Thai Geoscience Journal 2(2), 2021, p. 30-37

ISSN-2730-2695; DOI-10.14456/tgj.2021.3

The 'new normal' for geoscience in a post-COVID world: connecting informed people with the Earth

Steven M. Hill*, Jane P. Thorne, Rachel Przeslawski, Rebecca Mouthaan, and Chris Lewis

Geoscience Australia, Canberra, Australia.
**Corresponding author: Steve.Hill@ga.gov.au*
Received 17 March 2021; Accepted 17 June 2021.

Abstract

We consider how our society can use data, information and knowledge of the Earth under a broad definition of geoscience to better connect with the Earth system. This is important in our changing world, in particular how geoscience contributes to our response to the societal impacts of the COVID-19 pandemic. Ultimately, informed decisions utilizing the best geoscience data and information provide key parts of our economic, environmental and cultural recovery from the pandemic. The connection to country and more widely connection to our planet and the greater Earth system that comes from personal experience has been especially challenged in 2020. Much of Australia's population have been encouraged to stay in our homes, first because of major fires and more recently in response to isolation from the COVID-19 pandemic. Although domestic travel became increasingly allowable, international travel has been restricted for much longer. This has increased the importance of trusted data and information initially from domestic locations and for more extended time between countries that are now less accessible. We discuss ways that geoscience governs our discovery and use of minerals, energy and groundwater resources and builds resilience and adaptation to environmental and cultural change. A broad definition of geoscience also includes positioning and location data and information, such as through integrated digital mapping, satellite data and real-time precise positioning. Important here is sharing, with two-way exchange of data, information and knowledge about the Earth, through outreach in geoscience education programs and interactions with communities across Australia, into neighboring countries in Asia and the Pacific, and across the world. An aspiration is for geoscience to inform social license through evidence-based decisions, such as for land and marine access, for a strong economy, resilient society and sustainable environment. At Geoscience Australia, we have developed a ten years strategic plan (Strategy 2028) that guides us to be a trusted source of information on Australia's geology and geography for government, industry and community decision making. This will contribute to a safer, more prosperous and well-informed Australia and its connection to neighbouring countries, such as in Asia, as well as people that are better connected to country and our planet.

Keywords: community education and outreach, earth system science, environment, geoscience, mapping, resources

1. Introduction

The importance of trusted, high-quality and relevant science to inform and advise governments and our communities is greater now than it ever has been. This is particularly the case for geoscience and its role to guide people's connection to the Earth as the place where we live and obtain the resources we need to live our lives. Our community's recognition of the value of geoscience ensures the future viability and evolution of geoscience and it's ability to contribute to informed impact in our nations, and our planet. This recognition, however, is not to be presumed (or assumed). The world changes and as such the roles and perceptions of geoscience need to evolve and adapt for its continued resilience and relevance.

This paper has three main parts:

1. It considers how geoscientists project and define themselves in society and suggests

that a broad definition of geoscience within a greater Earth system has greater value than more narrow, specialized foundations;

2. Demonstrations of how Geoscience Australia strategically supports and develops its science as part of the broad context of geoscience within an Earth system for maximum impact and value; and,

3. Consideration of how this approach is being developed in response to the post-COVID demands of our society and their connection to our planet.

2. Geoscience in the Earth System

Traditionally in Australia there has been an emphasis on the links between geology, geologists and our resources industry, particularly for mineral commodities such as iron ore, gold and base metals, but also energy commodities such as coal, oil, gas, and uranium. This largely reflects the importance of this industry for export earnings and our nation's prosperity. This has meant that the projection of the role of the geologist has not been challenged so much in the past as it is today. Rather than the vision of mining to express progress and prosperity there is now a greater call for the industry to be viewed on the basis of more trusted equitable and ethical criteria and the sustainable public value of the industry for not only the economy but also the environment and community. This includes assessment and visibility of the entire resources chain from investment, exploration, mining, and the destiny (such as uses, recycling or reuse) of the resources. This broader perspective calls for a broader context of our science of the Earth that extends beyond just rocks and resources but into the broader field of geoscience.

Geoscience embodies the science of the Earth. It especially includes but extends beyond geology to also include fields of geography, geodesy, Earth observation, marine science, pedology, geophysics, geochemistry, geohazards, and many parts of climatology, ecology, hydrology, space and planetary science and, environmental science. Geoscience investigates the past, measures the present and models the future behavior of the planet. It links closely with the biological, chemical and physical sciences as part of Earth system science (Steffen et al., 2020), to include a holistic view on interactions and dynamic processes between ice, rocks, water, air and life.

3. Geoscience Australia: role and science

At Geoscience Australia we embrace the broad perspective of geoscience, not just in our name, but in the strategic planning of our role, activities and our science. Geoscience Australia is Australia's national public-sector geoscience entity. We provide advice on the geology and geography of Australia to support progress, growth, and investment towards a safer, more prosperous and well-informed Australia. Our main stakeholders include government, industry and the community.

Our decadal strategy, *Strategy 2028*, sets out the impacts our work will have over the next decade under six key areas:

1. Building Australia's resource wealth. Australia has a rich and diverse mineral and energy endowment, which is a major contributor to the nation's wealth, economically and socially. The provision of high quality regional--scale geoscience data and information lowers the risks of exploration, advanced exploration, mining and processing technologies;

2. Supporting Australia's community safety. Providing disaster risk information to help Australians understand the consequences of hazard events, which contributes to more resilient communities now and in the future;

3. Securing Australia's water resources. Supporting the fair sharing of water resources by identifying the location, quantity and quality of groundwater resources to support sustainable water management in the driest inhabited continent;

4. Managing Australia's marine jurisdictions. Including baseline mapping, understanding of marine resources and assets, and the ability to measure change over time;

5. Creating a location-enabled Australia. Providing information on when and where

events and activities occur is essential to make decisions and improve economic, environmental and social outcomes. This includes delivery of real-time precise positioning, digital location information and Earth observation from satellite data platforms; and,

6. Enabling an informed Australia. Delivering world-class, trusted data and platforms and expertise to support high-impact geoscience, transparent evidence-based decisions and social licence to operate. This includes our education and science outreach programs.

To achieve these strategic impacts we need to be the best people and organization that we can as well as ensure that we have a strong foundation of excellent and relevant science. The Geoscience Australia Science Principles describe how we conduct science in both long--term planning and day-to-day operations. The six Science Principles are:

1. Relevant science to ensure that Geoscience Australia provides quality assured information to the right people in the right timeframe so they can make evidence-based decisions, particularly related to the Australian Government. This includes the provision of scientific advice to meet national and international obligations (e.g. *Paris Climate Agreement*, *Australia New Zealand Foundational Spatial Data Framework and United Nations Integrated Geospatial Information Network, Offshore Petroleum and Greenhouse Gas Storage Act 2006, and the United Nations - Global Geodetic Reference Frame Sustainable Development Goals, and Sendai Framework for Disaster Risk Reduction).*

2. Collaborative science to allow Geoscience Australia to meet emerging challenges that are more complex than any single individual, team or agency can achieve. This requires us to engage with not only the broader research and data community, but also non-scientific stake-holders who are more likely to use and value our information if they are involved in our work.

3. Quality science to maximise stakeholder confidence that the data and information we provide is accurate, results are repeatable, and any uncertainties are explained and accounted for. All of these mean our science reflects not just quality, but integrity. Data and information can then be used to inform current decisions and debate, and be re-used and re-purposed long after it is created. As both a government agency and a member of the Australian research community, we have key compliance requirements, including the Australian Code for the Responsible Conduct of Research.

4. Transparent science to demonstrate that our scientific activities are unbiased and reflect commitment to extend the role that science plays in the transparency of Australian Government processes (e.g. Principles on Open Public Sector Information, Declaration of Open Government). By openly sharing our work and abiding by the FAIR data principles (findable, accessible, inter-operable, reusable) we create a platform that supports further innovation in the tradition of scientific discovery.

5. Communicated science to ensure that Geoscience Australia's scientific data and information is accessible to and understandable by a variety of stakeholders. By tailoring the communication of scientific information to a particular audience and purpose, Geoscience Australia's scientific work can be valued by stakeholders. This also means communicating appropriate background knowledge to stake-holders and the public to increase their capability to understand complex ideas often associated with scientific research. Part of communication here also involves active listening, particularly to ensure that stake-holder's matters of concern and their needs are well understood.

6. Sustained science capability to undertake scientific activities that meet current and future strategic priorities. The type and level of science capability we retain in-house is inherently controlled by strategic demands and available budget. It is also dependent on technical and business capabilities such as information management, outreach and education, engineering, and communication.

Three examples of major projects from Geoscience Australia's work program are briefly outlined as well as their impact and value for our nation. These include:

i) Positioning Australia;
ii) Digital Earth Australia (DEA); and,

iii) Exploring for the Future (EFTF).

i. Positioning Australia

The Positioning Australia Program is developing a world-leading satellite positioning capability, which many refer to as GPS (Global Positioning System). The program will provide accurate, reliable, and real-time positioning across Australia. It will enable increased productivity, new and innovative technologies, and accelerate economic growth, particularly for regional Australia and businesses.

The program encompasses the National Positioning Infrastructure Capability (NPIC) and a Satellite Based Augmentation System (or SBAS) and is underpinned by the Australian Geospatial Reference System. Currently, we can know our position on the Earth within 5-10 metres of accuracy. By upgrading our existing ground stations, we will improve our positioning accuracy to within 3-5 centimetres. We are doing this by building the physical and data infrastructure and analytics capabilities to deliver 3 things:

1. 10 cm accuracy of positioning across Australia and its maritime zones through SBAS;
2. 3-5 cm accuracy of positioning for areas with mobile phone coverage, in particular regional and metropolitan areas, through NPIC; and,
3. Open-source tools and software to support use of positioning, navigation and timing services.

This work is vital for the next wave of innovation, from location-based automation or artificial intelligence, to augmented reality. Positioning Australia is fundamental in supporting the transformational technologies that will benefit our economy.

To trial this, we established 27 SBAS projects across 10 industry sectors including agriculture, aviation, construction, consumer, resources, road, rail, maritime, mining and water utilities. Based on the SBAS trial across 10 industry sectors, we have estimated the economic value of our positioning program. An independent report, which investigated the benefits of SBAS, found that it would create A$6.2 billion of value over 30 years; over A$200 million p/a economic benefit initially, with plenty of upside across a range of sectors. The benefits included:

- Improving the efficient spraying of = water on farms (by between 1 and 7%) by being able to spray exactly where water is needed;
- Finding injured patients to facilitate helicopter rescues more effectively;
- Enabling intelligent transport systems, to reduce road fatalities;
- Improving safety at mine sites; and,
- Supporting virtual fencing to manage livestock better.

It is also important to note that we expect there will be uses that we have not thought of yet, enabling innovation and new businesses to start and flourish

ii. Digital Earth Australia (DEA)

In the DEA program, we are transforming satellite imagery into insights about changes in Australia's natural and built environments. DEA provides access to high quality satellite imaging of the Earth's surface, to detect physical changes across Australia in unprecedented detail, including soil and coastal erosion, crop growth, water quality, and changes to cities and regions over time. It gives farmers, land managers, industry, and governments the information they need to make better decisions about how they optimise the use of their resources.

DEA will benefit users that need accurate and timely information on the health and productivity of Australia's landscape. It will support government and industry to better monitor change, to protect and enhance Australia's natural resources and enable more effective policy responses to natural resource management problems. Information extracted from satellite images of the Earth will assist emergency managers in real time during disasters like bushfires and floods. It will assist in more productive farming and enable informed decision making across governments.

iii. Exploring for the Future (EFTF)

Through the EFTF program, we are building a prospectus of mineral, energy, and groundwater resources for Australia. The program launched in 2016, and the first four years of work has focused on northern Australia, using innovative techniques to map the surface and image deep into the Earth, developing a much better understanding of Australia's resource potential.

The first phase of the EFTF program set out to address the strategic need for more geoscience information in northern Australia. Some 21 projects have delivered over 250 new datasets and technical reports, covering more than 3 million square kilometres of the continent, and creating images of the Earth's crust and upper mantle, down to 200 kilometres depth, assisting in identifying the regional--scale systems that result in the creation of ore deposits, oil and gas fields and groundwater resources.

All of these data are freely available through our digital catalogue and world-leading data discovery portal. The portal includes innovative 3D visualisation and analytical tools that can create maps to support analysis and decision--making. The portal can be visited at **eftf.ga.gov.au.**

The EFTF program has changed perceptions and behaviours in the minerals and petroleum industries, with the program's pre-competitive data and information translating into real impacts. For example, since 2018, 17 companies have acquired new exploration acreage in the region in between Tennant Creek and Mount Isa covering more than 100,000 square kilometres. This uptake of exploration tenements and the investment that follows, can be linked back to Geoscience Australia's program activities and outputs. Importantly, this new interest is in 'greenfield' areas—locations that have only seen limited exploration in the past. Nearby, the program has also stimulated work program commitments valued at close to $100 m in the South Nicholson Basin, an emerging petroleum play on the Queensland Northern Territory border. An independent analysis of the EFTF program's projected economic impacts indicates that the return on the government's investment will be substantial. The report considered three projects representing $40 million of investment under the program. The returns from the potential discovery and development of new mineral and energy resources were estimated by ACIL Allen to range from $446 million under the most conservative modelling to more than $2.5 billion under the most optimistic modelling.

The first phase of the program created hundreds of jobs, through more than 300 contracts worth $69.4 million. This included the creation of 11 jobs for Indigenous Australian trainees in Alice Springs, processing geological samples with the Centre for Appropriate Technology—a not-for-profit Aboriginal and Torres Strait Islander company. Any investments in mining and agricultural operations will also create further opportunities for employment in regional Australia, supporting economic recovery in regions where opportunities may otherwise be limited. Large mines can directly employ thousands of people and indirect employment can be several times that. Importantly, this brings with it the opportunity for significant levels of employment for Indigenous Australians in regional areas. These benefits further demonstrate the importance of the resources sectors as "engines" of the Australian economy – engines that are needed more than ever in the economic recovery from the COVID-19 pandemic.

The outcomes and impacts from the first phase of EFTF have inspired the extension of EFTF for a second phase. In June 2020, this program received a $125 million extension and expansion over the next four years. The emphasis of this phase is to take the program national. While the work will be extended into southern Australia, two corridors that extend north-south across the continent will ensure continued focus on prospective regions in northern Australia. This is a fantastic opportunity to continue our use of innovative geoscientific techniques to expand the national coverage of key datasets and to take more detailed looks into new regions to encourage further greenfield exploration. Through encouraging investment, the program will contribute towards the nation's post COVID-19 economic recovery, creating jobs where they are needed

in regional and remote communities both now and into the future.

4. Geoscience in response to change following COVID-19

COVID Change and Challenge

The COVID-19 pandemic has brought obvious illness and death to our world, but it has also brought challenges for our industries and economies, employment, travel and most particularly it has challenged the mental health of people and communities. For many it has created a new experience of uncertainty and loss of control of their lives, and as such has been a reminder that our society and the world changes. We live in interesting times and probably the most inevitable feature of our time is "change". Key here is going to be how we are resilient, how we adapt, but most of all how we adopt changes as opportunities.

One challenge that we still have to adapt to is how we will maintain and grow our "connection" within our community of scientists and extend that into our society. Most particularly how we best live and connect to our country and the nation and planet in which we live. In Australia, domestic travel within states and territories has flourished (particularly for tourism), however, interstate travel has had the risk of uncertainty due to border closures, while international travel has been extremely limited. With busy lives and then lockdowns and border closures and other pressures, maintaining and growing our connection to country and planet will challenge us. This leaves us open to risks of mis-information about regions and nations that we are now have less physical connection.

Indigenous Science

We have much to learn from indigenous people and their connection to country but also their traditions of respect and passing on skill and knowledge related to country. How many in our increasingly urban society understand where they live in relation to geology, geography and landscape? Despite the amount of landscaping and concreting, asphalt and artificial lawn that we cover the ground with, we still live as part of an active and changing Earth system.

Indigenous science incorporates traditional knowledge and perspectives that have built on thousands of years of observation and experimentation, and then may be combined with more conventional scientific methods. Indigenous science is typically expressed as observations, know-how, practices, skills and innovations. Previously it has been recognised in applications for agriculture, land management, ecology and medicine, although emerging potential exists in geoscience applications.

With much of this work being implemented in regional and remote areas we are also building opportunities to partner with indigenous communities, encouraging indigenous participation by sourcing goods and resources directly through local communities. Our motivation is to develop and sustain respectful and meaningful relationships, build local indigenous capacity and contribute to local economic development for mutual benefit.

Our best people and science to meet the challenge

To meet the challenges of a changing world, our science is more important than it has ever been, especially because of the risk of mis-information and poor decisions about country and places that we are less connected with. Skill and knowledge will be important here but so too how we make our data and information accessible as well as ensuring that we provide "fit-for-purpose" and relevant data and information for making efficient and connected decisions about our country.

Education and communication of our science will be important here. Geoscience Australia maintains an active and engaging geoscience education and outreach program with visiting school groups but also an increasing amount of online teaching materials and delivery. In 2019 our education centre hosted visits from over 11,300 students and 1050 teachers, and although the centre was closed for on-site visits for much of 2020, our online delivery into schools reached out to

many more than this. We are also making our national collection of minerals and fossils more accessible via online "galleries" and associated information. One example of this is our online Google Arts and Culture exhibit of "Minerals in ModernTechnology" (https://artsandculture.google.com/story/RQXxTbNbs585MQ).

This also is reflected in the respectful way that we access land and marine areas to conduct our science, and as part of this, Geoscience Australia has recently established a Land and Marine Access team (LAMA) to lead us on a best practice approach in this area. It is increasingly important that this access is legally compliant but also prevents harm and includes timely and accountable record keeping, such as access agreements. A key component here is that access is purposeful, transparent, effective and inclusive. This means that all stakeholders interested in, or affected by field activities will be engaged using the most appropriate communication channels and language. Communication will be open and honest, seeking to build trust and credibility. Engagement will occur early in the planning process and will continue throughout the project life cycle, providing opportunities for stakeholders to ask questions, seek clarification and to contribute their own experiences and information. The field access cycle will be closed by all data obtained by field activities being delivered back to those communities that have been impacted by data acquisition.

Whilst communication and education are important pursuits we also need to bring our best ears and actively listen to the community and their matters of concern that we are trying to engage with (e.g. Stewart & Lewis, 2017). We must continue to nurture an inclusive culture in our geoscience community, to ensure that all of us feel we can belong, that we are valued for who we are as well as our knowledge, skills and experience. This includes providing equal opportunities to participate, contribute and progress. To maximise our opportunities for success we need to tap into the full breadth and diversity of expertise, people and talent that we possess across our geoscience community and our science partners. This not only makes us better people and provides a better place to work but also improves scientific outcomes and innovations, such as through contributions from our cognitive diversity and the novel questions, new discoveries, and greater networks and connections that come from that (Medin & Lee et al., 2012; Dutt, 2019; Handley et al., 2020; Hanson, Woden, & Lerback, 2020).

5. Conclusions

We hope that it has given you some new insights and perspectives on how a definition of ourselves as ***geoscientists*** within the context of a broader Earth system can bring higher impact and value to our nation, neighboring countries, such as in Asia, and across the world. Let's bring our best and most connected person to achieve better geoscience!

Acknowledgements

This paper has been published with permission of the Chief Executive Officer of Geoscience Australia. The authors acknowledge the insights and benefits from discussions with other staff at Geoscience Australia. We also thank the organizers of the CCOP Thematic Session (56th CCOP Annual Session) for providing the opportunity to present this orally and now as a written manuscript. Feedback and discussion with delegates of CCOP conference following the oral presentation have also been valuable and inspirational.

We acknowledge the owners and communities, including aboriginal communities whose land and sea country that we have worked on to conduct our geoscience. Our collaboration with Australia's state and territory governments have also been important for enabling our geoscience to have its value, impact and connection.

References

Dutt, K. (2019). Race and racism in geosciences. *Nature Geoscience*, *13*, 2-3. https://doi.org/10.1038/s41561-019-0519-z

Handley, H.K., Hillman, J., Finch, M., Ubide, T., Kachovich, S., McLaren, S, Petts, A., Purandare, J., Foote, A. & Tiddy, C. (2020). In Australasia, gender is still on the agenda in geosciences. *Advances in Geoscience*, *53*, 205-226. https://doi.org/10.5194/adgeo-53-205-2020

Hanson, B., Woden, P. & Lerback, J. (2020). Age, gender and international author networks in the Earth and space sciences: implications for addressing implicit bias. *Earth and Space Science, 7(5).* https://doi.org/10.1029/2019EA000930

Medin, D.L. & Lee, C.D. (2012, April). Diversity makes better science. *Association for Psychological Science Observer, 25(5).* Retrieved from https://www.psycho-logicalscience.org/observer/diversity-makes-better-science

Steffen, W., Richardson, K., Rockstrom, J., Schellnhuber, H.J., Dube, O.P., Dutreuil, S., Lenton, T.M. & Lubchenco, J. (2020). The emergence and evolution of Earth System Science. *Nature Reviews Earth & Environment, 1*, 54-63. https://doi.org/10.1038/s43017-019-0005-6

Stewart, I.S. & Lewis, D. (2017). Communicating contested geoscience to the public: moving from 'matters of fact' to 'matters of concern', *Earth-Science Reviews, 174*, 122-133. https://doi.org/10.1016/j.earscirev.2017.09.003