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Ernest Marsden's Nuclear New Zealand: from Nuclear Reactors to Nuclear Disarmament

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Abstract: Ernest Marsden was secretary of New Zealand's Department of Scientific and Industrial Research from 1926 to 1947 and the Department's scientific adviser in London from 1947 to 1954. Inspired by his early career in nuclear physics, Marsden had a post-war vision for a nuclear New Zealand, where scientists would create radioisotopes and conduct research on a local nuclear reactor, and industry would provide heavy water and uranium for use in the British nuclear energy and weapons programmes, with all these ventures powered by energy from nuclear power stations. During his retirement, however, Marsden conducted research into environmental radioactivity and the impact of radioactive bomb fallout and began to oppose the continued development and testing of nuclear weapons. It is ironic, given his early enthusiasm for all aspects of nuclear development, that through his later work and influence Marsden may have actually contributed to what we now call a 'nuclear-free' New Zealand.

Keywords: Ernest Marsden, heavy water, nuclear, New Zealand

INTRODUCTION

In the 1990s, Ross Galbreath established Ernest Marsden as having been the driving force behind the involvement of New Zealand scientists on the Manhattan and Montreal projects, the creation of a nuclear sciences team at the Department of Scientific and Industrial Research (DSIR), and the subsequent plans for a nuclear reactor in New Zealand [1]. In an article about New Zealand's involvement in the British hydrogen bomb tests of 1957–58, defence historian John Crawford identified Marsden as advising Prime Minister Sidney Holland against allowing the United Kingdom to test hydrogen bombs on New Zealand territory. Crawford also covered the joint United Kingdom-New Zealand plans for the establishment of a heavy water plant to provide raw materials for the British nuclear energy and nuclear weapons programmes, but it was outside the scope of his article to cover Marsden's initiation and encouragement of the heavy water project [2].

This article focuses on Ernest Marsden as the brains behind New Zealand's nuclear schemes in the 1940s and 1950s, adds the context of his early work in the radiation and nuclear sciences, and examines how his attitude to nuclear weapons development – which he was happy to support in the 1940s and 1950s – changed in his later years. By necessity this article includes some material already covered by Galbreath and Crawford but it also covers new ground. The principal sources for this article are the records of the DSIR, External Affairs Department, and New Zealand Atomic Energy Committee held at Archives New Zealand in Wellington, and Ernest Marsden's personal papers held at the Alexander Turnbull Library in Wellington. Biographical pieces in the history of science in some cases overlook the institutional and wider social context of science. In the case of the present study, however, which concerns both the very small country of New Zealand and a field as focussed as nuclear science, the very reverse is true. In this case, one person significantly shaped both the institutional setting and the wider social environment for his science and we learn much about the context precisely by examining his influence. Ernest Marsden's wide experience, outspokenness and apparent capriciousness towards nuclear weapons development makes him an interesting study, providing some insight into the changing attitudes to nuclear development in the nation of New Zealand as a whole.

ERNEST MARSDEN AND THE NEW PHYSICS

Ernest Marsden was well known in early twentieth-century scientific circles as a result of his hands-on involvement in the birth of nuclear physics. In 1909, Marsden was a 20-year-old undergraduate student at Manchester University, under Ernest Rutherford. Marsden had been assisting Hans Geiger with experiments in which a beam of alpha particles was scattered after passing through a thin metal foil, and in response to Geiger's advice that Marsden was now ready for a research project of his own, Rutherford asked Marsden to see if he could get evidence of alpha particles directly reflected from a metal surface. In a now famous experiment, Marsden observed that instead of passing through, a tiny fraction of alpha particles were deflected straight back from a thin gold foil. Rutherford later described this result as being 'almost as incredible as if you fired a fifteen-inch shell at a piece of tissue paper and it came back and hit you'. After pondering this result for two years, Rutherford came up with a new theory for the structure of the atom. He proposed an atom with a centralised concentration of mass and positive charge – which he called the nucleus – surrounded by empty space and a sea of orbiting negatively-charged electrons [3].

In 1915, on Rutherford's recommendation, Marsden came to New Zealand to replace Thomas Laby as Professor of Physics at Victoria University College in Wellington. In 1922 Marsden turned from research to bureaucracy. He first became Assistant Director of Education, and in 1926 was appointed Secretary of New Zealand's new Department of Scientific and Industrial Research, the DSIR. The people who worked with Marsden at the DSIR described his 'infectious enthusiasm' and 'irrepressible optimism' [4]. As one DSIR staff member said about Marsden and his deputy Frank Callaghan, 'Dr Marsden spends his time giving the moon away and Mr Callaghan spends his time getting it back' [5].

Fig 1. Ernest Marsden, secretary of New Zealand's Department of Scientific and Industrial Research from 1926 to 1947. Photo: Sir C. Fleming Collection, Reference number F-18564-1/4, Alexander Turnbull Library, Wellington, New Zealand.

Marsden used his characteristic enthusiasm, along with his lifelong interest in radiation and nuclear sciences, to initiate a number of projects that kept New Zealand in touch with international developments in the field. In the late 1930s, with a young scientist called Charles Watson-Munro, he conducted a survey of radioactivity in New Zealand soils in an (unsuccessful) attempt to establish a connection between radioactivity and the regional incidence of goitre [6]. He also established a cosmic-ray meter at the DSIR's Magnetic Observatory in Christchurch [7].

In 1939 Marsden pioneered the non-medical use of radioisotopes in New Zealand. An animal wasting disease known as 'bush sickness' had been found to be linked to a deficiency in cobalt. Using a small quantity of radioactive cobalt prepared in Ernest Lawrence's cyclotron at the University of California Marsden worked with Watson-Munro on a series of experiments to determine the role of cobalt in animal metabolism [8].

THE SECOND WORLD WAR AND NEW ZEALAND'S CONTRIBUTIONS TO THE MANHATTAN AND MONTREAL PROJECTS

With the outbreak of the Second World War Marsden was given the title of Director of Scientific Developments, in which role he was charged with mobilizing New Zealand's scientific manpower. Marsden made several wartime trips to the United Kingdom, mostly to advance a secret programme to develop radar in New Zealand. While radar development was initially the Allies' top priority, the United Kingdom and United States soon began attempts to develop an atomic bomb [9]. In December 1943, Marsden was travelling through the United States on his way to the United Kingdom where, in Washington DC, he chanced upon James Chadwick (scientific director of the British nuclear research project), Mark Oliphant (an Australian physicist working on the British nuclear programme) and Danish physicist Niels Bohr, who had been smuggled out of Denmark and was travelling under an assumed name. Following the August 1943 signing of the Quebec Agreement, Chadwick and Oliphant – like Marsden, they had both worked with Rutherford – were in Washington with the top secret task of arranging details of scientific cooperation between the United Kingdom and United States' nuclear research programmes. Oliphant later recalled they were in their hotel lobby waiting for the elevator when they felt taps on their shoulders and turned to find Marsden in full military uniform. They were taken aback to hear Marsden say, 'I can guess why two nuclear physicists are here!' During the elevator journey Marsden put in a good word for New Zealand's participation in the bomb project. He followed this up in London with Sir John Anderson, Chancellor of the Exchequer. Many of the Commonwealth scientists working on the British nuclear research programme had, like Marsden, been students or colleagues of Ernest Rutherford and Marsden was able to successfully trade on his reputation of being involved in the birth of nuclear physics [10].

Following the necessary protocol, the British Government asked New Zealand Prime Minister Peter Fraser for five New Zealand men to join the British nuclear research team [11]. Robin Williams, a young DSIR physicist, recalled reporting to Wellington in July 1944 to find Ernest Marsden 'cock-a-hoop about the fact that he had managed to get a number of New Zealanders in on the atom bomb project' [12]. Robin Williams was joined by Bill Young, George Page and Charles Watson-Munro. Their terms of employment seconded them to the UK DSIR for 'a period of one year or for the duration of the war, whichever is the longer'. Marsden was very keen for New Zealand to launch an atomic research programme when the war finished and following the secondment the men were required to return to New Zealand for at least one year [13]. In late July 1944 Williams and Page arrived in San Francisco to work with Ernest Lawrence and Mark Oliphant on the electromagnetic separation of uranium. Two other New Zealanders were already working at Berkeley, having arrived from the United Kingdom with the British team [14].

In Canada, a team of mostly English and Canadian scientists, led by another Rutherford old-boy, John Cockcroft, had begun a project to develop a heavy-water nuclear reactor. Watson-Munro and Young travelled to Montreal from New Zealand and Ken George reported directly to Montreal from his post as the DSIR's scientific liaison officer in Washington. As part of the Canadian team, they began work on building a low energy atomic pile, using natural uranium fuel and heavy water as a moderator [15]. Marsden, as a scientist turned administrator, was tremendously excited about these new applica-

tions of nuclear physics and felt stymied and frustrated in his administrative and managerial role. He wrote regularly to the American-based scientists, asking, sometimes inappropriately, for details of their research. In response to Cockcroft's request for three more New Zealand men, Marsden offered himself, 'in any direction of work, for any period of time' [16]. His offer was ignored and three more young New Zealand scientists were sent to join the Montreal team. The New Zealanders in Montreal, led by Watson-Munro, played a major role in the construction of the Zero Energy Experimental Pile, or ZEEP, the first nuclear reactor built outside the United States, which was completed in September 1945 [17].

WARTIME URANIUM SURVEY

Unable to participate in the North American nuclear research programme, Marsden directed his enthusiasm to a search for uranium in New Zealand. The United Kingdom had initiated a Commonwealth search for uranium in 1942, but had excluded New Zealand, whose geology was not considered promising [18]. In December 1943, while on his fruitful trip through the United States, Marsden had taken matters into his own hands, writing to the Director of New Zealand's Geological Survey to ask him to initiate a search for radioactive minerals in the South Island [19]. The New Zealand War Cabinet approved funding for the uranium survey in July 1944 and a team of DSIR physicists assembled at the Dominion Physical Laboratory in Wellington to start work on the uranium project [20]. In October 1944, a mining engineer and a physicist, carrying a Geiger counter to measure radioactivity, began secretly exploring beach sands along the West Coast of the South Island, from Karamea to the Moeraki River. Surveys of Stewart Island beach and river sands, and of beach sands and dredge tailings at Gillespies Beach, followed [21]. In March 1945, the DSIR chartered the Government ship *New Golden Hind*, and the secret uranium survey was extended. The ship sailed down the South Island's east coast and around Bluff to investigate the eight sounds from Milford Sound to Nancy Sound, but failed to find any promising sources of radioactive minerals [22].

In August 1945 the Manhattan Project culminated in the dropping of atomic bombs on Hiroshima and Nagasaki in Japan. In recognition of the military and economic importance of uranium, the New Zealand Atomic Energy Act was passed on 7 December 1945 to give the State full ownership and control over uranium and other radioactive elements, with the Minister of Mines having power to control the mining and disposal of uranium-bearing rock and its products [23]. In January 1946 Marsden organised a second *New Golden Hind* expedition – this one not secret – to complete the initial survey with a search of the rocks, beaches and gravels in the Southern Sounds from Preservation Inlet up to Thompson Sound. As the only result of the two-year survey, uranium-bearing minerals were found in gold dredge tailings on the West Coast, but their quantity and concentration was deemed too small to permit their economic recovery [24].

A NUCLEAR NEW ZEALAND

After the war, Marsden started to enact his vision for a nuclear New Zealand. If he couldn't be part of the big science taking place in Europe and America he would make it happen at home. In January 1946 Marsden gained Cabinet approval to establish a new team of 10 scientists at the Dominion Physical Laboratory. Their mission was to carry out fundamental and applied atomic research and advise on atomic energy and the application of isotope techniques to problems in agriculture, health and industry. The same Cabinet decision allowed for the secondment of physicists, chemists or engineers to nuclear organisations in the United Kingdom and Canada to ensure New Zealand kept up to date with new developments and techniques. An annual budget of £19,000 was allocated to implement these proposals [25].

In 1946 Watson-Munro and three of the other New Zealanders left Canada for the newly established United Kingdom Atomic Energy Research Establishment in Harwell, while another three of the New Zealand team re-

mained in Canada. In the United Kingdom, Watson-Munro took charge of the construction of a Graphite Low Energy Experiment Pile, or GLEEP, the first nuclear reactor in the United Kingdom, which was completed in August 1947 [26]. Before returning to New Zealand, Watson-Munro, in consultation with Marsden, submitted a report to the New Zealand Government on the construction of a low energy atomic pile in New Zealand. The pile was recommended on two grounds: for the production of radioisotopes for industrial and agricultural research; and to serve as the nucleus of an atomic research project [27]. Marsden also believed the pile would provide a 'long term contribution to Commonwealth defence' [28]. In August 1947, based on Marsden and Watson-Munro's report, New Zealand's newly-established Atomic Energy Research Committee recommended the construction of an Australasian low energy pile in New Zealand [29].

In September 1947 Marsden left his position as secretary of the DSIR to become the DSIR's Scientific Adviser in London. When Marsden arrived in London, he and Watson-Munro met Lord Portal, head of the Atomic Energy (Review of Production) Committee, to talk about the Commonwealth atomic pile. They discussed the advantages of a small atomic pile in New Zealand for research purposes, to be followed up by a large power production pile in Australia, 'capable of producing fissile materials suitable for the manufacture of atomic bombs' [30]. On receiving sympathetic responses to the proposal from both Lord Portal and John Cockcroft, who was now director of the Atomic Energy Research Establishment at Harwell, Marsden was tremendously excited. He admitted he had initially thought the reactor proposal was an 'ambitious dream', but was now convinced it would be 'a statesmanlike step to take at higher levels with enormous repercussions for the good of our country' [31]. In late 1947, in response to a ministerial request, Marsden and Watson-Munro provided an advisory report, which was agreed to by John Cockcroft, on the construction and use of an atomic pile in New Zealand. The report recommended a graphite uranium pile costing £100,000 to construct and up to £35,000 a year to run. The project would use the skills of the New Zealand scientists who had worked on the North American nuclear programmes and would take one-to-two years to build [32]. The Minister of Scientific and Industrial Research, however, was critical of the report, questioning the need for a New Zealand pile on the basis that radioisotopes were available from overseas and New Zealand scientists would be best trained in more sophisticated offshore facilities [33]. Henry Tizard, scientific advisor to the British Ministry of Defence also gave the proposal a lukewarm reception, telling Marsden the defence arguments in favour of the pile were weak [34]. Peter Fraser, the New Zealand Prime Minister, sought the opinion of the British Prime Minister on the value of the project [35]. Clement Atlee replied favourably, saying the project would be of advantage to the Commonwealth and offering the assistance of the United Kingdom Government [36].

Marsden continued to advocate for construction of an atomic pile in New Zealand [37]. But with him being away from New Zealand, and – despite Atlee's offer of assistance – with limited government support for an atomic pile, many of the DSIR's original nuclear sciences team moved into other areas of research. Two of the New Zealand scientists who had worked on ZEEP and GLEEP, Charles Watson-Munro and George Page, eventually moved to the Australian Atomic Energy Commission Research Establishment, where Watson-Munro became director [38]. The DSIR nuclear sciences team Marsden had established continued, though rather than operating a research reactor they were focusing on measuring environmental radioactivity, using radioactive tracers, and experimenting with radiocarbon dating [39].

HEAVY WATER FOR THE BRITISH NUCLEAR PROGRAMME

From London, while continuing to promote the construction of a low energy atomic pile [40]. Marsden also encouraged the New Zealand production of heavy water as a moderator for British atomic piles [41]. In 1949 Marsden reiterated an earlier suggestion to John Cockcroft

[42], that New Zealand's geothermal steam – which was being investigated for electricity generation – could be used to concentrate heavy water through fractional distillation [43]. Cockcroft was receptive to Marsden's suggestion and a DSIR scientist, J.A. (Tony) McWilliams, was transferred to Harwell to study the distillation of ordinary water to heavy water through use of geothermal steam [44]. In March 1952 the New Zealand government received formal advice that the British authorities attached great importance to the development of additional supplies of heavy water and requested a thorough survey of its potential production in New Zealand be undertaken as a matter of urgency [45]. Marsden continued to encourage the project, liaising between Harwell, the DSIR and the Prime Minister's Department. Economic production of heavy water by distillation depended on the design of an efficient production plant and the availability of sufficient steam. Distillation experiments continued at Harwell, while in New Zealand, the DSIR focussed on assessing the availability of geothermal steam and its corrosive properties and conducting heat transfer tests [46]. On a visit to New Zealand in September 1952 John Cockcroft met with Cabinet and the Defence Science (Policy) Committee and made it clear the British wanted heavy water not just to use as a moderator in atomic piles, they were also interested in it from a 'defence research angle' [47].

In May 1953 the New Zealand Cabinet approved in principle the construction of a joint New Zealand/United Kingdom combined heavy water and electricity generating plant [48]. The focus now moved to determining the economics of the project and the nature of the agreement between New Zealand and the United Kingdom. In December 1953, however, the British High Commissioner in Wellington informed Prime Minister Sidney Holland that the Atomic Energy Board in the United Kingdom had decided that it could no longer recommend British participation in the project, citing the possibility that the United States might soon be offering heavy water at 'a keen price' [49]. In March 1954 the heavy water project was briefly revived. At a meeting of the British Chiefs of Staff on 19 March 1954, Sir Norman Brooks, Secretary to the Cabinet, reported plans to improve Britain's capacity to manufacture hydrogen bombs by obtaining thorium from South Africa and heavy water from New Zealand [50]. The next week Marsden was advised that the United Kingdom might reopen discussions on the heavy water project. Loathe to put the reasons for the renewed interest in writing, Marsden cryptically described it to the DSIR secretary in New Zealand as 'a very special urgent important reason' [51]. On 23 April 1954, Viscount Swinton, Secretary of State for Commonwealth Relations, advised Sidney Holland that, on the basis of new cost and supply information, the United Kingdom Government now wanted to proceed with the heavy water project but this time attached great importance to maintaining secrecy [52]. On the same day, Cabinet authorised Holland to tell the British High Commissioner that the New Zealand Government was willing to go forward with the proposed combined heavy water and electricity plant in the Wairakei geothermal area [53]. While Marsden, in London, knew of the secret plans to develop a hydrogen bomb and of its links to the heavy water plant, it is unclear how widely this was known in New Zealand. A report on the revived heavy water plans in a Prime Minister's Department file deduced from official statements and press reports that the project was now focused more on civil development of atomic power and less on defence requirements [54].

By July 1954, moreover, this surmise proved correct. When the British cabinet formally decided to proceed with building a hydrogen bomb, heavy water was abandoned in favour of other materials [55]. But revised cost estimates from American sources meant New Zealand heavy water was again considered attractive for the United Kingdom's nuclear reactor programmes and in February 1955 Geothermal Developments Ltd, whose shareholders were the New Zealand Government and the United Kingdom Atomic Energy Authority (UKAEA), was formed to produce electricity and heavy water at Wairakei. Marsden, who had retired from the public service at the end of July 1954 and returned to New Zealand, was appointed tech-

nical adviser to the Board [56]. The Ministry of Works would be responsible for constructing the planned plant, which aimed to be ready for heavy water production by 30 June 1957, and for electricity production a year later [57]. Design work proceeded to the stage where prices for equipment, materials and labour could be accurately estimated but this doubled the cost of the plant, raising the cost of the heavy water it would produce from £44,000 to £90,000 per ton [58] and in January 1956 the UKAEA advised that, faced with the projected price increases, they felt forced to withdraw from the project [59]. Plans were revised to construct a larger power station to absorb the steam, which would no longer be needed for heavy water production [60].

RADIOACTIVE FALLOUT AND NUCLEAR TESTING IN THE PACIFIC

Marsden had a very active retirement – as well as conducting his own research, he was a member, and later chairman, of the Defence Scientific Advisory Committee. He was a member of New Zealand's Atomic Energy Committee, set up in 1958 to advise on New Zealand's activities in atomic affairs, including the organisation and administration of the DSIR's new Institute of Nuclear Sciences [61]. He was part of the New Zealand delegation to the 1958 International Conference on the Peaceful Uses of Atomic Energy [62]. Marsden encouraged the government support of uranium prospecting that began in 1954 and at the second reading of the 1957 Atomic Energy Amendment Act, which dealt with the search for uranium, the Minister of Health took the opportunity to speak on Marsden's role in the birth of nuclear physics [63]. His speech was later discussed in Cabinet, after which Marsden was recommended for a knighthood [64]. Marsden became Sir Ernest Marsden in 1958 [65].

Throughout the 1950s, Marsden continued to recommend the construction of a research reactor in New Zealand while also advocating nuclear power as a cheaper option than a Cook Strait cable, which was also being considered [66]. Not everyone shared his enthusiasm for the nuclear option, however, and in 1956 Marsden told the Dominion newspaper that those who were holding New Zealand back from nuclear power were 'lazy-minded conservative diehards who are afraid of change' who were afraid that nuclear science had become 'a malevolent, uncultured arbiter of our destiny instead of the traditional servant of the industrial revolution' [67]. Marsden's enthusiasm for things nuclear, however, had limits, and following revelations about world-wide radioactive fallout from nuclear bomb tests, he began his own research into the effects of fallout in New Zealand and the Pacific Islands, and in a small way – through his advice to Prime Ministers Sidney Holland and Keith Holyoake – he actually helped to keep New Zealand 'nuclear free'.

By 1955 the United Kingdom needed New Zealand's help for another aspect of their nuclear programme. Australian Prime Minister Robert Menzies had ruled out the testing of hydrogen bombs on or near the Australian mainland so when the United Kingdom began plans to test the hydrogen-bomb, a new test range had to be found. Scientists from the Aldermaston weapons development laboratory estimated the site should be at least 500 miles from inhabited land or shipping lanes. The best options were considered to be 'various remote islands or the icy wilderness of Antarctica' [68]. The Kermadec Islands, a New Zealand territory some 1000 km north-east of New Zealand (and now part of New Zealand's largest marine reserve), was chosen as the most promising site. In May 1955 Sir Anthony Eden, the British Prime Minister, contacted Sidney Holland to request the use of the Kermadec Islands for the bomb tests. Eden described how the weapons could be either exploded on one of the islands from a tower, or fired in a ship anchored near an island, and asked if Holland would agree in principle to the weapons trials so the United Kingdom could investigate the site further. Eden concluded by expressing his earnest 'hope that, in the interests of our common defence effort and the importance of the deterrent for Commonwealth Strategy, you will find it possible to agree' [69].

Fig 2. Source: Auckland Star, 27 April 1956.

Holland was wary of the British request and took note of negative publicity surrounding earlier newspaper reports of British plans to test in Antarctica. He sought the opinion of Ernest Marsden, who advised Holland that while an isolated island in the Pacific was 'a logical choice' for the proposed weapons test, the Kermadec Islands were not necessarily the best option. He acknowledged the weather was suitable but noted the presence of occasional ships and aircraft in the area and reminded Holland of the Japanese fishermen who suffered radiation sickness – one died – after their boat was unintentionally stationed 135 kilometres from the United States's first hydrogen bomb detonation at Bikini Atoll on 1 March 1954. Marsden acknowledged the Government might on the one hand feel a 'moral obligation' to cooperate with the British request but on the other hand might 'feel that the sacrifice and difficulties in the use of the Kermadecs is questionable'.

Without bluntly advising Holland to refuse the request Marsden suggested the Auckland Islands, some 320 kilometres south-south-west of New Zealand, as a preferable alternative to the Kermadecs [70].

On 15 July 1955 Holland warned the British High Commissioner in Wellington that the use of the Kermadecs for nuclear tests would be a 'political H-bomb' in New Zealand – not least because they would take place in an election year – and declined the British request [71]. Eden expressed his disappointment at Holland's refusal, reiterating the importance of the planned trials to the 'defence of the free world' and advising that if Britain did not find a suitable alternative he might be compelled to ask Holland to reconsider the matter [72]. Britain looked for a new site and in 1956 eventually settled on Christmas Island and Malden Island (now part of the Republic of Kiribati).

While not offering New Zealand territory for the tests, Holland still supported them in principal. New Zealand was happy to assist the United Kingdom with logistical support for the bomb tests and in May 1956, when three Labour MPs asked if Holland would protest at the continuation of nuclear bomb tests in the Pacific. Holland replied that 'the development of this branch of the nuclear sciences must continue' and 'periodic tests are essential to this work' [73]. In a later statement he added 'New Zealand will be helping to ensure that the United Kingdom remains in the forefront in the field of nuclear research' [74].

RETIREMENT PROJECTS ON RADIOACTIVITY

At about the same time that he was advising Holland against allowing the United Kingdom to test hydrogen bombs in the Kermadec Islands, Marsden was beginning his own research into the biological effects of background radiation. In his retirement he worked up to six days a week, from either his attic laboratory at his home, or as a guest worker at the DSIR's Dominion Physical Laboratory or the Royal Cancer Hospital in London [75]. He was passionate about this new line of work, telling a colleague 'I wish I could start my career again and work on these radiobiological problems' [76]. Marsden liked an audience and received a lot of press coverage – he sometimes talked up the effects of radiation from bomb tests and sometimes minimalised them, pointing out radiation levels from fallout were very low in comparison to natural background radiation [77]. He rightly, however, said the effects of radiation from bomb fallout were not fully understood and deserved further study [78]. Much of Marsden's research was interesting and unusual and attracted coverage in the daily press. His most publicised findings came from his research into Niue Island, where a DSIR Soil Bureau study had showed the island's soil had unusually high levels of radioactivity [79]. This prompted Marsden to further research and he found the radioactivity of food grown on the island to be up to 100 times normal [80]. His findings caused quite a stir internationally, with the popular press picking up on Marsden's assertions that Niueans were a master race. Not only were they taller, much happier and less prone to disease than other races, he was reported to have said, selective breeding had led to the population building up a resistance to radiation which would be advantageous in the event of a nuclear war [81]. Despite criticism of his theory, Marsden persisted, stating in 1962, 'My contention that the people of Niue Island would be better off in a nuclear war than the rest of us is a good story and I'm sticking to it!' [82].

Another of Marsden's high profile projects was his investigations into the radioactivity of tobacco. By the 1960s, links between cigarette smoking and lung cancer had been established. Marsden saw the striking increase in British deaths from lung cancer as being possibly linked to increased imports of Southern Rhodesian tobacco, which he had found to have high levels of polonium-related radioactivity [83]. In 1965, at Marsden's request, the DSIR's chemistry division developed a new type of cigarette filter to reduce the amount of polonium inhaled when smoking cigarettes [84].

Despite his seemingly eccentric scientific pursuits, Marsden maintained his international scientific connections and was held in high regard by the physics community. While working on his retirement projects he corresponded with some of the top Commonwealth nuclear scientists – including John Cockcroft and William Penney in the United Kingdom, and Charles Watson-Munro in Australia – using his connections to call in favours for advice or equipment that may otherwise have been difficult to obtain. In return, Marsden was known to send eminent scientists parcels of New Zealand lamb, to arrive just in time for Christmas [85]. In 1961 he was invited to be President of the Rutherford Jubilee International Conference in Manchester, a gathering of 500 of the world's leading physicists to commemorate the fiftieth anniversary of the discovery of the atomic nucleus [86].

A 'NUCLEAR-FREE' NEW ZEALAND?

In 1959, by which time the United Kingdom had completed its nuclear testing programme in Australia and the Pacific, Marsden began speaking out against the testing of nuclear weapons. He highlighted the worldwide increase in radioactive fallout resulting from Russian and American nuclear tests and told the Auckland Star 'the time has come for an absolute standstill on such atomic explosions to give time for a proper assessment of the damage already done to us and to our children even yet unborn' [87]. This wasn't the first time Marsden had publicly opposed nuclear weapons. Following the Second World War he had supported the 1946 Baruch Plan, which called for international inspection of all nuclear-related facilities to ensure they were not working on atomic weapons and stipulated that the United States dispose of its atomic weapons, stop all weapons work and turn over its atomic energy knowledge to the United Nations. In a 1947 speech, Marsden, who advocated atomic energy as being of 'untold benefit to the world' said that it was not, however, safe to develop atomic energy on a world-wide scale until there was a practical and enforceable agreement that it would not be used for atomic bombs [88]. No such agreement was put in place and his stated views on atomic weapons seem to conflict with his concurrent plans for development of a nuclear reactor in New Zealand, which he promoted as being of defence significance to the Commonwealth. They also conflicted with his support, in the early 1950s, of British plans to develop nuclear weapons, and his enthusiasm for New Zealand to assist the British nuclear programme by constructing a nuclear reactor, and providing heavy water and uranium.

After the British nuclear programme was concluded in 1958, Marsden declared that New Zealand was partly to blame for the Commonwealth 'falling miserably behind in nuclear development'. If there was a third nuclear power, Marsden declared, there would be no 'bombing competition' between Russia and America [89]. Marsden continued to criticise New Zealand's lack of investment in defence science, including telling Prime Minister Keith Holyoake that New Zealand had been 'grossly discourteous and negligent of opportunities to help Britain' in this area [90]; a reference to New Zealand's continued failure to construct an atomic pile [91].

But why, at the same time as implicating New Zealand in the United Kingdom's failure to keep up with the arm's race, was Marsden speaking out against nuclear weapons? As journalist Tony Reid described in a newspaper profile of Marsden, his attitudes to nuclear weapons development were, 'ambiguous and sometimes contradictory' [92]. It is possible that despite his initial personal misgivings about the post-war development of nuclear weapons, Marsden's loyalty to Britain, along with the close involvement of many of his friends and former colleagues in the British nuclear programmes, caused him to push these misgivings aside. Marsden was easily seduced by science – as demonstrated by his willingness in early 1945 to leave his position as head of the DSIR to take a junior physicist's role on the North American nuclear programme – and the development of nuclear weapons was at the forefront of scientific and technological development. Once the British nuclear testing programme was concluded, therefore, and with evidence of increased environmental radioactivity resulting from bomb fallout, Marsden had no hesitation in publicly opposing nuclear weapons.

After a number of anti-nuclear statements to the media from 1959 onwards, Marsden began communicating his anti-nuclear weapons sentiments to Prime Minister Keith Holyoake in 1961 [93]. Then in 1963, when the French announced their proposal to move their test site to the South Pacific, Marsden advocated, in a letter to Holyoake, a nuclear-bomb free Southern Hemisphere. He pointed out that fallout from nuclear bomb tests had so far impacted more on the Northern Hemisphere than the Southern, and called on Holyoake to announce that New Zealand would not provide any assistance to countries carrying out bomb tests in the Southern Hemisphere, and suggested he call on other Southern Hemisphere countries to do the

same [94]. In May 1963 the New Zealand Government formally protested to the French Government over their preparations for a nuclear test at Gambier Island [95]. Later that year New Zealand being the first country, after the United States, United Kingdom and USSR, to ratify the Partial Test Ban Treaty, demonstrating, in Holyoake's words, New Zealand's 'desire to see an end to nuclear tests that are likely to give rise to contamination of the atmosphere' [96].

While focussing on his research into environmental radioactivity, Marsden continued to speak out against nuclear weapons development and testing. On a visit to South Africa Marsden described the hydrogen bomb as 'the most striking example of the possibilities of misuse of modern scientific knowledge' [97]. In June 1965 he told Salient, the Victoria University student newspaper, 'we must do what we can to stop nuclear warfare. We must do what we can to promote nuclear disarmament' [98]. In 1966, the year France began testing nuclear bombs in the Pacific, a stroke left Marsden confined to a wheelchair, and in December 1970, at the age of 81, he died.

CONCLUSION

In 1985, 15 years after Marsden's death, New Zealand gained international attention for its nuclear-free policy, which was enshrined in legislation two years later. By 1970, however, the year of Marsden's death, New Zealand was already on a path to being nuclear free. In 1968 the New Zealand Government had ratified the Treaty on the Non-Proliferation of Nuclear Weapons, and was now making diplomatic protests over French tests in the Pacific, monitoring fallout in the South Pacific, and working internationally towards disarmament [99]. Ernest Marsden, who had a significant role in establishing and encouraging nuclear science in New Zealand, had a lesser-known role speaking out about against nuclear weapons development and testing. Through his advice to Prime Ministers Holland and Holyoake, and through his regular public lectures and statements to the media, he alerted the country to the extent of radioactive fallout from nuclear bomb tests, and the potential biological effects of environmental radiation, and in so doing helped to encourage the country on a path to what we now call a 'nuclear free' New Zealand.

Fig 3. Sir Ernest Marsden in June 1961, on board the Sydney Star at Bluff, New Zealand, testing the radioactivity of a sample of seawater. Photo: Reference number F-153607-1/2, Alexander Turnbull Library, Wellington, New Zealand.

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