

The role of women in the history and development of geology: an introduction

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A conference held at the London Geological Society, Burlington House, London, on 28 November 2005, hosting over 70 participants, was the first to deal solely with the role that women played in the history and development of the science of geology. Sixteen papers were read and there were two poster presentations. Prior to this, there have been individual articles written and papers published on the historical role of women in the history of the geosciences, but this collection of conference papers is, surprisingly, the first time a book has been published bringing the evidence together and giving an overview and a selection of detailed case histories.

In carrying out this project the authors ask: 'Can we really analyse the situation for women in the geosciences today without knowing what happened in the past?' Consequently, the collection of papers in this book mainly deals with the late 1700s to early 1900s, but also offers some links to the present day. It attempts to evaluate the contribution of women, and their changing roles, in the development of geology as a science. This undertaking has allowed a number of themes and common issues to emerge and be identified, which will be drawn out and discussed in this introduction. This work suggests that, in relation to our question, the past is the key to the present.

It is interesting to note that it is not only women who have researched these case histories; there are valuable contributions from respected male colleagues. The mix includes review papers referring not only to the development of geology in Great Britain, but also in other European countries, Australia, and North America. There are papers that look at a particular role, such as women as museum curators, or at a particular issue, such as travel for women during field studies. There are also several papers that focus on the contribution of a particular individual. The conference was publicized using the image of Etheldred Benett (1776–1845), and so an introduction to this early pioneer, originally submitted as a poster, is included in this book.

The book is not intended to be an exhaustive study of all women who played a role, as the work of well-known individuals, such as Mary Anning (1799–1847), (Torrens 1995; Tickell 1996; Burek 2001, 2002, 2004) are documented in detail elsewhere. There are other important histories still waiting to be uncovered, including some very influential women, such as Professor Janet Watson (1923–85), first female President of the Geological Society of London, Dr Doris Reynolds (1899–1985), who developed new ideas on the origin of granites, and Marie Tharp (1920–2006), whose work led directly to the first map of the Atlantic seabed and helped forward ideas on seafloor spreading.

The book is necessary because both historians and scientists have neglected the topic to a certain extent. Historians have sometimes omitted to mention a male geologist's female research assistant, or intellectual wife, sister or daughter, beyond stating that: 'she was following the fashion' or 'she was unusual for her time'. Modern scientists have considered these stories and the gender issue unimportant to their present-day specialized research. However, the picture emerging suggests that these stories are important to the present day. It seems that the treatment of women in the past has left a legacy that has not entirely been overcome in the 21st century. In this book we want to bring these issues to a wider audience, to highlight this legacy, and to ask: 'What *has* changed?'

This book crosses the divide between science and the humanities. It is important to note that many contributors are writing outside of their normal discipline to document the role of women in the history of geology. They are palaeontologists, geoconservationists, geophysicists and hydrogeologists, to name but a few. Why would they do this? It is because there has been a gap in our understanding of the role that women have played, and because the research has uncovered fascinating stories. Those who began this research some time ago are becoming more proficient and expert in this interdisciplinary work. The book has benefited from a wide range

of reviewers, including geologists, historians and educationalists. A variety of styles in this book is evident and is a result of the interdisciplinary nature of the project. During the review process the strict science historians, when reviewing, were quite critical of the style of some of the contributions, while disciplinary geologists were highly complimentary of the same papers and vice versa!

Characteristics of women who played a role

The early female scientists had a number of common characteristics. They were often born into influential families, for example Grace Milne who was 'born in 1832 . . . eldest child of Louis Falconer and sister of the eminent botanist and palaeontologist, Hugh Falconer' (Mather 2007). This position in society allowed some women to work voluntarily, for no pay and usually no status, because they had a private income or were supported by a man. It was common for male scientists to have women assistants, and the well-known male geologists of the time encouraged women to do some of the time-consuming work of writing and illustrating. These women often went unacknowledged and become lost to history. For example, Mary Morland (1797–1857) illustrated some of George Cuvier's work before she became Mrs William Buckland. Mary Orr (2007) also writes of Cuvier's 'extraordinarily enlightened encouragement and employment of his daughter, and perhaps even more importantly his step-daughter, in his collaborative projects . . . as his "research assistants"'. Their stories have not been told before.

A number of women benefited from their associations and wrote geological articles under their own names. These were often for wider audiences, for example, in the case of Muriel Agnes Arber (1913–2004), it was her aim 'to present Earth history . . . in terms that the general public could understand' (Robinson 2007). Some of these geological articles were particularly for women and children. For example, Grace Milne (1832–99) wrote six chapters in *Every Girls Magazine*, and for women she wrote three articles in *Good Words* on the forces of nature that shaped the Earth (Mather 2007). This formed part of the whole genre of literature for women and children at this time (often written by women) and was in the form of conversations between a parent and child or between a teacher and pupil. For example, Arabella Buckley (1840–1929), Charles Lyell's long-time secretary, took to writing this kind of literature after Lyell's death in 1875 (Burek 2007). Her book entitled *The Fairy-land of Science* (Buckley 1879) is based on a series of lectures she

gave to children and contains chapters on 'The history of a piece of coal' and 'The two great sculptors – water and ice'. It can be argued that, as Lyell's secretary, she was exposed to new geological ideas and, as a woman herself, she was well placed to pass on this knowledge to other women.

Several biographies of men were written after their death by women to whom they were related. These biographies show the depth of understanding the authors had of the geological material. Most telling was that some women were capable of understanding the importance of publishing their husband's work posthumously, such as Hugh Falconer's wife Lydia. Indeed William Buckland would not have finished the Bridgewater treatise without his wife Mary. However, in the 19th and 20th centuries, it was common for women to publish their own scientific work anonymously, or under the name of a male relation. Wyse Jackson & Spencer Jones (2007) in researching women as curators, report that:

Women typically were employed in the major national or university museums as preparators, illustrators or assistants and this trend continued until the 1930s. These women received little academic credit for their research as it was frequently incorporated into the publications of the men for whom they worked.

In the past, women with geological ambitions had to be pioneers (even during the last 40 years), sometimes 'ploughing a lonely [and marginalized] furrow' (Watchler & Burek 2007). However, in bringing together the histories of individual women, it can be seen that they were supported by a network of other women and male supporters. For example, Archibald Geikie supported Marie Ogilvie Gordon (1864–1939) (Watchler & Burek 2007), and Professors McKenny and Lapworth supported Ethel Wood (1871–1945) and other members of Newnham and Girton Colleges in Cambridge (Burek 2007). Several of the women highlighted in this book knew each other, either as contemporaries or role models. For example, Grace Milne met Mary Somerville on her travels, and later helped in the establishment of Somerville Hall (Mather 2007). Gertrude Elles (1872–1960) and Ethel Wood were collaborators with Margaret Crosfield (1859–1952) and Ethel Skeat (1865–1939) (Burek & Malpas 2007), and Catherine Raisin (1855–1945) acted as a role model for Doris Reynolds, as well as other early geologists (Burek 2007).

Influence of society

Women had to have a pioneering spirit because society as a whole did not support the ambitions of women to follow their geological interests until the late 20th century. The learned scientific

societies were slow to accept women. It seems that those in power held real and deep-seated prejudices. For example, Murchison, who was president of the Geological Society, has private journals that show his low regard for women (Mather 2007; Burek & Malpas 2007). Women were regarded by some as weak and frivolous, reducing the seriousness of any study if allowed to participate (McEwan 1998). Thus, they were barred from scientific societies, such as the Royal Society and the Geological Society of London (until they were forced to accept women by law in 1919), due to the perception that women had a lack of intellectual rigour and understanding necessary to engage in serious science. They were also discouraged from fieldwork.

[Geologists and] geographers were not just men of science, but men of action. Women were therefore doubly excluded, first by the refusal to admit them to the 'rational sphere' of science, learning and public debate; but also by assumptions about their (lack of) ability to meet the physical challenge that fieldbased work involved. (Bracken & Mawdsley 2004)

Brickhouse (2001) offers insights into these attitudes towards women. Enlightenment epistemology was significant in that it persuaded society that dualisms, such as masculine and feminine, existed. The perceived masculine characteristics, such as objectivity and reason, were seen as superior and were aligned with science. In this way science was culturally defined in opposition to women. This work can help us to understand the attitudes of male scientists at the time and also allow us to gauge whether positive change has occurred.

To its credit, the Geologists' Association (GA), based in London, stands out from the other societies because it devoted itself to the needs of the amateur. From its foundation in 1858, women members had equal rights with men within the society (Burek 2007). In 2006, GA female members numbered about 439, out of 1650, or roughly 25%, of the members. This is higher than most other geological societies and associations except the Open University Geological Society (*c.* 50%). The Geological Society of London stands at an average of 17% female fellows, but this ranges from 46% (aged 21–25 years) to 7% (aged 51–55 years) in 2006 (Boning 2007) and demonstrates the slow leakage that occurs as women progress through their geological career. It is interesting to note that the Geological Society is taking this very seriously and is looking to set up a pilot project on the mentoring of younger fellows by their older colleagues (Boning 2007).

It is clear from the contributions in this book that access to education played a crucial part in the advancement of women's roles in the geological community. Women had to struggle for decades to change male opinion. The availability of schooling, and then tertiary level education, enabled the gender

imbalance to begin to be redressed. In this book, the evolution of two female colleges of higher education, Bedford College, London, and Newnham College, Cambridge, both offering geological education within science, is outlined and evaluated (Burek 2007). Here role models existed in the forms of Dr Catherine Raisin, based at Bedford College, London, and Dr Gertrude Elles at Newnham College, Cambridge. In this struggle for education, women had their male opponents, such as the well-known mineralogist and educationalist Sir Robert Kane, but they also had their supporters, such as the professors of geology, Samuel Haughton and McKenny Hughes.

Several papers highlight the fact that, even when women gained a job, there were other barriers to overcome.

Anna Birchall Hastings was appointed to the British Museum of Natural History, but upon her marriage was required to relinquish her post, even though she had married a museum palaeontologist – he remained in his post while she became a volunteer. (Wyse Jackson & Spencer Jones 2007)

Compare this with Dorothea Bate (1878–1951), who never received payment for her work as an employee at the museum and never married (Shindler 2007). She was still producing research work into her 70s as was Maria Ogilvie Gordon (Wachtler & Burek 2007).

In the 1960s in Europe, female undergraduate students were told there were no professional jobs for women in geology and that teaching in a school was the only outlet (Kölbl Ebert 2007). Certainly geological mapping was considered unsuitable for women. So it must have come as a surprise to some when the first female field geologist, Audrey Jackson (Higgs & Wyse Jackson 2007), was appointed by the British Geological Survey in 1969. Interestingly, even into the 1970s, women postgraduate researchers had to use covert measures to gain access to coal mines for their sampling. Typically a student would write only their initials on a letter requesting a site visit (Langley pers. comm.). The mine manager, when responding positively, would assume the request was from a male student. Excuses then followed and varied from 'We do not have shower facilities for females' to 'It is unlucky to allow women down the mine'.

So, historically, barriers to employment as a field geologist existed and, until 1975, women who married had to resign from the Geological Survey and other Civil Service roles. Archives show that women typically worked for 2 or 3 years before disappearing from the records (Burek 2007; Higgs & Wyse Jackson 2007). The young male geologists of 30 years ago are now in senior positions of power, sitting on committees and selection panels. Do undergraduate women see academia as a no-go

area for themselves, perpetuating the situation? Whitelegg & Smidt (2004) believe that, when there are no female role models, women have a dislike for the culture and develop pessimistic views about their own career potential.

The situation today

As Professor Dervilla Donnelly, an influential physicist at the Dublin Institute for Advanced Studies (DIAS) said, at the launch of a Women in Science, Engineering and Technology (WiSET) initiative at University College Cork, Ireland, in September 2006: 'Women are no longer discriminated against in science'. Is she correct (Higgs *et al.* 2005)? When asked why the present-day numbers do not tally, she admitted that there was a legacy to overcome. Members of the audience, in response, said that, even today, women continue to have challenges that their male counterparts do not have. The responsibility of bringing up the next generation may be shared to an extent, but the burden still weighs heavier on women. For example, in Ireland, only two women have succeeded in having professional geological careers in academia while also being mothers.

What is this legacy?

The legacy of the model that saw science as a masculine pursuit has given us a deficiency of female role models in the geological sciences. Most lecturers and leaders of geological field trips are male. The structures that still exist today were set up by men, for men.

The masculine culture of departments was universally recognised; there is a sense in which women have to become honorary men in order to survive as students. (Ward 1992)

Some literature suggests that having female role models could make progress in academia easier. The Women into Science and Engineering (WISE) initiative saw this as important and included positive role models to encourage female students into science. The GETSET women (Get Science Engineering & Technology) initiative used participation in 'empowering residential courses' to engage women in science (Whitelegg & Smidt 2004). In running the conference (The Role of Women in the History of Geology) we were fortunate to receive a grant from the UK Resource Centre for WiSET, based at Bradford University, as it was an innovative project.

It is clear that some changes are being made today to allow for equality of opportunity. However, Whitelegg & Smidt (2004) believe that unwelcoming behaviours still exist, both cultural and societal, and although they may be small and

seemingly unnoticeable, yet cumulatively they are significant informal barriers. Indeed, some women will see their opportunities as limited and will not engage in science.

When women do engage in science do they get what they need? Should they be treated differently? There has been very little work done on gender inclusivity in the field-based sciences in higher education. Is the experience any different for female and male students? Some evidence, which suggests that it is, comes from the description of a field activity by Dixon (1999) in the United Kingdom. His work suggests that females favour collaborative and group work. Bracken & Mawdsley (2004), however, writing specifically about physical geography fieldwork, mention the diverse nature of fieldwork and seek to stress that fieldwork must not continue to be coded and perceived as a masculine area (see also Hart 2007). As fieldwork moves to more local domains, detailed field research may be more attractive to women scientists. Fieldwork problems in the past are covered by Burek & Kölbl-Ebert (2007).

It is good to note that, in awarding prizes for undergraduate fieldwork in some universities over the past 10 years, women have succeeded as often as men. However, encouraging women into academia is still problematic. In the geology departments of the higher education institutions in Ireland, for example, only two female full-time permanent staff members have been appointed, highlighting the deficiency in role models.

A report by the UK Earth, Marine and Environmental Science cost centre for the Higher Education Statistical Agency (HESA) in 1994/5 listed 4 female professors out of 160 male while in 2003/4 it had increased to 25 female professors out of a total of 325 male (HESA 1995, 2004), an increase from 2.5% to 7% of the total. In British universities, role models include the 20 professors who are researching and working in the broad area of earth science (see Table 1 & Fig. 1).

These 20 female professors are from 16 different universities, with Royal Holloway, University of London and University of Leeds, topping the list with three entries. In order to find these statistics, 37 university departmental websites were searched using the Geological Society of London listings. It is interesting to note that the majority of professors are researching in the field of geophysics, physical geography/Quaternary earth science and environmental issues. These last two perhaps reflect the growing concern with issues of climate change and the well-being of the planet in general. This is a very different picture from a century ago, when the majority of work undertaken by females at all levels was in the palaeontological area. Figure 1 shows the distribution of professors and their disciplines.

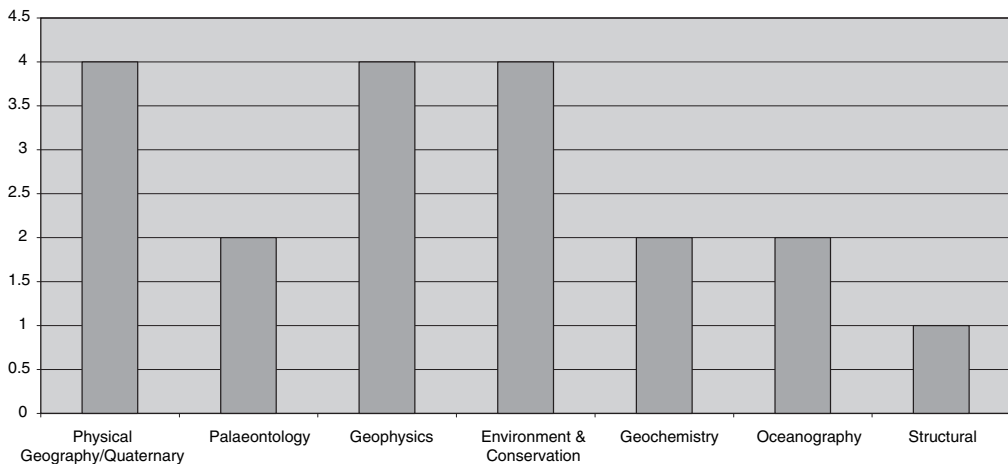
Table 1. *Female professors in Earth sciences January 2007 (including relevant archaeological applications) in the UK (listed alphabetically)*

Professor	University	Chair or area of research
Burek, Cynthia	Chester	Geoconservation
Burgess, Jacqueline	East Anglia	Environmental Geography
Collinson, Margaret	Royal Holloway, London	Plant Palaeobiology
Das, S.	Oxford	Earth Sciences seismology
Downes, Hilary	Birkbeck/University College, London	Geochemistry
Ebinger, Cynthia	Royal Holloway, London	Structural
Edwards, Dianne	Cardiff	Palaeobotany
Foulger, Gillian	Durham	Geophysics
Fowler, Mary	Royal Holloway, London	Geophysics
Francis, Jane	Leeds	Palaeoclimateology
Frostick, Lynne	Hull	Physical Geography
Hart, Jane	Southampton	Physical Geography
Heywood, Karen	East Anglia	Oceanography
Kneale, Pauline	Leeds	Applied Hydrology & learning
Petts, Judith	Birmingham	Environmental Risk Management
Plant, Jane	Imperial College, London	Applied Geochemistry
Ragnarsdottir, Vala	Bristol	Environmental Sustainability
Whaler, Kathryn	Edinburgh	Geophysics
Wilson, B. Marjorie	Leeds	Igneous Petrogenesis
Wintle, Ann	Aberystwyth	Quaternary geoscientist

So, acquiring positive role models is still problematic. For the most part, in the 'power situation', females are still the students; males are the teachers and supervisors. In 1997 nearly 75% of women geoscientists were under 40 years old and so few role models were available (Geological Society 1997). As Whitelegg & Smidt (2004) point out, there are still many factors combining to discourage women from progressing to academia. One exception is the Open University, United Kingdom, where a large number of women are employed to tutor Earth sciences, including field-based courses. This may

initially seem to be very positive. However, these positions are typically part-time and temporary.

The lessons of the past presented in this book (Burek 2007; Higgs & Wyse Jackson 2007; Kölbl-Ebert 2007) show that most male geologists do not do U-turns and change their minds about the role of women in geology. The geological debate on gender focused on women as 'the problem', when it could have been focusing on teaching and societal attitudes as the problem. If women have different educational needs, and these needs are ignored, then equal treatment may fail to deliver equal

**Fig. 1.** UK female professors and their disciplines (October 2006).

outcome. This is an important realization and message for the future; 'equal treatment' does not necessarily mean 'equality of opportunity'.

Brickhouse (2001) documents a call to change unreflective 'masculine curricula' into empowering curricula, with an increase in collaborative group work; for changes to the traditional teacher/student hierarchy; and for new pedagogies which try to give more consideration to students' ideas and students' needs. In addition, Brickhouse (2001) recommends mentors to encourage female students to consider new territories. With appropriate scaffolding, linking students to the outside world, new identities can be built. Current practice in higher education may be failing to help with this finding identity, due to lack of awareness, and stereotypes may dominate. Using contexts with which female students identify, and which allow them to see a path they would like to follow, is more likely to motivate them to progress in science (Whitelegg & Edwards 2001). So, we must not simply add women to science, but change the structure of science to make it accessible to women who would like to pursue a career in science. This is discussed in detail by Schiebinger (1999).

A survey carried out by Burek & Higgs (2004), asking people to name ten female scientists, revealed that the public perception and knowledge of women's contributions in science is poor. This on-going study is part of a project on 'Public understanding of women in the history of science' and has tested the hypothesis that women were influential in the history of science, but have been forgotten. The countries sampled were the United Kingdom, Ireland, France, Spain and Germany. The authors found that people cannot name ten female scientists from any historical age, or nationality, even though they are there. From a total sample of 500 respondents, typically only one or two female scientists were named, with Marie Curie being the most well known and listed by 72% of participants across Europe; 28% of respondents listed her alone. The most common female geologist named in the British Isles was Mary Anning, 'the dinosaur woman'. She was listed by 10% of respondents.

On the positive side, there has been an increase in the number of women taking places in consultancy companies that engage in fieldwork. This is partly because the number of commercial geoscience companies has increased in recent years. It is the expansion of job opportunities in the geosciences during the past two decades that has allowed an increase in the number of female (as well as male) professional geologists. This is seen particularly in environmental geology, hydrogeology and geophysics and, during the last decade, in the petroleum, mining and quarrying industries. These women are mapping out paths

and providing role models in industry and government bodies, and lifting the aspirations of current female students. Today there is a lack of young people entering the geoscience professions (Geological Society 1997). Perhaps by providing role models for half of the population, we can address this shortfall.

It was reported in a talk given by Annette Williams in 2004, at the UK All-Party Parliamentary Group for Earth Science Conference on improving the effectiveness of education resources for earth science and industry, that women are still hugely under-represented in science, engineering and technology, including the earth sciences. This is despite outperforming their male counterparts at GCSE and 'A' level examinations in key subjects. Thus women represented an untapped resource of creativity and innovation. The Science, Engineering and Technology (SET) unit at the University of Bradford has established an expert-women's database (GETSET) and is working to raise the profile of women in SET in the media. They hope this will make an impact on neutralizing gender stereotypes and overcoming cultural barriers. Women lost to industry or not using their qualifications in the fullest sense are classified as 'potential returners' to STEM (Science, Technology, Engineering and Maths). Many of these women may be working on the 'edges of science', for example as part-time workers at heritage centres, in middle management, in environmental education centres, etc. The question is 'Why do they choose to leave the industry?'. The SET unit is working with companies to look at retention, work-place issues and attitudes to women in the workplace. Whatever the answers, industry and some geological surveys have been ahead of the game, employing more women than the academic institutions. There are still some university geology departments that are into their third century of existence and have yet to appoint a female to a full-time permanent academic post (Higgs & Wyse Jackson 2007).

Conclusions

Our understanding of the present-day contribution of women in the geological sciences depends on an understanding of their past roles and the restrictions of travel, study and work placed upon them. Despite the difficulties of prejudice and adversity, especially within Victorian society, women have contributed significantly to the development and history of geology through the various roles they have played. These roles include researchers, teachers, illustrators, collectors and practitioners. Their contributions have often been lost, or buried

under the wealth of new knowledge and publications emanating from the leading men within the field. The understanding of the societal context in which they (both men and women) operated is paramount, and the subsequent conclusions drawn, must be evidence based. For this reason, the overviews and case histories presented at the November 2005 conference represent many months of researching this evidence in archives, museums, private collections, libraries, and even in churchyards, as well as by personal communications and reflections. Some of the evidence is documented in previous books, which dealt with broader histories. If geologists did not venture outside of their normal specialized disciplines to research and write, there is a danger that some of this evidence would be lost. If non-geologists do not see the value of their research within geological science, the evidence would be lost too (Orr 2007). The bringing together of this evidence has allowed new connections to be made and will provide a valuable base on which future work will build.

It is hoped that both geoscientists and historians will expand on this work so that more stories are told and the effect of societal restrictions is not forgotten. Histories such as these help us to understand the present, to plan for the future, and to build a diverse, multi-talented and equitable community of scientists.

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