# Possible dielectric breakdown weathering effects on the comminution of lunar polar regolith

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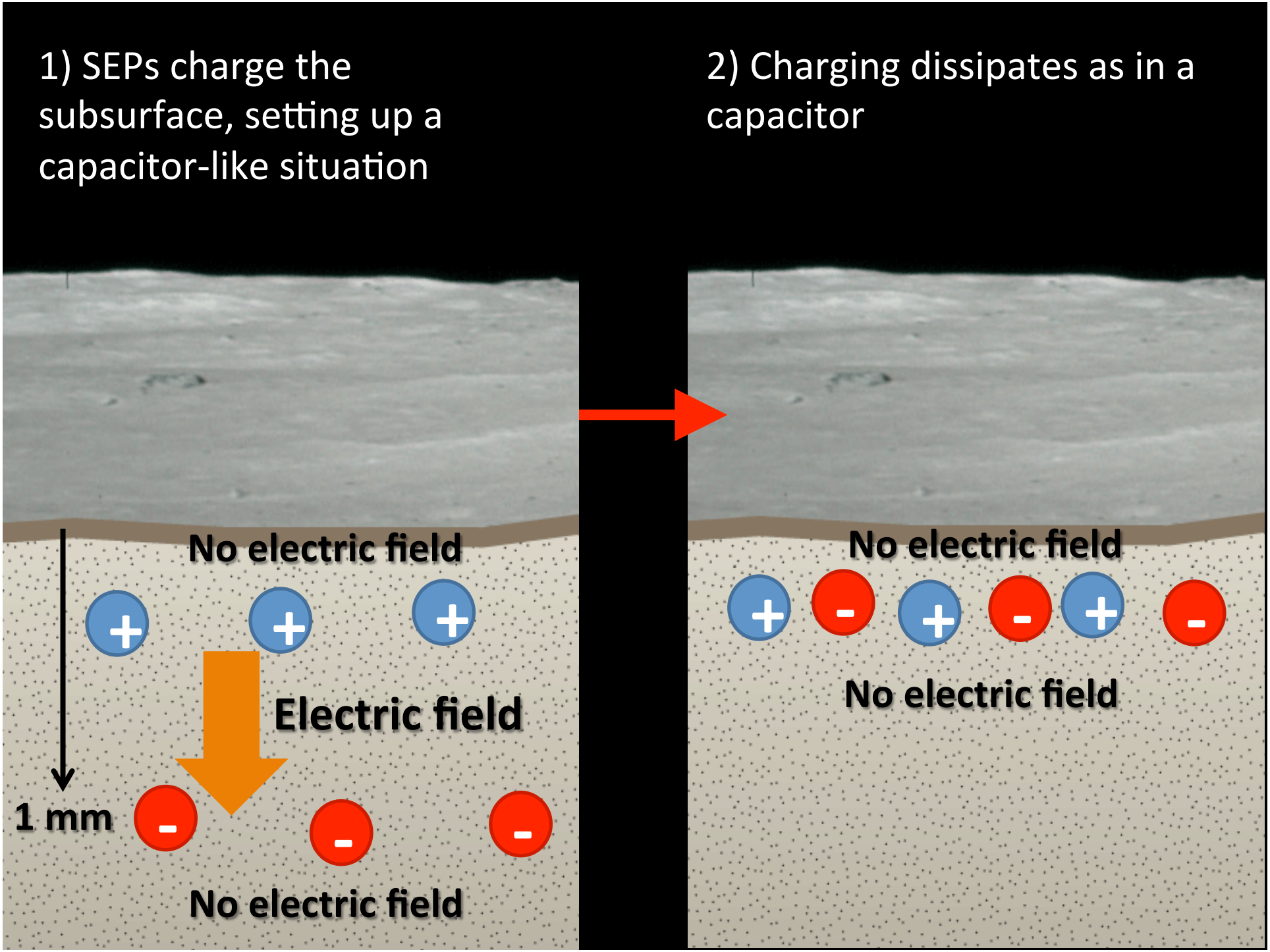
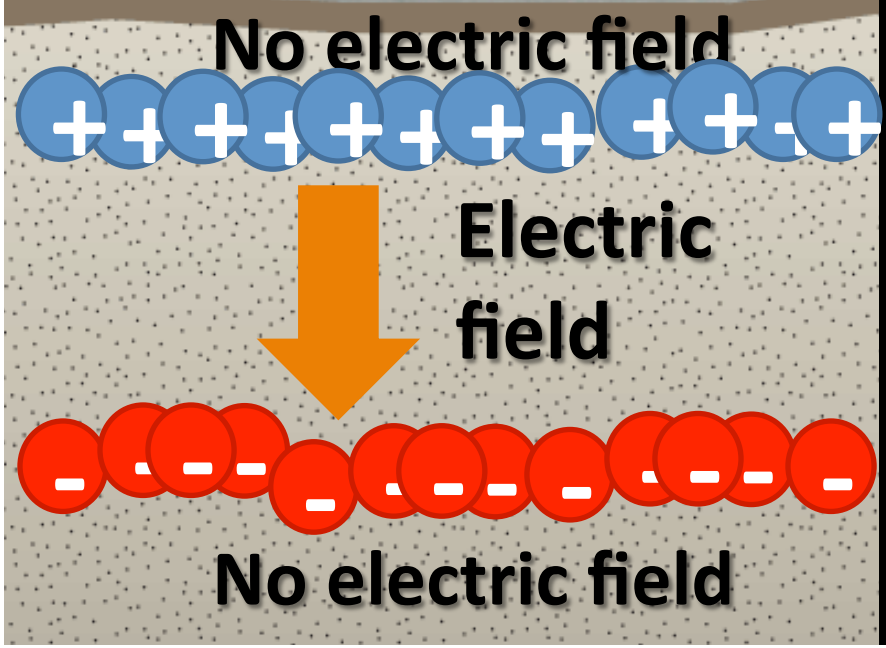
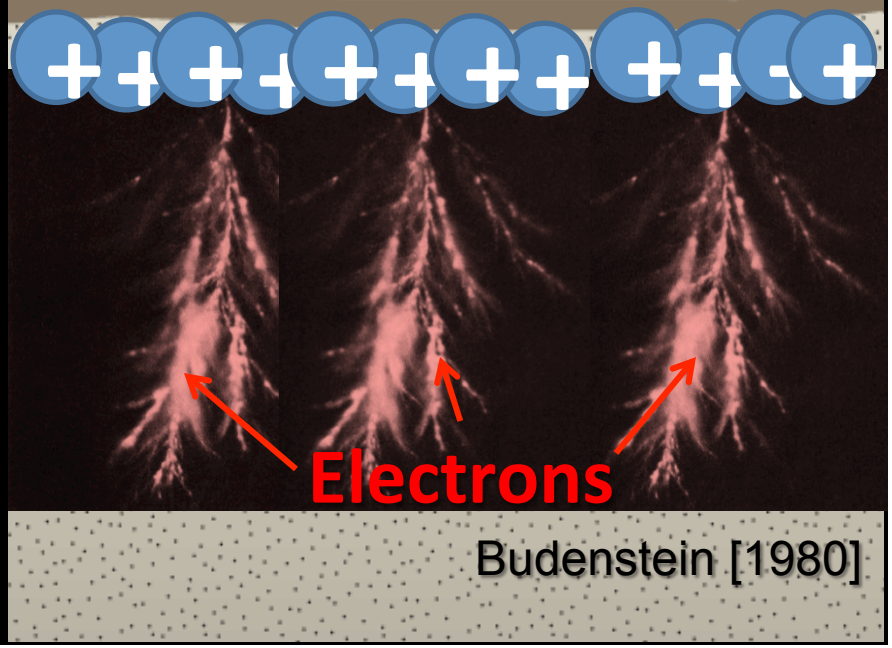

1) SEPs charge the subsurface, setting up a capacitor-like situation
2) Charging dissipates as in a capacitor
No electric field
Electric field
1 mm
No electric field
No electric field
No electric field

If SEPs charge regolith faster than it can discharge (fluence of $10^{10}$-$10^{11}$ $cm^{-2}$)…

… electric field can increase to threshold for dielectric breakdown ($10^6$-$10^7$ V/m)

**Colder regolith → lower conductivity → more charging**



# How much energy has breakdown deposited in PSR regolith?

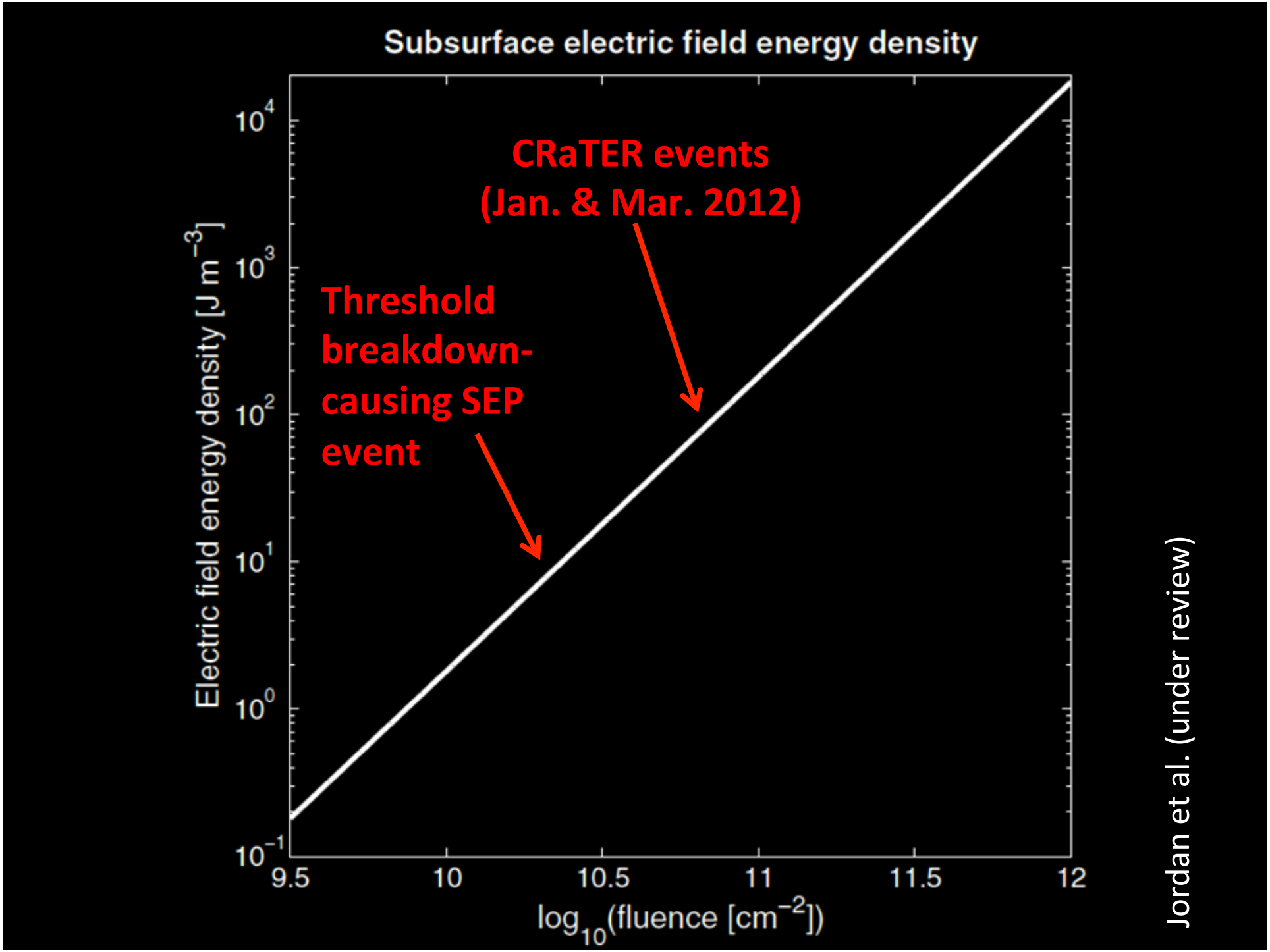
Event's E-field energy density (function of SEP fluence)

Event rate (function of SEP fluence)

Rate at which energy density is deposited

Exposure time (limited by gardening): $10^6$ years

Total breakdown energy deposited


Subsurface electric field energy density
CRaTER events
(Jan. & Mar. 2012)
Threshold
breakdown-
causing SEP
event
Electric field energy density [J m$^{-3}$]
$10^{4}$
$10^{3}$
$10^{2}$
$10^{1}$
$10^{0}$
$10^{-1}$
9.5
10
10.5
11
11.5
12
$\log_{10}$(fluence [cm$^{-2}$])
Jordan et al. (under review)

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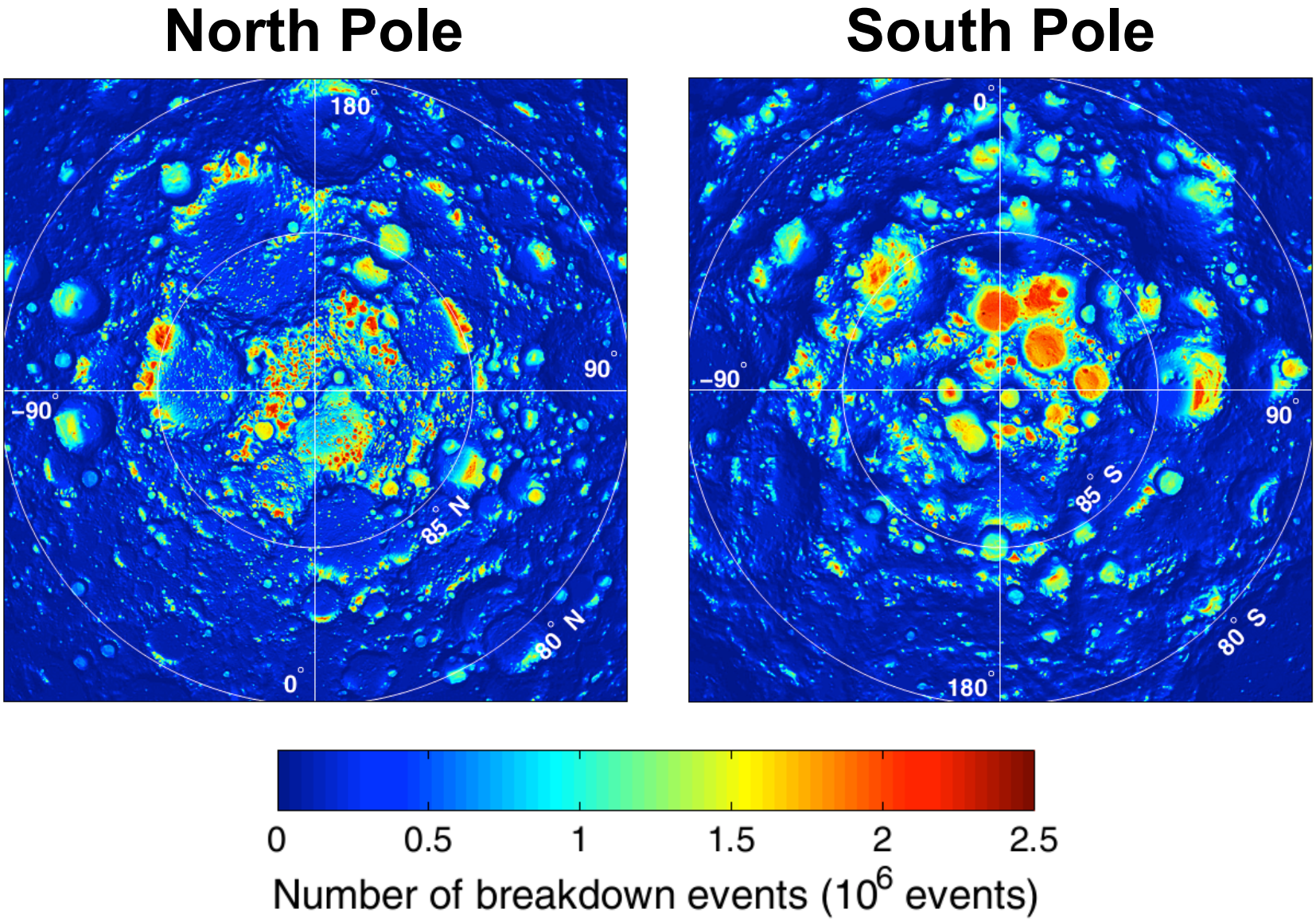



(Jordan et al., 2015)

# How much energy has breakdown deposited in PSR regolith?

Event's E-field energy density (function of SEP fluence)

Event rate (function of SEP fluence)

Rate at which energy density is deposited

Exposure time (limited by gardening): $10^6$ years

Total breakdown energy deposited

Energy density deposited over $10^6$ yr of exposure ($10^6$ SEP events):
**$8.8 \times 10^8$ J m$^{-3}$**

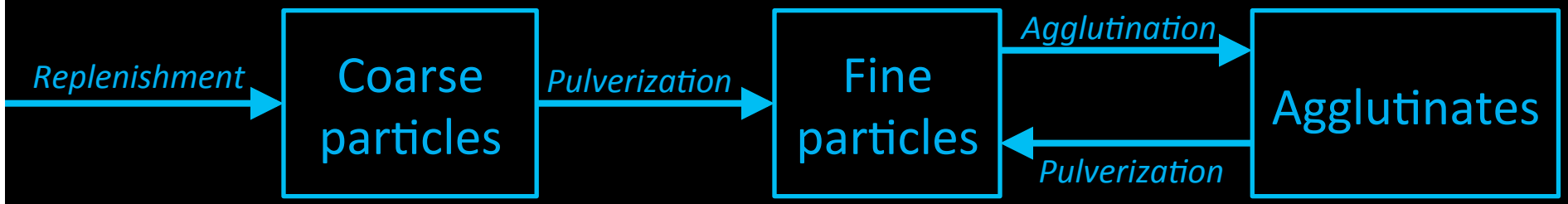
Energy density needed to vaporize all regolith:
$\rho_{reg}\, c_p\, (T_{vapor} - T_{PSR}) =$
**$7.3 \times 10^9$ J m$^{-3}$**

| Weathering process | Energy flux (J m$^{-2}$ yr$^{-1}$) | Vapor + melt production (kg m$^{-2}$ yr$^{-1}$) | % Gardened soil melted or vaporized |
|---|---|---|---|
| **Meteorites** | 12 | $1.8 \times 10^{-7}$ | ~10% |
| **Breakdown** | 0.88 | $1.8 - 3.4 \times 10^{-7}$ | ~10-25% |

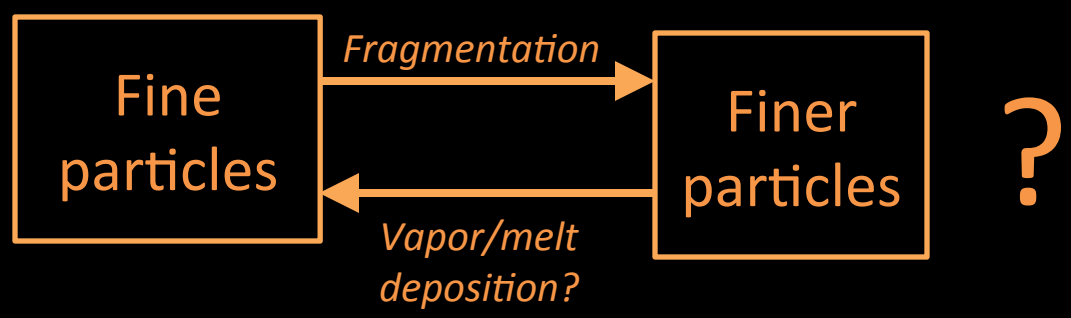
Jordan et al. (under review)

Breakdown weathering may be comparable to meteoritic weathering in PSRs

## Impact model of soil evolution (McKay et al., 1974):

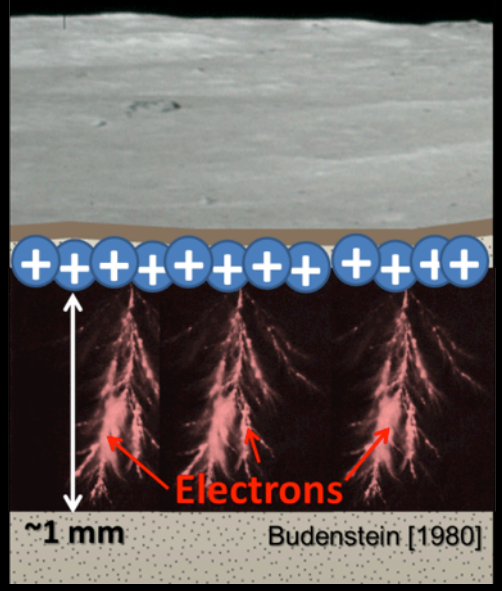



## Breakdown model of soil evolution:

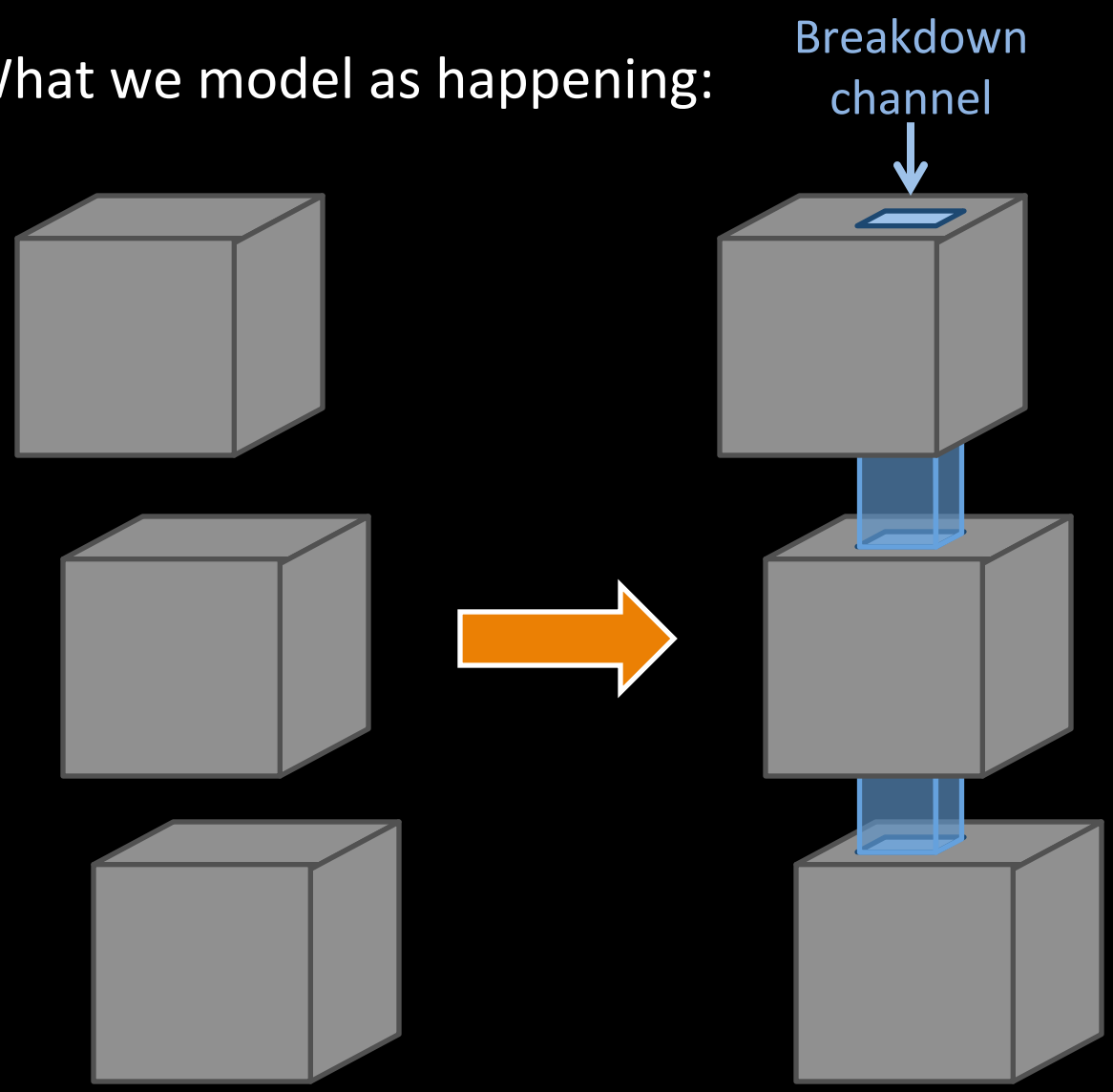


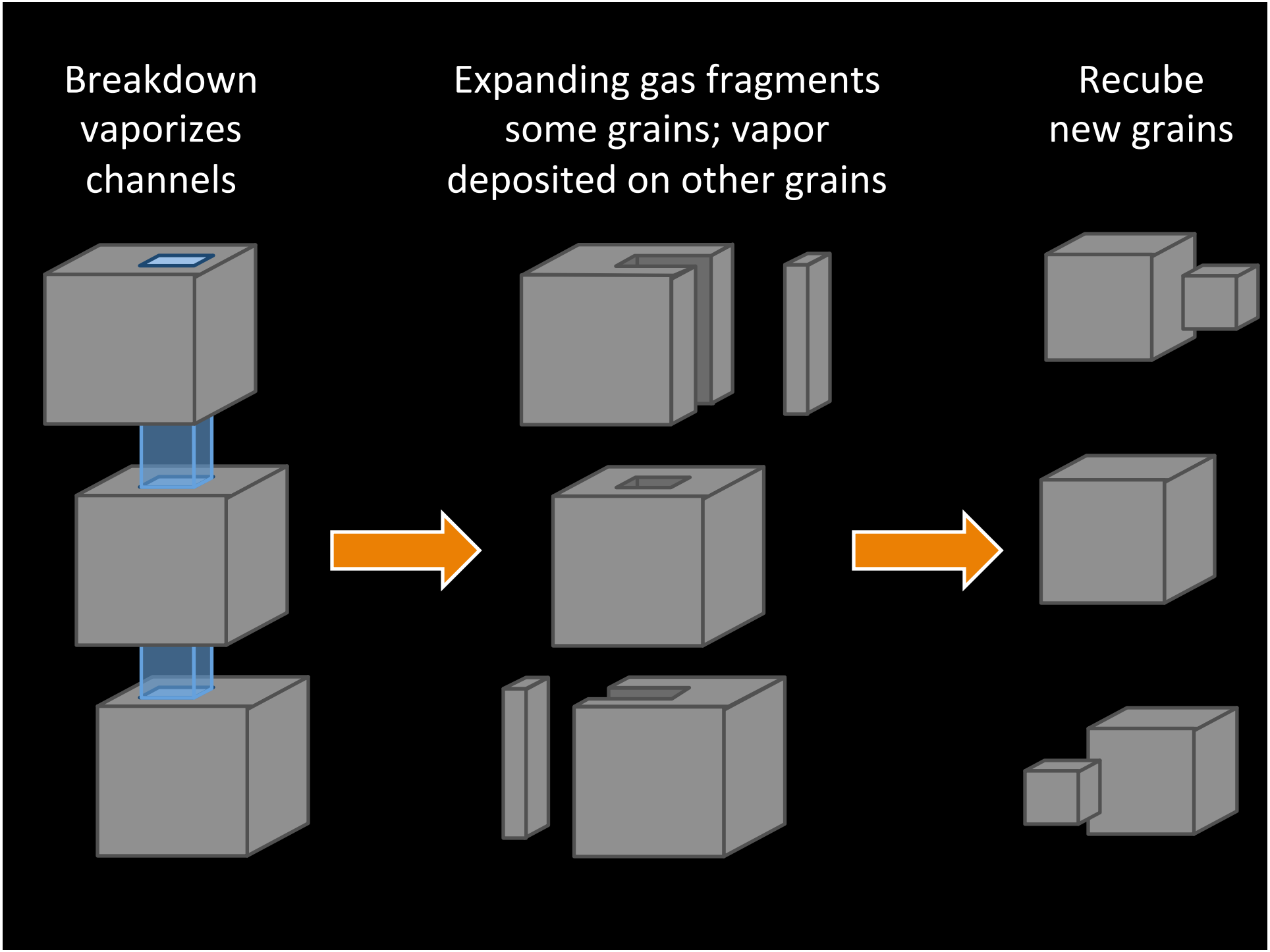

## Impact + breakdown soil evolution: ?

What probably happens
(need experiments):




What we model as happening:

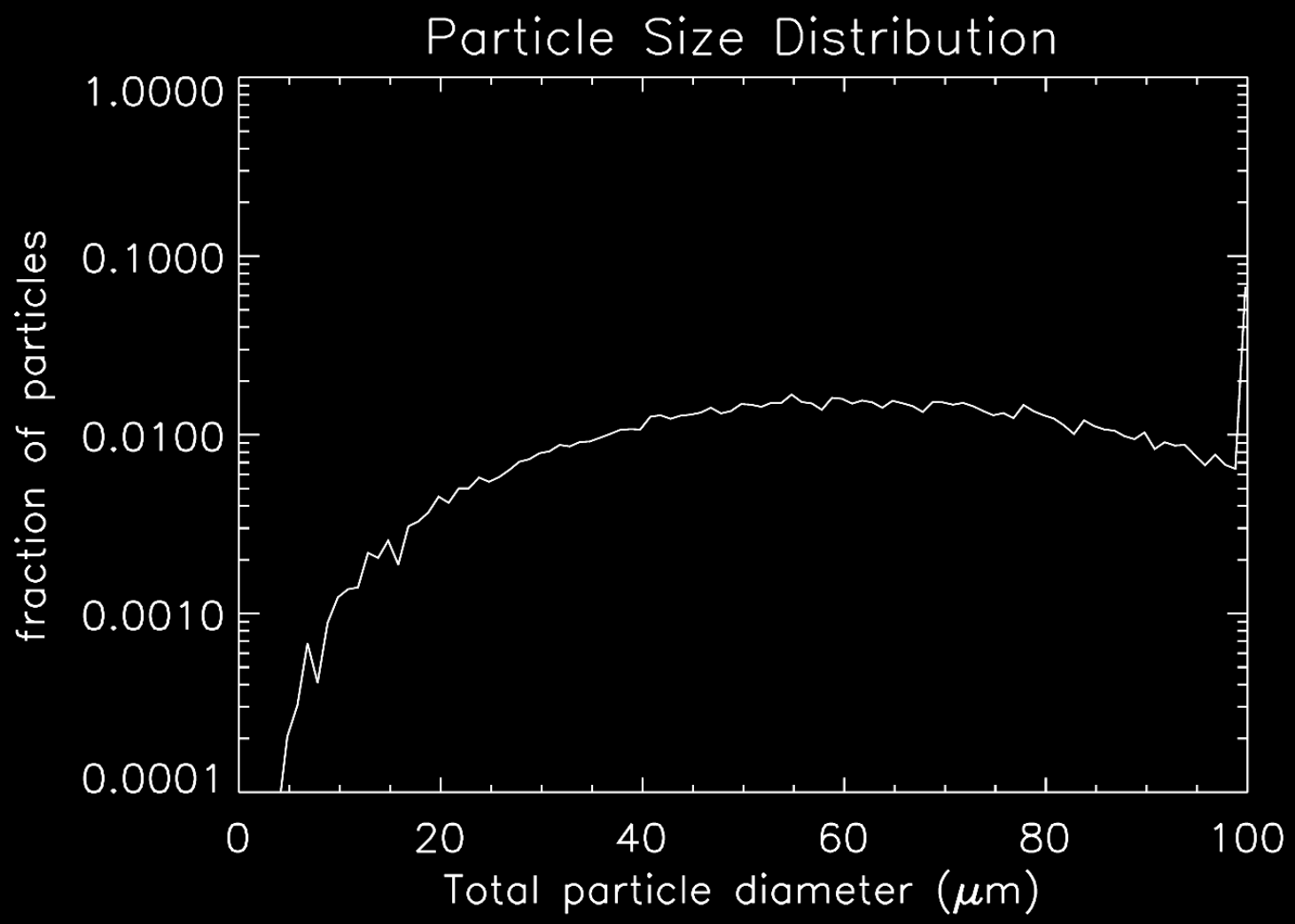


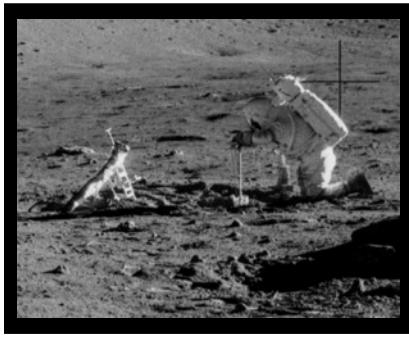

Breakdown vaporizes channels
Expanding gas fragments some grains; vapor deposited on other grains
Recube new grains

# Preliminary Results

Starting particle size: 100 μm

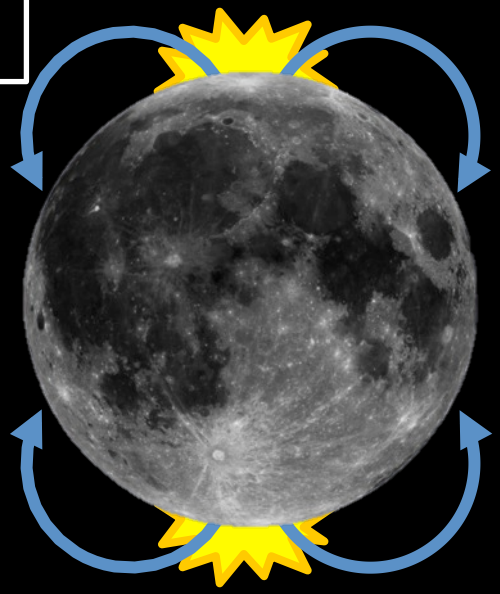
Input breakdown energy: $10^9$ J $m^{-3}$





Is it in Apollo samples?

Impacts could spread breakdown-affected regolith to lower latitudes.



~0.01% of all gardened regolith may have experienced breakdown, but only a fraction of this would make it to lower latitudes.

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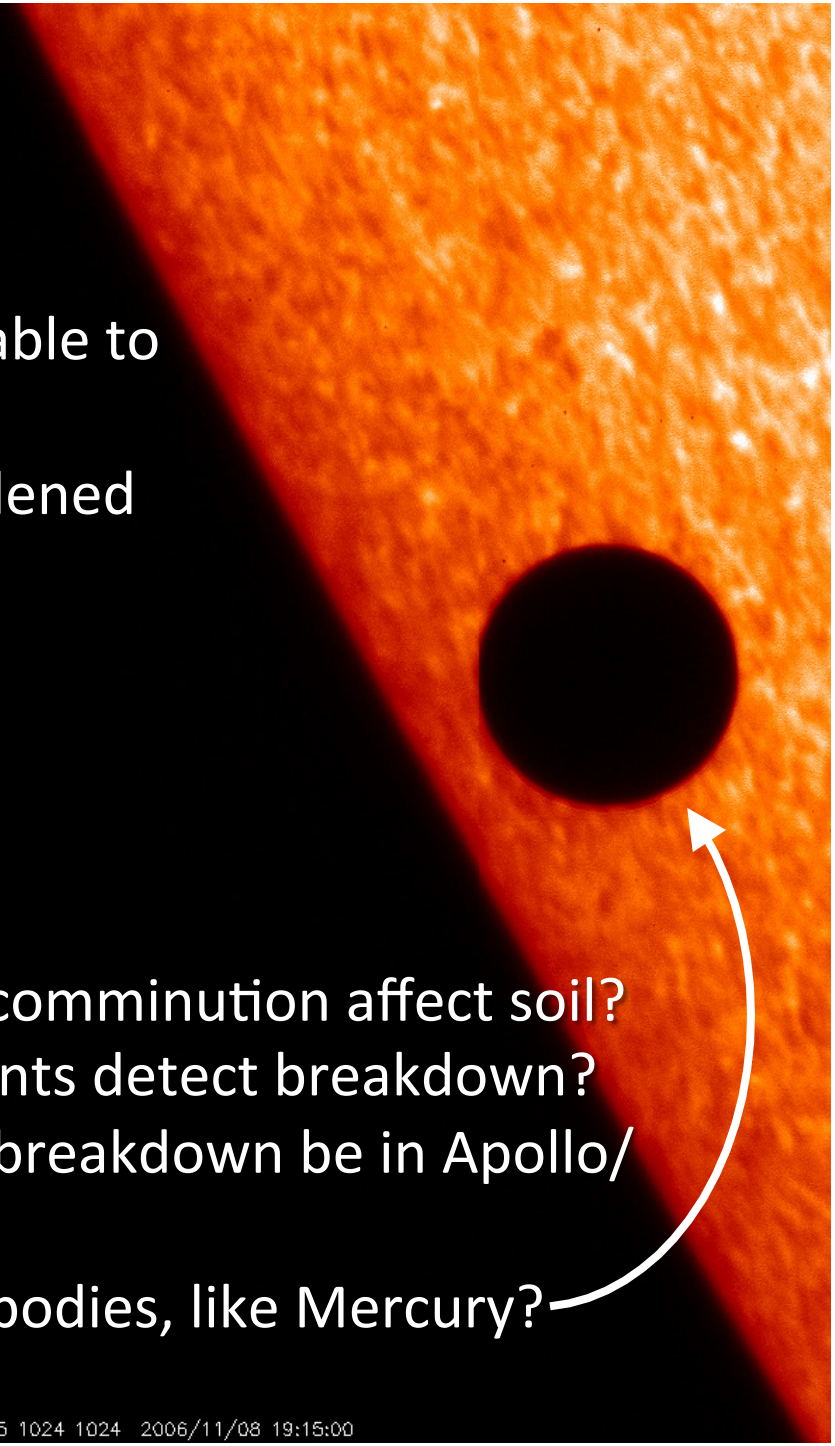
Breakdown may occur on the nightside, which can be < 100 K.

If so, 3-6% of all gardened regolith may have experienced breakdown.

# Conclusions

- Breakdown weathering in PSRs:
  - may produce vapor/melt comparable to meteoritic weathering
  - may have affected 10-25% of gardened regolith
  - may help drive comminution
- Need experiments!

# Questions

- How would meteoritic + breakdown comminution affect soil?
- Could LRO or ground-based instruments detect breakdown?
- Could material that has experienced breakdown be in Apollo/Luna samples?
- Does breakdown affect other airless bodies, like Mercury?