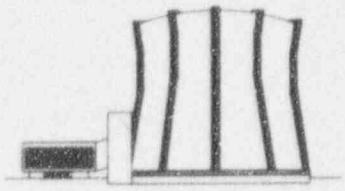
TEXAS ENGINEERING EXPERIMENT STATION

TEXAS A&M UNIVERSITY

COLLEGE STATION, TEXAS 77843-3575



NUCLEAR SCIENCE CENTER
409/845-7551

8 May 1996

96-0123

Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

SUBJECT: Annual Report for Nuclear Science Center Reactor

REF: Reactor Facility License R-83, Docket 50-128

Dear Sir/Madam:

Attached you will find the 1995 Annual Facility Report for the Texas A&M University Nuclear Science Center. Please contact me if you have any questions.

Respectfully,

Sean O'Kelly
NSC Assistant Director

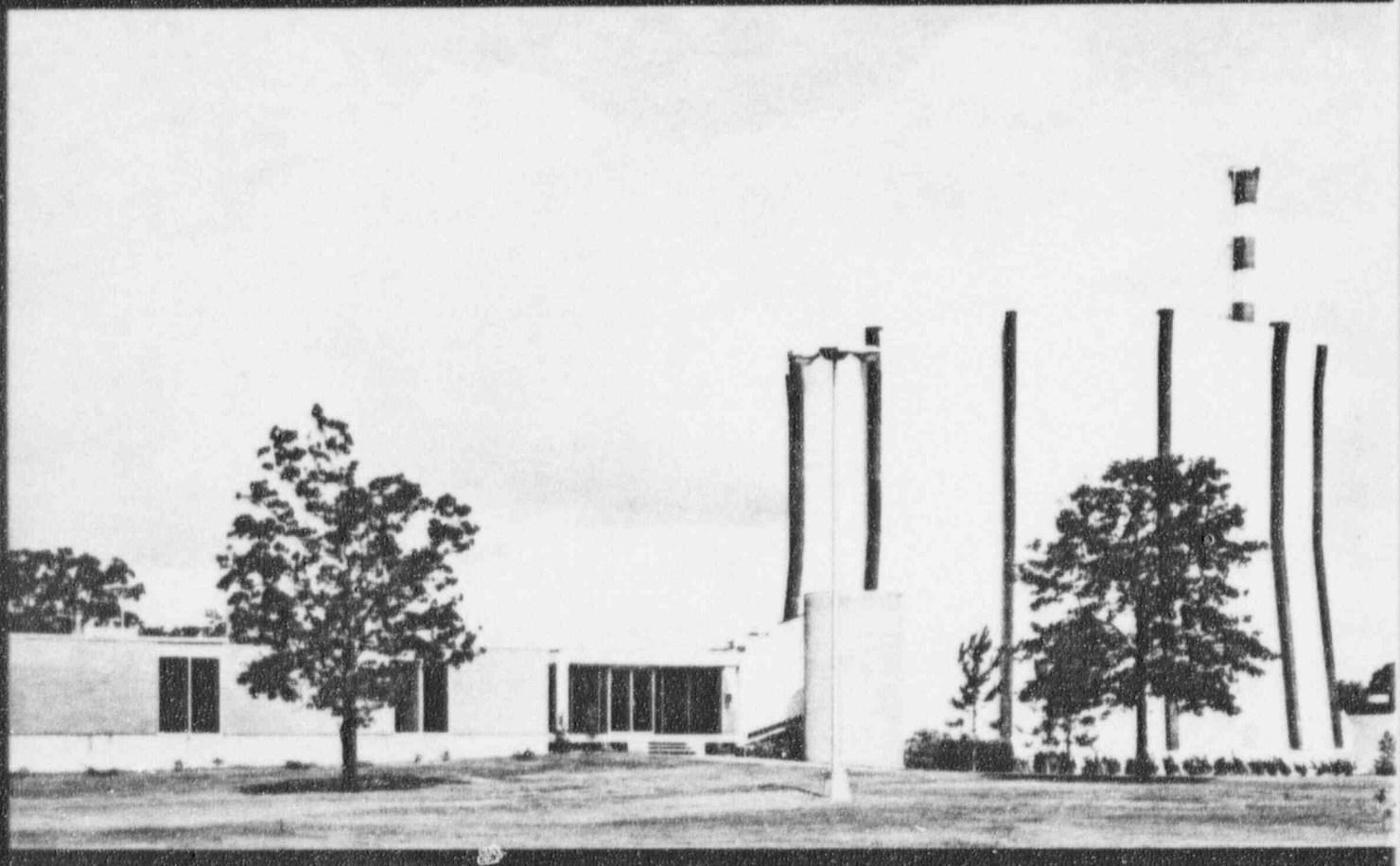
SOK/sjm

Attachment: 1995 Annual Facility Report

xc: File 17122, NRC/R-83
NRC Region IV
12110/Central File

Texas A&M University
Nuclear Science Center

1995 Annual Report



NUCLEAR SCIENCE CENTER
TEXAS ENGINEERING EXPERIMENT STATION
ENGINEERING PROGRAM
TEXAS A&M UNIVERSITY SYSTEM
COLLEGE STATION, TEXAS

Texas A&M University
Nuclear Science Center

1995 Annual Report

Texas Engineering Experiment Station
F.E. Box 89
College Station, Texas
77843-3575

Reactor Facility License R-83
Docket 50-128

DOE University Reactor Fuel Assistance
DE-AC07-76ER02426

Contents

1. 0 Introduction

The Nuclear Science Center is operated by the Texas Engineering Experiment Station as a service to the Texas A&M University System and the state of Texas. The Nuclear Science Center (NSC) is a multi-disciplinary research and education center supporting basic and applied research in all nuclear related fields of science and engineering as well as providing educational opportunities for students in those fields. In addition, the NSC provides services to commercial ventures requiring radiation or isotope production services.

This annual report has been prepared by the NSC staff to satisfy the reporting requirements of Technical Specification 6.6.1 of the facility operating license R-83 and of the Department of Energy University Reactor Fuel Assistance Program subcontract No. C87-101594 (DE-AC07-76ER02426). The facility operating license currently extends to March, 2003.

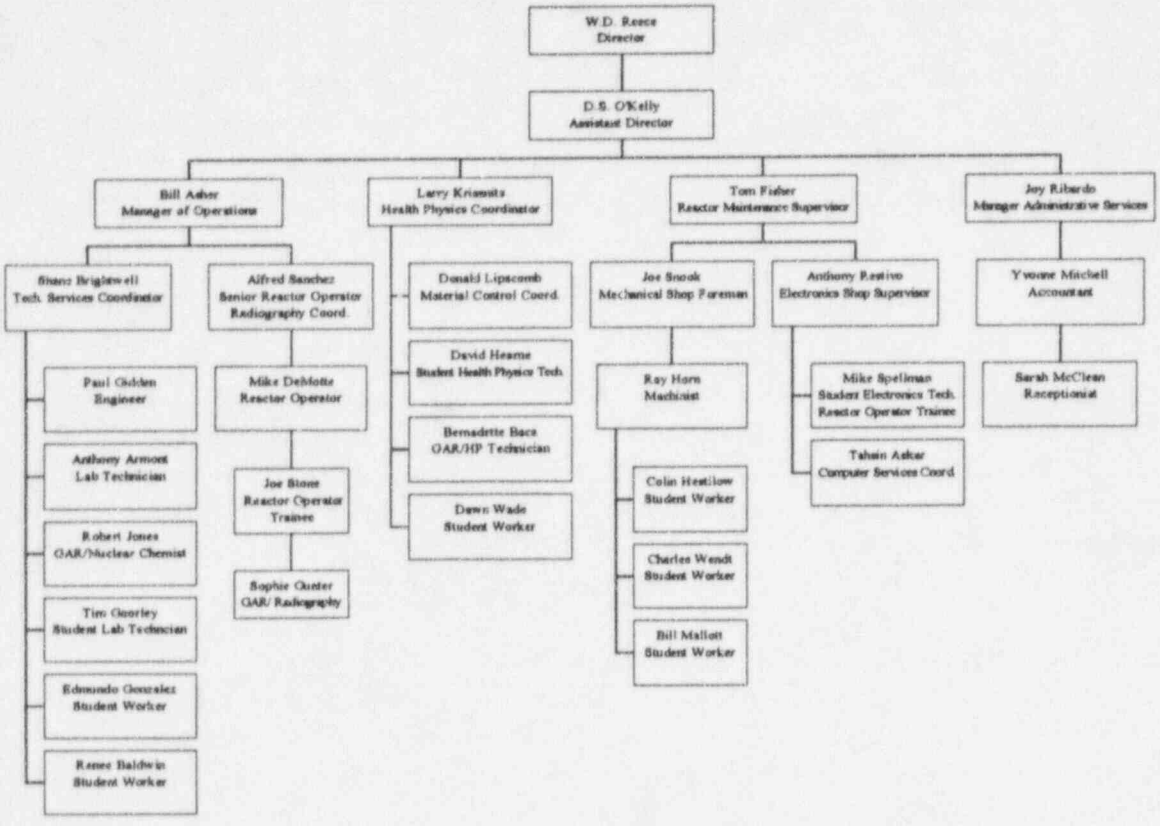
The NSC increased the diversity of its services during this reporting period. A Fast Flux Irradiator for the support of $^{39}Ar/^{40}Ar$ dating of geologic samples was designed, built and tested as a Master's thesis project. Users of this new facility have been very impressed and consider it to have excellent fast neutron activation characteristics. The completion of a radioactive material handling cell in the chemistry lab will let researchers perform on-site radiochemical separations. The NSC has also begun providing gamma irradiation services on a regular basis using the facility Irradiation Cell. The total operating hours of the reactor and the number of experiments increased this year from those of 1994.

In the past, NSC reactor maintenance and fuel inspections were performed in January following the University Christmas Break. This has impacted experimenters and commercial users because it resulted in the reactor being shutdown for several consecutive weeks. To reduce these extended shutdowns, the maintenance period was moved to September. Therefore, there were two periods of maintenance and fuel inspections in 1995.

There were no changes to the NSC operating license or the Security Plan this period. A change to the Emergency Plan has been submitted to the NRC and is still under review.

1.1 Nuclear Science Center Staff

The staff at the Nuclear Science Center is split into four primary work groups; Operations, Health Physics, Maintenance and Administration. Personnel directly involved with the operation and maintenance of the reactor are NRC-licensed operators. The NSC is committed to its educational responsibilities and many of the staff are part or full-time students at Texas A&M University.



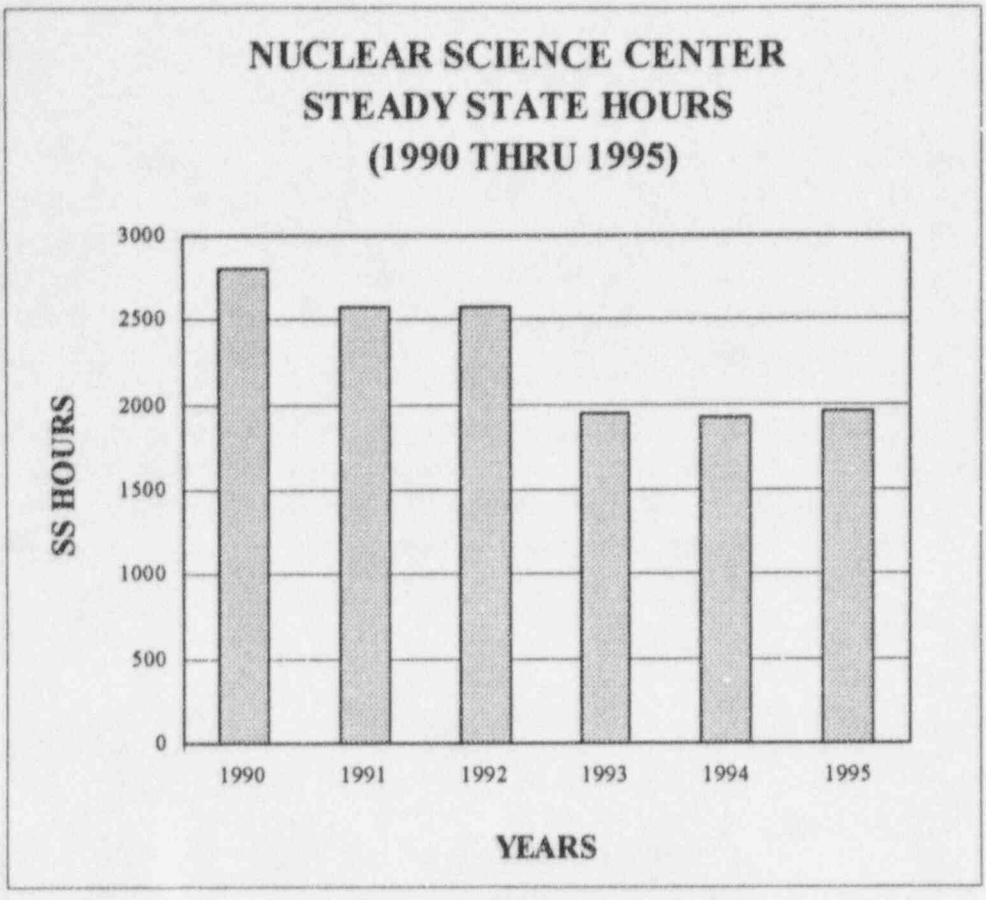
2.0 Reactor Utilization for 1994-1995

The Nuclear Science Center reactor has been in operation since 1962. The reactor is a 1 Megawatt MTR converted to TRIGA fuel. The TRIGA fuel is high-enrichment uranium (HEU) with 70% enrichment, but will be converted to 20% enriched fuel when funds become available. Core VIII-A is the current core configuration and has been used since March, 1986. The NSC reactor is pulse operational with nearly twice as many pulses performed this year as compared to 1994.

The NSC reactor operated for 1963 hours in 1995 with a total integrated power of 80.4 Mw-Days. There were 671 irradiations and services performed at the NSC during the reporting period. The NSC provided services to TAMUS departments, other universities, research centers and secondary schools in and outside the state of Texas. The reactor was used by 12 departments at TAMU and 6 other universities.

Reactor Utilization Summary
1994-1995

Days of Reactor Operation	225
Integrated Power	80.4
Number of Hours at Steady-State	1963
Average Hours of Operation a Week	37.8
Number of Pulses	28
Number of Reactor Irradiations	671
Beam Port Experiment Hours	64.4
Hours Irradiation Cell Use	4.2
Number of Visitors	2808


NUCLEAR SCIENCE CENTER
STEADY STATE HOURS
(1990 THRU 1995)
SS HOURS
3000
2500
2000
1500
1000
500
0
1990
1991
1992
1993
1994
1995
YEARS

2.1 Research Enhancement Program

2.1.1 Introduction

The 70th Texas Legislature established the Research Enhancement Program (REP) in 1987 to "encourage and provide for research conducted by faculty members". The REP replaced the former "Organized Research" program.

The REP funds are administered by the TAMU Office of the Vice President for Research. Due to a reduction in the state allocation in 1995, the REP funds allocated to the NSC were reduced to $22,000 from a nominal $42,000. Unused funding from the previous year of $1697.60 was brought forward. This sizable reduction in funding limited much of the normal faculty exploratory research. Several research programs were curtailed by the limited funds and a few required support by TEES and the NSC in order to complete projects after REP funds were expended.

A new disbursement plan was initiated this year to ensure REP funds allocated to NSC researchers are used prior to the end of the fiscal year. This reduces the chance of not expending the funds for research and bringing unused funds forward to the next fiscal year. Research projects are evaluated during the second and fourth quarters for use of REP funds. If by mid-fiscal year a researcher has not used or scheduled reactor services, his or her funding is reduced by one-half. These funds will then be available for other researchers who require funding. Early in the fourth quarter all unexpended REP funds administered by the NSC are made available to all qualified researchers on a case-by-case basis until all the NSC's REP allocation is expended.

Funds for reactor services were made available to the individual colleges as follows;

College of Science	$ 2,771.72
College of Engineering	$ 495.30
College of Liberal Arts (Archeology)	$ 10,489.30
College of Geoscience	$ 9941.28
Total	$ 23,697.60

2.1.2 Research Projects Supported

Development and Evaluation of Recoil-Nucleus Time-of-Flight Neutron Depth Profiling (TOF NDP)

Emile A. Schweikert, John F. Welch Jr., W. Ricky Ferrell

Center for Chemical Characterization and Analysis, Department of Chemistry

Objective of research is the development of a new method of analysis, recoil-nucleus TOFNDP. NSC provided support in the construction of TOF spectrometer for use with radioactive charged particle emitter. Po-210, an alpha emitter, will be used as a model for nuclides undergoing (n, charged particle) reactions for the purpose of instrumental development. The Po-210 will be used in two spectrometers. NSC personnel produced the Po-210 source by the activation of a Bismuth target.

Paper presented at 1995 Fall Meeting of Materials Research Society:

Characterization of Bismuth Deposits and keV Implants Using Recoil-nucleus Time-of-flight Neutron Depth Profiling and Plasma Desorption Mass Spectrometry

Polymerization of Silicon Oils Using Gamma Radiation for Artifact Conservation

Donny L. Hamilton, C. Wayne Smith, R. Paul Gidden

Nautical Archaeology Program (Department of Anthropology), Department of Nuclear Engineering

A series of experiments were designed to develop a set of working parameters for using a variety of molecular weights of polymer silicones for the purpose of bulking and stabilizing waterlogged archaeological materials. Once these parameters are established, additional experimentation will be conducted to address issues of types of cross-link bonds, process reversibility and scission.

Neutron Activation Analysis Determination of the Effects of Alkaline Dithinote on Ancient Bronze Coins

Donny L. Hamilton, Georgia L. Fox

Nautical Archaeology Program (Department of Anthropology)

A Note on the Use of Alkaline Dithionite for Treating Ancient Bronze Artifacts; Studies in Conservation, Vol. 40 (1995) 139-142

Research was carried out to determine the percentage of metallic copper and tin in solutions of alkaline dithinote. Alkaline dithinote is a chemical used in archaeological conservation to preserve cuprous metal artifacts. The efficacy of this procedure is confirmed through the conservation of several small bronze artifacts from Tel Nami, Israel. Tel Nami is located near the Mediterranean Sea, therefore the bronze artifacts suffered from cuprous chloride contamination. An experiment with bronze Chinese coins confirms that some metal is lost to solution when using alkaline dithionite; however, the

loss is minimal in comparison to the overall success rate for treating ancient bronze artifacts.

Cr-Spinel in Depleted Basalts from the Lau Basin Backarc: Petrogenetic History from Mg-Fe Crystal-Liquid Exchange

James F. Allan

Texas A&M Ocean Drilling Program, Department of Geology

Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 135

Cr-spinels in cores drilled during Ocean Drilling Program Leg 135 exhibit wide variation in composition and morphology that reflect complex petrogenetic histories. These Cr-spinels are found within basaltic lava flows that erupted in north-trending sub-basins within the Lau Basin backarc. Cr-spinels from Sites 834 and 836 occur as euhedral groundmass grains and inclusions in plagioclase, and range up to 300 mm in size. These Cr-spinels are similar in composition, morphology and mode of occurrence to Cr-spinels found within depleted, N-type mid-ocean-ridge basalts (N-MORB), reflecting similar crystallization conditions and host lava composition to N-MORB.
Cr-spinel-bearing rock samples were analyzed to provide a compostional framework for the mineralogical studies. Due to the rarity of glassy material in the core and restrictions on glass sampling, only whole-rock powders were available for major and trace element analysis. Instrumental neutron activation analysis was performed on powder samples and compared to shipboard X-ray fluorescence. Samples were run in duplicate , with 2-hr counts obtained at 7-12 days, 28-33 days, and 4 months using lead-shielded Ortec coaxial intrinsic germanium detectors at Texas A&M Center for Chemical Characterization and Analysis.

Petrologic Evolution of Lau Basin Sites 834 through 839

James W. Hawkins and James F. Allan

Geological Research Division. Scripps Institution of Oceanography, La Jolla CA
Texas A&M Ocean Drilling Program, Department of Geology

Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 135

Ocean Drilling Program Leg 135 provided igneous rock cores from six sites drilled on a transect across the Lau Basin between the Lau Ridge remnant arc and the modern spreading ridges of the Central and Eastern Lau Spreading Centers. The drill cores sampled crust from the earliest stage of backarc extension (latest Miocene time, about 6 Ma), and younger crust (late Pliocene, about 3.8-2 Ma, and Middle Pleistocene, about

0.64-0.8 Ma). Nearly all of the igneous samples are from tholeitic basalt flows; many of them are interbedded with arc-composition volcaniclasic sediments.

A major focus of study for Leg 135 was the long-standing problem of the petrologic/tectonic controls on backarc magmatism and the relationship between coeval arc and backarc magmatism. Understanding these processes has implications to the nature of mantle sources for magmas and to magmatic processes in arc, backarc and forearc settings. It also can give insight to the nature of tectonic processes that form these wide zones of crustal extension at convergent intraoceanic plate margins.

Instrumental neutron activation analysis was performed on bulk-rock powders split from samples analyzed by shipboard XRF. These bulk-rock samples give a fairly reliable indication of magma evolution.

Data Report: **Trace Element Geochemistry of Leg 142 Basalts by Instrumental Neutron Activation Analysis**

James F. Allan

Texas A&M Ocean Drilling Program and Department of Geology

Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 142

During Leg 142, two units of moderately evolved basalt were recovered from the East Pacific Rise axis at 9°30'N. Instrumental neutron activation analysis of seven samples from these units shows them to be light rare-earth-element (REE)-depleted, normal mid-ocean ridge basalt, with $(La/Sm)_N$ of 0.52-0.56, flat chondrite-normalized medium-to-heavy rare earth patterns, and slight negative europium anomalies. Unit 2 contains slightly higher amounts of RE and Hf and lower amounts of Cr than Unit 1, with both units similar in composition to the most-evolved samples previously collected from this section of the ridge crest.

Drilling and coring at mid-ocean ridge spreading centers has been a long-standing goal in the earth science community. Site 864 located on the East Pacific Rise (EPR), represented the initial attempt in a long-range plan to core the entire crustal section at the EPR. The principle scientific goal of Leg 142 was to core 100 m into the uppermost crust of this fast-spreading center (11cm/year). Sample counting was performed at Texas A&M Center for Chemical Characterization and Analysis.

Petrology of Selected Leg 147 Basaltic Lavas and Dikes

James F. Allan, Trevor Falloon, Rolf Pedersen, B. Shankar Lakkapragada, James Natland, John Malpas

Texas A&M Ocean Drilling Program and Department of Geology
University of Tasmania Department of Geology, Tasmania, Australia
University of Bergen Geological Institute, Bergen, Norway
University of Miami Rosenthiel School of Marine and Atmospheric Sciences, Miami, FL
Memorial University of Newfoundland Department of Earth Sciences, St. John's NF

Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 147

Sites 894 and 895 of Ocean Drilling Program Leg 147 recovered a variety of basaltic material from the Hess Deep intrarift ridge, including cores of dikes that cut gabbroic and peridotitic wall rock and fragments of pillowed, surficial laval flows. The site 894 basalts are more depleted than EPR N-MORB in incompatible elements, with extreme depletions in both the light rare earth elements (LREE) and Ta and Nb. The intrusive relations, mineralogy, and geochemistry of these samples support an off-axis origin of these samples during opening of the Hess Deep.

The Site 895 basalts sampled from both dikes and pillowed flows, are aphyric, more evolved and less depleted in LREE, Ta and Nb than the Site 894 samples. Unlike the Site 894 samples, these characteristics allow derivation from a mantle similar in composition to that underlying the EPR. Intrusive relations and geochemical characteristics support a mixed origin for the Site 895 samples, with some originating at or near the EPR crest, and others representing volcanism associated with Hess Deep opening.

INAA was performed at the Texas A&M TRIGA reactor with counting performed at Texas A&M CCCA.

Uranium and Thorium in Paleozoic Aquifers Surrounding the Llano Uplift Area, Central Texas (Delayed-Neutron Counting)

Thomas T. Tieh, Youngjo Kim, Earnest B. Ledger

Texas A&M Department of Geology and Geophysics
Stephen F. Austin State University Department of Geology

Aquifer Mineralogy and Natural Radionuclides in Groundwater--The Lower Paleozoic of Central Texas (Gulf Coast Association of Geological Societies Transactions, Vol. XLV, 1995)

*Uranium and Thorium in Paleozoic Aquifers Surrounding the Llano Uplift Area, Central Texas (*presented at 1995 Annual Convention of the American Association of Petroleum Geologists, March, 1995, Houston, TX)

Water-mineral interactions in an aquifer may give rise to high levels of Ra and Rn in groundwater. An understanding of aquifer mineralogy is therefore essential to determine the sources of natural radionuclides and design possible means for improving water quality. Anomalous Ra and Rn concentrations have been detected in groundwater produced from the Cambrian Hickory and Cap Mountain aquifers in the Llano Uplift area of central Texas.

Analysis of uranium in 123 samples by delayed-neutron counting at the Nuclear Science Center shows an average concentration of 3.8 ppm. Shaly samples generally contain significantly higher U. Gamma-ray analysis of Th in 21 samples yields an average of 13.7 ppm. Fission-track imaging, also performed at the NSC, shows that U occurs predominantly in: (1) phosphatic fossil fragments and intraclasts, especially in the Cap Mountain; (2) thin shaly laminae which are more abundant in the Hickory; (3) authigenic minerals including hematite and clay minerals.

Trace Element Analysis of Prehistoric Ceramics from the American Southwest and Mesoamerica

Harry J. Shafer, Dennis James
Department of Anthropology, TAMU Center for Chemical Characterization and Analysis

The research is to identify geographic loci of ceramic production in the prehistoric southwest and in Belize. The 94-95 research emphasized the American Southwest, specifically the production of Mimbres black-on-white pottery in the Mimbres and Gila River drainages. This phase raised a number of new questions regarding ceramic production and additional samples were selected and examined. Additional samples are now being prepared for a final analysis of Southwestern pottery and a new project will begin on ceramic craft specialization among the lowland Maya. The Maya study will examine a Late-Terminal Classic Period polychrome ware from sites in northern Belize. This will be a very important contribution to the study of Maya ceramics and will be a pioneering effort to identify craft specialization through trace analysis.

Interregional Networks in the Classic Mimbres Period: The Ceramic Evidence

Robbie L. Brewington, Dennis James

Department of Anthropology, TAMU Center for Chemical Characterization and Analysis

Paper presented at the 60th Meeting of the Society of American Archeology, Minneapolois, 1995.

Previous research indicates that Mimbres decorated ceramics exhibit spatial variation--specific designs were more commonly used in some areas than others. This finding

suggests that Mimbres pottery was locally produced and used. At the same time, however, there is a consistent patterning in design that allows us to recognize Mimbres pottery wherever it occurs. A social mechanism that might be responsible for this patterning is participation is a shared symbolic system.

Other research indicates that Mimbres ceramics were widely distributed--which would blur the distinctiveness of local design variation. Whether the regional homogeneity of Mimbres ceramic design resulted from distribution of vessels or a shared iconographic system, or both, the result is hetrogeneity in design at the local level and homogeneity at a regional level.

Neutron Activation Analysis was performed at the NSC and CCCA in order to establish distribution patterns for the 130- year Mimbres Classic Period from 1000 A.D. to 1130 A.D.

Compositional Analysis of American Southwestern Ceramics by Neutron Activation Analysis

W.D. James, R.L. Brewington, H.J. Shafer

TAMU Center for Chemical Characterization and Analysis, Department of Anthropology
Journal of Radioanalytical and Nuclear Chemistry, Vol. 192, No. 1(1995) 109-116

Instrumental neutron activation analysis was used to perform compositional analysis on more than 200 potsherds from prehistoric ceramic pottery collected in or near the Mimbres Valley in New Mexico. Statistical evaluation of the data was used to identify samples of similar origin. Results indicate that at least two sites within the Mimbres heartland and one in the Upper Gilla Valley existed for the production of the characteristic Classic Mimbres pottery.

Application of Neutron Activation Analysis Techniques to TAMU Research Problems at CCCA

W.D. James

TAMU Center for Chemical Characterization and Analysis

REP funds were used for method development in NAA and to apply these techniques to wide range of problems. Often, CCCA funds were used to perform exploratory work for campus researchers. The following is a list of non-CCCA projects:

Dr. James Haw, Department of Chemistry

Determination of transition metal concentrations in zeolite. Three separate student research projects on this related material were performed during this year. Eleven separate NAA projects were performed during the year.

Graduate students: David Murray, Mike Krawitz and Timothy Howard.

Dr. Abraham Clearfield, Department of Chemistry

Determination of elemental components of pillared clay samples. These are aluminum oxide rich clays, one being saponite containing about 15% zirconium.

Dr. Kevin Burgess, Department of Chemistry

Search for adsorbed markers on microbeads. Potential is for the development of a method of tracking individual beads in chemical reactions.

Dr. Timothy Phillips, Veterinary Anatomy and Public Health

Multi-element trace analysis of ammonium-exchanged montmorillonite clays under investigation as possible natural ion exchange materials.

Graduate student: Kent Washburn

Dr. Gerald Bratton and Dr. Raymond Tarpley, Veterinary Anatomy and Public Health

Multi-element determination of trace constituents in whale liver and blubber. Potential for adding the method to a suite of techniques used in an existing survey program for marine environmental measurements.

An Instrumental Neutron Activation Analysis of 18th Century Lead-glazed Earthenwares from Four Spanish Missions in Texas

S.D. Carlson, W.D. James

Department of Anthropology and Archaeology, TAMU Center for Chemical Characterization and Analysis

Submitted to J. Radioanalytical and Nuclear Chemistry (1995) and presented as an invited paper at the 1994 Winter Meeting of the American Nuclear Society in Washington, D.C.

Neutron Activation Analysis was performed on pottery sherds at the NSC for multi-element trace analysis. The research was performed to determine relative manufacturing

centers of these earthenwares in 18th century Texas. Some of the results of the study indicate that some "Mexican" lead glazed earthenwares were likely made by Indians at the individual missions.

Characterization of Guatemalan Ceramics by NAA

S.D. Carlson, W.D. James

TAMU Center for Environmental Archaeology, TAMU Center for Chemical Characterization and Analysis

359 samples of Guatemalan ceramics were studied this past year. These samples were obtained from the Guatemalan southern highlands, in an area around Lake Atitlan.

Provenance Determination of Guatemalan Obsidian Artifacts by NAA

H. J. Shafer, M.R. Woodward

Department of Anthropology

214 obsidian samples were analyzed to determine sources of origin. Sixty-six samples were source material from volcanic outcroppings that were used to produce prehistoric tools. Three outcroppings were used and considered to be sources. It was found that the majority (95%) of the tools were produced from the so-called San Martic Jilotepeque outcropping and none came from the Ixtepeque location. It is hypothesized that the Ixtepeque outcrop had not been exposed early enough to be used to produce stone/obsidian tools.

Texas A&M University Trace Element Research Laboratory
Department of Oceanography

P.N. Boothe, B.J. Presley, Robert Taylor

The Trace Element Research Laboratory (TERL) is considered to be one of the premier inorganic environmental chemistry laboratories in the United States. TERL has an international reputation, earned through numerous blind intercalibration exercises and documented project performances, for consistently producing the highest quality trace element data for any type of environmental sample. TERL specializes in low detection level measurements of trace metals in environmental samples (including water, wastewater, sediment and biota) conducted under a comprehensive quality assurance/ quality control program.

The following is a list of TERL projects performed using REP funds, but many of the TERL projects are externally funded.

Intercalibrations

TERL participates in national and international intercalibration exercises each year.

1. *U.S. Geological Survey.* Evaluation Program for Standard Reference Water Samples. TERL placed fourth among the 137 laboratories participating. NAA was used to confirm the analysis of several elements in the unknown sediment sample.

2. *National Research Council of Canada and U.S. National Institute of Standards and Technology.* Annual NOAA National Status and Trends Trace Element Intercalibration Exercise. TERL received honors and a long-term proficiency award for superior ratings in Exercise #8 in 1994.

3. *Quality Assurance of Information for Marine Environmental Monitoring in Europe (QUASIMEME).* TERL is the only U.S. laboratory participating in this European Community sponsored low detection level intercalibration exercise for tissue and sediment. In the latest round, TERL received the highest possible rating for both matrices.

Quality Assurance Program

Neutron Activation Analysis is performed as an independent check of other methods of analysis. This helps to identify and correct problems with other TERL spectroscopy-based methods. NAA is also used to do an annual method detection limit study on sediment and tissue samples.

Methods Development

TERL is constantly developing new methods or applications for NAA in research. This past year considerable effort went into developing and refining NAA methods for marine tissue analysis. These new methods were applied to a externally funded NOAA National Status and Trends program. The methods developed are now routinely used in determining Ag, As, Cr, Fe, Sb, Se, and Zn concentrations in bivalve tissue for the NS&T program.

Exploratory Research

REP funds allowed TERL to support small unfunded research studies and to expand funded projects. For example, the Minerals Management Service Gulf Offshore Operations Monitoring Experiment (GOOMEX) was a large study aimed at investigating the chronic impacts of offshore petroleum development and production in the Gulf of

Mexico. This project involved a large amount of funded NAA analyses of marine sediment for BA, Cr, Fe, Sb, and Zn. There was no funding to analyze sub-surface sediments. REP funds were used to analyze selected sediment core material. This approach added a new historical perspective to the study and was critical to the interpretation of the sediment data.

2.2 Texas A&M University Academic Support Program

2.2.1 Introduction

Texas A&M University provides funding for at the reactor for such academic activities as nuclear engineering laboratories, neutron activation analysis demonstrations and laboratories, graduate student thesis research and undergraduate research projects. The program has been very successful and is crucial for many graduate students whose chosen research uses the NSC reactor in some way, but is not supported by any research grant.

The NSC's reputation as a multidisiplinary institution is reflected in the wide range of the academic users from the university.

2.2.2 Texas A&M University System Academic Projects Supported

Trace Metal Contamination of Waters, Sediments, and Organisms of the Swan Lake Area of Galveston Bay (M.S. Thesis, Junesoo Park, Department of Oceanography)

Swan Lake is a sub-bay of the Galveston Bay system. The area received runoff from a tin smelter via the Wah Chang Ditch which ran through it in the past but the ditch is now cut off by a hurricane protection levee. An industrial waste disposal facility (Gulf Coast Waste Disposal Authority) is located north of the Wah Chang Ditch. Consequently there have been concerns about possible metal contamination in this area.

Trace metal concentrations in water, sediments, and organisms (oyster, mussel, snail, crab, fish, shrimp, and spartina) in the area were determined. Sediments were analyzed for total Ag, Al, As, Cd, Cu, Fe, Hg, Mn, Ni, Pb, Se, Sn, and Zn. Water samples were analyzed for Cd, Cu, Fe, Mn, and Sn.

The variabilities and geographic trends in sediment trace metals indicated that waste disposal and airborne inputs from facilities located at the Tex Tin site were likely sources for metal pollution found in the sediments. Sediments in the study area showed elevated trace metals relative to Galveston Bay and other Texas bay sediments,

Three different samplings of the Wah Chang Ditch showed no temporal patterns in metal distribution in the sediments. Lead concentrations were uniformly high from the three samples. Metal enrichments at depth in the sediment column indicated that the Swan Lake area has recently received less input of metal contaminated sediment than in the past. Anthropogenic inputs did not greatly influence the natural concentrations of Fe, Al, and Ni in sediments either in the past or at present.

Most organisms showed very small spatial variations. However, the oysters in Swan Lake are enriched in most metals relative to Galveston Bay and other U.S. Gulf of Mexico oysters. The mussels in this study do not reflect the unusually elevated environmental metal concentrations in the sediments from which they were taken. Iron and Pb

concentrations in oysters seemed to be directly related to sediment concentrations at each location. Oysters show higher concentrations in most metals compared to mussels. The Zn level was 113 times higher in oysters. For organisms collected from the Swan Lake area trace metal concentrations were generally oysters-snail-crab-shrimp-fish, from highest to lowest.

Metal concentrations in Wah Chang Ditch water were very elevated relative to those of the Brazos River and Galveston Bay. These concentrations closely reflect those in the sediments of the Wah Chang Ditch.

Spatial and Temporal Variations of Trace Metals in Bottom Sediments of Peter the Great Bay, the Sea of Japan.

A.V. Tkalin, Fullbright Research Fellow at TAMU
Far Eastern Regional Hydrometeorological Research Institute
Vladivostok, Russia

B.J. Presley, P.N. Boothe
Trace Element Research Laboratory
Department of Oceanography

In 1994, the Russian Federation, Japan, the People's Republic of China, and the Republic of Korea signed an Action Plan for the protection of the marine environment of the northwest Pacific Ocean. An initial step in the Plan was a characterization of the current environment in the Sea of Japan and the Yellow Sea. INAA was one of the methods used in this characterization program.

Cold Neutron Facility at Texas A&M
Tim Goorley
Nuclear Engineering Department

An undergraduate research project was to design, construct and test a cold neutron beam using the NSC Beam Port No. 1. The student used liquid nitrogen cooled light water as the cold source. The project involved the construction of a simple beam chopper system and the setup of the necessary electronics. The student found that the low beam flux was hidden by the background radiation.

Other Projects and Labs using Academic Support Funds

Kim, Yongje, Thomas T. Tieh, "*Uranium and Thorium in Paleozoic Aquifers surrounding the Llano Uplift Area, Central Texas*" , presented at 1995 Annual Convention of the American Association of Petroleum Geologists

Nuclear Engineering 405, Reactor Experiments Laboratory

Nuclear Engineering 402, Nuclear Detection and Isotope Technology Laboratory

Chemistry 464, Nuclear Chemistry Laboratory

Burrows, Ron, "Characterization of Nuclear Accident Dosimeter" (Master's Thesis)

2.3 Reactor Sharing Program

2.3.1 Introduction

The University Reactor Sharing Program provides funds for reactor experimentation to those institutions which do not normally have access to a research reactor. The Nuclear Science Center (NSC) has participated in the program since 1980 with great success. During the 1994-1995 contract year, eleven research institutions utilized the NSC with the support of the Reactor Sharing Program. Additionally, the funding provided reactor tours and "hands-on" projects to many secondary schools.

The research projects supported by the program range from geological dating to higher current superconducting magnets. The funding gave small colleges and universities the opportunity to use the NSC for teaching courses in nuclear processes; specifically neutron activation analysis and gamma spectroscopy. The Reactor Sharing Program supported the construction of a Fast Neutron Flux Irradiator for users at New Mexico Institute of Mining and Technology and the University of Houston. This device has been characterized and has been found to have near optimum neutron fluxes for A^{39}/Ar^{40} dating.

Funding this year was significantly reduced from previous years and several researchers were unable to complete research projects before all available funds were expended.

2.3.2 Summary of Projects Supported by Reactor Sharing Program

$^{40}Ar/^{39}Ar$ Geochronology at New Mexico Geochronology Research Laboratory

New Mexico Tech — Dr. Matthew Heizler
Department of Earth and Environmental Sciences — Dr. Bill McIntosh

10 Graduate Students participated and 3 Undergraduate Students

20 presentations at professional meetings
3 dissertations and 7 theses in progress

University Reactor Sharing Support Provided: $ 5,314.59

$^{40}Ar/^{39}Ar$ Geochronology at University of Houston

University of Houston, Department of Geosciences — Dr. Peter Copeland, Dr. Terry Spell

1 Graduate Student and 1 Undergraduate Student participated
3 Presentations and 1 Thesis were the result of the work performed
Thesis title:

"Magnetostratigraphy and $^{40}Ar/^{39}Ar$ Analysis of the Siwalik Group, Dhansar Khola, Southern Nepal: Constraining Timing of Uplift in the Greater Himalaya"

University Reactor Sharing Support Provided: $ 5,198.35

A Description of the $^{40}Ar/^{39}Ar$ Dating Technique

The conventional K-Ar dating technique involves the radioactive decay (half-life 1.25 Ga) of naturally occurring ^{40}K to ^{40}Ar. This decay scheme is the most commonly used dating technique exploited by the geological community because of the ubiquitous occurrence of K in most geologic materials and because it is applicable to all time-scales relevant to the earth and solar system. A major drawback to the K-Ar method is the requirement to make two absolute measurements on very chemically distinct species. ^{40}Ar is measured on one aliquot using isotope dilution techniques and rare gas mass spectrometry and ^{40}K is commonly measured using flame photometry on a second aliquot. These methods limit the precision of the dating technique to ~ 1% and also provide no means to test some of the underlying assumptions required to calculate an apparent age.

In the middle 1960's it was recognized that irradiation of K bearing samples with fast neutrons could facilitate the reaction $^{39}K(n,p)^{39}Ar$ and thus potentially provide a means of measuring K with non-naturally occurring ^{39}Ar. This led to the dating technique referred to as $^{40}Ar/^{39}Ar$ ratio dating and has numerous advantages over the conventional K-Ar method; such as:

1. A single analysis is conducted on one aliquot of sample thereby reducing the sample size and eliminating sample inhomogeneity.
2. Analytical error incurred in determining absolute abundances is reduced by measuring only isotopic ratios. This also eliminates the need to know the exact weight of the sample.
3. The addition of an argon spike is not necessary.
4. The sample does not need to be completely fused, but rather can be incrementally heated.
5. The $^{40}Ar/^{39}Ar$ ratio (age) can be measured for each fraction of argon released and this allows for the interrogation of an age spectrum.

The age of a sample as determined with the $^{40}Ar/^{39}Ar$ method requires comparison of the measured $^{40}Ar/^{39}Ar$ ratio with that of a standard of known age. Also, several isotopes of other elements (Ca, K, Cl, Ar) produce argon isotopes during the irradiation procedure and require a correction.

Neutron Activation Analysis of Aerosols from Antarctica Volcanoes

New Mexico Tech, Department of Geoscience Dr. Philip Kyle

1 Graduate Student Thesis. *"Emission and Dispersion of Gaseous S, F and Cl from Mt. Erebus, Antarctica"*

University Reactor Sharing Funding Provided: $ 1,915.64

Mt. Erebus, Antarctica, provides a unique laboratory to study degassing behavior of a stable alkaline body. Sixty-four samples of the gas plume emitted from Erebus were collected on filter packs during the 1992,1993 and 1994 Austral summers. Filter packs consisted of a 2 mm Teflon particulate filter followed by two ^{7}LiOH-impregnated Whatman 41 filters. Filter packs were connected to a small vacuum pump at a site on the crater rim.

Filter samples were analyzed for Cl, In, and Na using neutron activation analysis. A method of detecting Cl and F using rapid counting techniques was performed by the experimenter during a week-long stay at Texas A&M .

Model predictions as well as trace element data from atmospheric and snow sampling clearly show that measurable amounts of Erebus gases can reach the South Pole. Based on current levels of activity and the absence of a mechanism responsible for transferring significant amounts of SO_2 and Cl to the stratosphere it is unlikely that gases from Erebus play a major role in ozone depletion above Antarctica.

Effects of Shearing on Trace Element Mobility

New Mexico Tech — Dr. Kent C. Condie
Department of Geoscience

With increasing degree of deformation and retrogression of a granitoid in the Brevard shear zone in North Carolina, Ca and LOI (H_2O) are enriched, and Si, Mg, K, Na, Ba, Sr, Ta, Cs, and Th are depleted at the ultramylonite boundary. Al, Ti, Fe, P, Sc, Rb, REE, Hf, Cr, and U, however, remain unchanged. A volume loss of 44% is calculated for the Brevard ultramylonite relative to an Al-Ti-Fe isocon. The increase in Ca and LOI is related to a large increase in retrograde epidote and muscovite in the ultramylonites, the decreases in K, Na, Si, Ba, and Sr reflect the destruction of feldspars, and the decrease in Mg, the destruction of biotite during mylonitization. In an amphibolite facies fault zone separating gray and pink granitic gneisses in the Hope Valley shear zone in New England, compositional similarity suggest the ultramylonite is composed chiefly of the pink gneisses. Utilizing and Al-Ti-Fe isocon for the pink gneisses, Sc, Cr, Hf, Ta, U, Th and M-HREE are relatively unchanged, Si, LOI, D, Mg, Rb, Cs, and Ba are enriched , and Ca, Na, P, Sr and LREE are lost during deformation. In contrast to the Brevard mylonite, the Hope Valley mylonite appears to have increased in volume by about 70%.

Among the element ratios most resistant to change during mylonitization in the Brevard shear zone are La/Yb, Hf/Ta and Hf/Yb. However, until more trace element data are

available from other shear zones, these ratios should not be used alone to identify protoliths of deformed rocks.

Mobilization of Major and Trace Elements During Progressive Weathering of a Granodiorite in Colorado (Published in January 1995, Geochimica et Cosmochimica Acta, v. 59)

New Mexico Tech
Department of Geoscience

Dr. Kent C. Condie

A weathering profile on the Boulder granodiorite in northern Colorado provides an opportunity to trace the behavior of REE from parent rock, through a weathering profile, into unconforming overlying Permian sediments. With progressive upward weathering of the granodiorite, Na_2O, CaO, SiO_2,Ta/Hf, Co/Th, Zr/Hf, La/Sc, Zr/Y and La/Th decrease; Al_2O_3 and Fe_2O_3T increase; and TiO_2, MgO,K_2O, P_2O_5, Rb, Zr, Sc, Cr, Co, Hr, Nb, Ta, Y, Th, U, REE (rare earth elements), Ti/Nb, and Zr/Nb increase to maximum values and then either level off or decrease.

L(light)REE enrichment is less in the weathering profile than in the parent granodiorite and although the parent does not have an Eu anomaly (or only a slight positive anomaly), all samples from the weathering profile and overlying sediments have significant negative Eu anomalies. This observation is especially important in that it shows conclusively that a negative Eu anomaly can be produced during chemical weathering of granitoids. We suggest these Eu anomalies are due to relative enrichment of the other REE and partial loss of Eu during the breakdown of plagioclase. The Boulder weathering profile also has a very minor negative Ce anomaly that is within error of a Ce anomaly in the parent. In the unweathered parent, >50% of the REE are contained in sphene, and in the case of La, also in allanite. From 10 to 20% of the REE are contained in apatite and biotite, and from 7-10% of the H(heavy)REE are in zircon. With exception of Eu, for which feldspars contribute about 8%, negligible amounts of REE occur in feldspars. In weathered samples, >75% of the REE are contained in clay minerals. The crossover between sphene and clay control of REE occurs over a distance of 1 m near the contact with fresh rock. Except for their small negative Eu anomalies, the clay minerals have REE patterns very similar to those of the parent rock.

Isocon plots suggest apparent enrichments of many elements in the Boulder weathering profile result from losses of Na, Ca, and Si during plagioclase weathering. In addition, variable amounts of Sr, Eu, Ta, Nb, P, and Ba were lost during weathering. Although Th/U, Zr/Y, Th/Sc, Zr/Hr, Lu/Hf, and Ti/Zr may have been transferred relatively unchanged from granodiorite parent to the bulk weathering profile, most other element ratios and REE distributions were significantly changed during weathering. This observation implies that caution needs to be exercised when using REE patterns and element ratios to trace sediment provenance.

The fact that most element ratios and REE distributions also differ between Fountain sediments and the bulk weathering profile may be related to one or a combination of four factors, listed in order of probable decreasing importance: contribution of other sources to the Fountain sediments, sorting of minerals during sediment deposition, remobilization of elements during deagenesis, and leaching of elements by water flow through the upper meter of the weathering profile.

Study of Optimum Use of Columnar Pinning Centers in High T_c Superconductors

Institute of Beam and Particle Dynamics
University of Houston

Dr. Roy Weinstein
Dr. Yanru Ren
Dr. Jay Liu

3 Graduate Students, 7 Undergraduate Students and 1 Pre-College Student were involved with this research

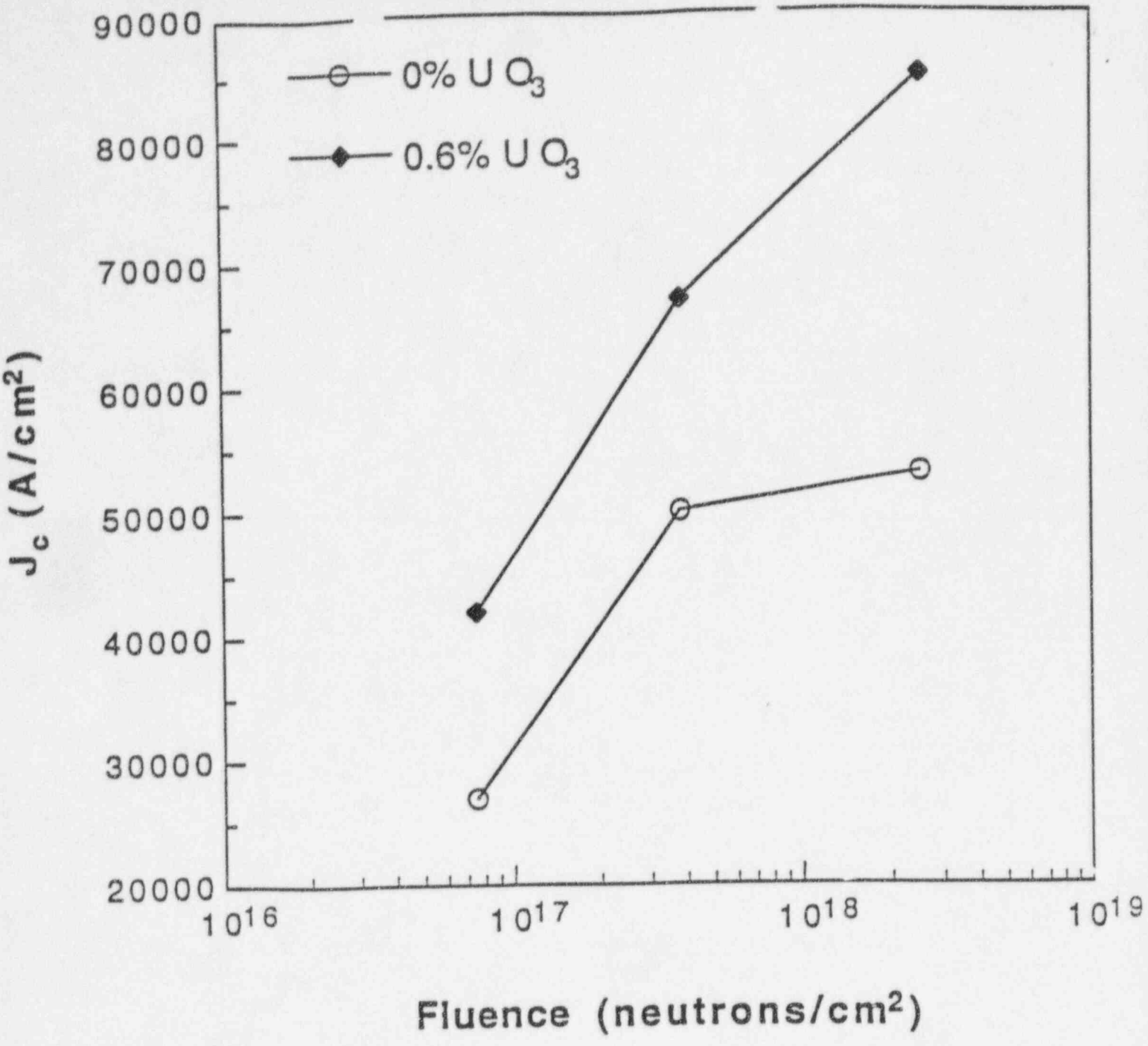
4 Publications, 2 Presentations, and 1 MS thesis resulted from this work

Previous work:
"Effects of High Energy Irradiation of MT Y123 on J_c, Trapped Field, Creep, and the Irreversibility Line" R. Weinstein, J. Liu, Y. Ren, I-G Chen, V. Obot, R.P. Sawh, C. Foster, A. Crapo. Presented at International Workshop on Superconductivity, Kyoto, Japan, June 1994.

Reactor Sharing Support Provided: $ 1,876.10

The Institute of Beam and Particle Dynamics (IBPD) continued to explore a unique type of pinning center in the high temperature superconductor (HTS), $YBa_2Cu_3O_{7}$-d(Y123). Pinning centers are regions of poor or zero superconductivity. These regions permit the presence of magnetic field, despite the Meissner Effect, and are essential to achieve high currents. The pinning centers explored are created by the fission fragments of normal thermal fission of U^{235}. The uranium (235 and some 238) was added to and dispersed within the HTS. The fission fragments create a columnar damage region about 20mm long, and 50 Angstroms in diameter. These short columns are homogeneously distributed in the HTS, and are randomly oriented. It is desirable to know the effects of these centers on current density (J_c), critical temperature (T_c), trapped field (B_t) and other variables.

Columnar defects are theoretically superior to pinning centers formed directly by proton or neutron interactions. These latter defects are very nearly point damage centers. The results of the research this past year was that the J_c of Y123 was increased by a factor of 4, and exhibited an optimum value.



Results for J_C, due to n° irradiation at TAMU Reactor. The value of J_C achieved using 0.6% depleted U is the highest ever achieved in Mt Y123. The activation of the samples with 0% U is consistent with the assumption that activation is due to the fast n° component of the TAMU Reactor.

An Assessment of the Viability of Energy Dispersive X-ray Fluorescence for the Analysis of Metals in Contaminated Soils

A K-series Trachyte to Rhyolite Eruptive Center, Davis Mountain Volcanic Field, Texas

Neutron Activation Analysis at the Sul Ross State University Analytical Laboratory

Sul Ross State University Analytical Laboratory — Dr. Kevin Urbanczyk
Department of Geology and Chemistry
Sul Ross State University, Alpine, Texas

3 Graduate Students were involved in this work and 22 Undergraduates

Reactor Sharing Support Provided: $ 5,894.00

Sul Ross State University actively used the NSC reactor to provide neutron activation of rock samples for graduate and undergraduate research projects. This past year, the radiation detection and counting equipment was out of commission at Sul Ross; therefore, the NSC counted the radioactive samples at the facility and sent the results to Sul Ross for further analysis.

Fission Track Thermochronology

Fission Track Thermochronology — Dr. Mark Cloos
Department of Geological Sciences — Dr. Sharon Mosher
University of Texas at Austin — Dr. Earle McBride

4 Graduate Students from UT and 1 from University of Kansas

Reactor Sharing Support Provided $ 766.16

Publications resulting from this work:

Boettcher, S.S, and Milliken, K.L., 1994, *"Mesozoic-Cenozoic Unroofing of the Southern Appalachian Basin: Evidence from Apatite Fission Track Thermochronology"*, Journal of Geology, v. 102, in press.

Specific projects in progress:

"Investigation of Mesozoic Shortening and Cretaceous-Tertiary Exumation in the Maria Fold and Thrust Belt, Southern United States Cordillera" (Ph.D. dissertation research for Stefan S. Boettcher)

"Tertiary Emplacement of the Irian Ophioloite Belt and Unroofing of the Derwo-Rouffaer Metamorphic Belt, Irian Jaya, Indonesia" (Ph.D. research for Richard J. Weiland)

"Three-dimensional distribution of heat-producing elements in the southern Basin and Range, USA" (Ph.D. research for Richard A. Ketcham)

"Annealing of Fission Tracks in Apatite over Geologic Timescales: Investigation of the Influence of Composition"

"Burial and Unroofing History of Middle Pennsylvanian Sandstones from the Applachian basin in Kentucky and Virginia"

"Thermal Histories of Piggy-Back and Foreland Basins in the North Apennies, Italy, Derived from Apatite Fission Track Thermochronology"

"Investigation of Uranium Distribution in Apatite fission Track Age Standards"

"Timing and Thermal Characteristics of Sevier Belt Thrust Faulting and Synorogenic Sedimentation in the Pavant and Canyon Ranges, Central Utah" (Jonathan K. Linn, University of Kansas)

Methodology

Fission track analysis is a geochronological method that utilizes the spontaneous fission of U-238 in uranium rich minerals such as apatite, zircon, and sphene. The spontaneous fissioning of uranium in these minerals produces two highly ionized fission fragments whose passage through the crystal lattice leaves a linear trail of atomic defects referred to as fission tracks. The preferential etching of these tens of angstroms-wide trails of defects with respect to the bulk crystal enlarges the tracks allowing their lengths and density to be measured under a high powered (1000X-1500X) petrographic microscope.

Apatite is the most common mineral used in fission track thermochronology because more is known about the annealing characteristics of fission tracks in apatite than in sphene and zircon. In apatite, fission tracks are rapidly destroyed by annealing at temperatures above ~125°C. Because the spontaneous fission occurs at a statistically constant rate, the density of fission tracks in a mineral is a function of uranium concentration and fission track age. Fission track age is defined as the elapsed time during which tracks accumulated in the mineral. Determination of fission track ages in apatite, zircon, and sphene involves measuring: (1) the density of spontaneous (fossil) fission tracks; (2) the density of induced fission tracks in a mica external detector that is placed on top of the apatite grain mount and irradiated with thermal neutrons; (3) the density of induced fission

tracks in a standard glass (neutron fluence); and a zeta factor (z) determined from the density of fission tracks in a suitable standard. These variables, combined with the total decay constant (l_D) for ^{238}U and the age of a standard, are used to calculate the age of the material. The irradiation of the grain mounts is performed with thermal neutrons in the NSC reactor Heavy-Water Irradiator.

Annealing of fission tracks refers to those processes that result in the repair of lattice defects such that the trail of defects is shortened or eliminated. Temperature is a dominant factor in fission track annealing in apatite. Fission track length distributions record information on the rate at which the rocks passed through the zone of partial annealing of fission tracks (50°C-125°C). As fission tracks form continuously through time with an initial length of ~16mm, the final distribution of etchable fission track lengths in apatite contains a record of temperature variation with time below ~125°C.

In summary, fission track analysis involves both the measurement of fission track ages and track lengths. The age is a minimum estimate of the timing of the most recent cooling event in the mineral. The track length distribution provides additional information about the cooling history of a sample such as cooling rate, post-cooling thermal pulses, or post-cooling geothermal gradients.

Neutron Activation Analysis Program at the University of Texas at El Paso

Reactor Sharing Support Provided $ 2,028.15

"Geochemistry of Quaternary Lavas from the Chyulu Hills, Eastern Kenya"

Department of Geological Sciences
University of Texas at El Paso

Dr. Elizabeth Anthony
Michelle Barnes
John Carney
Peter Omenda

Mines and Geological Dept.
Nairobi, Kenya

John Omenge

Submitted to the South-Central Geological Society of America Meeting,
Lincoln, Nebraska, April 27-28, 1995

Samples were collected from lavas representing seven different stratigraphic or eruptive units in the Chyulu Hills of eastern Kenya. This volcanic field is very young, with the most recent activity thought to be within the last thousand years, and is on the eastern flank of the African Rift. Previous studies have shown that the lavas are olivine-phyric, nepheline-normative and enriched in the light rare earth elements.

The purpose of the study was to use the field knowledge of the stratigraphic position of the various units in order to understand whether crystal fractionation is an important process in this volcanic field and if so, what minerals are responsible for the geochemical trends observed. Samples were analyzed using neutron activation analysis and inductively-coupled plasma spectroscopy for the major elements. Preliminary analyses indicate that although most of the lavas are not primitive in terms of their Mg number and thus have undergone some crystal fractionation, they are not related to each other by fractionation but rather represent separate magmatic pulses.

The Quaternary Western Potrillo Volcanic Field, Southern Rio Grande Rift: $^{40}Ar/^{39}Ar$ Geochronology and Geochemistry

Geological Sciences
University of Texas at El Paso

Wendi J. Williams
Joesph G. Miller
Elizabeth Y. Anthony

Los Alamos National Laboratory

Jane Poths

Geochronology Laboratory
New Mexico Institute of Mining and Technology

William C. McIntosh

The petrogenetic history of the Quaternary Potrillo volcanic field, located in the southern Rio Grande rift, has been explored. ^{3}He surface exposure dating provides refined temporal constraints for major and trace-element geochemical modeling. The eruption history in the central and eastern parts of this field is from 140 ka t 20 ka, with episodes at approximately 20 ka intervals. Except for maare-related products, the dominantly basanitic magmas resulted from low pressure, olivine crystal fractionation. With over two hundred cones and flows, the western part of the Potrillo volcanic field is an order of magnitude greater in volume than the central and eastern complexes combined.

Geochronologic and paleomagnetic surveys suggest the West Potrillo Mountains record a much longer eruption history that the remainder of the field. There is a series of reversed polarity flows present. Due to the older nature of this western alignment, current geochronology studies emphasize high precision $^{40}Ar/^{39}Ar$ dating methods.

Apatite Fission-Track Thermochronology of Southern Rocky Mountain-Rio Grande Rift- Western High Plains Provinces

New Mexico Institute of Mining and Technology

Shari A. Kelley

New Mexico Bureau of Mines and Mineral Resources

Charles E. Chapin

Apatite fission-track (AFT) thermochronology has been a useful tool in evaluating the tectonic and topographic evolution of the Southern Rocky Mountains, Rio Grande Rift, and western High Plains provinces. AFT data from the Front Range and Wet Mountains document that little differential uplift has occurred in the late Cenozoic between the Southern Rocky Mountains and the High Plains in Colorado, except the southern end of the Wet Mountains. AFT results support a model whereby the central portion of the Front Range was uplifted vertically and the eastern and western flanks of the range were thrust laterally during early Laramide compression. Only about 1 km of denudation occurred in the central Front Range during early Laramide deformation, while approximately 2.5 km of material was removed during late Laramide deformation and the development of the Rocky Mountain erosion surface.

Fission-track Data Indicates the Wichita Mountains of Oklahoma Were Recently Uplifted (Presented at Fall 1995 Meeting of the Geological Society of America)

Department of Geoscience
University of Texas at Dallas

Jennifer E. Winkler
Robert J. Stern

Department of Geological Science
Southern Methodist University at Dallas

Shari A. Kelley

The Wichita Mountains are associated with a series of basement-involved uplifts and associated basins within the foreland of the Ouachita orogen. The exhumation timing of the Wichita Mountains is a matter of debate. Originally, erosional surfaces found on the granitic rocks of the Wichita Mountains were thought to be Permian age wave cut benches. New interpretations suggest that the grante platforms are Pliocene pediment surfaces.

It was found by AFT analysis that the Wichatia Mountains were uplifted in the late Paleozoic, during the Ouachita Orogeny, then weathered and eroded. During Mesozoic time, these rocks were probably covered with sediments. As a result of burial to 1-2km depth, the temperature of the rocks was elevated to 60°-90°C into a partial annealing zone and the fission track lengths were shortened. Beginning in the Late Cretaceous to Early Eocene time, the Mesozoic rocks were uplifted and eroded. Uplift continues through Present time with brief episodic periods of tectonic stability. Modeling of thermal histories reemphasizes uplift beginning in the Late Cretaceous to Early Eocene time and continuing to Present time.

Evidence for Post-Laramide Displacement on the Picuris-Pecos Fault

Department of Geosciences
New Mexico Tech

Shari A. Kelley

The middle to late Cenozoic uplift history of the Santa Fe Range portion of the southern Sangre de Cristo Mountains is anomalous with respect to other mountain ranges bordering the northern Rio Grande rift. Recent models that describe rift flank development call upon significant isostatic uplift of mountain blocks adjacent to the side of asymmetric half-grabens bounded by master faults with large displacement. Mountain ranges on the hinged side of half-grabens tend to have lower relief. The development of the Sandia Mountains on the east side of the east-tilted northern Albuquerque Basin is a good example of the relationship between half-graben structure and the evolution of topographic relief. It has been determined that the Santa Fe Range does not follow the expected trend.

Apatite fission-track (AFT) dating gives ages of 50 to 70 Ma determined from an age-elevation traverse on Santa Fe Baldy are among the oldest AFT ages found in mountain ranges bordering the northern Rio Grande rift. It is suggested that the modern topographic relief in this area developed in the late Cenozoic.

In this investigation, AFT thermochronology is used to determine relative offset across the fault near the south end of the Santa Fe Range. AFT thermochronology has proven to be very useful in deciphering the cooling histories of mountain ranges in the Southern Rocky Mountains. Based on this preliminary study, the Picuris-Pecos fault has accommodated some of the middle to late Cenozoic uplift and westward tilting of the Santa Fe Range. The relative displacement across the fault is only about 400 m in the vicinity of Glorieta Baldy, but the amount of offset may vary along the strike of the fault. Other major faults within the Santa Fe Range, such as the Garcia Ranch-Borrego fault, may also be important in the evolution of late Cenozoic relief in this range.

2.4 Commercial Activity and External Research

The NSC provides services to a variety of users who have their own funding. A majority of the commercial activities are related to isotope production of radioactive tracers for support of the Texas petroleum and chemical industries. Another commercial activity uses the converted Thermal Column Area for the production of micropore filters that are now being used in ultra-pure water systems in the semiconductor industry. A significant amount of research at the reactor is funded by outside research grants.

The NSC has many years of experience in the production of radioisotopes and has developed several customer-specific methods for radioactive sample handling. The production of radioisotopes generally involves handling high-activity radioactive materials during unloading, therefore the staff take all possible precautions to minimize their exposures during the transfer of materials to the shipping shields.

Company or Institution	User
Advanced Isotope Technologies	Dr. Floyd McDaniel
Arco Exploration and Production Technology	Dr. Steven Bergman
Cardinal Survey Company	Mr. George Newman
Donelick Analytical	Dr. Raymond Donelick
Frac-Mate Ltd.	Mr. Cam Carlson
ICI Tracerco	Mr. Dave Ferguson
IsoTag Specialist Incorp.	Mr. Fred Calaway
Los Alamos National Lab	Mr. Archie Velarde
Lockheed Engineering	Mr. David Stanley
M.D. Anderson Cancer Center	Mr. Tim Ochran
Methodist Hospital, Houston	Dr. William Cole
New Mexico Tech	Dr. Matthew Heizler
Poretics Corporation	Mr. Greg Stasny
Protechnics/Spectratek	Mr. Mike Brewer
Texas Instruments Corp.	Dr. Joe Keenan
TN Technologies	Mr. Mark McCray
Tracer Services Ltd.	Mr. Norman Seely
Tru-Tec	Mr. Chuck Winfield
Sam Houston State University	Dr. David Donnelly
University of Houston	Dr. Peter Copeland
Zimmerman BCS	Mr. Helmut Zimmerman

3.0 Facility and Procedure Changes

In accordance with the requirements of 10 CFR 50.59, changes to the facility and procedures were reviewed and documented. During this reporting period there were no changes that required additional safety analysis or changes to the Technical Specifications. The following changes and experiments were implemented as not representing an unreviewed safety question and not increasing the probability of an accident previously analyzed in the Safety Analysis Report (SAR). No procedures contained in the SAR were changed.

3.1 Facility Modifications

Replacement of Control Rod Drive System (MA-46)

A lack of replacement parts for the current rod drive system necessitated an upgraded system. The new system will use DC stepping motors for increased reliability and accuracy. The system will be controlled using modules with lower heat generation and electronic noise. The control rod run-out accident was analyzed and the new system worst-case reactivity insertion rates will always remain well below the limiting rates.

Transient Rod Drive Motor Upgrade (MA-47)

A bent motor shaft on the existing motor has caused excessive binding during Transient Rod withdrawals. A new design using a new motor and coupling system will be installed. Rod position indication will be provided by a digital encoder signal to the control module.

Installation of Upgraded Logarithmic and Pulse Power Channels (MA-48)

The channels were replaced with modular drawers built by Gamma-metrics. The channels contain no microprocessor circuits and were extensively tested by the vendor at other research reactor facilities. The installation included movement of the linear and logarithmic chart recorders for improved operator monitoring of reactor parameters.

Replacement of Safety Channel Drawer Multimeter (MA-49)

A lack of parts for a failed analog meter required a substitution with a more reliable and precise digital multimeter that was installed adjacent to the existing drawer.

3.2 Experiment Authorizations

There were no new experiments approved by the Reactor Safety Board during this reporting period. All experiments performed were modifications of existing approved experiments and were reviewed in NSC staff meetings.

4.0 Reactor Maintenance and Surveillance

4.1 Scheduled Maintenance

Reactor scheduled maintenance was performed twice during the reporting period. The primary shutdown maintence period was changed from the first week in January to the first week in September. This coincides with the University fiscal year and, in general, has been a period of low reactor activity. The result was an overlap of semi-annual and annual required maintenance.

Calibrations were performed on the Fuel Element Temperature Channel, Area Radiation Monitors and the Linear, Log, and Safety Power Channels as required by the Technical Specifications.

Control rod worth, and scram time measurements were performed in January 1995 and September 1995. The worths were found to be $16.45 and $ 16.63 respectively. The difference in the worths were attributed to an increased Transient Rod worth. This is likely resulting from a change in total rod travel after an adjustment of the TR drive motor. Rod Scram times are well within the limit of 1.2 seconds.

Control rod visual inspections were performed and all rods appeared normal. A calorimetric calibration was performed following each maintenance period. Fuel inspections were performed as required by the Technical Specification with no abnormalities noted.

The cold critical reactivity worth for each reactor experiment was measured prior to full experiment approval. The most reactive fixed experiment has been found to be the Fast Flux Irradiation Device (-$1.28) due to the high boron loading.

4.2 Emergency Planning and Review

The Facility Security Plan and Emergency Plan were review by the NSC staff on 2/24/95 and by the RSB on 3/2/95. A site emergency drill involving the College Station Fire Department and the local hospitals was conducted was 8/31/95. All required external audits were completed in the reporting period.

4.3 Unscheduled Shutdowns

A total of eight unscheduled shutdowns occured during 1994. Seven shutdowns were a result of a loss of facility power and another was caused by a malfunction in the new Log Power Monitor during testing.

4.4 Reportable Occurences

There were no reportable occurrences.

5.0 HEALTH PHYSICS SURVEILLANCES

A dedicated Health Physics group is maintained at the NSC reactor facility as an integral part of the line organization. Additional support is provided, upon request, by the TAMU Office of Radiological Safety.

5.1 Radioactive Shipments

The Health Physics's monitoring and technical support that was provided in 1995, assured minimal, hazard exposure as well as state and federal regulation compliance during sample handling, shipment of radioactive material, and normal reactor operation. During 1995, there were 400 radioactive material shipments of which 72 were sent to various departments on the campus of Texas A&M.

5.2 Personnel Monitoring

Personnel monitoring was provided to 37 NSC employees. All radiation exposure to personnel was below the limit set forth in 10CFR20. One individual did receive greater than 10% of the annual maximum exposure, his exposure was 650 mrem. A total of 3.43 man-rem was recorded for 1995.

During 1995, 2,808 visitors toured the Nuclear Science Center. Minimal exposures were measured with pocket ion chambers worn by these visitors and their tour guides.

NSC employees wore TLDs and film badges that were provided by Landauer, an accredited supplier. Landauer also provided the analysis reports of the exposure received.

5.3 Facility Monitoring

Surveys of the Nuclear Science Center facilities were performed to assess radiological hazards to NSC workers. Radiation levels and sources of radioactive contamination were frequently monitored. Approximately 350 smear samples were collected and evaluated each month.

5.4 Particulate Effluent Monitoring

Radioactive particulates were monitored in the central exhaust stack and summarized on a monthly basis. The isotopes identified by gamma analysis were Sc-46 and Ir-192. The NSC monitoring system currently does not differentiate natural radioactive materials from man-made materials. Although very small amounts of Sc and Ir were released, all activities were conservatively considered to be caused by those identified isotopes produced in the NSCR. The annual average release rate was 4.02×10^{-11} mCi/cc. Total activity released for 1995 was 4.74×10^{-3} Ci.

The following table summarizes annual particulate effluent releases during 1995.

1995 Radioactive Particulate Release Summary

Qtr	Month	Average Conc.[1] (uCi/cc)	Diluted Conc.[2] (uCi/cc)	Exhaust Volume[3] (cc)	Total Release[4] (Ci)
I	January	8.40E-11	4.20E-13	1.01E+13	0.000849804
	February	4.79E-11	2.39E-13	9.14E+12	0.000437421
	March	1.74E-11	8.72E-14	1.01E+13	0.000176435
	Average:	4.98E-11	2.49E-13	9.79E+12	0.000487887
			total:	2.90E+13	0.001101743
II	April	2.80E-11	1.40E-13	9.79E+12	0.00027413
	May	3.58E-11	1.79E-13	1.01E+13	0.000362178
	June	1.01E-10	5.05E-13	9.79E+12	0.000988827
	Average:	5.49E-11	2.75E-13	9.90E+12	0.000541712
			total:	2.98E+13	0.001892718
III	July	1.85E-12	9.25E-15	1.01E+13	1.87159E-05
	August	< MDA	< MDA	1.01E+13	< MDA
	September	7.42E-11	3.71E-13	9.79E+12	0.000726445
	Average:	2.535E-11	1.27E-13	1.00E+13	0.000248387
			total:	2.99E+13	0.000974832
IV	October	4.59E-11	2.30E-13	1.01E+13	0.000464357
	November	1.97E-11	9.85E-14	9.79E+12	0.00019287
	December	2.65E-11	1.325E-13	1.01E+13	0.000268093
	Average:	3.07E-11	1.54E-13	1.00E+13	0.00030844
			total:	2.99E+13	0.000769403
Annual Average:		4.02E-11	2.01E-13	9.93E+12	0.000396606
			total released:	1.19E+14	0.004738696

Notes:

1. Average Release Concentration data from NSC form 805, Channel 1 "Activity Released"
2. Diluted Concentration equal to Average Release Concentration multilied by 0.005 (Technical Specification 3.5.2, dilution value for release concentration at exclusion boundary)
3. Exhaust Volume equal to: (# days/month)*(24hrs/day)*(60min/hr)*(8000cfm)/ 3.53E-5cfm/cc)
4. Total Release equal to:(Average Release Concentration)*(Exhaust volume)*(1Ci/ 1E6 uCi)

5.5 Gaseous Effluents Monitoring

Argon-41 is the major gaseous effluent produced and released at the Nuclear Science Center. This effluent is monitored in the central exhaust stack. Total Argon-41 released during 1995 was 26.848 Ci with an annual release rate of 1.68×10^{-7} mCi/cc (no dilution factors applied). Release rates are also determined using the dilution factors for the release rate at the restricted area boundary. The total amount released is determined from the undiluted release rate. These data are summarized below:

1995 Radioactive Gaseous Release Summary

Qtr	Month	Average Conc.[1] uCi/cc)	Diluted Conc.[2] (uCi/cc)	Exhaust Volume[3] (cc)	Total Release[4] (Ci)
I	January	8.70E-08	4.35E-10	1.01E+13	0.880
	February	4.17E-08	2.09E-10	9.14E+12	0.381
	March	2.53E-07	1.27E-09	1.01E+13	2.560
	Average:	1.27E-07	6.36E-10	9.79E+12	1.274
			total:	2.93E+13	5.095
II	April	1.69E-07	8.45E-10	9.79E+12	1.655
	May	6.50E-08	3.25E-10	1.01E+13	0.658
	June	1.55E-07	7.75E-10	9.79E+12	1.518
	Average:	1.30E-07	6.48E-10	9.90E+12	1.277
			total:	2.97E+13	5.108
III	July	1.08E-07	5.40E-10	1.01E+13	1.093
	August	4.31E-07	2.15E-09	1.01E+13	4.360
	September	1.24E-07	6.20E-10	9.79E+12	1.214
	Average:	2.21E-07	1.11E-09	1.00E+13	2.222
			total:	2.99E+13	8.889
IV	October	1.76E-07	8.8E-10	1.01E+13	1.781
	November	2.20E-07	1.1E-09	9.79E+12	2.154
	December	1.86E-07	9.3E-10	1.01E+13	1.882
	Average:	1.94E-07	9.7E-10	1.00E+13	1.939
			total:	2.99E+13	7.756
	Annual Average:	1.68E-07	8.40E-10	9.93E+12	1.678
			total released:	1.19E+14	26.848

Notes:

1. Average Release Concenration data from NSC form 805, ``Channel 3 Activity Released"
2. Diluted Concentration equal to Average Release Concentration multiliedby 0.005 (Technical Specification 3.5.2, dilution value for release concentration at exclusion boundary)

3. Exhaust Volume equal to: (# days/month)*(24hrs/day)* (60min/hr)*(8000cfm)/ 3.53E-5cfm/cc)
4. Total Release equal to:(Average Release Concentration)*(Ehaust volume)* (1Ci/ 1E6 uCi)

5.6 Liquid Effluents Monitoring

Radioactive liquid effluents are maintained in collection tanks prior to release from the confines of the Nuclear Science Center. Sample activity concentrations and isotope identifications were determined prior to each release. There were 39 releases in 1995, totaling 1.01E +09 liters, excluding dilution from the Nuclear Science Center. The total radioactivity released was 1.19E -02 Ci with an average concentration of 9.27E -11 Ci/cc. Summaries of the release data are presented in the table below. Radioactivity concentrations for each isotope found were below the limits specified in 10CFR20, Appendix B.

Month	Number of Releases	Amount Released (cc)	Activity Released (Ci)	Concentration Released (Ci/cc)
January	0	0.0	0.0	0.0
February	0	0.0	0.0	0.0
March	7	2.39E+08	6.25E-04	2.61E-12
Quat. Total :	7	2.39E+08	6.25E-04	2.61E-12
April	3	6.62E+07	1.03E-04	1.55E-12
May	0	0.0	0.0	0.0
June	8	2.22E+08	7.24E-04	3.26E-12
Quat. Totals :	11	2.88E+08	8.26E-04	4.81E-12
July	4	1.63E+07	5.36E-05	3.29E-12
August	5	1.48E+08	4.48E-04	3.03E-12
September	3	8.49E+07	3.15E-04	3.71E-12
Quat. Totals :	12	2.49E+08	8.16E-04	1.00E-11
October	5	1.06E+08	4.71E-04	4.44E-12
November	0	0.0	0.0	0.0
December	4	1.29E+08	9.14E-03	7.09E-11
Quat. Totals :	9	2.35E+08	9.61E-03	7.53E-11
Annual Totals:	39	1.01E+09	1.19E-02	9.27E-11

	January	February	March	April	May	June	Total
# of releases	0	0	7	3	0	8	18
Sc-46	0	0	5.95E-04	4.05E-04	0	2.07E-03	0.000307
Cr-51	0	0	4.71E-04	0	0	7.93E-04	0.000126
Mn-54	0	0	2.85E-03	2.44E-04	0	2.83E-03	0.000592
Co-58	0	0	1.82E-04	8.00E-05	0	1.66E-04	0.000042
Co-60	0	0	1.73E-03	1.32E-04	0	1.68E-04	0.000203
Zn-65	0	0	1.56E-04	1.68E-05	0	2.19E-04	0.000039
Sb-124	0	0	2.18E-04	1.48E-04	0	6.24E-04	0.000099
Ir-192	0	0	4.31E-05	0	0	3.69E-04	0.000041
Volume (cc)	0	0	2.39E+09	6.62E+08	0	2.22E+09	52720000
Activity (Ci)	0	0	6.25E-03	1.03E-03	0	7.24E-03	0.001452
Conc.(Ci/cc)	0	0	2.61506E-	1.55589E-	0	3.26126E-	7.43222E-

	July	August	September	October	November	December	Total
# of releases	1	5	3	5	0	4	18
Sc-46	4.65E-04	8.27E-04	2.60E-03	2.77E-03	0	4.14E-04	0.000707
Cr-51	0	5.51E-04	0	4.44E-04	0	7.93E-02	0.008029
Mn-54	2.47E-05	1.57E-03	3.83E-04	8.22E-04	0	3.06E-03	0.000585
Co-58	0	1.36E-04	0	7.05E-05	0	2.67E-04	0.000047
Co-60	2.49E-05	1.06E-03	1.53E-04	5.61E-04	0	1.62E-03	0.000335
Zn-65	0	1.89E-04	0	3.69E-05	0	1.82E-03	0.000204
Sb-124	2.10E-05	1.45E-04	1.39E-05	6.71E-05	0	1.18E-03	0.000142
Ir-192	0	0	0	0	0	0	0
Volume (cc)	1.63E+08	1.48E+09	8.49E+08	1.06E+09	0	1.29E+09	48420000
Activity (Ci)	5.36E-04	4.48E-03	3.15E-03	4.71E-03	0	9.14E-02	0.010427
Conc.(Ci/cc)	3.28834E-	3.02703E-	3.71025E-	4.44340E-	0	7.08527E-	8.53217E-

6.0 ENVIRONMENTAL MONITORING

In conjunction with representatives from the State of Texas Department of Health, a quarterly environmental survey program is conducted to insure compliance with federal regulations. This program consists of TLD monitors located at various locations on the NSC site and a background monitor located at the Brazos River, 5.25 miles west of the site. The collection, analysis, and evaluation of soil, water, and milk samples are also included in the program.

6.1 Environmental Survey Samples

The environmental survey samples were collected in accordance with the schedules of the cooperative surveillance program between the Texas State Department of Health and the Texas A&M University. These samples were analyzed using an intrinsic germanium detection system for isotopic identification at the NSC. A second set of samples are also analyzed by a Texas Department of Health lab for comparison to NSC results. Data collected from this analysis reflect the continued positive use of retention facilities and sample analysis for laboratory effluents prior to their release.

Summaries of the environmental survey program for 1995 are presented in the three tables below. Isotopic activity is listed as reported to, or determined by, the NSC (when data from the state was unavailable.)

Envioronmental Water Samples

1995 Quarter	Sample Location	Concentration (mCi/ml)
1st	Brazos River	none found
1st	NSC Creek	none found
2nd	Brazos River	none found
2nd	NSC Creek	none found
3rd	Brazos River	none found
3rd	NSC Creek	none found
4th	Brazos River	none found
4th	NSC Creek	none found

Milk Samples

1992 Quarter	Sample Location	Concentration (mCi/ml)
1st	TAMU Dairy	none found
2nd	TAMU Dairy	none found
3rd	TAMU Dairy	none found
4th	TAMU Dairy	none found

Soil Samples

1992 Quarter	Sample Location	Concentration (mCi/ml)
1st	NSC Soil	1.07 E-07

2nd	NSC Soil	1.005 E-06
3rd	NSC Soil	none found
4th	NSC Soil	none found

6.2 Site Boundary Monitoring

The environmental survey program measures the integrated radiation exposures at the restricted area boundaries. These measurements are made for periods of approximately 90 days, using TLDs. The dosimeters are provided and processed by Texas Department of Health, Bureau of Radiation Control, Division of Environmental Programs. The state background monitor (survey point 14) is located at a point 52.25 miles west-southwest of the facility and is generally at right angles to the prevailing southeasterly winds.

Site #	Location	Average exposure Rate (mR/91day)	Annual Exposure 1995 (mR)
2	300 ft. W of reactor building, near fence corner	21.8	70.0
3	250 ft W-SW of reactor building, on SW chain link fence	28.2	123.0
4	200 ft NW of reactor building, on chain link fence, near butane tank.	24.4	83.0
5	225 ft NE of reactor building, on fence N of driveway	11.5	39.0
6	300 ft N-NE reactor building, near fence corner	25.6	80.0
10	190 ft SE of reactor building, near fence corner	7.7	32.0
11	300 ft NE of reactor building, near fence corner	3.8	22.0
18	375 ft NE of reactor building	12.8	49.0
19	320 ft NE of reactor building	10.3	45.0
14	5.25 miles W-SW of reactor building, at FM 60 bridge over Brazos River	0.0	0.0

The highest exposure point was determined to be at site #3 (123.0 mR/yr) which is at the W-SW corner of the reactor building near a storage building. The material stored in this building should be moved in 1996 and the exposure should be reduced at that time. The closest off-site point of extended occupancy is located just beyond the site boundary fence directly behind the site #10 monitoring location; the occupants of this area continue to receive only background exposure.

6.3 RADIOACTIVE WASTE

Solid Waste

During the 1995 year, there was no solid waste released from the NSC for disposal offsite.

7.0 Reactor Safety Board

The Reactor Safety Board is responsible to the licensee for providing an independent review and audit of the the safety aspects of the NSCR. The RSB meets at least once a year to review audit reports, security and emergency plans, new experiments and modifications to the facility.

Membership (1994-1995)

Chairman:

Dr. Gary Hogg, Associate Director, TEES

Members:

Dr. Marvin Adams, Professor,
Nuclear Engineering Department

Dr. Ted Parish, Professor
Nuclear Engineering Department

Dr. Robert Kenefick, Professor
Physics Department

Dr. Roger Koppa, Associate Professor,
Industrial Engineering Department

Dr. Earl Morris, Professor
Veterinary Medicine-Large Animal Clinic

Dr. William Dennis James, Research Chemist
Chemistry Department

Ex-Officio Members:

Dr. Warren Reece, Director,
Nuclear Science Center

Mr. Sean O'Kelly, Assistant Director,
Nuclear Science Center

Mr. Chris Meyer, Interim Director,
Radiological Safety Office

Dr. John Poston, Professor and Head,
Nuclear Engineering Department

TEES:

Dr. Raymond Flumerfelt, Licensee