MASTER

"Pollution of Ground Water Due to
Inactive Uranium Mill Tailings"

RENEWAL PROPOSAL

October 1, 1980 - September 30, 1981

Summary of Progress

October 1, 1979 - September 30, 1981

Dr. Willard R. Chappell, Director
Center for Environmental Sciences
University of Colorado, Denver
Contract #DE-AC02-76ET44206
(Formerly #EY-76-S-02-4017)

An extensive program of characterization of several inactive uranium tailings piles has been carried out in the past year. The geotechnical engineering program, under the direction of Dr. Nelson, conducted a drilling program at the Salt Lake City and Grand Junction sites. The locations of slimes and sands in these sites have been characterized. In general, it was found that slimes exist in the impoundments in lower percentages than normally produced from mill tailings.

Few or no zones can be found in which clean sand tailings exist. Throughout the impoundments water contents are generally very high, but phreatic surfaces were low, indicating considerable moisture is retained within the tailings as capillary water. Shear strength tests indicated angles of internal friction ranging from 33° to 45° . Photomicrographs indicated that the tailings are subangular; this angularity would account for the relatively high shear strength.

Permeability tests were conducted yielding values ranging from 10^{-3} cm/sec to 10^{-6} cm/sec.

The fine-grained slimes were seen to have a pronounced effect on the hydraulic conductivity of the tailings. Pressure-saturation curves were produced for a limited number of samples.

The geochemical studies, under the direction of Dr. Markos, made considerable progress in the past year. Extensive sampling of several sites was conducted. Sampling programs have been completed for seven sites and are underway for nine other sites. The work to date has indicated the importance of salts in controlling the direction and rate of movement of contaminants. The work has also indicated that a number of non-radioactive elements such as As are of environmental importance. The work also indicates the importance of the fact that the tailings piles are out of chemical equilibrium with their environment.

The analytical chemistry laboratory, under the direction of Dr. Meglen, has made considerable progress in expanding its capability to produce more samples. Computer software was developed and implemented for data storage and retrieval. Automation hardware was installed and tested for the Inductively Coupled Plasma Emission Spectrometer. A number of analytical protocols were developed for routine analyses. A comprehensive quality control program was implemented. More than 18,000 chemical analyses were performed.

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"Pollution of Ground Water Due to
Inactive Uranium Mill Tailings"

RENEWAL PROPOSAL

October 1, 1980 - September 30, 1981

Progress Report

October 1, 1979 - September 30, 1980

Analytical Laboratory
Dr. Robert R. Meglen
Center for Environmental Sciences
University of Colorado, Denver
Contract #DE-AC02-76ET44206
(Formerly #EY-76-S-02-4017)

Introduction

The Analytical Laboratory provides the following services to the project's Principal Investigators:

1. Develops reliable analytical methods for the analyses of study materials.
2. Performs routine chemical analyses on solid and liquid samples.
3. Provides quality control for assessment of accuracy in sampling, treatment and analysis.
4. Provides data processing techniques such as statistical analysis and pattern recognition to assist in interpretation of multicomponent data.

This report describes the progress made in the development and implementation of the above mentioned services.

Summary of Significant Progress

- Completion and implementation of computer software for data storage, retrieval and computation.
- Installation and testing of automation hardware for Inductively Coupled Plasma Emission Spectrometer.
- Methods Development and creation of analytical protocols for routine analyses.
- Implementation of comprehensive quality control scheme.
- Completion of over 18,000 chemical analyses.

New Instrument Status

Since the last quarterly report, the plasma emission spectrometer has been installed. Extensive testing of the instrumental capabilities indicate that the anticipated benefits of this automated technique will be realized for the routine analyses of a wide variety of elements. The calibration and testing of the instrument includes the following steps:

- testing the manufacturer's specifications for detection limits,
- creation of analytical task files for routine work on the various aqueous matrices encountered in this work,
- estimation of analytical accuracy of this technique for each matrix type.

While the instrument is operational for most work, some additional "fine tuning" is still required before it will fully meet the manufacturer's detection limit specifications. Its linear range, wavelength accuracy and stability meet expectations. Initial software evaluation indicated that some modifications were required in order to simplify the operation of the instrument. These modifications have been made and we are undergoing a more extensive evaluation with routine use by all laboratory personnel. The final modifications will be made after a period of routine operation using this configuration.

The ICP instrument operates totally under control of the computer. The only functions which the operator performs are lighting the argon torch, loading the automatic sampler and creation of analytical task files. These task files consist of the list of elements to be determined, the appropriate wavelengths for detection, any on-line or off-line correction parameters to account for interelement interferences or background correction and the concentrations of the calibration standards. All these parameters must be determined for each different type of sample matrix. Once they have been established they are stored on magnetic disks for all future analyses. Five task files have been created for analysis of about twenty elements in geological solid fusion digestates (XT), high ionic strength aqueous solutions (UW) and dilute aqueous samples (GW). Listings of the parameters are shown in the following tables.

Analysis are performed by recalling the appropriate analytical task file from storage. The selected elements are then placed in order according to increasing wavelength. A set of calibration standards and samples are then placed in the automatic sampler. The computer accepts commands to perform the calibration for all elements and to run the analyses. The results of analyses are printed out in a final report form for presentation to the investigators.

LISTING OF ANALYTICAL TASK FILE XT1

NO.	ELEM	WAVELENGTH	LOW LIMIT	ATTEN	INTEG	BCOR1	BCOR2
1	FE	2599.4	.02	6	1	0	0
2	MN	2576.1	.01	6	1	0	0
3	CU	3247.54	.02	6	1	0	0
4	CR	2055.52	.02	8	1	0	0
5	MO	2816.15	.04	6	1	-6	5
6	AL	3082.15	.3	6	1	0	0
7	SI	2881.58	.2	6	1	0	0
8	V	2924.02	.05	6	1	0	0
9	U	4090.14	1	6	1	0	0

LISTING OF ANALYTICAL TASK FILE XT2A

NO.	ELEM	WAVELENGTH	LOW LIMIT	ATTEN	INTEG	BCOR1	BCOR2
1	CA	4226.73	.3	4	1	0	0
2	MG	2790.8	.5	6	1	0	0
3	NA	5895.92	.2	10	1	0	0
4	K	7664.91	1	10	1	0	0
5	CD	2265.02	.03	6	1	0	0
6	BA	4554.03	.004	6	1	0	0

LISTING OF ANALYTICAL TASK FILE GW1

NO.	ELEM	WAVELENGTH	LOW LIMIT	ATTEN	INTEG	BCOR1	BCOR2
1	NA	5895.92	.2	10	1	0	0
2	K	7664.91	1	10	1	0	0
3	CA	3179.33	.03	6	1	0	0
4	MG	2790.8	.5	6	1	0	0
5	AL	3961.52	.15	6	1	0	0
6	CO	2378.62	.02	6	1	0	0
7	NI	2316.04	.04	6	1	0	0
8	BA	4554.03	.004	6	1	0	0
9	SR	4077.71	.002	6	1	0	0

LISTING OF ANALYTICAL TASK FILE GW2

NO.	ELEM	WAVELENGTH	LOW LIMIT	ATTEN	INTEG	BCOR1	BCOR2
1	FB	2203.53	.2	8	1	-7	0
2	CD	2144.38	.02	6	1	0	0
3	MN	2576.1	.01	6	1	0	0
4	FE	2599.4	.02	6	1	0	11
5	MG	2795.53	.001	6	1	0	0
6	MO	2816.15	.04	6	1	0	14
7	CR	2055.52	.02	6	1	0	13
8	SI	2516.11	.1	6	1	0	0
9	CU	3247.54	.02	6	1	0	11
10	V	3110.7	.04	6	1	0	11
11	ZN	2138.56	.01	6	1	0	0

LISTING OF ANALYTICAL TASK FILE UW1

NO.	ELEM	WAVELENGTH	LOW LIMIT	ATTEN	INTEG	BCOR1	BCOR2
1	CA	3179.33	.03	14	1	0	0
2	MG	2790.8	.5	14	1	0	0
3	MO	2816.15	.04	14	1	-6	5
4	AL	3082.15	.3	14	1	0	0
5	SI	2881.58	.2	14	1	0	0
6	NA	3302.37	20	14	1	0	0
7	FE	2599.4	.02	14	1	0	0
8	K	7664.91	1	15	1	0	0

Accuracy and Quality Control

A total quality assurance program for chemical analyses requires two procedures. First, the validity of the chosen analytical technique must be established before routine analyses may begin. Secondly, a continuous surveillance of the sampling, treatment, preparation and analysis must be maintained. The following description outlines the methods used to accomplish these tasks.

The quality assurance protocol adopted for this work has been designed to meet the needs of the other principal investigators. Many of the samples submitted for analysis are the result of sampling which takes place over a long period of time and analyses must be performed at several intervals during the year. In order to assure the compareability of analytical results obtained over the extended time periods, the following quality control protocol has been adopted. The protocol is based upon initial establishing accuracy using the methods previously described. The accuracy is then time-linked by repeated analyses on a single real sample composite, whose matrix composition is identical to the unknowns. Duplicate analyses performed on this quality control sample provides continuous monitoring of precision. Figure 1 shows the quality control scheme diagrammatically.

While it is impossible to determine absolute accuracy, it is possible to obtain an estimate by using several techniques. Table I shows the principal techniques available for estimation of accuracy and precision of analytical results. All of these results have been used in this laboratory to establish the validity of the chosen standard for many of the materials encountered in this project; we have relied upon the analysis by independent methods such as x-ray fluorescence, neutron activation atomic absorption, etc. and collaborative testing with other laboratories.

Analyses of waters using the above mentioned task files has been performed as a preliminary check of the appropriateness of the parameter selections. The water sample was analyzed by atomic absorption in two laboratories, by plasma emission in three laboratories. Table II shows a comparison of these results for eleven trace constituents. Similar comparisons for solids analyses have been made using independent methods such as x-ray fluorescence, neutron activation and atomic absorption. These results will be reported in more detail in the annual report.

The persistent problem of quality control during routine analyses requires continuous monitoring of analyses to determine the onset of systematic errors and the sudden appearance of large random errors which affect precision. Research being performed in this project has spanned several years. It is essential that results obtained early in the project be comparable to those obtained at later stages. We have therefore, employed the quality control procedure described in detail below.

QUALITY CONTROL SCHEME

Figure 1

TABLE I

Techniques for Estimation
of Accuracy and Precision

<u>Method Used to Estimate Accuracy*</u>		<u>Method Used to Estimate Precision**</u>
Primary:	1. Analysis of certified stds.	Replicates
	2. Independent methods	Replicates
	3. Collaborative tests (other labs)	Replicates
Secondary:	1. Secondary (in house) stds.	Replicates
	2. Spike Recovery Tests (inferential only)	

* Accuracy: Measure of closeness to "true" result or agreed upon value.

** Precision: Measure of reproducibility of a given result.

Table II

Comparison of Interlaboratory/Independent Methods
Accuracy Test on Trace Constituents of Water
(Results in mg/ml)

	<u>3 Labs</u>	<u>Atomic Abs. 2 Labs</u>	<u>This Lab ICP</u>
Pb	0.39 ± .03	0.47 ± .05	0.47
Cd	0.088 ± .01	0.079 ± .018	0.091
Mn	0.45 ± .04	0.52 ± .01	0.52
Fe	0.88 ± .03	0.98 ± .09	1.04
Mg	.001 ±	.005 ±	.001
Cr	0.27 ± .02	0.23 ± .04	0.26
Si	0.28 ± .02	—	0.36
Cu	0.34 ± .02	0.36 ± .03	0.36
V	—	0.99 ± .06	0.88
Zn	0.45 ± .04	0.41 ± .04	0.41

There are two types of errors associated with any chemical analysis; systematic (determinate) and random (indeterminate). Inaccurate results which occur due to systematic errors are always higher or lower than the "true" value. That is, they tend to have the same algebraic sign. These errors are the result of erroneous calibration, instrumental drift, loss of analyte or contamination during sample treatment, failure to account for blank or background effects, etc. Through adequate testing procedures it is possible to determine the magnitude of this type of error (hence the known determinate error). The validation phase of any analytical methods development is designed to eliminate this source of error. Occasionally systematic errors suddenly appear after the methods have been in use for some time. An effective quality control scheme should permit the rapid identification of the appearance of these systematic errors.

Random or indeterminate errors have a frequency of occurrence which is symmetrical. Small positive or negative errors have the highest probability of occurrence, while very large positive or negative deviations are less probable. These errors are inherent in any measurement technique which is based upon a continuous interval scale such as reading peak heights, analog scales, masses, etc. While careful control of experimental variables can minimize the magnitude of these errors; they are always present. These errors establish the precision of the measurements and the ability to detect sudden changes in the magnitude of these errors is essential to a quality control scheme.

The ability to distinguish between random and systematic error in measurement is important for the diagnosis of problems within the analytical procedure. The technique described in this discussion is based upon the method described by W.J. Youden. The Youden treatment is designed for the separation and identification of systematic and random errors which occur among laboratories participating in interlaboratory tests. The present modification is designed for use within a single laboratory. The results obtained from day-to-day are treated like the analyses performed in separate laboratories. Two different plotting techniques are used to monitor daily performance. A description of these graphical methods will be provided after a brief mathematical treatment of the technique has been presented.

Assume that a single sample is split into two portions labeled A and B. Analysis should yield the "true" value X plus any systematic error and random error.

$$A = X + S + R$$

$$B = X + S + R'$$

Where S is the systematic error (same algebraic sign and magnitude for each split), and R and R' are the random errors (Positive and negative signs are equally probable. The magnitude of these errors

follow a normal distribution function). The sum T of the results obtained for both splits will yield a result which is double the systematic error of one analysis.

$$T = A + B = 2X + 2S + R + R'$$

Since the random errors come from a symmetrical frequency distribution with both algebraic signs these two terms will, on average, cancel each other after many analyses.

When the difference D between the results A and B is computed, the systematic errors which have the same magnitude and sign will cancel leaving the sum of the two random error components.

$$D = A - B = R + R'$$

By plotting the A and B sums T and differences D in time ordered sequence the variation of these two sources of error can be monitored from analytical run to analytical run.

The procedure used for day-to-day monitoring utilizes a single real sample (usually a large composite of previously analyzed samples) is split into two aliquots labeled A and B. These samples are carried through the analytical procedure together with the unknown samples. The results of the sum T, and difference, D, are plotted in time ordered sequence.

The results of such a plot are shown in Figure 2 which covers a five month span consisting of 26 analytical runs. The long term mean with plus and minus one standard deviation are designated on the T plot. Similarly the mean of all differences should be zero as shown and the plus/minus standard deviation in the mean is also designated. Large deviations of T from the mean with small or no deviation in D indicates systematic errors dominate. (e.g., results of 2/6/79 and 4/19/79.) Conversely, large deviations in D with small deviation in T such as on 5/14/79 and 6/1/79 are indications that reproducibility is poor. Obvious difficulties showing both poor precision and accuracy were observed on 5/3/79 and 6/6/79.

These plots are used to establish quality control criteria. When either plot shows that a given analytical run produces results outside of the control limit the method is reviewed for sources of error, the analyses for that day are discarded and new analyses are performed. The appearance of various patterns in these plots can be used to isolate and identify potential sources of difficulty in the analytical procedure. Eight basic patterns have been identified, and their characteristics and possible causes have been catalogued for quick diagnosis of problems.

The second type of graphical representation which has been used to separate systematic and random errors is the quadrant plot. The result of analysis on split A is plotted against the results obtained on split B. If no systematic error were present and only random errors prevailed, there would be four possible outcomes:

<u>A</u>	<u>B</u>	
+	+	Both higher than true
-	-	Both lower than true
-	+	One higher and one
+	-	lower than true.

Each outcome is equally probable. The plot of these results would show a circular distribution of points. By drawing horizontal and vertical axes to designate the mean values of A and B, four quadrants are defined.

Similarly, in NO random errors were present and only systematic high (++) and systematic low (--) errors existed, a linear distribution of points would appear spanning quadrants I and III at 45° from the horizontal. In real situations one obtains distributions somewhere between these two extremes. By connecting the points with straight line segments in time ordered sequence, one can monitor the day-to-day performance of the analytical method. Lines with negative slopes indicate changes in systematic error between analytical runs. The lengths of the connecting line segments are proportioned to the magnitude of the changes. A control limit circle with radius equal to one or two standard deviations may be used for rejection criteria. Figure 3 shows the quadrant plot of the same data shown in Figure 2.

Both of the graphical methods described above provide the same information. They provide alternate ways of recognizing the occurrence of changing dominance of systematic and random errors in day-to-day analytical performance. In this laboratory both techniques are used daily to assess performance for possible data rejection.

TIME ORDERED ANALYTICAL RUNS

Figure 2 Quality control charts for sums (T) and differences (D) vs. time.

Figure 3 Quadrant plot used for monitoring systematic and random errors. (Points connected in time ordered sequence.)

In addition, the long term occurrence of patterns within the time ordered T and D plots is used to help in the diagnosis of analytical errors. The technique is easily implemented with either mineral preparation of quality control charts or through daily computer generated plots such as those included here. The primary concerns with any quality control scheme are rapidity with which problems are detected and the efficiency of its implementation. This scheme has advantages in both regards. It is particularly efficient since it requires a small number of additional analyses (two per analytical run). This small addition to the analytical sample load provides a rigorous statistical basis for establishing rejection criteria.

"Pollution of Ground Water Due to
Inactive Uranium Mill Tailings"

RENEWAL PROPOSAL

October 1, 1980 - September 30, 1981

Progress Report

October 1, 1979 - September 30, 1980

Physics Laboratory
Dr. Stuart Saunders
Center for Environmental Sciences
University of Colorado, Denver
DOE Contract #DE-AC02-76ET44206
(Formerly #EY-76-S-02-4017)

Data Produced

In the past 12 months, 112 solid samples have been processed in house for Pb^{210} and Ra^{226} concentrations, while 177 have been handled through a private lab (GEOLABS). These latter have been processed for Ra^{226} concentrations only. No water samples have been processed; none have been received for processing.

Technical Development

The gamma spectroscopic technique of iodionuclide determination has been developed to where sample concentration determination may be performed in as little as two hours and, at most, two days, depending upon activity of the sample. The accuracy of this technique has been proven through the use of multiple reference standards and independent lab checks.

The minimum detectability is currently 10. pCi/g for Pb^{210} and 18. pCi/g for Ra^{226} . This is based upon a maximum practical counting time of two days and the widely adopted condition for minimum detectability as an area under the peak in question being about one-third the total count in the region of interest. In fact, sample concentrations have been determined for values as low as 6.0 pCi/g, Pb^{210} , and 12. pCi/g, Ra^{226} . The rather high values for minimum detectability is now with more certainty to be due to a lack of sufficient shielding of the instrument.

Although a microcomputer has been hardware interfaced to the analyzer, not all needed parts have been received. Calculations for radionuclide computations are, therefore, still currently performed with the aid of only a pocket calculator.

An alpha counting system has been assembled and demonstrated to be functioning properly. However, alpha counting is not being performed at this time due to a lack of wet lab facilities and a lack of technical capability needed to process samples for alpha counting. Further progress in this area will occur as the need arises.

Difficulties

Equipment problems have been the chief cause of laboratory down time and delays in the development of the necessary spectroscopic technique. Periods during which progress was affected mainly or entirely by these problems amounted to 63% of the total time.

Recent Progress

Since the last quarterly progress report a temporary fix to the instrument problem described herein has been received and is currently being checked out. A permanent fix has been promised by the manufacturer.

In addition, an attempt to improve the detector shielding with the limited resources available has been made and it appears that this will result in a slight lowering of the minimum detectability.

INACTIVE URANIUM MILL TAILINGS SITES
ANALYSIS OF STABILITY

Renewal Proposal
October 1, 1980 - September 30, 1981

Progress Report
October 1, 1979 - September 30, 1980

prepared for
Center for Environmental Sciences
University of Colorado at Denver

by

Dr. John Nelson
Geotechnical Engineering Program
Civil Engineering Department
Colorado State University

DOE Contract #DE-AC02-76ET44206
(Formerly #EY-76-S-02-4017)

INACTIVE URANIUM MILL TAILINGS SITES

ANALYSIS OF STABILITY

I. INTRODUCTION

This report summarizes the progress to date at Colorado State University during the fiscal year 1980. To date there have been two quarterly reports submitted which will be referred to herein as the First Quarterly Report, covering the period October, 1979 to December, 1979; and the Second Quarterly Report, covering the period January, 1980 to March, 1980. The data presented in those reports will be referred to and will not be reproduced herein in this progress report. Considerable efforts in the first quarter and the first part of the second quarter was devoted to program definition, drilling and sampling, and characterization of existing impoundments. Considerably more data will be obtained in the remaining five months of the program.

II. CHARACTERIZATION OF IMPOUNDMENTS

Prior to investigation of the stability of the existing impoundments, primary consideration was given to characterization of the tailings piles and identification of the zones existing within the impoundments. An extensive program of drilling was conducted at the Salt Lake City and Grand Junction sites. The results of these investigations are presented in the Second Quarterly Report. Figures 3, 4, 5, and 6 of that quarterly report are appended hereto for reference.

In general it can be seen from those figures that slimes areas exist within the impoundment, but not to the extent that was expected on the basis of general percentages normally produced from mill tailings. In the sandy areas, sand and slime zones are interbedded throughout. Little or no zones can be found in which clean sand tailings exist.

Throughout the impoundment, water contents are generally very high, but phreatic surfaces were low within both piles. This indicates that considerable moisture is retained within the tailings as capillary water. Residual water content in the tailings are considerably higher, therefore, than one would expect from uniform fine sands. This is probably due to the presence of considerable percentages of slimes mixed with the sand.

All tailings and surface embankments constructed of either tailings or imported borrow were of low density. There appears to have been little or no compaction imparted to the material during placement.

On the basis of the above observations, it may be expected that the shear strength and stability of the existing impoundments is low.

III. EXPERIMENTAL PROGRAM

A flow chart for laboratory experiments on selected samples of tailings was presented in the First Quarterly Report. Experiments are being conducted in general accordance with that flow chart. A copy of the flow chart is included herein for reference.

Various size fractions of each tailings have been identified for testing in accordance with the flow chart.

A. Shear Strength

Shear strength of the coarse beach sand has been determined for the Grand Junction site. The results of these experiments have been presented in the Second Quarterly Report. On the basis of approximately twenty samples compacted to densities ranging from about 85 lbs. per cubic foot to about 110 lbs. per cubic foot, the angle of internal friction was seen to vary from approximately 33° up to about 45°. These shear strength values are relatively high in comparison to most naturally occurring sands. Photomicrographs indicated that the tailings are subangular and some fracturing of the grains probably occurred during milling. The angularity of the grains would account for the relatively high shear strength.

Additional shear tests are currently being performed on additional samples having different grain sizes. Samples from both the Grand Junction site and the Salt Lake City site are being investigated.

B. Permeability

Permeability values determined on saturated samples of tailings were tabulated in the Second Quarterly Report. In general, the permeability varied from 10^{-3} cm/sec to 10^{-6} cm/sec. The data to date is not sufficiently complete to allow conclusions to be drawn. However, the fine-grained slimes are seen to have a pronounced effect on the hydraulic conductivity of the tailings.

Additional experiments are being conducted to evaluate the permeability of horizontal and vertical samples. Both undisturbed and recompacted samples are being investigated.

C. Pressure-Saturation Curves

Pressure-saturation curves were determined for a limited number of samples. Considerable difference existed in the capillary head and residual water content, depending on the density of the sample and the method of sample placement. Additional experiments are being performed to define the pressure-saturation characteristics for additional size fractions and mixtures of fine and coarse tailings.

D. Chemical Analyses

A limited number of chemical analyses were performed on samples taken by the Colorado State University field crews to supplement the investigation performed by Markos and Bush at South Dakota School of Mines and Technology. These results have been forwarded to South Dakota School of Mines and Technology with no interpretation of the results.

IV. FUTURE PLANS FOR THIS YEAR'S INVESTIGATION

In general, the progress to date has been in close agreement with the milestone chart that was previously presented. Efforts for the next four months will continue along the lines outlined in the Program Plan. Experiments will be conducted in accordance with the flow chart appended hereto. Personnel who are currently working on the project include John D. Nelson, Professor and Principal Investigator; Thomas A. Shepherd, Research Assistant Professor; Joseph P. Martin, Graduate Research Assistant; David M. Nasiatka, Graduate Research Assistant; Luis F. Osorno, Graduate Research Assisant; George E. Veyera, Graduate Research Assistant.

Figure 1. FLOW-CHART
(from First Quarterly Report)

INTERPRETIVE PROFILES OF VITRO INACTIVE TAILINGS SITE, SALT LAKE CITY, UTAH

APPROXIMATE HORIZONTAL SCALE
1" = 80'

DATA BASED EXPLORATIONS OF: OCTOBER 1979 & MARCH 1980
WATER LEVEL - MARCH 17-19, 1980

Figure 3.
(from Second Quarterly Report)

INACTIVE SITES PROJECT
 INTERPRETIVE PROFILES OF GRAND JUNCTION PILE
 SECTION A-A

Colorado State University
 Civil Engineering Department
 Geotechnical Engineering Program

Data base: Explorations
 March 1980

Figure 4.
 (from Second Quarterly Report)

INACTIVE SITES PROJECT
INTERPRETIVE PROFILES OF GRAND JUNCTION PILE
SECTION B-B

Colorado State University
Civil Engineering Department
Geotechnical Engineering Program

Data base: Explorations
March 1980

Figure 5.
(from Second Quarterly Report)

INACTIVE SITES PROJECT
INTERPRETIVE PROFILES OF GRAND JUNCTION PILE
SECTION C-C

Colorado State University
 Civil Engineering Department
 Geotechnical Engineering Program

Data base, Explorations
 March 1980

Figure 6.

(from Second Quarterly Report)

APPENDIX A
Resumes

WILLARD R. CHAPPELL

ADDRESS: Center for Environmental Sciences
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80202
940 McIntire Street
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EDUCATION: University of Colorado: B.A. (Mathematics), 1962
Harvard University: M.A. (Physics), 1963
University of Colorado: Ph.D. (Physics), 1965

EMPLOYMENT:

1978 - Present	Chairman, Department of Energy Task Force on Environmental Impacts of Modified In Situ Oil Shale Processes
1977 - Present	Professor of Preventive Medicine University of Colorado Medical Center
1977 - Present	Professor of Physics University of Colorado Denver, Colorado
1976 - Present	Professor Adjoint Department of Astrogeophysics University of Colorado
1975 - Present	Director, Environmental Trace Substances Research Program University of Colorado
1976 - 1977	Assistant to the Vice President and Senior Scientist Science Applications, Inc. La Jolla, California
1975 - 1976	Chairman Governor's Scientific Advisory Committee Colorado
1973 - 1976	Professor of Physics and Astrophysics University of Colorado Boulder, Colorado
1973 - 1975	Member Governor's Scientific Advisory Committee Colorado

1971 - 1978	Director The Molybdenum Project University of Colorado
1970 - 1973	Associate Professor University of Colorado Boulder, Colorado
1969 - 1973	Director University of Colorado North High College Motivation Program
1967 - 1970	Assistant Professor University of Colorado Boulder, Colorado

GRANTS:

1969 - 1971	Fleishmann Foundation - \$8,000 "College Motivation Program"
1970	Council on Research and Creative Workshop \$4,000 University of Colorado "Environmental Transport of Molybdenum"
1971 - 1973	Denver Public Schools - \$8,000 "College Motivation Program"
1971 - 1976	National Science Foundation \$1,210,000 "Transport and the Biological Effect of Molybdenum in the Environment"
1975 - 1978	Environmental Protection Agency \$355,000 "Human Health Effects of Molybdenum"
1975 - 1978	Environmental Protection Agency \$211,000 "Human Health Effects of Water Reuse"
1976 - 1980	Department of Energy \$1,300,000 "Trace Contaminants in Oil Shale"
1978 - 1980	Chairman - DOE Oil Shale Task Force

1976 - 1979	Environmental Protection Agency \$287,000 "Effect of Ozone on Organics in Wastewater"
1978 - 1979	Environmental Protection Agency \$100,000 "Critical Review of Research on Impact of Energy-related Wastes on Aquatic Environment"
1978 - 1980	Department of Energy \$590,000 "Ground Water Pollution from Inactive Uranium Tailing Piles"
1979 - 1981	Environmental Protection Agency \$150,000 "Evaluation of Risks, Energy Costs, and Associated Economic Factors of Wastewater Disinfection Alternatives"
1979 - 1980	Department of Energy \$84,000 "Joint Faculty/State Review Program: Synfuel and Energy Impact Section"
1979 - 1981	Environmental Protection Agency \$70,000 "Chemistry of Renovated Wastewater"
1979 - 1981	U.S. Bureau of Mines \$353,000 "Groundwater Contamination due to Uranium Mining & Milling"

COURSES TAUGHT:

Undergraduate:	Freshman and Sophomore General Physics Thermodynamics Atomic and Nuclear Physics Electricity and Magnetism Energy and the Environment
Graduate:	Quantum Mechanics Electromagnetism Statistical Mechanics Kinetic Theory

PROFESSIONAL AND HONORARY SOCIETIES:

Phi Beta Kappa
American Physical Society
Sigma Xi
American Association for the Advancement of Science
Society for Environmental Geochemistry and Health

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Publications

13. "Kinetic Theory of Quantum Plasma and Radiation in an External Magnetic Field", Phys. Rev., 152:113 (1966).
14. "Microscopic Approach to Kinetic Theory", J. Math. Phys. 8:298 (1967).
15. "Microscopic Kinetic Theory", In Lectures in Theoretical Physics, ed. W. E. Brittin (Gordon and Breach Co., New York, 1967), Vol. IXC, pp. 97-113.
16. "Microscopic Approach to Kinetic Theory - Inhomogenous Systems," J. Math. Phys., 9:1921 (1968).
17. "Functional Methods in Statistical Mechanics, Part 1, Classical Theory", (with W. E. Brittin) J. Math. Phys., 10:661 (1969).
18. "Electron Correlations in Stark Broadening", (with J. Cooper and E. W. Smith), J. Quant. Spec. and Rad. Transfer 9:149 (1969).
19. "Investigation of the Dynamics of Ionized Media, Plasmas", (with W. E. Brittin), U.S.A.R.L. Technical Report 69-0068 (1969).
20. "Non-thermal Effects in Stark Broadening", (with J. Cooper and E. W. Smith), J. Quant. Spect. and Rad. Transfer, 10:1195 (1970).
21. "Kinetic Equations of Autocorrelation Functions in Dilute Gases," J. Stat. Phys., 2:267 (1970).
22. "The Role of Plasma Kinetic Theory in Spectral Line Shapes", In Kinetic Equations, ed. R. L. Liboff and N. Rostoker (Gordon and Breach Co., New York, 1971) pp. 99-109.
23. "Microscopic Theory of Density Fluctuations and Diffusion in Weakly Ionized Plasmas", (with R. H. Williams), Phys. Fluids, 14:591 (1971).
24. "Density Fluctuations in a Magnetized, Weakly Ionized Plasma", (with R. H. Williams), Phys. Fluids, 14:1938 (1971).
25. "An Impact Theory for Doppler and Pressure Broadening, I. General Thoery", (with E. W. Smith, J. Cooper, and T. Dillon), J. Quant. Spect. and Rad. Transfer, 11:1547 (1971).

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Publications

26. "An Impact Theory for Doppler and Pressure Broadening, II. Atomic and Molecular Systems," (with E. W. Smith, J. Cooper, and T. Dillon), J. Quant. Spect. and Rad. Transfer, 11:1567 (1971).
27. "An Adiabatic Treatment of Ion Dynamics for Forbidden Line Profiles", (with E. W. Smith and J. Cooper), Phys. Letter, 24A:363 (1971).
28. "A Kinetic Theory of Spectral Line Shapes", (with J. Cooper, E. W. Smith, and T. Dillon), J. Stat. Phys., 3:401 (1971).
29. "Microscopic Theory of Conductivity of a Weakly Ionized Plasma", (with R. H. Williams), Phys. of Fluids, 15:1059 (1972).
30. "A Physics-Oriented College Motivation Program for Minority Students", (with J. Baur), Phys. Teacher, 10:188 (1972).
31. "The Molybdenum Project: Geochemical Aspects", (with D. D. Runnells and R. R. Meglen), Geological Society of America, Special Paper 155, pp. 61-72 (1975).
32. Transport and the Biological Effects of Molybdenum in the Environment, Progress Report to NSF. (ed. and author - The Molybdenum Project, University of Colorado, Boulder, January 1, 1973). NTIS Publication No. WGA-68-73-41; Document No. PB-222616/5WP.
33. "Interdisciplinary Approach to Geothermal Development", Proceedings of Conference on Interdisciplinary Analysis of Water Resource Systems, ed. J. E. Flack (ASCE, NY, 1975), pp. 220-229.
34. "Problems and Opportunities in Interdisciplinary Research: The Molybdenum Project", Proceedings of First Annual NSF Trace Contaminants Conference, eds. W. Fulkerson, W. D. Shults, and R. I. Van Hook (USAEC, Oak Ridge, 1974).
35. A Scientific and Policy Review of the Prototype Oil Shale Leasing Program - Final Environmental Impact Statement of the U.S. Department of the Interior, (contributor) eds. K. Fletcher and M. F. Baldwin (Institute of Ecology, Washington, D.C., 1973).

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36. "Transport and Biological Effects of Molybdenum in the Environment", Proceedings of the International Conference on Heavy Metals in the Aquatic Environment", ed. P. A. Krenkel (Pergamon Press, N.Y., 1975), pp. 167-188.
37. "Comments on Directed Panspermia", (with R. R. Meglen and D. D. Runnells), Icarus, 21:513-5-5 (1974).
38. "Some Comments on the Management of Problem-Oriented Interdisciplinary Research", Proceedings of Second Annual NSF Trace Contaminants Conference, (Lawrence Berkeley Laboratory, Berkeley, 1975), pp. 350-356.
39. "Health Effects Relating to the Direct and Indirect Reuse of Wastewater for Human Consumption - Report of WHO Meeting of Experts", Contributor, in press.
40. "Review of Federal Research and Development Policy", (with F.C. Mann and C.M. York), Energy Development in the Rocky Mountain Region: Goals and Concerns, eds. J. A. Pulver and B. J. Polich (Federation of Rocky Mountain States, Inc., Denver, 1975), Vol. 3, Chap. IX.
41. "Report of the Governor's Task Force on Energy Coordination", with F. C. Mann, et.al. (University of Colorado, Boulder, 1975).
42. Transport and the Biological Effects of Molybdenum in the Environment - Progress Report to NSF (ed. and author - The Molybdenum Project, University of Colorado, Boulder, January 1, 1974 and January 1, 1975).
43. "Symposium on Molybdenum in the Environment - Proceedings", Vol. I, co-editor (with K. Petersen), (Marcel Dekker, NY, 1976).
44. "Symposium on Molybdenum in the Environment - Proceedings", Vol. II, co-editor (with K. Petersen), (Marcel Dekker, NY, 1977).
45. "The Molybdenum Project", in "Symposium on Molybdenum in the Environment - Proceedings", Vol. I., Co-editor (with K. Petersen), (Marcel Dekker, NY, 1976).

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Publications

46. "The Oil Shale Project", (with D. Runnells) Trace Substances in Environmental Health, Vol. XI, editor, D. D. Hemphill, (University of Missouri, Columbia, 1977), pp. 383-388.
47. "Biochemical Abnormalities in Workers Exposed to Mo Dust", (with R. Moure-Eraso, C. C. Solomons, and S. Bentley) to be published in Archives of Environmental Health, 1978.
48. "Biochemical Changes in Workers Exposed to Mo Dusts" (with R. Roure-Eraso, C. C. Solomons, and S. Bentley) to be published in Proceedings of the Conference on Trace Elements Metabolism in Animals, 1978.
49. "Toxic Trace Elements and Oil Shale Production", to be published in the Proceedings of the 11th Oil Shale Symposium, Colorado School of Mines, 1978.
50. "Molybdenum in the Diet: An Estimate of Average Daily Intake in the United States", (with Tsongas, Meglen and Walravens), American Journal of Clinical Nutrition, 1979.
51. "Human Health Effects of Molybdenum in Drinking Water", (with R. R. Meglen, R. Moure-Eraso, C. C. Solomons, T. A. Tsongas, P. A. Walravens, and P. W. Winston), Final Report to EPA, Sept. 1978.
52. "Environmental Impacts of Oil Shale", presented at International Conference on Energy Use Management, Los Angeles: October 22-26, 1979; published in proceedings.
53. "Heavy Metal Pollution from Shale Oil Production", presented at the International Conference of Heavy Metals in the Environment, London, England: Sept. 18-21, 1979; published in proceedings.
54. "The Oil Shale Task Force: Past Present and Future", to be presented at the Second Environmental Control Symposium, March 17-18, 1980, London, England, and to be published in the proceedings.

RESUME

NAME: Gergely Markos

BUSINESS ADDRESS: Department of Geological Sciences
University of Colorado, Boulder, CO. 80309

PERSONAL DATA: Born 7/29/30 in Budapest, Hungary; married; no physical limitations; permanent resident of U. S.

Languages: Hungarian: fluent; German: read and speak; Italian: read.

Military service: 1951-1954; Hungarian Army, Artillery; sergeant.

EDUCATION: Ph.D. (1977) Dept. Geol. Sci., Univ. Colo., Boulder, CO.

Thesis title: Geochemical alteration of plagioclase and biotite in glacial and periglacial deposits.

B.A. (1967) Dept. Geogr., Univ. Colo., Boulder, CO., phys. geogr./geomorph.

Mech. Eng. (1956) Techn. Univ., Budapest, Hung., materials/processing.

State gymnasium (1950) Budapest, Hung., science and mathematics.

ACADEMIC SPECIALIZATIONS: Geochemistry and mineralogy of clay minerals;

Theory of low temperature mineral alterations (thermodynamics);

Thermodynamics of genesis of layer silicates, oxides and hydroxides in low temperature geochemical environments;

Geochemistry and genesis of uranium deposits;

Geochemistry in mineral exploration;

Application of statistics in geochemistry.

EMPLOYMENT: Current: Adj. Prof., Dept. Geol. Sci. and Research Scientist, Environmental Trace Substances Research Programs, Univ. Colo.

Duties: Graduate student advising; co-principal investigator in NURE (National Uranium Resources Evaluation) pilot studies.

Consultant; geochemistry, uranium exploration, clay mineralogy for industry.

Manager, Geosciences and Water Resources Department, VTN Colorado, Inc. 2600 S. Parker Rd., Parker Place Four, Aurora, CO. 80014 (1977-1978).

Research Associate, Dept. Geol. Sci., Univ. Colo. Boulder, CO.; co-principal investigator in NURE pilot studies (1975-1977).

Consultant; industrial engineering (1970-1972).

Visiting Lecturer; INSTAAR, Univ. Colo., Boulder, CO. (Summer, 1974).

Instructor; Clarion State College, Geography and Earth Sciences Dept. Clarion, PA. (1968-1970).

Teaching Assistant; Dept. Geol. Sci., Univ. Colo., Boulder, CO. (1973-1975), Dept. Geogr., Univ. Colo., Boulder, CO. (1966-1968).

Tool and die maker; various industries (1959-1965).

Assistant head; Engineering operations research, Budapest, Hung.

Instructor; applied mathematics, steel metallurgy; Budapest, Hung.

SCIENTIFIC AFFILIATIONS: Mineralogical Society of America

The Geochemical Society

Soil Science Society of America

American Society of Agronomy

HONORS: Decoration for "oustanding leadership and courage" in flood disaster prevention of a strategic industrial area; Hungarian Army, 1953.
Teaching Excellence Award; Univ. Colorado., Dept. Geogr., 1967.

REFERENCES: Dr. Donald D. Runnells, Professor
Dept. Geol. Sci., Univ. Colorado, Boulder, CO. 80309; (303) 492-8323.

Dr. Peter W. Birkeland, Professor
Dept. Geol. Sci., Univ. Colorado, Boulder, CO. 80309, (303) 492-6985.

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VTN Colorado, Inc., 2600 S. Parker Rd., Parker Place 4, Aurora, CO.
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Dr. Jack D. Ives, Professor and Director
Institute for Arctic and Alpine Research, Univ. Colo., Boulder, CO.
80309; (303) 492-7909.

BIBLIOGRAPHY:

Markos, G. (1974a) Occurrence of boehmite in alpine tundra soils on Quaternary deposits in the Front Range, Colorado: Abstract with Programs, The Geological Society of America, Rocky Mountains Section, 27th Annual Meetings, p. 436-457.

Markos, G. (1974b) Clay mineralogy of soils in the alpine tundra and forest, Colorado Front Range; Abstract of the Third Biennial Meeting, American Quaternary Association, Univ. Wisc., Madison, Wisc., p. 118.

Markos, G. (1974c) Biotite weathering in some alpine soils in Colorado: Agronomy Abstracts, Soil Science Society of America, 1974 Annual Meetings, Chicago, Ill., p. 182.

Markos, G. (1975a) Representation of some soil mineral reactions in Eh-pH and AG_p-pH fields: Agronomy Abstracts, Soil Science Society of America, 1975 Meetings, Knoxville, Tenn., p. 175.

Markos, G. (1975b) Rates and kinetics of plagioclase dissolution in late Quaternary tills in Colorado and Wyoming: Abstract with Programs, The Geological Society of America, 1975 Annual Meetings, Salt Lake City, Utah, p. 1190.

Markos, G. (1976) Thermodynamic analysis of low temperature mineral alterations: Abstract with Programs, The Geological Society of America, 1976 Annual Meetings, Denver, Colo., p. 998.

Markos, G. (1977) Geochemical alteration of plagioclase and biotite in glacial and periglacial deposits: Ph.D. Thesis, Univ. Colorado, Boulder, Colo., 236 p., Dissertation Abstract No. 77-24252.

LaPoint, D.J. and Markos, G. (1977) Geochemical interpretation of ore zonation at the Rifle vanadium mine, Colorado: U. S. Geol. Survey Circular 753, p. 53-55.

VITA

Robert R. Meglen

Personal:

Academic Record:

B.S.	1966	Iowa State University (Chemistry)
M.S.	1969	University of Colorado (Physical Chemistry)
Ph.D.	1971	University of Colorado (Physical Chemistry)

Positions:

1966-68	Teaching Assistant University of Colorado Boulder, Colorado
1968-79	Research Assistant University of Colorado Boulder, Colorado
1970-71	Teaching Assistant/Lecturer University of Colorado Boulder, Colorado
1971-75	Research Chemist The Molybdenum Project University of Colorado Boulder, Colorado
Fall, 1973	Visiting Professor Department of Chemistry University of Colorado Boulder, Colorado
1975-76	Assistant Professor Department of Chemistry Hobart and William Smith College Geneva, New York
1977-	Director of Analytical Laboratory Environmental Trace Substances Research Program University of Colorado Boulder, Colorado

Professional and Honorary Societies:

American Chemical Society
Society of the Sigma XI
Phi lambda Upsilon

Publications:

1. Bentley, Markowitz, Meglen; "The Analysis of Molybdenum in Biological Materials", in Ultra trace Metal Analysis in Biological Sciences and Environment; Advances in Chemistry Series #172 (1978).
2. Chappell, Meglen, Runnells; "Comments on Directed Panspermia," Icarus 21 pp. 513-515 (1974).
3. Jackson, Meglen; "A Procedure for the Resin-Extraction and Colorimetric Analysis of Molybdenum in Soils," Soil Sci. Soc. American Proc. (1975), 2:373-374.
4. Jordan, Meglen; "Aqueous Release of Molybdenum from Point and Non-point Sources," Proceedings of 7th Annual Conference on Trace Substances in Environmental Health, ed. D.D. Hemphill. Columbia, Missouri, June 12-14, 1973; pp. 105-115 Vol. VII 1974.
5. Rudolph, H.; "Determination of Trace Amounts of Fluorine by Nuclear Inelastic Scattering," (also with Kraushaar, Ristinen, Meglen) Proceedings of 7th Annual Conference on Trace Substances in Environmental Health, ed. D.D. Hemphill. Columbia, Missouri, June 12-14, 1973. p.38+ Vol. VII 1974.
6. Meglen, Glaze; "Special Analytical Problems in the Analysis of Molybdenum by Atomic Absorption Spectrophotometry and Colorimetric Methods," Presented at 1st Annual NSF Trace Contaminants Conference, Oak Ridge, Tenn., August 8-10, 1973. Published in Proceedings, ed. W. Fulkerson, 1973.
7. Runnells, Chappell, Meglen; "Molybdenum Project: Geochemical Aspects," Trace Element Geochemistry in Health and Disease, ed. J. Freedman, Special Paper 155, p. 61-72, 1975.
8. Runnells, LeGendre, Meglen; "Scavenging of Dissolved Molybdenum by Ferric Oxhydroxide as a Function of pH: Natural Examples and Possible Economic Application," Geological Soc. of America, 5(7) (1972). (Abstract)
9. Wildeman, Meglen; "The Analysis of Oil Shale Materials for Element Balance Studies," in Analytical Chemistry of Liquid Fuel Sources; Advances in Chemistry Series #170. p. 195-212 (1978).
10. Chappell and Meglen, Eds; Human Health Effects of Molybdenum in Drinking Water. To be published by U.S.E.P.A. Health Effects Research Laboratory, Cincinnati, Ohio (1979).
11. Meglen, R. and A. Krikos; "The Determination of Fluorine in Oil Shale Related Matrices Using Graphite Furnace Molecular Absorption," To be presented at Oil Shale Sampling, Analysis and Quality Assurance Symposium. March, 1979, Denver, Colorado.

Thesis:

"Dielectric Models for Solvated Electrons," Ph.D. Thesis, University of Colorado, Boulder, Colorado, 1971.

JOHN D. NELSON

Civil Engineering Department
Colorado State University
Fort Collins, Colorado 80523

PRESENT

POSITION: Professor, Civil Engineering Department
Program Leader, Geotechnical Engineering Program
Colorado State University

EDUCATION: 1967 - Ph.D. in Civil Engg., Illinois Inst. Tech.
1962 - M.S. in Civil Engg., Illinois Inst. Tech.
1960 - B.S. in Civil Engg., Illinois Inst. Tech.

OTHER

QUALIFICATIONS: Registered Professional Engineer in the States of
Colorado, Wyoming and Illinois.

EXPERIENCE:
Sept. 1973 -
Present

Colorado State University, Fort Collins, Colorado,
Associate Professor. Program Leader of Geotechnical
Engineering Program. Responsible for administration
of Program, and coordination of teaching and research
activities. Developed undergraduate and graduate
level coursework for the program. Has taught all
courses in the program as well as selected other
mechanics and engineering courses.

Research areas of primary interest include tailings
management, long-term stability of tailings, expansive
soils, progressive creep failure of clayshales and
liquefaction potential during earthquakes. Responsible
for development of research projects, preparation of
proposals and direction of research efforts. Has been
principal investigator on several research projects in
the areas of tailings management, seepage from uranium
mill tailings impoundments, pressure-volume relationships
of expansive soils, and long-term stability of tailings.
Has contributed on several other projects including
water migration in frozen soils, slope stability near
rivers and scour around culverts. Directed several
workshops, short courses and symposia on tailings
disposal.

July 1968 -
Sept. 1973

Asian Institute of Technology, Bangkok, Thailand,
Associate Professor (Assistant Professor until 1970).
Taught graduate courses and supervised research.
Developed soil dynamics and field operations programs.
Research areas included field instrumentation in clays,

shear strength and dilatation of clay, vibrations of foundations and surface waves in clay.

Director or co-director of several projects including instrumentation of a full-scale test embankment, field investigation for New Bangkok International Airport, site investigation for water supply tunnel in soft clay, and pre-consolidation of clay foundations by sand drains.

August 1962 -
July 1968

IIT Research Institute, Chicago, Illinois, Research Engineer. Responsible for development of research, preparation of proposals and direction of research projects. Major research areas included Lunar Soil Mechanics and Soil Dynamics. Director or co-director of projects including basic investigations of Lunar Soil Mechanics, response of Apollo footpads, penetrometer data from Surveyor, and stress wave testing of caissons.

**SIGNIFICANT
CONSULTING
ACTIVITIES:**

Formerly principal in Ackenheil and Associates, Colorado Inc. from 1975 - 1978. Also consultant either independently or through various consulting engineering firms on such projects as:

Review of proposed uranium mill tailings management plans. Nuclear Regulatory Commission.

Stability analysis of coal tailings dam. Kaiser Steel Corporation.

Seepage analysis of coal sludge impoundment. Jones and Laughlin Corporation.

Analysis of drop-forge hammer foundation. Colorado Forge Corporation.

Analysis of pipe line failure. Expert witness. Boone, Karlberg and Haddon, Law Offices, Attorneys for Felton Construction Company.

Analysis of foundation wall failure. Boone, Karlberg and Haddon, Law Offices.

Analysis of floor slab failure on expansive soils. Neenan Construction Company.

Review of slope failure, City of Fort Collins.

Consultant for design of new tailings dams (for Kaiser Steel Corporation), Lincoln-DeVore Consulting Engineers.

SCIENTIFIC AND
PROFESSIONAL
SOCIETIES:

American Society of Civil Engineers
Southeast Asian Society of Soil Engineering
International Society for Soil Mechanics and
Foundation Engineering
American Society for Testing and Materials
American Society for Engineering Education
Sigma Xi
Tau Beta Pi
Chi Epsilon

PROFESSIONAL ACTIVITIES:

1978 - present	Member Expansive Soils Research Council, ASCE.
1978, 1979	Organizer and Lecturer, <u>Short Course on Design and Construction of Tailings Impoundments</u> , Denver.
1978	Chairman, <u>Symposium on Uranium Mill Tailings Management</u> , Colorado State University.
1976, 1977	Chairman, Geotechnical Division, Colorado Section, ASCE.
1975, 1976	Vice Chairman, Geotechnical Division, Colorado Section, ASCE.
1974 - present	Member, ASCE Committee on Embankment Dams and Slopes.
1974 - present	Chairman, ASTM Subcommittee Section D18.05.01 Standard Methods of Test for Triaxial Testing of Soils.
1974 - present	Member TRB Committee on Soil and Rock Properties.
1971 - 1973	Executive Committee, International Society for Soil Mechanics and Foundation Engineering.
1968 - 1973	Secretary, Southeast Asian Society of Soil Engineering.
1971	Secretary Fourth Asian Regional Conference of the ISSMFE, Bangkok, July 1971.
1970	Organizing Committee, Second Southeast Asian Conference on Soil Engineering, Singapore, June 1970.
1967 - 1977	Reviewer, <u>Applied Mechanics Reviews</u> .
1963 - 1967	Committee on Continuing Education, Illinois Section, ASCE. Chairman in 1966 when <u>Design Construction of Structures to Resist Earth Pressures</u> was published.

SPECIAL RECOGNITION:

1960	Associate Membership Award, Illinois Section, American Society of Civil Engineers, 1960.
1973	Elected Honorary Member, Southeast Asian Society of Soil Engineering, 1974.
1976	Outstanding Professor Award, Chi Epsilon, Colorado State University, 1976.

JOHN D. NELSON

M. ENG. THESES SUPERVISED

1. Shear Strength Characteristics of the Stiff Bangkok Clay, by Diti Hengchaovanich (1969).
2. Shear Strength Characteristics of Bangkok Clay in the Weathered Zone, by Manoon Arayasiri (1969).
3. Prediction of the Modulus of Deformation of Soil under Vibratory Loading from Static Triaxial Tests, by Chong Nyok Yeong (1970).
4. Shear Strength Characteristics of Anisotropically Consolidated Stiff Bangkok Clay, by Bashir Ahmad (1970).
5. Shear Strength of Clay under Vibratory Loading, by Pranai Satyavanija (1970).
6. Effect of Soil Structure on Dilatation of Clays, by Siu Kong-Lam (1970).
7. The Influence of End Restraint and Length to Diameter Ratio on Measured Strength of Soil Specimens, by B.K. Khurana (1971).
8. Effect of Embedment on Response of Vibrating Footings, by Samuel S.H. Lee (1971).
9. Shear Strength of Marine Clay under Rapid Transient Loading, by Suvit Viranuvut (1971).
10. Shear Strength of Compacted Clay under Rapid Transient Loading, by Pipat Taravayut (1971).
11. Propagation and Screening of Rayleigh Waves, by Peng, Shoei Muh (1972).
12. Effect of Pressure and Aging on Diagenetic Bonds, by Boonsiang Boonyaratganon (1972).
13. Performance of Sand Drains at Tha Chang Bridge, by William Ciridon (1972).
14. Dynamic Penetration of Projectiles, by Udom Udommongkolkul (1972).
15. Fundamental Studies of Pore Pressure Parameters, by Chitchai Anantasech (1973).
16. Development of Diagenetic Bonds in Kaolinite, by Ernesto C. Roque (1973).
17. Probabilistic Definition of Soil Strength over an Area, by Chaisith Keesookpun (1973).

M. ENG. THESES SUPERVISED (Continued)

18. Effect of Sampler Type on Soil Strength, by Sriwiroj Chantawong (1973).
19. Strain Field Beneath Model Vibrating Footings, by Lee, Tsong-Hwei (1973).
20. Mechanics of Swelling in Expansive Clays, by Andrew A. Porter (1977).

JOHN D. NELSON

LIST OF PUBLICATIONS

1. NELSON, J. D. (1964), Laboratory Simulation of Lunar Surface Conditions, Journal of Environmental Sciences, Vol. 6, No. 4, August.
2. NELSON, J. D. and VEY, E. (1964), Bearing Capacity of the Lunar Soil, ASME Paper No. 64 - WA/AV-13, December.
3. VEY, E. and NELSON, J. D. (1965), Engineering Properties of Simulated Lunar Soils, J. Soil Mech. & Found. Div., ASCE, Vol. 91, SM1, January.
4. NELSON, J. D. and VEY, E. (1968), Relative Cleanliness as a Measure of Lunar Soil Strength, Journal of Geophysical Research, Vol. 73, No. 12, June.
5. MOH, Z. C., NELSON, J. D. and BRAND, E. W. (1969), Strength and Deformation Behavior of Bangkok Clay, Proc. VII International Conference on Soil Mechanics and Foundation Engineering, Mexico City, August.
6. NELSON, J. D. (1969), Sampling of Lunar Soil, Symposium in Print-Specialty Session No. 1, Soil Sampling, VII International Conference on Soil Mechanics and Foundation Engineering, Mexico City, August.
7. NELSON, J. D. and HENGCHAOVANICH, D. (1970), Effects of Over-consolidation on the Shear Strength Characteristics of a Marine Clay, Proc. Second Southeast Asian Conference on Soil Engineering, Singapore, June.
8. SATYAVANIJA, P. and NELSON, J. D. (1971), Shear Strength of Clays Subjected to Vibratory Loading, Proc. Fourth Asian Regional Conference on Soil Mechanics and Foundation Engineering, Bangkok, 1971.
9. NELSON, J. D., BRAND, E. W., MOH, Z. C. and MASON, I. D. (1971), The Use of Residual Stress to Define Sample Quality, Symposium on 'Quality in Soil Sampling', convened by IGSS at IV Asian Regional Conference on Soil Mechanics and Foundation Engineering, Bangkok, July.
10. NELSON, J. D. and SIU, K. L. (1971), The Influence of Structure on the Dilation of Clay, Proc. First Australia-New Zealand Conference on Geomechanics, Melbourne, Australia, August.
11. NELSON, J. D. (1971), Discussion on Paper "Apollo 11 Soil Mechanics Results" by N. C. Costes, W. D. Carrier, J. K. Mitchell, and R. F. Scott, J. Soil Mech. & Found. Div. ASCE, Vol. 97, No. SM10, October.

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12. NELSON, J. D., BRAND, E. W. and MOH, Z. C. (1971), A Probabilistic Approach to the Correction of Measured Soil Strengths, Proc. Conference on Applications of Statistics and Probability to Soil and Structural Engr. Univ. of Hong Kong, Hong Kong, September.
13. MOH, Z. C., BRAND, E. W. and NELSON, J. D. (1972), Pore Pressure Under a Bund on Soft Fissured Clay, Proc. Specialty Conference on Performance of Earth and Earth-Supported Structures, Lafayette, ASCE, June.
14. NELSON, J. D. (1972), Pore Pressure Response Beneath Embankments, Proc. Third Southeast Asian Conference on Soil Engineering, Hong Kong, November.
15. NELSON, J. D. (1973), Influence of Clay Fabric on Bonds and Dilatation, Proc. Int'l. Symposium on Soil Structure, Gothenburg, August.
16. NELSON, J. D., MOH, Z. C. and BRAND, E. W. (1973), Laboratory and Field Consolidation of Soft Clay, Proc. VIII International Conference on Soil Mechanics and Foundation Engineering, Moscow, August.
17. PENG, S. M. and NELSON, J. D. (1973), Ground Motion of Surface Waves, Specialty Session No. 8 - Soil Dynamics and Seismic Effects on Foundations, Proc. VIII International Conference on Soil Mechanics and Foundation Engineering, Moscow, August.
18. NELSON, J. D. and VIRANUVUT, S. (1973), Traffic Induced Vibrations at Wat Po, Bangkok, Geotechnical Engineering, Vol. 4 No. 1, June, pp. 15-30.
19. NELSON, J. D. and THOMPSON, E. G. (1974), Creep Failure of Slopes in Clay and Clay Shale, Proc. 12th Annual Symposium on Engineering Geology and Soil Engineering, Boise, Idaho, April.
20. NELSON, J. D., Shepherd, J. A. and Charlie, W. A. (1977), Parameters Affecting Stability of Tailings Dams, Proc. Geotechnical Practice for Disposal of Solid Waste Materials, ASCE Specialty Conference, Ann Arbor, Michigan, June.
21. NELSON, J. D. and THOMPSON, E. G. (1977), A Theory of Creep Failure in Overconsolidated Clay, Journal of Geotechnical Engineering, ASCE, Vol. 103, No. GT11, November.
22. NELSON, J. D. and EDGAR, T. V. (1978), Moisture Migration Beneath Impermeable Membranes, Proc. 15th Annual Symposium on Engineering Geology and Soil Engineering, Boise, Idaho, April.
23. MCWHORTER, D. B. and NELSON, J. D. (1978), Seepage in the Partially Saturated Zone Beneath Tailings Impoundments, Preprint No. 78-AG-306, Soc. of Mining Engrs., AIME Fall Meeting, Lake Buena Vista, Florida.

24. MCWHORTER, D. B. and NELSON, J. D. (1978), Drainage of Earthen Lined Tailings Impoundments, Proc. Symposium on Uranium Mill Tailings Management, Fort Collins, Colorado.
25. SHEPHERD, T. A. and NELSON, J. D. (1978), Long-Term Stability of Uranium Mill Tailings, Proc. Symposium on Uranium Mill Tailings Management, Fort Collins, Colorado.
26. NELSON, J. D. and PORTER, A. A., Mechanics of Swelling in Expansive Clay Shale, Submitted to Journal of Geotechnical Engineering, ASCE (in review).
27. MCWHORTER, D. B. and NELSON, J. D., "Unsaturated Flow Beneath Tailings Impoundments," submitted to Journal of the Geotechnical Engineering Division, ASCE, (in review).

RÉSUMÉ

Ralph Stuart Saunders

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health: good

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EDUCATION AND TRAINING

Central Michigan University, Mt. Pleasant, Michigan, B.S. majors in Physics and Mathematics, 1966.

Michigan Technological University, Houghton, Mich., M.S. Physics, 1968; including an experimental thesis.

U.S. Army Engineer School, Ft. Belvoir, Va., Engineer Officer Basic Course, 1969; a 10 week course including classroom instruction and practical exercises in several areas of civil engineering, strength of materials, road and airfield construction, bridging, etc..

U.S. Army Engineer Reactors Group, Ft. Belvoir, Va., Nuclear Plant Engineer, 1969; a 6 week course in nuclear power reactor operation including 3 weeks of instruction in water chemistry, health physics, steam and electrical equipment operation, etc., 1 week of training on a control room simulator, and 2 weeks training on an operational nuclear power reactor - 1 week as an equipment operator and 1 week as a control room operator.

Massachusetts Institute of Technology, Boston, Mass., 2 week intensive course in nuclear reactor safety offered jointly by the A. E. C. and M. I. T., 1970.

Control Data Institute, Rockville, Md., a one week course in computer systems program (Scope Applications and Usage) and a 1 week course in

machine language (CP Compass), for the CDC 6600 computer, 1971.

University of Denver, Denver, Colo., Ph.D. Physics, 13 August, 1976, including a theoretical dissertation in the area of physics of the earth's magnetosphere.

WORK EXPERIENCE

During high school worked in a truck farm and a farm implement repair shop.

During undergraduate college period worked in a pickle packing plant, part-time as a caterer, part-time as a stockroom assistant in the physics department and as a projectionist in the Audio Visual Aids department at C.M.U., and during summers in the heat treatment division of the Detroit Diesel diesel manufacturing plant.

As a graduate student at Mich. Tech. Univ. worked as a teaching assistant teaching 10 contact hours per week of undergraduate physics laboratory courses. During the last quarter was responsible for organizing the lab courses as well. Completed the design and construction of an interferometer with a laser source to be used eventually in the measurement of electron densities in plasmas.

On active duty with the U.S. Army Corps of Engineers was permanently assigned to the Nuclear Branch, Engineering Division of the U.S. Army Engineer Reactors Group at Ft. Belvoir, Va., for three years from Jan. 1969 through Dec. 1971. Duties were split between administrative and operational. The operational portion consisted mainly of thermal hydraulic safety design analysis, using computer modeling techniques, for the Army's three nuclear power reactors. Became familiar with several types of computers including the IBM 1130, 7094 and 360-91 models, the UNIVAC 1108, and the CDC 6400 and 6600 models, including remote terminal operation. Became the "Computer Consultant" and managed the computer budget for the Engineering Division. Engineering projects for which I was directly responsible included core management cost analysis for the MH-1A, the steady state thermal hydraulic analysis of core IV for the SM-1A, the core flow distribution analysis of the SM-1, a review of the Navy's emergency core cooling system design for the PM-3, made at the request of the Navy Nuclear Power Unit, and the initial stages of the emergency core cooling system design analysis for the MH-1A (the MH-1A, SM-1, SM-1A, and PM-3A are pressurized water power reactors).

As a graduate research assistant at the University of Denver from Jan. 1972 through Aug. 1976, was engaged in graduate course work and research related to the earth's magnetosphere. Specifically, using a computer model of the solar wind-magnetosphere interaction, conducted a theoretical study of the polar cap electric fields assuming as the source steady state magnetic

field line connection across the magnetopause. Obtained results in good agreement geometrically and fair agreement in terms of intensity, with in situ satellite measurement.

ADMINISTRATIVE EXPERIENCE

As executive officer of the Headquarters Company of the U. S. Army Engineer Reactors Group was directly responsible for the general welfare, pay, quarters, discipline, etc., of 20-30 enlisted reactor operator students and 5 senior NCO's for a period of approximately 5 months.

As assistant branch chief of the Nuclear Branch, Engineering Division, U. S. Army Engineer Reactors Group during the final 8 months of active duty was indirectly responsible for the work of 4 civilian engineers and 4 military engineers and technicians.

As head of the MH-1A Emergency Core Cooling System Analysis Team was directly responsible for the work of a team of 3 engineers for a period of 4 months.

PUBLICATIONS

A Laser Interferometer for the Measurement of the Refractive Indices of Gases, M. S. thesis, Mich. Tech. Univ., Houghton, Mich., 1968.

ED-6920, Core Management Plan for the MH-1A, technical report for the Engineering Division, U. S. Army Engineer Reactors Group, Corps of Engineers, Ft. Belvoir, Va., 1969.

ED-7006, SM-1A Core IV Design Analysis, technical report for the Engineering Division, U. S. Army Engineer Reactors Group, Corps of Engineers, Ft. Belvoir, Va., 1970.

ED-7108, SM-1 Flow Distribution Analysis, technical report for the Engineering Division, U. S. Army Engineer Reactors Group, Corps of Engineers, Ft. Belvoir, Va., 1971.

The Characteristics of Magnetospheric Convective Electric Fields as Mapped onto the Polar Caps, Ph. D. thesis, University of Denver, Denver, Colo., 1976.

SPECIAL SKILLS

Computer programing in FORTRAN (7 years experience), Basic and CP COMPASS (CDC machine language).

Moderate reading ability in French.

Experience in the use of Wang and Hewlett Packard programmable desk calculators.

Certified as an Engineer-In-Training in the state of Colorado.

REFERENCES

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