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The trials and tribulations of PAHs in asteroids: investigating aqueous alteration of polycyclic aromatic hydrocarbons under asteroidal conditions

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List of publications

First Author

Giese, C.-C.; ten Kate, I. L.; van den Ende, M. P. A.; Wolthers, M.; Aponte, J. C.; Camprubi, E.; Dworkin, J. P.; Elsila, J. E.; Hangx, S.; King, H. E.; Mclain, H. L.; Plümper, O. and Tielens, A. G. G. M. **2022**. Experimental and Theoretical Constraints on Amino Acid Formation from PAHs in Asteroidal Settings. Special Issue: Chemical Complexity in Planetary Systems, ACS Earth and Space Chemistry 6 (3), 468-481.

Giese, C.-C.; ten Kate, I. L.; Plümper, O.; King, H. E.; Lenting, C.; Liu, Y.; and Tielens, A. G. G. M. **2019**. The evolution of polycyclic aromatic hydrocarbons under simulated inner asteroid conditions. Meteoritic and Planetary Science 1-21.

Giese, C.-C.; King, H. E.; van den Ende, M. P. A.; Plümper, O.; ten Kate, I. L.; and Tielens, A. G. G. M. **2018**. In situ nanoscale investigation of step retreat on fluoranthene crystal surfaces. ACS Earth and Space Chemistry 2 (12): 1301- 1311.

Contributed Author

Müller, U.F.; Elsila, J. E.; Trail, D.; DasGupta, S.; **Giese, C.-C.**; Walton, C. R.; Cohen, Z. R.; Stolar, T.; Krishnamurthy, R.; Lyons, T. W., Rogers, K.; Williams, L. D. **2022**. Origins of Life and Evolution of Biospheres, Workshop Report. Frontiers in prebiotic chemistry and early Earth environments 52: 165-181.

In Preparation

Giese, C.-C.; van den Ende, M. P. A.; ten Kate, I. L.; and Tielens, A. G. G. M. **in prep**. Water convection shapes the distribution of PAHs in carbonaceous parent bodies

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Curriculum Vitae

I was born on 21 January 1987 in East Berlin, German Democratic Republic, as the youngest of four. Growing up after reunification, I witnessed both new opportunities and my parents' struggles in a changing world. From my parents, I learned the value of care, curiosity, determination, and discipline. However, discipline was not my strength when it came to limiting my after-school TV time. Fortunately, this was not always time wasted: *Sailor Moon* (by Naoko Takeuchi) ignited my fascination with astronomy, astrology, and mineralogy, while *Mila Superstar (Attack No. 1)* by Chikako Urano inspired both my volleyball game and my willpower.

After finishing secondary school at the Realschule Schwanebeck in 2003, I switched to the natural science-oriented Barnim Gymnasium Bernau. After finishing high school in 2006, I pursued mineralogy at the Friedrich Schiller University Jena, aiming to study the extraterrestrial world. Alongside my studies, I was active in student politics, serving as an independent representative in various councils, which broadened my perspective and introduced me to diverse people. In 2012, I earned my diploma (equivalent to a combined bachelor's and master's) in mineralogy with a minor focus in geophysics. My thesis focused on high-temperature effects on zircons in Suevite (impact rock) from the Nördlinger Ries impact crater in collaboration with the Natural History Museum in Berlin.

Building on my experience, I continued my education after university. I took short courses in planetary physics, impact rocks, transmission electron microscopy, and solid-state NMR in Berlin (Prof. W. Reimold, Dr. Wünnemann, Natural History Museum), Jena (Prof. F. Langenhorst, Friedrich Schiller University), and Bochum (Dr. M. Fechtelkord) between 2012 and 2013 before starting my PhD.

In 2014, I finally began my PhD project at Leiden University's Astronomical Observatory in collaboration with Utrecht University's Geosciences Institute. The project was supported by Prof. A.G.G.M. Tielens' Spinoza award

money, and integrated knowledge from different disciplines to explore polycyclic aromatic hydrocarbons from the interstellar medium into asteroids and meteorites. At the same time as I started my PhD journey, eight other PhD students from the PEPSci (Planetary and Exoplanetary Science) program funded by the Dutch Research Council (NWO) started theirs. The PEPSci program provided me with a network of colleagues and a supportive community from which I draw to this point.

During my PhD, I collaborated with colleagues from Germany (University of Bonn; Prof. Dr. Thorsten Geisler-Wierwille, Dr. Christoph Lenting), the USA (NASA Goddard Space Flight Centre; H.L. Mclain, Dr. J. Dworkin, Dr. J.C. Aponte, Dr. J.E. Cook), and France (Utrecht University/Université Côte d'Azur; Dr. Martijn van der Ende). These collaborations broadened my scientific horizon and resulted in three publications and my last PhD chapter. I presented my research at national conferences like NAC (Dutch Geoscience Congress; 2014, 2016) and international conferences, including the Annual Meeting of the Meteoritical Society (USA 2015, Germany 2016) and the Goldschmidt Conference (Japan 2016). The COVID-19 pandemic cancelled my final presentation at the American Chemistry Society National Meeting (USA, 2020). To further widen my knowledge and experience, I attended various courses for PhD students in the Netherlands and summer schools abroad. The courses included time and self-management courses, effective and communication in science courses by Leiden University, and research and CV writing courses by Utrecht University. I also took the opportunity to attend summer schools on Planetary Mineralogy (Scotland, 2014), Water, Ice, & Origin of Life in the Universe (Iceland, 2015), Radiogenic & Non-Traditional Isotopes (Germany, 2017), and Complex Molecule Formation in Space and on Planets – From interstellar Clouds to Life (Estonia, 2017). These experiences connected me with scientists across disciplines.

After my PhD funding ended in 2018, I worked as a researcher and manager at a start-up developing alternative concrete in Kinderdijk, Netherlands (2019-2021). After the start-up closed, I became a scientific coordinator at the NWO in Den Haag, Netherlands (2022-2025). At NWO, I had the privilege of accompanying the PEPSCI II program, the next generation of planetary scientists.

Throughout my 11-year PhD journey, I encountered significant challenges, including periods of self-doubt and the devastating loss of my parents and brother. Yet, despite these tribulations, I remained committed to my PhD research. Each obstacle only fuelled my determination, and today, I take immense pride in having successfully completed this journey.



Acknowledgement

Over the 11 years from starting my PhD project to defending it, I have built, maintained, and bid farewell to many relationships with friends, colleagues, and mentors. Experiencing loss has reinforced the importance of cherishing life and celebrating every positive moment, no matter the circumstances.

In the following pages, I acknowledge those who contributed to my success and sanity. While I regret not being able to mention everyone, I hope those I missed know they have my gratitude.

Research

I could not have reached my goals without the generosity and support of others. I am grateful to Dr. Junfeng Z. (PAHs) and Prof. Dr. Oliver P. and Dr. Helen E.K. (olivine samples, Utrecht University) for providing materials, and to those who assisted in preparation and analysis: Roel v.E. (mineral preparation, VU Amsterdam), Jord v.S. (HPLC, Utrecht University), Fouad S., Dr. Helen E.K., Prof. Dr. Thorsten G.-W., and Dr. Christoph L. (Raman, University of Bonn), Tilly B., Dr. Yang L., Dr. Sergei M., and Dr. Markus O. (SEM/TEM, Utrecht University), and Dr. Lucas P. (CentriVap, VU Amsterdam).

Collaborations

My research was shaped by collaborations, particularly with Prof. Dr. Thorsten G.-W. and Dr. Christoph L. (Steinmann Institute, University of Bonn), whose contributions were invaluable. I also thank Dr. José C.A., Dr. Jason P.D., Dr. Jamie E.E., and Hannah L.M. (NASA Goddard Space Flight Centre) for their contributions and insights. Utrecht University colleagues Dr. Yang L., Dr. Martijn P.A. v.d.E., Dr. Suzanne A., Prof. Dr. Mariette W., Dr. Suzanne H., and Dr. Eloi C. provided critical

support. Special thanks to my core supporters, Prof. Dr. Xander T., Prof. Dr. Inge Loes t.K., Dr. Helen E.K., Dr. Martijn P.A. v.d.E. and Prof. Dr. Oliver P., for their guidance and encouragement.

Utrecht

Although my PhD title bears Leiden's insignia, I remain deeply grateful to the Geosciences Department at Utrecht. I thank Pien, Magda, and Marjolein for their administrative support and the entire community for scientific discussions, social gatherings, and even the occasional lab mishap. Special appreciation goes to Prof. Dr. Douwe v.H., Dr. Helen E.K., Prof. Dr. Inge Loes t.K., Dr. Leo K., Prof. Dr. Mariette W., Prof. Dr. Oliver P., Prof. Dr. Paul M., and Dr. Suzanne H. for their mentorship and inspiration. Dr. Maartje Ho. and Dr. Peter M. helped me settle in the Netherlands, and I fondly recall my early PhD days. Office mates Arjen B., Dr. Alejandro R., Dr. Aleksandra G., Alexandra Z., Özlem E., Dr. Paul O., and Dr. Nina K. provided invaluable camaraderie.

Beyond the office, I was lucky to meet remarkable people. Dr. Chloe M., Dr. Eloi C., Dr. Evangelos K., Dr. Markus O., Dr. Mariska S., Dr. Martijn v.d.E., Nicole K., Dr. Su T.S. and Dr. Alberto P.d.A.O, and Dr. Suzanne A., your support and perspectives enriched my journey. Thank you also to Floris T., Kalijn P., Dr. Loes v.B., Dr. Magriet L., Dr. Ronald P., and Dr. Wen Z. for shaping my time at Utrecht.

Outside academia, Aram d.H., Lily W., Dr. Mariana P., Dr. Marielle Z., Dr. Ole M., Roelien C., and Rianne d.V. made life richer.

Leiden

I never became as rooted at Leiden Observatory as I did in Utrecht. Still, I appreciate the kindness and support I received. Evelijn G. was instrumental in helping me settle in, and Prof. Dr. Harold L., who is deeply missed, was a great advocate. Office mates Dr. Raymond O. and Dr. Junfeng Z. helped introduce me to astronomy. I am incredibly grateful to Dr. Alessandra C. and Dr. Annemieke P., for guiding me during my early days in PAH research. Thanks to PEPSci, I met fantastic PhD fellows: Dr. Andrew R.H., Dr. Christian E., Dr. Dario C., Dr. Eva B., Dr. Ko-Ju C., and Dr. Vincent K.. A special thank you to M'MAZYNC: Dr. Marieke V., Dr. Zexu G., Dr. Agnieszka K., Dr. Yuxi N., and Dr. Nikki S. A random PhD course brought us together, but our time together was anything but random.

Beyond Leiden and Utrecht University

The PEPSci network introduced me to a broader community. I cherish my time with Dr. Edgar S., Dr. Kaustubh H., Dr. Lucas P., Dr. Kateryna F., Yue Z., and Orr B. Other encounters left lasting impressions. Dr. Stephanie C., I treasure our time in Annapolis and beyond. Dr. Anna N. and Dr. Charity L., our Icelandic summer school was unforgettable. Heiko P. and Pallavi P., you were my first non-science friends on this journey. After my PhD funding ended, I valued my time at IHC Medusa B.V. I am grateful to Joost K. for introducing me to the business world and to Yarno K. for his kindness and support.

Vor meinen Leben in der Niederlande (Life before the Netherlands)

Starting a PhD abroad comes with initial solitude, but I was never truly alone. Lifelong friends and mentors shaped my journey: Anja S., Prof. Dr. Bhabani K.S., Franziska M., Dr. Franziska S., Jennifer B., Dr. Johannes M., Prof. Dr. Juliane D., Karola S., Karoline H., Katharina H., Katharina L., Linda R., Dr. Matthias Q., Dr. Mirko T., Ole S., Paul L., Dr. Rene G., Romy K., Sabine M., Sophia H., Stefanie B., and Youyou Z. Some of you have been in my life for over 30 years, and all of you have supported me on this path. Thank you for your friendship and unwavering belief in me.

Family

Although it breaks my heart that my parents can no longer witness my success, I am very grateful for the love and values they passed on to me.

Pim, we met a few months before my dad passed, before I hit rock bottom, and you are now standing strong again beside me when I am grieving the loss of my brother. You have supported me from day one. Thank you for believing and loving me. I am glad you did not run away after the jacket incident. Your calmness, generosity, and love are helping me grow and emerge as a better person. Thank you for standing by my side in the dark moments and giving me the strength for an illustrious future.

Closed chapter

This journey has made me stronger, wiser, and perhaps more knowledgeable. I am deeply thankful for what my journey brought me and grateful to everyone who walked alongside me throughout, helping me to get this chapter of my life to a noteworthy closure.