Bulletin No. 16. *December*, 1927.

UNIVERSITY OF ALBERTA

COLLEGE OF AGRICULTURE

SOIL SURVEY
OF
SOUNDING CREEK SHEET

BY

F. A. WYATT AND J. D. NEWTON

(With Appendix II by J. A. Allan)

University of Alberta

Edmonton, Alberta

Distributed by
Department of Extension, University of Alberta
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The authors of this report wish to acknowledge their appreciation of the sympathy and support given by the Minister of Agriculture and the executive member of the Alberta Department of Agriculture, and those of the Dominion Department of the Interior, who have aided and made possible the preparation and publication of this soil survey report.

The soil survey report for the Sounding Creek Sheet is the result of co-operation between the Alberta Department of Agriculture, Dominion Department of the Interior, Topographical Branch, and the University of Alberta, Soils Department; together with Dr. J. A. Allan, Professor of Geology.

The Alberta Department of Agriculture has provided the funds for conducting the field work and the cost of printing the soil maps.

The Department of the Interior, Topographical Branch, has supplied the topographical data from the revision survey of this area and has been responsible for the drawing, lithographing and printing of the soil maps.

The members of the Soils Department of the University of Alberta have conducted the field and laboratory work in connection with mapping the soil types, collecting the samples, making the physical and chemical analyses and preparing the report. Dr. J. A. Allan has inspected the area covered by this report, and kindly prepared the chapter in the appendix dealing with the geology of the Sounding Creek Sheet.

(Published by the University of Alberta at the request of Hon. George Hoadley, Minister of Agriculture.)

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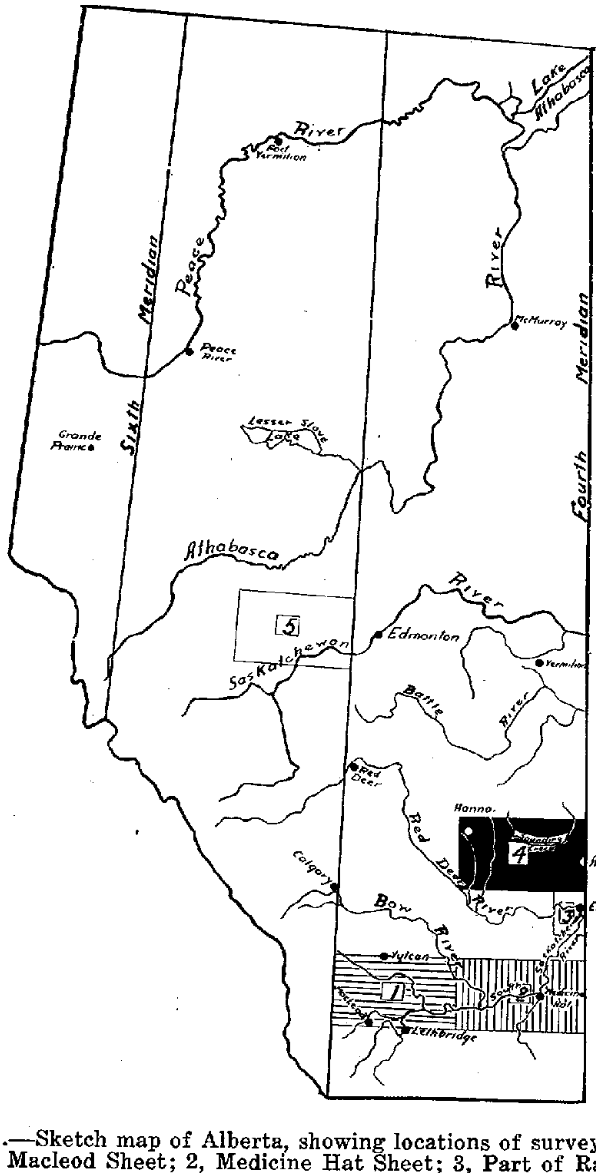

Fig. 1.—Sketch map of Alberta, showing locations of surveyed areas. 1, Macleod Sheet; 2, Medicine Hat Sheet; 3, Part of Rainy Hills Sheet; 4, Sounding Creek Sheet; 5, St. Ann Sheet. Reports issued for 1, 2 and 4.

PREFACE

The farmer is among the first to recognize the fact that soils vary tremendously in their power to produce crops. This variation is due to differences in physical, chemical, and biological relationships within the various soil types. The report of the soil survey classifies the lands of the surveyed area according to these various characteristics and relationships, and discusses their effects upon crop production. The report is, therefore, valuable to the farmers, and likewise valuable to any other persons interested in the soils of the surveyed area, as, for example: land seekers, colonization agents, land appraisers, district agricultural representatives, experimental farm officials, bankers, road commissioners, real estate dealers, provincial and Dominion government officials.

The report accompanying the soil map describes the properties of the surface and subsoil of the various soil types, topography, drainage, crop adaptation, water supply, fertility invoice of the soils, systems of farming and methods of soil management, and alkali problems. It also contains a brief discussion of the climate and agricultural development of the area together with the important farm crops, transportation facilities and population.

The soil map is an important part of the report. It is made on the scale of three miles to the inch, and shows not only the different soil types represented by different colors, but also important physical features such as topography, roads, railroads, streams, towns, schools, and farm dwellings. Furthermore the soil map serves as a very convenient reference by which the better land can be distinguished from the poor land by any person interested in the soils of the surveyed area.

Our best land should be settled first, and since our soil resources are enormous it is unwise to allow farmers to settle on poor land until all the good land is taken up. It will mean greater prosperity for the province as a whole, as well as for the individual farmers, if only the better land is broken up at first. True, this particular argument does not apply to a large part of the area covered in this report, since much of the land was settled long before the survey was conducted. It would have been better to have conducted a survey of this kind before the land was brought under cultivation. Then certain of the lighter tracts, especially, might have been held for range land only, and not broken at all. It would have been a kindness to many of the then prospective settlers if this had been done, as many of these settlers have abandoned their farms after wasting a great deal of money, and years of their lives, in a vain attempt to produce wheat profitably in certain sections of the Sounding Creek Sheet.

It is true that in many cases rainfall is the main limiting factor in crop production, but, in a given district, with a given rainfall, different soil types differ greatly in their crop-producing power, or ability to resist drought. The sand and sandy loam soils, for example, are not nearly as drought resistant as the loam and silt loam soils.

The results of crop, fertilizer and cultural method experiments obtained at the larger government experiment stations in our province do not necessarily apply to all parts of the province. The men in charge of the experiments recognize that it is very often necessary to determine whether the results obtained at the stations do or do not apply to the various local districts. When planning extension experiments in various parts of the province the soil maps should prove very valuable, since they would show where the plots should be placed in order to represent important or extensive soil areas. The farmers round about would then know whether a certain crop or treatment could be expected to bring them results similar to those obtained on the experimental plots, since the soil maps would tell them whether the soils were, or were not, alike.

Similarly, the soil report tends to place the information of one farmer at the disposal of other farmers. If one farmer sees that another farmer on land classified the same as his, is making more money, he can observe what crops the more successful farmer is growing, and how he is working his land, and, by adopting similar crops and methods he may expect to obtain similar results.

Within recent years considerable attention has been paid to the study of plant diseases in the prairie provinces, as it is known that the losses caused by such diseases are frequently very large. The prevalence of certain of these diseases, such as grain root rot and potato scab, is probably influenced by the type of soil, and it would be interesting and important to correlate soil types and plant diseases. Important relationships might likewise be found to exist between soil types and certain insect pests.

If it is worth while to conduct surveys to determine our mineral, timber and various other resources, and to map out in detail the topographical features of the province, surely it is worth while to take an inventory of our most important natural resource, namely, the soil. Soil surveys are of the greatest economic importance and furnish information that can be secured in no other way.

Soil Survey of Sounding Creek Sheet, Alberta

BY

F. A. WYATT AND J. D. NEWTON*

(With Appendix II by J. A. Allan)

DESCRIPTION OF THE AREA

The Sounding Creek Sheet is located in south-eastern Alberta, as indicated by the sketch map. It consists of an area of 90 miles east and west by 48 miles north and south, and its southern boundary line is 144 miles north of the international boundary. More exactly, it consists of that portion of townships 25 to 32 (inclusive) which occupies ranges 1 to 15 (inclusive), west of the 4th meridian.

The eastern boundary of the surveyed area is formed by the Saskatchewan boundary, and extends from a point about four miles south of Compeer, on the Coronation Branch of the C.N.R., south to a point about nine miles north of the Red Deer River at Empress. The western boundary extends from a point about fourteen miles north-west of Hanna, south to the Red Deer River just south of the Hand Hills. Hanna, the largest town within the area, lies in the north-west corner of the Sheet.

The soil map for the area above described represents 120 townships, or 2,764,800 acres.

The area covered by this report lies wholly within the treeless or bald prairie portion of southern Alberta, and almost wholly within the large "Brown" soil belt of south-eastern Alberta. The north-west corner of the Sheet, however, belongs to the so-called "Transition" soil belt, which lies west and north of the "Brown" belt, and separates the "Brown" from the "Black" soil belt. This "Transition" belt, as its name implies, possesses intermediate properties, which, in this case, lie between those of the "Brown" and "Black" soil belts.

The surface of the Sounding Creek Sheet is, in greater part, undulating or gently rolling. There are, however, some very considerable areas of rolling, and even hilly land, especially in

*Messrs. T. H. Mather, J. L. Doughty, and A. S. Ward assisted with the field, analytical and mapping work during the course of the preparation of this report.

the eastern half of the Sheet, and in the north-west corner, where the topography is influenced by the Hand Hills. The extent of these rolling and hilly areas is shown by the hatching on the map, and is discussed later in connection with the description of the various soil types. (See map and Plate 1, Fig. 3.)

The general elevation of the Sounding Creek Sheet is about 2,500 feet. At the western end of the Sheet, on the Hand Hills slope, the elevation is about 3,000 feet, and just beyond the western end of the sheet the Hand Hills rise to an elevation of 3,500 feet or more.

The southern half of the Sheet is drained by a number of coulees and creeks which originate within the Sheet and run south into the Red Deer River. The most important of these, from east to west, are: Alkali, Blood Indian, Berry, and Bullpound creeks. The northern half of the Sheet, apart from a fairly large area in the north-west corner, is very largely drained by Sounding Creek, which originates within the Sheet, and runs east and then north through the northern half of the Sheet. These creeks, as a rule, do not carry water at all seasons of the year. Dowling Lake, the principal drainage basin in the north-west corner of the Sheet, has no well defined outlet, and consequently contains a great deal of alkali salt. There are a few small lakes in various parts of the Sheet, containing, as a rule, a good deal of alkali salt. Among these might be mentioned Dowling, Hand Hills, and Antelope lakes. Hand Hills lake, at the western end of the Sheet, lies partly within and partly without the surveyed area. Alkali sloughs and flats are fairly numerous throughout the area. Many of the sloughs and smaller lakes dry up during the summer months of the drier years, but contain water at all seasons during the years of heavier rainfall. Apart from these scattered lakes and sloughs the country is naturally well drained.

The soil material consists mainly of glacial drift. It is doubtful if much glacial material from the Rockies was carried as far east as the Sounding Creek Sheet. Considerable material has been carried by the glaciers from north central Canada, or from the region just west of Hudson Bay, although most of the drift no doubt consists of material weathered from the underlying sandstones and shales, and moved about to some extent by glaciers and glacial streams.

The main towns or centers of population occur along the railways. Hanna, a divisional point on the C.N.R. with a population of about 1,400, is the largest center, and lies in the north-west quarter of the Sheet. The principal towns along the main line east of Hanna are: Youngstown, Chinook, Cereal, Oyen, Sibbald, and, at the Saskatchewan border, Alsask. Other towns and villages, along the Steveville branch line south of Hanna, are Sheerness, Roselynn, Sunnynook, and Pollockville. Sedalia and Loverna lie on a branch line entering the north-east quarter of the Sheet, the latter at the Saskatchewan border, and, in the south-east corner of the Sheet is located the village of Acadia Valley.

The transportation facilities for a large part of the Sheet are good. The Goose Lake Line of the C.N.R., running from Calgary to Saskatoon, traverses the area from west to east. The Hanna-Steveville branch of the C.N.R. runs south from Hanna through the western part of the Sheet, and the Hanna-Warden branch runs north from Hanna through the north-west corner of the Sheet. A branch of the C.N.R. enters the eastern end of the Sheet at Loverna, and runs through the north-east quarter of the surveyed area, and another branch of the C.N.R. which enters the eastern end of the Sheet south of the main line, serves the south-east corner of the surveyed area. Most of the farmers are located within easy reach of these railroads, although, in some cases, it is necessary for farmers to haul their grain a distance of twenty miles or more.

For the most part the district is well traversed by public highways, of which the main ones are well graded dirt roads. These roads are good during the greater part of the year.

CLIMATE

The climate of the Sounding Creek Sheet is typical of the climate of the high plains region of Western Canada. It is characterized by long, bright, moderately warm summer days, and bright, cold, dry, winter weather. There are occasional high winds on this treeless plain, and the area is in the path of the "Chinooks," or warm south-west winds from the Pacific, which bring about occasional thaws during the winter. The climate is characterized by a high proportional amount of sunshine (2,354 hours per year as an average of 14 years).

Meteorological records show that evaporation from a free water surface is greater on the treeless plains of Alberta than in the park belt. This is in all probability due chiefly to the higher and more frequent winds of the plains. For example, the figures for May, June, July, August and September, 1919, show evaporation from a free water surface to be 28.11 inches at Claresholm, as against 19.25 inches at Olds. The evaporation at both places was greatest during July. These records indicate that losses of water by evaporation from a moist soil of the treeless plain would be greater than from a similarly moist soil of the park belt.

At no point in the Sounding Creek Sheet have meteorological records been kept for any great length of time; but such records for the Medicine Hat Sheet are applicable to the Sounding Creek Sheet.

Table I, compiled from the Dominion Meteorological Records, shows the average seasonal distribution of precipitation for a period of thirty years at Medicine Hat. This distribution is representative of the Sounding Creek Sheet. For the annual distribution see Table II.

TABLE I.—SEASONAL DISTRIBUTION AT MEDICINE HAT.
PRECIPITATION IN INCHES—YEARS 1885-1914

	PRECIPITATION			SNOW		
	Average Monthly Fall	Greatest Amount in 1 Month	Total Am't in driest year, 1886	Total Am't in wettest year, 1899	Average Monthly Fall	Greatest Amount in 1 Month
December	0.53	1.42	0.28	0.91	4.7	12.0
January	0.61	1.72	0.00	1.12	6.1	16.8
February	0.61	1.51	0.00	1.13	6.0	15.1
Winter....	1.75		0.28	3.16	16.8	
March	0.61	1.62	0.32	1.17	5.0	16.2
April	0.61	2.26	0.80	0.87	2.4	12.9
May	1.75	6.29	1.41	3.32	.5	8.0
Spring....	2.97		2.53	5.36	7.9	
June	2.57	5.62	1.53	2.60	T	1.2
July	1.73	4.86	0.78	3.79	......	......
August	1.51	5.65	0.11	7.60	......	......
Summer..	5.81		2.42	10.99	T	
September ..	0.92	2.41	0.19	1.66	0.4	4.0
October	0.62	3.48	0.79	0.80	1.1	21.0
November ...	0.72	3.11	0.51	0.31	6.4	31.1
Fall........	2.26		1.49	2.77	7.9	
Year........	12.79		6.72	22.28	32.6	

From Table I it may be seen that about 45 per cent. of the average annual precipitation at Medicine Hat for the 30-year period, 1885-1914, fell during the summer months; that the growing season, May, June, July and August, received almost 60 per cent. of the yearly rainfall, and that approximately 76 per cent. fell during the months of April to October inclusive. With such a favourable distribution the rainfall is decidedly more effective in producing crops than a similar annual precipitation would be, provided it were more largely distributed over the winter and early spring seasons. At best, of course, the average annual precipitation is rather small.

It may be noted that there occur great differences in the annual rainfall, as that of the driest season is less than one-third that of the wettest season. This fact may be further perceived by referring to Table II. There is probably as much proportional variation in the distribution of the snowfall as of rainfall, and the soils of the Sheet are often left bare for long periods during the winter months, which permits them to dry out to some extent, and occasionally blow. Soil drifting, however, is by no means as great a problem as in the Macleod Sheet to the south-west.

Rainfall records have been kept at Medicine Hat since 1885. In Table II, however, only the records for the 21-year period, 1904-1924, are given, thus making it possible to give the records for the same years at Lethbridge and Edmonton, for the purposes of comparison.

TABLE II.—PRECIPITATION RECORDS FOR MEDICINE HAT, LETHBRIDGE AND EDMONTON, 1904-1924.

Year	Rainfall in Inches		
	Medicine Hat	Lethbridge	Edmonton
1904	9.70	11.30	19.87
1905	8.99	13.78	15.56
1906	12.62	22.48	19.35
1907	6.86	15.50	16.62
1908	10.22	16.37	12.50
1909	9.78	11.69	12.94
1910	7.55	7.97	14.93
1911	16.24	21.28	20.67
1912	10.38	13.21	20.18
1913	13.62	14.17	19.54
1914	12.17	17.58	25.29
1915	16.13	17.40	18.64
1916	17.90	25.92	20.95
1917	11.13	18.87	15.25
1918	10.19	8.94	17.86
1919	7.66	13.36	16.43
1920	10.74	14.05	18.16
1921	11.74	12.13	15.22
1922	11.34	13.22	13.73
1923	13.64	16.40	16.91
1924	9.86	16.00	18.76
Average	11.35	15.03	17.59

From Table II it may be noted that for the three points mentioned, during the wettest year there was, approximately, from two to four times as much rainfall as during the driest year. During seven of the twenty-one years, 1904 to 1924, the annual rainfall at Medicine Hat dropped below 10 inches, and in two of the years at Lethbridge the annual rainfall was less than 10 inches. At Edmonton, however, the lowest record for this period was 12.5 inches. The average annual precipitation was lower at Medicine Hat than at either of the other two points referred to. It should be noted, however, that the precipitation records at Medicine Hat are not quite representative of the entire Sheet. For example, the rainfall near the Hand Hills, in the north-west corner of the Sounding Creek Sheet, is usually somewhat greater than at Medicine Hat.

When the annual precipitation is below a certain minimum it is almost impossible to produce a crop for that year, and what little rainfall does come has a very low efficiency factor. This is discussed in connection with the topic of agriculture.

The frost-free periods have a considerable bearing upon the risk in producing certain of the farm crops, and usually we may expect the time taken to mature the crop to be longest during the wettest years; thus the danger from frost would be increased for the wettest years.

The average length of the frost-free period for the twenty-three years from 1902 to 1924 was 127 days at Medicine Hat, 109 days at Lethbridge, and 90 days at Edmonton.

The shortest frost-free period in any one year, at any one of the three places was 52 days; this short period occurred at Edmonton in 1918. The shortest frost-free period at Lethbridge was 70 days (1902) and at Medicine Hat 98 days (1917). The longest frost-free period at Edmonton was 118 days, at Lethbridge 142 days, and at Medicine Hat 148 days. In only one year out of the twenty-three was the frost free period less than 100 days at Medicine Hat, and in only seven years at Lethbridge, but at Edmonton the frost-free period was less than 100 days in seventeen out of the twenty-three years.

It should be noted also, that the frost-free period is not usually as long as the growing season for wheat and many other crops. As a rule the earliest fall frosts are too light to damage the ripening wheat, and the late spring frosts seldom affect the wheat crop seriously.

As previously stated, the climate of the plains area is characterized by moderately warm summer weather, and cold, dry winter weather, with a high proportional amount of sunshine, and occasional high winds. An idea of the variations in temperature may be obtained from Table III taken from the Dominion Meteorological Records for the ten-year period, 1905-1914. In order to make clear the various column headings in Table III let us consider the December figures in the uppermost line.

The first column, first line, simply states the average or mean temperature for December throughout the ten-year period.

In the second column, first line, is given the mean or average maximum temperature for December. This is obtained as follows: an average of the highest daily temperatures of each of the ten Decembers is taken and 30.8 represents an average of these ten figures thus obtained. The mean minimum temperature for December is calculated similarly for column three.

In the fourth column, first line, is given the highest monthly mean, which in this case represents the average temperature of the warmest December during the ten-year period. Similarly, the figure in the fifth column represents the average temperature of the coldest December that occurred during the ten-year period.

In the sixth column, first line, is given the highest or warmest December temperature that occurred in the ten-year period, and in the seventh the lowest, or coldest.

TABLE III.—MONTHLY, SEASONAL AND ANNUAL MEANS AND EXTREMES AT MEDICINE HAT, ALBERTA, 1905-1914.

Month	Temperature						
	Mean	Mean Maximum	Mean Minimum	Highest Monthly Mean	Lowest Monthly Mean	Extreme Highest	Extreme Lowest
December	21.1	30.8	11.4	29.4	15.0	64	—32
January	11.3	21.5	1.0	26.3	—8.1	56	—41
February	16.5	27.0	6.0	25.8	9.6	64	—44
Winter	16.3	26.4	6.1			64	—44
March	30.5	42.9	18.1	45.0	17.5	84	—22
April	46.1	60.1	32.2	54.7	36.8	96	— 3
May	54.6	67.4	41.7	58.2	48.5	99	15
Spring	43.7	56.8	30.7			99	—22
June	64.1	77.1	51.1	68.6	59.2	102	30
July	69.2	83.4	55.0	75.6	65.1	104	38
August	66.3	80.8	51.8	69.6	62.0	103	31
Summer	66.5	80.4	52.6			104	30
September	58.1	71.5	44.6	63.1	51.5	92	20
October	46.2	57.8	34.7	51.8	42.4	85	2
November	32.5	42.4	22.6	38.5	20.7	69	—26
Fall	45.6	57.2	34.0			92	—26
Year	43.0	55.2	30.8			104	—44

The yearly mean or average temperature is 43 degrees Fahrenheit. The mean maximum yearly temperature is about 55 degrees. This figure represents an average of the highest daily temperatures throughout the year, for the ten-year period under consideration. Similarly, the mean minimum yearly temperature, which is about 39 degrees, represents an average of the lowest daily temperatures throughout the year, for the ten-year period under consideration.

The highest temperature recorded is 104 degrees, and the lowest 44 degrees below zero. However, these extremes do not give a correct idea of the usual variations in temperature. A better idea of ordinary temperature variations is given by a consideration of mean maximum and mean minimum temperatures. The mean maxmium for winter is about 26 degrees, and the mean minimum about 6 degrees; in other words, the average highest temperature for winter is several degrees below freezing, and the average lowest is about 6 degrees above zero. The mean temperatures for spring and fall are about equal to one another, although it will be observed that the fall is a bit the warmer.

The mean temperature for summer is about 66 degrees, the average maximum being about 80 degrees, and the average minimum about 53 degrees. During this season the mercury seldom reaches the 100 mark, and very rarely goes down to the freezing point. In general, the summer has long, warm days of bright sunshine which permits of very rapid growth of crops. The nights are cool.

AGRICULTURE

The big rush of homesteaders, with its consequent development of the grain farming industry, began in 1909 and continued for the next three years. Previous to 1909 the agriculture of the Sounding Creek Sheet consisted almost wholly of a limited number of ranches.

Most of the farmers throughout this area keep little livestock and practice mixed farming to but a very limited extent. As a rule they depend on the wheat crop as the chief source of income.

A large proportion of the area is uncultivated, and ranching is still practised in various places. It is altogether likely that much of the unoccupied land, of which a good deal was homesteaded and then deserted, will again be used for ranching in the near future.

The number of cultivated acres in the Sounding Creek Sheet can be computed only very roughly. If we estimate the untilled areas on our township maps, surveyed in 1924 and 1925, and add to this area the eroded, river bottom, and water areas, there are left about 644,000 acres or approximately 23 per cent. Considerable areas of the cultivated land were abandoned in 1926 and 1927, and it is now doubtful if more than 20 per cent. of the land in this Sheet is being cultivated.

TABLE IV.—ACREAGE OF VARIOUS CROPS PRODUCED IN SOUNDING CREEK SHEET (1915-1920).

Year	CROPS					
	Wheat	Oats	Barley	Rye	Flax	Total
1915:						
Acres	92,087	34,869	3.064	454	4,343	134,817
% Total Crops	68.3	25.8	2.3	0.3	3.2	....
1916:						
Acres	94,379	28,561	2,800	675	5,371	131,786
% Total Crops	71.6	21.6	2.2	0.5	4.1	....
1917:						
Acres	85,370	80,334	8,262	837	10,998	185,801
% Total Crops	45.9	43.3	4.4	0.4	6.0	....
1918:						
Acres	134,464	36,442	4,930	678	3,716	180,230
% Total Crops	74.6	20.3	2.7	0.3	2.1	....
1919:						
Acres	247,740	27,020	1.003	1,628	7,650	285,041
% Total Crops	86.9	9.4	0.3	0.5	2.7	....
1920:						
Acres	391,153	62,006	2,319	2,685	15,411	473,574
% Total Crops	82.6	13.2	0.5	0.5	3.2	....

The data in Table IV, showing the acreage of various crops produced in the Sounding Creek Sheet are obtained from the Provincial Annual Reports of Agriculture, and are the figures given for the constituency of Acadia. It will, therefore, be understood that the figures in this table are simply estimations of the crop acreage of the Sounding Creek Sheet.

While Table IV includes figures for only six years, it is sufficient to show the general distribution of the various agricultural crops of the Sounding Creek Sheet, and it will be observed that the wheat and oat crops nearly always make up over 90 per cent. of the total crop area, and that wheat is usually grown to a much greater extent than oats. There is a small proportion of the total crop area devoted to corn, alfalfa, cultivated grasses, and other crops, not mentioned in Table IV, but exact figures for these crops are not available, and they are, therefore, omitted from the table.

TABLE V.—COMPARATIVE YIELDS OF CROPS IN ALBERTA.

BUSHELS PER ACRE—13-YEAR AVERAGE, 1910-1922

Constituency	Spring Wheat	Winter Wheat	Oats	Barley	Rye	Flax
Acadia*	14.38	14.19	23.77	18.29	10.66	5.95
Claresholm	19.24	20.57	31.11	21.10	18.69	10.57
South Edmonton	23.76	22.53	36.46	28.60	17.76	11.58
Aver. for Province	19.52	19.30	31.71	22.81	18.17	8.87

*14-year average, 1913-26.

Figures for the comparative yields in bushels per acre obtained in the principal constituency (Acadia) of the Sounding Creek Sheet are recorded in Table V. These were taken from the Annual Report of the Department of Agriculture of the Province of Alberta for the year 1922. Yields for the constituencies of Claresholm and South Edmonton, and for the province as a whole, are also included in this table, in order to compare the yields of the Sounding Creek Sheet with the yields of the moister sections to the west and to the north, and with the average yield of the whole province. It will be observed that the yields obtained in the Sounding Creek area are distinctly lower than obtained in districts at some distance to the west and to the north, and lower than the average yields for the whole province. For example, the average yield of spring wheat, the principal crop of the Sounding Creek Sheet, is 14.38 bushels, whereas the average for the whole province is 19.52 bushels.

The yields in Table V are obtained from threshers' returns, and are the most reliable estimates we have, yet they do not tell the entire story. The threshers' returns include the bushels actually threshed and the statement as to the acres thus represented; but, in the first place, the exact acreage is not always known, and, in the second place, a considerable portion of the crop seeded may never be threshed in the poorer seasons. Therefore, the returns are very good estimates for the better crop years, but are somewhat too optimistic for the poorer years.

The amount and distribution of annual rainfall are two of the most important factors in the production of crops in the Sounding Creek Sheet. In order to show the relationship of wheat yields, total precipitation, and precipitation during the wheat growing months, Table VI, has been constructed.

At no point in the Sounding Creek Sheet have consistent rainfall records been kept for the years for which wheat yields are reported in Table VI. However, the rainfall for this Sheet must be very similar to that of the Medicine Hat Sheet since the native vegetation and the soil profiles are very similar. The annual yields of wheat are for the Acadia constituency, which is almost identical in area and location with the Sounding Creek Sheet.

From Table VI, it is quite evident that the fluctuations in wheat yields are quite closely related to the fluctuations in rainfall.

The average annual yield of wheat is 14.38 bushels and the average annual precipitation is 12.33 inches. The extreme variation in yield is from 5.4 to 40.4 bushels per acre, whereas the extreme variation in annual precipitation is from 7.66 to 17.90 inches.

TABLE VI.—YIELDS, SEASONAL AND ANNUAL PRECIPITATIONS.

1913-1926.

Year	Wheat per acre, bus.	Precipitation April, May, June, July	Annual precipitation	Bushels per inch of annual precipitation
1913	17.91	7.10	13.62	1.31
1914	8.87	2.89	12.17	.73
1915	40.39	10.97	16.13	2.50
1916	29.11	10.70	17.90	1.61
1917	18.00	3.31	11.13	1.61
1918	5.39	3.52	10.19	0.53
1919	5.52	3.74	7.66	0.72
1920	15.73	5.46	10.74	1.47
1921	7.93	6.71	11.74	0.67
1922	6.70	6.51	11.34	0.59
1923	20.83	9.78	13.64	1.52
1924	6.0	1.69	9.86	0.61
1925	10.0	7.61	14.61	0.68
1926	9.0	3.67	11.90	0.75
Average	14.38	5.97	12.33	1.16

The lowest yield does not always occur during the season of lowest rainfall, neither does the highest yield always occur during the season of greatest rainfall, otherwise 1916 should have shown the highest yield. Other factors, such as a succession of either wet or dry years, distribution of rainfall, severe frosts, crop diseases, etc., prevent absolute harmony between rainfall and yields. However, in general, the seasons of low rainfall are the seasons of low yields, and likewise the seasons of high rainfall are the seasons of high crop yields.

As previously pointed out, the economic efficiency of a unit of rainfall is generally comparatively low during the drier seasons, since the rainfall during such seasons is sufficiently low to materially reduce, or even almost inhibit, the maturing of crops. By dividing the yield figures by the rainfall figures for the corresponding year we obtain figures representing the bushels of wheat produced for each inch of rainfall. Such values for the 14 years are reported in Table VI. There is a great amount of variation from season to season; the drier years produced only about .5 bushels of wheat per inch of annual rainfall, whereas 2.5 bushels were produced in 1915 for a similar unit of rainfall. As an average of the 14 years, each inch of annual precipitation produced 1.16 bushels of wheat. The efficiency of a unit of rainfall in the Sounding Creek Sheet is very similar to rainfall efficiency in any other part of the drier belts of Alberta as shown by the following summarized tabulation.

POUNDS OF WATER REQUIRED TO PRODUCE ONE POUND OF DRY MATTER.

	Sounding Creek Sheet	Medicine Hat Sheet	Macleod Sheet
Grain and Straw.............	1628	1642	1701
Grain only (wheat)	3256	3284	3402
Bushels of wheat per acre per inch annual ppt.	1.16	1.15	1.11

It is shown, in Table VI, that each inch of annual rainfall produced as an average of 15 years, 1.16 bushels of wheat per acre. From this it may be calculated that each pound of wheat (grain only) required about 3,256 pounds of water. Now, if we assume that the yield of straw per acre is equal to the yield of grain we have an average water requirement of 1,628 pounds per each pound of dry matter produced in the form of the wheat crop.

These figures represent the actual conditions as they exist in the Sounding Creek Sheet, according to the present system and methods of farming.

The relationship of crop yields to the evapo-transpiration and run-off water, or to the sum of the quantities of water removed from the soil by evaporation, transpiration through plants, and run-off, is clearly shown. The water requirement is undoubtedly too high, and the farmer, by paying more attention to crop rotation, fallowing, and other cultural practices, should be able to materially reduce it. For example, the introduction of summer fallow substitutes, such as corn, would almost certainly lead to a more efficient utilization of available moisture.

On account of a series of dry years much of the land that had been homesteaded and broken for wheat farming was, a few years later, deserted, and this land has become very weedy, Russian thistle being especially abundant. Gradually, however, these weeds are being displaced by native grasses, and eventually a good grass sod will be formed, and the land will once more be valuable as pasture or ranch land. No doubt this process could be hastened in many places by sowing suitable grass seed.

Even yet settlers are moving away from the district, and it is evident that the unmodified wheat farming practice cannot be depended upon as a permanent system of agriculture. Where suitable water supplies are available from wells or rivers, some live stock should be kept and some forage or green feed crops should be grown in addition to the wheat crop. Among the forage crops which might be suggested are rye, oats, corn, brome grass and sweet clover. It is possible to produce green feed for live stock in dry years when the wheat crop is not satisfactory. Cattle and sheep should be kept in greater numbers, and some of the land could then be left in pasture at all times.

For much of the rougher land, however, and for some of the larger sand areas, the only solution would seem to be to turn the land back to ranching. Here again, of course, an adequate water supply is essential. Increases in cattle and sheep ranching are to be expected.

SOILS OF THE SOUNDING CREEK SHEET.

The soils of the Sounding Creek Sheet (see accompanying map) consist chiefly of Glacial drift derived largely from the material weathered from the underlying formations. Some of the drift material, however, was undoubtedly carried long distances by the Keewatin glaciers which moved down from the Hudson's Bay region. The formations underlying this glacial drift material were laid down during the upper Cretaceous Period. (For detailed statement of the geology of this area, see Appendix II, by Dr. J. A. Allan.) The Sounding Creek Sheet is underlaid, from east to west, by the Belly River, Bear Paw, and Edmonton formations, and, at the western end, by a small area of Paskapoo formation in the vicinity of the Hand Hills. The glacial drift and boulder clay overlying the various formations varies in thickness from a few inches to more than two hundred feet. In a few locations there is no covering of drift, and the country rock may be seen at the surface, weathering in place. The underlying formations consist mainly of sandstone and shale or clay, each of which forms a somewhat different soil on erosion. (See Plate 3, Fig. 1.)

The general effect of glaciation has been to level up the lowest areas and leave a wide plain. This plain is by no means uniformly level, however, as it varies considerably in elevation, and it is cut up by many drainage channels consisting of coulees (see Plate 1, Fig. 2), creeks, and, in the south-west corner, the Red Deer River. A good deal of the plain is rolling in nature, and in some parts it is quite hilly (see Plate 1, Fig. 3). About 40 per cent. of the land in the eastern half of the Sheet is of a rolling and, occasionally, hilly nature, and, in the north-west quarter of the Sheet, there is a large area of rolling land in ranges 15 and 16 (see map). The rolling and hilly land of the Sounding Creek Sheet was largely formed by glacial deposits and post glacial erosion, with the exception of that part occurring in ranges 15 and 16, which undoubtedly consists largely of eroded or worn down extensions of the Hand Hills (see Plate 3, Fig. 1).

Much of the glacial material remains in nearly the same position as when deposited by the melting ice sheet. There is evidence of only a moderate amount of reworking of the materials. Some of the rolling and hilly areas are rather stony and gravelly, and are evidently morainal formations (see Plate 1, Fig. 3.) Much of the rolling area at the western end of the Sheet is not morainal in nature, but was evidently formed by the erosion of the Hand Hills plain. Water-worn stones scattered over certain parts of this rolling area have come from the formation capping the Hand Hills (see Plate

2, Fig. 1). It will be observed that most of the important sandy loam, sand, and mixed areas occupy positions adjacent to lakes, flats, or drainage channels, where sorting by water has undoubtedly been responsible for the deposition of sand. Many of the leveler areas (see Plate 1, Fig. 1) of intermediate and fine soil were laid down in temporary lakes developed when the glaciers were melting and temporarily damming up the natural outlets.

As previously stated the underlying formations consist largely of sandstones and shales. The sandstones are composed of the finer grades of sand held together by clay, some of which apparently is calcareous. Typical shales are made up largely of clay, but these shales are often very sandy, with clay as the chief binding material. Thus it might be expected that the weathering of these country rocks, and the subsequent mixing and reworking of the materials, would give rise to soils of intermediate character. In some instances the reworking and assorting by water has been carried on to such a degree as to separate the weathered materials into areas of sand and clay, or clay loam. For the most part, however, the soils are intermediate in texture, and intermediate soils are, after all, the most desirable general purpose classes of soils.

The figures in Table VII show that over half of the area of the Sounding Creek Sheet consists of loam and silt loam soils, and that about four-fifths of the area consists of soils of medium to heavy texture. The lighter types, sands and sandy loams, make up about eleven per cent. of the total, while the mixed, eroded, alkali, and water areas occupy about seven per cent. Only about five per cent. of the soils consist of clays and clay loams, or soils sufficiently heavy to cause some difficulty in tillage operations. It is rather fortunate that such a large proportion of this area consists of soils of medium to heavy texture, with good subsoils, since such soils absorb and carry more moisture from one season to another than do the lighter soils.

TABLE VII.—VARIOUS SOIL TYPES IN THE SOUNDING CREEK SHEET.

Soil Types.	Acres.	% of Total.
Sand	60,928	2.3
Sandy Loam	245,499	8.8
Course Sandy Loam	9,504	0.3
Loam	1,231,577	44.6
Silt Loam	244,656	8.8
Clay Loam	81,200	3.0
Clay	51,066	1.8
Blowout Loam	55,482	23.1
Mixed Areas	51,608	1.8
Eroded Areas	118,760	4.3
Alkali	15,213	0.5
Water	19,307	0.7
Total	2,764,800	100.0
Total rolling areas	581,726	21.8
Total hilly areas	69,120	2.5

The colors of the soils of this Sheet vary as follows: very dark brown, dark brown, reddish brown, light brown, dark gray. The subsurface soils and subsoils are almost invariably light colored, varying from very light brown to gray or light gray, and in some cases they are almost white.

The organic matter extends down from a few inches to about a foot, with an average of perhaps four to seven inches. In some instances these soils are deficient in organic matter, and in no instances do they contain as much organic matter as the soils in some other parts of the province, but they are fertile for the most part, and respond with excellent crop yields when the supply of water is sufficient. They are generally well supplied with the mineral plant foods (see Table VIII). The surface layers are lowest in limestone, because this constituent is readily leached into the lower layers, and because plants absorb more calcium from the surface than from the subsoil.

Brief descriptions of the two most characteristic loam profiles found in the Sounding Creek Sheet are given below:

No. 1. This profile is characterized by its relatively shallow A and B horizons and the nearness of the lime layer to the surface. A_1: Average thickness 4 to 6 inches; brown loam to silt loam; granular tendency and almost never acid in reaction. A_2 or B_1: average thickness 4 to 8 inches; brown silt loam; indication of columnar structure, though somewhat granular. B_1 not always easily distinguished from A_2. B_2: average thickness 8 to 12 inches; gray silt loam to clay loam; no pronounced structure; this is the lime layer and may be encountered at depths varying from 9 to 22 inches. C: parent glacial drift; gray silt loam to clay loam; spotted or streaked with occasional iron stains; this parent material is relatively high in lime. Stones may occur throughout the entire profile. (See Plate 4, Fig. 1.)

No. 2. This profile of the "blowout" area is characterized by its relatively shallow A and B horizons,, but differs from profile No. 1 in that the A horizon is often absent from the slick spots; the lime is found relatively nearer the surface; the B layers are much heavier in texture and very impervious to water. The A_1 horizon is similar in texture and structure to that of profile No. 1, but is usually very slightly acid in the "blowout" areas. B_1: very shallow, heavy in texture and decidedly granular. B_2: decidedly granular, heavy clay loam; this is the lime layer and is encountered at depths varying from 6 to 12 inches. TheB layers are very impervious to water. C: parent glacial drift; gray clay loam to clay; spotted with lime accumulations and iron stains. Very similar to the corresponding horizon in profile No. 1. Glacial stones are less abundant in this soil class than in the case of profile No. 1. (See Plate 4.)

Sand.

The sand areas constitute only about two or three per cent. of the soils of the Sounding Creek Sheet. By definition they contain less than 20 per cent. of clay and silt, and 80 per cent. or more of sand (see Appendix I). They belong chiefly to the medium sand class, since they are made up very largely of medium sand, but in certain parts they grade into find sand, and occasionally into coarse sand. The subsurface and subsoil, as a rule, have about the same texture as the surface soil, and the sand layer varies in depth from a few feet to upwards of thirty feet, especially in the dune areas.

The topography of sand dune areas is, for the most part, undulating, but there is an area of rolling sandy soil in the north-east corner of the Sheet, and sand dunes are to be found scattered over the two main sandy areas, as indicated on the map.

In color the surface soil varies from dark brown to light brown, and the subsurface and subsoil from light brown to gray. The color of the surface soil is influenced by the amount of organic matter present, and the depth of organic matter varies from practically nothing, in some of the active dune areas, to perhaps six or eight inches in the better areas.

The sand areas of this Sheet have been formed by the weathering of the underlying sandstones, belonging chiefly to the Belly River, Bearpaw, and Edmonton formations. As previously observed, most of the important sand, sandy loam and mixed areas occupy positions adjacent to lakes, flats, or drainage channels, where sorting by water has undoubtedly been responsible for the deposition of sand. The largest sand area, by far, occurs in the north central part of the Sheet, or north of Youngstown, in the vicinity of Antelope Lake. Then there is an area of sand in the north-east corner of the sheet, and another relatively small area occurs on the eastern edge of the Sheet, south of Alsask. Apart from these there are no large or important areas of sand.

These sands are incoherent in nature and blow readily if the grass covering is disturbed. Dunes are to be found in parts of the large sand areas (see soil map). The dune areas cannot be successfully cultivated, and should be kept covered by native vegetation, if possible, to prevent their further spread.

In many places the native vegetation is characteristic of sandy soils in the southern part of the province, and includes sand grass, spear grass, and a native legume called buffalo bean.

These sands absorb water readily and are naturally well drained, but they do not retain much of the absorbed water. The excess water percolates rapidly until it encounters impervious layers, where it is usually beyond the reach of ordinary crop plant roots. For this reason crops on sands suffer readily from drought. Moreover, the reserves of plant food, as shown in Table VIII, are not nearly as great in sands as in the heavier soils. It will be seen that the nitrogen content of sand is only about one-third as great as that of the heavier soils. These sands should be devoted largely to the production of permanent natural grasses, or such grasses as brome and western rye, for pasture, and thus avoid, as far as possible, any further drifting of soil and formation of sand dunes.

Coarse Sandy Loam.

The coarse sandy loam soils constitute less than one-half of one per cent. of the soils of the Sounding Creek Sheet. By definition sandy loam soils contain 50 per cent. to 80 per cent. of sand, and less than 20 per cent. of clay (see Appendix I). These soils are fairly light in texture. There are only two relatively small areas in the Sounding Creek Sheet classified as coarse sandy loam, and these are so-called because they contain a good deal of coarse sand and fine gravel. One of these areas occurs on the eastern edge of the Sheet, south of the Goose Lake Line, and the other occurs on the northern edge, west of the large sand area previously discussed. The topography of both of these areas is undulating rather than rolling. The coarse sandy loams absorb water readily, and retain it better than the sands, but not as well as the finer soils. Hence crops on sandy loams suffer more severely from drought than crops on heavier classes of soil, but less severely than crops on sands. The two areas referred to are not extensive and it seems advisable that they should be devoted to the production of permanent natural grasses, or such grasses as brome and western rye, for pasture.

Medium Sandy Loam.

There are numerous scattered areas of sandy or medium sandy loam soil in the Sounding Creek Sheet. The largest of these surrounds a large sand area in the north central part of the Sheet, or lies north of Youngstown, Scotfield, and Dobson, but most of the sandy loam areas are relatively sma (see map). They constitute altogether about nine per cent. of the total area of the Sheet. These soils are fairly light in texture. Generally the subsurface soils and subsoils are heavier than the surface soils, but this is not always the case. There are some small patches within the fine sandy loam areas which are lighter or heavier than the general class; but which are not large enough to outline separately in a survey of this kind. In some cases, also, there is no sharp divisional line between different soil classes, but a gradual transition from sandy loam into sand, on the one hand, or into loam on the other, and in these cases the divisional line was chosen arbitrarily. The soil map shows that in most cases the soil classes adjacent to sandy loam are either sand or loam.

The topography of the sandy loam areas is for the most part undulating, but there are occasional areas within this Sheet where the sandy loams are rolling or even hilly.

The color of the surface soil is generally dark brown, but it varies from dark brown to light brown, and the subsurface and subsoil vary from light brown to gray. The organic matter layer varies in depth from about four inches to about one foot.

The sandy loams absorb water readily and retain it better than the sands, but not as well as the finer soils. The excess percolates to a depth greater than that of the ordinary plant roots, or until it encounters less previous layers. Hence crops on sandy loams suffer more severaly from drought than crops on heavier classes of soil, but less severely than crops on sands. Furthermore, the average sandy loam is more fertile than the average sand, being richer in nitrogen, phosphorus, potassium, calcium and magnesium, and for this reason, also, may be expected to produce better crops (see Table VIII). Since sandy loams are relative loose and open, and drift rather easily when the organic matter content is reduced, a cropping system should be followed which would tend to maintain the soil's supply of fibre and fertility. Grasses such as brome and western rye, and legumes such as sweet clover and alfalfa, should be grown at intervals in the rotation.

Loam.

The loam areas, apart from the blowout phase, constitute about forty-five per cent. of the total area of the Sheet, and are therefore more extensive, by far, than any other class of soil. By definition (see Appendix I) the loams contain less than 20 per cent. clay, less than 50 per cent. silt, and less than 50 per cent. gravel and sand. The proportions of sand, silt, and clay are, therefore, such as to impart no predominating property of one constituent, and the soil is intermediate in character. In practise, of course, the loam areas are not altogether uniform, and this is particularly true of the rolling and hilly phases. There are some patches of loam that are lighter or heavier than the general class, but these are not large enough to outline separately in a survey of this kind. In some cases, also, there is no sharp division line between the different soil classes, but a gradual transition from loam into sandy loam, on the one hand, or into a heavier class of soil on the other hand, and in these cases the divisional line was, of necessity, chosen arbitrarily.

Loam is the predominating class of soil in the eastern half of the Sheet; then there is a wide belt in which blowout loam is the principal class of soil, and, at the western end of the Sheet loam again predominates. The blowout loams will be discussed separately, however.

The topography of the loams is in part undulating or gently rolling, in part rolling, and occasionally hilly. The rolling and hilly phases may be distinguished on the soil map by a special cross-hatching. It will be observed that they are together about as extensive as the undulating or gently rolling loam areas.

The surface soils vary in color from very dark brown to brown, with dark brown predominating, and the subsurface and subsoils vary from brown to light gray, with gray predominating. The organic matter layer varies in depth from about six inches to about one foot, the average depth being closer to the former figure than to the latter.

In various places within the Sheet the loams are more fertile or more favorably located in relation to rainfall than they are throughout the Sheet in general. The rolling loam area in the north-west corner of the Sheet is really an extension of the Hand Hills, and is, on the whole, relatively fertile. The loam area just south of Sheerness has also been influenced by the Hand Hills, and is likewise relatively fertile. Other areas of relatively fertile loam farther east might also be mentioned, but these areas are comparatively small.

The loams absorb water readily, and retain fairly large quantities of moisture that may be used by crops in periods of scanty rainfall, or carried over from season to season. In fact the loam and silt loam classes are very desirable from the standpoint of resistance to drought. Furthermore the average loam is relatively fertile (see Table VIII). If surface soils are compared it will be observed that loam contains as much nitrogen and organic matter as any other soil class except clay, and contains as much phosphorus as any other class except clay loam and clay. Loams are, therefore, desirable from the standpoint of texture and fertility, and are adapted to a wide variety of corps.

The agricultural value of land is often greatly reduced by the presence of many stones. It is therefore important to refer to certain of the loam areas which are especially stony. Stones are numerous along the Sounding Creek and tributary coulees and erosions in township 30, ranges 5, 6, 7, and 8, and especially in township 30, range 5. Stones are also rather plentiful in the south-east quarter of the Sheet, in the rolling loam areas lying north, east and west of Acadia Valley. In some of the rolling loam areas south of Cereal, or west of Alkali Creek, stones are numerous, and in the south-west corner of the Sheet, near the Red Deer River, the loam soil is rather stony for cultivation.

Loam (Blowout Phase).

The very large area in the western half of the Sheet, classed as blowout-phase loam, and distinguished on the map by a special color, constitutes about twenty-three per cent. of the total area of the Sheet. In general topography these soils are undulating or gently rolling. Stones are numerous along the various erosion courses, creeks, and coulees within this area, particularly in the south-west quarter of the Sheet, where the principal drainage courses referred to are, Blood Indian, Berry, and Bullpound Creeks.

Many areas of soil of this peculiar nature are to be found in south-eastern Alberta, in the other prairie provinces and the United States, and in other parts of the world. Numerous shallow depressions or "blowout spots" varying in depth from about six inches to about eighteen inches, irregular in shape, but varying in diameter from about five feet to about fifteen feet or more, are to be found throughout the entire area (see Plate 2, Fig. 2). In some places these depressed spots are very numerous and make up nearly half the entire surface, but for the most part they are not so numerous, and in some places there are only a few scattered depressions or "blowouts.'

Depressed spots of this nature are given various names, such as "blowouts," "burnouts," "slick spots," etc. Often the depressions are almost bare, or but scantily covered with grass, although the surface soil round about is covered by prairie grass. An examination of the soil structure reveals the fact that the surface of the depression is usually rather fine and impervious in nature, and this rather impervious layer extends for some distance underneath the surface layer surrounding the depression, and may form a continuous subsurface layer between depressions. As a rule the surface soil between depressions is distinctly more open in texture, and when soils of this class are plowed and cultivated for some years the depressions are filled in, the finer and coarser layers are mixed up, and the resulting surface soil could properly be classed, in this area, as loam. But because of the lack of grass in the depressed spots, and the rather undesirable nature of the subsurface layer, this class of soil, when first brought under cultivation, is not as fertile, nor as desirable in texture as ordinary silt loam. The surface soil is lower in nitrogen than any other class of soil except fine sand (see Table VIII).

We have called these spots "blowouts" rather than "burn-outs," as it seems unlikely that the depressions could have been burned out, since the surface layer between the depressions consists of soil which is not exceptionally rich in combustible organic matter, and could not possibly be burned off to the depth of the depressed spots. On the other hand, when rain falls, puddles are formed in depressions, and it is suggested that this water and the "alkali" salts which tend to accumulate in the depressions have kept down the growth of grass, and have thus permitted the looser surface soil to blow away from these spots, and form the so-called "blow-outs."

It is remarkable that, in the places where the blowout spots are numerous the surface soils were always found to be slightly acid in reaction, and this was true not only of such areas within the Sounding Creek Sheet, but of all the areas surveyed in south-eastern Alberta where blowout spots are numerous. In no other cases were the soils surveyed in this or other Sheets of south-eastern Alberta found to be acid. So far no satisfactory explanation of this condition has been found, and these soils are deserving of further special study.

Silt Loam.

The silt loam areas constitute about nine per cent. of the total area of the Sheet. By definition (see Appendix I) silt loams contain less than 20 per cent. clay, and more than 50 per cent. silt. The predominating constituent is silt, which constituent naturally gives to the soil its characteristic property. The soil texture is, therefore, fine, but only moderately sticky. The silt loam areas, like other areas, are not altogether uniform, and this is particularly true of the rolling phase. There are some patches of silt loam that are lighter or heavier than the general class, but which are not large enough to outline separately in a survey of this kind. In some cases, also, there is no sharp divisional line between different soil classes, but a gradual transition from silt loam, usually into loam, on the one hand, or into clay loam or clay, on the other hand.

The subsoils are usually heavier than the surface soils and could be classed, in most cases, as heavy silt loam, or silty clay loam. For the most part the subsoils are fairly uniform in texture with high proportions of silt.

Numerous areas of silt loam are to be found east of Range 10, but none of the soils farther west have been so classified. Some of these scattered areas are very small, while others are moderately large.

The topography of these silt loam areas is in part undulating or gently rolling, and in part rolling, with only a very small area classified as hilly. In most places the land is relatively free from stones and gravel.

The surface soil varies in color from brown to very dark brown, with dark brown predominating, and the subsurface soils and subsoils vary from brown to light gray, with gray predominating. The organic matter layer varies in depth from about six inches to about one foot, the average depth being closer to the former figure than to the latter.

The silt loams absorb water rather readily and retain fairly large quantities of moisture that may be used by crops in periods of scanty rainfall, or carried over from season to season. On the whole, there is probably no more desirable class of soil, from the standpoint of resistance to drought, than a silt loam with a deep silty subsoil. Heavier soils absorb more water, but the rate of absorption is slower, run-off losses are greater, and plants cannot extract as much water from heavier soils, as it is held more tenaciously by the finer soil particles.

The average silt loam is relatively fertile (see Table VIII). If surface soils are compared it will be observed that silt loam contains about as much nitrogen and phosphorus as any other soil except clay. Silt loams are, therefore, desirable from the standpoint of fertility as well as texture, and are adapted to a wide variety of crops.

Clay Loam.

The areas classed as clay loam make up only about three per cent. of the total area of the Sheet. The largest individual area is located in the south central part of the Sheet. A number of smaller clay loam areas are to be found near the eastern end of the Sheet, and in various other parts, the individual areas being, as a rule, rather small.

By definition (see Appendix I) clay loams contain 20 to 30 per cent. of clay, and they are, therefore, somewhat sticky and rather heavy to work, and should not be cultivated when too wet, as this would injure the soil texture, at least temporarily. Some of the low-lying clay loam flats contain a good deal of salt, as, for example, the "alkali" clay loam flat a few miles west of Youngstown. For this reason these flats are not as productive as they would be otherwise, and should not be brought under cultivation. Clay loams, however, can withstand more "alkali" than the lighter soil classes, and, since they absorb and retain a good deal of moisture, they are also fairly resistant to drought. From the standpoint of soil fertility clay loams are usually satisfactory also (see Table VIII).

Clay.

No very extensive areas in the Sounding Creek Sheet have been classed as clay, the clays altogether making up only about two per cent. of the total area of the Sheet. The largest individual area is located in the south-east corner of the Sheet, in the vicinity of Acadia Valley, and other smaller areas of clay are to be found in various parts of the sheet. Numerous small clay flats, which were outlined on the township maps, were considered too small to transfer to the printed maps. Most of the mixed areas outlined on the map contain a considerable proportion of clay soil. The clay areas are rather flat in nearly all cases, but it will be observed that rolling areas were found occasionally.

The clay soils are for the most part exceedingly heavy and tenacious, and are worked with some difficulty. By definition (see Appendix I), any soil which contains over 30 per cent. of clay is classed as clay. Such soils must be handled carefully and should not be worked when too wet, as this injures the soil texture. The disc plow may be advantageously substituted for the mold board plow in these areas.

Since clay soils absorb a good deal of moisture, and retain it tenaciously, they are fairly resistant in drought, and will often produce better crops in dry years than some of the lighter soils. Moreover, the average clay soil is richer in nitrogen, phosphorus, and other essential elements than any other class of soil (see Table VIII).

Mixed Areas.

The areas outlined as mixed constitute about two per cent. of the total area. Mixed areas are to be found in all quarters of the Sheet, and they consist of more than one, and usually several, classes of soil, so mixed together as to make it impossible to outline each class separately in a survey of this kind. In some cases it would be necessary to call the areas mixed, even with a detailed survey, as it would be impossible to establish boundaries between different soil classes. No doubt most of the mixed areas were formed as a result of the sorting action of water during glacial or more recent times. This in indicated by the fact that most of the mixed areas are now found along drainage creeks or around lakes, as, for example, along Bullpound, Alkali, and Soundings Creeks, and in the vicinity of Dowling Lake.

Eroded Areas.

The eroded areas constitute about four or five per cent. of the total area of the Sheet, and occur chiefly along or adjacent to creeks, coulees, and drainage ways generally. There is some eroded land along the Red Deer River, where it touches the south-west corner of the Sheet, but most of the eroded land occurs along Sounding, Blood Indian, Berry, and Bullpound Creeks. In many cases these areas consist of clay subsoil from which the surface soil has been washed away, and in many places boulders, stones, or gravel have been left exposed upon the surface. In other places the banks are relatively free from stones, and are fairly smooth and loamy in character. For the most part, however, the eroded areas are composed of land which, because of its steep, rough, or stony character, is difficult or impossible to till.

COMPOSITION OF SOILS OF SOUNDING CREEK SHEET.

The average chemical compositions of the soils of the Sounding Creek Sheet are given in Table VIII.

It may be seen from Table VIII that for all types of soil the nitrogen content is highest in the surface and usually lowest in the subsoil. This is accounted for by the fact that nearly all of the nitrogen is held in the form organic matter, and most of the organic matter is to be found near the surface. There is a gradual decrease in nitrogen from surface to subsoil, and in general the surface contains two to three times as much nitrogen as the subsoil. The clay contains most nitrogen and the sand least.

The average phosphorus is about the same for the surface, subsurface, and subsoil of any one soil type, and the various soil types do not differ markedly, although here again the clay contains most and the sand least. Our best Alberta soils contain about twice as much phosphorus as the average shown in Table VIII and our poorest only about two-thirds as much.

TABLE VIII.—AVERAGE CHEMICAL COMPOSITION OF THE VARIOUS SOIL TYPES.

Depth	N%	P%	K%	Ca%	Mg %	Carbonates in terms of $CaCO_3$ %
			SAND.			
Surface	.048	.035	1.12	.61	.12	.05
Subsurface	.026	.028	1.07	.62	.10	.09
Subsoil	.017	.025	1.11	.66	.12	.33
			SANDY LOAM.			
Surface	.153	.045	1.29	.66	.14	.03
Subsurface	.049	.044	1.20	.57	.18	.17
Subsoil	.023	.035	1.33	.87	.18	.57
			LOAM.			
Surface	.177	.060	1.33	.87	.28	.46
Subsurface	.092	.055	1.37	1.30	.37	2.15
Subsoil	.061	.059	1.44	2.11	.66	4.45
			LOAM BLOWOUT PHASE			
Surface	.177	.061	1.33	.59	.23	.05
Subsurface	.102	.053	1.32	.79	.42	.34
Subsoil	.058	.055	1.77	1.09	.56	1.28
			SILT LOAM.			
Surface	.174	.055	1.39	.68	.39	.43
Subsurface	.101	.054	1.57	1.60	.72	4.84
Subsoil	.054	.055	1.57	2.10	.73	6.43
			CLAY LOAM.			
Surface	.113	.066	......	.82	.49	.28
Subsurface	.062	.063	......	1.78	.61	2.60
Subsoil	.086	.064	......	.79	.32	.52
			CLAY.			
Surface	.214	.074	1.68	1.37	1.05	1.62
Subsurface	.136	.063	1.63	1.63	1.12	2.18
Subsoil	.116	.059	1.57	1.44	1.19	2.64

NOTE: Surface 0 to 6 2/3 inches; Subsurface 6 2/3 to 20 inches, and Subsoil 20 to 40 inches.

The calcium and magnesium are frequently lowest in the surface soils and highest in the subsoils, whereas the phosphorus and potassium are about equally abundant in the surface and subsoils. This is accounted for by the fact that the former two elements are much more soluble than the phosphorus or potassium of the soil, and any rain penetrating the soil carries them downwards. Again, the quantities required to produce the native grasses and farm crops are taken largely from the surface soil. Many of the soils contain more than twice as much calcium as magnesium. The magnesium of the soil is less soluble than the calcium, and the plants demand less magnesium than calcium. It should be noted that the soils of this Sheet are not generally deficient in either calcium or magnesium.

The potassium as a rule is about the same in the surface as in the subsurface and subsoil. The finer textured soils contain more potassium than the coarser soils, clay having the highest percentage and sand the lowest.

The carbonates, expressed as calcium carbonate (limestone), are usually lowest in the surface and highest in the subsoils. The reason for this is given above under the statement about calcium and magnesium. The soils of this sheet are not so high in carbonates (limestone) as are the soils of the Macleod Sheet to the south-west. The formations underlying much of the Sounding Creek Sheet are not nearly as rich in limestone as are the newer formations which underlie the soils of the Macleod Sheet.

The sandy loam (Table VIII) contains the lowest amount of carbonate, .025 per cent. in the surface. This is equal to about ¼ ton of limestone. The clay is highest with 1.62 per cent., or about 16 tons per acre. There is sufficient limestone in all these soils to permit the growth of legumes.

Practically all of the elements mentioned in Table VIII are least abundant in sand and most abundant in clay. As a rule, sand is the least productive type in the area surveyed. Next to sand, sandy loam is usually poorest in essential elements. Because of their physical nature, clay loam and clay are not altogether desirable types, but they are exceptionally rich in plant food, as a rule. Because of its physical nature, also, the "blowout phase" loam is not an altogether desirable type of soil. The intermediate types, silt loam and loam, are usually intermediate in fertility as well as in physical nature, and are usually our best general purpose soils.

Fig. 1.—Typical level topography of Sounding Creek Sheet.

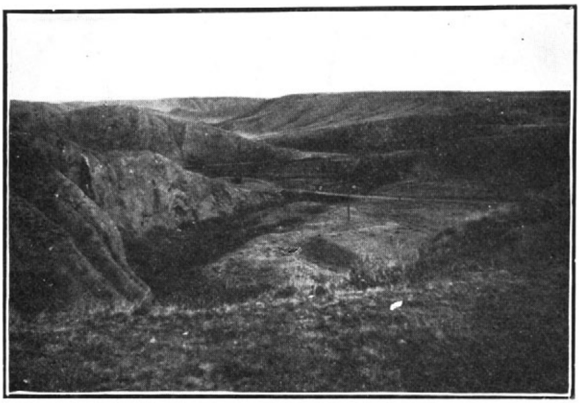

Fig. 2.—Rough topography typical of areas classed as "eroded."

Fig. 3.—Hilly topography, in this case morainal in nature. Note glacial stones.

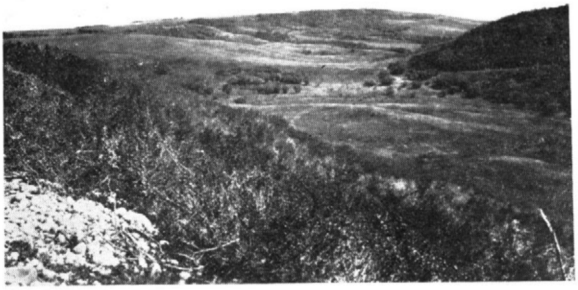

Fig. 1.—North-western part of Hand Hills. Note conglomerate and tree growth.

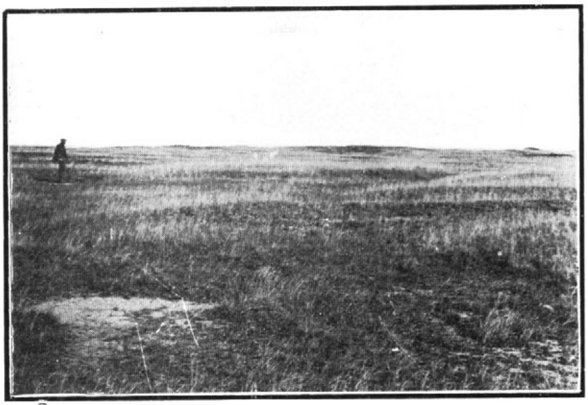

Fig. 2.—"Blowout" area. Note irregularity of vegetation and depressed bare patches from which surface soil has been blown.

Fig. 3.—Note the alkali salts on the dry bed of the lake, giving the appearance of snow.

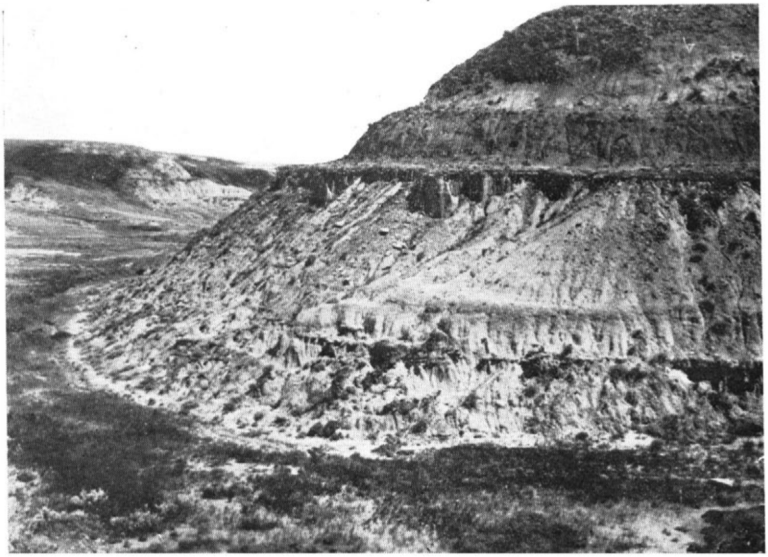

Fig. 1.—Exposure on branch of Bullpound Creek, Tp. 28, R. 14. Note glacial drift on top and underlying formation consisting of thick layers of shale and thin layers of sandstone.

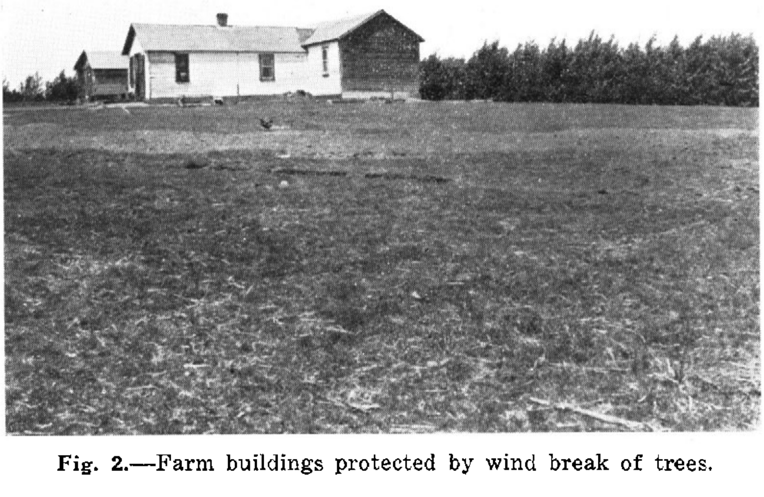

Fig. 2.—Farm buildings protected by wind break of trees.

Fig. 1.—Brown soil profile. Note nearness to the surface of B2 (lime layer).

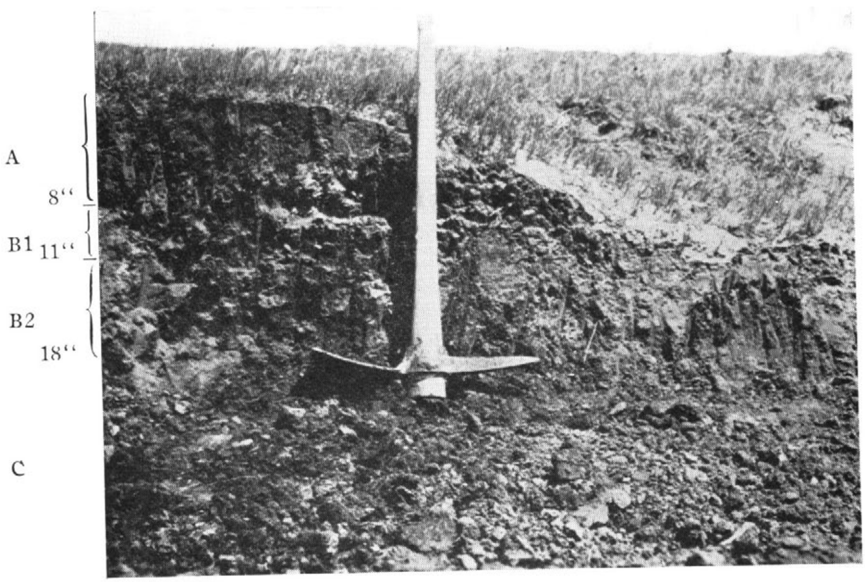

Fig. 2.—Blowout soil profile.

Again we may make another kind of comparison showing the relation between the supply of essential elements present in the soils and the quantities required by crops. From the per cent. of any essential element found in the soil and the crop, it is not difficult to calculate the quantity present in a given depth and area of soil, and how many crops such a soil could theoretically produce. For example, a thirty-bushel crop of wheat, including straw, would require about 57 pounds of nitrogen, 9 pounds of phosphorus, 6.3 pounds of calcium, 4.8 pounds of magnesium, and 35 pounds of potassium. The average soil to the depth of 6 to 7 inches would weight two million pounds per acre. Thus by using the data in Table VIII, we find that the average sand from the Sounding Creek Sheet contains, in the surface, enough nitrogen to produce 17 thirty-bushel crops of wheat, enough phosphorous for 78 crops, enough calcium for 1,940 crops, enough magnesium for 500 crops, and enough potassium for 640 crops. But sand is the least fertile soil. Therefore, making similar calculations for clay, the most fertile soil, we find, in the surface, enough nitrogen to produce 75 thirty-bushel crops of wheat, enough phosphorus for 164 crops, enough calcium for 4,160 crops, enough magnesium for 3,960 crops, and enough potassium for 960 crops.

Apart from water the only soil elements essential for plant growth other than those given in Table VIII, are sulphur and iron, and it is seldom considered worth while to determine the quantities present since most soils contain large quantities as compared with the amounts required by crops.

From these figures and statements it might seem as though the supply of essential elements, other than nitrogen and phosphorus, is practically inexhaustible. However, the fact of the matter is that crop growth may be retarded by the lack of a certain element, even though there is enough of that element present to produce hundreds of crops. The explanation for this is that the essential element dissolves slowly or becomes available slowly. It should be noted here that the rate of solution can often be hastened by better methods of tillage and soil management, and by rotation of crops. The decomposition of organic matter is more intense in fallow soil and under tilled crops than under untilled crops. It is likewise more rapid under legumes than under cereals.

Although the importance of soil moisture as a limiting factor in crop production in Alberta, and particularly in southeastern Alberta, should be emphasized, the importance of soil fertility should not be lost sight of. Because of the limited amount of leaching the soils usually contain considerable quantities of the soluble salts essential for plant growth, and in years of abundant rainfall large crops are produced. However, it is important to realize that the total quantities of some important plant food elements are not any greater than in good soils of more humid regions, as may be observed in Table IX.

TABLE IX.—CHEMICAL COMPOSITION OF SEVERAL NORTH AMERICAN SURFACE SOILS.

	Nitrogen %	Phosphorus %	Calcium %	Magnesium %	Potassium %
Sounding Creek Sheet, Alberta, Loam	.177	.060	.87	.28	1.33
Edmonton, Alberta, Loam	.620	.108	1.22	.62	1.49
Guelph, Ontario, Loam	.181	.097	1.39	.40	1.66
Illinois, U.S.A., Brown Silt Loam	.247	.054	......	......	1.78

The nitrogen figures indicate the desirability of growing a legume such as sweet clover, occasionally, where grain farming is practised, in order to maintain the nitrogen as well as the fibre content of the soil. Of course it will be understood that continuous wheat growing will not exhaust the soil's nitrogen supply under dry farming conditions as quickly as under more humid conditions.

LOSS OF ORGANIC MATTER AND ITS RELATIONSHIP TO LOSS OF FERTILITY.

The one-crop grain farming system followed so largely in the west, tends to reduce the soil's supply of organic matter, and of nitrogen also, since the soil-nitrogen is very largely held in the form of organic matter. Organic matter is constantly decaying in the soil, and the only source which tends to replenish the supply is the stubble and roots of grain together with any residue from weeds that may have grown on the land. When the land is fallowed the increased air and moisture favor a more rapid decomposition of the organic matter, and at the same time no organic matter is added to replace that decomposed. It is, therefore, not difficult, to understand why this system of farming tends to exhaust the soil's supply of readily decomposable organic matter.

Dr. Shutt shows that soils from Portage la Prairie lost 22 per cent. of its nitrogen in the twenty-five years it had been cropped and fallowed; or the nitrogen content fell from .651 to .506 per cent. This is equal to about 2,900 pounds per acre for the surface soil.

Much of the nitrogen reported in the above loss could not be accounted for in the crops produced. Thus it can be seen that the straight grain system is rather extravagant with the soil's organic matter. Rotations including sod-forming crops and summer fallow substitutes would be more conservative.

The decomposition of organic matter in soils is a necessary process, and a soil's producing power depends, in a large measure, upon the decomposition of organic matter in that soil. Non-legumes depend for their nitrogen supply upon the nitrates set free when organic matter decomposes. The mineral plant foods are likewise made more available when the organic matter decomposes. As pointed out elsewhere, the total stores of mineral matter in most soils are large in comparison with what the crop removes, but crop growth depends upon the supply of essential elements dissolved in the soil water. When organic matter decomposes in soil it sets free a quantity of mineral salts which dissolve readily in the soil water and supply the growing plants with required nutrients.

Organic matter increases a soil's water-holding capacity, and it is very important that the soil should retain as much of the rainfall as possible, since moisture supply so often limits crop production. The average soils may hold from 15 to 40 per cent. of water when saturated, whereas organic matter may hold from 50 to 200 per cent. at saturation.

The amount and condition of the organic matter materially affects the ease with which soils will drfit. (See Soil Drifting).

For the above reasons on attempt should be made to maintain the soil's supply of organic matter. This might best be done by modifying the straight grain system so that it consisted of rotations, including sod-producing forage crops and summer fallow substitutes, as well as a winter cereal such as rye. Among the most promising grass crops Brome and Western Rye are worthy of mention.

SOIL DRIFTING.

Soil drifting is not as serious a problem in the Sounding Creek Sheet as it is in the areas to the south-west. Nevertheless soil drifting is a serious menace and does considerable damage in seasons of high winds. The principal sand dune areas are indicated on the map by special legends.

All soil types appeared to drift provided they had been cropped for a number of years and happened to be in a fine, loose, dry condition when swept by strong winds. Some types drift earlier after breaking than others. Some likewise drift more severely than others. The sands start very shortly after breaking, whereas a number of years may elapse before the finer types are affected. The lighter types and the heavier types of soil are more severely affected than those of intermediate texture. Some parts of the sand areas are so loose that they have drifted even before breaking.

As previously stated, there are a few very sandy districts in which the soil drifted before it was brought under cultivation, but for the most part drifting did not occur until the sod was broken for grain growing. The original soil was full of root fibre, and the grass covering the surface held the soil.

The summerfallow has undoubtedly been directly responsible for the menace of soil drifting, but we cannot dispense entirely with it; thus it would seem that we are justified in somewhat modifying it.

The longer we cultivate our soils the greater will become the tendency for them to drift, but fortunately by somewhat modifying our present system we can lessen and finally minimize this menace. Discussions of the ways of controlling soil drifting have elsewhere occurred in printed form, but it is not out of place to briefly mention a summary of these control measures as follows: Regulate time of plowing so that the soil is moist when plowed. Leave the surface rough; beware of implements which pulverize the surface soil. Control weeds on summerfallow by using such implements as rod weeder, duckfoot cultivator, etc., which do not disturb and pulverize surface soil. At critical time, as during winter and early spring, keep soil ridged at right angles to prevailing wind by using lister plow, or other implement; even the springtooth harrow may do, provided the surface is moist. Spread manure on spots most likely to start blowing. Sow a very light crop of oats on summerfallow land in the early fall. Alternate strips of crop and fallow at right angles to prevailing wind. Do not have very large areas of fallow in one field, or in adjacent fields. Use summerfallow substitutes such as corn, sunflowers, sweet clover. Use systematic rotations, including a certain amount of grass crops, and keep some live stock, thus maintaining the fibre in the soil. Include a fall cereal, such as rye, in the rotation. Plant more trees for wind breaks. (See Plate 3, Fig. 2.)

CROP ROTATION.

It has been shown experimentally that a crop will give a higher yield if it is grown in rotation with other crops than if it is grown year after year on the same soil. For example, the wheat yields in the much quoted long term Rothamsted experiments were decidedly greater when grown in rotation with other crops than when grown year after year on the same plot. Some of the reasons for such increased yields, and some advantages of rotations, will now be brief reviewed; without, however, attempting to discuss the relative merits of special rotations.

A good rotation of crops will nearly always include a sod-forming grass or clover crop. Such crops tend to increase the soil's supply of organic matter, the importance of which, in relation to maintenance of soil fertility and preventing of soil drifting, has already been discussed.

If a legume, such as alfalfa, sweet clover, or red clover, can be successfully grown, it should be included in the rotation because such crops are able to obtain their nitrogen supply from the air, and may therefore be used to increase the supply of nitrogen in the soil available for other crops.

Certain insect pests, plant diseases, and weeds naturally accompany certain crops, and do not accompany other crops. By rotating the crops it is, therefore, often possible to escape much of the damage which would be done by the accumulation of these pests, where the crop is grown year after year on the same ground.

In places where the rainfall is sufficient to produce crops without fallowing, a cultivated crop, such as corn, is nearly always included in the rotation, thus enabling the farmer to kill the weeds which usually accumulate in crops which are not intertilled. A well cultivated fallow will kill accumulated weeds, but, in many instances, in the district surveyed, it will undoubtedly be found possible to reduce the frequency of fallowing, and possible in some instances, to displace fallowing altogether by growing intertilled crops, such as corn.

Then again a crop rotation means a variety of crops, and a variety of crops means less danger of complete loss of crops. Moreover, a variety of crops usually means live stock farming, which is a much safer and more permanent system than the system of grain farming alone, which is commonly followed. (Information as to rotations adapted to the Sounding Creek Sheet may be obtained by writing to the nearest experimental station, or to the district agricultural representative.)

SUMMERFALLOW.

By carefully controlled experiments it has been found that growing plants utilize a surprisingly large amount of water. The amount utilized varies with the kind of crop and the growing conditions. The average of many determinations and many crops is over 400 pounds of water for each pound of dry matter. The water must pass from the soil into the plant roots and out through the leaves. This quantity of water thus transpired for each pound of dry matter produced is known as the transpiration ratio. Using this figure and a given weight for a given crop we can calculate roughly how much water would be transpired by that crop. Thus, for example, a thirty-bushel crop of wheat, including grain and straw, would contain at least 5,000 pounds of dry matter, and require 1,000 tons, or about 9 acre-inches of water. There are additional losses of water from soil caused by evaporation and run-off. These added losses would bring the above figures somewhat higher.

It has been shown that, under actual farming conditions in southern Alberta the wheat crop has required, not 400 pounds of water, but about 1,700 pounds of water to produce one pound of dry matter, or twice this amount to produce one pound of grain and one pound of straw, and the farmer has received only about 1.1 bushels of wheat for each inch of rainfall. It would thus seem that the utmost effort should be made towards greater efficiency in the use of our rainfall. Considerable losses, due to evaporation and run-off are unavoidable, but better rotations and soil management would materially reduce moisture losses. The margin of precipitation over actual crop needs throughout the areas surveyed is small during the average season. The average annual precipitation is about 11.3 inches, and since it often drops below this amount it is not strange that the summerfallow must be resorted to. However, the fallow must be better managed than in the past if we are to expect the most efficient use of the rainfall.

The main objects of the summerfallow are to collect moisture for the next season's crop, and to increase the availability of the plant foods. When land is plowed and kept free from weeds the water which normally would pass out through the plants is kept in the soil, provided, of course, the soil is of a retentive nature. It is quite evident that early plowing or cultivation of the fallow is important, because it stops the loss of water caused by the transpiration of growing plants. Weeds, when permitted to grow on the fallow, pump water from the soil in exactly the same manner as any of the crops, and thus defeat the main object of the summer fallow. If a soil sample from a good fallow is compared with a sample from a weedy fallow or a cropped soil, it is found that the good fallow sample contains much more moisture than either of the other samples.

Since a good fallow has a higher moisture content and better conditions for the decomposition of organic matter, it is found to contain more available plant foods than a poor fallow or cropped soil. From published data of the Soils Department of the University, fallow at Edmonton was found to contain from 5 to 10 times as much soluble nitrate nitrogen as cropped soil at the end of the growing season. Data from soils collected from the southern end of the province show fallow to contain at least three times as much nitrates as cropped soil.

For a detailed discussion of the summerfallow practice, see "Summerfallow in Southern Alberta," by James Murray, issued by the Provincial Department of Agriculture.

ALKALI.

All soils are formed from weathered rock materials, and alkali salts come originally from decomposed rocks. Many of the stratified rocks such as shales, contain various salts because of their having been formed in salt waters. Soluble salts set free by the decomposition of such rocks tend to accumulate wherever the rainfall is not sufficient to dissolve and carry off the salts.

Alkali lands usually occur where the annual rainfall is less than twenty inches. Alkali does not generally occur on hills or slopes, but rather in the valleys or depressions among the hills or undulations, where such depressions receive the drainage from the surrounding soils and there is no drainage outlet. Such an alkali lake is shown in Plate 2, Fig. 3.

However, alkali frequently occurs on level land, if not too well drained, even though that land is elevated. Porous soils, like sands and sandy loams, other conditions being equal, are less apt to contain injurious quantities of alkali than fine textured soils.

The alkali salts are commonly classed as brown, black or white. Brown alkali consists chiefly of the nitrates. Black alkali consists chiefly of the carbonate and bi-carbonate of sodium, and owes its name mainly to the fact that when this alkaline salt is present it dissolves organic matter and produces a dark brown to black color. White alkali consists chiefly of the neutral salts, such as sodium sulphate, sodium chloride, magnesium sulphate, magnesium chloride, and the similar salts of calcium, and even at time potassium. The main salts of both the brown and white alkali are neutral in reaction and not alkaline, as is the case with black alkali.

Black alkali is the most toxic, and when present in quantities exceeding .1 of one per cent. is usually detrimental to plant growth. The white alkali is least toxic and seldom causes injury unless present in quantities exceeding .5 of one per cent. Black alkali deflocculates fine textured soils and causes them to become tough and impervious. White alkali has no injurious effect upon the physical condition of soils, but tends rather to produce a granular character which accompanies good tilth. The injurious effect of black alkali is largely caused by its corroding effect upon the plant roots; however, in the case of white alkali it is believed that the high concentration of salt outside the plant roots prevents transpiration or water absorption. If the concentration of the salt outside the plant roots is sufficiently great the osmotic pressure would cause the water to be drawn from the plant roots into the soil, thus causing the death of the plant.

Many samples of soil, shales, alkali incrustations, and drainage water collected in the district south of the Sounding Creek Sheet, and representing different soils conditions of southern Alberta, were analysed, but only sufficient data to represent the various soil conditions are brought together in Table X. Although most of the samples were taken outside the Sounding Creek Sheet, they are undoubtedly representative of the alkali salts of southern Alberta.

The soils from some areas are relatively free from alkali salts, whereas in other areas there are considerable quantities present. In general the heavier types of soil contain the greater quantities of alkali salts. Most productive arid or semi-arid soils contain from .25 to .50 per cent. of water soluble salts. Soils containing more than .50 per cent. of total water soluble salts, exclusive of calcium sulphate, are justly viewed with suspicion, but soils containing large quantities of gypsum (calcium sulphate), as do many of the soils of southern Alberta, will produce crops when they contain quantities of soluble salts which would be decidedly injurious provided there were no calcium sulphate present, since this salt ameliorates the toxic effect of the other alkali salts. The amounts of calcium sulphate shown in Table X do not indicate the total amounts in these soils, since not more than one per cent. of calcium sulphate will be dissolved under the conditions of extraction used. Many of these soils contain at least several per cent. of total calcium sulphate. Even the clay loam represented by samples 215, 216 and 217 produces good crops under dry farming conditions. This soil, of course, would cause early trouble under irrigation.

By observing the composition of some of the shale samples it is seen that they are at least one source of the salts found in the adjoining soils. That they are the main source of gypsum is unquestionable, since large selenite crystals were often encountered in the excavated shales. Distinct granules consisting largely of calcium sulphate were often encountered in the subsurface and subsoil samples. Some of the shales contain appreciable but not excessive amounts of nitrates. Drainage waters leaching from some of the shales were heavily charged with nitrates (see sample 290).

Whenever there is movement of water through these soils some salts likewise move about, and the more easily soluble ones tend to accumulate in the alkali spots, as may be seen from samples 123, 183, etc.

These soils in general have a high content of limestone and gypsum; thus the tendency is to retard the formation of black alkali. It is remarkable that these soils are almost devoid of black alkali, in fact, there is but a small amount present even in the alkali incrustations. The salts occurring in these soils belong to the white alkali group, and are less toxic than the brown or black alkali. The total carbonates (column one) are reported as sodium carbonate, but in fact the alkalinity is generally due to the bicarbonate. The only instances where

Table X.—Water Soluble or "Alkali" Salts of Southern Alberta.

Sample No.	LOCATION	Per cent.						P.P.M. Nitrate Nitrogen
		Na_2CO_3	Na Cl	Na_2SO_4	$Mg SO_4$	$Ca SO_4$	Total	
102	Clay loam surface 2-12-25	.02	......	......	.04	.07	.13	......
103	Clay loam subsurface 2-12-25	.06	......	......	.04	.14	.24	......
104	Clay loam subsoil 2-12-25	.05	......	......	.20	.35	.60	......
215	Clay loam surface 24-15-23	.05	......	......	.05	.10	.20	......
216	Clay loam subsurface 24-15-23	.03	......	.07	.25	.42	.77	......
217	Clay loam subsoil 24-15-23	.03	......	2.01	.35	.35	2.74	......
136	Silt loam surface 23-10-22	.03	......	......	.04	.07	.14	......
137	Silt loam subsurface 23-10-22	.05	......	......	.05	.07	.17	......
138	Silt loam subsoil 23-10-22	.05	......	......	.05	.07	.17	......
206	Silt loam surface 1-17-24	.02	......	.18	.10	.14	.44	......
207	Silt loam subsurface 1-17-24	.02	......	......	trace	.03	.05	......
208	Silt loam subsoil 1-17-24	.02	......	.63	.30	.63	1.68	......
168	Loam surface 32-16-26	.02	......	......	trace	trace	.02	......
169	Loam subsurface 32-16-26	.04	......	......	.01	.01	.06	......
170	Loam subsoil 32-16-26	.03	......	.08	.05	.05	.21	......
270	Fine sandy loam surface 22-13-17	.03	......	......	trace	trace	.03	......
271	Fine sandy loam subsurface 22-13-17	.05	......	......	trace	.03	.08	......
272	Fine sandy loam subsoil 22-13-17	.03	......	......	.05	.77	.85	......
123	Surface alkali incrustation from lake S.W. ¼ 14-13-25	.26	1.10	48.77	22.50	.49	73.12	2.9
183	Surface alkali incrustation from lake S.W. ¼ 30-14-25	.18	.58	53.64	39.00	.77	91.17	......
143	Surface alkali incrustation from road, N.W. Corner, 22-10-24	.04	trace	5.49	1.15	.84	7.52	37.5
297	Surface soil around alkali depression	.64	......	4.10	.05	.04	4.83	43.0
285	Alkali incrustation salt seeping from shale	.10	trace	44.20	1.80	.87	46.97	25.00
279	Yellowish brown shale 20 ft. below surface	......	......	.57	.05	.26	.88	6.34
280	Reddish brown shale just above 297	.02	......	.36	trace	.07	.45	11.76
199	Sandstone several feet below surface 10-11-24	.02	......	......	trace	trace	.02	8.1
200	Sandy shale just below 199 19-11-24	.02	......	trace	.05	.02	.09	15.9
201	Sandy shale just below 200 10-11-24	.03	......	.31	.10	.04	.48	4.9
202	Shale	.03	......	trace	.05	.14	.22	3.9
203	Shale weathered from contact of drift 10-11-24	.06	......	.31	.08	.04	.49	5.4
204	Coal shale just below 203	.05	......	.66	.05	.04	.80	3.9
289	Drainage water	.02	trace	.02	.12	.13	.29	1.00
290	Drainage water	.01	trace	.86	.14	.22	1.23	112.00

(Salts extracted by using 50 gms. of soil and 250 cc. of water, shaking for three minutes, allowing to settle for twenty minutes, then filtering through Berkefeld filters.)

any appreciable normal carbonates occur are in the salt incrustations, and often they are absent from these. The actual toxicity caused by black alkali will therefore be less than is indicated by the figures in column one.

No areas of typical brown alkali were encountered, but the shales do contain appreciable quantities of nitrates, as shown by samples 285, etc. Again considerable nitrates have been dissolved in the waters draining from the soil and shales as represented by sample 290. This sample contains nitrate equivalent to about 680 pounds of sodium nitrate per million pounds of water. Now, one million pounds of water is a very reasonable amount of drainage from an acre of heavily irrigated land, and there is enough nitrogen in this amount of water to produce 58 bushels of wheat. The total salts in solution in this sample are about 12,400 parts per million as against about 2,900 for sample 289.

In the soils of arid or semi-arid regions the greatest concentration of alkali is often found at about the depth of annual percolation of rains. The tendency of irrigation frequently is to produce a concentration near the surface. The water dissolves the salts, and when evaporation begins, especially if excessive amounts of water have been applied, the water moves upward carrying the salts and leaving them at the surface. This may ruin the land for ordinary crops. Seepage waters from canals and ditches sometimes pass through porous soil formations, which permit of large losses of water, and may cause a great deal of alkali trouble. The water may come to the surface at some spot or field below the ditch and bring up alkali gathered while passing through the soil, resulting in the spoiling of valuable land.

It should be mentioned that, in general, southern Alberta contains a smaller proportional amount of soil with excessive alkali salts than the great majority of districts of similar size in arid and semi-arid regions, but that with irrigation caution should be taken not to over-irrigate, otherwise certain sections will soon give trouble resulting from the accumulation of alkali salts. The best possible natural drainage should be utilized. It is more difficult to reclaim alkali lands than it is to prevent their formation. The lack of sufficient natural drainage has caused the formation of alkali flats and lakes (see Plate 2, Fig. 3). When the farmer applies irrigation water in excess he only facilitates the formation of alkali spots, unless he controls the amount used and provides for the drainage of any excess.

Since a great deal of land is injured or rendered useless by alkali its reclamation is an important problem. It is sometimes possible to produce crops on soils which contain considerable alkali by choosing alkali resistant crops, such as sweet clover or sugar beets, and by making an effort to prevent the accumulation of salts at the surface of the soil, as this is the point at which alkali salts do most of their injury. Deep plowing, just previous to seeding, and turning down the alkali which has accumulated near the surface will enable the seeds to germinate and the young plants to become established, and by proper tillage a mulch may be provided which checks evaporation and the rise of alkali until the crop is large enough to shade the ground. The removal of the excess salts from the soil, however, is the only remedy that will permanently reclaim alkali land. Leaching out the salts through underdrains or open ditches is usually the most practical and permanent remedy. This, of course, means the expense of a drainage system, and it may afterwards be necessary to flood the land several times before the excessive salts have been removed.

SUMMARY.

The Sounding Creek Sheet is located in south-eastern Alberta and lies wholly within the treeless or bald prairie portion of the Province. It consists of an area of 90 miles east and west, by 48 miles north and south, and its southern boundary is 144 miles north of the international boundary. The soil map for the area represents 120 townships, or 2,764,800 acres.

The general elevation of the Sounding Creek Sheet is about 2,500 feet, with the extreme variations from 2,200 to 3,000 feet. The southern half of the Sheet is drained by a number of coulees and creeks which originate within the Sheet and follow south into the Red Deer River. The northern half of the Sheet, apart from a fairly large area in the north-west corner, is very largely drained by Sounding Creek, which originates within the Sheet and runs east and then north through the northern half of the Sheet. The topography is generally undulating or gently rolling, but there are some very considerable areas of rolling and even hilly land. especially in the eastern half of the Sheet and again in the northwest quarter.

The main towns or centers of population occur along railroads, and the largest of these is Hanna.

The transportation facilities for a large part of the Sheet are good, and for the whole area the transportation facilities are probably as good as the average for other districts of similar size in the southern half of Alberta.

Within the boundaries of the Sounding Creek Sheet are included some of the dryest districts of Alberta, and some areas of soil drifting. No important irrigation districts are located within this Sheet.

The climate of the Sounding Creek Sheet is typical of the high plains region of western Canada. It is characterized by long, bright, moderately warm summer days, and bright, cold, dry winter weather. The average annual precipitation is about 12 inches at Medicine Hat, and during the average season about 60 per cent. of the total precipitation falls during the growing season, May, June, July and August.

The average frost free period for 20 years, from 1902 to 1921, was 125 days at Medicine Hat, 106 days at Lethbridge, and 90 days at Edmonton. The yearly mean or average temperature is 43 degrees Fahrenheit. The average temperatures of the different seasons are as follows: winter 16.3 degrees, spring 43.7 degrees, summer 66.5 degrees, fall 45.6 degrees. The average maximum temperature for winter is about 26 degrees, whereas the average maximum for summer is about 80 degrees and the average minimum about 53 degrees. During the summer the mercury seldom reaches the 100 mark, and very rarely goes down to freezing. This season has long warm days of bright sunshine, which permit of rapid growth of crops.

It is estimated that a little more than one half-million acres within this area are at present cultivated.

The wheat crop is the chief source of income within the area, as mixed farming is practised to but a limited extent. During the 6-year period, 1915 to 1920, about 71 per cent. of the crops consisted of wheat and about 22 per cent. of oats, these two crops constituting over 90 per cent. of the total.

For the 13-year period, the average yield of spring wheat was 14.4 bushels, and the average yield of oats was 23.8 bushels.

The yields obtained under dry farming vary with the rainfall. In general, the seasons of low rainfall are the seasons of low yields, and the seasons of high rainfall are the seasons of high yields, although certain factors such as seasonal distribution, etc., prevent perfect agreement in this respect. As a rule a unit of rainfall is found to be less efficient in producing crops during the extremely dry years than during the wetter years; for example, the dry years produced about one-half bushel of wheat for each inch of rainfall, whereas the wetter years produced as much as two and one-half bushels for each inch of rainfall. As an average of 14 years each inch of rainfall has produced about 1.16 bushels of wheat.

It is shown that with the present system of farming in the Sounding Creek Sheet it requires about 1,628 pounds of water to produce one pound of dry matter in the form of wheat crop, and it is suggested that better attention to the fallow and rotation practices should enable the farmer to obtain larger yields from the water or rainfall available.

Many wheat farmers have moved away from the Sounding Creek district, and it is evident that the unmodified grain farming practice cannot be depended upon as a permanent system of agriculture. It is suggested that more live stock and forage crops would materially lessen the farming hazard, and that some of the land should be turned back to ranching.

The soils of the Sounding Creek Sheet (see soil map, also page 16) consist chiefly of glacial drift derived largely from the materials weathered from the underlying shale and sandstone formations. A large proportion of the soils are medium and heavy in texture. The lighter soils, such as sand, and sandy loams constitute only about 11 per cent. of the area.

The Sounding Creek Sheet soils are usually fertile and well supplied with plant food(see Table VIII), although as a rule they do not contain as much organic matter and nitrogen as the soils of some other parts of the province, and continent (see Table IX). The lack of nitrogen is more apt to reduce crop production than the lack of any other plant food, and in this connection the importance of growing legumes such as alfalfa and sweet clover, in order to add nitrogen to the soil, is discussed. The only instances in which a deficiency of limestone was found in any of the soils of this Sheet was in the case of A horizon of the blowout soils. In all other cases the A horizon was neutral or alkaline in reaction. The sands of this Sheet are fertile as compared with most sand soils, but they will not hold up under cropping as well as the other soil types.

Experiments quoted show that the straight grain farming system is tending to reduce the soil's supply of readily decomposable organic matter, and it is pointed out that rotations including sod-forming crops, such as Brome grass, and summerfallow substitutes, such as corn, would be more conservative. Since a soil's crop producing power depends, in large measure, upon the decomposition of organic matter in the soil, it is important that a supply of readily decomposable organic matter should be maintained. Organic matter also increases water holding capacity, and if fresh or fibrous, helps to prevent soil drifting.

Soil drifting is discussed in the body of the report. It is not as serious a problem in the Sounding Creek Sheet as it is in the areas to the south-west. Nevertheless it is a menace and does considerable damage in seasons of high winds. All soil types drift somewhat during seasons of high winds, when not protected by crop growth, although the sands undoubtedly drift earlier after breaking than the other soil types. Methods of control are briefly presented, special emphasis being placed upon the need of maintaining fibre in the soil.

The advantages of a rotation of crops as compared to the one crop grain farming system are discussed, and the importance of including grass and legume crops at intervals in the rotation, in order to maintain the fibre and nitrogen content of the soils, is stressed.

In the discussion on summerfallow figures are given which show that a single season's moisture supply is not always sufficient to produce a crop, and that the summerfallows (or summerfallow substitutes, such as corn) are absolutely necessary. It is pointed out, however, that it should be possible to produce greater yields from the rainfall available than are now obtained. Furthermore, it is shown that crops following a fallow are benefited by the soluble plant food which accumulates in fallow soil to a much greater extent than in cropped soil, as well as by the accumulated moisture.

Appendix I (see page 46) contains certain details which it seemed advisable to omit from the body of the report, including notes on soil classification and characteristics of different classes of soil.

In Appendix II (see page 52) will be found a discussion of the geology of the area by Dr. J. A. Allan, Professor of Geology in the University of Alberta.

APPENDIX I.

SOIL SURVEY METHODS.

The soil survey was generally carried out by driving along the roads and stopping frequently to take notes regarding class of soil and subsoil, topography, stones, suitability of soil for cultivation, etc. The roads running north and south are one mile apart, and the roads running east and west are two miles apart. In most cases the land was traversed at intervals of one mile. In some cases roads had not been opened up, and it was then necessary to drive across the prairie. The location was usually obtained from corner posts and speedometer readings. In some cases one soil class changes abruptly to another, and in these cases there is no doubt regarding the point at which the boundary line should be placed, but more often one soil class merges gradually into another, and in these cases the point at which the boundary line is placed must be chosen arbitrarily. Then, of course, it is necessary to draw in the boundaries arbitrarily between roads, or between points of observation. After the boundaries had been established in this way the areas were sampled systematically and the samples were sent into the laboratory for analysis.

Most of the field notes were recorded on township maps obtained from the Topographical Surveys Branch of the Dominion Department of the Interior. The township map is made with a scale of two inches to the mile. Further notes were recorded in convenient field note books.

In a survey carried out in this manner, and recorded finally on a map with a scale of three miles to the inch, minor areas cannot be outlined, and boundaries cannot always be very accurately established. Hence, although the extensive soil types are outlined fairly accurately, the map should not be depended upon, without further inspection, for the purchase or sale of individual quarter sections. Many factors influence land value, but the maps should prove very useful, in a general way, as a guide for the purchase or sale of land.

SOIL CLASSES.

All soils are composed of particles of different sizes, which are designated by various grades. Generally only the finer soil particles (less than 2 mm. in diameter) are analyzed and used in classification. In order to confirm our field classification we determine the following grades:—

		Number of Soil Particles per inch.
1. Fine Gravel	2— 1 mm.	12— 25
2. Coarse Sand	1— .5 mm.	25— 50
3. Medium Sand	.5— .25 mm.	50— 100
4. Fine Sand	.25— .1 mm.	100— 250
5. Very Fine Sand	.1— .05 mm.	250— 500
6. Silt	.05—.005 mm.	500—5000
7. Clay	less than .005 mm.	more than 5000

A better idea of the diameter of the various grades may be obtained by comparing the mm. scale with the inch scale.

We are using the same system of soil classification as that used by the Dominion Department of the Interior. It has been adopted from the systematic classification used by the United States Bureau of Soils. It is briefly outlined below.

1. SANDS contain less than 20% of clay and silt, and 80% or more of sand.
   - (a) Coarse Sand—more than 25% fine gravel and coarse sand, and less than 50% of any other grade of sand.
   - (b) Medium Sand (usually designated sand)—more than 25% fine gravel, coarse and medium sand; and less than 50% fine and very fine sand.
   - (c) Fine Sand—more than 50% of fine and very fine sand; less than 50% of very fine sand.
   - (d) Very Fine Sand—more than 50% very fine sand.

2. SANDY LOAMS contain 20-50% clay and silt, with less than 20% of clay (50-80% sand).
   - (a) Sandy Loam—more than 25% gravel, coarse and medium sand.
   - (b) Fine Sandy Loam—more than 50% fine sand and less than 25% gravel, coarse and medium sand.
   - (c) Very Fine Sandy Loam—more than 50% very fine sand and less than 25% gravel, coarse and medium sand.
   - (d) Sandy Clay—less than 20% silt (very seldom used).

3. LOAMS (other than sandy loams) — Soils containing more than 50% clay and silt.
   - (a) Loam—contains less than 20% clay, less than 50% silt, less than 50% gravel and sand.
   - (b) Silt Loam—less than 20% clay, more than 50% silt.
   - (c) Clay Loam—20-30% clay, less than 50% silt.
   - (d) Silty Clay Loam—20-30% clay, more than 50% silt (seldom used).
4. CLAY—more than 30% clay.

Sand particles vary in size from 1/25 to 1/500 of an inch. They feel rough and gritty, and will not stick together either when wet or dry. They consist chiefly of the more resistant rock particles such as quartz.

Silt particles vary in size from 1/500 to 1/5000 of an inch and are midway between sand and clay. When wet they feel velvety, but lack both the roughness of sand and the stickiness of clay.

Clay particles are the smallest of individual soil grains and have a diameter of less than 1/5000 of an inch. Some of them are so small that it is impossible to see them with a powerful microscope. They settle out of water so slowly that the solution may be turbid for months. When wet they are greasy and sticky, and upon drying shrink and become hard.

Sands.—Sand soils consist chiefly of the more resistant rock particles which have withstood the centuries of weathering. The particles were formed originally by the disintegration of native country rocks. This weathered material may remain in place, but usually it is subjected to assorting and placing by water and winds, and generally occupies positions relative to water areas and prevailing winds.

From the preceding classification it may be seen that at least 80 per cent. of the particles of sand soils have diameters greater than .05 mm. (1/500 of an inch). Since sands do not contain over 20 per cent. of the finer particles they are always easily worked. Their water holding capacity is small; and, although they absorb a certain amount of water readily, they retain it poorly, and are easily leached. They can be worked when either wetter or drier than any other kind of soil, and may be kept in good tilth with less cultivation than is required for other kinds of soil. They are always warm and early, but are frequently too loose and dry to form an ideal seed bed.

The finer sands usually contain more silt than the coarser sands, and this improves their physical properties. When sand areas are subjected to the continued action of winds the finer material is carried farther to leeward than the coarser particles. Thus in typical sand areas we frequently find the coarser sand piled up in dunes, while to the leeward there is a gradual transition into the finer sands and ultimately into the sandy loams and loams.

Sandy soils are generally found to be relatively infertile. This low production power is explained by the fact that initially the sands, as a rule, are high in silica or quartz, and low in plant food, and that, in climates with heavy rainfall they are greatly leached. However, with the materials which have contributed to the formation of sand areas in Alberta, and under the climatic conditions of the western Canadian prairie, we find that the sands are comparatively fertile. (See discussion of sand areas.)

Owing to their loose open nature, and to their low initial content of organic matter, sands begin to blow sooner after breaking than the heavier soils. The greatest problems in the management of sands are the maintenance of organic matter and plant foods, and the control of moisture. The maintenance of root fibre and organic matter automatically tends to lessen drifting and conserve moisture.

These properties of sands adapt them to truck gardening, to crops such as potatoes and fruits, and to certain early field crops such as fall rye and sweet clover. Of all our grain crops winter rye does best on sands, since it becomes established in the fall, and starts growth very early in the spring, and can thus more completely utilize the annual precipitation. It likewise tends to prevent winter drifting of soil. In very wet years our sands will respond with enormous crops, but they are not nearly as durable as the heavier soils.

Sandy Loams, Loams, Silt Loams, Clay Loams.—Between sands and clays there is a group of intermediate or loam soils. These various loams are designed by property names, and are known as sandy loams, loams, silt loams, and clay loams. The lightest sandy loam does not contain over 80 per cent. of sand, and the heaviest clay loam does not contain over 30 per cent. of clay. When the proportion of sand is great the soil possesses properties closely related to those of sands, and when the proportion of clay is great the soil is more closely related to the clays. When the proportions of sand, silt, and clay are such as to impart no predominating property of one constituent, the soil is just called loam.

The sandy loams are adapted to the early crops, but are better suited to a greater variety of crops than the sands, because of their greater water-holding capacity and fertitlity. The loams are often spoken of as the all-round soils, and are, as a rule, adapted to a greater variety of crops than any other class of soils. The silt loams and clay loams require more careful management than the lighter soils, in order to maintain good tilth, and they are fertile, durable, and usually well adapted to cereals, grasses, legumes, and other common farm crops.

Clays.—Soils containing large proportions of very fine particles are designated clays. All clays contain at least 30 per cent. of soil particles with a diameter of less than .005 mm. (one-five-thousandeth of an inch). Generally a large percentage of the particles of clay soils is silt. These soils owe their origin, generally, to the finer particles which have settled out of bodies of quiet water, the material having first been carried into settling basins by streams. Many of the glacial boulder clay areas have been subjected to a lesser extent to separation and settling, and consequently contain coarser material and stones mixed with the clay.

We often hear the terms "gumbo," "buckshot," "adobe" used in reference to clay soils. Gumbo is an exceptionally heavy kind of clay, usually dark brown or black in color, occurring both on river bottoms and upland flats. It is more sticky and bakes more readily than any other kind of soil. Buckshot is a certain kind of calcareous clay, which, upon drying, forms small granules rather than large clods, thus producing a good natural tilth. Adobe soils are heavy clay soils occurring chiefly in the arid south-western states. They consist of material, part of which has been placed by water, and part blown in by wind.

Clays are just the opposite of sands in physical properties, and the characteristic properties of clays are due to their extremely fine texture. Sands are loose, open, easily worked, early, and less productive, whereas clays are fine, compact, sticky, hard to work and late. Clays absorb water slowly and give it up slowly. Upon drying clays shrink, crack and become hard and cloddy. Such soils are often hard on plants, as well as hard to till, as they shrink at times until they break the plant roots. The greatest problem in connection with clay soils is that of cultivation. When worked too wet the particles run together, and, with subsequent drying hard clods are formed. At a certain moisture content between extreme wet and dry soil, clays pulverize and form a good seed bed. They should never be plowed when too wet. One such plowing may practically ruin the tilth for a number of years. Clays are often deficient in organic matter, and one of the most effective methods of improving poor clay soils is to incorporate organic matter with the soil, either by addition of manure, or by growing and plowing down legumes. When properly handled clays usually produce good crops, since they are generally well supplied with mineral constituents needed for plant food.

Clay soils are adapted to many of the grasses, cereals, and legumes, and because of our climatic and market conditions, some of the best crops for our heavier soils are western rye grass, brome grass, wheat, oats and sweet clover. Under irrigation the choice of crops might be extended, and might include timothy, red top, alfalfa, and roots. Sweet clover and alfalfa are among the most promising crops for our heavier soils, since they readily penetrate the heavy subsoil, making channels for water and air. Furthermore they add nitrogen as well as organic matter to the soil.

APPENDIX II.

THE RELATION OF THE GEOLOGY TO THE SOILS IN THE SOUNDING CREEK SHEET

BY

JOHN A. ALLAN.*

Soils may be regarded as unconsolidated rock. Most soils have been derived from the decomposition and disintegration of older rocks. There is usually a close relationship between the soils in an area and the geology in or close to that area.

Much of the surface of the southern half of Alberta east of the Rocky mountains is mantled with unconsolidated deposits of Pleistocene and Recent ages. The soils of Pleistocene age are chiefly of glacial origin, and the younger Recent deposits have been derived quite largely from the older glacial deposits, or from the rocks immediately underlying the soil. The depths of these deposits vary from a few inches to over two hundred feet, depending upon the locality. Along valley depressions the depth of unconsolidated deposits is even considerably greater than that given above. This condition of soil origin occurs throughout almost all of the Sounding Creek sheet.

The entire area of this map has been traversed to obtain geological data but only a short time has been spent in the field examining the surface deposits in this map-area, so that the following notes must not be regarded as a complete geological report on the surficial deposits in the Sounding Creek sheet. An attempt will be made to point out some of the more prominent geological features responsible for the distribution of several of the soil types shown on the map accompanying this report. More detailed observation would have to be carried out in the field before all soil types in every part of the area mapped could be correctly interpreted. A correct interpretation of the soil occurrences in every case required a knowledge of the sub-surface geology and structure of the rocks. This detailed information is not yet available in some parts of the Sounding Creek sheet, because there are very few rock exposures except along Sounding Creek and the tributaries extending southward into Red Deer river.

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ALTITUDES ALONG CANADIAN NATIONAL RAILWAY.

The surface topography in the Sounding Creek sheet is not shown on the accompanying map and the contours have not yet been determined. It might be of interest to the reader to record the altitudes of the stations along the Canadian National railway across this map area. These are taken from "Altitudes of Canada," Ottawa, 1915.

Reading from west to east the altitudes above sea-level are as follows: Craigmyle, 2,851 ft.; Watts, 2,734 ft.; Hanna, 2,677 ft.; Bonar, 2,734 ft.; Alness, 2,659 ft.; Richdale, 2,527 ft.; Stanmore, 2,582 ft.; Scotfield, 2,498 ft.; Youngstown, 2,534 fa.; Dobson, 2,555 ft.; Chinook, 2,538 ft.; Cereal, 2,511 ft.; Excel, 2,604 ft.; Oyen, 2,521 ft.; Benton, 2,461 ft.; Sibbald, 2,358 ft.; Alsask, 2,303 ft.

SUB-SURFACE GEOLOGY.

A few notes are here given on the geological formations that underlie the Sounding Creek sheet. The formations that underlie almost the entire map-area belong to the upper Cretaceous, the older rocks occurring at the east side of the sheet and the younger ones at the west. Possibly not more than 10 or 15 square miles at the western side of the map are underlain by rocks younger than the Cretaceous, belonging to the Tertiary period. In order of age from the youngest formations to the oldest, the rocks under the Sounding Creek sheet are as follows:

Tertiary	Paskapoo.
Cretaceous	Edmonton (St. Mary River).
	Bearpaw.
	Belly River.

The *Belly River* rocks underlie the eastern side of Sounding Creek sheet, particularly in ranges 1, 2, 3 and the greater part of 4. The contact between the *Belly River* and the younger *Bearpaw* occurs on Sounding creek at the western edge of range 5. The eroded areas along this creek in range 5 are formed in the strata belonging to this formation. At the southern edge of the map the *Belly River* beds extend west into range 7. The exact position of the western edge of these strata cannot be observed because of the glacial and other unconsolidated material overlying this rock formation, but Red Deer valley to the south indicates the extent of these rocks. The *Belly River* strata consist of clay sandstones, sandy shales, clay shales, and some less indurated shales that are almost clays. This formation also carries coal beds in other parts of Alberta. The rocks in this formation are of fresh- and brackish-water origin from sediments that were deposited along the shore of a sea that lay to the south-east. On account of the thick deposit of glacial debris over much of this area it is not believed that the *Belly River* rocks have formed much residual soil in this map-area.

At the close of *Belly River* time the land surface was submerged and the sea extended to the west. In this sea were deposited marine muds that have given rise to shales. These strata form the *Bearpaw* formation and consist generally of dark, clay shales, with occasional beds of sandy shale and a few bands of ironstone nodules. The *Bearpaw* strata are almost entirely free from lime so that any soils formed from these rocks will not contain any appreciable amount of lime unless it has been washed in from the glacial till or from the higher land to the west.

Calcium sulphate in the form of gypsum crystals occurs rather abundantly in this formation, but gypsum is also a common mineral constituent in the overlying formation. Sodium, magnesium and aluminum sulphate have been observed by the writer in this formation in other parts of the province. It seems certain that these sulphates are also present in the *Bearpaw* shales in the Sounding Creek sheet and are at least in part responsible for the alkali content of the soils, and particularly the alkali flats that are shown to occur abundantly in ranges, 9, 10 and 11.

The *Bearpaw* shales underlie the entire central part of the Sounding Creek sheet and extend over nearly one-half of the map-area. From range 5 west to Berry creek is underlain almost entirely by *Bearpaw*. Along the Canadian National railway the contact occurs between Richdale and Stanmore. The shales belonging to this formation outcrop along the Red Deer valley in the south-west corner of the map and extend up Bullpound creek into township 27. It is believed that these shales and possibly the basal shaly beds in the overlying *Edmonton* formation have been to a large extent responsible for the formation of the "blow-out loam" type of soil shown on the accompanying map to be widely distributed in ranges 10, 11, 12 and 13. This point is discussed in that part of the report dealing with the origin of surficial deposits.

The *Edmonton* formation overlies the *Bearpaw* shales and represents uppermost Cretaceous strata in Alberta. At the close of *Bearpaw* time the sea receded to the east and brackish- and fresh-water sediments were deposited, which consolidated to form the *Edmonton* formation. This formation in southwestern Alberta is correlated with the *St. Mary River* formation. The *Edmonton* strata consist of rather soft, cross-bedded sandstones and sandy shales and include several coal beds. It is from this formation that the coal is mined in the Drumheller district,[1] and also at Sheerness and Richdale in the Sounding Creek sheet. The Sheerness coal occurs near the base of the formation and is classed as domestic or black lignite. A complete section of the *Edmonton* formation is exposed along Red Deer river in the vicinity of Drumheller. This section has been measured by the writer and has a thickness of 1,242 feet.[1] The lower members in the *Edmonton* formation are more shaly in character and in some places it is difficult to determine the base of this formation.

The lime content in these rocks is high and in some beds the cementing material holding the sand beds together is high in lime. *Bentonite*, known as *gumbo* in the impure form, is an important constituent of the sandstones of the *Edmonton* formation. Very heavy clay and gumbo-high soils are formed from the residual weathering of the *Edmonton* formation. This is not a characteristic type of soil in the western part of the Sounding Creek sheet because the material weathered from the *Edmonton* formation has been mixed with lighter types of soil. It is, however, quite possible that the small patches of clay, clay loam, and mixed type of soil shown on the accompanying map, particularly around the head of Bullpound creek, have been formed very largely from the bentonitic rocks in this formation. The sandy loam area in the Sheerness ridge east of Bullpound creek in range 13 and extending to the north-west towards Hanna, has also been formed quite largely from the Edmonton strata. The Sheerness ridge is underlain by this formation.

West of the Sounding Creek sheet the Hand Hills occur, and the eastern flank of these hills extends into the Sounding Creek sheet in townships 28, 29 and 30, range 15. The Hand Hills are capped by Tertiary rocks and the lowest of these strata form the *Paskapoo* formation. As previously men-

[1] Allan, J. A., Geology of Drumheller Coal Field, Alberta. Sci. & Ind. Res. Coun., Alta., Report No. 4, 1922.

[1] Allan, J. A., Geology of Alberta Coal. Trans., Can. Inst. Mining & Metallurgy, Vol. XXVIII, 1925.

tioned, a few square miles of Sounding Creek sheet on the east side of Hand Hills lake are underlain by this formation, but the exact distribution of these rocks has not been observed. The *Paskapoo* rocks in the Hand Hills consist of soft, clayey sandstones, weathered yellowish, and shales that are sometimes so soft that they are classed as clays. The lime content in the *Paskapoo* strata is higher than it is in the underlying *Edmonton* strata. No doubt the weathered sand and clay from this formation in the Hand Hills have been washed down the slope to the east and mixed with the soil types in the western side of Sounding Creek sheet. On the top of the Hand Hills in the Rosebud sheet west of this map-area, the uppermost formation consists of a few feet of conglomerate and pebbly sandstone. This formation is younger than the *Paskapoo* and is believed to be of Oligocene age. Some of the pebbles of coarse sand can no doubt be found in the soils along the extreme western edge of the Sounding Creek sheet.

ORIGIN OF SURFICIAL DEPOSITS.

The soil differs from underlying deposits upon which it is developed in that weathering agents have changed its original texture, color and composition. In some soils the accumulation of organic material, both vegetable and animal, has caused the soils, particularly the surface soils, to assume a dark color. In most cases surface leaching has deprived the soils of certain original minerals, and often the mineral content of the subsoils has been changed. In many of the soils in the Sounding Creek sheet the calcareous content has been reduced by processes of weathering and an increase of the lime content occurs in the subsoils. In general it is a fact that the surface unconsolidated deposits in the Sounding Creek sheet are lower in calcium carbonate than are the deposits to the west and south-west of the map-area. This is due to the fact that the older rocks underlying much of the Sounding Creek sheet are lower in calcium content than are the younger rock formations closer to the foothills. On the other hand, if the unconsolidated deposits contain certain soluble minerals these are brought to the surface in the ground waters, and in such cases the soils will be richer in those minerals than the subsoils. All these conditions have to be considered in explaining the origin of the soil types that occur in the map-area.

The unconsolidated deposits in the Sounding Creek sheet can be classified into four types:

(1) Glacial moraine, unsorted.

(2) Resorted glacial deposits.

(3) Transported deposits of alluvial, laccustrine, and dune origin.

(4) Residual deposits.

The glacial deposits consist of *till* or *boulder clay* in the form of moraines that have been left by the ice-sheet that covered the area. These deposits are unstratified, and consist of an unsorted mixture of clay, sand and gravel.

Ground moraine occurs over much of this map-area east of range 9 and in the north-western corner of the area on the eastern flank of Hand Hills. This unsorted material varies in thickness, and in some places is almost missing, having been removed by later erosion. Much of the rolling and hilly surface in the eastern half of this area and in the north-western corner consists in large part of boulder clay.

Glacial drift in the form of terminal or lateral moraines occurs in this area. These deposits usually occur as ridges, and have been formed by deposition of material from the glaciers along the margin. The material is similar to that in ground moraine, but a thicker deposit in the form of a ridge marks the position where the front of the ice halted for a time. The eastern edge of this map-area is very distinctly morainal in character. This moraine can be traced northwards to the North Saskatchewan valley. It is largely due to this morainal deposit that Sounding creek makes a sharp bend to the north in township 30, range 3, following the western flank of this moraine beyond the northern boundary of this map-area. These morainal deposits, forming rolling and hilly topography, also extend across the southern part of the area as far west as Blood Indian creek. The surface topography from Cereal station eastward to Excel, Oyen, and to the eastern edge of the area is largely the result of this glacial debris. There are morainal deposits on the south flank of the Neutral Hills and west of Sounding creek. The rolling surface at the north side of the map-area and north of New Brigden has been formed on this moraine.

In the morainal covered areas local depressions are common. These depressions are often circular in outline and even conical in shape, sometimes more irregular. These depressions are called "kettle holes" and are formed by entrapped blocks of ice melting after the glacier left that surface, with the result that the moraine settled to form such depressions. In some of these there may be soft ground or slough conditions, or even sufficiently drained to form a firm surface. There are a number of these kettle holes in the vicinity of Excel. In a few cases observed a few trees are growing in a circular line about the depression. This is due to the growth that resulted while the central part of the depression was covered with water or while slough conditions existed. Such surface conditions are unmistakeable evidence of the presence of morainal material in that area.

The second type of soil is that resulting from *glacial drift* that has been *resorted* and deposited along old glacial drainage courses or in ponds and lakes close to or near the front of the retreating ice sheet. In some cases *outwash plains* have been formed from deposits carried out by streams coming from under the ice sheet around its margin. The plain represented by Acadia valley in the south-east corner of the map-area has been, at least in part, developed from the finer material washed out of the glacial moraine that surrounds this plain.

Where the moraine is gravelly or contains many small boulders it is usually the case that the finer particles have been removed from the glacial drift since time of deposition. This type of reworked glacial material occurs in the south-west corner of the map, along the upper slopes of the Red Deer valley. Due to the pronounced slope of the surface to Red Deer river considerable amounts of the finer material have been removed from the glacial drift by the "run-off" along the valley slopes. The result of this removal of finer material is the development of stony soils. Two other areas of stony land formed in the same way might be mentioned. North of Excel and Chinook, along the valley of Sounding creek, in township 30, ranges 5, 6, 7 and 8, the finer material has been removed and a stony soil remains. Stones are more numerous in range 5, where they have been derived from the thicker deposits of glacial debris. The other area is at the head of Alkali creek along the side of the morainal, higher land, where the surface deposits are more stony than in adjoining areas.

The third type of surface material includes the *transported deposits*. The transporting agents are running water and wind. The former gives rise to alluvial and laccustrine deposits, the latter to sand dunes. All transported deposits are bedded in character due to the sorting action of the transporting agents. The sand and clay may occur in separate beds, forming a sandy soil or a clay soil. These deposits may also be a mixture of sand and clay with varying proportions of each, giving rise to a sandy clay or a clay loam soil.

Alluvial material occurs along the bottoms of valleys where there are streams at the present time, or along old drainage courses where there is no apperent drainage today. The laccustrine deposits include those clays and sands deposited on lake basis, sometimes small, sometimes large in area. There may be a small lake remaining or there may not be any surface evidence of such a lake at the present time except a broad, plain surface. In this type of deposit the character and composition of the soils are usually quite uniform. The clay and silt loams along Sounding Creek east of range 4 are of alluvial origin. The mixed type of soils at the head of Bullpound creek, Berry creek and Alkali creek, and in the flatter land surface south of Sunnydale, have been formed in the same way.

There are many examples of lake basins in this map-area, some of them still containing small bodies of water. Only a few examples will be cited. Antelope lake is a remnant of a much larger lake, the basin of which is now drained by Sounding creek in range 9 and the east side of range 10. Badger lake was at one time much larger, and possibly extended to the north boundary of this map-area, along the present course of the stream that occurs today at the eastern edge of township 32, range 12. This stream flows south into a long, narrow lake, partly in section 31, township 31, range 11. There is no surface outlet to this lake. Rather extensive former laking occurred along Acadia valley and also around Benton. This is indicated by the broad, nearly flat surfaces that occur in these localities. It may be taken as a fact that wherever there is a broad, flat surface, nearly level, that that area consists of lake deposits and these will be found to be quite uniform in composition, at least below the immediate surface soil where it may be slightly different in composition on account of material added by wind or in other ways since the laking period.

The lakes in the Sounding Creek sheet are almost without exception irregular in shape and very few have surface outlet drainage. These marked characteristics, the irregular shape and lack of outlet, are typical of lakes formed in irregular depressions on glacial moraine. The numerous irregular lakes in the vicinity of Rearville and Clemens in townships 25, 26, and 27, ranges 6 and 7, are excellent examples of the type of lake formed on morainal deposits. Dowling lake, in the north-west corner of the map-area and the largest on the Sounding Creek sheet, is also of glacial origin in that it is formed on moraine, but it is possibly part of an old drainage course that extended to the south by Bullpound lake, Hanna and Bullpound creek. This explanation seems evident from the surface topography. The altitude at Hanna is 57 feet lower than at Watts to the west and Bonar to the east.

One of the most suggestive drainage features in the Sounding Creek sheet is the distribution of alkali flats from the north boundary of the map in range 10, south by Oldman lake, Reist, Scotfield and Plover lake. Scotfield station has an altitude of 2,498 feet, which is the lowest station point on this map-area along the Canadian National railway west of Benton. It is quite probable that at one time the drainage from townships 31 and 32 in ranges 9 and 10 was southwards by Scotfield, Stoppington and Berry creek, instead of by Sounding creek as at present. The distribution of these alkali flats in such a narrow belt is due, no doubt, in part to the imperfect drainage along this belt, and possibly in part to the soluble salts in the underlying *Bearpaw* shales.

The wind deposits are represented by sand dunes. These deposits are found chiefly in the large sand area around Antelope lake, where the sand has been derived principally from the sandstones in the *Belly River* and *Edmonton* formations by glacial erosion. Smaller dune areas occur in the sandy loam west of Sedalia and in extensive glacial morainal deposits at the north-east corner of the map east of Ester and also in the same moraine south of Alsask in township 27, range 1. Other sand dune areas could easily be formed, especially in this eastern moraine and in the sandy loam, if the mantle of vegetation were removed.

The fourth type of soil includes the *residual deposits* that have been formed by erosion processes from the underlying strata. Soils formed in this way will have a composition somewhat similar to the composition of the underlying rock from which they have been formed. For example, certain areas of sandy loam indicate the occurrence of clayey sandstone below, while silt loam and clay loam suggest the presence of shale formation in the underlying rocks.

In the Sounding Creek sheet residual soils are believed to have a wide distribution, especially in the western half of the sheet. It has already been mentioned that a considerable part of the eastern half of this map area is covered with morainal material. It may be that even in this area, influenced largely by glacial deposits, there are local areas where the soil consists in part at least of an admixture of the underlying sandstones and shales. There is a large loam area, chiefly north of the Canadian National railway in ranges 3, 4, 5, 6 and 7, and more especially north of Sounding creek, where it is believed that soils are largely of residual origin from the underlying *Bearpaw* shales. Where the surface is rolling is this loam area there have been certain constituents removed by surface leaching so that the composition of the soil is not identical with the composition of the underlying rock.

In the west half of the Sounding Creek sheet the loam "blow-out" type occupies about three-quarters of this area. Glacial deposits are not common throughout this area and in many parts are absent. Much of the area is underlain by shales of the *Bearpaw* formation and sandy shales in the lawer part of the *Edmonton* formation. Along several of the streams the rock formations are exposed almost to the level of the adjoining country. These facts indicate strongly that much of the loam in this "blow out" area west of range 9 has been derived largely from the underlying rock formations and is therefore of residual origin. If this is the correct interpretation the unconsolidated deposits, especially west of range 12, should be more sandy at depth than those east of Berry creek and south of township 27, in the west half of the Sounding Creek sheet.

All four types of soil are represented in this map-area, but in order of importance the types are four, two, one and three.

In discussing the origin of the various types of soil shown on the accompanying map, mention must be made of the "eroded area" type. In almost every case these eroded areas occur along the present drainage, or along former drainage, courses.

"Eroded areas" are formed in one of two ways.

(1) Along steep valley sides or on slopes where the gradient is large and where the "run-off" is rapid and therefore active in wearing down the unconsolidated material.

(2) Along slopes where the underlying rock formations are outcropping.

The rocks outcrop along Red Deer river and along most of the tributaries that drain into the Red Deer from the western half of the Sounding Creek sheet. On the Bullpound, Berry and Blood Indian creeks outcropping rocks form eroded topography well up to the central part of the map-area. Plate 3, Figure 1, shows one of these rock exposures near the headwaters of Bullpound creek in the southwest corner of township 29, range 14. North of this locality there are several eroded belts along former drainage courses on the east flank of Hand Hills. The narrow, eroded area extending north from Berry lake also marks an old drainage course where the slopes are steep.

Considerable erosion occurs along Sounding creek, especially west of Seal in range 4. In some of these areas the bedrock is exposed and eroded, in other places it is the unconsolidated deposits that have been eroded on steep slopes along Sounding creek or tributary drainage channels. The eroded area west of Helmsdale in range 6 is formed along the steep slope of the glacial deposits. The two small areas on either side of Blood Indian creek, at its head and close to Benachi are on former drainage courses of this creek. Where the soil is heavy, a clay or clay loam as on Berry creek west of Badger lake in range 12, erosion is not pronounced.

GLACIAL HISTORY OF THE SOUNDING CREEK SHEET.

The study of the surface deposits and the present physiography of the Sounding Creek sheet involves the glacial history of this part of Alberta. The glacial history of this sheet, insofar as it is related to soil types, is so intimately connected with the glaciology over a large part of southern Alberta that it is in order to include a few general notes on the subject.

During late Tertiary time and long before the southern advance of the continental ice sheet from the west side of Hudson Bay there was a pronounced topography in southern Alberta. The physical features became more pronounced by erosion as the Glacial Period approached. The erosional features in this part of Alberta were formed largely through the uplift of the Rocky Mountains. It was towards the close of the Cretaceous period in the Mesozoic era that the initial uplift of the Rocky Mountains occurred. As this uplift continued, drainage channels were formed on the eastern slope. Ultimately a pronounced system of drainage was developed, with major streams having a general easterly direction. This pre-glacial drainage down the east slope of the Canadian

Rocky Mountains is today represented in general by such rivers as the Red Deer, North Saskatchewan, Athabaska, Peace and many other smaller rivers.

It is not necessary in this report to discuss details regarding pre-glacial topography. It is apparent, however, that the general surface of this part fo Alberta at the close of the Tertiary was a rolling plain, deeply incised with many valleys. The elevation of this plain was considerably above the present elevation—at least as high as the top of the Hand Hills. When the glacier advanced this part of the province was covered with what is known as the Keewatin ice sheet, which originated in the snow fields west of Hudson Bay. This ice sheet advanced beyond the southern boundary of Alberta. The advancing ice sheet brought with it Precambrian boulders and finer rock debris from the north-east, but the largest part of the load of the ice consisted of rock debris from the younger Cretaceous and Tertiary formations over which the ice passed. The original elevation of the plain in the Sounding Creek sheet was lowered by erosion from the ice sheet. There is no way of determining the exact amount of material that has been removed by erosion over all parts of southern Alberta, but, if the glaciers ever covered the Hand Hills, the thickness of ice over these hills was not great. The Hand Hills have an altitude of 3,578 feet and the lowest altitude on the Sounding Creek sheet is about 2,275 feet. On this evidence it can be assumed that several hundred feet, possibly as much as one thousand feet, have been removed by ice erosion over much of the Sounding Creek sheet. There is no exact data on how thick the ice was in this part of Alberta, but it was possibly quite thin in some places and possibly absent from other areas because there are local driftless areas; that is, areas where there are no glacial deposits.

With a more moderate climate the ice sheet melted and the enclosed rock debris was left as glacial drift. It is important to bear in mind that this drift was made up of heterogeneous rock debris consisting in large part of silica-, alumina-, potash- and magnesia-rich debris from the Precambrian rocks to the from the Cretaceous and younger rocks at the surface north-north-east, and silica-, lime-, and alumina-rich sand and clay east of the Sounding Creek sheet, which were ground up by the advancing ice sheet. There is no debris in the map-area that has been derived from the Rocky Mountains.

Glacial erosion is always caused by the forward movement of the ice. During the retreat of the ice sheet the ice does not move backward, but the front of the ice sheet is melted more rapidly than the forward movement of the ice. The front of any ice sheet is irregular and lobate in outline. Tongues of ice project farther forward than other parts of the ice mass. This applies to the Pleistocene ice sheets as well as to modern glaciers. As the ice-front retreated, the water from the melting ice became impounded where drainage courses from the ice became blocked by debris from the ice. In many places in Alberta drainage courses were developed sub-parallel to the ice-front. This type of drainage is not in evidence on Sounding Creek sheet. It has been stated in another part of this report that certain surface conditions indicate that Dowling lake was previously drained to the south by Bullpound. Such a drainage course was no doubt influenced by the ice front.

Post-glacial erosion has deepened many of the depressions that originated during the glacial retreat. The several small streams shown on the southern half of the Sounding Creek sheet flowing south into Red Deer river are largely of post-glacial age.

The distribution and origin of the glacial deposits on this map-area are discussed in another part of this appendix. Details on the glaciology of Alberta have yet to be worked out, and no doubt many interesting features on the glacial history of this province are not yet known.

WATER SUPPLY.

There is very little accurate information on the possible water supply or on the possible water-bearing horizons in the Sounding Creek sheet. It is believed that many valuable data are available in this map-area from the existing water wells, but the necessary time and funds for the compilation of these data were not available. A few general remarks on the water problems may be of interest to some of the readers.

Considerable time has already been given to certain sources of water in the Rosebud and Red Deer sheets west of this map-area, and conditions in the Sounding Creek sheet should not be very different from those to the west. It is an observed fact that there is an excellent water horizon on the contact between the *Paskapoo* and the *Edmonton* formation. In the vicinity of Hand Hills and Wintering Hills and also west of Red Deer river springs of sweet water are common on the line of contact between these two formations. In every case where observations were made the water is sweet and also hard, due to the lime content in the water that has been derived largely from the *Paskapoo* strata. There should be a good water supply not far from the surface along the western side of the Sounding Creek sheet on the eastern flank of the Hand Hills.

The underlying *Edmonton* formation consists of clayey sandstones and shales usually high in gumbo. The gumbo clay in the *Edmonton* strata forms impervious layers that are suitable for the retention of water. Small water supplies might be encountered at shallow depth in any part of the *Edmonton* formation.

The *Bearpaw* shales are impervious in texture and are not suitable as a source of underground water. Any wells that are drilled on that part of the Sounding Creek sheet which is underlain by the *Bearpaw* shales would have to be drilled into the underlying *Belly River* formation before an underground supply of water could be expected. Over much of this map-area the Bearpaw is thin, in many places less than 100 feet in thickness. It is quite possible to encounter underground water supplies within about 250 feet of the surface over much of the map-area that is underlain by *Bearpaw* shales, but the water would be encountered in the uppermost beds in the *Belly River* formation and not in the *Bearpaw*.

The *Belly River* formation contains porous sandstone interbedded with impervious shales. These are two conditions necessary for the occurrence of an underground water supply. A small quantity of water may be expected in the uppermost strata in the *Belly River* formation but no definite, continuous horizon has been recognized in this formation in this part of Alberta. It is from the lower part of the *Belly River* formation that the artesian water supply occurs in south-eastern Alberta in the Milk river district, but this horizon might not contain water in the Sounding Creek sheet and, furthermore, the depth to this horizon would be too great. Two wells have been drilled through the entire *Belly River* formation on the Sounding Creek sheet, but large flows were not encountered in either of these wells. The one well was drilled in the north-east quarter of section 29, township 32, range 4, north of New Brigden, to a depth of 3,304 feet by the Imperial Oil Company. The other well is being drilled by the Fuego Oils, Ltd., in the north-east quarter of section 34, township 25, range 4, west of Acadia valley. The depth of this well at the present time is 2,860 feet and operations have ceased for the winter. Neither water nor gas has been reported from this well.

The glacial deposits are usually too loosely compacted to form reservoirs for surface water, but a small supply of ground water may be encountered at, or close to, the contact between the glacial deposits and the underlying rocks, especially if these are the impervious shales of the *Bearpaw* formation.

Although very few exact data on the underground water-supply in this map-area have yet been obtained, yet it can be said that in most parts of the Sounding Creek sheet there is a good chance of encountering an underground water supply, possibly not a very large one, at depths which will vary, in most places under 500 feet but depending upon the locality. On the other hand, there is not much chance of getting large flows of artesian water within this map area, but the ordinary domestic supplies can be obtained without much difficulty in almost any part of the Sounding Creek sheet.