feature article

Adventures in scientific nuclear diplomacy

Siegfried S. Hecker

A former director of Los Alamos National Laboratory offers a first-person perspective on the important contributions scientists can make toward improving the safety and security of nuclear materials and reducing the global nuclear dangers in an evolving world.

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On 11 November 2010, Ambassador Li Gun of North Korea leaned over the dinner table at the Pothonggang Hotel in Pyongyang and said to me, "Tomorrow, Dr. Hecker, you will have really big news." So started my most recent adventure in science diplomacy. The following day, the chief process engineer of a new nuclear facility at North Korea's Yongbyon complex led me and my Stanford University colleagues John Lewis and Robert Carlin up the polished granite steps to the observation windows overlooking the stunning site of 2000 centrifuges in a modern uranium-enrichment plant. Most Western analysts, including me, had not believed North Korea could build such a facility, and North Korea had previously denied its existence vehemently. "We did not want to show you this facility," the engineer told us. "But our superiors made us do so." We published our findings soon after, and the news was an international blockbuster.

The visit was one of more than 80 international scientific trips I have made with colleagues in the past 25 years. In visits to Russia, China, India, Kazakhstan, and North Korea, we helped bring together some of the world's top nuclear scientists in an effort to tackle the challenges of managing the awesome power of atomic energy. During those visits, we built trust with one another, developed ways of protecting the world's nuclear arsenal and stocks of fissile materials, and helped create the kind of diplomatic space required for policymakers to effect long-lasting change.

From competition to collaboration

My extraordinary journey, which is still ongoing, began in 1968 at the laboratory orientation for new employees at Los Alamos National Laboratory, where I was starting a postdoctoral fellowship. There, I was struck by the words of Norris Bradbury, J. Robert Oppenheimer's successor as director of the laboratory: "We don't build bombs to kill people; we build them to buy time for the leaders of the world to find other ways of solving the world's problems." Over the next 20 years, I pursued my interests in metallurgy and materials with a special focus on plutonium, the most complex of all the elements. Then, in January 1986, in the depths of the cold war, I became director of the laboratory, and turned my attention to international nuclear policy because I was convinced that the leaders of the world needed help solving the world's problems—and that we scientists had a critical role to play.

Soviet and US scientists had collaborated during the cold war to confront the dangers of atmospheric nuclear testing and the nuclear arms race. But scientists and engineers in US and Soviet nuclear weapons laboratories had little contact because we were in a technological race, both to stay ahead of

Figure 1. "I have been waiting 40 years for this." With those words, Yuli Khariton (center), the 88-year-old scientific leader of the Russian Federal Nuclear Center–All-Russian Research Institute of Experimental Physics (RFNC-VNIIEF), greeted me along with my colleagues on the tarmac in the closed city of Sarov on 23 February 1992. At a banquet that night, Khariton explained how they got the bomb, including the role of Klaus Fuchs, who passed atomic secrets from Los Alamos to the Soviet government. Khariton spoke remarkably good English, with a British accent he acquired while a student of Ernest Rutherford's at Cambridge University from 1926 to 1928.

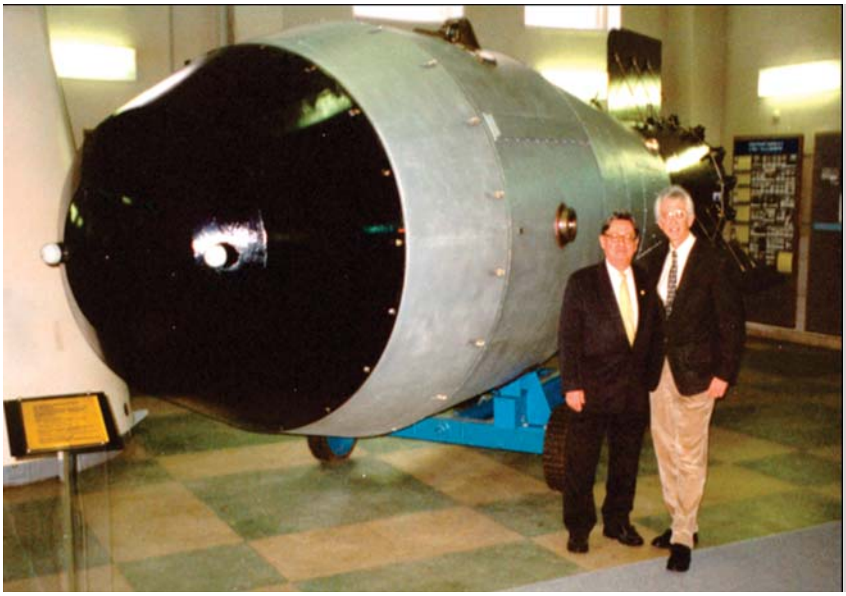


Figure 2. Yuri Trutnev of the RFNC-VNIIEF with me at the Russian Atomic Weapon Museum, in Sarov, next to the 100-megaton "Tsar Bomba" he co-designed with Andrei Sakharov. Over dinner that night at his house, I asked him to resolve an argument I had with one of my Los Alamos colleagues: When the bomb was detonated at half the design yield on 30 October 1961, did it produce 50 or 57 megatons? Yuri simply stated, "At that level it doesn't matter." He went on to explain that the bomb had no military utility and wasn't particularly challenging; the most challenging designs were the small, peaceful nuclear devices that had to be particularly clean in terms of radioactive contamination.

one another and to avoid technological surprise. What moved us from competition to collaboration was the summit between Ronald Reagan and Mikhail Gorbachev in Reykjavik, Iceland, in October 1986. Although the two leaders did not achieve their goal of eliminating nuclear weapons because of Reagan's stubborn insistence on developing ballistic missile defenses, they tasked Soviet and US nuclear scientists with developing verification techniques to help ratify the 1974 Threshold Test Ban Treaty (TTBT). The Joint Verification Experiments, designed to build confidence in verification technologies, brought the scientists and engineers from the Soviet nuclear weapons institutes to the US nuclear test site in Nevada and brought US specialists to the Soviet's Semipalatinsk test site in what now is Kazakhstan.

After months of preparation, on 17 August 1988 my US colleagues and I sat in the control room at the Nevada Test Site during the countdown for our underground nuclear test, code-named Kearsarge. The setting was surreal: There in the control room of that supersecret US facility, I sat across the table from Viktor Mikhailov, scientific leader of the Soviet delegation, later to become the first Russian minister of atomic energy. I was hoping our device would work but not exceed the permitted limit of 150 kilotons, and he was hoping his emplaced cable would function, measure the yield accurately, and validate seismic measurements made in the US and Soviet Union. Everything worked, the test was a success, and it, along with a reciprocal test on 14 September at Semipalatinsk, cleared the remaining hurdles to allow ratification of the TTBT in 1990.

The Joint Verification Experiments exposed each side to the idea that we could work toward a common objective instead of as adversaries. We gained respect for one another, and the meetings cracked open the door to future scientific collaboration.

Lab-to-lab contact

That door opened wider still when in 1991 it became evident that the collapse of the Soviet Union was imminent. At a meeting of the Department of Energy laboratory directors on 16 December 1991, Secretary of Energy James Watkins expressed President George H. W. Bush's concern about Soviet nuclear security and the potential of brain drain from Soviet weapons laboratories. Sitting there in Washington, I knew that closer ties between Soviet and US scientists could be a difficult sell because the cold war mindset was still deeply entrenched in Congress and nothing short of Soviet disarmament would do for some cold warriors. But I used the occasion to push for an exchange visit of US and Soviet nuclear weapons laboratory directors. Watkins, having just come from a meeting at the White House, immediately supported the idea.

Within days, the Soviet Union collapsed. Four nuclear states were born out of one: Russia, Ukraine, Kazakhstan, and Belarus. The roughly 1 million people employed in the Soviet nuclear complex, military and civilian combined, suddenly faced dire economic hardship. The Russian government was bankrupt, which meant the guns required to secure the nuclear sites were not always loaded, the guards often went unpaid, and the security services were in disarray. The security of the Soviet arsenal of tens of thousands of nuclear weapons and more than 1000 tons of fissile materials was in question.

By February the directors of the two Russian nuclear design labs visited Lawrence Livermore and Los Alamos National Laboratories. Almost immediately after, Livermore director John Nuckolls and I, accompanied by two senior scientists each, were on our way to the secret sites of Arzamas-16, the Russian Los Alamos in the closed city of Sarov, nearly 500 km east of Moscow (figure 1), and then Chelyabinsk-70, the Russian Livermore in the town of Snezhinsk in the Urals.[1] Such meetings helped establish the trust and confidence required to collaborate on the greatest vulnerability resulting from the Soviet breakup—namely, the security and safeguards of Russia's huge stock of fissile materials: highly enriched uranium and plutonium.

The US government shared those concerns. Senators Sam Nunn and Richard Lugar sponsored legislation that became known as the Nunn–Lugar Cooperative Threat Reduction (CTR) Program. It provided US support for the destruction of Soviet nuclear weapons, their secure transport, and verifiable safeguards against proliferation. The government-to-government CTR programs run by the US Department of Defense facilitated the secure return of Soviet nuclear weapons from Ukraine, Kazakhstan, and Belarus to Russia. But claiming they were in control of the situation, officials from the Russian Ministry for Atomic Energy (Minatom) declined US government help to secure the enormous stocks of fissile materials. Unfortunately, it was the fissile materials, spread out over the immense former Soviet landmass, that represented the greatest immediate security risk. Whereas the weapons had serial numbers and were still controlled by guards, the large stocks of weapons-usable material existed in hundreds of sites and buildings in every imaginable form.[2]

In parallel with the official government channels, my colleagues at the US nuclear weapons labs and I developed a track that we later called lab-to-lab: US and Russian nuclear laboratories working in partnership to deal with the new nuclear dangers. In 1994 I received the backing and financial support from Undersecretary of Energy Charles Curtis to launch the lab-to-lab nuclear material protection, control, and accounting (MPC&A) program with Russian nuclear institutes. The program was designed to provide US financial and technical assistance to help the Russians secure and safeguard their nuclear facilities and nuclear materials. To get governmental approvals for the lab-to-lab approach, we US scientists persuaded Washington, and our Russian counterparts persuaded Moscow, that together we could make progress without jeopardizing the secrecy required for the sensitive Russian facilities.

On behalf of DOE, I signed the first MPC&A contracts with three Russian institutes in June 1994, and over the next 17 years, hundreds of US scientists, engineers, and technicians from the DOE nuclear laboratories worked side-by-side with their Russian counterparts (see figure 2) to help secure and safeguard the Russian nuclear materials. We enlisted several Russian civilian institutes to make rapid security upgrades at their facilities. We also brought Russian scientists and officials to US nuclear sites, including the plutonium facility at Los Alamos, to let them see firsthand how we handle physical security, control, and accounting of nuclear materials.

The lab-to-lab contact not only helped secure Russian nuclear materials, it also helped bring a sense of hope to Russia's beleaguered nuclear workers. No technology can succeed if its stewards are constantly stressed to the breaking point. Such was the case in the Russian nuclear complex. People in the closed cities went overnight from lives of privilege to poverty. During several of our visits to the Russian nuclear cities we found that our colleagues had not been paid for three to six months and were living only on credit they got at the local grocery stores. The people-focused programs, such as our scientific collaborations (see the box on page 36), the DOE Nuclear Cities Initiative and Initiative for Proliferation Prevention programs, and the State Department's Institute for Science and Technology programs brought financial support to the nuclear cities and showed Russian nuclear workers that they had a future in nonweapons work, and that someone cared about their well-being.

When the Comprehensive Nuclear-Test-Ban Treaty (CTBT) was signed in 1996, President Bill Clinton gave us the green light to work with our Russian counterparts to ensure that each side's nuclear arsenal remained safe, secure, and reliable in the era of no nuclear testing.[3] The collaborations gave both nations a glimpse of how the other pursued stockpile stewardship (see figure 3). Those efforts enhanced transparency and gave greater confidence that weapons safety and security was receiving adequate attention.

Unfortunately, over the past decade, lab-to-lab cooperation has declined substantially. US–Russian nuclear cooperation became bureaucratically more constrained, the Russian security services restricted the access afforded US scientists in the 1990s, and the Russian nuclear complex was no longer in dire financial straits. It is time to renew lab-to-lab cooperation. A new US–Russia civilian nuclear agreement is in place that provides an opportunity to collaborate on nuclear power. And the challenges we face in reducing nuclear arsenals, stopping the spread of nuclear weapons, and preventing nuclear terrorism would all benefit greatly from increased technical cooperation.

Securing Kazakhstan

After stepping down from the Los Alamos directorship in November 1997 to return to research, I began spending more of my time on nuclear materials security around the world. That included more time in Russia, to which I have made 42 trips so far, and in Kazakhstan. During Soviet times, Kazakhstan was an integral part of the Soviet nuclear and space programs. In addition to many other nuclear research sites, the republic housed the Baikonur space center; the Semipalatinsk nuclear test site, which included three research reactors; the huge Ulba metallurgical complex in Ust-Kamenogorsk; and a fast breeder reactor in Aktau on the Caspian Sea. The Soviets conducted 456 nuclear tests, both atmospheric and underground, at Semipalatinsk. (Ukraine and Belarus also had numerous sites with inadequate nuclear materials security measures. I was not involved in their MPC&A programs, but my colleagues from the DOE nuclear labs were.)

Although Kazakhstan returned Soviet nuclear weapons to Russia thanks to Defense Secretary William Perry and his Pentagon team, it did not return the nuclear materials, and their security was my principal concern. Only the Russians would know what they had left behind at the test site and in the rest of the huge enterprise in Kazakhstan, but at first my Russian colleagues told me that their government had no intention of sending them back to Kazakhstan. Moscow was concerned that it would be held liable for the health and environmental consequences of Soviet nuclear tests.

I visited the test site in 1998 with Kairat Kadyrzhanov, head of Kazakhstan's Institute of Nuclear Physics (see

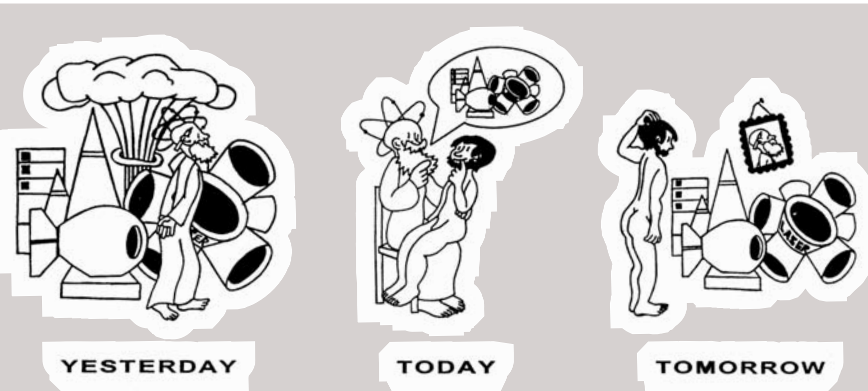


Figure 3. Russian depiction of challenges of stockpile stewardship. RFNC-VNIIEF director Rady Ilkaev presented this diagram at one of our meetings circa 1999. We had many discussions about how the US and Russia would each ensure the safety, security, and reliability of its nuclear stockpile. He called our stockpile stewardship program brilliant and lamented Russia's inability to invest in advanced computational capabilities and new facilities because of financial hardship.

Figure 4. Kazakhstan's Semipalatinsk test site. My first visit in 1998 was extraordinary. We entered the test site through the abandoned guard station (left). Then we saw kilometers of trenches (right) dug throughout the vast site by copper-cable thieves, whom the Kazakhs were neither prepared nor inclined to stop. Amid eerie remnants of concrete diagnostic towers, we visited ground zero of the first Soviet nuclear test, and we visited the three research reactors on site. Once upon a time, the reactors were among the most ambitious and innovative Soviet reactor facilities. Now, the chief operator told us, "we have only memories of the good times." Over the past decade, collaborative US, Russian, and Kazakh efforts have made much progress in improving the security of the nuclear materials there.

figure 4). We stood at ground zero of the first Soviet test and assessed the site's security risks. When I subsequently shared my findings and concerns with Russia's nuclear specialists, I was able to get them to return and share their knowledge of the Soviet test and experimental history at the site to help us in a trilateral effort to mitigate the potential risks. Much progress had been made in improving nuclear materials security at Semipalatinsk by the time of my visit last September. During that visit we also explored ways in which Kazakhstan could become a model for nuclear energy development without nuclear proliferation, particularly in light of its recently becoming the world's largest exporter of uranium for reactor fuel.

Collaboration with China

Having seen the post-Soviet nuclear materials vulnerabilities firsthand, I began in 1994 to look more closely at the Chinese nuclear complex. I made an exploratory visit to Fudan University in Shanghai and to Chinese civilian and military nuclear laboratories in Beijing in the early part of that year. Soon after, I persuaded Washington to approve a visit to Los Alamos by high-ranking Chinese nuclear weapons officials. That October I took a Los Alamos team to Beijing and to "China's Los Alamos," the Chinese Academy of Engineering Physics in Mianyang, Szechuan Province. The US knew very little about the state of China's scientific nuclear enterprise. As in our first visit to the Russian nuclear weapons complex, we were surprised by how open and engaging our Chinese counterparts were. We were impressed by their experimental facilities. We also saw that they practiced nuclear security Soviet style—that is, primarily through physical protection. Unlike Russia, however, the Chinese government was still firmly in control, and its stockpile of nuclear materials was a small fraction of the Soviets'.

Chinese scientists proposed scientific collaborations over a wide range of topics, including nuclear energy, environmental modeling, civilian technologies, and nuclear monitoring technologies. We took our list back to Washington with the recommendation that we start slowly with a lab-to-lab collaboration initially focused on MPC&A; DOE and the National Security Council concurred. Scientific collaborations were riskier than with the Russians because the Chinese weapons program was not as sophisticated as the Russian program. As a result, the Chinese could learn much more from technical cooperation with their US counterparts. During the next several years, technical specialists from the US nuclear labs made slow but significant progress in MPC&A with Chinese counterparts. The effort culminated in a joint MPC&A demonstration at a civilian Chinese nuclear facility in Beijing in 1998.

Then in April 1999 the axe fell on US–China nuclear cooperation. The congressional Cox Report[4] stated that "PRC [People's Republic of China] penetration of our national weapons laboratories spans at least the past several decades and almost certainly continues today." The Chinese weapons institutes and the US labs, Los Alamos in particular, were implicated—unjustly, in my opinion—in transferring nuclear weapons secrets to China. A Stanford group[5] challenged the veracity of the Cox Report, but the damage was done. US relations with the Chinese nuclear scientific community were devastated. Both Los Alamos and the Chinese institutes suffered because of domestic political pressures. All scientific cooperation was terminated, and meaningful contact was not reestablished until 2004.

Since then, the DOE labs have resumed MPC&A collaborations with the Chinese civilian nuclear institutes, but similar efforts have not been reestablished with the defense institutes. I have also worked with Chinese nuclear weapons specialists to compare assessments of North Korea's nuclear program and to discuss the challenges of CTBT ratification in a world with fewer or no nuclear weapons. But at a time when contact between the Chinese and US nuclear weapons laboratories could help to clear up some of the mistrust and misperceptions about the nuclear programs on both sides, little such contact exists.

South Asia's nuclear risks

After I left Los Alamos in 2005 and joined Stanford Univer-

Figure 5. The Yongbyon nuclear complex during my August 2007 visit to North Korea. Unlike during my first visit in 2004, my hosts allowed me to see the plutonium laboratory. It would not have passed safety protocol at Los Alamos National Laboratory. Although I had reservations about venturing into the lab, whose electricity had just been turned back on after a power outage, I entered suited up (third from right). The tour was most informative, and I was able to make a good assessment of their plutonium capabilities and capacities. That visit convinced me that Pyongyang was prepared to shut down plutonium operations at Yongbyon. They now still appear to be, although my November 2010 visit suggested an alternate route to the bomb: uranium enrichment.

sity, I began to expand my outreach to India, Pakistan, Iran, and North Korea. The Stanford "Five-Nation Project" brought together political and physical scientists, along with current and former government officials, from Pakistan, India, Russia, China, and the US in an effort to defuse the tensions and control the dangers resulting from India's decision to conduct a series of nuclear tests in 1998, which were followed by Pakistani nuclear tests two weeks later. Those tests and the ensuing nuclear buildup between the two historic rivals make South Asia the most likely place for a nuclear confrontation.

Pakistan is also at the top of my list of nuclear risks because it is the most likely place in which fissile materials could find their way out of the hands of government and into those of terrorists. However, it is also the most difficult place to do science diplomacy. The five-nation dialog facilitated discussions with Pakistani officials on nuclear materials security and the proliferation activities of Pakistani nuclear scientist Abdul Qadeer Khan. But Pakistan's nuclear scientific community is not accessible, and the problems are difficult and extremely sensitive politically.

My visits to India, by contrast, have proved to be quite productive. Following the "peaceful" nuclear explosion India conducted in 1974, its nuclear complex was under sanctions for 34 years, until the US–India nuclear deal in 2008. But over the past six years, I have made five visits there, traveling to see the Bhabha Atomic Research Center in Mumbai, which houses both civilian and weapons research, and the Indira Gandhi Center for Atomic Research in Kalpakkam, which is focused primarily on fast reactors. I toured Indian commercial nuclear reactor facilities and learned about their ambitious plans for a three-stage nuclear energy program. I found a superbly trained community of nuclear scientists and engineers with a passion for nuclear energy—the bomb business at the laboratories appears to be more of what an Indian colleague called a "cottage industry."

Constrained by sanctions, India developed most of its nuclear energy capabilities indigenously, especially its excellent nuclear R&D; the extent and functionality of its nuclear experimental facilities are matched only by those in Russia and are far ahead of what is left in the US. I believe India has the most technically ambitious and innovative nuclear energy program in the world. Our government has been concerned about leakage of US nuclear technologies to India, when we should instead be trying to learn from that country.

Further science diplomacy with India can help tackle the many serious challenges posed by its nuclear program. Building trust is critical. Many in India continue to believe Washington wants to stop both its weapons and civilian programs. At the same time, India's 2008 nuclear deal with the US and the strengthening of the Indian military have elicited very negative responses from Islamabad: Pakistan is rapidly building up its plutonium-producing reactors to strengthen its deterrent against India. What's more, India is not a signatory of the Nuclear Non-Proliferation Treaty (NPT), and treating India as a special case in the nonproliferation regime undermines the regime.

During my most recent visit to India earlier this year, I found an encouraging new interest in light-water reactors (LWRs) and a bit more caution about moving ahead aggressively with plutonium breeder reactors. Such moves would not only produce more electricity for that energy-starved nation but also reduce the potentially serious safety and security vulnerabilities of its nuclear program.

The most difficult countries in the world

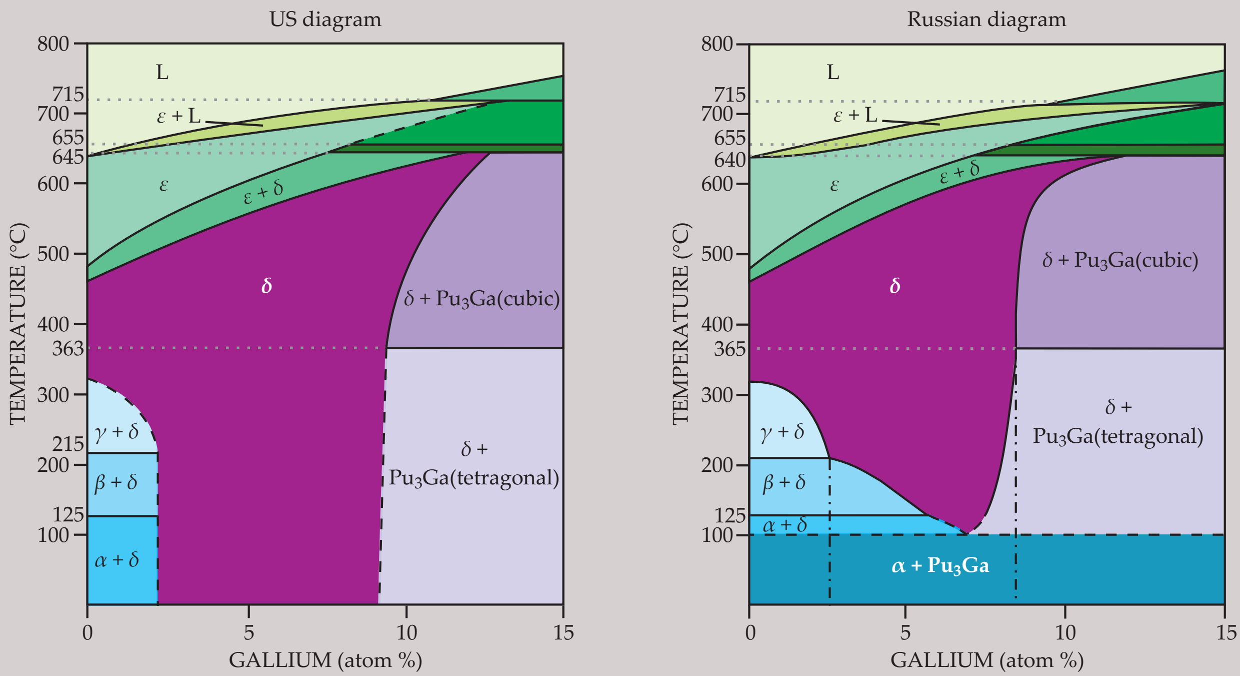
Over the years I have made many visits to the UK and France to support our mutual nuclear agreements, those with the UK being comprehensive and those with France focused primarily on nuclear weapons safety. I have worked with Germany, Japan, South Korea, and Mongolia to promote cooperation in the nuclear sciences and nuclear energy. I have also tried to tackle difficult proliferation challenges by dealing with scientists and officials of some of the most difficult countries in the world: Iran and North Korea. I focus on North Korea here since I have had the opportunity to visit its nuclear complex.

The big news of November 2010 matched that of 8 January 2004, when I made my first visit to North Korea and the Yongbyon nuclear complex. Stanford's Lewis, who had been to North Korea nine times on so-called Track II (unofficial, nongovernmental) visits, invited me to accompany him during a particularly delicate time in US–North Korean relations.

Pyongyang choreographed my 2004 visit carefully—showing us as much of its nuclear program as it believed necessary for us to conclude that it had the bomb, short of showing us the bomb. Yongbyon scientists took us through the plutonium production reactor, which had been idled in 1994 by the US–North Korean Agreed Framework but restarted in

Plutonium metallurgy

One of the most gratifying collaborations for me has been the pursuit of a fundamental understanding of the physics and metallurgy of plutonium and the actinides. Much as the US has been studying the puzzling behavior of plutonium, so have the Russians, particularly at the Bochvar All-Russian Scientific Research Institute for Inorganic Materials in Moscow. That effort has been led for the past 30 years by Lidia Timofeeva, shown here with Boris Litvinov, chief designer, and Evgeny Kozlov, dynamic properties specialist, both with the All-Russian Scientific Research Institute of Technical Physics, and me. When my Russian colleagues in the weapons institutes were not able to answer my scientific queries about plutonium, they told me that such expertise resides not in their institutes but rather at Bochvar. My 1998 introduction to Timofeeva has led to many discussions and 10 workshops on fundamental plutonium science. It also resulted in a publication, "A tale of two diagrams," in which we resolved a 40-year disagreement on the plutonium–gallium phase diagram—in the Russians' favor: The δ phase of plutonium, the phase with desirable engineering properties, is thermodynamically unstable.[8] So its use in weapons is thanks to the slow kinetics. I would have preferred to be saved by thermodynamics rather than kinetics, especially considering that we still have lots to learn about plutonium's self-irradiation effects. (Plots adapted from ref. 8.)



2003 after North Korea withdrew from the NPT; to the spent fuel pool to show that the 8000 spent fuel rods stored there during the Agreed Framework were gone; and to the plutonium reprocessing facility, in which they claimed to have extracted the plutonium produced while the reactor was operational from 1986 to 1994 (an amount we estimated to be approximately 25 kilograms).

When I expressed skepticism that they had actually accomplished all they claimed, they asked if I wanted to see their "product." "You mean the plutonium?" I asked. "Why, yes," they responded, and they took the extraordinary step of showing me a sample of metallic plutonium. I wound up in a conference room holding a sealed glass jar with 200 grams of what they said was a scrap piece of plutonium from their most recent casting. It was heavy and warm. The North Korean technical specialists and I had a remarkably candid exchange about the details of the characteristics of the plutonium in that jar.

Upon my return to Washington, I reported that based on what I saw in Yongbyon we must assume North Korea can make a rudimentary bomb. The US government learned a lot from that visit, since it had cut off contact with North Korea in late 2002. My visit and the manner in which I presented the results opened the door for a visit to North Korea every year since 2004, including four to Yongbyon, each featuring candid discussions with Yongbyon scientists and government officials[6] (see figure 5).

The November 2010 uranium-enrichment revelation was the result of a relationship built over many years. Pyongyang had learned to trust me to report my observations accurately and they were apparently willing to gamble on how I would analyze what I saw. For example, the official line from Pyongyang during last year's visit was that they began an LWR program and the associated uranium-enrichment program in 2009 only after all attempts to get LWRs from the outside were rebuffed. I concluded, however, that to have come as far as they did in their centrifuge facility they must have started decades earlier, in direct contradiction to what they had been telling the world and in breach of their agreements.[7]

Scientists' important role

Twenty years after I started lab-to-lab contacts, I believe more firmly than ever that scientists can be an important part of international security diplomacy. Scientists look through different lenses from politicians and build different relationships—often deeply personal friendships. They speak a common language and usually respect each other, which makes it easier to build trust. Communications are much less formal, with email instead of diplomatic cables, and scientists can explore a broader spectrum of potential solutions than government officials can.

To conduct science diplomacy effectively, I've found it is crucial to work constructively with the government. But sharing findings with the public at large is also important. In his landmark book *Stalin and the Bomb* (Yale University Press, 1994), my Stanford colleague David Holloway observed that nuclear history is not only the history of weapons but also of societies and individual destinies: "This fact was obscured . . . during the cold war, and yet it is in the human dimension of nuclear history that one has to look for hope that the nuclear danger can be overcome."

I agree with that sentiment, and as former director of Los Alamos National Laboratory, the birthplace of the bomb, I feel a special professional obligation to help manage the evolving global nuclear dangers. Personally, the many collaborations changed my life, and I believe the same is true for all those involved. Society benefited, too. The relationships we established built trust and had concrete effects—and they continue to buy time for the leaders of the world to find other ways of solving the world's problems.

I thank the hundreds of DOE laboratory scientists, engineers, and technicians who worked tirelessly and often at great personal sacrifice in places far from home to tackle nuclear dangers. Likewise, my thanks go to the technical specialists at our counterpart laboratories around the world for their contributions and friendship. Finally, I offer special thanks to those visionary leaders in government who supported us and created sufficient space for scientists and engineers to help make the world a safer place.

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