

# Benjamin T. Cardenas

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Principal Investigator - The Planetary Sedimentology Laboratory  
Founder – Society for Sedimentary Geology Planetary Research Group  
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## PROFESSIONAL APPOINTMENTS

The Pennsylvania State University, since July 2022  
Department of Geosciences, College of Earth and Mineral Sciences  
Assistant Professor

California Institute of Technology, September 2019 – June 2022  
Division of Geological and Planetary Sciences  
Postdoctoral Scholar Fellowship Trainee in Geology  
National Science Foundation Earth Sciences Postdoctoral Fellow  
Mars Science Laboratory Science Team Collaborator  
Advisors: Mike Lamb and John Grotzinger

## EDUCATION

PhD, Geological Sciences, 2019  
The University of Texas at Austin, Jackson School of Geosciences  
Advisor: David Mohrig  
Dissertation: The accumulation and preservation of fluvial and aeolian strata

MS, Geological Sciences, 2014  
The University of Texas at Austin, Jackson School of Geosciences  
Advisors: David Mohrig and Gary Kocurek

BS, Geological Sciences with Mathematics minor, 2012  
The University of Texas at San Antonio  
Undergraduate Research Advisors: Hongjie Xie and Judy Haschenburger

## MISSION EXPERIENCE

1. Mars Science Laboratory Science Team Collaborator, 2020-2022

## FUNDING

### At The Pennsylvania State University

#### 2022

1. PI Cardenas, NASA Solar System Workings program, Can martian fluvial ridges be used to measure structural tilt? Funding period 2022 – 2025.

### **Prior to appointment at The Pennsylvania State University**

11. National Science Foundation Earth Sciences Postdoctoral Fellowship: A channel-belt scale source of autogenic topography controlling fluvial sedimentation and preservation: Investigation using 3D seismic volumes, May 2021 – June 2022
10. University of Texas at Austin Graduate School Summer Fellowship, Summer 2019
9. University of Texas at Austin Graduate Student Scholarship, January 2019
8. University of Texas at Austin Undergraduate Research Fellowship for field work at White Sands National Monument, New Mexico. Awarded to undergraduate mentee Feifei Zhao, Spring 2018
7. NASA/Mars Exploration Program Travel Grant to the Fourth landing site workshop for the Mars 2020 rover mission, October 2018
6. NASA/Mars Exploration Program Travel Grant to the Fifth Planetary Dunes Workshop, May 2017
5. Jackson School of Geosciences Seed Grant, January 2016
4. Jackson School of Geosciences Planetary Science Theme Scholarship, January 2015
3. Jackson School of Geosciences Off-Campus Research Grant, May 2013
2. Jackson School of Geosciences Entry Fellowship, 2012-2013
1. Best Talk Award, Minority Opportunities for Research in Engineering and Science Colloquium, University of Texas at San Antonio, May 2012

### **PUBLICATIONS**

#### **Planetary Sedimentology Lab members in bold**

#### **In Review/In Revision**

2. Wu, C., Kim, W., Herring, R., **Cardenas, B.T.**, Dong, T., Ma, H., Moodie, A., Tsai, F., Li, A., and Nittrouer, J. Pace of meandering and avulsion set river sinuosity near coast on Earth and Mars. In review.
1. **Cardenas, B.T.** and Lamb, M.P. Paleogeographic evolution of a martian shoreline. In review.

#### **Accepted/In Press**

2. **Cardenas, B.T.**, Lamb, M.P., and Grotzinger, J.P. Carving martian landscapes from ancient sedimentary basins. Accepted for publication in Nature Geoscience.
1. **Cardenas, B.T.**, Grotzinger, J.P., Lamb, M.P., Lewis, K., Fedo, C., Dietrich, W., Bryk, A., Stein, N., Turner, M., and Caravaca, G. Barform deposits of the Carolyn Shoemaker formation, Gale crater, Mars. Accepted for publication in Journal of Sedimentary Research.

#### **Published**

**2022**

12. Swartz, J., **Cardenas, B.T.**, Mohrig, D., and Passalacqua, P. Tributary channel networks formed by depositional processes. *Nature Geoscience*, v. 15, p. 216-221.

### **2021**

11. Hayden, A.T., Lamb, M.P., Myrow, P., Mohrig, D., Williams, R.M.E., Cuevas Martinez, J.L., **Cardenas, B.T.**, Findlay, C.P., Ewing, R.C., and McElroy, B.J. The Oligocene-Miocene Guadalupe-Matarranya fan, Spain, as an analog for long-lived, ridge-bearing megafans on Mars. *Journal of Geophysical Research – Planets*, v. 126, e2021JE006993.
10. Zhao, F., Kim, W., and **Cardenas, B.T.** (2021) Controls of aeolian dune height on cross-strata architecture: White Sands, New Mexico, USA. In Press, *Journal of Sedimentary Research*, v. 91, p. 1-12.

### **2020**

9. Mason, J., **Cardenas, B.T.**, Day, M.D., Daniller-Varghese, M., Brothers, S.C., Kocurek, G., and Mohrig, D. (2020) Pattern evolution and interactions in subaqueous dune fields: North Loup River, Nebraska, U.S.A. *Journal of Sedimentary Research*, v. 90, p. 1734-1746.
8. **Cardenas, B.T.**, Mohrig, D., Goudge, T.A., Hughes, C.M., Levy, J.S., Swanson, T., Mason, J., and \*Zhao, F. The anatomy of exhumed river-channel belts: Bedform- and belt-scale kinematics of the Ruby Ranch Member, Cretaceous Cedar Mountain Formation, Utah, USA. *Sedimentology*, v. 67, p. 3655-3682.

### **2019**

7. **Cardenas, B.T.**, Swanson, T., Goudge, T.A., Wagner, R.W., and Mohrig, D. The effect of remote sensing resolution limits on aeolian sandstone measurements and the reconstruction of ancient dune fields on Mars: Numerical experiment using the Page Sandstone, Earth. *Journal of Geophysical Research – Planets*, v. 124, p. 3244-3256.
6. Swanson, T., Mohrig, D., Kocurek, G., **Cardenas, B.T.**, Wolinsky, M.A. (2019) Preservation of autogenic processes and allogenic forcings within set-scale aeolian architecture I: numerical experiments. *Journal of Sedimentary Research*, v. 89, p. 728-740.
5. **Cardenas, B.T.**, Kocurek, G., Mohrig, D., Swanson, T., Hughes, C.M., and Brothers, S.C. (2019) Preservation of autogenic processes and allogenic forcings in set-scale aeolian architecture II: the scour-fill dominated Jurassic Page Sandstone, Arizona, USA. *Journal of Sedimentary Research*, v. 89, p. 741-760.
4. Kocurek, G., Martindale, R.C., Day, M.D., Goudge, T.A., Kerans, C., Hassenruck-Gudipati, H.J., Mason, J., **Cardenas, B.T.**, Petersen, E.I., Mohrig, D., Aylward, D.S., Hughes, C.M., and Nazworth, C.M. (2019) Antecedent aeolian dune topographic control on carbonate and evaporate facies: Jurassic Todilto Member, Wanakah Formation, Ghost Ranch, New Mexico, USA. *Sedimentology*, v. 66, p. 808-837.
3. Hughes, C.M., **Cardenas, B.T.**, Goudge, T.A., and Mohrig, D. (2019) Deltaic Deposits Indicative of a Paleo-Coastline at Aeolis Dorsa, Mars. *Icarus*, v. 317, p. 442-453.

### **2018**

2. Goudge, T.A., Mohrig, D., **Cardenas, B.T.**, Hughes, C.M., and Fassett, C.I. (2018) Stratigraphy and Paleohydrology of Delta Channel Deposits, Jezero Crater, Mars. *Icarus*, v. 301, p. 58-75.

1. **Cardenas, B.T.**, Mohrig, D., and Goudge, T.A. (2018), Fluvial stratigraphy of valley fills at Aeolis Dorsa, Mars: Evidence for base-level fluctuations controlled by a downstream water body. GSA Bulletin, v. 130, p. 484-498.

#### **Other Publications**

2. **Cardenas, B.T.** (2019) The Accumulation and Preservation of Fluvial and Aeolian Strata. PhD Dissertation, University of Texas at Austin.
1. **Cardenas, B.T.** (2014) Evidence for coastline-controlled changes in base level from fluvial stratigraphy at Aeolis Dorsa, Mars. MS Thesis, University of Texas at Austin.

#### **MENTORSHIP**

##### **The Pennsylvania State University**

###### ***PhD***

1. Kaitlyn Stacey, PhD (expected 2027)

###### ***Undergraduate***

1. Zachary Baran, BS (expected 2023)

##### **Prior to appointment at Penn State**

###### ***Caltech (as a postdoctoral fellow)***

1. Patrick Donahoe, Undergraduate Class of 2024.

###### ***University of Texas at Austin (as a PhD student)***

2. Feifei Zhao, BS 2020.

1. Cory Hughes, BS 2018.

#### **TEACHING**

##### **The Pennsylvania State University**

#### **SERVICE**

##### **Manuscript Reviews**

Earth and Planetary Science Letters  
Earth Surface Processes and Landforms  
Geology  
Geophysical Research Letters  
Geosphere  
Icarus  
Journal of Geophysical Research: Earth Surface  
Journal of Geophysical Research: Planets  
Nature Communications  
Science Advances  
The Sedimentary Record  
Sedimentology

## **Proposal Review Panels**

### **2022**

National Aeronautics and Space Administration

### **2021**

National Aeronautics and Space Administration

## **Synergistic Activities**

8. Co-convener of AGU's Planetary Surface Processes session, Chicago, IL, December 2022.
7. Co-organizer of Second Annual Meeting of SEPM's Planetary Research Group, GSA Meeting, Denver, CO, October 2022
6. Co-organizer of First Annual Meeting of SEPM's Planetary Research Group, 2021
5. Founder of Planetary Science Research Group, SEPM Society for Sedimentary Geology, 2020 - current
4. Participant in online workshop *Hard Conversations: Intro to Racism and its Undoing*, September-October 2020
3. Official Twitter microblogger for the 50<sup>th</sup> Lunar and Planetary Science Conference, March 2019
2. Organizer of the UT Austin Soft Rock Seminar, 2016–2017
1. Graduate Student Representative for the Planetary Science Research Theme at the JSG, 2015-2017

## **INVITED TALKS**

15. University of Arkansas, Department of Geosciences Colloquium, November 2022.
14. Texas A&M, Geology and Geophysics Seminar, November 2021.
13. University of Texas at San Antonio, Geology Seminar, October 2021.
12. University of Washington, June 2021.
11. Georgia Southern University, April 2021.
10. The Pennsylvania State University, Department of Geosciences Colloquium Series, March 2021.
9. University of Illinois at Chicago, Earth and Environmental Science Seminar, March 2021.
8. University of California, Berkeley, EPS Department Colloquium, February 2021.
7. Caltech, guest lecture in Geomorphology, November 2020.
6. University of Washington, October 2020.
5. Caltech, Geoclub Seminar, June 2020.

4. Stanford University, guest lecture, June 2020.
3. University of Washington, cancelled due to covid-19 concerns, April 2020.
2. Brown University, Planetary Lunch Bunch, Providence, Rhode Island, January 2020.
1. Rice University, Sedimentology Seminar, Houston, Texas, September 2017.

## **PRESS**

6. Comment on a published manuscript, "Satellite Images Reveal a New View of Ancient Earth's Rivers" by Joel Goldberg in Eos, July 2022. <https://eos.org/articles/satellite-images-reveal-a-new-view-of-ancient-earths-rivers>
5. Science Salutation, for Setting up the Preservation of Fluvial Channel Belts, Salutation by Kyle Straub. Shaw Sedimentology and Stratigraphy Laboratory at the University of Arkansas, <https://sandandmud.org/2020/12/05/ss4-cardenas-et-al-setting-up-the-preservation-of-fluvial-channel-belts/>, December 5, 2020.
4. Live television interview, 'Water on Mars', Fox 7 Austin KTBC, July 25, 2018.
3. Interview discussing analogs in planetary science, We Martians Podcast, Episode 39, [www.wemartians.com](http://www.wemartians.com).
2. "Mars research finds evidence of vast bodies of water" by Sabrina Tran in the Daily Texan, Oct. 2017.
1. "Study of Martian sedimentary layers reveals more about the planet's past" by Matt Williams in Universe Today, Sep. 2017.

## **PROFESSIONAL ORGANIZATION MEMBERSHIP**

3. Geological Society of America, 2012 - current
2. American Geophysical Union, 2012 - current
1. SEPM Society for Sedimentary Geology, 2013 – current

## **CONFERENCE ABSTRACTS**

### **Planetary Sedimentology Lab members in bold**

#### **2022**

31. **Cardenas, B.T.**, Grotzinger, J.P., Lamb, M.P., Lewis, K. Fedo, C., Dietrich, W., Bryk, A., Stein, N., Turner, M., and Caravaca, G. Preserved barform deposits in the Carolyn Shoemaker formation, Gale crater, Mars. Abstract ID 1062763, presented at American Geophysical Union Fall Meeting, Chicago, IL, Dec.
30. **Cardenas, B.T.**, Lamb, M.P., and Grotzinger, J.P., 2022, Erosional windows into ancient sedimentary basins on Mars. Abstract ID 378687, presented at Geological Society of America Connects 2022 in Denver, CO, Oct.

## 2021

29. Wu, C., Kim, W., Moodie, A.J., **Cardenas, B.T.**, Herring, R., Dong, T.Y., Ma, H., and Tsai, F. T.-C., Li, A., and Nittrouer, J.A., 2021, Pace of meandering and avulsion set river sinuosity near coast on Earth on Mars: EP31A-07, presented at American Geophysical Union Fall Meeting, New Orleans, LA, 13-17 Dec.

## 2020

28. **Cardenas, B.T.**, Lamb, M.P., Woodward, W.W., Dickson, J.L., and Hayden, A.T., 2020, Reconstructing paleo-topography from river deposits on Mars: SEPM Society for Sedimentary Geology International Sedimentary Geosciences Conference, Flagstaff, AZ, USA, canceled due to COVID-19 concerns.

## 2019

27. **Cardenas, B.T.**, Kocurek, G., Mohrig, D., Swanson, T., Hughes, C.M., and Brothers, S.C., 2019, Autogenic processes and environmental forcings recorded in aeolian stratigraphy I: the Jurassic Page Sandstone, Arizona, USA: AAPG ACE 2019, San Antonio, TX, USA.
26. Swanson, T., Mohrig, D., Kocurek., G., **Cardenas, B.T.**, 2019, Autogenic Processes and Environmental Forcings Recorded in aeolian stratigraphy II: numerical experiments: AAPG ACE 2019, San Antonio, TX, USA.
25. **Cardenas, B.T.**, Swartz, J.M., and Mohrig, D., 2019, The length of fluvial sinuous ridges on Mars: 50th Lunar and Planetary Science Conference, 18-22 March, 2019, held at The Woodlands, Texas, LPI Contribution No. 2132, id.1677.

## 2018

24. \*Zhao, X., **Cardenas, B.T.**, and Kim, W., 2018, Grainflow thickness: surface process to subsurface record: EP51C-1832, presented at 2018 AGU Fall Meeting, Washington, D.C., 10-14 Dec.
23. Liu, X.C., Mohrig D.C., Buttles, J.L., Kim, W., Slyvester, Z., Hudec, M.R., Fernandez, N., and **Cardenas, B.T.**, 2018, Unraveling the geometric signals in mini-basin development that are connected to turbidity-current sedimentation versus gravity sliding: An experimental approach: EP51A-03, presented at 2018 AGU Fall Meeting, Washington, D.C., 10-14 Dec.
22. **Cardenas, B.T.**, Mohrig, D.C., Goudge, T.A., Hughes, C.M., Levy, J., Swanson, T., and Mason, J., 2018, Anatomy of exhumed river channel-belts: EP52A-01, presented at 2018 AGU Fall Meeting, Washington, D.C., 10-14 Dec.
21. Hayden, A., Lamb, M.P., Mohrig, D.C., McElroy, B.J., Williams, R.M.E., Myrow, P., Ewing, R., **Cardenas, B.T.**, and Findlay, C.P., 2018, Sinuous ridges are exhumed fluvial channel belts formed over millions of years: implications for inverted channels on Mars: EP13B-03, presented at 2018 AGU Fall Meeting, Washington, D.C., 10-14 Dec.
20. **Cardenas, B.T.**, Goudge, T.A., Hughes, C.M., Mohrig, D., Mason, J., Swanson, T., and Levy, J.S., 2018, Testing the Preservation of River Channel Properties in Earth Analogs to Martian Fluvial Sinuous Ridges: 49th Lunar and Planetary Science Conference, 19-23 March, 2018, held at The Woodlands, Texas, LPI Contribution No. 2083, id.1541.

19. **Cardenas, B.T.**, Kocurek, G., Mohrig, D., Hughes, C.M., Swanson, T., Brothers, S.C., and Goudge, T.A., 2018, Ancient Environmental Forcings Recorded in Aeolian Stratigraphy: An Earth Analog to Aeolian Strata on Mars: 49th Lunar and Planetary Science Conference, 19-23 March, 2018, held at The Woodlands, Texas, LPI Contribution No. 2083, id.2971.

## 2017

18. **Cardenas, B.T.**, Kocurek, G., Mohrig, D., and Swanson, T., 2017, Coupling aeolian stratigraphic architecture to paleo-boundary conditions: the scour-fill dominated Jurassic Page Sandstone: EP33A-1918, presented at 2017 AGU Fall Meeting, New Orleans, LA, 11-15 Dec.
17. Hayden, A., Lamb, M.P., Mohrig, D., Williams, R.M.E., Myrow, P., Ewing, R.C., **Cardenas, B.T.**, Findlay, C.P., Reconstructing paleo-discharge from geometries of fluvial sinuous ridges on Earth and Mars: EP33A-1917, presented at 2017 AGU Fall Meeting, New Orleans, LA, 11-15 Dec.
16. **Cardenas, B.T.**, Kocurek, G., and Mohrig, D., The Jurassic Page Sandstone: coupling aeolian stratigraphic architecture to water table and sea level fluctuations: Fifth International Planetary Dunes Workshop, Proceedings of the conference held 16-19 May, 2017 in St. George, Utah. LPI Contribution No. 1961, 2017, id.3050.
15. Goudge, T.A., Mohrig, D., **Cardenas, B.T.**, Hughes, C.M., and Fassett, C.I., 2017, Stratigraphy and evolution of delta channel deposits, Jezero crater, Mars: Lunar and Planetary Science XLVIII, #1195.
14. **Cardenas, B.T.**, Mohrig, D., and Goudge, T.A., 2017, Fluvial stratigraphy at Aeolis Dorsa, Mars, records base level changes and backwater sedimentation controlled by a fluctuating downstream body of water: Lunar and Planetary Science XLVIII, #1938.
13. **Cardenas, B.T.**, Goudge, T.A., Hughes, C.M., Mohrig, D., and Levy, J.S., 2017, Stratigraphic architecture of compound channel-filling deposits in the Cedar Mountain and Morrison Formations, Utah: stratigraphic analogs to martian sinuous ridges: Lunar and Planetary Science XLVIII, #1946.
12. **Cardenas, B.T.**, Goudge, T.A., Hughes, C.M., Levy, J.S., and Mohrig, D., Justifying martian fluvial sinuous ridge measurements using Earth analog stratigraphy: Fourth International Conference on Early Mars: Geologic, Hydrologic, and Climatic Evolution and the Implications for Life, Proceedings of the conference held 2-6 October, 2017 in Flagstaff, Arizona. LPI Contribution No. 2014, 2017, id.3060

## 2016

11. Goudge, T.A., Mohrig, D., **Cardenas, B.**, Hughes, C., Levy, J., and Fassett, C.I., 2016, Stratigraphy and paleohydrology of delta channel deposits, Jezero Crater, Mars: Geological Society of America Abstracts with Programs. Vol. 48, No. 7, doi: 10.1130/abs/2016AM-279574.
10. Petersen, E., Holt, J., Levy, J.S., Stuurman, C., Nerozzi, S., **Cardenas, B.T.**, Pharr, J., Aylward, D., Schmidt, L., Hoey, W., Prem, P., Rambo, J., Lim, Y., and Maharaj, K., A possible climate signal in the surface morphology and internal structure of Galena Creek Rock Glacier, Wyoming: EGU General Assembly 2016, held 17-22 April, 2016 in Vienna Austria, id. EPSC2016-10541.
9. **Cardenas, B.T.**, Bryk, A.B., Goudge, T.A., Hughes, C.M., and Mohrig, D., Determining paleoflow direction of martian channel belts using preserved channel-bend asymmetry: case study at Aeolis Dorsa,



Mars: 47th Lunar and Planetary Science Conference, held March 21-25, 2016 at The Woodlands, Texas. LPI Contribution No. 1903, p.2367.

8. Goudge, T.A., Mohrig, D., **Cardenas, B.T.**, Hughes, C.M., Levy, J.S., and Fassett, C.I., Sedimentology of the Jezero crater western fan deposit: 2. Secular changes in the style of channelization: 47th Lunar and Planetary Science Conference, held March 21-25, 2016 at The Woodlands, Texas. LPI Contribution No. 1903, p.1656.
7. Hughes, C.M., **Cardenas, B.T.**, Goudge, T.A., and Mohrig, D., Deltaic deposits indicative of a paleo-coastline at Aeolis Dorsa, Mars: 47th Lunar and Planetary Science Conference, held March 21-25, 2015 in The Woodlands, Texas, LPI Contribution No. 1903, p.2139.

#### **2015**

6. **Cardenas, B.T.**, and Mohrig, D., Incised valley formation in response to sea or lake level changes at Aeolis Dorsa, Mars: 46th Lunar and Planetary Science Conference, held March 16-20, 2015 in The Woodlands, Texas. LPI Contribution No. 1832, p.2797.
5. Ustipak, K., Buttles, J., Mohrig, D., Perillo, M., and **Cardenas, B.T.**, Development of banding in the deposits of experimental transitional flows. AAPG Annual Convention and Exhibition, Denver, CO, USA, May 31-June 3.

#### **2014**

4. **Cardenas, B.T.**, and Mohrig, D., Evidence from fluvial deposits for changes in water surface levels of a sea or large lake at Aeolis Dorsa, Mars: Eighth International Conference on Mars, held July 14-18, 2014 in Pasadena, California. LPI Contribution No. 1791, p.1307.
3. **Cardenas, B.T.**, Lalich, D.E., Petersen, E., McKinnon, E.A., Andry, C.M., Nerozzia, S., Levy, J.S., Holt, J.W., Assessing the potential of debris-covered glaciers in the Uinta Mountains as martian analogs: 5th Lunar and Planetary Science Conference, held 17-21 March, 2014 at The Woodlands, Texas. LPI Contribution No. 1777, p.2362.
2. **Cardenas, B.T.**, and Mohrig, D., 2014, Evidence for shoreline-controlled changes in baselevel from fluvial deposits at Aeolis Dorsa, Mars: 45th Lunar and Planetary Science Conference, held 17-21 March, 2014 at The Woodlands, Texas. LPI Contribution No. 1777, p.1632.

#### **2011**

1. **Cardenas, B.T.**, and Xie, H., 2011, Observations of change in surface characteristics of the Louth crater using HiRISE and CTX images: P23A-1702, presented at 2011 AGU Fall Meeting, San Francisco, CA, 5-9 Dec.