ECOLOGICAL SCIENCES SERIES

RADIOACTIVE RISK SET

Volume 4

Disarmament and Decommissioning in the Nuclear Domain

Jean-Claude Amiard

ISTE

WILEY

Disarmament and Decommissioning in the Nuclear Domain

Radioactive Risk Set

coordinated by
Jean-Claude Amiard

Volume 4

Disarmament and Decommissioning in the Nuclear Domain

Jean-Claude Amiard

ISTE

WILEY

First published 2021 in Great Britain and the United States by ISTE Ltd and John Wiley & Sons, Inc.

ISTE Ltd
27-37 St George's Road
London SW19 4EU
UK

www.iste.co.uk

John Wiley & Sons, Inc.
111 River Street
Hoboken, NJ 07030
USA

www.wiley.com

Library of Congress Control Number: 2021938220

British Library Cataloguing-in-Publication Data
A CIP record for this book is available from the British Library
ISBN 978-1-78630-721-7

Contents

Preface

Nuclear energy is used in two main areas: military and civil. In the military field, nine countries are currently manufacturing nuclear weapons of mass destruction, which is a serious threat to humanity and all living beings. Therefore, the UN and many NGOs are working to limit nuclear proliferation, as well as to limit the number of nuclear weapons. The ultimate goal, probably utopian, is a complete eradication of these weapons. Like all human creations, the life span of nuclear weapons is limited. The military must therefore deconstruct obsolete weapons and, unfortunately, manufacture new ones that are more powerful, more precise and therefore more destructive than previous ones. The military must also urgently clean up old nuclear facilities that have become obsolete, as well as highly contaminated.

In the civil field, nuclear energy is mainly used to produce electricity and in many medical applications for diagnostic or therapeutic purposes, with radiotracers (scintigraphy) and ionizing radiation destroying cancer cells (brachytherapy and radiotherapy). Here again, various nuclear installations, nuclear power reactors, plants, particle accelerators, etc. have a limited lifespan and must be decommissioned and dismantled. However, these operations are long, costly and present both environmental and health risks. They must therefore be carefully programmed, seriously supervised and controlled. The ideal is for the site to return to its initial state (often called “greenfield”).

The aim of this book, the fourth in the “radioactive risk” series, is to take stock of the state-of-the-art nuclear disarmament and dismantling. As with the previous works in this series, we have tried to use multiple information sources and verify them, in order to get as close as possible to the truth.

The first part of this book is devoted to the international efforts to limit nuclear proliferation, with various international treaties signed and some ratified, as well as agreements to limit the number of nuclear weapons held by the nuclear powers.

The second part deals with the decommissioning and dismantling of various types of nuclear facilities, including power, prototype and research reactors, as well as plants upstream and downstream of the nuclear fuel cycle or nuclear research centers.

May 2021

Acknowledgments

Jean-Claude Zerbib, a former CEA Senior Expert and radiation protection engineer, had the difficult task of reading, annotating and criticizing the original manuscript. He also provided me with the precious documents needed to complete the abundant literature that fed the writing of this book.

Professor Philip Rainbow (former Keeper of Zoology, Natural History Museum, London, UK) has done the same for the English version. I would like to thank them both for their time and effort.

I would also like to thank the members of the ANCCLI Scientific Council who helped me to understand certain subjects. The same goes for all of the members of the *Groupe Radioécologie Nord Cotentin* (GRNC), a pluralist group, for the remarkable work they carried out together courteously.

1

Nuclear Non-Proliferation

1.1. Introduction

Nuclear weapons pose an immense risk to human beings, as well as to all living beings and to the environment. For this reason, many individuals and organizations have been working to limit the number of states capable of manufacturing this type of weapon.

UN efforts to prevent, or at least limit, nuclear proliferation are significant and ongoing. For example, the UN Security Council Resolution 1540 (April 28, 2004) echoes the terms of the UN Security Council's statement from January 31, 1992 by stating that "the proliferation of nuclear, chemical and biological weapons, as well as their means of delivery constitutes a threat to international peace and security". However, in this resolution, it is the risks associated with the acquisition of such weapons by "non-state actors" that are specifically targeted. Some analysts consider that this resolution may justify the use of force to combat proliferation [IRS 19b].

Unfortunately, and in spite of its efforts for 35 years, it is obvious that the UN's policy of nuclear disarmament has been a failure. The traditional vision of security that seems to be shared by the actors involved in the process of arms control and nuclear disarmament limits their capacity and willingness to abolish this type of armament [LAZ 06]. Hence, France and the United States are exerting strong pressure on the French-speaking states and on Japan to not sign the treaty on the Prohibition of Nuclear Weapons (TPNW).

In an interview with the IRIS (*Institut de Relations Internationales et Stratégiques*, the French Institute for International and Strategic Affairs), Jean-Marie Collin [COL 18b], expert and spokesman for ICAN FRANCE, an organization

Disarmament and Decommissioning in the Nuclear Domain,
First Edition. Jean-Claude Amiard.

awarded the Nobel Peace Prize in 2017, noted that nuclear weapons constitute a permanent and very real danger for the international community; otherwise, no treaty would have been signed at the UN, and the nuclear deterrent would be null and void. The International Committee of the Red Cross (ICRC) has stressed that no international plan or actor will be able to adequately address the needs of victims in the event of the use of nuclear weapons.

Nuclear weapons operate on the balance of terror. However, the problem with balance is that the risk of falling is always great. This "balance" is undesirable to an overwhelming majority of the world, because their security is directly at stake [COL 18b].

1.2. The first countries to acquire the atomic bomb

Five states have carried out their first atomic tests: the United States on July 16, 1945, the Soviet Union on August 29, 1949, the United Kingdom on October 3, 1952, France on February 13, 1960 and China on October 16, 1964.

In order to prevent the number of states possessing nuclear weapons from becoming too large, the United Nations has been concerned with nuclear disarmament from the outset, and four UN structures are particularly responsible for this task: the Security Council, the Disarmament Commission, the Conference on Disarmament and the Office for Disarmament Affairs [GIL 18].

The Security Council has primary responsibility under the UN Charter for the maintenance of international peace and security. It is composed of five permanent members (China, France, the Russian Federation, the United Kingdom and the United States) and 10 non-permanent members elected by the General Assembly for a period of two years. The general organization of the UN is shown in Figure 1.1.

The United Nations Disarmament Commission (UNDC) was established in 1952, within the framework of the Security Council, by General Assembly Resolution 502 (VI), to deal with disarmament issues. However, it only met occasionally after 1959. In 1978, the first special session of the General Assembly devoted to disarmament established a new Disarmament Commission as a subsidiary organ of the Assembly, composed of all UN member states of the Organization. It was established as a deliberative body to consider various disarmament issues and monitor the implementation of the relevant decisions and recommendations adopted

at the special session. It sits in New York for three weeks each year (usually in early spring). It considers a limited number of agenda items on a three-year cycle and submits an annual report to the General Assembly [GIL 18].

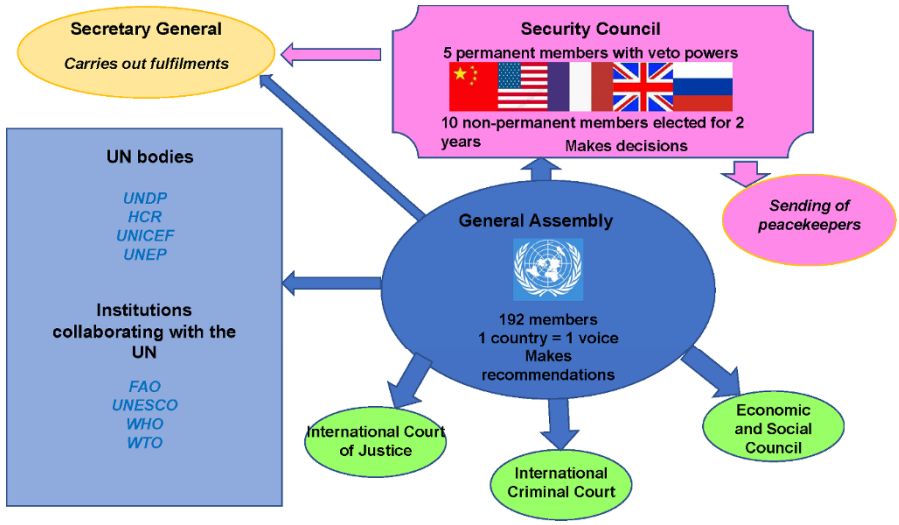

Figure 1.1. *The United Nations organization. For a color version of this figure, see www.iste.co.uk/amiard/disarmament.zip*

The Conference on Disarmament is the only multilateral forum for negotiating disarmament agreements. It is composed of 65 permanent members who hold three sessions a year in Geneva (usually January to March, May to June and August to September). It operates on the basis of consensus to ensure full support for the agreements reached. It has completed negotiations on the Comprehensive Nuclear-Test-Ban Treaty, but has not yet entered into force [GIL 18].

The Office for Disarmament Affairs, established in 1982, works to promote disarmament and non-proliferation and to strengthen disarmament regimes. Part of its work focuses on nuclear weapons [GIL 18] (Figure 1.2).

The first treaty limiting the use of weapons (particularly nuclear weapons), the Antarctic Treaty, signed in Washington, entered into force on June 23, 1961. This treaty stipulates that the Antarctic is an area exclusively reserved for peaceful purposes and prohibits all activities of a military nature, such as military maneuvers and the testing of any kind of weapon.

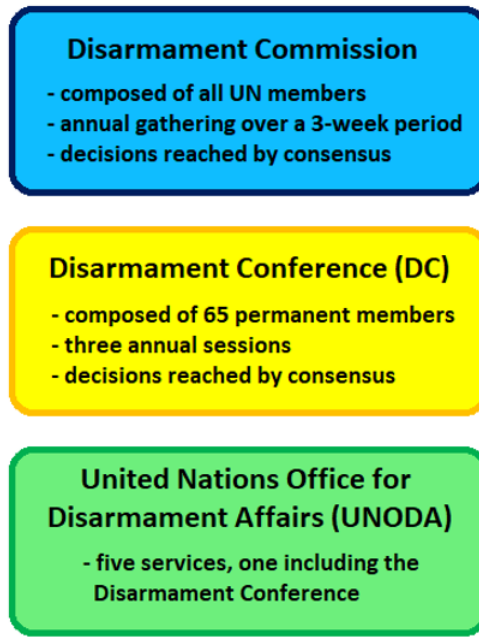

Figure 1.2. *The various UN bodies working on non-proliferation and disarmament. UNODA: United Nations Office for Disarmament Affairs. For a color version of this figure, see www.iste.co.uk/amiard/disarmament.zip*

1.3. The NPT

The International Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was developed within the UN by the Eighteen-Power Committee on Disarmament. Concrete negotiations lasted three years, from 1965 to 1968. The text was mainly drawn up by the United States and the Soviet Union. On July 1, 1968, the treaty was opened for signature in Moscow, Washington and London. It entered into force on March 5, 1970 after ratification by the three depositary Powers and 40 other signatory states [AIE 70].

For the treaty itself, the parties had to decide on its extension 25 years after its entry into force. Despite the reluctance of some non-aligned countries (Mexico and Indonesia) and Arab countries (because of Israel's absence from the treaty), the NPT was extended indefinitely on May 11, 1995 [IRS 19a].

The NPT is now close to universality, with 191 states as members. Only four states have not joined: India, Israel, Pakistan and Southern Sudan. However, in January 2003, North Korea initiated a procedure to withdraw from the treaty [FRA 19b].

1.3.1. *The functioning of the Treaty*

In the operation of the NPT, states are divided into two categories. The first category consists of the nuclear-weapon states (NWS). These are the five official nuclear powers (United States, Russia, United Kingdom, France, China), which according to Article IX "*had manufactured and detonated a nuclear explosive device prior to 1 January 1967*" and are entitled to possess such weapons. The second category includes all non-nuclear weapon states (NNWS), which make up the rest of the NPT membership. For the purpose of control or safeguarding, this last category is divided into two sub-categories depending on whether or not the states have access to nuclear facilities (see section 4.1.1).

For many years, this NPT has not been functioning well. This is mainly due to non-compliance with two clauses. The first clause is the non-implementation of a process to create a zone free of nuclear weapons and weapons of mass destruction in the Middle East. The second clause is related to the hypocrisy of the five weapon states, who do not respect the spirit and letter of the NPT. Indeed, while no one can deny that the nuclear arsenals of these states, with the exception of China, have indeed decreased since the Cold War, it must also be noted that all of these states have undertaken processes of modernizing nuclear weapons and delivery systems.

This treaty seems to have reached its maximum effectiveness with regard to the two pillars of non-proliferation and the peaceful use of nuclear energy, but it seems limited in effectively forcing the NWS to implement the third pillar, that of a real disarmament policy [COL 15].

1.3.2. *Revision of the NPT*

This treaty is subject to a Review Conference (RevCom) every five years: the next one was due to take place in 2020, interspersed with three so-called Preparatory Conferences (PrepCom). The RevCom is an opportunity to take stock of the progress made in the past and the future of the treaty in a roadmap, which is called the Final Document [COL 15].

1.3.3. *Successes of the NPT*

The main success of the treaty is South Africa's renunciation of nuclear weapons. The first, and only South African nuclear research reactor is the SAFARI-1 (South African Fundamental Atomic Research Installation 1), built between 1961 and 1965 on the Pelindaba site. This site also housed a reprocessing plant (Plant Y). The country also had a secret military program for the South African Defence Force, abandoned by the ratification of the Treaty on the Non-Proliferation of Nuclear Weapons before the African National Congress came to power. The six aerial atomic bombs with a power of 15 to 20 kt, built between 1982 and 1989, and a seventh, which was under construction, were dismantled before 1993 [TOU 13].

Historically, the AEC (Atomic Energy Corporation) had two sites – Valindaba, for the production of highly enriched uranium (HEU) and Pelindaba, for research. The ARMSCOR (Armaments Corporation of South Africa) depended on the Ministry of Defense with two sites – Kentron and Naschem. The production of highly enriched uranium by the South African enrichment plant Y in 1994 was 993 kg (enriched on average to 68% in ^{235}U), of which 515 kg were enriched to 85% in ^{235}U [ALB 16].

South Africa's only nuclear test likely occurred in 1979. On the night of September 22, 1979, a double flash was spotted off the Prince Edward Islands by the American satellite Vela 6911. The double flash of light is the signature of an atmospheric atomic explosion. The initial flash burst at the start of the explosion and corresponded to a fireball. Then, the glow was obscured for a fraction of a second by the shock wave, which made the atmosphere opaque. Then, when the cloud dissipated, the second flash appeared. Since South Africa was the only power in the region with the means to enrich uranium, it was immediately suspected, but foreign support, possibly Israeli, was also envisaged [BAT 18].

South Africa's disarmament program was complicated by its division State into two countries (South Africa and Namibia) [DZI 17].

The program to dismantle South Africa's nuclear program began with the dismantling of the six nuclear weapon devices and the seventh, which was in production. The highly enriched uranium was returned to the AEC to be kept under secure surveillance. The second stage was the complete decontamination of the Armscor installations (1990–1991) and the return of highly contaminated equipment, such as melting furnaces, to the AEC. Advena/Circle's facilities were converted into commercial civil or military activities, but with conventional weapons: the destruction and disposal of non-nuclear components, as well as engineering design and manufacturing information provisions. South African nuclear officials informed the de Klerk government of an appropriate timetable for

the state's accession to the NPT, the signing of a comprehensive safeguards agreement with the IAEA (International Atomic Energy Agency), and the submission of a complete national inventory of nuclear materials and facilities, as required by the safeguards agreement. Finally, the closure of plant Y was to take place as soon as possible [ALB 16].

Other countries have developed nuclear programs in the past: Brazil, Algeria, Libya, Ukraine, Sweden, Belarus and Kazakhstan, but have abandoned nuclear deterrence.

1.3.4. *Failures of the NPT*

Despite the NPT's entry into force, four countries have since acquired atomic weapons (Israel, India, Pakistan and North Korea).

Israel has always used deliberately ambiguous language with respect to nuclear weapons and has refused to sign the NPT. The only public revelation of Israel's nuclear capabilities was made by a former Dimona nuclear power plant technician, Mordechai Vanunu, in the Sunday Times on October 5, 1986 [COH 05].

Historically, Israel benefited from French aid, between 1956 and 1961, for scientific advice for the construction of the Dimona reactor, as well as the supply of many nuclear materials by the British between 1950 and 1960. Between 1961 and 1969, American experts visited Israeli installations, but with advanced notice of their arrival. This made it possible to camouflage the real activities of the installations. In 1969, President Richard Nixon agreed to allow Israel to possess nuclear weapons, on the condition that it would not conduct nuclear tests or display its nuclear warheads [COH 98, BIA 09, COH 10, TÉN 10].

No nuclear tests have been officially recognized. However, it is possible that an underground test took place in 1963 in the Negev desert, as well as a 3 kt atmospheric test in 1979 in South African waters, in collaboration with South Africa (double Vela flash). Indeed, on September 22, 1979, the American satellite Vela 6911 detected an optical signal characteristic of an atmospheric nuclear explosion over the southern Indian or Atlantic Ocean. Weiss believes that the flash was an Israeli nuclear test assisted by South Africa [WEI 11]. In a new analysis of radionuclide and hydroacoustic data, it was concluded that the double flash resulted from a low-yield nuclear weapon test [DEG 18]. Among the evidence put forward by these authors, the concentration of iodine-131 found in the thyroids of some Australian sheep could suggest that they had grazed grass in the path of a potential radioactive fallout plume from this test.

In September 1996, when the Comprehensive Test Ban Treaty was signed, it was reasonable to believe that this would become a general rule of behavior accepted by all states. However, in May 1998, India and Pakistan defied the international community by conducting nuclear tests. Faced with the new risk of a regional nuclear conflict involving Kashmir in particular, the Western powers needed to integrate these two states into the nuclear non-proliferation regime. There were only two ways to do this: sanctions or dialogue. However, India and Pakistan were no longer ordinary states that could be dictated to. They had become nuclear powers with all that this implies in terms of prestige and political weight on the international scene [CAP 98].

India developed a nuclear program as soon as it gained independence in 1948, with the adoption of the Atomic Energy Act, aimed at developing nuclear energy for peaceful purposes. Today, India is not a signatory to the Nuclear Non-Proliferation Treaty (NPT), but has more than 20 nuclear reactors, mainly Canadian-designed CANDU pressurized heavy water reactors.

India's Atomic Energy Commission detonated its first underground nuclear weapon, the Smiling Buddha, at a depth of 100 meters in Pokharan on May 18, 1974. This led to the cessation of all forms of international cooperation in favor of India's civilian program and exclusion from the Nuclear Non-Proliferation Treaty (NPT). Subsequent nuclear tests took place underground on May 11 and 13, 1998. India conducted three tests on May 11, testing an A-bomb and an H-bomb, and two more tests on May 13, using small charges [CAP 98]. In 2018, the Indian Nuclear Deterrent Air Force had 48 nuclear warhead-launching aircrafts, 60 ground-based ballistic missiles, and about 18 cruise missiles for a total of 130–140 nuclear bombs [KRI 18a].

Pakistan (Islamic Republic) began its nuclear program in January 1972. This program was originally a response to India's development of nuclear weapons. The military nuclear program began in 1987. Pakistan's first underground nuclear test was conducted on May 28, 1998, codename Chagai-I (Chagai district, Balochistan province). This test was a series of five low-power nuclear tests. The second test (Chagai-II), took place in the Kharan desert two days later. The power was equivalent to 12 kt of TNT. Of the six tests, one used plutonium and the others used enriched uranium. Pakistan, which is not a signatory of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), thus became the seventh country in the world to develop and test nuclear weapons and is also the only Muslim country to possess nuclear weapons.

Its capacities have not been made public, leading to estimates. Thus, in 2013, one source indicated that the Pakistani armed forces possessed 300 to 350 nuclear

warheads (Le Monde, June 3, 2013), compared to around 50 in 2007, while SIPRI estimated Pakistan's arsenal to be 250 to 300 warheads in 2017, much higher than India [GAI 17, SIP 18].

The Indian and Pakistani nuclear programs can be explained by the exacerbated rivalry between the two states. In addition, the Pakistani nuclear physicist A.Q. Khan, has established strong nuclear proliferation ties with Iran, North Korea and Libya because of his personal motivations, religious orientation and anti-Western worldview [ABB 18]. The Pakistani people were overcome with fever dreams for the future and were very proud after the first atomic tests. However, in India, the population was more reserved about the Indian tests and regretted the practice of secrecy in this field [ABR 09].

The third failure of the NPT is that of North Korea, which after signing the treaty withdrew from it. In October 2006, North Korea announced that it had detonated its first nuclear bomb. Other tests were carried out in 2009, 2013, 2016 and 2017. The best estimate of the stocks of highly enriched uranium (HEU) in the Yongbyon nuclear complex at the end of 2015 were between 75 and 320 kg [BRA 18].

In order to stop this North Korean nuclear program, in the early 1990s, successive American presidents tried to negotiate with the North Korean government. American decision-makers were left asking themselves about the usefulness of such a negotiation, the timeframe and the objectives of these diplomatic talks with Pyongyang.

The United States began four major rounds of formal nuclear and missile negotiations with North Korea. These were the bilateral framework (1994–2002), bilateral missile negotiations (1996–2000), multilateral Six-Party Talks (2003–2009) and bilateral Leap Day Deal negotiations (2012). In general, North Korea agreed, ostensibly, to end, or even deactivate its nuclear and/or missile programs in return for economic and diplomatic incentives. But despite some progress in some negotiations, North Korea has continued to advance its nuclear and missile programs [NIK 17].

In April 2018, Pyongyang announced the end of its nuclear tests, and in June 2018, an official meeting between Donald Trump and Kim Jong-un took place in Singapore. On June 30, 2019, another historic meeting between the US and North Korean presidents took place on the border between North Korea and South Korea. However, no specific agreement has been reached.

1.3.5. *Future nuclear-weapon states*

Alongside these four states that have acquired nuclear weapons, nuclear proliferation has been observed in several countries. This is developed in section 4.1.3.

The fact that Israel is the only state in the Middle East that possesses nuclear weapons, and that this state enjoys privileges at the UN and the IAEA, since no control is exercised over its production of fissile material, nor over these nuclear weapons, inevitably leads to strong tension in this region. Also, there are many candidates to acquire nuclear weapons. The first candidate is Iran, which has begun to enrich uranium and has a missile program. Among the other postulants is Saudi Arabia, which is anxious to thwart Iran's influence in the Near East. This state is supported by the United States in this desire. This is obvious and by issuing authorizations for the transfer of American nuclear technology to Saudi Arabia, without any guarantee of non-proliferation, the American president at the time (Donald Trump) was provoking Iran [TIS 19].

1.4. Other nuclear non-proliferation treaties

Three international treaties and several regional treaties restrict the use of nuclear weapons.

1.4.1. *The CTBT Treaty*

In January 1946, the first General Assembly resolution specifically called for the elimination of all nuclear and other similar weapons "capable of being used for purposes of mass destruction", including biological and chemical weapons.

Among the solutions available to the UN, a nuclear test ban can be a very effective way to prevent horizontal proliferation (to states) and vertical proliferation (improvement of nuclear weapons). This solution is not a panacea but could help to limit the number of nuclear weapons.

According to Duarte, a test ban has three advantages. First, it makes it possible to prevent certain forms of "vertical proliferation", in particular, the development of new generations of nuclear weapons or the modernization of existing arsenals. Second, it helps to begin the process of dismantling the complex institutional infrastructures that have been put in place to develop and maintain these arsenals. Third, a ban also contributes to the process of delegitimizing nuclear weapons

themselves, in the eyes of the world, and thus makes it more difficult for policy makers to support the need for nuclear deterrence [DUA 19].

Prior to the Comprehensive Nuclear-Test-Ban Treaty (CTBT), five other anti-nuclear test treaties had been signed. The first Partial Test-Ban Treaty, signed on August 5, 1963, prohibited nuclear explosions in the atmosphere, under the seas and in outer space. Its main purpose was to stop radioactive substances from contaminating the environment. The second treaty signed on January 27, 1967 prohibited the placement of nuclear weapons or weapons of mass destruction in space. It entered into force on October 10, 1967. The third treaty, signed on February 11, 1971, prohibited the introduction and placement of nuclear weapons or other weapons of mass destruction on the seabed and ocean floor and in the subsoil. It entered into force on May 18, 1972. The fourth treaty concerned the limitation of underground testing, and was signed on July 3, 1974. The fifth treaty, signed on May 28, 1976, prohibited underground explosions for peaceful purposes. Finally, on September 24, 1996, the CTBT Treaty was signed [COL 19b, IRS 19b].

The Comprehensive Nuclear-Test-Ban Treaty (CTBT), along with the Non-Proliferation Treaty (NPT), is now one of the pillars of the global nuclear non-proliferation structure.

Negotiations took place between 1994 and 1996 and the treaty was opened for signature on September 24, 1996. As of May 1, 2019, only 184 states have signed the CTBT and it has only been ratified by 168 of them. In order for the treaty to enter into force, the negotiators defined, among other things, a list of nuclear-capable countries whose ratification was indispensable (regardless of the number of states that had ratified the treaty elsewhere). These were the 44 so-called Annex 2 states. As of May 1, 2019, eight Annex 2 states had not yet ratified the treaty: Iran, the United States, China, Israel, Egypt, India, Pakistan and North Korea, the last three of which were also expected to sign [RÉP 19].

1.4.2. *The TPNW*

Faced with the non-compliance of one of the pillars of the NPT, effective nuclear disarmament, the non-nuclear weapon states decided to start drafting a new treaty at the level of the UN General Assembly. This made it possible to bypass the undertakings of the five nuclear powers that were hindering this disarmament.

The International Treaty on the Prohibition of Nuclear Weapons (TPNW) was the first multilateral treaty on nuclear disarmament, open for signature in 1996, and is supported by a very large majority of UN member states. It was written by diplomats whose ambition was to both respect the mosaic of treaties that codify

nuclear weapons (NPT, CTBT and the future FMCT), in accordance with the safeguarding system currently being formulated by the IAEA, and to move the international community towards a world without nuclear weapons [COL 18a].

In the last decade or so, nuclear weapons have been reclassified, thanks to the humanitarian initiative, as weapons with catastrophic humanitarian consequences. This has led to a change in consciousness. The illegality of nuclear weapons, as well as the illegality of the policy of threatening to use them, appears shocking to the states that possess them because they have not yet made their "moral revolution". The rest of the world is now aware that the presence of these weapons is no longer acceptable and that they are generating growing insecurity, particularly because of their potential humanitarian, environmental and climatic impact at the global level [COL 18a].

On July 7, 2017, an International Nuclear Weapons Ban Treaty was adopted at the UN. Approved by 122 states and ratified by 50 nations on October 24, 2020, it entered into force on January 22, 2021. Historically, this text will prohibit signatory countries from manufacturing, stockpiling or using nuclear weapons. Will the threat to use these weapons, i.e. the policy of deterrence, also become prohibited [SOR 18]?

It should be noted that many states are revising their policy on nuclear weapons. This is the case for the Vatican, for example. For many years, this state accepted nuclear deterrence as a "tragic illusion" (Paul VI, June 7, 1978), as "a step on the road to progressive disarmament, can still be considered morally acceptable" (John Paul II, June 7, 1982) or as "the prospect [of deterrence based on balance], apart from being fatal, is utterly fallacious" (Benedict XVI, January 1, 2006). Pope Francis, on the contrary, has a much stronger stance on rejecting the use of atomic weapons and balanced nuclear deterrence.

States that possess nuclear weapons, or support a policy of deterrence, can no longer afford to question their understanding of nuclear disarmament. The Nuclear Weapons Treaty offers them this opportunity. This norm of international law exists and is likely to enter into force around the 10th NPT Review Conference (scheduled for May 2020, although it has been postponed). The (non-exhaustive) proposals set out in Annex 1 offer some ideas on how to overcome some of the misunderstandings and demonstrate a common will among states to move forward together and create a world free of nuclear weapons [COL 18a].

1.4.3. *The Fissile Material Cut-Off Treaty (FMCT)*

The treaty banning the production of fissile material or other nuclear explosive devices (FMCT or " Cut-off ") is an old draft of the UN General Assembly. It was

on December 16, 1993 that this Assembly adopted a resolution (A/RES/48/75L) that called for the opening of negotiations to elaborate such a treaty. The reasoning was simple: stopping the production of fissile materials (military plutonium or ^{239}Pu and highly enriched uranium) constitutes one of the essential locks of nuclear proliferation.

For more than 20 years, the Disarmament Conference (DC) has been working on the text of this treaty. Several drafts have been submitted by France and Canada. However, the impasse in which the DC still finds itself today is due to the abuse of the consensus rule, which allows any state to block the progress of work for any reason whatsoever.

The main causes of divergence on this treaty concern the delimitation of the scope for negotiating this prohibition. Egypt and Pakistan want the stockpiles of nuclear-weapon states (NWS) to be taken into account, which the five strongly reject. China wants to increase its stockpile in the face of India's expanding stockpile. The same is true for Pakistan with regard to India. France has always been favorable and actively supports the process of creating this treaty, but its stockpile (30.6 tons of highly enriched uranium and 6 tons of plutonium 239) would allow it to produce several thousand nuclear weapons [COL 15]. For nearly 15 years, France has been strongly committed to the negotiation of a treaty banning the production of fissile material for nuclear weapons, known as the Cut-Off Treaty. This is one of the French proposals for disarmament, announced by the President of France in his speech in Istres on February 19, 2015 [FRA 15, FRA 19a].

In spite of this lack of progress, there is hope, however, with the shifting of discussions to the level of the General Assembly. In October 2012, the UN General Assembly voted in favor of a Canadian-sponsored resolution that established a Group of Governmental Experts (GGE) on TIPMF. In 2016, the UN General Assembly adopted another resolution introduced by Canada, and co-sponsored by Germany and the Netherlands, establishing a 25-member High-Level Preparatory Group of Experts (Preparatory Group) to build on the work of the GGE and make recommendations on the substantive elements of a treaty being prepared for negotiation [UN 17a, UN 17b].

At its last meeting in June 2018, the Preparatory Group successfully negotiated a consensus report recommending the elements of a future treaty. The UN Secretary General transmitted this report to the DC in the hope that they will begin formal negotiations on a treaty that will help end the global nuclear arms race [GOU 18].

1.4.4. *Regional disarmament treaties*

Nuclear-Weapon-Free Zone Treaties represent a regional approach to strengthening international norms for nuclear non-proliferation and disarmament, coupled with the promotion of international peace and security.

In 2016, there were five nuclear-weapon-free zones established under different treaties: (a) Latin America and the Caribbean, under the Treaty of Tlatelolco; (b) the South Pacific, under the Treaty of Rarotonga; (c) Southeast Asia, under the Treaty of Bangkok; (d) Africa, under the Treaty of Pelindaba; and (e) Central Asia, under the Treaty of Semipalatinsk.

The Treaty of Tlatelolco was the first international instrument establishing a nuclear-weapon-free zone in a densely populated part of the world.

In addition to these regional zones, the UN recognized Mongolia's self-proclaimed nuclear-weapon-free status by adopting the biennial General Assembly resolution entitled "Mongolia's international security and nuclear-weapon-free status".

In 2018, the treaties of Tlateloko and Ranotonga were signed and ratified by the five nuclear powers. The treaties of Pelindaba and Central Asia have been signed by all five powers, but the United States (alone) has not ratified them. The Treaty of Bangkok is in the process of being signed. The text of these treaties and the list of countries that have acceded to them are available at: http://disarmament.un.org/treaties/ [ONU 18]. The geographic scope of these regional treaties is shown in Figure 1.3.

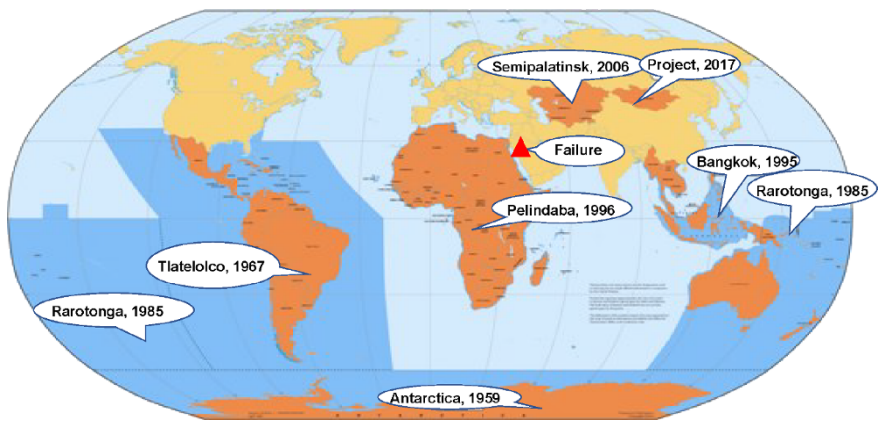

Figure 1.3. *The various regional treaties banning nuclear weapons. For a color version of this figure, see www.iste.co.uk/amiard/disarmament.zip*