DOE/EM--98006440

Environmental Management Activities

Summer 1998

UNITED STATES - RUSSIA

MASTER

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dy A U.S. Department of
Energy Cooperative
Program with the
Russian Federation

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INTRODUCTION

During the 50-year Cold War the U.S. and the Soviet Union developed the largest nuclear weapons complexes in the world. They also created the world's largest inventories of radioactive waste. Although both countries instituted waste management systems to convert and store waste, significant discharges into the environment occurred. The U.S. now faces the environmental legacy of the nuclear arms race—nuclear weapons complexes with a multitude of waste management, site contamination, and dismantlement issues.

The Department of Energy (DOE) established the Office of Environmental Management (EM) in 1989 to clean up the U.S. nuclear weapons complex. The mission of EM has three facets:

- 1. assess, remediate, and monitor sites and facilities*
- 2. store, treat, and dispose of wastes from past and current operations*
- 3. develop and implement innovative technologies for environmental restoration and waste management*

The sheer magnitude of this directive necessitated looking beyond our domestic capabilities to technological solutions outside U.S. borders.

At the same time, Russia was also coming to terms with its own waste management issues. Discharge of radioactive waste into the environment was much greater in the Soviet Union than in the U.S. during the Cold War.

Dissolution of political tension between the U.S. and the Soviet Union during the final days of the Cold War led to an increased awareness of common problems in remediation efforts. Formerly restricted elite Soviet scientific expertise became available in the West. The best technical experts in the field began to communicate and share experiences about some of the world's most difficult environmental cleanup tasks.

In September 1990, due to mutual interest, DOE and the Ministry of Atomic Energy for the Russian Federation (MINATOM) signed a Memorandum of Cooperation (MOC) in the areas of Environmental Restoration and Waste Management under the Umbrella of the Peaceful Uses of Atomic Energy (PUAE) Agreement between the U.S. and Russian governments, which was signed in 1972. The historic signing of the MOC marked the beginning of a highly successful, cooperative technology development program that is now in its eighth year.

EM OFFICE OF SCIENCE AND TECHNOLOGY (OST)

OST conducts an aggressive technology development program of applied research, development, demonstration, testing, and evaluation of innovative technologies for deployment in environmental clean-up activities. Since its inception in 1989, EM estimates that it has realized a cost-savings to taxpayers of approximately \$115 million through implementation of innovative technologies. (EM Progress and Plans, November 1996, pg. 1)

It is also widely believed that the investment made by the U.S. in environmental management activities should serve a dual purpose. Taxpayer dollars are spent primarily to clean up sites, but the money spent should also help strengthen the national economy by creating jobs and export opportunities. A stronger domestic environmental services industry will improve U.S. competitiveness in the international environmental market, currently estimated at over \$300 billion annually. (Technology for a Sustainable Future, pg. 10)

The environmental legacy of the Cold War in the U.S. is an expensive one. DOE estimates the cost of managing its own cleanup effort of former nuclear weapon complexes at \$227 billion over the next 75 years. (EM Progress and Plans, November 1996, pg. 1) Investing in innovative technology and creative scientists with the vision to develop it, will result in huge savings over time. In 1996, the Army Corps of Engineers estimated that OST will generate \$20 billion in life-cycle cost-savings through implementation of innovative technology. (EM Progress and Plans, November 1996, pg. 10)

BENEFITS OF COOPERATION

In addition to the obvious benefit of sharing experience with common problems among leading scientists in the field, there has been an enormous economic incentive to work together on the world's most difficult environmental technology challenges. DOE's investment in joint U.S.-Russian technology programs is strengthened by leveraging dollars spent on research and development using the Russian labor rates. For example, the average annual salary for a top level nuclear scientist in Russia is currently \$6,000, providing a leverage ratio of approximately

20:1 as compared to a U.S. national laboratory scientist. The 20:1 labor ratio makes this the most highly leveraged program in EM. At the same time, MINATOM is acquiring desperately needed resources to keep their top nuclear scientists employed and identifying, adapting, and commercializing technologies at their own sites.

BENEFITS OF COOPERATION

This cooperative program with Russian scientific institutes meets domestic cleanup objectives by:

- *identifying and accessing Russian EM-related technologies, thereby leveraging investments and providing cost-savings*
- *improving access to technical information and scientific expertise applicable to EM needs*
- *increasing U.S. private sector opportunities in Russia in EM-related areas*

Secondary Benefits include support of Administration foreign policy objectives:

- *Assist in defense conversion of nuclear institutes*
- *Employment of nuclear scientists in peaceful uses of atomic energy*

The end of the Cold War and financial collapse of the former Soviet Union left Russia lacking critical funding for environmental management programs. Russian scientists, struggling with hyperinflation and salary cuts, found themselves highly marketable abroad. Funding which is considered minimal by U.S. standards is employing dozens of Russian scientists at multiple Institutes throughout Russia. This program assists in curtailing the exodus of top Russian nuclear scientists. By contracting with Russian scientists, U.S. taxpayers benefit from highly leveraged labor, and Russia keeps its top scientists working on its most critical environmental problems.

ENVIRONMENTAL SITUATION: **COMPARISON OF DOE AND** **RUSSIAN COMPLEXES**

As the political winds shifted to reflect a new era of U.S.-Russian relations in the early 1990s, the two countries began to come to terms with the extent of environmental remediation necessary at former nuclear weapons production facilities. During the 50 years of operation, radioactive waste disposal ranged from burial, storage in tanks, and conversion into more stable forms such as glass. Over the years, existing disposal sites began to pose serious threats to environmental health, such as leaking into nearby groundwater. Others showed the potential to develop serious problems in the near future.

DOE has approximately 4,000 contaminated sites covering tens of thousands of acres (approximately 3,300 square miles) replete with hazardous or radioactive waste, soil, or structures even though production reactor and reprocessing plant activities ceased at all U.S. sites in 1988. Currently EM is managing roughly 375,000 cubic meters of transuranic (TRU) waste and at least 15,640,000 cubic meters of low-level radioactive waste. The major nuclear weapons complex sites in the U.S. are at Hanford, Washington; Savannah River, South Carolina; and Oak Ridge, Tennessee.

Since the break up of the Soviet Union in December 1991, Russia has continued to reprocess spent fuel from production reactors. In fact, Russia is still operating three dual-purpose reactors that produce both power and fissile material which are located at Seversk and Zheleznogorsk (towns near MINATOM sites Tomsk-7 and Krasnoyarsk-26). Closing these dual-purpose reactors will mean the loss of power production in remote areas. In June 1994, a protocol was signed between Vice President Gore and then Prime Minister Chernomyrdin to shut down these reactors by the year 2000. To support this directive, a study is being conducted to determine alternative power sources for the affected regions.

According to experts on Radioactive Waste Management, reprocessing nuclear fuel has been the cause of significant environmental contamination in Russia. Current Russian cleanup activities are focused on three primary reprocessing facilities in Russia Chelyabinsk-65 (near Ozersk), Tomsk-7 (near Seversk), and Krasnoyarsk-26 (near Zheleznagorsk). Since the late 1940s, some of the waste from reprocessing spent fuel, primarily fission products, has been released into surface-water systems; since the 1960s, this waste has also been disposed of underground by means of deep well injection. Together, these methods have led to significant contamination problems.

ADMINISTRATIVE FRAMEWORK FOR COOPERATION

In September 1990, DOE and MINATOM signed a Memorandum of Cooperation (MOC) in the areas of Environmental Restoration and Waste Management, under the umbrella of the far-reaching 1972 Peaceful Uses of Atomic Energy agreement between the U.S. and Russian governments. Signing of the MOC afforded the opportunity for a wealth of data and expertise to be freely exchanged, ending the former isolation of the U.S. and Russian scientific communities, who had been independently engaged in technology development programs over the past several decades. The MOC is one of the most productive public sector cooperative programs between the U.S. and Russia.

The JCCEM is currently co-chaired by Deputy Assistant Secretary Gerald Boyd, DOE and Deputy Minister Nikolai Egorov, MINATOM. JCCEM membership consists of a fluid organization of specialists who represent each technical area of cooperation.

A Joint Coordinating Committee for Environmental Restoration and Waste Management (JCCEM) was established as the managing body for the MOC. The JCCEM meets annually to review and approve proposals, assess program progress, and make determinations as to the protection of intellectual property rights (IPR), data transmission, and the level of effort on future activities. The next (eighth) JCCEM meeting will be held in Washington, D.C. in September 1998.

EM participation in the JCCEM ensures that the areas of technical cooperation address the most critical needs of the EM focus areas. JCCEM projects are all funded, reviewed, and evaluated by focus area technical staff for scientific merit,

applicability to key DOE site needs, and the expressed interest of a DOE user.

Participation in cooperative work with Russia also provides improved access to technical information, early guidance in the development of cost-saving technologies, continued dialogue among technical specialists, and possible access to commercial opportunities with Russia.

Two individuals were instrumental in overcoming the obstacles to initiate cooperation: Former Deputy Assistant Secretary Clyde Frank, DOE and Former Head of Department Eugeny Mikerin, MINATOM. They were the initial signatories at the first JCCEM, and through their efforts the program developed. This exchange on the most pressing environmental technology concerns facing both countries has resulted in the sharing of an immense amount of knowledge and good will between experts.

More information on the JCCEM program and participating Russian Institutes can be found on the JCCEM website: <http://zx.res.fsu.edu/DOERussianActivities>

JCCEM HISTORY

The 1st JCCEM meeting was held in Moscow in November 1990. At that time, Russia was in the process of instituting broad economic and political reforms. There was anticipation on both sides that cooperation would yield tremendous results. A detailed plan was developed to implement technical exchange workshops in three areas: vitrification, separations, and contaminant transport. Initial efforts in this first year were designed to build trust and foster understanding about DOE and MINATOM structures, roles, and organizations.

The 2nd JCCEM meeting was held in Moscow in November 1992. The first pilot contracts were signed with Russian institutes in separations chemistry and contaminant transport modeling. Both sides committed to protect the rights of intellectual property developed both prior to and during cooperative research. It was agreed that non-disclosure agreements would be signed at the beginning of JCCEM projects.

By the 3rd JCCEM meeting in September 1993, it was apparent that the separations and contaminant transport work was viable and that Russian experience in these areas would be directly useful to DOE's cleanup efforts. Using this pilot project model, two new areas of cooperation were added: radiochemical processing safety and geologic repositories.

When the 4th JCCEM convened in September 1994, twelve new pilot projects were developed and funded. One of the highlights of the year was the first U.S. demonstration of the earliest separations project, which uses Cobalt Dicarbolide to process Idaho high-level waste.

The 5th JCCEM was held in Berlin, Germany in September 1995, in conjunction with the 5th International Conference on Radioactive Waste Management. Project successes included Cobalt Dicarbolide demonstrations in Idaho, and installation of a pilot-scale Russian-developed Plasma Induction Cold Crucible Melter at the Georgia Institute of Technology in Atlanta, Georgia. The contaminant transport modeling work reached new levels of success when four U.S. scientists participated in the First Chelyabinsk Field Study at the Mayak site in Russia. It was agreed that Decontamination and Decommissioning (D&D) would be added as a new area of cooperation.

At the 6th JCCEM in Phoenix, Arizona in April 1996, the program grew to 27 full scale projects supported by \$1.3 million in funding. Areas of cooperation were expanded to include Risk Assessment, TRU Stabilization, and Spectral Tables. The JCCEM agreed to launch a web site, and its home page is now up and running. The website address is <http://www.zx.res.fsu.edu/DOERussianActivities>.

In May 1997, the 7th JCCEM meeting was held in St. Petersburg, Russia. The JCCEM began to focus on projects in the later stages of research and development, which are being demonstrated on actual waste in the U.S. Technology demonstrations were

conducted in the U.S. on four JCCEM technologies in 1997 and a Russian field study was conducted with the participation of U.S. scientists. Emergency Response was added as an area of cooperation.

The 8th meeting of the JCCEM will be held in Washington, D.C. in September 1998.

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PROGRAM MANAGEMENT PROCESS

DOE has established a process to evaluate and identify technology development efforts at key Russian institutes in order to reduce the risks associated with working internationally and to ensure success. The process consists of U.S. scientists reviewing the credentials of Russian scientists and the institutes' capabilities prior to funding new projects.

DOE contracts directly with the Russian institutes in full compliance with both U.S. Government procurement practices and the laws of the Russian Federation. Statements of Work are written as Fixed Price Contracts. Contract payments are made via wire payment through the DOE Office of Accounting, and are based on the receipt of monthly progress reports and other deliverables. This contract mechanism ensures fiscal accountability and provides an audit trail without the cost associated with contractor or national laboratory overhead expenses, resulting in a 30-45% cost-savings.

All technology projects are developed and funded by the EM Focus Area managers. Focus Area needs are communicated to their Russian counterparts by the U.S. points of contact. Proposals that respond to those needs are prepared and reviewed in Russia, then transmitted to the U.S. side for technical review. All funding for Russian projects comes directly from the Focus Areas, and therefore must meet the same technical specifications required of U.S. contractors.

Projects under the JCCEM are phased through the technology development process to ensure applicability to the critical needs of the focus areas. For example, technologies are demonstrated in Russia on simulated U.S. waste, then in the U.S. on simulated waste, and eventually small-scale demonstrations on actual waste in the U.S. Currently, five projects have been demonstrated in the U.S. at the laboratory scale.

<u>TECHNOLOGY</u>	<u>U.S. DEMONSTRATION SITE</u>	<u>DATE</u>
<i>Cobalt Dicarbolide</i>	<i>Idaho National Environmental Engineering Laboratory</i>	<i>June 1998 November 1997 April 1997 April 1996 July 1995 April 1994</i>
<i>Copper Ferrocyanide</i>	<i>Idaho National Environmental Engineering Laboratory</i>	<i>May 1998 July 1996</i>
<i>Iron Phosphate Ceramics</i>	<i>Idaho National Environmental Engineering Laboratory</i>	<i>August 1998 October 1997</i>
<i>Tank Retrieval Equipment</i>	<i>Pacific Northwest National Laboratory Quarter-Scale Test Facility</i>	<i>July 1997</i>
<i>Plasma Induction Cold Crucible Melter</i>	<i>Georgia Institute of Technology</i>	<i>July 1996</i>

As more projects graduate to the later stages of research and development, there is a growing need to consider transitioning to the next step in development. The JCCEM is beginning to study the unique challenges that Russian technologies will face on the path to deployment at U.S. sites.

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**INTELLECTUAL PROPERTY RIGHTS (IPR):
FROM DEVELOPMENT TO DEPLOYMENT**

The MOC was signed at a time when political and legal uncertainties overshadowed Russia. Even today the Russian business and regulatory climates pose unique challenges to international technology transfer. Mutual assurance of professionalism, respect, and advocacy is vital to the continuation of the program. A commitment was made early on to protect intellectual property as a way of building trust and protecting the interests of both sides. This was fundamental to the success of activities conducted under the MOC.

The JCCEM has instituted several practices to ensure mutual respect for intellectual property developed both prior to and during collaborative projects. Non-disclosure agreements are signed by all involved parties for each contract to assist in protecting intellectual property. In addition, principal investigators are contractually obligated to notify the JCCEM when new or novel knowledge is developed under the auspices of JCCEM contracts so that IPR issues can be addressed immediately.

JCCEM PATENTS

Historically, it has been DOE procedure to file a U.S. patent on behalf of the Russian owners for technologies developed under the JCCEM that have a commercial potential. In these cases, DOE held no ownership rights other than a non-exclusive, irrevocable license for application at DOE sites. The following three patent applications were filed using this process:

Removal of Dissolved Actinides from Alkaline Solutions by the Method of Appearing Reagents, N. N. Krot and R.A. Charushnikova. Patent Number: 5,640,668.
Date Granted: June 17, 1997.

Processing of Solid Mixed Waste Containing Radioactive and Hazardous Materials, V. T. Gotovchikov, E.A. Filippov, and A. V. Ivanov. Patent Number: 5,750,822.
Date Granted: May 12, 1998.

Apparatus for Processing of Solid Mixed Waste Containing Radioactive and Hazardous Materials, V. T. Gotovchikov, E.A. Filippov, and A. V. Ivanov. Serial Number: 08/911,071. Filing Date: August 19, 1997.

PATENT PROCESS

PATENT PROCESS FLOW CHART

Documentation of Intellectual Property provided to DOE

DOE conducts a search for similar patents

2 - 4 months

Patent Application is prepared and submitted to the U.S. Patent Office

18 months - 2 years

U.S. Patent Office issues patent

When the patent application process is initiated, the principal investigators prepare a technical document describing the new intellectual property to be protected. DOE conducts a patent search to determine whether patents are already on file for similar technologies before an application is submitted to the U.S. Patent Office. The search generally takes 2-4 months. If the technology is found to be truly original, a patent application is prepared and submitted to the U.S. Patent Office. Once the application is submitted, it can take from 18 months to 2 years before a decision on whether to patent will be rendered. Patent certificates are issued approximately 6 months after the decision is rendered.

As additional technologies mature, the JCCEM is in the process of re-evaluating the best way to protect IPR for technologies developed under the MOC. Recently, issues

have been raised about the relationship between the method of IPR protection and the path to eventual deployment at DOE sites. DOE is currently exploring how patents are handled under the auspices of other cooperative agreements with Russia. Under other federal programs, the U.S. partner retains ownership of the patent with an agreement to share 50% of the net income from licensing fees with their Russian partners, and to retain 50%. This method avoids some of the institutional and structural difficulties that Russian institutes face when trying to enter the U.S. market.

Russian institutes often do not otherwise have access to commercial partners who can prepare their inventions to meet regulatory requirements of the U.S. market. Having a U.S. patent does not in itself yield any economic gain; the technology must be put to use to generate income. This arrangement allows for organizations or companies within the U.S. to bring the technology to market while still generating income for their Russian counterparts. OST plans to propose that the JCCEM adopt a similar strategy for all new projects.

IPR PROCESS PROPOSED FOR ADOPTION AT THE 8TH JCCEM MEETING:

- 1. Principal investigators for each JCCEM project will identify new and novel developments in the monthly progress reports and provide a joint recommendation as to whether a U.S. patent application should be filed. The recommendation should be summarized in the final report. Reports that contain descriptions of inventions should be marked proprietary and should not be published until adequate steps have been taken to obtain patent protection. Non-disclosure agreements should be signed by all interested parties. Inventors should file Record of Inventions for each invention that is made.*
- 2. The appropriate principal investigators from the U.S. side will meet with OST headquarters technical personnel and International Programs staff to determine the patent application filing procedure according to steps 3 and 4.*
- 3. The U.S. partner should be given the first option to file and own the U.S. patent. However, when the technology is commercialized, 50% of the royalties or other income will be shared with the Russian inventors. License agreements will specify that the Russian inventors will be paid 50% of the net income and the mechanism for payment.*
- 4. In the event that the U.S. partner does not wish to file a patent application, DOE-HQ will file and own the patent. License Agreements with private companies will specify that 50% of the royalties or other income be paid directly to the Russian inventors via wire transfer to bank accounts specified in the License Agreement, and the remaining 50% be paid by the private company to DOE for distribution among U.S. inventors and partners according to current law.*
- 5. Mr. Gerald Boyd, the U.S. JCCEM Co-Chairman will officially notify Dr. Nikolai Egorov, the Russian JCCEM Co-Chairman, of the U.S. recommendation for the patent application filing procedure for the technology in question.*
- 6. Dr. Egorov will officially respond to Mr. Boyd as to whether the recommendation is acceptable to the Russian side. If it is acceptable, Dr. Egorov will also identify the Russian owners of the IPR. This correspondence will be made part of the patent application.*

Three additional patent applications are in preparation which, pending approval, may be filed using the proposed new process:

Iron-Phosphate Ceramics for Solidification of Mixed Low-Level Wastes, A. Aloy, E. Kovarskaya, T. Koltsova, and P. Medvedev.

New Solvent for the Simultaneous Recovery of Radionuclides from Liquid Radioactive Wastes, V. Romanovskiy, I. Smirnov, and V. Babain.

New Extraction Processes and Solvents for the Recovery of Cesium, Strontium, Rare Earth Elements, Technetium, and Actinides from Liquid Radioactive Wastes, B. Zaitsev, V. Esimantovskiy, L. Lazarev, V. Romanovskiy, and E. Dzekun.

<u>PROJECT</u>	<u>PATENT APPLICATION FILED</u>	<u>PATENT ISSUED</u>	<u>U.S. DEMONSTRATION</u>
Actinide Chemistry	Yes	October 1997	no
PICCM Process	Yes	October 1997	July 1996
PICCM Melter Apparatus	Yes	Expected Spring 1998	July 1996
Iron-Phosphate Ceramics	Summer 98	TBD	October 1997 August 1998
Cobalt Dicarbollide Universal Solvent	In Preparation	TBD	April 1994 April 1995 April 1996 April 1997 November 1997 June 1998
Cobalt Dicarbollide Process	In Preparation	TBD	April 1994 April 1995 April 1996 April 1997 November 1997 June 1998
Copper Ferrocyanide	Decision Pending	Decision Pending	June 1996 May 1998
Tank Retrieval Equipment	Decision Pending	Decision Pending	July 1997

IPR AND TECHNOLOGY TRANSFER

IPR protection is an integral part of developing a long-range strategy for moving from research and development to implementation of technologies. The Russian program is following the lead of EM in emphasizing the later stages of technology development and eventual deployment. DOE is in the process of preparing cost and performance data on all Russian technologies that have been demonstrated at a U.S. site, which will contain the data necessary for evaluation by potential commercial users. This strategy is promising because it not only addresses patent issues, but also the larger issues related to deployment.

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JCCEM AREA: **EFFICIENT SEPARATIONS**

Separation of long-lived radionuclides from high-level waste (HLW) significantly reduces the volume of waste required for vitrification and disposal. Separations was identified as an area of cooperation at the 1st JCCEM meeting in Moscow in 1990. At that time, MINATOM began constructing a full-scale chemical separations facility at the Mayak Production Association, and DOE was exploring methods for HLW streams at the Idaho, Hanford, and Savannah River sites.

The Efficient Separations & Processing Crosscutting Program was established to concentrate contaminants, and/or purify waste streams, or to down grade the waste to a form that requires less difficult and less expensive disposal.

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JCCEM AREA: EFFICIENT SEPARATIONS **COBALT DICARBOLLIDE**

SITE NEED:

Separation of cesium (Cs) and strontium (Sr) from Idaho liquid and calcine waste.

RUSSIAN INSTITUTES:

Khlopin Radium Institute and Mayak Production Association

BACKGROUND:

In 1992, the Russians were already separating their long-lived radionuclides from defense HLW. OST initiated the first technology development project to be conducted under the auspices of the JCCEM to study the possibility of applying the cobalt dicarbollide process to pretreat U.S. liquid waste. By adapting the Russians' experience to DOE sites, the JCCEM program was able to capitalize on their expertise and leverage the Russian investments previously made on research and development. In the first year of the project, it was demonstrated that a suitable flow sheet could be developed for the U.S. liquid complex concentrate waste form.

Though the U.S. has investigated other alternatives for the removal of Cs and Sr from Idaho calcine and high sodium liquid wastes, the Russian operating experience with cobalt dicarbollide, since 1986, is significantly greater than the U.S. experience with any Cs and Sr process that is currently being considered for HLW.

A full scale industrial facility was commissioned in Russia at the Mayak Production Association site for HLW reprocessing in August 1996. The technology used in the facility was developed in part by the exchanges of the JCCEM. Within three months, 320m³ of highly salted defense HLW with a total activity of 9.3 mln Ci were reprocessed at the facility. The total facility throughput is 700 liters/hour. Recovery of Cs and Sr was at highly successful rates: 99.96% and 99.94%, respectively. The remaining concentrated Cs and Sr were vitrified.

TECHNOLOGY DESCRIPTION:

Chlorinated Cobalt Dicarbollide (ChCoDiC) is an unusual molecule that has a high selectivity for Cs in acidic solutions. Because it leaves other materials in the waste stream, the removed Cs is relatively pure and easily vitrified. With the use of an additive, cobalt dicarbollide also removes Sr.

ACCOMPLISHMENTS:

The multi-year program of development and testing continues at INEEL. In the first year three tasks were completed:

1. laboratory investigations on reprocessing of simulated solid phases of HLW
2. design and construction of a test facility for dynamic testing
3. dynamic trials of reprocessing technology applied to simulated HLW

The second year focused on optimizing and testing a flow sheet for application to the sodium bearing wastes at INEEL with an alternative diluent that could be

The molecule itself consists of two cage-shaped carbollide groups attached to a cobalt ion. Under proper conditions, it prefers to bond with Cs and Sr. It is this property that makes it so potentially useful in treating nuclear waste solutions. The radio-nuclides can be chemically stripped from the cobalt dicarbollide, which is cleaned and recycled. Recycling provides additional cost-savings to industrial production.

THE PROCESS IS AS FOLLOWS:

1. HLW clarification by filtration through metal and corundum powders from 0.2-1.0 mm
2. recovery of Cs and Sr by extraction into cobalt dicarbollide
3. stripping of Cs and Sr
4. washing of extractant with diluted nitric acid for subsequent reuse
5. filtration of recycled extractant to remove solids
6. evaporation of raffinate to initial volume and storage
7. preparation of Cs and Sr re-extractant for vitrification

Scientists observe testing of universal extractant in INEEL hot cell

more easily implemented in accordance with U.S. regulations. The Russian commercial flow sheets use aromatic nitrobenzenes, which are considered hazardous in the U.S. (though they could be used with proper precautions). The new diluent, which promised to be less hazardous, was successfully tested on a simulated waste at INEEL.

The next stage in the project development identified a universal solvent for all radionuclides in the U.S. waste stream. With the addition of a CMPO actinides, Cs, and Sr are removed in a single solvent extraction operation. (CMPO stands for carbamoylmethylphosphine oxide; it is a chemical process.) Dynamic tests on simulated Idaho HLW have given 99.5 percent to 99.9 percent recovery of all the long-lived radionuclides (Cs, Sr, Eu, Pu, Np, Am, and U).

Current testing continues using 26-stage, 3.3 cm centrifugal contactors, or extractors, which were developed and manufactured by NIKIMT, a Russian company. In past testing at INEEL, the contactors in the testing facility were designed for a different process, which resulted in less than optimum performance. By installing Russian centrifugal contactors, the team can test the process under conditions similar to those in the Russian testing facility at Gatchina. The first testing of the modified flow sheet was conducted in November 1997 and the preliminary results are promising. A second testing with actual waste was conducted in June of 1998. Preliminary results indicate that the tests were extremely successful.

V. Esimantovskiy and L. Shklyar take samples during Universal Extractant (UE) testing at INEEL using NIKIMT-developed centrifugal contactors.

Two U.S. patent applications are currently being prepared for cobalt dicarbollide technology:

New Solvent for the Simultaneous Recovery of Radionuclides from Liquid Radioactive Wastes, V. Romanovskiy, I. Smirnov, and V. Babain.

New Extraction Processes and Solvents for the Recovery of Cesium, Strontium, Rare Earth Elements, Technetium, and Actinides from Liquid Radioactive Wastes, B. Zaitsev, V. Esimantovskiy, L. Lazarev, V. Romanovskiy, and E. Dzekun.

FUTURE:

Because of its proven success in Russia and strong results from benchmark tests in the U.S., cobalt dicarbollide is an extremely promising separations technology and a strong contender for deployment pending a decision to pretreat Idaho waste prior to vitrification. An Environmental Impact Statement, which will include technology recommendations, is expected to be released in September 1999.

Operating parameters and cost information from current tests are being compiled for publication in 1998.

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*I. Smirnov, V. Babain and K. Brewer
discuss Universal Extractant testing*

NIKIMT 3.3 cm centrifugal contactor pilot plant at the INEEL

*Dicyclogexano - 18 - crown - 6
For Strontium 90*

*Dibenzo - 21 - crown - 7
For Cesium 137*

DRAWING OF CROWN ETHERS MOLECULES
USED IN RUSSIAN RESEARCH

JCCEM AREA: EFFICIENT SEPARATIONS **CROWN ETHERS**

SITE NEED:

Removal of Cesium (Cs) and Strontium (Sr) from high-level waste.

RUSSIAN INSTITUTE:

Institute of Chemical Technology

BACKGROUND:

This three-year project evaluated Russian-developed crown ethers technology for removing long-lived radionuclides and toxic metals from low-and high-level waste. The Russian work has complemented related work being conducted at the Oak Ridge National Laboratory and has resulted in valuable insight into the parameters that affect selectivity in solvent extraction with crown ethers. While the U.S. investigated a large number of crown ethers and a relatively small number of diluents, the Russians worked on a relatively small number of crown ethers and large number of diluents.

TECHNOLOGY DESCRIPTION:

Crown ethers are carbon and oxygen compounds that have an electronegative selectivity for metals. This property was explored in various solutions for the extraction of Cs in acidic and alkaline waste, based on two macrocyclic polyethers, di-cyclohexyl-18-crown-6 and di-benzo-21-crown-7.

Using this technology, it is possible to process liquid nitric acid wastes, including those with high salt contents, without any adjustment to their composition. This simplifies the subsequent management of the concentrated radionuclides without any accumulation of metal salts in the concentrated waste.

Technology for selective recovery of Sr has been tested on a commercial scale at the Mayak Production Association. More than 2,000,000 curies of Sr have been produced in the form of a highly pure, salt-free concentrate.

ACCOMPLISHMENTS:

Crown ether compounds were identified which select for both Cs 137 and Sr 90 cations. The advantage of complex extraction of radionuclides is aqueous back extraction of both elements. Following two years of testing on simulated Idaho waste, the Russian team conducted dynamic tests using the solvent extraction system in conjunction with a multi-pass counter flow extractor.

FUTURE:

There has not yet been a strong expression of interest from any specific U.S. site for application of this technology due to shifting priorities within the EM complex. A technology summary document will be prepared for public dissemination in the near future.

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JCCEM AREA: EFFICIENT SEPARATIONS COPPER FERROCYANIDE

SITE NEED:

Separation of Cesium (Cs) 137 from Idaho liquid and calcine waste.

RUSSIAN INSTITUTE:

Institute of Physical Chemistry

BACKGROUND:

This project began in 1995 and draws on Russian experience in the application of copper ferrocyanide based sorbents for the recovery of Cs from Idaho high level waste (HLW). This technology has been used in Russia for approximately ten years to separate over 40 million curies of Cs from HLW, and is in continued use within Russia today. This alternative pre-dates cobalt dicarbollide use on an industrial scale in Russia.

TECHNOLOGY DESCRIPTION:

The technology is based on digesting the sludge in a mixture of phosphoric and nitric acids at a temperature of 110-113 degrees Celsius. Under certain conditions, 99.5 percent of the sludge will be digested. The solution may then be decontaminated using copper ferrocyanide. Total dynamic capacity of the sorbent with respect to cesium is approximately 3,000 curies per liter.

Ion exchange column used for testing of FS-2 (Ferrocyanide) sorbent from Institute of Physical Chemistry

The flow sheet that has been developed uses three steps:

- 1. waste is pumped through a column containing a ferrocyanide sorbent and sorption occurs*
- 2. Cs is removed from the ferrocyanide by a process of desorption*
- 3. the Cs in a pure form is vitrified and the ferrocyanide is regenerated and recycled to be used again*

ACCOMPLISHMENTS:

At the start of this project, a technology evaluation was conducted to determine the suitability of copper ferrocyanide to DOE waste streams. The project was later expanded to experimentally verify the results of the technology evaluation. Dynamic flow tests with simulated Idaho waste in a 10 cm³ column were performed in Russia. Testing was conducted on real INEEL waste in the U.S. in July 1996. A 1 cm³ column test was performed on actual waste and cold tests with INEEL simulant with 10 cm³ column were also conducted.

Current year testing includes:

- *the development of an alternative to the reductant hydrazine for selected compound(s)*
- *studying the effect of mercury on the process*
- *studying the effect of basic calcine components (fluoride, etc.) on the sorption of Cs 137*

In addition to improving the kinetic and mechanical sorbent properties of copper ferrocyanide, these tasks will maximize results of hot cell tests on actual Idaho high level, liquid, and calcine waste samples. Current Russian testing indicates that the best alternative to hydrazine is sulfamic acid, but that it is still not as desirable as hydrazine. It was determined that mercury interferes with the removal process, but that in the presence of chlorine, the effect is negated.

FUTURE:

Hot cell tests on actual Idaho waste were successfully conducted in June of 1998 at INEEL. Results are currently being prepared in a final report.

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JCCEM AREA: EFFICIENT SEPARATIONS

ACTINIDES IN ALKALINE SOLUTIONS

DOE NEEDS:

These projects meet the needs of 2 DOE organizations:
Hanford and Savannah River Waste Tank Storage and Processing for Sludge Processing, Transuranic (TRU) Element Removal, and Fission Product Removal.

EM/Energy Research Basic Science Program: Partial organic destruction; Partitioning of waste components over a range of temperatures, including high ionic strength media; Dissolution and precipitation kinetics; Effect of processing on radionuclide distribution on solids; and Study of actinide speciation in alkaline waste.

RUSSIAN INSTITUTE:

Institute of Physical Chemistry

BACKGROUND:

The Hanford, Savannah River, and Oak Ridge sites store radioactive wastes from reprocessing in alkaline conditions. The chemistry of TRU elements and technetium (Tc) in alkaline media is key to the disposal of radioactive waste. Because most chemical processing has been conducted in acid media, relatively little information has been available in the technical literature on the chemistry of actinides in alkaline solutions. However, the Institute of Physical Chemistry of the Russian Academy of Sciences (IPC/RAS) has studied this topic for over 30 years, and is the world's leading center of expertise in this specialized area.

The unique experience of 30 years of research in this area is an invaluable resource to DOE sites, especially Hanford. In recognition of the status of IPC/RAS scientists as the world-renown leaders in this area, two Russian principal investigators were invited to conduct an advanced course on the chemistry of actinides and Tc in alkaline media at the Tri-City's campus of Washington State University in Richland, Washington in the spring of 1998. Enrollment for the course was very high.

Because of the nature of this technical exchange, the principal investigators on both sides have stressed the importance of getting the results of this work into the public forum. (See chart on page 17 for a list of current Publications.) Products of this ongoing collaboration are literature and laboratory studies in technical areas directly related to Hanford and Savannah River site needs for waste tank storage and processing. In light of the international importance of this work, four Russian scientists presented the results of work conducted under the auspices of the JCCM at the Actinides '97 conference in Baden-Baden, Germany in September 1997.

TECHNOLOGY DESCRIPTION:

Two current research tasks address the solid phase chemical behavior of plutonium in alkaline media to answer questions related to the potential of nuclear criticality in the storage and processing of tank waste:

Studies of the Interactions between Pu(IV, VI) (Hydr)oxide Compounds and d-Elements to Forecast Phase Composition and Pu Distribution in Alkaline Waste

Solid State Transformation of Pu(IV) Hydroxide Precipitates in Alkaline Waste Over Long Time

A third task is also being funded as a continuation of two years of previous projects, *Investigation of Removal of TRU and Technetium from Alkaline Wastes by Coprecipitation*

Now in its second year of development, the coprecipitation technology is an appealing solution to the decontamination process approach for pretreating Hanford tank waste.

It requires no additional process vessels because existing (sludge-washing) flow sheets already call for the solid-liquid separation required by coprecipitation. Because of the promising results of 1996 work, application of the process was extended to Tc.

ACCOMPLISHMENTS:

PUBLICATIONS:

The first five documents listed below are available on the Internet under the address:
<http://www.hanford.gov/twrs/tech/treat.htm>

Technical Literature Review:

Alkaline chemistry of Transuranic Elements and Technetium and the Treatment of Alkaline Radioactive Wastes

Actinide and Technetium Compound Solubility:

Determination of the Solubility of Np(IV)-(V), Am(III)-(VI), and Tc(IV), (V) Hydroxo Compounds in 0.5 - 14 M NaOH Solutions

Radiation Chemical Reactions:

Radiolysis of Actinides and Technetium in Alkaline Media

Oxidation/Reduction Reactions:

Investigation of Some Redox Reactions of Neptunium, Plutonium, Americium, and Technetium in Alkaline Media

Coprecipitation Decontamination of Solutions:

Investigation on the Coprecipitation of Transuranium Elements from Alkaline Solutions by the Method of Appearing Reagents

A U.S. patent was filed on this technology on behalf of the Russian inventors.

Sodium Nitrate Removal from Radioactive Waste:

Crystallization of Sodium Nitrate from Radioactive Waste is a literary review recounting the Russian and Soviet radiochemical plants experience in this subject area. The use of "Clean Salt" recovery of sodium nitrate from radioactive waste, which is discussed in depth in this document, is currently being considered at the Hanford Site as an effective and cost-saving alternative to baseline vitrification processing of low-level waste.

Stability of Pentavalent Plutonium:

Investigation on Behavior of Plutonium (V) in Alkaline Media of Various Composition in Liquids and Model Sludges

Catalytic Oxidation and Reduction Reactions for Organic Destruction and

Neptunium Precipitation:

Investigation on Application of Homogeneous and Heterogeneous Catalysis for Alkaline Waste Treatment

Decontamination of Alkaline Solutions from Technetium and Other Fission Products and from Some Actinides by Reductive Coprecipitation and Sorption on Metals is a literary review recounting the Russian and Soviet radiochemical plants in the subject area.

FUTURE:

Proposals for continued work in this area will be submitted to the Efficient Separations Crosscutting Program in the summer of 1998.

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JCCM AREA: CONTAMINANT TRANSPORT AND SITE CHARACTERIZATION

MAYAK SITE DESCRIPTION:

The area of Ozersk, approximately 70 km north of Chelyabinsk in the southern Ural mountains of Russia, presents an unfortunate but unique opportunity to study the movement of radioactive contaminants in soils and groundwater. The contamination comes from the Mayak Production Association, which was the first production reactor complex built in the Soviet Union 50 years ago.

The Mayak site is contaminated with approximately 1 billion curies (Ci) of radioactive waste. Approximately 800 to 900 million Ci of this waste is stored in tanks or vitrified and stored in bunkers, 12 million Ci are in solid-waste burial sites, and 130 million Ci have been released into the environment through open-reservoir disposal, groundwater seepage, and gaseous and accidental airborne releases.

Mayak's history of radioactive-waste releases into the environment began with the discharge of plutonium-reprocessing wastes containing 2.7 million Ci of Strontium (Sr) 90 and Cesium (Cs) 137 directly into the Tcha River in 1949-51. Beginning in 1951, liquid radioactive wastes were discharged into Lake Karachay, a natural lake that served as an unlined liquid waste repository. Current inventory in Lake Karachay is 120 million Ci of Sr 90 and Cs 137. Starting in 1953, storage-tank facilities were used for most liquid wastes.

The largest one-time environmental release at the Mayak Site occurred in 1957, when a tank containing high-level liquid waste exploded, ejecting the tank's 20 million Ci of waste 1,000 meters into the air on a windy day. The airborne plume spread 2 million Ci of radioactive fallout with a concentration exceeding 0.1 Ci/km² over an area 300 kilometers long and 30 to 50 kilometers wide. During a drought in 1967 in which the water level of Lake Karachay decreased significantly, 600 Ci of Sr 90 and Cs 137 from the exposed lake-bottom sediments were scattered by the winds up to 75 kilometers from the site along the radioactive trace from the 1957 tank explosion. In comparison, the Three Mile Island accident released 5-50 Ci.

(Source: Behind the Nuclear Curtain: Radioactive Waste in the Former Soviet Union, Bradley, Don, Battelle Press, 1997.)

Chelyabinsk-65 Area

A map of the September 1994 field site demonstration in Russia near the city of Chelyabinsk-65. The demonstration site, labeled as "Study Area," was located 2 km south of Lake Karachay along the Mishelyak River.

Waste management operations at the former Soviet Union's three nuclear production and reprocessing sites in the West Siberian Basin (Figure 1) have been discussed openly by Russia since the early 1990s. The Mayak site (also called Chelyabinsk-65) near Ozersk is now being studied jointly by DOE and MINATOM under the JCCEM. Additional studies have been conducted under the auspices of the JCCEM at the Tomsk site.

JCCEM AREA: CONTAMINANT TRANSPORT & SITE CHARACTERIZATION

CHELYABINSK FIELD STUDIES AND

OVERSEAS TECHNOLOGY

DEMONSTRATIONS

SITE NEEDS:

Demonstration of cost-effective plume migration monitoring system and development of understanding about the flow of contaminants in groundwater through a fractured rock system.

RUSSIAN INSTITUTES:

Mayak Production Association and Hydrospeztzgeologiya

BACKGROUND:

The contaminant transport and site characterization studies at the Mayak Site were among the first to be approved by the JCCEM and are among the best developed. The studies are designed to develop and calibrate computer models of Mayak's contaminant-transport history, then validate the models with focused field verification studies. U.S. and Russian scientists have been conducting low-cost direct monitoring of the Lake Karachay contaminated groundwater plume where it reaches the surface along the Mishelyak River to provide input to the model, and also to demonstrate a cost-effective plume migration monitoring system.

JCCEM work at the Mayak Site centers on the Mishelyak river system and contaminant plume from Lake Karachay. (Lake Karachay originally had a surface area and volume of 0.45 Km² and 4.2 x 10⁵ m³, respectively; currently these have been reduced by lake backfilling to 0.14 Km² and 1.2 x 10⁵ m³. An accumulated total of 120 million Ci of liquid waste has been deposited into this lake.) Groundwater is carrying contaminants from the lake towards the Mishelyak River approximately 2 km south (see page 20). The Mishelyak River flows into the Techa river, which is already heavily contaminated downstream from the early direct waste discharges.

TECHNOLOGY DESCRIPTIONS:

There are two technologies being studied under this program, a contaminant migration monitoring program and a three-dimensional (3-D) computer model of contaminant migration. The contaminated groundwater is a relatively dense brine and flows in both porous sediments and fractures in the rocks beneath them. Field measurements were taken to characterize the 3-D flow used in the model. The following field studies in Chelyabinsk were designed to demonstrate that field testing is the most cost-effective method for plume characterization.

ACCOMPLISHMENTS:

1ST CHELYABINSK FIELD STUDY:

The 1st Chelyabinsk Field Study was an intercomparison of hydrogeological, geochemical, geophysical, and radiometric measurements, techniques, and methods during which scientists:

1. conducted surface-and soil-water sampling for radiometric and chemical analyses, and in situ radiometric analyses of river water
2. isolated specific hydrologic intervals in two different wells using well packers and produced water from the intervals to compare isolated and Russian open-well sampling techniques, and to determine hydraulic transmissivities of these intervals
3. measured surface electrical resistivity profiles in areas of expected contrasting resistivities using a dipole-dipole array

2ND CHELYABINSK FIELD STUDY:

The 2nd Chelyabinsk Field Study consisted of three separate projects:

Multi-Packer Well Tests

Multi-packer studies of boreholes were performed to identify the transmissivity and water storage properties of the fractured rocks in the Mishelyak River valley in the area of discharge of the Lake Karachay contamination plume and to ascertain the 3-D connectivity of subsurface fracture zones. This array consisted of two monitoring wells with five isolated fractured zones each and an adjacent sample-collection well.

Surface-Water Studies

In coordinated surface-water investigations, several hydrogates were installed above and below the zone of contaminant plume groundwater discharge into the Mishelyak River. Surface-water discharge and surface elevation were monitored simultaneously with the water levels in nearby monitoring wells. Sediment cores were obtained to determine radionuclide inventories in the river bottom.

Self-Cleaning of the Mishelyak River

The radionuclide concentration levels in the river water were determined, as were depth profiles of radionuclides deposited in river sediments. This study is invaluable to DOE in forecasting and decision making in support of cleanup versus land use restriction, particularly at the Idaho site.

3RD CHELYABINSK FIELD STUDY:

The seasonal hydrodynamic changes in groundwater flow were estimated, and the sorption properties of sediments in the river valley were determined. To estimate the seasonal groundwater flow distribution, multi-packer assemblies were installed in four wells to isolate different aquifer zones.

The coefficient of Sr 90 distribution was performed by comparing its inventory in the groundwater to its inventory in the unconsolidated sediments. Representative samples of water and bulk sediment from discrete intervals were collected using a well sampling device known as a StrataSampler™, designed for this program and patented by scientists from the Savannah River Technology Center. Chemical analyses of these water samples and bulk sediment cores collected during drilling enabled the determination of sorption characteristics of the sediments for the main contaminants in the plume Sr, Cs, and nitrates.

Field team for the 3rd Chelyabinsk Field Study, July 1997

***FIRST JCCEM OVERSEAS
DEPLOYMENT: STRATASAMPLER™**

StrataSampler™ characterization technology was developed at the Savannah River Technology Center for this program to meet EM's need for depth discrete data sampling of groundwater flow through fractured rock. Existing methods, including geophysics and open boreholes in fractured rock, did not provide sufficient depth discrete data. It was deployed during the 3rd Chelyabinsk Field Study in Chelyabinsk, Russia. It has been patented and licensed to Timco, Inc. of Wisconsin. The overseas deployment of the StrataSampler™ is an example of the significant contributions that can be made to the U.S. domestic clean-up effort through international cooperation. As the first deployment of a JCCEM developed technology, it is also a marker of the success of the JCCEM program.

Scientists installing the StrataSampler™ during the 3rd Chelyabinsk Field Study, July 1997.

Recent publications on the results of the field studies are available upon request:

"Joint Russian-American Hydro-geochemical Studies of the Karachay-Mishelyak System, South Urals, Russia," E.G. Drozhko, et al., Environmental Geology, February, 1997.

Technical Report: WRSC-TR-96-0350, "Summary of Three Dimensional Pump Testing of a Fractured Rock Aquifer in the Western Siberian Basin," R.L. Nichols, B.B. Looney, et al., 1996.

For a list of related publications, please see Appendix A.

FUTURE:

The fieldwork required to gather data for input to the regional model is complete. If additional funds become available, the principal investigators have identified additional studies, which would add to the understanding of the hydrogeology of the region, including a study of the effects of the spring thaw on contaminant migration.

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**JCCCEM AREA: CONTAMINANT TRANSPORT & SITE CHARACTERIZATION
3-D REGIONAL MODEL:****SITE NEEDS:**

Information about the flow of contaminants in groundwater through fractured rock, which will assist in validating U.S. computer models of contaminant flow and establishment of risk-based standards for the evaluation of contaminated sites in the U.S. Three U.S. sites Hanford, Washington; Idaho Falls, Idaho; and Oak Ridge, Tennessee have analogous composite layered-overburden/fractured-rock geologies.

RUSSIAN INSTITUTES:

Mayak Production Association and Hydrospeztzgeologiya

BACKGROUND:

Based on the JCCCEM demonstrations, this characterization strategy of low-cost monitoring combined with predictive computer modeling can be used to devise remediation strategies at similar U.S. sites. Work began on the regional model in 1995.

TECHNOLOGY DESCRIPTION:

Data gathered during the field studies provide characterization and calibration information in support of contaminant migration computer modeling of the Mayak region. This joint program has been developing a regional 3-D hydrodynamic model of the area surrounding Lake Karachay to explore groundwater flow and contaminant migration through fractured rocks and the linkages between ground and surface waters.

**PROCESS FOR CONSTRUCTION OF THREE-DIMENSIONAL
HYDROGEOLOGICAL MODEL, MAYAK SITE, URALS, RUSSIA**

FIGURE 1: DIAGRAM OF THE VARIOUS TECHNICAL EFFORTS FOR 1997 AND INTERRELATIONSHIP BETWEEN THEM.

ACCOMPLISHMENTS:

Analyses of all field studies' data collected are published annually in peer-reviewed technical journal articles under joint authorship. In addition, the results are presented at international scientific and technical conferences. Two papers have been submitted and will be presented at Spectrum 98 in Denver, Colorado, which will be held in September 1998.

For a list of related publications, please see Appendix A.

FUTURE:

The 3-D regional model of the Mayak site will be completed in late 1998. Opportunities to demonstrate the model will be sought at Hanford, Idaho National Engineering and Environmental Laboratory, or Oak Ridge National Laboratory. Preliminary discussions are already underway.

The Russians have been collecting and analyzing data on radioactive wastes and contaminant migration since 1957. The database is a unique resource for studying physical and chemical processes of radioactive contaminant transport at the field scale. Once the data is analyzed, it can provide an invaluable tool for model verification in the U.S. Discussions are underway to develop a program for the public release of this information.

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JCCCEM AREA: CONTAMINANT TRANSPORT & SITE CHARACTERIZATION
VADOSE ZONE MODELING**SITE NEEDS:**

Determine the feasibility of applying Russian contaminant migration data to the problem of modeling contaminant flow in the Hanford Zone.

RUSSIAN INSTITUTES:

Mayak Production Association and Hydrospeztzgeologiya

BACKGROUND:

The area directly beneath the HLW storage tanks is called the Vadose Zone. Contaminant migration in this area is extremely difficult to measure because it is hard to take groundwater samples. A project was started in June 1998 to determine whether the Russian experience at Lake Karachay can be used to model the vadose zone in order to predict the flow of radionuclides. The issue at Hanford has become a high priority because of the proximity of the Hanford Tank Farm to the Columbia River.

TECHNOLOGY DESCRIPTION:

For this preliminary feasibility study, the Russian side will gather relevant data and write a report, which is due in October 1998. In order to prepare this study, the Russian side will participate in a Vadose Zone Workshop in Lawrence Berkeley National Laboratory.

FUTURE:

The preliminary results will be presented at a DOE sponsored workshop on the Vadose Zone at Warsaw 98 in Warsaw, Poland in September 1998. Based on the results of the preliminary study, a future work plan will be designed at a program review meeting in November 1998.

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JCCEM AREA: CONTAMINANT TRANSPORT & SITE CHARACTERIZATION

INTERNATIONAL COOPERATION: LAKE KARACHAY AND THE EUROPEAN COMMISSION

In January 1998, U.S. and Russian members of the JCCEM team participated in an international workshop on contaminant migration from Lake Karachay sponsored by the European Commission. This was the first meeting of its kind, and 50 representatives from Norway, Italy, United Kingdom, U.S., and Russia met in order to better organize and plan future work. The objectives of the workshop were:

- exchange information and assess the progress of all international programs
- identify areas for further study
- improve coordination among the international projects

The cooperative program conducted under the auspices of the JCCEM was determined to be the strongest of the international projects in the region.

The participants proposed the formation of a Lake Karachay International Expert Group to coordinate international research efforts in the region. Organizations that are currently conducting research in the region would be represented in the Expert Group. The Expert Group would develop a research plan addressing risk assessment and identification of countermeasures to remediate contaminant plumes, which would be planned for completion by the year 2000.

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JCCEM AREA: CONTAMINANT TRANSPORT & SITE CHARACTERIZATION

**CHARACTERIZATION OF DEEP WELL
INJECTION AT THE TOMSK SITE**

SITE NEED:

Predict and verify U.S. contaminant migration models.

RUSSIAN INSTITUTES:

Siberian Chemical Combine, Hydrospeetzgeologiya, and VNIIPromtehnologii

BACKGROUND:

TOMSK-7 SITE DESCRIPTION:

The second production reactor and reprocessing site built in the former Soviet Union is located in Siberia, approximately 10 to 12 km northwest of the city of Seversk, at a site known as Tomsk-7. A total of 130 million curies (Ci) (about 8 million cubic meters) of waste has been discharged into reservoirs and basins at Tomsk-7, making the ponds as contaminated as surface waters at Mayak. These releases are dwarfed however, by the amount of liquid waste that has been injected into subsurface geologic formations for the past 30 years. Over 30 million cubic meters of different types of waste with a combined radioactivity of approximately one billion Ci have been injected into two well fields in sandy Mesozoic-Cenozoic strata below the water table. Russian scientists believe that waste injected into the subsurface will remain isolated from the biosphere due to the presence of confining clay layers above and below the sandy injection horizons.

(Source: Behind the Nuclear Curtain: Radioactive Waste in the Former Soviet Union, Bradley, Don, Battelle Press, 1997.)

Even though the Tomsk site is not an analog of any DOE site (the U.S. does not inject radioactive wastes, nor is there a significant problem with contaminated, confined aquifers) it is interesting because it is potentially the most reliable source of information about the migration of radionuclides in porous media. Deep well injection at Tomsk-7 was a carefully planned activity with substantial prior characterization work.

TECHNOLOGY DESCRIPTION:

TOMSK THREE-DIMENSIONAL REGIONAL MODEL PLANNING

The topographic, geologic, hydrologic, hydrogeologic, and radiochemical data necessary for construction of the mathematical model of groundwater and contaminant transport at Tomsk-7 have been acquired through exchanges with Russian scientists.

ACCOMPLISHMENTS:

A conceptual framework for a computer model has been developed, and the necessary data has been identified. Furthermore, a book about deep well injection at the Tomsk site that was authored by Russian scientists has been translated into English and is expected to be published by Battelle Press in late 1998.

FUTURE:

Due to constrained U.S. budgets, the JCCEM Tomsk-7 contaminant transport work is currently on hold in order to complete the regional model of the Mayak site.

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V.G. Khlopin Radium Institute in St. Petersburg

Gatchina Hot Cell Facility outside of St. Petersburg

JCCEM AREA: **MIXED WASTE**

In 1993, the JCCEM began discussing cooperative projects in the area of Mixed Waste. DOE had been aggressively investigating and implementing innovative and cost-saving technologies in the treatment of waste off-gases and vitrification.

JCCEM AREA: MIXED WASTE

PLASMATRON WITH INDUCTION **COLD CRUCIBLE MELTER (PICCM)**

SITE NEED:

Disposition of spent fuel at Savannah River, Idaho, and Hanford.

RUSSIAN INSTITUTE:

Institute of Chemical Technology

BACKGROUND:

One of the first JCCEM pilot projects in the area of Mixed Waste began in 1994. Its goal was to evaluate the application of a unique combination of plasma and induction heating in a cold crucible melter to reduce the volume of mixed waste. This technology, the Plasma Induction Cold Crucible Melter (PICCM), can handle a broad spectrum of waste compositions and could possibly scale up to a capacity able to treat 55 metal drums containing transuranic (TRU) waste.

TECHNOLOGY DESCRIPTION:

The PICCM is known as a hybrid melter. It operates on a low frequency (1-10kHz) and is capable of processing high metal content waste streams. It utilizes a steel sleeve inside the cold crucible, which acts as an electrode in contact with the glass melt, effectively heating up the glass pool. This allows the current to flow with any type of glass. This is different from other crucibles that are only able to handle glass that already contains components that allow the current to flow.

ACCOMPLISHMENTS:

Initial testing during the pilot project was conducted on simulated waste, which was expanded to design and conduct experiments to determine the disposition of TRU elements in the melting process, and to design and construct a melter system for delivery and installation at a U.S. lab. Hot tests with actual TRU materials were conducted at the Institute for Chemical Technology in Moscow.

A PICCM system was successfully assembled and tested at a site called Podolsk near Moscow. In early 1996, it was disassembled and shipped to Atlanta, Georgia, where it was installed in the Plasma Research Facility at the Georgia Institute of Technology. Non-radioactive tests were conducted to verify the Russian test results. Due to changing priorities within the Mixed Waste Focus Area, funding was discontinued in 1997.

Because of the unique characteristics of the apparatus, two patent applications were filed by DOE on behalf of the Russian inventors. This is one of the first JCCEM projects for which patent protection was filed.

Processing of Solid Mixed Waste Containing Radioactive and Hazardous Materials,
V. T. Gotovchikov, E.A. Filippov, and A. V. Ivanov.

Apparatus for Processing of Solid Mixed Waste Containing Radioactive and Hazardous Materials, V. T. Gotovchikov, E.A. Filippov, and A. V. Ivanov.

FUTURE:

A new facility for the melter was identified at Mississippi State University in its Diagnostic Instruments and Analysis Laboratory (DIAL). The DIAL facility has extensive expertise in melter operations. The PICCM melter was installed at DIAL in June 1998. Development and testing of the melter will be continued under an EM University Programs grant to DIAL. Activities during the first year include:

- Testing of the PICCM melter with simulated spent nuclear fuel and borosilicate glass raw materials
- Testing of the PICCM melter with simulated spent nuclear fuel and a crystalline product called Synroc
- Making a recommendation on further testing and the value of the system for this application based on these results

Preliminary performance data from DIAL testing will be compiled in a technology summary in early 1999.

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JCCEM AREA: MIXED WASTE

IRON-PHOSPHATE CERAMICS DEVELOPMENT AND DEMONSTRATION

SITE NEEDS:

Immobilize volatile, hazardous, or radioactive components that may accumulate in off-gas systems of high-temperature processes. Applicable to the treatment of Pu contaminated ash at Rocky Flats, filter cake or filter leachates, and blown down sludges, as well as for nitrate salts that are not compatible with cementatous waste forms.

RUSSIAN INSTITUTE:

Khlopin Radium Institute (KRI)

BACKGROUND:

In 1996, a project was initiated to develop a room temperature ceramic for the treatment and disposal of DOE mixed and TRU waste. One main advantage of this process is that it utilizes iron oxides, which are steel industry wastes. The process, therefore, combines DOE and industrial waste streams to produce excellent quality waste forms acceptable for disposal. The process is similar to cementation in simplicity. It produces waste forms that allow waste loading as high as 50% of total weight.

Operating parameters:

feed settings, temperature and time of phase formation

System parameters:

position of phosphate phases and the method of mixing and pouring into form

Waste form parameters:

open and closed porosity, hardness (mechanical strength), phase analysis and microstructure, and leachability by Product Consistency Test or Toxicity

Characteristic Leaching Procedure:

Tests performed in Russia indicate mechanical compression strength of up to 500 kg/cm²; open porosity of up to 10% of the volume; and leachability of toxic and radioactive elements is within the permissible limits.

Some of the U.S. residue wastes, including Rocky Flats incinerator ash, are planned to be stabilized in a matrix such as glass. The wastes contain significant organic residues of incomplete incineration, which could present problems during vitrification. In addition, it requires more complex equipment.

A Russian graduate student at Idaho State University, whose studies were sponsored by the JCCEM scientist exchange program, wrote his Master's thesis on developing the application of iron-phosphate ceramics to Rocky Flats ash immobilization. His efforts in part led to the development of the joint research project. For more information about his work, please see the Scientist Exchange Chapter on the Idaho State University Exchange.

TECHNOLOGY DESCRIPTION:

Current efforts are focused on utilization of magnesium oxide (MgO) as a reactant to "set" the waste. Problems experienced with using MgOs are caused by the reaction rate, which is rapid and exothermic. Iron-Phosphate bonded ceramics technology provides an alternative means of controlling the

reaction rate and therefore alleviates the mixing and temperature control problems.

ACCOMPLISHMENTS:

In the summer of 1997, scientists at the KRI facilities performed experiments on simulated ash from an Idaho recipe to determine the optimal formulation for its immobilization. In October 1997, experiments were conducted in the laboratory at the INEEL Waste Experimental Reduction Facility on actual ash. Data on the amount of ash immobilized during these tests were compiled, and additional tests will be conducted in August of 1998.

Additional studies are currently being done to determine the effectiveness of iron-phosphate ceramics technology in treating other DOE waste streams. The results of this project will be used by the Mixed Waste Focus Area to evaluate the technical and economic viability as well as regulatory compliance of this waste treatment process.

This is a very promising technology for both Russian and U.S. waste. The Russians filed a Russian patent application on this technology

Albert Aloy describing phosphate bonded ceramic (Pbc) formation in INEEL lab

A. Aloy, T. Koltsova, E. Kovarskaiya in INEEL lab

1300 g sample of Pbc made
with 500 g of actual INEEL
mixed waste ash

in the spring of 1997. In preparation for discussions with commercial partners, a U.S. patent application is being prepared. The principal investigators anticipate a wide range of potential applications and are verifying the results of the fall demonstration before releasing performance data.

FUTURE:

A large-scale (1,000 kg) demonstration will be conducted at INEEL in August of 1998. The results will be compared with those of 3 competing technologies in the fall of 1998.

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JCCEM AREA: MIXED WASTE

**ASSESSMENT OF RUSSIAN WASTE
TREATMENT TECHNOLOGIES AND
THEIR APPLICABILITY TO THE DOE
MIXED WASTE FOCUS AREA (MWFA)**

SITE NEED:

Review and evaluate Russian mixed waste treatment technologies which may be applicable to DOE MWFA needs.

RUSSIAN INSTITUTE:

Khlopin Radium Institute (KRI)

TECHNOLOGY DESCRIPTION:

The Russian side was tasked with evaluating the stage of development, the feasibility of joint development and demonstration, and the applicability to DOE waste problems. In addition, KRI developed a technology search and evaluation process through ties with Russian users and developers.

ACCOMPLISHMENTS:

The study results were documented in a Russian waste treatment technology assessment report, which contained a table with MWFA needs cross-linked with appropriate Russian technologies. Data in the table included estimated financial and time requirements for completion and/or adaptation to MWFA needs. A database of Russian technologies was developed at KRI.

FUTURE:

The relationships developed through the tracking of Russian capabilities could stimulate the development of new Russian technologies that are applicable to MWFA needs.

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JCCEM AREA: MIXED WASTE

**COLD PROCESS OF SOLIDIFICATION
AND STABILIZATION OF SOLID WASTES
CONTAINING RADIONUCLIDES
AND HARMFUL IMPURITIES USING
ORTHOSILICIC ACID DERIVATIVES****SITE NEED:**

Prevention of contaminant migration, low-temperature immobilization.

RUSSIAN INSTITUTE:

Institute of Chemical Technology

BACKGROUND:

This project, funded in FY97, complemented the work on phosphate-based ceramics. The technology may provide an alternative means of low-temperature immobilization for volatile or high-nitrate wastes. A very stable spatial structure is formed around the contaminant, and it will retain its geometry after solidification. It is useful for sodium-bearing wastes up to 25 wt%.

TECHNOLOGY DESCRIPTION:

A sodium nitrate solution is mixed with orthosilicic acid derivatives to form a solidified translucent water glass puck, which is hard to the touch but fragile enough to be crushed by hand. It is cured for a few days, and the residual alcohol and water are removed.

This process breaks down the material into fine granules. The granules are treated with ferrocyanide to prevent the leaching of cesium.

ACCOMPLISHMENTS:

Tests were conducted at the Institute of Chemical Technology on simulated waste.

FUTURE:

Due to changing priorities in the Mixed Waste Focus Area there is no plan to continue funding of this project.

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JCCM AREA: MIXED WASTE

HIGH FREQUENCY INDUCTION MELTER

SITE NEED:

Radionuclide partitioning and vitrification.

RUSSIAN INSTITUTE:

Khlopin Radium Institute (KRI)

BACKGROUND:

In 1996, a project with the KRI was initiated to perform a series of laboratory tests on a high frequency induction melter to study radionuclide partitioning during the melting process. The results of the study will contribute to a fundamental understanding of the process, as well as provide valuable practical data.

TECHNOLOGY DESCRIPTION:

The cold crucible design of this melter is well suited to generating a glassy slag from wastes, which mixes satisfactorily in the induced 1.76 MHz electromagnetic field. This type of melter appears most applicable to inorganic solids. The melter walls are not refractory; a cold skull isolates the melt and the melt temperature is easily controlled. The melt inventory is small, yet the throughput is high.

ACCOMPLISHMENTS:

Testing was conducted in Russia on simulated waste streams with chemical compositions of interest to the Mixed Waste Focus Area (MWFA).

FUTURE:

Due to changing priorities in the MWFA, there is no plan to continue funding of this project.

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JCCM AREA: MIXED WASTE

**TIN DIOXIDE FOR USE AS REFRACTORY
AND/OR ELECTRODES FOR JOULE
HEATED GLASS MELTERS**

SITE NEEDS:

Improved refractory and/or electrode materials in joule heated melters to lower corrosion rates, and improve performance and reliability for melters at Savannah River, Hanford, West Valley, and INEEL.

RUSSIAN INSTITUTES:

Khlopin Radium Institute (KRI) and the Institute of Inorganic Materials

BACKGROUND:

A project was initiated in 1997 with the KRI and the Institute of Inorganic Materials, which have experience in using tin dioxide to improve the performance of their Joule Heated Glass Melters.

TECHNOLOGY DESCRIPTION:

This project assessed potential advantages over existing materials currently in use or being tested in the U.S., provided performance data, limitations, and direct comparisons with other materials.

ACCOMPLISHMENTS:

A final report is available upon request.

FUTURE:

This project was completed.

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JCCEM: **HIGH-LEVEL WASTE** **TANK REMEDIATION**

SITE NEED:

Sludge removal from waste tanks at Savannah River, Oak Ridge, and Hanford.

RUSSIAN INSTITUTES:

Integrated Mining Chemical Association and Radiochemservice, a Joint Stock Company
Affiliated with the Institute of Chemical Technology

BACKGROUND:

Russian decontamination and decommissioning plans for the radiochemical production complex at the Mining Chemical Association (Krasnoyarsk-26) made it critical to retrieve the sludge from their HLW tanks. These 3000m³ tanks are similar to Hanford tanks, and contain similar sludge. This equipment is in use in Krasnoyarsk-26, and was tested in the U.S. in the fall of 1997, was used to empty three Russian tanks. Investment in Russian technology may offer the U.S. a new series of inexpensive, proven effective, and readily available retrieval tools.

TECHNOLOGY DESCRIPTION:

A high-capacity pulsating pump was designed for retrieval from 3000m³ tanks. The Russian pulsating pump was constructed with a productivity of 12-15 m³/hr for sludge retrieval from a depth of 10-30 m. A pulsating monitor was also developed as part of the tank retrieval equipment tool kit.

The pulsating pump and monitor operate by drawing waste into a vertical cylindrical chamber through an immersed foot-check valve and then expelling it. In the pump, the waste slurry is expelled through a riser stem-pipe and a check valve at the head of the riser into process piping on a holding tank. The monitor, on the other hand, expels the waste through an array of nozzles at the bottom of the device that mobilize and mix the water and scour the tank floor. The working fluid is atmospheric air delivered to the chamber in alternating pulses of a partial vacuum (-60kPa) and pressure (-400kPa) through a motorized rotary valve. The vacuum is furnished by an eductor operating from the same compressor that supplies the pressurized air.

The components of the system that are actually placed into the tank are simple, rugged, and inexpensive—making it economically feasible to leave the pump in the tank after use. The more costly system components do not become contaminated under normal operating conditions, and can be readily reused without expensive decontamination operations.

ACCOMPLISHMENTS:

The Russian tank retrieval equipment was demonstrated at the Quarter-Scale Tank Test

Facility at Hanford in July 1997. The pulsating pump performed as predicted on water and kaolin slurries up to 1.3 gravities. The developers were able to demonstrate that the equipment can recover from blockage to flow by means of back flushing and valve-clearing techniques facilitated by the equipment design.

The design of the current control system limits operating pressure to 6 atm. Planned engineering modifications will extend the technology's range of applicability and extend the operating pressures to 30 atm. (450psi.)

FUTURE:

Discussions were conducted with Oak Ridge about modifications that would be necessary to deploy the Russian tank retrieval technology in a tank. Deployment of this technology at Oak Ridge in FY98 or FY99 is likely. Efforts to identify alternative funding sources for additional research and development activities are ongoing.

The Russian side has made the following suggestions for further development of the tank retrieval equipment:

- developing and testing a new distributor that operates at 30 atmospheres
- developing and testing new monitors that efficiently wash heavy aluminate sludges, increase operational radius, vertically mix the sludge, and allow for decontamination of tank walls

The Russians also propose to develop a process to remove the hard heels from the tanks, maximizing the application of working liquid. This would significantly reduce the working liquid used for retrieval.

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JCCEM AREA: HIGH-LEVEL WASTE TANK REMEDIATION

**U.S./RUSSIAN RETRIEVAL
USERS-DEVELOPERS WORKING GROUP**

RUSSIAN INSTITUTES:

Khlopin Radium Institute, Mayak Production Association, Mining Chemical Combine, Siberian Chemical Combine, and All-Russian Planning and Design, Research and Technological Association

BACKGROUND:

A working group of senior level site managers in Russia and the U.S. was established to exchange technology development approaches, needs, and solutions. This working group met in Augusta, Georgia in September 1997.

TECHNICAL DISCUSSION:

The objectives of the exchange were:

- discuss the activities involved in retrieval in the U.S. and Russia
- discuss the technical difficulties facing both countries in achieving acceptable retrieval for processing and disposal
- discuss the options being evaluated for both countries

ACCOMPLISHMENTS:

The exchange was considered fruitful by both sides. The site managers shared their experiences on several topics, most notably, tank decontamination and waste transport.

FUTURE:

Discussions are underway to continue this type of technical exchange. As a result of this workshop, a new project is currently being negotiated on the Chemical Decontamination of HLW Tanks. This project with the Khlopin Radium Institute and The Mining Chemical Combine, will conduct experiments on the use of oxalic acid and other chemicals for the dissolution of sludge. Tests will be conducted in Russia on simulated sludges. The statement of work will be finalized and work began in the July of 1998.

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JCCCEM AREA: HIGH-LEVEL WASTE TANK REMEDIATION

SOLIDIFICATION EXPERIENCES

RUSSIAN INSTITUTES:

A.A. Bochvar Institute of Inorganic Materials, Khlopin Radium Institute, Mining Chemical Combine, and Mayak Production Association

BACKGROUND:

A third workshop was conducted in September 1997 to bring technical experts together to discuss vitrification, glass formulation, melter operation, and melter decontamination and decommissioning.

RUSSIAN VITRIFICATION EXPERIENCE:

Russia has been vitrifying liquid waste on an industrial scale for 20 years. The latest direct heat electric melter, called the EP 500, was shut down in January 1997 due to leaking glass melt into the conveyor. It had been in operation at the Mayak facility for six years, three years longer than intended by design. 11,460 m³ of liquid radioactive waste had been processed, producing 2,200 tons of phosphate glass with total beta-activity of 278 million curies. Two similar melters are under construction at the second stage of the Mayak vitrification facility, which is scheduled for start-up in 1999.

TECHNICAL DISCUSSION:

The objectives of the meeting were:

- discuss the status of U.S. and Russian HLW vitrification facilities
- discuss the status of relevant U.S. and Russian technology development activities
- discuss issues related to melter decontamination and decommissioning

ACCOMPLISHMENTS:

Both the U.S. and Russian participants agreed that the technical workshop provided an excellent forum for the exchange of technical information and that it should be continued. They identified three areas of interest for further development:

- studies on glass chemistry
- vitrification of medium-level waste
- melter safety from operational and technical perspectives

FUTURE:

At this time, there are no firm plans for future solidification exchanges.

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JCCEM AREA: TRANSURANIC STABILIZATION

The U.S. production of plutonium was stopped in 1986, but the stabilization of stored plutonium continues to be a problem for both countries. It was agreed at the 6th JCCEM to collaborate in the area of transuranic stabilization as a way to join efforts in developing the most effective technologies for the task. A workshop was held in August 1996, during which representatives from major U.S. sites met with technology development specialists from key Russian institutes to share experiences with solid residues from plutonium processing.

The result of the initial meeting and subsequent discussions was the initiation of the following three projects in 1997:

Plutonium Immobilization in Silica Gel from Liquid Waste by means of High-Temperature Adsorption, Institute of Chemical Technology and the Mayak Production Association

Synthesis and Thermodynamics of Super-Stable Crystalline Matrices for Stabilization and Immobilization of Plutonium-Bearing Waste, Khlopin Radium Institute and the Institute of Silicate Chemistry

*Determination of Radiolytic Gas Generation in Chemically-Bonded Iron Phosphate Matrices Formed by Cold Ceramic Immobilization of Transuranic Ash Residue Wastes.**

**For a summary of a related Iron-Phosphate Bonded Ceramics project, please see the Mixed Waste section.*

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JCCEM AREA: TRANSURANIC STABILIZATION

SILICA GEL

SITE NEED:

Immobilization of Plutonium (Pu) in residue waste streams.

RUSSIAN INSTITUTES:

Institute of Chemical Technology and the Mayak Production Association

BACKGROUND:

Silica gel technology is a simple and efficient process of high-temperature adsorption of Pu and transuranics from solutions by a porous inorganic matrix. It has been tested for a wide range of applications in the DOE complex. By leveraging the work of past years, a relatively small investment is required to determine the feasibility of applying this process to complex-wide Pu residue waste streams. This would provide DOE with a back-up technology to stabilizing Rocky Flats Pu solutions and a primary technology to stabilize other waste solutions that might be generated in the future.

TECHNOLOGY DESCRIPTION:

The simple batch process involves adsorption of the waste solution on pellets of silica gel, followed by a brief heating cycle for solidification and stabilization of the Pu and subsequent recovery. A hermetically sealed apparatus for the conversion process, which can be made critically safe for Pu waste processing solutions, has been tested.

ACCOMPLISHMENTS:

In 1995, the Mixed Waste Focus Area sponsored testing at the Savannah River Technology Center (SRTC) using rare earth, uranium, transition, alkaline, and alkaline earth elements. The average loadings were 0.5% g/g, representing about a 30 wt% by oxides. Preliminary tests indicated that silica gel has a very high capacity, up to 0.8 g/g silica gel for Pu, up to 0.75 g/g for neptunium (Np), and more than 0.68 g/g for americium (Am), and produces a chemically stable and mechanically robust product. With added gadolinium or boron, the treatment process meets most of the criticality requirements. Limited testing was also conducted at the SRTC to duplicate Russian work using uranium, cerium, silver, cadmium, and chromium. Simulated dissolved fuel compositions were also tested on a limited scale.

Tanks Focus Area continued testing silica gel adsorption of technetium (Tc), Np, and Pu for high-level waste pretreatment or immobilization.

The work included:

- *testing the sorption capacity of silica gel for Tc, Np, Am, and Pu for tank solution compositions*
- *the effects of silica gel particle size on sorption capacity, strength, and chemical durability*
- *the effects of undissolved solids on capacity, drying, and calcining*
- *the effects of anions on the process and product*
- *the effects of solution pH on adsorption and sintering process for Tc*

Current testing includes representative U.S. "lean" and "rich" Pu and transuranic waste streams with a wide range of impurities such as halides, nitrates, phosphates, and sulfates. Specific tasks include determining the gaps in previous testing, determining the loading level and efficiency for Pu and transuranic residues, and verifying results of radioactive tests on actual Russian waste.

FUTURE:

Due to changing priorities within the Plutonium Focus Area, there is no plan to continue funding of this project.

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JCCEM AREA: TRANSURANIC STABILIZATION

**SYNTHESIS AND THERMODYNAMICS OF
SUPER-STABLE CRYSTALLINE MATRICES
FOR STABILIZATION AND IMMOBILIZA-
TION OF PLUTONIUM-BEARING WASTE**

SITE NEED:

Immobilization of plutonium in 94-1* (Rocky Flats ash) waste streams.

**94-1 waste streams refers to the Defense Nuclear Facility Safety Board Recommendation 94-1, which identified the plutonium residues left from the manufacturing process when the production facility was shut down, which are not safely stored or stable and need to be remediated. Some of this material includes Rocky Flats ash from previous incineration.*

RUSSIAN INSTITUTES:

Khlopin Radium Institute and the Institute of Silicate Chemistry

BACKGROUND:

The 94-1 plutonium residue wastes generally contain a larger amount and variety of impurities than wastes from weapons dismantling, and can contain more than 50% impurities. Russian laboratories have developed thermodynamic modeling for stability of materials under difficult experimental conditions and development of stable material matrices for long-term storage.

TECHNOLOGY DESCRIPTION:

This novel process for the synthesis of super-stable mineral matrices for immobilization and long-term storage of plutonium and transuranic elements uses potential mineral matrices, which have been well characterized using both simulated and actual transuranics and plutonium.

This project will utilize the Russian expertise and extensive database to determine whether feasibility studies and thermodynamic modeling can be conducted on U.S. waste stream compositions. Thermodynamic modeling has successfully predicted a number of physical properties of molten silicate glass chemical systems in Russia, and can be extended to waste stream processing and interim storage applications including oxides, sand, slag, crucible, pyrochemical crucibles, and ash.

Specific tasks include evaluation of previous thermodynamic measurements and modeling, application of modeling to stability under interim storage conditions, preparation and characterization of candidate mineral waste forms using surrogates for transuranics, identification of impacts of impurities and experimental conditions, and verification tests using plutonium or other transuranics.

ACCOMPLISHMENTS:

Results from this project are scheduled to be completed in the summer of 1998.

FUTURE:

Future work will be determined based on the final report.

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JCCM AREA: TRANSURANIC STABILIZATION

**STUDY OF RADIOLYTIC GAS GENERATION
DURING SOLIDIFICATION OF PLUTONIUM-
BEARING WASTE****SITE NEEDS:**

Low temperature alternative to vitrification that is applicable to transuranic (TRU) and plutonium (Pu) residue, and the study of radiolytic gas generation in this waste form.

RUSSIAN INSTITUTE:

Khlopin Radium Institute (KRI)

BACKGROUND:

Previous tests have shown that a cold-phosphate ceramic can be a durable alternative for immobilizing waste, which is less complex and less expensive than vitrification. In fact, the Mixed Waste Focus Area is studying the applicability of this waste form for low-level waste streams. However, the radiation stability for gas generation has not been established for low-temperature ceramic. The Plutonium Focus Area is funding a JCCEM project to determine the radiation stability and potential for gas generation during long-term storage, and thus determine if these materials are a feasible, lower cost alternative to vitrification. This task will also benefit related radiation stability tests for other phosphate ceramics being developed at Argonne National Laboratory.

TECHNOLOGY DESCRIPTION:

To test radiolytic gas generation during its formation, the simulated ceramic will be exposed to alpha irradiation at known dose rates. The effect on the ceramic will be determined by measuring various physical characteristics, as well as the amount and composition of gas generated in an enclosed capsule. By estimating the amount and composition of gas generated as a function of the absorbed dose, it will be possible to predict the behavior of iron-phosphate ceramics during long-term disposal and storage.

ACCOMPLISHMENTS:

Samples of iron-phosphate ceramics containing Pu-238 were prepared to simulate U.S. transuranic ash residue. The samples were then placed into an experimental assembly and irradiated. Monthly measurements of the radiolytic gas, which is generated inside the Pu-238 capsule were taken. The results of the experiments were described in a final report.

FUTURE:

Due to changing priorities within the Plutonium Focus Area, there are no plans to continue funding this project.

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JCCEM AREA: DECONTAMINATION AND DECOMMISSIONING

BACKGROUND:

Three technical exchanges have been conducted in the area of Decontamination and Decommissioning (D&D) under the auspices of the JCCEM since 1996. This is an important area for both the U.S. and Russia, and it is expected to become one of the largest areas of cooperation in FY99. The first workshop lead to a number of proposals from the Russian side, of which, one was accepted by the U.S.

ACCOMPLISHMENTS:

A small scale project was conducted with the Institute of Chemical Technology (ICT) on "Plasma Chemical Processing of Depleted Uranium Hexafluoride." The plasma conversion system was developed by the ICT in the 1980s, and five tons of UF_6 were processed and made suitable for long term storage. The JCCEM project consisted of a review report on the Russian process which contained cost analysis for bringing the technology to maturity for potential use in the U.S. The final report was received, but because UF_6 is not currently classified as a waste within EM's domain, funding for this project was discontinued in FY98.

In December 1997, Russian scientists participated in a fruitful exchange at a workshop in Miami, Florida. Following this meeting, in June 1998, a reciprocal exchange was conducted in Russia. The D&D Focus Area Program Manager, Dr. Paul Hart, visited several institutes, including MINATOM, the Khlopin Radium Institute, VNIPIET, Mayak Production Association, Mining Chemical Combine, Siberian Chemical Combine, the ICT, the Institute of Theoretical and Experimental Physics (ITEP), NIKIMT, and NIKIET. The purpose of these exchanges was to develop projects of mutual interest in support of the D&D Focus Area's Large Scale Demonstrations. As a result of these exchanges, six opportunities for further cooperation were identified:

1. Development of a proposal for the Russian side to critically review a report describing the alternative end states for the Canyon Disposition Initiative.
2. Development of a proposal for the Russian side to critically review the technical baseline for the Highly Enriched Uranium (HEU) Fuel Fabrication Facility at the Savannah River Site, and the identification of Russian technologies that might be considered for demonstration at the HEU Facility.
3. Development of a proposal for the Russian side to demonstrate their decontaminating foam and electrochemical cleaning technologies for Los Alamos National Laboratory Glovebox Decontamination. Discussions are underway to examine the technical and legal issues associated with shipping a U.S. contaminated glovebox to Russia for this purpose.
4. Possible collaboration on a D&D technology database which would combine databases from the D&D Focus Area in the U.S. and the ITEP in Russia.

5. Preparation by the Russian side of a proposal for the extraction of tritium from tritiated concrete.
6. Exploration of possibilities for Russian participation in the Large Scale Demonstration on the D&D of underwater research reactors at the INEEL.

FUTURE:

These proposals will be drafted for approval at the 8th JCCEM meeting, which will be held in September 1998 in Arlington, Virginia.

A D&D Russian workshop, co-sponsored by EM and DOE's Office of Nuclear Energy (NE), will be conducted at Spectrum 98. Several Russian reactors are dual-use reactors, which means they are designed to produce both plutonium and energy for the surrounding community. There are three dual-use reactors still in use in Russia, though NE is working on a plan with MINATOM to convert these reactors to solely energy production. The U.S. has never used dual-purpose reactors. Even so, because the D&D technologies are essentially the same for both and because Russia does not have as clear a distinction between weapons production and commercial use, EM and NE are excited about the possibilities for inter-organizational cooperation with their Russian counterparts.

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JCCEM AREA: **EMERGENCY** **RESPONSE**

BACKGROUND:

Three technical exchanges have been conducted in the area of Emergency Response between the Hazardous Materials Management & Emergency Response Training Center (HAMMER) Training and Education Center in Richland, Washington, and the MINATOM Emergency Response Centers. Topics of discussion have included scripts used for radiological training exercises, organization of emergency responders, training of first responders to the scene of a radiological accident, and interactions between local, regional, and federal organizations during transportation accidents.

A delegation of MINATOM Emergency Response Center managers attended the HAMMER opening ceremonies in September 1997. A technical exchange workshop was conducted which included participation by personnel from the regional office of the Federal Emergency Management Agency.

ACCOMPLISHMENTS:

A reciprocal exchange was conducted in Moscow, Russia in November 1997, at that time, the JCCEM drafted five potential areas of cooperation for consideration:

1. development of a radiological monitoring simulation system using of global positioning systems computer technology
2. piloting an integral emergency response process involving all levels of local, state, tribal, and Federal governments
3. joint participation of training and education programs using the teleconferencing capabilities of both sides
4. development and implementation of transportation emergency preparedness training tools and courses
5. determination of necessary technologies to be used in emergency situations which are consistent with the HAMMER business plan

FUTURE:

These five proposals were reviewed for their applicability to OST's domestic cleanup mission, and though they were determined to have merit, they fell outside the scope of OST's primary responsibilities. These proposals are being developed by the U.S. and Russian points of contact for submittal to other DOE program offices that have more appropriate missions.

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JCCEM AREA: SCIENTIST EXCHANGE

At the 1st JCCEM meeting in November 1990, it was agreed that senior scientists would need a forum to exchange information about technology development, policy, and experience to ensure the success of future cooperation. A scientist exchange program was established to enable Russian and U.S. scientists the opportunity to investigate the following EM-related issues:

1. policy and practices associated with past and current operations relating to the nuclear fuel cycle
2. problems of process design development and operations related to environmental remediation and control of contaminated materials
3. research directed at improving the effectiveness, economics, safety, and public acceptability of methods of handling, storing, and disposing of radioactive waste
4. investigations related to waste partitioning to facilitate permanent disposal
5. investigations related to geological disposal of wastes

TECHNOLOGY DEVELOPMENT WORKSHOPS:

OST program managers have been active in pursuing technical exchanges with their Russian counterparts. These technical exchanges take the form of workshops where scientists from both sides bring the latest developments to the table for discussion; demonstrations where technologies are taken into the lab; and program reviews where principal investigators jointly decide the course of technology development on a particular project or area. To maximize cost effectiveness, these workshops are often held in conjunction with international scientific or technical conferences such as Spectrum or the American Chemical Society annual meetings.

<i>Separations Workshop</i>	<i>February 1992</i>	<i>Tucson, Arizona</i>
<i>Contaminant Transport Workshop</i>	<i>June 1993</i>	<i>Berkeley, California</i>
<i>1st Cobalt Dicarbolide Separations Demonstration</i>	<i>April 1994</i>	<i>Idaho Falls, Idaho</i>
<i>Contaminant Transport Workshop</i>	<i>May 1994</i>	<i>Berkeley, California</i>
<i>Crown Ethers Workshop</i>	<i>August 1994</i>	<i>Gatlinburg, Tennessee</i>
<i>Tank Remediation Workshop</i>	<i>August 1994</i>	<i>Miami, Florida</i>
<i>2nd Cobalt Dicarbolide Demonstration</i>	<i>July 1995</i>	<i>Idaho Falls, Idaho</i>
<i>Radiochemical Processing</i>	<i>August 1995</i>	<i>Los Alamos, New Mexico</i>
<i>Contaminant Transport Program Review</i>	<i>November 1995</i>	<i>Washington, DC</i>

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<i>Tank Retrieval Workshop</i>	<i>January 1996</i>	<i>Augusta, Georgia</i>
<i>Mixed Waste Workshop</i>	<i>January 1996</i>	<i>Idaho Falls, Idaho</i>
<i>Site Characterization Workshop</i>	<i>February 1996</i>	<i>Augusta, Georgia</i>
<i>3rd Cobalt Dicarbolide Demonstration</i>	<i>April 1996</i>	<i>Idaho Falls, Idaho</i>
<i>Modeling Workshop</i>	<i>June 1996</i>	<i>Richland, Washington</i>
<i>Copper Ferrocyanide Testing</i>	<i>July 1996</i>	<i>Idaho Falls, Idaho</i>
<i>D&D Workshop</i>	<i>August 1996</i>	<i>Morgantown, West Virginia</i>
<i>Spectral Tables Workshop</i>	<i>August 1996</i>	<i>Seattle, Washington</i>
<i>Risk Assessment Workshop</i>	<i>August 1996</i>	<i>Seattle, Washington</i>
<i>TRU Stabilization Workshop</i>	<i>August 1996</i>	<i>Seattle, Washington</i>
<i>Solidification Experiences Workshop</i>	<i>August 1996</i>	<i>Seattle, Washington</i>
<i>Russian Home Pages Workshop</i>	<i>August 1996</i>	<i>Seattle, Washington</i>
<i>Tank Retrieval Workshop</i>	<i>November 1996</i>	<i>Richland, Washington</i>
<i>Sludge Modeling Workshop</i>	<i>November 1996</i>	<i>Augusta, Georgia</i>
<i>Contaminant Transport Program Review</i>	<i>December 1996</i>	<i>Arlington, Virginia</i>
<i>Modeling Workshop</i>	<i>December 1996</i>	<i>Richland, Washington</i>
<i>Site Characterization Workshop</i>	<i>December 1996</i>	<i>Augusta, Georgia</i>
<i>Emergency Response Workshop</i>	<i>January 1997</i>	<i>Richland, Washington</i>
<i>Tomsk Modeling Workshop</i>	<i>March 1997</i>	<i>Richland, Washington</i>
<i>4th Cobalt Dicarbolide Demonstration</i>	<i>April 1997</i>	<i>Idaho Falls, Idaho</i>
<i>Tank Retrieval Equipment Demonstration</i>	<i>July 1997</i>	<i>Richland, Washington</i>
<i>Solidification Experiences Exchange</i>	<i>September 1997</i>	<i>Augusta, Georgia</i>
<i>Tank Users/Developers Working Group</i>	<i>September 1997</i>	<i>Augusta, Georgia</i>
<i>Emergency Response HAMMER Opening</i>	<i>September 1997</i>	<i>Richland, Washington</i>
<i>Modeling Workshop</i>	<i>September 1997</i>	<i>Richland, Washington</i>
<i>Iron-Phosphate Development Workshop</i>	<i>October 1997</i>	<i>Idaho Falls, Idaho</i>
<i>Separations Program Review</i>	<i>October 1997</i>	<i>Gatlinburg, Tennessee</i>
<i>5th Cobalt Dicarbolide Demonstration</i>	<i>November 1997</i>	<i>Idaho Falls, Idaho</i>
<i>Contaminant Transport Program Review</i>	<i>November 1997</i>	<i>Arlington, Virginia</i>
<i>D&D Workshop</i>	<i>December 1997</i>	<i>Miami, Florida</i>
<i>Copper Ferrocyanide Testing</i>	<i>May 1998</i>	<i>Idaho Falls, Idaho</i>
<i>6th Cobalt Dicarbolide Demonstration</i>	<i>June 1998</i>	<i>Idaho Falls, Idaho</i>
<i>Model Calibration Workshop</i>	<i>July 1998</i>	<i>Richland, Washington</i>
<i>Vadose Zone Workshop</i>	<i>July 1998</i>	<i>Berkeley, California</i>
<i>Iron-Phosphate Demonstration</i>	<i>August 1998</i>	<i>Idaho Falls, Idaho</i>
<i>8th JCCM Meeting</i>	<i>Planned Fall 1998</i>	<i>Washington, DC</i>

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*Irina Glagolenko during testing
of UE process using NIKIMT
centrifugal contactors*

JCCEM AREA: SCIENTIST EXCHANGE

**IDAHO STATE UNIVERSITY
EXCHANGE**

In 1994, in a very successful mentoring and partnering exchange, four Russian graduate students entered nuclear engineering, chemical engineering, and computer science programs at Idaho State University in Pocatello, Idaho. During the summers, the students were employed as research assistants at INEEL, Argonne National laboratory, and private companies.

All four students successfully completed their course work and were conferred Masters of Science degrees in 1997. The exchange has been advantageous for INEEL, as well because one of the students' (Pavel Medvedev) thesis on the application of phosphate-bonded ceramics for disposal of transuranic ash has developed into continuing

research, and is part of both U.S. and Russian patent applications. His work was presented at the American Ceramic Society's 99th Annual Meeting in the spring of 1997, and is published in the proceedings.

STUDENTS

TOPICS OF RESEARCH

Pavel Medvedev

*Phosphate-bonded Ceramics; Plasma
Hearth Project; and Isotope Production*

Oleg Tolsitkhine

*Plasma Hearth Project, and IR Spectral
Analysis of PHP Off-Gas*

Irina Glagolenko

*Rare Earth Extraction from high-level waste,
and Experimental Study of Analytical
Chemistry Techniques for Determination
of Radioisotopes and Other Elements*

Dmitri Drozhko

*Deposition of Materials in Electro-Chemical
Systems, and Removal of Actinides from
Soil and Groundwater (Pending Completion)*

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JCCEM AREA: SCIENTIST EXCHANGE

BERKELEY POST-DOCTORAL CANDIDATE

A scientist from the Khlopin Radium Institute has been conducting a post-doctoral fellowship at the Seaborg Institute for Transactinium Science at the Lawrence Livermore National Laboratory. Dr. Vadim Valer'evich Romanovsky completed his undergraduate and graduate studies at the St. Petersburg Institute of Technology, specializing in the technology of rare and trace elements, and worked as a staff scientist at the Khlopin Radium Institute before receiving the Berkeley fellowship.

Dr. Romanovsky develops technologies designed to treat primary or secondary waste streams containing low concentrations of actinide ions. He is part of a group that evaluates and tests the complexing ability of promising new agents that have already shown the potential for selectively binding plutonium (Pu)(IV) in a wide range of solutions in the presence of other metals. Molecular modeling is used to design and synthesize ligands based on modification of natural siderophores, or their analogs, for chelation of actinides. The ligands are then modified for use as liquid/liquid and solid/solid extractants.

In nature, bacteria and other microorganisms produce siderophores, low-molecular weight multidentate iron chelators, to scavenge ferric ions from their environments. The main binding groups employed by siderophores are catechol 1, 2-hydroxypyridinone and hydroxamate. These bidentate chelating groups are strong Lewis bases and show remarkable selectivity for acidic metal ions, including Pu(IV) and thorium(IV). Very selective sequestering agents can be synthesized by incorporating these chelating groups into multidentate ligands. These chelating groups can also be incorporated into molecules appropriate for use as liquid/liquid extractants or into insoluble polymers for use as ion exchange resins.

Additional experiments are in progress to test the chemical stability of resins and extractants and complete the evaluation of the resins and liquid extractants to remove Pu from aqueous solutions. Successful development and characterization of such complexing agents could be instrumental in the design of a process for removing Pu (and possible other actinides) from waste streams; thereby reducing the volumes of liquid waste and minimizing the volume of transuranium waste to be disposed of in a geological repository. In addition, these derivatives are relatively inexpensive, biodegradable, and would not involve the addition of toxic chemicals. It can be used wherever low-level actinide contaminated organic or aqueous waste streams are located within the DOE complex.

Dr. Romanovsky has made several presentations at technical conferences and published in peer-reviewed journals as a Post-Doctoral Fellow:

PUBLICATION:

Romanovski, V.V., D.W. Whisenhunt, A.C. Veeck, W.A. Anderson, D.C. Hoffman, X. Jude, D. White, K. Raymond, "Potential Agents for Removal of Actinides from Waste Solutions," *Proceedings from the International Topical Meeting on Nuclear and Hazardous Waste Management, Seattle, Washington, August 18-23, 1996, Vol. 3, pp. 2330-2334, Seattle, WA, American Nuclear Society, LaGrange Park, IL 1996.*

PRESENTATIONS:

Whisenhunt Jr., D. W., A. C. Veeck, V. Romanovski, D. C. Hoffman, "Natural Sequestering Agents for the Removal of Plutonium from Waste Streams," *Efficient Separations and Processing Crosscutting Program Review, Gaithersburg, Maryland, April 16, 1996.*

Romanovski, V.V., D.W. Whisenhunt, A.C. Veeck, W.A. Andersen, D.C. Hoffman, X. Jude, D. White, K. Raymond, "Potential Agents for Removal of Actinides from Waste Solutions," *SPECTRUM '96 International Topical Meeting on Nuclear and Hazardous Waste Management, Seattle, Washington, August 22, 1996.*

Hoffman, D.C., V.V. Romanovski, A.C. Veeck, P. Zhao. 1997. "Evaluation and Testing of Sequestering Agents for Removal of Actinides from Waste Streams." In *Proceedings from the, Efficient Separations and Processing Crosscutting Program 1997 Technical Exchange Meeting, Gaithersburg, Maryland, January 28-30, 1997.*

Hoffman, D.C., C.E.A. Palmer, V.V. Romanovski, P. Zhao, A.C. Veeck. 1997. "Evaluation and Testing of Sequestering Agents for Removal of actinides from Waste Streams." *Efficient Separations and Processing Crosscutting Program's FY97 Mid-Year Review, Gaithersburg, Maryland, April 1-3, 1997.*

Mohs, T.R., V.V. Romanovski, A.C. Veeck, D.J. White, Jide Xu, K.N. Raymond and D.C. Hoffman, "The Transition from Natural Complexing Agents to Actinide Specific Sequestering Agents," *Oral Presentation, 213th ACS National Meeting, San Francisco, California, April, 1997.*

Romanovski, V.V., P. Zhao, D.C. Hoffman, D.W. Whisenhunt Jr., D. White, X. Jide, K.N. Raymond. 1997. "Pu sorption and extraction by the 1,2-hydroxypyridinone based agents." *Plutonium Futures - The Science, Topical Conference on Plutonium and Actinides, Santa Fe, New Mexico, August 25-27, 1997.*

Zhao, P., V.V. Romanovski, D.C. Hoffman, C.E.A. Palmer, D.W. Whisenhunt Jr., P.G. Allen, D.K. Shuh, J.J. Butcher, N.M. Edelstein, D. J. White, X. Jide, K.N. Raymond. 1997. "Spectroscopic Study of Chelation between Pu and Modified Siderophores." *Plutonium Futures - The Science, Topical Conference on Plutonium and Actinides, Santa Fe, New Mexico, August 25-27, 1997.*

Mohs, T. R., J. Xu, K.N. Raymond, V.V. Romanovski, P. Zhao and D.C. Hoffman, "Ligands and Extractants for the Separation and Immobilization of Actinide Ions," *Oral Presentation, 214th ACS National Meeting, Las Vegas, Nevada, September, 1997.*

Reports are available upon request.

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JCCEM AREA: SCIENTIST EXCHANGE

**NATIONAL ACADEMY OF
SCIENCES RESEARCH GRANTS**

The National Academy of Sciences/National Research Council (NAS/NRC) is administering an EM-sponsored program that provides grants of \$16,000-\$30,000 to American scientists wishing to conduct joint research projects with colleagues from the former Soviet Union. The program provides support for foreign visitors to spend six to twelve months at U.S. national laboratories and universities conducting research on various aspects of radioactive waste management. Nineteen exchanges have been carried out since the program began, with five more planned for 1998.

**FOLLOWING IS A LIST OF THE ELEVEN PROJECTS SUPPORTED
DURING 1996-1997 UNDER THE NAS/NRC'S RADIOACTIVE
WASTE MANAGEMENT GRANTS PROGRAM WITH THE
FORMER SOVIET UNION:**

Development of an integrated model of equilibria and sorption by clay minerals of selected actinide and lanthanide elements, Stephen Aja (City University of New York - Brooklyn College) hosting Dmitry Kulik, State Scientific Institute for Environmental Geochemistry, Ukrainian Academy of Sciences, Kiev, Ukraine)

Experimental investigation of the sorption of lanthanides on clays and clay minerals under hydrothermal conditions, Stephen Aja (City University of New York - Brooklyn College) hosting Vasily Sinitsyn (Institute of Geochemistry, Mineralogy, and Ore Formation, Ukrainian Academy of Sciences, Kiev, Ukraine)

Development of an arbitrarily high order transport method for unstructured grids, which has applications in shield design and optimization, exposure field characterization, and environmental impact studies, Yousry Azmy (Oak Ridge National Laboratory) hosting Igor Suslov (Institute of Physics and Power Engineering, Russian Ministry of Atomic Power, Obninsk, Russia).

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Synthesis and evaluation of inorganic ion exchange materials for removal of strontium from high hardness groundwater, Garrett Brown (Washington State University and Battelle Pacific Northwest National Laboratory) hosting Dmitry Marinin (Institute of Chemistry, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russia) *In situ extraction of radionuclides from natural waters*, William C. Burnett (Florida State University) hosting Evgeny Kontar (Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia)

Design of waste forms for actinide immobilization, Rodney Ewing (University of New Mexico and University of Michigan) hosting Boris Burakov (Khlopin Radium Institute, Russian Academy of Sciences, St. Petersburg, Russia)

Mathematical modeling of porous media flow and radionuclide transport, Thomas Fogwell (Fogwell Associates and Lawrence Livermore National Laboratory) hosting Dmitry Silin (Moscow State University, Moscow, Russia)

Modify existing 3D finite-element solute-transport model so that it could be used for cold-region remedial technology development and evaluation, Steven Grant (Cold Regions Research and Engineering Laboratory) hosting Mikhail Mironenko (Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Moscow, Russia)

Development of a safety assessment methodology for the Russian regulatory system, Matthew Kozak (QuantiSci, Inc.) hosting Boris Serebryakov (Institute of Biophysics, Ministry of Health, Moscow, Russia)

Chemical speciation of heavy metals, Dale Sayers (North Carolina State University) hosting Pavel Pleshanov (Applied Ecology Research Laboratory, Russian Ministry of Health, Moscow, Russia)

Separation of actinides and other fission products from solid and liquid wastes, Chien Wai (University of Idaho) hosting Trofim Trofimov (Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Moscow, Russia)

Reports are available upon request.

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FUTURE ACTIONS/ CONCLUSIONS

As EM enhances the current emphasis of applied research and development to include technology deployment, the JCCEM has also begun to focus on developing a path for potential deployment of maturing technologies. The objectives of cooperation with Russia are manifold, including international recognition, leveraging the labor ratio, and meeting administration desires to stop the exodus of top Russian nuclear scientists. The ultimate measure of success will be when the research and development investment pays off and Russian technologies are deployed to assist in the cleanup of a DOE site.

In order to accomplish this goal, it is key that the Russian programs remain focused on prioritized needs within the DOE complex. The Russian teams are using the Internet to keep abreast of changing priorities in Focus Area and site technology development needs. By coordinating with the Site Technology Coordinating Groups (STCGs), the principal investigators on both sides will be better able to keep current, flexible, and responsive during the challenges on the road to deployment. In addition to the STCGs, the program is working toward building strategic relationships with other DOE organizations that will leverage the research and development investment that has been made in JCCEM projects. To highlight a few, discussions are underway with the Basic Science program, the Decontamination and Decommissioning Focus Area's Large Scale Demonstrations program, the Hanford Privatization Initiative, the Technology Deployment Initiative, and University Programs.

PROGRAM ACCOMPLISHMENTS:

- *To date, four patent applications have been filed, and two patents have been issued. Additional technologies are under consideration for patent protection.*
- *There have been twelve technology demonstrations on seven technologies, with three additional demonstrations were conducted in the spring and summer of 1998.*
- *A three-dimensional regional model of contaminant migration is nearing completion.*
- *Three field studies/overseas demonstrations of monitoring technology have been conducted in the formerly closed region of Chelyabinsk, Russia.*
- *Commercial interest has been expressed in at least two technologies.*
- *Over fifty journal articles and reports have been published and made available to the public.*
- *Thirty-nine technical exchange workshops have been conducted, and at least four additional workshops are planned for 1998.*
- *There are fourteen current projects underway, and two additional contracts are being negotiated.*

The 8th JCCEM will be held in Washington, DC in September 1998 to determine the direction and scope of future cooperation.

*Stained Glass from the History of Glass display
at the Institute of Silicate Chemistry in Russia*

NON-JCCEM **RUSSIAN ACTIVITIES**

THE EM BASIC SCIENCE PROGRAM

The Russian institutes have a wide variety of expertise in environmental management. Through the JCCEM program, promising technologies have been developed to meet the needs of DOE sites. Through the relationships that have been formed with their Russian colleagues, U.S. specialists have become familiar with their work in basic science, which then plays a crucial role in determining the path for technology development. U.S. principal investigators have encouraged their Russian counterparts to submit proposals to the EM Basic Science program, as a way of obtaining additional funding for research and development that is not yet at the applied level. In late 1997, several Russian Institutes responded to the EM Basic Science request for proposals in the areas of High-Level Radioactive Waste (Notice Number 98-08) and Research Related to Decontamination and Decommissioning of Facilities (Notice Number 98-04). These pre-applications were reviewed in the spring of 1998.

The following are lists of their pre-application titles:

PROGRAM NOTICE 98-04: RESEARCH RELATED TO DECONTAMINATION AND DECOMMISSIONING OF FACILITIES

<i>#</i>	<i>Organization</i>	<i>Principal Investigator</i>	<i>Project Title</i>
1.	Institute of Chemical Technology	Dr. Evgeniy Filippov	Microwave heating for safe and effective evaporation of uranium hexafluoride from defective containers
2.	Institute of Chemical Technology	Dr. Vitaly Gotovchikov	Radioactive Scrap Metal Decontamination for Recycle of Metal by Remelting Method in Low Frequency Induction Furnace with Cold Crucible*
<i>*Accepted for submission of a grant application</i>			
3.	Khlopin Radium Institute (KRI)	Dr. Andrei Shadrin	Supercritical Fluid Extraction for Recovery of Radionuclides and Organic Pollutants from Soils and Organic and Aqueous Solutions
4.	KRI	Dr. Andrei Shadrin	Supercritical Fluid Extraction for Decontamination of Solids

#	Organization	Principal Investigator	Project Title
5	Institute of Chemical Technology	Dr. Evgeniy Filippov	Testing of an Aqueous Desorption Solution based on Fluoroboric Acid for Removal of Solid uranium-235 and plutonium Deposits from Contaminated Equipment
PROGRAM NOTICE 98-08: RESEARCH RELATED TO HIGH-LEVEL RADIOACTIVE WASTE			
1.	KRI	Dr. E.B. Anderson	Synthesis of Crystalline Ceramics for Immobilization of High-Level Waste (HLW) of Complex Composition
2.	KRI	Dr. V.A. Babain	Impact of Diluent Composition on Extraction Capability
3.	Institute of Physical Chemistry	Prof. B.G. Ershov	Sorption of neptunium and americium from Alkaline Solutions with Significant Concentrations of Salts and Complex-Forming Ions by Chitin-Containing Materials
4.	KRI	Dr. B.Ya. Galkin	Application of Magnesium- Containing Compositions for Sorption of Radionuclides from HLW Solutions and their Further Solidification
5.	KRI	Dr. V.B. Gervits	Development of Chemical Adsorber (Getter) of Aqueous Vapor and Acid Gases for Minimization of Radioactive Release and Corrosion of HLW Storage Design Materials
6.	KRI, and Vernadsky Institute of Geochemistry and Analytical Chemistry	Dr. V.N. Romanovsky	New Method for Separation of Radionuclides Based on Extractants Synthesized in the Course of Extraction
7.	KRI	Dr. V.N. Romanovsky	Destruction of Ammonium Salts in Nitric Acid Media as applied to HLW Processing
8.	KRI	Dr. V.N. Romanovsky	Destruction of Organic Com- pounds in Alkaline Solutions

#	Organization	Principal Investigator	Project Title
9.	KRI , and All-Russia Research and Design Institute for Power Engineering Technologies	Dr. V.N. Romanovsky	Behavior of Actinides on Stainless Steel Surfaces During Electro-Chemical and Foam Decontamination
10.	KRI	Dr. A.B. Kolyadin	Development of Closed Cycle Off-Gas System for High- Temperature HLW Treatment by Acoustic Impact to the Gaseous Flow
11.	KRI	Dr. R.I. Lubtsev	Development of Instrumenta- tion for Evaluation of Tritium Concentrations in Various Media
12.	KRI	Dr. L.B. Shpunt	Synthesis of Actinide-Containing Ceramic Materials by Plasma Chemical Processes
13.	KRI	Mr. V.A. Starchenko	Complex Formation and Extraction of Radionuclides into Supercritical Media During Sample Preparation and Decontamination
14.	Institute of Physical Chemistry, and Mining Chemical Association	Dr. E.V. Zakharova Dr. Yu.A. Revenko	Handling of Aluminum-Based Sludge Stored in Tanks

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NON-JCCEM RUSSIAN ACTIVITIES

INITIATIVES FOR PROLIFERATION PREVENTION

The Newly Independent States Initiatives for Proliferation Prevention (NIS-IPP) program was initiated by DOE in 1994 to minimize the risk of proliferation of weapons of mass destruction, particularly nuclear weapons. The program focuses on retraining weapons scientists and engineers to develop non-weapons commercial opportunities in NIS countries and the U.S. in the areas of accelerators, energy, manufacturing, waste management, biotechnology, environment, materials, and sensors/instrumentation.

The program is designed to bring together scientists from DOE laboratories and Russian institutes who collaborate on projects with a potential for future commercial development; these are considered Thrust I projects and generally have a performance period of one year.

Thrust II projects are usually a follow-on to Thrust I projects, and must involve a U.S. industrial partner who is required to provide matching funding for the project, and must participate in a Cooperative Research and Development Agreement with a DOE laboratory. The intent is for Thrust II projects to result in commercial deployment of the technology, either as a joint venture company, a new NIS company, or in U.S. industry payments to NIS inventors for use of intellectual property rights.

Two proposals, which are related to JCCEM activities, are currently under consideration for NIS-IPP funding. A decision is expected in the spring of 1998:

“U.S.-Russian Consortium for Environmental Remediation,” Sandia National Laboratory, and the Mayak Production Association and the Khlopin Radium Institute

“Development of Environmental Hydrology through Partnering of Russian Weapon Scientists, Russian Geo-environmental Scientists, and U.S. Industrial Companies Doing Business in Russia,” Lawrence Berkeley National Laboratory, the Institute of Geology Ore Deposits, Petrography, Mineralogy, and Geochemistry, and the Mayak Production Association

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NON-JCCEM RUSSIAN ACTIVITIES

INTERNATIONAL SCIENCE AND TECHNOLOGY CENTER (ISTC)

The ISTC is a multi-lateral, non-proliferation program organized by the U.S., Europe, and Japan to fund research projects proposed by scientists and engineers from the Newly Independent States who have been working in the Weapons of Mass Destruction area to redirect their activities. The objectives of the ISTC are:

- Redirect weapon scientists and engineers from weapons of mass destruction and missile delivery systems to peaceful uses
- Promote the integration of scientists and the states of the Commonwealth of Independent States and Georgia into the international scientific community
- Support basic and applied research and technology development in fields of environmental protection, energy production, or nuclear safety
- Contribute to the solution of national and/or international technical problems (other than those above)
- Assist in transition to market-based economies and commercialization

The ISTC requires that organizations from member countries collaborate on funded projects. DOE organizations had technical interest in three proposals submitted to the ISTC in 1997, which compliment JCCEM activities:

“Development of the Technology for Recovery of Promethium-147 from Spent Fuel Reactor Fuel for Fabrication of the Artificial Neutron Source and Elaboration of the Technique for Its Certification,” Russian Scientific Center, Institute of Nuclear Research, Institute of Physical Chemistry, and Mayak Production Association

“Working out Education and Methodological Base and Technical Means for the Federal Training Center in the Field of Radioactive Waste Management,” A.A. Bochvar Institute of Inorganic Materials, United Ecologo-Technological and Science Research Center of Radioactive Waste Management and Environmental Restoration “Radon,” and Rosekotechnologiya

“Immobilization of Long-lived Radionuclides Using Ultraporous Blocks Based on Thermostable Microspheres,” Khlopin Radium Institute

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APPENDIX A: JCCCEM PUBLICATIONS

<u>AUTHORS</u>	<u>REPORT TITLE</u>	<u>AFFILIATION</u>
<i>Mironeko, M.V., Spasennykh, M. Yu, Polyakov, V.B., Ivanitskii, O.M., Garanin, A.V., Volosov, A.G., Khodakovskiy, I.L., Smirnov, A. B., Mokrov, G., Yu., Glagolenko, Y.G., Drozhko, E. G.</i>	<i>The Cascade Reservoirs of the Mayak Plant: Case History and the First Version of a Computer Simulator</i>	<i>Mayak Production Association, Chelyabinsk, Russia</i>
<i>Mironenko, A.A., Rumynin, B.G., Konosavsky, P.L., Pzdniakov, S.P., Shestakov, V.M., Roshal, A.A.</i>	<i>Development of Analytical and Numerical Models for the Assessment and Interpretation of Hydrogeological Field Tests</i>	<i>Russian Academy of Sciences, Moscow, Russia</i>
<i>Malkovsky, V.I., Pek, A.A.</i>	<i>Computer Simulation of Radionuclide Radionuclide Transport Through Thermal Convection of Groundwater from Borehole Respositories</i>	<i>Institute of Geology of Ore Deposits (IGEM), Russian Academy of Sciences, Moscow, Russia</i>
<i>Wollenber, H., Tsang, C.F., Frangos, W., Solbau, R., Lowder, W., Stevenson, K., Foley, M., Drozhko, E., Romanov, G., Glagolenko, Y., Posochov, A., Yvanov, Y., Samsonova, L., Petrov, A., Ter-Saakian, S., Vasil'kova, N., Glagolev, A.</i>	<i>A Joint Russian American Field Test Chelyabinsk-65 (Mayak) Site Test Description and Preliminary Results</i>	<i>Mayak Production Association, Hydrospetzgeologiya, and Lawrence Livermore National Laboratory</i>
<i>Rumynin, V.G., Mironenko, V.A., Pereverzeva, S.A.</i>	<i>Development of Hydrogeological Modeling Approaches for Assessment of Consequences of Hazardous Accidents at Nuclear Power Plants</i>	<i>Russian Academy of Sciences</i>
<i>Solodov, I.N., Velichkin, V.I., Zotov, A.V., Kochkin B.T., Drozhko, E.G., Glagolev, A.V., Skokov, A.N.</i>	<i>Distribution and Geochemistry of Contaminated Subsurface Waters in Fissured Volcanogenic Bed Rocks of the Lake Karachay Area, Chelyabinsk, Southern Urals</i>	<i>IGEM, Russian Academy of Sciences, Hydrospetzgeologia, and Mayak Production Association</i>
<i>Pozdniakov, S.P., Tsang, C.F.</i>	<i>Random Fields Generation by the Source Point Method</i>	<i>Russian Academy of Sciences, and Lawrence Livermore Laboratory</i>
<i>Pek, A.A., Malkovsky, V.I.</i>	<i>Modelling of the Fault-Controlled Hydrothermal Ore-Forming Systems</i>	<i>Russian Academy of Sciences, and Lawrence Livermore Laboratory</i>

continued

<u>AUTHORS</u>	<u>REPORT TITLE</u>	<u>AFFILIATION</u>
Drozhko, E.G., Glagolenko, Y.U., Mokrov, Y.G., Ivanov, I.A., Postovalova, G.A., Samsonova, L.M., Glagolev, A.V., Terr-Saakian, S.A., Glinsky, M.L., Vasil'kova, N.A., Skokov, A.V., Wollenburg, H.A., Tsang, C.F., Frangos, W., Solbau, R.D., Stevenson, K.A., Lowder, W.M., and Foley, M.G.	Joint Russian - American Hydrogeological Geochemical Studies on the Karachay- Mishelyak System, South Urals, <u>Journal of Environmental Geology</u>	Mayak Production Association, Chelyabinsk, Russia; Hydrospeztzgeologiya, Lawrence Berkeley National Laboratory (LBNL) Moscow, Russia; L. Berkeley, California; Environ- mental Measure- ments Laboratory, New York; Pacific Northwest National Laboratory, Richland, Washington
Frangos, W and Ter-Saakian, S.A.	Resisivity and Induced Polarization Survey at a Russian Nuclear Waste Site (submitted to <u>Geophysics</u> , January 1996)	LBNL, Berkeley, California; Hydrospeztzgeologiya, Moscow, Russia
Solodov, I.N., Zotov, A.V., Khoteev, A.D., Mukhamet-Galeev, A.P., Tagirov, B., Apps, J.A.	Geochemistry of Natural and Contaminated Subsurface Waters in Fissured Bed Rocks of the Lake Karachay Area, Southern Urals, Russia (submitted to <u>Journal of Applied Geochemistry</u> , February 1996)	Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry (IGEM), Moscow, Russia; LBNL, Berkeley, California
Velichkin, V.I., Asadulin, A.A., Tarasov, N.N., Poluektov, V.V., Petrov, V.A., and Myskin, V.I.	Geology and Geochemical Features of the "Mayak" Area Bedrock	IGEM, Russian Academy of Sciences Moscow, Russia
Novikov, A.P., Paviotskaya, F.I., Korobova, E.M., Goryachenkova, T.A., Kazinskaya, I.E., Kuzovkina, E.N., and Myasoedov, B.F.	Distribution, Specialization and Computational Migration Model of Selected Radioactive Nuclides in Some Ecosystems From the Mayak Region	Radiochemical Laboratory, Vernadsky Institute of Chemistry, Geochemistry and Analytical Russian Academy of Sciences, Moscow, Russia
Myasoedov, B.F.	The Development of Radiochemical Procedures for Determination of Uranium, Neptunium, Plutonium, Americium, Strontium-90, and Cesium-137 in Selected Samples From Mayak Region	Radiochemical Laboratory, Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Moscow, Russia

<u>AUTHORS</u>	<u>REPORT TITLE</u>	<u>AFFILIATION</u>
<i>Petrov, A.V., Samsonova, L.M., Vasil'kova, N.A., Zinin, A.L., and Zinina, G.A.</i>	<i>Numerical Modeling of the Groundwater Contaminant Transport for the Lake Karachay Area: The Methodological Approach and the Basic Two-Dimensional Waste Solutions Through Fresh Groundwaters Regional Model</i>	<i>Hydrospetzgeologiya, Moscow, Russia; Institute of Physics</i>
<i>Samsonova, L.M., and Drozhko, E. Chelyabinsk, Russia</i>	<i>Migration of High-Density Industrial Power Engineering, Obninsk, Russia</i>	<i>Hydrospetzgeologiya, Moscow, Russia; Mayak</i>
<i>Mironenko, V.A.</i>	<i>Flow and Tracer Tests at Sites for Underground Storage of Liquid Waste</i>	<i>St. Petersburg Mining Institute, St. Petersburg, Russia</i>
<i>Rybal'chenko, A.L., Pimenov, M.K., and Munaev, E.N.</i>	<i>Application of Accumulated Experience of Deep-Well Injection of Radioactive Waste in Hazardous and Industrial Waste Management</i>	<i>Scientific Research and Design Institute for Industrial Technology, Moscow, Russia</i>
<i>Rybal'chenko, A.I., Kurochkin, V.M., Kostin, P.P., and Pavlov, P.N.</i>	<i>Basic Principles of Safety Assessment and System Control During Deep-Well Injection of Radioactive Wastes</i>	<i>Scientific Research and Design Institute for Industrial Technology, Moscow, Russia</i>
<i>Rybal'chenko, A.I., Pimenov, M.K., and Kurochkin, V.M.</i>	<i>Deep-Injection Disposal of Liquid Radioactive Waste in Russia</i>	<i>Scientific Research and Design Institute for Industrial Technology, Moscow, Russia</i>
<i>Zakharova, E.V., Kaimin, E.P., Mikerin, E.I., Kudryavtsev, E.G., Rybal'chenko, A.I., Pimenov, M.K., and Kurochkin, V.M.</i>	<i>Behavior of Radionuclides in Geologic Formations Used for Underground Disposal of Liquid Nuclear Wastes</i>	<i>Institute of Physical Chemistry and Design Institute for Moscow, Russia; MINATOM, Moscow, Russia; Scientific Research Industrial Technology, Moscow, Russia</i>
<i>Solodov, I.N., Velichkin, V.I., and Laverov, N.P.</i>	<i>Safe Geological Disposal of Liquid Wastes; Isolating Geochemical Properties of the Injection Zone Rocks</i>	<i>Department of rare Metals Geology and Radiogeoecology (IGEM), Moscow, Russia</i>

<u>AUTHORS</u>	<u>REPORT TITLE</u>	<u>AFFILIATION</u>
<i>Dorogokupets, P.</i>	<i>Development of Thermodynamic Databases for Geochemical Models, with Potential Application to Containment Transport</i>	<i>Institute of the Earth Crust, Siberian Division of Russian Academy of Sciences, Irkutsk, Russia</i>
<i>Pozdniakov, S.P., and Shestakov, V.M.</i>	<i>A Model of Salt/Fresh Groundwater Flow in the Layered Aquifer</i>	<i>Hydrogeological Division, Geological Department of Moscow State University, Moscow, Russia</i>
<i>Pozdniakov, S.P., Tsang, C.F., and Korneev, V.A.</i>	<i>Flow and Tracer Transport of a Double Well System in an Aquifer with a Circular Inclusion</i>	<i>LBNL, Berkeley, California</i>
<i>T.A. Todd, I.Y. Glagolenko, R.S. Herbst, and K.N. Brewer</i>	<i>The Extraction of Rare Earth Elements from Idaho Chemical Processing Plant Sodium-Bearing Waste and Dissolved Zirconium Calcine by CMP and TRUEX Solvents</i>	<i>Idaho National Engineering Laboratory (INEL), Idaho Falls, Idaho</i>
<i>R.S. Herbst, K.N. Brewer, T.A. Todd, and I.Y. Glagolenko</i>	<i>Chemistry of Mercury in INEL Acidic Sodium-Bearing Waste with the TRUEX Solvents</i>	<i>INEL) Presented (at the American Chemical Society National Meeting, New Orleans, Louisiana, March 1996</i>
<i>Caroline Purdy, Karen Stevenson</i>	<i>2nd Chelyabinsk Field Study</i>	<i>DOE/Em-53; Environmental Measurements Laboratory, New York</i>