Illinois State Water Survey Division

ATMOSPHERIC CHEMISTRY SECTION

SWS Contract Report 483

SURFACE DUST ELEMENTAL PROFILES - OGLESBY (CEMENT PLANT)

by Stephen J. Vermette and Allen L. Williams

Sponsored by the
Illinois Department of Energy and Natural Resources
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Champaign, Illinois
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Introduction

Numerous receptor modeling studies have indicated the significance of fugitive dust sources to ambient PM-10 loadings. The IEPA monitor in Oglesby (308 Portland Ave.) has consistently recorded TSP and PM-10 excursions above the annual and 24 hour primary standards (IEPA, 1989). The proximity of the monitoring site to a cement plant implicates the cement plant as the primary source of particulates. Source profiles available in the literature include 'Cement' (Vermette et_al., 1987), 'Cement Production' (Hopke, 1985), and 'Coal-Fired cement Kiln' (USEPA, 1984). Profiles for Oglesby are not available in the literature. As a part of the studies necessary to prepare an effective and efficient State Implementation Plan (SIP) for Oglesby, dust samples were collected from numerous sites in and around the cement plant and elemental profiles were developed. These surface dust profiles are to be incorporated in subsequent receptor modeling work.

This report outlines the preliminary development of surface dust elemental profiles for Oglesby. This report is also available on a floppy disk. Included in this report are:

	Hard Copy	Disk
1. Methodology and Comments	Text	OGTEXT.TX5
2. Surface Dust Profiles	Appendix A	PROFILE.ASC
3. NAA & XRF Comparison	Appendix B (Graphs)	NAA-XRF.WK1 (data)
4. Field Sampling Notes	Appendix C	
5. XRF Elemental Data		XRF.ASC
6. NAA Elemental Data		NAA.WK1
7. Bulk NAA Data		BULK.WK1

Sample Collection

Dust samples on the cement plant grounds (road dust, soil samples etc.), from specific batch processes (clinker dust, cement etc.) and from areas around Oglesby (farm field, quarry etc) were collected by the IEPA in late autumn of 1988. Samples were scooped or swept off surfaces and placed in a plastic bag. Sampling locations were focused near suspected fugitive dust sources. Of the 23 samples collected six were chosen for elemental analysis (see Figure 1 and 2, as well as Appendix C):

OG7	Clinker Dust
OG9&13	Paved Roadway, Plant Soil/Kiln Track-Out
OG17	Cement Dust
OG18	Unpaved Shoulder, Plant Cement Load-Out
OG19	Soil On Plant Property, Impacted By Kiln
OG23	Soil, Regional Background

The six choices reflect suspected sources of fugitive dust, however, the analyzed samples represent only 25% of the collected samples and thus an important source may have inadvertently been omitted.

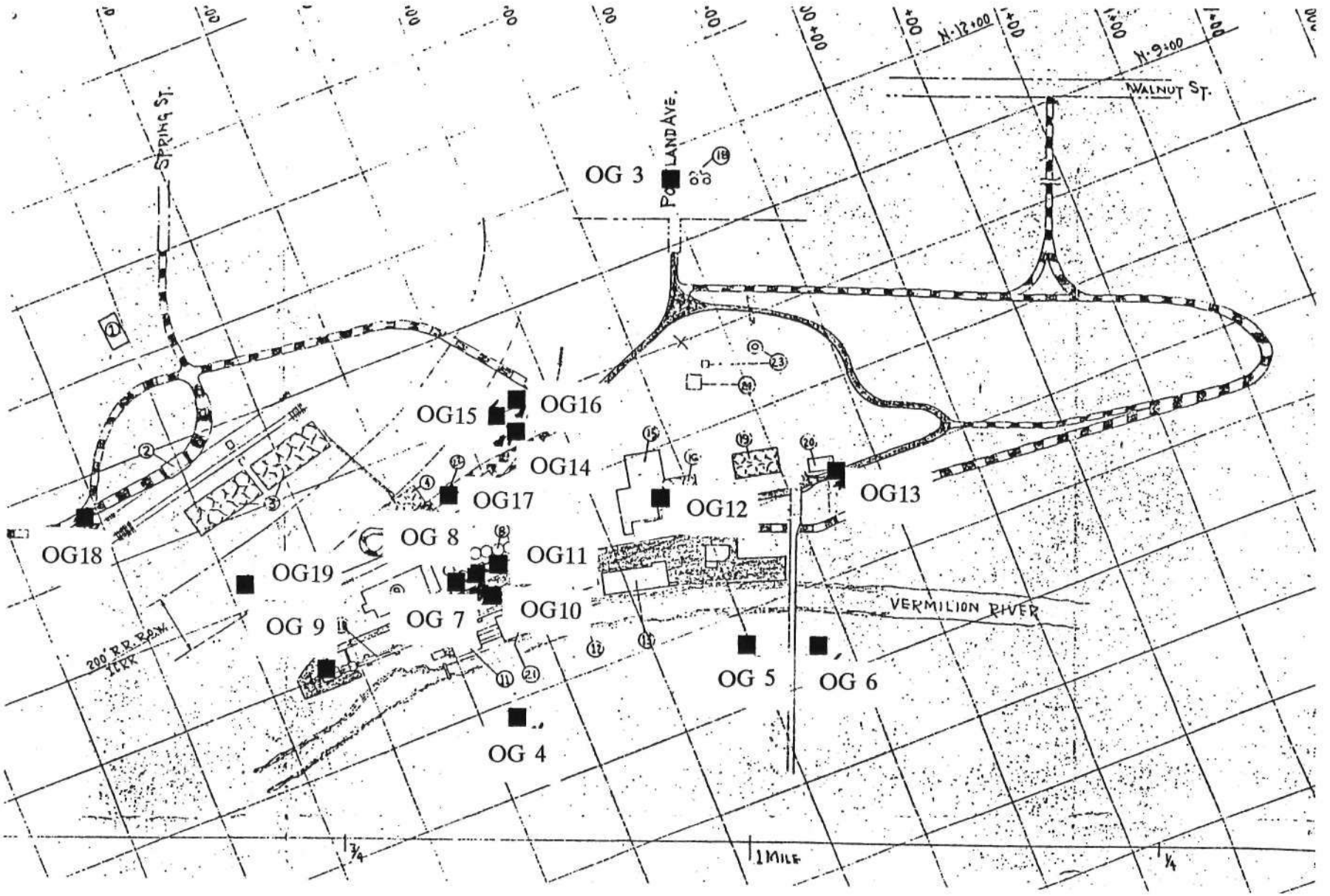

Figure 1. Cement Plant Sampling Sites.

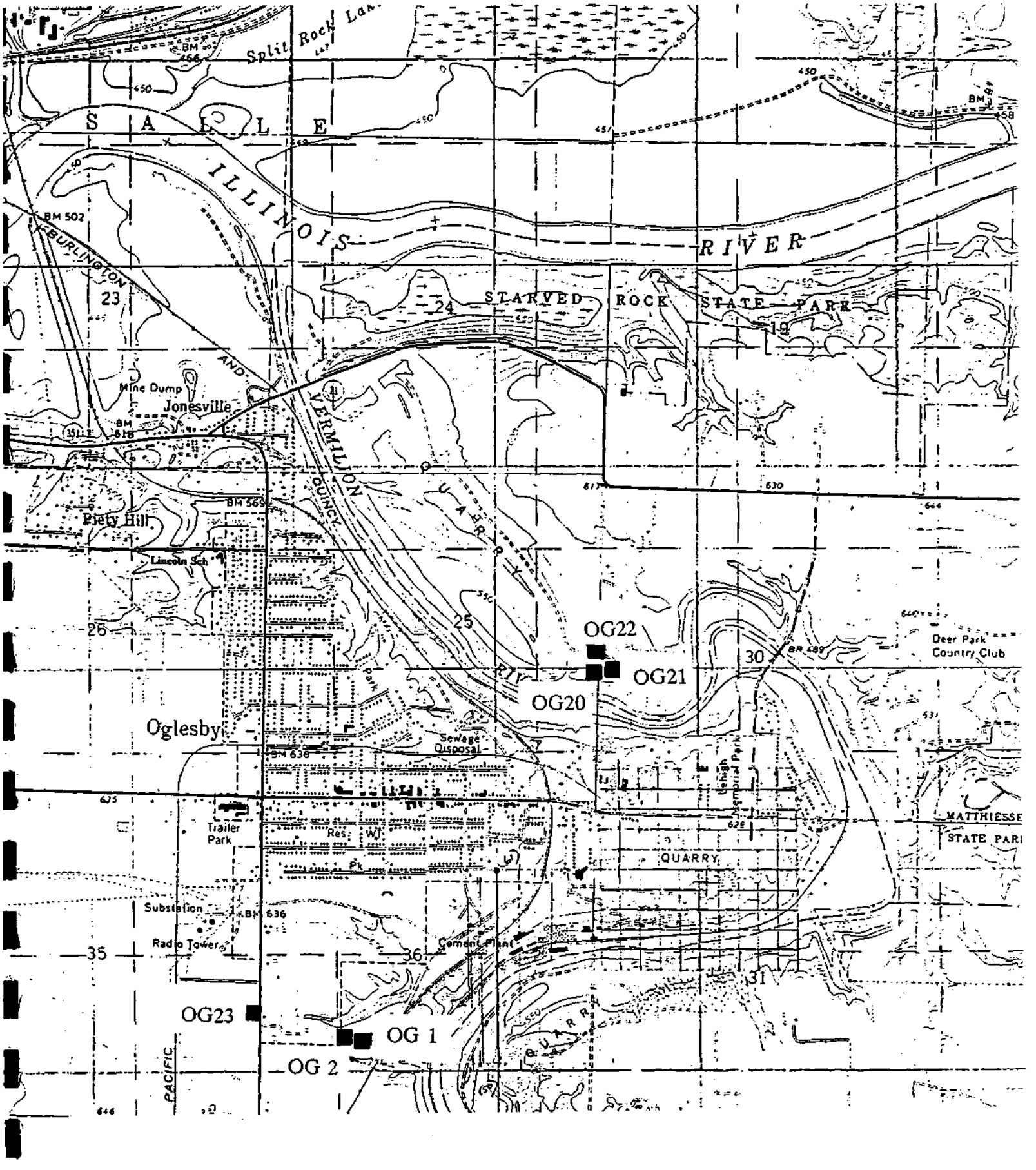

Figure 2. Quarry and Background Sampling Sites.

Suspension

The surface dust samples were sieved to < 53 um to be used as the bulk material for suspension and deposit onto filters. The suspension chamber consists of a swirl chamber where the dust was suspended by a continuous supply of filtered compressed air (see Figure 3). The compressed air and suspended dust were forced into a circular air motion (swirl) about the axis of the chamber where the particles are mixed and disaggregated. The disaggregation of the particles removes possible elemental inhomogeneity between filters due to fractionation effects (e.g. coarse particles are truly coarse particles and not aggregates) and assures true particle sizes for techniques requiring particle standards and corrections (e.g. XRF). The flow was exhausted into a 8 ft^3 cardboard box for dichotomous and PMS sampling (the box was replaced for each dust sample).

Particle samples were collected within the cardboard box using an automatic dichotomous virtual impactor fitted with a PM-10 inlet made by Anderson, Inc., Atlanta, GA(Series 245). The sampler is designed to collect particulate matter with an aerodynamic size cut off of 10 um and to further separate particles into two size fractions, a fine particle fraction (<2.5 um) and a coarse particle fraction (2.5 to 10 um). The fine and coarse deposits were collected on 37 mm diameter Teflon disks with a polyethylene support ring (for elemental analyses) and on 37 mm diameter glass fiber disks (for carbon analysis). Both filter types are made by Gelman Science, Ann Arbor, MI. Two PM-10 inlets within the box allows for the simultaneous sampling on Teflon and glass fiber filters. The similarity in particle size composition of loaded filters (disaggregation) was ensured by the continuous monitoring of particle size distribution using a PMS laser probe particle counter (model CSAS-100-HV).

Elemental and Carbon Analyses

The suspended filter deposits (fine and coarse) on Teflon were subjected to elemental analysis by X-ray fluorescence (NEA, Inc. of Beaverton, OR) and neutron activation analysis (Department of Nuclear Engineering, University of Illinois). The method of XRF is based on the atomic excitation of electrons with the subsequent emissions of characteristic x-rays when electrons from higher levels fill the void spaces. The method of NAA is based on the measurement of induced radioactivity where the radioactive decay of each element emits a characteristic gamma-ray energy spectrum.

Filters were equilibrated 24 hours at 50% relative humidity before weighing. Loaded filters were weighed prior to XRF analysis and than reweighed prior to NAA analysis. All filter handling and weighing was done in a clean room with a laminar flow clean bench. Using a Cahn microbalance, the precision (standard deviation) of duplicate weighings under these conditions is ±. 5 ug.

Fine and coarse deposits have been corrected for fine particles collected on the coarse filter (dichot correction), as outlined in the automatic dichotomous sampler instruction manual (Anderson Bulletin No. 1079-245-IM).

A subset of the collected samples were analyzed in bulk form (< 53 um material prior to suspension) by NAA.

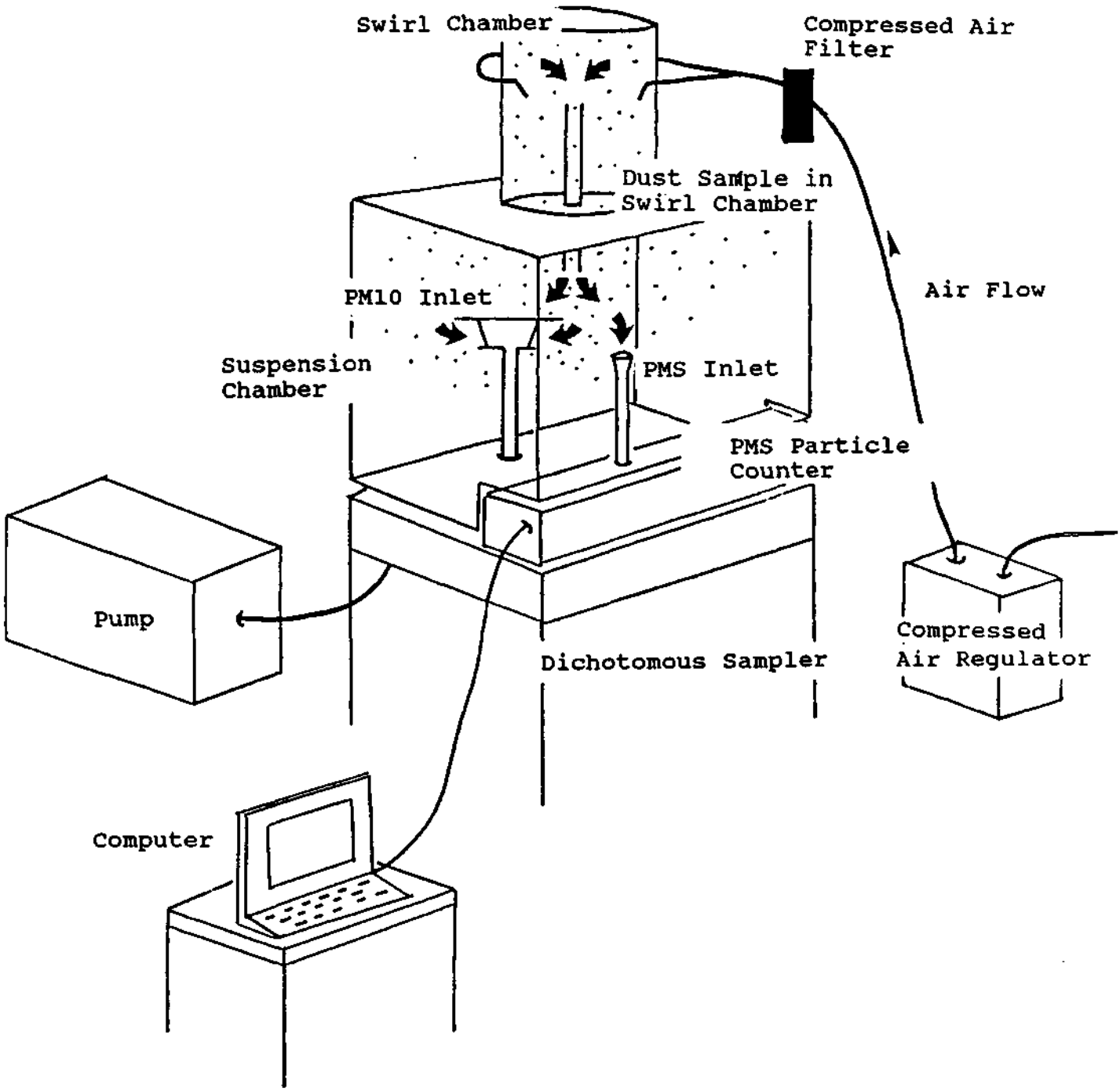

Figure 3. Schematic of the Suspension Chamber.

Total carbon analysis was carried out by the Analytical Chemistry Section of the Illinois State Water Survey. Suspended filter deposits on the glass fiber filters were treated with HCL acid to remove carbonate and then combusted at 800 C for $C0_2$ determinations by a Dohrmann carbon analyzer. Earlier experiments have demonstrated the effectiveness of carbonate removal with HCL treatments. By way of example, consider a fine deposit sample collected on a glass fiber filter (test filter). Carbon on the fine deposit (not treated with HCL) measured 45.3%. When the fine deposit was treated with HCL acid the carbon measurement was reduced to 3.7%. Thus, 41.6% of the originally measured carbon was actually carbonate. This estimated carbonate value (41.6%) compares well with a measured carbonate value of 53% for the bulk sample (some differences are to be expected between the fine deposit (<2.5um) and bulk samples (<53 um) due to particle size fractionation effects).

The dust profiles presented in this report are predominantly from XRF determinations. Important inputs were made by NAA for elements determinations not provided by XRF (Na, Mg and Sm) or determinations which are at or below XRF detection limits (V, Sb and La). Total C values were provided from the Dohrmann analyzer.

Redundant Measurements - Quality Check

The use of XRF and NAA techniques provides for a number of redundant measurements which serve as a quality check for reported concentrations. Fine and coarse determinations of Al, Ca, Mn, Ti, K, Cl and V are sufficiently above detection limits to allow for comparison.

A comparison of XRF and NAA determinations for each element (Al through to V) and sampled dust source are presented in Appendix E. In general, agreement between the two techniques is good (within analytical errors). Agreement is not as good for V. The NAA V determinations were used for the dust profiles as they are farther removed from detection limits than that of the XRF determinations.

Comments

This report provides a first look at the analytical data provided for the development of Oglesby dust source profiles. A more detailed analysis will follow with a receptor modeling study, but some general observations are worth noting here.

The source profiles available in the literature (as noted in the introduction), exhibit little similarity to the profiles developed for Oglesby. The differences in profile composition underlines the need to develop site specific profiles for use in receptor modeling.

The variability in elemental concentrations between Oglesby dust profiles reinforces our contention that a single dust profile is not adequate to properly characterize fugitive dust sources in receptor modeling statistics. Taking Ca and Al as examples, the fine fraction concentrations for Ca varied from 57.5% to 2.3% and the coarse fraction of Al varied from 6.6% to 1.9%. However, it should be noted, profile variability from samples within the cement plant are somewhat less distinctive than profiles taken from a more

complex source area (i.e. Granite City — Vermette and Williams, 1989).

A third point exhibited by the Oglesby dust profiles is the variability of elemental fractionation between fine, coarse and bulk samples. Taking Ca as an example, substantial fractionation is evidenced for clinker dust - OG7 (fine = 57.5%, coarse = 14.0%, and bulk = 43.0% - see Figure 4). Clinker dust also shows substantial fractionation for Mn, S, Fe and Si. The high degree of fractionation in the clinker dust is illustrative of the importance of proper suspension techniques, most importantly, the disaggregation of particles. The degree of fractionation, when compared to other profiles, brings up the possibility of an error. Redundant filter weighings and analysis (NAA and XRF) of OG7 shows good agreement and dispels the possibility of an analytical type error. There is the possibility of an error in the initial tare measurement of the OG7 filter, however, a review of the OG7 tare weights shows them to be in general agreement with other tare weights.

Other points of interest include:

Arrangement of the dust profiles from cement process to background soil - OG7 (Clinker Dust), OG17 (Cement Dust), OG9&13 (Paved Roadway), OG18 (Unpaved Shoulder), OG19 (Soil on Plant Property), OG23 (Background Soil) - Ca in the fine deposits shows a decreasing trend and Ti, Si and Al in the coarse deposits shows an increasing trend. These trends reflect the dominance of an anthropogenic (cement industry) source for Ca and the dominance of a soil source for Ti, Si and Al.

The highest Cl concentrations in the fine deposits, and less so in the coarse deposits, occurs on road samples (OG9&13 and OG 18). The high Cl concentrations from road samples may reflect the usage of de-icing salt.

A more thorough examination of the developed dust profiles will follow with proposed receptor modeling, and will no undoubtedly reveal more insights. A point to be made is that the variabilities in elemental concentrations, between samples and particle size ranges, reinforces the need to develop site-specific surface dust libraries. Furthermore, careful consideration of the samples collected and of the suspension techniques is necessary to optimize these profiles for receptor modeling statistics.

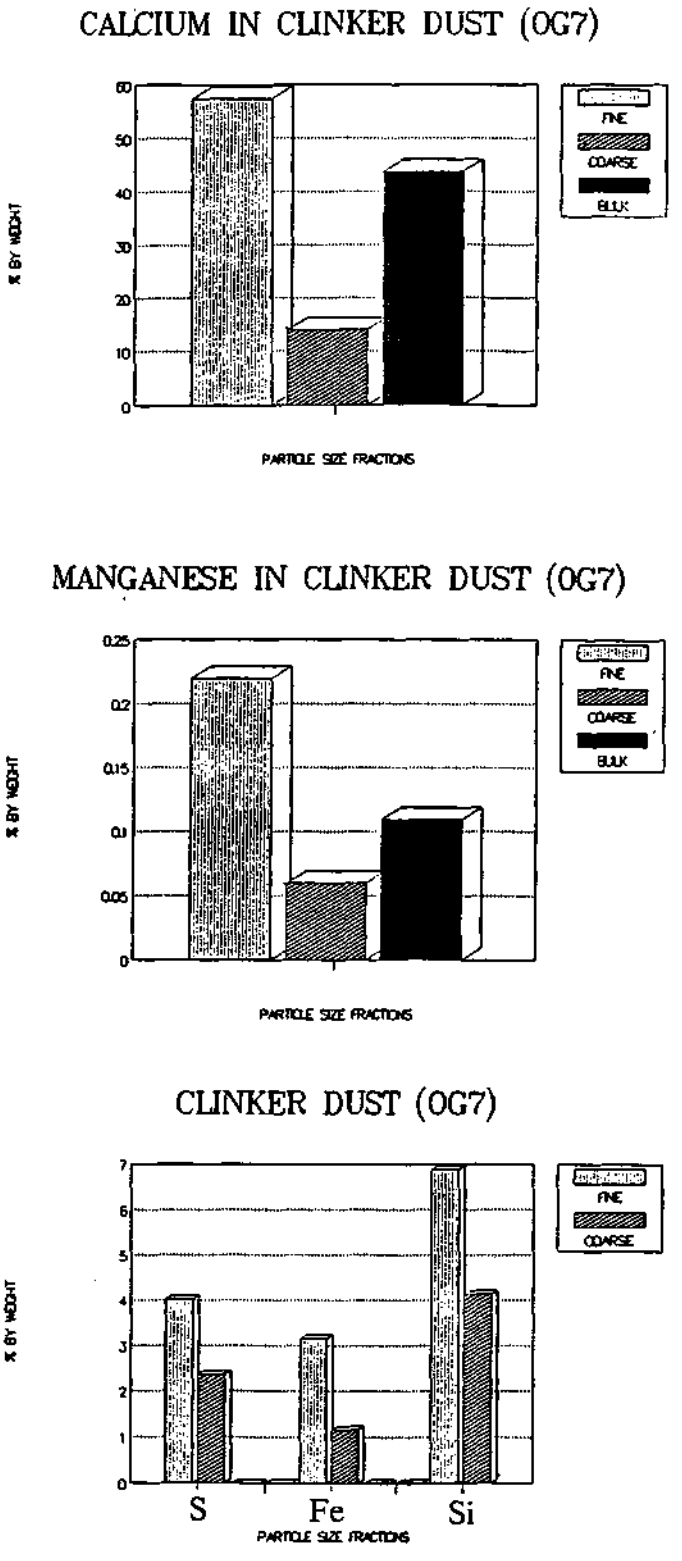

Figure 4. Clinker Dust - Fine, Coarse and Bulk Elemental Fractionation.

References

Hopke, P.K. 1985: "Receptor Modeling in Environmental Chemistry". John Wiley & Sons, New York p. 319.

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United States Environmental Protection Agency (U.S. EPA), 1984. "Receptor Model Source Composition Library". EPA 450/4-85-002, Research Triangle Park, NC 27711.

Vermette, S.J., Irvine, K.N., and Drake, J. 1987: "Elemental and Size Distribution Characteristics of Urban Sediments: Hamilton, Canada". Environmental Technology Letters. 8, 619-634.

Vermette, S.J. and Williams, A.L. 1989: "Surface Dust Elemental Profiles - Granite City". Illinois State Water Survey Contract Report 482, Atmospheric Chemistry Section, 2204 Griffith Dr, Champaign, IL 61820-7495.

APPENDIX A

Surface Dust Elemental Profiles
(Profile.asc)

SAMPLE ID: OG7
DESCRIPTION: CLINKER DUST
PARTICLE SIZE: F

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 1270 MICROGRAMS
NAA 1257 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					2.0	
NA			13.561+-	.532	1.198+-	.047
MG			16.079+-	2.455	1.420+-	.217
AL	5.3968+-	.7204	35.619+-	4.754	2.805+-	.377
SI	13.2323+-	1.9602	87.333+-	12.937	6.877+-	1.025
P	.2914+-	.1188	1.923+-	.784	.151+-	.062
S	7.7616+-	1.0057	51.226+-	6.638	4.034+-	.527
K	9.4079+-	1.0877	62.092+-	7.179	4.889+-	.571
CA	110.5763+-	12.5087	729.804+-	82.557	57.465+-	6.570
TI	.3738+-	.0235	2.467+-	.155	.194+-	.013
V			.076+-	.003	.007+-	.001
CR	.0457+-	.0044	.301+-	.029	.024+-	.002
MN	.4173+-	.0242	2.754+-	.160	.217+-	.013
FE	6.0770+-	.3217	40.108+-	2.123	3.158+-	.175
NI	.0596+-	.0043	.393+-	.029	.031+-	.002
CU	.0450+-	.0038	.297+-	.025	.023+-	.002
ZN	.0312+-	.0030	.206+-	.020	.016+-	.002
AS			.010+-	.002	.001+-	.000
SE	.0032+-	.0014	.021+-	.010	.002+-	.001
BR	.0070+-	.0019	.046+-	.012	.004+-	.001
RB	.0684+-	.0047	.452+-	.031	.036+-	.003
SR	.1674+-	.0096	1.105+-	.063	.087+-	.005
CD	.0276+-	.0155	.182+-	.102	.014+-	.008
SB	.0637+-	.0459	.420+-	.303	.033+-	.024
LA			.018+-	.002	.002+-	.000
SM			.005+-	.000	.001+-	.000

SAMPLE ID: OG7
DESCRIPTION: CLINKER DUST
PARTICLE SIZE: C

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 1836 MICROGRAMS
NAA 1822 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					1.6	
NA			14.198+-	.445	.659+-	.024
MG			12.418+-	1.900	.539+-	.104
AL	5.2723+-	.7766	34.797+-	5.125	1.895+-	.280
SI	11.5015+-	1.8209	75.910+-	12.018	4.135+-	.656
P	.3345+-	.0739	2.208+-	.487	.120+-	.027
S	6.5902+-	.9164	43.495+-	6.048	2.369+-	.330
K	8.4077+-	1.0629	55.491+-	7.015	3.022+-	.384
CA	38.9510+-	5.9475	257.077+-	39.253	14.002+-	2.144
TI	.1841+-	.0161	1.215+-	.106	.066+-	.006
V			.066+-	.003	.003+-	.000
CR	.0365+-	.0037	.241+-	.024	.013+-	.001
MN	.1779+-	.0143	1.174+-	.094	.064+-	.005
FE	3.2263+-	.2147	21.294+-	1.417	1.160+-	.078
NI	.0502+-	.0041	.332+-	.027	.018+-	.001
CU	.0403+-	.0038	.266+-	.025	.014+-	.001
ZN	.0143+-	.0025	.094+-	.016	.005+-	.001
AS			.005+-	.001	.001+-	.000
SE	.0024+-	.0014	.016+-	.009	.001+-	.001
BR	.0018+-	.0017	.012+-	.011	.001+-	.001
RB	.0509+-	.0042	.336+-	.028	.018+-	.002
SR	.0853+-	.0066	.563+-	.044	.031+-	.002
PD	.0192+-	.0103	.127+-	.068	.007+-	.004
AG	.0216+-	.0123	.143+-	.081	.008+-	.004
IN	.0207+-	.0191	.137+-	.126	.007+-	.007
LA			.015+-	.001	.001+-	.000
HG	.0056+-	.0034	.037+-	.023	.002+-	.001
PB	.0111+-	.0058	.073+-	.039	.004+-	.002

SAMPLE ID: OG9&13
DESCRIPTION: PAVED ROADWAY, PLANT SOIL/KILN TRACK-OUT
PARTICLE SIZE: F

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 587 MICROGRAMS
NAA 568 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
NA			2.193+-	.214	.428+-	.038
MG			5.450+-	1.440	1.065+-	.253
AL	5.6401+-	.7515	37.225+-	4.960	6.345+-	.859
SI	10.8097+-	1.6013	71.344+-	10.569	12.161+-	1.824
P	.1466+-	.0250	.968+-	.165	.165+-	.028
S	.4617+-	.0995	3.047+-	.656	.519+-	.113
CL	.2654+-	.0472	1.751+-	.311	.299+-	.054
K	2.2800+-	.2602	15.048+-	1.717	2.565+-	.299
CA	16.3823+-	1.8542	108.123+-	12.237	18.430+-	2.131
TI	.2754+-	.0159	1.818+-	.105	.310+-	.019
V			.052+-	.003	.010+-	.001
CR	.0192+-	.0021	.127+-	.014	.022+-	.002
MN	.0888+-	.0056	.586+-	.037	.100+-	.007
FE	2.7330+-	.1456	18.038+-	.961	3.075+-	.179
NI	.0061+-	.0014	.040+-	.010	.007+-	.002
CU	.0051+-	.0019	.034+-	.012	.006+-	.002
ZN	.0148+-	.0021	.098+-	.014	.017+-	.002
AS			.005+-	.001	.001+-	.000
SE	.0019+-	.0012	.012+-	.008	.002+-	.001
RB	.0170+-	.0025	.112+-	.016	.019+-	.003
SR	.0272+-	.0029	.180+-	.019	.031+-	.003
AG	.0124+-	.0107	.082+-	.070	.014+-	.012
SB			.002+-	.000	.001 + -	.000
LA			.014+-	.001	.003+-	.000
SM			.003+-	.000	.001+-	.000
PB	.0051+-	.0051	.034+-	.034	.006+-	.006

SAMPLE ID: OG9&13
DESCRIPTION: PAVED ROADWAY, PLANT SOIL/KILN TRACK-OUT
PARTICLE SIZE: C

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 1826 MICROGRAMS
NAA 1739 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					.913	
NA			5.427+-	.756	.269+-	.043
MG			15.889+-	3.474	.807+-	.043
AL	10.7274+-	1.4948	70.801+-	9.866	3.877+-	.541
SI	25.9419+-	3.8000	171.216+-	25.080	9.375+-	1.375
P	.2664+-	.0804	1.758+-	.531	.096+-	.029
S	1.6775+-	.2940	11.072+-	1.941	.606+-	.106
CL	.5501+-	.1025	3.631+-	.676	.199+-	.037
K	4.5775+-	.5477	30.212+-	3.615	1.654+-	.198
CA	61.7695+-	7.1098	407.679+-	46.925	22.322+-	2.574
TI	.5127+-	.0353	3.384+-	.233	.185+-	.013
V			.116+-	.005	.006+-	.000
CR	.0208+-	.0034	.137+-	.023	.008+-	.001
MN	.2606+-	.0160	1.720+-	.105	.094+-	.006
FE	6.6707+-	.3530	44.027+-	2.330	2.411+-	.129
NI	.0171+-	.0021	.113+-	.014	.006+-	.001
CU	.0168+-	.0025	.111+-	.017	.006+-	.001
ZN	.0352+-	.0031	.232+-	.021	.013+-	.001
AS			.012+-	.001	.001+-	.000
GA	.0022+-	.0012	.015+-	.008	.001+-	.000
SE	.0053+-	.0015	.035+-	.010	.002+-	.001
BR	.0072+-	.0018	.047+-	.012	.003+-	.001
SR	.1149+-	.0068	.758+-	.045	.042+-	.002
RB	.0398+-	.0034	.263+-	.023	.014+-	.001
CD	.0220+-	.0148	.145+-	.097	.008+-	.005
IN	.0308+-	.0191	.203+-	.126	.011+-	.007
SN	.0315+-	.0234	.208+-	.154	.011+-	.008
LA			.029+-	.001	.001+-	.000
HG	.0076+-	.0038	.050+-	.025	.003+-	.001
SM			.007+-	.000	.001+-	.000
PB	.0159+-	.0062	.105+-	.041	.006+-	.002

SAMPLE ID: OG17
DESCRIPTION: CEMENT DUST
PARTICLE SIZE: F

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 1094 MICROGRAMS
NAA 1073 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					7.253	
NA			3.641+-	.307	.377+-	.029
AL	8.3416+-	1.1111	55.055+-	7.333	5.030+-	.676
SI	18.7060+-	2.7708	123.460+-	18.287	11.281+-	1.682
P	.2609+-	.0450	1.722+-	.297	.157+-	.027
S	2.8675+-	.3540	18.926+-	2.337	1.729+-	.216
CL	.1617+-	.0467	1.067+-	.308	.098+-	.028
K	2.8850+-	.3300	19.041+-	2.178	1.740+-	.201
CA	28.9728+-	3.2783	191.220+-	21.637	17.472+-	2.000
TI	.3936+-	.0222	2.597+-	.147	.237+-	.014
V			.094+-	.003	.010+-	.000
CR	.0292+-	.0029	.193+-	.019	.018+-	.002
MN	.1317+-	.0079	.869+-	.052	.079+-	.005
FE	4.5437+-	.2409	29.988+-	1.590	2.740+-	.153
NI	.0129+-	.0021	.085+-	.014	.008+-	.001
CU	.0097+-	.0026	.064+-	.017	.006+-	.002
ZN	.0400+-	.0035	.264+-	.023	.024+-	.002
GA	.0019+-	.0012	.012+-	.008	.001+-	.001
AS			.010+-	.001	.001+-	.000
BR	.0029+-	.0020	.019+-	.013	.002+-	.001
RB	.0207+-	.0031	.136+-	.021	.012+-	.002
SR	.0742+-	.0052	.490+-	.035	.045+-	.003
AG	.0221+-	.0142	.146+-	.094	.013+-	.009
SB			.003+-	.001	.001+-	.000
LA			.022+-	.001	.002+-	.000
SM			.004+-	.000	.001+-	.000
HG	.0042+-	.0038	.028+-	.025	.003+-	.002

SAMPLE ID: OG17
DESCRIPTION: CEMENT DUST
PARTICLE SIZE: C

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 975 MICROGRAMS
NAA 688 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					8.197	
NA			3.408+-	.612	.458+-	.089
MG			10.276+-	2.703	1.494+-	.393
AL	5.6304+-	.8690	37.160+-	5.735	3.813+-	.593
SI	16.1042+-	2.5523	106.288+-	16.845	10.906+-	1.741
P	.1959+-	.0456	1.293+-	.301	.133+-	.031
S	2.0404+-	.3161	13.467+-	2.086	1.382+-	.216
CL	.2559+-	.0552	1.689+-	.364	.173+-	.038
K	1.7871+-	.2439	11.795+-	1.610	1.210+-	.167
CA	30.1089+-	3.7350	198.719+-	24.651	20.391+-	2.559
TI	.2543+-	.0206	1.679+-	.136	.172+-	.014
V			.077+-	.003	.010+-	.000
CR	.0173+-	.0025	.114+-	.016	.012+-	.002
MN	.1519+-	.0100	1.003+-	.066	.103+-	.007
FE	4.1175+-	.2413	27.176+-	1.592	2.789+-	.172
NI	.0125+-	.0017	.083+-	.011	.008+-	.001
CU	.0167+-	.0022	.110+-	.015	.011+-	.002
ZN	.0423+-	.0034	.279+-	.022	.029+-	.002
AS			.007+-	.001	.001+-	.000
BR	.0016+-	.0013	.011+-	.009	.001+-	.001
RB	.0114+-	.0021	.075+-	.014	.008+-	.001
SR	.0714+-	.0049	.471+-	.033	.048+-	.003
AG	.0103+-	.0096	.068+-	.063	.007+-	.007
IN	.0226+-	.0153	.149+-	.101	.015+-	.010
SB			.003+-	.000	.001+-	.000
LA			.016+-	.001	.002+-	.000
HG	.0036+-	.0027	.024+-	.018	.002+-	.002
SM			.003+-	.000	.001+-	.000
PB	.0162+-	.0048	.107+-	.032	.011+-	.003

SAMPLE ID: OG18
DESCRIPTION: UNPAVED SHOULDER, PLANR CEMENT LOAD-OUT
PARTICLE SIZE: F

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 1229 MICROGRAMS
NAA 1224 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					2.3	
NA			3.943+-	.534	.357+-	.044
MG			12.972+-	2.898	1.176+-	.237
AL	11.0946+-	1.4774	73.224+-	9.751	5.959+-	.800
SI	27.7612+-	4.1118	183.224+-	27.138	14.910+-	2.222
P	.3407+-	.0502	2.249+-	.331	.183+-	.027
S	1.6340+-	.2371	10.785+-	1.565	.878+-	.128
CL	.5508+-	.0827	3.635+-	.546	.296+-	.045
K	4.0209+-	.4573	26.538+-	3.018	2.160+-	.248
CA	26.7219+-	3.0237	176.364+-	19.957	14.352+-	1.642
TI	.5027+-	.0302	3.318+-	.199	.270+-	.017
V			.090+-	.003	.008+-	.000
CR	.0261+-	.0031	.172+-	.021	.014+-	.002
MN	.1519+-	.0098	1.002+-	.065	.082+-	.005
FE	5.5796+-	.2955	36.825+-	1.950	2.997+-	.166
NI	.0148+-	.0019	.098+-	.013	.008+-	.001
CU	.0150+-	.0023	.099+-	.015	.008+-	.001
ZN	.0617+-	.0043	.407+-	.029	.033+-	.002
AS			.011+-	.001	.001+-	.000
GA	.0022+-	.0011	.015+-	.007	.001+-	.001
SE	.0014+-	.0012	.010+-	.008	.001+-	.001
RB	.0236+-	.0027	.155+-	.018	.013+-	.001
SR	.0606+-	.0042	.400+-	.028	.033+-	.002
MO	.0109+-	.0084	.072+-	.056	.006+-	.005
PD	.0152+-	.0091	.100+-	.060	.008+-	.005
SB			.007+-	.000	.001+-	.000
LA			.021+-	.001	.002+-	.000
HG	.0050+-	.0031	.033+-	.021	.003+-	.002
PB	.0203+-	.0055	.134+-	.036	.011+-	.003

SAMPLE ID: OG18
DESCRIPTION: UNPAVED SHOULDER, PLANT CEMENT LOAD-OUT
PARTICLE SIZE: C

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 2128 MICROGRAMS
NAA 2110 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					2.1	
NA			7.478+-	.880	.319+-	.042
MG			26.848+-	4.137	1.155+-	.042
AL	14.7053+-	2.0985	97.055+-	13.850	4.561+-	.652
SI	42.0490+-	6.3179	277.523+-	41.698	13.041+-	1.963
P	.4193+-	.0929	2.767+-	.613	.130+-	.029
S	2.3501+-	.3771	15.510+-	2.489	.729+-	.117
CL	.8588+-	.1369	5.668+-	.904	.266+-	.043
K	5.2176+-	.6400	34.436+-	4.224	1.618+-	.199
CA	59.2263+-	6.9514	390.893+-	45.879	18.368+-	2.163
TI	.6416+-	.0436	4.235+-	.288	.199+-	.014
V			.156+-	.006	.007+-	.000
CR	.0301+-	.0038	.199+-	.025	.009+-	.001
MN	.2733+-	.0171	1.804+-	.113	.085+-	.005
FE	7.6165+-	.4209	50.269+-	2.778	2.362+-	.132
NI	.0186+-	.0023	.123+-	.015	.006+-	.001
CU	.0118+-	.0025	.078+-	.017	.004+-	.001
ZN	.0720+-	.0051	.475+-	.034	.022+-	.002
GA	.0028+-	.0012	.018+-	.008	.001+-	.000
AS			.020+-	.001	.001+-	.000
SE	.0039+-	.0015	.025+-	.010	.001+-	.000
BR	.0071+-	.0019	.047+-	.013	.002+-	.001
RB	.0316+-	.0033	.209+-	.022	.010+-	.001
SR	.1351+-	.0081	.892+-	.053	.042+-	.003
CD	.0218+-	.0155	.144+-	.102	.007+-	.005
IN	.0231+-	.0200	.152+-	.132	.007+-	.006
SB			.011+-	.001	.001+-	.000
LA			.037+-	.001	.002+-	.000
HG	.0104+-	.0042	.069+-	.028	.003+-	.001
PB	.0265+-	.0065	.175+-	.043	.008+-	.002

SAMPLE ID: OG19
DESCRIPTION: SOIL ON PLANT PROPERTY, IMPACTED BY KILN
PARTICLE SIZE: F

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 270 MICROGRAMS
NAA 246 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					6.8	
AL	2.0630+-	.2755	13.616+-	1.818	5.043+-	.708
SI	6.4133+-	.9503	42.328+-	6.272	15.677+-	2.421
P	.0830+-	.0113	.548+-	.075	.203+-	.029
S	.1178+-	.0307	.777+-	.202	.288+-	.076
CL	.0190+-	.0123	.125+-	.081	.046+-	.030
K	.7604+-	.0878	5.019+-	.580	1.859+-	.229
CA	4.1016+-	.4651	27.071+-	3.069	10.026+-	1.218
TI	.1736+-	.0106	1.145+-	.070	.424+-	.032
V			.022+-	.001	.010+-	.000
CR	.0058+-	.0014	.038+-	.010	.014+-	.004
MN	.0597+-	.0041	.394+-	.027	.146+-	.012
FE	1.5847+-	.0852	10.459+-	.562	3.874+-	.268
NI	.0032+-	.0013	.021+-	.009	.008+-	.003
CU	.0028+-	.0018	.018+-	.012	.007+-	.004
ZN	.0097+-	.0019	.064+-	.013	.024+-	.005
GA	.0012+-	.0009	.008+-	.006	.003+-	.002
AS			.005+-	.001	.002+-	.000
SR	.0036+-	.0022	.023+-	.015	.009+-	.005
ZR	.0256+-	.0133	.169+-	.088	.062+-	.033
SB			.003+-	.000	.001+-	.000
LA			.012+-	.001	.005+-	.000
HG	.0032+-	.0028	.021+-	.018	.008+-	.007

SAMPLE ID: OG19
DESCRIPTION: SOIL ON PLANT PROPERTY, IMPACTED BY KILN
PARTICLE SIZE: C

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 1208 MICROGRAMS
NAA 1114 MICROGRAMS

ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					6.5	
NA			2.395+-	.689	.215+-	.062
MG			11.715+-	3.006	1.051+-	.270
AL	8.3281+-	1.0996	54.965+-	7.258	4.550+-	.602
SI	26.4093+-	3.7074	174.301+-	24.469	14.429+-	2.030
P	.3684+-	.0481	2.431+-	.317	.201+-	.026
S	.2361+-	.0788	1.558+-	.520	.129+-	.043
CL	.1069+-	.0320	.706+-	.211	.058+-	.018
K	3.1355+-	.3536	20.694+-	2.334	1.713+-	.194
CA	22.6372+-	2.5368	149.406+-	16.743	12.368+-	1.390
TI	.6558+-	.0376	4.328+-	.248	.358+-	.021
V			.095+-	.004	.008+-	.000
MN	.1288+-	.0138	.850+-	.091	.070+-	.008
FE	6.2053+-	.3135	40.955+-	2.069	3.390+-	.174
NI	.0134+-	.0017	.088+-	.011	.007+-	.001
CU	.0129+-	.0020	.085+-	.013	.007+-	.001
ZN	.0940+-	.0056	.620+-	.037	.051+-	.003
GA	.0020+-	.0010	.013+-	.007	.001+-	.001
AS			.017+-	.001	.001+-	.000
BR	.0035+-	.0014	.023+-	.009	.002+-	.001
RB	.0228+-	.0024	.150+-	.016	.012+-	.001
SR	.0427+-	.0032	.282+-	.021	.023+-	.002
ZR	.0148+-	.0123	.098+-	.081	.008+-	.007
PD	.0096+-	.0078	.063+-	.051	.005+-	.004
AG	.0169+-	.0095	.112+-	.063	.009+-	.005
SB			.003+-	.000	.001+-	.000
LA			.035+-	.001	.003+-	.000
HG	.0056+-	.0029	.037+-	.019	.003+-	.002
PB	.0245+-	.0050	.162+-	.033	.013+-	.003

SAMPLE ID: OG23
DESCRIPTION: SOIL, REGIONAL BACKGROUND
PARTICLE SIZE: F

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 287 MICROGRAMS
NAA 279 MICROGRAMS

ELEMENT	UG/CM2	UG/FILTER	PERCENT
C			3.0
NA		1.174+- .277	.468+- .168
AL	2.9833+- .3980	19.690+- 2.627	6.868+- .959
SI	9.2882+- 1.3760	61.302+- 9.081	21.385+- 3.289
P	.1320+- .0159	.871+- .105	.304+- .039
S	.0826+- .0281	.545+- .186	.190+- .065
CL	.0253+- .0129	.167+- .085	.058+- .030
K	.7714+- .0889	5.091+- .587	1.776+- .217
CA	.9979+- .1141	6.586+- .753	2.297+- .279
TI	.2156+- .0128	1.423+- .084	.496+- .036
V		.036+- .002	.014+- .000
CR	.0252+- .0025	.166+- .016	.058+- .006
MN	.0470+- .0035	.310+- .023	.108+- .009
FE	1.8268+- .0980	12.057+- .647	4.206+- .285
NI	.0041+- .0014	.027+- .010	.009+- .003
CU	.0059+- .0021	.039+- .014	.014+- .005
ZN	.0273+- .0028	.180+- .019	.063+- .007
GA	.0017+- .0010	.011+- .007	.004+- .002
AS		.004+- .000	.002+- .000
RB	.0053+- .0024	.035+- .016	.012+- .006
MO	.0139+- .0092	.092+- .061	.032+- .021
PD	.0116+- .0098	.076+- .065	.027+- .023
SB		.002+- .000	.001+- .000
LA		.015+- .001	.006+- .000
HG	.0036+- .0032	.023+- .021	.008+- .007
SM		.002+- .000	.001+- .000
PB	.0078+- .0056	.051+- .037	.018+- .013

SAMPLE ID: OG23
DESCRIPTION: SOIL, REGIONAL BACKGROUND
PARTICLE SIZE: C

EXPOSED AREA: 6.60 SQUARE CM
MASS OF DEPOSIT: XRF 1149 MICROGRAMS
NAA 1106 MICROGRAMS

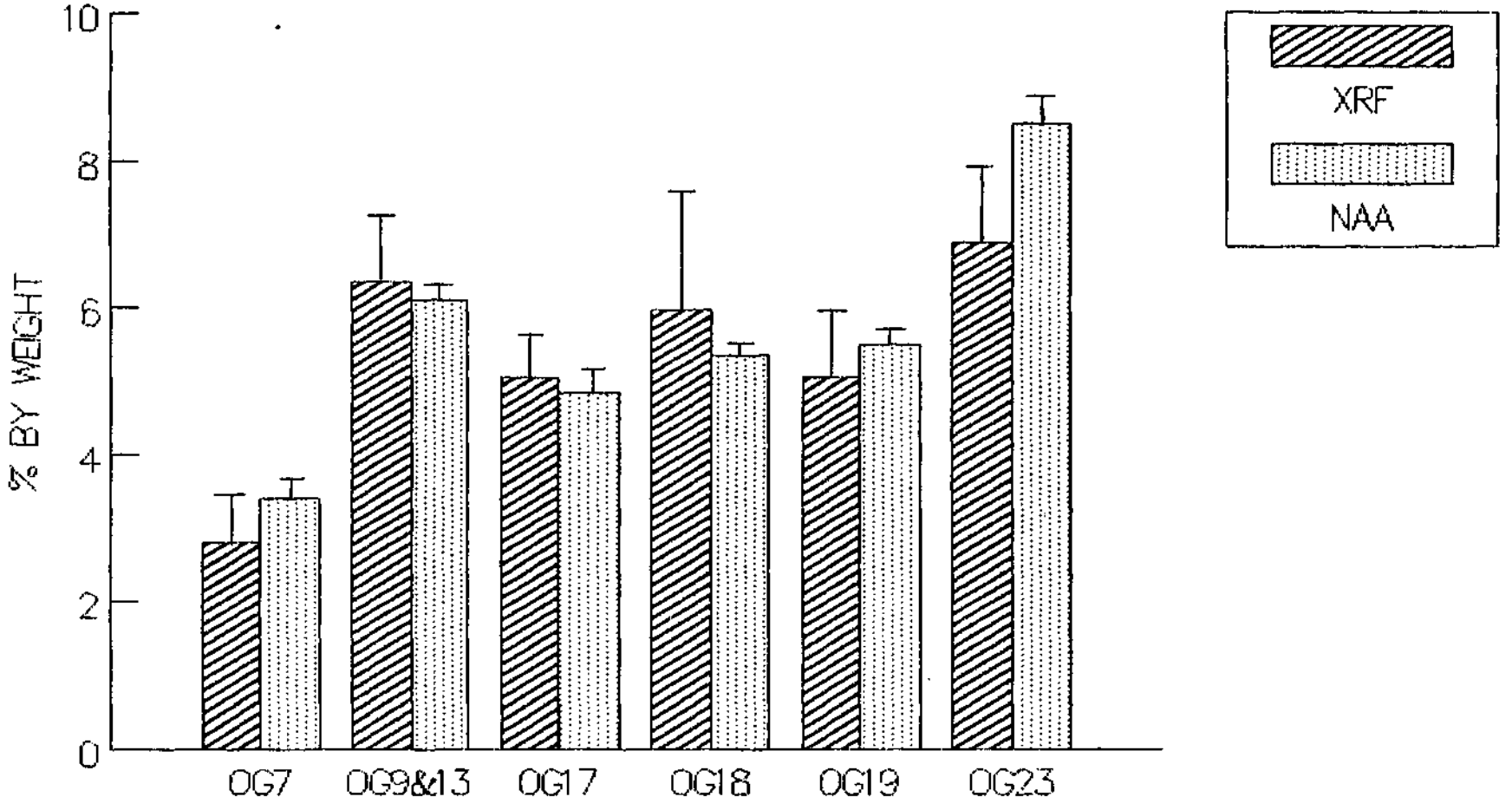
ELEMENT	UG/CM2		UG/FILTER		PERCENT	
C					4.6	
NA			4.452+-	.560	.356+-	.051
AL	11.4981+-	1.5582	75.888+-	10.284	6.603+-	.897
SI	45.5327+-	6.5247	300.516+-	43.063	26.147+-	3.755
P	.4227+-	.0498	2.790+-	.329	.243+-	.029
CL	.0886+-	.0216	.585+-	.143	.051+-	.012
K	3.4869+-	.4003	23.013+-	2.642	2.002+-	.231
CA	3.5615+-	.4119	23.506+-	2.719	2.045+-	.237
TI	.8941+-	.0504	5.901+-	.333	.513+-	.029
V	.0387+-	.0103	.255+-	.068	.022+-	.006
CR	.0687+-	.0056	.453+-	.037	.039+-	.003
MN	.1236+-	.0089	.816+-	.059	.071+-	.005
FE	6.8181+-	.3546	45.000+-	2.340	3.915+-	.207
NI	.0138+-	.0017	.091+-	.011	.008+-	.001
CU	.0149+-	.0020	.098+-	.013	.009+-	.001
ZN	.0585+-	.0040	.386+-	.027	.034+-	.002
GA	.0016+-	.0009	.011+-	.006	.001+-	.001
AS			.015+-	.001	.001+-	.000
SE	.0020+-	.0010	.013+-	.007	.001+-	.001
BR	.0038+-	.0013	.025+-	.009	.002+-	.001
RB	.0260+-	.0024	.171+-	.016	.015+-	.001
SR	.0261+-	.0025	.172+-	.017	.015+-	.001
PD	.0098+-	.0075	.065+-	.049	.006+-	.004
AG	.0163+-	.0091	.108+-	.060	.009+-	.005
SB			.004+-	.001	.001+-	.000
BA	.1597+-	.0818	1.054+-	.540	.092+-	.047
LA			.048+-	.002	.004+-	.000
PB	.0149+-	.0046	.098+-	.031	.009+-	.003

APPENDIX B

NAA & XRF Comparison
(NAA-XRF.wkl)

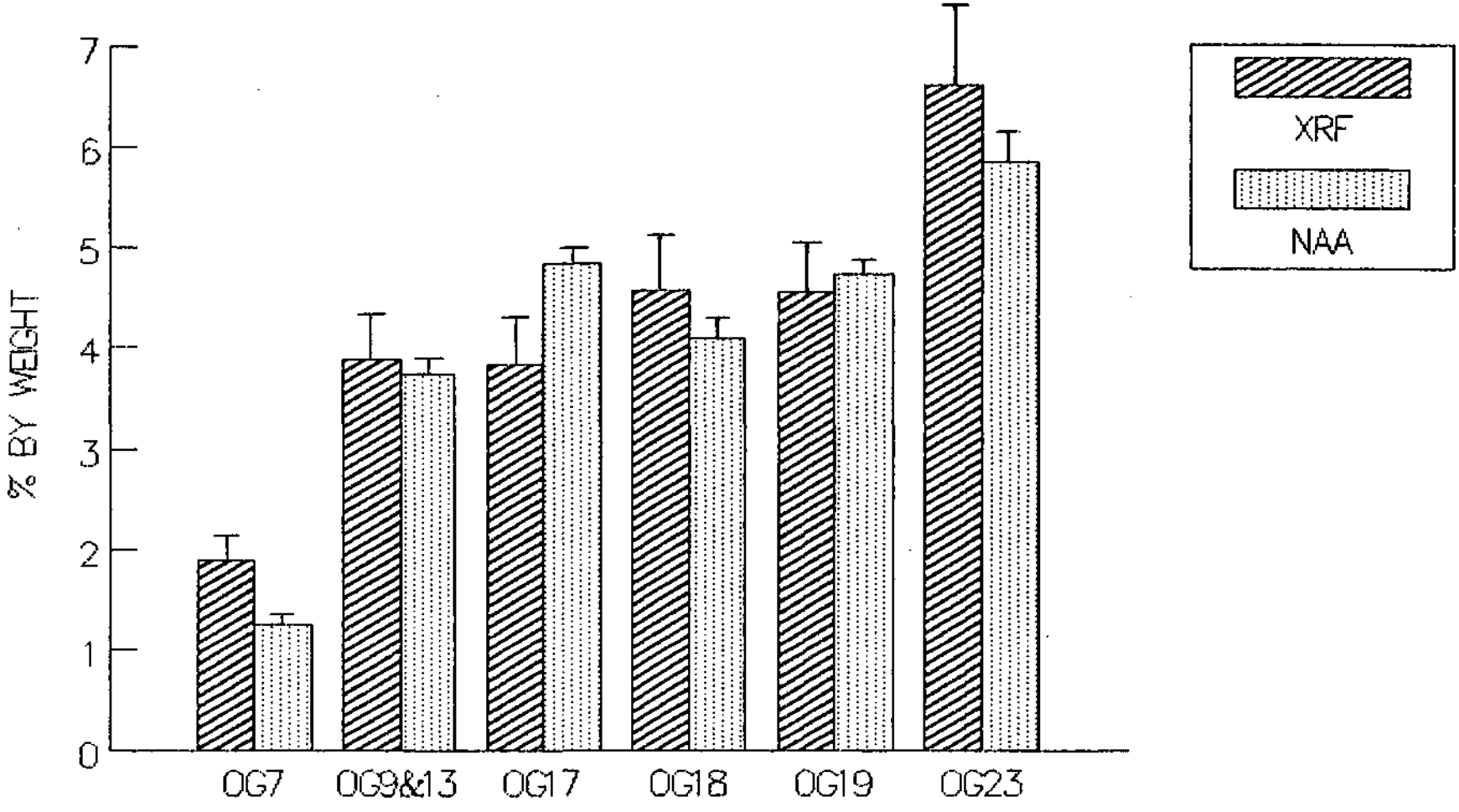
ALUMINUM

FINE DEPOSIT



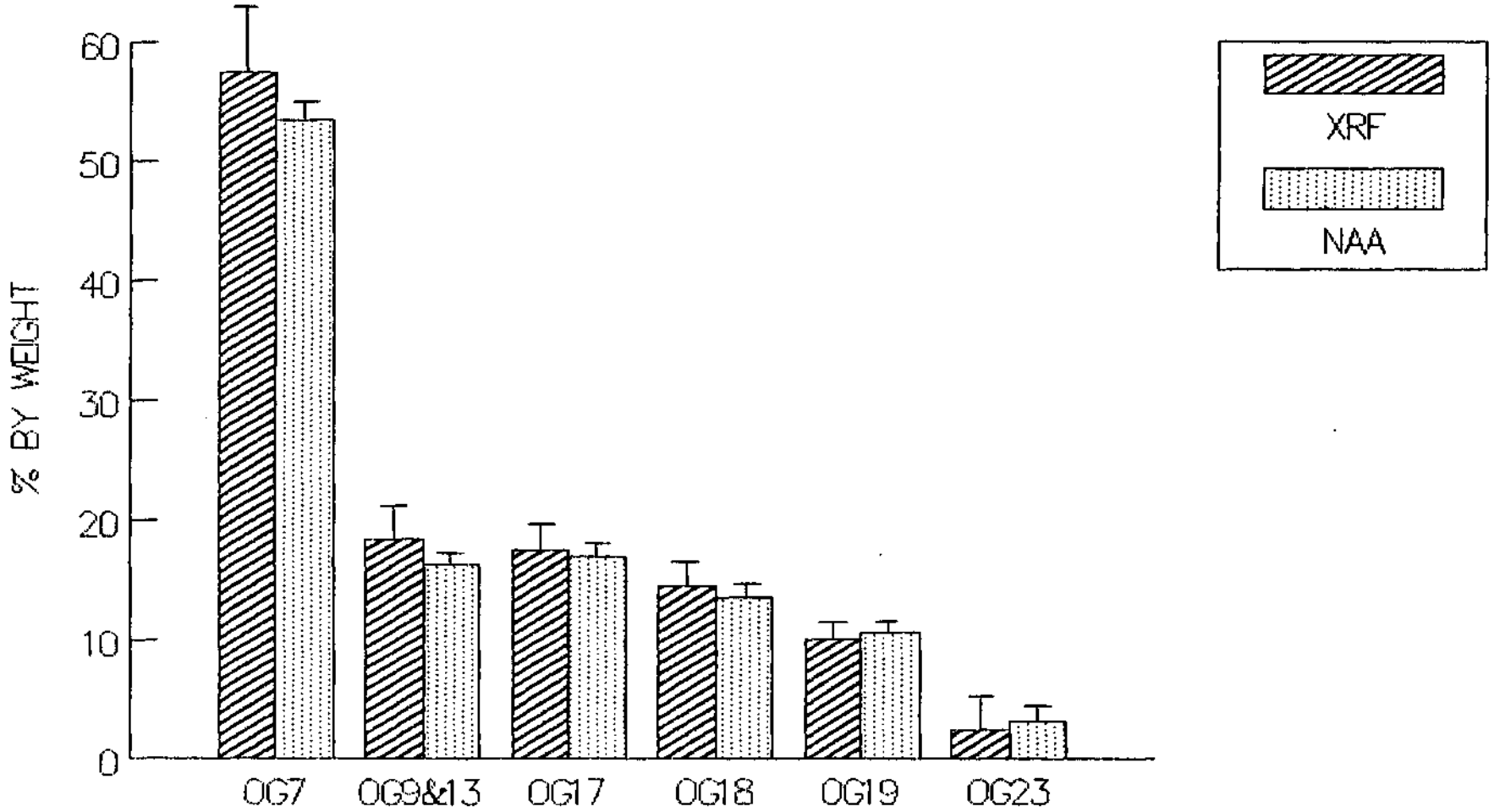
ALUMINUM

COARSE DEPOSIT



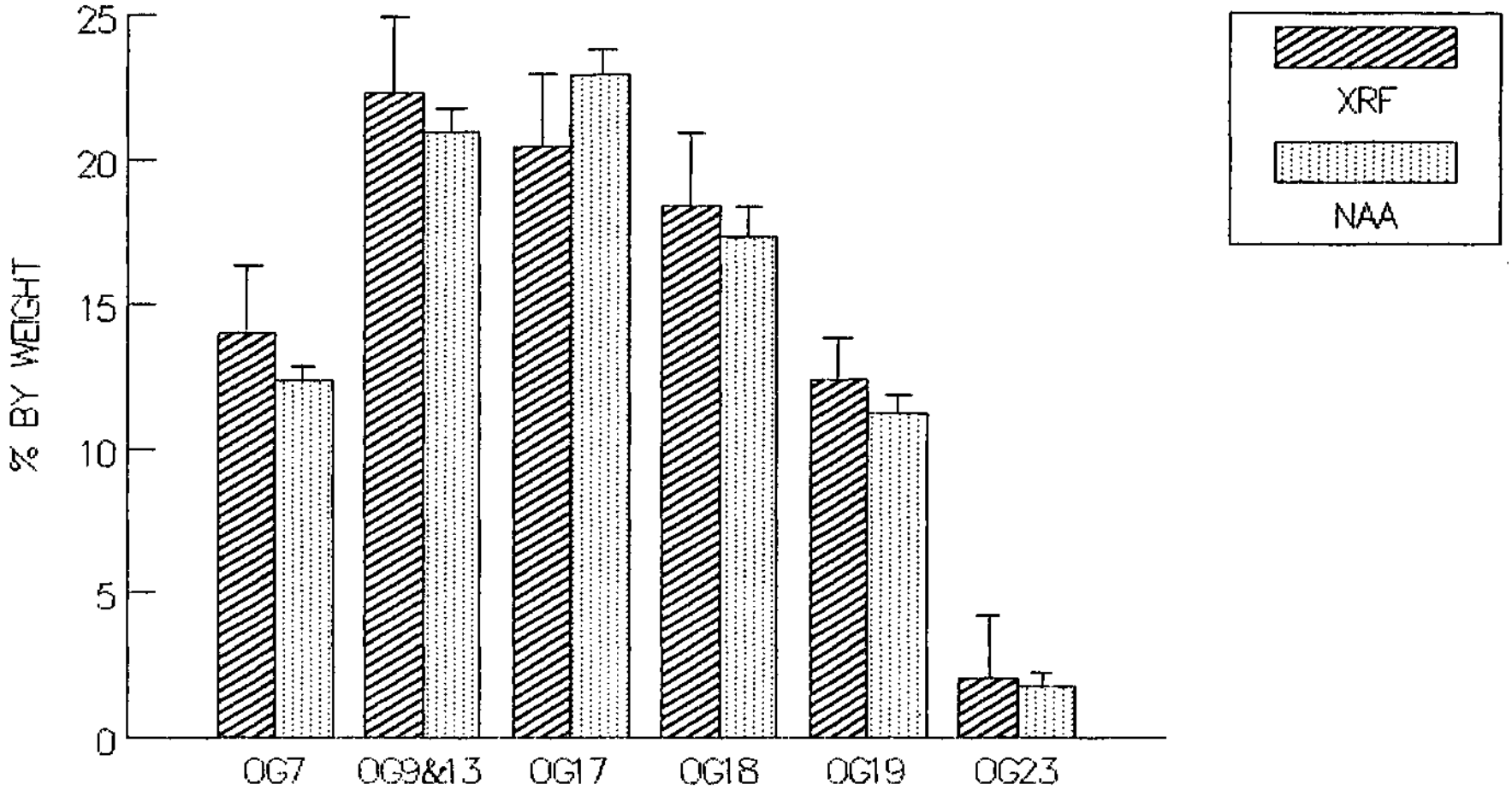
CALCIUM

FINE DEPOSIT



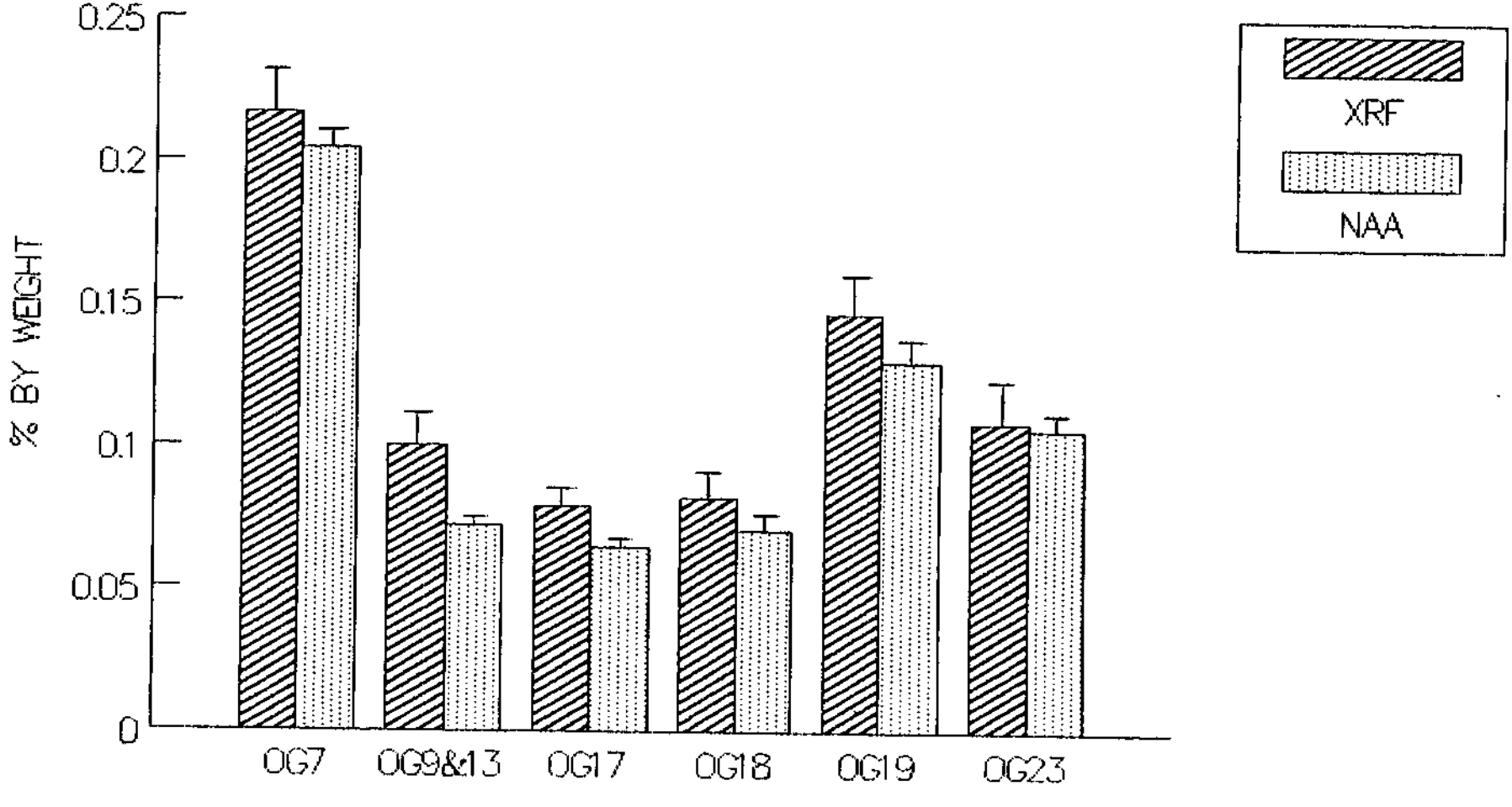
CALCIUM

COARSE DEPOSIT



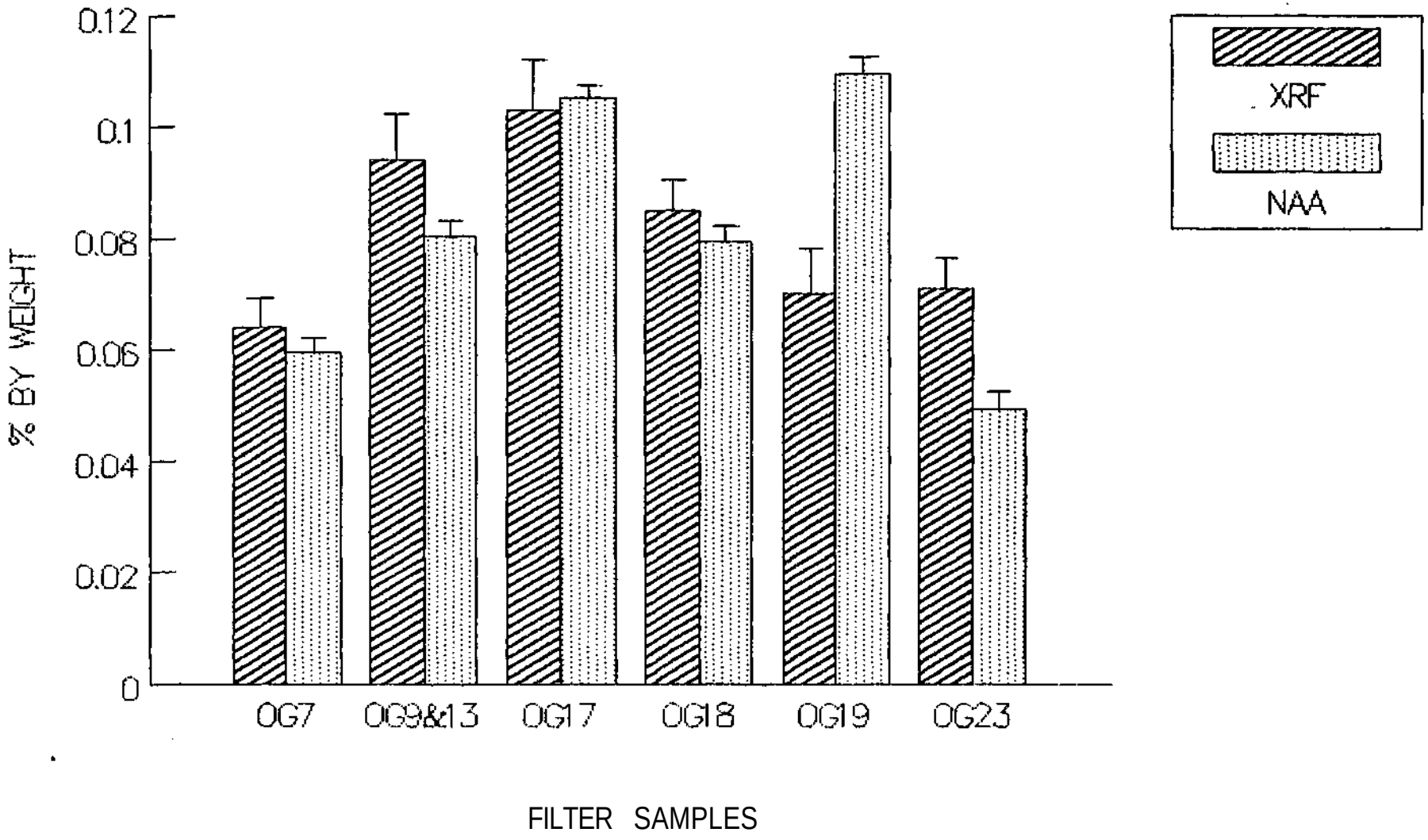
MANGANESE

FINE DEPOSIT



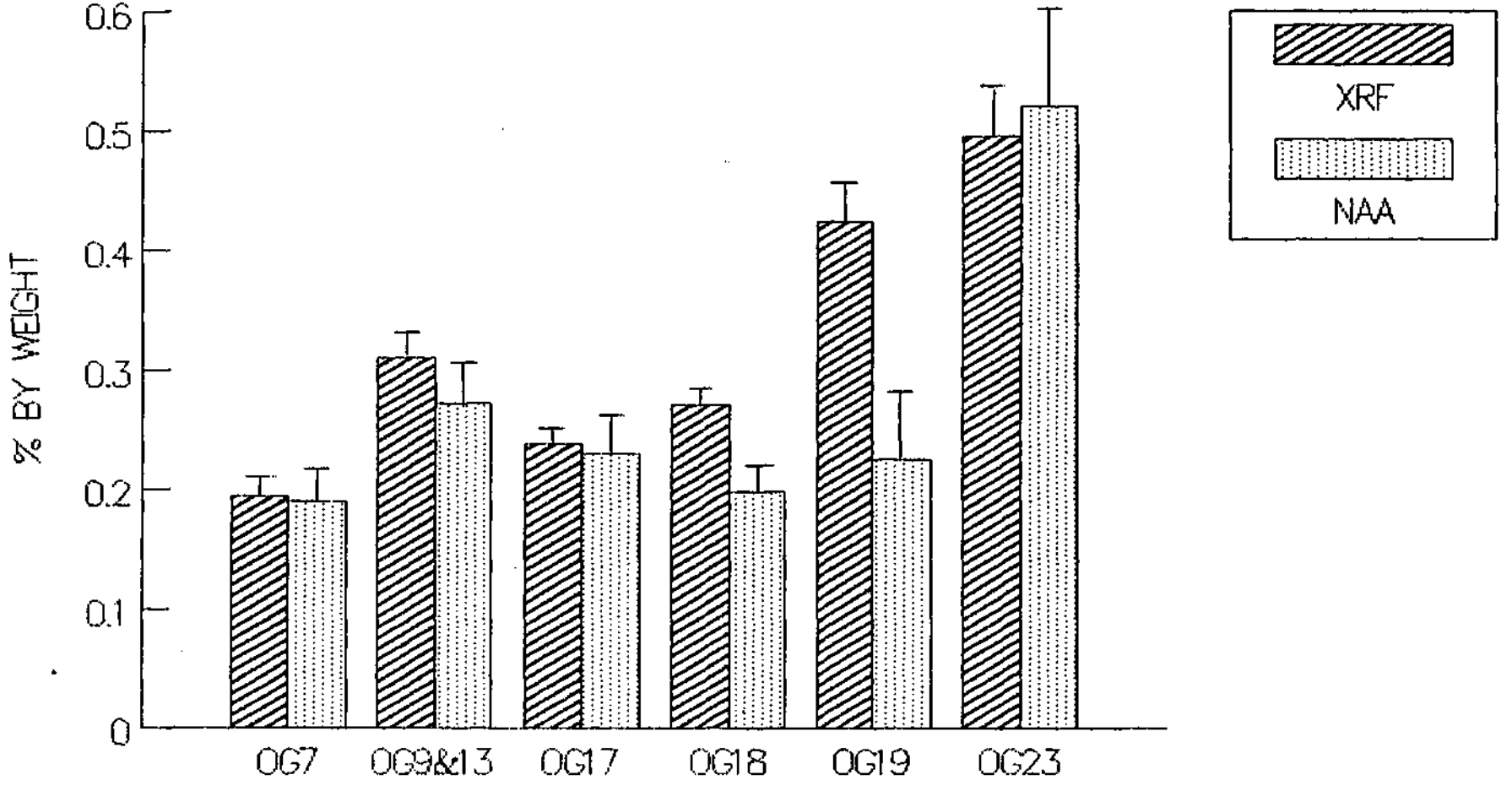
MANGANESE

COARSE DEPOSIT



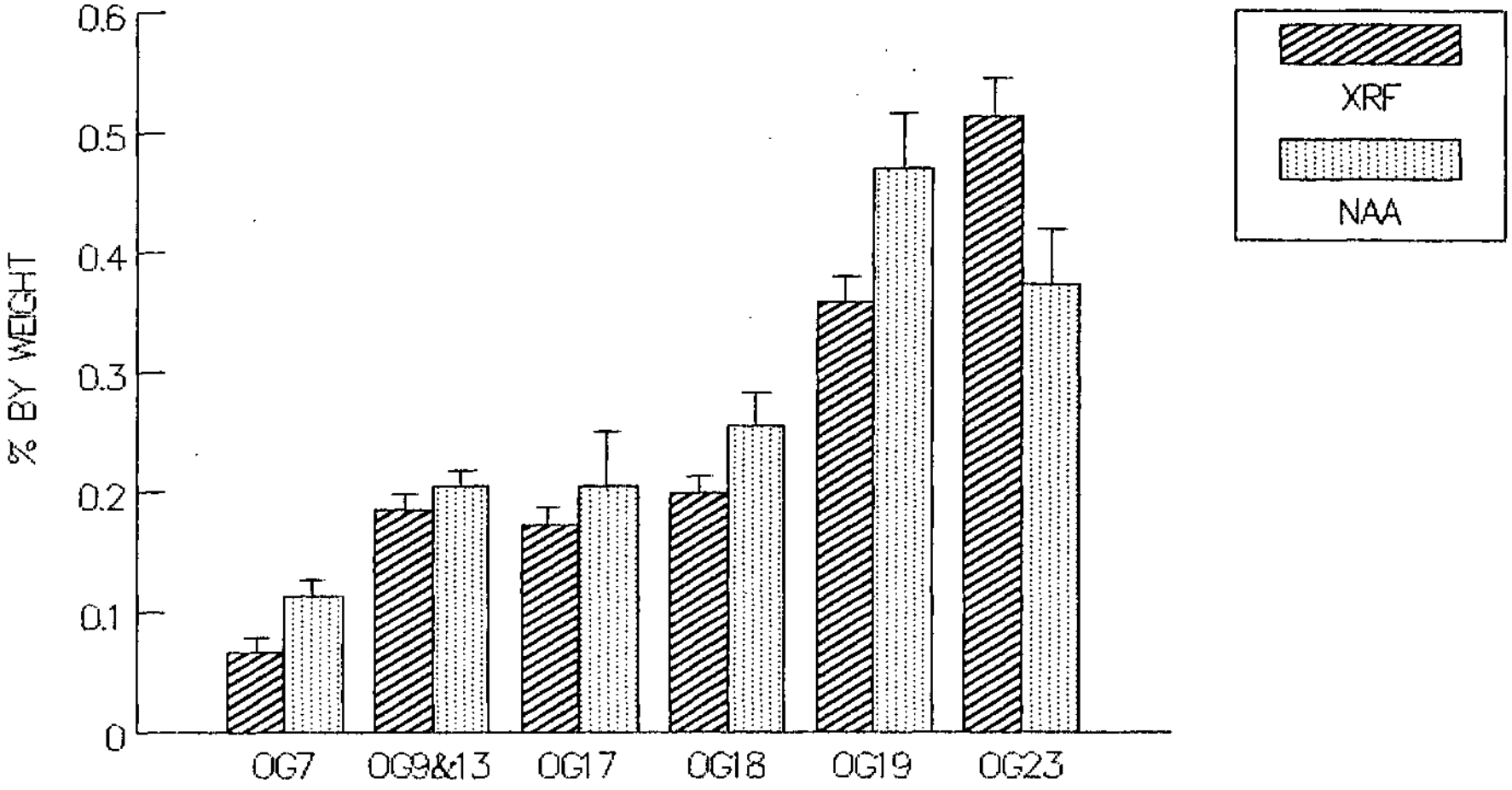
TITANIUM

FINE DEPOSIT



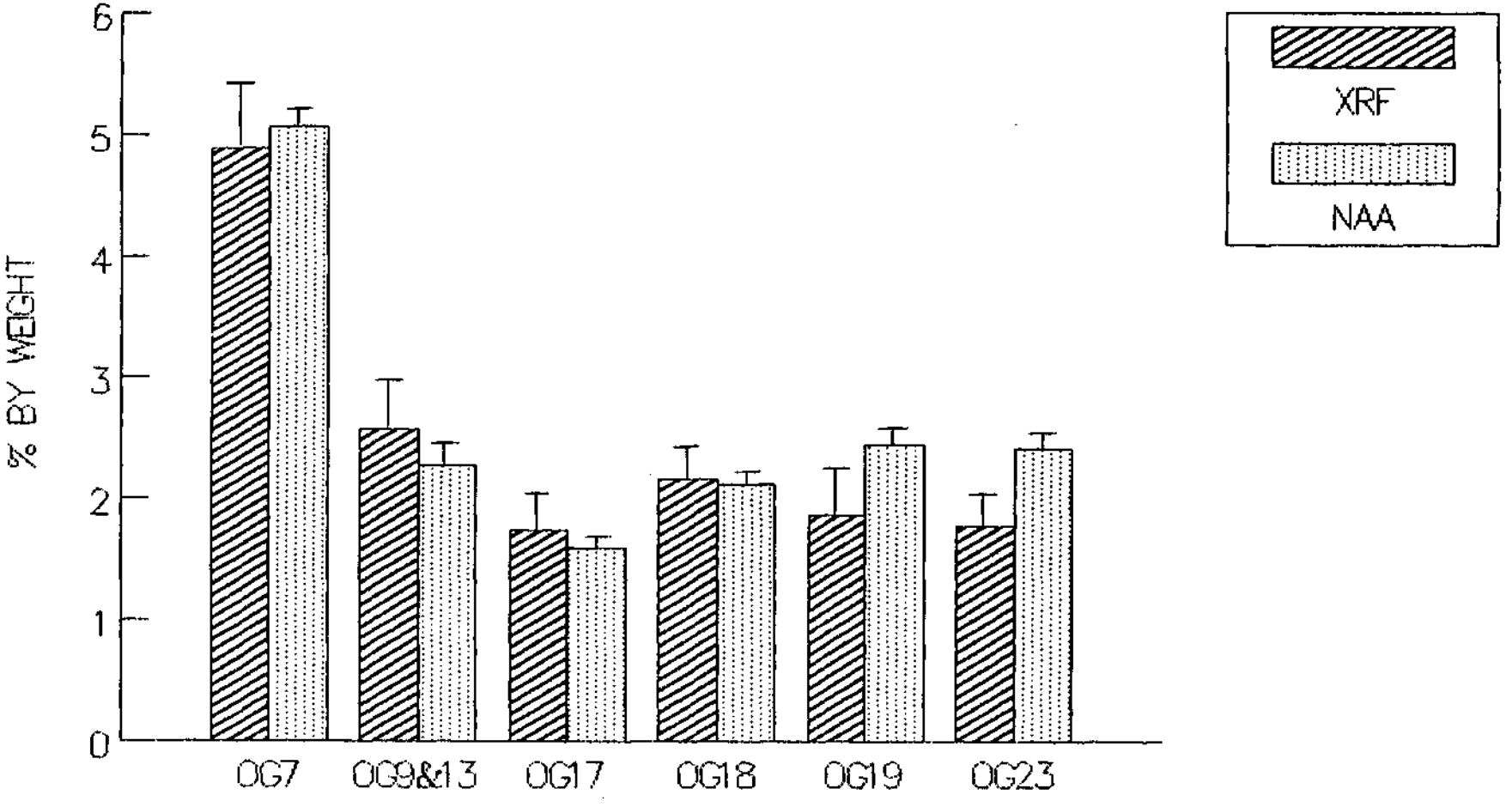
TITANIUM

COARSE DEPOSIT



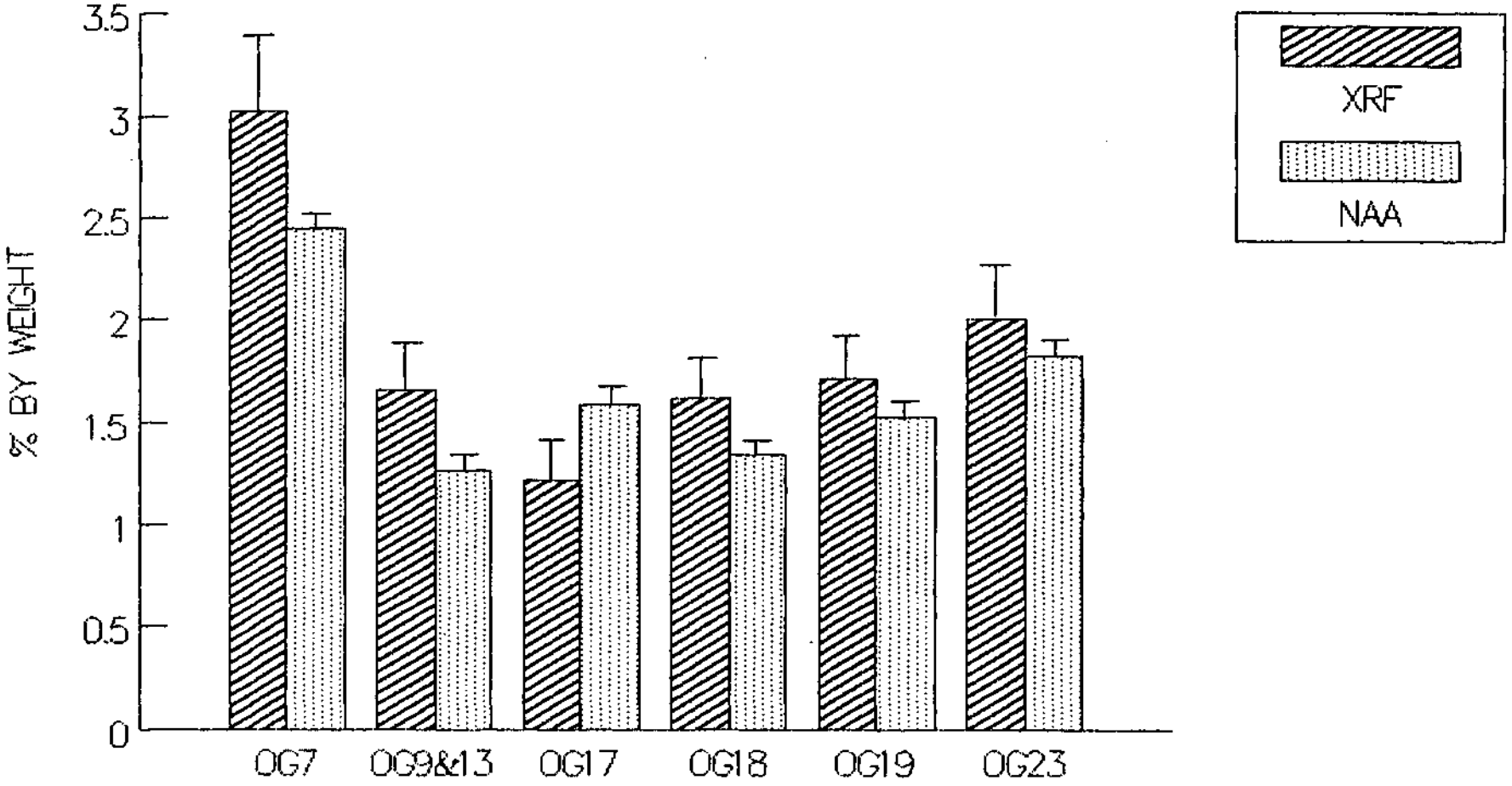
POTASSIUM

FINE DEPOSIT



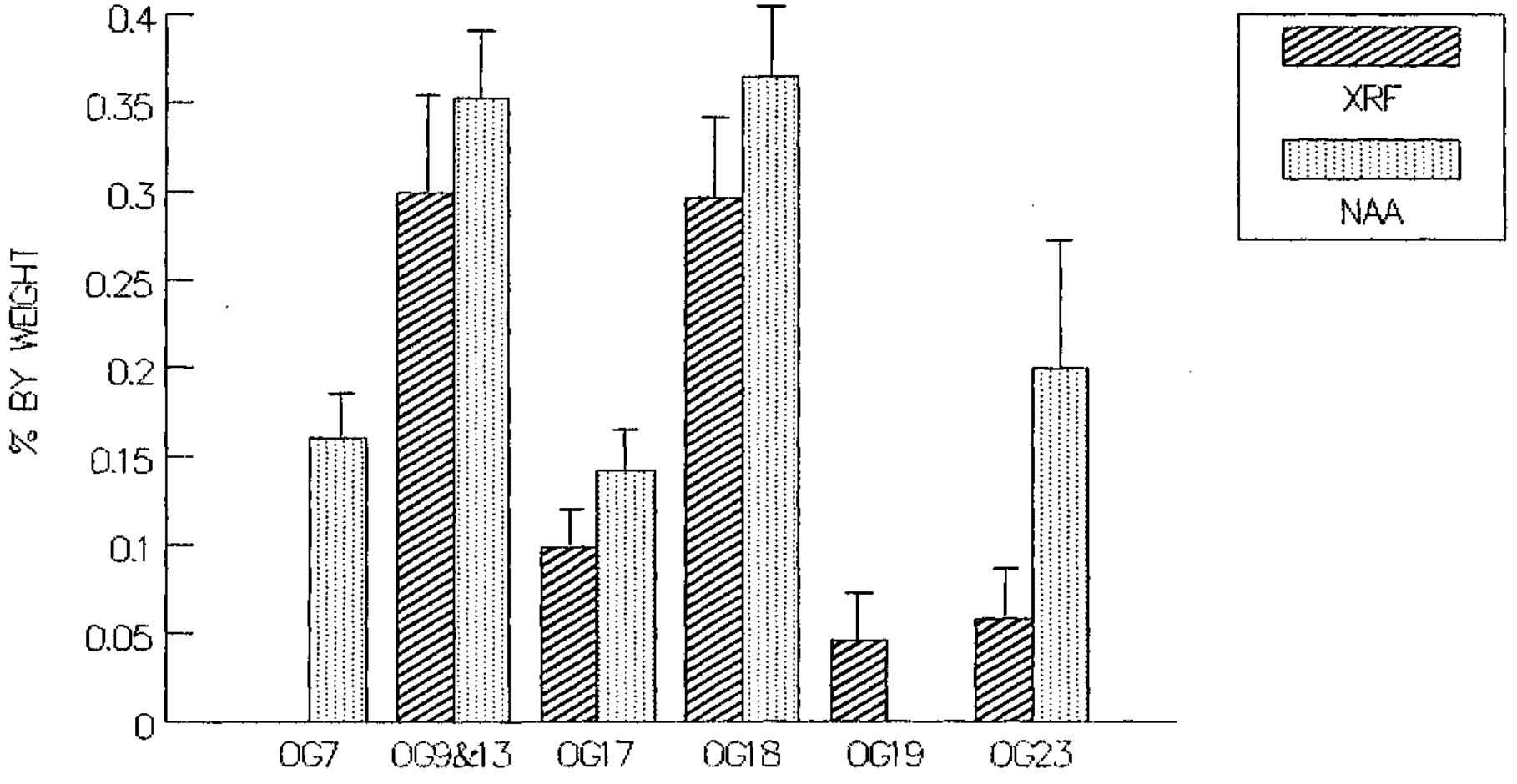
POTASSIUM

COARSE DEPOSIT



CHLORIDE

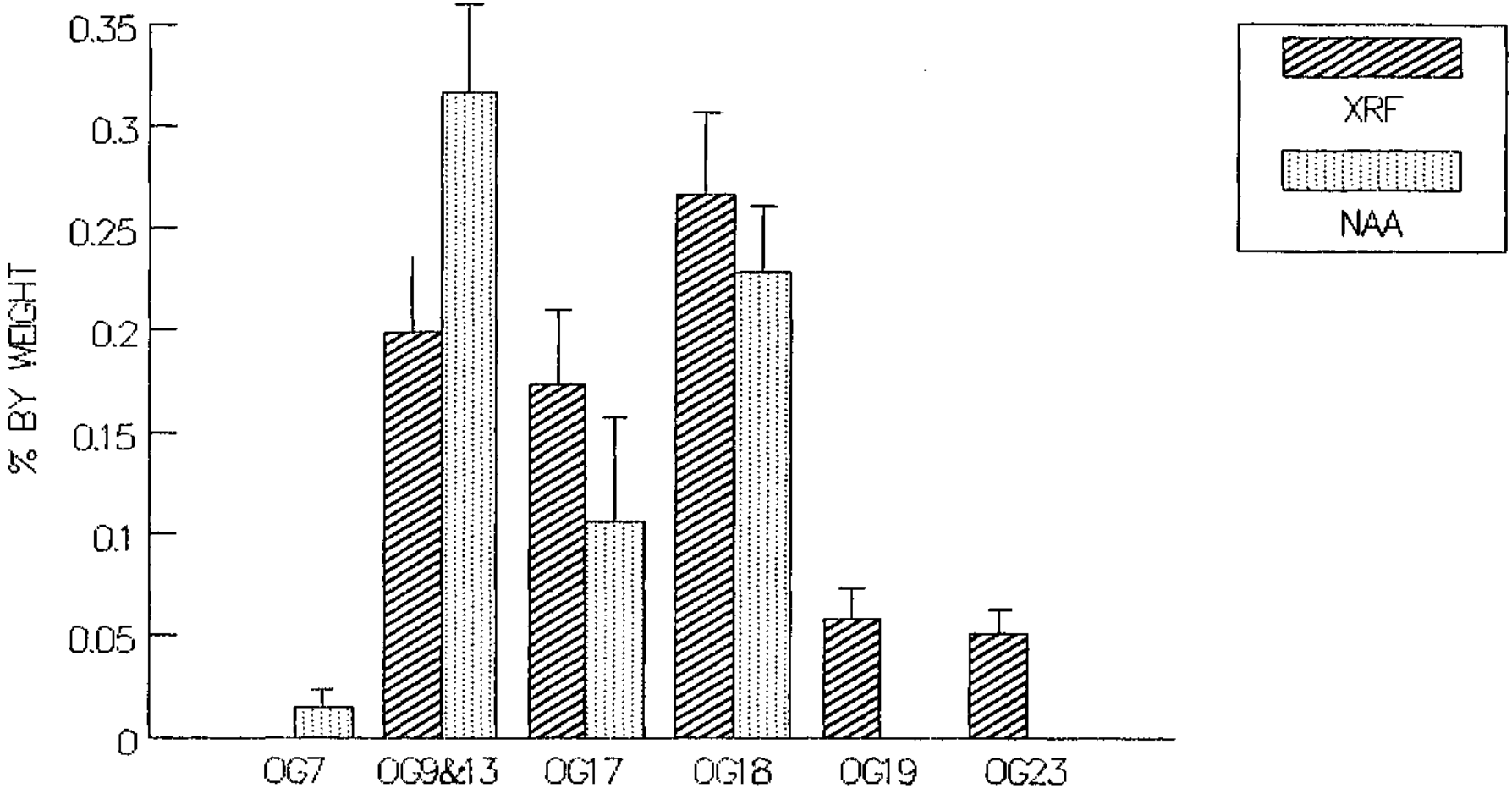
FINE DEPOSIT



FILTER SAMPLES

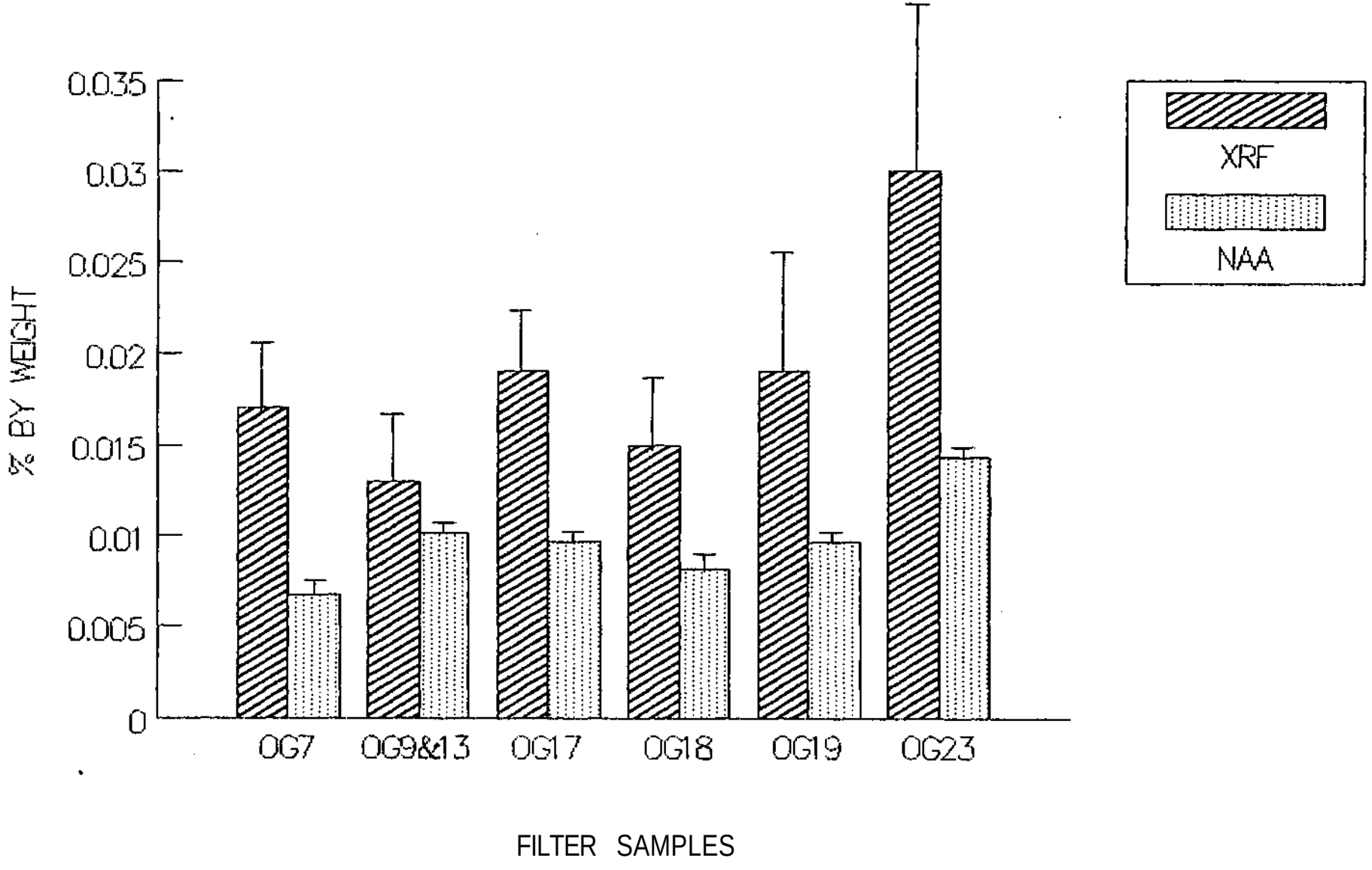
CHLORIDE

COARSE DEPOSIT



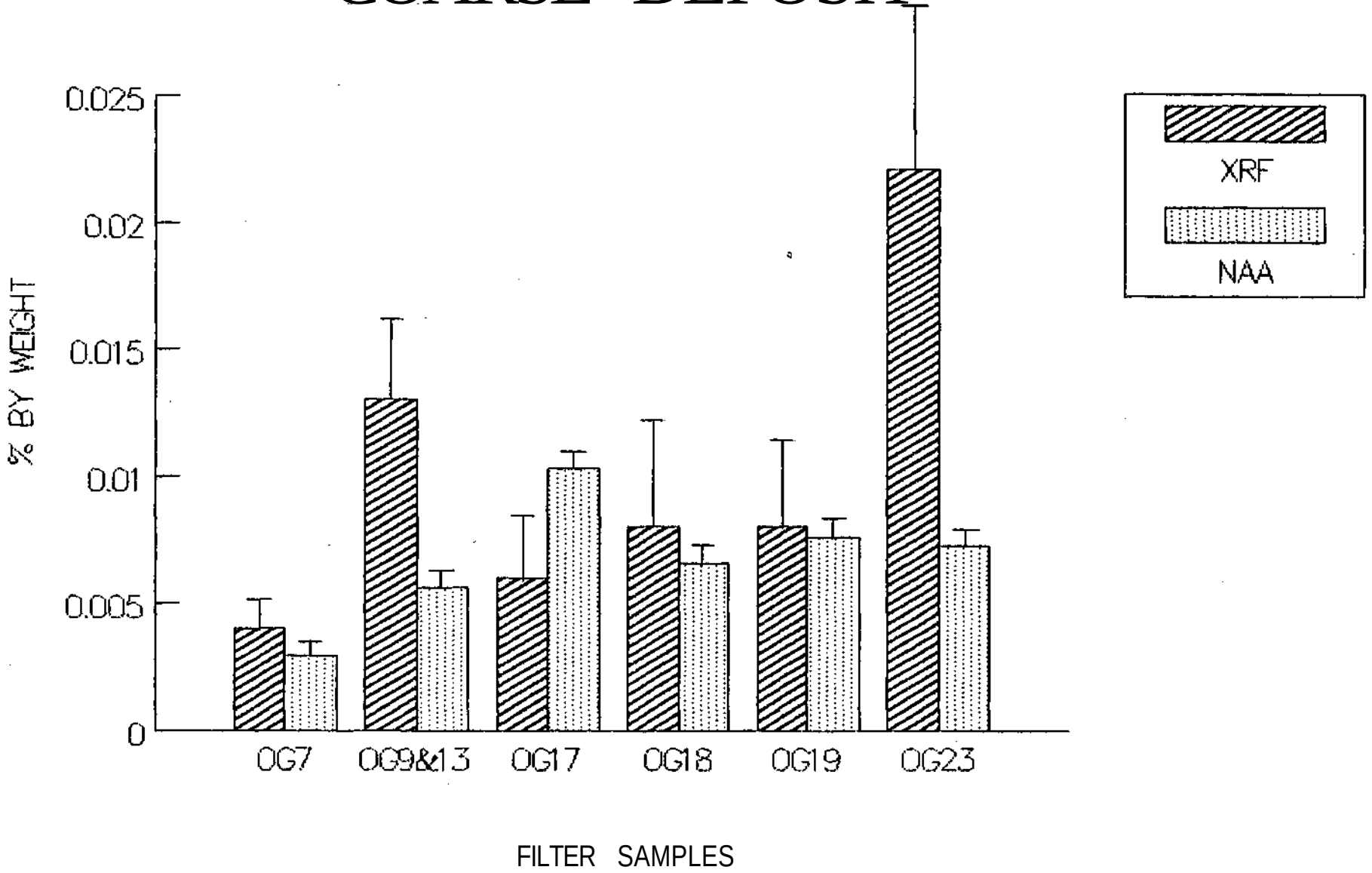
VANADIUM

FINE DEPOSIT



VANADIUM

COARSE DEPOSIT



APPENDIX C

Field Sampling Notes

OGLESBY NO. 1

Notes: TAKEN @ NEW SUBDIVISION. (ENTRANCE .75 MILE SOUTH OF WALNUT STREET)

Type of Sample: DISTURBED SOIL (PLOWED CORN STUBBLE)

Location sample taken at: OPEN GROUND SOUTHWEST OF NEW LOGHOUSE. THIS IS AT THE END OF THE GRAVEL ROAD (CIRCLE DRIVE). TAKEN .3 MILE OFF OF HIGHWAY 351. (.25 NORTH OF INTERSECTION BETWEEN N24TH RD & 351; ADJ. TO IC RIGHT-OF-WAY)

OGLESBY NO. 2

Notes:

Type of Sample: ROAD GRAVEL (UNPAVED ROAD - NEW SUBDIVISION)

Location sample taken at: FAR EAST END OF CIRCLE DRIVE. THIS SAMPLE WAS TAKEN APPROXIMATELY 80 FEET FROM OGLESBY NO. 1.

OGLESBY NO. 3

Notes: SAMPLE ADJACENT TO CURB (APPROX. 64 SQUARE INCHES

Type of Sample: PAVED ROAD DUST

Location sample taken at: DIRECTLY ~~ADJACENT~~ OPPOSITE TO MONITORS. WEST SIDE OF PORTLAND AVENUE

OGLESBY NO. 4

Notes: TAKEN AT MAR-
GIN OF FILL.

Type of Sample: KILN DUST

Location sample taken at: KILN DUST STORAGE PILE; COM-
PACTED BY TRUCK TRAFFIC.

OGLESBY NO. 5

Notes: POSSIBLE SIZE
CHARACTERISTICS DIFFERENCE
FROM PILE.

Type of Sample: ROAD (UNPAVED)

Location sample taken at: KILN DUST HAUL ROAD; JUST
SOUTHWEST OF ENTRANCE ON TO BRIDGE

OGLESBY NO. 6

Notes:

Type of Sample: SOIL SAMPLE; SOME SLOPEWASH ADDITION

Location sample taken at: SOUTH END OF KILN DUST HAUL
ROAD BRIDGE; UPLAND AREA THAT MAY BE A SPOIL
PILE (NOW STABILIZED BY VEGETATION. (EAST SIDE OF
ROAD; ≥15% SLOPE)

Notes:

OGLESBY NO. 7

SUSPENDED AND ANALYZED

Type of Sample: CLINKER DUST

Location sample taken at:
SOUTHWEST CLINKER [redacted] SILO - BETWEEN SILO AND ROADWAY AT ROAD LEVEL

Notes:

OGLESBY NO. 8

Type of Sample: GYPSUM DUST

Location sample taken at:
BETWEEN GYPSUM SILO AND PLANT ROAD (AT EAST SIDE OF CLINKER SILOS)

Notes:

OGLESBY NO. 9

SUSPENDED AND ANALYZED

Type of Sample: PAVED ROAD DUST (IN PLANT)

Location sample taken at:
NORTH EDGE OF PAVED ROADWAY, NORTH OF #5 ESP. (KILN ESP)

OGLESBY NO. 10

Notes:
COLLECTED DUST
FROM 240 sq in.
OF SURFACE

Type of Sample: CLINKER DUST

Location sample taken at:
UNDER KICK-OUT BIN - GROUND LEVEL
(SURFACE IS PAVED - CONCRETE)

OGLESBY NO. 11

Notes:

Type of Sample: ROADWAY DUST

Location sample taken at:
RAMP TO CLINKER/GYPSUM HOPPER FEEDING
RECLAIM SYSTEM (ADJACENT TO CLINKER/GYP
MOTOR CONTROL ROOM

OGLESBY NO. 12

Notes:

Type of Sample: RAW ROCK DUST — FALLOUT FROM INSIDE BLDG

Location sample taken at:
DUST DUMP ENCLOSURE AT EAST SIDE OF RAW MILL/
DRYER BUILDING

OGLESBY NO. 13

SUSPENDED AND ANALYZED

Notes: 260 SQ IN OF DUST FROM BLACKTOP ROADWAY

Type of Sample: ROADWAY DUST

Location sample taken at: PLANT ENTRANCE ROAD AT INTERSECTION WITH ROADWAY TO VERMILLION RIVER BRIDGE, AT EXTREME SE CORNER OF MAINTENANCE BLDG.

OGLESBY NO. 14

Notes:

Type of Sample: COAL DUST / COKE DUST (FINE GRAIN ALG

Location sample taken at: SOUTHWEST EDGE OF COALPILE? IN [redacted] AREA COMPACTED BY ENDLOADER TRAFFIC. (100' N. OF COAL HOPPER FEEDING PLANT)
DESCRIBED AS "WASTE COAL" (FINER GRAINED), LOWER GRADE

OGLESBY NO. 15

Notes:

Type of Sample: COAL DUST

Location sample taken at: SOUTHWEST EDGE OF SMALL COAL PILE 200' N. OF COAL FEED HOPPER, 100' SW OF CYP PILE

OGLESBY NO. 16

Notes: INCLUDES PELLE SAMPLES. (» 200 u)

Type of Sample: SURFACE MATERIAL -

Location sample taken at: GYPSUM STORAGE PILE EAST OF COVERED GYP PILE

OGLESBY NO. 17

SUSPENDED AND ANALYZED

Notes: 500 sq in. OF DUST FROM FLOOR (NOT TRAFFIC AREA)

Type of Sample: CEMENT DUST (PRODUCT)

Location sample taken at: INSIDE NEW ST. PAUL LOADOUT BUILDING, SOUTH SIDE OF SCALE

OGLESBY NO. 18

SUSPENDED AND ANALYZED

Notes: 144 SQ IN AREA, NOT IN NORMAL TRAFFIC LANE.

Type of Sample: UNPAVED ROAD SURFACE (SHOULDER)

Location sample taken at: 120' W. OF I C LOADOUT, 8' N. OF RR TRACK

OGLESBY NO. 19

SUSPENDED AND ANALYZED

Notes: 1-2 CM OF SURFACE DUST

Type of Sample: SURFACE MATERIAL - SOIL

Location sample taken at: UNDISTURBED TOP OF BLUFF BETWEEN KILN STACK AND MIDDLE OF IC SILOS (CREST OF HILL)

OGLESBY NO. 20

Notes: NON-TRAFFIC AREA 8' ABOVE ROADWAY LEVEL

Type of Sample: RAW ROCK DUST - QUARRY

Location sample taken at: UNDER #3 BELT, NORTH EDGE OF MAIN STORAGE PILE

PLACE SAMPLE TAG HERE

OGLESBY No. 21

Notes: ≈ 144 SQ IN. SURFACE AREA

Type of Sample: ROADWAY DUST - QUARRY

Location sample taken at: 10' EAST OF SE CORNER OF OLD [redacted] MAINTENANCE GARAGE, LEHIGH QUARRY

PLACE SAMPLE TAG HERE

OGLESBY No. 22

Notes:

Type of Sample: CRUSHER DUST - QUARRY

Location sample taken at: WEST SIDE OF CRUSHER, BASE LEVEL.

PLACE SAMPLE TAG HERE

OGLESBY No. 23

SUSPENDED AND ANALYZED

Notes:

Type of Sample: SURFACE SOIL - FARM FIELD

Location sample taken at:
WEST SIDE OF ILL RT 351, SOUTH OF OGLESBY AT CULVERT ≈ 400' N. OF NEW SUBDIVISION ROAD (.1 MILE FROM ENTRANCE LEADING TO LOG HOME)

PLACE SAMPLE TAG HERE

Notes:

Type of Sample:

Location sample taken at: