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Introduction

So far, I have introduced active female researchers in this column. I have met most of them as colleagues at conferences or through collaboration. It thus has been quite easy to recruit them, but I do not always succeed. I have also lately been contacted by people who had read the column and recommended other interesting scientists in our field. Radio science has been very male dominated from the beginning, and there have not been many active women in the early 1900s who are still remembered, but there exist several very interesting lives' work.

Wars have, in their brutal way, been promoters of new technology. Radars showed their important role during World War II at many frontiers. Since the men were at war, technically capable women had to take over some traditionally male tasks at the home frontiers. Some of them showed extremely good capacity, such as Joan Clarke and many others as code-breakers at Bletchley Park.

In this column, we now present another remarkable female scientist, Dr. Elizabeth Alexander. In a short time, she made important contributions in both her major subject of geology, in Singapore, and in radars as scientific instruments, while employed as Head of Operations Research at the Radio Development Laboratory in New Zealand, during the war. This article was written by Elizabeth Alexander's daughter, Mary Harris, based on her biography [1] of her mother.

Elizabeth Alexander: An Extraordinary Scientist

Mary Harris

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Elizabeth Alexander (Figure 1) was an extraordinary scientist. She changed thinking in two separate sciences, and then disappeared from history. It happened because of the second world war in the Far East.

Elizabeth Caldwell had left Cambridge University in 1935 with a PhD in geology, but remained a good physicist from her first degree there in natural sciences. In 1936, she moved to Singapore, where her husband, Norman Alexander, a New Zealander whom she had met at Cambridge, took up the post of Professor of Physics at Raffles College. In Singapore, Elizabeth had no formal status because she was only a professor's wife, but she began her own research into the geology of the island. She became interested in some of the processes and products of the weathering of rocks under tropical conditions. It seemed as if products of weathering were not just washed away, but were reforming as fresh, hard rock, rather quickly. She set up an experiment, burying particular pieces of rock in mangrove swamp and keeping controls in the laboratory she had made in her own home.

Figure 1. Elizabeth Alexander.

At the same time, and for their own amusement, the Alexanders made themselves a terrestrial globe about 1.2 meters in diameter. They had almost finished it when Elizabeth happened to meet an old school friend while shopping in Singapore. The friend had married a Royal Navy officer in the Hydrographic Service at Singapore Naval Base. There the Admiralty, the governing body of the Royal Navy, was setting up a network of radio-direction-finding stations covering the Indian and Pacific Oceans, and centered on Singapore. The Navy was using traditional Mercator charts for plotting bearings within this network, but it turned out to be quicker to take direct readings from the Alexanders' globe, and just as accurate. The Navy therefore requisitioned the globe, and employed Elizabeth to work on the statistics of bearings that did not meet at a single point. However, the work developed quickly, and she soon became more involved in more technical aspects of radio direction finding (RDF) itself. At that time, the new technologies of radar were also called RDF, for the sake of secrecy.

In 1940, when WWII had started in Europe but not yet in the Far East, Elizabeth went on leave to New Zealand with Norman and their two children. There, she found that New Zealand was well ahead in the development of radar for both home use and Pacific Ocean defenses. Much of the work was in the hands of physicists who had been students at Lord Rutherford's Cavendish Laboratory at Cambridge, at the same time as she and her future husband. There had also long been close links in the intelligence services between Singapore and New Zealand, and the New Zealand Navy itself was still a squadron of the Royal Navy.

On her return to Singapore in 1940, Elizabeth became more heavily involved in RDF at the Singapore Naval Base. In December 1941, the Imperial Japanese Army attacked Pearl Harbor, Hong Kong, the Philippines, Thailand, Malaya, and Singapore, and began its swift progress down the Malay Peninsula towards Singapore. In January 1942, Elizabeth was ordered by the Royal Navy to evacuate her now three children to her husband's family in New Zealand, and return to the Singapore Naval Base with specialist equipment being made in Australia. However, Singapore surrendered soon after she arrived in New Zealand, and she was stranded with her small children, with no news of Norman and no income. Her work in Singapore was known both to New Zealand's intelligence services and radar physicists, and she was invited to set up – from scratch – and run the Operations Research Section of New Zealand's secret radar research unit at its Radio Development Laboratory, the cover name for radar. During her nearly four year's work there and almost in passing, Elizabeth made the interpretation that an anomalous "radar" signal, picked up by a Royal New Zealand Air Force station on Norfolk Island, was in fact coming from the sun. This became the beginning of radio astronomy in Australia, for New Zealand itself did not continue with the research. At the time, Norfolk Island, though nominally Australian, was within New Zealand's wartime region of control, under boundaries set by the USA.

In 1948, reunited with Norman – and with her children left in the care of her sister in England so that they could go to school there – Elizabeth returned to Singapore to help in its recovery from enemy occupation. At first she worked as temporary Registrar, as Raffles College became the University of Malaya in processes held up by the war, and gave personal support to students traumatized by the occupation. In 1949, and then working as geologist again, she was appointed by the Singapore Government to survey the whole island for sources of granite for reconstruction. In this work, which included the first reasonably accurate geological map of the island (still in use), she was able to pick up on her own pre-war research in tropical weathering, and to develop her second contribution to changing thinking in the sciences. Although her own geological laboratory had been stripped bare at the end of the occupation of Singapore, it was possible to retrieve some of her buried samples, and to develop her theory that fresh rock was growing from the products of weathered rocks at previously unrecognized speed. However, her work was again interrupted by Norman's appointment to the professorship of physics at University College Ibadan, Nigeria, where at last he was able to do some research of his own, during the International Geophysical year of 1958. Elizabeth continued to work as "the only geologist on the island of Singapore," but by airmail from Nigeria. In this way, she was able to give advice on tropical soils, on preventing the quarrying out of what later became Singapore's Bukit Timah Nature Reserve, and on work she had started herself in Singapore on improving its water supplies. However, in December 1958, just before her 50th birthday, and worn out with the stresses of the war, she suffered a cerebral hemorrhage and died. Her work on tropical weathering was published

posthumously, and her secret work on South Pacific radars simply faded from history.

During Elizabeth's time in New Zealand, she kept a personal diary, written as an extended letter to Norman in internment in Singapore, so that he would know about the life of his family when they met again. I am one of their daughters. Elizabeth's diary came into my possession in the 1990s, at about the time that the New Zealand government declassified its own Radar Narrative, written from reports made during the war. Between them, these two previously unpublished documents fill a gap in New Zealand's own highly significant history of radar developments in the South Pacific. It was obvious to me that I must write Elizabeth's biography [1].

For a full biography of such a scientist, much research was necessary so that her contributions could be placed in several contexts at the same time. Firstly, it was necessary to record enough of the history of the two separate sciences to reveal the significance of the changes to thinking that she made. War is a great motivator for science, and Elizabeth's life covered the effects of the first world war, the politically charged period following it, and the urgencies of the second world war. It was therefore necessary to weave the political and military contexts through those of the sciences. However, there is a third issue in writing about the fall of Singapore to Japan in 1942, because the literature is still dominated by what Prof. Mary Beard aptly called "Big Books By Blokes about Battles." There is no need for feminist aggression in challenging this dominance. My main aim in writing this biography was not only to reveal the contributions to science of a particular woman scientist, but to redress the lack of balance as I went along by putting back into the literatures from which they should never have been excluded many other women scientists. At the same time, it was necessary to ensure that the work was properly academic so I have justified all I have written by references. However, it is never necessary for academic writing to be turgid, so my greatest aim was to make the book comfortably readable, too.

Reference

1. M. Harris, *Rocks, Radio and Radar: The Extraordinary Scientific, Social and Military Life of Elizabeth Alexander*, Singapore, World Scientific, ISBN 978-1-78634-664.