School of Earth and Environmental Science —Strategic plan 2021-2026

Aspiration

Our aspiration is to be one of the finest Earth and Environmental Science programmes in the world. We have the long-term vision of continuing to broaden our academic gamut via adopting a broad Earth system approach to addressing the evolution of the solid Earth, the oceanic and atmospheric interactions with it, and how such interactions have shaped our planet and its life over billions of years. We aspire to undertake the highest quality research to understand how our planet operates, both now and in the past, and in order to address the great challenges of the present and future. We embed this research ethic into all of our teaching to prepare our students to be the intellectual leaders that society will need to address the critical challenges of climate change and resourcing the green technology needed to address it.

An Earth System Approach

It is estimated that 44% of global energy production needs to be low carbon to keep global warming below 2^{o}C. As the critical global challenges of climate change and natural resource management become a focal point for our society, the need to push science towards real and practical solutions has become increasingly apparent. At St Andrews we have adopted an Earth System approach, in both our research and our teaching, to tackling some of the biggest questions of our time including Climate Change, the Green Revolution and the Origin of Life on Earth. The Earth Systems approach emphasises the need to first understand the natural global system of our planet and how it may change in order to harness that information to determine how to respond to both natural and human impacts. We must find and utilise our natural resources in a responsible way to enable new technologies and sources of energy.

Our research encompasses planetary and biosphere evolution, natural hazard mitigation, natural resources and climate change through our commitment to quantitative, analytical science underpinned by fieldwork and modelling. We engage with issues pertinent to society, such as finding critical metal resources for future technologies, identifying sustainable geothermal energy sources, finding novel geological carbon sequestration reservoirs and protecting cultural heritage sites such as early hominid footprints around the globe or the standing stones of Britain. We encourage research that bridges disciplines and brings together Earth scientists with other natural scientists, social scientists and scholars in the humanities. Our activities deepen knowledge of the complex interconnectedness between Earth's internal processes and ever-changing surface environments, and we extend those insights to the study of other planetary bodies throughout the Solar System.

World Leading Research

In the School of Earth and Environmental Science we are committed to world-leading research that addresses the grand questions of planetary evolution and resources management. We combine curiosity-driven research, methodological development and applied research. We have an outstanding record of high impact research and a burgeoning reputation as a scientific powerhouse despite the school's modest staff size. We are a smaller school than many in the UK, and world-wide, but consistently rank higher than many much larger schools in national and international measures of excellence. Our research success is underpinned by high research funding success and an international collaborative footprint.

Within this aim for sustained world-leading research we have identified two broad themes that will guide future research funding priorities and staffing, being:

Earth surface processes and climate evolution: the development and evolution of life on our planet has always required a unique interaction of the solid Earth with the oceans and atmosphere. Here the school undertakes leading research into these critical interactions. We use modern analytical and computational methods to explore how our planet's surface environment has changed in the past and how current climate change will impact the oceans, atmosphere and society in the next 100 years.

We look to broaden our research scope via continuing to develop innovative analytical and modelling capacity to address scientific questions that will define our planet's future habitability. Achieving this will involve developing research streams that further cross traditional scientific boundaries into geobiology and astrobiology, archaeological geophysics and geochronology, and ocean & atmospheric chemistry and dynamics.

Planetary dynamics: we study how Earth and other planets geodynamically operate using an array of approaches and methods. This work ranges from cosmochemistry and the formation of planetary materials, the differentiation of the planet into layers, formation of the first continents and the Earth's supercontinent cycle through to trying to understand the physical and chemical processes that define plate tectonics and make our planet uniquely dynamic in our solar system. We strive to build future research streams to better understand how these processes combine to provide the critical metals, water, heat, carbon reservoirs and construction materials we need to build the 21st century technologies required to address climate change.

Underpinning our research objectives are a suite of world class analytical facilities and methodological advances that allow our researchers to produce world leading research that is internationally recognised. Amongst our key facilities are:

- State of the art mass spectrometry laboratories. The St Andrews Isotope Group StAiG brings together many of our staff within one of the best equipped mass-spectrometer and clean laboratory facilities in the world to address a diverse range of natural process ranging from birth of our planet, through the formation of continents and Earth's first life to the effect of humans on our climate. This facility uses the trace element and isotopic signatures in rocks, fossils, water and ice to understand both ancient and modern planetary evolution.
- World class electron microscope/microprobe facility. The Light Element Analytical Facility (LEAF) is a cutting-edge electron microscope & microprobe facility aimed specifically at understanding the behaviour of light elements critical for both life (e.g. C, N, O) and 21st century technology (e.g. Li). This facility, established in late 2020, will provide new analytical opportunities synergistic with our other geochemical facilities and those in the School of Chemistry to understand how the volatile elements that dominate the oceans and atmosphere behave in geological reservoirs.
- A state-of-the-art geomagnetics laboratory allows us to investigate the alteration fingerprint of ore deposits, measure deformation in the crust following plate tectonic events and to understand how magma chambers are filled and emptied during destructive volcanic eruptions.
- A high temperature experimental facility allows us to create deep Earth analogues in the laboratory. This facility combined with expertise in thermodynamic modelling allows us to simulate many inaccessible deep-Earth processes such as diamond formation, growth of continents and processes occurring in the interior of mountain belts.
- Our spectroscopic facilities and optically stimulated infra-red and thermo-luminescence dating facility allow us to image minerals and date recent geological and archaeological events using spectroscopic methods. Spectroscopic methods are commonly applied to ore minerals, and in particular the new generation of critical and rare-earth element ores that underpin most modern technology from smartphones to wind turbine magnets.
- A live coral bioculture laboratory to allow experiments of how reefs may adapt to different environmental conditions, giving advance data on how reefs worldwide may adapt to changing ocean temperature and chemistry.
- A geobiology laboratory to enable the cultivation, manipulation, and molecular investigation of micro-organisms, including under anaerobic, phototrophic, and lithotrophic conditions mimicking early Earth ecosystems.

We aim to expand our research capacity via extending our analytical facilities over the next 5 years through competitive grants schemes complemented by a sustainable proportion of entrepreneurial use for external academic and commercial analysis. We aim to maintain cutting edge analytical technology to stay on the forefront of analytical geosciences, particularly in isotope geochemistry. Furthermore, we will target new opportunities via engaging with new and established mineral resource companies with a view to enhancing the carbon efficiency of mineral extraction processes around the globe. Towards this goal, SEES staff have won considerable research grant funding, much of which was specifically for capital improvement via cutting-edge instrumentation.

A global research vision. The scientific diversity in the School of Earth and Environmental Science has allowed us to build key connections throughout the university with links to the Scottish Oceans Institute, Centre for Exoplanet Science, all other science schools and several of the social sciences and arts schools. We will continue building pan-university collaborations with a specific future focus towards achieving the University's sustainability and carbon goals. Beyond the University we will continue to cement our national reputation through collaborative research within the UK and globally building on our analytical capacities.

Beyond the UK, the school has a truly global scientific footprint with one of the most far-reaching collaborative networks of any Earth science school worldwide: 96% of our publications are associated with international co-authors. This global footprint stems from the school having attracted more than half of its staff from other world-class research institutes. We aim to exploit our research depth, global reputation and established international connections to be at the centre of an international nexus for visiting scientists and postgraduate students via actively engaging in University, national and international travelling scholarship and fellowship schemes.

Educational Excellence

The School of Earth and Environmental Sciences has a long-standing reputation as one of the finest Earth science schools in the UK and is consistently ranked in the top handful of Earth science schools in the UK and the top school in Scotland for undergraduate study in an array of different league tables. Our students are sought after both in industry and academia for their intellectual capability, field and laboratory experience and independence.

Earth science is facing challenges caused by the country-wide withdrawal of teaching geology in secondary education, uncertainties of Brexit and turbulence in the employment sector as companies seek to withdraw from traditional hydrocarbon energy sources and embrace new more sustainable technologies. We will continue to formulate initiatives to address these challenges and enhance recruitment, particularly in the environmental Earth sciences and to address demands for graduates for careers covering broader Earth and Environmental Science, water and land management, technology and finance needs. We address the needs for broader training in Earth sciences via ongoing curriculum development, and establishment of new joint degree programmes. This approach strategically builds upon the new secondary school environmental science curriculum. Thus, in tandem with our research objectives, the school looks to broaden its education gamut to critically cover Earth science in its broadest sense.

Specifically, we are developing new programmes such as a joint BSc degree programme with physical geography, focusing on Earth's surface environment in the recent geological past to present. We look to expand enrolments in both of our taught MSc courses as their reputations grow and to broaden our sub-honours curriculum to be more attractive to students in the other sciences following the success of this approach in our first-year Astrobiology module.

We will look to continue to modernise our teaching infrastructure to support our vision of 21st century Earth and Environmental Science teaching. This includes completing the purchase of new teaching microscopes, expanding our environmental field and laboratory analytical capacity, and developing new digital platforms. Access to teaching lab space has traditionally hampered our ability to teach larger year groups — to address this we aim to harness additional digital resources to deliver more of our

experiential learning in the field. This new approach provides a more realistic work environment that is in-line with evolving industry best practice be it resources, engineering geology or environmental sectors.

Underpinning the delivery of all our teaching are two guiding principles, 1) the importance of practical skills development in the lab, and most importantly, the field, and 2) the integration of cutting-edge research ideas and methodologies into our curriculum. Integration of additional digital field methods broadens access and reduces pressures on teaching laboratory facilities. At a time when many UK universities are cutting back on the delivery of experiential learning and practical skills development, teaching staff at St Andrews continue to uphold and evolve the highest standards for graduating students by delivering a second-to-none laboratory and field skills training curriculum that will continue to produce the most reliable and best prepared Earth and Environmental Science professionals.

Broadening diversity and enhancing access to education in underprivileged parts of the UK is a central strategic aim that our GeoBus team continue to prioritise via the delivery of science education in statistically disadvantaged secondary schools. GeoBus specifically design and deliver STEM teaching materials that appeal to school leavers and look to developing short summer school programmes for senior school students to give them a taste of Earth and Environmental Sciences that is otherwise difficult to access in Scottish schools. These endeavours will further help to increase the number of students who enrol in Earth and Environmental science subjects though building awareness of the challenges facing our environment and delivering a positive learning experience.

Entrepreneurial Activities

The school aims to expand its entrepreneurial activities over the next five years to help support undergraduate and postgraduate activities along with ongoing upgrades of basic school facilities. The school has identified three potential avenues for increased entrepreneurial activities:

Summer schools: Utilising Scotland's reputation as the home of geology the school looks to reactivate post covid and potentially expand its three international summer schools.

Application of our skills to industrial needs: The school seeks to increase its range of industrial and applied science interactions as a potential research funding source. This will build on existing activities with the minerals industry, geotechnical organisations and non-academic government bodies.

Utilisation of our analytical facilities for paid collaborative research: Much of the previous five years have involved the development and growth of our world class isotope and magnetics facilities. One of our aims for the next five years is to take advantage of this to develop greater national and international collaborative research. Such activities have the double benefit of funding the facilities and increasing research output.

Environmental Statement

Out planet's climate has constantly changed and evolved, and in the School of Earth and Environmental Science one of our key foci is understanding why this has happened, how our planet is physically responded to this and how this has affected life on our planet. Thus, the school has the capacity to contribute centrally, helping shape the university's policies on climate change and carbon neutral operations. Staff in the school are actively involved in this process already and we aim to increase our contributions in this area via applied research on carbon sequestration, public outreach and education, and expanding on our considerable efforts within learned societies in developing guidance for government. These efforts are coupled with educational developments addressing these problems being increasingly integrated into our curriculum to prepare students for the challenges ahead.

Physical Environment

The school aims to take advantage of the move of staff and postgraduate student offices to the Bute building to create a more distinctive school identity. While this move consolidates our staff and much of our teaching space into a single building, our research laboratory space remains spread over four buildings within St Andrews ranging from the SOI to the Purdie building. The long-term vision for the

school is for consolidation of all school facilities within the North Haugh science campus to be achieved within the University buildings strategy in this area.

School Ethos, Equality Diversity and Wellbeing

The School of Earth and Environmental Sciences is built on the ethos of inclusiveness, cooperation and respect. Anonymous feedback repeatedly describes us as a friendly and supportive school for staff and students alike. The school has a small but active EDI committee which we plan to expand to ensure greater representation from all groups within the school. Over the past few years we have focused especially on the support for, and professional development of, the early career members of our school, as well as embracing family-friendly policies such as flexible working, and are developing a future school framework to address racial biases within the geosciences. We have active and successful mentorship schemes, including between postgraduates and undergraduates. Beyond our own walls, we actively seek to foster interest in STEM education and careers in young people across Scotland, particularly those in the most underprivileged regions and those from underrepresented groups, through continuing and expanding our long-running GeoBus outreach and education programme. In recent years for which there are comparable data, the percentage of female UG students in the school has exceeded the national average, with an approximately equal gender split over the past 5 years. That said, we recognise that we must challenge and change ingrained perceptions of the geosciences to ensure we are welcoming to all, diversifying our own school body, and eventually the wider field by better illustrating the wide diversity within the Earth Sciences and its many positive achievements worldwide.