

# Anouk M Borst, PhD, MSc, BSc

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## EMPLOYMENT

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- 2020-present **Associate Lecturer** in Earth Sciences, UNIVERSITY OF ST ANDREWS, SCOTLAND, UK
- Module coordinator ES4003 (Dissertation), ES4002 (Research essay), ES4013 (Independent mapping)
  - Equality, diversity and inclusivity (EDI) officer, Chair of School EDI committee
- 2016-2020 **Postdoctoral Research Fellow** UNIVERSITY OF ST ANDREWS, SCOTLAND, UK  
Igneous Petrology, Magmatic Ore Deposits, Isotope Geochemistry, Mineralogy
- H2020, HiTechAlkCarb Consortium (Jan 2020)
  - SFC GCRF & KE Impact Fund, Project: Hi-Tech Metal Potential In Angola (Sept-Oct 2019)
  - Nerc, Sosrare Consortium, Project: Security Of Critical Raw Materials (Aug 2016-Dec 2019)
- OCT 2015 **Visiting Researcher** GREENLAND INSTITUTE FOR NATURAL RESOURCES, NUUK, GREENLAND
- 2014-2015 **Visiting Researcher**, NATURAL HISTORY MUSEUM OSLO and UNIVERSITY OF OSLO, NORWAY
- XRD, SEM and EMPA analyses for PhD research. Collaboration with Prof Henrik Friis
- 2006-2012 **Recruiter, Teaching- and Lab-assistant** VU UNIVERSITY AMSTERDAM, THE NETHERLANDS
- 2009 **EuroGeoMars Crew 76 geologist** MARS DESERT RESEARCH STATION, MARS SOCIETY, UTAH USA
- Crew geologist/Health and Safety Officer in Crew 76. Responsible for acquisition, deployment and testing of geological instruments designed for planetary exploration by ESA and NASA.
- 2008-2009 **Research internship** EUROPEAN SPACE AGENCY (ESA-ESTEC), NOORDWIJK, THE NETHERLANDS
- 6 month research project on lunar geology and planetary exploration

## EDUCATION

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- 2012-2016 **Doctor of Philosophy**, UNIVERSITY OF COPENHAGEN, based at GEOLOGICAL SURVEY OF DENMARK AND GREENLAND, COPENHAGEN, DENMARK  
Funded by Geocenter Denmark. Advisors: Prof Tod Waight, Dr Henrik Friis and Dr Troels Nielsen
- Thesis: '*Mineralogy and Geochemistry of REE, Zr, Nb mineralised nepheline syenites in the peralkaline Ilímaussaq Complex, South Greenland*'
- 2009-2012 **Master of Science, Solid Earth** (Cum Laude) VU UNIVERSITY AMSTERDAM, THE NETHERLANDS  
Advisor: Prof Gareth Davies
- Thesis: '*Formation and modification of the sub-cratonic lithospheric mantle beneath Botswana: A petrological, geochemical and isotopic study of mantle xenoliths from the Letlhakane kimberlite.*'
- 2005-2009 **Bachelor of Science, Earth Sciences** (High Merit) VU UNIVERSITY AMSTERDAM, THE NETHERLANDS  
Advisors: Prof Gareth Davies, Prof Wim van Westrenen and Prof Bernard Foing
- Thesis: '*Geological and geochemical analysis of the lunar South Pole – Aitken Basin*'

## GRANTS & AWARDS

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- 2019 **SFC ODA GCRF & KE Impact Fund**, Title: The Economic Potential of Green Technology Metals in Angola. Knowledge exchange & field-campaign in Angola, supporting 4 Angolan BSc projects (**£19.124**) PI
- 2017 **NERC Facility Grant**: Project: 'Reconstructing an Ancient Rift, timing of Gardar Magmatism' (**£99.000**) Co-I
- 2017 **Diamond Light Source**:  
5 days I18 beamtime awarded for XANES/EXAFS (**eq. to £50.000**) Co-I

- 2017 3 days I18 beamtime awarded for XANES/EXAFS studies of REE-minerals (**eq. to £30.000**) PI  
**KIT Karlsruhe Light Source:**
- 2012-2015 5 days SUL-X joint beamtime awarded with Dr Platon Gamaletsos (**eq. to £30.000**) Co-I  
**GeoCenter Denmark:** PhD scholarship and fieldwork, with additional support from **MIMA & GEUS (eq. to €240.000)**  
**Society for Arctic Research:** Travel grant for analytical work at Natural History Museum of Oslo (**€750**)
- 2015 **DGF Annual Meeting:** Best PhD Poster Award
- 2014 **NordMin Travel grant:** Travel costs for PhD course Sustainable Mining at Luleå University, Sweden (**€500**)
- 2009 **International Lunar Exploration Working Group:** Financial support for EuroGeoMars Field Campaign (**€500**)
- 2008 **ESRON:** Bursary for ESA/FFG Summerschool Alpbach, Austria (**€250**)

## PUBLICATIONS

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- Borst, A.M.,** M. Smith, Finch, A.A. G. Estrade, E. Marquis, C. Villanova-de-Benavent, N.J. Horsburgh, K. Goodenough, P. Nason, J. Kynicky, C. Xu, T. Geraki, *Nature Communications* 11, 4386 (2020) Adsorption of rare earth elements in regolith-hosted clay deposits. <http://doi.org/10.1038/s41467-020-17801-5>
- Borst, A.M.,** Finch, A.A. Horsburgh, N.J.H. Friis, H., Gamaletsos, P.N., Goettlicher, J., Steiniger, R., Geraki, K. *Mineralogical Magazine* (2019) Structural State of Heavy Rare Earths in Eudialyte-hosted Critical Metal Deposits, p. 1-49,. <http://doi.org/10.1180/mgm.2019.50>
- Hutchison, W., Babieli, R. J., Finch, A. A., Marks, M. A. W., Markl, G., Boyce, A. J., Stueeken, E. E., Friis, H., Borst A.M., Horsburgh, N. J. (2019) Sulphur isotopes of alkaline magmas support deep recycling of Earth's crust. *Nature Communications* 10, 4208 (2019), p. 1-12, <https://doi.org/10.1038/s41467-019-12218-1>
- Van de Ven, M., Borst, A.M., Davies, G.R, Hunt, E.J., Finch, A.A. (2019) Hydrothermal Alteration of Eudialyte-Hosted Critical Metal Deposits: Fluid Source and Implications for Deposit Grade. *Minerals* 9(7), 422, <http://doi.org/10.3390/min9070422>
- Borst, A.M.,** Waight, T.E., Finch, A.A., Storey, M., Le Roux, P.J (2019) Dating agpaitic rocks: A multi-system (U/Pb, Sm/Nd, Rb/Sr and 40Ar/39Ar) isotopic study of layered nepheline syenites from the Ilímaussaq complex, Greenland, *Lithos* 324-325, 74-88, <http://doi.org/10.1016/j.lithos.2018.10.037>
- Borst, A.M.,** Friis, H., Waight, T.E., Nielsen, T.F.D. (2018) Bulk and mush melt evolution in agpaitic systems: Insights from compositional variations in eudialyte-group minerals of the Ilímaussaq complex, South Greenland, *Journal of Petrology* 59:4. p. 589-612
- Borst A.M.,** Friis, H., Andersen, T., Waight, T.E., Nielsen, T.F.D., Smit, M. (2016) Zirconosilicates in the kakortokites of the Ilímaussaq complex, South Greenland: Implications for fluid evolution and HFSE-REE mineralisation in agpaitic systems, *Mineralogical Magazine* 80(1), p. 1-26
- Borst, A.M.,** Foing, B.H., Davies, G.R., van Westrenen, W. (2012) Surface mineralogy and stratigraphy of the lunar South Pole-Aitken basin determined from Clementine UV/VIS and NIR data, *Planetary and Space Science* 68, Terrestrial Planets 1, p. 76-85

## INVITED TALKS

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- JUNE 2019 **Global Rare Earth Industry Association Conference.** Brussels, Belgium. "Secondary alteration in rare earth deposits – implications for processing and extraction"
- MAY 2019 Early Career Researcher Keynote 3<sup>rd</sup> **International Critical Metals Conference.** Edinburgh, United Kingdom.  
"Peralkaline-hosted Critical Metal Deposits: From magmatic enrichment to hydrothermal mobilisation"
- NOV 2018 **Symposium on Rare Earth Elements.** University of São Paulo, Brazil "Subsolidus mobility of REE in the Ilímaussaq complex, Greenland"

- JUNE 2017 **British Geological Survey**, NIGL, Keyworth UK. "Reconstructing an ancient Rift: the Gardar Province"
- JUNE 2016 **USGS Geological Survey**, Denver, USA. "REE mineralisation in the Ilímaussaq complex, Greenland"

## PROFESSIONAL SKILLS

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- Analytical skills:** Thin section preparation, petrography and microstructural analyses (microscopy, CL, BSE, XRD), Mineral separation (heavy liquids, magnetics, picking, mounting), Mineral and whole rock geochemistry (XRF, ICPMS, EPMA, LA-ICPMS, SEM-EDX), Clean Lab work (sample digestion, column chemistry), Isotope geochemistry (MC-ICPMS, ID and IC-TIMS and MC-LA-ICPMS, CA-ID-TIMS), Synchrotron X-ray absorption spectroscopy (SXRF, XANES, EXAFS)
- Field skills:** Geological mapping, sampling and field experience in Greenland, Brazil, Belgium, Spain, France, USA, Angola, South Africa, Botswana, Cyprus, Serbia, Montenegro, Scotland, Germany and the Netherlands
- Conference organisation:** VMSSG local organizing committee 2019, Nordic Geological Winter Meeting session chair 2018, SOS RARE local organizing committee 2017, Magmas and Resources fortnightly group meetings, SGA field excursion guide Gardar Province Greenland 2016, EGU conference 2009
- Teaching:** Module coordinator of Earth and Environmental Science **BSc Dissertations** (ES4003), **Literature Review Essays** (ES4002), and **Independent Mapping Projects** (ES4013). Lecturer in **Magmatic Ore Deposits** (ES5300, UniStA), **Introduction to Earth Science** (ES1901, UniStA) & **Radiogenic isotope geochemistry** (UCPH). Field and Lab demonstrator on **Field mapping course** (ES3006, UniStA) to the Isle of Mull, **Digital mapping course** (ES5305, UniStA) to the Isle of Rum, **Igneous and Metamorphic Petrology** (ES3009, UniStA), **Advanced Petrogenesis** (ES5013, UniStA), **Metallogenesis** (ES5006, UniStA), **Advanced Field Methods** course in Utah, USA (UCPH) and **Lithospheric Geology and Geochemistry** fieldtrip to Sorbas Spain (UCPH). Supervised 5 MSc Dissertation students (UniStA)
- Committees:** Early Career Researchers Forum Social Representative, L'AVA sorority, GeoVUsie Study Association Amsterdam, AAPG/SPE Amsterdam Student Chapter
- Journal referee:** Reviewer for *Geochimica Cosmochimica Acta*, *Dansk Geologisk Forening Bulletin*, *Journal of Geosciences*, *Journal of Petrology*, *Johnson Matthey Technological Reviews*, *Lithos*, *Mineralogical Magazine*, *Minerals and Scientific Reports*
- Languages:** Dutch (native), English (fully professional proficiency), Danish (elementary proficiency)

## REFERENCES

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**Prof Adrian A. Finch**  
 University of St Andrews  
 School of Earth & Env. Sciences  
 North Street, KY16 8JY, St Andrews  
[aaf1@st-andrews.ac.uk](mailto:aaf1@st-andrews.ac.uk)

**Prof Tod E. Waight**  
 University of Copenhagen  
 Geology Section, Denmark  
 Øster Voldgade 10, 1350 København K  
[todw@ign.ku.dk](mailto:todw@ign.ku.dk)