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Chemical Composition and Variability of Soils from the Capps Coal Field, Alaska

By

R. C. Severson and L. P. Gough

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INTRODUCTION

The Capps Coal Field study site is located about 100 km west of Anchorage, Alaska within the Beluga coal area (Fig. 1). This resource region is estimated to contain 2.1 billion tons of subbituminous coal (Barnes, 1966). The coal beds are well suited for exploitation because the geologic structure of the area is simple (Schmoll and others, 1980), a large potential electric power market exists at Anchorage, and there are possibilities for export if marine terminal facilities are constructed on the Cook Inlet at about 30 km distance (Sanders, 1975).

The study was initiated because of the high probability that surface mining of coal would become a reality in the Capps Coal Field in the near future (Placer Amex, 1977), and also because no data currently exist on the geochemistry of natural soils in this coal field or in the Cook Inlet region in general. Some geochemical data are available for over-burden rock material (Hinkley and others, 1982). Data on geochemistry of undisturbed soils in areas to be stripmined are essential for objective evaluation of the rehabilitation potential of replaced soils. Assessment of the importance of changes in the chemical composition of natural soils resulting from the rearrangement of rock strata and the disruption of soil development require pre-development data. Such data are useful because lands altered by stripmining are subject to chemical evaluation based on specific rehabilitation guidelines and regulations.

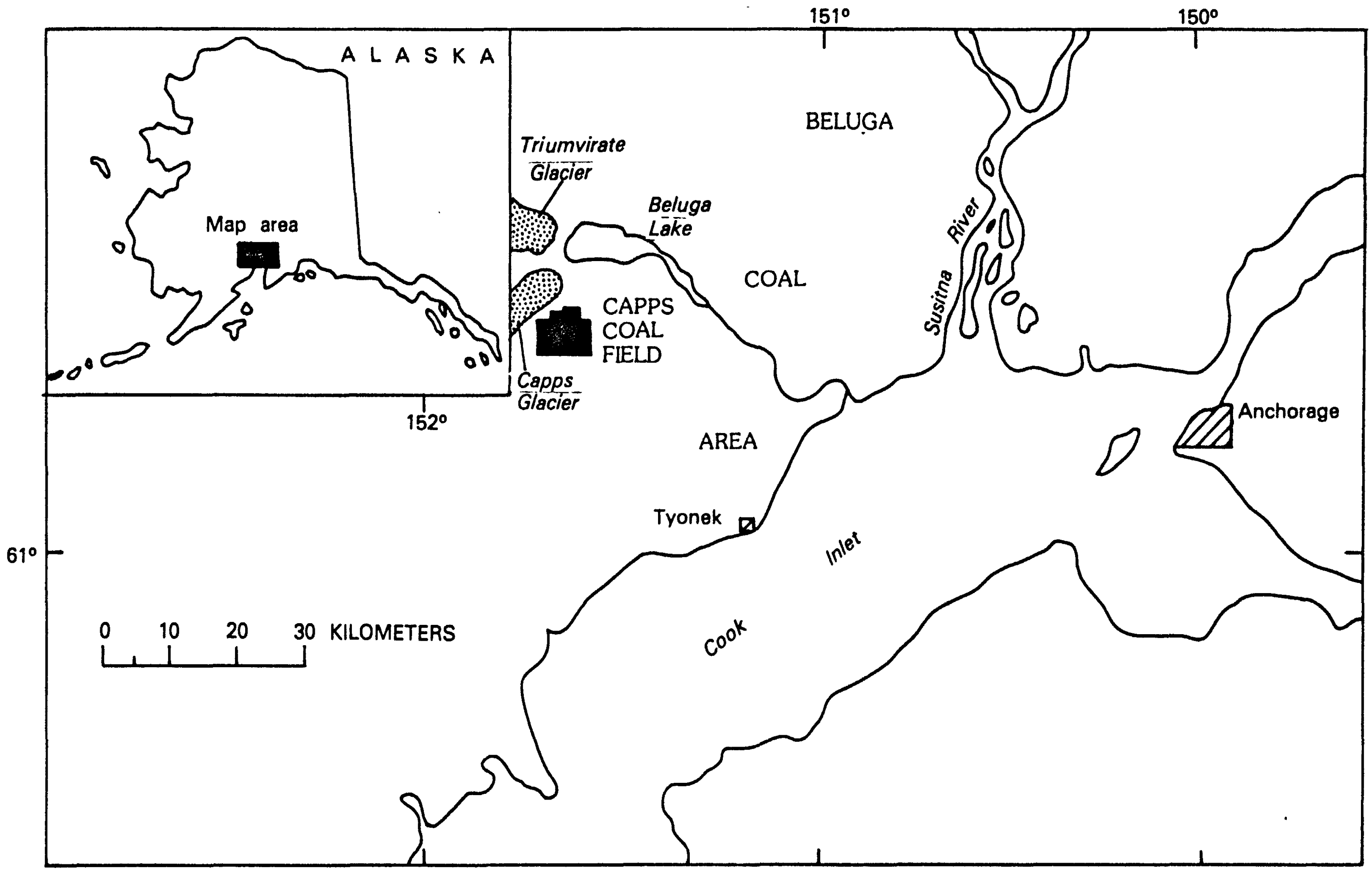

Figure 1.--Location of the Capps Coal Field, Alaska.

ACKNOWLEDGMENTS

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METHODS

Field Sampling

Based on the statistical sampling design described in figure 2 and in the following section, sampling locations were identified on aerial photographs (scale 1:15,840). Generalized sampling locations are shown in figure 3. At each location, a soil pit was dug, the soil profile examined, and samples were collected for chemical analyses. Two soil samples were collected from each profile. The first sample consisted of a gray medium-sand-sized volcanic ash layer at the surface, which ranged from 2 to 8 cm in thickness. This layer is most probably a result of the 1953 eruption of Mt. Spurr. The second sample consisted of a composite of material from below the first sample to a depth of 40 cm. At nearly all sampling locations, this composite sample consisted of three or four layers of volcanic ash. The uppermost layer was a 5- to 20-cm-thick dark reddish-brown silt loam material, the next layer was a 2- to 5-cm-thick zone of dark reddish-brown coarse sand, and the last two layers were light yellowish-brown material, the upper one being silt loam and the lower one being very fine sand. Because of rodent burrowing, frost heaving, and hummock formation, the various layers of volcanic ash were often intermixed

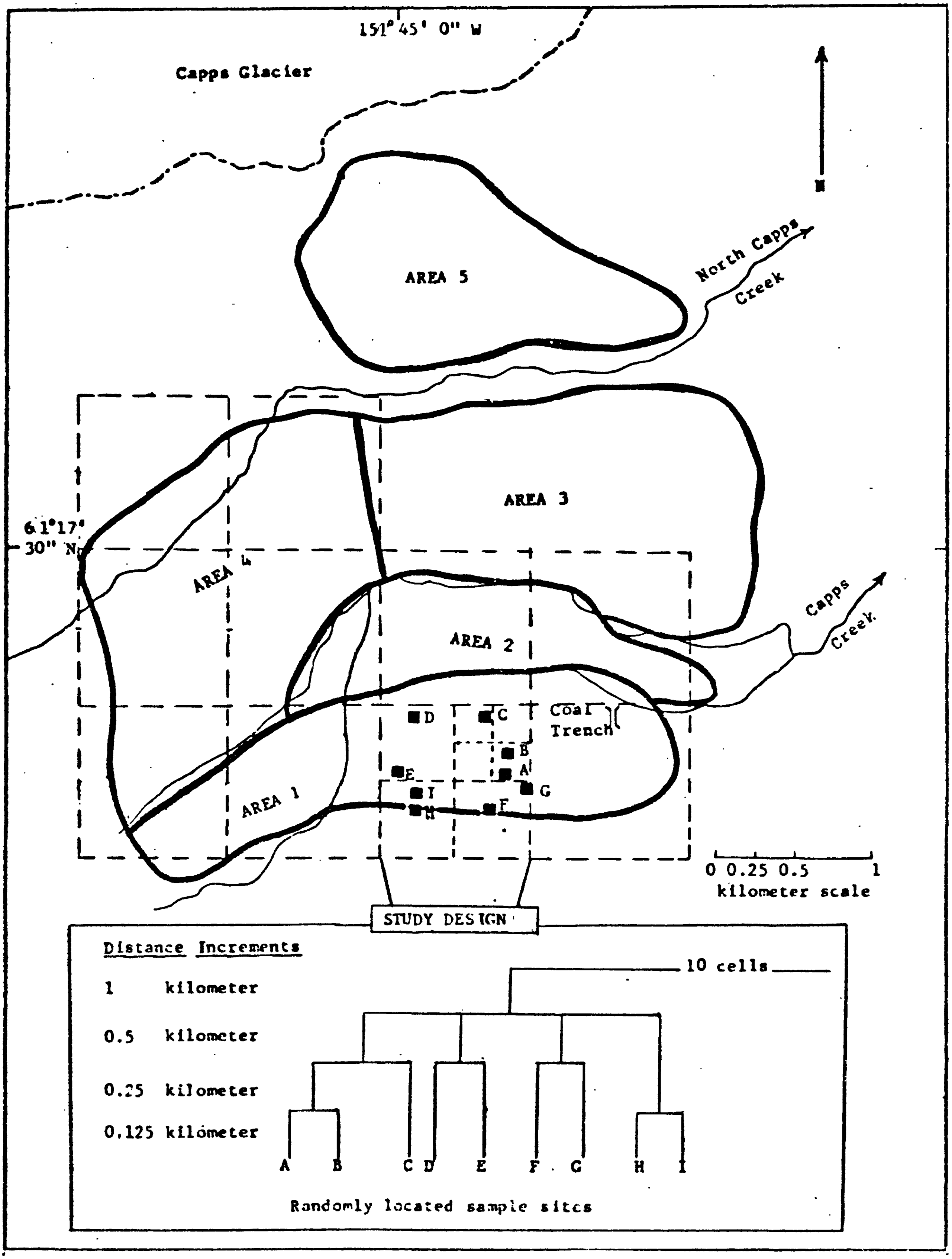

Figure 2. Diagram illustrating the analysis-of-variance sampling design used in the Capps Coal Field. Area numbers indicate the proposed mining sequence (Placer Amex, 1977).

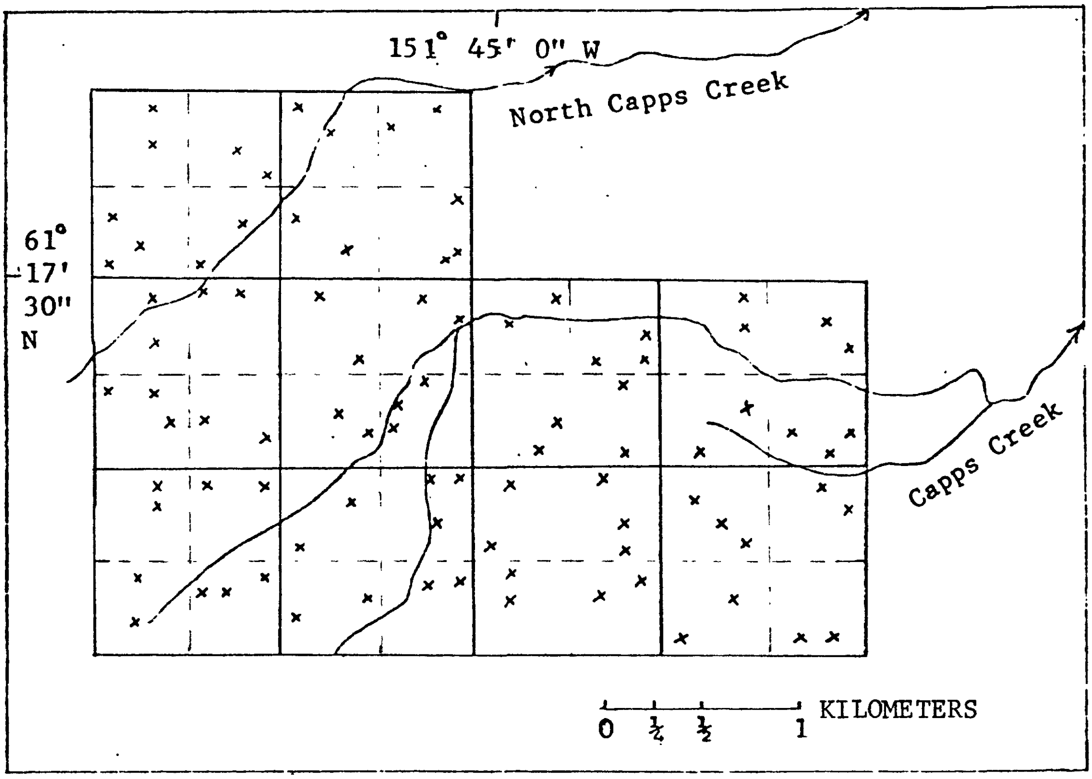

Figure 3. Generalized sampling locations in the Capps Coal Field. (X's are sampling locations.)

and/or convoluted and were not zoned in a uniform horizontal manner. Each sample consisted of about 1 kg of material. The sample was placed in a water-resistant paper bag and mailed to the U.S. Geological Survey laboratory in Denver, Colorado.

Laboratory Analysis

Air-dried samples were disaggregated in a motor-driven ceramic mortar and pestle. The portion of the disaggregated sample passing a 2 mm stainless-steel sieve was saved. Splits of the less-than-2-mm material were further ground in a ceramic plate grinder to minus-100 mesh. The minus-2-mm material was used for extractable-element determinations and pH, and the minus-100-mesh material was used for total element determinations.

The elements Al, Cd, Co, Cu, Fe, Mn, Ni, P, Pb, and Zn were analyzed in an AB-DTPA (ammonium bicarbonate-diethylenetriaminepentaacetic acid) extract of soil using the method of Soltanpour and Schwab (1977) and the ICP-OES (inductively coupled plasma-optical emission spectroscopy) instrumental method of Taggert, Lichte, and Wahlberg (1981). Total concentrations of 46 elements were analyzed in an acid-digested sample using ICP-OES. Not all of the elemental concentrations were high enough to be detected in all samples; detection limits, detection ratios, and the observed ranges in concentration are given in table 1.

A random subset of 40 samples was analyzed for hot-water soluble B and Ca, Mg, K, Na, SO_4, Cl and electrical conductivity (EC) in a water saturation extract using the methods of Crock and Severson (1981). Data on the detection limits and on the observed ranges are given in table 1 for these properties.

Table 1.--Detection ratios and limits for constituents of soils from the Capps Coal Field, Alaska

[ppm, parts per million; pct, percent, me/L, milliequivalents per liter, mmhos/cm, millimhos per centimeter]

Element, unit of measure	Detection Ratio[1]	LLD[2]	Observed Range
Based on AB-DTPA[3] extraction			
Al ppm----------	200 : 200	6	19 - 760
Cd ppm----------	21 : 200	.2	<.2 - .3
Co ppm----------	101 : 200	.2	<.2 - .7
Cu ppm----------	200 : 200	.1	1.1 - 15
Fe ppm----------	200 : 200	10	140 - 750
Mn ppm----------	200 : 200	.1	.7 - 64
Ni ppm----------	89 : 200	.5	<.5 - 1.2
P ppm-----------	200 : 200	6	6 - 60
Pb ppm----------	18 : 200	1.0	<1.0 - 2.3
Zn ppm----------	176 : 200	.5	<.5 - 8.2
Based on hot-water extraction			
B ppm-----------	0 : 40	.5	---
Based on water saturation extraction			
Ca me/L---------	40 : 40	.05	.07 - 1.8
Cl me/L---------	40 : 40	.1	.3 - 1.4
K me/L----------	32 : 40	.3	<.3 - 1.5
Mg me/L---------	39 : 40	.05	<.05 - 1.4
Na me/L---------	40 : 40	.1	.3 - .9
SO_4 me/L--------	32 : 40	.1	<.1 - 1.2
EC[4] mmhos/cm----	24 : 40	.2	<.2 - .4
SI[5] pct---------	40 : 40	.1	40.2 - 91.2
Based on total analysis			
Ag ppm----------	0 : 200	8	---
Al pct----------	200 : 200	.1	4.0 - 10
As ppm----------	52 : 200	20	<20 - 80
Au ppm----------	0 : 200	20	---
Ba ppm----------	200 : 200	2	290 - 2400
Be ppm----------	0 : 200	2	---
Bi ppm----------	0 : 200	40	---
Ca pct----------	200 : 200	.1	.68 - 5.8
Cd ppm----------	116 : 200	4	<4 - 7
Ce ppm----------	199 : 200	10	<10 -40

Table 1.--Continued

Based on total analysis - Continued			
Co ppm----------	200 : 200	2	5 - 26
Cr ppm----------	200 : 200	2	14 - 150
Cu ppm----------	200 : 200	2	11 - 120
Dy ppm----------	54 : 200	10	<10 - 40
Er ppm----------	0 : 200	10	---
Eu ppm----------	0 : 200	8	---
Fe pct----------	200 : 200	.1	1.3 - 18
Ga ppm----------	45 : 200	20	<20 - 21
Gd ppm----------	3 : 200	20	<20 - 20
Ho ppm----------	0 : 200	8	---
K pct-----------	199 : 200	.1	<.1 - 2.0
La ppm----------	170 : 200	8	<8 - 20
Li ppm----------	200 : 200	4	12 - 40
Mg pct----------	200 : 200	.1	.51 - 3.1
Mn ppm----------	200 : 200	8	220 - 2800
Mo ppm----------	1 : 200	8	<8 - 14
Na pct----------	200 : 200	.2	.85 - 3.8
Nb ppm----------	2 : 200	10	<10 - 10
Nd ppm----------	139 : 200	10	<10 - 40
Ni ppm----------	186 : 200	8	<8 - 140
P pct-----------	200 : 200	.02	.03 - 1.2
Pb ppm----------	64 : 200	20	<20 - 30
Pr ppm----------	0 : 200	20	---
Sc ppm----------	200 : 200	4	6 - 24
Sm ppm----------	3 : 200	10	<10 - 10
Sn ppm----------	5 : 200	10	<10 - 30
Sr ppm----------	200 : 200	4	150 - 630
Ta ppm----------	94 : 200	20	<20 - 40
Tb ppm----------	0 : 200	100	---
Ti pct----------	200 : 200	.02	.16 - .55
Th ppm----------	13 : 200	8	<8 - 13
U ppm-----------	8 : 200	80	<80 - 110
V ppm-----------	200 : 200	2	59 - 200
Y ppm-----------	200 : 200	4	6 - 17
Yb ppm----------	0 : 200	4	---
Zn ppm----------	200 : 200	4	30 - 110

[1] Number of samples above the LLD : total number of samples analyzed.

[2] Lower limit of determination of the analytical method.

[3] Ammonium bicarbonate - diethylenetriaminepentaacetic acid.

[4] Electrical conductivity.

[5] Saturation index.

Study Design and Statistical Analysis

The study design was based on sampling locations randomly selected according to a five-level, unbalanced, nested, analysis-of-variance design. Figure 2 illustrates the unbalancing and nesting arrangement, and shows how 1-km-square cells were positioned to cover the area most likely to be stripmined for coal. This figure also gives an example of how each 1-km cell was subdivided into increasingly smaller areas (0.5-, 0.25-, and 0.125-km-square cells). The locations of sampling sites, based on the random selection procedure within each cell, are shown in figure 3. The fifth level of the sampling design consisted of duplicate analyses of about 10 percent of the samples, and it is used to estimate variation due to all laboratory procedures, or analytical error.

The type of sampling scheme described above permits estimation of chemical variation among and within the various cell sizes. Data from this analysis of the variation at distance-related increments can be used to indicate the appropriate scale for preparing geochemical maps, and the number of samples necessary to prepare stable maps (maps that show a geochemical pattern which would be reproducible). The details of these types of interpretations are given in Miesch (1976a, 1976b) and an example of their application is given in Severson and Tidball (1979).

All statistical analyses were done on a computer using programs in the U.S. Geological Survey's STATPAC Library (VanTrump and Miesch, 1977). The following discussion explains the techniques used in data handling. Data that were "missing" because they were below the detection limit of the analytical method used, were either (1) replaced by a value equal of 0.7 times the detection limit (for use in the analysis-of-variance computations), or (2) were estimated using the technique of Cohen (1959) (for use in the estimation of the mean). When more than 25 percent of the samples in a suite were below the detection limit for a given element, that element was omitted from the study. Omitted elements, therefore, had detection ratios of less than 150:200 (table 1).

Frequency distributions were examined for each element and, except for pH, the distributions were changed to a more normal form by taking common logarithms of the data. All data except pH are reported in terms of logarithmic variances, means, and deviations.

Techniques used in evaluating the data for purposes of preparing element distribution summaries, or in deciding on the feasibility of preparing geochemical maps, are included in the following sections of the report.

RESULTS AND DISCUSSION

Soil Variability

Spatial variability for each of the two soil zones sampled was evaluated by the analysis of variance described previously. These results are given in Table 2. Total variation for AB-DTPA-extractable elements was in general greater than for total-element determinations. The upper and lower soil zones were similar in their total variation for AB-DTPA-extractable elements; however, for total-element determinations, the upper soil zone tended to be much less variable than the lower soil zone. The similar variability exhibited by both soil zones for AB-DTPA-extractable elements seems reasonable because this method reflects amounts of elements in the soil solution and on the mineral and organic exchange complexes, rather than mineralogical composition. Both soil zones were composed of volcanic ash and both contained organic matter from presently growing vegetation or buried surface horizons. The tendency for smaller variability for total-element determinations in the upper horizon also seems reasonable because this soil zone consists of volcanic ash from a single, recent eruption of Mt. Spurr, while the lower soil zone consisted of many layers of older volcanic ash of different thickness from Mt. Spurr eruptions and other volcanoes in the region.

The differences in total variation between upper and lower soil zones has a large effect on the lowest level of the sample design--variation between duplicate analyses. This level represents the cumulative errors in processing, dissolution, and instrumental analysis of splits of the same sample, relative to the total variation in the data. Because total variation for the upper soil zone tends to be smaller for total-element determinations, while analytical variation is similar for both soil zones, the proportion of the total variation between duplicate analyses is large for the upper soil zone (table 2). For nearly all total-element determinations, this component of variation between duplicate analyses approaches, or is greater than, 50 percent in the upper soil zone while it is much less than 50 percent for nearly all elements in the lower soil zone. When more than 50 percent of the total variation occurs between duplicate analyses, we suggest an evaluation of the need for greater accuracy in laboratory techniques in future studies to reduce this component of error.

For many elements in table 2, statistically significant variation occurs in at least one of two levels of the sampling design--among 1-km cells and among 0.125-km cells. This suggests that in general maps showing variation in element content in soils should be prepared at either of these scales, whereas maps based on 0.5 or 0.25-km cells would not in general be practical because they would tend to show the same pattern as maps based on 1-km cells but would require many more samples and analyses for their preparation. Therefore, 1-km cells were selected as the basis for preparing maps showing variation in element content in soils because we did not collect a sufficient number of samples to prepare maps at a scale of 0.125 km.

To test the feasibility of preparing maps of each element in each soil zone based on the data already collected, the variance mean ratio (v_m) of Miesch (1976a) was computed. An estimate of the number of random samples (n_r) needed within a 1-km cell to attain a v_m value equal to 1.0 was calculated. The values for v_m and n_r are given in table 2 for each element. Map patterns for elements with significant variation among 1-km cells but with $v_m<1.0$ are probably not stable.

Table 2.--Variance components for constituents of soils from the Capps Coal Field, Alaska

			Percent of total variance among:						
Soil property	Soil zone[1]	Total $\log_{10}$ variance	1-km cells	0.5 km cells	0.25 km cells	0.125 km cells	Duplicate analyses	n_r	v_m
Based on AB-DTPA[2] extraction									
Al------	U	.0322	6.7*	0.0	75.3*	0.4	17.6	12	.5
	L	.0427	15.2*	5.5	0.0	53.8*	25.5	6	1.5
Cu------	U	.0232	12.5*	6.5	0.0	55.5*	25.5	6	1.1
	L	.0382	8.4*	0.0	39.4	38.3*	13.9	9	.7
Fe------	U	.0110	7.5*	0.0	23.1	38.3	31.1	11	.7
	L	.0447	4.3	8.6	0.0	66.3*	20.8	18	.4
Mn------	U	.0890	36.9*	0	8.7	45.0*	9.4	3	5.4
	L	.0763	0	0	17.7	69.7*	12.6	[4]---	---
P-------	U	.0275	45.7*	0	3.5	42.8*	8.0	3	7.9
	L	.0266	5.6	13.2	0	62.5*	18.7	13	.5
Zn------	U	.1189	27.8*	12.3	0	47.1*	12.8	4	3.0
	L	.1110	9.8*	0	47.4*	35.3*	7.5	8	.8
Based on specific ion electrode									
pH[3]-----	U	.0737	18.7*	0.0	38.2	26.2*	16.9	5	1.7
	L	.0427	12.5*	0.0	29.3	40.7*	17.5	6	1.1
Based on total analyses									
Al------	U	.0009	13.3*	.6	6.7	27.8	51.6	6	1.4
	L	.0042	4.0	0	50.7*	39.1*	6.2	19	.3
Ba------	U	.0376	0.0	0.0	13.3	84.8*	1.9	---	---
	L	.0306	0	0	12.7	0	87.3	---	---
Ca------	U	.0020	18.3*	0.0	3.6	29.8	48.3	5	2.0
	L	.0216	3.7	0	52.9*	35.8*	7.6	19	.3
Ce------	U	.0658	0.0	0.0	14.0	0.0	86.0	---	---
	L	.0268	1.1	2.2	0	50.0	46.7	>20	<.1
Co------	U	.0074	4.2	7.6	0.0	0.0	88.2	18	.4
	L	.0127	8.0*	0	47.5*	27.4*	17.1	9	.6
Cr------	U	.0285	1.8	12.4*	0.0	0.0	85.8	>20	<.1
	L	.0166	7.5	0.7	0	87.6*	4.2	11	.7

Table 2.--Continued

Based on total analyses - Continued

Cu------	U	.0109	0.0	17.9	0.0	0.0	82.1	---	---
	L	.0209	2.6	0	29.4	30.4	37.6	>20	<.1
Fe------	U	.0016	17.5*	0.0	5.3	0	77.2	5	2.0
	L	.0144	5.4	0	0	91.4*	3.2	14	.5
K-------	U	.0379	0.0	0.0	46.9*	0.0	53.1	---	---
	L	.0083	0.1	0	8.8	49.8	41.3	---	---
La------	U	.0237	1.9	0.0	20.6	0.0	77.5	>20	<.1
	L	.0046	0.6	0	5.2	52.8	41.4	>20	<.1
Li------	U	.0028	1.6	10.0	0.0	0.0	88.4	>20	<.1
	L	.0095	0	9.7	0	82.0*	8.3	---	---
Mg------	U	.0033	18.8*	0.0	0.0	0.0	84.2	6	1.9
	L	.0121	5.9	0	63.5*	21.7*	8.9	13	.4
Mn------	U	.0016	0.0	15.6	12.8	5.4	66.2	---	---
	L	.0159	8.7*	0	10.9	73.1*	7.3	9	.8
Na------	U	.0042	0.0	6.9	4.9	33.5	54.7	---	---
	L	.0139	0	0	63.5*	9.0	27.5	---	---
Nd------	U	.0313	0.0	0.0	22.0	9.1	68.9	---	---
	L	.0532	2.5	8.9	0	22.1	66.5	>20	<.1
Ni------	U	.0086	3.1	0.0	0.0	0.0	96.9	20	.3
	L	.0384	6.9*	16.0	0	66.9*	10.2	12	.5
P------	U	.0027	13.2*	0.0	27.1	0.0	59.7	6	1.3
	L	.0456	6.3*	6.6	0	83.2*	3.9	12	.5
Sc------	U	.0035	2.7	0.0	12.3	0.0	85.0	20	.3
	L	.0071	7.8	0	69.1*	3.2	19.9	10	.6
Sr------	U	.0011	20.3*	0.0	7.1	3.7	68.9	5	2.4
	L	.0156	4.4	0	42.8	51.0*	1.8	18	.3
Ti------	U	.0017	6.4	0.0	5.5	0.0	88.1	12	.7
	L	.0050	7.5*	0	65.0*	20.1*	7.4	11	.5
V-------	U	.0022	11.0*	0.0	2.4	0.0	86.6	6	1.2
	L	.0048	8.2	0	59.6*	21.6*	10.6	9	.6
Y-------	U	.0039	0.0	7.2	0.0	33.3	59.5	---	---
	L	.0060	3.5	21.3	1.1	54.8*	19.3	19	.2
Zn------	U	.0041	2.1	10.7	0.0	0.0	87.2	>20	<.1
	L	.0083	2.1	0	55.6*	32.3*	10.0	>20	<.1

*Significant at the 0.05 probability level.

[1] U, surface layer of volcanic ash, L, composite of 40 cm soil zone below surface layer.

[2] AB-DTPA (ammonium bicarbonate-diethylenetriaminepentaacetic acid).

[3] Variance is arithmetic.

[4] ---, not determinable.

Elements with non-significant variation among 1-km cells, are not represented on maps because of a high probability that no mappable pattern exists at this scale. For these elements, a single estimate of the mean and expected range over the entire study area is probably the best summary of their variability. This expected range, or "geochemical baseline", is computed after adjusting the total variation for its analytical error component using the method described by Connor (1976). Geochemical baselines for such measurements are presented in table 3.

Figures 4 and 5 are maps showing distributions of elements in soils based on average values for the nine samples collected within each 1-km cell. Figure 4 presents those elements that have v_m values greater than one, and have significant variation among 1-km cells. Figure 5 presents those elements with significant variation among 1-km cells but have a v_m value of less than one. The element distributions displayed in figure 4 should be stable; that is, similar patterns would be obtained if a new suite of samples were collected and analyzed. The map patterns shown in figure 5 are not statistically stable. The data are, however, presented on maps because the significance test indicates that at the least, the highest mean value is probably distinct from the lowest one; thus, a single geochemical baseline may not be the best way to summarize these data.

Table 3.--Geochemical baselines for soils from the Capps Coal Field, Alaska

[ppm, parts per million; pct, percent]

Soil property	Soil zone	GM[1]	GD[2]	GE[3]	Expected range
Based on AB-DTPA[4] extraction					
Al ppm--	U	97	1.51	1.19	46 - 210
	L	270	1.61	1.27	120 - 620
Cu ppm--	U	4.2	1.42	1.19	2.3 - 7.7
	L	6.4	1.57	1.18	2.8 - 15
Fe ppm--	U	360	1.27	1.14	240 - 540
	L	290	1.63	1.25	120 - 690
Mn ppm--	U	14	1.99	1.24	3.8 - 52
	L	6.3	1.89	1.25	1.9 - 21
P ppm---	U	17	1.47	1.12	8.1 - 36
	L	21	1.46	1.18	11 - 42
Zn ppm--	U	1.2	2.21	1.33	.3 - 5.7
	L	1.3	2.15	1.23	.3 - 5.7
Based on specific ion electrode					
pH[5]-----	U	4.8	0.272	.112	4.3 - 5.3
	L	5.0	0.207	.087	4.6 - 5.4
Based on total analyses					
Al pct--	U	8.9	1.07	1.05	8.1 - 9.8
	L	7.8	1.16	1.04	5.9 - 10
Ba ppm--	U	390	1.56	1.06	160 - 940
	L	450	1.50	1.46	340 - 600
Ca pct--	U	4.6	1.11	1.08	4.0 - 5.3
	L	2.7	1.40	1.10	1.4 - 5.1
Ce ppm--	U	14	1.81	1.73	8.9 - 22
	L	21	1.46	1.29	12 - 37
Co ppm--	U	19	1.22	1.20	16 - 22
	L	13	1.30	1.11	8.0 - 21
Cr ppm--	U	30	1.48	1.43	22 - 41
	L	26	1.35	1.06	14 - 47

Table 3.--Continued

	Based on Total Analysis - Continued				
Cu ppm--	U	34	1.27	1.24	28 - 42
	L	30	1.40	1.23	18 - 51
Fe pct--	U	4.9	1.10	1.09	4.5 - 5.3
	L	3.8	1.32	1.05	2.2 - 6.6
K pct----	U	.67	1.57	1.39	.36 - 1.2
	L	.80	1.23	1.14	.58 - 1.1
La ppm--	U	8.8	1.43	1.37	6.3 - 12
	L	12	1.17	1.11	9.5 - 15
Li ppm--	U	16	1.13	1.12	15 - 18
	L	16	1.25	1.07	10 - 24
Mg pct--	U	2.5	1.14	1.13	2.3 - 2.7
	L	1.5	1.29	1.08	.92 - 2.4
Mn ppm--	U	1060	1.10	1.08	950 - 1200
	L	820	1.34	1.08	470 - 1400
Na pct--	U	2.6	1.16	1.12	2.1 - 3.1
	L	2.1	1.31	1.15	1.3 - 3.3
Nd ppm--	U	11	1.50	1.40	7.0 - 17
	L	12	1.70	1.54	6.5 - 22
Ni ppm--	U	14	1.23	1.22	12 - 16
	L	11	1.57	1.16	4.7 - 26
P pct---	U	.093	1.13	1.10	.080 - .11
	L	.10	1.64	1.10	.038 - .26
Sc ppm--	U	19	1.15	1.14	17 - 21
	L	15	1.21	1.09	11 - 21
Sr ppm--	U	560	1.08	1.07	520 - 600
	L	390	1.33	1.04	220 - 690
Ti pct--	U	.39	1.08	1.07	.36 - .42
	L	.35	1.18	1.05	.26 - .48
V ppm---	U	150	1.12	1.11	140 - 160
	L	120	1.17	1.05	89 - 160
Y ppm---	U	11	1.16	1.12	9.1 - 13
	L	11	1.20	1.08	7.9 - 15
Zn ppm--	U	80	1.16	1.15	72 - 88
	L	64	1.23	1.07	43 - 95

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[1] Geometric mean.

[2] Geometric deviation.

[3] Geometric error.

[4] Ammonium bicarbonate-diethyltriaminepentaactic acid.

[5] Summary statistics are arithmetic rather than geometric.

Figure 4. Maps showing mean values (GM, geometric; AM, arithmetic) for samples collected within a 1-km cell for soil properties with significant variation among cells and a variance mean ratio greater than one.

4-A. AB-DTPA extractable Al, lower soil zone

4-B. AB-DTPA extractable Cu, upper soil zone

4-C. AB-DTPA extractable Mn, upper soil zone

4-D. AB-DTPA extractable P, upper soil zone

4-E. AB-DTPA extractable Zn, upper soil zone

4-F. pH, upper soil zone

4-G. pH, lower soil zone.

4-H. Total Al, upper soil zone

4-I. Total Ca, upper soil zone

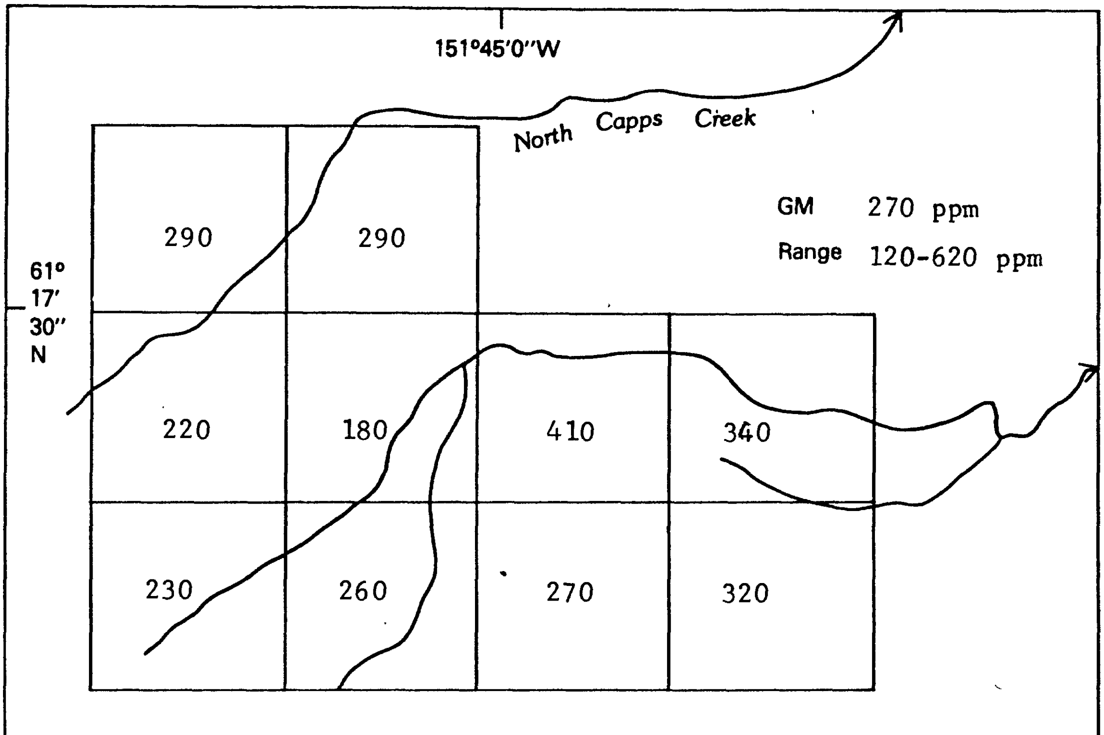
4-J. Total Fe, upper soil zone

4-K. Total Mg, upper soil zone

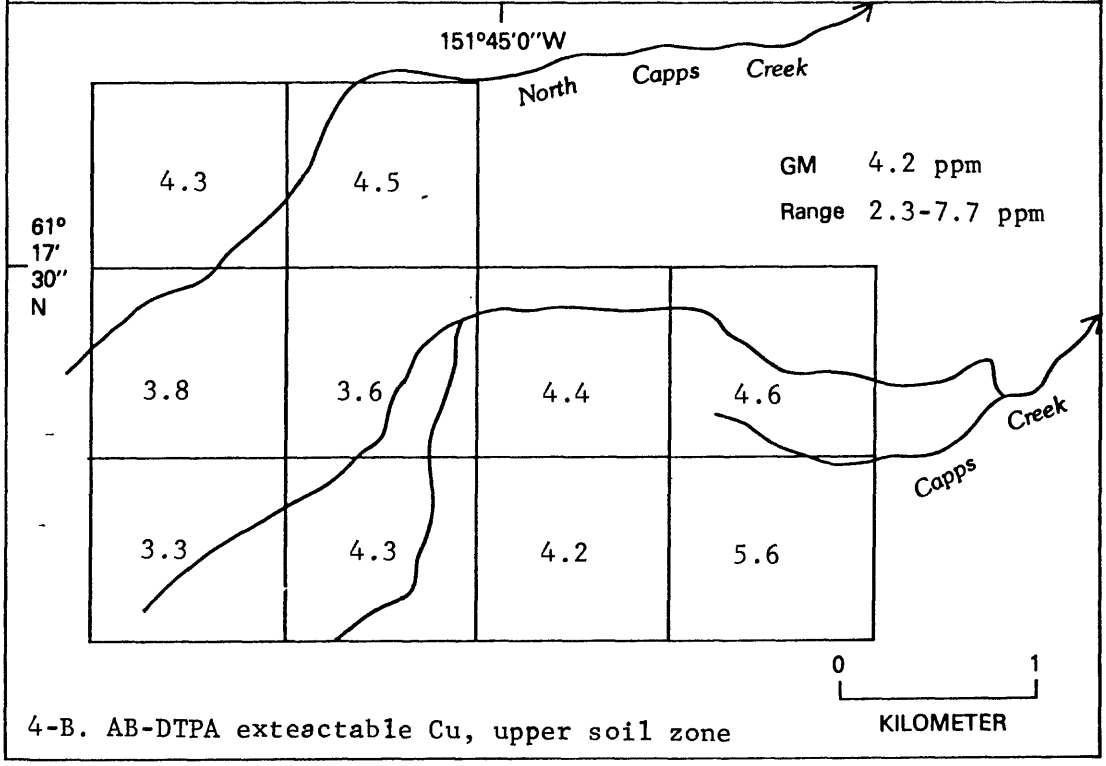
4-L. Total P, upper soil zone

4-M. Total Sr, upper soil zone

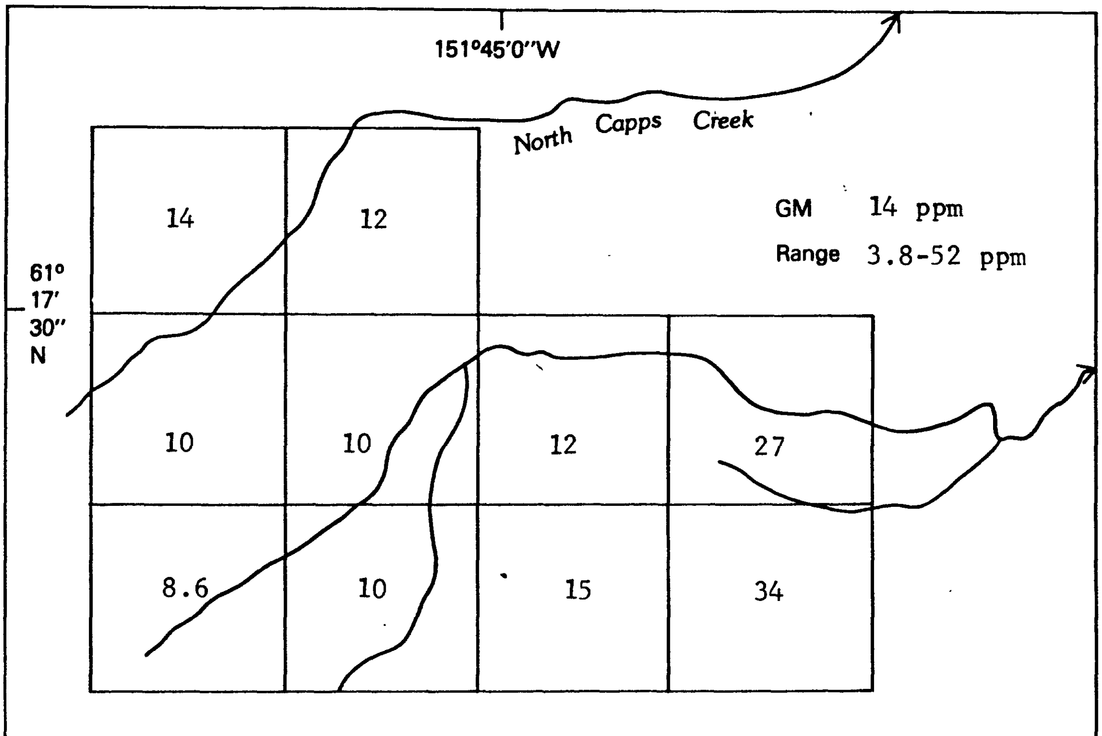
4-N. Total V, upper soil zone.



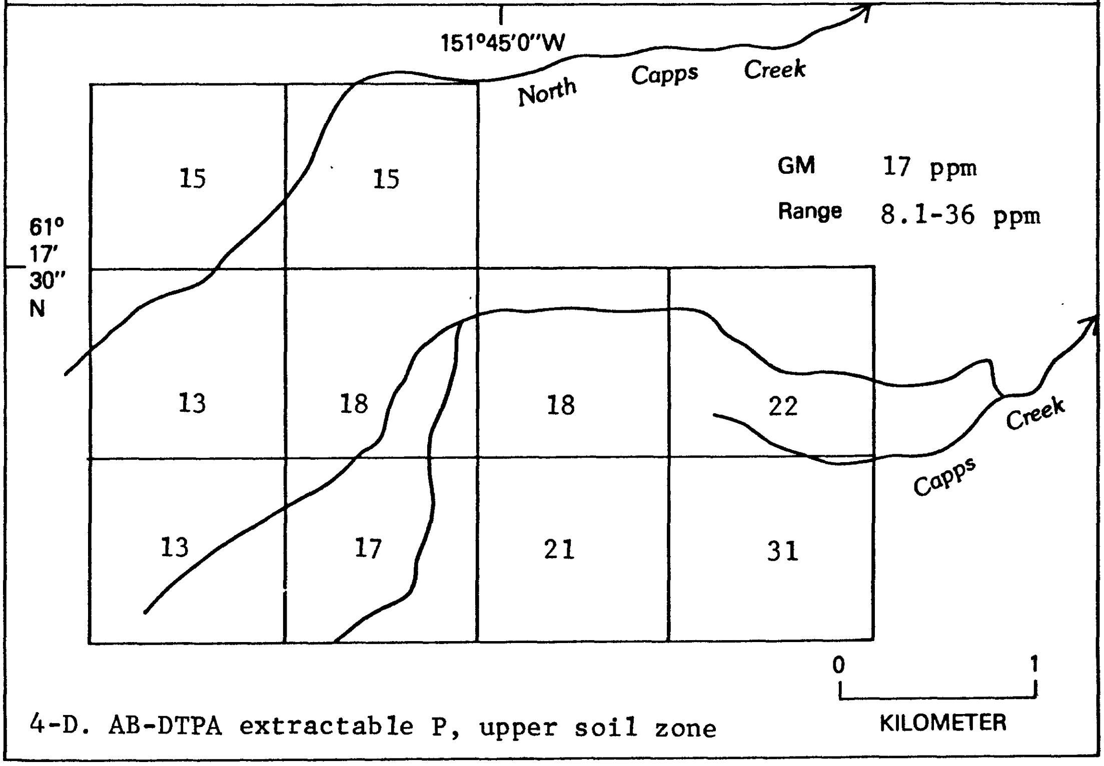
4-A. AB-DTPA extractable Al, lower soil zone



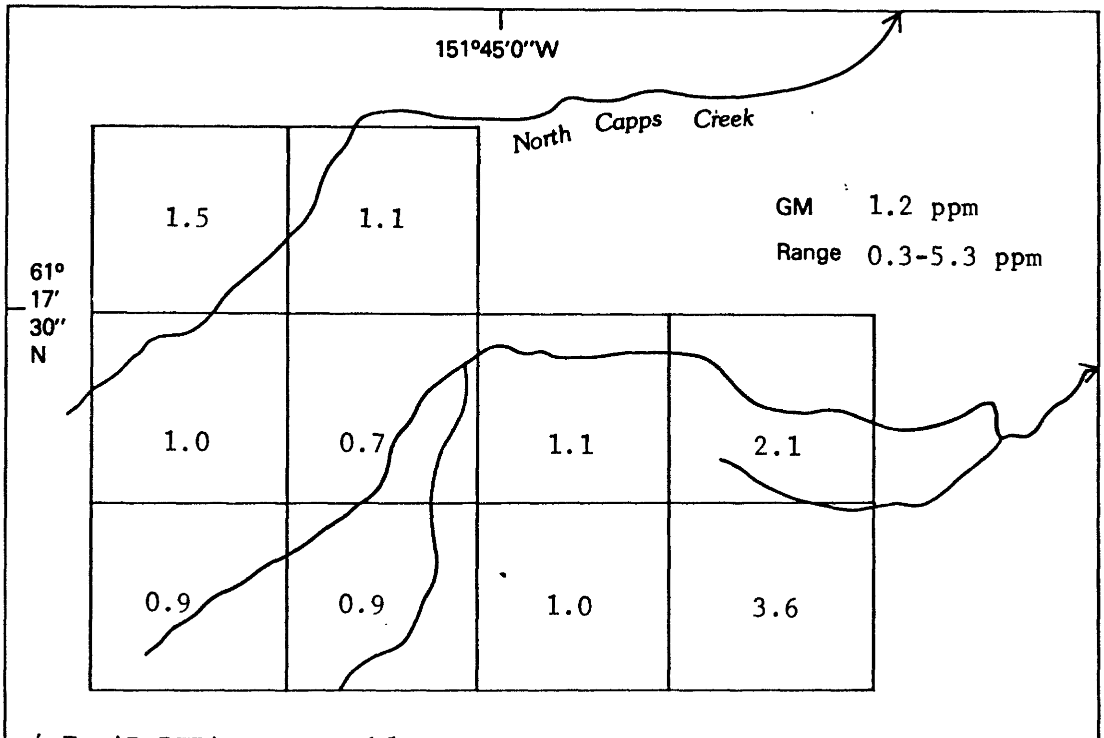
4-B. AB-DTPA exteactable Cu, upper soil zone



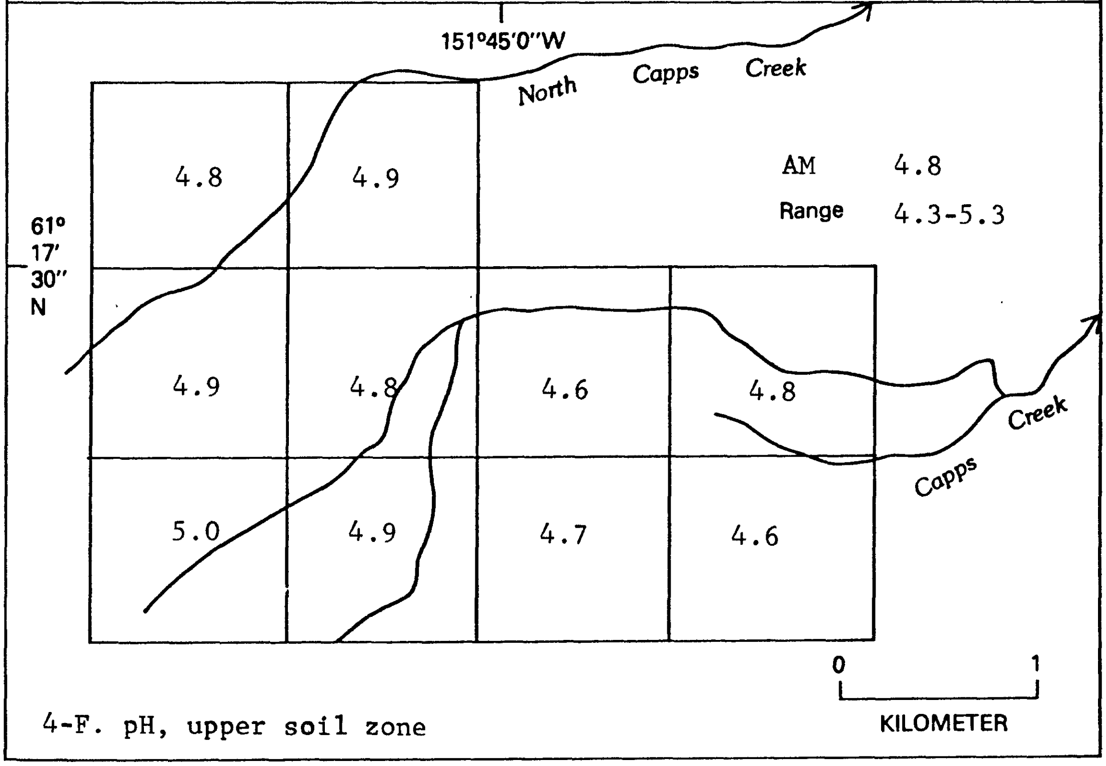
4-C. AB-DTPA extractable Mn, upper soil zone



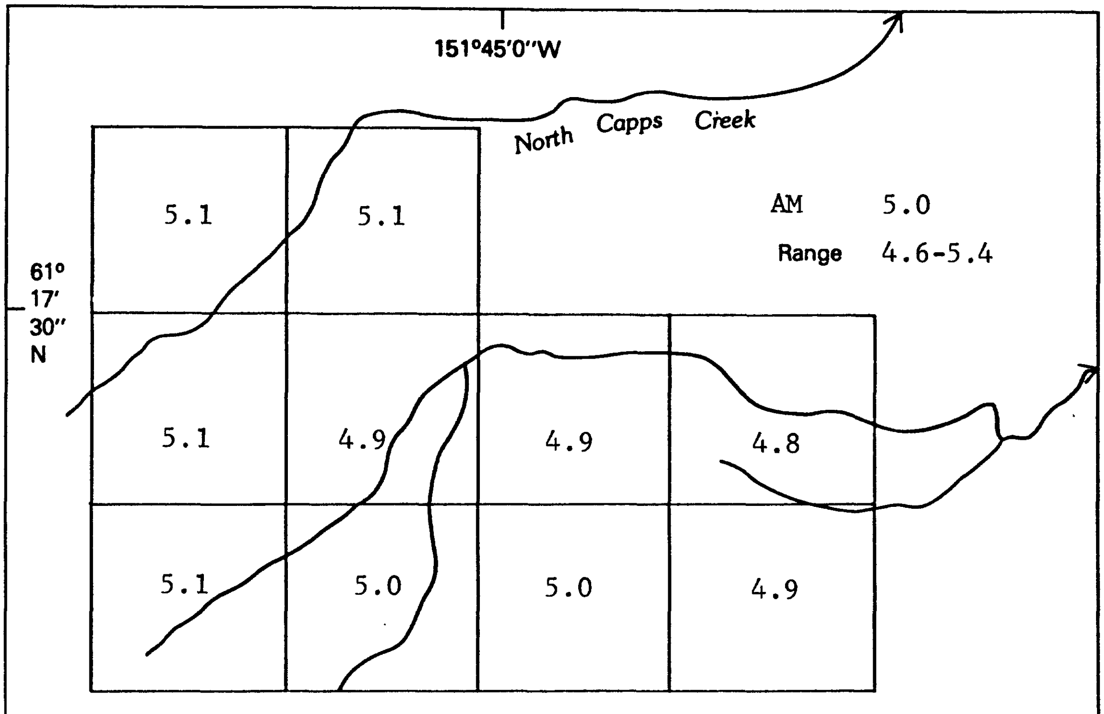
4-D. AB-DTPA extractable P, upper soil zone



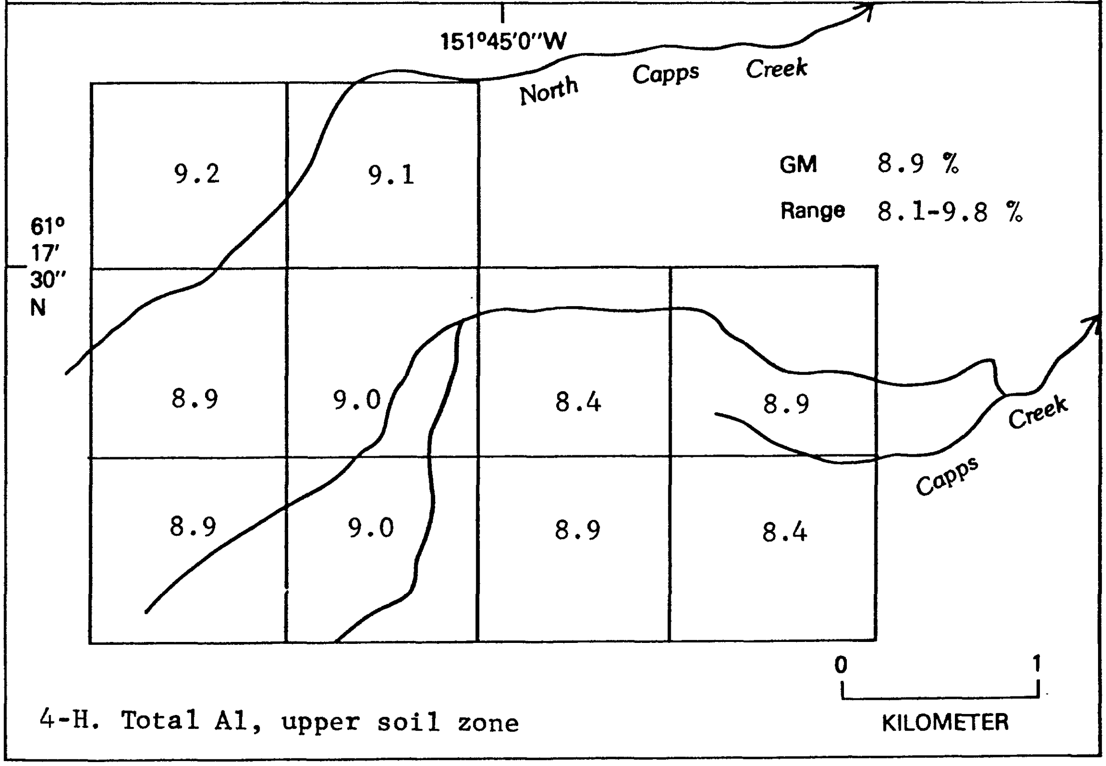
4-E. AB-DTPA extractable Zn, upper soil zone



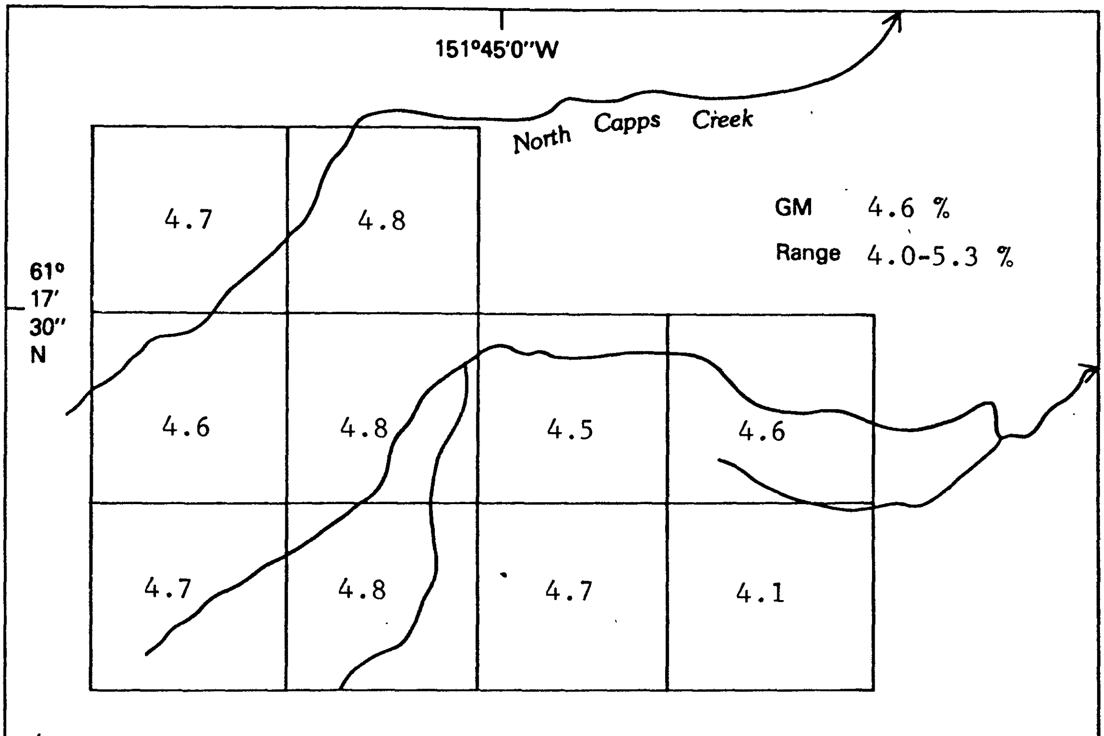
4-F. pH, upper soil zone



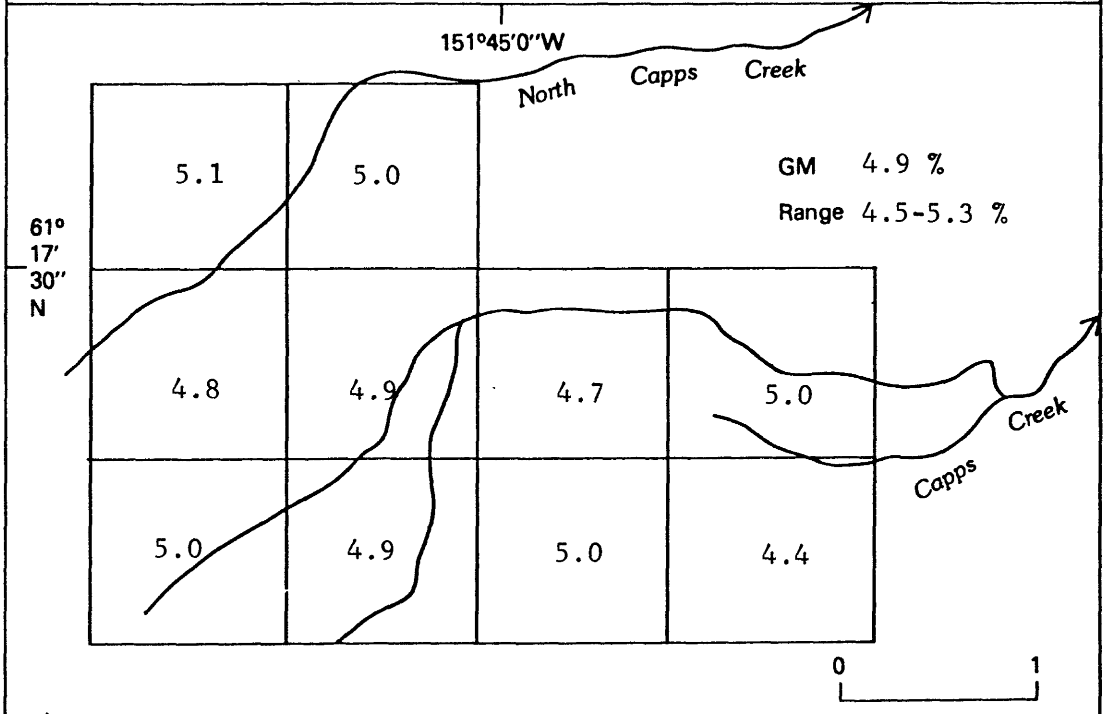
4-G. pH, lower soil zone



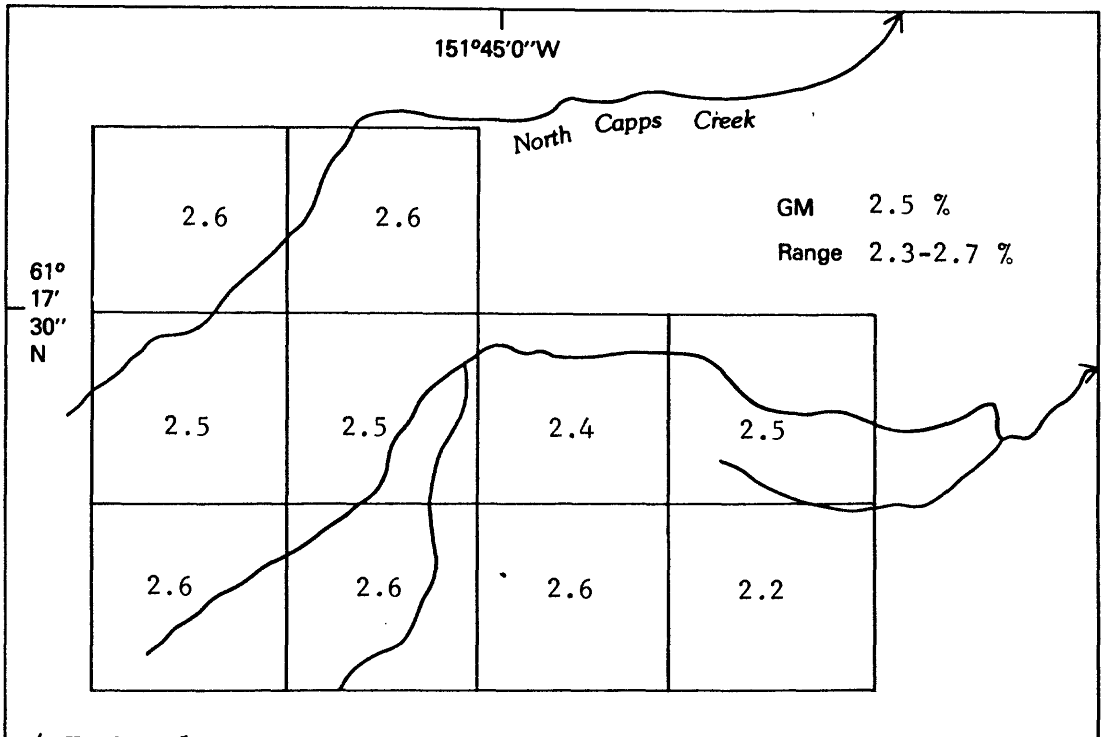
4-H. Total Al, upper soil zone



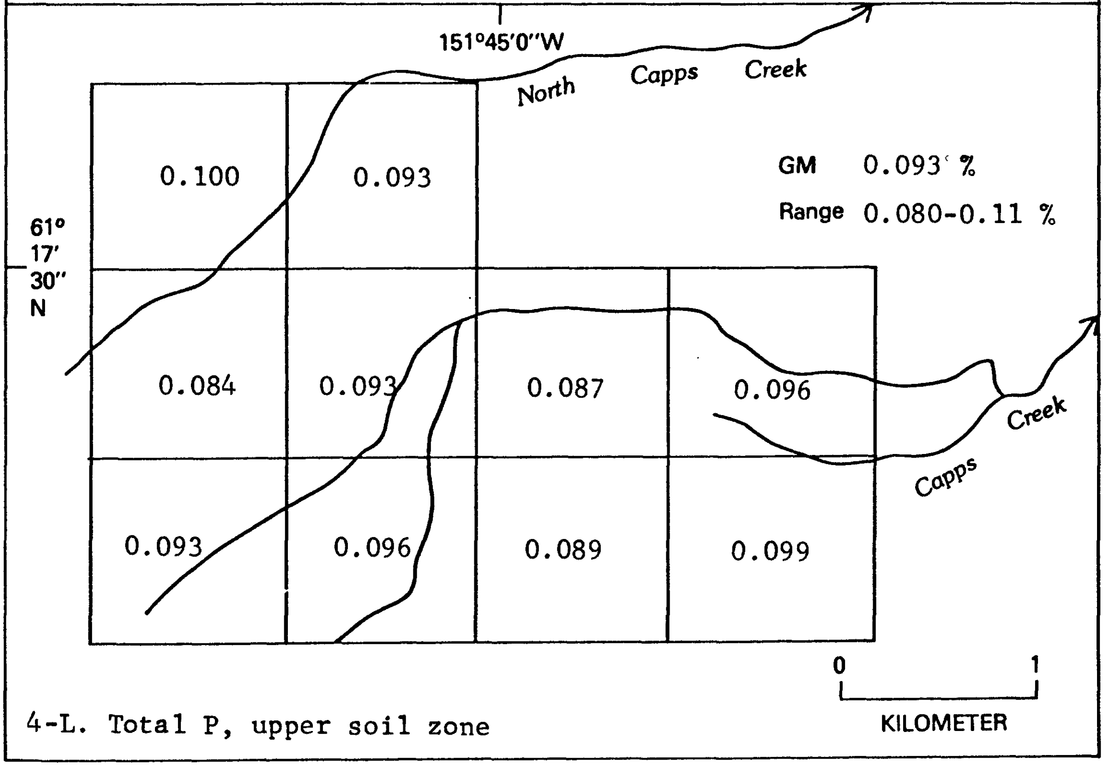
4-I. Total Ca, upper soil zone



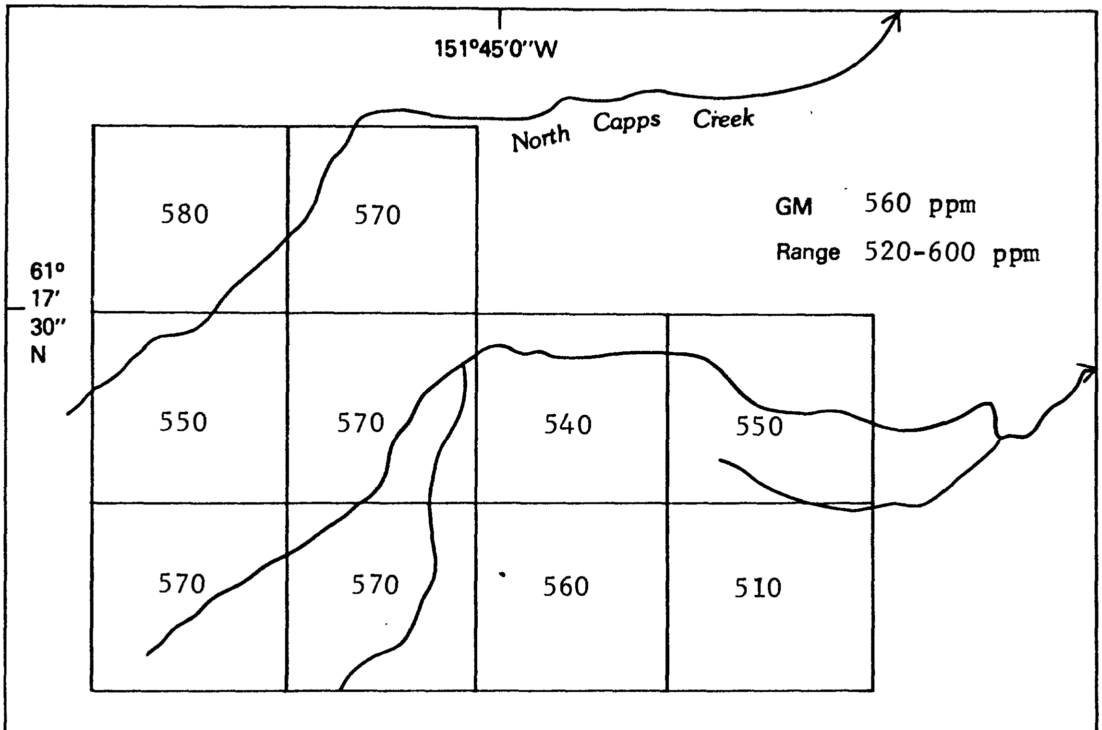
4-J. Total Fe, upper soil zone



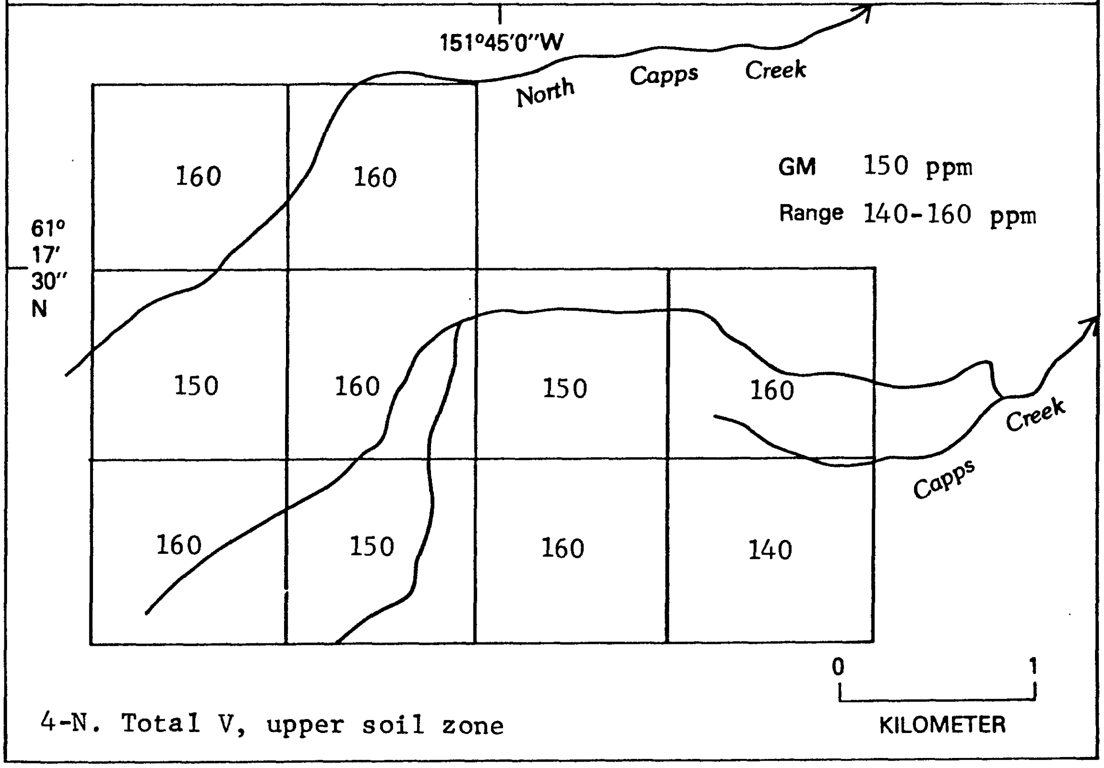
4-K. Total Mg, upper soil zone



4-L. Total P, upper soil zone



4-M. Total Sr, upper soil zone



4-N. Total V, upper soil zone

Figure 5. Maps showing mean values (GM, geometric; AM, arithmetic) for samples collected with a 1-km cell for soil properties with significant variation among cells, analytical error less than 50 percent of the total variation, and a variance mean ratio of less than one.

5-A. AB-DTPA extractable Al, upper soil zone

5-B. AB-DTPA extractable Cu, lower soil zone

5-C. AB-DTPA extractable Fe, upper soil zone

5-D. AB-DTPA extractable Zn, lower soil zone

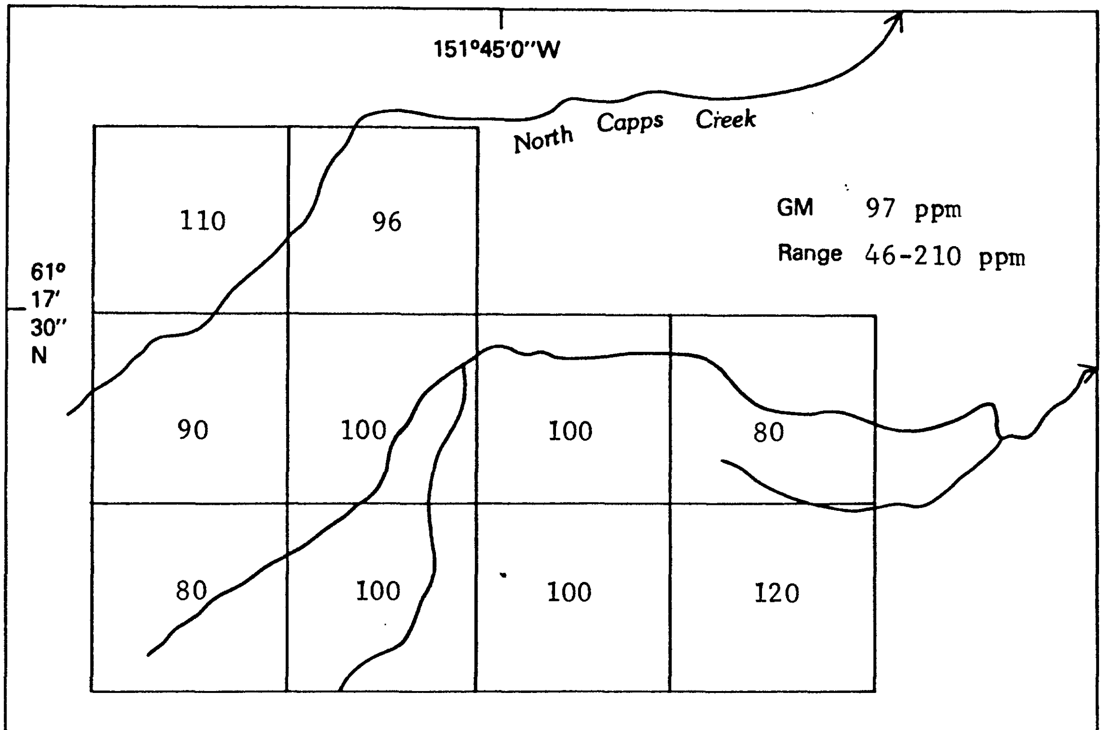
5-E. Total Co, lower soil zone

5-F. Total Mn, lower soil zone

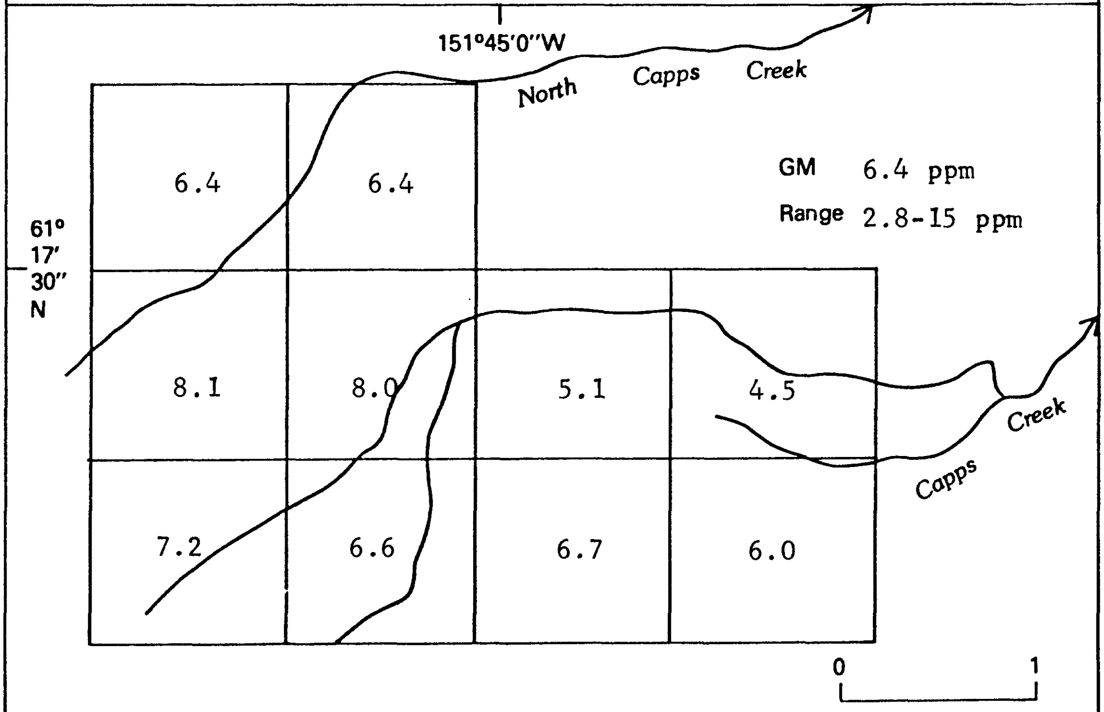
5-G. Total Ni, lower soil zone

5-H. Total P, lower soil zone

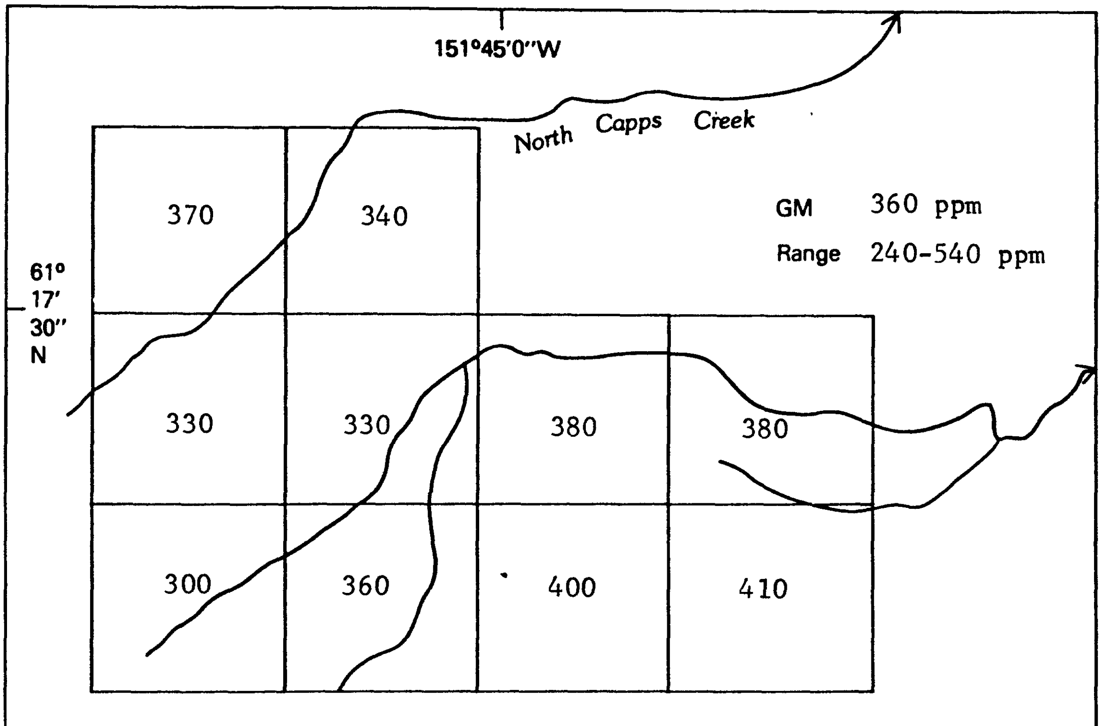
5-I. Total Ti, lower soil zone.



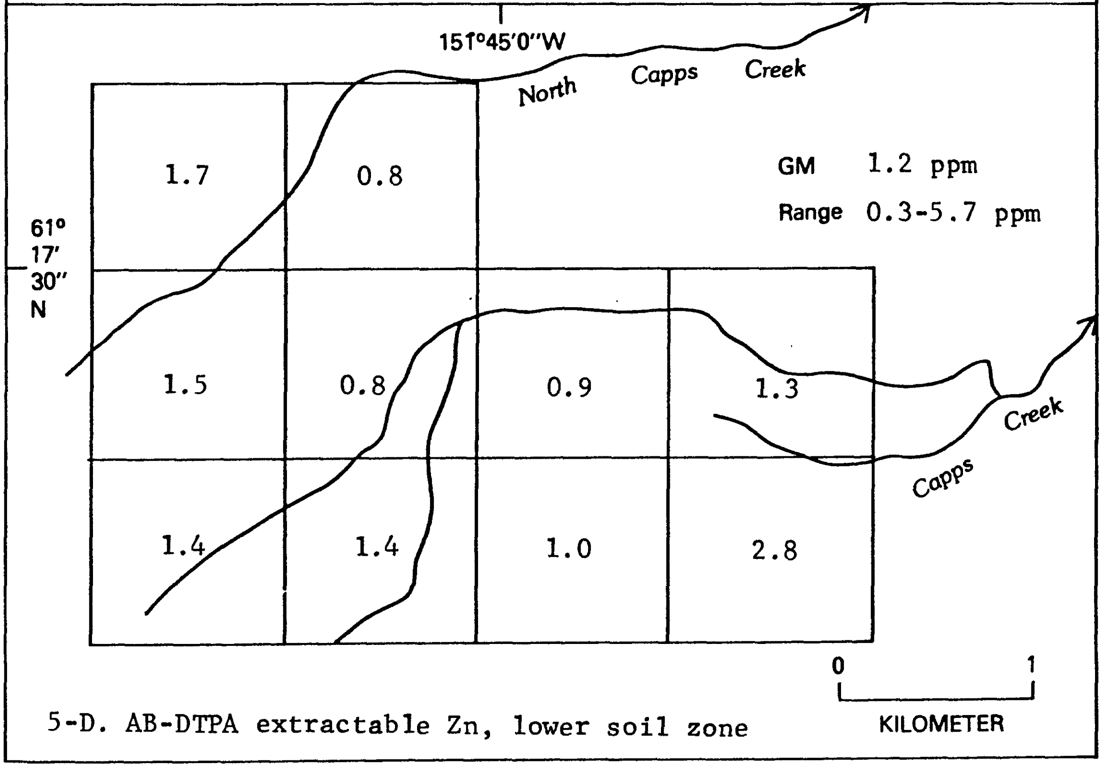
5-A. AB-DTPA extractable Al, upper soil zone



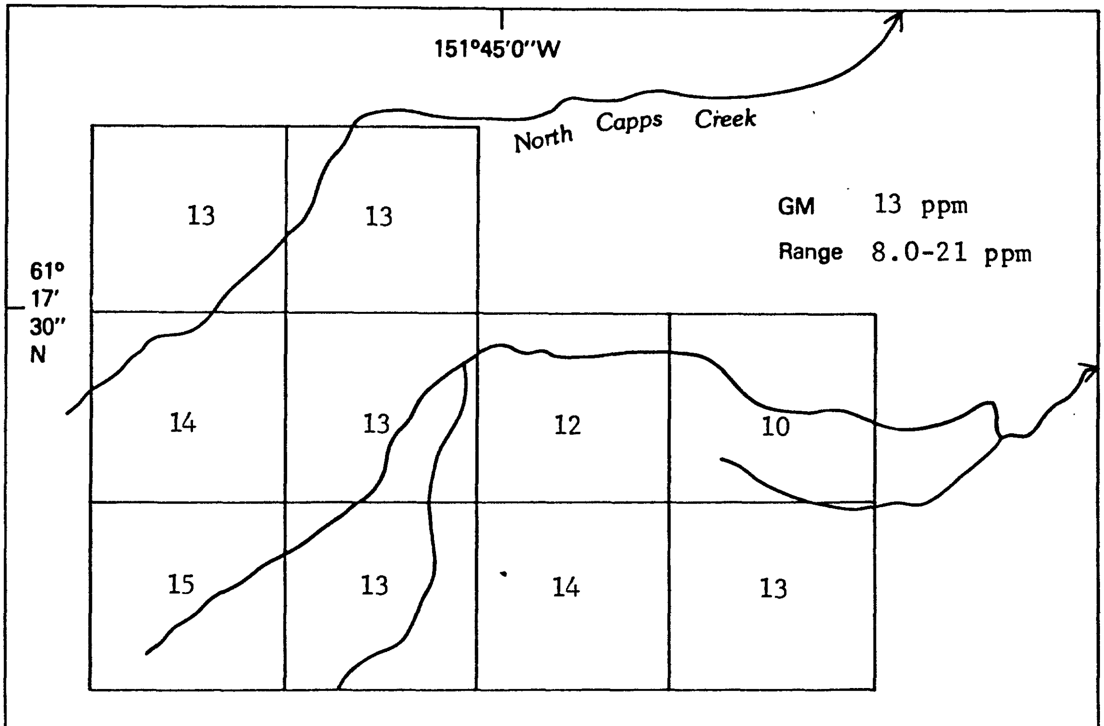
5-B. AB-DTPA extractable Cu, lower soil zone



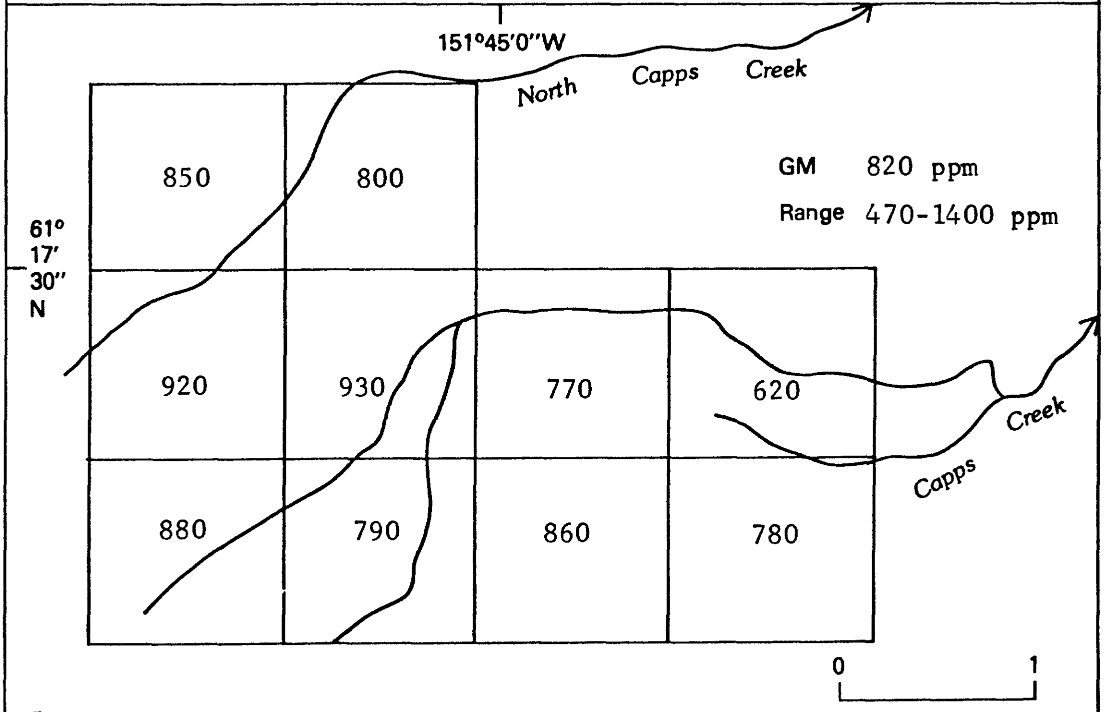
5-C. AB-DTPA extractable Fe, upper soil zone



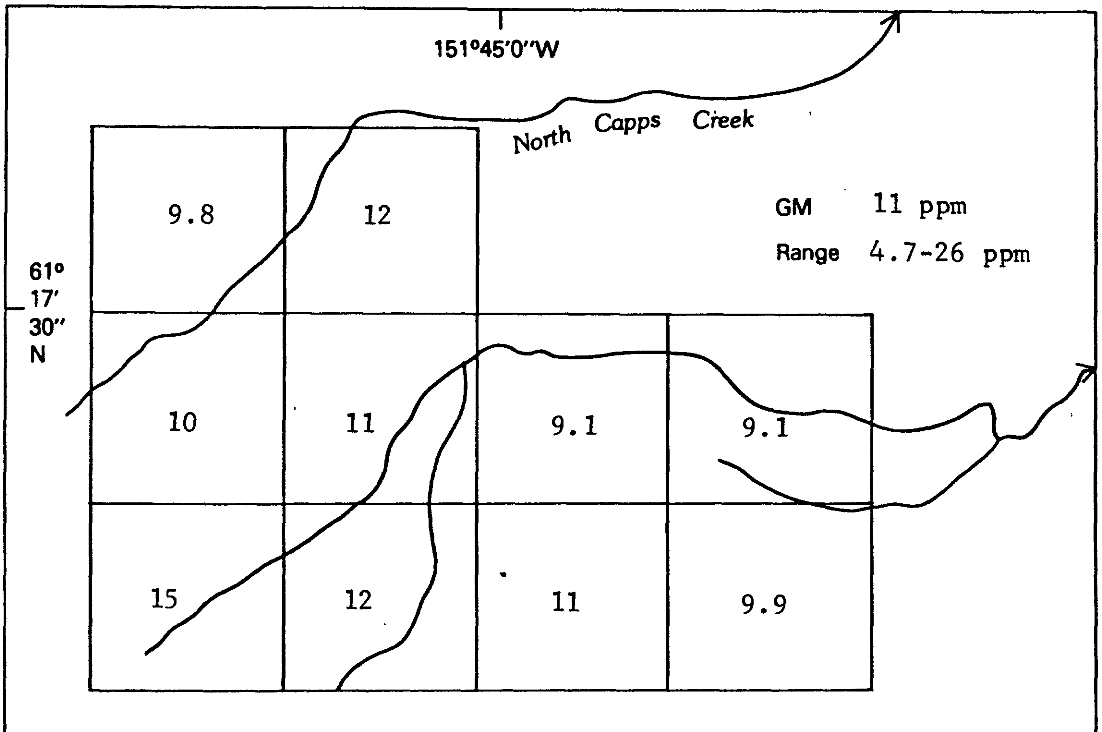
5-D. AB-DTPA extractable Zn, lower soil zone



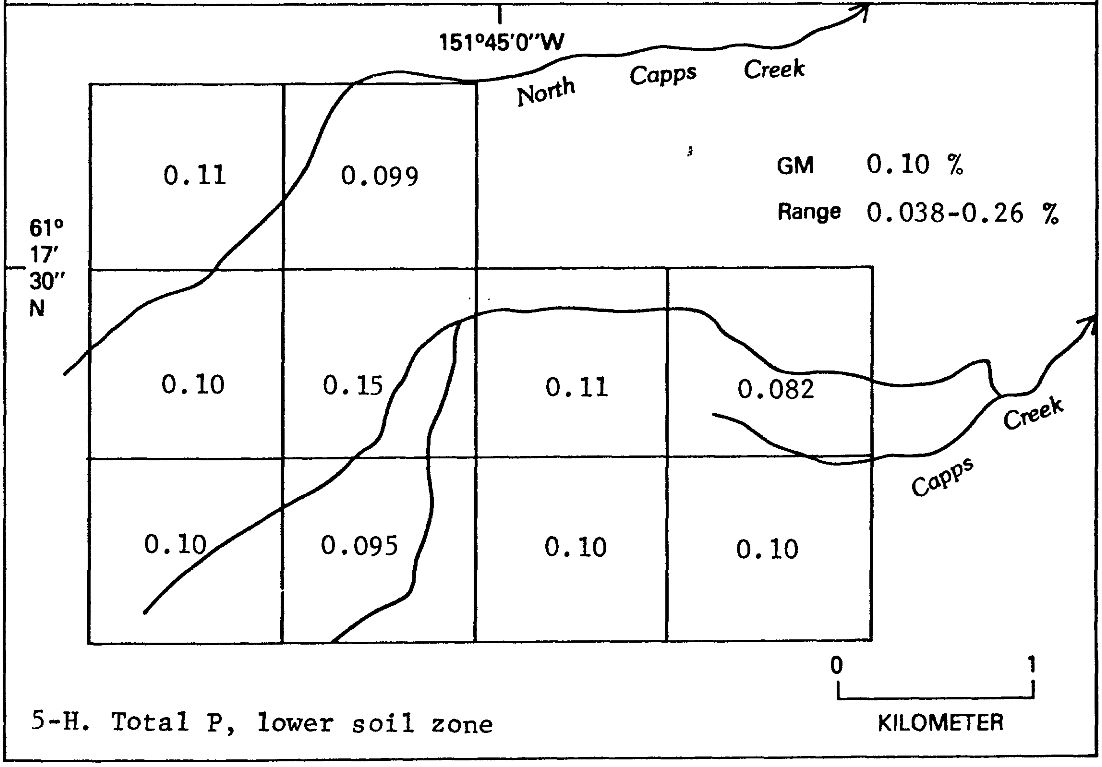
5-E. Total Co, lower soil zone



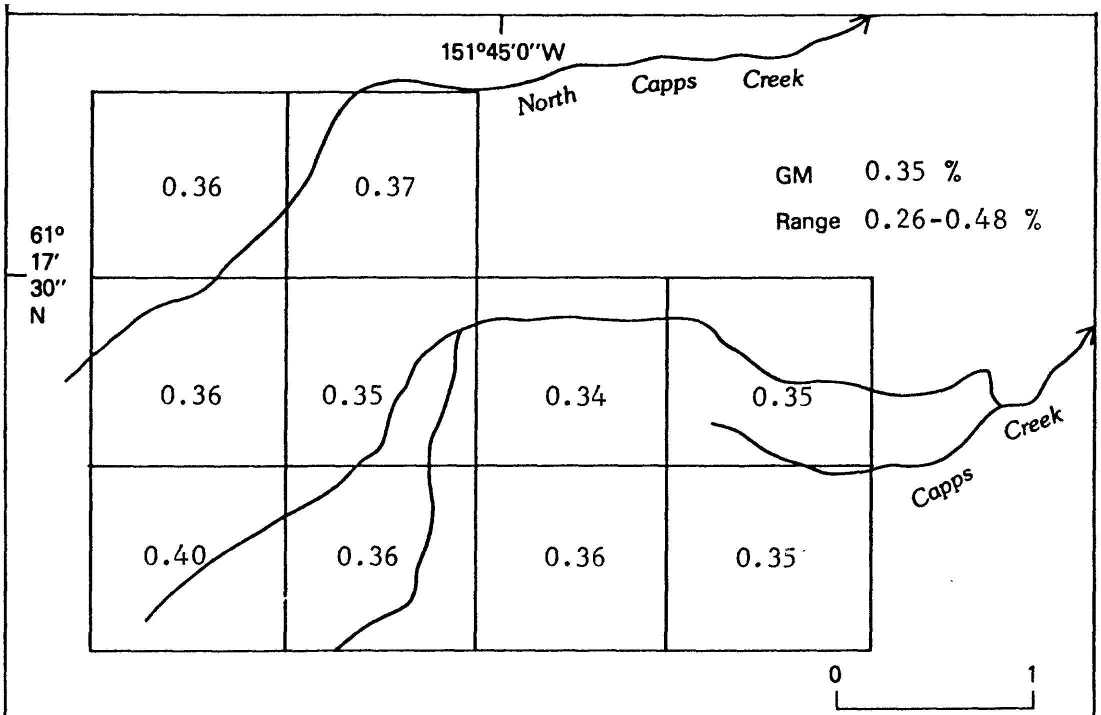
5-F. Total Mn, lower soil zone



5-G. Total Ni, lower soil zone



5-H. Total P, lower soil zone



5-I. Total Ti, lower soil zone

Soil Composition and Revegetation Potential

Comparisons of the geochemical baseline data shown in table 3 and figures 4-6 with other studies (Gough, Severson, and Briggs, 1982; Ebens and Shacklette, 1982) suggest that the soils of the Capps Coal Field are not highly unusual in their total and extractable chemical composition. The fact that these soils support a diverse and actively growing plant community suggests that the total and extractable element composition of soils shown in table 1 represents an acceptable range within which growth occurs. Whether or not introduced plant species would respond similarily can not be adequately assessed from the data of this study. In order to adequately evaluate the rehabilitation potential for introduced plant species, further research using field plot and greenhouse studies is needed. Such a field plot experiment is currently being undertaken at Palmer, Alaska by University of Alaska Agricultural Experiment Station personnel. They have established revegetation plots at the Capps Coal Field on spoil adjacent to a trench where a sample of coal had been extracted. Mitchell and others (1981) have reported on the needed soil amendments for revegetating Alaskan coal mine spoils.

The recent geologic history of the Capps area indicates that natural revegetation has occurred many times quite successfully without man's help. Specifically, the area has been buried by successive 10- to 20-cm-thick layers of volcanic ash. The soil profiles consist of many buried surface horizons. Apparently, after each ash layer was deposited, the surface revegetated and became stable quite rapidly because very little hillslope erosion is evident in the soil profiles examined.

In planning for the revegetation of stripmined areas, the following generalizations on the chemical characteristics of these soils may be useful:

1. Whether or not the AB-DTPA soil test will adequately predict element-availability measures needs to be tested for these Alaskan soils. Transferring soil test technology from one area to another quite different area without adequate testing may result in invalid interpretations. Plants were sampled with each soil in this study but, as of this writing, the evaluation of the plant data are still pending.

2. A salinity problem in these soils is judged to be nonexistent, based on the analyses of a random group of samples (table 1, water saturation extract data).

3. The low pH and extractable Al levels (figs. 4 and 6, table 3) may need further evaluation. Successful establishment of introduced plant species may be affected by Al toxicity.

4. Low amounts of water soluble B, Ca, Mg, and K (table 1) may affect the growth of introduced species. Generally, N and P are required fertilizers also for adequate growth of most introduced plant species.

5. The map patterns for pH (fig. 4) and for AB-DTPA-extractable elements (figs. 4 and 6) correspond inversely to each other. The east half of the study area is slightly below and the west half is slightly above the average pH, while the extractable element concentrations are greatest in the east half and smallest in the west half. An inverse relation between pH and AB-DTPA-extractable metals was expected because it is commonly reported in the literature. The map patterns for total element concentration (Figs. 5 and 6) show no consistent patterns among themselves nor do they correspond to patterns displayed by AB-DTPA-extractable elements or pH. This suggests that total element concentration cannot be used as a general estimate of the extractable or "plant-available" fraction.

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