Adrien P. M. Broquet

Lunar and Planetary Laboratory
University of Arizona
Tucson, AZ, USA

abroquet@lpl.arizona.edu
https://www.lpl.arizona.edu/postdocs/adrien-broquet
GitHub: https://github.com/AB-Ares

EMPLOYMENT

2020 –	**Postdoctoral Research Associate (advisor: Jeffrey Andrews–Hanna)** – Lunar and Planetary Laboratory, University of Arizona, Tucson, USA.
2018	**InSight collaborator.**
2017 – 2019	**Teaching assistant** – Department of Earth, Environment & Space, Université de Nice Côte d'Azur, Nice, France.

EDUCATION

2020	**P.h.D** — Planetary Geophysics, Observatoire de la Côte d'Azur, Nice, France Grant: Doctoral School SFA, Nice. Advisor: Mark A. Wieczorek, Subject: *The lithosphere of Mars*
2017	**Master 2** — Solid-Earth Geophysics, Institut de Physique du Globe de Paris, France With honors
2016	**Master 1** — Geosciences, Université Pierre et Marie Curie, Paris, France With honors
2015	**BSc** — Earth Sciences, Université Pierre et Marie Curie, Paris, France Best student honors

RESEARCH INTEREST

My scientific interest encompasses various aspects of planetary geophysics and is fueled by data collected from space missions. More specifically, I enjoy studying and modeling large-scale physical processes with geologic implications, from lithospheric compensation mechanisms, thermal evolution models, to the spatio-temporal variation of the magnetic field.

THESIS PROJECT

Links: Manuscript – Defense slides

My thesis characterizes the strong and cold outermost portion of Mars, conventionally referred to as the lithosphere. When the lithosphere is loaded by volcanoes or ice caps, it deviates from its original state and bends. This compensation mechanism gives rise to two principal observables that are detectable from orbit: gravity anomalies, and topographic expressions.

As a first project, I conducted an analysis (Broquet & Wieczorek, 2019) of the gravitational signature of kilometer-sized Martian volcanoes. In this study, we model the deformation of the lithosphere under volcanic loads and compare the resulting theoretical gravitation signal to observations. The bulk density of the volcanic structures is found to have a mean value of 3200 ± 200 kg m^{-3}, which is representative of iron-rich basalts as sampled by the Martian basaltic meteorites. The elastic part of the lithosphere, which maintains loads over geologic timescale, is constrained to have been weak when the oldest volcanoes (>3.2 Ga) formed, which implies that the lithosphere was hot and thin (<20 km) early in geologic history. Conversely, we obtain that younger volcanoes (<3 Ga) were emplaced on colder and stronger elastic lithospheres (30–100 km). This chronology of formation is consistent with a geodynamic history in which the lithosphere strengthens with time as the planet cools and controls the surface expression of magmatism.

In a second project, I investigated the composition and geodynamic state of the lithosphere beneath the polar caps of Mars (Broquet et al., 2020, 2021). In these studies, we make use of radar and gravity data coupled with a lithospheric loading model to self-consistently estimate the composition of the polar cap, and the elastic thickness of the lithosphere underneath. We show that the lithosphere below the north polar cap is currently extremely rigid and cold (>330 km). In the south polar region, the present-day lithosphere is potentially thinner (>150 km), which helps satisfy global thermal evolution simulations that predict hemispheric differences in surface heat flow. Our inferred compositions suggest that for reasonable dust content, a minimum of 10% CO_2 are buried in the north polar deposits. This is the first time a large quantity of dry ice is found within the north polar regions of Mars. Like on Earth, where the composition of buried ices gives hints on the climatic evolution of our planet, having CO_2 at the north pole of Mars will help improve scenarios for the climate evolution of the planet.

MISSION INVOLVEMENT

NASA Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight), Collaborator (2018 –)

PROFESSIONAL ACTIVITIES

Reviewer for the *Journal of Geophysical Research* and *Geophysical Research Letter*.

TEACHING

- Department of Earth, Environment & Space, Université de Nice Côte d'Azur, Nice, France. Classes per level: 1st year - Planetology, Stratigraphy & Paleontology ; 2nd year - Sedimentology, Magmatism, Metamorphism, Mineralogy, Geophysics; 3rd year - Mass wasting & risks, Geophysics.
- About 15 hours of teaching Planetology in middle schools with Educosmos & MEDITES.

OUTREACH

- 2021 Invited speaker – Société d'Astronomie de Cannes, Cannes, France – *Exploration of the terrestrial planets*
- 2020 Namazu Contest Scientific tutor — French international school, Ireland, IES Nueve Valles, Spain, Middle School Roy d'Espagne, France.

- 2020 Invited speaker — Externat Saint Joseph la Cordeille, Toulon, France
  Our solar system
- 2020 Invited speaker — Insight@School, Sophia Antipolis, France
  The lithosphere of Mars
- 2019 Invited speaker — Club Véga, Ollioules, France
  The worlds around us: history and future of space exploration
- 2019 Interview La science en chemin, avec Adrien Broquet (Ciel & Espace, David Fossé)
- 2017 Science Festival, Nice, France
- 2018 Science Festival, Nice, France

AWARDS

- 2019 My thesis in 180 seconds, Final in Nice, 3rd place (video link)
- 2018 Workshop in Geology and Geophysics of the Solar System scholarship
- 2016 29th International School of Space Science scholarship

PUBLICATIONS, PEER-REVIEWED (*)

1) **Broquet A.**, and J. C. Andrews-Hanna (2022). Is there an active mantle plume underneath Elysium Planitia? *Lunar Planet. Sci.* 53, Abstract #.

2*) Khan A., Ceylan S., van Driel M., Giardini D., Lognonné P., Samuel H., Schmerr N. C., Stähler S. C., Duran A. C., Huang Q., Kim D., **Broquet A.**, Charalambous C., Clinton J. F., Davis P. M., Drilleau M., Karakostas F., Lekic V., McLennan S. C., Maguire R. R., Michaut C., Panning M. P., Pike W. T., Pinot B., Plasman M., Scholz J.-R., Widmer-Schnidrig R., Spohn T., Smrekar S. E. and Banerdt W. B. Upper mantle structure of Mars from InSight seismic data, *Science,* doi: https://doi.org/10.1126/science.abf2966.

3*) Knapmeyer-Endrun B., Panning M. P., Bissig F., Joshi R., Khan A., Kim D., Lekić V., Tauzin B., Tharimena S., Plasman M., Compaire N., Garcia R. F., Margerin L., Schimmel M., Stutzmann E., Schmerr N., Bozdağ E., Plesa A.-C., Wieczorek M. A., **Broquet A.**, Antonangeli D., McLennan S. M., Samuel H., Michaut C., Pan L., Smrekar S. E., Johnson C. L., Brinkman N., Mittelholz A., Rivoldini A., Davis P. M., Lognonné P., Pinot B., Scholz J.-R., Stähler S., Knapmeyer M., van Driel M., Giardini D. and Banerdt W. B. Thickness and structure of the martian crust from InSight seismic data, *Science,* doi: https://doi.org/10.1126/science.abf8966.

4*) **Broquet A.**, Wieczorek M. A. (2021), and W. Fa. The composition of the south polar cap of Mars derived from orbital data. *Journal of Geophysical Research: Planets,* doi: https://doi.org/10.1029/2020JE006730.

5) **Broquet A.**, and J. C. Andrews-Hanna (2021). Plume-induced flood basalts on Hesperian Mars: An investigation of Hesperia Planum. *Lunar Planet. Sci.* 52, Abstract #1893.

6*) **Broquet A.**, Wieczorek M. A., and Fa W. (2020). Flexure of the lithosphere beneath the north polar cap of Mars: Implications for ice composition and heat flow. *Geophysical Research Letters*, doi: https://doi.org/10.1029/2019GL086746.

7) **Broquet A.**, Plesa A.-C., Michaut C., and Wieczorek M. A. (2020). Constraints on the thermal state of Mars from orbital data. *Lunar Planet. Sci.* 51, Abstract #2064.

8) **Broquet A.**, Wieczorek M. A., and Fa W. (2020). Composition of the Martian polar caps and planetary heat flow. *Lunar Planet. Sci.* 51, Abstract #1838.

9*) **Broquet A.**, and Wieczorek M. A. (2019). The Gravitational signature of Martian volcanoes. *Journal of Geophysical Research: Planets*, doi: https://doi.org/10.1029/2019JE005959

10) **Broquet A.**, Wieczorek M. A., and Fa W. (2019). Geodynamic state of the lithosphere beneath the northern polar cap of Mars. *Lunar Planet. Sci.* 50, Abstract #1892.

11) **Broquet A.**, and Wieczorek M. A. (2019). The gravitational signature of Martian volcanoes. *Lunar Planet. Sci.* 49, Abstract #1859.

SELECTED LIST OF TALKS

- 2021 **ETH Zurich, Zürich, Switzerland (invited)**
  Loading the Martian lithosphere in space and time

- 2020 **DLR Institute, Berlin, Germany (invited)**
  The lithosphere of Mars

- 2020 **InSight Science Team meeting, Nice, France**
  Flexure of the lithosphere beneath the polar caps of Mars

- 2019 **50th Lunar and Planetary Science Conference, Houston TX, USA**
  Geodynamic state of the lithosphere beneath the northern polar cap of Mars

- 2018 **InSight French Team meeting, Paris, France**
  Constraints on the Martian lithosphere from gravity and topography

- 2018 **49th Lunar and Planetary Science Conference, Houston TX, USA**
  The gravitational signature of Martian volcanoes

- 2018 **Martian crust workshop, Ecole Normale Supérieure de Lyon, France**
  The lithosphere of Mars as seen by gravity and topography

- 2018 **DLR Institute, Berlin, Germany (invited)**
  Composition, elastic and thermo-mechanical properties of the Martian lithosphere

- 2017 **Geodesy & Rheology, Université Valrose, Nice, France**
  The gravitational signature of Martian volcanoes