Institution: Royal Holloway, University of London

Unit of Assessment: Earth Systems and Environmental Sciences

a. Overview

We are a research-led Earth Sciences department with the overriding aim of combining excellent international research with strong industrial and societal relevance. To that end our strategy is to encourage and promote collaborative, multi-university and, where appropriate, multi-disciplinary research underpinned by world-class infrastructure. Our research activities, into the past, present and future of Planet Earth and its resources, are organized in themes: **Geodynamics and Sedimentary Systems; Global Environmental Change;** and **Physics and Chemistry of Earth Processes**. Our specific research strengths are in *analogue/numerical modelling, atmospheric and climate science, computational geodynamics, environmental proxies, global and exploration geophysics, sedimentology and structural geology, and solid Earth geochemistry*. A healthy balance of RCUK, EU, Leverhulme, and Royal Society funding and major industrial consortia supports our research portfolio (2008-13 £10.2M). The breadth, and societal relevance of our research is evident in our leadership of, and participation in, a wide range of multi-university international projects, and global industrial consortia.

b. Research strategy

The Department's research strategy is to support internationally-esteemed academics in their pursuit of innovative and excellent research underpinned by world-class infrastructure, in many cases designed, developed and located in the Earth Sciences Department at Royal Holloway. Recent novel research directions include: cave-monitoring of climate proxies*;* laser-based provenance studies of ash, teeth & bones*;* Precambrian hydrocarbons in glacial deposits; sources & pathways of atmospheric methane based on C isotopes; fossil tomography revealing the early record of modern species*.* As a natural consequence of our structure and strategy, inter-disciplinary research flourishes at all thematic interfaces. For example: snow photochemistry & climate; mathematical modelling & turbidity currents; climate change & rainforest survival & links between volcanism, human migration and environmental change*.* Collaboration with partners worldwide is key to our inter-disciplinary research. Our decades-long collaborations with industrial partners have helped us enhance both blue-skies and industrially-relevant research through funding for four multi-million pound oil industry consortia, and to pioneer the design and application of a new generation laser-ablation system.

The Head of Department *(Waltham 2008-12, Morgan [ex-Cornell, 2012-)* chairs the Management Group that oversees all aspects of departmental work. The Research Committee (RC) sets research priorities, reviews proposals and administers finance so that we can develop and foster new research initiatives. The RC and Royal Holloway provide funding for (1) pilot studies to underpin UKRC applications, (2) capital expenditure, (3) six annual undergraduate Lyell bursaries to promote final year research projects; (4) two annual PGR (PhD & PDRA) publication prizes for peer-reviewed journal articles; and (5) conference participation by Early Career Researchers (ECR) and PGR students. During the REF period Royal Holloway hosted two international conferences, 'SE Asian gateway: history and tectonics of Australia-Asia collision' 2010 and 'Astrobiology' 2010; and plans are well underway for a third, the 12th European Workshop on Laser Ablation 2014 (http://ewla.rhul.ac.uk/). Honorary researchers, visiting academics and industry personnel together with Emeritus Professors collaborate in research programs, co-supervise students, and run short-courses etc. In the REF period 2008-2013 the overseas visitors included: Lister *(Australian National University);* Sheldon *(Ann Arbor, Michigan);* Burchette *(BP);* Xu *(Chinese Academy Guangzhou),* and Gerdes *(Shell)*.

RAE2008 Aims and Outcomes and our Future Research plans

Our academic & industrial funding initiatives in the REF period have fostered our research within three overarching themes which have developed from those reported in RAE2008. In the majority of cases the research objectives of RAE2008 have been successfully achieved. Below, under each of the three research themes, we summarise past RAE2008 and our future research aims (2014-20).

1. GEODYNAMICS & SEDIMENTARY SYSTEM

Broadly this theme investigates the interaction between tectonic, volcanic and sedimentary

processes and the generation of surface and sub-surface architectures. Researchers integrate geophysics, structural geology, sedimentology and modelling to improve our understanding of a wide range of geodynamic settings. Our interests range from the evolution of rift systems and passive margins to the tectonics of mountain belts and include an emphasis on sediment dynamics in all these diverse settings. Industrial funding continues to underpin this research theme. ***Staff****: Adam, Armitage, Burgess, Eagles, Elders, Hall, Hernández-Molina, Le Heron, McClay, Morgan, Pérez-Gussinyé, Waltham, Watkinson and Vannucchi.*

RAE2008 outcomes include an innovative approach to salt basin evolution on passive margins; new models of carbonate platform and siliciclastic delta dynamics; a demonstrable link between global shifts in biodiversity hotspots and Indo-Pacific plate reconstructions*;* the discovery that southern hemisphere interglacial successions are inconsistent with Snowball Earth; a solution to conjugate margin mismatches with a new model of sequential faulting; demonstration that the temperature and deformation of the Cordilleran crust is linked to quartz; a causative relationship between seismicity & subduction-related fluids defined in both active and palaeo-subduction zones.

Future research aims include:

Plates to Basins to Grains: COMPASS - a new multi-disciplinary, multi-scale, industry-supported research consortium targeting the initiation and evolution of rifted margins, a critical area of interest for current and future hydrocarbon exploration. Research will integrate analogue and numerical models, as well as use new fault-dating methods to investigate margin processes from the scale of plates to basins to grains. The project will include industry-tied studentships.

Fluids, Faults & Subduction: will focus on the role of fluids and the mechanics of seismogenesis, the link to subduction erosion and the initiation of megathrust earthquakes. Integration of seismic stratigraphy, plate reconstructions and sediment provenance will help reconstruct the subduction-related extensional tectonics of active margins including SE Asia.

Passive margins: *(a)* Royal Astronomical Society funding will be used to explore what processes maintain the apparent stability of the passive ("passive-aggressive") margin after break-up, yet eventually fail with the onset of subduction. (b) there will be an industry-funded investigation of the dynamics and controls on salt basins using the Atlantic margin as a target for scaled analogue modeling and 3D seismic analyses of salt tectonic processes.

Snowball Earth & ancient ice sheet dynamics: There will be an expansion of the inventory of geological & geochemical studies that constrain Neoproterozoic *(Scotland, Namibia, Australia)* & Paleozoic ice sheet dynamics will be used to test the viability of the Snowball Earth hypothesis by modelling Neo-Proterozoic glaciogenic successions using Pleistocene-Recent ice sheet analogues.

Deep-water processes: We will investigate the sedimentary processes of bottom currents and Contourite Depositional Systems (CDSs) and possible links to thermohaline circulation.

2. GLOBAL ENVIRONMENTAL CHANGE

This research theme aims to understand the causes and effects of key transitions in Earth history including modern global environmental change. Since 2008 there has been a greater focus on the application of finger-printing techniques to a range of global change proxies. ***Staff****:, Collinson, Falcon-Lang, Fisher, Grassineau, Hall, King, Lowry, Mattey, Menzies, Müller, Nisbet, Scott.*

RAE2008 outcomes include the proposal that the Younger Dryas was linked to impacts discredited as "spherules" are shown to be fungus; multi-proxy data demonstrate a lack of global wild fires at the Cretaceous-Tertiary boundary; Palaeocene-Eocene Thermal Maximum may have been caused by a catastrophic release of methane from the Kilda basin*;* seasonality of Arctic methane emission revealed to be primarily boreal in the summer and sourced in gas fields in the winter; a crucial link revealed between snow chemistry and the oxidising potential of the atmosphere*;* new palaeoclimate reconstructions produced using Mediterranean speleothems including a 50 year match of climate proxy calibrations*;* the influence of solar & climate on Monsoon variability demonstrated from Chinese cave archives; a multi-disciplinary approach showed that the Neanderthals survived climate change and the largest European eruption in the last 50ka*;* new palaeo-thermometric data from forams raises concerns about absolute pre-Pleistocene temperature estimates*;* the role of fire in abrupt climate change constrained with evidence of a switch from "high fire to a low fire" worlds at the Cretaceous-Eocene transition.

Future research aims include:

Deep time seasonality: *a* NERC-funded investigation of seasonal variations in palaeo-temperatures and palaeo-salinity to provide new high-resolution tests for models of climate change. This work will target key Paleogene climatic transitions during 'deep-time', using seasonally-resolved palaeoceanic proxy recorders.
Global methane inventory: This NERC and EU-funded group will develop C isotopic distribution maps in order to determine global methane provenance on decadal timescales *(i.e., tropical, Arctic wetlands, clathrates, or gas leaks).* Royal Holloway-designed cave monitoring equipment and climate-chemical proxy relationships will be used to investigate and quantify the contribution of atmosphere-karst gas exchange to global greenhouse gas sequestration and budgets;
Cryogenic climate records & feedbacks: a Royal Holloway-funded investigation of ancient records by decoding the Greenland ice-cores at unprecedented time resolution using the cryo-UV-LA-ICPMS system designed and developed at Royal Holloway. This will vastly improve our understanding of *rapid climate change.* NERC-funded analogue sea-ice simulation experiments will further explore the effects of black carbon on the albedo feedback of sea-ice.
Pacific speleothem transect: a NERC-funded future characterisation of the El Niño–Southern Oscillation, and links to the monsoon, will be investigated by targeting ocean island speleothems across the Pacific Ocean. In addition this group will investigate the impact of the Little Ice Age on human migration in the Pacific Basin.
Humans & the environment: Leverhulme-funded studies of Ca-Sr isotopes in vertebrate enamel will be used to better understand Neanderthal extinction by considering human subsistence strategies. The human and natural dimensions of fire will be investigated using charcoal proxies in both deep time and the Anthropocene.
Biodiversity & key climate transitions: Several NERC-funded investigations will tackle whether (1) biodiversity tracks Paleogene global change, (2) increased wetland methane emissions were caused by Eocene warm wet climate conditions, and (3) the Eocene greenhouse was low fire and caused by changes in peat-forming vegetation.

3. PHYSICS & CHEMISTRY OF EARTH PROCESSES
Our strategy is the pursuit of innovative, cross-disciplinary physical and chemical methodologies to improve our fundamental understanding of Earth processes. The main contribution of this research theme extends well outside traditional geophysics and geochemistry into areas such as sedimentology, tectonics, palaeontology, oceans and atmospheres, magmatism and tectonics, and the nature of the deep Earth. ***Staff****: Adam, Armitage, Eagles, Grassineau, Gudmundsson, Hier-Majumder, King, Lowry, Manning, Mattey, McClay, Menzies, Morgan, Müller, Thirlwall, Waltham.*

RAE2008 outcomes include three pioneering analytical breakthroughs (1) design of cave monitoring equipment for in-situ measurements by international climate groups; (2) laser fluorination C-O isotope technique for resolving seasonality in environmental archives; & (3) a cryogenic LA-ICPMS cell for in-situ analysis of dust in ice cores.
In addition, strategic partnerships with instrument manufacturers have led to the design, development and application of new technologies (e.g., Ca-Hf-Pb isotopes, laser-based studies of teeth; C-O-S isotopes).
Other highlights include: development of tomographic 3D strain monitoring in physical experiments; new kinematic models for Gondwana break-up; new constraints on the opening of the Drake passage and opening of the South Atlantic; geochemical & geophysical evidence for recycled mantle components beneath Africa and the Canaries; influence of de-glaciations on stress fields, dike-sill geometries and magma chamber formation; importance revealed of organic molecules on snow albedo and atmospheric oxidation of cloud droplets in the Arctic and Antarctic; high resolution laser-based technique for rapid analysis of volcanic ash, dust & teeth; geochemical evidence of channelled mantle flow in a lithospheric corridor beneath Africa; and crustal telescoping in NW Scotland revealed from multi-isotopic studies of garnet-bearing crustal rocks; and a new interpretation of seismic data shows that the asthenosphere is fed by upwelling plumes (i.e., the "fast halo" imaged in the Hawai'ian PLUME experiment).

Future research aims include:
Aerosols & Clouds: NERC-funded research into cloud formation and atmospheric chemistry using laser tweezer devices to investigate oxidation of layered particles;
Bend-fault serpentinization: Royal Society funding will explore the link between serpentinization during plate subduction "bending" and hydrothermal circulation above the bend-fault region, plate

hydration, carbon uptake and transport into the deep mantle*;*
Palaeodiet: Leverhulme funding will support the development of in-situ Ca isotopes to constrain paleodiet as a proxy of physiology;
Afar spreading-axis fluids: Royal Holloway funded development of S & C isotope techniques will be further used in the search for deeply sourced mineralising fluids in the "active" Afar Triangle and for early atmospheric oxygen in the Belingwe Greenstone Belt;
Carbonate Reservoirs: Industry-supported seismic modeling of complex subsurface phenomena is planned to investigate the role of chaotic media on carbonate platform margins;
Fault & fracture networks: Statistical mechanics/information theory will be used to explore (with industry support) the evolution of lineaments; the energy budget of fault displacements, associated earthquakes, and volcanic eruptions;
Analogue Experiments: Industry-funded development of novel 4-D strain monitoring techniques and new analogue materials *(e.g. cohesive granular media)* for physical fault fracture simulation;
Geodynamic modeling: Royal Society funded computer-cluster experiments of 3D hydrothermal MOR systems, 3D mantle flow & melting which will utilize a "toolbox" of parallel-MATLAB-FEM codetools whose establishment in Earth Sciences was funded by Royal Holloway**.** A Royal Astronomical Society Research Fellow will explore how mantle dynamics and climatic change have altered sediment accumulation within continental passive margins during the late Tertiary;
2D/3D melt migration/MuMap: We will develop a microgeodynamics code to permit the study of feedback between very small and intermediate length scale geological processes linked to fluid-rock mixtures (e.g. melt migration & storage).

c. People

(i) STAFFING STRATEGY AND STAFF DEVELOPMENT

We have initiated a succession plan for academic staff with the appointment of eight new academics and three early-career researchers (ECR). Our staffing strategy has not only rejuvenated the Department, yielding a flat age profile, it provides continuity in teaching/research through periods of staff retirement, and enhances and extends our research expertise, opportunities, professional connections, and portfolios across all the three research themes.

The new academic/ECR appointments were **Armitage** *(IPG Paris, geodynamics/geophysics);* **Falcon-Lang** (*Univ Bristol, paleoenvironments*); **Fisher** (*Royal Holloway ECR, atmospheric sciences),* **Hernández-Molina** *(Univ Vigo, deepwater sedimentology),* **Hier-Majumder** *(Univ. Maryland, geodynamical modelling);* **Le Heron** *(Univ. Hannover, clastics);* **Manning** (*Royal Holloway ECR, geochemistry*); **Morgan** (*Cornell, geodynamics*), **Vannucchi** *(Univ. Florence, tectonics),* **Watkinson** (*Royal Holloway ECR, structural geology*); **Pérez-Gussinyé** *(Univ. Barcelona, tectonophysics)*. Staff leaving since the RAE2008 took university positions at Curtin, Rochester NY, Bristol, Erlangen-Nürnberg, AWI Bremerhaven, Ann Arbour and in the international hydrocarbon industry.

Royal Holloway is compliant and actively endorses the seven principles outlined in the *Concordat to Support the Career Development of Researchers* and has policies and practices at both institutional and departmental level designed to facilitate full implementation of these principles, for example; mandatory training for all members of selection panels including equal opportunities training, equitable treatment for part-time and fixed-term staff, clear and an equitable promotions process. Extensive staff development opportunities are offered including a centrally administered mentoring programme (supplemented by departmental mentoring for early career staff) which is open to all research staff and a comprehensive annual equality and diversity data monitoring and review exercise.

Within Earth Sciences all fixed-term contract staff are embedded in the thematic research groupings, have a formal line-manager and are included in the training, mentoring, appraisal and other support activities.

The established and experienced staff formally mentor and foster new staff *(e.g., Menzies/Pérez-Gussinyé; Thirlwall/Vannucchi; Fowler/Morgan)* with advice and support on establishing, funding and managing research, opportunities for pump-priming finance, assistance from the Science Faculty, managing staff/students, HR matters, and university administrative processes as well as

matters related to teaching including planning/ leading fieldtrips and examination processes.

For new academics the Department provides "start-up" funding for their research, a reduced teaching load and minimal administration. For an ECR the reduction in teaching and administration last for a minimum of one year. Royal Holloway's 2-year formal induction programme for new academic staff provides professional training in teaching, research administration and other key skills. Successful completion of the programme is a key probation requirement.

From the outset, all new academics are encouraged and assisted to build a research group/team and to establish research connections within the Department and Faculty. New and established academics are fully involved in the formal development of departmental research themes and strategic planning through research group discussions and committee membership in the Department and more widely.

The Department seeks to enable academics to spend periods away during term-time through careful scheduling and team-teaching and academics benefit from a flexible sabbatical leave program (*one term in nine*) that allows for mini-sabbaticals (1 term) to help maintain teaching and PhD supervisory commitments. The Head of Department *(Waltham 2008-12; Morgan 2012-15)* reviews research performance and opportunities with individuals and agrees upon future plans. Staff achievements were recognised by promotions in the REF period: four staff promoted to Senior Lecturer, three to Reader, and one to Professor. Annual appraisal with the HoD (or designate) includes discussion of research achievements, plans, hindrances and opportunities. The Science Faculty Research & Enterprise Committee is a key forum for the departmental Research Committee Chairs.

Royal Holloway achieved an institutional Bronze award from the Athena SWAN organisation (*Charter for women in science*) which also recognised Earth Sciences with a Bronze award in 2013, confirming the Department's commitment and action plan to advance equality and opportunities. The implementation of the Action Plan is overseen by the Departmental Athena SWAN Self Assessment Team comprising female and male departmental members representing all career stages.

(ii) RESEARCH STUDENTS

The graduate school is fundamental to the life of Earth Sciences with 64 registered PhD students in 2013 and 35 PhD graduands during 2008-13. The students come from UK, EU and overseas universities funded by NERC, charities, industry, governments and Royal Holloway. The Research Committee oversees, guides and monitors the progress of all research students. Each student has one or two supervisors (to guide and oversee the research) and an additional advisor (for pastoral support). The Director of Graduate Studies *(Collinson)* is responsible for the formal progress and welfare of all postgraduate students and liaises with the Supervisors and Advisor.

Training for research students (MSc & PhD) involves the following courses:
(1) 'Research Development Programme' for all Royal Holloway research students
(2) Departmental discipline-specific courses across the earth and environmental sciences
(3) Postgraduate Certificate in 'Skills of Teaching to Inspire Learning' (inSTIL)
(4) Departmental analytical course *(Thirlwall, Müller, Lowry)* which includes hands-on experience with analytical equipment *(e.g., Laser Ablation (LA), & multi-collector (MC) inductively coupled plasma mass spectrometer (ICPMS), Thermal ionization mass spectrometer (TIMS), & X-ray fluorescence (XRF))*. This course is also offered to research students from other universities.

All research students have individual personal workstations in open-plan fully networked offices in the Department, allowing straightforward access to all laboratories and to the academic staff offices. Research students are strongly encouraged to lead co-authorship of publications as well as presenting their work at departmental seminars, as a test-bed for national and international conferences. The Research Committee administers support for conference participation.

Throughout their time at Royal Holloway all researchers benefit from in-house activities:
(1) Lyell Research Thematic Day, an annual event with invited national/international speakers sponsored by industry. The topic in 2013 was "*the Impact of Geology on Life & Evolution"* sponsored by *Statoil, BG group, Neftex, bp;*
(2) MSc symposia *(Petroleum & Environmental)* with >100 attendees an increasing proportion of

whom are ex-Royal Holloway graduands from the oil/gas and environmental sectors, and;
(3) Departmental seminar series that run weekly and include invited international researchers and local researchers.

d. Income, infrastructure and facilities

The Earth Sciences Department is distinctive in the UK in atmospheric science & greenhouse gas monitoring; geochemistry (Sr-Nd-Hf-Pb isotopes; LA-MC-ICPMS elemental, C-O stable isotopes); paleoenvironments and key transitions; and theoretical-numerical-analogue modeling in structural geology & sedimentology. Recent innovations in stable isotopes and laser-based elemental analysis originated from the in-house design and application of equipment. Since 2008 our facilities have benefitted from substantial new investment from the institution and industrial partners.

INCOME
Research has generated grant announcements totalling £10.2M (2008-13) and £1.16M (2008-13 incl) of "in-kind" funding. This funding supported the registration of 69 PhD students and the employment of 19 PDRAs during the REF period.

Geodynamics & sedimentary systems (39 PhDs and 11 PDRAS) was supported by major industrial consortia accounting for the largest cohort of PG researchers in Earth Sciences.

Global Environmental Change (22 PhDs and 5 PDRAs) was supported by sixteen UKRC/EU Leverhulme grants.

Physics & Chemistry of Earth Processes (8 PhDs and 3 PDRAs) operated with various sources of funding due to its interdisciplinary nature.

Royal Holloway policy on IPR and consultancy encourages innovation by ensuring that the bulk of any income goes to the originator. Industrial sabbaticals are also encouraged. Consultancy is an important component of the dialogue between academia and industry. It allows us to better understand their technical challenges so that we can better design and refine our programs of applied academic research *(e.g. STAR, SEARG, COMPASS).* Current consultancy links are with Petrobras; Shell, BG, BHP Billiton, Saudi Aramco and Nautilus.

INFRASTRUCTURE & FACILITIES
Geochemical, Ice & Atmospheric laboratories were funded, wholly or partly by Royal Holloway and SRIF. Investment in facilities in the REF period included the installation of:
(a) Laurin-Technic-Resonetics LA-ICP-MS (£370k) in 2008 a new generation prototype coupled to a two-cell excimer laser-ablation system
(b) Sea-ice simulator laboratory (£140k) custom-designed and installed in 2008
(c) PANalytical Axios XRF (£120k) installed in 2011
(d) High-precision cavity-based continuous analyzers for greenhouse gases (N_2O, CO, CO_2, CH_4) (£171k) installed in 2011
(e)Thermal Ionisation Mass Spectrometer installed in 2013 (£300k) as a joint Royal Holloway-UCL initiative for isotopic micro-analysis.

Other geochemical/ice facilities include the stable isotope and atmospheric gas laboratories; Langmuir trough for air-water interfaces and spectrometers for snowpack and sea-ice. Our world-class methane lab houses Europe's leading CH_4 stable isotope facility capable of rapid high-precision measurement in small ambient air samples. The multi-partner *Equianos* network *(Royal Holloway-UEA-BAS-NILU-FMI)* involves Royal Holloway as lead and key provider of Atlantic greenhouse gas measurements.

Structural analogue laboratories: Royal Holloway and industry provided investment for significant laboratory refurbishment and modernization of the structural analogue modelling laboratories during 2008-13. Our departmental world-class interpretation laboratories have 20 dual-screen/dual-boot workstations together with an in-house 3-D Visualisation Facility. Two Digital Image Correlation systems permit detailed time-lapse strain and displacement measurements for both 2D and 3D experiments including flow patterns in polymer models simulating salt deformation. In addition, the structural analogue modelling laboratories, unique in the UK, have routine laser scanning capability.

Sedimentology, stratigraphy & palaeontology: Research is underpinned by the provision of industry-standard software packages *(Geoframe, Ikon, Kingdom, Landmark, Midland Valley, Paradigm, Petrel),* high-end PCs for stratigraphic modelling *(e.g., Midland Valley, Technology Strategy Board)* and 3D Visualization Facility. These facilities are complemented by palaeobiology labs, sedimentology labs, specialist microscopy and imaging labs.

e. Collaboration and contribution to the discipline or research base

Our contribution to the discipline and wider research base is primarily through our involvement in international, interdisciplinary, multi-university UKRC & EU funded research projects and major industry-funded consortia projects. Whilst the prime focus of the Research Council & EU-funded research programs is global environmental change *(both modern and deep-time),* tectonic sedimentological and geochemical research funded by the oil and gas industry and analytical equipment suppliers means that the Department has a wide base of research funders and is highly respected across the international university and industrial sectors.

STAFF LEADERSHIP IN MULTI-UNIVERSITY INTERNATIONAL RESEARCH PROGRAMS
Collinson: multi-university, international project (NERC 2012-16 terrestrial methane cycling during the Paleogene Greenhouse Climates) with Univs. Bristol, Sheffield and project partners in Venezuela, India, New Zealand and Germany
Hernandez-Molina: co-chief of IODP Expedition 339 (2011-12); co-proponent of IODP Proposal 644 on the broader significance of Mediterranean Outflow Water (MOW) in North Atlantic circulation and climate; & co-ordinator of **MOWER** Spanish "*Comisión Interministerial de Ciencia and Tecnología (CYCIT)*" (Project: CTM 2012-39599-C03, 2012-14)
King: multi-university international NERC projects on Antarctic solar radiation & chemical exchange [atmosphere-snow-sea] with a UK/Italian Antarctic consortium calibrating EO satellites. Partners: BAS, Edinburgh, NPL, CNRS, INO Trieste, UC Davis & McGill (NERC OPAL/NSF OASIS/GRASS 2008-12)
Mattey: multi-university international project (NERC 2009-13 speleothem) with UCL, Birmingham, UEA, Bristol & Univ. Sydney tackling climate proxies with stable isotope investigation of speleothems
Menzies: workpackage leader in multi-disciplinary, multi-university consortium NERC-RESET (2008-13) investigating causative links between volcanism, environmental change & human migration. Partners: Univ. Oxford (Archaeology), NHM (Anthropology), NOCS (Oceanography) and Royal Holloway (Quaternary Geography)
Morgan: international leadership in subduction zone exploration and lead involvement in multi-university multi-disciplinary projects, e.g., RIDGE, Volatiles in Subduction Zones/SFB574, PLUME Hawai'i, Chikyu & Reunion (2013)
Müller: pioneering leadership in the creation of new laser based systems for elemental analysis underpinning major NERC & EU Conosortia (e.g., EU Throughflow 2010-13; NERC RESET 2008-13; Leverhulme 2012-14)
Nisbet: workpackage Leader/Board EU 'Global Monitoring' [GEOmon], 'Eurohydros', and 'Integrated nonCO_2 Greenhouse Gas Observing System' [InGOS] [various 2007-15]. Lead PI on multi-university NERC projects with UEA, Cambridge, Birmingham, BAS. Co-PI on NERC projects with Cambridge, NOCS.
Vannucchi: Co-proponent IODP CRISP multiplatform drilling programme. Co-chief IDOP Exp. 334.

STAFF LEADERSHIP IN OIL AND GAS CONSORTIA.
We have a long record of successful industrial consortia. Several staff have devised/initiated, sustained and led major consortia with industrial partners. The active dialogue between researchers and the industrial partners during the tenure of the research program helps inform research plans so that outcomes are of significant benefit to both sides of the partnerships. Royal Holloway retains the academic "lead" and IPR in consortia-funded research. Publications in mainstream journals are key deliverables (e.g. REF2 outputs).
(a) **Burgess** pioneered modelling of carbonate platform dynamics and carbonate heterogeneity in collaboration with Shell, BG, BP and BHP-Billiton. Innovative work included a new stratigraphic forward model (CarboCAT), seismic stratigraphic methods for isolated platform ID, analysis of

lithofacies thickness distributions & lateral extent.
(b) **Hall** leads the internationally renowned South-East Asia Research Group undertaking fundamental geological, geophysical and geochemical research in SE Asia supported by multi-million pound industrial consortia.
(c) **McClay** initiated, led and managed two major industrial consortia in analogue modelling STAR I & II (2006 to date) continuing a tradition of industrial partnerships over two decades. Research exchange, with Geoscience Australia, BHP, Woodside & Shell, led to an increased focus on 4D fault linkages and quantitative analysis with special reference to the NW Shelf Australia. Feedback from Shell with regard to the Nigerian and NW Borneo margins has led to a focus towards reservoir structure and integrity and timing of those structures as opposed to regional assessments.

CONTRIBUTION TO THE DISCIPLINE
Staff presented fifty invited and twenty-six keynote/plenary lectures; organised and convened international conferences (i.e., AGU, EGU, GSA) and served as editors for twenty international journals. Three staff were elected to the Royal Netherlands Academy, Academia Europaea, and the Geological Society of America Fellowship program. Awards were forthcoming from the Royal Society, the Chinese Academy of Sciences, the American Association of Petroleum Geologists, the Royal Astronomical Society and the Geological Society of London. Highlights are listed below:

Advisory Board Membership/Leadership: Chair CSDMS carbonate focused research group (*Burgess*), NERC Peer Review College (*Falcon-Lang, King, Menzies, Nisbet, Waltham*), NERC Isotope Geosciences & Field Spectroscopy Facilities steering groups (*Mattey, King*), European Research Council (*Nisbet*), Mineralogical Society Council (*Lowry*), Geological Society Cttees (*Falcon-Lang*) & Chinese Academy of Sciences expert review panel (*Menzies*).

Editorships: JGR (*Mattey*); Geology (*Eagles, Vannucchi*); Geochimica Cosmochimica Acta (*Menzies*); JVGR/Bulletin of Volcanology (*Gudmundsson*); Journal Sedimentary Research (*Burgess*), Palaeontographica B (*Collinson*), Tectonics (*Vannucchi*), Terra Nova (*Morgan*), Tectonophysics (*Hall*), Palaeogeography, Palaeoclimatology, Palaeoecology (*Scott*); Journal of the Geological Society (*Falcon-Lang*); Solid Earth *(Perez-Gussinye).*

Conference Chair/Convenor: GSA Penrose, China (*Hall*); GSA Penrose, Italy (*Vannucchi*); AGU Chapman, USA (*Menzies*); William Smith conf. (*Burgess*); Internat. Org. of Paleobotany Bonn & Tokyo (*Collinson*), EGU 2008-13 (*Menzies, Morgan, Nisbet, Scott, Vannucchi*); IAVCEI 2011, 2012 (Gudmundsson); Goldschmidt 2013 (*Menzies, Vannucchi*); 10 & 11th European Workshop on LA-ICPMS 2010&12 (*Müller*); AGU 2008-2013 (*Morgan, Nisbet, Vannucchi*).

Plenary/Keynote Lecture: NASA Astrobiology Inst. Colombia, 2012 (*Waltham*); AAPG California 2012 (*Burgess*); Antarctic Research Conference Buenos Aires 2010 *(Eagles*); Chikyu+10 Conference Tokyo 2013 (*Morgan, Vannucchi*); GSA Turkey, 2010 (*Hall*); IGC Oslo 2008 (*Müller*) & Brisbane 2012 (*LeHeron, Pérez-Gussinyé*); Chinese Academy of Sciences Cratons Beijing 2011 (*Menzies*); Italian Volcanological Association 2013 (*Menzies*); CSDMS USA, 2010 (*Burgess*).

Learned Societies: elected member Royal Netherlands Academy, 2007- (*Collinson*); elected President International Organisation of Palaeobotany (IOP) 2004-2008 *(Collinson);* Geological Society of America Fellow 2008 *(Scott).*

Fellowships: Marie Curie EU Fellowship *(Armitage);* Royal Astronomical Research Fellowship *(Armitage);* Natural History Museum Fellowship 2013-16 (*Collinson*); NERC Advanced Fellowship (*Falcon-Lang*); Humboldt Experienced Fellow 2011-12 (*Falcon-Lang*); Royal Society Kan Tong Po Professorship, Hong Kong 2010 (*Nisbet*); Chinese Academy of Sciences Distinguished Professorship, Guangzhou 2014 (*Menzies)*

Awards & prizes: Geol. Soc. Author of the Year 2011 *(Armitage);* AAPG R.H. Dott, Memorial Award 2013 (*McClay*); Geol. Soc. Young Author 2008 (*LeHeron*); Aberconway Medal Geol. Soc. (*Burgess*); Chinese Academy of Sciences International Co-operation Medal (*Menzies, candidate 2013/14);* William Smith Fund, Geol. Soc. 2011 (*LeHeron*); Murchison Fund Geol. Soc. 2009 (*Falcon-Lang*), Fermor Fund Geol. Soc. 2012 (*LeHeron),* Royal Society Wolfson Award *(Morgan, 2012).*