

Institution: Royal Holloway University of London

Unit of Assessment: 07 – Earth Systems and Environmental Sciences

Section 1. Unit context and structure

Our Unit is embedded within the new School of Life Sciences and the Environment (established 2019). Our research tackles the critical challenges faced by people living on a rapidly evolving Earth: securing clean energy, understanding climate change and its environmental consequences, managing geological hazards and tracing the limits of habitability and the origins of life. Our staff have leading roles in the development, coordination, and delivery of ambitious research projects with international and UK-based academic and industrial partners. Our work has resonance in fields including environmental governance, resource exploration and the ethical and inclusive conduct of research.

1.1 Research structures

Our researchers are positioned within three core themes: *Geodynamics and Sedimentary systems*; *Global Environmental Change*; *Physics and Chemistry of Earth Systems*. These groupings encourage collaboration and expertise is shared across each thematic area. Research groups focused on specific aspects of our research (e.g. greenhouse gases, ocean sediments, South East Asian tectonics) are embedded into the broader cross-department themes and allow us to nurture investigator-led proposals, build cohorts of post-graduate research students (PGRs) and support post-doctoral researchers and fellows.

1.1.1 Geodynamics and sedimentary systems

Our research enables us to tackle critical issues of resource management, tectonic hazard planning and mitigation, and the impact of climate change on marine systems. These topics crystallise around research projects that allow us to build industrial networks and partnerships to leverage funding, expertise, exchange opportunities and impact. These partnerships have been a major force driving PhD student recruitment. Our research into *geological fault and fracture evolution* impacts on hazard prediction: Gudmundsson applies tectonic theory to predict volcanic hazards on Iceland and Santorini. Our leading work on *tectonic analogue modelling* (Adam) allows us to advise external partners on resource distributions and subsurface fluid flow. Our *planetary remote sensing* research advances our understanding of the landslide and tsunami hazard potential on Earth and the composition of planetary bodies such as Venus (Ghail, Watkinson). Our critical mass of researchers investigating *ocean sediments* allows us to reconstruct past ocean currents, sea-level and geological processes, which resonate with industry partners and inform narratives of past ocean change to the general public (impact case-study: Hernandez-Molina) as well as attracting Royal Society Newton and Marie-Curie Fellows (e.g. Dorador). Our *South East*

Asia Research Group (SEARG) has revolutionized understanding of the tectonic evolution, resource and hazard potential of South East Asia and works with governmental and academic partners to disseminate knowledge and training in the region.

1.1.2 Physics and chemistry of Earth systems

Researchers in our Physics and Chemistry theme use cutting-edge modelling and measurement techniques to advance our understanding of Earth System behaviour and its impact on the environment. Our research creates impact on national and international climate policy, public understanding of climate change and natural hazards and the management of critical water resources. We measure atmospheric *greenhouse gas compositions* and the *molecular chemistry of atmospheric aerosols and pollutants* to understand the carbon cycle and the impact of atmospheric particles on climate forcing and air quality. Our work impacts on national and international climate and industrial strategies (impact case-study: Nisbet). Research into the *isotopic composition of natural materials* creates tools for tracing the evolution of the Earth System and enhances our understanding of environmental process at times of rapid climate change. Our researchers' work to characterize the environments and processes that form economically important *mineral reserves* has enabled PhD recruitment through collaborations including the British Geological Survey.

1.1.3 Global Environmental Change

We produce narratives of past life and environments that inspire the general public to environmental awareness and that impact on environmental governance. The breadth of our work includes the use of fossil plants to evaluate vegetation-climate interactions from the Paleogene and Paleozoic, and the climatic and ecological impacts of wildfires. Our research in this theme informs policy decisions by the UK Government and national and international agencies (impact case-study: Scott).

1.2 Research objectives

1.2.1 Objectives and successes 2013–2020

Our research is informed by *four strategic objectives*: (i) to address the challenges of global environmental change and the sustainable energy transition; (ii) to foster a diverse, supportive and engaged research community by recruiting early and mid-career scientists and PhD students, and by supporting all our staff involved with investigator and challenge-led projects; (iii) to improve our operational infrastructure to foster impactful, multi-disciplinary research; (iv) to strengthen our extensive industrial collaborations and networks built up since 2003 to leverage income, access to specialist facilities, collaborative networks, and to facilitate impact and knowledge exchange activities. This strategy has informed the work of our three core themes.

Geodynamics and sedimentary systems: Fault dynamics and analogue modelling research includes the COMPASS industrial consortium (Shell, Petrobras, Chevron, ~£600,000 and tied studentships) to Adam that was highlighted as a target in REF2014. Similarly, our REF2014 aim to develop research in deep-water depositional systems is reflected by the success of the Drifters Group, led by Hernandez-Molina: >£800,000 of Joint Industry Partnerships (JIPs) have been awarded since 2013 and research, e.g. on the influence of Mediterranean Outflow Water on Atlantic sedimentary systems (*Science*, 2018), underpins one of our impact case-studies. In REF2014 we stated our aim to *investigate fluids, faults and subduction processes, and bend-fault serpentinization*: Watkinson and Hall demonstrated the impact of human irrigation schemes on co-seismic landslide risk in *Nature Geoscience* (2019), and Morgan secured NERC funding in 2017 to investigate the interactions of fluids and carbonate mineralisation during crustal subduction. Work not anticipated in REF2014 includes research by ECR Dorador to develop a new method to quantify sediment bioturbation as a proxy for climate change and deep-sea sedimentary processes (*Nature Scientific Reports*, 2019, 2020).

Physics and chemistry of Earth systems: Our aim to study the global methane inventory, identified in REF2014, has been progressed through major reviews by Nisbet, Lowry and Fisher in *Reviews in Geophysics* (2020) and *Science* (2014). Multiple UKRI awards from 2016–2020 allowed the purchase of new equipment (e.g. ECR Fisher, £245,000, 2019) that underpins ongoing efforts to track the methane cycle and impact on climate policy. Our *REF2014 aim to quantify aerosol and cloud effects on climate* was strengthened by multiple facility grants with the Rutherford-Appleton Laboratory/ISIS plus a NERC standard grant in 2019 (King, ~£648,000). Our *REF2014 aim to investigate biodiversity and rapid climate transitions* was supported by a Leverhulme grant on Mesozoic climate change to Thirlwall (2014, £250,000) and NERC DTP studentships to Dickson focusing on the end-Triassic Mass Extinction (2019-) and the Early Paleogene (2019-). *We aspired to apply our LA-ICP-MS to produce high-resolution records of cryosphere change*: in 2019, Müller published high resolution reconstructions of Quaternary atmospheric circulation from ice cores in *Nature Communications* (2015). Our newly appointed staff have been supported through college seed-funding and infrastructure investment, producing world-leading outputs not anticipated in REF2014: Dickson used a newly installed (2018) mass spectrometer to determine the Re-isotope composition of seawater for the first time (*Geochimica et Cosmochimica Acta*, 2020) and Koelemeijer co-led a high-profile study in *Science* (2020) that showed worldwide decreases in anthropogenic seismicity during the 2020 Covid-19 pandemic.

Global Environmental Change: Building on work initiated between 2008–2013, the geochemistry of minimally altered lignite was used to document continental palaeoclimate in *Nature Geoscience* (2018). A key aim in REF2014 was to investigate *human-environment relationships*: Scott and Collinson have documented the relationships between fire occurrence, past warm climates and

atmospheric oxygen, leading to substantial impacts on UK policy, documented as an impact case-study.

Our three impact case studies (wildfires: Scott; deep-water sedimentary systems: Hernandez-Molina; methane cycle: Nisbet) show how our overarching strategy of working in critical areas of environmental change and resource sustainability, supporting ECRs and PGRs, and working closely with industrial and commercial partners, has yielded social economic and political impacts. Our Methane Cycle impact study, for example, is a rich narrative of how world leading research results, supported by our strategy of nurturing *both* investigator and challenge-led research, has enabled impact in social, economic and political spheres by establishing our academics as expert consultants in UN advisory panels and in the media.

1.2.2 Research and impact objectives 2021–2026

Our goal for 2021–2026 is to undertake excellent research that impacts on critical issues of environmental sustainability, energy and resource management. We have identified several targets to achieve this goal:

- We will develop our research *themes* into three **Centres** (*Centre for Energy, Environment and Resources; Centre for Dynamic Earth and Solar System; Centre for Atmospheres, Oceans and Climate*). Centres will raise the profile of key areas of impactful research in our unit, improve coordination of funding and impact activities, coordinate training events for staff, support for PGR students, and harmonise support and resources for researchers. The Centre names allow us to move away from groupings based on *techniques* and towards groupings based on areas of *strategic impact*.
- We will advance our agenda to support fairness and equality as a basic requirement of excellent, impactful research. We will undertake a root and branch review of our department's existing policies to support women, BAME and disabled staff and students, recommend mechanisms to ensure that researchers are treated equally and sensitively in all areas of activity, and apply to renew our Athena Swan award in 2021.
- We will bid to redesign our research spaces to accommodate new areas of activity, make more efficient use of space (e.g. by establishing multi-purpose departmental laboratories), to improve their aesthetic to attract new research fellows and collaborators, and to create flexibility for future installation of new equipment. A consultation was started in 2019 and will continue into 2021 with input from our partners in academia and industry.
- Our collaborations with external partners including the GeoNetZero CDT, ARIES DTP, Natural History Museum, JAXA and NASA (Chan), the European Space Agency (Ghail) and the Rutherford Appleton Laboratory/ISIS (King), will allow us to diversify into emerging research areas including the *sustainable energy transition, composition of extraterrestrial bodies, sustainable water resources, planetary remote sensing and deep-Earth*

seismology. Our collaborations and knowledge exchange partnerships will also give us access to rare sample material (e.g. meteorite via *Hayabusa-2*) and enrich our training opportunities for staff and PGRs.

- We will support our staff to bid for cutting edge equipment via funders including NERC and the Royal Society, to develop our capabilities in micro-scale geochemistry of geological materials, to improve our in-house server capacity to accommodate new research into deep-Earth seismology (Koelemeijer) and to create new opportunities for citizen-science engagement in seismology (e.g. with micro-seismometers) and water resources (Paul).

1.3 Strategies for enabling impact

Our four strategic objectives (section 1.1) are supported by enabling structures at College (REF5a), School and Department level to enable impact. A School research strategy, implemented in 2019, is overseen by the School Director of Research and Knowledge Exchange, who also chairs internal UKRI demand management panels. Our strategies to generate impact include:

- Building knowledge-exchange partnerships with our industrial funders, who provide data, co-supervise PGR students, advise on the design of our training and research programmes via our MSc advisory panels, and deliver training and networking events for our researchers in sedimentology and fault dynamics. These relationships allow us to explore how our research can benefit the economic activities of our partners.
- Annual reporting of research and impact activities during a Personal Development Review (PDR), with discussion about how the department can support activities with time allocation, research committee funding, or publication via our social media and formal network of contacts. Personal research reports were established as part of the PDR in 2020 and we aim to gauge their success on supporting impact activities through the next REF period via the annual review process.
- We have explored the commercialisation of our research infrastructure to stimulate **impact** in local and regional economies. The mass spectrometry laboratory in Earth Sciences was added to the '*Clustermarket*' commercial database in 2018, generating income and new commercial partnerships for elemental and Pb-isotopic analyses.
- We initiated a series on online outreach talks ('learn with us') in 2020 to disseminate our research to school children, members of the public and research partners. These talks attracted ~30–60 people each and reached an international audience consisting of academic colleagues, the general public and prospective student applicants.
- We maintain a database of outreach activities undertaken by staff members. This database allows us to notify feeder schools, industrial and academic partners, local government agencies and special interest groups of upcoming activities and novel research.

- We have an active social media team (Gough, Scarselli, Chiarella, Solferino) supported by our departmental website manager (Longbottom) who highlight job advertisements, publications, grants and outreach activities such as media interviews.

1.4 Supporting interdisciplinary research

Our strategy to support interdisciplinarity includes creating new synergies and identifying structural changes to our research themes and facilities that can support partnerships.

- We will develop an inter-disciplinary *Energy Institute* with the departments of Physics, Electrical Engineering, Computer Sciences, Management, Law, Economics and International Relations. The Institute, led from our Unit by Adam, will coincide with a critical time in the UK's energy strategy post-2021. By linking with RHUL's *Sustainable Living Catalyst* it will create opportunities for our interdisciplinary research to impact strongly on the UK's evolving political-economic landscape and decarbonisation agenda.
- Our partnership with 5 HEIs and >30 partner institutes in the NERC London DTP and ARIES DTP consortia stimulates inter-disciplinary research proposals. Synergies are supported by annual DTP *sandpit* events and all students have an *independent impact advisor* drawn from the network of DTP industry partners who advise on wider applications of research results. Our membership of the industry-funded *GeoNetZero* CDT (established in 2019) enables our researchers to interact with the energy industry to formulate new projects and extract datasets, following from our successful involvement in the NERC Oil and Gas CDT prior to 2018.
- The School of Life Sciences and the Environment connects our researchers with staff in the Departments of Geography, Biology and Psychology. Emerging synergies are coordinated by the School Lead in Research and Knowledge Exchange (Dodds) and will continue from 2021 with the *Sustainably Living Catalyst*, which will support impact activities and networks in priority areas such as energy security, governance and clean growth.

1.5 Supporting open access to the research environment

The department research committee provides guidance and annual bespoke research integrity and ethics training to all members of staff and research students in research publishing in open-access journals. Departmental guidance is supported by College structures including the *Advance Researcher Programme* (*Advance*, and its predecessor *On Track*). Early career staff attend *Advance* sessions as part of their probationary conditions. All staff and PGRs are required to deposit author-accepted versions of papers into the Royal Holloway PURE database. PURE is administered by an open access team in the College library who check all submissions for compliance and discuss with academics how to achieve this. Open-access Article Processing Charges (APCs) are supported by college in three ways: (i) RHUL is part of the JISC agreement with Wiley (from January 2020), allowing APCs to be paid for all researchers; (ii) RHUL receives

an annual block grant to support UKRI funded researchers. (iii) The department research committee allocates funds for APCs for category A staff and PGRs.

Section 2. People

2.1 Staffing strategy and staff development

2.1.1 Staffing and recruitment policies

Our staffing policies support our research and impact strategies. We have 29 category A members of staff, comprising 26.13 FTE, compared to our REF2014 submission of 24.95 FTE. This growth has been possible by recruiting early- and mid-career scientists to bolster and sustain areas of strength and to diversify our research, and by supporting our experienced researchers with continuing professional development. In 2020, our category A members of staff included 5 lecturers, 5 senior lecturers, 5 readers, 12 professors and 2 Research Fellows. We have recruited 12 new early- and mid-career academics: Chiarella, Basu, Solferino, Dickson, Gough, Ghail, Chan, Paul, Fisher, Manning, Koelemeijer, Scarselli: 7 men, 5 women. Two category A staff are independent research fellows: Dorador (Royal Society Newton Fellow, 2017–2019, Marie-Curie Fellow, 2019–) and Koelemeijer (Royal Society University Research Fellow and proleptic lecturer, 2019–). We have 9 technical staff.

We aim to maximise staff potential by adopting inclusive and supportive structures. These structures have enabled us to become a more diverse body of researchers: ~30% of our FTE are women (24% in REF2014), ~26% are early-career researchers (12% in REF2014), and ~11% are from BAME backgrounds (0% in REF2014). This change has occurred despite a small increase in category A FTE, due to (semi) retirements of Alderton, Menzies, McClay, Thirlwall, Matthey, Nisbet and by staff taking up professorships elsewhere (Muller: Frankfurt; Le Heron: Vienna; Burgess: Liverpool; Vannucchi: Florence; Morgan: SUSTech, China; Perez-Gussinye: Bremen). Our appointments provide continuity in areas of excellence (e.g. geochemistry and sedimentology: Chiarella, Dickson, Basu, Gough) and allow us to develop new strategic research in *environmental hydrology* (Basu, Paul), *sustainable energy* (Solferino, Scarselli) and *planetary/extraterrestrial geology* (Ghail, Chan, Koelemeijer).

2.1.2 Staff development strategies

We aim to maximise the potential of all staff (ECR and experienced) by following RHUL's commitment to continuing training according to the *Research Development Concordat*. We undertake annual PDRs to identify good practice and research targets commensurate to career stage. The research committee provides feedback on research and impact plans submitted by staff prior to their PDRs. Appraisals are used to help staff develop their profiles for promotion, discuss opportunities for inter-disciplinary collaborations, and to support investigator- and challenge-led ideas. Technical staff and post-doctoral researchers also have PDRs where their

well-being and career goals are discussed with their line manager. The department Research Lead organises training events from college staff to improve research skills and awareness of funding routes: examples include open access training (October 2016), and bidding for GCRF funding (February 2019).

2.1.3 Supporting early career researchers

New academics undertake a departmental induction and a three-year probationary period. During their probation they are given reduced teaching loads to allow them to participate in College-led research skills training (e.g. *Advance*) and to develop new research proposals. These activities are supported by experienced staff mentors and by a £3000 'new starters fund' that facilitates network-building and the purchase of critical resources. Post-doctoral research assistants are supported by: annual appraisals and dedicated skills training by academic line-managers, encouragement to engage in the bi-weekly research seminar series, access to funds to attend conferences to expand their academic network, time to participate in the college InSTILL programme to develop teaching and engagement skills, and encouragement to write independent research fellowships. Fellowship bids are supported by the department Research Lead and Research and Innovation.

2.1.4 Policies for research and sabbatical leave

Academic staff can apply for sabbatical leave, with the approximate weighting of 1 term in every 9. Applications are monitored by the research committee and approved at School level. All colleagues are invited to apply and between 2013–2020 six colleagues were able to take sabbatical research leave. We actively encourage colleagues at all levels to take advantage of this scheme via mentoring programmes and the annual PDR.

2.1.5 Recognition and reward

Our staff development procedures have supported promotions of ECR and experienced staff: Adam (2017), Falcon-Lang (2017), King (2014), Hernandez-Molina (2018), Ghail (2020), Müller (2015) and Vannucchi (2017) were promoted to Professor; Hier-Majumder (2018), Clemitshaw (2018), Lowry (2019), Chiarella (2020) and Dickson (2020) were promoted to Reader; Manning (2019), Scarselli (2019), Watkinson (2019), Basu (2020) and Solferino (2020) were promoted to Senior Lecturer. Grassineau was promoted from Teaching Fellow to Lecturer (2020).

2.2 Research students

2.2.1 Culture

We have a thriving postgraduate community that is integral to our research culture. Half of our REF2021 outputs are authored/co-authored by PGRs. Our results in the Postgraduate Research Experience Survey have consistently been within 1–2% of the sector average. In the most recent

2020 survey, our results for 'resources' and 'research skills' were respectively 12% and 3% above the sector averages. Our PGRs are provided with dedicated office space that allows them to bond as a cohort. This space allows cross-fertilization of ideas and the development of social links. The supportive and cohesive atmosphere of our PGR student community is enhanced by non-academic activities such as: departmental summer barbeques, social events organized by the student-led Lyell Geoscience Society, an annual PGR conference, and an annual 'Lyell Day' during which teaching is replaced by a series of talks by invited speakers. Lyell Day talks held from 2013–2020 attracted audiences between 30–100 from a cross section of our unit. Research students are encouraged to meet with academic staff during our bi-weekly coffee and cake sessions and initiated a student-staff Friday social.

2.2.2 Recruitment strategy

The success of our strategies to recruit PGR students is reflected in the number of students who graduated in the last REF period. From 2014–2020 our staff have supervised **95** PhD students to completion, higher than the 37 graduates in REF2014. 42% of our PhD graduates were women, and almost a third (30%) were from BAME backgrounds. Our large PGR community was supported by membership of the London NERC DTP from 2013–2018 and the NERC Oil and Gas CDT from 2013–2018. We joined the ARIES NERC DTP in September 2018 to strengthen our NERC PGR recruitment and to develop new training and research links with the 4 other HEIs and >30 research institutes affiliated to ARIES. Our candidates have received 3 studentship offers in the first 2 years of the DTP. We play a leading role in the DTP: Dickson co-authored the DTP proposal and acted as DTP head of impact (2018–2023) and deputy director (2019–2020). We joined an industry-funded *Geoscience and the Low Carbon Energy Transition* (GeoNetZero) CDT in March 2020. This consortium partners us with 12 HEIs across the UK and will recruit 2 fully funded students each year. Our DTP and CDT PGR recruitment is supported by a college contribution of 35% for each DTP studentship, a matched studentship for the CDT allocation and an international component fee waiver for 2021 studentship recipients. We recruit strongly to our MSc by Research degree programme, with 37 successful completions since 2014. Many of these students benefit from research expenses awarded by the department research committee.

2.2.3 Support and monitoring

Our PGR community is supported by a Postgraduate Research Lead (Collinson) who organizes induction events for new students, manages student progression, provides feedback on written work and chaired the annual PGR seminar series that preceded the current PGR annual conference. All PGRs have two internal supervisors and DTP/CDT students additionally have an independent 'impact' advisor from outside of academia. PGRs have annual review meetings attended by supervisory teams and an independent member of staff. The departmental research committee supports PGR research and has awarded ~£35,000 since 2013 for analytical work,

minor equipment, fieldwork, conference attendance and collaborative visits. 46% of our REF2021 outputs have PGR authors. All three of our impact case-studies have been underpinned by PGR research, such as mobile gas monitoring of methane emissions by PhD student Giulia Zazzeri.

2.2.4 Skills development and career progression

We follow the view of the UK Industrial Strategy (2017) that PGR students need to be trained for careers outside of academia. Students involved in the NERC DTPs participated in multi-institutional training courses. ARIES DTP students are trained according to the *Vitae Researcher Development Framework*, in research ethics, presentation skills and advanced research skills. Our non-DTP PGR students can access DTP training as co-opted members of annual cohorts. The RHUL *Advance* programme offers courses for PGRs. Our academics participate in other novel training activities for PGR students: Lowry teaches on the Marie-Curie MEMO2 network for PGRs across Europe. All PGRs can enrol in the RHUL InSTILL programme that leads to associate fellowship of the Higher Education Authority. The destinations of 8 graduates in a single year (2016) illustrate typical career pathways, with 1 working as a university lecturer, 4 as post-doctoral researchers, 2 as research assistants (one at the European Commission) and 1 as an environmental risk consultant.

2.3 Equality, diversity and inclusion

Our strategy is based on the conviction that excellent research must be accompanied by a commitment to equality, diversity and inclusion. We have addressed historical shortfalls by adopting recruitment policies to promote greater gender balance in our staffing, to improve our diversity of researchers from BAME backgrounds, and to support the personal development of all of our staff. We do not positively discriminate in recruitment but appoint the best candidates by removing impediments to female, disabled and BAME researchers. Our job advertisements guarantee interviews to candidates declaring a disability and carry a statement encouraging applications from females and under-represented minorities. Our selection and interview panels are composed of a cross-section of our department to promote a culture of inclusivity to interviewees. Interviewers must have completed college training on unconscious bias delivered by the *Advance* programme.

Two of our women staff have benefitted from the college maternity policy (2019 and 2020), which includes back to work interviews, a reduced teaching load, and protected time to allow research activities to be developed. These mechanisms have helped to maintain the proportion of women researchers in our category A FTE staff despite the departures of Vannucchi and Perez-Gussinye. Women have occupied leadership roles including Undergraduate Teaching Lead (Manning), Postgraduate Research Lead (Collinson), Director of Finance (Vannucchi), Senior Tutor (Fisher)

and Director of the South East Asia Research Group (Gough). Our academic composition reflects a diverse set of ethnic and cultural backgrounds from Europe, Asia, Africa and North America.

All members of staff with 26 weeks' service are eligible to apply for flexible working and time for professional development under the college's *Flexible Working Policy*. This policy provides options for non-standard working routines to accommodate parental or caring commitments, health, retirement planning, travel to work or charity work. Access to the scheme is equal for all employees. Staff wellbeing is supported by the college intranet '*Working Well Hub*' which provides easily accessible advice about working from home and campus and allows staff to order critical equipment (desks, IT hardware etc). It also provides advice for staff to balance work/life demands, teaching online, parenting during the Covid-19 pandemic, and support for women, LGBTQ and BAME staff.

We appointed an Equality and Diversity Lead in 2017 (Grassineau), who champions these issues on all department committees. Staff participate in college-led training initiatives such as the Strategic Leadership Programme (Adam) and bespoke line manager training for staff managing Post-Doctoral Research Associates. Our REF2021 submission followed the College's code of conduct: outputs were selected on the basis of excellence and to reflect our unit's staff composition and were screened and approved by a diverse cross-department panel. Our REF5b submission was made available to all researchers to provide input and feedback.

Our departmental mechanisms complement College-wide initiatives, including an *Equality Impact Assessment* for staff returning to campus following the first Covid-19 UK shutdown. We influence attitudes to equality and diversity in our wider discipline: Chiarella published articles on facilitating access to fieldwork for students with disabilities in *Science* (2018) and *Nature Communications* (2020).

Section 3. Income and infrastructure

Our income, infrastructure and facilities are integral to our research, impact and knowledge exchange activities. A strategy of income stream diversification, targeted improvement of existing departmental facilities, and a burgeoning range of links to world-class resources with our partners, positions us as leaders in our fields, and as strategically important players in interdisciplinary research activities into the 2021–2026 period.

3.1. Strategies for generating research income

3.1.1 Income strategy 2013–2020

Our research strategy called for the growth of existing areas of strength and diversification into new areas of environmental sustainability, energy and extraterrestrial/planetary geoscience. We supported this objective by investing in critical infrastructure to attract new highly-qualified staff members and to leverage competitive grants; and by strengthening our partnerships with industrial collaborators to sustain growth in consortia funding agreements, and to secure access to our partners' facilities and datasets. We appointed new staff to strengthen our Joint Industry Partnerships (e.g. Gough as South East Asia Group lead in 2019, Chiarella in 2016), expertise in extraterrestrial geology (Chan, Ghail) and hydrogeology (Basu, Paul).

3.1.2 Research Income 2013–2020

Our research income from 2013–2020 was ~£12.51M, representing ~12% of the RHUL total. Our income is greater than our REF2014 income of ~£10.2M, despite the retirement of professorial staff and appointment of several early-career researchers. **Our total UKRI in-kind income has increased to ~£1.76M from £1.16M in REF 2014.** When including in-kind contributions, our total income of ~£13.8M also exceeded our total REF2014 figure (~£11.36M), reflecting the success of our strategic measures to support our research.

Our income supports investigator-led research into 'blue skies' areas. Funding from NERC, the Royal Society and the UK Space Agency has supported our *geodynamics and sedimentary systems* theme investigate fault mineralisation (Morgan, 2017, £156,000). Funding from NERC, the Leverhulme Trust, STFC, BEIS and the EU have supported our *Physics and Chemistry of the Earth* researchers develop isotopic techniques to trace continental weathering (Dickson, 2019, £345,000), aerosol radiative forcing (King, 2020, £648,000), the global methane cycle (Nisbet, 2013–2020, >£1.3M), and deep-Earth seismicity (Koelemeijer, 2020, £167,000). In-kind awards have been important to our *global environmental change* researchers: Collinson was awarded 208 hours of beamtime at the Swiss Light Source synchrotron between 2014–2019, totalling ~£172,000 in-kind.

Industrial collaborations are a major income stream, contributing 58% of our total, compared to ~52% in REF2014. The South East Asia Group was funded by a consortium of end-users including ENI, GDF Suez, Statoil, and Marathon, and received ~£3.7M from 2014–2017 (Hall, Gough). Our strategy of upgrading our laboratories and facilities has attracted income from academic and non-academic collaborative agreements and consultancy: e.g. £6,000 from Woodside and Fault Rocks Ltd. (2019, Scarselli) and £7,900 from the Norwegian Institute for Air Research (2020, Fisher).

In-kind awards support our staff in accessing facilities such as the ISIS Neutron and Muon Source (King), the Diamond Light Source (King) and NERC airborne monitoring facilities (Nisbet, Lowry,

Fisher). These resources help us address critical, impactful topics such as industrial gas emissions and atmospheric climate forcing and have been critical to our impact case-studies.

Seed funding: The RHUL Research Strategy Fund (RSF) allocates ~£5,000 to individuals to build research capacity. Researchers in our Unit have received ~£25,000 of RSF funding over the REF2014 period (Scott, Basu, Solferino, Dickson, Chan) (80% ECR at the time of award). RSF funding for Dickson enabled method development on a mass spectrometer installed in 2018, leading to three publications, a NERC standard grant (2019), a Royal Society grant (2019) and two further grant submissions (2020). An RSF grant to Basu enabled the development of a GCRF collaborative network in India (University of Bangalore) to explore the problem of zinc deficiency in Indian soils and human health. Chan was awarded £5,000 in 2020 to establish an extraterrestrial material storage facility to receive materials returned by the Japan Aerospace Exploration Agency (JAXA) *Hayabusa-2* mission. This facility supported the appointment of a college-funded PhD student in 2020. The research committee re-invests unspent funds to support PGRs and manages an internship scheme (*Lyell* bursaries) for second year UG students to experience hands-on research training during the summer break, and a privately funded award (Kirsty Brown memorial) that gives students research experiences outside their degree programmes. 38% of Kirsty Brown awards have been awarded to women since 2014.

3.2 Organisational infrastructure

3.2.1 Organisational infrastructure

Staff are mainly based in the Queens Building, Egham, with one floor of office and teaching spaces and a second level of dedicated laboratory spaces. External laboratory facilities include the purpose-built Electron Microscopy building and the first purpose-built Sea Ice Simulator in the UK. The RHUL premises in Bedford Square, central London, and rooms in Senate House (REF5a), were used to host HEI partners for ARIES DTP writing group, Strategy Board and Operational Group meetings in 2018 and 2019. Strategic investment in departmental infrastructure is coordinated in an annual planning round. From 2013–2020, college investment (~£400,000) has enabled the renovation of teaching rooms, communal areas, and staff offices in Queens Building.

Our specialist facilities are overseen by a Technical Operations Manager (ToM, Parsonage) as resources for *all* suitably trained researchers. Our laboratories are supplied by a UPS power network and gas lines for our high-precision instruments. Our research infrastructure is supported by the College Estates and IT Departments, who maintain air-handling units, gas lines, gas monitors, fume hoods, ducting and IT servers. Our **research engineering workshop** (Morris) allows us to design and manufacture unique items such as Teflon analysis stages for use in synchrotron facilities (King) and a computer-controlled unit for producing sand-box analogue deformation rigs (Adam). Morris also maintains mobile greenhouse gas monitoring equipment.

The department management committee, chaired by the HoD and ToM, oversee conflicts of interest and laboratory health and safety.

3.2.1.1 Geodynamics and sedimentary systems

Our advanced **Analogue Tectonic Modelling Laboratories** include ~10 modular experimental rigs to simulate rock deformation. To support our industrial partnerships, strain monitoring techniques (2D/3D surface flow) were upgraded (£5,400) and further developed with Digital Volume Correlation for 3D volume strain analysis in collaboration with industry partner LaVision. The **Geomaterials Research Laboratory** was upgraded in 2015 with a Uniaxial Tester from college investment (£18,000) and industrial sponsorship (£17,000). Our **research computing laboratories** are used for geophysical and fluid modelling and are underpinned by industry-standard software packages (e.g. *Ikon, Kingdom, Landmark, Petrel*) and high-end workstations (e.g., *Midland Valley, Technology Strategy Board*). Our capabilities have been boosted by the donation of industry software licenses (e.g. 'Move' software totalling £1.53M in December 2019). Capital investment of £126,000 and £30,000 in 2017 enabled the purchase and installation of high-end workstations. Our development of deep-sea sedimentology outlined in REF2014 was supported by our **Thin-Section Laboratory**, which produces thin and thick sections, specialized stains, mounts and other products for optical microscopy and SEM. The lab supports many of our research objectives and is run by an experienced manager (Holloway).

3.2.1.2 Physics and chemistry of Earth systems

The **Greenhouse Gas Laboratory** is one of Europe's leading CH₄ facilities. Its gas source mass spectrometers and spectroscopic analysers were expanded to include mobile gas emissions monitoring and deuterium fingerprinting of methane sources from 2016–2020. A ~£273,000 NERC award to ECR Fisher in 2019 enabled the purchase of a Toyota RAV4 car, Licor portable CO₂ and CH₄ analyser (~£30,000), Picarro 10Hz flux analysis CH₄ and CO₂ spectrometer (~£94,000) and a Picarro methane isotope and ethane spectrometer (~£107,000) to develop mobile monitoring capabilities. These resources were deployed to quantify emissions from sensitive UK infrastructure such as the fracking test site in Lancashire. In the **Aerosol Laboratory** we can remove trace-level organic matter from particulate filters under low-blank conditions. The lab supports our partnerships with agencies such as the Diamond Light Source and has benefitted from a NERC grant to King in 2019, and several jointly-funded and CASE-funded studentships. The aerosol lab is linked with the **Sea Ice Simulation Facility**, whose research was used for a public film in November 2019.

Between 2013–2020, College investment of ~£50,000 enabled renovations to our **non-traditional isotope laboratory**. A Neptune Plus MC-ICP-MS spectrometer was installed in 2018 with ~£606,000 of college investment. This machine allows the measurement of ultra-low abundance

samples at world-leading levels of precision. The Neptune adds to our existing capabilities in Thermal Ionisation Mass Spectrometry, Laser Ablation Mass Spectrometry, light stable isotopes (three IRMS instruments), X-Ray Fluorescence and ICP-AES and supports the research of Basu, Dickson, Manning and Thirlwall. Our HEPA-filtered **Metal-Free Laboratories** were upgraded with an ultra-high purity Merck water system in May 2018 (£25,000). The new infrastructure supports our strategy of encouraging research into environmental change and the global energy transition.

A technician (Brakeley) was appointed in 2018 to support our geochemistry facilities. Brakeley also manages the **Rock Crushing and Mineral Separation** laboratories where our researchers can extract minerals for petrographic identification and geochemical analysis. In 2018, the department invested ~£90,000 to build a state-of-the-art **Geomicrobiology Laboratory**, managed by Basu, that opens up new frontiers for research into interactions between life and the environment. The new facilities, including a two-person anoxic glovebox, underpin funding applications to NERC and the US-NSF.

3.2.1.3 Global environmental change

The department's **microscopy facilities** were bolstered by the purchase of two advanced petrographic microscopes through the annual department planning round (£60,000, 2017, 2019, Solferino and Vannucchi). A fluid inclusion stage was added following further funding (£20,000, 2019, Solferino). Our **Electron Microscopy Unit** housed a Zeiss EVO-10 VP instrument that was decommissioned in 2018. A new instrument will be installed in 2021 following the award of £333,000 from college in 2020 and will be vital to stimulating inter-disciplinary research with the departments of Biology and Physics. New microscopy facilities support the **Paleobiology Laboratory**, equipped for physical and chemical pre-treatment of samples for fossil extraction and subsequent storage. Our unique collections were used in collaborative publications by Collinson in e.g. *Nature Geoscience*. The lab is supported by a technician (Gibbons).

3.2.2 Operational infrastructure in support of income and facilities

Our operational infrastructure underpins our strategic aim of building areas of excellence while diversifying into important new areas. Research is overseen by our Research Committee, chaired by the departmental Research Lead (King). The committee advises on funding opportunities, oversees grant applications, distributes departmental and research funds, coordinates scholarship schemes for undergraduates, manages research facilities and implements equality and diversity mechanisms.

Our research income is administered by the Research and Innovation Department (expanded following REF2014), who administer application costings and collaboration agreements, grant management and impact activities. All staff receive fair and equal access to infrastructure and

support services to apply for grant funding. Proposal calls for NERC, DTP and CDT schemes are open to all eligible staff. Proposals are scored blind by a diverse panel membership, chaired by the School or Departmental Research Leads. Our improved School management structures, support for research funding and strategic decisions to join new PhD funding partnerships contributed to the successful awards of NERC standard grants (>£650,000 each) in consecutive rounds in July 2019 and January 2020. Our infrastructure improvements have led to improvements to facilities (new equipment and maintenance), new post-doctoral researchers, networks and a larger pool of supervisors for our expanded PGR cohort.

3.2.3 Collaborative infrastructure

Collaborative partnerships provide our staff with access to novel capabilities for ambitious projects. Our partners amplify the impact of our research through engagement with external stakeholders and they allow our research students to gain access to a huge diversity of instrumentation and world-class training. Facilities at our research partners include: Scanning Electron Microscopy and rare sample collections at the Natural History Museum (Chan, Collinson), stable isotope mass spectrometry at the British Geological Survey (Gough, Hall, Matthey), the Central Laser Facility at the Rutherford-Appleton Laboratory, the ISIS Pulsed Neutron Spallation Source and ISIS Diamond Light Source synchrotron (King), airborne monitoring by the NERC Facility for Airborne Atmospheric Measurements (FAAM) (Nisbet, Fisher, Lowry). FAAM has been used by Nisbet, Lowry and Fisher to quantify sources of methane to the atmosphere from northern European and tropical African wetlands. Our partners have supported our increased PGR body: NPL and RAL supported 4 NERC CASE or joint-funded studentships. Our participation in the ARIES NERC DTP since 2018 provides our PGR students with collaborative access to research facilities at partner HEIs at in-house rates.

3.2.4 Infrastructure support for impact activities

Improvements to our world-class infrastructure benefitted our impact case studies. New mobile monitoring and mass spectrometry facilities installed by our Greenhouse Gas laboratory from 2016–2020 strengthened the position of our academics as leading authorities advising international (UN, IPCC) and national (BEIS) bodies on climate mitigation and carbon emission strategies. Our geophysical, thin-section, paleobiology and sedimentology labs support our research on seafloor sedimentary processes and fire in the environment and the leading roles our researchers have on environmental advisory panels (Scott) and in advising the resource exploration industry (Hernandez-Molina). Our strategy to refocus our research into impact-led *Centres*, and our support for laboratory restructuring and equipment funding bids, will support impactful research for the period 2021–2026.

3.3 Effect of the covid-19 pandemic on access to research infrastructure

Our research facilities closed in March 2020 as a result of the covid-19 pandemic. From 28th May, we were able to open specific laboratories for critical use by PGR students or post-doctoral researchers on time-limited contracts. Access requests were scrutinized by the HoD, Research Lead and ToM, and were subject to strict health and safety measures detailed in covid-focused risk assessments. Laboratory use has continued throughout late 2020/early 2021 in a similar manner: labs have maximum occupancies, one-way access routes, and requirements for hand-sanitizing and PPE. No evidence of person to person transmission has been documented.

Section 4. Collaboration and contribution to the research base, economy and society

4.1 Overview of research impact

Our staff make substantial and sustained contributions to industry, government and wider society, underpinned by a commitment to making the benefits of our research widely available. We build collaborative partnerships to develop pathways to impact on matters of importance such as climate change, clean energy generation, and ecosystem sustainability. We contribute to public debates about hazard mitigation and waste management and serve on national and international bodies charged with strategic policy making. Our researchers are recognised for their willingness to undertake academic, educational and policy-relevant leadership.

4.2 Research collaborations

4.2.1 Academic collaborations, networks and partnerships

Our researchers have developed collaborative partnerships with leading scientists and research institutes in fields related to our strategic research areas. In addition to our extensive JIPs, researchers in our *Geodynamics and sedimentary systems* theme built a new network of academics from Europe and the USA on the ICDP/IODP proposal, *Mediterranean-Atlantic Gateway Exchange*, which was awarded £1.5 M by the Intercontinental Drilling Program in 2019 (Hernandez-Molina and Chiarella). This programme enhances our future capacity to attract funding for projects tied to this drilling.

Our partnerships strengthen our *Geochemistry and Mineral Resources* theme: Nisbet leads *The Global Methane Budget* (NERC, 2016, £471,000) with 14 UK universities, which raises the profile of RHUL in the UK and the EU. Staff and infrastructure investments in our geochemistry research have stimulated new collaborations with Swansea, Copenhagen, Guangzhou, Central Michigan, Columbia and Lanzhou Universities, leading to ERC, NSF, US-National Institute of Health and NERC grant submissions from 2018–2020 (Basu, Dickson), alongside visiting PhD students from Oxford, Cambridge and Copenhagen. Koelemeijer is part of a consortium of 9 UK HEIs that were awarded a NERC large grant in 2020 (£167,000 to RHUL) called *Mantle Convection Constrained (MC2)*. This project aims to understand mantle upwelling using multi-disciplinary observations from across the Earth Sciences and enhances our academic partnerships in global seismology.

Ghail has established a network of partnerships in extraterrestrial geology: he leads *EnVision*, a high-profile, *multi-agency* European Space Agency candidate mission to characterize geological activity on Venus. Our 'space' networks and partnerships are strengthened by Chan's collaboration with NASA and JAXA in world-leading missions such as *Hayabusa-2* to determine the organic properties of asteroids and meteorites (2017–present). The unique sample collections of our *global environmental change* researchers stimulated collaborations with Bristol and Southampton universities to study Paleogene terrestrial paleotemperatures (Collinson).

4.2.2 Industrial partnerships

Industrial collaborations provide income, data, and support for our PGRs and enable impact through knowledge exchange and industrial applications. We foster our partnerships through presentations to partners at (e.g.) Cairn Energy and Namcor (Scarselli); and by inviting scientists from these companies to be advisors on our MSc programmes and co-supervisors and CASE sponsors for our PGR students. Knowledge exchange relationships initiated via our *Joint Industrial Partnerships* (JIPs) have opened up embargoed datasets for research and leveraged co-funding/supervision of 16 PhD students, from companies including Petrobras, Spirit Energy, ENI, Total and BG Group (Hernandez-Molina, Chiarella, Adam). Scarselli coordinated our membership of the fully industry-funded GeoNetZero CDT consortium from 2018.

Interdisciplinary partnerships and secondments enable impact in fields beyond the Earth Sciences: Ghail applies radar interferometry to monitor subsidence associated with major construction projects in the capital, including Crossrail and Thames Tideway Tunnel. Adam has knowledge exchange partnerships with LaVision Ltd (UK) and LaVision GmbH (Germany) (2013–present) to develop optical strain analysis software for solid material testing. This relationship has yielded in-kind contributions towards software and hardware and has led to three joint publications. Lowry and Fisher collaborate with *Elementar UK* to develop new mass-spectrometers for the hydrogen isotope analysis of gases. PhD student Juli Fernandez was seconded to Elementar (2017) to help develop a new instrument, which was then delivered to RHUL in November 2019. Another collaboration with *LiCor Ltd* will develop a range of mobile gas monitoring instruments.

4.3 Relationships with research users, beneficiaries and audiences

Our public engagement and events are led by a diverse team of ECR and experienced staff: Waltham, Gough, Chan, Chiarella, Solferino and Koelemeijer. We have delivered >200 outreach talks to schools (e.g. in Wiltshire, London and Gloucestershire), local geological and environmental societies (e.g. Wooton Bassett Environmental Society, Glasgow Geological Society), and public lectures (e.g. at the Carnegie Institute in Washington, Duriston Castle). We keep a database of outreach talks that is circulated to schools via the RHUL School liaison team, with requests

coordinated by the outreach team. These activities encourage student recruitment and allow us to disseminate our findings to the public.

We deliver geoscience research to a public audience via the media. Koelemeijer appeared on BBC's Radio 4 and the World Service to talk about seismicity in the Covid-19 pandemic. The work of the Greenhouse Gas Group has been reported in the *Economist* and *Newsweek*. Our sea-ice simulator (King) was the focus of a short film *Rehearsals for Uncertain Futures* by the RHUL Centre for Geohumanities and was part of the UK Green Film Festival (November 2019). Our outreach and social media team will maintain and grow our online presence post-2021 as an effective means to engage with wider society in the UK and beyond.

We tackle some of the major environmental problems facing society. Staff in all three of our research themes investigate *natural hazards* (e.g. volcanism, earthquakes, landslides). Through regional conferences and links to schools and universities, our research has enabled communities in South East Asia to understand the tectonic forces driving volcanic and earthquake activity and associated tsunamis (Watkinson). Our research on atmospheric greenhouse gases and aerosol climate forcing allows us to adopt leadership roles on climate change mitigation strategies: Scott is a member of the *England and Wales Wildfire Forum* that provides science-based fire policy advice for the UK government, and Nisbet is a member of the UN Climate and Clean Air Coalition methane advisory panel and the executive board of the Council of Europe's INGO council.

4.4 Contributions to the economy and society

Our research activities contribute to the UK economy. We train the next generation of geoscientists, equipping them with the skills to tackle the challenges facing 21st Century society. We also undertake research that provides economic and societal value through the acquisition of new knowledge and techniques.

4.4.1 Training a geoscience literate workforce

The 95 PGR students we have trained include industry secondments. PhD training equips them with the specialized research skills to further their career and to drive innovation within their companies. Our staff chair NERC DTP/CDT studentship interview panels (Dickson, Scarselli), and CDT/DTP whole-cohort training events (Dickson, Scarselli, Morgan). Our PGR destinations (section 2) evidence the employability of our research graduates.

4.4.2 Links to the economy

The Joint Industry Partnerships (JIPs) initiated within our *Earth Physical Processes and Planetary Structure* theme influence economic activity by the sharing of knowledge and technical expertise. A JIP led by Hernandez-Molina from 2017–2020 helped Petrobras re-evaluate the resource

potential of the Campos Basin, Wintershall Dea GmbH to quantify uncertainty in resource potential on the Argentine continental margin and TGS Ltd to market their seismic data from the Mozambique Channel. The South East Asia Research group (Hall, Gough) support the energy industry in Indonesia, Malaysia, Myanmar and Singapore by providing training in the use of geological materials and resources: for example the PGSEA course in Singapore led by Hall in 2019. In our *Geochemistry and Mineral Resources* theme, Dickson consulted on the setup of a new Shell geochemistry laboratory in 2020 through a knowledge exchange partnership which has since supported two NERC grant proposals and a CASE studentship.

4.4.3 Links to society

Our *physics and chemistry* researchers inform societal interest in *extraterrestrial habitability*: Ghail leads the *EnVision* candidate mission, Waltham contributes to the *ARIEL* project approved by the ESA that aims to study exoplanets and Chan will study extra-terrestrial organic molecules as part of the science team of the JAXA *Hayabusa-2* mission. These missions are of great public interest and we plan to leverage impact with an active media campaign, the College press office and outreach talks. Basu and Paul develop new methods for understanding water quality and communicating these issues to local communities. Our research guides the monitoring and mitigation of environmental pollution, supported by environmental consultancy and governmental organisations, who fund, support and collaborate in our PGR supervision (Clemithshaw). The Greenhouse Gas Group's work influences *environmental and economic policy* through their long-term membership of the UN WMO Greenhouse Gas measurement team (formerly Expert Panel), and by leadership of symposia including public Royal Society Discussion Meetings. Our *global environmental change* researchers inform society about the *consequences of climate change for the world's flora and fauna* via their links to advisory panels (Scott) and learned societies (Collinson).

4.5 Contribution to the sustainability of the discipline

Our researchers contribute to the geoscience knowledge base through a diverse set of activities that evidence the reach, significance, and esteem of our activities.

4.5.1 Publications, reviewing and editing

We drive the direction of cutting-edge research in our discipline. We published ~850 peer-reviewed papers in high-impact journals such as *Science*, *Nature Geoscience* and *Geology*. Almost half of our category A staff have been scientific editors for 25 journals. Gudmundsson is Editor-in-Chief of *Frontiers in Structural Geology and Tectonics*, and associate editor for *Nature Scientific Reports*. Falcon-Lang is an Editor-in-Chief of *Palaeogeography, Palaeoclimatology, Palaeoecology*. Morgan is an editor for *Terra Nova* and *Frontiers*; Vannucchi is an editor for *Tectonics*; Ghail is an editor for the *Quarterly Journal of Engineering Geology and Hydrogeology*.

King set up the *Environmental Briefs* series as part of the Royal Society of Chemistry's largest specialist interest group, the Environmental Chemistry Group (<https://rsc.li/2KoOR9Q>). We have reviewed proposals for UKRI, the US National Science Foundation, the European Research Council, the Leverhulme Trust, the Royal Society, National Geographic, the Swiss National Science Foundation, AXA Insurance, Innovation and Entrepreneurship (Belgium Government Agency) and the Iceland Science Foundation since 2013. The breadth of sub-disciplines affected by our members' activities evidences the reach of our unit across the spectrum of the Earth and Environmental Sciences.

4.5.2 Scientific presentations

Since 2013, we have contributed >50 invited and keynote talks at conferences including AGU Fall Meetings (Morgan, Vannucchi, Hall), Gordon Research Conferences (Koelemeijer, Dickson) and the International Association of Sedimentology (Chiarella). Our staff were invited to give >100 seminars at research institutions around the world, at locations including Columbia (Basu), Malaya (Hall) and Harvard (Morgan). These presentations strengthen our network of academic partnerships and provide fertile ground for new collaborative relationships.

4.5.3 Membership of scientific panels

We influence the research agenda and contribute to excellence in our discipline through our membership of advisory panels. Seven of our researchers serve on the *NERC peer-review college*: King, Basu, Hier-Majumder, Falcon-Lang, Dickson, Clemitshaw, Nisbet. Gudmundsson is a panel member for the *European Science Foundation*, Vannucchi is a member of the *advisory group for UK-IODP*, a member of the *Science Evaluation Panel of the International Ocean Discovery Programme* the Deputy President of the EGU Division on Tectonics and structural Geology (since 2018). Ghail is an invited member of the *Space Academic Network* that coordinates government consultations into space research, an emerging research topic we will engage with during the next REF period. Chiarella is a member of an expert panel for PhD evaluation for *Flanders Innovation and Entrepreneurship*. King was a member (2014–2015) and chaired (2014–2018) the *Soft Matter Advisory Panel* of STFC and was a member of the *Prize panel for the Royal Society of Chemistry* from 2015–2017. Collinson served on the *Research Advisory Committee of the Evolutionary Studies Institute and the Centre of Excellence for Palaeobiological Research* in South Africa (2014–2017). Falcon-Lang has served on the *Education Committee of the Geological Society* since 2009.

4.5.4 Awards and public recognition

The influence of our researchers on their disciplines is reflected in prizes: Nisbet was appointed as a distinguished fellow of the Geological Association of Canada in 2015; Morgan received the prestigious EGU Augustus Love medal in 2017; Koelemeijer received the early-career Doornbos

Unit-level environment template (REF5a)

Memorial Prize in 2018 and Vannucchi was made an ECORD distinguished lecturer in 2015. The outstanding contribution of Collinson to the botanical sciences has been recognized through her award as a distinguished fellow of the Botanical Society of America (2015).