ANNUAL OPERATING REPORT FOR LICENSE R-74
TO THE UNITED STATES NUCLEAR REGULATORY COMMISSION

FOR

FISCAL YEAR 1978-1979

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ANNUAL REPORT

A. SUMMARY OF OPERATIONS

1. Instructional Use - UW-Madison Formal Classes

Three Nuclear Engineering Department classes make use of the reactor. The 45 Students enrolled in NE 231 participated in a two-hour experiment designed to acquaint students with behavior characteristics of a nuclear reactor. This experiment was repeated four times. NE 427 had a total enrollment of 29 students as it was offered in both Fall and Spring semesters. Several NE 427 experiments use materials that are activated in the reactor while one experiment entitled, "Radiation Survey" requires that students make measurements of radiation levels in and around the reactor laboratory. NE 428 makes extensive use of the reactor as it is taught during both semesters and summer school. 32 students completed NE 428 during the fiscal year. NE 428 incorporates three experiments ("Critical Experiment", "Control Element Calibration", and "Pulsing") which require exclusive use of the reactor. These experiments were repeated five times for NE 428 classes. Two additional 428 experiments ("Fast Neutron Flux Measurements by Threshold Foil Techniques" and "Resonance Absorption") were repeated ten times each during the year. These experiments use the reactor for activation of foils for the measurements.

At least one session in the reactor laboratory was included in the courses of the Departments of General Engineering, Metallurgical and Mineral Engineering, Physics, Chemistry, Journalism, and Mechanical Engineering. In addition, laboratory personnel presented formal lectures for Introductory Chemistry and Physics classes on the general subject of nuclear power and with specific applications to the Three-Mile Island accident.

2. Reactor Sharing Program

The work by the University of Minnesota-Duluth group (3 staff members and 2 graduate students) on identification of copper and tin artifacts and ores by multielement Instrumental Neutron Activation Analysis continued. Personnel from the University of Wisconsin-Stevens Point participated in the Reactor Sharing Program two ways. First, during the summer, they brought a group of 25 high school students enrolled in a summer program for a reactor operation demonstration. In addition, during the semester, a group of students (5 students, 1 staff member)

came to our laboratory and participated in the reactor operation demonstration previously developed for our NE 231 classes. 12 students from the University of Wisconsin-Milwaukee spent three hours in a laboratory session on Instrumental Neutron Activation Analysis as a part of their course number CE 891-3. A group of 8 Advanced Physics students from Carroll College attended a 3-hour Neutron Activation Analysis laboratory at our facility. 8 students from Beloit College attended a reactor operation demonstration. Finally, 12 students from the University of Wisconsin-Platteville attended a 3-hour Neutron Activation Analysis laboratory session.

3. Utility Operating Personnel Training

Two-week research reactor familiarization courses were held for two groups of 6 trainees from Cleveland Electric Illuminating Company. The 12 people trained will be part of the operating staff of the two-unit BWR Perry Generating Plant. The program occurs early in the academic training of individuals who are candidates for operator and senior operator licensing and who do not have considerable previous nuclear training. Most of the students in the two groups are persons with operating experience in conventional power plants. The program acquaints the students with reactor kinetic behavior, instrumentation, operating practice, and general techniques involved in dealing with radioactive materials. The session at Wisconsin is essentially the laboratory portion of a training program conducted for Cleveland Electric Illuminating by the General Physics Corporation.

4. Sample Irradiation and Neutron Activation Analysis Services

During the year, 4,803 samples were irradiated. 1217 of these sample irradiations were for 15 minutes or less, while the remainder accumulated 9,121.95 sample hours of irradiation. The irradiation work can be further classified into 862 irradiations and 447.7 irradiation space hours. 3,637 of the samples irradiated (76% of the total) were irradiated as part of the laboratory's Nuetron Activation Analysis Service in which samples are submitted by outside users for subsequent sample preparation and analysis by Instrumental Neutron Activation Analysis.

A listing of the individual groups for whom irradiations were performed follows. In this listing, information is supplied on the object of the research, personnel involved, and sponsoring organization where known.

The parenthetical expression (NAA) with an entry indicates the work was performed by the UWNR Neutron Activation Analysis Service.

Agricultural Engineering. (NAA) 8 samples, all less than 15 minutes. Professor J. Converse and 1 graduate student. Use of NAA in study to find methods of controlling odor in stored pig manure. Supported by Hatch Act.

Allis Chalmers. 95 samples, all less than 15 minutes. Activation of limestone for use in tests of grinding and mixing equipment.

Beloit (Wisconsin) Sewage Treatment District. (NAA) 36 samples, 72 sample hours. NAA of sewage sludges for determination of suitability for use on agricultural lands.

Biochemistry. (NAA) 30 samples, 14 less than 15 minutes, 25.6 sample hours. Professor M. A. Stahmann and 1 graduate student. Establish levels of metals influencing the fruiting of the mushroom Lentinus Edodes. Supported by WARF.

Biochemistry. 7 samples, 21 sample hours. Professors W. Orme-Johnson, N. Orme-Johnson, and T. Rademacher, M. D. Production of copper-64 for tracer use in atloradiography of cells. Supported by NIH.

Chemical Engineering. (NAA) 47 samples all less than 15 minute irradiations. Professor E. Lightfoot and 1 graduate student. Determination of amount of glass suspended in mineral oil by NAA of sodium content. Supported by NSF.

Chemistry. (NAA) 35 samples, 14 less than 15 minutes, 10.5 sample hours. Graduate student M. Louise Bleam studies the binding of small cations to nucleac acids using sodium. Supported by NSF.

Civil and Environmental Engineering (Water Chemistry). 182 samples, 82 less than 15 minutes, 282 sample hours. Professor A. Andren, 3 graduate students, and 1 post-doctoral fellow. Use of NAA for qualification of composition of sediments and particulates. Supported by EPA, Corps of Engineers, and Sea Grant Program.

Dairy Science Department. (NAA) 1707 samples, 5223 sample hours. Professors L. Satter and N. Jorgensen, 2 graduate students, 1 undergraduate student. Use of stable tracers in feed to determine digestability, rumen turnover, and rate of passage in dairy cattle. Supported by Hatch Act, state funds, and gift funds.

Geology and Geophysics. (NAA) 116 samples, 53 less than 15 minutes. 126 sample hours. Professor G. Medaris and 3 graduate students. Chemical

analysis of basalt to investigate geological history of the area and for mineral exploration purposes. Supported by Geology Department fund and Industrial Grant.

Globe Union. (NAA) 148 samples, 269 sample hours. NAA for quality control purposes, primarily investigation of radiomechanism in lead acid storage batteries by multielement analysis of rejected battery components.

Institute of Paper Chemistry (NAA) 3 samples, all less than 15 minutes; other 72 samples, 78 sample hours. NAA of fibers to determine their utilization as tracers and irradiation of fibers to be used in tracer experiments in laboratory scale process investigations.

McArdle Labs. 6 samples, 3 less than 15 minutes, 6 sample hours. Professor C. Kasper and 1 graduate student. NAA of trace quantities of metals in microsomal membrane. Funded by National Cancer Institute.

Mechanical Engineering. (NAA) 2 samples, both less than 15 minutes. Professor Seireg and 1 graduate student. Determination of amount of tungsten in tool bit fragment. Supported by Falk Corporation.

Mechanical Engineering. 13 samples, all less than 15 minute irradiations. Professor G. Borman and 1 graduate student. Production of Argon-41 tracer used to trace fluid motion in a deisel engine combustion chamber. Supported by DOE and Detroit Deisel-Allison Division of General Motors.

Mechanical Engineering. (NAA) 208 samples, 205 less than 15 minutes 1.5 sample hours. Professor K. Ragland, 2 graduate students. Use of NAA in air pollution emissions control for combustion of coal and refuse. Supported by DOE.

Medicine. (NAA) 51 samples, all less than 15 minute irradiations. Professor R. Barreras and 1 staff member. Determination of relative dissolution of aluminum and magnesium hydroxides from mixed gels reacting with acid and gastric juice (studying efficiency of mixed antacids for human use). Supported by a gift from the Louis Howe Corporation.

Medicine. (NAA) 6 samples, 2 less than 15 minutes, 5 sample hours. Professor M. Evenson, 3 additional staff members, 2 graduate students, and 1 post-doctoral fellow. NAA of trace elements in biological specimens. Funded by University Hospitals.

Medicine. 8 samples, all less than 15 minute irradiations. Professor S. Updike, 2 additional staff members, and 1 post-doctoral fellow. Production of tracers used to measure catalytic effects in membranes used in artificial kidneys. Supported by National Institutes of Health.

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Metallurgical and Mineral Engineering (Energy Storage Project). (NAA) 65 samples, 130 sample hours. Professor R. Boom, 4 graduate students, 1 post-doctoral fellow. Use of NAA to measure concentration of impurities in superconducting alloys. Supported by DOE, NSF.

Nuclear Engineering - NE 427. 110 samples, 84 less than 15 minutes, 26 sample hours. Irradiations of foils and Neutron Activation Analysis samples for a student laboratory course.

Nuclear Engineering - Reactor Laboratory. 188 samples, 69 less than 15 minutes, 256.3 sample hours. Irradiation of materials for Neutron Activation Analysis tests, production of materials for instrument calibrations, and irradiations incident to operator training programs.

Radiology-Nuclear Medicine Section. 30 samples, 30.56 sample hours. Professor S. Gatley and 2 graduate students. Production of fluorine-18 labeled radiopharmaceuticals. Supported by a Medical School Research Committee.

Radiology-Human Oncology. (NAA) 67 samples, 32 less than 15 minutes. 14.5 sample hours. Professor A. Wiley and 1 graduate student. Detection and monitoring of heavy elements in human tumors. Supported by private patient donations, University Radiotherapy Associates R & D Funds, and National Cancer Institute.

Raltech Incorporated. (NAA) 25 samples, 16 less than 15 minutes, 18 sample hours. NAA of biological material for contamination checks.

Reactor Sharing Program. (NAA) 116 samples, 8 less than 15 minutes, 162 sample hours. Most of these samples were irradiated for the research group at the University of Minnesota-Duluth. Professor Rapp, 2 additional staff members, 1 graduate student, and 1 undergraduate are concerned with this study in which Neutron Activation Analysis is used to investigate the composition of copper and tin containing archaeological samples for determination of origin and technology. This work is supported by the Department of Energy through the Reactor Sharing Program, and the remainder of Professor Rapp's work is supported by a private philanthropist.

Department of Soil Science. 273 samples, 24 less than 15 minutes, 946 sample hours. Professor P. Helmke, 2 graduate students, 1 post-doctoral fellow, and 1 undergraduate use the reactor as an irradiation device in their Neutron Activation Analysis of soils, rocks and biological samples. Research is supported by EPA, Wisconsin Power & Light, DOE, and the Cooperative State Research Service (Hatch).

University of Wisconsin-Milwaukee. (NAA) 82 samples, 82 sample hours. Professor E. Christensen and 1 graduate student. Use of Neutron Activation Analysis for analysis of sediment samples in studies of environmental protection. Supported by Advanced Opportunity Program.

U.S. Army Cold Regions Research Laboratory. (NAA) 543 samples, 306 less than 15 minute irradiations. 474 sample hours. Samples of soil, particulates, sediments, and foliage were investigated to determine impact on the environment of human activity in a polar area.

U.S. Department of Agriculture, Beltsville, Maryland. (NAA) 315 samples, 27 less than 15 minutes, 144 sample hours. Dr. Haaland is using stable tracers and Neutron Activation Analysis in a study of dairy cattle foodstuff utilization.

Wisconsin Department of Natural Resources - Rhinelander, Wisconsin. Analysis of municipal waste water sludges and soils.

5. Changes in Personnel, Facility, and Procedures

Daniel E. Range, a full-time reactor operator/technician joined the staff during the summer of 1978 and is presently licensed as a reactor operator. Three part-time employees, Herbert O. Nelson, Michael C. Jensen, and Jeffrey P. Ladewig have been licensed as operators during the year.

No reportable changes in the facility as described in the Safety Analysis Report were made during the year. The refueling of the core toward a full FLIP core was continued. The last run with a mixed core was completed on 14 June 1979. Six additional FLIP bundles were received on 13 June 1979 and loaded by Critical Experiment into the core on 15 June 1979. The full FLIP core was critical at 1432 on 15 June 1979, on 18 bundles, with an excess reactivity of ~.08% and a shutdown margin of 7.5%. The core was loaded to a 21-bundle all-FLIP configuration which was checked for compliance with Technical Specification requirements on shutdown margin and transient rod worth and then operated at power in order to bring the new FLIP fuel to self-protecting levels. This was necessary to assure that the license requirement limiting quantity of non-protected 70% enriched fuel was met. An additional shipment of FLIP to complete the 25-bundle FLIP core is expected the last week in July, and a full test program will then be completed. A complete description of the reloading and test program on the full FLIP core will be issued subsequent to completion of the test program.

Only minor changes to procedures were made to update procedures for current conditions. None of the changes are reportable under conditions of

the Technical Specifications. Some changes were made in the 130 series of procedures (dealing with sample irradiation) in order to conform to the changes in campus requirements for transfer of material to the University's broad license. The changes require a telephone check of the current status of the authorization of individuals to whom reactor-produced radioisotopes are to be transferred. In addition, the individual picking up a sample will receive a copy of the irradiation request, and another copy of the irradiation request with information on date and time of the irradiation will be submitted to University Health Services as a receipt document.

6. Results of Surveillance Tests

Surveillance tests and inspections during the year revealed no problems in safety-related systems. Surveillance of licensed operator performance under the Operator Proficiency Maintenance Program showed no deficiencies on written examinations. One operator was suspended from licensed duties because of an unsatisfactory evaluation in oral examination. He is required to undergo additional training and at least ten reactor startup cycles before he may be re-evaluated and restored to operating status.

B. OPERATING STATISTICS AND FUEL EXPOSURE

	Startups	Critical Hours	MW Hours	Pulses
FY 78-79	155	480.27	13.[illegible]	55
Total on TRIGA Cores	*2065	7111.87	211.66	1361

*Summary of exposures since converting to TRIGA fuel

Initial Standard TRIGA Core - 1st Critical - 14 November 1967			
Total on Standard Core	4807.5	144.96	941
9 Bundle FLIP - 16 Bundle Standard - 1st Critical - 4 March 1974			
Accumulated	1575.30	49.54	303
For Total of	(6382.80)	(194.52)	(1224)
15 Bundle FLIP - 10 Bundle Standard - 1st Critical - 3 January 1978			
Accumulated	696.95	15.99	137
For Total of	(7079.75)	(210.51)	(1361)

At last run, excess reactivity had decreased 0.13% from the initial value for this core of 3.90% ΔK/K.

21 Bundle ALL FLIP - 1st Critical - 15 June 1979			
Accumulated (to 30 June)	32.12	1.15	0
(Totals Above)			

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

There were no emergency shutdowns during the year. There were, however, 13 inadvertent automatic shutdowns (scrams). Nine of these were due to operator errors (12 utility operator trainees and 4 UW trainees during the year). Two were due to noise spikes from bumping control element drive or instrument channel components while loading samples, and two were due to instrument failure. A description of each of these events is indicated below in chronoligical order. On one additional occasion (24 October 1978), the operator on duty manually scrammed the reactor when the log-N period channel indication drifted downscale after reaching a level power. An investigation indicated the insulation resistance of the detector had decreased due to moisture buildup.

20 July 1978 -- Trainee turned picoammeter #1 range switch to a lower range while intending to switch to the highest range to fire a pulse.

15 September 1978 -- Trainee failed to uprange #1 picoammeter in a timely fashion while increasing power level.

15 September 1978 -- Control blade #1 drive bumped while loading a sample into irradiation position. The blade was knocked loose from its magnet.

10 and 12 January 1979 -- Trainee turned range switch on #1 picoammeter in wrong direction while increasing power level.

16 January 1979 -- Period trip due to trainee increasing power level too rapidly as log-N period channel came on scale.

18 January 1979 -- Trainee failed to uprange #1 picoammeter in time while increasing power level.

1 February 1979 -- Trainee failed to uprange #2 picoammeter in time while increasing power level (had changed #1 in time).

6 February 1979 -- Period trip from noise induced in channel when cables were bumped during sample loading. A second trip from the channel the same day while level at full power led to further investigation which showed a decrease in insulation resistance at the input to the instrument. This channel becomes sensitive to ground loop noise when the insulation resistance between electrodes or between the detector can and the waterproof housing decreases below about 10^{12} ohms. In this case, the insulation resistance of the log diode feedback element had decreased to about 10^{11} ohms, causing extreme noise sensitivity.

16 March 1979 -- Trip from both #1 and #2 picoammeters when operator failed to uprange in time during a rapid power increase.

5 April 1979 -- Trip from both picoammeters when setting up for pulse mode. Reactor was level at 300 watts with all permissives for pulse mode met. The operator was preparing to initiate a pulse. The pulsing switch was stuck in the actuated position because of mechanical binding. When the mode switch was turned into square wave position (intermediate between manual and pulse positions), the transient rod fired, initiating the pulse before the power level scram was defeated by the mode switch and pulsing interlocks. The switch housing was modified to prevent recurrence.

14 June 1979 -- Operator failed to downrange picoammeter #1 in time while increasing power level because his attention was on period channel at that time.

It should be noted that #1 picoammeter is involved in most of the operator error trips. This is not due to a deficiency in that instrument but to the fact that it is usually the first range switch to be switched by the operator.

D. MAINTENANCE OPERATIONS

Ordinary preventative maintenance was performed on equipment and resulted in acceptable performance except for two items of corrective maintenance on the log-N period channel detailed in section C above. There were no reportable maintenance operations.

E. CHANGES IN THE FACILITY OR PROCEDURES PURSUANT TO SECTION 50.59 OF 10 CFR PART 50

There were none.

F. RADIOACTIVE WASTE DISPOSAL

1. Solid Waste

There was no solid waste transferred out of the laboratory during the year.

2. Liquid Waste

Table 1 shows the record of liquid waste disposal during the fiscal year.

3. Particulate and Gaseous Radioactivity Released to the Atmosphere

Table 2 presents information on stack activity discharged during the year.

TABLE 1

LIQUID WASTE TO SANITARY SEWER

	11 SEPT 78	7 FEB 1979	5 JUNE 1979	TOTAL
TOTAL ACTIVITY DISCHARGED (Microcuries)	7.00	5.48	177.1	189.58
LIQUID QUANTITY (Gallons)	950.	800.	900.	2650.
Ra^{226} - MPC USED - 4×10^{-7}				
AMOUNT (µCi)	1.33	0	0.42	1.75
CONC (µCi/ml)	1.48×10^{-8}	0	4.7×10^{-9}	
Ru^{106} - MPC USED - 4×10^{-4}				
AMOUNT (µCi)	0	9.3×10^{-5}	0	9.3×10^{-5}
CONC (µCi/ml)	0	1.0×10^{-12}	0	
Co^{60} - MPC USED - 1×10^{-3}				
AMOUNT (µCi)	2.90	0.43	0.62	3.95
CONC (µCi/ml)	3.22×10^{-8}	4.73×10^{-9}	6.83×10^{-9}	
Zn^{65} - MPC USED - 3×10^{-3}				
AMOUNT (µCi)	2.09	1.42	0	3.51
CONC (µCi/ml)	2.32×10^{-8}	1.58×10^{-8}	0	
Mn^{54} - MPC USED - 4×10^{-3}				
AMOUNT (µCi)	0.37	0	0.14	0.51
CONC (µCi/ml)	4.11×10^{-9}	0	1.6×10^{-9}	
Co^{58} - MPC USED - 4×10^{-3}				
AMOUNT (µCi)	0.31	0	0.29	0.60
CONC (µCi/ml)	3.41×10^{-9}	0	3.2×10^{-9}	
K^{40} - MPC USED - 9×10^{-3}				
AMOUNT (µCi)	0	3.63	32.6	36.23
CONC (µCi/ml)	0	4.03×10^{-8}	3.6×10^{-7}	
Fe^{59} - MPC USED - 2×10^{-3}				
AMOUNT (µCi)	0	0	2.60	2.60
CONC (µCi/ml)	0	0	2.89×10^{-8}	
Fe^{55} - MPC USED - 2×10^{-2}				
AMOUNT (µCi)	0	0	140.5	140.5
CONC (µCi/ml)			1.56×10^{-6}	

Average concentration at point of release to sewer = 1.89×10^{-5} µCi/ml (includes natural radioactivity).

Average daily sewage flow for dilution = 2.37×10^{4} gallons.

Average concentration after dilution = 5.79×10^{-9} µCi/ml.

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TABLE 2

EFFLUENT FROM STACK

1. Particulate Activity

There was no discharge of particulate activity in excess of background levels.

2. Gaseous Activity - All Argon 41

Month	Activity Discharged (Curies)	Maximum Instantaneous Concentration $\mu Ci/ml \times 10^{-6}$	Average Stack Concentration $\mu Ci/ml \times 10^{-8}$	MPC Used $\mu Ci/ml$
July 78	0.1327	6.0	7.18	2.4×10^{-5}
August	0.0125	0.3	0.72	
September	0.0009	0.08	0.05	
October	0.1486	1.8	8.64	
November	0.1605	1.8	9.14	
December	0.1075	1.6	5.69	
January 79	0.0847	0.7	5.00	
February	0.0777	0.4	4.80	
March	0.0774	0.6	4.20	
April	0.1283	0.9	7.58	
May	0.0850	1.0	7.34	
June	0.1990	1.0	11.10	
TOTAL	1.215	6.0×10^{-6} Maximum	5.74×10^{-8} Yearly Average	

The MPC value above is that calculated in the SAR to be equivalent to 3×10^{-8} $\mu Ci/ml$ in the area surrounding the laboratory.

G. SUMMARY OF RADIATION EXPOSURES (1 July 1978 - 14 April 1979)

No significant exposure of personnel occurred due to operation of the reactor. For occupationally exposed personnel, the highest annual whole body dose was 145 mrems, while the highest extremity dose for the entire year was 440 mrems. For laboratory students, the highest annual whole body dose was 20 mrems. No facility visitor received any measurable dose.

Routine radiation and contamination surveys of the facility revealed no areas of high exposure rates or contamination.

H. RESULTS OF ENVIRONMENTAL SURVEYS

The environmental monitoring program at Wisconsin consists of thermoluminescent dosimeters (LiF TLD service from Eberline) located in the area surrounding the Reactor Laboratory.

The table below lists doses for persons continuously in the area for representative dosimeter readings.

Annual Dose Data-Environmental Monitors

Location	Average Dose Rate-mrem/week
Inside Wall of Reactor Laboratory	2.33
Inside Reactor Laboratory Stack	.87
Highest Dose Outside Reactor Laboratory (Reactor Lab roof entrance window: Monitor adjacent to stone surface)	2.27
Highest Dose in Occupied Nonrestricted area (third floor classroom facing away from Reactor Lab)	.61
Average Dose in Occupied Nonrestricted Area	.42
Average Dose in All Unrestricted Areas (29 Monitor Points)	.58

I. PUBLICATIONS AND PRESENTATIONS ON WORK BASED ON REACTOR USE

Dairy Science

N. A. Jorgensen. Two papers have been submitted for publication.

Engineering Experiment Station (Energy Storage Project)

V. Mizutani, K. T. Hartwig, R. W. Hopper, T. B. Massalski, "Low Temperature Specific Heats of Glassy $Pd_{1/x-y}Si_xCu_y$ Alloys", to be published in Journal of Applied Physics Letters in August 1978.

Mechanical Engineering

G. L. Borman, "Heterogeneous Engine In-Cylinder Mixing Measurements Using a Tracer Technique--Part 2", Department of Energy Report COO-4492-2, March, 1979.

A. J. Jessel, PhD Thesis, "Measurement of Fluid Motion in a Diesel Engine Cylinder by Use of a Tracer Gas Technique", May, 1979.

Medicine

M. C. Shults, S. J. Updike, P. M. Treichel, and I. W. Treichel, "High Efficiency Oxford Type Oxygenator Based on Hemodialysis and Transmembrane Catalysis of Hydrogen Peroxide", Trans. Amer. Soc. Artif. Int. Organs, 20, 286-292, 1974.

S. J. Updike, M. Y.-D. Chen, M. Shults, "Membrane Oxygenator Based on Transmembrane Catalysis of Hydrogen Peroxide. Trans. Am. Soc. Artif. Int. Organs, 23. 40;-497, 1977.

M.Y.-D Chen, M. C. Shults, and S. J. Updike, "Rotating Disk Membrane Oxygenator Based on Transmembrane Catalysis of Hydrogen Peroxide", Trans. Am. Soc. Artif. Organs, 24, 632-636, 1978.

Metallurigical and Mineral Engineering

Ali A. Nayeb Hashemi, PhD preliminary report.

R. C. Voigt and C. R. Loper, Jr., "A Technique for Measuring Tungsten Contamination During GTA Welding", to be presented at American Welding Society Conference, 1980.

Radiology - Human Oncology

W. S. Kan, A. L. Wiley, P. Moran, G. Wirtanen, T. A. Lang, and R. J. Cashwell, "Detection and Quantitation of High Z Elements in Human Sarcomata by Multi-Energy Computerized Tomographic Scanning and Neutron Activation Analysis", submitted to the American Journal of Roentgenology.

Soil Science

R. D. Koons and P. A. Helmke, "Neutron Activation Analysis of Standard Soils", Soil Science Society of America Journal 42, pp 237-240 (1978).

A. C. Stamm, M. S. Thesis, "Trace Elements in Whole Shales and Selected Shale Components", 1978.

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Soil Science (Continued)

R. D. Koons and P. A. Helmke, "Control of Trace Element Concentrations by Iron Oxides during Rock Weathering". Presented at Annual Meeting of American Society of Agronomy, Chicago, IL, December, 1978.

P. A. Helmke and R. D. Koons, "Behavior of Trace and Major Elements During Early Stages of Weathering of Diabase and Granite". Presented at 11th International Society of Soil Science, Edmonton, Alberta, Canada, July, 1978.

University-Industry Research Program

Reports in preparation.

Water Chemistry

A. Andren, "Mass Balance and Speciation of Arsenic in the Menominee River, Wisconsin". Project report to U.S.E.P.A., Athens. Georgia. In preparation.

A. Andren, J. Hendricks, "Menominee-Marinette Sediment Investigation". Project report to U. S. Army Corps of Engineers, Chicago District.

University of Minnesota-Duluth
Geology and Archaeometry Laboratory

George Rapp, Jr., "Trace Elements as a Guide to the Geographical Source of Tin Ore: Smelting Experiments" in The Search for Ancient Tin, Edited by A. D. Franklin, J. S. Olin, and T. A. Wertime, Smithsonian Institution Press.

George Rapp, Jr., Eiler Henrickson, Michael Miller, and S. E. Aschenbrenner, "Trace-Element Fingerprinting as a Guide to the Geographic Sources of Native Copper", submitted for publication.