ATOMIC ENIGMA: BRUNO PONTECORVO © 2022 by Paul McKay

In the summer of 1947, two years after atomic bombs devastated the Japanese cities of Hiroshima and Nagasaki and brought the Second World War to a harrowing close, two celebrations took place in a newly-minted, idyllic town carved from the Canadian Shield north of Ottawa.

Called Deep River, it was partly built by German prisoners of war in 1944, on a clearing used long before by indigenous peoples. Improbably, it featured a new hospital, schools, recreation buildings, a movie theatre that showed Hollywood and foreign films, and a shopping plaza that stocked the latest mod cons, New York fashions, even caviar.

At one 1947 celebration, an amiable, sun-drenched crowd cheered as the local tennis favorite, Bruno Pontecorvo, won the singles title. At the other, he watched from the control room as a nuclear furnace he chiefly designed sustained a chain reaction with the highest neutron radiation intensity, or *flux*, in existence. Even the Americans then had no such atomic marvel.

The charismatic, cosmopolitan Italian fit perfectly into this nuclear enclave. Pontecorvo was born near Pisa into a distinguished, wealthy Jewish family, had a stellar academic

record, connections with world-renowned scientists, suave charm, a beautiful Swedish wife and three precocious children, a coveted sports car.

Pontecorvo was also widely regarded as the most brilliant among the ‘boffins’ he worked with at the nearby, equally new Chalk River nuclear research site. Many British, French, American and Canadian physicists, mathematicians, chemists and engineers had helped to design, build and run experiments for the only nuclear reactor anywhere outside of America.

After Hiroshima, Canada had declared it would renounce the use of atomic weapons – so the new reactors and scientific work at Chalk River were nominally meant to pursue strictly civilian uses. But that was a mirage.

The first Chalk River NRX reactors were approved and largely paid for by the U.S. War Department precisely because their unique components and design created plutonium – one of the two fissile elements key to atomic weapons.

After 1945, the U.S. continued to underwrite Chalk River construction and operating expenses by purchasing some 250 kilograms of high-purity plutonium for its atomic arsenal. After proof that the Canadian NRX reactor also uniquely produced the key hydrogen bomb ingredient *tritium*, the U.S. military quickly

built four Chalk River clone reactors stateside – to create both plutonium and tritium solely for its atomic arsenal.

All this was first approved under the aegis of the war-time Manhattan Project and its U.S. commander, General Leslie Groves. He vetted and approved atomic research, budgets and security regimes for all nuclear complexes, including Chalk River and the first NRX.

Groves had been promised a military plutonium production reactor that could also spur civilian research as a collateral benefit. A clandestine fissile element factory, with a public fig leaf. That's what Groves paid for, and that's what Canada delivered in 1947.

Pontecorvo had been among the first to deduce this double identity of an NRX, thanks to earlier star apprenticeships in Europe. One was with Enrico Fermi, who later masterminded the worlds first sustained nuclear reaction, and became an elite member of the Manhattan Project bomb design team. The other was with French scientist Frederic Joliet-Curie, a 1935 Nobel Prize co-winner with his chemist wife, Irene.

Both men were working on experiments in Paris with an extremely rare substance called deuterium (or heavy water), when Hitlers armies invaded France in June, 1940. Terrified that

the heavy water might be used in the making of a Nazi atomic weapon, all 185 kilograms were smuggled in barrels to the famed Cavendish physics laboratory in England on a daring, last-second escape. Then Churchill sent commandoes to sabotage the Nazi-held Norwegian plant where that heavy water was created.

By 1944 the French deuterium was in Canada, along with Pontecorvo, two of the French heavy water scientist/guardians, and a French chemist who perfected the way to extract plutonium for bombs there. Joining them were British and Canadian scientists, who soon knew that military uses were embedded in the materials they worked with, and created.

No wonder that General Groves wanted these Chalk River secrets leaked to no other country. Ever. His military and political imperatives were to keep America's atomic and hydrogen bomb monopolies.

No wonder that Soviet dictator Joseph Stalin wanted to break that seal of secrecy, and attain nuclear weapons parity with the U.S., at any cost. Inexplicably, in Pontecorvo he had a perfect pawn.

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The frightening advent of fascism fused with anti-Semitism in Germany, Italy and Spain in the 1930's, and the Great

Depression, had convinced Pontecorvo (then in his early 20's) that the only viable counter-force was communism.

When Hitler and Mussolini passed laws stripping Jews of academic posts, businesses, property and civic rights, Josef Stalin's Russia appeared to be a bulwark of freedom and an avatar of a new world order. Many of Pontecorvo's family members, friends and scientific colleagues also became communists.

They then knew nothing of Stalin's despotic brutality's in every sphere of Russian life: Siberian prisons, slave labour conscripts by the millions, anti-Semitic pogroms, the closing of churches, the mass state takeover of farms, and serial political assassinations ordered by the paranoid supreme commander.

On the surface, it seemed to many, only Stalin would stand up to Hitler and Mussolini. Then Russia signed a 1939 pact with Nazi Germany to jointly invade Poland and carve up that country from east and west. In the aftermath, almost 22,000 captured Polish officers and soldiers were slaughtered in what became known as the Katyn Massacre. The order came from Stalin; it was presided over by his infamous secret police chief, Lavrenti Beria.

When fascists forced Pontecorvo's Jewish family to flee Italy, his communist beliefs deepened. They were buttressed by the Nobel Prize winning Joliet-Curie couple in Paris, where lab experiments with heavy water and 'slow neutrons' ignited fears that elite German physicists would inevitably discover a route to atomic bombs.

So on the eve of war, Pontecorvo's anti-fascist convictions and his scientific mission fused into one alloyed purpose: beat Hitler to The Bomb. As Nazi armies approached Paris in 1940, he and his family fled to the U.S., where he hoped his mentor Enrico Fermi might enlist his brilliant brain.

But a posting at the cutting edge of nuclear physics in America was not immediately possible, especially for an Italian refugee with communist affiliations. Desperate for work to support his family, Pontecorvo invented a 'neutron pulse' receptor gadget to help American oil exploration companies probe formations deep underground. He would later use it to help detect prime uranium lodes in Canada's frozen far north; that ore's only customer soon became the Manhattan Project. One of his British colleagues on that mission later proved to be an atomic spy for Stalin.

Finally, Pontecorvo was offered the chance to join a team designing and testing the first nuclear reactor at Chalk River. Called ZEEP, it was the half-way step between Fermi's famous

basement ‘pile’ of uranium bricks that had first gone nuclear in late 1942, and the far more powerful NRX reactor Pontecorvo would conceive next.

From 1943 to 1949, the nuclear physicist with a love of tennis and sports cars presided at the centre of world-first atomic accomplishments at Chalk River. Its stock of heavy water allowed other top scientists from France, Britain, Canada and the U.S. to do thrilling, ‘slow neutron’ science in the new NRX reactor.

That cutting edge status, and Pontecorvo’s persuasive blend of precision, charm and bold ideas, underpinned a heady *esprit d’ corps* and dazzling results. Some led to advances in nuclear medicine, to insights into sub-atomic particles, and to revelations about elements such as plutonium and tritium – man-made isotopes with only atomic weapon applications. Atomic secrets

The latter was what Russian dictator Josef Stalin desperately wanted. He ordered his murderous Moscow henchman, Lavrenti Beria, to scour western physics labs, bomb production plants, universities, specific industries and experts for atomic secrets, then assemble an elite Soviet science team to turn the fruits of that espionage into weapons only America yet possessed.

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The first chilling evidence of Stalin's atomic bomb quest appeared in Ottawa, of all places, when a lowly cipher clerk at the Russian embassy there attempted to defect in September, 1945.

In a now legendary sequence of the 'you can't make this stuff up' variety, no one in authority would at first believe Igor Gouzenko's claim he had encoded proof that Soviet spies in Canada had access to atomic secrets. He was shunted from doubting police, to feckless federal offices, to a bewildered newsroom, then back through a 'repeat and rinse' cycle.

At one point, the hapless defector was advised to take himself and his purported evidence back to the Russian embassy to avoid a diplomatic incident. Meanwhile, that embassy had sent operatives to hunt Ottawa streets for Gouzenko, with orders to 'capture or kill'.

Eventually the RCMP and the famed Canadian code-cracker William "Intrepid" Stephenson grilled Gouzenko, approved his permanent asylum, and began de-coding copies of secret embassy cables between Ottawa and Moscow.

The verdict was worse than feared: Stalin's agents had been ferreting out every available scrap of atomic and military evidence in Canada since 1943. Some was stolen and passed on by unidentified, sympathetic scientists cultivated by Russia after Hitler double-crossed Stalin and invaded *his* nation.

This put Chalk River scientists in the frame, but so far those who did help the Russians were not exposed. Prime Minister King was alerted; his senior security and diplomatic staff had the unenviable task of telling American and British allies that Stalin had breached the Manhattan Project firewall via Canada.

There were blistering rebukes from Washington, General Groves, FBI chief J. Edgar Hoover, and London (because British scientists still working at Chalk River were implicated by association). One British scientist, Alan Nunn May, was later convicted of giving classified documents and a sample of fissile material to Russia while he was in Canada. He was sentenced to ten years in a British prison.

The Ottawa/Nunn May scandal seemed politically apocalyptic at the time, but in fact *simultaneous* U.S. and British nuclear security breeches were far more egregious. Ironically, the Gouzenko defection in Ottawa prompted American security agencies to dust off thousands of secretly intercepted, yet

unread, cipher messages the Russian consulate in New York and embassy in Washington had cabled to Moscow before 1945.

That Russian intelligence was ingeniously double-encrypted, but with key assistance from British cryptographers what became known as the VENONA trove of secrets was exposed. That allowed the U.S. to secretly de-code contemporaneous Soviet cables sent to Moscow, but also to exhume key details about Stalin's recent infiltration of the Manhattan Project.

Washington was aghast, General Groves humiliated. Virtually every plant and laboratory involved in producing America's atomic arsenal was breached, including the remote, seemingly inviolable bomb design site at Los Alamos.

Key diagrams, blueprints and bomb blast calculations were revealed. Worse, VENONA decryptions showed the atomic espionage was ongoing. And that one of the unidentified traitors was talented and trusted enough to be part of the inner circle working on a hydrogen bomb design – a weapon potentially one hundred times more powerful than the plutonium bomb dropped on Nagasaki.

Unknown to Groves, or even the traitors themselves, all this espionage was directed from Moscow by Stalin's secret police chief, Beria. He was the conduit between the demanding dictator

and his elite Soviet scientists. Tasked with making atomic bombs in a country ravaged by its war with Hitler (and also related debts, a decimated industrial capacity, and scant nuclear experience or physics journals), they were told they faced death if they failed.

With no near-term hope of replicating the Manhattan Project effort to build a vast, expensive industrial infrastructure to enrich uranium-235 for bombs like that dropped on Hiroshima, Beria was pressed by both Stalin and the Soviet scientists to steal all the secrets of reactors that would produce plutonium.

Stalin also ordered Beria to ship thousands of German and Polish POWs, Ukraine nationalists, political dissidents and criminals to work as slave labourers at remote, low-grade uranium mines where donkeys carried ore bags for days to get processed. Only a trickle of uranium was gleaned, so Beria sought a new, highly classified Western gadget to scan Russia's vast territories for high-quality uranium deposits.

Both could be provided by Pontecorvo. Soviet archives confirm Beria's operatives obtained blueprints for the NRX reactor, then the first of four Soviet-built NRX clones went critical in 1949. Soon after, the Soviets were using a 'neutron pulse' device to detect and find richer uranium ore bodies.

There is no definitive proof that Pontecorvo was such a brazen traitor, and for decades after he kept quiet about any complicity with Beria and Stalin.

Russia detonated its first atom bomb in 1949, with Beria proudly watching. Soon after, Stalin approved plans to build hydrogen bombs using plutonium and tritium created in NRX clones, although most Soviet plutonium was created in graphite-based reactors. The first Soviet H-bomb was detonated only three years after the first American one was tested in 1952.

Stalin died in 1953, and months later Beria was liquidated by equally ruthless rivals. So those dead men told no tales about Bruno Pontecorvo. However, we do know the following:

Pontecorvo suddenly left his plum perch at Chalk River in 1949, just as the FBI was reviewing his security clearance status and discovering his past communist beliefs as part of the VENONA aftermath. That FBI dragnet would soon expose some of the Los Alamos spies, and lead to the eventual arrest and execution of Julius and Ethel Rosenberg. After decades of debate, there is no doubt now that they passed on key atomic secrets to Russia.

Pontecorvo himself left Chalk River with his family to take up a leading physics post at Britain’s premier nuclear research

complex at Harwell. None of his charm, theoretical brilliance, or taste for tennis and sports cars were left behind.

He impressed his elite colleagues, especially two top British physicists who were welcomed at Los Alamos during the Manhattan Project and after. Both had fled Hitler's Germany vowing to help build an atomic weapon before Nazi scientists did.

One, Rudolf Peierls, was later cleared of false claims he spied for Stalin, and honoured with a knighthood. The other, Klaus Fuchs, was then under belated scrutiny by Britain's secret service for possibly giving Stalin's agents nuclear classified documents – including key details about hydrogen bomb performance Fuchs had worked on at Los Alamos.

Soon after the counter-espionage curtain fell on Fuchs, his Harwell colleague and fellow communist Bruno Pontecorvo announced a family vacation to Italy, mere months after he arrived. Then followed a flight to Sweden, nominally to visit his wife's parents. A flight to Finland came next, then a clandestine car trip to the Russian border – with Pontecorvo hidden in the trunk.

Pontecorvo had vanished from the West. The timing was impeccable, the rewards debatably handsome.

Klaus Fuchs was convicted and spent nine years in British jails after confessing and pleading guilty to being an atomic spy for Russia. On his release, he was deported to communist East Germany. Of all the atomic spies, it is generally agreed that the nuclear secrets Fuchs passed on to Stalin were the most precise and dangerous. He also reportedly aided Communist China in the same way.

By contrast, Pontecorvo was honored with a prize post at Russia's top physics research complex at Dubna, a Kremlin-approved medal for scientific service to the nation, a prestigious Moscow apartment, a limousine and driver, a country dascha, and lifetime salary/pension.

This allowed him to continue his brilliant probes into the nature of neutrinos and cosmic rays he began at Chalk River. But that new research had little practical or military value to Stalin's successors – and only rarely was he noted in western journals. With few exceptions, he was forbidden to travel outside the Soviet orbit.

Some physicists believe Pontecorvo lost out on a Nobel Prize because of this, and over time his genius regained some of its lustre before he died in 1993. In a strange twist of fate, he was elated to learn that his solar neutrino hypothesis was about to be tested by experiments deep in a Canadian mine shaft in Sudbury.

He was proved right, a half century after his Chalk River prediction.

What relevance does the enigmatic Pontecorvo have today?

Setting aside his deserved stature as an elite theoretical physicist of the 20th Century, his story has elements of Greek tragedy akin to the fall from grace of Robert Oppenheimer – the "American Prometheus" physicist/architect of the Manhattan Project.

After an initial surge of pride and an afterglow of praise, Oppenheimer was gradually overcome with shame and remorse about what was wrought at Hiroshima and Nagasaki.

He knew an atomic arms race was inevitable, and that other bright minds would glean fatal secrets. After lamenting to President Truman that he had 'blood on his hands', a scornful Truman banned Oppenheimer from his sight, approved building even more powerful hydrogen bombs, and slow-walked non-proliferation appeals from former Manhattan Project scientists.

It was likely the fastest 'hero to zero' case in American history; Oppenheimer died an anguished, hollowed-out ghost. A failed figure of pathos, rather than a scarred but proud hero.

Bruno Pontecorvo may have been a more dazzling physicist than Oppenheimer at the chalk board, but he did not have nearly the same stature, and his fall from grace was less a center-stage tragedy than a decades long, gilded cage reckoning with false idols.

When asked about his incomprehensible allegiance to Stalinist communism until Soviet tanks surrounded Prague in 1968, Pontecorvo quietly confessed: “I was a cretin.” For a man who prided himself most on his diamond-bright intellect, it was a devastating answer.

Years later, nearing death and still a Soviet citizen, an unwelcome apparatchik sought to coax Pontecorvo into disclosing for posterity why he had chosen his adopted country.

“I want to die as a great scientist,” he snapped. “Not as your fucking spy.”

Perhaps this was Bruno Pontecorvo’s final, unintended admission that he was both. And proof that he was oblivious to an elementary equation: Dozens of countries with thousands of nuclear weapons could not add up to a safer world.

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Now, eighty years after the race for atomic weapons began, enough details have been unearthed to disclose which global proliferation pathways can be traced back to Chalk River. The pattern embodies both the laws of nuclear physics, and men like Bruno Pontecorvo who possessed both incandescent brilliance and appalling judgement.

Proof abounds in official histories of atomic agencies of the U.S., Canada, Britain, France, India and Pakistan; from scholarly reports, memoires, biographies, unclassified archives and de-coded diplomatic cables of the former Soviet Union; and from respected historians and investigative reporters. Taken together, the following history comes into focus:

- Led by Bruno Pontecorvo, scientists at Chalk River first designed and perfected a reactor (NRX) which used natural uranium and heavy water to maximize neutron bombardment density, which in turn produced a high ratio of plutonium and tritium.

- Also at Chalk River, the French chemist Bertrand Goldschmidt devised a way (PUREX) to extract the plutonium from reactor waste using nitric acid and a special solvent nicknamed Trigly.

- The U.S. military immediately recognized this Chalk River reactor as the fastest, cheapest, most efficient route to plutonium bombs. So it purchased all future NRX plutonium, built four cloned NRX versions in the U.S., and used the PUREX method to extract the fissile material for decades. It also extracted tritium from the same reactors.

- Many nuclear experts who worked at Chalk River returned to an atomic research site in England (Harwell), then parlayed much of what they had learned in Canada to help produce and extract plutonium and tritium for the British atomic arsenal.

- Key French scientists (Kowarski, Goldschmidt) who worked at Chalk River replicated the NRX to create and extract plutonium and tritium for France's *force du frappe* arsenal. Called the EL-1, it went critical in 1948.

- Then France passed its secrets on to Israel, which built an NRX clone beneath the Negev desert at Dimona, and a related plant to extract and purify plutonium using the PUREX process first used at Chalk River. It has served as the primary source for Israel's plutonium bombs since 1964.

- Using a Canadian-donated, modified NRX, India produced and extracted plutonium to detonate its first nuclear bomb in 1974, then subsequently built more NRX

clones and Candu reactors to expand its plutonium inventory

- India's arch-rival Pakistan (then a military dictatorship) copied that India playbook, using a scaled-up NRX reactor (Candu) to produce grid power, plutonium and tritium for its weapons program. Pakistan then built four more NRX plutonium production clones to bolster its atomic arsenal.

- Pakistan then parlayed its nuclear weapons production secrets to North Korea in exchange for advanced missile technology. That dictatorship can now produce both plutonium and uranium bombs, and has an estimated combined stockpile of 60 or more.

- North Korea, Pakistan, China and Russia then transferred reactor technology, materials and training to build an NRX clone at Arak in Iran. Alarmed about the prospect of that country acquiring plutonium for atomic weapons, the U.S and European allies imposed sanctions on Iran (which were soon after scrapped by President Trump)

- Canada donated an NRX reactor to Taiwan when it was ruled by a military dictatorship, but it was shut down after U.S. intelligence warned of pending military misuse

- Canada sold vastly scaled up, power-generating models of the NRX (Candus) to military dictatorships in Argentina,

Romania, South Korea and Communist China. These heavy-water, natural uranium power reactors all produce a high ratio of plutonium-239 and tritium.

This history makes it clear that the only dividing line between military and civilian uses of Canadian reactor technology is *intent*.

Plutonium-239 is an entirely man-made element which – once created – has an immutable half-life of 24,100 years. That's how long it will take to lose just half its mass and radioactive energy. It will take far longer to decay to the point where it vanishes as a proliferation threat.

In essence, plutonium is forever. The laws of physics give it a longevity beyond the bounds of generations, centuries and even civilizations. Those same laws of physics also endow plutonium with a latent lethality almost beyond comprehension.

The "Fat Man" bomb that devastated Nagasaki in 1945 was crude by current standards – yet had ten times the explosive force of the "Little Boy" uranium-235 bomb which blasted Hiroshima three days earlier. It converted only 600 milligrams of uranium-235 – the weight of a butterfly – into apocalyptic heat and radiation energy.

Moreover, because plutonium warheads have weight and space advantages over uranium bombs, miniaturization allows them to be put on cruise missiles, or long-range rockets armed with multiple warheads that can destroy many Nagasaki's simultaneously.

Named after the Greek god of the underworld, plutonium is now the optimal weapon of mass destruction. A modern warhead requires only 5 kilograms. Some 450 tonnes has been created since the 1940's. There is no rational motive to make another gram.

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Almost eight decades ago, some spy sent the Russian dictator Josef Stalin the blueprints for the plutonium producing NRX reactor. Just like the U.S. under Truman, the Soviet military began using cloned copies (and graphite-based variants) to make plutonium and tritium for its atomic arsenal. As did France, Israel, India and Pakistan among others.

United by a common bond of communism, Stalin's successors dealt China a nuclear 'full house' in the late 1950's: all the technical training, designs, technology, and knowledge to replicate the $2 billion Manhattan Project. As if to jeer America's doomed attempt to keep its atomic monopoly, even a Soviet-made replica of the Nagasaki plutonium bomb was included in the package deal.

That wholesale transfer of atomic secrets allowed Beijing to acquire its first atomic bombs at minimal cost, with virtually no spying required. In short, a free ticket to the elite Nuclear Weapons Club. That in turn helped garner Communist China a permanent seat on the powerful U.N. Security Council.

China detonated its first A-bomb at a Gobi Desert site in 1964, then developed hydrogen weapons capable of being delivered by long-range missiles. China later passed on many atomic secrets to allies like Pakistan, North Korea and Iran. Today, China is accelerating plutonium production using advanced 'breeder' reactors, which are expected to go critical by 2025.

Much of the Russian plutonium created long ago still exists today, either in active warheads pointing westward or in protected stockpiles. But now that country, after a tumultuous century bereft of democracy, has a Stalin clone.

Vladimir Putin has shown he will stop at nothing to attain his self-ordained 'I *am* the State' destiny. The Russian shelling near the Zaporizhzhia reactor complex in a Ukraine under siege, and threats to unleash nuclear terror in Europe if Sweden and Finland join NATO, is proof enough. It is beyond reckless – the gambit of a madman.

The very nature of plutonium is not compatible with civilization because its lethality and longevity make it

diabolically immortal. It is, simply and starkly, too powerful for mere mortals like Stalin, Putin and Pontecorvo, Oppenheimer and Truman, Indira Gandhi and Golda Meir, the mullahs of Iran, the warlords of China and North Korea, the former generals of France and Pakistan.

No person, no country, no ideology, and no religion can be trusted with it. This is a lesson Canada has abjectly failed to learn, and its blithe, global dispersal of reactors which enabled plutonium production has earned it the title: “Atomic Accomplice”. The same applies to uranium exports – the primal source in the nuclear weapons supply chain.

To export more reactors and uranium in the guise of averting climate change, or to promote reactors which intrinsically magnify plutonium production and extraction dangers, amounts to gifting current Putins and future Hitlers the weapons of their dreams.

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