DR FRED RICHARDS

Imperial College Research Fellow, Imperial College London

Geophysicist and geologist with expertise in numerical modelling of geodynamic, palaeoclimatic, and surface processes.

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ACADEMIC POSITIONS

Oct 2019 – Present: Imperial College Research Fellow
Department of Earth Science and Engineering, Imperial College London.

- Awarded the Geological Society of London's 2022 William Smith Fund.
- Published 4 manuscripts in *EPSL, GJI*, *JGR*, and *PEPI* (invited), 3 currently under review (*Nat. Geosci., Miner. Depos.*, and *EPSL*) and 6 to be submitted in early 2022 (*Nature, GRL, JGR*, and *EPSL*).
- Received 9 conference talk and seminar invitations (including SEG [keynote], SEDI, and ETH) and 2 invited chapters for *Encyclopaedia of Quaternary Science* and *Elsevier Science*.
- Offered A$170,000 (~£90,000) grant from Geoscience Australia to study Earth structure and dynamics.
- Lead supervisor for NERC PhD student (James Hazzard), secured £10,000 for Greenland fieldwork.
- Developed and maintained collaborations with researchers at institutions including Oxford, Imperial, Harvard, UC Berkeley, Columbia, Los Alamos, ANU, and GFZ Potsdam.

Sep 2018 – Sep 2019: Schmidt Science Fellow
Department of Earth and Planetary Sciences, Harvard University.

- 5 published manuscripts stemming from this work in *Nat. Geosci*, *Ann. Rev. Earth Plan. Sci*, and *Icarus*.
- Received 5 talk invitations (including AGU, EGU, and IUGG)
- Mineral deposit research estimated to be worth A$147-752 million to the Australian economy by independent consultancy, ACIL Allen; covered in *The Economist* and *Scientific American*.
- Developed new collaborations with researchers at institutions including Harvard, Columbia, and ANU.

EDUCATION

Oct 2014 – Aug 2018: PhD Earth Sciences – passed with no corrections.
Bullard Laboratories, Department of Earth Sciences & Jesus College, University of Cambridge.

Thesis: *Global Analysis of Predicted and Observed Dynamic Topography* (NERC-funded)

Supervisor: Prof. Nicky White

- Awarded a RAS Keith Runcorn Prize for best thesis in geophysics and planetary science (runner-up).
- Received G^3 Editors' Highlight award for paper on topographic evolution of Indian Peninsula.
- 3 first-author papers published in G^3 and *JGR*; invited talks at Imperial and Columbia.

Oct 2010 – Jun 2014: MSci Earth Sciences: 1st Class Honours – graduated top of the class.
Department of Earth Sciences & St. Anne's College, University of Oxford.

MSci Project: *The Origin, Structural Evolution and Potential Field Signatures of the Tasmantid Seamount Chain.*

Supervisors: Dr. Lara Kalnins & Prof. Tony Watts

- Project awarded highest mark in year (84%); findings published in G^3.

GRANTS & AWARDS

2022 **Geological Society of London William Smith Fund (£500)**
Awarded for excellence in contributions to applied and economic aspects of geoscience.

2022–2024 **Geoscience Australia (A$170,000; ~£90,000)**

Title: *Dynamics of the Australian Upper Mantle: Impacts on Future Sea-Level Change and Mineral Deposit Formation*
Role: Principal Investigator.

2019–2023 **Imperial College Research Fellowship (~£48,500 p.a. + £28,200 research expenses)**
Title: *Quantifying the Impact of Earth's Internal Dynamics on the Cryosphere.*
Role: Principal Investigator (personal fellowship), sponsored by Gareth Roberts.
Notes: 1 of 20 selected.

SSCP DTP Fieldwork Fund (£10,000)
Notes: Awarded to partially cover field trip to Greenland and dating of rock samples.

2018–2019 **Schmidt Science Fellows in partnership with the Rhodes Trust ($100,000; ~£75,000)**
Title: *Contribution of Solid Earth Dynamics to Late Cenozoic Relative Sea-Level Change*
Role: Principal Investigator (personal fellowship), advised by Jerry Mitrovica
Notes:1 of 14 selected in inaugural class, only successful UK, and Earth Science applicant.

2018 **RAS Keith Runcorn Prize** for best thesis in geophysics and planetary science – runner-up.

2017 ***G*^{3} Editors' Highlight** for first-author paper ("Cenozoic Epeirogeny of the Indian Peninsula").

2015 **Jesus College Travel Grant (£500)** – used to attend EGU 2015, Vienna.

2014–2018 **NERC PhD Studentship** (**£14,000 p.a. + £10,000 research expenses**)

2014 **BP Prize** for best MSci Project, Oxford Earth Sciences Department.

2013 **Burdett-Coutts Prize** for top mark in Final Honour School, Oxford Earth Sciences Department.

2013 **Shell Prize** for top mark in Geochemistry, Oxford Earth Sciences Department.

2011-2014 **St. Anne's College & University of Oxford Scholarship** for performance in examinations.

TEACHING & SUPERVISION

Research Supervision

Principal PhD supervisor of James Hazzard, through Imperial College SSCP DTP (2019-Present).

Designed and supervised MSci project of Imperial Applied Computational Science and Engineering MSci student (Sian Arnold [2020]).

Mentored and supervised 4 Cambridge MSci students during 4th-Year MSci projects (2014-2018).

Mentored, supervised, and designed projects for 2 visiting PhD students at Cambridge (2017). Advised and collaborated with 5 other PhD students in my group (2015-2018).

Postgraduate

Co-designed and led 4 practical sessions for Modelling and Numerical Methods - Part I module of Imperial's Applied Computational Science and Engineering MSci (2021).

Delivered Basin Analysis lecture and practical for Imperial Petroleum Geoscience MSci (2020).

Delivered lecture to Harvard Sea Level Change course (2019; "Q" score of 4.5 out of 5).

Undergraduate

Lecturer for Imperial 3rd-Year Continental Tectonics (2019-2021), delivering 7 lectures and practicals, and 2 revision sessions.

Supervisor (~8 hrs/term) and demonstrator (~2 hrs/wk) for Cambridge Sedimentary Basins (2nd-Year), Core Geophysics (3rd-Year) and Basin Analysis (4th-Year) courses (2014-2018).

Field Teaching

Demonstrator and group leader on 4th-Year Apennines virtual field trips (2020 & 2021). Wrote summaries, practical sessions and Jupyter notebooks for geophysical element.

Demonstrator on Cambridge Isle of Arran Field Trip (2016-2018).

FIELD EXPERIENCE

2018 **Geochronological Sampling and GPS Surveying:** Field assistant on 2-week trip to Bahamas to sample and survey MIS 5 corals and beach rocks on Eleuthera to build sea-level chronology.

2015 **Geochronological Sampling, GPS, and Drone Surveying:** Field assistant on 4-week trip to Madagascar. GPS and drone surveyed raised coral terraces. Collected basalt for rare-earth element inversion, corals for U-Th dating, and granitic/gneissic samples for apatite fission track analysis (AFTA) and apatite-helium geochronology (AHe).

2013 **Oceanography:** two-day long cruise to Bermuda Atlantic Time Series site, taking CTD measurements and learning how to process ADCP and multi-beam bathymetry data.

2012 **Bedrock Mapping**: 5-week long mapping project on Bracco Ophiolite in Liguria, Italy.

INVITED TALKS

(K) = *keynote or plenary*

2021 **Richards, F. D.**, Inferring upper mantle thermomechanical structure using calibrated parameterisations of anelasticity, GFZ Potsdam Basin Modelling Seminar, **GFZ Potsdam**, Potsdam (DE).

Richards, F.D., How high will sea-levels rise? Lessons from the geological record, Climate Change: Impacts and Innovations Virtual Conference in association with **Schmidt Science Fellows**.

Richards, F. D. (K), Gigayear stability of cratonic edges controls global distribution of sediment-hosted metals, **Society of Economic Geologists 100 Meeting**, Whistler (CA).

2020 **Richards, F. D.**, Hoggard, M. J., Ghelichkhan, S. & Lau, H. C. P., What Are LLSVPs? Geodynamic Insights into Lower Mantle Chemistry and Structure, **SEDI 2020**, Taipei (TW). Postponed to 2022.

Richards, F. D., Mapping Seismic Tomography into Earth Structure: Implications for Dynamic Topography, Lithospheric Stability, and Sea-Level Reconstructions, Bullard Laboratories Wednesday Seminar, **University of Cambridge**, Cambridge (UK).

Richards, F. D., Earth's Dynamic Topography: Implications for Mantle Structure and Sea-Level Records, Geophysical Fluid Dynamics Seminar, **ETH Zürich**, Zürich (CH).

Richards, F. D., Mapping Seismic Tomography into Upper Mantle Structure: Implications for Dynamic Topography and Sea-Level Reconstructions, Earth and Planets Seminar, **Imperial College**, London (UK).

Richards, F. D., Gigayear stability of cratonic edges controls global distribution of sediment-hosted metals, Mineral Deposits Group Seminar, **Natural History Museum**, London (UK).

2019 **Richards, F. D.**, Hoggard, M. J., Ghelichkhan, S. & Lau, H. C. P., What Are LLSVPs? Geodynamic Insights into Lower Mantle Chemistry and Structure, **AGU** Fall Meeting, San Francisco (USA), DI23A-03.

Richards, F. D., Hoggard, M. J., Ghelichkhan, S. & Lau, H. C. P., The Role of LLSVPs in Reconciling Observations and Predictions of Earth's Dynamic Topography, **IUGG**, Montréal (CA), IUGG19-3669.

Richards, F. D., Hoggard, M. J., Ghelichkhan, S. & Lau, H. C. P., Reconciling Observations and Predictions of Earth's Dynamic Topography, *Geophysical Research Abstracts*, **21**, **EGU**, Vienna (AT), EGU2019-3744.

Richards, F. D., Mapping Upper Mantle Heterogeneity and Its Impact on Dynamic Topography, Geodynamics Seminar, **Lamont-Doherty Earth Observatory**, **Columbia University**, Palisades (USA).

2018 **Richards, F. D.**, Reconciling Observations and Predictions of Earth's Dynamic Topography, BiSEPPS Seminar, **Harvard University**, Cambridge (USA).

Richards, F. D., Global Dynamic Topography and its Impact on Australian Sea-Level, Friends of PlioMax Meeting, **Lamont-Doherty Earth Observatory**, **Columbia University**, Palisades (USA).

Richards, F. D., Resolving Discrepancies Between Observed and Predicted Dynamic Topography, Earth and Planets Seminar, **Imperial College**, London (UK).

N.B. ***37*** *regular conference presentations at AGU* ***(26)****, EGU* ***(10)****, IUGG* ***(1)*** *not shown.*

SELECTED MEDIA COVERAGE

2020 Scientific American: *"Science Pinpoints Global Metal Deposit Locations"*.
Eos: *"Cratons Mark the Spot for Mineral Bonanzas"*.

2019 The Economist: *"Ore bodies, it has been discovered, are not randomly distributed"*.
Mining Journal: *"The story behind one of the year's biggest discoveries"*.

ACADEMIC SERVICE

2021 Lead convenor of *Links Between Earth's Internal Dynamics and Surface Evolution from Archean to Present* session at 2021 AGU Fall Meeting, New Orleans (USA).

2020–Present Events Team Lead, Royal Astronomical Society Early Career Network.

Imperial College Earth & Planets Seminar organiser.

Geodynamics, Climate and Surface Processes Reading Group founder and organiser.

Imperial-MIT Seed Fund Review Panel member (1 of 4 selected).

Imperial Schmidt Science Fellows Application Review Panel member.

2019–Present Developer of NSF-supported open-source code ASPECT (aspect.geodynamics.org) that solves the equations governing thermochemical convection in planetary mantles.

2018–2019 Harvard University Graduate Student and Postdoc Seminar organiser.

2016–Present Peer Reviewer: *AGU Books*; *Earth-Science Reviews*, *G*^{3}; *Geology*; *GRL*; *JGR*; *Mar. Geophys. Res.*; *PEPI*, *Proc. R. Soc. Lond.: A*, *Science Advances*.

OUTREACH & PUBLIC POLICY ENGAGEMENT

2021 Organised and chaired 3 careers events and a poster competition for the RAS Early Career Network.

Application shortlisted for Royal Society Pairing Scheme, which connects researchers to politicians.

"How to become a Geologist" talk for School21 Career Paths (https://www.youtube.com/watch?v=l2jC5zz2o7s).

2020 Invited post on dynamic topography for EGU's Geodynamics blog.

"What's Our Planet Made Of?" outreach event at Hurlingham School.

Speaker at UCL Insight "Careers in Research within Academia" event.

2019 Co-organised AGU Town Hall session entitled "Disaster Policies or Disastrous Policies? A Town Hall at the Junction of Natural Hazards, Society, Science Policy, and Communication".

Wrote article on science-policy interaction for Schmidt Science Fellows website.

2017 Organised and coordinated Planet Earth section of Cambridge Pint of Science festival; chaired "Breathe Easy: The Future of Energy Is Here" evening (16th May).

2016–2018 Workshops Coordinator for Cambridge University Science and Policy Exchange.

MEMBERSHIPS

2015–Present Royal Astronomical Society; European Geosciences Union; American Geophysical Union.

2010–Present Geological Society of London; Royal Geographical Society.

PUBLICATIONS

** = yet to be published; ^ = not research-related.; ´ = equal contribution.*

In Review (16*) **Richards, F. D.**, Hoggard, M. J., Ghelichkhan, S., Koelemeijer, P. & Lau, H. C. P., Geodynamic, Geodetic and Seismic Constraints Favour Deflated and Dense-Cored LLVPs, *under review at Nature Geoscience*, preprint doi: 10.31223/X55601.

(15*) Huston, D. L., Champion, D. C., Czarnota, K., Duan, J., Hutchens, M., Paradis, S. G., Hoggard, M. J., Ware, B. D., Gibson, G. M., Doublier, M. P., Kelley, K. D., McCafferty, A. E., Hayward, N., **Richards, F. D.**, Tessalina, S. D. & Carr, G. R., Zinc on the edge: isotopic and geophysical evidence that cratonic edges control shale-hosted zinc-lead deposits, *under review at Mineralium Deposita*, preprint link.

2021 (14) Austermann, J., Hoggard, M. J., Latychev, K., **Richards, F. D.** & Mitrovica, J. X., The effect of lateral variations in Earth structure on Last Interglacial sea level, *Geophys. J. Int.*, **227**, pp. 1938-1960, doi: 10.1093/gji/ggab289.

(13) Ghelichkhan, S., Fuentes, J. J., Hoggard, M. J., **Richards, F. D.** & Mitrovica, J. X., The Precession Constant and its Long-Term Variation, *Icarus*, **358**, 114172, doi: 10.1016/j.icarus.2020.114172.

(12^) O'Brien, A. C., Boubert, D., Bowman, D. M., **Richards, F. D.** & Maunder, M., Pandemic Posters, *Astron. Geophys.*, **62**(1), pp. 19, doi: 10.1093/astrogeo/atab039.

(11^) Bowman, D. M., Maunder, M., **Richards, F. D.**, O'Brien, A. C. & Boubert, D., Hear it through the grapevine, *Astron. Geophys.*, **62**(4), pp. 12-14, doi: 10.1093/astrogeo/atab076.

2020 (10) **Richards, F. D.**, Hoggard, M. J., Crosby, A. G., Ghelichkhan, S. & White, N. J., Structure and Dynamics of the Oceanic Lithosphere-Asthenosphere System, *Phys. Earth Plan. Int.*, **309**, 106559, doi: 10.1016/j.pepi.2020.106559. Invited submission.

(9) **Richards, F. D.**, Hoggard, M. J., White, N. J. & Ghelichkhan, S., Quantifying the relationship between short-wavelength dynamic topography and thermomechanical structure of the upper mantle using calibrated parameterization of anelasticity, *J. Geophys. Res.: Solid Earth*, **125**, e2019JB019062, doi: 10.1029/2019JB019062.

(8) Hoggard, M. J.´, Czarnota, K.´, **Richards, F. D.´**, Huston, D. L., Jaques, A. L. & Ghelichkhan, S., Global distribution of sediment-hosted metals controlled by craton edge stability, *Nature Geoscience*, **13**, pp. 504-510, doi: 10.1038/s41561-020-0593-2.

(7) Klöcking, M., Hoggard, M. J., Rodríguez Tribaldos, V., **Richards, F. D.**, Guimarães, J. A., Maclennan, J. C. & White, N. J., A tale of two domes: Neogene to recent volcanism and dynamic uplift of northeast Brazil and southwest Africa, *Earth Plan. Sci. Lett.*, **547**, 116464, doi: 10.1016/j.epsl.2020.116464.

(6) Mitrovica, J. X., Austermann, J., Coulson, S. L., Creveling, J. R., Hoggard, M. J., Jarvis, G. T. & **Richards, F. D.**, Dynamic Topography and Ice Age Paleoclimate, *Ann. Rev. Earth Planet. Sci.*, **48**(1), pp. 585-621, doi: 10.1146/annurev-earth-082517-010225.

(5) Czarnota, K., Hoggard, M. J., **Richards, F. D.**, Teh, M., Huston, D. L., Jacques, A. L. & Ghelichkhan, S., Minerals on the edge: Sediment-hosted base metal endowment above steps in lithospheric thickness, *Exploring for the Future: Extended Abstracts*, Geoscience Australia, Canberra, doi: 10.11636/134991.

(4) Huston, D. L., Champion, D. C., Czarnota, K., Hutchens, M., Hoggard, M. J., Ware, B. D., **Richards, F. D.**, Tessalina, S. D., Gibson, G. M. & Carr, G., Lithospheric-scale controls on zinc-lead-silver deposits of the North Australian Zinc Belt: evidence from isotopic and geophysical data, *Exploring for the Future: Extended Abstracts*, Geoscience Australia, Canberra, doi: 10.11636/134276.

2018

(3) **Richards, F. D.**, Kalnins, L. M., Watts, A. B., Cohen, B. E. & Beaman R. J., The Morphology of the Tasmantid Seamounts: Interactions Between Tectonic Inheritance and Magmatic Evolution, *Geochem. Geophys. Geosyst.*, **19**, pp. 3870-3891, doi: 10.1029/2018GC007821.

(2) **Richards, F. D.**, Hoggard, M. J., Cowton, L. R. & White, N. J., Reassessing the Thermal Structure of Oceanic Lithosphere with Revised Global Inventories of Basement Depths and Heat Flow Measurements, *J. Geophys. Res.: Solid Earth*, **123**, pp. 9136-9161, doi: 10.1029/2018JB015998.

2016

(1) **Richards, F. D.**, Hoggard, M. J. & White, N. J., Cenozoic Epeirogeny of the Indian Peninsula, *Geochem. Geophys. Geosyst.*, **17**, pp. 1525-2027, doi: 10.1002/2016GC006545.

MANUSCRIPTS IN PROGRESS*

**Only in-progress manuscripts expected to be submitted in first half of 2022 are listed.*

Richards, F. D., Coulson, S. L., Austermann, J., Hoggard, M. J. & Mitrovica, J. X., The Impact of Mantle Dynamics on Australian Mid-Pliocene Sea-Level Records, *in prep. for submission to Nature*, bibcode: 2020AGUFMDI014..05R, presentation link.

Hazzard, J. A. N., **Richards, F. D.**, Roberts G. G. & Goes, S. D. B., Thermomechanical Structure of the Antarctic Upper Mantle, *in prep. for submission to JGR: Solid Earth*, bibcode: 2021AGUFMDI14A..02C, presentation link.

Coulson, S. L., **Richards, F. D.**, Hoggard, M. J., Austermann, J. & Mitrovica, J. X., Dynamic Topography Across the Canadian Arctic and Implications for Plio-Pleistocene Glacial Inception, *in prep. for submission to Earth Plan. Sci. Lett.*, bibcode: 2019AGUFM.C14B..07C, presentation link.

Hoggard, M. J., Shorttle, O., **Richards, F. D.**, White, N. J. & Maclennan J. C., Reconciling Geophysical and Geochemical Observations of Supercontinent Insulation, *under review at Earth Plan. Sci. Lett.*, preprint link.

Ghelichkhan, S., Moore K. M., Hoggard, M. J., **Richards, F. D.**, Chan, N.-H., Creveling, J. R. & Mitrovica, J. X., Closing the budget of 20th Century True Polar Wander, *in prep. for submission to Geophys. Res. Lett.*, preprint link.

Richards, F. D., Modelling global mean sea level since the Pliocene, *in prep. for submission to Encyclopedia of Quaternary Science*. Invited book chapter.

Davies, D. R., Ghelichkhan, S., Hoggard, M. J., Valentine, A. P. & **Richards, F. D.**, Observations and Models of Dynamic Topography: Current Status and Future Directions, *in prep. for submission to Elsevier Science*. Invited book chapter.

REFEREES

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Prof. Nicholas J. White, Professor of Cymatogeny, Bullard Laboratories, Department of Earth Sciences, University of Cambridge.
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