LEACHING OF SLAG FROM STEEL RECYCLING

DATA REPORT

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INTRODUCTION

In this data report we present leaching results for five slags that were produced by recycling steel. Two of the slags were generated at facilities that treat radioactively contaminated scrap, consequently the slag contains radionuclides. The slag from the other three was not contaminated. Because of this, we were able to examine the chemical composition of the slag and of the leachate generated during tests of these slags. For these materials we believe that leach rates of the stable elements can be used as analogs for radionuclides if the same steel processing method were used for radioactive material.

Slags were obtained by personnel at Jack Faucett and Associates, from 5 facilities:

- Carolina Metals in Barnwell, South Carolina, (Samples = CM)
- SEG in Oak Ridge Tennessee, (Samples = SEG)
- Heckett Multiserve, Provo, Utah (slag from Geneva Steel) (Samples = Q-BOP)
- Ameristeel, Knoxville, Tennessee, and (Samples = AS)
- Steel Slag Coalition, Washington , D.C. (Samples = E)

The first two listed above were radioactively contaminated slags. Each company sent three samples of slag.

TESTS

The objective of this project is to examine the leachability of a set of slags, to determine if there is a significant hazard presented by releases from radioactive slags that are disposed of. Two types of leach tests were used. The Accelerated Leach Test (ALT) (ASTM-1308-95) and a flow-through column test. The ALT is a semi-static leach test in which the leachate is replaced periodically over a period of 11 days. It is used to determine leach rates of waste materials and to test if diffusion controls releases from materials. It has associated with it a computer code that examines the data generated in the test against a set of release models (diffusion and dissolution). Flow through tests are thought to be more realistic than a semi-static test and to represent flow through a deposit of a granular waste.

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January 14, 1997

Dr. Carey Johnston
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401 M. Street
Washington, D.C. 20460

Dear Dr. Johnston:

Per your request, I am pleased to enclose our data report entitled "Leaching of Slags from Steel Recycling". Also find two computer diskettes containing Excel files of the data. We thank you for the opportunity to conduct this research.

This was a particularly interesting project and some of our results have important implications for the long-term behavior of some of the contaminants in the slag samples that we examined. Some of the slags (the non-radioactive samples) are very alkaline and present a complex geochemistry when exposed to air and as precipitation takes place. Deposition of contaminants, along with the precipitate, beneath a heap of this material may take place. As the chemistry eventually becomes less alkaline, what will be the fate of the contaminants ? What amount of time will be required? What contaminants will be associated with this deposit? Use of a model such as BLT-EC (NUREG/CR-6515), which was developed at BNL, combines geochemical modeling with a transport code. This may be ideal for examining these issues.

We observed precipitation of at least two forms of material: carbonates and Fe-oxyhydroxides. If contaminants are associated with these precipitates, facilitated transport of colloid/contaminant may take place. This is particularly a concern because we have observed that Fe-oxide colloids become stable around a pH of 10 (Fuhrmann et al, submitted to Applied Geochemistry). They also have a strong capacity to sorb radionuclides, particularly ^{90}Sr.

Our experiments were all conducted in distilled/deionized water. While this is a reasonable leachant, it may be appropriate to examine releases under conditions of synthetic acid rain.

If you have any questions or comments on the report, or if you would like to discuss these issues further, please fell free to call me at (516) 344-2224 or E-mail at fuhrman1@ bnl.gov.

Sincerely,

Mark Fuhrmann/la

Mark Fuhrmann
Environmental and Waste Technology Center

MF:la
enclosures
cc: B. Riordan

ALT

The method description and the Model Users Guide for the ALT are included with this data report. Subsamples of each slag (15 in total) were tested at 20°C and at 60°C. The leachant was distilled /deionized water. Because one of the slags was only supplied as a powder, some tests were conducted with the pulverized slag loaded in dialysis membrane (Spectra/Por #2, 12,000-14,000 Daltons). Other slags were supplied as monolithic pieces. Consequently, two sets of experiments were conducted for one of the slags; pulverized subsamples were leached in the dialysis membrane and other subsamples were leached as monoliths. This test will allow correlation of releases from the two different forms. Most tests (all of the radioactive samples) were conducted on monoliths. For the membrane experiments, 200 mL of water were used at each sampling interval. The monoliths were leached in 300 mL because the slag pieces required a greater depth of water to be covered. As per the test method, the leachate was not filtered prior to analysis.

Flow-Through Tests

To investigate leaching under dynamic flow conditions, experiments were set-up using plexiglass columns, 7.3 cm in length with inside diameters of 3.2 cm. For the slag from Carolina Metals a column 6.3 cm long and 1.5 cm in diameter was used because of the amount of granular material available. The column was mounted vertically, with the inlet at the bottom. Water was pumped through the column with a low-speed peristaltic pump (Gilson, Minipuls 2). Flow velocities were maintained that were similar to groundwater flow within an aquifer (~60 mL/day). Effluent was initially collected daily, and then at longer intervals. Pre-weighed polyethylene bottles were used for sampling, which were subsequently re-weighed to determine daily flow rates. Aliquots of these samples were taken for analysis.

Leachate Analysis

Leachates from the non-radioactive slags were analyzed for Ca, Si, Al, Fe, Mn, Zn, Sr, and Na by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP). Spot checks were made for B, U, Nd, Ce, V and Mo; none was observed. ICP analysis was conducted with reagent and instrument blanks, standards and calibration checks from a source different than the standards. Samples were acidified with 50% Ultrex HNO_3. A standard and a blank were run every 10 samples.

Leachates were also analyzed by Ion Chromatography (Dionex) for SO_4-, Cl-, and F-. Standards were made from reagent grade salts and were run every 7 samples. An interference was observed with F- analysis when Al concentrations were greater than about 20 mg/L in the leachate. Hence, in Al-rich samples the F concentration is depressed.

Leachate samples from the radioactive slags were analyzed in two ways. First, spot checks were made by counting 20-30 mL of leachate on an intrinsic Ge gamma-spectrometer (with a Canberra computer system). Count times ranged from 1000 to 2000 minutes. Only very low (if any) counts were observed in most samples. Because of the low count rates for gamma-spectroscopy, all samples were analyzed by Liquid Scintillation. Three mL of leachate were mixed with 15 mL of Ultima Gold XR scintillation cocktail and each sample was counted for 10 minutes on a Packard Liquid Scintillation System (Model 1900 TR). Distilled water blanks were run at the

same time. Windows were set at 0-18.6 keV, 18.6-156 keV and 156-2000 keV.

Source Terms of Slags
Each non-radioactive slag was subsampled and sent to Activation Laboratories LTD in Ancaster, Ontario. A standard, of a composition unknown to the company, was included in the set of samples. Analysis was done by neutron activation and by digestion and ICP, giving data for about 60 elements. Comparison of results of the standard analysis with known quantities in the standard were acceptable.

The radioactive slags could not be submitted for this type of analysis because of the quantity of radionuclides present in them. Each sample, prior to leaching was analyzed by gamma spectroscopy. These pieces of slag were irregularly shaped, they did not conform to our standard geometries. But it was necessary to analyze each specific piece of slag that was to be leached in order to minimize intersample variability. Because of this, determination of radionuclide concentration is probably not better than +/- 20%.

RESULTS

Results are presented as both hard copies and as .XLS files on two computer diskettes, using Excel 5.0. Each experiment (the ALT or Column tests) as well as the elemental and radionuclide source terms are on separate files.

Source Terms

There are two data sets for the source terms; the elemental data and the radionuclide data. The elemental source terms are contained in the "composition" directory of the data diskettes. This is data from Activation Labs. The compositions of the non-radioactive slags were dominated by Ca, Fe, Si, Mg and Al. Sr was present at concentrations from 184 - 308 ppm. Source terms for the radioactive samples are contained The radioactive slags contained ^{134}Cs, ^{137}Cs, ^{60}Co, ^{54}Mn, and daughter isotopes of the ^{238}U decay chain, specifically, ^{234}Th , ^{214}Pb and $^{226}Ra/^{235}U$ (185 keV). Not all samples contained all radionuclides. Because of the geometry issue, only ^{137}Cs is given in terms of both counts per minute/gram (cpm/g) and in pCi/g as an example of the approximate activity levels.

Leachates from ALT

Results for each non-radioactive ALT experiment consists of a file containing summary data such as concentrations in the leachate of Al, Ca, Fe, Na, Si, Sr, F-, Cl-, SO_4, and pH. There are also data blocks of Cumulative Mass Released, and Cumulative Fraction Released for the cations (no source term is available for the anions), as well as figures showing Cumulative Releases. This is also given as hardcopy. In each file additional information is contained including; the summary, modeling results which indicate if the diffusion model fits the data and the diffusion coefficient for each element, and a series of graphs of the data and modeling results. This is the standard format of output from the ALT computer model.

For the radioactive slags, data is more limited. Gamma-spectroscopy was done for one or two samples per ALT experiment, because of the long count times required. No activity was observed

by gamma spectroscopy. Detection limits are approximately 0.13 pCi/g of ^{137}Cs. As a result, all samples were analyzed by Liquid Scintillation. Although this method does not provide radionuclide specific information, it is much more sensitive are than gamma-spectroscopy and therefore gives information on total alpha/beta activity. Results are contained in the radionuclide directory of the data diskettes. As with the gamma-spectroscopy, radionuclide concentrations in the leachate were very low if at all above background. Typical corrected values were no more than several cpm/g of leachate, although the first leaching interval often contains the most activity due to surface rinse-off. Activity detected by LSC was generally in the first channel, from 0-18.6 keV implying that a low energy Beta is being detected; possibly ^{90}Sr or ^{99}Tc.

Leachates from Flow-through Tests

Five flow-through leach tests were conducted, two of which contained radioactive slags. Results are given in the "column" directory of the data diskettes. Many of the leachate samples for the radioactive slags were counted by gamma-spectroscopy and all were analyzed by liquid scintillation as well.

PRELIMINARY OBSERVATIONS

- Leachate chemistry of non-radioactive slags was dominated by Ca and high pH. With Al and Si as other major cations released to solution.

- In many of the ALT experiments on radioactive slags, no radioactivity was observed by LSC in the leachate.

- Higher activity was observed in the column than in the ALT tests; reasonable because of the greater mass and surface area of the solid and smaller volume of water per unit time. The highest activities were found at the beginning of the tests.

- Daily fractional release rates of Na from the ALT experiments averaged about 1.3×10^{-2} at the end of the experiment. Na can be taken as an analog for Cs.

- Daily fractional release rates of Sr from ALT experiments averaged about 1.2×10^{-3} at the end of the experiment.

- Releases of Fe were typically at the detection limits of the ICP (about 150 ppb) this translates to daily fractional release rates on the order of 10^{-5}. Fe releases can be considered similar to those of other transition metals.

- Releases of Si appear to have a different controlling mechanism than the other elements examined. Si releases started low and then accelerated over time. This is possibly due to an increase in pH over time. At high pH, the solubility of Si in water increases drastically.

- Uranium daughter radionuclides were observed in the slag. The column leachate with the greatest activity by LSC was counted by gamma-spectroscopy. No ^{238}U daughters were

observed above background levels.

- Due to very high concentrations in column leachates, precipitates are observed in the column itself and in the tubing leading from the outlet to the sample container. This is probably a $CaCO_3$, but other phases are possible given the high Al and Si concentrations in the leachate and the high pH.

- Fe-hydroxide precipitation was observed in one column experiment (CM column). The precipitate occurred as a colloidal aggregate.

- The formation of secondary phases, such as Fe-hydroxides, alumino-silicates, and calcium carbonates, upon exposure of slags to water results in controls on the release of contaminants. On one hand, the precipitation of these secondary phases may attenuate the transport of contaminants; while on the other hand, the formation of colloidal particles may facilitate the transport of contaminants.

Experiment	**Q-BOP-A**
Temp(C)	**20**
material	**powder in membrane**
volume(mL)	**200**

Concentration (ppm)

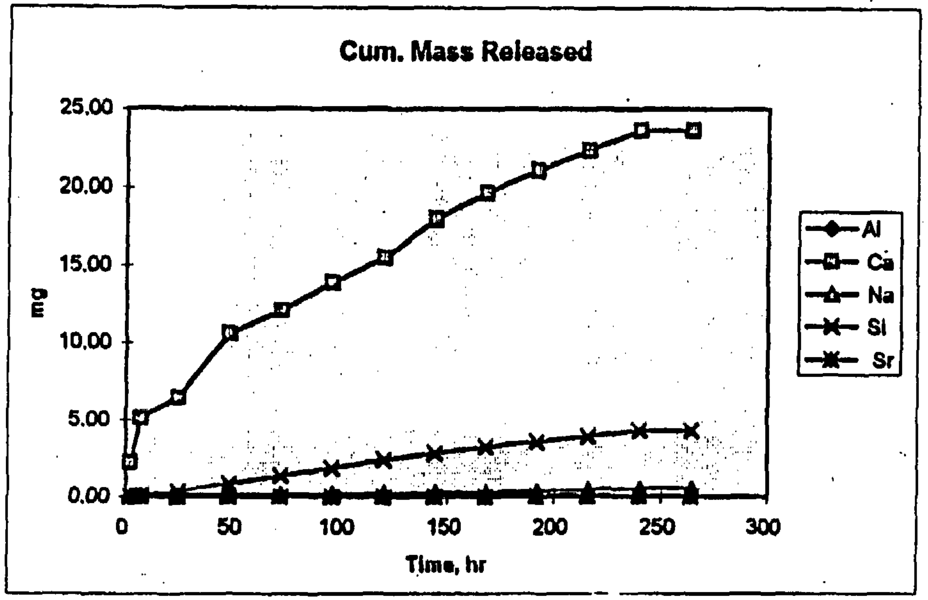
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
QBOPA-1	2	0.04	11.22	0.01	0.47	0.11	0.01	n.a.	n.a.	n.a.	9.30
QBOPA-2	7	-0.02	14.58	0.01	0.04	0.26	0.00	n.a.	n.a.	n.a.	
QBOPA-3	24	0.07	6.75	0.00	0.13	1.39	0.01	n.a.	n.a.	n.a.	10.20
QBOPA-4	48	0.07	20.44	0.01	0.14	2.55	0.02	n.a.	n.a.	n.a.	10.50
QBOPA-5	72	0.01	7.33	0.01	0.14	2.46	0.01	n.a.	n.a.	n.a.	10.10
QBOPA-6	96	0.04	9.18	0.00	0.10	2.51	0.01	n.a.	n.a.	n.a.	10.40
QBOPA-7	120	0.00	8.15	-0.02	0.20	2.83	0.02	n.a.	n.a.	n.a.	10.00
QBOPA-8	144	0.03	12.26	-0.02	0.17	2.18	0.01	n.a.	n.a.	n.a.	10.32
QBOPA-9	168	-0.01	8.39	-0.01	0.16	2.10	0.01	n.a.	n.a.	n.a.	9.35
QBOPA-1C	192	0.00	7.02	-0.01	0.40	1.68	0.03	n.a.	n.a.	n.a.	9.70
QBOPA-11	216	0.00	6.20	-0.01	0.41	1.73	0.03	n.a.	n.a.	n.a.	9.78
QBOPA-12	240	0.02	6.52	-0.01	0.30	1.90	0.03	n.a.	n.a.	n.a.	
QBOPA-13	264										10.05

Cumulative Mass Released (mg) / Cumulative Fractional Releases (cations)

	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4	Al	Ca	Na	Si	Sr
E3-20-1	2	0.01	2.24	0.09	0.02	0.00	n.a.	n.a.	n.a.	9.8E-05	6.1E-04	5.3E-02	1.1E-05	4.5E-04
E3-20-2	7	0.00	5.16	0.10	0.07	0.00	n.a.	n.a.	n.a.	4.2E-05	1.4E-03	5.7E-02	3.9E-05	7.4E-04
QBOPA-3	24	0.02	6.51	0.13	0.35	0.00	n.a.	n.a.	n.a.	2.3E-04	1.8E-03	7.1E-02	1.9E-04	1.5E-03
QBOPA-4	48	0.03	10.60	0.16	0.86	0.01	n.a.	n.a.	n.a.	4.0E-04	2.9E-03	8.6E-02	4.6E-04	2.9E-03
QBOPA-5	72	0.03	12.06	0.18	1.35	0.01	n.a.	n.a.	n.a.	4.2E-04	3.3E-03	1.0E-01	7.2E-04	4.1E-03
QBOPA-6	96	0.04	13.90	0.20	1.85	0.01	n.a.	n.a.	n.a.	5.0E-04	3.8E-03	1.1E-01	9.9E-04	5.1E-03
QBOPA-7	120	0.04	15.53	0.24	2.42	0.02	n.a.	n.a.	n.a.	5.0E-04	4.2E-03	1.3E-01	1.3E-03	6.5E-03
QBOPA-8	144	0.05	17.98	0.28	2.86	0.02	n.a.	n.a.	n.a.	5.6E-04	4.9E-03	1.5E-01	1.5E-03	7.7E-03
QBOPA-9	168	0.04	19.66	0.31	3.28	0.02	n.a.	n.a.	n.a.	5.4E-04	5.4E-03	1.7E-01	1.7E-03	8.9E-03
QBOPA-1C	192	0.04	21.06	0.39	3.61	0.03	n.a.	n.a.	n.a.	5.5E-04	5.8E-03	2.2E-01	1.9E-03	1.1E-02
QBOPA-11	216	0.04	22.30	0.47	3.96	0.03	n.a.	n.a.	n.a.	5.5E-04	6.1E-03	2.6E-01	2.1E-03	1.3E-02
QBOPA-12	240	0.05	23.61	0.53	4.34	0.04	n.a.	n.a.	n.a.	6.1E-04	6.5E-03	3.0E-01	2.3E-03	1.6E-02
QBOPA-13	264	0.05	23.61	0.53	4.34	0.04	n.a.	n.a.	n.a.	6.1E-04	6.5E-03	3.0E-01	2.3E-03	1.6E-02

QBOPA-13	264	0.05	23.61	0.53	4.34	0.04	0.00	0.00	0.00	6.1E-04	6.5E-03	3.0E-01	2.3E-03	1.6E-02

Experiment Q-BOP-A



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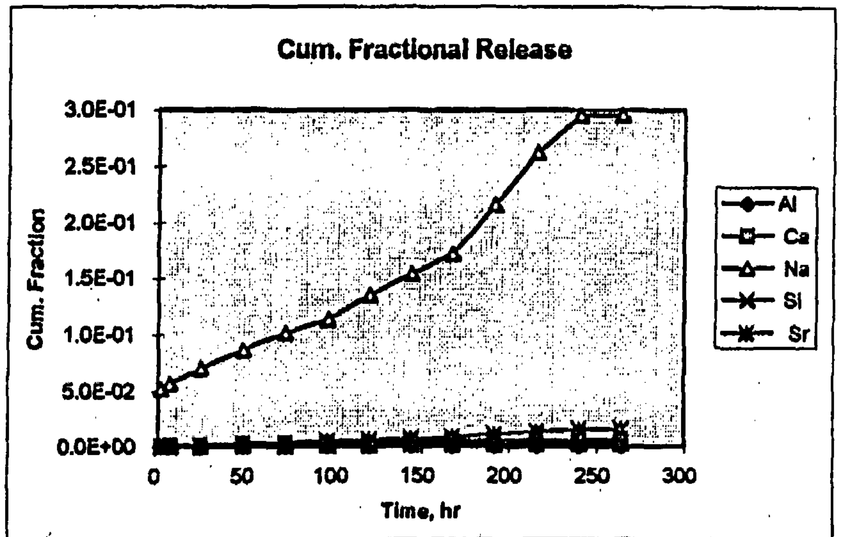


Summary

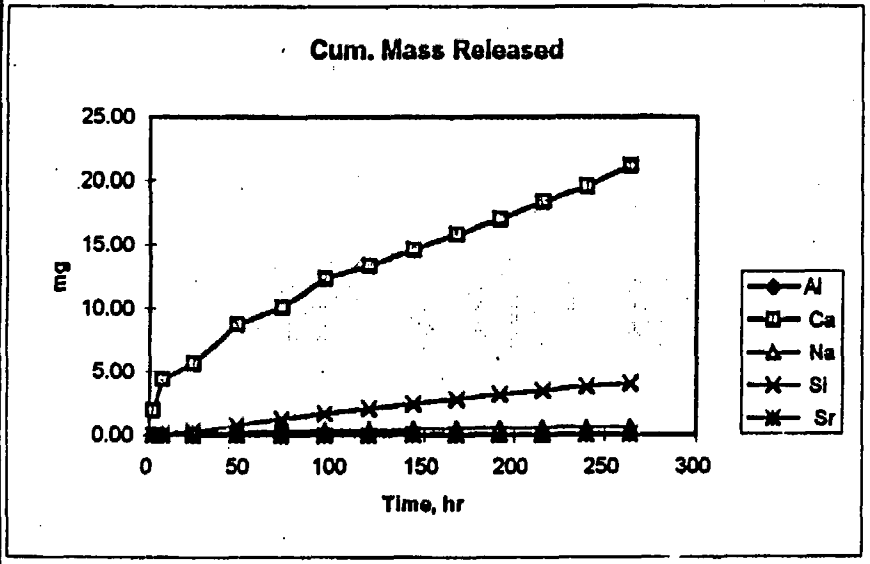
Experiment	Q-BOP-B
Temp(C)	20
material	powder in membrane
volume(mL)	200

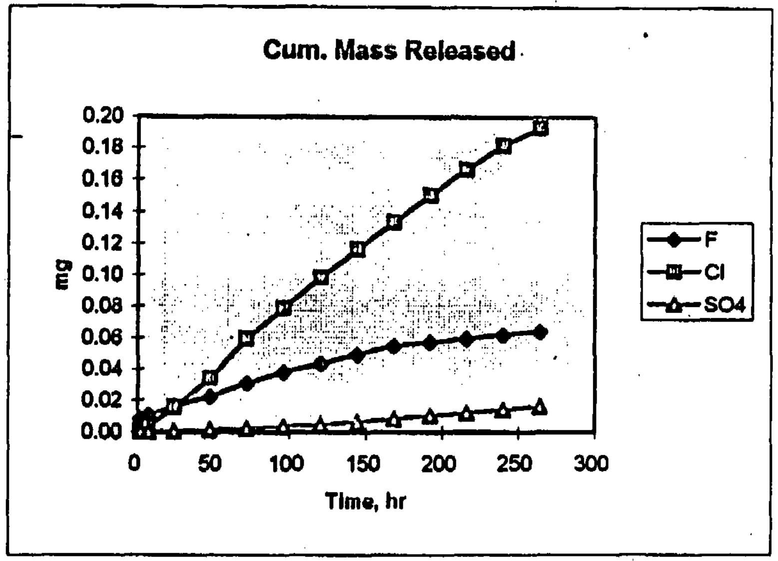
Concentration (ppm)

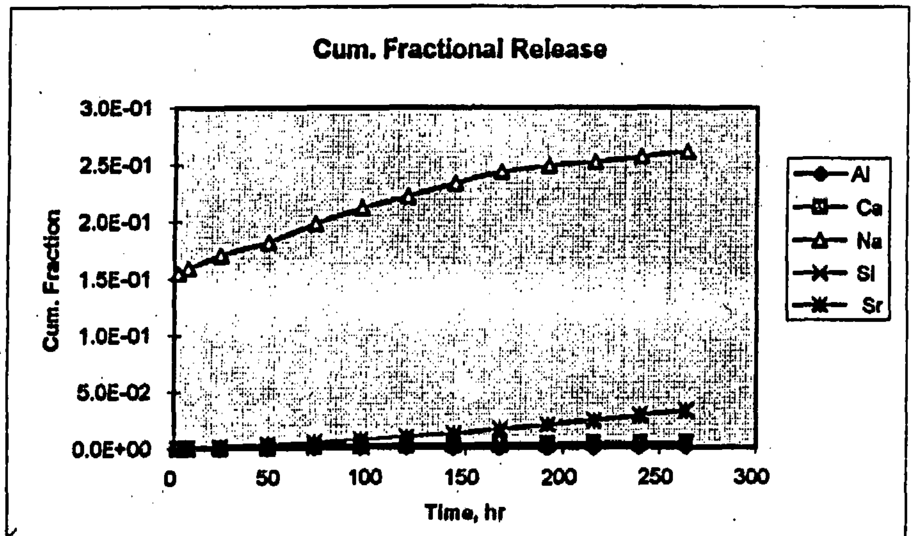
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
QBOPB-1	2	0.00	9.56	-0.01	0.39	0.09	0.01	0.04	0.00	0.00	10.50
QBOPB-2	7	0.00	12.34	-0.01	0.12	0.28	0.00	0.01	0.01	0.00	10.60
QBOPB-3	24	0.03	6.50	-0.01	0.29	1.30	0.01	0.03	0.06	0.00	10.32
QBOPB-4	48	0.05	15.26	-0.01	0.28	1.92	0.02	0.03	0.09	0.00	10.80
QBOPB-5	72	0.05	6.71	-0.01	0.40	2.67	0.02	0.04	0.13	0.00	10.12
QBOPB-6	96	0.05	11.48	-0.01	0.34	2.09	0.03	0.04	0.10	0.01	10.52
QBOPB-7	120	-0.01	5.29	-0.01	0.25	2.02	0.03	0.03	0.10	0.01	10.02
QBOPB-8	144	0.05	6.25	-0.01	0.28	1.91	0.04	0.03	0.09	0.01	9.55
QBOPB-9	168	0.03	5.84	0.00	0.25	1.78	0.05	0.03	0.08	0.01	9.90
QBOPB-10	192	0.04	6.02	0.00	0.13	1.83	0.05	0.01	0.09	0.01	
QBOPB-11	216	0.05	6.65	-0.01	0.09	1.60	0.04	0.01	0.08	0.01	9.20
QBOPB-12	240	0.05	5.76	0.00	0.12	1.61	0.06	0.01	0.08	0.01	10.34
QBOPB-13	264	0.05	8.06	-0.01	0.12	1.21	0.05	0.01	0.06	0.01	10.52

		Cumulative Mass Released (mg)								Cumulative Fractional Releases (cations)				
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4	Al	Ca	Na	Si	Sr
QBOPB-1	2	0.00	1.91	0.08	0.02	0.00	0.01	0.00	0.00	0.0E+00	4.8E-04	1.6E-01	2.1E-05	4.6E-04
QBOPB-2	7	0.00	4.38	0.10	0.07	0.00	0.01	0.00	0.00	1.7E-09	1.1E-03	1.6E-01	8.3E-05	8.4E-04
QBOPB-3	24	0.01	5.68	0.16	0.33	0.00	0.02	0.02	0.00	6.7E-05	1.4E-03	1.7E-01	3.7E-04	1.8E-03
QBOPB-4	48	0.02	8.73	0.21	0.72	0.01	0.02	0.03	0.00	1.9E-04	2.2E-03	1.8E-01	8.0E-04	3.3E-03
QBOPB-5	72	0.03	10.07	0.30	1.25	0.01	0.03	0.06	0.00	3.2E-04	2.5E-03	2.0E-01	1.4E-03	5.2E-03
QBOPB-6	96	0.03	12.37	0.36	1.67	0.02	0.04	0.08	0.00	4.4E-04	3.1E-03	2.1E-01	1.9E-03	7.4E-03
QBOPB-7	120	0.03	13.43	0.41	2.07	0.02	0.04	0.10	0.00	4.2E-04	3.4E-03	2.2E-01	2.3E-03	9.6E-03
QBOPB-8	144	0.04	14.68	0.47	2.45	0.03	0.05	0.12	0.01	5.4E-04	3.7E-03	2.3E-01	2.7E-03	1.3E-02
QBOPB-9	168	0.05	15.85	0.52	2.81	0.04	0.05	0.13	0.01	6.3E-04	4.0E-03	2.4E-01	3.1E-03	1.7E-02
QBOPB-10	192	0.06	17.05	0.55	3.17	0.05	0.06	0.15	0.01	7.4E-04	4.3E-03	2.5E-01	3.5E-03	2.1E-02
QBOPB-11	216	0.07	18.38	0.56	3.50	0.06	0.06	0.17	0.01	8.7E-04	4.6E-03	2.5E-01	3.9E-03	2.4E-02
QBOPB-12	240	0.08	19.53	0.59	3.82	0.07	0.06	0.18	0.01	1.0E-03	4.9E-03	2.6E-01	4.3E-03	2.9E-02
QBOPB-13	264	0.09	21.14	0.61	4.06	0.08	0.06	0.19	0.02	1.1E-03	5.3E-03	2.6E-01	4.5E-03	3.3E-02

Experiment Q-BOP-B





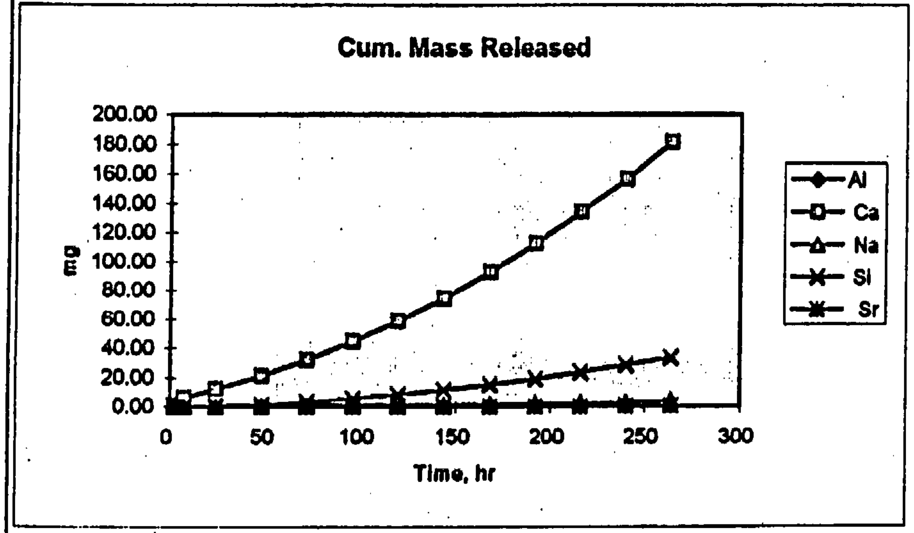


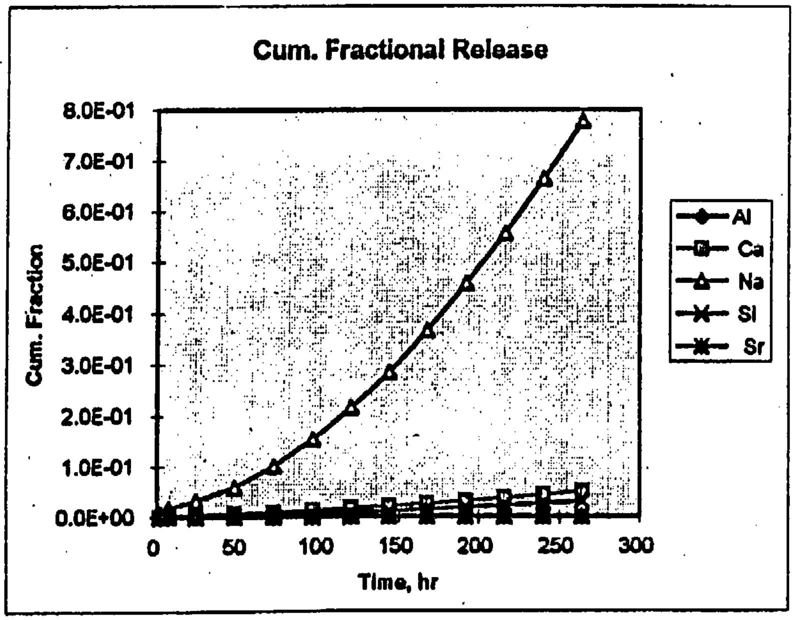
Experiment	**Q-BOP-C**
Temp(C)	**20**
material	**powder in membrane**
volume(mL)	**200**

		Concentration (ppm)									
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
QBOPC-1	2	0.00	7.50	-0.01	0.19	0.06	0.00	n.a.	n.a.	n.a.	10.45
QBOPC-2	7	0.00	21.65	-0.02	0.22	0.31	0.01	n.a.	n.a.	n.a.	10.70
QBOPC-3	24	0.00	30.73	-0.04	0.42	1.75	0.02	n.a.	n.a.	n.a.	10.60
QBOPC-4	48	0.05	46.12	-0.05	0.65	4.63	0.03	n.a.	n.a.	n.a.	10.70
QBOPC-5	72	0.06	53.38	-0.06	1.04	8.21	0.06	n.a.	n.a.	n.a.	10.30
QBOPC-6	96	0.09	62.78	-0.08	1.31	11.01	0.08	n.a.	n.a.	n.a.	10.52
QBOPC-7	120	0.10	70.28	-0.09	1.53	13.67	0.10	n.a.	n.a.	n.a.	9.60
QBOPC-8	144	0.08	78.14	-0.11	1.73	16.04	0.12	n.a.	n.a.	n.a.	9.60
QBOPC-9	168	0.12	91.41	-0.11	2.07	18.22	0.16	n.a.	n.a.	n.a.	9.70
QBOPC-10	192	0.14	99.30	-0.11	2.30	20.33	0.19	n.a.	n.a.	n.a.	
QBOPC-11	216	0.13	107.47	-0.12	2.45	22.30	0.21	n.a.	n.a.	n.a.	9.25
QBOPC-12	240	0.17	114.17	-0.12	2.70	23.96	0.26	n.a.	n.a.	n.a.	10.30
QBOPC-13	264	0.20	122.00	-0.13	2.83	25.33	0.30	n.a.	n.a.	n.a.	10.22

		Cumulative Mass Released (mg)								Cumulative Fractional Releases (cations)				
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4	Al	Ca	Na	Si	Sr
E3-20-1	2	0.00	1.50	0.04	0.01	0.00	n.a.	n.a.	n.a.	0.0E+00	4.1E-04	7.6E-03	1.1E-05	1.7E-04
E3-20-2	7	0.00	5.83	0.08	0.07	0.00	n.a.	n.a.	n.a.	0.0E+00	1.6E-03	1.6E-02	6.9E-05	1.7E-04
QBOPC-3	24	0.00	11.98	0.17	0.42	0.00	n.a.	n.a.	n.a.	0.0E+00	3.3E-03	3.3E-02	4.0E-04	1.7E-04
QBOPC-4	48	0.01	21.20	0.30	1.35	0.01	n.a.	n.a.	n.a.	6.9E-05	5.8E-03	5.9E-02	1.3E-03	1.8E-04
QBOPC-5	72	0.02	31.87	0.50	2.99	0.02	n.a.	n.a.	n.a.	1.5E-04	8.8E-03	1.0E-01	2.8E-03	1.8E-04
QBOPC-6	96	0.04	44.43	0.77	5.19	0.04	n.a.	n.a.	n.a.	2.9E-04	1.2E-02	1.5E-01	4.9E-03	1.9E-04
QBOPC-7	120	0.06	58.49	1.07	7.93	0.06	n.a.	n.a.	n.a.	4.3E-04	1.6E-02	2.1E-01	7.4E-03	1.9E-04
QBOPC-8	144	0.08	74.11	1.42	11.14	0.08	n.a.	n.a.	n.a.	5.6E-04	2.0E-02	2.8E-01	1.0E-02	2.0E-04
QBOPC-9	168	0.10	92.40	1.83	14.78	0.11	n.a.	n.a.	n.a.	7.3E-04	2.5E-02	3.7E-01	1.4E-02	2.1E-04
QBOPC-10	192	0.13	112.26	2.29	18.84	0.15	n.a.	n.a.	n.a.	9.4E-04	3.1E-02	4.6E-01	1.8E-02	2.3E-04
QBOPC-11	216	0.15	133.75	2.78	23.30	0.19	n.a.	n.a.	n.a.	1.1E-03	3.7E-02	5.6E-01	2.2E-02	2.4E-04
QBOPC-12	240	0.19	156.58	3.32	28.10	0.25	n.a.	n.a.	n.a.	1.4E-03	4.3E-02	6.6E-01	2.6E-02	2.6E-04
QBOPC-13	264	0.23	180.98	3.89	33.16	0.30	n.a.	n.a.	n.a.	1.7E-03	5.0E-02	7.8E-01	3.1E-02	2.8E-04

Experiment Q-BOP-C





Experiment	E1
Temp(C)	20
material	chunk
volume(mL)	300

Concentration (ppm)

	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
E1-20-1	2	10.98	36.27	0.56	5.62	2.60	0.02	1.08	0.69	2.48	11.20
E1-20-2	7	19.85	40.24	0.15	1.70	0.65	0.04	1.52	0.24	0.61	11.40
E1-20-3	24	59.23	92.91	0.04	1.73	0.32	0.10	0.00	0.30	0.54	11.70
E1-20-4	48	79.50	107.00	0.02	1.17	0.25	0.11	0.00	0.27	0.43	11.35
E1-20-5	72	67.54	92.30	-0.01	0.88	0.27	0.08	0.00	0.22	0.41	11.30
E1-20-6	96	60.09	82.34	0.01	0.54	0.40	0.07	0.00	0.16	0.41	11.25
E1-20-7	120	50.25	70.54	0.02	0.50	0.42	0.07	0.00	0.15	0.41	11.25
E1-20-8	144	40.74	62.76	0.01	0.46	0.56	0.06	0.00	0.17	0.39	11.20
E1-20-9	168	32.95	52.39	0.00	0.41	0.55	0.05	0.00	0.00	0.00	11.15
E1-20-10	192	25.74	45.04	0.02	0.35	0.65	0.05	0.00	0.08	0.29	11.10
E1-20-11	216	21.29	36.35	0.01	0.29	0.72	0.04	0.95	0.06	0.27	11.05
E1-20-12	240	19.87	36.56	0.03	0.31	0.90	0.04	0.94	0.08	0.27	11.05
E1-20-13	264	17.57	37.55	0.01	0.27	0.85	0.04	0.83	0.05	0.25	11.00

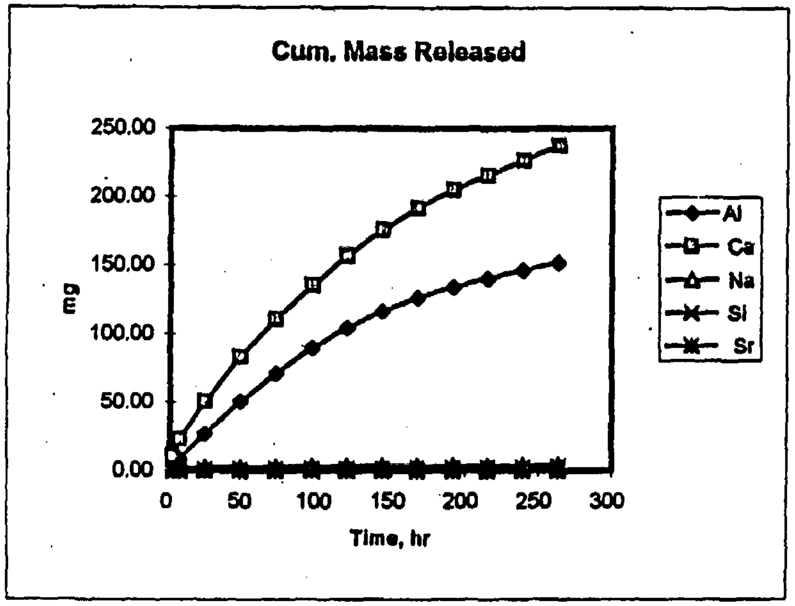
Cumulative Mass Released (mg)

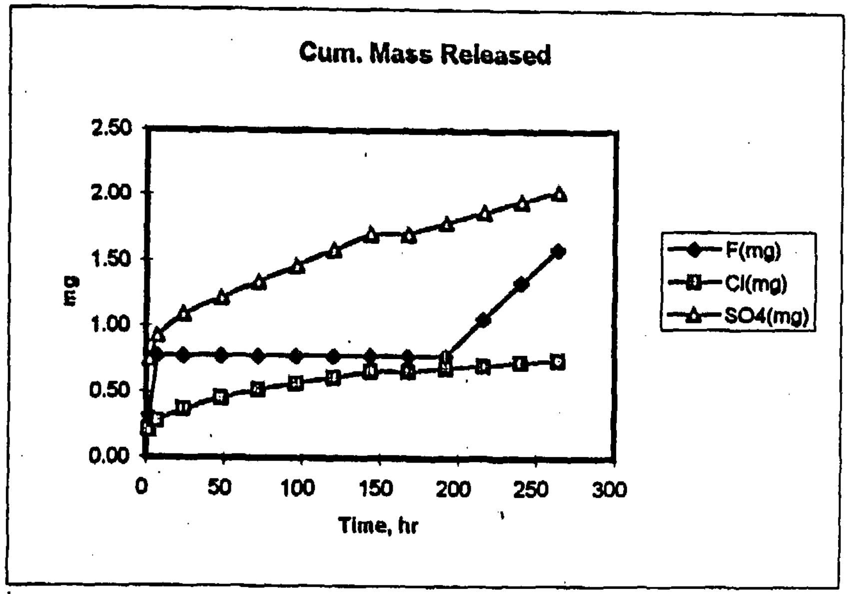
	time(hrs)	Al	Ca	Na	Si	Sr	F(mg)	Cl(mg)	SO4(mg)
E1-20-1	2	3.29	10.88	1.69	0.78	0.01	0.32	0.21	0.75
E1-20-2	7	9.25	22.95	2.19	0.97	0.02	0.78	0.28	0.93
E1-20-3	24	27.02	50.83	2.72	1.07	0.05	0.78	0.37	1.09
E1-20-4	48	50.87	82.93	3.07	1.15	0.08	0.78	0.45	1.22
E1-20-5	72	71.13	110.62	3.33	1.23	0.11	0.78	0.52	1.34
E1-20-6	96	89.16	135.32	3.49	1.35	0.13	0.78	0.57	1.46
E1-20-7	120	104.23	156.48	3.64	1.47	0.15	0.78	0.61	1.59
E1-20-8	144	116.45	175.31	3.78	1.64	0.17	0.78	0.66	1.70
E1-20-9	168	126.34	191.03	3.91	1.80	0.18	0.78	0.66	1.70
E1-20-10	192	134.06	204.54	4.01	2.00	0.20	0.78	0.69	1.79
E1-20-11	216	140.45	215.44	4.10	2.21	0.21	1.06	0.71	1.87
E1-20-12	240	146.41	226.41	4.19	2.48	0.22	1.34	0.73	1.95
E1-20-13	264	151.68	237.68	4.27	2.74	0.23	1.59	0.75	2.03

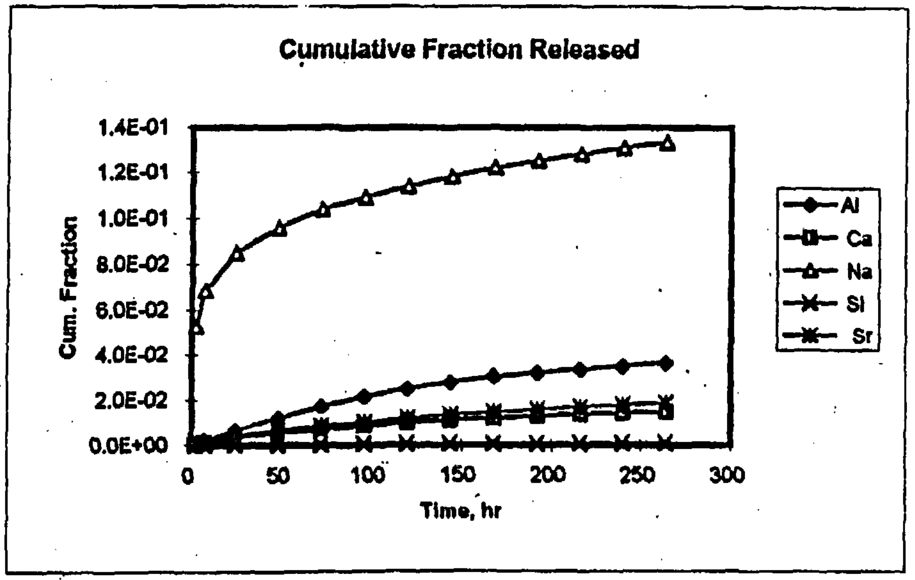
Cumulative Fractional Releases (cations)

	Al	Ca	Na	Si	Sr
E1-20-1	7.9E-04	6.8E-04	5.3E-02	2.6E-04	5.8E-04
E1-20-2	2.2E-03	1.4E-03	6.9E-02	3.2E-04	1.5E-03
E1-20-3	6.4E-03	3.2E-03	8.5E-02	3.6E-04	4.0E-03
E1-20-4	1.2E-02	5.2E-03	9.6E-02	3.8E-04	6.5E-03
E1-20-5	1.7E-02	6.9E-03	1.0E-01	4.1E-04	8.5E-03
E1-20-6	2.1E-02	8.4E-03	1.1E-01	4.5E-04	1.0E-02
E1-20-7	2.5E-02	9.7E-03	1.1E-01	4.9E-04	1.2E-02
E1-20-8	2.8E-02	1.1E-02	1.2E-01	5.4E-04	1.3E-02
E1-20-9	3.0E-02	1.2E-02	1.2E-01	6.0E-04	1.5E-02
E1-20-10	3.2E-02	1.3E-02	1.3E-01	6.6E-04	1.6E-02
E1-20-11	3.4E-02	1.3E-02	1.3E-01	7.4E-04	1.7E-02
E1-20-12	3.5E-02	1.4E-02	1.3E-01	8.2E-04	1.8E-02
E1-20-13	3.6E-02	1.5E-02	1.3E-01	9.1E-04	1.8E-02

Experiment E1







Experiment	E2
Temp(C)	20
material	chunk
volume(mL)	300

Concentrations mg/L

	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
E2-20-1	2	7.35	31.07	2.47	2.32	2.53	0.02	0.69	0.18	1.13	11.03
E2-20-2	7	8.86	25.71	0.52	1.16	0.93	0.02	1.02	0.17	0.84	11.22
E2-20-3	24	16.23	34.63	0.19	1.14	1.11	0.03	1.87	0.21	1.02	11.40
E2-20-4	48	13.97	42.29	0.15	0.77	1.60	0.04	2.13	0.17	0.88	
E2-20-5	72	9.08	35.95	0.08	0.49	2.28	0.03	1.54	0.10	0.68	11.05
E2-20-6	96	5.13	31.20	0.12	0.32	2.91	0.03	1.18	0.07	0.56	11.03
E2-20-7	120	3.68	33.43	0.04	0.24	3.89	0.03	1.06	0.04	0.54	11.02
E2-20-8	144	2.87	32.51	0.12	0.22	4.33	0.04	1.00	0.05	0.52	11.00
E2-20-9	168	2.38	37.15	0.01	0.18	5.08	0.04	1.06	0.03	0.54	11.10
E2-20-10	192	1.94	36.08	0.04	0.17	4.95	0.03	0.95	0.03	0.50	11.00
E2-20-11	216	1.77	31.63	0.03	0.13	4.83	0.03	0.95	0.02	0.46	11.00
E2-20-12	240	1.58	22.33	0.00	0.15	5.20	0.03	0.90	0.02	0.47	10.90
E2-20-13	264	1.63	32.63	0.00	0.14	5.49	0.03	0.92	0.02	0.45	11.00

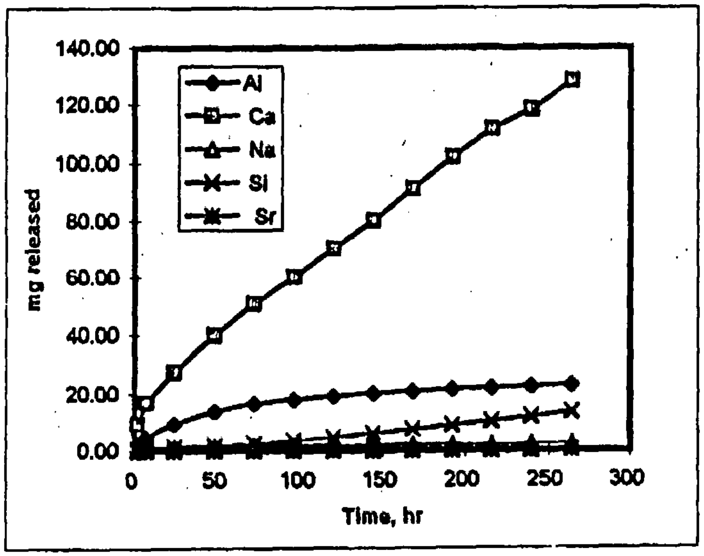
Cumulative Mass Released (mg)

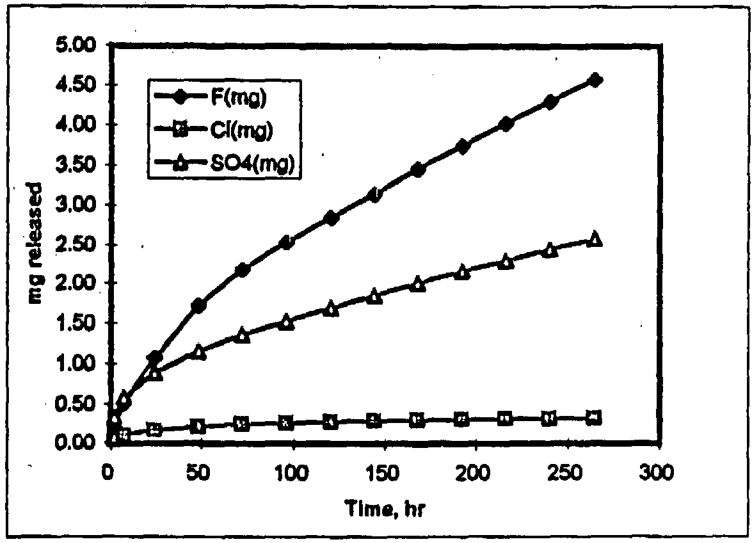
	time(hrs)	Al	Ca	Na	Si	Sr	F(mg)	Cl(mg)	SO4(mg)
E2-20-1	2	2.21	9.32	0.69	0.76	0.01	0.21	0.05	0.34
E2-20-2	7	4.86	17.03	1.04	1.04	0.01	0.51	0.10	0.59
E2-20-3	24	9.73	27.42	1.38	1.37	0.02	1.08	0.17	0.89
E2-20-4	48	13.92	40.11	1.62	1.85	0.03	1.72	0.22	1.16
E2-20-5	72	16.64	50.90	1.76	2.53	0.04	2.18	0.25	1.36
E2-20-6	96	18.18	60.26	1.86	3.40	0.05	2.53	0.27	1.53
E2-20-7	120	19.29	70.28	1.93	4.57	0.06	2.85	0.28	1.69
E2-20-8	144	20.15	80.04	2.00	5.87	0.07	3.15	0.30	1.85
E2-20-9	168	20.86	91.18	2.05	7.40	0.08	3.47	0.31	2.01
E2-20-10	192	21.44	102.01	2.10	8.88	0.09	3.75	0.31	2.16
E2-20-11	216	21.97	111.50	2.14	10.33	0.10	4.03	0.32	2.30
E2-20-12	240	22.44	118.19	2.19	11.89	0.11	4.31	0.33	2.44
E2-20-13	264	22.93	127.98	2.23	13.53	0.12	4.58	0.33	2.58

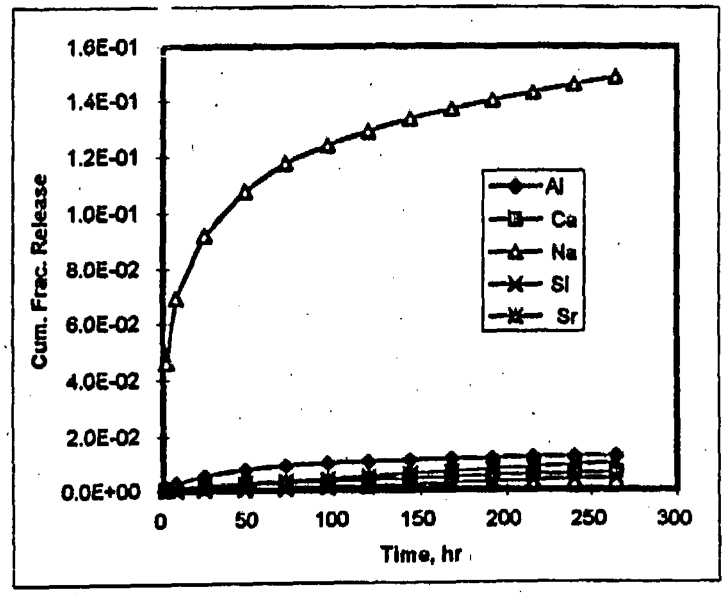
Cumulative Fractional Releases (cations)

	Al	Ca	Na	Si	Sr
E2-20-1	1.2E-03	4.7E-04	4.6E-02	2.4E-04	4.6E-04
E2-20-2	2.7E-03	8.5E-04	7.0E-02	3.3E-04	8.6E-04
E2-20-3	5.4E-03	1.4E-03	9.2E-02	4.3E-04	1.6E-03
E2-20-4	7.7E-03	2.0E-03	1.1E-01	5.9E-04	2.5E-03
E2-20-5	9.2E-03	2.5E-03	1.2E-01	8.0E-04	3.3E-03
E2-20-6	1.0E-02	3.0E-03	1.2E-01	1.1E-03	4.1E-03
E2-20-7	1.1E-02	3.5E-03	1.3E-01	1.4E-03	4.9E-03
E2-20-8	1.1E-02	4.0E-03	1.3E-01	1.9E-03	5.8E-03
E2-20-9	1.2E-02	4.6E-03	1.4E-01	2.3E-03	6.7E-03
E2-20-10	1.2E-02	5.1E-03	1.4E-01	2.8E-03	7.5E-03
E2-20-11	1.2E-02	5.6E-03	1.4E-01	3.3E-03	8.3E-03
E2-20-12	1.2E-02	5.9E-03	1.5E-01	3.8E-03	9.1E-03
E2-20-13	1.3E-02	6.4E-03	1.5E-01	4.3E-03	9.9E-03

Experiment E2





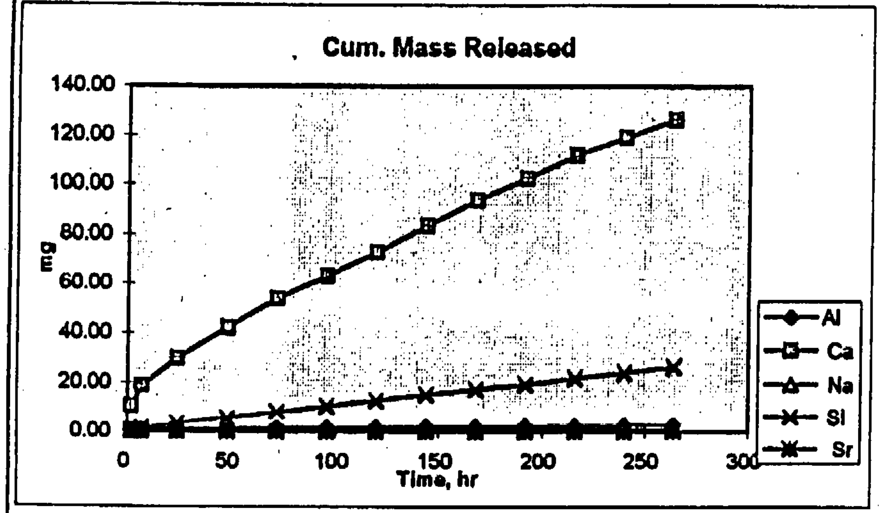


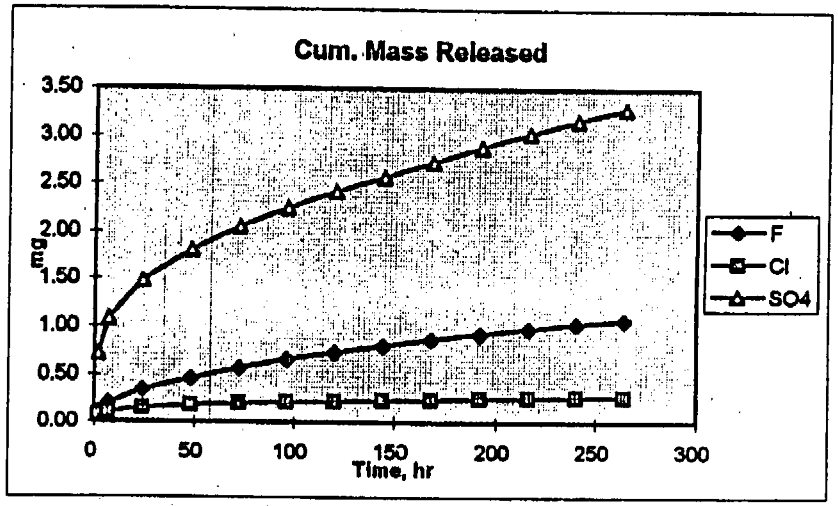
Experiment **E3**
Temp(C) **20**
material **chunk**
volume(mL) **300**

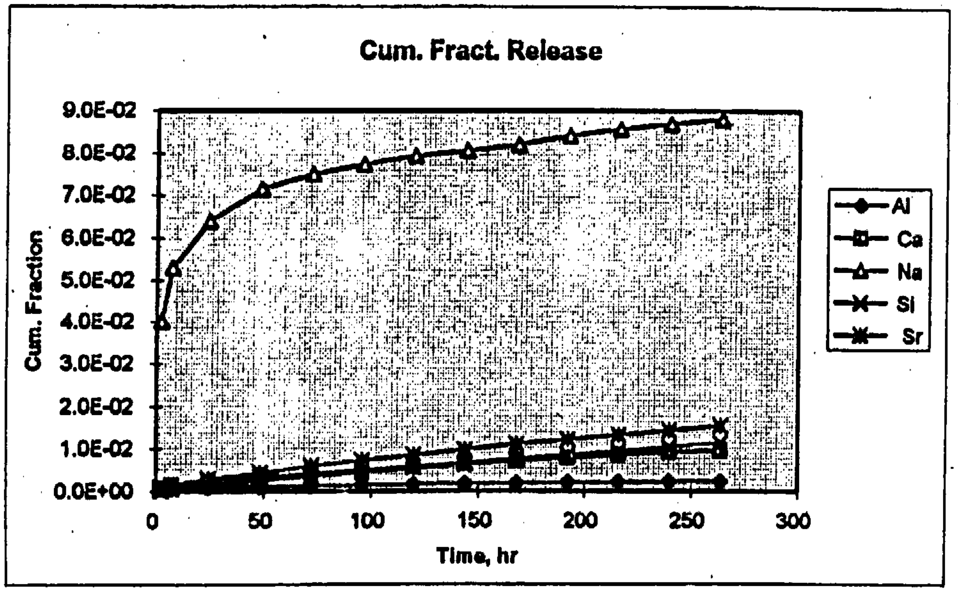
	time(hrs)	Concentration (ppm) Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
E3-20-1	2	2.498	34.81	1.017	1.338	2.671	0.02463	0.38	0.26	2.40	11.38
E3-20-2	7	1.044	28.98	0.1912	0.4311	2.862	0.02122	0.30	0.12	1.20	11.42
E3-20-3	24	0.9202	34.93	0.08689	0.3648	5.957	0.03674	0.46	0.14	1.34	11.50
E3-20-4	48	0.7685	41.8	0.05356	0.2466	7.529	0.04373	0.44	0.10	1.06	11.15
E3-20-5	72	0.6275	38.39	0.02717	0.1217	7.823	0.04476	0.36	0.07	0.82	11.10
E3-20-6	96	0.6174	31.91	0.00482	0.07572	7.815	0.03805	0.28	0.05	0.66	11.10
E3-20-7	120	0.5651	32.04	0.00131	0.06386	7.919	0.03483	0.25	0.04	0.57	11.10
E3-20-8	144	0.5994	35.68	0.0491	0.04535	7.964	0.0375	0.23	0.04	0.52	11.10
E3-20-9	168	0.5609	34.08	-0.00569	0.04342	7.632	0.0367	0.22	0.03	0.52	11.08
E3-20-10	192	0.5283	29.47	-0.00292	0.07138	7.411	0.03362	0.20	0.03	0.53	11.05
E3-20-11	216	0.4989	30.89	-0.00652	0.0547	7.499	0.03148	0.18	0.02	0.47	11.00
E3-20-12	240	0.5164	23.68	-0.00549	0.04211	7.575	0.03184	0.16	0.02	0.47	
E3-20-13	264	0.4763	24.32	-0.00939	0.03653	7.615	0.03171	0.13716	0.00951	0.40906	

		Cumulative Mass Released (mg)								Cumulative Fractional Releases (cations)				
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4	Al	Ca	Na	Si	Sr
E3-20-1	2	0.75	10.44	0.40	0.80	0.01	0.12	0.08	0.72	5.8E-04	8.1E-04	4.0E-02	3.5E-04	8.6E-04
E3-20-2	7	1.06	19.14	0.53	1.66	0.01	0.20	0.11	1.08	8.2E-04	1.5E-03	5.3E-02	7.2E-04	1.6E-03
E3-20-3	24	1.34	29.62	0.64	3.45	0.02	0.34	0.15	1.48	1.0E-03	2.3E-03	6.4E-02	1.5E-03	2.9E-03
E3-20-4	48	1.57	42.16	0.71	5.71	0.04	0.47	0.18	1.80	1.2E-03	3.3E-03	7.1E-02	2.5E-03	4.4E-03
E3-20-5	72	1.76	53.67	0.75	8.05	0.05	0.58	0.20	2.05	1.4E-03	4.2E-03	7.5E-02	3.5E-03	5.9E-03
E3-20-6	96	1.94	63.25	0.77	10.40	0.06	0.66	0.22	2.25	1.5E-03	4.9E-03	7.7E-02	4.5E-03	7.3E-03
E3-20-7	120	2.11	72.86	0.79	12.77	0.07	0.74	0.23	2.42	1.6E-03	5.6E-03	7.9E-02	5.5E-03	8.5E-03
E3-20-8	144	2.29	83.56	0.81	15.16	0.08	0.81	0.24	2.57	1.8E-03	6.5E-03	8.1E-02	6.6E-03	9.8E-03
E3-20-9	168	2.46	93.79	0.82	17.45	0.10	0.87	0.25	2.73	1.9E-03	7.3E-03	8.2E-02	7.6E-03	1.1E-02
E3-20-10	192	2.62	102.63	0.84	19.67	0.11	0.93	0.26	2.89	2.0E-03	8.0E-03	8.4E-02	8.5E-03	1.2E-02
E3-20-11	216	2.77	111.89	0.86	21.92	0.11	0.99	0.27	3.03	2.1E-03	8.7E-03	8.6E-02	9.5E-03	1.3E-02
E3-20-12	240	2.92	119.00	0.87	24.20	0.12	1.03	0.27	3.17	2.3E-03	9.2E-03	8.7E-02	1.0E-02	1.4E-02
E3-20-13	264	3.07	126.29	0.88	26.48	0.13	1.08	0.28	3.29	2.4E-03	9.8E-03	8.8E-02	1.1E-02	1.6E-02

Experiment E3







Experiment	**E1**
Temp(C)	**60**
material	**chunk**
volume(mL)	**300**

Concentration (ppm)

	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
E1-1	2	30.38	78.55	0.9938	2.987	1.837	0.08396	0.86	1.87	1.91	11.3
E1-2	7	23.77	62.47	0.01983	1.259	0.4343	0.06049	0.76	0.76	0.99	11.52
E1-3	24	18.31	92.05	0.01492	1.573	0.9529	0.1123	1.23	0.94	2.75	12.5
E1-4	48	8.975	81.65	-0.00158	1.167	1.76	0.109	1.23	0.48	3.59	
E1-5	72	5.401	70.2	0.001946	0.6918	2.744	0.08745	0.86	0.23	2.67	
E1-6	96	3.726	55.4	-0.00235	0.5916	3.207	0.07357	0.69	0.14	2.14	
E1-7	120	3.111	59.57	-0.0034	0.4884	3.629	0.07313	0.65	0.09	1.83	
E1-8	144	2.578	50.92	0.007021	0.4093	3.331	0.06742	0.63	0.07	1.65	12.27
E1-9	168	2.307	47.8	0.006615	0.3994	3.159	0.0588	0.62	0.01	1.37	
E1-10	192	2.631	50.49	0.000708	0.3349	3.162	0.05578	0.65	0.03	1.37	
E1-11	216	2.43	42.05	0.006997	0.3526	3.062	0.05347	0.64	0.03	1.26	
E1-12	240	2.583	43.33	0.004456	0.3125	2.935	0.05175	0.59	0.03	1.16	
E1-13	264	2.567	43.63	0.003933	0.2908	3.543	0.05893	0.06	0.03	1.18	12.15

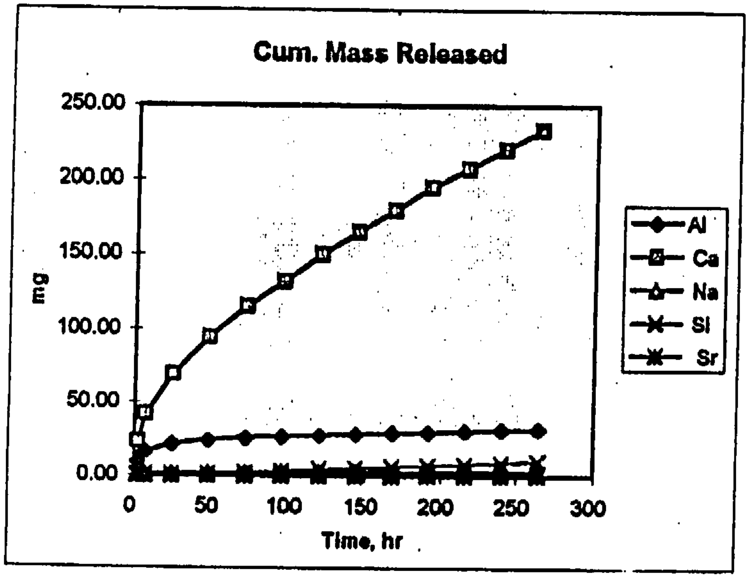
Cumulative Mass Released (mg)

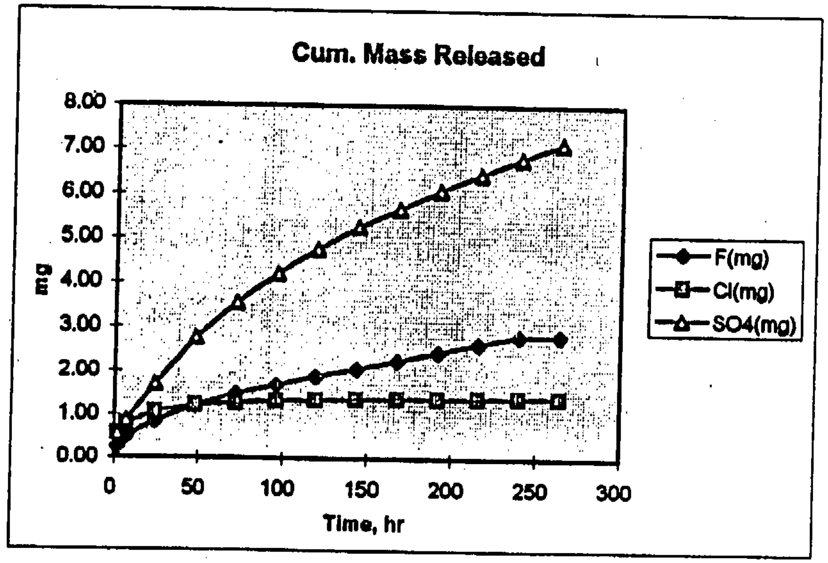
	time(hrs)	Al	Ca	Na	Si	Sr	F(mg)	Cl(mg)	SO4(mg)
E1-1	2	9.11	23.57	0.90	0.55	0.03	0.26	0.56	0.57
E1-2	7	16.25	42.31	1.27	0.68	0.04	0.48	0.79	0.87
E1-3	24	21.74	69.92	1.75	0.97	0.08	0.85	1.07	1.69
E1-4	48	24.43	94.42	2.10	1.50	0.11	1.22	1.22	2.77
E1-5	72	26.05	115.48	2.30	2.32	0.14	1.48	1.28	3.57
E1-6	96	27.17	132.10	2.48	3.28	0.16	1.69	1.32	4.21
E1-7	120	28.10	149.97	2.63	4.37	0.18	1.88	1.35	4.76
E1-8	144	28.88	165.24	2.75	5.37	0.20	2.07	1.37	5.26
E1-9	168	29.57	179.58	2.87	6.32	0.22	2.26	1.38	5.67
E1-10	192	30.36	194.73	2.97	7.26	0.23	2.45	1.39	6.08
E1-11	216	31.09	207.35	3.08	8.18	0.25	2.65	1.40	6.46
E1-12	240	31.86	220.34	3.17	9.06	0.27	2.82	1.41	6.81
E1-13	264	32.63	233.43	3.26	10.13	0.28	2.84	1.42	7.16

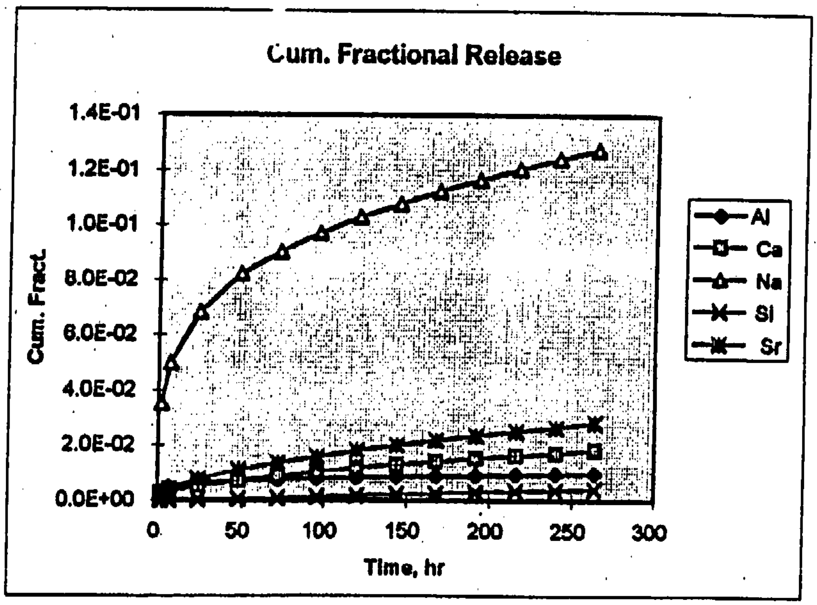
Cumulative Fractional Releases (cations)

	Al	Ca	Na	Si	Sr
E1-1	2.7E-03	1.9E-03	3.5E-02	2.3E-04	2.5E-03
E1-2	4.9E-03	3.3E-03	5.0E-02	2.9E-04	4.4E-03
E1-3	6.6E-03	5.5E-03	6.8E-02	4.1E-04	7.8E-03
E1-4	7.4E-03	7.4E-03	8.2E-02	6.3E-04	1.1E-02
E1-5	7.9E-03	9.1E-03	9.0E-02	9.7E-04	1.4E-02
E1-6	8.2E-03	1.0E-02	9.7E-02	1.4E-03	1.6E-02
E1-7	8.5E-03	1.2E-02	1.0E-01	1.8E-03	1.8E-02
E1-8	8.7E-03	1.3E-02	1.1E-01	2.3E-03	2.0E-02
E1-9	8.9E-03	1.4E-02	1.1E-01	2.7E-03	2.2E-02
E1-10	9.2E-03	1.5E-02	1.2E-01	3.1E-03	2.4E-02
E1-11	9.4E-03	1.6E-02	1.2E-01	3.4E-03	2.5E-02
E1-12	9.6E-03	1.7E-02	1.2E-01	3.8E-03	2.7E-02
E1-13	9.8E-03	1.8E-02	1.3E-01	4.3E-03	2.9E-02

Experiment E1







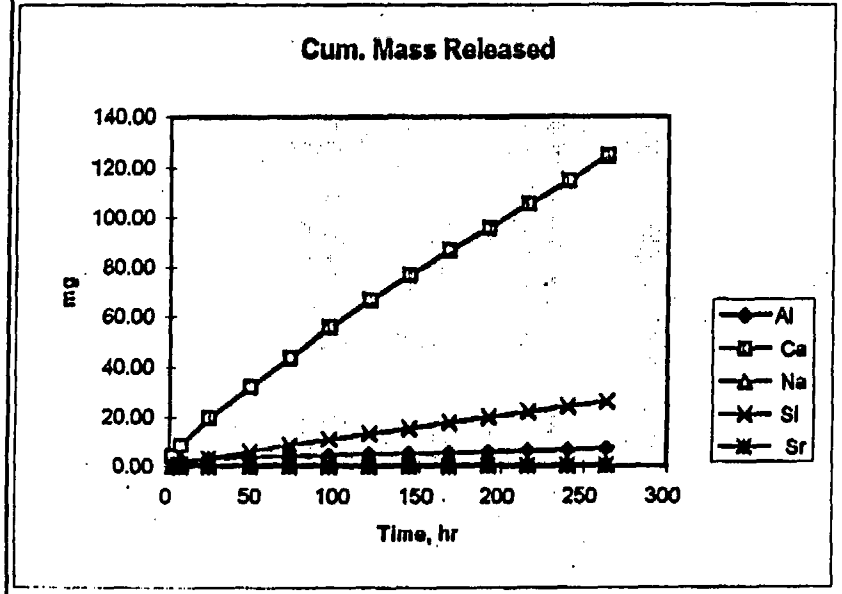
Experiment	**E2**
Temp(C)	**60**
material	**chunk**
volume(mL)	**300**

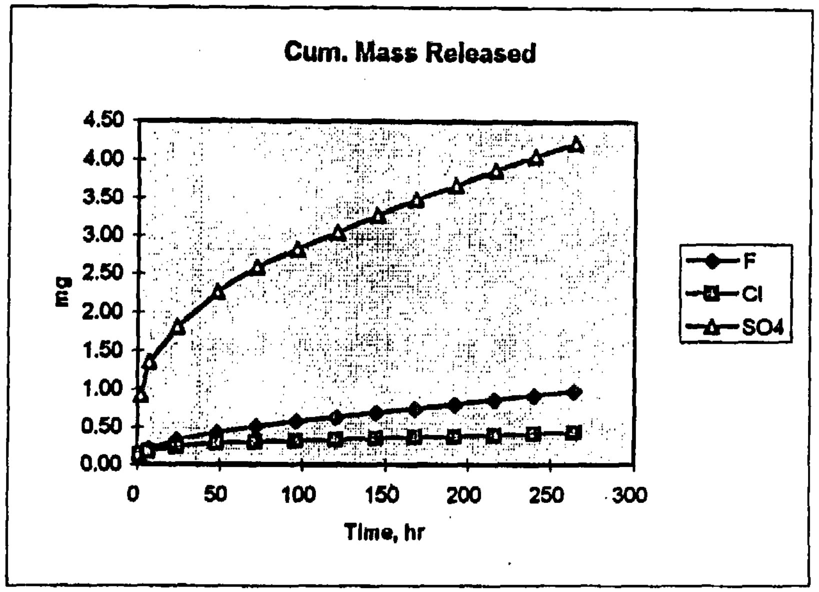
Concentration (ppm)

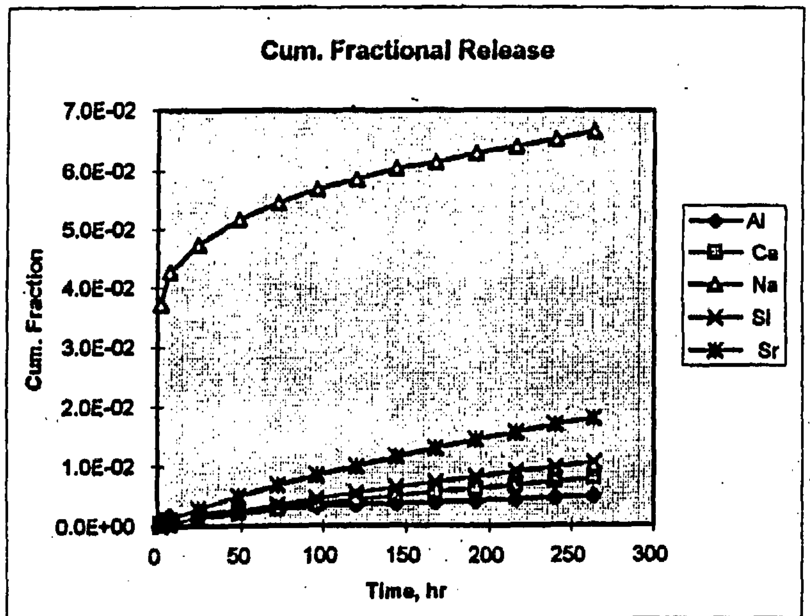
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
E2-1	2	6.399	13.870	0.002	1.452	1.356	0.016	0.44	0.42	3.06	
E2-2	7	2.298	14.820	-0.001	0.212	2.209	0.021	0.24	0.16	1.47	
E2-3	24	2.160	37.500	-0.003	0.183	7.630	0.056	0.42	0.21	1.49	
E2-4	48	1.582	40.680	-0.003	0.171	8.677	0.064	0.33	0.14	1.53	
E2-5	72	1.407	39.280	-0.005	0.113	8.717	0.061	0.26	0.08	1.07	
E2-6	96	1.459	40.030	-0.004	0.089	8.238	0.053	0.23	0.06	0.78	
E2-7	120	1.217	36.250	0.001	0.064	7.724	0.048	0.19	0.05	0.77	
E2-8	144	1.106	33.250	-0.005	0.072	7.678	0.050	0.20	0.06	0.74	
E2-9	168	1.105	33.340	-0.007	0.041	7.347	0.048	0.19	0.04	0.70	
E2-10	192	1.021	29.960	-0.004	0.060	7.037	0.044	0.19	0.03	0.63	
E2-11	216	1.218	32.480	-0.005	0.040	7.272	0.042	0.19	0.05	0.67	
E2-12	240	1.137	31.120	-0.010	0.050	6.758	0.039	0.19	0.07	0.59	
E2-13	264	1.253	32.280	-0.010	0.053	6.159	0.037	0.19	0.05	0.59	

		Cumulative Mass Released (mg)								Cumulative Fractional Releases (cations)				
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4	Al	Ca	Na	Si	Sr
E2-1	2	1.92	4.16	0.44	0.41	0.00	0.13	0.12	0.92	1.4E-03	2.7E-04	3.7E-02	1.6E-04	5.0E-04
E2-2	7	2.61	8.61	0.50	1.07	0.01	0.20	0.17	1.36	1.8E-03	5.5E-04	4.3E-02	4.3E-04	1.2E-03
E2-3	24	3.26	19.86	0.55	3.36	0.03	0.33	0.24	1.81	2.3E-03	1.3E-03	4.7E-02	1.4E-03	2.9E-03
E2-4	48	3.73	32.06	0.61	5.96	0.05	0.43	0.28	2.27	2.6E-03	2.1E-03	5.2E-02	2.4E-03	4.9E-03
E2-5	72	4.15	43.85	0.64	8.58	0.07	0.51	0.30	2.59	2.9E-03	2.8E-03	5.5E-02	3.5E-03	6.8E-03
E2-6	96	4.59	55.85	0.67	11.05	0.08	0.57	0.32	2.82	3.2E-03	3.6E-03	5.7E-02	4.5E-03	8.5E-03
E2-7	120	4.96	66.73	0.68	13.37	0.10	0.63	0.34	3.05	3.5E-03	4.3E-03	5.9E-02	5.4E-03	1.0E-02
E2-8	144	5.29	76.70	0.71	15.67	0.11	0.69	0.36	3.27	3.7E-03	4.9E-03	6.0E-02	6.3E-03	1.2E-02
E2-9	168	5.62	86.71	0.72	17.87	0.13	0.75	0.37	3.48	4.0E-03	5.6E-03	6.1E-02	7.2E-03	1.3E-02
E2-10	192	5.93	95.69	0.74	19.98	0.14	0.81	0.38	3.67	4.2E-03	6.1E-03	6.3E-02	8.1E-03	1.4E-02
E2-11	216	6.29	105.44	0.75	22.17	0.15	0.87	0.39	3.87	4.5E-03	6.8E-03	6.4E-02	9.0E-03	1.6E-02
E2-12	240	6.63	114.77	0.76	24.19	0.16	0.92	0.42	4.05	4.7E-03	7.4E-03	6.5E-02	9.8E-03	1.7E-02
E2-13	264	7.01	124.46	0.78	26.04	0.17	0.98	0.43	4.23	5.0E-03	8.0E-03	6.7E-02	1.1E-02	1.8E-02

Experiment E2







Experiment	**E3**
Temp(C)	**60**
material	**chunk**
volume(mL)	**300**

Concentration (ppm)

	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
E3-1	2	7.09	45.07	0.57	1.61	2.81	0.03	0.53	0.60	6.38	11.88
E3-2	7	3.26	35.10	0.03	0.26	3.81	0.07	0.00	0.80	0.88	11.22
E3-3	24	3.35	108.40	0.20	0.26	5.32	0.09	0.00	0.28	3.81	12.49
E3-4	48	4.52	187.10	-0.01	0.15	1.84	0.07	0.00	0.29	4.29	
E3-5	72	3.19	99.00	-0.01	0.09	4.84	0.05	0.32	0.11	2.50	
E3-6	96	1.36	72.04	-0.01	0.11	7.11	0.05	0.22	0.03	1.23	
E3-7	120	1.07	64.75	0.04	0.53	9.37	0.06	0.33	0.71	0.87	
E3-8	144	0.79	61.07	0.01	0.15	11.98	0.06	0.17	0.13	0.63	12.22
E3-9	168	0.71	52.61	-0.01	0.14	11.62	0.06	0.15	0.06	0.58	
E3-10	192	0.68	51.56	-0.01	0.11	11.55	0.06	0.14	0.03	0.56	
E3-11	216	0.73	51.41	0.00	0.10	11.14	0.06	0.14	0.02	0.53	
E3-12	240	0.66	49.67	0.00	0.11	11.57	0.06	0.14	0.05	0.50	
E3-13	264	0.70	44.76	0.02	0.18	10.13	0.05	0.15	0.11	0.49	11.83

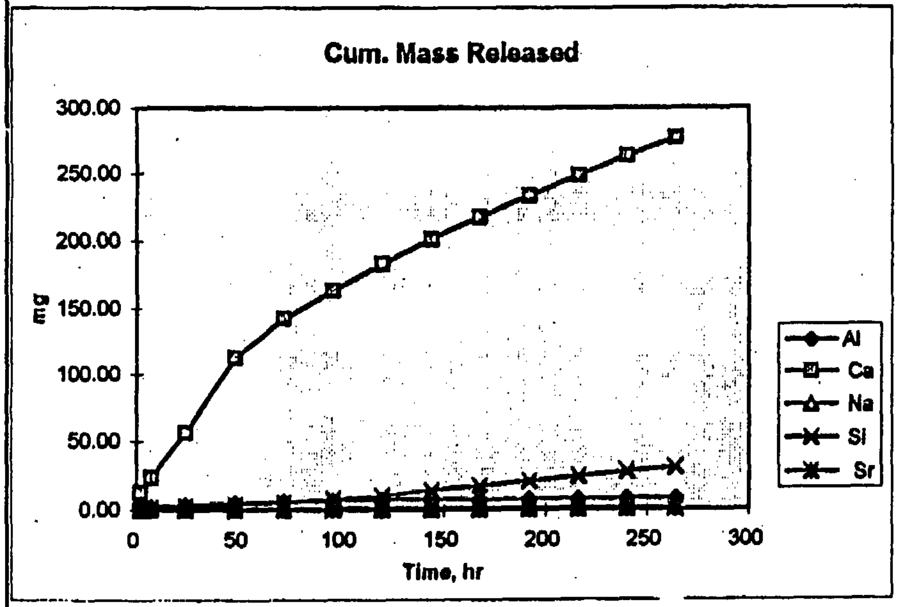
Cumulative Mass Released (mg)

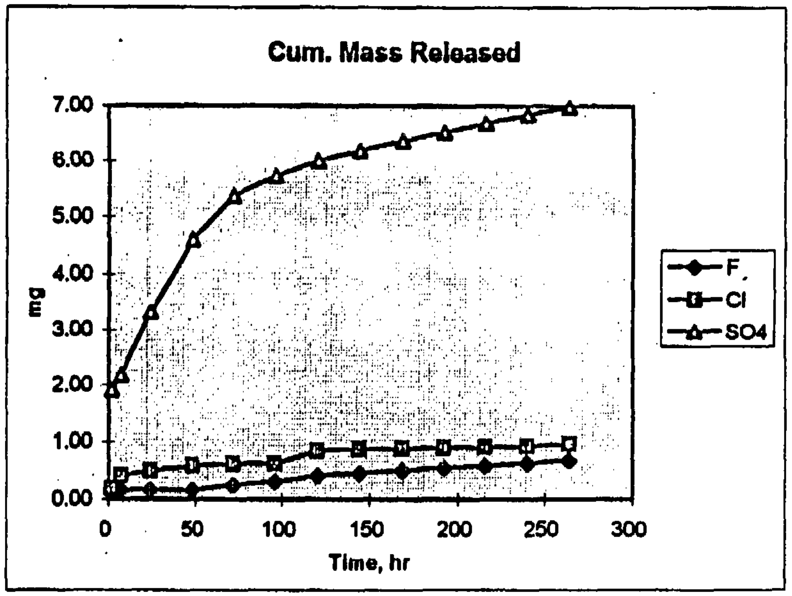
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4
E3-1	2	2.13	13.52	0.48	0.84	0.01	0.16	0.18	1.91
E3-2	7	3.11	24.05	0.56	1.99	0.03	0.16	0.42	2.18
E3-3	24	4.11	56.57	0.64	3.58	0.06	0.16	0.51	3.32
E3-4	48	5.47	112.70	0.68	4.14	0.08	0.16	0.59	4.61
E3-5	72	6.42	142.40	0.71	5.59	0.09	0.26	0.63	5.36
E3-6	96	6.83	164.01	0.74	7.72	0.11	0.32	0.64	5.73
E3-7	120	7.15	183.44	0.90	10.53	0.13	0.42	0.85	5.99
E3-8	144	7.39	201.76	0.94	14.13	0.14	0.47	0.89	6.18
E3-9	168	7.60	217.54	0.99	17.61	0.16	0.52	0.90	6.36
E3-10	192	7.81	233.01	1.02	21.08	0.18	0.56	0.91	6.52
E3-11	216	8.03	248.43	1.05	24.42	0.20	0.60	0.92	6.68
E3-12	240	8.22	263.33	1.08	27.89	0.22	0.64	0.94	6.83
E3-13	264	8.43	276.76	1.13	30.93	0.23	0.69	0.97	6.98

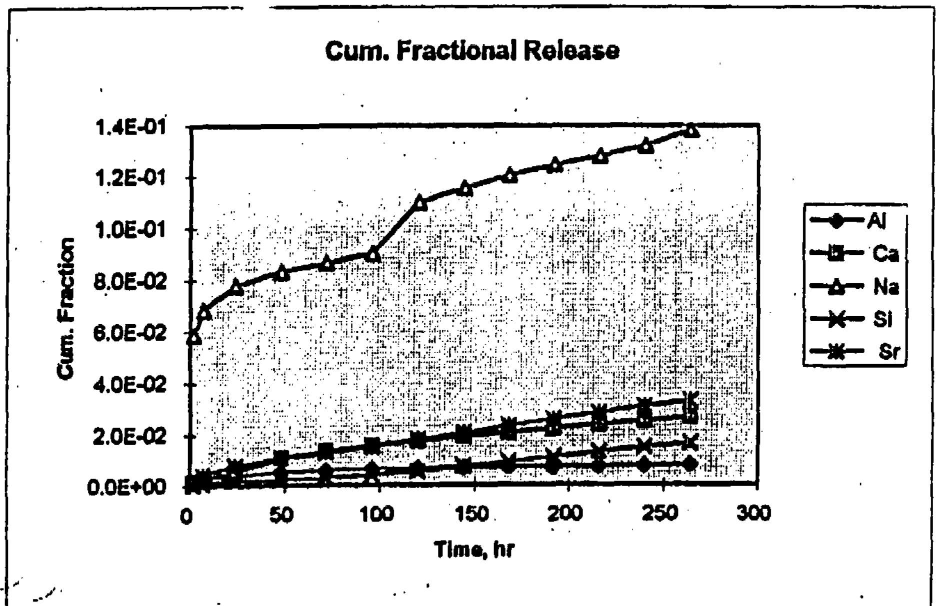
Cumulative Fractional Releases (cations)

	Al	Ca	Na	Si	Sr
E3-1	2.0E-03	1.3E-03	5.9E-02	4.5E-04	1.4E-03
E3-2	3.0E-03	2.3E-03	6.8E-02	1.1E-03	4.2E-03
E3-3	3.9E-03	5.4E-03	7.8E-02	1.9E-03	7.9E-03
E3-4	5.2E-03	1.1E-02	8.3E-02	2.2E-03	1.1E-02
E3-5	6.1E-03	1.4E-02	8.6E-02	3.0E-03	1.3E-02
E3-6	6.5E-03	1.6E-02	9.0E-02	4.1E-03	1.5E-02
E3-7	6.8E-03	1.8E-02	1.1E-01	5.6E-03	1.8E-02
E3-8	7.0E-03	1.9E-02	1.2E-01	7.6E-03	2.1E-02
E3-9	7.2E-03	2.1E-02	1.2E-01	9.4E-03	2.3E-02
E3-10	7.4E-03	2.2E-02	1.2E-01	1.1E-02	2.6E-02
E3-11	7.7E-03	2.4E-02	1.3E-01	1.3E-02	2.8E-02
E3-12	7.8E-03	2.5E-02	1.3E-01	1.5E-02	3.1E-02
E3-13	8.0E-03	2.7E-02	1.4E-01	1.7E-02	3.3E-02

Experiment E3







Experiment	AS001
Temp(C)	20.00
material	powder in membrane
volume(mL)	200.00

Concentration (ppm)

	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
AS001-1	2.00	0.08	1.25	-0.03	0.17	0.20	0.00	0.00	0.58	0.07	9.10
AS001-2	7.00	0.48	2.55	-0.02	0.21	0.29	0.00	0.00	0.86	0.05	9.55
AS001-3	24.00	1.15	6.51	-0.02	0.27	0.85	0.01	0.00	1.29	0.06	9.60
AS001-4	48.00	1.36	8.39	-0.02	0.12	1.07	0.01	0.00	0.87	0.53	9.70
AS001-5	72.00	1.42	10.21	-0.03	0.05	1.28	0.01	0.00	0.62	0.07	9.80
AS001-6	96.00	1.30	8.71	-0.02	0.03	1.12	0.01	0.00	0.41	0.00	9.80
AS001-7	120.00	1.17	8.54	-0.03	0.00	1.09	0.01	0.00	0.29	0.00	9.10
AS001-8	144.00	1.17	6.46	-0.02	0.00	0.68	0.01	0.00	0.23	0.23	9.20
AS001-9	168.00	1.12	6.38	-0.02	0.00	0.67	0.01	0.00	0.18	0.32	9.20
AS001-10	192.00	1.09	7.86	-0.02	0.00	0.95	0.01	0.00	0.15	0.21	
AS001-11	216.00	1.32	7.34	-0.03	0.02	0.72	0.01	0.00	0.15	0.27	9.50
AS001-12	240.00	1.30	8.23	-0.03	0.10	0.75	0.01	0.00	0.20	0.41	9.22
AS001-13	264.00	0.82	6.73	-0.03	0.14	0.64	0.01	0.00	0.17	0.34	9.52

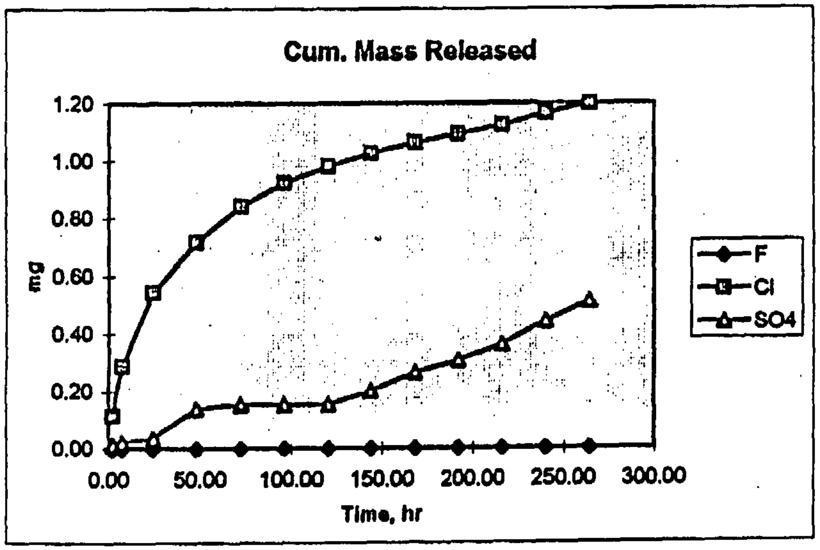
Cumulative Mass Released (mg)

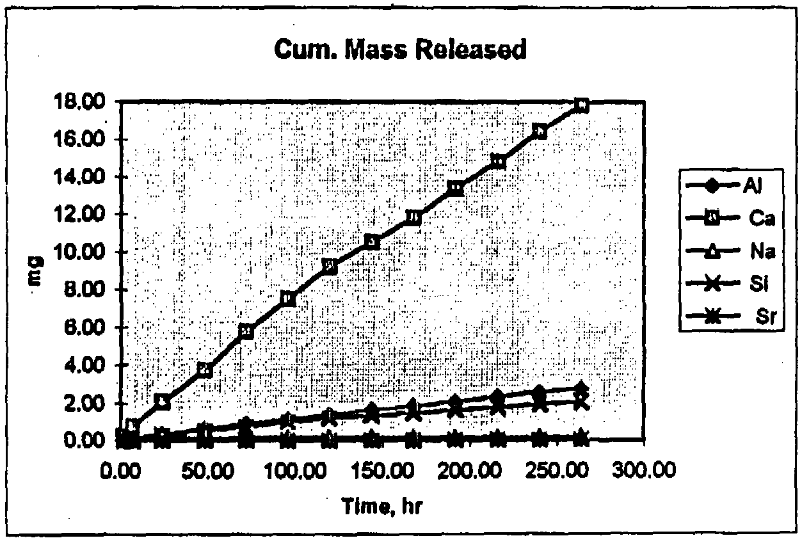
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4
AS001-1	2.00	0.02	0.25	0.03	0.04	0.00	0.00	0.12	0.01
AS001-2	7.00	0.11	0.76	0.08	0.10	0.00	0.00	0.29	0.02
AS001-3	24.00	0.34	2.06	0.13	0.27	0.00	0.00	0.54	0.04
AS001-4	48.00	0.61	3.74	0.15	0.48	0.01	0.00	0.72	0.14
AS001-5	72.00	0.90	5.78	0.16	0.74	0.01	0.00	0.84	0.15
AS001-6	96.00	1.16	7.52	0.17	0.96	0.01	0.00	0.92	0.15
AS001-7	120.00	1.39	9.23	0.17	1.18	0.01	0.00	0.98	0.15
AS001-8	144.00	1.63	10.52	0.17	1.32	0.01	0.00	1.03	0.20
AS001-9	168.00	1.85	11.80	0.17	1.45	0.02	0.00	1.06	0.26
AS001-10	192.00	2.07	13.37	0.17	1.64	0.02	0.00	1.09	0.31
AS001-11	216.00	2.33	14.84	0.17	1.79	0.02	0.00	1.12	0.36
AS001-12	240.00	2.59	16.49	0.19	1.94	0.02	0.00	1.16	0.44
AS001-13	264.00	2.75	17.83	0.22	2.07	0.02	0.00	1.20	0.51

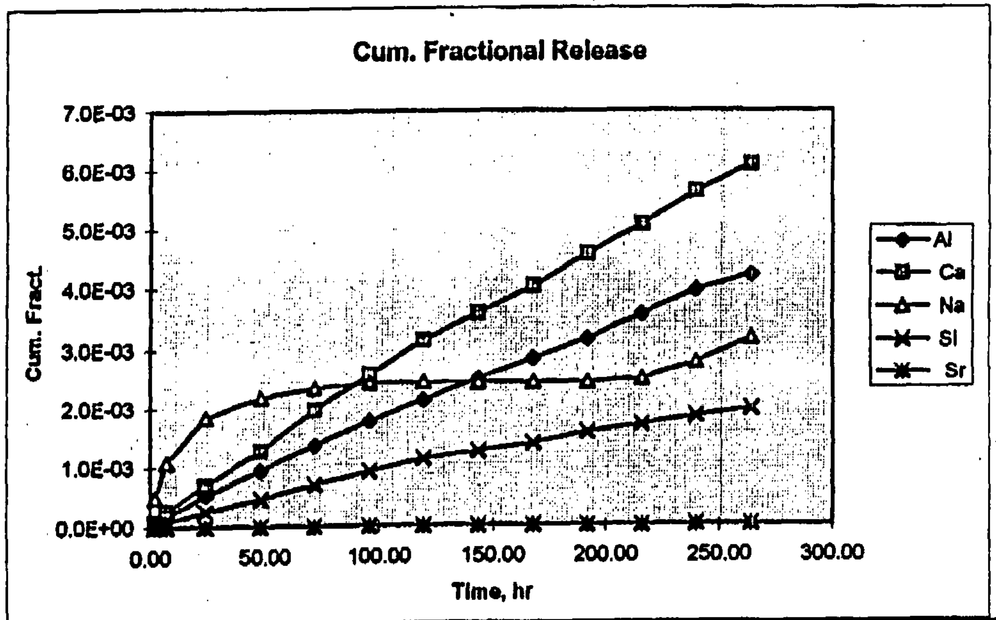
Cumulative Fractional Releases (cations)

	Al	Ca	Na	Si	Sr
AS001-1	2.4E-05	8.5E-05	4.9E-04	3.8E-05	7.1E-08
AS001-2	1.7E-04	2.6E-04	1.1E-03	9.2E-05	2.9E-07
AS001-3	5.2E-04	7.0E-04	1.8E-03	2.5E-04	9.1E-07
AS001-4	9.4E-04	1.3E-03	2.2E-03	4.6E-04	1.7E-06
AS001-5	1.4E-03	2.0E-03	2.3E-03	7.0E-04	2.5E-06
AS001-6	1.8E-03	2.6E-03	2.4E-03	9.2E-04	3.1E-06
AS001-7	2.1E-03	3.2E-03	2.4E-03	1.1E-03	3.6E-06
AS001-8	2.5E-03	3.6E-03	2.4E-03	1.3E-03	4.0E-06
AS001-9	2.8E-03	4.0E-03	2.4E-03	1.4E-03	4.5E-06
AS001-10	3.2E-03	4.6E-03	2.4E-03	1.6E-03	4.9E-06
AS001-11	3.6E-03	5.1E-03	2.5E-03	1.7E-03	5.4E-06
AS001-12	4.0E-03	5.6E-03	2.8E-03	1.8E-03	5.8E-06
AS001-13	4.2E-03	6.1E-03	3.2E-03	2.0E-03	6.2E-06

Experiment AS001







Experiment	AS002
Temp(C)	20
material	powder in membrane
volume(mL)	200

Concentration (ppm)

	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
AS002-1	2	1.74	2.60	-0.01	0.09	0.00	0.00	0.00	0.11	0.00	9.05
AS002-2	7	4.60	6.17	-0.02	0.05	0.02	0.00	0.00	0.06	0.00	9.62
AS002-3	24	7.49	11.70	-0.03	0.29	0.05	0.02	0.00	0.09	0.00	9.50
AS002-4	48	11.52	11.16	-0.03	0.84	0.11	0.08	0.00	0.15	0.00	10.10
AS002-5	72	10.29	13.22	-0.03	0.34	0.11	0.08	0.00	0.12	0.00	10.13
AS002-6	96	11.16	13.03	-0.02	0.27	0.13	0.08	0.00	0.13	0.00	10.38
AS002-7	120	11.15	12.44	-0.03	0.16	0.07	0.09	0.00	0.11	0.00	9.60
AS002-8	144	12.95	13.92	-0.01	0.14	0.11	0.07	0.00	0.11	0.00	9.70
AS002-9	168	12.50	13.87	0.00	0.08	0.11	0.08	0.00	0.12	0.00	9.90
AS002-10	192	13.72	13.93	-0.03	0.12	0.11	0.08	0.00	0.11	0.00	
AS002-11	216	12.86	13.29	-0.02	0.11	0.11	0.06	0.00	0.10	0.00	9.95
AS002-12	240	13.90	13.42	-0.02	0.13	0.11	0.07	0.00	0.15	0.00	10.22
AS002-13	264	12.52	12.58	-0.02	0.21	0.10	0.05	0.00	0.18	0.00	10.32

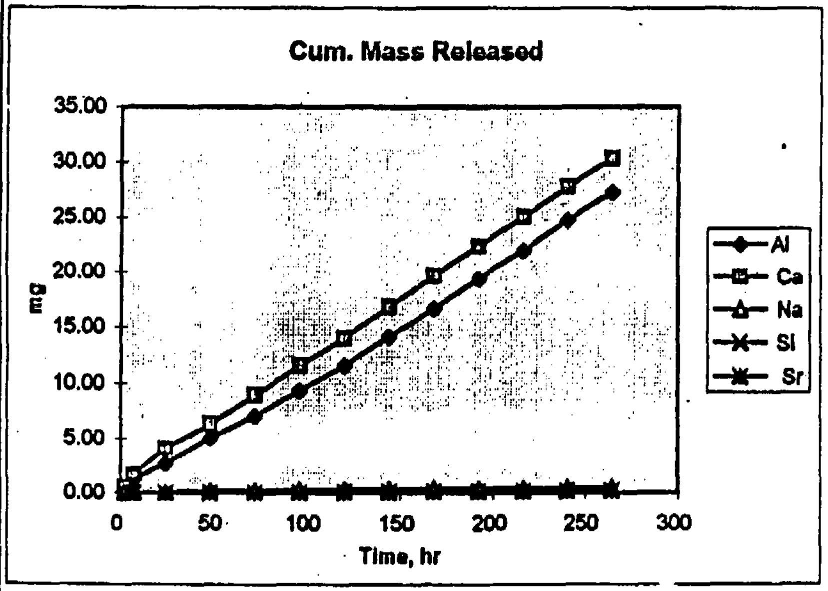
Cumulative Mass Released (mg)

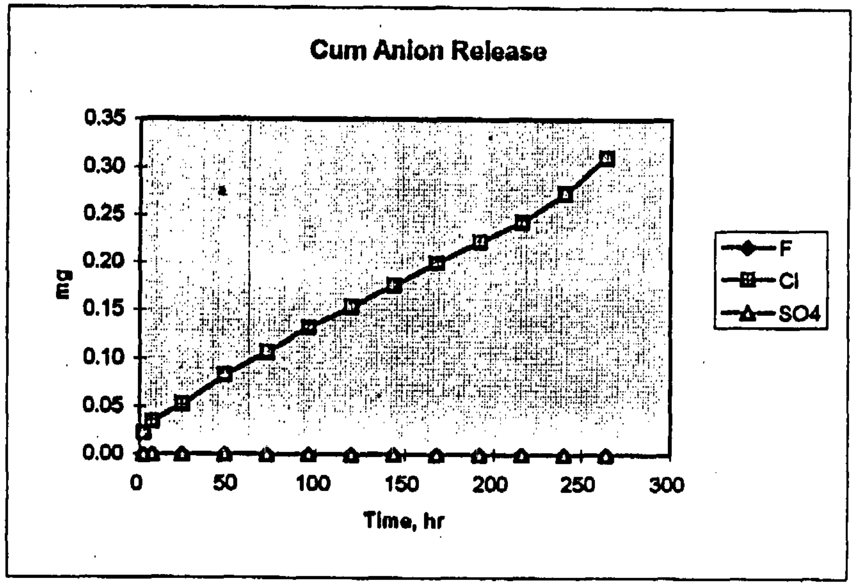
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4
AS002-1	2	0.35	0.52	0.02	0.00	0.00	0.00	0.02	0.00
AS002-2	7	1.27	1.75	0.03	0.00	0.00	0.00	0.03	0.00
AS002-3	24	2.77	4.09	0.09	0.01	0.00	0.00	0.05	0.00
AS002-4	48	5.07	6.32	0.25	0.04	0.02	0.00	0.08	0.00
AS002-5	72	7.13	8.97	0.32	0.06	0.04	0.00	0.11	0.00
AS002-6	96	9.36	11.57	0.38	0.09	0.05	0.00	0.13	0.00
AS002-7	120	11.59	14.06	0.41	0.10	0.07	0.00	0.15	0.00
AS002-8	144	14.18	16.85	0.44	0.12	0.09	0.00	0.18	0.00
AS002-9	168	16.68	19.62	0.45	0.14	0.10	0.00	0.20	0.00
AS002-10	192	19.42	22.41	0.48	0.17	0.12	0.00	0.22	0.00
AS002-11	216	22.00	25.06	0.50	0.19	0.13	0.00	0.24	0.00
AS002-12	240	24.78	27.75	0.52	0.21	0.14	0.00	0.27	0.00
AS002-13	264	27.28	30.26	0.57	0.23	0.15	0.00	0.31	0.00

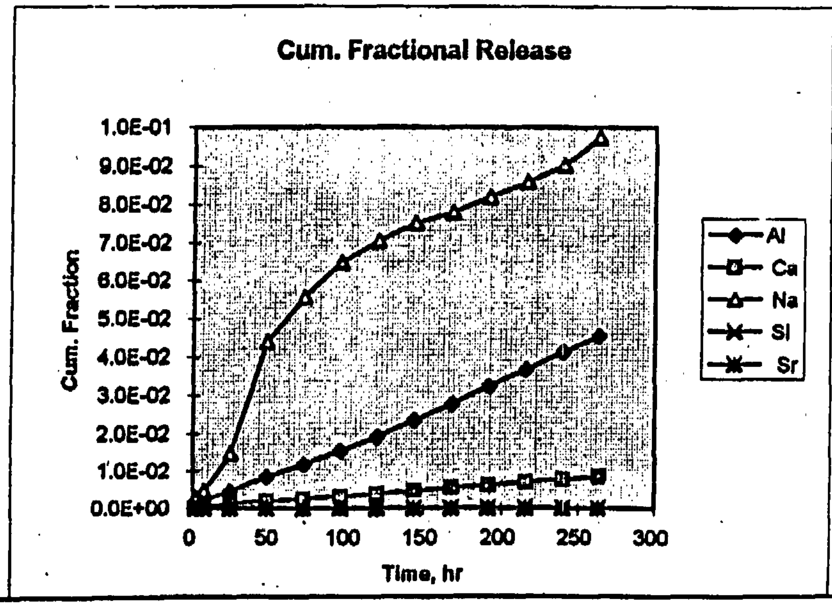
Cumulative Fractional Releases (cations)

	Al	Ca	Na	Si	Sr
AS002-1	5.8E-04	1.5E-04	3.1E-03	9.5E-07	1.1E-07
AS002-2	2.1E-03	5.0E-04	4.9E-03	4.2E-06	3.9E-07
AS002-3	4.6E-03	1.2E-03	1.5E-02	1.5E-05	1.5E-06
AS002-4	8.5E-03	1.8E-03	4.4E-02	3.6E-05	6.3E-06
AS002-5	1.2E-02	2.6E-03	5.6E-02	5.9E-05	1.1E-05
AS002-6	1.6E-02	3.3E-03	6.5E-02	8.6E-05	1.6E-05
AS002-7	1.9E-02	4.0E-03	7.0E-02	1.0E-04	2.2E-05
AS002-8	2.4E-02	4.8E-03	7.5E-02	1.2E-04	2.6E-05
AS002-9	2.8E-02	5.6E-03	7.8E-02	1.4E-04	3.1E-05
AS002-10	3.2E-02	6.4E-03	8.2E-02	1.7E-04	3.6E-05
AS002-11	3.7E-02	7.1E-03	8.6E-02	1.9E-04	4.0E-05
AS002-12	4.1E-02	7.9E-03	9.0E-02	2.1E-04	4.4E-05
AS002-13	4.5E-02	8.6E-03	9.7E-02	2.3E-04	4.7E-05

Experiment AS002







Experiment	**AS003**
Temp(C)	**20**
material	**powder in membrane**
volume(mL)	**200**

Concentration (ppm)

	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
AS003-1	2	-0.02	1.18	0.00	0.22	-0.03	0.00	0.06	0.69	0.31	8.45
AS003-2	7	0.61	2.73	0.00	0.02	0.04	0.00	0.00	0.14	0.00	
AS003-3	24	3.20	6.96	-0.01	0.05	0.05	0.01	0.00	0.02	0.06	8.85
AS003-4	48	3.60	6.86	0.01	0.06	0.05	0.01	0.00	0.00	0.06	9.05
AS003-5	72	1.77	6.21	-0.01	0.13	0.06	0.01	0.00	0.10	0.00	8.70
AS003-6	96	3.83	6.76	0.00	0.19	0.08	0.02	0.00	0.01	0.00	9.20
AS003-7	120	4.59	9.65	0.01	0.38	0.15	0.04	0.00	0.14	0.10	9.45
AS003-8	144	5.05	11.08	0.00	0.20	0.16	0.06	0.00	0.10	0.27	9.68
AS003-9	168	6.08	13.09	0.00	0.13	0.09	0.08	0.00	0.02	0.25	9.20
AS003-10	192	8.30	11.42	-0.01	0.02	0.08	0.12	0.00	0.03	0.18	9.55
AS003-11	216	0.32	21.76	0.00	0.03	0.05	0.16	0.11	0.14	0.08	
AS003-12	240	17.47	20.26	-0.01	0.02	0.07	0.14	0.06	0.11	0.04	
AS003-13	264	15.54	17.05	-0.01	0.01	0.07	0.09	0.06	0.10	0.06	10.50

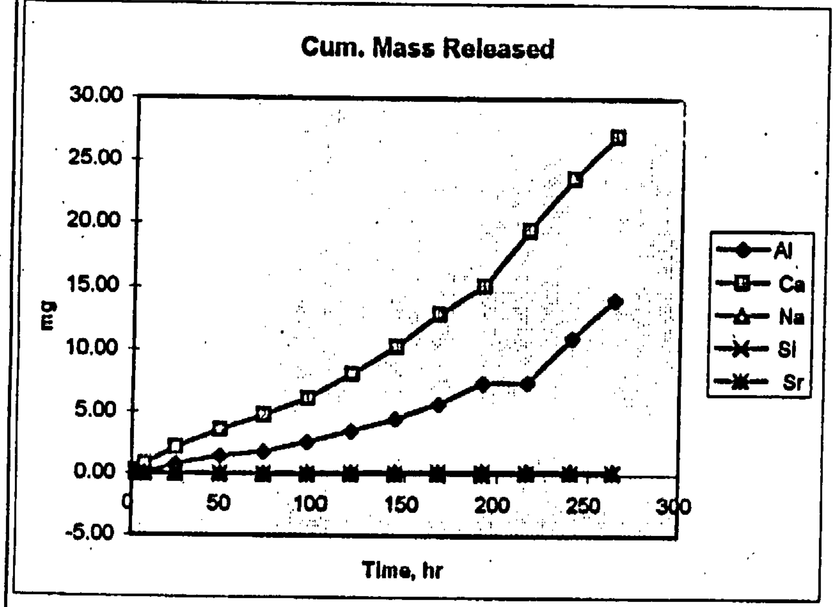
Cumulative Mass Released (mg)

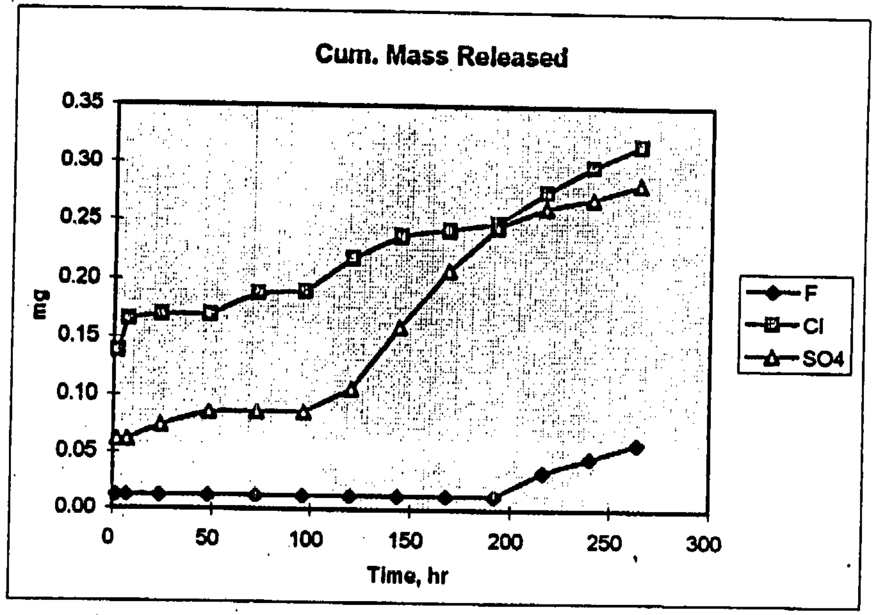
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4
AS003-1	2	0.00	0.24	0.04	-0.01	0.00	0.01	0.14	0.06
AS003-2	7	0.12	0.78	0.05	0.00	0.00	0.01	0.17	0.06
AS003-3	24	0.76	2.17	0.06	0.01	0.00	0.01	0.17	0.07
AS003-4	48	1.48	3.55	0.07	0.02	0.00	0.01	0.17	0.09
AS003-5	72	1.83	4.79	0.10	0.03	0.01	0.01	0.19	0.09
AS003-6	96	2.60	6.14	0.13	0.05	0.01	0.01	0.19	0.09
AS003-7	120	3.52	8.07	0.21	0.08	0.02	0.01	0.22	0.11
AS003-8	144	4.53	10.29	0.25	0.11	0.03	0.01	0.24	0.16
AS003-9	168	5.74	12.90	0.28	0.13	0.05	0.01	0.24	0.21
AS003-10	192	7.40	15.19	0.28	0.15	0.07	0.01	0.25	0.25
AS003-11	216	7.47	19.54	0.29	0.16	0.10	0.03	0.28	0.26
AS003-12	240	10.96	23.59	0.29	0.17	0.13	0.05	0.30	0.27
AS003-13	264	14.07	27.00	0.29	0.19	0.15	0.06	0.32	0.28

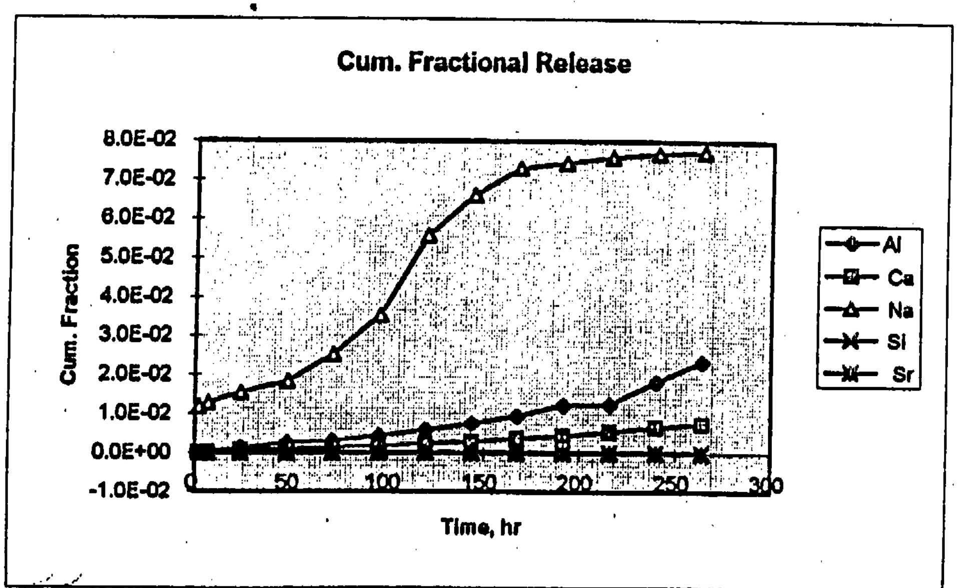
Cumulative Fractional Releases (cations)

	time(hrs)	Al	Ca	Na	Si	Sr
AS003-1	2	-5.1E-06	6.6E-05	1.2E-02	-5.1E-06	3.1E-08
AS003-2	7	2.0E-04	2.2E-04	1.3E-02	2.8E-06	1.3E-07
AS003-3	24	1.3E-03	6.1E-04	1.5E-02	1.1E-05	5.1E-07
AS003-4	48	2.5E-03	9.9E-04	1.8E-02	2.1E-05	9.8E-07
AS003-5	72	3.1E-03	1.3E-03	2.5E-02	3.3E-05	1.7E-06
AS003-6	96	4.3E-03	1.7E-03	3.5E-02	4.9E-05	2.9E-06
AS003-7	120	5.9E-03	2.3E-03	5.6E-02	7.8E-05	5.1E-06
AS003-8	144	7.5E-03	2.9E-03	6.6E-02	1.1E-04	8.1E-06
AS003-9	168	9.6E-03	3.6E-03	7.3E-02	1.2E-04	1.2E-05
AS003-10	192	1.2E-02	4.3E-03	7.4E-02	1.4E-04	1.9E-05
AS003-11	216	1.2E-02	5.5E-03	7.6E-02	1.5E-04	2.7E-05
AS003-12	240	1.8E-02	6.6E-03	7.7E-02	1.6E-04	3.4E-05
AS003-13	264	2.3E-02	7.6E-03	7.7E-02	1.8E-04	3.9E-05

Experiment AS003







Experiment	**AS001**
Temp(C)	**60**
material	**powder in membrane**
volume(mL)	**200**

Concentration (ppm)

	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
AS001-1	2	0.12	2.16	0.00	0.15	0.27	0.00	0.00	0.30	0.05	10.14
AS001-2	7	0.25	6.14	-0.01	0.19	0.87	0.01	0.00	0.32	0.05	10.54
AS001-3	24	1.35	18.95	-0.01	0.39	2.86	0.03	0.00	1.29	0.12	11.02
AS001-4	48	3.11	28.91	-0.02	0.44	4.66	0.05	0.00	7.03	0.28	10.84
AS001-5	72	4.36	37.81	-0.03	0.48	6.48	0.06	0.00	0.14	0.23	10.98
AS001-6	96	4.91	44.99	-0.03	0.55	9.21	0.08	0.03	0.07	0.26	10.98
AS001-7	120	5.18	52.18	-0.04	0.58	12.35	0.11	0.05	0.04	0.22	10.85
AS001-8	144	5.36	59.22	-0.05	0.58	15.67	0.13	0.02	0.03	0.14	11.02
AS001-9	168	5.50	65.92	-0.05	0.62	19.14	0.15	0.02	0.01	0.09	11.08
AS001-10	192	5.61	72.84	-0.06	0.66	22.32	0.17	0.02	0.04	0.08	11.05
AS001-11	216	5.73	80.86	-0.07	0.68	25.12	0.19	0.01	0.02	0.07	11.05
AS001-12	240	5.86	89.51	-0.07	0.70	27.76	0.21	0.03	0.03	0.06	10.80
AS001-13	264	6.01	98.47	-0.08	0.74	30.49	0.22	0.02	0.02	0.06	10.80

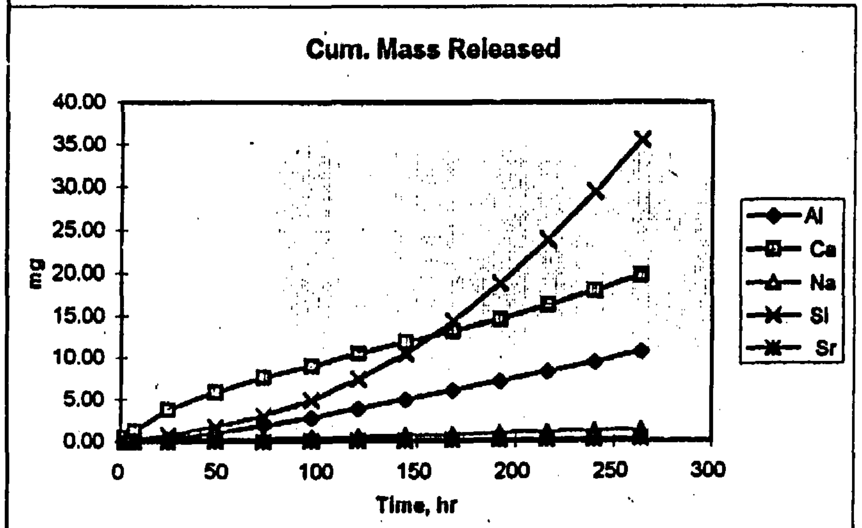
Cumulative Mass Released (mg)

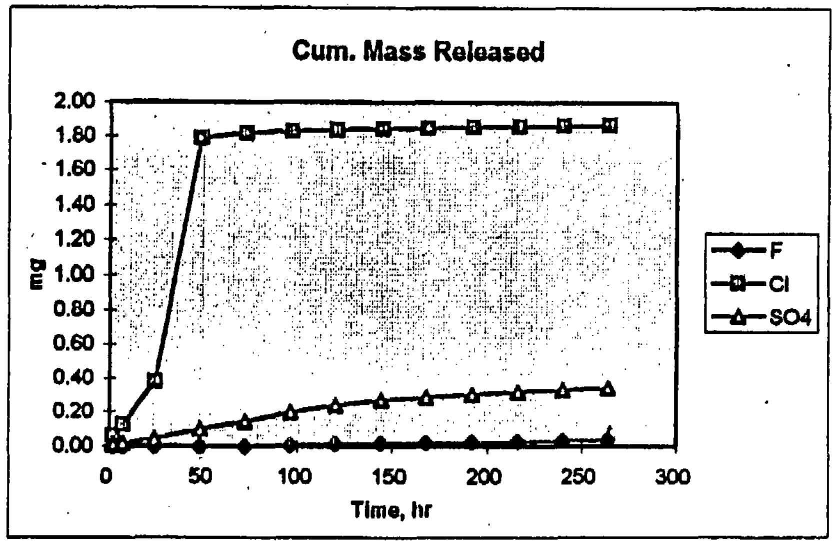
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4
AS001-1	2	0.02	0.43	0.03	0.05	0.00	0.00	0.06	0.01
AS001-2	7	0.07	1.23	0.07	0.23	0.00	0.00	0.12	0.02
AS001-3	24	0.34	3.79	0.15	0.80	0.01	0.00	0.38	0.04
AS001-4	48	0.97	5.78	0.23	1.73	0.02	0.00	1.79	0.10
AS001-5	72	1.84	7.56	0.33	3.03	0.03	0.00	1.82	0.15
AS001-6	96	2.82	9.00	0.44	4.87	0.05	0.01	1.83	0.20
AS001-7	120	3.86	10.44	0.55	7.34	0.07	0.02	1.84	0.24
AS001-8	144	4.93	11.84	0.67	10.48	0.09	0.02	1.84	0.27
AS001-9	168	6.03	13.18	0.79	14.30	0.12	0.02	1.85	0.29
AS001-10	192	7.15	14.57	0.93	18.77	0.16	0.03	1.85	0.30
AS001-11	216	8.30	16.17	1.06	23.79	0.19	0.03	1.86	0.32
AS001-12	240	9.47	17.90	1.20	29.34	0.24	0.03	1.86	0.33
AS001-13	264	10.67	19.69	1.35	35.44	0.28	0.04	1.87	0.34

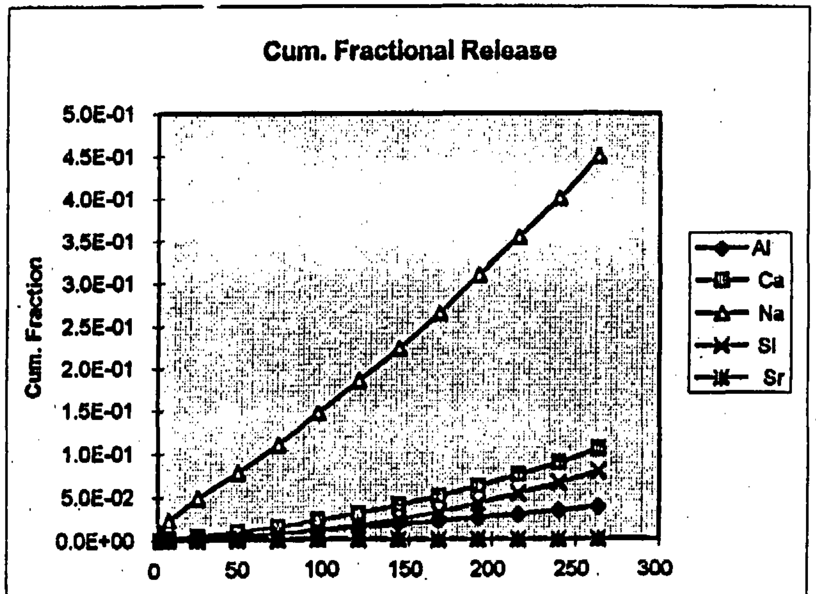
Cumulative Fractional Releases (cations)

	Al	Ca	Na	Si	Sr
AS001-1	8.8E-05	3.4E-04	1.0E-02	1.2E-04	3.0E-07
AS001-2	2.6E-04	1.3E-03	2.3E-02	5.1E-04	1.3E-06
AS001-3	1.2E-03	4.3E-03	4.8E-02	1.8E-03	4.9E-06
AS001-4	3.4E-03	8.9E-03	7.8E-02	3.8E-03	1.1E-05
AS001-5	6.5E-03	1.5E-02	1.1E-01	6.7E-03	1.9E-05
AS001-6	1.0E-02	2.2E-02	1.5E-01	1.1E-02	3.0E-05
AS001-7	1.4E-02	3.0E-02	1.8E-01	1.6E-02	4.4E-05
AS001-8	1.7E-02	4.0E-02	2.2E-01	2.3E-02	6.0E-05
AS001-9	2.1E-02	5.0E-02	2.6E-01	3.2E-02	7.9E-05
AS001-10	2.5E-02	6.2E-02	3.1E-01	4.2E-02	1.0E-04
AS001-11	2.9E-02	7.4E-02	3.5E-01	5.3E-02	1.2E-04
AS001-12	3.4E-02	8.8E-02	4.0E-01	6.5E-02	1.5E-04
AS001-13	3.8E-02	1.0E-01	4.5E-01	7.8E-02	1.8E-04

Experiment AS001







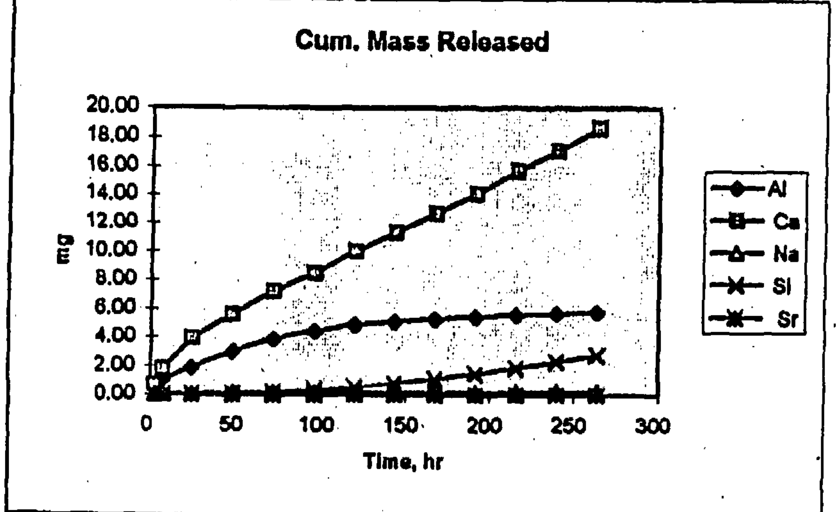
Experiment	**AS002**
Temp(C)	**60**
material	**powder in membrane**
volume(mL)	**200**

Concentration (ppm)

	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
AS002-1	2	1.958	3.38	-0.00517	0.1005	0.01249	0.002991	n.a.	n.a.	n.a.	9.58
AS002-2	7	3.192	5.763	-0.01326	0.04459	0.04261	0.005768	n.a.	n.a.	n.a.	9.93
AS002-3	24	4.477	10.62	-0.01255	0.2281	0.3143	0.01897	n.a.	n.a.	n.a.	10.25
AS002-4	48	5.766	8.335	-0.00815	0.5392	0.3825	0.03178	n.a.	n.a.	n.a.	10.35
AS002-5	72	4.247	7.887	-0.0086	0.1842	0.4945	0.02745	n.a.	n.a.	n.a.	10.35
AS002-6	96	2.684	6.541	-0.00585	0.06669	0.6566	0.0237	n.a.	n.a.	n.a.	10.38
AS002-7	120	2.41	7.739	-0.01021	0.03706	0.8366	0.01882	n.a.	n.a.	n.a.	10.26
AS002-8	144	1.178	6.633	-0.00929	0.01955	1.316	0.01691	n.a.	n.a.	n.a.	10.42
AS002-9	168	0.8959	6.708	-0.01126	0.006186	1.714	0.01775	n.a.	n.a.	n.a.	10.20
AS002-10	192	0.6685	6.968	-0.00599	0.004493	1.791	0.01648	n.a.	n.a.	n.a.	11.14
AS002-11	216	0.5937	7.883	-0.01543	0.03843	2.024	0.01594	n.a.	n.a.	n.a.	11.16
AS002-12	240	0.4324	6.992	-0.01853	0.04067	2.392	0.01794	n.a.	n.a.	n.a.	11.20
AS002-13	264	0.4418	7.742	-0.0146	0.04185	2.239	0.01403	n.a.	n.a.	n.a.	11.02

		Cumulative Mass Released (mg)								Cumulative Fractional Releases (cations)				
	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4	Al	Ca	Na	Si	Sr
AS001-1	2	0.39	0.68	0.02	0.00	0.00	n.a.	n.a.	n.a.	1.3E-03	3.7E-04	6.7E-03	4.9E-06	3.6E-07
AS001-2	7	1.03	1.83	0.03	0.01	0.00	n.a.	n.a.	n.a.	3.4E-03	1.0E-03	9.7E-03	2.1E-05	1.0E-06
AS001-3	24	1.93	3.95	0.07	0.07	0.01	n.a.	n.a.	n.a.	6.3E-03	2.2E-03	2.5E-02	1.4E-04	3.3E-06
AS001-4	48	3.08	5.62	0.18	0.15	0.01	n.a.	n.a.	n.a.	1.0E-02	3.1E-03	6.1E-02	2.9E-04	7.1E-06
AS001-5	72	3.93	7.20	0.22	0.25	0.02	n.a.	n.a.	n.a.	1.3E-02	4.0E-03	7.3E-02	4.8E-04	1.0E-05
AS001-6	96	4.46	8.51	0.23	0.38	0.02	n.a.	n.a.	n.a.	1.5E-02	4.7E-03	7.8E-02	7.4E-04	1.3E-05
AS001-7	120	4.95	10.05	0.24	0.55	0.03	n.a.	n.a.	n.a.	1.6E-02	5.5E-03	8.0E-02	1.1E-03	1.6E-05
AS001-8	144	5.18	11.38	0.24	0.81	0.03	n.a.	n.a.	n.a.	1.7E-02	6.3E-03	8.1E-02	1.6E-03	1.8E-05
AS001-9	168	5.36	12.72	0.25	1.15	0.03	n.a.	n.a.	n.a.	1.7E-02	7.0E-03	8.2E-02	2.2E-03	2.0E-05
AS001-10	192	5.50	14.11	0.25	1.51	0.04	n.a.	n.a.	n.a.	1.8E-02	7.8E-03	8.2E-02	2.9E-03	2.2E-05
AS001-11	216	5.61	15.69	0.25	1.92	0.04	n.a.	n.a.	n.a.	1.8E-02	8.6E-03	8.5E-02	3.7E-03	2.4E-05
AS001-12	240	5.70	17.09	0.26	2.40	0.04	n.a.	n.a.	n.a.	1.9E-02	9.4E-03	8.7E-02	4.7E-03	2.6E-05
AS001-13	264	5.79	18.64	0.27	2.84	0.05	n.a.	n.a.	n.a.	1.9E-02	1.0E-02	9.0E-02	5.5E-03	2.7E-05

Experiment AS002



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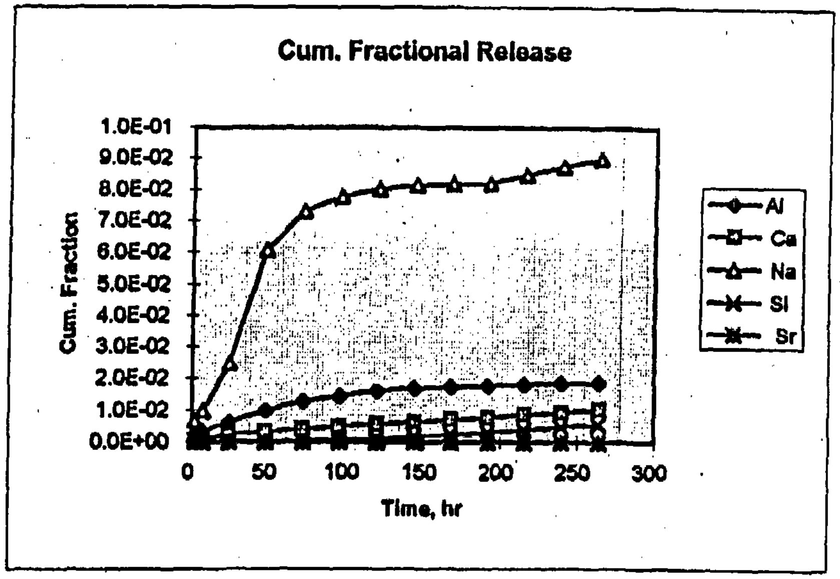


Experiment	AS003
Temp(C)	60
material	powder in membrane
volume(mL)	200

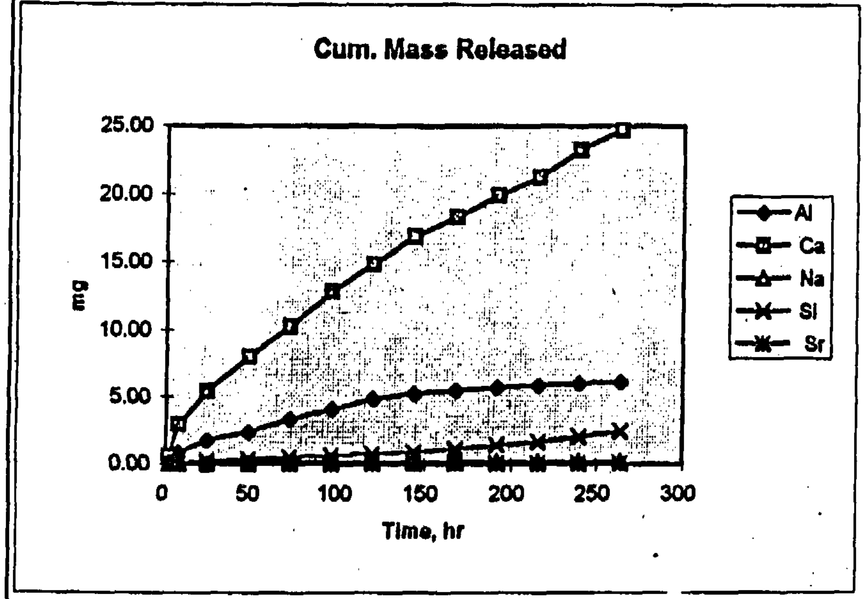
Concentration (ppm)

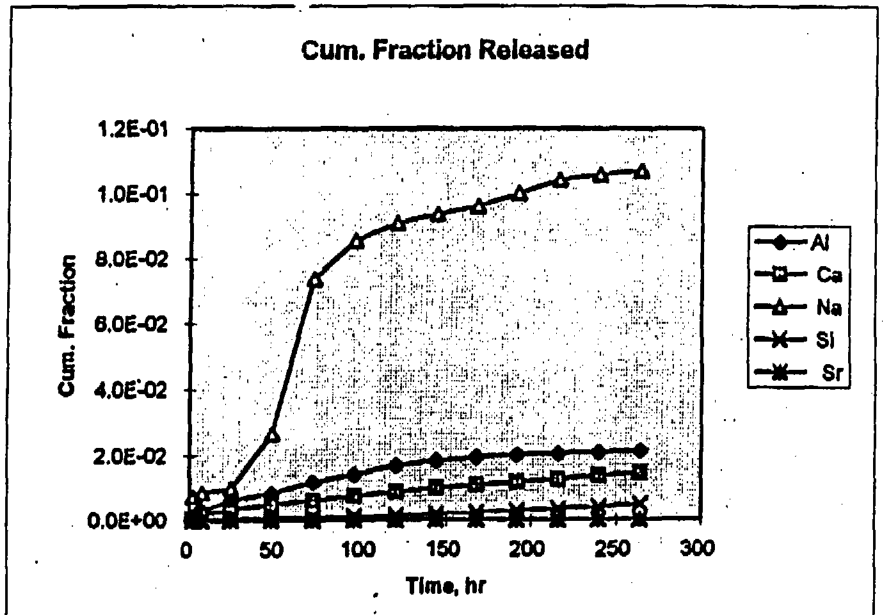
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	pH
AS003-1	2	1.55	3.01	-0.02	0.07	0.01	0.00	n.a.	n.a.	n.a.	9.55
AS003-2	7	2.80	11.67	-0.02	0.01	0.10	0.01	n.a.	n.a.	n.a.	9.98
AS003-3	24	4.28	12.43	-0.01	0.01	0.81	0.01	n.a.	n.a.	n.a.	10.38
AS003-4	48	3.31	12.85	-0.01	0.15	0.87	0.02	n.a.	n.a.	n.a.	9.70
AS003-5	72	4.72	11.42	-0.02	0.42	0.54	0.03	n.a.	n.a.	n.a.	10.44
AS003-6	96	3.56	12.74	-0.01	0.11	0.51	0.04	n.a.	n.a.	n.a.	9.90
AS003-7	120	3.88	9.92	-0.01	0.05	0.73	0.04	n.a.	n.a.	n.a.	10.12
AS003-8	144	1.99	10.20	0.00	0.03	0.90	0.03	n.a.	n.a.	n.a.	10.00
AS003-9	168	1.34	7.22	-0.01	0.02	1.14	0.02	n.a.	n.a.	n.a.	10.10
AS003-10	192	1.16	8.08	0.00	0.04	1.29	0.02	n.a.	n.a.	n.a.	10.14
AS003-11	216	0.75	6.84	-0.01	0.04	1.45	0.02	n.a.	n.a.	n.a.	10.45
AS003-12	240	0.59	9.99	0.00	0.01	1.80	0.02	n.a.	n.a.	n.a.	10.12
AS003-13	264	0.52	7.14	0.00	0.01	1.97	0.02	n.a.	n.a.	n.a.	10.38

Cumulative Mass Released (mg) / Cumulative Fractional Releases (cations)

	time(hrs)	Al	Ca	Na	Si	Sr	F	Cl	SO4	Al	Ca	Na	Si	Sr
AS003-1	2	0.31	0.60	0.01	0.00	0.00	n.a.	n.a.	n.a.	1.1E-03	3.6E-04	7.4E-03	2.4E-06	3.3E-07
AS003-2	7	0.87	2.94	0.02	0.02	0.00	n.a.	n.a.	n.a.	3.1E-03	1.7E-03	8.6E-03	4.4E-05	1.1E-06
AS003-3	24	1.73	5.42	0.02	0.19	0.00	n.a.	n.a.	n.a.	6.1E-03	3.2E-03	9.9E-03	3.7E-04	2.5E-06
AS003-4	48	2.39	7.99	0.05	0.36	0.01	n.a.	n.a.	n.a.	8.4E-03	4.7E-03	2.7E-02	7.2E-04	4.4E-06
AS003-5	72	3.33	10.28	0.13	0.47	0.01	n.a.	n.a.	n.a.	1.2E-02	6.1E-03	7.4E-02	9.3E-04	7.9E-06
AS003-6	96	4.05	12.82	0.15	0.57	0.02	n.a.	n.a.	n.a.	1.4E-02	7.6E-03	8.6E-02	1.1E-03	1.2E-05
AS003-7	120	4.82	14.81	0.16	0.72	0.03	n.a.	n.a.	n.a.	1.7E-02	8.7E-03	9.1E-02	1.4E-03	1.6E-05
AS003-8	144	5.22	16.85	0.17	0.90	0.04	n.a.	n.a.	n.a.	1.8E-02	9.9E-03	9.4E-02	1.8E-03	1.9E-05
AS003-9	168	5.49	18.29	0.17	1.12	0.04	n.a.	n.a.	n.a.	1.9E-02	1.1E-02	9.6E-02	2.2E-03	2.2E-05
AS003-10	192	5.72	19.91	0.18	1.38	0.04	n.a.	n.a.	n.a.	2.0E-02	1.2E-02	1.0E-01	2.8E-03	2.5E-05
AS003-11	216	5.87	21.27	0.19	1.67	0.05	n.a.	n.a.	n.a.	2.1E-02	1.3E-02	1.0E-01	3.3E-03	2.7E-05
AS003-12	240	5.99	23.27	0.19	2.03	0.05	n.a.	n.a.	n.a.	2.1E-02	1.4E-02	1.1E-01	4.1E-03	2.9E-05
AS003-13	264	6.09	24.70	0.19	2.43	0.06	n.a.	n.a.	n.a.	2.1E-02	1.5E-02	1.1E-01	4.9E-03	3.1E-05

Experiment AS003



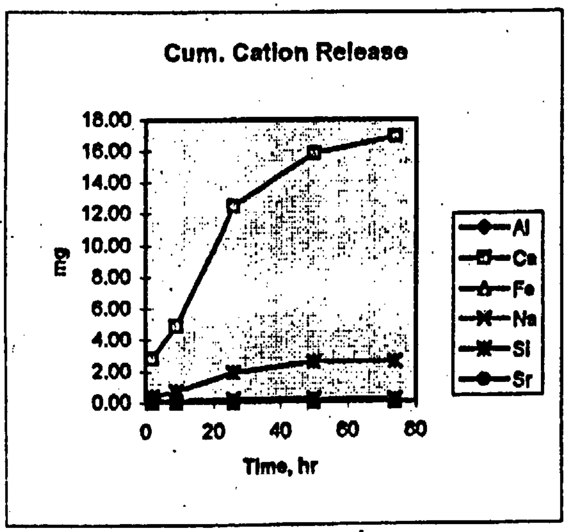


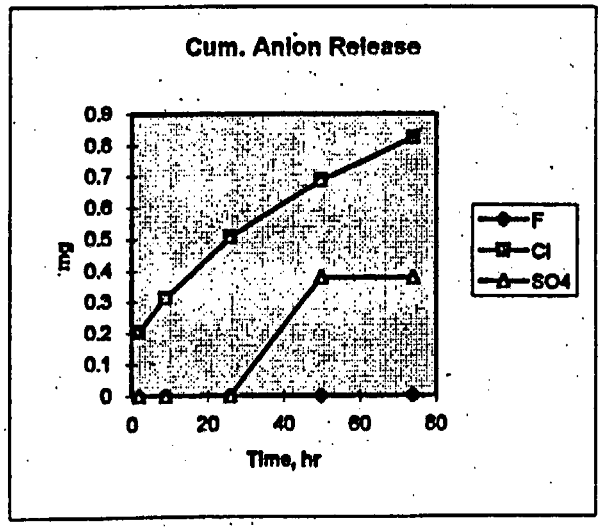
Experiment	**AS001**
Temp(C)	**20**
material	**chunk**

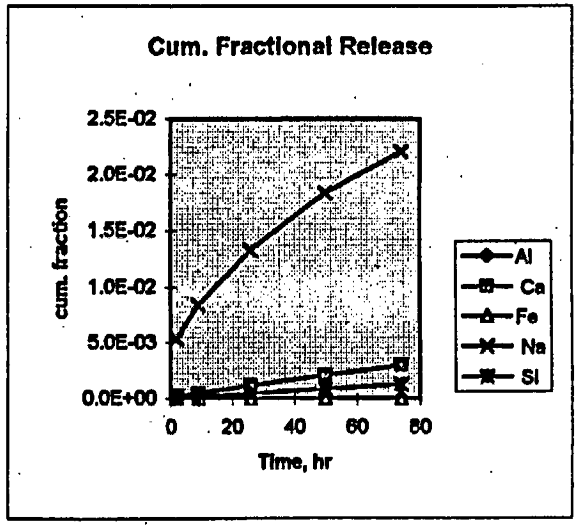
Slag Leaching of AS samples ALT for 5 intervals (4 days) these are monolithic samples

		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4
AS001-1	2	0.03	2.81	0.00	0.22	0.36	0.00	0.00	0.68	0.00
AS001-2	9	0.00	4.87	0.00	0.13	0.69	0.01	0.00	0.37	0.00
AS001-3	26	0.05	12.46	0.00	0.21	1.90	0.01	0.00	0.64	0.00
AS001-4	50	0.06	15.85	0.00	0.21	2.54	0.02	0.00	0.60	1.26
AS001-5	74	0.05	16.91	0.00	0.16	2.56	0.02	0.00	0.45	0.00

											Cumulative Fractional Releases (cations)					
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	Al	Ca	Fe	Na	Si	Sr
AS001-1	2	0.01	0.84	0.00	0.07	0.11	0.00	0	0.203806	0	7.9E-06	1.6E-04	0.0E+00	5.4E-03	5.7E-05	2.2E-04
AS001-2	9	0.01	2.30	0.00	0.11	0.31	0.00	0	0.313548	0	7.9E-06	4.4E-04	0.0E+00	8.4E-03	1.7E-04	4.8E-04
AS001-3	26	0.02	6.04	0.00	0.17	0.88	0.01	0	0.506381	0	2.1E-05	1.1E-03	0.0E+00	1.3E-02	4.7E-04	1.2E-03
AS001-4	50	0.04	10.80	0.00	0.23	1.65	0.01	0	0.686671	0.37848	3.7E-05	2.0E-03	0.0E+00	1.8E-02	8.7E-04	2.0E-03
AS001-5	74	0.06	15.87	0.00	0.28	2.42	0.02	0	0.823065	0.37848	5.1E-05	3.0E-03	0.0E+00	2.2E-02	1.3E-03	2.9E-03



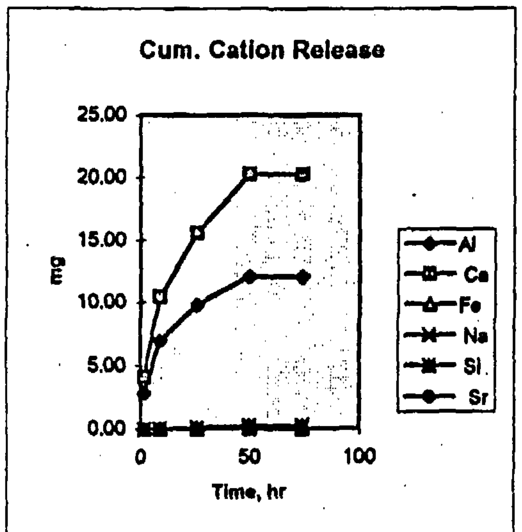


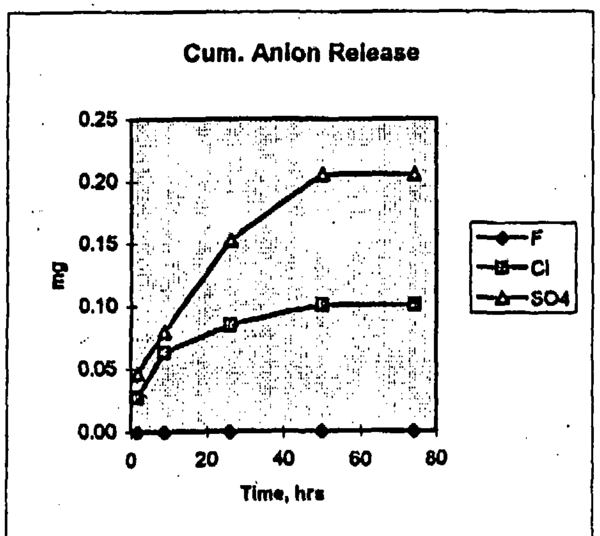


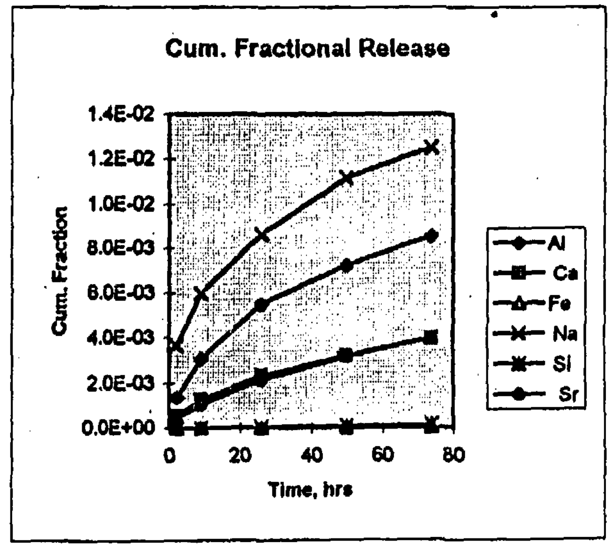
Experiment	AS002
Temp(C)	20
material	chunk

		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4
AS002-1	2	7.56	11.00	0.07	0.12	0.04	0.01	0.00	0.13	0.66
AS002-2	9	9.50	13.72	0.03	0.07	0.03	0.01	0.00	0.09	0.15
AS002-3	26	13.77	21.26	0.01	0.09	0.10	0.02	0.00	0.11	0.11
AS002-4	50	9.63	16.98	0.01	0.08	0.25	0.02	0.00	0.07	0.24
AS002-5	74	7.44	15.59	0.01	0.04	0.50	0.02	0.00	0.05	0.18

											Cumulative Fractional Releases (cations)					
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	Al	Ca	Fe	Na	Si	Sr
AS002-1	2	2.85	4.12	0.01	0.02	0.01	0.00	0.00	0.03	0.05	1.3E-03	5.6E-04	7.3E-06	3.7E-03	6.5E-06	4.4E-04
AS002-2	9	6.98	10.49	0.01	0.05	0.04	0.01	0.00	0.06	0.08	3.0E-03	1.3E-03	1.1E-05	6.0E-03	1.3E-05	1.0E-03
AS002-3	26	9.87	15.59	0.02	0.07	0.12	0.01	0.00	0.08	0.15	5.5E-03	2.3E-03	1.2E-05	8.6E-03	3.1E-05	2.1E-03
AS002-4	50	12.10	20.27	0.02	0.09	0.27	0.02	0.00	0.10	0.21	7.2E-03	3.2E-03	1.3E-05	1.1E-02	7.6E-05	3.1E-03
AS002-5	74	12.10	20.27	0.02	0.09	0.27	0.02	0.00	0.10	0.21	8.5E-03	4.0E-03	1.5E-05	1.3E-02	1.7E-04	4.0E-03

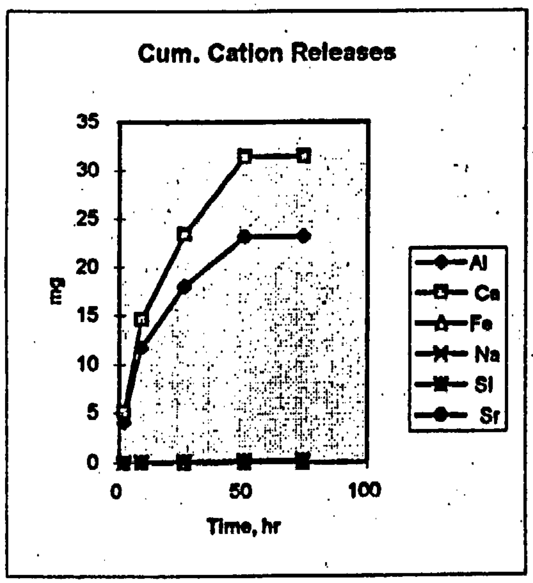


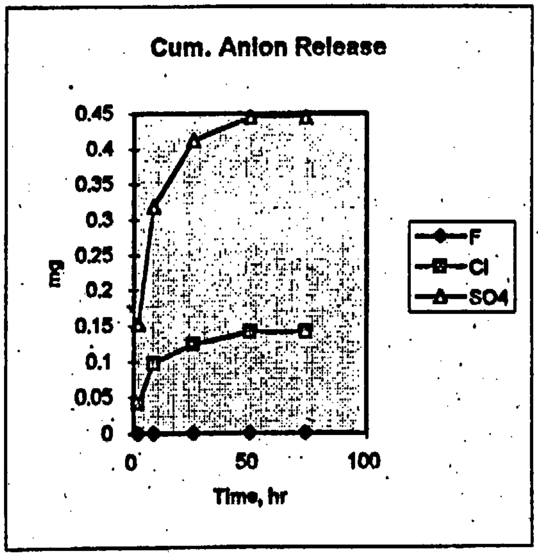


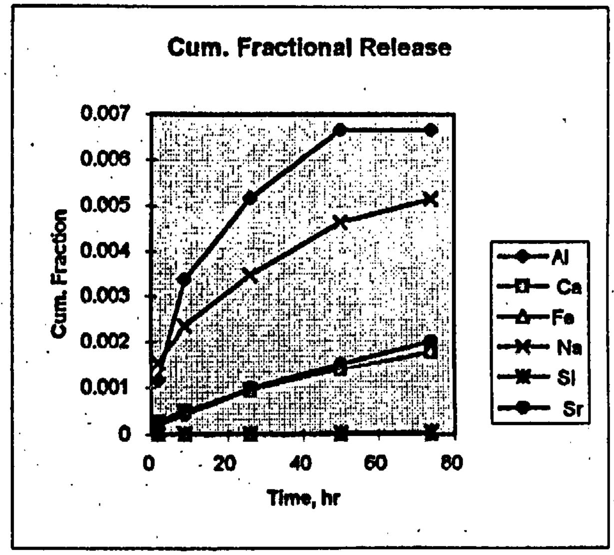


Experiment	AS003									
Temp	20									
material	chunk									
	Concentration									
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4
AS chunk	1.92	12.14	18.13	0.8255	0.1128	0.4229	0.0157	0	0.1568	0.6419
AS chunk	8.88	13.57	17.28	0.0191	0.0601	0.0483	0.0158	0	0.1411	0.5091
AS chunk	25.92	25.54	31.36	0.0191	0.0817	0.1131	0.0415	0	0.1829	0.5533
AS chunk	49.92	20.81	29.54	0.0162	0.0848	0.2006	0.0391	0	0.0888	0.3099
AS chunk	73.92	17.31	26.54	0.0179	0.0377	0.3605	0.0365	0	0.0575	0.1107

		Cumulative Mass Release(mg)									Cumulative Fractional Release					
	time(hrs)	Al	Ca	Fe	Na	Si	Sr	F	Cl	SO4	Al	Ca	Fe	Na	Si	Sr
AS chunk	1.92	4.071	5.184	0.0057	0.018	0.0145	0.0047	0	0.0423	0.1527	0.0012	0.0003	1E-05	0.0015	2E-05	0.0002
AS chunk	8.88	11.733	14.592	0.0115	0.0425	0.0484	0.0172	0	0.0972	0.3187	0.0034	0.0005	1E-05	0.0024	2E-05	0.0004
AS chunk	25.92	17.976	23.454	0.0163	0.068	0.1086	0.0289	0	0.1239	0.4117	0.0052	0.001	1E-05	0.0035	3E-05	0.001
AS chunk	49.92	23.169	31.416	0.0217	0.0793	0.2167	0.0398	0	0.1411	0.4449	0.0067	0.0014	1E-05	0.0046	4E-05	0.0015
AS chunk	73.92	23.169	31.416	0.0217	0.0793	0.2167	0.0398	0	0.1411	0.4449	0.0067	0.0018	1E-05	0.0051	6E-05	0.002



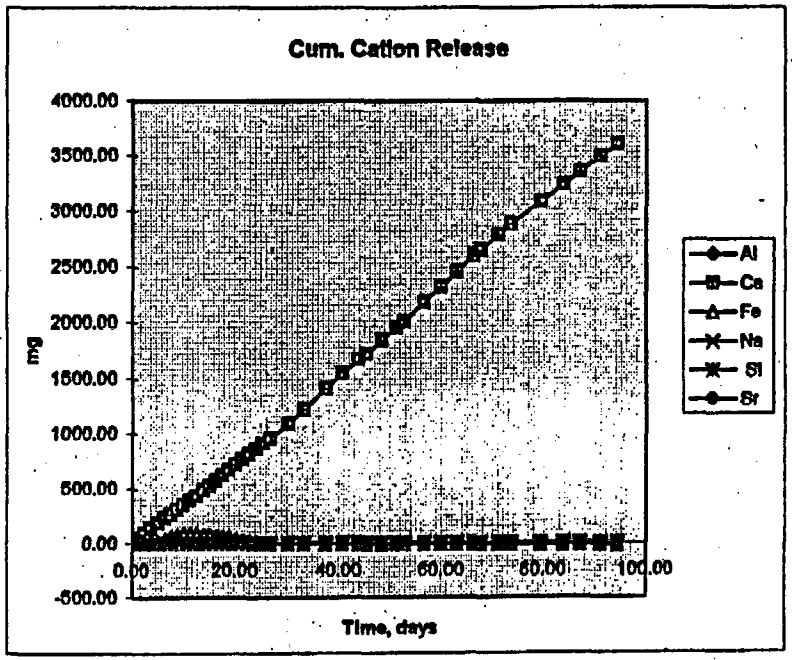


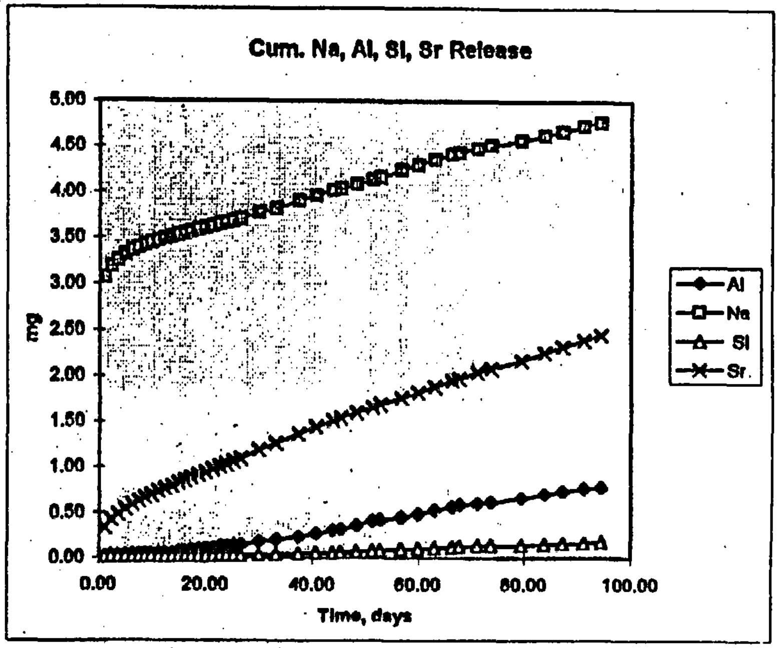


Column Q-BOP

Sum Effluent g	Time Days	Sum Al	Sum Ca	Sum Fe	Sum Na	Sum Si	Sum Sr
71.43	1.08	0.01	49.61	-0.14	3.06	0.01	0.33
155.32	2.35	0.02	95.17	1.88	3.19	0.01	0.42
239.75	3.63	0.02	140.54	6.51	3.25	0.01	0.48
328.21	4.97	0.03	186.82	27.02	3.31	0.02	0.54
413.90	6.27	0.03	234.85	42.09	3.36	0.02	0.59
492.72	7.47	0.04	271.93	64.04	3.39	0.02	0.63
575.67	8.72	0.04	315.16	77.02	3.41	0.02	0.67
657.37	9.96	0.05	355.02	86.89	3.44	0.02	0.70
741.51	11.24	0.05	396.52	88.18	3.46	0.02	0.74
824.00	12.48	0.05	436.38	89.42	3.48	0.02	0.77
912.46	13.83	0.05	488.01	82.65	3.51	0.02	0.80
989.17	14.99	0.06	528.39	80.69	3.53	0.02	0.83
1067.43	16.17	0.07	573.50	71.43	3.54	0.02	0.86
1151.18	17.44	0.08	625.16	62.58	3.56	0.02	0.89
1235.15	18.71	0.09	675.79	51.56	3.58	0.02	0.92
1324.00	20.06	0.10	720.23	40.94	3.60	0.02	0.95
1411.05	21.38	0.11	769.90	30.29	3.62	0.02	0.98
1496.05	22.67	0.13	814.56	19.78	3.64	0.03	1.01
1581.85	23.97	0.13	866.58	9.59	3.66	0.03	1.03
1668.41	25.28	0.14	912.53	-0.39	3.67	0.03	1.06
1757.11	26.62	0.14	953.69	-1.13	3.70	0.03	1.09
1980.55	30.01	0.18	1090.73	-4.02	3.76	0.04	1.19
2184.21	33.09	0.21	1219.65	-4.28	3.81	0.04	1.26
2459.18	37.26	0.24	1409.44	-7.47	3.90	0.05	1.36
2680.45	40.61	0.27	1545.44	-10.09	3.95	0.06	1.44
2883.53	43.69	0.31	1665.63	-12.61	4.01	0.06	1.51
2985.51	45.24	0.32	1717.61	-12.88	4.03	0.06	1.54
3189.25	48.32	0.37	1842.75	-13.95	4.08	0.07	1.60
3385.20	51.29	0.42	1955.63	-12.40	4.13	0.08	1.66
3486.16	52.82	0.43	2010.76	-12.36	4.16	0.08	1.69
3743.24	56.72	0.46	2179.76	-12.77	4.24	0.10	1.77
3951.32	59.87	0.49	2317.92	-15.08	4.30	0.11	1.82
4157.22	62.99	0.53	2455.25	-13.79	4.35	0.11	1.88
4375.71	66.30	0.57	2601.74	-12.61	4.41	0.12	1.95
4467.18	67.68	0.59	2650.10	-12.97	4.43	0.13	1.97
4692.66	71.10	0.61	2788.75	-14.79	4.47	0.13	2.04
4858.78	73.62	0.62	2877.34	-16.21	4.51	0.14	2.08
5237.30	79.35	0.67	3083.33	-18.78	4.57	0.14	2.18
5527.30	83.75	0.71	3234.80	-20.38	4.62	0.15	2.26
5747.66	87.09	0.74	3350.86	-21.56	4.67	0.16	2.32
6013.66	91.12	0.77	3490.50	-22.28	4.73	0.17	2.40
6224.03	94.30	0.79	3600.34	-23.03	4.77	0.18	2.45

Column Q-BOP

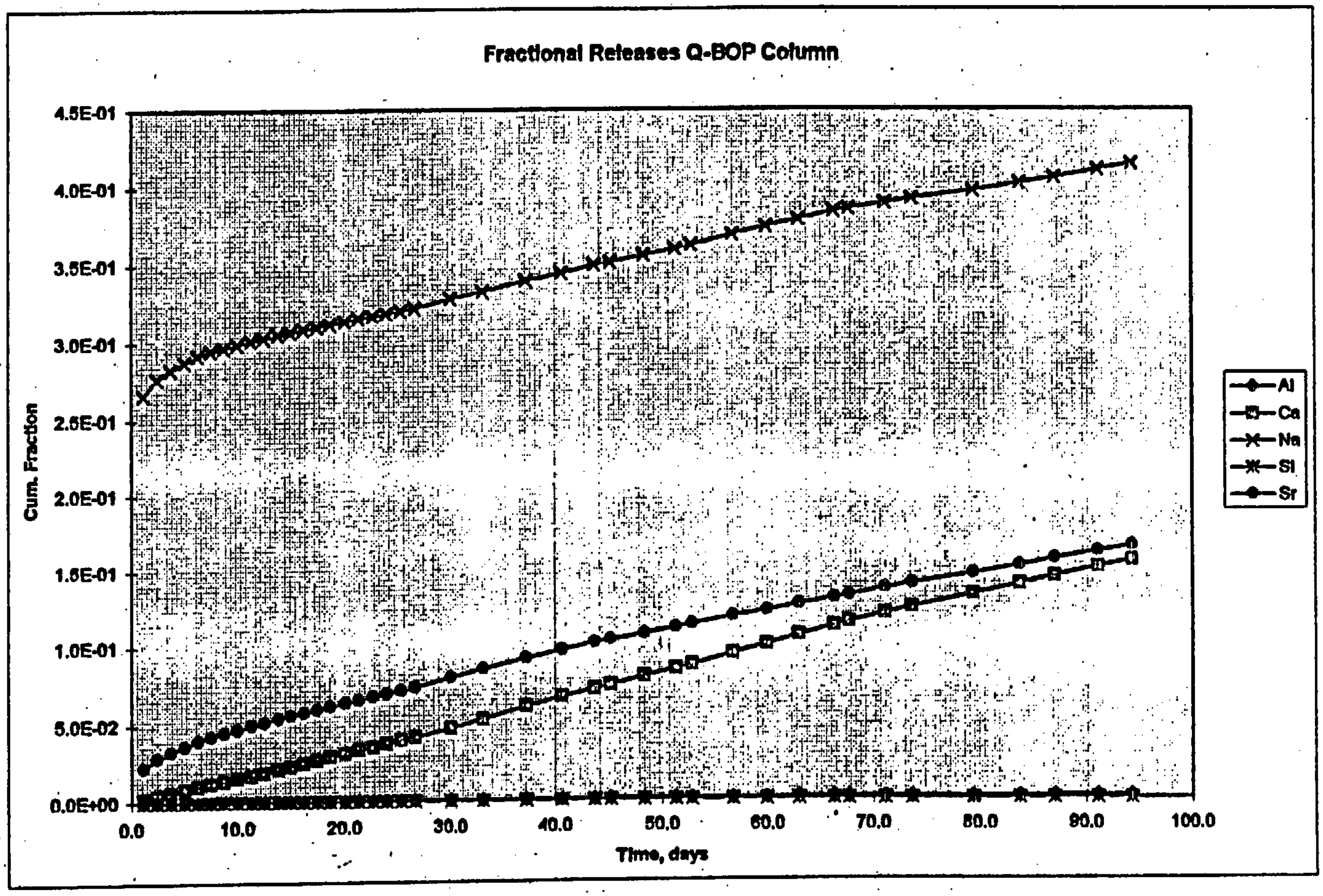




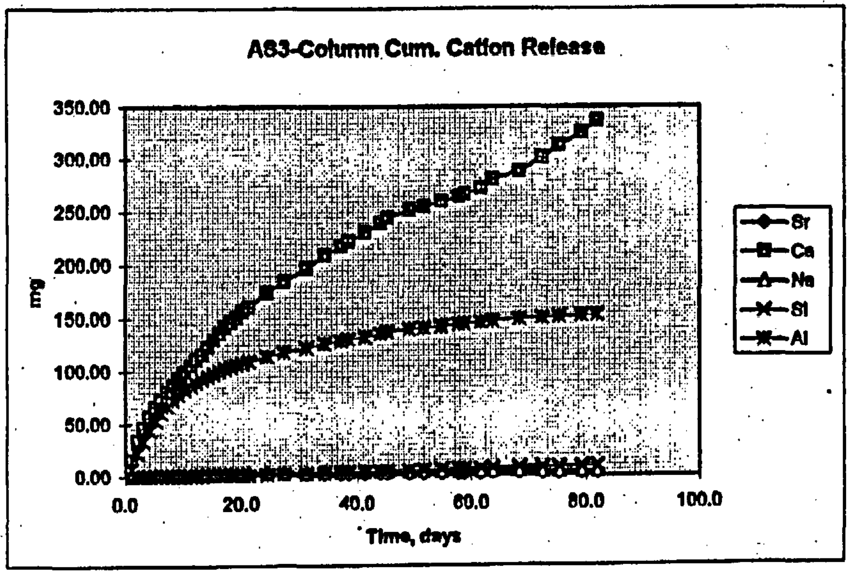
No Anion Data Available

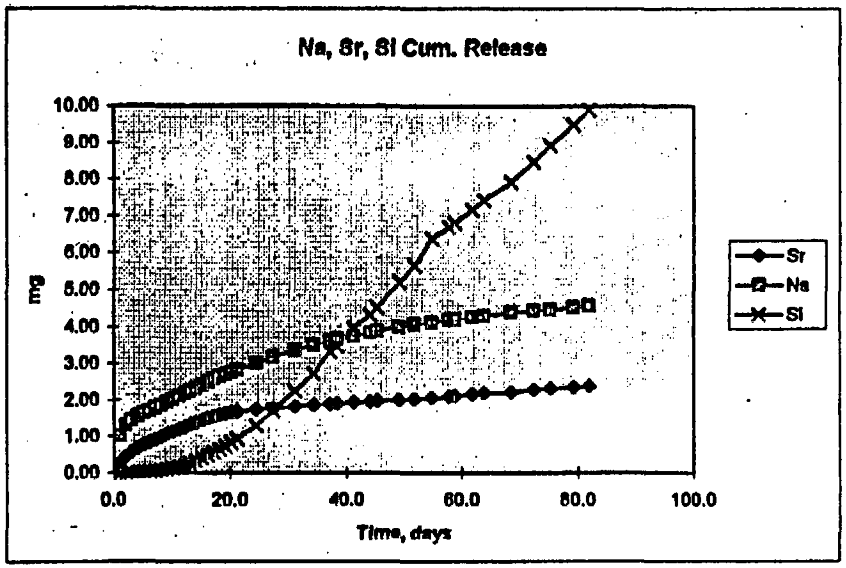
Column Experiment for Slag Q-BOP-A

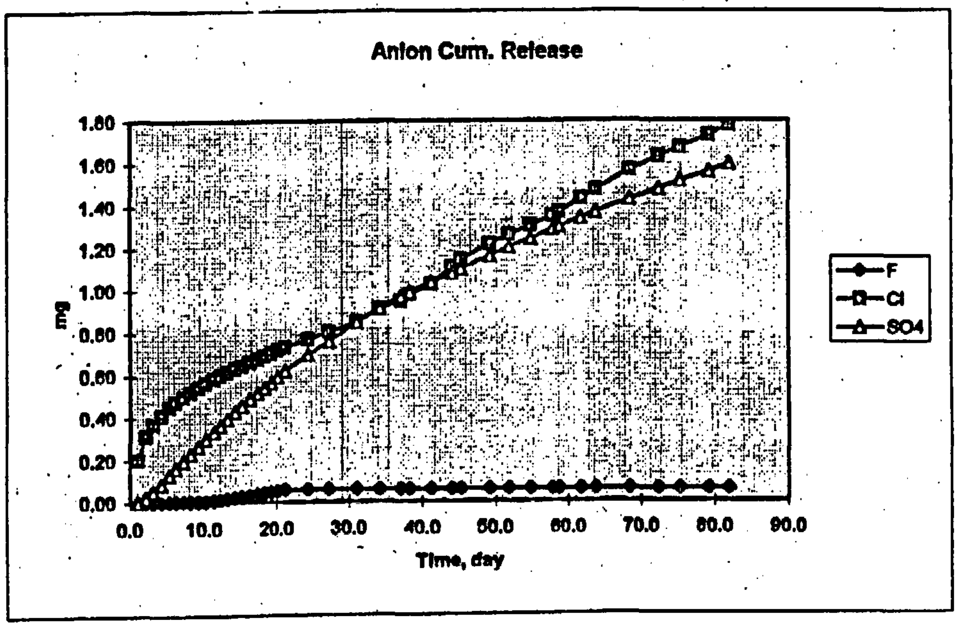
	Effluent g Sum	Days Time	Fraction Al	Fraction Ca	Fraction Fe	Fraction Na	Fraction Si	Fraction Sr
QBOP A Col 1	71.4	1.1	2.1E-05	2.1E-03	-1.0E-05	2.7E-01	2.0E-06	2.2E-02
QBOP A Col 2	155.3	2.4	3.6E-05	4.1E-03	1.4E-04	2.8E-01	2.4E-06	2.8E-02
QBOP A Col 3	239.8	3.6	4.0E-05	6.1E-03	4.7E-04	2.8E-01	2.6E-06	3.3E-02
QBOP A Col 4	328.2	5.0	6.2E-05	8.1E-03	1.9E-03	2.9E-01	2.7E-06	3.6E-02
QBOP A Col 5	413.9	6.3	6.5E-05	1.0E-02	3.0E-03	2.9E-01	3.0E-06	4.0E-02
QBOP A Col 6	492.7	7.5	7.7E-05	1.2E-02	4.6E-03	2.9E-01	3.0E-06	4.3E-02
QBOP A Col 7	575.7	8.7	8.4E-05	1.4E-02	5.5E-03	3.0E-01	3.1E-06	4.5E-02
QBOP A Col 8	657.4	10.0	9.2E-05	1.5E-02	6.2E-03	3.0E-01	3.2E-06	4.7E-02
QBOP A Col 9	741.5	11.2	9.8E-05	1.7E-02	6.3E-03	3.0E-01	3.3E-06	5.0E-02
QBOP A Col 10	824.0	12.5	9.3E-05	1.9E-02	6.4E-03	3.0E-01	3.4E-06	5.2E-02
QBOP A Col 11	912.5	13.8	1.1E-04	2.1E-02	5.9E-03	3.0E-01	3.5E-06	5.4E-02
QBOP A Col 12	989.2	15.0	1.3E-04	2.3E-02	5.8E-03	3.1E-01	3.6E-06	5.6E-02
QBOP A Col 13	1067.4	16.2	1.4E-04	2.5E-02	5.1E-03	3.1E-01	3.7E-06	5.8E-02
QBOP A Col 14	1151.2	17.4	1.7E-04	2.7E-02	4.5E-03	3.1E-01	3.9E-06	6.0E-02
QBOP A Col 15	1235.2	18.7	1.8E-04	2.9E-02	3.7E-03	3.1E-01	4.0E-06	6.2E-02
QBOP A Col 16	1324.0	20.1	2.0E-04	3.1E-02	2.9E-03	3.1E-01	4.1E-06	6.4E-02
QBOP A Col 17	1411.1	21.4	2.2E-04	3.3E-02	2.2E-03	3.2E-01	4.3E-06	6.6E-02
QBOP A Col 18	1496.1	22.7	2.5E-04	3.5E-02	1.4E-03	3.2E-01	4.5E-06	6.8E-02
QBOP A Col 19	1581.9	24.0	2.6E-04	3.7E-02	7.0E-04	3.2E-01	4.5E-06	7.0E-02
QBOP A Col 20	1668.4	25.3	2.7E-04	3.9E-02	-6.4E-05	3.2E-01	4.7E-06	7.2E-02
QBOP A Col 21	1757.1	26.6	2.8E-04	4.1E-02	-1.0E-04	3.2E-01	5.0E-06	7.4E-02
QBOP A Col 22	1980.6	30.0	3.6E-04	4.7E-02	-2.9E-04	3.3E-01	6.3E-06	8.0E-02
QBCP A Col 23	2184.2	33.1	4.1E-04	5.3E-02	-3.1E-04	3.3E-01	7.5E-06	8.5E-02
QBOP A Col 24	2459.2	37.3	4.7E-04	6.1E-02	-5.4E-04	3.4E-01	9.3E-06	9.2E-02
QBOP A Col 25	2680.5	40.6	5.3E-04	6.7E-02	-7.2E-04	3.4E-01	1.0E-05	9.7E-02
QBOP A Col 26	2883.5	43.7	6.1E-04	7.2E-02	-9.0E-04	3.5E-01	1.1E-05	1.0E-01
QBOP A Col 27	2985.5	45.2	6.4E-04	7.4E-02	-9.2E-04	3.5E-01	1.1E-05	1.0E-01
QBOP A Col 28	3189.3	48.3	7.3E-04	8.0E-02	-1.0E-03	3.6E-01	1.3E-05	1.1E-01
QBOP A Col 29	3385.2	51.3	8.3E-04	8.5E-02	-8.9E-04	3.6E-01	1.4E-05	1.1E-01
QBOP A Col 30	3486.2	52.8	8.5E-04	8.7E-02	-8.9E-04	3.6E-01	1.5E-05	1.1E-01
QBOP A Col 31	3743.2	56.7	9.1E-04	9.4E-02	-9.2E-04	3.7E-01	1.7E-05	1.2E-01
QBOP A Col 32	3951.3	59.9	9.8E-04	1.0E-01	-1.1E-03	3.7E-01	1.9E-05	1.2E-01
QBOP A Col 33	4157.2	63.0	1.1E-03	1.1E-01	-9.9E-04	3.8E-01	2.0E-05	1.3E-01
QBOP A Col 34	4375.7	66.3	1.1E-03	1.1E-01	-9.0E-04	3.8E-01	2.2E-05	1.3E-01
QBOP A Col 35	4467.2	67.7	1.2E-03	1.1E-01	-9.3E-04	3.9E-01	2.3E-05	1.3E-01
QBOP A Col 36	4692.7	71.1	1.2E-03	1.2E-01	-1.1E-03	3.9E-01	2.4E-05	1.4E-01
QBOP A Col 37	4858.8	73.6	1.2E-03	1.2E-01	-1.2E-03	3.9E-01	2.4E-05	1.4E-01
QBOP A Col 38	5237.3	79.4	1.3E-03	1.3E-01	-1.3E-03	4.0E-01	2.6E-05	1.5E-01
QBOP A Col 39	5527.3	83.7	1.4E-03	1.4E-01	-1.5E-03	4.0E-01	2.7E-05	1.5E-01
QBOP A Col 40	5747.7	87.1	1.5E-03	1.4E-01	-1.5E-03	4.1E-01	2.9E-05	1.6E-01
QBOP A Col 41	6013.7	91.1	1.5E-03	1.5E-01	-1.6E-03	4.1E-01	3.1E-05	1.6E-01
QBOP A Col 42	6224.0	94.3	1.6E-03	1.6E-01	-1.7E-03	4.1E-01	3.3E-05	1.6E-01


Fractional Releases Q-BOP Column
4.5E-01
4.0E-01
3.5E-01
3.0E-01
2.5E-01
2.0E-01
1.5E-01
1.0E-01
5.0E-02
0.0E+00
Cum. Fraction
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Time, days
Al
Ca
Na
Si
Sr

	Sum Time Days	Eluent wt	Sum Volume	Sum mass Sr	Sum mass Ca	Sum mass Na	Sum mass Si	Sum mass Al	Sum (mg) F	Cl	SO4
as3 Col 1	1.1	73.73	73.73	0.29	16.53	1.01	0.00	7.47	0.00	0.20	0.00
as3 Col 2	2.1	70.13	143.86	0.45	34.03	1.30	0.00	22.81	0.00	0.32	0.02
as3 Col 3	3.1	70.23	214.09	0.57	46.30	1.44	0.01	34.06	0.00	0.37	0.05
as3 Col 4	4.2	74.79	288.88	0.67	57.17	1.54	0.02	44.30	0.00	0.41	0.08
as3 Col 5	5.3	71.61	360.49	0.77	65.83	1.63	0.03	53.36	0.00	0.45	0.13
as3 Col 6	6.2	64.47	424.96	0.84	73.73	1.70	0.04	60.86	0.00	0.48	0.16
as3 Col 7	7.2	69.12	494.08	0.92	80.75	1.77	0.05	67.27	0.00	0.50	0.20
as3 Col 8	8.2	67.93	562.01	0.98	86.96	1.84	0.07	72.92	0.00	0.52	0.23
as3 Col 9	9.2	70.35	632.36	1.06	93.82	1.93	0.09	78.13	0.00	0.54	0.27
as3 Col 10	10.2	68.71	701.07	1.13	99.82	2.01	0.12	82.54	0.00	0.56	0.30
as3 Col 11	11.3	75.50	776.57	1.20	105.93	2.10	0.16	86.44	0.00	0.58	0.33
as3 Col 12	12.2	62.55	839.12	1.25	111.76	2.17	0.20	89.70	0.01	0.60	0.36
as3 Col 13	13.2	64.38	903.50	1.31	116.17	2.24	0.24	92.49	0.01	0.62	0.39
as3 Col 14	14.2	70.10	973.60	1.38	123.52	2.32	0.31	95.45	0.02	0.63	0.43
as3 Col 15	15.2	70.70	1044.30	1.44	130.28	2.41	0.39	97.96	0.03	0.64	0.46
as3 Col 16	16.3	71.26	1115.56	1.49	136.39	2.49	0.47	100.37	0.03	0.66	0.49
as3 Col 17	17.3	68.79	1184.35	1.54	141.78	2.58	0.55	102.66	0.04	0.68	0.52
as3 Col 18	18.2	67.28	1251.63	1.59	147.26	2.65	0.63	104.53	0.04	0.69	0.54
as3 Col 19	19.2	67.37	1319.00	1.62	151.46	2.71	0.72	106.20	0.05	0.71	0.57
as3 Col 20	20.2	68.21	1387.21	1.65	156.64	2.77	0.83	107.80	0.05	0.72	0.59
as3 Col 21	21.3	70.87	1458.08	1.67	160.83	2.83	0.92	109.74	0.06	0.73	0.62
as3 Col 22	24.4	218.81	1676.89	1.73	174.39	3.01	1.31	114.65	0.06	0.77	0.70
as3 Col 23	27.3	196.90	1873.79	1.76	184.20	3.17	1.70	118.34	0.06	0.80	0.76
as3 Col 24	31.1	259.84	2133.63	1.81	196.81	3.36	2.24	122.40	0.06	0.85	0.85
as3 Col 25	34.3	216.94	2350.57	1.84	209.10	3.50	2.73	126.66	0.06	0.91	0.91
as3 Col 26	37.1	197.21	2547.78	1.87	217.62	3.61	3.32	129.10	0.06	0.95	0.97
as3 Col 27	38.4	85.97	2633.75	1.89	221.94	3.66	3.48	130.57	0.06	0.98	0.99
as3 Col 28	41.3	198.10	2831.85	1.91	230.38	3.74	3.97	132.82	0.06	1.03	1.03
as3 Col 29	44.1	192.54	3024.39	1.94	239.12	3.84	4.33	136.04	0.06	1.11	1.08
as3 Col 30	45.3	86.45	3110.84	1.96	243.94	3.88	4.52	137.44	0.06	1.14	1.10
as3 Col 31	49.1	261.12	3371.96	2.00	251.46	3.98	5.19	140.02	0.06	1.22	1.16
as3 Col 32	51.8	180.31	3552.27	2.02	254.94	4.05	5.64	141.52	0.06	1.26	1.20
as3 Col 33	54.8	206.02	3758.29	2.05	259.66	4.12	6.38	142.91	0.06	1.30	1.24
AS Col 34	57.8	204.18	3962.47	2.09	264.10	4.18	6.69	144.27	0.06	1.35	1.29
AS Col 35	58.7	68.07	4030.54	2.11	266.83	4.20	6.80	144.86	0.06	1.37	1.30
AS Col 36	61.7	201.97	4232.51	2.15	272.45	4.26	7.15	146.56	0.06	1.43	1.34
AS Col 37	63.8	141.66	4374.17	2.19	280.63	4.30	7.42	147.75	0.06	1.47	1.37
AS Col 38	68.4	320.24	4694.41	2.21	287.56	4.37	7.92	149.57	0.06	1.57	1.43
AS Col 39	72.4	270.36	4964.77	2.27	301.30	4.43	8.46	150.92	0.06	1.63	1.48
AS Col 40	75.2	196.05	5160.82	2.31	312.53	4.47	8.92	151.77	0.06	1.67	1.52
AS Col 41	79.2	271.63	5432.45	2.35	324.89	4.52	9.49	152.81	0.06	1.73	1.56
AS Col 42	81.9	186.29	5618.74	2.38	336.56	4.56	9.90	153.43	0.06	1.77	1.60

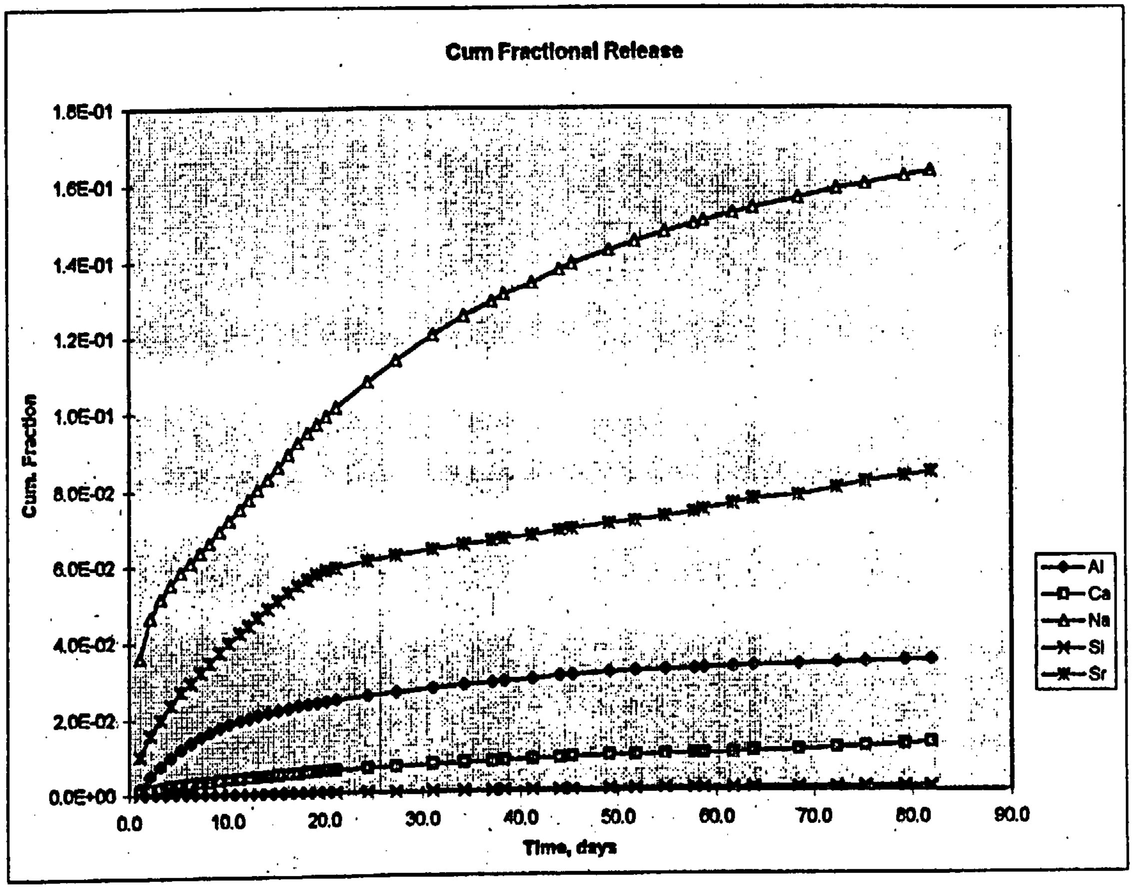

AS3-Column Cum. Cation Release
mg
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.0
20.0
40.0
60.0
80.0
100.0
Time, days
Sr
Ca
Na
Si
Al


Na, Sr, Si Cum. Release
mg
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.0
20.0
40.0
60.0
80.0
100.0
Time, days
Sr
Na
Si

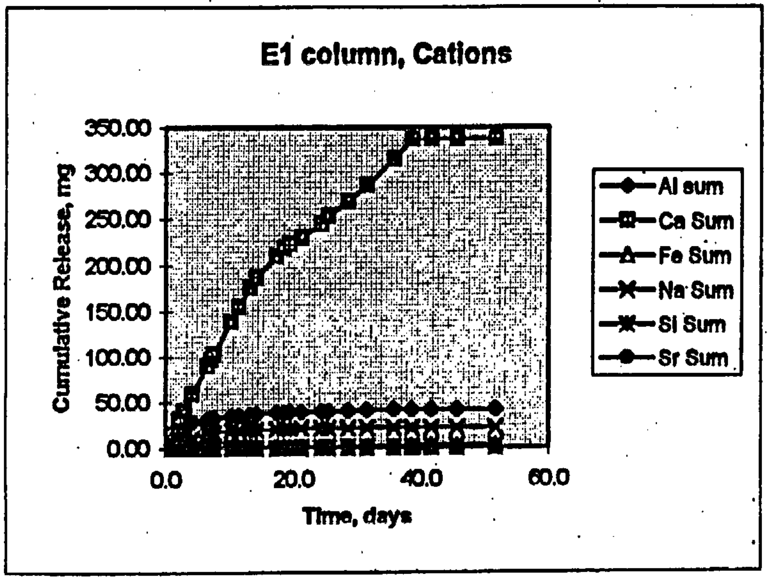

Anion Cum. Release
mg
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
Time, day
F
Cl
SO4

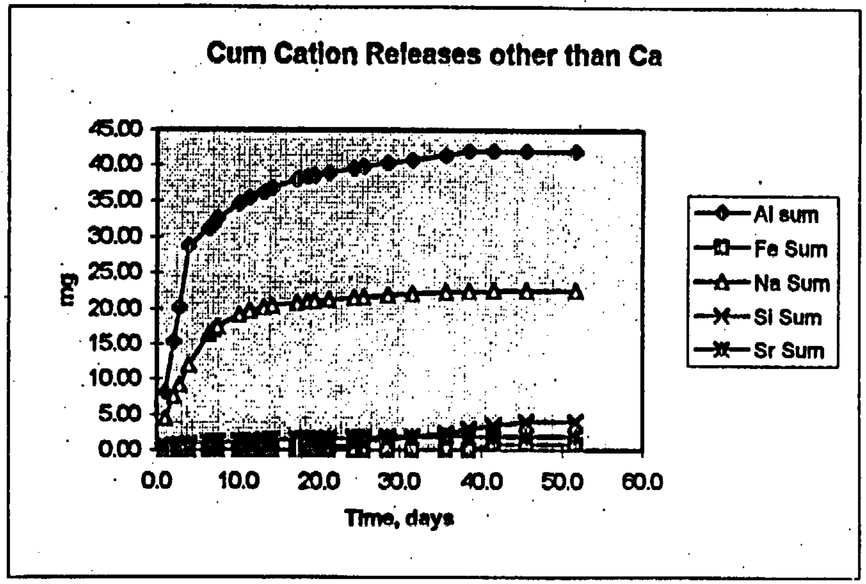
	Sum mL Volume	Sum Time Days	Fraction Released Al	Fraction Released Ca	Fraction Released Na	Fraction Released Si	Fraction Released Sr
as3 Col 1	73.7	1.1	1.7E-03	6.3E-04	3.6E-02	1.3E-07	1.0E-02
as3 Col 2	143.9	2.1	5.2E-03	1.3E-03	4.7E-02	4.5E-07	1.6E-02
as3 Col 3	214.1	3.1	7.7E-03	1.8E-03	5.2E-02	1.4E-06	2.0E-02
as3 Col 4	288.9	4.2	1.0E-02	2.2E-03	5.5E-02	2.3E-06	2.4E-02
as3 Col 5	360.5	5.3	1.2E-02	2.5E-03	5.8E-02	3.2E-06	2.7E-02
as3 Col 6	425.0	6.2	1.4E-02	2.8E-03	6.1E-02	4.6E-06	3.0E-02
as3 Col 7	494.1	7.2	1.5E-02	3.1E-03	6.4E-02	6.5E-06	3.2E-02
as3 Col 8	562.0	8.2	1.6E-02	3.3E-03	6.6E-02	8.7E-06	3.5E-02
as3 Col 9	632.4	9.2	1.8E-02	3.6E-03	6.9E-02	1.2E-05	3.8E-02
as3 Col 10	701.1	10.2	1.9E-02	3.8E-03	7.2E-02	1.6E-05	4.0E-02
as3 Col 11	776.6	11.3	2.0E-02	4.0E-03	7.5E-02	2.1E-05	4.2E-02
as3 Col 12	839.1	12.2	2.0E-02	4.2E-03	7.8E-02	2.6E-05	4.4E-02
as3 Col 13	903.5	13.2	2.1E-02	4.4E-03	8.0E-02	3.1E-05	4.6E-02
as3 Col 14	973.6	14.2	2.2E-02	4.7E-03	8.3E-02	4.0E-05	4.9E-02
as3 Col 15	1044.3	15.2	2.2E-02	4.9E-03	8.6E-02	5.0E-05	5.1E-02
as3 Col 16	1115.6	16.3	2.3E-02	5.2E-03	8.9E-02	6.1E-05	5.3E-02
as3 Col 17	1184.4	17.3	2.3E-02	5.4E-03	9.2E-02	7.0E-05	5.5E-02
as3 Col 18	1251.6	18.2	2.4E-02	5.6E-03	9.5E-02	8.2E-05	5.6E-02
as3 Col 19	1319.0	19.2	2.4E-02	5.7E-03	9.7E-02	9.3E-05	5.7E-02
as3 Col 20	1387.2	20.2	2.4E-02	5.9E-03	9.9E-02	1.1E-04	5.9E-02
as3 Col 21	1458.1	21.3	2.5E-02	6.1E-03	1.0E-01	1.2E-04	5.9E-02
as3 Col 22	1676.9	24.4	2.6E-02	6.6E-03	1.1E-01	1.7E-04	6.1E-02
as3 Col 23	1873.8	27.3	2.7E-02	7.0E-03	1.1E-01	2.2E-04	6.2E-02
as3 Col 24	2133.6	31.1	2.8E-02	7.5E-03	1.2E-01	2.9E-04	6.4E-02
as3 Col 25	2350.6	34.3	2.9E-02	7.9E-03	1.3E-01	3.5E-04	6.5E-02
as3 Col 26	2547.8	37.1	2.9E-02	8.3E-03	1.3E-01	4.3E-04	6.6E-02
as3 Col 27	2633.8	38.4	3.0E-02	8.4E-03	1.3E-01	4.5E-04	6.7E-02
as3 Col 28	2831.9	41.3	3.0E-02	8.7E-03	1.3E-01	5.1E-04	6.8E-02
as3 Col 29	3024.4	44.1	3.1E-02	9.1E-03	1.4E-01	5.6E-04	6.9E-02
as3 Col 30	3110.8	45.3	3.1E-02	9.3E-03	1.4E-01	5.8E-04	6.9E-02
as3 Col 31	3372.0	49.1	3.2E-02	9.5E-03	1.4E-01	6.7E-04	7.1E-02
as3 Col 32	3552.3	51.8	3.2E-02	9.7E-03	1.5E-01	7.3E-04	7.1E-02
as3 Col 33	3758.3	54.8	3.2E-02	9.9E-03	1.5E-01	8.2E-04	7.3E-02
AS Col 34	3962.5	57.8	3.3E-02	1.0E-02	1.5E-01	8.6E-04	7.4E-02
AS Col 35	4030.5	58.7	3.3E-02	1.0E-02	1.5E-01	8.8E-04	7.5E-02
AS Col 36	4232.5	61.7	3.3E-02	1.0E-02	1.5E-01	9.2E-04	7.6E-02
AS Col 37	4374.2	63.8	3.3E-02	1.1E-02	1.5E-01	9.5E-04	7.7E-02
AS Col 38	4694.4	68.4	3.4E-02	1.1E-02	1.6E-01	1.0E-03	7.8E-02
AS Col 39	4964.8	72.4	3.4E-02	1.1E-02	1.6E-01	1.1E-03	8.0E-02
AS Col 40	5160.8	75.2	3.4E-02	1.2E-02	1.6E-01	1.1E-03	8.2E-02
AS Col 41	5432.5	79.2	3.5E-02	1.2E-02	1.6E-01	1.2E-03	8.3E-02
AS Col 42	5618.7	81.9	3.5E-02	1.3E-02	1.6E-01	1.3E-03	8.4E-02

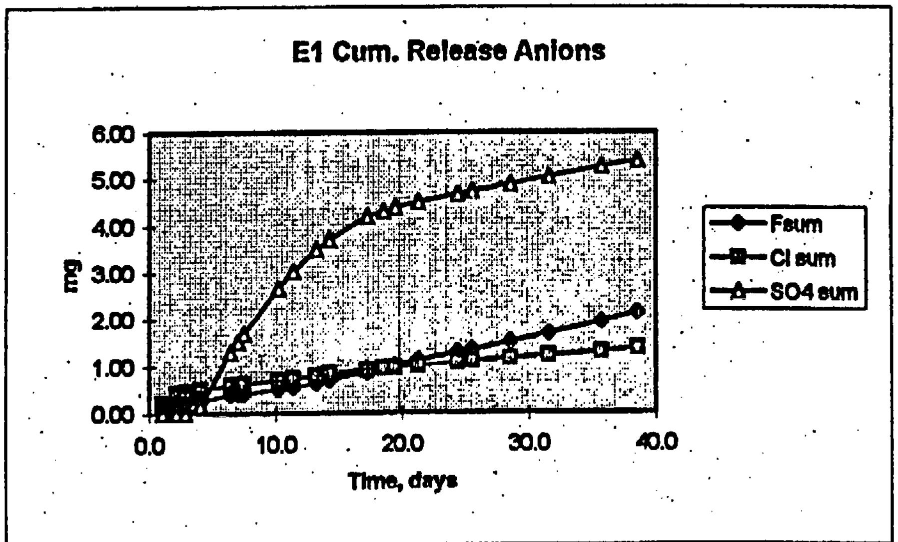
AS3 Column

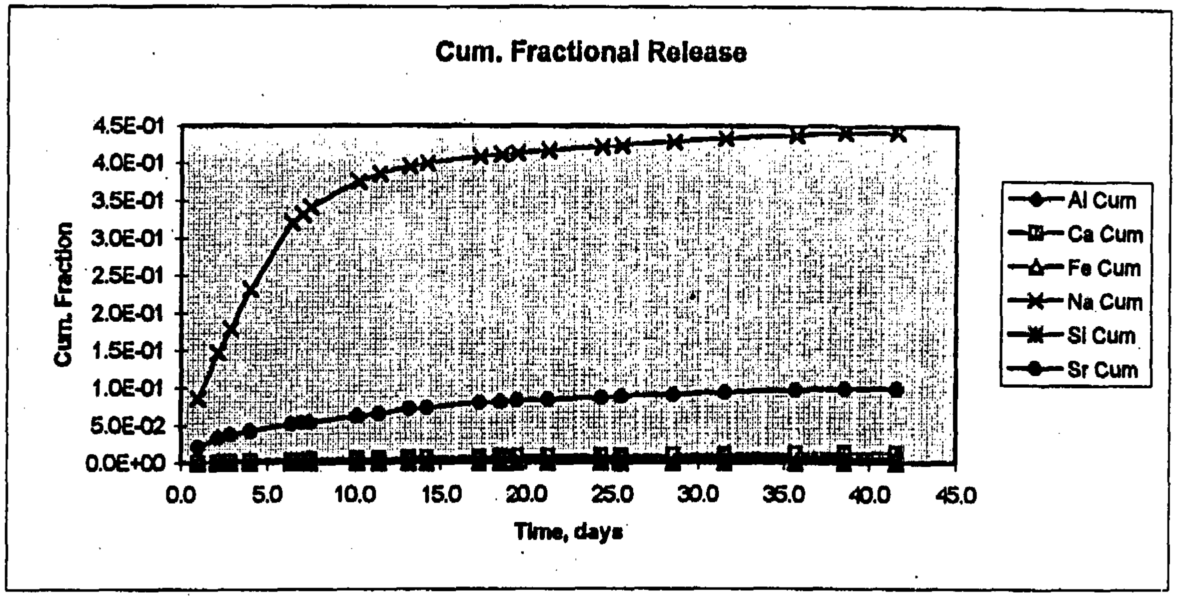

Cum Fractional Release
Cum. Fraction
Time, days
0.0E+00
2.0E-02
4.0E-02
6.0E-02
8.0E-02
1.0E-01
1.2E-01
1.4E-01
1.6E-01
1.8E-01
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
Al
Ca
Na
Si
Sr

	Sum Time Days	Al sum mg	Ca Sum mg	Fe Sum mg	Na Sum mg	Si Sum mg	Sr Sum mg	Fsum mg	Cl sum mg	SO4 sum mg	pH
E1 Col 1	1.0	8.09	16.87	0.00	4.39	0.01	0.42	0.08	0.21	0.00	
E1 Col 2	2.1	15.28	31.83	0.00	7.50	0.03	0.66	0.15	0.42	0.00	12.1
E1 Col 3	2.8	20.12	41.24	0.00	9.12	0.03	0.75	0.23	0.45	0.00	
E1 Col 4	4.0	28.75	59.18	0.00	11.85	0.04	0.85	0.25	0.51	0.16	
E1 Col 5	6.4	31.00	89.96	0.00	16.35	0.05	1.03	0.39	0.59	1.28	12.3
E1 Col 6	7.0	31.66	97.37	0.00	16.92	0.06	1.06	0.40	0.61	1.51	
E1 Col 7	7.5	32.52	102.85	0.00	17.42	0.06	1.08	0.41	0.62	1.68	
E1 Col 8	10.2	34.53	138.94	0.00	19.17	0.07	1.23	0.51	0.69	2.66	12.4
E1 Col 9	11.4	35.30	154.98	0.00	19.71	0.09	1.31	0.55	0.73	3.03	
E1 Col 10	13.2	36.08	176.03	0.00	20.19	0.10	1.42	0.63	0.79	3.48	
E1 Col 11	14.2	36.68	186.27	0.00	20.39	0.11	1.47	0.68	0.82	3.70	
E1 Col 12	17.3	37.87	210.19	0.00	20.84	0.14	1.59	0.86	0.90	4.18	12.2
E1 Col 13	18.5	38.26	218.37	0.00	20.99	0.35	1.62	0.94	0.94	4.31	
E1 Col 14	19.4	38.49	223.08	0.00	21.08	0.47	1.65	1.00	0.96	4.39	
E1 Col 15	21.3	38.86	229.02	0.00	21.26	0.57	1.67	1.10	1.00	4.50	11.7
E1 Col 16	24.4	39.52	244.36	0.00	21.53	0.78	1.73	1.27	1.07	4.67	
E1 Col 17	25.5	39.72	252.64	0.00	21.62	1.20	1.75	1.34	1.09	4.72	
E1 Col 18	28.5	40.22	268.11	0.00	21.86	1.39	1.81	1.51	1.15	4.88	12.0
E1 Col 19	31.6	40.70	286.20	0.00	22.08	1.81	1.86	1.68	1.20	5.03	
E1 Col 20	35.7	41.33	314.51	0.00	22.33	2.27	1.93	1.94	1.30	5.26	
E1 Col 21	38.5	41.94	336.33	0.00	22.49	2.98	1.97	2.13	1.36	5.39	12.1
E1 Col 22	41.6	41.98	337.19	0.84	22.53	3.43	1.97				
E1 Col 23	45.6	41.98	337.19	0.84	22.53	3.93	1.97				
E1 Col 24	51.7	41.98	337.19	0.84	22.53	3.93	1.97				
		41.98	337.19	0.84	22.53	3.93	1.97				


E1 column, Cations
Cumulative Release, mg
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.0
20.0
40.0
60.0
Time, days
Al sum
Ca Sum
Fe Sum
Na Sum
Si Sum
Sr Sum


Cum Cation Releases other than Ca
mg
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Time, days
Al sum
Fe Sum
Na Sum
Si Sum
Sr Sum


E1 Cum. Release Anions
mg
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.0
10.0
20.0
30.0
40.0
Time, days
Fsum
Cl sum
SO4 sum


Cum. Fractional Release
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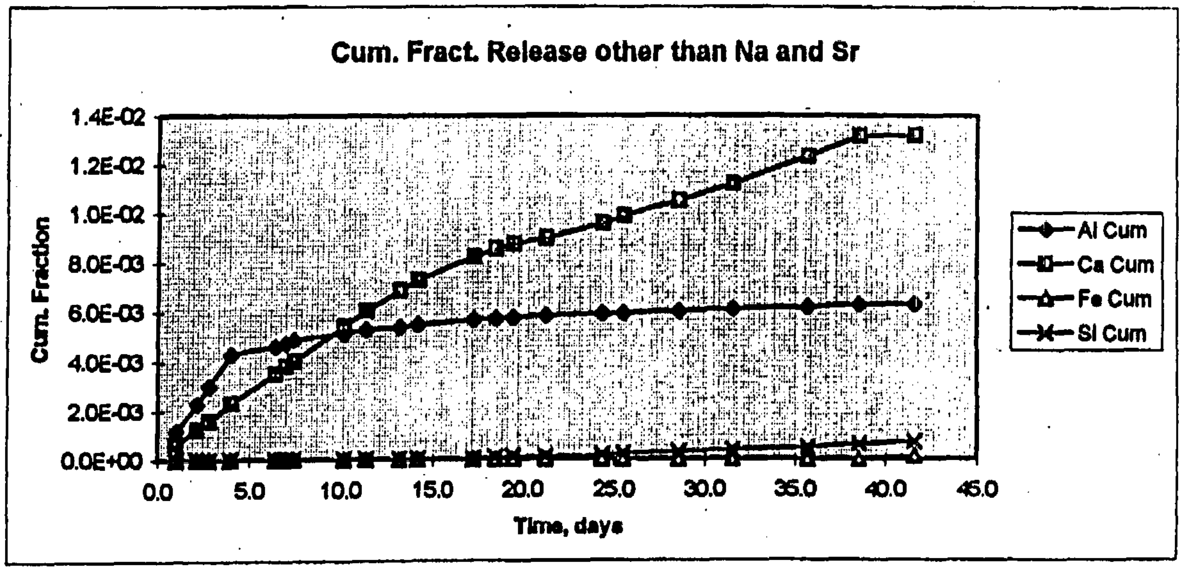
4.0E-01
3.5E-01
3.0E-01
2.5E-01
2.0E-01
1.5E-01
1.0E-01
5.0E-02
0.0E+00
Cum. Fraction
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
Time, days
Al Cum
Ca Cum
Fe Cum
Na Cum
Si Cum
Sr Cum


Cum. Fract. Release other than Na and Sr
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1.2E-02
1.0E-02
8.0E-03
6.0E-03
4.0E-03
2.0E-03
0.0E+00
Cum. Fraction
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
Time, days
Al Cum
Ca Cum
Fe Cum
Si Cum

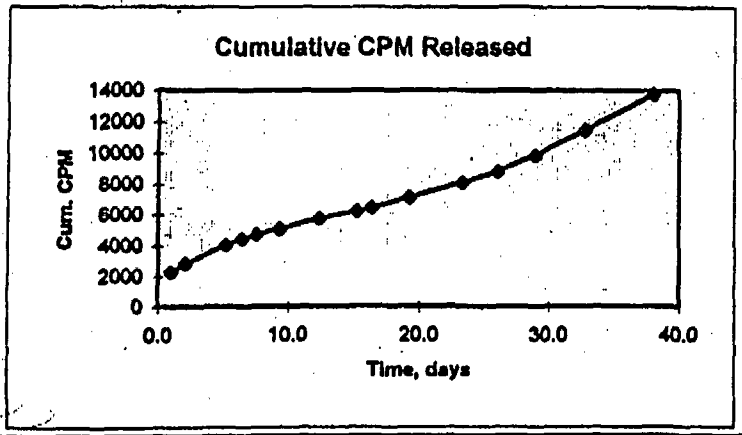
	Sum Effluent	Sum Time Days	Al Cum Fraction Released	Ca Cum Fraction Released	Fe Cum Fraction Released	Na Cum Fraction Released	Si Cum Fraction Released	Sr Cum Fraction Released
E1 Col 1	64.3	1.0	1.2E-03	6.6E-04	4.7E-08	8.6E-02	2.8E-06	2.1E-02
E1 Col 2	134.7	2.1	2.3E-03	1.2E-03	3.9E-08	1.5E-01	5.6E-06	3.3E-02
E1 Col 3	178.8	2.8	3.0E-03	1.6E-03	4.7E-08	1.8E-01	7.2E-06	3.8E-02
E1 Col 4	250.8	4.0	4.3E-03	2.3E-03	1.0E-07	2.3E-01	8.0E-06	4.3E-02
E1 Col 5	404.5	6.4	4.7E-03	3.5E-03	2.0E-07	3.2E-01	9.9E-06	5.2E-02
E1 Col 6	441.0	7.0	4.8E-03	3.8E-03	2.4E-07	3.3E-01	1.3E-05	5.3E-02
E1 Col 7	470.0	7.5	4.9E-03	4.0E-03	3.0E-07	3.4E-01	1.3E-05	5.4E-02
E1 Col 8	641.2	10.2	5.2E-03	5.4E-03	5.5E-07	3.8E-01	1.4E-05	6.2E-02
E1 Col 9	717.3	11.4	5.3E-03	6.1E-03	5.6E-07	3.9E-01	1.9E-05	6.6E-02
E1 Col 10	829.1	13.2	5.4E-03	6.9E-03	7.0E-07	4.0E-01	2.1E-05	7.2E-02
E1 Col 11	894.8	14.2	5.5E-03	7.3E-03	7.1E-07	4.0E-01	2.4E-05	7.4E-02
E1 Col 12	1088.7	17.3	5.7E-03	8.2E-03	3.4E-07	4.1E-01	3.0E-05	8.0E-02
E1 Col 13	1166.2	18.5	5.7E-03	8.5E-03	3.8E-07	4.1E-01	7.3E-05	8.2E-02
E1 Col 14	1225.1	19.4	5.8E-03	8.7E-03	4.2E-07	4.1E-01	9.8E-05	8.3E-02
E1 Col 15	1339.4	21.3	5.8E-03	9.0E-03	4.9E-07	4.2E-01	1.2E-04	8.4E-02
E1 Col 16	1534.9	24.4	5.9E-03	9.6E-03	4.8E-07	4.2E-01	1.6E-04	8.7E-02
E1 Col 17	1607.8	25.5	6.0E-03	9.9E-03	4.3E-07	4.2E-01	2.5E-04	8.8E-02
E1 Col 18	1798.4	28.5	6.0E-03	1.0E-02	3.3E-07	4.3E-01	2.9E-04	9.1E-02
E1 Col 19	1987.7	31.6	6.1E-03	1.1E-02	4.5E-07	4.3E-01	3.8E-04	9.3E-02
E1 Col 20	2248.4	35.7	6.2E-03	1.2E-02	3.9E-07	4.4E-01	4.7E-04	9.7E-02
E1 Col 21	2428.1	38.5	6.3E-03	1.3E-02	5.9E-07	4.4E-01	6.2E-04	9.9E-02
E1 Col 22	2618.5	41.6	6.3E-03	1.3E-02	1.2E-04	4.4E-01	7.2E-04	9.9E-02

Flow Through Column
Slag SEG- 009

Note
LSC chA is the cpm measured between 0 and 18.6 keV on a Liquid Scintillation Counter
Corrected LSC chA data is corrected for blank and normalized per gram of solution
Sum LSC is the cumulative release
Column Leach Test of sample SEG-96-009855

Column Leach Test of sample SEG-96-009855

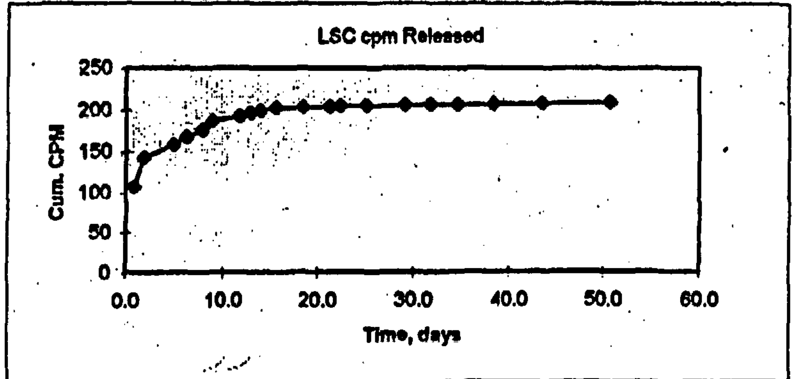
	Time Days	Sample Volume	Sum Vol g	LSC cpm A	LSC cpm released	Sum LSC cpm released	Cs-137 cpm/g	Co-60 cpm/g	Cs-137 pCi/g
SEG-Col-1	1.0	98.3	98.3	72.2	2343	2343	0.016	0.008	0.67
SEG-Col-2	2.1	68.9	167.3	24.7	552	2895	0.005	<0.001	0.21
SEG-Col-3	5.2	202.3	369.6	18.7	1214	4108	0.003	<0.001	0.13
SEG-Col-4	6.5	79.4	449.0	15.6	394	4503	0.003	<0.001	0.13
SEG-Col-5	7.6	70.6	519.5	13.3	296	4799			
SEG-Col-6	9.4	113.2	632.7	10.1	355	5154			
SEG-Col-7	12.4	193.2	825.9	11.1	670	5823	0.002	<0.001	0.08
SEG-Col-8	15.3	186.9	1012.8	8.0	455	6278	0.003	<0.001	0.13
SEG-Col-9	16.4	71.6	1084.4	9.1	200	6479			
SEG-Col-10	19.3	183.4	1267.8	11.5	660	7139			
SEG-Col-11	23.3	260.3	1528.1	11.7	954	8093	<0.001	<0.001	<0.04
SEG-Col-12	26.1	174.1	1702.2	12.9	708	8801	<0.001	<0.001	<0.04
SEG-Col-13	28.9	184.1	1886.3	18.0	1062	9863			
SEG-Col-14	32.8	245.1	2131.4	20.4	1610	11473			
SEG-Col-15	38.1	338.6	2470.0	21.1	2302	13775			



Flow through Column
Slag CM-53

Note
LSC chA is the cpm measured between 0 and 18.6 keV on a Liquid Scintillation Counter
Corrected LSC chA data is corrected for blank and normalized per gram of solution
Sum LSC is the cumulative release
Column Leaching Experiment for Slag Sample CM-0053

	Time Days	Effluent Wt g	Sum Effluent	LSC chA cpm	corrected LSC chA cpm/g	Sum LSC cpm Released	Cs-137 cpm/g	Cs-137 pCi/g	Cs-134 cpm/g
CM-53-1	0.8	49	49	330.9	106.97	106.97	0.061	2.54	0.014
CM-53-2	1.8	63.83	112.8	116.5	35.50	142.47	0.013	0.54	0.011
CM-53-3	4.9	193.37	306.2	57.7	15.90	158.37	0.004	0.17	<0.003
CM-53-4	6.2	81.65	387.9	38.4	9.47	167.84	0.005	0.21	<0.003
CM-53-5	7.8	105.61	493.5	34.7	8.23	176.07	0.004	0.17	<0.003
CM-53-6	8.8	61.67	555.1	41.6	10.53	186.60	0.004	0.17	<0.003
CM-53-7	11.7	182.83	738.0	26.3	5.43	192.04			
CM-53-8	12.9	72.42	810.4	22.2	4.07	196.10	0.003	0.13	<0.003
CM-53-9	13.9	65.37	875.8	18.7	2.90	199.00			
CM-53-10	15.6	105.7	981.5	18.3	2.77	201.77			
CM-53-11	18.4	180.5	1162.0	12.9	0.97	202.74	<0.003	<0.13	<0.003
CM-53-12	21.3	177.3	1339.3	12.7	0.90	203.64			
CM-53-13	22.3	67.63	1406.9	12.9	0.97	204.60	<0.003	<0.13	<0.003
CM-53-14	25.1	175.05	1581.9	9.9	-0.03	204.57			
CM-53-15	29.1	252.15	1834.1	13	1.00	205.57	0.003	0.13	<0.003
CM-53-16	31.8	167.08	2001.2	11.4	0.47	206.04	<0.003	<0.13	<0.003
CM-53-17	34.6	177.44	2178.6	9.5	-0.17	205.87			
CM-53-18	38.3	236.24	2414.8	13.1	1.03	206.90			
CM-53-19	43.5	324.86	2739.7	13.1	1.03	207.94			
CM-53-20	50.7	457.13	3196.8	14.2	1.40	209.34			



ACCELERATED LEACH TEST FOR DIFFUSIVE RELEASES FROM SOLIDIFIED WASTE AND A COMPUTER PROGRAM TO MODEL DIFFUSIVE, FRACTIONAL LEACHING FROM CYLINDRICAL WASTE FORMS

January 1995

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1. Scope

1.1 This practice provides a method for accelerating the leach rate of solidified waste and determining if the release is diffusion controlled. The method is applicable to any material that does not degrade, deform or change leaching mechanism during the test.

1.1.1 If diffusion is the dominant leaching mechanism then results of this test can be used to model long-term releases from waste forms. Diffusion can be confirmed as the leaching mechanism through the use of a computerized mathematical model for diffusion from the finite cylinder (Note 1).

1.1.2 The leaching mechanism should be verified as diffusion controlled by a means other than analysis of the leach test data. For this purpose analysis of post-leaching concentration profiles within the solid waste form is recommended.

Note 1- The computer program and the models are briefly described in the annex to this practice and elsewhere [1].

2. Referenced Documents

2.1 *ASTM Standards*

E632 Standard Practice for Developing Accelerated Tests to Aid Prediction of the Service Life of Building Components and Materials [2].

D1193 Standard Specification for Reagent Water [3].

2.2 Other Documents

1. Fuhrmann, M., Heiser, J., Pietrzak, R., Franz, E.M., and Colombo, P., Users' Guide for the Accelerated Leach Test Computer Program, BNL-52267, Brookhaven National Laboratory, Upton, NY 11973, October 1990.
2. 1983 Annual Book of ASTM Standards, Vol. 04.07.
3. 1982 Annual Book of ASTM Standards, part 31, Water.
4. Hespe, E.D., "Leach Testing of Immobilized Radioactive Waste Solids, A proposal for a Standard Method", Atomic Energy Review, Vol. 9, No. 1, p. 195-207, April, 1971.
5. American Nuclear Society, "Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure", ANSI/ANS 16.1-1986, American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois, 60525, April, 1986.
6. Fuhrmann, M., Pietrzak, R.F., Franz, E.M., Heiser, J.H., and Colombo, P., "Optimization of the Factors that Accelerated Leaching," Topical Report, BNL-52204, Brookhaven National Laboratory, Upton, New York 11973, March 1989.
7. Pescatore, C., "Improved Expressions of Modeling Diffusive, Fractional Cumulative Leaching from Finite Size Waste Forms," Waste Management, Vol. 10, p. 155-159, 1990.
8. Dougherty, D.R., Pietrzak, R.F., Fuhrmann, M., and Colombo, P., "An Experimental Survey of Factors that Affect Leaching from Low-Level Radioactive waste Forms," Topical Report, BNL-52125, Brookhaven National laboratory, Upton, New York 11973, September 1988.
9. Fuhrmann, M., Pietrzak, R.F., Heiser, J., Franz, E.M., and Colombo, P., Accelerated Leach Test Development Program, BNL-52270, Brookhaven National Laboratory, Upton, New York 11973, October 1990.
10. Fuhrmann, M. and Kalb, P.D., "Leaching Behavior of Polyethylene Encapsulated Nitrate Waste, "Stabilization and Solidification of Hazardous, Radioactive and Mixed Wastes, STP 1240, T. Michael Gilliam and Carleton C. Wiles, Eds. American Society for Testing and Materials, Philadelphia, 1993

3. Terminology

3.1 *Cumulative Fraction Leached*—The sum of the fractions of a species leached during all sampling intervals calculated as $CFL = \Sigma a_n/A_0$ and assuming no radioactive decay, where a_n is the quantity of a species in the leachate during any interval and A_0 is the quantity of that species originally present in the sample.

3.2 *Diffusion Coefficient (Diffusivity)*—Based on Fick's Laws for diffusion, the diffusion coefficient is the ratio of the rate of transfer of a diffusing substance through the unit area of a section to the concentration gradient measured normal to the section.

3.3 *Effective Diffusion Coefficient (Effective Diffusivity)*—The diffusion coefficient that results from diffusion as it is modified by other processes (e.g. adsorption) or physical constraints (tortuosity and constrictivity).

3.4 *Finite Cylinder (Finite Medium)*—A bounded body for which Fick's diffusion equation can be solved.

3.5 *Incremental Fraction Leached*—The fraction leached of a specie of interest during a single sampling interval calculated as IFL= a_n/A_0 and assuming no radioactive decay.

3.6 *Leachant*—The liquid that contacts the specimen during a leach test or contacts a waste form in the disposal environment.

3.7 *Leachate*—The leachant after contacting the specimen or the waste form.

3.8 *Leaching*—The process (or processes) by which mass transport from a solid to a liquid takes place.

3.9 *Leaching Interval*—The length of time during which a given volume of leachant is in contact with a specimen.

3.10 *Leaching Mechanism*—The process that controls the rate of mass transport out of a specimen during leaching.

3.11 *Reference Leach Test*—A leach test conducted under defined conditions the results of which are used as a standard against which the results of other leach tests (e.g. accelerated) are compared. In this method a reference leach test is one that is conducted at 20°C.

3.12 *Semi-dynamic Leach Test*—A leach test method that exposes the specimen to fresh leachant on a periodic schedule.

3.13 *Semi-infinite Medium*—A body, used in diffusion theory, the outer boundary of which is effectively at an infinite distance from the inner region.

3.14 *Source Term*—The original concentration, prior to leaching, of a species of interest in a specimen or a waste form.

3.15 *Surface Area*—For purposes of this test method, surface area is defined as the geometric surface area of a specimen calculated from macroscopic measurements of its dimensions.

3.16 *Volume*—For purposes of this test method, volume is defined as the volume of a specimen calculated from macroscopic measurements of its dimensions.

3.17 *Waste Form*—A stable, solid body composed of the waste and a solidification agent.

4. Summary of Test Method

4.1 This method is a semi-dynamic leach test; that is, the leachant is sampled and replaced periodically. It is based on earlier semi-dynamic tests such as the IAEA test [4] and the ANS 16.1 Leach Test [5]. Elevated temperatures, large volumes of leachant, frequent leachant changes and small specimen size are used to obtain accelerated releases. This is a short-term test, requiring sampling on each of eleven or more successive days. Tests must be performed to demonstrate that the leaching mechanism does not change at the elevated test temperature. This may be done by performing leach tests at a minimum of three temperatures to ascertain that the mechanisms and structural controls of leaching do not change with increasing temperature. If the test is to be used only for making comparisons among specimens, then testing at a single temperature is adequate.

4.2 The results of this accelerated test can be extrapolated to long times if the data from tests run at elevated temperatures and the tests run at the reference temperature (20°C), can be modeled by diffusion. A computer program is available from ASTM that plots the experimental data and a curve calculated from an effective diffusion coefficient for diffusion from a finite cylinder (Figure 1). If the data from the accelerated tests, the reference test and the modeled curve fit within defined criteria, the leaching mechanism is taken to be diffusion. In this case, the model can be used to project releases from full-scale waste forms and to long times. The accelerated test provides a measure of the maximum fractional release to which the modeled data can be extrapolated. By generating data over a specified temperature range, an Arrhenius plot can be produced allowing projections to be made at temperatures other than those tested. If the diffusion model cannot fit the data other models (diffusion plus partitioning and solubility limited leaching) contained

in the computer program can be used to indicate the leaching mechanism that controls releases. No extrapolations are allowed with these models. If no model fits the data, then an alternative graphical comparison of the data is recommended. A linear plot of modeled CFL plotted against experimental CFL verifies that the accelerated data is comparable to the reference data, showing that the accelerated test is appropriate. With this technique, no extrapolation of data can be made.

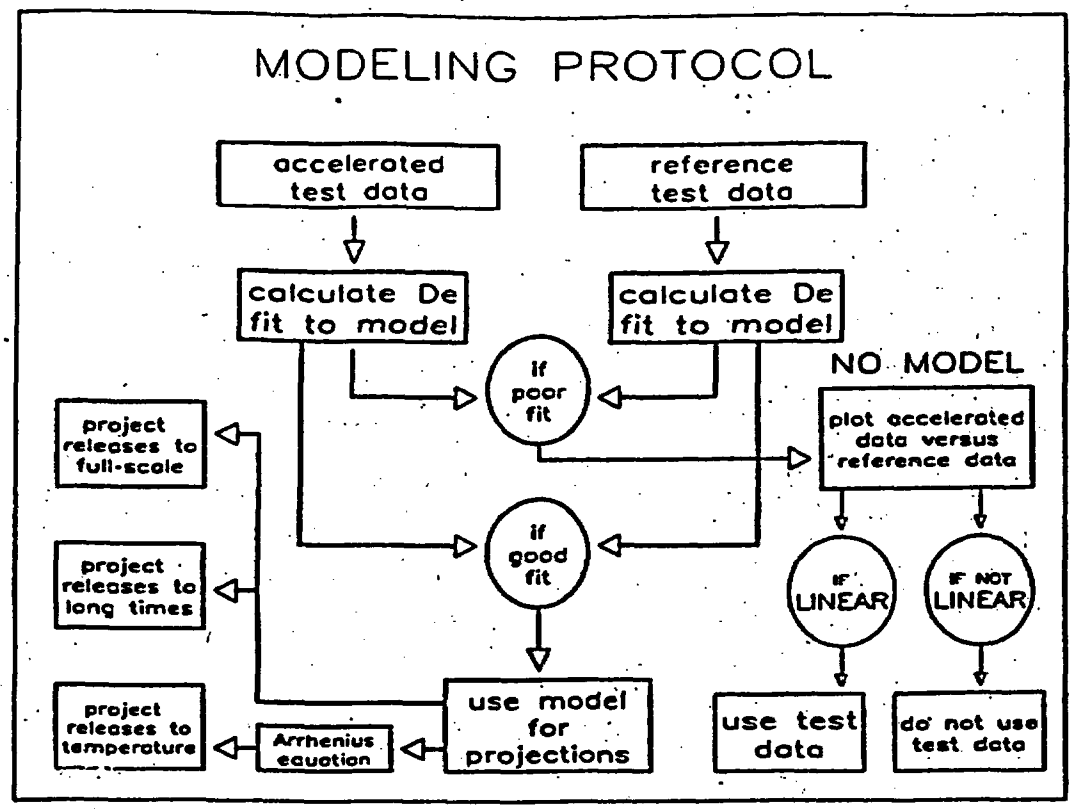

Figure 1. A schematic of the concepts used in this test method to combine experimental and modeling approaches.

5. **Significance and Use**

5.1 This test method measures mass transport from a cylindrical solidified waste form into water under conditions that accelerate leaching. Test parameters, such as the volume of leachant and the frequency at which the leachant is changed, have been optimized to eliminate experimental effects (e.g. saturation effects that can complicate modeling of the net forward diffusion rate).

5.2 This method can be used to:

5.2.1 Provide diffusion coefficients for waste forms

5.2.2 Obtain higher fraction releases than can be achieved with expected service conditions for greater confidence in waste form properties

5.2.3 Obtain measurable leachate concentrations from materials that have very low release rates under service conditions

5.2.4 Compare releases from various types of solidification agents and formulations

5.3 Modeling the experimental observations obtained in the test allows the extrapolation of leaching results to long times and to full-scale waste forms under the following constraints:

5.3.1 Results of this practice cannot be taken to apply to releases in specific disposal environments unless tests are conducted to determine the leaching mechanism under those conditions.

5.3.2 Projections of releases require the long-term stability of the waste form, which may or may not be indicated adequately by short-term tests.

5.3.3 Extrapolations are limited to the maximum CFL obtained with the accelerated test.

5.3.4 The leaching mechanisms observed in tests conducted at elevated temperatures must be the same as the mechanisms observed in the tests run at the reference temperature.

6. Apparatus

6.1 A forced air environmental chamber or a circulating water bath capable of controlling leachant temperatures to ± 1°C shall be used.

6.2 Balance- The balance shall be accurate to 0.1% of the test load.

7. Reagents and Materials

7.1 Leachant- The leachant shall be distilled or deionized water meeting or exceeding standards for types II or III reagent water as specified in ASTM D1193.

7.2 Containers- Leaching containers shall be made of a material that does not react with the leachant/leachate and the specimen. It is particularly important to select materials that allow very little plateout of radionuclides from solution. High density polyethylene has been found to be a suitable container material. The top of the container shall fit tightly to minimize evaporation. This fit must be checked at test temperatures to assure that evaporative losses are less than 1% over 24 hours.

7.3 Specimen Supports- Supports for the specimens shall be made of a material that does not react with the leachant/leachate or the specimen and does not allow plateout onto the support. The method of support should not impede leaching by obstructing the surface area of the specimen by more than 1%. Moreover, it should not interfere with replacement of the leachate. If is often convenient to suspend the waste form from the cover of the leaching container using monofilament string.

7.4 Sample Containers- Containers to hold aliquots of leachate for storage prior to analysis should not allow any plateout of radionuclides. The containers should be checked to ascertain that evaporation over long times is acceptably small.

7.5 Stirrers- Stirrers, long enough to reach the bottom of the leaching containers, are required. Wood or plastic tongue depressers are adequate.

7.6 Filtration Equipment- If particulates are present in the leachate, filtration is necessary. Tests must be conducted to assure that the filter and the filtration apparatus does not adsorb the species of interest. The filter medium should be capable of removing particulates that are 0.45 μm in diameter. Disposable syringe filters are recommended.

8. Specimens

8.1 Right circular cylindrical specimens shall be used with a diameter to height ratio between 1:1 and 1:2. A convenient size is 2.5 cm diameter by 2.5 cm height. Smaller sizes should be avoided to preclude problems of mixing and producing inhomogeneous samples.

8.2 Specimens shall be representative of the full scale solidified waste form. Particular attention should be paid to ensuring that the laboratory specimen is homogeneous. The specimens should be prepared using the same techniques as those used to produce full-scale waste forms. Curing conditions, especially the temperatures experienced by the large waste forms, should be duplicated for laboratory-scale specimens. Care should be taken to assure that surfaces of the laboratory specimens reflect the structure of surfaces of large waste forms. This refers to surfaces that are cast against container walls as opposed to free or cut surfaces.

8.3 A minimum of three specimens should be tested at any given temperature.

8.4 The dimensions, weight, composition and curing history shall be recorded for each specimen. Accurate determination of the source term (A_0), that is, the amount of the species of interest in the specimen at the start of the leach test, shall be made and recorded.

9. Procedure

9.1 *Removal of Specimen from Mold-* After removing the specimen from its container or mold, any excess material should be removed prior to weighing the specimen. The mold should be rinsed in a volume of water equal to the volume of the specimen. If the quantity of the species of interest contained in this rinse water represents more than 0.5% of the total quantity in the specimen, the value should be subtracted from the source term (A_0).

9.2 *Leachant Volume*— The leachant volume used for each interval is 100 times the surface area of the specimen as calculated below:

$$\frac{\text{Leachant volume (cm}^3\text{)}}{\text{Specimen surface area (cm}^2\text{)}} = 100\text{cm} \pm 2\%$$

This ratio requires a large volume of water, for example a 2.5 cm x 2.5 cm specimen has a surface area of approximately 30 cm^2 giving a leachant volume of 3000 ml. Specimens that are much larger than this will require volumes of water that need more sophisticated means of waste water handling (such as peristaltic pumps for draining the containers) since large volumes are too unwieldy for pouring.

Some waste form materials, such as glass, have such low leach rates that a Volume to Surface Area ratio of 100 cm is not necessary. In some cases, such a large volume of leachant can make analysis challenging, even for major constituents of the specimen. Under these circumstances the Volume to Surface Area Ratio may be reduced to 10 cm.

9.3 *Temperature*— For materials and formulations that have not been previously tested, leach tests shall be conducted at a minimum of three temperatures to establish that leaching increases systematically with higher temperatures. One temperature must be 20°C. The recommended maximum temperature is 50°C, which is below the threshold of anomalous releases observed so far [6]. Temperatures above 50°C can be used if it is demonstrated that releases follow the trend observed at low temperatures, i.e. that the leaching mechanism has not changed.

9.4 *Leachate Replacement*— Leachant replacements shall take place at the time intervals shown in Table 1. The time at which the specimen is first placed in the leachant should be noted. The leachant shall be brought to the test temperature before the specimen is place in it.

If the specimen is suspended from the top of the container, the most convenient method of changing the leachant is to lift off the cover (with the specimen attached) and place it on a new container full of fresh leachant that is at the test temperature. This can be replaced in the temperature controlled environment while the leachate in the other container is being sampled. During leachant changes, the specimen should be exposed to air for as short a time as possible.

TABLE 1

Replacement Intervals for the Accelerated Test Leachant

Interval	Incremental Time (t)	Cumulative time (Σt)
1	2 hours	2 hours
2	5 hours	7 hours
3	17 hours	1 day
4	1 day	2 days
5	1 day	3 days
6	1 day	4 days
7	1 day	5 days
8	1 day	6 days
9	1 day	7 days
10	1 day	8 days
11	1 day	9 days
12	1 day	10 days
13	1 day	11 days

9.5 *Leachate Sampling*—Immediately after the specimen has been moved to fresh water, the old leachate should be stirred thoroughly and sampled to minimize any artifacts caused by cooling (e.g. precipitation). These samples will be used to determine quantities of the species of interest that have leached from the specimen during each interval and should be preserved in a way appropriate for the analytical techniques. This may require that several aliquots be taken during each sampling. If particulates are present in the leachate, it is necessary to account for the quantity of the species of interest associated with them. Two approaches can be used. One requires filtration of the leachate and subsequent analysis of both the filtrate and the particulate material on the filter. The other is to acidify the leachate to dissolve the particulates and thereby include the associated species of interest in the leachate.

9.6 *Analysis and Standards*—Analysis of species in the leachate will be conducted by standard methods. Appropriate standards will be used for analysis. If necessary, standards will be prepared to match the matrix elements in the samples. For radioactive specimens, the preferred method of analysis includes use of a standard prepared from an aliquot of the original solution (or waste) used to make the specimens. From this aliquot dilutions are made from which the standard is taken. With this method leachate samples can be counted relative to standards without the need for absolute standards, detector efficiencies or decay corrections.

10. Calculations

10.1 *Incremental Fraction Leached*—Several parameters shall be calculated from the data obtained. The incremental fraction leached (IFL) is calculated by the following equation:

$$IFL = \frac{{}_ia_n}{{}_iA_0}$$

${}_ia_n$ is the quantity of species i observed in the leachate at any given time interval. This value is corrected for radioactive decay to the time of the beginning of the test.

${}_iA_0$ is the source term, the total original quantity contained in the leaching specimen at the beginning of the test.

The rate of release for any interval can be calculated by dividing IFL by the elapsed time of the interval. The rate can then be divided by the surface area of the specimen to obtain the fraction released per square centimeter per second.

10.2 *Cumulative Fraction Leached*—Another parameter is cumulative fraction leached which is calculated as:

$$CFL = \frac{\Sigma_i a_n}{{}_i A_0}$$

which is the sum of the fractions of a species of interest leached during the test. This value for each interval, plotted against cumulative time, provides a useful means of graphically comparing data to other test results and to modeling results. An example of this type of plot is shown in Figure 2.

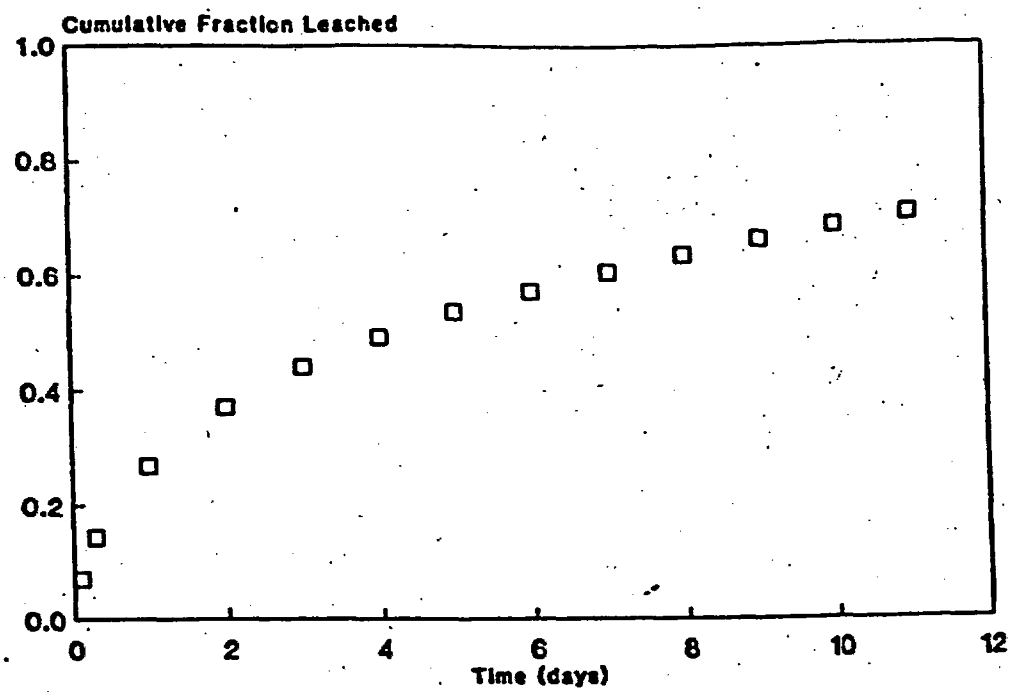

Figure 2. The cumulative Fraction Leached plotted versus Time. The top of the plot (CFL=1) represents 100% release.

10.3 *Diffusion Coefficient* - This test method has an associated computer program that calculates a best fit effective diffusion coefficient based on the solution to diffusion from the finite cylinder [7,8]. The computer program calculates D_e from the test data so that the curve $\Sigma a_n/A_0$ calculated from D_e can be plotted against time and readily compared to the data itself. This should be done for data from the accelerated test and from the reference test. If the curves of the data and the model all fall within a designated value describing "goodness of fit," then it can be concluded that diffusion is the dominant leaching mechanism. In this case, the model can be used to project releases to long times. This projection requires the assumption that the waste form remains intact and the leaching mechanism does not change with time.

The computer program that accompanies this test method contains two models in addition to the two diffusion models. One model partitions the source term into a leachable component and an unleachable component. It then uses the diffusion models to determine releases from the leachable portion of the source term. The other model is used to determine if solubility constraints are limiting leaching. This model produces a graph of incremental fraction leached plotted as a function of time. Although the partition model allows extrapolation of releases based on the leachable fraction of the source term, neither the partitioning model nor the solubility model should be used to make projections. Rather, these models are intended to indicate if mechanisms other than simple diffusion are controlling releases.

The "goodness of fit" of the model to the data is determined by calculating the sum of the residuals between the optimized model curve and the experimental data. The sum of the residuals is expressed as E_R, which is a percentage of the final CFL value of the experimental data. With a perfect fit of the model to the data, E_R will be zero. A value of E_R equal to or less than 0.5% is taken to mean that the diffusion model accurately represents the data. Projections using the diffusion model should be limited to the maximum achieved in the leach test. This maximum CFL must be taken from data which fit the model being used to make the projections.

10.4 *Relationship of Temperature to Leaching*—The accelerated leach test relies on elevated temperature as the primary means of increasing mass transport from specimens, consequently the leach rate must show a positive relationship to increasing temperature. Theoretically, the temperature dependence of a chemical process, in this case leaching as expressed by the diffusion coefficient D_e, depends on the Arrhenius equation, however, knowledge of the temperature dependance of leaching in some materials may not be adequate to strictly apply the Arrhenius equation. Consequently the equation:

$$De = A \exp(k/T)$$

can be applied, where D_e = effective diffusion coefficient at T, A = constant, k = derived constant, T = temperature in degrees kelvin.

From this equation, the log of the diffusion coefficients determined from experiments conducted at several temperatures are plotted against 1/T, as shown in Figure 3. A linear plot indicates that the increase in leaching is proportional to the increase in temperature. This linear relationship means that:

- the leaching mechanism, as well as the structural controls on leaching (e.g. tortuosity,porosity) are unchanged by increasing temperature
- effective diffusion coefficients can be calculated for temperatures other than those tested.

For this test method it must be demonstrated that a linear relationship exists on the plot for every material tested under accelerating conditions. In some cases the plot may not be linear at elevated temperatures. This effect can limit the maximum test temperature. For all materials the relationship of leaching to elevated temperature must be determined for at least three temperatures to ascertain that the maximum temperature to be used is mechanistically acceptable. A convenient maximum test temperature is 50°C, although in some cases a lower temperature is required to conserve the leaching mechanism.

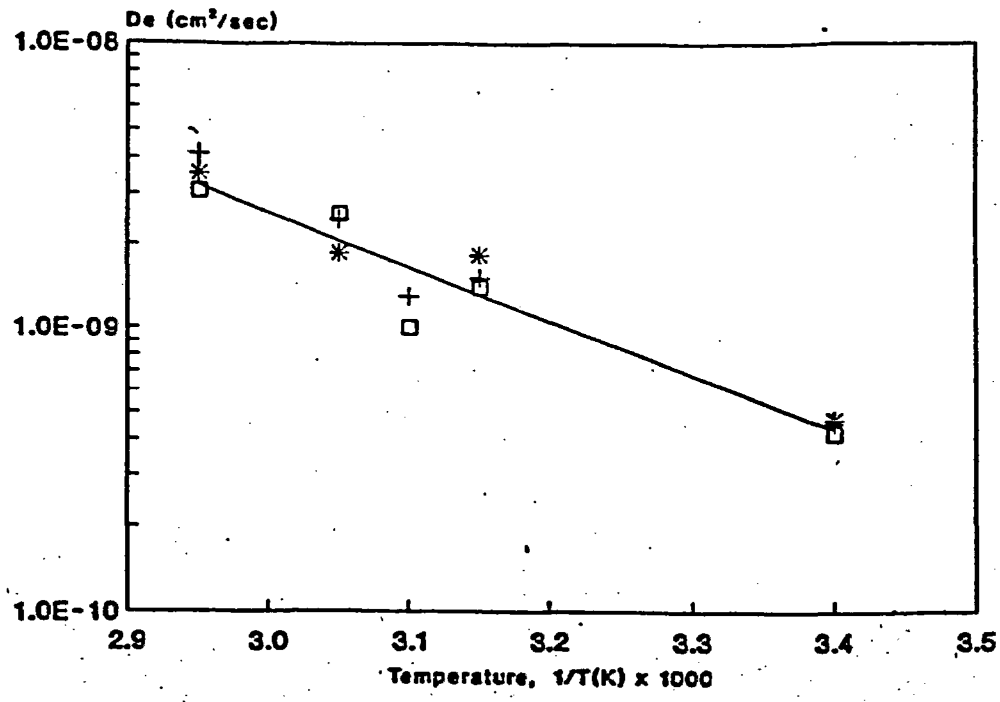

Figure 3. An example of a plot of the temperature dependance of leaching with y-axis as the logarithm of the effective diffusion coefficient, De, and the x-axis as the reciprocal of absolute temperature. This figure is for Sr-85 leaching from a cement waste form and indicates that there is a linear relationship between the data and temperature to 65°C (X=2.95).

10.5 *Empirical Correlation*—If the data and the model do not provide a good fit, indicating that diffusion is not the leaching mechanism, an empirical approach can be taken to compare releases from the accelerated test with releases from the reference test. This is done by plotting CFL from the accelerated test on the y-axis of a graph and CFL from the reference test on the x-axis. The points are matched according to interval. If this scatter plot results in a linear graph, the data from the two tests can be compared and the results of the accelerated test can be said to accurately reflect the data from the reference test. However, this method of correlation cannot be used to extrapolate the data to long times.

11. Precision and Bias

11.1 The precision of this method will vary depending on the solid waste being tested and on the species of interest being leached.

11.2 Determining the accuracy of this method is not possible, as no standard reference material exists.

11.3 Results of tests of four replicate solid waste forms are shown in Figure 4, for polyethylene waste forms containing fifty and seventy weight percent sodium nitrate. Diffusion coefficients of sodium, fractional releases, and values of E_r (indicating goodness-of-fit of the model to the experimental data, see section 10.3) are shown in Table 2. The data shown in Figure 4 is for 50 Wt % loading leached at 20°C. Other data and modeling results are available [6,9,10].

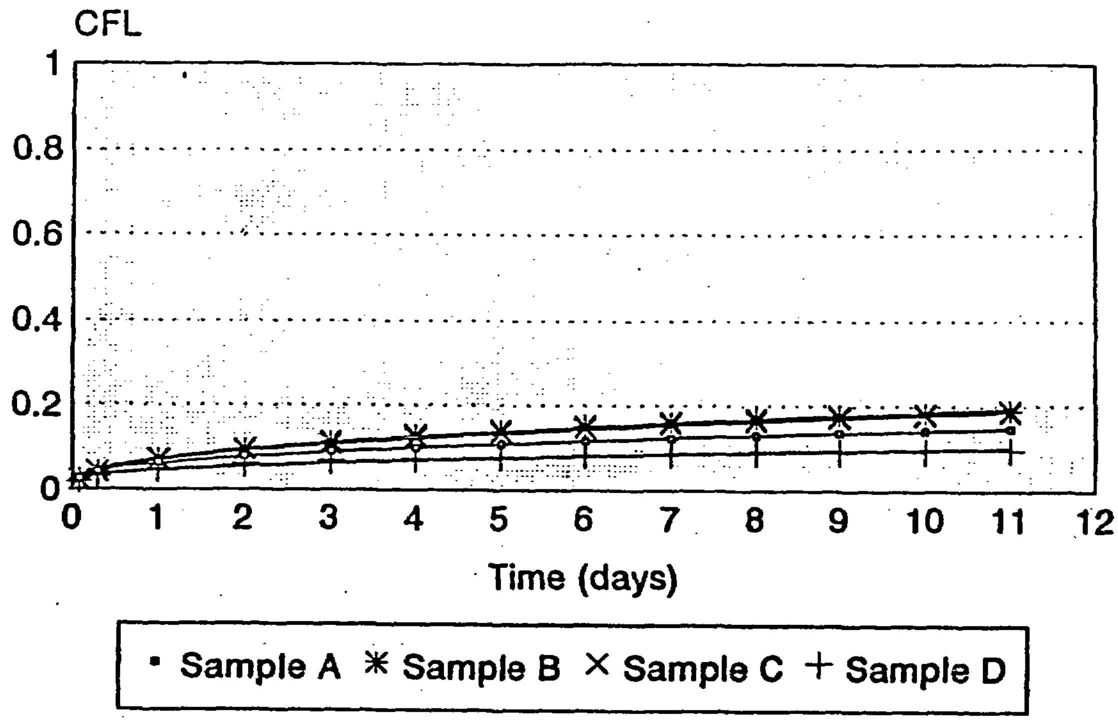

Figure 4. CFL of sodium at 20°C from replicates of polyethylene containing 50 Wt % $NaNO_3$.

TABLE 2

Fractional Releases and Diffusion Coefficients of Sodium from Sets of Four Replicate Polyethylene Samples Containing 50% and 70 % $NaNO_3$ Leached at 20°C

Sample	Cumulative Fraction Released (%)	E_R (%)	Diffusion Coefficient (cm^2/Sec)
50% A	14.8	0.25	2.32×10^{-9}
50% B	18.9	0.43	4.67×10^{-9}
50% C	18.5	0.27	4.37×10^{-9}
50% D	9.6	2.52	8.84×10^{-10}
50% Mean	15.5	0.87	3.05×10^{-9}
70% A	50.2	0.41	4.74×10^{-8}
70% B	54.4	0.39	6.10×10^{-8}
70% C	47.6	0.92	4.82×10^{-8}
70% D	57.3	0.77	6.60×10^{-8}
70% Mean	52.4	0.62	5.57×10^{-8}

Annex A

Computer Program for the Accelerated Leach Test

This Annex is a brief outline of the "ALT" computer program that was developed to accompany the accelerated leach test. The program serves a variety of functions including:

- compares experimental data to curves generated by four models
- calculates incremental and cumulative fractional releases
- stores data in a form compatible with Lotus 1-2-3

The Accelerated Leach Test computer program and a detailed Users' Guide [1] are available from:

ASTM
1906 Race Street
Philadelphia, PA 19103

A.1 Equipment

The computer program that is available for this test method is a compiled version and runs on IBM or IBM compatible personal computers. A math co-processor is desirable to decrease the computation time. A graphics board is required to generate plots and can be a CGA, EGA, VGA or a Hercules color or monocolor board. Without a compatible graphics board, the program will do all calculations and list the results.

A.2 Approach

The ALT program contains four mathematical models that can be used to represent the data. The leaching mechanisms described by these models are:

1. diffusion through a semi-infinite medium (for low CFL)
2. diffusion through a finite cylinder (for high CFL)
3. diffusion plus partitioning of the source term
4. solubility limited leaching

These mechanisms were observed in studies with various materials during development of the test method [2,3]. Theoretical background for each mechanism is given in Appendix A of the Users' Guide.

For models containing the diffusion mechanism the computer program plots both the experimental data and a curve, calculated from the selected model, that best fits the data. This is done through an iterative method that optimizes the fit to the entire data curve (Figure A.1). The solution to the finite cylinder equation that is used in the program was developed by Pescatore [4,5]. This method is particularly attractive because it becomes asymptotic at high fraction releases while using relatively little computer time, a failure of some other solutions. If the goodness-of-fit between the data curve and the model gives an E_R value that is less than 0.5% then the model is taken to represent the leaching mechanism of that material. In this case the model can be used to project releases to long times. In the case of diffusion, projections can also be made for full size cylinders. If the value of E_R is greater than 0.5% then the model cannot be used to make projections.

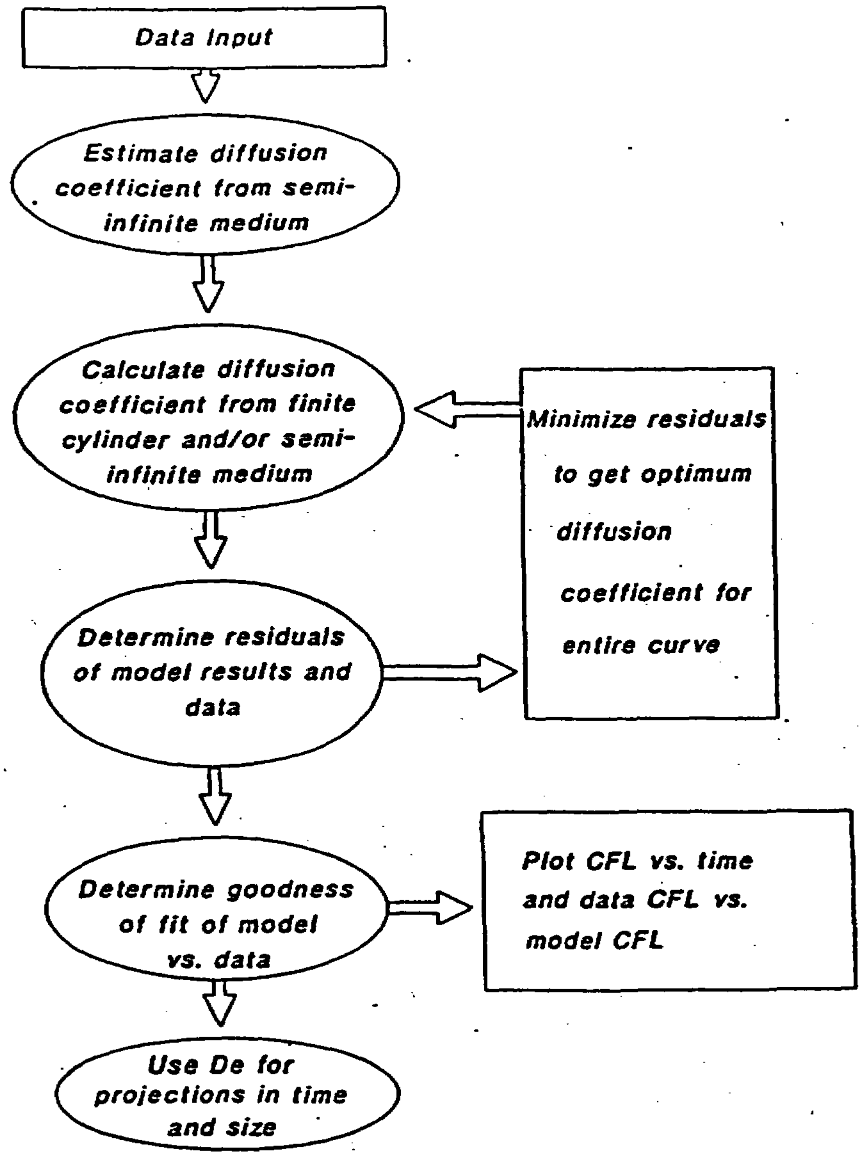

Figure A.1 A flow chart of the major functions of the Accelerated Leach Test Computer Program.

The solubility limited leaching model is based on the concept that the concentration of the species of interest in the leachate (and therefore the incremental fraction leached) should be the same at the end of each sampling interval. The mean of the IFL, the standard deviation and the coefficient of variation about the mean are calculated. If the coefficient of variation is less than 10%, then the dissolution model is taken to be appropriate.

The results of the ALT program are presented in several forms. Tables of data and associated parameters (e.g. diffusion coefficient and E_a) are displayed on the screen and can be printed if desired. Graphs of CFL plotted as a function of time are generated on-screen and contain both experimental data points and the curve produced by the model. In addition, graphs are available in which the experimental data is plotted on the x-axis and model generated values are plotted on the y-axis. This type of plot allows easy comparison of the relationship between the data and the model results. If the test has been run at three or more temperatures, the activation energy can be determined by the program. Projections of future releases and for full-scale waste forms can be made if the leaching mechanism is found to be diffusion.

A.3 Running the Program

The program starts by giving the user eight options, including entering "new (raw) data," entering data in the form of CFL, retrieving data from files or editing data. Key F1 provides explanations of these choices.

Some prompts in this program have default answers that appear in brackets. Pressing "ENTER" will select the default choice.

Inputs required by various portions of the program are explained below.

Multiple Source Term Data - Some data require a new value for the source term for each interval. This would be necessary for a very short half-life radionuclide. The source term value that is input here is the number of counts from a standard. Corrections for dilutions are made automatically. The standard counts are separated by a comma from the leachate counts.

Single Source Term Date - Some data require only a single value for the source term throughout the entire experiment. This can be in the form of counts per minute (CPM) or as concentration (for stable elements). For some specimens that contain radioactivity, liquid standards may not be available. In this case, the activity in the specimen should be calculated. This value can be input as "concentration" in the single source term option.

Number of Sampling Increments - this is the number of samplings in the experiment. The default value is 13.

Number of Species - This input is the number of elements or radionuclides analyzed in each set of leachate samples that need to be addressed by the program. A maximum of eight species is allowed in each data file.

Leachate Volume (liters) - This is the volume of leachate used during each sampling interval. The test method recommends 3 liters.

Default Times (standard ALT) - The default time intervals (in days) are 0.083, 0.208, 0.708, 1.00, 1.00. 1.00, etc. to a total of eleven days.

Sample Diameter (cm) - Diameter of the specimen that was leached.

Sample Height (cm) - Height of the specimen that was leached.

Counting Sample Volume (ml) - The volume of the aliquot used for radionuclide counting.

Source Term Multiplication Factor - The factor by which the original source solution was diluted to make the counting standard. For example: 3 ml of tracer were added to a specimen when it was made and 1 ml of that solution was diluted 1000-fold to produce the standard that was counted. The multiplication factor would be 3000.

Detailed instructions, in a screen by screen format, are given in the Users' Guide [1].

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