Data Article

Geospatial data from a global survey of martian fan-shaped sedimentary landforms

Alexander M. Morgan\textsuperscript{a,b,*}, Sharon A. Wilson\textsuperscript{b}, Alan D. Howard\textsuperscript{a}

\textsuperscript{a}Planetary Science Institute, 1700 E. Fort Lowell, Suite 106 Tucson, AZ 85719, United States
\textsuperscript{b}Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, PO Box 37012, MRC 315 Washington DC 20013-7012, United States

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\textbf{ABSTRACT}

Data in this article are related to the research article “The global distribution and morphologic characteristics of fan-shaped sedimentary landforms on Mars”. We used globally available image and topographic data to document the location of every fan-shaped sedimentary landform on the surface of Mars. We mapped fan outlines and associated drainage basins and collected a number of morphologic metrics. These data can be used as a boundary condition for studies of global scale studies of Mars, including climate and hydrologic modeling. Data files publicly available on Figshare include point shapefile of fan apices, and polygon shapefiles of fan outlines and drainage basins.

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* Corresponding author.
E-mail address: amorgan@psi.edu (A.M. Morgan).
Social media: @geologyonmars (A.M. Morgan)

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Specifications Table

| Subject                | Earth and Planetary Science |
|------------------------|-----------------------------|
| Specific subject area  | Space and Planetary Science, Geographical Information System, Earth-Surface Processes |
| Type of data           | Digital maps and metadata attributes |
| How the data were acquired | Data were collected using the following sources: |
|                        | • Context Camera (CTX) Reduced Data Records (https://viewer.mars.asu.edu/) |
|                        | • CTX global mosaic (http://murray-lab.caltech.edu/CTX) |
|                        | • Mars Orbiter Laser Altimeter (MOLA) Precision Experiment Data Records (https://pds-geosciences.wustl.edu/missions/mgs/gedr.html) |
|                        | • MOLA Mission Experiment Gridded Data Records (https://astrogeology.usgs.gov/search/map/Mars/GlobalSurveyor/MOLA/Mars_MGS_MOLA_DEM_mosaic_global_463m) |
|                        | • HRSC digital elevation models (http://hrscview.fu-berlin.de/) |
| Data format            | Raw and processed data (vector shapefiles consisting of .shp and associated files) |
| Description of data collection | Onscreen vectorization of features from orbital remote sensing data |
| Data source location   | Data locations range from 63°S to 44°N across all longitudes on Mars. The raw data used to construct the dataset can be found here: |
|                        | • Context Camera (CTX) Reduced Data Records: https://viewer.mars.asu.edu/ |
|                        | • CTX global mosaic: http://murray-lab.caltech.edu/CTX/ |
|                        | • Mars Orbiter Laser Altimeter (MOLA) Precision Experiment Data Records: https://pds-geosciences.wustl.edu/missions/mgs/gedr.html |
|                        | • MOLA Mission Experiment Gridded Data Records: https://astrogeology.usgs.gov/search/map/Mars/GlobalSurveyor/MOLA/Mars_MGS_MOLA_DEM_mosaic_global_463m |
|                        | • HRSC digital elevation models: http://hrscview.fu-berlin.de/ |
| Data accessibility     | Repository name: Figshare. |
|                        | Data identification number: 10.25573/data.19952486 |
|                        | Direct URL to data: https://www.doi.org/10.25573/data.19952486 |
| Related research article | A.M. Morgan, S.A. Wilson, A.D. Howard, The global distribution and morphologic characteristics of fan-shaped sedimentary landforms on Mars, Icarus. 385 (2022) 115,137. https://doi.org/10.1016/j.icarus.2022.115137 |

Value of the Data

- These data are useful because they document the global distribution and morphologic properties of fan-shaped sedimentary landforms on Mars in a format that can be easily utilized.
- These data benefit researchers interested in the formation and modification of sedimentary landforms across the martian surface.
- These data can be used as a boundary condition for testing hypotheses regarding hydrologic or climatic conditions on ancient Mars.

1. Data Description

The global distribution of water-formed sedimentary landforms is an important parameter in understanding Mars’ hydrologic and climatic evolution. The digitized fan-shaped landforms in these datasets describe the locations and morphologic properties of 1501 alluvial fans and scarp fronted deposits (SFDs; putative deltas) across the surface of Mars.

This article contains a .zip file which contains three Esri shapefiles:

1. Morgan2022_FanDatabase_outlines Polygon vector file marking the approximate outline of each fan in the database
2. Morgan2022_FanDatabase_catchments: Polygon vector file marking the approximate outline of catchments (i.e., watersheds or drainage basins) upstream of each fan in the database
Table 1
Description of the columns within the three shapefiles.

| Column name | Column Description |
|-------------|--------------------|
| fan_id      | A unique id for each fan in the database, with format [prefix]_[i], where [prefix] is either the Robbins and Hynek (2012) crater ID for fans in craters or the quadrangle for fans not in craters, and [i] is a sequential number. |
| fan_type    | The type of fan deposit. Channelized scarp fronted deposit (SFD), smooth SFD, terraced SFD, alluvial fan, equivocal fan, or outflow canyon SFD. |
| reference   | Original reference if used. Some fans marked as “this work” may have been previously noted by other workers but were identified independently here. |
| CRATER_ID   | CRATER_ID from the Robbins and Hynek (2011) database |
| apex_lat_N  | Fan apex latitude (°N) |
| apex_lon_E  | Fan apex longitude (°E) |
| apex_el_km  | Fan apex elevation (km) |
| f_area_km2  | Fan area (km²) |
| bearing     | Azimuthal orientation of fan apex relative to crater center |
| f_sl_deg    | Fan slope along long profile (degrees) |
| f_sl_src    | Data source used to measure fan slope |
| basin_OC    | Type of depositional basin |
| geo_set     | General geomorphic setting |
| catch_cert  | Confidence of catchment mapping, with 3 being most confident |
| c_area_km2  | Catchment area (km²) |
| c_len_km    | Catchment length (km) |
| c_mea_el_m  | Mean catchment elevation (km) |
| c_med_el_m  | Median catchment elevation (km) |
| c_rel_km    | Difference between apex elevation and 90th percentile elevation in the catchment (km) |
| c_len_km    | Catchment length (km) |
| conc_src    | Data source (either 'PEDR' or the HRSC Product ID) for the concavity calculation |
| conc        | Concavity |
| conc_R2     | R² value of measured concavity |

3. Morgan2022_FanDatabase_apices: Point vector file marking the apex of each fan in the database

Each Esri shapefile consists of 6 files (.shp - the main file that gives features their geometry; .shx - an index file that stores the index position of the feature geometry; .dbf - a table that stores feature attribute information; .prj - a file that stores the coordinate and projection system; .sbn and .sbx - spatial index files which speed up data loading times) and can be opened in most GIS software (e.g., ArcGIS or QGIS). The data have a Plate carrée projection and use the GCS_Mars geographic coordinate system.

The .dbf file is a dBASE table that can be opened in spreadsheet applications such as Microsoft Excel and contains 23 columns of data as listed in Table 1.

2. Experimental Design, Materials and Methods

For the associated research article [1], we compiled a global database of fan-shaped sedimentary landforms across the entire surface of Mars. We began by compiling the locations of previously identified alluvial fans and putative deltas [2–4]. In ArcGIS Pro-we conducted a new survey, systematically searching the martian surface in moving search windows of 15° latitude by 30° longitude using the Context Camera (CTX) global mosaic [5] and 50 m topographic contours derived from 128 pixels/degree (463 m/pixel at the equator) Mars Orbiter Laster Altimeter Mission Experiment Gridded Data Records (MOLA MEGDR) topographic data [6].

We identified fan landforms using the following criteria:

1. Patterns in contour orientation, such as a shift from convergent flow in the catchment to divergent flow downslope of the fan apex
2. A break in slope at the fan toe
3. Textural changes between fan surfaces and the surrounding terrain
4. Linear ridges radiating outward from the apex in the downfan direction

For each identified fan, we marked the apex with a point, and mapped the boundaries of the fan and its associated upstream drainage basin with polygons. The lower boundary of the fan was delineated by both the change in CTX-resolvable texture (from smoother fan to rougher crater floor) and by termination of convex-outward contours. Fan catchments were mapped as the eroded upstream region of each fan apex.

The following data were collected for each fan system: fan apex latitude and longitude, fan area, fan length, fan relief, fan gradient, catchment area, catchment length, and catchment relief. Locations and areas were calculated using the “Calculate Geometry” tool in ArcGIS Pro. Fan orientations (column “bearing”) were obtained by dividing each crater into 32 11.25° radial segments and identifying the segment within each fan apex lies. Elevation data for fan and catchment relief were extracted from the global MOLA DEM raster using the ArcGIS Tool Extract Values to Points, using a bilinear interpolation to account for the values of adjacent raster cells. Large gaps between MOLA points, particularly in equatorial regions, make the global DEM unsuitable for measuring fan gradient or concavity. For these metrics we used higher-resolution topographic data from team-produced High Resolution Stereo Camera (HRSC; [7]) digital elevation models (DEMs), or, when these were unavailable for the area, Mars Orbiter Laser Altimeter (MOLA) Precision Experiment Data Records (PEDR) data. For those fans covered by HRSC DEMs, profiles were drawn from the apex to the lowest point along the fan outline (excluding impact craters), and elevations were extracted at a distance equal to the square root of double the square of the DEM resolution. Elevation points that intersected post-fan impact craters were discarded. For fans not covered by HRSC DEM data, we identified all PEDR points that geographically intersected the mapped fan outline and discarded any that intersected post-fan impact craters. The remaining PEDR points were used to construct long profiles from the fan apex to the fan toe. If multiple paths were available, the one with the most PEDR points was used. Fan long profile concavity $B$ was found by fitting a negative exponential function to the equation

$$z = z_0 + (z_a - z_0) \exp[-B(x - x_a)]$$

where $z$ is the local elevation, $z_0$ is the base level elevation (a point beyond the fan toe), $z_a$ is the apex elevation, and $x$ is the distance from the fan apex at $x_a$.

Ethics Statements

No human or animal subjects were involved in data collection.

CRediT Author Statement

**Alexander M. Morgan**: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data Curation, Writing – original draft, Writing – review & editing, Visualization, Project administration, Funding acquisition; **Sharon A. Wilson**: Conceptualization, Methodology, Validation, Investigation, Data Curation, Writing – review & editing, Funding acquisition; **Alan D. Howard**: Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Geospatial data from a global survey of martian fan-shaped sedimentary landforms (Original data) (Figshare).

Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2022.108494.

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