Artificial Spatter Piles:

Constraining cooling and eruption rates in Idaho and on the Moon

Erika Rader – NASA Ames

Outline

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

Spatter is :

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


Tephra
Spatter
Lava

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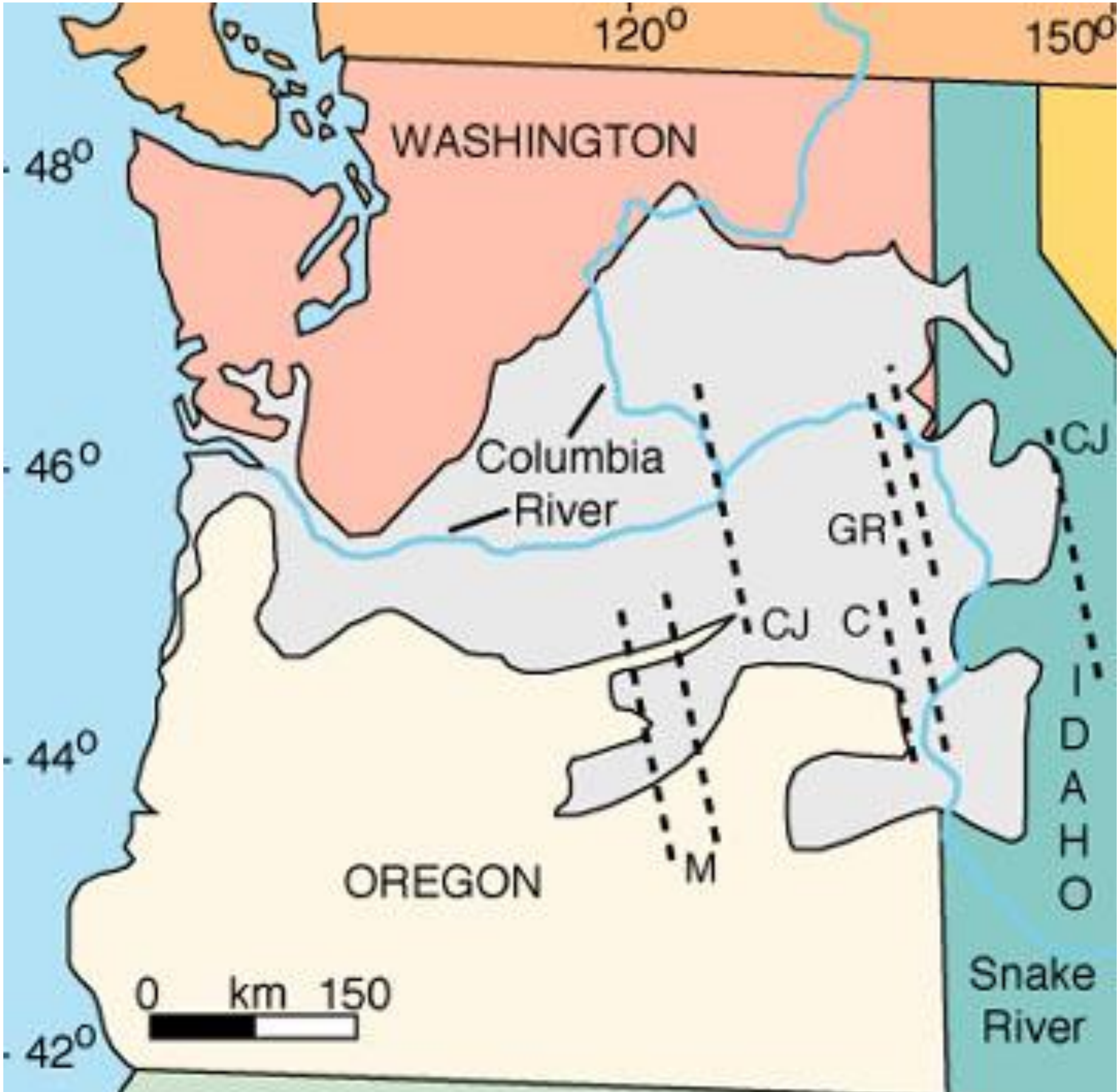
Magmatic gas and vent region

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

Basaltic eruptions are very common

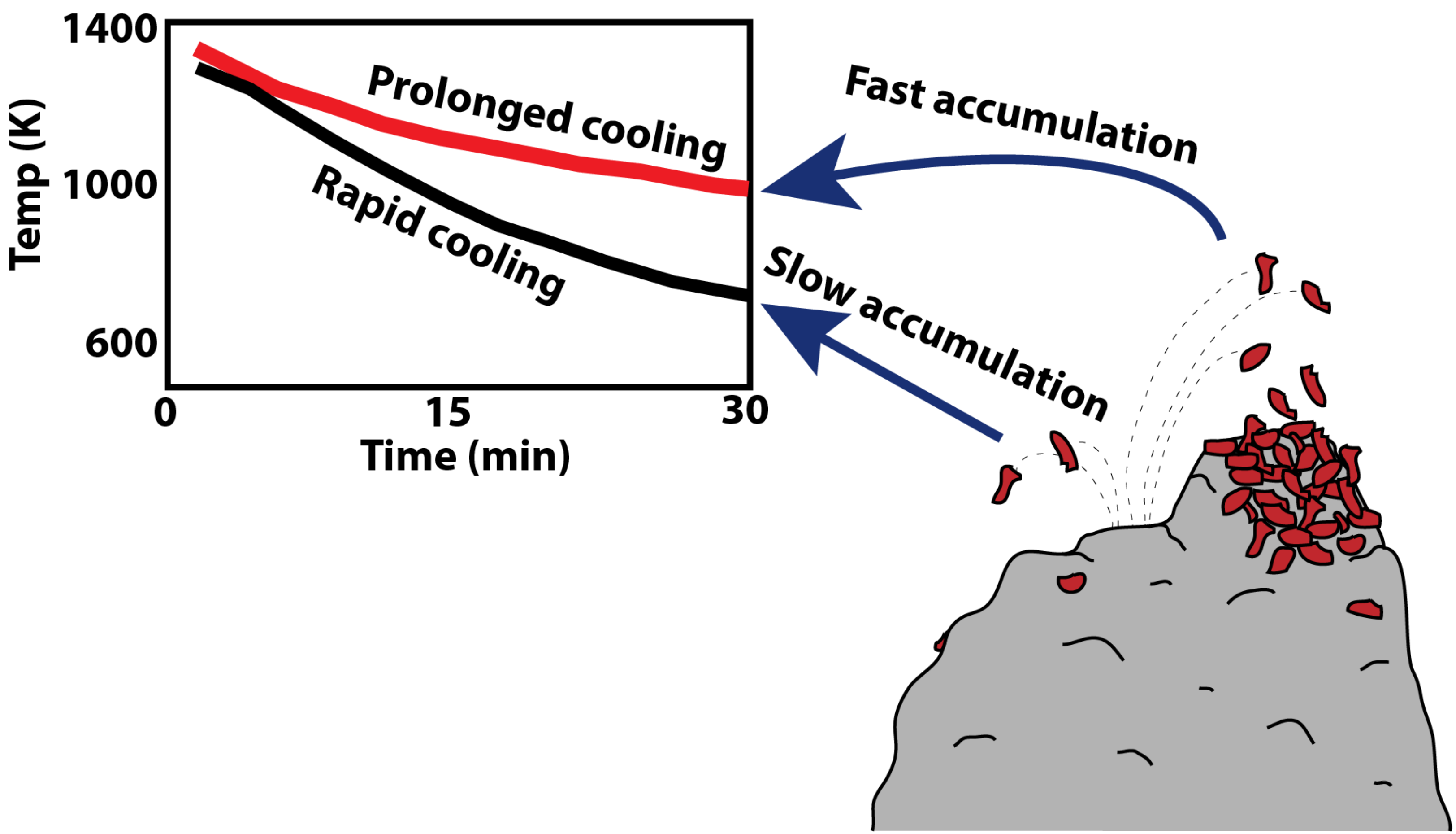
But the timing is poorly constrained

- *How does morphology relate to…*
  - *Chemistry*
  - *Process*
  - *Age*

Spatter – the Goldilocks of basaltic morphologies

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

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




COLGATE
GEOLOGY

Volcanic glass is **ductile** and will **anneal** above the

glass transition temperature

Classification of basaltic eruptive products

Cooling Rate

Modified from a diagram in Sumner et al. 2005

Lava flows show lateral consistency across long distances

Classification of basaltic eruptive products

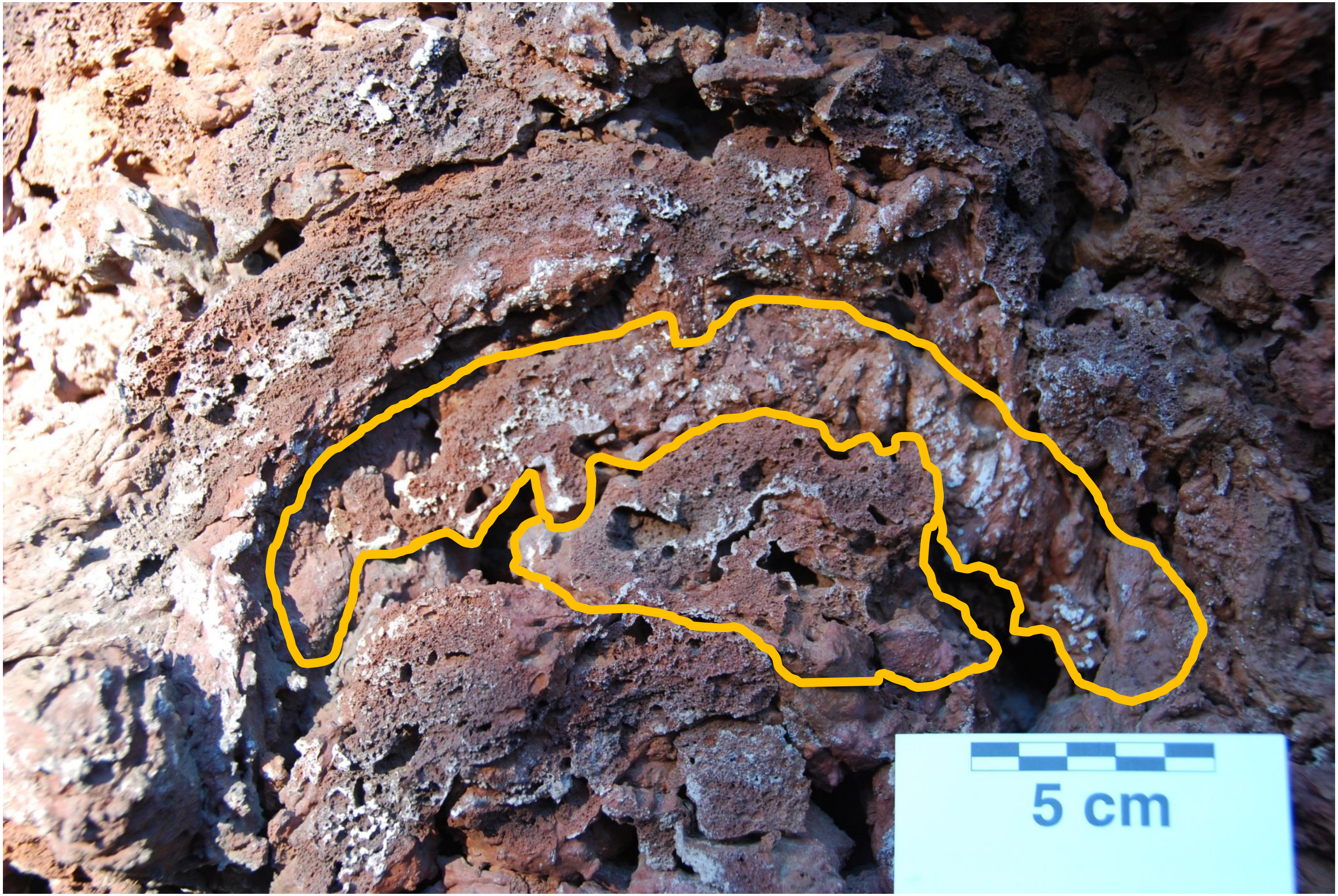
Cooling Rate


42
41
40
39
38
37
36
35
34

Classification of basaltic eruptive products

Cooling Rate


0
10
20
30
40
50
60
70
80
14
12
1:1000 METRIC
5 CM


5 cm

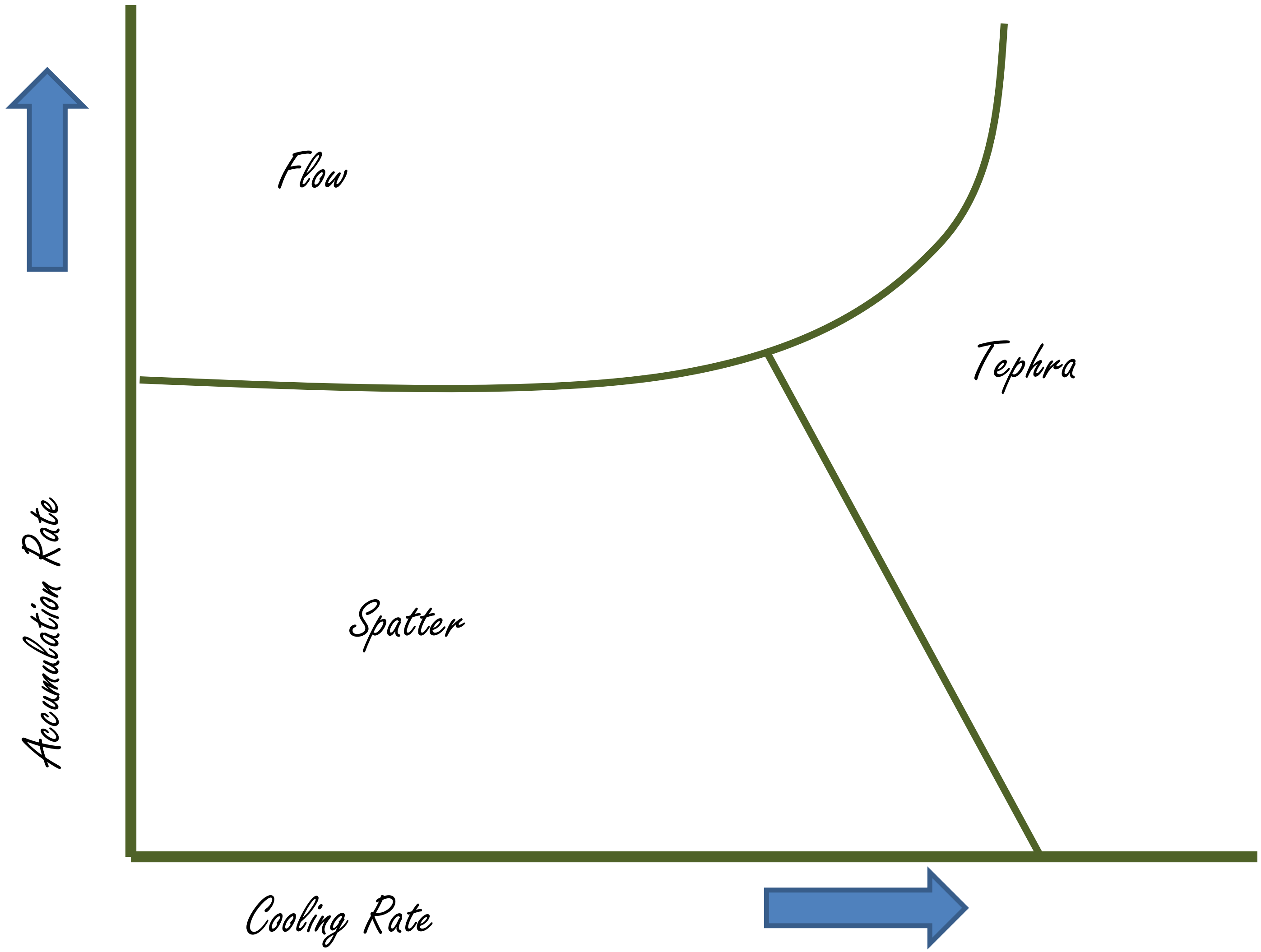
Classification of basaltic eruptive products

Accumulation Rate

Cooling Rate

Classification of basaltic eruptive products

If we can put numbers on this diagram, can we constrain eruptive rates?



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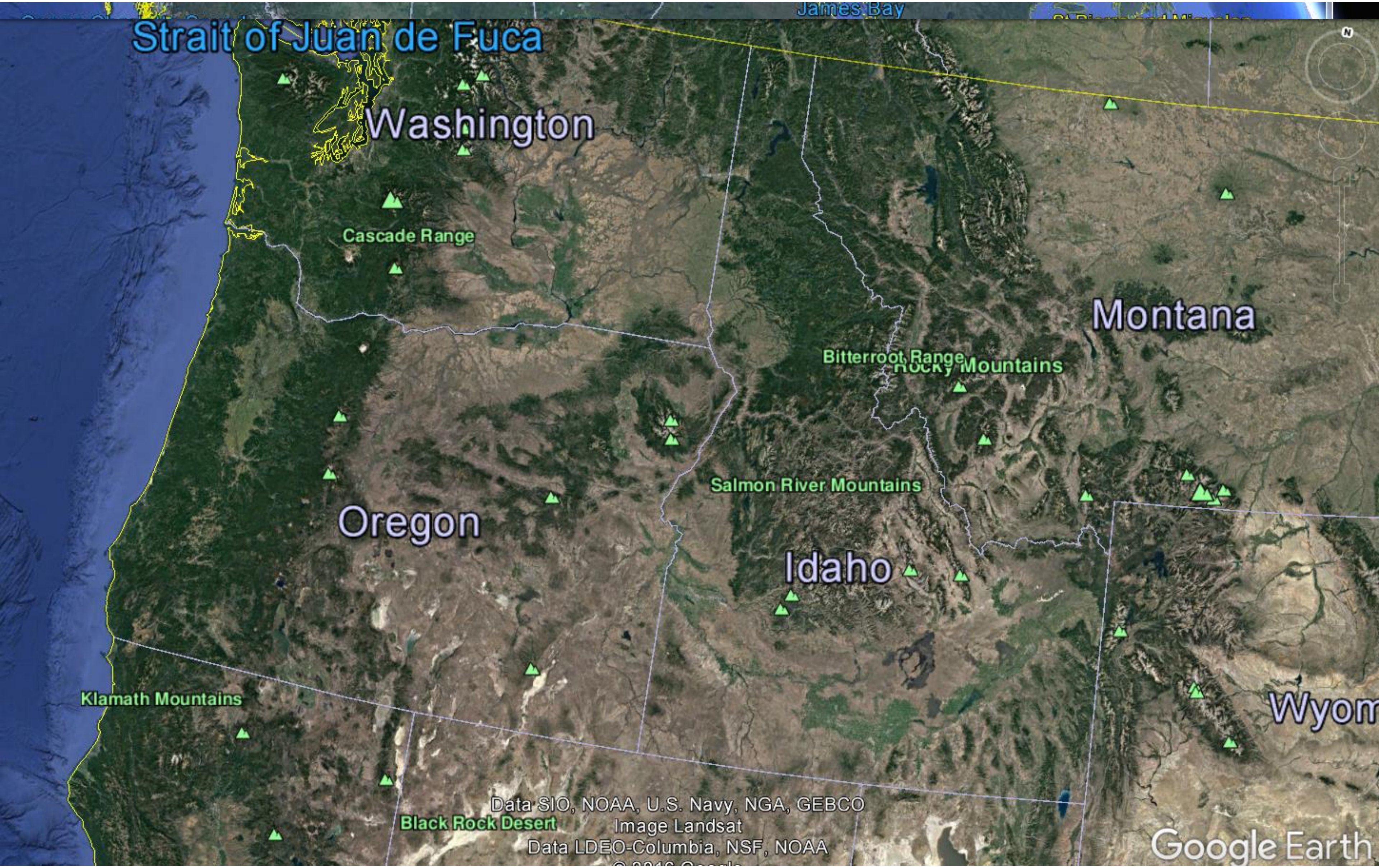
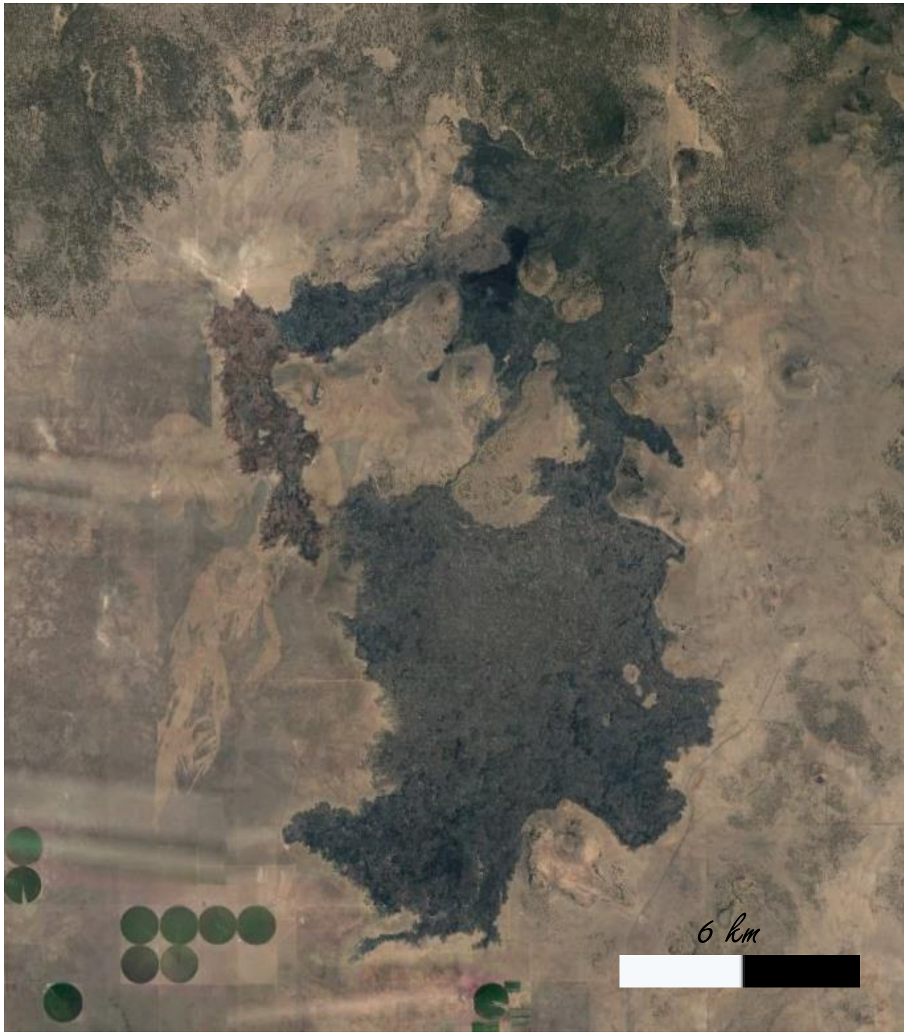
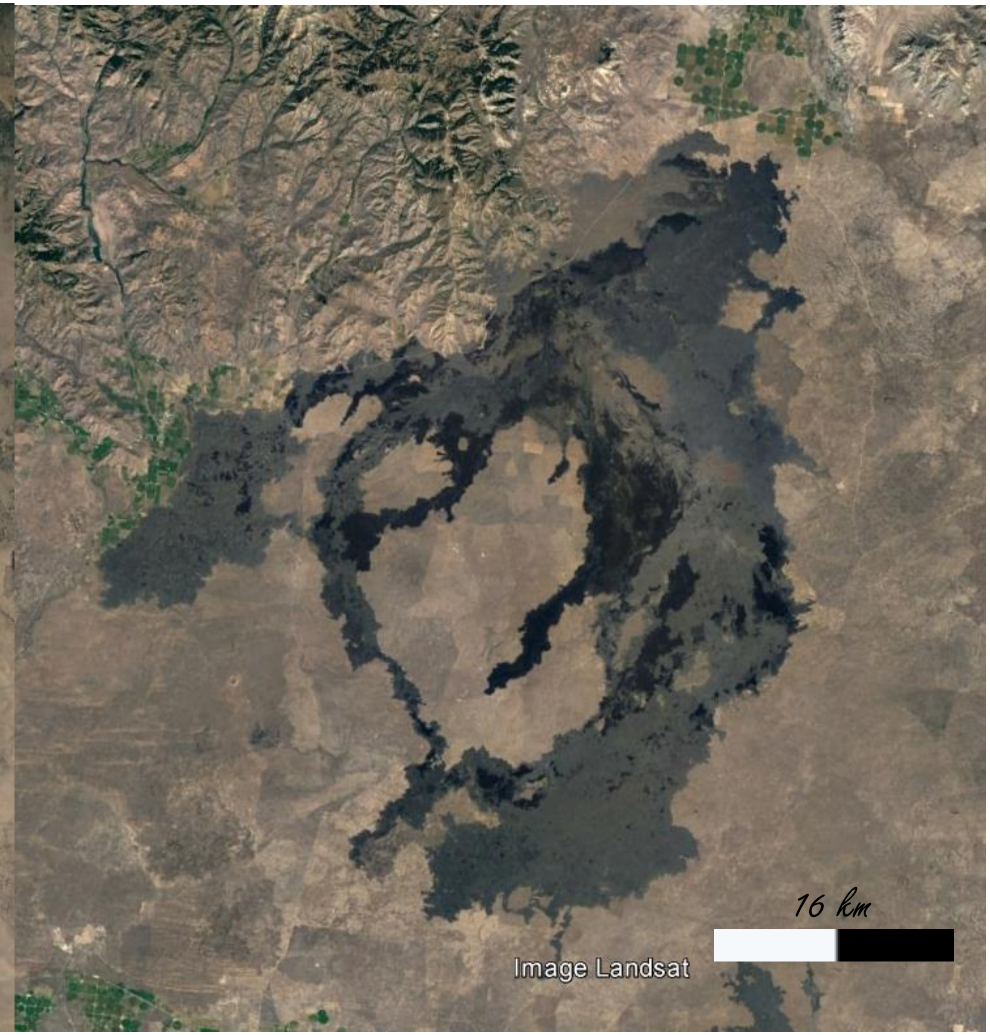
Location of field work



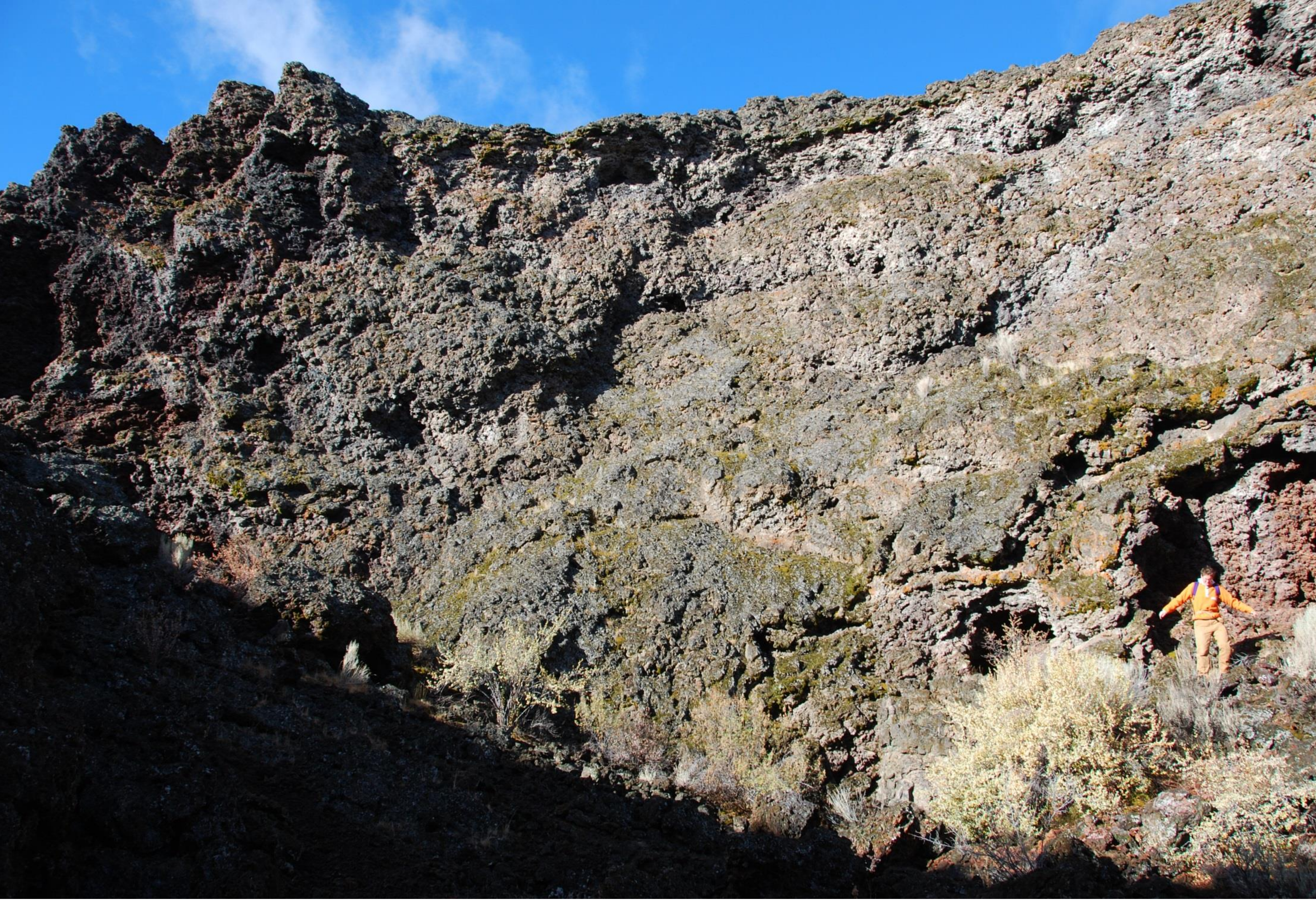
Location of field work



Devil's Garden, OR



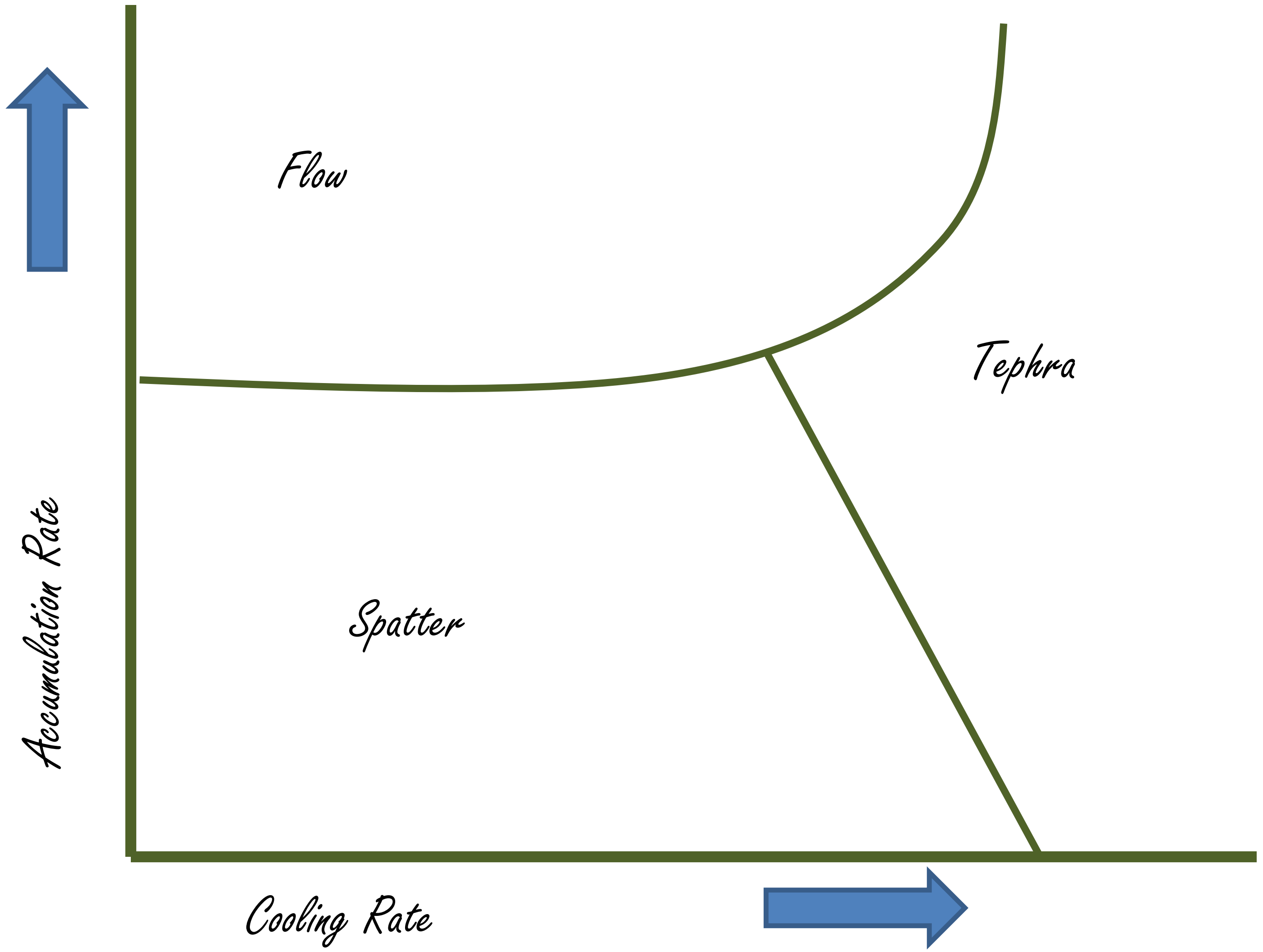
Craters of the Moon, ID



Realistic rates?

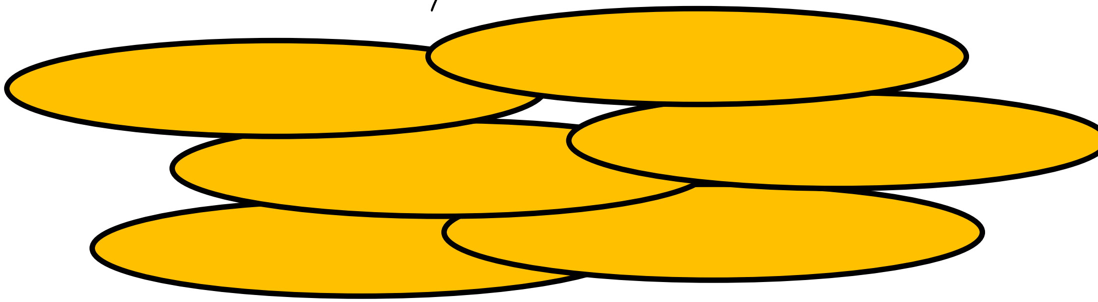
Artificial spatter pile

Controlled cube experiments suggests we can find the boundary between spatter and tephra



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

Hotter deposit

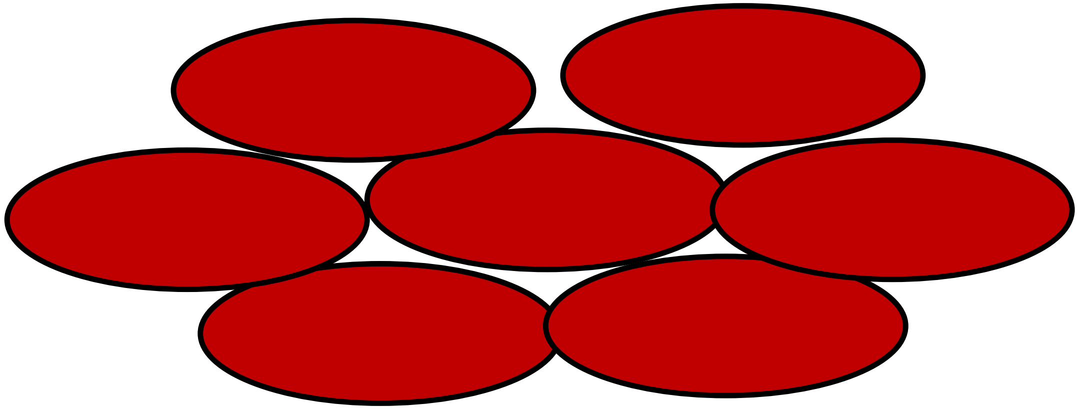


More connections

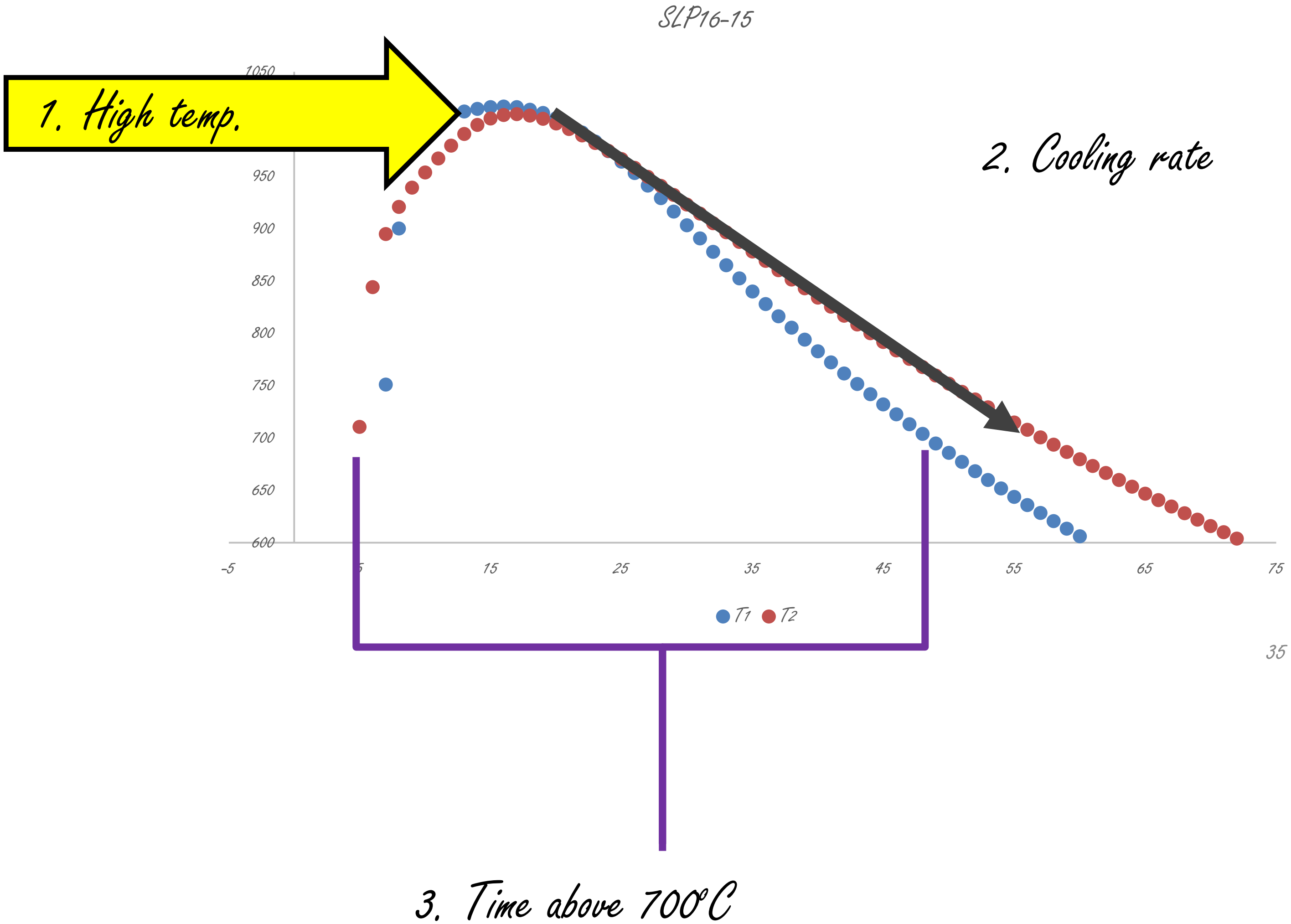
More squashed clasts (lower w/l ratio)

Less void space

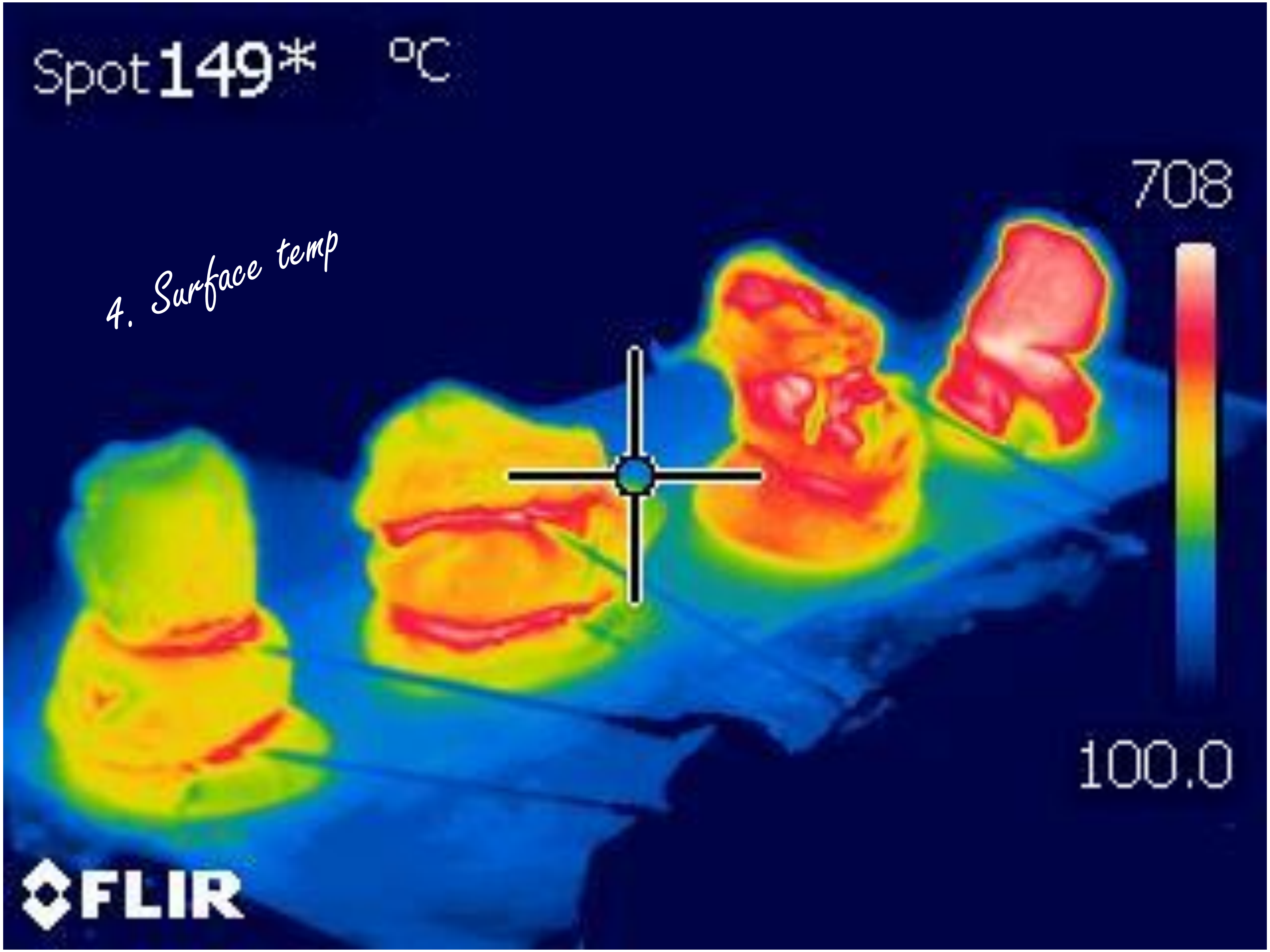
Cooler deposit

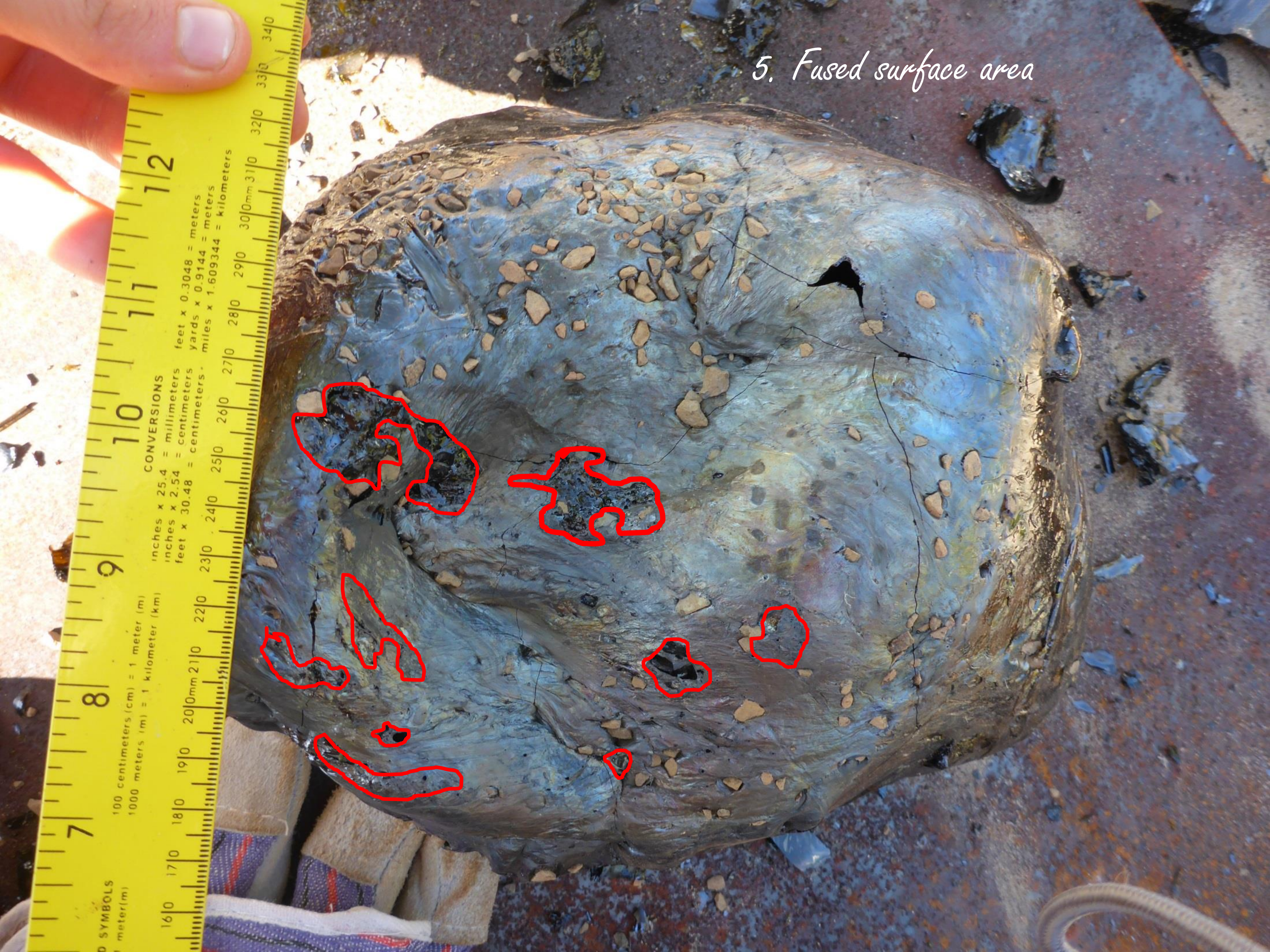


Data Collection



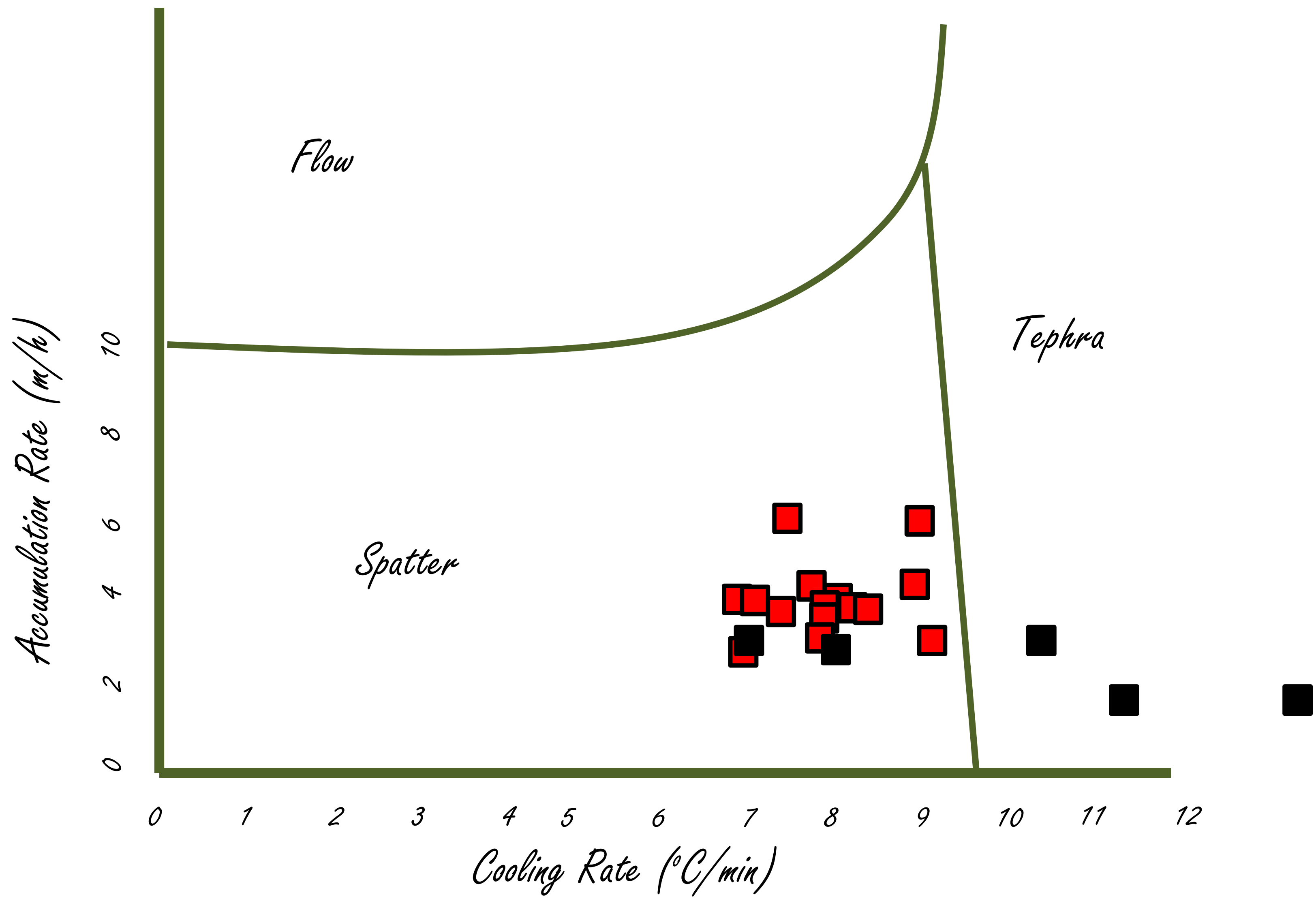
Data Collection



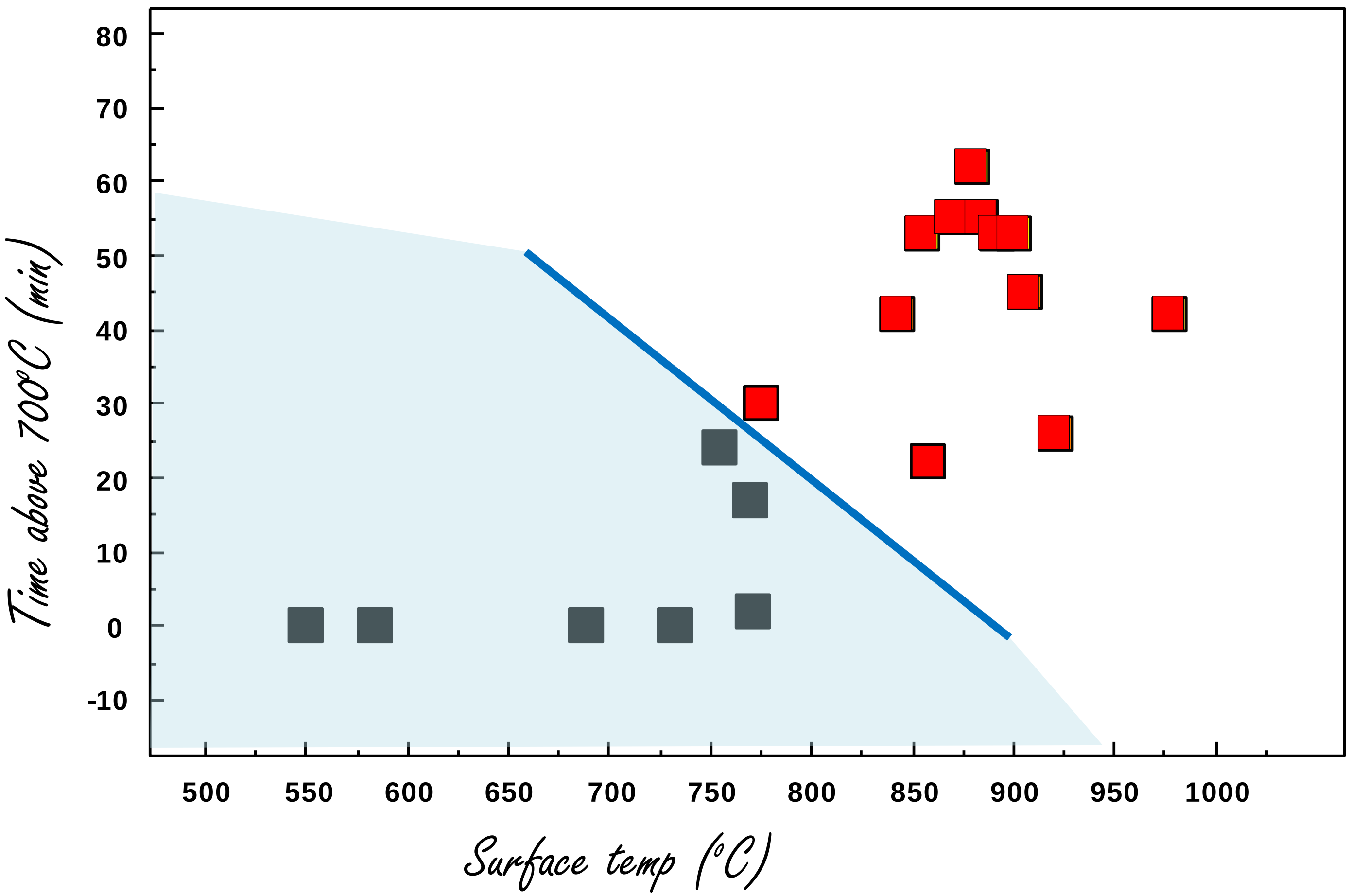

5. Fused surface area


To read length in centimeters, omit the final zero after the
index line. To read length in millimeters, include the final zero
1000 millimeters

Fused and unfused spatter



Minimum conditions for welding



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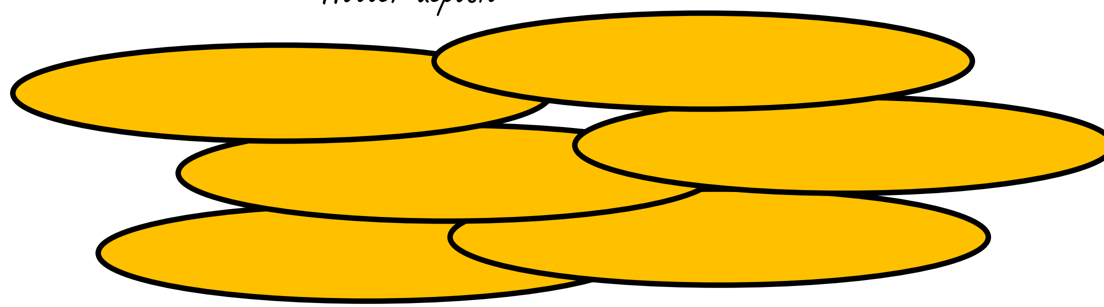
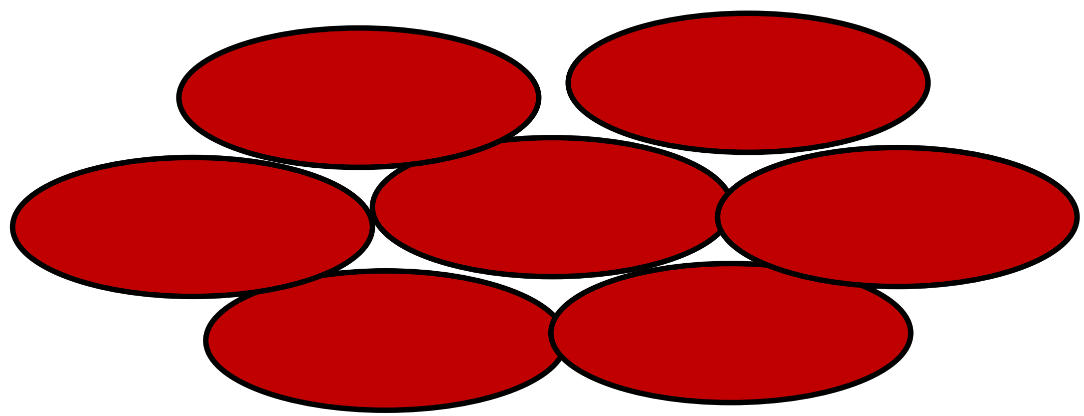


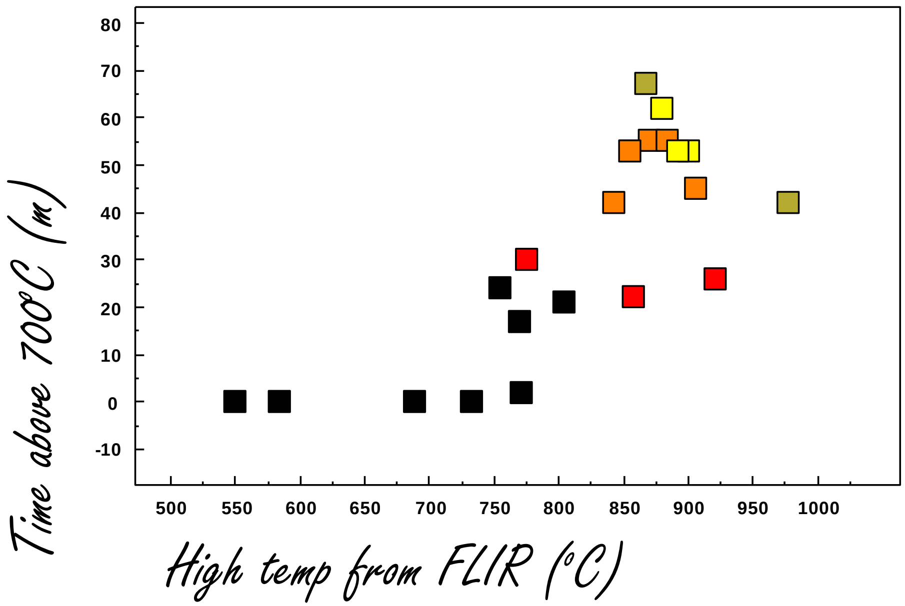
More connections

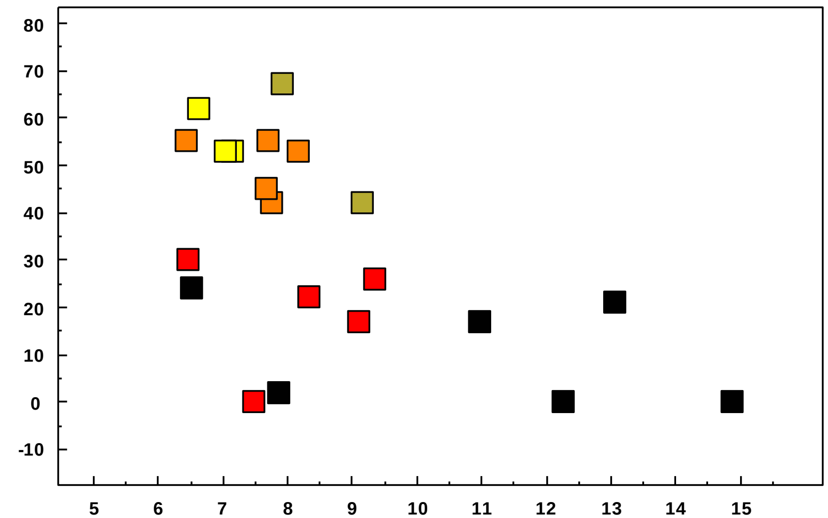
More squashed clasts (lower w/l ratio)

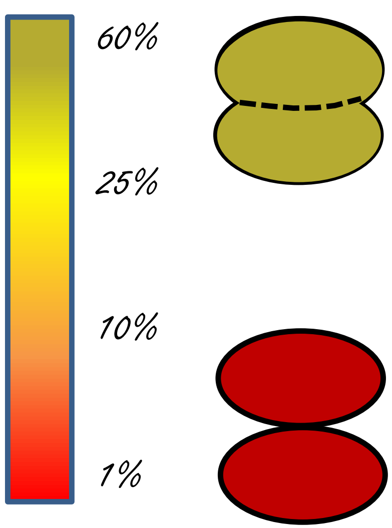
Less void space

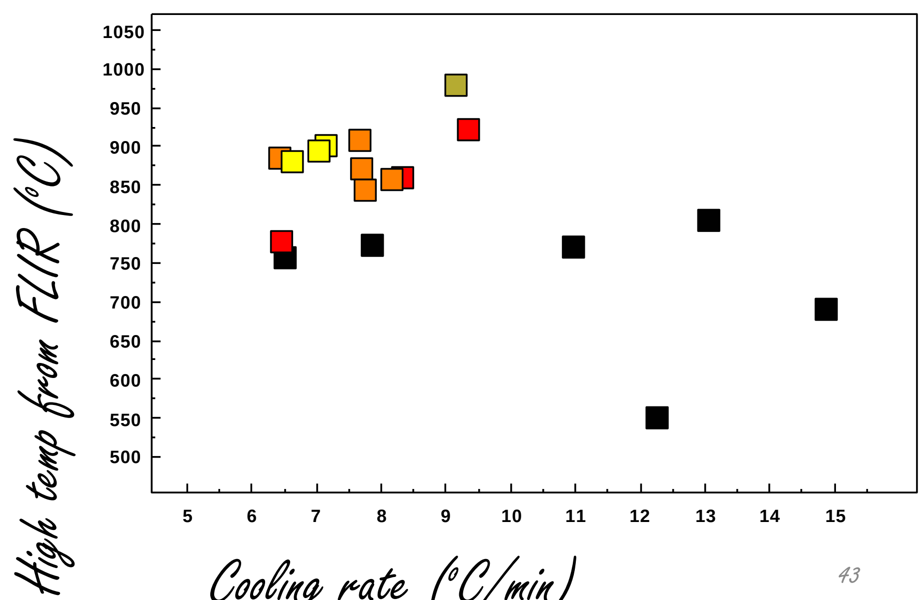


More connection: *Amount of fusion between clasts is dependent on starting temp and time above 700°C.*

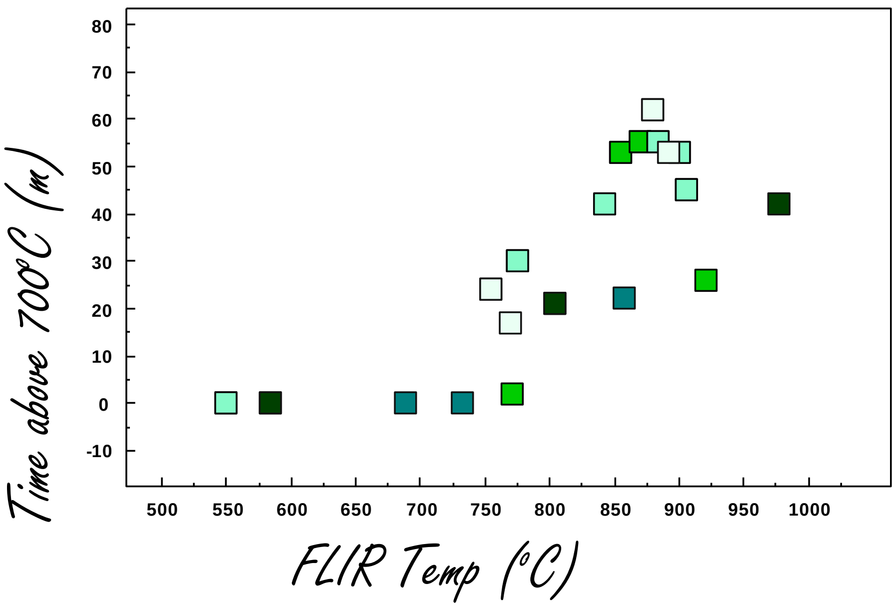


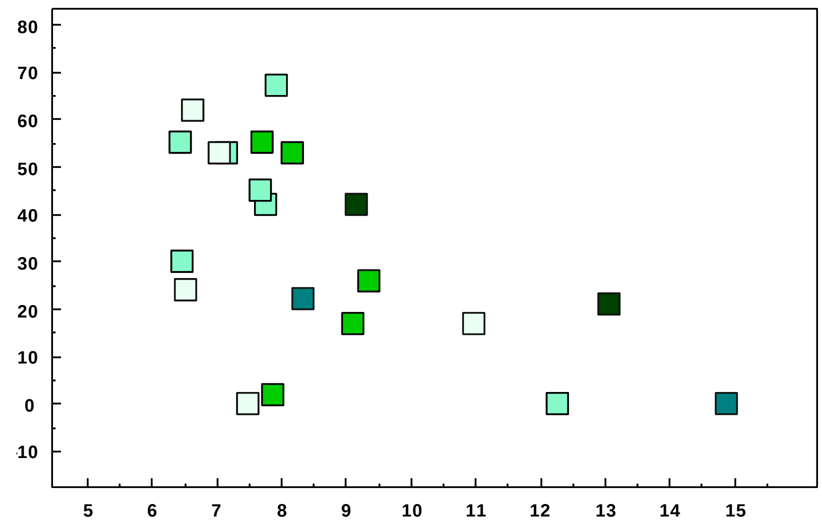


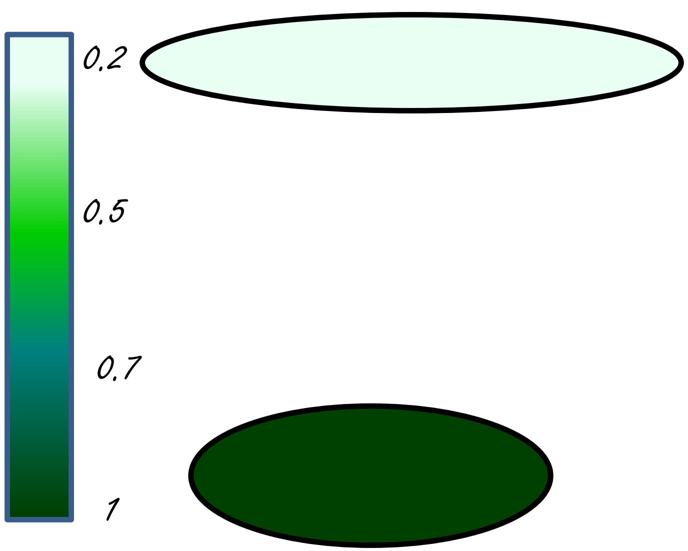


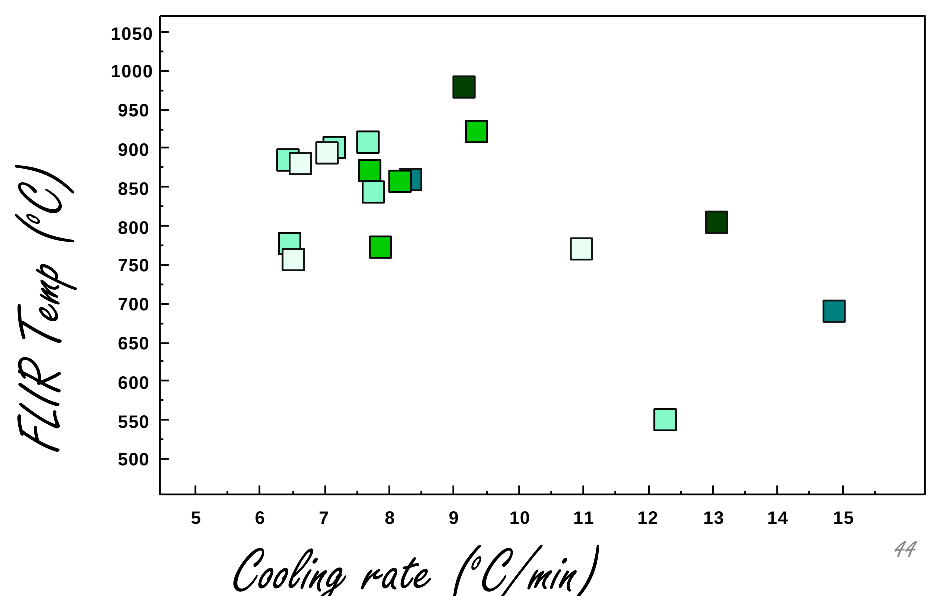


Squashed clasts: Temperature, time, and cooling rate are weakly correlated. Though can be overruled by shaping during flight.

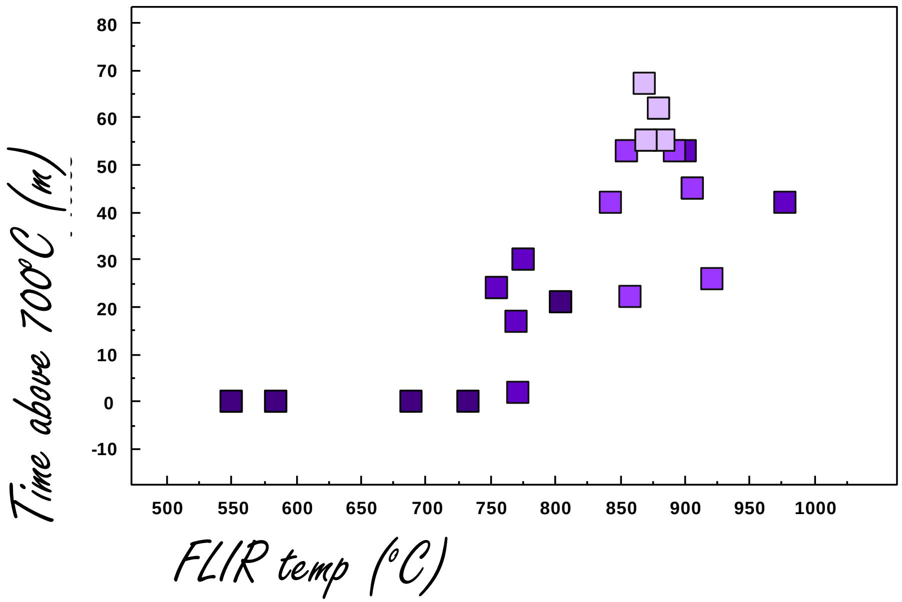


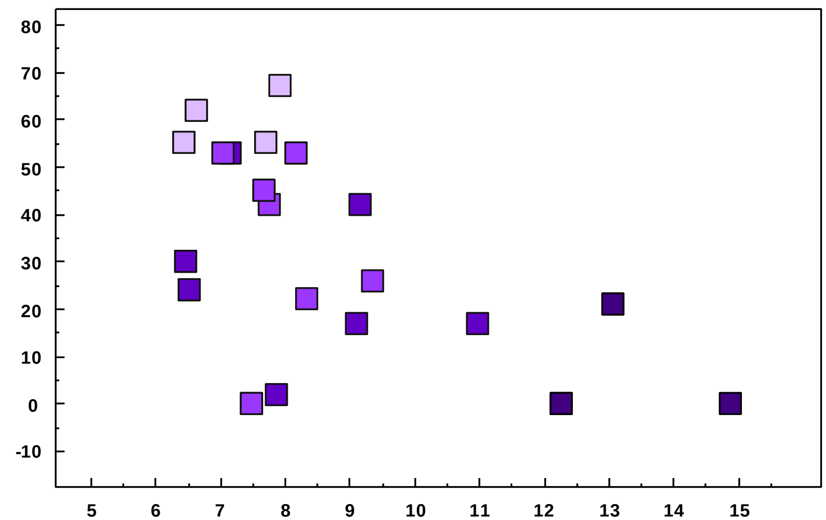


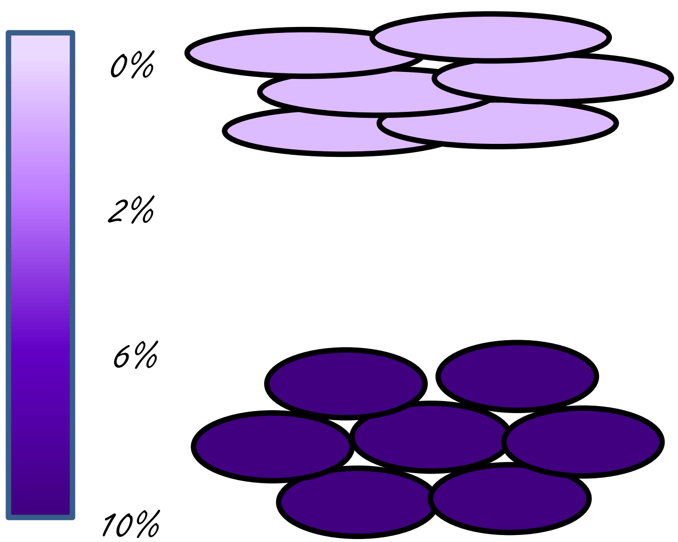


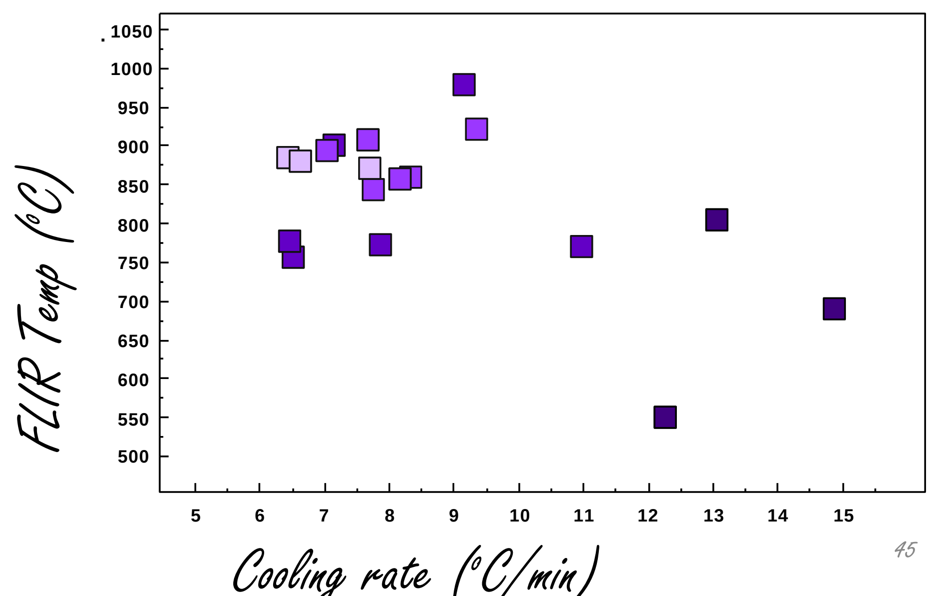


Void space: *Well correlated with time and temperature. High heat = less void space.*

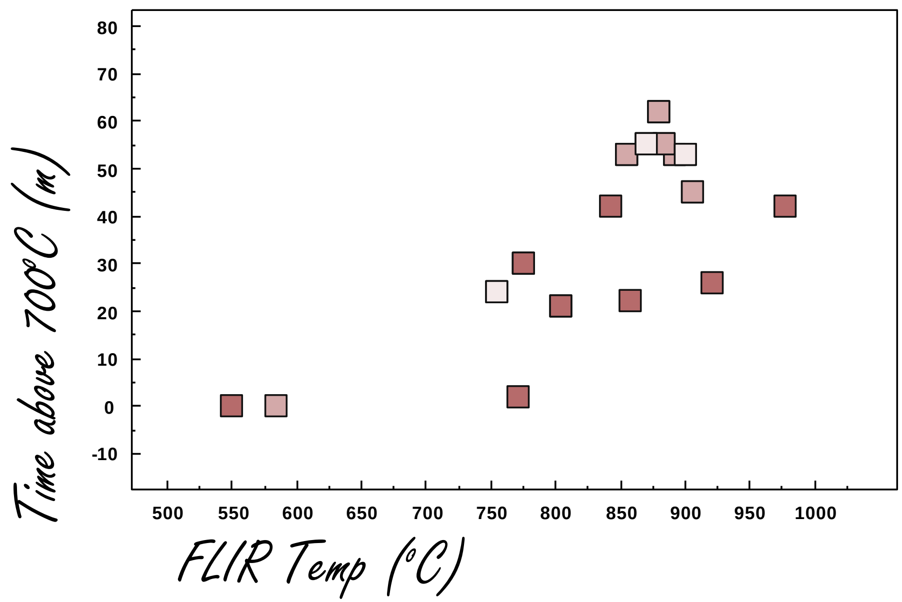


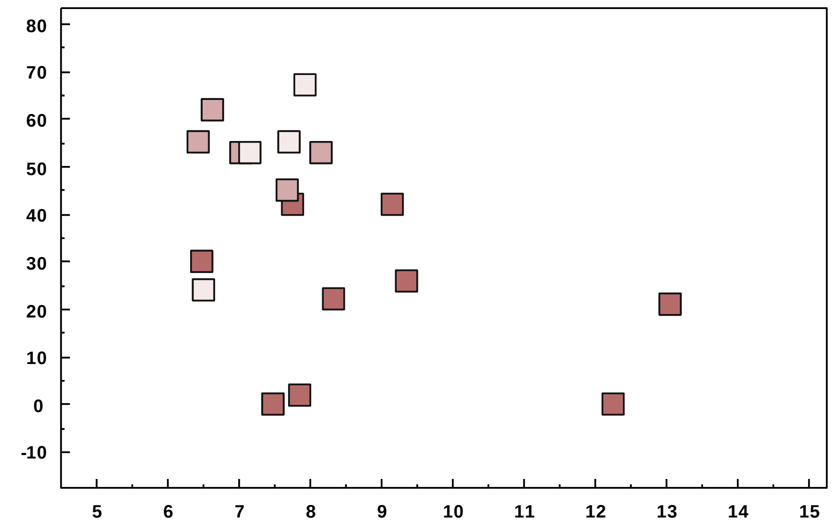


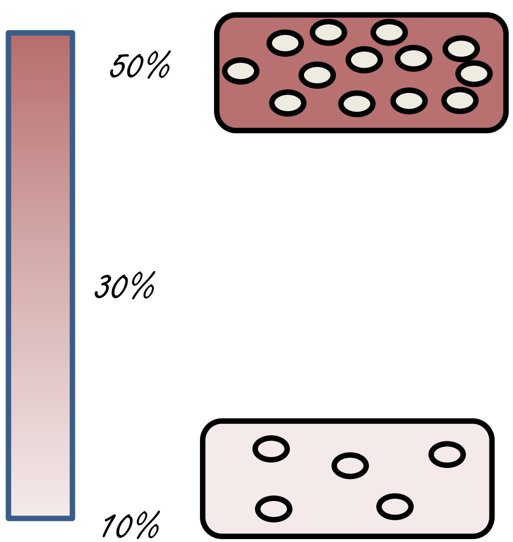


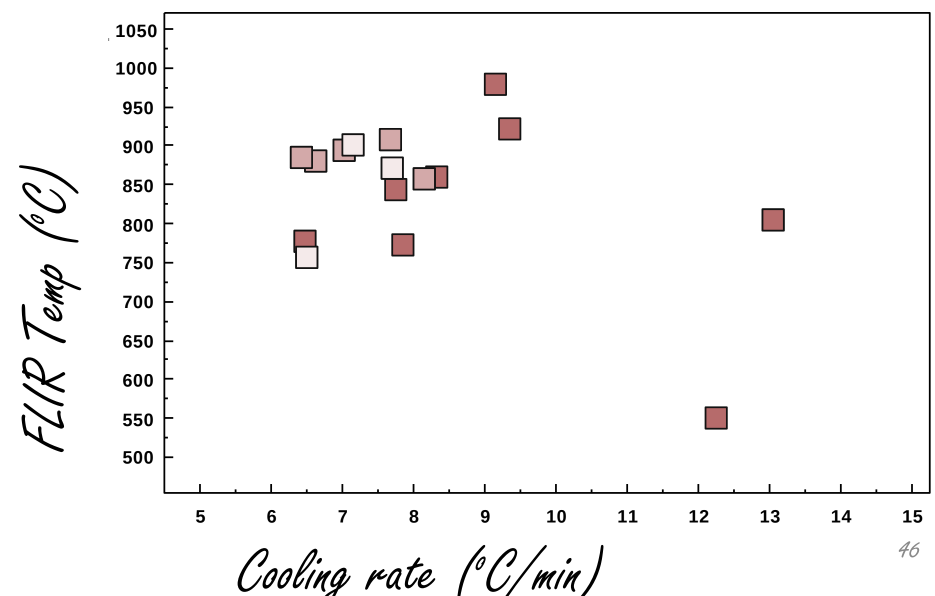


Vesicle mode: More vesicular at faster cooling rates, lower temp…. with caveats due to clast manipulation

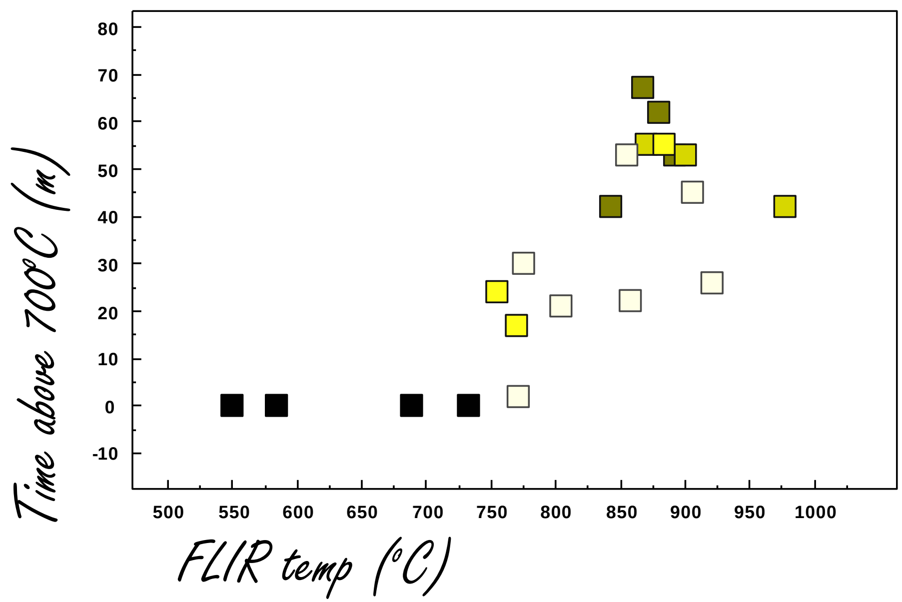


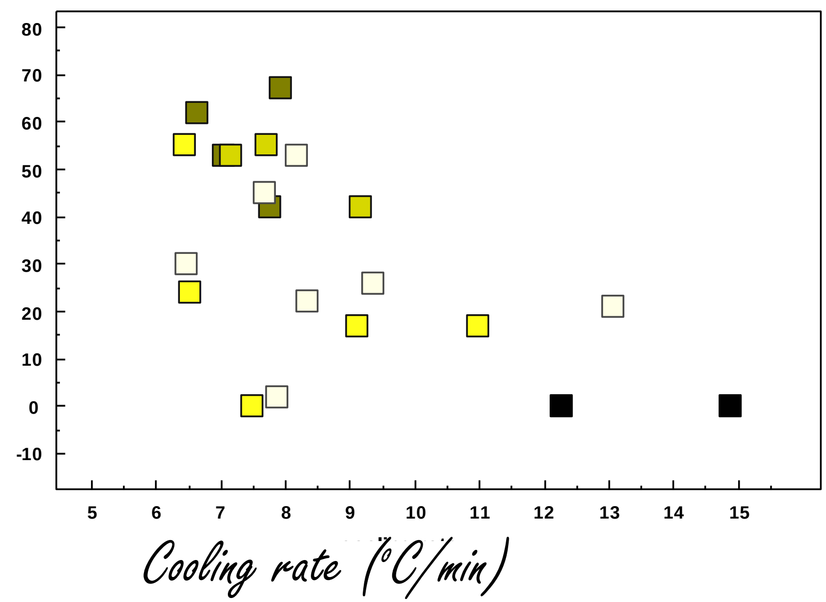


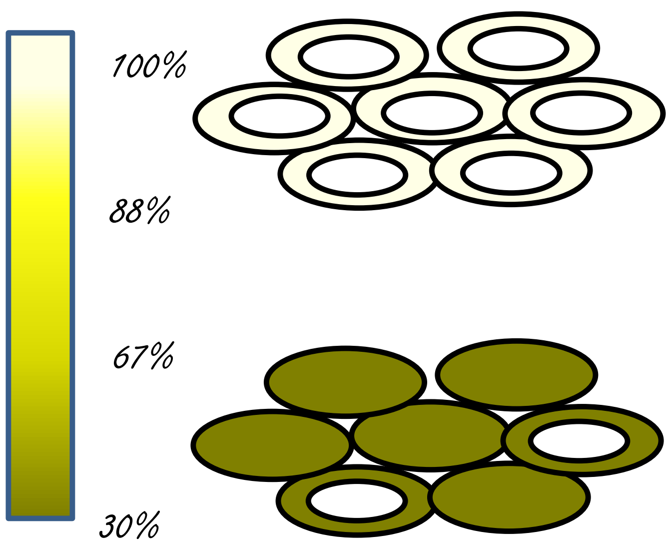


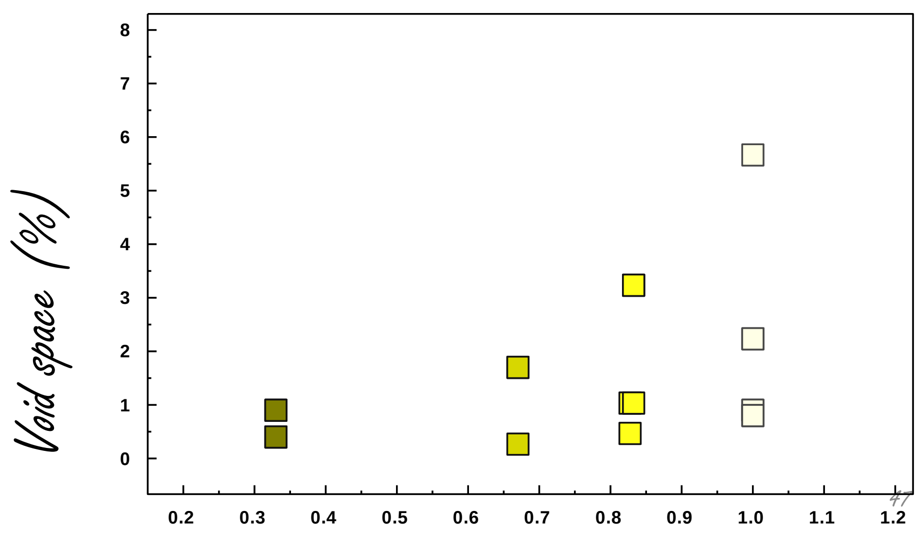


Central cavity in clast: Found more often in cooler clasts or clasts that cooled quickly.









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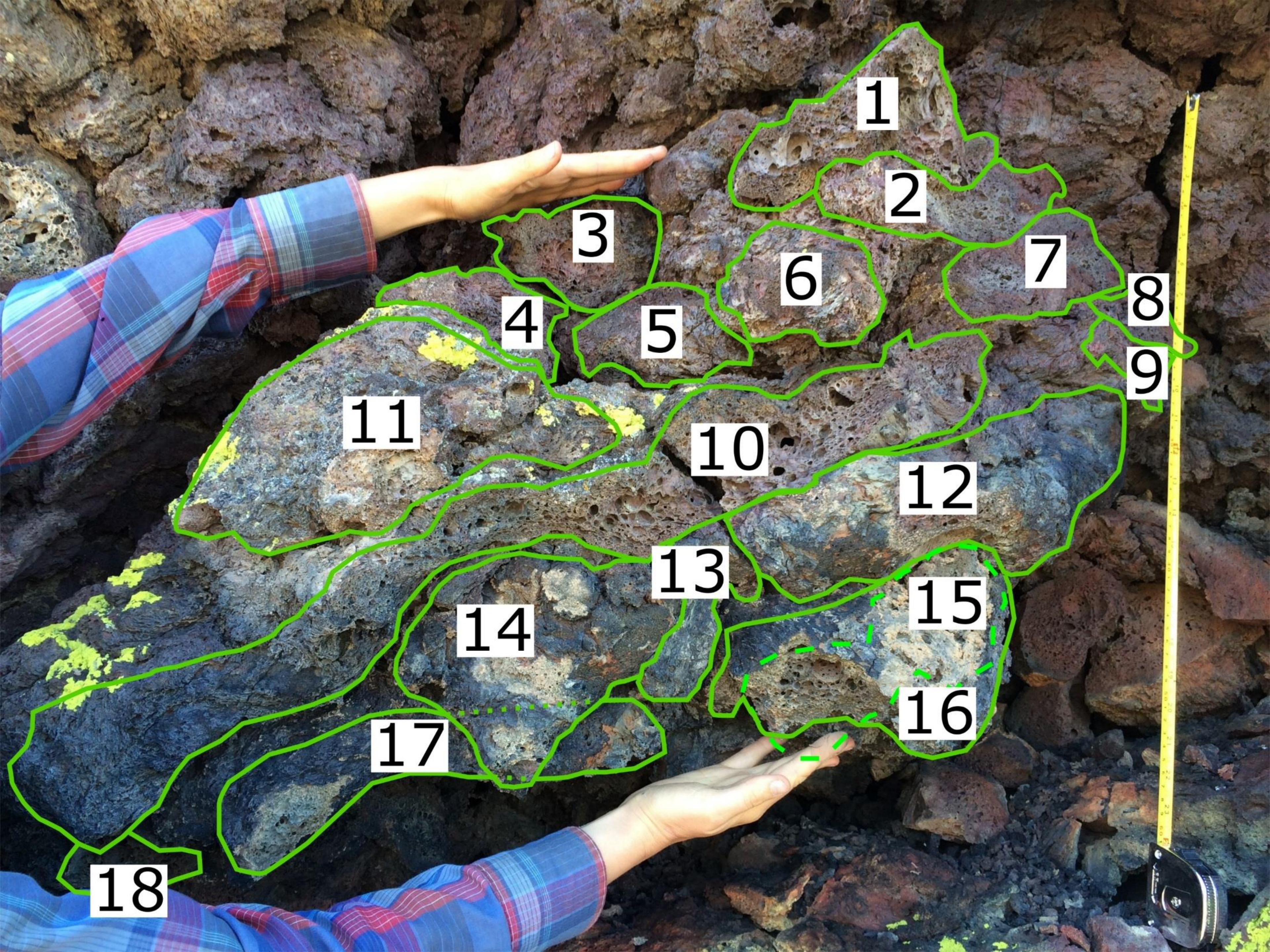
1
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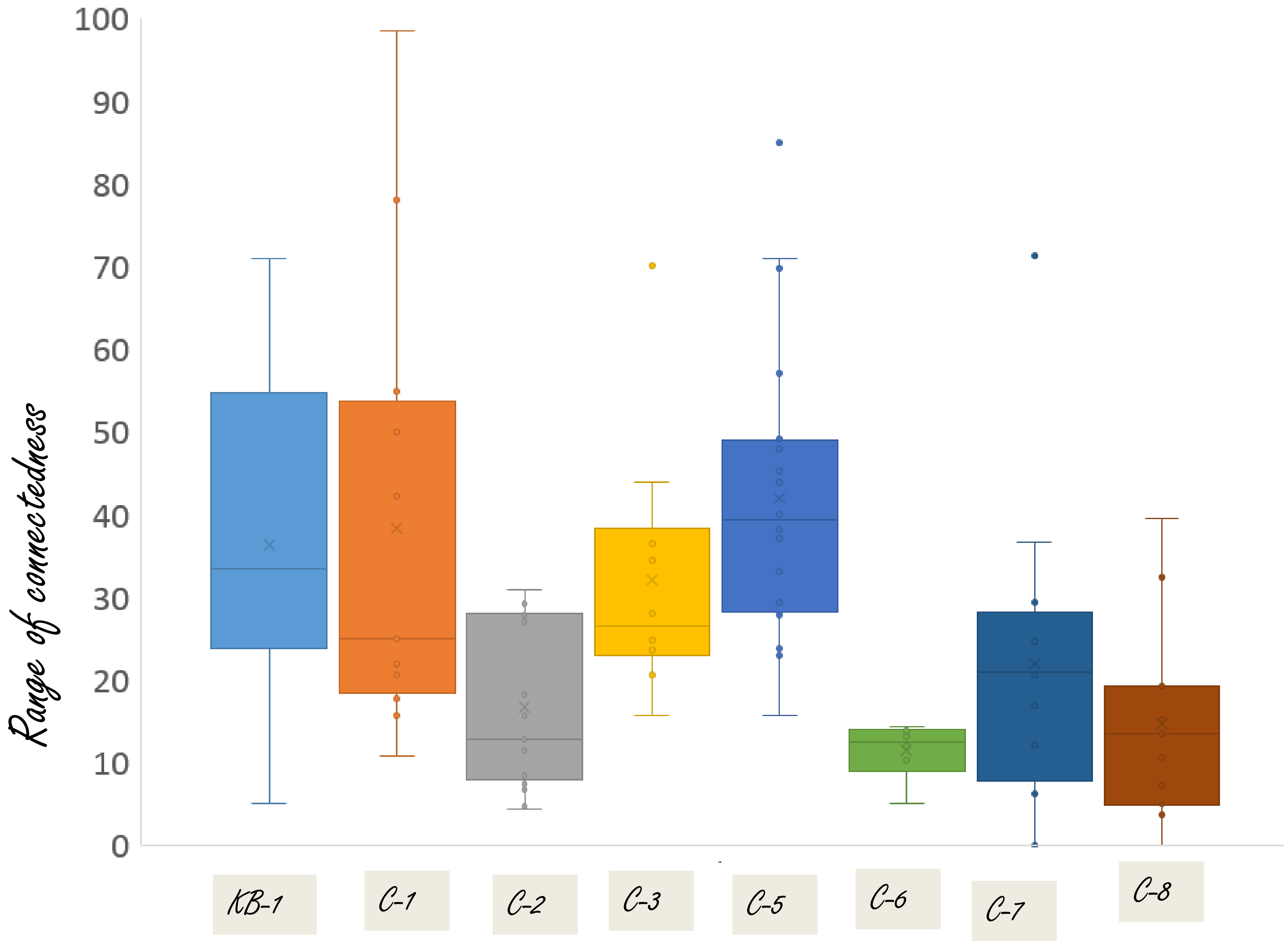
100
90
80
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50
40
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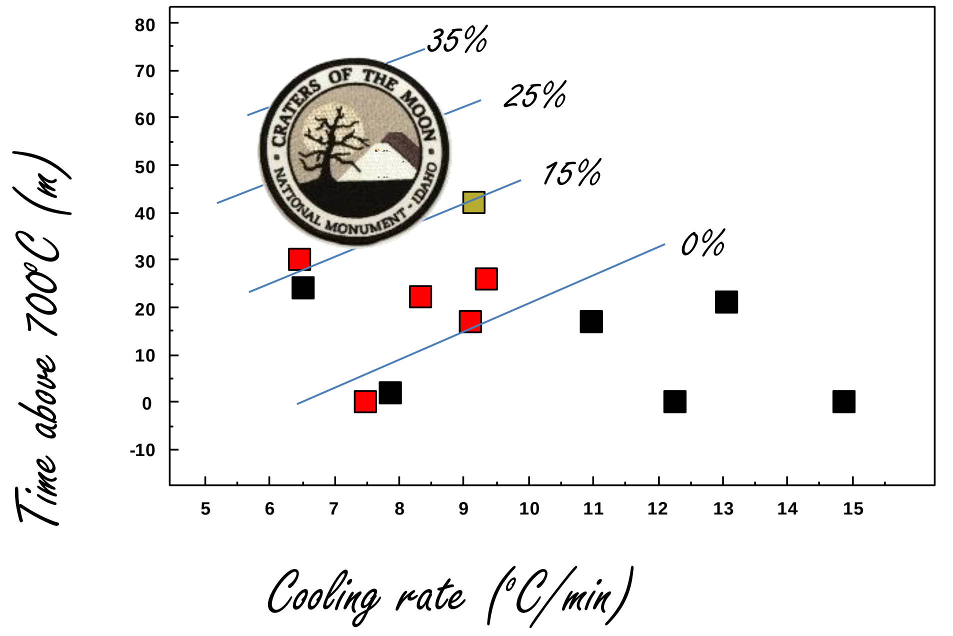
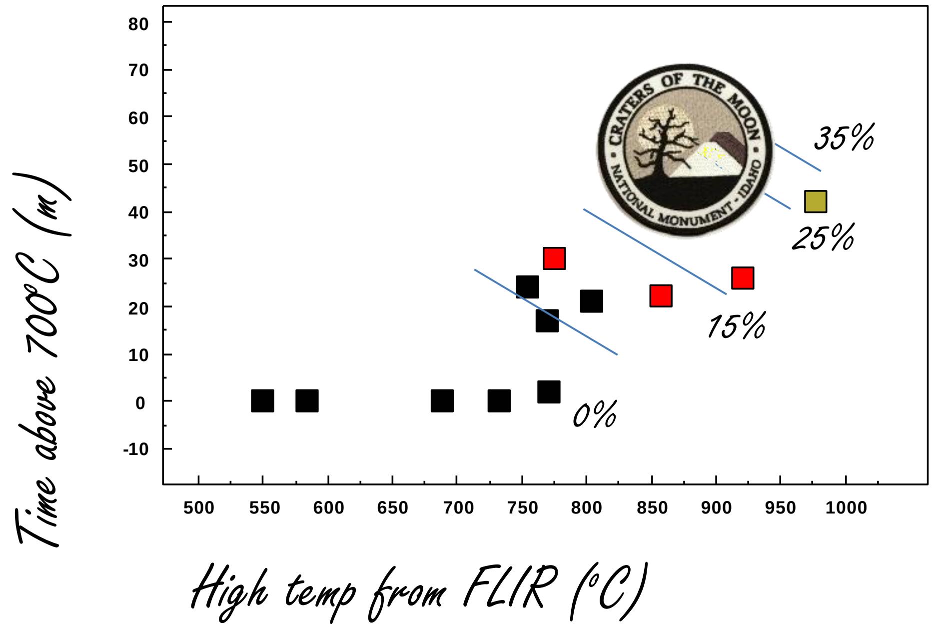
0
Range of connectedness
KB-1
C-1
C-2
C-3
C-5
C-6
C-7
C-8

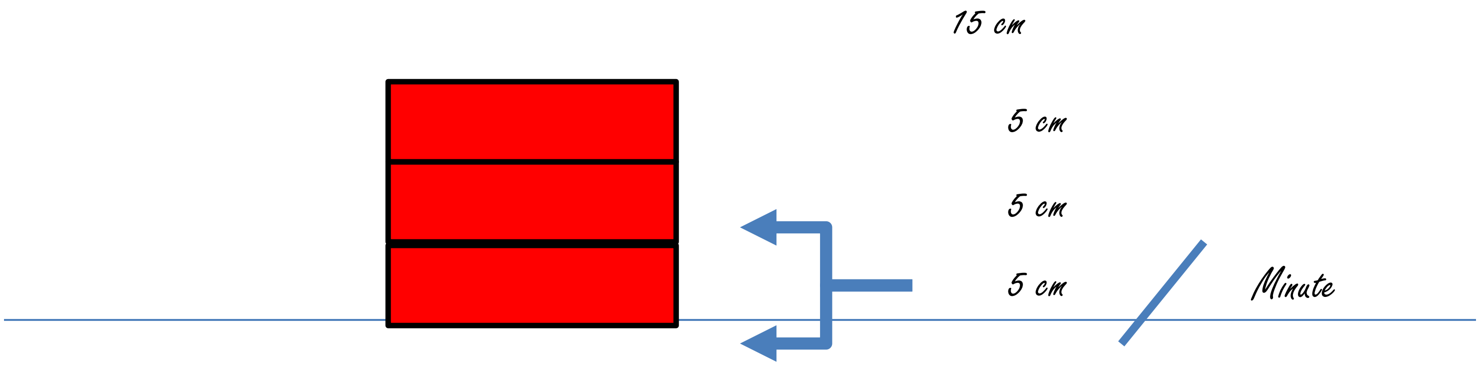


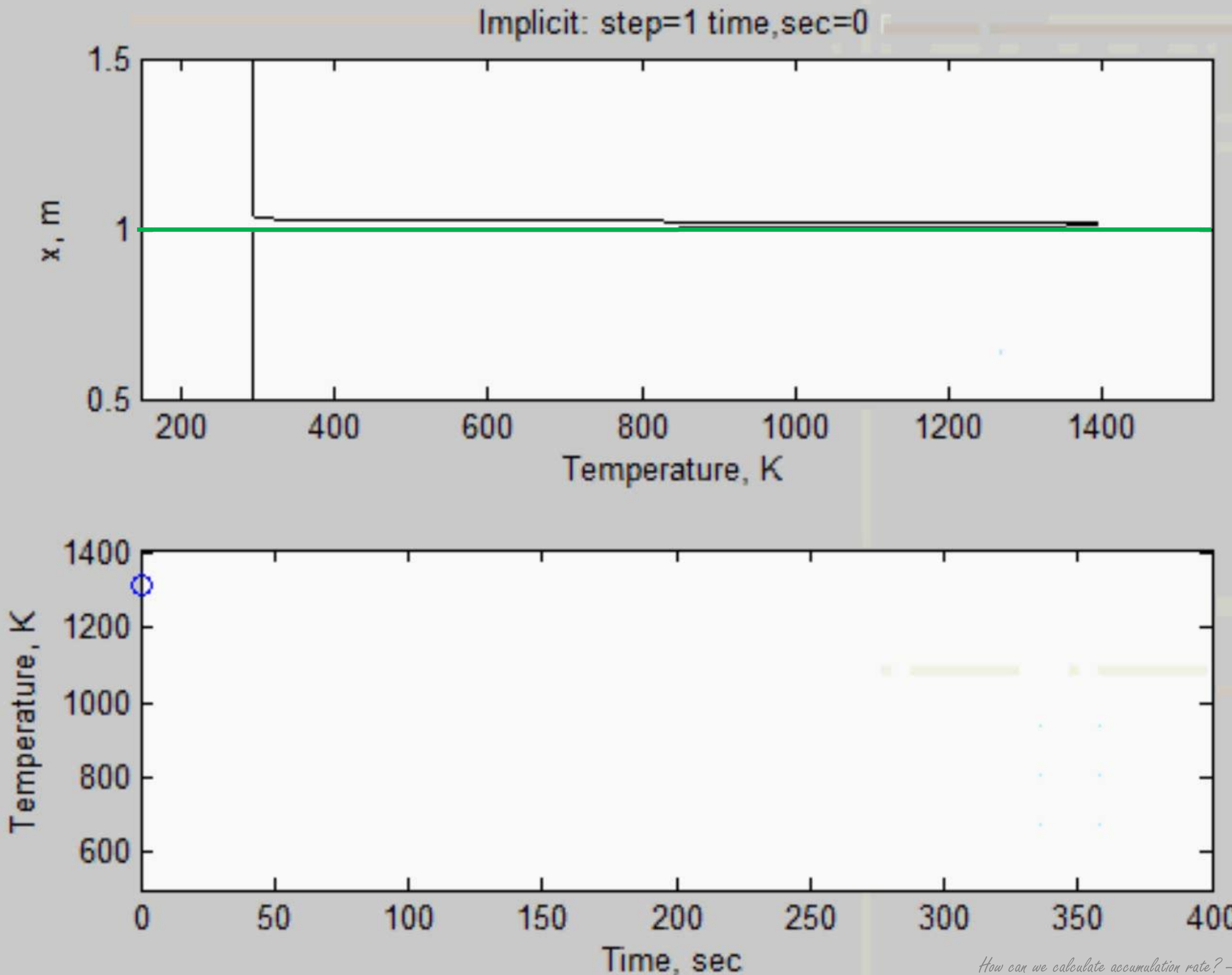
	Craters of the Moon spatter
Cooling rate	6-9°C/min
Time above 700°C	35 to 70 min
Landing temperature	
Accumulation rate	
Time to build cone	



	Craters of the Moon spatter
Cooling rate	6-9°C/min
Time above 700°C	35 to 70 min
Landing temperature	800-950°C
Accumulation rate	
Time to build cone	

Numerical model to examine thermal history of deposit




Implicit: step=1 time,sec=0
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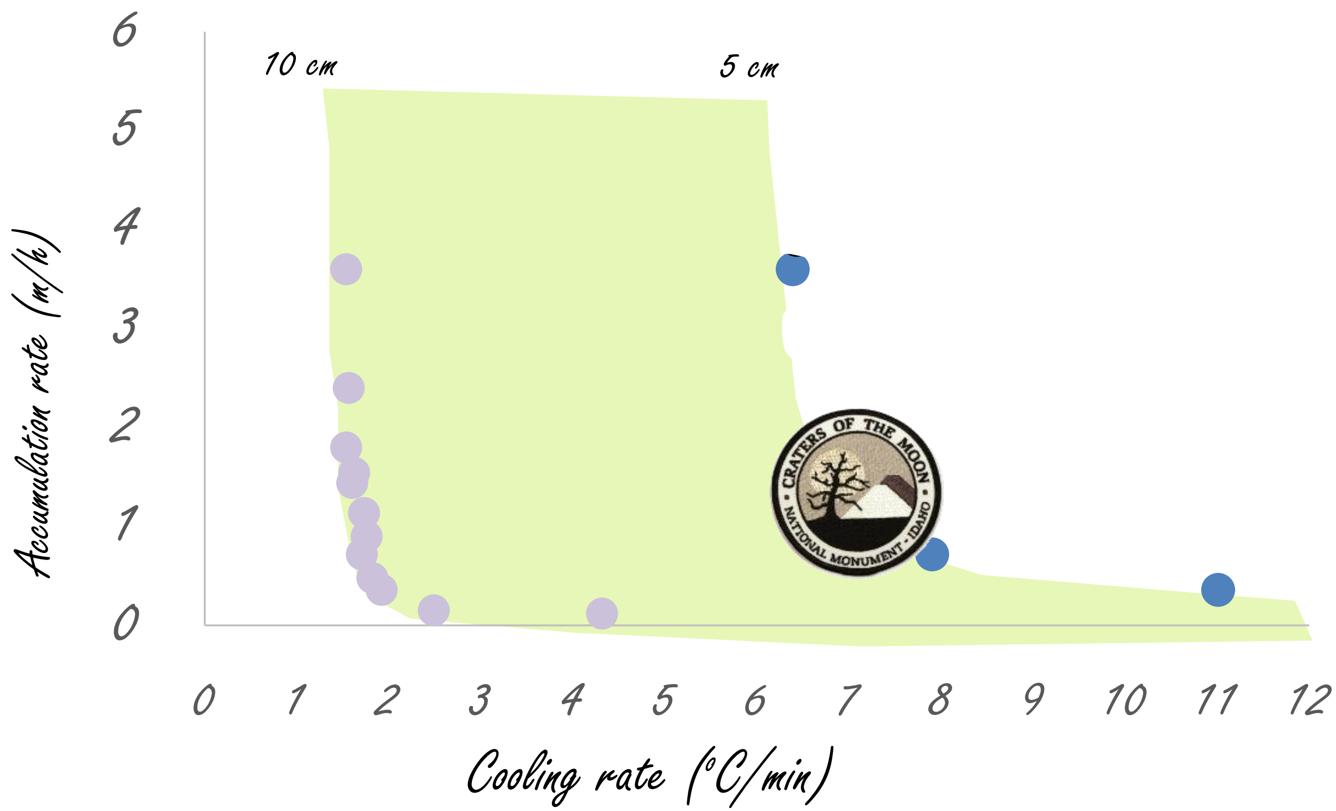
Time, sec



	Craters of the Moon spatter
Cooling rate	6-9°C/min
Time above 700°C	35 to 70 min
Landing temperature	800-950°C
Accumulation rate	0.5-2 m/h
Time to build cone	

30 meters high = betwee

COTM - 0.5-2 m/h.

Artist's rendering of LRO spacecraft.
Credits: NASA

Marius Hills/Domes 2007.12.21.

21:51UT Seeing: 5-7/10 Transp: 7/10, Location: 51:53:13n, 08:45:23e
Celestron C9.25XLT, TeleVue 2.5x Powermate, Astronomik Red Type II, ImagingSource DMK21AF04.AS @30fp
882 frames used, 11 point auto MAP processing

Application to planetary science

LAWRENCE ET AL.: MARIUS HILLS CONES AND LAVA FLOWS

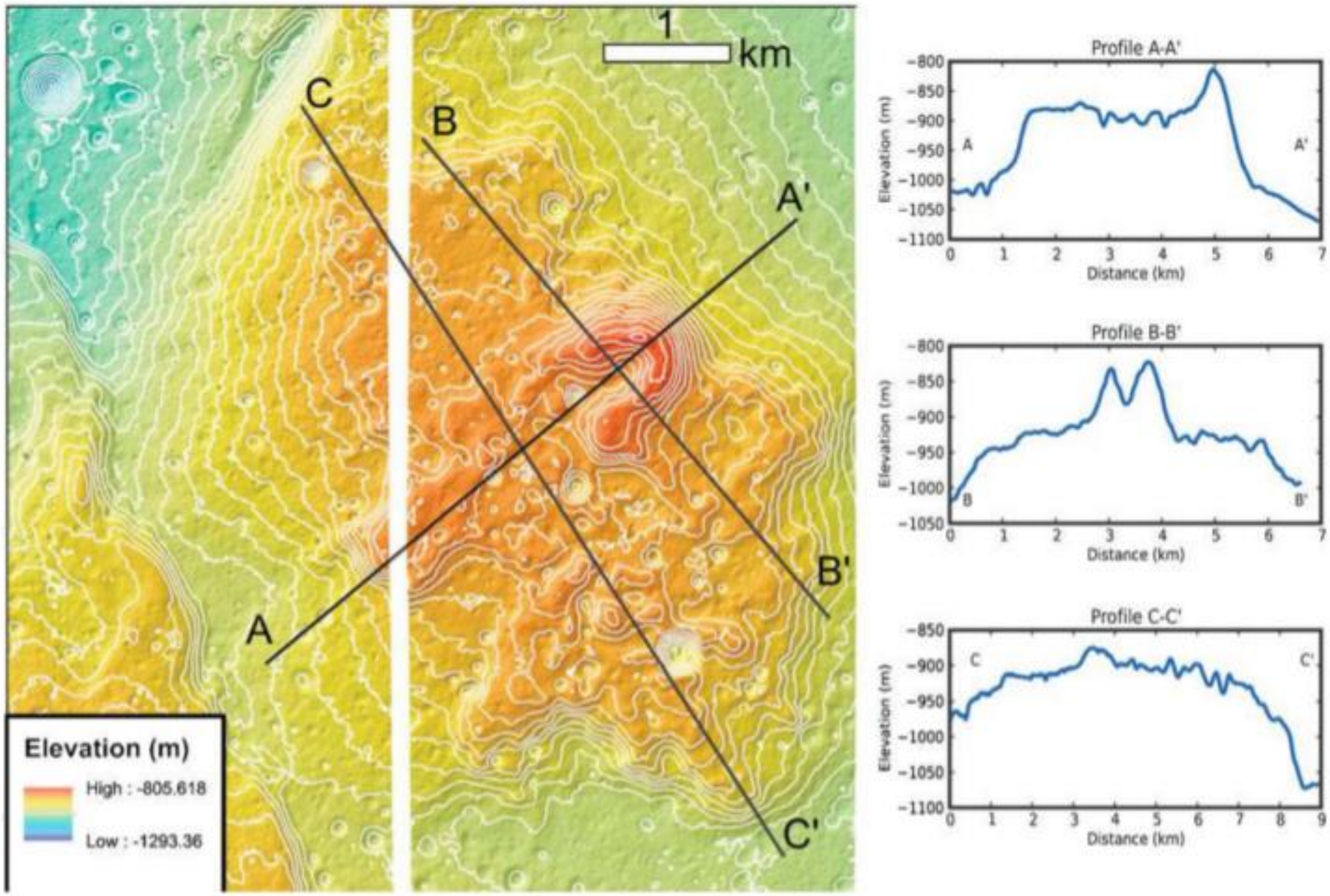
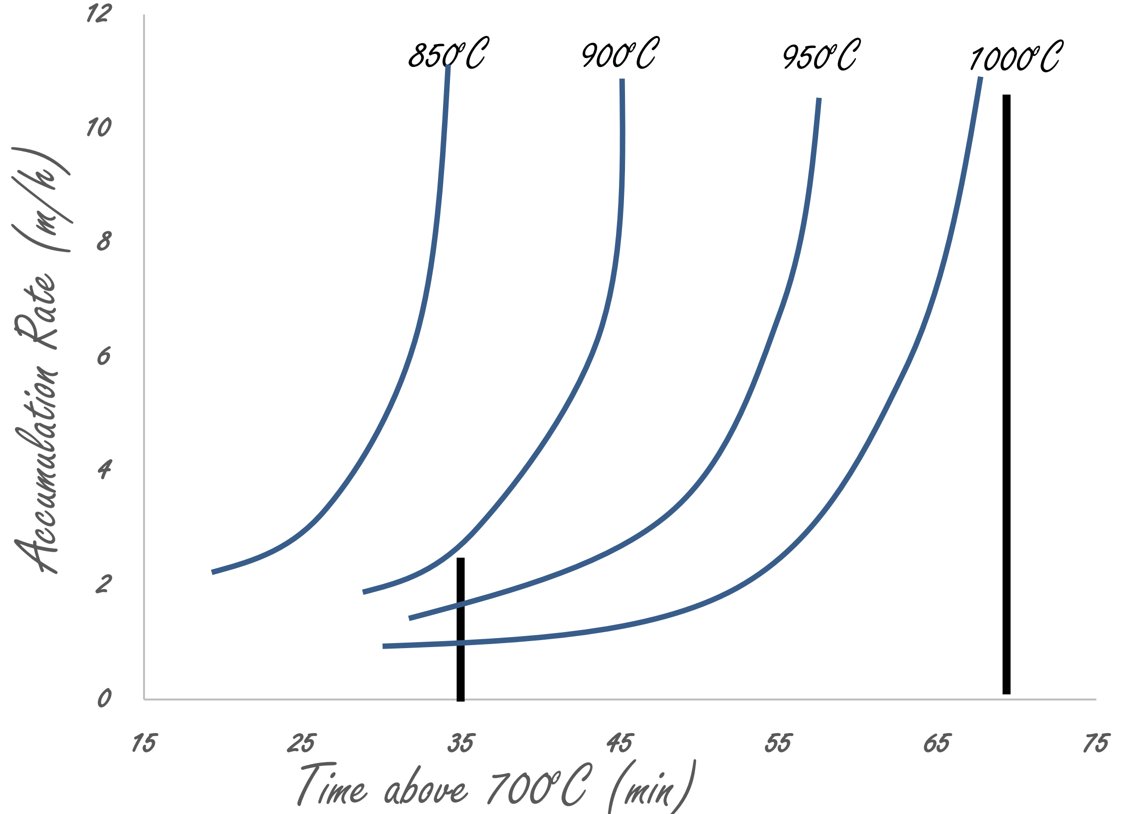


Figure 3. Digital Elevation Model (5 m contour intervals) derived from LROC NAC images of a volcanic dome with cone in the Marius Hills near the Constellation Program Region of Interest. Representative profiles across the lava flows are reproduced on the right.



	Craters of the Moon spatter	Moon spatter
Cooling rate	6-9°C/min	~4°C/min
Time above 700°C	35 to 70 min	
Landing temperature	800-950°C	or 1000°C
Accumulation rate	0.5-2 m/h	1-10 m/h
Time to build cone	15-60 h	10-100 h

Grand Conclusions

1. By combining field observations, analytical experiments, and numerical modeling we have shown the boundary between explosive basaltic morphologies (cinder/spatter) can be quantified.

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4. Lunar thermal regimes result is slower cooling, requiring slower accumulation rates, resulting in extended duration of deposition for the Marius Hills.

Thanks and Questions