The Nuclear Crisis in North Korea

Siegfried S. Hecker

Siegfried S. Hecker, a senior fellow and former director of Los Alamos National Laboratory, was the only scientist in an unofficial U.S. delegation that visited North Korea's nuclear facilities in Yongbyon on January 8, 2004, to assess the extent of the nation's nuclear weapons program. That effort continues today as Hecker works with the delegation leader, Stanford University Professor John W. Lewis. This article presents a unique insight into the role of science in international diplomacy by providing a snapshot of Hecker's involvement this past winter. After visiting the facilities, Hecker presented his findings on January 21 at a hearing of the U.S. Senate Committee on Foreign Relations. This article, summarizing his report, is reprinted with permission from Bridge ***34*** *(2) (Summer 2004) pp. 17–23, a publication of the U.S. National Academy of Engineering (www.nae.edu);*

I was somewhat startled when my North Korean host asked me, "Do you want to see our product?" I responded, "You mean the plutonium?" When he nodded, I said "sure." Scientists and engineers often find themselves in the middle of major diplomatic issues. In the past 12 years, I have worked closely with Russian scientists and engineers (more than 30 visits) to help them deal with their nuclear complex after the breakup of the Soviet Union. However, my visit to North Korea was unexpected.

This adventure began with a phone call in late 2003 from my colleague, Professor John W. Lewis of Stanford University, who has been engaged in unofficial Track II discussions with North Korea since 1987. He was there in August 2003 (his ninth visit) trying to help resolve the current nuclear crisis on the Korean Peninsula, and his interactions with the North Korean government had gained him sufficient trust to be invited to visit the nuclear facilities at Yongbyon. He asked me to come along so there would be a nuclear specialist present.

This nuclear crisis, the second one in 10 years, was precipitated when North Korea expelled international nuclear inspectors in December 2002, withdrew from the Nuclear Nonproliferation Treaty, and claimed to be building more nuclear weapons with plutonium extracted from spent-fuel rods heretofore stored under international inspection. These actions were triggered by a disagreement over U.S. assertions that North Korea had violated the Agreed Framework (which had frozen the plutonium path to nuclear weapons to end the first crisis in 1994) by clandestinely developing uranium-enrichment capabilities as an alternative path to nuclear weapons.

Diplomatic efforts to resolve the nuclear crisis made little progress in 2003. The United States insisted on talking with the North Korean government only in a six-party format that included North Korea's four neighbors, South Korea, China, Russia, and Japan. The inaugural meeting in Beijing in August 2003 made little apparent progress. Our "unofficial" U.S. delegation was the first to visit the nuclear facilities at Yongbyon (about a two-hour drive north of the capital, Pyongyang) since the crisis erupted. Joining our delegation at Prof. Lewis's invitation was Charles L. (Jack) Pritchard, Visiting Scholar at the Brookings Institute and formerly the U.S. special envoy for negotiations with the Democratic People's Republic of Korea. In addition, we were joined by two Senate Foreign Relations Committee experts on Asian affairs, W. Keith Luse and Frank S. Januzzi, who had separately planned a trip to North Korea.

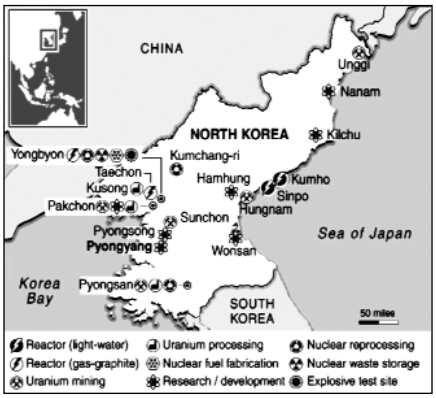

Figure 1. Map showing North Korean nuclear facilities. Source: Center for Nonproliferation Studies.

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I told our North Korean hosts that my objective was to reduce the ambiguities associated with their nuclear program. I realized that some ambiguities might be deliberate. However, ambiguities often lead to miscalculations, and in the case of nuclear weapons-related matters, miscalculations can be disastrous. I also stated that I believe scientists and engineers can play three important roles in the diplomatic process. First, they can clarify the issues and thus facilitate a diplomatic solution to the nuclear crisis. Second, if a diplomatic solution is found, scientists can help implement the solution, such as a freeze or the eventual elimination of the nuclear program. Third, scientists can play a crucial role in verifying a solution.

Our principal host, Vice Minister of Foreign Affairs Kim Gye Gwan, responded positively and explained the motivation for inviting us to Yongbyon. He indicated that North Korea wanted to resume the six-party talks to negotiate a freeze and eventual elimination of its nuclear program. A freeze, he explained, means "no manufacturing, no testing, and no transferring of nuclear weapons." He continued, "We view the delegation's visit to Yongbyon as a way to help contribute to breaking the stalemate and opening up a bright future. We will not play games with you. We have invited you to go to Yongbyon. The primary reason for this is to ensure transparency. This will reduce the assumptions and errors. . . . This visit can have great symbolic significance."

"We want you to take an objective look, and we will leave the conclusions to your side," he said. "This is why the inclusion of Dr. Hecker is so significant. Hecker's presence will allow us to tell you everything. This is an extraordinary approval by us. . . . We, too, emphasize that you are not making an inspection. But, because we are allowing this visit, we will provide you enough access to have good knowledge."

Vice Minister Kim explained that U.S. actions in November 2002 had convinced the North Koreans that adhering to the Agreed Framework was no longer in their

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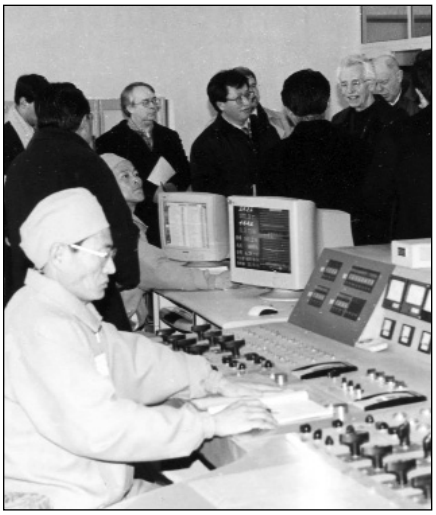

Figure 2. American delegation in the control room of the 5 MWe reactor.

interest, so they terminated the International Atomic Energy Agency (IAEA) inspections and withdrew from the Nonproliferation Treaty. "We decided to operate the 5 megawatt electric (MWe) reactor and resume reprocessing plutonium for peaceful nuclear activities. However, the hostile U.S. policy had been intensified. So, we changed our purpose and informed the U.S. that the plutonium that was to have been used for peaceful purposes would now be used for weapons."

Vice Minister Kim added that North Korea wants a peaceful resolution of the nuclear crisis and denuclearization of the Korean Peninsula. He emphasized that North Korea had been very flexible and very patient, adding, "I should note that the time that has been lost [in dealing with us] has not been beneficial to the U.S. side. With an additional lapse in time, our nuclear arsenal could grow in quality and quantity. The outcome has not been a success for the U.S."

These comments provide the context for our invitation to Yongbyon. In public statements, the North Korean government said fuel rods have been reprocessed to extract plutonium and strengthen the country's "deterrent." Concerned that the United States (and perhaps others) did not believe these statements, they may have invited us to provide independent confirmation of their claims. However, Vice Minister Kim also expressed a concern about the decision to invite us to Yongbyon. "If you go back to the United States and say that the North already has nuclear weapons, this may cause the U.S. to act against us."

In spite of these reservations, the North Korea government arranged our visit to Yongbyon to verify that it had taken significant steps forward in its nuclear program since December 2002 and to impress us with its nuclear capabilities. The leadership and specialists at Yongbyon were very cooperative within the boundaries of what they were authorized to show us.

The offer to show us their plutonium "product" followed visits to North Korea's 5 MWe reactor, the spent-fuel pool building, and, on January 8, 2004, the Radiochemical Laboratory at Yongbyon. The key questions in my mind were: (1) the operating status of the 5 MWe reactor and its two larger companions, a 50 MWe reactor at the Yongbyon site and a 200 MWe reactor about 20 km away, that were under construction at the time of the freeze in 1994; (2) the status of the 8,000 spent-fuel rods that were removed from the 5 MWe reactor in 1994 and stored in a pool under international safeguards; (3) the extent of the nuclear weapons program; and (4) the existence of a uranium-enrichment program.

On the drive from Pyongyang to Yongbyon in two Toyota Land Cruisers, our drivers wound their way past young policewomen directing more traffic than I had expected at Pyongyang intersections, then along a well built, all but deserted, four-lane highway to the north (Figure 1). After about an hour, we turned off onto a dirt road toward the city of Yongbyon with its historic South Gate and Great Wall. As we drove along the Nine Dragon (Kuryong) River, we passed many peasants on foot and on bicycles. The nuclear center is located in its own "closed" city, reminiscent of Russia's closed nuclear cities, with Soviet-style apartment complexes and monuments to the Great Leader and Dear Leader and memorials to the Korean war. The streets and playgrounds were clean and bustling with people.

We met our technical host, director Ri Hong Sop at the Guest House for introductions before visiting the technical facilities. The tours were conducted by knowledgeable chief engineers at each site. I will address the four questions I listed above by first summarizing what we were told by our North Korean hosts (in italics) and then describing my observations.

Status of the Reactors

The 5 MWe reactor was restarted in February 2003 and is now operating smoothly at 100 percent of its rated thermal power. Since shipments of heavy fuel oil from the United States were cut off, it is producing electricity and heat for the town.

We confirmed that the 5 MWe reactor is operating smoothly. We were shown the control room and the reactor hall, and, based on our discussions and the displays in the control room, all indications were that the reactor is now operating smoothly (Figure 2). The steam plume emanating from the cooling tower confirmed operation. We also note that, in addition to producing electricity and heat, the reactor is accumulating approximately 6 kilograms (kg) of plutonium annually in natural-uranium fuel rods.

Construction of the 50 MWe reactor had been stopped in 1994, when it was within one year of completion. No work has been done on the reactor since. The government is currently evaluating its options and deciding what to do with the reactor.

We drove past the 50 MWe reactor site twice. This reactor is similar in design to the 5 MWe reactor, but with an annual plutonium production capacity roughly 10 times greater. We confirmed that no construction is going on at this site. The reactor building appeared to be in a terrible state of repair. The concrete building structure showed cracks. The steel exhaust tower and other steel equipment on the site were heavily corroded. The building was not closed up and resembled a deserted structure. Director Ri expressed his great dismay about the deterioration of the facility during the eight-year freeze on construction. This reactor is much more than one year from completion now. It is not clear how much of the structure can be salvaged.

Our hosts stated that construction of the 200 MWe reactor at Tacheon, 20 km from Yongbyon, also stopped in 1994 and that the government is currently evaluating what to do with the reactor.

Because we did not visit the site, we were not able to assess the current situation. However, it was clear from our discussions that neither of the two reactors under construction in 1994 could be completed any time soon. Therefore, it will not be possible for North Korea to increase its plutonium output beyond the 6 kg/year being produced in the 5 MWe reactor.

Status of Spent Fuel Rods

At the spent-fuel storage building, we were told that all 8,000 fuel rods had been removed from the storage pool and reprocessed (to extract the plutonium) in the Radiochemical Laboratory.

The spent-fuel rods had been removed from the 5 MWe reactor after operation ceased in 1994 as part of the Agreed Framework. The fuel rods were "re-canned" by a U.S. Department of State and Department of Energy team (supported by the Pacific Northwest National Laboratory and the Nuclear Assurance Corporation) to ensure safe, secure storage before eventual ship-

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ment of the plutonium-containing fuel rods out of North Korea. It was imperative that the spent-fuel rods be re-canned in an inert atmosphere because their initial exposure to water in the pool would be detrimental to the magnesium alloy cladding. In addition, the fuel rods had to be stored under the watchful eyes of IAEA inspectors to ensure that no fuel rods were removed clandestinely. However, the inspectors were expelled in December 2002.

Our initial look into the spent-fuel pool showed that the safeguarding equipment previously used by the inspectors was gone (video cameras were still present but were disconnected) (Figure 3). We confirmed that not all of the fuel rods were in the pool because many of the canisters were missing and many were open. When I expressed concern that some of the canisters were still closed, our hosts took the extraordinary step of allowing me to pick one at random and have it opened (all done underwater in the pool) to demonstrate that no fuel rods remained, even in the closed canisters. The empty randomly selected canister and other observations convinced me that the spent-fuel pool is empty; the fuel rods are gone. It is possible that the 8,000 fuel rods had been moved to a different storage location, but such storage would represent a serious health and safety hazard.

At the Radiochemical Laboratory, we were told that all 8,000 spent-fuel rods had been reprocessed to plutonium metal in the Radiochemical Laboratory during one continuous campaign from mid-January 2003 to the end of June 2003. We were told that the campaign had been completed and that the facility is not operating now. (It is estimated that the spent-fuel rods contained 25 to 30 kg of plutonium.)

In this six-story, industrial-scale reprocessing facility, we were conducted through the corridor next to the hot cells where reprocessing is done remotely with manipulators (Figure 4). We noted that the North Koreans had the requisite facilities, equipment, and technical expertise for large-scale plutonium reprocessing. They use the standard PUREX (plutonium uranium extraction) process for separating plutonium from the fission products and uranium fuel. All of our technical questions about reprocessing chemistry were answered very competently. Based on our tour, we concluded that the facility had been operated, but we could not confirm that all of the fuel rods had been reprocessed.

Although we were not permitted to see the plutonium glove-box operations, our hosts took the extraordinary step of showing us the "product" of what they claimed was the most recent reprocessing campaign. In a conference room following the tour, a metal case was brought in for us to inspect. The box contained a wooden box with two glass jars, one said to contain 150 grams of plutonium oxalate powder and the other 200 grams of plutonium metal.

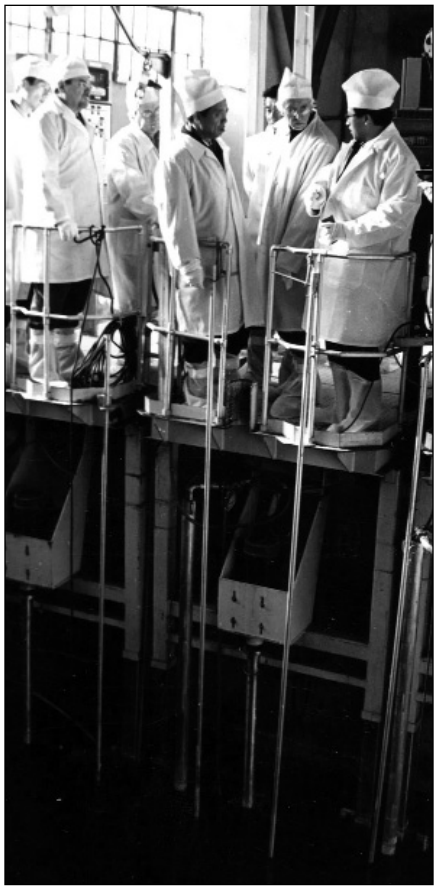

Figure 3. American delegation at the storage pool for spent-fuel rods.

"We must assume that the North Koreans are able to construct at least a primitive nuclear device."

The glass jars were fitted with screw-on metal lids and were tightly taped with transparent tape. (The plutonium's alpha-radiation is easily stopped by the glass jar.) The green color of the plutonium oxalate powder was consistent with the color of plutonium oxalate that has been stored in air for some time. The plutonium metal was a thin-walled funnel that was described as scrap from a casting from this reprocessing campaign. When we asked about its density, we were told that it was "between 15 and 16 g/cm^3 and that it was alloyed" (a common metallurgical practice to retain the δ-phase of plutonium to make it easier to cast and shape). When I asked what alloying element had been used, I was told that that they could not answer that question, but that I know what the United States uses and that theirs is the same. The surface and color of the metal were consistent with moderately oxidized plutonium metal from a casting. I tried to get a feel for the density and heat content of the metal by holding the glass jar in my gloved hand. The very thick glass jar was reasonably heavy and slightly warm (importantly, it was definitely not cold as was everything else in this building). With the rather primitive tools at hand, I was not able to identify definitively the metal or the powder as plutonium. The metal was radioactive, however, because a Geiger counter turned on near the wooden box containing the glass jars registered a count. With a few relatively simple tests, we could have made a positive identification of the product as plutonium metal, but that was not possible during this visit.

Nuclear Weapons

During follow-up discussions with Vice Minister Kim and Ambassador Li Gun in Pyongyang, we were told that North Korea had strengthened its nuclear "deterrent"—in both quality and quantity—because of recent hostile actions by the United States. Ambassador Li inquired if what I had seen at Yongbyon had convinced me that they possessed this deterrent. I explained that nothing we had seen enabled me to assess whether or not they possessed a nuclear deterrent, if that meant a nuclear device or nuclear weapon. The North Koreans tend to use the term "deterrence" rather ambiguously.

I explained that I consider a "deterrent" to have at least three components: (1) the ability to make plutonium metal; (2) the ability to design and build a nuclear device; and (3) the ability to integrate the nuclear device into a delivery system. Our visit to Yongbyon had shown us that the North Koreans apparently have the capability to make plutonium metal. However, I saw nothing and talked to no one that gave me a basis for assessing their ability to design a nuclear device. And, of course, we were not able to assess the integration of such a device into a delivery vehicle.

During additional discussions, I cautioned that "deterrence" might have worked between the United States and the Soviet Union, two equally armed

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nuclear superpowers under rather predictable circumstances. The concept of nuclear deterrence may have little meaning, however, for the U.S.-North Korean situation. I asked Ambassador Li in the late morning of the last day of our visit if I could meet individuals who could talk to me in some detail about their "deterrent" in the spirit that I had just described. He said he would try, but that evening he told me that there was not enough time to make such arrangements.

Based on the overall technical capabilities we observed, and given that they apparently have sufficient plutonium metal, we must assume that the North Koreans are able to construct at least a primitive nuclear device. On April 13, 2004, David Sanger reported in the *New York Times* that Pakistani scientist A.Q. Khan had told authorities that he was shown three nuclear weapons during one of his visits to North Korea in 1999. However, given Khan's record of deceit and his sketchy description of the weapons, one must treat his statement with great skepticism.

The Highly Enriched Uranium Issue

We discussed the contentious issue of North Korea's admission on October 4, 2002, that it had a clandestine highly enriched uranium (HEU) program in violation of the 1994 Agreed Framework. There is still a good deal of controversy over whether or not the North Koreans had admitted having such a program at a meeting with U.S. officials. Mr. Pritchard, who was present at the October meeting, told our hosts that regardless of what may have been said, the HEU issue is very serious and that it is now mandatory that we come to a complete, verifiable resolution of this issue. In response, Vice Minister Kim Gye Gwan stated categorically that the North Koreans had no HEU program.

Upon further questioning, Vice Minister Kim stated that they had chosen the plutonium path to a deterrent and that North Korea had no facilities, equipment, or scientists dedicated to an HEU program. These statements now ring hollow because a few weeks after our visit reports surfaced of A.Q. Khan having clandestinely transferred uranium-enrichment technology to North Korea, Iran, and Libya. Vice Minister Kim concluded our discussions with: "However, we can be very serious when we talk about this. We are fully open to technical talks."

Conclusion

I found the remarkable access afforded us to North Korean nuclear facilities and specialists very encouraging. Based on this visit, we were able to answer some key questions of interest to our government. Upon my return home, I presented my findings to several U.S. government agencies and to the Senate Committee on Foreign Relations. However, before I left Pyongyang, I gave my hosts a summary of my findings at the closing banquet so they would be the first to hear them and would not be surprised by reports from the United States. Vice Minister Kim had hoped that I would draw more definitive conclusions, but he recognized that from a scientific perspective this would be difficult. He said: "I understand. I would like you to make this report to your government. Don't add anything and don't subtract anything."

Our report provided input to the second round of six-party talks held on February 25–28 in Beijing. However, the contentious and unresolved HEU issue limited progress. Professor Lewis and I hope to return to North Korea in the coming months and contribute to a diplomatic solution of the nuclear crisis. In the meantime, a great deal could be done to prepare for the eventual complete, verifiable, irreversible dismantlement of the nuclear program. North Korea's ability to shut down safely and securely and eliminate its nuclear program will depend on what is done technically in the nuclear complex in the short term.

Finally, our delegation met with other government officials regarding economic, military, and human rights issues. On behalf of the U.S. National Academies, we also met with officials of the North Korean Academy of Sciences to explore the potential for future cooperative activities in the areas of energy and agriculture. If the nuclear crisis can be resolved diplomatically, it will be essential that the technical communities help to resolve the chronic energy and food problems faced by the people of North Korea.

Figure 4. American delegation in the Radiochemical Laboratory (reprocessing facility).

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