Final Report for University Reactor Sharing Program
Texas A&M University Nuclear Science Center
DOE Grant No. DE-FG07-01ID14156

University:	Texas A&M University	Location:	College Station, TX
Project Director:	W. D. Reece	Telephone:	979/845-7551

Introduction

The University Reactor Sharing Program provides funds for reactor experimentation to institutions that 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 10/01-09/02-contract period, ten research institutions utilized the NSC with the support of the Reactor Sharing Program. The funding also provided reactor tours and “hands-on” projects to many secondary schools.

Research projects supported by the program include items such as dating geological material and producing high current super conducting magnets. The funding continues to give small colleges and universities the valuable opportunity to use the NSC for teaching courses in nuclear processes; specifically neutron activation analysis and gamma spectroscopy. The Reactor Sharing Program has 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. Institution final reports and publications resulting from the use of these funds are on file at the Nuclear Science Center.

Summary of Projects Supported

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

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

18 Graduate Students participated and 2 Undergraduate Students

$^{40}Ar/^{39}Ar$ Geochronology at Nevada Isotope Geochronology Laboratory

University of Nevada	Dr.Terry Spell
Department of Geoscience	Ms. Kathleen Zanetti

11 Graduate Student and 1 Undergraduate Student participated
5 Presentations and 3 dissertations and 16 theses were the result of the work performed

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 occuring ^{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 occuring ^{39}Ar. This led to the dating technique refered 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.

Fission Track Thermochronology Methodology at University of Texas Thermochonology Laboratory

University of Texas @ Austin Dr. Mark Cloos

1 Graduate Students
8 Publications

Fission Track Thermochronology Methodology at New Mexico Institute of Mining and Technology

Department of Earth and Environmental Sciences Dr. Shari A. Kelley

2 Graduate Students

Fission Track Thermochronology Methodology at University of Minnesota

Department of Geology and Geophysics — Dr. Annia Fayon, Dr. Donna Whitney

3 Graduate Students
3 Theses in progress

A Description of the Fission Track Thermochronology Methodology

Fission track analysis is a geochronological method that utilizes the spontaneous fission of ^{238}U in uranium-rich minerals such as apatite, zircon and sphene. The spontaneous fission 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 a fission track. The preferential etching of these tens of angstroms-wide defect trails with respect to bulk crystal etching enlarges the tracks which allows their lengths and density to be measured under a high powered petrographic microscope. The procedure of fission track dating requires thermal neutron irradiation of mineral grain mounts and standard glasses in order to induce fission of ^{235}U atoms.

Fission tracks from continuously through time. The final distribution of etchable fission track lengths in apatite contains a record of temperature variation with time below 125 degree Celsius. The principal factors controlling track length distribution is the rate at which the rocks cool as they passed through the zone of partial annealing and time elapsed since cooling below 50 degrees Celsius. In volcanic and very rapidly exhumed samples, mean etchable track lengths will be relatively long because early-formed tracks underwent little annealing. In slow-cooling plutonic rocks, the mean etchable track length distributions will show a greater spread and be negatively skewed as more of the early-formed tracks are partially annealed because of the longer time spent passing through the partial annealing zone. Additionally, the variation of mean etchable fission track length derived from sedimentary rocks may reflect the interplay between the pre-basin thermal history experienced by the detrital apatite grains, the post-depositional thermal history, and the range of composition in the apatite composition and it's consequent effect on annealing rates.

In summary, apatite fission-track analysis involves both the measurement of fission track ages and track length distributions. The fission-track age is a minimum estimate of the time since the most recent cooling event below 125 degrees Celsius. The track length distribution provides additional information about the cooling history of a sample such as cooling rates, post-cooling geothermal gradients or post-cooling thermal pulses.

Neutron Activation Analysis Laboratory for Baylor University

Department of Physics — Dr. Ken-His Wang

2 Graduate Students

A Description of Neutron Activation Analysis Laboratory at the NSC

Neutron Activation Analysis is an effective technique for measuring certain elements in various applications. This technique requires a neutron exposure and a spectroscopy counting system. Baylor Physics students activate various samples in the NSC Reactor and use the NSC counting system to identify the radioactive isotopes. They then calculate the concentration and/or actual mass of the element. This project is for educational purposes.

Pining Centers in High Temperature Superconductors (HTS) at Beam Particle Dynamics Laboratory

University of Houston — Dr. Roy Weinstein, Dr. Ravi-Sawh

1 Graduate Student and 3 Undergraduate Students

The University of Houston has developed a method to produce pinning centers in High Temperature Superconductors containing uranium, using the linear damage caused by 235U + n fission. They are applying this method to leading superconductor systems. To date, each application has resulted in a world record current density in the superconductors used. The method has also resulted in world records for levitation, pressure and trapped magnetic flux.

Texas A&M University
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Location: College Station, Texas
Telephone Number: 979-845-7551
Reactor Type: 1 MW TRIGA

New Mexico Institute of Mining and Technology	Dr. Matthew Heizler		Ar-40/Ar-39 Geochronology	6,118
New Mexico Institute of Mining and Technology	Dr. Shari A. Kelly		Fission Track Geochronology	1,560
Baylor University	Dr. Ken-His Wang		Neutron Activation Analysis Lab	630
University of Nevada	Dr. Terry Spell		Neutron Activation Analysis of Geologic Materials	2,640
University of Texas at Austin	Dr. Mark Cloos		Fission Track Geochronology	311
University of Houston	Dr. Roy Weinstein		Pinning Centers of High Temperature Superconductors doped with U-235	3,356
University of Southwest Louisiana	Dr. John Meriweather		Neutron Activation Analysis	622
University of Minnesota	Dr. Annia Fayon		Neutron Activation Analysis of Rock and Mineral Samples	1,050
Various Secondary Schools and Colleges			Reactor Tours and Demonstrations. Lab Training. University Outreach Programs.	7,713
Total University Reactor Sharing Funds Expended				24,000