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SOIL CLASSIFICATION AND CHARACTERIZATION AT SITE NUMBER DjOn 26 IN CYPRESS HILLS PROVINCIAL PARK, ALBERTA

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PREFACE

Soil samples were collected during the summer of 1975 from an archaeological site excavated by the Outdoor Recreation Planning Branch of Alberta Recreation and Parks, in the Cypress Hills Provincial Park. A detailed field soil profile description was made, and laboratory analyses of the samples have been carried out. The soil profile description and results of chemical and physical analyses are presented in this report.

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Mr. Eugene Gryba assisted in collecting the soil samples, and identified the culture layers and Mazama Ash encountered in the section.

Mrs. Kathy Gates typed and assisted in compiling and proof-reading the report, while Messrs. A. Schwarzer and W. McKean determined the soil chemical and physical analyses.

MATERIALS AND METHODS

Site Description

The site is located about 1 km east of Elkwater on the east side of Highway 48, or about 26 km east and 35 km south of Medicine Hat; in the northeast quarter of section 19, township 8, range 2, west of the fourth meridian. The exact location and a detailed site description are given in writings elsewhere (Alberta Recreation and Parks files). The physiography and surficial deposits, climate and vegetation of the Cypress Hills in general are described in Greenlee (1981). Also, some common plant species noted at the sample site are listed along with the soil profile description. The surface soils have been classified as dominantly Gleyed Regosols with significant occurrences of Gleyed Rego Black Chernozems, developed on medium to moderately fine textured fluvial sediments. At the site, they were classified as Orthic Black Chernozems.

The buried horizons are exposed on the face of a large pit, dug about 4.5 m deep with lateral dimensions of 4.5 m x 6 m for the upper meter, then stepped in to 2 m x 2.5 m for the remainder.

Analytical Methods

Samples were taken on the south wall of the pit from all identifiable soil horizons, which were given standard designations used in Canada

(Canada Soil Survey Committee, 1978). The following analyses were conducted, and a brief explanation of the significance of each is included.

1) Soil Reaction (pH)

This test measures soil acidity or alkalinity. Acid soils have pH values of 5.5 or less; decreasing pH values indicate increasing soil acidity. Neutral soils have pH values between 5.5 and 7.4; alkaline soils have pH values of 7.4 or more. Increasing pH values indicate increasing soil alkalinity. The best pH range for most crops in Alberta is 5.5 to 7.5 (Alberta Soil and Feed Testing Laboratory, O.S. Longman Building, Edmonton).

A Beckman model Zeromatic pH meter equipped with a glass and calomel electrode was used to determine the pH in water, on a saturated soil paste (Doughty, 1941). The method is given in McKeague (1978), reference number 3.14.

2) Total Nitrogen

Nitrogen is of special importance because plants need it in rather large amounts, and it is easily lost from the soil through leaching, erosion, and as gases. Moreover, it is usually present in comparatively small amounts in mineral soils. The primary natural source of soil nitrogen is air. Ammonium and nitrate salts are brought down by precipitation, and atmospheric nitrogen is fixed by certain microorganisms. Important artificial sources are commercial fertilizers, animal manures, green manures, and various crop residues. General soil test ratings for supplies of available nitrogen, expressed in pounds per acre, are: low, 0 to 20; medium, 21 to 50; and high, 51 or more (Alberta Soil and Feed Testing Laboratory, O.S. Longman Building, Edmonton).

Total nitrogen was determined by the semi-micro Kjeldahl method without precautions to include NO_3 and NO_2 (Prince, 1952). The catalyst used was commercially prepared Kel-Pack. Distilled ammonia was collected in 4% boric acid solution and titrated against standard H_2SO_4 using a mixed indicator (methyl red and bromo cresol green in ethanol). The method is given in McKeague (1978), reference number 3.622.

3) Calcium Carbonate Equivalent

This is a measure of the amount of free lime contained in the soil. Free lime may restrict nutrient availability to plants in the following ways:

a) Deficiencies of available iron, manganese, copper or zinc may occur.

b) Phosphate availability may be low due to the formation of complex and insoluble calcium phosphates.

c) The uptake and utilization of boron may be hindered.

d) The high pH in itself may be detrimental.

Free lime cannot be readily removed from the soil. The only practical way to counteract its effect is to increase soil organic matter content.

The calcium carbonate equivalent was determined by the inorganic carbon manometric method of Bascomb (1961). The method is given in Black (1965), section 91.6.

4) Organic Carbon

The determination of organic carbon in soil is considered the best method of estimating the amount of organic matter. Generally it is assumed that soil organic matter contains 58 percent carbon, and that an estimate of organic matter is made by multiplying the amount of organic carbon by the factor 1.7.

Organic matter influences physical and chemical properties of soils far out of proportion to the small quantities contained therein (Brady 1974). It commonly accounts for at least half the cation exchange capacity of soils and is responsible, perhaps more than any other single factor, for the stability of soil aggregates.

Total carbon was determined by dry combustion using an induction furnace (Allison et al. 1965) with a gasometric detection of evolved CO_2 (Leco Carbon Analyzer Model 577-100). The method is given in McKeague (1978), reference number 3.611.

Organic carbon was determined by subtracting carbonate carbon from total carbon.

5) Particle Size

The determination of sand, silt and clay sized particles (particle size distribution) in a soil sample allows the grouping of soils into textural classes. Where soil texture is known, approximations and estimates can be made of soil properties, such as permeability and moisture-holding capacity. In general, clay soils (those with 40 percent or more of clay sized particles) have high moisture-holding capacity and high cation exchange capacity, but often low permeability. Sandy soils on the other hand usually have low moisture-holding and cation exchange capacities, but high permeability.

Particle size analysis was carried out by the pipette method of Kilmer and Alexander, as modified by Toogood and Peters (1953). The method is given in McKeague (1978), reference number 2.112.

RESULTS AND DISCUSSION

Soil Profile Description

Map Unit: 17 (Greenlee, 1981).

Classification: Orthic Black Chernozem (surface soil).

Date Sampled: 30 September, 1975.

Location: NE 19-8-2-4

Parent Material: Medium to moderately fine textured fluvial sediments.

Landform: Level fluvial (F1).

Relief: About 0.3 m over a frequency of about 100 m.

Slope and Topography Class: About 1% (b).

Slope Range: 0.5 to 2%.

Elevation: About 1240 m.

Aspect: Slightly south of west (nearly level).

Erosion: Nil.

Surface Stoniness: Nonstony (0).

Estimated Drainage: Well drained (seasonal water table fluctuates between 1 and 4 m below surface.

Vegetation (Moss, 1959; Cormack, 1967):

100% tree cover with aspen (Populus tremuloides) (70%), balsam poplar (Populus balsamifera) (29%), and white spruce (Picea glauca) (1%); about 50% shrub cover with wild gooseberry (Ribes spp) (20%), hawthorn (Crataegus spp) (15%), dogwood (Cornus stolonifera) (9%), willow (Salix spp) (1%), saskatoon-berry (Amelanchier alnifolia) (1%), alder (Alnus spp) (1%), wild rose (Rosa spp) (1%), wild red raspberry (Rubus strigosus) (1%), and snowberry (Symphoricarpos albus) (1%); 100% herb cover with goldenrod (Solidago spp) (60%), cow parsnip (Heracleum lanatum) (20%), common nettle (Urtica gracilis) (12%), meadow rue (Thalictrum spp) (1%), aster (aster spp) (1%), wild vetch (Vicia americana) (1%), Canada anemone (Anemone canadensis) (1%), Canada thistle (Cirsium arvense) (1%), Western Canada violet (Viola rugulosa) (1%), twisted stalk (Streptopus amplexifolius) (1%), and horsetail (Equisetum spp) (1%); and 100% grass cover with mountain timothy (Phleum alpinum) (5%) brome grass (Bromus spp) (5%), and two other unidentified tall-growing coarse-leaved species (90%).

Profile Description:

Horizon	Depth (cm)	Description
Ah	0–13	Very dark brown (10YR 2/2 m) loam; medium granular; very friable, moist; plentiful, very fine to medium, random roots; no effervescence; clear, smooth boundary; neutral.
Bm1	13–35	Dark brown (10YR 4/3 m) loam; medium prismatic, breaking to fine and medium subangular blocky; very friable, moist; few, very fine to coarse, random roots; no effervescence; clear, smooth boundary; alkaline.
Ahb1 (culture layer 1)	35–52	Very dark grayish brown (10YR 3/2 m) clay loam; medium granular; friable, moist; few, very fine to medium, oblique roots; no effervescence; clear, smooth boundary; alkaline.
Bm2	52–62	Dark grayish brown (10YR 4/2 m) loam; medium prismatic, breaking to fine and medium subangular blocky; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; abrupt, smooth boundary; neutral.
Ahb2 (culture layer 2)	62–71	Very dark grayish brown (10YR 3/2 m) loam; medium granular; very friable, moist; few, very fine to fine, oblique roots; no effervescence; clear, smooth boundary; alkaline.
Bm3	71–76	Dark brown (10YR 3/3 m) loam; medium prismatic, breaking to fine and medium subangular blocky; very friable, moist; few, very fine to fine, oblique roots; no effervescence; clear, smooth boundary; alkaline.
Ahb3 (culture layer 3)	76–91	Very dark gray (10YR 3/1 m) loam to clay loam; medium granular; very friable, moist; few, very fine to fine, oblique roots; no effervescence; clear, smooth boundary; alkaline.
Ck	91–113	Dark brown (10YR 4/3 m) loam; medium prismatic, breaking to fine and medium subangular blocky; very friable, moist; few, very fine to fine, oblique roots; no effervescence; abrupt, smooth boundary; alkaline.
Ahb4 (culture layers 4 and 5)	113–128	Very dark brown (10YR 2/2 m) clay loam; medium granular; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; abrupt, wavy boundary; alkaline.
Bmb	128–131	Dark brown (10YR 3/3 m) clay loam; fine to medium subangular blocky; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; abrupt, wavy boundary; alkaline.

Ahb5 (culture layer 6)	131–139	Very dark brown (10YR 2/2 m) clay loam; medium granular; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; clear, wavy boundary; alkaline.
Bmb2	139–145	Dark grayish brown (10YR 4/2 m) clay loam; fine to medium subangular blocky; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; abrupt, wavy boundary; alkaline.
Ahb6 (culture layer 7)	145–150	Very dark brown (10YR 2/2 m) loam; medium granular; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; clear, wavy boundary; alkaline.
Bmb3	150–156	Dark brown (10YR 3/3 m) sandy loam; fine to medium subangular blocky; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; clear, wavy boundary; alkaline.
Ahb7 (culture layer 8)	156–160	Black (10YR 2/1 m) loam; medium granular; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; clear, wavy boundary; alkaline.
Bmb4	160–165	Dark brown (10YR 4/3 m) sandy clay loam; fine to medium subangular blocky; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; abrupt, wavy boundary, alkaline.
Ahb8 (culture layer 9)	165–173	Very dark grayish brown (10YR 3/2 m) clay loam; medium granular; very friable, moist; very few, very fine to fine, oblique roots; no effervescence; gradual, smooth boundary; alkaline.
Ckb	173–207	Dark yellowish brown (10YR 4/4 m) loam; fine to medium subangular blocky; very friable, moist; very few, micro to very fine, oblique roots; no effervescence; abrupt, smooth boundary; alkaline.
Ccab	207–220	Grayish brown (10YR 5/2 m) loam to clay loam; fine to medium subangular blocky; very friable, moist; very few, micro to very fine, oblique roots; moderate effervescence; abrupt, smooth boundary; alkaline.
Ahcab (culture layer 10)	220–223	Very dark brown (10YR 2/2 m) silty clay loam; medium granular; very friable, moist; very few, micro to very fine, oblique roots; strong effervescence; abrupt, smooth boundary; alkaline.
Ccab2	223–278	Light brownish gray (10YR 6/2 m) loam; many, coarse, faint, grayish brown (10YR 5/2 m) mottles; fine and medium subangular blocky; very friable, moist; very few, micro to very fine, oblique roots; strong

effervescence; abrupt, smooth boundary; alkaline.

Ckb2 (Mazama ash)	278-283	Brown (10YR 5/3 m) silt loam; many, coarse, faint, yellowish brown (10YR 5/4 m) mottles; medium platy; very friable, moist; no roots; moderate effervescence; abrupt, smooth boundary; alkaline.
Ccab3	283-315	Grayish brown (10YR 5/2 M) loam; many, coarse, faint, dark brown (10YR 4/3 m) mottles; fine and medium subangular blocky; very friable, moist; strong effervescence; abrupt, smooth boundary; alkaline.
Ahcab2	315-317	Black (10YR 2/1 m) loam; medium granular; very friable, moist; moderate effervescence; abrupt, smooth boundary; alkaline.
Ccab4 (culture layer 11)	317-331	Grayish brown (10YR 5/2 m) loam; many, coarse, faint, dark brown (10YR 4/3 m) mottles; fine and medium subangular blocky; slightly sticky, slightly plastic, wet; strong effervescence; abrupt, smooth boundary; alkaline.
Ahkb (culture layer 12A)	331-337	Black (10YR 2/1 m) loam; medium granular; very friable, moist; moderate effervescence; abrupt, smooth boundary; alkaline.
Ckb3 (may include culture layers 12B and 12C)	337-347	Brown (10YR 5/3 m) clay loam; fine and medium subangular blocky; sticky, plastic, wet; weak effervescence; alkaline.

The Buried Soils

Results of the chemical and physical analyses are presented in Table 1.

TABLE 1 - Chemical and Physical Analyses of Horizons at Site DjOn 26

Horizon	Depth cm	pH H_2O	Total [1]N %	[2]OC %	CaCO3 equiv %	Particle Size Analysis % from frac 2mm diam sand	silt	clay	Texture
Ah	0-13	7.3	0.48	4.57	1.9	38	37	25	L
Bm1	13-35	7.6	0.16	1.25	1.2	36	39	25	L
Ahb1	35-52	7.6	0.33	2.91	1.3	27	40	33	CL
Bm2	52-62	7.3	0.15	1.17	1.7	44	31	25	L
Ahb2	62-71	7.6	0.26	2.39	0.4	42	35	23	L
Bm3	71-76	7.7	0.13	1.22	0.5	42	32	26	L

Ahb3	76-91	7.6	0.20	2.07	0.6	42	31	27	L-CL
Ck	91-113	7.5	0.08	0.71	4.9	42	34	24	L
Ahb4	113-128	7.6	0.21	1.74	0.6	23	43	34	CL
Bmb	128-131	7.6	0.11	1.00	1.7	34	38	28	CL
Ahb5	131-139	7.6	0.19	1.81	0.6	23	43	34	CL
Bmb2	139-145	7.5	0.08	0.33	0.5	37	27	36	CL
Ahb6	145-150	7.6	0.14	1.12	0.3	40	34	26	L
Bmb3	150-156	7.6	0.07	0.61	0.3	57	24	19	SL
Ahb7	156-160	7.4	0.14	1.27	0.5	49	30	21	L
Bmb4	160-165	7.6	0.05	0.29	0.2	55	24	21	SCL
Ahb8	165-173	7.5	0.06	0.57	0.3	32	37	31	CL
Ckb	173-207	7.6	0.04	0.37	4.3	48	31	21	L
Ccab	207-220	7.6	0	0	10.8	27	46	27	L-CL
Ahcab	220-223	7.7	0.12	1.06	15.0	10	54	36	SiCL
Ccab2	223-278	7.9	0	0	16.3	48	33	19	L
Ckb2	278-283	8.2	0	0	6.5	16	62	22	SiL
Ccab3	283-315	7.9	0	0	13.6	36	40	24	L
Ahcab2	315-317	7.6	0.14	2.59	9.7	37	38	25	L
Ccab4	317-331	7.8	0	0	12.1	32	45	23	L
Ahkb	331-337	7.8	0.12	2.68	5.5	30	46	24	L
Ckb3	337-347	7.7	0.07	1.01	1.7	24	45	31	CL

[1]N - Nitrogen, [2]OC - Organic Carbon

The texture of slightly more than 50% of the horizons is loam; several have clay loam textures; and one each have sandy loam, sandy clay loam, and silty clay loam textures. These variations illustrate the normal magnitude that can be expected in fluvial sediments. The texture of the Mazama ash layer (Ckb2 horizon) is silt loam, which reflects the eolian origin of this material. Organic carbon content of the surface Ah horizon is low to average; of the buried Ah horizons is low; and of other horizons is low to average, as compared to that reported for other chernozemic soils in the Cypress Hills (Greenlee, 1980, 1979, 1978). However the expected larger amount in each buried Ah horizon as compared to the underlying B or C is readily discernible. This chemical data is consistent with the field evidence of a series of superimposed soil profiles. Only two horizons, the Ah, and Bm2 have neutral pH; all others are alkaline. All horizons below the Ckb, excluding the Ahkb and Ckb3, are strongly calcareous as shown by the $CaCO_3$ equivalent results; the Ah, Bm1, Ahb1, Bm2, Ck, Bmb, Ckb, Ahkb, and Ckb3 horizons are all weakly calcareous.

In order to show that the buried organic layers at this site are actually soils and not simply accumulations of organic matter, it would be necessary to prepare thin sections of some of the buried Ah horizons (Valentine et al, 1980). The thin sections would be inspected for evidence of soil microfabric typical of Ah horizons; and for secondary pedological features that would indicate post-burial change due to subsurface leaching, which can alter the original profile characteristics. Since thin sections were not prepared for any of these buried Ah horizons, the premise that they are in fact Ah horizons is speculative. However, the combination of field morphology and chemical analyses supports the appearance of a sequence of superimposed Chernozemic soil profiles. The principle soil forming process appears to have been decalcification of at least the upper horizons of each soil. Below the 173 cm depth all horizons are calcareous, and have probably been recalcified after burial due to fluctuating water tables and modern day leaching. Well decomposed organic matter derived from plants growing in the soil appears to have been mixed with the mineral material, probably by faunal activity, in each buried Ah horizon. Several of these buried Ah horizons are underlain by dark brown B horizons, indicating lengthy periods of stability. In summary, the characteristics of all the buried soils appear quite similar to the Black Chernozemic soils found on the present terrace surface, which implies an environment similar to the present at the time of their formation.

REFERENCES

Allison, L.E. Bollen, W.B. and Moodie, C.D. 1965. Total Carbon. In: Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties. Black, C.A. (ed.) Agronomy Series No. 9, American Society of Agronomy, Madison, Wisconsin, pp. 1346-1366.

Bascomb, C.L. 1961. A Calcimeter for Routine use on Soil Samples. Chemistry and Industry, Part 2, pp. 1826-1827.

Black, C.A. (ed.) 1965. Methods of Soil Analysis, Part 2. Agronomy Series No. 9, American Society of Agronomy, Madison, Wisconsin, 1572 pp.

Brady, N.C. 1974. The Nature and Properties of Soils. 8th ed. MacMillan Publishing Co. Ltd., New York, U.S.A. 639 pp.

Canada Soil Survey Committee, Subcommittee on Soil Classification. 1978. The Canadian System of Soil Classification. Can. Dept. Agric. Publ. 1646. Supply and Services Canada, Ottawa, Ont. 164 pp.

Cormack, R.G.H. 1967. Wild Flowers of Alberta. Gov't of Alberta, Dept. of Industry and Development. Queen's Printer, Edmonton, Canada. 415 pp.

Doughty, J.L. 1941. The Advantages of a Soil Paste for Routine pH Determinations. Scientific Agriculture 22:135-138.

Greenlee, G.M. 1981. Soil Survey of Cypress Hills, Alberta and Interpretation for Recreational Use. Alberta Research Council, Earth Sciences Rep. 80-4, Edmonton, Canada. 68 pp.

Greenlee, G.M. 1980. Soil Classification and Characterization for Selected Sites in Cypress Hills Provincial Park. Alberta Institute of Pedology Number M-80-1. Alberta Research Council, Edmonton, Canada. 26 pp.

Greenlee, G.M. 1979. Addendum to Soil Classification and Characterization for Grassland Ecology Study in Cypress Hills, Alberta. Alberta Institute of Pedology Number M-79-1. Alberta Research Council, Edmonton, Canada. 29 pp.

Greenlee, G.M. 1978. Soil Classification and Characterization for Grassland Ecology Study in Cypress Hills, Alberta. Alberta Institute of Pedology Number M-78-2. Alberta Research Council, Edmonton, Canada. 25 pp.

McKeague, J.A. (ed.) 1978. Manual on Soil Sampling and Methods of Analysis, 2nd Edition. Canadian Society of Soil Science, Ottawa, Ontario. 212 pp.

Moss, E.H. 1959. Flora of Alberta. University of Toronto Press, Ontario, Canada. 546 pp.

Prince, A.L. 1952. Determination of Total Nitrogen, Ammonia, Nitrates, and Nitrites in Soils. Soil Science 59:47-52.

Toogood, J.A., and Peters, T.W. 1953. Comparison of Methods of Mechanical Analysis of Soils. Canadian Journal of Agricultural Science 33:159-171.

Valentine, K.W.G., Fladmark, K.R., and Spurling, B.E. 1980. The Description, Chronology, and Correlation of Buried Soils and Cultural Layers in a Terrace Section, Peace River Valley, British Columbia. Canadian Journal of Soil Science 60:185-197.