The Graphite Reactor: Isotopes and a New Element

(As published in The Oak Ridger's Historically Speaking column on March 18, 2013)

Carolyn Krause focuses on one of my favorite subjects, the historical Graphite Reactor and medical isotopes that were generated there.

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"If at some time a heavenly angel should ask what the Laboratory in the hills of East Tennessee did to enlarge man's life and make it better, I daresay the production of radioisotopes for scientific research and medical treatment will surely rate as a candidate for first place." —Alvin Weinberg, Director, Oak Ridge National Laboratory, 1955-1973.

The late Art Rupp would agree. He was especially proud of the Lab's isotope development program, which he helped create and then led.

However, in an interview in 2003 with Steve Stow for the ORNL Oral History Project, he said that the isotope program started at the Lab's Graphite Reactor, which was built in 1943, had not received the recognition it deserves, either locally or nationally.

In its heyday, the program separated, purified, promoted, packaged and scheduled the delivery of radioisotopes. The isotopes shipped from Oak Ridge to hospitals were used to diagnose and treat cancer and other diseases, prolonging lives. Other isotopes were useful for industry, agriculture and research.

Also, separation work in the program provided chemical proof for the existence of Element 61 in the periodic table. Henry Moseley, the brilliant English physicist who was killed at the age of 27 in World War I, confirmed in 1914 the 1902 prediction that an element with this atomic number exists.

Radioactive forms of various elements, called radioisotopes, were produced in and isolated from the spent uranium fuel of the Graphite Reactor. This Oak Ridge facility was the world's first continuously operated nuclear reactor. It enabled researchers to demonstrate that gram quantities of plutonium-239 could be produced in a reactor and separated from the spent uranium fuel.

Researchers created other radioisotopes, such as radioactive phosphorus, by immersing a nonradioactive target material, such as melted sulfur in aluminum cans, in the sea of neutrons inside the reactor.

Under John Gillette's stewardship, the program made up to 12,000 shipments of isotopes a year, or 104,000 shipments between 1946 and 1957.

The first radioisotope produced and shipped from a reactor – the Graphite Reactor – was carbon-14. It was sent in 1946 to a hospital in St. Louis for cancer research.

Rupp, a chemical engineer trained at Purdue University where he was once president of the poetry club, noted that New York City's Rockefeller Center has a statue of Prometheus, but Oak Ridge does not. Why is this important?

The element discovered in Oak Ridge was named after Prometheus, the titan in Greek mythology who stole fire from Mount Olympus and brought it down to mankind.

In 1945 Jacob Marinsky, Lawrence Glendenin and Charles Coryell isolated the new element in a hot cell after separating rare earths from radioactive fission products. They were members of George Boyd's group, which pioneered the use of ion-exchange chromatography for separating radioisotopes.

Employing a spectroscopic method, they identified Element 61, the only radioactive rare-earth

metal. Coryell's wife, Grace Marie, proposed the name promethium for the new element – a suggestion accepted by the International Union of Pure and Applied Chemistry.

"Promethium is an element that does not exist naturally on Earth," Rupp told Stow. Like technetium, it occurs only as a byproduct of fission. Promethium has been identified in the spectrum of a star in the Andromeda galaxy. Promethium made on Earth is used for atomic batteries in missiles and spacecraft.

"Its discovery in Oak Ridge is something that has just been forgotten," Rupp said.

Rupp was involved in separating the first milligram of plutonium from the first uranium slugs removed from the Graphite Reactor. The goal was to capture laboratory quantities of plutonium for testing. Plutonium is a highly toxic, man-made element heavier than uranium. Universities using accelerators had produced only micrograms of plutonium. (A microgram is a thousandth of a milligram. One ounce = 28,350 milligrams.)

After a separations system of tanks and centrifuges was built, Rupp and Irwin Higgins used lanthanum fluoride as a "precipitate" to pick up plutonium and carry it away from uranium in a spinning centrifuge.

"The last bits of plutonium we massaged out of the centrifuge using big heavy gloves over our hands," Rupp said. "Health physicists now would consider that action a horror.

"We got all the precipitate out and separated the plutonium from the lanthanum fluoride over an ion-exchange column. In the small amount of green liquid that came out was, I believe, the very first milligram of plutonium that had ever been separated from uranium."

This small step led to the construction of large reactors in Hanford, Wash. They produced enough plutonium for the second atomic bomb dropped on Nagasaki, Japan, ending World War II in 1945.

"We handled hundreds of thousands of curies of radioactivity of all kinds over 30 years," Rupp said. "As far as I know, we never had a serious accident. I'm quite proud of that."

And despite the potential dangers of his work environment, Rupp lived into his mid-80s. Many believe he met a heavenly angel upon his death in 2005.

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Thanks Carolyn. What a wonderful treatment of an "old friend" the National Historic Landmark that is the Graphite Reactor and an excellent tribute to Art Rupp.

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A view of the Graphite Reactor building from an unusual angle

An early aerial of X-10 featuring the Graphite Reactor building

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John Gillette (Identified in original article as Art Rupp. Corrected online and apology published the following day)

Art Rupp