

WOMEN IN NEW ZEALAND GEOSCIENCE

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Introduction

Geoscience, covering the related fields of geology, geophysics and physical geography, has traditionally been one of the most male-dominated areas of science. No woman was employed in geoscientific work in New Zealand until World War 2. A gradual change over the last sixty years means that women are now involved in most areas of geoscience, although generally still a minority. This paper has been prepared to record the pioneering efforts of a small number of women geoscientists in the second part of the twentieth century who paved the way for a second generation in the 21st century. It builds on two previous short articles (Nathan 1999 & 2006), as well as interviews and further research, and is an attempt to answer the challenge laid down by Hannah (2017) to ensure that the history of science fairly reports the contributions of both women and men.

Until the 1970s, social pressure limited career choices for professional women in New Zealand mainly to teaching and nursing. The few women who moved into science were restricted to fields such as mathematics, botany and entomology, which could be mainly carried out in the office or laboratory. There were also two specific factors that ruled out a career in geoscience for women:

1. Legislation passed in the nineteenth century, based on that in Britain, banned the employment of women underground or

in quarries. Although regarded as socially progressive when introduced, this effectively blocked women from obtaining jobs in economic geology.

2. Most areas of geoscience involve fieldwork, and there were ongoing debates about the 'moral' aspects of a woman working outside by herself or in company. For example, Daphne Suggate was keen to study geology at university in 1940, but was talked out of it, being told that she would never be allowed to do fieldwork (interview with SN, 1999).

Kolbl-Ebert and Turner (2017) have recently published a worldwide review of women in geoscience for the International Commission on the History of the Geological Sciences (INHIGEO) which provides a useful reference with which to compare experience in New Zealand. They raise several points that are relevant to this paper:

- Paleontology was one of the first areas of geoscience in which women could find employment;
- The earliest women geoscientists were often supported by a male relative or mentor;
- Women were sometimes employed as 'computers', undertaking lengthy or tedious computations in the days before the invention of electronic calculators.

Within New Zealand, most geoscientists were employed in the Department of Scientific and Industrial Research (DSIR). The Geological Survey, a branch of DSIR,

included both geological and geophysical work until 1951 when Geophysics Division split off as a separate branch (Burton 1965; Hatherton 1980). In a major reorganisation of government science in 1992, DSIR was disbanded, and both geological and geophysical work was incorporated in the Institute of Geological & Nuclear Science, now known as GNS Science.

In order to limit the scope of this project, I have deliberately focussed on women working in positions designated as scientists rather than research assistants or technicians. As the project progressed, however, it became clear that the proportion of women employed as science support staff is approximately the same as those designated scientists. In contrast, there is a higher proportion of women employed in clerical roles or as librarians.

Nineteenth and early twentieth century

In their worldwide survey, Kölbl-Ebert & Turner (2017) outline the impediments to women obtaining university qualifications and employment in geoscience in the nineteenth and early twentieth centuries. They document a few exceptional women who had successful careers, as well as some who worked as unpaid research assistants and/or amanuenses to their husbands, brothers or other male geologists. So far I have been unable to find any similar examples in New Zealand – the small local geoscience community appears to have been entirely male prior to World War 2.

The New Zealand Geological Survey was reorganised in 1905 under the direction of J.M. Bell, with a strong emphasis on field mapping, and this tradition was maintained for the next 35 years. Geologists were expected to be in the field for at least six months every year, and worked in large

field parties including surveyors, field hands and a camp cook. It was an entirely male environment akin to the army. Funding for fieldwork was reduced in the depression years of the late 1920s and early 1930s, with much smaller field parties, often limited to a single geologist and a student assistant. Doris Fyfe accompanied her husband Horace as cook and housekeeper during fieldwork for the Murchison and Kaikoura subdivisions, and was the first of many geological wives who provided unpaid support over the years.

Most universities in the UK and USA did not provide a supportive environment for women to study geoscience subjects, but there were exceptions. Newnham College at Cambridge contained a small geological teaching and research group under Gertrude Elles and Ethel Wood. In the late 1920s Elles supervised the PhD research work of Robin Allan (later professor of geology at Canterbury University), and a few years later Dorothy Hill (later professor of geology at the University of Queensland).

Within New Zealand each of the university colleges had a small geology department, generally only a single lecturer apart from Otago where geology was taught in association with the School of Mines. Although male students predominated, there were generally several women in first year classes as geology was regarded as a good background subject for geography teachers. Photographs in the University of Auckland centenary booklet (Brothers 1983) show both men and women on field trips. Mrs Bartrum (wife of the professor) regularly joined the excursions as a chaperone.

I can find only a single example of a woman who completed an undergraduate degree in geology before the war. Rose Bonner (later Mrs Wilson) started taking university classes at Auckland in 1925 while working as a

pupil-teacher. She chose geology because the early evening classes could be fitted into her working day. When her final year results were announced in 1929 she was awarded a Senior Scholarship so she could study for a masters degree. Although Professor Bartrum encouraged her to take up the scholarship, she decided that she needed to earn her living, and embarked on a career as a science teacher (Mason 2010).

The DSIR did not employ any women as scientists until the late 1930s – it is unclear if this was official policy or simply an unstated understanding. Ruth Mason graduated with a degree in botany, but found that she could not get a job. Her father, a cabinet minister, worked behind the scenes, and thereafter applications from women were not automatically rejected (Hancock 2019).

A scan of the Bibliography of New Zealand Geology up to 1950 (Adkin & Collins 1967) illustrates the almost complete absence of research publications by women authors. I can find only two such papers, both undertaken overseas:

1. While studying at the University of Stockholm, botanist Lucy Cranwell undertook pollen analysis of cores from Southland, previously collected by Dr Carl Caldenius, the first work on Holocene vegetation changes in New Zealand (Cranwell & von Post 1936, Cranwell 1938).
2. In 1936 Danish seismologist Inge Lehmann used data from the 1929 Murchison (Buller) earthquake to infer that the Earth had a solid core (Kölbl-Ebert 2001).

The impact of World War 2

The outbreak of war in 1939 caused major changes in employment within New Zealand. As men were sent overseas for military service, opportunities for women opened up in what were previously thought to be

male-only occupations. Until that time no women had been employed in the Geological Survey, but a small number of women were progressively employed in clerical positions and as technical assistants and cartographers. Although there was a critical shortage of geologists and geophysicists to aid the wartime search for strategic minerals (Burton 1965, p 79–80), no women were appointed to the scientific staff during this period, presumably because there was no-one available with appropriate training or experience.

Elsewhere in DSIR, the Director-General, Dr Ernest Marsden actively recruited young male scientists with a background in physics and mathematics to work on wartime projects ranging from the development of radar to munitions manufacture. He also employed two notable women geoscientists. With a degree in mathematics, Jean Bullen worked as a secondary school teacher. Her older brother, Edward Bullen was a seismologist with an international reputation, who would have been known to Marsden. Jean was recruited to fill a vacancy in the Magnetic Observatory in Christchurch (Fig 1). During the war years she travelled widely around New Zealand, making magnetic observations to provide accurate data for navigation. She later became a foundation member of Geophysics Division.

English-born Elizabeth Caldwell (Alexander) studied at Newnham College, Cambridge under Gertrude Elles, and was a contemporary of Dorothy Hill while they both completed PhDs in geology in the early 1930s. Married to New Zealand physicist Norman Alexander, the couple moved to Singapore where Elizabeth undertook research on tropical weathering, but at the outbreak of war she was co-opted into military research on radio direction finding (radar). In late 1941 she was sent to New



Fig 1. The first two women geoscientists employed by DSIR during World War 2. Left: Jean Bullen (source, North Shore Advertiser). Right: Elizabeth Alexander (source, Mary Harris). When appointed, Elizabeth was faced with the problem of what to wear to work. She chose a military look.

Zealand to pick up urgently needed equipment, but was stranded here after the invasion of Singapore in February 1942. Because of her expertise, Marsden recruited her to run New Zealand's Radio Development Laboratory where secret work on radar was being undertaken (Fig 1). A natural leader, Elizabeth Alexander ran her unit effectively for the next four years until she was reunited with her husband and returned to Singapore in 1946 (Harris 2017, 2019). Her departure was a loss for New Zealand as she would have been a role model as a science leader.

Until the 1960s, women's salaries were less than those paid to men, based on the argument that a man would be supporting a family. For example, in 1943 Elizabeth Alexander (who had three dependent children) was initially employed on an annual salary of £350. This compares with geologist Colin Hutton, also with a Cambridge PhD (a

few years later than Elizabeth) who was on a salary of £515, but with considerably less responsibility.

Post-war pioneers, 1946-59

The Geological Survey expanded rapidly after the war under new Director Mont Ongley, with demands for coal, hydro-electric development and geothermal energy. Ongley actively recruited new staff, including a group of young British geologists, who were entirely male. Jean Luke was a pioneer who had completed an MA in geography with a thesis on land-use in the Wanganui area. Initially employed as a technician at Rotorua, she moved to Wellington so that she could take advanced geology papers at Victoria, and was then reclassified as a scientist. Jean worked on groundwater exploration, and recalled that Ongley was supportive of the few women staff, but she encountered

problems in 1952 when Ongley retired and was replaced by Grange. He vetoed a proposal for her to undertake a groundwater project for a dairy company, saying that it would be an insult to send a woman to meet the manager [Jean Luke, interview with SN, 2001]. Thereafter she was confined to the office where she worked as a scientific editor.

Three of the earliest appointments of women scientists within the Geological Survey were as paleontologists. All came from a similar background, with a BSc in biological sciences. Shona Bell (employed 1948-50) worked on fossil leaves in an attempt to aid the dating of late Cretaceous and early Cenozoic coal measures. She married geologist Tom Grant-Taylor, and resigned as was expected in those days. Heather Leed (employed 1947-53) worked on fossil corals, including the first identification of Permian corals in Northland, and also resigned when she was married. Anne Boreham (employed

1957-63) worked on Tertiary mollusca, and married micropaleontologist George Scott. An account of the 1952 Geological Survey conference in the *Weekly News* of 14 May 1952 included a paragraph on 'Women in Geology' mentioning Jean Luke, Heather Leed and Mabel Rice (DSIR science editor) [Fig 2]. The writer clearly did not place much importance on their work as the following paragraph notes "the fascinating and useful work of the band of highly-qualified men" who made up the Geological Survey [Johnston & Nathan 2017].

After the war a small number of women studied geology at university to advanced levels. Hope MacDonald (later Hope Sanderson) started at Auckland University College in 1945, completing her BSc in geology, and was encouraged by Professor Bartrum to undertake an MSc on the petrography of the Jurassic conglomerates at Kawhia. Her MSc in 1951 was the first



Fig.2: Three woman scientists at the 1952 Geological Survey Conference. From left, Mabel Rice (scientific editor, Heather Leed (paleontologist), and Jean Luke (assistant geologist). Source: *Weekly News*, 14 May 1952.



Fig. 3: Two leading women geoscientists. Left, Joan Wiffen with the humerus of a new species of elasmosaur she described, *Turangisaurus keysi* (Source, GNS Science, VML 4462). Right, Alva Challis with her microscope (Source, S. Nathan collection).

postgraduate degree in geology by a woman at a New Zealand university. She later worked as a technician in the Geology Department for several years before travelling overseas (Sanderson 2010; Black 2017). Inspired by the example of Hope MacDonald, Heather Halcrow (later Heather Nicholson) undertook a field-based MSc thesis, mapping the whole of Waiheke Island, which she later published (Halcrow 1956; Nicholson 1999).

Although a small number of women geoscience graduates were looking for work in the 1950s, none were recruited as scientists within the Geological Survey or Geophysics Division. Alva Challis [Figure 3], who had trained in the UK as a radiographer, joined the Petrology Section of the Geological Survey in 1958 as a technician. She studied part-time at Victoria University, completing a master's thesis on the geology of the Mt Lookout area in Marlborough. Harold Wellman was one of her supervisors,

whom she remembered treating her like an honorary man. But when it came time for him to visit her in the field, she was startled to find that he was accompanied by Professor Bob Clark, who had previously shown little interest in her work, but was presumably there as a chaperone (Nathan 2005, pp 167–168).

During this period and subsequent years, several women acted as unpaid research assistants to their geologist husbands. Joan Wellman regularly accompanied Harold in the field, collecting fossils, compiling maps and acting as driver and navigator (Nathan 2005). Similarly, Peg Fleming worked closely with Charles in his geological and biological activities (McEwen 2005, Fleming 2014), and Daphne Suggate worked as a field assistant with Pat (Suggate 1999). Although they contributed substantially to many projects, none were included as co-authors in published papers or reports.

Increasing opportunities in the 1960s

One of the most significant changes in the 1960s was the employment of women in teaching positions in the universities who were able to act as role models to their students. Jane Soons was appointed as a lecturer in physical geography at Canterbury University in 1960, and the following year Dawn Rodley (subsequently Dawn Beck) was appointed assistant lecturer in paleontology at Canterbury. Later appointments included Philippa Black (geology, Auckland) and Alexa Cameron and Jocelyn Campbell (geology, Canterbury).

Alva Challis was awarded a post-graduate scholarship to study at Cambridge and completed her PhD in 1963 on the petrology of ultramafic rocks from New Zealand – the first geoscience doctorate by a New Zealand woman. Using the newly developed electron microprobe she discovered and described the microscopic mineral wairauite. On return to New Zealand in 1963 she married her former lecturer, Ross Lauder. They worked at different organisations, and social conventions had changed, so she was not pressured to resign, change her name, and give up her scientific work as had happened in earlier generations. In 1965, the centenary



Fig. 4: Two of the first women geologists to undertake projects involving extensive fieldwork. Heather Nicholson (neé Halcrow) (left) mapped Waiheke Island for her MSc thesis in 1953., and Jocelyn Campbell (neé Adamson) mapped a rugged, bush-covered area near Lake Rotoiti for her MSc thesis in 1964.

Photo: Simon Nathan, taken at the 2005 Geological Society of New Zealand conference.

year of the Geological Survey, Alva Challis was the only woman scientist employed in that organisation, and this was not to change for several years.

Traditionally postgraduate research to PhD level was undertaken overseas, but from the 1950s onwards such work could be undertaken within New Zealand. Dawn Seed completed her PhD in 1964 on the mineralogy and environment of New Zealand glauconites (Canterbury), and in 1967 Philippa Black completed her PhD on the Paritutu and Cuvier plutons in Coromandel (Auckland). These research degrees were significant because they clearly demonstrated that there was no longer a shortage of well qualified women geoscientists within New Zealand.

Some aspects of geophysical analysis involve considerable routine work and calculation, and from the early 1960s onwards young women technicians were employed in Geophysics Division. Within the Seismological Observatory they undertook the work of identifying earthquakes from paper records and making preliminary estimates of epicentres for the annual New Zealand Seismological Record. Major or complex earthquakes were calculated by more experienced male seismologists after the technicians had done the background work (Chris Locke, pers. comm. 2019). Another group of primarily female technicians worked on the 1:250,000 gravity survey of New Zealand supervised by Ian Reilly who considered that young women were more conscientious and productive than young men. He involved his staff in all aspects of the project, including planning, fieldwork and data reduction as well as including them as co-authors of the published maps (Christine Whiteford, pers. comm 2019). Although this worked well, concerns were expressed by some older staff about the safety of young

women undertaking fieldwork (T. Hurst, pers comm 2019). Margaret Cowan was the sole woman geophysicist classified as a scientist during this period, preparing several papers on aspects of gravity analysis.

Although several women had been employed as paleontologists within the Geological Survey after the war as noted in the preceding section, there was a subtle change about 1960. Although there was a major expansion in the paleontology group, no women were appointed to scientific positions for over 30 years although there were women applicants. All of the approximately 15 appointments during this period were male. It is hard to escape the conclusion that those making recruitment decisions felt that women were likely to leave after a few years, so they were not seriously considered.

Revolutionary times, 1970 to 1992

The 1970s was a period of considerable change in the geosciences, with the recognition that plate tectonics provided an explanation for past and present crustal movements. Tanya Atwater, a young American geologist was a prominent advocate of plate tectonics, with her well-publicised work on sea-floor spreading and the crustal evolution of western North America, providing a powerful demonstration that a woman was involved in major scientific discoveries.

From the 1970s a small number of younger women graduates were appointed to a variety of geoscience positions: Julie Palmer was a geologist with Petrocorp, the government-owned exploration company; Sarah Beanland was appointed to the Earth Deformation group within the Geological Survey; Margot Syms and Helen Anderson were employed by Geophysics Division; and Diane Seward undertook fission track

dating at the Institute of Nuclear Sciences. Although it was becoming accepted that women could undertake scientific work, all found difficulties as they worked in isolation, and found that they were constantly under scrutiny.

Apart from Julie Palmer, it proved almost impossible for women to get employment in economic geology within New Zealand. The prohibition against women working in mines and quarries was still in force, and not effectively repealed until the 1990s. A small number of graduates, including Nola Walker from Otago, left for Australia where they were able to obtain employment in mineral exploration. The School of Mines (originally at Otago, but moved to Auckland in 1987) had traditionally been wholly male, but a few women enrolled in the late 1980s. One of these, Marianne Rogers, found that it was almost impossible to get underground practical experience – the local mine manager at Huntly where she was employed claimed that it would cause trouble with the unions if she was allowed to go underground – so she moved to Australia where she gained her Mine Manager's certificate (Priestley 1991).

Joan Wiffen was a keen amateur geologist. In December 1972 she visited Mangahouanga Stream in Hawkes Bay where fossil reptile bones had previously been noted. She was astounded that no one was working on these fossils and spent the next 35 years extracting and describing them. She found a range of fossil reptiles, including plesiosaurs and mosasaurs, and discovered the New Zealand's first dinosaur bone in 1979. She published her work in local and international journals, and became a recognised expert on Cretaceous reptiles (Martin 1993, Nathan 2018). Joan was a outlier compared to other women geoscientists mentioned in this paper as she had no university education – perhaps

an advantage as she might otherwise have been discouraged by the difficulties of vertebrate paleontology. Her achievements are remarkable because she was largely self-taught, and driven by determination to collect and describe her unique fossils.

The late 1980s were marked by a major reorganisation of government departments, with a substantial number of redundancies within DSIR, eventually leading to the formation of the Institute of Geological & Nuclear Sciences (now GNS Science) in 1992. Although there had been some progress in employing women in previous decades, the final report of DSIR Geology & Geophysics (formed by the amalgamation of the Geological Survey and Geophysics Division in 1990) in 1992 listed only 5 women scientists compared to 126 men.

Into the 21st century, 1992-2020

The 1993 New Zealand Official Yearbook, marking the centenary of women's suffrage, optimistically stated (p 292) that, "Life as a woman scientist looks more promising in 1993. The restructuring of government science over the last five years has left all scientists feeling very insecure and has removed the security of long-term employment. We believe that women can complete well in this new environment. While women tend not to be strong negotiators, employment contracts can offer increased flexibility in working arrangements. With the predicted shortage of scientists worldwide in the next decade, opportunities can only increase for women in science" (Fleming & Davenport 1993). What the statement did not mention was that the majority of redundancies in the preceding years had been of older men, thus opening some opportunities for younger women.

The period from 1993 onwards has certainly

seen a gradual increase in the number and proportion of women in geoscience. In part this has been due to gradual social acceptance as has happened in other conservative professions such as engineering and law, but an additional influence has been the provision in Section 17 of the Crown Research Institute Act (and similar legislation covering other government bodies and universities) that every annual report must include details of the impact of their equal opportunities programmes, thus putting pressure on management to demonstrate progress. For GNS Science the change can be seen in the following figures showing the increasing percentage of women scientists:

1992:	4%
2005:	17%
2019:	38%

An article compiled by the present writer in GSNZ Newsletter 129 (November 1999, pages 8-16)], under the heading "Geological Herstories", included contributions by 23 women geoscientists, and was a striking demonstration of the employment possibilities that had opened up since the 1980s.

An analysis of women academic staff in university geoscience departments in 1998 showed that while women made up just under 20%, they dominated in junior positions, and several were working part-time or on short-term contracts (Nathan 1999). For example, Daphne Lee was employed initially on short-term contracts because Otago University would not recognise permanent part-time positions. Over the succeeding 20 years the proportion of women in senior positions has slowly increased. In 2020 women make up at least 50% of almost all geoscience classes, so there will be no shortage of qualified women geoscientists in the future.

The McKay Hammer, the major award by the Geoscience Society of New Zealand

for research excellence, had always been awarded to male geoscientists until 2014. The winners for the next four years were all women (Julie Rowland 2015, Helen Bostock 2016, Daphne Lee 2017, and Laura Wallace 2018).

Although women gradually made progress within geoscience, it was as individual scientists rather than in senior administrative or management roles. Before the 1990s there was a reluctance from senior management for women to be in charge of men, but this gradually changed so that the following landmark appointments can be noted:

- In the 1990s Philippa Black and Jane Soons were both appointed administrative head of their respective departments;
- Julie Palmer was the first woman president of the Geological Society of New Zealand in 2002-03
- Helen Anderson was Chief Executive of the Ministry for Research, Science & Technology from 2003-10, and has subsequently held senior governance roles in a number of organisations;
- Nicola Crawford has been Chair of the Board of Directors of GNS Science since 2015.

Women in Antarctic geoscience

Although New Zealand has played an important role in exploring the geology of the Ross Sea and Transantarctic Mountains, this was traditionally a male-only area. During the International Geophysical Year (1957-58) there was a period of concentrated geophysical work at Scott Base. Jean Bullen spent considerable time preparing instrumentation for upper atmosphere observations, but to her great disappointment she was not able to visit Scott Base and make any observations herself. Her role

was restricted to preparing the instruments, training the male observers how to use the equipment, and later interpreting the results.

Despite the restriction on women working in Antarctica, Dawn Rodley was selected for a Victoria University geological party in 1958, but the US Navy (which provided transport to and from Antarctica) refused to accept her. This prohibition continued until 1969 when they agreed to allow an all-woman party from Ohio State University's Institute of Polar Studies to work in the Dry Valleys. This party included Eileen McSaveney, who subsequently settled in New Zealand (McSaveney 2020). A Victoria University party the following year included Rosemary Askin, a paleontologist who later returned to Antarctica several times.

Margaret Bradshaw first visited Antarctica in 1975 to collect rocks and fossils for the new Antarctic Hall at Canterbury Museum. She subsequently organised nine return trips to Antarctica, collecting fossils from the Devonian Period from different areas.

Despite initial reluctance to allow women to visit Antarctica, they are now routinely included in field parties and research programmes.

Conclusions

Before World War 2 there were no women employed in the geosciences in New Zealand. Changes in social attitudes during and after the war meant that women were able to enter a wider range of professions, but it took several decades before there were many women with Tertiary qualifications in geology, geophysics and physical geography. By 1990 there were a small number of women employed in most areas of geoscience, but they often worked in isolation, with little or no management responsibility.

In the first two decades of the 21st century there has been a steady increase in the number of women employed in geoscience, and a few have achieved positions with significant responsibility. Apart from changing social attitudes, a major factor in the increasing employment of women is the requirement that public sector organisations report regularly on the effectiveness of their equal opportunity plans, encouraging managers to take this more seriously.

As the proportion of women students in most university geoscience courses is now at or above 50%, it is likely that the proportion of women employed in geoscience will continue to increase.

APPENDIX: Biographical notes on pioneering women geoscientists in New Zealand

The following list contains biographical data on fifteen women who were pioneers in different aspects of New Zealand geoscience in the twentieth century. It has been arranged in chronological order. There is remarkably little written information about women geoscientists. Although the five volumes of the Dictionary of New Zealand Biography, published between 1990 and 2000, contain entries on 40 male geoscientists, it includes no women; an online entry about Joan Wiffen was added in 2018. It is hoped that this compilation may lead to further documentation of New Zealand's women geoscientists.

Jean Bullen (1918-2002)

Having completed a BA in mathematics and philosophy, Jean trained and worked as a teacher. Her career changed dramatically in 1942 when she was recruited for wartime service in the DSIR Magnetic Survey. She travelled widely around New Zealand making magnetic observations to provide accurate magnetic declination data for a new series of topographic maps then being produced.

After the war she was transferred to Western Samoa for two years as assistant director of the Geophysical Observatory in Apia. When she returned to New Zealand she joined the Christchurch Geophysical Observatory, specialising in upper atmosphere research. She was highly involved in planning and interpretation of data collected during the International Geophysical Year (1957-58), and published several papers. She retired early in 1968 to look after her elderly parents. After their deaths she returned to teaching in the late 1970s.

Source: North Shore Times Advertiser, 22 January 2002, p 5.

Elizabeth Alexander, neé Caldwell (1908-58)

After spending her early years in India, Elizabeth was sent to the UK as a 'colonial orphan' for her education. She obtained entrance to Newnham College, Cambridge where she intended to study natural sciences but later changed to geology, in which she was one of the earliest women to complete a PhD. At Cambridge she met and married New Zealand physicist Norman Alexander, and in 1935 they moved to Singapore. Elizabeth's early research was on local geology and tropical weathering, but at the outbreak of war in Europe she began work for the Royal Navy at Singapore naval base on radio direction finding, the term used as a cover for the new technology of radar. In January 1940 she was ordered to take her three children to the safety of New Zealand and return with urgently-needed equipment, but was stranded here after the fall of Singapore in February. Because of her expertise, Marsden recruited her to set up a new Operational Research Section in New Zealand's Radio Development Laboratory where secret work on radar was being undertaken – the first woman scientist in a management position in New Zealand. She returned to Singapore with her husband in 1946, and they subsequently

moved to Nigeria where she died in 1958. Her research on tropical weathering was published posthumously.

Source: Harris (2017 & 2019).

Jean Luke (1921-2016)

Jean studied at Canterbury University College, and was one of the first women to complete an MA in geography (with a thesis on land-use around her home town of Wanganui). She obtained a job as a technician at the Rotorua office of the Geological Survey in 1946, assisting in fieldwork and measuring temperatures in boreholes. She transferred to Wellington so that she could take advanced university papers in geology, and was subsequently reclassified as a scientist. Initially she worked on groundwater investigations but, to her regret, was moved to scientific editing where she was responsible for the production of many NZ Geological Survey monographs in the 1950s and 1960s. In 1969 she was seconded to the Geological Survey of Iran where she worked as a scientific editor for a decade until she retired and returned to New Zealand.

Source: Interview with SN, 2001.

Joan Wiffen, neé Pedersen (1922-2009)

Joan spent her childhood in rural parts of the King Country and Hawkes Bay. Her education was partly by correspondence and partly at local primary schools, finishing when she was aged 12. During World War 2 she joined the Woman's Auxiliary Air Force, where her abilities were quickly recognised, and she was trained and worked as a radar plotter. In 1953 she married Pont Wiffen, and worked on their small landholding. In the 1960s the Wiffens became keen amateur geologists. Joan heard of a remote locality in inland Hawkes Bay where reptile bones had been discovered. In December 1972 they visited Mangahouanga Stream and saw the fossils. Joan was astounded that this locality was almost unknown, and extracting and

working on the fossils was to be the focus of her life for the next 35 years. By patient and painstaking work she extracted plesiosaur and mosasaur fossils, taught herself the fundamentals of vertebrate paleontology, and described the fossils with the aid of overseas experts. In 1979 she found the first dinosaur bone from New Zealand, and subsequently found fragments of other dinosaurs. From the 1980s onwards she was recognised as the expert on New Zealand's Cretaceous reptiles. She was awarded an honorary doctorate by Massey University in 1994 and a CBE in 1995.

Sources: Wiffen (1991), Martin (1993), Nathan (2018).

Hope Sanderson, néé MacDonald (1925-2016)

Hope was raised on a farm near Colville, at the tip of the Coromandel Peninsula. Studying for a BSc at Auckland, she decided to major in geology. She enrolled for an MSc, and for her thesis undertook a petrographic study of the Jurassic conglomerates at Kawhia – the first woman to undertake geological postgraduate study in New Zealand. She subsequently worked as a technician for almost five years in the Geology Department, and prepared her thesis for publication (MacDonald 1954). After travelling to the UK, she was offered a position undertaking petrographic work with the British Geological Survey. In 1964 she married Robin Sanderson, a fellow petrologist, and was forced to resign her position as was customary in those days.

Sources: Sanderson (2010), Black (2017)

Alva Challis (1930-2010)

Born in Wales, Alva studied radiography before emigrating to New Zealand with her family in 1952. Initially she worked as a radiographer in different hospitals before joining DSIR as a technician. Studying part-time at Victoria University, she

completed a BA in geology and Russian before undertaking a masters thesis on the geology of the Mt Lookout area in Nelson. By this time she was working as a petrologist with the Geological Survey, and she was subsequently awarded a DSIR scholarship to undertake a PhD at Cambridge. She studied New Zealand ultramafic rocks, and discovered the new mineral Wairauite using the electron microprobe. On return to New Zealand she married her former lecturer, Ross Lauder, and they often worked together in the field, especially in the Longwood Range in Southland and the area around Lake Rotoroa in the Nelson Lakes district. With her background in radiography, she experimented with the use of X-rays in the analysis of rocks and minerals. Over the years she worked on a variety of petrological problems, including identification of unknown minerals, identification of drillhole cores, and possible contamination of samples collected by prospectors. She retired to live at Motueka in 1995.

Sources: Smale (1995), Watters (2011)

Jane Soons

Born in England, Jane won scholarships to her local grammar school and later to the University of Sheffield. In 1958 she was the first woman PhD graduate in geography at the University of Glasgow, and in 1960 was appointed lecturer in geography at the University of Canterbury – the only woman member of staff in her department for many years. Her research and that of her students focussed on the glacier-sculpted landscapes of the South Island and changing climates during the Quaternary period. In 1971 she became the first woman professor at the University of Canterbury, and was head of department from 1990 until her retirement in 1993. She served as president of the International Union of Quaternary Research, and was awarded an honorary DSc by the University of Glasgow in 2009.

Sources: Wikipedia, Hanson (2009)

Heather Nicholson, nee Halcrow (1931-2019)
 Studying physical geography at school led Heather to enrol at Auckland University in 1949, graduating with a BSc in geology. She embarked on an MSc thesis on the geology of Waiheke Island, working alone and staying at local farmhouses. Although she was the first woman in New Zealand to undertake a major geological mapping project, she never felt that this was difficult or unusual. No jobs in geology were available when she graduated, so she took up a teaching career, eventually becoming head of science at Westlake Girls High School. In the 1970s she moved into craft work, writing the award-winning book, "The Loving Stitch: a history of knitting and spinning in New Zealand". She decided to revive her scientific career, undertaking a PhD on the history of greywacke rocks in New Zealand, and graduated in 2003, exactly 50 years after completing her MSc degree.

Sources: Nicholson (1999), Obituary in Dominion Post 30/7/2019

Philippa Black

After attending New Plymouth Girls' High School, Philippa enrolled at Auckland University, graduating MSc in 1964 with a thesis on the igneous and metamorphic rocks of Tokatoka in Northland. Subsequently she completed her PhD on the petrology of the Cuvier and Paritutu plutons in northern Coromandel. A post-doctoral fellowship from the NZ Federation of University Women allowed her to study in the US, and she was then appointed lecturer in geology at Auckland University. Her research in later years covered petrological aspects of rocks in Northland and New Caledonia as well as microscopic studies of New Zealand coals. In 1986 she was appointed professor, and was head of the Geology department for 15 years. After being elected a Fellow of the Royal Society of New Zealand, she became

president of the society from 1993-97, the first woman to hold that position, and was awarded a CZNM for her services to science. Since retiring she has completed a PhD in history on the nickel mining industry in New Caledonia (Black 2015) and studied the properties of engineering aggregates. In 2013 she was elected Companion to the Institution of Professional Engineers (IPENZ).

Margaret Bradshaw

Despite discouragement from teachers, Margaret was keen to study geology, and was the first woman to be accepted in geology at Queen Mary College, University of London. She moved to New Zealand with her husband in 1976. Appointed curator of geology at Canterbury museum (and later deputy director), she initially worked on Devonian strata in the South Island. She first visited Antarctica in 1975 to collect rocks and fossils for the museum's Antarctic display, and has returned nine times, studying Devonian fossils and sedimentation. From 1999 she became a Senior Research Fellow in Geological Sciences at the University of Canterbury. She was awarded a DSc from the University of London for her published work. She served as president of the New Zealand Antarctic Society for ten years and was awarded a Polar Medal by the New Zealand government. She has also lectured on 11 Antarctic tour cruises.

Diane Seward

Diane studied for a BSc at the University of Wales and an MSc at McMaster University in Canada before moving to New Zealand with her husband. She completed a PhD at Victoria University in 1974 on tephras in the Wanganui basin, undertaking some of the earliest fission track dating in New Zealand. Subsequently she was employed at the Institute of Nuclear Sciences, DSIR, where she expanded her work on fission

track dating to cover uplift of older rocks. After moving to ETH, Zurich, she worked on a number of projects involved with analysing tectonic uplift in China, the Himalayas and the European Alps, and has continued this work since returning to Victoria University.

Eileen McSaveney

At the State University of New York at Buffalo, Eileen was the sole woman in her undergraduate geology class. She subsequently studied at Ohio State University, completing a PhD on glaciofluvial gravels in Ohio. In 1969 she was invited to join an all-woman party in the dry valleys of Antarctica as a field assistant to the first group of women geoscientists to work in Antarctica. She returned in the 1971-72 summer to assist with fieldwork on Meserve Glacier in the Wright Valley [McSaveney 2020]. Married to a New Zealand geologist, she moved to Christchurch with her husband, and taught evening classes on a variety of geoscience topics. Subsequently she worked as a freelance science writer, and was associate editor of the New Zealand Journal of Hydrology for many years. She has written several articles relating to geology and natural hazards for Te Ara, the online Encyclopedia of New Zealand.

Daphne Lee

Daphne was raised on a farm in Southland and studied geology at Otago University where she completed a PhD on fossil and living brachiopods. She was the first woman to be appointed to the academic staff of the Geology Department, University of Otago, and later appointed Associate Professor. She has supervised many post-graduate research students, and in recent years she has led a research group on the very rich fossil faunas and floras of maar deposits in Otago. She was awarded the McKay Hammer by the Geoscience Society of New Zealand in 2017 for her research. The recent campaign

to save Foulden Maar is underpinned by the research done by Daphne and her group. She has had a long involvement with the Geological Society of New Zealand, both as secretary and convenor of its Geological Education special interest group.

Helen Anderson

After studying geophysics at Otago and Auckland Universities, Helen joined Geophysics Division, DSIR. She specialised in the seismology of large earthquakes, and completed a PhD at Cambridge University in 1985 on the seismotectonics of the western Mediterranean. From 1997-2003 she was Chief Science Advisor at the Ministry for Research, Science & Technology (MoRST), and from 2004-10 was Chief Executive of that organisation. She was awarded a QSO in 2010 for her services to science. Since then she has worked as an independent director, serving on the boards of Scion, Building Research Association (BRANZ), Antarctica New Zealand, NIWA, Fulbright New Zealand, and Dairy New Zealand. She was also Pro-Chancellor of Massey University, and is a Fellow of the Institute of Directors and a Companion of the Royal Society of New Zealand.

Julie Palmer

After graduating MSc from Victoria University, Julie was appointed as an exploration geologist to Petrocorp (later Fletcher Petroleum) where she became Regional Manager for SE Asia from 1989-92. After a period as an independent consultant, she was appointed lecturer in earth science at Massey University in 1994, and has remained there to the present day. Her research covers stratigraphy and sedimentology of the Wanganui and Taranaki basins. Julie has had a long involvement with the Geological Society of New Zealand, progressively as secretary, treasurer and the first woman president from 2002-03. ■

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