CraterTools Manual

(Version: 2.1)

CraterTools is a set of tools to measure crater size-frequency distributions (CSFDs) on map-projected image data. Additional information about the CraterTools software can be found in Kneissl et al. (2011; Kneissl et al., 2014; Kneissl et al., 2015). For support contact Thomas Kneissl (Thomas.Kneissl@fu-berlin.de).

Uninstall previous versions of the CraterTools software:

To uninstall previous CraterTools versions please close all ArcGIS applications and go to C:\Program Files (x86)\ArcGIS\Desktop10.1\bin. Execute the 'Categories.exe' file as administrator. Scroll down to 'Esri Mx CommandBars' and select the CraterTools object. Remove the object by pressing the 'Remove Object' button. Then go to 'Esri Mx Commands' and remove all other CraterTools objects. Then start ArcMap as administrator and the toolbar should be gone.
NOTE: The CraterTools objects can only be removed/ unregistered correctly from ArcGIS if the CraterToolsNET.dll and CraterToolsNET.tlb files still exist at their original locations. Thus, please make sure NOT to delete or move the older files before running the Categories.exe tool.

Installation:

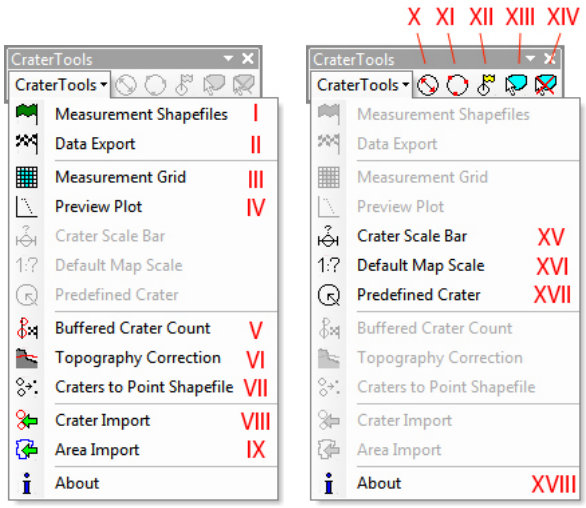
This CraterTools version uses the standard "add-in" format for ESRI's ArcMap. It can be installed by executing (double click) the file (ArcGIS must be closed). Alternatively, CraterTools can be installed using the "Customize – Customize Mode - Add From File" dialog within ArcMap. Both installation methods do not need administration rights. However, as a consequence the add-in is only available within the user account that was used for the installation.

System Requirements:

- Windows 7 or higher
- ArcGIS 10.1 or higher

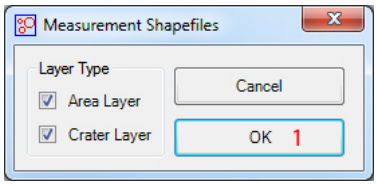
Software Features in the CraterTools add-in:

Outside edit session ***Within edit session***



I	Generate two shapefiles with CraterTools format.
II	Export measurement data to SCC/DIAM file.
III	Generate custom grid for systematic CSFD measurements.
IV	Preview SFD plot of crater measurement.
V	Perform buffered crater count analysis.
VI	Correction of topography-related crater and area distortions.
VII	Generate point shapefile with crater centers.
VIII	Import craters from Diam/Scc file.
IX	Import areas from Scc file.
X	Digitize crater by two opposing points on crater rim.
XI	Digitize crater by any three points on the crater rim.
XII	Mark selected craters. They can optionally be excluded in the export/analyses processes.
XIII	Make all AREA layers selectable.
XIV	Make all AREA layers unselectable.
XV	Define crater scale bar that can be shown at the cursor position.
XVI	Set the default map scale.
XVII	Generate crater with predefined diameter.
XVIII	About CraterTools.

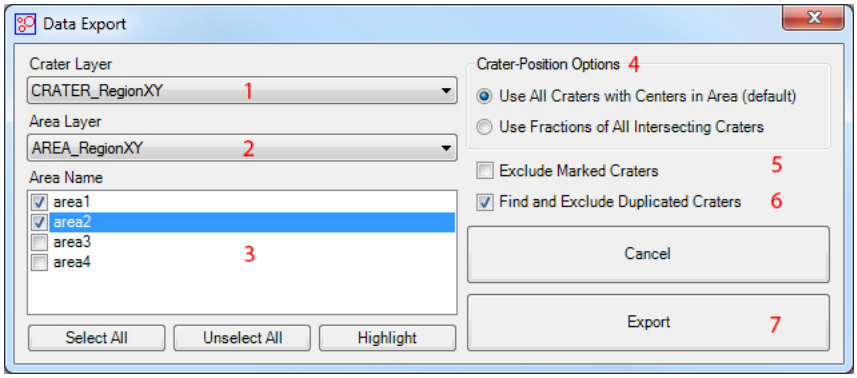
I *Measurement Shapefiles*



[1] Opens a file dialog to define the name and location of the created shapefiles.

Comments: In the file dialog the user is asked for a primary measurement name that will be used to name both shapefiles. Additionally, the software adds the prefix “AREA_” to the shapefile for the areas, the name of the crater shapefile is extended with the prefix “CRATER_”. The created shapefiles are automatically added to the project and get the same spatial reference as the current data frame. This must be a projected coordinate system using ‘meters’ as map units. The attribute tables of the shapefiles contain all fields needed for the CSFD measurement and export processes.
NOTE: Each area shapefile can contain several measurement areas, whose names have to be defined in the ‘Area_Name’ field in the attribute table. Furthermore, the crater shapefile can contain the impact craters digitized within several measurement areas, as the software automatically performs spatial queries for the data export process.

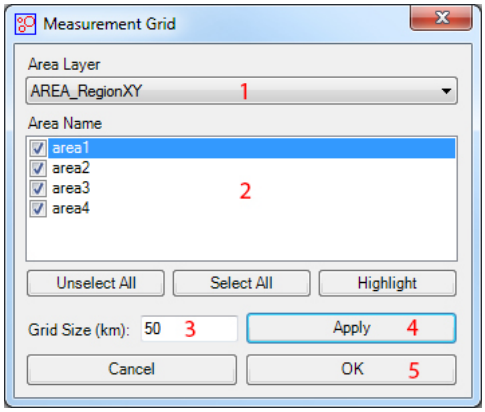
II *Data Export*



[1] Defines the layer that contains the impact craters. This combo box only contains polygon-feature layers whose names start with the word “CRATER”.
[2] Defines the layer that contains the measurement areas. This combo box only contains polygon-feature layers whose names start with the word “AREA”.
[3] Defines one or more measurement areas whose CSFD data shall be exported. This list contains all area names that are defined in the ‘Area_Name’ field of the area layer’s attribute table.
[4] Defines whether only craters are exported whose crater centers are located inside the area (default) or if all intersecting craters are exported with their corresponding fractions (for details see comments below).
[5] Excludes marked craters from the crater export (see XII).
[6] Removes duplicated craters from the scc/diam file (craters with identical coordinates and diameters).
[7] Opens a file dialog to define the name, type (.scc or .diam), and location of the export file.

Comments: If more than one measurement area is selected in 3, the software adds all selected areas together and treats them as one single CSFD measurement. Same applies for areas that got assigned the same name in the ‘Area_Name’ field of the area layer’s attribute table. During the export process the software calculates the true areas (geodesic areas) of all polygon features within the defined area layer and writes the value into the attribute table of the area shapefile.
The software supports two formats for the data export, ‘spatial crater count’ files (.scc) or ‘diameter’ files’ (.diam). Both formats are simple ASCII files that may be viewed and/or modified in standard text editors. In contrast to .diam files, which only contain crater-related information, the .scc files additionally include the vertices of the measurement areas.
Using the ‘Use Fractions of All Intersecting Craters’ option, the software exports all craters that intersect with the respective area. Here, the software calculates the ‘fractions’ of the crater diameters that are located inside the area and writes these values in the scc/diam files. Subsequent statistical analyses (e.g., using the CraterStats software) can make use of the ‘fraction’ values to calculate the relative crater frequencies. Using the ‘Use All Craters with Centers in Area’ option, only the craters whose crater centers are located inside the area are exported. Here, all exported craters get a ‘fraction’ value of 1, no matter if they are located entirely inside the area. This is the conventional approach of crater counting and, thus, it is the default setting.

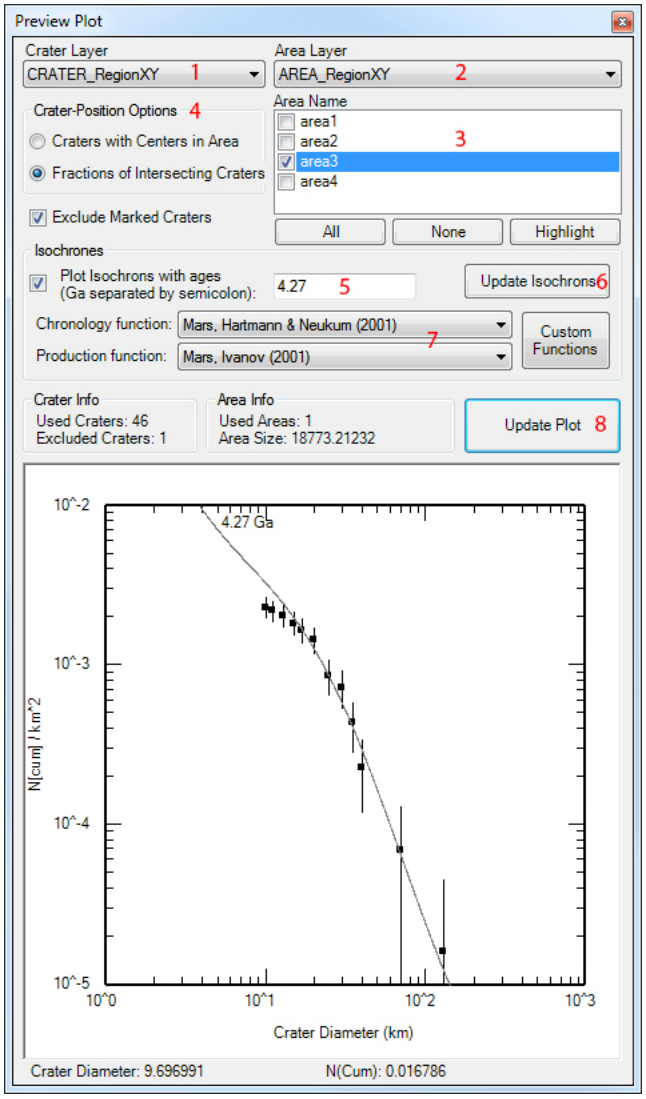
III *Measurement Grid*



[1] Defines the layer that contains the measurement areas.
[2] Defines one or more measurement areas to create an overlaying grid.
[3] Defines the size of the created grid cells (in km).
[4] Builds a preview of the grid showing up as red graphics in the data frame.
[5] Creates a permanent shapefile containing the measurement grid. This button opens a file dialog to define the name and location of the shapefile.

Comments: A measurement grid might help to investigate larger measurement areas using a systematic crater digitization approach cell by cell. The coordinate values of the lines are a multiple of the given grid size, i.e. for a grid size of, e.g., 12 km the resulting grid lines can only be located on projected coordinates like 0, 12 000, 24 000 and so forth (x and y directions). Here, the software uses the spatial reference of the active data frame. Using this approach it does not matter if one creates a grid for several areas at once or one after another. As long as the same grid size is used, the grid cells will not overlap. The software creates the grid cells from the lower left to the upper right.

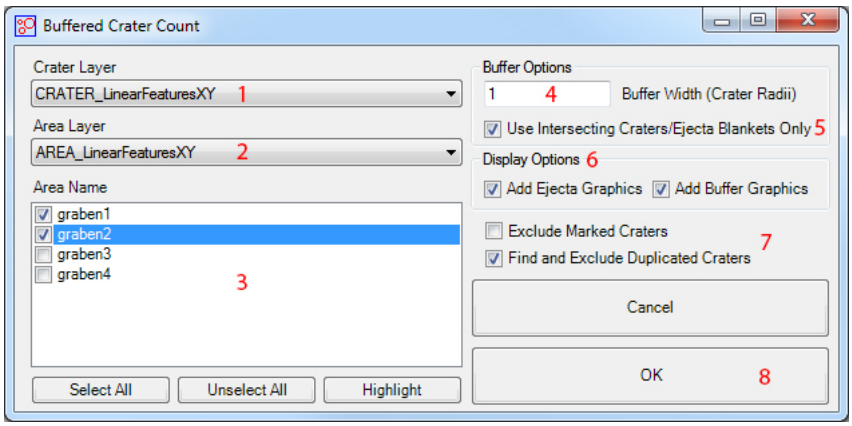
IV *Preview Plot*



[1] Defines the layer that contains the impact craters.
[2] Defines the layer that contains the measurement areas.
[3] Select one or more measurement areas to plot their CSFD. If more than one area is selected, the CSFDs will be added together.
[4] Defines whether the conventional or the fractional crater counting approach is used for the analysis (see II for details).
[5] Define one or more ages (in Ga) that are shown as isochrones in the plot window. Multiple ages have to be separated by semicolon.
[6] Updates only the isochrones in the plot window (might save time if the plot contains a large number of craters). If the plot is not created yet, this button has the same function as the 'Update Plot' button.
[7] Defines the chronology function and production function used for the isochrones.
[8] Creates the CSFD plot of the selected areas.

Comments: The "Preview Plot" software feature allows the creation of cumulative double-logarithmic diagrams of the measured crater size-frequency data using the pseudo-log Neukum crater-diameter bins. Clicking on the diameter bins in the plot window selects and highlights the corresponding impact craters in the data frame. For plotting isochrones the software provides various chronology and production functions for different planetary bodies. Additionally, the software has the possibility to use custom functions using the custom function files of the CraterStats software (Michael and Neukum, 2010). Please copy the files "functions.txt" and "functions_user.txt" from the CraterStats folder to the 'Common Files' folder of ArcGIS. (e.g., C:\Program Files (x86)\Common Files\ArcGIS\). Functions contained in the file "functions.txt" will replace the default list of functions in the preview plot window. Functions contained in the file "functions_user.txt" will be added to the default list.

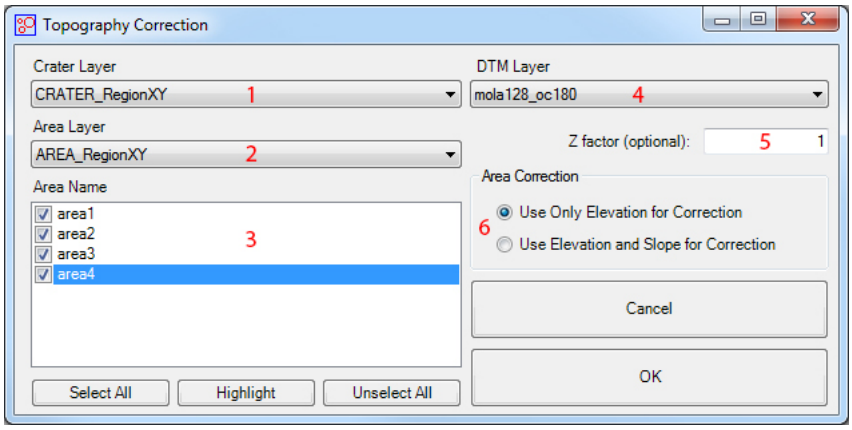
V *Buffered Crater Count*



[1] Defines the layer that contains the impact craters postdating the linear features.
[2] Defines the layer that contains the measurement areas.
[3] Defines one or more measurement areas where the BCC technique shall be applied.
[4] Defines the buffer width used for the buffer creation.
[5] Option to limit the BCC analysis to craters (ejecta blankets) that intersect with the linear feature (on by default).
[6] Options to create graphics of the calculated buffers and assumed ejecta blankets. In case the buffer width is defined to be 1 crater radius, the ejecta graphics will represent the crater rims.
[7] Options to find and exclude duplicated craters or marked craters
[8] Opens a file dialog to define the name and location of the .scc export file.

Comments: The Buffered Crater Counting (BCC) technique allows the age determination of linear/curvilinear surface features that provide only very limited areas for the conventional crater counting approach (e.g., Tanaka, 1982; Fassett and Head, 2008).
In order to apply the BCC technique with the CraterTools software, the user has to map the linear features (as polygons) and all postdating impact craters using the two- or three-point crater digitizing methods (X or XI). Here, one has to use the standard area and crater shapefiles. The software automatically creates geodesic buffer polygons around the linear features for each crater size and calculates the respective buffer areas. Overlapping buffers are merged together. The software calculates for each crater the ratio of the buffer area to the area of the mapped linear feature to define the fraction of the crater that can be used for the age determination. Results are exported into standard .scc files, which can be directly used in the CraterStats software. Option 4 defines the buffer width (in crater radii) used for the buffer creation. Here, a buffer width of 1 corresponds to the simple approach, i.e., only direct intersections of the crater rim with the linear features were used for the stratigraphic judgment of whether the crater pre- or postdates the linear features. Buffer widths >1 correspond to the ejecta approach, i.e., also ejecta blankets were used for the stratigraphic interpretation. Further details on this specific feature of the CraterTools software as well as on the BCC technique in general are given in Kneissl et al. (2015).
This BCC analysis can be combined with the topography correction, i.e., the software uses the diameter and area values given in the “corr_Area” and “corr_Diam” attribute fields if they exist.

VI *Topography Correction*

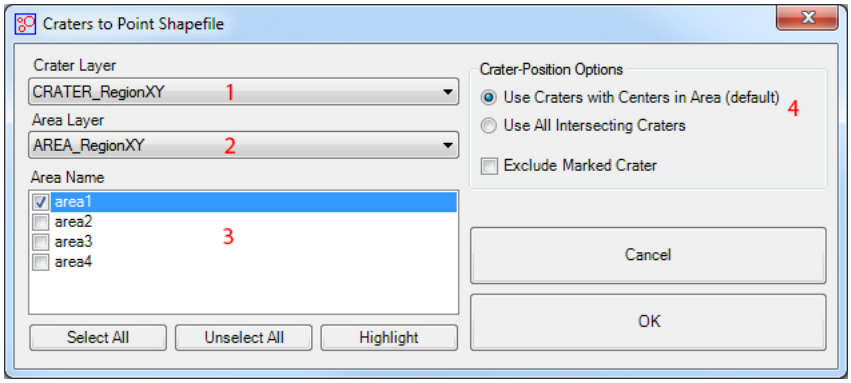


[1] Defines the layer that contains the digitized impact craters.
[2] Defines the layer that contains the measurement areas.
[3] Select one or more measurement areas where the topography correction should be applied.
[4] Define the DTM layer that will be used for the correction.
[5] Define an optional z factor for the DTM.
[6] Set area correction method.

Comments: The topography correction is particularly useful for crater size-frequency measurements on smaller bodies, which are often characterized by proportionally large deviations of the actual surface from the reference body used for the map projection. These deviations cause additional distortions of measurement areas and craters in the projected image data

independently of the used map projection. In order to correct for these distortions the software needs a georeferenced DTM whose elevation values are related to the same reference body as used for the map projection. Option [5] defines whether the software only corrects the elevation-induced lateral distortions or if area distortions caused by slopes are corrected as well. Please see Kneissl et al. (2014) for more details on these corrections.
This software function does NOT export the CSFD data to a .scc file. Instead, the corrected crater diameters and measurement areas are stored within additional fields ("corr_Diam" and "corr_Area") of the crater and area layer's attribute tables and can optionally be used in the "Data Export", "Preview Plot", or "Buffered Crater Count" software features.
NOTE: At the moment this software feature only supports spherical reference bodies. Furthermore, the software does not support areas crossing the +/-180° transition (can be solved by setting the central meridian to 180°).

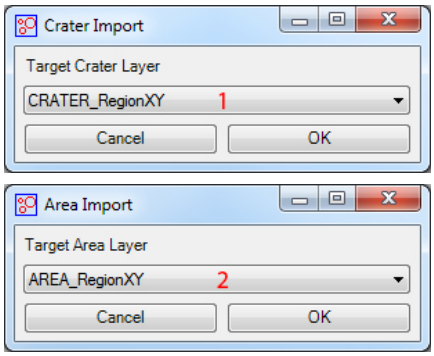
VII *Craters to Point Shapefile*



[1] Defines the layer that contains the impact craters.
[2] Defines the layer that contains the measurement areas.
[3] Select one or more measurement areas whose crater centers shall be exported as point shapefile.
[4] Defines whether only craters are exported whose crater centers are located inside the area (default) or all intersecting craters are exported into the point shapefile.

Comments: This software feature allows for exporting of all crater-centers into a point shapefile. This might be useful when the location of craters should be displayed in a map without masking their crater rims.

VIII / IX *Crater Import/ Area Import*



[1] Defines the layer in which the crater shapes will be imported.
[2] Defines the layer in which the area shapes will be imported.

Comments: These software features allow for an easy import of crater and area shapes from .scc files. Craters can also be imported from .diam files. Since .scc and .diam files are much smaller and much easier to handle than the standard shapefile format, these export and import functions allow for an easy exchange of CSF measurement data between different researchers.

X / XI *Circle by Line and Circle by Points*

Using the CraterTools software impact craters can be digitized by either defining two opposing points on the rim of the crater (the start and end point of the crater diameter) or by any three points on the crater rim. The 'Circle by Line' method might be slightly faster than the 'Circle by Points' method. However, using the latter method it seems to be easier to produce accurate measurements, especially if only parts of the crater rim are preserved or if the crater is distorted by the map projection. Both digitizing methods produce geodesic circles and write the correct (undistorted) crater diameters into the attribute table of the crater shapefile. Using the 'Circle by Points' method, the user has the possibility to delete the last measurement point by pressing the 'e' key on the keyboard. Using the 'Circle by Line' method, the 'e' key aborts the measurement of the respective crater.
NOTE: Please make sure that the crater shapefile is selected in the standard ArcGIS – "Create Feature" window before starting the crater digitizing process.

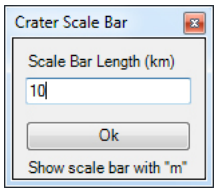
XII *Mark Crater*

For later inspections or subsequent discussions with colleagues it might be helpful to mark specific craters during a measurement. This can be done by selecting one or several craters and pressing the "Mark Crater" button in the toolbar. This will change the attribute in the "tag" field in the crater layer's attribute table from "standard" to "marked" and changes the color of the crater to yellow (the actual color depends on the symbology settings of the layer but yellow is the default). Marked craters can optionally be excluded in subsequent operations, e.g., within the software features "Data Export", "Preview Plot", or "Buffered Crater Count".

XIII / XIV *Area Layers selectable / unselectable*

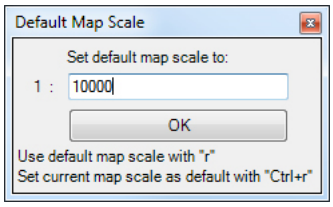
Using the standard settings in ArcMap a manual selection of digitized craters within a measurement area also selects the area polygon. In order to avoid accidental modification or removal of the underlying measurement areas the CraterTools software makes all "AREA_" layers un-selectable by default when activating the "Circle by Line" or "Circle by Points" tools. The buttons "AREA Layers selectable" and "AREA Layers unselectable" provide quick access to define whether all AREA layers are selectable or not. Using the "List By Selection" view within the standard ArcGIS "Table Of Contents" provides the same functionality for individual layers.

XV *Crater Scale Bar*



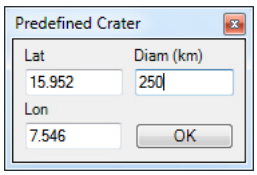
This software feature allows for overlaying a scale bar of user-defined length on top of the mouse cursor. This feature is in particular useful if only craters within a specific diameter range should be digitized. The scale bar can only be shown if either the "Circle by Line" or the "Circle by Points" tools are active. For showing the scale bar press the "m" key on the keyboard. The length of the scale bar can be defined in the "Crater Scale Bar" window.

XVI *Default Map Scale*



For a systematic and homogeneous CSFD measurement it might be valuable to use a consistent map scale for the entire measurement. The digitizing process of individual craters, however, often makes it necessary to zoom in and out from this default map scale. For a prompt return to the default map scale press the "r" key. Use the "Default Map Scale" window to define this map scale or press "Ctrl+r" during your measurement to set the current map scale as the default map scale.

XVII *Predefined Crater*



Using the "Predefined Crater" tool it is possible to create geodesic circles (craters) with a predefined diameter. The location of the crater center can be defined by latitude and longitude coordinates in the "Predefined Crater" window (the crater will be created by pressing "OK") or by a mouse click in the data frame. The created circle is a standard crater polygon and the diameter and coordinates of the crater center will be written into the layer's attribute table.

XVIII About

The "About" window contains a short walkthrough for a CSF measurement using the CraterTools software.

References

Fassett, C. I., Head, J. W., 2008. The timing of martian valley network activity: Constraints from buffered crater counting. Icarus, 195, 61-89, DOI: 10.1016/j.icarus.2007.12.009.

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Kneissl, T., Schmedemann, N., Neesemann, A., Raymond, C. A., Russell, C. T., 2014. Crater Counting on Small Bodies - The Influence of Topography-Related Distortions. Lun. Planet. Sci. Conf. Abs., Vol. 45, #2398.

Kneissl, T., van Gasselt, S., Neukum, G., 2011. Map-projection-independent crater size-frequency determination in GIS environments—New software tool for ArcGIS. Planet. Space Sci., 59, 1243-1254, DOI: 10.1016/j.pss.2010.03.015.

Michael, G. G., Neukum, G., 2010. Planetary surface dating from crater size-frequency distribution measurements: Partial resurfacing events and statistical age uncertainty. Earth Planet. Sci. Lett., 294, 223-229, DOI: 10.1016/j.epsl.2009.12.041.

Tanaka, K. L., 1982. A new time-saving crater-count technique, with application to narrow features. NASA Technical Memo, NASA TM-85127, pp. 123-125.