DR FRED RICHARDS

Imperial College Research Fellow, Imperial College London

Geophysicist and geologist with expertise in geodynamics, palaeoclimate, and geomorphology.

ACADEMIC POSITIONS

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

- 4 research manuscripts published: *EPSL, GJI*, *JGR*, and *PEPI* (invited); 3 in rev.: *AGU Adv., Miner. Depos.*, and *Elsevier Science*; 6 in prep. for 2022 submission, including: *Nature, GRL, JGR*, and *EPSL*.
- 9 invited conference talks and seminars, including: SEG (keynote), SEDI, and ETH Zurich.
- 2 invited chapters for *Encyclopaedia of Quaternary Science* and *Elsevier Science* (in rev.).
- Awarded Geological Society of London's 2022 William Smith Fund for *"excellence in contributions to geoscience research and its application"*.
- Offered A$170,000 (~£95,000) grant from Geoscience Australia to study Earth structure and dynamics.
- PhD supervision/co-supervision: James Hazzard (2020-Present)/Matt Morris (2022-Present).
- Collab. network: Oxford, Imperial, Harvard, Berkeley, Columbia, Los Alamos, ANU, and GFZ Potsdam.

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

- 5 manuscripts published, including: *Nat. Geosci*, *Ann. Rev. Earth Plan. Sci*, and *Icarus*.
- 5 invited talks, including: AGU, EGU, and IUGG.
- Mineral deposit research estimated to be worth A$147-752 million (~£85-430 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 ESS DTP-funded)

- Awarded an 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

GRANTS & AWARDS

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

Imperial College Wings for Ideas Fund (£2,500)
Title: *Making Machine Learning-Based Treasure Maps for Critical Metal Resources*

2022–2024 **Geoscience Australia – Exploring for the Future Program (A$170,000; ~£95,000)**
Title: *Dynamics of the Australian Upper Mantle: Impacts on Future Sea-Level Change and Mineral Deposit Formation*

2020-2024 **SSCP DTP Fieldwork Fund (£10,000)**
Notes: Awarded to partially cover field trip to Greenland and dating of rock samples.

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*
Notes: 1 of 20 selected.

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*
Notes: 1 of 14 selected in inaugural class, only successful UK, and geoscience 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, Imperial SSCP DTP student (2019-Present), AGU 2021 OSPA award winner. Co-supervisor of Matthew Morris (2022-Present).
- Sian Arnold (2020), MSc project, Imperial Applied Comp. Sci. and Engineering.
- Supervised and designed projects for 2 visiting PhD students at Cambridge (2017).

Postgraduate
- Co-designed and led 4 practical sessions for Modelling and Numerical Methods - Part I module of Imperial Applied Comp. Sci. and Engineering MSc (2021).
- Delivered Imperial Petroleum Geosci. MSc Basin Analysis lecture & practical (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. Received universally positive 'SOLE' feedback and 2 bonuses from departmental management committee for *"excellent contributions"* to teaching.
- Supervisor (~8 hrs/term) and demonstrator (~2 hrs/wk) for Cambridge Sed. Basins (2nd-Year), Core Geophysics (3rd-Year) and Lithospheric Dynamics (4th-Year) courses (2014-2018).

Field Teaching
- Demonstrator and group leader on 4th-Year Apennines virtual field trips (2020 & 2021). Course handbook, practical sessions and Jupyter notebooks for geophysical element.
- Demonstrator on Cambridge Isle of Arran Field Trip (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).

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).

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* (x2).

OUTREACH & PUBLIC POLICY ENGAGEMENT

2021
- Organised and chaired 3 careers events and a poster competition for RAS Early Career Network.
- Application shortlisted for Royal Society Pairing Scheme, connecting 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 (17*) 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, *submitted to Elsevier Science (Dynamics of plate tectonics and mantle convection - Ed: J.C. Duarte)*, preprint link. Invited book chapter.

(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 AGU Advances*, 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 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., Probabilistic Assessment of the Thermomechanical Structure of the Antarctic Upper Mantle, *in prep. for submission to JGR: Solid Earth*, bibcode: 2021AGUFMDI14A..02C, presentation link. Received an Outstanding Student Presentation Award at AGU Fall Meeting 2021.

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.

REFEREES

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