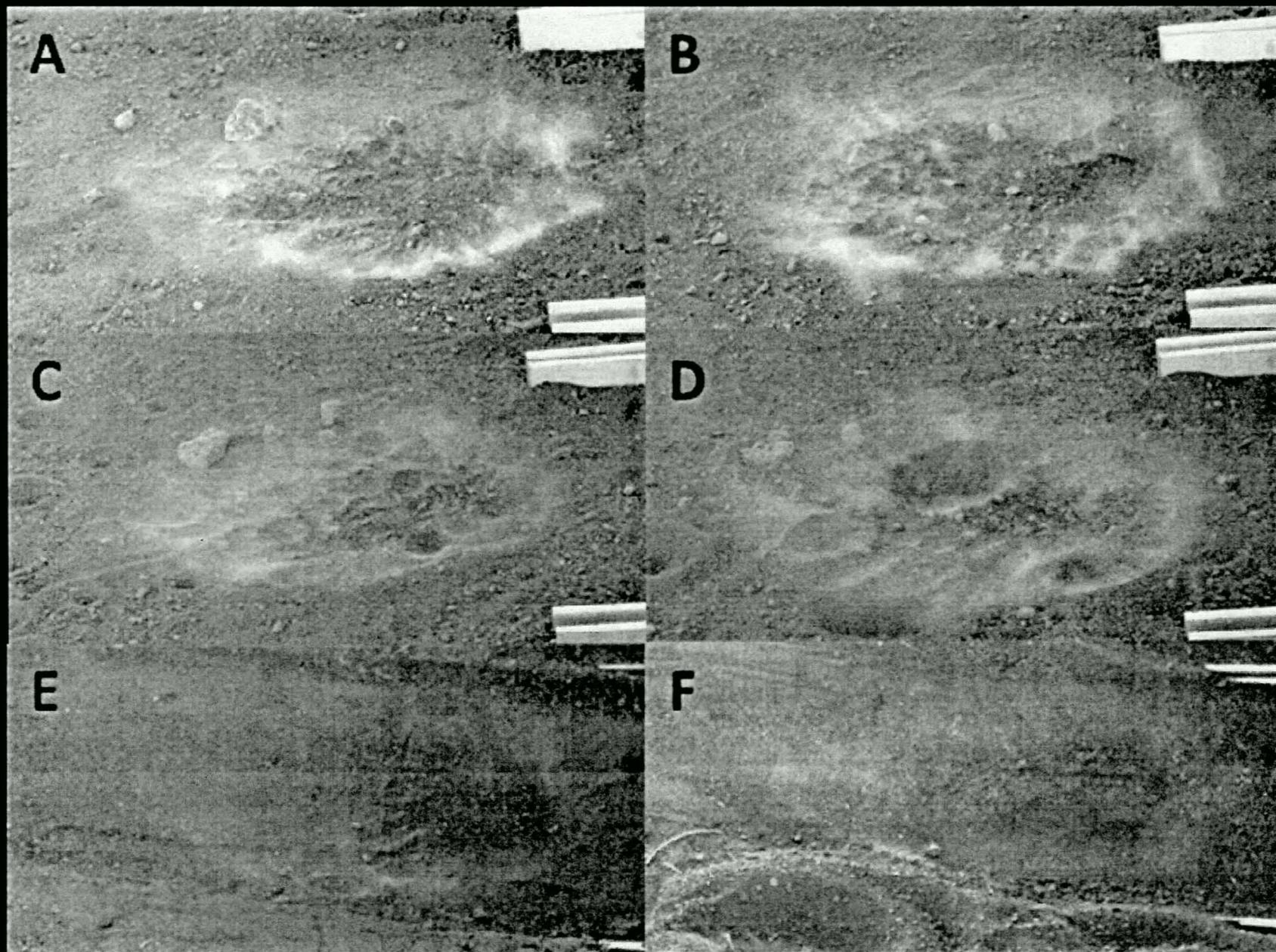


Show video
Discuss rolling transport
Dust release
Rock exhumation
Lack of visible sand motion

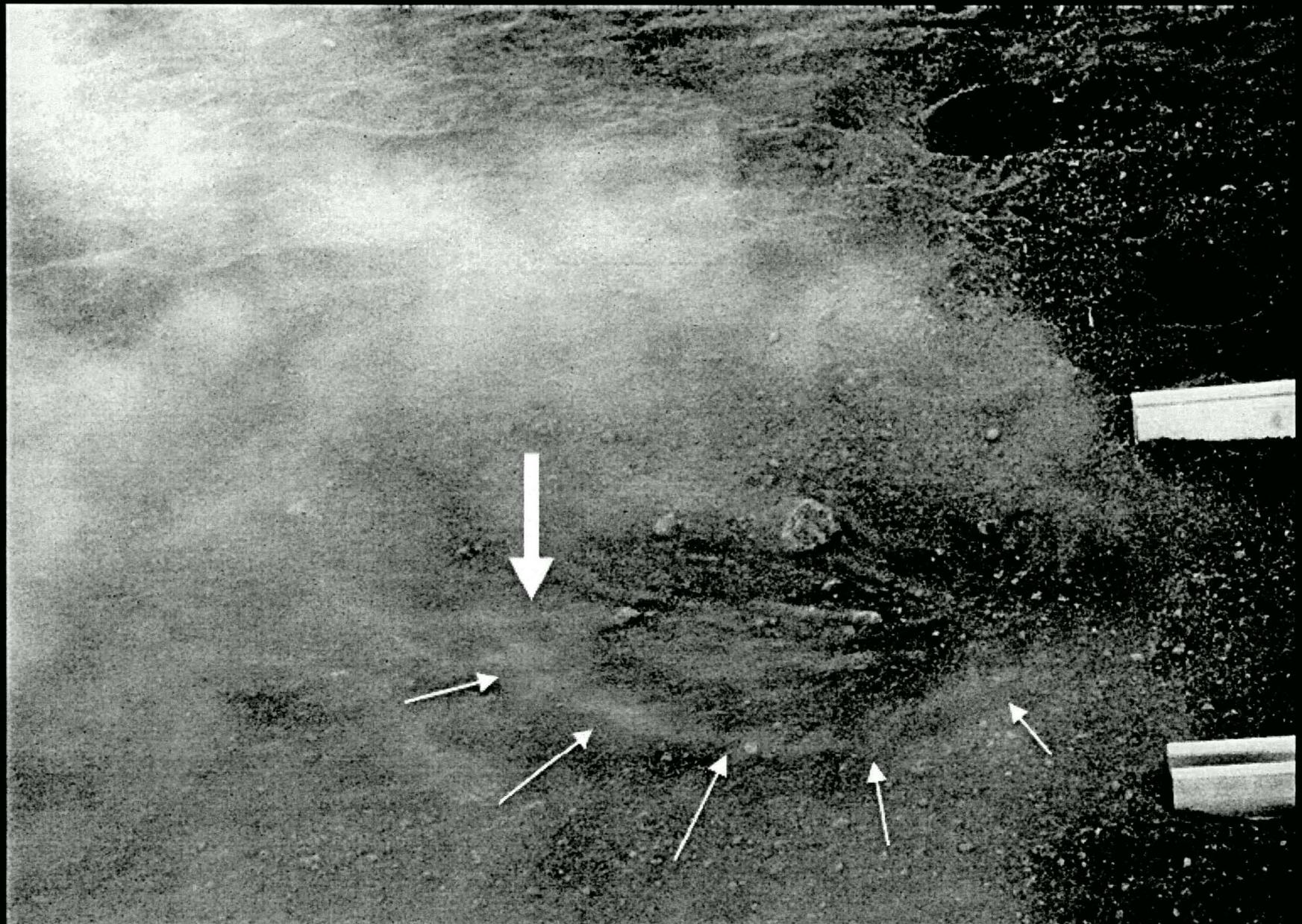
Don't Trust Your Eyes



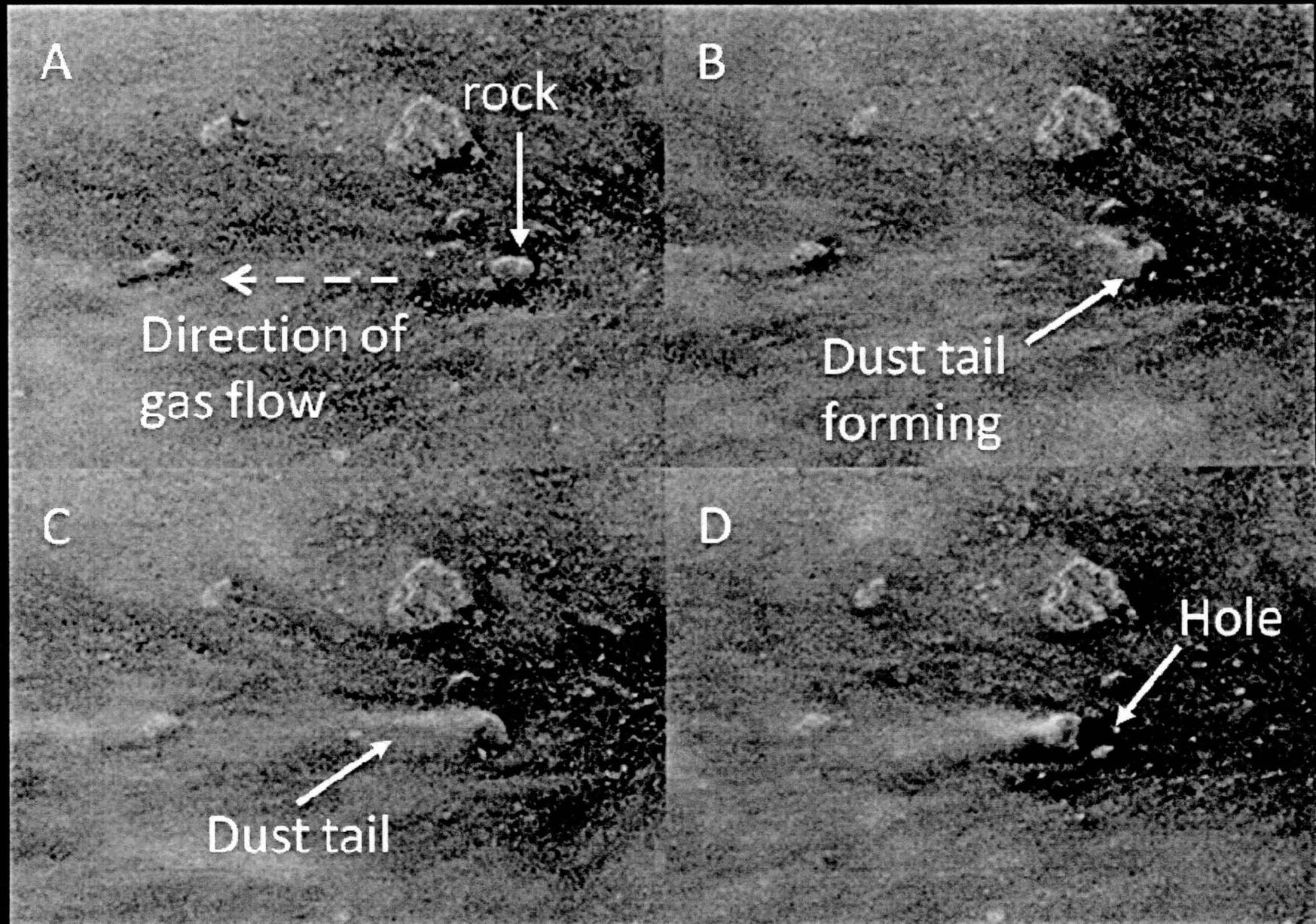
Transient Dust Rings



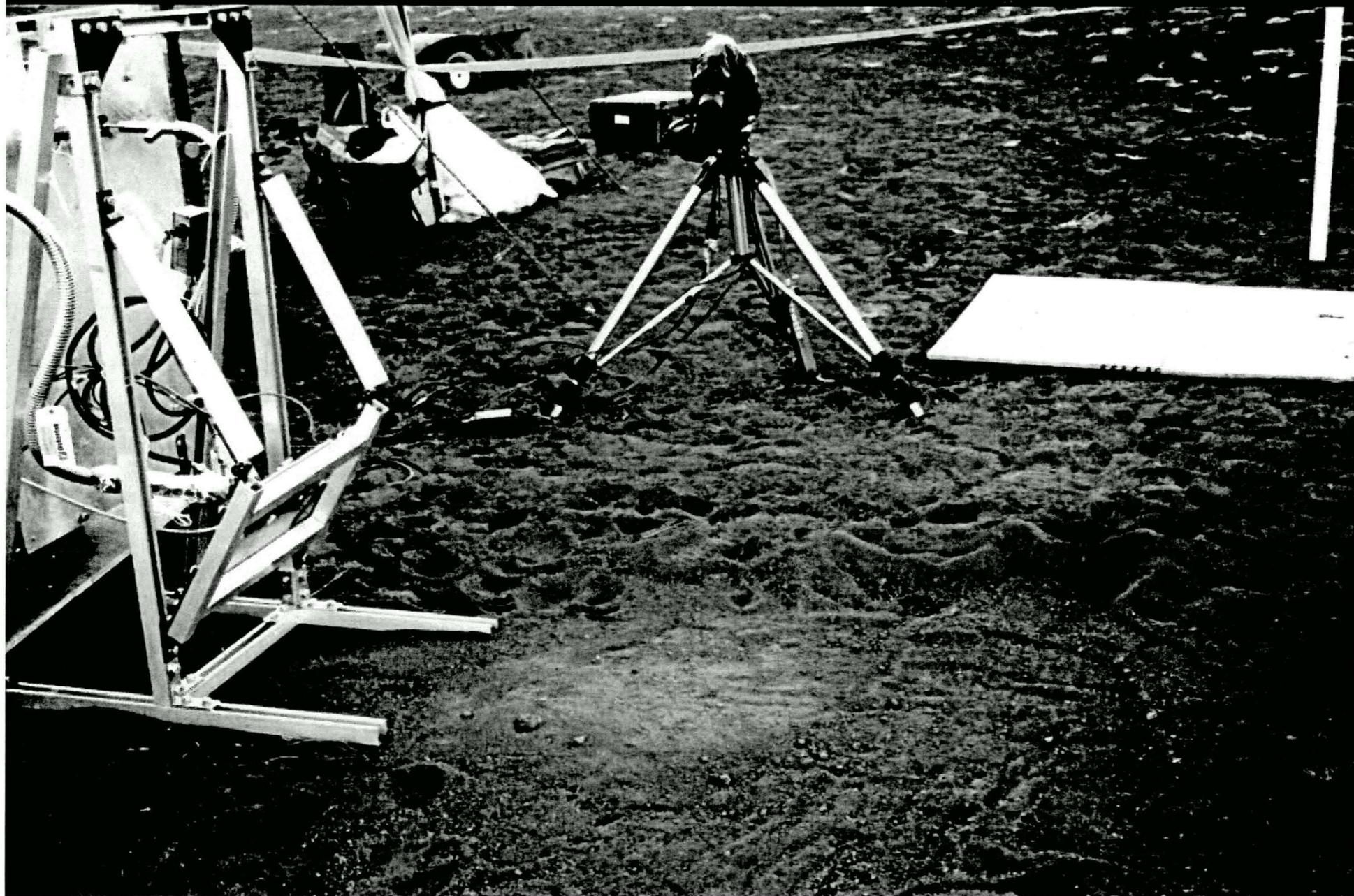
Arcs and Streaks



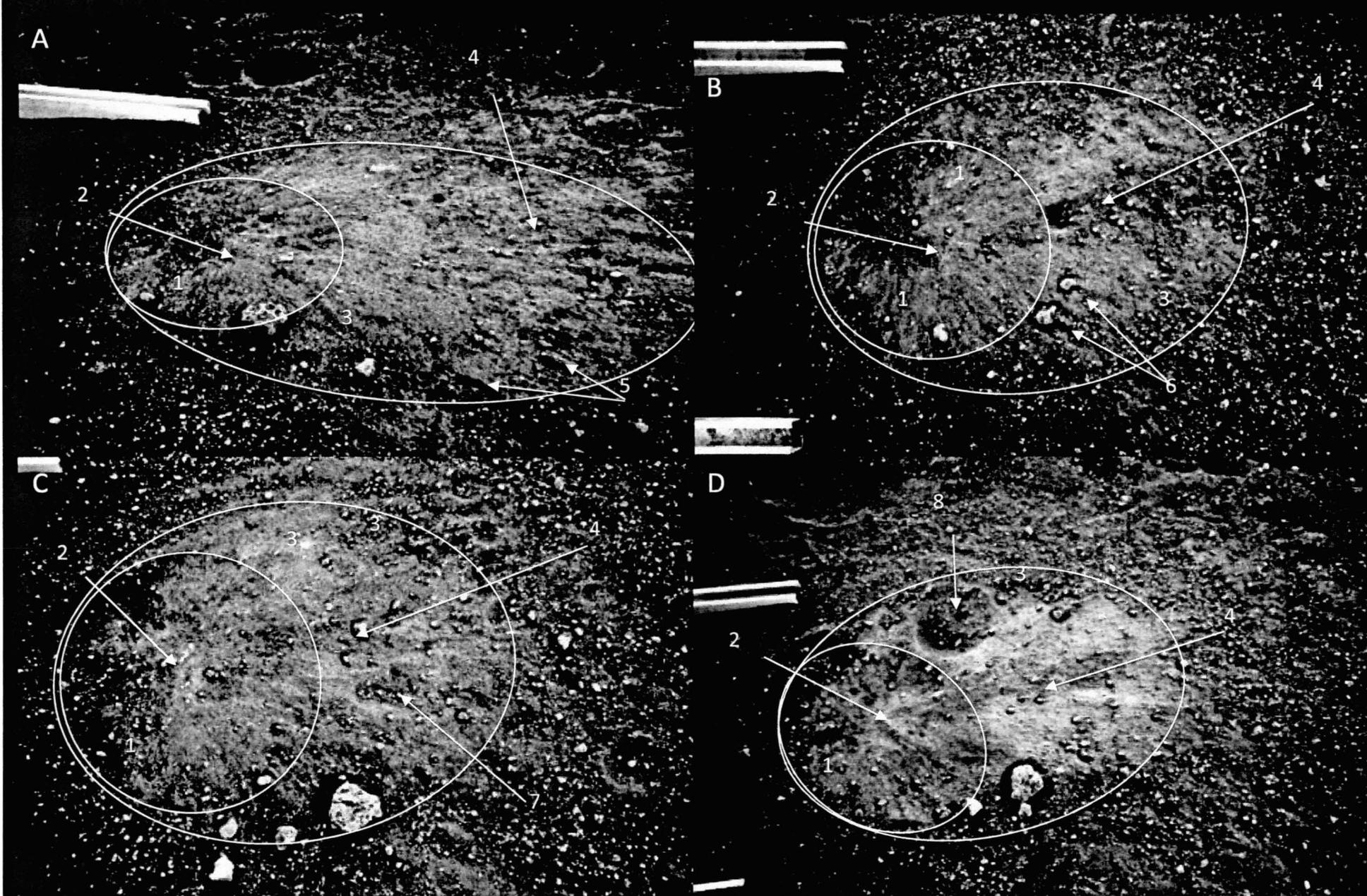
Streaks and Exhuming Rocks



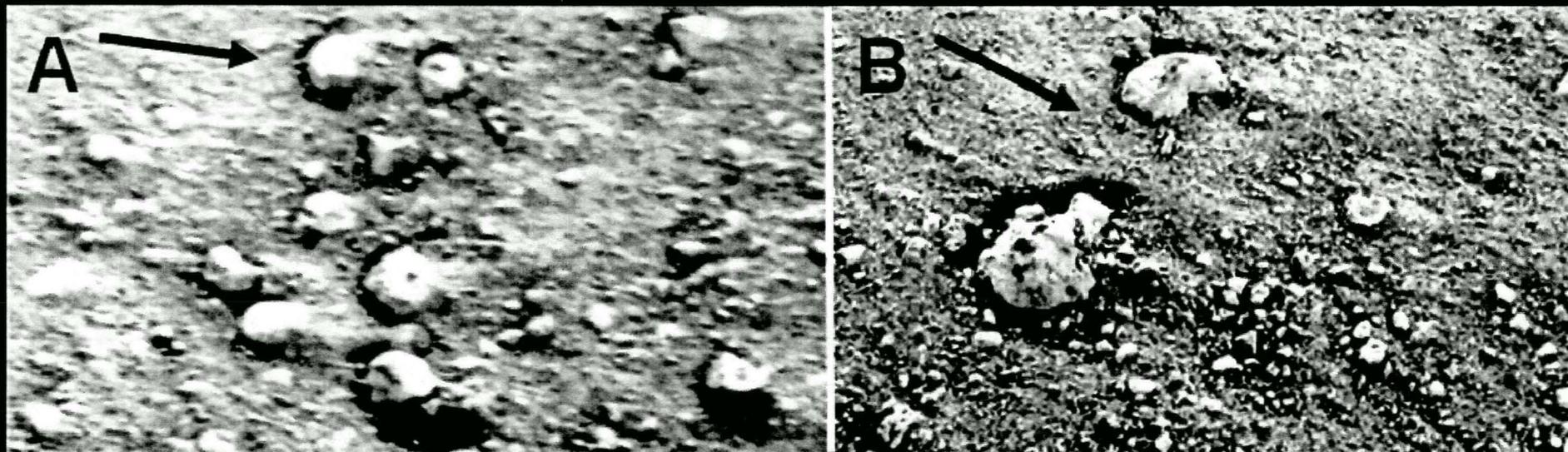
Surface Brightening



Bedforms from Plume Impingement



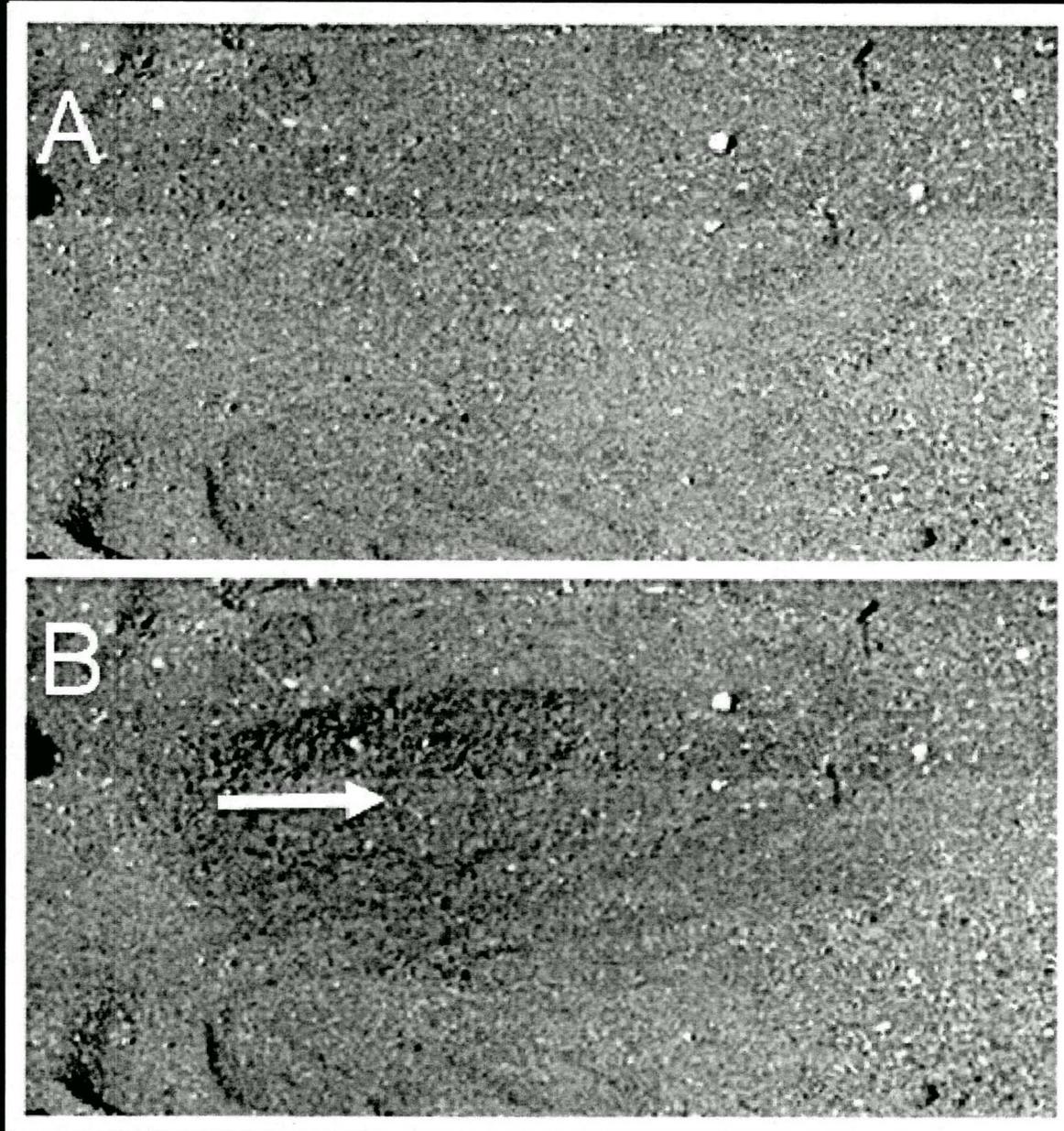
Scour Pools



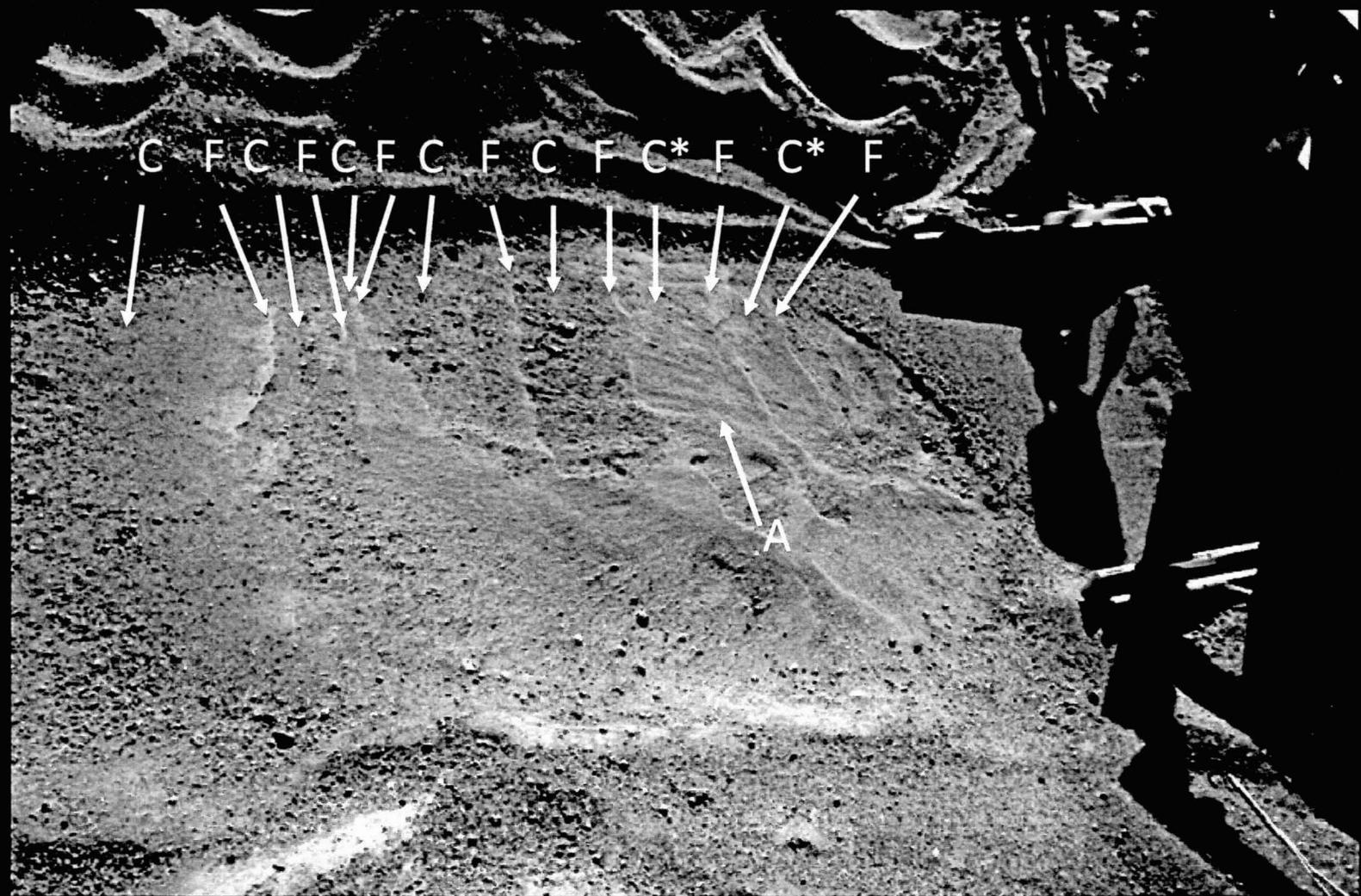
Dust Deposition on Small Length Scales



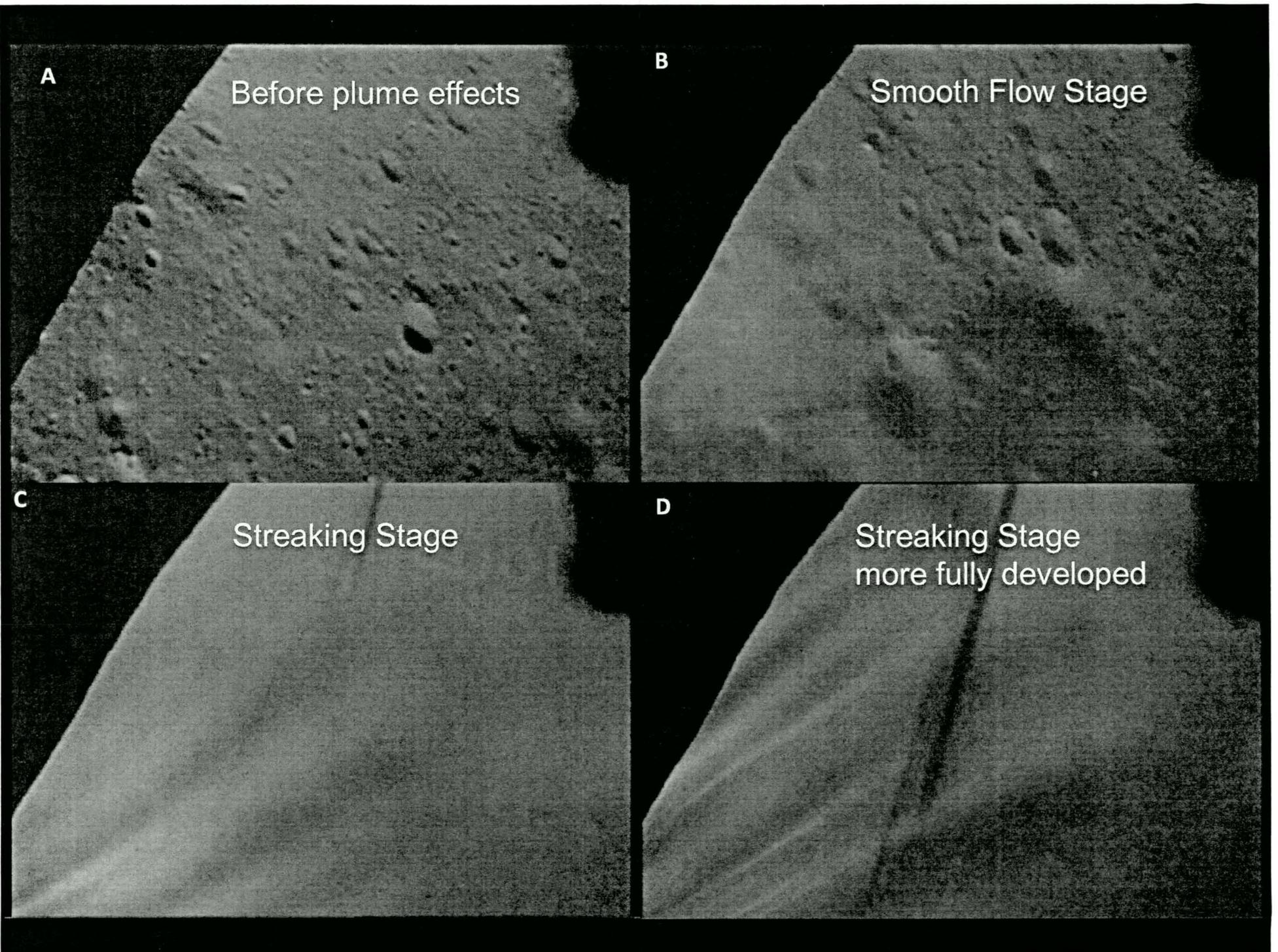
Cohesion: Absence of Dust Ring



Terraced Craters



Phenomenology in Apollo



E

Terrain Modification
Stage

F

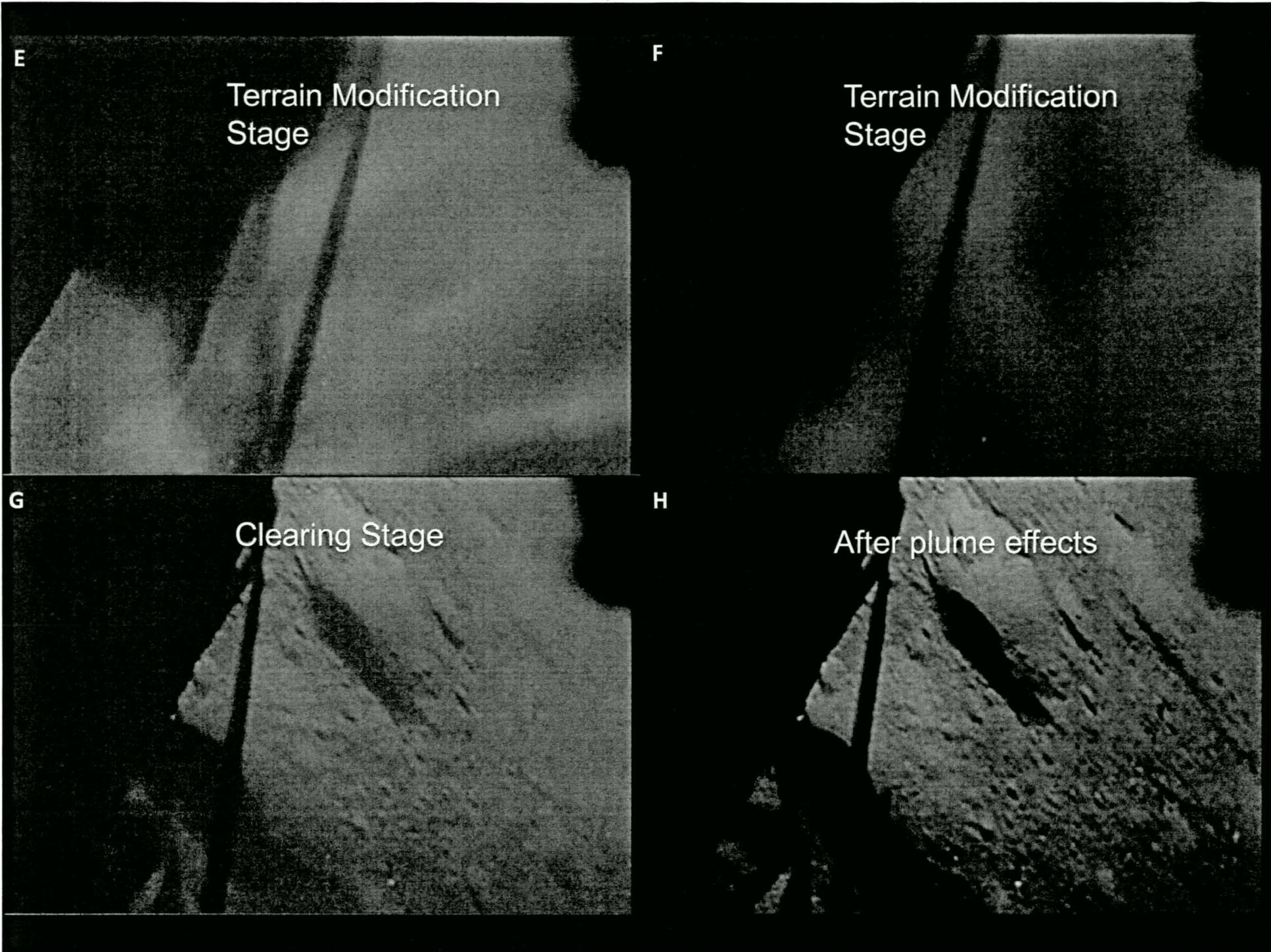
Terrain Modification
Stage

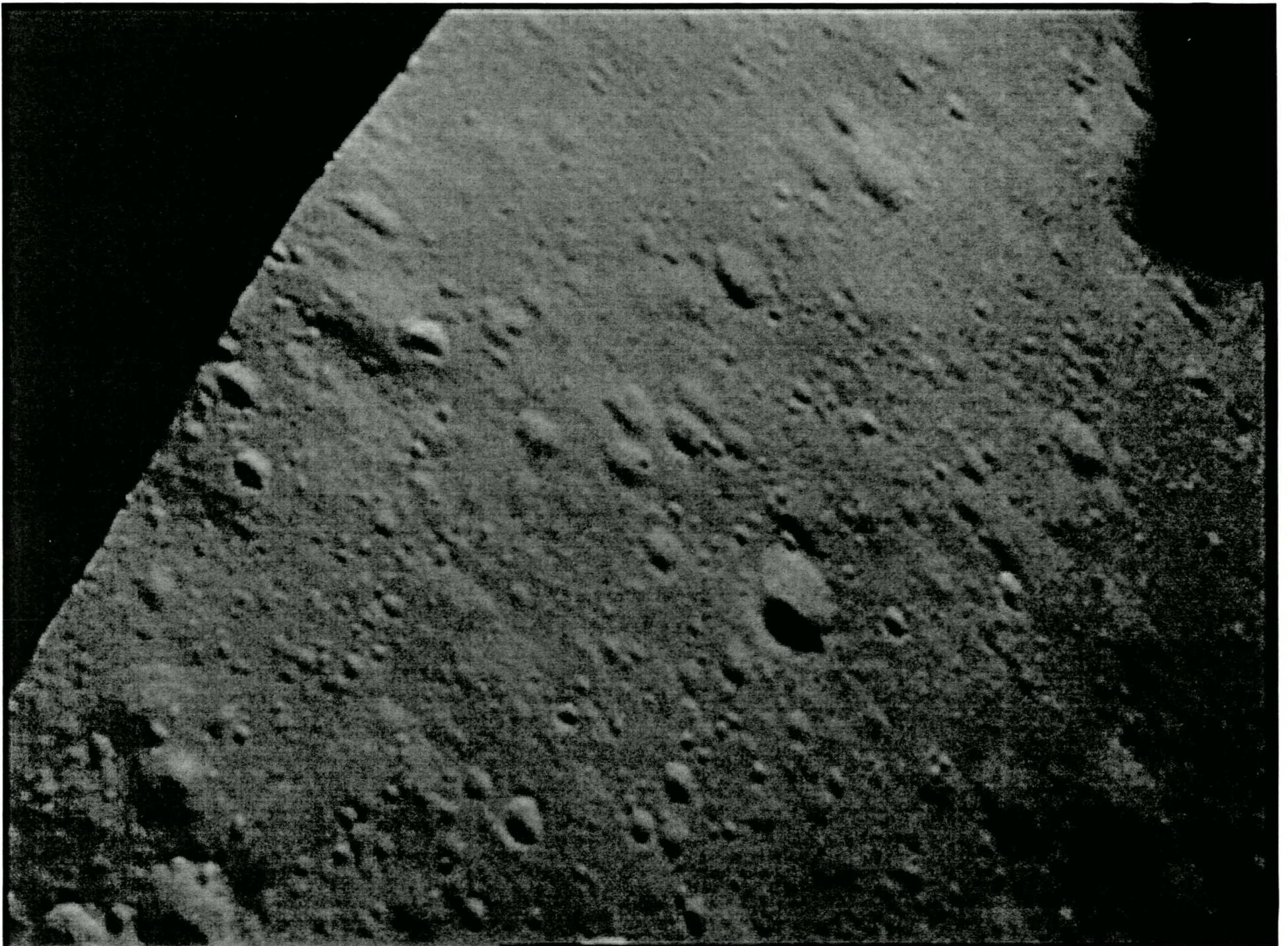
G

Clearing Stage

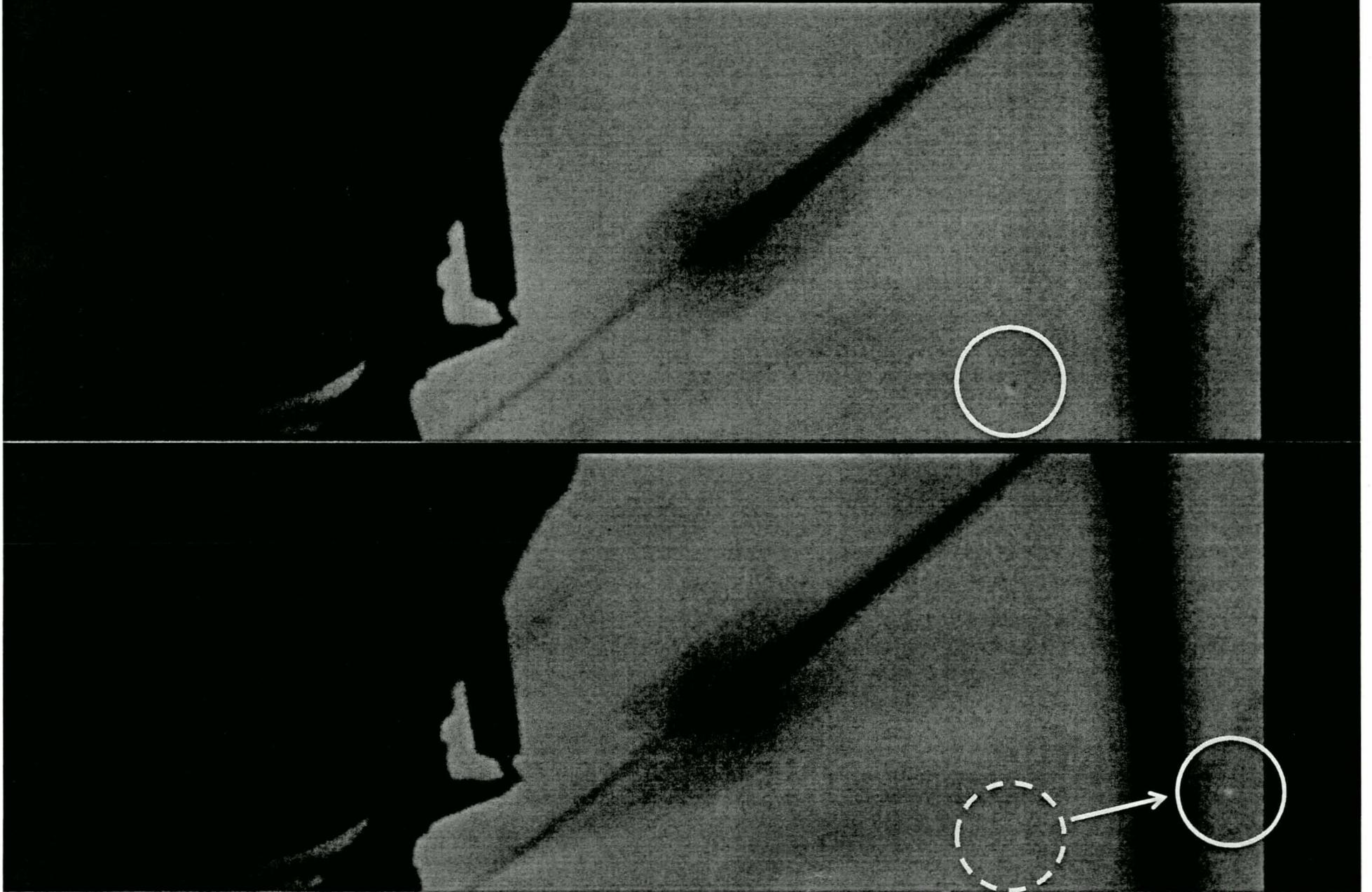
H

After plume effects

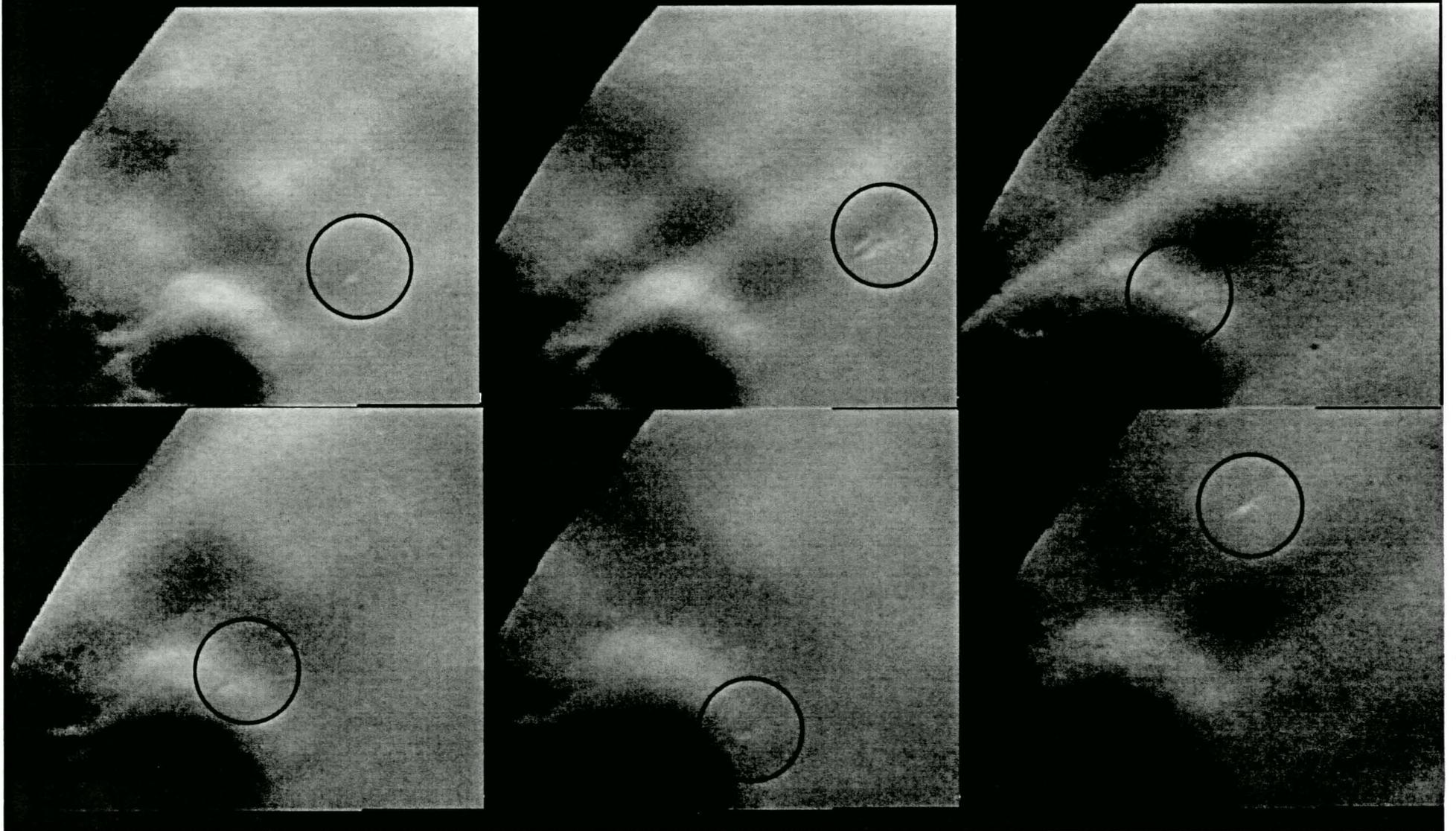




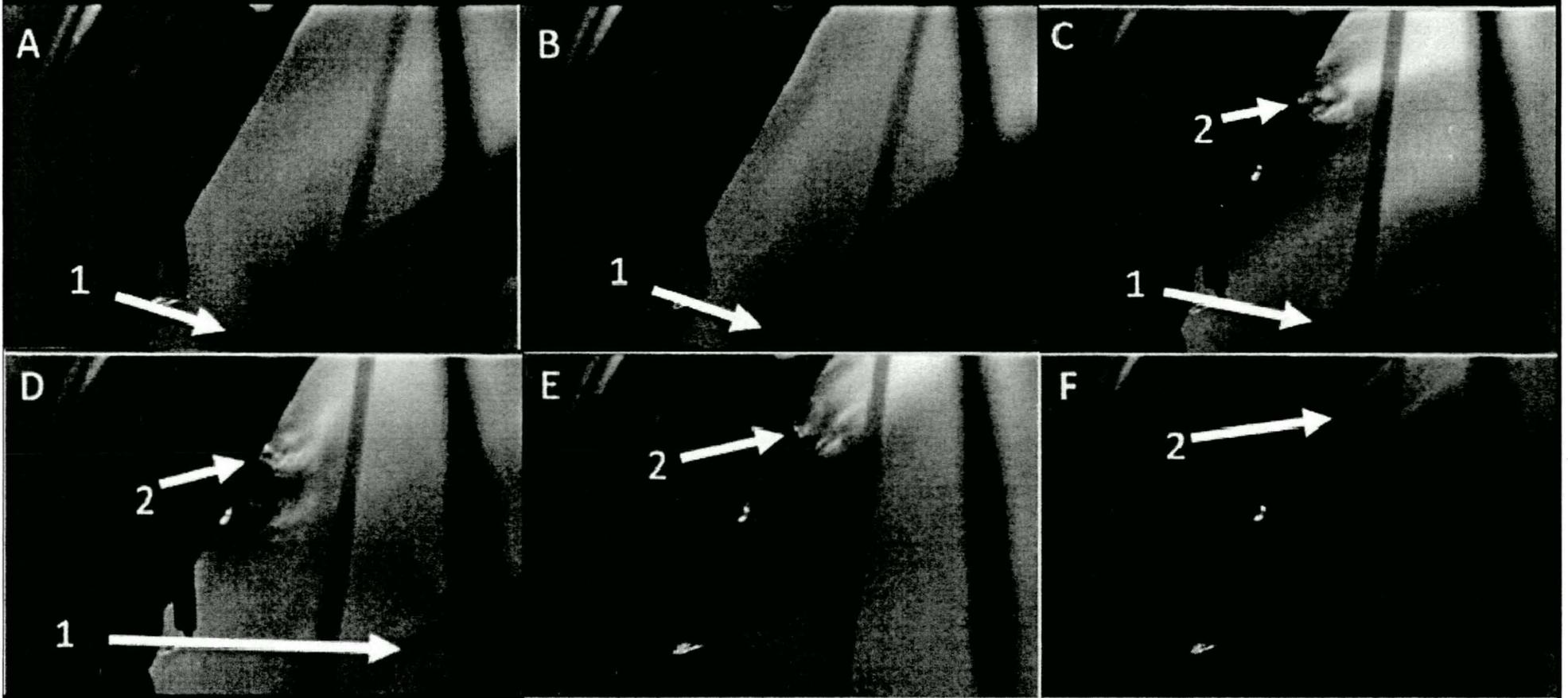
Rocks Blowing



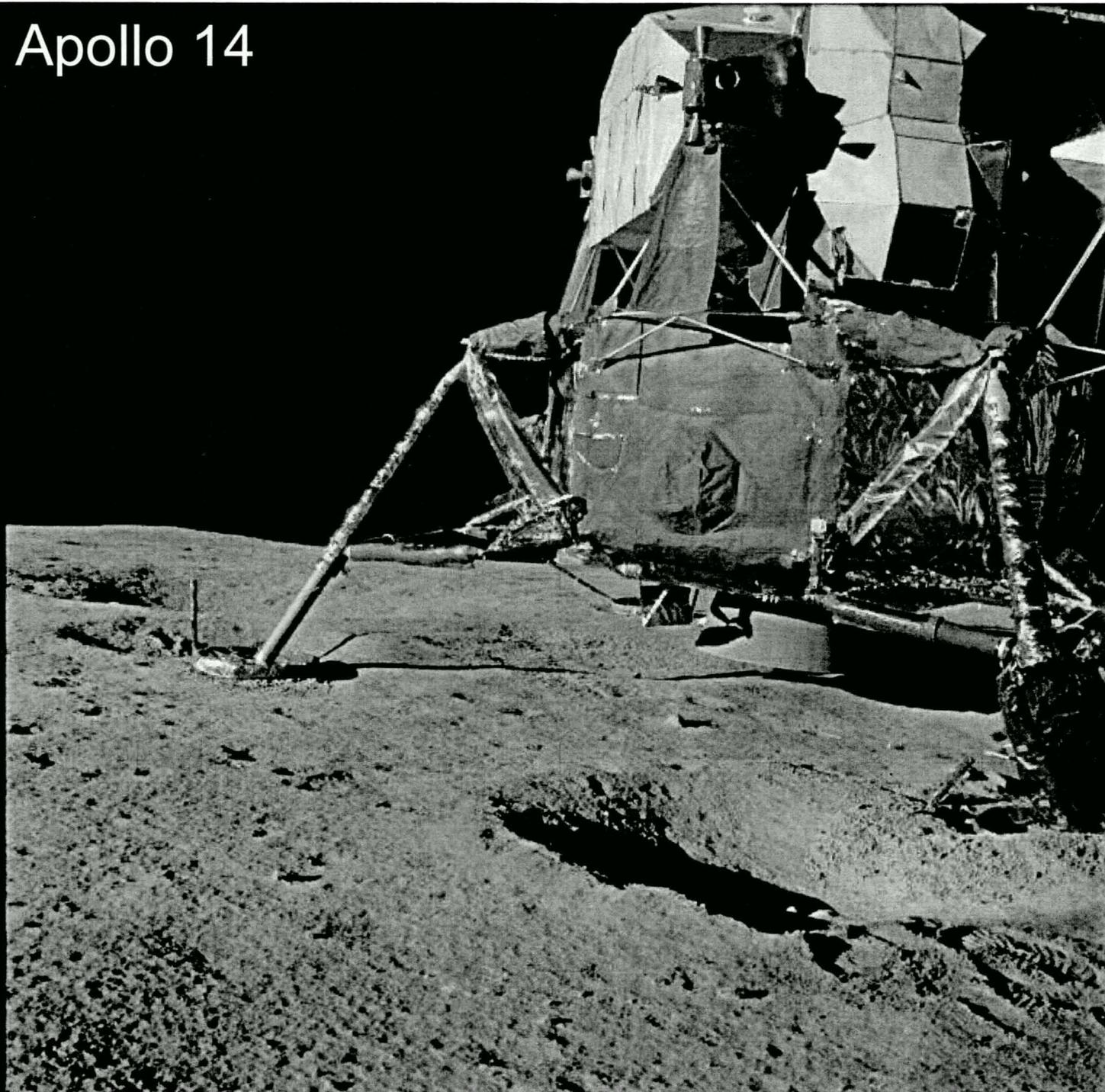
Dust Tails



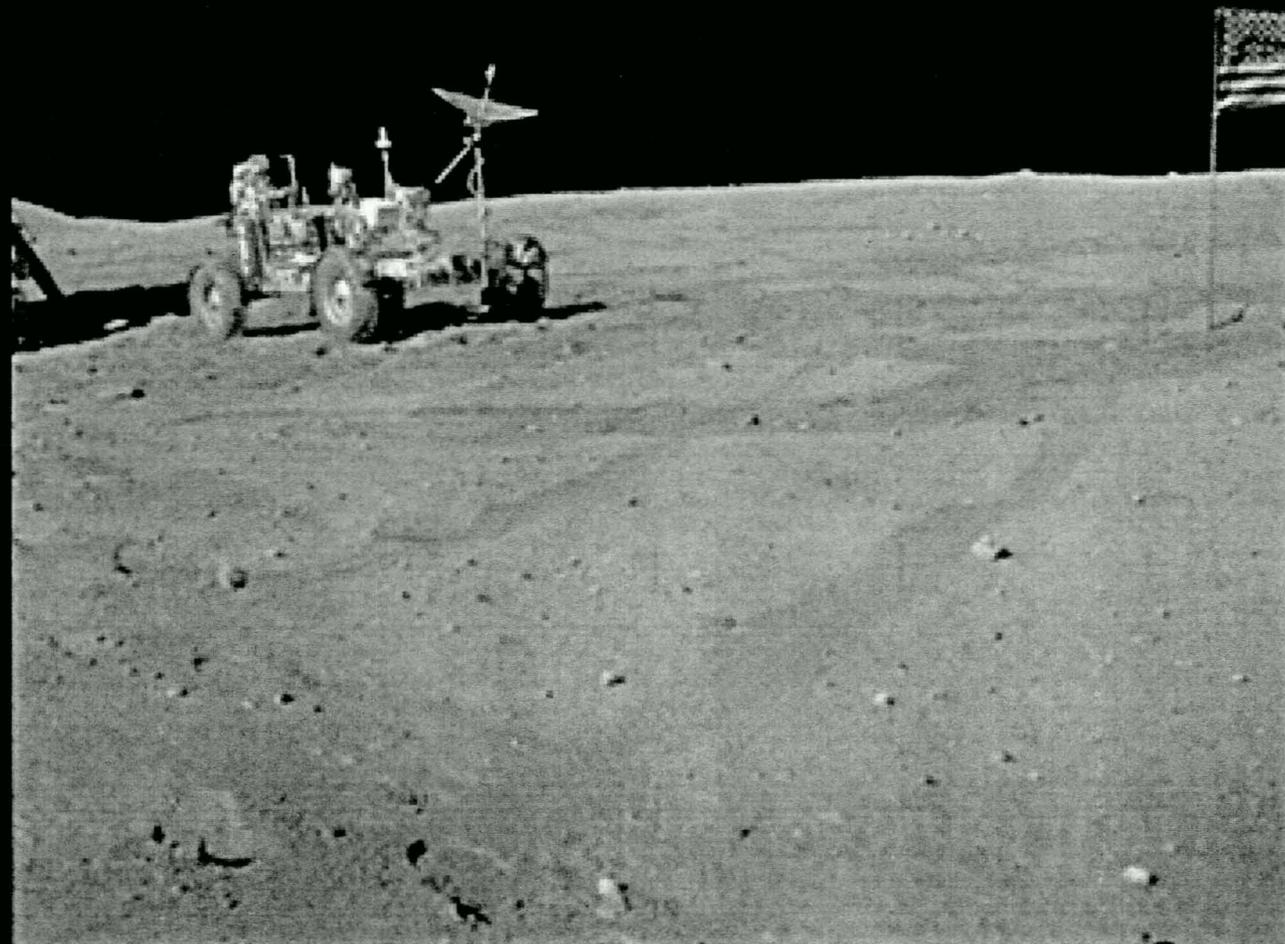
Terrain Modification



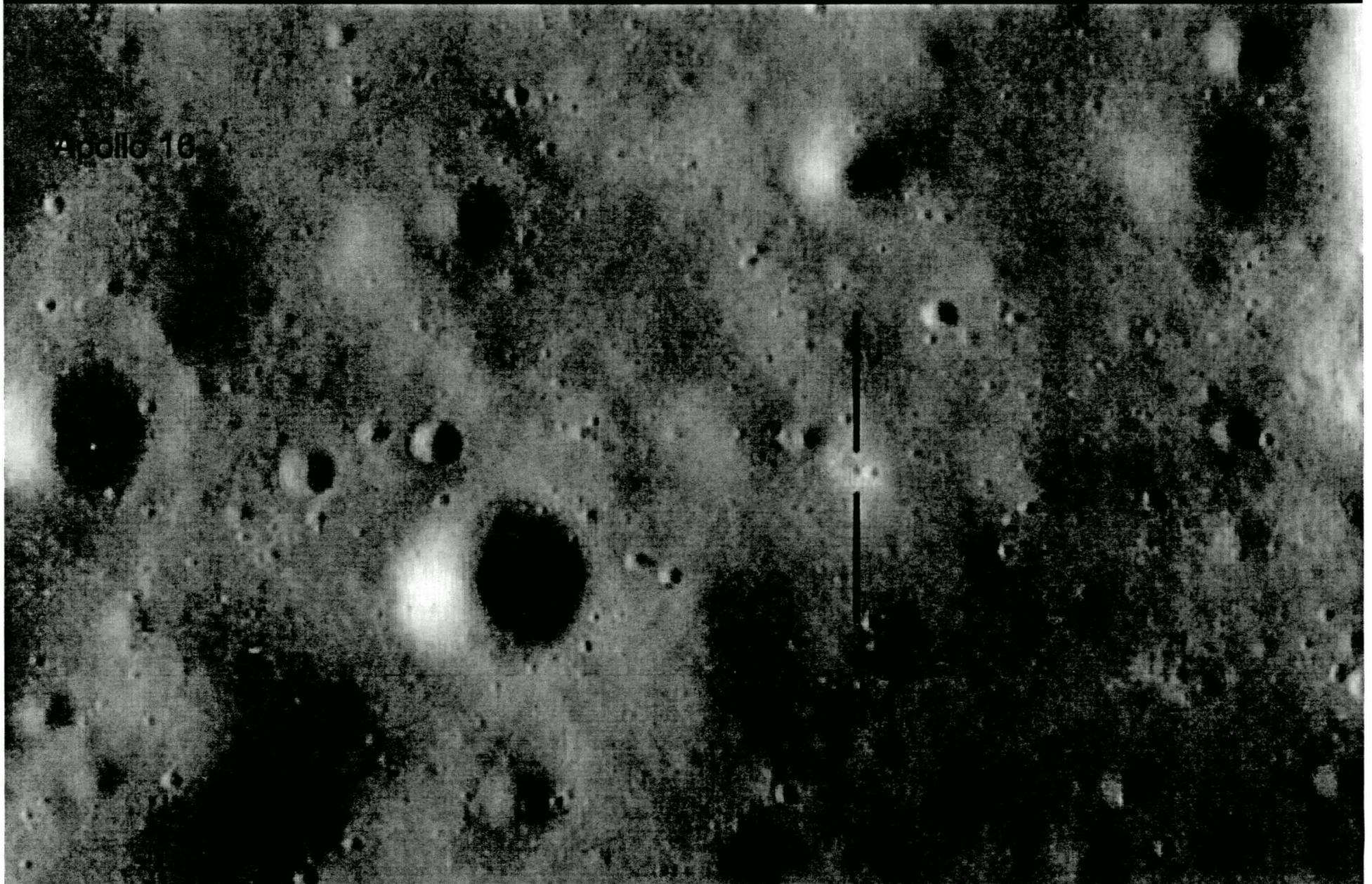
Apollo 14



Brightened Soil at Landing Site



Surface Brightening of Landing Site

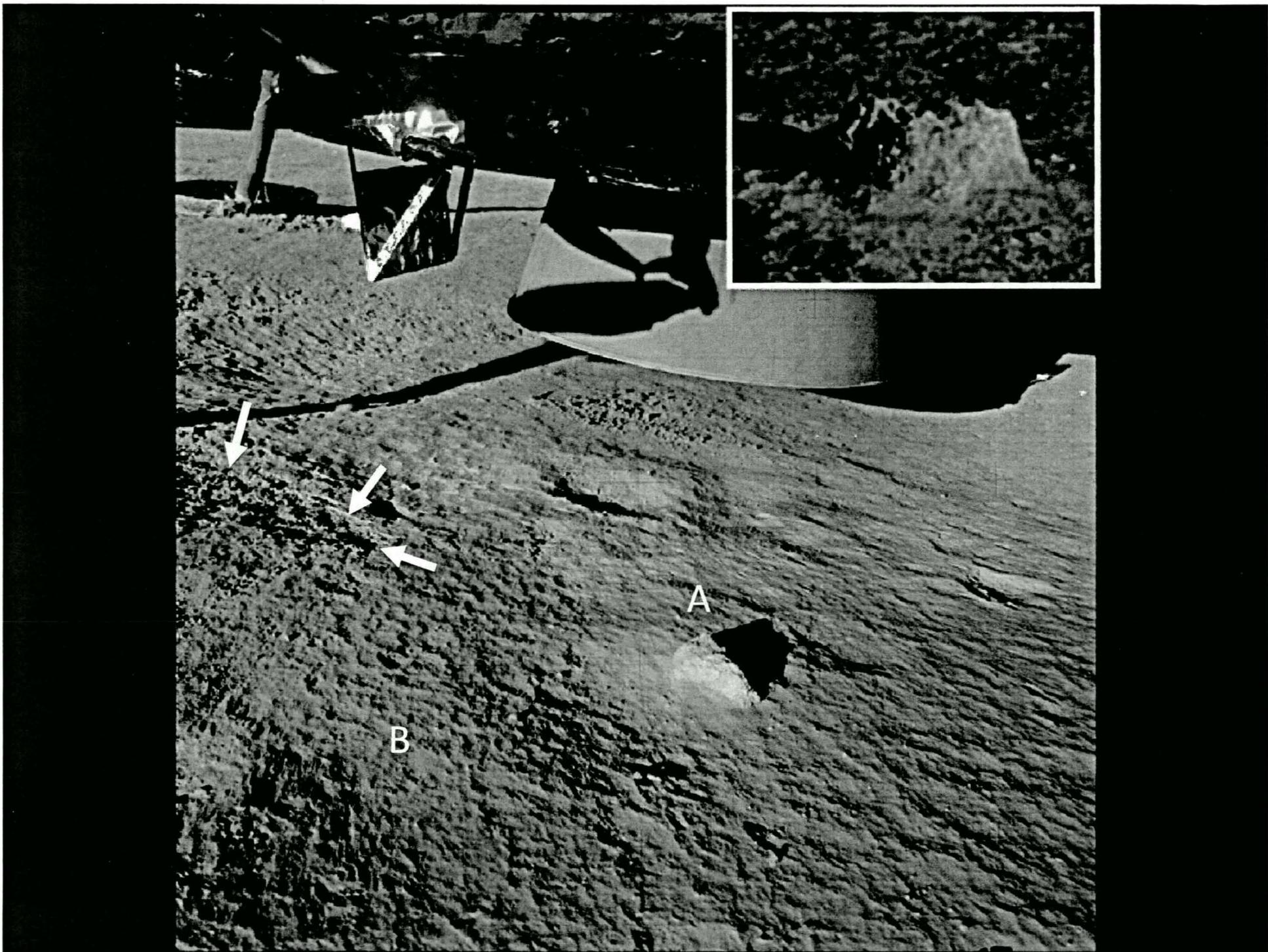


Rough Ejecta Ray

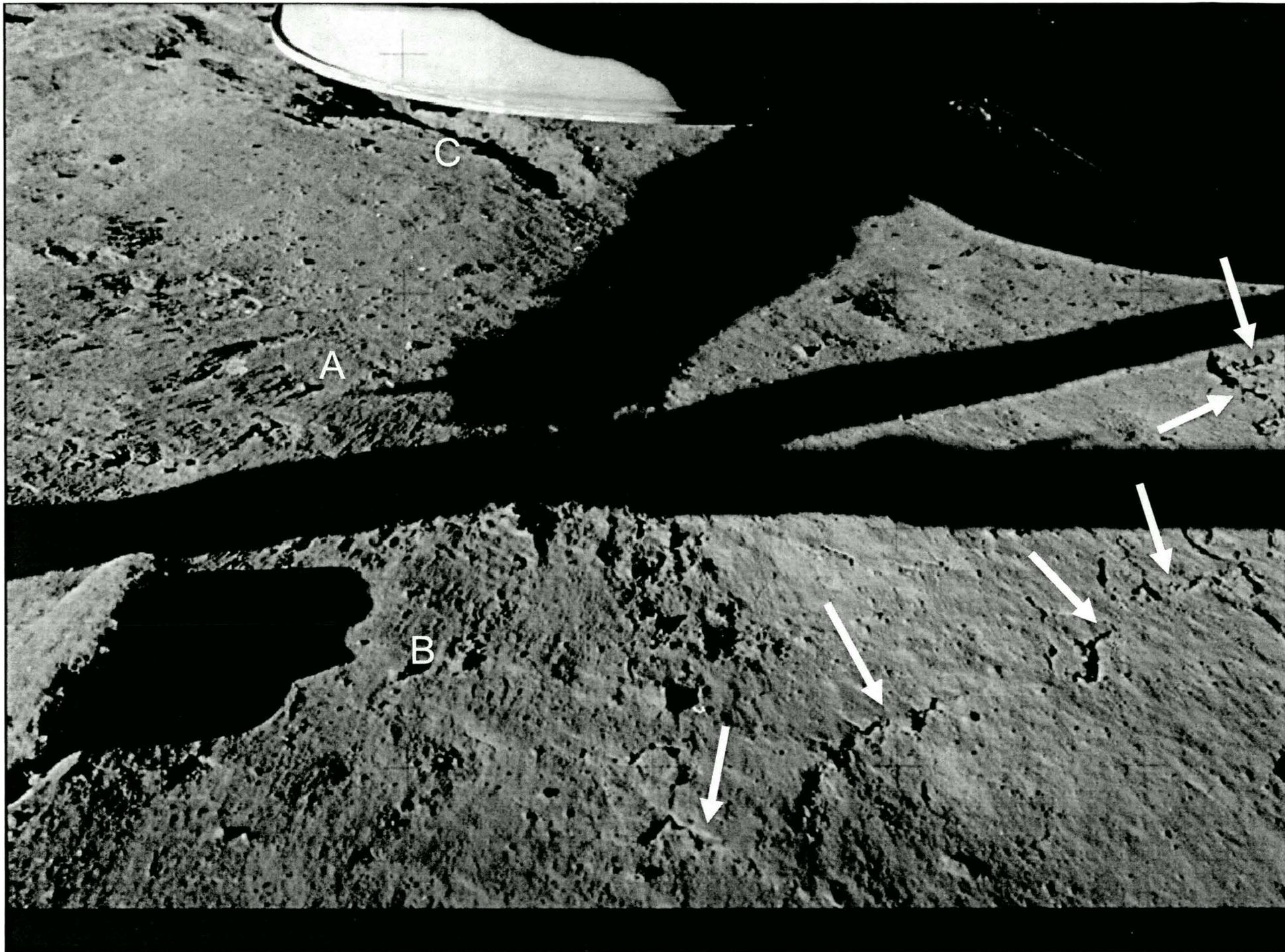




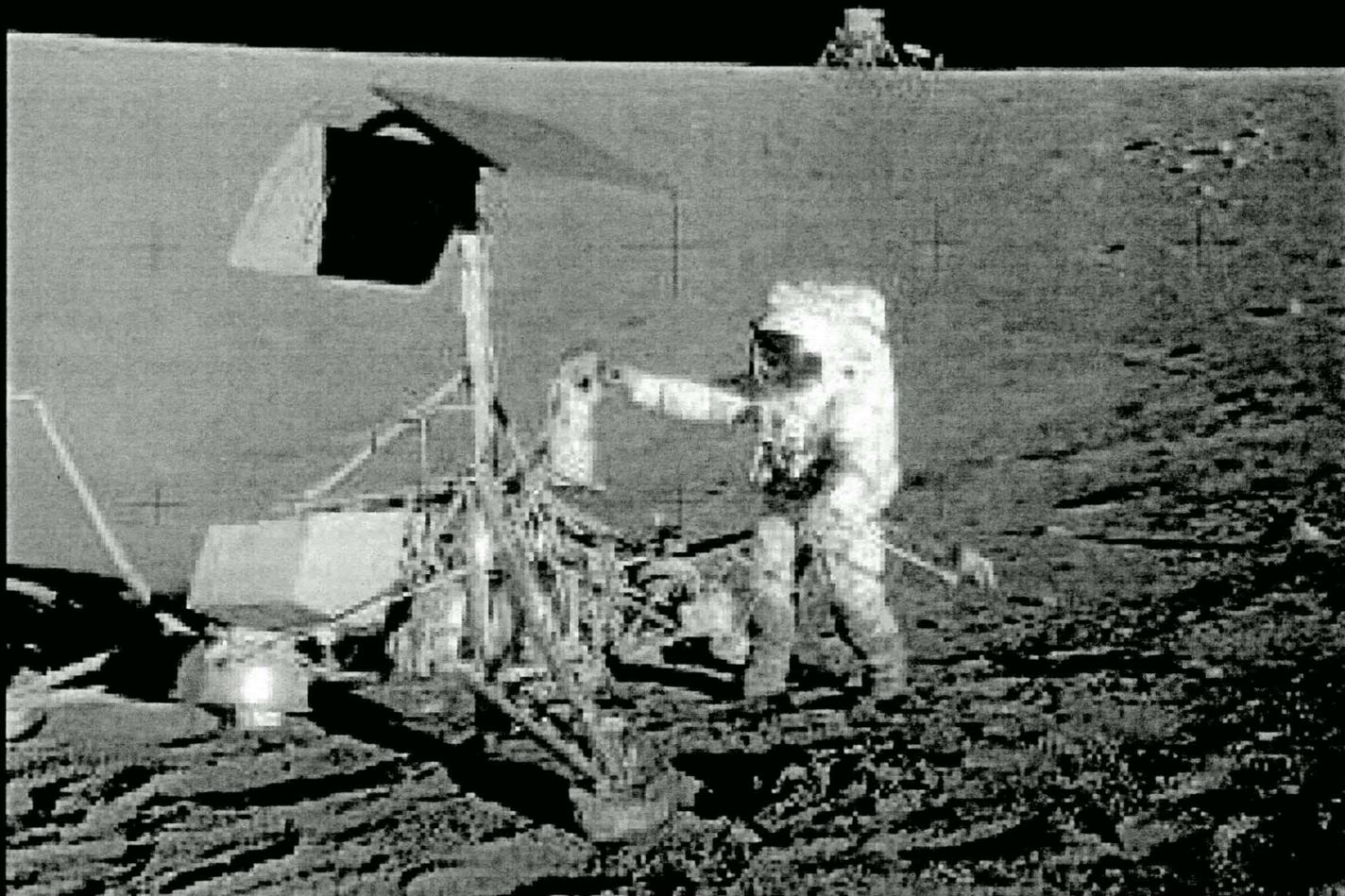




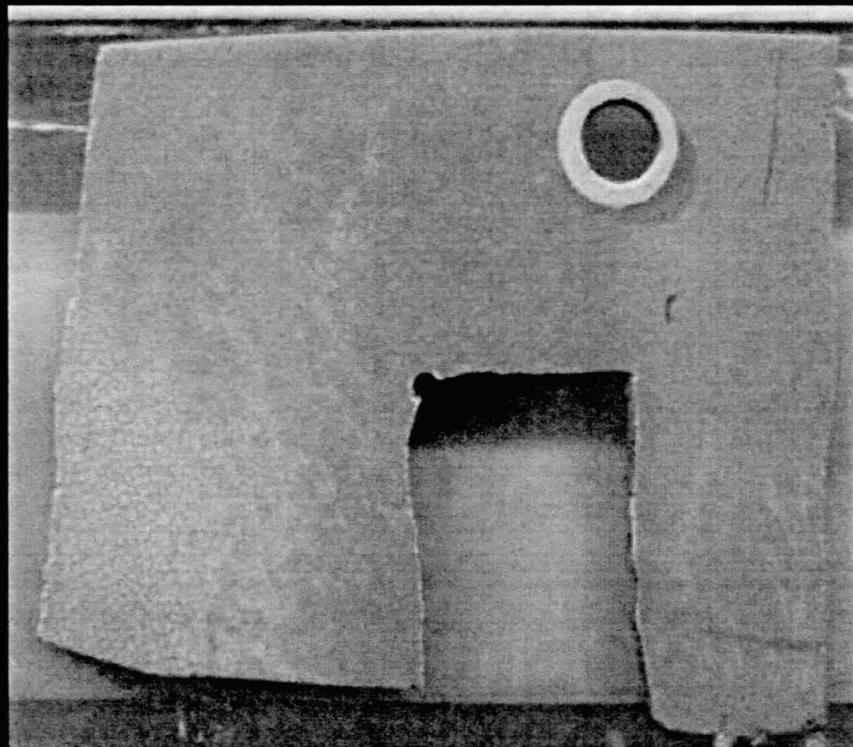
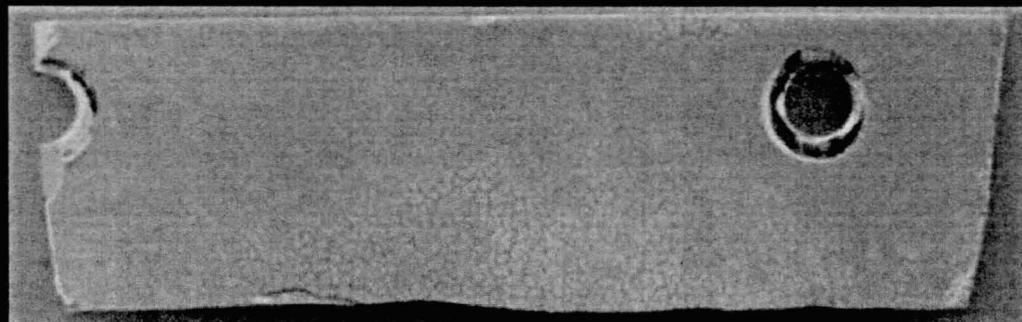




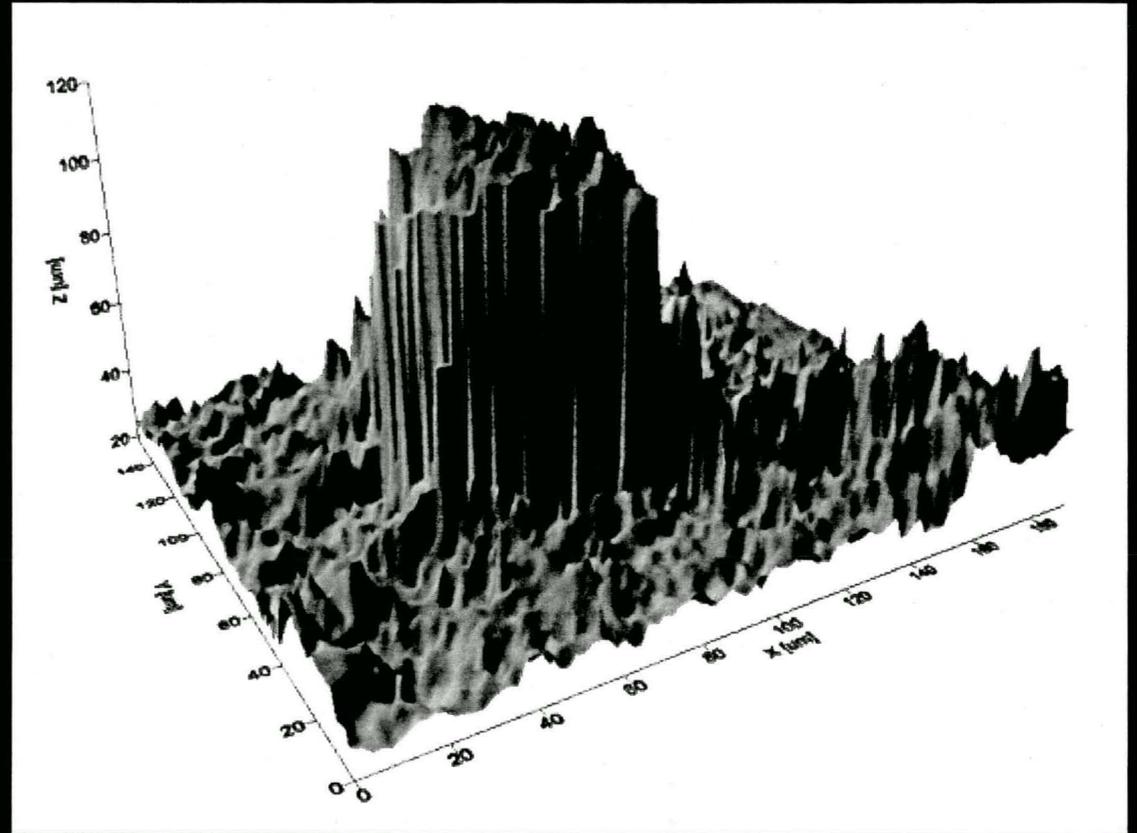
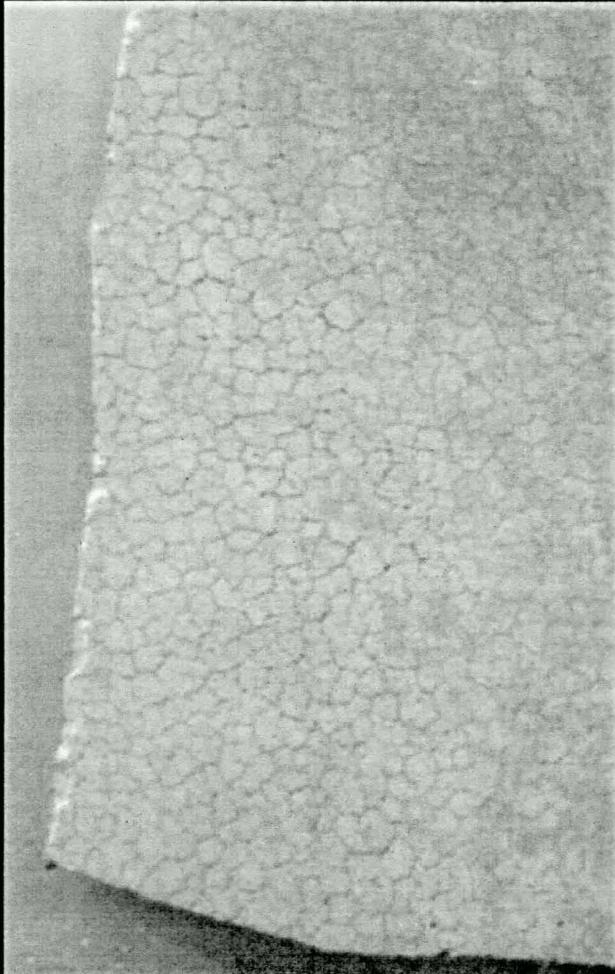
Surveyor III Coupons



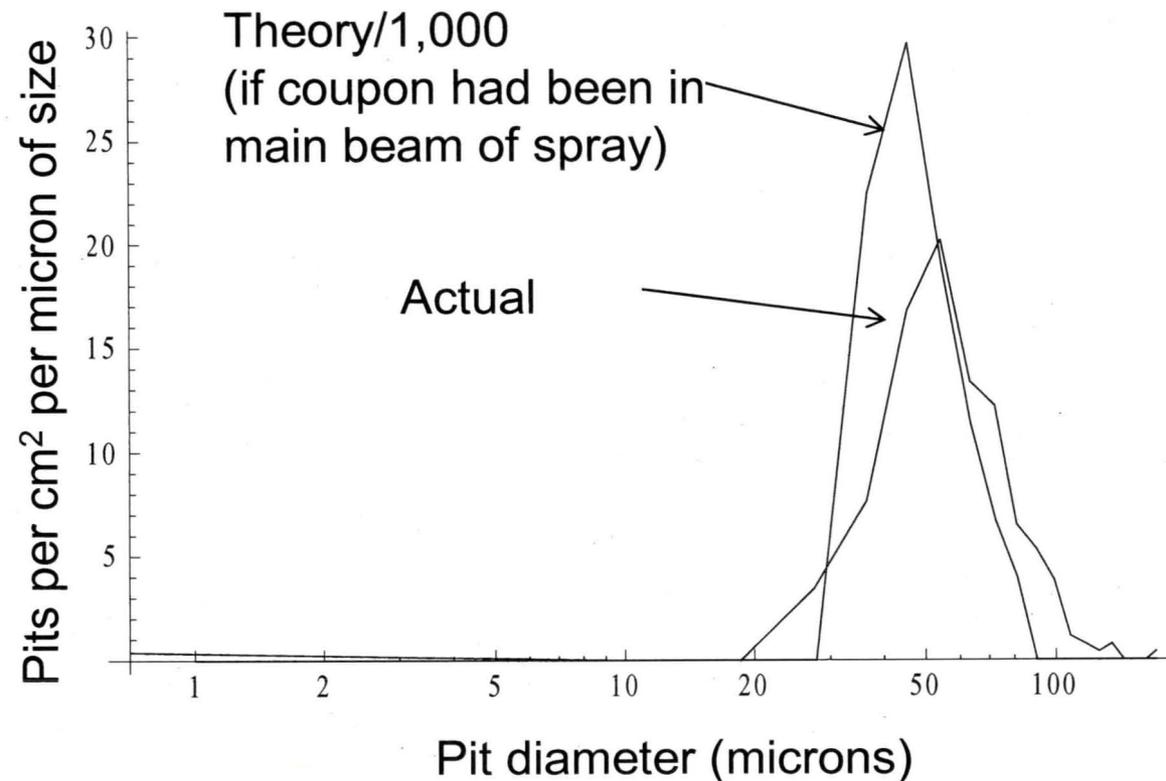
Surveyor III Coupons



Pits and Cracks



Comparison of Optical Density with Surveyor



- Surveyor shows 10^3 x fewer divots than if it were in main beam
- Surveyor show 34x less scouring than if it were main beam

What is Needed

What is Needed?

- A strategy to handle bulk soil failure
 - such as produces the terracing
- Rolling transport and effects on erosion rate
- Surface realism
- Layering of lunar soil
- Particle collisions
 - Momentum cascade
 - Scattering
 - Enhanced erosion and re-deposition