

Diviner Observations of Lunar Swirls: Implications for Space Weathering

Timothy Glotch, Stony Brook University

Paul Lucey, Benjamin Greenhagen, Joshua Bandfield,
and the Diviner Science Team

Lunar Swirls

- High-albedo features that occur in both mare and highlands regions.
- Swirls have high UV-VIS ratios (appear “bluer” in Clementine data) [*Blewett et al.*, 2007].
- Many correspond to magnetic anomalies [*Hood et al.*, 2001].
- Some correspond to antipodes of large impact basins
- Occur in a continuum of morphologies [*Blewett et al.*, 2007]
- Three general mechanisms suggested for their formation.

Clementine UV-VIS image of the Reiner Gamma Formation

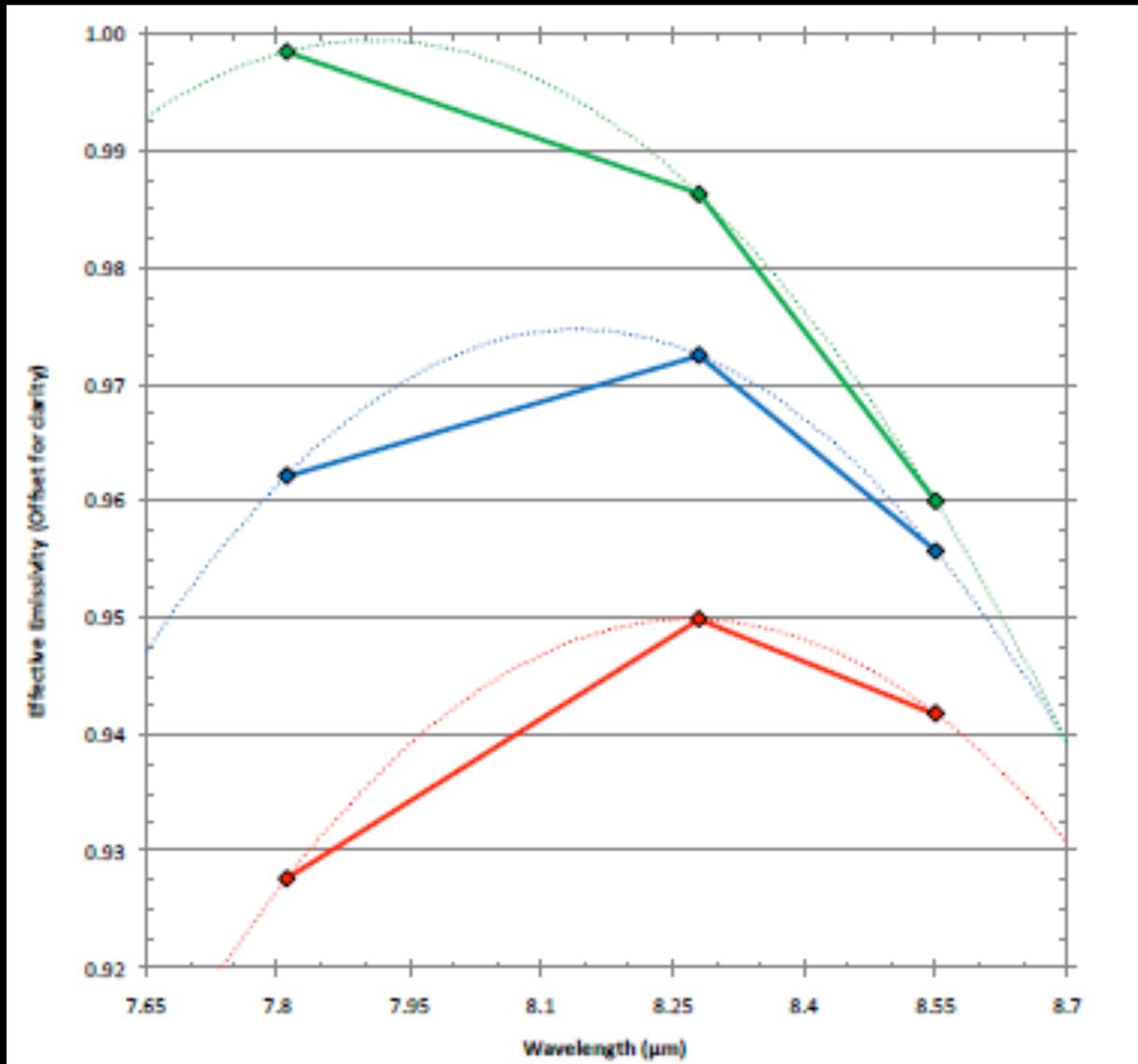


Lunar Swirls: Possible Formation Mechanisms

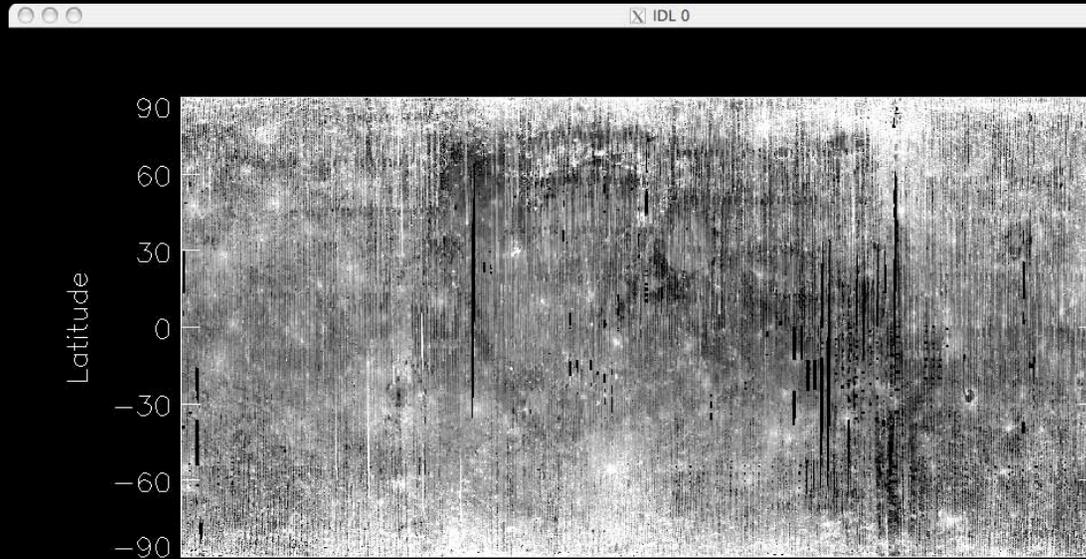


1. Space Weathering [e.g. *Hood et al.*]
 - Some swirls associated with strong magnetic fields. B- fields protect the surface from charged solar wind particles.
2. Impact by swarms of micro-comets or meteors [*Schultz; Starukhina and Shkuratov*]
 - Swarms disturb regolith, revealing unweathered subsurface
3. Dust Transport [*Garrick-Bethel et al.*]
 - Feldspathic dust lofted by electric fields generated as terminator passes over surface

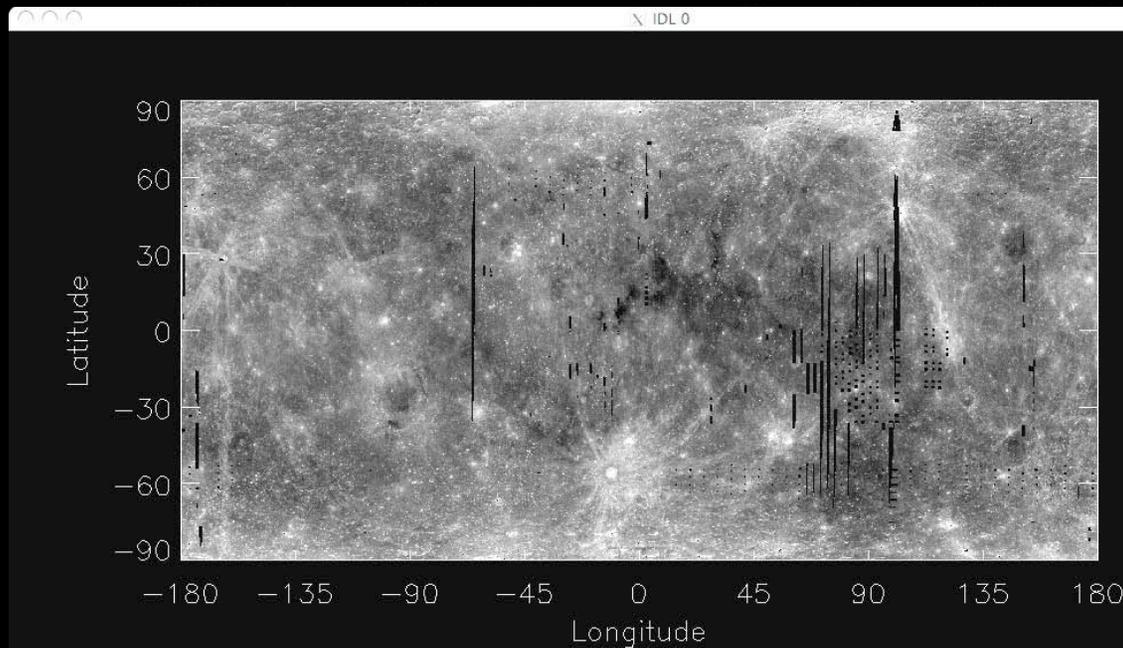
Diviner 8 μm Measurements



Diviner is sensitive to Space Weathering



CF Map,
FeO Removed



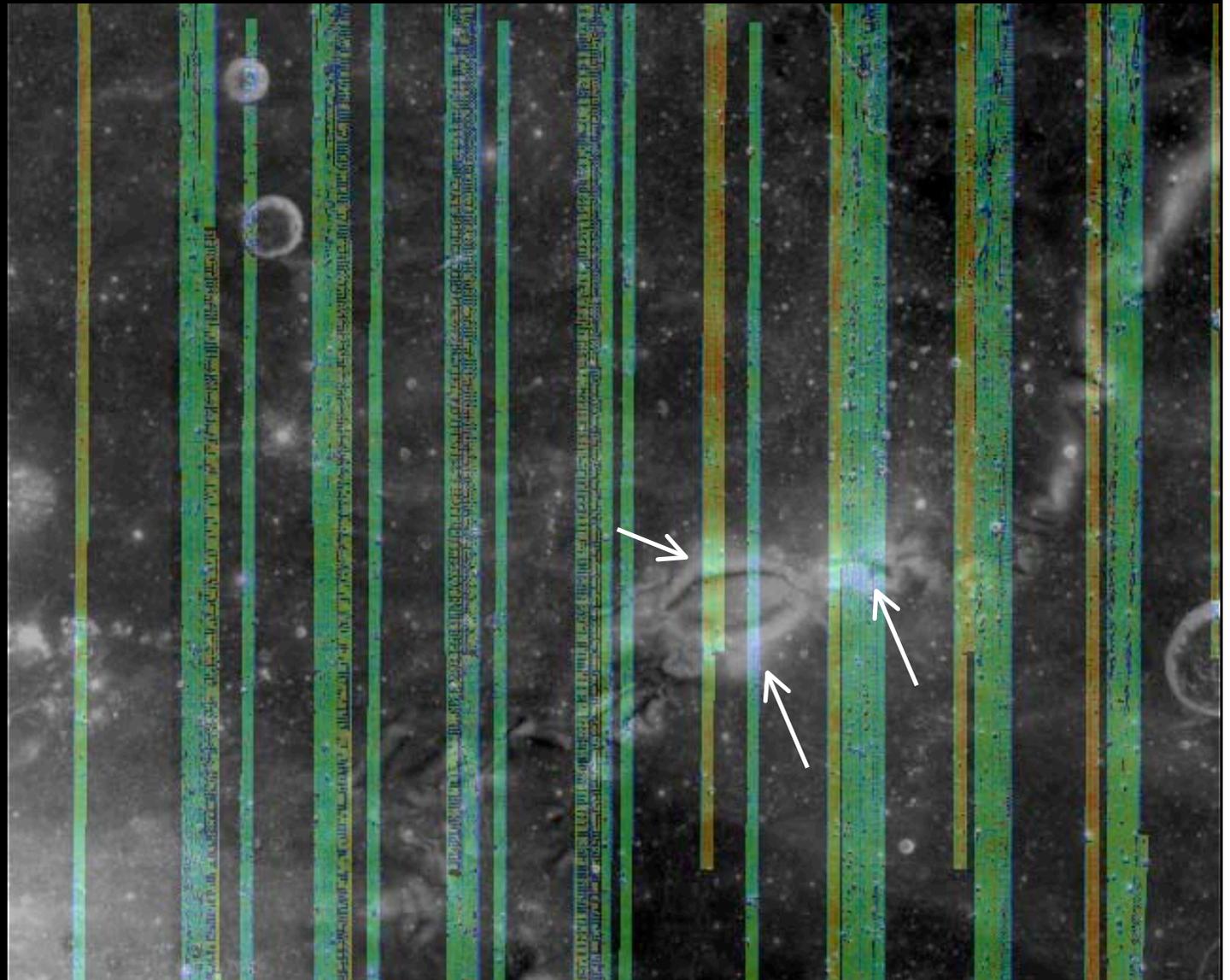
OMAT

Lucey et al., 2010



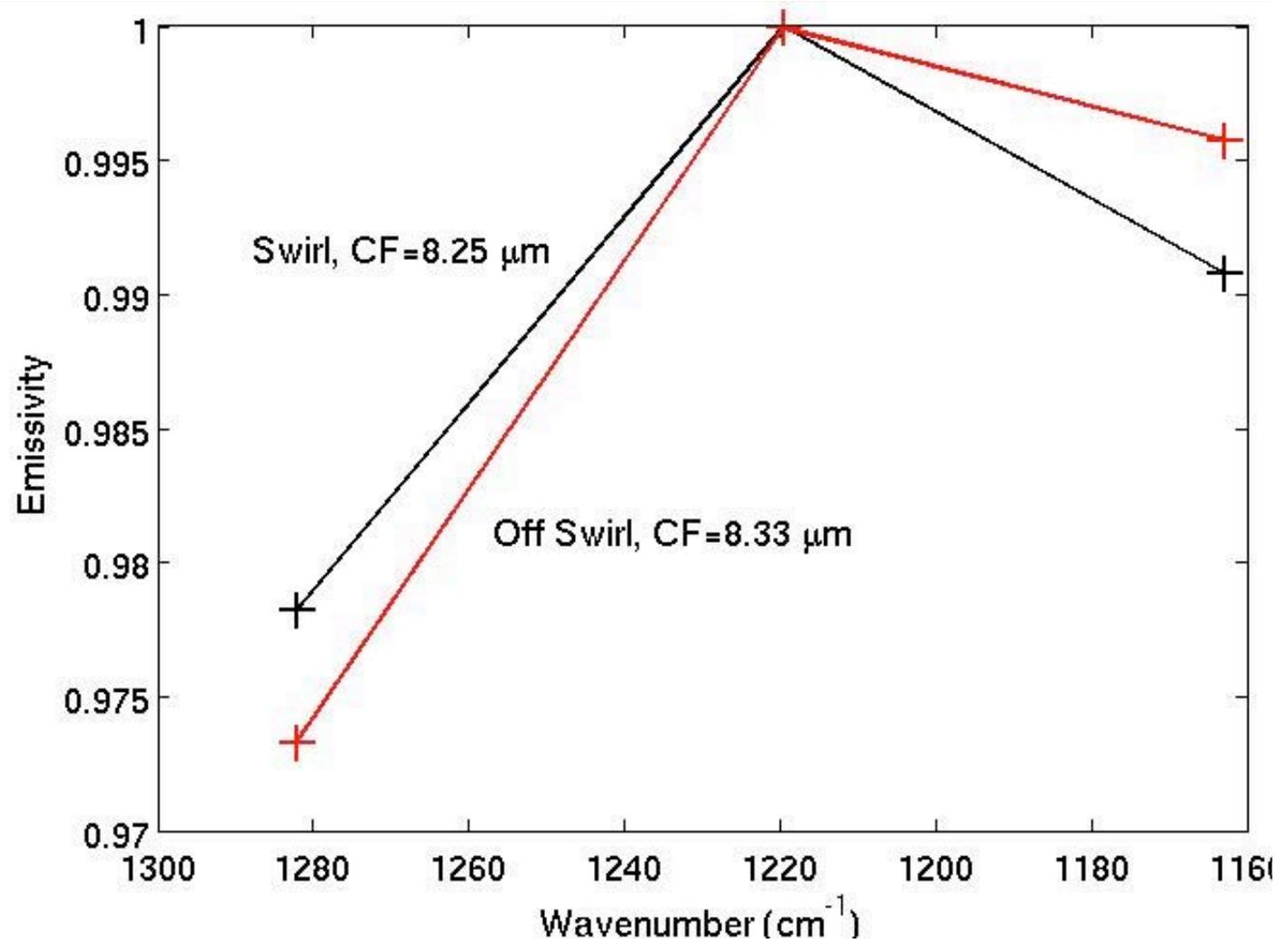
Reiner Gamma, Oceanus Procellarum

High albedo
swirls have lower
CF positions than
surrounding
terrain



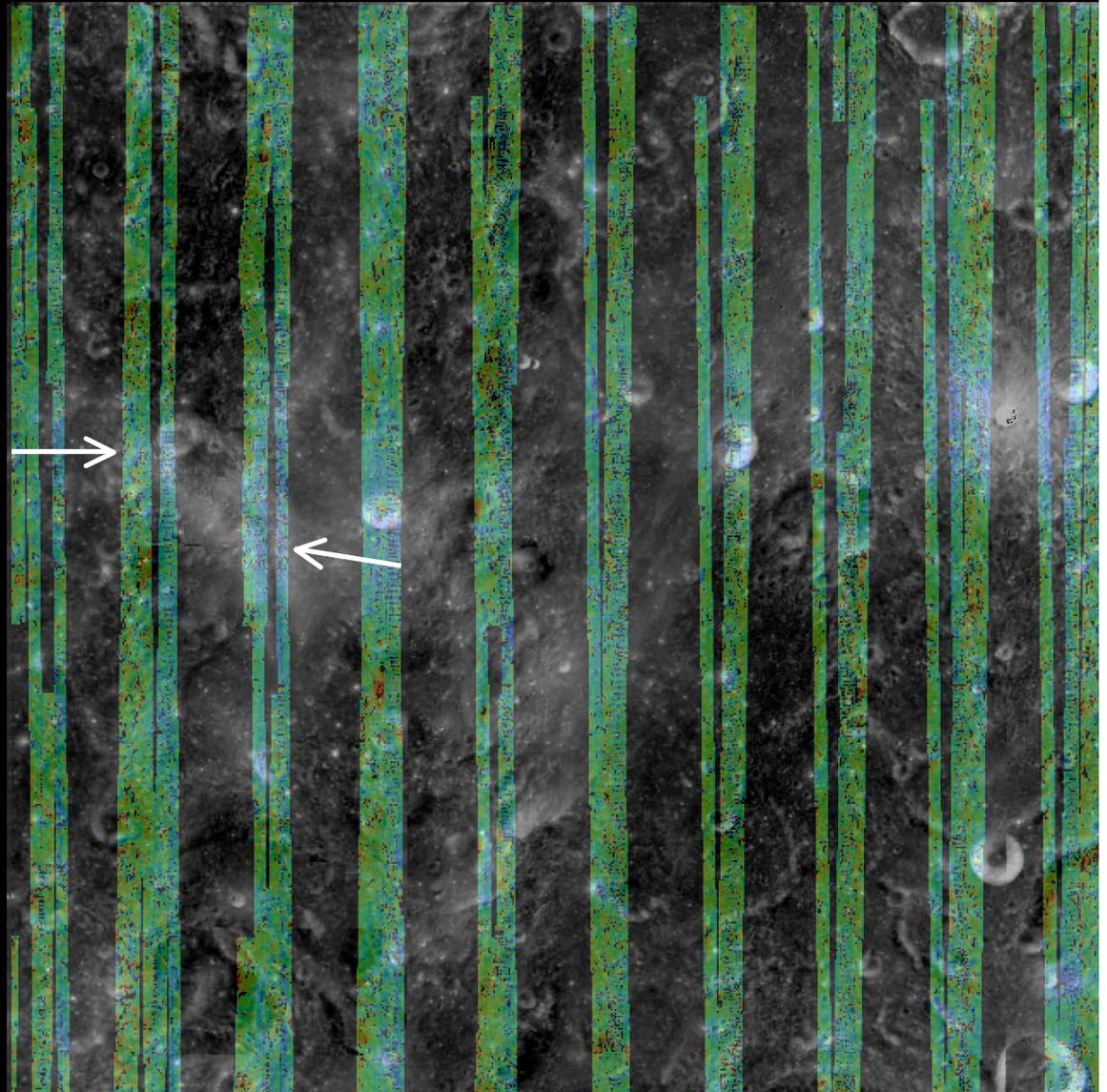
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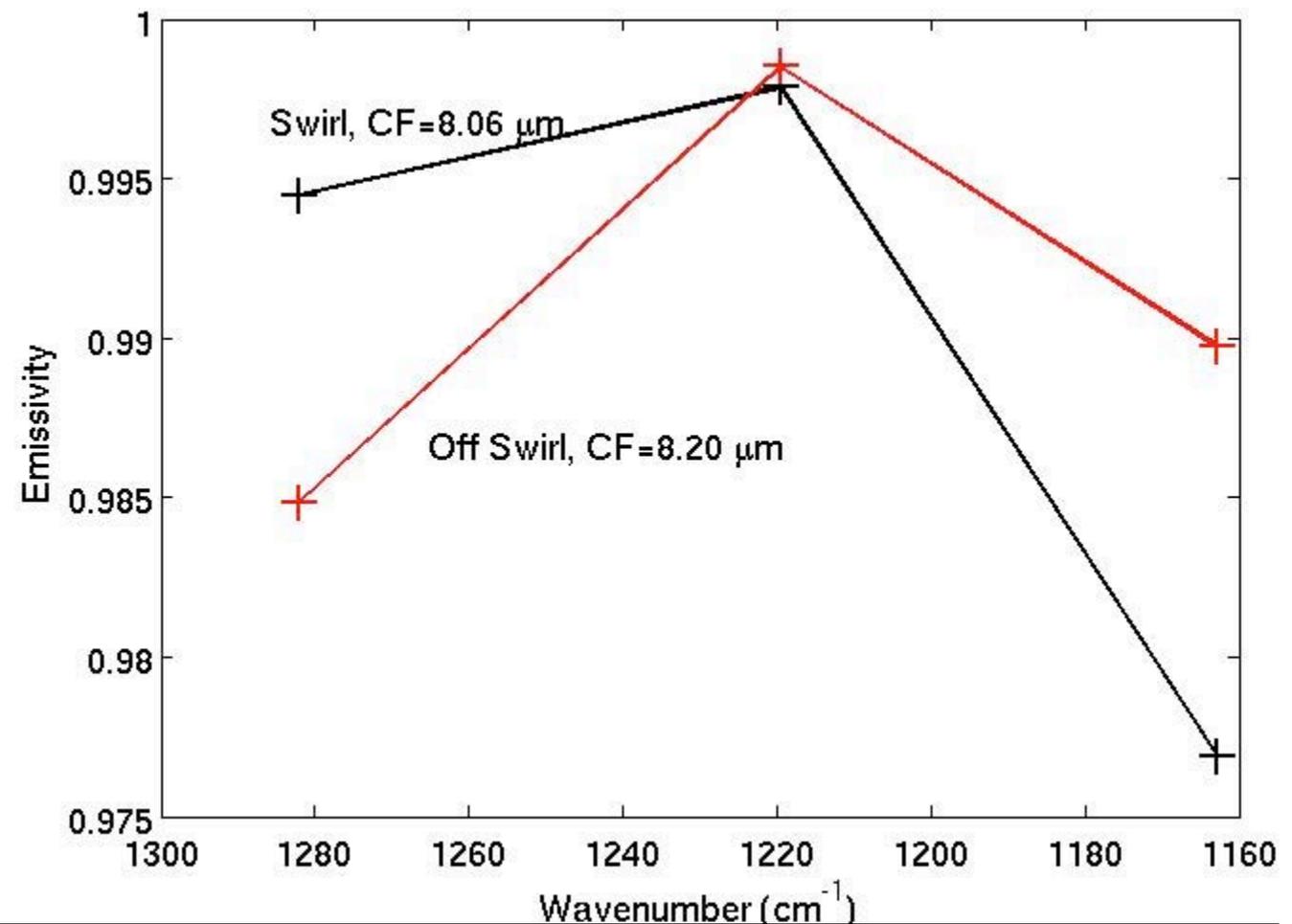
Airy Feature, Nearside Highlands

Relatively sparse coverage, but Diviner data do show a lower CF position than surrounding terrain.



Airy Feature, Nearside Highlands

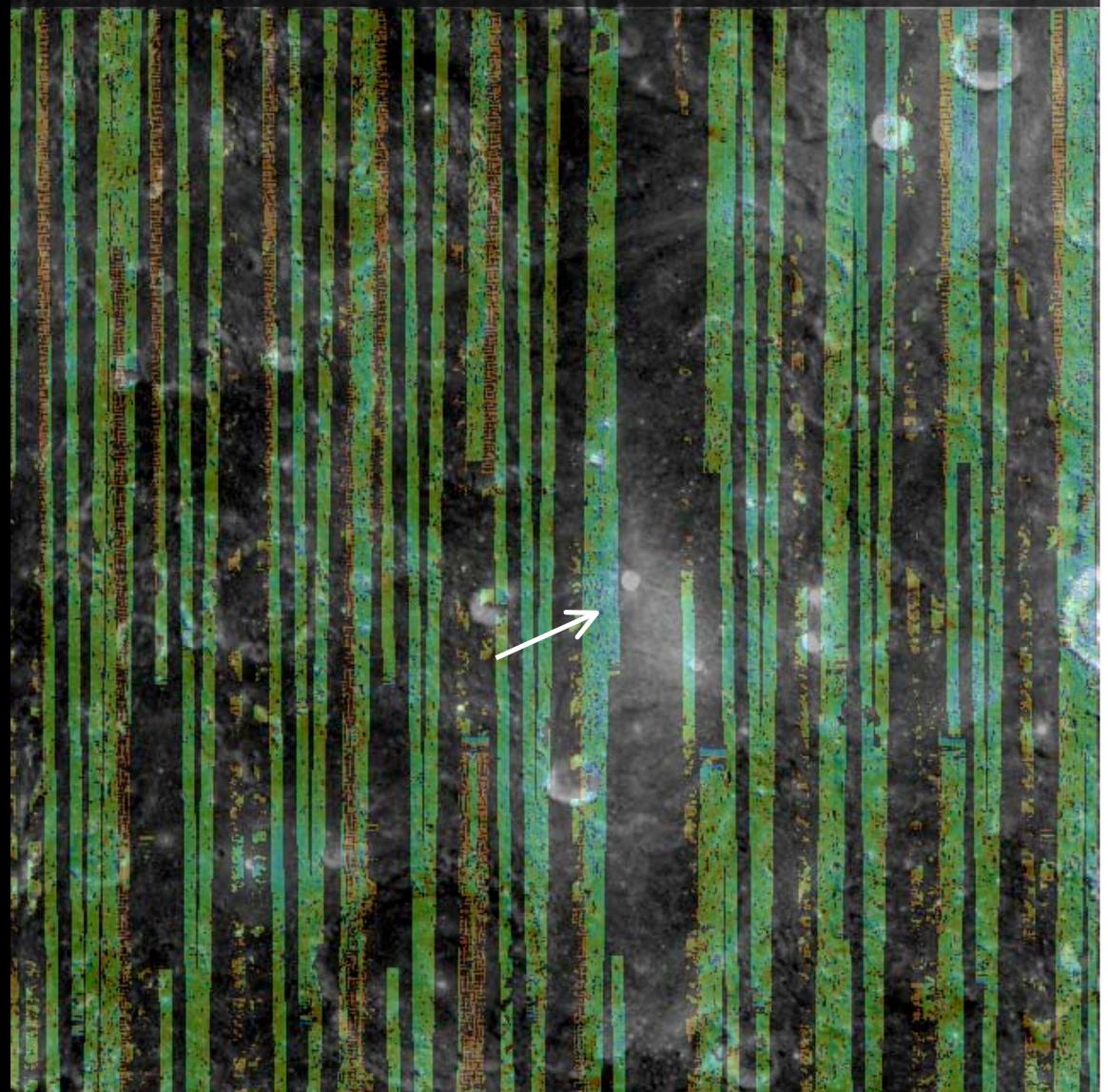
Overall CF values are lower, but ΔCF is comparable



Descartes Feature, Nearside Highlands

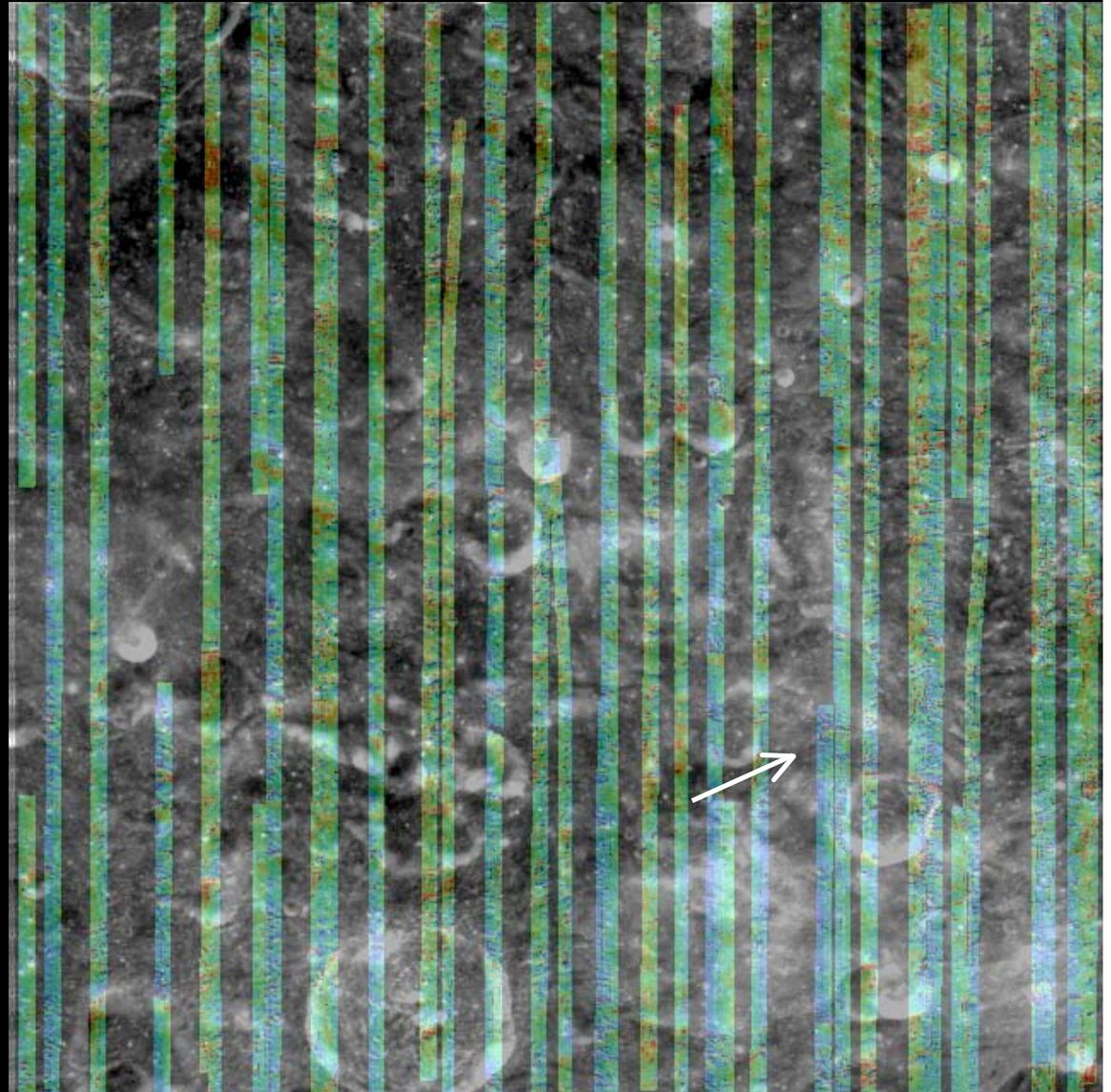
Bright albedo spot, not a
well-developed swirl.

CF values on and off swirl
and ΔCF values are
comparable to Airy



Gerasimovich Feature, Farside Highlands

Large, diffuse swirl,
antipodal to Crisium basin



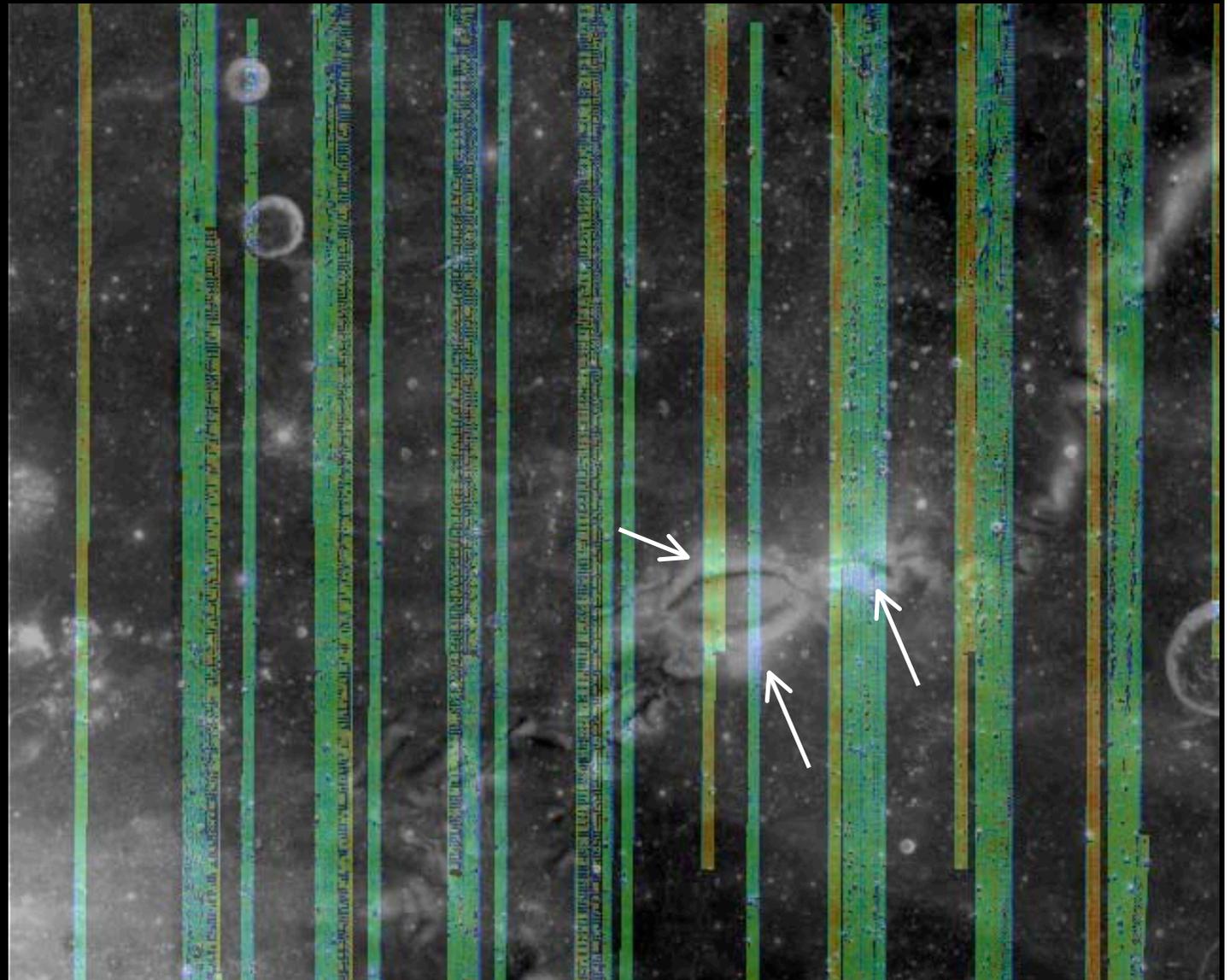
Assessing Formation Hypotheses

- Currently difficult to assess comet/meteor swarm hypothesis using Diviner data.
- Diviner night-time temperature data and daytime CF measurements may help to distinguish between space weathering and dust transport mechanisms.
 - Feldspathic dust vs. unweathered surface

Reiner Gamma, Oceanus Procellarum

What is the
composition
(based on CF)
of
RG swirl?

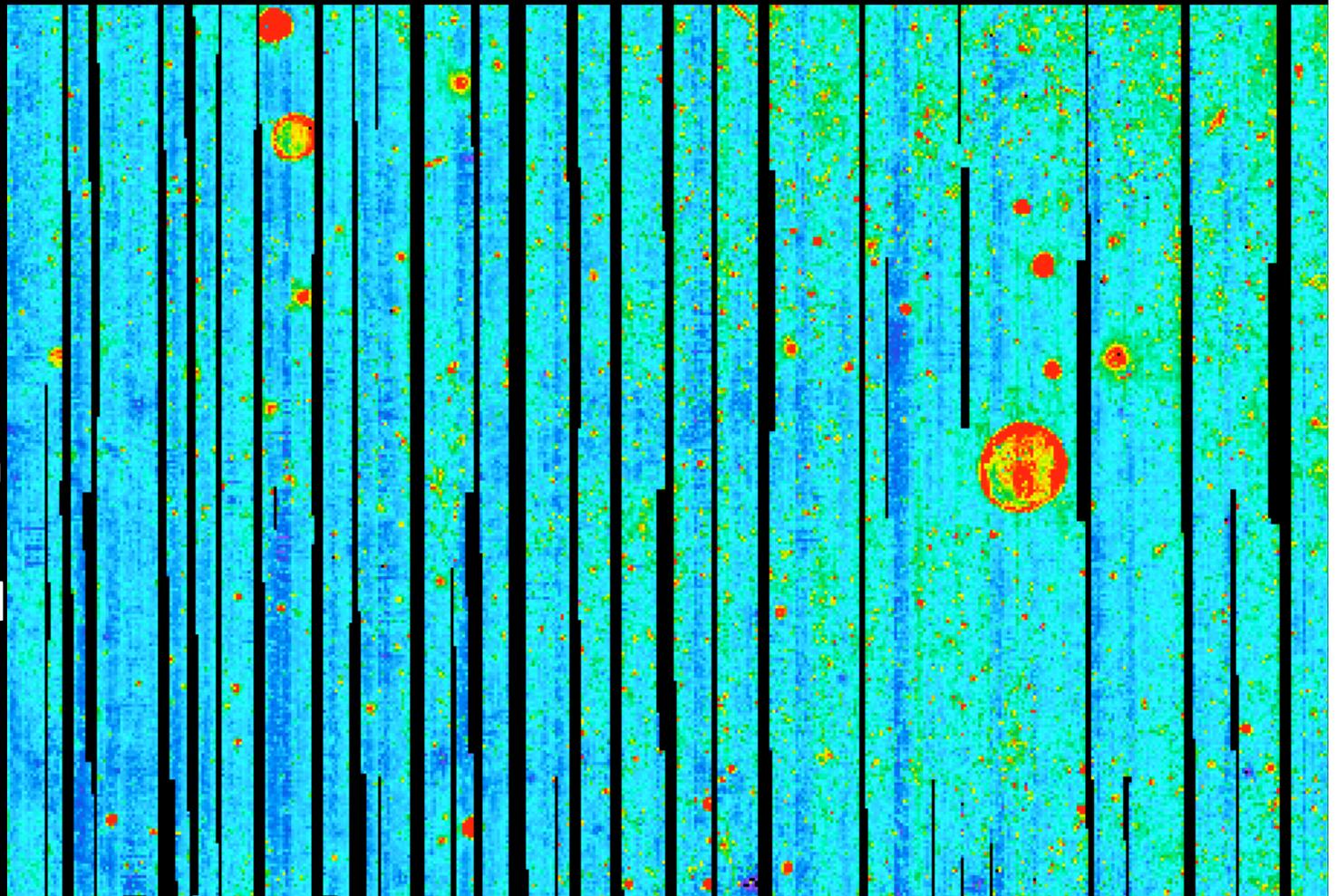
If this swirl is a
“dust pile”, can
we see it nigh-
time temp-
erature data.



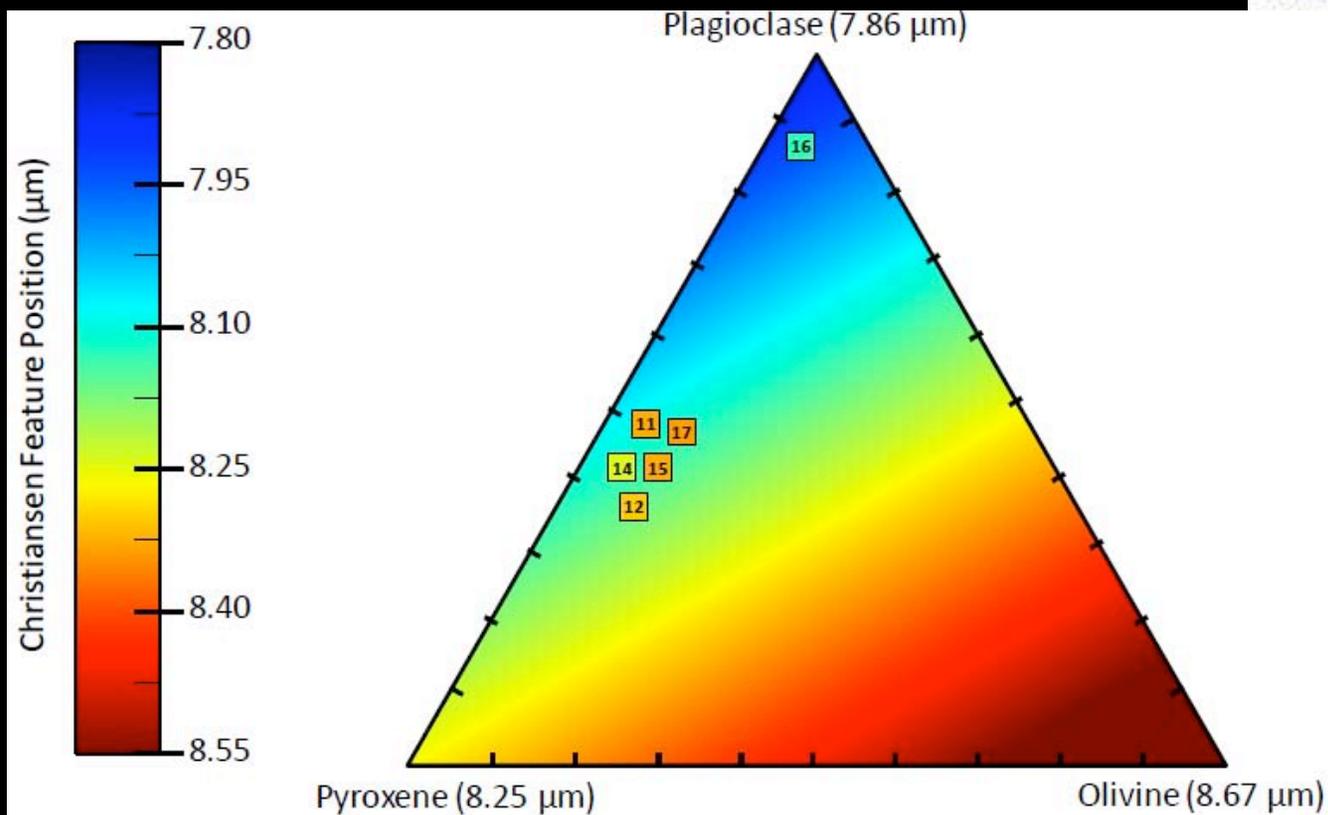
Reiner Gamma, Oceanus Procellarum

Diviner Night-
time regolith
temperature

Weak if any cor-
relation between
regolith temp-
erature and swirl



CF Positions of Swirls



Feature	Off-swirl CF	Swirl CF	Δ CF
Reiner Gamma	8.33	8.25	0.08
Airy	8.20	8.06	0.14
Descartes	8.19	8.05	0.14
Gerasimovich	8.19	8.08	0.11

Summary of Results

- Diviner detects a “CF anomaly” associated with lunar swirls.
- Swirls have CF positions that are $\sim 0.1 \mu\text{m}$ shorter than the surrounding terrain.
- Swirls do not have CF positions that are consistent with a pure feldspathic composition.
- Night-time Diviner data do not indicate a significant dust layer associated with Reiner Gamma.
- Space weathering the strongest hypothesis for formation?

Implications for Space Weathering

- Magnetic fields shield surface from solar wind implantation, but not micrometeorite bombardment
- Solar wind implantation, rather than micrometeorite bombardment must be primarily responsible for optical effects of space weathering.

Keller et al., 1999

