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Los Alamos National Laboratory

# The Actinide Research Quarterly

Nuclear Materials Research and Technology

a U.S. Department of Energy Laboratory

## In This Issue

## Researchers in California Discover Plutonium-231, The Long-Sought Isotope

Nearly 60 years after its discovery, plutonium still has the magic associated with being one of the first synthetic elements produced by humans. After so many years, chemists are still thrilled by the complexity of its chemical properties and behavior. Mastering the chemical complexity of plutonium has always been a challenge, but the key challenge in the identification of the long-sought $^{231}$Pu isotope was its expected brief half-life of 3 to 30 minutes.

Authors of this article are **Dr. Carola A. Laue** and **Professor Darleane C. Hoffman** (left). Professor Hoffman is a member of the NMT Division Review Committee.


XBD9811-03028.tif photo courtesy of University of California, Berkeley

Soon after plutonium's initial discovery in 1941, researchers associated with Glenn T. Seaborg's group at the University of California Radiation Laboratory began looking intensively for the lighter (neutron-deficient) plutonium isotopes. In 1951, D. A. Orth found, $^{232}$Pu, the lightest plutonium isotope known at that time and remaining so for nearly 40 years. In the early 1990s, a Russian team at the Joint Institute of Nuclear Research at Dubna identified three lighter isotopes, $^{228,229,230}$Pu, leaving a vacancy in the chart of nuclides for $^{231}$Pu, as Figure 1 (page 2) shows.

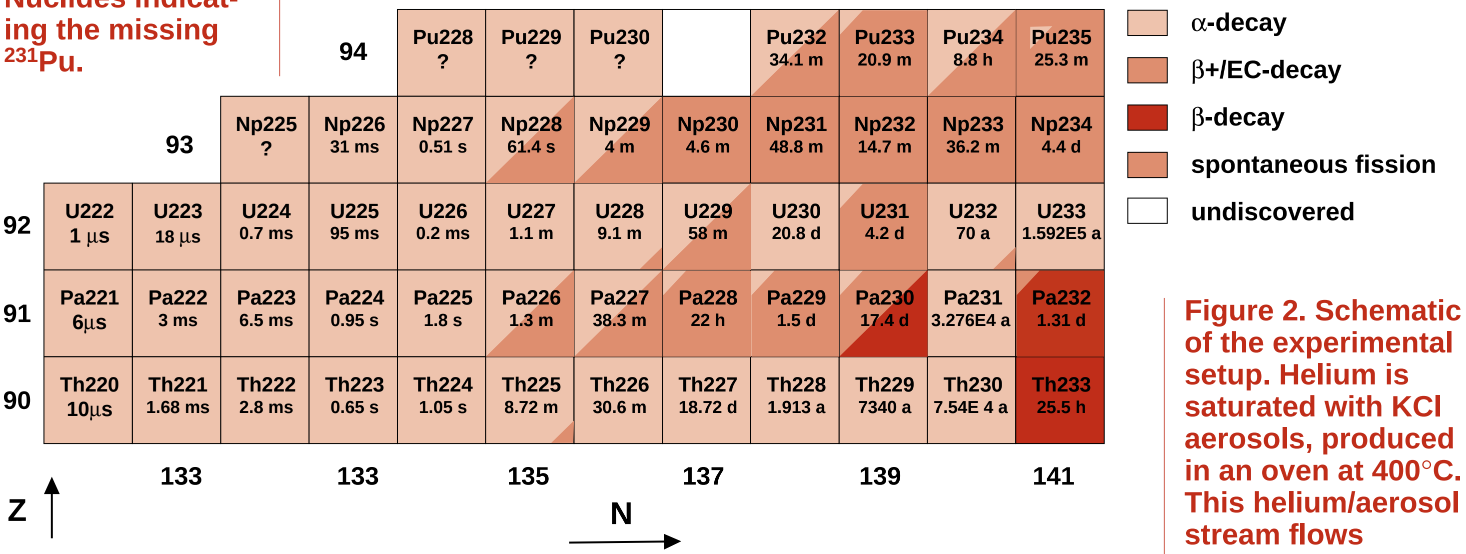
In our successful identification experiment, an array of eleven very thin (~52 mg/cm$^2$) $^{233}$U targets was irradiated with 48-MeV $^3$He ions from the 88-Inch Cyclotron at the Lawrence Berkeley National Laboratory. In this experimental setup, nuclear reaction products recoil out of the thin $^{233}$U targets, stop in the helium atmosphere, and attach to potassium chloride aerosols, which are continuously introduced into the target chamber by flowing helium gas. The activity-laden aerosols were then transported by the flowing helium through a capillary to a collection site away from the target chamber.

*continued on page 2*

Dr. Laue is an Alexander von Humboldt Fellow, a joint postdoctoral position between the Alexander von Humboldt Foundation and The Lawrence Berkeley National Laboratory. Dr. Laue works in the laboratory of Professor Hoffman.

# Researchers in California Discover Plutonium-231, The Long-Sought Isotope *(continued)*

**Figure 1. Region of the Chart of the Nuclides indicating the missing $^{231}$Pu.**



| Z | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 94 | | | | | Pu228<br>? | Pu229<br>? | Pu230<br>? | | Pu232<br>34.1 m | Pu233<br>20.9 m | Pu234<br>8.8 h | Pu235<br>25.3 m |
| 93 | | | Np225<br>? | Np226<br>31 ms | Np227<br>0.51 s | Np228<br>61.4 s | Np229<br>4 m | Np230<br>4.6 m | Np231<br>48.8 m | Np232<br>14.7 m | Np233<br>36.2 m | Np234<br>4.4 d |
| 92 | U222<br>1 µs | U223<br>18 µs | U224<br>0.7 ms | U225<br>95 ms | U226<br>0.2 ms | U227<br>1.1 m | U228<br>9.1 m | U229<br>58 m | U230<br>20.8 d | U231<br>4.2 d | U232<br>70 a | U233<br>1.592E5 a |
| 91 | Pa221<br>6µs | Pa222<br>3 ms | Pa223<br>6.5 ms | Pa224<br>0.95 s | Pa225<br>1.8 s | Pa226<br>1.3 m | Pa227<br>38.3 m | Pa228<br>22 h | Pa229<br>1.5 d | Pa230<br>17.4 d | Pa231<br>3.276E4 a | Pa232<br>1.31 d |
| 90 | Th220<br>10µs | Th221<br>1.68 ms | Th222<br>2.8 ms | Th223<br>0.65 s | Th224<br>1.05 s | Th225<br>8.72 m | Th226<br>30.6 m | Th227<br>18.72 d | Th228<br>1.913 a | Th229<br>7340 a | Th230<br>7.54E 4 a | Th233<br>25.5 h |
| | | 133 | | 133 | | 135 | | 137 | | 139 | | 141 |

The entire setup is shown schematically in Figure 2. Experiments consisting of 10-minute collections of the aerosols followed by chemical separation and measurement of the α-particle energies of the isotopes were repeated every 10 minutes. The decay data from all of the single experiments were summed to provide sufficient data for determination of the half-life and decay modes of $^{231}$Pu.

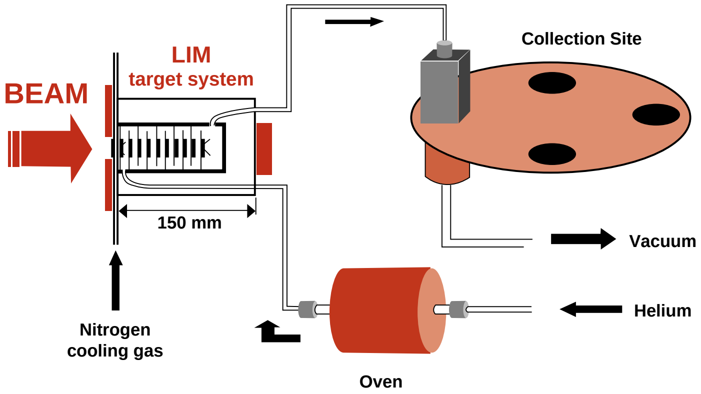
$^{231}$Pu was expected to decay by orbital electron capture (EC) to $^{231}$Np, as well as by emission of an α-particle to $^{227}$U. Both decay branches were found and are illustrated in Figure 3. The $^{231}$Pu identification could only be performed by using the α-α-correlation technique. This technique can be used when α-decay of a parent nucleus leads to a known daughter nucleus, which decays by α-emission. The individual times and energies of each detected α-particle were stored sequentially using a coumputer-controlled data-aquisition system. The recorded data were analyzed off-line. Time-correlated pairs of α-particles were sorted according to the time of occurrence of the parent, the time interval between parent and daughter decay, and the characteristic α-particle energies of parent and daughter. This information provided the powerful tool needed for positive identification of the atomic and mass numbers of the isotopes.

Using this α-α-correlation technique, we measured a half-life of 8.6 ± 0.5 minutes for $^{231}$Pu. The energy of its emitted α-particle was found to be 6.72 ± 0.03 MeV. The $^{231}$Pu α-decay branch is approximately 10%, the remainder decaying by electron capture.

Often, we are asked why our experiment was successful in identifying $^{231}$Pu when so many previous attempts had failed. Primarily, because we devised the following improvements, which increased the sensitivity of our experiment and were crucial in identifying this elusive isotope.

- We chose the $^{233}$U ($^{3}$He, 5n) reaction, which was predicted to have a higher production rate for $^{231}$Pu than those previously investigated.

**Figure 2. Schematic of the experimental setup. Helium is saturated with KCl aerosols, produced in an oven at 400°C. This helium/aerosol stream flows through the light-ion multiple (LIM) target system, picking up the recoiling reaction products and transporting them via a ~10-m-long capillary (2-mm ID) to a four-position rotatable wheel at the collection site outside the irradiation area. The aerosol deposit is then removed manually and chemically processed.**



(The Russian team was unable to identify $^{231}$Pu because the $^{208}$Pb ($^{26}$Mg, 3n) $^{231}$Pu reaction has a low production rate. In addition, their kinematic separator “VASSILISSA” cannot measure isotopes that have half-lives longer than the time intervals (about 0.2s) between random events in their detectors.)

- The overall reaction yield was increased by using a new, specially designed multiple-target system. It employed the well-known recoil technique, which previously was used only in single-target irradiations.

In the recoil technique, the momentum of nuclei formed in the production reaction causes the nuclei to recoil out of the target, provided the recoil range is long compared to the target thickness. The disadvantage in light-ion-induced reactions is that the recoil ranges of the reaction products are rather small. Consequently, the light-ion multiple (LIM) target system (Figure 2) was developed in our group some years ago to overcome this disadvantage. The light-ion beam passes successively through closely spaced thin targets, losing only a small fraction of its energy in each target. The beam still has enough energy to induce the desired nuclear reaction and, as a result, the production rate increases proportionally to the number of targets. In the much earlier attempts at Berkeley, very heavy uranium oxide targets were irradiated, but because of the target thickness, the recoil technique was not applicable. Although large amounts of plutonium were produced, the entire target had to be dissolved, making the separation slow and difficult, thus limiting the possibility of finding shorter-lived isotopes.

- We developed the required fast and efficient chemical separation method based on a modern analytical technique, solid-phase extraction. The uniqueness of our method lies in its simplicity, speed, and the use of the TEVA-resin®, which adsorbs only tetravalent actinide ions from dilute nitric acid. It is a strong anion exchanger (a quaternary amine salt) sorbed on an inert support. We used small columns (2-mm ID and 1.5-cm long) and moderate positive pressure to achieve an optimum flow rate.

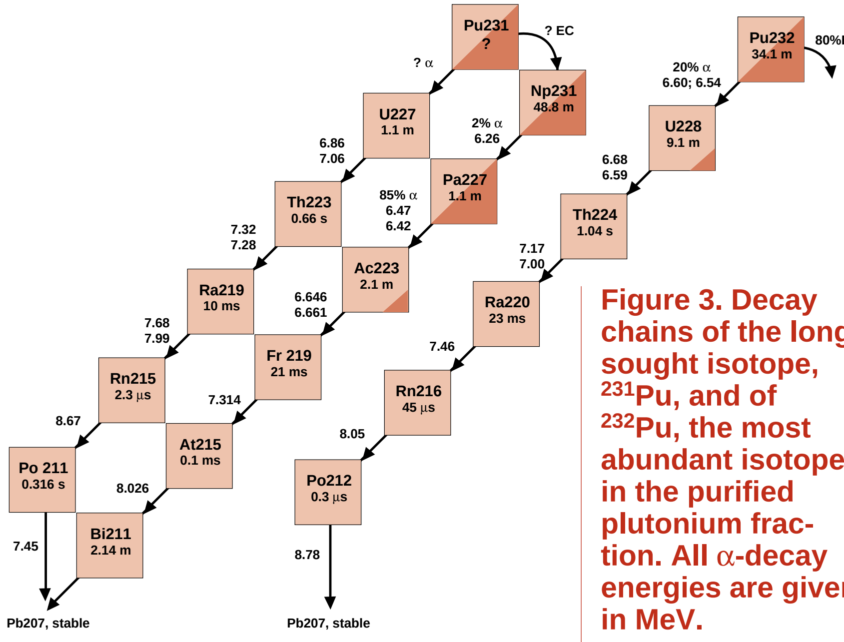


**Figure 3. Decay chains of the long-sought isotope, $^{231}$Pu, and of $^{232}$Pu, the most abundant isotope in the purified plutonium fraction. All α-decay energies are given in MeV.**

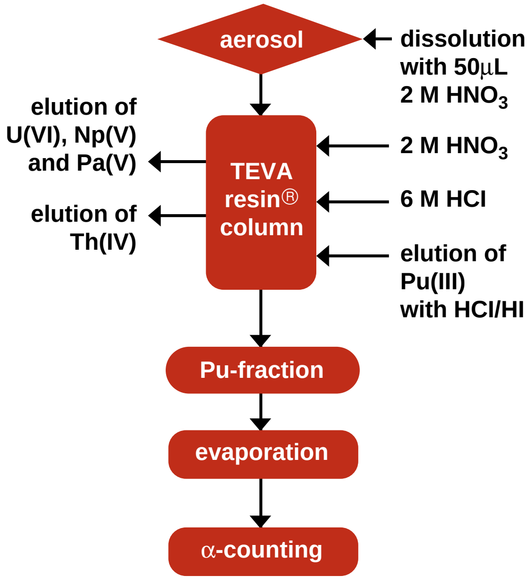
The procedure is described in the flow chart in Figure 4.

Previous researchers tried to save time by skipping the separation of neptunium from plutonium, but the interferences resulting from the decay of neptunium isotopes (see Figure 3) completely obscured the $^{231}$Pu decay.

- Major developments and advances in computer-controlled data acquisition, handling, and analysis were essential and allowed us to store data in list mode (sequentially), to perform off-line data analysis, to search for specific parent-daughter α-α-correlations, and to identify specific α-decay chains.

In summary, the increases in sensitivity, including larger production rates, and advances in chemical separation techniques and in data acquisition and analysis enabled us to successfully identify the long-sought $^{231}$Pu isotope nearly 50 years after the search began.

**Figure 4. Flow chart of the plutonium separation method using solid-phase extraction.**



# Program Addresses Plutonium Pit Conversion in Russia

This article was contributed by **Warren T. Wood** (NMT-6) and **Edouard M. Glagovsky** (State Scientific Center of Russian Federation, A. A. Bochvar All-Russian Research Institute of Inorganic Materials, Moscow, Russia)

The Russian Federation is dismantling its nuclear weapons and plans to convert the plutonium pits into a form that is suitable for mixed-oxide (MOX) fuel fabrication. The United States, through the Department of Energy (DOE), working with the Los Alamos National Laboratory, is studying plutonium conversion technologies as part of its own disposition plan. Los Alamos has also been tasked by DOE to lead a concurrent effort with the Russians on plutonium conversion. This article will discuss the plan for the US-Russian cooperative activities for the conversion of weapons-origin plutonium in Russia.

The joint US-Russian program for pit conversion is divided into the following three major activities: 1) cooperative research and development; 2) nondestructive assay (NDA) and material protection, control and accountability (MPC&A); and 3) the Pit Conversion Pilot Plant Demonstration. The first activity includes the cooperative research and development of technologies to convert weapons-origin plutonium to a suitable form for MOX fuel fabrication. Conversion technologies being considered are the following:

- Pyrochemical conversion (hydride / oxidation),
- Aqueous conversion,
- Combined conversion (pyrochemical / aqueous technologies), and
- Pyroelectrochemical conversion (molten salt).

In addition, support technologies being considered are the following:

- Storage requirements for oxide, container development, and transportation requirements;
- Comparison of oxides for MOX fuel produced by the above conversion technologies; and
- Radiation and nuclear safety analysis.

The NDA / MPC&A process is an integral component of pit conversion. It ensures material accountability for the conversion line and initiates material accountability for storage and subsequent operations. The NDA system for the plutonium conversion could be used to support independent verification through bilateral or international agreements on the dismantlement of nuclear weapon pits. This set of activities will include developing an NDA system for the Russian Pilot Demonstration Line; developing an MPC&A system for the line; integrating the NDA system with the Line; and forging agreements with International Atomic Energy Agency (IAEA) regarding this approach to material analysis. These activities are similar to US efforts with IAEA toward the US NDA system. The Russian NDA system will be very similar in concept and function to the US system, facilitating agreement on each nation's material measurements.

The Pit Conversion Pilot Plant Demonstration will include the design, construction, and operation of a pilot demonstration line in Russia for conversion of surplus, weapon-origin plutonium ingots to oxide.

**Figure 1. Roundtable discussion of the joint US/Russian nondestructive assay team.**

**Figure 2. The joint US/Russian committee for plutonium disposition poses for a picture after their tour of the ARIES (Advanced Recovery and Integrated Extraction System) and MOX (mixed-oxide) facilities in Building PF-4.**

As presently conceived, the line will have as its input the metal ingots from earlier processing in which the plutonium was removed from surplus nuclear weapons components and melted into ingots of unclassified shape and mass. The pilot line will convert the ingots into plutonium oxide of suitable quality for fabrication into MOX fuel or for other disposition options.

Significant accomplishments for the program to date are the following:

- Signing of a contract with the A. A. Bochvar All-Russian Institute in Inorganic Materials (VNIINM) to prepare a master plan outlining the required steps for determining the optimum conversion process for weapons-origin plutonium metal into oxide that can be used to produce MOX fuel. The master plan has been approved by both the Los Alamos National Laboratory and VNIINM.
- Signing of a contract (initial phase) with VNIINM to develop and implement an NDA system for accounting and control of nuclear materials. Representatives of Russia visited Los Alamos in October 1997 under this contract to test and evaluate Russian gamma ray spectroscopy hardware for use in the Russian NDA system.
- Signing of a contract (initial phase) with VNIINM to develop technologies needed to determine the optimum conversion process for weapons-origin plutonium metal into oxide that can be used to produce MOX fuel.
- Signing of a contract with the Russian State Specialized Design Institute (GSPI) to perform a feasibility study, data-gathering, and preparation tasks for conversion of weapons-origin plutonium metal into oxide that can be used to produce MOX fuel. This was accomplished by GSPI in May 1998.

**Figure 3. Teresa Cremers (NMT-4) reviews the circuit board provided by her counterparts in Russia who perform nondestructive assay. The circuit board was tested for performance and compatibility with US equipment.**

## Editorial

# We Need Science for Our Future Well-being

**Kyu Chull Kim** is the Chief Scientist for NMT.

**The opinions in this editorial are mine; they do not represent the opinion of Los Alamos National Laboratory, the University of California, the Department of Energy, or the U.S. Government.**

***"The subjects of investigation are not restricted, but can be selected by individuals according to the internal demands of their own scientific interests,"*** stated Professor Hideo Akamatu, the director of Japan's Institute of Molecular Science (IMS) in the 1979 Annual Review of IMS. Two years later his successor, Professor Saburo Nakakura, states in his 1981 annual review, ***"The researchers in the Institute should be allowed to demonstrate their abilities and be encouraged to develop original areas of study."***

Initially, these statements may sound like a recipe for the work of "sandbox scientists," as expressed by fellow scientists. It is remarkable that in a country renowned for its technological innovations rather than its scientific discoveries, the importance of basic science is emphasized in this simple and straightforward way in one of its premier research institutes. Science knows no national or geographical boundary, so we can be envious of the scientific atmosphere that the scientists of IMS have created for themselves with their government sponsorship.

From the beginning Los Alamos National Laboratory also has cultivated a certain sense of intellectual and academic freedom to pursue the frontiers of science and technology within a well-defined mission. In this climate, one's own imagination and creativity have been the main limiting factors toward scientific progress. Sponsors of large Laboratory programs have understood the importance of basic as well as applied research and have supported it as an important element of their overall program goals. It is this culture, with national support, that has made Los Alamos one of the nation's premier scientific institutions.

Today, however, a new trend has emerged that evaluates most scientific endeavors according to their short-term benefits rather than their long-term contributions to the goals and accumulated knowledge of society. This new trend encourages productivity over creativity. As a consequence less money is allocated to scientific projects, and the scientific community finds it more and more difficult to justify the need for adequate funding for the work performed by scientists. Innovative technologists, on the other hand, are having a heyday bringing ever new technologies and innovations to the marketplace. This trend is a quite natural phenomenon because scientific progress is typically measured on the time scale of years while technological development strives to meet the present needs. On a more fundamental basis the fruit of scientific progress does not perish with time, but technology development matures within a finite time period. It is worth noting, however, that science is a resource tree from which many new technological innovations grow.

The present wave of technological advances will soon have to be followed by new sciences, however. For example, the advanced computer era has followed immediately after the invention of semiconductors, which in turn depended upon the discovery and refinement of quantum mechanics, and the computer-related technologies are still advancing at a breathtaking pace. Biological sciences are making great strides these days unlocking the mysteries of all life forms and their evolution. New technologies based on these scientific discoveries will undoubtedly contribute enormously to the benefit of mankind.

But without advancements in science, a deficit in the scientific knowledge base, much like a bank account, represents a scientific bankruptcy. When today's needs are met, this does not guarantee that tomorrow's needs will be met, that human intellectual curiosity will be fulfilled, or that all scientific discoveries will be exhausted. Science, by its very nature, rejuvenates itself constantly. However, it flourishes best when there is well-intended and farsighted support.

The practitioners of science also need to be replenished. Therefore, a part of this support requires continual sustained emphasis, effort, and resources expended on educating and training the next-generation scientists in all fields of science. National laboratories in concert with universities, as well as the universities themselves, have a responsibility and are positioned to advance this goal to meet our future need for scientists. The present tendency of our national laboratories to focus on near-term programs and tasks is very short-sighted. If this trend continues, the nation will face a state of “science bankruptcy,” a state in which the future growth of our technological society is stunted as a result of general science illiteracy and / or indifference. One, therefore, has to ask “can there be any progress through ignorance and indifference?”

Science is not for scientists only; science education in general prepares us for the well-being of successive generations. The very fabric of our modern society is woven in science—so much so that we rarely stop to think of all the benefits we derive from the reservoir of human scientific discoveries. Informed and well educated, the next generation will be the beneficiaries of today’s science, and the next-generation science sows the seeds of prosperity for the following generation, and so on. In this tradition, therefore, each generation has the supreme responsibility of educating the following generation.

The Laboratory-Directed Research and Development (LDRD) program, for example, is an important element of the Laboratory’s science programs, and it has supported many creative research areas “where no man has gone before.” Because the Laboratory’s programs are mainly national-security-mission-oriented, there is a growing tendency to believe that only LDRD funds are for novel research in new directions. This way of thinking misses the point that the LDRD funds are limited to only a small fraction of the annual budget, and therefore are grossly inadequate for all the basic research activities in a scientific institution like Los Alamos. The 6% maximum investment alone in the basic and underlying science would not sustain a world-class scientific institution in this fast-changing technological world. In planning for science funding, we also need to distinguish research from development just as we distinguish science from technology development.

Another shortcoming of the present-day investment strategy in the basic science is its decidedly short-term nature. It is rare to see any sponsors including government entities spending funds on basic studies lasting more than a few years. The trend has been to fund small and short-term projects. In this climate researchers are not allowed enough resources and time to concentrate on long-term and large scientific problems, although all the faculty at the nation’s major research universities have become very adept at breaking up a career-long major research problem into tasks that can be accomplished by small teams in shorter time periods and funded piecemeal. Following the survival-of-the-fittest trend, then, today’s scientists behave more like technologists in the society’s eye. They make devices, bring new technologies to the newest applications, and try to solve many of our present day problems

In this technologically driven society, we should not lose sight of the underlying science in everything we do. Science is the foundation on which all technologies rest. Science is about discovering the as-is state of all things; technologies are merely human applications of tiny pieces of that underlying science. Science is not about providing answers to many of our national problems. Science is all about discovering what we—and the universe—are, and the pursuit of knowledge into the unknown. Therefore, we, individually and institutionally, might even begin to say that we do science; therefore we exist.

Artwork by Dave Delano

**“Informed and well educated, the next generation will be the beneficiaries of today’s science, and the next-generation science sows the seeds of prosperity for the following generation, and so on.”**

# NMT-1 Group Installs New Analytical Instrument for Plutonium Analysis

This article was contributed by **Deborah Figg** (below) and **Lawrence Drake** (both of NMT-1).

Researchers in the Analytical Chemistry Group (NMT-1) have installed laser ablation—inductively coupled plasma—mass spectrometry (LA-ICP-MS) in a glove box in the CMR Building for the analysis of plutonium samples. LA-ICP-MS is the latest direct-solids technique to be put into a glove box for trace inorganic analysis. The system “went hot” (radioactive materials were introduced) in May of 1998. NMT-1 has an ongoing effort to expand the direct inorganic analysis techniques to meet the increasing demands for faster and more cost-effective techniques for chemical characterization and waste reduction efforts. The direct inorganic analysis capabilities in NMT-1 are dc arc atomic emission spectroscopy (DC-ARC-AES), x-ray fluorescence (XRF), glow discharge mass spectrometry (GDMS), and LA-ICP-MS. The DC-ARC-AES, XRF, and LA-ICP-MS can be used for plutonium analyses, and efforts are continuing to install the GDMS into a glove box for the same purpose. The DC-ARC-AES capability is also being upgraded to a CID (charge injection device) detection system. These direct techniques are not meant to totally replace the wet chemistry techniques (hot plate or microwave dissolution followed by analysis with ICP-MS, ICP-AES, ion chromatography or cold vapor atomic fluorescence for Hg analysis) but rather to complement them. Often a customer will request an analysis to be preformed by two independent techniques in order to confirm a result. The use of both wet and direct-solid techniques in such cases provides a powerful analytical tool.

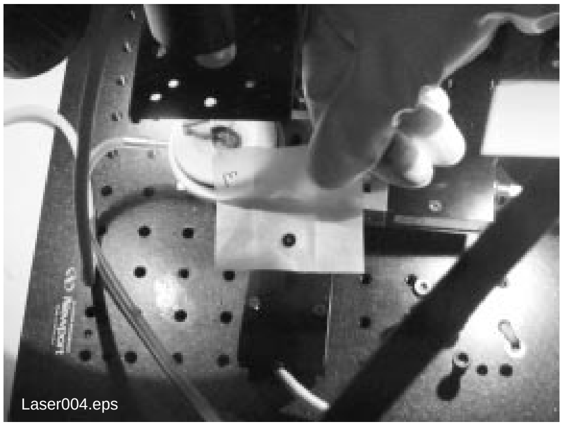


Figure 1. The black pellet in this picture is a plutonium oxide pellet that has already been ablated. The lighter color in the center of the pellet is where the ablation occurred.

LA-ICP-MS is an excellent qualitative and semiquantitative tool, and with good standards it can provide good quantitative results. In LA-ICP-MS a laser is used to vaporize a small portion of the solid sample. (See Figure 1.) The vaporized portion is then transported to the ICP, where the particles are dissociated, atomized, and ionized. The elemental ions are then drawn into the mass spectrometer, where they are analyzed. Ninety to ninety-five percent of the elements can be surveyed in a few minutes. The LA-ICP-MS has low detection limits (ppm, ppb), a large linear dynamic range, and high elemental coverage. It gives isotopic information and spectra that are easy to interpret. LA-ICP-MS has been used to analyze soils, cements, metals, alloys, glass, polymers, food, plants, and plutonium-containing materials.

LA-ICP-MS has all the benefits that come with direct-solid techniques. Direct techniques bypass the dissolution of the sample and therefore do not generate acid waste streams such as those produced with sample dissolution. In fact, in many instances the samples can be returned to their place of origin after analysis rather than being placed in a waste container, as is done with samples used in other techniques. Each of the above attributes reduces the cost of analyses. Because there is the potential for less sample handling, the risk of sample contamination and possible loss of analyte is reduced. And more importantly, worker exposure is reduced for analysis of radioactive samples.

The LA-ICP-MS system in place at the CMR facility consists of a compact Nd:YAG laser mounted on top of a glove box. Optical mirrors and windows are used to transport the laser beam into the glove box. Previous work indicates that better analytical results are obtained using the ultraviolet wavelengths as compared to the infrared wavelengths; thus, the fundamental energy at 1064 nm is tripled to 355 nm before it enters the glove box. The samples are enclosed in a sample cell with a quartz window. The sample cell is then interfaced to an 11-year-old ICP-MS that is used for the routine analysis of digested plutonium samples. This instrument does not have the detection capabilities of the newer ICP-MS models, but single ppm detection limits for most elements in plutonium samples is the goal. With a newer-generation ICP-MS, detection limits in the low ppb are routinely reported for LA-ICP-MS.

The long-term plans are to use the new LA-ICP-MS for the analysis of plutonium oxides, plutonium-uranium mixed oxides, plutonium metal, and cemented wastes containing plutonium. (See Figure 2.) Oxides represent the first type of plutonium samples that will be analyzed by LA-ICP-MS. High-fired plutonium oxides can be extremely difficult to digest, and therefore a direct sample analysis that bypasses digestion could prove to be the better technique.

Method development for the analysis of plutonium oxides has begun. Currently the sample is ground to 100 mesh. Then 60 mg of sample is mixed with 40 mg of cellulose binder. The mixture is pressed into a 7-mm diameter pellet and then analyzed by LA-ICP-MS. A 3-mm × 3-mm raster pattern is used to sample the pellet surface. It is estimated that each laser shot removes microgram quantities of the sample from the pellet. At 5–10 hertz a steady stream of ablated material is sent into the ICP-MS for analysis. Typically 3, 60-second data acquisitions are taken from the stream of ablated material. The signal stability for elements at greater than 10-ppm concentration levels is 10% relative standard deviation or less. Initial quantitative experiments show nice calibration curves and results that compare well with the wet chemistry techniques.

More work and experiments are needed to complete the method development for plutonium oxide samples. One of the problems that needs to be worked on is the lack of good plutonium oxide standards. There are some plutonium and uranium oxide standards, but only 10–20 analyte concentrations are known and certified. Most of our customers need the analysis of other elements that are not certified in any of these standards. For this reason, considerable effort will be dedicated to obtaining or preparing suitable plutonium oxide standards. Another problem with the current standards is that they are all low-fired material. Preliminary experiments suggest that the ablation efficiency is different for a high-fired versus a low-fired plutonium oxide sample. This may be due to the more refractive properties of the high-fired oxides as compared to the low-fired oxides, and / or a particle size difference. The low-fired oxides are a more fluffy powder that easily goes through a 100-mesh screen. The high-fired oxides are more granular, and considerable grinding is required to get them through the 100 mesh screen. Perhaps grinding to a smaller particle size will help even out the ablation efficiencies between the high-fired and low-fired oxides.

**Figure 2. Lawrence Drake operates the laser ablation—inductively coupled plasma—mass spectrometer (LA-ICP-MS) for the analysis of plutonium samples. The LA-ICP-MS is installed in the CMR Building.**

Other experiments will include testing different signal normalization techniques, extending the linear dynamic range of the analysis, and investigating those elements that have not been calibrated well initially. When the oxide analysis method is fully defined, the method development efforts will probably move into the analysis of cemented waste. LA-ICP-MS could be used for bulk analysis of plutonium metal, but the digestion and wet technique analysis of such samples is relatively easy. Spatial profiling of analyte concentrations is also possible with spatial and depth resolutions as small as 10 microns.

# Publications and Invited Talks
## (SEPTEMBER 1998—NOVEMBER 1998)

*Actinide Research Quarterly (ARQ)* publishes invited talks, accepted journal articles, and *published* conference proceedings, books, book chapters, and formal LA reports. In this issue September, October, and November 1998 publications are listed. December publications will be listed in the first quarter of 1999.

S. M. Bowen, M. R. Cisneros, L. L. Jacobson, N. C. Schroeder, and R. L. Ames, "Stabilization of Rocky Flats Combustible Residues Contaminated with Plutonium Metal and Organic Solvents," Los Alamos National Laboratory report LA-UR-98-4407 (October 1998).

G. E. Brown Jr. (Stanford University); V. E. Henrich (Yale University), W. H. Casey (University of California at Davis), D. L. Clark, C. Eggleston (University of Wyoming), A. R. Felmy (Pacific Northwest National Laboratory—PNNL), D. W. Goodman (Texas A&M), M. Grätzel (Ecole Polytechnique Federale de Lausanne), G. Maciel (Colorado State University), M. I. McCarthy (PNNL), K. Nealson (Cal Tech), D. A. Sverjensky (Johns Hopkins), M. F. Toney (IBM), J. M. Zachara (PNNL), "Metal Oxide Surfaces and Their Interactions with Aqueous Solutions and Microbial Organisms," *Chem. Rev*., in press.

R. J. Butcher (Howard University), D. L. Clark, J. C. Gordon, J. G. Watkin, "Synthesis and X-Ray Crystal Structures of the Samarium Mono(pentamethylcyclopentadienyl) Aryloxide Complexes $(h\text{-}C_5Me_5)Sm(O\text{-}2,6\text{-}t\text{-}Bu_2C_6H_3)^2(THF)$ and$(h\text{-}C5Me_5)Sm(O\text{-}2,6\text{-}i\text{-}Pr_2C_6H_3)^3Li(THF)]$. Differences in Metathesis Chemistry of 2,6-Di-Iso-Propylphenoxide and 2,6-Di-Tert-Butylphenoxide Ligands," *J. Organomet. Chem*., in press.

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## Invited Talks

D. L. Clark, S. Conradson, D. W. Keogh, M. Neu, P. Palmer, R. Rogers (University of Alabama), W. Runde, B. Scott, C. D. Tait, "Coordination chemistry of transuranic ions (U, Np, Pu) under highly alkaline conditions," 10th International Conference on X-Ray Absorption Fine Structure (XAFS X), Chicago, Il, August 10–14, 1998, Session T2-1.

D. L. Clark, C. D. Tait, M. P. Neu, P. D. Palmer, D. W. Keogh, S. A. Ekberg, N. J. Hess (PNNL), S. D. Conradson, "Structural Studies of Tetra-, Penta-, and Hexa-Valent Actinide Ions in Carbonate Solutions Using NMR, Raman, EXAFS, and XRD Techniques, Actinide-XAS-98." A Euroconference and NEA Workshop on Speciation, Techniques, and Facilities for Radioactive Materials at Synchrotron Light Sources, Grenoble, France, October 4–6, 1998.

D. L. Clark, "The Chemistry of Actinide Ions Under Highly Alkaline Conditions," presented to University of Texas at El Paso; University of Oxford; British Nuclear Fuels Limited, Sellafield, Great Britain; VALHRO, CEA-Marcoule, France; Brigham Young University, Rice University, University of Houston, and Louisiana State University.

## NewsMakers

### ■ Senator Pete Domenici Leads Congressional Visit to TA-55

*(From NMT Insider, December 10, 1998)*

On Monday, December 7, Senator **Pete Domenici** led members of the Senate Task Force on Plutonium Disposition, which he chairs, on a tour of the ARIES demonstration line. The staff specialists are in the process of becoming more familiar with the US approach to the plutonium disposition issue.

Domenici used the occasion to prod the Clinton administration once more to appoint a special envoy who can facilitate a protocol signed in Moscow this summer in which the US and Russia each agreed to dispose of 50 tons of surplus weapons-grade plutonium.

“This issue is so important to our national interests and global security that we cannot sit idle. I believe our window of opportunity is limited. So far, progress on the plutonium disposition protocol has been slow. The President should act now to appoint a special American envoy to coordinate this bilateral plutonium accord,” Domenici said.

C339-3.tif photo by Joe Reidel

**Figure 1. Tim Nelson (right) explains the ARIES concept to Senator Pete Domenici.**

### ■ Plutonium Futures-The Science Conference Reconvenes in 2000

Planning for the Plutonium Futures-The Science conference in the year 2000 is well underway. It will be held at La Fonda on the Plaza in Santa Fe, New Mexico (USA) during the week of July 10–13. The first conference in the series (in 1997) had over 300 participants representing 14 countries as well as Department of Energy national laboratories and other federal and international institutions, universities, and industries. The conference is sponsored by the Los Alamos National Laboratory in cooperation with the American Nuclear Society. The Program Committee comprises the following members: **Richard A. Bartsch** (Texas Tech University); **Rodney C. Ewing** (University of Michigan); **Gregory Choppin** (Florida State University); **Darleane Hoffman** (University of California); **Douglas C. Crawford** (Argonne National Laboratory); **Harold McFarlane** (Argonne National Laboratory West); **Charles W. Forseberg** (Oak Ridge National Laboratory); **Gordon Brown** (Stanford University); **Kenneth L. Peddicord** (Texas A&M University); **William G. Sutcliffe** (Lawrence Livermore National Laboratory); **Mal M. McKibben** (Westinghouse Savannah River Company); **Gerd Rosenblatt** (Lawrence Berkeley National Laboratory); and from Los Alamos National Laboratory—**Allen Hartford, Jr., Paul T. Cunningham, David L. Clark, Sandra Mecklenburg, K. K. S. Pillay** (Co-Chair) and **K. C. Kim** (Co-Chair). The last seven members also serve on the Conference Organizing Committee.

The conference email address is <Puconf2000@lanl.gov>. Write to us with your comments, suggestions, and inquiries. Also visit the conference Web page at <http://www.lanl.gov/Pu2000.html> for further information.

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