This section describes the methodology to calculate the eroded volume of rocks in valleys where the distribution of the non-eroded rocks is known. The observed deposits in the Las Minas area are presented as a reference to reproduce this methodology.

The following files are necessary to reproduce this method:

- Digital Elevation Model. In this case, a 30 m resolution SRTM and a duplicate of the DEM layer with hillshade effect for visualization are used.
- Polygon shapefile layer with the observed deposits (OD). This layer can include all the areas of interest since later they will be saved individually as separate layers. If the polygon shape includes only one feature, start from step 2.

The data analysis was performed using the following software:

- QGIS V.2.8.4-Wien with the SAGA Processing tools loaded.
- Worksheet space. In this case, Microsoft Excel.

Steps

1. Load the DEM and the shapefile of the observed deposits as layers in QGIS (Fig A.1).

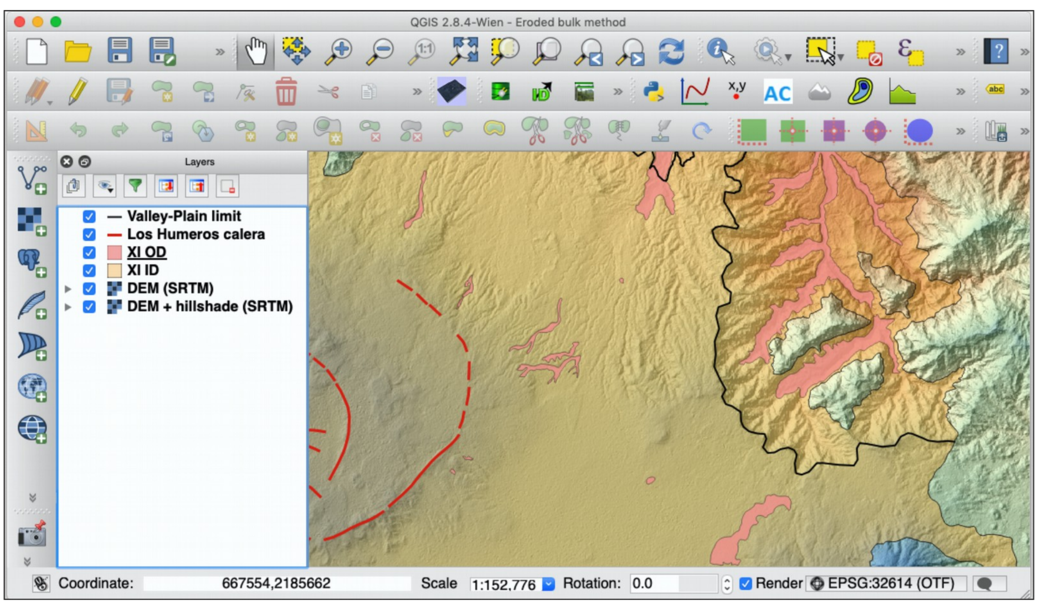


Figure A.1

2. Select and save the polygon as an individual shapefile (select feature → Layer → Save as). Select the "*Save only selected features*" option. Rename the file as "*LM*" in the "*Save as*" field and click "*OK*" (Fig. A.2).

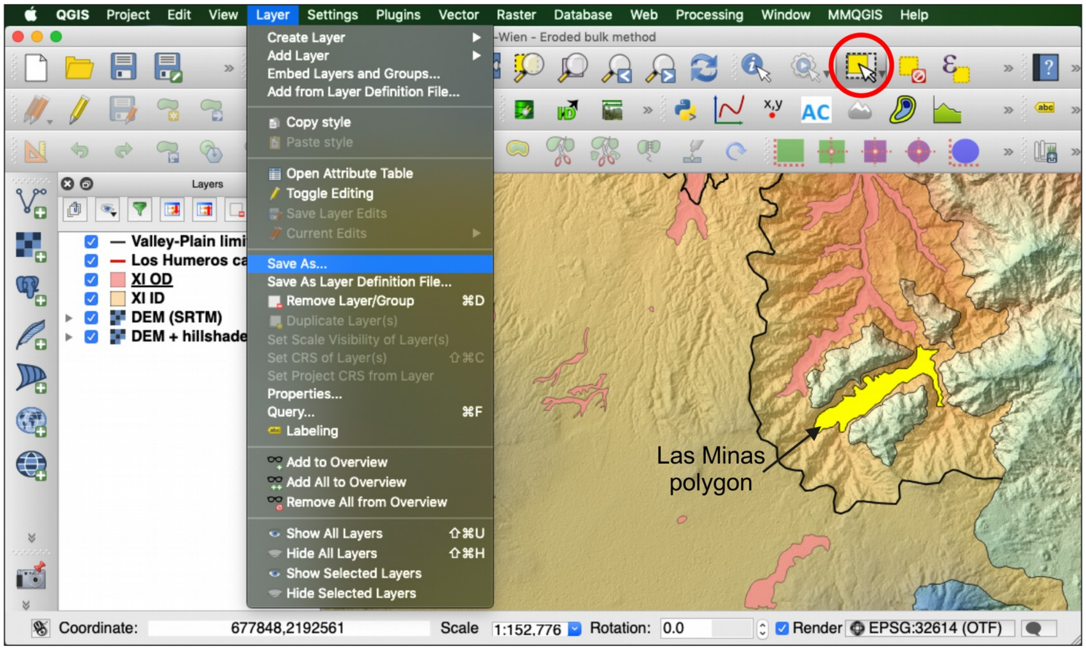


Figure A.2a

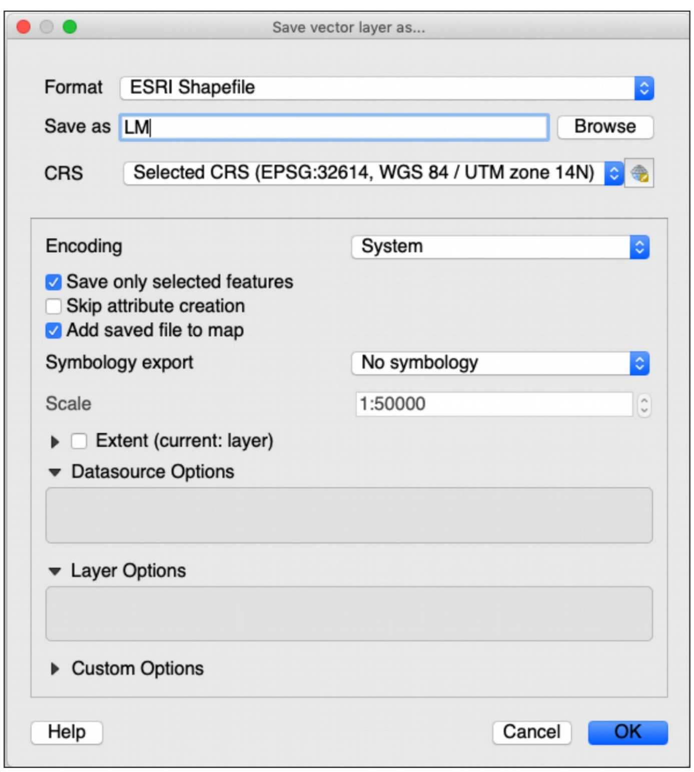


Figure A.2b

3. Convert the polygon shapefile "*LM*" to a line shapefile by using the "*Polygon to Lines*" tool (Vector → Geometry Tools → Polygon to Lines) (Fig. A.3a). Insert the "*LM*" shapefile in the "*Input polygon vector layer*" field and create a new shapefile, here named "*LM lines*" (Fig A.3b).

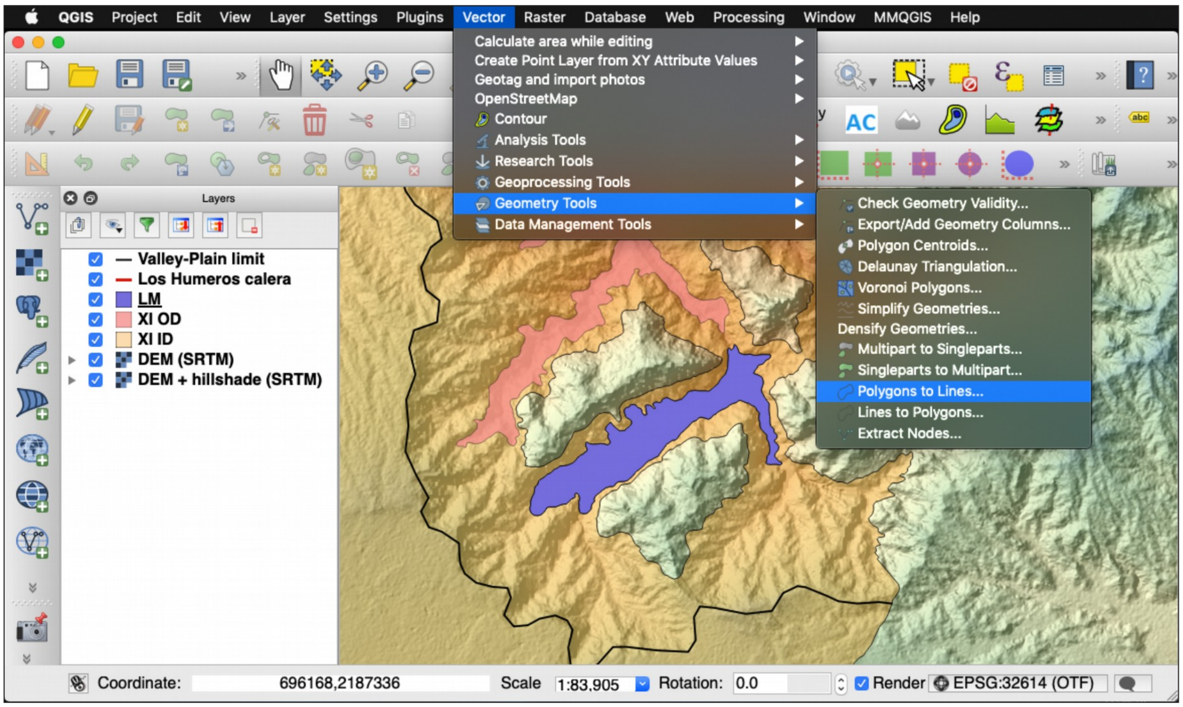


Figure A.3a

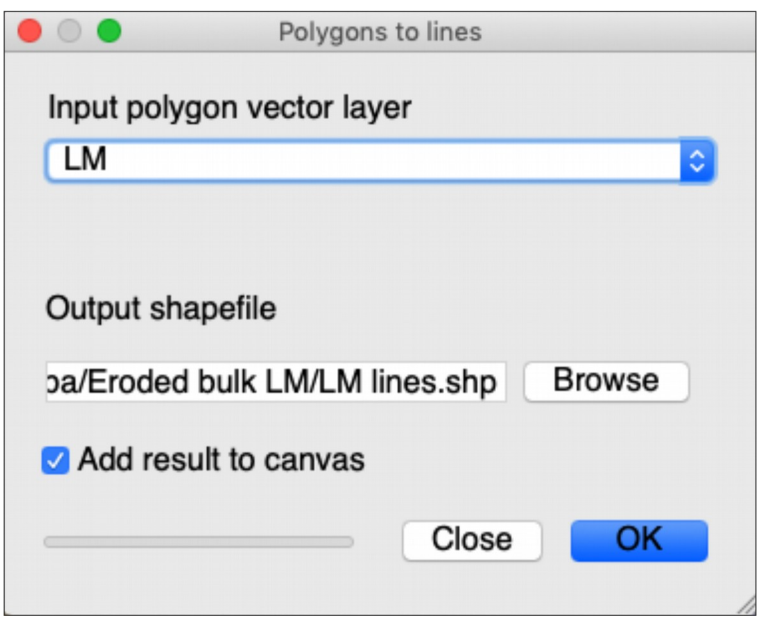


Figure A.3b

4. Convert the line shapefile "*LM line*" to a point shapefile by using the "*Convert lines to points*" tool (Processing → Toolbox → Convert lines to points) (Fig A.4a). Insert the "LM lines" in the "*Lines*" field, select a 10 m distance in the "*Insert Distance*" field, save the file as "*LM point*" in the option "*Points*" field, and click "*Run*" (Fig A.4b). A new layer named "*Points*" is created, which is here renamed as "*LM point*" (Fig. A.4c). The resulting polygon is a shapefile with a point spaced every 10 m around the contour of the original LM shapefile (Fig. A.4d).

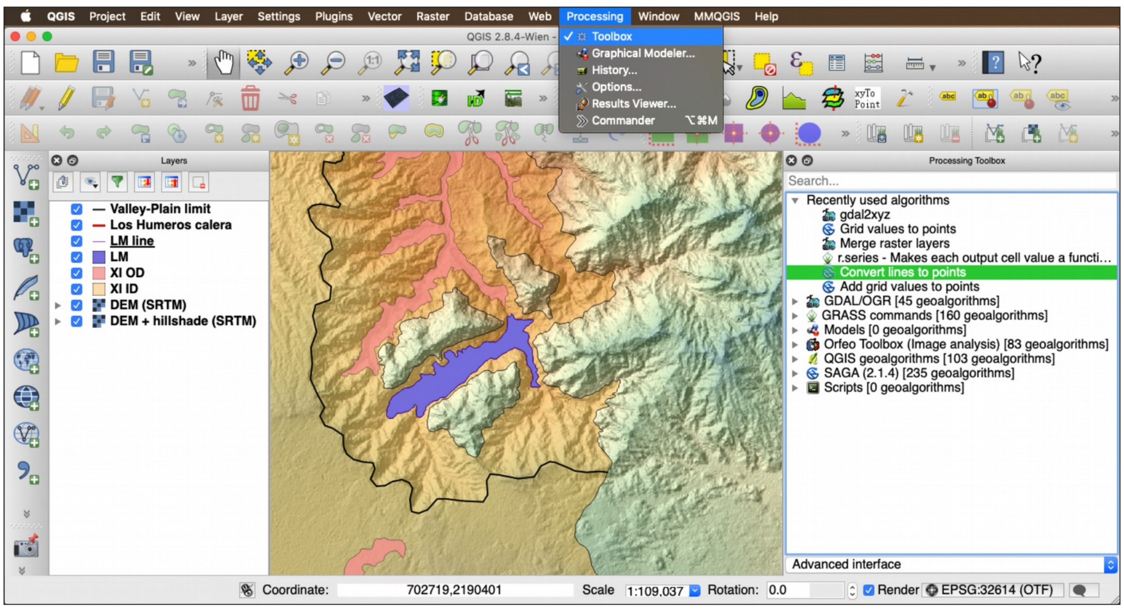


Figure A. 4a

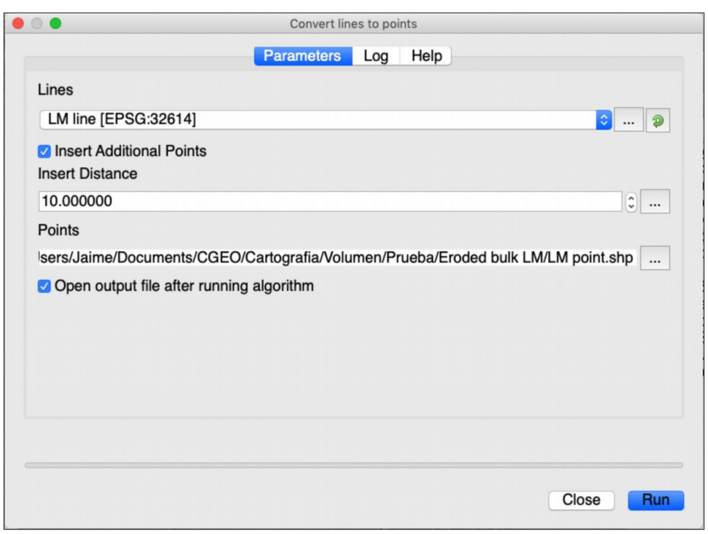


Figure A.4b

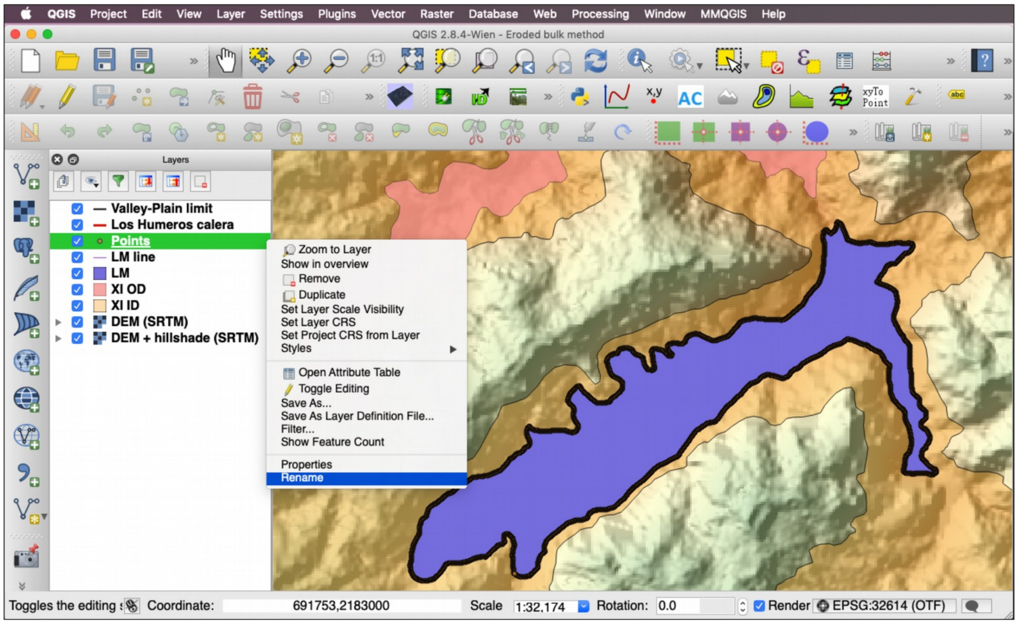


Figure A.4c

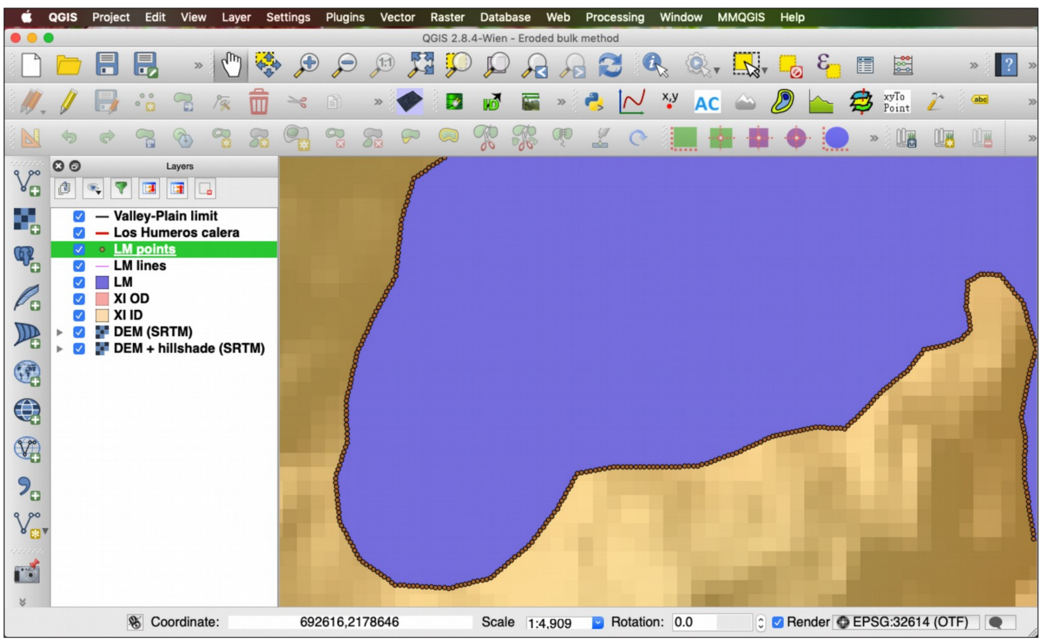


Figure A.4d

5. Assign an altitude value to each point by using the "*Add grid values to points*" tool (Processing → Toolbox → Add grid values to points) (Fig. A.5a). Select the "*LM points*" layer in the "*Points*" field, select the "*DEM (SRTM)*" in the "*Grid*" field, and select the "*Nearest Neighbor*" option for the Interpolation (Fig A.5b). This process generates a new

layer named “Result” that will be renamed “LM point Z”, which includes an attribute column in the shapefile with the Z value obtained from the DEM (Fig A.5c).

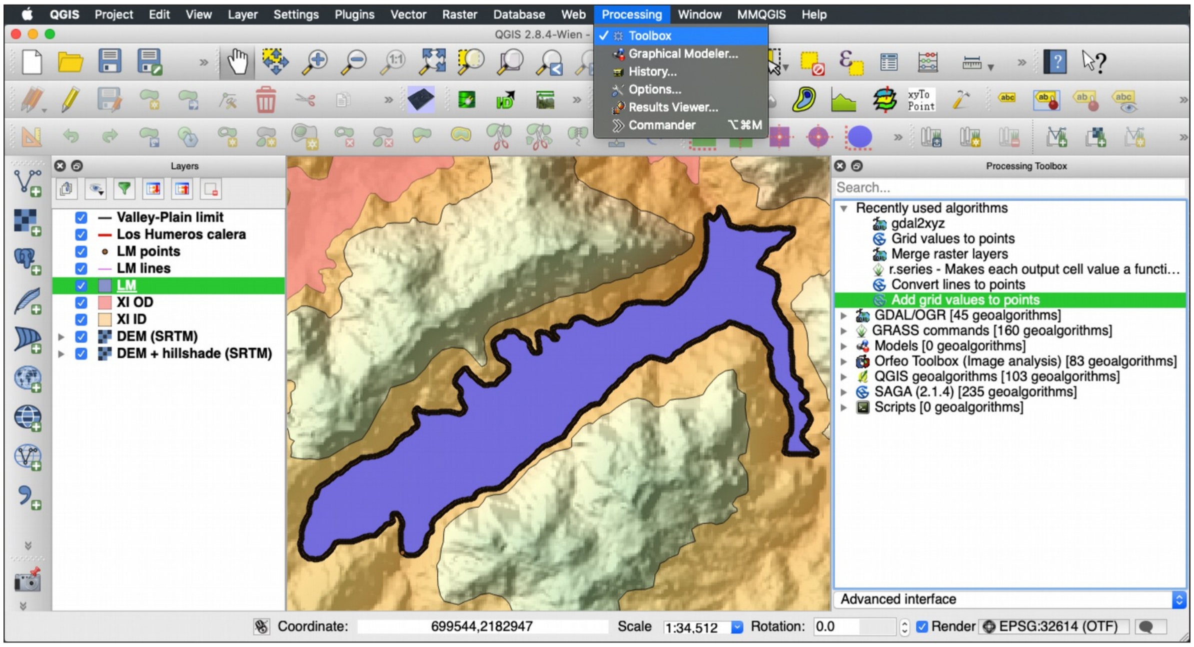


Figure A.5a

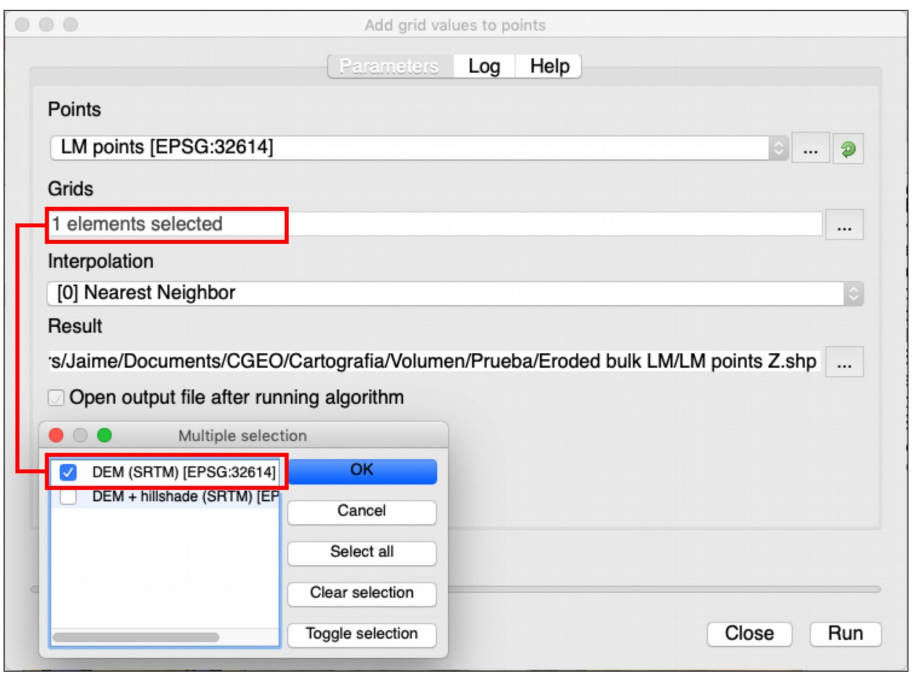


Figure A.5b

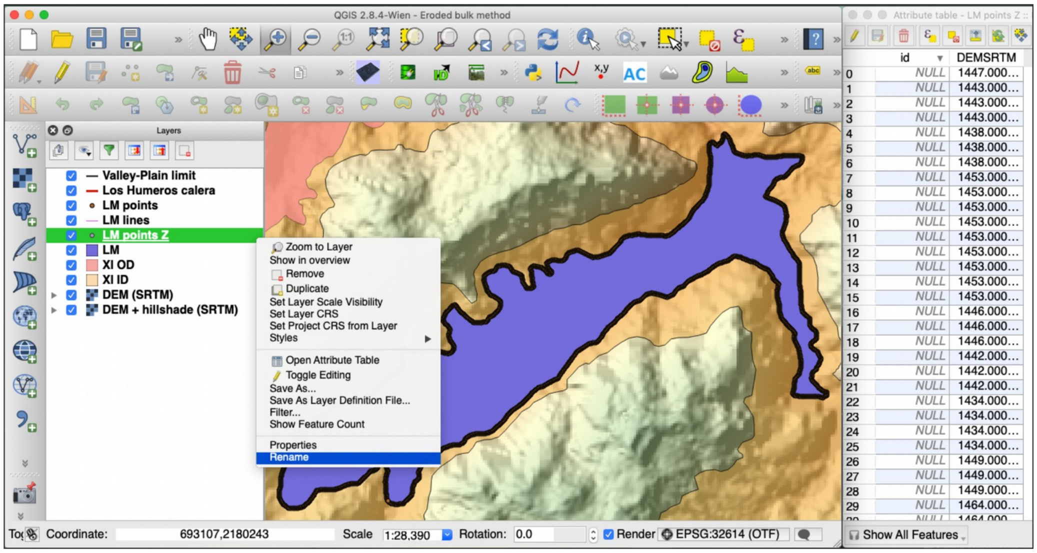


Figure A.5c

6. Generate an interpolated elevation surface using the elevation value of each point using the "*Interpolation*" tool (Raster → Interpolation → Interpolation) (Fig. A.6a). Fill the inputs "*Vector layers*" with "*LM point Z*" and "*Interpolation attribute*" field with "*DEMSRTM*", click "*Add*" button to create a new vector layer, select the "*Triangular interpolation (TIN)*" as the "*Interpolation method*", define a "*Cellsize*" resolution of 15 m for X and Y, create an output file named "*LM interpolated*", and click "*OK*" (Fig A.6b).

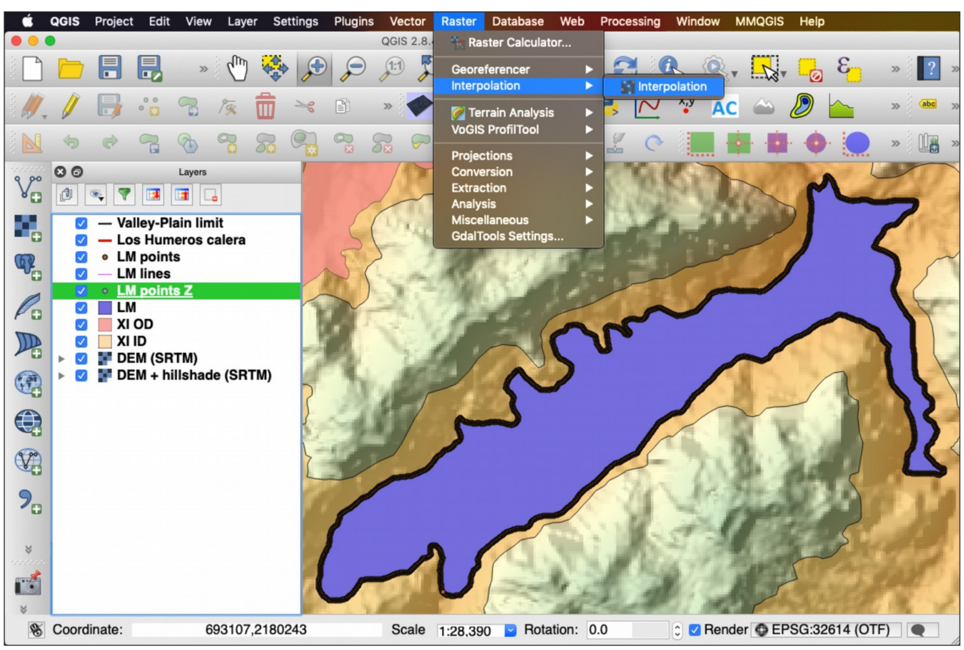


Figure A.6a

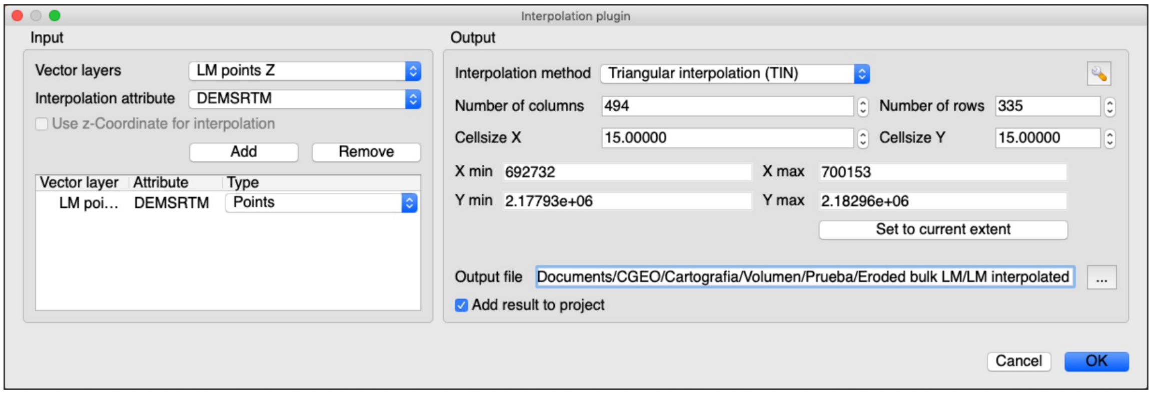


Figure A.6b

7. Clip the created polygon “*LM interpolated*” to the original “*LM*” layer (raster → extraction → clipper) (Fig. A.7a). In the “*Clipper*” menu, select the “*LM interpolated*” file in the “*Input file (raster)*” field. Create a new file, here named “*LM interpolated clipped”*, in the “*Output file*” field, select the “*Mask layer*” option and use the “*LM*” file and click “*Ok*” (Fig. A.7b).

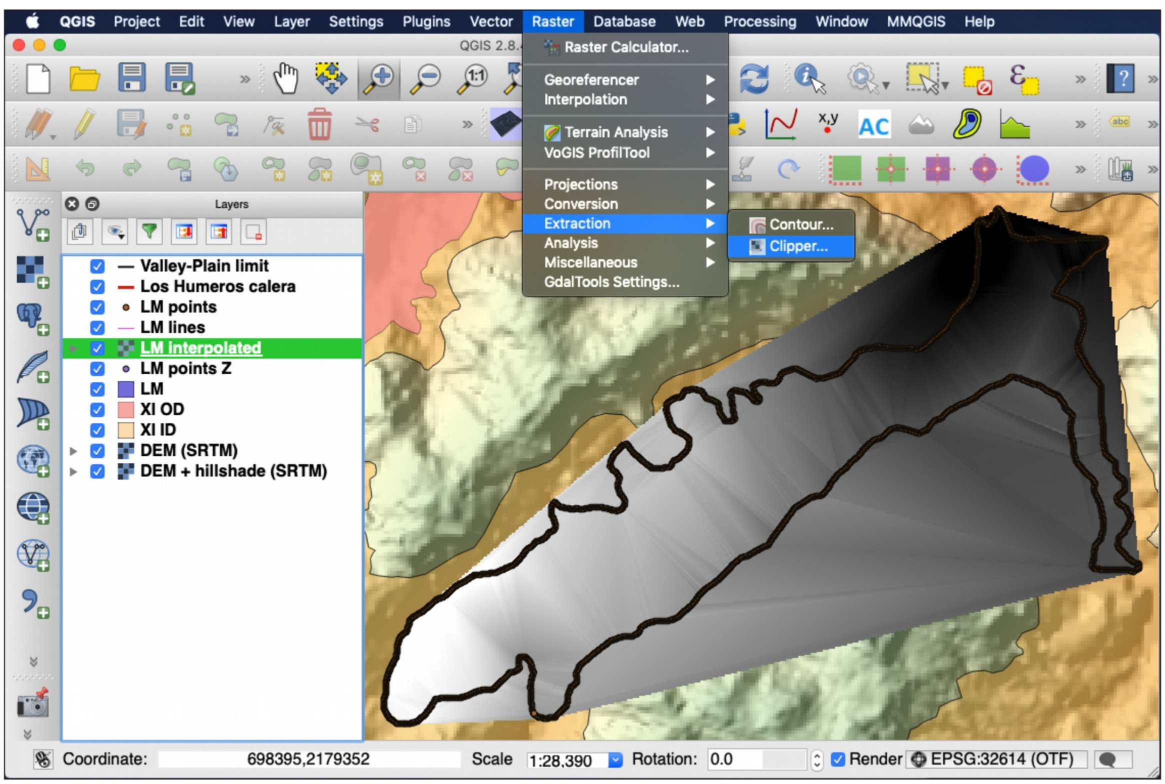


Figure A.7a

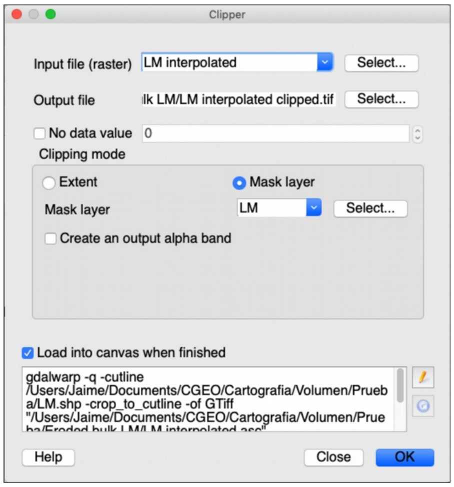


Figure A.7b

8. The "*LM interpolated clipped*" polygon displays the surface of the deposit before erosion. This surface can be visualized using the Qgis2threejs plugin available in the QGIS "Manage and Install plugins" repository (ref of the plugin?) (Fig. A8).

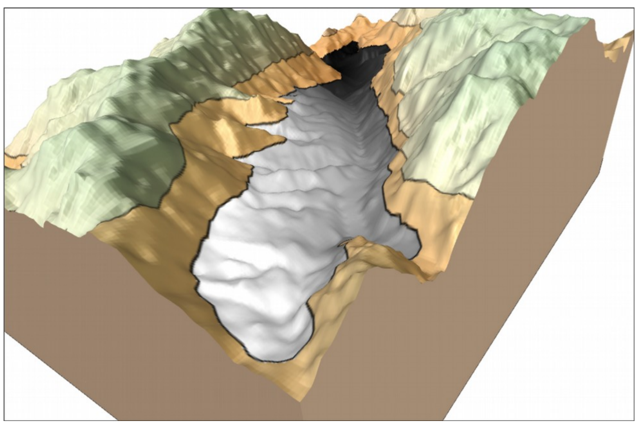


Figure A.8a

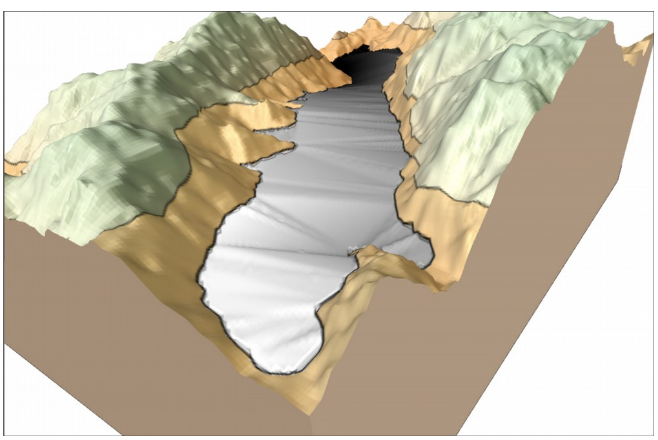


Figure A.8b

9. Calculate the altitude difference between the interpolated surface and the actual DEM by using the “*Raster calculator tool*” (Raster → Raster calculator) (Fig A.9a). Select the files from the “Raster bands” to form the subtraction "LM interpolated clipped@1" - "DEM (SRTM)@1" in the “Raster calculator expression” field (Figure A.9b). Create the new file in the “*Output layer*”, here named “*LM altitude diff*”, and click “*OK*”. This process generates a new raster image with altitude values that represent the eroded thickness in each pixel.

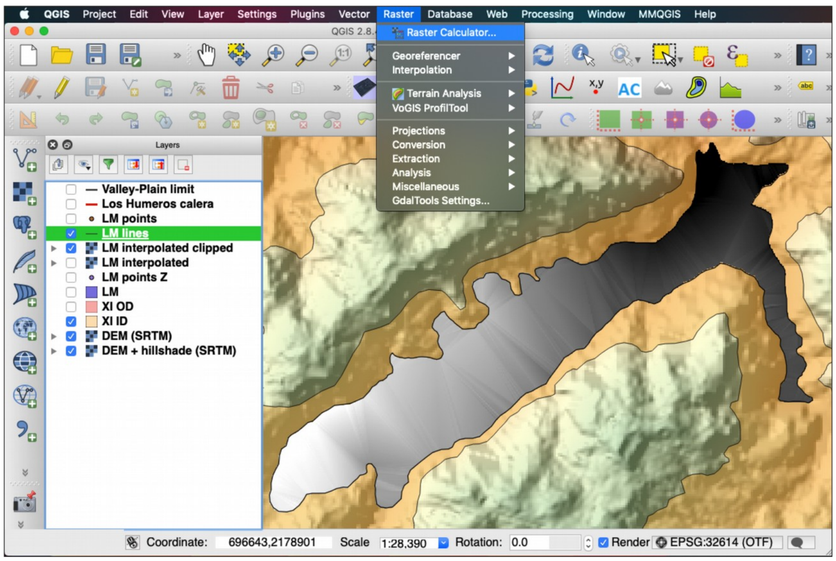


Figure A.9a

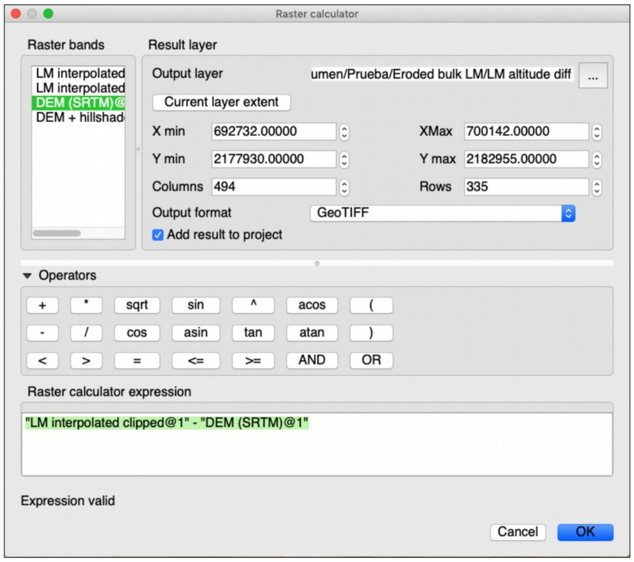


Figure A.9b

10. Convert the raster to a shapefile that contains the information of the eroded thickness for each pixel (raster → conversion → Polygonize (Raster to Vector)) (Fig. A.10a). Select the "*LM altitude diff*" file in the "*Input file*" field. Create the new vectorized file, here named "*LM diff vectorized*", in the "*Outputfile file for polygons (shapefile)*" field and click "*OK*" (Fig. A.10b). The resulting layer groups the pixels (15 x 15 m resolution defined in step 6) according to their height value. In the case of adjacent pixels with the same height value, this will appear merged (A10c). The height values can be consulted in the attribute table. Note the negative values; these will be later deleted because they mean areas topographic mounds that were not covered by the filling deposit.

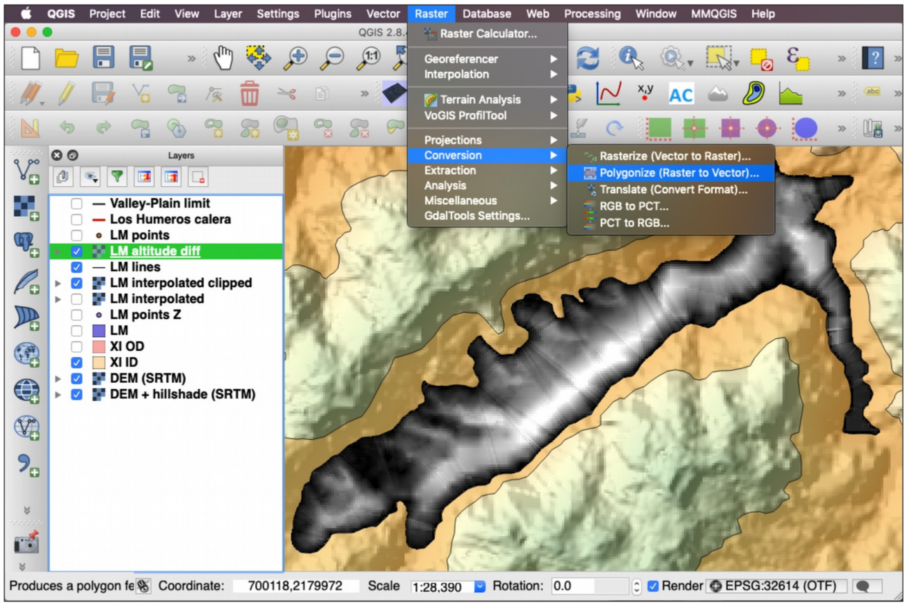


Figure A.10a

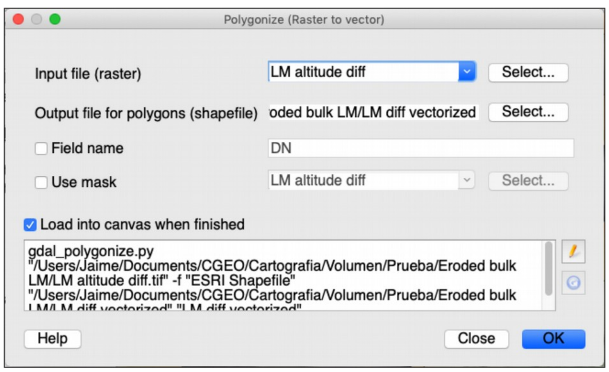


Figure A.10b

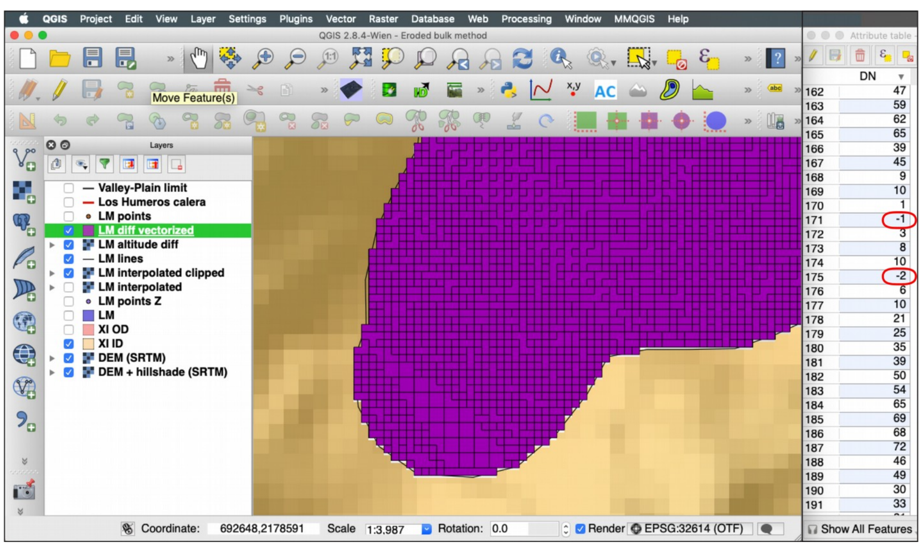


Figure A.10c

11. To calculate the volume of each pixel, create a column with the area of each pixel. For this, use the "*Field calculator*" in the "*attribute table*". In "*Field calculator*" select the "*Create a new field*" option, here named "*area*", in the "*Output file name*". Select "*Whole number (integer)*" in the "*Output file type*". Finally, select the "*$area*" function from the "*Functions*" menu (Fig. A.11a). A new column titled "*area*" is created in the attribute table, note that the areas are multiples of 225, this due the 15x15 m resolution of the vectorized image (Fig. A.11b).

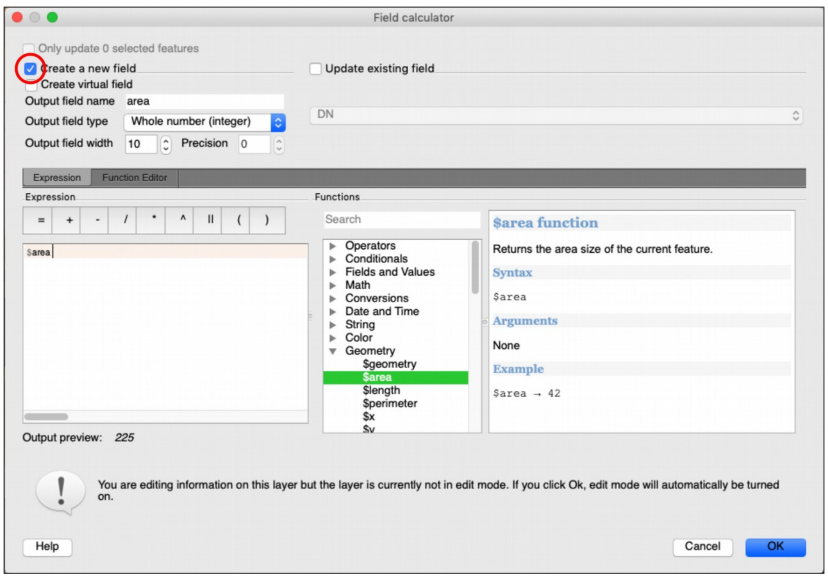
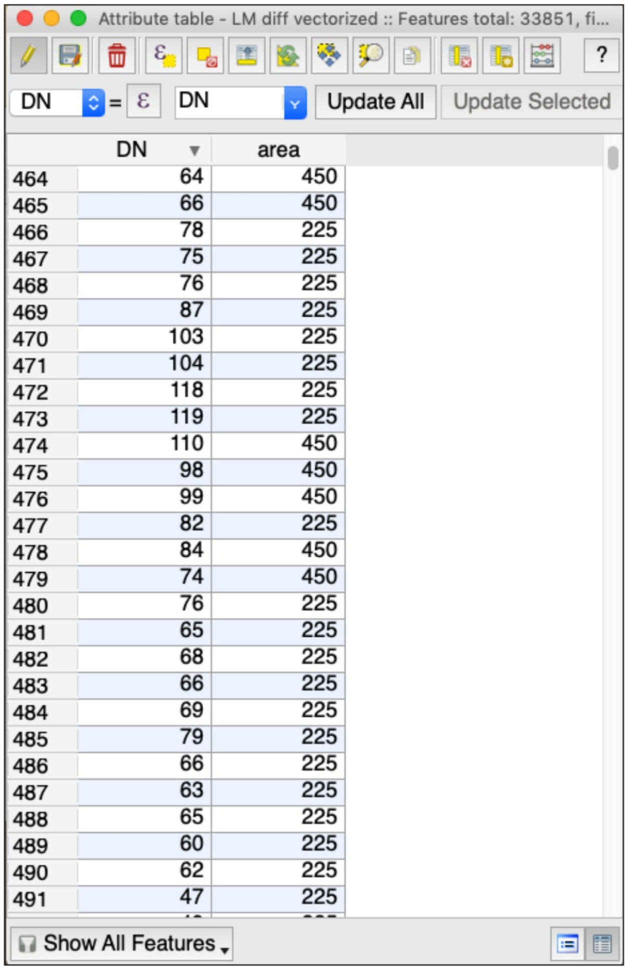


Figure A.11a



	DN	area
464	64	450
465	66	450
466	78	225
467	75	225
468	76	225
469	87	225
470	103	225
471	104	225
472	118	225
473	119	225
474	110	450
475	98	450
476	99	450
477	82	225
478	84	450
479	74	450
480	76	225
481	65	225
482	68	225
483	66	225
484	69	225
485	79	225
486	66	225
487	63	225
488	65	225
489	60	225
490	62	225
491	47	225

Figure A.11b

12. Calculate the volume by exporting the attribute table to a worksheet, in this case to a Microsoft Excel sheet. Here, sort the cells by the height value, and delete the negative and null values (Table A1). Multiplicate the height value by the area of each polygon in a new column named "*volume*". Finally, sum all the volumes to calculate the total volume eroded in m^3. A conversion to km^3 is recommended (Table A2).

height (m)	area (m^2)
~~-47~~	~~225~~
~~-32~~	~~225~~
~~-30~~	~~225~~
...	...
261	225
263	225
264	225

Table A.1

height (m)	area (m^2)	volume (km^3)	
1	225	225	
1	225	225	
1	225	225	
...	...	...	
261	225	58725	
263	225	59175	
264	225	59400	
		857159100	Total volume (m^3)
		0.86 Total volume (km^3)	

Table A.2

For further Dense Rock Equivalent corrections of pyroclastic deposits, additional data is needed, such as rock density and lithic content.