



› Editorial

Dear readers,

With the beginning of the second funding period of the collaborative research center TRR 170 “Late Accretion onto Terrestrial Planets” we will have regular newsletters, which will keep you informed about recent activities and developments, research results and publications, and provide a list of important upcoming dates and events.

During the first months of this year we have been very active with getting started with the second funding period. This involved moving most of the administration to the University of Münster, electing a new Speaker (Thorsten Kleine) and Deputy Speaker (Harry Becker), electing the TRR 170 executive board, hiring a new Scientific Coordinator (Sabine Hunze), and hiring new PhD students and Postdocs. A brief CV, contact information, and an overview of scientific and other interests of all our new members are provided in this newsletter. You will also find a list of current guests and fellows that work on TRR 170-related subjects in Berlin and Münster.

Our activities have been (and still are) strongly influenced by the corona crisis. Many of us had planned to attend LPSC this year, which like other conferences has been cancelled. We still don’t know if it will be possible to attend or host any larger scientific meetings or even small workshops this year. This not only affects workshops that some of us have planned, but also the TRR 170 Summer School that we originally planned for September this year.

The corona crisis has also influenced the hiring process for new personnel, as interviewing candidates became much more difficult. We have nevertheless managed to fill most positions, so many thanks to everybody for the extra effort that went into this during these difficult times. We realize of course that getting started with a new project is much more difficult, given the restrictions arising from the corona crisis. Please let us know if and how this affects your project and if you need additional help.

At the last board meeting we decided to introduce a new presentation award for our PhD students. This award will be given annually for the best oral or poster presentation at the Annual Retreat. More details about this award and the selection procedure will follow shortly.

Finally, the newsletter also contains a list of our most recent publications of this year. These nicely cover the breadth of TRR 170, and include topics such as the accretion of primitive planetesimals, the origin of the Moon, and impact processes on the lunar surface.

We hope you will enjoy reading the newsletter.

All the best and stay healthy!

Sabine Hunze & Thorsten Kleine



› Personnel

New Scientific Coordinator



Dr. Sabine Hunze (WWU) shunz_01@uni-muenster.de

My motivation as the scientific coordinator of TRR 170 is the organization, communication, and documentation to support the scientists at the interface between science and administration. I have been working as a science manager since 2013 and I used to organize the TRR 61 (nanotechnology and self-organization) at the WWU physics department in cooperation with physicists and chemists from Münster and Beijing.

My scientific background: I studied geology in Bonn and Aachen and did my PhD in applied geophysics in Hannover with the main focus on downhole logging, log interpretation, and marine sedimentology.

In my free time I do Gongkwon Yusul (Korean martial arts) as well as running.

New PhD students



Caroline Brachmann (DLR, project C6, supervisor: Frank Sohl)
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My research will focus on refining and enhancing a model of crust formation and outgassing of early Earth and Mars, which was developed in the first funding period. I obtained my master's degree in metamorphic petrology at Freie Universität Berlin. However, during my master studies I developed - next to my interest in the chemistry of geological processes - a major passion for extraterrestrial systems and I am now 'over the moon' to have the opportunity to become a part of the TRR 170.

Besides my scientific interests, I enjoy mountain climbing, cycling and sewing.



Tobias Dürr (FUB, project A1, supervisor: Harry Becker)
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My work will focus on the in-situ U-Pb dating of zircon, baddeleyite and phosphates to provide reliable and precise ages within the petrological context of the samples remaining intact. Obtaining precise ages and interpreting them within the preserved context of the analysed grains is crucial to gain a better understanding of the early lunar timeline with a particular focus on the history of the basin-forming impacts. Samples from various Apollo landing sites will be studied during this project.

I decided to pursue a doctorate in TRR 170 as I wish to continue working on the dating of Zr-bearing phases and intend to apply my previous experience in a new and challenging framework that I am personally and professionally interested in.



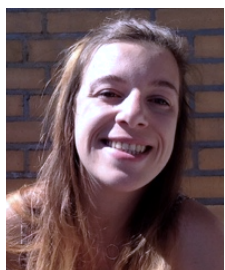
Cordula Haupt (WWU, project A5, supervisor: Stephan Klemme)
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My career as a geologist started at the Universität Potsdam and I achieved my Master degree at the TU Bergakademie Freiberg. In the course of my PhD I will experimentally determine partition coefficients of key elements between clinopyroxene and melts of lunar composition, to refine existing models of the lunar magma ocean in cooperation with geophysicists of the DLR, Berlin. This PhD gives me the chance to participate in a research program which is of great interest to me. Contributing to a multi-approach scientific project which aspires to understand late accretion processes is a unique chance. Besides cosmogeochemistry and experimental petrology, I am also interested in volcanology, sedimentology and hydrothermal processes.



Ann-Kathrin Krämer (FUB, project B8, supervisor: Timm John)
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We will try to constrain processes that caused the re-enrichment of volatile elements in refractory inclusions of meteorites based on petrology and variations in stable isotope composition. I am very interested in the origin of the solar system and terrestrial planets, and in that regard, I was previously able to work on petrology and isotope geochemistry of certain meteorites for my bachelor thesis (lunar meteorites) and master thesis (eucrites). I am happy to be a part of the TRR 170 program because I had the chance to regularly attend TRR seminars during my studies and was impressed with its member's commitment to high-quality research and the communication thereof. I am looking forward to being able to contribute to this exchange!



Julie Salme (FUB, project B8, supervisor: Harry Becker)
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My scientific interests comprise elemental and isotopic study of extraterrestrial bodies to constrain their formation and evolution, as well as processes occurring in the solar nebula. With an academic background in chemistry and geochemistry at the Ecole Normale Supérieure (Paris, France), I started a fellowship at the Freie Universität of Berlin within the TRR 170 program. I took part in a research project on siderophile volatile element distributions in lunar highland rocks using isotope dilution – ICP-MS (Subproject B1). I am currently working on my doctoral project, focused on moderately volatile elements (namely Zn, Cu, K) in bulk carbonaceous chondrites and components therein. This includes the development of low-blank extraction and stable isotope analysis methods.



Jonas Schneider (WWU, project A5, supervisor: Thorsten Kleine)

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I took the chance to join the TRR because I really like the interdisciplinary approach and the exchange between students and supervisors from different backgrounds. That is also what I especially like about my subtopic. Since my bachelor degree I am interested in geochemical processes in nature and how isotopes can be used to track and understand them. After my first contact with cosmochemistry and meteoritics during my masters I now want to dive deeper into the history of the Solar System. The accretion history and differentiation processes of terrestrial planets and especially the moon are topics which I will work on during my PhD in the TRR.

Next to spending time in the lab I like to ride boards on concrete and water and enjoy making music.



Fridolin Spitzer (WWU, project B6, supervisor: Christoph Burkhardt)

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My PhD project aims at investigating and comparing the late accretion history of Earth and Mars. I am particularly interested in the genetic heritage of the delivered material as well as in the timescales and dynamics of the responsible processes. I am generally interested in the chemical and isotopic evolution of our Solar System and like to make use of various isotopic systems to unravel its secrets. This process first started after attending Thorsten Kleine's cosmochemistry lecture in 2016. Therefore, I am eager and very happy to participate in the TRR 170 to further follow my interests in this interdisciplinary approach.

Other than that, I always enjoy a good cup of coffee and a Darts or Pool competition after work.



Jakob Storz (WWU and FU Berlin, project B5, supervisors: Addi Bischoff and Timm John) jakob.storz@uni-muenster.de

I study volatile-rich clasts in meteorites. One main objective is the isotopic characterization of these volatile-rich xenoliths, and to evaluate their relevance for the volatile element inventory of terrestrial planets. I've been working on meteorites since my bachelor studies, and found exotic extraterrestrial matter particularly interesting ever since. My latest work focused on the carbon allotropes graphite and diamond, which establishes a strong link to the current project. The project does not only offer me the opportunity to further investigate volatile-rich components in meteorites, but also to gain experience with state-of-art SIMS techniques. I'm always interested in having a conversation, and you'll most likely to meet me in the early morning with a coffee mug in my hand.



TRR 170

LATE ACCRETION

ONTO TERRESTRIAL PLANETS

**Elias Wölfer** (WWU, project B7, supervisor: Christoph Burkhardt)

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My scientific interest is focused on understanding the early evolution of the protoplanetary disk and the formation of terrestrial planets, using high-precision isotope measurements of meteorites and terrestrial samples. Currently, my main research focus lies on the accretion of (moderately) volatile elements onto planetary bodies in the inner Solar System and their geochemical behavior during differentiation. Planetary bodies are generally characterized by a depletion in (moderately) volatile elements relative to primitive Solar System objects (e.g., comets and carbonaceous chondrites), however, it is matter of debate, whether this depletion mainly originates from nebular processes or from large-scale degassing of planetesimals. During my PhD studies I intend to shed new light on this issue, and particularly to improve the understanding of the timing and the processes responsible for the volatile depletion of the terrestrial planets.

Beyond planetary science, I have a passion for geography and maps, as well as football, cycling, and hiking.

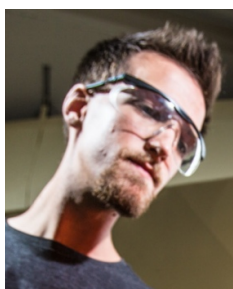
New Postdocs

**Jonas Pape** (WWU, project B3) jonas.pape@uni-muenster.de

The project focuses on nucleosynthetic Ru isotope anomalies in meteorites in order to study the origin and composition of late-accreted materials, terrestrial building blocks and the dynamics of planet formation.

Before I started this Postdoc position, I was a PhD student at the Isotope Geology group in Bern (CH) till Dec 2018 and worked as a Research Assistant at the Natural History Museum in Bern – both positions focusing on meteorites and the evolution of the Early Solar System.

Currently I spend much of my free time with watching barges and ducks on the Dortmund-Ems Canal (much excitement) and changing diapers (not mine).

**Christian Renggli** (WWU, project B7) renggli@uni-muenster.de

My main research interest lies in the properties and behavior of hot gases in terrestrial and planetary processes, and the gas-solid reactions involved. In my PhD at the Australian National University I studied gas-solid reactions between SO₂ gas and silicate glasses, melts and minerals, to understand how sulfur is scavenged in the sub-volcanic environment and in explosive volcanic eruptions. More recently I have worked on gas-solid reactions and metal transport processes in fumarolic systems, both on Earth and on the Moon, by applying novel experimental methods. In an ongoing project I investigate the formation of sulfides at highly reducing conditions and in low pressure environments relevant for Mercury and enstatite chondrites. Over the coming years I will apply experiments to study kinetic and equilibrium stable isotope fractionation in gas-solid reactions, specifically degassing from silicate melts relevant for processes in magma oceans and planetary nebulae. I am currently involved in a group of postdocs across the WWU with the aim to establish a Postdoc Association at the university later this year. I am also a member of the university orchestra Collegium Musicum Instrumentale, where I play the Cello.



› Fellowships

- **Imene Kerraouch**

Time period: 01.02.-31.07.2020

TRR 170 host: Addi Bischoff, WWU

Home university: University of Science and Technology, Algiers, Algeria

Imene worked on volatile fragments in meteorites, especially on very different lithologies from water-containing chondrites. In this context, the chondritic breccia Aguas Zarcas is particularly interesting, as it contains fragments of various CM lithologies as well as fragments with a unique mineralogy.

- **Maxime Maurice**

Time period: 01.01.-31.07.2020

TRR 170 host: Thorsten Kleine, WWU

Home university: TU Berlin

Maxime worked on the chronology of the lunar magma ocean and the connection of a thermal model of the magma ocean with the observed chronology of lunar rocks. During his stay in Münster, he incorporates the ^{146}Sm - ^{142}Nd chronology of the Moon into his thermal and crystallization model of the lunar magma ocean. The anticipated results will provide new constraints on the age of the Moon, the lifetime of the magma ocean, and ultimately on the composition of the Moon.

- **Julie Salme**

Time period: 01.10.2019-31.03.2020

TRR 170 host: Harry Becker, FUB

Home university: Ecole Normale Supérieure, Paris, France

Julie worked on the siderophile volatile elements budget in pristine lunar highland rocks with Dr. Philipp Gleißner. The repartition of these elements in such pristine rocks gives clues on processes occurring on the Moon during its formation and evolution, such as volatilization and metal-sulfide-silicate partitioning.

- **Prof. Alexander Basilevsky**

Time period: 01.10.-30.11.2020

TRR 170 host: Kai Wünnemann, MfN

Home university: Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow

Together with postdoc Tiantian Liu and the external project partner Dr. Greg Michael, Alexander Basilevsky plans to work on the influence of the water-ice admixture on the formation and evolution of small impact craters at the lunar polar regions. The ultimate aim of this work is to improve our understanding of the evolving distribution of water-ice at the lunar surface and, hence, to better estimate the present-day volume of water-ice at the polar regions. The results may also help to better constrain the water volume that has been delivered to the terrestrial planets during late accretion.



› Publications (January – April 2020)

- Hopp, T., Budde, G., Kleine, T. (2020): Heterogeneous accretion of Earth inferred from Mo-Ru isotope systematics. *Earth Planet. Sci. Lett.* 534. doi.org/10.1016/j.epsl.2020.116065
- Kruijer, T., Kleine, T., Borg, L.E. (2020): The great isotopic dichotomy of the early solar system. *Nature Astronomy* 4, 32-40. doi.org/10.1038/s41550-019-0959-9
- Lammer, H., Leitzinger, M., Scherf, M., Odert, P., Burger, C., Kubyshkina, D., Johnstone C., Maindl, T., Schäfer, C.M., Güdel, M., Tosi, N., Nikolaou, A., Marcq, E., Erkaev, N.V., Noack, L., Kislyakova, K.G., Fossati, L., Pilat-Lohinger, E., Dorfi, E.A. (2020): Constraining the early evolution of Venus and Earth through atmospheric Ar, Ne isotope and bulk K/U ratios. *Icarus* 339:113551. DOI: 10.1016/j.icarus.2019.113551
- Liu, T., Michael, G., Wünnemann, K., Becker, H., Oberst, J. (2020): Lunar megaregolith mixing by impacts: Spatial diffusion of basin melt and its implications for sample interpretation. *Icarus* 339, 113609. doi.org/10.1016/j.icarus.2019.113609
- Lunning, N. G. , Bischoff, A., Gross, J., Patzek, M., Corrigan, C. M. , McCoy, T. J. (2020): Insights into the formation of silica-rich achondrites from impact melts in Rumuruti-type chondrites. *Meteoritics & Planetary Science*, Vol 55, 1. doi.org/10.1111/maps.13430
- Patzek, M., Hoppe, P., Bischoff, A., Visser, R., John, T. (2020): Hydrogen isotopic composition of CI- and CM-like clasts from meteorite breccias - Sampling unknown sources of carbonaceous chondrite materials. *Geochimica et Cosmochimica Acta* 272, 177-197. doi.org/10.1016/j.gca.2019.12.017
- Riedel, C., Minton, D.A., Michael, G., Orgel, C., van der Bogert, C., Hiesinger, H. (2020): Degradation of Small Simple and Large Complex Lunar Craters: Not a Simple Scale Dependence. *Journal of Geophysical Research: Planets.* 125, 4. doi.org/10.1029/2019JE006273
- Secchiari, A., Gleissner, P., Li, C., Goncharov, A., Milke, R., Becker, H., Bosch, D., Montanini, A. (2020): Highly siderophile and chalcophile element behaviour in abyssal-type and supra-subduction zone mantle: New insights from the New Caledonia ophiolite. *Lithos* 354-355, 105338. doi: org/10.1016/j.lithos.2019.105338
- Steenstra, E.S., Berndt, J., Klemme, S., van Westrenen, W. (2020): An experimental assessment of the potential of sulfide saturation of the source regions of eucrites and angrites: Implications for asteroidal models of core formation, late accretion and volatile element depletions. *Geochimica et Cosmochimica Acta*, 269, 39-62. doi: 10.1016/j.gca.2019.10.006
- Steenstra, E.S., Berndt, J., Klemme, S., Fei, Y., van Westrenen, W. (2020): A possible high-temperature origin of the Moon and its geochemical consequences. *Earth and Planetary Science Letters*, 538, 116222. doi: 10.1016/j.epsl.2020.116222
- Steenstra, E.S., Seegers, A.X., Putter, R., Berndt, J., Klemme, S., Matveev, S., Bullock, E.S., van Westrenen, W. (2020): Metal-silicate portioning systematics of siderophile elements at reducing conditions: A new experimental database. *Icarus*, 335, 113391. doi.org/10.1016/j.icarus.2019.113391



- Steenstra, E.S., van Haaster, F., van Mulligen, R.M., Flemetakis, S., Berndt, J., Klemme, S., van Westrenen, W. (2020): An experimental assessment of the chalcophile behavior of F, Cl, Br and I: Implications for the fate of halogens during planetary accretion and the formation of magmatic ore deposits. *Geochimica et Cosmochimica Acta*, 273, 275-290.
doi.org/10.1016/j.gca.2020.01.006
- Steenstra, E.S., Berndt, J., Klemme, S., van Westrenen, W., Bullock, E.S., Shahar, A. (2020): Addressing matrix effects for 193 nm excimer LA-ICP-MS analyses of Fe-rich sulfides and a new predictive model. *Journal of Analytical Atomic Spectrometry*, 35, 498-509.
[doi: 10.1039/C9JA00391F](https://doi.org/10.1039/C9JA00391F)
- Wahl, D., Wieczorek, M.A., Wünnemann, K., Oberst, J. (2020): Crustal porosity of lunar impact basins. *Journal of Geophysical Research: Planets*, 125, 4, e2019JE006335.
doi.org/10.1029/2019JE006335



› Outreach



First results of the "Sensation Meteorite Fall" in Flensburg

Planetary researchers of the University of Münster show: Meteorite contains minerals that were formed with the participation of water in the early phase of the solar system.

A fireball in the sky, accompanied by a bang, amazed hundreds of eyewitnesses in Northern Germany last September. The reason for the spectacle: A meteorite entered the earth's atmosphere and partially burned up there. A day after the event, a citizen found a 24.5 grams black stone on the lawn of his garden in Flensburg.

Dieter Heinlein from the Augsburg Institute for Planetary Research of the German Aerospace Center recognized the stone as a fragment of a meteorite and gave the sample to the experts at the Institute für Planetologie at the University of Münster (WWU). Prof. Dr. Addi Bischoff and PhD student Markus Patzek have been studying the stone mineralogically and chemically since then – in the meantime around 15 university and research institutes in Germany, France and

Switzerland are now involved in the research.

The first research results show that "Flensburg", the name given to the meteorite, can be compared to very rarely fallen meteorites only, so-called charcoal chondrites. Scanning electron microscopic studies show that Flensburg contains only minerals that have formed with the participation of water in the early phase of our solar system. These are particularly layered silicates and carbonates. Thus, the original source rock can be seen as part of a possible building block of the earth, which could have brought water in the early phase of the planet's development.

"The Flensburg meteorite belongs to an extremely rare meteorite class and is the only meteorite fall in Germany that proves that 4.56 billion years ago there had to be small bodies in the early solar system with liquid water on them. Perhaps such bodies also supplied water to the earth", says Addi Bischoff.

(www.uni-muenster.de/news/view.php?cmdid=10840)

TV and radio reports:

- 3sat:
<https://www.3sat.de/wissen/nano/meteorit-flensburg-wasserspuren-100.html>
- YouTube:
<https://www.youtube.com/watch?v=o3XfO5-1LRk&feature=youtu.be>
- Radio SRF 2 Kultur (Schweiz):
<https://www.srf.ch/kultur/wissen/meteorit-im-vorgarten-was-ein-golfballgrosser-stein-ueber-unseren-planeten-verraet>



› Events

Usually, we would provide a list of upcoming workshops and conferences, and internal TRR 170 meetings such as the Annual Retreat or the Summer School. However, due to the restrictions related to the corona crisis, we currently don't know when it will be possible again to hold scientific meetings. The next relevant international scientific meeting may be the AGU Fall meeting in San Francisco (Dec. 7–11 2020), but as for other meetings, it is still unclear in which form this meeting will take place.

Our current planning is that we will have our Annual Retreat in November or December this year in Berlin, and this year's Summer School will likely be moved to early next year. We will of course inform you as soon as we have any news about upcoming events, in particular the Annual Retreat and the Summer School.



› Impressum

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