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COMET 67P/CHURYUMOV- GERASIMENKO NORTHERN HEMISPHERE GEOLOGICAL MAPS

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CHANGE LOG

Reason for change	Issue	Revision	Date
Completed the executive summary and mostly the extended introduction. Inserted bibliography.	1	1	2021/02/08
Employed new dedicated PUG preamble file and macro for title page generation therein.	1	2	2021/02/11
Employed new macro for change log generation. Employed new macro for nice final page.	1	3	2021/02/11
Finalized the extended introduction. Added contact information. Completed (concise draft of dataset introduction. Added many acronyms.	1	4	2021/02/15
Slightly revised dataset introduction. Drafted Scientific Objectives.	1	5	2021/03/02
Extended the Science Objectives and wrote some Acknowledgements.	1	7	2021/04/14
Completed Acknowledgements. Started with Data Product Generation. Included automatically generated file tree in Archive Format and Content.	1	11	2021/04/28
Completed Data Product Generation and wrote Archive Format and Content, Known Issues, and Software.	1	12	2021/05/12
Removed the earlier version of the Paper directory from the data set, added the combined geological feature maps, and updated the PUG accordingly. Applied changes suggested by Sebastien Besse (page format, title, few rephrasings). Corrected several typos.	2	2	2021/05/14

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1 Introduction

1.1 Executive Summary

This data set contains products from geological mapping of comet 67P/Churyumov-Gerasimenko conducted at the European Space Astronomy Centre (ESAC) in 2020. They consist of global maps of the complete comet and regional maps of the individual geological regions. Maps are presented in different versions of the Quincuncial Adaptive Closed Kohonen (QuACK) map projection. The geological features which have been mapped are also provided as shape files in the format of the Small Body Mapping Tool (SBMT). The results of this work have been published by Leon-Dasi et al. (2021) in *Astronomy & Astrophysics*.

1.2 Extended introduction

The data from the Rosetta mission enabled the reconstruction of the shape of comet 67P and the identification of the terrains and features forming its surface. The highly irregular shape of the comet (Preusker et al., 2015) poses a challenge for the depiction of these geological features on two-dimensional maps. Standard global map projections cannot display the complete surface of 67P because different points on the surface can have the same longitude and latitude. As a consequence, the geological maps published to date are created on top of comet images (e.g., Pajola et al., 2015; Giacomini et al., 2016), making them dependent on the viewing angle and image coverage and resolution.

Here, we made use of the QuACK map projection (Grieger, 2019). It projects the complete surface of 67P unambiguously onto a square. The QuACK map is topologically equivalent to the Peirce quincuncial projection of the world (Peirce, 1879), which projects a sphere conformally onto a square. This makes it possible to define generalized longitudes and latitudes. These can be used within any global map projection in order to obtain an unambiguous QuACK version. The data set contains global maps of the entire comet showing the region boundaries in different version of the QuACK map projection and for comparison also the commonly used equidistant cylindrical projection.

The mapping of geological features was carried out in three dimensions employing the SBMT (Ernst et al., 2018). We used images from OSIRIS NAC aboard Rosetta (available in the PSA, see section 2.1) which had been pro-



jected onto the shape model of the SBMT. The mapped features were exported to shape files, which are also provided in this data set. They can be re-imported into the SBMT.

The three-dimensional coordinates of the features were then projected onto two-dimensional maps, either in the QuACK map projection or in the QuACK version of the equidistant cylindrical projection. Individual maps for 17 of the 26 regions of 67P, mostly located in the northern hemisphere, are provided in this data set. The new maps combine features published in previous studies with newly identified features. In addition, there are two maps illustrating proposed adjustments to the redefinition of the regional boundaries for the Anubis-Atum and Aker-Babi frontiers.

1.3 ESA-AURORA_67P-GEOMAP_OSIRIS_V1.0 introduction

The purpose of this PUG is to enable the user to exploit the data products contained in this data set. These are:

- global maps of region boundaries in SVG, PNG, and EPS format,
- regional maps of geological features in PNG format,
- SBMT shape files of geological features in XML format,
- QuACK map coordinates of geological features as plain text files,
- statistics of geological features and regions in XLSX format,
- MATLAB code to convert the region definitions available in a VTK file to the XML format readable by the SBMT, to read SBMT shape files, and to create the maps,

All products are described in section 4. For a comprehensive introduction, please consult the respective scientific paper by Leon-Dasi et al. (2021).

For information about this data set, contact

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1.4 Abbreviations and Acronyms

67P	— Comet 67P/Churyumov-Gerasimenko
EPS	— Encapsulated PostScript, a format for graphical data
ESA	— European Space Agency
ESAC	— European Space Astronomy Centre
MATLAB	— “matrix laboratory”, a proprietary multi-paradigm programming language and numeric computing environment
NAC	— Narrow Angle Camera
OSIRIS	— Camera system aboard the Rosetta S/C
PNG	— Portable Network Graphics, a raster-graphics file format
PSA	— Planetary Science Archive of ESA
PUG	— Product User Guide
QuACK	— Quincuncial Adaptive Closed Kohonen map projection
SBMT	— Small Body Mapping Tool
S/C	— Spacecraft



- SVG — Scalable Vector Graphics, an Extensible Markup Language (XML)-based vector image format for two-dimensional graphics
- VTK — Visualization Toolkit, an open-source software system for 3D computer graphics
- XLSX — Excel Spreadsheet XML format
- XML — Extensible Markup Language, a markup language that defines a set of rules for encoding documents

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2 Scientific Objectives

Geological features on the surface of solar system bodies tell the story of the creation and evolution of the individual body itself as well as of the whole solar system. Few comets have been visited by S/C for a close up and personal inspection. The most detailed investigation of a comet to date was performed by the Rosetta S/C at 67P from 2014 to 2016.

The OSIRIS camera system aboard Rosetta has acquired a wealth of images at different resolutions and illumination conditions. These have been used by various groups (e.g., Pajola et al., 2015; Giacomini et al., 2016) to map geological features. However, these mappings were performed on individual images, so they cannot be studied in a common framework.

Here, we have collected the available data on geological features from literature, re-mapped them with the SBMT (Ernst et al., 2018) to obtain consistent 3D coordinates, added additional features mapped in the same way, and projected all features in the common framework of the QuACK map projection (Grieger, 2019). We cover mostly the Northern hemisphere of 67P because the shape model available in the SBMT is an early version where the Southern hemisphere that was in polar night at the beginning of the comet escort is not represented very accurately.

We present global maps of the comet in the commonly used equidistant cylindrical projection and two novel projections based on the QuACK map. While

common projections cannot display the complete surface of comet 67P, the QuACK based projections can. We also present regional maps of individual regions of the comet as defined by Thomas et al. (2018). Even for spherical bodies, there is no projection that displays the complete surface without any considerable distortions. Similarly for the much more challenging shape of 67P, we could not find one single projection that displays all regions nicely. However, this can be achieved using only two different projections, both based on the QuACK map. For almost all regions, with the exception of four, the generic QuACK map projection in quincuncial layout is quite appropriate. For the four special regions, we used a generalized version of the equidistant cylindrical projection based on QuACK generalized longitude and latitude (or rather for three of the four regions — one we did not map). For details on these projections, see Grieger (2019), Leon-Dasi et al. (2021).

2.1 Acknowledgments

The geological mapping effort from which these data resulted was supported by an internship from the European Space Agency (ESA) at the European Space Astronomy Center, Madrid, in the period March to December 2020.

For the geological mapping, we have used a total of 66 images from OSIRIS NAC aboard the Rosetta S/C. The images selected were acquired between August and September 2014, at an altitude range from 29 to 116 km, resulting in a spatial resolution ranging from 0.5 to 2.2 m/pixel. The images correspond to the MTP007 (European Space Agency, 2019-01-31, RO-C-OSINAC-3-PRL-67PCHURYUMOV-M07, V3.0. <https://doi.org/10.5270/esa-y6dezqw>) and MTP008 (European Space Agency, 2019-01-31, RO-C-OSINAC-3-PRL-67PCHURYUMOV-M08, V3.0. <https://doi.org/10.5270/esa-18om101>) periods and are available at the Planetary Science Archive (Besse et al., 2018).

If you use data from this data set, please acknowledge it as follows:

European Space Agency, 2021,
ESA-AURORA_67P-GEOMAP_OSIRIS_V1.0,
<https://doi.org/10.5270/esa-kokoti7>

and cite the paper by Leon-Dasi et al. (2021).

3 Data Product Generation

Geological features were identified on OSIRIS NAC images and mapped in 3D employing the SBMT. A complete list of all images used is provided in Leon-Dasi et al. (2021), appendix A “Image list”. At the time of this study, the SBMT used the SHAP4S shape model, which is not very accurate in the Southern hemisphere. For this reason, this study is mostly limited to the Northern hemisphere. Shape files with the 3D coordinates of the mapped features in XML format (contained in this data set) were exported from the SBMT.

The regions of 67P were taken as defined by Thomas et al. (2018) per plate on the SHAP7 shape model with a resolution of 0.2 million plates. They were provided as VTK file and have been converted to SBMT shape files which describe the boundaries between regions (cf. section 6.2). So the boundaries are at first also available as 3D coordinates.

The 3D coordinates of region boundaries and geological features were projected onto the QuACK map (Grieger, 2019) in different layouts employing the quack command line tool. It is available at <https://github.com/esaSPICEService/QuACK>. In order to give an idea of how the quack tool works, its help message is listed in section 6.1.

Renderings of maps were created with MATLAB. Program code is contained in the data set (cf. section 6.2).

The data provided in this data set was presented in a peer-reviewed paper by Leon-Dasi et al. (2021) which was published by *Astronomy & Astrophysics*.

4 Archive Format and Content

4.1 Data set structure

A complete listing of the data set is provided in section A. In the base directory, there are (besides this PUG) two top level directories:

‘Paper’: Maps displayed and SBMT shape files used in the paper by Leon-Dasi et al. (2021).

‘Internship’: QuACK map coordinates of geological features, feature statistics tables, global maps in SVG format, and MATLAB programs.

4.2 ‘Paper’

4.2.1 ‘Global maps’

This directory contains global maps of 67P in different projections in EPS and PNG format. These have been converted from SVG files, which are also contained in this data set (cf. section 4.3.1). For a detailed description of the projections, refer to Leon-Dasi et al. (2021).

These maps depict regions and do not show geological features. Maps combining the mapped features of all regions are in ‘Regional geological maps/Geological maps EPS’.

4.2.2 ‘Regional geological maps’

Individual geological maps in .png format for the 17 regions mapped.

- Equidistant cylindrical layout contains the maps for the Anuket, Apis and Aten in generalized coordinates in the equidistant cylindrical projection.
- QuACK layout contains the maps for the remaining regions in generalized coordinates, QuACK layout North (all except Khepry) and South (Khepry).
- Modified boundaries contains the images for the proposed change in the Atum-Anubis and Babi-Aker boundaries
- Geological maps eps contains all geological maps with axis and scalebar in EPS format

(from the file ‘Readme.txt’)

4.2.3 ‘SBMT shape files’

This directory contains 3D coordinates of geological features exported from the SBMT. The subdirectory and file names should be self-explanatory. The files are in XML format. The syntax is quite simple with reliable line breaking conventions so that the files are relatively easy to parse, even without specific XML tools.



4.3 ‘Internship’

4.3.1 ‘Global maps_SVG’

This directory contains global maps in the original SVG format from which the EPS and PNG versions were created.

4.3.2 ‘Statistics_database’

Excel databases for all the features per region in ‘Regions’ folder and per feature in ‘Features’ folder. For each feature, the name, location (lon,lat) and main characteristic (length or diameter) is provided.

(from ‘Readme.txt’)

Files are in XLSX format.

4.3.3 ‘Code’

We will briefly discuss the MATLAB code contained in this data set in section 6.2. Here, we note that the subdirectory

`Create_Maps/QuACK coordinates features`

contains QuACK map coordinates computed with the quack command line tool (cf. section 6.1):

To generate the map, the shapefiles from the SBMT and the QuACK coordinate features are required. QuACK coordinates features contains, for each region, the coordinates of each point in the paths and each ellipse in the QuACK projection. The `_q` extension refers to coordinates in QuACK layout and the `_c` extension to coordinates in the Generalized Equidistant cylindrical projection

(from ‘Readme.txt’)

5 Known Issues

Different shape models were used to map geological features from images onto the shape with the SBMT (SHAP4S) and to define region boundaries

(SHAP7). In the Northern hemisphere (to which this study is limited), both shape models are very similar, but not identical. Therefore, small scale inconsistencies between region boundaries and geological features can be expected.

6 Software

6.1 The quack command line tool

The quack command line tool which was used to project 3D coordinates onto the QuACK map in different layouts is available at <https://github.com/esaSPICEService/QuACK>. In order to give an idea of how the quack tool works, we list here its help message:

NAME

```
quack - Quincuncial Adaptive Closed Kohonen map
```

SYNOPSIS

```
quack [OPTION]... DSK [FILE]...
```

DESCRIPTION

Project arbitrary 3D points onto the QuACK map.

The first operand has to be the Digital Shape Kernel of a 160,000 plates QuACK shape model.

All subsequent operands are text files containing 3D points to be projected, one vector per line. If option -4 or -l (mutually exclusive, last one takes effect) is given (see below), additional or different values are expected in each line. All spatial dimensions are in kilometers.

When FILE is -, read standard input.

Without any argument or with option --help, print this help message and exit.

OPTIONS

```
-l FILE
```

Compute generalized longitudes and latitudes in degree and write them to FILE. As third value the elevation of the original point relative to the QuACK shape model surface is written to each line.

**-2 FILE**

Compute the 2D map coordinates for hemispheres side by side layout and write them to FILE. As third value the elevation of the original point relative to the QuACK shape model surface is written to each line.

-3 FILE

Project the points onto the surface of the QuACK shape model and write the resultant 3D surface points to FILE. Behind each 3D vector, the ID of the plate where the surface point resides and the elevation of the original point relative to the shape model surface are written in addition.

-4

Expect as input a file which has previously been written with option -3, providing plate ID and elevation behind the 3D vector in each line. This is much faster.

-5 FILE

Compute the 2D map coordinates for quincuncial layout with the Northern hemisphere centered and write them to FILE. As third value the elevation of the original point relative to the QuACK shape model surface is written to each line.

-c TYPE

Write to standard output (console). The type of the output to be computed is one of 1, 2, 3, 5, or s and corresponds to the output requested by option -1, -2, -3, -5, or -s, respectively.

-1

Expect as input in each line generalized longitude and latitude in degree and elevation relative to the QuACK shape model surface. The elevation is just propagated to the output and can safely be given as 0. Output option/type 3 is not supported with this option.

-s FILE

Compute the 2D map coordinates for quincuncial layout with the Southern hemisphere centered and write them to FILE. As third value the elevation of the original point relative to the QuACK shape model surface is written to each line.

--help Print this help message and exit.

EXAMPLES

```
quack -5 quincuncial.txt chury_quack_tri_02_01.bds points.txt
```

Read 3D positions from file points.txt and write the respective



coordinates on the QuACK map in quincuncial layout to file quincuncial.txt.

```
echo '2.442 -0.068 -0.345' | quack chury_quack_tri_02_01.bds - -c5
```

Compute the QuACK map coordinates in quincuncial layout for the point '2.442 -0.068 -0.345' and write the result to the console. The result should be 0.685386121 0.953147292 1.48380529E-02.

```
quack -3 onshape.txt quack chury_quack_tri_02_01.bds points.txt
quack -1 lonlat.txt -4 chury_quack_tri_02_01.bds onshape.txt
```

First, read the positions from file pointst.txt, project them onto the QuACK shape model, and write the results to file onshape.txt. Second, read the projected points from file onshape.txt, compute generalized longitudes and latitudes, and write them to file lonlat.txt.

Generalized longitudes and latitudes can be manipulated by other means (e.g., rotated in order to create a traverse or oblique aspect) and then fed back into quack:

```
quack -15 quinc_traverse.txt chury_quack_tri_02_01.bds lonlat.txt
```

6.2 MATLAB programs contained in the data set

In the subdirectory

Internship/Code

there are MATLAB programs to 'Create_Maps', 'Read_SBMT', and a 'VTK converter'. Concerning the latter:

vtk2xml.m is a script to convert the region definitions from Thomas in vtk format to the xml format readable by the SBMT, either as point data or as polygon data

(from 'Readme.txt')

A Complete listing of the data set

ESA-AURORA_67P-GEOMAP_OSIRIS_V1.0


```

|-- Internship
|   |-- Code
|       |-- Create_Maps
|           |-- Colors.mat
|           |-- Mesh2M_out.txt
|           |-- QuACK\ coordinates\ features
|               |-- Aker_ellipses_q.txt
|               |-- Aker_paths_q.txt
|               |-- Anubis_ellipses_q.txt
|               |-- Anubis_paths_q.txt
|               |-- Anuket_ellipses_c.txt
|               |-- Anuket_ellipses_q.txt
|               |-- Anuket_paths_c.txt
|               |-- Anuket_paths_q.txt
|               |-- Apis_ellipses_c.txt
|               |-- Apis_ellipses_q.txt
|               |-- Apis_paths_c.txt
|               |-- Apis_paths_q.txt
|               |-- Ash_ellipses_q.txt
|               |-- Ash_paths_q.txt
|               |-- Aten_ellipses_c.txt
|               |-- Aten_ellipses_q.txt
|               |-- Aten_paths_c.txt
|               |-- Aten_paths_q.txt
|               |-- Atum_ellipses_q.txt
|               |-- Atum_paths_q.txt
|               |-- Babi_ellipses_q.txt
|               |-- Babi_paths_q.txt
|               |-- Hapi_ellipses_q.txt
|               |-- Hapi_paths_q.txt
|               |-- Hathor_ellipses_q.txt
|               |-- Hathor_paths_q.txt
|               |-- Hatmehit_ellipses_q.txt
|               |-- Hatmehit_paths_q.txt
|               |-- Imhotep_ellipses_q.txt
|               |-- Imhotep_paths_q.txt
|               |-- Khepry_ellipses_c.txt
|               |-- Khepry_ellipses_q.txt
|               |-- Khepry_paths_c.txt

```

```

| | | | |-- Khepry_paths_q.txt
| | | | |-- Maat_ellipses_q.txt
| | | | |-- Maat_paths_q.txt
| | | | |-- Nut_ellipses_q.txt
| | | | |-- Nut_paths_q.txt
| | | | |-- Serqet_ellipses_q.txt
| | | | |-- Serqet_paths_q.txt
| | | | |-- Seth_ellipses_q.txt
| | | | '-- Seth_paths_q.txt
| | | |-- Readme.txt
| | | |-- Region_projection.m
| | | |-- idx_sub.mat
| | | |-- region_order.mat
| | | |-- triangulation_2M.mat
| | | '-- triangulation_sub.mat
| | |-- Read_SBMT
| | | |-- Ellipse_reader.m
| | | '-- Path_reader.m
| | '-- VTK\ converter
| | | |-- Readme.txt
| | | |-- cart2llr.m
| | | |-- read_vtk.m
| | | '-- vtk2xml.m
| |-- Global\ maps_SVG
| | |-- Equidistant_cylindrical.svg
| | |-- QuACK_cylindrical.svg
| | |-- QuACK_polar_N.svg
| | |-- QuACK_polar_N_cut.svg
| | |-- QuACK_polar_S.svg
| | |-- QuACK_polar_S_cut.svg
| | |-- QuACK_projection_N.svg
| | '-- QuACK_projection_S.svg
| '-- Statistics_database
| | |-- Features
| | | |-- Bright_Patches.xlsx
| | | |-- Complete_Fractures.xlsx
| | | |-- Complete_Niches.xlsx
| | | |-- Complete_Ridges.xlsx
| | | '-- Complete_Terraces.xlsx

```

```
|      |-- Mapping_Database.xlsx
|      |-- Readme.txt
|      '-- Regions
|          |-- Aker_Ellipses.xlsx
|          |-- Aker_Paths.xlsx
|          |-- Anubis_Ellipses.xlsx
|          |-- Anubis_Paths.xlsx
|          |-- Anuket_Ellipses.xlsx
|          |-- Anuket_Paths.xlsx
|          |-- Apis_Ellipses.xlsx
|          |-- Apis_Paths.xlsx
|          |-- Ash_Ellipses.xlsx
|          |-- Ash_Paths.xlsx
|          |-- Aten_Ellipses.xlsx
|          |-- Aten_Paths.xlsx
|          |-- Atum_Ellipses.xlsx
|          |-- Atum_Paths.xlsx
|          |-- Babi_Ellipses.xlsx
|          |-- Babi_Paths.xlsx
|          |-- Hapi_Ellipses.xlsx
|          |-- Hapi_Paths.xlsx
|          |-- Hathor_Ellipses.xlsx
|          |-- Hathor_Paths.xlsx
|          |-- Hatmehit_Ellipses.xlsx
|          |-- Hatmehit_Paths.xlsx
|          |-- Imhotep_Ellipses.xlsx
|          |-- Imhotep_Paths.xlsx
|          |-- Khepry_Ellipses.xlsx
|          |-- Khepry_Paths.xlsx
|          |-- Maat_Ellipses.xlsx
|          |-- Maat_Paths.xlsx
|          |-- Nut_Ellipses.xlsx
|          |-- Nut_Paths.xlsx
|          |-- Serqet_Ellipses.xlsx
|          |-- Serqet_Paths.xlsx
|          |-- Seth_Ellipses.xlsx
|          '-- Seth_Paths.xlsx
|-- PUG_ESA-AURORA_67P-GEOMAP_OSIRIS.pdf
'-- Paper
```

```

|-- Global\ maps
|   |-- EPS
|   |   |-- Equidistant_cylindrical.eps
|   |   |-- QuACK_cylindrical.eps
|   |   |-- QuACK_polar_N.eps
|   |   |-- QuACK_polar_N_cut.eps
|   |   |-- QuACK_polar_S.eps
|   |   |-- QuACK_polar_S_cut.eps
|   |   |-- QuACK_projection_N.eps
|   |   |-- QuACK_projection_N_Colored.eps
|   |   |-- QuACK_projection_S.eps
|   |   |-- QuACK_projection_S_Colored.eps
|   |-- PNG
|   |   |-- Equidistant_cylindrical.png
|   |   |-- QuACK_cylindrical.png
|   |   |-- QuACK_polar_N.png
|   |   |-- QuACK_polar_N_cut.png
|   |   |-- QuACK_polar_S.png
|   |   |-- QuACK_polar_S_cut.png
|   |   |-- QuACK_projection_N.png
|   |   |-- QuACK_projection_N_Colored.png
|   |   |-- QuACK_projection_S.png
|   |   |-- QuACK_projection_S_Colored.png
|-- Regional\ geological\ maps
|   |-- Equidistant\ cylindrical\ layout
|   |   |-- Anuket_axis.png
|   |   |-- Apis_axis.png
|   |   |-- Aten_axis.png
|   |-- Geological\ maps\ EPS
|   |   |-- Atum_Anubis.eps
|   |   |-- Babi_Aker.eps
|   |   |-- Consolidated.eps
|   |   |-- Depressions.eps
|   |   |-- Fractures.eps
|   |   |-- Niche.eps
|   |   |-- QuACK_all.eps
|   |   |-- QuACK_all_South.eps
|   |   |-- Smooth.eps
|   |-- Modified\ boundaries

```

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| | |-- Atum_Anubis.png
| | |-- Atum_Anubis_axis.png
| | |-- Babi_Aker.png
| | '-- Babi_Aker_axis.png
| |-- QuACK\ layout
| | |-- Aker_axis.png
| | |-- Anubis_axis.png
| | |-- Ash_axis.png
| | |-- Atum_axis.png
| | |-- Babi_axis.png
| | |-- Hapi_axis.png
| | |-- Hathor_axis.png
| | |-- Hatmehit_axis.png
| | |-- Imhotep_South.png
| | |-- Khepry_axis.png
| | |-- Maat_axis.png
| | |-- Nut_axis.png
| | |-- Serqet_axis.png
| | '-- Seth_axis.png
| '-- Readme.txt
'-- SBMT\ Shapefiles
    |-- 00_All
    | |-- Complete_Boulders
    | |-- Complete_Ellipses
    | |-- Complete_Fractures
    | |-- Complete_Niches
    | |-- Complete_Patches
    | |-- Complete_Paths
    | |-- Complete_Polygons
    | |-- Complete_Ridges
    | '-- Complete_Terraces
    |-- Aker
    | |-- Aker_Ellipses
    | '-- Aker_Paths
    |-- Anubis
    | |-- Anubis_Ellipses
    | |-- Anubis_Paths
    | |-- Anubis_Paths_Giacomini
    | '-- Anubis_Paths_own

```

```
|-- Anuket
|   |-- Anuket_Ellipses
|   |-- Anuket_Paths
|   |-- Anuket_Paths_Giacomini
|   '-- Anuket_Paths_own
|-- Apis
|   |-- Apis_Ellipses
|   '-- Apis_Paths
|-- Ash
|   |-- Ash_Ellipses
|   |-- Ash_Paths
|   |-- Ash_Paths_Giacomini
|   '-- Ash_Paths_own
|-- Aten
|   |-- Aten_Ellipses
|   |-- Aten_Paths
|   |-- Aten_Paths_Giacomini
|   '-- Aten_Paths_own
|-- Atum
|   |-- Atum_Ellipses
|   '-- Atum_Paths
|-- Babi
|   |-- Babi_Ellipses
|   '-- Babi_Paths
|-- Boundaries
|   '-- Boundaries
|-- Hapi
|   |-- Hapi_Ellipses
|   '-- Hapi_Paths
|-- Hathor
|   |-- Hathor_Ellipses
|   '-- Hathor_Paths
|-- Hatmehit
|   |-- Hatmehit_Ellipses
|   |-- Hatmehit_Paths
|   |-- Hatmehit_Paths_Giacomini
|   '-- Hatmehit_Paths_own
|-- Imhotep
|   |-- Imhotep_Ellipses
```



```
| |-- Imhotep_Ellipses_Auger
| |-- Imhotep_Ellipses_own
| |-- Imhotep_Paths
| |-- Imhotep_Paths_Auger
| '-- Imhotep_Paths_own
|-- Khepry
| |-- Khepry_Ellipses
| '-- Khepry_Paths
|-- Maat
| |-- Maat_Ellipses
| |-- Maat_Paths
| |-- Maat_Paths_Giacomini
| '-- Maat_Paths_own
|-- Nut
| |-- Nut_Ellipses
| |-- Nut_Paths
| |-- Nut_Paths_Giacomini
| '-- Nut_Paths_own
|-- Readme.txt
|-- Regions_50k
| |-- Regions_50k_facets
| '-- Subregions_50k_facets
|-- Serqet
| |-- Serqet_Ellipses
| '-- Serqet_Paths
'-- Seth
    |-- Seth_Ellipses
    |-- Seth_Paths
    |-- Seth_Paths_Giacomini
    |-- Seth_Paths_Vincent
    '-- Seth_Paths_own
```



END OF PUG