Jour. Geol. Soc. India (2023) 99:151-155
https://doi.org/10.1007/s12594-023-2280-6

EDITORIAL

Earth Science Education at a Crossroad – Headed Toward an Irreversible Decline or Paving the Way to a Sustainable Future?

Courtney Jermyn[1], Victoria Corcimaru[2] and Eduardo de Mulder[3*]
Executive Director[1], Youth Outreach Representative[2], Chair of the Board[3]
Earth Science Matters (ESM) Foundation, Wageningen, The Netherlands
E-mail: *c.jermyn@earthsciencematters.org; victoriacorcimaru@hotmail.com; e.demulder@planet.nl*,*

Received: 14 October 2022 / Accepted: 20 November 2022

Introduction

Negative impacts on society and ecosystems caused by climate change, increasing demand for natural resources, and rising competition for skilled work to meet the needs for a sustainable economy are only some global challenges needing to be solved in the coming decades. As many or even most global challenges involve the Earth to some degree, society needs more awareness about the Earth. To develop a sustainable balance on an ever-changing planet, we require ingenuity and innovative science-based solutions that balance Earth's and society's demands.

As all UN member countries have committed themselves to radically reduce greenhouse gas (GHG) emissions, such as CO_2 and CH_4 through the Paris Agreement in 2015, transition towards a low-carbon economy has become a global imperative. However, this transition does not come without an environmental cost: a low-carbon economy still demands a lot of our planet for its natural resources, such as silica and many rare earth metals (Gloaguen et al., 2022). An additional challenge, is that the metals required for scaling up the renewable industry are also competing with the metals the growing population require for the rapidly increasing technology developments simultaneously taking place.

To address such challenges in an environmentally sustainable manner, leaders in public and private organizations should be provided with adequate and reliable information, also based on sufficient professional Earth science expertise. The problem is that such expertise is in the process of vanishing today due to current and upcoming retirement waves in the public sector and in industry. Normally such challenges would be compensated by the inflow of junior geo-experts graduated from universities. However, the number of students enrolling in Earth science education is unfortunately diminishing in many countries for various reasons (Woodfork and de Mulder, 2011).

In this paper we discuss examples of such declining enrolment numbers, potential mitigation measures and what can be done to make Earth science (also referred to as geoscience) education more appealing to the youth. We also outline key actions taken in the past by the International Year of Planet Earth (IYPE) and what actions the Earth Science Matters Foundation (ESM) has been and currently is taking to address the issues.

Earth Science Enrolment: Background

Fluctuations in student's interest in Earth sciences are not unfamiliar. Cyclical market patterns in the resource extraction industries, such as mining and oil and gas, have influenced public interest and impacted student registration over the past decades and still occur today. A notable gap occurred in 1980s, which resulted in the talent gap in the oil and gas industry that is still present in the 21st century (KPMG, 2014).

In some countries, such as the UK, the numbers of new students in the geosciences programs have been monitored for decades and show that they are rapidly declining (Figure 1). The Geological Society of London and the University of Geosciences UK reported a 43% decline of geoscience enrolment in the UK since 2014. This development is well demonstrated in the graph below displaying enrolment of advanced level geology students from 1972 to 2018 – a period of almost half a century. Apart from this dramatic decline, the graph also shows a decreasing disparity between male and female geology students in the UK, especially from 1995 onwards. The declining trends in geoscience programs indicate that geoscience

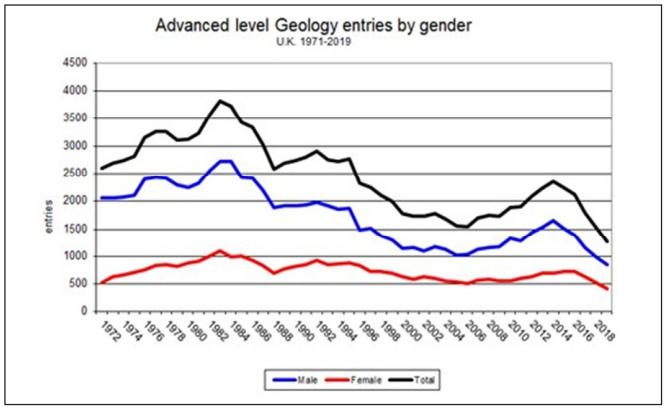

Fig.1. Development in geology entries in UK Universities from 1971-2019 by gender (Boatright et al., 2019). Based on written communication from Iain Stewart (2022), the total trend has reached below 1000 entries in the UK in 2022.

programs are not experiencing the rebound or growth expected considering the need for geoscience knowledge to mitigate and adapt to impacts caused by environmental problems and climate change.

Education Demands

Youth usually face a challenging life phase of having to decide what career path to pursue and what studies they should follow to

achieve their goals. With the introduction of the internet and rapid developments in technology, many career pathways are available for youth, causing a "fight for talent" for education institutions and between industries as well. In addition, the young "internet" generations (born post-1995) seem to have different needs compared to previous pre-internet generations.

Studies by Hegade and Shettar (2022), Rani et al. (2022) and Seemiller and Grace (2017)) on the general characteristics of generation z (those born after 1995) in USA, UK, or Indonesia, found that this generation (in a broad sense) is looking for educational programs and employment that are flexible and reliable. The younger generations are also seeking knowledge that can be directly applied in the real world, and employment where they can bring value and enjoy. These career aspirations can be achieved by following a career in geoscience. Unfortunately, elementary or secondary school programs currently available offer students limited to no exposure to the diverse geosciences opportunities potentially available to them: this formative period is one of the most critical times to inspire and grab students' attention.

Furthermore, geoscience programs have a hard time competing with disciplines that are less controversial, especially with the current volatility in the global resource market and uncertain outlook for the future; geoscience sectors are mainly held responsible for causing the anthropogenic influence negatively impacting the environment. Geoscience-based industries, such as the energy sector, have already identified several talent retention challenges needing to be addressed within the next few years. 10. These challenges include talent and gender gaps, cross-generation knowledge sharing, and negatively perceived reputation (KPMG, 2014; KPMG, 2017; Ershaghi & Paul, 2020; Boatright, et al., 2019). As society is transitioning away from fossil fuels to combat the negative impacts of climate change, these challenges are expected to increase, especially when fossil fuels are the primary focus.

The talent and knowledge gap in Earth sciences are an immediate concern as there will be insufficient experts to fill the positions of the aging work force to locate new resources to address the increasing demand on our finite natural resources. The knowledge drain, as a result of reduced geoscience graduates, will reduce the level of expertise required to find smart Earth-based solutions to accommodate the growing global population. Action to prevention for further decline in geoscience expertise is urgently required.

To mitigate the downward spiral, efforts to regenerate interest in geoscience among young people and the general public are necessary to limit hazards or reduce risks to society, manage natural resource demands of raw materials, and to contribute to a proper energy transition to reduce negative impacts caused by climate warming. In addition, continued efforts are needed to increase awareness of the relevance of integrating Earth science information in decision making processes for a safer, healthier and prosperous future.

Challenges in Earth Science Education

The decline in enrolment in geoscience programs is a great concern for the future of Earth science education because geoscience provides the necessary knowledge to understand Earth's natural resources and processes required to satisfy and secure all societal needs and well-being. Extensive knowledge of the Earth's various systems is critical to secure a sustainable planet for all future generations to thrive - an outreach campaign every Earth science department should be marketing to excite and attract the interest of perspective students to overturn the decline in enrolment.

Generating interest and inspiring young people to explore a career in Earth sciences starts with the youth (Boatright et al., 2019). Earth science educators are the ones who practice communication and outreach on a daily basis. Ideally, they have a university degree in the Earth sciences or are at least knowledgeable in the discipline having kept themselves up-to-date concerning recent developments in the geosciences. However, a recent (2020) report on geological and Earth science data, shows that the proficiency of high school Earth science teachers in the USA has declined in the past decades because they are required to teach in at least one other discipline. This unfortunate development is not limited to the USA but occurs at a much larger scale as schools face severe shortages in qualified personnel and mutually compete to attract professionals (Geological Society of London & University Geoscience UK, 2020).

To address the enrolment and educational challenges in geoscience, the approach to Earth science education will have to be explored and modified to fit the dynamic needs of the global youth, and address human resources and industry challenges.

Addressing Challenges and Fostering a Sustainable Planet through Global Earth Science Education – A Previous and Current Example

The International Year of Planet Earth (IYPE) – from 2007-2009

In the year 2000, when the International Union of Geological Sciences (IUGS) tried to match current scientific knowledge about the Earth against the application of such knowledge in daily life, it found a major discrepancy. Abundant and publicly available Earth scientific knowledge was not adequately applied by decision makers.

That observation and the ongoing declining numbers of students enrolling in geoscientific disciplines urged the IUGS leadership to take unconventional actions.

Inspired by the success of the International Geophysical Year some 5 decades earlier, the IUGS, soon followed by UNESCO, embarked on a project to eventually arrive at an International Year of Planet Earth (IYPE).

Likewise, to also collect global political support the United Nations was approached for support. In December 2005, the UN General Assembly adopted Resolution 192 proclaiming 2008 as the UN Year of Planet Earth.

IYPE aimed to capture people's imagination and to generate new excitement about our knowledge of our planet, and to ensure that it was used more effectively to make the Earth a safer and heathier place. That ambition was reflected in the IYPE's subtitle: Earth Science for Society. In 2006, a national Year of Planet Earth was held in Germany. That German Year of Planet Earth generated significant public exposure and resulted in a much higher enrolment of German students in the Earth sciences in subsequent years. That information fuelled in particular the outreach program of the IYPE.

IYPE coordinated its main activities through science and outreach programs during a Triennium (2007-2009). The Science Program consisted of 10 broad, societally relevant, and multidisciplinary themes. The Outreach Program was mainly implemented at national levels. A global launch event was organized at UNESCO headquarters in Paris in February 2008. Other, continent-wide IYPE launch events took place for Africa (in Arusha, Tanzania) and for Latin America (in Brasilia, Brazil). Finally, a closing event was organized in Lisbon, Portugal, in November 2009. On an international level, brochures and flyers were produced in many languages and a global IYPE web-portal was maintained. Moreover, numerous activities in the many countries with IYPE National Committees were monitored and registered.

Earth science education was an essential element in the IYPE program. Many of the national and international activities involved students and focused on participation by secondary and primary school pupils. Students were actively involved in all national and international events providing opportunities for them to meet eventually resulting in the creation of the Young Earth Science (YES) Network with a membership currently exceeding 5000.

Until today, the IYPE has been the largest and most successful of attempts worldwide to raise public awareness of the relevance of Earth Sciences for society, in particular through its thousands of national outreach activities receiving significant political support spurred by the official proclamation of the International Year by the General Assembly of the United Nations. The UN Proclamation generated a flood of public statements by leading politicians, including heads of state, who pleaded for implementation of the aims and ambitions of the IYPE: to base decision making more on science and knowledge of the Earth for safer, healthier, and more prosperous societies.

The 80 national and regional IYPE Committees belong to the most important legacy items of the IYPE. At national levels, such committees united key players of several, sometimes competing organizations under a single, joint ambition to raise awareness for the Earth sciences among decision makers and the public.

An evaluation among the National IYPE Committees in 2009 proved that outreach had been the most successful component of the IYPE Program. This success was observed by Anderson (2018) as he noted the rising numbers of students following the IYPE until its peak about 2014 was attributed to the massive media output; a positive tribute to the success of the program in captivating the attention of the next generation of geoscientists (see Figure 1, Boatright, et al., 2019). By the end of the Triennium, the IYPE team developed plans to arrive at a more permanent geoscience outreach platform, which eventually resulted in the creation of the Earth Science Matters (ESM) Foundation in 2011.

Earth Science Matters Foundation – 2009 to Present

As a legacy of the IYPE, over the past 10 years, ESM has been operating under a small international secretariate driven by a shared passion for bringing Earth science knowledge to everyone, in particular youth and early career and young professionals, through in-person conferences, publications and lecture series. ESM also supports partners in their education and outreach activities by translating their research using terms that do not assume thorough scientific training in the respective field (Fig.2).

In 2018, while working with a partner organisation on their outreach activities, ESM noticed a disconnect between the Earth science community and the younger generation. Distance between the older and younger generations became apparent with the decline in student memberships. ESM recognised that its partner's traditional communication channels were no longer effective on their own in reaching the younger generation. To adapt to the new ways youth communicate and receive information, implementation of an online, social media presence was required to complement the traditional organisation's activities to improve engagement with younger members.

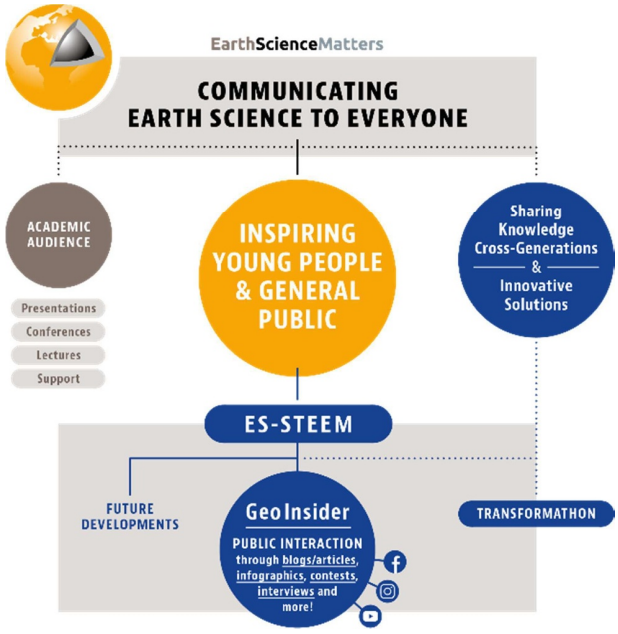

Fig. 2. Flow chart of the Earth Science Matters Foundation and its activities.

ESM leadership also recognised a gap of Earth science principles in educational programs offered to the youth. For example, the during or after school Science, Technology, (Environment), and Mathematics (STE(E)M) programs available to young people often focused on coding, engineering, and biotech but have little or no focus on the Earth sciences. As Earth science is cross disciplinary, ESM decided to launch a program that put Earth science in Science, Technology, Environment, and Mathematics (ES-STEEM) to explore innovative ways to mitigate some of the challenges involving Earth science education and associated perception.

ESM's ES-STEEM Program

In 2021, during the global COVID-19 pandemic, ESM recognized that with rapid changes in technology and online access to information, youth's expectations for education are changing in many areas of the world. To evolve with these changes, varied approaches to educate on geoscience concepts, principles, and opportunities are required. Therefore, ESM launched its first two ES-STEEM activities: the Geo-Insider platform and a geo-hackathon in collaboration with the Transformathon initiative. Through these activities, ESM stepped up its virtual presence to engage, inspire and uplift the general public, and in particular the younger generation.

Geo-Insider

Bringing geoscience experts from all over the world to a virtual platform where they can share their expertise with a global audience and impact young people – is the essence of Geo-Insider, which is itself the legacy of a global effort to stimulate Earth science education. This project creates a youth-moderated platform for geoscience content covering expert interviews, infographics, and written material on Earth science topics and related current events, thus giving the project more resonance with the audience.

Since its launch in 2021, Geo-Insider has expanded the social media presence of ESM to platforms such as YouTube and Instagram, where the goal is to further connect with a younger audience through brief, creative, short geoscience content. As a result, the combined content across all ESM platforms ranges from 30-second videos to 40-minute lectures by professional experts in a range of Earth science fields, covering various topics such as volcanic lightning, sedimentation environments, interpretation biases, and more. Geo-Insider also aims to bring awareness on how these geoscience principles are applied in real life and bring value to society.

While Geo-Insider is still in its infancy, individual reach using social media platforms such as Facebook and Instagram has increased ESM's international following to at least 1950 and 39 followers respectively (as of September 2022). While the founding followers comprise predominately family members, friends, colleagues, and members of the Young Earth Scientist (YES) Network ongoing exposure to new regions, organic growth of new followers continues to increase and is expected to evolve over time.

Based on Facebook's analytics, followers are characterized as 29% women and 70% men, and 1% not disclosed, reaching age groups from early career and older. As ESM further develops its strategy and content on these social media platforms, the number of followers are

Fig.3. ESM's Geo-Insider followers growth curve from 25 September 2021 to 25 September 2022

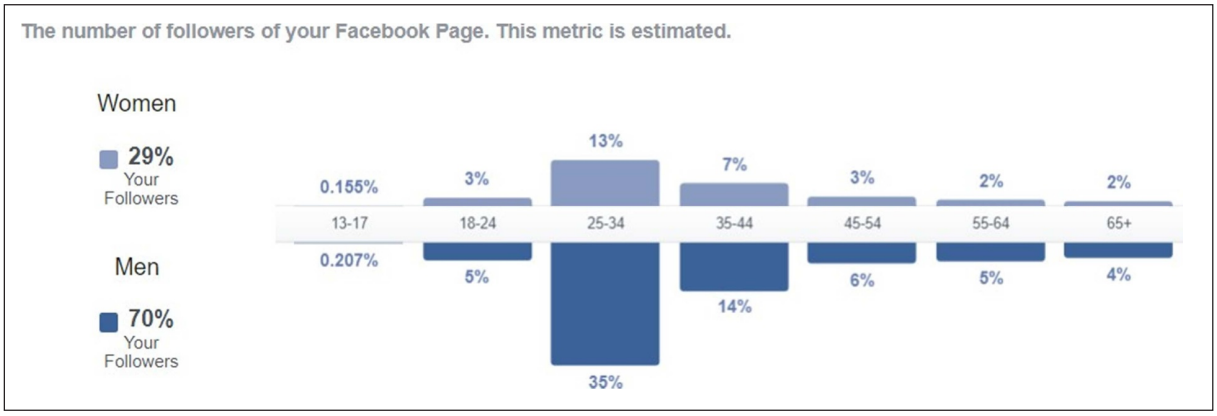

Fig.4. Age and gender breakdown of ESM's followers obtained from Facebook analytics on 16-09-2022.

projected to grow and become more diverse in gender, age, region, etc. (see Figure 4). These results provide important insight that supports ESMs communication strategy and guides directions on how to improve its efforts in the future to attract a more diverse and inclusive audience.

Transformathon

ESM works jointly with Transformathon, an initiative that brings together a large international network of professionals, business delegates, and students from various disciplines to stimulate necessary change for a sustainable future. Transformathon's virtual platform promotes a high degree of self-direct learning and collaborative exchange when working with international participants across generations, industries, gender, and disciplines addressing themes on energy, sustainability, and innovation.

One of the key aspects of the Transformathon platform is the hackathon event. During Transformathon hackathons, participants are asked to develop innovative solutions (proof of concept/prototype level) that are relevant to current industry issues and can reach the market quickly. To achieve successful results, a multi-dimensional/ multi-disciplinary perspective is required.

Transformathon's first hackathon, *The Journey Begins,* took place in collaboration with ESM Foundation and UNESCO-IGCP, in March 2021. The challenge topic was focused on supporting the oil and gas industry transition towards a low-carbon economy to help combat the negative impacts on our planet caused by anthropogenic influence predominately greenhouse gas emissions derived from fossil fuels. This transition is a task that is very difficult for some, or seen as an impossible task by others.

To educate and create awareness about the challenge topic, a four-day speaker session of international speakers across the energy sector was organised during the week prior to the hackathon. Participants were then able to apply their new knowledge into the hackathon challenge to develop their innovative solutions. This exercise provided an opportunity for participants to join in cross-discipline and cross-industry discussions giving geoscience professionals an opportunity to apply their knowledge to address new types of industry problems, resulting in personal development and achievement.

Registration to the event resulted in thirty-one participants initially registered with three cancelations. Demographics of the teams consisted of graduate students to senior level participants; 14 female and 14 male, from the Middle East, Africa, EU, UK, North America, South America. The final 28 participants formed seven teams made-up of a maximum 6 people/team.

Direct impact resulting from the event was in the transfer of peer to peer knowledge and the personal and professional development. The 28 enthusiastic participants provided positive feedback stating they were inspired by what they had learned and achieved during the hackathon and that they were keen to share their new acquired knowledge with their organisation and continue their educational journey.

Resume

Enrolment in geoscience programs is rapidly declining in many areas of the world as a result of the competition for talent across disciplines and industries, and the negative perception currently associated with the Earth science extraction (mining and oil and gas) sectors. A decline that creates great concern as the need for geoscience knowledge and expertise is arguably more critical to solve today's global challenges than at any other time in history.

To address the evolving needs of the younger generations and stimulate interest to overturn the decline in enrolment and improve public perception of the geosciences, efforts to help demystify the geosciences and develop knowledge are required. A first step to demonstrate how the Earth sciences applies to society and the opportunities it offers students, is to integrate applied Earth sciences into education syllabuses. In many areas of the world, geoscience is not adequately incorporated. Therefore, science programs need to be adapted to better incorporate geoscience principles and real world examples.

Furthermore, while captivating the attention of the younger generation is critical in attracting new generations of geoscientists, it is also important to not lose track of knowledge building and collaborative in person (or now hybrid) activities, such as conferences and lectures. These platforms are significant for the geoscience community of all generations to build relationships and transfer knowledge. Dialogue between peers, political leaders, and industries is vital to continue to innovate and realize science-based solutions necessary to meet needs of the future.

Therefore, by applying Earth science education and outreach activities that incorporate traditional models, successful approaches learned from the IYPE, and new channels such as virtual learning, and interactive in-person and virtual events, the geoscience community can bring knowledge about the Earth to everyone and captivate the attention of the next generations of geoscientists.

Acknowledgement: The authors would like to thank Iain Stewart and Lionel Jackson for their valuable feedback and comments.

References

Anderson, M. (2018) Future of university geoscience meeting: Opening Talk. 21 November 2018 London, Geological Society of London.

Boatright, D., Davies-Vollum, S. and King, C. (2019) Earth Science Education: The current state at play. *In:* A. Whitchurch (Ed.), Geologist. London: Geological Society of London, pp.16-19.

de Mulder, E.F.J. and Eder, W.E. (2011) International Year of Planet Earth, UN - background, legacy and perspectives. *In:* Gupta, H. (Ed.), Encyclopaedia of Solid Earth Geophysics, Springer, pp.614–618 [Online].

Ershaghi, I. and Paul, D.L. (2020) Engineering the Future of Petroleum Engineering and Geoscience.

Geological Society of London & University Geoscience UK (2020) Enrolment in crisis: a UK-wide strategy for exciting, engaging and retaining students in the geosciences. [Online] Available at: https://www.geolscoc.org.uk/Geoscientist/Archive/September-2019/Feature-2

GeoScientist (2019) From the editor's desk: Halt the decline. Geologist, v.29(08), pp.0-32.

Gloaguen, R., Ali, S.H., Herrington, R., Ajjabou, L., Downey, E. and Stewart, I. (2022) Mineral revolution for the wellbeing economy. Global Sustainability, v.5(15), p.4.

Hegade, P. and Shettar, A. (2022) Elevate-Z: A model to Create Learning Space for Generation Z Students. Jour. Engg. Educ. Transformation, v.35(Spec. Iss,), pp.175-180.

IPCC (2021) Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. *In:* V. Masson-Delmotte, et al. (Eds.), Contribution of working Group I to the Sixth Assessment Report of the intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, pp. 1-3949.

KPMG (2014) Addressing the energy industry talent gap - Where should you put your energy? KPMG Global Energy Institute, p. 8.

KPMG (2017) Global CEO Outlook - Energy perspective - A 3 year outlook. KPMG Global Energy Institute, p.48.

Mazzetti, P. et al. (2022) Knowledge formalization for Earth Science informed decision-making: The GEOEssential knowledge base. Environ. Sci. Policy, v.131, pp.93-104.

Nicolet, M. (1984) The International Geophysical Year (1957-1958): Great Achievements and Minor Obstacles. GeoJournal, v.8(4), pp.303-320.

Purvis, B., Mao, Y. and Robinson, D. (2019) Three pillars of sustainability: in search of conceptual origins. Sustainability Science, v.14, pp.681-695.

Rani, I.H., Jalih, J.H. and Widyowati, L.A. (2022) Indonesian Generation Z Work Expectation and Intention to Apply for Job: Role of Social Media. Qantitative Economics and Management Studies, v.3(2), pp.193-206.

Seemiller, C. and Grace, M. (2017) Generation Z: Educating and Engaging the Next Generation of Students. About Campus, Volume July-August, pp. 21-26.

Stewart, I. (2020) Geology for society: Earth science for sustainable development. *In:* Humanistic futures of learning. Perspectives from UNESCO Chairs and UNITWIN networks. Paris: UNESCO, pp.39-41.

Stewart, I.S. and Hurth, V. (2022) Selling planet Earth: re-purposing geoscience communication. *In:* Geoethics: status and future perspectives. London: Geological Society, v.508, pp.265-283.

Woodfork, L.D. and de Mulder, E.F.J. (2011) International Year of Planet Earth, Wageningen, The Netherlands: Earth Science Matters Foundation, 76 p.