EDITIO POPULARIS

compiled by Barb Mulkin

With this issue we introduce "editio popularis''—popular edition. These brief accounts of ongoing work at the Laboratory are designed to provide a glimpse of the diversity of research conducted here. They are based on recent press releases sent from the Public Affairs Office to a national audience. Jim Breen is the Laboratory's Public Affairs Officer and Barbara Mulkin is the Deputy. Further information may be obtained by contacting the Public Affairs Office.

GEOCHEMICAL CONTROLS ON FISSION PRODUCT CONTAINMENT

Remarkably, remnants of natural fission reactors in the Oklo uranium mines in Africa still contain most of their nuclear wastes. David B. Curtis. Timothy M. Benjamin, and Alexander J. Gancarz have co-authored papers on migration of radionuclides from the site of several natural reactors discovered in thick layers of uranium ore at the Oklo Mines in equatorial Africa's Republic of Gabon.

The remains of the reactors were first identified in 1972 when French researchers found that uranium ore mined there was depleted in the fissionable isotope uranium-235. A complicated investigation revealed that uranium-235 was in short supply because it had been the fuel for natural fission reactors billions of years ago. The mere existence of these fossil reactors attests to their remarkable stability for about half the age of the earth. They also provide a unique opportunity to study the containment of waste from nuclear reactors in the earth's crust for geologic periods.

Los Alamos researchers are studying the migration of elements produced by neutron capture, nuclear fission, and radioactive decay. The latest papers report new data on the elements molybdenum, ruthenium, technetium, neodymium, and uranium and use these data to reconstruct the physical and chemical history of the reactors. The authors determined that fission began in the thick layers of uranium two billion years ago and that nuclear criticality was sustained for a few hundred thousand years. At some time within one million years after fission began. hot water circulating through the reactor cores removed certain elements and transported them into the surrounding rocks. Many of these mobile nuclear products were retained within a few meters of the reactor core. By comparing the chemistry of the mobile elements the authors were able to identify specific geochemical processes that may have controlled the loss of elements from the rocks of the reactor zones and led to their retention in peripheral rocks. Such information will be useful in evaluating the long term effectiveness of specific geologic sites in retaining commercially generated nuclear wastes.

The energy production of Oklo was about 15 times the energy that would be released in a nuclear-waste repository containing the entire 1980 U.S. inventory of spent commercial reactor fuel. The inventory in the Oklo reactors corresponded to 10 to 20 per cent of the uranium and 1 to 2 per cent of the nuclear products in the United States spent fuel inventory as of 1980.

Isotope and Nuclear Chemistry Division

SHUFFLER DESIGNED FOR FAST FACILITY

Los Alamos has designed and constructed a 15-ton nuclear material assay instrument for installation in the Department of Energy's new fuel reprocessing plant near Idaho Falls, Idaho. The instrument. nick named "Shuffler, " is designed to measure the uranium-235 content of both spent fuel assemblies and the solid wastes generated by fuel reprocessing. It will be installed in the $200 million Fluorinel and Fuel Storage Facility (FAST) to be operated by EXXON Nuclear Idaho Company (ENICO).

George Eccleston, principal investigator and a member of the Laboratory's Energy Division Safeguards Assay Group, says the instrument is unique in that it was designed as an integral part of the facility and will be installed permanently. Usually, such instruments are portable or brought into a facility after it is complete.

In contrast to many foreign nations, the United States has no operating facilities for commercial reprocessing of spent reactor fuel, but federal facilities, such as that near Idaho Falls, will store and reprocess noncommercial spent uranium fuel from United States government test and research reactors and from the Navy's nuclear ship propulsion program.

Fuel assemblies will be brought to Idaho and stored in cooling ponds. Depending on their size, they may be cut into pieces before being reprocessed in an acid mixture. For materials accountability and criticality safety, the Shuffler will measure the uranium content in the fuel prior to dissolution of the fuel and separation of uranium.

The instrument irradiates. or interrogates, the fuel with a high flux of neutrons to produce uranium fissions and then counts the delayed neutrons resulting from the fissions. Given the high background of neutrons (17 million neutrons per second) and gamma rays (50,000 rads per hour), accurate measurements are difficult to make.

The californium-252 neutron source is manmade and emits up to 10 billion neutrons per second through spontaneous fission. This source is shuffled back and forth between a fuel interrogation position and a storage shield. The delayed neutrons are measured while the californium source is in the storage shield. The source may shuffle back and forth as many as 100 times while the instrument measures the uranium-235 in a spent fuel assembly.

The Shuffler's intricate functions were designed and evaluated using a Monte Carlo computer code developed by personnel of the Applied Theoretical Physics Division. The assay system will be remotely controlled and operated by a dedicated minicomputer system that can be easily operated by plant personnel. Design of the instrument as an integral part of the facility, rather than as a retrofit, enables both facility operations and assay measurements to be better coordinated. The instrument will be shipped and assembled at the FAST facility in the fall of 1982.

Energy Division

SPACE DETECTOR TESTED ON M-87

Researchers report a milestone in the effort to provide new tools for verifying activity in space that might violate the Limited Test Ban Treaty. A new system that is a marriage of two highly desirable features—good x-ray energy resolution and position sensitivity—has been developed and then tested successfully in space.

Richard Blake and Gordon Smith say the test 153 miles above the earth's atmosphere last summer imaged the galaxy M-87 in x rays and provided its x-ray energy distribution. M-87 is a powerful x-ray emitter and was chosen for this reason.

The Los Alamos equipment was lofted by a Black Brant rocket from White Sands Missile Range in New Mexico. In less than 150 seconds, the instrument package was on target. For almost 300 seconds, x rays streaming from the galaxy were focused by a telescope onto a detector that is a combination of a gas scintillator and an imaging proportional counter. X rays hitting the scintillator produced ultraviolet light that was passed through an optical window to the imaging counter. An electronic processor recorded the position and energy of each x-ray event. The data provided an image of the galaxy and its halo. The energy data can be transformed into information on the elements present in the galaxy and their physical properties, such as temperature.

Astrophysicists will be interested in data from the launch that may, for the first time, confirm a theory that elements in M-87 are not uniformly distributed throughout the galaxy, but "settle out" from the halo surrounding the galaxy's x-ray source according to their mass.

The experiment is one step in an effort to develop better capability to monitor nuclear explosions in space. More advanced versions may now be developed for longer space missions with higher sensitivity.

Because the new system is position sensitive, Blake also believes a modified version of this detector with suitable x-ray optics has potential for medical diagnosis, being able, in his opinion, to deliver high-resolution pictures with much lower x-ray doses to the patient.

Earth and Space Sciences Division

DATA "SANDWICHES" REVEAL NEW RESOURCES

Laboratory researchers have developed a rapid, efficient method of resource evaluation that turns reams of geologic and geophysical data and information from NASA satellites into photographic "sandwiches." The data-integration system is the latest tool in the battle to keep up with the information onslaught.

Thomas Weaver, principal investigator, says information is being "thrown at us so rapidly that we cannot keep up with the data." This system, which was developed as part of a DOE uranium resource evaluation program called NURE, was given a dry run at Talkeetna, Alaska. The success of the test led to development of a full-scale system that uses the Laboratory's Cray-1 supercomputers.

The Crays are programmed to accept data from aerial geophysical surveys, geologic maps, geochemical data, and Landsat imagery. The information is digitized, then transformed into photographic images that are overlaid, or "sandwiched," on film. The result is a spatially complete photo of all available information for a specific area.

After the success at Talkeetna, researchers chose to run a larger, more complex test on an area in southern Colorado's Montrose Quadrangle, which was also part of the earlier DOE uranium study. There are known mineral deposits and several types of mines in the quadrangle, and calibration data for the new system were available. Startling evidence of heretofore unknown concentrations of copper, lead, and zinc was shown. It would appear that much of the guesswork has been taken out of mineral exploration, and perhaps the wildcat methods of searching for mineral deposits may no longer be necessary.

The Department of Energy has contracted with the Laboratory to produce a geochemical atlas of the entire state of Alaska, using the sandwich format. Researchers believe the system could perhaps be adapted to include information on seismicity, gravity, and elevation, and so predict the probability of floods or earthquakes in various areas.

Earth and Space Sciences Division

SOVIETS COMMITTED TO NUCLEAR POWER

Short of a major policy switch, the Soviets will attempt a 10-fold increase in nuclear power by the year 2000, keeping the nuclear genie a factor in world negotiations regardless of public pressure in the West to dispense with this form of energy.

That's the conclusion of a Los Alamos report, "Soviet Nuclear Power," written by physicist William G. Davey.

Davey says although nuclear power is withering away in the United States—a victim of criticism and public pressure—the Soviet Union is demonstrating a commitment to nuclear power for electricity generation that is unmatched anywhere but France. Unless Soviet leadership changes its convictions, a 10-fold increase in generating capacity is likely in the next two decades. This 20-year projection is consistent with figures available for the period from 1971 to 1985. The figures show that the Soviet Union is doubling nuclear electrical generating capacity every five years. Official statements, which may be inflated, say that by 1985 the total electrical generating capacity will reach 1.6 trillion kilowatt-hours, with 14 per cent of that being nuclear and 15 per cent hydroelectric. Davey believes the 20-year projection is a conservative one in that it makes no allowance for special-purpose or fast breeder reactors, which were not included in the study because the detailed information was not available.

"The Soviets have an ingrained belief that large-scale high technology should support the national industrial base," Davey writes. "Also, they believe in political systems that allow centralized technical decisions to be implemented without regard to local or societal concerns. They recognize that nuclear fuel, because it is very compact, is especially valuable in a nation such as Russia, which encompasses great distances and harsh climates. And, finally, the Soviets maintain iron control over nuclear weapons' potential, when reactors are exported."

Office of the Assistant Director
for Planning and Analysis

REACTOR PROBE SHIPPED

A unique tool for diagnosing the physical events in loss-of-coolant experiments in nuclear reactor simulators has been shipped to Germany. The tool, a sophisticated videoprobe system, will be used at the PKL Facility at Erlangen, West Germany. The system is the third produced here; two others are in use at a similar facility in Japan under the Nuclear Regulatory Commission's multinational experimental and analytical research program known as 2D/3D.

Walter Kirchner says experiments in electrically heated reactor simulators reproduce the extremely harsh environment of a large reactor core. The video probe must withstand pressures varying from 600 pounds per square inch to atmospheric and rapid thermal shocks from 660 degrees Fahrenheit to ambient.

The probe looks a little like a fat Gatling gun. A miniature television camera, developed for military use and chosen for its extremely high resolution, is mounted in the barrel, and the barrel is inserted into the wall of the reactor simulator. Pictures are taken through a l-inch-diameter window and lighted by miniature halogen lamps through four even smaller windows. Xenon strobe light is transmitted through bundles of fiber optics and synchronized at 30 frames per second to the TV camera.

A gold-plated annulus surrounds the jacket that holds the video equipment; it is tilled with xenon gas to protect the delicate equipment and minimizes disturbance to the experimental reactor facility from the intrusion of the probe. Less than 300 watts of heat are removed from the simulator by the Los Alamos equipment—minimal disturbance.

Probes in use at the Japan Atomic Energy Research Institute at Tokai have worked well for more than a year. A similar probe, although not developed at Los Alamos, was recently used to examine the core of the crippled reactor on Three Mile Island.

Energy Division

BRITISH-AMERICAN PATENT ISSUED

Although joint patents between inventors from different countries are not rare, they are fairly uncommon in weapons-research establishments. A joint patent for a new detonator that is extremely safe and efficient has been issued to Los Alamos staff member Robert H. Dinegar and John Kirkham of the British Atomic Weapons Research Establishment. Their low-voltage, non-primary-explosive detonator has innumerable applications for defense and industry.

Most detonators, such as commercial blasting caps, use a sensitive primary explosive that propagates a shock wave to detonate an explosive charge. Commonly used detonator explosives are lead azide and lead styphnate, and both are touchy materials.

"Traditionally, detonators must be handled carefully and the best of them are rather dangerous," Dinegar says. "We have looked for years for a detonator that was efficient, small enough to be useful, but much safer than existing models. We believe the device we have patented meets these criteria."

The new detonator employs a configuration that provides confinement for a deflagration-to-detonation sequence (burning that builds up into a detonation) and uses a much less sensitive explosive. The device has obvious implications for safer weapons and also has potential for many industrial applications, especially in energy research. Dinegar says geothermal energy development and oil and gas exploration are obvious areas of interest. The detonator can also be used as a valve actuator to drive a piston. Research on this application is now underway.

Dynamic Testing Division

PLUTONIUM RECOVERY TECHNIQUE IMPROVED

A new technique for electrorefining of metal has allowed Los Alamos to almost double its recovery of pure plutonium metal. Electrorefining has been an effective tool for recycling metallic plutonium scrap since 1964, but the amount of plutonium processed at one time has been limited to 4 kilograms because of criticality considerations. The new procedure allows researchers to process up to 6 kilograms of plutonium without compromising safety, yield, or quality. The process costs about $45,000 and can yield $500,000 worth of plutonium. Principal investigator Lawrence Mullins claims the new method results in recovery of 82 per cent of the plutonium in scrap metal. The recovered plutonium has an average purity of 99.96 per cent.

Plutonium recycling at Los Alamos dates back to 1943. As greater amounts of scrap were generated in radiochemistry programs, reactors, and defense research, recovery became increasingly important. To meet its demands, the Laboratory switched from a slower, more complicated aqueous processing method to electrorefining. In aqueous processing the scrap metal was dissolved in acid and purified by solvent extraction. Additional steps were then necessary to convert the purified plutonium to metal. In electrorefining the impure metal is heated in a crucible to 750 degrees Celsius; then an electric current is applied. The plutonium, which is first oxidized and then reduced, drips to the bottom of the container. When it cools, the solidified pure metal is removed as a ring.

Los Alamos has also perfected a new process for direct reduction of plutonium oxide to plutonium metal. The processing of oxide by this method coupled with electrorefining uses less manpower and permits higher throughput than conventional aqueous methods.

Materials Science and Technology Division

SPACE BENEFITS IDENTIFIED

Consumers are reaping enormous benefits—more than $300 million a year—from the aggressive development of space, but the United States, which pioneered much of the research, may lose its competitive edge if the present research funding trend continues.

This view is expressed in a Laboratory report by Herbert "Bill" Lorber and Robert H. Drake. The authors conclude that NASA, the agency that put man on the moon, "finds itself trapped in the mundane activity of trying to reverse a negative cash flow."

Their report, "The Economic Benefits of Space Development," provides a glimpse of international space activity, summarizes the benefits of military and civilian space ventures, and characterizes areas of space research. Contrary to public perception, there is no single space program, but four separate efforts including military, intelligence, civilian-public, and commercial.

Most of the benefits to the consumer from the overall effort come from communications. A single Intelstat (international commercial communications) circuit has dropped from an annual cost of $64,000 in the 1960s to less than $6000 today. A rough estimate of the economic measure called "consumers' surplus" shows consumers are already enjoying a $300 million a year benefit in international telephone communications alone. While benefits are expected to increase as the industry grows, a

potential problem is the crowding at 23,000 miles from the earth, where communication satellites are placed in geosynchronous orbits. The Los Alamos economists say 97 satellite communication systems are in operation now, and because they must orbit at least two degrees apart, there is room for only 180.

The report describes other benefits that accrue from satellite observation systems. For example, the accuracy of routine weather forecasts has doubled since 1965 and improved monitoring of hurricanes and tornadoes has saved countless lives. Remote-sensing space systems such as Landsat bring direct economic benefits. A single, typical observation program of annual snowcover in the western United States, costing half a million dollars to perform, saves $50 million annually through improved water management in hydroelectric and irrigation systems.

Consumers can also look forward to savings from manufacturing in space. A 1984 launch is scheduled to manufacture high-yield semiconductors at dramatic cost reductions and gains in quality. The launch may also test low-gravity separation techniques for producing diabetic and antihemophilic drugs.

Analysis and Assessment Division

LASERS USED IN COAL GASIFIER

The original London Bridge was illuminated by coal-gas lamps. In the mid 1850s New York, Boston, and many other American cities were using town, or water, gas, as it was called. However, widespread use of coal gases fell victim to the development of cheap and abundant supplies of crude oil. Today there is growing interest in synthetic gas, but the coal gasification process must meet much more stringent requirements for cleanliness and environmental safety before it will be accepted as a leading technology.

To this end the Department of Energy has set up an experimental coal gasification system at its Morgantown Energy Technology Center in West Virginia. Now Los Alamos researchers have tested systems for on-line monitoring of gas composition and scrubber efficiency. The systems, involving laser-induced breakdown spectroscopy (LIBS) and coherent anti-Stokes Raman scattering (CARS), were set up in two sections of the experimental gasifier. Both worked well in the extremely harsh environmental conditions.

Lee Radziemski, David Cremers, and David Taylor describe LIBS as a straightforward method for determining the elemental composition of coal gasification streams—including products that are extremely corrosive. CARS is a sophisticated method for determining the presence and temperature of many molecules in the gasifier stream. The systems are complementary.

Both systems use readily available lasers. In LIBS pulses of laser light lasting 10 billionths of a second are focused down to a very small volume. The intense light creates a tiny fireball of hot plasma and reduces the material it strikes to its basic, elemental components. A multichannel analyzer can readily identify the resultant atomic spectra. Nitrogen, oxygen, hydrogen, and sulfur have been identified in real-time monitoring of the gasifier effluent, an improvement over the 10-minute turnaround time of existing monitoring equipment.

CARS relies on the fact that different molecules have different vibrational frequencies. By mixing two laser beams of different frequencies in the effluent gas, it is possible to stimulate the molecular species of interest to emit coherent radiation of a third frequency. The intensity of this third beam yields the species concentration. The CARS technique was successful in measuring concentrations of nitrogen, carbon monoxide, and hydrogen sulfide in a very "dirty" part of the gas stream, where the temperature is normally 1000 degrees Fahrenheit, the pressure is 200 pounds per square inch, and particle and tar-vapor loadings are high.

Chemistry Division

PROTON STORAGE RING PLANNED

By 1985 a major addition to the Weapons Neutron Facility will be operating at Los Alamos. Ground has been broken for a Proton Storage Ring, a $19 million facility designed to assist both weapons research and basic research in physics and materials science.

The ring will accept and store protons from the half-mile-long accelerator at the Los Alamos Meson Physics Facility (LAMPF). The stored protons will be released in short bursts to generate intense fluxes of neutrons at the Weapons Neutron Research target facility. The neutrons will then be employed in a wide range of basic nuclear research and practical applications. George Sawyer, construction manager, says the ring will make the Weapons Neutron Facility "the most powerful pulsed-neutron source anywhere, over a very broad neutron energy range." With this intense source researchers will be able, for the first time, to perform certain neutron experiments in nuclear physics, solid-state physics, and condensed matter science and to study high-current phenomena important to accelerator applications and fusion experiments.

LAMPF produces medium-energy protons at a higher intensity than any other accelerator in the world. It is a pulsed beam with an average current of 600 microampere. When the proton storage ring is complete, it will receive every tenth pulse from the accelerator, accumulating the protons until the number of particles in the ring reaches 50 trillion.

Accelerator Technology Division ■

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