Lunar surface dating with *Craterstats-III:* instant workshop

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Background

Craterstats is a software tool to analyse and plot crater count data for lunar and planetary surface dating. It has evolved through several iterations since 2007, and the current one, Craterstats-III, was initiated with the support of the US Geological Survey with the intention to make it available as a long-term resource for planetary scientists, independent of proprietary software.

This poster provides a quick introduction to the tool, both for new users and for people working with the previous Craterstats-II, showing some of the changes in usage, improvements in output, and new features.

Installation

1. Install the Miniforge3 Python environment manager for your OS (see craterstats github page for link)

2. Launch the Miniforge prompt (Windows) or command prompt (MacOS, Linux) and enter the following to create a Python environment for craterstats:

```
conda create -n craterstats python=3.12
```

3. Activate this environment:

```
conda activate craterstats
```

4. Install the craterstats package:

```
pip install craterstats
```

Crater counts

The raw data for a crater dating analysis is a list of measured crater diameters together with the area they were counted on. Some analyses also need a digitization of the count area boundary and a measure of the boundary perimeter. OpenCraterTools [1] covers all these requirements in QGIS, but data from other sources can also be used.

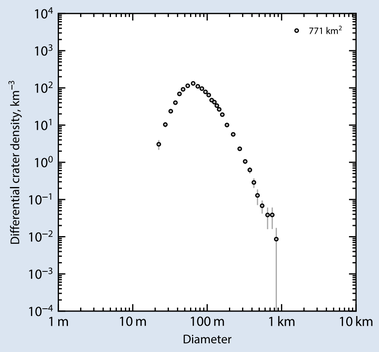
area1.diam

```
area = 771.368
crater = {diameter
0.713898
0.553604
0.41967
0.40932
0.392591
...}
```

Data plot

Craterstats-III is a command-line program. The simplest command is just to plot some data:

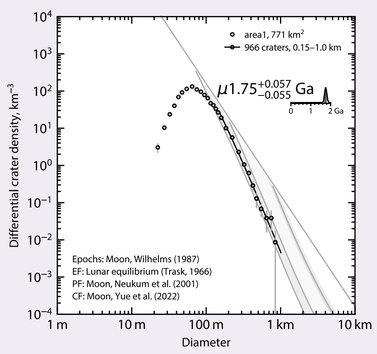
```
craterstats -p source=area1.diam
```



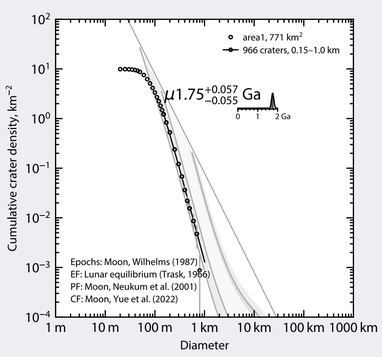
Age estimate

A model age estimate is made by specifying a chronology model, and providing a diameter range and calculation type (Poisson, buffered-Poisson, differential-fit, cumulative-fit):

```
craterstats -cs yue22 -ep wilhelms -ef trask
-p source=area1.diam
-p type=poisson,range=[.15,1.]
```



-pr differential

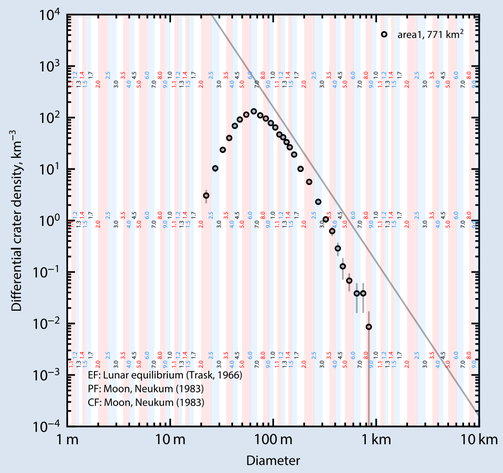


-pr cumulative

Diameter range selection

Adding `-b` adds a temporary bin overlay to aid range selection:

```
craterstats -p source=area1.diam -ef trask -b
```



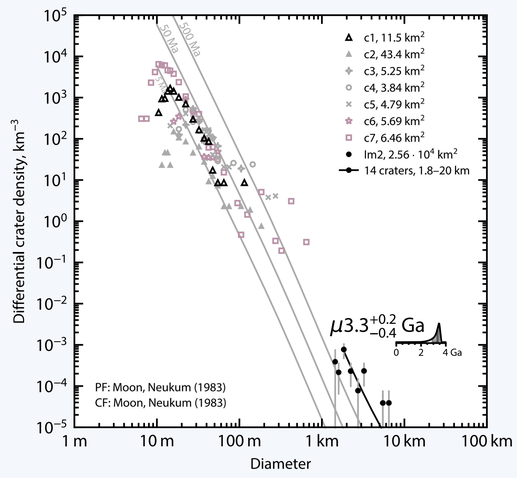
More complex plots

may be constructed using a plot definition file instead of a command line:

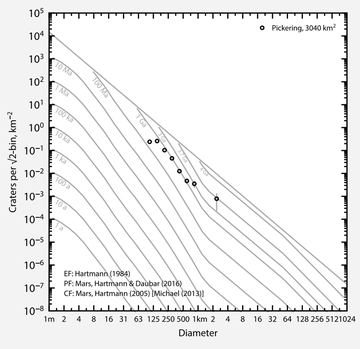
```
craterstats -i fig3.cs
```

fig3.cs

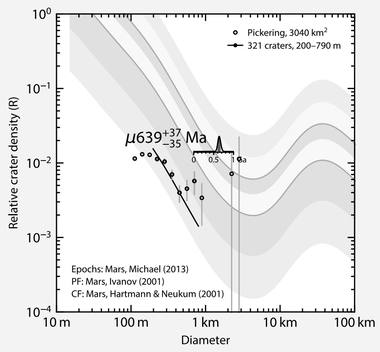
```
-p src=c1.scc,sym=^,err=0
-p src=c2.scc,sym=f^,col=grey
-p src=c3.scc,sym=s4
-p src=c4.scc,sym=o
-p src=c5.scc,sym=x
-p src=c6.scc,sym=s5,col=pink3
-p src=c7.scc,sym=sq
-p src=Im2.scc,sym=fo,col=blk,err=1
-p type=poisson,range=[1.8,20],snap=0,offset=[-5,2]
-isochrons .5a,.05a,.005s
-xrange -3 2
-yrange -5 5
-sf 2
```



Other data presentations



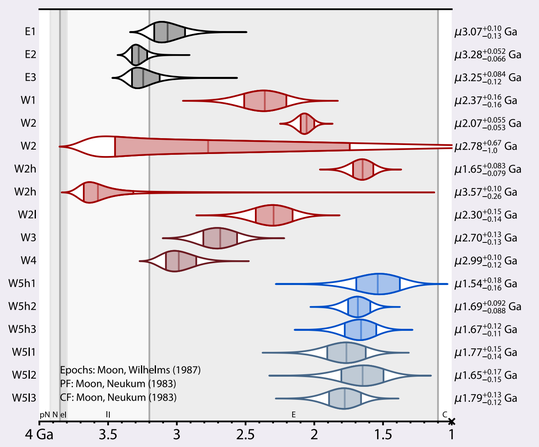
-pr hartmann



-pr r-plot

Sequence plot

For a set of related measurements in a study, this plot can help to visualize the sequence of events in combination with the uncertainty of the model age [2].




```
craterstats -i ce6-vicinity.cs
```

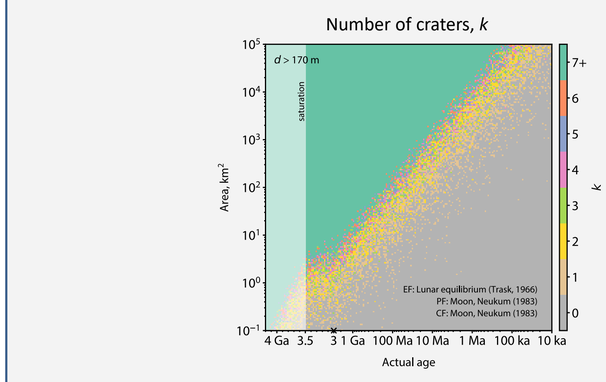
ce6-vicinity.cs

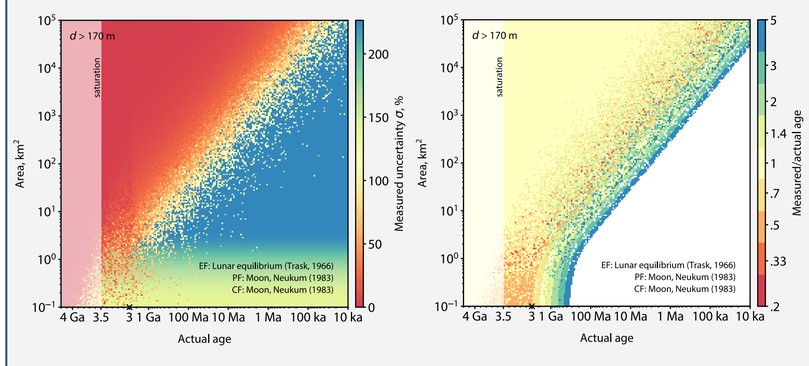
```
-pr sequence
-cs n83
-ep wilhelms
-xrange 4.0 1
-legend fA
-p src=e1.diam,range=[0.24,1.5],name=E1,type=poisson
-p src=e2.diam,rng=[0.25,1.5],nm=E2
-p src=e3.diam,rng=[0.24,1.5],nm=E3
-p src=w1.diam,rng=[0.21,1.2],colour=red,nm=W1
...
```

Uncertainty analysis

"*What is the smallest area that can be used for crater dating?*" – these plots explore the relationship between the crater counting area, the minimum crater diameter used for dating, the actual age of the surface, and the expected measurement uncertainty predicted by a given chronology model [3].

```
craterstats -pr uncertainty -d_min 0.17
-cs n83 -ef trask
```





Pixelated cells represent random Poisson realisations of the chronology model for the given age–area combination.

Numerical results

are produced for each age estimate:

area1.csv

Numerical output

Name	Area	Binning	d_min	d_max	Method	Resurf	N	N_event	Age	Age-	Age+	a0	a0-	a0+	N(1)	N(1)-	N(1)+	Source
area1	771.37	pseudo-log	0.15	1	poisson	0	966	966	1.75	1.69	1.8	-2.874	-2.888	-2.86	1.34E-03	1.30E-03	1.38E-03	area1.diam

Formatted output to paste into Word or Latex

Range	Age	N(1)
0.15–1.0 km	$\mu 1.75^{+0.057}_{-0.055}$ Ga	$1.34^{+0.044}_{-0.042} \cdot 10^{-3}$ km^{-2}

Detailed instructions, examples, and download from https://github.com/ggmichael/craterstats

References

[1] Heyer, T., Iqbal, W., Oetting, A., Hiesinger, H., Van Der Bogert, C.H., Schmedemann, N., 2023. A comparative analysis of global lunar crater catalogs using OpenCraterTool – An open source tool to determine and compare crater size-frequency measurements. Planet. Space Sci. 231, 105687. [2] Michael, G., Zhang, L., Wu, C., Liu, J., 2025. Planetary surface dating from crater size–frequency distribution measurements: Sequence probability and simultaneous formation. Did the close Chang'E-6 mare units form simultaneously? Icarus 438, 116644. [3] Michael, G., Liu, J., 2025. Planetary surface dating from crater size–frequency distribution measurements: Interpretation of small-area and low number counts. Icarus 431, 116489.