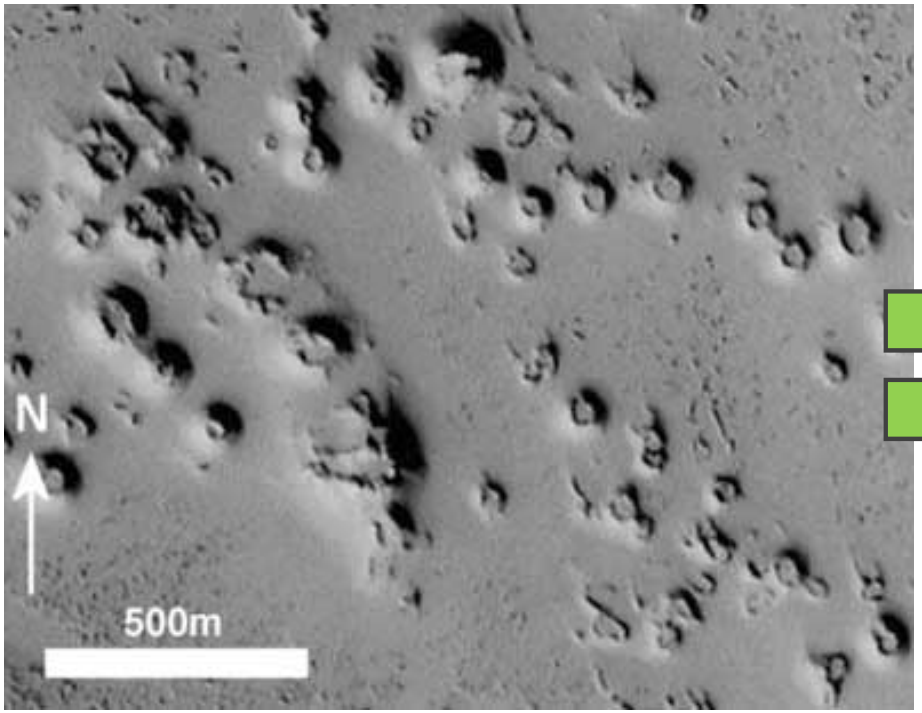
Volcanic Spatter Across the Solar System:

How Idaho + lava bombs = water on Mars

Erika Rader – University of Idaho

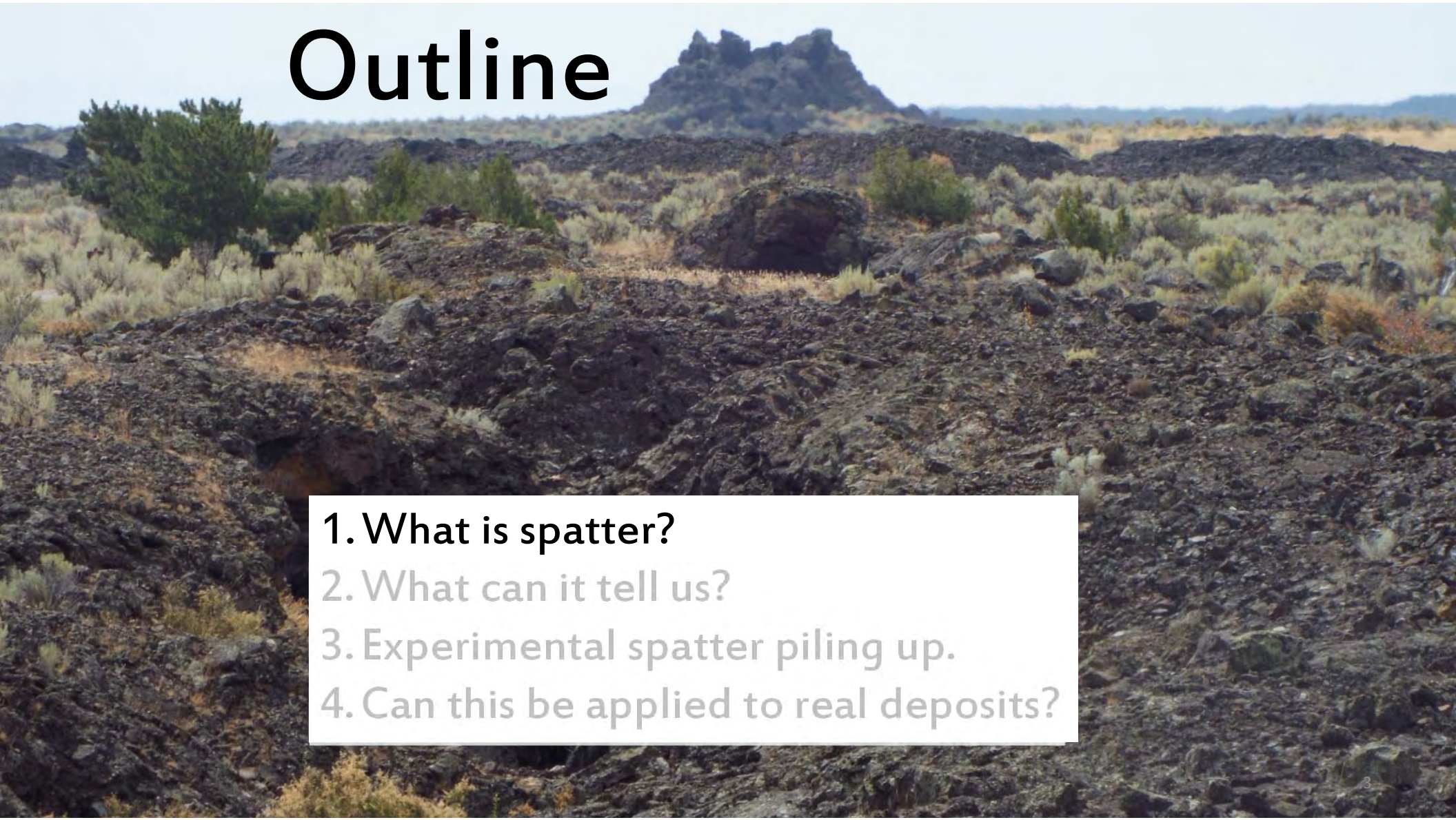


?

Mars

Earth

Outline

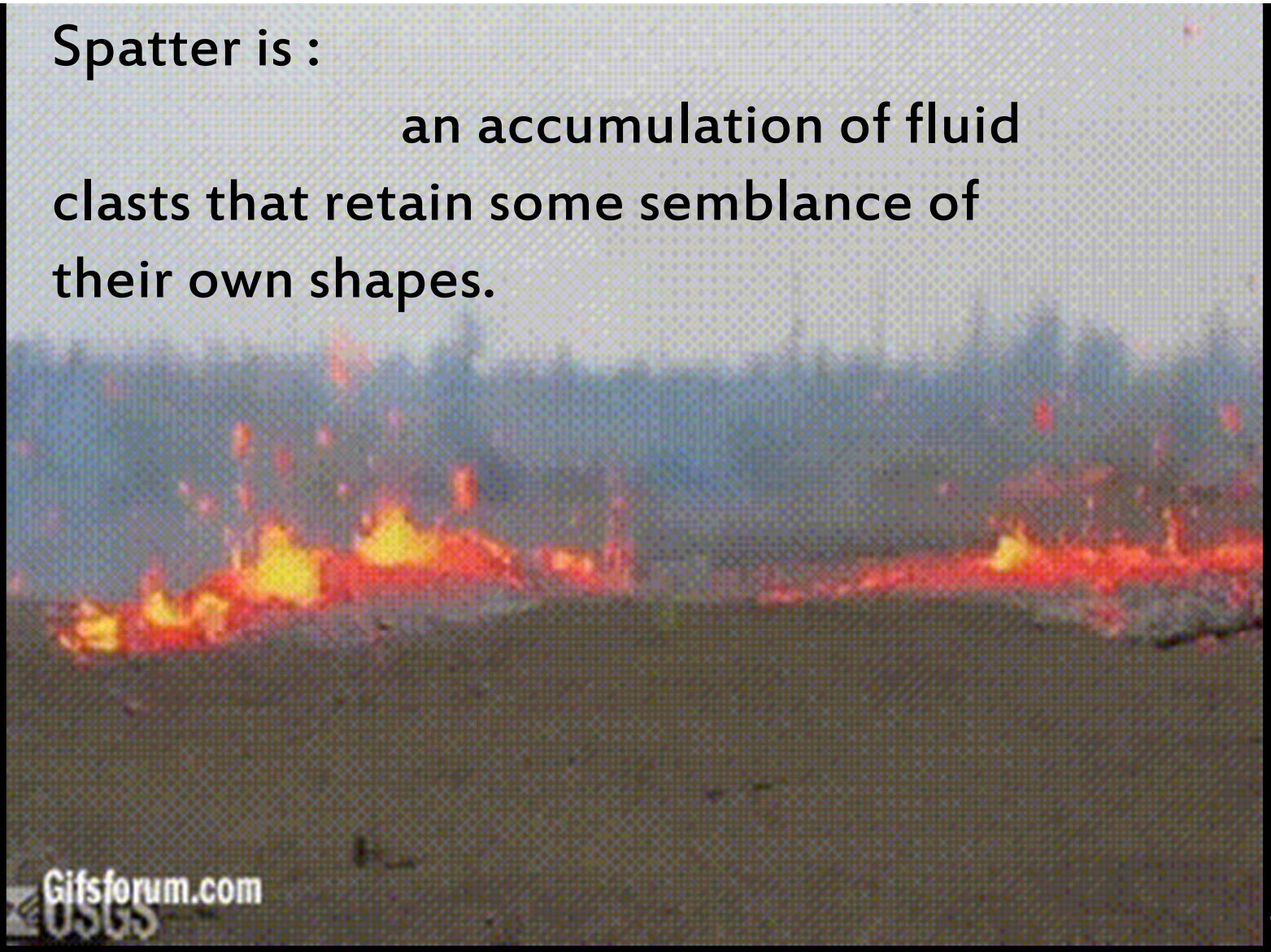


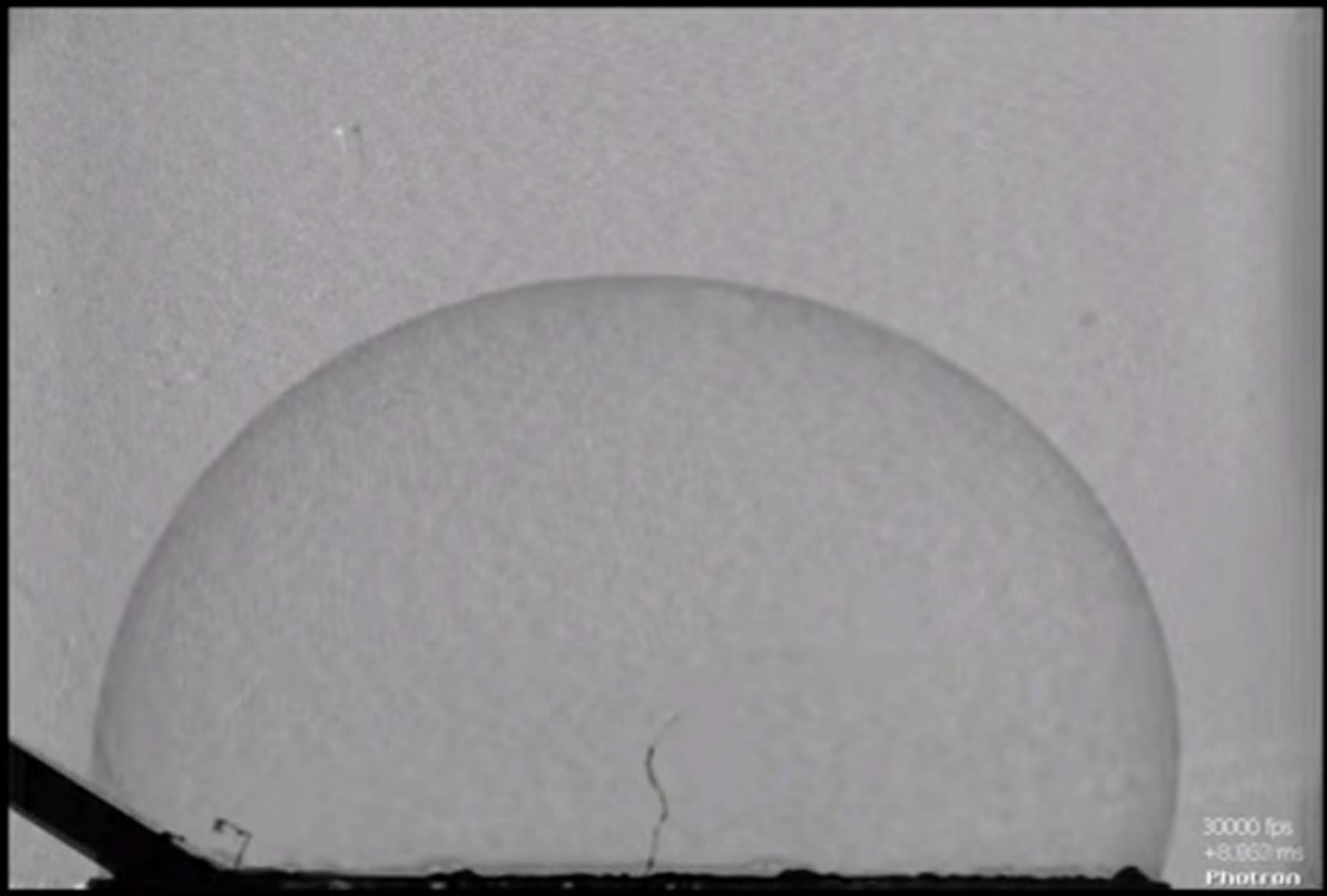
1. What is spatter?
2. What can it tell us?
3. Experimental spatter piling up.
4. Can this be applied to real deposits?


Tephra
Spatter
Lava

Spatter is :

an accumulation of fluid clasts that retain some semblance of their own shapes.





bursting soap bubble

Outline

1. What is spatter?
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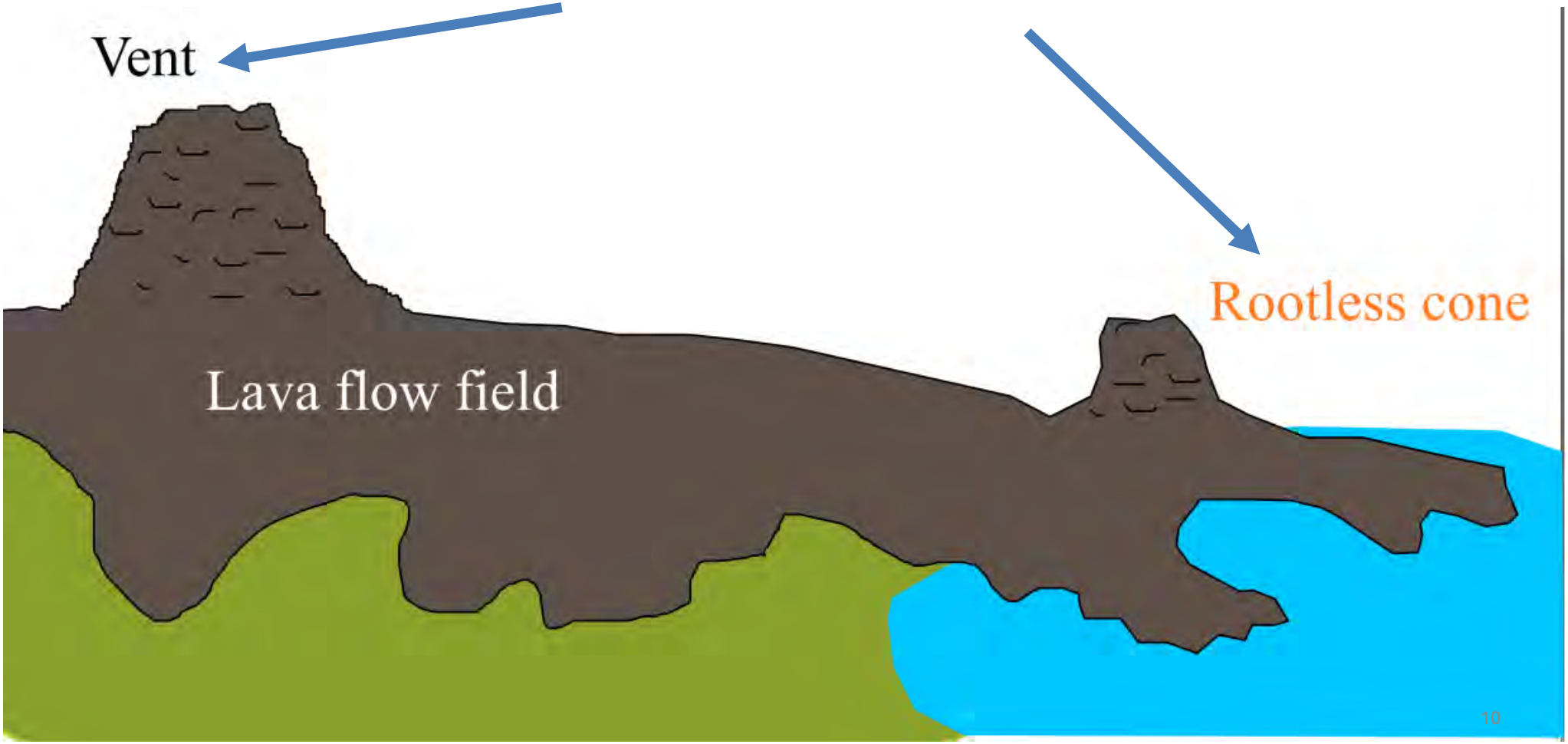
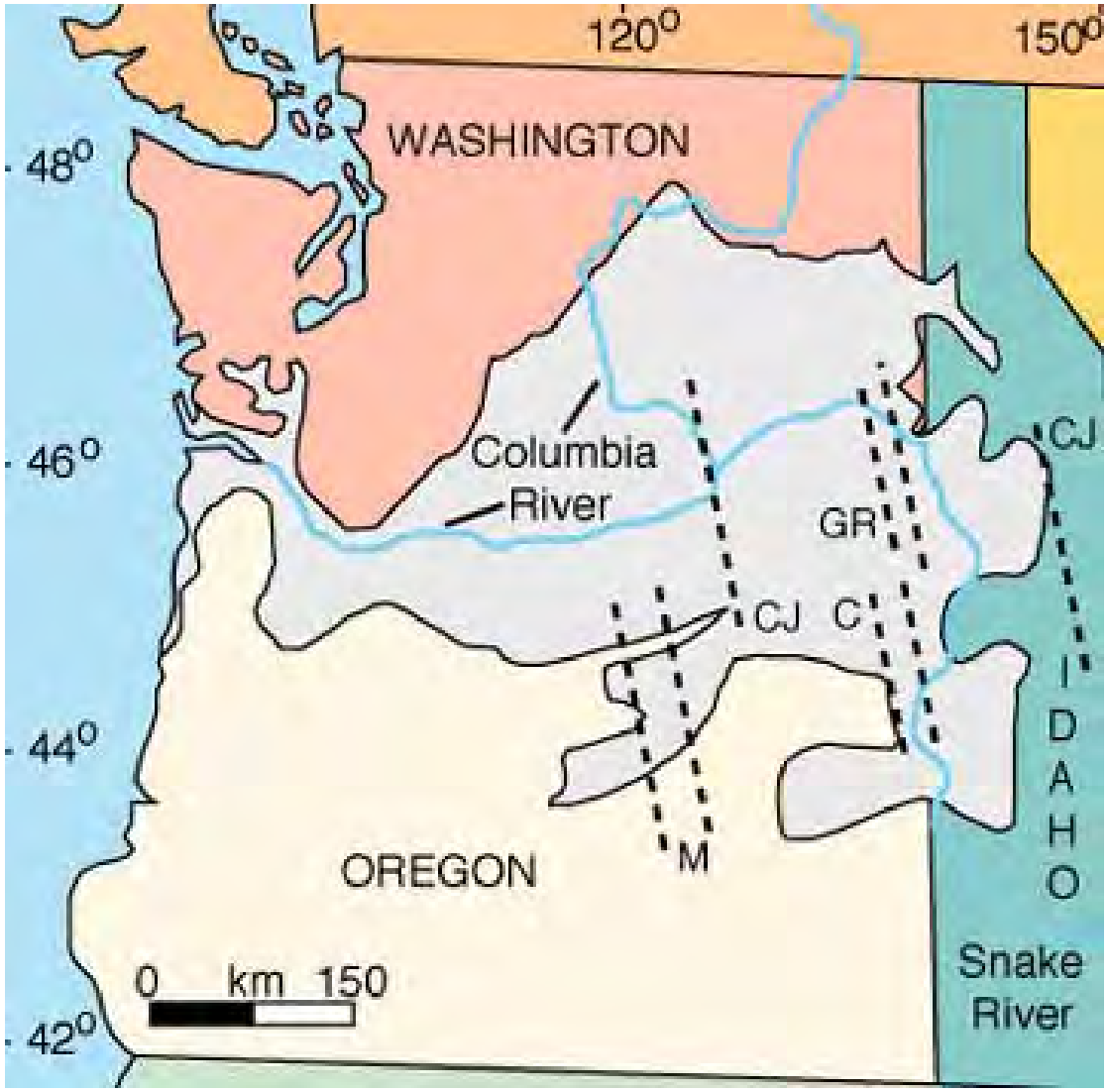
2 major environments

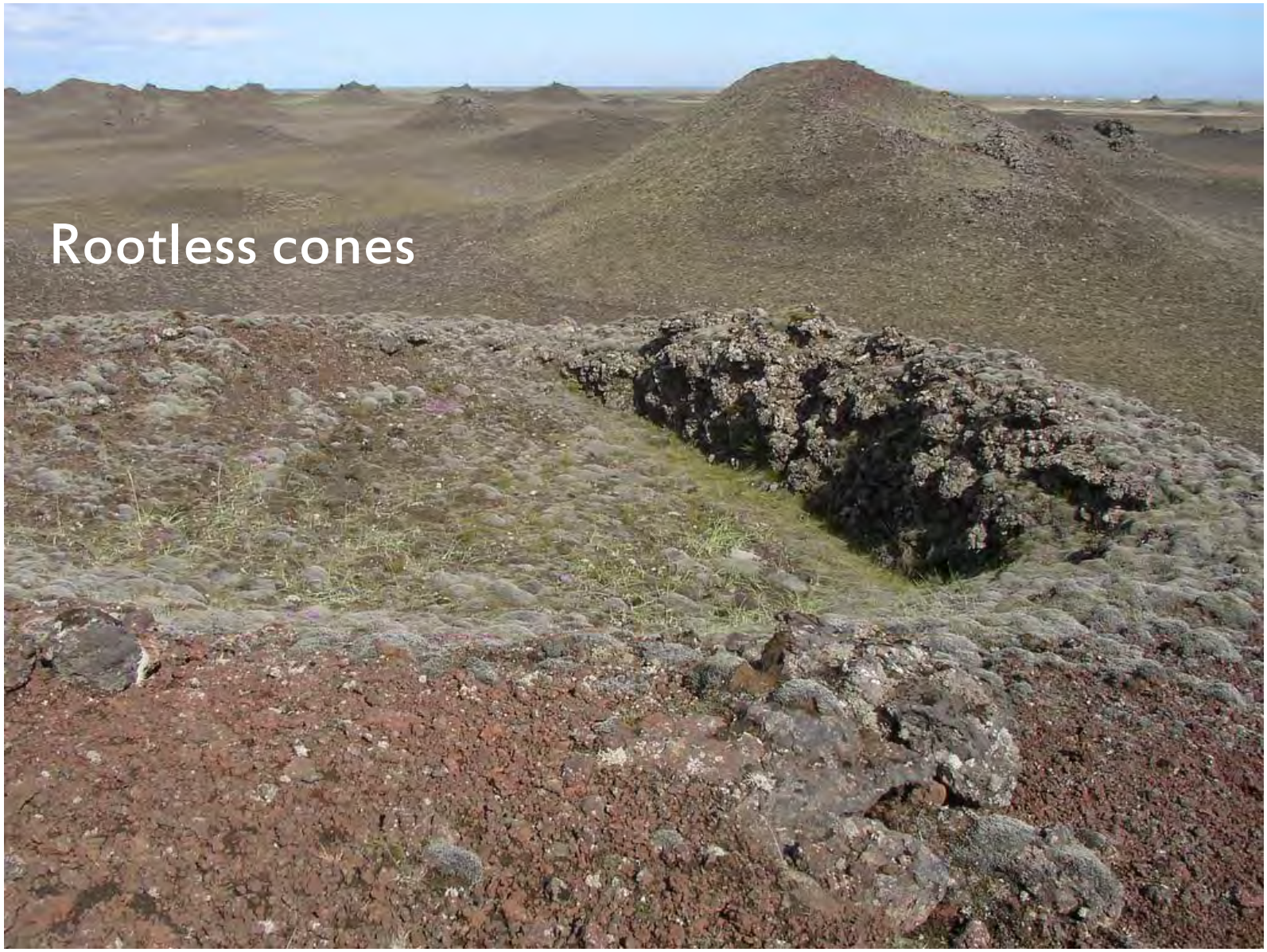


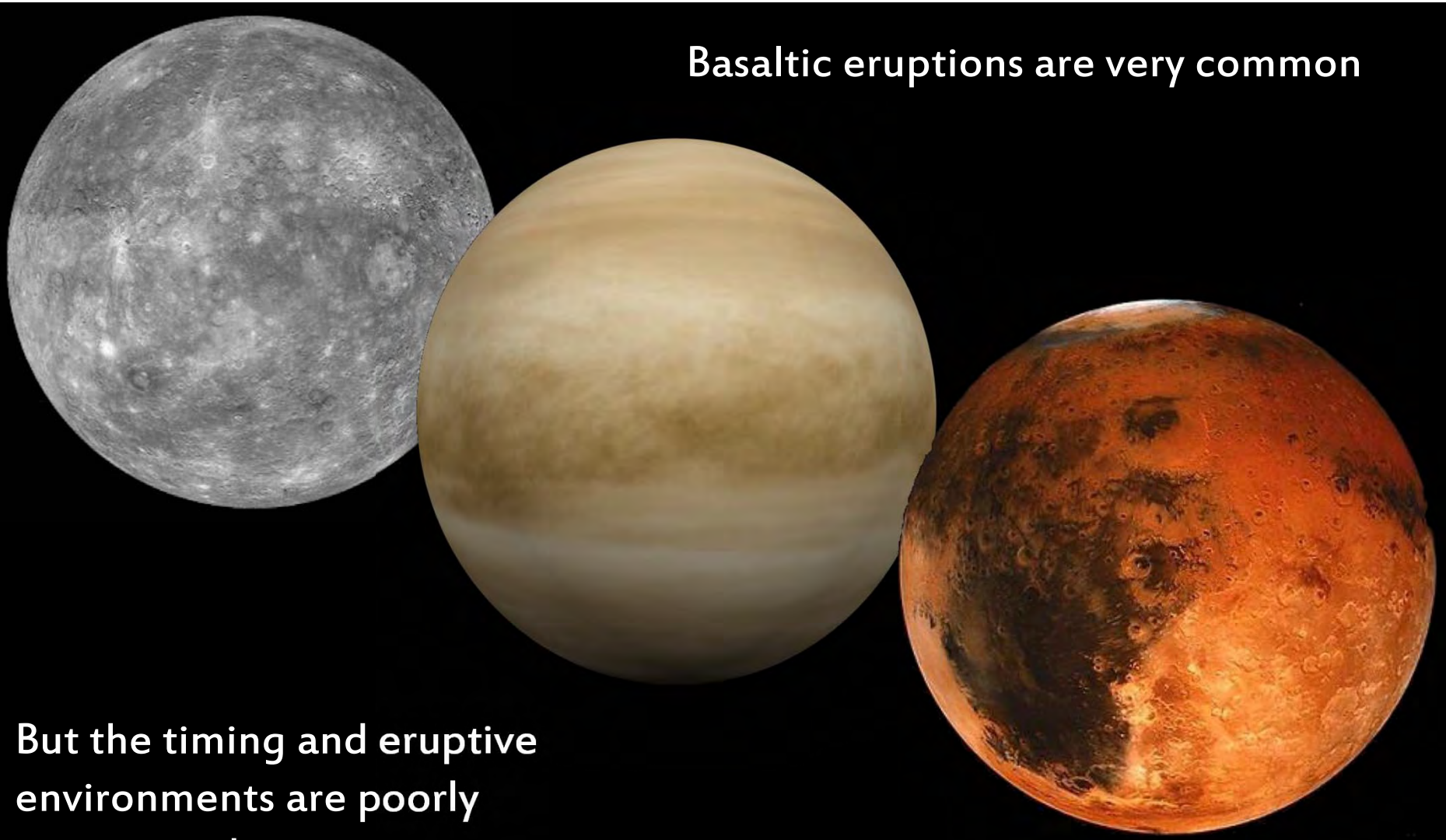
Magmatic gas and vent region

http://www.grillnation.ro/27-05-2016-ce-este-un-gratar-cu-roca-vulcanica/



Map based on Hooper (1997) volcano.oregonstate.edu/Columbia-river-flood-basalts


Rootless cones



Basaltic eruptions are very common

But the timing and eruptive environments are poorly constrained

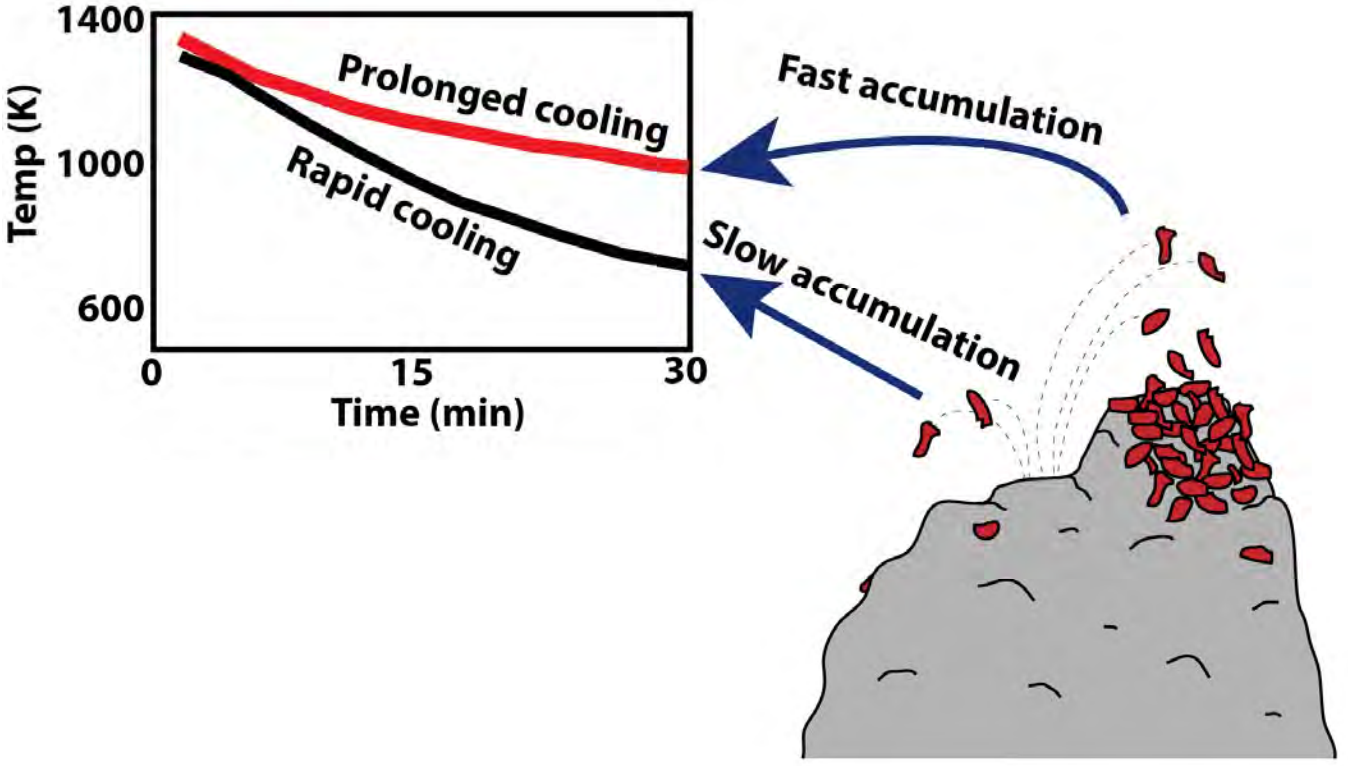
Spatter – the Goldilocks of basaltic morphologies

https://hvo.wr.usgs.gov/multimedia/archive/2002/Aug/20020802-0912_RPH_large.jpg

Lava is **ductile** and will **anneal** above the glass transition temperature

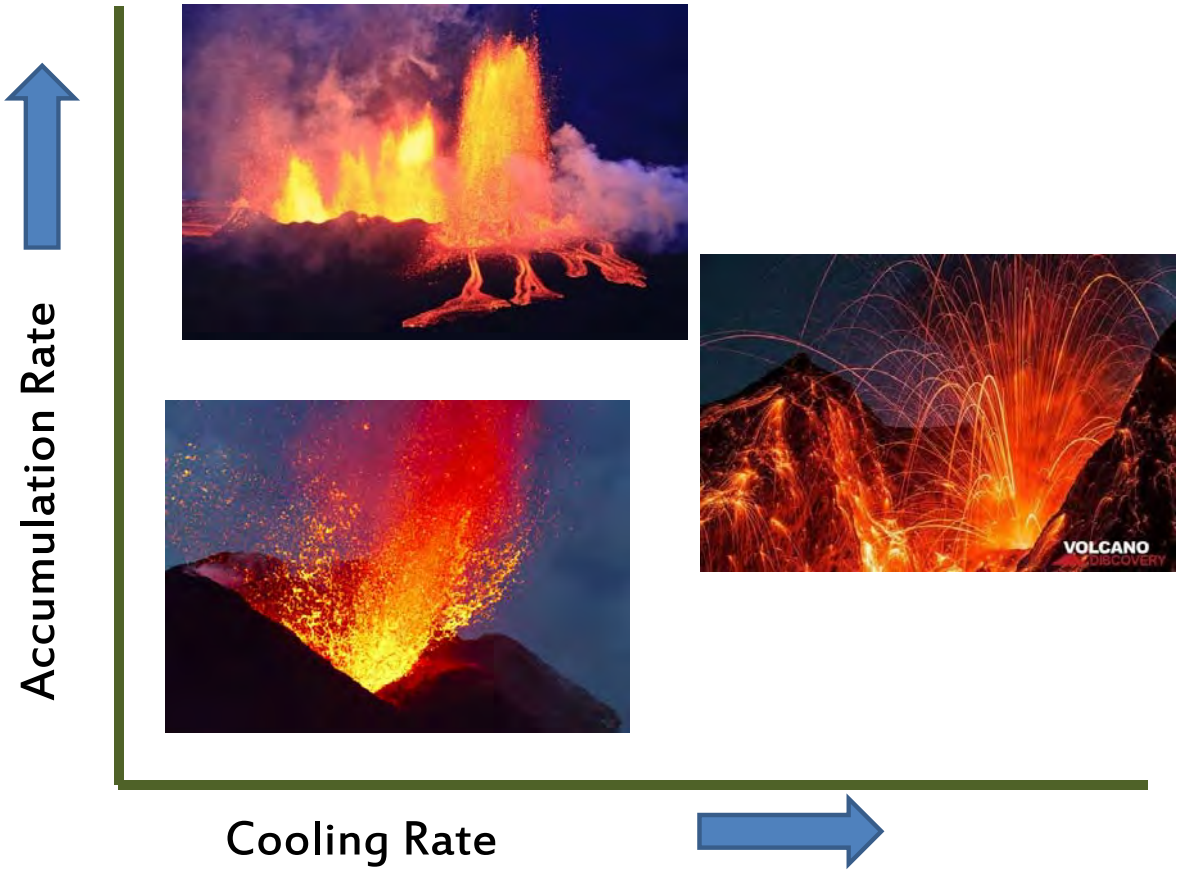

Youtube: volcanochaser
Published on Jul 16, 2007

Theory: The degree of welding in a spatter pile is due to the accumulation rate of spatter clasts

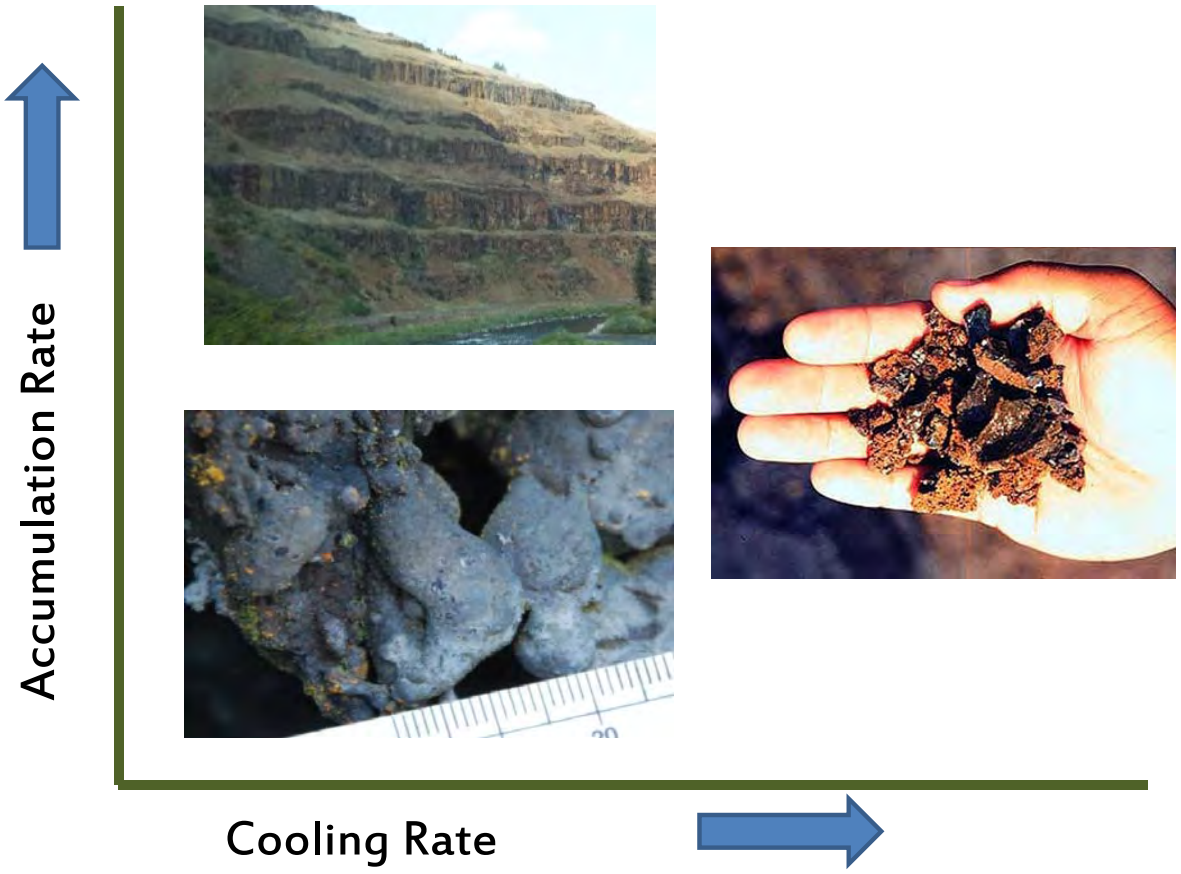


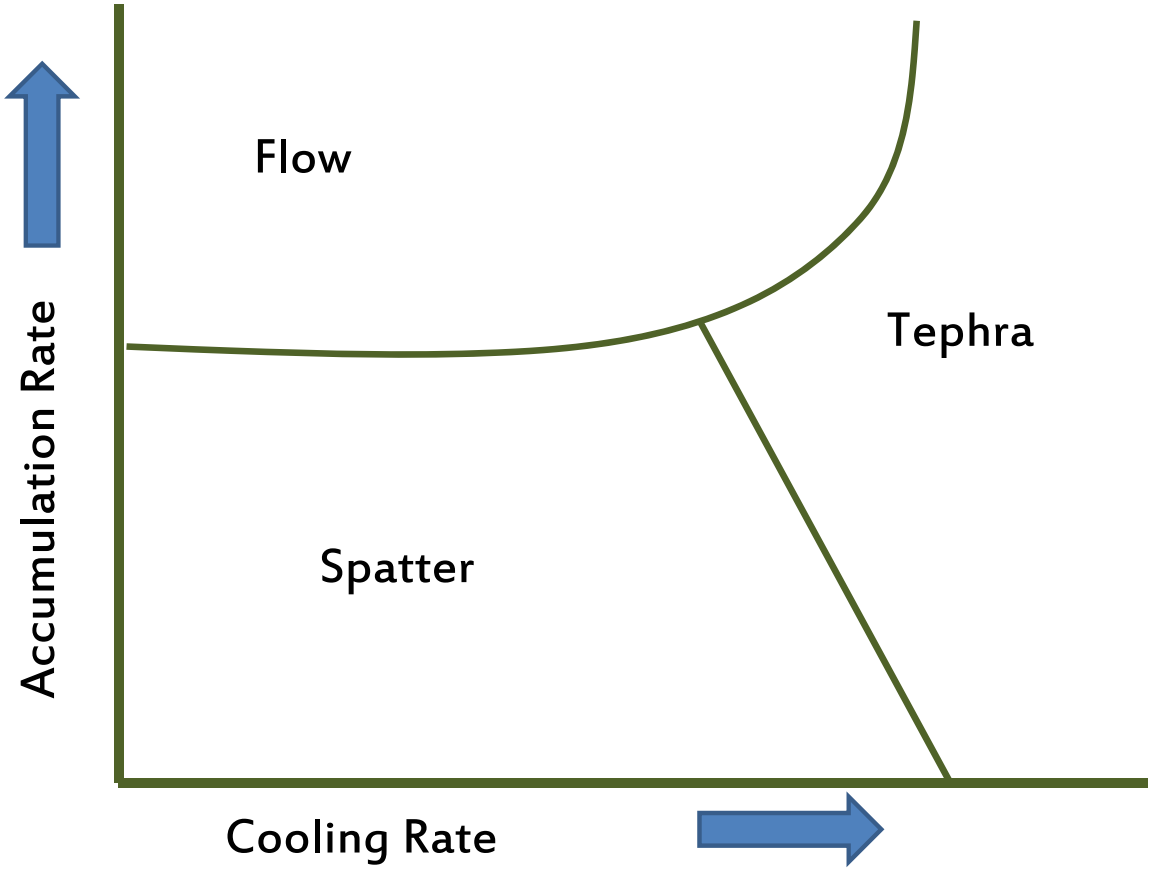

COLGATE
GEOLOGY

Classification of basaltic eruptive products

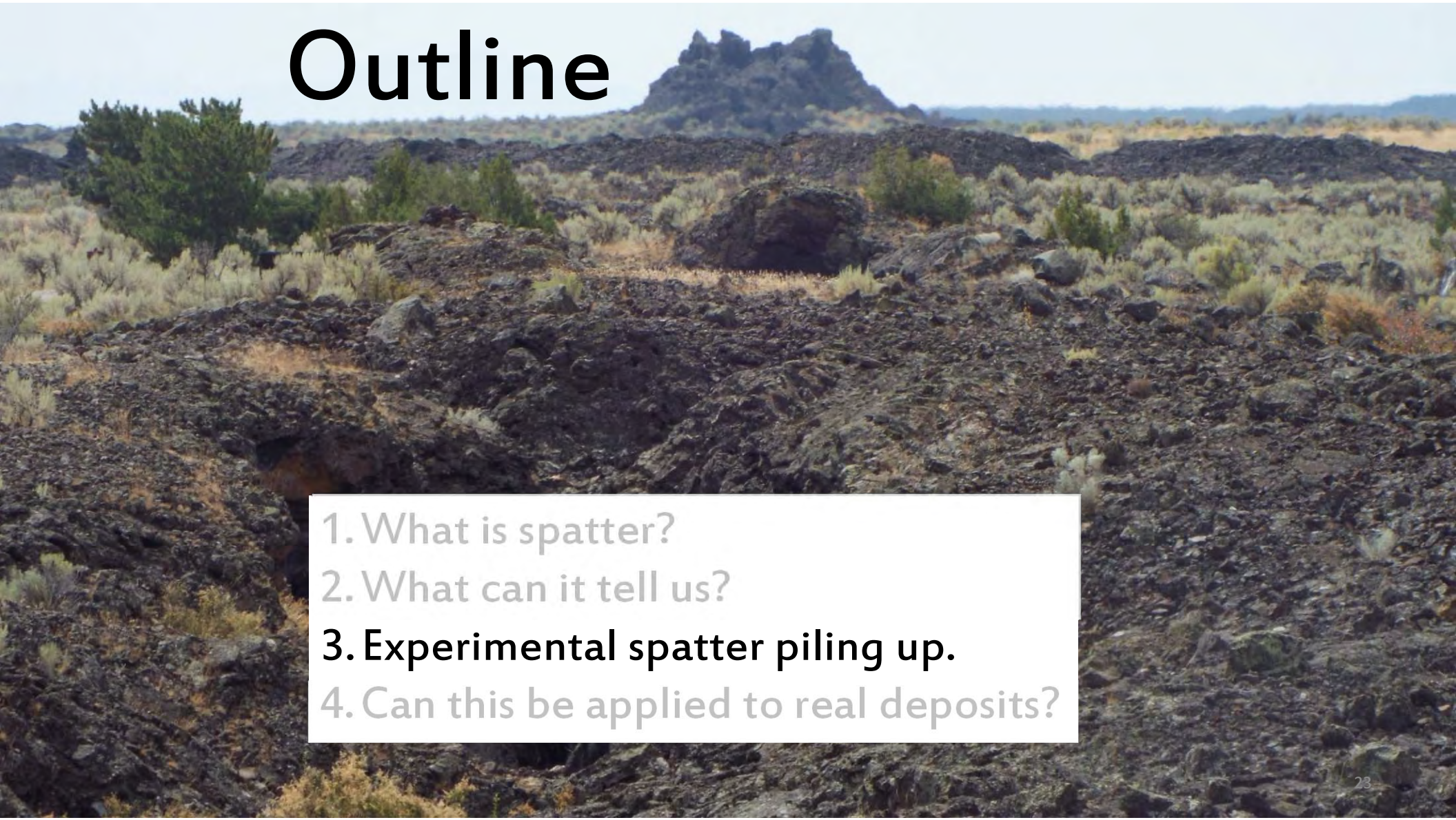


Classification of basaltic eruptive products




Flow
Tephra
Spatter
Accumulation Rate
Cooling Rate

Outline



1. What is spatter?
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Maybe we can quantify eruption rates from spatter morphology?

Maybe we can identify different eruptive environments from spatter morphology?

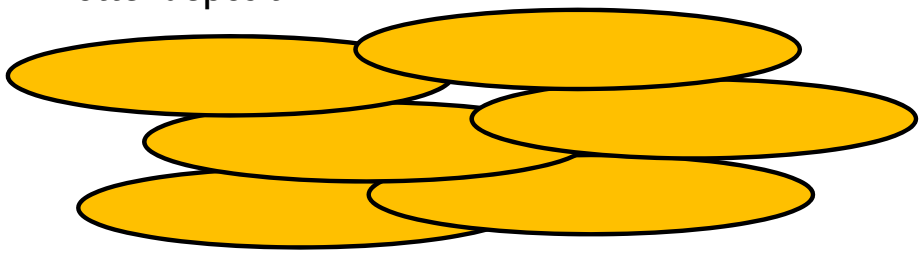
Maybe this can tell us how vigorously lunar volcanoes erupted?

Maybe we can show there was abundant water on Mars even in places with no sedimentary rocks.

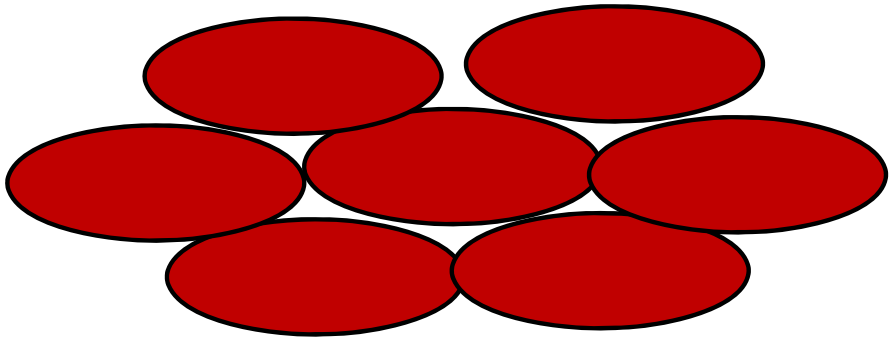
Characteristics that should be correlated with overall high heat in a deposit

More connections
More squashed clasts (lower w/l ratio)
Less void space

Hotter deposit



Cooler deposit



How to make spatter bombs?

Trial 1 - leaf blower

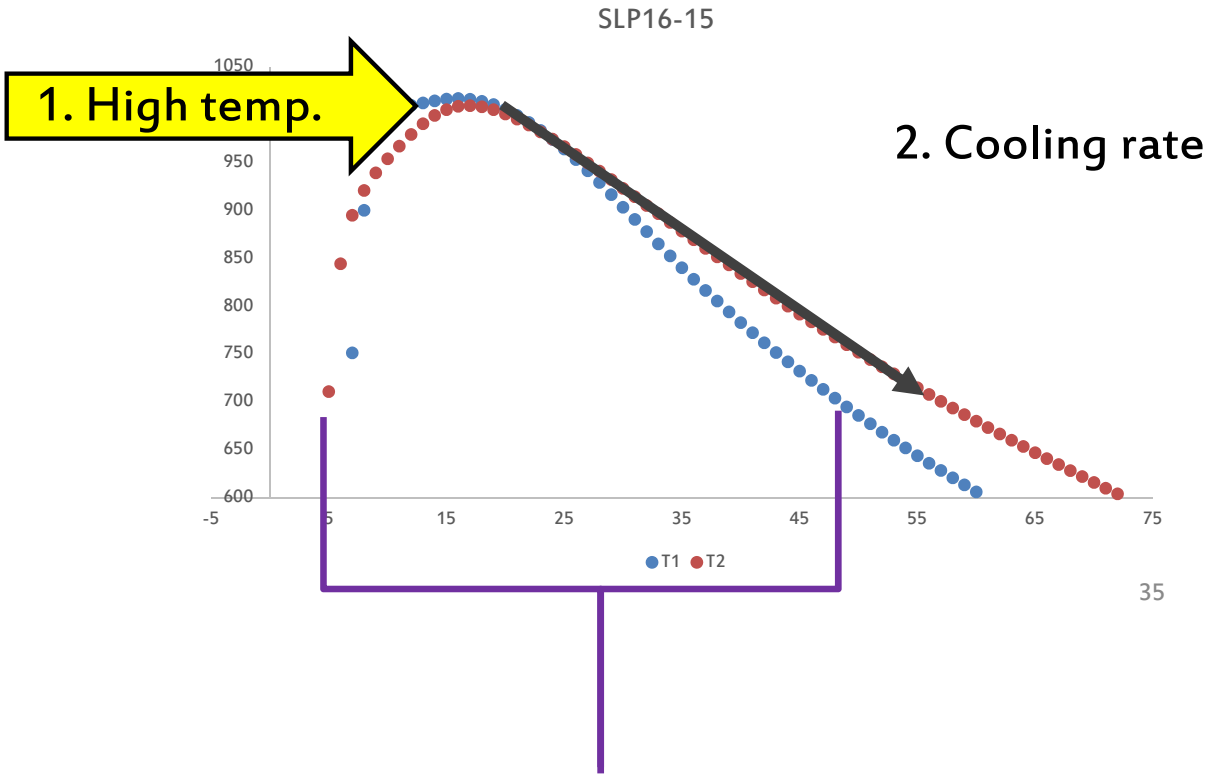
Pintrest
spatter cone

NAILED IT!

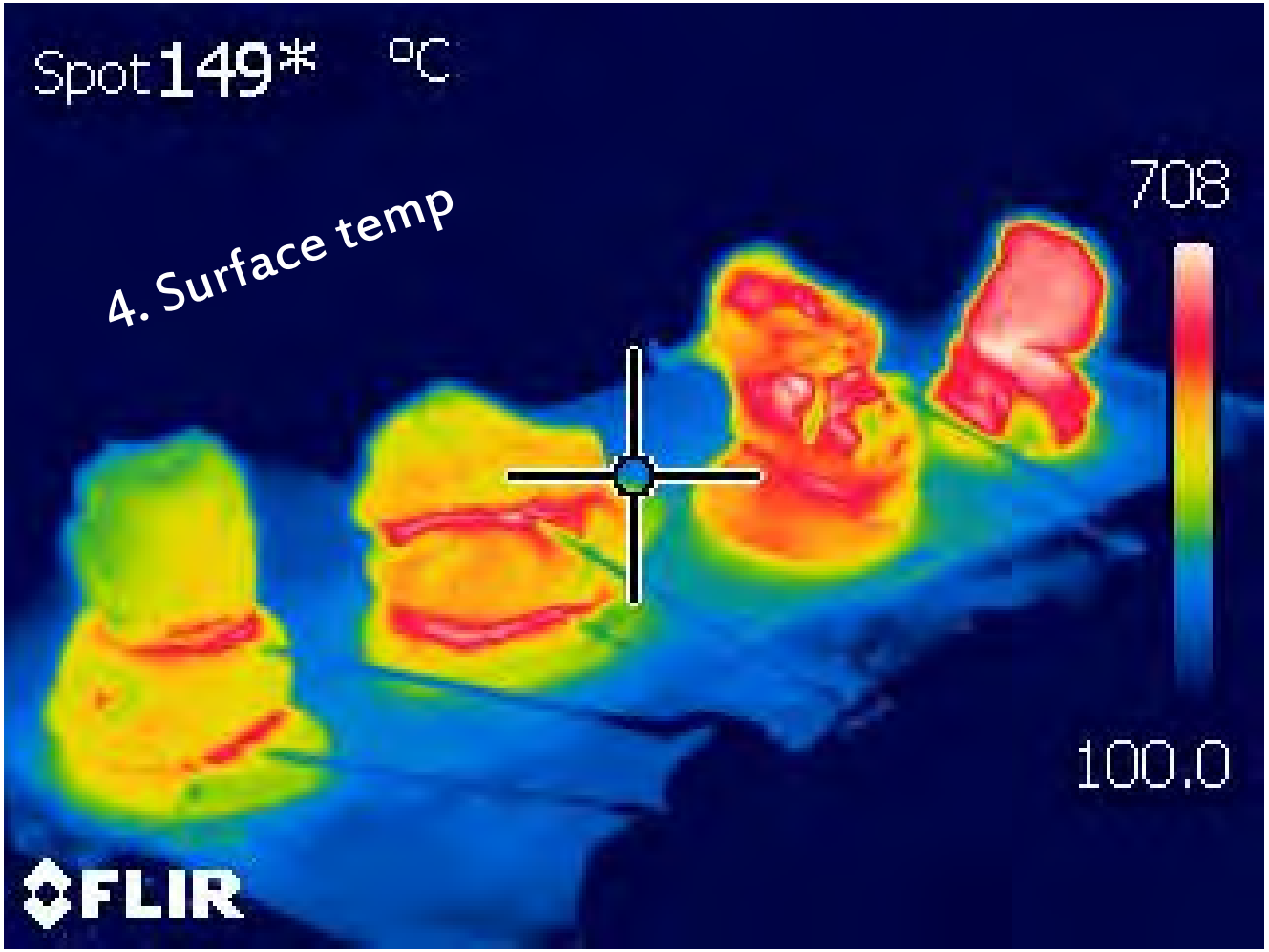

Trial 2 - air cannon

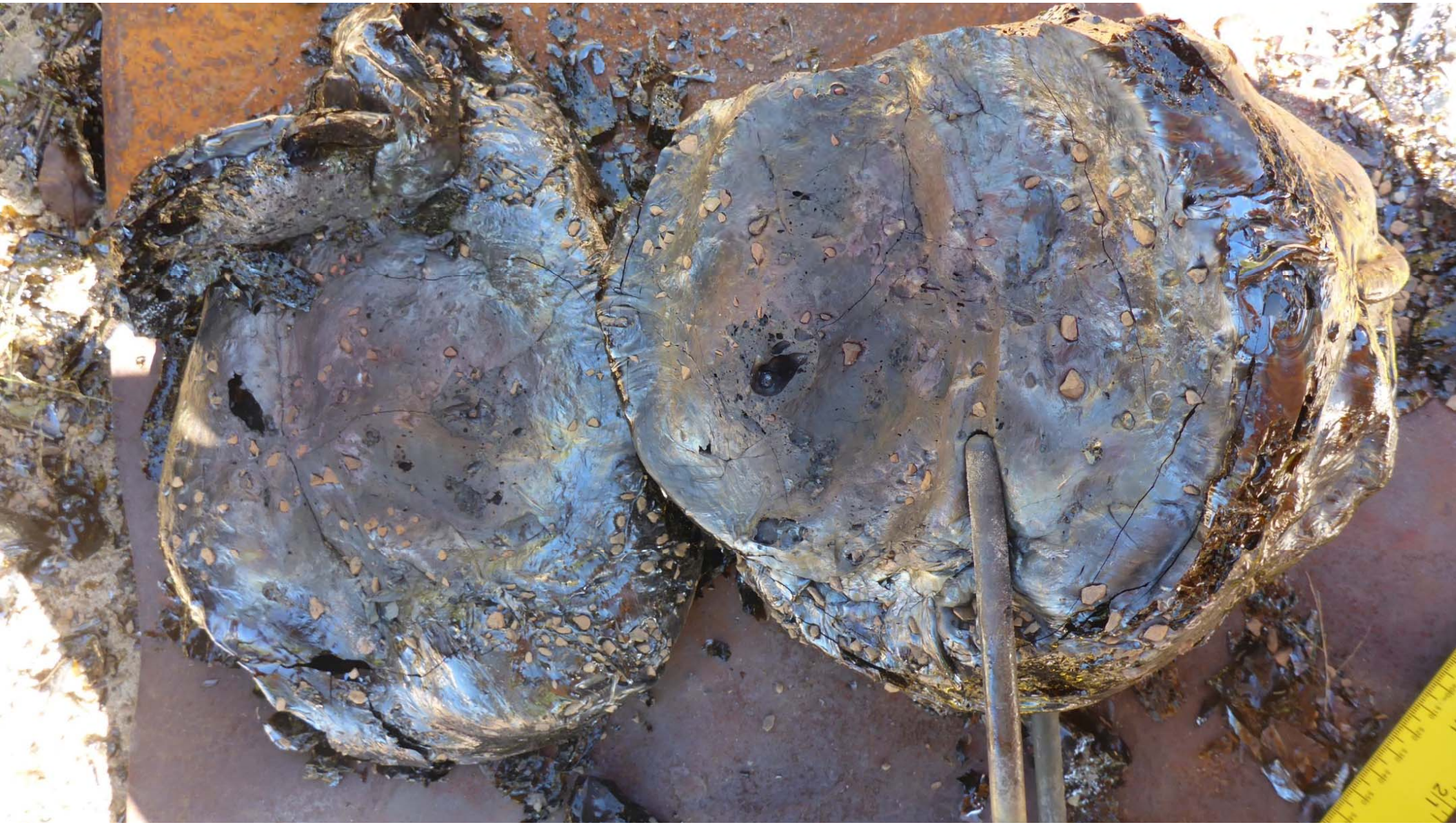

0414

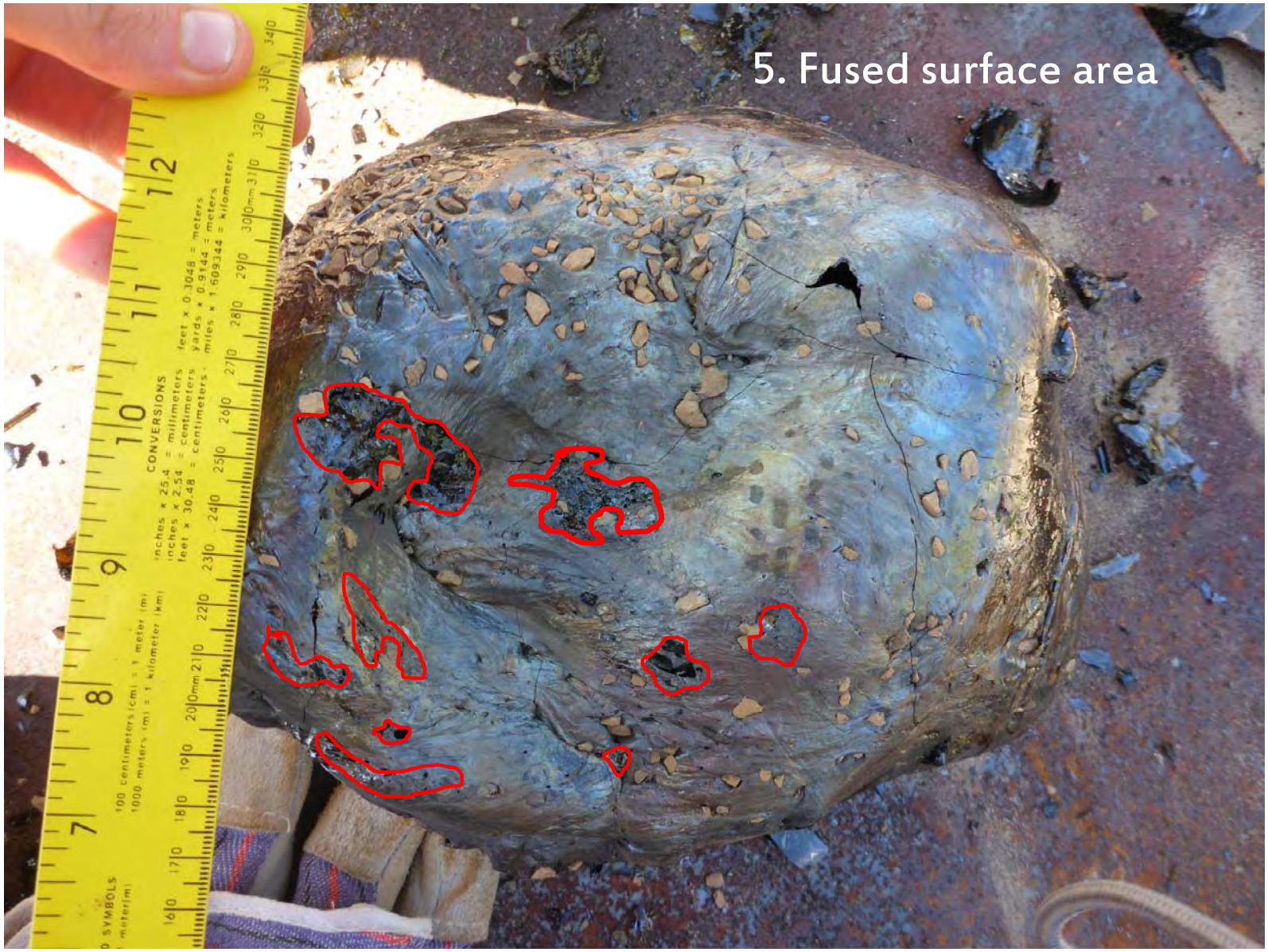
Data Collection



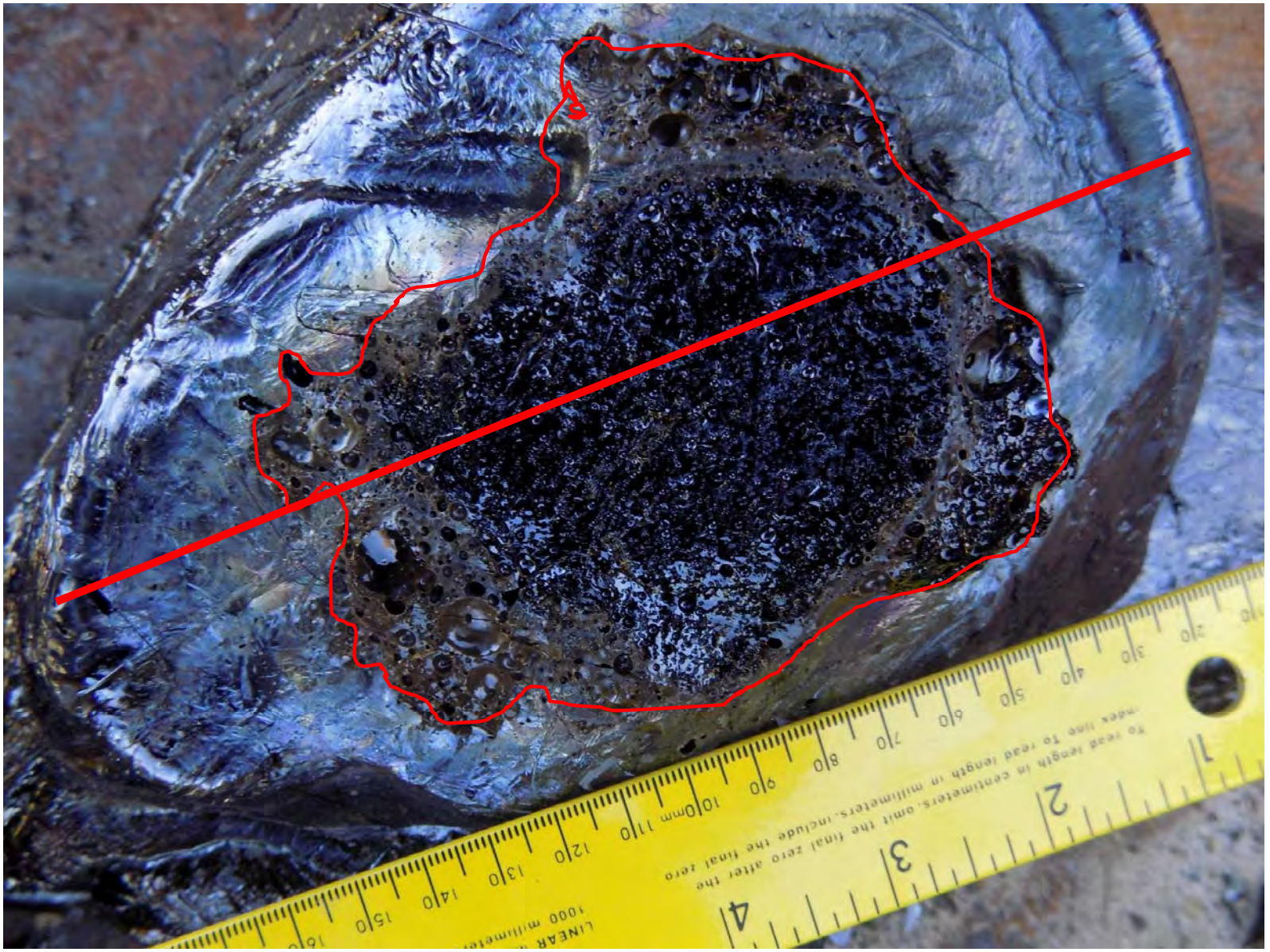
Data Collection





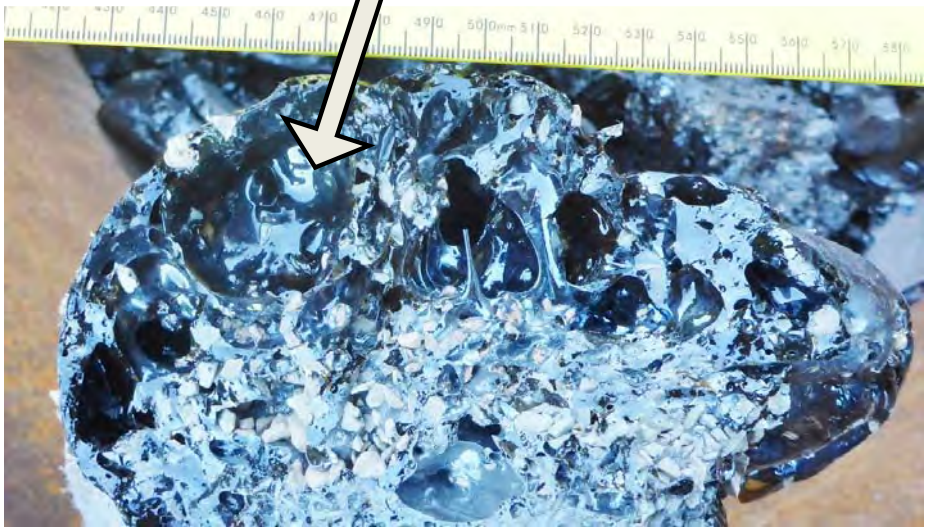

5. Fused surface area
CONVERSIONS
inches × 25.4 = millimeters
inches × 2.54 = centimeters
feet × 30.48 = centimeters
feet × 0.3048 = meters
yards × 0.9144 = meters
miles × 1.609344 = kilometers
100 centimeters (cm) = 1 meter (m)
1000 meters (m) = 1 kilometer (km)

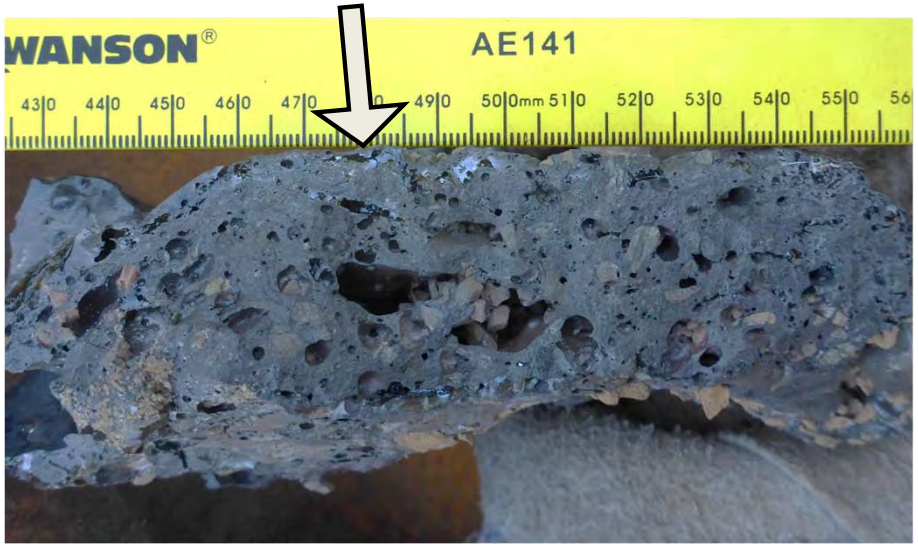
F-value

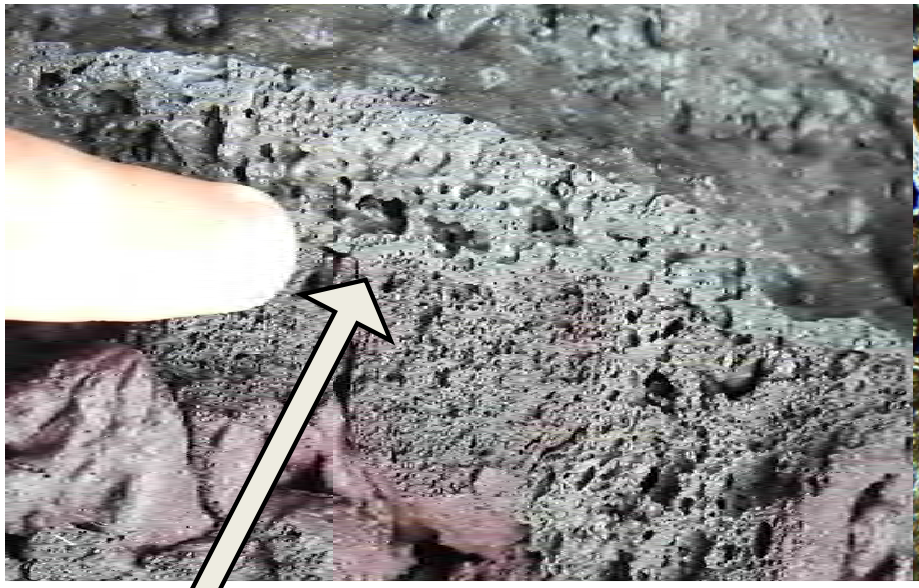


Hollow core from gas accumulation

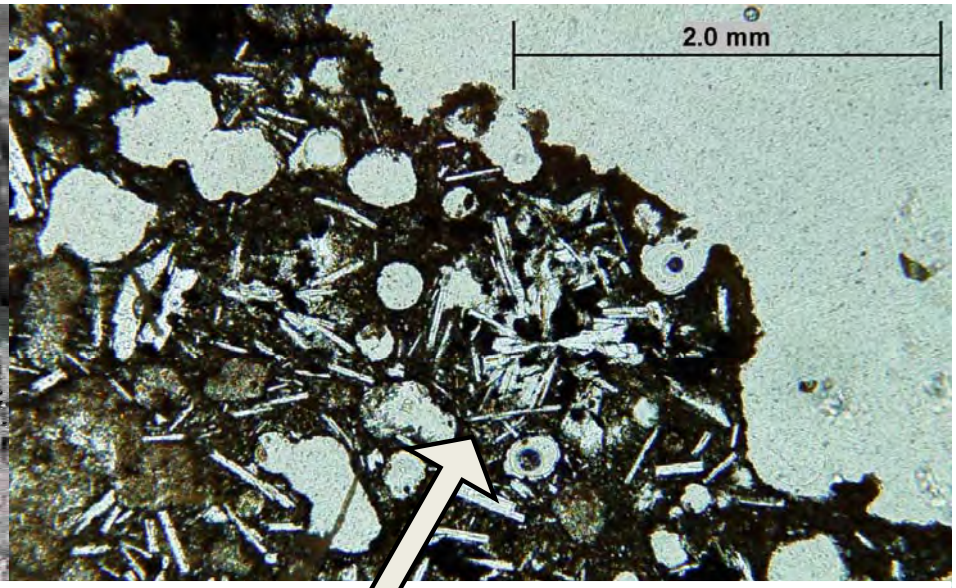
Vesiculated core surrounded by dense rim



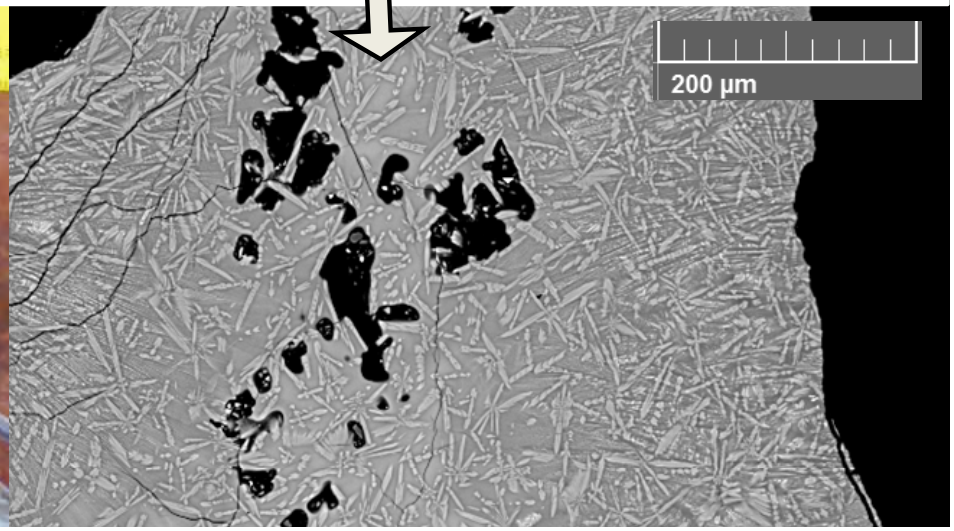




Matte luster due to small crystals within glassy matrix



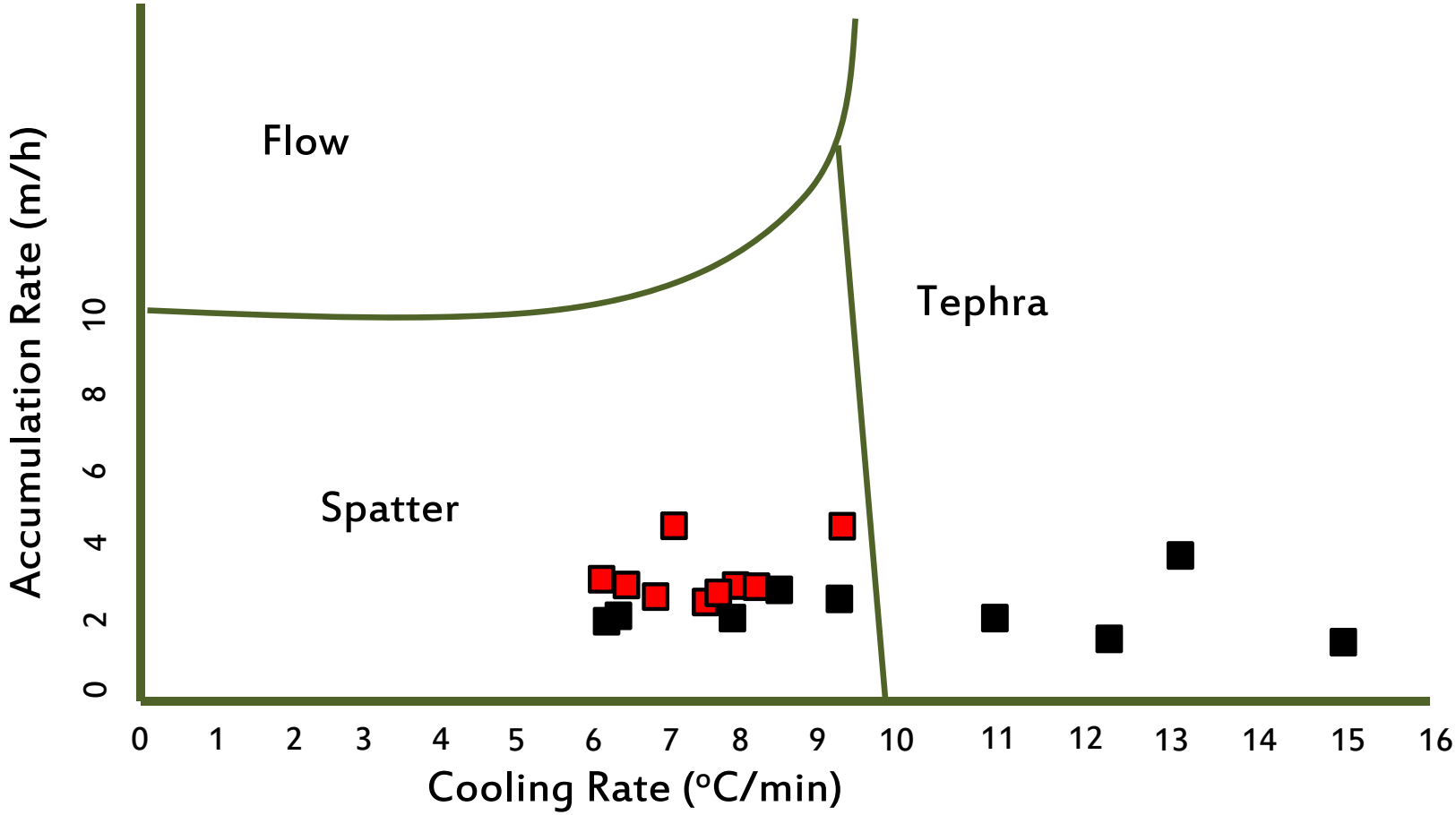
Needle-like crystals characteristic of rapid cooling



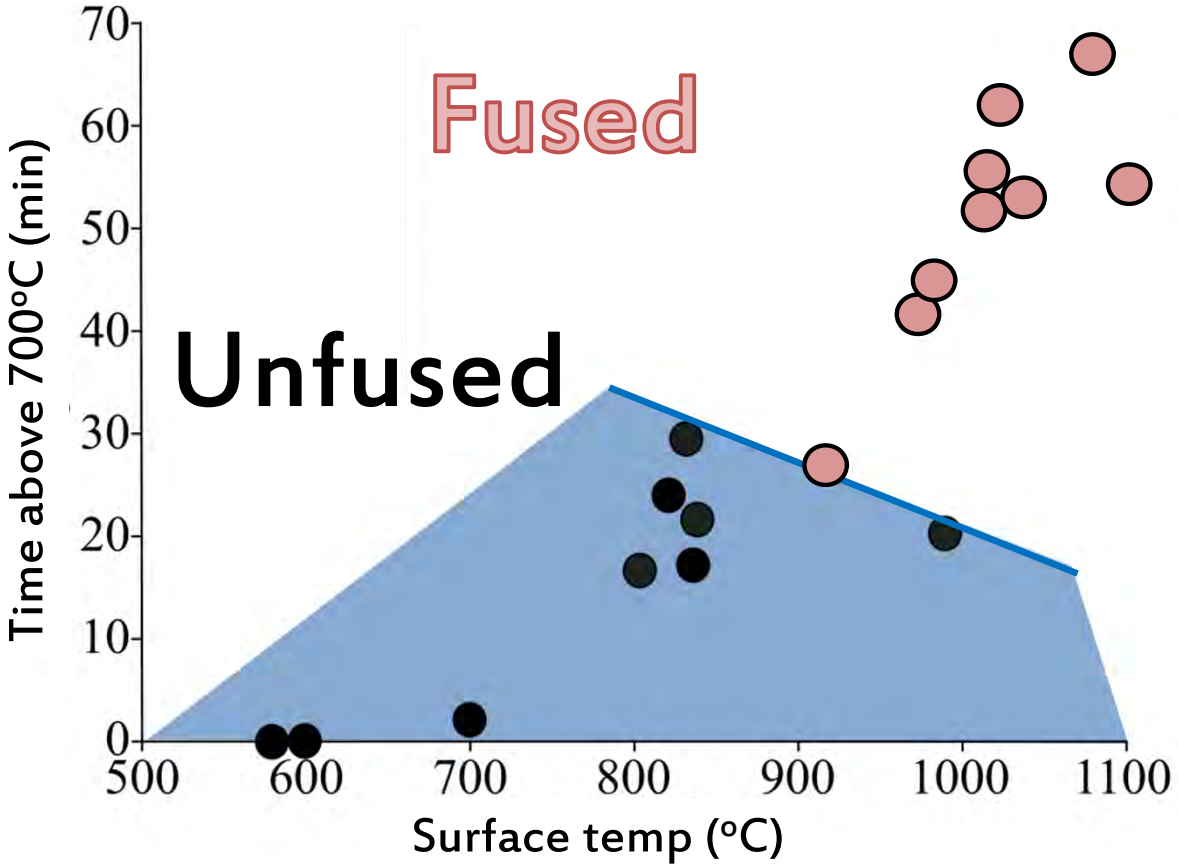
Breadcrust tears in spatter bomb rind

Shiny blue coating

Fused and unfused spatter



Minimum conditions for welding



Characteristics that should be correlated with overall high heat in a deposit

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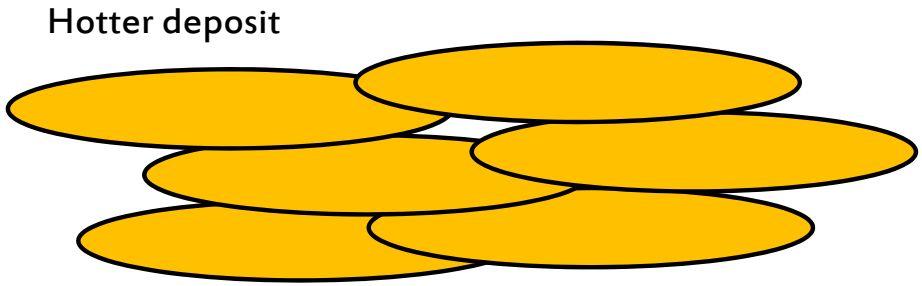
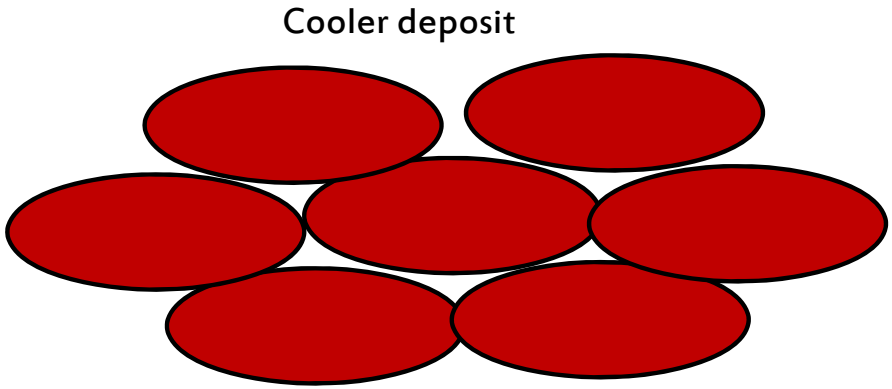
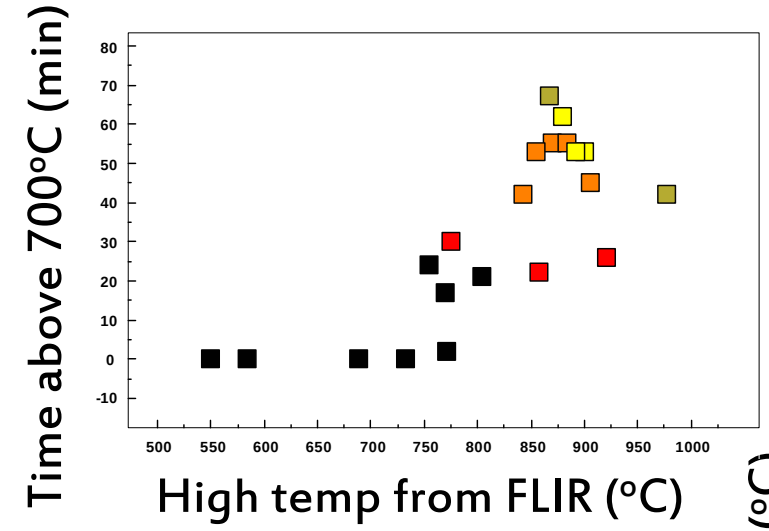
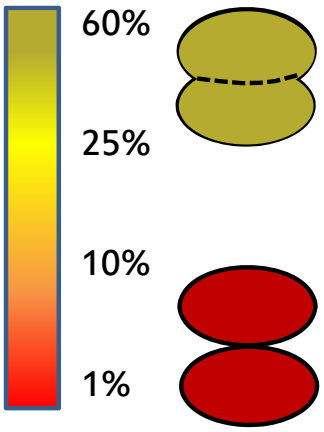
Less void space

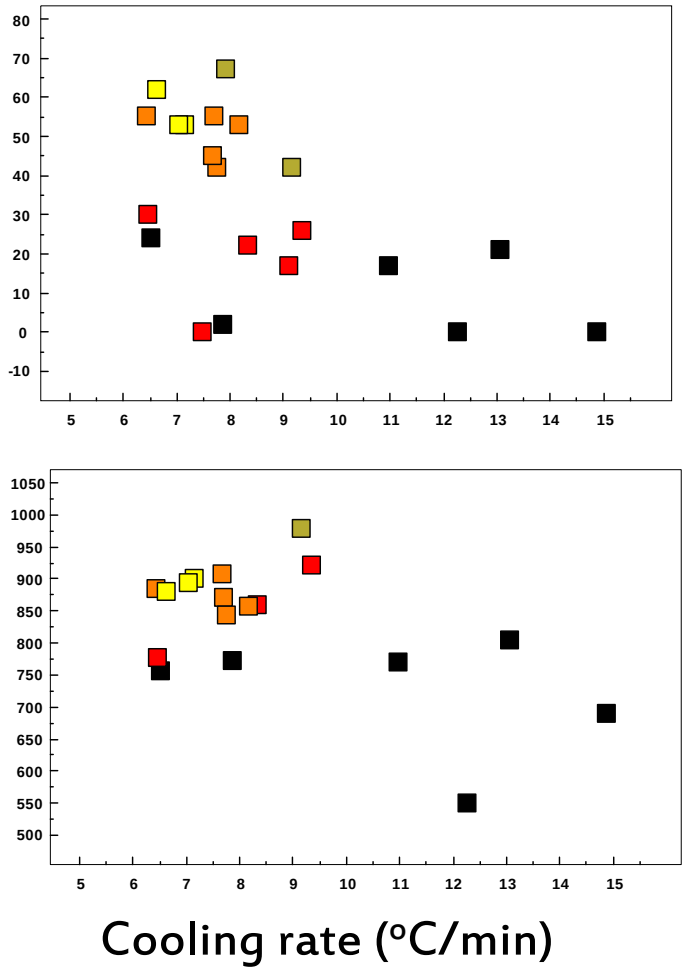




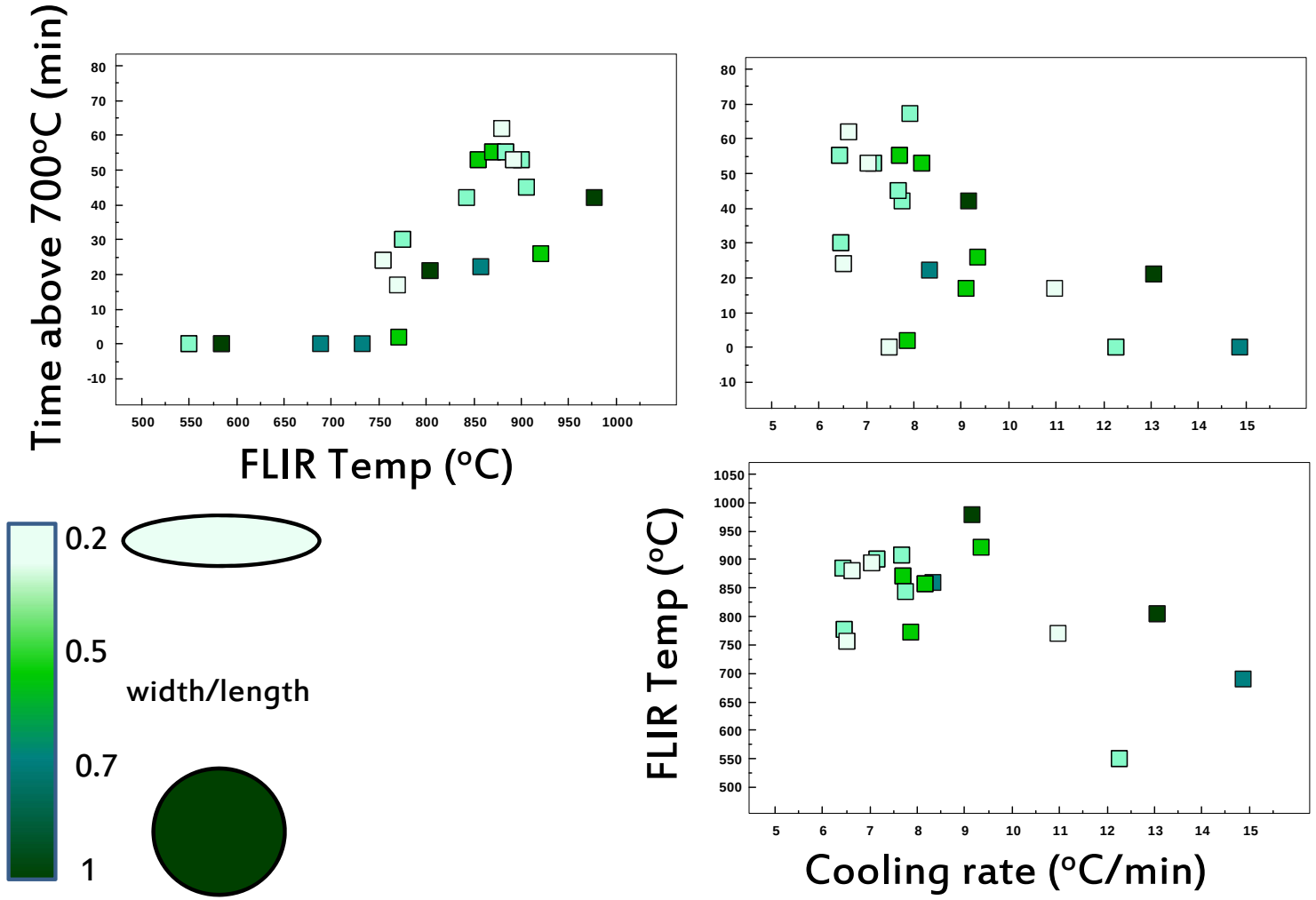
More connection: Amount of fusion between clasts is dependent on starting temp and time above 700°C.





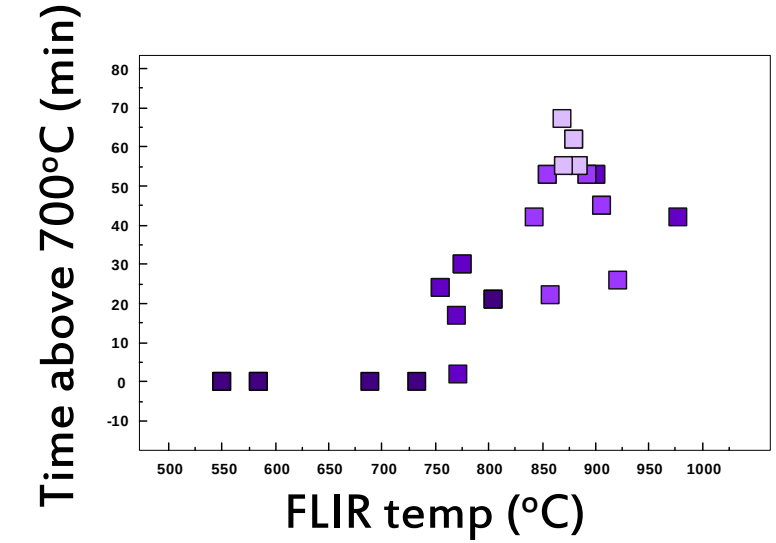


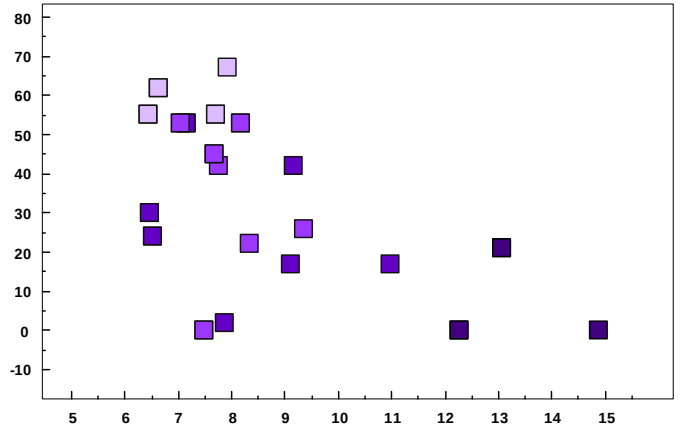
Squashed clasts: Temperature, time, and cooling rate are weakly correlated. Though can be hidden by shaping during "flight".

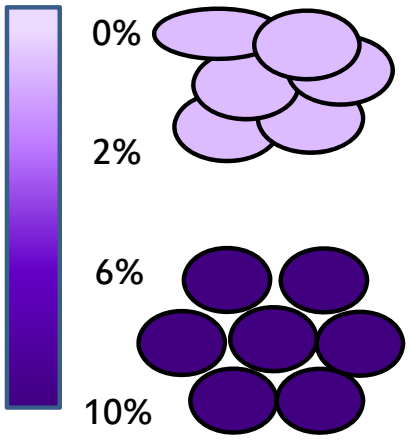


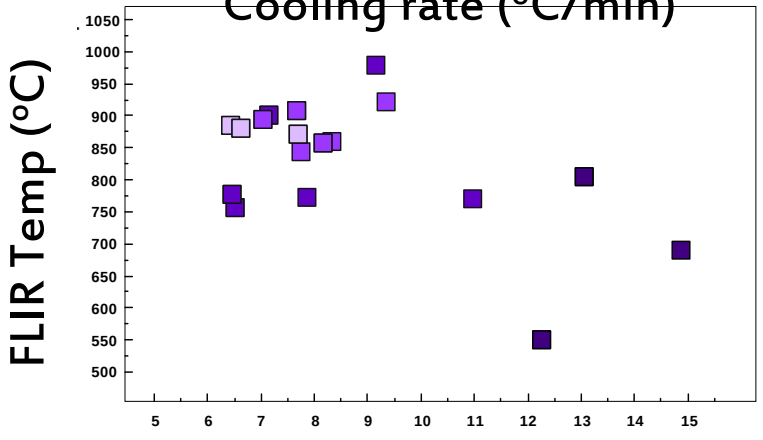
Void space: Well correlated with time and temperature.

High heat = less void space.









Summary of Experiments

- Hotter clasts have:
  - More squashed
  - More fusion
  - Less void space

- Effects of method must be considered.

Outline

1. What is spatter?
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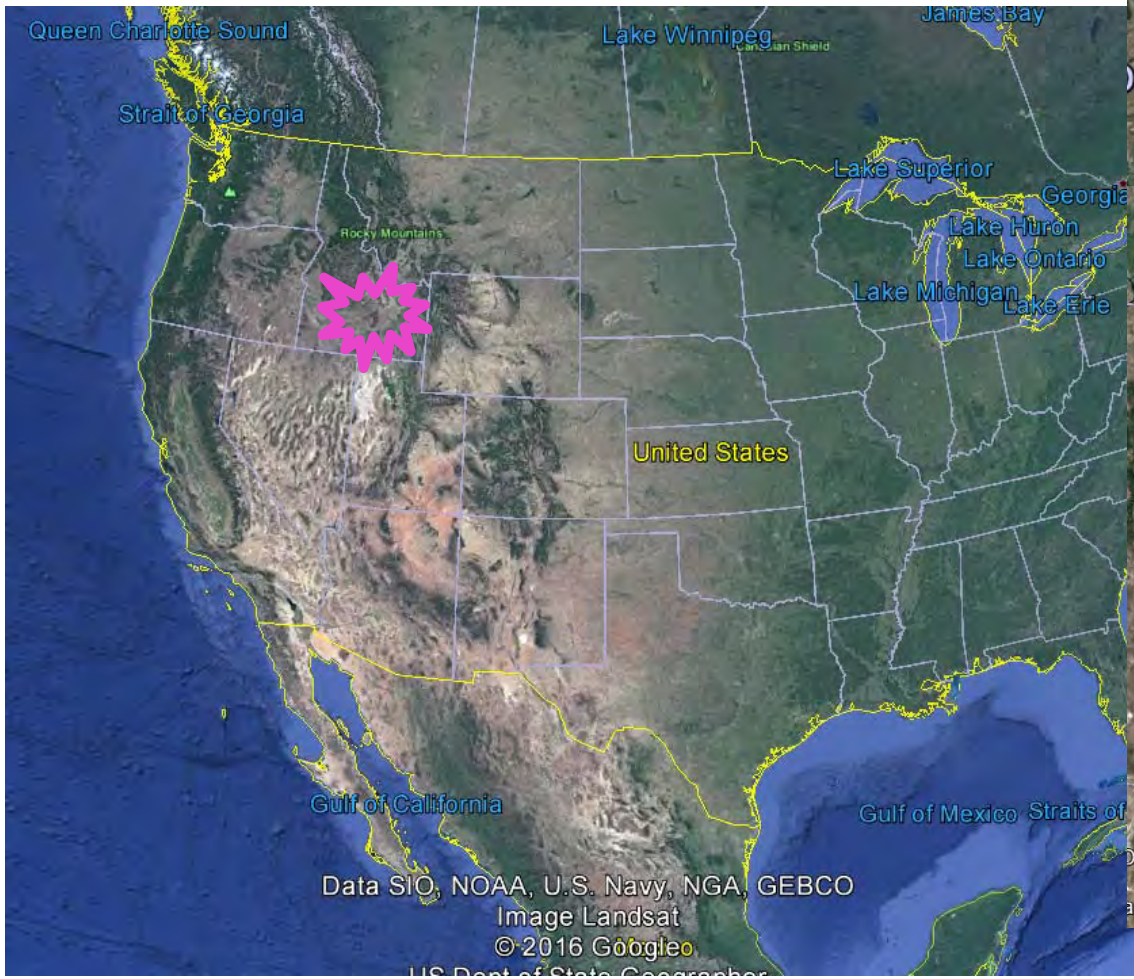
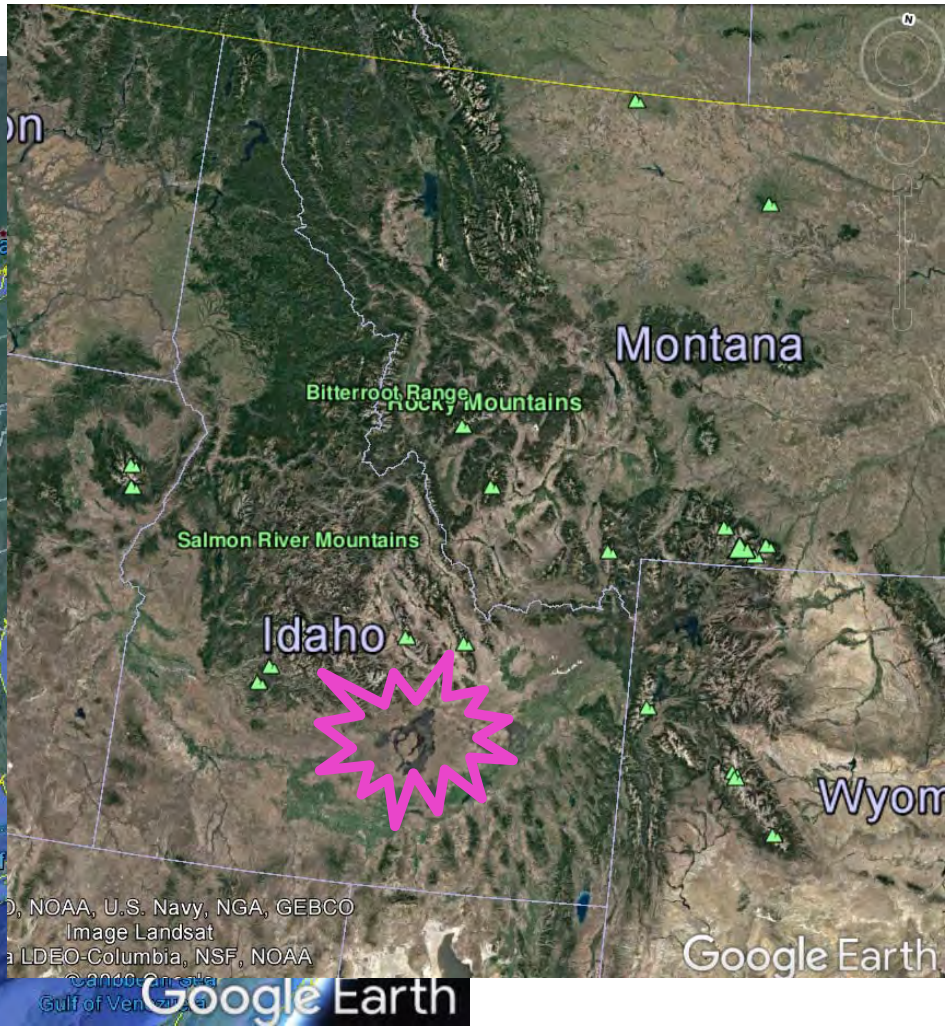
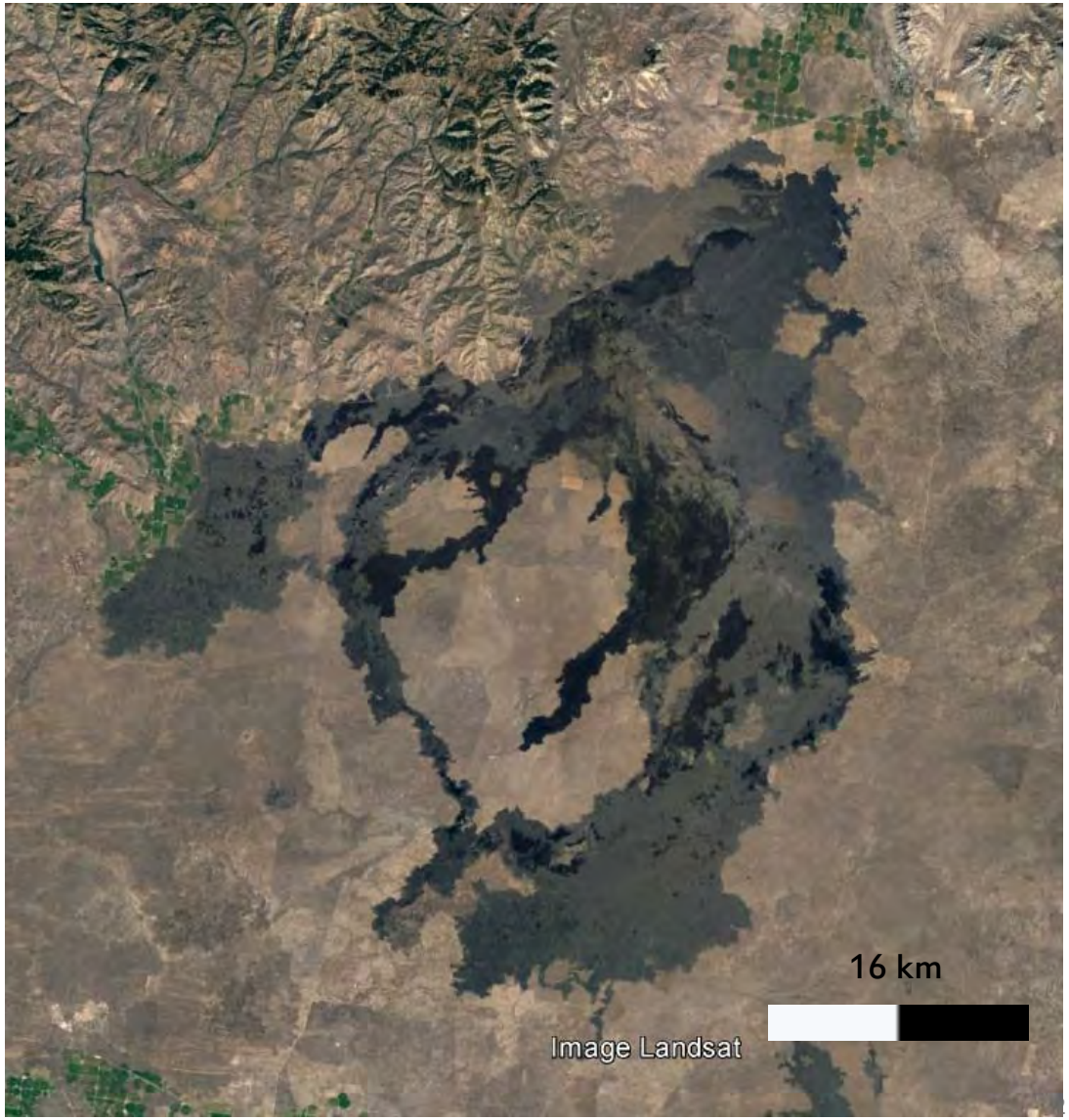
Location of field work

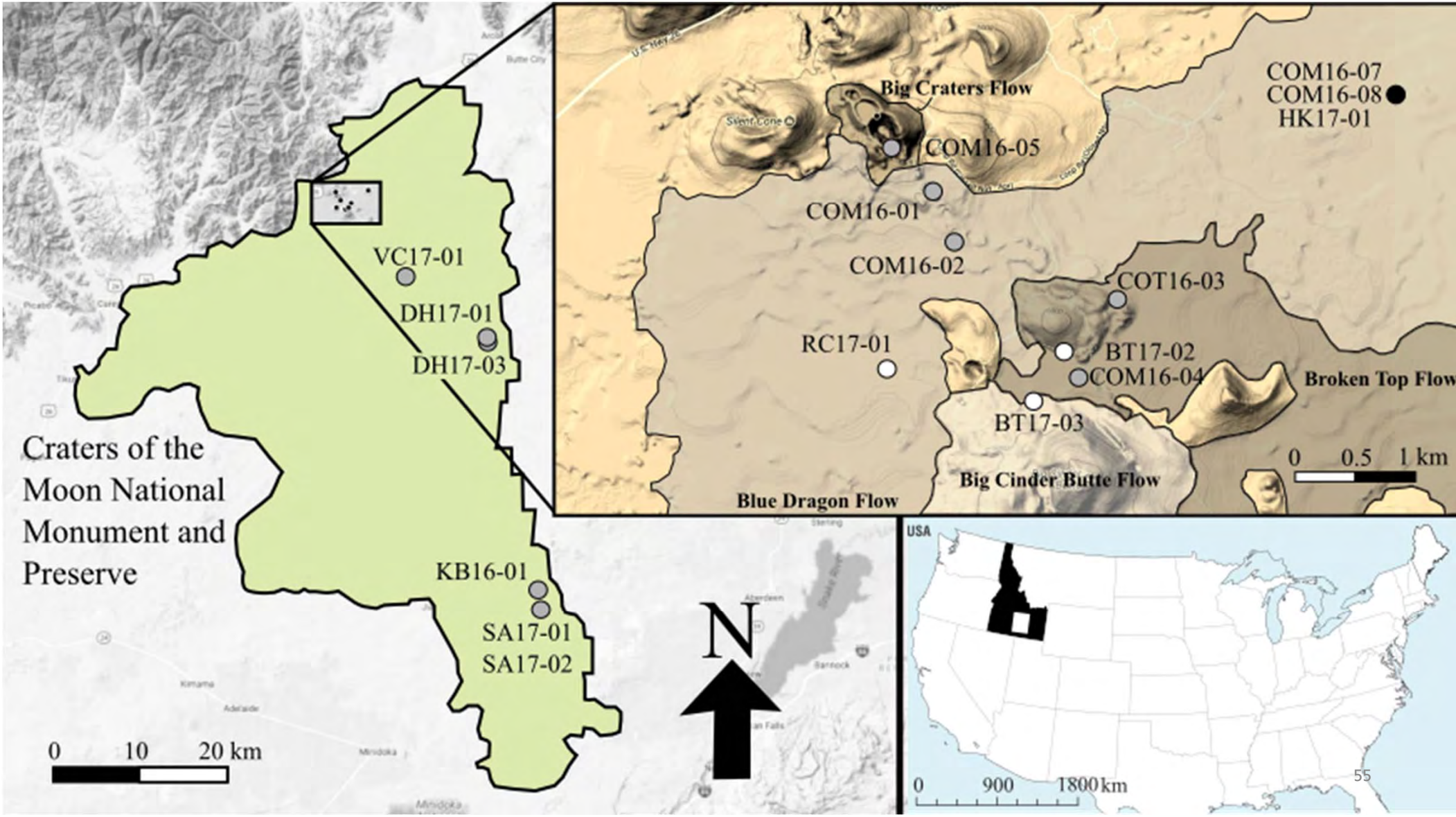


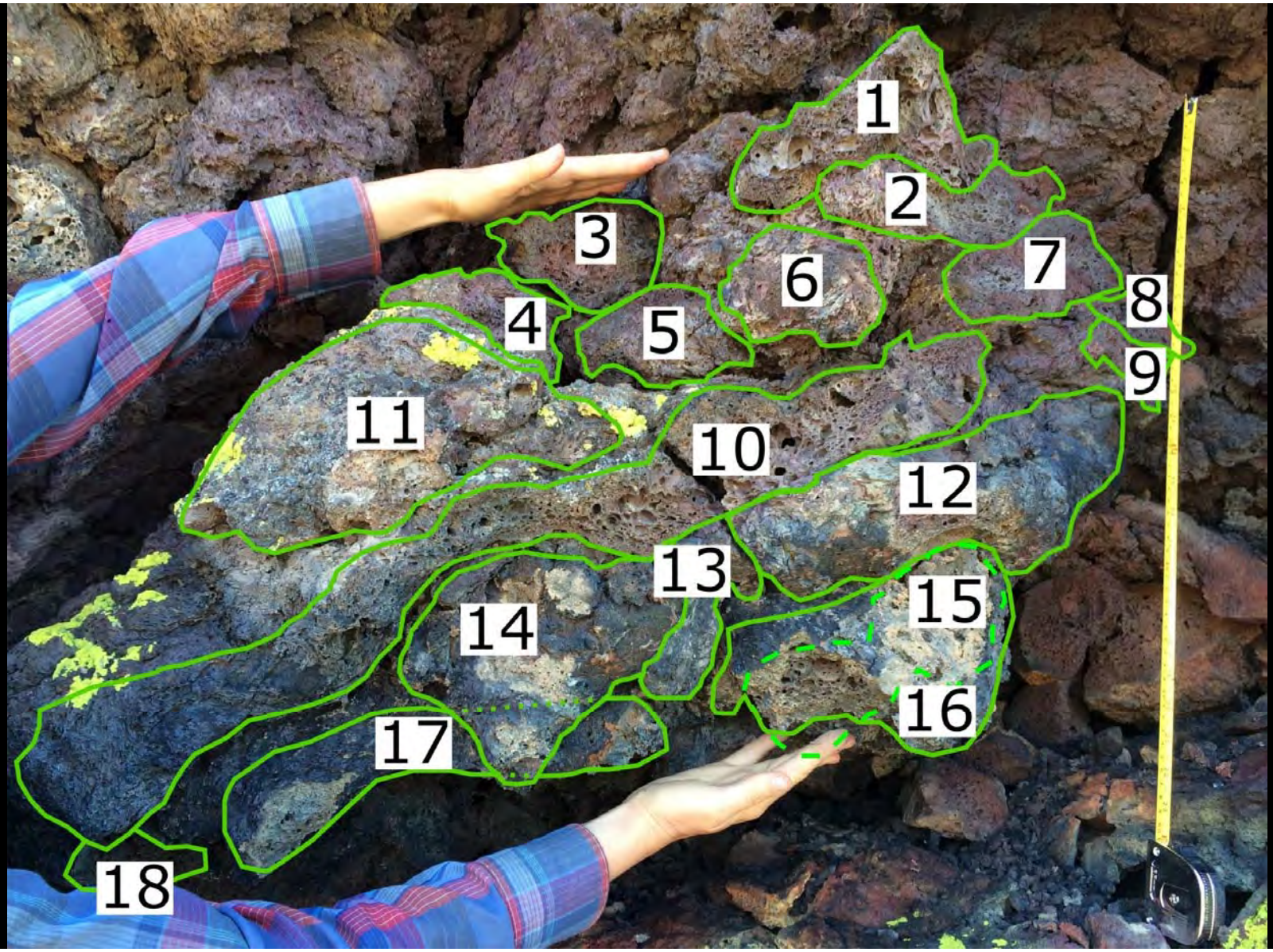


Location of field work

1. Craters of the Moon, ID




Craters of the Moon National Monument and Preserve
VC17-01
DH17-01
DH17-03
KB16-01
SA17-01
SA17-02
0 10 20 km
N
Big Craters Flow
COM16-07
COM16-08
HK17-01
COM16-05
COM16-01
COM16-02
COT16-03
RC17-01
BT17-02
COM16-04
BT17-03
Broken Top Flow
Big Cinder Butte Flow
Blue Dragon Flow
0 0.5 1 km
USA
0 900 1800 km


1
2
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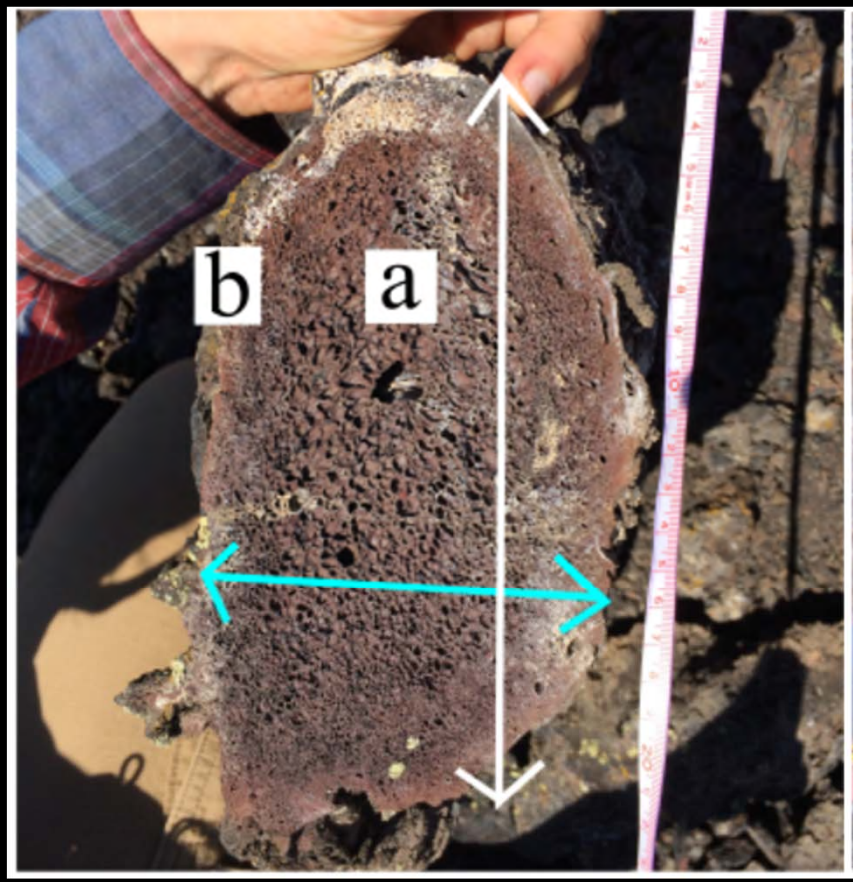
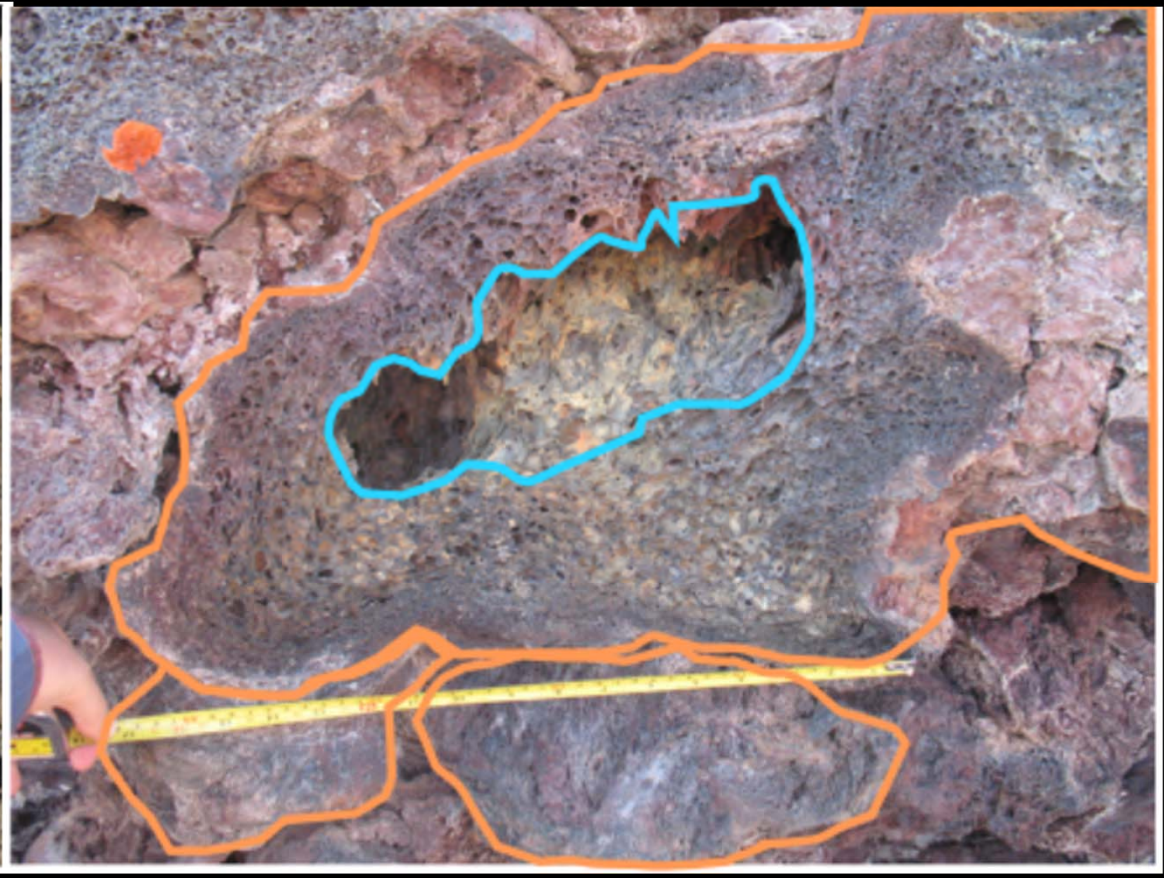
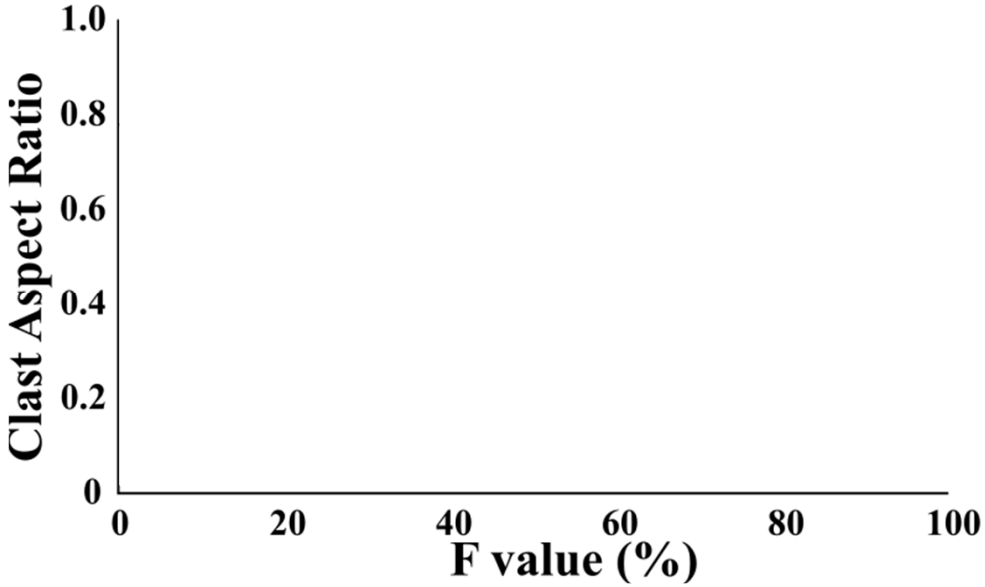
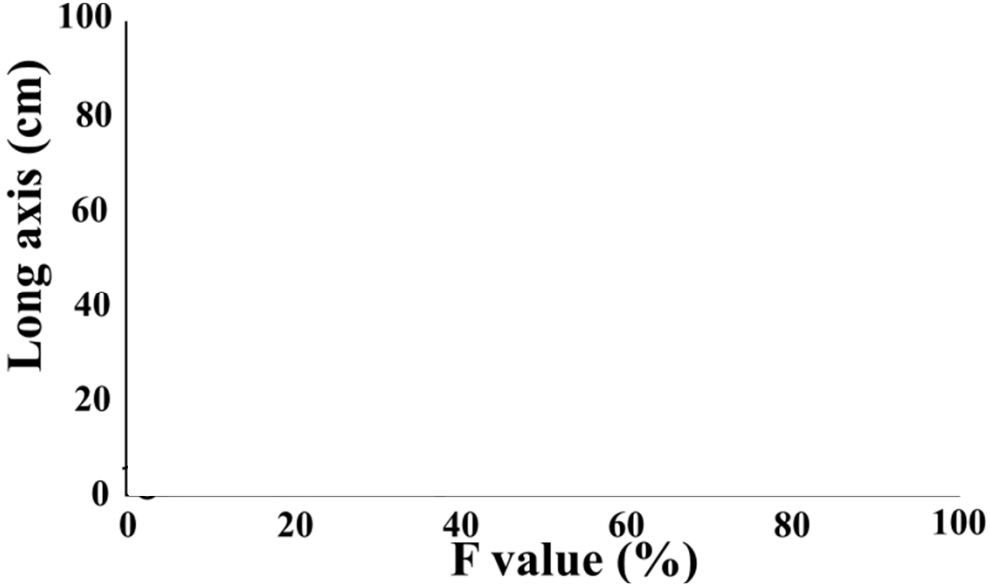
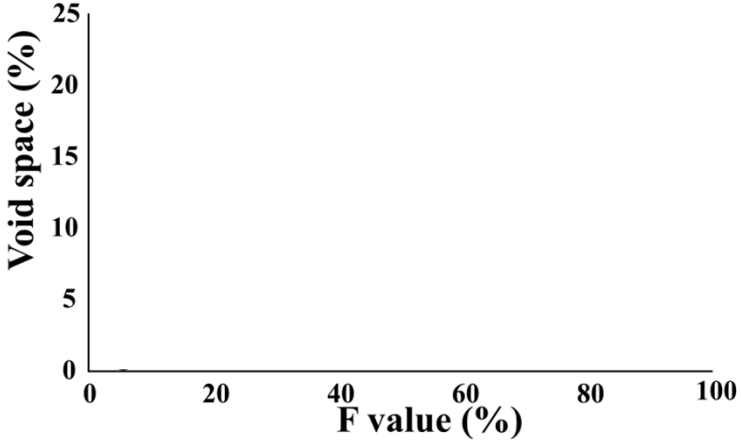
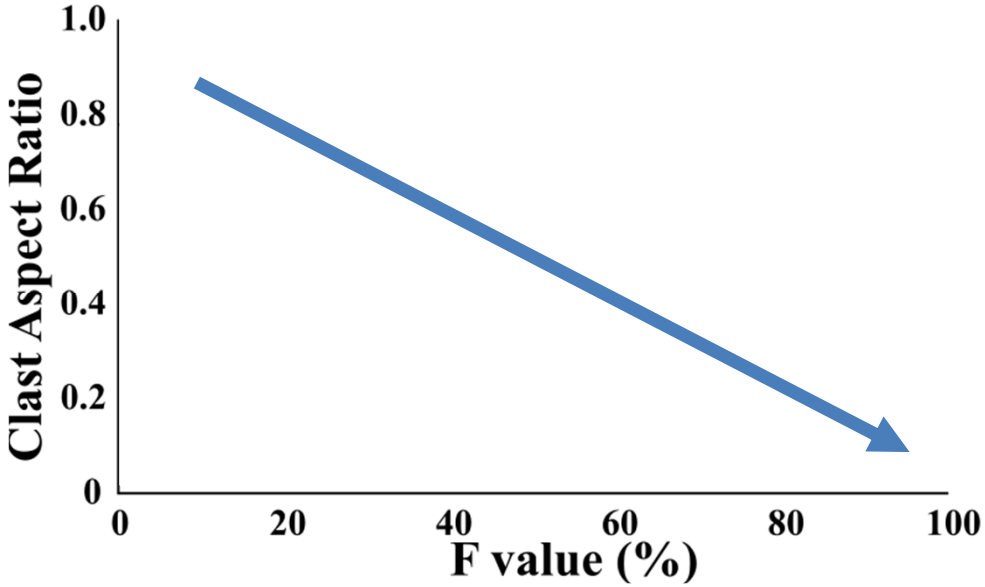

b
a

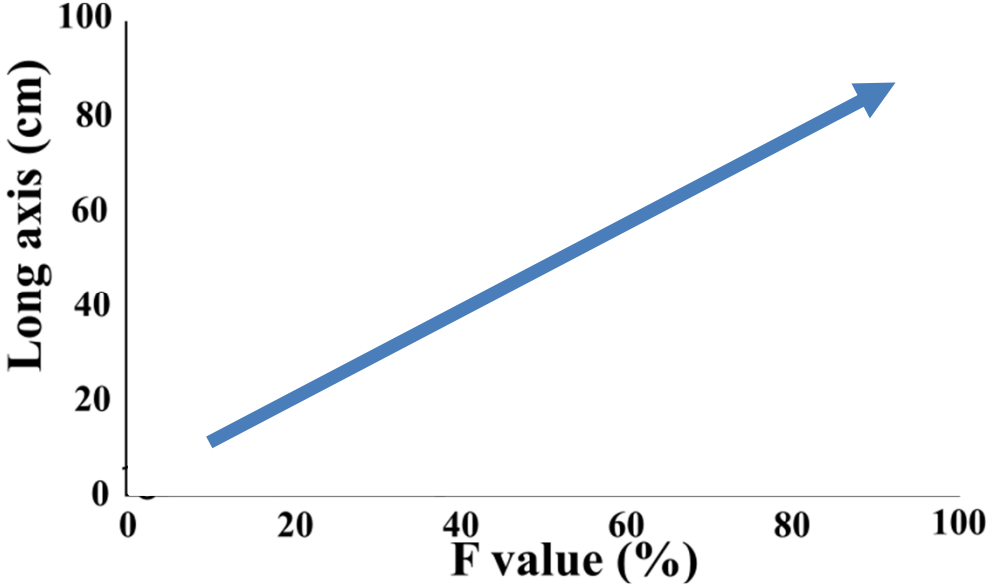


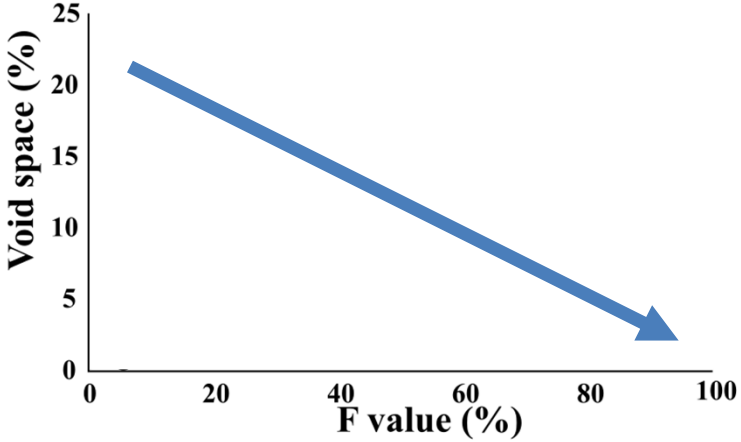

Clast Aspect Ratio
1.0
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
F value (%)

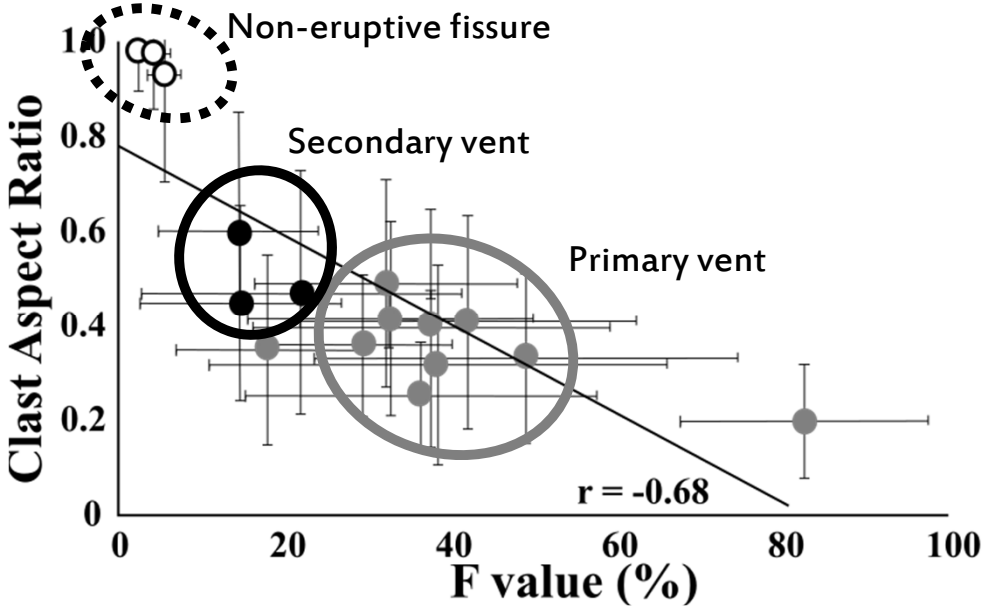

Long axis (cm)
100
80
60
40
20
0
0
20
40
60
80
100
F value (%)

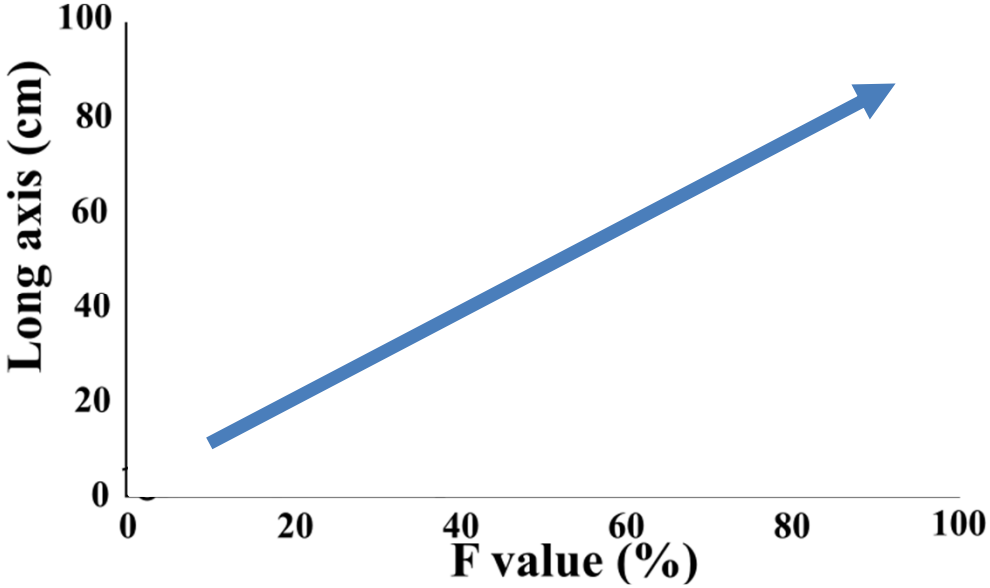

Void space (%)
25
20
15
10
5
0
0
20
40
60
80
100
F value (%)

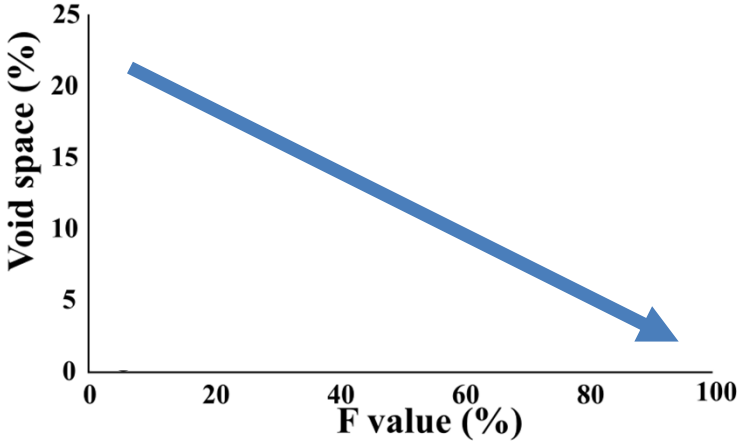

Clast Aspect Ratio
1.0
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
F value (%)

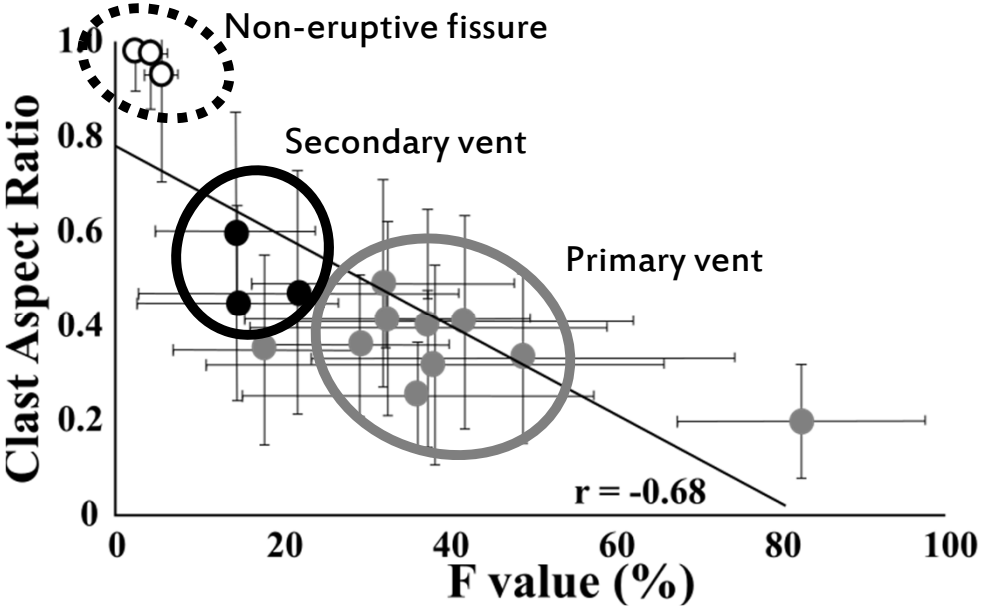

Long axis (cm)
100
80
60
40
20
0
0
20
40
60
80
100
F value (%)

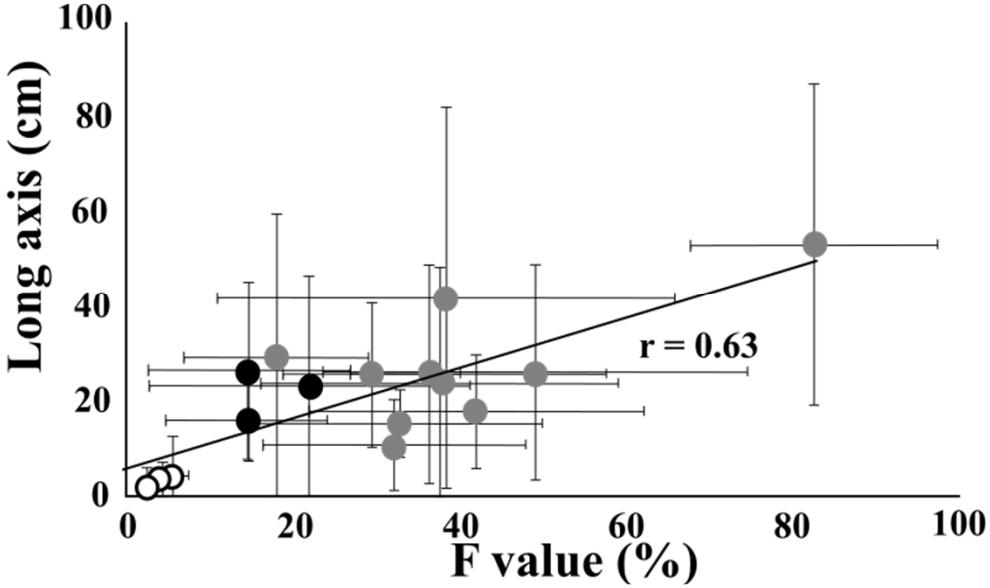

Void space (%)
25
20
15
10
5
0
0
20
40
60
80
100
F value (%)

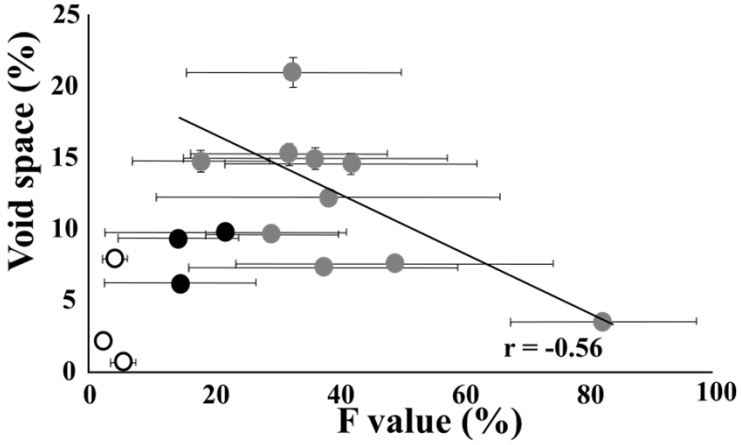

Non-eruptive fissure
Secondary vent
Primary vent
r = -0.68
Clast Aspect Ratio
F value (%)
0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100

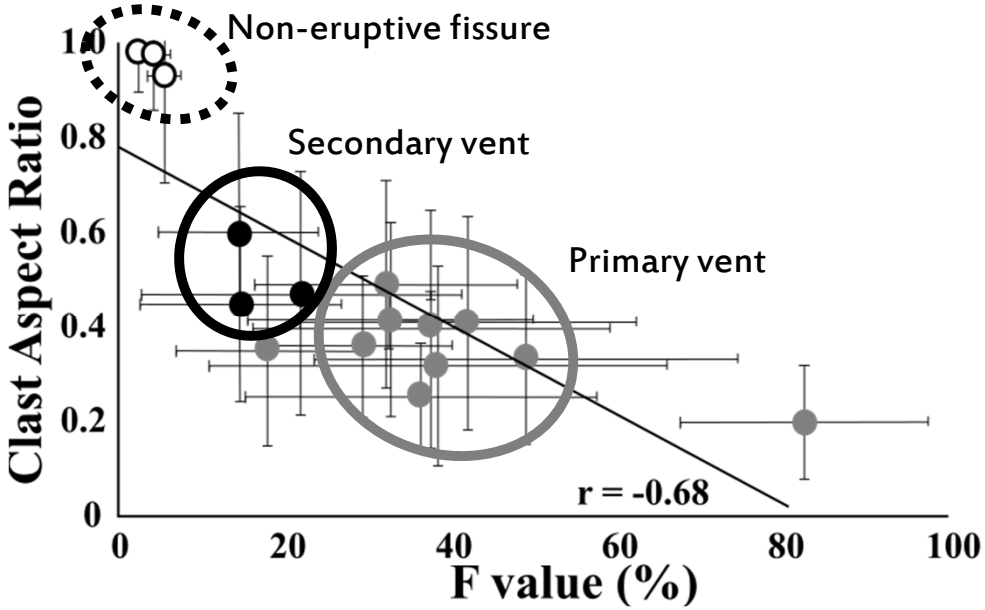

Long axis (cm)
F value (%)
0
20
40
60
80
100

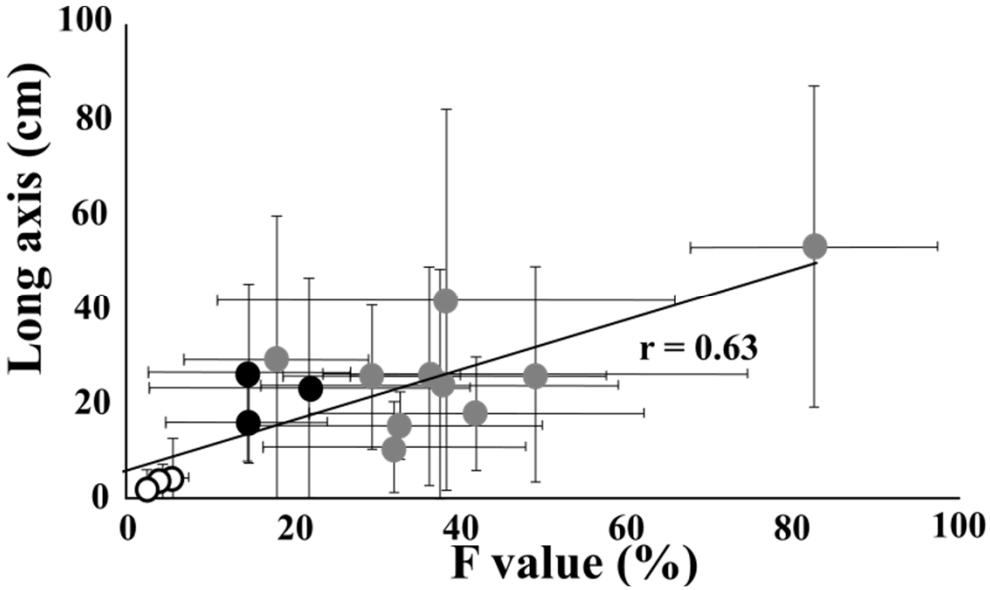

Void space (%)
F value (%)
0
5
10
15
20
25
0
20
40
60
80
100

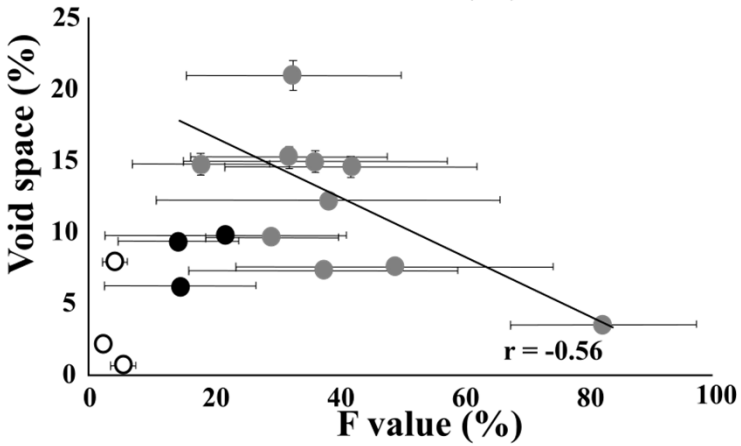

Non-eruptive fissure
Secondary vent
Primary vent
r = -0.68
Clast Aspect Ratio
F value (%)
0
0.2
0.4
0.6
0.8
1
0
20
40
60
80
100

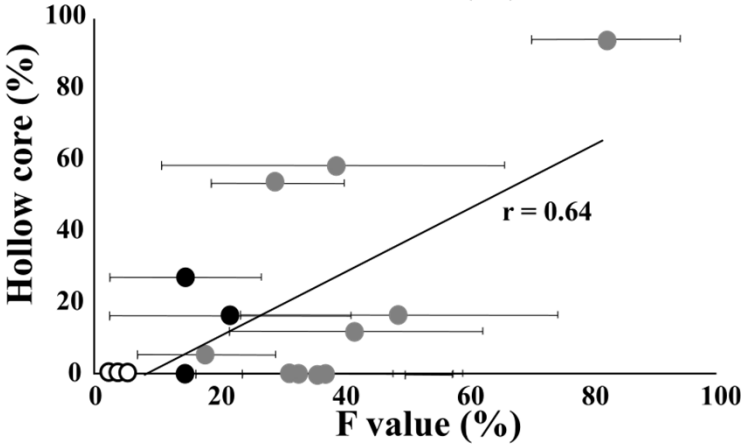

r = 0.63
Long axis (cm)
F value (%)
0
20
40
60
80
100


r = -0.56
Void space (%)
F value (%)
0
5
10
15
20
25
0
20
40
60
80
100


Non-eruptive fissure
Secondary vent
Primary vent
r = -0.68
Clast Aspect Ratio
F value (%)


r = 0.63
Long axis (cm)
F value (%)


r = -0.56
Void space (%)
F value (%)


r = 0.64
Hollow core (%)
F value (%)

40%

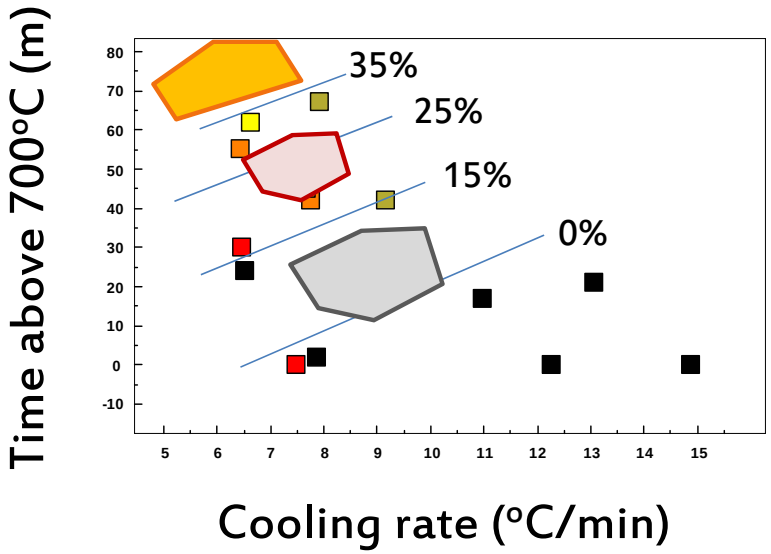
Primary vent

20%

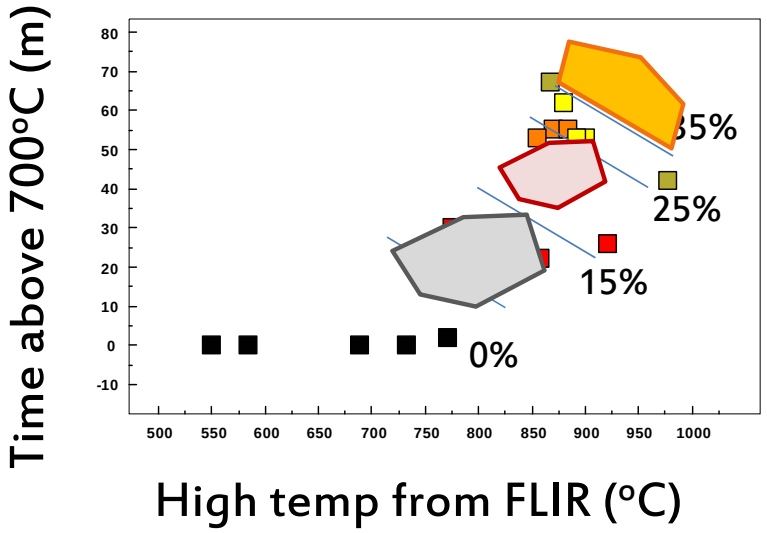
Secondary vent

1%

Non-eruptive fissure

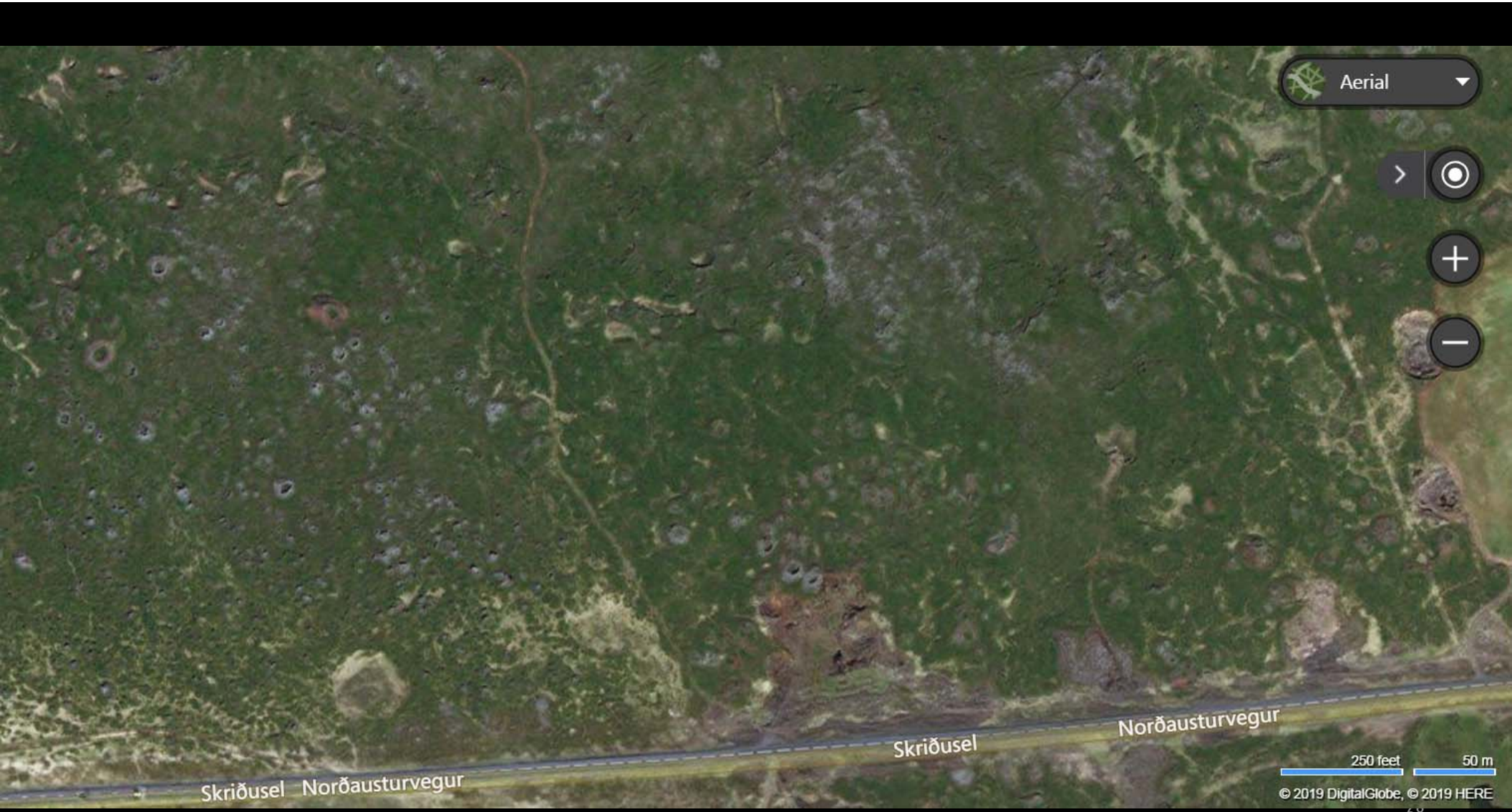


	Primary vent spatter	Secondary vent	Non-E fissure spatter
Cooling rate	6-7.5°C/min	7-9°C/min	7.5-10.5°C/min
Time above 700°C	>60 min	35-55 min	10-30 min
Landing temperature			

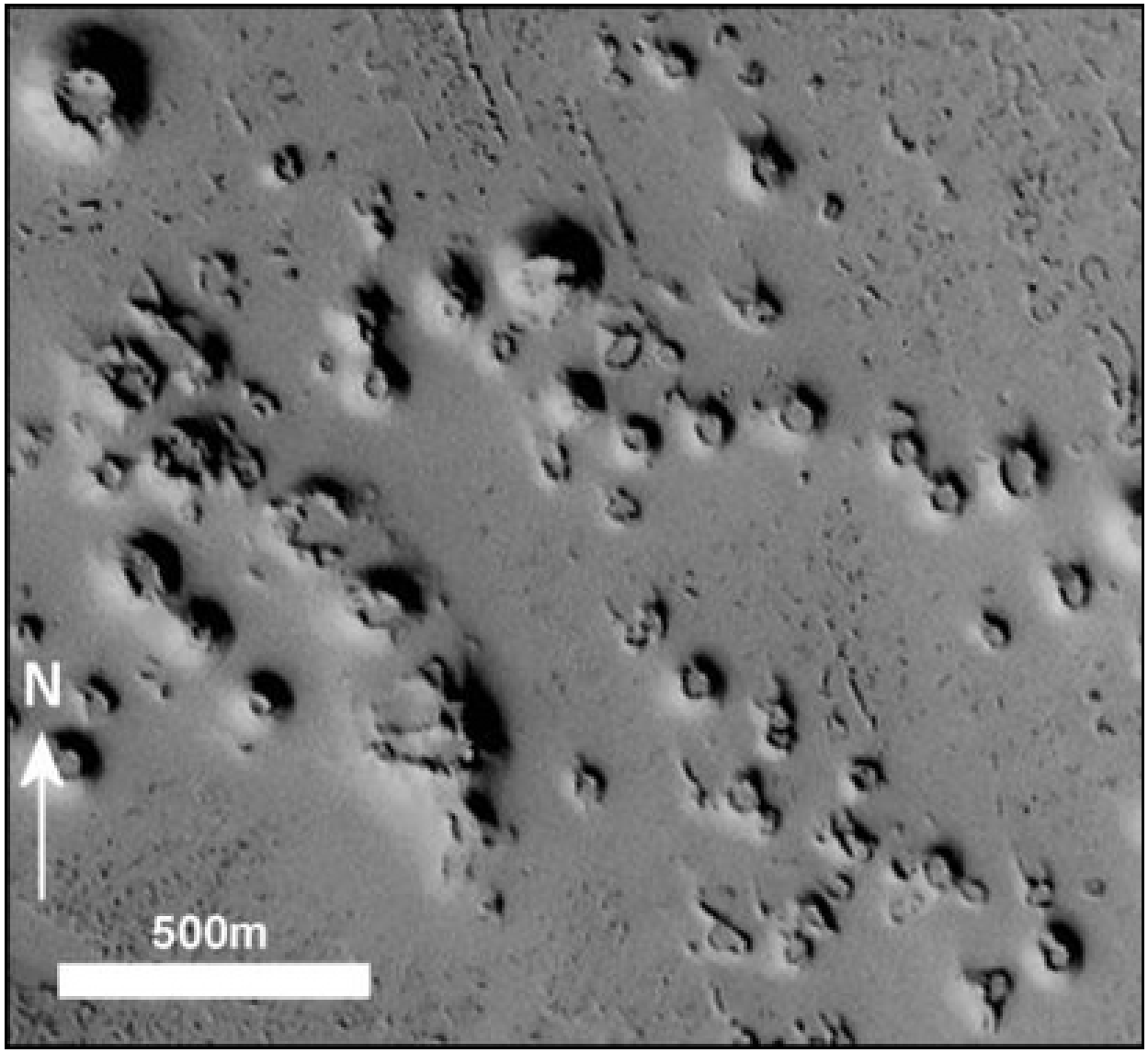


	Primary vent spatter	Secondary vent	Non-E fissure spatter
Cooling rate	6-7.5°C/min	7-9°C/min	7.5-10.5°C/min
Time above 700°C	>60 min	35-55 min	10-30 min
Landing temperature	850-975°C	815-915°C	725-875°C

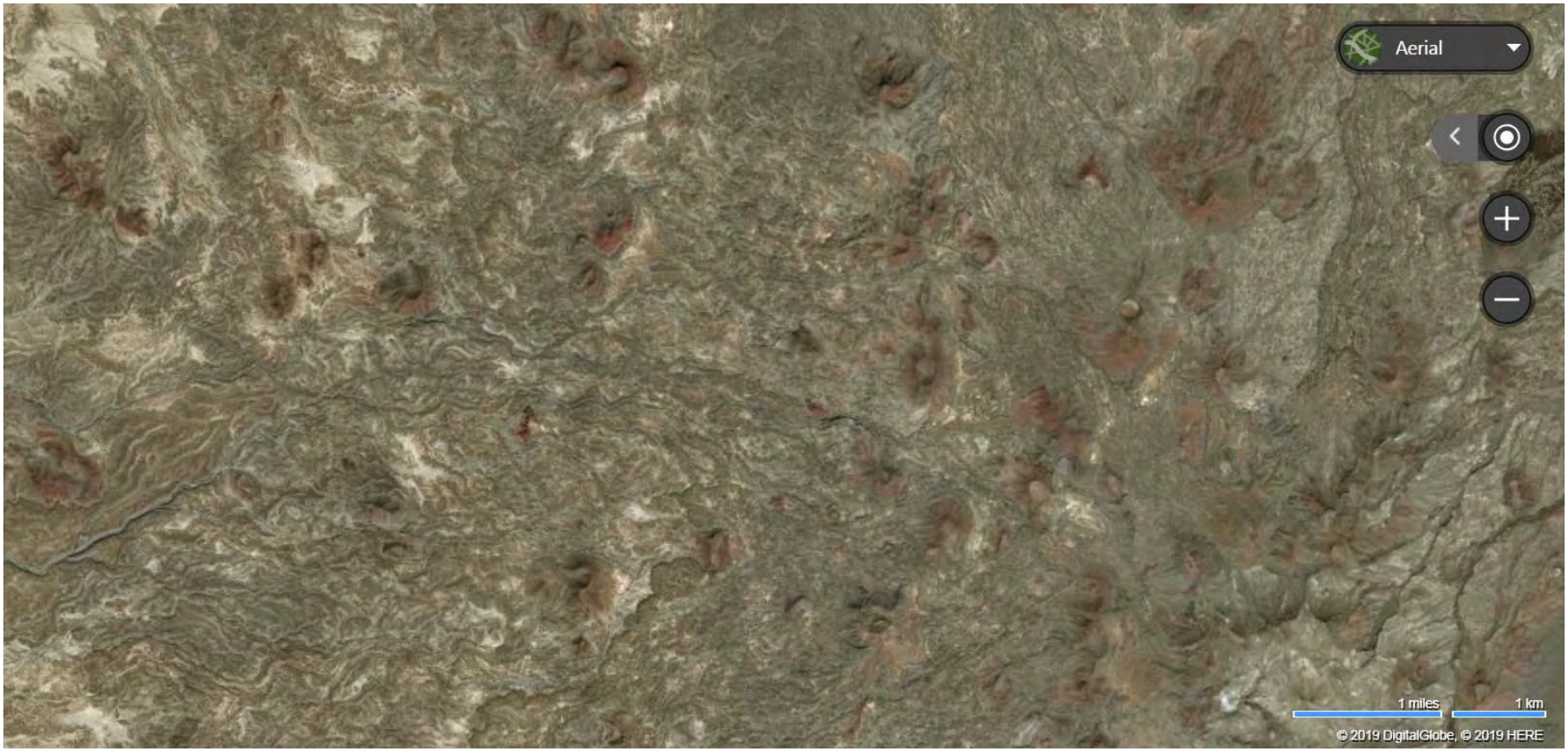

ICELAND
Reykjavík
50 miles
100 km
Earthstar Geographics SIO, © 2019 HERE

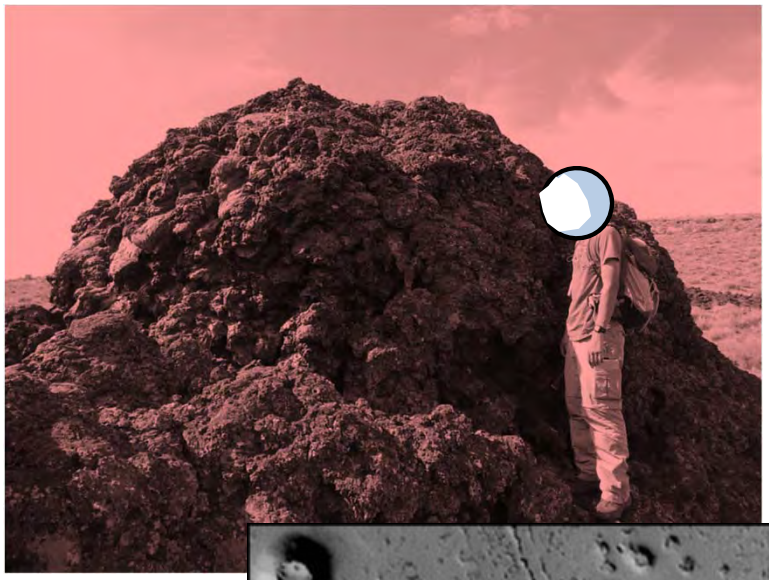

Aerial
Skriðusel
Norðausturvegur
Skriðusel
Norðausturvegur
250 feet
50 m
© 2019 DigitalGlobe, © 2019 HERE

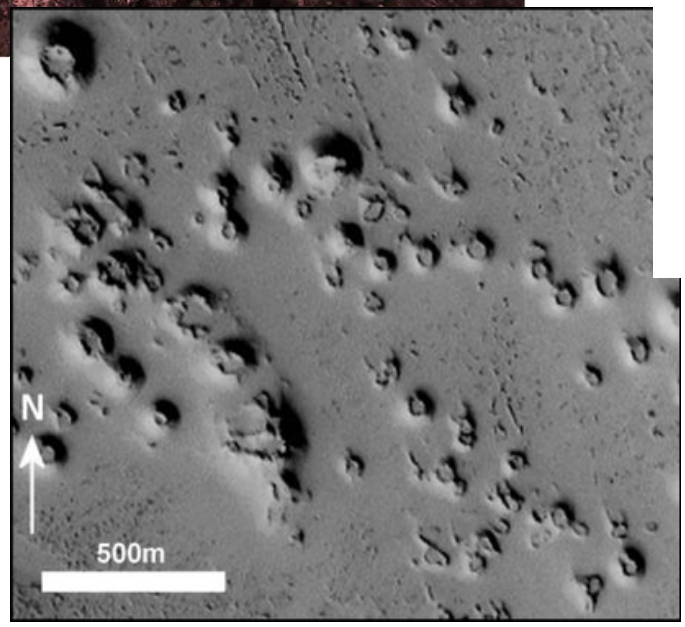

Secondary Vents

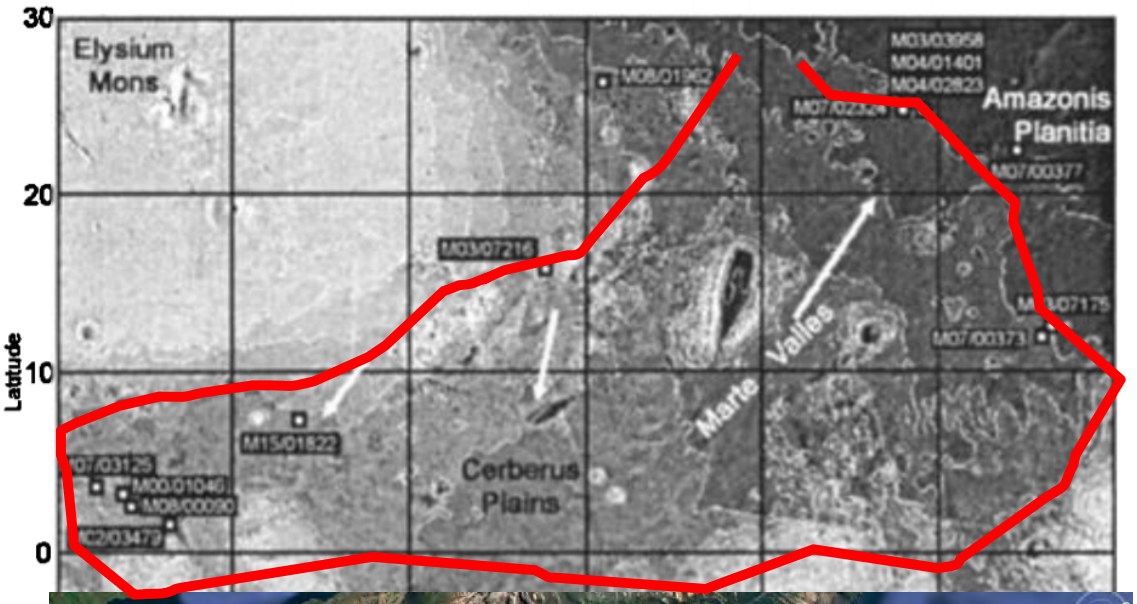


Cone cluster on Mars
(26.0°N, 189.7°W)


Aerial
1 miles
1 km
© 2019 DigitalGlobe, © 2019 HERE




N
500m

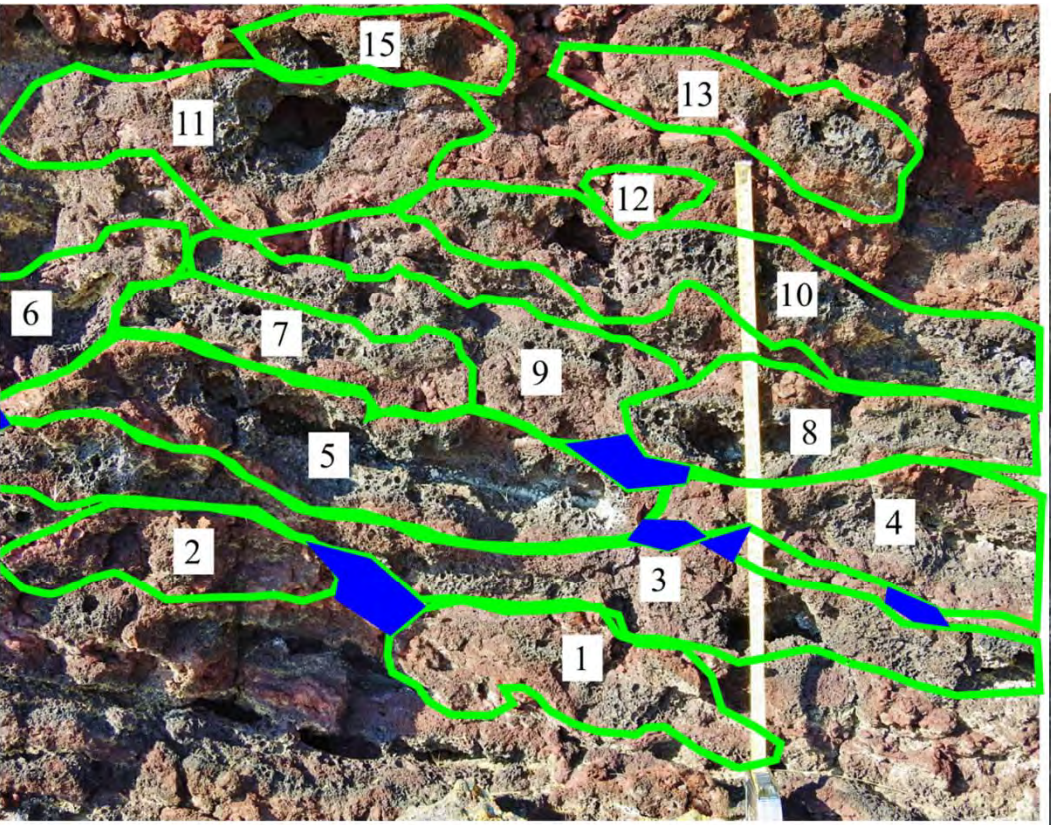

30
20
10
0
Latitude
Elysium Mons
M08/01962
M03/03958
M04/01401
M04/02823
M07/02324
Amazonis Planitia
M07/00377
M03/07216
M07/00373
Valles Marte
M15/01822
Cerberus Plains

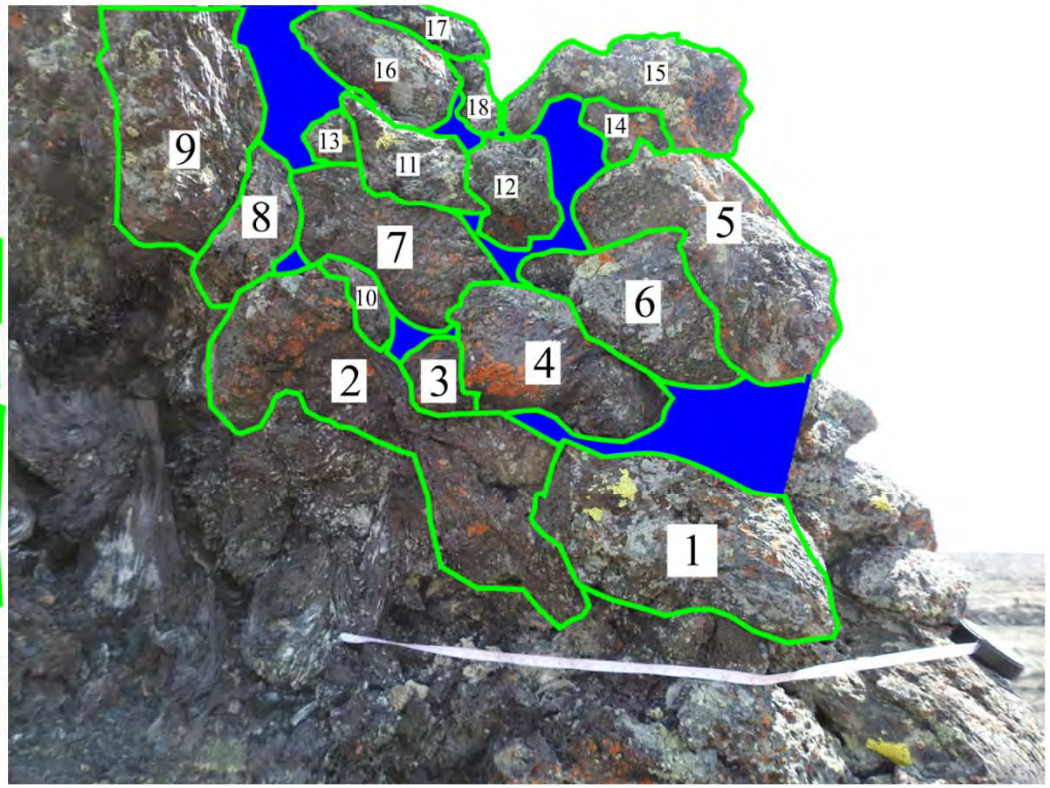
Coming soon: Spectral signatures of spatter!

Grand Conclusions

1. Types of spatter can be identified based on morphological differences in the deposit.

TBD: lava-water induced spatter





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TBD: lava-water induced spatter

2. Clast length/width and fusion are correlated to thermal history of the deposit.

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3. Spatter at COTM was similar to experiments with 6-10.5°/min, 10-60 min time above 700°C, and 0.5-2 m/hr.

4. Potential secondary spatter features on Mars could be confirmed through these techniques, constraining past watery Martian environments.

Thanks and Questions

Lab group @ Idaho: Sheridan Ackiss, Kevin Cerna, Adrianne Reeder, myself, Aly Doloughan, and David Cavell